Software Interface Specification

Small Forces File

for
Dawn

Version 1.1
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Custodian: T. Weise
Dawn Spacecraft Team

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List of Acronyms

delta-V	Change in velocity
DSN	Deep Space Network
ODP	Orbit Determination Program
SFF	Small Forces File
SIS	Software Interface Specification
STAS	Spacecraft Team Analysis Software
SRDS	Software Requirements and Design Specification

Change History

Version	Date	Reason
1.0	04-20-05	First draft, for review
1.1	07-03-07	Update with ancillary data (s.collins)

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 Dawn spacecraft. It covers both "predict" and "reconstruction" situations. It will cover primarily RCS firings used to perform reaction wheel assembly momentum unloads.

1.3 Applicable Documents

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

make_sff	Dawn reconstruction SFFs (TBD)
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 based on expected performance or knowledge of the spacecraft attitude control system and the mission profile.

2.2 Reconstruction Mode

A Small Forces File may be produced in "reconstruction" mode by a set of scripts and programs that obtain AC_Ancillary packets returned from the spacecraft and post-process this data into an SFF. This process includes some computations of derived parameters. See the make_sff User's Guide (TBD) and the relevant Operations Interface Agreements, Operational Procedures and STAS 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.

The merging of reconstruction data with predict data can be accomplished with the SMALLFORCEMERGE program. (TBR)

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 (DAWN)
SPACECRAFT_NAME	name of the spacecraft (DAWN)
DSN_SPACECRAFT_ID	DSN ID for the spacecraft: (Dawn = 203)
PRODUCTION_TIME	file production date and time, taken from the local computer clock
PRODUCER_ID	name/organization of the producer; example: SCT/JPL
	OPTIONAL HEADER ITEMS:
SPK_FILENAME	Trajectory files used in this run
ECSV_FILENAME	Telemetry file used a source of reconstructed data
INCLUDED_SFF_FILENAME	Name of optional "included SFF" used a source of reconstructed data
SFFTOOL_VERSION	Version string of SFFTOOL used for this run

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
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).
DMASS (Kg)	Estimate of prop used during this event. Positive DMASS value means mass loss.
DVX (m/s)	resultant delta-V in J2000 frame X direction for the accumulation time period
DVY (m/s)	resultant delta-V in J2000 frame Y direction for the accumulation time period
DVZ (m/s)	resultant delta-V in J2000 frame Z direction for the accumulation time period

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)

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 Dawn Mission Additional Data

For the Dawn mission, the additional data part of a small forces data record consists of the following parameters. These data items are separated by commas and appear on the same line as, and after, the primary data.

Q1, Q2, Q3, Q4,RCS1T, RCS2T, RCS3T, RCS4T, RCS5T, RCS6T, JetControlSet, F_EST, EVENT_TYPE, COMMENT, DPSCLK
where

Q1	First element of average attitude quaternion at center time of thruster firings
Q2	Second element of average attitude quaternion at center time of thruster firings
Q3	Third element of average attitude quaternion at center time of thruster firings
Q4	Fourth element of average attitude quaternion at center time of thruster firings (scalar component)
RCS1T	Accumulated on time during time period for RCS1 (sec)*
RCS2T	Accumulated on time during time period for RCS2 (sec)*
RCS3T	Accumulated on time during time period for RCS3 (sec)*
RCS4T	Accumulated on time during time period for RCS4 (sec)*
RCS5T	Accumulated on time during time period for RCS5 (sec)*
RCS6T	Accumulated on time during time period for RCS6 (sec)*
	*RCS1-6 correspond to the 6 thrusters on the currently selected jet control set (i.e., if the redundant side is selected, that data will still fill the slots listed above.
JetControlSet	Integer (0= ODD, 1= Even)
F_EST	Estimated thrust level for each thruster (N)
EVENT_TYPE	String (“DESAT”, “Predicted DESAT”, “PUFF”)

COMMENT String (max 256 chars) The method for computing delta-v, and other info may be reported here

DPSCLK SPICE double precision SCLK (SCLK ticks)

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.

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

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

4.1 Example Reconstruction Small Forces File for Dawn

```
MISSION_NAME = DAWN
SPACECRAFT_NAME = DAWN
DSN_SPACECRAFT_ID = 203
PRODUCT_CREATION_TIME = 2007-07-03 18:45:11
PRODUCER_ID = SCT/JPL
SPK_FILENAME = dawn_ref_070620-081006_060906_v1.bsp
ECSV_FILENAME = temp.ecsv
INCLUDED_SFF_FILENAME =
SFFTOOL_VERSION = V1.00.000
$$EOH
1, R, 2007-07-03 18:45:11, 2007-07-01 19:16:10.657, 2007-07-01 19:19:06.055, 175.398, 0.001317, 0.000626, 0.000701, -0.001258, 0.652868082, 0.631440027, 0.402178210, 0.115323230, 2.040, 0.000, 0.272, 0.000, 0.000, 0.272, 0, 0.900, DESAT, DV by valve-time method , 60566918026.240
2, R, 2007-07-03 18:45:11, 2007-09-29 12:25:07.254, 2007-09-29 12:25:52.254, 45.000, 0.000065, 0.000088, -0.000005, -0.000036, 0.191616546, 0.310048575, 0.930513725, 0.036016509, 0.000, 0.000, 0.064, 0.000, 0.000, 0.064, 0, 0.900, DESAT, DV by valve-time method , 62551243504.128
3, R, 2007-07-03 18:45:11, 2007-09-29 21:42:47.254, 2007-09-29 21:44:46.254, 119.000, 0.000379, 0.000219, 0.000325, 0.000113, -0.037350490, -0.569520354, -0.821125289, 0.002183499, 0.480, 0.000, 0.000, 0.000, 0.000, 0.264, 0, 0.900, DESAT, DV by valve-time method , 62559818736.128
4, P, 2007-07-03 18:45:11, 2007-10-01 00:44:46.254, 2007-10-01 00:44:46.254, 0.000, 0.003234, -0.002050, -0.001734, -0.002001, 0.031516395, -0.944096287, 0.328152782, 0.002160795, 3.488, 0.000, 0.000, 1.447, 1.407, 0.000, 0, 0.900, predicted DESAT, DV by momentum+geom method , 62584717168.129
5, P, 2007-07-03 18:45:11, 2007-10-03 00:44:46.254, 2007-10-03 00:44:46.254, 0.000, 0.006074, -0.003886, -0.003460, -0.003526, -0.040624555, 0.936543380, -0.348113931, 0.007268730, 6.563, 0.000, 0.000, 5.059, 0.291, 0.000, 0, 0.900, predicted DESAT, DV by momentum+geom method , 62628953968.130
6, P, 2007-07-03 18:45:11, 2007-10-05 00:44:46.254, 2007-10-05 00:44:46.254, 0.000, 0.006384, -0.004372, -0.003671, -0.003276, -0.049290625, 0.929318843, -0.365584233, 0.016884637, 6.569, 0.000, 0.000, 4.881, 1.071, 0.000, 0, 0.900, predicted DESAT, DV by momentum+geom method , 62673190768.130
7, P, 2007-07-03 18:45:11, 2007-10-07 00:44:46.254, 2007-10-07 00:44:46.254, 0.000, 0.006337, -0.004398, -0.003780, -0.003007, -0.057571578, 0.922431488, -0.380915458, 0.026628527, 6.492, 0.000, 0.000, 4.781, 1.156, 0.000, 0, 0.900, predicted DESAT, DV by momentum+geom method , 62717427568.130
8, P, 2007-07-03 18:45:11, 2007-10-09 00:44:46.254, 2007-10-09 00:44:46.254, 0.000, 0.006359, -0.004471, -0.003905, -0.002778, -0.065510347, 0.915864568, -0.394425714, 0.036453305, 6.481, 0.000, 0.000, 4.689, 1.302, 0.000, 0, 0.900, predicted DESAT, DV by momentum+geom method , 62761664368.129
9, P, 2007-07-03 18:45:11, 2007-10-11 00:44:46.254, 2007-10-11 00:44:46.254, 0.000, 0.006370, -0.004520, -0.004013, -0.002561, -0.073151753, 0.909607466, -0.406345935, 0.046325587, 6.477, 0.000, 0.000, 4.608, 1.409, 0.000, 0, 0.900, predicted DESAT, DV by momentum+geom method , 62805901168.128
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