Code 582
Flight Software Systems Branch

cFS DS Requirements

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ID	Summary
6960	cFS DS Requirements Document

SR_Contains:

ID	ReqID	Text	Rationale	Heritage Reference
6962		# CFS Data Storage (DS) Requirements		
7072		# 1.0 Introduction ## 1.1 Document Purpose The Core Flight Software System (CFS) Data Storage (DS) Application will be developed by the Flight Software Branch (FSB) of the Software Engineering Division (SED). The purpose of this requirements specification is to define the requirements to be satisfied by the Data Storage Application. This application is developed for re-use. For this reason, several nomenclatures are used in this document to identify configurations for a mission. The CFS is specified as a multi-platform product. Mission-specific features and customization requirements which are applicable for all platforms are tagged with <MISSION_DEFINED>. Platform-specific features and customizations requirements are tagged with either "<PLATFORM_DEFINED>" or "<OPTIONAL>." Additional nomenclature is used along with the tag to specify a CFS default value for the platform-specific feature: "<PLATFORM_DEFINED, Default_Value>". Reference platforms (single processor and multi-processor architectures) are defined to supply the default CFS application		

configuration. These configurations define the "maximum" CFS Application deployments such that any refined deployment is a subset of a reference platform.

1.2 Document Scope

The scope of this document is limited to the specification of requirements for the Data Storage Software. These include functional, performance, qualification, and design requirements.

1.3 Document Organization

This document is organized into three additional sections and several appendices.

Section 2 gives the Data Storage context.

Section 3 documents the Data Storage system design decisions and constraints.

Section 4 contains the Data Storage functional and performance requirements.

Appendix A contains a list of Terminology used in this document. Note that items that are capitalized, generally indicate a term used in this document.

1.4 Relevant Documents

1.4.1 Parent Documents

None

1.4.2 Reference Documents

1. Operating System Abstraction Layer (OSAL) Library
2. cFE Application Developer's Guide 582-2007-001
3. cFE User's Guide

2.0 CFS Data Storage Application Context

The Data Storage application is responsible for storing messages in files. These file are generally stored on a storage device such as a solid state recorder but they could be stored on any file system. Another application such as CFDP must be used in order to transfer the files created by DS to the ground.

Figure 1.0 shows the context diagram for the CFS Data Storage (DS) Application. During initialization, DS subscribes to messages from other applications as defined in the Data Storage Filter Table. The Scheduler Application (SCH) sends periodic commands to DS as defined in the SCH Schedule Table which requests housekeeping from DS (note that a mission must define this request in the SCH table). Ground commands come from the Command Ingest task (CI). Messages are routed to DS by the cFE SB Application. DS learns of ground updates to the DS tables through the cFE Table Services application.

DS defines 2 tables:

1. Filter Table – for each message ID, specifies filter scheme, filter parameters and which file or files to write the message to. Note that each message can be written to a <PLATFORM_DEFINED> number of destination files.

2. File Table – specifies information about each Destination File.

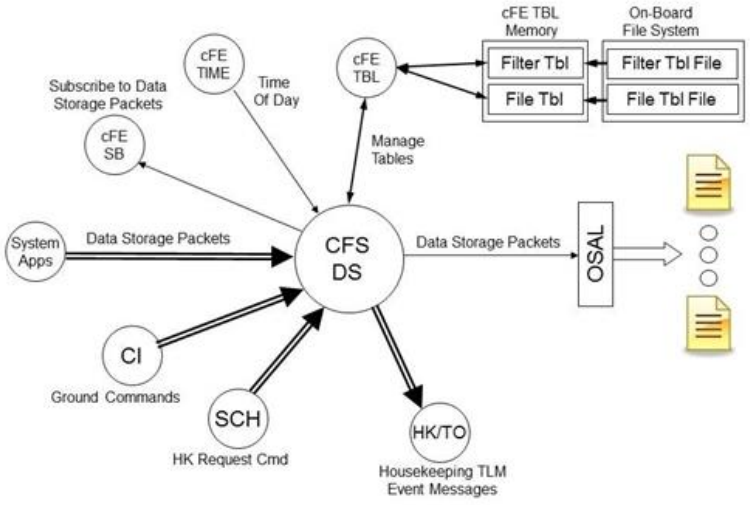

Figure 1.0 – CFS DS Context

2.1 Assumptions

The following list summarizes the assumptions made by the CFS Data Storage Application:

- cFE API and OSAL are being used
- DS does not provide the interface to the hardware used for storing the data. DS simply writes to files and assumes that the interfaces required to write to the devices/partitions are available. EEPROM generally requires that writing be enabled prior to writing. DS does NOT provide this capability.
- A command is sent to DS to request DS housekeeping message (i.e. from the SCH application)
- Destination files defined in the DS Destination File Table should be disabled until a disk is created for DS to use to store the destination file. Once the disk has been created the Enable commands should be sent to enable the use of that Destination File.

3.0 Design Specifications

The Data Storage Application's requirements and design are based on the results of reviewing the requirements, design and code of LRO's Data Storage Application. No formal heritage analysis was done on the application since LRO was the only mission that used a file system where we had enough details to evaluate. There are, however, some features that were available on SDO that are referenced in the "heritage reference" column of the requirements.

Data Storage provides the ability to store messages at different rates using 2 possible filtering schemes allowing "N of X" housekeeping data messages to be stored starting at offset O: 1) Sequence Based Filtering, 2) Time Based Filtering .

Filter Tables are identified by a Filter Table ID. Each Filter Table contains Filter Table data that includes a Message ID and filter factors along with a filter type for four destinations. Each of the four destinations is identified by a Destination Table Index. Filter Tables are indexed by the Message ID. The filter factors are specified with three (3) 16-bit parameters (N, X, O). The filter allows "N of X" housekeeping data messages to be stored starting at offset O. The DS software supports two methods of filtering: 1) sequence based filtering and 2) time based filtering.

Sequence based filtering - uses the message sequence number to determine if the message should be filtered or not. If X is greater than zero, the message shall be stored if and only if the sequence number of the message modulo X is less than N.

Time based filtering - uses the spacecraft time. Messages will be stored if and only if message time stamp modulo X is less than N.

Data Storage supports 2 different schemes that control when to close/open files for storage – 1) Size and 2) Time. Note that messages are stored in a file (or files) in their entirety (i.e. messages are not segmented between files).

- **Size** –messages are written to a file until the maximum file size has been reached (size of the input message + current file size >= max size). If that is true, DS closes the file, creates a new file and writes the message to the new file.

- **Time** – messages are written to a file until the current time (seconds) is greater than or equal to the file creation time + file time maximum. Once the time is reached or exceeded, DS closes the file. DS opens a new file upon receipt of the next message slated for the Destination File.

3.1 Design Constraints

The CFS Data Storage Design assumes that a file system is being used. Some heritage missions such as SDO and ST-5, stored the data as messages or VCDUs in buffers that it then uses to playback the information upon request. In the CFS DS design, files are used to store the data. In order to get the data to the ground, a file transfer mechanism such as CFDP must be used; Data Storage is not responsible for transferring the data.

Since some of the definitions used by DS are contained in two separate tables, careful attention needs to be paid to ensure that the tables are consistent with each other. The Filter Table can be set up to filter based on any valid message id so any type of message can be stored.

DS simply write the files to the partition. Another application such as CFDP is required in order to transfer the files. DS includes some logic to monitor the free space and alert the ground when it is getting low. DS does NOT include any wrapping function where the oldest file is removed in order to write a new file.

4.0 Subsystem Requirements

7066	CFS-550	The CFS shall store table defined data messages into files for later transmission to the ground.	Need to be able to store messages when no ground contact is available.	LRO
7068	CFS-551	The CFS shall provide the capability to store the files on any available file system.	Want to be able to store files on any file system. Note that DS uses the OSAL routines to write files. No "write-enables" are performed by DS in order to write to EEPROM.	LRO
7070	CFS-552	The CFS shall provide the ability to filter the data messages to be stored.	Required in order to manage the amount of data written to the file system.	LRO, SDO
7074		# 5.0 Detailed Requirements ## 5.1 Basic Requirements The following requirements are basic requirements of Data Storage. Some of them are included here to avoid repeating these requirements for each applicable requirement.		
6964	DS1000	Upon receipt of a No-Op command, DS shall increment the DS Valid Command Counter and generate an event message.	Debug command to verify application is alive	LRO
6966	DS1001	Upon receipt of a Reset Counters command, DS shall reset the following housekeeping variables to a value of zero: a) Valid Command Counter b) Command Rejected Counter c) Packets discarded (DS was disabled) Counter d) Packets discarded (pkt has no filter) Counter e) Packets discarded (failed filter test) Counter f) Packets that passed filter test Counter g) Good destination file I/O Counter	Important for testing and on-orbit flight operations in order to start with a "clean slate".	LRO, SDO

		h) Bad destination file I/O Counter i) Good updates to secondary header Counter j) Bad updates to secondary header Counter k) Destination file table loads Counter l) Failed attempts to get table data pointer Counter m)Packet filter table loads Counter n) Failed attempts to get table data pointer Counter		
6968	DS1002	For all DS commands, if the length contained in the message header is not equal to the expected length, DS shall reject the command and issue an event message.	Basic command verification in the event of SEU or memory corruption.	LRO, SDO
6970	DS1004	If DS accepts any command as valid, DS shall execute the command, increment the DS Valid Command Counter and issue an event message.	Operators require feedback on command execution. No te that this only applies to "ground commands" (i.e. does not include requests that come from the scheduler).	LRO, SDO
6972	DS1005	If DS rejects any command, DS shall abort the command execution, increment the DS Command Rejected Counter and issue an error event message.	Operators require feedback on command execution.	LRO, SDO
6974	DS2000	Upon receipt of a message, if the Packet Processing State is ENABLED, DS shall determine if the message shall be stored based on the contents of the Packet Filter Table and the Destination File Table.	Filter provides ability to store messages using different schemes at different rates.	LRO, SDO
6976	DS2000.1	The Packet Filter Table contents shall include: a) Message ID b) Destination file table index c) Filter type (time/sequence count) d) Algorithm N value e) Algorithm X value f) Algorithm O value		LRO, SDO
6984	DS2000.2	The Destination File Table contents shall include: a)Pathname		LRO, SDO

		b) Basename c) Extension d) Filename type (time/sequence) e)Default Destination enable state f) Max file size (in bytes) g) Max file age (in seconds) h) Initial Sequence Count		
8379	DS2001	DS shall store "N of X" messages starting at offset O.		
8381	DS2001.1	If either the X value or the N value is zero, then the message shall not be stored.		
8383	DS2002	DS shall store each message in up to <PLATFORM_DEFINED> different destination files.		
8385	DS2002.1	Destination files shall be created when the first message is received that is passed by the filter algorithm for that particular message and selects that particular destination file.		
8387	DS2003	The input argument to the filter algorithm shall be determined by the Filter Type indicator.		
8389	DS2003.1	If Filter Type indicates Sequence based filtering then the algorithm input argument is a value equal to the packet sequence count.		
8391	DS2003.2	If Filter Type indicates Time based filtering then the algorithm input argument is a value created from the lower 11 bits of packet timestamp seconds plus the high 4 bits of timestamp subseconds.		
6990	DS3000	DS shall construct filenames based on the following definitions provided in the Destination File Table: path + base + [time/sequence characters] + extension	Table are used to define which messages go into which file.	LRO
6992	DS3000.1	If Filename Type indicates naming based on Sequence the constructed filename will include a character representation of the Sequence Count value from the Destination File Table.	Provides ability to store messages based on file size (e.g. 1 Mbyte files).	LRO
6994	DS3000.1.1	If Filename Type indicates naming based on Sequence the value of Sequence Count shall be incremented each time a file is created.	The new file is not created until the new message is received. This avoids potential empty files.	LRO

6998	DS3000.2	If Filename Type indicates naming based on Time the constructed filename will include a character representation of the packet timestamp.	DS creates a new file upon receipt of a message if there is no file already open for that message.	New
7000	DS3000.2.1	If Filename Type indicates naming based on Time the file date and time shall be represented in the following format: "YYYYDDDHHMMSS".	Provides ability to identify/organize files with unique filename based on time. The basename is specified in the DS file table.	New
7006	DS3001	Prior to writing a packet to an existing destination file, DS shall verify that the resulting file size (after the write) shall not exceed the file size limit as defined in the Destination File Table.	The cFE already specifies a header for each file. This is some additional information that is included in the header.	LRO
8415	DS3001.1	If the resulting file size would exceed the file size limit then DS shall close the existing file and open another file.		
8417	DS3001.2	A minimum of one packet shall be written to a file.		
7008	DS3002	Periodically, DS shall test the age of all open destination files. If any file age exceeds the maximum age defined for that file in the Destination File Table, then DS shall close the file.	DS may store any message in any one of the defined file locations. Provides ability to store a single message into multiple files.	New
7010	DS3002.1	DS shall update file age and test age limits every time DS processes its housekeeping telemetry request command.	Provides ability to store a single message using	LRO

			different filter schemes (in different files).	
7012	DS3003	Each DS destination file shall contain a primary cFE file header with the following information: a) Content Type b) SubType c) Primary header length d) Spacecraft ID e) Processor ID f) Application ID g) File creation time (seconds) h) File creation time (sub-seconds)	Ground needs to know if a file write error occurs. The event message provides the details of where the write error occurred.	LRO
8393	DS3004	Each DS destination file shall contain a secondary file header with the following information: a) File close time (seconds) b) File close time (sub-seconds) c) File table index d) Qualified Filename		
8395	DS3005	For every file write error, DS shall: a) Send an event message b) Increment total number of file write errors c) Close the destination file d) Disable the destination		
7030	DS5000	Upon receipt of a Disable command, DS shall stop filtering and storing messages. Note: This command will set the Packet Processing State to DISABLED.	Since DS has multiple tables that are tightly coupled, want to be able to stop DS from using the tables until all tables are updated.	New
7032	DS5001	Upon receipt of an Enable command, DS shall begin filtering and storing messages. Note: This command will set the Packet Processing State to ENABLED.	Need to be able to enable since you can disable.	New
7034	DS5002	Upon receipt of a Close File Command, DS shall close the command-specified files.	Provides the ability for the ground to close a file so that it can be downlinked.	LRO

7036	DS5003	Upon receipt of a Set File Basename command, DS shall set the file basename for the command-specified destination file.	This is used to modify the Baseline for a File Set. Note that this affects the next file opened in the File Set. Note also that this does not affect the File Sequence Counter.	LRO
7038	DS5004	Upon receipt of a Set Next File Sequence Counter command, DS shall set the command-specified file counter for the command-specified Destination File.	Could be used in the event of a power-on reset so that sequence numbers continue. In a cFE Processor reset, should be preserved.	LRO
7042	DS5005	Upon receipt of an Enable Destination File command, DS shall enable file collection for the command-specified Destination File.	Provides ground ability to write files in a file set without having to load a table.	LRO
7044	DS5006	Upon receipt of a Disable Destination File command, DS disable file collection for the command-specified Destination File.	Provides ground ability to quickly stop writing files in a file set without having to load a table.	LRO
8397	DS5008	Upon receipt of a Set File Index for a Packet Filter Table entry command, DS shall update the destination file index.		
8399	DS5009	Upon receipt of a Set Filter Type for a Packet Filter Table entry command, DS shall update the filter type to the command-specified filter type.		
8401	DS5010	Upon receipt of a Set Filter Parameter for a Packet Filter Table entry command, DS shall update the N, X, O Parameters to the command-specified values		

8403	DS5011	Upon receipt of a Set Destination Type for a destination file type command, DS shall update the Destination type to the command-specified destination type.		
8405	DS5012	Upon receipt of a Set Path for a destination filename command, DS shall update the path to the command-specified path.		
8407	DS5013	Upon receipt of a Set Extension for destination filename command, DS shall update the file extension to the command-specified extension.		
8409	DS5014	Upon receipt of a Set Maximum Size for a destination file command, DS shall update the maximum file size to the command-specified maximum.		
8411	DS5015	Upon receipt of a Set Maximum Age for a destination file command, DS shall update the maximum destination file age to the command-specified maximum age.		
15426	DS5016	Upon receipt of an Add Message ID to Packet Filter Table command, DS shall add the command-specified Message ID to the next unused entry in the Packet Filter Table.		
15428	DS5016.1	If the command-specified Message ID is invalid DS will reject the command and send an event message.		
15430	DS5016.2	If the Packet Filter table is not loaded DS will reject the command and send an event message.		
15432	DS5016.3	If the command-specified Message ID is already specified in the Packet Filter Table DS will reject the command and send an event message		
15434	DS5016.4	If there are no unused entries in the Packet Filter Table DS will reject the command and send an event message		
7048	DS8000	DS shall generate a housekeeping message containing the following: a) Valid Command Counter b) Command Rejected Counter c) Packets discarded (DS was disabled) Counter d) Packets discarded (pkt has no filter) Counter e) Packets discarded (failed filter test) Counter f) Packets that passed filter test Counter g) Good destination file I/O Counter h) Bad destination file I/O Counter i) Good updates to secondary header Counter j) Bad updates to secondary header Counter k) Destination file table loads Counter l) Failed attempts to get table data pointer Counter m) Packet filter table loads Counter n) Failed attempts to get table data pointer Counter o) Application State	Housekeeping telemetry to indicate basic DS status	LRO, SDO (loosely)

		p) Destination file(s) state: 1) File age 2) File size 3) File rate 4) Sequence count 5) Enable state 6) Open state 7) Filename q) Filename of last loaded Filter Table		
7050	DS9000	Upon cFE Power-On DS shall initialize the following Housekeeping data to Zero (or value specified): a) Valid Command Counter b) Command Rejected Counter c) Packets discarded (DS was disabled) Counter d) Packets discarded (pkt has no filter) Counter e) Packets discarded (failed filter test) Counter f) Packets that passed filter test Counter g) Good destination file I/O Counter h) Bad destination file I/O Counter i) Good updates to secondary header Counter j) Bad updates to secondary header Counter k) Destination file table loads Counter l) Failed attempts to get table data pointer Counter m)Packet filter table loads Counter n) Failed attempts to get table data pointer Counter	Need to initialize values to a default state on cFE Power-on reset.	LRO
7052	DS9001	Upon cFE Power-On DS shall initialize the DS tables from the default files.		
7056	DS9002	Upon a cFE Processor Reset or DS Application Reset, DS shall close all files.	The OS should do this, however, should DS do this as a precaution?	
7058	DS9003	Upon a cFE Processor Reset or DS Application Reset , DS shall restore the following if the associated <PLATFORM_DEFINED> Preserve Flag is set to TRUE: a) Packet Filter Table b) Destination File Table c) File Sequence number for all Destination File Sets d) Packet Processing State (ENABLED or DISABLED)	Provides ability to “fly through” a cFE processor reset or DS Application reset.	New
7060	DS9004	Upon a cFE Processor Reset or DS Application Reset , DS shall restore the following if the associated <PLATFORM_DEFINED> Preserve Flag is set to FALSE:	Want to save the sequence counter so that there is no danger of	LRO

		a) File Sequence Counters b) <PLATFORM_DEFINED> Packet Processing State	writing over files Need to provide a default packet processing state	
7062	DS9005	Upon any initialization and/or Packet Filter Table Update, DS shall validate the Packet Filter Table: a) table descriptor text for each packet entry: b) message ID (0 = unused, else ok) c) destination file table index d) filter type (time/sequence) e) filter parms (N,X,O)		New
7064	DS9006	Upon any initialization and/or Packet Filter Table Update, DS shall subscribe to the messages defined in the Data Storage Packet Filter Table.	Must subscribe to all of the messages defined in the Data Store Filter table.	LRO
8413	DS9007	Upon any initialization and/or Destination File Table Update, DS will validate the Destination File Table: a) table descriptor text for each destination file entry b) pathname c) basename d) extension e) filename type f) file enable/disable state g) max file size h) max file age i) sequence count	Need to identify what is validated in the Destination File Table.	
23057	DS9008	Upon cFE Power-On DS shall set the Packet Processing State to the <PLATFORM_DEFINED> state (ENABLED or DISABLED).	Allows missions to control packet processing during start up.	New
7076		# Appendix A Terminology This appendix contains the list of terminology for the CFS Data Storage Application used in this document • File Location – full path file specification.		

		• File Sequence Counter – Counter, maintained by DS, which is used to uniquely identify a file. Filenames that use the Size schema are named using the following notation: ○ Basename + File Sequence Counter + Extension (e.g. InstrumentX12345678.xyz) • Partition – top level directory of a location. Partitions may be fixed sized file systems or simply directory names.		