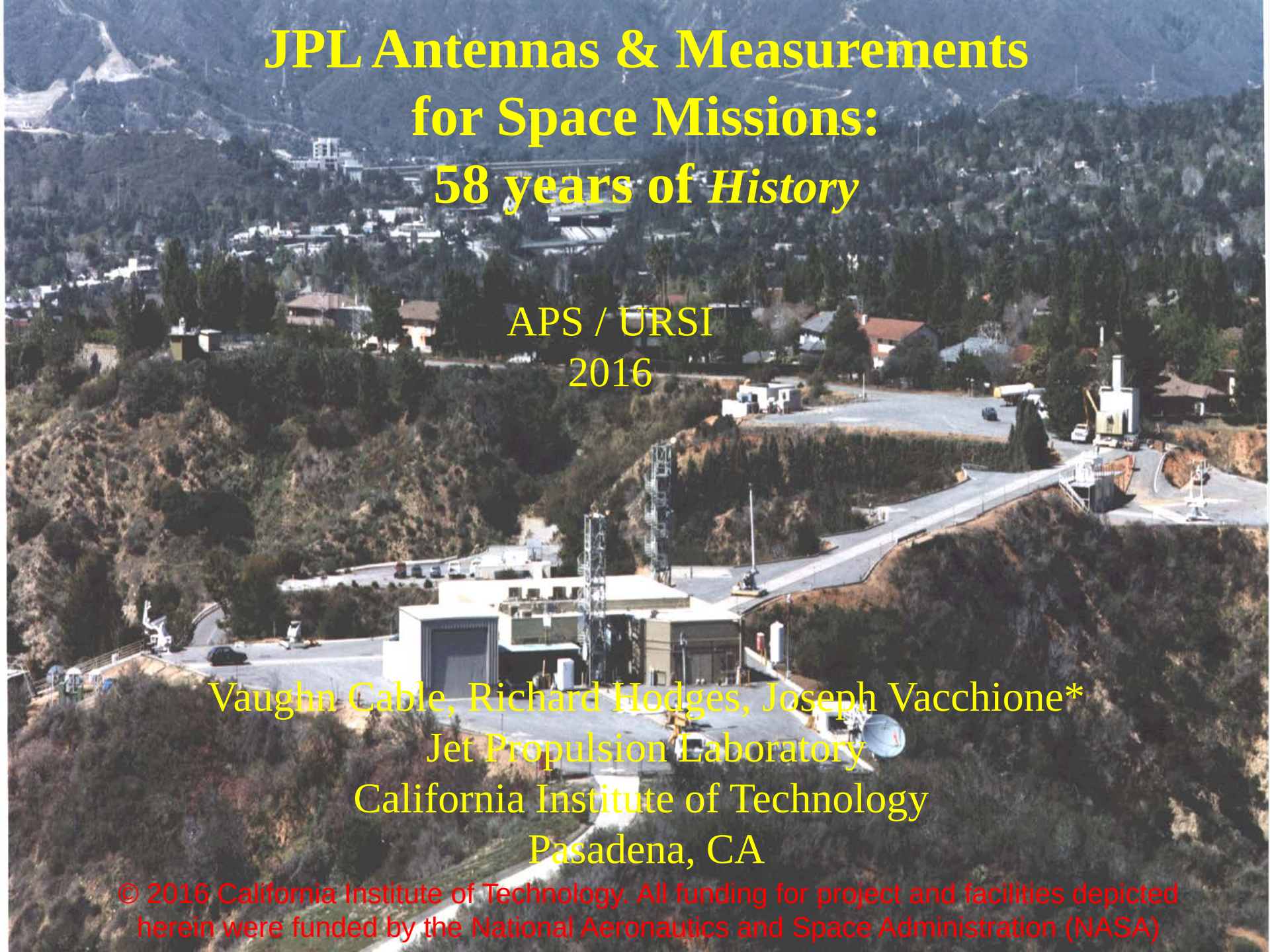

JPL Antennas & Measurements for Space Missions: 58 years of *History*

APS / URSI
2016

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA

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Overview

- Early Years: VHF, UHF, L-band, S-band & Building an Antenna Range
- Galileo: Exploring Measurement Approaches
- Deep Space Network: X-band to Ka Band and Beam waveguide
- Missions from the 2000's
- Conclusion

Explorer 1

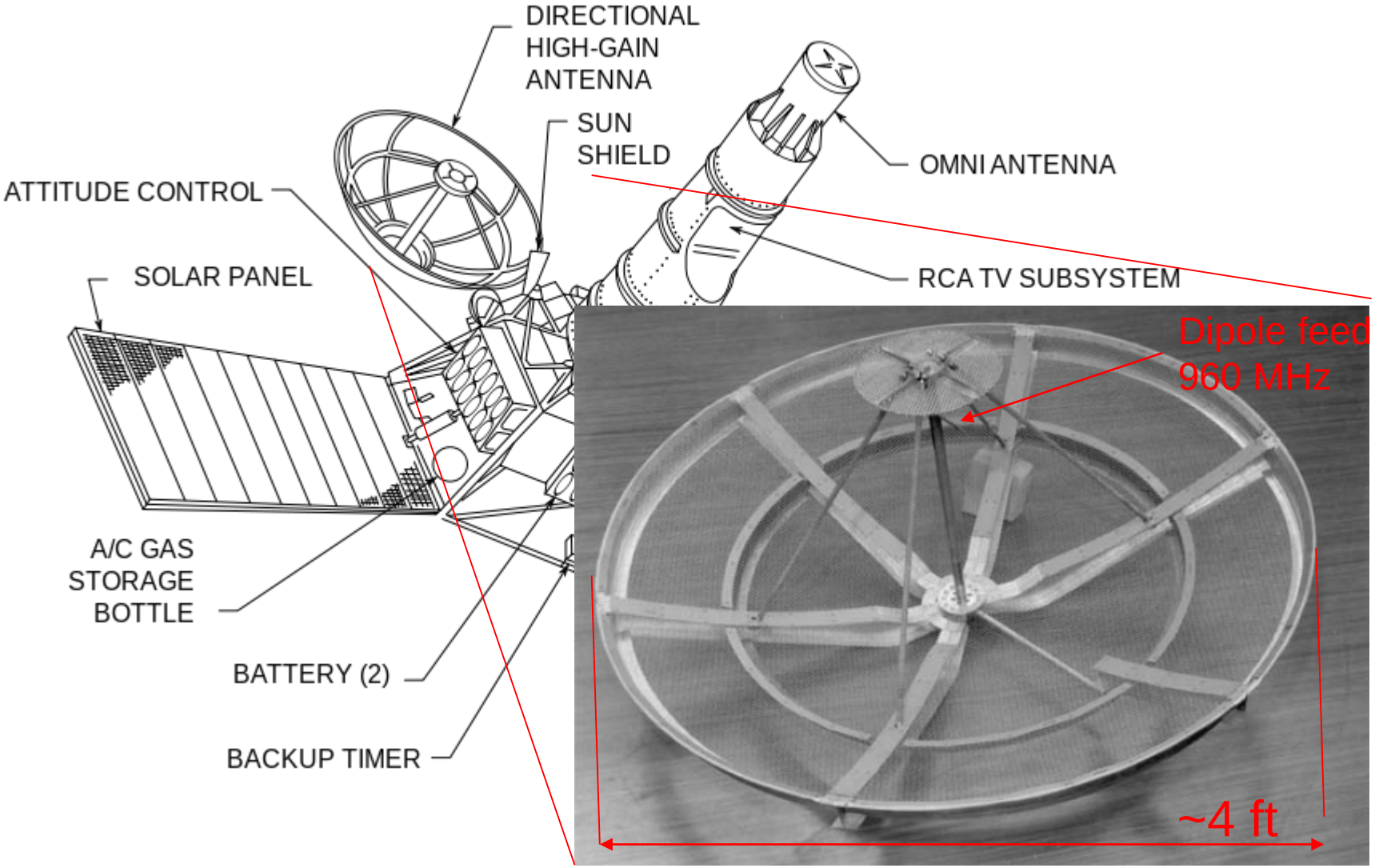
Pioneer

Pioneer 4 Spacecraft

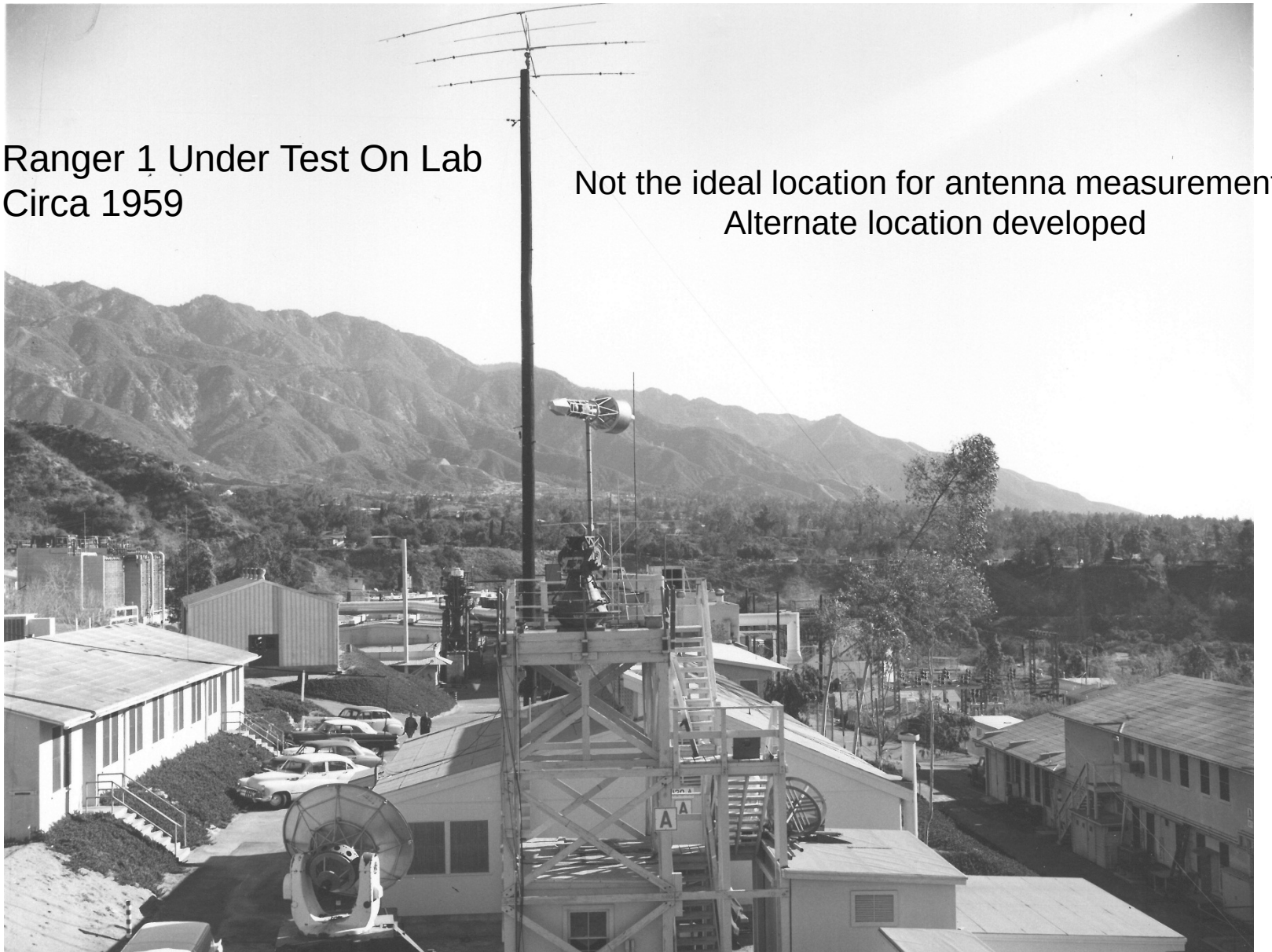
- Pioneer 4 - March 3, 1959
- Used a dipole consisting of a lower cone and upper probe
- Operated at 960 MHz.
- Goal was to do close flyby of moon for photos Trajectory was off and could not get clear pics

~12”

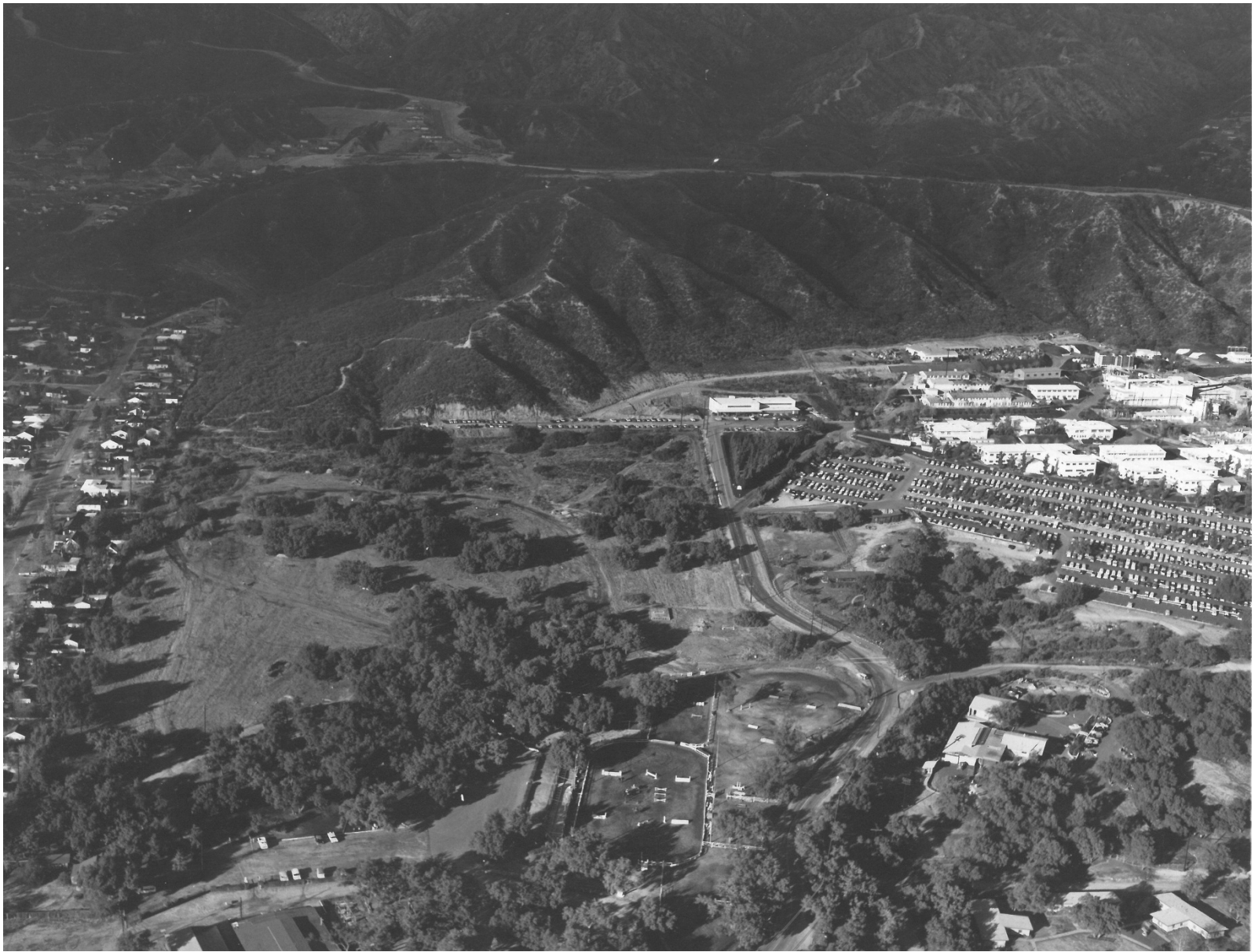
Ranger


DIRECTIONAL HIGH-GAIN ANTENNA
SUN SHIELD
OMNI ANTENNA
ATTITUDE CONTROL
SOLAR PANEL
RCA TV SUBSYSTEM
A/C GAS STORAGE BOTTLE
BATTERY (2)
BACKUP TIMER
Dipole feed 960 MHz
~4 ft

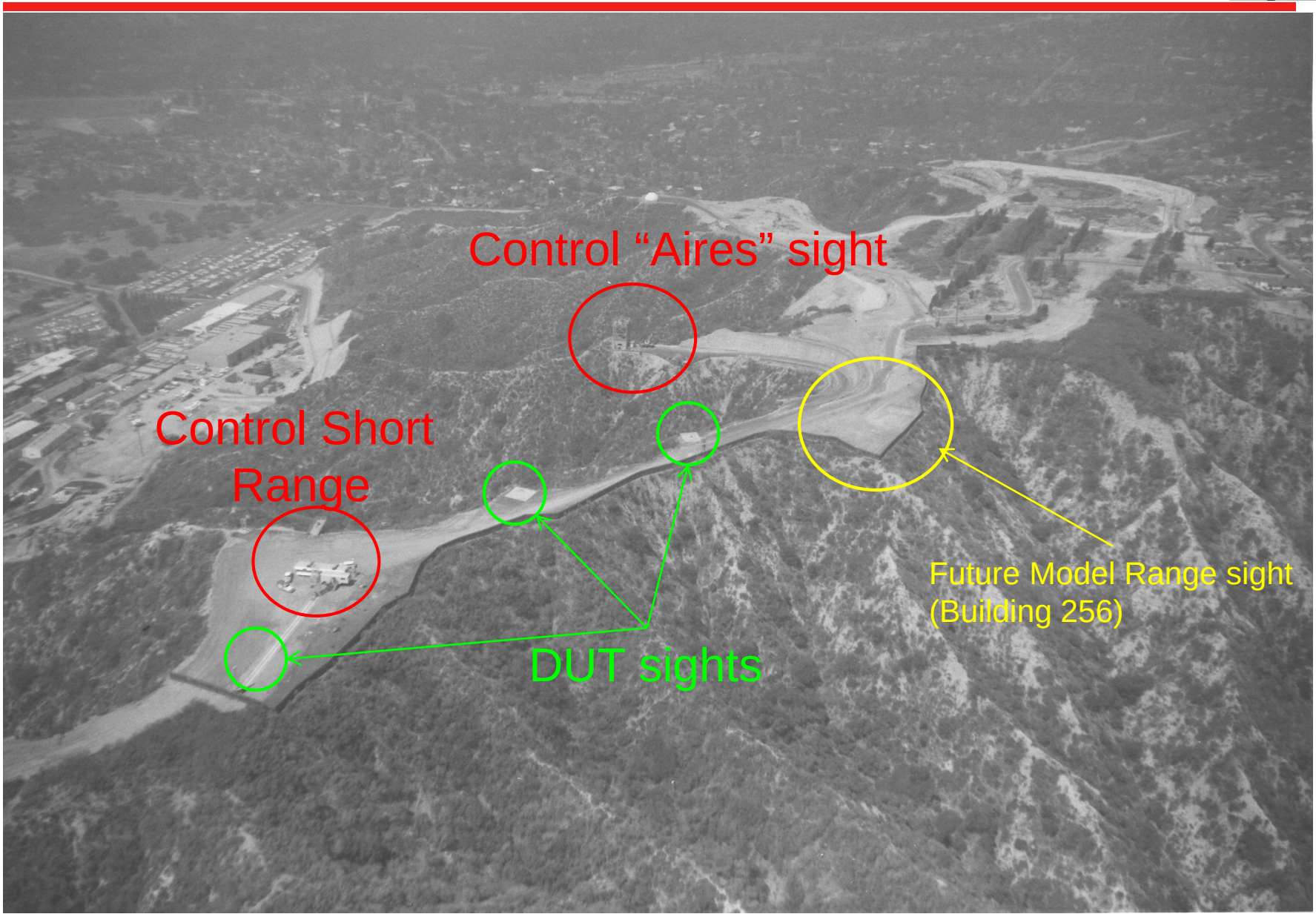
Ranger 1 Under Test On Lab
Circa 1959



JPL Circa 1958



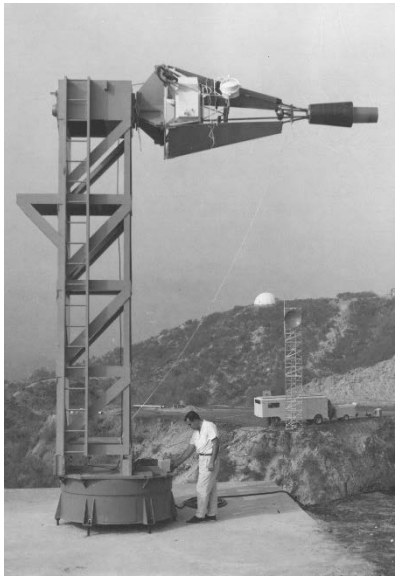
Mesa Circa 1960
Original Antenna Test Operations



Mesa Circa 1960
Original Antenna Test Operations

Transmit sight &
Test operations trailer

Ranger 2 (Lunar Orbiter)
Launched Nov 1961

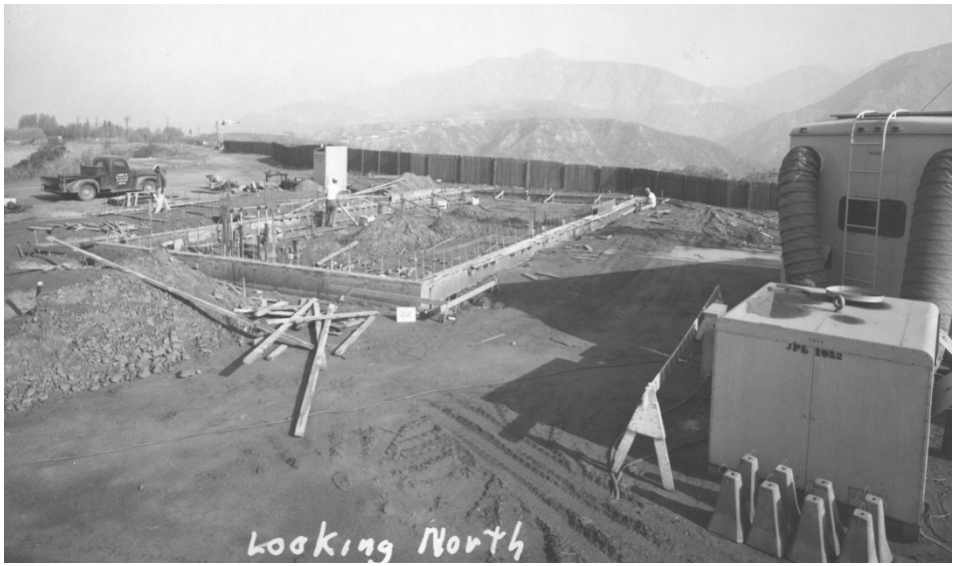


Building 212 Plan Circa 1960

AUSTIN · FIELD & FRY A.I.A. ARCHITECTS & ENGINEERS
WHEELER & GRAY STRUCTURAL ENGINEERS
HOLLADAY & WESTCOTT MECHANICAL & ELECTRICAL ENGINEERS

ANTENNA RANGE LABORATORY
BUILDING 212 JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY

Building 212 Circa 1961



Jet Propulsion Laboratory
California Institute of Technology

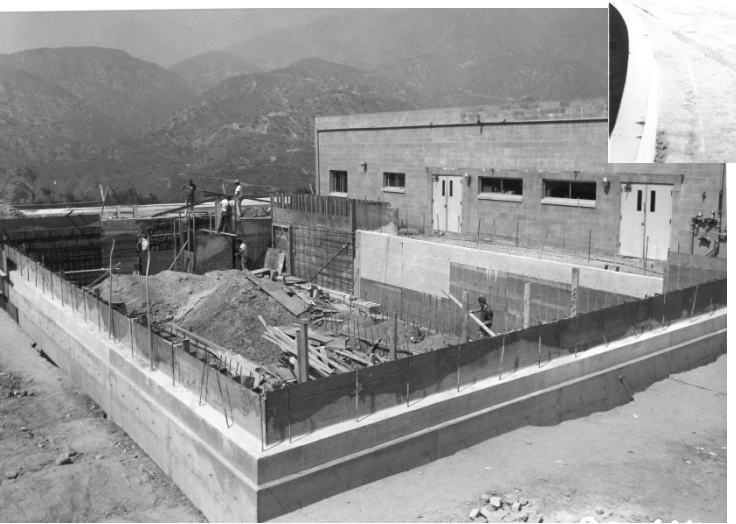
Mesa Extension #1
1964

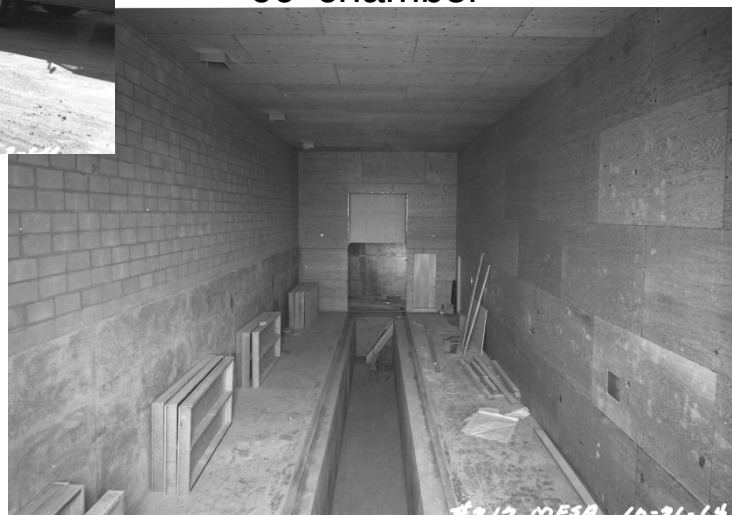
JPL Mesa Antenna Test Facility

Foundations
2x subterranean chambers

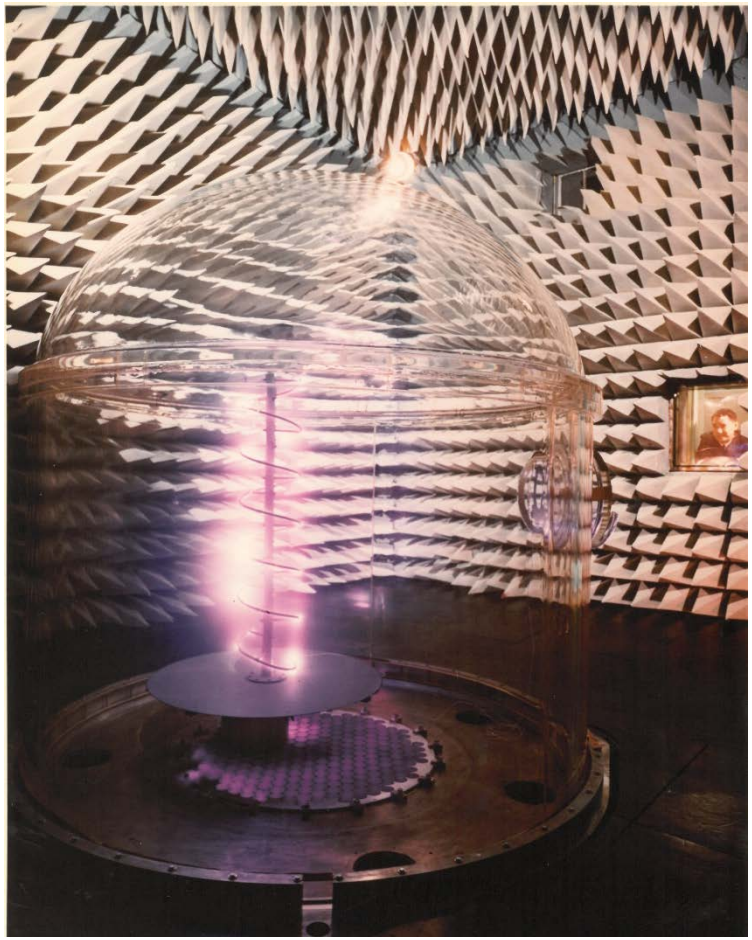
Upper Level Office Space

60’ chamber



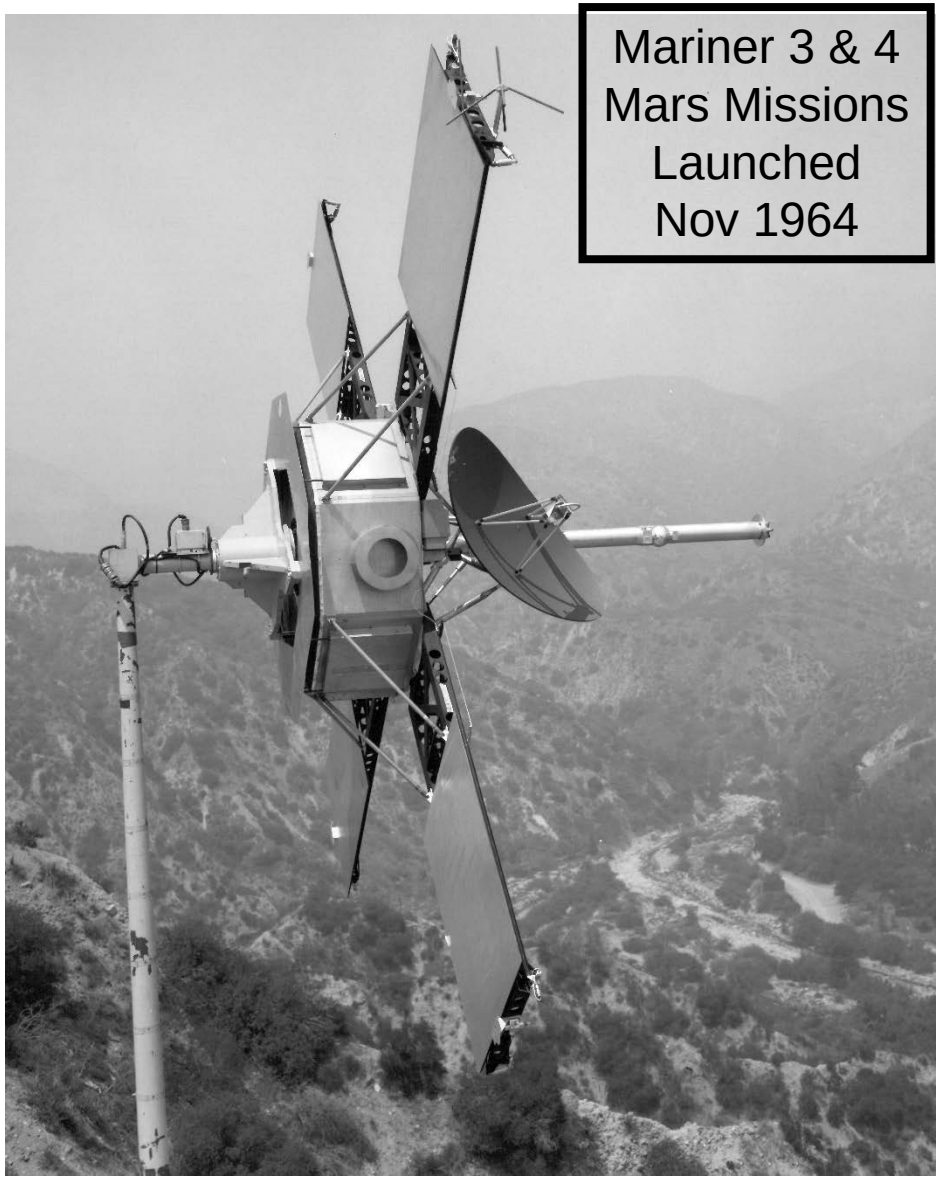


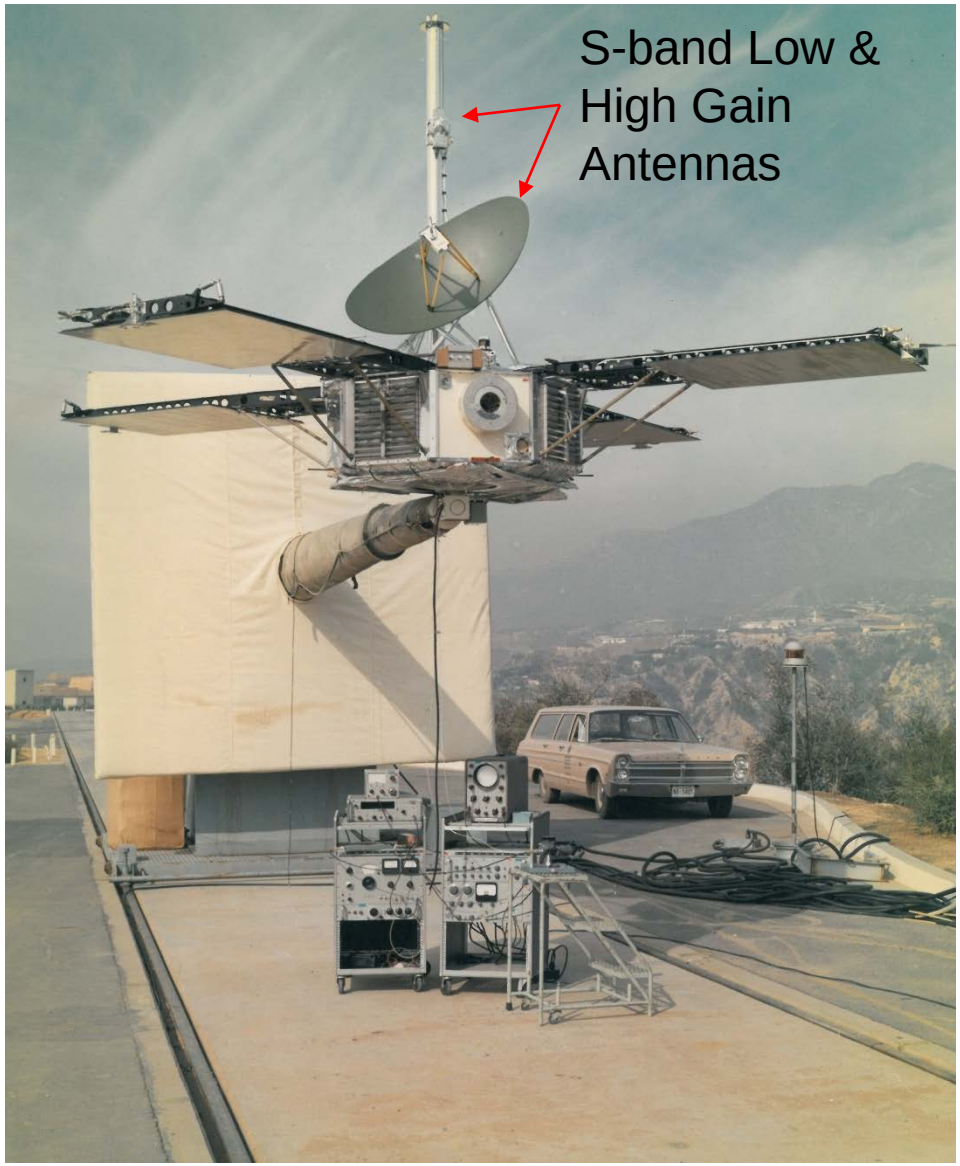
Mesa Extension #2
High Power Vacuum Chamber



Not too long after the Indoor chamber extensions the vacuum bell jar chamber is erected

Mariner 3 & 4 1964



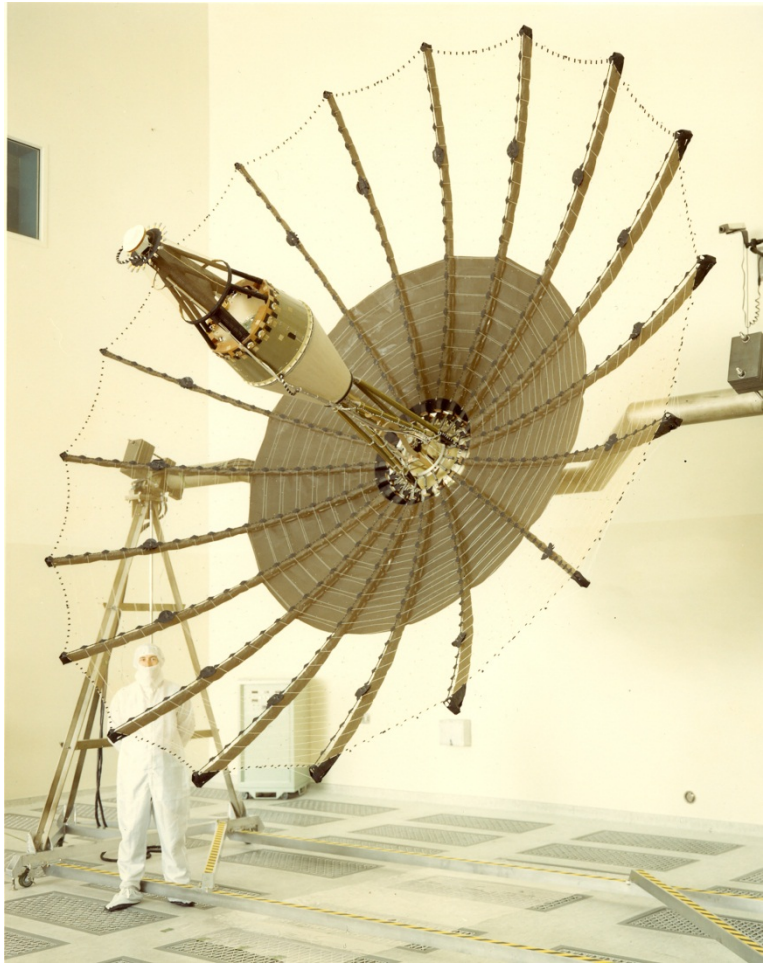


Mesa Circa 1970

Galileo Circa 1983-86

Galileo
Mission to Jupiter
Launched: Oct 18, 1989

4.76 m diameter S/X-band Galileo High Gain Antenna in Mesa 40' chamber
Measured using a custom developed plane-polar near-field technique

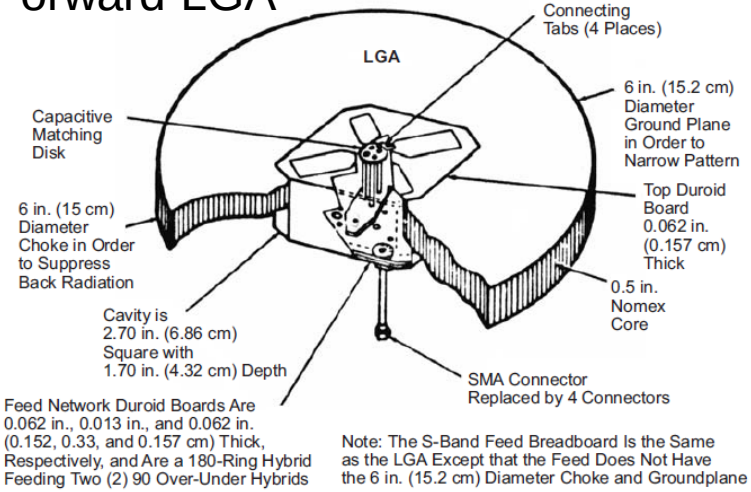


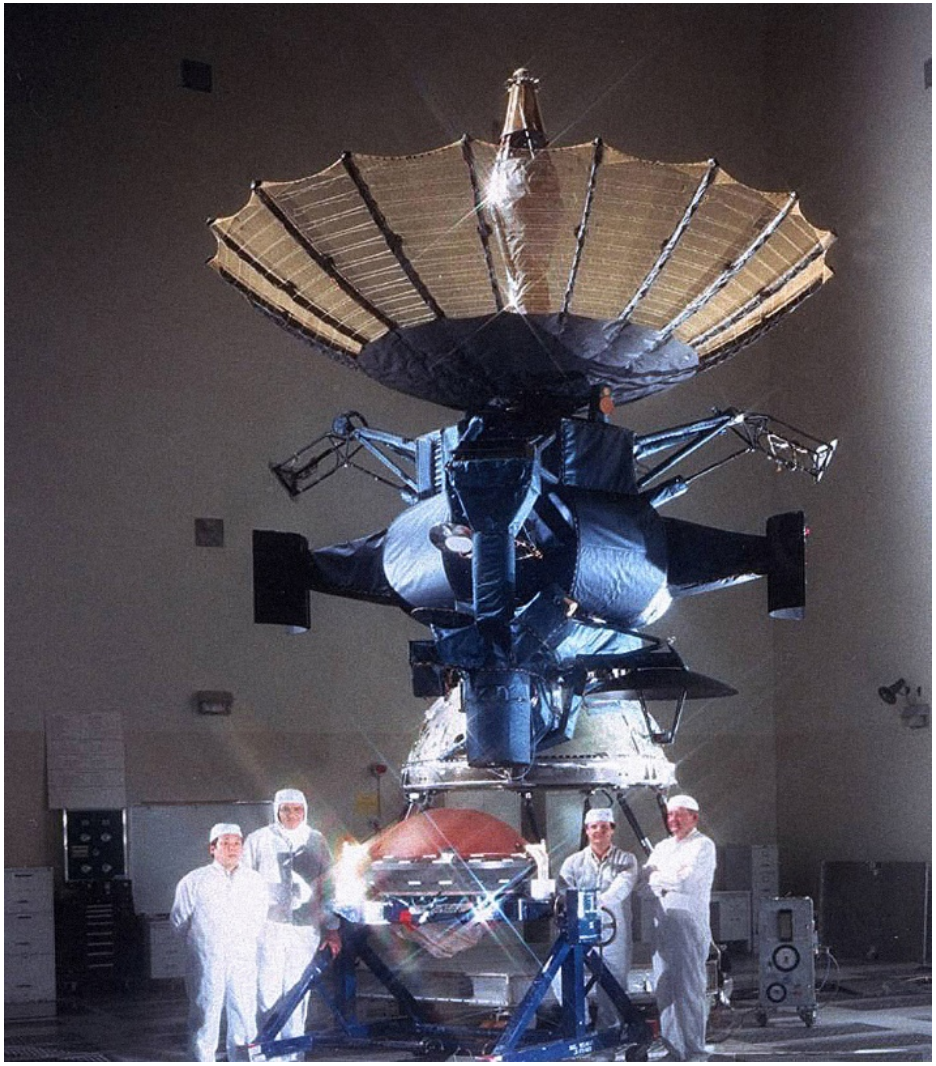
Plane Polar Near Field Test Facility

- Plane polar range setup in 40 ft Long x 20 ft wide x 20 ft high chamber
- Viking Orbiter S-Band High Gain Antenna used to test measurement approach

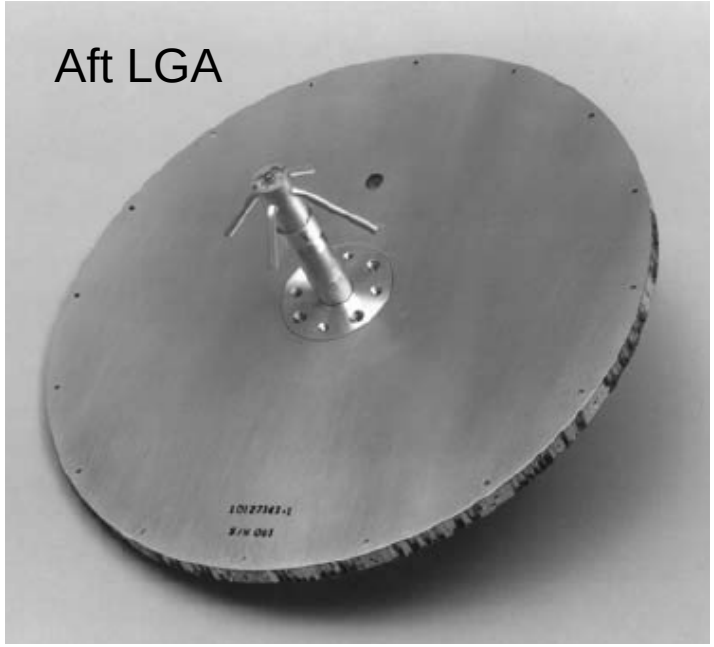
Best Laid Plans …: Mission completed using LGAs

Forward LGA





Aft LGA



From Plane Polar to Cylindrical Near-Field

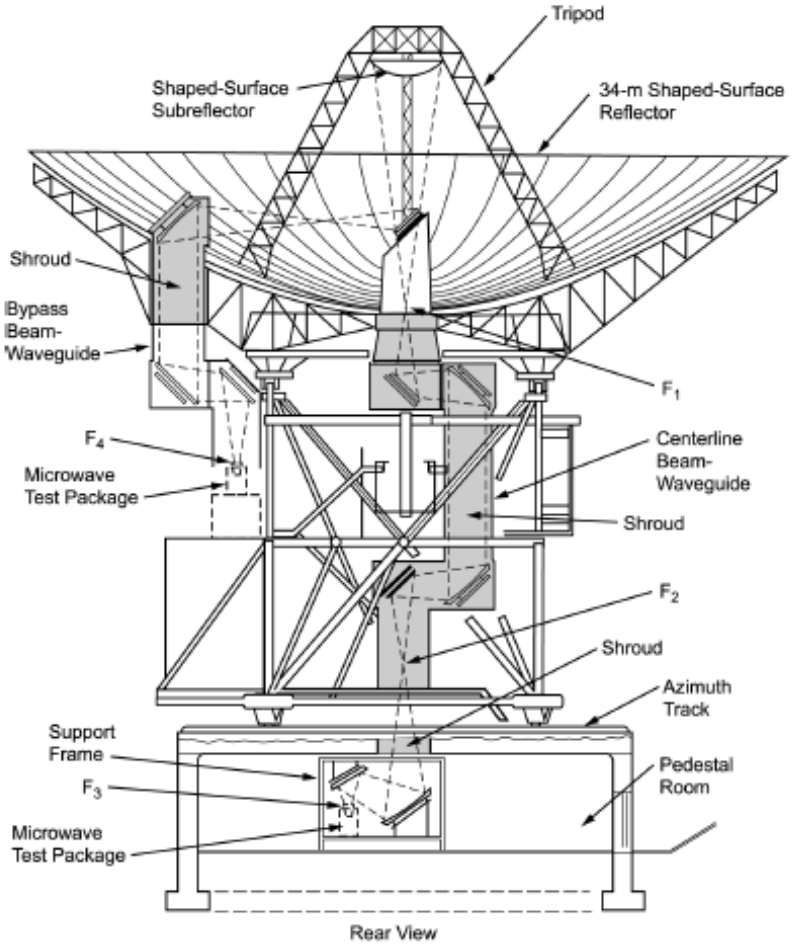
NSCAT
Earth Ocean Winds
Mission
Launched: Aug 1996

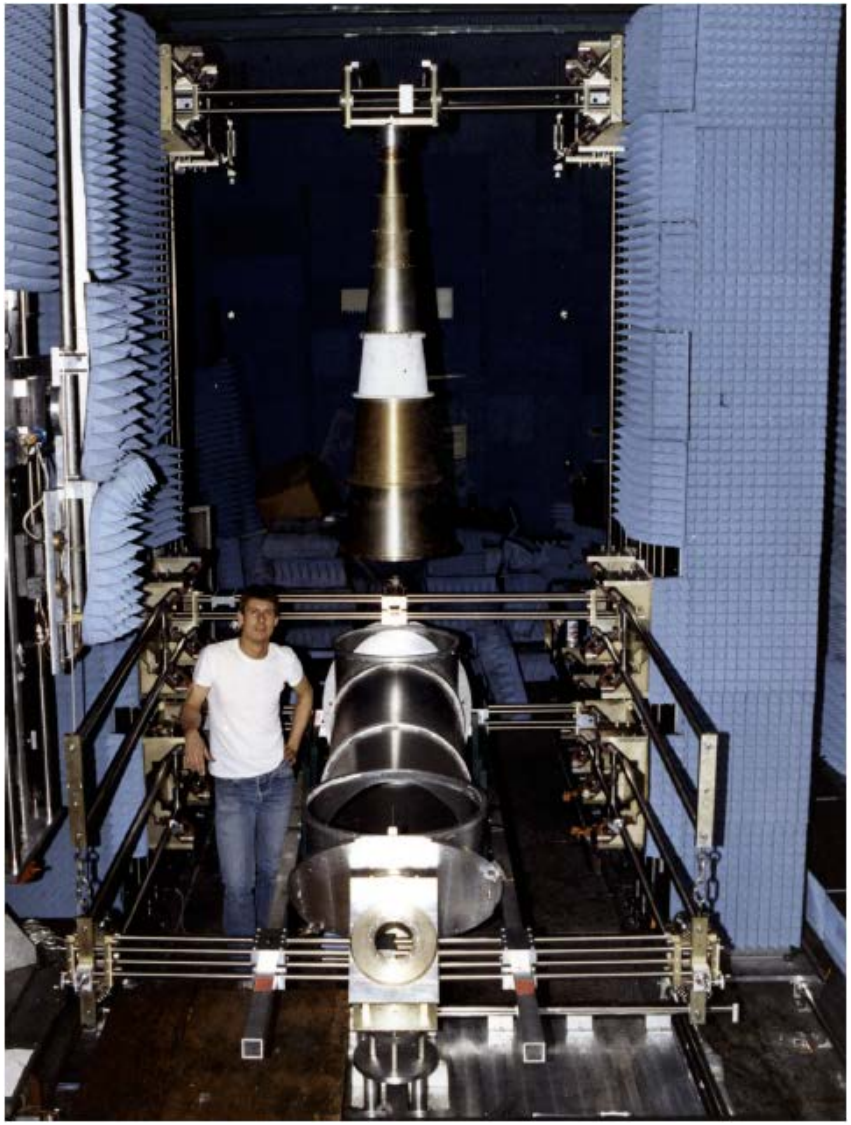
NSCAT Antenna Element measured in Mesa 40’ Chamber using custom developed Cylindrical Near Field Approach

This Cylindrical NF setup still heavily used today

Deep Space Network Beam Waveguide Development

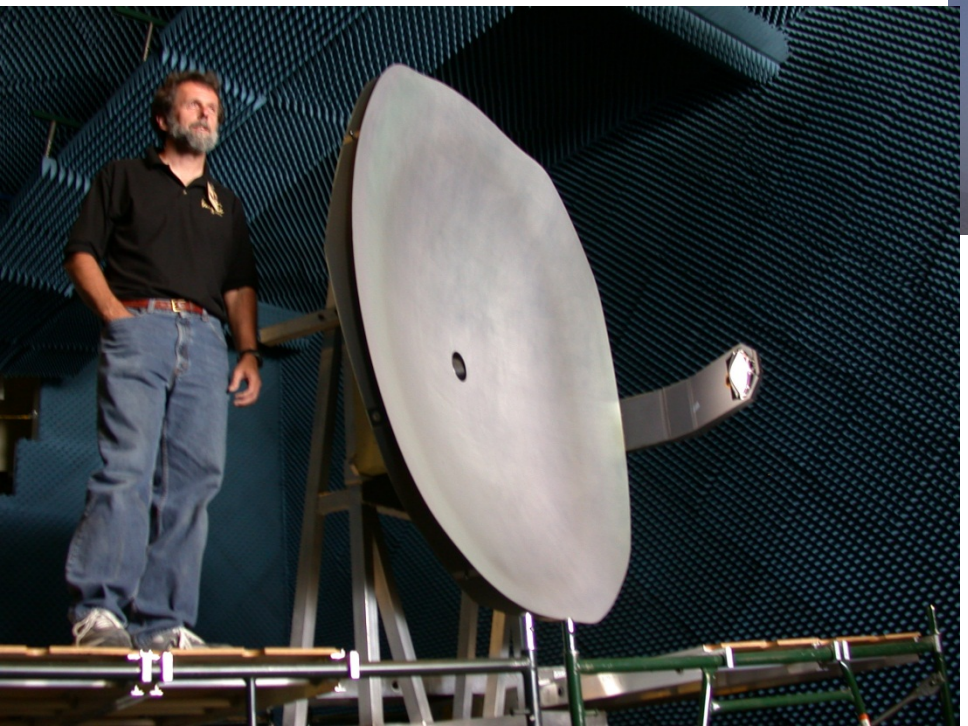
Late 1980's saw expansion to Ka-band and introduction of Beam waveguide





Cloudsat Antenna Circa 2001

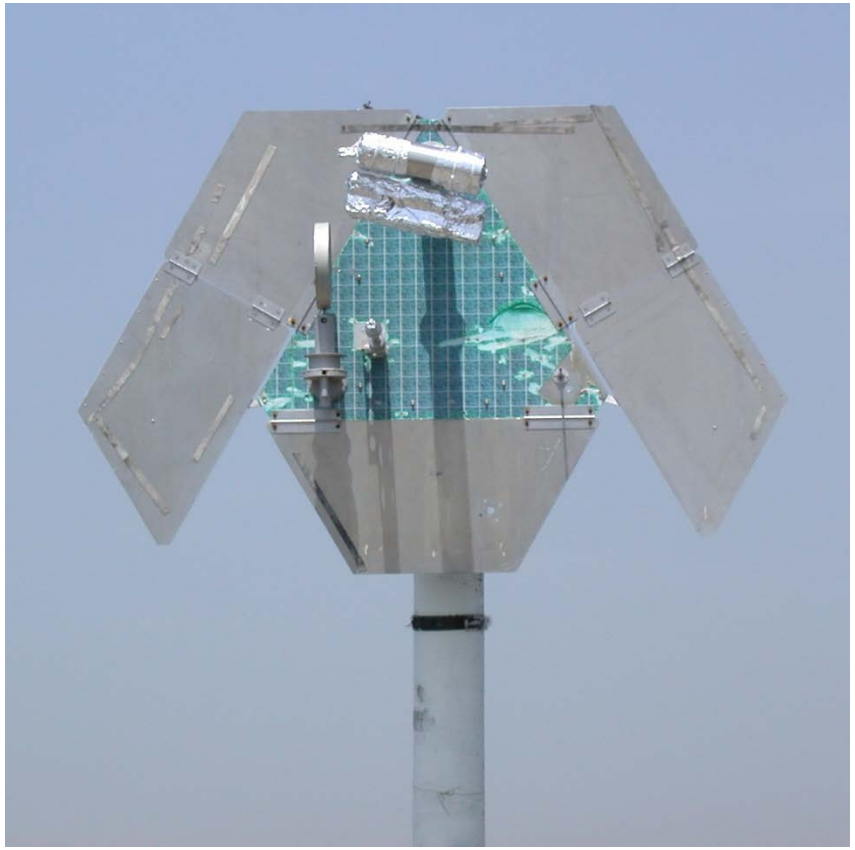
Cloudsat
94 GHz Earth Cloud radar
Launched: April 2006



Cloud Sat Antenna Measured on 3000' range (top left) and in the Mesa 40' chamber using the cylindrical NF scanner (bottom left)

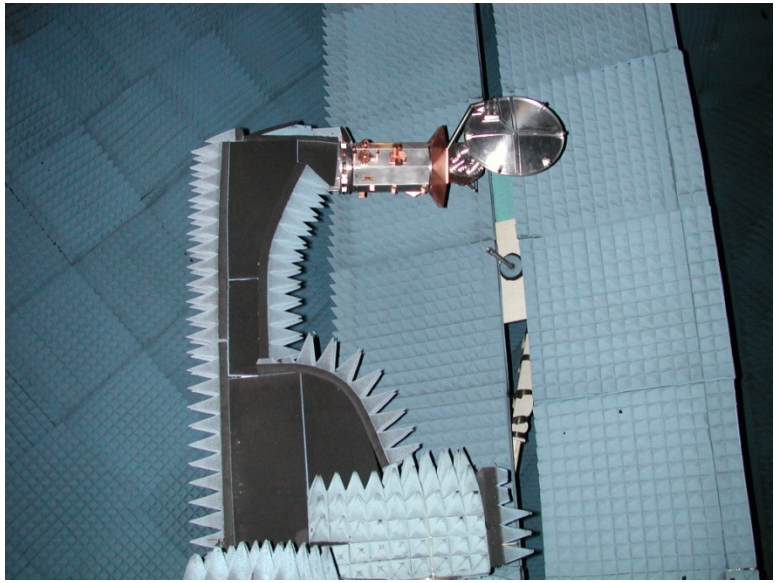
Mars Exploration Rover
Circa 2003

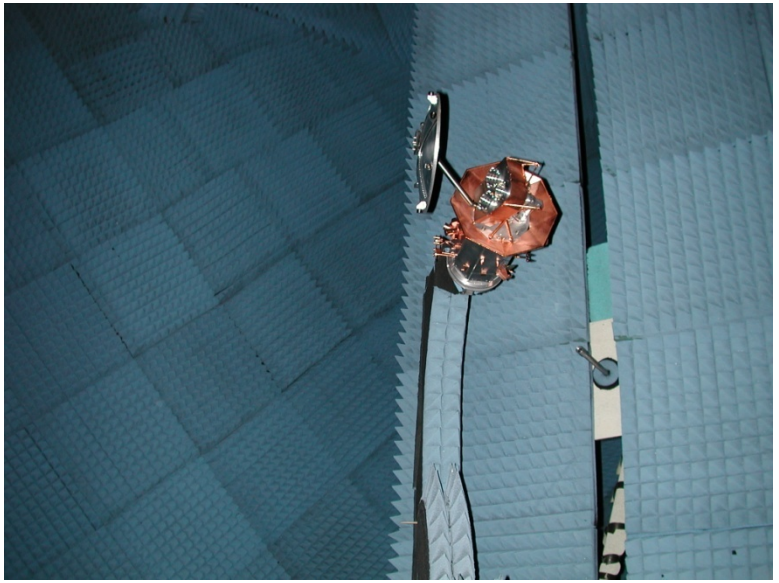
Mars Exploration Rover
Mission to Mars
Launched
Jun & July 2003

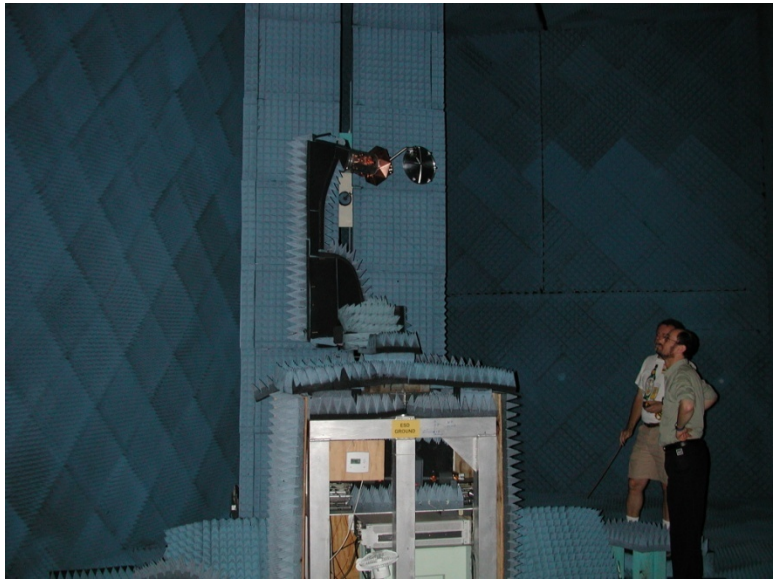


MER Rover Mockup

Aquarius Scale Model 2006



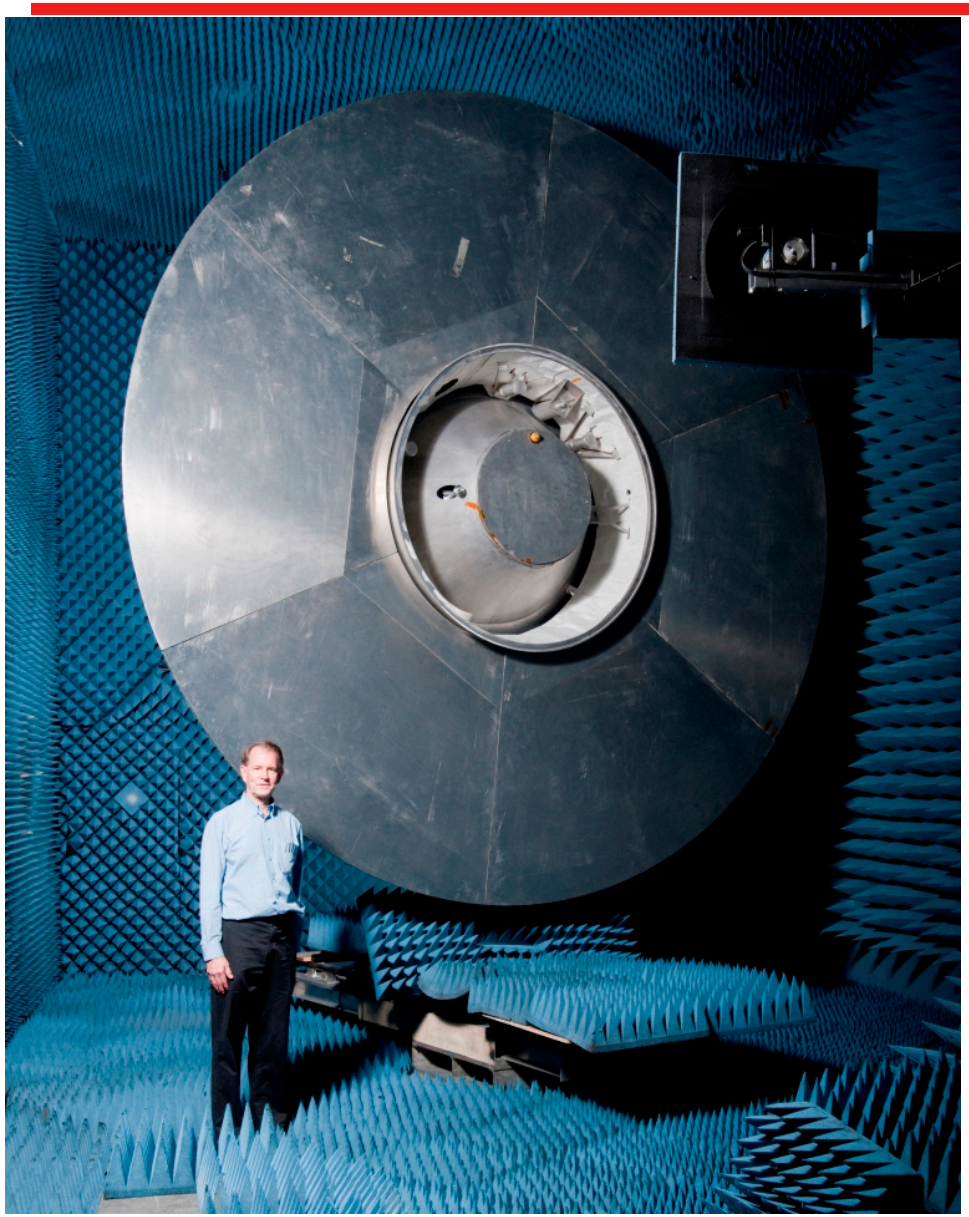




- Aquarius Scale Model Measured in the Mesa 40’ chamber using the cylindrical NF scanner
- L-band system scaled by ~1/10 for testing at Ku-band

Aquarius
Mission to measure Earth Ocean Salinity
Launched: June 2011

Mars Science Laboratory Cruise Stage Mockup 2010

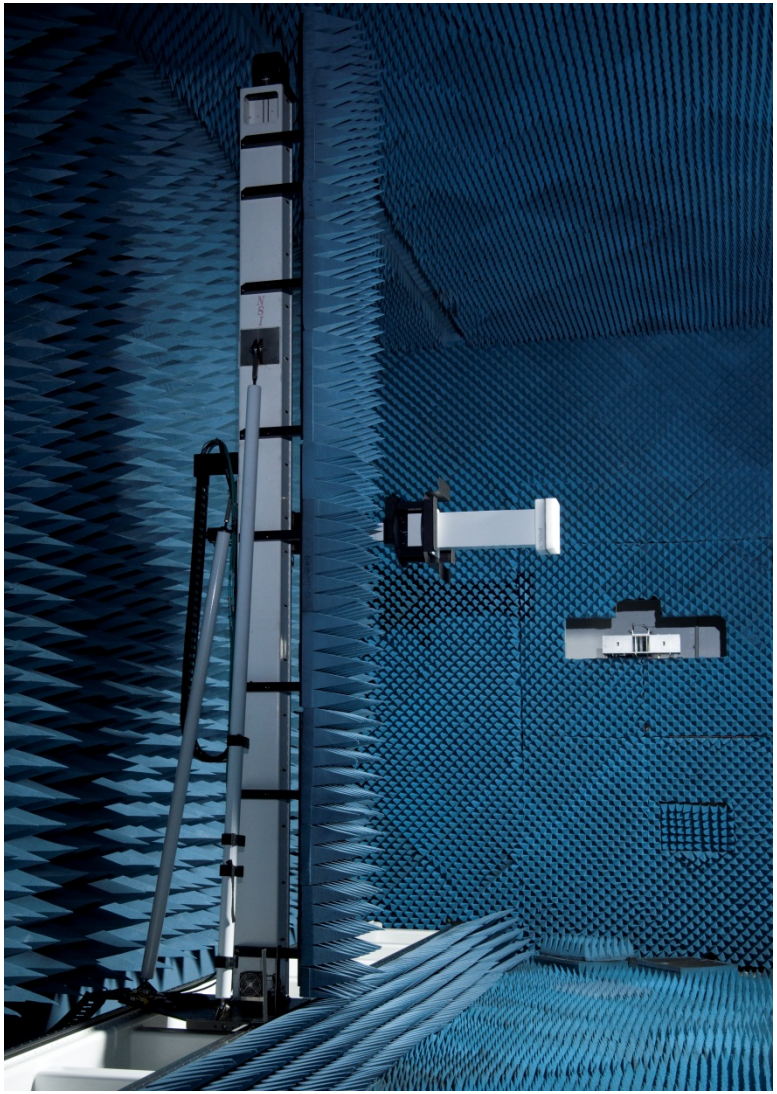


MSL Cruise Stage Mockup measured in Mesa 60’ chamber using a custom spherical near-field scanning approach

MSL
Mission to Mars
Launched: Nov 2011

Newest Addition
Planar Near-field Scanner
2008

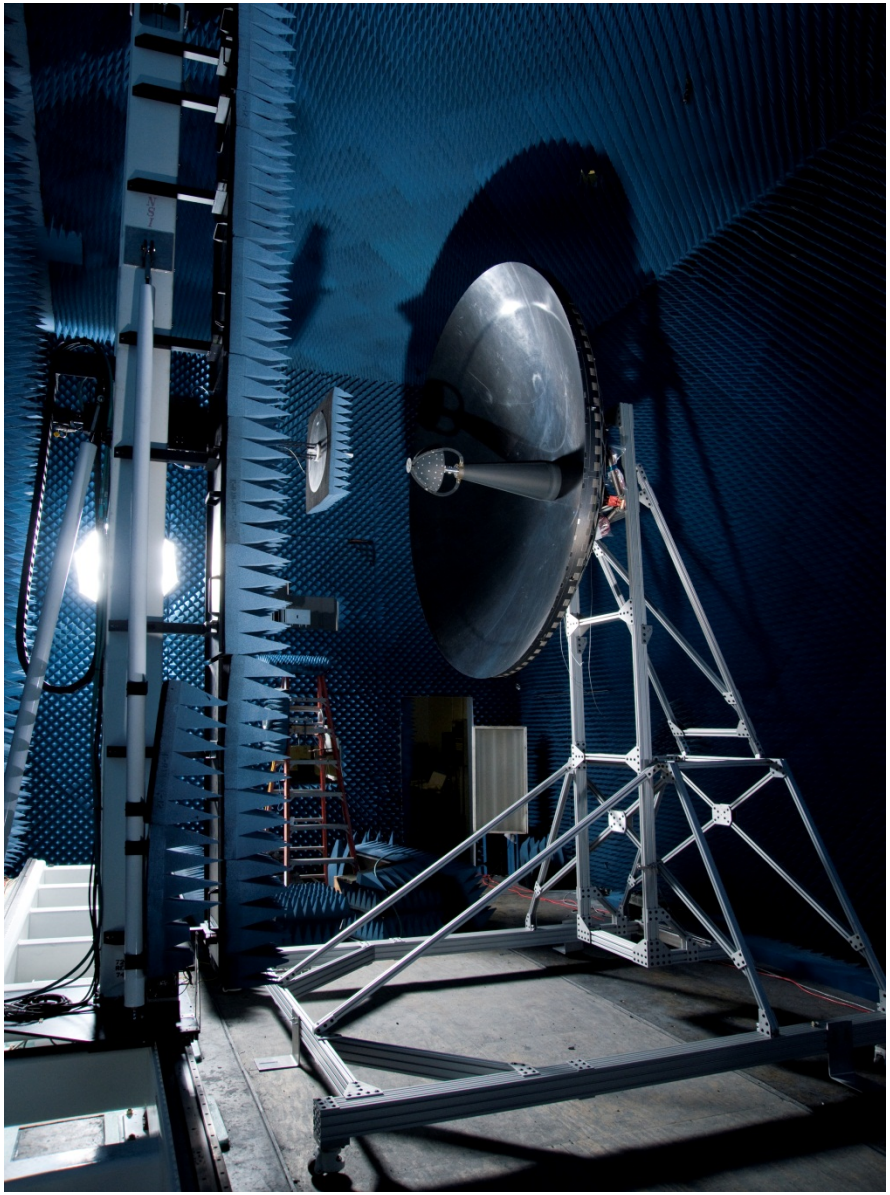
Installation of 30'x15' planar near-field scanner in Mesa 60' range for operations from L-band – Ka-band



Juno High Gain Antenna 2010

Juno
Mission to Jupiter
Launched: Aug 2011

Arrives at Jupiter on July 4, 2016



Juno High Gain Antenna measured in the Mesa 60' chamber using the 30'x15' planar near-field scanner

Conclusions

- As NASA missions have advanced – new antenna types and associated measurement capabilities have been required
- We continue to evolve the antenna designs to larger apertures and with very tight antenna pattern knowledge.
- Near-field techniques measurement techniques have helped to meet our metrology requirements
- Antenna Modeling has moved further to the fore with measurement providing model validations