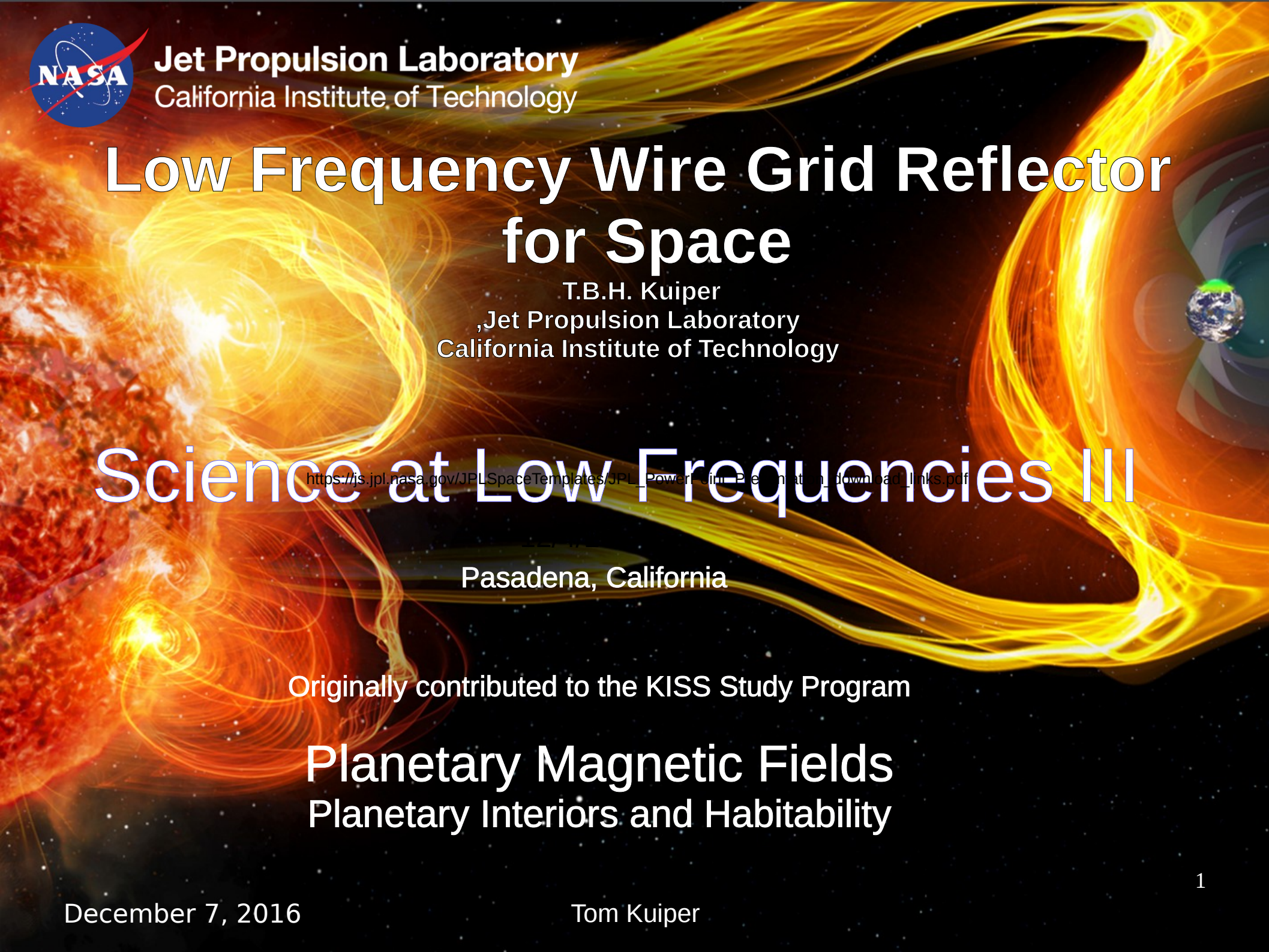

Low Frequency Wire Grid Reflector for Space

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Science at Low Frequencies III

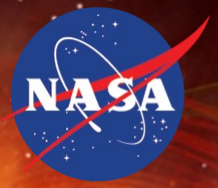
https://is.jpl.nasa.gov/JPLSpaceTemplates/JPL_PowerPoint_Slide_Templates_download_links.pdf

Pasadena, California

Originally contributed to the KISS Study Program

Planetary Magnetic Fields

Planetary Interiors and Habitability



Jet Propulsion Laboratory
California Institute of Technology

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?

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:

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

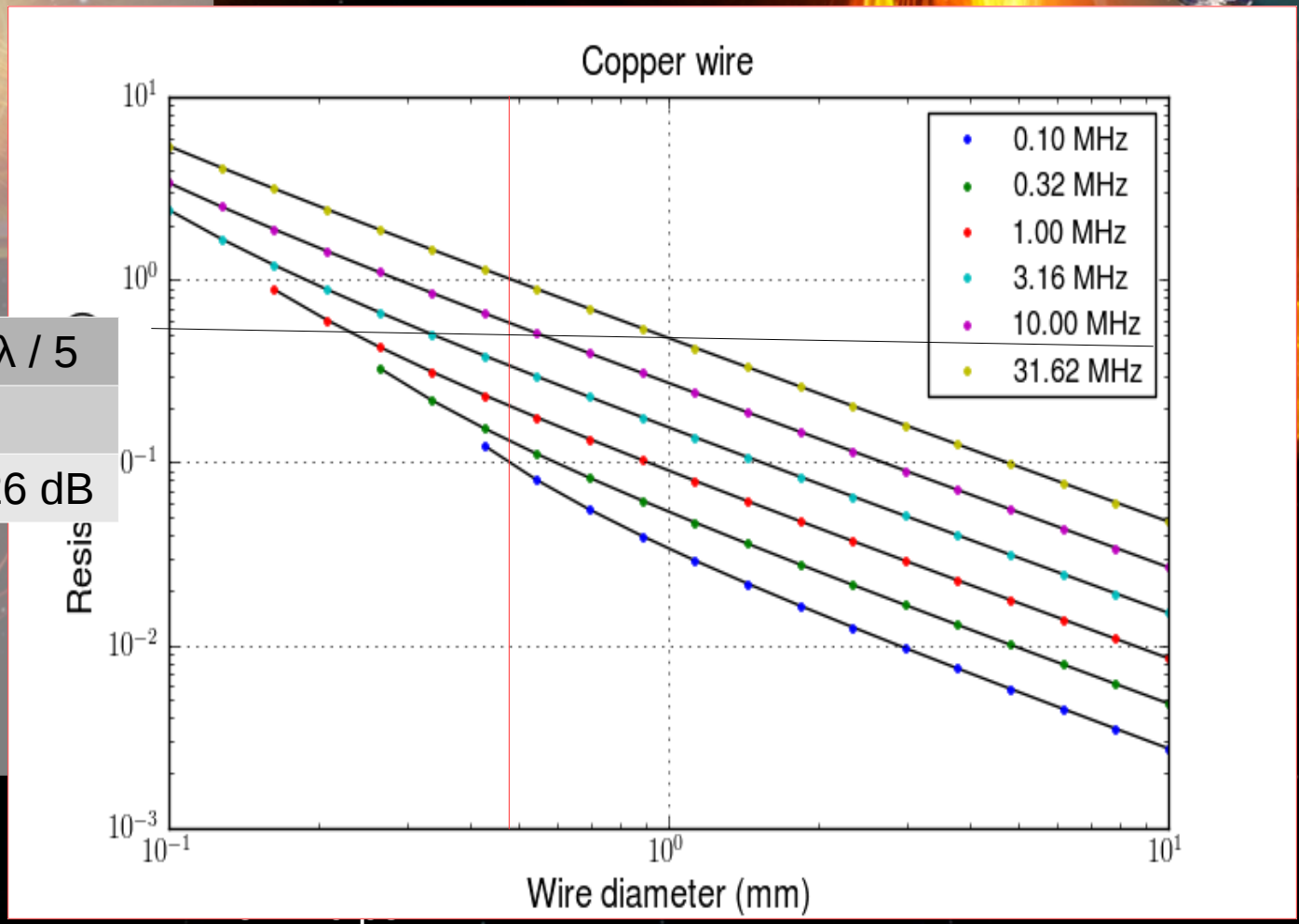
Resistance & Skin Depth:

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

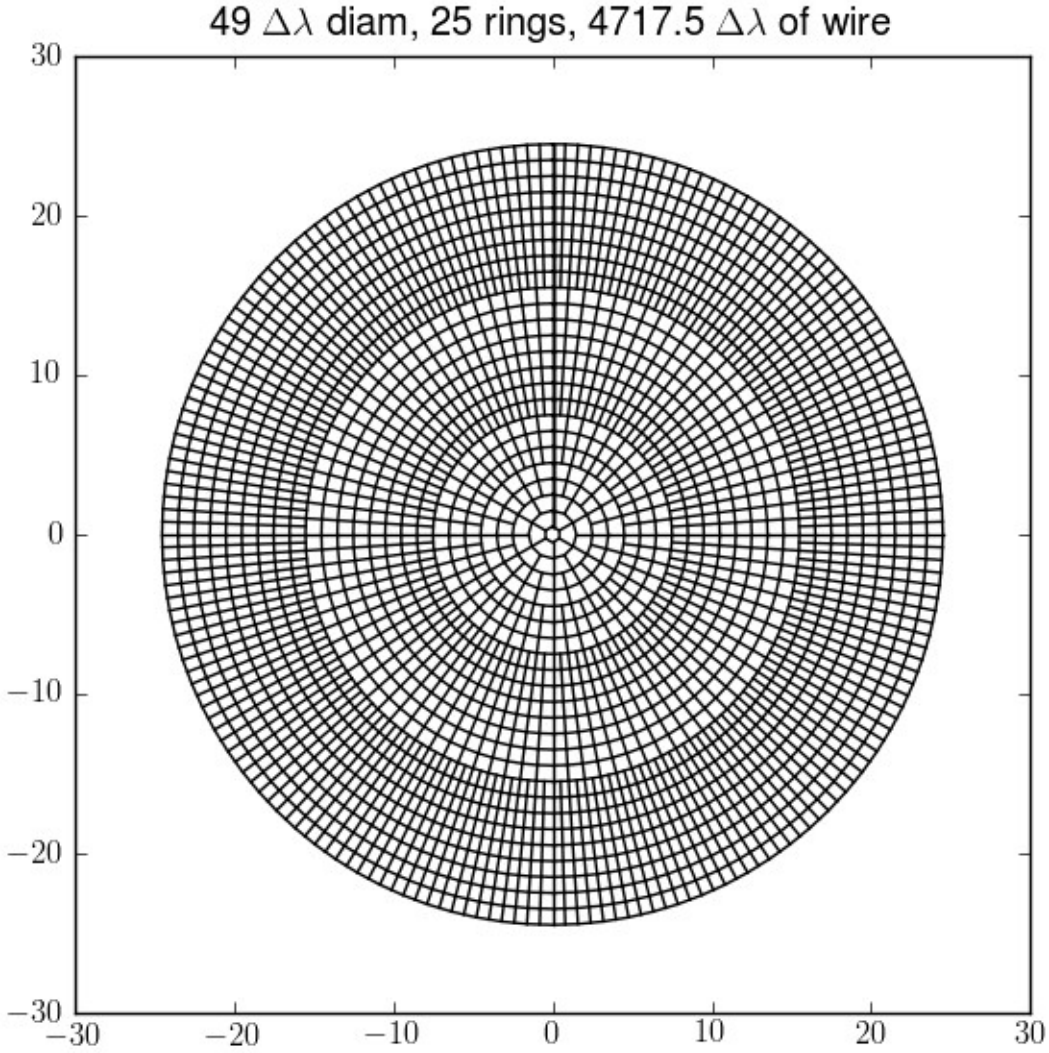
Cell size:

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

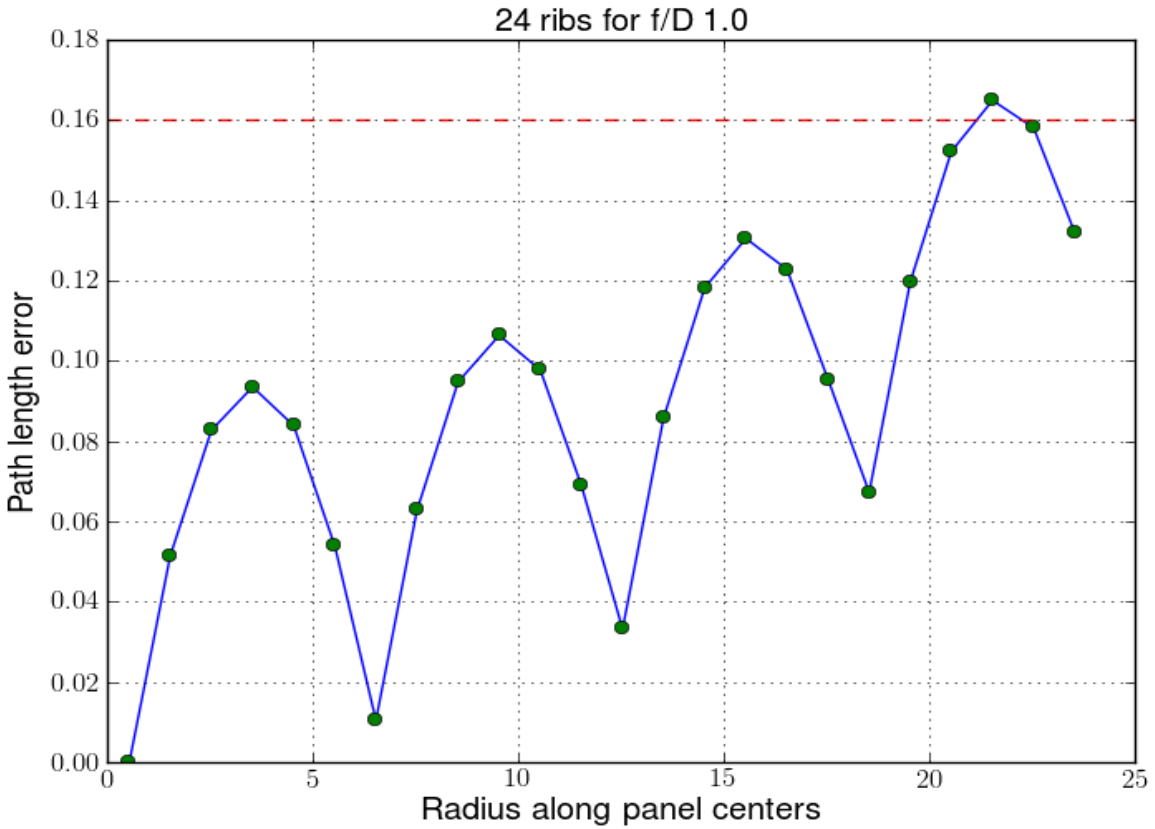


Anchoring

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 = π x 0.0025^2 m^2 = 2 x 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

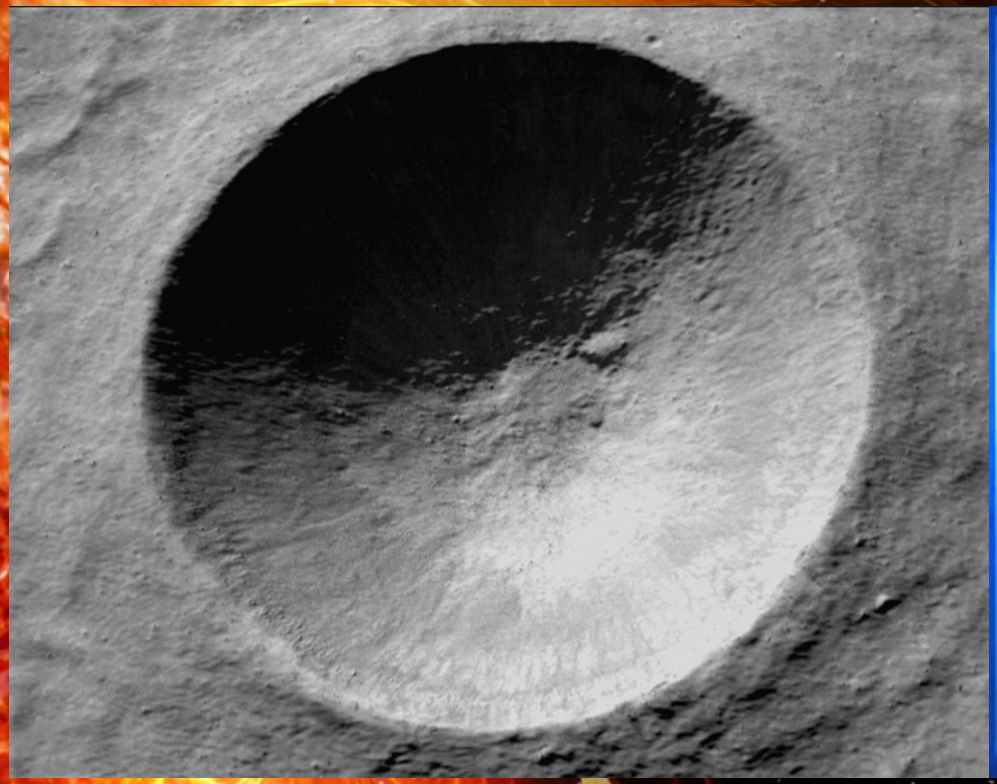
Launch Capacity to LEO

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



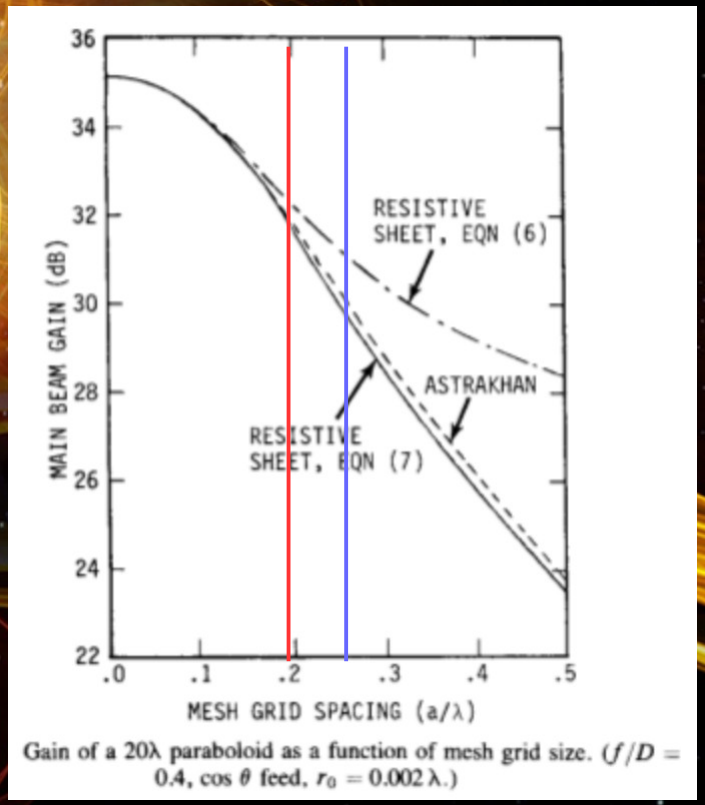
Linne Crater, 2.2 km diameter

Courtesy of Gregg Hallinan

Conclusion

It can be done!

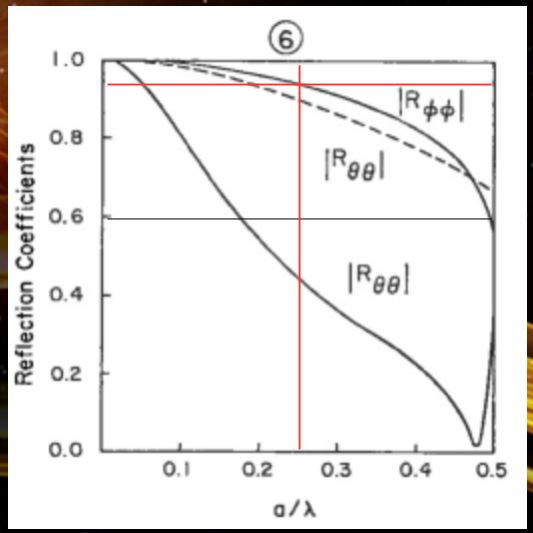
Backup: Parabaloid Mesh Gain



Gain of a 20λ paraboloid as a function of mesh grid size. ($f/D = 0.4$, $\cos\theta$ 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).