

Proposed Concepts for File based Operations

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ADCCS

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- An ESA Working Group has been tasked to define a technical concept for the adoption of files and associated services/operations in future ESA missions;
- The Working Group consisted of several experts from ESTEC and ESOC with complementary roles/expertise:
 - space and ground segment engineering
 - representing support and program directorates
 - design and execution of mission operations
 - the relevant standards (PUS, CFDP, SOIS, Packet TM/TC, SLE);
- The Working Group recently completed its tasks.

- Analyse the lessons learned of on-going ESA missions in the area of large data units transfer and associated solutions;
- Define an end-to-end concept enabling and promoting the adoption of files in space operations;
- Analyse the relevant standards and provide recommendations about their adoption/extension;
- Propose a roadmap to support end-to-end “file based operations” for future ESA missions.

- Identification of possible use cases and associated benefits for File based Operations
- Analysis of applicability of the use cases to current and future ESA missions
- Analysis of the main related standards (in particular PUS, CFDP, SOIS)
- Specification of the applicable requirements and constraints
- Various trade-off analysis and definition of general concepts
- Identification of proposed solutions for various mission scenarios
- Assessment of impact (on standards, ground infrastructure, spacecraft)
- Conclusions, Recommendations and Proposed Roadmap

- Upload of control data
 - TC Files (e.g. schedule increments) for immediate or delayed execution
 - Binary data (e.g. OBCPs, OBSW patches, configuration tables)
- Download of non-science data
 - On-request reports/dumps/recorded data
 - Stored housekeeping TM
 - Ancillary data (e.g. on-board sensors data)
- Download of science data
 - “Data takes”
- Support of data relays in the space segment

- Data delivery completeness
- End-to-end traceability
- Support of 'multi-hop' transfers (including data relays in the space segment)
- Reduced latency and optimised bandwidth to recover from data losses (when using closed loop)
- Capability to 'transparently' support the upload/download of non-packetised data
- Increased efficiency in data compression
- Significant simplification and increased robustness of operations related to the delivery of large data units (e.g. patches/dumps, OBCPs, M&C service configurations, reports)
- Simplified management of 'end-to-end' security (e.g. encryption)

- Requirements categorised in 4 distinct areas
 - Data Transport
 - The low level communication protocols
 - Files Transfer
 - File Delivery Protocol and associated management
 - Files Management (on ground and in space)
 - Basically a File System
 - Files Utilisation (on ground and in space)
 - This is the only layer which deals with the file content
- A full solution covering all areas is needed!
 - E.g. transferring files from/to a spacecraft that doesn't have a file system would only bring limited benefits

Proposed Solutions for Various Operational Scenarios - Drivers



- A number of operational scenarios have been identified which are believed to cover most current and future ESA missions
- Solutions for file based operations covering these scenarios have been proposed on the basis of the following drivers
 - Compatibility with existing ground infrastructure, especially in the area of ground stations;
 - Commonality of solutions across different mission topologies/scenarios;
 - Clear separation between the monitoring and control and the data delivery roles. This latter one is to be considered as a service provider with well defined interfaces;
 - Identification of a minimal set of cross-support needs at the lowest possible level

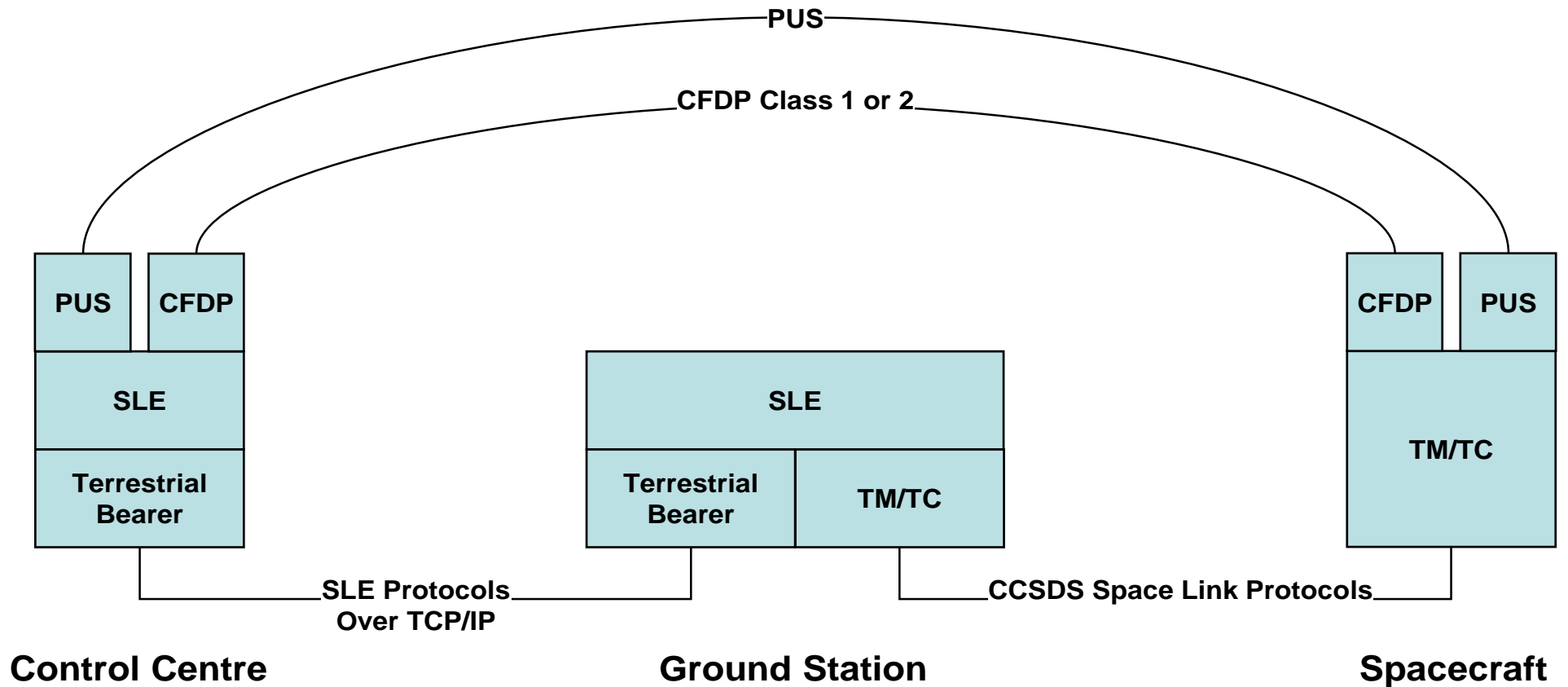
Proposed Solutions for Various Operational Scenarios - Highlights



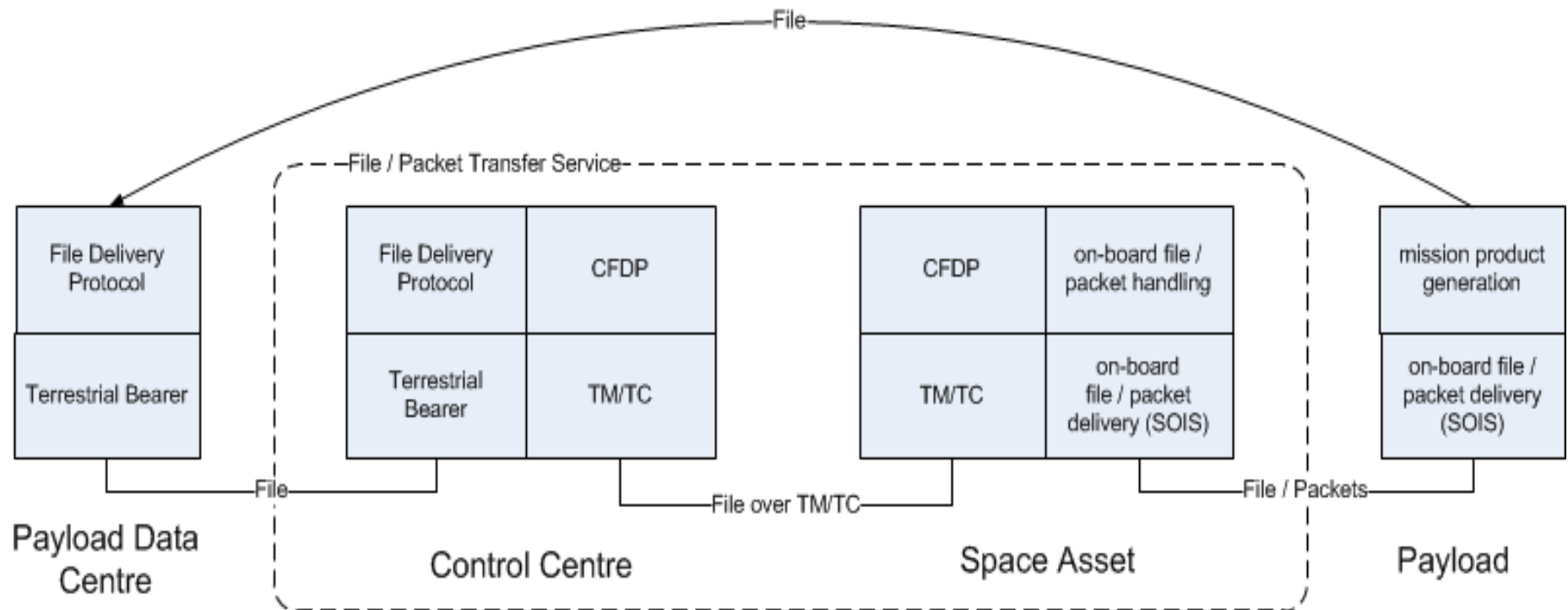
- Combination of packets and files as space/ground data units
 - Both packets and files supported 'natively' end-to-end
 - Packets for 'message oriented' interactions
 - Files to manage data which originate/target to data storages on both ends
 - Distinction between on-board control services and data services
- Files delivered using CCSDS File Delivery Protocol (point-to-point or with Store and Forward in space)
- CFDP protocol data units transmitted over the space link using CCSDS Packets or Encapsulation Service
- Compatibility with existing cross-support protocols
 - SLE, Space Link and Proximity (only needed for data relays in space). File delivery cross-support standard (currently being defined) only needed for multi-hop transfers
- Use of closed and open loop protocols as appropriate

Spacecraft Control Scenario

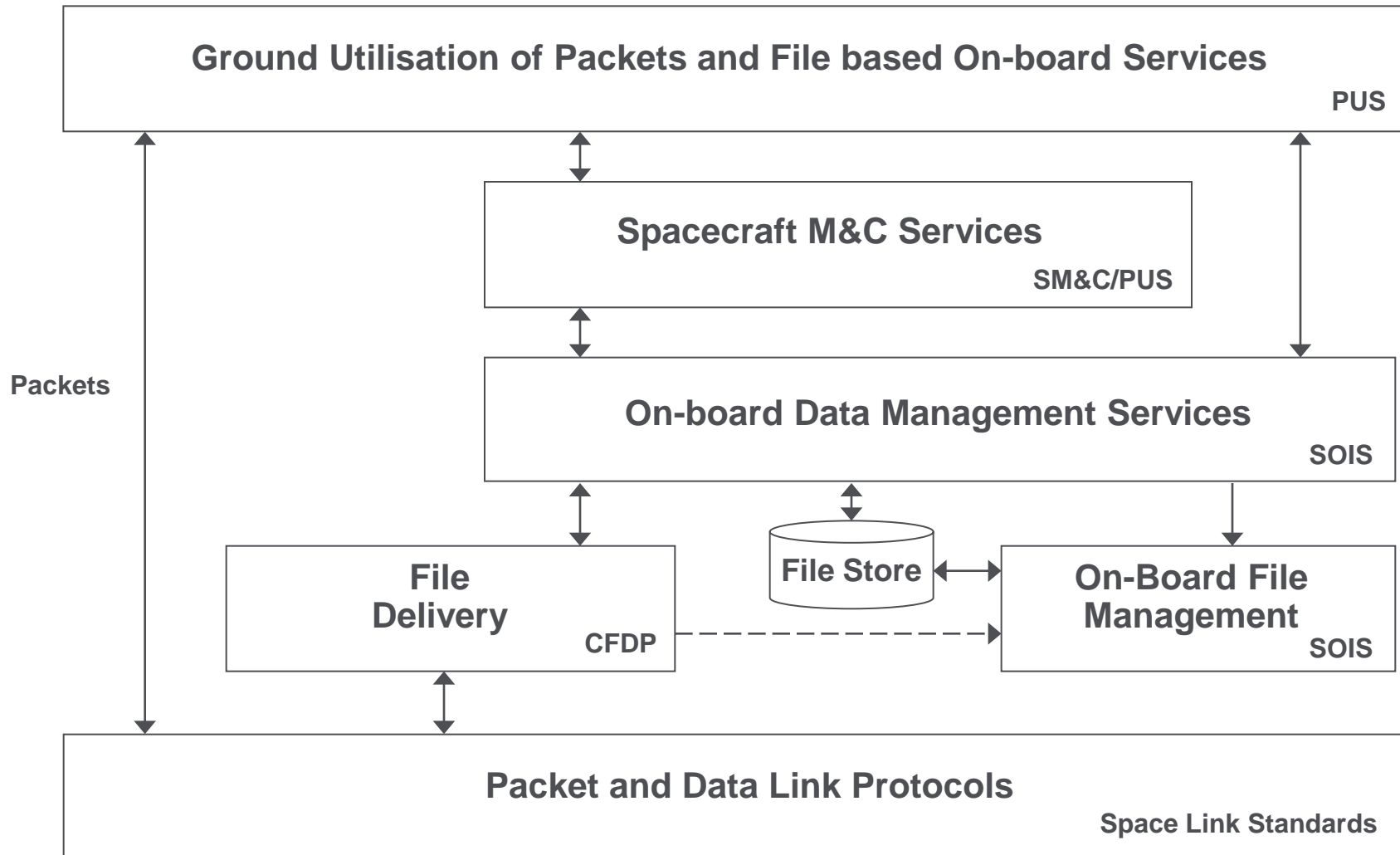
CFDP Class 1: Point-to-point Open Loop
CFDP Class 2: Point-to-point Closed Loop



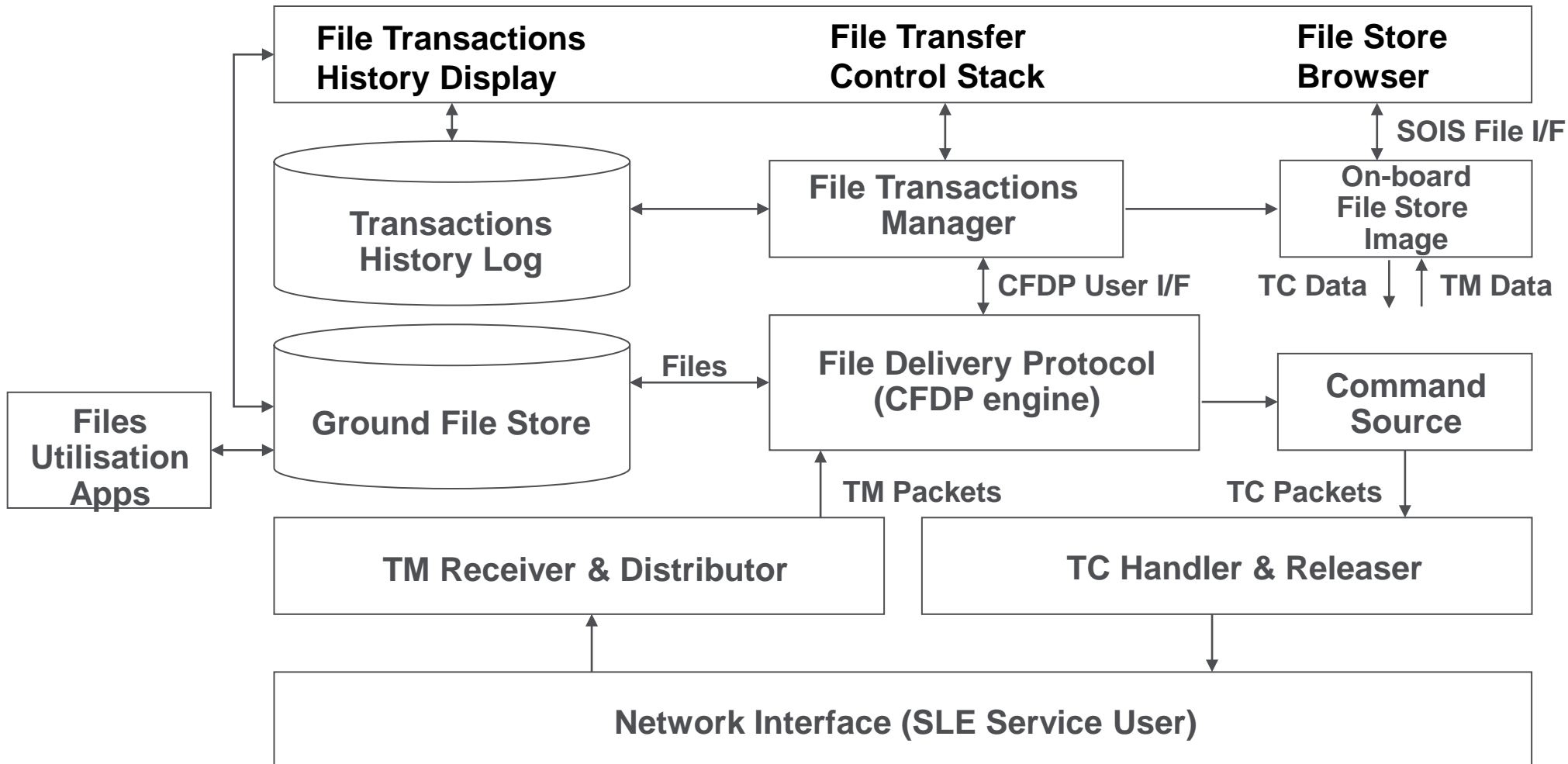
Mission data delivery to end users



Interaction analysis of related standards



Ground System Architecture



- The adoption of file based operations may bring significant benefits to spacecraft operations of all ESA missions (not only the ones requiring a data relay in space)
- Packets and Files are largely complementary (similarly to ground systems)
- It is possible to deploy the existing file delivery protocols on the 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, current PUS does not cover files at all)

- File based operations shall be promoted for all future ESA missions, adopting a consistent approach
- The transport and application layer shall be kept clearly separated, such to ensure that the operational concepts are not affected by the advent and adoption of different protocols (e.g. MO services, DTN)
- The space segment for future ESA missions shall be required to support files natively (similar to ground file systems), ideally by adopting the SOIS Packet and File Store Services
- The space segment shall expose file transfer and file management services to ground

- Consolidate and demonstrate the concept through a TRP study covering the complete system (space and ground)
 - Kick-off in the next weeks
 - The main operational scenarios will be addressed
 - The ground infrastructure will be complemented to introduce support of files (in addition to packets)
 - The TEC reference implementation of the on-board avionics will be extended and consolidated to support sample files utilisation services
- Collaborate with the PUS Revision and Savoir-Faire Working Group to ensure proper consideration of the needs associated to File based Operations

- Support Euclid in the definition and design of file based downlink
- Extend the ESOC control centre infrastructure to introduce support for:
 - CFDP based (downlink and uplink) file transfer with the space segment
 - Support of ground image of on-board file store
 - Management (generation and verification) of TC files
 - User applications (file store browser, file transactions history display, file transfer control stack)
- Provide in-flight demonstration of the full concept through a micro-mission (OPS-SAT)

The outputs of the ESA Working Group about File based Operations have been documented in a report which is available upon request (mauro.pecchioli@esa.int)

THANK YOU FOR YOUR ATTENTION