Multimission Software Interface Specification (SIS)

SPICE
Planetary Constants Kernel

PcK

NAIF Document No. 368
Version 1.0

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PURPOSE: This SIS describes the format and content of SPICE Planetary Constants Kernel (PcK) file, used to specify size, shape, and orientation of planets, satellites, the sun, and occasionally even comets or asteroids. It also describes and gives examples of how to use SPICE Toolkit modules to access and use the data in a PcK file.

CHANGE LOG

Version	Date	Page Nos.	Reason
1.0	20 Oct 2001	All	New multimission version.

List of Acronyms

AMMOS	Advanced Multimission Operations System
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
CCSDS	Consultative Committee on Space Data Standards
CK	SPICE C-kernel
DAF	Double Precision Array File
ET	Ephemeris Time
FK	SPICE Frames Kernel
FTP	File Transfer Protocol
FTS	SFOC File Transfer Service
JPL	Caltech/Jet Propulsion Laboratory
MSOO	Mars Surveyor Operations Office
NAIF	Navigation and Ancillary Information Facility
PcK	SPICE Planetary Constants Kernel
PDB	Project Data Base
PDS	Planetary Data System
SFDU	Standard Formatted Data Unit
SIS	Software Interface Specification
SPICE	S-, P-, I-, C- and E-kernels; the principal logical data components of a particular NASA ancillary information system
VMS	Digital Equipment Corporation's Virtual Memory Operating System

Section 1
General Description

1.1 Purpose of Document

This Software Interface Specification (SIS) describes the contents and structure of a SPICE Planetary Constants (PcK) file. It also describes and gives examples of how to use SPICE Toolkit modules to access and use the data in a PcK file.

1.2 Scope

This is a multimission SIS, applicable for all flight projects.

1.3 Applicable Documents

No.	Document ID	Version	Title
1.	NAIF Doc. No. 318	Latest release	Kernel Required Reading
2.	NAIF Doc. No. 254	Latest Release	Planetary Constants Kernel (PcK) Required Reading
3.	NAIF Doc. No. 167	Latest Release	Double Precision Array File (DAF) Required Reading

Also useful as a reference is the PCK tutorial, available from the NAIF server:

ftp://naif.jpl.nasa.gov/pub/naif/toolkit_docs/Tutorials/

1.4 Functional Description

PcK files are the physical realization of the target “constants” portion of the SPICE P-kernel. PcK files contain certain physical and cartographic data needed to determine observation geometry involving a natural solar system body Planet, satellite, sun, comet, asteroid).

Typically data from a PcK file are used with SPICE Toolkit modules to determine the rotation matrix used to rotate an inertially referenced Cartesian state vector into the equivalent target body fixed vector. Obtaining the values of the radii that define triaxial ellipsoid models of extended bodies is the other principal use for PcK files (text types, only). Text PcK files may also contain other body-specific data such as Gm values.

Most PcK files are text format files containing only ASCII data. They are constructed or updated using a text editor and are easily read by a human. There exist special cases for earth and the moon in which high precision orientation data are stored in a binary PcK file. These binary PcK files contain ONLY earth or lunar orientation information–they do not provide size and shape data.

1.4.1 Data Source, Destinations, and Transfer Method

A text PcK file may be created or modified on any computer having a text editing capability. Special NAIF software is used to create the high precision binary format PcK available for the earth and moon; this process is carried out only by the NAIF Group at JPL.

Planetary Constants Kernels are made available to flight projects through whatever mechanism is used for providing access to SPICE products, such as a Project Database (PDB), a File Interchange System (FIS) or a SPICE Server.

PcK files are transferred to the project's SPICE data base using the means mandated by the project, such as File Transfer Service (FTS) or plain ftp. Text PcK files must be transferred in text mode, while binary PcKs must be transferred in binary mode.

If a binary PcK is being transferred to a destination computer that uses a different binary standard than the source computer, the binary PcK must first be converted to SPICE transfer format using either the toxfr or spacit utility program from the SPICE Toolkit. It is then ftp'd to the destination computer using ASCII mode of ftp. At the destination computer it is converted to the local binary form using either the tobin or spacit utility program.

1.4.2 Labeling and Identification

PcK files may and should include internal identification information, although there is no general requirement for such. PcK file names may utilize any syntax picked by a flight project, although limiting the length to the "27.3" specification adopted by the Planetary Data System (PDS) is suggested. Using the "*.tpc" file name extension (or "*.bpc" for binary PcK files) as normally used by NAIF is also suggested. It is further recommended that transfer format PcK files use the "*.xpc" file name extension.

1.4.3 Assumptions and Constraints

Contents of a PcK file must adhere to SPICE text kernel specifications as described in NAIF Document "Kernel Required Reading," Reference 1.

Section 2
Data Object Definition

2.1 Structure and Organization

2.1.1 Text PcK

A text-type Planetary Constants Kernel is a simple ASCII file containing data sections and descriptive text sections. The structure conforms to the specifications described in Reference 1.

Text sections of a PcK are used to describe the data. They are preceded by the token:

```
\begintext
```

which must appear on a line by itself.

If it appears first in the file, before any data, the first text section does not need this delimiter—it is interpreted as a text section by default.

The initial text section may contain labels (metadata) providing provenance for the file. This labeling practice is highly recommended by NAIF, although it is not a SPICE requirement. Such labels may utilize the same "keyword = value" syntax used in data sections of the IK. In general the text sections are not restricted to a particular format other than each line must not exceed 79 characters.

All data sections start with the begin data delimiter,

```
\begindata
```

which must appear on a line by itself.

Data are provided using a "keyword = value" syntax. The data sections are parsed by SPICE kernel file readers and so must adhere to the format specified in the NAIF Document Kernel Required Reading (Reference 1).

2.1.2 Binary PcK

Binary PcK files are built upon the Double Precision Array File (DAF) architecture frequently used within SPICE (Reference 3). As for any DAF-based SPICE file a “comment area” is available for holding any amount of descriptive information.

2.2 Data Format and Definition

2.2.1 Metadata Description

At the beginning of a text PcK file is usually found an introduction to the Planetary Constants Kernel. This may include version and date, references, author, and comments about using the PcK file. It also contains substantial information about the source of the data placed in the PcK file.

A binary PcK may also contain descriptive metadata; this is placed in the "comment area" of the file. The Toolkit utility program named "commnt" is used to put comments in a binary PcK and read or extract comments from a binary PcK.

2.2.2 Data Description

2.2.2.1 Data in Text PcK Files

Planetary Constants Kernel data in text-type PcK files follow the specifications described in Reference 1 (Kernel Required Reading) and Reference 2 (PcK Required Reading), using a KEYWORD = VALUE syntax. Each assignment must appear on a separate line and each line must not exceed 79 characters. Examples of PcK assignments are:

```
BODY699_RADII   = ( 60268   60268  54364 )
BODY699_POLE_RA = ( 40.58  -0.036     0. )
```

All keywords in a PcK are constructed using the template BODY[ID]_[WORD] where [ID] is replaced with the instrument ID and [WORD] completes the keyword, specifying the piece of information.

The number of assignments included in a PcK is not specifically limited, but the total number of assignments provided from all text kernels used at run time must not exceed 10,000.

2.2.2.2 Data in Binary PcK Files

Planetary Constants Kernel data in binary PcK files follow the specifications described in Reference 3 for a SPICE Double Precision Array File. These are polynomials that, when evaluated by the appropriate Toolkit interface module, return the orientation and prime meridian of the user-specified body (the earth or the moon).

Section 3
Using a PcK File

3.1 SPICE Toolkit APIs

Included in the SPICE Toolkit are several APIs (subroutines or C modules) for accessing PcK data and computing derived quantities. These SPICELIB or CSPICE APIs are the only recommended method for using PcK data.

3.1.1 Initialization

In order to use a PcK file the file must first be “loaded” into your SPICE-based application. This is accomplished with the following code.

If you are using a text PcK, when you load the file all of the data contained in the PcK are parsed and placed in memory. If you have a very large PcK, and a slower computer this operation can take a noticeable amount of time. If you are using a binary PcK, “loading” the file simply establishes a pointer to the file.

```
CALL FURNSH ( <pck file name>)                FORTRAN version
furnish_c   (<pck file name>);                   C version
```

3.1.2 Computing a State Transformation Matrix

A 6x6 state transformation matrix that rotates a state vector from J2000 frame to the body-fixed frame may be constructed using the SXFORM API.

```
CALL SXFORM ( FROM, TO, ET, XFORM )       FORTRAN version
sxform_c    ( from, to, et, xform );            C version
```

The output XFORM is a full 6x6 state transformation matrix.

3.1.3 Computing a Position Rotation Matrix

If you are interested only in position information–and not velocity–you can use a somewhat more simple API.

```
CALL PXFORM ( FROM, TO, ET, ROTATE )      FORTRAN version
pxform_c    ( from, to, et, rotate );           C version
```

The output ROTATE is a 3x3 position vector rotation matrix.

3.1.4 Other Access Modules

The SPICE Toolkit also contains lower level access modules. These may be used to retrieve individual data items from the PcK file, without doing any computations that use the data items. The most obvious use for this kind of access is to obtain the triaxial radii for a given body.

```
CALL BODVAR ( 699, 'RADII', N,  RADII )
bodvar_c    ( 699, "RADII", &n, radii );
```

These calls retrieve values associated with the variable BODY699_RADII. The variable name is case sensitive, so the string “RADII” above must be in upper case.

You can also use general kernel pool fetch routines to fetch data having non-standard names:

GCPOOL, GDPOOL, GIPOOL

APPENDIX A

Example of a Text-Type PcK

To save space, only the introductory text and the data for Mars are included in this example. These data were obtained from (cut and pasted from) the NAIF generic PcK named pck00007.tpc.

```
KPL/PCK

P_constants (PcK) SPICE kernel file
===========================================================================

        By: Nat Bachman (NAIF)    2000 April 24


Organization
--------------------------------------------------------

     The contents of this file are as follows.

     Introductory Information:

         --   Version description

         --   Disclaimer

         --   Sources

         --   Explanation

         --   Body numbers and names

     Pck Data:

         --   Orientation constants for the Sun and planets

         --   Orientation constants for satellites

         --   Orientation constants for asteroids Gaspra and Ida

         --   Radii of Sun and planets

         --   Radii of satellites, where available

         --   Radii of asteroids Gaspra and Ida


Version description
--------------------------------------------------------

     This file was created on April 24, 2000.  This version
     incorporates new data from the ``Report of the IAU/IAG/COSPAR
     Working Group on Cartographic Coordinates and Rotational
     Elements of the Planets and Satellites:  1997.''  The authors
     published in the 1997 report only changes from the 1994 report.

     The data in the file are based primarily on the ``Report
     of the IAU/IAG/COSPAR Working Group on Cartographic
     Coordinates and Rotational Elements of the Planets
     and Satellites:  1994.''  See ``Sources'' below for details.

     This file contains updates of constants contained in the
     previous version of the file, plus data for the asteroids
```

Gaspra and Ida.

Disclaimer

This constants file may not contain the parameter values that you prefer. Note that this file may be readily modified by you or anyone else. NAIF suggests that you inspect this file visually before proceeding with any critical or extended data processing.

NAIF requests that you update the ``by line' and date if you modify the file.

Sources

The sources for the constants listed in this file are:

1. ``Report of the IAU/IAG/COSPAR Working Group on Cartographic Coordinates and Rotational Elements of the Planets and Satellites: 1997.''

2. ``Report of the IAU/IAG/COSPAR Working Group on Cartographic Coordinates and Rotational Elements of the Planets and Satellites: 1994.''

3. ``The Astronomical Almanac,'' 1993.

4. ``Planetary Geodetic Control Using Satellite Imaging,'' Journal of Geophysical Research, Vol. 84, No. B3, March 10, 1979, by Thomas C. Duxbury. This paper is cataloged as NAIF document 190.0.

5. Letter from Thomas C. Duxbury to Dr. Ephraim Lazeryevich Akim, Keldish Institute of Applied Mathematics, USSR Academy of Sciences, Moscow, USSR. This letter is catalogued as NAIF document number 195.0.

6. ``Geophysical Coordinate Transformations,'' by Christopher T. Russell. Cosmic Electrodynamics 2 (1971) 184-186. NAIF document 181.0.

7. ``Placeholder'' values were supplied by NAIF for some radii of the bodies listed below:

Body	NAIF ID code
Thebe	514
Metis	516
Helene	612
Larissa	807

See the discussion below for further information.

8. ``Revised rotation angle for Jupiter satellite 516 Metis,"
by J. H. Lieske. JPL IOM 312.F-97-059. September 16, 1997.

Most values are from the ``IAU/IAG/COSPAR Working Group on Cartographic Coordinates and Rotational Elements of the Planets and Satellites: 1994.'' All exceptions are commented where they occur in this file. The exceptions are:

-- The following data have been taken from [1]:

 The W0 term for Mercury.
 The W1 term for Jupiter.
 Radii for Io, Europa, Ganymede and Callisto.

 The reference [1] specified corrections to the following items, but these corrections had already been incorporated into the previous version of this PCK:

 The W1 term of Saturn: X Janus.
 The W0 term for Gaspra.

-- Radii for the Sun are from [3].

-- The values for the latitude and longitude of the Northern hemisphere projection of the Earth's magnetic dipole are from [6].

-- The second nutation precession angle (M2) for Mars is represented by a quadratic polynomial in the 1994 IAU report. The SPICELIB subroutine BODEUL can not handle this term (which is extremely small), so we truncate the polynomial to a linear one.

-- The expressions for the pole and prime meridian of Neptune given in the IAU report include trigonometric terms which BODEUL doesn't yet handle. We omit these terms. See the comments accompanying the data for Neptune for further information.

-- For several satellites, the 1994 IAU report either gives a single radius value or a polar radius and a single equatorial radius. NAIF Toolkit software that uses body radii expects to find three radii whenever these data are read from the kernel pool. In the cases listed below, NAIF has supplied an additional radius value in order to allow the software to function. Wherever this was done, the fact has been noted, and comments indicate which radius values were given by the IAU report. The ``invented'' values were created by NAIF and should not be used in any application requiring values sanctioned by an authoritative source.

The affected satellites are:

Body	NAIF ID code
Thebe	514
Metis	516
Helene	612
Larissa	807

``Old values'' listed are from the SPICE P_constants file dated June 25, 1990. Most of these values came from the 1988 IAU report.

Explanation

The NAIF Toolkit software that uses this file is documented in the NAIF ``Required Reading'' file PCK.REQ. See that document for a detailed explanation of the NAIF text kernel file format. PCK.REQ is available in both printed and electronic form.

This file, which is logically part of the SPICE P-kernel, contains constants used to model the orientation and shape of the Sun, planets, and satellites. The orientation models express the direction of the pole and location of the prime meridian of a body as a function of time. The shape models represent all bodies as ellipsoids, using two equatorial radii and a polar radius. Spheroids and spheres are obtained when two or all three radii are equal.

Orientation models

All of the orientation models use three Euler angles to describe body orientation. To be precise, the Euler angles describe the orientation of the coordinate axes of the ``Body Equator and Prime Meridian'' system with respect to an inertial system. By default, the inertial system is J2000 (also called ``EME2000''), but other frames can be specified in the file. See the PCK Required Reading for details.

The first two angles, in order, are the right ascension and declination (henceforth RA and DEC) of the north pole of a body as a function of time. The third angle is the prime meridian location (represented by ``W''), which is expressed as a rotation about the north pole, and is also a function of time.

For the Sun and planets, the expressions for the north pole's right ascension and declination, as well as prime meridian location, are always (as far as the models that appear in this file are concerned) quadratic polynomials, where the independent variable is time. Some coefficients may be zero.

In this file, the time arguments in expressions always refer to Barycentric Dynamical Time (TDB), measured in centuries or days past the a reference epoch. By default, the reference epoch is the J2000 epoch, which is Julian ephemeris date 2451545.0, but other epochs can be specified in the file. See the PCK Required Reading for details.

Example: 1991 IAU Model for orientation of the Earth. Note that these values are used as an example only; see the data area below for current values.

```
   alpha   =   0.00 - 0.641 T             ( RA )
        0

   delta   =  90.0  - 0.557 T             ( DEC )
        0

   W       =  190.16 + 360.9856235 d      ( Prime meridian )
```

```
   T represents centuries past J2000 ( TDB ),

   d represents days past J2000 ( TDB ).
```

In this file, the polynomials' coefficients above are assigned to the symbols

```
   BODY399_POLE_RA
   BODY399_POLE_DEC
   BODY399_POLE_PM
```

as follows:

```
   BODY399_POLE_RA        = (    0.       -0.641         0. )
   BODY399_POLE_DEC       = (  +90.       -0.557         0. )
   BODY399_PM             = (  190.16  +360.9856235     0. )
```

Note the number ``399''; this is the NAIF ID code for the Earth.

You'll see an additional symbol grouped with the ones listed here; it is

```
   BODY399_LONG_AXIS
```

This term is zero for all bodies except Mars. It represents the offset between the longest axis of the triaxial ellipsoid used to model a body and the prime meridian of the body.

Expressions for satellites are a little more complicated; in addition to polynomial terms, there are trigonometric terms. The arguments of the trigonometric terms are linear polynomials. In this file, we call the arguments of these trigonometric terms ``nutation precession angles.''

In this file, the polynomial expressions for the nutation precession angles are listed along with the planet's RA, DEC, and prime meridian terms.

Example: 1991 IAU nutation precession angles for Earth. Note that these values are used as an example only; see the data area below for current values.

```
   E1 = 125.045 -  0.052992 d
   E2 = 250.090 -  0.105984 d
   E3 = 260.008 + 13.012001 d
   E4 = 176.625 + 13.340716 d
   E5 = 357.529 +  0.985600 d

   d represents days past J2000 ( TDB )
```

Because the NAIF Toolkit software expects the time units for the angles to be CENTURIES (as in the IAU models for most bodies--the Earth is an exception), the linear coefficients are scaled by 36525.0 in the assignments:

```
   BODY3_NUT_PREC_ANGLES  = (  125.045    -1935.5328
                               250.090    -3871.0656
                               260.008   475263.336525
                               176.625   487269.6519
                               357.529    35999.04     )
```

As stated above, the satellite orientation models use polynomial and trigonometric terms, where the arguments of the trigonometric terms are the ``nutation precession angles.''

Example: 1988 IAU values for the Moon. Again, these values are used as an example only; see the data area below for current values.

```
   alpha   =  270.000  +  0.003 T  -  3.878 sin(E1) - 0.120 sin(E2)
        0
                                   +  0.070 sin(E3) - 0.017 sin(E4)  (RA)


   delta   =  66.541   +  0.013 T  +  1.543 cos(E1) + 0.024 cos(E2)
        0
                                   -  0.028 cos(E3) + 0.007 cos(E4)
(DEC)


   W       =  38.317   + 13.1763582 d    +  3.558 sin(E1)

                                         +  0.121 sin(E2)

                                         -  0.064 sin(E3)

                                         +  0.016 sin(E4)
```

```
                                          +  0.025 sin(E5)  ( Prime
                                                              meridian )
```

d represents days past J2000.

E1--E5 are the nutation precession angles.

The polynomial terms are assigned to symbols by the statements

```
BODY301_POLE_RA        = (  270.000    0.003        0. )
BODY301_POLE_DEC       = (  +66.541    0.013        0. )
BODY301_PM             = (   38.317  +13.1763582    0. )
```

The coefficients of the trigonometric terms are assigned to symbols by the statements

```
BODY301_NUT_PREC_RA  = (  -3.878  -0.120  +0.070  -0.017   0.    )
BODY301_NUT_PREC_DEC = (  +1.543  +0.024  -0.028  +0.007   0.    )
BODY301_NUT_PREC_PM  = (  +3.558  +0.121  -0.064  +0.016  +0.025 )
```

Note that for the RA and PM (prime meridian) assignments, the ith term is the coefficient of sin(Ei) in the expression used in the IAU model, while for the DEC assignment, the ith term is the coefficient of cos(Ei) in the expression used in the IAU model.

NAIF software expects the models for satellite orientation to follow the form of the model shown here: the polynomial portions of the RA, DEC, and W expressions are expected to be quadratic, the trigonometric terms for RA and W (satellite prime meridian) are expected to be linear combinations of sines of nutation precession angles, the trigonometric terms for DEC are expected to be linear combinations of cosines of nutation precession angles, and the polynomials for the nutation precession angles themselves are expected to be linear.

Eventually, the software will handle more complex expressions, we expect.

Shape models

There is only one kind of shape model supported by the NAIF Toolkit software at present: the triaxial ellipsoid. The 1994 IAU report does not use any other models.

For each body, three radii are listed: The first number is the largest equatorial radius (the length of the semi-axis containing the prime meridian), the second number is the smaller equatorial radius, and the third is the polar radius.

Example: Radii of the Earth.

```
BODY399_RADII     = (     6378.14    6378.14      6356.75   )
```

```
Body numbers and names
--------------------------------------------------------


        1  Mercury barycenter
        2  Venus barycenter
        3  Earth barycenter
        4  Mars barycenter
        5  Jupiter barycenter
        6  Saturn barycenter
        7  Uranus barycenter
        8  Neptune barycenter
        9  Pluto barycenter
        10 Sun

        While not relevant to the P_constants kernel, we note here for
        completeness that 0 is used to represent the solar system
        barycenter.

        199 Mercury


        299 Venus


        399 Earth

        301 Moon


        499 Mars

        401 Phobos      402 Deimos


        599 Jupiter

        501 Io          502 Europa      503 Ganymede    504 Callisto
        505 Amalthea    506 Himalia     507 Elara       508 Pasiphae
        509 Sinope      510 Lysithea    511 Carme       512 Ananke
        513 Leda        514 Thebe       515 Adrastea    516 Metis


        699 Saturn

        601 Mimas       602 Enceladus   603 Tethys      604 Dione
        605 Rhea        606 Titan       607 Hyperion    608 Iapetus
        609 Phoebe      610 Janus       611 Epimetheus  612 Helene
        613 Telesto     614 Calypso     615 Atlas       616 Prometheus
        617 Pandora     618 Pan


        799 Uranus

        701 Ariel       702 Umbriel     703 Titania     704 Oberon
        705 Miranda     706 Cordelia    707 Ophelia     708 Bianca
```

```
709 Cressida    710 Desdemona   711 Juliet      712 Portia
713 Rosalind    714 Belinda     715 Puck


899 Neptune

801 Triton      802 Nereid      803 Naiad       804 Thalassa
805 Despina     806 Galatea     807 Larissa     808 Proteus


999 Pluto

901 Charon


9511010 Asteriod Gaspra
2431010 Asteroid Ida
```

Orientation constants for the Sun and planets

Mars

Old values:

Values shown are from the 1991 IAU report.

```
body499_pole_ra          = (  317.681     -0.108       0.  )
body499_pole_dec         = (  +52.886     -0.061       0.  )
body499_pm               = (  176.868   +350.8919830   0.  )

body4_nut_prec_angles  = (  169.51     -15916.2801
                            192.93  +41215163.19675
                             53.47       -662.965275
                             36.53       +662.965275  )
```

Current values:

```
\begindata

BODY499_POLE_RA          = (  317.681     -0.108       0.  )
BODY499_POLE_DEC         = (  +52.886     -0.061       0.  )
BODY499_PM               = (  176.901   +350.8919830   0.  )

\begintext
```

Source [4] specifies the following value for the lambda_a term (BODY4_LONG_AXIS) for Mars.

This term is the POSITIVE WEST LONGITUDE, measured from the prime meridian, of the longest axis of the ellipsoid representing the ``mean

```
planet surface,'' as the article states.

   body499_long_axis        = (  110.  )

Source [5] specifies the lambda_a value

   body499_long_axis        = (  104.9194  )

We list these lambda_a values for completeness. The IAU gives equal
values for both equatorial radii, so the lambda_a offset does not
apply to the IAU model.

The 1994 IAU report defines M2, the second nutation precession angle,
by:

                                        2
   192.93  +  1128.4096700 d  +  8.864 T

We truncate the M2 series to a linear expression, because the PCK
software cannot handle the quadratic term.

Again, the linear terms are scaled by 36525.0:

    -0.43576400000000000       -->     -15916.28010000000
  1128.409670000000            -->   41215163.19675000
    -1.8151000000000000E-02   -->       -662.9652750000000

We also introduce a fourth nutation precession angle, which
is the pi/2-complement of the third angle.  This angle is used
in computing the prime meridian location for Deimos.  See the
discussion of this angle below in the section containing orientation
constants for Deimos.

\begindata
BODY4_NUT_PREC_ANGLES  = (  169.51     -15916.2801
                            192.93  +41215163.19675
                             53.47       -662.965275
                             36.53       +662.965275  )

\begintext
```

Satellites of Mars

Phobos

Old values:

Values are unchanged in the 1994 report.

Current values:

The quadratic prime meridian term is scaled by 1/36525**2:

```
8.864000000000000   --->   6.6443009930565219E-09
```

```
\begindata

BODY401_POLE_RA       = (  317.68      -0.108       0.  )
BODY401_POLE_DEC      = (  +52.90      -0.061       0.  )
BODY401_PM            = (   35.06
                         +1128.8445850
                             6.6443009930565219D-09     )

BODY401_LONG_AXIS     = (    0.         0. )

BODY401_NUT_PREC_RA   = (   +1.79   0.    0.  0. )
BODY401_NUT_PREC_DEC  = (   -1.08   0.    0.  0. )
BODY401_NUT_PREC_PM   = (   -1.42  -0.78  0.  0. )

\begintext
```

Deimos

Old values:

Values are unchanged in the 1994 report.

New values:

The Deimos prime meridian expression is:

$$W = 79.41 \ + \ 285.1618970\ d \ - \ 0.520\ T^2 \ - \ 2.58 \sin M_3 \ + \ 0.19 \cos M_3 .$$

At the present time, the constants kernel software (the routine BODEUL in particular) cannot handle the cosine term directly, but we can represent it as

$$0.19 \sin M_4$$

where

$$M_4 \ = \ 90.D0 - M_3$$

Therefore, the nutation precession angle assignments for Phobos and Deimos contain four coefficients rather than three.

The quadratic prime meridian term is scaled by 1/36525**2:

```
   -0.5200000000000000  --->   -3.8978300049519307E-10

\begindata

BODY402_POLE_RA       = (  316.65     -0.108       0.             )
BODY402_POLE_DEC      = (  +53.52     -0.061       0.             )
BODY402_PM            = (   79.41   +285.1618970  -3.897830D-10  )
BODY402_LONG_AXIS     = (    0.                                   )

BODY402_NUT_PREC_RA   = (    0.   0.   +2.98   0.    )
BODY402_NUT_PREC_DEC  = (    0.   0.   -1.78   0.    )
BODY402_NUT_PREC_PM   = (    0.   0.   -2.58   0.19  )

\begintext
```

Radii of Sun and Planets

Mars

Old values:

Values for Mars are the same in the 1991 and 1994 reports.

Current values:

```
\begindata

BODY499_RADII       = (     3397.      3397.         3375.     )

\begintext
```

Radii of Satellites

Satellites of Mars

Old values:

Values for Phobos and Deimos are the same in the 1991 and 1994 reports.

```
Current values:

   \begindata

   BODY401_RADII      = (        13.4         11.2            9.2    )
   BODY402_RADII      = (         7.5          6.1            5.2    )

   \begintext
```