



2018 IEEE AP-S International Symposium



When Deployable Spacecraft Antennas Don't

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Why Deployables

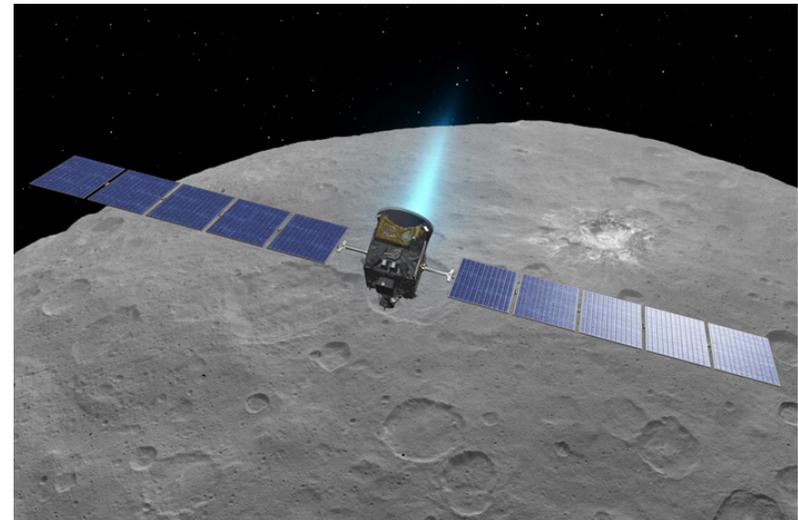


Some portion(s) of launch payload may need to be “collapsed” to fit, & “deployed” after launch & separation

→ **Examples**



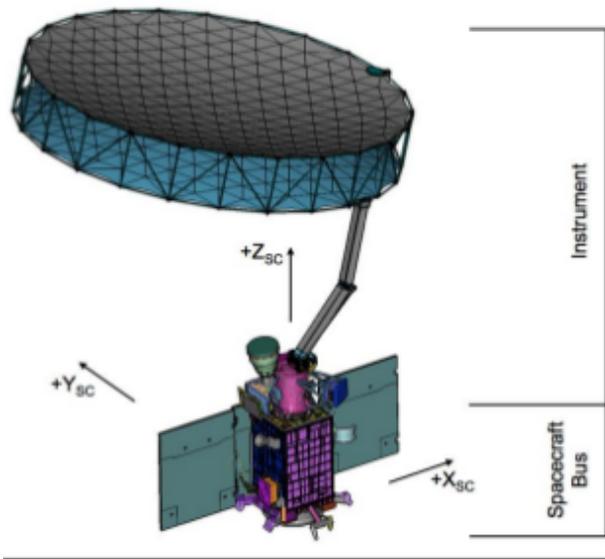
Magnetometer Boom



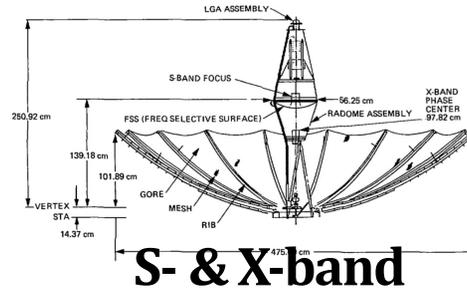
Solar Panels



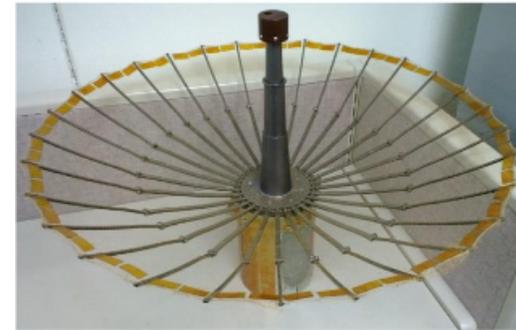
A Few Antenna Examples



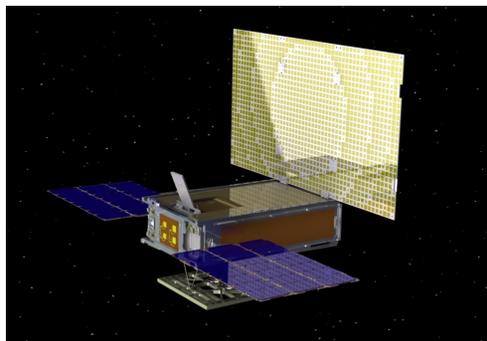
L-band



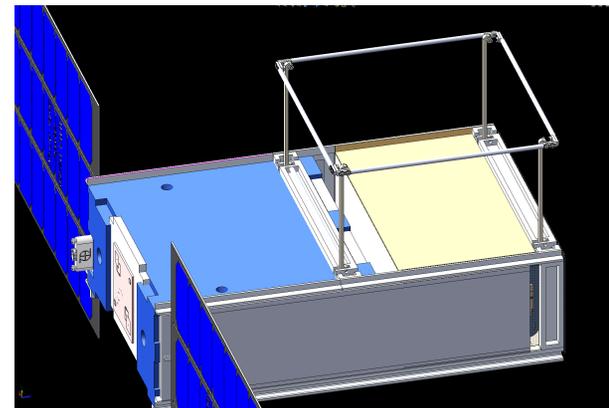
S- & X-band



Ka-band



X-band



UHF



Focus here will be on Antennas



Antenna functions

- Communications
- Remote sensing

End objective – it depends

- Data rate
- Range/sensitivity
- Resolution
- Field of view (FOV)

The key parameter

- Gain (effective)



Antenna Gain



Higher gain

- Greater data rate
- Greater range/sensitivity for remote sensing
- Greater resolution
- Less FOV
- Greater size

Less gain

- The opposite



Antenna Deployments



Full deployment

- Full functionality

Partial deployment

- Some of original functionality
 - Reduced gain
 - Skewed beam
 - Increased sidelobes
 - Degraded polarization
 - Impedance changes

No deployment

- *Plan B*
 - *Use non-deployable antenna*



Focus on Partial Deployments



Illustrate the possibility of continued use in 4 hypothetical examples

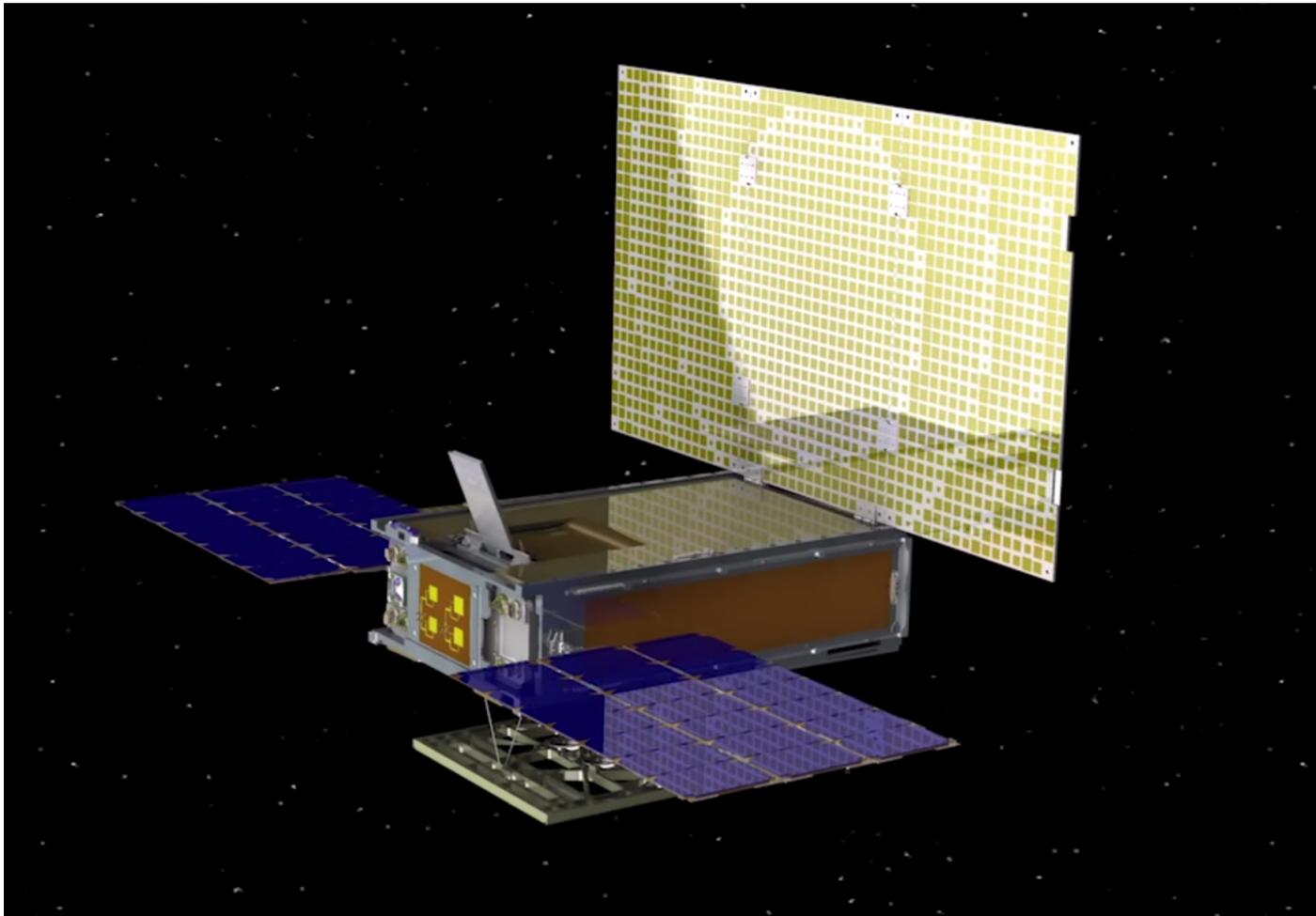
Measure of remaining functionality will be effective gain – i.e., all effects rolled into one number.

The deployment mechanism is not discussed

Partial deployment failure mode in each case has been highly simplified



X-band Reflectarray Example 1



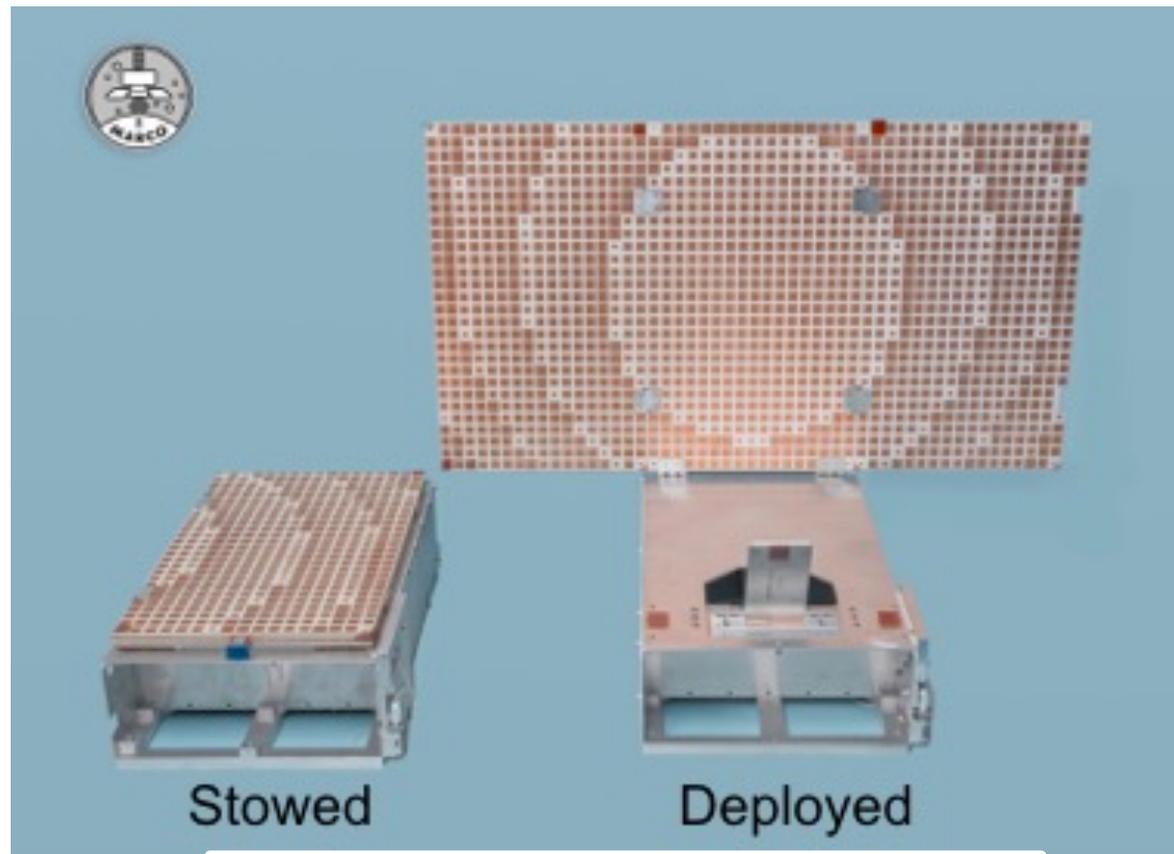
Host S/C is a 6U CubeSat design (MARCO)



Reflectarray Panels (3) Deployment



Mockup for measurement of antenna performance

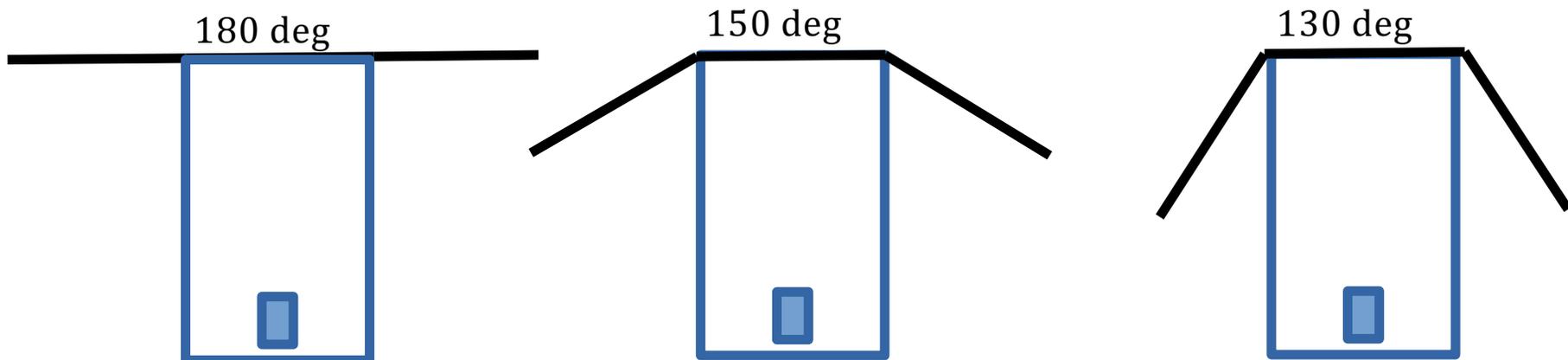




Reflectarray Partially Deployed Performance



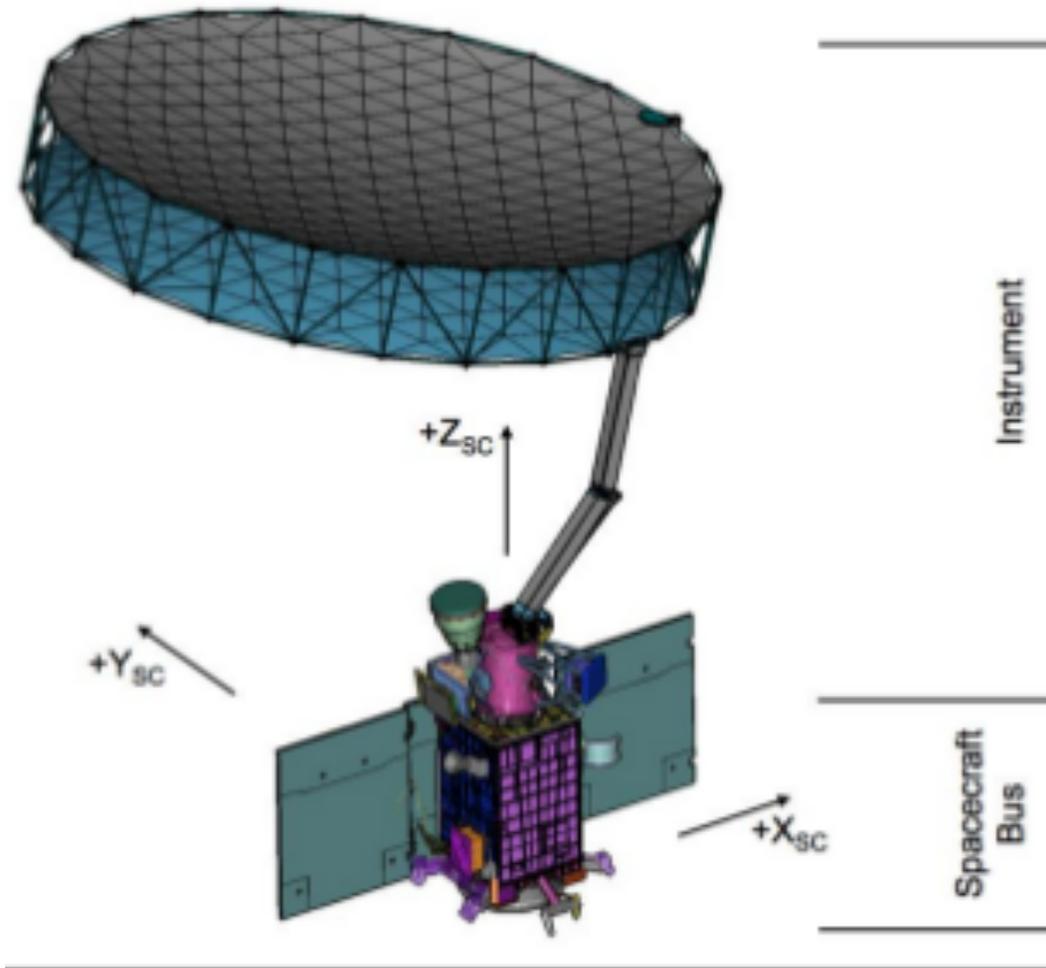
Angular Foldout (deg)	Boresight Gain (dBi)
180 Full Deployment (flat)	24.4
150	23.7
120	19.7





L-band Mesh Reflector

Example 2



6 m Offset Fed Parabolic Mesh (SMAP)



Mesh Reflector Deployment



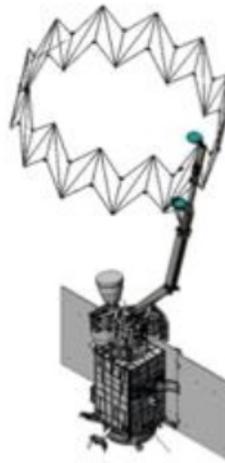
Deployment Sequence



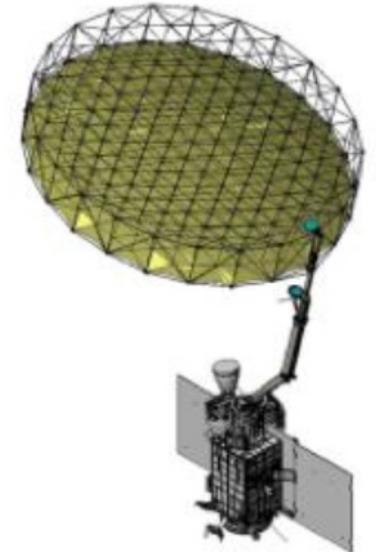
Stowed Reflector



Secondary Restraint Release



Powered Reflector Deployment
(~27 min)



Reflector Deployed



6 m Mesh Reflector Partially Deployed Performance



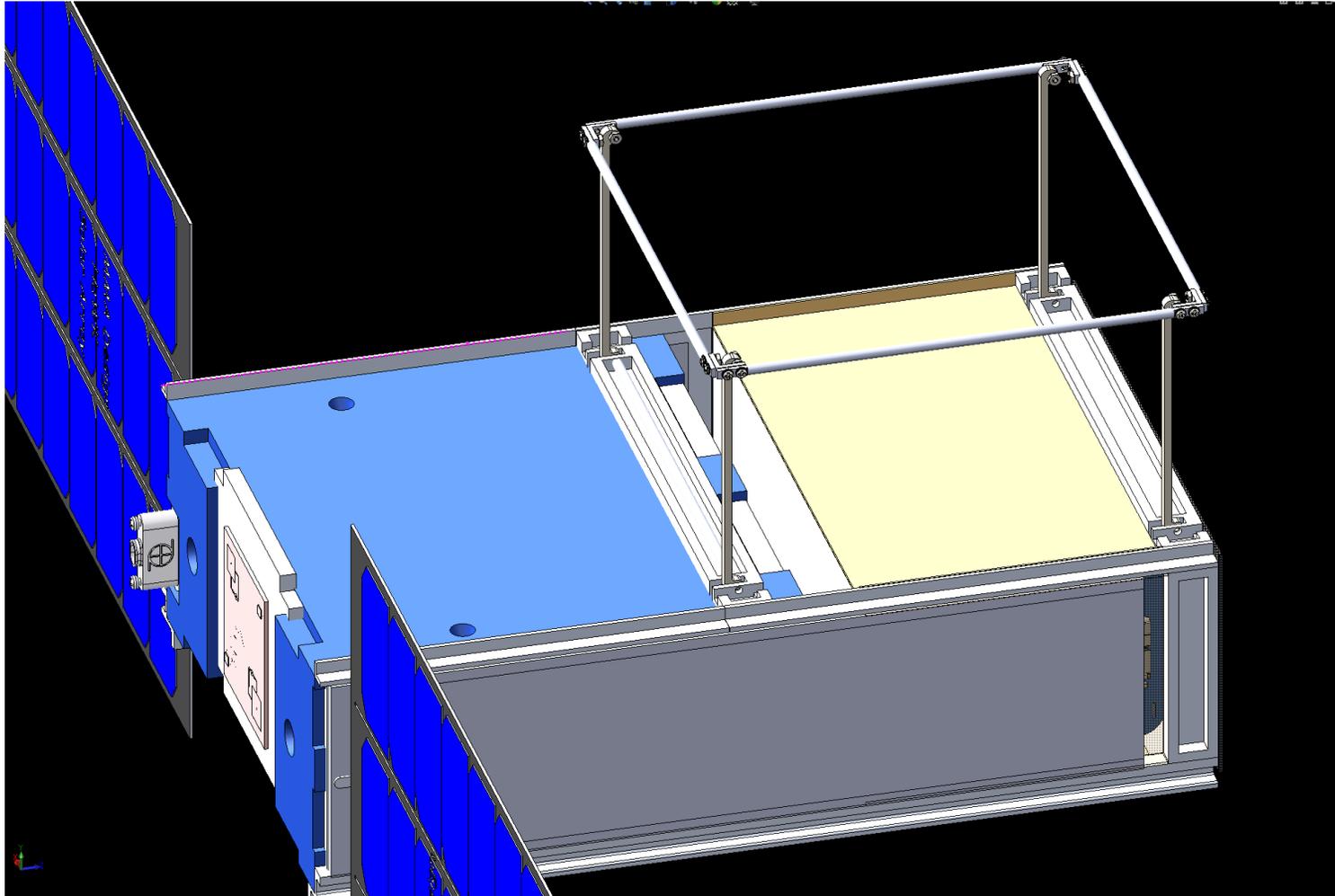
Surface Degradation* (RMS cm)	Boresight Gain (dBi)
0 Full Deployment (smooth)	37.1
3	36.2
6	33.0
9	31.0

* Random “wrinkles” in parabolic surface



UHF Loop

Example 3



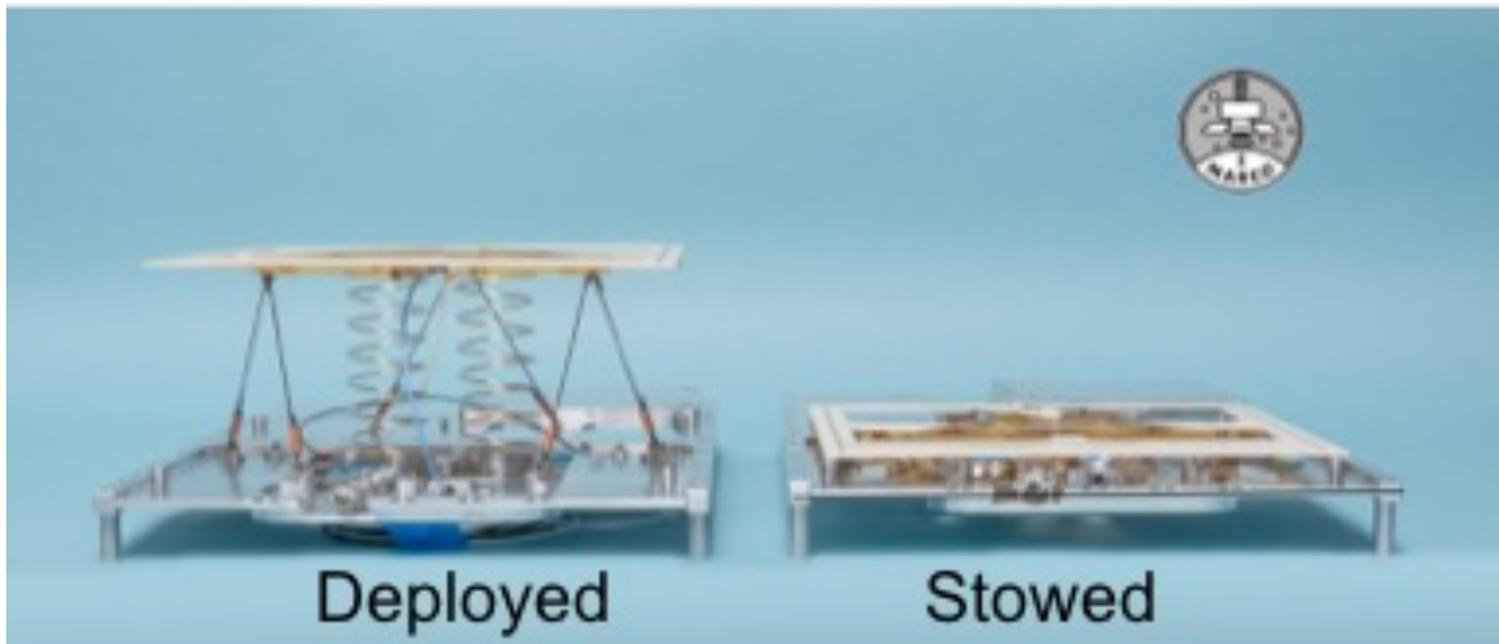
Full wave loop with reflecting GP (MARCO)



UHF Loop Deployment



Deployment Sequence



Loop printed on G10 pops up over reflecting surface



UHF Loop Partially Deployed Performance



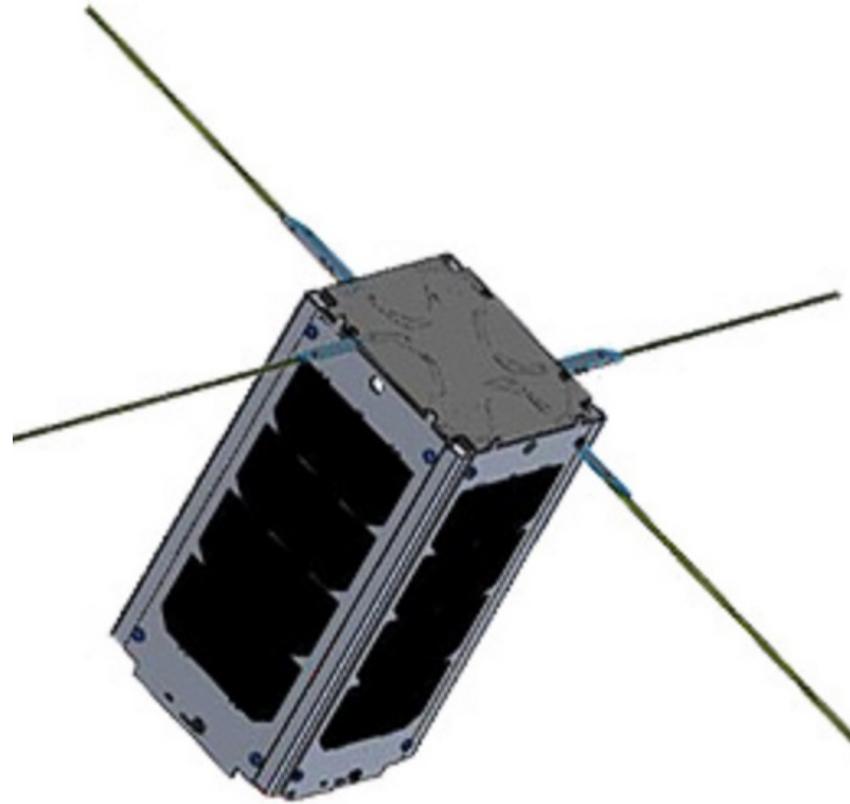
Degradation* (deg)	Boresight Gain (dBi)
0 Full Deployment (Tilt ang)	6.2
10	6.1
20	4.7

* Tilt angle – loop plane not parallel to GP



4 Coplanar Monopoles

Example 4



*Four 1/4-wave monopoles on 2U CubeSat
(CSUNSat1)*



Monopole Deployment

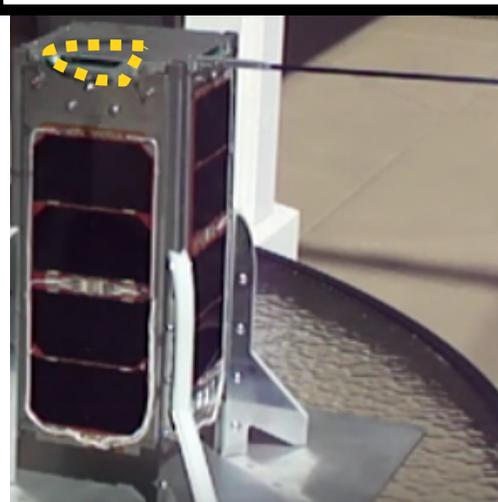


Deployment Sequence

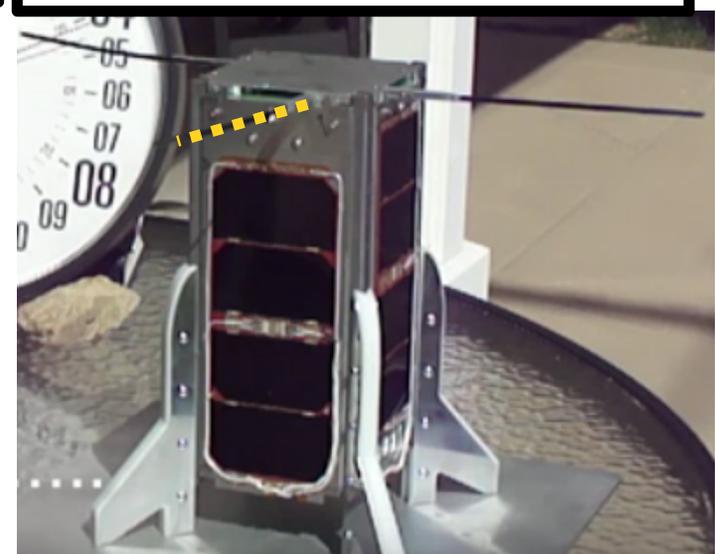
Monopole 1 Deployed



Monopole 2 Mid-Deploy



Monopoles 1, 2, & 3 Deployed



Test (demo) performed with flight HW



4 Monopoles Partially Deployed Performance



Degradation (elements missing)	Tumble Average Gain (dBi)
0 Full Deployment (all 4 ele)	-2.1
1 missing	-2.3
2 missing	-2.7
3 missing	-2.9



Summary & Conclusions



Investigated 4 cases of remaining functionality of partially deployed antennas

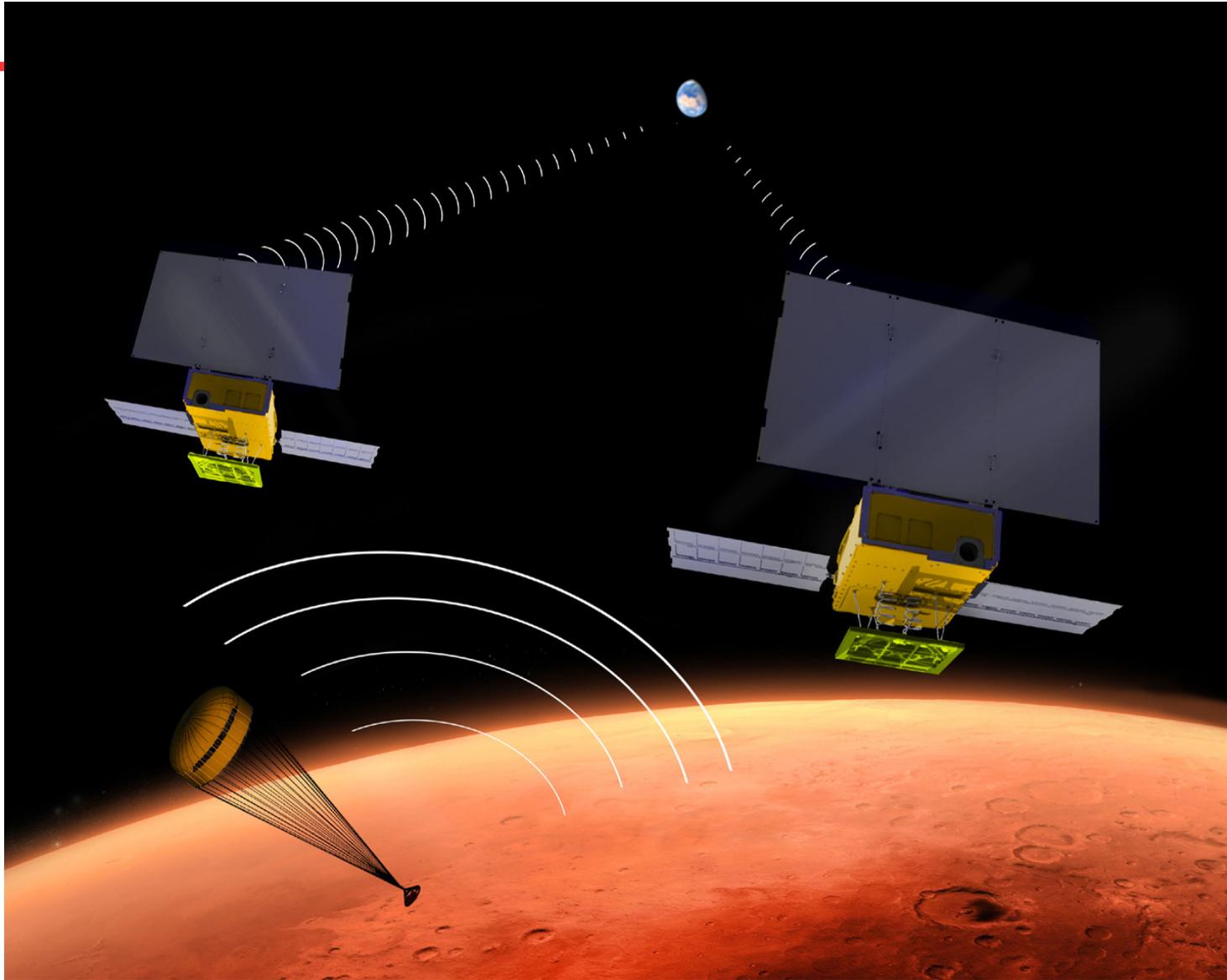
- **Reflectarray**
- **Mesh reflector**
- **Horizontal loop over a GP**
- **Multiple monopoles**

Partially deployed antennas can retain some functionality

- **No surprise!**
- **Deserves some consideration**



MARCO(s) in Action



[Facebook Video](#)