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-1159
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.

```
   L  SLJ  TCK
   L+1  NOP  T
         NOP  AZ
   L+2  NOP  EL
         NOP  SR
   L+3  Normal return
```

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.
ITEM VALUE       DATA TYPE
0                 Mod 2
1                 Doppler (Range-Rate)
2                 TIML8
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/Rate</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.

<table>
<thead>
<tr>
<th>ASCENT</th>
<th>DATLAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCOORD</td>
<td>NBURN</td>
</tr>
<tr>
<td>COMPARE</td>
<td>REDUCE</td>
</tr>
</tbody>
</table>

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 $\Delta t$
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:

- FIX
- OUTERR
- FLOAT
- OUTPUT
- SUBERR

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.

- Program Steps: 135 cells
- Storage: 12 cells
- Constants: 8 cells
- TOTAL: 155 cells

B. Program Storage.

<table>
<thead>
<tr>
<th>TAG</th>
<th>DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td>TCK901</td>
<td>Delta Time (Δt)</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>
</tr>
</tbody>
</table>
C. Program Constants.

<table>
<thead>
<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>
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<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>F4</td>
<td>Delta Time for TML8 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 = TML8
   3 = UHF
4. \( t = \text{Delta time} \)
   Doppler = 2 seconds
   Mod II, TLM18 = 4 seconds
   UHF = \text{Pass Duration} \) seconds

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

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

9. LISTTFST = \text{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\text{=}0, 1, \ldots, 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 \( K \)
   \[
   \sum_{p=0}^{p=NT-1} \alpha_{pk} + K-(NT-1) \geq \sum_{p=0}^{p=NT-1} \alpha_{pj} + j-(NT-1)
   \]
   where:
   \( \alpha_{pk} = 1 \) if \( T_p > T_k \)
   \( \alpha_{pk} = 0 \) if \( T_p \leq T_k \)
   \( \alpha_{pj} = 1 \) if \( T_p > T_j \)
   \( \alpha_{pj} = 0 \) if \( T_p \leq T_j \)

C. Range Determination and Check
1. Compute Range (FLL, FUL)
   \[
   \sum_{j=0}^{j=NT-1} \beta_{ij} \geq \sum_{j=0}^{j=NT-1} \beta_{lj}
   \]
where: \( \beta_{ij} = 1 \) if \( T_i^1 + 0.5 \Delta t (i + D_{\text{sum}}) < T_j^1 + \Delta t (NT-1-i) \)

\( \beta_{ij} = 0 \) otherwise

\( \beta_{lj} = 1 \) if \( T_i^j + 0.5 \Delta t (j + D_{\text{sum}}) \leq T_j^j + \Delta t (NT-1-i) \)

\( \beta_{lj} = 0 \) otherwise

\( p = NT-2 \)

\( D_{\text{sum}} = \sum_{p=0} dp \)

\( dp = 0 \) if \( \frac{T_{i+1}-T_i}{\Delta t} - 1 > \text{LIMPTS} \)

\( dp = \frac{T_{i+1}-T_i}{\Delta t} - 1 \) otherwise

\( j = NT-1 \)

a. If \( \sum_{j=0}^{NT-1} \beta_{ij} > \sum_{j=0}^{NT-1} \beta_{lj} \)

b. If \( \sum_{j=0}^{NT-1} \beta_{ij} = \sum_{j=0}^{NT-1} \beta_{lj} \)

2. Examine all points \( K \)

a. If \( \text{FLL} < T_i^K < \text{FUL} \)

b. If \( T_i^K < \text{FLL} \)

or

\( T_i^K > \text{FUL} \)

2 points is in range.

Point is out of range. Eliminate point \( K \) (See Note)

Note: To eliminate point \( K \)

1. For \( m = K, K+1, \ldots, NT-2 \)

a. If \( \text{FORMAT} = 1 \)

\( \text{Set } T_m = T_{m+1} \)

\( \text{Set } K_m = K_{m+1} \)
If FORMAT ≠ 1

Set: $T_m = T_{m+1}$

$E_{m} = E_{m+1}$

$AZ_m = AZ_{m+1}$

$SR_m = SR_{m+1}$

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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<th>PROGRAM</th>
<th>PAGE</th>
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<tr>
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<td>45.10.01</td>
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<td>OUTERR</td>
<td>50.05.01</td>
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<tr>
<td>SUBERR</td>
<td>50.06.01</td>
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<tr>
<td>CCOORD</td>
<td>55.05.21</td>
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<tr>
<td>REDUCE</td>
<td>55.25.29</td>
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<table>
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<th>PAGE</th>
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</thead>
<tbody>
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<td>3.2.1</td>
</tr>
<tr>
<td>NBURN</td>
<td>3.4.1</td>
</tr>
<tr>
<td>REENTRY</td>
<td>3.6.1</td>
</tr>
</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:
i, 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
Δt = Delta Time
Doppler = 2 seconds
MODII, TLM18 = 4 seconds
UHF = Pass Duration

Tracking Data Point
T = Time
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 = An integer denoting the number of Times in the tracking data set which are greater than a given time in the set(T_i).

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

B
Doppler Data

Format = 1?
Doppler Data

YES

TCK6

Set: \( \Delta t = 2 \) Seconds

TCK3

Store: \( \Delta t \)

Common = 0?
Output List

YES

Output
"Time Check"

ERR IN
Output Routine?

YES

TCK Halt

NO

TCK66

Format = 3?
UHF Data?

NO

YES

TCK2

Format = 0 Or 1
MODII Or TML8
Set: \( \Delta t = 4 \) Seconds

Set: \( \Delta t = \) FSDUR
NT-1
Seconds
Compute:
Count\(_c\) =
NGT\(_i\) + i -
(NT-1)

Set:
Count\(_p\) = \(\frac{\text{Count}\_c}{\sqrt{k}}\)
\(k = i\)

Common = 0?
Output List

Output Rejected Time
Set:
\[ i \times 0 \]
\[ \text{Count}_p = 0 \]
\[ D_{\text{sum}} = 0 \]

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

\[ D_i > 15 \]

Set:
\[ D_i = 0 \]

Set:
\[ D_{\text{sum}} = D_{\text{sum}} + D_i \]
Compute: \( TF = 0.5 + \Delta t \left[ b_{sum} + (N-1) \right] \)

Set: \( i = 1 + 1 \)

Set: \( i = 0 \)

Compute: \( CLL = T_1 - \left[ 0.5 + \Delta t \left( i + b_{sum} \right) \right] \)

\( \text{CUL}_1 = \text{CLL} + TF \)

Compute: \( \text{Count}_c = N \times \left( T > \text{CUL} \right) + \left( T > \text{CLL} \right) \)
TCK55

Count > Count

TCK58

Set:
PUL = CUL
FLL = CLL
Count = Count

TCK56

i = NT-1?

TCK60

Set:
i = i+1

TCK61

Set:
i = 0
j = 0

TCK60.1

TCK59

Count = Count

TCK59

Set:
PUL = CUL
TCK60.1

\( T_1 < FUL \) And \( T_2 \geq FLL \)

Set:
\( T_j = T_1 \)
\( E_{L_j} = E_{L_1} \)

Format = 1?
Doppler Data

\( \text{YES} \)

\( \text{Output List} \)

\( \text{YES} \)
Output Rejected

\( \text{NO} \)
Common = 0?

\( \text{YES} \)
Output List Rejected

\( \text{NO} \)
Common

TCK62

TCK62.5

Set:
\( N_T = N_T - 1 \)

TCK65

\( \text{Set:} \) \( j = j + 1 \)

TCK63

\( i = N_T - 1 \)

\( \text{YES} \)
TCK69

\( \text{NO} \)

Set:
\( i = i + 1 \)

TCK60.1
Save: \( i \)

Convert Time To Fixed Point

Err in Fix Subroutine?

YES

Output Err Information On 1612 Printer

NO

Compute: \( |T| \div 86400 \)

Store: Remainder In Storage
Call TCK307
Restore: \( i \)

TCK202
TCK802

Time < 0?

NO

TCK904

Output

Output Rejected
Time On Tape 3

Err In The
Output Sub-
routine?

NO

OUTERR

Output Err
Information
On 1612 Printer

YES

Was Time
Rejected
Because Of
Range?

YES

TCK62.5

NO

Order
Check
Reject

TCK75

Set:

TCK907 = 56400 - TCK907
External Distribution List

Space Systems Division
(Contracting Agency)
   Major. C. R. Bond (SSOCD)

61594th Aerospace Test Wing
(Contracting Agency)
   Col. A. W. Dill (TWRD)
   Lt. Col. M. S. McDowell (TWRU) (4)
   TWACS

PIR-E1 (Lockheed)
   N. N. Epstein
   C. H. Finnie
   H. F. Grover
   W. E. Moorman
   461 Program Office
   6966K Program Office

PIR-E2 (Philco)
   J. A. Bean
   J. A. Issaacs
   R. Morrison
   S. M. Stanley

PIR-E3 (LFE)
   D. F. Criley
   K. B. Williams

PIR-E8 (Mellonics)
   F. Druding

PIR-E5 (Aerospace)
   F. M. Adair
   R. O. Brandsberg
   L. H. Garcia
   G. J. Hansen
   C. S. Hoff
   L. J. Kreisberg
   T. R. Parkin
   E. E. Retzlaff
   H. M. Reynolds
   D. Saadeh
   R. G. Stephenson
   V. White

PIR-E7 (STL)
   A. J. Carlson
   R. L. Mills

PIR-E4 (GE - Sunnyvale)
   D. Alexander
   J. Farrentine
   N. Kirby

PIR-E4 (GE - Box 8555)
   J. S. Brainard
   H. G. Klose
   J. D. Selby

PIR-E4 (GE - 3198 Chestnut)
   J. F. Butler
   H. D. Gilman

PIR-E4 (GE - Box 8661)
   J. D. Rogers
## Distribution List

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Phone</th>
<th>Notes</th>
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<tbody>
<tr>
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<tr>
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System Development Corporation, 
Santa Monica, California 
GENERAL PURPOSE SATELLITE COMPUTER 
PROGRAM DESCRIPTIONS MILESTONE 11 
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.