Dynamics Explorer

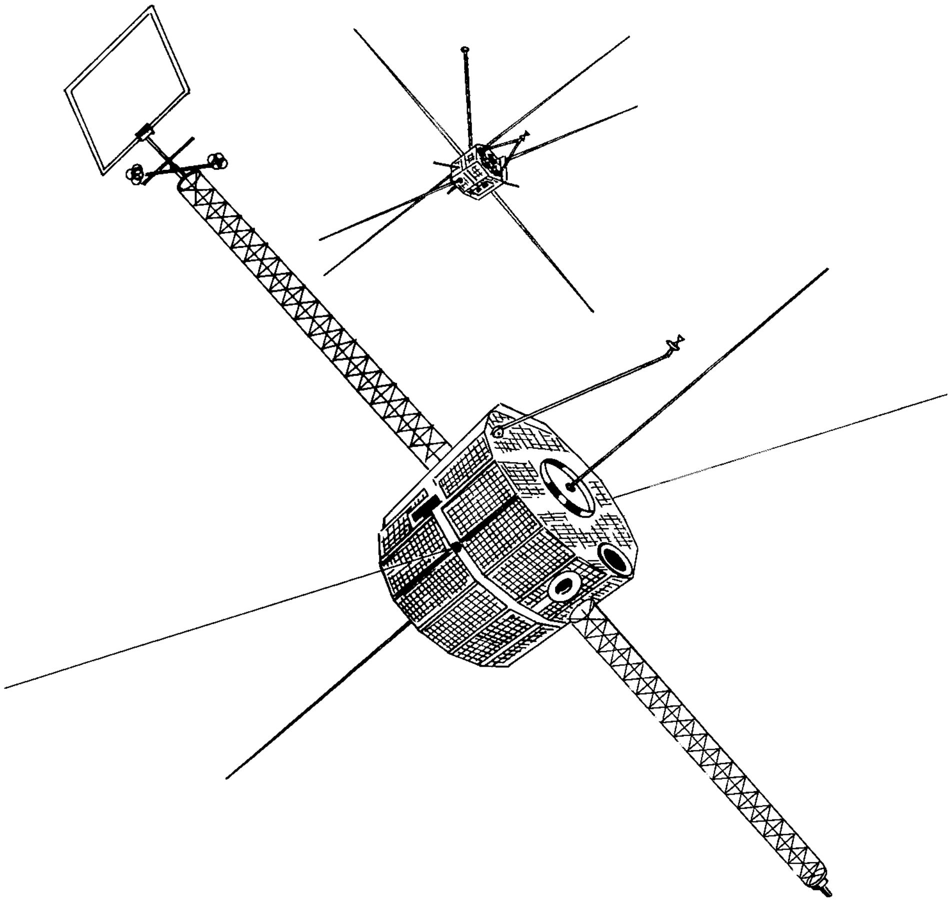
Edited by

R. A. HOFFMAN

Reprinted from

Space Science Instrumentation, Vol. 5 No. 4

D. Reidel Publishing Company
P.O. Box 17, 3300 AA Dordrecht, Holland



Sketch of the dynamics explorer spacecraft.

Dynamics Explorer

Edited by

R. A. HOFFMAN

Reprinted from

Space Science Instrumentation, Vol. 5 No. 4

D. REIDEL PUBLISHING COMPANY
DORDRECHT : HOLLAND / BOSTON : U.S.A.
LONDON : ENGLAND

Printed in The Netherlands

TABLE OF CONTENTS

DYNAMICS EXPLORER PROGRAM: AN OVERVIEW

R. A. HOFFMAN
Electrodynamics Branch, Code 696, Goddard Space Flight Center, Greenbelt, MD 20771, U.S.A.

and

E. R. SCHMERLING
Space Plasma Physics, Code SC-7, NASA Headquarters, Washington, D.C. 20546, U.S.A.

(Received 20 April, 1981)

The Dynamics Explorer program is an important part of the broad Solar-Terrestrial Physics program of the National Aeronautics and Space Administration (NASA) dedicated to achieving an understanding of the processes which control man's near space environment. Two Dynamics Explorer spacecraft will be launched together for the purpose of studying coupling between the magnetosphere, ionosphere and the atmosphere [1, 2]. Forms of this coupling include:

- electric current systems primarily along high latitude magnetic field lines with closure in the ionosphere;
- a convection electric field system imposed upon the ionosphere and originating from the interaction of the solar wind with the earth's magnetosphere;
- energy transfer, including the acceleration of charged particles and thermal heat conduction;
- momentum transfer, especially between convecting ions and the neutral atmosphere;
- thermal charged particle interchange between the ionosphere and magnetosphere;
- wave, particle and plasma interactions in the ionospheric and magnetospheric plasmas.

Launch is scheduled for July 31, 1981.

The program developed out of informal discussions in the late 1960s on the best practical way to study the strong and complex interactive processes within the atmosphere-ionosphere-magnetosphere system. The basic concept that a multisatellite mission was necessary for a comprehensive study of these coupling problems emerged in the early 1970s, and evolved further through a number of formal and informal meetings. The strong case that the scientific community prepared and maintained for a program in atmosphere-ionosphere-magnetosphere coupling led to the recognition that these scientific problems represented many of the highest priority problems in space plasma physics [1].

To carry out this program NASA established a Project Office at the Goddard Space Flight Center and selected the Investigators and complement of instruments (Table I). In addition, many co-investigators, including scientists from four foreign institutions, have been active participants.

The Science Team, composed of the Investigators, developed a set of 24 major scientific objectives for the program. The detailed objectives along with background

Space Science Instrumentation **5** (1981) 345–348. 0377–7936/81/0054–0345 $00.60.

TABLE I

Dynamics Explorer Investigators

L. H. Brace	Goddard Space Flight Center	Langmuir probe
J. L. Burch	Southwest Research Institute	High altitude plasma instrument
G. R. Carignan	University of Michigan	Neutral mass spectrometer
C. R. Chappell	Marshall Space Flight Center	Retarding ion mass spectrometer
F. V. Coroniti	University of California, Los Angeles	Theoretical program
L. A. Frank	University of Iowa	Global auroral imager
W. B. Hanson	University of Texas at Dallas	Retarding potential analyzer
P. B. Hays	University of Michigan	Fabry-Perot interferometer
R. A. Heelis	University of Texas at Dallas	Ion drift meter
R. A. Helliwell	Stanford University	Controlled and naturally occurring wave-particle interactions analysis
R. A. Hoffman	Goddard Space Flight Center	Low altitude plasma analysis
N. C. Maynard	Goddard Space Flight Center	Vector electric field instrument
H. G. Mayr	Goddard Space Flight Center	Theoretical program
A. F. Nagy	University of Michigan	Theoretical program
R. G. Roble	National Center for Atmospheric Research	Theoretical program
E. G. Shelley	Lockheed Palo Alto Research Laboratory	Energetic ion mass spectrometer
S. D. Shawhan	University of Iowa	Plasma wave instrument
N. W. Spencer	Goddard Space Flight Center	Wind and temperature spectrometer
M. Sugiura	Goddard Space Flight Center	Magnetometers
J. D. Winningham	Southwest Research Institute	Low altitude plasma instrument

material and discussions of the required measurements are given in reference [1]. During the development of the program, the Science Team has compared the scientific objectives with the measurement capabilities of the instruments selected for the mission for consistency, and made adjustments where necessary. The instruments selected are capable of measuring the following parameters:

- thermal electrons: temperature and density;
- thermal ions: temperature, density, composition and bulk motion;
- thermal neutral particles: density, temperature, composition and bulk motion;
- suprathermal particles: electron and ion distribution functions and composition;
- vector magnetic field;
- vector electric field;
- plasma waves;
- auroral optical images;

– ground VLF transmission (Siple, Antarctica).

A unique and necessary feature of the program involves the launch of two spacecraft into coplanar orbits. This orbit configuration provides for data acquisition at two altitudes within common magnetic flux tubes, fulfilling the requirement for simultaneous data sets in the magnetosphere and in the ionosphere/atmosphere. The 90° inclination of the orbits also maintains coplanarity, since the orbit planes do not precess. The Science Team performed detailed trade-off studies of the remaining orbit parameters to define the orbits which will optimize the quality of the data. Many criteria influenced the parameter selection.

The altitude at apogee for the high altitude satellite must be sufficiently high for global auroral imaging, plasmasphere and plasmapause observations near the equator, wave and particle measurements in the heart of the magnetosphere, and passage through the region of interaction between the electromagnetic waves injected by the Siple VLF transmitter and magnetospheric charged particles. Auroral viewing of the northern polar cap region (which is heavily instrumented with ground observatories) during northern winter requires apogee to occur at high latitudes at this time, while the requirement for the ionosphere over Siple to be in darkness during transmission experiments demands apogee be near the equator around noon during southern winter. A near equatorial apogee in the noon sector enhances plasmasphere studies, and also allows measurements of wave-particle interactions for significant periods while the spacecraft travels along magnetic flux tubes. Investigations of the recently identified auroral particle acceleration region at a few earth radii require crossings of auroral field lines at high altitudes in the late evening sector.

Measurements from the low altitude spacecraft require perigee to be below 350 km to provide long orbital path lengths below 500 km for neutral particle and thermospheric wind measurements. There is also a desire for an apogee to be above 1000 km for measurements above the region of interaction between suprathermal ions and the atmosphere.

Finally, several spacecraft constraints, which are based on power, thermal, launch and early operations factors, had to be considered in the selection of orbital parameters. Details of the orbit characteristics appear in the following article.

The coupling studies to be performed by the Dynamics Explorer Investigators demand that data sets derived from groups of instruments on both spacecraft be made readily available for analysis. To fulfill this requirement, the type of ground data system successfully developed for the Atmosphere Explorer program [3] has been selected. The Science Data Processing System centers around a central computer facility located at the Goddard Space Flight Center, with remote terminals located at Investigators' facilities. The system will perform the majority of the data processing and analysis functions for the investigators associated with the program and will permit adaptive mission planning by rapidly providing summary data plots from instruments on both spacecraft. The approach adopted assures that the specific data required for each of the studies associated with the mission objectives are acquired, processed and made easily accessible to the investigators.

In an attempt to enhance the science return from the mission, the Science Team is collaborating with scientists who have on-going rocket, satellite and ground based experimental programs. The collaborating scientists can request special satellite operations to acquire data for coordination purposes by working through the program Investigators. They will also be able to enter appropriate data into a common data base in the Science Data Processing System and will have access to related satellite data.

In addition, a formal Guest Investigator program will be announced through a 'Dear Colleague' letter. Initially this program will make available limited funds to assist in the analysis of the data acquired from the collaborative program. As the data from the spacecraft mature, Guest Investigators will be selected to participate in analyses in the traditional manner. To become a Guest Investigator, a scientist will submit a proposal to the Space Plasma Physics Program Office at NASA Headquarters for a specific study using Dynamics Explorer data. The proposal will then be evaluated in competition with other proposals, and if accepted, the Project Office will arrange to provide the required data to the Guest Investigator.

This brief overview introduces the articles which provide details of the Dynamics Explorer program. The spacecraft systems and ground operations approach are first described, followed by fourteen instrumentation articles. The final article deals with the Science Data Processing System. With this issue an attempt has been made to provide a working document, which will not only describe details of the program, but more importantly be valuable to all scientists associated with the program at the present, as well as those joining the scientific analysis and interpretation phase at some later time.

Acknowledgments

During the development of the Dynamics Explorer program, many scientists and engineers from universities, NASA and industry made essential contributions. A number of the pioneers in the effort are listed in the first reference, and to these people, especially the late Prof. N. M. Brice, the Science Team is most grateful. The work of the Dynamics Explorer Program Panel, the committee charged by NASA Headquarters to redefine the former Electrodynamics Explorer program, was key to the approval of the current project. Appreciation is expressed to Dr Frank Martin, Director, Solar Terrestrial and Astrophysics Division, and Dr Harold Glaser, former Director, Solar Terrestrial Division, for their continued support, as well as to Mr Frank Gaetano and Mr Marius Weinreb, former and current Program Managers, all of NASA Headquarters. Special appreciation and credit are due to Dr David Cauffman, the initial Program Scientist at NASA Headquarters, and Mr Nelson Spencer, Chief of the Laboratory of Planetary Atmospheres at Goddard Space Flight Center, for their unwavering guidance and assistance during the evolution of the Dynamics Explorer program.

References

1. Hoffman, R. A.: NASA Goddard Space Flight Center (1978).
2. Hoffman, R. A.: *EOS*, **61**, 689 (1980).
3. Spencer, N. W.: NASA Goddard Space Flight Center (1977).