ESA Operational Ground CFDP & DTN Implementations

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Agenda

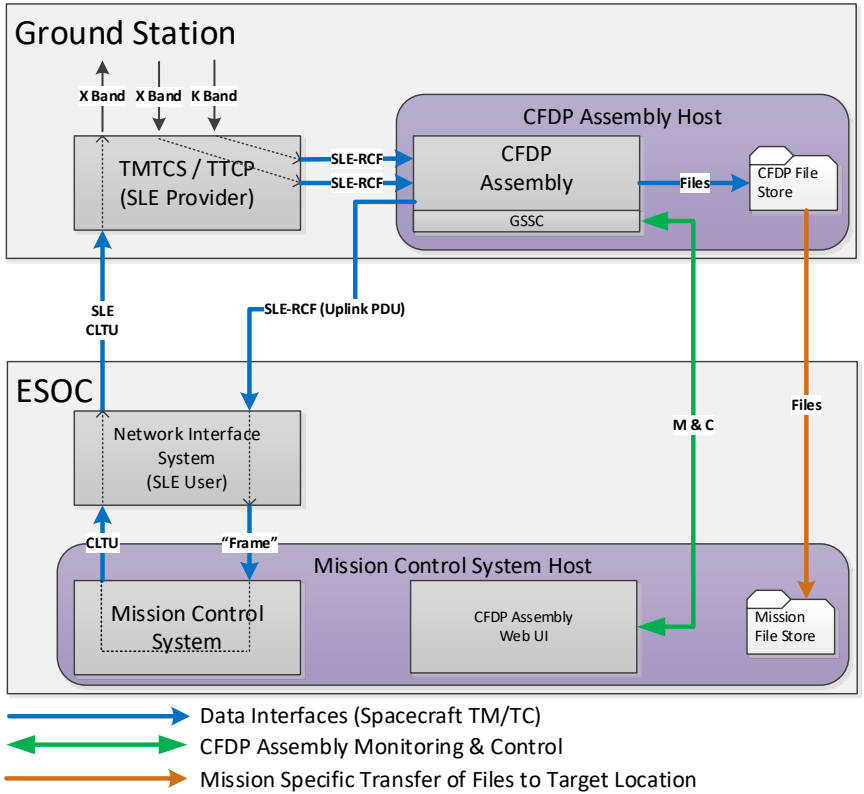
- CCSDS File Delivery Protocol (CFDP)
  - CFDP Ground Implementation
  - CFDP at the Ground Station – Euclid Example
  - Distributed CFDP - Copernicus Extension
- Delay Tolerant Networking
  - Application Scenarios
  - Ground DTN Implementations – Bundle Protocol & Licklider Transmission Protocol
  - Ground DTN Assembly
  - OPS-SAT Demonstration
- Conclusion

CCSDS FILE DELIVERY PROTOCOL (CFDP)

CFDP Implementations

- Operational **Ground Segment CFDP Implementation** (Java)
  - used by Euclid, Juice, Plato, OPS SAT (on-ground & on-board), …
  - licenseable to European Industry and under maintenance
  - all CFDP Protocol features (Class 1-4)
  - pluggable UT Layers (UDP, TCP, SPP, SLE) and Filestores
  - Used in Mission Control Systems (S2K, EGOS-CC), Simulators (GSTVi), Ground Station Systems (CFDP Assembly, NDIU), Test & Validation
- **Remote CFDP Assembly** (Euclid)
  - receives/sends CFDP PDU via SLE (Space Packets / TM Frames)
  - web-based UI
- Planned: **Distributed CFDP** for EO Payload Downlink (Copernicus Extension)

CFDP Class 2 with less reliable links – Euclid Mission Example

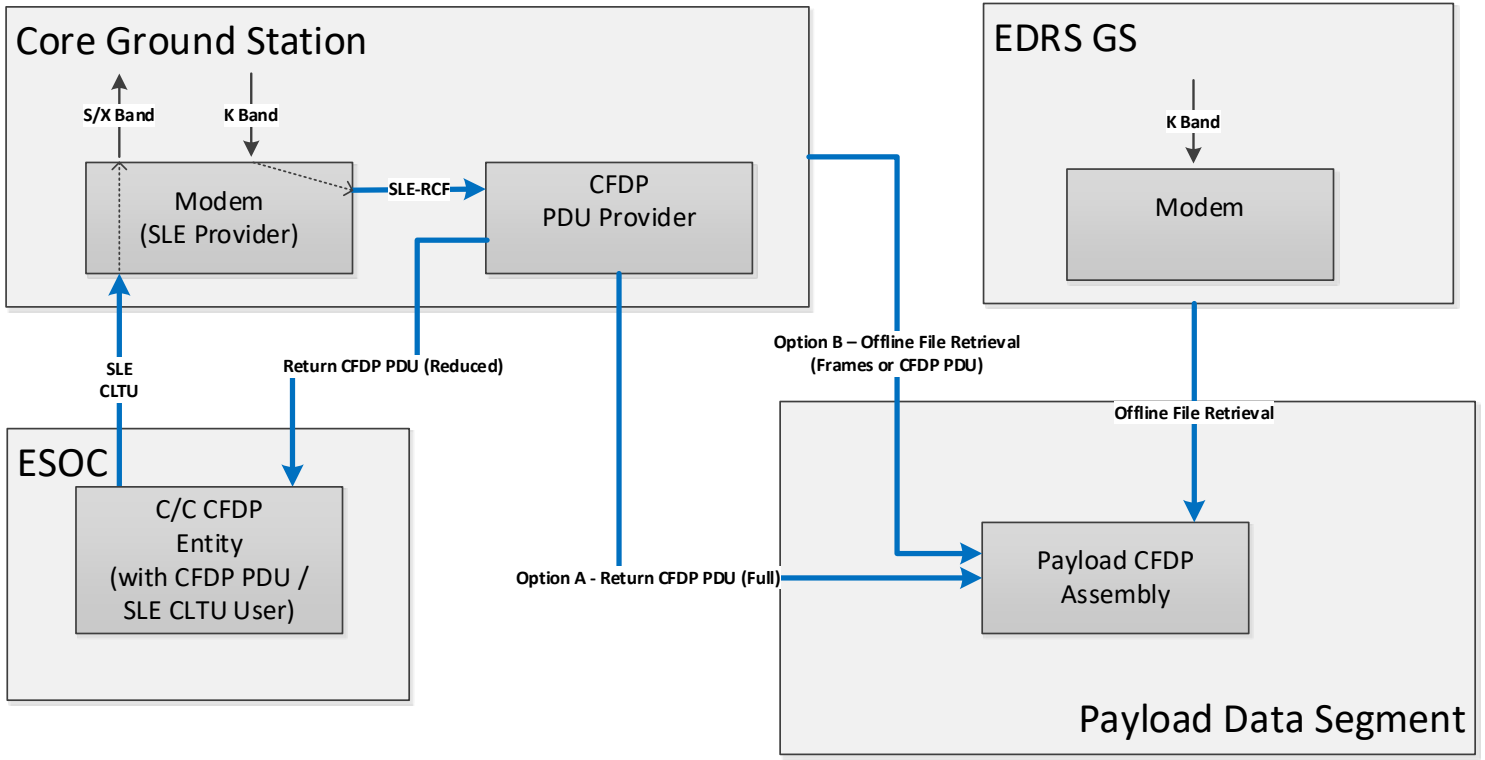


Euclid Mission (L2):

- Less reliable Ka-Band link (re-transmission necessary)
- 5-10 seconds round-trip delay
- ~ 75 Mbit/sec science downlink but only ~ 2 Mbit/sec guaranteed terrestrial bandwidth + ?? Mbit/sec un-guaranteed bandwidth (academic internet)

→ Re-assemble files in the ground station and download later

Copernicus Extension – Distributed CFDP (proposal)



DELAY TOLERANT NETWORKING (DTN)

DTN Intended Application Scenarios

1. **Human Space Flight and Robotic Exploration**
    - DTN is in the LOP-G communication requirements and the IOAG Lunar Communications Architecture
2. **Optical Ground Stations**
    - BP as inter-operable protocol for less predictable downlinks (“data-volume” instead of “pass-based” data delivery approach)
    - LTP (extended/optimised as required) to replace the proprietary re-transmission schemes on the uplink beacon for optical Direct-to-Earth links
3. **Earth Observation Missions**
    - LTP for less reliable links (K-Band, optical)
    - De-coupling of file data from transmission units (LTP segments / bundles) allowing transparent use of multiple (downlink-only) ground stations

→ Please note that Scenario 2 + 3 will need **high performant implementations** (up to 10 Gbit/sec) which might require optimisation of the standards themselves

ESA Ground DTN Protocol Implementations

- Bundle Protocol (CCSDS 734.2-B-1 compliant)
  - Plain Java Library & BP Daemon (ZeroMQ Client Interface)
  - Flexible structure similar to CFDP Implementation
  - BP 1.0.0 released Q3/2019
  - Update to BPv7 planned

- Licklider Transmission Protocol
  - Operational implementation kicked-off
  - Study on protocol performance improvements (update to LTP standard) planned

Ground DTN Node – DTN Assembly

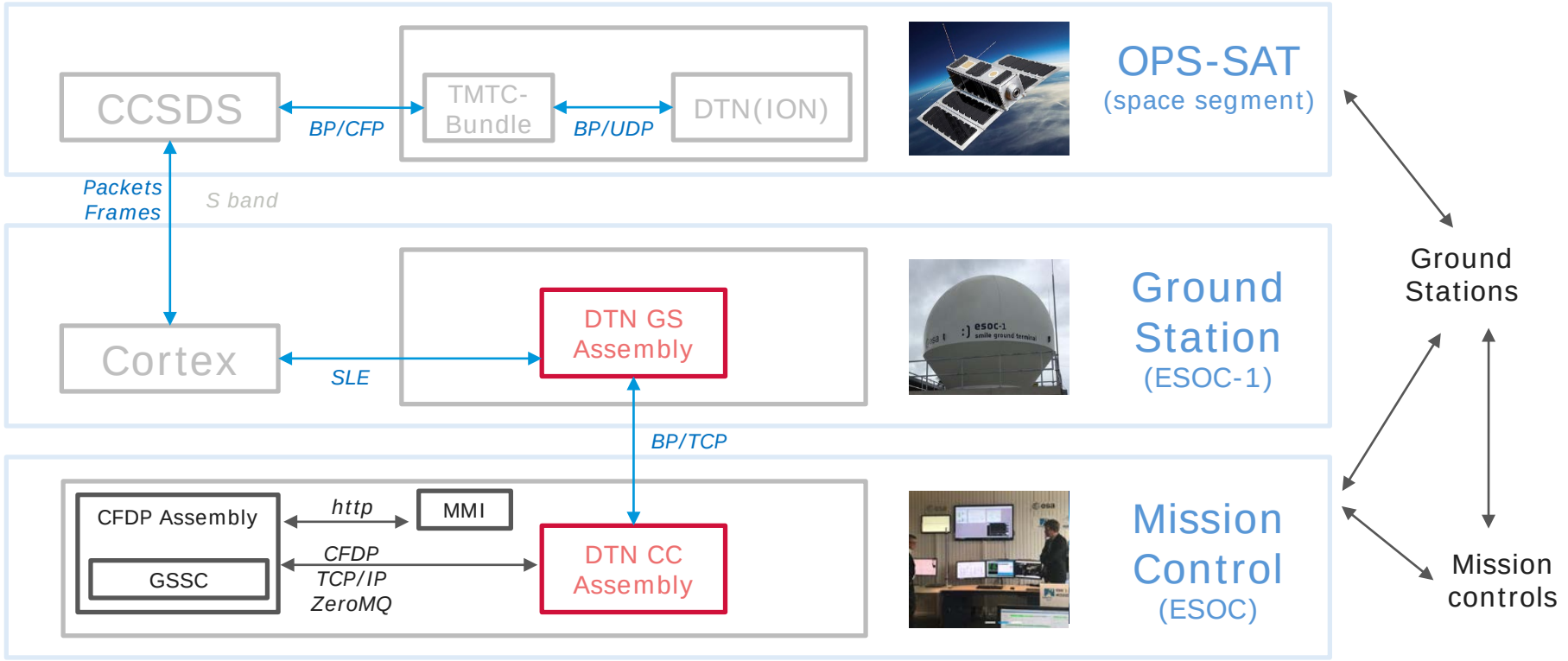
- based on Java BP Implementation, includes LTP implementation
- SLE-RCF / SLE-CLTU interfaces for integration with existing modems (Cortex, ESA TTCP)
- TM / TC Frame & CCSDS Space Packet Processing
- ESA M&C protocol for ground station integration
- Web-based MMI

→ Full operational implementation has been kicked-off; focus on “operability”

OPS-SAT

Experiment

CFDP-enabled System Overview



CONCLUSION

Conclusion

- File-based operations with CFDP Class 1 / Class 2 as File Delivery Protocol baseline for current and upcoming ESA missions
  - Mature Ground Implementation available
  - Ground deployment depending on mission characteristics in Mission Control System, the Ground Station or as Distributed CFDP
- Delay Tolerant Networking considered in the context of Exploration Missions (Lunar, Mars & Beyond), optical ground stations and future Earth Observation
  - Operational Ground Implementation started for Bundle Protocol, LTP
    - High-performance implementations needed
    - Updated (LTP) & additional standards (BPSec, Network Management) expected
  - Demonstrations with OPS-SAT and potentially other cubesat missions