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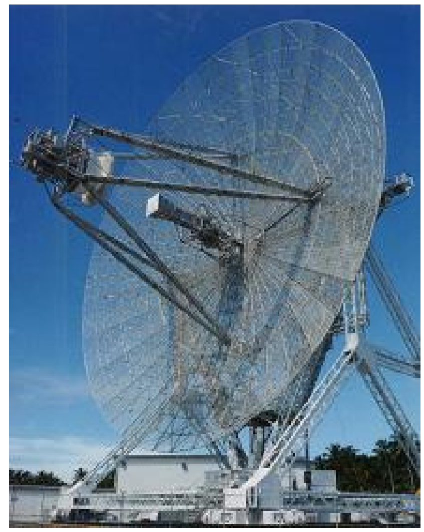
UNDETECTABLE RADAR? (PROBABLY NOT)

Active radar signals, due to those pesky laws of physics, are generally easy to detect. Because a radar system emits a powerful beam of electromagnetic radiation, traditionally in a very narrow frequency band, an adversary equipped with only a passive radiation detector can easily zero in on the platform carrying the radar.



For decades the military has been searching for a less visible (and vulnerable) "low probability of intercept" (LPI) radar. This June, Ohio State University's ElectroScience Laboratory claimed that its engineers—led by Dr. Eric K. Walton—had succeeded and "invented a radar system that is virtually undetectable."

A flurry of fawning press coverage followed. Even Dr. Walton, though, acknowledges that he did not invent noise radar, as the technology is called—it was first proposed in the 1950s. He did, however, receive the first patent for the technology earlier this year. Heavy signal-processing requirements kept noise radars in the lab for decades, but they have finally proved feasible (and, according to Walton, cheap—he claims around $100 per unit).

And they probably are undetectable—by typical radar detectors.

Typical radar signals are high-power, narrowly focused pulses;* each signal is extremely short. Most radars can't send and receive at the same time, so immediately after a pulse is sent out the radar switches to listening mode and strains to hear the pulses's echo. Incidentally, this makes them farsighted—-they can't see objects up close.

To detect these radar signals, an adversary can simply sweep his field of view searching for high-powered pulses that are narrowly focused at a single frequency. Since radar signals cannot be perfectly focused and are not constrained like lasers—the beams become larger as they travel, to form a cone—this is easier than it might sound.

Engineers have developed new techniques to make detection more difficult. For example, frequency-hopping radars move each chirp to a different frequency (the F-22 radar system reportedly does this), while spread-spectrum (radars and radios) use a (small) band of frequencies simultaneously. The signals are still extremely powerful compared to background noise, though, and are relatively easy to find with the simple detectors mentioned above.

Noise radar is different in two main ways. Like spread-spectrum radar, it spreads its signal over a band of frequencies, but the band is about 1,000 times wider than most spread-spectrum technologies. Furthermore, the signal is also shaped to look like noise—the radio equivalent of ants racing on a TV screen.

The wide band of frequencies has several advantages. Different frequencies interact with different materials in different ways—basically, using an ultra-wideband (UWB) signal allows you to see through walls, trees, rock, and many other obstacles if the signal is well constructed.

More relevant to this discussion, UWB noise radar signals also spread their power out over the different frequencies; the result is that traditional detectors, searching for very powerful signals near a particular frequency won't see noise radar. They will just "hear" more static.

And since the noise radar signal is shaped like, well, noise, it would also be hard—if not impossible—to find it by looking for a pattern in the chaos. The noise radar can only detect its own returned signal by first recording it, then comparing a time-delayed version of the recording to what it hears reflected back. (This characteristic also means noise radars detect in "rings" -- the simplest version would detect movement only at a fixed radius from the radar, but it is possible to scan many "rings" very quickly for a more complete picture. The computing requirements for this type of scanning make placing noise radars on fast-moving platforms impractical for now, but they would make exceptionally good proximity detectors, for example.)

Because of their UWB signals, noise radars work best by looking for specific targets -- they must incorporate some knowledge of what a specific target's reflection will look like. They would have great difficulty detecting an unforeseen obstacle—without prior knowledge of what its reflection

The best way for an adversary to detect a noise radar would be to search, directionally, for sources of UWB noise. The key question here is how "loud" the radar's noise would be, compared to background sources like the sun, the galactic center, local power lines, battlefield electronics, etc. Noise radars could be constructed in any number of different ways, and the signal could also be endlessly changed for different applications; lacking specific data, it is hard to speculate on how difficult they will be to detect with this technique.

From what we know now, the "undetectable" claim is something of a stretch, but these radars will almost certainly find uses. They do not interfere with each other or nearby electronics (which are designed to filter out noise), and they can see through walls. If ever used in a military capacity, they would likely force a change in radar detection and seeking technologies. It might cost the Pentagon a pretty penny to detect these new toys, but undetectable radars are probably still a long way off.

-- Eric Hundman

*UPDATE: Thanks to Rutty for the clarification. I originally wrote "chirps" here rather than pulses, which was incorrect. "Chirping" in this context refers to a popular type of signal modulation often used in radars--it ultimately allows for greater resolution.

August 3, 2006 05:43 PM | Gadgets and Gear | SHARE

Comments

rutty comments that "Noise, by definition, has infinite bandwidth". This is only true for "white" noise which does not exist. Non-white noise is called "Pink" noise and is band-limited.
The basic problem with Pink noise is that it has high correlation sidelobes when compared to, say, "chirp" pulses. If there are any large companies in the Radar or Sonar business, I have solved the problem of turning Pink noise into Almost White noise having correlation sidelobes of -100 dB. Please contact me at radson@verizon.com for licensing information.

Posted by: Dr. Renato D'Antonio at January 31, 2008 12:39 PM

"Typical radar signals are high-power, narrowly focused "chirps;" not because they sound like birds, but because each signal is extremely short"

Actually, they are called chirp signals because they are linearly frequncy modulated just like a chirp you would here from a bird. LFM signals are popular because they have a high pulse compression ratio, meaning that you can compress a long duration signal into a 'short duration' signal, typically using a matched filter or what is known as 'deramping'. The width to which a pulse compress is a direct function of its RF bandwidth (0.886 * speedOfLight / 2 / bandwidth to be exact). Transmitted bandwidth, however, in LFM systems is a function of two things: the chirp rate and the pulse length. So the short pulse asumtpion is not correct either. It may sound counter intuitive, but the a longer pulse will have a finer resolution than on half as long if the chirp rates are equal. (Google 'chirp matched filters' for more easy-to-find info.) The length of the chirp chose for a given system, like all things in engineering, depends on many things (SNR requirements and transmit power, for example) and will be tradeoff to meet design requirements.

"To detect these radar signals, an adversary can simply sweep his field of view searching for high-powered pulses that are narrowly focused at a single frequency."

Single frequency radars (most likely continuous wave) are not the most common. Most have bandwidth for the reason outlined above. I'm not sure what you mena by 'leak sideways'. The beampatern is function of the shape of the antenna amongst other things.

Noise, by definition, has infinite bandwidth.

"The wide band of frequencies has several advantages. Different frequencies interact with different materials in different ways—basically, using an ultra-wideband (UWB) signal allows you to see through walls, trees, rock, and many other obstacles if the signal is well constructed."

I havent got my learn on with foilage penetration in a while, but I believe it is the frequency band more than anything that allows for this, viz., VHF/UHF. The UWB name comes about beacuse of the fractional bandwidth required to get decent resoltuion (factionalBandwidth = RFBandwidth / carrierFrequency). This requires more sophisticated signal processing techniques than narrow band signals.

As for Nicholas' comment, there has been a lot of research in this field. I remember reading about a project where a cheap plane would be used to actually paint the sky and then it would send its detections out to the fighters so they would have to give away their location. And, isn't that how the serbs will able to track the stealh bomber? I remember something along the lines of it flying between the transmit/recieve path for some communications system or something.

Anyways, I'd bet dollar to doughnuts that there is a wealth of research out there on noise radar, it just hasnt been declassified yet.

Posted by: rutty at August 3, 2006 07:31 PM

What will be far worse, however, are multipath radars. Rather than a single sender/receiver, a multipath radar uses a group of distributed senders, all sending, and a group of distributed receivers.

This is critical: it detects many stealth techniques (any stealth technique which requires scattering rather than absorbtion or being tranparent), AND it separates out the transmitters from the receivers.

All the transmitters are dumb, cheap, plentiful, and noisy. The USAF can launch all the HARMs they want. But the receivers are smart and silent: now the anti-radar attacks are far less effective.

I've heard reports of british researchers doing multipath radar using cell-phone towers as the (ambient) transmitters.

Posted by: Nicholas Weaver at August 3, 2006 07:06 PM

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