A LARGE ARRAY OF SMALL ANTENNAS TO SUPPORT FUTURE NASA MISSIONS.

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Introduction: A team of engineers and scientists at JPL is currently working on the design of an array of small radio antennas with a total collecting area up to twenty times that of the largest existing (70-m) DSN antennas. An array of this size would provide obvious advantages for high data rate telemetry reception and for spacecraft navigation. Among these advantages are an order-of-magnitude increase in sensitivity for telemetry downlink, flexible sub-arraying to track multiple spacecraft simultaneously, increased reliability through the use of large numbers of identical array elements, very accurate real-time angular spacecraft tracking, and a dramatic reduction in cost per unit area. NASA missions in many disciplines, including planetary science, would benefit from this increased DSN capability. The science return from planned missions could be increased, and opportunities for less expensive or completely new kinds of missions would be created. The DSN array would also be an immensely valuable instrument for radio astronomy. Indeed, it would be by far the most sensitive radio telescope in the world.

The Deep Space Network Array Concept: The current concept for the DSN array is based on 4000 commercially mass-produced parabolic antennas, each 5 meters in diameter, and operating at 8 and 32 GHz. The total cost for this array is estimated to be far less than the cost of an equivalent collecting area provided by traditional large-diameter (34-m or 70-m) antennas. If funding begins early in FY 2002, a two-element test interferometer could be running by December 2003, a prototype array with an area equivalent to a single 70-m diameter antenna could be finished by the middle of 2005, and construction of the full DSN array could be started in early 2007 and be completed by the end of 2009.

Advantages of a Large Array for the DSN: There are a number of reasons for DSN interest in a large array of many small antennas:

- Large decrease in cost per decibel of link margin
- Lighter, lower power, and less expensive spacecraft telemetry hardware
- Flexible scheduling – simultaneous tracking of multiple spacecraft over wide areas of the sky
- New spacecraft navigation capability: real time, high precision angular position measurements – complements range and Doppler data and provides full 3-D spacecraft positions without the need for trajectory modeling or for long tracking passes
- High reliability – graceful degradation of array performance if individual antenna elements fail; moving mechanical parts are small and light weight; simplified operations and low-tech maintenance
- Array is continuously expandable and upgradable
- Enable new types of mission: radio occultation measurements with very distant spacecraft, direct reception of lander/rover/penetrator signals on earth, multi-spacecraft interferometer arrays, spacecraft with no on-board data storage, down-links with both high data rates and high duty cycles

The most frequently discussed configuration for the DSN tracking array consists of a central region containing a dense network of array elements along with a smaller number of elements spread over a large (>100 km) geographic area. Such a configuration combines ease of phasing the central elements for telemetry reception and more precise spacecraft position measurements with the longer baselines. A separate, but potentially important, benefit for spacecraft navigation is the ability to detect and image the thermal emission from a large number of solar system targets, including asteroids and moons as well as planets. This will provide accurate positions for these targets in the same reference frame as the astrometric spacecraft tracking measurements.

Summary: Future NASA missions will require high downlink data rates to maximize their scientific productivity. Higher frequency RF and optical communication systems are being developed for this purpose, but it will probably be more cost effective to provide additional downlink data rate capability with a large increase in ground antenna area, especially if the cost per unit area is reduced significantly. In addition, missions with short-duration, high priority phases such as planetary flybys, radio occultations, atmospheric probe arrivals, etc., would require less on-board data storage if higher real-time downlink rates were available. Finally, very low power signals from landers, atmospheric probes, or ground penetrators could be received directly on Earth, giving additional geometric information and greater mission redundancy. Placing more of the complexity and mass of a communication link on Earth rather than on a spacecraft could open up entirely new ways of doing planetary science, and the cost of a ground array can be amortized over a large number of future NASA missions (not just planetary ones). For all of these reasons one or more large, low-cost arrays are a promising approach for NASA spacecraft tracking during the next decades.