Software Interface Specification

Small Forces File

for
Mars Polar Lander, Stardust, Genesis, Mars Odyssey 2001 Orbiter, Deep Impact and Mars Reconnaissance Orbiter

Version 2.0
September 2, 2004

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edited-down version containing details only for Stardust

Table of Contents

List of Acronyms

delta-V	Change in velocity
DSN	Deep Space Network
M98	Mars Surveyor 98 Mission, consisting of the Mars Polar Lander (MPL) and Mars Climate Orbiter (MCO) spacecraft
MPL	Mars Polar Lander
M01	Acronym for the Mars Odyssey 2001 Orbiter spacecraft
GNS	Acronym for the Genesis Spacecraft
LANDSF	Program to produce Mars Polar Lander predict SFFs
MAKSDP	Program to produce Stardust predict SFFs
SMF_PREDICT	Program to produce Genesis short-term predict SFFs
MAKGNP	Program to produce Genesis long-term predict SFFs
MAKSFF	Program to produce Mars Polar Lander and Stardust reconstruction SFFs
ODP	Orbit Determination Program
Sdu	Acronym for the Stardust spacecraft
SIS	Software Interface Specification
SFF	Small Forces File
SPAS	Spacecraft Performance Analysis Software
SRDS	Software Requirements and Design Specification

Change History

Version	Date	Reason
1.0	06-15-98	First draft, for review
1.1	09-05-98	Updated after first review
1.2	10-25-98	Updated after second review
1.3	11-09-98	Updated after third review
1.4	03-16-99	Updated to reflect optional addition of the SPICE DP SCLK
1.5	10-22-00	Updated for Genesis
1.6	01-08-01	Updated for Mars Odyssey 2001 Orbiter
1.7	02-24-01	Updated after GNS/M01 review
1.8	03-16-01	Replaced OPENED with OPEN in optional GNS fields
1.9	08-20-04	Updated for Deep Impact and MRO
2.0	09-02-04	Added clarification regarding sign of DMASS

1. General Description

1.1 Purpose

The Small Forces File (SFF) provides to JPL's Orbit Determination Program (ODP) and interested science teams the cumulative delta-V effect of attitude thruster firings over one or more specified intervals of time. In some cases it also provides an estimate of the cumulative spacecraft mass loss due to the use of propellant in those attitude thrusters.

The same format file is also produced to model predicted accelerations.

1.2. Scope

This SIS is applicable for the Mars Polar Lander (MPL), Stardust (SDU), Genesis (GNS), Mars Odyssey 2001 Orbiter (M01), Deep Impact Flyby (DIF) and Mars Reconnaissance Orbiter (MRO) spacecraft. It covers both "predict" and "reconstruction" situations. For Stardust predict situations, it covers two kinds of predict Small Forces Files: one containing delta-velocity (typically from spacecraft slews, dead-band walks and other delta-V generating events) and one containing acceleration (typically from cruise limit cycling).

1.3 Applicable Documents

Several programs exist for creating this Small Forces File. See the relevant program User Guides for operating details. These are:

LANDSF	Mars Polar Lander predict SFFs
MAKSDP	Stardust predict SFFs
SMF_PREDICT	Genesis short-term predict SFFs
MAKGNP	Genesis long-term predict SFFs
MAKSFF	MPL, SDU, GNS, M01, DIF, and MRO reconstruction SFFs
SMALLFORCEMERGE	Program for merging predict and reconstruction SFFs

See the relevant Operations Procedures and Operational Interface Agreements for information about production procedures, schedules and file destinations.

2. Method of Generation

2.1 Predict Mode

A Small Forces File may be produced in "predict" mode by a program that models expected delta-V (and acceleration, in the case of Stardust) based on expected performance or knowledge of the spacecraft attitude control system and the mission profile. Separate programs for producing predict Small Forces Files are available for the Mars Polar Lander, Stardust and Genesis flight projects. See the LANDSF, MAKSDP, MAKGNP and SMF_PREDICT User's Guides, respectively.

2.2 Reconstruction Mode

A Small Forces File may be produced in "reconstruction" mode by a set of scripts and programs that obtain Small Forces File packets returned from the spacecraft and post-process and/or reformat this data into an SFF. This process includes some computations of derived parameters. See the MAKSFF User's Guide and the relevant Operations Interface Agreements, Operational Procedures and SPAS SRDS documents for production details.

2.3 Merging Predict and Reconstruction Delta-V Files

The file merging information in this subsection does not deal with the format or content of an SFF and so is not a subject appropriate for detailed discussion in this SIS. See the appropriate operational procedure for the mission of interest for the official instructions about merging SFF files.

The ODP can read only one delta-V Small Forces File during execution. Consequently, means external to the ODP are needed to combine "predict" and "reconstruction" delta-V SFF data as needed into a single file.

For all six spacecraft — MPL, SDU, GNS, M01, DIF, and MRO — the merging of reconstruction data with predict data can be accomplished with the SMALLFORCEMERGE program.

The ODP can also read only one accelerations file. Since there is no reconstruction accelerations file, merging of accelerations SFFs is not an issue. Note, however, that the accelerations file must be truncated to start where the delta-V reconstruction file ends; otherwise inconsistent data will be input to the ODP.

3. Detailed Data Object Definition

3.1 General Structure

A small forces file consists of two sections–header and data–separated by an end of header character flag on a line by itself:

<header>
$$EOH
<data>

where

<header> is a set of KEYWORD=VALUE assignments

$$EOH is end-of-header delimiter, on a line by itself

<data> is one or more small forces data records

There is no special end of file marker inserted at the end of the data section.

3.2 Header Section Structure

The header section consists of the following KEYWORD=VALUE assignments, each on a line by itself. Any amount of white space, including none, can appear on each side of the "=" sign.

MISSION_NAME = <character string>
SPACECRAFT_NAME = <character string>
DSN_SPACECRAFT_ID = <positive integer>
PRODUCTION_TIME = YYYY-MM-DD HR:MN:SC[.XXX]
PRODUCER_ID = <character string>

where

MISSION_NAME	name of the mission (Stardust, M98, GNS, M01, DI, MRO)

SPACECRAFT_NAME	name of the spacecraft (Sdu, M98, Gns, Or1, Dif, Mro)
DSN_SPACECRAFT_ID	DSN ID for the spacecraft: (Stardust = 29, Mars Polar Lander = 116, Genesis = 47, M01 = 53, DIF = 140, MRO = 74)
PRODUCTION_TIME	file production date and time, taken from the local computer clock
PRODUCER_ID	name/organization of the producer; example: NAIF/JPL

It is noted here that within the Stardust, Mars Surveyor 98, Genesis, Mars Odyssey 2001, Deep Impact, and Mars Reconnaissance Orbiter projects, and particularly their ground systems, several names for the missions and spacecraft are in use. The values for MISSION_NAME and SPACECRAFT_NAME shown in the table above seem not to be the best choices in all cases, but they are the only consistent set of names that can be placed in the SFF header by the SFF production programs. The software for which this SFF product was designed does not use either of these items (it uses only the DSN_SPACECRAFT_ID from the header) so the values (including case) for MISSION_NAME and SPACECRAFT_NAME placed in the header are not important.

3.3 Data Section Structure

The data section of a small forces file consists of one or more data records, each record occupying a single line:

<data record 1>
<data record 2>
...
<data record N>

Although the records are usually sorted in increasing order by STOPTIM field from the primary portion of the record, this sorting is not guaranteed.

3.3.1 Data Record Structure Overview

Each data record of a small forces file consists of two parts delimited by a comma, the primary data part and additional data part:

<primary data>,<additional data>

The additional data part is optional. If it's not present, the delimiting comma is omitted.

Spaces preceding or following commas are insignificant.

3.3.2 Data Record Primary Data Structure

The primary data part of a small forces data record consists of the following required parameters in the order shown, separated by commas:

INDEX,RECTYPE,GENTIM,STARTTIM,STOPTIM,DTIME,DMASS,DVX,DVY,DVZ

where

INDEX index of the record in the file (1...N)

RECTYPE type of the record, one character string:

	for velocity files: P = predicted, R = reconstructed for predicted acceleration files: A = continuous, X = discontinuous
GENTIM	record generation time; format: YYYY-MM-DD HR:MN:SC[.XXX]; taken from the local computer clock (implies UTC for TMOD computers)
STARTTIM (ET)	data accumulation period start time; format YYYY-MM-DD HR:MN:SC.XXX. For predict delta-V files, this item = STOPTIM and corresponds to the time for application of delta-V for a delta-V generating event event.
STOPTIM (ET)	data accumulation period stop time; format YYYY-MM-DD HR:MN:SC.XXX. For predict delta-V files, this item = STARTTIM and corresponds to the time for application of delta-V for a delta-V generating event event.
DTIME (Seconds)	For reconstruction files, data accumulation period duration (STOPTIM - STARTTIM). For Sdu predict delta-V files, computed from a table of estimated delta-V generating event durations, varying by delta-V generating event type. For MPL predict files, corresponds to the length of the interval ending at STOPTIM that is used to determine the predicted delta-V. For GNS predict files, this is zero.
DMASS or DMASS rate (Kg or kg/sec)	Always zero for MPL, GNS, M01, DIF, and MRO files. For SDU reconstruction velocity files this is computed from estimated mass flow rate (parameter updated after each major maneuver) and thruster on time (kg). For Sdu predicted velocity files, computed from table of estimated mass decrement by delta-V generating event type (kg). For Sdu predicted acceleration files, mass flow rate is computed from specific impulse and predicted ACS acceleration (kg/sec). Positive DMASS value means mass loss.
DVX or AX (m/s or m/s**2)	resultant delta-V in J2000 frame X direction for the accumulation time period; or for Stardust acceleration files, resultant acceleration in X direction
DVY or AY (m/s or m/s**2)	resultant delta-V in J2000 frame Y direction for the accumulation time period; or for Stardust acceleration files, resultant acceleration in Y direction
DVZ or AZ (m/s or m/s**2)	resultant delta-V in J2000 frame Z direction for the accumulation time period; or for Stardust acceleration files, resultant acceleration in Z direction

3.3.3 Data Record Additional Data Structure

The additional data part of a small forces data record consists of the following parameters requested by a particular mission in the order in which they appear in the mission's small forces APID, plus optional SPICE DPSCLK, separated by commas:

AAAA, BBBB, CCCC, ..., ZZZZ, DPSCLK

where

AAAA	a field from a mission small forces APID
BBBB	a field from a mission small forces APID
CCCC	a field from a mission small forces APID
...	...
ZZZZ	a field from a mission small forces APID

DPSCLK SPICE double precision SCLK (SCLK ticks)

These additional data are not provided in the SFF for Mars Polar Lander but are provided in the SFFs for Stardust, Genesis, M01, DIF, and MRO. See the description below of the fields that will be included. SPICE double precision SCLK must be provided in any reconstruction SFF even if other additional fields aren't present in order use the file with as input to the MAKSFF program (version 3.0.0 or later).

3.3.3.1 Stardust Mission Additional Data

For the Stardust mission the additional data part of a small forces data record consists of the following parameters, occurring in the order in which they appear in the small forces APID. These data items are separated by commas and appear on the same line as, and after, the primary data.

Q1, Q2, Q3, Q4, RCS1N, RCS2N, RCS3N, RCS4N, RCS5N, RCS6N, RCS7N, RCS8N, TCM1N, TCM2N, TCM3N, TCM4N, TCM5N, TCM6N, TCM7N, TCM8N, RCS1T, RCS2T, RCS3T, RCS4T, RCS5T, RCS6T, RCS7T, RCS8T, TCM1T, TCM2T, TCM3T, TCM4T, TCM5T, TCM6T, TCM7T, TCM8T

where

Q1	First element of average attitude quaternion at time of thruster firings
Q2	Second element of average attitude quaternion at time of thruster firings
Q3	Third element of average attitude quaternion at time of thruster firings
Q4	Fourth element of average attitude quaternion at time of thruster firings (scalar component)
RCS1N	Number of firings during time period for RCS1
RCS2N	Number of firings during time period for RCS2
RCS3N	Number of firings during time period for RCS3
RCS4N	Number of firings during time period for RCS4
RCS5N	Number of firings during time period for RCS5
RCS6N	Number of firings during time period for RCS6
RCS7N	Number of firings during time period for RCS7
RCS8N	Number of firings during time period for RCS8
TCM1N	Number of firings during time period for TCM1
TCM2N	Number of firings during time period for TCM2
TCM3N	Number of firings during time period for TCM3
TCM4N	Number of firings during time period for TCM4
TCM5N	Number of firings during time period for TCM5
TCM6N	Number of firings during time period for TCM6
TCM7N	Number of firings during time period for TCM7
TCM8N	Number of firings during time period for TCM8

RCS1T	Accumulated on time during time period for RCS1
RCS2T	Accumulated on time during time period for RCS2
RCS3T	Accumulated on time during time period for RCS3
RCS4T	Accumulated on time during time period for RCS4
RCS5T	Accumulated on time during time period for RCS5
RCS6T	Accumulated on time during time period for RCS6
RCS7T	Accumulated on time during time period for RCS7
RCS8T	Accumulated on time during time period for RCS8
TCM1T	Accumulated on time during time period for TCM1
TCM2T	Accumulated on time during time period for TCM2
TCM3T	Accumulated on time during time period for TCM3
TCM4T	Accumulated on time during time period for TCM4
TCM5T	Accumulated on time during time period for TCM5
TCM6T	Accumulated on time during time period for TCM6
TCM7T	Accumulated on time during time period for TCM7
TCM8T	Accumulated on time during time period for TCM8

4. Sample Small Forces Files

Shown here are made-up examples of SFF data for all missions. The first two and the last two examples are for a "reconstruction" period with velocity data, as indicated by the "R" in the second field. A "P" would appear in this location for a "predict" velocity SFF. The third example is for a Stardust predict accelerations file.

Note that the data records do not have a fixed width format; rather, each data item is simply comma delimited from the previous item.

Note that in SDU predict files for both delta-V and acceleration the last four data items are given in scientific notation.

The data portion of each file begins with data record number one.

4.2 Example Reconstruction Small Forces File for Stardust

This example is for a SFF containing delta-V information. In this example the "additional data" portion of each record is not shown due to the length of the data.

```
MISSION_NAME = Stardust
SPACECRAFT_NAME = Sdu
DSN_SPACECRAFT_ID = 29
PRODUCTION_TIME = 2001-11-10 13:04:21
PRODUCER_ID = NAIF/JPL
$$EOH
1, R, ...
...
7821, R, 2001-11-07 13:00:00, 2001-11-06 13:00:00.000, 2001-11-07 01:00:00.000, 43200.000, 0.003, 0.012, 0.006, 0.002
7822, R, 2001-11-08 01:00:43, 2001-11-07 01:00:43.560, 2001-11-07 13:00:43.560, 43200.000, 0.002, 0.002, 0.009, 0.001
7823, R, 2001-11-08 13:01:27, 2001-11-07 13:01:27.120, 2001-11-08 01:01:27.120, 43200.000, 0.004, 0.021, 0.009, 0.009
7824, R, 2001-11-09 01:02:10, 2001-11-08 01:02:10.680, 2001-11-08 13:02:10.680, 43200.000, 0.003, 0.001, 0.023, 0.001
7825, R, 2001-11-09 13:02:54, 2001-11-08 13:02:54.240, 2001-11-09 01:02:54.240, 43200.000, 0.001, 0.003, 0.002, 0.001
7826, R, 2001-11-10 01:03:37, 2001-11-09 01:03:37.800, 2001-11-09 13:03:37.800, 43200.000, 0.002, 0.009, 0.002, 0.003
7827, R, 2001-11-10 13:04:21, 2001-11-09 13:04:21.360, 2001-11-10 01:04:21.360, 43200.000, 0.004, 0.000, 0.011, 0.009
...
etc.
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