AIRPLANE PIONEER BOEING EXTENDS ITS AVIATION LEGACY WITH THE CONNEXION NETWORK, WHICH BRINGS BROADBAND-INTERNET ACCESS DIRECTLY TO YOUR PASSENGER SEAT.

Picture this scene: You’re crammed into a midrow seat on an airplane flying at 30,000 feet, en route to Europe or Asia eight or more hours hence. On your right is a screaming child who’s already spilled food and crayons all over your lap. The man on your left has bad breath and worse body odor and has just launched into a detailed and comprehensive recounting of his mind-numbing life story. Plus, you’ve got hundreds of unviewed e-mails sitting on your corporate server from the last intercontinental trip you took, your Web site is staler than a year-old saltine, and the Ebay auction for that rare Joe Schlabotnik baseball card you bid on before you got on the plane ends in a half-hour. What’s a poor traveler, searching for a time-efficient and computer-centric distraction, to do?

If your plane is equipped with a Connexion by Boeing network, and you’re willing to shell out $35 or so, you may find the solution to your Internet-access problems as soon as early 2004. (The actual cost will depend on the airline and the flight.) Boeing hopes to emulate the network-access experience that many of you have grown accustomed to in your homes and offices. All engineering projects, including Connexion’s development and rollout, experience, to varying degrees, the same sorts of implementation trade-offs and market-driven midcourse corrections. Alternatives implement different visions of these same trade-offs and market needs (see sidebar “Cautious competitors”). And satellite-centric Internet access isn’t restricted to airplanes; trains and motor vehicles are surfing the same Net wave (see sidebar “Train tracking” at the Web version of this article at www.edn.com).

Connexion’s history begins in the mid-1980s, when Boeing...
was working with the US government to employ Ku-band, 10- to 17-GHz satellite communication based on electronically steered phased-array antennas that routed video streams to airplanes. Boeing representatives are loath to elaborate on the specifics of their government work, which continues to this day. But it’s easy, for example, to imagine the benefits to the occupants of Air Force One of both public and private real-time news feeds on in-progress world events. And, although I’m not suggesting that the President occasionally tunes into DirecTV or Dish Network to catch a movie during a cross-country flight, such a diversion would also be possible on a Ku-band-based system.

Fast-forward to the late 1990s, and Boeing’s vision had broadened beyond BSS (broadcast-satellite services) to include FSS (fixed-satellite services) for data, but its foresight was still restricted to airplane-to-airline bidirectional communication of location, environmental conditions, equipment health, and other information.

By February 2000, though, when the Boeing board of directors approved the Connexion project, the Mosaic Web browser was seven years old, and the Internet boom was well under way. On June 13, 2001, the three main US carriers—American, Delta, and United Airlines—each announced 500-airplane-minimum commitments along with plans to take an equity stake in Connexion, and Lufthansa four days later unveiled its own Connexion-implementation (but not investment) plans at the Paris Air Show. Regulatory-approval applications were smoothly moving along, and all the pieces of the puzzle were falling into place for a spring 2002 rollout. But the tragedy of September 11 and the US airlines’ subsequent fight for survival left no near-term financial room for Connexion.

After much internal soul-searching and consultation with its US and international airline partners, Boeing released American, Delta, and United from their investment obligations and plunged forward, albeit under a deaccelerated implementation schedule. In January 2002, Boeing held its first Connexion Working Together meeting with American, Delta, Lufthansa, United, and 11 other airlines; to date, five such meetings have occurred. Lufthansa began a three-month trial of Connexion on Jan 15, 2003 over its Frankfurt-to-Washington, DC route, and British Airways on Feb 18, 2003, initiated its own three-month trial over the London-to-New York flight path. According to Boeing, the objectives of the two trials differed greatly; Lufthansa aggressively marketed its FlyNet program, offered free access along with loaner notebook computers for passengers to use in flight, and generally intended its trial as a means of assessing network robustness (Figure 1).

British Airways, in contrast, lightly promoted its trial and used it to test-drive various pricing schemes. Boeing reports that British Airways encountered tremendous price inelasticity, which assured British Airways of the program’s viability. Connexion service is currently available for installation in private business and government aircraft. Lufthansa is poised to begin rolling out FlyNet on March 17, 2004, and SAS (Scandinavian Airlines) plans to join late in the first quarter or early in the second. As of press time, British Airways had not committed to a firm implementation schedule; such factors as the war in Iraq, labor strikes, and the phase-out of the Concorde program have understandably distracted the airline. Boeing reports that it’s close to securing an agreement with JAL (Japan Airlines), which will join fellow Asian carriers ANA (All Nippon Airways), which publicly committed to Connexion in September, and Singapore Airlines, which came aboard in mid-November. By year-end, Boeing hopes to sign up at least one US airline.

Boeing representatives consistently and vigorously claim that their market research concluded that potential customers would accept no regression from the broadband-Internet access they were used to in their homes and workplaces. Therefore, they would not accept the constraints of the 800-MHz to 2-GHz L band’s comparatively lower broadcast frequency range and consequent limited data throughput. Users wouldn’t pay for such rudimentary e-mail services, but conversely they’d pay more for a more robust Internet-access experience.

The diversity of worldwide cellular providers and protocols, regulatory barriers on airplane-to-terrestrial cellular communication, and lack of service over water and in rural locales were all factors that precluded a 2.5 or 3G cellular-based scheme. Satellite-based communication was the obvious candidate, but it presented Boeing’s engineers with a seeming contradiction: how to maximize each network user’s perceived access performance while minimizing data traffic over the notoriously high-cost satellite links with their lengthy throughput delays.

One quickly discarded idea involved the construction of a proprietary satellite network, analogous to Ellipso, Iridium, Sirius, Teledesic, or XM Radio’s approaches. Although such a tactic held the advantage of giving Boeing more complete control over the various network-operating variables, it also incurred high development costs that were at odds with the lackluster return on investment the proprietary pioneers had experienced. Reliance on the Ku band enabled Boeing to leverage its more than 15 years’ worth of expertise with this technology, and it also allowed the company to lease transponders on satellites. (Company representatives claim that more than 200 suitable satellites together housing more than 2000 Ku-band transponders are currently operating.) The company was also able to lease ground facilities that partner companies built and operate (Figure 2).

Leased ground stations with gateways are planned for Littleton, CO; Leuk, Switzerland; Ibaraki, Japan; and Moscow; a Boeing-owned central-command center in Kent, WA, and a network-operation center in Irvine, CA, coordinate these ground stations. The company may eventually add worldwide ground stations, both for network redundancy and, in Boeing’s words, “political” reasons. The political factor ties into broadcast-spectrum approval in some countries.

The 747-400 planes that British Airways and Lufthansa employed in 2003 for

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**AT A GLANCE**

- **Ku-band satellite connectivity enables always-accessible, high-speed Internet access on airplanes.**
- **Maximizing network performance and minimizing bandwidth costs requires careful balancing and trade-offs of various parameters.**
- **In-plane wireless connectivity reduces retrofitting cost and complexity.**
- **Regulatory approval is under way and is a necessary prerequisite to service rollout.**

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**Figure 1**
their tests, along with the Boeing-owned Connexion One 737-400, all use dual Boeing phased-array antennas—one for transmission and the other for reception (Figure 3). Such antennas have two primary constraints: their high cost and their ability to operate only at coordinates below 64°N latitude because of restricted line-of-sight visibility to geostationary satellites. The Connexion-equipped Airbus and Boeing airplanes that Lufthansa and other airlines will begin moving into service in 2004 instead employ a Mitsubishi-designed single elliptical Cassegrain reflector antenna, handling both transmission and reception tasks and offering lower cost and operation to 75°N latitude (Figure 4). The design of the antenna, which Mitsubishi conducted in close coordination with Boeing, involved balancing a challenging set of parameters, including reception quality, weight, air drag, and applicability to a diversity of aircraft shapes and sizes. To reiterate, in case you didn’t catch the Airbus mention earlier in this paragraph, Boeing plans to employ Connexion on competitors’ airplanes! SAS’s entire fleet, for example, consists of Airbus aircraft.

Connexion will not at first employ all of its performance-optimizing capabilities, and not every airline will decide to implement all of them. Many features have terrestrial-network equivalents, but some are uniquely tailored to satellite transmission’s strengths and shortcomings. The best way to minimize the cost of data transmission to and from the plane is to minimize the amount of data transmitted. Toward that end, a server on each plane locally handles DNS (domain-name-server) lookup, and it caches frequently accessed Web pages (Figure 5). The servers also act as firewalls and can, if an airline desires, also handle spam filtering, virus scanning, Web-site blocking, and other restricted-access functions.

Many airlines plan to supplement broader Internet content with server-resident information that would generate no data traffic between the airplane and satellite. For example, a few Web pages and a credit-card-based order-processing system could easily implement the duty-free shopping that today requires paper catalogs and currency. Up-to-date weather conditions outside the airplane, along with the airplane’s location, height, and speed, can derive from locally housed monitoring equipment. Weather reports at the destination airport don’t necessarily require constant updating; most passengers will be content with locally stored and occasionally refreshed data that’s no more than 15 minutes or so out of date, and such data would obviate the need for passengers’ frequently accessing the Weather Channel Web site.

Leased and company-owned ground facilities combine with satellites and on-plane equipment to implement Boeing’s vision.

On-the-fly image recompression for both data transmission and reception is, like content caching, a common technique to minimize bandwidth that the Connexion network will optionally support. Less common is the hardware on board each Connexion-equipped airplane that disassembles and losslessly compresses the contents of each packet before transmission, along with decompressing each received packet. To minimize the number of potentially problem-causing network variables, Boeing plans to disable packet compression at the initial commercial aircraft-system rollout but will subsequently phase it in as overall network-traffic conditions warrant.

Other Connexion features will be even less familiar to those of you who work in the terrestrial-networking field. Some airline carriers plan to switch the airplane’s Connexion link from a satellite to a ground-based WiFi (Wireless Fidelity) access point when the plane is at or near

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**CAUTIOUS COMPETITORS**

Seattle-based Tenzing Communications, which Boeing competitor Airbus now partially owns, is Connexion’s primary rival. Instead of going with a much higher bandwidth but more expensive Ku-band retrofit of airplanes, Tenzing instead chose to leverage the L-band satellite-phone infrastructure. Network implementations differ from one airline to another, but, for a fixed fee you can download either e-mail headers or headers plus the first few lines of each message to a seat-mounted LCD or directly to your tethered laptop computer.

Viewing an entire e-mail incurs additional per-message or per-kilobyte costs, and batched e-mail uploads and downloads create processing delays that may frustrate users who are spoiled by the real-time, instant-gratification response of their usual network connections. Per-flight cost comparisons of Connexion and Tenzing are difficult, because, in Tenzing’s case, the base cost is lower, but the total price you pay depends on how many e-mails you download and how big each e-mail is. It is clear, though, that Tenzing’s approach, like that of L-band competitor Verizon, is less rich and diverse than Connexion’s.

It will be interesting to watch which alternative—evolutionary or revolutionary—will both in the short and the long term win in the market or whether enough room exists for both approaches.
its gate. More elaborate wireless schemes based on 802.11 or other protocols, broadcasting on the 2.4- and 5-GHz unlicensed bands or on licensed or ultra-wideband alternatives, can provide coverage whenever the plane is on the ground.

When the plane’s network is satellite-connected, its clients will normally experience lengthy delays from when they send packets to when they receive acknowledgments from the server on the other end of the connection. Similarly, they will generate extended acknowledgment delays in response to incoming data. These delays are unalterable functions of the protracted bidirectional path from the airplane to the satellite and then to the ground. Unless you circumvent them, these delays couple with the speed of light and the peak and sustained bit rates of Ku-band-modulated data to wreak havoc on conventional TCP/IP (Transmission Control Protocol/Internet Protocol). If a network client fails to receive a timely acknowledgment, it either assumes that the connection is broken, or it resends the packet; neither scenario is desirable.

The most elementary means of resolving extended acknowledgment delays is through TCP “spoofing.” Imagine, for example, that you’re on an airplane, doing a Web-page search via Google. Hardware or software on the airplane, the satellite, the ground station, or some or all of these places sits between your computer and the Google server. This hardware or software mimics the Google server, sending acknowledgments back to you when it receives your packets and simultaneously forwarding those packets on to Google. It performs a similar function for the packets returning to you from the Google server. It must have the intelligence, to react appropriately and stop spoofing if and when either your computer or Google’s server goes offline. More elaborate techniques involve hand-shaking algorithms between the airplane and ground that coordinate the transfer of packets in this extended-delay environment and, by transforming the fundamental parameters upon which TCP operates, thereby obviate the need for spoofing.

Passengers can access the Connexion network either from wired-Ethernet plugs built into the seats or from WiFi connections. Wired Ethernet has the advantage of its more ubiquitous presence in notebook computers, speedier access to locally served content, and fewer and less stringent regulatory roadblocks. Its obvious disadvantage, though, is a much higher per-airplane hardware-retrofit cost to the airline, which is necessary to run Category 5 or other network cabling to appropriate seats. This rewiring project doesn’t necessarily apply to the whole plane; the airline might extend it only to premium-business-class seats whose occupants would be most likely to use Connexion, anyway.

The idea of using WiFi within an airplane might at first glance seem anathema to those of you who’ve heard the airline instructions to “turn off all electronic devices during takeoff and landing” and “keep cellular phones off during the entire flight.” Boeing doesn’t promise it can do anything about the takeoff and landing restrictions, though it hopes that in-progress investigations by the FAA (Federal Aviation Administration), RTCA (Radio Technical Commission for Aeronautics), and other regulatory and advisory bodies on the effects of various operating electronics devices on airplane systems will lead to more relaxed constraints. But it’s optimistic that it’s well on its way to overcoming transmission restrictions, both within the airplane—that is, 802.11—and between the airplane and the satellite—that is, Ku band.

First off, realize that the ban on cellular-phone use came from the FCC (Federal Communications Commission), which concerns itself with electronics emissions outside the plane, not the FAA, which focuses on intra-airplane matters. The ban centered on the FCC’s concern that frequent cellular-phone rollovers from one terrestrial base station to another, the result of the airplane’s height and speed, would complicate and potentially overwhelm the cellular network. (Cynical observers also suggest possible collusion between the FCC and airplane-satellite-phone operators.) Boeing and its airline partners are working with regulatory bodies to approve satellite-to-airplane transmissions in the various countries’ airspaces where the airplanes will fly, as well as with international regulatory groups, such as the ITU (International Telecommunications Union) for trans-oceanic flight.

Intra-airplane wireless networking is in a sense easier to accomplish, because it involves only obtaining regulatory approval from each airline’s country of origin. Germany’s LBA (Luftfahrt-Bundesamt Authority)’s Federal Office of Civil Aeronautics and Great Britain’s CAA (Civil Aviation Authority) approved Lufthansa and British Airways’ respective trials, just as the FAA has approved Boeing’s use of 802.11b in Connexion One. Full LBA approval will enable Lufthansa passengers to use 802.11 in all countries’ airspaces in which Lufthansa flies, and approval from the regulatory bodies of other airlines’ countries of origin will incur similar worldwide-usage freedom.

Boeing strictly adheres to common Internet-access standards to maximize passengers’ ease of using Connexion. That adherence led to a decision to implement no proprietary hardware- or software-based encryption scheme for intra-airplane network traffic. However, you can employ VPN (virtual-private-networking) or other encryption techniques for
communication with the destination server, as you can do with any other Internet-access method. Boeing also plans no encryption for WEP (wired-equivalent-privacy) or WPA (WiFi-protected-access) intra-airplane 802.11 data traffic, again to simplify passenger use. This encryption would be easy to provide if an airline partner requested it, however. This trade-off is reasonable; using the service requires a server login, and it’s difficult to imagine being able to snoop the access point of an airplane flying six miles overhead at 600 mph!

Boeing does, however, plan to encrypt the data traffic flowing between the airplane and satellite. The company is mum on details, citing a “security by obscurity” objective, but company literature mentions “128-bit encryption,” and Boeing’s long history of government work has undoubtedly bolstered its security capabilities. A company spokesman admits that, to further beef up Connexion-network robustness, Boeing is involved in nondisclosure-based relationships with adept hackers to track down and plug potential network vulnerabilities.

Transponders in the satellites amplify the incoming Ku-band signals from airplanes or terrestrial facilities, translate them to different regions of the band if necessary, and pass them on to their destinations. Some of the satellites that Boeing has leased offer movable spot beams to cover popular air corridors in the Atlantic and Pacific oceans; these areas are normally less enveloped by transponder signals than are landmasses. Within a 36-MHz Ku sub-band, Connexion employs spread-spectrum techniques for data traffic to the airplane and CRMA (code-reuse multiple access) for the return link. Both the forward and the return links use turbo-product forward ECC (error-correction coding), delivering a claimed Eb/No (threshold ratio of energy per bit to spectral-noise density) of approximately 2 dB.

At some point in a transcontinental flight, the Connexion system will likely need to implement a satellite-to-satellite and, therefore, ground station-to-station handoff procedure, conceptually analogous to base-station-to-base-station handoffs in other wireless networks (Reference 1). This handoff affects the airplane’s network in several ways, most notably if the airplane is moving between two of the three Ku-band regions—the Americas, Asia, and Europe and Africa—and therefore needs to alter its broadcasting and receiving frequency ranges. It also will need to update its routing tables to reflect the new ground-station facilities it will use. But, because passengers’ computers within the plane receive IP addresses via DHCP (dynamic-host-configuration protocol), the transition will be imperceptible to them.

CURRENT CAPABILITIES AND FUTURE PLANS

You now know how the Connexion network came about and how it’s constructed, but what about the most important question of all: How well does it work? Feedback from Lufthansa customers during the three-month trial was positive. (Keep in mind, though, that this was a free trial!) They suggested a perceived network performance between ISDN (integrated-services-digital-network) and DSL (digital-subscriber-line) data rates. Boeing cautions, though, that you shouldn’t automatically extend this passenger experience to a prediction of the network as Boeing begins to roll it out in early 2004.

Recall, for example, that, until British Airways began its own trial, the Lufthansa flight had the network resources all to itself (with the exception of Connexion One trials and private traffic). Lufthansa also explicitly encouraged passengers to do their utmost to stress the network, which consequently averaged 50 to 80 users’ being simultaneously online with a peak of 150 simultaneous connections. Many of these users engaged in bulk file transfers, video streaming, and other high-data-rate operations. The trials involved antenna technology that Boeing did not plan to use in production aircraft, and they included no TCP spooflike techniques, image and packet compression, rich onboard content, or other bandwidth-reduction mechanisms.

For Connexion’s performance, Boeing’s network-performance targets for Connexion specify 5- to 10-Mbps downstream, or, as Boeing refers to it, “forward,” bandwidth broadcasting from each satellite transponder to the airplane. Depending on network conditions at any
point in time, multiple aircraft and multiple passengers may share this bandwidth. Upstream, or “reverse,” bandwidth exiting each plane back to the satellite is 1 to 2 Mbps. The lower data rate is a function of the smaller antennas, with lower broadcast power, on airplanes as compared with the antenna size and broadcast-signal strength of ground stations. The data rate also varies based on the plane’s proximity and angle of view at a given time to its partner satellite. This asymmetrical bandwidth, analogous to what users experience with dial-up analog modems, ADSL (asymmetric-digital-subscriber-line), cellular, and most other common network protocols, might be a problem only if a passenger were attempting to, for example, engage in large-frame and high-frame-rate two-way videoconferencing.

Beyond Internet access, Boeing has big plans for passenger applications of Connexion. Connexion’s use of the Ku band strongly hints at an expansion of the program to encompass DirecTV, Dish Network, and similar television broadcasts directly to passengers’ seats. The company is also reviewing several forms of IP-telephony applications. In one implementation, IP-telephony variants would replace the satellite phones now behind passengers’ seats, near lavatories, and elsewhere on the plane. In another, pas-

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**Figure 5**

The equipment inside a Connexion-enabled aircraft, aside from the satellite antenna and Ku-band modulator and demodulator circuitry, will likely be familiar to anyone who has installed or maintained a LAN.
sengers would be able to use their cellular phones, but, instead of connecting with base stations on the ground, they’d interface to picocells within the plane that would convert cellular traffic to IP-telephony data.

Boeing is equally enthused about Connexion’s benefits to airlines themselves, harking back to the company’s original vision for the network in the late 1990s. Rich two-way data flow between an airline and its in-flight fleet could, for example, provide early warning of equipment-out-of-tolerance variances or outright breakdowns, enabling advance diagnosis, preventive in-flight maintenance, and the in-advance placement of repair mechanics and replacement parts at the flight’s destination. A real-time-updated manifest of passengers and their preferences enables improved customer service. Cash- and cart-less duty-free cabins reduce the required number of on-plane airline staff, and enable that staff to focus on higher-priority duties. And, when a passenger becomes ill, data-rich and real-time telemedicine capability speeds diagnosis and treatment and avoids expensive midflight reroutings and emergency landings. This technology would help in cases when, for example, a patient who seems to be having a heart attack turns out to be suffering only from heartburn.

Although its airline partners have the final word on pricing, Boeing estimates that on an eight- to 14-hour flight, Connexion access will cost $25 to $35. Access on four- to eight-hour flights will be less expensive, and access on even shorter flights is anyone’s guess. The airlines would need to compare the cost of retrofitting their fleets with Connexion with the price passengers are willing to pay and, therefore, the potential revenue gain of such a rollout. Boeing expects airlines to implement per-flight pricing plans, rather than per-megabyte or -hour plans. As far as paying for Connexion, the company envisions that some airlines will work with corporate customers to provide “Connexion calling cards” and that passengers will also be able to trade in frequent-flier miles for Connexion access.

Reference

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Author’s biography
Technical editor Brian Dipert wonders if broadband on-plane Internet access will be an effective distraction from foul-tasting airline food. Reach him at 1-916-454-5242, bdipert@edn.com.

For more information go to the Web version of this article at www.edn.com.
My frequent travels between Sacramento and Silicon Valley usually involve my jumping on a Capitol Corridor Amtrak train and renting a car at the San Jose destination. I can access the Internet en route, except for the five or so minutes when the train’s crossing San Francisco Bay, via my Sprint PCS Vision CDMA (code-division multiple access) 1xRTT connection. Originally, I USB-tethered my cellular phone to my notebook PC, but Sprint recently revised its service terms and conditions to discourage this practice, citing customer “overenthusiasm” and consequent network overload (Reference A). Instead, I now employ a Sprint Business Connection PC Card with an $80/month unlimited-data-access plan.

My equipment averages approximately 150-kbps downstream bandwidth on PCS Vision, adequate for casual Web-site surfing and for e-mail—unless someone sends me a huge Acrobat or PowerPoint file attachment. But the bandwidth pales in comparison to what I achieve with my SBC Yahoo DSL account at my home office.

So, I was excited to recently learn that PointShot Wireless is running a three-month trial of its satellite-based network on one Capitol Corridor passenger car. The company’s network in partnership with Bell Canada currently operates on Via Rail’s trains in Canada. PointShot is also running a three-month trial on ACE (Altamont Commuter Express) commuter trains in the San Francisco Bay area.

PointShot employs a Ku-band satellite connection for data to the VSAT (very-small-aperture-terminal) antenna-inclusive train along with WiFi (Wireless Fidelity) for intratrain network connectivity, both conceptually similar to Connexion’s approach. Instead of relying on a satellite connection for upstream data traffic, though, PointShot is leveraging a 2.5G cellular link for its California trials from an unnamed CDMA partner. PointShot has implemented several network enhancements in its laboratories, including multi-channel bonding of multiple CDMA and GPRS (general-pack-et-radio-service) cellular providers’ connections and dynamic switching between the connections based on cost, speed, and signal-strength factors. Other enhancements include upstream connections to satellites when cellular access is unavailable and connectivity to WiFi-access points when a train pulls into a station.

Both Connexion’s and PointShot’s networks assign IP (Internet Protocol) addresses via DHCP (dynamic-host-configuration protocol) to connected client computers, and Connexion’s Web site contains documentation generally did not result in tech-support calls from folks whose computers are normally configured with static IP addresses, who have corporate proxy-server assignments, and similar situations. The lack of these problems results from both the tech-savvy nature of the Silicon Valley participants, the few numbers of users during the trial, and the fact that most of the participants’ computers are DHCP-aware due to their connectivity to home-based networks and to public “hot spots,” such as Starbucks. He admits that the DHCP requirement was more problematic to Canadian users but that the level of support calls was moderate and that PointShot easily resolved the issues that users encountered.

I’ll soon be taking the PointShot Wireless network, which, like Connexion, touts benefits for both train passengers and operators, for a test-drive. Surf to the version of this article sidebar on the EDN Web site at www.edn.com for a look at my experiences and conclusions.

Reference

For more information on products such as those discussed in this article, contact any of the following manufacturers directly, and please let them know you read about their products in EDN.

Airbus
www.airbus.com

All Nippon Airways
www.fly-ana.com

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American Airlines
www.aa.com

Amtrak
www.amtrak.com
www.amtrakcapitols.com

Bell Canada
www.bell.ca

Boeing
www.boeing.com/connexion
www.connexionbyboeing.com

British Airways
www.british-airways.com

Civil Aviation Authority (CAA)
www.ca.co.uk

Delta Air Lines
www.delta.com

DirectTV
www.directtv.com

Dish Network
www.dishnetwork.com

Ebay
www.ebay.com

Ellipso
www.ellipso.com

Federal Aviation Administration (FAA)
www.faa.gov

Federal Communications Commission (FCC)
www.fcc.gov

Federal Office of Civil Aeronautics (Luftfahrt-Bundesamt, or LBA)
www.luftrecht-online.de

Google
www.google.com

Iridium
www.iridium.com

Japan Airlines
www.jal.co.jp

Lufthansa
www.lufthansa.com

Mitsubishi
www.mitsubishi.com

PointShot Wireless
www.pointshtwireless.com

SBC Yahoo
http://sbc.yahoo.com

Scandinavian Airlines (SAS)
www.sas.se

Singapore Airlines
www.singaporeair.com

Sirius
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www.viarail.ca

Weather Channel
www.weather.com

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