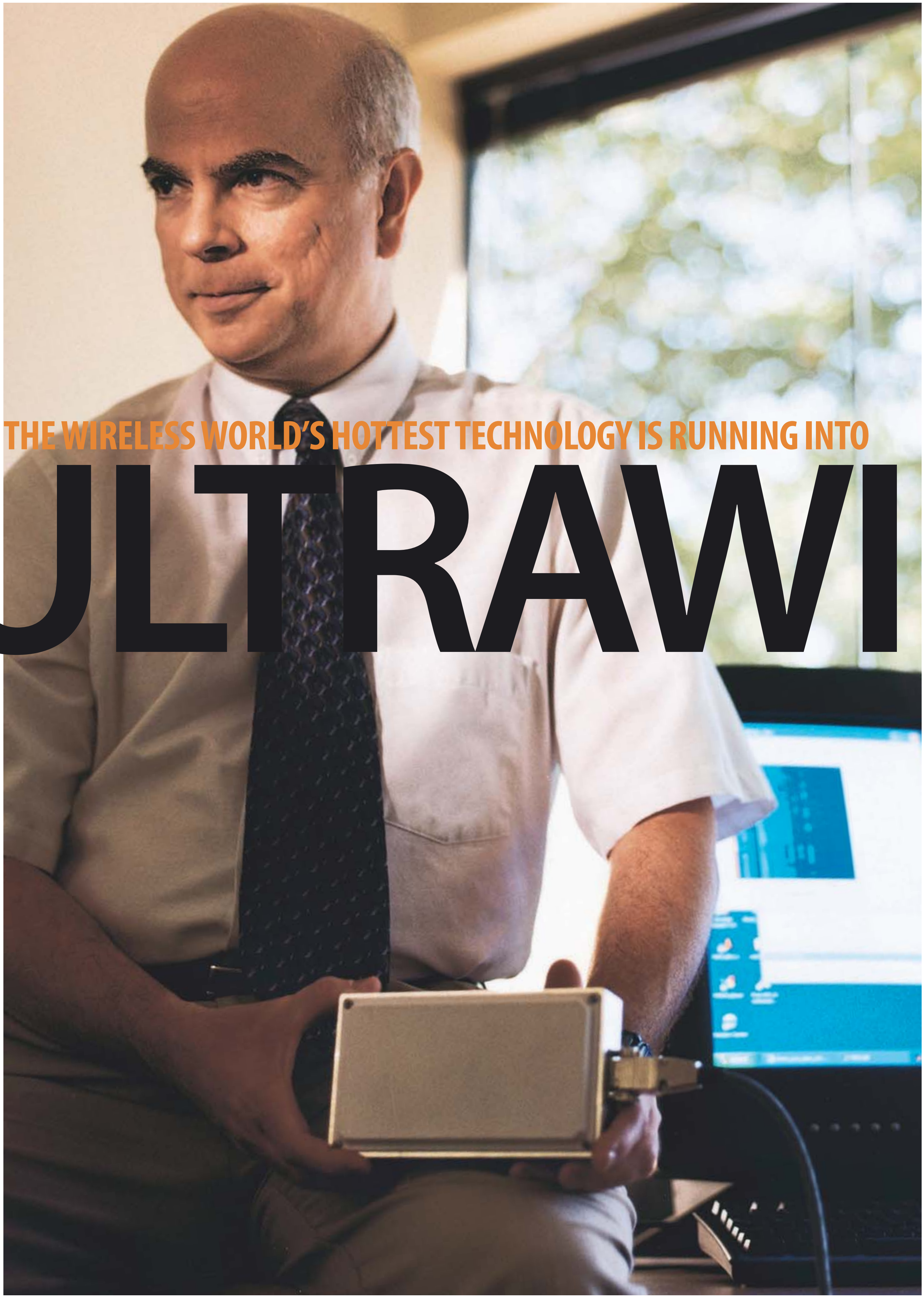


THE WIRELESS WORLD'S HOTTEST TECHNOLOGY IS RUNNING INTO

ULTRAWI

Penetrating vision: Robert Fontana, president of Multispectral Solutions, shows off an ultrawideband radar that can track objects through walls and other obstacles.
PHOTOGRAPH BY CHRIS HARTLOVE

STIFF OPPOSITION FROM THOSE WHO SEE INTERFERENCE AHEAD.

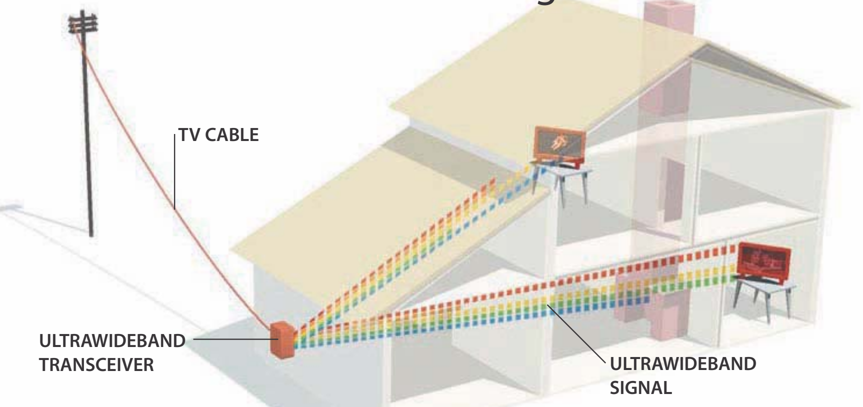
IDEBAND squeezes in

BY ERIKA JONIETZ

Robert Fontana disappears into a hallway. Seconds later, a small reddish blob of pixels appears and moves around a field of blue and green on a computer monitor hooked up to a shoebox-sized device. The splotch tracks Fontana's position in the building, even through the two walls between him and the technology he's showing off: a tracking and collision avoidance system that can "see" through barriers like walls (or trees) and measure a target's position, bearing and speed. Fontana, president of Germantown, MD-based Multispectral Solutions, says what's inside his shoebox can one day help keep helicopters, cars and other vehicles from ramming into obstacles like power lines or people.

Behind the device is a radio technology called ultrawideband that for decades was the province of military labs. But in the last few years, startups, information technology companies and consumer electronics giants have begun pushing ultrawideband beyond the radarlike systems the military pioneered and into applications that could transform the home. Sony and newcomer XtremeSpectrum in Vienna, VA, for instance, are both pursuing the possibility of using ultrawideband transmission to wirelessly link DVD players, stereos and TVs in home entertainment systems.

Ultrawideband Comes Through



An ultrawideband box could transmit different cable channels to TVs throughout a home. Although walls block some of the frequencies used, enough penetrate to reconstruct the signal.

SLIM FILMS

In the future, ultrawideband links could distribute extremely information-rich content, endowing a home or office with high-resolution 3-D virtual-reality simulation. Ultrawideband can also zap data between computing devices up to 10 times faster than today's rat's nests of wired links.

Other potential applications include tracking objects and people to centimeter accuracy (even through walls) and ultra-sensitive detectors for everything from home security systems to virtual pet enclosures. Ultrawideband tags could let robotic lawn mowers or vacuum cleaners go about their tasks without ever hitting a tree or a sofa. "We've got the most feasible technology for the George Jetson-like homes of the future," says Bruce Watkins, president of Pulse-Link, an ultrawideband startup in San Diego.

Ultrawideband, proponents say, will deliver all of this via cheap, low-power radios. And, they contend—albeit over vigorous disagreement from skeptics—it won't suffer from the interference problems that plague many existing wireless devices. "It's a tremendous new technology," says Geoffrey Anderson, vice president of Sony Electronics' Advanced Wireless Technology Group. "Ultrawideband could really be a huge benefit to the consumer market."

But the same qualities that enable such an array of applications also make ultrawideband divisive. In February, the Federal Communications Commission gave limited approval to the technology, opening the door to its commercialization, if only a crack. The FCC process generated almost 1,000 public comments—many more than most proposals elicit. And while much of the feedback was supportive, cell phone makers and service providers, Global Positioning System companies, satellite radio firms, airlines, and a slew of civilian and military government agencies all objected to the FCC's plans to approve ultrawideband. Their beef: ultrawideband transmissions would interfere with the radio frequencies they rely on. These groups cited consequences ranging from the inconvenience of dropped cell phone calls to the frightening scenarios of foiled guidance systems preventing planes from landing in poor weather and wayward bombs that hit civilians. "The price of that interference is going to be very severe if a bomb is misdropped," says Badri Younes, assistant secretary of defense and director of the U.S. Defense Department's office of spectrum management.

For now, with few systems around for testing, discussions of ultrawideband's promise and peril are largely theoretical. Although the FCC and other agencies have done some testing of the technology, the trials have mostly been conducted using lab devices—whose ultrawideband signals may be stronger, or weaker, or otherwise very different from those that will be produced by real-world devices.

With the new regulatory backing, companies will finally bring the technology to market over the next few years, and the practical answers needed to resolve the technical and political uncertainties about ultrawideband's potential should emerge. Then we'll see whether ultrawideband will transform the wireless world—or bring it crashing down.

PULSES OF POWER

Ultrawideband was born in the military labs of the 1960s. Looking for a way to let radar "see" through trees, researchers came up with the idea of using extremely short pulses of radio energy. Fundamental physics dictates that ultrashort pulses occupy a wide swath of the radio frequency spectrum; at least some of these frequencies, the theory went, were sure to penetrate leaves and branches.

Familiar wireless devices ranging from FM radios to cell phones to wireless computer networks using the increasingly common 802.11b standard all transmit continuous signals on narrow frequencies within the radio spectrum. Digital cell phones on the Sprint PCS network, for example, operate at around 1.9 gigahertz; 802.11b networks (and newer cordless phones) operate at 2.4 gigahertz. These transmissions occupy a thin slice of the spectrum and so generally do not interfere with other systems that depend on radio wave transmissions.

Ultrawideband radios, however, work in a fundamentally different way, emitting extremely short bursts of radio waves—just billionths or trillionths of a second long. Each pulse covers up to several gigahertz of radio spectrum. Information is transmitted by modulating the timing, amplitude, polarity or some other aspect of the pulses. An object's location can be inferred by methods like those used in traditional radar systems, such as "listening" for the echo of a directional signal and timing how long it takes to return, or triangulating on a target with multiple transceivers. The extremely short pulses used in ultrawideband make the position information highly accurate, down to the centimeter scale—unlike GPS, which is typically accurate only to tens of meters.

Sending information in pulses makes the radios much simpler, and therefore cheaper, to build than typical transmitters. That's because conventional narrowband radios require, among other design complexities, multiple analog components to tune the frequencies they emit. An ultrawideband transmitter, however, works like a tuning fork. Striking a tuning fork causes it to vibrate, sending out sound waves at a particular frequency. A semiconductor chip in an ultrawideband radio "hits" an antenna with carefully timed electrical pulses; the antenna responds by generating radio waves at every frequency possible. "Ultrawideband systems are just brain-dead simpler to build," says Carl Howe, an analyst at Forrester Research in Cambridge, MA.

Simpler circuit designs and the pulsed nature of the transmissions also allow ultrawideband radios to transmit at much lower power than other wireless technologies. This gives ultrawideband an edge when it comes to battery-powered devices, since other high-bandwidth technologies require multiple power-consuming components *(see "How Ultrawideband Stacks Up," this page)*. And the wide swath of frequencies that ultrawideband transmissions occupy helps them travel through walls; even if one frequency is distorted or doesn't make it through, others still carry the signal *(see "Ultrawideband Comes Through," p. 73)*.

Another advantage of ultrawideband is its relative immunity to so-called multipath interference. When radio waves encounter obstacles, they bounce off them; echoes that arrive at the receiver out of phase with the original signal can cancel it out. A cordless-phone user walking away from the phone's base station in his or her home experiences this phenomenon as the fading of the caller's voice. But with ultrawideband's extremely short pulses, the original signal reaches the receiver in its entirety before the first echo arrives. Today's microchips are sophisticated enough to tell the difference between the two—or even to add them together to make the signal stronger. So ultrawideband can operate well in echo-prone places where conventional wireless systems suffer, such as living rooms or crowded cities.

HOME WITHOUT WIRES

The FCC's February decision allows the commercialization of ultrawideband on an unlicensed basis—the same arrangement under which technologies like cordless phones and wireless data networks such as Bluetooth and 802.11b operate. The good news here for companies deploying ultrawideband systems is that they will not have to pay for the spectrum their technology uses. The bad news is that to assuage licensed service providers (like cell phone companies) who fear that ultrawideband might interfere with their slices of the radio spectrum, the FCC put strict limits on the new technology. Consumer ultrawideband radios are permitted to transmit only very feeble signals, at one-thousandth the power that personal computers are allowed to radiate just by being on, and only in specific frequency ranges: below 960 megahertz, between 3.1 and 10.6 gigahertz, and between 22 and 29 gigahertz. Practically, this means that the new radios will be limited in either the distance they can transmit or the data rates they can achieve.

But even within those constraints, one of the technology's most promising applications might well have room to blossom. Ultrawideband could serve as a near ideal medium for short-range "personal-area networks" that connect electronic devices. This concept is already embodied in the communications standard known as Bluetooth. But ultrawideband radios will be like "Bluetooth on steroids," says Martin Rofheart, XtremeSpectrum's cofounder and CEO.

For one thing, ultrawideband will be a lot faster than its rival—capable initially of transmitting 100 megabits per second across a distance of 10 meters, or about 100 times Bluetooth's speed. That makes ultrawideband suitable for connecting devices like camcorders and TVs or computers and peripherals—applications requiring more bandwidth than Bluetooth can deliver. XtremeSpectrum, for example, has built a prototype that simultaneously sends DVD-quality audio and video across a room from player to TV. The system, cited as "best wireless technology of 2002" at the Wireless Systems Design conference in San Jose, CA, sends data from as many as four players to four television sets. Such a hookup could potentially distribute different cable television signals to multiple TVs in a home. That's an application that has lured AT&T into studying the technology as well. "There are a lot of benefits," says wireless researcher Saeed Ghassemzadeh of AT&T Labs-Research—not least of which would be the elimination of the cost of materials and labor to wire multiple access points around a house or apartment.

The same broadband-data capabilities could also make ultrawideband a wireless replacement for the cables that connect computers with peripherals like printers and scanners. Intel began an ultrawideband research project about two years ago and is considering the technology's potential to replace the newest version of the Universal Serial Bus (USB) standard, which transmits data at 480 megabits per second via cables. Both XtremeSpectrum and another ultrawideband company, Time Domain of Huntsville, AL, aim to reach data rates of 400 to 500 megabits per second within the next year. And Pulse-Link's Watkins says that by year's end his company hopes to be making prototypes that approach speeds of one gigabit per second for distances up to 10 meters—faster than Ethernet and other current wired con-

Ultrawideband tags could let robotic vacuum cleaners or lawn mowers do their household chores without ever hitting a sofa or a tree.

How Ultrawideband Stacks Up

TECHNOLOGY	RANGE (METERS)	DATA RATE (MEGABITS/SECOND)	POWER (MILLIWATTS)	BEST SUITED FOR	COMMERCIAL AVAILABILITY
Ultrawideband	10	100	200 (peak)	Short-range, high-speed data transfer (such as wireless video and audio)	2003 (estimated)
802.11a	50	30	1,000-2,000	High-speed wireless computer networks	Now
802.11b	100	6	500	Computer networking and Internet access	Now
Bluetooth	10	1	30	Connecting computing devices over short distances for text transfer	Now

nections. Within three to five years, Watkins adds, Pulse-Link will build devices that transmit data much farther—50 to 100 meters—and at speeds 10 to 50 times faster than today's 802.11a and 802.11b wireless networking technologies.

PINPOINT POSITIONING

But the technology's real strengths go beyond wireless data transfer. Walter Hirt, ultrawideband-project leader at IBM's research lab in Zürich, says ultrawideband is exciting because it offers the ability to combine data transmissions with location information in a way other wireless technologies cannot.

Three ultrawideband outfits, for example—Æther Wire and Location in Nicasio, CA, Israeli company Pulsicom and Multispectral Solutions—are developing systems of extremely high precision to track people and objects in real time. Small transceivers attached to merchandise would allow stores to accurately track, retrieve and catalogue inventory in warehouses and storerooms; the tracking systems would also monitor against theft. Multispectral Solutions has already built a system for the navy that it hopes to apply to retail shipping and warehousing problems. Hospitals, meanwhile, could use the technology to quickly run down equipment and people in emergencies.

Æther Wire also hopes to combine GPS receivers with ultrawideband for positioning systems. GPS, which works best outdoors, would locate an object to within a few meters; then a local ultrawideband infrastructure would pinpoint location to within a few centimeters—even indoors. In the short term, pager-sized versions of the technology could be used for public safety applications like tracking firefighters in a burning building; such devices could transmit temperature, oxygen levels and vital signs to the fire marshals outside. "In an emergency situation, you need to know where people are," says Æther Wire cofounder Robert Fleming. "When you have guys in buildings, you can't see where people are. Your own guy could be six inches away, across the next wall." Ultimately, the company envisions systems so cheap that parents could slap sticky ultrawideband tags on their kids to keep tabs on them in malls or theme parks.

Collision avoidance radars—like the one built by Fontana's Multispectral Solutions—are another ultrawideband strength. Initially built to sense the proximity of obstacles to unmanned aerial vehicles, such systems could serve as backup sensors in cars. DaimlerChrysler has already built a prototype car that couples an ultrawideband-based collision avoidance radar with controllers that gently engage the brakes if the vehicle appears to be heading for a crash. "It's extraordinary driving it, because as your foot is on the gas and you're backing up towards a pole, even though your foot is on the gas, the car comes to a gradual stop," says Tim McBride, who helped DaimlerChrysler push for FCC approval of ultrawideband as the company's vice president of Washington affairs. McBride says that, with the necessary approvals, cars incorporating the system could be on the road within the next few years.

Even a single ultrawideband radio, critics say, could interfere with airline safety systems—like those that help planes land in bad weather.

Ultrawideband companies hope to establish markets for both types of applications quickly. This year, both Time Domain and XtremeSpectrum released their first ultrawideband chips, which electronics makers like Sony (a Time Domain investor) could incorporate into consumer products like TVs, camcorders, computers and stereos. XtremeSpectrum's Rofheart expects to see ultrawideband radios in high-end consumer electronics (like plasma screen TVs) by late 2003. He says that the wireless links may start appearing in mass-market products a year later.

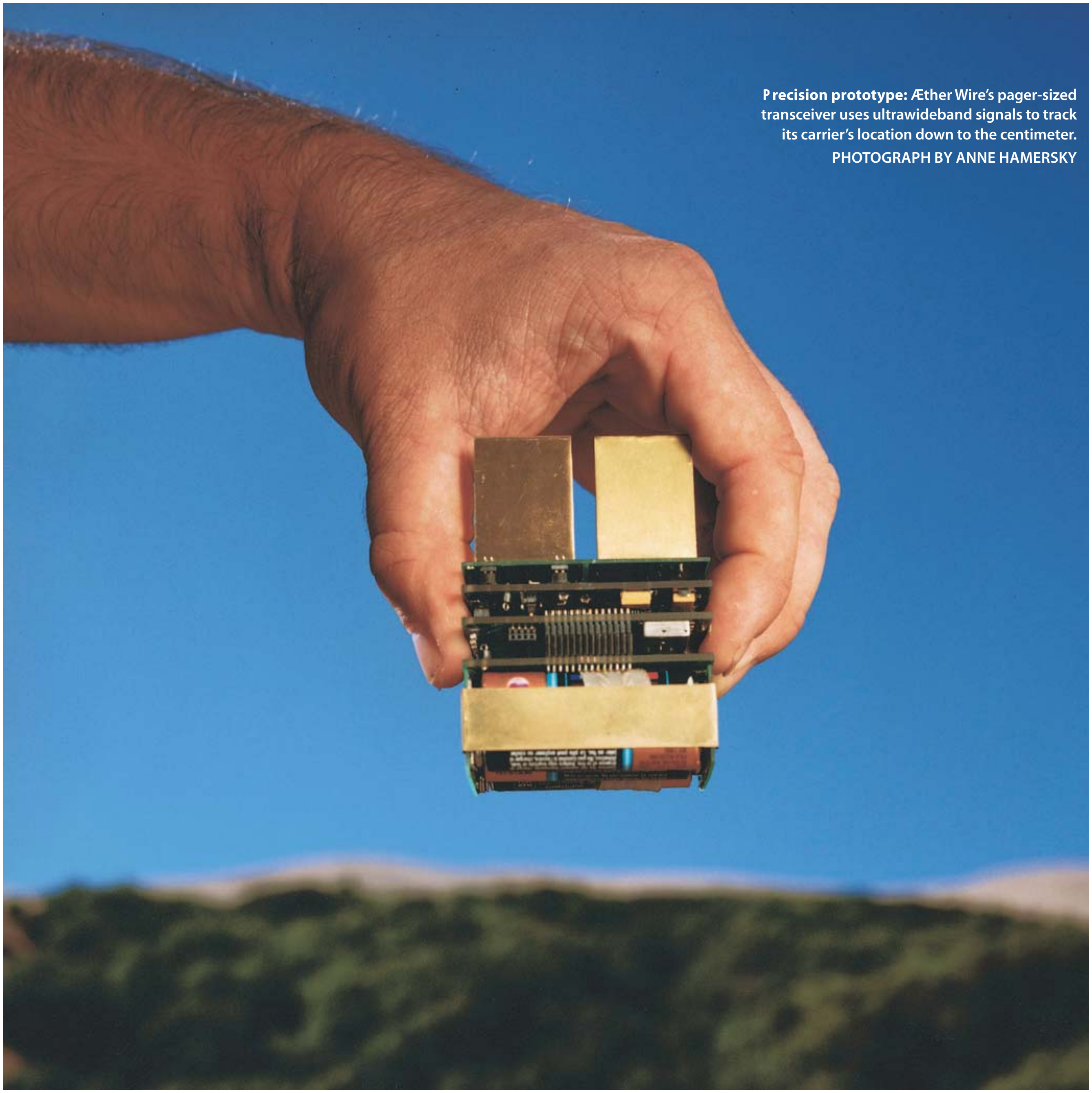
RUNNING INTERFERENCE

Despite ultrawideband's promise, attempts to deploy the technology face significant obstacles. The most immediate barrier is the FCC rules, which are designed to mitigate ultrawideband's potential to interfere with virtually every existing radio frequency service. "With the rules the commission enacted, you'll be lucky to get a signal across a room," says Dewayne Hendricks, founder of the Fremont, CA, wireless engineering firm the Dandin Group and a technical advisor to the FCC on new wireless technologies.

Ultrawideband's unique nature made the FCC's approval process especially contentious. The proposed short-range applications would use very low power pulses, which ordinarily would lessen their potential to cause interference. But ultrawideband signals overlay large parts of the radio spectrum. Although many proponents say these broadband pulses look like harmless "noise" to other radios, the signals could, in theory at least, disrupt a host of wireless applications—from TV to cell phones to GPS—that have paid big money for their slices of the spectrum. And if large numbers of ultrawideband transmitters come into use, the cumulative effects might inflict even greater interference. Many of the comments to the FCC on ultrawideband constitute a "yes it does, no it doesn't" back and forth on the interference question—even in the interpretation of data from technical studies. "As usual with studies," says Hendricks, "you can get credible scientists on both sides of the story."

Sprint PCS, for example, conducted tests indicating that ultrawideband signals could lead to more dropped calls and even lower the number of calls the network could handle, meaning more busy signals. Satellite radio companies Sirius and XM Radio are concerned about potential interference with their services. And tests performed by the National Telecommunications Information Administration showed that ultrawideband signals could make it more difficult for GPS receivers to lock onto satellite signals—and could also reduce their accuracy. That prospect would be especially troubling for the air traffic control system, which in coming years will rely increasingly on GPS.

The FCC's prohibition on ultrawideband emissions at certain frequencies was designed specifically to prevent potential interference with such systems. But those limitations are not enough, say some in the affected industries. Preliminary tests by NASA's Langley Research Center using ultrawideband emitters placed inside and outside United Airlines planes show that even at frequencies that the FCC is permitting, ultrawideband interference could compromise the instrument landing system pilots use to land in



Precision prototype: Æther Wire's pager-sized transceiver uses ultrawideband signals to track its carrier's location down to the centimeter.
PHOTOGRAPH BY ANNE HAMERSKY

bad weather. James Miller, program manager of flight operations technology at United, says that ultrawideband noise could additionally affect voice communications between air traffic controllers and pilots, the radars air traffic controllers use to track aircraft, and the collision avoidance system designed to prevent planes from crashing in midair. Airlines and the Federal Aviation Administration adamantly oppose permitting ultrawideband to operate in any frequency used by airlines; even a single ultrawideband radio could cause problems with these critical systems. "The question is not whether there's interference, the question is how much interference can flight crews tolerate," says Miller—and he says the airline industry's position is zero tolerance. "Any interference injected into the cockpit is a bad idea."

Many ultrawideband proponents contend that improper testing exaggerates the technology's interference effects. "A lot of the stuff put up for testing purposes with the FCC—you can't build efficient systems that way," says Pulse-Link's Watkins. Others suggest that the approval process became highly politicized. "Science wasn't really part of the debate anymore after a time—it became politics," says the Dandin Group's Hendricks.

Makers of ultrawideband systems hope that working commercial products will demonstrate that the radios do not cause interference. In fact, some devices under development—like Æther Wire's systems combining GPS and ultrawideband—would not work if ultrawideband caused as much interference as critics say it will. Indeed, says XtremeSpectrum's Rofheart, avoidance of interference-caused "radio fratricide" is key to future applications that would mingle cell phone, GPS and ultrawideband radios.

Adamant opponent: James Miller of United Airlines says ultrawideband signals could cause dangerous interference in radio bands used for airline safety.
PHOTOGRAPH BY CHRIS LAKE

Ultrawideband proponents also worry about the trouble other radio technologies might cause them. Because conventional narrowband systems, like cordless phones, operate at much higher power than ultrawideband radios, their transmissions could overwhelm nearby ultrawideband devices. Designing ultrawideband receivers so that they block certain frequencies could solve the problem—but also make the radios more complex and costly.

SETTING THE STANDARD

In the long run, the interest of major players like Intel, IBM and Sony could well give ultrawideband the push it needs to become as ubiquitous as cell phones. But first, its adherents will have to resolve the present multitude of proprietary approaches into a single standard, like the wireless networking standards 802.11a and 802.11b. Without standardization, one brand of DVD player, for instance, might not be able to send ultrawideband data to a TV from a different maker. Rofheart predicts that by early next year, the Institute of Electrical and Electronics Engineers will endorse an "802" standard for personal-area networks that incorporates ultrawideband. That, he says, will go a long way toward securing a market for the technology.

European and Asian adoption of regulations similar to the FCC's could help the technology even more, by creating a worldwide regulatory framework that would finally allow wireless devices to work in any country. "Because we're not dealing with frequencies that have been assigned differently in different countries, we have the first possibility of creating a global interoperable standard," says Pulse-Link president Watkins. IBM's Hirt says that the European Conference of Postal and Telecommunications Administrations plans to formulate an ultrawideband policy by the end of 2003 and seems to be leaning toward mirroring the FCC regulations.

Ultrawideband opens the possibility for a common global standard that would finally allow wireless devices to work anywhere in the world.

The action that would most benefit ultrawideband would be for the FCC to allow transmissions with higher power and at lower frequencies. And indeed, the commission is scheduled to revisit its ultrawideband regulations within six to 12 months and has signaled an intent to relax its restrictions. That could result in even simpler-to-design systems that might, among other things, solve the expensive "last-mile" problem by transmitting data from high-speed fiber-optic Internet networks to homes. Such hookups would provide connections tens of times faster than those offered by telephone and cable companies.

Some skeptics think it will be years before ultrawideband takes off at all. Kevin Kahn, who heads Intel's efforts, believes a practical data transmission product is at least three to five years away. Ken Dulaney, a mobile-computing analyst at the consulting firm Gartner, is even more conservative, estimating that it may take seven years for the technology to gain the kind of consumer acceptance 802.11b networks enjoy—if it ever does. Ultrawideband, he says, is "really an engineering experiment that now at least has a legal backing."

But whether ultrawideband matures in two to three years or unfolds over the course of a decade, Multispectral Solutions president Fontana is confident that the technology will eventually succeed. "When the FCC opens up over nine gigahertz of spectrum, even if these companies don't survive—including us—there will be other companies that will take advantage of that," he says. And when they do, the world may be a giant step closer to living like the Jetsons. TR

An Ultrawideband Who's Who

COMPANY	FUNDING	APPLICATIONS	STATUS
Time Domain (Huntsville, AL)	Investors include Sony and Siemens	Data transfer; precision location; radar	Radar products on the market; first communications chips to be released this year
Multispectral Solutions (Germantown, MD)	Military contracts (primarily DARPA, air force and navy)	Voice communications; data transfer; precision location; radar	Military systems in use; civilian applications under development
XtremeSpectrum (Vienna, VA)	Investors include Cisco Systems, Motorola and Texas Instruments	Multimedia data transfer	First chips released this year
Æther Wire and Location (Nicasio, CA)	Military contracts (primarily DARPA)	Precision location	Prototype demonstrated
Pulse-Link (San Diego, CA)	Undisclosed	Data transfer; precision location	Chips scheduled for release 2003
Pulsicom (Or Yehuda, Israel)	Investors include Intel Capital	Precision location	Chips scheduled for release late 2003
Intel (Santa Clara, CA)	Internal	Data transfer	Prototype demonstrated
IBM Research (Zürich, Switzerland)	Internal	Networking	Long-range R&D
AT&T (New York, NY)	Internal	Multimedia data transfer	Long-range R&D