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File Management Services Interface Standardization

Executive Summary

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25/04/16

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Abstract

This document is the Executive Summary for the FMSIS Study.

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1 INTRODUCTION

1.1 Purpose of the Document

This document is the Executive Summary for the FMSIS Study.

1.2 Applicable Documents

The following documents are applicable to the project. In the body of the text, these documents are referenced as listed here below. Without any indication of issue, the latest issue is applicable. If one issue is indicated, only that issue of the document is applicable.

[AD01] File Management System Interface Standardisation - Cover Letter
AO/1-8073/14/NL/FE – 23.10.2014

[AD02] File Management System Interface Standardisation - Statement of Work
Appendix1 to AO/1-8073/14/NL/FE
TEC-SWE/14-718/SoW - Issue 1.1 – 13.09.2014

[AD03] File Management System Interface Standardisation – Draft Contract
Appendix2 to AO/1-8073/14/NL/FE

[AD04] File Management System Interface Standardisation – Special Conditions of Tender
Appendix3 to AO/1-8073/14/NL/FE

1.3 Normative Documents

The following normative documents are applicable to the project. In the body of the text, these documents are referenced as listed here below. Without any indication of issue, the latest issue is applicable. If one issue is indicated, only that issue of the document is applicable.

[ND01] Space Engineering Software
ECSS-E-ST-40 C – 6 Mar. 2009

[ND02] Space Product Assurance Software
ECSS-Q-ST-80 C – 6 Mar. 2009

1.4 Reference Documents

The following documents are used as inputs for this report. In the body of the text these documents are referenced as listed below.

[RD01] Avionics Architecture Modelling Language Executive Summary Report, GMV 21740/14 V1/14, Issue 1.0, 21/05/2014

[RD02] FMSIS-WP-1200-TASF-TN1 Analysis of Mass Memories & Protocols

[RD03] FMSIS-WP-1200-TASF-TN2 System Requirements (SRD/OIRD update)

[RD04] FMSIS-TN03 Use Cases specification and demonstrator architecture

[RD05] FMSIS-WP-1200-TASF-TN4 SAVOIR Mass Memory specification

[RD06] FMSIS-WP-1200-TASF-TN5 Impact analysis on Avionics and OBSW Reference Architectures

[RD07] FMSIS-WP-1200-TASF-TN6 Mass Memory communication protocols specification

[RD08] FMSIS-TN07 Use Cases execution results

[RD09] FMSIS-TN08 User's Manual

1.5 Property of the Document

1.6 Abbreviations and Acronyms

Acronym	Definition
AAML	Avionics Architecture Modelling Language
ASIC	Application-Specific Integrated Circuit
CCSDS	Consultative Committee for Space Data Systems
CEL	Critical Event Log
CFDP	Coherent File Distribution Protocol
CPTP	CCSDS Packet Transfer Protocol
EEPROM	Electrically Erasable Programmable Read-Only Memory
FIFO	First In First Out
FLASH	Fast Low-Latency Access with Seamless Handoff
FMS	File Management System
FS	File System
FTS	File Transfer System
HK	Housekeeping
HKTM	Housekeeping Telemetry
HW	Hardware
MASAIS	Mass Storage Access Interfaces and Services
MM	Mass Memory
MMI	Man-Machine Interface
MMU	Mass Memory Unit
MTL	Mission Timeline
OBC	On-board Computer
OBSW	On-board Software
PDU	Packet Data Unit
PUS	Packet Utilization Standard
RD	Reference Document
RF	Radio Frequency
SAVOIR	Space Avionics Open Interface Architecture
SGM	Safeguard Memory
SOIS	Spacecraft Onboard Interface Services

Acronym	Definition
SRAM	Static Random Access Memory
SSMM	Solid State Mass Memory
SVF	Software Validation Facility
SW	Software
TC	Telecommand
TM	Telemetry
UART	Universal Asynchronous Receiver Transmitter
VC	Virtual Channel

2 FOREWORDS

Over the current years, mass memories for space missions are evolving from simple storage areas to being central to the overall spacecraft avionic architecture. Missions are no longer using mass memories only for the storage of science and housekeeping data, they now also rely on this storage capability to hold mission-critical items such as telecommand timelines, software images, on-board control procedures or recovery configurations.

In parallel, the concept of mission operations is also slowly shifting from the packet paradigm to the file paradigm. With the significant quantity of data that needs to be transferred between space and ground, and the availability of reliable file transfer protocols (such as CFDP) which can ensure global consistency of the transferred files, the usage of files becomes common on the near-future missions.

In this context, the SAVOIR community has decided to setup a working group dedicated to the establishment of unified functional and interface requirement of the mass memory function: the SAVOIR Mass Storage Access Interfaces and Services, or SAVOIR-MASAIS in short. They have issued a first draft set of requirements.

These requirements have been analysed, reviewed, consolidated and verified during the course of the study. Producing an updated version of this functional and interface requirement document was one of the main objectives of this study.

As part of the interface specification, another important topic of this study was the definition of a communication protocol with the mass memory. The goal was to standardise this protocol as much as possible in order to meet the needs of various existing standards, such as SOIS, CFDP and PUS (C-version). Such a standard could then be proposed to the relevant standardisation offices.

3 STUDY LOGIC

The study started with an Inventory and a taxonomy of the main configurations of the Mass Storage devices. These inputs as well as the preliminary requirement documents from the SAVOIR MASAIS WG and the main relevant communication standards were then submitted to a Critical Analysis. The lessons learnt from past missions and the needs, requirements and constraints of future missions were also considered. The Update of the System Requirements was then undertaken taking the above inventory and analysis as input. The preliminary requirements of the working group documents were refined and completed.

A preliminary identification and Definition of the Use Cases typical of the present and future missions was performed in parallel, based on the above inputs and on the resulting user and system requirements. The definition relied on a Model Based approach supported by AAML. AAML was used to represent the functional and logical architecture and, once updated, to model the physical deployment, which came at a later stage. The Definition of the Demonstrator Architecture was, on its turn, based on the identified Use Cases. A pure software wise approach based on a simulation infrastructure and models has been selected as it was deemed more flexible than hardware, while representative of typical Mass Storage devices configuration.

The Specification of the Mass Memory naturally followed the inventory and analysis phase. The requirements specification covers the whole scope of the specification. The Specification of the Communication Protocols was carried out in parallel. These specifications resulted in two Technical Notes, which were submitted to an Assessment of Impact on the Avionic and Software Reference Architectures.

The Update of the Avionics Architecture Modelling Language was triggered as soon as possible to support the Definition of the Use Cases. It was performed in parallel to the previous activities. This adaptation mainly concerned the physical deployment (e.g. the communication over a SpaceWire) and the modelling of the interface functions and protocols. An update of the AAML has been made available.

The team proceeded with the Consolidation of the Use Cases which served as a specification of the test to be performed on the Prototype. In this context, they made use of the updated AAML to model the physical deployment.

The Development of the Prototype Infrastructure was initiated so that the demonstration infrastructure has been made available to support the Implementation of the Prototype. It consists of a simulation kernel and of the simulation models required to build a test environment representative of a typical Mass Memory Unit.

The Implementation of the Prototype consisted in the development or the adaptation and the integration of the communication protocols, the file management services and the applications specified in the simulated demonstration infrastructure. The Test Scenarios that exercise this prototype according to the Use Cases were also developed. A User Manual (UM) of the prototype has been issued together with the prototype.

The Execution of the Use Cases were performed. The results of the execution were analysed and a verification report containing the test scenario together with the corresponding results and their analyses has been produced.

4 TEST CAMPAIGN RESULTS

All tests have been successfully implemented and executed. However, during testing, some limitations have been detected in the standard as it is currently defined.

Performance issue

The read and write requests do not allow specifying a position in the file. There is a specific seek request for this purpose. This works fine but can impact the overall performance of the system.

The FMSIS specification has consequently been updated to solve this issue.

Write requests

The FMSIS protocol did not specify the packet returned as an answer to a request to write in a file, as requested by SAVOIR.

The FMSIS specification has also been updated to solve this issue.

File Mapping

When autonomous storage of data has been initiated via file mapping, there is no means to stop this autonomous storage. This means that if continuous storage has been selected, the storage will continue until the store is full.

A proper way to handle this problem is to define a "stop file mapping" telecommand.

File attributes

There is an inconsistency between the PUS and SAVOIR standards with regard to file attributes/status terminology.

Download content of a file

Thanks to the file mapping mechanism, it is possible to redirect PUS telemetry packets to a dedicated file. In such a case, this file is used as packet store.

In the scope of the prototype, we have defined a basic telecommand to download all PUS packets contained in a file. Ideally the service 15 should have been used instead.

It must be stressed that different implementations for the same service are required when packet stores are implemented on top different memory architectures, files and raw memory in our case.

A possible solution to select the right implementation when addressing a store is to define specific store IDs corresponding to dedicated "packet store files".

5 CONCLUSIONS

The Mass memory specification has been initiated smoothly thanks to the legacy of the SAVOIR Group works. However enriching it has been a long process as definition and concepts have been reviewed. This caused many iterations but it ended with an unambiguous specification.

Major enrichments of this specification are the layered memory architecture and the concurrency management.

The layering allows technological choices that, as up to now, have rarely (or maybe never) been made. The possibility to have a file stored over two kinds of media devices.

The concurrency management is a rather big gap in the evolution of Mass Memory. This specification is proposing a change of paradigm (use of files), as it is done on "ground technologies" for decades, but, for operational reasons, files must be accessed simultaneously by several entities. This is a non-standard requirement (even for ground technologies as in the computer world).

Finally those enhancements, although the team struggled to define them accurately, are easily implementable as a communication protocol.

The protocol/specification showed to be implementable without particular problems but the points discussed in section 4 above.

The prototype is able to handle files and stores per PUS services 15/23 and via CFDP simultaneously.

The demonstrator works with 2 computers running their own onboard software in parallel, each implementing its own mass memory and providing access to its MM to the other computer.

The onboard software is compliant with PUS C for the services 23 and 6 applied to files.

In the scope of the prototype, the stores are defined in static tables, so it is not possible to redefine dynamically the allocation of the different stores in the complete mass memory. However, the stores are created by the onboard software at startup if they do not exist in the mass memory.

Finally, all functionality defined in [RD07] has been fully implemented in the prototype.

The AAML Toolset demonstrates the usefulness of model-based approaches for model-based methodologies for avionics designs. The proposed approach is based on a single architectural model implemented using different viewpoints and allowing the execution of several analyses taking into account the information defined in the model at that development stage. This allows the configuration of parameters, make some trade-offs and architectural choices.

In the scope of FMSIS, the modifications performed on the AAML Toolset suited the FMSIS project goals, allowing designing the system used for the demonstrator and obtaining the memory and bus load analysis results for studying the protocol/specification.

END OF FILE