

## The Euclid Ground Segment Design for File-based Operations

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Ground Segment and File Transfers

Use Cases of File Based Operations

**CFDP in Ground Stations** 

"SpaceZilla"

Benefit of File Based Operations

**Outlook and Visions** 

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### **Euclid Mission Profile**



- ESA medium class science mission
- to explore dark energy and dark matter

   (in order to understand the evolution of the Universe since the
   Big Bang and its present accelerating expansion)

- Launch:
  - Soyuz-Fregat from Kourou End of 2020
- Operational Orbit: L2
- Nominal Duration: 6 years



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- S/C facts relevant for the Euclid Ground Segment:
- Data generated per day: ~100 GByte
- "Offline" mission (4h communication per day)
- One-Way Light Time (orbit around L2): Max. ~6 s
- X-band uplink (16 kbps) and downlink (26 kbps)
- K-band downlink (75 Mbps)
- MMU hosts on-board file store
- File up- and download using CFDP

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- High rate downlink via K-band for huge data amount
- K-band not reliable
- CCSDS File Delivery Protocol (CFDP) will ensure completeness of file transfer via K-band
- Two ground stations on both hemispheres
  - Pass scheduling considers lower rain probability

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## Euclid Ground Segment - Sites





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## **CFDP Entities and File Transfers**





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# Upload of new OBCP as file Command to start/stop OBCP MOC S/C If desired: Download of OBCP file

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On-Board Diagnostics:

Diagnostics data stored in files (high rate, bigger than R/T TM bandwidth)

TC-Files:

Sequence of TCs (for repeating sets of commands)

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## **CFDP Assembly in Ground Station**





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## **CFDP Assembly in Ground Station**



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**CFDP** in Ground Stations

## "SpaceZilla"

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"Reading Emails, not counting Ethernet packets."

- Simpler operations
  - Split of data transfer and operations
  - Operations can just rely on read/write to/from local files
  - CFDP cares about transfer of files (incl. completeness)
- Less processing on ground, e.g.
  - Memory dumps arrive in files
  - Science data arrive as files (incl. file names with a meaning)

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### **Outlook and Visions**



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- File access for SOC at ground stations
  - No need to transfer science file to MOC
- Autonomous passes for data transfers using F-SP (without MOC)
- New paradigm for ground station scheduling:
  - Long data transfer pass (no experts required, perhaps autonomous), flexible scheduling
  - Short ops pass (with experts), fixed scheduling
- IOAG Service Catalogue #1 (issue 2 revision 0 23/08/2016)
  - Forward CFDP-File Service
  - (Forward Packets-File Service)
  - Return CFDP-File Service
  - Return Packets-File Service

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# **QUESTIONS** ?

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# **BONUS SLIDES**

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Total Attenuation in Cebreros as per Time Series Model (11 of 1000 simulated days):



Ref.: K-Band Operations Study - Data Downlink Analysis (KOS-D-AST-TN-004, i4.1, 12.05.2012, by ASTRIUM)

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### **Euclid CFDP Data Units**





### CFDP PDUs inside Space Packets without DFH:

CFDP TM Packet via K-Band (max. 65542 Bytes)												
	TM Packet Header (6 Bytes) Packet Data Field (max. 65536 Bytes											
	2 B	ytes										
	Packet Ide	entification		Sequenc	e Control	Dealart	Source	Packet				
Packet Version Number	Packet Type	Data Field Header Flag	APID	Sequence Flags	Sequence Count	Packet Data Length	Data	Error Control				
3 bits	1 bit	1 bit	11 bits	2 bits	14 bits	2 Bytes	max. 65534 Bytes	2 Bytes				
000 <sub>BIN</sub>	OBIN	0 <sub>BIN</sub>		11 <sub>BIN</sub>			Contains one CFDP PDU	CRC				

	CFDP TM Packet via X-Band (max. 1024 Bytes)												
	TM Packet Header (6 Bytes) Packet Data Field (max. 1018 Bytes												
	2 B	ytes		2 B	ytes	2 Bytes							
	Packet Ide	entification		Sequenc	e Control	<b>B</b>	Source	Packet					
Packet Version Number	Packet Type	Data Field Header Flag	APID	Sequence Flags	Sequence Count	Packet Data Length	Data	Error Control					
3 bits	1 bit	1 bit	11 bits	2 bits	14 bits	2 Bytes	max. 1016 Bytes	2 Bytes					
000 <sub>BIN</sub>	O <sub>BIN</sub>	0 <sub>BIN</sub>		11 <sub>BIN</sub>			Contains one CFDP PDU	CRC					

TC Packet for CFDP PDUs (max. 1016 Bytes)													
	TC Packet Header (6 Bytes) Packet Data Field (max. 1010 Byte												
	2 B	ytes		2 B	ytes	2 Bytes							
	Packet Ide	entification		Sequenc	e Control	D I I	Application Data	Packet Error Control					
Packet Version Number	Packet Type	Data Field Header Flag	APID	Sequence Flags	Sequence Count	Data Length							
3 bits	1 bit	1 bit	11 bits	2 bits	14 bits	2 Bytes	max. 1008 Bytes	2 Bytes					
000 <sub>BIN</sub>	1 <sub>BIN</sub>	0 <sub>BIN</sub>		11 <sub>BIN</sub>			Contains one CFDP PDU	CRC					

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Euclid is an European Space Agency's (ESA) medium class science mission in the Science Program currently under development. Euclid will be launched in 2020 to explore dark energy and dark matter in order to understand the evolution of the Universe since the Big Bang and, in particular, its present accelerating expansion. It will have an operational orbit around Sun-Earth-Liberation-Point 2 and will generate about 100 GB of science data per day, which must be downlinked, processed and distributed within the ground segment.

To transfer these data to ground a high telemetry rate via K-band is required. The weather depending quality of a K-band link requires a failure detecting downlink protocol with automatic retransmissions of corrupted or missing data segments. For this purpose Euclid will host an on-board file system and will use CFDP (CCSDS File Delivery Protocol) to transfer files between S/C and ground. This straight forward approach of implementing an on-board file system makes Euclid the first ESA mission to use new features for spacecraft operations based on files.

This presentation describes Euclid's "game-changing approach to ground systems", the use of files, the CFDP ground implementation and benefits of file based operations for the overall ground segment, including spacecraft operations, mission planning and science data processing. With Euclid being "first of its kind" there are some demanding changes to be applied to ESA's traditional ground segment which required a fair trade-off between requirements, innovation and dependability. Therefore an outlook will be provided about potential improvements which could be applied to future missions.

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