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Low Frequency Wire Grid Reflector for Space

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Science at Low Frequencies III

https://is.jpl.nasa.gov/JPLSpaceTemplates/JPL_PowerPoint_Presentation_download_links.pdf

Pasadena, California

Originally contributed to the KISS Study Program

Planetary Magnetic Fields

Planetary Interiors and Habitability

Low Frequency Wire Grid Reflector for Space

Objective:

Is a 1-km diameter reflector for operation at 0.1 to 3.75 MHz feasible given current launch capabilities?

https://sspl.nasa.gov/NPI-Space-templates/NPI-Ed-verbal-pulse-generation-download-links.pdf

Approach:

Design a minimum mass paraboloid wire mesh reflector anchored by small maneuverable satellites.

Wire Size and Spacing

Reflectivity of a sheet:

$$\Gamma(R_s) = \frac{R_s - R_0}{R_s + R_0}$$

For 95% and R0 = 377Ω, Rs <= 10Ω.

Resistance of a grid cell LxW in size:

$$R = R_s \frac{L}{W} \simeq R \leqslant 10\,\Omega$$

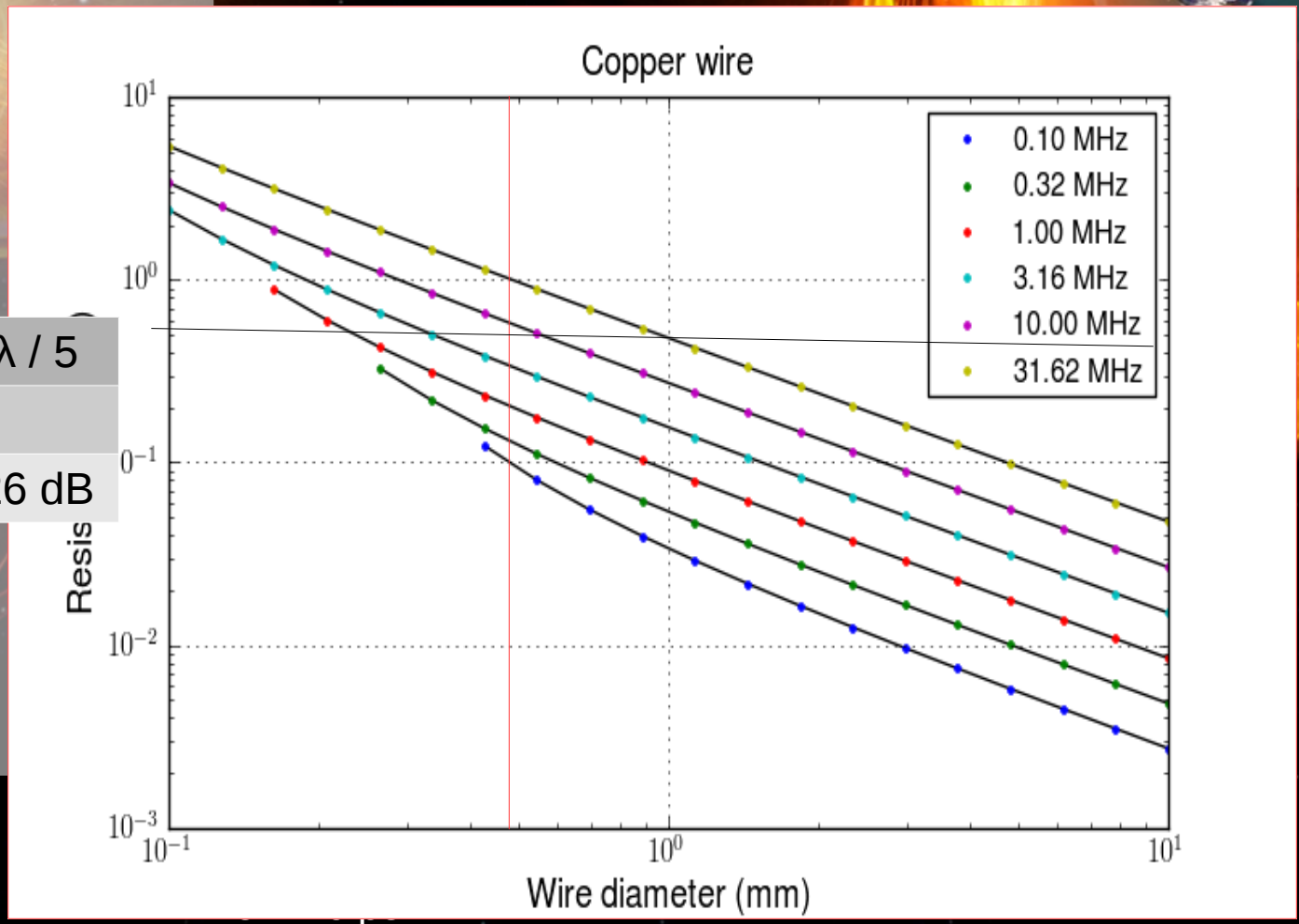
Resistance & Skin Depth:

$$R(d) = \frac{\rho}{\pi\,\delta(d-\delta)}$$

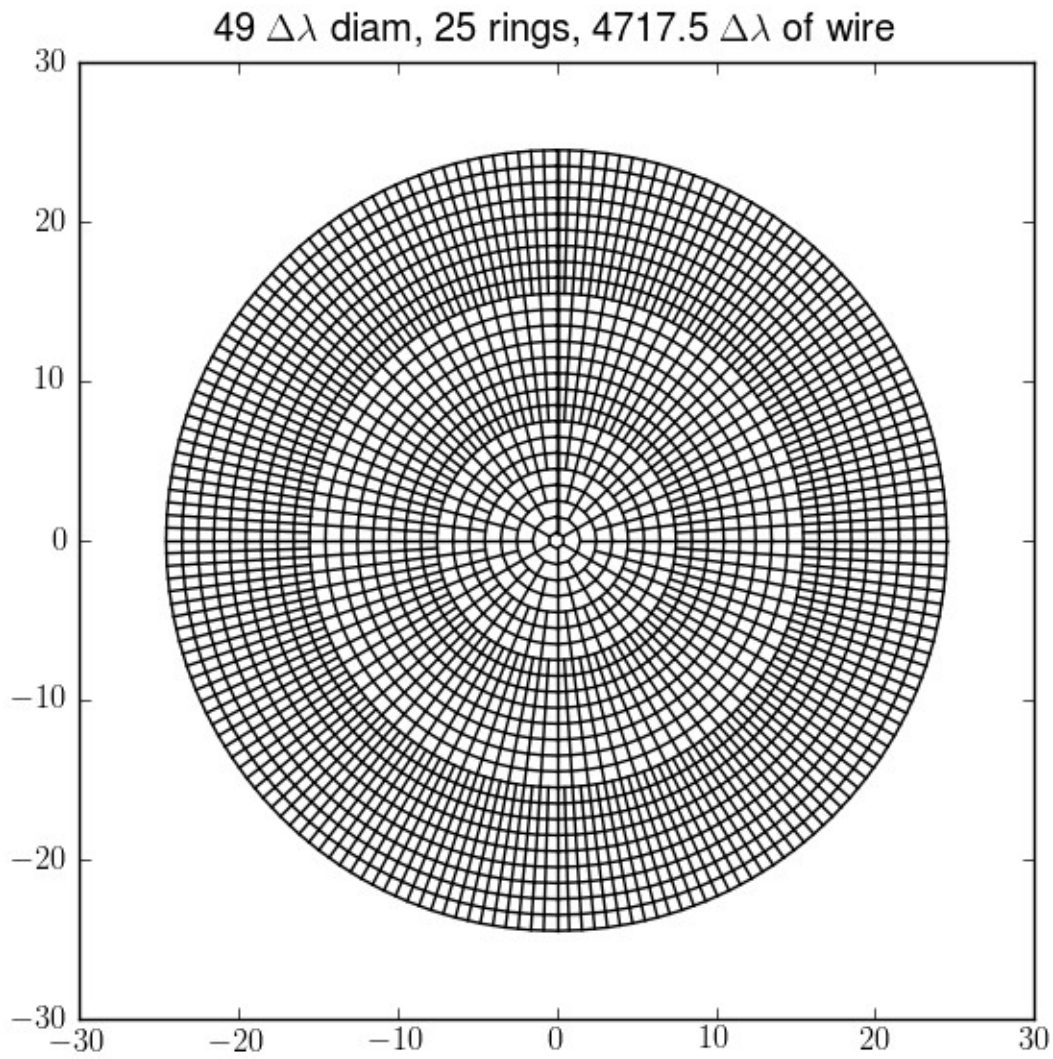
Cell size:

spacing	λ / 2	λ / 4	λ / 5
reflectivity	0.6	0.9	
directivity	31 dB	28 dB	26 dB

3.75 MHz (80 m wavelength) requires a cell size of 20 m which implies a wire 0.5 mm in diameter.



Wire Arrangement

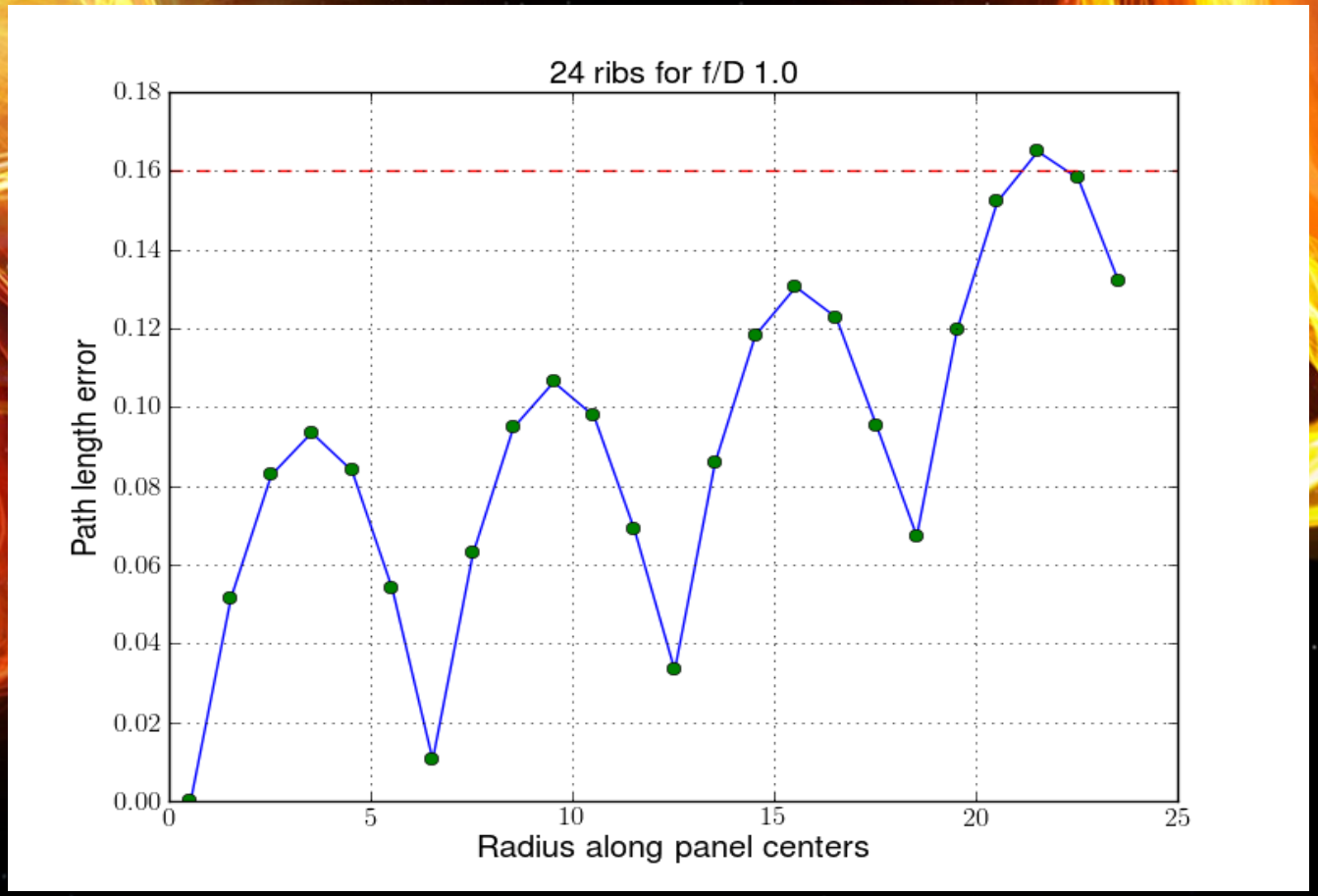


Anchoring

Radial

f/D	0.25				0.6		1.0	
anchors	6	7	8	9	4	5	4	5
r.m.s. error	0.16	0.12	0.08	0.06	0.29	0.10	0.18	0.06
max. error	-0.30	-0.26	-0.16	-0.15	-0.56	-0.14	-0.35	-0.08
err. radius	6.5	12.5	2.5	8.5	18.5	2.5,4.5	18.5	var.

Azimuthal



Mass of the Mesh Paraboloid

Mesh Mass

Wire length: 4717.5 x 20 m = 94.35 km
Cross-section area = $\pi \times 0.0025^2$ m^2 = 2×10^{-7} m^2
Volume = 0.018 m^3
Density of copper = 8940 kg m^{-3}
Mass = 169.7 kg

Anchor Mass

Number of anchor satellites = 96
Mass of a 2U Cubesat = 4.5 kg
Mass = 430 kg

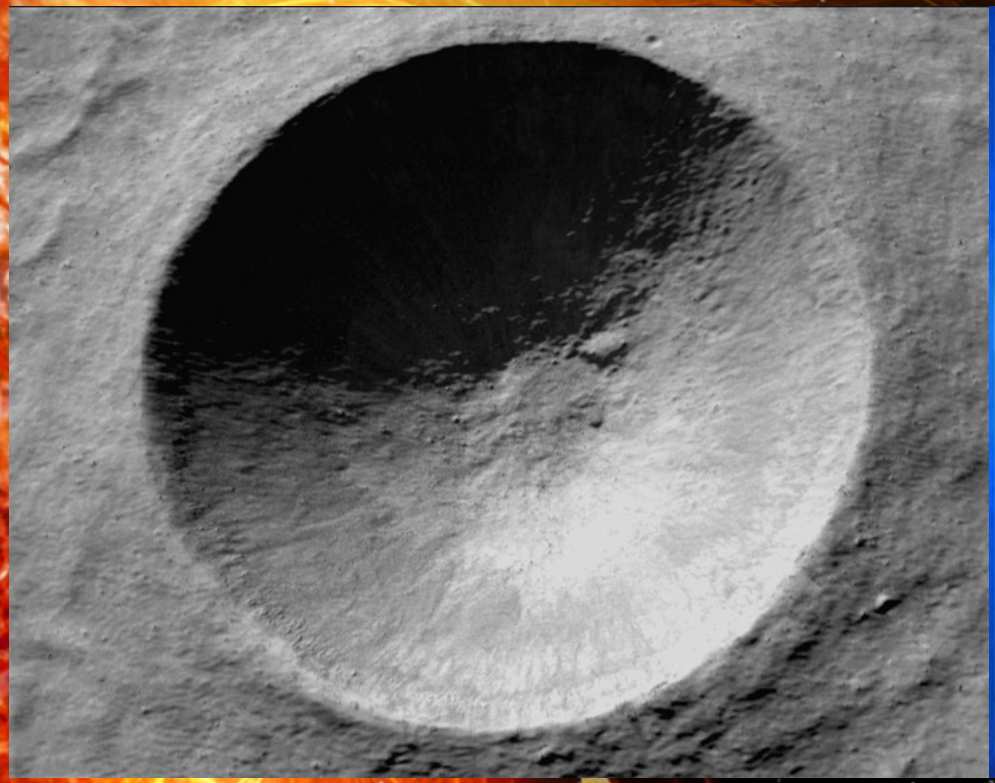
Launch Capacity to LEO

Light : up to 2000 kg
Medium: 2000-20,000 kg
Heavy: 20,000 to 50,000 kg

Escape Velocity

To LEO: 9.3 km/s
To the Moon: 11.2 km/s

Another Approach to Anchoring

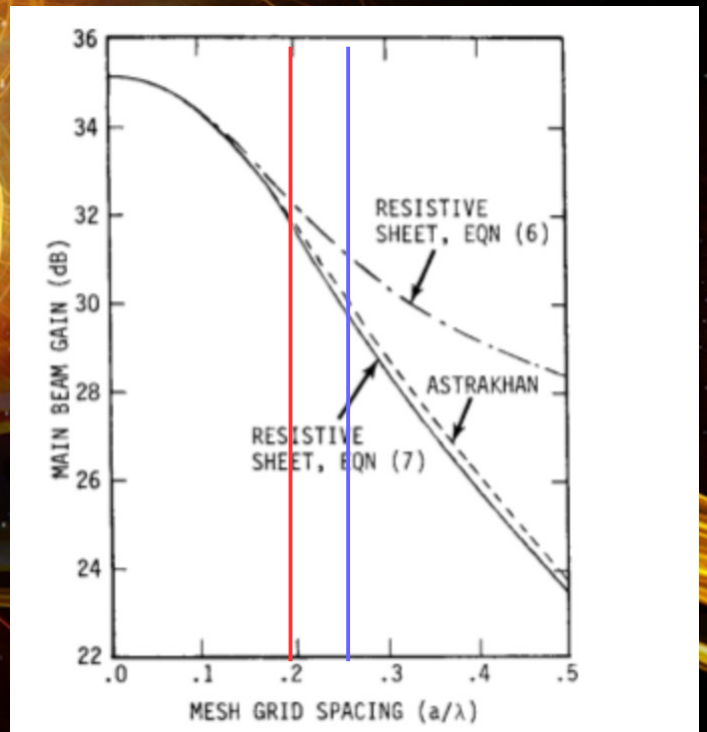


Linne Crater, 2.2 km diameter

Courtesy of Gregg Hallinan

Conclusion
It can be done!

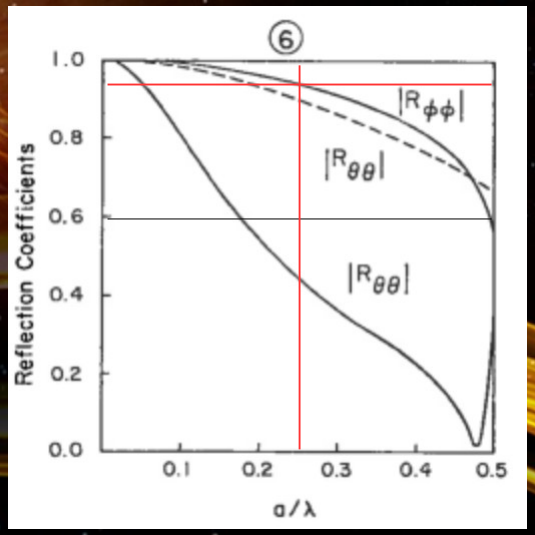
Backup: Parabaloid Mesh Gain



Gain of a 20λ paraboloid as a function of mesh grid size. (f/D = 0.4, cos θ feed, $r_0 = 0.002\,\lambda$.)

D. C. Jenn *et al.*, *IEEE Trans AP*, **37**, 1484 (1989)

Backup: Wire Mesh Reflectivity



D. A. Hill and J. R. Wait, *Can. J. Phys.*, **54**, 353 (1976).