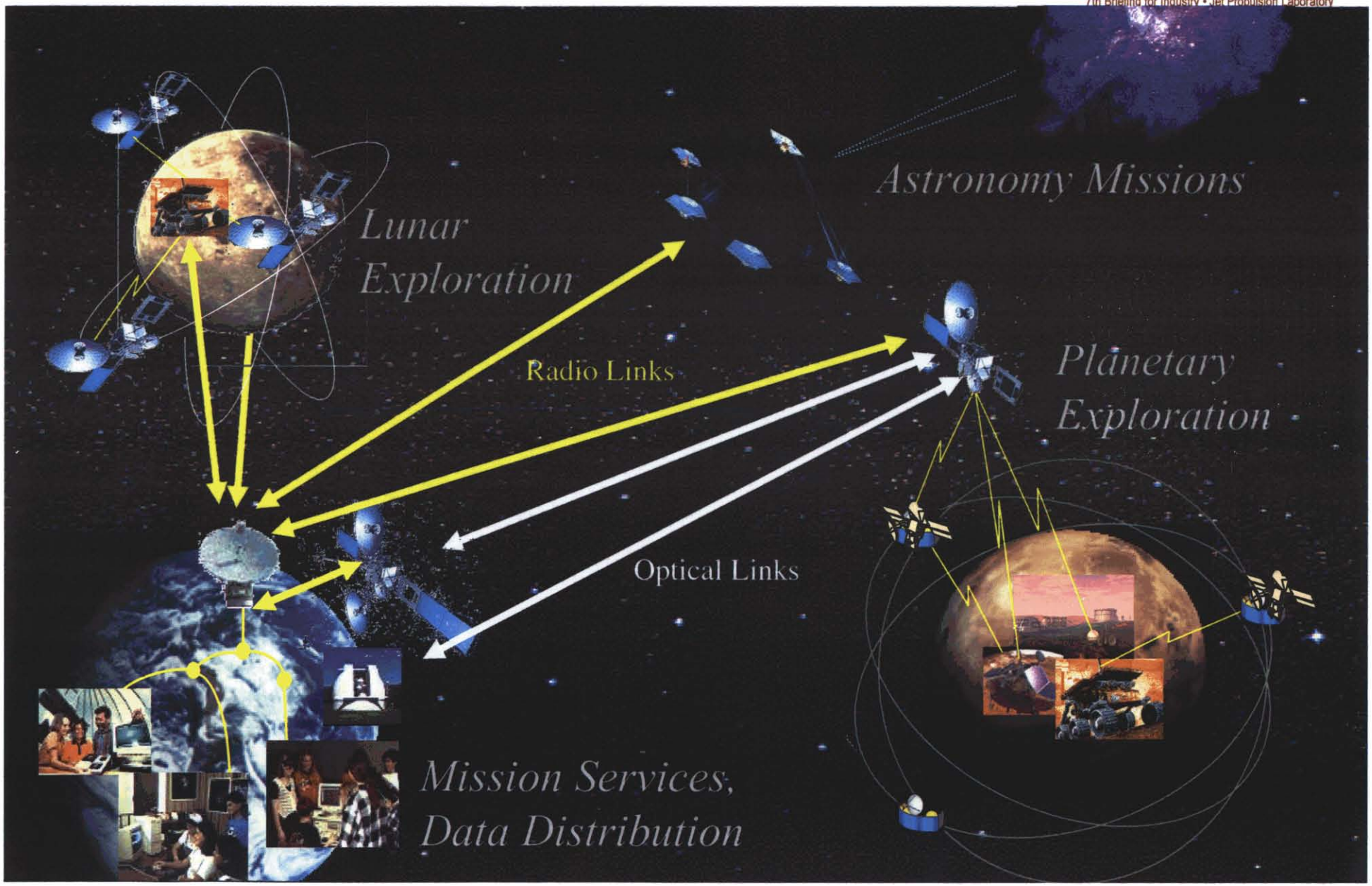
Interplanetary Network Directorate

Bill Weber

Director

The Interplanetary Network:
Enabling NASA's Exploration



Attributes of the Interplanetary Network

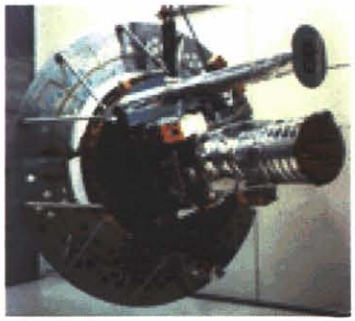
- Reliable
- High Performance
  - Minimum of 1000x performance gain by 2030
- Cost-Effective
  - Standard, inexpensive interfaces
- Architecture for growth
  - Communication and navigation assets operating seamlessly across the solar system
  - Planetary local area networks with relay assets at places of intense exploration
  - Intelligent network management

Destinations in Technology

New Mission Classes

Low-Earth-orbit solar and astrophysical observatories.

→ Observatories located farther from Earth. (e.g., SIRTF, JWST)



Single, large spacecraft for solar and astrophysical observations.

→ Constellations of small, low-cost spacecraft. (e.g., MMS, MagCon)

Preliminary solar system reconnaissance via brief flybys.

→ Detailed Orbital Remote Sensing. (e.g., MRO, JIMO)

In situ exploration via short-lived probes.

→ *In situ* exploration via long-lived mobile elements. (e.g., MER, MSL)

Today's DSN

Global coverage of Deep Space

Current state of the art

Large Array of Small Antennas

Modular and expandable

Low cost manufacturing and operations

x100 performance

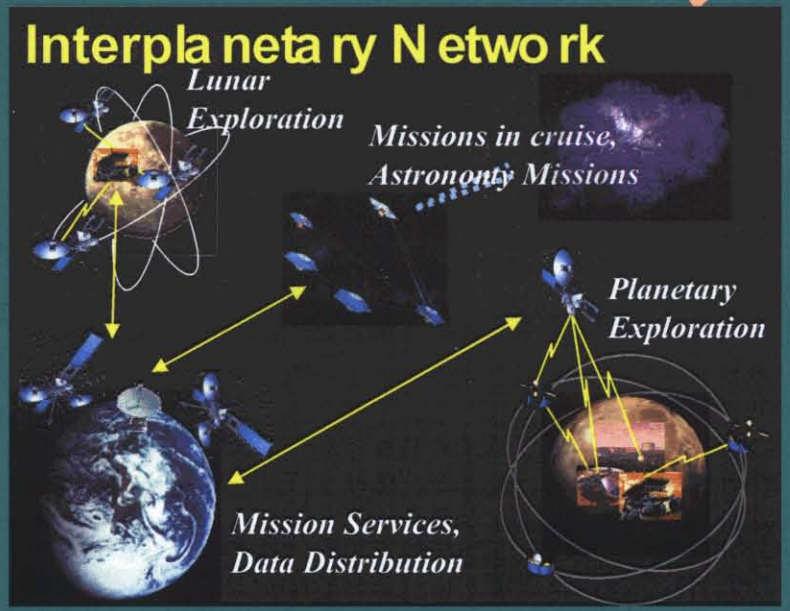
Optical Communications

High bandwidth communications

Low mass spacecraft components

Beginning of technology growth curve

Interplanetary Network



High reliability

High Performance: ≥x1000 by 2030

Cost effective

Planetary networks & seamless connectivity

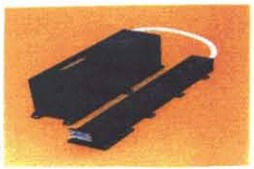
Bringing the sensors to the scientists and the universe to the public.

Destinations in Technology

Responding to the Future Challenges


Pioneer deep space optical communications

Build large arrays of small antennas




Advance flight hardware capabilities


Evolve local networks around Mars and possibly at the Moon

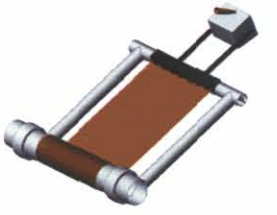

Develop network and multi-mission ops systems and tools



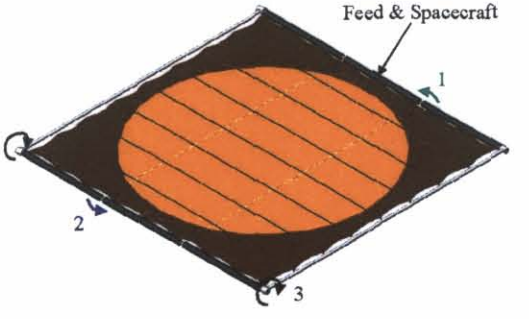
Advance mission design, navigation, and science/public user tools

Spacecraft Antennas

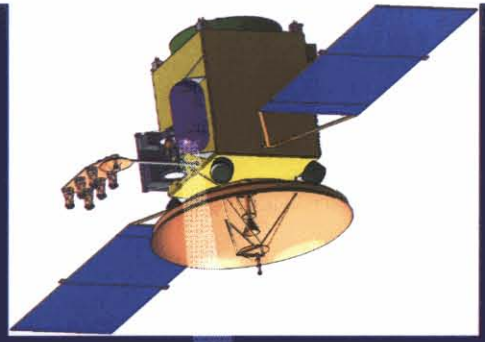
- Large (>10 m) deployable spacecraft antennas
  - Initial technology developments and lab demonstrations underway
  - Demonstration in space in the 2008 time frame



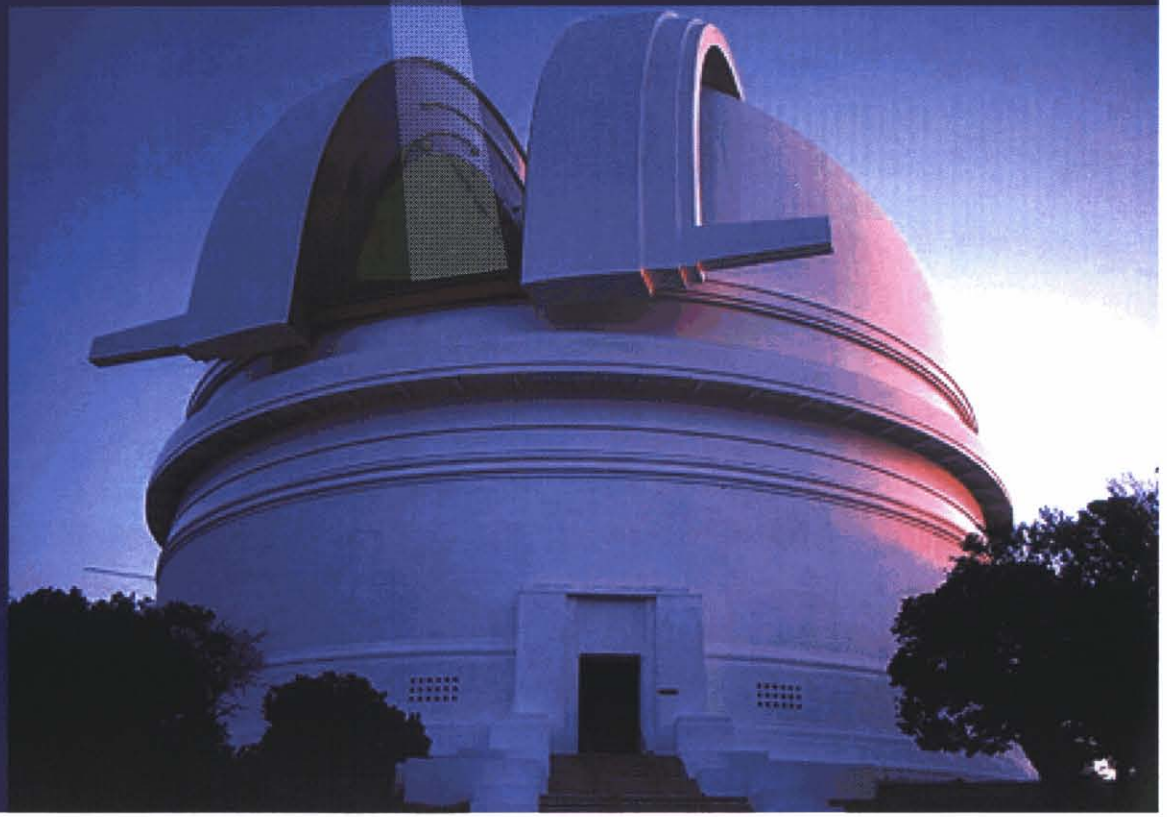
- Critical system and component needs
  - High efficiency reflectarray panels for X/Ka-band signals
  - Reliable and controllable deployment systems
  - Self-rigidization after deployment



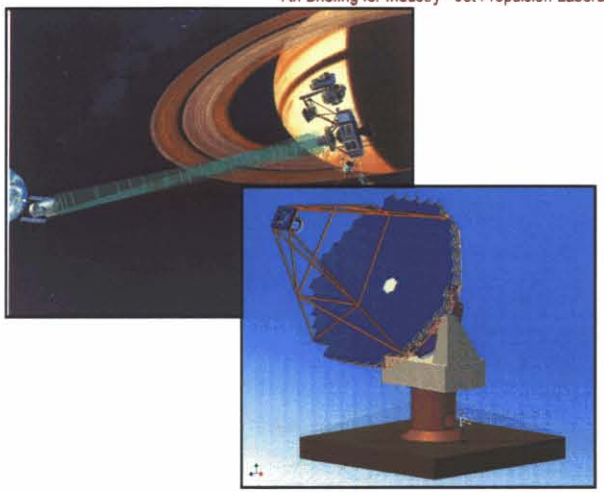
Optical Communications: A New Element of the DSN



Deep space optical communications will enter a new age with the 10+ Mbps demo on MTO in 2009

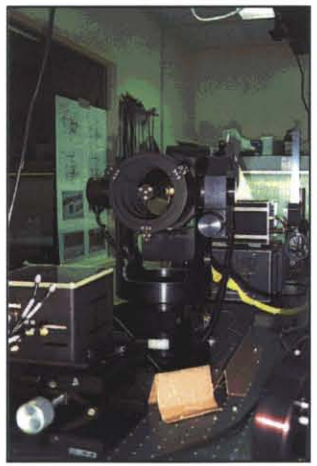


Optical Communications



- Technology development has been underway for 20 years and continues
- Flight demonstration planned for 2009
- Critical system and component needs
  - Low-cost, large aperture (e.g. 10m) ground telescopes and enclosures
  - Low-cost, high performance flight terminals
  - Efficient (>30%) single photon detectors
  - Strategies/systems to mitigate effects of atmospheric turbulence and daytime skylight
  - High-power (kW-level) optical uplink transmitters

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.



Mars LaserCom Demonstration

MLCD Important Features

Demonstrate optical communications from Mars.

Flight Terminal will be a payload on the Mars Telecom Orbiter

Launch Date: October 2009

Demonstration Lifetime: 2 years, Extended lifetime TBD yrs

Demonstration Requirements

Downlink rate of at least 10 Mbps (goal of 30 Mbps); minimum of 1 Mbps down to 3 degrees from the sun.

Uplink of at least 10 bps to Mars.

Measure, characterize, and model the system performance

Demonstrate weather mitigation techniques and handover strategies

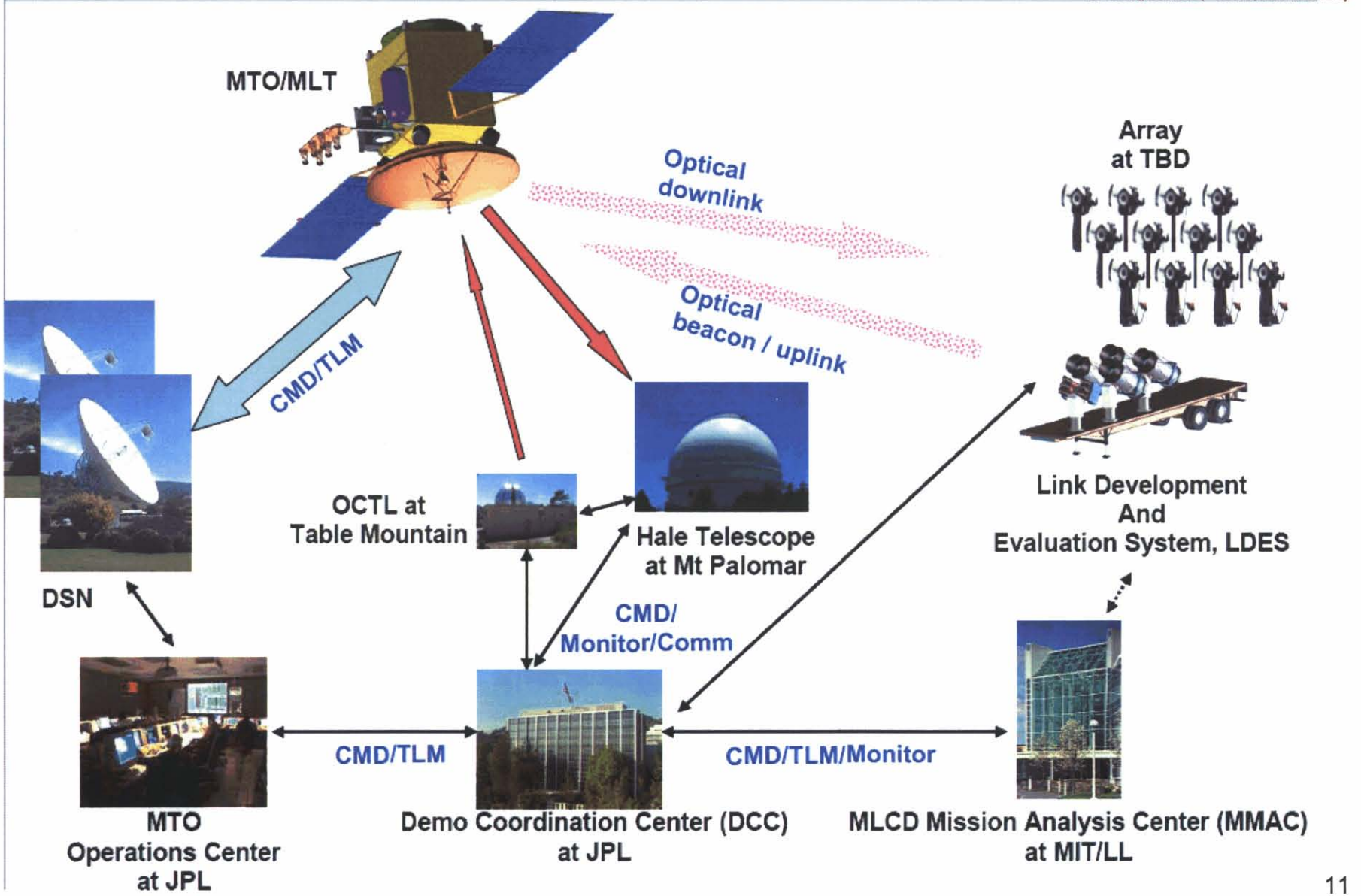
Programmatics

Goddard Space Flight Center: project lead responsibility (PM),systems engineering, delivery of flight terminal and co-investigator

JPL: deputy PM, operational ground terminals, mission operations, principal investigator, data analysis, provide deputy project manager

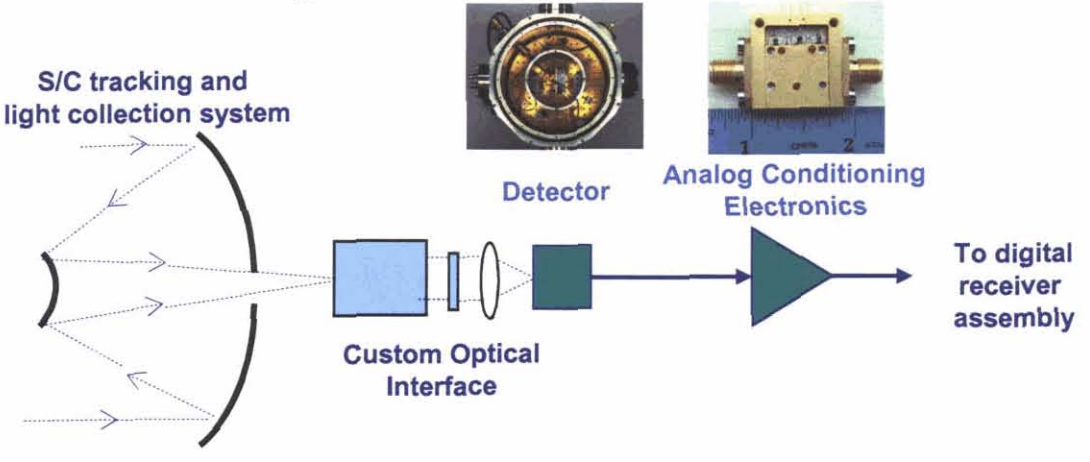
Lincoln Laboratory: flight terminal, systems engineering, co-investigator

MLCD System Block Diagram

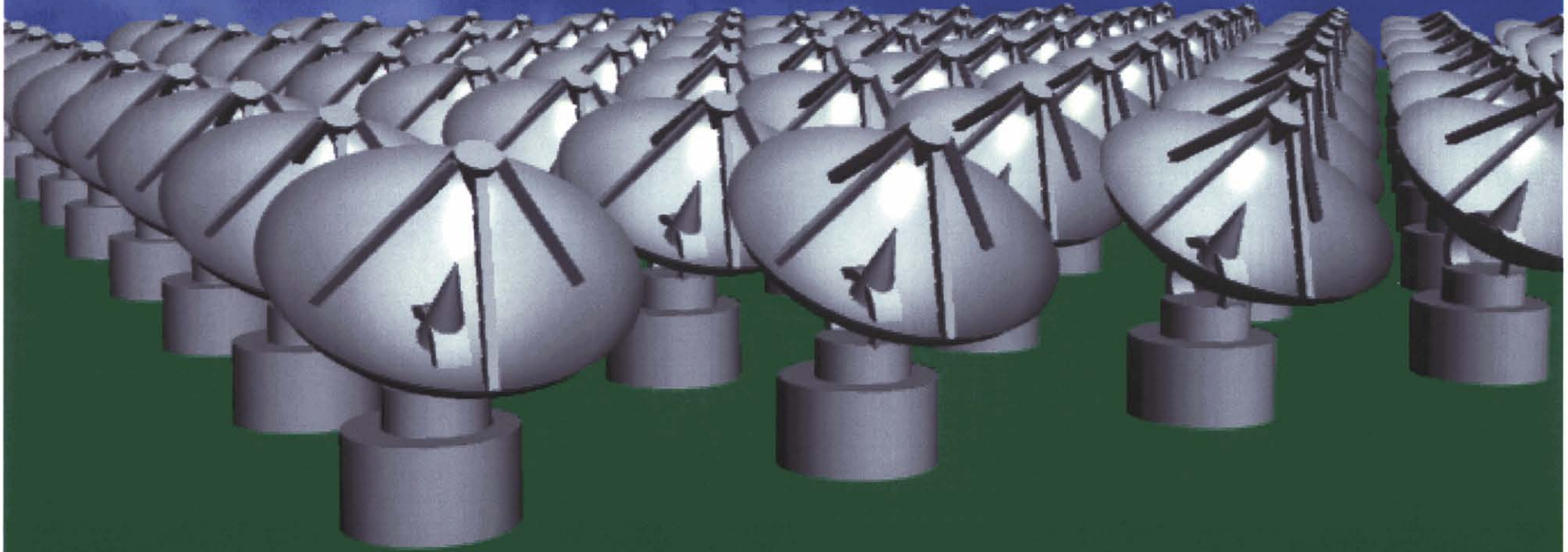


Detectors

- Links are "photon starved", thus need photon counting approach
- Avalanche Photodiode (APD) is detector of choice
  - Important parameters are detection efficiency and bandwidth
- Also considering Hybrid Photomultiplier Tube
- Detector must match flight transmitter wavelength
  - Presently 1064 nm
- Must meet PPM link operational requirements
  - 1 ns minimum slot width
  - Must operate in presence of high optical background



Arrays of Smaller Antennas: Another New Element in the DSN

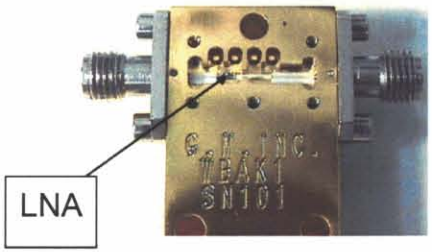


We will increase the RF capability of the DSN by at least a factor of 100 in the next 25 years.

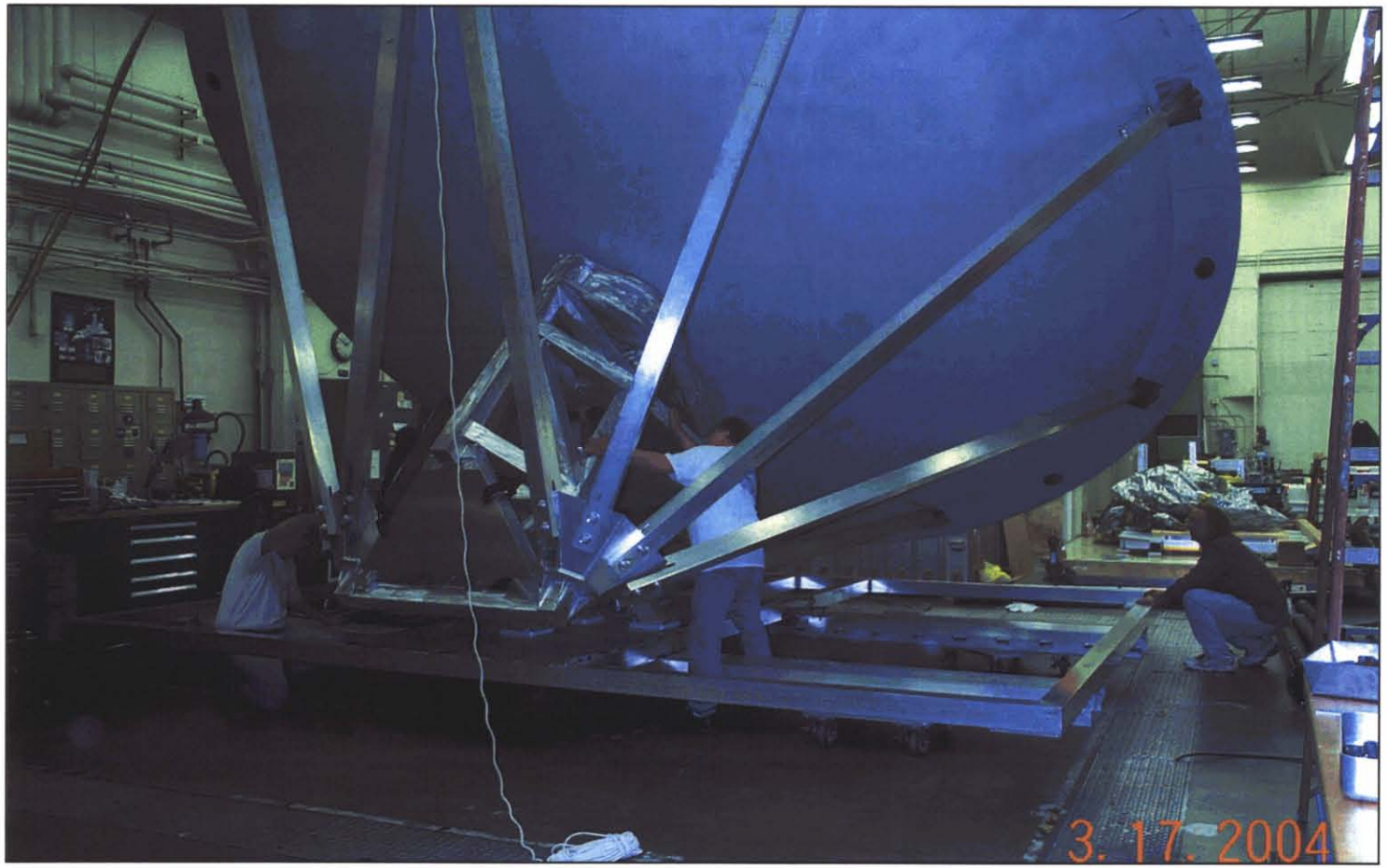
Arrays of Smaller Antennas

- Expected to be more cost-effective than large monolithic antennas
  - Studies and technology developments underway
  - Large-scale prototype possible start in 2008
  - Deployment of network sites could follow quickly
- Critical system and component needs
  - Low-cost, easily-produced antenna surfaces
  - Low-cost, precision steerable antenna mounts
  - Low cost, low-noise amplifiers and cryocoolers
  - Array signal combination and calibration techniques

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.



50% Scale Antenna

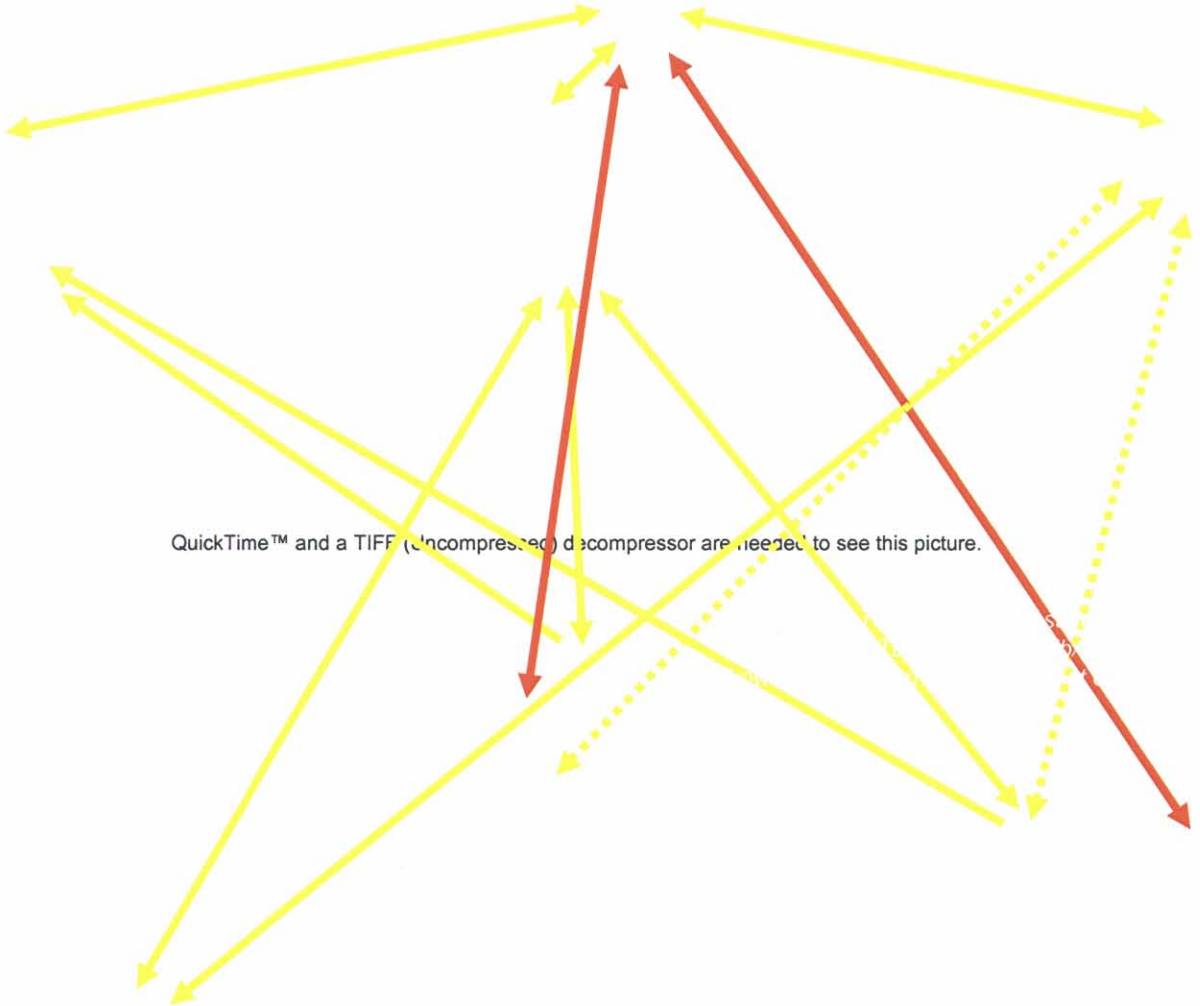


First 6m antenna set at 45° elevation for RMS measurement

Industry Opportunities

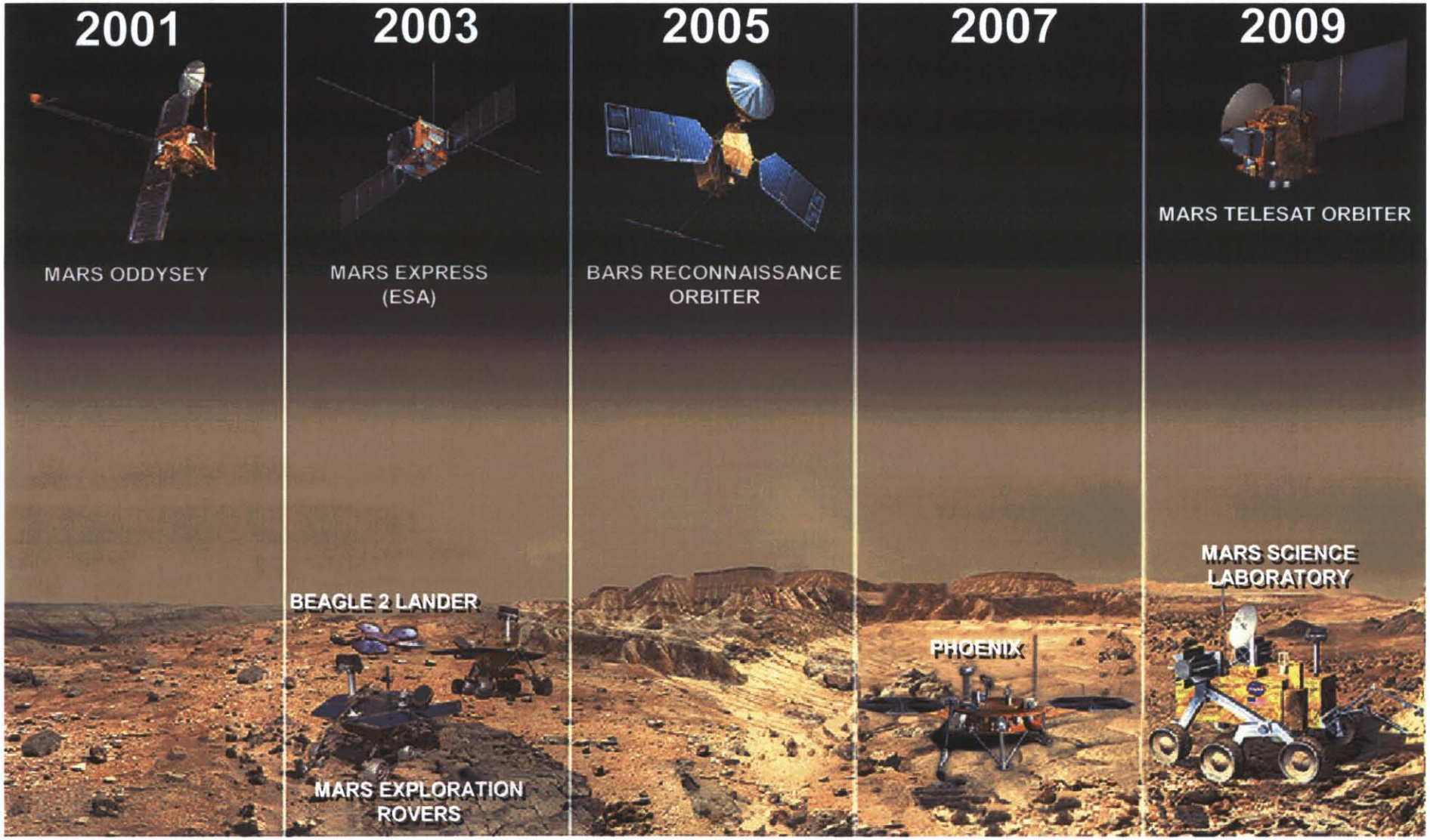
- Arrays will require large scale production (by JPL standards)
  - 1200 12-m antennas with associated front-end electronics
  - Must be manufactured in a cost-effective manner
  - Will dominate the development cost
- Prototyping is underway
  - Industry contracts for full-scale and partial scale antennas and components

03/04 Mars Telecommunications



Destinations in Technology

A Decade of Mars Exploration



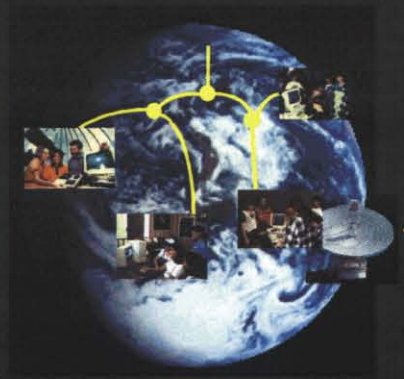
Interplanetary Network
Three Layers to the Stack

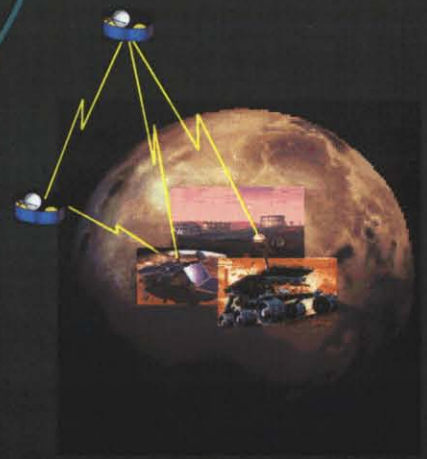
The *applications* that create information

IPN Applications

The *middleware* that processes data and routes and shares information

IPN Middleware



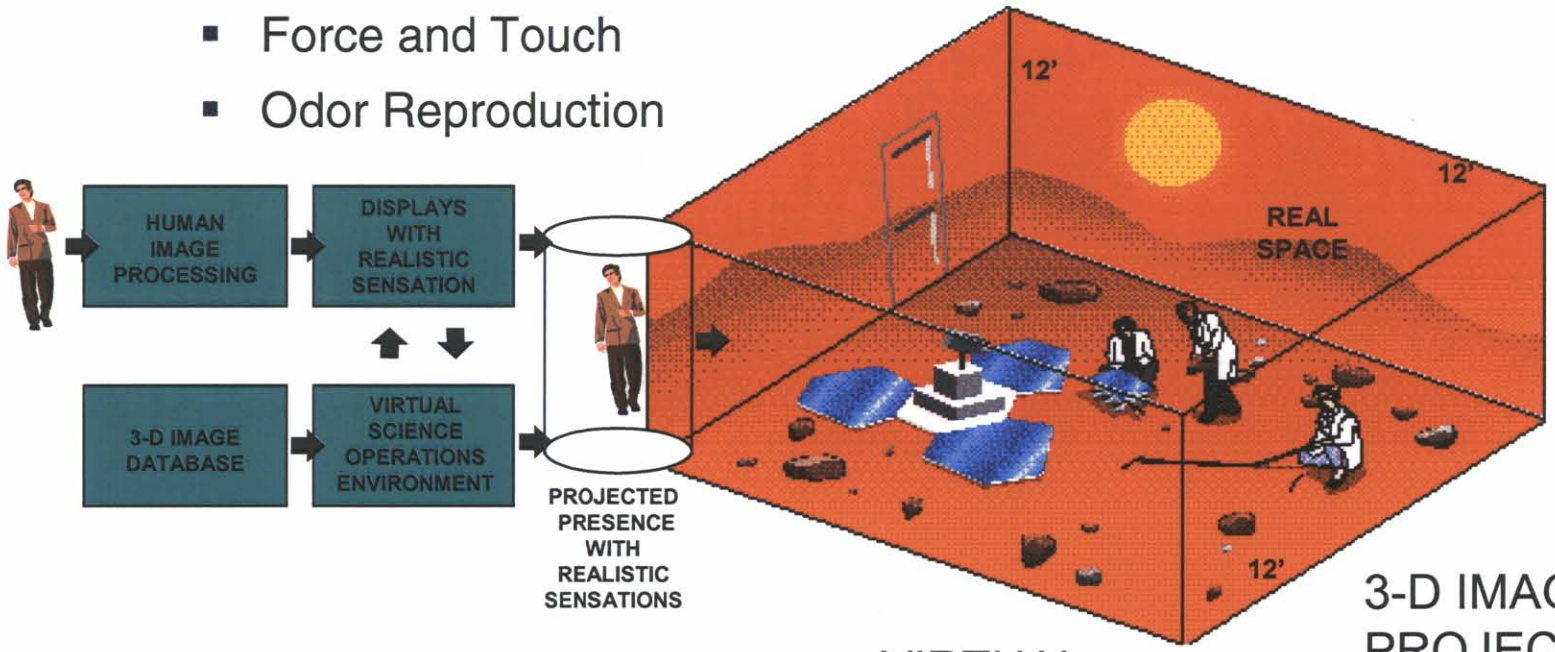


IPN Communications

The *communications* that move data

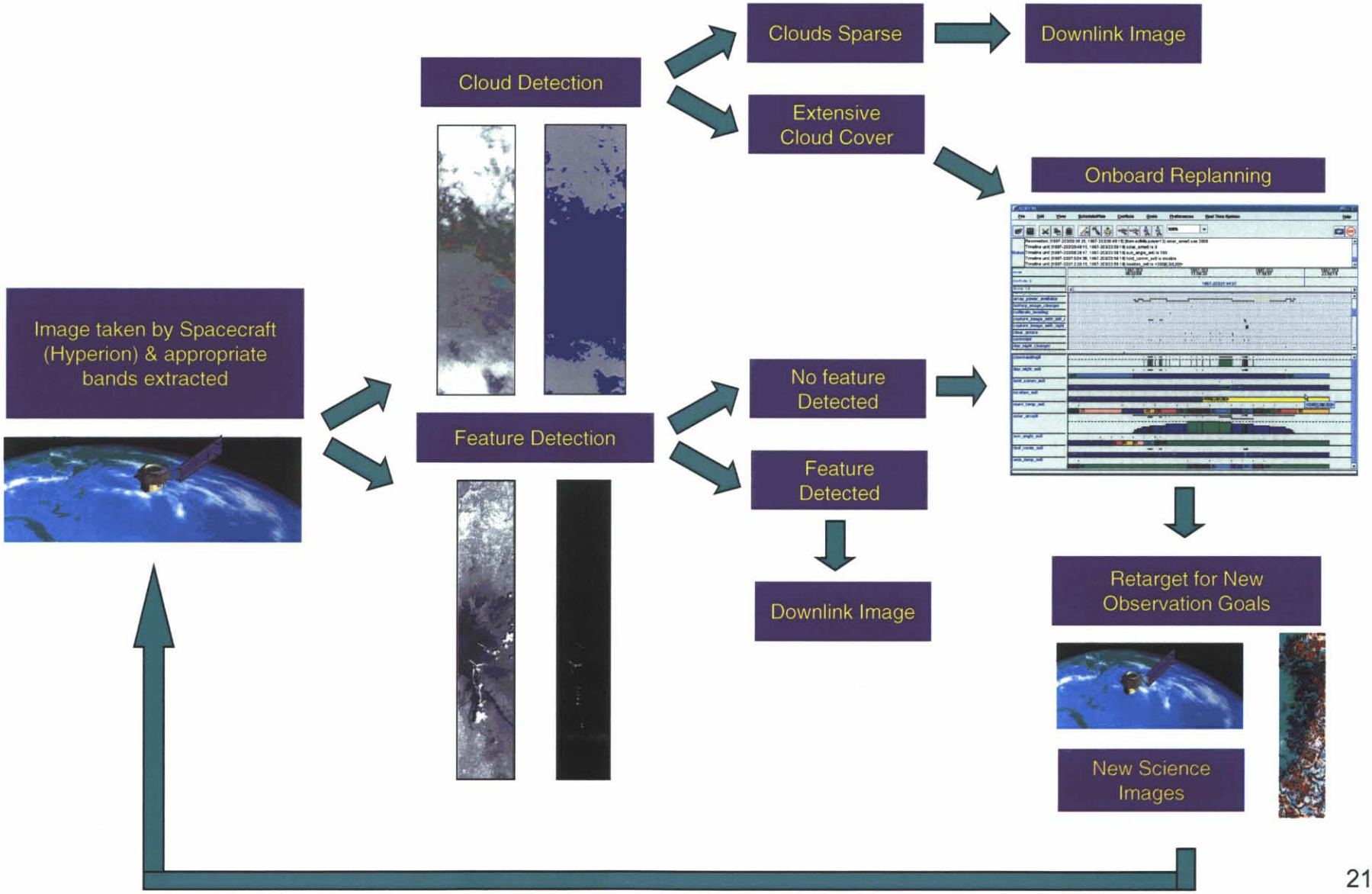
Interplanetary Network
Virtual Sense of Presence

- Virtual sense of presence techniques could include
  - Immersive Visualization
  - 3-D Acoustic Imaging
  - Force and Touch
  - Odor Reproduction



Destinations in Technology

EO-1 Autonomous Sciencecraft Experiment



Mission Data System (MDS)

System engineering methodology

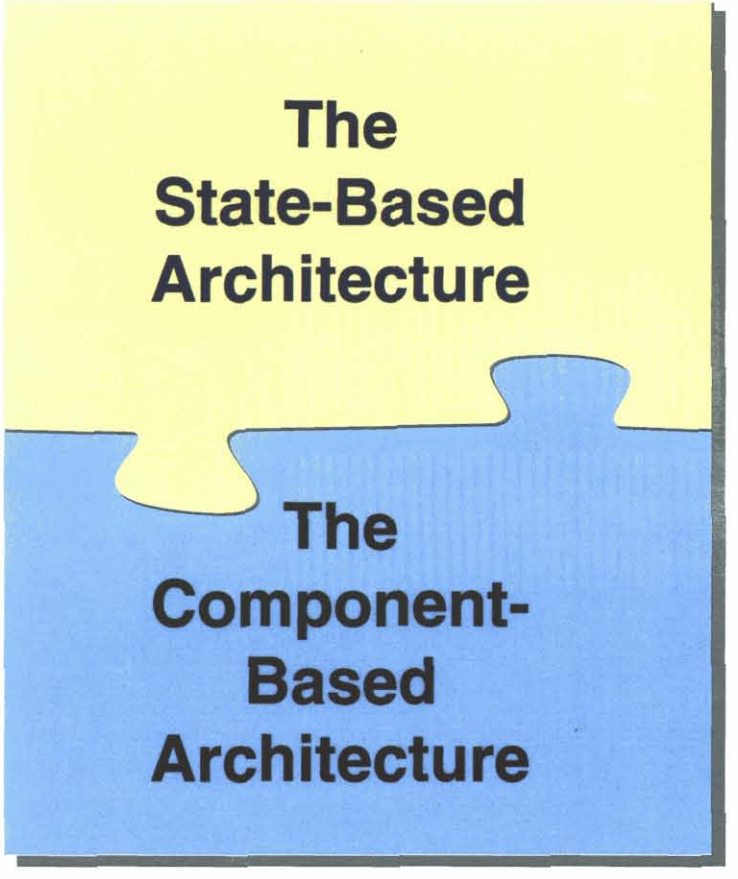
- Structured, disciplined process
- Model-based design for estimation and control

Architectural patterns

- State architecture
- Component architecture

Frameworks and adapter's guides

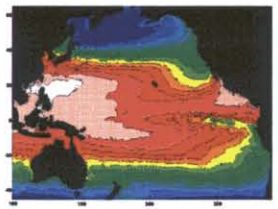
- Reusable building blocks in object-oriented design
- Guides for how to adapt it for concrete tasks
- Examples of framework usage



State and component architectures are pieces of the same design methodology

High-Capability Computing

- Computing, Modeling, Simulation and Visualization to develop *modeling frameworks* and seed new high-end *applications*
  - Common Earth Science models
  - Common engineering subsystem models
  - Computationally intensive parallel and distributed processing for science, engineering and outreach applications



- Populate computing environment with an engineer *tool suite*
  - Tools for modeling, analysis, simulation, and visualization
  - Interactive and scalable high-capability computing

- Upgrade high-capability *computing* capability
  - Modernize existing institutional supercomputing
  - Add Teraflops-class Beowulf clusters
  - Add JPL Grid to sweep up unused cycles
  - Purchase cycles from external supercomputing facilities

Information Technology
Industry Opportunities

	Mission Data System	***Mission Information Technology***	***Interplanetary Network***	***Reimbursable Projects***
Partnership Topics	Systems and SW Eng'g for Mission-Critical Systems	Autonomy, Computing, SW Eng'g, Data Mgmt, Modeling & Simulation, etc.	Networked Comm, DSN Resource Allocation and Automation	Software Development, Device Prototyping and Fabrication

Partnership Example:
CMU and Sun Microsystems

JavaOne™
Sun's 2003 Worldwide Java Developer Conference