Galileo Spacecraft Trajectory SPK file, Robert Jacobson's 2021 Solution
==========

Created by Marc Costa Sitja, NAIF/JPL, February 9, 2022.

Objects in the Ephemeris

This file contains trajectory data for the Galileo spacecraft (NAIF ID -77) with respect to the Jupiter Barycenter (5) in the J2000 inertial reference frame.

It also contains ephemerides of the Sun (10), planetary barycenters (1-9), Mercury (199), Venus (299), Earth (399), Moon (301), Mars (499), and Jupiter (599) and of a few Jovian satellites -- Io (501), Europa (502), Ganymede (503), Callisto (504), Amalthea (505), and Thebe (514).

The planetary ephemerides included in this SPK are version DE440; the satellite ephemerides included in this file are versions JUP365 and MAR097.

Approximate Time Coverage

The Galileo trajectory stored in this SPK file provides continuous coverage for the complete mission, specifically:

Start of Interval (ET)	End of Interval (ET)
1995 NOV 21 00:00:00.000	2002 NOV 26 08:00:00.000

Status

This file contains reconstructed Galileo trajectory determined by Robert A. Jacobson, Solar System Dynamics group, in 2021. It is intended for use in support of the Galileo experiment data processing and for archiving with the Planetary Data System (PDS).

Pedigree

This file was created by Marc Costa Sitja using the trajectory solution provided in the form of a single SPK file by Robert A. Jacobson in January 2021. The SPK was provided along with a document internal to to JPL:

R. A. Jacobson, ``The Reconstruction of the Galileo Tour''
Interoffice Memorandum 392R-21-002, 11 January 2021

This single SPK file was originated from a number of SPK files merged together using the SPKMERGE program by Robert A. Jacobson. The SPKMERGE log is provided in the Appendix 1 of these comments.

The SPK file was merged then together by Marc Costa Sitja with DE440 planetary ephemerides and JUP365 and MAR097 satellite ephemerides using the SPKMERGE program. The SPKMERGE log is provided in the Appendix 2 of these comments.

Segment Boundary Discontinuities

The original SPK file contains a large number of Galileo trajectory SPK segments that came from original individual SPK files. Although, each segment provides continuous trajectory within the interval that it covers, in general a position and velocity discontinuity exists at the boundary of the segment and the segments whose coverage immediately precede and follow it. The times and magnitudes of these discontinuities are provided in the Appendix 3 of these comments.

Contacts

If you have questions regarding this data contact

Marc Costa Sitja

(818) 354-4852,
Marc.Costa.Sitja@jpl.nasa.gov

Appendix 1: SPKMERGE Log for the original SPK

The log from the SPKMERGE run that created this SPK is below.

```
; galileo.sc.bsp LOG FILE

; Created 2021-01-12/16:37:04.00.
;
; BEGIN SPKMERGE COMMANDS

LEAPSECONDS_KERNEL   = naif0012.tls

SPK_KERNEL           = galileo.sc.bsp
  SOURCE_SPK_KERNEL  = pfile.Io.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1995 NOV 20 23:58:58.817
    END_TIME         = 1995 DEC 31 23:58:59.816
  SOURCE_SPK_KERNEL  = pfile.Ganymede0.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1995 DEC 31 23:58:59.816
    END_TIME         = 1996 JUN 12 11:58:58.815
  SOURCE_SPK_KERNEL  = pfile.Ganymede1.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1996 JUN 12 11:58:58.815
    END_TIME         = 1996 AUG 05 23:58:58.817
  SOURCE_SPK_KERNEL  = pfile.Ganymede2.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1996 AUG 05 23:58:58.817
    END_TIME         = 1996 SEP 10 23:58:58.818
  SOURCE_SPK_KERNEL  = pfile.Callisto3.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1996 SEP 10 23:58:58.818
    END_TIME         = 1996 DEC 15 23:58:58.817
  SOURCE_SPK_KERNEL  = pfile.Europa4.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1996 DEC 15 23:58:58.817
    END_TIME         = 1997 JAN 21 11:58:58.815
  SOURCE_SPK_KERNEL  = pfile.Europa6.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1997 JAN 21 11:58:58.815
    END_TIME         = 1997 MAR 14 23:58:58.814
  SOURCE_SPK_KERNEL  = pfile.Ganymede7.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1997 MAR 14 23:58:58.814
    END_TIME         = 1997 APR 21 23:58:58.814
  SOURCE_SPK_KERNEL  = pfile.Ganymede8.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1997 APR 21 23:58:58.814
    END_TIME         = 1997 JUN 03 23:58:58.815
  SOURCE_SPK_KERNEL  = pfile.Callisto9.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1997 JUN 03 23:58:58.815
    END_TIME         = 1997 AUG 18 11:58:57.817
  SOURCE_SPK_KERNEL  = pfile.Callisto10.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1997 AUG 18 11:58:57.817
    END_TIME         = 1997 OCT 15 23:58:57.818
  SOURCE_SPK_KERNEL  = pfile.Europa11.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1997 OCT 15 23:58:57.818
    END_TIME         = 1997 NOV 09 23:58:57.817
  SOURCE_SPK_KERNEL  = pfile.Europa12.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1997 NOV 09 23:58:57.817
    END_TIME         = 1998 JAN 17 11:58:57.816
  SOURCE_SPK_KERNEL  = pfile.Europa13.bsp
    INCLUDE_COMMENTS = NO
```

```
    BODIES           = -77
    BEGIN_TIME       = 1998 JAN 17 11:58:57.816
    END_TIME         = 1998 MAR 14 00:58:57.814
  SOURCE_SPK_KERNEL  = pfile.Europa14.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1998 MAR 14 00:58:57.814
    END_TIME         = 1998 JUN 27 00:58:57.816
  SOURCE_SPK_KERNEL  = pfile.Europa16.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1998 JUN 27 00:58:57.816
    END_TIME         = 1998 AUG 10 09:58:57.817
  SOURCE_SPK_KERNEL  = pfile.Europa17.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1998 AUG 10 09:58:57.817
    END_TIME         = 1998 DEC 31 23:58:57.816
  SOURCE_SPK_KERNEL  = pfile.Europa19.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1998 DEC 31 23:58:57.816
    END_TIME         = 1999 APR 10 23:58:56.814
  SOURCE_SPK_KERNEL  = pfile.Callisto20.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1999 APR 10 23:58:56.814
    END_TIME         = 1999 JUN 04 23:58:56.815
  SOURCE_SPK_KERNEL  = pfile.Callisto21.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1999 JUN 04 23:58:56.815
    END_TIME         = 1999 AUG 05 23:58:56.817
  SOURCE_SPK_KERNEL  = pfile.Callisto22.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1999 AUG 05 23:58:56.817
    END_TIME         = 1999 AUG 28 23:58:56.817
  SOURCE_SPK_KERNEL  = pfile.Callisto23.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1999 AUG 28 23:58:56.817
    END_TIME         = 1999 OCT 08 23:58:56.818
  SOURCE_SPK_KERNEL  = pfile.Io24.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1999 OCT 08 23:58:56.818
    END_TIME         = 1999 NOV 11 01:58:56.817
  SOURCE_SPK_KERNEL  = pfile.Io25.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1999 NOV 11 01:58:56.817
    END_TIME         = 1999 DEC 26 23:58:56.816
  SOURCE_SPK_KERNEL  = pfile.Europa26.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 1999 DEC 26 23:58:56.816
    END_TIME         = 2000 FEB 06 05:58:56.815
  SOURCE_SPK_KERNEL  = pfile.Io27.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 2000 FEB 06 05:58:56.815
    END_TIME         = 2000 APR 07 23:58:56.814
  SOURCE_SPK_KERNEL  = pfile.Ganymede28.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 2000 APR 07 23:58:56.814
    END_TIME         = 2000 NOV 18 23:58:56.817
  SOURCE_SPK_KERNEL  = pfile.Ganymede29.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 2000 NOV 18 23:58:56.817
    END_TIME         = 2001 APR 28 23:58:56.814
  SOURCE_SPK_KERNEL  = pfile.Callisto30.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 2001 APR 28 23:58:56.814
    END_TIME         = 2001 JUL 16 23:58:56.816
  SOURCE_SPK_KERNEL  = pfile.Io31.bsp
    INCLUDE_COMMENTS = NO
    BODIES           = -77
    BEGIN_TIME       = 2001 JUL 16 23:58:56.816
    END_TIME         = 2001 AUG 27 23:58:56.817
  SOURCE_SPK_KERNEL  = pfile.Io32.bsp
    INCLUDE_COMMENTS = NO
```

```
            BODIES           = -77
            BEGIN_TIME       = 2001 AUG 27 23:58:56.817
            END_TIME         = 2001 DEC 01 11:58:56.817
          SOURCE_SPK_KERNEL  = pfile.Io33.bsp
            INCLUDE_COMMENTS = NO
            BODIES           = -77
            BEGIN_TIME       = 2001 DEC 01 11:58:56.817
            END_TIME         = 2002 JAN 31 23:58:56.815
          SOURCE_SPK_KERNEL  = pfile.Amalthea34.bsp
            INCLUDE_COMMENTS = NO
            BODIES           = -77
            BEGIN_TIME       = 2002 JAN 31 23:58:56.815
            END_TIME         = 2002 NOV 26 07:58:55.817

        ; END SPKMERGE COMMANDS
```

Appendix 2: SPKMERGE Log

The log from the SPKMERGE run that created this SPK is below.

```
        ; gll_951120_021126_raj2021.bsp LOG FILE

        ; Created 2022-02-08/17:02:23.00.
        ;
        ; BEGIN SPKMERGE COMMANDS

        LEAPSECONDS_KERNEL   = naif0012.tls

        SPK_KERNEL           = gll_951120_021126_raj2021.bsp
          LOG_FILE           = gll_951120_021126_raj2021.log
          SOURCE_SPK_KERNEL  = galileo.sc.bsp
            INCLUDE_COMMENTS = NO
            BODIES           = -77
            BEGIN_TIME       = 1995 NOV 20 23:58:58.817
            END_TIME         = 2002 NOV 26 07:58:55.817
          SOURCE_SPK_KERNEL  = jup365.bsp
            INCLUDE_COMMENTS = NO
            BODIES           = 3, 5, 10, 399, 501, 502, 503, 504, 505, 514, 599
            BEGIN_TIME       = 1995 NOV 20 23:58:58.817
            END_TIME         = 2002 NOV 26 07:58:55.817
          SOURCE_SPK_KERNEL  = de440s.bsp
            INCLUDE_COMMENTS = NO
            BODIES           = 1, 2, 4, 6, 7, 8, 9, 199, 299, 301
            BEGIN_TIME       = 1995 NOV 20 23:58:58.817
            END_TIME         = 2002 NOV 26 07:58:55.817
          SOURCE_SPK_KERNEL  = mar097.bsp
            INCLUDE_COMMENTS = NO
            BODIES           = 499
            BEGIN_TIME       = 1995 NOV 20 23:58:58.817
            END_TIME         = 2002 NOV 26 07:58:55.817

        ; END SPKMERGE COMMANDS
```

Appendix 3: Segment Boundary Discontinuity Summary

This SPK file contains a large number of Galileo trajectory SPK segments that came from original individual SPK files. Although, each segment provides continuous trajectory within the interval that it covers, in general a position and velocity discontinuity exists at the boundary of the segment and the segments whose coverage immediately precede and follow it. The times and magnitudes of these discontinuities are provided in the table included in this Appendix.

The top portion of the table contains the name of this SPK file. All descriptive lines in the top portion of the file start with the ``#'' character to allow direct plotting of the data in the freeware ``gnuplot'' application.

The table consists of 4 columns. The first column contains the UTC time of that segment boundary. The last three columns (2..4) contain view coordinate frame components -- ``down track'' (this direction is parallel to the velocity vector), ``normal to plane'' (this direction is computed as cross product of position vector by velocity vector) and ``in plane'' (this direction is computed as a cross product of ``down track'' by ``normal to plane'') -- of the difference between the state vectors computed at that UTC time defining segment boundary at which a discontinuity exists.

The pairs of segments and discontinuity times are determined using an algorithm that emulates the standard SPK loading priority --

```
      ``last loaded segment takes precedence''. Therefore, the
      discontinuities summarized in the file are those which a user
      reading file would actually see.

      The difference components in the view coordinate frame were
      computed for each discontinuity using the following algorithm:

          --   A single state was computed from each pair of segment the
               J2000 frame at the time of discontinuity.

          --   For this pair of states, a position difference vector was
               computed by subtracting the state computed from the
               segment with higher priority from the state computed from
               segment with lower priority. Then, a frame transformation
               matrix rotating these difference vectors from J2000 to
               the view coordinate frame defined by the state obtained
               from the higher priority segment was computed, and the
               position difference vector was rotated to the view frame
               coordinates using this matrix.

      The Galileo trajectory segment boundary discontinuities for this
      file are:

          #
          # Summary of discontinuities at segment boundaries for
          # SPK file gll_951120_021126_raj2021.bsp:
          #
          #  BOUNDARY TIME (UTC)   DOWNTRK     INPLANE     NORMAL
          #---------------------- ----------- ----------- -----------
          1995-12-31T23:58:59.816  0.73777875  3.05855190  1.70016531
          1996-06-12T11:58:58.815  0.49318365 -0.30425715  2.34315209
          1996-08-05T23:58:58.816  0.20880007  0.25673874  2.34782592
          1996-09-10T23:58:58.817  0.53910429 -0.45957421  4.81900349
          1996-12-15T23:58:58.816 -0.45540739  0.18648817  0.69239848
          1997-01-21T11:58:58.815  0.15598341 -0.08845606 -0.35510145
          1997-03-14T23:58:58.814  0.03064078  0.04483393  0.35993303
          1997-04-21T23:58:58.814  0.70259885  0.08486730  3.16198356
          1997-06-03T23:58:58.815  0.25916332  0.08584065 -1.50849680
          1997-08-18T11:58:57.817 -0.38957599 -0.39219369  0.25946116
          1997-10-15T23:58:57.817  0.06000665  0.01338684  0.63462772
          1997-11-09T23:58:57.817 -0.02012859  0.04095586 -4.26007811
          1998-01-17T11:58:57.815  0.47138036  0.21924480  0.23766881
          1998-03-14T00:58:57.814  3.13823188  1.14874343  4.77883004
          1998-06-27T00:58:57.815  1.85987448  0.30707415 -0.89771972
          1998-08-10T09:58:57.816  0.15886198 -0.15573049  1.70722887
          1998-12-31T23:58:57.816  0.24856732  0.23045015  1.99873491
          1999-04-10T23:58:56.814  1.08059712  1.16629482  0.46699413
          1999-06-04T23:58:56.815 -0.01717521 -0.07515067 -1.99044351
          1999-08-05T23:58:56.816 -0.18424028 -0.26042192 -1.64846542
          1999-08-28T23:58:56.817 -0.07200383 -0.10931291 -2.58892428
          1999-10-08T23:58:56.817  0.56124298  0.93289188  2.03218730
          1999-11-11T01:58:56.817 -0.09542287  0.05278765  0.94665727
          1999-12-26T23:58:56.816  0.09514248  0.07191734 -0.66437086
          2000-02-06T05:58:56.815  0.53047673  0.01823408 -0.44762939
          2000-04-07T23:58:56.814  0.23215130 -0.48853520 -2.51614097
          2000-11-18T23:58:56.817  0.53999022  0.53280979  1.97455504
          2001-04-28T23:58:56.814  0.22678806 -0.60829861  0.75780194
          2001-07-16T23:58:56.816 -0.10276735  0.11372174 -0.24367506
          2001-08-27T23:58:56.817 -0.12299208  0.18122583 -1.65177305
          2001-12-01T11:58:56.816  0.11869450  0.29319630 -3.28587612
          2002-01-31T23:58:56.815  0.10231004 -0.08704455  0.05562704


   End of comments.
```