File-based Operations from the ESA Perspective

SAVOIR Mass Memory Day – 14 February 2014

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Background

- All ESA missions are currently based on the Packet Utilisation Standard
- This approach has enabled a significant level of harmonisation in the mission operations concept
- However, the use of packets only shows significant limitations in some operational scenarios
- Several ESA scientific missions have already adopted partial solutions enabling the use of files as a complementary space/ground data unit
- An ESA Working Group has been tasked to identify an operational concept about the use of files for spacecraft operations of ESA missions

Main use cases for File based Operations

- Upload of control data (TC Files, OBCPs, Plain Files, etc)
  - Implemented on Rosetta, Mars Express, Venus Express, GAIA, BepiColombo (PUS S13 derived and mission specific services)
  - Specified on Exomars and Solar Orbiter (PUS S13 derived), Euclid (CFDP Class 1)
  - Is being specified for JUICE
- Download of science data ('data takes')
  - Implemented on BepiColombo (PUS S13 derived and mission specific services)
  - Specified for Exomars and Solar Orbiter (PUS S13 derived), Euclid (CFDP Class 2)
  - Is being considered for JUICE
- Download of non-science data (on-request TM, ancillary TM, diagnostic)
  - Not supported nor specified for the moment
- Support of data relays in the space segment: Exomars

Highlights of the proposed concept

- Combination of packets and files as space/ground data units:
  - Both packets and files supported ‘natively’ end-to-end
  - Distinction between on-board control services and data services
  - Use of files to transport data which originate/target to data storages on both ends
- Clear separation between:
  - Files utilisation (on-board application layer)
  - Files Management (on-board file system with remote access/control from ground)
  - Files Delivery (based on a standardised space-to-ground protocol e.g. CFDP in open/closed loop)
  - Data Transport (ensuring compatibility with the existing space/ground I/F)
- Cross-support supported at the simplest possible level

Main Expected Benefits of File based Operations

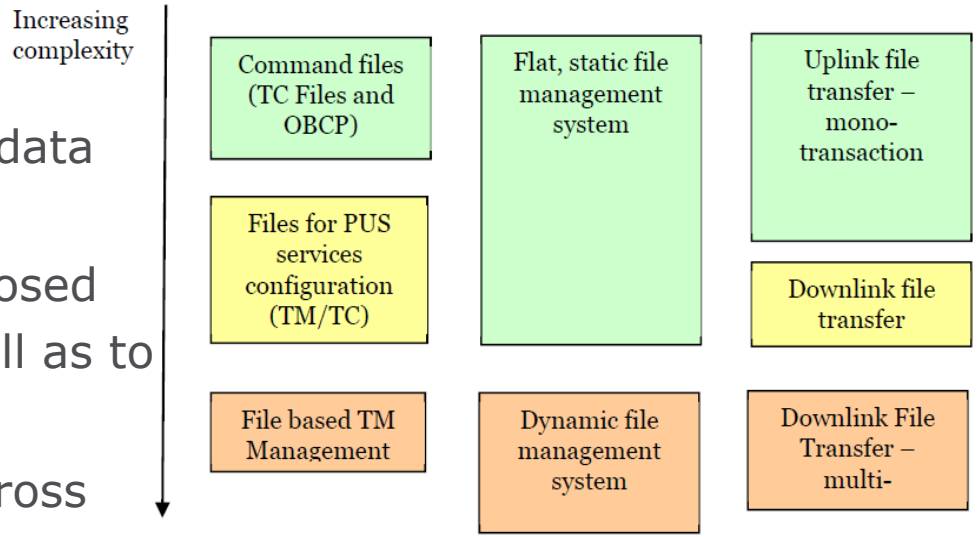
- Completeness
- End-to-end traceability and simplified on-ground data handling (e.g. interfaces among centres, archives, etc.)
- Reduced latency (when using closed loop and in case of data losses)
- Optimised bandwidth utilisation (when using closed loop)
- Capability to 'transparently' support the upload/download of non-packetised data
- Simplified delivery of large data units (e.g. patches, OBCPs, service configurations, reports, dumps)
- 'Transparent' delivery of files to any space system (including both the space and the ground segment)
- Simplified management of data relays in the space segment
- Simplified management of 'end-to-end' security (e.g. encryption) and optimisations (e.g. data compressions)

Conclusions of the ESA Working Group

- The adoption of file based operations may bring significant benefits to spacecraft operations to all ESA missions
- Packets and Files are largely complementary
- It is possible to deploy the existing file delivery protocols on top of the existing space link standards
- There is no end-to-end off-the-shelf solution described in any standard covering all needs of file based operations (e.g. CFDP only covers transfer, SOIS only covers storage and management, PUS does not cover files at all)
- The investment required to achieve effective File based Operations is primarily on the space segment side (limited effort is required on the ground side)

Possible Roadmap

- Adoption of file based operations requires evolution of on-board architecture beyond the selected file transfer protocol
- Main areas to be addressed:
  - File based access to on-board data storage
  - File management services exposed to on-board applications as well as to ground
  - Capability to exchange files across on-board applications / file stores
  - On-board management of a downlink queue supporting multiple parallel transactions and priority handling



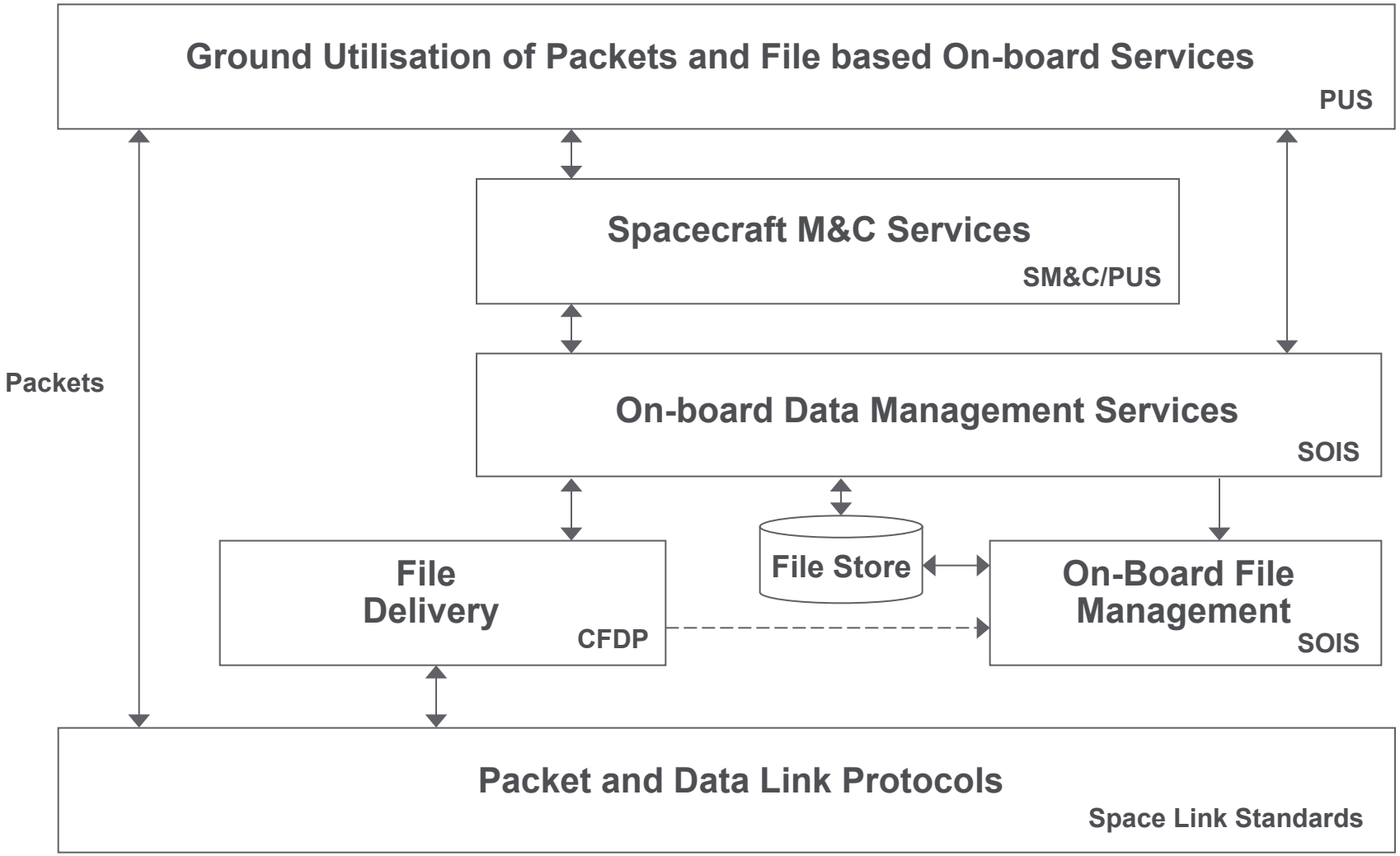
Related activities on ESA missions

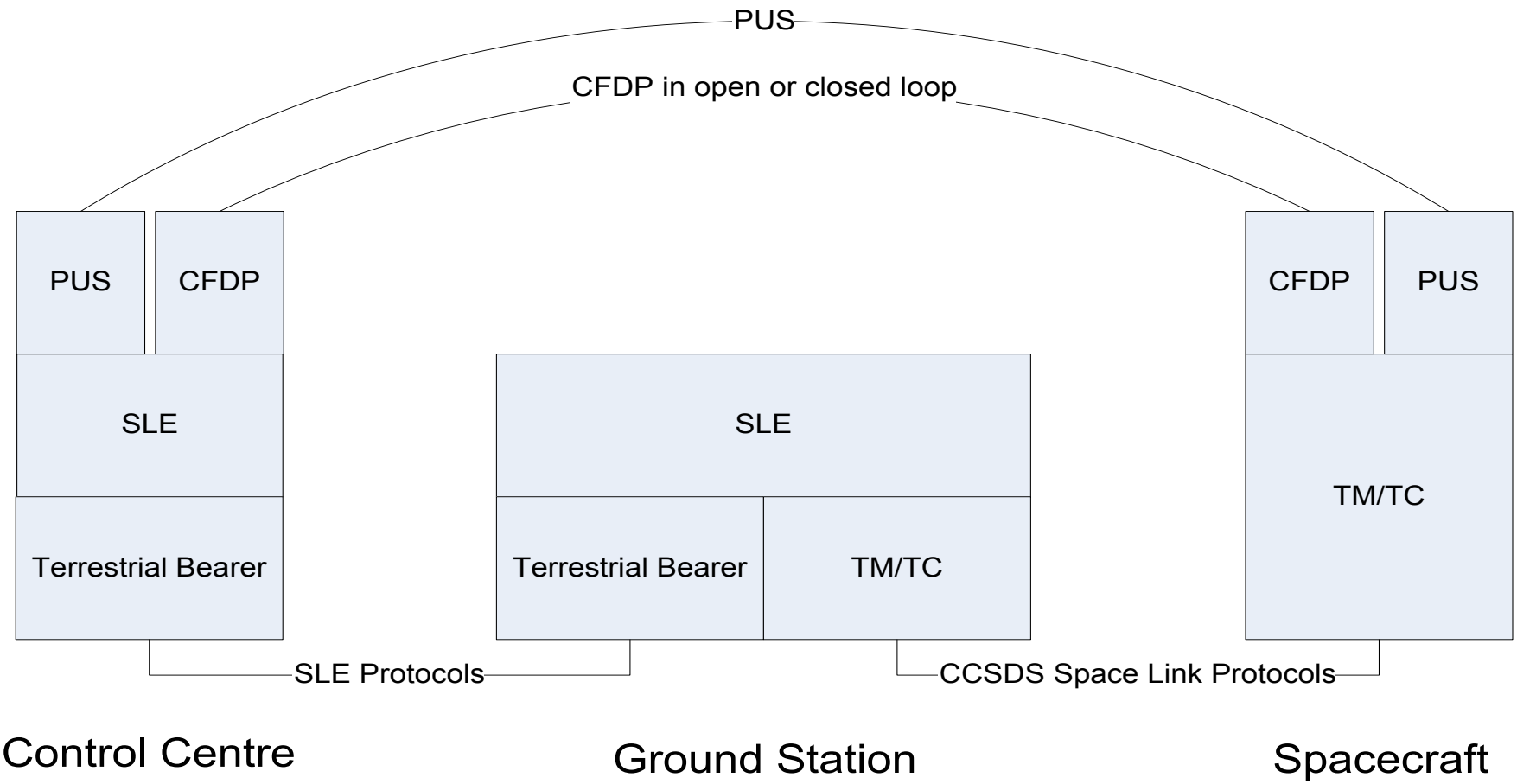
- Bepi Colombo will be the first mission using ‘file’ based downlink (in addition to the uplink).
  - Additional mission specific services added for on-board downlink queue management, no native file system on mass memory
  - Same implementation re-used on Solar Orbiter.
  - Alternative implementation being deployed on Exomars.
  - MCS updated accordingly on BepiColombo following a generic architecture, will be reused on Solar Orbiter and Exomars.
- Euclid
  - CFDP will be used as protocol for both uplink and downlink
  - Mass memory will host a native file system, science observation data will be stored as files, no automatic handling of downlink queue on-board
  - MCS will be designed to support the protocol

Conclusions and Recommendations

- The space segment for future ESA missions is increasingly required to support files natively (similar to ground file systems) – evolution of the on-board architecture is needed to support this.
- The transport and application layer shall be kept clearly separated, such to enable 'transparent' migration to more sophisticated protocols (e.g. DTN) in the future, without affecting the concepts and application standards
- On-board services accessible to ground via PUS-based TM/TC interface to be expanded to cover the use of files in addition to packets and data services exposed by other standards deployed on-board (e.g. CFDP, SOIS)
- Standardisation bodies shall recognise the need to provide missions with 'full solutions' rather than a collection of individual/uncorrelated standards: need better integration of CCSDS standards with ECSS ones (especially PUS), expand PUS to define new standard services

THANK YOU


Ground Utilisation of Packets and File based On-board Services
PUS
Spacecraft M&C Services
SM&C/PUS
Packets
On-board Data Management Services
SOIS
File Store
File Delivery
CFDP
On-Board File Management
SOIS
Packet and Data Link Protocols
Space Link Standards



Similar diagrams are available for relay missions.