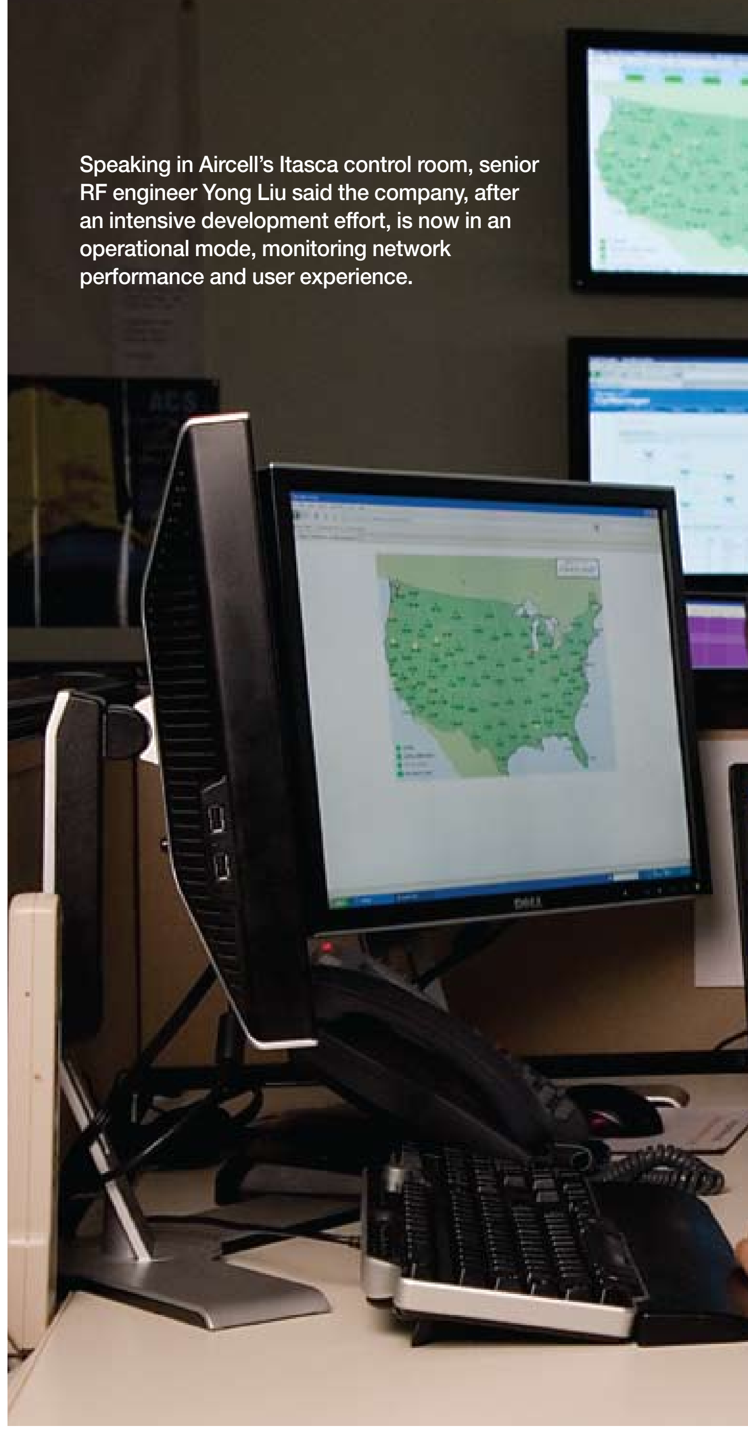
WiFi takes FLIGHT



Speaking in Aircell's Itasca control room, senior RF engineer Yong Liu said the company, after an intensive development effort, is now in an operational mode, monitoring network performance and user experience.

Innovative emulation and testing of an air-to-ground broadband communications link facilitated the deployment of Aircell's Gogo Inflight Internet service to more than 1000 commercial aircraft.

BY RICK NELSON, EDITOR IN CHIEF

ITASCA, IL—Engineers at Aircell have been working to bring WiFi service to commercial airline passengers, and the torrid pace of their efforts led to the first implementation aboard an American Airlines jet in 2008, less than three years after the company demonstrated airborne WiFi capability on a test flight in 2005. Their pace of innovation has not waned, leading to the company's August 31 announcement that it had deployed its Gogo Inflight Internet service on its 1000th aircraft—a Delta Air Lines DC-9. Aircell reported that as of August 31, roughly one third of all mainline domestic US aircraft are now equipped to offer Gogo Inflight Internet service to passengers who bring their laptops or WiFi-enabled mobile devices on board.

The rate of deployment is remarkable, considering that Aircell's commercial in-flight Internet initiative began from scratch as a new business that would complement the company's traditional role as a provider of in-flight telephony services to business-aviation customers (see "Aircell at a glance," p. 28). The initiative got a boost when Aircell won rights to spectrum once allocated to first-generation Advanced Mobile Phone Service ATG (air-to-ground) voice telephony. The company announced in June 2006 that it was the high bidder in the Federal Communications Commission's spectrum auction for 800-MHz air-to-ground broadband spectrum, and it announced in November of that year that the FCC had officially granted it the frequency license that would enable it to provide exclusive broadband connectivity to US airlines.

Base stations and aircraft modems

The effort that brought the service to fruition in 2008 involved the design and deployment of ground base stations as well as the aircraft-based portion of the ATG communications channel. Aircell worked closely with its partners, the wireless infrastructure company ZTE and the fabless wireless-communications chipmaker Qualcomm, to get the system up and running, to the point where Gogo is now avail-

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able to passengers on 3800 flights daily—up from 2100 flights a day in August 2009.

The system provides flyers with WiFi access by means of ZTE's CDMA EV-DO Rev. A ground-based networking equipment and aircraft-mounted modems that employ Qualcomm chipsets. The airborne portion of the system—modem, controller, wireless access points, antennas, and cables—weighs in at less than 150 lb (143 lb for a Boeing 767) and can be installed in approximately 8 hr. When the service launched, the ground infrastructure consisted of 92 fixed cell sites and several COWS (cell sites on wheels).

Air-to-ground wireless connectivity presents challenges not found on terrestrial implementations of CDMA. These challenges required modifications to off-the-shelf EV-DO technology to accommodate the delays and Doppler shifts seen in the commercial-airliner air-to-ground environment. Deploying the system rapidly while overcoming these challenges required extensive test efforts as Aircell worked with ZTE on infrastructure and worked with Qualcomm on silicon firmware to ensure that the system could provide adequate capacity and successfully handle station-to-station handoff at commercial aircraft speeds, altitudes, and distances.

Test flights, of course, are a key component of ensuring that the system works properly, but performing extensive test flights after every firmware tweak would be prohibitively expensive and time-consuming. Consequently, Aircell engineers deployed emulators and other test instrumentation in their Itasca, IL, lab to mimic the conditions the system would see in real-world flight.

Yong Liu, senior RF engineer at Aircell, described his company's role as that of a system integrator, working with Qualcomm and ZTE on the air- and ground-based portions of the system. And indeed, the challenges centered on the air-to-ground portion of the system—not on the WiFi implementation within the aircraft.

"Inside the aircraft, we just use standard 802.11 wireless access points. It's no different inside an airplane than in an office or big auditorium," Liu said, although he added, "We do have to consider whether we have enough coverage and enough capacity to serve the passengers. We have planned so that for a typical 160-seat jet, every passenger could access the system." He added, "Within the aircraft, WiFi is basically a solved issue."

Aircell at a glance

The Gogo Inflight Internet initiative for commercial airliners represents a new direction for Aircell, which began in 1991 when, at a barbecue restaurant, company founder Jimmy Ray sketched out on a paper napkin an idea for an affordable telephone system for airplanes. Aircell's initial efforts targeted business aviation, and the company reports that its products are installed aboard three of the world's largest fractional ownership fleets: NetJets, Flight Options, and CitationAir. And in September, Aircell announced that Flexjet will offer Gogo Biz Inflight Internet service as a standard feature on its fractional program. Although the commercial service is currently limited to the continental US, Aircell provides business customers with worldwide access to voice, fax, and narrowband data through the Iridium satellite infrastructure.—*Rick Nelson*

ATG presents challenges

It's the ATG portion, Liu said, that Aircell and its partners are the first to address, and that's where the key challenges lay. Liu, who holds an electrical engineering degree and has performed design work for cellular operators and communications equipment manufacturers, said he welcomed the challenges that developing the Gogo system offered. "It's not often you get a chance to work with a greenfield network in the US," he said, adding that at the beginning of the project, "We were kind of naive, not knowing what would work and what wouldn't work until we tried it."

And at first, Liu said, nothing worked, and he outlined the challenges the companies faced as they began to debug the system and the decisions they made to get the system up and running on schedule. One of the first decisions, he said, was to employ CDMA EV-DO Rev. A technology, but that technology had limitations that required adjustment to accommodate aircraft speed, altitude, and distance as well as base-station locations. They also had to overcome obstacles in designing the processes for mobile-radio acquisition and network registration as well as the process of handoff.

"The handoff was a major challenge," Liu said, adding, "How do we hand off from one site to another site when the aircraft could be 50 miles from one site and 150 miles from another, target, site?"

CDMA EV-DO, he explained, employs search windows in which a receiver performs constant correlations on successive time slices looking for a signal. Even 100 miles, Liu said, represents a delay of about 550 μs—a much longer delay than is encountered in typical ground-based CDMA implementations. So, one of the first modifications Qualcomm made was to expand the search window to accommodate differential distances beyond 200 miles.

Fortunately, the revisions Qualcomm made throughout the development process did not require custom chips. As Liu noted, the 12-month-to-18-month period required to bring up a new chip would have prevented reaching the target date for the first commercial deployment in 2008. "That was a very aggressive schedule," Liu said, "and we made a lot of our design decisions based on meeting the target date." The search-window and other modifications required throughout the development cycle could all be accommodated through firmware changes to Qualcomm commercial off-the-shelf chipsets.

The EB Propsim radio channel emulator replaces the real-world radio channel between transmitter and receiver to bring air-interface testing into the lab. Aircell employed the instrument to help develop and test its Gogo Internet service for commercial airplanes. Courtesy of Elektrobit.

Site placement

A key concern was site placement, which occurred throughout 2007. Lacking time to go through extensive permitting and zoning processes, Aircell and ZTE decided to place their antennas on existing towers whenever possible. At 8x2 ft, the antennas, Liu said, are a bit larger than standard cellular base-station antennas and have a slight up-tilt to them, but otherwise they look like standard antennas. Ideally, he said, the stations would be located on a 225-mile grid, but adjustments were made based on terrain and aircraft flight-path information obtained from the FAA.

Liu said Aircell made use of four test planes—two jets and two turboprops—for test flights during the development effort. The jets could fly at commercial-airliner altitudes and speeds, he said,

To implement Aircell Gogo Inflight Internet service, a commercial aircraft establishes an 800-MHz CDMA EV-DO ATG link with one or more terrestrial base stations, set nominally on a 225-mile grid but adjusted to accommodate terrain and flight patterns. More than 1000 commercial aircraft in the US are equipped to offer the service. Courtesy of Aircell.

adding that although the turboprops fly lower and slower, they permitted testing over the necessary distances, which represented the most challenging of the problems encountered during the development effort.

But jet or turboprop, Liu said, "It is very expensive to fly, and it takes a significant amount of time to set up the tests and get the data back." The test flights generate about 50 Mbytes of test data per minute, he said, adding, "So, if you fly a couple of hours, you have gigabytes of data, and it takes time to process it." To help with that processing, he made use of QxDM (Qualcomm eXtensible Diagnostic Monitor) and Xceed WindCatcher software.

Building a test cell

As an alternative to operating test flights and dealing with the voluminous data that results, Aircell established a lab in its Itasca facility. "With a lab test setup, we can simulate the environment well enough to do our basic tests very quickly and catch any problems and then feed the results back to Qualcomm," Liu said, adding that with the setup, he can simulate delay and Doppler shift and readily duplicate problems that might occur only intermittently during a test flight. "In testing, if you can duplicate a problem, it's a lot easier to solve it," he noted, and being able to reproduce a problem can help in determining, for example, whether a particular anomaly is a ground issue or an aircraft issue.

Key components of the lab setup are Elektrobit's EB Propsim radio channel emulators and ASO (Aerospace and Satellite modeling tool Option) software, which can create realistic scenarios of various flight conditions. With the EB products, Aircell can define and emulate ATG communication links in the lab with emulations representing various aircraft cruising at different altitudes or speeds. The equipment establishes virtual links that can be user-defined or that can be based on a recorded link database.

Said Liu, "We have a feel for what the signal strength should be and what the delay should be for various flight conditions, so we set up the emulator to represent those conditions." Then, he said, he can investigate whether a handoff occurs successfully or even whether an aircraft can see a target sector at all.

Liu said he evaluated fader offerings from a competitor that offered a lower cost per instrument, but the EB instruments provided higher bandwidths, allowing, for example, full-duplex operation in one fader channel. "Typically, you would put the forward link on one fader and reverse link on another fader," Liu said, "and that creates a need for double the number of faders. With Elektrobit, we can put both links on one fader channel and save money." He added that the additional bandwidth of the Elektrobit instruments lets him simulate more sectors or more aircraft in the lab environment.

Liu noted that meeting the target deployment date wasn't the only pressure facing Aircell engineers. He said that an erstwhile competitor, who was promoting a Ku-band satellite system for delivering broadband service to aircraft, was suggesting that an ATG approach would not work or would not deliver sufficient bandwidth, and the Aircell team wanted to put any concerns about the ATG approach to rest.

Aircell took several steps to get the most capacity from the 3-MHz-wide ATG channel—deploying orthogonally polarized antennas, for example, to effectively double channel capacity. And in 2009, the company doubled the number of antennas per site, converting each site from a three-sector site to a six-sector site. Liu said availability of the service exceeds 99%.

As this article goes to print, Aircell reports that Gogo Inflight Internet is installed on 1030 commercial aircraft. A similar service, Gogo Biz Inflight Internet for business aviation, includes equipment small and light enough to fit on business aircraft from manufacturers including Cessna Aircraft, Dassault Falcon Jet, and Hawker Beechcraft. Liu said development efforts continue in an effort to boost capacity, but the breakneck pace of the initial development effort has slowed.

Speaking in Aircell's Itasca control room, where personnel monitor the status of every Gogo-equipped commercial airliner in flight, Liu said, "Now, we are in operational mode where we need to monitor network performance and user experience and decide when to add another cell site or when to split sectors. So right now, we are operating in much more of a typical service-provider role." T&MW