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**DRAFT FINAL REPORT**

**NASA Contract Number NAS5-33032**

**Dynamics Explorer -1  
Energetic Ion Composition Spectrometer (EICS)**

**Period: December 1, 1989 - August 31, 1994**

**Submitted to the National Aeronautics and Space Administration  
Goddard Space Flight Center  
Greenbelt, Maryland 20771**

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## 1. Background

The Energetic Ion Composition Spectrometer (EICS) experiment was selected as part of the Dynamics Explorer (DE) Program via competitive proposals in response to a NASA Announcement of Opportunity. Dr. E.G. Shelley of the Lockheed Space Sciences Laboratory lead the proposal effort, development of the instrument and the operations and data analysis efforts which were funded through a series of NASA contracts. The most recent contract, NAS5-28710, expired on November 30, 1989. Contract NAS5-33032 covers the period from December 1, 1989 to August 31, 1994. The tasks involved operations of the EICS instrument until spacecraft operations terminated in 1991, analysis and interpretation of data from the EICS instrument, participation in the activities of the DE science team, archiving of EICS data at the National Space Science Data Center (NSSDC), and support of scientific investigations lead by other members of the DE science team.

The Dynamics Explorer Program was conceived and flown in response to the need for studies of auroral phenomena and the processes coupling the dynamic plasmas found the magnetosphere and ionosphere. The EICS experiment was selected as a component of the DE science payload because ion composition measurements provide one of the most direct means to study the sources, energization, transport, and loss mechanisms of space plasmas. The EICS instrument returned useful data from September, 1981, until early 1991 when the last on-board tape recorder failed.

One of the primary goals of the DE program was to investigate in detail the plasma physics processes responsible for energizing thermal ( $\sim 1$  eV) ionospheric ions and transporting them to the Earth's plasma sheet and distant polar cap. For a review of the pioneering work on ionospheric ion acceleration and escape see Johnson [1983]. It is generally agreed that the high latitude auroral ionosphere interacts with the neutral atmosphere to damp plasma motions driven by the solar wind interaction with the magnetosphere. The energy imparted by the solar wind in these time and spatially variable interactions produces a variable intensity upward flux of ionospheric ions. These ions are transported along magnetic field lines, further energized, and become a significant and highly variable fraction of the plasma in the Earth's plasma sheet. The plasma sheet in turn is unstable and periodically releases energy in explosive events called magnetospheric substorms. Some of the energy released in substorms is transported back to the ionosphere where it also interacts with ionospheric ions. In the absence of

a significant source of energy from the magnetosphere, heavy ions (i.e.  $O^+$ ,  $N^+$ ,  $N_2^+$ ,  $O_2^+$ , and  $NO^+$ ) cannot escape from the ionosphere. Nevertheless large fluxes of these heavy ions are routinely found at high altitudes (i.e. above 5,000 km) [Yau et al., 1984; Craven et al., 1985; Kleckler et al., 1986].

An important part of the DE Program was the realization that progress in understanding the complex, dynamic, interactions between the ionosphere and magnetosphere could come only by acquisition and analysis of complete particle and field data from multiple satellites. The coordinated analysis of EICS data since 1989 supported by this contract has significantly advanced our quantitative and qualitative understanding of the role of geogenic (i.e. ions originating in the Earth's ionosphere) in macro- and micro-scale processes in the Earth's magnetosphere.

The results of the EICS data analysis (including the support of other investigators) and of the archiving efforts supported by this contract are summarized below. We also report on some aspects of our operational support activities. Appended to this report are a complete listing of all publications and presentations prepared using funds from this and prior EICS data analysis contracts and copies of all publications appearing in the refereed literature during the period covered by contract NAS5-33032.

## 2. Scientific Accomplishments

During the period of performance of this contract 32 papers have appeared in the refereed literature reporting on analysis and interpretation of EICS data. These papers were the direct result of the tasks supported by this contract. In addition several unique coordinated data sets were accumulated as a result of efforts funded by this contract. In the sections below we briefly outline the most important scientific accomplishments reported in the 32 papers. Complete copies of the papers are included in Appendix B. For convenience we have divided the discussion into broad areas: investigations of micro-scale plasma physics processes; morphological studies of magnetosphere/ionosphere interactions; investigations of large scale magnetospheric features; review papers; support of other investigators; and a discussion of the significant coordinated data bases that were accumulated in the course of instrument operations.

## 2a. Investigations of micro-scale plasma physics processes

Ten of the 32 papers summarizing analysis and interpretation of EICS data addressed the broad topic of micro-scale plasma physics processes. In the paragraphs below we briefly mention the most important scientific results of these papers. Complete copies of the papers can be found in Appendix B organized in alphabetical order by first author.

Many micro-scale processes have been invoked to account for the energization and transport of heavy ions. Peterson et al. [1993a] investigated simultaneous observation of  $H^+$  and  $O^+$  ion fluxes at two altitudes on the same magnetic field line and demonstrated for the first time that heavy ions reach their plasma sheet energy through a series of processes acting at various altitudes. This analysis was made possible because of the systematic acquisition of data from the NASA DE -1 and Japanese Akebono satellites from 1989 to 1991 described in Section 2f.

Four papers (Peterson et al., 1989; André et al., 1990a,b; and Crew et al., 1990) addressed the micro-scale physics associated with the ion cyclotron resonance heating (ICRH) mechanism. Peterson et al. [1989] were able to exploit the unique geometry of the dayside cusp region to determine that sufficient wave energy was available for the ICRH mechanism to account for the energization of thermal  $O^+$  ions as they convected into the cusp region and encountered a spatially restricted region with intense low frequency waves. André et al. [1990a,b] extended the analysis presented by Peterson et al. [1989] to include a simulation. This series of three papers provided the first direct measurement in space of the energy input to a micro-scale plasma process simultaneously with direct observations of the associated ion energization. Crew et al. [1989] re-formulated the theory of ICRH heating to address energization of  $O^+$  ions over extended altitude ranges on auroral field lines. Crew et al. used data from several DE -1 instruments, including EICS, to test the theory. They found that the ICRH mechanism could account for the creation of the class of ion conic distributions first identified in EICS data and reported by Klumpar et al. [1984].

Boardsen et al. [1990] examined  $H^+$  velocity space distributions and detailed plasma wave spectra near multiples of the hydrogen cyclotron frequency encountered at mid altitudes (i.e.  $< 3.5 r/R_E$ ) in the Earth's auroral zone. They concentrated on events where two peaks, rather than one, were associated with each harmonic in the plasma wave spectrum. They showed that this feature in

the wave spectrum was the result of motion of the satellite relative to the plasma rest frame. They were able to exploit this insight to determine the wavelength and phase velocity of the waves providing significant new information on the complex plasma wave modes that occur at mid altitudes on auroral field lines.

Winglee et al. [1993] examined EICS and HAPI (High Altitude Plasma Instrument) data from a cusp injection event at the highest possible time resolution. They found significant modulations on the time scale of 18 to 30 seconds in the intensity of the injected solar wind ions and noted that this implies that a fast time scale and/or short spatial scale length process modulating the injection of magnetosheath plasma. They also found evidence that the precipitating flux of magnetosheath ions interacted with an upflowing, conic-shaped, ion distributions causing them to briefly change direction.

Three papers (Winglee et al., 1989; Bergman, 1990; and Schriver et al., 1990) addressed energy transfer between beams of energetic  $H^+$  and  $O^+$  as they travel along auroral field lines. Earlier in the DE program, Kaufmann et al. [1986] used data from the EICS instrument and an energetic ion mass spectrometer on the S3-3 satellite to investigate the stability of upflowing beams of ionospheric ions. They showed that  $H^+$  ions in the low velocity tail of the beam were decelerated and  $O^+$  ions in the high velocity tail are accelerated by the micro-scale process known as the ion two stream instability. Bergman [1990] reviewed the extensive work on the problem and extended the analysis to show that observations from one spacecraft were inadequate to completely model the evolution of the two stream instability on auroral field lines. Winglee et al. [1989] simulated the interactions between upflowing beams of  $H^+$ ,  $He^+$  and  $O^+$  and showed that bulk heating of heavy (i.e.  $O^+$  and  $He^+$ ) ions occurs when their relative density is low while high-energy tails are produced in the heavy ion distributions when their relative density is high. Schriver et al. [1990] performed a slightly different simulation of an  $H^+$  and  $O^+$  plasma and confirmed the results of Winglee et al. [1989]

## 2b. Morphological studies of magnetosphere/ionosphere interactions

One of the most important accomplishments associated with the analysis of EICS data prior to this contract was the quantification of the magnitude and distribution of upflowing fluxes of energetic  $H^+$  and  $O^+$ , [Yau et al. 1984, 1985a, 1985b, 1988, Sagawa et al. 1987]. This analysis was based on EICS data binned

in three broad energy ranges considered individually with limited pitch angle information. The energy bins were 0.01 — 1 keV, 1—4 keV, and 4—17 keV. Kondo et al. [1990] extended the analysis to consider the crude energy spectra formed by these three broad energy channels. Kondo et al. examined hybrid type distributions consisting of conic like distributions in the lower and beam like distributions in the higher energy channels. They concluded that the electric potential drop along auroral field lines is small ( $< 1\text{keV}$ ) except perhaps in the dusk to midnight sectors.

A second summary data base of EICS data with higher energy resolution (15 energy bins) and well defined pitch angle coverage for  $\text{He}^+$  as well as  $\text{H}^+$  and  $\text{O}^+$  was accumulated during the later phases of the DE program. The first use of this data base was to determine the altitude, latitude, and local time distribution of the new class of bi-modal conics identified in the EICS data by Klumpar et al. [1984]. The results of this investigation were presented by Peterson et al. [1992, 1994] and Doherty et al. [1993]. Doherty et al. [1993] described the two dimensional, model based algorithm based on standard image processing techniques developed to search the data base for bi-modal conics and other types of ion distributions. Peterson et al. [1992] showed that extended (i.e. bi-modal) conic distributions occur at about the same frequency above 8,000 km as the previously identified (i.e. restricted) type. The data presented directly demonstrated that above 8,000 km energetic ion conic formation by localized transfer of energy to a cold ion population in a restricted altitude region is not common. Figure 3 in this paper was picked up by the editor of *Geophysical Research Letters* and used on the cover of the July 24, 1992 issue. Peterson et al. [1994] presented a more complete presentation of the results of the initial results summarized in *Geophysical Research Letters*.

## 2c. Investigations of large scale magnetospheric features

In the course of preparing the Peterson et al. [1993a] paper, Peterson et al. [1993b] attempted to better define the geometry of the magnetic conjunction to use the method developed by André et al. [1990] to evaluate the component of ion heating caused by the ICRH mechanism mentioned in Section 2a. In the course of this analysis a narrow ( $\sim 15$  km at ionospheric altitudes) feature in the magnetometer data observed at two altitudes on the equatorward edge of the cusp was identified. This feature was not consistent with the expected interpretation that the perturbation in the magnetometer signal was caused by a quasi-stationary

field-aligned current. The primary evidence was the nonconservation of the quantity  $j/B$  (apparent field-aligned current density divided by magnetic field intensity) as a function of altitude and the unphysically large inferred current magnitudes. Peterson et al. [1993b] concluded that the feature was most likely the signature of a standing Alfvén wave. This report brings to a close the long running controversy about the interpretation that a fraction of events showing variations of magnetic intensity at low altitudes arise from wave activity (see, for example, the discussion in Gurnett et al. [1984]).

Maynard et al. [1991] analyzed the broad spectrum of particle and field measurements acquired on DE -1 and -2 near local noon during the large magnetic storm of September 6, 1982. At apogee DE -1 sampled the magnetospheric boundary layer. Variance and de Hoffman-Teller analysis of electric and magnetic field data acquired during the magnetopause crossing showed a rotational discontinuity which is consistent with the open model of magnetospheric topology. Detailed analysis of the particle data, including EICS, from DE -1 and -2 suggests that the dayside boundary layer is made up of closed magnetic flux tubes, a large fraction of which drift to the magnetopause where merging with the interplanetary magnetic field (IMF) occurs.

Boardsen et al. [1992] examined the relationship between the commonly occurring funnel-shaped, low-frequency radiation, as observed in frequency time spectrograms acquired near the Earth's magnetic equator from DE -1 and the velocity space distributions of  $H^+$  ions observed the EICS. Boardsen et al. [1992] concluded that the energy source for the wave emissions is a ring-type distribution with a positive slope in the velocity space density distribution in the energetic  $H^+$  ions at energies on the order of 10 keV. Their analysis suggested that this ring-type distribution is maintained by the Earthward convection of plasma sheet ions and the dissimilar energy dependences of eastward ( $\mathbf{E} \times \mathbf{B}/B^2$ ) and westward ( $\mathbf{B} \times \nabla B/B^2$ ) ion drifts.

Lu et al. [1992] and Reiff et al. [1993] examined ion and electron data acquired nearly simultaneously at two altitudes on closely collocated auroral field lines to investigate ion energization and extraction mechanisms. Lu et al. [1992] used the EICS and other high altitude data first presented by Reiff et al. [1988] and measured upflowing fluxes at low altitudes to estimate the low altitude limit of the auroral acceleration region. Lu et al. [1992] estimated that the bottom of the auroral acceleration region is between 1,400 and 1,700 km for the region of peak potential drop. Reiff et al. [1993] extended the analysis to include an estimate of the high altitude limit of the acceleration region based on the analysis of simultaneously obtained ion and electron velocity space distributions.



Kozyra et al. [1993] examined DE -1 energetic and thermal ion data in conjunction with those obtained on the AMPTE/CCE satellite for an interval in September 1994. Previously Kozyra et al. [1987a] had shown the energy source for the well known SAR (sub auroral red) arc emissions come from energetic (~10 keV)  $O^+$  ions in the ring current. However an examination of SAR arc emissions over the last solar cycle indicates that the strongest emissions often occur in association with the main phase of a magnetic storm. The variation of  $O^+$  content of the ring current, as function of the phase of a magnetic storm is not consistent with energetic  $O^+$  as the energy source for the intense emissions associated with the main phase of the storm. In their paper, Kozyra et al. [1993] identify the enhanced ~20 keV  $H^+$  component of the ring current during the main phase as the source of energy for the intense SAR arcs.

Chen et al. [1990] and Horwitz et al. [1992] examined the plasma characteristics associated with upflowing ion beams in the polar cap region. Chen et al. [1990] examined data from EICS, the Retarding potential Ion Mass Spectrometer (RIMS) and the Plasma Wave Instrument (PWI) from two polar ion streams. They found the plasma to consist of multiple streaming and quasi-isotropic components. They found a significant  $O^+$  content, even during magnetically quiet times and polar ion streaming events with a filamentary structure with spatial scales of tens to hundreds of kilometers in the ionosphere. Horwitz et al. [1992] used data from EICS, RIMS, PWI and the High Altitude Plasma Analyzer (HAPI) and the Scanning Auroral Imager (SAI) to investigate the same region. Horwitz et al. [1992] also used measurements of the upflowing distribution of photoelectrons to place limits on the potential drop encountered on polar cap field lines.

## 2d. Review Papers

Two general review papers were written by members of the EICS science team during the period of this contract. Shelley and Collin [1991] reviewed the general topic of auroral ion acceleration and its relationship to ion composition which was included in *Auroral Physics*, the book prepared to honor the 100th birthday of Sydney Chapman. Yau [1988] reviewed the work on quantitative measurement of ion outflows from the polar ionosphere.

## 2e. Support of other investigators

In the final years of the DE program, investigators from many institutions found that analysis and interpretation of data from the EICS instrument provided significant insights into their research problems. In the period of this contract 8 papers appeared that used data from the EICS instrument in a significant way. Typically these investigators would contact a member of the EICS science team and some data and accompanying analysis were provided. Support for this work was provided by Contract NAS5-33032.

Ball and André [1990] used data from the EICS and Plasma Wave Instrument (PWI) to determine the relative importance of ion heating by double-cyclotron absorption compared to the ion cyclotron resonance mechanism. Simulation techniques were used and demonstrated that for any particular event cyclotron resonance can probably heat ions over a much greater altitude range than double-cyclotron absorption is capable of doing. On the other hand they showed that double-cyclotron absorption has a much stronger dependence on local intensifications of the wave spectral density. They concluded that relatively narrow regions of intense wave activity may be sufficient for this heating process to account for the  $O^+$  conic distributions observed by the EICS instrument.

Bering and Ignatiev [1990] reported on a simulation of the particle environment expected to be produced by the vacuum Wake Shield Facility (WSF) that was recently flown on the shuttle. W.K. Peterson provided these authors EICS data that appeared as Figure 3 in the paper and was used as input to their simulation. Prior to discussions with the EICS science team Drs. Bering and Ignatiev were unaware of the significant fluxes of thermal ( $\sim 10$ eV)  $O^+$  ions found at low altitudes in the periods following large geomagnetic storms.

Several workers have proposed imaging the plasma in the Earth's plasmasphere and plasma sheet from various orbits. EICS data were used in a series of papers by Chiu et al. [1990] Robinson et al. [1992] and Garrido et al. [1994] evaluating the possibility of imaging the Earth's magnetospheric and exospheric plasmas in the extreme ultraviolet. Chiu et al. [1990] used computer simulations based, in part, on data from the EICS instrument to show that it is realistic to use the extreme ultraviolet line emissions from exospheric oxygen ions and neutrals to form images of the dynamic magnetospheric regions with sufficient speed to provide a global means of observing the dynamics of magnetospheric-ionosphere coupling processes. Robinson et al. [1992] expanded the simulations of Chiu et al. and showed that for a near equatorial orbit viewing locations greater

than 9 Earth radii are required to observe outflowing ions above the cold plasmaspheric background. Garrido et al. [1994] further extended the analysis to simulate images of the plasmasphere and trough regions from resonant scattering by  $O^+$  (83.4 nm) and  $He^+$  (30.4 nm). They concluded that imaging the plasmasphere was done most efficiently using the  $He^+$  line emissions.

Ludlow et al. [1991] and Ludlow and Hughes [1993] examined electromagnetic ion cyclotron waves near the Earth's geomagnetic equator observed both from DE-1 and ground based observatories. Ludlow et al. [1991] reported a survey of ion cyclotron emission events obtained from DE -1 inside geosynchronous orbit and simultaneously by ground based observatories. An analysis, based in part, on data plasma densities obtained from the EICS instrument on DE -1, showed that the observed 30-100 s delay in observation time on the spacecraft and ground could be accounted for by the group delay time associated with propagation of the signals to the ground. Ludlow and Hughes [1993] used measured EICS particle distributions in conjunction with the warm dispersion relation to calculate the group delay of ion cyclotron waves from the equatorial source region near the plasmopause to the foot of the field line.

Olsen [1992] investigated the density minimum found near the Earth's magnetic equator. The density depletion typically extends  $\pm 5^\circ$  to  $\pm 20^\circ$  in latitude and occurs at geocentric distances from 2 to 5  $R_E$ . The analysis and discussion was based primarily on data from the DE -1 Retarding Ion Mass Spectrometer (RIMS), but Olsen supplemented his analysis by including data from the EICS instrument in several instances.

## 2f. Support of instrument operations

DE -1 was launched in late August 1981 and the EICS instrument was activated and started to return useful information on September 15, 1981. Useful data (i.e. data that have been presented at scientific meetings and appeared in publications [Persoon et al., 1991]) were returned just weeks before satellite operations ceased in early 1991. The instrument had a programmable, on-board, memory, that provided the opportunity to customize instrument operations in support of numerous scientific investigations [Shelley et al., 1981]. In addition to customizing the EICS mode, EICS operational support also consisted of coordinated acquisition of data bases from multiple platforms. In this section we briefly discuss two of the more important instrument operation endeavors lead by members of the EICS science team during the period of this contract — those related to

acquisition of EICS data in support of the Japanese Akebono and the NASA CRRES programs.

The Akebono satellite was launched in February 1989 and continues to operate in July 1994 as this report is written. The Akebono orbit was inclined  $75^\circ$  with an apogee of 10,500 km and a perigee of 274 km. Details about the Akebono satellite and its extensive complement of particle and field instruments are given by Tsuruda and Oya [1991]. Drs. Peterson and Yau of the EICS science team developed a method of informing both the DE and Akebono operations centers of the predicted ephemerides and operational plans. This provided the opportunity to acquire a data base consisting of several hundred intervals when both DE -1 and Akebono were operating and were located on nearly conjugate magnetic field lines. Measures of the success of the coordination effort are: 1) before November 1989, when the coordination plan was implemented, almost no conjunctions were found in the data; whereas most of the usable conjunctions were found after this date; and 2). Two papers have appeared [Peterson et al. 1993a, 1993b] reporting on data acquired as a result of this coordinated effort. Exploitation of this data base was pursued by Dr. Peterson during his extended visit to Ottawa in the summer and fall of 1993 funded by the Canadian government.

Operations of the DE EICS instrument were optimized for the detection of  ${}^7\text{Li}^+$  from the NASA/Air Force CRRES chemical release program. It was not possible, however, to recover the data acquired to detect ions from a January 13, 1991 release from a tape recorder on DE -1. During November, 1990, DE -1 stopped accepting commands, presumably because of the degradation in satellite thermal control that resulted in a operating environment at and above the nominal service temperatures. Spacecraft operations were suspended until December, 1990, when DE -1 cooled because of the changing solar aspect angle and the reduced power dissipation associated with suspended operations. The data on the tape recorder acquired on November 17, 1990, when commands were first not accepted, were recovered on December 17th, when commanding was restored. Limited operations using the tape recorder were resumed in January, 1991. Data were acquired on the only working tape recorder and transmitted to the ground from 16:03 to 16:19 on January 4, from 11:39 to 13:41 on January 8, and from 08:24 to 08:40 on January 11, 1991. The spacecraft stopped accepting commands again shortly after 11:00 on January 13th during the period data were being acquired in support of the CRRES G-7 release. Presumably the power dissipated by the tape recorder and limited instrument complement operating at the time raised the satellite temperature to the point where the spacecraft would not accept commands. When the spacecraft cooled and again began accepting commands in February,

1991, the tape recorder had failed. Limited data were acquired from DE -1 using a real-time data link between February 14 and 18. Repeated and creative attempts to recover the data from the January 13th chemical release that are still on the tape recorders were made until the DE -1 operations center was physically dismantled in April, 1991.

### 3. Data archiving and continued support for data analysis

The goal of the EICS archiving effort was to preserve the data so that it will be possible for a graduate student working from archived data and meta-data to be able to access EICS data at sufficient resolution to address all of the major science objectives of the DE program. This goal necessarily implies that it is inadequate to archive only averages of the data over fixed time intervals with fixed energy, angular, and mass resolution. To meet our archiving goal we archived stand alone telemetry files (SATF). The basic EICS archiving plan is described in detail in the DE Team archiving plan submitted in May 1989 by the DE Project Scientist, Dr. R. A. Hoffman. The plan outlines archiving the pre-existing tape-based EICS Stand Alone Telemetry Files (SATF) on optical disks in a format acceptable to the National Space Science Data Center (NSSDC). The archive of SATF consists of over 15,000 stand alone telemetry files (SATF), a general purpose program that provides detailed EICS fluxes for normal EICS operational modes, a data catalog that gives summary data quality information, and extensive documentation on how to use the code and catalog. Copies of this documentation have been provided to both the NSSDC and the DE Project Scientist.

Almost all of the EICS data acquired from September 15, 1981 to February 1, 1982, and during intervals of general interest such as the 1986 PROMIS campaign, has been converted to the SATF format and entered into the archive. Approximately 50% of all of the EICS telemetry acquired since September 15, 1981 have been converted to the SATF format and archived. As noted in the DE Project archiving plan, the EICS investigators transferred the tape-based archive of SATF onto optical disks in a form acceptable to the NSSDC. This effort involved 8 specific tasks which were completed in 1992. As reported in our regular quarterly reports, the completion date was delayed by problems encountered with the NASA supplied hardware and software for creating optical disk platters and staff shortages at the NSSDC which delayed required approvals of EICS produced documentation.

Analysis of the EICS data will continue beyond the end of this contract because of the availability of the archive of SATF files. At this writing (July 1994), two NASA Supporting Research and Technology (SR&T) proposals for the continuing analysis of EICS data have been funded and several others are in preparation. (A.M. Persoon et al. "Multi-Ion, Multi-Event Test of Ion Cyclotron Resonance Heating"; and W.K. Peterson and H.L. Collin, "Local and Global Studies of Ion Outflow from the High Latitude Ionosphere"). W.K. Peterson also received support from the Canadian Government in 1993 to pursue analysis of the data assembled during the times of DE -1/Akebono magnetic conjunction.

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## 5. Appendix A

A complete list of all publications and presentations based on the analysis and interpretation of Energetic Ion Composition Spectrometer data from launch of the DE -1 spacecraft in 1981 through July 1994.

Papers, Invited, and Contributed Presentations Based on Data from the  
Energetic Ion Mass Spectrometer (EICS)  
on the Dynamics Explorer -1 Satellite

Revised: July, 1994

**1) Published Papers:**

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## 6. Appendix B

Copies of publications appearing during the period of this contract, December 1989 through August 1994. The papers are ordered by the last name of the first author.

# REPORT DOCUMENTATION PAGE

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<b>13. ABSTRACT (Maximum 200 words)</b> The Energetic Ion Composition Spectrometer (EICS) experiment was selected as part of the Dynamics Explorer (DE) Program. One of the primary goals of the DE program was to investigate in detail the plasma physics processes responsible for energizing thermal (~1 eV) ionospheric ions and transporting them to the Earth's plasma sheet and distant polar cap.  The results of the EICS data analysis (including support of other investigators) and of the archiving efforts supported by this contract are summarized in this document. Also reported are some aspects of our operational support activities.				
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