3.2.2 OAREAD

3.2.2.1 Purpose

The purpose of the OAREAD subroutine is to provide FORTRAN-callable access to the AE orbit/attitude data base on the Central Computer. Requests for data are time referenced. Specific orbit/attitude parameters are selected through an output mapping feature. Data may be requested at a number of uniformly distributed times over (up to) a 30-minute period with a single call to OAREAD.

3.2.2.2 Calling Sequence

CALL OAREAD (SATID, DATE, TIME, IERR, MAP, DATA, N, INC, MAX)

3.2.2.3 Input

Argument	Type	Definition
SATID	Character	A character specifying the AE satellite identification (must be C, D, or E). A literal such as C is an acceptable argument. If a (fullword) variable is used as the argument, the character must be the left-most byte in the word (i.e., left justified); the right-most three bytes may have any value.
DATE	Integer	A five-digit number of the form yyddd , which specifies the year (e.g., 73) and Julian day of year (e.g., January 1st = 001) of the first requested orbit/attitude data.
TIME	Integer	The number specifying the time in milliseconds of day of the first data requested.
MAP	Integer	An array (of length equal to the number of orbit/attitude parameters requested plus one) the contents of which are selection codes for orbit/attitude parameters. (See Table 3-2 for available orbit/attitude parameters.) MAP(1) must contain the number of additional words in MAP, say

Table 3-2. OAREAD Parameters (1 of 4)

MAP NO.	SYMBOL	DESCRIPTION	UNITS
1		PREDICT/DEFINITIVE ORBIT FLAG = 0, DEFINITIVE, = 1, PREDICTED	
2	P	PERIOD	MINUTES
3	i	INCLINATION	DEGREES
4	e	ECCENTRICITY	
5	a	SEMIMAJOR AXIS	KILOMETERS
6	ω	ARGUMENT OF PERIGEE	DEGREES
7	Ω	RIGHT ASCENSION OF ASCENDING NODE	DEGREES
8 – 10		GEI VECTOR NORMAL TO ORBIT PLANE (IN DIRECTION P x V)	UNIT VECTOR
11		APOGEE HEIGHT	KILOMETERS
12		PERIGEE HEIGHT	KILOMETERS
13		ORBIT NUMBER	
14		TIME FROM PERIGEE	SECONDS
15		SUNLIGHT/DARKNESS FLAG = 0, DARKNESS, = 1, SUNLIGHT	
16	GST	GREENWICH SIDEREAL TIME ANGLE MEASURED EASTWARD FROM THE FIRST POINT OF ARIES TO THE GREENWICH MERIDIAN. GST_0 WILL BE STORED ONCE PER DAY AT 0 U. T. (= t_0). $GST = GST_0 + \omega(t - t_0)$.	RADIANS
17 – 19	$S_xS_yS_z$	GEI VECTOR TOWARD SUN	UNIT VECTOR
20 – 22	$M_xM_yM_z$	GEI VECTOR FROM SATELLITE TOWARD MOON	KILOMETERS
23 – 25	$P_xP_yP_z$	GEI SATELLITE POSITION VECTOR	KILOMETERS
26 – 28	$V_xV_yV_z$	GEI SATELLITE VELOCITY VECTOR EACH VELOCITY COMPONENT WILL BE EVALUATED USING THE 4TH DEGREE POLYNOMIAL DERIVED FROM THE 5TH DEGREE FIT TO THE CORRESPONDING POSITION COMPONENT.	KILOMETERS PER SECOND
29 – 31	$R_xR_yR_z$	GEI SATELLITE VELOCITY RELATIVE TO ROTATING ATMOSPHERE $R_x = V_x + \omega P_y$ $R_y = V_y - \omega P_x$ $R_z = V_z$	KILOMETERS PER SECOND

Table 3-2. OAREAD Parameters (2 of 4)

MAP NO.	SYMBOL	DESCRIPTION	UNITS
32	h	HEIGHT ABOVE SPHERIOD FIRST COMPUTE $r = \sqrt{P_x^2 + P_y^2 + P_z^2}$ AND $\sin \varphi' = P_z/r$ THEN $h = r - R_e\,[1 - (f + 3/2f^2)\,\sin^2 \varphi' + 3/2f^2 \sin^4 \varphi']$	KILOMETERS
33	φ	GEODETIC LATITUDE OF SUBSATELLITE POINT FIRST COMPUTE $\tan \varphi' = P_z / \sqrt{P_x^2 + P_y^2}$ THEN APPROXIMATE THE SUBSATELLITE POINT BY THE INTERSECTION OF THE RADIUS VECTOR WITH THE SPHERIOD AND CALCULATE ITS GEODETIC LATITUDE: $\varphi = \frac{180}{\pi} \tan^{-1} [(1-f)^{-2} \tan \varphi']$	DEGREES
34	λ	EAST LONGITUDE OF SATELLITE $\lambda = \frac{180}{\pi}\,[\mathrm{ATAN2}\,(P_y, P_x) - \mathrm{GST}]$	DEGREES
35		MINIMUM RAY HEIGHT	KILOMETERS
36		MINIMUM RAY LATITUDE IF $(P \cdot S) \geq 0$, LET $Q = P$. IF $(P \cdot S) < 0$, CALCULATE $Q = P - (P \cdot S)S$. APPROXIMATE HEIGHT AND LATITUDE AS FOR PARAMETERS 32 AND 33 USING Q IN PLACE OF P	DEGREES
37		LOCAL APPARENT SOLAR TIME $12 + \frac{12}{\pi}\,\mathrm{ATAN2}\,(P_yS_x - P_xS_y, P_xS_x + P_yS_y)$	HOURS
38		LOCAL MAGNETIC TIME SUPPOSE φ'_n AND λ_n ARE GEOCENTRIC LATITUDE AND EAST LONGITUDE OF NORTH MAGNETIC POLE: FIRST COMPUTE UNIT VECTOR, N, TOWARD MAGNETIC POLE $N_x = \sin \varphi'_n \cos (\lambda_n + \mathrm{GST})$ $N_y = \sin \varphi'_n \sin (\lambda_n + \mathrm{GST})$ $N_z = \cos \varphi'_n$ THEN COMPUTE SUN IN PLANE OF MAGNETIC EQUATOR $SX = S - (S \cdot N)N$ $SY = N \times SX$ THEN LOCAL MAGNETIC TIME = ATAN2 (P SY, P SX)	HOURS
39	L	McILWAIN'S SHELL PARAMETER	EARTH RADIUS

Table 3-2. OAREAD Parameters (3 of 4)

MAP NO.	SYMBOL	DESCRIPTION	UNITS
40		INVARIENT LATITUDE $= \frac{180}{\pi} \cos^{-1} \sqrt{1/L}$	DEGREES
41	$\|B\|$	MAGNETIC FIELD STRENGTH	GAUSS
42 – 44	$B_x B_y B_z$	GEI MAGNETIC FIELD VECTOR	GAUSS
45 – 47	$B_r B_\theta B_\varphi$	POLAR COMPONENTS OF MAGNETIC FIELD FIRST COMPUTE UNIT VECTORS IN THE DIRECTIONS $1_r = P / \sqrt{P_x^2 + P_y^2 + P_z^2}$ $1_\varphi = < -P_y, P_x, 0 > / \sqrt{P_x^2 + P_y^2}$ $1_\theta = 1_\varphi \times 1_r$ THEN THE POLAR COMPONENTS OF THE FIELD ARE $B_r = B \cdot 1_r$ $B_\theta = B \cdot 1_\theta$ $B_\varphi = B \cdot 1_\varphi$	GAUSS
48	I	GEOCENTRIC MAGNETIC INCLINATION $I = \frac{180}{\pi} \sin^{-1} (-B_r / \|B\|)$	DEGREES
49 – 51	$I_x I_y I_z$	GEI COORDINATES OF INGRESS (NORTH) INTERSECT OF MAGNETIC FIELD LINE THROUGH SATELLITE	KILOMETERS
52 – 54	$E_x E_y E_z$	GEI COORDINATES OF EGRESS (SOUTH) INTERSECT POINT	KILOMETERS
55, 56	$\varphi_I \lambda_I$	GEODETIC LATITUDE AND LONGITUDE OF INGRESS POINT $\varphi_I = \frac{180}{\pi} \tan^{-1} [(1-f)^{-2} I_z / \sqrt{I_x^2 + I_y^2}$ $\lambda_I = \frac{180}{\pi}$ [ATAN2 (I_y, I_x) –GST]	DEGREES
57, 58	$\varphi_E \lambda_E$	GEODETIC LATITUDE AND LONGITUDE OF EGRESS POINT	DEGREES
59 – 67	T	3-BY-3 ROTATION MATRIX FOR TRANSFORMATION FROM SPACECRAFT COORDINATES TO GEI COORDINATES. THIS MATRIX WILL BE COMPUTED AS DESCRIBED BY GRELL AND HEADRICK IN THEIR OCTOBER 6, 1972 CORRESPONDENCE. THIS CALCULATION TAKES INTO EFFECT PRECESSION (CONING) BUT NOT NUTATION DUE TO CYLINDRICAL ASYMMETRY. NOTE THAT $T^{-1} = T^T$ WILL TRANSORM A GEI VECTOR INTO SPACECRAFT COORDINATES. NOTE ALSO THAT THE LAST COLUMN OF T (i.e.,	ORTHOGONAL MATRIX

Table 3-2. OAREAD Parameters (4 of 4)

MAP NO.	SYMBOL	DESCRIPTION	UNITS
59 – 67 (CONT'D)		T (·, 3) = ITEMS 65 – 67) GIVES THE GEI COMPONENTS OF THE INSTANTANEOUS SPACECRAFT Z-AXIS.	
68 – 70	$L_xL_yL_z$	GEI COORDINATES OF SPACECRAFT ANGULAR MOMENTUM VECTOR	UNIT VECTOR
71		PHASE ANGLE OF SPIN – MEASURED FROM VELOCITY VECTOR TO X-AXIS OF SPACECRAFT	RADIANS
72	ω_z	SPIN RATE WITH RESPECT TO NADIR	RADIANS PER SECOND
73	θ_p	CONING ANGLE (BETWEEN L AND SPACECRAFT Z-AXIS)	RADIANS
74	ω_p	CONING RATE	RADIANS PER SECOND
75	ω_p	CONING PHASE – MEASURED FROM ASCENDING NODE IN PLANE NORMAL TO L	RADIANS

Argument	Type	Definition
MAP (Cont'd)		NP. MAP(2) through MAP(NP+1) contain the parameter codes of the parameters to be returned in the order that they are to be returned.
N	Integer	The number of parameter sets requested.
INC	Integer	A number representing the desired time resolution of the returned points in milliseconds. That is, the returned parameter sets will correspond to TIME, TIME+INC, TIME+2*INC, ..., TIME+(N-1)*INC. N times INC must be less than or equal to 30 minutes (i.e., 1,800,000 milliseconds).
MAX	Integer	A number equal to the actual leading dimension of the DATA array as specified in the DIMENSION statement. MAX must be greater than or equal to N.

3.2.2.4 Output

Argument	Type	Definition
IERR	Integer	Return code indicators: = 0, all requested data were returned = 1, at least one requested orbital map parameter (i.e., from 1-58) could not be computed; fill data inserted = 2, at least one requested attitude map parameter (i.e., from 59-75) could not be computed; fill data inserted = 3, file not available at this time (being updated) = 4, end of file encountered on one of the orbit/attitude data files = 5, invalid SATID argument passed = 6, invalid DATE or TIME argument passed = 7, invalid MAP element passed, i.e., element is greater than 75 or the element is duplicated = 99, outdated version of OAREAD exists in the executing load module

Argument	Type	Definition
IERR (Cont'd)		= -1, a disk input/output (I/O) error occurred = -2, invalid N or INC argument passed, i.e., either N is less than or equal to 0 or INC is less than 0 or N times INC is greater than 30 minutes (i.e., 1,800,000 milliseconds)
DATA	Real	An array that will contain the returned orbit/attitude parameters. All parameters are returned as real (floating point) values. Each set of parameters, corresponding to a time, is stored in a row of the array. (DATA must be dimensioned at least N × NP. Thus, the parameter requested by MAP(2) at TIME is stored in DATA(1, 1), from TIME+INC in DATA(2, 1), and so on. Fill data (i.e., 9999999.0) is inserted for those requested parameters which could not be computed.

3.2.2.5 Processing Narrative

Initially, OAREAD performs a syntax check on the parameters in the user's calling sequence. Barring no errors, OAREAD then determines which routines are to be invoked according to the requested map elements. The routines read data from one or more of the orbit/attitude data files before performing computations. In cases where the user's request time does not exactly correspond to the times of the data on the orbit/attitude data files, interpolations are performed to ensure accuracy. Following the computations of all of the map parameters for the N time requests, OAREAD sets the return code denoting the success of the call prior to returning to the calling program.

3.2.2.6 Programming Notes

The OAREAD routine performs only those calculations necessary to produce the requested parameters. Requesting parameters which are not used, wastes CPU time.

In the case where the user desires many parameter sets over a particular time interval, the most efficient manner is to make as few calls to OAREAD as possible and set N to a high value as opposed to making many calls to OAREAD with N set to a low value. Certain logic is repeated when multiple calls to OAREAD are made, but performed only once on a single call. However, this method can cause an anomaly if no attitude data exists for the specified start date/time. In this case, fill data is returned in the DATA array, even though data might exist for a portion of the time span. To avoid this, N should be set equal to 1 and INC equal to 0 to check whether data exists for the specified date/time. Then, if data does exist, N should be set to a high value for the actual data retrieval. Another possible approach would involve having two OAREAD calls, one for orbit data with N set to a high value, and one for attitude data with N set to a low value.

The size of the DATA array passed to the OAREAD routine must be large enough to accommodate the user's current request of M parameters (up to 75) for N time requests. Fill data (9999999.0) are inserted into the applicable portion of the DATA array [i.e., DATA(1, 1) through DATA(N, M)] before any computations are attempted by OAREAD.

3.2.2.7 Restrictions

N times INC must be less than 30 minutes or 1,800,000 milliseconds. Therefore, for each call to OAREAD, data may not be requested for a period greater than 30 minutes.

3.2.2.8 Size

8.3K words.

3.2.2.9 Example

In this example, orbit/attitude information on January 13, 1974, beginning at noon is requested. Ten points (times) at half-second intervals are specified.

```
INTEGER DATA
DIMENSION MAP(4), DATA(10,3)
DATA MAP/3, 2, 10, 12/, N/10/, MAX/10/
.
.
.
CALL OAREAD ('C', 74013, 43200000, IERR, MAP, DATA, N,
               500, MAX)
```

The 2nd, 10th, and 12th orbit/attitude parameters (orbit period, Z component of the GEI orbit normal, and perigee height) are selected for return. Upon return from OAREAD, N will contain the number of parameters sets returned and IERR will contain the appropriate return code for conditions encountered. Return orbit/attitude parameters will be stored in DATA as follows:

DATA(1, 1) = 2nd parameter for time 43200000

DATA(1, 2) = 10th parameter for time 43200000

DATA(1, 3) = 12th parameter for time 43200000

DATA(2, 1) = 2nd parameter for time 43200500

DATA(2, 2) = 10th parameter for time 43200500

.

.

.

DATA(10, 3) = 12th parameter for time 43204500

Nx = SIN(phi'n)COS(lambdan+GST)
Ny = SIN(phi'n)SIN(lambdan+GST)
Nz = COS(phi'n)

Then compute sun in plane of magnetic equator

SX = S-(S.N)N
SY = N x SX

Then local magnetic time =

ATAN2(P SY, P SX)

39 McIlwain's shell parameter L — Earth radius

40 Invarient latitude = (180/PI)COS(1/L)**-1 — Degrees
41 Magnetic field strength — Gauss

42-44 GEI Magnetic field vector — Gauss

45-47 Polar components of magnetic field — Gauss

First compute unit vectors in the directions

1r = P/SQRT(Px**2+Py**2+Pz**2)

1phi = <-Py,Px,0>/SQRT(Px**2+Py**2

1theta = 1phi x 1r

Then the polar components of the field are — Normilized Vector

Br = B.1r
Btheta = B.1theta
Bphi = B.1phi

NOT DONE IN OARCAP

48 Geocentric magnetic inclination — Degrees

I = (180/pi)(SIN(-Br/ABS(B))**-1)

49-51 GEI coordinates of ingress (north) — Kilometers

Intersect of magnetic field line through satellite

52-54 GEI coordinates of egress (south) — Kilometers

intersect point

A=6378.16
B=6356.7746
F= 1/298.25

55, 56	Geodetic latitude and longitude of ingress point phiI = (180/pi)((TAN(((1-f)**-2)Iz/ SQRT(Ix**2+Iy**2)))**-1) lambdaI = (180/pi)(ATAN2(Ix,Iy)-GST)	Degrees
57, 58	Geodetic latitude and longitude of egress point	Degrees
59-67	3-by-3 rotation matrix for transformation from spacecraft coordinates. This matrix will be computed as described by Grell and Headrick in their October 6, 1972 correspondence. This Calculation takes into effect precession (coning) but not nutation due to cylindrical asymmetry. Note that T**(-1) = T**T will transform a GEI vector into spacecraft coordinates. Note also that the last column of T (i.e.,3) = Items 65-67) gives the GEI components of the instantaneous spacecraft Z-axis.	Orthogonal Matrix
68-70	GEI coordinates of spacecraft angular momemtum vector	Unit Vector
71	Phase angle of spin-measured from velocity vector to X-axis of spacecraft	Radians
72	Spin rate with respect to NADIR	Radians per second
73	Coning angle (between L and spacecraft Z-axis)	Radians
74	Coning rate.	Radians per second
75	Coning phase-measured from ascending node in plane normal to L	Radians
76	Solar zenith angle THETA = COS**-1((PxSx+PySy+PzSz)/ (SQRT((Px**2)+(Py**2)+(Pz**2))))	

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