FINAL REPORT

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PLASMA DENSITY AND RADIO ECHOES IN THE MAGNETOSPHERE

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This project provided a opportunity to study a variety of interesting topics related to radio sounding in the magnetosphere. The results of this study are reported in two papers which have been submitted for publication in the *Journal of Geophysical Research* and *Radio Science*, and various aspects of this study were also reported at meetings of the American Geophysical Union (AGU) at Baltimore, Maryland and the International Scientific Radio Union (URSI) at Boulder, Colorado. The major results of this study were also summarized during a one-day symposium on this topic sponsored by Marshall Space Flight Center in December 1994.

The purpose of the study was to examine the density structure of the plasmasphere and determine the relevant mechanisms for producing radio echoes which can be detected by a radio sounder in the magnetosphere. Under this study we have examined density irregularities, biteouts, and outliers of the plasmasphere, studied focusing, specular reflection, ducting, and scattering by the density structures expected to occur in the magnetosphere, and predicted the echoes which can be detected by a magnetospheric radio sounder.

This study has thus led to significant new insights pertinent to radio sounding in the magnetosphere, as discussed in the following attached manuscripts and reports.

The feasibility of radio sounding in the magnetosphere, by W. Calvert, R. F. Benson, D. L. Carpenter, S. F. Fung, D. L. Gallagher, J. L. Green, D. M. Haines, P. H. Reiff, B. W. Reinisch, M. F. Smith, and W. W. L. Taylor, revised manuscript submitted to *Radio Science* 18 Oct. 1994.

Wave ducting in different wave modes, by W. Calvert, submitted to *Journal of Geophysical Research* 10 Feb. 1995, revised 24 Mar. 1995, accepted 3 April 1995.

Electron density structure of the Earth's plasmasphere, report of a study of CRRES and ISEE data relevant to radio sounding in the magnetosphere.

The earth's plasmasphere awaits rediscovery, by D. L. Carpenter, published in *EOS Trans. AGU, 76*, 89-92, 28 February 1995. (Although not produced under this project, this additional paper is of major interest to radio sounding in the magnetosphere.)

HIGHLIGHTS

The structure of the Earth's plasmasphere. ISEE and CRRES wave data were analyzed for density structures which are relevant to radio sounding in the magnetosphere. The following features were identified and it was concluded that radio sounding is essential for understanding the plasmasphere.

- o Irregularities at and beyond the plasmapause
- o Biteouts inside the plasmasphere
- o Outliers

Echo geometry and focusing by the magnetopause. The effects of a varying radius of curvature and ripples in the magnetopause were analyzed in order to determine the echo geometry and detectability of these features, including

- o Estimates for the strength of spread echoes from the magnetopause.
- o The geometry of multiple echoes from different directions
- o Focusing at the center of curvature of the magnetopause

The feasibility of radio sounding in the magnetosphere. An analysis of the feasibility of radio sounding in the magnetosphere was completed and submitted for publication. The new features of radio sounding determined by this study are as follows:

- o Derivation of new formula for focusing by curved surfaces
- o Predicted echo flux of the plasmapause as a function of latitude
- o Analysis of transmitted power and receiver tuning
- o Dependence of angular resolution on signal-to-noise ratio
- o Optimum three-dimensional spatial resolution

Ray-tracing studies. Ray-tracing studies were carried out in order to verify the predicted echoes from the plasmasphere and magnetopause.

- o Calculation of plasmagrams showing echo delay as a function of frequency
- o Confirmation of predicted echo power flux

Wave ducting. An analysis of wave ducting by magnetic-field-aligned density irregularities was completed, submitted, and accepted for publication. The new results of this study are as follows:

- o Seven regions of ducting in the O, X, W, and X wave modes
- o Calculations of the duct strength as a function of frequency and density