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Feature Articles

# Probing public safety antenna standards

By D. A. Keckler, Features Editor

*A technical standard, separate from commercial ones and specific to public safety, is available to aid law enforcement agencies in procuring and using communications antennas. What does this standard require, and how useful is it as a purchasing and operations guide?*

[The main text of this article appears in the March 2000 issue of MRT. We asked individuals associated with antenna standards, manufacturing, procurement and operations to share their comments on the article, the NIJ standard and the antenna industry with our Web audience. Their contributions appear below at the end of the main article. Additional comments are welcome at mailto:mrt@intertec.com]

*A fable: An analyst comes out to a tower site to advise the manager on antenna spacing. He shimmies up the tower, unravels an old ball of string from his pocket and, like a tailor, matches the distance between the sticks with his string. When he comes back down, the manager asks "What next?" The analyst says "Well, I guess the length of the string, which gives us an estimation of the separation, and then we change the spacing accordingly. "Good grief, man," the manager cries, "In that case, why not just estimate the spacing to begin with?" The analyst shakes his head and replies, "You don't understand analysis; there has to be a standard."*

**M**any standards apply to public safety radio. The most celebrated example in recent years is Project 25. Standards aid procurement, facilitate replacement, promote interoperability and act as quality control. The commercial minimum standard for communication antennas is TIA/EIA 329-B. One of its counterparts in the public safety realm is *NIJ Standard-0204.02: Fixed and Base Station Antennas.*

The standard[1] is one of many projects of a government program created by Congress 21 years ago to determine technology needs for justice agencies, to set technology performance standards and to distribute those results to the federal, state and local law enforcement communities. This program, the National Institute of Justice (NIJ), essentially provides impartial and free resources that a user, e.g., the communications division head of a local police department, can turn to for technical standards, reports and user guidelines.

1To trace where the standard comes from involves some government alphabet soup. The standard was developed at the National Institute of Standards and Technology for the Law Enforcement and Corrections Standards and Testing Program of the Office of Law Enforcement Standards (OLES). OLES is an office of the National Law Enforcement and Corrections Technology Center (NLECTC), which is a program of the Office of Science and Technology (OS&T) of the National Institute of Justice (NIJ). NIJ is the R&D section of the Office of Justice Programs (OJP), which is a branch of the U.S. Department of Justice (DOJ). Printed copies of the standard are available from the National Law Enforcement and Corrections Technology Center, P. O. Box 1160, Rockville, MD 20849-1160. The standard can also be downloaded from the Internet as a PDF file at http://www.%20nlectc.org/pubs/#comm.

The NIJ Standard 0204.02 for antennas, released about a year and a half ago, replaces version 0204.01, created in 1981. Its stated purpose is to "establish minimum performance requirements and methods of test for antennas that are used at base stations or other fixed sites by law enforcement agencies." Land mobile antennas covered by the standard are those for use at VHF lowband, VHF highband, UHF and 800MHz/900MHz.

## Equipment requirements

• *Minimum performance* — The minimum performance standards in 0204.02, meeting or exceeding TIA/EIA 329-B, include:

1. Operating at the *rated power output* with no physical damage.

2. A *radiation pattern* ±1.5dB of the specified gain for the main lobe (or full range for omnis) and ±5dB of the gain in the minor lobes.

3. A *VSWR* of 1.5 or less on all frequencies (referenced to a 50-ohm system).

4. A *wind-load rating* times 1.65 the values specified in Chapter 16 of the TIA/EIA-222F tower/support structure standard; or the local building code, whichever is more stringent.

• *User information* — To meet the standard, OEMs, system integrators or distributors must provide the antenna purchaser with information on:

- operating frequency range.
- power rating.
- relative antenna gain, in standard gain unit, over the frequency range to be used.
- polarization.
- vertical radiation pattern.
- horizontal radiation pattern.
- nominal impedance,
- VSWR over the frequency range.
- connector type.
- wind load rating and ice load rating, if applicable.
- physical dimensions.
- weight.
- material composition.
- installation, operation and maintenance instructions.
- RF radiation hazard zone at full power.
- certification of compliance with the standard.

• *Operating environment* — Many environmental factors can degrade the structural or electrical performance of an antenna, including its radome, insulating materials and connector. For environmental and climatic endurance, the 0204.02 standard references military standard MIL STD 210C and requires the testing methods specified in MIL STD 810E as the means for manufacturers to demonstrate compliance. It does recognize that some environmental specifications not applicable to the user's climate may be waived by the procuring agency. Other specific requirements include:

- the ability to operate under sustained temperatures as high as 43ºC (110ºF) and solar radiation as high as 1,120W/$m^2$, except in the Southwestern United States, where a more stringent temperature standard of 49ºC (120ºF) is applied.

- the ability to operate under sustained temperatures as low as –32ºC (–25ºF), except for Alaska, where the requirements range from –46ºC (–50ºF) to –51ºC (–60ºF)

- the ability to resist moisture penetration from blowing rain at a rate of 5.9 inches/hour at 24ºC (75ºF) in a 35-knot wind for at least one hour.

- the ability to resist a sustained relative humidity of 100% at the high and low

temperature ranges.

• the ability to resist sustained exposure to salt fog, for installations intended in coastal areas.

• the ability to withstand exposure to blowing sand, dust and snow.

• the ability, for installations in ice-prone states, to withstand a 0.75-inch-thick ice glaze at the wind load.

• *Radiation hazard* — Radiation hazard zones are the volume of space surrounding an antenna where its power density or field strength when operating at full power exceeds recognized specified limits. The standard points out that this is not an environmental condition, nor can it be waived in a request for proposal. The standard references ANSI/IEEE standard C95.3 (1991). (However, since the issuance of 0204.02, the OSHA and the FCC have revised minimum permissible exposure limits, and these standards should be taken into account when specifying.)

## Test methodology

The detailed test methods specified in 0204.02 are mostly of interest to the OEMs, system integrators and distributors, who must certify compliance with the standard. However, a brief review of the procedures will give the procuring agent an idea of how these certifications are achieved.

• *Test frequencies and sites* — Three frequencies are chosen from the operating range of the antenna under test, occurring roughly at the lower, middle and upper portions of that range. For multiband antennas, each frequency band must be tested in this fashion. Outdoor test sites, or ranges, have to be open, level ground. Above ground, they have to be free of any obstruction (trees, poles overhead wires, buildings, etc.) that would interfere with an EMF for at least 50 wavelengths, or 100m, whichever is greater. Below ground, the soil has to be free of geologic peculiarities, and any buried utility lines or control cables have to be at least one foot below the surface.

Elevated test ranges, to simulate mountainous conditions, have additional range design requirements. For the higher land mobile frequencies (800MHz/900MHz), indoor ranges can be used.

• *Instrumentation* — Test equipment standards include specifications for frequency stability, phase noise limits and transmitter power minimums to exceed ambient RF noise. Receivers have to have frequency stability equivalent to transmitters and must be phase-locked to them. Pattern recorders have to be accurate to ±0.2dB. Power meters must be able to measure forward and reflected power in a 50-ohm system to a tolerance of 5% or less. The reference antenna for measuring gain is specified as either an adjustable, half-wavelength standard dipole, or an EIA standard gain antenna.

• *Lowband modeling* — Scale model techniques are allowed for testing VHF lowband antennas because their physical size can make getting accurate radiation pattern and gain measurements difficult on a range. Equivalents for scaling down the antennas are provided in the standard.

Procedures are also outlined for polarizing the test and source antennas through various planes of rotation and for assessing the environmental ratings previously mentioned, as shown in Figure 1 below.

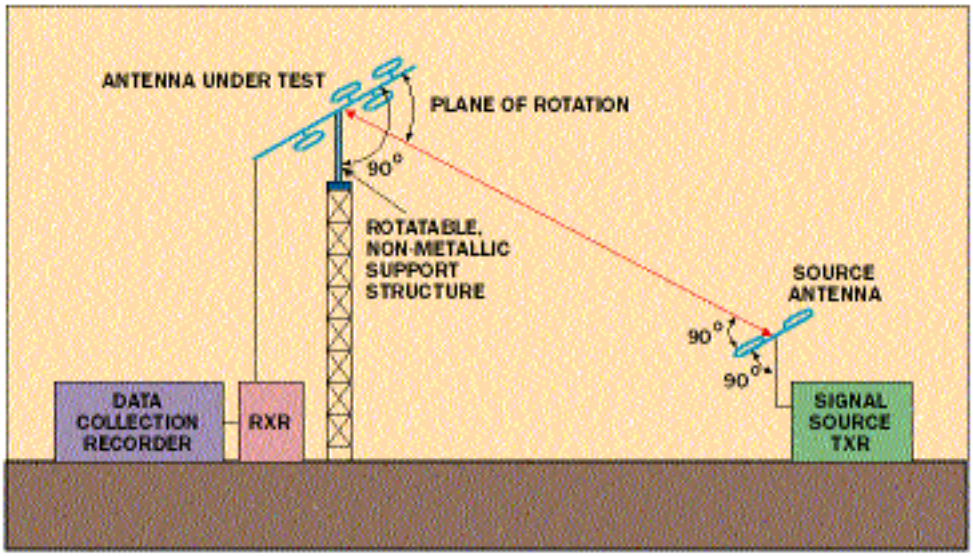


Figure 1. Example of an elevation plane radiation pattern measurement at a slant range, as described by the NIJ standard's section on radiation pattern testing. *Source: NIJ Standard 0204.02.*

*Figure 1. Example of an elevation plane radiation pattern measurement at a slant range, as described by the NIJ standard 0204.02 section on radiation pattern testing.*

## Practical applications of standards

Standards are generally derived in three ways. The first situation is when an OEM that has an advantage in the manufacturing process or a proprietary technology imposes a de facto standard on the industry for a component or system. If there is widespread adoption of the technology, then there is improved interoperability for all customers. The disadvantage is that customers have a sole source for replacement parts, service and resupply. The customer also may be forced to commit to an entire product line to maintain compatibility. If the line is dropped or superseded for any reason, the customer is stuck.

The second situation is when an industry or professional association acts as a clearinghouse or sponsor for standardizing the technology. Advantages are broad adoption, the creation of standard definitions, procedures and advertising guidelines, and the discouragement of substandard manufacturers. Disadvantages include exclusion of some ideas and technical approaches, and the onus of being non-compliant and shut out of the RFP process if you are a manufacturer with a different idea.

The third situation is where an independent or government "think tank" designs an ideal standard, which, if adhered to, would produce the best component for durability, redundancy and performance. Advantages in this case are relative freedom from commercial bias and a focus on the consumer. These standards are also usually freely distributed, as opposed to those that form a reprint profit center for an association. The disadvantage is that such standards, like isotropic antennas, are theoretical concepts. They often ignore physical—or commercial—realities.

Like the analyst in the opening fable, we can agree that the worst standard is none at all. All standards, including NIJ 0204-02, are useful tools for obtaining quality, durable equipment. However, there are other practical considerations when procuring equipment for a public safety agency: budget and cost, warranties, maintenance costs and specific operating conditions in the agency's environment. Encompassing all of these is the reality that communications systems generally require a holistic approach. That is, they are purchased *as* a system.

In the public safety arena, only the largest city, state and federal agencies buy directly from

manufacturers and have the luxury of dictating a tight set of standards. Most systems for police, fire and EMS at the local level are purchased from a trusted or familiar radio dealership with which there is an ongoing relationship. Superseding product quality, service and support, the main factor in this relationship is usually cost.

The NIJ standard draws heavily on other standards created by the Institute of Electrical and Electronics Engineers (IEEE), the Electronics Industry Association/Telecommunications Industry Association (EIA/TIA), the American National Standards Institute (ANSI) and the U.S. military, acting separately or cooperatively. In addition to these bodies, there are test procedures and test ranges maintained by individual manufacturers, the National Institute of Standards and Technology (NIST), the FCC and the National Telecommunications and Information Administration (NTIA). (The NTIA just added an advanced test bed for smart antennas at its Institute for Telecommunication Sciences [ITS] in Boulder, CO, last November.)

With all these sources of information, is there a demonstrated need for separate standards specific to the public safety market? Antennas are "transparent equipment" to most radio systems; that is, one manufacturer's antenna will work with 50 different manufacturers' base stations. However, part of the NIJ mission has been to raise the level of technical awareness in the public safety communications arena. Many radio managers and technicians come into the job with little experience in land mobile. Concepts like wind loading and radiation patterns may be new to those with only dispatch, computer or digital backgrounds. Distribution of this type of information can help them make more informed equipment choices. There are also mission-related differences between public safety systems and commercial or private radio.

*To explore this issue of separate public safety communications standards further, we requested assessments from public safety procurement officers, manufacturing engineers and those who create technical standards. The following are the responses these professionals gave:*

### The standardization perspective

"The standard was actually updated here in Boulder at ITS (for OLES).

"The article seems to summarize the information in the standard quite nicely. ... Your comments relative to the standard's direct utility to users, and their agencies, were interesting. Please be aware that beside standards, NIJ publishes "guides" which are less technical in nature and are addressed to the potential users of the equipment. They may include a general discussion of the equipment, important performance attributes, various types or models currently on the market, objective test data (where available) and any other information that might help the reader make a rational selection among various options or available alternatives.

As a matter of fact, an *NIJ Antenna Guide for Land Mobile Radio* should be published this year.

***--Val Pietrasiewicz***
Institute for Telecommunication Sciences, NTIA
Boulder, CO

### The public safety community perspective

"When faced with the plethora of antennas available to purchasers of wireless hardware in the Public Safety arena, a well written standard can facilitate well informed decisions. However, the standards available must present information clearly and at a level that can be easily interpreted by the target audience.

"While the NIJ standard is by definition a technical document and seeks to present it's

findings as clearly and concisely as possible, the value of the information included in the standard can only be appreciated by persons who are familiar with the concepts and theories quoted therein. Generally the procurement decision rests with individuals who may not be familiar with these sometimes arcane requirements. Usually these standards are then interpreted by vendors and consultants who should be able to present their clients with a palatable summary. In this case, the standard serves to present a reliable technical source but in the end must be reduced to a digestible format for the committee that signs the checks. It has been my experience that purchasing decisions are not often made on the basis of technical specifications but on the recommendation of a peer who has had a satisfactory result with the piece of equipment. Most antenna equipment in our market is designed to meet a minimum technical standard and this standard may be developed by either the NIJ or TIA/EIA. Many times the technical requirement question boils down to a one liner: "Does it meet the industry standard published by ___?" To this end, manufacturers should be willing to advertise the specification as being part of the design protocols.

"This need for interpretation has been bridged by the user guides that are also available from NIJ for specific equipment. Unfortunately, there is not a guide that is specific for fixed and base station antennas.

"APCO supports any step that serves the interest of public safety communications and applauds the efforts of NIJ to create a suite of standards that can be referred to by our members. However, the NIJ antenna standard was not a familiar document for most of the members I have polled. Interestingly, more mention was made of the TIA/EIA 329B and TIA/EIA 22F standards, which are directed to the commercial providers. I would hope that in the near future a guide that presents antenna information in a manner similar to the existing non-technical publications will be available for enforcement agencies."

***--Nigel Mann, staff engineer***
*Association of Public-Safety Communications Officials--International*
*South Daytona, FL.*

## The antenna designer and manufacturer perspective

"I find it very interesting that, having been working in the base station antenna industry in excess of 15 years, this is the first exposure I have had to this standard. I find it even more interesting that there was no mention of this standard within the TIA technical committee which has been working on an update to EIA/TIA 329B over the past two years, even though APCO, NIST, NTIA, FBI, Treasury, Secret Service and other state and local agencies are represented and we even held our October meeting at NIST in Boulder.

"I have yet to see a written requirement for certification to this specification from a customer, and I have yet to see a competitor detail the MIL-spec environmental requirements, such as salt fog, blowing dust and sand, moisture penetration, etc. When the rubber hits the road, it seems that product cost is the ultimate driver, with all commercially available antennas assumed to be equal. Other important parameters such as intermod performance, downtilt and null-fill performance are not mentioned because they are not present in the (outdated) reference specifications.

"There is nothing wrong with the NIJ specification as it stands (other than the onerous environmental requirements which seem to be ignored by commercial antenna manufacturers), especially if one considers that it is little more than a cut-and-paste of the specifications it references. Since the EIA/TIA is chartered by ANSI for the development and maintenance of these types of standards in the United States, and public safety is well represented on these committees, I feel that the public would be better served by adherence to a single, universal standard.

"The update to 329B is coming along nicely. A new standard has been added (it doesn't

have an official number yet) to define the method of presentation of antenna pattern data. This is based upon the NMSA data standard which they relinquished control of to TIA. The data presentation standard should be going out to re-ballot momentarily, and should be in place within the next three to six. The rewrite of 329B itself is almost complete and should go out to ballot within the next three months. These will be balloted jointly with TR45 (cellular / PCS) as they have agreed to TR8 controlling the spec. [TR45 and TR8 are working groups within EIA/TIA.]

"In general, the TR8 committees are keeping up with industry, since the technical leaders of industry are the major players. A concerted effort is being made to flag specifications that are 'aging' so that the case of 329B will not be repeated. In fact, now, if a specification is over 10 years old, it loses its ANSI accreditation.

"We supply customers with the information they ask for. If certification to a specification is required by our customers, of course we would have to comply. However, in the 19 years this NIJ 'specification' has been in existence, no company I have been associated with (Antenna Specialists, Decibel Products, Allen Telecom or TX RX) has been required to provide this certification to a public safety customer or integrator."

***--Ronald J. Jakubowski, director of engineering***
*TX RX Systems*
*Angola, NY*
*[Jakubowski is also a member of the EIA/TIA working group revising 329B]*

## The public safety procurement and operations perspective

"The analogy that I draw, as part of the big picture, is that antenna manufacturers have worked with a couple of things at their disposal. Some physical limitations: We know that the antenna, historically, couldn't be more than 20 feet tall, because then it would exceed the towertop mounting requirement imposed by the FAA. We know that they wanted to achieve as much radiation gain as practical. We know that they wanted to do this on a mass production basis, so they had to have some economies of scale and economies of construction, i.e., they had to make it as cheaply as practical and still make it functional. And they wanted to be able to produce these things in pretty good quantities to get them out to the public. So they had a lot of competitive pressures, some internal, some externally applied. That led competition, by a significant part, in the development of antennas.

"Theoretically, I guess, the best-radiating, best-performing antenna would slowly get a market name and achieve success amongst the buyers. Historically, the buyers have been the technical people affiliated with the radio shops, which typically, are not the people within the law enforcement community. Most law enforcement departments, absent the big boys, rely on a relationship with a local radio shop, and rely on the judgment of 'Joe the Technician' or 'Mike the Manager' in terms of a recommendation. Some of them even rely on the recommendation of the factory man from Motorola, General Electric, or the radio service, or system supplier. We've seen over the years several relationships between manufacturers of radio systems and manufacturers of RF components, whether they be combiners, duplexers, couplers, those kinds of RF products--and antennas as well, My opinion is that that has probably been born of economics, not by technical necessity.

"That kind of leads back to this standard. Well, a standard for this product, to my way of thinking, absent the manufacturing and testing standards which allow certain advertising--I guess you'd call it truth in advertising--absent the EIA 329, then perhaps a standard would be useful, would be beneficial, would be *necessary.* But as it turns out, the marketplace has dictated, through the competitive forces, the free marketplace forces: the type of construction, the market approach to the design, the delivery, and in short, the entire commercial process for the production of these things. I think there's an analogy here to

radio systems themselves, and it's a little bit disturbing when you think that there are a variety of manufacturers of antennas, who make products which are essentially transparent to users. That is, they are critical, integral parts of the system, yet antennas, which within a specific technical design work with anybody's RF equipment. I don't think anybody, other than personal preference, has a demonstrated history of one antenna being better with one particular base station or radio.

"We get into standards, which are very popular now for radio technology and radio system *control* technology, and those same free marketplace forces are not allowed to play out, We in public safety don't really have the freedom to choose from free marketplace-developed forces. More importantly, we don't have the luxury of being able to buy equipment, or procure equipment that works transparently in a system like some of the RF components do. So that's my complaint.

"The NIJ standard is very interesting to read, and it will provide an excellent primer to any technical person who is doing RF antenna work because it relates directly to land mobile applications. As most shop operators know, finding somebody who is versed in land mobile RF is pretty difficult. A lot of people come to us who have an excellent digital background, but very few come to us with any land mobile or RF background. So this addresses directly several of the points and issue associated with land mobile antennas. In terms of necessity, I think that the commercial marketplace has dictated what's available to us. There has not been a drought of products, such that we must stimulate production based on a standard. Many people produce with their individual philosophies, and seem to have done very well commercially. And there are new people coming into the antenna manufacturing community all the time. Some possibly have read the standard, some probably have not, based on the appearance of some of the products.

"Public safety people get all self-righteous because we think in terms of people's lives, which really has a baseline of *accountability* and *liability.* In public safety, one thing that we are taught is that we are *accountable.* Our commodity of exchange is this accountability. The commodity of exchange in a private setting is money Is there a profit involved? I think sometimes that the prospect of financial profit drive harder than the prospect of personal accountability in public safety. Our needs are the same, in terms of communications, as the private sector, we need reliability and we need consistent performance."

***--David O. Dunford, technical service manager***
*Lenexa Police Department*
*Lenexa, KS*
*[Dunford,* MRT's *public safety consultant, writes the "Public Safety: '10-2,'" column.]*

Back