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BOSTON COLL CHESTNUT HILL MASS SPACE DATA ANALYSIS LAB  
DATA BASE DEVELOPMENT FOR AIR FORCE SATELLITES, (U)

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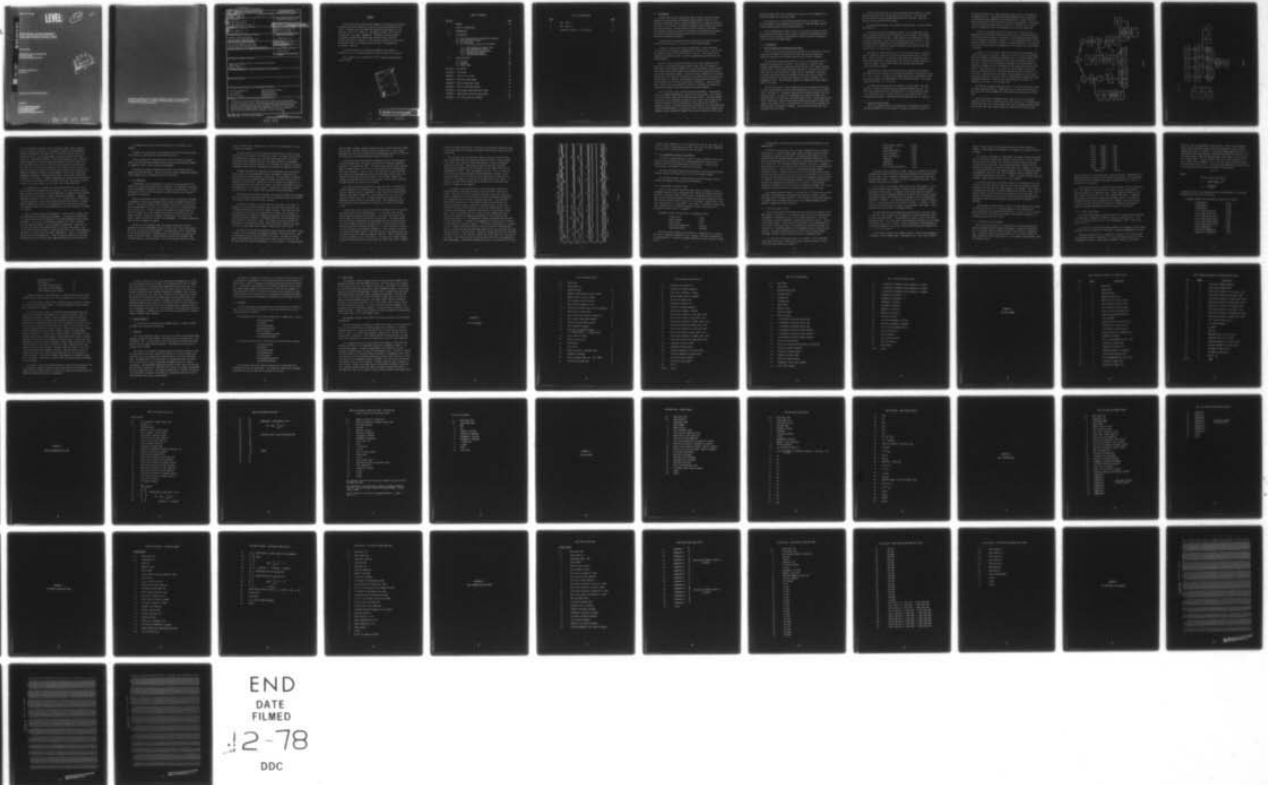
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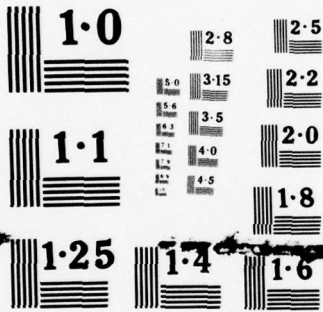
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**DATA BASE DEVELOPMENT  
FOR AIR FORCE SATELLITES**

Dennis E. Delorey

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PREFACE

The author wishes to thank several members of the Space Data Analysis Laboratory for their efforts in relation to the tasks described in this report. Administrative assistance was provided by the Director of the laboratory, Mr. Leo F. Power, Jr. The analysis efforts of Mr. Paul N. Pruneau were, once again, commendable. Additional analysis support, programming and data base efforts were provided by Ms. Carolyn M. Parsons, Mr. Roger P. Vancour, Jr., Mr. Brian J. Donovan, Ms. Lisa Silva, Mr. Kenneth Dieter, Mr. Timothy Latson, Mr. Neil J. Grossbard and Mr. Brian F. Sullivan.

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## TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
PREFACE	iii
LIST OF ILLUSTRATIONS	v
1.0 INTRODUCTION	1
2.0 S3 SATELLITES	2
2.1 Vehicle Operations and Spacecraft Telemetry	2
2.2 Data Processing Systems	3
2.3 S3-1 Data Base	10
2.4 S3-2 Experiments, Analysis and Software	13
2.4.1 Cold Cathode Ion Density Gauge	15
2.4.2 Mass Spectrometer (MSIV)	16
2.4.3 Piezoelectric Accelerometer	18
2.4.4 Fluxgate Magnetometer	19
2.4.5 Electrostatic Analyzer	21
3.0 SCATHA SATELLITE	24
3.1 Overview	24
3.2 Telemetry	24
3.3 Agency Tapes	25
APPENDIX A - B&L Format	27
APPENDIX B - GSF Format	32
APPENDIX C - Indices File Format	36
APPENDIX D - MESA Data Base Format	38
APPENDIX E - MSI Ion Data Base Format	43
APPENDIX F - MSIV Ion Data Base Format	47
APPENDIX G - Ion Density Gauge Data Base Format	52
APPENDIX H - MSIV Neutral High Data Base Format	56
APPENDIX I - S3-1 Data Base List (sample)	62

LIST OF ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
1	DPS - Phase I	5
2	DPS - Phase II	6
3	Geophysical Indices - S3-1 Lifetime	14

## 1.0 INTRODUCTION

The Space Data Analysis Laboratory (SDAL) of Boston College has been contracted by the Analysis and Simulation Branch (SUA) of the Air Force Geophysics Laboratory (AFGL) to develop mathematical and computer techniques necessary for the analysis of digital information from payloads flown aboard Air Force Satellites. The data analysis efforts require an integrated and systematic approach in order to incorporate the mathematical procedures associated with individual payloads while taking into account vehicle attitude and ephemeris parameters.

The prime efforts during the period covered by this report were associated with Satellites S3-1, S3-2, S3-3 and the SCATHA program.

In order to satisfy data analysis requirements, a data processing system (DPS) was developed and implemented for satellite S3-1. This system was adapted for use with the S3-2 and S3-3 vehicles. The system will be modified and adapted in order to satisfy requirements associated with the SCATHA program.

The S3-1 effort involved the creation of the final geophysical data bases for a Cold Cathode Ionization Density Gauge (IDG), the Miniature Electrostatic Accelerometer (MESA) and two mass spectrometers (MSI and MSIV). This effort entailed the completion of standard processing and the processing of data from problem orbits. Efforts were also expended on the selective processing of data from the Piezoelectric Accelerometer and from another ion density gauge. In addition, data compaction aimed toward the creation of a unified history file for this vehicle was of importance. Analysis efforts were involved in the development of software to integrate the appropriate data bases and produce history displays of selected parameters.

The S3-2 efforts dealt with the following experiments: Electrostatic Analyzer, Fluxgate Magnetometer, Piezoelectric Accelerometer, Cold Cathode Ionization Density Gauge and the MSIV mass spectrometer. The main emphasis was placed on the development of analysis to be used in the systematic processing of the data and the translation of the analysis into efficient computer software. Selected data has been processed for the probes mentioned. Creation and maintenance of the raw data files, the B&L files (magnetic and ephemeris data), Geophysical Support Files (neutral atmospheric model data)

and output module (OM) files (coefficients necessary for the computation of vehicle attitude) was an on-going effort.

For satellite S3-3, the principal responsibility of the SDAL lies in the development of the compacted raw data bases for the AFGL probes and the creation and maintenance of the B&L and OM files.

For the SCATHA project which is part of an Air Force program to investigate spacecraft charging at high altitudes, preliminary investigations were conducted into data analysis requirements in order to begin the adaptation of the S3 DPS for the SCATHA effort.

## 2.0 S3 SATELLITES

### 2.1 Vehicle Operations and Spacecraft Telemetry

The S3-1, S3-2 and S3-3 satellites were made of the same basic structural frame and the telemetry systems for all three vehicles were identical. Spacecraft operations for the three vehicles were, however, different.

The AFGL probes flown aboard the S3-1 vehicle were operated primarily during the perigee portion of orbits. This data was, in general, tape recorded and played back to Satellite Control Facility (SCF) remote tracking stations (RTS). Other operational modes allowed for the acquisition of full orbit and real time data but the perigee data was considered to be prime. For normal operations, data was recorded on every other orbit although increased coverage was obtained during periods of special interest, e.g., geomagnetic storms. Data from this vehicle was transmitted through approximately 2700 orbits.

The S3-2 spacecraft is still operational and has exceeded 10,000 orbits. The AFGL probes aboard the vehicle were categorized into two classes labeled Group I and Group II. The group I payloads were designed primarily for high latitude studies. The group II experiments were similar to probes flown aboard satellite S3-1 and, thus, the prime data was that of the perigee region. Vehicle operations allowed for the tape recording and playback of data from group I only, group II only or shared orbits in which data was acquired from both the group I and group II payloads. Real time acquisitions were also available for this vehicle.

The S3-3 satellite which is still operational obtains data over a longer orbital period than either of the other two S3 vehicles. The prime data for this vehicle is tape recorded and played back to SCF RTS. Real time data is also available for this vehicle.

As previously mentioned, the telemetry system used for all three vehicles was identical.

The satellite pulse code modulation (PCM) data is telemetered to SCF remote tracking stations by Bi- $\phi$ -L modulation of the carrier. The PCM data is transmitted at two data rates. Real time data is telemetered at 16,384 bits per second (bps). Tape recorder playbacks occur at 131,072 bps. Thus, the tape recorder playback to real time transmittal ratio is 8 to 1. Real time PCM data is transmitted by phase modulation in the reverse order from the real time data transmissions.

The satellite PCM systems consist of a 128 word main frame. Each data word is composed of eight bits and thus each main frame consists of 1,024 bits. Data is read out at a rate of 16 main frames per second with each main frame containing 24 subcom frames (sc) and five sub-subcom frames (ssc) in the sub frames. Thus a master frame (one read out from each word) occurs over 256 main frames.

The processor provides an analog-to-digital converter which produces the eight bit digital values for all analog measurements providing an accuracy of  $\pm .2\% \pm 1/2$  LSB. Included in this figure are all error contributions from the processor input, at sampling time, to the processor output. The voltage range for encoding is 0 to 5.12 VDC.

The PCM processor generates the satellite time word (STW). The STW consists of 28 bits and allows for an accumulation through 194 days. The four least significant bits of the STW serve as a subcom identifier while least significant bits 5 through 8 identify the sub-subcom frame. The synchronization pattern is contained in main frame words 126, 127 and 128.

## 2.2 Data Processing Systems

Due to the volume of data to be processed, the complexity of the processing requirements and the necessity of taking a systematic approach to

the data processing task, a data processing system (DPS) was developed and implemented for S3-1. The DPS allowed for maximum data flow, flexibility of implementation and adaptability to future vehicles. In fact, the S3-1 DPS was generalized for use with the S3-2 and S3-3 spacecrafts. The program interfaces and general data flow are identical in the DPS for all three vehicles although versions of some programs exist for each spacecraft.

In order to understand the effort involved in the creation of the geophysical unit data bases and unified history file, a brief description of the data processing system is now presented. The processing may be thought of as occurring in two phases. Figure 1 is a flow diagram of Phase I of the DPS while Figure 2 represents the Phase II program interfaces. For vehicles S3-1 and S3-2, both phases are implemented. For satellite S3-3, only Phase I is required.

In Phase I, all files to be input into the individual experiment data processing routines are created. These files consist of the raw experiment data files, magnetic parameter and ephemeris files, atmospheric model files and files containing the coefficients to be used in determining vehicle attitude. In Phase II, the individual experiment processing routines are executed and geophysical unit data bases for each spacecraft revolution are created. For satellite S3-1, in addition to these geophysical unit data bases, a unified history file containing reduced data from all probes is to be created. Through history file usage, reduced geophysical unit correlations may be made for all probes which are simultaneously studying the same atmospheric phenomena. Moreover, the unified history file results in compaction of the data to one flexible file.

The PCM data transmitted from the vehicle is recorded on tape at various SCF remote tracking stations. These tapes are, in turn, sent to the Space and Missile Test Center (SAMTEC) for digitization and storage onto 9 track tape.

The file name used by SAMTEC for this digital data is the Standard Telemetry Format (STF). The STF for each orbit consists of a file descriptor record (FDR), data index records (DIR), data index continuation records (DIC), data records (DR), end of data records (ED) and end of real records (ER).

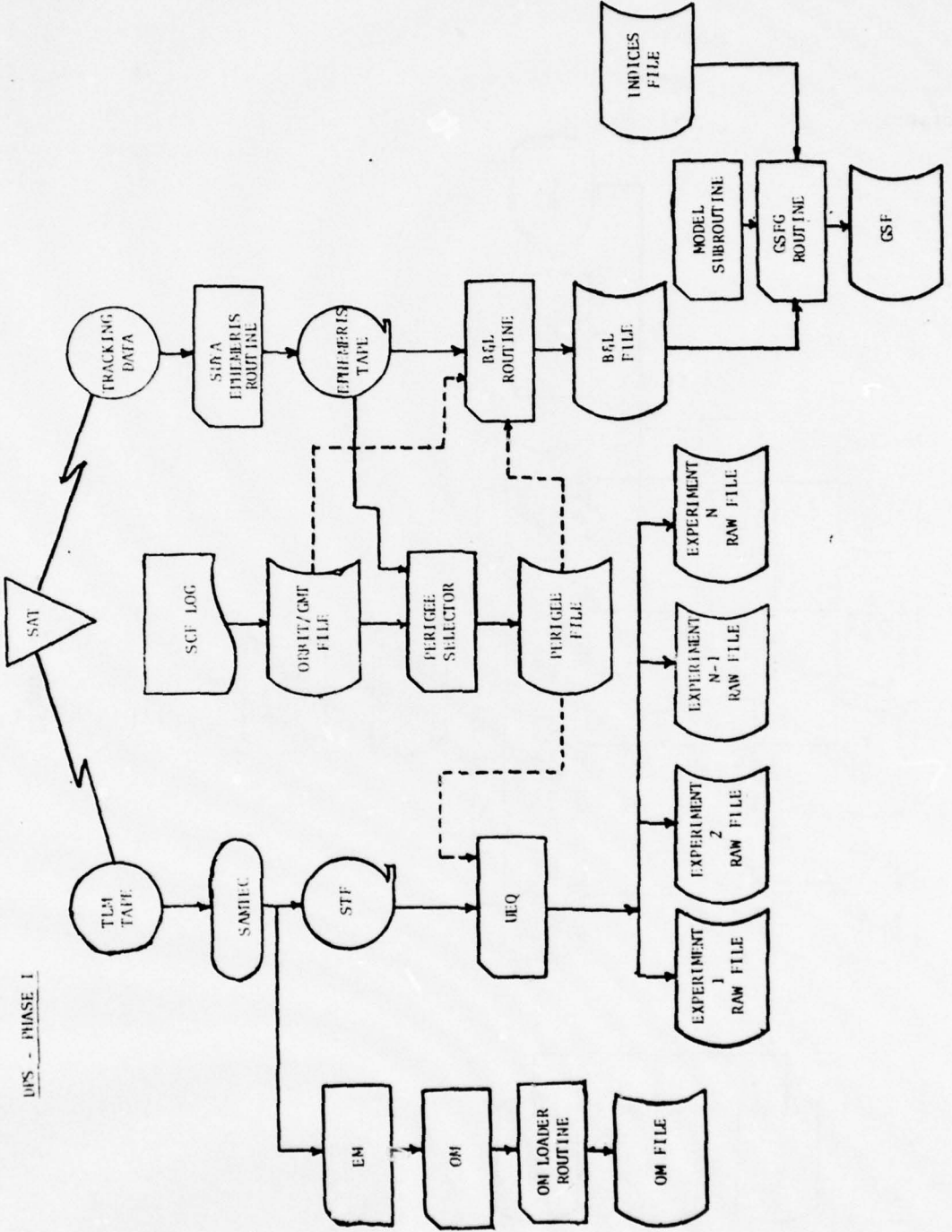


Figure 1

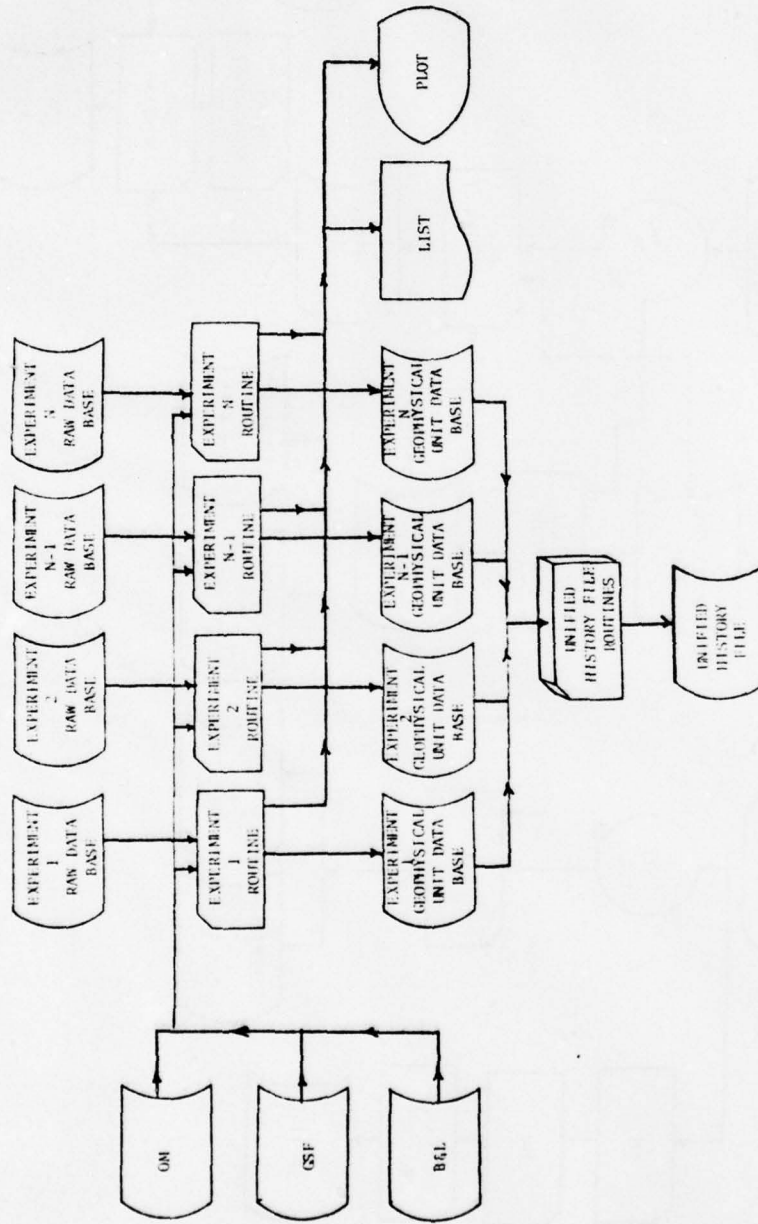


Figure 2

The FDR contains parameters related to the particular orbit on the STF tape, such as, analog tape number, date of orbit and date of digitization. DIR and DIC records exist for the purpose of defining word locations within DR's for both clock correlation factors and all word designations from the telemetry data. Data records for the telemetry data always begin with sub-com frame 1, but the first data frame on each STF tape is random relative to the sub sub-com frame. Sync and spare words are deleted in the digitization process. Thus, in general, the DIR and DIC information will not be consistent from one STF tape to another. The ED records signal the end of information for the time correlation and telemetry information for each STF tape. ER is the signal for end of reel operations. The set of data products received at AFGL/SUA for each orbit processed through the SAMTEC digitization system is the STF tape, its associated scan listing and a deck of cards for attitude determination. The scan listing contains orbit number, start and stop times of the digitized signal and satellite time words (STW) at which digital dropout occurred. The card deck, generated in conjunction with the STF creation, results from a computer routine called the Estimation Module (EM). The cards contain sets of coefficients to be used in the computation of vehicle attitude.

Another item used in the DPS is the Satellite Control Facility tape recorder log. Copies of this log are also received by AFGL/SUA.

With these items provided by sources external to AFGL, the first phase of the DPS is ready for implementation.

A card image file of the SCF tape recorder log, called the Orbit/GMT file, is created. This file contains the orbit number, date and start and stop times of each tape recorder orbit. For S3-1 and Group II operations for S3-2, prime data occurred for the AFGL probes in the perigee region of each orbit but satellite turn-on normally occurred prior to an extending beyond the perigee region. In order to determine the areas of each pass containing the prime data, a computer routine was written to input the orbit/GMT file and to interrogate ephemeris files. Outputs from the perigee selector routine consist of the orbit number, date and start and stop time of the perigee sections. These parameters are stored on a file which can be displayed but which is also used as input to routines written to construct

the experiment raw data files and their associated model and magnetic parameter files. The use of the perigee information file plays a key role in data compaction for the B&L and GSF files for S3-1 and S3-2 Group II operations. The orbit/GMT file plays a similar role for S3-2 Group I data as well as the S3-3 data.

When the STF, scan listing and EM deck are received at AFGL/SUA, the tape number and pertinent orbit information are entered into a cross-reference log, the scan listing is filed and the card deck, called the output module (OM), is prepared for loading onto a monthly OM file. Since the SAMTEC digitization process is not done chronologically by orbit number, the systematic approach taken in the storage of these cards is to create one file for each month of vehicle lifetime. A cross-reference listing of file and orbit number is produced whenever OM data is added to any file.

Since the STF contains data from the full PCM data stream, a computer routine was written to create raw data files for each experiment. This routine is called the unpack/edit/quality check (UEQ) routine. This routine uses as input the STF tape and pertinent information from the perigee file, if applicable, such as the prime data area. Perigee file usage is required only on S3-1 and S3-2. The UEQ then extracts all necessary information from the FDR, DIR and DIC; unpacks data records according to DIR and DIC specifications; quality checks time code information and sub-com frame numbers; determines occurrences of signal loss; edits out bad data frames; calculates GMT from the STW information; performs averages of specific designations as necessary; and creates a raw data file for each experiment in a format which optimizes data storage and retrieval. Permanent storage of output files is, of necessity, accomplished through the use of off-line devices. A version of the UEQ exists for each of the S3 vehicles.

The SCF sends tracking data to AFGL/SUA and this data is, in turn, used by SUA to produce ephemeris files. These files created by SUA cover periods of one month at a time with data provided in 1 minute intervals. Parameters contained on the SUA ephemeris file include altitude, longitude, geocentric and geodetic latitude, vehicle velocity in component form and local time. Since the data on the file covers a full one month period, it can be compacted by selecting out only the areas for which telemetry data was acquired.

Since all processing routines for the individual probes require ephemeris as well as magnetic parameters, the ephemeris compaction and combination ephemeris and magnetic file (B&L file) is created in the next step of the processing system. An existing routine was modified for use with these satellites. The modified routine, called the B&L program, uses as input the monthly ephemeris file and the pertinent parameters from the perigee file (or orbit/GMT file) to create a B&L file for the prime data of each orbit. One B&L tape is created for each month of the lifetime of the satellites. Among the quantities stored on the B&L file for each orbit are all pertinent ephemeris parameters, magnetic field components, total field, L-Shell and geomagnetic longitude, latitude and local time. Data occurs at 60 second increments for each pass. A modular subroutine was written for the extraction of any or all of the quantities on the B&L file at any time during an orbit. Versions of the B&L routine exist for each of the three satellites.

An INDICES file was created for the lifetime of satellite S3-1 and is being maintained and updated for S3-2 and S3-3. This file contains all geophysical indices necessary for the interpretation of geophysical unit measurements and for the calculation of model atmospheric parameters. Among the parameters contained on this file are  $K_p$ ,  $F_{10.7}$  CM solar flux,  $A_p$ , DST index, calcium plage indices, solar flare indices and solar declination. A modular routine, GPARAM, was written to interrogate this file and to allow for the determination of any of the above quantities for any orbit during the lifetime of a vehicle.

Most of the AFGL probes flown aboard S3-1 and the Group II probes from S3-2 perform neutral atmospheric measurements. The processing requirements for these probes include the knowledge of selected atmospheric neutral model parameters. To this end, the Geophysical Support File (GSF) is created. The GSF contains parameters such as exospheric temperature, temperature at altitude, mass density and number density for various constituents. The routine used to create the GSF is called the GSFC and it uses an SUA supplied subroutine to perform the actual model computations. Inputs to the GSFC are the B&L file and the INDICES file. Thus, the GSF are created on a one tape per month basis with file and orbit numbers matching those of the B&L file.

File formats for the B&L, GSF and INDICES file are included in the appendix.

Programs to be executed in the second phase of the DPS require raw data files, B&L files, OM files and in some cases GSF files.

Software developed in both phases of the DPS was written in modular fashion in order that multi-purpose routines could be used wherever elements of commonality exist in the processing requirements.

The processing routines developed for Phase II of the DPS create the geophysical unit data bases. These routines also create listings and displays of the geophysical unit parameters along with selected.

### 2.3 S3-1 Data Base

As mentioned in the introduction, the data bases for the probes flown aboard this spacecraft have been nearly completed. The addition of data from a small percentage of problem orbits will complete these data bases. A brief description of each of the S3-1 probes for which data bases were created is included in this section.

Satellite deceleration due to aerodynamic drag was measured by the MESA accelerometer and from the aerodynamic drag, neutral atmospheric density was derived. The sensing element of the instrument consists of an electrostatically suspended proof mass which is electrostatically force rebalanced along its sensitive axis. A digital output which represents the pulse rate and which is proportional to the applied acceleration is obtained from the restoring voltages. The probe is capable of operating in two sensitivity ranges. Range A provides low sensitivity measurements. The normal operational mode for the instrument was range B.

The MSI is an RF quadrupole mass spectrometer designed to provide atmospheric species measurements between 14 and 44 amu. Density measurements for O, O<sub>2</sub>, N<sub>2</sub>, NO and A<sub>r</sub> were obtained. The experiment was not synchronized to the PCM encoder and the instrument output was therefore free running with respect to the data stream. Probe operation consisted of two modes, each of approximately 12 seconds duration. One 12-second mode consisted of four

scans of masses from 14 through 44 amu. While in the second mode, only  $N_2$ , (28 amu) was examined.

The main output for the Cold Cathode Ionization Density Gauge is gauge current which was sampled at 16 points per second. The gauge current values were modulated by satellite spin with the maximum amplitude of the signal occurring at the minimum attack angle (the angle between the instrument's look angle and the velocity vector). The instrument was designed to provide atmospheric neutral density measurements and spatial and temporal variations.

The MSIV instrument was composed of an RF quadrupole mass spectrometer and a velocity mass spectrometer to measure atmospheric composition and species density of masses between 1 and 44 amu. The instrument was designed for operation in five different modes with mode switching occurring only by command to the spacecraft. Operation of the instrument was synchronized to the PCM encoder for each of the five modes. The spectra measurement from the instrument was a 24 bit digital output. Through the various modes, outputs were provided for ion, neutral high and neutral retarded measurements.

The processing and analysis techniques (including functional flow diagrams) used in the creation of the data bases for the individual probes were included in a previous report (AFGL-TR-76-0121, Delorey).

The general structure of the data base for each probe is the same. By keeping all files of the same general form, data retrieval and display can be effected through the use of multi-purpose routines. Data from each orbit is contained on a physical file consisting of a header record followed by data records which include the appropriate geophysical unit measurements and selected positional parameters. Information stored in both the header and data records is structured by frame. Two integer count words precede the information in each physical record. These count words represent the number of words in a data frame and the number of data frames in the record.

The MESA data base contains atmospheric neutral density measurements along with GMT, selected ephemeris and magnetic parameters and model density. Data is contained in the file for each orbit at two rates. One data set yields 2 density measurements per vehicle spin cycle (vehicle spin rate was  $5 \pm 1$  rpm). The other data set contains measurements in 2 km increments. The header record

for each orbit contains standard information such as acquisition orbit number, date of orbit, and data taking interval but coefficients to least squares polynomial fits are also included. Density measurements were fit as functions of altitude for the downleg and upleg portions of each orbit.

The MSI data base, which has been completed, follows the same general structure defined above. The header record contains standard information pertinent to the particular orbit. The data records provide density measurements (in number density) for selected constituents and the corresponding positional parameters. The data rate is one frame per 12 second scan mode. This converts to approximately one data set every other vehicle spin cycle. Computer software was developed in order to fit and hence compact the downleg and upleg data sets for each constituent. The fits were performed to number density as a function of altitude.

The Cold Cathode Ionization Density gauge data base is constructed in a manner analagous to the MESA data base. The data records include gauge pressure, ambient pressure, atmospheric neutral density and selected model, ephemeris and magnetic parameters. Data storage occurs at a rate of one frame per vehicle spin cycle. Fitting techniques were applied to the downleg and upleg portions of the density data. The coefficients, from which density versus altitude may be computed, are stored in the header record.

The main data bases created for the MSIV instrument were for the prime operational mode of the experiment-mode 1. In this mode, both ion and neutral high measurements were performed. Thus, there are two data bases for the MSIV; one for ions and one for neutral highs. The header records for each contain standard orbit related parameters such as date of acquisition, orbit number and GMT of the acquisition. The data records for the ion data base contain currents for masses 14, 16, 28, 30 and 32 in addition to selected magnetic and ephemeris parameters. These currents are readily convertible into number density. The data records in the neutral high data base were created in a manner analagous to the ions. These records contain currents for masses 14, 16, 28, 30 and 32. The data rate at which storage occurred for both data bases was one frame per vehicle spin cycle. Computer

software has been developed for the fitting of the upleg and downleg portions of each orbit with the resultant coefficients having density versus altitude applications.

The data bases for the individual probes are used to study structure within individual orbits and to perform analyses on small or large segments of the data. The creation of these data bases has yielded a tremendous compaction of the data. Approximately 1500 STF tapes were originally received and the geophysical unit data bases for all probes now reside on approximately 15 tapes. Thus, the compaction ratio is 100:1. A data base list routine was developed whereby selected parameters relevant to each acquisition and the file location for each probe within the data base are displayed. The geophysical index  $K_p$  is also displayed on the listing. A sample of the data base printout and the formats for the individual data bases are included in the appendix.

The concept of the unified history file was developed to provide a flexible data base from which studies of long term effects could be performed. This data base which is presently being put into final form will contain coefficients to fits which will allow the computation of geophysical unit parameters from each of the individual data bases. Note that these coefficients already exist in the header records of each orbit for the MESA and ion density gauge. Further, as already mentioned, software was developed to produce the coefficients for the mass spectrometers. Similar techniques were employed to produce coefficients for selected model parameters. Thus, the coefficients can be used to obtain geophysical unit or model data. Ephemeris and magnetic parameters are also selectable from the unified history file. The geophysical indices associated with each orbit are also retrievable. A display of the geophysical indices over the lifetime of the vehicle is included as Figure 3. The indices are displayed as a function of date. Displays have been created for some of the probes reflecting mass density at fixed altitude with additional grids for  $K_p$ ,  $F_{10.7}$  CM solar flux and latitude and local time of perigee. Additional constraints can easily be placed on data selection to, for instance, extract only orbits which fall into specific  $K_p$  ranges. The coefficients are the key element in extracting the geophysical unit measurements. One further advantageous feature of the unified history file

GEOPHYSICAL INDICES - S3-1 LIFETIME

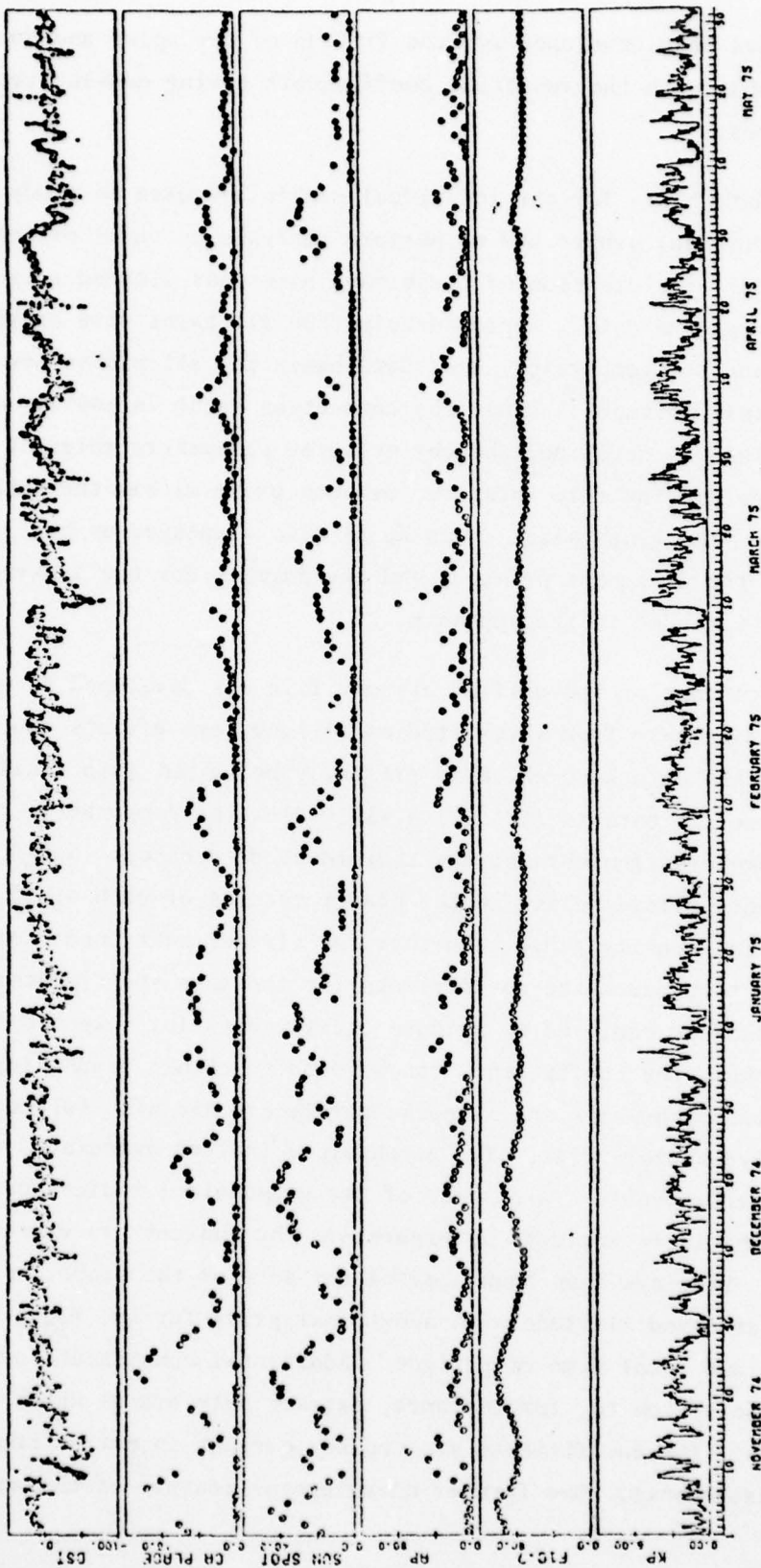


Figure 3

is that of data compaction. It is estimated that, when in final form, this entire file will be contained on one tape. Thus, the final data compaction ratio from STF to unified history file will be 1500:1.

#### 2.4 S3-2 Experiments, Analysis and Software

For the S3-2 spacecraft which is still in orbit, geophysical unit data bases are being developed for the Fluxgate Magnetometer, Electrostatic Analyzer, MSIV and Cold Cathode Density Gauge (IDG). The data for the Piezoelectric accelerometer is selectively processed.

Data base development implies the continuance of UEQ executions and the creation of B&L, GSF, OM and indices files in a systematic manner.

This section contains a brief description of each experiment and the analysis and computer software which were developed.

##### 2.4.1 Cold Cathode Ion Density Gauge

The S3-2 cold cathode ion density gauge flown was designed to provide atmospheric neutral density measurements and spatial and temporal variations. Basically, the output signal from the probe is modulated by the spin of the vehicle with the maximum response occurring when the angle between the instrument and the satellite velocity vector is at a minimum. Gauge current is the direct measurement of the instrument. The current is converted to pressure and then, through analysis techniques analagous to those developed for S3-1, atmospheric neutral density is computed.

Instrument readouts and data rates are summarized below:

Gauge Current	16 pps
Range Indicator	16 pps
High Voltage	1 pps
Electronics Temperature	.0625 pps
Gauge Temperature	.0625 pps

Due to the higher perigee of this vehicle, as compared to S3-1, many of the anlysis techniques developed for S3-1 required tailoring for application to this spacecraft. The basic instrument readouts were quite similar to those of S3-1.

The functional flow of data through the main processing routine is summarized below.

The frames of raw telemetry data are input through the use of a modular input routine. Instrument range, gauge current and gauge pressure are then calculated on a point-for-point basis. Instrument attack angles are then calculated for all pressure values through the OM module and OM file. The data is then separated into the decreasing and increasing attack angle portions of the ram cycle. The instrument sampling function,  $R(S,D,\alpha)$ , is computed. Gauge pressure is fit as a function of the  $R(S,D,\alpha)$  for the separated portions of the spin cycle. The data fitting is accomplished through a modular polynomial routine. Slopes of the fitted curves are extracted and corrected pressures are calculated for the into and out of ram portions of the satellite rotation and these pressures are then averaged and atmospheric neutral density is computed. All necessary ephemeris parameters are then extracted from the B&L file and atmospheric neutral density is calculated. Selected model atmospheric parameters are extracted from the Geophysical Support File. These parameters include mass density, pressure and temperature at altitude.

Each program execution results in the creation of listings, plots and the data base. The parameters listed and plotted are quite similar to those resulting from S3-1 program executions. The data base for each orbit consists of a header record and data records contain the computed geophysical unit, ephemeris, magnetic and model parameters.

#### 2.4.2 Mass Spectrometer (MSIV)

The mass spectrometer flown aboard the S3-2 satellite was similar to the MSIV flown on satellite S3-1. The probe was made up of an RF quadrupole mass spectrometer in combination with a velocity mass spectrometer. The probe was designed to measure atmospheric composition and species density. Species studied were between 1 and 44 amu with both neutral and ion measurements of O, N<sub>2</sub>, NO, N, H and H<sub>e</sub> provided. The operation of this MSIV experiment was synchronized to the PCM encoder and five commandable modes of operation were possible. The prime output from the probe was a 24 bit digital readout. Instrument readouts and associated data rates are summarized below:

It is possible that the gain values (G) in Table VI will be modified after some of the data is reduced and spectral radiance features in each of the four gain channels are compared.

24 bit digital spectra	64 pps
RF Monitor	64 pps
Beam ( EMR) Monitor	4 pps
Pressure Monitor	8 pps
Ratio ( $V_R$ ) Monitor	8 pps
DC Monitor	8 pps
Commutator	1 pps
Mode Monitor	1 pps
High Voltage (HV) Monitor	2 pps

The probe could be operated in 5 modes. Mode 1 was capable of providing a combination of neutral high (NH) and ion measurements or be operated in an ions only mode. Mode 2 provided a combination of neutral high and neutral retarded measurements. In mode 3, the data set consisted of NH only. Mode 4 and mode 5 were primarily diagnostic.

For all modes, the RF monitor indicated the mass being sampled. The 24 bit digital spectra output contained a range bit and the number of counts measured by the multiplier. A maximum of two output ranges was possible. A one readout lag was programmed between the RF monitor and the spectra output (the spectra lagged the RF monitor by one readout) but the lag sporadically extended to 2 readouts. The experiment timing cycle was 1 second for modes 1, 2 and 3; 2 seconds for mode 4 and 8 seconds for mode 5. In modes 1, 2 and 3 there were four readouts for each mass, thus producing a peak shape. Several monitors were also included as instrument outputs.

The main emphasis has been placed on the processing of the mode 1 data. In this mode, the instrument can be commanded to perform ion/neutral high or ion data only measurements. The mode monitor voltage is used to discern the measurement type. In ion only mode, data processing and analysis are performed on masses 14, 30, 28, 16, 1 and 4. In the ion/NH mode, ion measurements are performed on masses 14, 30, 28 and 16 while neutral high masses examined are 1, 4, 7, 14, 30, 28 and 16.

The functional flow of data through the mode 1 routine may be summarized as follows. The instrument mode is determined first. Then, the instrument

range is extracted and the corresponding multiplier counts converted to current. Attack angles corresponding to the currents are computed using the OM module.

For ion data, the peaks are translated to ram using a function dependent only on attack angle and the four seconds of data closest to ram are scanned and one group of ion readouts is selected for analysis based on criteria involving current amplitude. Ratio monitor ( $R_A$ ) data associated with ion readouts is converted to current and translated to ram. Magnetic pitch angle is calculated and pertinent positional parameters such as longitude, geodetic and geomagnetic latitude, local time and magnetic field are computed from information contained on the B&L file. A number of ratios involving individual currents, summed currents and the  $R_A$  are then computed.

For neutral high data, statistical techniques are employed in the data selection. The four readouts around each mass peak are examined, and after removing the two extrema, the remaining points are averaged. This procedure is employed for each mass in the four frames of data closest to ram. Once an average current value is obtained for each mass in those four frames, the currents are translated to ram by use of the neutral high sampling function. Statistical checks are then performed and one current for each mass is selected.

Each program execution results in plots, listings and data base storage. The plots and listings of the reduced geophysical unit parameters and associated magnetic and ephemeris information are similar to the S3-1 outputs. The data bases for both the ion and neutral high values are created in a structure similar to the S3-1 files.

#### 2.4.3 Piezoelectric Accelerometer

The triaxial piezoelectric accelerometer flown aboard the spacecraft provides atmosphere neutral density measurements. Satellite deceleration, due to aerodynamic drag, is measured along the three mutually orthogonal axes. Instrument outputs are analog signals (0V to 5V) with readouts for three sensitivity levels along each axis. The telemetry words and data rates are summarized below:

X-axis	range 3	4 pps
X-axis	range 2	1 pps
X-axis	range 1	1 pps
Y-axis	range 3	1 pps
Y-axis	range 2	1 pps
Y-axis	range 1	1 pps
Z-axis	range 3	1 pps
Z-axis	range 2	1 pps
Z-axis	range 1	1 pps
Temperature		.0625 pps

The processing of data from this probe is done selectively. Mathematical and computer techniques developed for the reduction and analysis of accelerometer data from previous spacecrafts were adapted and modified for use with S3-2 piezoelectric accelerometer.

Filtering techniques are required in the processing of this accelerometer data. The computer routine filters the signal in order to determine the portion of data due to atmospheric drag. A power spectral analysis of the data revealed the existence of two and sometimes three peaks. A numerical notch filter was designed to remove the extraneous signal. Once filtered, atmospheric neutral density measurements are computed. Plots and listings of the mass density measurements as functions of GMT and other ephemeris, magnetic and model atmosphere parameters are output by the routine.

#### 2.4.4 Fluxgate Magnetometer

The fluxgate magnetometers flown aboard the S3-2 spacecraft were designed to measure the 3 components of magnetic field to a resolution of 5  $\gamma$ . The full scale range for each axis (0V  $\rightarrow$  5V) corresponds to  $\pm 600 \gamma$  (.02V corresponds to 4.8  $\gamma$ ).

Each axis has a neutralizing winding current of 10 ma/gauss so that a known biasing field may be applied (to each axis) to keep the magnetometers on scale.

When the voltage level of a fluxgate axis reaches 0.1 or 4.9V the range switch provides current increments of 0.1 ma to the neutralizing coil (0.1 ma corresponds to 1000  $\gamma$ ). These current increments, applied in the proper

direction, keep the magnetometer from saturating. There are 128 different current levels available to each axis which correspond to steps of 1000  $\gamma$  ranging from -64000  $\gamma$  to +63000  $\gamma$ . The current being applied to any axis is determined by the range switching coarse and fine outputs for that axis. For the coarse outputs, there are eight telemetry levels from 0  $\rightarrow$  5V in steps of 0.71V (seven steps). For fine outputs, there are 16 levels between 0  $\rightarrow$  5V. The 15 steps are in increments of .-3V. The zero current step for coarse is at 2.84V and for fine is at 0V. The current steps for each axis vary from -64 to +63 and the step level may be determined by the expression

$$16N + M$$

where

N,M are integers determined by

$$N \approx \frac{\text{coarse volts} - 2.84}{.71}$$

$$M = \frac{\text{fine volts}}{.33}$$

Saturation levels for any range switch axis are determined by a coarse-fine voltage pair of (0.0,0.0) or (5.0,5.0).

Instrument outputs and associated data rates are as follows:

X-magnetometer	32 pps
Y-magnetometer	32 pps
Z-magnetometer	32 pps
X-axis range switch-fine	16 pps
Y-axis range switch-fine	16 pps
Z-axis range switch-fine	16 pps
X-axis range switch-coarse	2 pps
Y-axis range switch-coarse	2 pps
Z-axis range switch-coarse	2 pps
Sensor temperature	1 pps
Electronics temperature	1 pps
Range switch temperature	1 pps

All outputs are analog. The data for this payload is processed in two phases due to the high sensitivity of the instruments; differing readout rates for the fine, coarse and magnetometer designations; and the uncertainty of the alignment for the boom mounted sensor axes.

The first phase, called the preprocessing, is performed in order to create a data base of raw magnetometer readings (in gammas). Corrections for erratic fine and coarse readouts are performed in this routine. A more detailed description of the analysis efforts involved in the preprocessing is contained in a previous report (AFGL-TR-77-0103, Delorey). Plots, listings, and the raw magnetic field data base result from each execution of the preprocess routine.

The final processor uses the raw magnetometer data base and B&L files as input. Data is processed only in areas where the absolute value of the latitude exceeds  $45^\circ$ . The steps performed in this routine include the following:

- i) Digital filtering of the x, y and z magnetic field measurements to produce smoothed signals.
- ii) Computation of a correction to the  $\eta_2$  angle (caused by the twisting of the boom-mounted sensor axes). This angular correction is not constant for each orbit and is, thus, expressed as a function of time.
- iii) Calculate model magnetic field components and total field in the spacecraft coordinate frame of reference.
- iv) Transform the spacecraft principal axis measurements into the coordinate frame of reference used to express the model field parameters.
- v) In the model field coordinate system, difference the measured and model x,y,z and total field.
- vi) Compute an average curve from the x-axis data (principal axis system) at the extrema values of the signal and subtract from this curve the transformed y model field component.

- vii) Plot and list the computed parameters along with associated ephemeris and magnetic information.
- viii) Create a final data base in the same generalized structure as for other S3 probes.

#### 2.4.5 Electrostatic Analyzer

The S3-2 electrostatic analyzer was designed to perform a 32 channel differential energy analysis of electrons between approximately 1 keV and 16 keV by means of electric field deflection through a parallel plate system. A channeltron electron multiplier is used to detect the selected electrons which are counted in a 10 bit binary counter with an additional overflow bit indicator. An inflight calibration source and test pulse generator are included within the instrument to assure the accumulation of one count during each data interval.

A 5 bit up/down counter programs the deflection voltage in a 64 step sequence. The counter steps from  $00000_2$  to  $11111_2$  then back to  $00000$  in 64 steps. The 10 bit data counters, 1 bit overflow indicator and 5 bit up/down control counter are read out as a single 16 bit word at the uniform rate of 64 samples/second. The five bit control counter is incremented every other readout; therefore, a complete 64 step sequence (32 up, 32 down) is completed every 2 seconds.

There are 10 analog monitors which provide outputs used to ascertain proper instrument performance. Monitors 26-11-9 and 26-11-10 will assume different levels for each energy channel.

For the overflow bit, the normal value is 1. An overflow is indicated by a 0 value.

Instrument outputs and associated data rates are as follows:

ESA output (16 bit digital)	64
+5v monitor	2
+15v monitor	2
-5v monitor	2
+10v reference monitor	4
+28v monitor	1

Temperature monitor	1
+3kv monitor	8
+3kv input current monitor	8
-10kv input current monitor	8
-10kv reference input monitor	8

Computer software has been developed to create an ESA data base and to perform analyses upon the data base. This processing occurs in two phases.

In the first phase, science data is produced and a data base is created for later use in the analysis phase. The basic functions of this software may be summarized as follows:

The 16 bit digital readout is decoded and the accumulated counts are extracted; the readouts are ordered into 2 second data frames; areas of digitization dropout are dummy filled and flagged in order to maintain a consistent file structure; magnetic and ephemeris parameters are merged; average energy, average flux and total flux are computed on a sweep by sweep basis; plots listings and the data base are created. For each orbit, the listings are broken down into three sections: GMT and the raw counts readout by the instrument with areas of data dropout flagged; the housekeeping monitors converted to voltage and one minute averages of the monitors; GMT, magnetic pitch angle, average energy, average flux and total flux. Displays generated by the routine are segmented to produce one set of plots for each hemisphere. Each set of plots represents average energy, average flux, total flux and magnetic pitch angle as functions of GMT. Additional axes yield annotation for altitude, geodetic latitude, longitude, magnetic local time, invariant latitude and geomagnetic latitude. The data base consists of a header record followed by data records structured to allow easy input to analysis routines. Data records contain GMT, ephemeris and magnetic parameters and counts. The counts are always stored such that energy level 00000<sub>2</sub> begins the frame.

Two analysis routines have been written to access the ESA data base; the first produces displays of spectra (flux versus energy) for individual sweeps while the second routine is used to sort data into selectable bins and perform averages and statistical evaluations.

The basic functions of the second routine may be summarized as follows: the data from the data base is input to the routine and the orbit is immediately separated into the sunlight and shaded portions since the data is to be treated separately for the two cases; the data is then sorted into predefined latitude bins with starting, ending and incremental values optional; for each latitude bin, the counts are converted to flux and the flux values are sorted into energy bins of optional width; for each energy level, the average flux and statistical error is computed; flux data is sorted into predefined magnetic pitch angle bins (of optional width) for each energy bin and average flux statistical error and average energy are computed; finally, for each magnetic pitch angle bin, average energy, total energy flux and total flux are computed. Formulae used in this routine were detailed in a previous report (AFGL-TR-77-0103, Delorey).

### 3.0 SCATHA SATELLITE

In this section, an overview of the SCATHA project, telemetry systems and agency file concepts are discussed.

#### 3.1 Overview

The P78-2 spacecraft is part of an Air Force project to investigate Space Charging at High Altitude (SCATHA). The vehicle will be launched into a near synchronous orbit. On-orbit data will be controlled by the Satellite Control Facility and its remote tracking stations. The duration of the mission is scheduled for 12 months.

The vehicle is scheduled for launch from the Eastern Test Range in 1979. The space vehicle (SV) will initially be placed in a circular parking orbit from which it will be placed into a transfer orbit at the first ascending node. At apogee after 3 1/2 revolutions in the transfer orbit, the vehicle will be placed into its near synchronous final orbit with a 2.5 degree inclination. The approximate apogee and perigee in final orbit are 23100 nmi and 15038 nmi, respectively. This orbit will result in a nominal longitudinal drift of 6 degrees per day. The orbital orientation is such that the vehicle will experience a sequence of altitudes near synchronous altitude at local midnight during the vernal eclipse season.

The vehicle is expected to acquire up to 24 hours of data per day for the 1 year period. The payloads to be flown aboard the vehicle were designed to provide data related to charging, discharging and plasma interaction phenomena. In particular, investigations will be made on different particle types and energy ranges; magnetic field intensities of both the environment and those generated by the SV; the effects of charging and discharging on spacecraft materials; the interaction of the charging and discharging phenomena with SV operation and the techniques for controlling the SV charge condition.

### 3.2 Telemetry

The P78-2 telemetry system provides for the transmission of PCM and PM data. There are two primary encoders, an auxiliary encoder and two tape recorders aboard the vehicle.

The characteristics of the primary encoder may be summarized as follows:

- 128 words/mainframe
- 8 bits/word
- 1024 bits/mainframe
- 8 mainframes/seconds
- 8192 bits/second
- 128 mainframes/masterframe
- 16 seconds/masterframe.

The auxiliary encoder may be characterized in summary form as follows:

- 64 words/mainframe
- 8 bits/word
- 512 bits/mainframe
- 1 mainframe/second
- 512 bits/second
- 4 mainframes/masterframe
- 4 seconds/masterframe.

The broadband analog data from the vehicle will provide high rate information for several experiments. Five modes were defined for broadband operations but only one mode may be operated at any time.

### 3.3 Agency Tapes

A new concept, called the agency tape (AT), will be used by SAMTEC in the digitization of data for the SCATHA satellite. This new type of file replaces the STF used for the S3-1, S3-2 and S3-3 satellites. The actual file structure has resulted from meetings between SUA, SDAL and SAMTEC personnel. Rather than digitizing the entire PCM mainframe, an agency tape is created for each experiment which contains only the specific designations requested. Each orbit on the AT will have at least four types of records; header record, scan record, event record and telemetry records. The header record contains information specific to the vehicle and orbit such as orbit number, date of orbit, GMT at the start and end of the pass. The scan record will contain information pertaining to areas of digitization dropout. The event record is specific to each agency tape type. It may contain information from the telemetry stream obtained in the first pass of the 2 pass SAMTEC system.

The telemetry records contain GMT and the digital values for the specified designations.

One of the preliminary efforts of the SDAL with respect to this vehicle has been to aid the SUA analysts in defining agency tape information. From the overview section it is seen that coverage of up to 24 hours per day may be expected. Thus, it is obvious that efficient storage of the PCM data into the data records is imperative. The structure which was defined results in significant data compaction yet allows for compatibility with S3 system techniques.

It is suggested that each record contain masterframes of data with each masterframe starting at the mainframe containing subcommutator frame 0. By storing masterframes, as opposed to mainframes, on each physical record, a maximum of information may be stored on each magnetic tape. Further, by storing each masterframe in a consistent manner (starting at subcommutator level zero), the necessity of having individual processing routines search each file to find word locations of subcommutated data is removed. This will help in minimizing the computer coding in these routines. The more important factor, however, is data storage. Estimates were made using the preliminary telemetry lists from two of the AFGL probes aboard the vehicle and these estimates were used to conclude that a full day (24 hours) of data could be stored on each agency tape.

APPENDIX A

B%L FILE FORMAT

### B&L-File Header Record

0.1	Word Count	
0.2	Group Count (1)	
1	Satellite name	A
2	Modified Julian date at start of pass	F
3	Month of year at start of pass	F
4	Day of month at start of pass	F
5	Year (last two digits of 19xx)	F
6,7	Coefficients used in mag. field calculations	A
8	Epoch year of coefficients	F
9	Date coefficients initially updated to	F
10	Start time of pass (GMT) seconds	F
11	End time of pass (GMT) seconds	F
12	Time increment (seconds)	F
13	Indicator for magfield package 0. = INVAR/FIELDG, 1. = SHELLG/FELDG	F
14	Error value for INVAR	F
15	Semi-major axis (km)	F
16	Eccentricity	F
17	Inclination	F
18	Right ascension of ascending node	F
19	Argument of perigee	F
20	Time of perigee (GMT) sec - neg + <i>N/A</i>	F
21	Altitude of perigee (km)	F

B&L-File Header Record (Cont.)

22 Longitude of perigee (+E)  
23 Latitude of Perigee (geodetic)  
24 Local time of perigee - seconds  
25 Time of apogee (neg → no apogee)  
26 Altitude of apogee (km)  
27 Longitude of apogee (+E)  
28 Latitude of apogee (geodetic)  
29 Local time of apogee - seconds  
30 Start time of vehicle in sun<sub>1</sub> (neg → N/A)  
31 End time of vehicle in sun<sub>1</sub> (neg → N/A)  
32 Start time of vehicle in shade<sub>1</sub> (neg → N/A)  
33 End time of vehicle in shade<sub>1</sub> (neg → N/A)  
34 Start time of vehicle in sun<sub>2</sub> (neg → N/A)  
35 End time of vehicle in sun<sub>2</sub> (neg → N/A)  
36 Start time of vehicle in shade<sub>2</sub> (neg → N/A)  
37 End time of vehicle in shade<sub>2</sub> (neg → N/A)  
38 Longitude at start of pass  
39 Longitude at end of pass  
40 Latitude (geodetic) at start of pass  
41 Latitude (geodetic) at end of pass  
42 Altitude at start of pass  
43 Altitude at end of pass  
44 Rev no.  
45-50 Vacant

B&L - File Data Records

- 0.1 Word count
- 0.2 Group count
- 1 Modified Julian Date
- 2 Calendar month
- 3 Calendar day
- 4 Calendar year
- 5 Hour of day
- 6 Minute of hour
- 7 Second of minute
- 8 GMT in seconds
- 9 x coordinate of position vector (km)
- 10 y coordinate of position vector (km)
- 11 z coordinate of position vector (km)
- 12 x coordinate of velocity vector (km/sec)
- 13 y coordinate of velocity vector (km/sec)
- 14 z coordinate of velocity vector (km/sec)
- 15 Satellite altitude (km)
- 16 Distance of satellite from center of earth (km)
- 17 Satellite velocity (km/sec)
- 18 Geocentric latitude ( $\pm 90^\circ$ )
- 19 Geodetic latitude ( $\pm 90^\circ$ )
- 20 Satellite longitude (+E)
- 21 Geomagnetic local time (seconds)
- 22 Local time (seconds)

B&L - File Data Records (Cont.)

23 x coordinate of magnetic field (geodetic) in gamma's  
24 y coordinate of magnetic field (geodetic) in gamma's  
25 z coordinate of magnetic field (geodetic) in gamma's  
26 Geomagnetic coordinate - B  
27 Geomagnetic coordinate - L  
28 Geomagnetic latitude  
29 Geomagnetic longitude  
30 Magnetic inclination  
31 Magnetic declination  
32 Invariant latitude  
33 Corrected geomagnetic latitude  
34 Corrected geomagnetic longitude  
35 Local corrected magnetic time  
36 Solar zenith angle  
37 Solar longitude  
38 Solar right ascension  
39 Solar declination  
40 Mean anomaly  
41-50 Vacant

APPENDIX B  
GSF FILE FORMAT

(GSF) Geophysical Support File Header Record

CDC	FORMAT	DESCRIPTION
0.1	I	Word count
0.2	I	Group count
1	A	Satellite name
2	F	Modified Julian date
3	F	Month of year at start of pass
4	F	Day of month at start of pass
5	F	Year of month at start of pass
6	F	Time at start of pass-GMT (Sec)
7	F	Time at end of pass-GMT (Sec)
8	F	Time increment
9	F	Semi Major axis at start of pass
10	F	Eccentricity at start of pass
11	F	Inclination at start of pass
12	F	Right ascension of ascending node
13	F	Argument of perigee
14	F	Time of perigee-GMT Sec (neg → N/A)
15	F	Altitude of perigee (km)
16	F	Longitude of perigee (+E)
17	F	Latitude (geodetic) of perigee
18	F	Local time of perigee (Sec)
19	F	Time of apogee-GMT Sec (neg → N/A)
20	F	Altitude of apogee (km)
21	F	Longitude of apogee (+E)

(GSF) Geophysical Support File Header Record (Cont.)

CDC	FORMAT	DESCRIPTION
22	F	Latitude of apogee (geodetic)
23	F	Local time of apogee (sec)
24	F	Start time of vehicle in sun <sub>1</sub> (neg → N/A)
25	F	End time of vehicle in sun <sub>1</sub> (neg → N/A)
26	F	Start time of vehicle in shade <sub>1</sub> (neg → N/A)
27	F	End time of vehicle in shade <sub>1</sub> (neg → N/A)
28	F	Start time of vehicle in sun <sub>2</sub> (neg → N/A)
29	F	End time of vehicle in sun <sub>2</sub> (neg → N/A)
30	F	Start time of vehicle in shade <sub>2</sub> (neg → N/A)
31	F	End time of vehicle in shade <sub>2</sub> (neg → N/A)
32	F	F10.7 cm solar flux ( $F_{10.7}$ )
33	F	F (3 month average)
34	F	$K_p$ value
35	F	$A_p$ value
36	F	Longitude (+E) at start of pass
37	F	Longitude (+E) at end of pass
38	F	Latitude (geodetic) at start of pass
39	F	Latitude (geodetic) at end of pass
40	F	Altitude at start of pass
41	F	Altitude at end of pass
42	F	Rev no. (f)
43-50	F	Vacant

APPENDIX C

INDICES FILE FORMAT

### Indices File Format

WORD NO.	FORMAT	DESCRIPTION
1	F	Month of year
2	F	Day of month
3	F	Year (last 2 digits of 19xx)
4-11	F	$K_p$ values (8)
12	F	$F_{10.7}$ cm solar flux
13	F	Solar declination
14	F	$A_p$
15	F	Relative sunspot number
16	F	Daily solar index
17	F	Calcium plage
18-41	F	Hourly $D_{st}$ index

APPENDIX D

MESA ACCELEROMETER DATA BASE

MESA Accelerometer Data Base

Header Record:

- 0.1 No. of words in header record (45)
- 0.2 Integer (1)
- 1 Satellite Name
- 2 Month of year at start of pass
- 3 Day of month at start of pass
- 4 Year (last 2 digits of 19xx)
- 5 Time at start of pass (GMT sec)
- 6 Time at end of pass (GMT sec)
- 7 Time of perigee (GMT sec)
- 8 Altitude at perigee (km)
- 9 Geocentric longitude at perigee (Degrees, +E)
- 10 Geodetic latitude at perigee
- 11 Local time of perigee (sec)
- 12 Start time of vehicle in sun (neg N/A)
- 13 End time of vehicle in sun (neg N/A)
- 14 Start time of vehicle in shade (neg N/A)
- 15 End time of vehicle in shade (neg N/A)
- 16 Start time of vehicle in sun<sub>2</sub> (neg N/A)
- 17 End time of vehicle in sun<sub>2</sub> (neg N/A)
- 18 Start time of vehicle in shade<sub>2</sub> (neg N/A)
- 19 End time of vehicle in shade<sub>2</sub> (neg N/A)
- 20 F<sub>10.7</sub> cm solar flux
- 21  $\bar{F}$  (3 month average)
- 22 K<sub>p</sub>
- 23 Orbit Number
- 24 a<sub>0</sub>
- 25 a<sub>1</sub>
- 26 a<sub>2</sub>
- 27 a<sub>3</sub>
- 28 a<sub>4</sub>

Downleg data coefficients to fit

$$15 + \log \rho = \sum_{i=0}^4 a_i z^i$$

= density, z - altitude

MESA Accelerometer Data Base

29	b <sub>0</sub>	
30	b <sub>1</sub>	Upleg data - coefficients to fit
31	b <sub>2</sub>	
32	b <sub>3</sub>	$15 + \log \rho = \sum_{i=0}^4 b_i z^i$
33	b <sub>4</sub>	
34	T <sub>1</sub>	
35	C <sub>1</sub>	Constants used in bias correcting data
36	T <sub>2</sub>	
37	T <sub>2</sub>	
38	}	
39		
40		
41		Vacant
42		
43		
44		
45		

MESA Accelerometer Output Data Base - Data Records

Output values are for ram points only

0.1	Number of words in a group (20)
0.2	Number of groups in a logical record (25)
1	Time (GMT seconds)
2	Altitude
3	Geodetic latitude
4	Geocentric longitude
5	Geomagnetic latitude
6	Geomagnetic longitude
7	Local time (sec)
8	Drag
9	$\rho$ calculated
10	$\rho$ model
11	Ratio ( $\rho$ meas/ $\rho$ model)
12	Attack Angle
13	L-Shell
14	Orbit normal angle
15	Temperature and bias corrected counts
16	Drag coefficient
17	Geocentric latitude
18	Vacant
19	Vacant
20	Vacant

The ram point outputs for the full pass comprise the first part of the MESA data base.

The second part of the data base is made up of points from the curve fit in 2 km intervals between 250 km and perigee. Perigee point is added.

The two portions of the file are separated by IND = 1, JGRP - 1, DATA = 0.0.

For the fitted data

- 0.1 Word Count (10)
- 0.2 Group Count (50)
- 1 GMT
- 2 ALT
- 3 Geodetic latitude
- 4 Geocentric longitude
- 5 Geomagnetic latitude
- 6 Geomagnetic longitude
- 7  $\rho$  (from fit)
- 8  $\rho$  model
- 9 Ratio
- 10 Local time

APPENDIX E  
MSI DATA BASE

MSI Data Base - Header Record

0.1 Word Count (20)  
0.2 Group Count (1)  
1 Experiment (MSI)  
2 Orbit Number  
3 Month of Year  
4 Day of month of orbit  
5 Year (last two digits of 19xx)  
6 Start time of orbit (GMT-sec)  
7 End time of orbit (GMT-sec)  
8 Start time of vehicle in sun-GMT sec (<0→N/A)  
9 End time of vehicle in sun-GMT sec (<0→N/A)  
10 Start time of vehicle in shade - GMT sec (<0→N/A)  
11 End time of vehicle in shade - GMT sec (<0→N/A)  
12  $\bar{R}$  (average R for orbit)  
13 GMT (sec) of perigee  
14 Altitude (km) of perigee  
15 Longitude (+E) of perigee  
16 Latitude of perigee  
17 Local time of perigee (sec)  
18  $\bar{T}$  (average sphere temp for orbit)  
19 Vacant  
20 Vacant

MSI Data Base Data Records

0.1	Word Count (50)
0.2	Group Count (10)
1	Time (GMT sec) ram
2	Altitude (km)
3	Geodetic latitude
4	Longitude
5	Invariant latitude
6	L-shell
7	Geomagnetic latitude
8	Magnetic local time (sec)
9	Velocity (km/sec)
10	$I_{14}$ (current for mass 14)
11	$\alpha_{14}$ (attack angle of current for amu 14; + into ram, - out of ram)
12	$I_{16}$
13	$\alpha_{16}$
14	$I_{18}$
15	$\alpha_{18}$
16	$I_{28}$
17	$\alpha_{28}$
18	$I_{30}$
19	$\alpha_{30}$
20	$I_{32}$
21	$\alpha_{32}$
22	$I_{34}$
23	$\alpha_{34}$
24	$I_{40}$
25	$\alpha_{40}$

MSI Data Base - Data Records (Cont.)

26  $I_{44}$   
 27  $\alpha_4$   
 28  $N_{16}$   
 29  $N_{28}$   
 30  $N_{40}$   
 31  $N_{14}$   
 32  $N_T (N_T + \sum N_i)$   
 33  $\rho (\rho = k \sum N_i M_i)$   
 34 Time (sit mode  $70^\circ$  into ram) ( $T_{+70}$ )  
 35 Altitude  
 36  $\alpha$  at  $T_{+70}$   
 37  $I_{28+70}$   
 38  $N_{28+70}$   
 39 Time (sit - ram) ( $T_R$ )  
 40 Alt at  $T_R$   
 41  $\alpha$  at  $T_R$   
 42  $I_{28}$  ram  
 43  $N_{28}$  ram  
 44 Time (sit mode -  $70^\circ$  out of ram) ( $T_{-70}$ )  
 45 Alt at  $T_{-70}$   
 46  $\alpha$  at  $T_{-70}$   
 47  $I_{28-70}$   
 48  $N_{28-70}$   
 49 Vacant  
 50 Vacant

APPENDIX F  
MSIV ION DATA BASE

### MSIV Ion Data Base Header Record

0.1	Word Count (23)	
0.2	Group Count (1)	
1	Experiment (MSIV)	
2	Orbit Number	
3	Month of year of orbit	
4	Day of month of orbit	
5	Year (last 2 digits of 19xx)	
6	Start time of orbit (GMT-sec)	
7	End time of orbit (GMT-sec)	
8	Start time of vehicle in sun (<0→N/A)	
9	End time of vehicle in sun (<0→N/A)	
10	Start time of vehicle in shade (<0→N/A)	
11	End time of vehicle in shade (<0→N/A)	
12	GMT of perigee (sec)	
13	Altitude of perigee (km)	
14	Longitude (+E) of perigee	
15	Geodetic latitude of perigee	
16	Geomagnetic latitude of perigee	
17	Invariant latitude of perigee	
18	Local time of perigee	
19	Magnetic local time of perigee	
20	Corrected magnetic local time of perigee	
21	Commutator <sub>1</sub>	
22	Commutator <sub>2</sub>	
23	Commutator <sub>3</sub>	from first 8 frames
24	Commutator <sub>4</sub>	of data in pass
25	Commutator <sub>5</sub>	
26	Commutator <sub>6</sub>	
27	Commutator <sub>7</sub>	
28	Commutator <sub>8</sub>	

MSIV Ion Data Base Header Record (Cont.)

29	Commutator <sub>1</sub>	
30	Commutator <sub>2</sub>	
31	Commutator <sub>3</sub>	
32	Commutator <sub>4</sub>	From last 8 frames
33	Commutator <sub>5</sub>	of data in pass
34	Commutator <sub>6</sub>	
35	Commutator <sub>7</sub>	
36	Commutator <sub>8</sub>	
37	Vacant	
38	Vacant	

## MSIV Ion Data Base Data Records

- 0.1 Word Count (39)
- 0.2 Group Count (13)
  - 1 Time of start of selected frame (GMT seconds)
  - 2 Altitude (km)
  - 3 Geodetic latitude
  - 4 Geomagnetic latitude
  - 5 Invariant latitude
  - 6 L-Shell
  - 7 Longitude (+E)
  - 8 Magnetic local time (sec)
  - 9 Corrected magnetic local time (sec)
  - 10 Local time (sec)
  - 11  $I_{14}$  (corrected to ram)
  - 12  $I_{16}$  (corrected to ram)
  - 13  $I_{28}$  (corrected to ram)
  - 14  $I_{30}$  (corrected to ram)
  - 15  $I_{32}$  (corrected to ram)
  - 16  $\alpha_{14}$  at time of  $I_{14}$  ( $\alpha$  = attack angle)
  - 17  $\alpha_{16}$  at time of  $I_{16}$
  - 18  $\alpha_{28}$  at time of  $I_{28}$
  - 19  $\alpha_{30}$  at time of  $I_{30}$
  - 20  $\alpha_{32}$  at time of  $I_{32}$
  - 21  $\beta_{14}$  at time of  $I_{14}$  ( $\beta$  = pitch angle)
  - 22  $\beta_{16}$  at time of  $I_{16}$
  - 23  $\beta_{28}$  at time of  $I_{28}$
  - 24  $\beta_{30}$  at time of  $I_{30}$
  - 25  $\beta_{32}$  at time of  $I_{32}$

MSIV Ion Data Base Data Records (Cont.)

- 26  $\Sigma I_i$  (where  $I_i$  are corrected currents)
- 27  $RA_1$  (where RA has been translated to ram)
- 28  $\alpha RA_1$
- 29  $RA_2$  (translated to ram)
- 30  $\alpha RA_2$
- 31  $RA_3$  (translated to ram)
- 32  $\alpha RA_3$
- 33  $TI_1$
- 34  $TI_2$
- 35  $TI_3$
- 36  $TI_4$
- 37 Beam Monitor<sub>1</sub>
- 38 Beam Monitor<sub>2</sub>
- 39 High Voltage Monitor

APPENDIX G  
ION DENSITY GAUGE DATA BASE

Data Base Storage: Ion Density Gauge

Header Record

0.1	Word Count (35)
0.2	Group Count (1)
1	Orbit No.
2	Month of orbit
3	Day of orbit
4	Year of orbit (last two digits of 19xx)
5	$K_p$ for orbit
6	$F_{10.7}$ cm flux for orbit
7	Start time of orbit (GMT sec)
8	End time of orbit (GMT sec)
9	Start time of vehicle in sun
10	End time of vehicle in sun
11	Start time of vehicle in shade
12	End time of vehicle in shade
13	Perigee time (GMT sec)
14	Perigee altitude (km)
15	Perigee longitude (+E)
16	Perigee latitude
17	Local time of perigee (sec)
18	Electronics temperature (average)
19	Gauge temperature (representative value)
20	TGE (calculated Tg)

Data Base Storage: Ion Density Gauge (Cont.)

21  $a_0$  } Coefficients to least square fit for downleg  
 22  $a_1$  } where  
 23  $a_2$  }  
 24  $a_3$  }  $\log \rho = \sum_{i=0}^4 a_i z^i - 15$   
 25  $a_4$  }  $\rho = \text{density}; z = \text{altitude } z \leq 350 \text{ km}$   
 26  $b_0$  } Coefficients for up leg data fit  
 27  $b_1$  } Coefficients for up leg data fit  
 28  $b_2$  }  
 29  $b_3$  }  $\log \rho = \sum_{i=0}^4 b_i z^i - 15$   
 30  $b_4$  }  $z \leq 350 \text{ km}$   
 31 Gauge Number {value = 4 for -4, -6, value = 5 for -5, -7}  
 32 Eccentricity  
 33 Inclination  
 34  $F_{10.7}$  flux (3 month average)  
 35 Vacant

Data Records - Ion Density Gauge Data Base

- 0.1 Word Count (21)
- 0.2 Group Count (24)
  - 1 Time (ram) (GMT sec)
  - 2 Altitude (km)
  - 3 Longitude (+E)
  - 4 Latitude (Geodetic)
  - 5 Magnetic latitude
  - 6 Local time (seconds)
  - 7 I (current at 40° going into ram)
  - 8 Pg (pressure at 40° going into ram)
  - 9 R (S, D,  $\alpha$ ) (R factor at 40° going into ram)
  - 10 I (current at 40° going out of ram)
  - 11 Pg (pressure at 40° going out of ram)
  - 12 R (S, D,  $\alpha$ ) (R factor at 40° out of ram)
  - 13 Pressure into ram (from fit)
  - 14 Pressure out of ram (from fit)
  - 15 Average pressure (average of 13, 14 above)
  - 16 Measured density  $\rho$
  - 17 Model density (J '71)
  - 18 Model temperature (J '71)
  - 19 Model pressure (J '71)
  - 20 High Voltage
  - 21 Vacant

Words 1-21 repeat 23 times

APPENDIX H  
MSIV NEUTRAL HIGH DATA BASE

## MSIV Neutral High (NH)

### Header Record

0.1	Word Count (38)
0.2	Group Count (1)
1	Experiment (MSIV - NH)
2	Orbit Number
3	Month of year of orbit
4	Day of month of orbit
5	Year (last two digits of 19xx)
6	Start time of orbit (GMT sec)
7	End time of orbit (GMT sec)
8	Start time of vehicle in sun (<0 = >N/A)
9	End time of vehicle in sun (<0 = >N/A)
10	Start time of vehicle in shade (<0 = >N/A)
11	End time of vehicle in shade (<0 = >N/A)
12	GMT of perigee (sec)
13	Altitude of perigee (km)
14	Longitude (+E) of perigee
15	Geodetic latitude of perigee
16	Geomagnetic latitude of perigee
17	Invariant latitude of perigee
18	Local time of perigee
19	Magnetic local time of perigee
20	Corrected magnetic local time of perigee

MSIV Neutral High (NH) (Cont.)

21	Commutator 1
22	Commutator 2
23	Commutator 3
24	Commutator 4
25	Commutator 5
26	Commutator 6
27	Commutator 7
28	Commutator 8
29	Commutator 1
30	Commutator 2
31	Commutator 3
32	Commutator 4
33	Commutator 5
34	Commutator 6
35	Commutator 7
36	Commutator 8
37	Vacant

}  
From first 8 frames of data in  
the pass

}  
From last 8 frames of data in  
the pass

Data Records - MSIV Neutral High Data Base

0.1	Word Count (72)
0.2	Group Count) ( $\leq 7$ )
1	GMT at point closest to ram (sec)
2	Altitude
3	Geodetic
4	Longitude (+E)
5	Invariant latitude
6	L-shell
7	Geomagnetic latitude
8	Magnetic local time
9	Corrected magnetic local time
10	Velocity (km/sec)
11	Pitch Angle
12	T <sub>1</sub> ram
13	T <sub>1</sub> wake
14	I <sub>1</sub> ram
15	I <sub>1</sub> wake
16	T <sub>2</sub> ram
17	T <sub>2</sub> wake
18	I <sub>2</sub> ram
19	I <sub>2</sub> wake
20	T <sub>4</sub> ram
21	T <sub>4</sub> wake
22	I <sub>4</sub> ram
23	I <sub>4</sub> wake
24	T <sub>14</sub> ram
25	T <sub>14</sub> wake
26	I <sub>14</sub> ram
27	I <sub>14</sub> wake
28	T <sub>16</sub> ram
29	T <sub>16</sub> wake
30	I <sub>16</sub> ram
31	I <sub>16</sub> wake

Data Records - MSIV Neutral High Data Base (Cont.)

32	T <sub>28</sub> ram
33	I <sub>28</sub> ram
34	T <sub>28</sub> wake
35	I <sub>28</sub> wake
36	T <sub>30</sub> ram
37	I <sub>30</sub> ram
38	T <sub>30</sub> wake
39	I <sub>30</sub> wake
40	T <sub>32</sub> ram
41	I <sub>32</sub> ram
42	T <sub>32</sub> wake
43	I <sub>32</sub> wake
44	T <sub>40</sub> ram
45	I <sub>40</sub> ram
46	T <sub>40</sub> wake
47	I <sub>40</sub> wake
48	T <sub>44</sub> ram
49	I <sub>44</sub> ram
50	T <sub>44</sub> wake
51	I <sub>44</sub> wake
52	$\alpha_1$ of ram I <sub>1</sub> (+ = into ram; - = away from ram)
53	$\alpha_2$ of ram I <sub>2</sub> (+ = into ram; - = away from ram)
54	$\alpha_4$ of ram I <sub>4</sub> (+ = into ram; - = away from ram)
55	$\alpha_{14}$ of ram I <sub>14</sub> (+ = into ram; - = away from ram)
56	$\alpha_{16}$ of ram I <sub>16</sub> (+ = into ram; - = away from ram)
57	$\alpha_{28}$ of ram I <sub>28</sub> (+ = into ram; - = away from ram)
58	$\alpha_{30}$ of ram I <sub>30</sub> (+ = into ram; - = away from ram)
59	$\alpha_{32}$ of ram I <sub>32</sub> (+ = into ram; - = away from ram)
60	$\alpha_{40}$ of ram I <sub>40</sub> (+ = into ram; - = away from ram)
61	$\alpha_{44}$ of ram I <sub>44</sub> (+ = into ram; - = away from ram)

Data Records - MSIV Neutral High Data Base (Cont.)

62	Ratio monitor 4
63	Ratio monitor 5
64	Ratio monitor 6
65	Ratio monitor 7
66	Ratio monitor 8
67	Beam monitor <sub>3</sub>
68	Beam monitor <sub>4</sub>
69	High Voltage Monitor
70	Vacant
71	Vacant
72	Vacant

APPENDIX I

S3-1 DATA BASE LIST (Sample)

S3-1 DATA BASE NOVEMBER 1974 03/02/78  
 COMPLETED REV5

REV	DATE	START TIME	STOP TIME	START TIME	TIME	TIME	MSA	TO5	MSIV(TO5HS)	MSIV(UHS)	MSI
61	11/05/74	4141	4600	01100440	0151130	02222115	CC222115	CC222115	CC0001195	CC0229164	CC0229162 1+
62	11/05/74	13709	21304	05121153	0555157	072521154	CC2221154	CC0001196	CC0001196	CC01067070 1	
65	11/05/74	36476	36476	09133135	10107154	027611757	CC027611757	CC027611757	CC0229107 1		
68	11/05/74	50134	50134	15051133	16125141	027321156	CC027321156	CC027321156	CC0229107 1-		
70	11/05/74	72120	72120	20403133	20437125	033451261	CC033451261	CC0001197	CC0001197	CC01067029 2-	
77	11/05/74	31376	31376	04137135	09112130	032281183	CC032281183	CC0222153	CC0222153	CC01067019 2-	
78	11/05/74	46171	48237	12143130	13123146	032281182	CC032281182	CC0001198	CC0001198	CC01067020 3	
80	11/06/74	61237	63323	17101106	17135122	022521183	CC022521183	CC0001199	CC0001199	CC01067021 2+	
81	11/06/74	65415	70871	19106154	19141110	032281183	CC032281183	CC0001199	CC0001199	CC0229103 1+	
83	11/06/74	83311	85977	23119130	23152156	032281183	CC032281183	CC0001199	CC0001199	CC0229103 1+	
85	11/07/74	12616	14662	03130105	04104121	032281183	CC032281183	CC0001199	CC0001199	CC01067022 2+	
87	11/07/74	27330	29743	07161130	08115142	032281183	CC032281183	CC0279103	CC0279103	CC01067023 2	
89	11/07/74	42730	44412	11152133	12126151	032281183	CC032281183	CC0279103	CC0279103	CC0229122 1	
91	11/07/74	57434	59379	16103147	16137152	032281183	CC032281183	CC0279103	CC0279103	CC01067024 2+	
93	11/07/74	72931	74943	20149102	20149102	032281183	CC032281183	CC0279103	CC0279103	CC01067025 2+	
95	11/08/74	15755	3607	00175154	01100106	032211410	CC032211410	CC0279103	CC0279103	CC0229123 2+	
97	11/08/74	16623	18675	0437132	05111115	032211410	CC032211410	CC0279103	CC0279103	CC01067026 2-	
99	11/08/74	31519	37741	09148108	09122120	032211410	CC032211410	CC0279103	CC0279103	CC01067027 1	
100	11/09/74	33358	41274	11106107	11127153	032211410	CC032211410	CC0279103	CC0279103	CC01067001 1	
101	11/09/74	46775	44407	12153134	13133126	032211410	CC032211410	CC0279103	CC0279103	CC01067002 3	
103	11/09/74	61321	67873	17110120	17144132	032211410	CC032211410	CC0279103	CC0279103	CC01067003 3	
105	11/09/74	76317	74919	21121126	21155138	032211410	CC032211410	CC0279103	CC0279103	CC02291057 6-	
107	11/09/74	5533	7603	01132132	02106142	032211410	CC032211410	CC0279103	CC0279103	CC02291166 5+	
108	11/09/74	13075	15124	03137154	04112103	032211410	CC032211410	CC0279103	CC0279103	CC02291213 6-	
109	11/09/74	20572	22646	05143116	06117125	032211410	CC032211410	CC0279103	CC0279103	CC0229197 6-	
110	11/09/74	28119	30168	07149134	08122144	032211410	CC032211410	CC0279103	CC0279103	CC02291095 6-	
111	11/09/74	35011	37690	09154100	10128109	032211410	CC032211410	CC0279103	CC0279103	CC02261148	
112	11/09/74	43133	45212	12126112	13133131	032211410	CC032211410	CC0279103	CC0279103	CC0229109 5-	
113	11/09/74	50315	52734	14134145	15138153	032211410	CC032211410	CC0279103	CC0279103	CC02261150	
114	11/09/74	58205	60755	16110135	16144115	032211410	CC032211410	CC0279103	CC0279103	CC0229102 5-	
115	11/09/74	65316	67778	18115135	18149137	032211410	CC032211410	CC0279103	CC0279103	CC02261151	
116	11/09/74	73231	75300	20154100	20154100	032211410	CC032211410	CC0279103	CC0279103	CC01067006 2	
117	11/09/74	80723	82422	22126112	23100121	032211410	CC032211410	CC0279103	CC0279103	CC02261152	
119	11/10/74	9416	11465	02136155	03111104	032211410	CC032211410	CC0279103	CC0279103	CC02261148	
120	11/10/74	16318	18937	04142117	05116124	032211410	CC032211410	CC0279103	CC0279103	CC0229109 2+	
121	11/10/74	31273	34019	09152152	09126158	032211410	CC032211410	CC0279103	CC0279103	CC01067010 3	
122	11/10/74	39440	41530	10154137	11132109	032211410	CC032211410	CC0279103	CC0279103	CC02291164 1	
123	11/10/74	46376	49042	13103115	13137121	032211410	CC032211410	CC0279103	CC0279103	CC02291059 1	
124	11/10/74	54538	56554	15108127	15142133	032211410	CC032211410	CC0279103	CC0279103	CC02291059 2	
125	11/10/74	65431	72473	18108127	18142133	032211410	CC032211410	CC0279103	CC0279103	CC02291165 2	
127	11/11/74	13180	15226	03139139	04113145	032211410	CC032211410	CC0279103	CC0279103	CC01121104	
131	11/11/74	28237	30250	07150132	08124100	032211410	CC032211410	CC0279103	CC0279103	CC02291130	
132	11/11/74	34919	37277	09152152	09126158	032211410	CC032211410	CC0279103	CC0279103	CC02291013 2	
133	11/11/74	43440	45300	10154137	11132109	032211410	CC032211410	CC0279103	CC0279103	CC01067011 1	
134	11/11/74	52440	54942	13103115	13137121	032211410	CC032211410	CC0279103	CC0279103	CC02261151	
135	11/11/74	65740	67723	18115139	18149142	032211410	CC032211410	CC0279103	CC0279103	CC02291059 2	
136	11/11/74	73241	75245	20120140	20154142	032211410	CC032211410	CC0279103	CC0279103	CC02291059 2	
137	11/11/74	80742	82746	22125141	22150147	032211410	CC032211410	CC0279103	CC0279103	CC02291165 2	
138	11/11/74	87444	89447	01130143	01104145	032211410	CC032211410	CC0279103	CC0279103	CC01067012 3	
139	11/11/74	97134	99137	02141143	02109147	032211410	CC032211410	CC0279103	CC0279103	CC01067013 2	
140	11/12/74	1444	13487	01130143	01104145	032211410	CC032211410	CC0279103	CC0279103	CC02291013 2	
141	11/12/74	97134	99137	02141143	02109147	032211410	CC032211410	CC0279103	CC0279103	CC01067014 5	
142	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC01067015 7	
143	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC01067016 6	
144	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201001 6	
145	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201002 6	
146	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201003 6	
147	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201004 6	
148	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201005 6	
149	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201006 6	
150	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201007 6	
151	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201008 6	
152	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201009 6	
153	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201010 6	
154	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201011 6	
155	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201012 6	
156	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201013 6	
157	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201014 6	
158	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201015 6	
159	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201016 6	
160	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201017 6+	
161	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201018 6+	
162	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201019 6+	
163	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201020 6+	
164	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201021 6+	
165	11/12/74	31464	33492	03150148	03124151	032211410	CC032211410	CC0279103	CC0279103	CC05201022 6+	

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REV	DATE	START TIME	STOP TIME	START TIME	STOP TIME	MESA	IDS	MSIV(I)ONS)	MSIV(MH)	MSI	KT
156 *	11/12/74	33150	4193	105514	1129152	CC2977/033	CC055/206	CC2977/127	CC2977/132	CC1367/031	5
157 *	11/12/74	4394	4394	1100150	1334154	CC2977/034	CC055/207	CC0227/067	CC0219/182	CC1067/031	6-
158 *	11/12/74	43351	4394	15105151	1519154	CC2977/035	CC055/208	CC0227/034	CC0218/089	CC0229/066	5+
159 *	11/12/74	61557	6357	1710152	17144156	CC2977/036	CC055/209	CC0227/085	CC0218/090	CC1067/033	5+
153 *	11/13/74	57519	7558	01139120	02105157	CC2977/039	CC055/210	CC1795/231	CC0200/062	CC0229/067	5-
154 *	11/13/74	12919	15046	01135134	04110145	CC2977/040	CC055/212	CC0700/063	CC0200/063	CC1067/034	4
155 *	11/13/74	20334	22574	05143143	06115133	CC2977/041	CC0244/163	CC1795/232	CC0200/150	CC0229/207	4+
156 *	11/13/74	27915	30022	07143143	08120121	CC2977/042	CC055/177	CC1795/233	CC0200/061	CC1067/035	4+
157 *	11/13/74	35122	37516	09150131	10125115	CC2977/043	CC055/178	CC1795/233	CC0200/064	CC1067/036	5-
158 *	11/13/74	42930	44938	11154143	12129157	CC2977/043	CC2222/170	CC1795/234	CC0200/065	CC1067/037	4-
159 *	11/13/74	50378	52486	13153137	14134145	CC2977/044	CC2222/169	CC1795/237	CC0200/115	CC0229/111	4-
160 *	11/13/74	57356	59374	16104125	16139137	CC2977/044	CC0244/162	CC1795/238	CC0200/116	CC0229/172	5-
161 *	11/13/74	63355	67463	18109115	18144120	CC2977/045	CC0244/174	CC1795/236	CC0200/067	CC0229/094	5-
164 *	11/14/74	141A	3526	09123137	09158145	CC2977/045	CC2222/168	CC1795/240	CC0200/071	CC1067/038	6-
165 *	11/14/74	806	11014	09123125	09103137	CC2977/047	CC2222/171	CC1795/239	CC0200/070	CC1067/039	6-
166 *	11/14/74	16334	18502	04133117	05108121	CC2977/047	CC2222/172	CC1795/239	CC0200/069	CC1067/040	6-
168 *	11/14/74	31370	33478	03142149	03117157	CC2977/048	CC2222/173	CC1795/244	CC0200/075	CC1067/041	4+
169 *	11/14/74	38558	40946	10147137	11122145	CC2977/048	CC2222/174	CC1795/243	CC0200/074	CC0229/096	4+
172 *	11/14/74	61372	63430	17102101	17137109	CC2977/048	CC2222/175	CC0001/209	CC0311/155	CC0229/170	5-
175 *	11/14/74	83753	85866	23116132	23151105	CC2977/048	CC0244/164	CC1795/245	CC0200/076	CC0229/175	1-
176 *	11/15/74	12314	6941	01120116	01155140	CC2977/049	CC2222/175	CC0227/108	CC0219/113	CC0229/035	1+
177 *	11/15/74	14314	14415	01135117	04110115	CC2977/049	CC0244/165	CC1795/241	CC0200/109	CC0229/201	1
184 *	11/15/74	646+2	66747	17152121	18132126	CC2977/049	CC2222/180	CC0227/038	CC0218/093	CC0229/098	3-
185 *	11/15/74	73230	74225	22101100	22137104	CC2977/049	CC2222/182	CC3225/277	CC4327/076	CC0229/019	3-
186 *	11/15/74	73230	81703	22106137	22191142	CC2977/049	CC2222/181	CC3225/279	CC4327/078	CC0520/003	3-
188 *	11/15/74	8270	10259	02117143	02159158	CC2977/049	CC2222/183	CC3225/231	CC4327/080	CC0229/112	2
189 *	11/15/74	15532	17737	04120111	04155136	CC2977/049	CC2222/184	CC3225/278	CC4327/077	CC0229/099	4
191 *	11/15/74	30578	32679	08123137	09110138	CC2977/049	CC2222/185	CC3225/092	CC4327/114	CC0229/099	4
193 *	11/16/74	45398	47610	12139123	13113130	CC2977/049	CC2222/186	CC3225/316	CC4327/115	CC0229/086	3+
194 *	11/16/74	52975	55176	14142154	15117155	CC2977/049	CC2222/189	CC1795/165	CC4327/115	CC0229/087	4-
196 *	11/16/74	604+1	62542	16147119	17122121	CC2977/049	CC2222/189	CC3225/317	CC4327/115	CC0229/087	4-
197 *	11/16/74	67307	73008	19151146	19126147	CC2977/049	CC2222/188	CC3225/315	CC4327/114	CC0229/088	3+
198 *	11/16/74	75373	77474	20156112	21131113	CC2977/049	CC2222/190	CC3225/314	CC4327/117	CC0229/089	3-
198 *	11/16/74	82318	84339	23100137	23135139	CC2977/049	CC2222/191	CC3225/314	CC4327/113	CC0229/090	3-
201 *	11/17/74	13840	20941	05113100	05143100	CC2977/049	CC2222/192	CC3225/304	CC4327/103	CC1067/059	4-
203 *	11/17/74	33775	35876	09122154	09157155	CC2977/049	CC2222/193	CC3225/090	CC1243/164	CC0229/091	4-
204 *	11/17/74	41543	43343	11132142	12102122	CC2977/049	CC2222/195	CC3225/303	CC4327/102	CC0229/091	4-
205 *	11/17/74	48700	50811	13131145	14106158	CC2977/049	CC2222/196	CC3225/302	CC4327/101	CC0229/130	2+
206 *	11/17/74	56177	62278	15136116	16111117	CC2977/049	CC0244/168	CC1795/373	CC0200/151	CC0229/253	3
207 *	11/17/74	63878	65746	17143147	18115145	CC2977/049	CC2222/197	CC3225/306	CC4327/105	CC1067/060	3-
208 *	11/17/74	71112	73213	19145111	20120111	CC2977/049	CC2222/194	CC3225/305	CC4327/104	CC1067/061	3-
209 *	11/17/74	78379	80640	21143139	22124139	CC2977/049	CC2222/200	CC3225/304	CC4327/115	CC1067/043	3-
211 *	11/18/74	7115	9213	01158134	02113137	CC2977/049	CC2222/201	CC3225/093	CC1243/167	CC1067/044	3
217 *	11/18/74	22926	24124	05107105	06142103	CC2977/049	CC2222/202	CC3225/191	CC4327/120	CC1067/045	3-
215 *	11/18/74	35316	39034	10115115	10150137	CC2977/049	CC2222/199	CC3225/094	CC0226/156	CC1067/046	2+
216 *	11/18/74	46489	48411	12119150	12154148	CC2977/049	CC2222/190	CC3225/302	CC4327/121	CC1067/047	2
218 *	11/18/74	59112	61400	16128114	17103119	CC2977/049	CC2222/203	CC3225/305	CC4327/124	CC1067/049	2
219 *	11/18/74	66716	69056	18132115	19107133	CC2977/049	CC0244/202	CC3225/308	CC4327/107	CC0229/101	3-
220 *	11/18/74	76310	78417	21111140	21111140	CC2977/049	CC0244/185	CC3225/307	CC4327/136	CC0229/102	1-



REV	DATE	START TIME	STOP TIME	START TIME	STOP TIME	MESA	JDG	MSTV(TUMS)	MSI(VINH)	MSI
292	11/25/74	4317.	6347.	01420115	01454152	CC3226/009	CC0557/241	CC1795/128	CC2J00/156	CC0229/220
293	11/25/74	12220.	14306.	03127133	03156125	CC2252/127	CC0557/244	CC1795/179	CC2000/010	CC0229/061
294	11/25/74	19337.	21718.	05427111	05401157	CC2252/126	CC0557/247	CC1795/139	CC2000/011	CC0229/062
295	11/25/74	27034.	29170.	07430143	07405130	CC2252/125	CC0557/245	CC1795/133	CC2000/014	CC0229/063
297	11/25/74	42314.	47366.	11445103	12112135	CC3228/174	CC0557/135	CC0227/118	CC0218/123	CC0229/009
298	11/25/74	48333.	51369.	13441122	14115109	CC3228/133	CC0557/194	CC1795/187	CC2000/013	CC0229/010
299	11/25/74	56575.	58789.	15444134	16119140	CC3229/132	CC0274/191	CC4327/127	CC4327/127	CC0229/011
300	11/25/74	64107.	66193.	17143125	18123112	CC3228/141	CC0557/246	CC4327/094	CC4327/094	CC0229/012
301	11/25/74	71319.	73505.	19151133	20126145	CC3229/121	CC0557/121	CC4327/085	CC4327/085	CC0229/011
302	11/25/74	78331.	81017.	21055130	22130116	CC3229/126	CC0557/249	CC4327/084	CC4327/084	CC0520/012
304	11/26/74	7337.	9433.	02402116	02437112	CC2751/160	CC0557/120	CC1795/151	CC2000/012	CC0229/013
305	11/26/74	14770.	16856.	04075103	04440155	CC2752/159	CC0557/119	CC2000/015	CC2000/015	CC0229/256
308	11/26/74	35376.	39779.	10115115	10451118	CC2752/144	CC0557/250	CC1795/134	CC2000/015	CC0229/156
309	11/26/74	44633.	46440.	12124122	12454139	CC2752/153	CC0557/122	CC0227/093	CC0218/098	CC0229/039
310	11/26/74	51739.	53842.	14123119	14458101	CC2752/152	CC0557/124	CC0227/097	CC0218/008	CC0229/040
311	11/26/74	59770.	61237.	16126113	17401122	CC2752/151	CC0557/121	CC0227/094	CC0218/102	CC0229/046
312	11/26/74	66834.	68584.	18134113	19404125	CC3229/150	CC0557/251	CC3225/100	CC1243/174	CC0520/013
313	11/26/74	74013.	76086.	20133122	21408105	CC3229/149	CC0557/252	CC1225/230	CC4327/089	CC0520/014
315	11/27/74	2435.	4444.	00440104	01114147	CC2752/150	CC0274/175	CC0227/092	CC0218/037	CC0229/056
317	11/27/74	17218.	19291.	04146147	05421130	CC2752/147	CC0557/255	CC1795/186	CC2000/017	CC0229/070
318	11/27/74	24519.	26692.	06450108	07724151	CC3345/421	CC0274/180	CC1795/249	CC2000/030	CC0229/157
320	11/27/74	39379.	41495.	11004113	11171134	CC3229/129	CC0557/181	CC3225/202	CC4327/090	CC0520/015
321	11/27/74	45813.	48496.	13100112	13474155	CC3229/128	CC0557/182	CC3225/202	CC4327/091	CC0520/016
322	11/27/74	54214.	56207.	15103113	16108116	CC3229/127	CC0557/183	CC3225/203	CC4327/092	CC0520/017
323	11/27/74	61938.	63698.	17112117	17441120	CC3345/442	CC0274/178	CC1795/254	CC2000/014	CC0229/158
325	11/27/74	76418.	79501.	21113117	21448122	CC3229/152	CC0274/181	CC0227/112	CC0218/125	CC0229/242
326	11/27/74	83319.	85302.	23116113	23451141	CC3229/163	CC0274/182	CC0227/115	CC0218/120	CC0229/255
327	11/28/74	4321.	6904.	01120110	01455103	CC3945/441	CC0274/105	CC1795/251	CC2000/082	CC0229/159
328	11/28/74	12223.	14306.	03123112	03458125	CC3232/162	CC0274/134	CC0227/112	CC0218/117	CC0229/248
329	11/28/74	20035.	21705.	05174114	06401145	CC3232/161	CC0274/179	CC0227/111	CC0218/116	CC0229/249
330	11/28/74	27116.	29096.	07170115	08404155	CC2761/419	CC0274/306	CC1795/253	CC2000/111	CC0229/174
331	11/28/74	34477.	36447.	09113115	10403105	CC2761/418	CC0274/107	CC1795/230	CC2000/138	CC0229/250
334	11/28/74	54379.	58559.	15442118	16417138	CC2761/421	CC0274/109	CC1795/252	CC2000/033	CC0229/160
335	11/28/74	64030.	66049.	17142119	18420148	CC2761/426	CC0274/128	CC1795/245	CC2000/113	CC0229/176
336	11/28/74	74330.	77440.	19443119	20423100	CC2761/425	CC0274/131	CC1795/231	CC2000/159	CC0229/179
337	11/28/74	78751.	80831.	21152113	22427110	CC2761/424	CC0274/130	CC1795/239	CC2000/157	CC0229/209
341	11/29/74	21344.	23924.	06405113	06439153	CC2761/430	CC0274/113	CC1795/294	CC2000/112	CC0229/178
342	11/29/74	23715.	31345.	08103114	08473104	CC3232/164	CC0274/114	CC1795/236	CC2000/114	CC0229/217
344	11/29/74	44318.	46156.	12118117	12449121	CC2752/216	CC0274/197	CC0227/116	CC0218/121	CC0229/084
345	11/29/74	51477.	53557.	14117115	14452116	CC2752/215	CC0227/217	CC0227/095	CC0218/104	CC0229/049
346	11/29/74	58338.	60348.	16121117	16455114	CC2752/213	CC0227/216	CC0227/095	CC0218/100	CC0229/116
347	11/29/74	66251.	68344.	18174110	18455100	CC3232/162	CC0274/131	CC1795/239	CC2000/157	CC0229/209
348	11/29/74	73652.	75712.	20127111	21402111	CC2761/429	CC0274/135	CC1795/332	CC2000/160	CC0229/215
349	11/29/74	81042.	83122.	22170111	23405121	CC2761/430	CC0274/114	CC1795/337	CC2000/161	CC0229/219
350	11/30/74	2025.	4132.	03133115	03470121	CC2761/420	CC0274/171	CC1795/337	CC2000/087	CC0229/161
355	11/30/74	39472.	41006.	10157151	11423125	CC2752/214	CC0557/117	CC0227/096	CC0218/011	CC0229/051
356	11/30/74	45319.	48346.	12151143	13426121	CC2752/212	CC0274/118	CC0227/096	CC0218/011	CC0229/052
357	11/30/74	57630.	59567.	14154113	15429125	CC2752/215	CC0557/239	CC1795/194	CC0200/019	CC0229/065
358	11/30/74	64071.	63148.	16457150	17332127	CC2752/145	CC0557/240	CC1795/137	CC2000/013	CC0229/034
359	11/30/74	63451.	70520.	18400110	19435127	CC2752/144	CC0557/111	CC3225/101	CC1243/175	CC0229/072

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REV	DATE	START TIME	STOP TIME	START TIME	STOP TIME	MESA	MSIVATIONS	MSIVINH	MSI
343	12/01/74	13575	17652	03447331	03447331	CC2252/17A	CC2252/170	CC2252/170	CC0229/037 0+
364	12/01/74	18356	21033	05151555	15150122	CC2252/101	CC0557/150	CC2080/058	CC0229/054 0+
365	12/01/74	20337	28414	07410133	07415333	CC2252/094	CC0125/129	CC0112/129	CC0229/055 0+
366	12/01/74	33717	36794	03211155	09156133	CC2252/094	CC0125/129	CC0112/129	CC0229/073 1
367	12/01/74	41358	43126	11124137	11151334	CC2252/137	CC0557/003	CC0170/003	CC0229/074 1
368	12/01/74	49779	50556	13127169	14102135	CC2252/136	CC0557/003	CC0170/003	CC0229/077 1
369	12/01/74	56359	57936	15133133	16105135	CC2252/136	CC0557/003	CC0170/003	CC0229/077 1
376	12/02/74	21355	23130	05150154	06105130	CC2252/136	CC0557/003	CC0170/003	CC0229/135 2-
377	12/02/74	28427	30502	07453155	08128121	CC2252/136	CC0557/003	CC0170/003	CC0229/135 3-
380	12/02/74	50542	52517	14102121	14136156	CC2252/136	CC0557/003	CC0170/003	CC0229/236 3-
382	12/02/74	65450	67360	13110104	14142139	CC2252/101	CC0557/003	CC0170/003	CC0229/074 2+
384	12/02/74	80029	82107	22113153	22148122	CC2252/101	CC0557/003	CC0170/003	CC0229/080 3-
388	12/03/74	23030	25168	06124137	06155128	CC2252/100	CC0557/003	CC0170/003	CC0229/075 2+
389	12/03/74	30439	32570	08127138	09102109	CC2252/100	CC0557/003	CC0170/003	CC0229/224 2+
390	12/03/74	37420	38494	10130113	11104150	CC2252/100	CC0557/003	CC0170/003	CC0229/226 3-
391	12/03/74	45454	47253	12144117	13107132	CC2252/100	CC0557/003	CC0170/003	CC0229/122 3-
392	12/03/74	52342	54614	14135131	15110113	CC2252/100	CC0557/003	CC0170/003	CC0229/020 3-
393	12/03/74	59313	61975	16138122	17112154	CC2252/100	CC0557/003	CC0170/003	CC0229/021 2
394	12/03/74	67254	69336	18141113	19115135	CC2252/100	CC0557/003	CC0170/003	CC0229/022 4+
395	12/03/74	74625	76597	20147115	21116115	CC2252/100	CC0557/003	CC0170/003	CC0229/228 3+
396	12/03/74	81337	84058	22146126	23120157	CC2252/100	CC0557/003	CC0170/003	CC0229/081 3+
400	12/05/74	25312	27104	06157111	07131143	CC2252/100	CC0557/003	CC0170/003	CC0229/024 3-
416	12/05/74	56305	58376	15139124	16112155	CC2252/100	CC0557/003	CC0170/003	CC0229/022 2+
418	12/05/74	79974	73941	13142133	20117120	CC2252/100	CC0557/003	CC0170/003	CC0229/026 3
423	12/06/74	21316	23373	05155105	06129132	CC2252/100	CC0557/003	CC0170/003	CC0229/127 1-
427	12/06/74	50337	52780	14104152	14133119	CC2252/100	CC0557/003	CC0170/003	CC0229/129 1
429	12/06/74	65337	67454	19109166	19144113	CC2252/100	CC0557/003	CC0170/003	CC0229/130 0+
431	12/06/74	80900	82148	22144139	22149107	CC2252/100	CC0557/003	CC0170/003	CC0229/131 1-
433	12/07/74	4875	12287	01121115	03123126	CC2252/100	CC0557/003	CC0170/003	CC0229/132 2-
435	12/07/74	25025	25049	06123115	06158108	CC2252/100	CC0557/003	CC0170/003	CC0229/139 2-
437	12/07/74	37534	39754	10129113	11102137	CC2252/100	CC0557/003	CC0170/003	CC0229/265 2+
441	12/07/74	67333	69037	19137112	19111136	CC2252/100	CC0557/003	CC0170/003	CC0229/141 2-
443	12/07/74	81732	83766	22141141	23115105	CC2252/100	CC0557/003	CC0170/003	CC0229/140 2
445	12/08/74	3970	12034	02146133	03120133	CC2252/100	CC0557/003	CC0170/003	CC0229/140 2
451	12/08/74	53779	56043	14159133	15134102	CC2252/100	CC0557/003	CC0170/003	CC0229/210 3+
457	12/09/74	11544	13635	03112123	03146145	CC2252/100	CC0557/003	CC0170/003	CC0229/159 2-
459	12/09/74	26134	28256	07116113	07150155	CC2252/100	CC0557/003	CC0170/003	CC0229/190 4
461	12/09/74	40935	42906	11120115	11156107	CC2252/100	CC0557/003	CC0170/003	CC0229/191 5
463	12/09/74	55955	57556	15124115	15159115	CC2252/100	CC0557/003	CC0170/003	CC0229/193 5+
470	12/10/74	20333	22391	05139132	06113110	CC2252/100	CC0557/003	CC0170/003	CC0229/162 4-
471	12/10/74	34351	37019	07133106	08115104	CC2252/100	CC0557/003	CC0170/003	CC0229/162 4-
472	12/10/74	49539	51637	13146128	14120145	CC2252/100	CC0557/003	CC0170/003	CC0229/222 2+
474	12/10/74	64303	66951	17153122	18122140	CC2252/100	CC0557/003	CC0170/003	CC0229/134 3+
475	12/10/74	64217	66275	17153122	18122140	CC2252/100	CC0557/003	CC0170/003	CC0229/145 3
477	12/10/74	71571	74549	19152110	20126126	CC2252/100	CC0557/003	CC0170/003	CC0229/175 3
478	12/10/74	78455	80304	21154104	22128127	CC2252/100	CC0557/003	CC0170/003	CC0229/186 3-
481	12/11/74	14330	16468	03151143	04136107	CC2252/100	CC0557/003	CC0170/003	CC0229/014 4-
482	12/11/74	23752	24313	06115151	06145151	CC2252/100	CC0557/003	CC0170/003	CC0229/136 3+
484	12/11/74	74311	78355	10105100	10139115	CC2252/100	CC0557/003	CC0170/003	CC0229/229 4

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