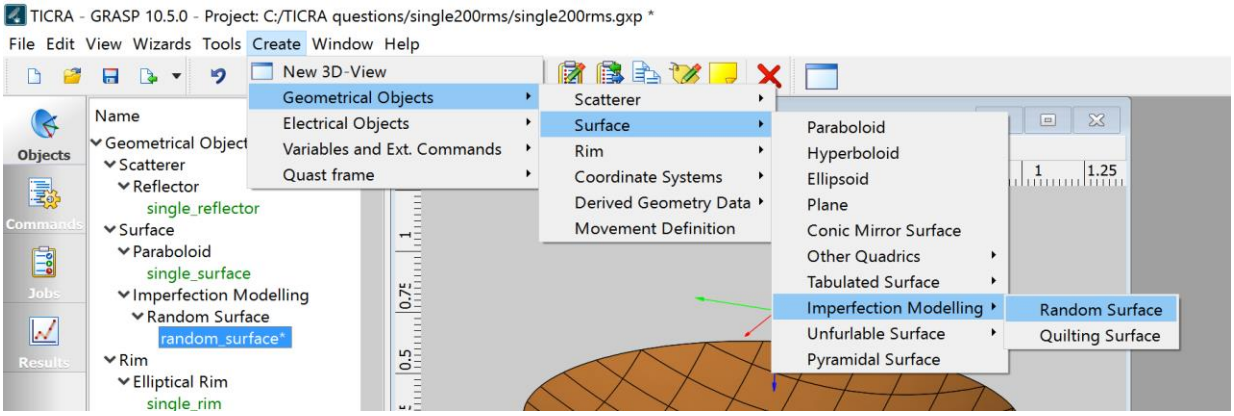
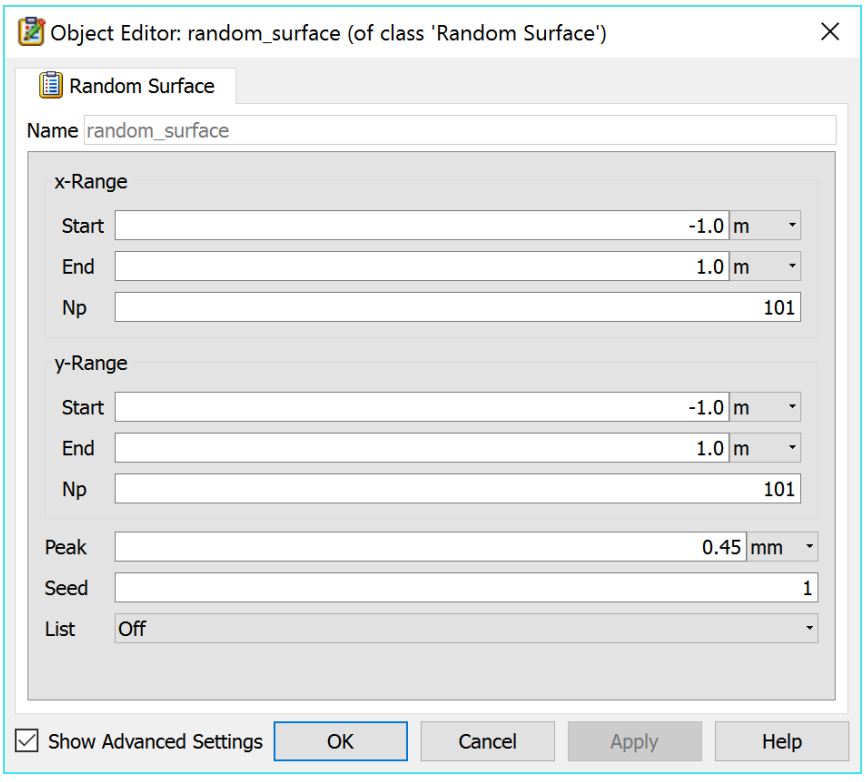
Adding Uniform Random Variation (RMS) to Reflector using GRASP

This write up details steps to include RMS surface errors on a reflector in a GRASP project. A 200λ diameter reflector with *f/D* = 0.4 was designed using the wizard in GRASP. Two random surfaces were considered that produce phase errors of 0.25- and 1.0-dB. The RMS surface errors were calculated to be 0.019λ and 0.038λ using the approximate formula for phase error loss given below. Selecting a design frequency of 30 GHz (λ = 1 cm) computes to RMS surface errors of 0.19 mm and 0.38mm.

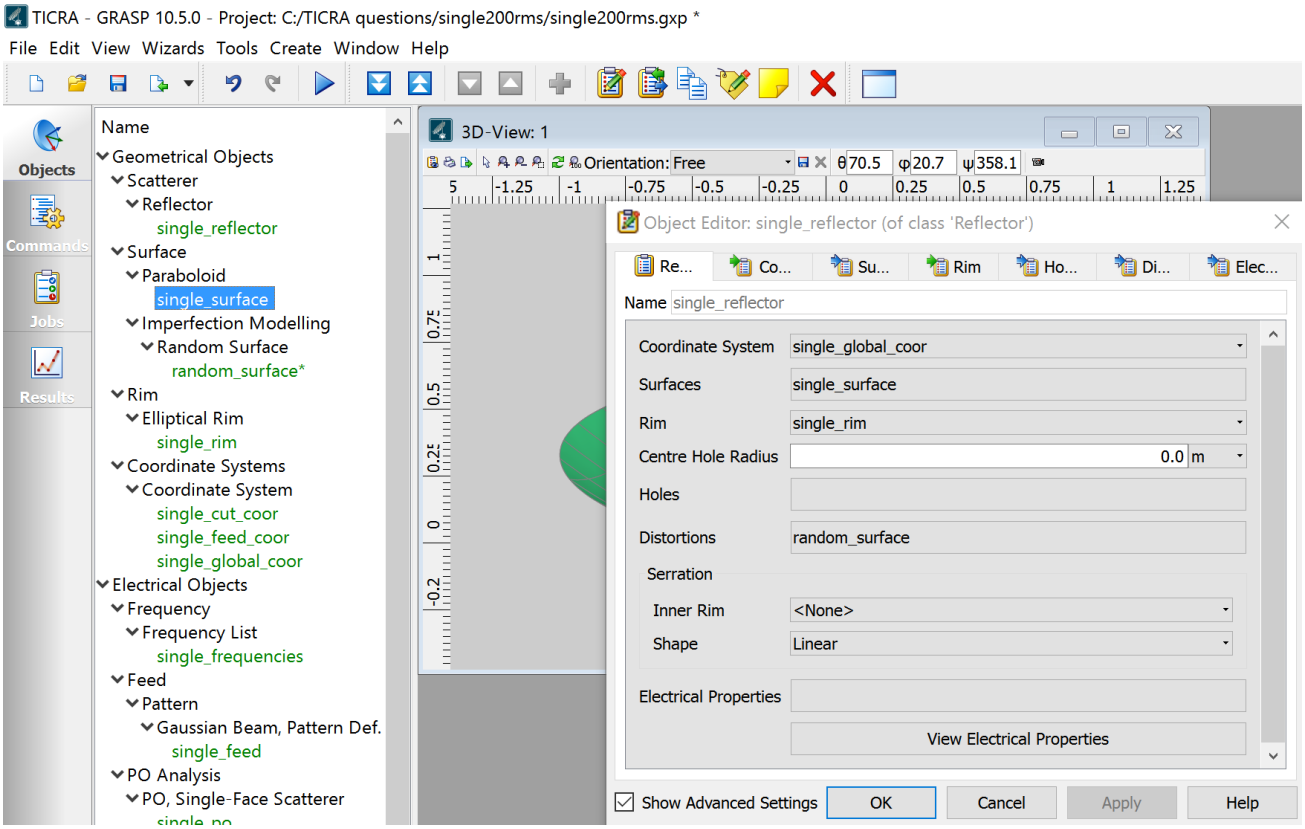
$$\mathrm{PEL(dB)} = -685.8\left(\varepsilon_0 / \lambda\right)^2 \qquad \text{(8-24)}$$

The random errors are added to the GRASP project by using the random surface geometrical object.





This case used a factor 0.422 to divide the RMS surface error to find the peak error. The GRASP manual suggests a factor of 0.47. Since equation above is accurate for PEL of uncorrelated area surface errors, the GRASP factor to convert RMS to peak error was adjusted until it gave the same loss using runs with and without errors. Below the effect of area correlation of random errors GRASP responses are illustrated. With only 101 points across the diameter of the reflector, there is a correlation length of 2λ. The "random surface" object is added to the "Scatterer – Reflector" object which appears sufficient.



When the reflector is analyzed ("job"), the random surface errors are added to the single reflector surface. A comparison of two patterns with and without surface errors with RMS of 0.019λ (0.25 dB) gives the pattern of Figure 1. Similarly, Figure 2 plots the pattern difference using RMS errors that give 1.0 dB (0.038λ) loss.

Figure 3 illustrates the effect of the number of points (correlation length) of the random error surface added to the ideal parabolic surface of the single reflector. A longer correlation length fills the sidelobes of the pattern and generally reduces the computed difference between patterns (PEL loss). The equation below predicts this effect; however, the effect is small.

$$\mathrm{PEL} = \exp(-\bar{\delta}^2) + \frac{1}{\eta}\left(\frac{2C}{D}\right)^2 \exp(-\bar{\delta}^2)\sum_{n=1}^{\infty}\frac{\left(\bar{\delta}^2\right)^n}{n\cdot n!} \qquad (8\text{-}19)$$

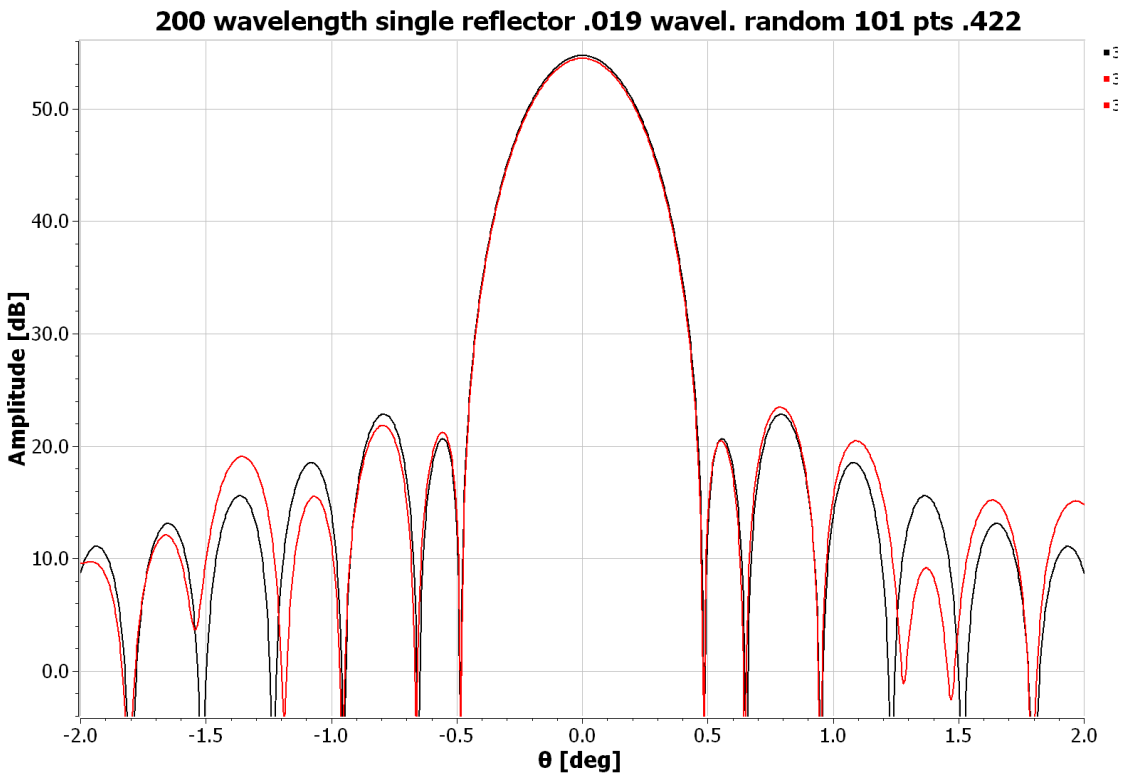


Figure 1 200λ diameter single reflector GRASP pattern w/o surface errors (black) and with (red) 0.25 dB

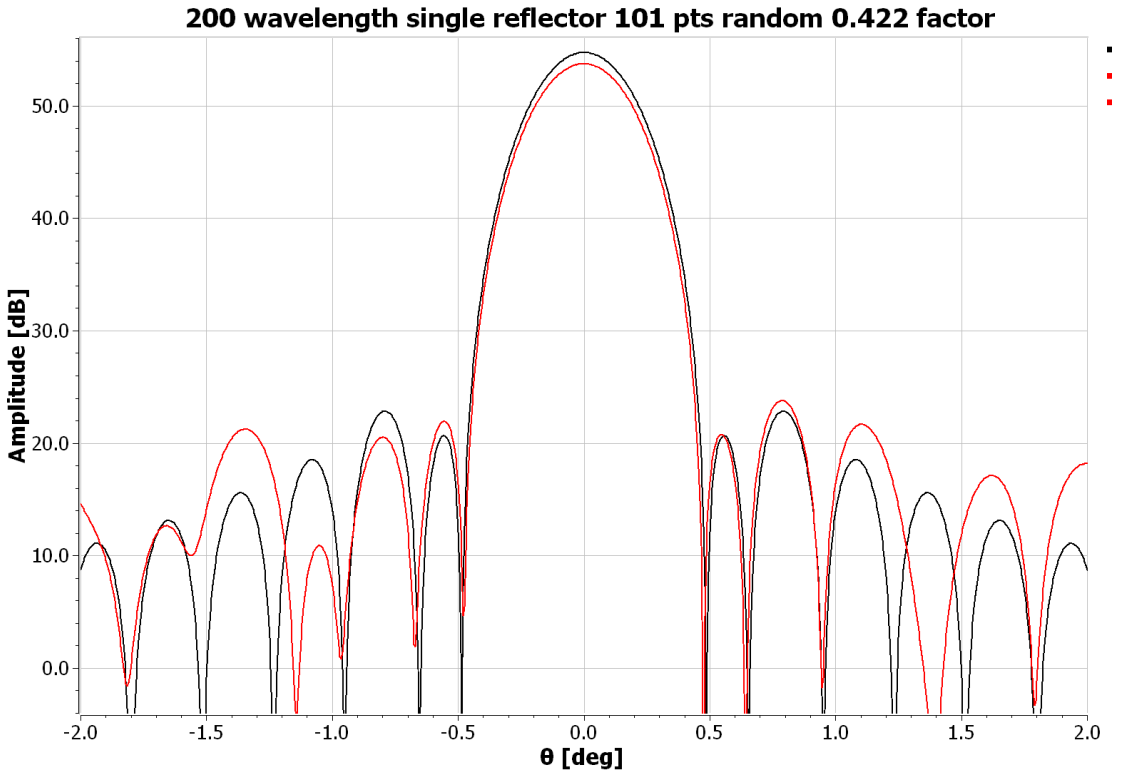


Figure 2 200λ diameter single reflector GRASP pattern w/o surface errors (black) and with (red) 1.0 dB

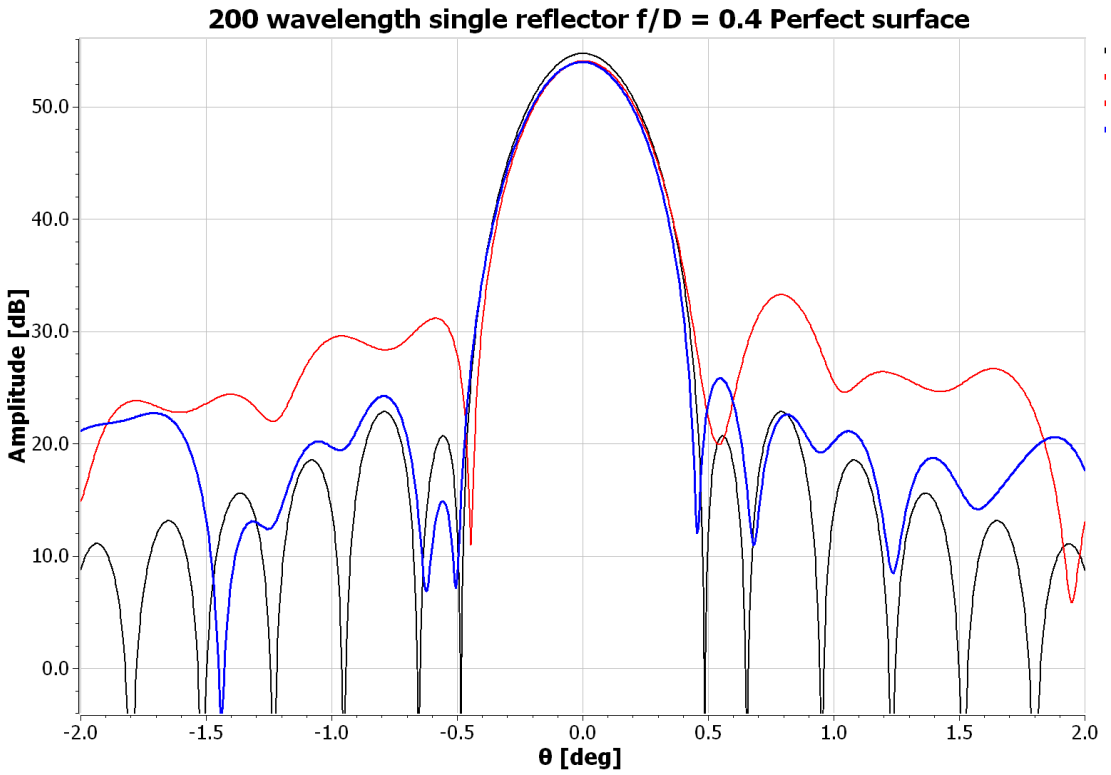


Figure 3 200λ diameter single reflector GRASP pattern w/o surface errors (black) and with 21 pts. (10λ correlation length) (red) and 51 pts. (4λ correlation length) (blue) 1.0 dB loss