

Euclid Operational Considerations and Ground Segment Infrastructure

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Euclid as a "prototype" for future use of CFDP in ESA missions will have an impact on the evolution of the generic ground segment infrastructure. The generic mission control system products and the ground station infrastructure (ESTRACK) should be updated to provide support for file-based operations and CFDP file transfer.

In particular, there may be a need to implement CFDP entities in the ground stations because of increasing TM data rates which are not supported or very expensive to achieve on the terrestrial links. However, such changes in the infrastructure should be implemented in a way that does not effect missions not using CFDP while at the same time taking future mission requirements into account. Changes to existing systems should be minimized and standard interfaces should be maintained as far as possible.

The presentation will introduce the Euclid ground segment requirements for ground segment CFDP and present concepts for CFDP support in the mission control system infrastructure and for the implementation of CFDP in ground stations.

1. Euclid File-based Operations

- Euclid CFDP Basics
- TM/TC Data Format for CFDP
- Euclid CFDP Entities

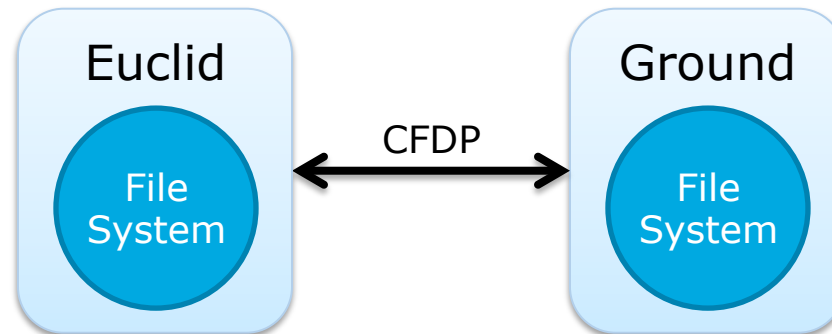
2. CFDP Ground Segment Infrastructure

- Mission Control System
- Ground Station

3. Summary & Conclusions

EUCLID FILE-BASED OPERATIONS

1. Big amount of science data and high TM rate via unreliable K-band
2. Reliable download of data required -> CFDP
3. CFDP requires files -> MMU shall host on-board file
4. Why not adding file upload capabilities as well...?! Easy and straight forward "add-on", which allows clean file-based operations -> Let's use CFDP in both directions



Euclid's MMU will host an on-board file system, which will be used for:

- Science Data Files
 - Files dedicated to observations
- Files as containers to store H/K TM Packets
 - One file per day
- Software images
 - Easy patching & dumping by one TC
- OBCPs
 - Simple maintenance by renaming/replacing files

EUCLID CFDP BASICS

Links:

- Uplink: X-Band (16 kbps)
- Downlink: X-Band (26 kbps) and K-Band (75 Mbps)

CFDP Classes:

- Upload: Class 1 via X-Band (uplink)
(COP-1 shall ensure data completeness)
- Download: Class 2 via X-Band (uplink) and K-Band (downlink), or
via X-Band (uplink) and X-Band (downlink) *

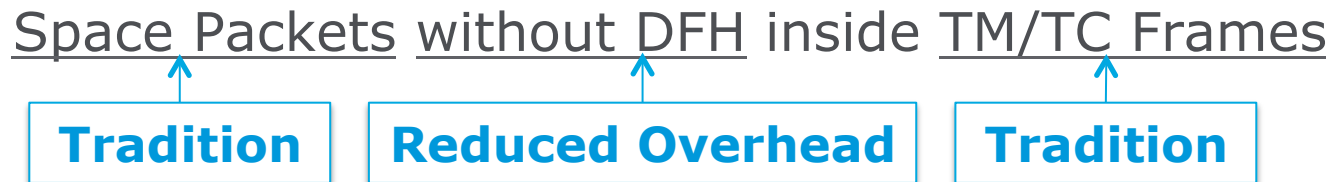
* Download of files via X-Band is much slower, but this option is required as fall-back in case of unavailability of the K-Band link

TM/TC DATA FORMAT FOR CFDP

CFDP standard does not demand a specific carrier for PDUs:

- CFDP PDUs could be placed inside
 - Packets (Space Packets or Encapsulated Packets)
 - which are carried by TM/TC or AOS Frames
 - Space Packets with or without DFH ?
 - Proximity-1 Frames

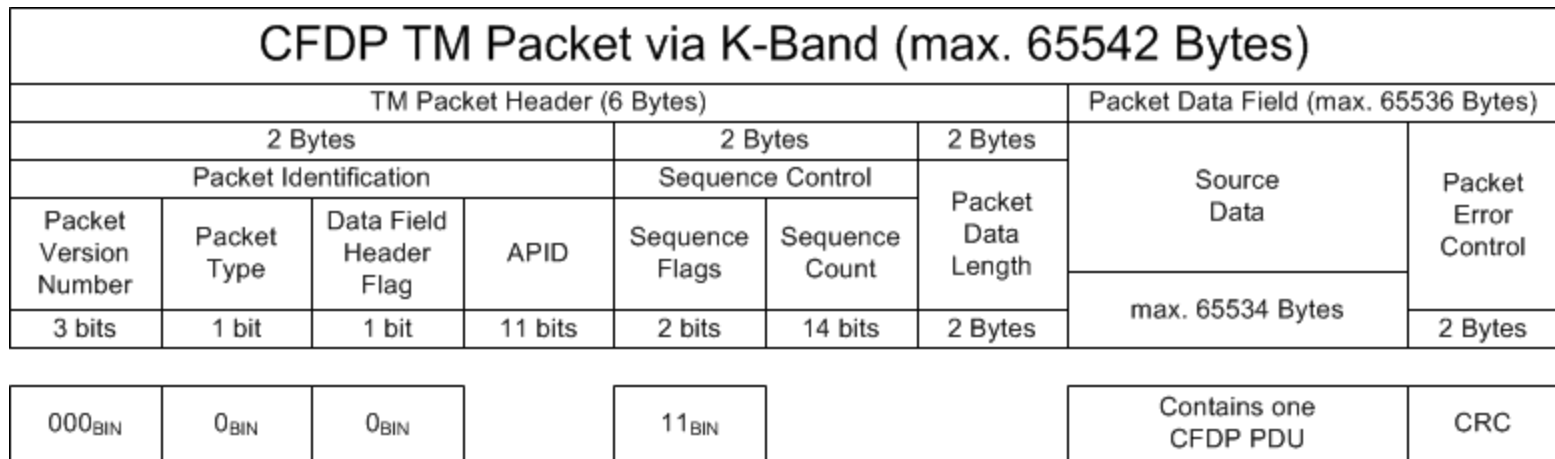
Decision for Euclid:



TM Data Format for CFDP (K-Band)



- Downlink CFDP PDU placed in data field of TM Packet
- CCSDS TM Packet without DFH (i.e. not PUS compliant)
- Dedicated APID for space CFDP entity

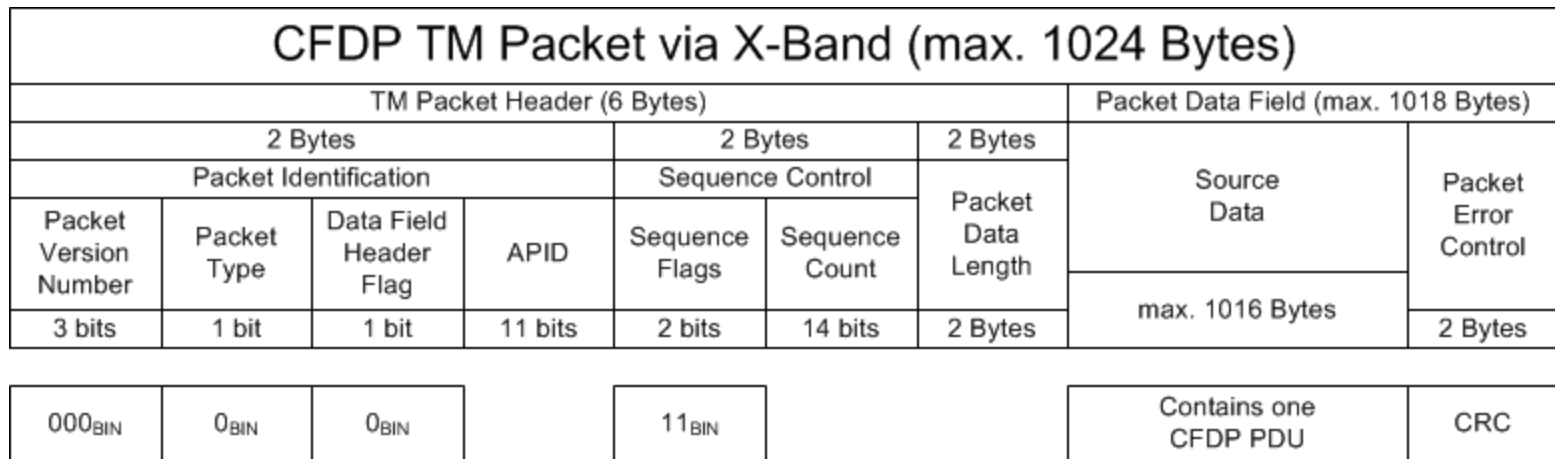


- Dedicated VC for TM Frames

TM Data Format for CFDP (X-Band)



- Downlink CFDP PDU placed in data field of TM Packet
- CCSDS TM Packet without DFH (i.e. not PUS compliant)
- Dedicated APID for space CFDP entity
- Shorter Packets required because of routing via 1553 bus



- Dedicated VC for TM Frames

TC Data Format for CFDP (X-Band)

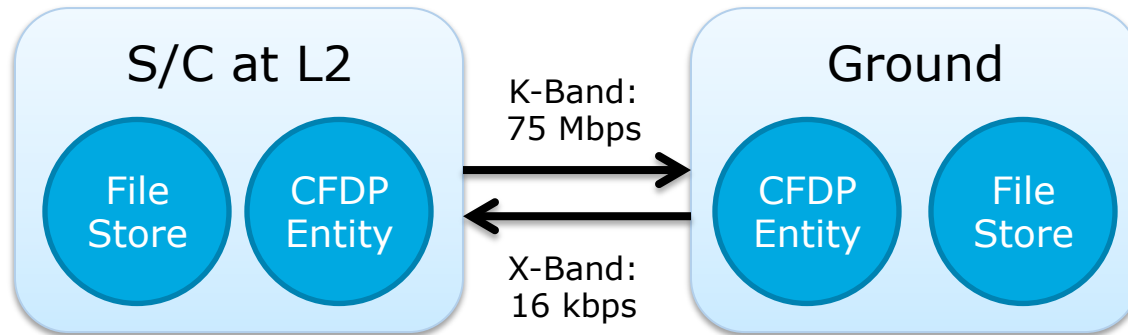


- Uplink CFDP PDU placed in data field of TC Packet
- CCSDS TC Packet without DFH (i.e. not PUS compliant)
- Dedicated APID for space CFDP entity

TC Packet for CFDP PDUs (max. 1016 Bytes)								
TC Packet Header (6 Bytes)						Packet Data Field (max. 1010 Bytes)		
2 Bytes			2 Bytes			2 Bytes	Application Data	Packet Error Control
Packet Identification			Sequence Control			Packet Data Length		
Packet Version Number	Packet Type	Data Field Header Flag	APID	Sequence Flags	Sequence Count		Packet Data Length	Application Data
3 bits	1 bit	1 bit	11 bits	2 bits	14 bits	2 Bytes	max. 1008 Bytes	2 Bytes

000 _{BIN}	1 _{BIN}	0 _{BIN}	11 _{BIN}	Contains one CFDP PDU	CRC
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EUCLID CFDP ENTITIES

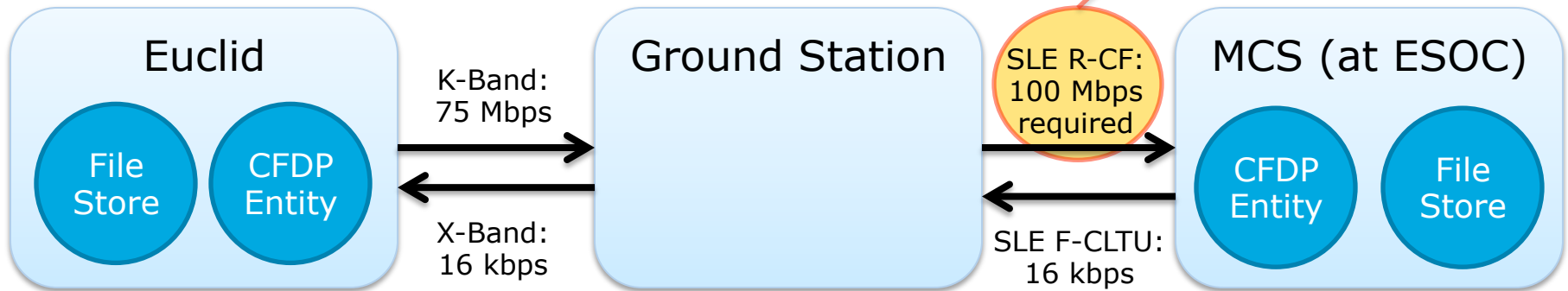


1. K-Band downlink not reliable
2. File download by CFDP class 2
3. Class 2 handshaking requires TC uplink
4. Class 2 reliability: Re-transmissions due to gap checking and timeouts
5. Timer needs reasonable timeout value!
What's the maximum round-trip-time between the two CFDP entities?

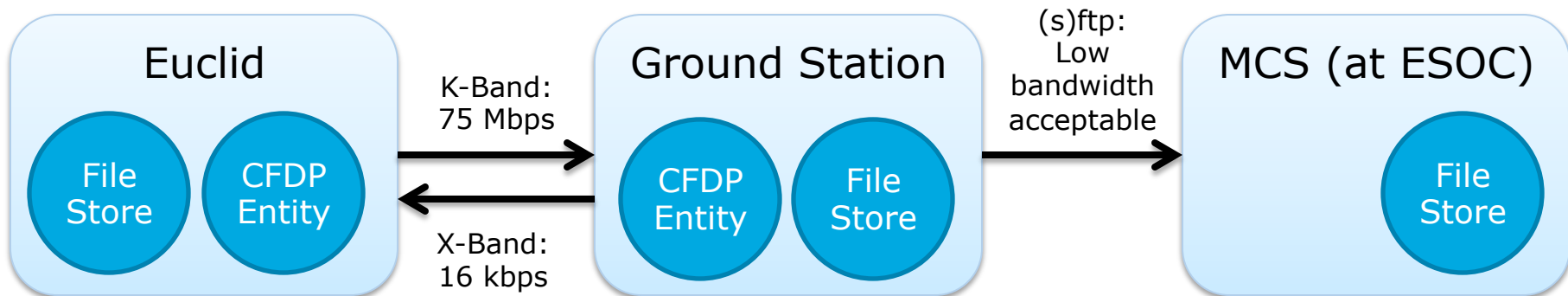
CFDP Entities – Closing the Loop

1. Closing the CFDP loop in MCS

Risk if bandwidth is not guaranteed:
Reasonable timeout value not predictable!



2. Closing the CFDP loop in Ground Station



In addition to the serious ground bandwidth requirement, multiple CFDP entities on ground would allow flexible file transfer scenarios:

- File upload from MCS to S/C
- File download from S/C to MCS
 - Files, which shall be processed by MCS (e.g. files containing H/K TM packets)
- File download from S/C to Ground Station
 - Files, which will not be processed by MCS (e.g. science files, scientists could get these files directly from ground station)

CFDP GROUND SEGMENT INFRASTRUCTURE

Goal:

Providing support for file-based operations as a feature of the common ground segment infrastructure.

Principles:

- Compatibility of common infrastructure with CFDP/PUS-13/non-FbO missions
- Use of standardised interfaces as much as possible
- Minimising changes to existing systems
- Minimum added complexity
- Potential to support future mission requirements (higher data rates, larger data volumes, ...)
- Reliability

1. Mission Control System

- SCOS-2000 (EGS-CC in the future)
 - tailored for mission families
 - tailored for specific missions

2. ESTRACK (Ground Station Subsystems, GS M&C, Scheduling, ICT)

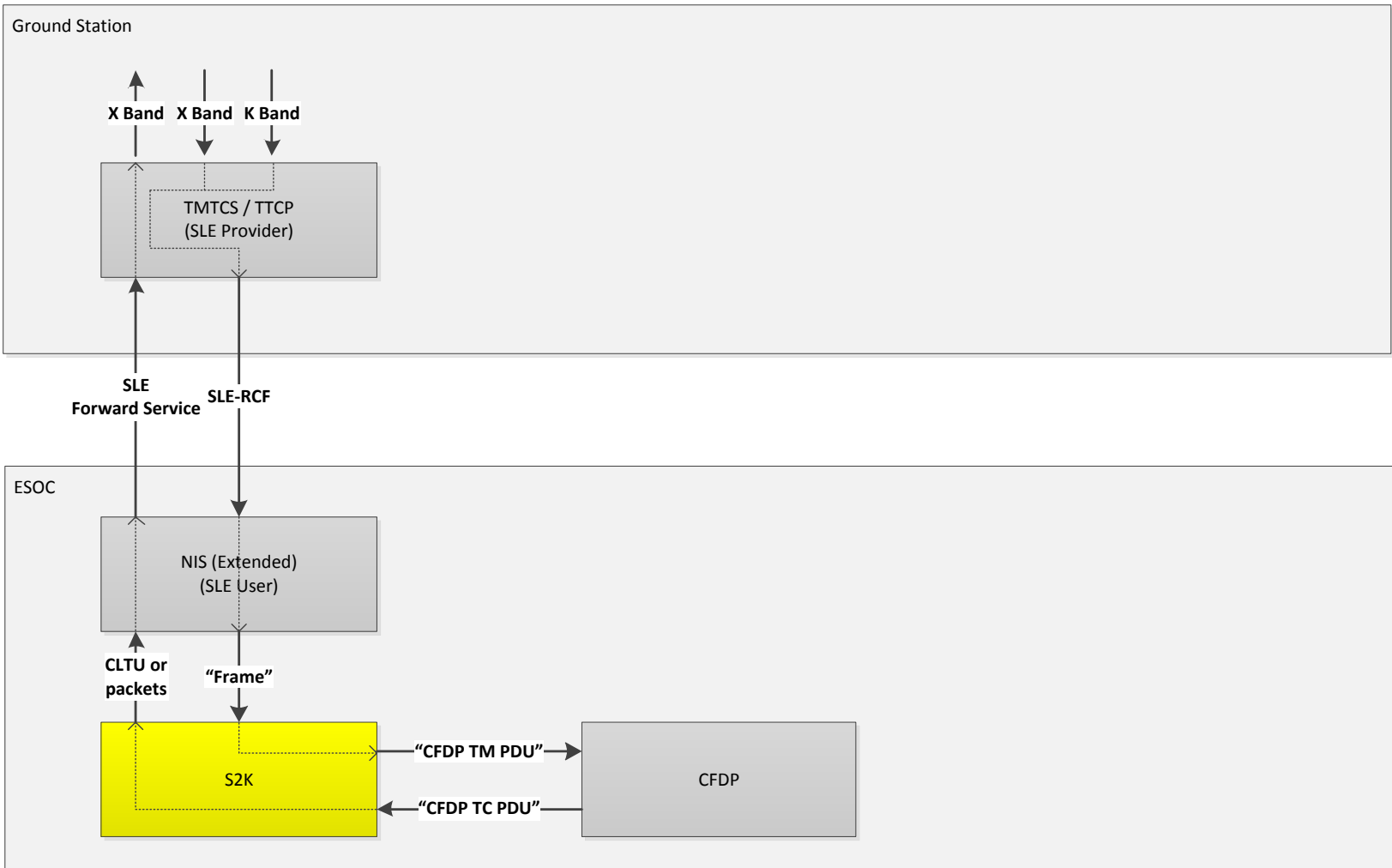
- Common infrastructure for all missions

3. Simulator (SIMSAT, GSTVi)

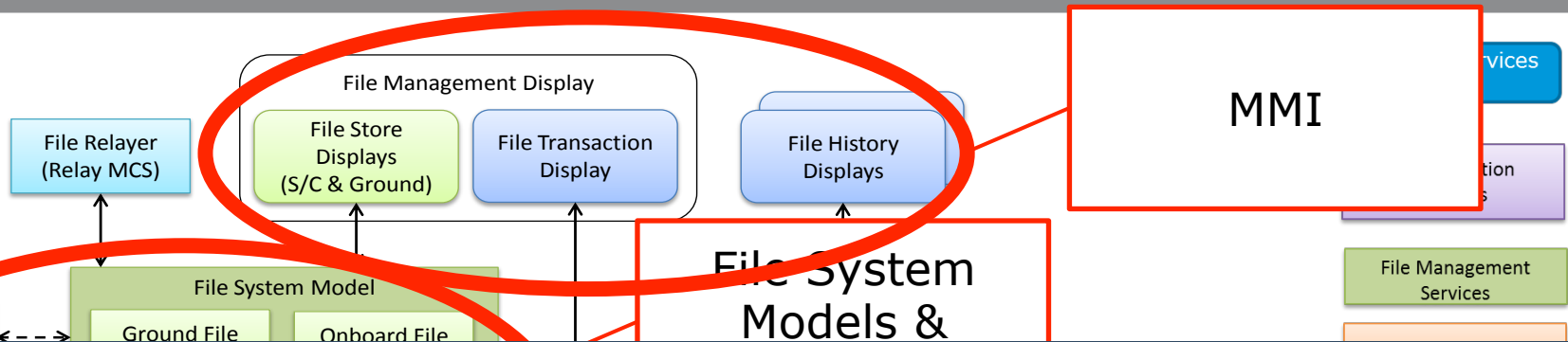
- tailoring for each mission (SIMSAT)
- common infrastructure simulation + eventual mission specific models (GSTVi)

Ground Segment CFDP Infrastructure

CFDP in Mission Control System



Ground Segment CFDP Infrastructure Mission Control System

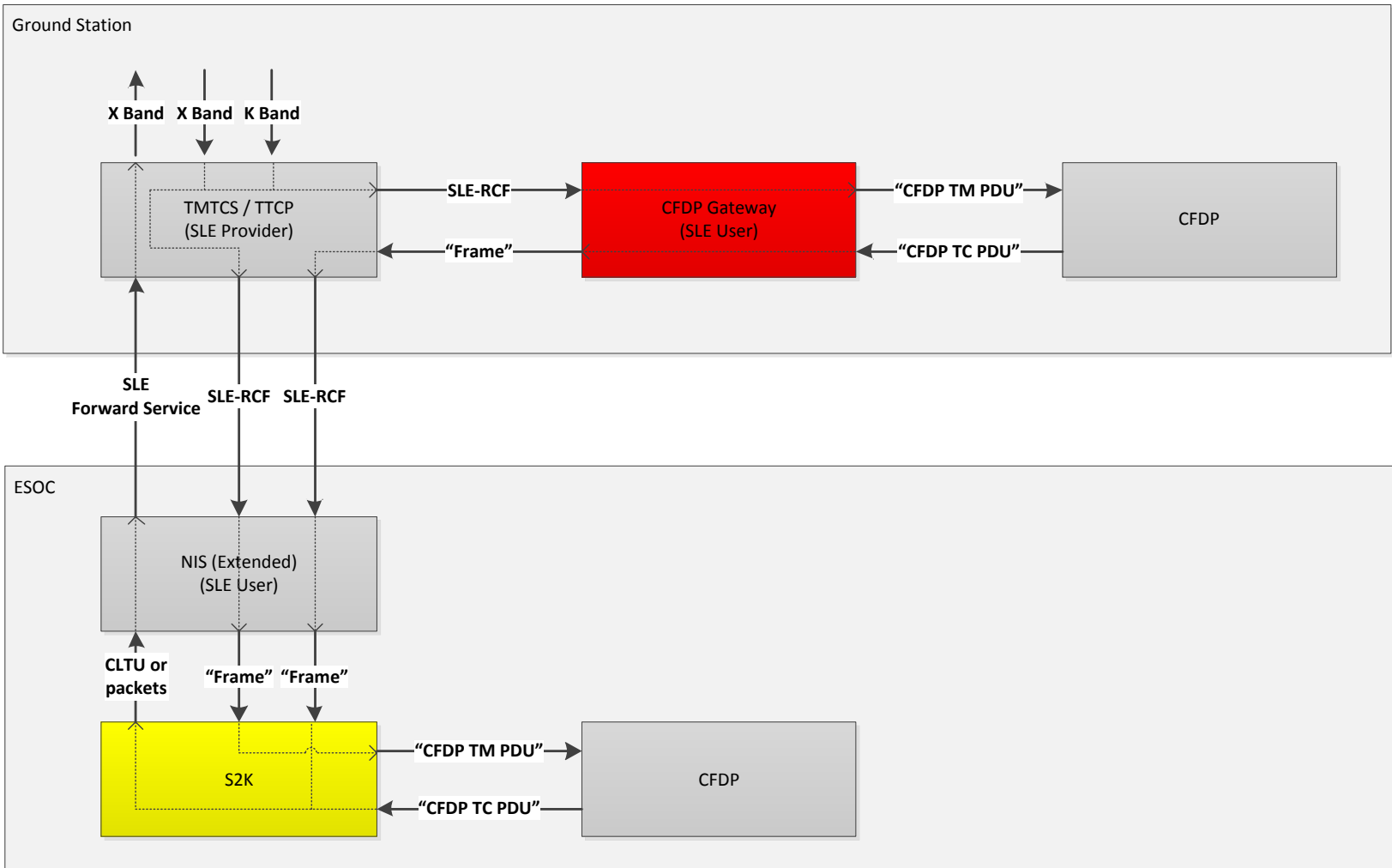


File Transaction Display

Transaction ID	Dest ID	Request Type	State	Source File	Destination File	Priority	Start Time	End Time
FBD_A_0	2	SEND_FILE	SUCCESSFUL	largefile.txt	SentFile.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:44 GMT 2014
▼ FBD_B_0	2	GET_FILE	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:43 GMT 2014
FBD_B_0.1	2	1	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:38 GMT 2014
FBD_B_0.2	2	2	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:39 GMT 2014
FBD_B_0.3	2	3	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:39 GMT 2014
FBD_B_0.4	2	4	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:40 GMT 2014
FBD_B_0.5	2	5	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:40 GMT 2014
FBD_B_0.6	2	6	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:41 GMT 2014
FBD_B_0.7	2	7	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:41 GMT 2014
FBD_B_0.8	2	8	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:42 GMT 2014
FBD_B_0.9	2	9	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:42 GMT 2014
FBD_B_0.10	2	10	SUCCESSFUL	large.txt	GotLarge.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:43 GMT 2014
FBD_E_0	2	SEND_FILE	FAILED	largefile.txt	SentFile.txt0	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:45 GMT 2014
FBD_C_0	2	DELETE_FILE	SUCCESSFUL	-	-	HIGH	Wed Feb 05 10:30:31 GMT 2014	Wed Feb 05 10:30:45 GMT 2014

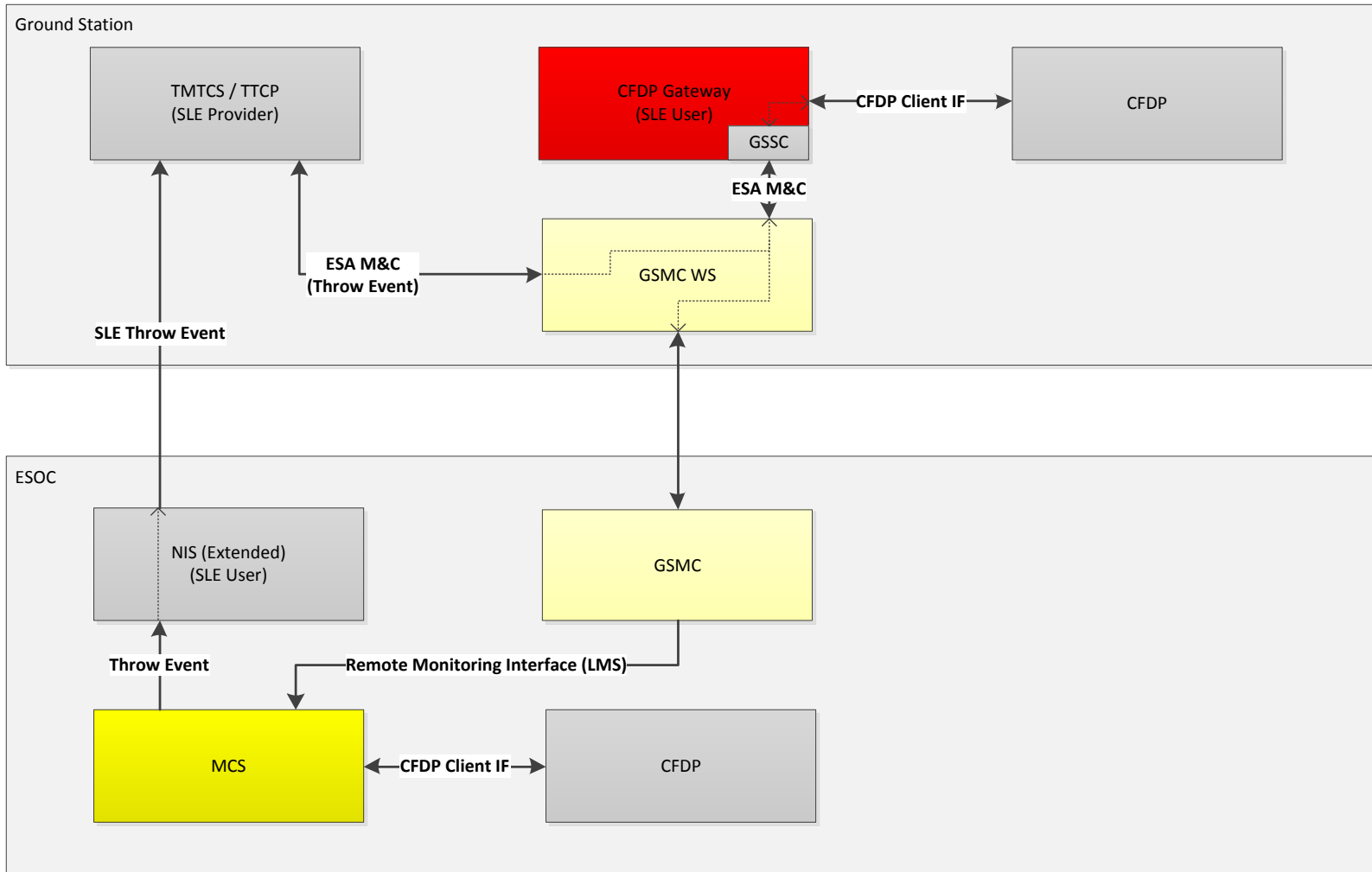
Ground Segment CFDP Infrastructure

Ground Station CFDP Concept – Data Path



Ground Segment CFDP Infrastructure

Ground Station CFDP Concept – M&C



SUMMARY & CONCLUSIONS

1. EUCLID will be the first ESA mission to use CFDP
2. File-based operations / CFDP support should be provided as part of the infrastructure for the MCS
3. Ground Station CFDP support may be necessary to cope with bandwidth limitations on Earth (maybe even more for future missions with even higher data rates)
4. Ground Station CFDP support could be implemented in a common way for missions requiring this feature (nevertheless, it increases complexity compared to running CFDP in the MCS only)