Progress at JPL Concerning Antenna and Wideband Receiver Design

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July 6, 2001

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2. Objectives at JPL
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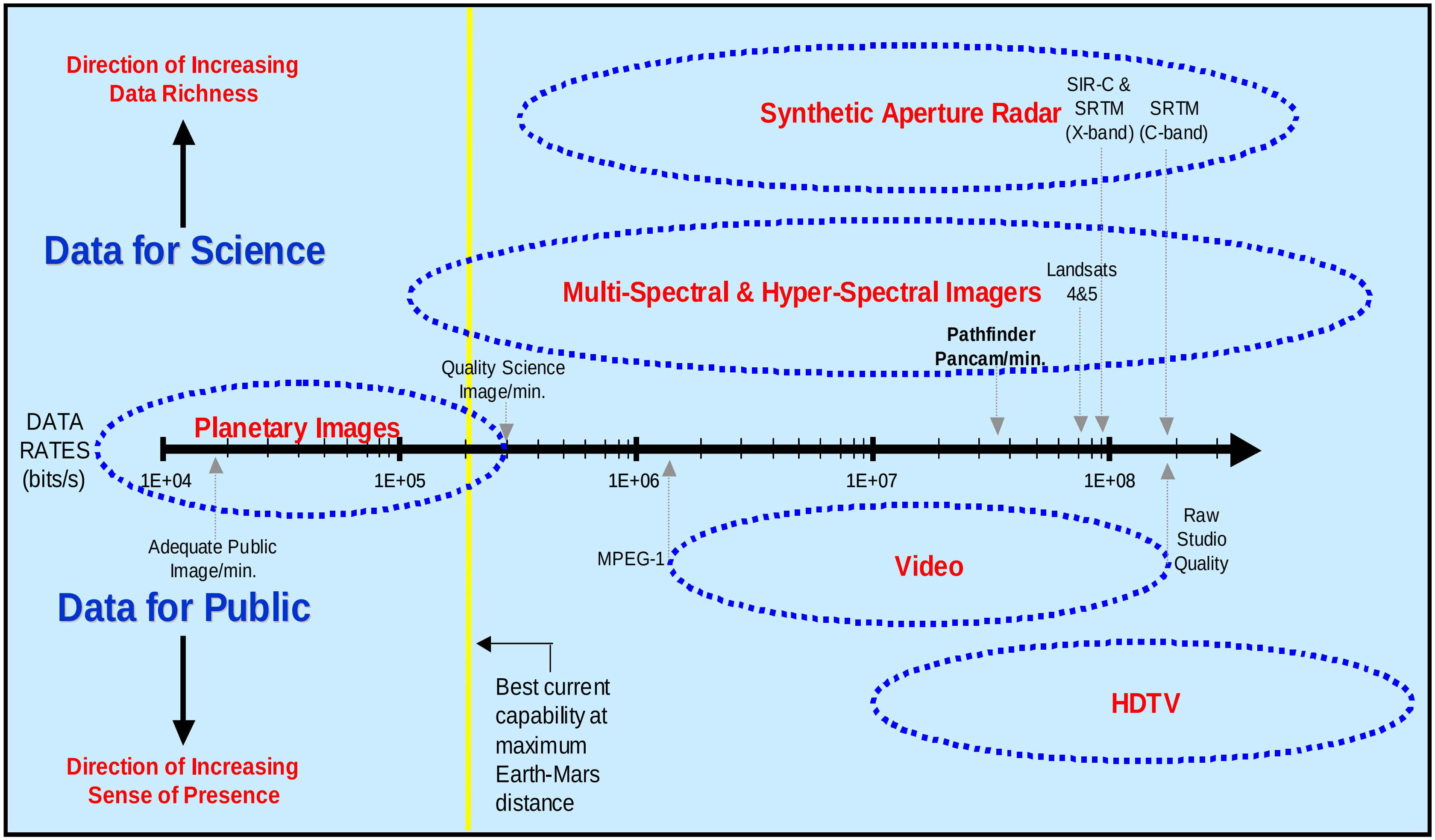
Data Rate Requirements for Deep Space Communications

The data rate requirements for HDTV, virtual presence, multi-spectral imagers, and synthetic aperature radar are factors of 10 to 100 higher than can be provided with the present DSN



New DSN Technology Thrusts

The future DSN will utilize an optimum combination of new technologies to increase data return, reduce costs, and improve mission robustness

Internet Network Architecture

- Decrease mission costs by adoption of standardized protocols
- Enhance productivity by making mission data easily accessible.
- Enhance reliability by multiple-paths.
- Reuse of software and hardware.

Orbiting Relay Satellites

- Provides orbiting relay with high-gain antenna to increase data transmission rate for outer planet missions
- Allows lander assets to be devoted to science instruments rather than direct to earth communications.

Optical Communications

- Very large increase in transmitter gain facilitates very high data rates with low power
- Explosion of new optical communication components and new era of astronomical instruments provides the core technology for optical space communications.
- Challenges are precision pointing, solar radiation, and weather diversity.

Microwave Arrays

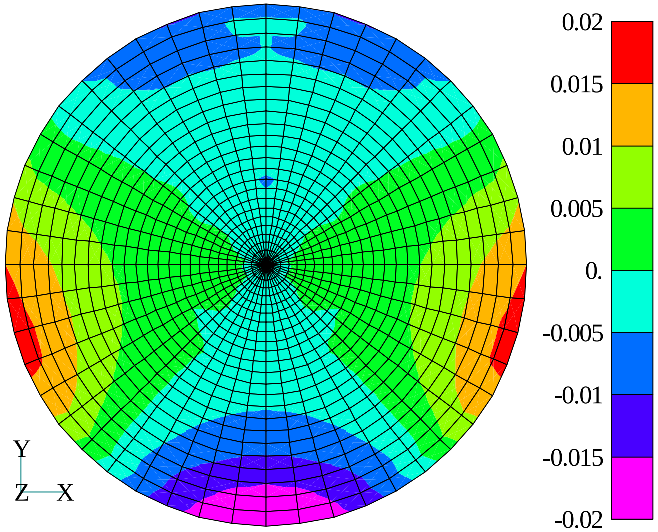
- Can provide large increase in data rate by increased receiving aperture on earth
- Minimum cost per unit area by choice of optimum diameter antenna element
- Advantages of multiple beams, soft failure, weather diversity, and expandability
- Synergistic with new developments in radio astronomy such as ATA, SKA, and ALMA.

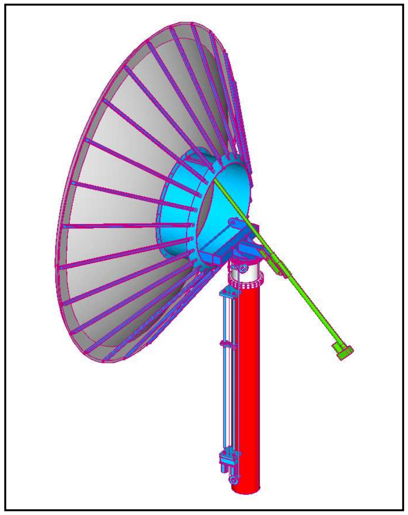
Objectives of a JPL DSN Array Technology Development Program

- **Liaison** with SKA, ATA, and eVLA array development tasks; assess technology and joint use for NASA applications.
- **Determine array cost vs antenna diameter** and electronics cost.
- **Verify cost** by fabrication and test of an array element followed by a prototype array.
- **Perform up-link phasing** experiments to gain experience and assess calibration burden.
- **Develop management confidence** in communication arrays by forming a group with the core expertise needed for implementation.

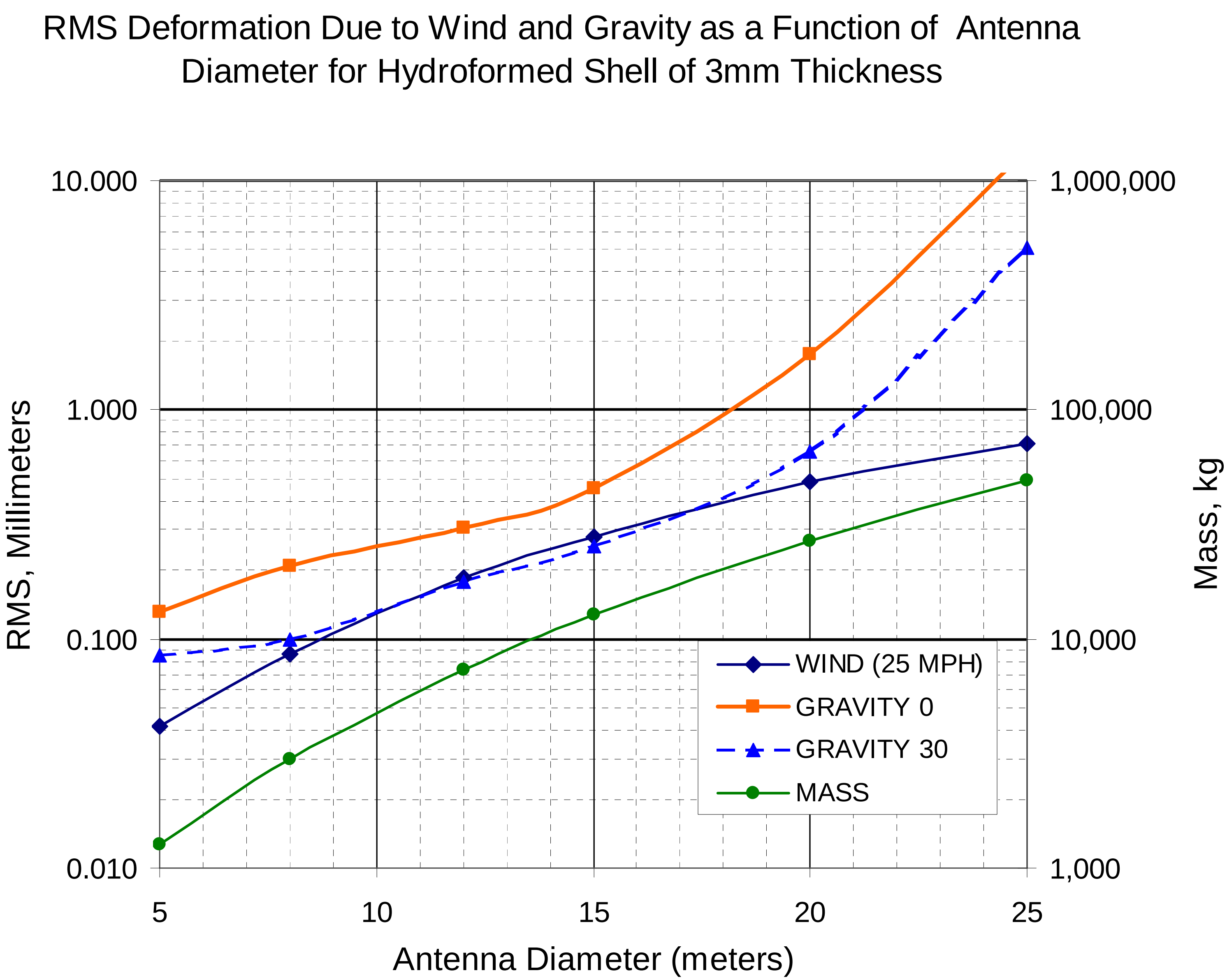
Hydroformed Aluminum Antennas

Hydroforming is a process of using a fluid or gas at very high pressure to force aluminum sheet to conform to a mold. The result is a stiff, accurate, and low cost reflector. JPL has performed a structural analysis of 5m through 25m hydroformed reflectors.



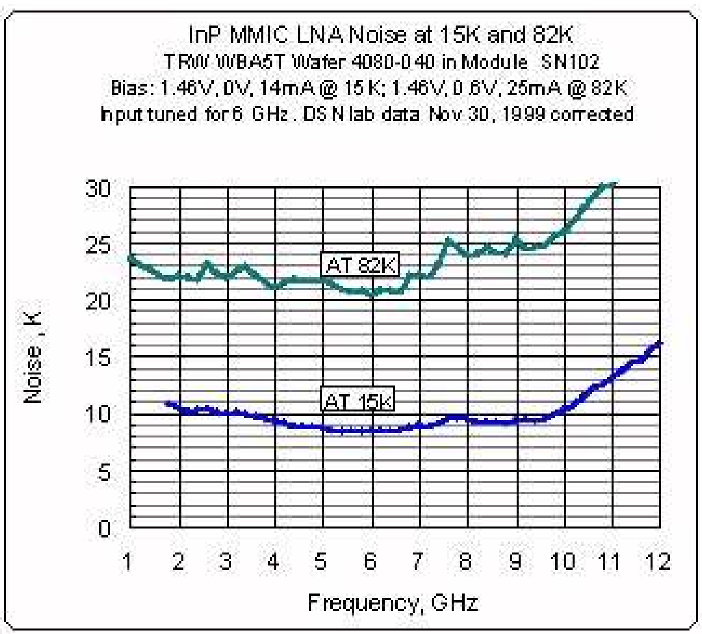


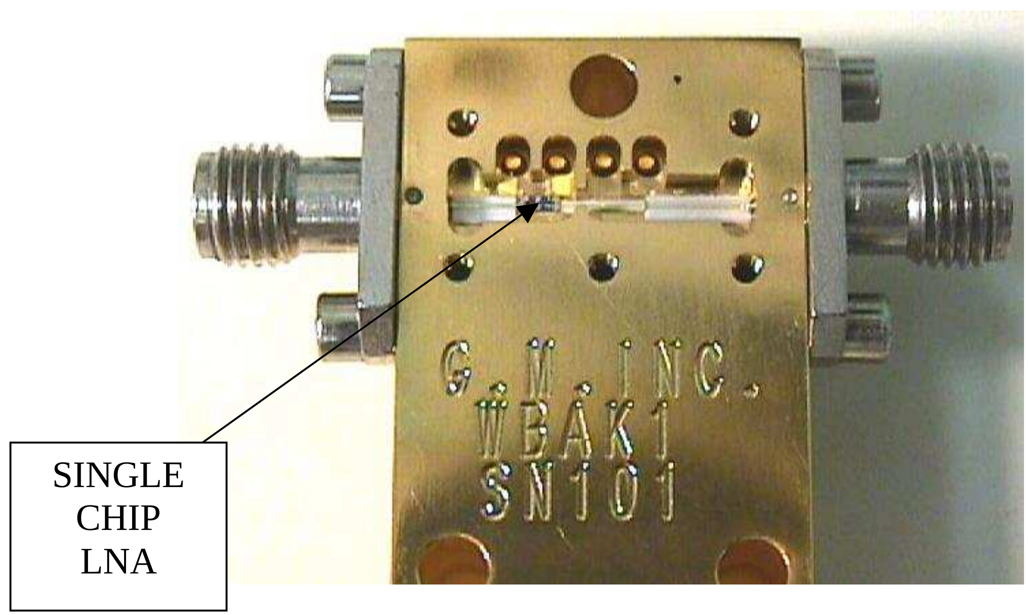
Example	Antenna Diameter	Cost per Antenna	Cost per m^2	Cost per km^2
New 70m DSN antenna	70m	$100M	$40.8K	$40.8B
25m VLBA antenna	25m	$3M	$9.6K	$9.6B
6m ATA antenna	6m	$30K	$1.7K	$1.7B
Target SKA cost	10m	$30K	$600	$0.6B
Hydroformed DBSTV antenna	4m	$2.8K	$350	$0.35B
Aluminum, 3mm thick sheet	Any	NA	$30	$.03B


RMS Deformation Due to Wind and Gravity as a Function of Antenna Diameter for Hydroformed Shell of 3mm Thickness
10.000
1.000
0.100
0.010
1,000,000
100,000
10,000
1,000
RMS, Millimeters
Mass, kg
5
10
15
20
25
Antenna Diameter (meters)
WIND (25 MPH)
GRAVITY 0
GRAVITY 30
MASS

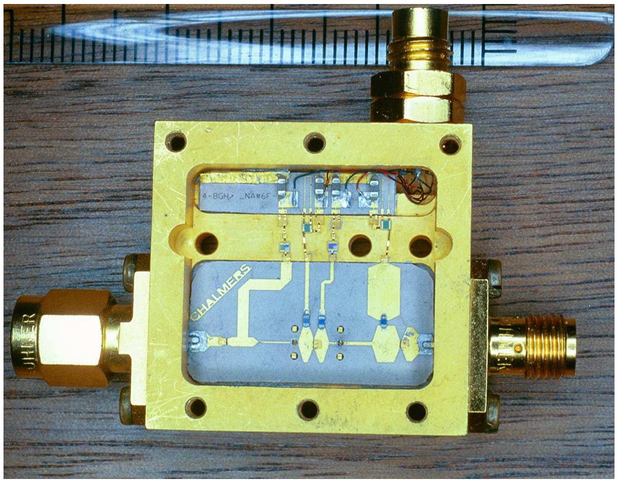
Low-Noise Amplifiers Under Development at Caltech and JPL

Frequency Range, GHz	Application	Noise
.5-11	ATA	23K @ 80K now, 15K later
4-12	ALMA IF	4K @ 4K, good input match
8-20	SIS IF Amplifer	10K @ 4K, good input match
1-60	NASA Atmospheric Sensor	400K @ 300K, 40K @ 15K
90-110	Planck, Cosmic Background	35K @ 15K
100-140	Atmospheric Sensor	600K @ 300K
170-210	Atmospheric Sensor	1500K @ 300K

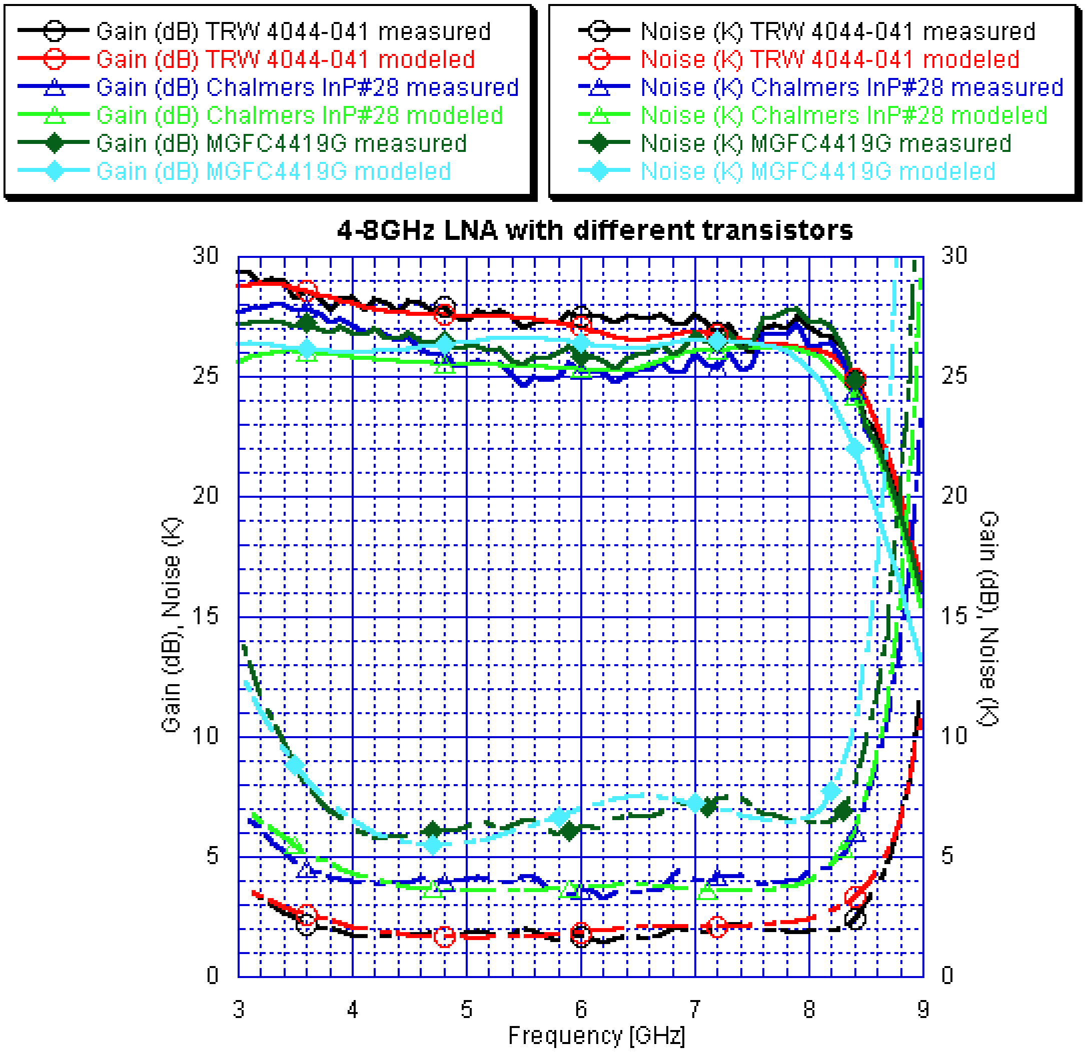




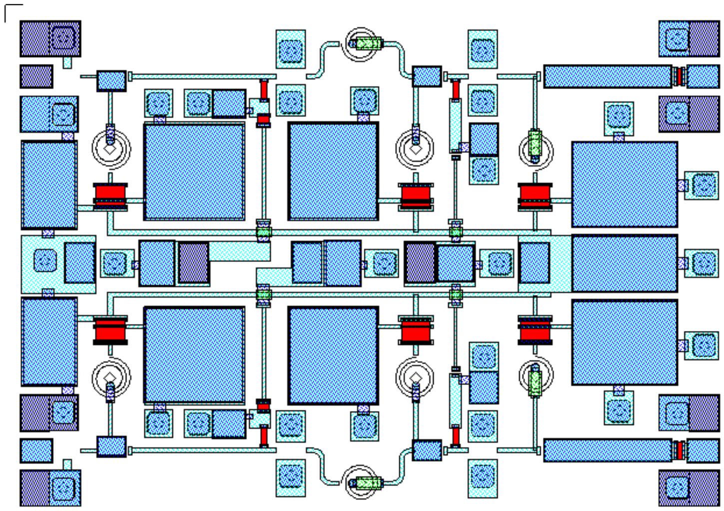
Chalmers 4-8 GHz Cryogenic Low Noise Amplifier



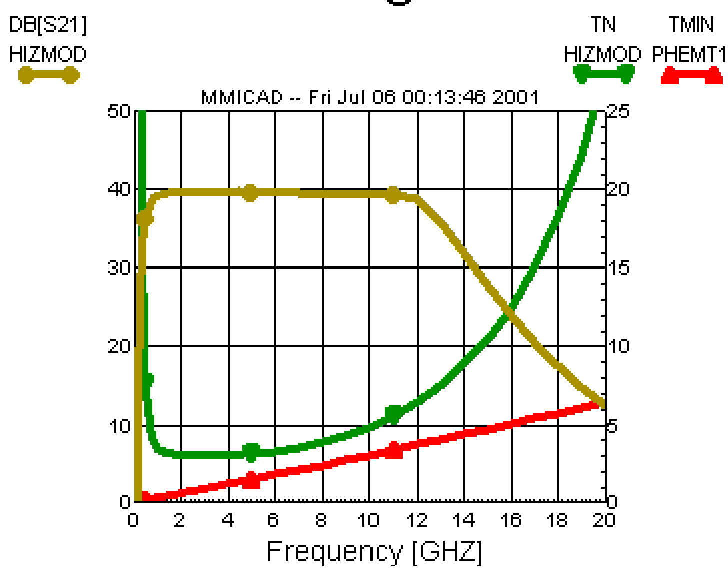
World record 2K noise temperature, measured in 4 laboratories, achieved with TRW 0.1um InP HEMT



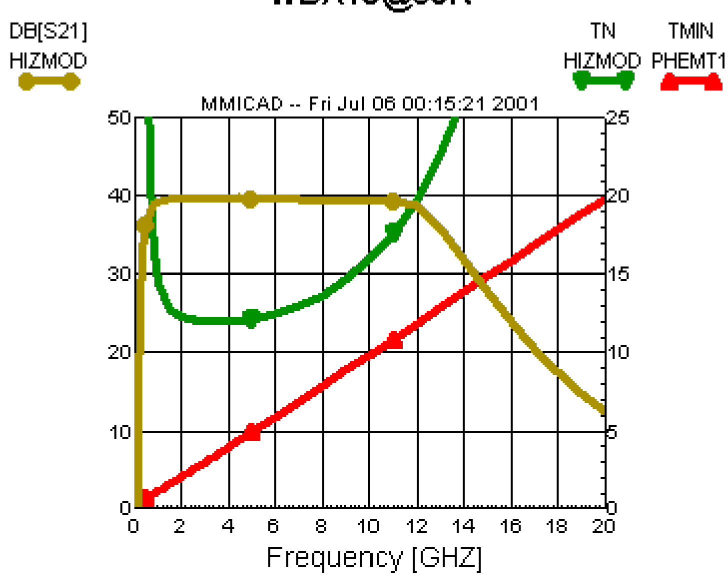
MMIC Dual LNA for ATA



WBA10@15K



WBA10@80K



21st Century DSN Visions

Year	Developmental Milestones	Operational System	Landmark Capability
2010	Optical link demos Prototype array demo	Robust 70m equivalent at Ka band at 3 DSN sites	Reliable service to all planned missions in decade
2020	Robust, low-cost 8 Gbt/s, W-band electronics	10 x 70m equivalent array performance; optical links to outer planets	Virtual presence HDTV exploration of outer planets
2030	Transmitters for interstellar communication	Square-KM arrays and optical links at 3 sites;	Detection of radio activity from identified earth-like planets