1992: The Air-Traffic-Control Radar Problem

You are to determine the power to be radiated by an air-traffic-control radar at a major metropolitan airport. The airport authority wants to minimize the power of the radar consistent with safety and cost.

The authority is constrained to operate with its existing antennae and receiver circuitry. The only option that they are considering is upgrading the transmitter circuits to make the radar more powerful.

The question that you are to answer is what power (in watts) must be released by the radar to ensure detection of standard passenger aircraft at a distance of 100 kilometers.

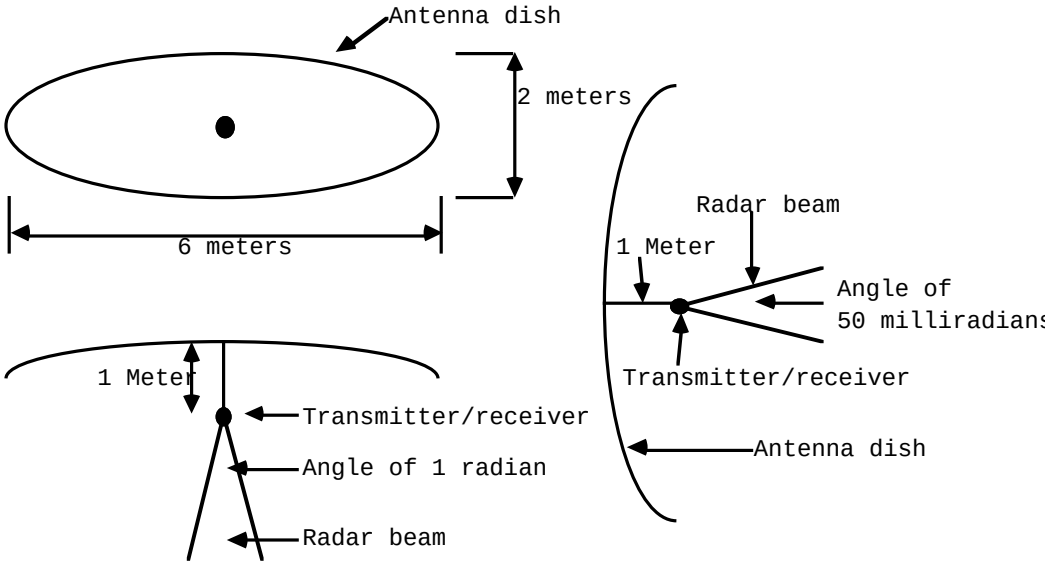

Figure 1. Measurements for the radar system.

Technical specifications (see also **Figure 1**):

- The radar antenna is a section of a paraboloid of revolution with focal length of 1 meter. Its projection onto a plane tangent to its vertex is an ellipse with a major axis of 6 meters and a minor axis of 2 meters. The main lobe energy beam pattern, located at the focus, is an elliptical cone that has a major axis of one radian and a minor axis of 50 milliradians. The antenna and beam are sketched in the figures provided below.
- The nominal class of aircraft is one that has an effective radar reflection cross-section of 75 square meters. For the purposes of this problem, this

means that in your initial model, the aircraft is equivalent to a 100% reflective circular disc of 75 square meters, which is centered on the axis of the antennae and is perpendicular to it. You may want to consider alternatives or refinements to this initial model.

- The receiver circuits are sufficiently sensitive to process a return signal of 10 microwatts at the feed horn of the radar (which is located at the focus of the radar antenna).

Comments by the Contest Director

The problem was contributed by John Edwards (Dept. of Mathematical Sciences, U.S. Military Academy, West Point, NY). The problem statement contains several ambiguities and some unrealistic information, and a major factor in judging the papers was how the teams attempted to resolve these issues.

The Outstanding papers were by teams from Pomona College and University of Colorado–Boulder. Their papers, together with commentaries, were published in *The UMAP Journal* 13 (3) (1992): 205–225.