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To: Holographers

From: Alan E.E. Rogers AEER

Subject: Errors in small scale roughness estimates

In previous memos (see memos dated 4 May and 6 April 1992) I estimated the small scale roughness (that unresolved in the holography) using the following relation:

$$e^{-\left(\frac{4\pi\delta}{\lambda}\right)^2} = P_1/(P_1 + P_2)$$

where

P_1	=	integrated power in the beam out to an angle θ_1 which corresponds to the maximum spatial resolution of the holography
P_2	=	integrated power from θ_1 to several degrees (i.e., to the limits of angles covered in the sun scan)
δ	=	small scale rms
λ	=	wavelength of sun scan

The angle θ_1 is

45 x 0.032 x freq. sun scan/freq. holog. deg.

The above relation assumes that the small scale roughness has little or no effect on the beamwidth or near sidelobes. If we consider the analogy with geometrical blockage as follows: 1% geometrical blockage results in a 1% loss in voltage or a 2% loss in gain. The blockage by the subreflector, for example, not only scatters energy into far-out sidelobes but also produces close-in sidelobes which reduce the gain. Consider also the case of an antenna whose outer 1% in area is spoiled. 1% of the energy will be scattered into far-out lobes and the beamwidth will be broadened because the antenna diameter is effectively reduced by 0.5%. The net loss in forward gain or aperture efficiency will be 2%. From another viewpoint the blockage loss can be considered as lost power from the source and additional loss from illuminating the blocked region so that not all the available power is received by the feed.

Both roughness loss and blockage will lower the main lobe amplitude and increase the first sidelobes so that not all the power will go into the far-out sidelobes. The fractional power in the far-out sidelobes is power that will become correctly phased with the main beam when the blockage is removed. Both blockage and roughness reduce the aperture field and increase the effective spill-over.

If the small scale roughness produces scattered power into the far-out sidelobes that would otherwise be phased with the antenna voltage, I think[1] the correct expression should be

$$e^{-\frac{1}{2}\left(\frac{4\pi\delta}{\lambda}\right)^2} = P_1/(P_1 + P_2)$$

in which case all the previous estimates of small scale roughness should be increased by a factor of $\sqrt{2}$. Another error I have made is not including the effects of the radome on P_1 and P_2. The first error substantially increases the estimates of small scale roughness while the second brings them back down somewhat. With the uncertainty in the sun scan method, and concern about the performance of the outer panels, I would like to suggest we consider making a survey of the region of the antenna which can be reached from the roof. Since we are interested only in estimates of the small scale, perhaps the survey could be done using templates or optical photographs (if the cost is reasonable).

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[1]I have no definite proof. This expression may also be incorrect. I thank John Ball and Rich Barvainis for helpful discussion of this problem.