Wireless MANs: The Sky's The Limit

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Wireless point-to-point links are a diverse lot, handling anywhere from 1 Mbps to 1 Gbps, and costing $5,000 to $50,000 per link.

Welcome to the wide world of wireless. Many enterprise network managers know their way around when it comes to cabling LANs and linking sites via terrestrial carrier circuits. But wireless represents an alternative—and one that, our hands-on testing concludes, is not only viable, but may even be preferable.

Several factors are opening network managers' eyes to wireless. For one, the ILECs' monopoly over the local phone network really hasn't diminished much in most areas. And prices for dedicated broadband links—such as DS3s and SONET-based fiber spans—remain sky high. Availability is still limited and, even where available, installation times remain long.

At the same time, wireless technologies have made impressive gains, delivering ever-increasing data rates over longer and longer distances. What's more, most wireless products no longer require expensive and time-consuming special-site preparation, or FCC frequency studies or licensing. This is in part because many wireless products operate at very high frequencies—well beyond where interference with broadcast TV and radio might have occurred. Also, today's wireless products consume very little power, and can span many miles, delivering high data rates with very low-power signals.

Our focus was on wireless network links that span modest campus and metropolitan-area distances—up to several kilometers. The longest distance we tested was 3.4 km (about 2.1 miles). That turns out to be the unobstructed distance between the rooftop of our main lab building and a nearby, 130-foot-high tower. We also tested over a "short" course, of exactly 1 km—about two-thirds of a mile (see "How We Did It", p. 54).

In metropolitan-area as well as in campus networks, backbone connections are typically point-to-point, linking LANs and subnets in different buildings, sites and locations. Traffic is invariably bi-directional and high speed—wireless links in this environment need to handle at least 10 Mbps.

That is all we required of wireless products to participate in this review: The ability to operate over our short (1 km) or longer (3.4 km) course, and the requirement they deliver at least 10 Mbps of bandwidth. One additional proviso: Time did not permit us to examine any wireless products that require FCC licensing.

We reasoned that many enterprises would approach the problem similarly: They'd have a fixed distance to be spanned, and need sufficient point-to-point wireless bandwidth to link their LANs, subnets, buildings or major locations. We did not believe, initially, that it would matter much what the wireless technology was, just as long as it satisfied those two requirements.

However, we ended up testing very different classes of wireless products. And we eventually concluded that their operational characteristics, capacities, features, even costs, were sufficiently different that they really couldn't be viewed as one-to-one replacements for each other. We therefore didn't think it fair to compare these apples-and-oranges wireless products side-by-side on the same scorecard, which has been a standard feature of many *BCR* Best-in-Test product reviews.

Classes Of Distinction

Table 1 underscores the differences among the seven products we tested. These represent three very different classes of wireless links:

1.) "Optical" wireless links—These products use transmission frequencies in and around the spectrum of visible light—including infrared and ultraviolet. These are much higher frequencies and much shorter wavelengths than the electromagnetic waves used by radio frequency (RF) wireless links. Where RF links typically work in the frequency range of 2 to 6 GHz (gigahertz), the two optical products we tested—both based on infrared lasers—transmit in the range of 0.8 to 1.5 THz (terahertz). In other words, infrared wavelengths are a thousand times smaller, and their frequencies a thousand times higher, than RF.

Based on the "optical" products we tested, this class of wireless link spans shorter distances than RF wireless links, but supports higher data rates.

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TABLE 1 Wireless MAN Links: Configurations Compared

	Canon www.canobeam.com	**fSONA** www.fsona.com	**Proxim** www.proxim.com
Product	Canobeam III/DT-50, v1.12 firm/software	SONAbeam 155-M TM, v2.1.8 firm/software	Stratum 100, v1.01e firm/software
First shipped	Dec 1999	May 2001	July 1999
Wireless technology	Infrared laser; 785-nanometer wavelength	Infrared laser; 1,550-nanometer wavelength	Radio frequency; 5.25 to 5.35 and 5.7 to 5.8 GHz
Practical max distance	0.1 to 2 km (100 to 2,000m) *	0.2 to 2 km (200 to 2,000m)	Up to 11 km
Separable transceiver and antenna?	No; a single integrated unit	No; a single integrated unit	Yes; indoor and outdoor units link via fiber, up to 1,000 feet apart
Interface(s) to user network	100BaseT or OC-3/Packet-over-SONET (PoS) via multimode fiber; or OC-12/PoS via single mode fiber (dual-SC)	100BaseT or OC-3 PoS via single mode fiber (dual-SC)	10/100BaseT (RJ-45) and two T1/DS1's (RJ-48C); multimode fiber (ST) link between units
Power	120V AC, consumes about 50 Watts	48V DC; consumes about 300 Watts	110/220V AC for indoor unit, which delivers 48V DC to remote unit
Wireless link data rate(s); half/full duplex	100, 155 or 622 Mbps (Fast Ethernet SONET OC-3 or OC-12); all full duplex	155 Mbps (SONET OC-3); full duplex	100 Mbps, full duplex, plus two full-duplex T1 channels
How wireless link appears to network	Functions as a Layer 1 hub/repeater	Functions as a Layer 1 hub/repeater router	Functions as a L2 bridge
Multipoint capable?	No	No	No
Price (US list) for full wireless link (both ends)	$50,000 for full 100BaseT/OC-3 link; $56,500 for OC-12 link	$30,700 for full 100BaseT/OC-3 link	$32,950 for full link, with antennas

* The product spans 2 kilometers with the OC-3/100BaseT card. The maximum distance with the OC-12 card we tested is 1 km.

From a network perspective, these wireless links are transparent; they function as bit-by-bit repeaters. The products we tested were:

- **Canon USA Inc.'s Canobeam III/DT-50**, a single, compact unit the size of a large home mailbox, which contains all the electronics as well as the infrared-laser transceiver. One configuration card lets you operate the wireless connection as a 100-Mbps Fast Ethernet link or a 155-Mbps packet-over-SONET OC-3 link. Another card supports a 622-Mbps packet-over-SONET OC-12 link. The Fast Ethernet/OC-3 card works at up to 2 km; the OC-12 spans up to only 1 km. The Fast Ethernet/OC-3 configuration costs $50,000 U.S. list for a full link (both ends); the OC-12 configuration costs $56,500.
- **fSONA Communications Corp.'s SONA beam 155-M TM.** Like Canon's, this is a self-contained unit, and also employs infrared lasers. And the system likewise supports a Fast Ethernet link or a 155-Mbps packet-over-SONET OC-3 link. U.S. list price for this product (both ends) is $30,700.

2.) High-speed, multi-link RF—The two products we tested in this class support considerably longer distances than the optical links—from 8 to 10 km (5 to 6 miles). We tested them over our 3.4-km "long distance" course. The products use different transmit and receive frequencies, but both are in the 5.3- to 5.8-GHz band. Both products support a full-duplex Fast Ethernet wireless link, along with two separate T1 channels. From a network perspective, these wireless links function as Layer 2 bridges—they work at the MAC layer and buffer and forward one full packet at a time. The products we tested in this class were:

- **Proxim Inc.'s Stratum 100.** At either end, there's an Outdoor Unit (ODU)—which sends and receives signals across the wireless link and includes the antenna—and an Indoor Unit (IDU), which connects to the user's LAN. The ODU and IDU can be separated by up to 1,000 feet via a multimode fiber cable, plus a copper cable (18-gauge UTP) that carries DC power from the IDU to the ODU. The IDU offers an RJ-45 for 100BaseT network connection, and two T1 ports (modular RJ-48C). U.S. list price for a two-site configuration is $32,950.
- **Western Multiplex Corp.'s Tsunami 100 Wireless Ethernet Bridge.** As with Proxim's Stratum 100, the main electronics unit is separable from the antenna part. In this case a coax cable

Western Multiplex www.wmux.com	OTC Wireless www.otcwireless.com	Proxim www.proxim.com	Wi-LAN www.wi-lan. com
Tsunami 100 Wireless Bridge, v1.0	AirEZY2411 BRG, v1804K firm/software	Stratum MP, v7.7 firm/software	AWE 120-24 Wireless Bridge, v2.0 software
Nov 2000	1999	Jan 2001	4Q00
Radio frequency; 5.3 and 5.8 GHz	Radio frequency; 2.4 to 2.48 GHz	Radio frequency; 2.4 to 2.48 GHz	Radio frequency; 2.4 GHz
Up to 8 km	Up to 12 km	Up to 19 km	30+ km (with large antennas)
Yes; antenna is coax-connected up to 600 feet away	Yes; antenna is coax-connected up to 40 feet away	Yes; antenna is coax-connected up to 300 feet away	Yes; antenna is coax-connected, distance varies with cable type
10/100BaseT (RJ-45 or fiber dual-SC) and two T1/DS1s (RJ-48C)	10BaseT (RJ-45)	10BaseT (RJ-45)	10/100BaseT (RJ-45); auto-senses speed and duplex
48V DC; antenna is powered via coax cable	5V DC (via 110V AC converter); antenna powered via coax cable	6V DC (via AC converter); antenna is powered via coax cable	6V DC (via AC converter); antenna is powered via coax cable
100 Mbps, full duplex, plus two full-duplex T1 channels	11 Mbps; half duplex	10 Mbps; half duplex	12 Mbps; half duplex
Functions as a L2 bridge	Functions as L2 bridge and IP	Functions as a L2 bridge	Functions as L2 bridge, with L3 protocol filtering
No	Yes	Yes	Yes
$37,000 for full link, with antennas	$4,800 for full link, with antennas	$4,400 for full link, with antennas	$5,000 for full link, with antennas

The adapted multipoint products had lower throughputs—and prices

connects the antenna at up to 600 feet away. The antenna requires no other power for transmission and reception, and a variety of different antenna types and sizes can be used, depending on distance and other RF-configuration factors. The user interfaces for the 100BaseT and T1 connections are the same as with the Stratum 100, except that a fiber LAN link is also offered (100BaseFX). U.S. list price for Western Multiplex's product (both ends) is $37,000.

3.) Low-speed, adapted-multipoint RF—We tested three products in this class. All support "multipoint" topologies, where multiple "client" wireless sites connect to a common master or server station. All these products could also be configured to operate in a "point-to-point" environment, which is how they were tested (given our "wireless MAN" focus). We did not conduct any multipoint wireless testing for this article. The products tested in this class all operate in the RF frequency band around 2.4 GHz.

The products tested all support only half-duplex data flow—reflecting their multipoint orientation, where a master station typically polls each client station in fast rotation. What's more, the total available system bandwidth is about 10 to 12 Mbps, and this is divvied up among all clients and in all directions. This means that the maximum one-way throughput achievable over a two-node, point-to-point wireless link—assuming comparable data flow in both directions—is somewhere in the 2- to 5-Mbps range. This is little more than a conventional routed T1 WAN link between two remote LANs can carry.

Therefore, these products' applicability for the high-speed, point-to-point environment we created is questionable. Clearly their throughputs are far below those of the other product classes. However, so are their prices.

Note that this class of product is also considerably different than the products being offered for the "IEEE 802.11" wireless LAN environment. IEEE 802.11 products enable wireless LAN access by multiple end user "clients" over a relatively small physical area. In the 802.11 environment, splitting the 11 Mbps of half-duplex bandwidth among all the multipoint users can still yield acceptable throughput performance.

The products we tested in this "low-speed, adapted-multipoint" were:

■ **OTC Wireless Inc.'s AirEZY2411 BRG.** Like the others in this class, this is a multipoint product that was configured for our point-to-point environment. The product package includes IP routing, as well as Layer 2 bridging. Besides IP-level functions like a DHCP server and NAT (network address translation) support, the package also supports Layer 2 protocol filtering and the spanning-tree protocol. The main unit connects via coax to an antenna as far away as 40 feet. We tested the unit over our 3.4-km course. U.S. list price for this product (both ends) is $4,800.

■ **Proxim's Stratum MP,** which stands for multipoint. The product functions as a Layer 2 bridge only. Like the other products in this class, the main unit can be located apart from the antenna,

Wireless Product Highlights

Canon Canobeam III/DT-50. This was the only product tested that supported OC-12 capacity, although to a maximum of just 1 km at that speed. Physically, the integrated unit looks a little bulky, but that is only a concern with regard to wind resistance—i.e., the wind could move the unit slightly, just enough for it to lose alignment with the far end. If that were to happen, the link would go down. However, the unit's auto-tracking capabilities help ameliorate that concern to a large extent.

Indeed, the auto-tracking is very impressive. There's a nice signal-strength indicator on the device, which provides a very understandable assessment of receive signal strength in a two-digit display from 0 to 100. You don't need any other tools or equipment to deploy this system; by comparison, many other products require special software or a voltmeter. There is a PC-based GUI application that facilitates configuration and monitoring. However, this tool operates over a serial connection. SNMP is supported, but there is no other in-band, IP-based, GUI- or browser-based management access.

fSONA SONAbeam 155-M TM. This system features redundant lasers, which significantly enhances link reliability. The lasers automatically reduce or increase power as required. Compared to Canon, the fSONA product seems to have greater physical stability, but notably fewer features and options. There's no auto-tracking, although the alignment features provided, including a scope for set-up, are complete and sufficient. You need to dedicate a computer or laptop to managing this system, and management access is via an RS-232 serial cable. Overall, deployment is a snap. Documentation is excellent.

Proxim Stratum 100. For linking remote 100BaseT LANs, this is one of the best-performing products, which is also easy to install. There are four different tools and mechanisms provided for ascertaining signal strength for antenna alignment. The additional T1 channels are a valuable added feature, which in an enterprise MAN would certainly be used for inter-PBX trunks. The browser-based management of this product is the best of all the wireless products we tested in this round. It is SNMP-based under the covers, but provides an intuitive GUI with well-thought-out interfaces for alarms/events, configuration and superb real-time monitoring. The product is split into discrete indoor and outdoor units, which makes sense. However, the cabling between these components, including a proprietary cable for DC power delivery, is a bit unconventional.

Western Multiplex Tsunami 100 Wireless Ethernet Bridge. A solid RF product, designed to bridge between two 100BaseT LANs and deliver maximum performance. Functionally, it's comparable to Proxim's Stratum 100—this unit also supports two separate T1 channels—with a couple of worthwhile enhancements: For example, there are 100BaseT and 100BaseFX (fiber) ports to choose from for the LAN connection. There's also an FXS/RJ-11 port, which supports an analog phone connection over the wireless link. Management is very good, via an uncluttered, easily navigable GUI. This is the most configurable, and one of the most-straightforward-to-configure wireless products we tested.

OTC Wireless AirEZY2411 BRG. This product is oriented more to multipoint environments than to the point-to-point, LAN-to-LAN environment we created and tested. There's a small PC program that's used for basic management, although it requires a Novell IPX protocol stack on the PC in order to use it. There is an extra-priced, standalone component, which installs in-line between the network switch and the master (or server) RF wireless unit. This provides superb management via a GUI and very nice topology map. It also enhances buffering and flow control.

Performance of the OTC product, in all respects, is poor. However, this is offset somewhat by a broad set of features, including IP routing (via static routes or RIP), bridging, filtering of most common Layer 3 protocols, NAT, DHCP, spanning tree and more.

Proxim Stratum MP. This is a point-to-multipoint, 10-Mbps wireless link. We ran into some flow-control settings that frustrated the initial deployment. But once we figured it out, operation and performance went well. Management is very good, via a clean and intuitive GUI, with thorough and accurate, context-sensitive online help, and excellent documentation.

Signal strength and antenna alignment tools could be more numerous and improved. One very notable configuration feature is a second antenna port, which supports "antenna diversity." This is where two concurrent antenna links can be configured for redundancy and fail-over. The link exhibiting the best transmit and receive signal takes over automatically. This redundancy feature was not tested.

Wi-LAN AWE 120-24 Advanced Wireless Ethernet bridge. Despite the lack of a GUI or on-screen help, this wireless system is still fairly easy to set up via a menu-driven command-line interface. The documentation accompanying this product is excellent. Throughput performance over the 11-Mbps wireless link is very good, although latency, at 1.5 milliseconds, is on the high side. We note that this product offers very rich configurability for multipoint topologies, allowing the manager to tailor the bandwidth to deliver optimum throughput where needed. Besides functioning as a Layer 2 bridge, IP filters can also be applied, which can further bolster bandwidth efficiency and throughput□

which connects via a coax cable, and does not require any separate power supply. The unit was tested over our 3.4-km course. U.S. list price for this product (both ends) is about $4,400.

■ **Wi-LAN Inc.'s AWE 120-24 Advanced Wireless Ethernet bridge,** which we tested with a third-party's antennas—model TA-2408, from Til-Tek Antennas (www.tiltek.com). The product, which performs in the network as a Layer 2 filtering bridge, was tested over our 1-km course. U.S. list price for this product (both ends, plus the Til-Tek antennas) is about $5,000.

Varied Performance

The results shown in Table 2 are so varied that there would seem at first glance to be no pattern or consistency. But actually there is.

If you view products by class, then certain patterns emerge. For example, the two "optical" wireless products exhibit the highest throughputs—Canon with over 1 Gbps of combined bi-directional throughput, and fSONA with nearly 300 Mbps. In Canon's case, the 1,197 Mbps represents up to 96 percent throughput efficiency over its full-duplex OC-12 (622 Mbps), packet-over-SONET wireless link. And fSONA's 299 Mbps likewise represents upwards of 96 percent efficiency over its full-duplex OC-3 (155 Mbps), packet-over-SONET wireless link.

It's noteworthy, too, that the latency and jitter exhibited by these optical products is negligible. This is likely the result of the short distance (1 km), and efficient and consistent laser-optical encoding. But it may also reflect the fact that data passes through these devices bit-by-bit, like a repeater: In all the RF cases, by comparison, the wireless units act as a bridge or router: Some amount of full-packet buffering is performed, and so latencies are higher.

In the class of "high-speed, multilink RF" wireless products, the performance of Proxim's Stratum 100 and Western Multiplex's Tsunami 100 are nearly identical. With large packets, both exceed 98 percent efficiency in both directions. The Tsunami 100 exhibits slightly better (lower) latency, but even the Stratum 100's 0.46 milliseconds of added delay means that latency is not an issue with this class of product.

In the class of "low-speed, adapted-multipoint RF" wireless products, performance is more varied. The throughput performance of OTC Wireless is notably lower than that of competitive products from Proxim (the Stratum MP) and Wi-LAN. Throughput-wise, the Proxim and Wi-LAN products performed similarly. However, their latencies were quite varied: The Stratum MP's 0.5-millisecond latency is acceptable, while the Wi-LAN AWE 120-24's 1.5-millisecond latency is high enough to become a concern.

Details of the more notable aspects of each of the wireless-link products tested are summarized in, "Wireless Product Highlights."

Conclusion

"Optical" (infrared-laser) products clearly delivered the best performance, but carried fairly high price tags—in the $30,000 to $50,000 range. The performances of certain high-speed RF wireless links were also excellent. But their prices are similarly high, ranging from $33,000 to $37,000.

Whether wireless is right for your network depends on your wireline options—and physical topology

TABLE 2 Wireless MAN Links: Comparative Performance

	Wireless Link Data Rate, Duplex Mode	Wireless Link Distance Tested	Minimum-size packets (64 byte), Max Bi-directional Throughput (Mbps)	Maximum-size packets (1,518 bytes), Max Bi-directional Throughput (Mbps)	Latency (one way) and jitter—the standard deviation, in milliseconds (ms)
Canon Canobeam III/DT-50 (data here is based on testing with the OC-12 Packet-over-SONET card)	622 Mbps full duplex	1 km	1,179.6 Mbps	1,197.4 Mbps	latency: 0.065 ms jitter: 0.0007 ms
fSONA SONAbeam 155-M TM	155 Mbps, full duplex	1 km	227.8 Mbps	299.3 Mbps	latency: 0.075 ms jitter: 0.0002 ms
Proxim Stratum 100	100 Mbps, full duplex*	3.4 km	151.5 Mbps	197.4 Mbps	latency: 0.466 ms jitter : 0.004 ms
Western Multiplex Tsunami 100	100 Mbps, full duplex*	3.4 km	152.4 Mbps	197.4 Mbps	latency: 0.123 ms jitter: 0.002 ms
OTC Wireless AirEZY2411 BRG	11 Mbps half duplex	3.4 km	0.5 Mbps	4.9 Mbps	latency: 1.170 ms jitter: 0.13 ms
Proxim Stratum MP	10 Mbps, half duplex	3.4 km	1.8 Mbps	9.5 Mbps	latency: 0.527 ms jitter: 0.073 ms
Wi-LAN AWE 120-24	12 Mbps half-duplex	1 km	1.7 Mbps	8.9 Mbps	latency: 1.477 ms jitter: 0.22 ms

* Both the Proxim Stratum 100 and the Western Multiplex Tsunami 100 products also concurrently support two full-duplex T1 channels, which together yield an additional 3 Mbps of bi-directional bandwidth. The throughput data shown here does ***not*** reflect the added available bandwidth of those T1 channels.

All the products tested need clear, unobstructed lines of sight

How We Did It

For performance testing of the wireless links in this project, we required test systems that could perform two main functions: First, the systems had to be able to concurrently generate and receive test traffic via both ends of a wireless link, uni-directionally and bi-directionally, over a wide range of interfaces and data rates ranging from 1 Mbps to more than 1 Gbps. Additionally, we needed a system to synchronize time stamps between two devices on either side of the wireless link, in order to accurately assess latency and jitter.

To satisfy both requirements we turned to Ixia, which provided us with two of its Ixia 100 systems. In addition to traffic generation, the Ixia 100 offers integrated GPS (global positioning satellite)-based time synchronization in a small, light unit, making it ideal for our purposes. By swapping out modules, the Ixia 100 could accommodate all the data-network interfaces and traffic-generation and analysis loads we required: OC-3 and OC-12 packet-over-SONET (POS), as well as 10BaseT and 100BaseT Ethernet.

To emulate an enterprise customer with "typical" metropolitan-area (MAN) requirements, we defined two specific, fixed-location, wireless-link environments. One was a 1-km "short-range" course (0.62 miles), the other a 3.4-km (2.1 mile) "long-distance" course. The roof of our two-story main lab building served as the common end for both wireless spans.

The far end of the short course was a spot in a field one kilometer away, which we served with a portable generator, and ferried equipment and people to and from. The other end of the long-distance course was about 130 feet high, atop a nearby tower. Both courses were totally unobstructed and offered clear line-of-sight paths.

That's important, because all the vendors we tested emphasize that you need clear, unobstructed line of sight for their products to work optimally. But it turns out that "unobstructed clearance" means different things to the optical and the RF vendors. With optical, distances are shorter—1 to 2 km—and the required line of sight for optical is just that: absolutely clear view and devoid of any obstructions.

However, with RF, there are "cones" of clearance involved. The area between wireless ends needs to be considered as a big ellipsoid (a football-shaped space). And this whole ellipsoid needs to be clear of obstructions. The width of the ellipsoid depends on the RF frequency that's used: The higher the frequency, the narrower the ellipsoid width.

Another wireless issue that's been talked about a lot over the years is the effect of varying weather conditions on transmission quality. We did our field-testing only on dry, clear days, to ensure we gave all participants a level playing field. However, we also wanted to simulate various atmospheric conditions—again, in a way that was uniform for all products under test. We came up with a variety of "impairment" simulations:

- A water spray (a garden-variety sprinkler) applied in front of one transceiver, emulating light rain.
- A wood frame covered with a loose cotton fabric—about 50 percent opacity—emulating snow (but, notably, without the water-content aspect of snow).
- A frame covered with a plastic mesh screen (about like a screen door, as far as opacity).
- A large spun-glass filter (like out of a big air conditioner), with a fiberglass mesh, simulating partial and uneven obstruction, such as blowing leaves or wind-blown dust.

And here's the good news: *None* of these impairments/obstructions had *any* effect whatsoever on the throughput or error rate of any of the wireless products we tested□

Performance becomes more varied with low-speed, multipoint-oriented RF wireless links. These products exhibited bi-directional throughputs ranging from less than 1 Mbps up to 9.5 Mbps. The latency of some products in this class can also be a concern. Prices, however, are much more affordable—from $4,400 to $5,000.

The bottom line: With wireless point-to-point links you get what you pay for. These products work reliably and can be deployed quickly. Whether they are right for your MAN depends on the alternatives—such as dedicated wideband, terrestrial-cable services—and, of course, on the physical topology of the serving area□

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Companies Mentioned In This Article

Canon USA (www.canobeam.com)
fSONA Communications (www.fsona.com)
Ixia (www.ixiacom.com)
OTC Wireless (www.otcwireless.com)
Proxim Inc. (www.proxim.com)
Til-Tek Antennas (www.tiltek.com)
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Wi-LAN (www.wi-lan.com)