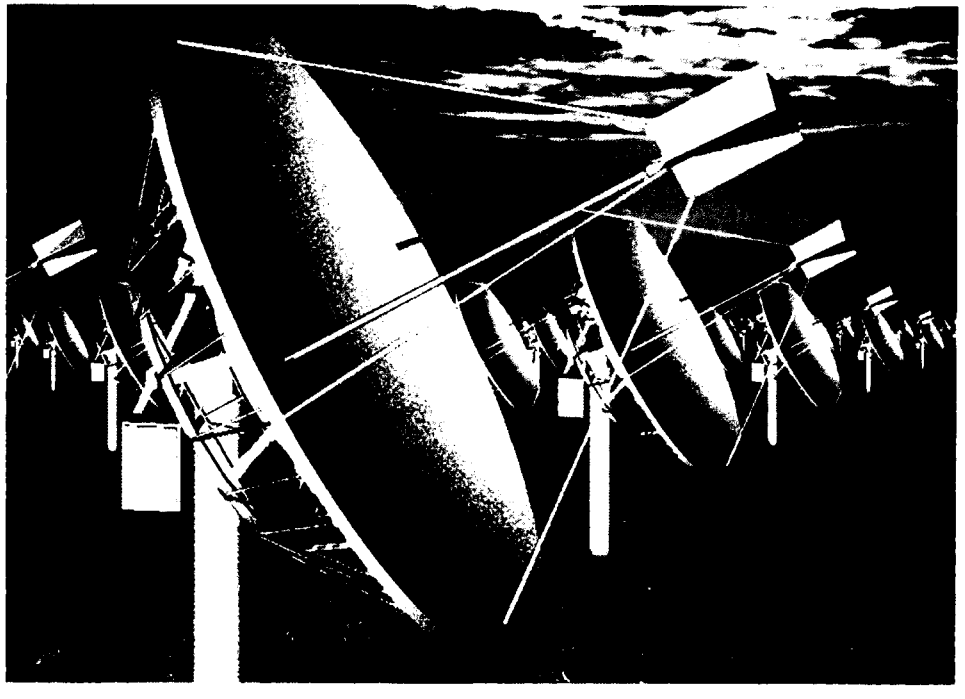
DSN Microwave Array Peer Review: Feeds/LNA/Cryo



Introduction to the DSN Microwave Array

Mark Gatti

December 18, 2003

What Leads to the DSN Array Development?

Mission Drivers:
- **Increase science data return**
- **Reduce DSN service unit costs**

Spacecraft Design Solutions:
- Increase transmission power
- Higher bandwidth

DSN Architecture Solutions:
- **Increase DSN apertures**
- Higher bandwidth
- Efficient utilization of apertures

DSN Design Options:
- Build more monolithic large antennas
- **Build large array of small RF antennas**
- Build optical communication telescopes

Validation Approaches for Cost Effectiveness:
- **Validation via breadboard**
- Validation via prototype array

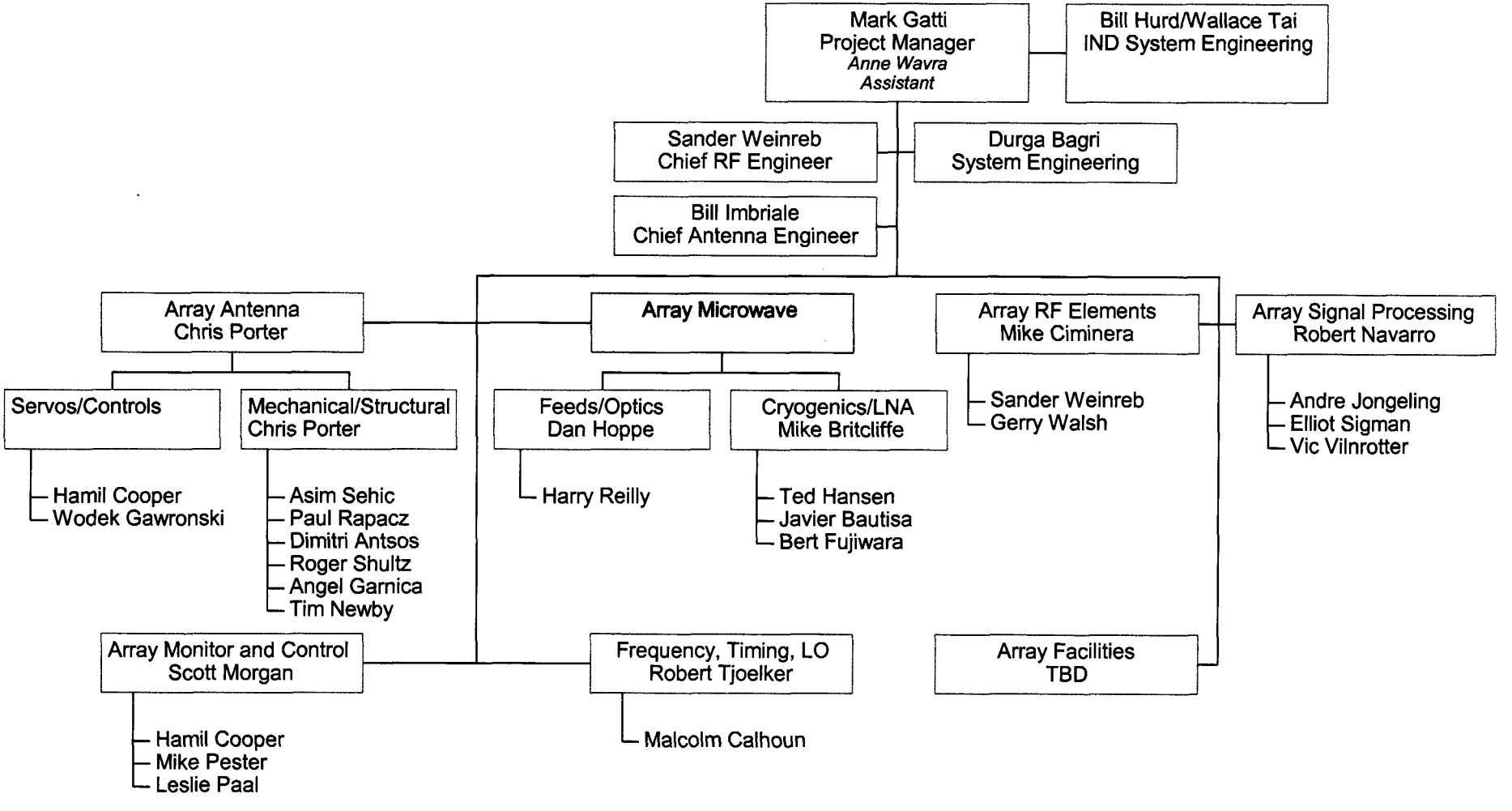
Spacecraft Data Rates (s/c limited)

Mission	Destination	S/C (limited) data rate at min Range	S/C data rate at max Range	Data Rate at all ranges with Array	Array Size that Guarantees max data rate	Date of Use
MRO	Mars	5.3 Mbps	500 Kbps	5.3 Mbps	75-100	'05 - '10
MRO (Ext msn)	Mars	5.3 Mbps	500 Kbps	5.3 Mbps	75-100	'10 - '15
MTO	Mars	10.6 Mbps	535 Kbps	10.6 Mbps	100	10/09 - 8/20
MSL (DTE)	Mars	10 Kbps (34m)	1 Kbps	8.5 Kbps (34m)	<100	'09
Cassini (Ext msn)	Saturn	165.9 Kbps	40 Kbps	165.9 Kbps	60-100	6/08 - 6/10
JIMO	Jupiter	20 Mbps	10 Mbps	20 Mbps	100	4/11 - 3/21
New Horizons	Pluto, Kuiper Belt	104 Kbps	10 bps	104 Kbps	100	10/06 - 3/17
Solar Probe	Solar	62 Kbps	25 Kbps	62 (25) Kbps	100 (40)	5/10 - 7/17

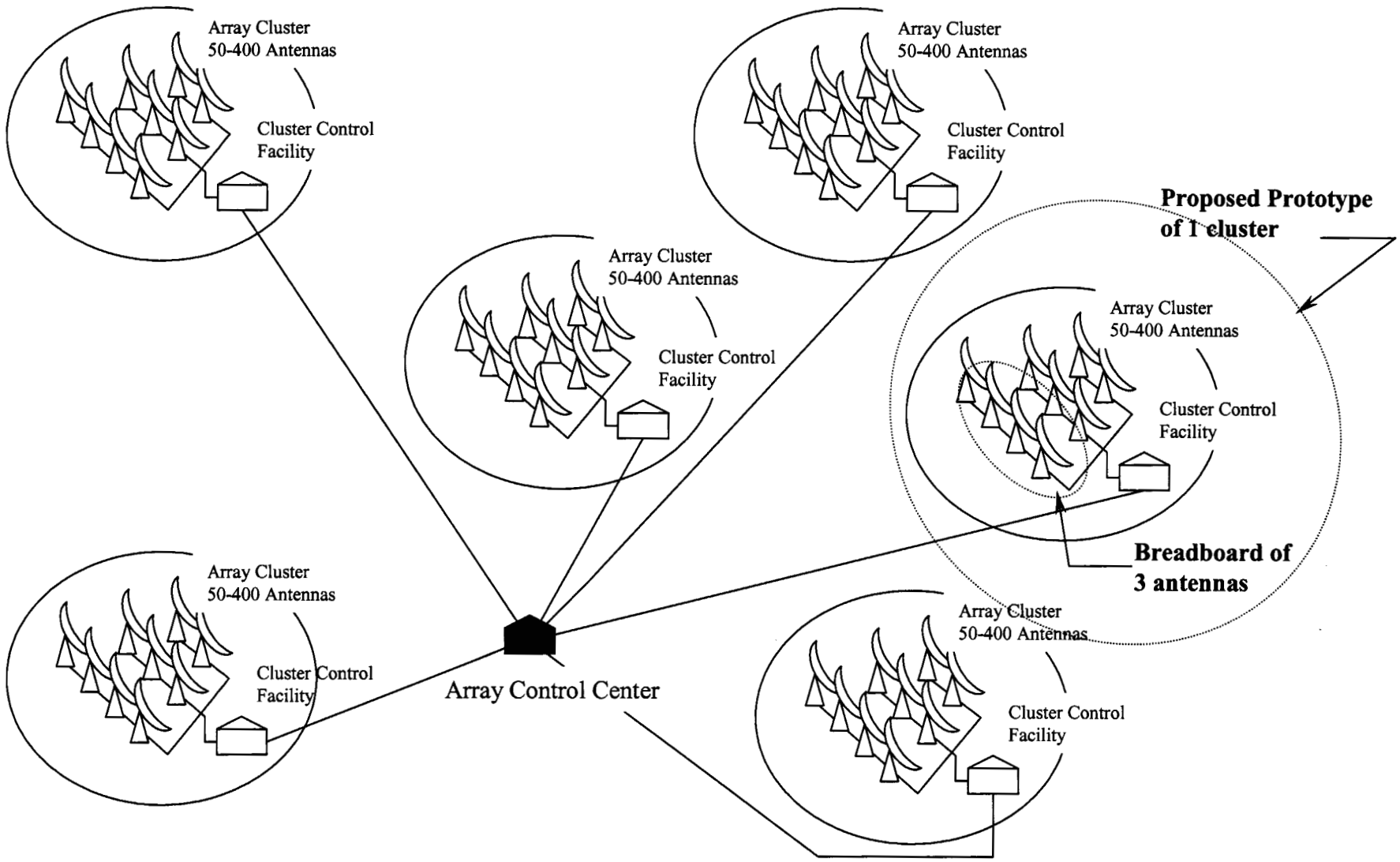
The need for more ground capability

- Deep space mission scientists desire orders of magnitude increased communications capability with their missions.
  - End-to-end improvement
    - Split between both flight and ground systems.
    - For the DSN it is desirable to attain at least 40x the current X-band capability of the 70m antennas for each longitude
- Recent advances in reflector antenna manufacturing and electronics cost and parametric studies of cost-vs-antenna size suggest that the optimum antenna size for a large array is approximately 12 meters.
  - An X-band array of 400 x 12m antennas with high aperture efficiency would provide approximately 10x the effective area of the 70m
  - Increasing frequency to Ka-band would provide another factor of greater than 4 in data capacity
    - Therefore a Ka-band 400 x 12m array provides approximately 40x data capacity of current X-band 70m

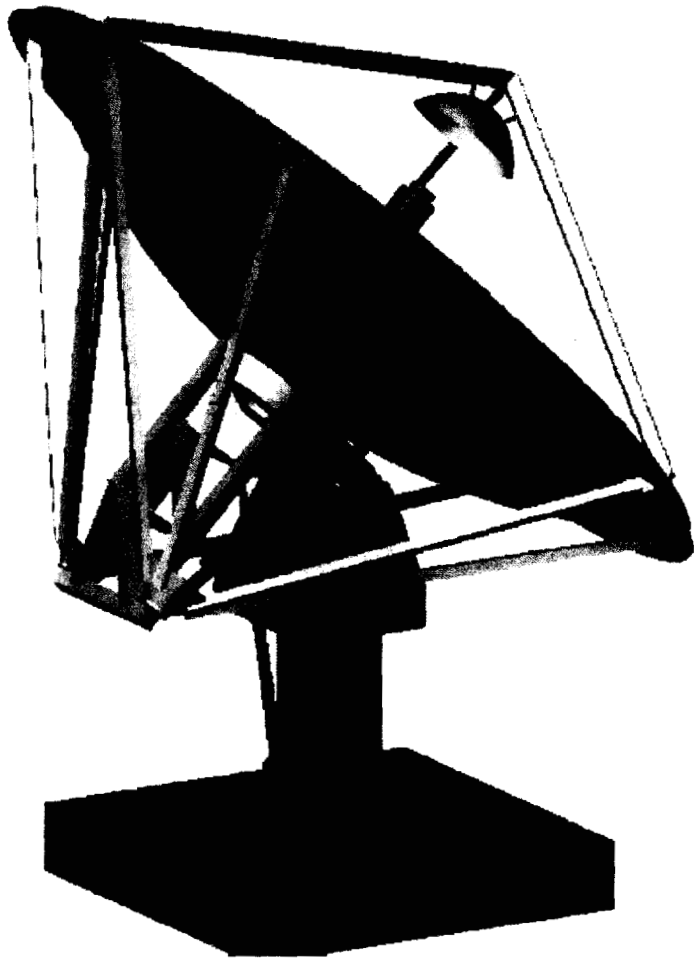
Organization

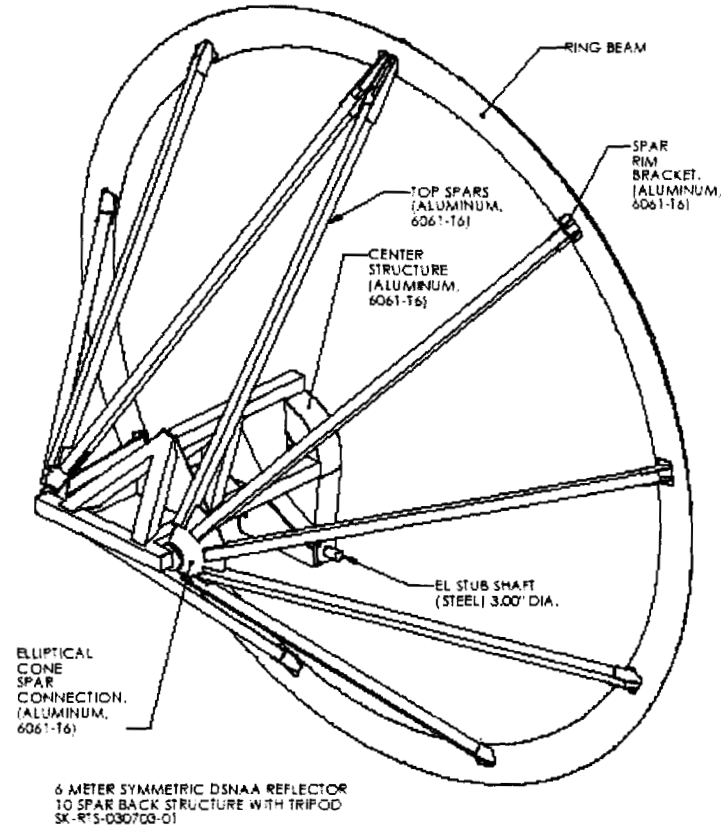


DSN Array Multiple Cluster Concept



6-m Breadboard Antenna





Breadboard Array

- In order to develop needed technologies, become familiar with the array system concept, and determine elemental costs, a breadboard array will be constructed at JPL/Caltech.
  - Three antennas
  - 6m size
    - Symmetric design
    - Hydroformed main/subreflector. (Potentially use composite reflector on the same mount)
    - Modified feed to operate at DSN bands
  - Electronics, signal processing, local oscillators, monitor and control
    - Technology developed will be used for the 12m array
  - Will be used as technology development test bed
  - Located at JPL (2) and Caltech (1)

Peer Review Process

- The Peer Review Process was mandated by the Project Manager
- Consider development of the breadboard
- Technical in nature
- Discuss options for development of 12m system
- "Informal"
  - No "Board"...instead a team of technical peers (both internal and external)
  - Notes *will* be recorded
  - Recommendations for Action are solicited
  - Memo written by organizer to document review.
- Costs discussed consistent with JPL Policies at the conclusion of the review
  - Non JPL employees are welcome to relax outside the review venue

Considerations for Technology Development

- As technologies are developed, there are several important considerations
  - Cost
    - The expectation is that the *total* array cost will be 10-20% of the cost of an equivalent 70m aperture
  - Ability to be fabricated in high quantities
  - Reliability/Long life
    - The mean time before failure (MTBF) requirement effects the maintenance of the array system
  - Automation
    - Systems that lend themselves to automation should be so.
  - Cost
    - Repeated here to emphasize the most important consideration

Review Team

- Todd Gaier, Principal Staff, Astrophysics Instrumentation Group, JPL Section 386
- Richard Hodges, Group Supervisor, Spacecraft Antennas Group, JPL Section 336
- John Sosnowski, Senior Engineer, Antenna Microwave Engineering Group, JPL Section 333
- Ron Ross, Group Supervisor, Advanced Thermal and Structural Technology Group, JPL Section 354
- Leo Fong, President of Quinstar Technology
- Jeff Childers, Microwave Engineer, Spacek Laboratories

Objectives

- Review the status of the DSN Feeds/LNA
- Identify areas in the work area (and across the system) that need additional attention.
- Review the plans for the development of the subsystem
- Review plans for development of a PDCR-level review for the DSN Array
- Note our issues and recommended solutions
- Gather input to help guide our activities

Agenda for Today's Review

- 1:00 - 1:10 Introduction (M. Gatti)
- 1:10 - 1:15 Microwave Subsystem Overview (W. Imbriale)
- 1:15 - 1:35 RF Optics Design (W. Imbriale)
- 1:35 - 2:15 X/Ka-band Feed (D. Hoppe)
- 2:15 - 2:35 MMICs (S. Weinreb)
- 2:35 - 3:15 MMIC Packaging and Test and Ka-band LNA (J. Prater)
- 3:15 - 3:25 LNA DC Bias Module (S. Weinreb)
- 3:25 - 3:35 Noise Calibration Source (S. Weinreb)
- 3:35 - 4:30 Cryocooler and Front-End Integration (M. Britcliffe)
- 4:30 - 4:45 Discussion (All)