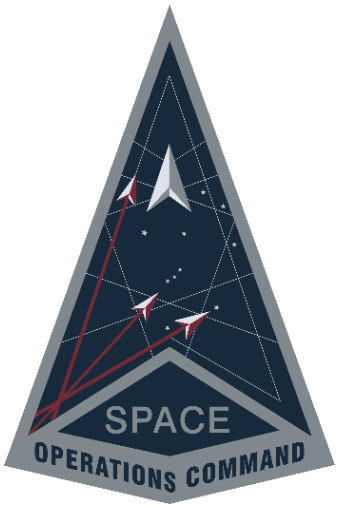
Astrodynamics Standards
Shared Library



Vector Covariance Message (VCM)

Version 9.4

May 2024

Contents

1. Introduction

VCM provides the users with library functions to load and manage satellite state vectors in VCM format.

If you are on Windows, the shared library files will end in ".dll". For example, "Vcm.dll". If you are on Linux, the shared library will begin with "lib" and end in ".so", and will be all lowercase. For example, libvcm.so.

2. Prerequisites

The following libraries MUST be loaded and initialized before using VCM:

- DllMain
- TimeFunc

3. Getting Started

To get started, please read the README.txt file that came in the root directory of your distribution. In addition to an overall description contained in the distribution, it has a description of a "**wrapper**".

To get started with **VCM**, there is a "wrapper" specific to VCM, under the **SampleCode** directory. Under your language of choice, you will see a "**DriverExample/wrapper**" subdirectory. The files under this directory will have all the Application Programming Interfaces (APIs) available. For VCM specific APIs, you should see a source file labelled with "VCM" in the file name. This will be where you will find all the APIs for that specific library. The "DriverExample" directory will also contain several examples of applications that should run by simply running the runExample.bat or runExample.sh script. You can use these examples as a starting point for building your application.

If you do not see your programming language under "SampleCode", look in the HTML documentation for the APIs. Open a browser to the "Documentation/APIDocs/index.html" file. This document will show all the APIs regardless of programming language.

The Astrodynamics Standards libraries should work with any language capable of using Dynamic Link Library (on Windows) or Shared object (on Linux) files.

4. Terminology

The terms SP satellites, VCM satellite, and VCM are used interchangeably in the documentation.

5. Understanding VCM

Internally, this library stores the loaded VCMs in its own binary tree. Each VCM, when added successfully to the binary tree, will receive a unique key. This unique key is commonly called 'satKey' in the documentation. The satKey is used to retrieve the VCM data.

The SP propagator library (SpProp), will have access to the root of the VCM's binary tree. Therefore, the associated VCM data can be retrieved via its satKey.

When loading VCMs into memory, the library will automatically copy the most recent time constants record among the loaded VCMs to the TimeFunc library's time constants buffer (see TimeFunc document).

6. Propagator

VCMs can only work with SP propagator, SpProp.

7. Vector Covariance Message (VCM) Data Description

7.1. What's VCM?

The Vector Covariance Message (VCM) is a Joint Space Operations Center (JSpOC) product constructed in the operational environment. Messages in the VCM format have specific operational implications and should not be constructed or altered by other organizations. It is expected that some users will want to construct their own Special Perturbations vectors and perturbation specifications and such vectors can be created using the more abbreviated B1P, 2P, and 4P control card format described in SPVEC and SP Propagator.

7.2. SP Workstation Vector/Covariance Message (VCM) Format

The message consists of 28 or more lines of data. All data lines are preceded by the 2-character sequence "<>" (less-than, greater-than) to distinguish the message data lines from additional lines that the various communication systems may insert. In the message, all fields must appear within the columns indicated.

The message will be transmitted in JANAP 128 narrative format. The message data lines detailed below will comprise multiple Format Lines 12I (FL12I) per the JANAP 128(J) specification. The message classification is indicated in Format Lines FL2 and FL4 of the message header and in the first line, FL12A, of the message text portion. For an unclassified message, the first 6 characters of line FL12A consist of "UNCLAS", and this line immediately precedes the message data lines detailed below.

The message lines detailed below appear as contiguous lines when created. However, communication system components used in message formatting and delivery may automatically break up address lines plus message body lines into pages of about 20 lines, and insert lines identifying page number, message source, and classification.

In the format, note that:

- "Tabs" and other non-printing characters (except for blanks) are not allowed
- "+" signs may be replaced by blanks
- Leading zeros on numerical fields may be replaced by blanks
- Alphabetic fields may contain blanks
- Character invariants are upper case only (lower case is NOT recognized as equivalent; message normally machine-generated; use caution if manually editing or composing)
- Trailing blanks on a line may be removed during transmission
- Each line will be followed by the JANAP end-of-line sequence (carriage return, carriage return, line feed, commonly represented as [CR][CR][LF])

Note that unlike many Astro Standard file formats, this file format, being externally defined, does not allow comment records (asterisk in column 1) or blank records to appear anywhere within the bounds of the message.

```
Column #:
         1         2         3         4         5         6
12345678901234567890123456789012345678901234567890123456789012345678901234567890

<> SP VECTOR/COVARIANCE MESSAGE - V2.0
<> ttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttt
<> MESSAGE TIME (UTC): yyyy ddd (dd mmm) hh:mm:ss.sss  CENTER: cccc
<> SATELLITE NUMBER: sssss                    INT. DES.: yyyy-lllppp
<> COMMON NAME: nnnnnnnnnnnnnnnnnnnnnnnn
<> EPOCH TIME (UTC): yyyy ddd (dd mmm) hh:mm:ss.sss  EPOCH REV: rrrrr
<> J2K POS (KM):   ±xxxxxx.xxxxxxxx ±yyyyyy.yyyyyyyy ±zzzzzz.zzzzzzzz
<> J2K VEL (KM/S): ±xx.xxxxxxxxxxx ±yy.yyyyyyyyyyy ±zz.zzzzzzzzzzz
<> ECI POS (KM):   ±xxxxxx.xxxxxxxx ±yyyyyy.yyyyyyyy ±zzzzzz.zzzzzzzz
```

```
<> ECI VEL (KM/S): ±xx.xxxxxxxxxxxx ±yy.yyyyyyyyyyyy ±zz.zzzzzzzzzzzz
<> EFG POS (KM):   ±xxxxxx.xxxxxxxx ±yyyyyy.yyyyyyyy ±zzzzzz.zzzzzzzz
<> EFG VEL (KM/S): ±xx.xxxxxxxxxxxx ±yy.yyyyyyyyyyyy ±zz.zzzzzzzzzzzz
<> GEOPOTENTIAL: gggggg mmZ,nnT  DRAG: dddddddddddd  LUNAR/SOLAR: ooo
<> SOLAR RAD PRESS: ooo  SOLID EARTH TIDES: ooo  IN-TRACK THRUST: ooo
<> BALLISTIC COEF (M2/KG): ±x.xxxxxxE±xx BDOT (M2/KG-S): x.xxxxxxE±xx
<> SOLAR RAD PRESS COEFF (M2/KG): ±x.xxxxxxE±xx  EDR(W/KG): ±r.rrE±rr
<> THRUST ACCEL (M/S2): ±x.xxxxxxE±xx  C.M. OFFSET (M): ±x.xxxxxxE±xx
<> SOLAR FLUX: F10: fff  AVERAGE F10: fff  AVERAGE AP: aaa.a
<> TAI-UTC (S): ss  UT1-UTC (S): ±s.sssss  UT1 RATE (MS/DAY): ±s.sss
<> POLAR MOT X,Y (ARCSEC): ±p.pppp ±p.pppp IAU 1980 NUTAT: ttt TERMS
<> TIME CONST LEAP SECOND TIME (UTC): yyyy ddd (dd mmm) hh:mm:ss.sss
<> INTEGRATOR MODE: mmmmmmmmmmmm  COORD SYS: ccccc  PARTIALS: tttttttt
<> STEP MODE: mmmm  FIXED STEP: fff  STEP SIZE SELECTION: ssssss
<> INITIAL STEP SIZE (S): ssss.sss  ERROR CONTROL: c.cccE±cc
<> VECTOR U,V,W SIGMAS (KM):       ±uuuu.uuuu ±vvvv.vvvv ±wwww.wwww
<> VECTOR UD,VD,WD SIGMAS (KM/S):    ±uu.uuuu    ±vv.vvvv    ±ww.wwww
<> COVARIANCE MATRIX (EQUINOCTIAL ELS): (nnxnn) WTD RMS: ±r.rrrrrE±rr
<> ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx
<> ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx
<> ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx
<> ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx
<> ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx ±x.xxxxxE±xx
        :            :            :            :            :
        :            :            :            :            :
```

In the above format:

ttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttttt = Real/Test/Exercise indicator (REAL, TEST, or EXERCISE//45-character exercise name//EXERCISE)

yyyy ddd (dd mmm) hh:mm:ss.sss = Date and UTC time (e.g. 1998 125 (05 MAY) 12:34:56.789)

cccc = Mission center performing the run (CMOC or NAV, may be left blank (four spaces))

sssss = NORAD satellite number

yyyy-lllppp = International Designator (Year of launch, launch #, piece designator)

nnnnnnnnnnnnnnnnnnnnnnnnn = Common name

rrrrr = Epoch revolution number

±xxxxxx.xxxxxxxx = X component of satellite's position (km)

±yyyyyy.yyyyyyyy = Y component of satellite's position (km)

±zzzzzz.zzzzzzzz = Z component of satellite's position (km)

±xx.xxxxxxxxxxxx = X component of satellite's velocity (km/s)

±yy.yyyyyyyyyyyy = Y component of satellite's velocity (km/s)

±zz.zzzzzzzzzzzz = Z component of satellite's velocity (km/s)

gggggg mmZ,nnT = Geopotential model used (one of EGM-96, WGS-84, WGS-72, JGM-2, GEM-T3, NONE, blank), truncated to mm degree zonals, nn degree/order tesserals

dddddddddd = Atmospheric density ("drag") model used (e.g. JACCHIA 70, JACCHIA 64, DCA (left-adjusted))

ooo = ON/OFF/JPL/ALL/BIG/MED/SMA indicator for lunar/solar perturbations; anything except "OFF" and "JPL" means "ON" (caution: case-sensitive, so "off" means "ON")

ON= analytic

JPL = JPL Ephemerides lunar/solar perturbations (JPL file required)

ALL = JPL Ephemerides lunar/solar + all planets perturbations (JPL file required)

BIG = JPL Ephemerides lunar/solar + Jupiter and Venus perturbations (JPL file required)

MED = JPL Ephemerides lunar/solar + Jupiter, Venus, Saturn, Mars, and Mercury perturbations (JPL file required)

SMA = JPL Ephemerides lunar/solar + all planets perturbations except Pluto (JPL file required)

ooo =ON/OFF indicator for solar radiation pressure, solid earth tides, and in-track thrust perturbations; anything except "OFF" means "ON" (caution: case-sensitive, so "off" means "ON")

±x.xxxxxxE±xx = Model parameter value for drag, solar radiation pressure, in-track thrust; or satellite center of mass offset

±r.rrE±rr = Energy Dissipation Rate

fff = F10 (10.7 cm) solar flux or 81-day average F10

aaa.a = Average geomagnetic index

ss = TAI minus UTC offset (s)

±s.sssss = UT1 minus UTC offset, (seconds)

±s.sss =Rate of change of UT1 (milliseconds/day)

±p.pppp = Component of polar motion (arc-seconds)

ttt = Number of terms used in nutation model (4, 50, or 106)

mmmmmmmmmmm = Integrator Mode (SPADOC or ASW)

ccccc = Numerical Integrator coordinate system (J2000 or EPOCH)

tttttttt = Type of partial derivatives used (ANALYTIC, FULL NUM, or FAST NUM)

mmmm = Integrator step mode (AUTO, TIME, or S)

fff = Fixed step size indicator (ON or OFF)

ssssss = Initial step size selection (AUTO or MANUAL)

ssss.sss = Initial integration step size (seconds)

c.cccE±cc = Integrator error control

±uuuu.uuuu = Standard deviation of error in satellite's position, U direction (km)

±vvvv.vvvv = Standard deviation of error in satellite's position, V direction (km)

±wwww.wwww = Standard deviation of error in satellite's position, W direction (km)

±uu.uuuu = Standard deviation of error in satellite's velocity, U direction (km/s)

±vv.vvvv = Standard deviation of error in satellite's velocity, V direction (km/s)

±ww.wwww = Standard deviation of error in satellite's velocity, W direction (km/s)

nnxnn = Size of covariance matrix

±r.rrrrrE±rr = Weighted RMS of last DC on the satellite

±x.xxxxxE±xx = Covariance matrix component

The covariance matrix values represent the lower triangular half of the covariance matrix in terms of equinoctial elements. The size of the covariance matrix is dynamic. The values are outputted in order across each row, i.e.:

Copy

```
 1   2   3   4   5
 6   7   8   9  10
 :   :   :   :   :
 :   :   :   :   :
51  52  53  54  55
 :   :   :   :   :
 :   :   :   :   :
```

The ordering of values is as follows:

Copy

```
      Af   Ag   L    N   Chi  Psi   B   BDOT AGOM  T   C1   C2  ...
Af     1
Ag     2    3
L      4    5    6
N      7    8    9   10
Chi   11   12   13   14   15
Psi   16   17   18   19   20   21
B     22   23   24   25   26   27   28
BDOT  29   30   31   32   33   34   35   36
AGOM  37   38   39   40   41   42   43   44   45
T     46   47   48   49   50   51   52   53   54   55
C1    56   57   58   59   60   61   62   63   64   65   66
C2    67   68   69   70   71   72   73   74   75   76   77   78
 :
 :
```

where C1, C2, etc, are the "consider parameters" that may be added to the covariance matrix. The covariance matrix will be as large as the last element/model parameter needed. In other words, if the DC solved for all 6 elements plus AGOM, the covariance matrix will be 9x9 (and the rows for B and BDOT will be all zeros). If the covariance matrix is unavailable, the size will be set to 0x0, and no data will follow.

7.3. Element Set and Vector Input Examples

Case 15 (job specification number 15 within the overall run specification) of the following example shows the use of a VCM within a batch input file specifying orbits and the times for which they are to be propagated.

SP Vectors, with 4P (EPHEM test case SPEPH.INP):

Copy

```
SPEPH
```

```
*   This set of 15 test cases for SSTS SPEPH evaluation includes the SAIC
*   constructed set of 10 cases (with minor deviations) incorporating the
    famous "naughty-nine" sats along with four additional cases designed
    specifically for SPADOC comparison, plus one for SPECTR compatibility.
*
*              CASE 1: satellite 16991 (280 km decay)
*   6th order STEM68R geopotential; drag model Jacchia 64 with constant flux
GEODIR=C:\V2\
     90  90  15                                                          C    F
*0611                                                                        4P
0311                                                                       4P
86352100754.029 360. 86353100754.029                                       6P
*234567891123456789212345678931234567894123456789512345678961234567897123456789 8
  -691.36316 -6629.20931    12.55177  2589.177025  -245.754333  7284.536689  B1P
16991SP TEST    86352100754.029      0    00.015000000.000000000.00000000     2P
ENDOFJOB
*              CASE 2: satellite 16261 (223 km decay)
*   8th order STEM68R geopotential; drag model Jacchia 70 with constant flux
                                                                           3P
     90  90  15                                                          C    F
*FLXFIL=CONSTANT.FLX
1 16261U SP TEST  86353.00000000  .00300000      0-0  00000-0 6    09
2 16261  51.6109 330.9300 0004064  80.4004  27.0659 16.17848673    08
*ELTFIL=16261.EL6 (modified decimal DOY)
*0812                                                                        4P
0412                                                                       4P
ENDOFJOB
*              CASE 3: satellite 16112 (Moly)
*  12th order WGS72 geopotential; no drag; luni-solar perts (4P in vector file)
                                                                 1440  60  1    3P
121001                                                                     4P
  9762.32299  -982.00665   140.19989  4205.192207  2701.396629  6422.582786  B1P
16112SP TEST    87075014656.955      0    00.000000000.000000000.00000000     2P
*VECFIL=16112.VEC
ENDOFJOB
*              CASE 4: satellite 16111 (580 km)
*    9th order WGS84 geopotential; drag model Jacchia 70 with flux from file
0912                                                                       4P
 67  75  73   5   5   5  10  10  10  20  20                            87        F
 68  75  73  27  24  14   6   8   8   4   5                            87        F
 69  72  73   6   7  29  14  32  24   7   5                            87        F
 70  71  73   6   4   5  10  13  11  13   4                            87        F
 71  70  72  12   9  14  22  13   7   9  30                            87        F
 72  70  72  12   7   9  15  19  10   7   9                            87        F
 73  72  72   8  18  16  15  12   6   9   6                            87        F
 74  71  72   7  19  13  13  10   9   8   9                            87        F
 75  72  72  14   4  17  30  32   7  10   8                            87        F
 76  72  72  14  39  22  11  14  10   7   4                            87        F
 77  73  72   9   5   8   6  12  18  13  29                            87        F
 78  72  72  26  14  10  17  14   9  12  13                            87        F
 79  74  72   6   5   4   8  11  12   8   5                            87        F
 80  75  72   7   6   8  22  27  50  26  64                            87        F
 81  74  72  35   8  14  17  10  12  25  32                            87        F
 82  76  72  17   5   8  14  13  11   8   5                            87        F
 83  76  72   3   3   9  12   7   6   7   4                            87        F
 84  76  73   3   2   3   7   7  18   8  11                            87        F
 85  76  73  15  13  23  24  17  20   7   4                            87        F
 86  76  73  14  30  26  48  40  38  17  10                            87        F
 87  75  73  35  18  16  18  10  13   5   3                            87        F
 88  76  73   4   5  14  13   7   8   7   4                            87        F
*FLXFIL=16111.FLX
            0.                1440.                                        6P
1 16111U SP TEST  87 68.00000000  .00010000      0-0  00000-0 6    04
2 16111  97.9029 133.9498 0065115  30.8970 118.1329 14.81298471    00
ENDOFJOB
*              CASE 5: satellite 13736 (DMSP)
*   12th order special DMSP geopotential from file; Jacchia 70; luni-solar perts
            0.  120          2880.                                        6P
 68  75  73  27  24  14   6   8   8   4   5                            87        F
 69  72  73   6   7  29  14  32  24   7   5                            87        F
 70  71  73   6   4   5  10  13  11  13   4                            87        F
 71  70  72  12   9  14  22  13   7   9  30                            87        F
```

```
 72  70  72  12   7   9  15  19  10   7   9                          87        F
 73  72  72   8  18  16  15  12   6   9   6                          87        F
 74  71  72   7  19  13  13  10   9   8   9                          87        F
 75  72  72  14   4  17  30  32   7  10   8                          87        F
 76  72  72  14  39  22  11  14  10   7   4                          87        F
 77  73  72   9   5   8   6  12  18  13  29                          87        F
 78  72  72  26  14  10  17  14   9  12  13                          87        F
 79  74  72   6   5   4   8  11  12   8   5                          87        F
 80  75  72   7   6   8  22  27  50  26  64                          87        F
 81  74  72  35   8  14  17  10  12  25  32                          87        F
 82  76  72  17   5   8  14  13  11   8   5                          87        F
 83  76  72   3   3   9  12   7   6   7   4                          87        F
 84  76  73   3   2   3   7   7  18   8  11                          87        F
 85  76  73  15  13  23  24  17  20   7   4                          87        F
 86  76  73  14  30  26  48  40  38  17  10                          87        F
 87  75  73  35  18  16  18  10  13   5   3                          87        F
 88  76  73   4   5  14  13   7   8   7   4                          87        F
*FLXFIL=13736.FLX
GEOPOT=C:\V2\WGS72-14.GEO
011201                                                                4P
   342.53834 -7192.20390    14.61274 -1123.632546   -31.719668  7353.143364  B1P
13736SP TEST    87079022250.523      0    00.010000000.000000000.00000000     2P
*VECFIL=13736.VEC
ENDOFJOB
*              CASE 6: satellite 11162 (350 km)
*   18th order WGS84 geopotential; drag model Jacchia 64
            0.                1440.                                       6P
 68  75  73  27  24  14   6   8   8   4   5                          87        F
 69  72  73   6   7  29  14  32  24   7   5                          87        F
 70  71  73   6   4   5  10  13  11  13   4                          87        F
 71  70  72  12   9  14  22  13   7   9  30                          87        F
 72  70  72  12   7   9  15  19  10   7   9                          87        F
 73  72  72   8  18  16  15  12   6   9   6                          87        F
 74  71  72   7  19  13  13  10   9   8   9                          87        F
 75  72  72  14   4  17  30  32   7  10   8                          87        F
 76  72  72  14  39  22  11  14  10   7   4                          87        F
 77  73  72   9   5   8   6  12  18  13  29                          87        F
 78  72  72  26  14  10  17  14   9  12  13                          87        F
*FLXFIL=11162.FLX
1 11162U SP TEST  87 75.00000000  .02000000      0-0  00000-0 6    00
2 11162  82.9009 178.9329 0130804 147.1127 213.8296 15.40094343    03
1811                                                                  4P
ENDOFJOB
*              CASE 7: satellite 10953 (geosynchronous)
*  30th order GEM-9 geopotential; no drag; luni-solar & radiation pressure perts
                                                        1440          3P
1 10953U SP TEST  87 74.00000000  .00000000      0-0  10000-2 6    05
2 10953   3.9278  80.7508 0000442 329.0471  31.3175  1.00268196    06
*ELTFIL=10953.EL6 (modified decimal DOY)
301011                                                                4P
ENDOFJOB
*              CASE 8: satellite 9786 (600 km)
*     16th order GEM-5 geopotential; drag model Jacchia 70
            0.                1440.                                       6P
 68  75  73  27  24  14   6   8   8   4   5                          87        F
 69  72  73   6   7  29  14  32  24   7   5                          87        F
 70  71  73   6   4   5  10  13  11  13   4                          87        F
 71  70  72  12   9  14  22  13   7   9  30                          87        F
 72  70  72  12   7   9  15  19  10   7   9                          87        F
 73  72  72   8  18  16  15  12   6   9   6                          87        F
 74  71  72   7  19  13  13  10   9   8   9                          87        F
 75  72  72  14   4  17  30  32   7  10   8                          87        F
 76  72  72  14  39  22  11  14  10   7   4                          87        F
 77  73  72   9   5   8   6  12  18  13  29                          87        F
 78  72  72  26  14  10  17  14   9  12  13                          87        F
 79  74  72   6   5   4   8  11  12   8   5                          87        F
 80  75  72   7   6   8  22  27  50  26  64                          87        F
 81  74  72  35   8  14  17  10  12  25  32                          87        F
 82  76  72  17   5   8  14  13  11   8   5                          87        F
 83  76  72   3   3   9  12   7   6   7   4                          87        F
 84  76  73   3   2   3   7   7  18   8  11                          87        F
 85  76  73  15  13  23  24  17  20   7   4                          87        F
```

```
 86  76  73  14  30  26  48  40  38  17  10                          87        F
 87  75  73  35  18  16  18  10  13   5   3                          87        F
 88  76  73   4   5  14  13   7   8   7   4                          87        F
*FLXFIL=9786.FLX
  6883.41520 -1435.89710     3.13072  1537.983322  6601.017740  3606.095799  B1P
 9786SP TEST    87075193638.412      0    00.001000000.000000000.00000000     2P
*VECFIL=9786.VEC
2212                                                                        4P
ENDOFJOB
*              CASE 9: satellite 9635 (Moly catastrophic decay)
*  Truncated geopotential (WGS72 J2-J5 zonals only); Jacchia 64 drag; luni-solar
                                                                            3P
 80  75  72   7   6   8  22  27  50  26  64                          87        F
 81  74  72  35   8  14  17  10  12  25  32                          87        F
 82  76  72  17   5   8  14  13  11   8   5                          87        F
 83  76  72   3   3   9  12   7   6   7   4                          87        F
 84  76  73   3   2   3   7   7  18   8  11                          87        F
 85  76  73  15  13  23  24  17  20   7   4                          87        F
 86  76  73  14  30  26  48  40  38  17  10                          87        F
 87  75  73  35  18  16  18  10  13   5   3                          87        F
 88  76  73   4   5  14  13   7   8   7   4                          87        F
 89  75  73   5   4   4   8  12   8   9   3                          87        F
 90  72  73   6  13   7  10  16   6   6   4                          87        F
*FLXFIL=9635.FLX
1  9635U SP TEST  87 74.00000000  .02000000      0-0  00000-0 6    09
2  9635  63.8673 358.2583 7478131 246.4166  23.0914  2.06340381    08
051101                                                                      4P
ENDOFJOB
*              CASE 10: satellite 12121 (decay with var. step size)
*    WGS72 geopotential truncated to 6th order/degree; Jacchia 70 drag
GEOPOT=C:\V2\WGS72-12.GEO
0112   95 96  10     06       1                                        1   4P
1.0067851083-.2137524995-.0000363682.124357991908.598843605562.773694330594  D1P
12121           93285222422.183            .008532913                       2P
                                              1                 60  1    3P
*VECFIL=DECAY.VEC
ENDOFJOB
*              CASE 11: satellite 80014 (Near Earth, Jacchia 70)
*    WGS72 geopotential truncated to 12th degree/order; Jacchia 70 drag;
*    luni-solar perts; fixed time step of 1.0 minutes
TIMCON=C:\V2\CER\SPEPH\tcon.96
             0.1440.           7200.                                        6P
1 80014U          96330.00000000  .00500000  00000-0  00000-0 6    000
2 80014  64.9132  14.3834 0038549  64.4446 296.0700 16.07429719    03
FLXFIL=C:\V2\CER\SPEPH\flux.96
*GEODIR=/usr2/people/nancy/spwork/
1212 1                  9                       5           1           1 1.04P
ENDOFJOB
*              CASE 12: satellite 80014 (Near Earth, Jacchia 64)
*    WGS72 geopotential truncated to 12th degree/order; Jacchia 64 drag;
*    luni-solar perts; fixed time step of 1.0 minutes
TIMCON=C:\V2\CER\SPEPH\tcon.96
             0.1440.           7200.                                        6P
1 80014U          96330.00000000  .00500000  00000-0  00000-0 6    000
2 80014  64.9132  14.3834 0038549  64.4446 296.0700 16.07429719    03
FLXFIL=C:\V2\CER\SPEPH\flux.96
*GEODIR=/usr2/people/nancy/spwork/
1211 1                  9                       5           1           1 1.04P
ENDOFJOB
*              CASE 13: satellite 80004 (Moly, 5123 x 35152 km)
*    WGS72 geopotential truncated to 12th degree/order; Jacchia 70 drag;
*    luni-solar perts; fixed time step of 1.0 minutes; forced t-integration
TIMCON=C:\V2\CER\SPEPH\tcon.96
             0.1440.           7200.                                        6P
1 80004U          96330.00000000  .00100000  00000-0  00000-0 6    000
2 80004  64.1883 194.2929 5664290 225.1895  71.7722  2.01165488    03
FLXFIL=C:\V2\CER\SPEPH\flux.96
*GEODIR=/usr2/people/nancy/spwork/
1212 1                  9                       5           1           1 1.04P
ENDOFJOB
*              CASE 14: satellite 80001 (Geosynchronous)
*    WGS84 geopotential truncated to 18th degree/order;
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*    luni-solar perts; fixed time step of 1.0 minutes
TIMCON=C:\V2\CER\SPEPH\tcon.96
            0.1440.          7200.                                          6P
1 80001U          96330.00000000  .00000000  00000-0  00000-0 6    000
2 80001   2.0335  72.6805 0001855 153.5960 309.6144  1.00274947    03
*GEODIR=/usr2/people/nancy/spwork/
1810 1                  9                       5           1           1 1.04P
ENDOFJOB
SPEPH
*              CASE 15:  satellite 7646  (EGM-70 x 70, with l-s & tides)
*                     7646 with full perts  - SPECTR COMPATIBILITY MODE
<> SP VECTOR/COVARIANCE MESSAGE - V2.0
<>
<> MESSAGE TIME (UTC):                                CENTER:
<> SATELLITE NUMBER:  7646                     INT. DES.: 1975-010A
<> COMMON NAME:
<> EPOCH TIME (UTC): 1998 060 (01 MAR) 07:01:38.393  EPOCH REV: 16499
<> J2K POS (KM):      6346.55363437     962.29908397    3233.48471234
<> J2K VEL (KM/S):   1.548618977537   5.729637836597  -4.621487407426
<> ECI POS (KM):      6347.55742811     959.82001183    3232.25094750
<> ECI VEL (KM/S):   1.550102853243   5.728816552258  -4.622008047169
<> EFG POS (KM):     -1585.79274374    6220.77174732    3232.25094750
<> EFG VEL (KM/S):  -5.400864724011   1.088827534151  -4.622008047169
<> GEOPOTENTIAL: EGM-96 70Z,70T  DRAG: JAC70         LUNAR/SOLAR: ON
<> SOLAR RAD PRESS: ON   SOLID EARTH TIDES: ON   IN-TRACK THRUST: OFF
<> BALLISTIC COEF: (M2/KG): 0.294494E-02 BDOT (M2/KG-S); 0.000000E+00
<> SOLAR RAD PRESS COEFF (M2/KG):  0.973835E-03  EDR(W/KG):
<> THRUST ACCEL (M/S2):  0.000000E+00  C.M. OFFSET (M):  0.000000E+00
<> SOLAR FLUX: F10:  94  AVERAGE F10:  95  AVERAGE AP:  29.0
<> TIME CONST REFERENCE TIME (UTC): 1998 060 (01 MAR) 00:00:00.000
<> TAI-UTC (S): 31  UT1-UTC (S):  0.10268  UT1 RATE (MS/DAY): -2.138
<> POLAR MOT X,Y (ARCSEC): -0.0598  0.1939 IAU 1980 NUTAT:   4 TERMS
<> TIME CONST REFERENCE TIME (UTC): 1998 069 (10 MAR) 00:00:00.000
<> TAI-UTC (S): 31  UT1-UTC (S):  0.08406  UT1 RATE (MS/DAY): -2.002
<> POLAR MOT X,Y (ARCSEC): -0.0732  0.2107 IAU 1980 NUTAT:   4 TERMS
<> INTEGRATOR: SPADOC MODE:OFF   COORD SYS: J2000  PARTIALS: FAST NUM
<> STEP MODE: AUTO  FIXED STEP: OFF  STEP SIZE SELECTION: MANUAL
<> INITIAL STEP SIZE (S):   30.000  ERROR CONTROL: 0.100E-13
<> VECTOR U,V,W SIGMAS (KM):           0.0001     0.0008     0.0002
<> VECTOR UD,VD,WD SIGMAS (KM/S):      0.0000     0.0000     0.0000
<> COVARIANCE MATRIX (EQUINOCTIAL ELS): ( 9x 9) WTD RMS:  0.18756E+01
<>  0.10002E-15  0.32675E-16  0.25660E-15  0.12836E-16  0.62796E-16
<>  0.20346E-14 -0.31504E-18  0.12878E-17  0.52625E-17  0.38661E-19
<>  0.24955E-16  0.11791E-16 -0.17712E-15 -0.13655E-17  0.23636E-15
<> -0.35378E-17  0.52047E-17  0.84723E-16 -0.89522E-19 -0.36749E-16
<>  0.12861E-15 -0.46777E-11  0.11905E-10  0.18779E-09  0.88731E-12
<> -0.43275E-11  0.30746E-11  0.31177E-04  0.00000E+00  0.00000E+00
<>  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
<>  0.00000E+00  0.19217E-09  0.83870E-09  0.13120E-09  0.35950E-11
<>  0.35726E-10  0.67658E-10  0.19493E-04  0.00000E+00  0.36185E-02
            0.1440.          7200.                                          6P
ENDOFJOB
ENDALL                       (file speph.inp)
```