ACQUISITION COORDINATE COMPUTATION
FOR TRACKING AND SURVEILLANCE SENSORS
PROGRAM DOCUMENT

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FOREWORD

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ACQUISITION COORDINATE COMPUTATION
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ABSTRACT

A computer program has been developed to calculate acquisition coordinates of earth satellites for three types of sensors: planar fan, horizontal fan and tracker. The program is equipped to consider the special requirements of phased array trackers, such as the AN/FPS-85. Included in the document are the program description, formulation, operating instructions, flow diagrams, and test cases.

Publication of this technical documentary report does not constitute Air Force approval of its findings or conclusions. It is published only for the exchange and stimulation of ideas.
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SECTION 1

INTRODUCTION

The Observing Schedule Program (OBSERV) is programmed for the Philco 2000 computer and is to be part of the B-3 Semi-Automatic Program System (SPS) at the SPADATS Center in Colorado Springs, Colorado. It functions in conjunction with the Executive Program and receives its input from the Schedule, SEAI and FAN input tapes.

OBSERV has been developed to compute sets of acquisition coordinates for stations with fixed beam surveillance devices and sensors that can track satellites. The capability to handle phased array trackers of the AN/FPS-85 type has also been included. For surveillance devices, the program computes the time and coordinates of beam penetration by all satellites requested on the input tape. For tracking devices, the program calculates acquisition coordinates at evenly spaced intervals of time, as specified by the input, during the periods that a satellite is within the tracker coverage.
The primary mode of operation for one specified sensor is the computation of acquisition coordinates of specified satellites in the current satellite population. The results are then presented for each station in chronological order. Data listed for each time point include the identification and the acquisition coordinates of the satellite currently being observed. Satellite positions are computed using the simplified general perturbations technique used in other SPS programs (Hilton, 1963). Flexibility in the program is provided by various input and output control options. The program has been designed for maximum computational efficiency. This will result in a significant reduction in the computer time required for each case.

In addition to the features mentioned above, the program may also be used to simulate sensor-satellite patterns.
SECTION 2

PROGRAM DESCRIPTION

The program OBSERV is designed to calculate acquisition coordinates for sensors of three primary types: planar fan, horizontal fan and tracker. The overall program functions are shown schematically in Figure 1 and are described in the following subsections.

2.1 INITIALIZATION

The initialization consists of two basic parts: (1) initialization for each sensor and (2) initialization for each satellite being processed for the given sensor.

a. **Initialization by Sensor**

In this section the time limits for acquisition coordinate computation are established, the topocentric coordinate system for this station is computed from the azimuth and elevation angle of the boresight vector (if required), and the sidereal time at the station is computed at the "beginning reference time."
OBSERVATIONAL LIMITS

INITIALIZE BY SENSOR

GET NEXT SATELLITE

INITIALIZE FOR SATELLITE

FINAL OUTPUT

NEXT CASE

NO MORE SATELLITES

DETERMINE MAX. ELEVATION FOR NEXT PASS

ABOVE MIN. ELEVATION?

CPA REQUIRED?

NO

COMPUTE & STORE ACQUISITION COORDINATES FOR CPA

NO MORE PASSES

NO MORE MODELS

GET NEXT ACQUISITION MODEL

PROCESS ACQUISITION MODEL

FIGURE 1 OBSERV PROGRAM FUNCTIONS
The time limits and the azimuth and elevation angles of the boresight vector are obtained from the input control card.

b. Initialization by Satellite

The orbital elements for each satellite are obtained from the system subroutine NXTELM. Using these, the calculations shown in Section 3.2 are performed. The minimum elevation angle, \( h_{\text{min}} \), is obtained from either the fan card or the tracker card depending on the radar type being processed.

2.2 PRELIMINARY ACQUISITION COMPUTATIONS

This section is entered once for each revolution of the satellite falling within the requested time limits. The formulation given in Section 3.3 is used to obtain the time at which the satellite is at a maximum elevation angle with respect to the sensor. If the point of maximum elevation is below the horizon of the sensor, the calculations are performed again for the next revolution, unless the upper time limit has been passed. If the point of maximum elevation is above the sensor's horizon, a return is made to the main program to test the point against the minimum observable elevation angle. If it is above, the calculation continues to obtain the acquisition points required; if not, a return is made to the beginning of the subroutine to try again on the next revolution.
If acquisition coordinates for the closest point of approach (CPA) are requested, they are computed at the time of maximum elevation.

2.3 ACQUISITION MODELS

The term "Acquisition Model" denotes a mathematical scheme which describes the manner in which a sensor effects satellite acquisition. Four such acquisition models are contained in this program (see Figure 2). They are: (1) the subroutine PACQUI, designed for planar fan radars; (2) the subroutine HACQUI, used for horizontal fan radars; (3) the subroutine TACQUI, a generalized tracker acquisition model; and (4) the subroutine TACQUI1, a specialized subroutine used by TACQUI to obtain acquisition times for phased array trackers. Each acquisition model is successively processed for one pass before the next pass is considered.

Each case may contain as many as thirty acquisition models for one station; however, only one tracker model may be used. The acquisition types need not be ordered.

a. Subroutine PACQUI

This subroutine uses iteration by halving to calculate the topocentric coordinates of the satellite at the time of fan penetration. It then checks to ensure that the satellite is within the observational limits of the fan. If it is, the acquisition coordinates are stored for output.
Figure 2 Radar coverage assumed by this program.
b. Subroutine HACQUI

The horizontal fan acquisition model calculates the points at which the satellite penetrates a cone which forms a constant angle with the horizon. If the points are within the azimuthal and range limits of the fan, they are stored for output. The maximum observable range is assumed to vary linearly between the angular limits of the fan.

c. Subroutine TACQUI

This subroutine makes use of either HACQUI or TACQUI1 (as required) to obtain the time span during which the satellite is observable by the tracker. It then computes the acquisition coordinates specified by the input tracker card: either a specified number of points per pass (ranging from two to eight), or a specified time interval between points.

Tracking limits for a normal tracker are determined by a vertical cone whose side forms an angle with the horizon equal to the minimum elevation angle. If the elevation angle of any point for a normal tracker is greater than the maximum, the point is rejected. No azimuth limits are assumed.

The tracking limits of a phased array tracker are determined by the minimum elevation angle, the limiting values of the direction cosines relative to the reference vectors normal to the boresight, and the maximum off-boresight angle.
d. **Subroutine TACQUI1**

This subroutine is used by subroutine TACQUI for phased array trackers. It uses iteration by halving to determine the acquisition coordinates and the times when the satellite enters and exits the coverage limits of the radar. Acceptable entry and exit points are stored for output.

2.4 **FINAL OUTPUT**

After every requested satellite has been processed through the acquisition models for one station, the accepted acquisition points are sorted either by time or by order of satellite appearance and output as shown in Figure 10.

The available output options are:

1. The fan number may be output.
2. The units of range and range-rate may be obtained in either nautical or MKS units.
3. The direction cosines with respect to the topocentric reference system may be obtained.
4. The point of maximum elevation may be computed as an acquisition point.
5. The output points may be restricted to the ascending half of each pass.
SECTION 3

FORMULATION

The acquisition coordinate computation program employs a simplified General Perturbations theory to calculate positions and velocities of the satellite. The formulation for this theory is given in the reference: Hilton, 1963. The remaining program formulation is detailed in the following subsections.

3.1 INITIALIZATION FOR EACH SENSOR

The following calculations are performed once for each station requiring acquisition coordinates:

(1) Compute the topocentric reference triad from the boresight azimuth and elevation:

\[
\begin{align*}
  x_{xh} &= \sin A_B \\
  x_{yh} &= \cos A_B \\
  x_{zh} &= 0
\end{align*}
\]

(1)
\[
\begin{align*}
Y &= \begin{cases} 
    y_{xh} = -\cos h_B \cos A_B \\
    y_{yh} = \cos h_B \sin A_B \\
    y_{zh} = \sin h_B \\
    z_{xh} = \sin h_B \cos A_B \\
    z_{yh} = -\sin h_B \sin A_B \\
    z_{zh} = \cos h_B 
\end{cases} \\
\end{align*}
\]

(2) Compute the sidereal time at the station at the "beginning reference time"

\[
\theta_1 = (\hat{\theta} - 360) D + \hat{\theta} F + \theta_{gr_0} + \lambda_E
\]

where \(D\) and \(F\) are, respectively, the days and fraction of a day of the "beginning time" into the reference year; \(\theta_{gr_0}\) is the Greenwich sidereal time at the start of the year, \(\lambda_E\) is the east longitude of the observing station and \(\theta\) is the rotation rate of the earth.

3.2 INITIALIZATION FOR EACH SATELLITE

The following calculations are performed once for each satellite.

(1) Enter the XYZI subroutine to compute the time independent initial parameters required for the ephemeris subroutine, XYZSB.

(2) Calculate the epoch Greenwich sidereal time, \(\theta_o\):

\[
\theta_o = \theta_1 + \dot{\theta} (t_o - t_B)
\]

where \(\theta_1\) is from equation (4) and \((t_o - t_B)\) is the difference between the epoch time, \(t_o\), and the input "beginning time" \(t_B\).
(3) Compute sin and cos:

\[
\sin \theta = \sin \left( (\Omega - \theta) \Delta t_1 \right)
\]

\[
\cos \theta = \cos \left( (\Omega - \theta) \Delta t_1 \right)
\]

(6) where \( \Omega = -\frac{3}{2} J_2 \frac{a e^2}{P} \) is the rotation rate of the earth and \( \Delta t_1 \) is 5 minutes.

(4) Compute \( K_1 \), the critical value for \( Z \cdot W \), above which visibility of this satellite is not possible for this station (see Figure 3).

\[
K_1 = q_2^{-1} \cos h_{\text{min}} \left\{ (q_2^2 - \cos^2 h_{\text{min}})^{1/2} - \sin h_{\text{min}} \right\}
\]

where \( q_2 \), the geocentric apogee distance, is given by:

\[
q_2 = a(1 + e)
\]

(10) (5) Compute the revolution number at the "beginning time":

\[
N_B = N_0 + I \left\lfloor \frac{n_o}{2\pi} (t_B - t_o) \right\rfloor
\]

where \( N_0 \) is the epoch revolution number and \( I \) represents the integral part of the bracketed quantity.

(6) The quantity \( t_o \), used in later calculations, is set equal to zero at this point.

(7) The quantity \( e \), also used in later calculations, is set equal to 1/2 of the beamwidth of the sensor.
\[ Z \cdot W = \sin C \]
\[ q_2 \sin C = b \cos h_{\text{min}} \]
\[ q_2 \cos C = R + b \sin h_{\text{min}} \]

Eliminating \( b \) to solve for \( \sin C \) from these two equations gives the critical value of \( Z \cdot W \) given by Equation (9). The assumption is made that the Earth is spherical and therefore that \( R = 1 \).

\( Z \) is a unit vector directed toward the observer's zenith.
\( W \) is a unit vector in the direction of orbital angular momentum.

**Figure 3** Derivation of critical value for \( Z \cdot W \).
3.3 COMPUTATION OF \( t \) AND \( L_{zh} \) FOR EACH PASS

This calculation is used to determine the point of maximum elevation angle of the satellite with respect to the sensor.

(1) Set \( t_i \) equal to \( t_L \) and initialize for \( Z \cdot W \) computation as follows:

\[
\begin{align*}
\theta_t &= \theta_o + \dot{\theta}(t_i + t_B - t_o) \\
\Omega &= \Omega_o + \dot{\Omega}(t_i + t_B - t_o)
\end{align*}
\]

Compute the sine and cosine of \( \Omega - \theta_t \)

(2) Iterate on \( Z \cdot W \) as follows: if \( t_i + t_B > t_F \) return to main program; otherwise,

\[
t_{i+1} = t_i + \Delta t_1
\]

\[
\sin (\Omega - \theta_t)_{i+1} = \sin (\Omega - \theta_t)_i \cos \Delta + \cos (\Omega - \theta_t)_i \sin \Delta
\]

\[
\cos (\Omega - \theta_t)_{i+1} = \cos (\Omega - \theta_t)_i \cos \Delta - \sin (\Omega - \theta_t)_i \sin \Delta
\]

\[
Z \cdot W_{i+1} = \sin (\Omega - \theta_t)_{i+1} \cos \phi \sin i + \sin \phi \cos i
\]

where \( t_F \) is the final time for which look angles are required and \( \phi \) is the station latitude.

if \( |Z \cdot W_{i+1}| \geq K_1 \) continue the iteration; otherwise,

(3) Set \( t_i \) equal to \( t_{i+1} - \Delta t_1 \) and iterate on \( L_{zh} \) as follows:

(a) Enter the XYZSB subroutine to obtain the position and velocity of the satellite at time \( t_i + t_B \)

(b) Compute \( \rho, \dot{\rho} \) and \( \Omega_h \) from equations (29) through (31).
(4) Compute $\dot{\rho}_{zh}$, the zenithal component of the range velocity and $L_{zh}$, the zenithal components of $L$.

$$\dot{\rho}_{zh} = (\dot{x} + \dot{\theta} y) \cos \phi \cos \theta + (\dot{y} - \dot{\theta} x) \cos \phi \sin \theta + \dot{z} \sin \phi$$  \hspace{2cm} (18)

$$L_{zh} = \frac{1}{\rho} (\dot{\rho}_{zh} - \frac{\rho}{\rho} \dot{\rho}_{zh})$$

where $\rho = \rho_0 + C (t_i + t_B - t_o)$  \hspace{2cm} (19)

If $L_{zh} \leq 0$ add $\Delta t_2$ to $t_i$ ($\Delta t_2 = 25$ min. at present) and continue the iteration; otherwise, enter the following iteration on $L_{zh}$:

add $\Delta t_2$ to $t_i$

(5) Enter the XYZSB subroutine to obtain the position and velocity of the satellite at time $t_i + t_B$

(6) Compute $L_{zh}$ as above

if $L_{zh} > 0$ continue the iteration; otherwise, set

$\Delta t_{i-1} = 25$ minutes and $N = 0$ and enter the following iteration on $L_{zh}$:

(7) Iterate to obtain the point of maximum elevation:

set $\Delta t_i = -\frac{1}{2} |\Delta t_{i-1}|$  \hspace{2cm} (20)

$t_{i+1} = t_i + \Delta t_i$  \hspace{2cm} (21)

$N = N + 1$  \hspace{2cm} (22)

Enter the XYZSB subroutine and compute $L_{zh}$ as above.

If $N$ is less than 7 test $L_{zh} : 0$; if $\dot{t}$ set $\Delta t_{i+1} = \frac{1}{2} |\Delta t_i|$ and continue iteration; if $\dot{t}$ set $\Delta t_{i+1} = -\frac{1}{2} |\Delta t_i|$ and continue iteration.
(8) If \( N = 7 \) compute \( \dot{L}_{zh} \) as follows:

\[
\dot{L}_{zh} = \frac{(\dot{L}_{zh_1} - \dot{L}_{zh_{i-1}})}{\Delta t}
\]

(23)

(9) Test the quantity \( \frac{\dot{L}_{zh}}{L_{zh}} \): if

\[
\frac{\dot{L}_{zh}}{L_{zh}} < \frac{\Delta t}{2} \quad \text{set} \quad t_{i+1} = t_i - \frac{\dot{L}_{zh}}{L_{zh}}; \quad \text{otherwise, set}
\]

\[
t_{i+1} = t_i + \frac{\dot{L}_{zh}}{L_{zh}} \frac{\Delta t_i}{|L_{zh}|} \quad \text{; then compute } \rho_h \text{ and } \dot{\rho}
\]

(24)

(25)

as follows:

\[
\theta = \theta_o + \dot{\theta} (t_{i+1} + t_B - t_o)
\]

(26)

\[
X = (X/\cos \theta) \cos \theta
\]

(27)

\[
Y = (X/\cos \theta) \sin \theta
\]

(28)

where \( X/\cos \theta \) is a station coordinate function obtained as input.

\[
\begin{align*}
\rho_{xh} &= (x + X) \sin \phi \cos \theta + (y + Y) \sin \phi \sin \theta - (z + Z) \cos \phi \\
\rho_{yh} &= -(x + X) \sin \theta + (y + Y) \cos \theta \\
\rho_{zh} &= (x + X) \cos \phi \cos \theta + (y + Y) \cos \phi \sin \theta + (z + Z) \sin \phi
\end{align*}
\]

(29)

\[
\rho = (\rho_{xh}^2 + \rho_{yh}^2 + \rho_{zh}^2)^{1/2}
\]

(30)

\[
\dot{\rho} = \frac{1}{\rho} \left\{ \left( x + X \right) \left( \dot{x} + y \dot{\theta} \right) + (y + Y) \left( \dot{y} - x \dot{\theta} \right) + (z + Z) \dot{z} \right\}
\]

(31)

Set \( t_L = t_{i+1} + \Delta t_1 + \Delta t_2 \)

(32)
(10) Test $\beta_{zh}$: if $\beta_{zh} > 0$, exit to next computation; otherwise return to the beginning of this section 3.3.(1) with the new $t_L$. If $\beta_{zh} \leq \alpha (\sin h_{\min})$, also return to the beginning of this section with the new $t_L$.

3.4 COMPUTATION OF THE MAXIMUM ELEVATION

If the point of maximum elevation (CPA) is required, compute $A$ and $h$ as follows:

$$A = \tan^{-1} \frac{\beta_{yh}}{-\beta_{xh}} ; \quad 0 \leq A \leq 2 \pi \quad (33)$$

$$h = \sin^{-1} \frac{\beta_{zh}}{\rho} \quad (34)$$

where $\beta$ and $L$ are available from the previous section at the time of closest approach.

3.5 DETERMINATION OF THE REQUIRED ACQUISITION MODEL

Test the radar type to determine which acquisition model is required:

Planar fans use PACQUI formulation.
Horizontal fans use HACQUI formulation.
Trackers use TACQUI formulation.

3.6 PACQUI FORMULATION

Acquisition model for planar fans

(1) Compute $\beta \cdot N$, where $N$ is a unit vector normal to and above the plane of the fan.

$$\beta \cdot N = \beta \cdot N_1 \quad (35)$$

Set $t = -10$ minutes and $t_2 = t_1$.
(2) Start iteration to make \( \ell \cdot N \) change sign:

(a) If \( \beta_{zh} \geq 0 \) continue the iteration with (c); otherwise,

(b) If this is the first time through, set \( t_i = t_2 \) and exit, if this is not the first time through, set \( \ell \cdot N \) equal to \( \beta_{N1} \cdot N \), \( \Delta t = +10 \) and \( t_i = t_2 \); then go to step (d) to obtain the descending observation time.

(c) If \( |\ell \cdot N| \leq \beta \) go to the next subsection; otherwise,

(d) \[ t_{i+1} = t_i + \Delta t \]  
\[ \ell_{N3} = \ell \cdot N \]  
(e) Compute \( \rho, \beta \) and \( \ell_h \) from equations (29) through (31).

(f) Compute \( \ell \cdot N \) and test \( \beta_{N1} (\ell \cdot N) \); if \( \geq 0 \) continue the iteration with (a) above; otherwise, go to the next subsection.

(3) Iterate, by halving, to determine the time when the satellite passes within the observational limits of the fan.

(a) \[ \Delta t_{i+1} = \frac{\beta_{N3} (\ell \cdot N)}{|\beta_{N3} (\ell \cdot N)|} \frac{\Delta t_i}{2} \]  
(b) \[ t_{i+1} = t_i + \Delta t_{i+1} \]  
\[ \beta_{N3} = (\ell \cdot N) \]  
(c) Compute \( \rho, \beta \) and \( \ell_h \) from equations (29) through (31).

(d) Compute \( \ell \cdot N \) and test: if \( \geq 0 \) go to the next subsection; otherwise return to (a) above to continue the iteration.
Test the observation with respect to the angular limits of the fan: if $\mathbf{L} \cdot \mathbf{L}_1 (\mathbf{L} \cdot \mathbf{L}_2) \geq (\mathbf{L} \cdot \mathbf{L}_2)$, (42) the observation is within the angular limits of the fan; otherwise, return to 3.6(2)(a).

\[ \mathbf{L} = \frac{\rho}{\rho}; \mathbf{L}_1 \text{ and } \mathbf{L}_2 \text{ are unit topocentric vectors defining the angular limits of the fan.} \]  

(5) If range limits are specified perform the following test: if $\rho \leq \rho_{\text{max1}} + \rho_{\text{max}} \cos^{-1}(\mathbf{L} \cdot \mathbf{L}_1)$ the range is observable.

$\rho_{\text{max1}}$ is the maximum observable range along $\mathbf{L}_1$

$\rho_{\text{max}}$ is the derivative of maximum observable range with respect to the angle $\cos^{-1}(\mathbf{L} \cdot \mathbf{L}_1)$. It is assumed linear for this program and is given by:

\[ \rho_{\text{max}} = \frac{\rho_{\text{max1}} - \rho_{\text{max1}}}{\cos^{-1}(\mathbf{L}_1 \cdot \mathbf{L}_2)} \]  

(6) If the satellite is observable and the time of observation falls within the requested time limits, then perform the following calculations if illumination information is required.

(a) Compute the sun's true longitude, $L_\odot$, at time 
\[ \frac{(t_B + t_i)}{1440} = T; \]  
\[ L_\odot = L_\odot + n_\odot T + 1.91 \sin (n_\odot T - M_{\odot}) \]  

where $n_\odot$ is the mean motion of the sun in degrees per day

$L_\odot$ is the mean longitude of the sun at time $T$, given by 

\[ L_\odot = L_{\odot0} + n_\odot T; \]  
\[ L_{\odot0} \] is the mean longitude of the sun at the beginning of the epoch year.
\begin{align*}
M_\odot &= L_{\odot_0} + n_\odot T - \pi_\odot; \pi_\odot \text{ is the sun's longtude of perifocus} \hspace{1cm} (49) \\

(b) Calculate the geocentric unit vector toward the sun, \( L_\odot \): \\
\begin{align*}
L_{x_\odot} &= \cos \delta_\odot \cos \alpha_\odot \\
L_{y_\odot} &= \cos \delta_\odot \sin \alpha_\odot \\
L_{z_\odot} &= \sin \delta_\odot \\
\end{align*} \hspace{1cm} (50)
\end{align*}

where \( \alpha_\odot = \ell_\odot - 2.47 \sin 2 \ell_\odot \) \hspace{1cm} (51)

\( \delta_\odot = \tan^{-1} (0.4336635 \sin \alpha_\odot) \) \hspace{1cm} (52)

(c) Calculate and test the elevation angle of the sun, \( h_\odot \):
\begin{align*}
h_\odot &= \sin^{-1} \left( -L_\odot \cdot \frac{\vec{R}}{R} \right) \hspace{1cm} (53)
\end{align*}

where \( \frac{\vec{R}}{R} \) is a unit vector from the station to the geocenter.

If \( h_\odot > -5^\circ \), no visual points may be calculated.

If \( h_\odot < -5^\circ \), the calculation continues to determine if the satellite is illuminated.

(d) It has already been established that the satellite is above the sensor's horizon. The Earth's shadow is assumed cylindrical. See Figure 4.
\begin{align*}
\cos \psi &= \frac{1}{r} (L_\odot \cdot \vec{r}) \hspace{1cm} (54)
\end{align*}

(e) If \( \cos \psi \) is positive, the satellite is illuminated. If \( \cos \psi \) is negative, the satellite may still be illuminated. This is determined from \( \gamma \) and \( \eta \) as follows.
\begin{align*}
\gamma &= \psi - 90^\circ \hspace{1cm} (55) \\
\eta &= \sin^{-1} \left( \frac{R}{r} \right) \hspace{1cm} (56)
\end{align*}

If \( \gamma + \eta > 90^\circ \), the satellite is not visible, if \( \gamma + \eta \leq 90^\circ \), the satellite is illuminated.
FIGURE 4. POSITION OF SATELLITE WITH RESPECT TO THE EARTH'S SHADOW
(7) If either the satellite is not observable or this is the first time through, and \( t_1 < t_2 \); then set

\[
\mathbf{N} \cdot \mathbf{N} = \mathbf{n}_{N1} \tag{57}
\]

\[
t_1 = t_2 \tag{58}
\]

\[
\Delta t = 10 \text{ min} \tag{59}
\]

and return to 3.6(3)(b). Otherwise, continue with the next subsection after storing the acquisition coordinates for output.

3.7 HACQUI FORMULATION

Acquisition model for horizontal fans

(1) Set \( t_2 = t_1 \) and \( \Delta t = -10 \text{ min} \).

(2) Iterate to make \( \rho z_h \) approach \( \rho \sin h_{\text{ref}} \), \( \cos h_{\text{ref}} \) and \( \sin h_{\text{ref}} \) available from the acquisition buffer (input quantities)

(a) If \( | \rho z_h - \rho \sin h_{\text{ref}} | \leq \rho \cos h_{\text{ref}} \) go to (4) below; otherwise, continue with (b).

(b) Set \( K_3 = 1 \) and \( t_{i+1} = t_i + \Delta t \) \( \tag{61} \)

(c) Compute \( \rho, \rho \) and \( \rho h \) from equations (29) through (31).

(d) If \( \rho z_h > \rho \sin h_{\text{ref}} \) return to (a) above; otherwise, continue with (3).

(3) Iterate to obtain the time of fan penetration

(a) \[
\Delta t_{i+1} = \frac{K_3 (\rho z_h - \rho \sin h_{\text{ref}})}{K_3} \cdot \frac{\Delta t_i}{2} \tag{63}
\]

(b) \[
K_3 = \rho z_h - \rho \sin h_{\text{ref}} \tag{64}
\]

\[
t_{i+1} = t_i + \Delta t_{i+1} \tag{65}
\]
(c) Compute $\rho$, $\dot{\rho}$, and $\frac{\rho}{\rho_{h}}$ from equations (29) through (31).

(d) If $|\rho_{zh} - \rho \sin h_{\text{ref}}| > \rho \varepsilon \cos h_{\text{ref}}$ return to (a); otherwise, continue with (4).

(4) Compute $A$ and $h$ from $\rho$ and $\frac{\rho}{\rho_{h}}$:

$$A = \tan^{-1} \frac{\rho_{zh}}{\rho_{xh}}$$  \hspace{1cm} (67)

$$h = \sin^{-1} \frac{\rho_{zh}}{\rho}$$  \hspace{1cm} (68)

(5) If this is a tracker to (8); otherwise, continue with (6).

(6) If $(A_{2} - A_{1}) (A - A_{1}) (A_{2} - A) > 0$ the observation is within the angular limits of the fan so continue with (7). $A_{1}$ and $A_{2}$ are the azimuthal limits of the fan.

If $< 0$ and $t_{i} < t_{2}$, set $T_{1} = t_{i}$, $\Delta t = 10$ min and $t_{1} = t_{2}$, then return to 3.7(2)(b); otherwise exit.

(7) If $\rho < \rho_{\text{max}1} + \rho_{\text{max}} (A - A_{1})$ the range is observable so continue with (8).

$\rho_{\text{max}1}$ is the maximum observable range in the $A_{1}$ direction

$\rho_{\text{max}}$ is the derivative of maximum range with respect to $(A - A_{1})$. It is assumed linear and is given by:

$$\rho_{\text{max}}' = \frac{\rho_{\text{max}2} - \rho_{\text{max}1}}{A_{2} - A_{1}}$$  \hspace{1cm} (69)

If $\rho > \rho_{\text{max}1} + \rho_{\text{max}} (A - A_{1})$ and $t_{i} < t_{2}$, set $T_{1} = t_{i}$, $\Delta t = 10$ min and $t_{1} = t_{2}$, the return to 3.7(2)(b); otherwise exit.

(8) If the satellite is observable and the time of observation is within the requested time limits; then, if required, test for solar illumination using equations (46) through (56). If this is the first time through and $t_{i} < t_{2}$, set $T_{1} = t_{i}$, $\Delta t = 10$ min and $t_{1} = t_{2}$, then return to 3.7(2)(b); otherwise, set $T_{2} = t_{i}$ and $t_{1} = t_{2}$ and exit to the next subsection. In either case, store the acquisition coordinates for output.
3.8 TACQUI FORMULATION

Acquisition model for trackers

(1) If a maximum range is specified test $\rho$, if $\rho > \rho_{\text{max}}$ exit, otherwise continue with (2).

(2) If this is a phased array tracker, go to TACQUI1 (3.9). Otherwise, set $A_1 = 0$, $A_2 = 2\pi$ and go to HACQUI (3.7).

(3) If only the ascending half of the pass is required, set $T_2 = t_2$.

(4) Test the points per pass integer, $P$:
If $P = 9$, an output interval, $\Delta t$, is specified, so go to (5); otherwise set

$$\Delta t = \frac{T_2 - T_4}{P - 1}$$  \hspace{1cm} (70)

$$t_4 = T_4$$  \hspace{1cm} (71)
and go to (6).

(5) Set $N = \text{integral part of } (T_2 - T_1)/2\Delta t$ and

$$t_4 = \frac{1}{2} (T_2 + T_1) - (N + 1) \Delta t$$  \hspace{1cm} (72)

(6) If this is a phased array, go to (8).

(7) If ascending points only are required, set

$$T_2 = T_2 + \Delta t$$  \hspace{1cm} (74)

(8) Compute $\rho$, $A$, $h$ and $\rho$, for output, at each time point between $T_1$ and $T_2$ required by (4) or (5) above.
3.9 TACQU1 FORMULATION

Acquisition model for phased array trackers

(1) Set $K_1 = 1$ and go to AFILT3 (3.10)
   
   (a) if this observation passes the tests in AFILT3 or is marginal and visible, go to (4).
   
   (b) if this observation fails the tests in AFILT3 or is marginal but not visible as described by equations 98-100, go to (2).

(2) Set $K_1 = -1$, $t_2 = t_1$, $K_3 = -1$ and $\Delta t = -0.2$ min

(3) Iterate to check for visible points on this pass
   
   (a) Set $t_{i+1} = t_i + \Delta t$
   
   (b) Compute $\rho$, $\dot{\rho}$ and $\rho_h$ from equations (29) through (31).

   (c) If $\rho_{zh} > 0$ go to (d); if $\leq 0$ and $t_i < t_2$, set
       
       $t_i = t_2$, $\Delta t = 0.2$ and $K_1 = +1$ and go to (a).
   
   (d) Go to AFILT3

   If the satellite fails the tests in AFILT3, return to (a).
   If it passes the tests, set $t_2 = t_i$ and go to (e).
   If it is marginal, set $t_2 = t_1$ and go to (8).

   (e) Set $\Delta t_{i+1} = \frac{1}{2} K_3 \Delta t_i$ and go to (7).

(4) Set $t_2 = t_1$, $K_3 = +1$ and $\Delta t = -10$ min

(5) Set $t_{i+1} = t_i + \Delta t$.

   Compute $\rho$, $\dot{\rho}$ and $\rho_h$ from equations (29) through (31).
   Go to AFILT3

   If the satellite passes the tests in AFILT3, return to the beginning of 3.9(5).
   If it fails the tests, go to 3.9(6).
   If it is marginal, go to 3.9(8).
(6) Set $\Delta t_{i+1} = -\frac{1}{2} K_3 \Delta t_i$ and $K_3 = -1$ \hspace{1cm} (81)

(7) Iterate to obtain the times of marginal visibility

(a) Set $t_{i+1} = t_i + \Delta t_{i+1}$

(b) Compute $\rho$, $\dot{\rho}$ and $\ddot{\rho}_h$ from equations (29) through (31).

(c) Go to AFILT3

If the satellite passes the tests in AFILT3 go to 3.9(3)(e). If it fails the tests go to 3.9(6). If it is marginal go to 3.9(8).

(8) Compute $A$ and $h$ from equations (67) and (68) and:

If this is the first time through set

\[
T_1 = t_i \hspace{1cm} (83)
\]

\[
t_1 = t_2 \hspace{1cm} (84)
\]

\[
\Delta t = 10 K_1 \hspace{1cm} (85)
\]

\[
K_3 = 1 \hspace{1cm} (86)
\]

and go to 3.9(5); otherwise, if $t_i > T_1$ set $T_2 = t_i$; if $< T_1$ set

\[
T_2 = T_1 \hspace{1cm} (87)
\]

\[
T_1 = t_i \hspace{1cm} (88)
\]

and exit.

3.10 AFILT3 FORMULATION

Determine whether the satellite is visible, invisible or marginally visible to the sensor at this time.

(1) Test against minimum elevation angle

(a) Set $\delta = \rho_{zh} - \rho \sin h_{\min}$ and \hspace{1cm} (90)

\[
E = \rho \in \cos h_{\min} \hspace{1cm} (91)
\]

$U_{\max}$, $V_{\max}$, $\cos \Psi_{\max}$, $\sin h_{\min}$, and $\cos h_{\min}$ are stored from input into the FANTAB buffer.
(b) Go to AFILT31 (3.11)

(2) Test against maximum off boresight angle

(a) Set \( \delta = \rho \cdot \mathbf{y} - \rho \cos \psi_{\text{max}} \) \hspace{2cm} (92)

\[ E = \rho \sin \psi_{\text{max}} \] \hspace{2cm} (93)

(b) Go to AFILT31

(3) Test against minimum angle from \( \mathbf{z} \) axis

(a) Set \( \delta = \rho \mathbf{U}_{\text{max}} - |\rho \cdot \mathbf{Z}| \) \hspace{2cm} (94)

\[ E = \rho \sqrt{(1 - U_{\text{max}}^2)^{1/2}} \] \hspace{2cm} (95)

(b) Go to AFILT31

(4) Test against minimum angle from \( \mathbf{x} \) axis

(a) Set \( \delta = \rho \mathbf{V}_{\text{max}} - |\rho \cdot \mathbf{X}| \) \hspace{2cm} (96)

\[ E = \rho \sqrt{(1 - V_{\text{max}}^2)^{1/2}} \] \hspace{2cm} (97)

(b) Go to AFILT31

3.11 AFILT31 FORMULATION

Subroutine used by AFILT3

(1) If \( \delta \geq 0 \) the satellite is visible \hspace{2cm} (98)

(2) If \( \delta < 0 \) the satellite is invisible \hspace{2cm} (99)

(3) If \( |\delta| < \varepsilon \) the satellite is marginally visible \hspace{2cm} (100)
The OBSERV module is programmed for the Philco 2000 computer. This section describes the tape setup, deck setup, input options and output formats.

4.1 GENERAL

This program has two modes of execution: (1) in conjunction with the Semi-Automatic System job-schedule mode of operation, where the normal operating procedures required for this mode are described in Section 2 of reference 3; and (2) the manual mode of operation which obtains input from the console typewriter instead of the SCHEDULE TAPE.

Input quantities are to specify which sensor is to be provided acquisition coordinates, which satellites are to be observed and the time period which calculations are to cover. The data are calculated and stored in core and on magnetic tape for one satellite at a time. Note that any or all types of acquisition models can be combined in the same case.

For one satellite, output data for the visual passes only and all the predictions for one pass may be printed in chronological order without being mixed with predictions for other satellites.
Due to changes in system operating procedures, OBSERV has become somewhat like a main sequence program, which reverses the original design specifications. Therefore, the program has been modified so that it may be run in the manual mode. In this mode the program may be called big using the console typewriter. The input is the same as for option 0 in the schedule tape mode except that the base day and base message numbers are typed in. Most of the changes are primarily concerned with input data processing.

4.2 TAPE SETUP

Tape assignments are displayed in Figure 5. When OBSERV is run in the manual mode of operation the SCHEDULE TAPE (logical 2) is not used.

4.3 DECK SETUP

For both modes of operation (schedule and manual), the FAN TAPE (logical 0) is generated from punched cards on the Philco 1000 in read-code mode with sense option on. Nine types of cards are used (see Figure 6):

<table>
<thead>
<tr>
<th>CARD TYPE</th>
<th>CONTENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&quot;FANCARDS&quot; Card</td>
</tr>
<tr>
<td>2</td>
<td>Control Card</td>
</tr>
<tr>
<td>3</td>
<td>Fan/Tracker Card</td>
</tr>
<tr>
<td>4</td>
<td>&quot;FROM&quot; Address Card</td>
</tr>
<tr>
<td>5</td>
<td>&quot;INFO&quot; Address Card</td>
</tr>
<tr>
<td>6</td>
<td>&quot;TO&quot; Address Card</td>
</tr>
<tr>
<td>7</td>
<td>&quot;ALL&quot;, &quot;ALL BUT&quot;, or &quot;ONLY&quot; Card</td>
</tr>
<tr>
<td>8</td>
<td>ENDCASE Card</td>
</tr>
<tr>
<td>9</td>
<td>ENDSCHED Card</td>
</tr>
</tbody>
</table>

Explanation of card types:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Used as the Tape Identifier. See Figure II-1</td>
</tr>
<tr>
<td>2</td>
<td>Must always be used and specifies data about the sensor, the calculations and the output. Fields 11 and 12 are used in the headings of the printed output. See Figure II-2</td>
</tr>
<tr>
<td>Logical Unit</td>
<td>Tape Identification</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>0</td>
<td>FANCARDS</td>
</tr>
<tr>
<td>1</td>
<td>70BIMST</td>
</tr>
<tr>
<td>2</td>
<td>70△ SCHTP</td>
</tr>
<tr>
<td>4</td>
<td>70△ SEAII</td>
</tr>
<tr>
<td>7 (write ring in)</td>
<td>SCRATCH</td>
</tr>
<tr>
<td>8 (write ring in)</td>
<td>SCRATCH</td>
</tr>
<tr>
<td>9 (write ring in)</td>
<td>SCRATCH</td>
</tr>
<tr>
<td>11 (write ring in)</td>
<td>70 OUTPUT</td>
</tr>
</tbody>
</table>

FIGURE 5. TAPE SETUP FOR OBSERV
"ENDSCHED" Card

"ENDCASE" Card

CONTROL Card

"ENDCASE" Card

"ALL," "ALL BUT", or "ONLY" Card(s)

"TO" Card(s)

"INFO" Card(s)

"FROM" Card

FAN/TRACKER Card(s)

CONTROL Card

"FANCARDS" Card

FIGURE 6. DECK SETUP FOR FAN TAPE - (LOGICAL 0)
**Type**  

<table>
<thead>
<tr>
<th>3</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAN Card - used to specify data for fixed beam surveillance sensors. As many as two fixed beams or fans may be specified on one card. A maximum of fifteen cards, specifying no more than 30 beams can be used. See Figure II-3.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4, 5, 6</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRACKER Card - used to specify data for a sensor with tracking capability. This card, one per sensor, must have a &quot;Δ-99.0&quot; punched in the first field. Any number 2 thru 8 points may be specified per satellite pass. If 9 is indicated—points are spaced Δt apart. See Figure II-4.</td>
<td></td>
</tr>
</tbody>
</table>

The FROM card indicates the address of the sending agency. There is one of these cards per case. The first TO card shows the address of the sensor to which the teletype message will be sent. This station has primary interest and maintains control over the message received. Other stations or persons may also be sent this message. They are indicated on a TO card if they have a secondary interest in the message. If the message is sent for information only then an INFO card is used. The total of INFO and TO cards cannot exceed nine per case. Columns 1-64 of the Address card are positioned on the DE line of the output, while those for the TO and INFO cards are positioned on the preceding line of the message in the format required by the automatic routing equipment. See Figure II-5.
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
</table>
| 7    | Specifies the satellites to be used. The ALL card indicates all satellites are to be used in the run. The ALL BUT card indicates all but the satellites specified in the variable field beginning in Column 9 are to be run. The ONLY card indicates only the ones specified in the variable field are to be run. The satellite numbers are specified by five digit numerics separated by commas. A range of satellites may also be specified. For example, assume satellites 00004, 00005, 00006, 00007, are to be run. This may be specified on an ONLY card in one of two ways:  
ONLY 00004, 00005, 00006, 00007,  
ONLY 00004 - 00007  
Data can continue on subsequent cards, the data beginning in Column 1. See Figure II-6. |
| 8,9  | Both cards have 11-8-2 punch in Column 9 for END BLOCK Control and both are the same as those used on Schedule Tape jobs.  
END CASE - separates each group of Case Data Cards.  
ENDSCHED - the last card in the deck. |

The required order of cards to be used for the FAN Input Data Tape is as follows:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CONTENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&quot;FANCARDS&quot; Card</td>
</tr>
<tr>
<td>2-7</td>
<td>Case Data Cards</td>
</tr>
</tbody>
</table>

33
<table>
<thead>
<tr>
<th>Type</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>END CASE Card</td>
</tr>
<tr>
<td>2-7</td>
<td>Case Data Cards</td>
</tr>
<tr>
<td>8</td>
<td>END CASE Card</td>
</tr>
</tbody>
</table>

The Case Data Cards are arranged in the following order:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CONTENT</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Control Card</td>
<td>One per case</td>
</tr>
<tr>
<td>3</td>
<td>Fan/Tracker</td>
<td>One Tracker card and/or any number of fan cards the total not to exceed 30 fans.</td>
</tr>
<tr>
<td>4</td>
<td>&quot;FROM&quot; Card</td>
<td>One per case</td>
</tr>
<tr>
<td>5</td>
<td>&quot;TO&quot; Card</td>
<td>Up to nine per case with limitation that the sum of &quot;TO&quot; and &quot;INFO&quot; Cards cannot exceed nine.</td>
</tr>
<tr>
<td>6</td>
<td>Either &quot;ALL&quot;, &quot;ALL BUT&quot; or &quot;ONLY&quot;</td>
<td>One per case; additional satellite specifiers can follow &quot;ALL BUT&quot; and &quot;ONLY&quot; Cards.</td>
</tr>
</tbody>
</table>

For schedule mode of operation the SCHEDULE TAPE (logical 2) is generated from punched cards in the same manner as the FAN TAPE is generated (see Figure 7). The cards are as follows:

- ID Card
- JOB Card
- REM Card (optional)
- SPS JOB Card
- Parameter (Base-Time) Card
- Data Cards (for options 1, 2, 3, 4, and 5 only) - Element, Sensor, etc.
- ENDOFJOB Card

The ID, JOB, REM, ENDOFJOB, ENDSCHED and the END CASE Cards are described in Section 5.4 of reference 3.

The parameter (Base-Time) Card is depicted in Figure II-7.
FIGURE 7. DECK SETUP FOR SCHEDULE TAPE - (LOGICAL 2)
4.4 INPUT OPTIONS

The program allows six input options while in the schedule tape mode of operation. The input option designates whether required data will come from the input tape or from standard system files.

**TABLE I INPUT OPTIONS**

<table>
<thead>
<tr>
<th>INPUT OPTION</th>
<th>Tape 4 (SEAI)</th>
<th>Tape 2 (SCHEDULE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>E-FILE</strong></td>
<td><strong>S-FILE</strong></td>
</tr>
<tr>
<td>0</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>2</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

*Use of these files is implied with this option.

**Notes:**
1. Parameter card - This card specifies the base day and base message number.
2. E-File - This file on the SEAI tape contains the elements of all satellite orbits.
3. S-File - File on the SEAI tape which contains the coordinates of all the sensors.
4. Element Cards - Each set of six cards contains the elements of any given satellite orbit.
5. Satellite Number Cards - These cards contain the numbers of satellites whose elements are to be obtained from the E-File.
6. Sensor Cards - These cards contain the coordinates of any one sensor.

Descriptions of the cards and tape files mentioned above can be found in Sections 5.4 and 5.5 respectively, of reference 3.
A description of each option follows:

0 - The elements of those satellite orbits on the E-File which are specified on the ALL, ALLBUT or ONLY card will be used in calculations. The coordinates of the sensor specified on the Control Card will be obtained from the S-File.

1 - The elements introduced by the Element Cards will be used in calculations. All other operations are the same as option 0.

2 - Those elements specified on the Satellite Number Cards will be read from the E-File and used for calculations. All other operations are the same as option 0.

3 - Operations are similar to option 1 except that the sensor coordinates are obtained from the Sensor Card.

4 - Operations are similar to option 2 except that the sensor coordinates are obtained from the Sensor Card.

5 - The elements of those satellite orbits on the E-File which are specified on the ALL, ALLBUT or ONLY card will be used in calculations. The sensor coordinates are obtained from the Sensor Card.

4.5 OUTPUT

a. Options

(1) -0- Specifies the generation of the output on printed copy and teletype tape.

(2) -1- Output is produced on printed copy only. Note that the information on the printed copy and the teletype tape are in the same order; however, the direction cosine printout is optional on hard copy but is not available for the teletype tape. When run in manual mode, option 0 is automatically specified. In the schedule mode, column 18 of the SPSJOB card specifies the option (0 or 1).

b. Format

Figure 8 shows the general format of the output with heading information. FAN number is optional on both hard copy and teletype tape; also, when requested for a tracker, FAN number prints "T" and for point of maximum elevation "MK". Every
SAT. SUMMARY FOR STA - XXX

NNNNN, . . . .

DECATING
NNNN, . . . .

100 DAYS PAST EPOCH
NNNNN, . . . .

SAT.NO./SET NO.
NNNNN/SSSS. . . .

PPP SSS TTTT WW

(up to 9 addresses)

DE RRMM C

FM SENDING STATION ADDRESS

TO STATION ADDRESS

INFO STATION ADDRESS

CLASSIFICATION (see below) DDD HHMM.FF

LOOK ANGLE SCHEDULE FOR STATION ADDRESS

SAT XXXX TIME ELEV AZMTH RANGE R-RATE FAN DIRECTION COSINES

U V W

DAY DDD DD/MM/YY (XX)

NNN NNNNN HHMM.FF EE.A AAA.A RRRRR RR.R NN + UUU + VVV + WWW

NO MORE DATA

DD/MM/YY MMM RRRRR

Classification Format
UNCLAS ISPADATLAS
CONFIDENTIAL ISPADATLAS
SECRET ISPADATLAS
SECRETNOPORN ISPADATLAS
SECRET RELEASABLE OUTSIDE SSO CHANNELS ISPADATLAS

XXX = Station ID Number
NNNNN = Satellite Number
NNNNN = 000 if no Satellites qualify for these two categories

Hard Copy Only

SSSS = Element Set Number

PPP = TTY Heading for each message or after every 100 lines if TTY is requested with addressing;

Priority and To and INFO Station Route Addresses

RRRR = Sending Station Route Address; MMM = Message Number; C = A or D

CCC = ZNR if unclassified

Current Time

Route Addresses may also be included

Current Time

XXX = ELEM or REV
XX = KM or NM

Hard Copy and TTY output

Data Within Period

Current Time; Month; Sending Station Route Address

TTY Wrapup

NOTES: Underlined quantities are of fixed format and are printed as shown.

This Format is subject to change without notice in order to comply with Military Network changes.
effort has been made to ensure that teletype headings conform with the procedure presently established for use within the military networks. The RANGE may print "0" kilometers - this indicates that the actual range was greater than 16,383 km. and could not be contained in the internal packed format.

c. **Satellite Summary**

The satellite summary output routine has been retained which lists the satellites being used and their corresponding element set numbers. This is printed on the hardcopy only. Special comments are printed if the predictions are more than one hundred days from epoch or if the satellite has reached decay conditions during the prediction.
d. **Diagnostic Error Comments**

The program may print any one of a number of diagnostic error comments some of which indicate an error in the input and others which indicate a malfunction of the program or the machine. They are nearly all self-explanatory and are intended to aid the user in the full utilization of the program. The comments which might appear are as follows:

(1) **"CASE REJECTED - BASE TIME CARD MISSING OR IN ERROR".**
   The entire job is rejected because of a faulty card or because the base time or message number was typed incorrectly.

(2) **"CASE REJ-INV ERR - STA XXX"** The current case only is rejected for one of the following stated reasons:
   - "ERROR ON ALL BUT OR ONLY CARDS".
   - "FAN PARAMETER (REQUEST) CARD MISSING (NO R IN COLUMN 79)."
   - "CHECK INPUT DATA FOR ILLEGAL CHARACTERS IN FIELDS."
   - "STA. NO. ON R AND F CARDS DIFFER."
   - "FAN CARDS MISSING (NO F IN COLUMN 79)."
   - "ADDRESS CARD MISSING"
   - "PRIORITY NOT PUNCHED IN PARAMETER (REQUEST) CARD."
   - "MORE THAN THIRTY RECORDS IN F TYPE CARDS"
   - "ALL, ALL BUT, OR ONLY CARDS MISSING"
   - "ROUTING DATA MISSING"
   - "TOO MANY ROUTE CARDS"

(3) **"ERROR ON TRACKER CARD. CARD REJECTED"** A tracker card is rejected for one of the following reasons:
   - "ONLY 1 TRACKER CARD ALLOWED"
   - "LIMITS ON BORESIGHT ANGLES WRONG"
   - "POINTS PER PASS WRONG"
   - "DELTA T IS ZERO"
   - "MAX, RANGE IS WRONG"
   - "MIN. ELEV. GREATER THAN 90"

(4) **"ERROR IN FAN RECORD. RECORD REJECTED"** A single fan record is rejected for one of the following reasons:
"FAN TYPE NOT H OR P"
"FAN ENDS TOO CLOSE TO COLINEAR"
"ELEVATION GREATER THAN 89 DEG"
"AZIMUTH LIMITS ARE EQUAL"
"MAX. RANGE IS WRONG"

(5) "SUBROUTINE ERROR FROM LOCATION XXXXX"
(6) "EXPOINENT OVERFLOW FROM LOCATION XXXXX"

After printing either of the above two comments, the program continues processing at the next logical point.

4.6 PROGRAM NOTES

a. Case Bypass Option

Toggle 47 in the on position causes the program to type the sensor about to be processed and wait for a "STOP" or a "GO" type-in from the operator. A "STOP" will cause the case to be bypassed. A "GO" will cause the case to be run.

b. Point of Maximum Elevation

The point of maximum elevation is the first point calculated. If the range at the point of maximum elevation exceeds the maximum range of the tracker, the entire pass is rejected. If this point falls within the maximum range, the entire pass is retained.

c. Use of the ALL, ALL BUT, and ONLY cards.

One of these cards must be present in every set of Case Data Cards that is used to generate the Fan Input Data Tape. The content of this card is important only for input options of zero and five, because Element and Satellite Number Cards are not used. Therefore, it becomes necessary to specify which satellites are desired from the E-File. 1 This is accomplished by using an ALL, ALL BUT or ONLY card as described in Section 4.3a.

For input options 1, 2, 3 and 4, the Schedule Tape contains either Element or Satellite Number Cards to specify which satellites are to be used. Because this tape overrides the Fan Input Data Tape, any one of the ALL, ALL BUT or ONLY cards can be used since it will not be read. Therefore, whichever card is used may either be blank or contain satellite numbers.

1 Refer to Table 1 in Section 4.4
d. **Use of the Satellite Summary**

The information printed on the Satellite Summary is dependent on the input option. This information is particularly helpful when using input option zero. For this input, the summary lists only those satellites available on the E-File of all those requested on the ALL, ALL BUT or ONLY Cards.

However, for options 1, 2, 3, and 4 the summary prints out all the satellites on the Element or Satellite Number Cards.

e. **Acquisition Buffer**

Depending on the type of sensor, the acquisition buffer (Figure I-1) holds the respective constants for processing planar fans, horizontal fans, and trackers.

f. **Operational Sequence**

The B-3 system is initialized by depressing the "load" button on the console. This rewinds the system tape, reads the first block into core and executes a jump to cell 0.

EXECMOD1 and EXECMOD2 are then loaded into core and the tape on logical 4 is checked for proper I.D. "NEXT FUNCTION" is then typed on the console typewriter. The operator can respond to this comment in several ways. He may type "MANUAL", "EXEC", or "WRAPUP". "WRAPUP" will wrap up the output tape and rewind it in lock-out.

1) **Manual Mode**

If the operator types "MANUAL" the system will request the program I.D. (OBSERV). After typing in the I.D. the system will execute the object program, which in turn will request the "BASE DAY" and "BASE MESSAGE NO." via the required input console typewriter. The operator must be certain that the data has been prestored onto a tape mounted on logical 0. Upon completion of the program, the system will again type "NEXT FUNCTION".

42
(2) Schedule Mode

If the operator types "EXEC" and toggle 24 is on, then the schedule tape mounted on logical unit 2 will be processed. A schedule tape program is requested by using an "SPSJOB" card. Such a request causes the system to load EXECMOD3 into core. EXECMOD3 then converts the input data and places it in the proper buffers. It then returns control to EXECMOD2 which loads the object program and executes it. When all the jobs on the schedule tape have been completed, the system again types "NEXT FUNCTION".
SECTION 5

PROGRAM TEST CASE

The test case included in this section illustrates many of the features of the modified program. The input data are shown in Figure 9 and the output in Figure 10.

The satellites which were used exhibit a wide variety of characteristics. Satellite 00001 has a period of approximately 20 hours and a small eccentricity; satellite 00002 has a very high eccentricity (0.7); and satellite 00003 a very low inclination (1.0°). Satellite 00004 has a very small perigee height; satellite 00005 has a high drag; and satellites 00006 and 00007 have typical direct and retrograde orbits, respectively. The sensor used is located at 30° north latitude and 90° west longitude.

The acquisition model is a complex one consisting of a composite of each of the different types. It contains the following:

(1) A phased-array tracker configuration with the boresight oriented at an elevation of 45° and azimuth of 180°. The limits imposed are 1° in elevation, 60° in α and β, (alpha and beta are respectively, the compliments of the angles between the range vector and the primary and tertiary topocentric reference vectors) and 70° in off-boresight angle.
A horizontal fan at an elevation of $5^\circ$ extending only within the tracker limits

A series of five planar fans which form a crude "S" centered about the boresight vector. This figure ranges in azimuth from $140^\circ$ to $220^\circ$ and in elevation from $25^\circ$ to $65^\circ$.

<table>
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<tr>
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<th></th>
<th></th>
<th></th>
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<td>$140^\circ$</td>
<td>$25^\circ$</td>
<td>$220^\circ$</td>
</tr>
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</table>

The point of maximum elevation is also requested and is printed regardless of elevation or azimuth.

No range test is requested, nor is a visual only test or up-pass only. It is requested that the passes not be interleaved.

The output shows the acquisition data for all satellites except 00001 and 00003. Satellite 00001 has a large period and was not positioned correctly for acquisition during the period of interest. Satellite 00003 has too low an inclination for the sensor location.

The output data for satellite 00002 shows the advantage of using maximum elevation as opposed to closest approach. One may note from the range-rate values that frequently such a satellite does not have a closest approach point during a complete pass.

The pass which satellite 00007 makes on revolution 994 illustrates well the use of the composite acquisition model. Observe that it rises through the lower tracker boundary, penetrates the horizontal fan, passes through 3 segments of the "S" configuration, reaches maximum elevation, and finally leaves the tracker coverage at one of the "corners".

The pass which satellite 00006 makes on revolution 899 illustrates the program's ability to detect very short passes. (Note that the
point of maximum elevation is not within the tracker coverage.) The period of time during which the satellite is within the tracker coverage is only .63 minutes.
JOB OBSERV TEST CASE

SPSJOB OBSERV 30
REM AS IN DOCUMENTATION

0333 300000 900000 300

00001 10 0000 166.8 100 4250 000000 0 10E
00001 38644400000000 300000 254.2999 59.9999 00009999 9.9999 10E
00001 1.19841762 00000000 02001 0.0912 0000000 10E
00001 0000000000 000000 000000 10E
00001 5869869888 0000000000 0000000000 10E
00001 120158444 0000000000 31023 200 100 5021921 10E
00002 20 0000 0000 41.1 200 4285 000000 0 10E
00002 3863940000000000 334.9999 400000 44.29999 6999999 400000 20E
00002 2.4731506 00000000 334.9999 39231 -23567.9 20E
00002 0000000000 000000 000000 20E
00002 3.66666663 -2880464 -2880464 334.9999 39231 -23567.9 20E
00002 593248074 0000000000 32 200 100 41012 4 20E
00002 30 0000 0000 6.1 300 4240 000000 0 30E
00002 3863440000000000 354.9999 300000 35.29999 9.9999 30E
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00002 0000000000 000000 000000 30E
00002 1.03103103 -3637922 3637922 334.9999 39231 -23567.9 30E
00002 85199234 0000000000 354.9999 39231 -23567.9 30E
00002 40.58 ALP 1 0000 0 6.3 400 4235 000000 0 40E
00002 3863940000000000 354.9999 300000 350000 400000 40.0000 40E
00002 15.81261428 00000000 364.9999 600000 600000 40E
00002 0000000000 000000 000000 40E
00004 1.05105104 -3504045 -3504045 334.9999 39231 -23567.9 40E
00004 910665514 0000000000 32 200 100 40827 7 40E
00004 50 58 BET 2 0000 0 6.5 500 4245 000000 0 50E
00004 3863940000000000 354.9999 300000 350000 400000 40.0000 50E
00004 15.15600388 00000000 354.9999 39231 -23567.9 50E
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00004 950110826 0000000000 325.0000 59.9999 134.9999 9.9999 50E
00004 0000000000 000000 000000 50E
00004 6000 0000 0 6.5 600 4230 000000 0 60E
00004 38624400000000 245.0000 74.9999 269.9999 420000 79.9999 60E
00004 14.33633205 0000147327 -1.15575 -282611 -13427.4 60E
00004 0000000000 000000 000000 60E
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00004 100444104 0 50000 658 600 100 4082323 60E
00007 70 0000 0 6.9 700 4230 000000 0 70E
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00007 0000000000 000000 000000 70E
00007 1.12244899 -1537982 -1537982 420000 420000 70E
00007 100444104 0 50000 658 600 100 4082323 70E
ENDJOB ENDSCHEDR

FIGURE 9 Input Data for Test Case (1 of 2)
AERONUTRONIC DIV* PHILCO CORP*  
SPACETRACK R AND D FACILITY 496L SPO ESD AFSC  
FIRST AEROSPACE CONTROL SQUADRON ADC  
ONLY 00001-00007  
END CASER  
ENDSCHEDR
BEGIN SCHED TAPE
JOB OBSERV TEST CASE
REM AS IN DOCUMENTATION
SPSJOB OBSERV 30

START OBSERV 01-04-04-04.0

FIGURE 10 Output Data for Test Case (1 of 13)
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FIGURE 10 (4 of 13)
# Loom Angle Schedule for Observ Test Sens

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**Figure 10 (5 of 13)**

53
**LOOK ANGLE SCHEDULE FOR OBSERV TEST SENS**

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**FIGURE 10 (7 of 13)**
## Look Angle Schedule for Observ Test Sens

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**Figure 10 (11 of 13)**
### Look Angle Schedule for Observ Test Sens

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**BT**

FIGURE 10 (12 of 13)
**Spacetrack 4 0408 80**

**Look Angle Schedule for Observ Test Sens**

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**No More Data**

**Figure 10 (13 of 13)**
The following flow diagram displays the logical flow and computational procedures used in the program. Standard symbols are maintained throughout.
B-2 SYSTEM SUBROUTINE

START OBSERV

INPUT READ IN CASE AND FILE DATA

SINIT INITIALIZE FOR SENSOR

MORE SATELLITES

YES

NO

NEXTLSM SET & UNPACK ELEMTSET OF SATELLITES

SATELITE FOUND

YES

NO

EINIT INITIALIZE FOR SATELLITE

SATELLITE IN DECAY

YES

NO

OBS5

OBS4

OBS6

OBS5

OBS6

OBS1

NXPASS OBTAIN POINT OF CLOSEST APPROACH FOR NEXT PASS

TIME OF CLOSEST APP. ENDING

NO

YES

SATELITE SEEN

OBS6

OBS1

OBS2

OBS3

AINIT INITIALIZE FOR SUBROUTINE NNACQ

NXACQ OBTAIN NEXT ACQUISITION MODEL

END OF ACQUISITION MODEL

NO

YES

ACQUIRE PROCESS ACQUISITION MODEL

OBS1

OBS4

OUTPUT READ OUT SATELLITE PREDICTIONS

MORE CASES

NO

YES

OUTPUT FINAL OUTPUT

ENDPK FINISH OUTPUT FOR THIS PASS

OBS5

OBS1
BEGINNING & ENDING TIME IN MINUTES "TO" & "FROM" 

COMPUTE
COSPH = COSφ
SINPH = SINφ

SET €
EPSLN = 1/2

RADIANs

COMPUTE
Θ1 = THAI

THATI

BUF1 = 0

OUTPUT CONTROL CONSTANT USED IN "STORE" & "ENDPK"

XYZI*
INITIALIZE TIME T = 0

XYZSB*
COMPUTES COORDINATES

EPOCHM = EPOCH*XMNPDA

THTAO (e_o) = THTAI + RPTTM*EPOCHM

SDEL = SIN(XNODOT - RPTIM)DT1

CDEL = COS((XNODOT - RPTIM)DT1)

SPCI = SINPH*COSI

CPST = COSPH*SINI

Q2 = AO(1+EO)

K1 = COSMIN

((Q2**2 - COSMIN**2)**.5 - SINMIN /Q2

LSTT = 0

SET UP INDEX REGISTER IR1 = L/SATNOS + SATCONT

COMPUTE BASE REVOLUTION = (EPOCHM - 1440)*XNO/2 +EPREV

BASE REV. POS.

NO SET BASE REV. = 0.0

YES

STORE BASE REV.

IN PACKED FORM

IN (IR1)

AJEXIT FLOATING TO FIXED PT. CONVERSION

CHANGE FROM FLOATING PT. TO FIXED PT.

*E-2 System Subroutine
* B-2 System Subroutine
APPENDIX I

FILE FORMATS

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XNX \{ Unit vector normal to plane 
XNY \{ Unit vector at one end of fan 
XNZ \{ Unit vector at other end of fan (note: XL1Z ≤ XL2Z) 
XL1X \{ 
XL1Y \{ 
XL1Z \{ 
XL2X \{ 
XL2Y \{ 
XL2Z \{ 
RHomax - Maximum range at first end of fan 
Rhodmax - Derivative of maximum range 
N - Fan Number (BCD); P - identification 

FIGURE I-1. FORMAT FOR ACQUISITION BUFFER
b. FANTAB - Horizontal Fan

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<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N A</td>
<td>A A A</td>
<td>SINHMIN</td>
<td></td>
<td>sine of minimum elevation</td>
</tr>
<tr>
<td>A A</td>
<td>A A A</td>
<td>COSHMIN</td>
<td></td>
<td>cosine of minimum elevation</td>
</tr>
<tr>
<td>A A</td>
<td></td>
<td>PPP</td>
<td></td>
<td>points per pass</td>
</tr>
<tr>
<td>A A</td>
<td></td>
<td>TRDELT</td>
<td></td>
<td>( \Delta t ) (minutes)</td>
</tr>
<tr>
<td>A A</td>
<td></td>
<td>RHOMAX</td>
<td></td>
<td>Maximum range</td>
</tr>
<tr>
<td>A A</td>
<td></td>
<td>TRTYPE</td>
<td>Tracker type 1 = Phased array 0 = normal</td>
<td></td>
</tr>
<tr>
<td>A A</td>
<td></td>
<td></td>
<td>T = identification</td>
<td></td>
</tr>
</tbody>
</table>

FIGURE I-1. FORMAT FOR ACQUISITION BUFFER (continued)
### APPENDIX II

#### CARD FORMATS

<table>
<thead>
<tr>
<th>Field</th>
<th>Column</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-8</td>
<td>&quot;FANCARDS&quot;</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>End of block character: 11-8-2 punch</td>
</tr>
</tbody>
</table>

**FIGURE II-1. FAN INPUT DATA TAPE IDENTIFIER**
<table>
<thead>
<tr>
<th>Field</th>
<th>Column</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-4</td>
<td>Sensor number right adjusted</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>Not used</td>
</tr>
<tr>
<td>3</td>
<td>6-12</td>
<td>Beginning time - days since base time</td>
</tr>
<tr>
<td>4</td>
<td>13-19</td>
<td>End time - days since base time</td>
</tr>
<tr>
<td>5</td>
<td>20-25</td>
<td>Not used</td>
</tr>
<tr>
<td>6</td>
<td>26-29</td>
<td>Beamwidth - degrees</td>
</tr>
<tr>
<td>7</td>
<td>30-33</td>
<td>Year</td>
</tr>
<tr>
<td>8</td>
<td>34</td>
<td>Output indicator for fan number column on output.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0: No fan number</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: Fan number</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
<td>Output indicator for units of range and range rate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0: Nautical units</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: MKS Units</td>
</tr>
</tbody>
</table>

FIGURE II-2. CONTROL CARD

80
<table>
<thead>
<tr>
<th>Field</th>
<th>Column</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>36</td>
<td>Not used</td>
</tr>
</tbody>
</table>
| 11    | 37     | Classification indicator  
|       |        | 0: Unclassified  
|       |        | 1: Confidential  
|       |        | 2: Secret  
|       |        | 3: Secret/No form  
|       |        | 4: Secret/Releasable outside SSO channels |
| 12    | 38-39  | Priority - printed on output message |
| 13    | 40     | Not used |
| 14    | 41     | Visual pass indicator  
|       |        | 0: All passes  
|       |        | 1: Visual passes only |
| 15    | 42     | Not used |
| 16    | 43     | Down pass indicator\(^1\)  
|       |        | 0: Complete pass computed  
|       |        | 1: No points after closest point of approach |
| 17    | 44     | Not used |
| 18    | 45     | Point of maximum elevation  
|       |        | 0: No  
|       |        | 1: Yes |
| 19    | 46     | Not used |
| 20    | 47     | Maximum range test for point of closest approach  
|       |        | 0: No test  
|       |        | 1: Test |
| 21    | 48     | Not used |
| 22    | 49     | Interlace inhibit  
|       |        | 0: Interlace predictions\(^2\)  
|       |        | 1: No mixture of predictions\(^3\) |
| 23    | 50-56  | Not used |
| 24    | 57     | Direction cosines print out  
|       |        | 0: No print out  
|       |        | 1: Print out |
| 25    | 58-64  | Elevation angle of the boresight in degrees\(^4\) |
| 26    | 65-71  | Boresight azimuth in degrees\(^4\) |
| 27    | 72     | Element number option  
|       |        | 0: Print revolution number  
|       |        | 1: Print element number |

1. For trackers only  
2. Output in strictly chronological order  
3. Same as (2) but satellite passes are not mixed  
4. These fields are needed only if the tracker card indicates an FPS type tracker and/ or it is desired to print direction cosines
<table>
<thead>
<tr>
<th>Field</th>
<th>Column</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>73-78</td>
<td>Not used</td>
</tr>
<tr>
<td>29</td>
<td>79-80</td>
<td>&quot;RP&quot; - must contain these two letters as ID</td>
</tr>
<tr>
<td>Field</td>
<td>Column</td>
<td>Contents</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>1, 9</td>
<td>1-6, 40-45</td>
<td>Elevation angle at start of fan (h₁) - in degrees</td>
</tr>
<tr>
<td>2, 10</td>
<td>7-12, 46-51</td>
<td>Azimuth at start of fan (A₁) - in degrees</td>
</tr>
<tr>
<td>3, 11</td>
<td>13-18, 52-57</td>
<td>Maximum range at start of fan (ρ₁max) - in kilometers</td>
</tr>
<tr>
<td>4, 12</td>
<td>19-24, 58-63</td>
<td>Elevation angle at end of fan (h₂) - in degrees</td>
</tr>
<tr>
<td>5, 13</td>
<td>25-30, 64-69</td>
<td>Azimuth at end of fan (A₂) - in degrees</td>
</tr>
<tr>
<td>6, 14</td>
<td>31-36, 70-75</td>
<td>Maximum range at end of fan (ρ₂max) - in kilometers</td>
</tr>
<tr>
<td>7, 15</td>
<td>37-38, 76-77</td>
<td>Fan number (BCD)</td>
</tr>
<tr>
<td>8, 16</td>
<td>39, 78</td>
<td>Fan type &quot;H&quot; - Constant elevation azimuth scan &quot;P&quot; - Planar fan &quot;FP&quot; - must contain these two letters as ID.</td>
</tr>
<tr>
<td>17</td>
<td>79-80</td>
<td></td>
</tr>
</tbody>
</table>

FIGURE II-3. FAN CARD
<table>
<thead>
<tr>
<th>Field</th>
<th>Column</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-6</td>
<td>&quot;Δ-99.0&quot; An elevation of -99° signifies a request for acquisition coordinates for a tracking device</td>
</tr>
<tr>
<td>2</td>
<td>7-18</td>
<td>Not used</td>
</tr>
<tr>
<td>3</td>
<td>19-24</td>
<td>Minimum elevation - degrees - floating point</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>Points per pass &lt;br&gt;2-8: 2-8 points per pass &lt;br&gt;9: points every delta T (field 8)</td>
</tr>
<tr>
<td>5</td>
<td>26</td>
<td>Not used</td>
</tr>
<tr>
<td>6</td>
<td>27</td>
<td>Tracker type &lt;br&gt;Δ or 0: Normal tracker &lt;br&gt;1: FPS-85 tracker</td>
</tr>
<tr>
<td>7</td>
<td>28-30</td>
<td>Not used</td>
</tr>
<tr>
<td>8</td>
<td>31-36</td>
<td>Time increment in minutes - (needed only if points per pass = 9)</td>
</tr>
<tr>
<td>9</td>
<td>37-42</td>
<td>Limiting value of the SIN of the boresight oriented angle α - sinα - floating point boresight oriented</td>
</tr>
<tr>
<td>10</td>
<td>43-48</td>
<td>Limiting value of the SIN of the angle β - sin β - floating point</td>
</tr>
<tr>
<td>11</td>
<td>49-54</td>
<td>Limiting value of the off-boresight angle, ψ, in degrees</td>
</tr>
</tbody>
</table>

FIGURE II-4. TRACKER CARD
<table>
<thead>
<tr>
<th>Field</th>
<th>Columns</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>55-60</td>
<td>Maximum observable range - floating point kilometers</td>
</tr>
<tr>
<td>13</td>
<td>61-66</td>
<td>Maximum elevation angle to be used for normal tracker only - if blank, 90° is assumed</td>
</tr>
<tr>
<td>14</td>
<td>67-72</td>
<td>Not used</td>
</tr>
<tr>
<td>15</td>
<td>73-75</td>
<td>Sensor number</td>
</tr>
<tr>
<td>16</td>
<td>76-78</td>
<td>Not used</td>
</tr>
<tr>
<td>17</td>
<td>79-80</td>
<td>&quot;FP&quot; - must contain these two letters as ID.</td>
</tr>
</tbody>
</table>

FIGURE II-4. TRACKER CARD (Continued)
<table>
<thead>
<tr>
<th>Field</th>
<th>Column</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-64</td>
<td>Station address - 64 BCD characters (can also include the routing address, even though this will be repeated in Columns 65-72)</td>
</tr>
<tr>
<td>2</td>
<td>65-72</td>
<td>Routing address - 6 or 7 BCD characters</td>
</tr>
</tbody>
</table>
| 3     | 73-80  | Card identifier, one of the following:
FROMXXXA,
TOXXXA, or
INFOXXXA; XXX is sensor number |

FIGURE II-5. ADDRESS CARD
### Field 1

**Column 1-8**

- ALL AAAA
- ALLBUTA
- ONLY AAAA

1. Not used for ALL Cards
2. For "ALL BUT" and "ONLY" Cards - This field contains five-digit satellite identifiers, separated by commas and/or two five-digit satellite identifiers separated by a minus.

### FIGURE II-6. ALL, ALL BUT, or ONLY CARD
### Field | Column | Contents
--- | --- | ---
1 | 1-7 | Base Time - day number in year and fraction, decimal punched in Column 4
2 | 8-11 | Not used
3 | 12-16 | Message number, right adjusted
4 | 17-78 | Not used
5 | 79 | B
6 | 80 | P

**FIGURE II-7. BASE TIME CARD**
JAGD

NOCYCLE ETA 1.5
ETD MASK 1
JAEQ NOMORE 1
SRA 18
TAM 16.35
AIXO 1.45
JMP NOCYCLE 1
ASN PASSONE, H/37545
NOMORE TMQ 24/1T147
ETA .3
ETD 1
JAEQ (P)+4H
TMQ 16/1T29
ETA .3
JMP NOMORE+5H
CH ,4
TMA NUCLEMS
SLA 245
AMS NOELMS
JMP TESTSNS 400

ECYCLE DRANA 400

ETD 16.3 1
SND 18 1
TDM 1.45
TMA 0/40B155
AMS NOELMS
TMD C/HLT, EBLOC
TDXLCS .3 1
JMP 30900+3H 1

L 451
TJM 451 B+2H
TMA 1/1
JMP (P)+3H 1

451 A
TJM 451 B+2H
CA
TMQ 12/0136/1
TMD C/HLT, SATNOSS

TDXLCS +1

L 451 R
RPTAN 1000
EIS 1.15
JMP 1

452
TJM (P)+1H
TMQ C/HLT, BUFH+1201C/HLT, BFRA+1205
AIXOL ,3
JOF (P)+3H
AIXOR ,3
JND (P)+2H
JMP R06AS
TMA 0.3
TMD W/END CASE
JAEQ 452-1H

453
TJM (P)+4H
TMA W/ENDSCHED
JAEQ (P)+4H
TMA W/ENDCASE
TMD 10.3
JAEQ 453 A
JMP R06AS
JMP 453+1H

/* END FAN INPUTS

453 A
TMA W/ENDSCHED
JMP FLEX
JMP PANT, ALLFIN
TJJ NXCAS1+1H
TJM NXCAS1
JMP NXCASE+1H

454
TJM 454 A+1H $ BIT 47¿, ERROR
CD 4 48,1, COMMA
SIXO 1.0 $ 45¿1, DASH
JOF 454 A $ 44¿1, END CASE
TMD 4T11
CA
SLAQ 6
TMQ 4T11
TMD 0/60T47
JAEQ 454+1
TMD W/0000000
JAEQ (P)+25
TMD W/000000-
JAEQ (P)+25

454 A
AIXO 1,3
SIXO 1.1
JNO (P)+2
JMP 452
JMP (P)+3
EDIT OF OBSERV 01 10 65

CD
SIXO 1.0
JNO (P) +4H
AIIXO 1.2
TIXZ 8.0
JMP 40UT 5a
SLA 6
TAM .2
JMP 40UT 5a
40UT 5i TJM 40UT 5 + 1H
TIXZ 6.1
TMD W
JMP (P) +4H
40UT 5c TJM 40UT 5 + 1H
TIXZ 48.1
TDM DUM
JMP 40UT 5 + 1H
4OUT5d TJM 40UT5 + 1H $
TQA $
TIXZ $
TIXZ M/60.0 $
SRAQ $ 6s
TQD $
SRD $ 10 $
SIXO $.05
JQF (P) +3H $
AIXO 6.1s
JMP (P) +2H $
SLQ 6.5
JMP (P) +2H $
JMP (P) +4H
TQH DUM $
JMP 40UT 5 + 1H

4SMRYX S
TMD 4SMRYX S
TDLCL ,05
JMP (P) $
4SUMRyTJM (P) +1H S
TXLCL ,05
TOM 4SMRYX S
TIJ 40UT1 + 3H
TJM 40UT1 + 2H
JMP PANT.PAGE
JMP 4CLEAR
TMA STAN
TMD 3U/1118/0
CIS 4C1*2
TMA N/3T15IP/4C1 .T39
JMP 4OUT1
JMP PANT.PAGE
TJIR
TJM 4NXTEL +6H$
There will be 4 groups of the following per line of output for SATNO./ELNO. Each group contains 3 words:

(SSSSS/EEE) (EEE/SSSSS) (S/EEEE)

First Sat. in group:

SATONE TMA 4T7S
TMQ 0/6115S
SLAQ 6%
TMQ 4T8S
SLO 24%
SLAQ 12%
TMQ MASKBS
SLAQ 12%
TM 1.0$
AIXO 1.0$
AIXO 1.1$
J NXTSET$

Second Sat. in group:

SATNO TMA 0.4%
TMQ 4T7S
SLO 6%
SLAQ 6%
TM 0.0
SLAQ 24%
TMQ 6%
SLO 24$
SLAQ 24$
TMQ MASKBS
SLAQ 12$
TM 1.0$
AIXO 2.0$
AIXO 1.1$
CSM D/1847$
TAM 4T15S
JAEQ (P)=2H$
J NXTSET$
CM 4T14S
TMA N/12715/1P/4BF,T39$
JMP 40UT1S
JMP 4CLEAR$
TMQ L/4BF,T3$
TXLC 0.0$
J NXTSET$

End of Satnos Table:

NonXSetCD $TXDL$ 0.0$
TDA $SM$ C/HLT,4BF,1C/HLT,0$
TAM 4T7S
JAZ 4SUMMRV-3$
TMQ 4T13S
JAZ SET00$
J SET11$

First Sat. in group:

SET00 TMA 0.0$
TMQ MASKBS
SLAQ 24$
TM 0.0$
J SETEND$

Second Sat. in group:

SET11 TMA 4T7S
AM P/4BF,T39$
J SETEND-1$
SETEND TMA 4T7S
AM C/HLT,1C/HLT,4BF$
JMP 40UT1S
JMP 4SUMMRV-3$
BINBCD TJM BNDONES $BM.SAT. NO. IN (A)$
CM BCDSAT$
TAO $TIXZ 0.2$
TIXZ 0.2
NXTCHAR CA $BDSONE,JAEQ (P)$
BDSONE,JAEQ $BNO. NOW CONVERTED TO BCD$
DAO 0/10$
SLA 0.2$
AMS BCDSAT$
AIXO 6.2$
JMP NXTCHARS$

L 4CLEAR TJM (P)=7H
TMD L/4BF
TXDRC 1.3
TMD W

L RPTA 11
TDM 1.3
SIMO 11.3
J JMP

L TAD TMA 1/1716
AMS (P)=1
TQA TGP
JMP
<table>
<thead>
<tr>
<th>EDIT OF OBSERV</th>
<th>01 10 65</th>
<th>PAGE 35</th>
</tr>
</thead>
<tbody>
<tr>
<td>4NXTEL</td>
<td>TMH</td>
<td>(P)-1H</td>
</tr>
<tr>
<td>THO</td>
<td>10/147S</td>
<td></td>
</tr>
<tr>
<td>ETA</td>
<td>.1</td>
<td></td>
</tr>
<tr>
<td>J2</td>
<td>4NXTEL-1H</td>
<td></td>
</tr>
<tr>
<td>THO</td>
<td>.1</td>
<td></td>
</tr>
<tr>
<td>AIXO</td>
<td>1.1S</td>
<td></td>
</tr>
<tr>
<td>SCD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JOP</td>
<td>(P)-6H</td>
<td></td>
</tr>
<tr>
<td>TMJ</td>
<td>4NXTEL-5H</td>
<td></td>
</tr>
<tr>
<td>4SET</td>
<td>TMJ</td>
<td>4SET3+1H</td>
</tr>
<tr>
<td>THO</td>
<td>C/HLT, SATNOS</td>
<td></td>
</tr>
<tr>
<td>TDLC</td>
<td>.1S</td>
<td></td>
</tr>
<tr>
<td>THO</td>
<td>L/4BFR</td>
<td></td>
</tr>
<tr>
<td>TDM</td>
<td>476</td>
<td></td>
</tr>
<tr>
<td>CSM</td>
<td>D/1847S</td>
<td></td>
</tr>
<tr>
<td>TAM</td>
<td>4T13S</td>
<td></td>
</tr>
<tr>
<td>CM</td>
<td>4T14S</td>
<td></td>
</tr>
<tr>
<td>JNP</td>
<td>4NXTEL</td>
<td></td>
</tr>
<tr>
<td>NOP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAM</td>
<td>477</td>
<td></td>
</tr>
<tr>
<td>4SET</td>
<td>1</td>
<td>JMPP</td>
</tr>
<tr>
<td>JMP</td>
<td>4SETH 2</td>
<td></td>
</tr>
<tr>
<td>TAM</td>
<td>478</td>
<td></td>
</tr>
<tr>
<td>TMA</td>
<td>477</td>
<td></td>
</tr>
<tr>
<td>AM</td>
<td>D/1847S</td>
<td></td>
</tr>
<tr>
<td>THO</td>
<td>4T8S</td>
<td></td>
</tr>
<tr>
<td>JAED</td>
<td>4SET 3S</td>
<td></td>
</tr>
<tr>
<td>TMA</td>
<td>477S</td>
<td></td>
</tr>
<tr>
<td>JNP</td>
<td>B2NCDs</td>
<td></td>
</tr>
<tr>
<td>JMP</td>
<td>4COMMA</td>
<td></td>
</tr>
<tr>
<td>JNP</td>
<td>4SET1</td>
<td></td>
</tr>
<tr>
<td>4SET2</td>
<td>THA</td>
<td>477S</td>
</tr>
<tr>
<td>JMP</td>
<td>B2NCDs</td>
<td></td>
</tr>
<tr>
<td>JMP</td>
<td>4BLANKS</td>
<td></td>
</tr>
<tr>
<td>TMA</td>
<td>4T6S</td>
<td></td>
</tr>
<tr>
<td>TOXL</td>
<td>.OS</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>C/HLT, 4BFRS</td>
<td></td>
</tr>
<tr>
<td>TAM</td>
<td>477S</td>
<td></td>
</tr>
<tr>
<td>THO</td>
<td>C/HLT1C/HLT, 4BFRS</td>
<td></td>
</tr>
<tr>
<td>JAED</td>
<td>(P)+2W</td>
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**BUFFER IS EMPTY**

**BUFFER EMPTY?**

**SAT.NOS. CONSECUTIVE?** YES

**4BFR? In Both Halves**
* READ SENSOR FILE

READSNSJMP SNSGETS
TMD C/HLT.SBLOC8
TDXLC ,3S
TMD IEENDS
TDXLC ,4S

R
RPTAA 9S
TMD 1,3S
TDM 1,4S
SIXP 9,3S
TMA 9,3S
TMD MASKBLS
JAED (P)+3HS
AIOX 9,3S
JMP (P)-8HS

* CASE BY PASS OPTION

4A 1 JMP R06A8
TMA ,3
TMD W/ENDSCHED
JAED 43S A
TMD W/END CASE
JAED 4A 1
TAM 4A3-1
TMA N/12T15IP/4A3-2,T39
JMP FLEX
TMD
SCD 1
JDP 4A 4
JMP 4A 2
4A 1A JMP 43S
JMP R06A8
TMA ,3
JMP 4A 1-6M
4A2 JMP STOPG0S
JMP 4A 4S
JMP 4A 1A$
A/STATION XXXXS

4A3 A/JANS
A/FEB8
A/MARS
A/APR8
A/MAYS
A/JUN8
A/JUL8

* ERROR OUTPUT

TQM A/JERR0R+8H
TAM D/54
ETA 9,3
TMD W/0000000RP

* DETERMINE TIME

4A 4 JMP AKLOK
TDM ZULUT
SLO 12
TDM TFN
TMD W/14A3=1
TDXLC ,0
SRAQ 7
CA
SLAQ 7
TMD D/64
JAGD (P)+7H
SLA 8
TAD
ADXR 0,0
TMD 0,0
TDM MONTH
JMP (P)+3H
SM D/94
JMP (P)-7H
JMP FKLOK
JMP FKLOK
JMP AJFIXIT
TAM DFN

* PROCESS CONTROL CARD

TJM 452
A/SEP8
A/OCT8
A/NOV8
A/DEC8

* CASE BY PASS OPTION

4A 1 JMP R06A8
TMA ,3
TMD W/ENDSCHED
JAED 43S A
TMD W/END CASE
JAED 4A 1
TAM 4A3-1
TMA N/12T15IP/4A3-2,T39
JMP FLEX
TMD
SCD 1
JDP 4A 4
JMP 4A 2
4A 1A JMP 43S
JMP R06A8
TMA ,3
JMP 4A 1-6M
4A2 JMP STOPG0S
JMP 4A 4S
JMP 4A 1A$
A/STATION XXXXS

4A3 A/JANS
A/FEB8
A/MARS
A/APR8
A/MAYS
A/JUN8
A/JUL8
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UNPACK SENSOR RECORD

CSM D/1815%
TAM SATCONT$ S
TMQ 1/1T8 $ E
ETA CARDDYP
JAZ (P)+9H
TMQ 18/1T47
ETA STAN
ETD STAI
JAED LOAD 50
TMD W/S AND
TDM AJERR9+1
TMA N/4T15IP/AJERR9,T30
JMP AJERR9+1%
TMD IEENDS
TDXLC .4S
TMQ 18/1T47
ETA .4
ETD STAN
JAED LOAD S
ETD MASKBLS
JAED (P)+3H
AIXO 9,4
JMP (P)+6H
TMQ 24/0/24/1
TMA STAN
SLA 24
EIS LOAD S-2
THA N/5T15IP/LOAD S-3,T30
JMP AJERR9+5H
A/STATION XXXX NOT ON SEAI93

LOAD S TMD C/HLT,STYPES
TDXLC .0
CA
RPTAA 9
TMD 1.4
TDM 1.0
THA STYPE
SLO 12

SLAQ 10
TAM STYPE
THA W/
SLAQ 10
TAM STAI
LOAD S0 SLA 6
TMQ 24/11/8/914/1
EIS LOAD S1-9H
EIS LOAD S1-5H
EIS LOAD S1-7H
JMP LOAD S5
W/FROMXXXA
W/TO XXXA
W/INFOXXXA

STORE FAN AND ADDRESS DATA
L HLT IREC
LOAD S1 TMD (P)
TDXLC ;0
TMD W/
L RPTA 256
TDM 1.0
TDM LOAD A$
TDXRC $0
AIXO 10.3$

LOAD F JMP 452
JMP LOAD A1
TMQ 12/1T47
ETA 9,3
ETD W/000000FP
JAED (P)+7H
SRQ 6
ETA 9,3
ETD LOAD S1-3H
JAED LOAD A
LOAD FTHA N/5T15IP/AJERR6,T30$
JMP AJERR9+5H
TMD C/HLT,AJERR+95C/HLT,(P)+4H$
AIXJ 0,0
THA N/5T15IP/AJERR5,T39$
JMP AJERR9+5H
R RPTAA 10
TMD 1.3
TDM 1.0
TMD W/
TDM 1.0$
JMP LOAD F$
R LOAD F2 TJM (P)+7H$
R RPTAA 9$
NQD STADR+50
R RPTAA 9
TMD 1.3
TDM 1.4
AIXO 1.3
AIXO 1.4
LOAD A TMA W/
TMD AJBFFR
JAED CHKME
TAM .0
TMA 9,3
TMD LOAD S1-7H
JAED (P)+3H
LOAD A1 TMA N/ST15IP/AJERR3,T39
JMP AJERR0R*5H
TMD LOAD F2*1H
TDXLC ,4
* TMD C/HLT,STADR*9/C/HLT,STADR*1
TDM STADR*6
JMP LOAU A7
TIXZ 18,2
TIXZ 30,1
TMA W/00000FM
JMP LOAD A9
JMP 452
JMP LOAD A1
TMA 9,3
TMD LOAD S1-5H
JAED (P)+2H
JMP LOAD A1
JMP LOAD A7
TIXZ 14,2
TIXZ 30,1
TMA W/00000TO
JMP LOAD A9
JMP 452
JMP LOAD A1
TMA 9,3
TMD LOAD S1-5H
JAED (P)+2H
JMP LOAD A7
JMP 40UT 2
JMP (P)+5H
LOAD A3 TMA N/ST15IP/AJERR10,T39
JMP AJERR0R*5H
* LOAD A4 JMP 452
JMP LOAD A9
JMP 452
JMP LOAD A5
TMA 9,5
TMD LOAD S1-3H
JAED (P)+2H
JMP LOAD A5
JMP LOAU A7
TIXZ 30,2
TIXZ 10,1
TMA W/000INFO
TIJ LOAD A6*1H
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AJNORMX TMD P/AJBFBR,T15
TDM AJGOL79
THD BEGIN
JMP AJFNN1
SLA 17
TMQ F/1073741824,
FMARS AJHOLD
TMA BEGIN
FSM AJHOLD
TMQ F/1440,
FMARS AJHOLD
TMA RNGFLG
JAZ <P>*2
TMA XNMPER
TAM AJCNV1
TQM AJCNV2
JMP START

AJFCAR TMD C/HLT,81C/TIJL,AJSPFW
AJFCAT TMD C/HLT,81C/TIJL,AJSPFW
JMP Start

AJFNTAB*2
TMA 3.6
TMQ 1.6
FMMR 1.6
FSM FL 1
JAP TRERR
TMQ 7.6
TMQ DE2RA
FMARS AJFNTAB+2
TMQ F/0
JAEQ TRERR
FSORT
TAM 2.6
FSORT
TAM 2.6
FSORT
AJFC3
TMA RCPTST
TAM 3.6
TAM 7.6
TMQ FL 2
JAGDF (P)*2H
JMP TRERR
TIXZ 4.4
TMD FL 2
JAEQ (P)*2H
JMP AJFC2
FCAMAS 8.6
TMD FL 0
JAEQ TRERR

AJFC1 TMD C/HLT,81C/TIJL,AJSPFW
CA USRCH
JAZ AJEROR
TMA AJFNTAB
FAM FL 90.0
JAP AJREGPN
TMA TFGL
JAZ (P)+3H
TIXZ 1.4
JMP TERR
THD FL 5
TMD PHAIN
TIXZ 0.4
JMP C/HLT,81C/TIJL,AJSPFW
JMP XSRCH
JAZ TERR
THD L/TEMPO
TOM L/TEMPO

AJFC2 TMD C/HLT,81C/TIJL,AJSPFW
RPTAA 11
THD 1.4
TMQ 1.6
SIXO 11.6
TMA 10.6
JAZ AJFC1
TIXZ 2.4
TMQ 0.6
FMARS F/1
JAP TERRR
TDM F/1
TMD F/1

AJFC3 TMD C/HLT,81C/TIJL,AJSPFW
RPTAA 11
THD 1.4
TMQ 1.6
SIXO 11.6
TMA 10.6
JAZ AJFC1
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JAP TERRR
TDM F/1
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TRC0M4 A/Delta T is zero

TRC0M5 A/MAX, Range is wrong

TRC0M6 A/MIN, ELEV, greater than 90°

TRC0M7 A/Error on Tracker Card, Card rejected

L AJSRFWICOZ 6x128+6
TMA AJFNTAB
ICOZ 24x128+6
TMA AJFNTAB*1
ICOZ 25x128+1
TMA TEMP7
ICOZ 34x128+6
TMA TEMP10
ICOZ 42x128+6
TMA TEMP0
ICOZ 48x128+6
TMA TEMP1
ICOZ 54x128+6
TMA AJFNTAB+2
ICOZ 64x128+6
TMA ELMAX
ICOZ 60x128+6
CAM TEMP9
L RSTSTWD 0
MLT AJREG1

AJREG#1AIK 3.3
TMD RSTSTWD
TXDLG 3
TMD RSTSTWD
AIK 5.3
TMD 1.3
TMD F/6
TMD PHAIN
AJREG1 TMA 0.3
SRAQ 6
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FNCO42 A/FAN ENDS TOO CLOSE TO COLINEARS S

FNCO44 A/ELEVATION GREATER THAN 89 DEGS S

FNCO45 A/AZIMUTH LIMITS ARE EQUALS S

FNCO46 A/ERROR IN FAN RECORD, RECORD REJECTED S

AJERR2 A/FAN PARAMETER (REQUEST) CARD MISSING (NO R IN CARD) S

AJERR3 A/FAN PARAMETER (REQUEST) CARD MISSING (NO R IN CARD) S

AJERR4 A/FAN ENDS TOO CLOSE TO COLINEARS S

AJERR6 A/ILLEGAL CARD EXISTS AFTER F CARDS S

AJERR7 A/CHECK INPUT DATA FOR ILLEGAL CHARACTERS IN FIELDS S

AJERR8 A/STA NO. ON R AND F CARDS DIFFER S

AJERR9 A/ALL, ALL BUT, OR ONLY CARDS MISSING S

AJERR10A/ALL, ALL BUT, OR ONLY CARDS MISSING S

AJERR10B/ROUTE CARDS MISSING S

AJERR11 A/ROUTING DATA MISSING S

AJERR12 A/T00 MANY ROUTE CARDS S
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YFX
YFY
YFZ
ZFV
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ZFLUM
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XNYH
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SATCONT

* * * * MAIN PROGRAM STARTS HERE * * * *

START1 CM PHAIN
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JMP SINIT
NXTEL TMD F/1
TDM PHAIN
TMA C/MLT,SATNOS
AM SATCONT
TAD
TADCI
TDXLC 0

NXTEL1 TMA 0/1113
AMHS SATCONT
AIKO 1.0
TMQ 1/110
ETA 0.0
JAN NXTEL2
TMA 0.0
JAZ AJENDPK
JMP NXTEL1

NXTEL2 TMD MASKSAT
ETA 0.0
JAZ AJENDPK
TAM SATN
JMP NXTEL1
JMP EZINET
TMQ XNO
TMA F/0.72220521
JAGQF (P)=4H
TMQ 1/1T1
DORMS 0.0
JMP NXTEL1
TMA EPOCH
FSM ENDT
TMQ F/-100
JAGQF (P)=3H
TMQ 1/1T2
DORMS 0.0

START2 TMD F/3
TDM PHAIN
JMP NXKPASS
JMP NXTEL
TMQ RH0
FMMR EPSLN
TMQ RH0XH
JAGQF START2
TMA FNCPA
JAZ (P)=5H
JMP RHARR
TMQ 0/36 T5
TMQ FANNO
JMP STONE
JMP AJEND

START3 TMD F/2

ERROR EXIT RETURNS TO NXCASE

SET ERROR EXIT TO RETURN
GET NEXT SATELLITE TO BE PROCESSED FROM SATNOS TABLE.

ERROR EXIT RETURNS TO NXCASE

SET ERROR EXIT TO RETURN
GET NEXT SATELLITE TO BE PROCESSED FROM SATNOS TABLE.

ALL SATELLITES DONE

ALL SATELLITES DONE

UNPACK ELEMENT SET

IF SATELLITE NOT FOUND

INITIALIZE FOR SATELLITE

SATELLITE NOT IN DECAY

IRS MUST BE PRESERVED

SATELLITE IN DECAY

NO MORE PASSES

SATELLITE CANNOT BE SEEN.

FIXED FANS BEING PROCESSED

AND CPA REQUESTED.

INITIALIZE WXACQ ROUTINE

SET ERROR EXIT TO RETURN
$ TO START3,
$ GET NEXT ACQUISITION MODEL
$ NO MORE ACS. MODELS
$ NORMAL RETURN FROM NXACQ
$ FINISH UP THIS PASS
$ SET ERROR EXIT TO RETURN
$ TO NXTEL.
$ GO BACK AND GET NEXT PASS.
$ PROCESS ACS. MODEL
$ GO BACK AND GET NEXT ONE.

* * * * MAIN PROGRAM ENDS HERE * * * *
EDIT OR OBSERV 01 10 65

PAGE 69

TMQ RHO
FMXMP SINHREF
FSM RHOZH
TAQ REMAG TEMP1
FMXMP EPSLN
THQ CASHREF
FMAR
THQ TEMP1
JAGOF MACQ1
JMP MACQ2
MACQ1 JMP RHARR
MACQ2 JMP A1H
TMQ ATYPES TEST FOR TRACKER TYPE
TDW/0000000TS
JAE D MACQ1X
JMP AFI LT2
JMP MACQ6
JMP AFI LT2
JMP MACQ6
MACQ1X JMP STORES
TMQ F/1.0
FAMX PAR4
MACQ6 JMP TI
MACQ7 JMP PAR2
JAGOF MACQ7
TAM TI
TMD F/10.0
TGM DT
TQM TI
JMP MACQ8
MACQ7 JMP T2
JAM PAR2
TDM TAQ
MACQX JMP T

AFIL T2 JMP AFI LT2X
THA A2H
FSM A1H
TAM TEMP1
TMA OBSAZ
FSM A1H
TAQ A2H
TAM OBSAZ
FMAR
THQ TEMP1
FMAR
JAN AFI LT2X
JMA D/1016
AFIL T2X INCREMENT RETURN ADDRESS FOR
NORMAL RETURN

EDIT OR OBSERV 01 10 65

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L AFI LT2X JMP 0

EXIT

RFILT2 TJM RFI LT2X
THA RCPYST
JAZ RFBI
THA OBSAZ
TMQ RHO
FMAR
THQ RHO
FAM
THA RHO
JAGOF RFILT2X
RFBI TJM D/1016
INCREM EN BY 1H
L RFILT2X JMP 0

ACQUI R1 JMP ACQUIRX
THA ATYPES
TMD A/0000000TS
JAE D ACQUI1
THA A/0000000HS
JAE D ACQUI2
THA A/0000000OTS
LA EQI
ACQUI3 JMP ACQUIRX
ACQUIRX JMP ACQUIRX
ACQUI1 JMP ACQUIRX
ACQUI2 JMP ACQUIRX
ACQUI3 JMP ACQUIRX
ACQUIRX JMP ACQUIRX

ACQUIR1 JMP ACQUIRX
THA ATYPES
TMD A/0000000PS
JAE D ACQUI1
THA A/0000000HS
JAE D ACQUI2
THA A/0000000OTS
LA EQI
ACQUI3 JMP ACQUIRX
ACQUIRX JMP ACQUIRX
ACQUI1 JMP ACQUIRX
ACQUI2 JMP ACQUIRX
ACQUI3 JMP ACQUIRX
ACQUIRX JMP ACQUIRX

PACQUI R1 JPACQUIX
THA PAR1
TAM PAR2
TMD CM CM PAR4
THA TMD XL1Z
FSM EPSLN
THA EPSLN
FMAR
THA EPSLN
FMAR

SUBROUTINE COMPUTES RHO DOT N
NORMAL RETURN FOR
PARAMETER

ERROR TRACKER SUBROUTINE

HORIZONTAL SUBROUTINE
EDIT OF OBSERV 01 10 65

PAGE 71

TMQ RHOZH
JAGQF PACQ1X
TDM DT
PACQ2 TMA RHOZH
JAP PACQ1
TMQ PAR2
JAGQF PACQ13
TDM PAR3
PACQ6 TDM RHOZTNS
TDM TII
TDM DT
PACQ8 TMA DT
FAMR TI
TDM RHOZTNS
TDM PAR3
JMP CRHOM
TMQ PACR1
FMAR PACQ2

COMPUTE DT = SIG(PAR3*RHOZTNS)*DT/2

TEMP1 = DT/2
TAM TEMP1
TMQ PAR3
FMMR RHOZTNS
TMO TEMP1
JAP PACQ3
FCSQ
TQM UT
FAMR TI
TDM RHOZTNS
TDM PAR3
JMP CRHOM
TMQ PACR1
FCQAG TEMP1
TMQ RHO
FMMR EPSLN
TMQ TEMP1
JAGQF PACQ4
JMP PACQ5
JMP AFILT1
JMP PACQ6
JMP AFILT1
JMP PACD6
JMP RARR
JMP STORE
TMA F/I/O
FAMS PAR4
JMP PACQ6

TEST IF RHO*EPSLN IS GREATER THAN OR
EQUAL TO ABS(RHOZTNS)

TEMP1 = ABS(RHOZTNS)

EXIT

COMPUTE RHO DOT N

EDIT OF OBSERV 01 10 65

PAGE 72

PACQ1 FCAMA. RHOZTNS
TAM TEMPT1
TMQ RHO
FMMR EPSLN
TMQ TEMPT1
JAGQF PACQ4
JMP PACQ5
PACQ3 TMD PAR2
PACQ4IVJMP 0
PACQ5DVNTJM PACRHDX
TMQ RH0XH
FMMR XNXY
TMQ RM0VWH
FMAD XNYH
TMQ RH02H
FMAD XNZH
TAM RHOZTNS
PACR5DVNDJM 0

TEST IF RHO*EPSLN IS GREATER THAN OR
EQUAL TO ABS(RHOZTNS)

TEMP1 = ABS(RHOZTNS)

EXIT

COMPUTE RHO DOT N

TEST IF (L1 CROSSL) DOT (L1 CROSSL2) IS POSITIVE

QTY TO BE TESTED = (XL2Z*RH0YH-XL2Y*RHOZH)*(X1L1Y*RHOZH-XL2Y*RHOZH)

*(XL2Z*RHOZH-XL2Y*RHOZH)+(X1L1Y*RHOZH-XL2Y*RHOZH)

EXIT

COMPUTE RHO DOT N

SUBL. TEST ANGULAR LIMITS OF FAN
SUBL. TEST RANGE LIMITS OF FAN
SUBL. Computes RHOHXH, RHOZTNS
SUBL. STORE PT FOR OUTPUT AFTER TESTS
EDIT OF OBSERV 01 10 65

PAGE 73

THQ TEMP2
FHAD TEMP1
JAN AFILTIX
TMA D/1816
AMS AFILTIX

L AFILTIX JMP 0

RFILT1 TJM RFILT1X
TMA REPTST
JAZ RFA1
THQ RHODXH
FHAD XL1X
THQ RHODY
FHAD XL1Y
THQ RHOZH
FHAD XL1Z
FDA RHO
TOA FACOS

S

RXQ RHODMAX
FAM RHOMAX
TAQ $%
THA RHO
JAGGF RFILT1X
RFA1 THA D/1816
AMS RFILT1X

L RFILT1X JMP 0 EXIT

EDIT OF OBSERV 01 10 65

PAGE 74

BUFFER ASTOR 6

NXACQ TJM NXACQX
TMD BUFFER
TMD RHO
TMD BUFFER+1
TMD RHOXH
TMD BUFFER+2
TMD RHOYH
TMD BUFFER+3
TMD BUFFER+4
TMD OBSRR
TMD BUFFER+5
TMD II
TMD IRSET
TDXLC .1
THA A/ZZZZZZZZ%
THD .1
JAGED NXACQX
TMD 0/77747
ETA 11.1
TMD A/000000008%
JAGED NXAP1
TMD A/000000008%
JAGED NXAH1
TMD A/000000008%
JAGED NXAT1
HLT 0

NXAP1 TMD ATYPE
TMD .1
TMD XNXH
TMD 1.1
TMD XNYH
TMD 2.1
TMD XNZH
TMD 3.1
TMD XL1X
TMD 4.1
TMD XL1Y
TMD 5.1
TMD XL2X
TMD 6.1
TMD XL2Z
TMD 7.1
TMD XL2Y
TMD 8.1
TMD XL3Z
TMD 10.1
TMD RHOOMAX

NXAH2 TMD 0/7775

HXAT2 TMD 0/7775
EDIT OF OBSERV 01 10 65

FDAS DT
TMD T1
TDM T1
JMP TACQ4A
TACQ2 TMD A1H
TDM A1H
TDM TACQ5
TDM STST
CM RCPST6
JMP MACQ1
TMD STST
TDM RCTPST
TMA DPA5S
JAZ TACQ3
TMD PAR2
TDM T2
CM RUF1
JMP TACQ3

AFILT3 TJM AFILT3X
CM MARG
FC5M RHO
TMD SINMIN
FMAR
FAM RHO2H
TMQ ERR
THQ RHO
FMRR EPSLN
TAM TEMPI
TMD COSMIN
FMARS EPS
JMP AFILT31
TMD RHO
TMA COSPSI
FMARS ERR
THQ RHO2H
FMRR YFX
THQ RHOYH
FMAD YFX
THQ RHO2H
FMAD YFX
FSMS ERR
TMA TEMPI
TMQ SINPSI
FMARS EPS
JMP AFILT31
TMD RHOYH
FMAR ZFX

ERR=ABS (RHO DOT ZF)
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SUBROUTINE TEST IF TF IS GREATER THAN OR EQUAL TO TI - IF YES JMP - IF NO EXIT

SUBROUTINE TEST IF ABS(OT) IS GREATER THAN OR EQUAL TO KL - IF YES JMP

SUBROUTINE TEST IF RHODOT IS GREATER THAN ZERO

SUBROUTINE TEST IF ZERO IS GREATER THAN OR EQUAL TO RHODOT - IF YES JMP

SET DT*=-.5*ABS(DT)

SUBROUTINE TEST IF NMAX-NMAX>7 OR 1ST CUT

TEST IF ZERO IS GREATER THAN OR EQUAL TO RHODOT - IF YES JMP

SET DT*=-.5*ABS(DT)
SUBROUTINE TEST
IF ABS(RHODOT/RHODOT) IS GREATER THAN OR EQUAL TO ABS(DT/2) TEMP1 = ABS(DT/2)

SUBROUTINE COMPUTE LSTT
TEMP1 = DT1

SUBROUTINE SET T = 0

SUBROUTINE COMPUTE EPOCHM

SUBROUTINE COMPUTE CPSI

SUBROUTINE COMPUTE Q2 * AQ11 * EO

SUBROUTINE EXIT
```
SINIT TJM  SINITX  S
  SINIT TMA  BEGT  S
  TQU XMNPDA  S
  FMARS TD  S
  TMA END1  S
  FMARS TF  S
  TMA PHIRD  S
  FSOS  S
  TDA COSPH  S
  TMA PHIRD  S
  FSIN  S
  TAM SINPH  S
  TQU BEAMW  S
  FMRR F7,S  S
  FMARS EPSLN  S
  CM BUF1  S
  TMA BEGT  S
  JRP FYKLOK  S
  TAN TOY  S
  TGA  S
  JRP SEPSUB  S
  TAM ORGDA  S
  TQM ORGTM  S
  TMD TOY  S
  TMQ TLC  S
  FMRR ORGDA  S
  TMQ ORGTM  S
  JRM FYKLOK  S
  FMAD ORGDA  S
  TMQ ORGTM  S
  FMAD SIDNT  S
  TMD ORGTM  S
  FMAD SIDRT+1  S
  FAM THGRO  S
  TMQ DEZRA  S
  FMAR  S
  FAM XLAMBA  S
  TAM THTAI  S
  SINITX JMP  0  S

TJM ZDWX  S
  FSOS DT1  S
  FAM TI  S
  JRM PRED  S
  TMA THIAQ  S
  TMQ RPTIM  S
  FMAD T  S

TJM THTA  S
  TDA CNMT  S
  TMA XMDE  S
  FSOS CNMT  S
  FMRR F7,S  S
  TMA CNMT  S
  TMD DT1  S
  FAM TI  S

TJM CNMT  S
  TDA EPSLN  S
  TMA CNMT  S
  TQM CNMT  S
  FAM CNMT  S

TJM EPSLN  S
  TDA EPSLN  S
  TMA EPSLN  S
  TQM EPSLN  S
  FAM CNMT  S

TJM EPSLT  S
  TDA EPSLN  S
  TMA EPSLN  S
  TQM EPSLN  S
  FAM CNMT  S

TJM EPSLE  S
  TDA EPSLN  S
  TMA EPSLN  S
  TQM EPSLN  S
  FAM CNMT  S
```

SAME  XYSB,XYS3  $  
ASGN  DTERM,  M/37525  
SAME  RJLCE,H/3  $  
XY21  TJM  $  
   (P)+3H  $  
   JMP  BEGIN  $  
   JMP  NTHCN  $  XYZI  
   JMP  (P)  $  
XY21  TJM  XYSW1  $  
   JMP  XYS25+1H  $  
XY22  TJM  XYSW1  $  
   JMP  (P)+4H  $  
XY23  TJM  XYSB8  $  
   TJJ  XYSB35  
   TJM  XYSW2  $  
   TJJ  XYSW1+1H  $  
   TJM  XYSW1  $  
   JMP  XYS25+1H  $  
XYS8G  TJM  XYSB8  $  
   TJJ  XYSB3  $  
   TJM  XYSW2  $  
   JMP  XYSB2  $  
BEGIN  TJM  BEGINX5  
   TMO  HXOS  
   FMHR  HKOS  
   TMQ  HYOS  
   FMAD  HYOS  
   TMO  H2OS  
   FMAD  H2OS  
   TAM  P5  
   S  FSORT  $  
   S  XSORT  $  
   TAM  RTPS  
   TMA  F/1S  
   FDA  RTPS  
   FMHR  HKOS  
   TAM  WX5  
   FMHR  HYOS  
   TAM  WYS  
   FMMR  H2OS  
   TAM  WZS  
   TDM  COSIS  
   TDO  $  
   FCSQ  $  
   FMAR  $  
   FAM  F/1S  
   S  FSORT  $  
   TAM  SINIS  
   TDM  XMZS  
   TDO  $  
   TMA  COSIS  
   JMP  ARCCTANS  
   TAM  XNOS  
   TMA  F/1S  
   FDA  SINIS  
   FMHR  WX5  
   TAM  SINOS  
   FMHR  WYS  
   TAO  $  
   FCSQ  COSOS  
   TMQ  SINOS  
   JPM  ARCCTANS  
   TAM  XNODES  
   TMO  AXOS  
   FMHR  AXOS  
   TMO  AYNOS  
   FMAD  AXNOS  
   TAM  ESOS  
   S  FSORT  $  
   TAM  EDOS  
   TMA  F/1S  
   FMS  ESOS  
   TAM  AUS  
   S  FSORT  $
<table>
<thead>
<tr>
<th>Line</th>
<th>Instruction</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>XYZS9X JMP</td>
<td>(P) S</td>
</tr>
<tr>
<td>2</td>
<td>XYZK25 TMA</td>
<td>XYZS9X S</td>
</tr>
<tr>
<td>3</td>
<td>TMQ F/.06</td>
<td>$</td>
</tr>
<tr>
<td>4</td>
<td>TMQ ED</td>
<td>$</td>
</tr>
<tr>
<td>5</td>
<td>JAGQF (P)+3H</td>
<td>$ COMPUTE D IF E LESS THAN .06</td>
</tr>
<tr>
<td>6</td>
<td>TMA F/0</td>
<td>$</td>
</tr>
<tr>
<td>7</td>
<td>JMP NODTERM</td>
<td>SET D = 0</td>
</tr>
<tr>
<td>8</td>
<td>TMA XYZND</td>
<td>$</td>
</tr>
<tr>
<td>9</td>
<td>TMQ XNO</td>
<td>$</td>
</tr>
<tr>
<td>10</td>
<td>JAGQF (P)+3H</td>
<td>$ K=66</td>
</tr>
<tr>
<td>11</td>
<td>TMQ F/13.8</td>
<td>$ K=66</td>
</tr>
<tr>
<td>12</td>
<td>JMP (P)+5H</td>
<td>$</td>
</tr>
<tr>
<td>13</td>
<td>TMQ F/3</td>
<td>$</td>
</tr>
<tr>
<td>14</td>
<td>FMARS A</td>
<td>$</td>
</tr>
<tr>
<td>15</td>
<td>FAM XYZND</td>
<td>$</td>
</tr>
<tr>
<td>16</td>
<td>FMHR C</td>
<td>$</td>
</tr>
<tr>
<td>17</td>
<td>FDA 1UVA</td>
<td>$</td>
</tr>
<tr>
<td>18</td>
<td>FMHR C</td>
<td>$</td>
</tr>
<tr>
<td>19</td>
<td>NODTERM TAM</td>
<td>DTERM = END COMPUTING D</td>
</tr>
<tr>
<td>20</td>
<td>TMQ F/1.5</td>
<td>$ START COMPUTING A</td>
</tr>
<tr>
<td>21</td>
<td>FMHR DTERM</td>
<td>$</td>
</tr>
<tr>
<td>22</td>
<td>TMQ T</td>
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<td>23</td>
<td>FMAR</td>
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<td>FAM C</td>
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<td>25</td>
<td>FMAR</td>
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EDIT OF OBSERV 01 10 65
PAGE 99

INCA XZB67  $  
JAED (P)+2W  $  
JMP XYL+1W  $  

XYZLB2 TMO SINEOS  
FMHR AYNs  
TMQ COSEOS  
FMAD AXNS  
TAM ESCOSE  

tq $  
FSA $  
TMO A5  
FMHRS RS  
TQA $  
FDA RS  
TQM ARS  
TMA RTAS  
FDAS SINUS  
FMRS RTESOS  
TAM RVDOTS  
FAM RTESOS  
TAM SINUS  
TMA ESINES  
FMAS SINUS  
FCAS AXNS  
THQ SINUS  
FMAD AYNs  
FAM COSEOS  
THQ ARS  
FHSRS COSUS  
FCASM AXNS  
TAO $  
FCASM AYNs  
FMAD SINUS  
FAM SINEOS  
THQ AYNs  
FHSRS SINUS  
THQ COSUS  
FMHR XNXS  
TMO SINUS  
FMAD XMXS  
TAM UXS  
FMHR XNXS  
THQ COSUS  
FMSU XMXS  
TAM XYS  
FMHR XMXS  
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THQ XNUS  
FMHR XMXS  
TAM UZS  
THQ R6  
FMHR UXS  
TAM X6  
FMHR UZS  
TAM Z6  
THQ RDOTS  
FMAD VXS  
TAM XDOTS  
FMHR VYS  
THQ RDOTS  
FMAD UYS  
TAM YDOTS  
FMHR UZS  
THQ RVDOTS  
FMAD VZS  
TAM ZDOTS  
THQ ZDOTS  

C ARCTAN TJM ONODES$  
TAM ONODE10$  
TDM ONODE10+1S  
TMA F/1S  

NODE ACCORDING TO USED. THE A.O.D REGISTERS 
ENTRY 

10TH. SIGNIFICANT DECIMAL DIGIT 

EDIT OF OBSERV 01 10 65
PAGE 100

FMSU XMXS  
TAM VYS  
FMHR XMXS  
TAM VZS  
THQ XNUS  
FMHR XMXS  
TAM UZS  
THQ R6  
FMHR UXS  
TAM X6  
FMHR UZS  
TAM Z6  
THQ RDOTS  
FMAD VXS  
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FMAD UYS  
TAM YDOTS  
FMHR UZS  
THQ RVDOTS  
FMAD VZS  
TAM ZDOTS  
THQ ZDOTS  

XYZLB7 JMP XZB67X$  

FMRS RTESOS  
TAM RVDOTS  
FAM RTESOS  
TAM SINUS  
TMA ESINES  
FMAS SINUS  
FCAS AXNS  
THQ SINUS  
FMAD AYNs  
FAM COSEOS  
THQ ARS  
FHSRS COSUS  
FCASM AXNS  
TAO $  
FCASM AYNs  
FMAD SINUS  
FAM SINEOS  
THQ AYNs  
FHSRS SINUS  
THQ COSUS  
FMHR XNXS  
TMO SINUS  
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THQ RVDOTS  
FMAD VZS  
TAM ZDOTS  
THQ ZDOTS  

C ARCTAN TJM ONODES$  
TAM ONODE10$  
TDM ONODE10+1S  
TMA F/1S  
NODE ACCORDING TO 
ENTRY 

10TH. SIGNIFICANT DECIMAL DIGIT 

SUBROUTINE.....
**Generalized Subroutine to Convert Any Floating Point Number to Its Fractional and Integral Parts.**

**Points to Remember:**
- Numbers in Acc. at Entry, Integer in Acc., Fraction in Q Reg. on Exit.

```plaintext
C SEPSUB
TJM SEPSUBxS
TMH SEPSUB3S
TMO 1/11110/43T47S
JAGQ SEPSUB1S
TAG $  
ETA 1/1136S
JAZ (P)*4/nS
TMO SEPSUB3S
JMP SEPSUBxS
ETA 1/11174S
SLA 2S
AM C/CAIC/SLAQN*12S
TAM SEPSUB2S
SAG 12S
L SEPSUB2 CA $ 
SLAQ 12S
AM 0/2S
TAM SEPSUB2S
TMO SEPSUB3S
JOP (P)*4/nS
FCSQ $ 
TAG $ 
FCSM SEPSUB3S
JMP (P)*4/nS
FCAQ $ 
TAQ $ 
FCAM SEPSUB2S
SEPSUBXJMP 0S
SEPSUB1TMO F/0S
THM SEPSUB3S
JMP SEPSUBxS
SEPSUB3S
```

**Constants Must Follow**

- 

```plaintext
MJ3A0J2F/2.1251E-3S
IXY VCONS F/98.67401S
FX/278.67975S
F/-3.5728S
F/99.18222S
F/279.1879S
F/98.94349S
F/278.9491S
F/-2.8431J
F/99.42094S
F/279.4267S
F/98.70477S
F/278.7104S
```

**Note:**

- A-1 HLT REMOVED
- XYSBZ S
- XYSNO F/0,72722025S
- YCONS F/98.67401S
- F/278.67975S
- F/3.5728S
- F/99.42094S
- F/279.4267S
- F/-2.8431J
- F/99.18222S
- F/279.1879S
- F/98.94349S
- F/278.9491S
- F/-2.8431J
- F/98.70477S
- F/278.7104S
CONVERT TO DAYS ELAPSED.

MINUTES, FRACTION OF HOURS.

JUMP TO FINAL OUTPUT PHASE.

AND TRY(IF RE CONTINUE ON OR FINISH AJJ K=1

READ T8 AND WRITE 9

READ AND WRITE COMMANDS.

READ AND WRITE

FINISH AJJ K=1

READ T8 AND WRITE 9

READ AND WRITE COMMANDS.
EDIT OF OBSERV 01 10 65

TDM 1.6X $ REMAINDER OF
SIXOL 3.2X $ REMAINder DATA
TMD C/HLT, AJBFXX+128/IC/HLT, AJDOCTOR $ ON TAPE.
AIXJ 0.6X $ NEW TAPE.
SIXOL 128.6X $
JMP AJT89 $
TMD C/HLT, 0IC/HLT, AJDORTT $
SIXJ 0.3X $
JMP AJREWP $
AJDORRTTMD C/JMP, SYSIC/TIO, 0.2X $
TDM AJT89+1 $

CD 0.3X $
SD 7 $
TDXL 0.3X $

AJMGC JMP AJT89 $
AIXOL 128.2X $
TMD C/HLT, 0IC/HLT, AJMGC $
SIXJ 1.6X $
TMD C/JMP, SYSIC/TIO, AJBFXX $
TDM AJT89+1 $

JMP AJREWP $
AJDOTPRPTAA $

TMD 1.5X $ REMAINDER OF TAPE DATA
TDM 1.6X $
TMD C/HLT, AJBFXX+128/IC/HLT, AJDOTPE $
AIXJ 0.6X $
SIXOL 128.6X $
SIXOL 128.5X $
JMP AJT89 $
TMD C/HLT, 0IC/HLT, AJDAPRTT $
SIXJ 1.4X $
TMD C/JMP, SYSIC/TIO, AJBFXX $
TDM AJT89+1 $
AJDAPRTMD C/JMP, SYSIC/TIO, AJBFXX $
TDM AJR89+1 $
JMP AJR89 $
TMD C/HLT, 0IC/HLT, AJDAPRTT+1 $
SIXJ 1.4X $
TMD C/JMP, SYSIC/TIO, AJBFXX $
TDM AJR89+1 $

AJREWTPM C/HLT, 0IC/HLT, SYSTAR+8 $
TMA $/NT23/JH/BA747 $
JMP REWIND $
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JMP REWIND $"
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