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Spacecraft CDR

Communication Antennas

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The communication antennas being discussed in this presentation are the shaped-beam nadir directed antennas and the hemispherical coverage zenith directed antennas shown in this block diagram. The nadir antennas can be used alone for best performance when the satellite is stabilized, or can be combined with the zenith antennas to achieve quasi-omnidirectional coverage. The antenna systems are fully redundant, with each IEM capable of independent selection of antenna configuration.

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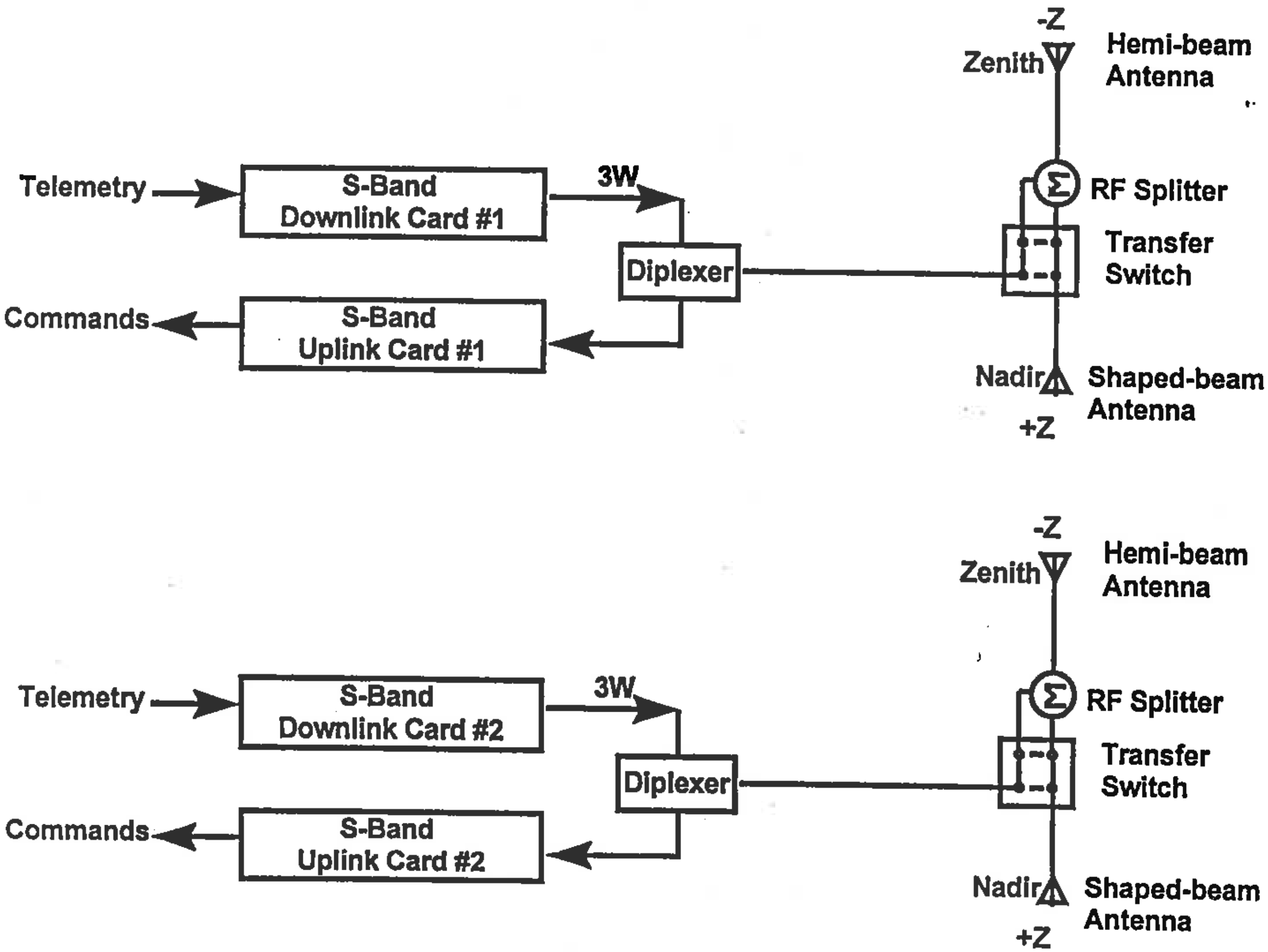
RF Communications Subsystem
Block Diagram



The locations of the communication antennas are shown in this illustration of the spacecraft configuration. A clear field of view has been obtained for the critical nadir antennas, and the obstructions to the zenith antennas have been kept to a minimum.

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Critical Design Review

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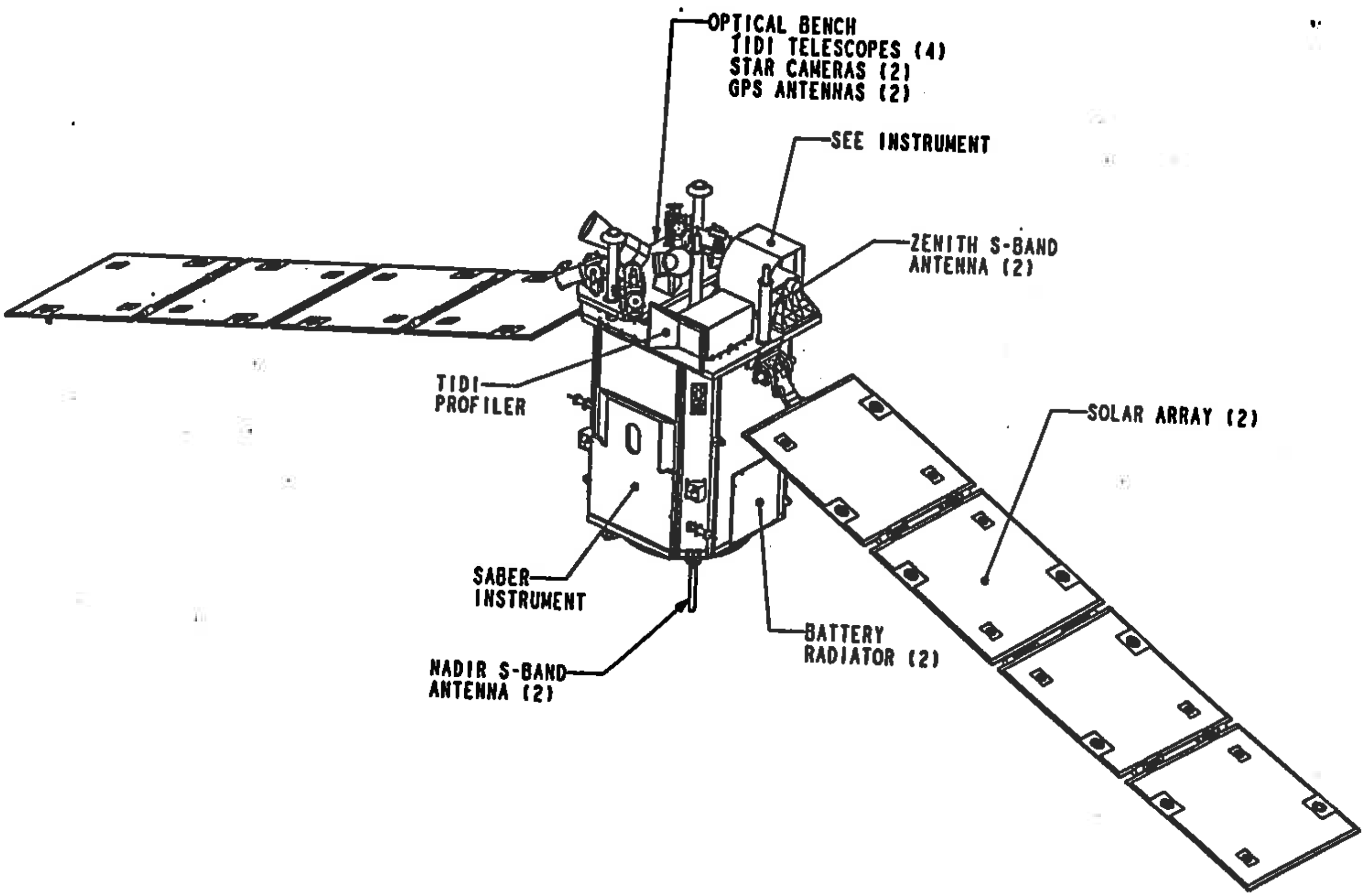
Spacecraft Configuration



For a satellite in a low orbit, the path loss to a ground station is a strong function of the angle from nadir. If the satellite is stabilized in an earth-oriented direction, the radiation pattern of the antennas can be shaped to favor the larger angles from the -Z axis. This results in some improvement to the worst-case communication links.

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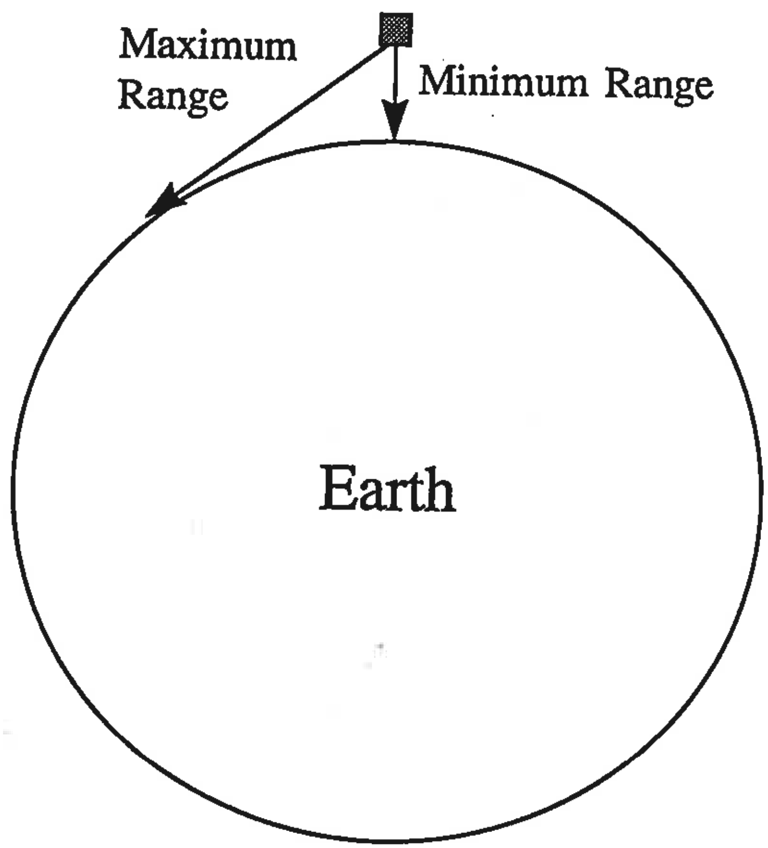
Variation in Slant Range for a Low Earth-Orbiting Satellite



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The type of antenna being used for the nadir directed shaped beam application is a backfire bifilar helix. An experimental antenna of this type is shown in this photograph.

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RKS-5

The goal of the shaped beam antenna is to supply a gain of +3 dBic for the longest slant range geometry (maximum altitude and minimum ground elevation angle of 5 degrees), and to yield an equal or better link performance for all other geometries. The minimum gain curve for the antenna is obtained from this goal along with the consideration of variations in orbit altitude, attitude error, and misalignment between the spacecraft axis and the antenna axis. The result is shown in this graph, along with the measured free-space performance of the experimental bifilar helix antenna. Some performance margin exists to counter the effects of reflections from the spacecraft structure and possible radome losses.

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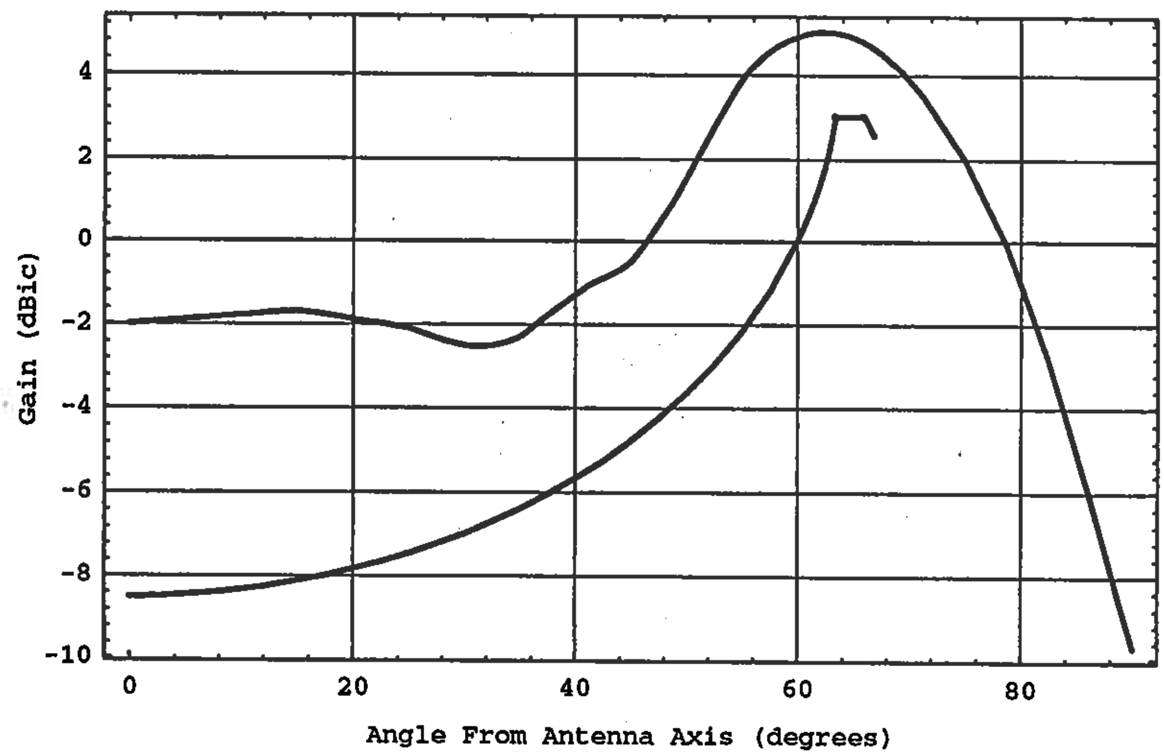
Shaped Beam Gain Requirements and Preliminary Experimental Results



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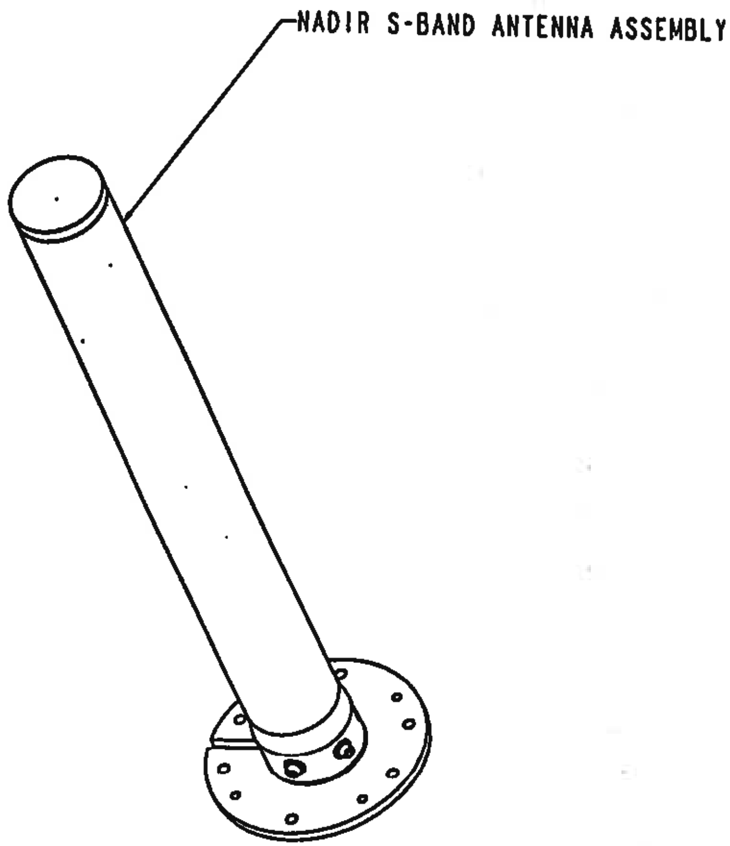
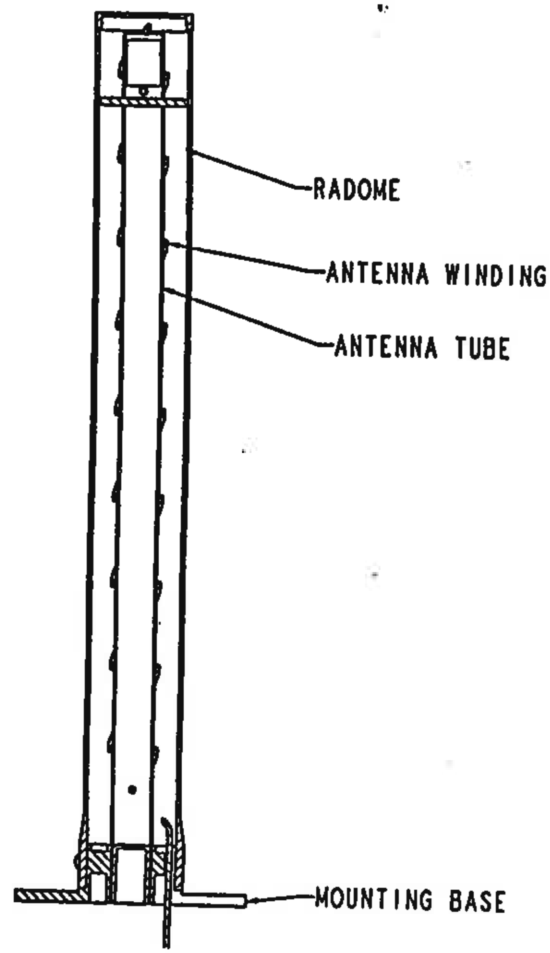
Nadir S-Band Antenna Assembly





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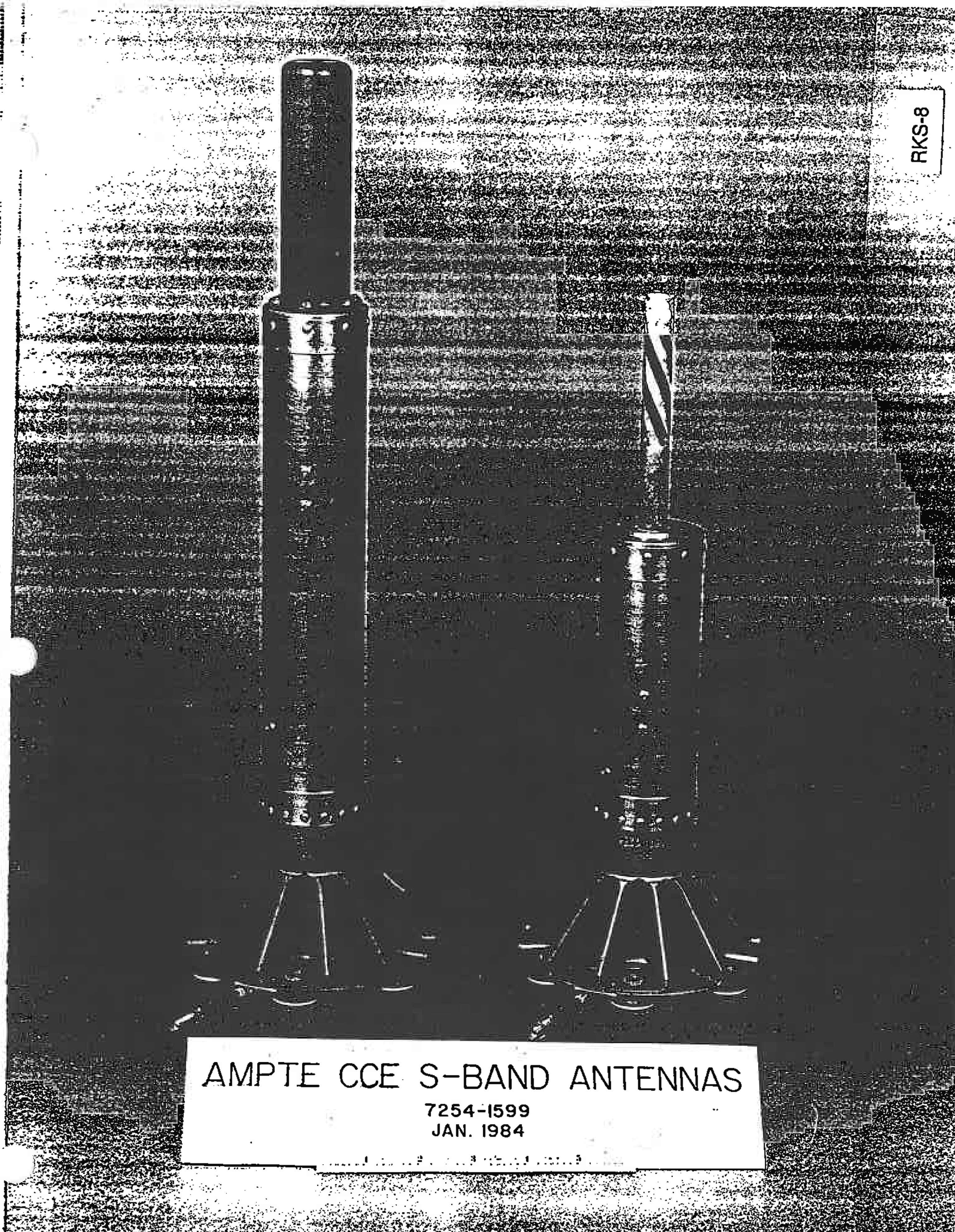
The type of antenna being used for the zenith directed hemispherical coverage application is a resonant quadrifilar helix. Variations of the basic design have been flown on numerous APL spacecraft. Shown in the photograph are two examples which flew on the Charge Composition Explorer Satellite.



RKS-8

This graph shows the measured free-space radiation pattern of a quadrifilar helix which is nearly identical to the TIMED zenith antenna.

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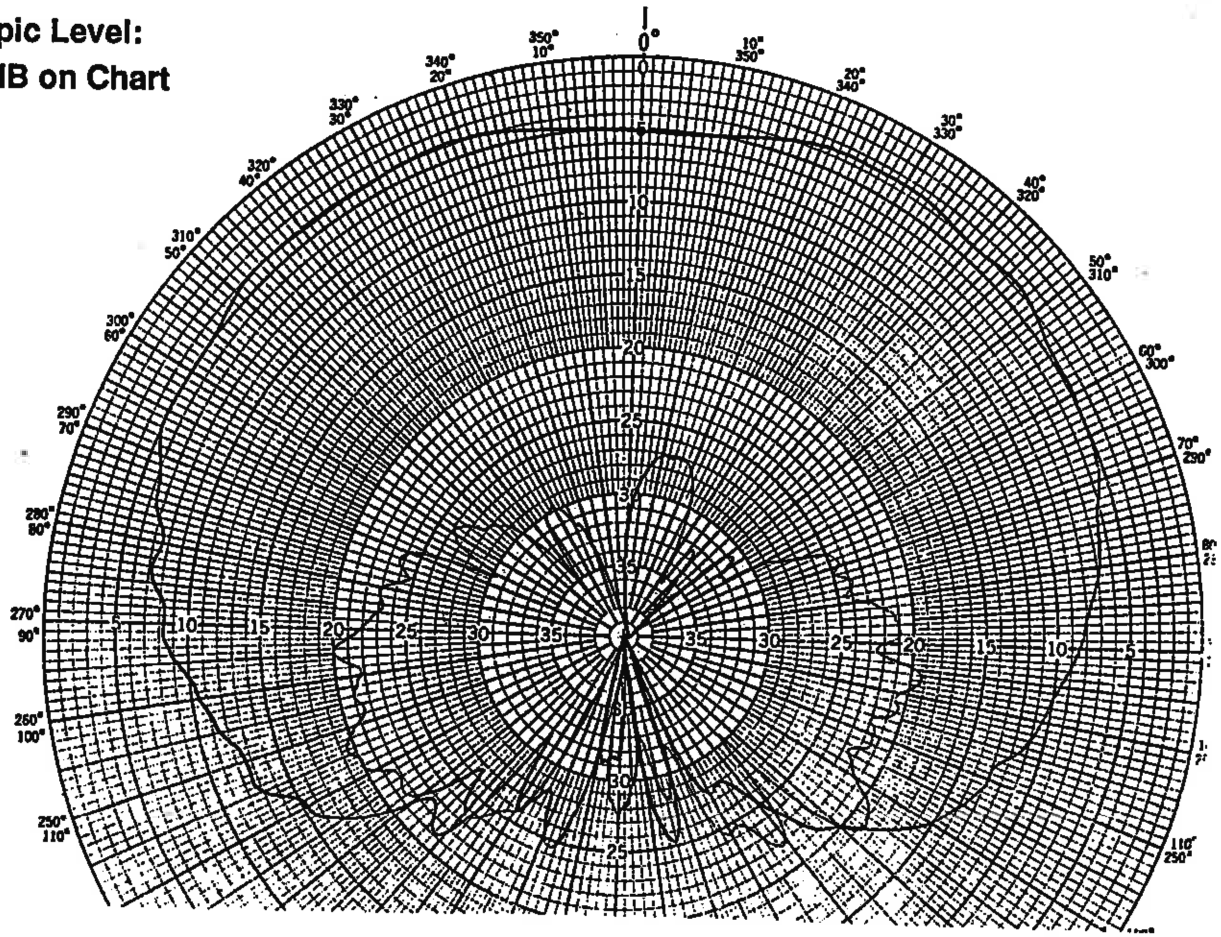
Hemispherical Coverage From a Resonant Quadrifilar Helix - The Zenith Antenna

Isotropic Level:
-6.25 dB on Chart



This graph shows what is to be expected when the nadir and zenith antennas are summed. The free space patterns of two representative antennas at the appropriate spacing have been combined mathematically. The relative phase of the two signals varies rapidly with aspect angle, resulting in narrow interference lobes. When the signals from the two antennas are nearly equal in amplitude, deep nulls in the composite antenna pattern can result. This occurs near the X-Y plane of the satellite. The envelope of the minimums of these interference lobes has been indicated on the graph. For this idealized case, the minimum envelope exceeds -10 dBic over 90% of the sphere and exceeds -20 dBic over 97% of the sphere.

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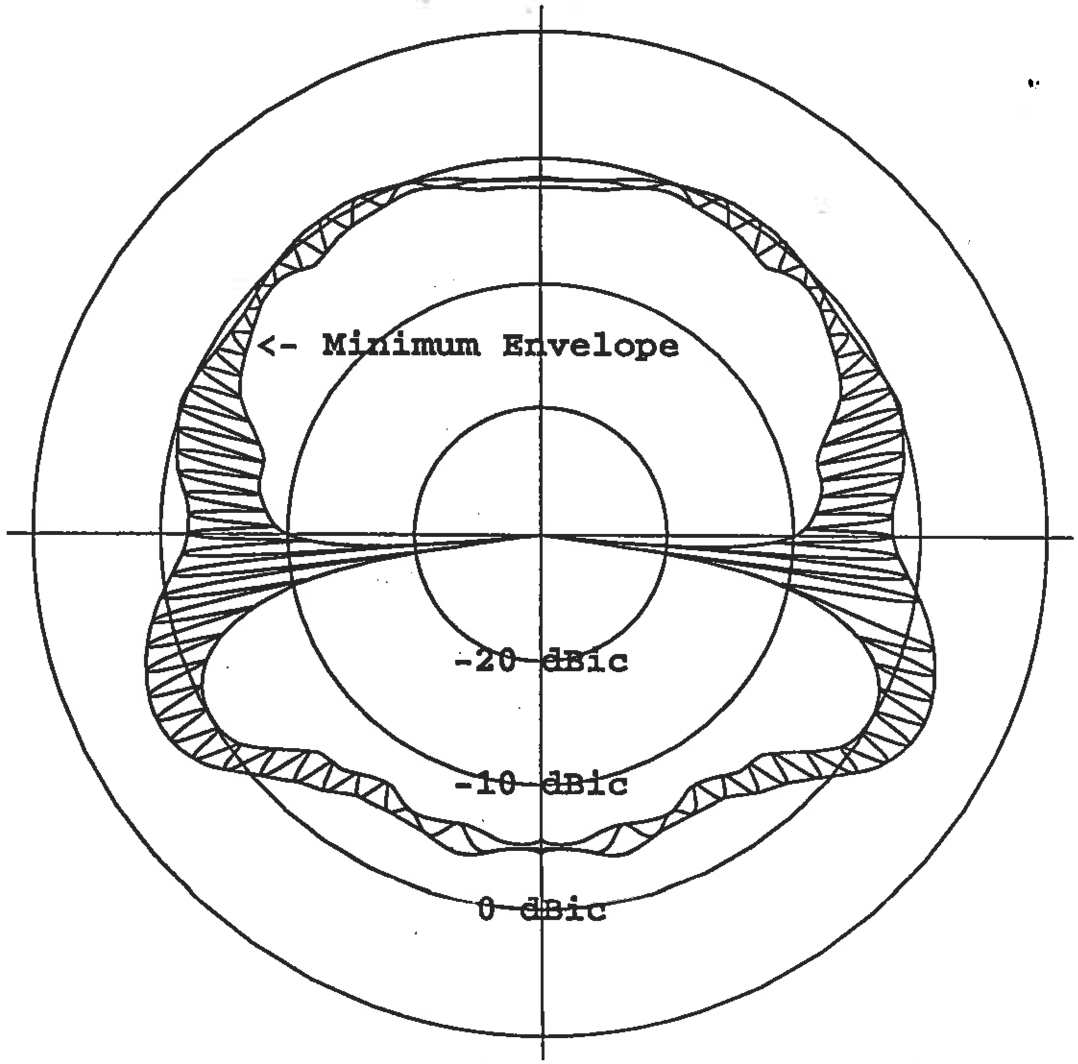
Arraying the Zenith and Nadir Antennas



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The effects of the spacecraft structure on the performance of the antennas will be determined both by testing on a full-scale mock-up of the satellite body (minus the large solar panels) and by numerical modelling. The numerical work will use Version 3 of Ohio State's Numerical Electromagnetic Code - Basic Scattering Code (NEC - BSC) which was originally developed for similar NASA Space Station studies.

Modelling Using the Numerical Electromagnetic Code - Basic Scattering Code (NEC-BSC)