Jet Propulsion Laboratory
California Institute of Technology

Antenna Technology for SmallSat

1M deployable Reflectarray Antenna For Earth Science Radar

Eucap 2017 – Paris, France

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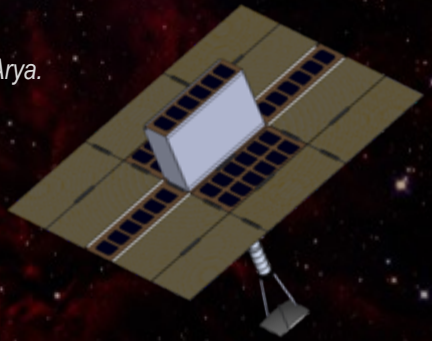
Nacer Chahat, Jonathan Sauder, Gregory Agnes, Manan Arya.

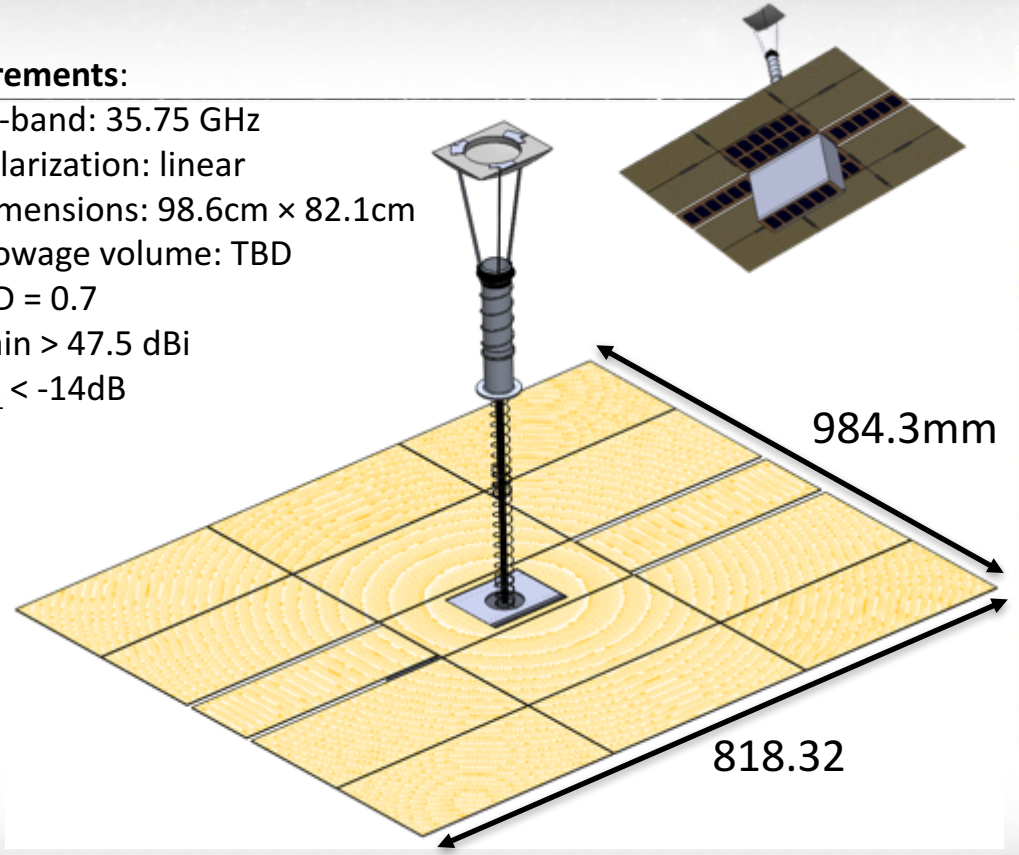


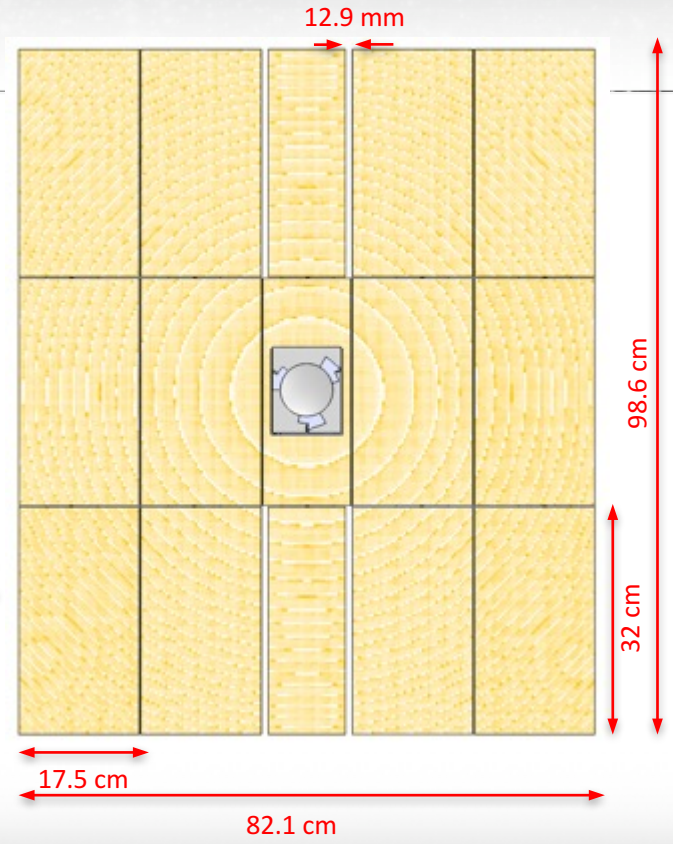
Dedicated to our dear friend ***Professor Per-Simon Kildal***

1-m Deployable reflectarray – Configuration A2b (1 mm Gap) – *Courtesy Raul Polit Casillas*

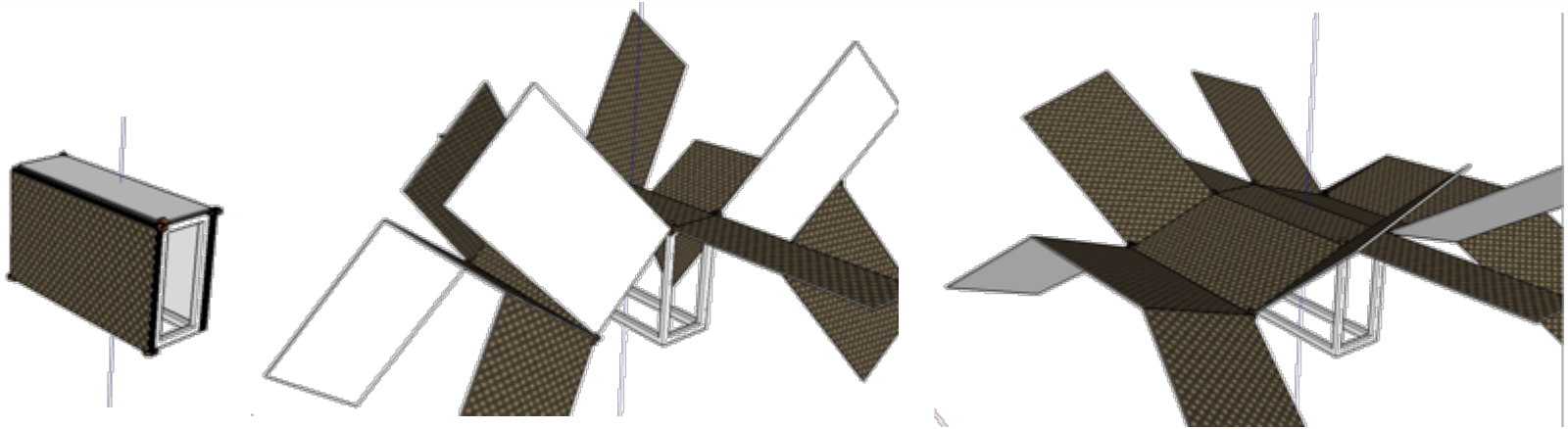
Requirements:

- Ka-band: 35.75 GHz
- Polarization: linear
- Dimensions: 98.6cm × 82.1cm
- Stowage volume: TBD
- F/D = 0.7
- Gain > 47.5 dBi
- S_{11} < -14dB



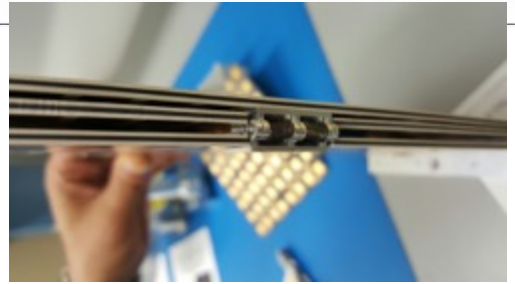


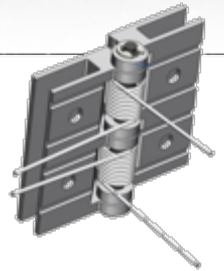
1-m Deployable reflectarray – Initial Deployment Scheme



1-m Deployable reflectarray – Panel description

MarCO's reflectarray heritage[1]:





MarCO's hinge

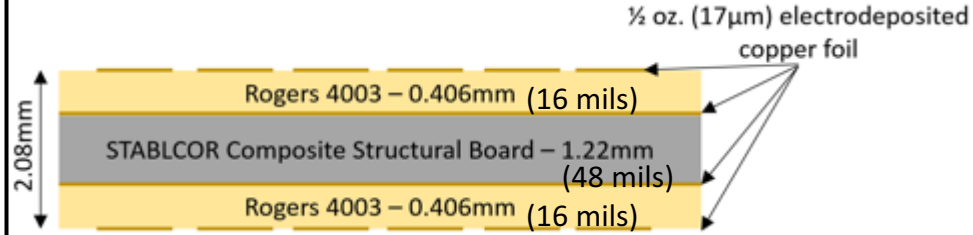
Panel structure:

- Survive launch vibration environment
- Maintain surface flatness over a range of temperature
- Panel symmetry for thermal management

MarCO's Hinges:

- Custom hinges with +/-0.1˚ deployment accuracy

OMERA panels and custom's hinges:

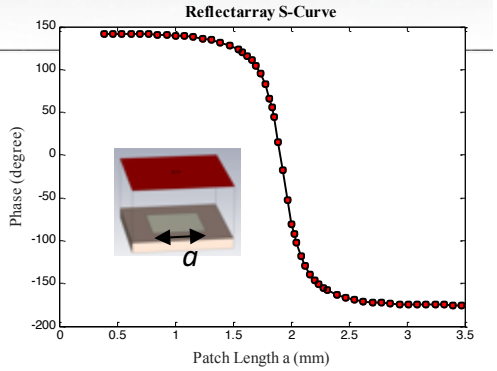


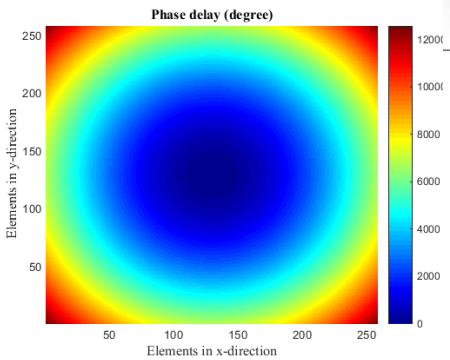
OMERA's hinge:

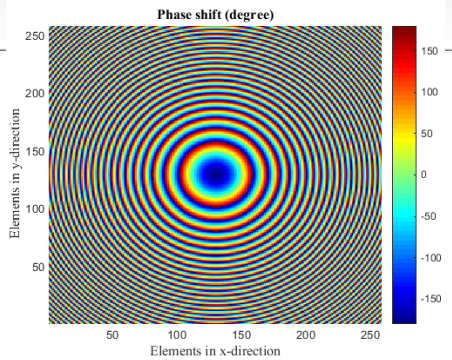
- Better deployment accuracy (+/-0.03˚)
- Smaller gap between folded panels ➔ better stowage volume

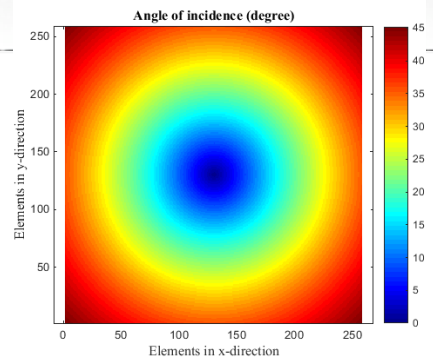
[1] R. E. Hodges, N. Chahat, D. J. Hoppe, and J. D. Vacchione, "A Deployable High-Gain Antenna Bound for Mars: Developing a new folded-panel reflectarray for the first CubeSat mission to Mars.," in *IEEE Antennas and Propagation Magazine* , Early access.

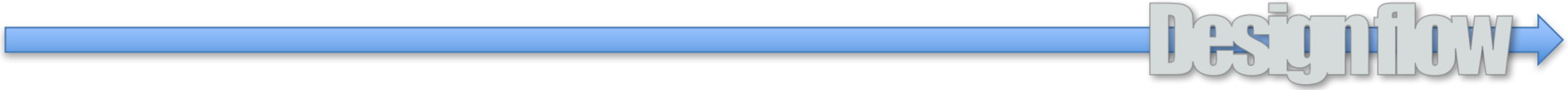
1-m Deployable reflectarray – S-curve







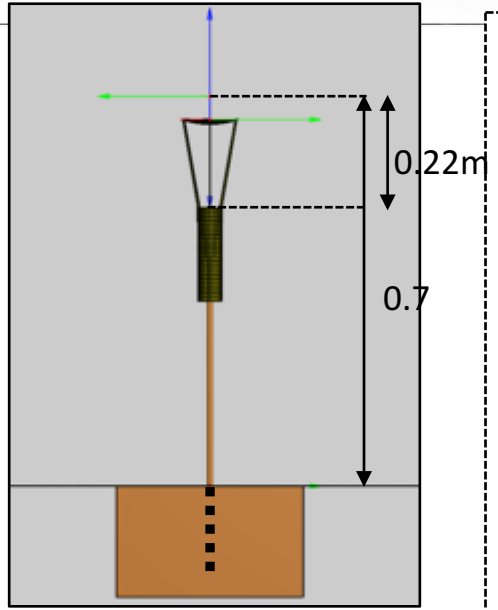


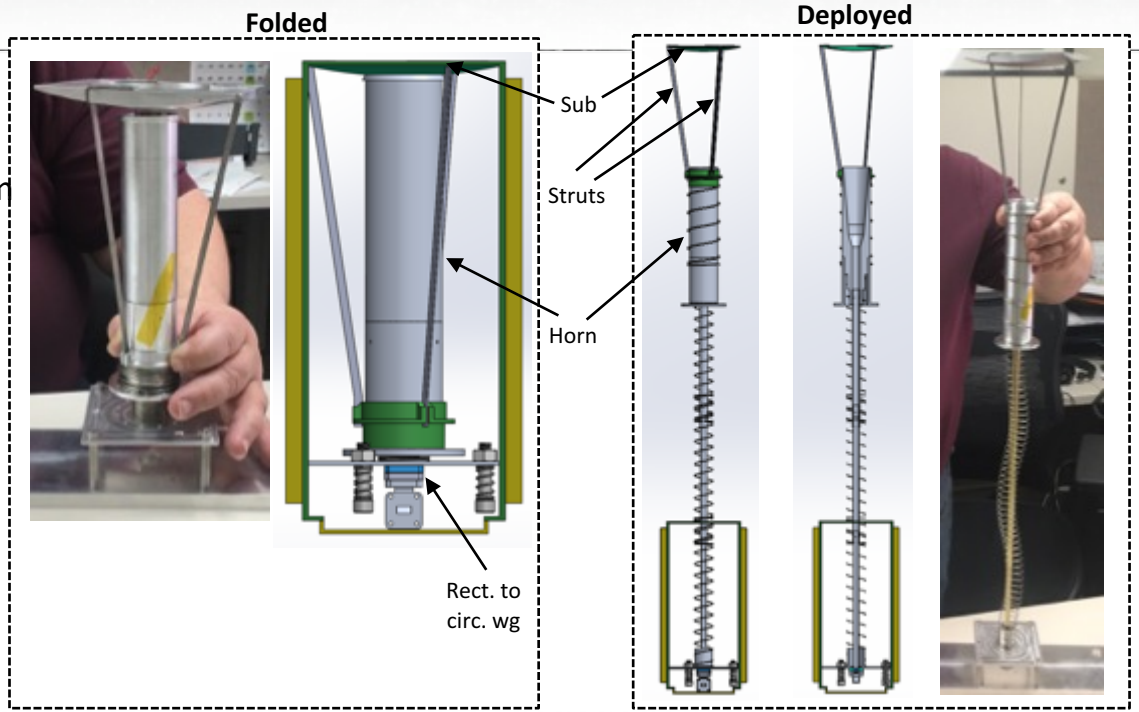


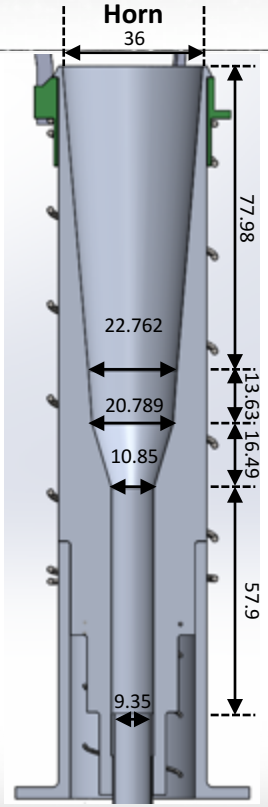
- Overall reflectarray dimensions of 984.3mm x 818.32mm
- Accounted for the angle of incidence because of low f/D
- Select the patch size providing the right phase shift for a given angle of incidence

1-m Deployable reflectarray – Telescoping feed design (mechanical)

The feed and sub-reflector location are driven by the f/D and the mechanical constraints.
The feed and telescoping waveguide have heritage from Raincube[2].



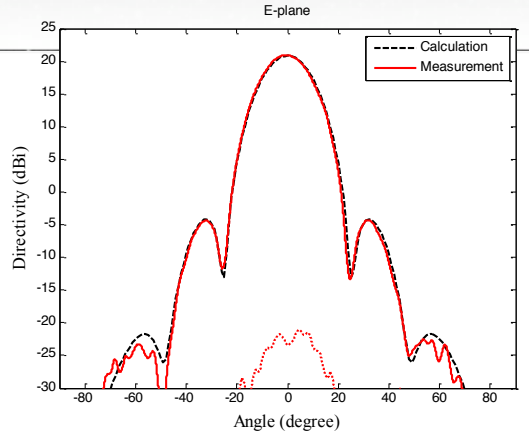


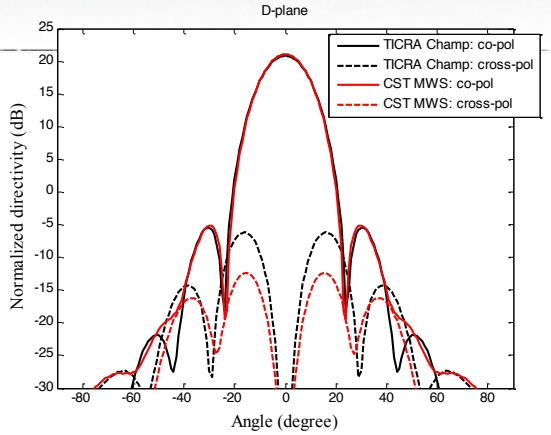


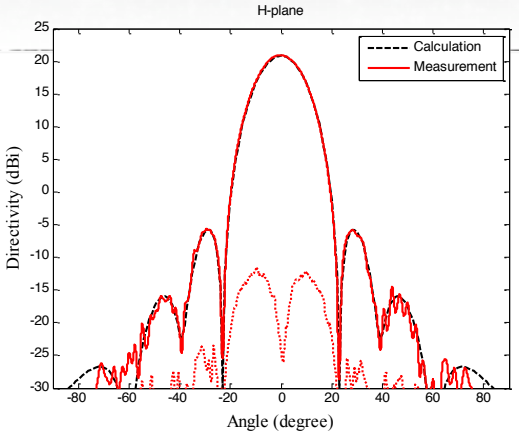
[2]N. Chahat, *et al.*, "CubeSat Deployable Ka-Band Mesh Reflector Antenna Development for Earth Science Missions," in *IEEE Transactions on Antennas and Propagation*, vol. 64, no. 6, pp. 2083-2093, June 2016.

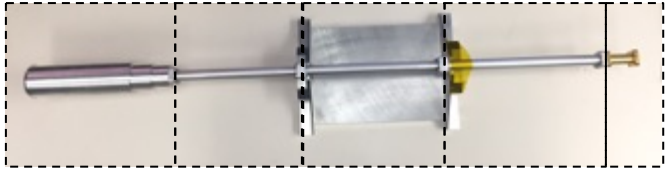
1-m Deployable reflectarray – Telescoping feed radiation pattern

- Calculation and measurement are in excellent agreement









Horn Wg1 Wg2 Wg3 Transition Rect-to-Circ

	Directivity (dBi)	Gain (dBi)
Calc.	20.82	20.52
Meas.	20.95	20.4

1-m Deployable reflectarray – Reflectarray Gain loss Table

Updated Gain Table (deployed antenna)

	Gain (dBi)	Loss (dB)
Ideal directivity	51.58	-
Spillover	50.67	0.91
Taper	49.95	0.72
Blockage	49.67	0.28
Struts	49.37	0.3
Gap loss	49.22	0.15
Patch dielectric / conductivity loss	48.92	0.25
Surface accuracy (±0.2mm)*	48.57	0.4
Angle deployment accuracy	48.24	0.33
Feed loss / telescoping waveguide / transition	47.94	0.3
Feed mismatch (RL=17dB)	47.85	0.09
Overall performance	**47.85**	3.72

➔ **Aperture efficiency of 42.4%**

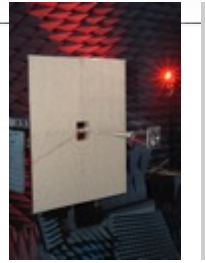
Updated Gain Table (fixed antenna)

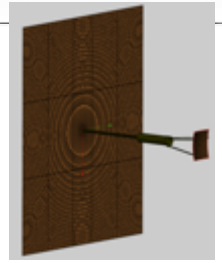
	Gain (dBi)	Loss (dB)
Ideal directivity	51.58	-
Spillover	50.67	0.91
Taper	49.95	0.72
Blockage	49.58	0.37
Struts	49.28	0.30
Patch dielectric / conductivity loss	49.03	0.25
Surface accuracy (±0.15mm)	48.81	0.22
Feed loss / telescoping waveguide / transition	48.51	0.3
Feed mismatch (RL=13dB)	48.31	0.2
Overall performance	**48.31**	3.27

➔ **Aperture efficiency of 47.1%**

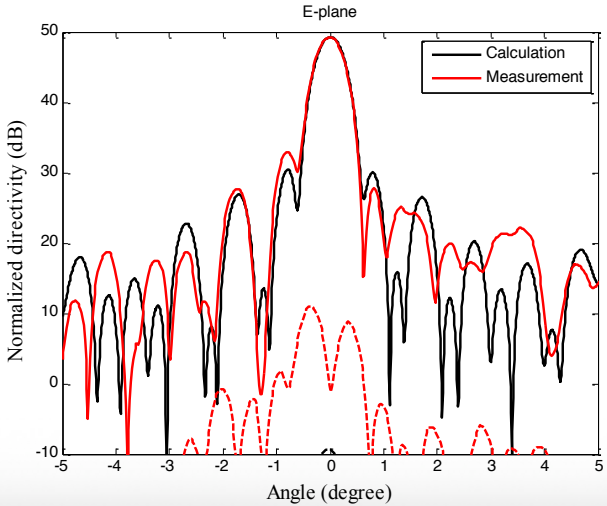
1-m Deployable reflectarray – Reflectarray radiation pattern

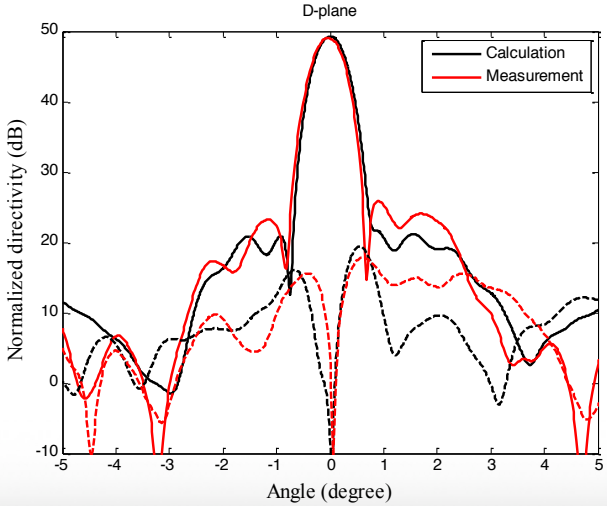
- The simulation includes the reflectarray, the 3 telescoping waveguides, the horn, the 3 struts, and the sub-reflector.
- No gaps are included yet between the panels.

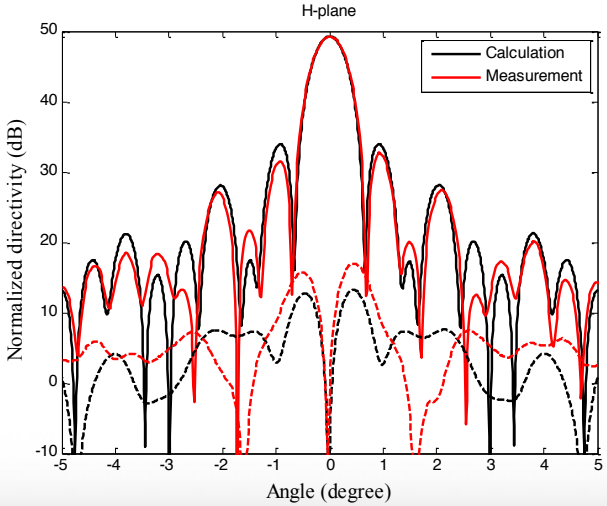




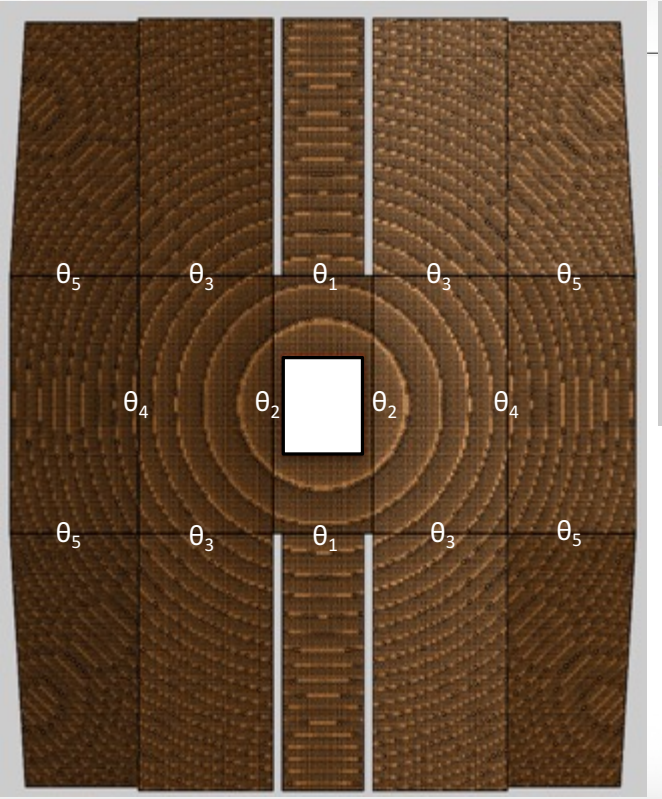
	Directivity (dBi)		Gain (dBi)		Loss (dB)*		Efficiency (%)	
	Calc.	Meas.	Calc.	Meas.	Calc.	Meas.	Calc.	Meas.
Fixed	49.28	49.27	48.31	48.5	0.97	0.77	47.10	49.20
Deployable	48.9	TBD	47.85	TBD	0.65	TBD	42.4	TBD

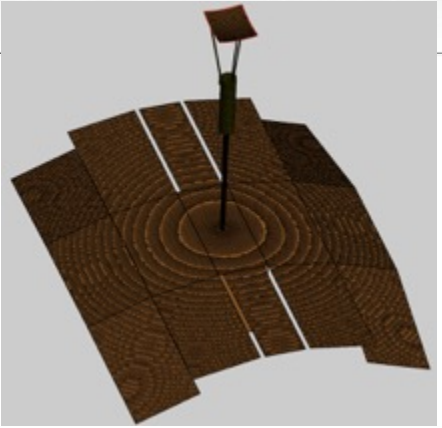






1-m Deployable reflectarray – Angle required deployment accuracy





Angles	Accuracy (degree)
θ_1	-0.04/+0.04
θ_2	-0.03/+0.03
θ_3	-0.03/+0.03
θ_4	-0.04/+0.04
θ_5	-0.1/+0.1