SELECTION OF PHASED ARRAY CONFIGURATION

David T. Thomas
Raytheon Company
Goleta, California

A major decision in the design of phased array antennas is the selection of array configuration. Once the coverage sector, net antenna gain, effective radiated power (ERP) and other system requirements are established, the effects of (1) subdividing the coverage sector, i.e., using multiple antennas and (2) choosing linear versus sector arc arrays can be determined.

In transmit arrays, the use of mini-amplifiers in each array element has several advantages over a single high power output amplifier: (1) low power amplifiers may be used, (2) all signal generation and switching is low level, (3) reliability is improved, and (4) simultaneous beams are possible. In arrays using one mini-amplifier per element, amplifier related costs far exceed the per element cost of other items - consequently, all transmit array tradeoffs assumed the same number of amplifiers (elements). The game is to generate maximum ERP from the fixed number of amplifiers as shown in Figures 1 and 2. For maximum broadside ERP, one linear array should be chosen for coverage less than 150°, and one arc array for coverage exceeding 150°. For maximum endfire ERP, one linear array should again be chosen for coverage less than 150°. However for coverage exceeding 150°, two linear arrays will provide the best endfire ERP. One important factor which could alter these results was the assumption of comparable phase errors in forming the beams of the various arrays. In practical situations this may not be the case and adjustments may be necessary. Other items which are considered in choosing transmit array configurations are (1) array size and weight, (2) number of beams in coverage sector, (3) ERP variation with scan angle.

In receive antenna systems high gain and few beams are desirable. The high cost item here is receivers and beam forming switches and circuits. Thus few beams will reduce cost. Most receive systems have a minimum desirable net antenna gain; hence, all receive array tradeoffs assume fixed minimum gain (endfire) and equal maximum beamwidth (endfire). In Fig. 3, choosing multiple arrays will produce fewer beams, but the difference is slight for sectors less than 90°. However, for 180° coverage two or three arrays are clearly favored. Minimizing gain and beamwidth variation for best signal levels direction finding accuracy also favors multiple arrays as shown in Fig. 4. In general, receive arrays should be limited to 60° coverage sectors for best performance. Other factors of less importance which were considered are (1) size and weight, (2) number of elements, (3) grating lobe criteria.

In combined receive-transmit antenna systems (separate antennas), identical receive and transmit beams are highly desirable to insure optimum ERP. In most cases, the compromise configuration will be the optimum transmit antenna, with the receive antenna identical. A non-optimum receive array configuration will affect performance and cost less significantly than a compromise transmit array configuration.

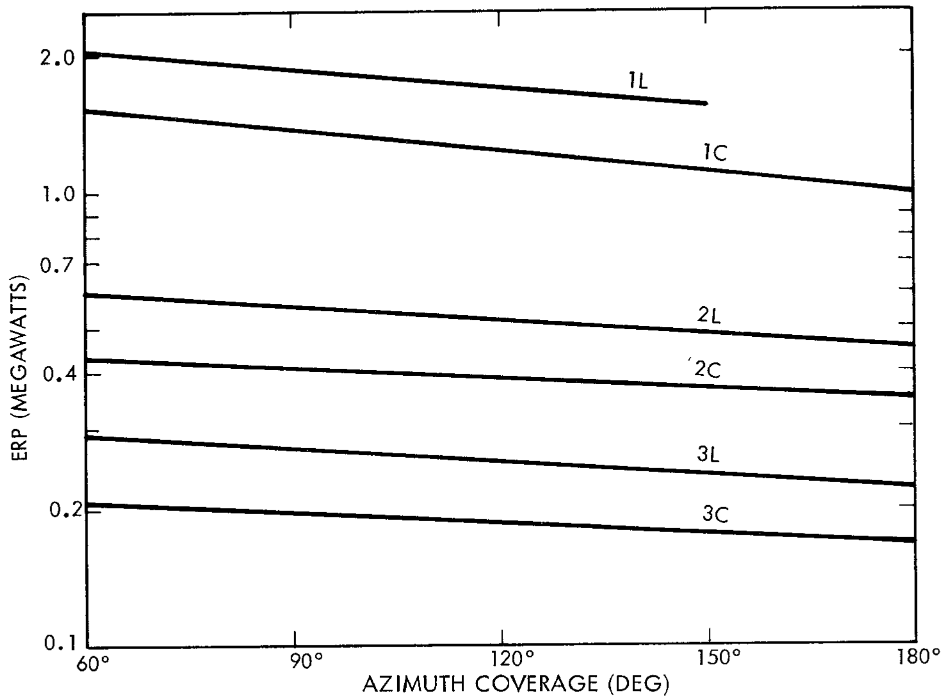

Figure 1. Broadside ERP For Fixed Total Number of Amplifiers

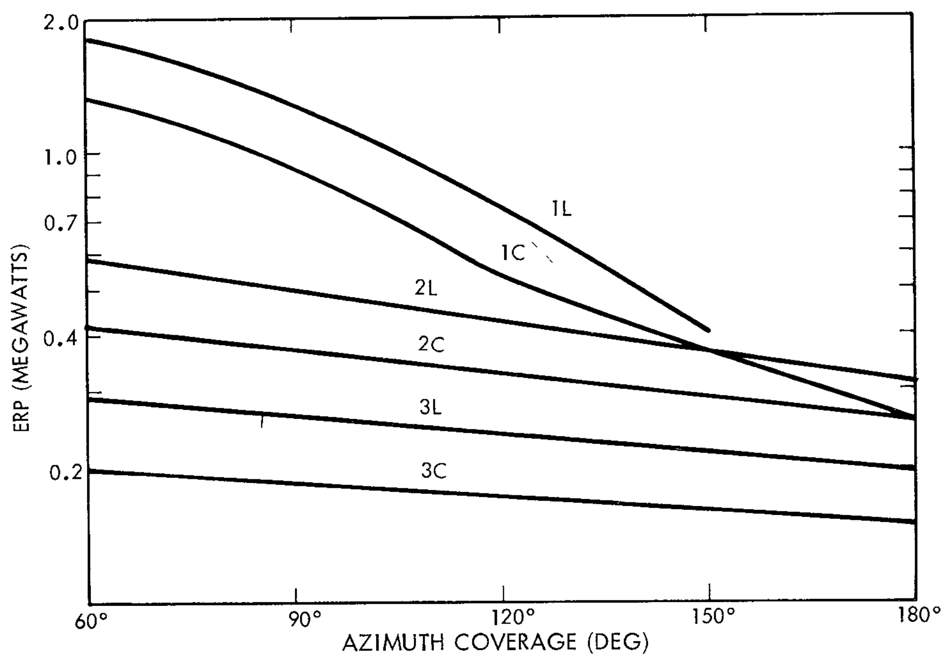

Figure 2. Endfire ERP for Fixed Total Number of Amplifiers

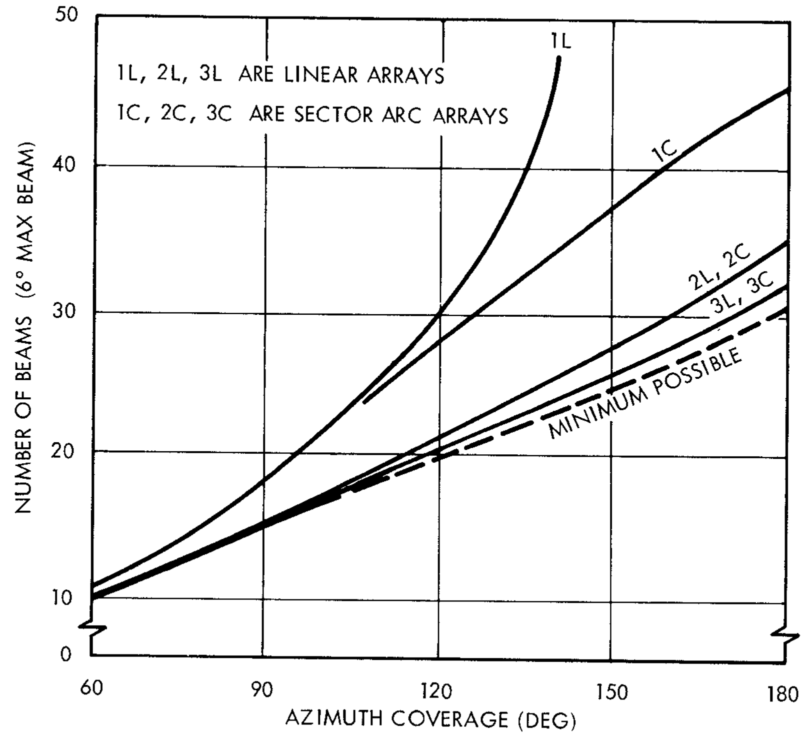

Figure 3. Number of Beams for Fixed 6° Endfire Beam

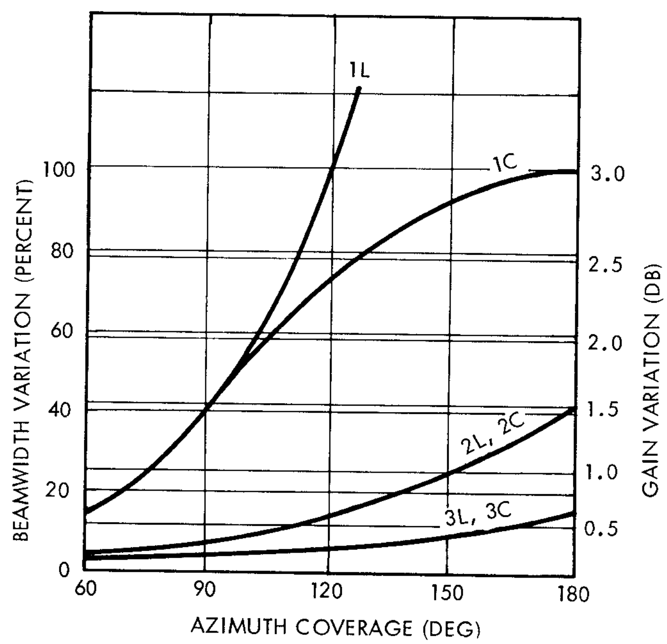

Figure 4. Gain and Beamwidth Variation