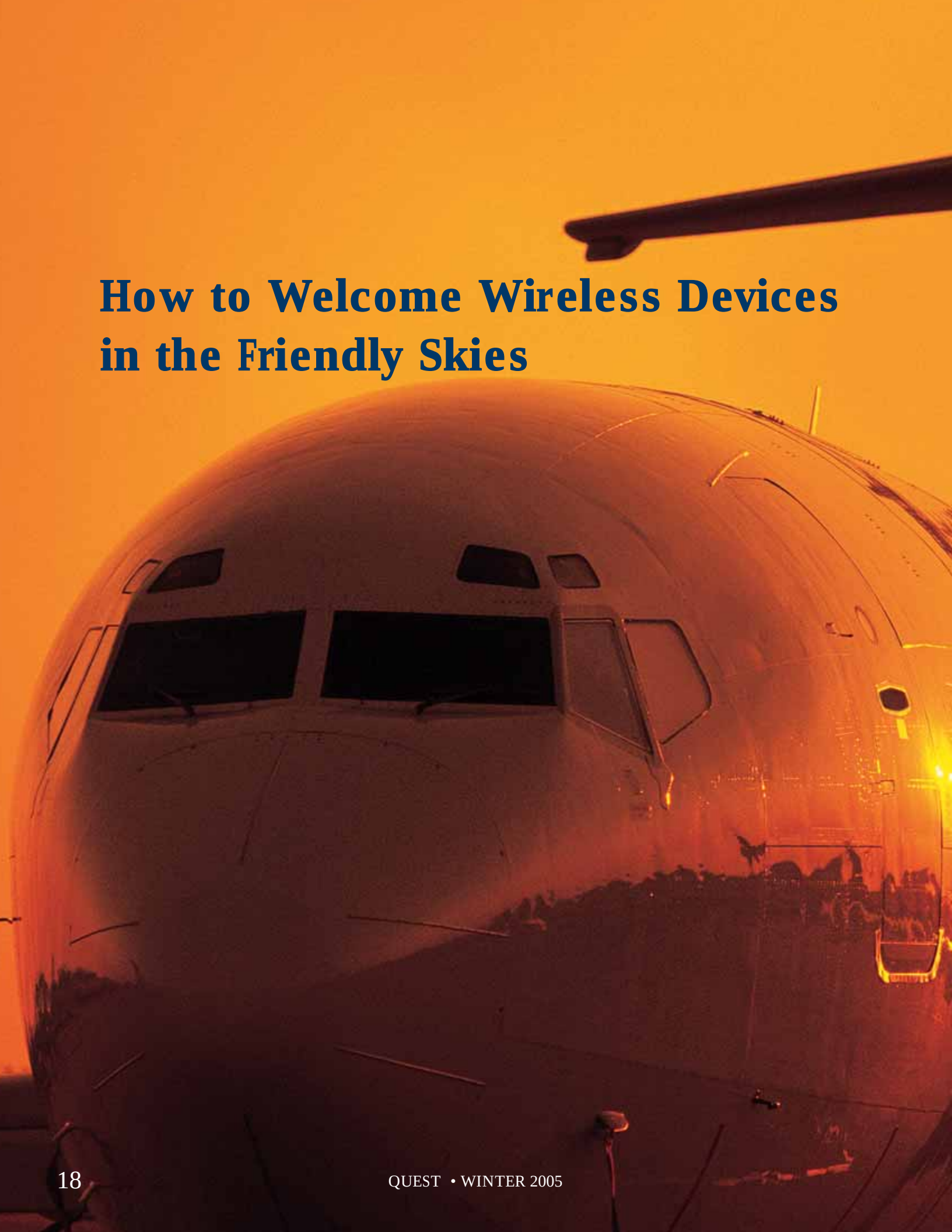
How to Welcome Wireless Devices in the Friendly Skies



Electrical and Computer Engineering Professor Studies How Wireless Computers Interfere With Airplane Communication Systems

BY ELIZABETH O. COOPER

You're sitting aboard a 737 awaiting takeoff when the pilot announces that the aircraft cannot go anywhere because someone's portable electronic device is wreaking havoc with the navigational equipment. Passengers begin to check their laptops, cell phones and other electronic devices, and you're shocked to discover that your cell phone, which you had accidentally left on, is the culprit.

Think that's an unusual incident not likely to happen again? Not according to Linda Vahala, associate professor of electrical and computer engineering at Old Dominion. Vahala has been working with NASA Langley Research Center engineers under John Beggs to study radiation patterns produced by wireless computers on board airplanes. The research conducted by Vahala and a group of Old Dominion graduate engineering students is especially pertinent in an age where an increasing number of passengers want to use wireless technologies while flying the friendly skies. While cell phones, wireless local area networks and other portable electronic devices (PEDs) have improved travelers' accessibility and productivity, they can also inadvertently cause electromagnetic interference to aircraft navigation and communication radio systems, thereby potentially endangering all on board. According to Vahala, PEDs may emit electromagnetic waves, with their signals detected by the various radio receiver antennas installed on the airplane. Electromagnetic waves, in certain frequency windows, can interfere with the GPS position detailing the plane's position and direction, as well as its VHF system used for communication.

"Phones, computers and other electronic devices must be turned off within 10,000 feet of the ground," Vahala notes. "Antennas on top of the plane are important for takeoff and landing and can be affected by radiation coming from those devices. Wireless cards inside a computer or personal electronic device can interfere with antennas on the plane." While cell phones cannot be used on board planes at all, some companies in the United States and other countries are trying to find ways to install wireless computers on planes.

Measuring Electromagnetic Wave Propagation On Airplanes

Vahala and Old Dominion electrical and computer engineering Ph.D. students Madiha Jafri, Mennatoallah Youssef and Genevieve Hankins have worked with NASA researchers to collect Interference Path Loss (IPL) data on out-of-service Boeing 737 and 757 airplanes since 2001. IPL is a measurement of the radiated field coupling between various locations in the passenger cabin and aircraft communication and navigation systems through their antennas. Their ultimate goal is to develop theoretical models to accurately predict electromagnetic wave propagation of wireless devices in aircraft and therefore determine if it is possible to safely use wireless computers on planes.

"It's challenging," Vahala notes. "People have just started looking at the effects of wireless systems added to current aircraft. The airlines want models that predict things because the incidents they've been having with wireless computers are not easily predictable."

NASA takes various electromagnetic measurements of planes that are out of commission for at least eight hours. "They get lots and lots of data from different frequencies and cover all the seats and rows," Vahala says. "Researchers are looking for a model to predict radiation wavelengths in larger planes. Airlines are always looking at building bigger aircraft, so it's important to have models reflecting what happens with electromagnetic patterns for those planes."

To formulate a theoretical model and determine electromagnetic waves' effect on future aircraft, Vahala's team combines experimental data from aircraft on the tarmac with findings from a reverberation chamber. Totally enclosed metal space with antennas that measure radiation levels, reverberation chambers are very isolated and provide a good standard for measuring PED emission levels. Known as modeling, the research involves placing boundary conditions - the mathematical contingencies to which physical laws apply - on a set of electromagnetic wave equations.

"It's easier to check using theoretical models since these models are designed to apply to large frequency regions and conditions," Vahala notes. "From these models, we plot the intensity of the radiation and have found that radiation is more intense around the plane's windows. This helps the industry as they build planes, to determine where they need to put more shielding against electromagnetic waves that could leak out and affect antennas or the pilot's controls."

Other students working with Vahala have placed wireless transmitters on these commercial aircraft to determine if the transmitters model the trends found in experimental data for the plane's size, number of passengers and seating arrangements. "If the plane is a 737, you would not expect the data to fit all types of planes," she notes.

If a plane has encountered problems with radiation produced from PEDs, the same scenario of passengers must be replicated in testing in order to accurately reproduce the problem. If passengers using PEDs are seated in 18A, 17B and 16 C, those exact circumstances must be reproduced during testing on an idle airplane. "You could have reflections off different objects the people in certain seats were using," Vahala says. "Electromagnetic waves propagate around the cabin and reflect off materials such as seats and other structures in the cabin. Waves reflect off metal objects and hit the antenna after propagating through the window."

Vahala and her students found that electromagnetic propagation of waves within buildings are applicable to those within an aircraft. "The building models are designed for square spaces with flat surfaces, and the students have to convert the electromagnetic boundaries to the curved areas found in an aircraft by appropriate transformations," she explains. "We did see that the data fits the experimental results and the maximum boundary conditions on electromagnetic power."

Random Wave Motion

The group also studied random wave propagation. "Research indicates that these waves fit some of the hot spot patterns seen in planes," Vahala notes. "Waves bouncing back and forth off different objects have a higher intensity of electromagnetic power. There is also a higher intensity by windows where you find more waves."

Plus, there are constant random changes within the cabin, making it an important medium for studying the effects of wave propagation. "People can affect the wave propagation as well as whatever it is they are holding. We changed the density across the rows and down the aisles so that puts a random effect into how the waves propagate."

Vahala believes wireless radiation effects could be overcome by placing shielding made of a fine, virtually invisible mesh on a plane's windows and insulating the doors between the cockpit and the cabin. The insulation would prevent electromagnetic waves from taking a direct path from the cabin to the pilot's controls. The waves would then be routed outside the plane's windows where they would lose intensity before hitting the antennas connected to the controls.

Wireless Antennas Used on European Airlines

The number and type of controls on the plane help determine the maximum number of wireless antennas that could be placed on an aircraft. No U.S. airplanes currently in operation have been fitted with wireless antennas; however, two European airlines – Lufthansa and Scandinavian Airlines System - recently began using wireless LANs to deliver Internet service to passengers. During three months of Internet testing on Lufthansa planes, researchers determined that the LAN did not interfere with this particular plane's systems.

Financial constraints and continuing questions concerning interference with the airplane systems have kept U.S. airlines from jumping on board the wireless bandwagon, although Vahala believes that may change as more and more passengers clamor to surf the net.

"A lot of people want to use wireless computers. There's no question of that, but we're very safety conscious here. We want to make sure that something is not going to affect the plane's function. In the next several years, a company may start coming out with something because wireless computers are very popular. Over the next 10 years, we expect to see more long-term solutions."

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—Linda Vahala