RDF PRODUCTS
Vancouver, Washington, USA 98682
Tel: +1-360-253-2181 Fax: +1-360-892-0393
E-Mail: mail@rdfproducts.com Website: www@rdfproducts.com

WN-005

Web Note

QUESTIONS & ANSWERS: A USER'S GUIDE TO RADIO DIRECTION FINDING SYSTEM BEARING ACCURACY

This Web Note discusses the basic issues associated with the definition and measurement of DF bearing accuracy in an informal, easy-to-read Question & Answer format. It is especially intended for users who are new to the field, and specifically addresses frequently asked questions.

Rev B01/12-06/wn005_apl_01

Original Writing: May, 1999

About RDF Products Application Notes...

In keeping with RDF Products' business philosophy that the best customer is well informed, RDF Products publishes Application Notes from time to time in an effort to illuminate various aspects of DF technology, provide important insights how to interpret manufacturers' product specifications, and how to avoid "specsmanship" traps. In general, these Application Notes are written for the benefit of the more technical user.

RDF Products also publishes Web Notes, which are short papers covering topics of general interest to DF users. These Web Notes are written in an easy-to-read format for users more focused on the practical (rather than theoretical) aspects of radio direction finding technology. Where more technical discussion is required, it is presented in plain language with an absolute minimum of supporting mathematics. Web Notes and Application Notes are distributed on the RDF Products Publications CD and can also be conveniently downloaded from the RDF Products website at www.rdfproducts.com.

About Adobe Acrobat...

All RDF Products publications are published as Adobe Acrobat portable documentation files (PDFs). Although documents published in PDF format can be viewed on a wide variety of computer platforms and operating systems, they require that the Adobe Acrobat Reader be installed on the recipient's computer. This reader is free and a suitable version for almost any computer operating system can be downloaded from Adobe's website at www.adobe.com.

If the print quality of an Acrobat PDF document is unsatisfactory, check the following guidelines:

1. If the printer is Post Script compatible, use the Post Script print driver if possible. This usually results in best print quality.

2. Use the most current version of the Acrobat Reader (V6.x or higher) if available. Version 6.x contains specific improvements for better graphics printing quality and is strongly recommended. It also provides improved print quality for the large number of printers employing HP PCL print drivers.

All Acrobat documents produced by RDF Products have been carefully mastered for good screen and print quality *as viewed on RDF Products' computer system.*

Question: **Why is it so difficult to get straight answers from DF equipment manufacturers in response to questions regarding bearing accuracy?**

Answer: In part, this is a result of the reality that there are certain complexities and subtleties associated with this subject that are difficult to succinctly explain. Unfortunately, it is also true that many DF equipment manufacturers are reluctant to disclose the limitations of DF technology in general and of their DF equipment in particular, and therefore sometimes duck the hard questions by obfuscating certain important issues legitimately raised by customers.

Q: **What are some of these limitations?**

A: In most cases, the primary one is the potentially vast disparity between DF instrument accuracy versus site accuracy.

Q: **What do you mean by "instrument accuracy" and "site accuracy"?**

A: Instrument accuracy refers to the accuracy of the DF system on an ideal site (one where there are no reflections or other anomalous effects that can degrade bearing accuracy). Site accuracy, on the other hand, refers to the bearing accuracy actually observed by a user when the DF system is deployed at a real-world (i.e., non-ideal) site, and is never as good as instrument accuracy.

Q: **Which type of accuracy is specified by DF manufacturers?**

A: DF manufacturers specify instrument accuracy. Although this might be criticized as being inconsistent with the legitimate desire of customers to know what degree of bearing accuracy they can expect in their actual operating environment, it is impractical for a manufacturer to replicate and test under real-world non-ideal conditions. Furthermore, the various environmental factors that degrade bearing accuracy of a customer's DF system are beyond the control of the manufacturer. In the interests of feasibility and objectivity then, manufacturers cannot be realistically expected to account for ill-defined variables beyond their control. As a result, they specify their DF systems in terms of instrument accuracy. Of course, it is important that manufacturers fully inform customers as to the limitations of DF technology so that these customers will be aware of the fact that the bearing accuracy they actually obtain will not be as good as the specified instrument accuracy.

Q: **To what degree is site accuracy worse than instrument accuracy?**

A: This varies over a wide range. In the case of a well-located fixed-site DF system, the site accuracy can approach the instrument accuracy. At the other extreme, the site accuracy of a mobile DF system with a car-top DF antenna operating in an urban environment can easily be an order of magnitude worse than the instrument accuracy.

Q: Can I improve bearing accuracy using site calibration?

A: Site calibration is an involved topic with a complete explanation being beyond the scope of this brief publication. To briefly summarize this issue, site calibration can be effective in reducing the *instrument* error of a fixed-site DF system. For a DF system employing a narrow-aperture DF antenna, however, site calibration is ineffective as a means of correcting *site error* (i.e., errors induced by multi-path reception). In general terms, the undesired multi-path component (reflection) has the effect of altering the apparent angle-of-arrival of the incoming wavefront. In the case of a narrow-aperture DF antenna, the very best that we can ask of it is to correctly report this *apparent* angle-of-arrival.

Q: Can you elaborate on this?

A: To put the matter in more technical terms, the reason for this is that the amount of bearing error induced by a multi-path reflection is dependent not only upon the *magnitude* of the reflected ray, but also upon its *phase* relationship to the direct ray. Depending upon this phase relationship, the bearing error induced by a reflection can vary anywhere between its peak positive and peak negative value (including zero). Since there is no *a priori* knowledge of this phase relationship in the general case, site calibration cannot offset the error. A corollary to this point is that site calibration is ineffective if the DF site is poor and most of the bearing errors are induced by multi-path.

On a more practical note, DF antenna site calibration is a difficult and time consuming task that very few customers are likely to attempt. Vendor claims that the poor instrument accuracy of a DF antenna can be mitigated by site calibration should therefore be dismissed.

Q: I notice that you have qualified some of your statements with "narrow-aperture". Do DF systems employing wide-aperture DF antennas behave differently?

A: Wide-aperture DF systems have the ability to reduce bearing errors induced by multi-path reception and it is thus possible that their site calibration constraints may be different than for narrow-aperture systems. The issues associated with this site error suppression capability are discussed in more detail in Web Note WN-004 ("A Comparison of the Watson-Watt and Pseudo-Doppler DF Techniques").

Q: Do I need good bearing accuracy in mobile DF applications?

A: In most cases, no. Mobile DF applications almost always involve tracking and homing on a target transmitter. Even if bearing errors are large, the mobile DF station will eventually arrive at the location of the target transmitter. To clarify this point, imagine two different scenarios, one where the mobile DF station has no bearing error and the other where the mobile DF station has a 30 degree bias error. In the first scenario, the mobile DF station will (in principle, at least) drive a straight line toward the target transmitter. In the second scenario, the mobile DF station will still arrive at the target transmitter, but will drive an arc rather than a straight line. Of course, this ability to forgive bearing errors eventually breaks down if the errors are too severe or if there are axis reversals.

Q: What do you mean by "bias error"?

A: A bias error is a constant offset bearing error. A good example of a bias error would be the case where a fixed-site DF antenna is inadvertently rotationally misaligned by 5 degrees. The resulting bearing readings would all be five degrees off (either high or low, depending upon the direction of the misalignment).

Q: Can bias errors be caused by factors other than DF antenna rotational misalignment?

A: In RDF Products DF systems, antenna rotational misalignment is the only factor that can cause instrument bias error. In most other DF systems, however, bias error can also be caused by uncompensated group delay anywhere in the DF system. The most common offender is the receiver IF filter. When the IF filter is switched to select a different IF bandwidth, the typically large difference in group delay between the two filters results in a large bias bearing error. Also, since the IF filter group delay is usually not constant across its passband, similar bias bearing errors also occur as a result of any slight receiver mistuning. This "group delay" bias error is a very serious performance shortcoming, and one of the major performance deficiencies separating professional-quality DF systems from non-professional-quality ones.

Q: Do pseudo-Doppler DF systems suffer from this "group delay" bias error problem?

A: Yes, they all do. In professional-quality pseudo-Doppler DF systems, however, special receivers are employed that have been specifically designed to mitigate this problem. To avoid the above-mentioned bearing changes when the IF filter is switched, for example, a code is automatically sent to the bearing processor so that it will appropriately offset the bearing error. To reduce bearing errors caused by receiver mistuning, special receiver IF filters are employed that have constant group delay across most of the IF passband. Of course, since these receivers must be very carefully designed and are inevitably produced in low volume, they are necessarily very expensive. This topic is addressed in more detail in Web Note WN-004.

Q: How do pseudo-Doppler DF systems designed for use with these low-cost consumer-market receivers handle this problem?

A: Essentially, they can't, since they have no control over the customer-supplied receiver. Those manufacturers are completely candid about this warn their customers of this major problem and suggest procedural remedies (such as not changing IF bandwidths and being careful to correctly tune-in signals to avoid mistuning errors). We suspect, however, that some of these manufacturers skirt this issue since to address it fully would be an admission that these are non-professional-quality DF systems where major performance deficiencies have been accepted as a necessary trade-off for economy. This subject is addressed in more detail in Web Note WN-004.

Q: Why don't RDF Products DF systems suffer from these bias errors?

A: RDF Products' implementation of the Watson-Watt DF technique employs a signal processing algorithm that is inherently immune to bias errors. It is true, however, that changing IF bandwidths can cause bearing errors to RDF Products DF systems, although these are not bias errors. Even so, these errors are at least an order of magnitude less than the above-mentioned bias errors experienced by pseudo-Doppler DF systems. Furthermore, bearing errors caused by receiver mistuning are negligible. As discussed in Web Note WN-004, this highly favorable quality of RDF Products' implementation of the Watson-Watt DF technique allows economical low-cost consumer-market receivers to be employed as a component of a professional-quality DF system. This is in sharp contrast to pseudo-Doppler DF systems, where attempts to use these low-cost consumer-market receivers invariably results in a non-professional-quality DF system for the reasons stated above.

Q: I just want to make sure that I understand what you mean by "receiver mistuning" bearing errors. Are you saying that the bearing can actually change if the receiver is tuned slightly off frequency?

A: Yes. Tuning the receiver slightly off the exact signal frequency can cause bearing errors. The reason for this is that the group delay of the most receiver IF filters is not constant over the IF passband. As mentioned, while this problem can be severe in pseudo-Doppler DF systems, it is negligible in RDF Products DF systems.

Q: That's a bold claim. Can you put some numbers on that?

A: In RDF Products DF systems, mistuning the receiver by an amount up to 25% of the IF bandwidth typically results in a mistuning bearing error of 0.2°. In pseudo-Doppler DF systems, the typical resulting mistuning bearing error would be from 2° to 15°, depending upon the antenna commutation (rotation) frequency.

Q: How is the mistuning bearing error dependent upon the pseudo-Doppler commutation frequency?

A: The mistuning bearing error is in direct proportion to the commutation frequency. If the commutation frequency is low (in the vicinity of 160 Hz, corresponding to the axis encoding tones used in RDF Products DF systems), typical mistuning bearing error is 2° or so. Unfortunately, pseudo-Doppler DF systems require a much higher commutation frequency in order to obtain reasonable sensitivity, resulting in a larger mistuning bearing error.

Q: I noticed that the bearing accuracy of the RDF Products DMA-1315B1 mobile

Adcock DF antenna is specified as 3 degrees RMS. What is meant by "RMS"?

A: RMS literally means "root mean square", and is a weighted averaging technique that applies more weight to larger errors as part of the averaging computation.

Q: Wouldn't peak error provide a better picture of the bearing accuracy capabilities of a DF system?

A: Actually, no. The problem with using peak error as a bearing accuracy figure-of-merit is that it is statistically "unclean" from the standpoint that as the number of measurement samples increases, the peak error can only get larger. For a proper sampling technique, a reasonable observer would expect that a larger number of samples should result in a converging bearing accuracy estimate (as would be the result with any averaging technique). Since peak error as a bearing accuracy figure-of-merit instead results in a diverging estimate, it is less meaningful and not widely used. RMS error is the most widely used bearing accuracy figure-of-merit in the DF industry.

Q: Could you provide an example to better illustrate RMS bearing accuracy computation?

A: Yes. See the table below representing a hypothetical bearing accuracy test at a single frequency where a mobile DF antenna is placed on a turntable and rotated and tested in 22.5 degree increments. Also refer to Application Note AN-003 ("Measuring Bearing Accuracy of Mobile Adcock DF Antennas") for more detailed information on this subject.

Bearing Accuracy Tabulation Example

True Azimuth	Measured Bearing	Bearing Error	Error Squared
000.0	000.0	0	0
022.5	020.5	-2	4
045.0	042.0	-3	9
067.5	065.5	-2	4
090.0	091.0	+1	1
112.5	113.5	+1	1
135.0	138.0	+3	9
157.5	159.5	+2	4
180.0	180.0	0	0
202.5	203.5	+1	1
225.0	224.0	-1	1
247.5	244.5	-3	9
270.0	268.0	-2	4
292.5	293.5	+1	1
315.0	317.0	+4	16
337.5	339.5	+4	16

Sum of squared errors - 0+4+9+4+1+1+9+4+0+1+1+9+4+1+16+16 = 80

Mean of squared errors - 80/16 = 5.0

* Square root of mean of squared errors (RMS error) - 2.24°

* Peak error - 4° (determined by inspection)

* Average error - (0+2+3+2+1+1+3+2+0+1+1+3+2+1+4+4)/16 = 1.88°

Bias error - (0-2-3-2+1+1+3+2+0+1-1-3-2+1+4+4)/16 = 0.25°

Asterisk (*) denotes DF bearing accuracy figures-of-merit for comparison

Q: I noticed in the above hypothetical example that bearings were taken every 22.5 degrees. Does this provide enough samples to provide an adequate bearing accuracy estimate? I noticed that another DF manufacturer claims that they take bearing readings in 1 degree increments.

A: It's doubtful that they actually do this in 1 degree increments since this would require enormous effort. As it turns out, however, they really don't need to. Many years ago, RDF Products conducted a study to determine how many test azimuths were really necessary to obtain a good estimate of DF antenna bearing accuracy. To facilitate this, a computer program (ANTERR1) was written to mathematically model all the essential components of a 4-aerial Adcock DF system that allowed various error mechanisms to be induced so as to ascertain their effects on bearing accuracy. Also included in ANTERR1 was the ability to compute overall bearing error for different numbers of test azimuths. A typical test run is illustrated below:

Effect Of Number Of Test Azimuths On Bearing Accuracy

# OF TEST AZIMUTHS	360	72	36	16	12	6
1) PEAK POS ERROR	8.3	8.2	8.2	8.1	7.6	7.2
2) PEAK NEG ERROR	12.2	12.2	12.1	12.1	12.0	12.0
3) BIAS ERROR	0.0	0.0	0.0	0.0	0.0	0.0
4) RMS ERROR	6.8	6.8	6.8	6.8	6.8	7.0

The above results bring to light two very important issues. First, notice that no bias error appears. In fact, running ANTERR1 exhaustively for all varieties and combinations of bearing error mechanisms never once resulted in a bias error being found. This is the basis for the earlier statement that RDF Products' implementation of the Watson-Watt DF system is immune to bias errors. The second point is that *RMS bearing error remains essentially constant, regardless of whether bearing readings are taken at 1 degree increments (360 test azimuths) or 30 degree increments (12 test azimuths), thus demonstrating that a large number of test azimuths is unnecessary*. To answer your question then, yes, taking bearing readings every 22.5 degrees (16 test azimuths) is more than adequate.

Q: When measuring bearing accuracy, is it better to rotate the DF antenna on a turntable in the presence of a stationary test transmitter, or should a test transmitter be walked around a stationary DF antenna?

A: If the test is conducted on an ideal site, there is no technical advantage one way or the other. In the more typical case where the test site is imperfect and some multi-path reception is likely, it is far better to rotate the DF antenna on a turntable in the presence of a stationary test transmitter. As discussed in Application Note AN-003 ("Measuring Bearing Accuracy Of Mobile Adcock DF Antennas"), this approach maintains a nearly constant reflection environment and allows any error induced by multi-path reception to manifest itself as a bias error that can then be ferreted out to provide a more accurate estimate of bearing accuracy. This quality is particularly attractive from the standpoint that it allows bearing accuracy tests to be conducted at marginal sites with good results.

Q: Does RDF Products provide any software that facilitates such testing by doing all the necessary computations once the bearing error data has been entered?

A: Yes. ANTDATA1 accepts bearing inputs for all 16 test azimuths at a single test frequency and then computes and prints all relevant information, including both apparent RMS bearing error (which includes the effect of bias error) and adjusted RMS bearing error (which excludes the effect of bias error). ANTDATA2 accepts adjusted RMS bearing error computed at each test frequency by ANTDATA1 and computes and plots overall adjusted RMS bearing error. This software is available at no charge on the RDF Products Publications CD. An actual ANTDATA1 test report is presented below:

** DF ANTENNA BEARING ERROR ANALYSIS AND OUTDOOR FIELD TEST REPORT **

UNIT: DFA-1310R1 SER#: 98AAL001 FREQ: 160 MHz
DATE: 09-23-1998 TEST: 01 ENGR: A. J. BURWASSER
NOTE:

TRUE AZIMUTH	ADJUSTED AZIMUTH	MEASURED BEARING	APPARENT ERR	ADJUSTED ERR
0	.1	0.7	+0.6	+0.2
22.5	22.4	23.4	+1.0	+0.6
45	45	45.5	+0.5	+0.1
67.5	67.6	66	-1.6	-2.0
90.0	89.9	89.8	+0.1	-0.5
112.5	112.3	114	+1.7	+1.3
135	135	136.1	+1.1	+0.7
157.5	157.6	157.9	+0.3	-0.2
180.0	180.1	180.9	+0.8	+0.3
202.5	202.3	203.5	+1.2	+0.8
225	225	224.6	-0.4	-0.8
247.5	247.7	246.2	-1.5	-1.9
270	270.1	270.3	+0.2	-0.3
292.5	292.4	294.4	+2.0	+1.6
315	315.1	316.3	+1.2	+0.7
337.5	337.6	337.8	+0.2	-0.3

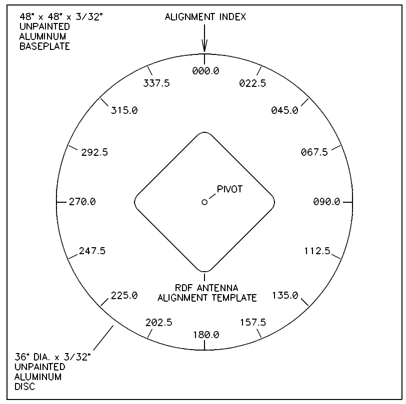
```
  -15       -10       -5          0        +5       +10       +15
   +----+----+----+----+----+----+----+----+----+----+----+----+
   |                             |                             |     R
000|    -    -    -    -    -    *    -    -    -    -    -    |000  E
   |                             |*                            |     F
045|    -    -    -    -    -    *    -    -    -    -    -    |045  E
   |                         *   |                             |     R
090|    -    -    -    -    -   *|    -    -    -    -    -    |090  E
   |                             |  *                          |     N
135|    -    -    -    -    -    |*   -    -    -    -    -    |135  C
   |                             *                             |     E
180|    -    -    -    -    -    |*   -    -    -    -    -    |180
   |                             | *                           |     A
225|    -    -    -    -    -  * |    -    -    -    -    -    |225  Z
   |                         *   |                             |     I
270|    -    -    -    -    -   *|    -    -    -    -    -    |270  M
   |                             |  *                          |     U
315|    -    -    -    -    -    |*   -    -    -    -    -    |315  T
   |                            *|                             |     H
   +----+----+----+----+----+----+----+----+----+----+----+----+
  -15       -10       -5          0        +5       +10       +15
                           ADJUSTED ERROR
```

PEAK POS ADJUSTED ERROR= +1.6
PEAK NEG ADJUSTED ERROR= -2.0
BIAS OR MEAN ERROR= +0.4
APPARENT RMS ERROR= 1.1
ADJUSTED RMS ERROR= 1.0

RF PRODUCTS - SAN DIEGO CA

Q: Can I inexpensively construct my own DF antenna turntable?

A: Yes. Application Note AN-003 explains exactly how to do this. See illustration below (borrowed from AN-003).



Q: How far should the test transmitter be from the DF antenna when conducting a bearing accuracy test?

A: There are two conflicting constraints. On the one hand, the test transmitter should be sufficiently far from the DF antenna so that it is illuminated by a far-field wavefront. On the other hand, it should be as close as possible to the DF antenna to reduce measurement errors caused by reflections. On the basis of our experience, we recommend a separation equal to five times the DF antenna aperture (i.e., the spacing between DF antenna opposing aerials) for most applications. See Application Note AN-003 for detailed information on this and other topics relating to measuring bearing accuracy of mobile DF antennas.

Q: When you conduct a bearing accuracy test, do the results also reflect any possible bearing error contribution by the DF receiver/bearing processor, or do they reflect only the DF antenna bearing errors?

A: When we conduct a DF antenna bearing accuracy test, we first measure and record bearings obtained from the DF receiver/bearing processor alone at all 16 test azimuths (we do this using our DTI-100B DF Bearing Synthesizer, which when used in conjunction with a signal generator simulates a DF antenna with near perfect bearing accuracy). This calibration data is then entered into ANTDATA1 (see "ADJUSTED AZIMUTH" column in the above ANTDATA1 test report), which then automatically subtracts out the effects of any bearing errors induced by the DF receiver/bearing processor so that the final result reflects the bearing accuracy of the DF antenna alone.

Q: So does the DF receiver/bearing processor have to be added to the DF antenna error to determine overall instrument error?

A: Yes, but not directly. Two RMS error numbers cannot simply be arithmetically added together to yield a composite RMS error. Also, keep in mind that the DF receiver/bearing processor bearing error is typically only a few tenths of a degree, and therefore small compared to the DF antenna bearing error. Furthermore, when a small RMS number is correctly added to a larger one, the resulting sum is much less than a straight arithmetic sum.

Q: Does ANTDATA1 allow direct measurement of overall DF system bearing accuracy if that is what I really want?

A: Yes. All you have to do is skip the above-mentioned calibration procedure.

Q: I noticed a claim by a competitor stating that their 8-aerial Adcock DF antenna offers the advantage of being more accurate than a standard 4-aerial Adcock. Is this correct?

A: No, but there is just enough element of truth in such a claim to confuse an uninformed audience. A more correct statement is that an 8-aerial Adcock is capable of covering a wider frequency range than its 4-aerial counterpart for *a similar degree of bearing accuracy*.

Q: Can you elaborate on this?

A: The bearing accuracy of an Adcock DF antenna is a function of the circularity of its gain pattern lobes, which in turn is influenced by the spacing (or *aperture*) of the opposing aerials as a percentage of a wavelength at the operating frequency as discussed in Web Note AN-002 ("Basics of the Watson-Watt DF Technique"). As the aperture is increased, the lobes become less circular and bearing error progressively increases. On the other hand, if the aperture is too small, sensitivity is reduced. As a practical matter then, the aperture of a 4-aerial Adcock is constrained to between approximately 1/10 and 1/3 of a wavelength, which is another way of saying that a well-designed 4-aerial Adcock can cover a frequency range of up to about 3:1 or 4:1 as a conservative figure.

Q: And with an 8-aerial Adcock, this range can be extended?

A: That's right. Although the aperture of an 8-aerial Adcock is also constrained to approximately 1/10 of a wavelength at the low end, its high end aperture can be extended out to about a full wavelength before gain pattern lobe circularity is impaired, thus increasing its frequency range up to about 10:1.

Q: That's an impressive amount of frequency coverage, but how can the aerials be efficient over such a wide frequency range? It seems to me that there would have to be a huge sensitivity compromise over much of the range.

A: That's precisely the problem. The wide frequency coverage is obtained at the expense of sensitivity over major portions of the range. A better approach to obtaining wide frequency coverage in most applications is to use a dual 4-aerial array. With this approach, longer aerials can be used for the low-band array and shorter ones used for the high-band array for better overall sensitivity. This is the approach RDF Products employs in its 80-520 MHz DMA-1315B1 mobile and DFA-1325B1 fixed-site DF antennas.

Q: Are there any other drawbacks to the 8-aerial Adcock?

A: Yes. They tend to be much more complex than their 4-aerial counterparts both electronically and mechanically and are therefore far less economical. Also, this added electronic complexity imposes the practical disadvantage of diminishing bearing accuracy somewhat.

Q: I also noticed a claim by another competitor who stated that pseudo-Doppler DF antennas are more accurate than Adcocks. Is this correct?

A: No, but once again, there is just enough smell of truth in this assertion to confuse a judge and a jury. This claim is probably based on the ability of a wide-aperture pseudo-Doppler DF antenna to significantly suppress errors caused by multi-path reception.

Q: How is a pseudo-Doppler DF antenna able to do that?

A: The mechanism by which this site error suppression occurs is “wavefront averaging”. The underlying principle behind wavefront averaging is that when reflections occur, the errors tend to offset or cancel each other if enough spatially-displaced samples are taken over a sufficiently large area. The best example of this are the wide-aperture pseudo-Doppler DF antennas used in air traffic control applications. These antennas are quite large, having an aperture of approximately 1.3 wavelengths and 32 aerials.

Q: And Adcocks can’t do this?

A: That’s correct. Adcocks inherently function as narrow-aperture DF antennas, even in their 8-aerial embodiments where their physical apertures are a full wavelength.

Q: Do narrow aperture pseudo-Doppler DF antennas provide site error suppression?

A: Narrow-aperture pseudo-Doppler DF antennas do not provide noticeable site error suppression. For mobile or any applications where compact DF antennas must be used, the site error suppression benefit of pseudo-Doppler arrays cannot be realized.

Q: Site error suppression issues aside, are pseudo-Doppler DF antennas more accurate than Adcocks?

A: In most cases, they are less accurate. A serious performance deficiency of pseudo-Doppler DF antennas is that bearing accuracy is greatly diminished by inter-aerial re-radiation. In effect, the presence of the aerials results in distortion to the incoming wavefront not unlike that which occurs in the presence of multi-path reception. This, of course, results in bearing errors. The effect can be diminished by using very short aerials or resistive loading, but this results in severe sensitivity loss. Although this loss of sensitivity might be acceptable in certain applications (such as in the wide-aperture pseudo-Doppler DF antenna used for air traffic control applications discussed above), it is unacceptable in most other applications. As a result, most pseudo-Doppler DF antennas are designed to sacrifice bearing accuracy in favor of sensitivity.

Q: And Adcocks don't have this problem?

A: Right. There is no comparable effect in Adcocks, so the accuracy-sensitivity trade-off does not have to be made. In fact, Adcock DF antennas maintain excellent bearing accuracy even at the resonant frequency of their aerials.

Q: One last question. What does RDF Products use for its DF antenna test site?

A: We originally used a 20' x 60' elevated test range located in a clear flat area in the middle of the Arizona desert. The test platform has been carefully leveled, and is fully covered with 1/4" wire mesh. The operating console is located beneath the platform to avoid interference to the measurements. Both mobile and fixed-site antennas can be tested. After our relocation to Vancouver, Washington, we constructed a 36' x 64' ground-mounted test site that provides equally good results.

20' x 60' Elevated DF Antenna Test Range

<>