TECHNICAL MEMORANDUM
(TM Series)

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General Purpose
Satellite Computer Program Descriptions
Milestone 11
Time Check (TCK)
by
C. M. Chiodini
14 November 1962
Approved
B. G. Ciaccia

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A-1259
SUBROUTINE IDENTIFICATION
A. Title: TCK, Time Check, Identification G31, Mod. 01.

PURPOSE
TCK deletes Tracking Data Points from the Constant Pool of the user function when the component times (T) are out of range or out of order.

USAGE
A. Calling Sequence.
   \begin{verbatim}
   L   SLJ  4   TCK
   L+1  NOP   T
   NOP   AZ
   L+2  NOP   EL
   NOP   SR
   L+3  Normal return
   \end{verbatim}

   where:
   T, AZ, EL, and SR are the beginning addresses of the tracking point components in the Constant Pool of the user function.

B. Input Parameters.
1. A Register: LIST TEST value. A zero value will result in an off-line listing of the deleted times modulo 86400 seconds. Any non-zero value in LIST TEST will bypass the output.
2. Q Register: The pass duration in floating point seconds if UHF Data (Format=3) is to be processed.
3. NT: The number of tracking data points. This integer item is in the Reference Pool.
4. FORMAT: The type of radar. This integer item is in the Reference Pool.
14 November 1962

ITEM VALUE | DATA TYPE
--- | ---
0 | Mod 2
1 | Doppler (Range-Rate)
2 | TIME
3 | UHF

5. Tracking data points in the Constant Pool of the user function.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DEFINITION</th>
<th>FORMAT</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Machine Time</td>
<td>Floating Point</td>
<td>Seconds</td>
</tr>
<tr>
<td>AZ</td>
<td>Azimuth</td>
<td>Floating Point</td>
<td>Radians</td>
</tr>
<tr>
<td>EL</td>
<td>Elevation/Range</td>
<td>Floating Point</td>
<td>Radians</td>
</tr>
<tr>
<td>SR</td>
<td>Slant Range</td>
<td>Floating Point</td>
<td>Feet</td>
</tr>
</tbody>
</table>

C. Output.

1. The number of valid tracking data points, NT in the Reference Pool.

2. A set of revised points in the Constant Pool of the user function with bad points deleted.

3. An off-line listing (on Tape 3) of component Times in the tracking data array which were out of range or out of order. This output is optional, dependent upon the LIST TEST value.

4. User Functions.

   ASCENT
   DATLAP
   COORD
   NBURN
   COMPARE
   REDUCE
   REENTRY

METHOD

TCK is subdivided into 4 major program regions and an internal output subroutine. In the first region, TCK obtains input parameters from the user function calling sequence and modifies program steps for data point processing. It also determines the type of data to be processed, and defines a delta time for the given type. In the second region, TCK determines if the component times in the point array are in
ascending order. A point whose time is out of order is deleted from the tracking data point array in the Constant Pool of the User Function. TCK then checks for missing data points in the third program region and computes a time range, upper and lower limit, for each of the component times in the array. A final range is then formulated and any point whose time is not within the range is also deleted from the tracking data set. An output of the rejected time is written on tape, if requested, by the TCK internal output subroutine.

RESTRICTIONS

A. The maximum number of points processed by TCK is contingent upon the Constant Pool tracking data allocation of the user function. The minimum number of points processed by TCK is two (2). If there is one point or less, TCK exits to the normal return address of the user function.

B. Index registers 1, 5 and 6, pre-TCK entry values, are saved and restored at the completion of TCK operation.

C. The Reference Pool items NT and FORMAT must be set prior to TCK operation. TCK uses NT to process all the data points and resets this item with the number of valid points upon completion. FORMAT (radar data type) is used by TCK to define a delta time (Δt) for range determination and to ascertain if Doppler (FR and T) data or other type data points (SR, EL, AZ, and T) are to be processed.

D. Since the component times in the tracking data point array must be in machine time, routine TEDIT, or a similar conversion routine, must be executed prior to TCK. TEDIT converts time from fixed point integer seconds to floating point machine time.

E. The components of the tracking data point (T, AZ, EL, SR), must be in parallel structured tables in the Constant Pool of the user function.

F. Two cells of COMMON are used in TCK operation.
G. The following subroutines are used by TCK:

<table>
<thead>
<tr>
<th>subroutine</th>
<th></th>
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<tbody>
<tr>
<td>FIX</td>
<td>OUTERR</td>
</tr>
<tr>
<td>FLOAT</td>
<td>OUTPUT</td>
</tr>
</tbody>
</table>

**TIMING**

TCK program execution time is dependent upon: (1) the number of points processed, (2) the number of times within a given range, (3) the number of times outside a given range, (4) the number of times not in ascending order, and (5) the off-line list option. Approximately 1146.7 milli-seconds are required to process 200 valid tracking data points by TCK.

**STORAGE REQUIREMENTS**

A. Program Allocation.

<table>
<thead>
<tr>
<th>Component</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Steps</td>
<td>135 cells</td>
</tr>
<tr>
<td>Storage</td>
<td>12 cells</td>
</tr>
<tr>
<td>Constants</td>
<td>8 cells</td>
</tr>
<tr>
<td>TOTAL</td>
<td>155 cells</td>
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B. Program Storage.

<table>
<thead>
<tr>
<th>TAG</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>TCK901</td>
<td>Delta Time ($\Delta t$)</td>
</tr>
<tr>
<td>TCK902</td>
<td>Current Upper Limit</td>
</tr>
<tr>
<td>TCK903</td>
<td>Current Lower Limit</td>
</tr>
<tr>
<td>TCK904</td>
<td>Final Upper Limit</td>
</tr>
<tr>
<td>TCK905</td>
<td>Final Lower Limit</td>
</tr>
<tr>
<td>TCK906</td>
<td>Time Factor</td>
</tr>
<tr>
<td>TCK907</td>
<td>Count</td>
</tr>
<tr>
<td>TCK908</td>
<td>FORMAT value -1</td>
</tr>
<tr>
<td>TCK950</td>
<td>Program loop control to process all points in the data array.</td>
</tr>
<tr>
<td>TCKMPTS</td>
<td>Number of missing points</td>
</tr>
<tr>
<td>TCKSUM</td>
<td>Summation of mission points in the data array</td>
</tr>
<tr>
<td>TCKXRI</td>
<td>Relative position of a given time in the array</td>
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</table>
C. Program Constants.

<table>
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<tr>
<th>TAG</th>
<th>DESCRIPTION</th>
<th>FORMAT</th>
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<tbody>
<tr>
<td>TCK951</td>
<td>Output list heading &quot;TIME CHECK&quot;</td>
<td>Binary Coded</td>
<td>Decimal</td>
</tr>
<tr>
<td>F1</td>
<td>Constant used in Missing Point Check(1.0)</td>
<td>Floating Point</td>
<td></td>
</tr>
<tr>
<td>F2</td>
<td>Delta Time for Doppler data (2.0)</td>
<td>Floating Point</td>
<td>Seconds</td>
</tr>
<tr>
<td>F3</td>
<td>Delta Time for TIML8 or MODII data (4.0)</td>
<td>Floating Point</td>
<td>Seconds</td>
</tr>
<tr>
<td>F.5</td>
<td>Time increment (.5)</td>
<td>Floating Point</td>
<td>Seconds</td>
</tr>
<tr>
<td>LIMMPTS</td>
<td>Limit for the number of missing point between successive times in the array (15.0)</td>
<td>Floating Point</td>
<td></td>
</tr>
<tr>
<td>MZERO</td>
<td>Program Mask used to complement arithmetic values (7777 7777 7777 7777)</td>
<td>Octal</td>
<td></td>
</tr>
<tr>
<td>D86400</td>
<td>Number of seconds in a 24 hour period (86400)</td>
<td>Fixed Point</td>
<td>Seconds</td>
</tr>
</tbody>
</table>

TRANSFER FUNCTION

A. Terms and Definitions

1. i, j, k, l, m, p = indexers to specify any given point in the tracking data array (relative position). In general, these indexers have a range from 0 to NT-1 or as indicated.

2. NT = Number of tracking data points

3. FORMAT = Type of radar
   0 = Mod II
   1 = Doppler (Range-Rate)
   2 = TIML8
   3 = UHF
4. \( t \) = Delta time
Doppler = 2 seconds
Mod II, TLM18 = 4 seconds
UHF = \( \frac{\text{Pass Duration}}{NT-1} \) seconds

5. Tracking Data Point
\( T \) = Time
\( EL \) = Elevation (Range-Rate for Doppler)
\( AZ \) = Azimuth (not used for Doppler)
\( SR \) = Slant Range (not used for Doppler)

6. FLL = Final Lower Limit
7. FUL = Final Upper Limit
8. LIMMPTS = Limit for number of missing points
   (See Program Constants)

9. LISTTFST = Output List Option Indicator

B. Ascending Order Check. Perform until points are in order.
1. If \( T_{i+1} > T_i \) for all \( i \) (1 to 0, ..., NT-2) Points are in order.
2. If \( T_{i+1} \leq T_i \) for any \( i \) A point is out of order
   Find worst point \( K > j \) such that:
   Eliminate point \( K \)

\[
\frac{\sum p_k + K-(NT-1)}{p=0} \geq \frac{\sum p_j + j-(NT-1)}{p=0}
\]
(See Note)

where:
\( \alpha_k = 1 \) if \( T_p > T_k \)
\( \alpha_k = 0 \) if \( T_p \leq T_k \)
\( \alpha_j = 1 \) if \( T_p > T_j \)
\( \alpha_j = 0 \) if \( T_p \leq T_j \)

C. Range Determination and Check
1. Compute Range (FLL, FUL)

\[
j=NT-1 \quad j=NT-1
\]
\[
\text{Find } i > l \text{ such that } \sum_{j=0}^{NT-1} a_{ij} \geq \sum_{j=0}^{NT-1} a_{lj}
\]
where: $\beta_{ij} = 1$ if $T_1[[0.5+\Delta t(i+Dsum)]<T_j<T_1+\Delta t(NT-1-i)]$

$\beta_{ij} = 0$ otherwise

$\beta_{lj} = 1$ if $T_j[[0.5+\Delta t(l+Dsum)]<T_j<T_1+\Delta t(NT-1-i)]$

$\beta_{lj} = 0$ otherwise

$p = NT-2$

$Dsum = \sum_{p=0}^{p} dp$

$dp = 0$ if $\frac{T_{p+1}-T_l}{\Delta t} -1 > LTIMEPTS$

$dp = \frac{T_{p}-T_l}{\Delta t} -1$ otherwise

\[ J = NT-1, \ j = NT-1 \]

\[ \sum_{j=0}^{j=NT-1} \beta_{ij} > \sum_{j=0}^{j=NT-1} \beta_{lj} \]

\[ J = NT-1, \ j = NT-1 \]

\[ \sum_{j=0}^{j=NT-1} \beta_{ij} \]

Set:

\[ FLL = T_1 - \Delta t(i+Dsum) \]

\[ FUL = T_1 + \Delta t(NT-1-i) \]

\[ J = 0, \ j = 0 \]

\[ \Delta T \]

\[ \Delta T \]

Point is in range.

Point is out of range.

Eliminate point K (See Note)

Note: To eliminate point K

1. For $m = K, K+1, .... NT-2$

a. If FORMAT = 1

Set

\[ T_m = T_{m+1} \]

\[ X_l = X_{l+1} \]
b. If FORMAT ≠ 1

Set:  
\[ T_m = T_{m+1} \]
\[ E_{L_m} = E_{L_{m+1}} \]
\[ A_{Z_m} = A_{Z_{m+1}} \]
\[ S_{R_m} = S_{R_{m+1}} \]

2. Reduce number of points

Set:  \[ NT = NT - 1 \]

3. If LISTTEST = 0

List Time Eliminated
off-line

VALIDATION TESTS

A test routine was written to provide input parameters to TCK and to output program results utilizing the COP Defines function. Ten tests were run consisting of a set of ten tracking data points for each type of data. In addition, several tests of 200 points were made to validate the missing point computations in TCK. After analysis of the test results, given data points were deleted from the tracking data array when a component time was out of order or out of the computed range. In a like manner, no points were rejected when the time interval between successive points was other than nominal and when the number of missing points was not greater than the program limit of 15 points. The program option to list "bad" times was exercised and operated correctly. The number of points (NT in the Reference Pool) was also updated correctly for each point rejected by TCK.

REFERENCE

A. IMSD-447578, 1604 Systems Manual

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<td>50.05.01</td>
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<td>CCOORD</td>
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<td>REDUCE</td>
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</thead>
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<td>55.50.25</td>
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<td>DATLAP</td>
<td>55.60.01</td>
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</tbody>
</table>

C. TM-(L)-715/008/00, General Purpose Satellite Control Program Description of FIX.

D. TM-(L)-715/009/00, General Purpose Satellite Control Program Description of FLOAT.
FLOW CHART

Terms and Definitions:

1, j, k = An integer to specify any given element in the tracking data array (relative position). This value has a range of 0 through NT-1 and is set as indicated.

NT = Number of tracking data points

At = Delta Time

Doppler = 2 seconds

MODII, TIM18 = 4 seconds

UHF = Pass Duration \( \frac{NT-I}{NT-1} \) seconds

Tracking Data Point

T = Time

Doppler (Range-Rate)

EL = Elevation

AZ = Azimuth

SR = Slant Range

D = The number of missing points between two successive times.

\( D_{SUM} \) = The summation of missing points in the tracking data set.

TF = Time Factor

CLL = Current Lower Limit

CUL = Current Upper Limit

COUNT\(_p\) = Previous Count

COUNT\(_e\) = Current Count

\((T>CLL)\) = An integer denoting the number of Times in the array which are greater than the current lower limit.

\((T>CUL)\) = An integer denoting the number of Times in the array which are greater than the current upper limit.

\(NTGT_1\) = An integer denoting the number of Times in the tracking data set which are greater than a given time in the set\( (T_1) \).

FLL = Final Lower Limit

FUL = Final Upper Limit
TCK Entry

Save: i, j, k

Set:
Common = A Register
(List Test Value)

Set:
Common + 1 = Q Register
(Pass Duration)

Store Input Parameters For Processing And To Facilitate Bad Point (Range) Deletions

Set:
Normal Return Address

A
Modify Input Locations To Facilitate Point Deletion Of Points Whose Times Are Out Of Order

Is NT=0 Or 1 ?

YES TCK Exit

NO

Modify Program Steps To Process All Tracking Data Points

TCK .5

FLOAT

Convert NT-1 To Floating Point

Initialize Count_p

B
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Doppler Data

Format = 1?

Doppler Data

NO

YES

Format = 3?

UHF Data?

NO

YES

TCK2

Format = 0 Or 1

MODII Or TML8

Set: Δt = 4 Seconds

Set: Δt

MODII Or TML8

Set: TCK6

Δt = 2

Seconds

TCK3

Store:

Δt

Common = 0?

Output List

YES

Output

"Time Check"

NO

Err In

Output Routine?

YES

TCK Halt

NO

TCK66
Is NT = 0 Or 1? 

Set: i = \emptyset

Restore: i, j, k. To Pre-TCK Entry Values

TCK Exit

TCK66

TCK69

TCK67

TCK70

TCK71

TCK67

TCKMC

Set: i = NT-1

k = 0

Count = 0
Compute:
Count\(_c\) =
NET\(_{i+1}\) + \(i - (NT-1)\)

\(\text{Count}_c \neq \text{Count}_p\)?

YES

Set:
\(\text{Count}_p = \text{Count}_c\)

\(k = i\)

TCK74.1

\(i = 0\) ?

YES

Common = 01
Output List

TCK74.2

NO

TCK300

Output Rejected Time

TCK75

TCK71
Set:
\[ T_k = T_{k+1} \]
\[ E_L_k = E_{L_{k+1}} \]

Format = 1? Doppler Data

YES

TCK76

k = NT-1?

NO

Set:
\[ k = k + 1 \]

Set:
\[ NT = NT - 1 \]

TCK66

NO

Set:
\[ AZ_k = AZ_{k+1} \]
\[ SR_k = SR_{k+1} \]
Set:
\[ i = 0 \]
\[ \text{Count}_p = 0 \]
\[ D_{\text{sum}} = 0 \]

Compute:
\[ D_i = \frac{T_{i+1} - T_i}{\Delta t} - 1 \]

If \( D_i > 15 \) then YES, go to TCKMC2.
If \( D_i \leq 15 \) then NO, go to TCKMC3.

Set:
\[ D_{\text{sum}} = D_{\text{sum}} + D_i \]

Set:
\[ D_i = 0 \]

Set:
\[ D_{\text{sum}} = D_{\text{sum}} + D_i \]
TCK300

Save: i

FIX
Convert FixeTo Fixed Point

Err in Fix Sub-
routine? YES

SUBERR
Output Err
Information On
1512 Printer

NO

TCK305

Compute:
\[ \frac{\vert T \vert}{86400} \]

Store: Remainder In Storage
Call TCK907
Restore: i

TCK302
TCK802

Time < 0?  

YES  

Set: TCK907 = 56400 - TCK907

NO  

TCK804

Output

Output Rejected
Time On Tape 3

Err In The
Output Sub-
routine?

YES  

OUTERR
Output Err Information On 1612 Printer

NO

Was Time Rejected Because Of Range?

YES  

TCK62.5

NO

Order Check Reject

TCK75
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   H. D. Gilman

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   W. L. Massey

PIR-E4 (GE - Box 8661)
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14 November 1962
### Distribution List (cont.)

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System Development Corporation,  
Santa Monica, California  
GENERAL PURPOSE SATELLITE COMPUTER  
PROGRAM DESCRIPTIONS MILESTONE II  
TIME CHECK (TCK).  
Scientific rept., TM(L)-714/012/00,  
by C. M. Chiodini. 14 November 1962,  
22p.  
(Contract AF 19(628)-1648, Space Systems  
Division Program, for Space Systems  
Division, AFSC)  

Unclassified report  

DESCRIPTORS: Satellite Networks.  
Programming (Computers).  

Reports that TCK (Time Check)  
deletes Tracking Data Points from  
the Constant Pool of the user  
function when the component times (T)  
are out of range or out of order.  

UNCLASSIFIED