A–3–1 METHODOLOGY FOR ASSESSING ANTENNA PERFORMANCE*

Leon J. Ricardi
M.I. T./Lincoln Laboratory

Prior to about 1960, most antennas were much simpler devices compared to the adaptive, tracking, multiple-beam, etc., antennas used in current communication and radar systems. In these earlier years, measurements of antenna gain, principal plane sidelobe level, and radiation impedance were adequate to assess its performance. In contrast, today's antenna systems are often so complex that human ability to study the measured performance data is not adequate to objectively determine if one antenna design is superior to another. Furthermore, the bulk of data required to properly assess the antenna's performance is usually not put in a convenient form for appropriate assessment. For example, visual inspection of a large number of antenna radiation pattern contour plots is realistically beyond any human's ability to quantitatively determine good performance from inadequate performance.

The foregoing is especially true when attempting to evaluate the discrimination performance of an adaptive antenna system. The antenna's configuration, the weight determining algorithm, the degree to which each element and its associated signal path are matched, the specific placement of desired and undesired signals in the antenna's field of view, etc., all affect the suppression of the undesired signal with respect to the desired signal. Suffice it to say, the development of suitable antenna systems requires more than an adequate specification of the important performance characteristics; it is necessary to have a suitable figure of merit (FOM) that adequately assesses the desired performance. This paper is addressed to the definition of such an FOM and the demonstration of its use in comparing the performance of two adaptive antennas.

Usually the performance of an adaptive antenna is judged by the difference between the directive gain (D_d) in the direction of the desired signal (S_d) source(s) to the directive gain (D_u) in the direction of the undesired (S_u) signal sources. The angular separation between these signal sources is also important. The system designer would like to know the ratio D_d/D_u so that he can choose other system parameters such as the required strength of S_d in the presence of a known S_u. When it is not possible to specify the probable location of all signal sources, the system designer needs either a "worst case" performance characteristic or a statistical distribution that will enable him to perform the necessary system tradeoffs.

A proposed FOM, for aiding in the system design, consists of dividing the angular field of view (FOV) into a grid of cells as indicated in Figure 1. A particular desired and undesired signal source scenario is defined, and the antenna system is allowed to adapt. Next, the directive gain (since the antenna is receiving signals, the correct term is receiving cross section which, for a reciprocal antenna, is equivalent to directive gain) is determined at each cell in the FOV. The cells are grouped according to their location with respect to the undesired signal source(s). For example, Zone 1 might include all cells within 1° of an undesired signal. Zone 2 would include all cells between 1° and 3° from an undesired signal. Zone 3 would include all cells more than 3° from an undesired signal source location. The values of directive gain would be stored according to the zone in which the associated cells are located.

The foregoing measurement and sorting process is repeated for many different locations of the desired and undesired signal source(s). The ratio D_d/D_u is then processed to determine its statistical distribution in each zone. A single graph will then yield not only the probability of achieving D_d/D_u greater than a specific value, but it could also show the worst and best case values. Repeating the entire process for another antenna system, weight determining algorithm, etc., would enable one to determine which, if any, of the antennas etc., is best.

If the directive gain in the direction of the desired and undesired sources and the undesired signal source strength are known, one can calculate the effective radiated power (ERP) required by the desired signal source to overcome the interfering source. The results of this calculation can be presented in the form of a statistical distribution; that is, what ERP is required to insure $S_u/S_d \geq A$ with a probability of X. If multiple interfering sources are present, one could determine an effective $D_u(D_u^\circ)$ in accordance with

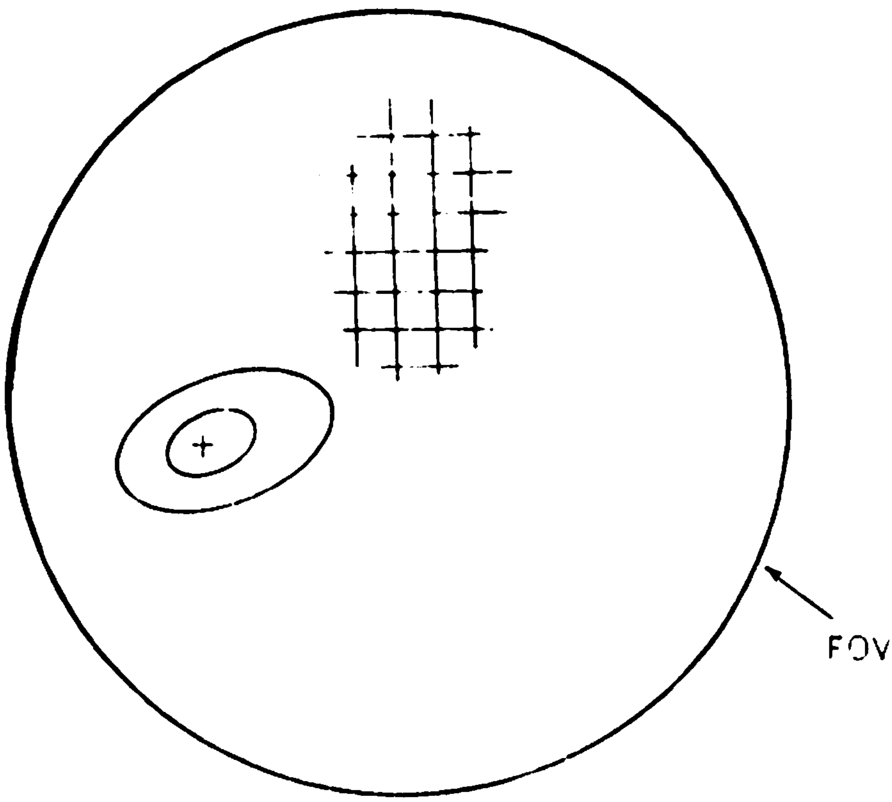
$$D_u^\circ = \left(\sum_{i=1}^{I} D_i P_i\right) / \left(\sum_{i=1}^{I} P_i\right) \tag{1}$$

Still further, it may be more meaningful to the antenna systems operational performance if the statistical distribution of D_d (or gain G_d) is processed as a function of signal source separation measured in miles on the earth's surface, instead of the foregoing angular separation.

An example of the use of this FOM will be presented.

*This work was sponsored in part by the Department of the Air Force and in part by the MILSATCOM Systems Office/Defense Communications Agency under Air Force Contract F19628-78-C-0002.

18- 6 - 18590



MULTIPLE UNDESIRED SOURCES

$$D_U^{\circ} = \frac{\Sigma D_j P_j}{\Sigma P_j}$$

SORT ACCORDING TO:

ANGULAR SEPARATION OR
DISTANCE SEPARATION

TO YIELD:

$$P\left[D_D/D_U > x\right] \text{ vs } x$$

$$P\left[D_D > x\right] \text{ vs } x$$

FIGURE OF MERIT