ADCSS 2012
Astrium - Current and Future Mass Memory Products

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All the space you need

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Heritage

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Astrium – current and future Mass Memory Products

- **Heritage:**
  Mass Memories with SDRAM Storage Technology
- Innovation:
  FLASH Memory Technology and future Technologies
- Flash in Space:
  Sentinel 2 MMFU and SPOT6 CoReCi
- Innovation:
  Introduction to future Mass Memory Architectures with SpaceFibre
- Communication:
  CFDP – Support by NGMMA

PDH Memory Product Heritage (SDR-SDRAM technology)

30 Mass Memory Units successfully operating in orbit since 1990

Project (Customer)	Name	Status	Cap.EoL [Gbit]	Datarate [Mbps]	Mass [kg]	Power (max.)
PDHU (Export)	SSMM & Data Compr.	PFM delivered in 2012	512	6700	32	220W
Sentinel-3 (ESA)	PDHU	PFM and FM delivered in 2012	512	400	14	60W
SSR (Export)	SSR	PFM and FM's delivered in 2011 and 2012	512	400	14	60W
PAZ (CDTI)	SSMM	FM delivered in 2011	384	2000	17	95 W
PDHU (Export)	SSMM & Data Compr.	FM successfully in orbit since 2012	512	5000	32	220 W
TanDEM-X (DLR)	SSMM	FM successfully in orbit since 2010	768	2000	17	100 W
CryoSat 2 (ESA)	MMFU	FM successfully in orbit since 2010	256	256	12	35 W
PLEIADES (CNES)	**CO**mpressor **ME**mory	1 FM (of 2) successfully in orbit since 2011	720	2250	34	215 W
Rapid Eye (Export)	MMCU	5 FM`s successfully in orbit since 2008	48	240	3	3 W
SSR (Export)	SSR	2 FM successfully in orbit since 2006	1280	1200	34	130 W
TerraSAR-X (DLR)	SSMM	1 FM successful in orbit since 2007	384	2000	17	95 W
Venus *EXPRESS* (ESA)	SSMM	1 FM successful in orbit since 2005	12	100	8.8	25 W
MARS *EXPRESS* (ESA)	SSMM	1 FM successful in orbit since 2003	12	100	8.8	23 W
Servis (Export)	SSMM	1 FM successful in orbit since 2003	2	10	4,5	6,5 W
ROSETTA (ESA)	OSIRIS MMB	1 FM successful in orbit since 2003	4	100	1.2	1.5 W
GRACE (NASA/DLR)	GRACE MMU	2 FM`s successful in orbit since 2000	1	100	1	1 W
CHAMP (DLR)	CHAMP MMU	1 FM successful in orbit since 2000	1	100	1	1 W
METOP (ESA)	METOP SSR	3 FMS in 2000/1, 2 in orbit since 2007/2012	32	75	20	30 W
CLUSTER 2 (ESA)	CLUSTER 2 SSR	4 FM`s successful in orbit since 2000	10	20	9	5 W
ENVISAT (ESA)	ENVISAT SSR	2 FM`s successful in orbit since 2002	70	125	23	40 W
SOHO (ESA)	SOHO 'SSR'	1 FM launched 1995 & still operating	1.5	20	7	6 W
GIOTTO (DLR)	HMC Image Memory	1 FM launched 1985	0,6	2	0.6	4.6 W
Hubble (ESA)	'FOC' Science Data Store	1 FM delivery 1980.	0,7	10	13	10 W

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Innovation: NAND Flash

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NAND Flash Storage Technology

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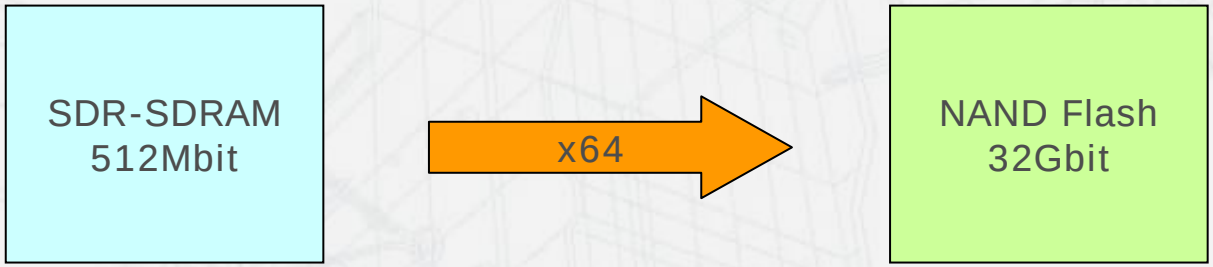
Inherently higher density and capacity per component



- Significant mass, volume and power savings at unit level when compared with SDRAM technology solutions,
- Avoids necessity to use stacking technology.

Non-volatile storage

- Memory banks / unit can be powered down while retaining data
- Enhanced radiation performance
- Recovery mechanisms for various failure modes minimises potential loss of data and provides higher data integrity when compared with SDR-SDRAM.

SSMM Example – High Capacity S2 MMFU

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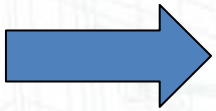
Unit with SDR-SDRAM (estimated figures)
2.8 Tbit Capacity BOL
27kg (11 Memory Modules)
< 120W Simult. Read & Write
< 100W Data Retention
2 x 540Mbps Input Data Rate
0.98 Reliability over 12.5 years
9 x 10^{-13} BER / day



Unit with NAND Flash (measured / estimated figures)
6 Tbit Capacity BOL
14kg (3 Memory Modules)
< 35/54W Simult. Read & Write
< 25/29W (0W) Data Retention
2 x 540Mbps Input Data Rate
0.988 Reliability over 12.5 years
5.9 x 10^{-14} BER / day

DDR3 Storage Technology

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DDR3 Memory Technology

- NGMMA (Next Generation Mass Memory Architecture - ESTEC Contract)
  - Definition of the next generation mass memory and memory module architecture, interface technologies and communication network
  - NGMMA is the main platform for driving the DDR3 storage technology and high speed interconnection networks.
- RHM (Rad Hard Memory – ESTEC Contract)
  - Radiation test program for Flash, DDR and SDR SDRAM applications in harsh radiation environment (JUICE)
  - Extended radiation testing of DDR3 SDRAM devices
- Memory (Technology Assessment - ESTEC Contract)
  - Technology Assessment of DRAM and Advanced Memory Products
  - Extended DDR3 Radiation Tests with devices not regarded up to now (e.g. low power DDR3 or mobile DDR2 technologies)
  - Evaluation of more exotic devices like FeRAM, MRAM, PCRAM.

Flash in Space

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Flash In Space: Sentinel 2 MMFU

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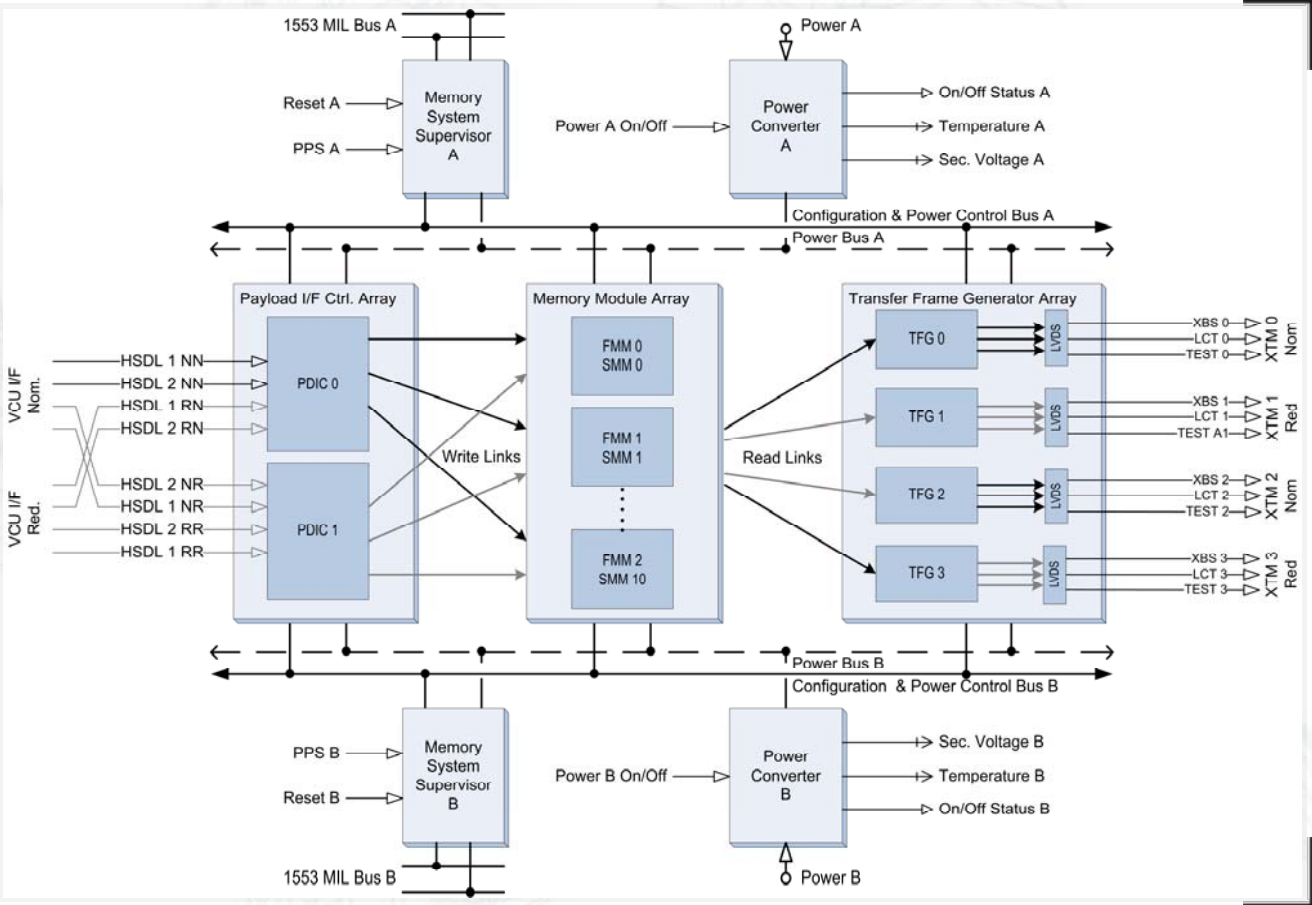
Sentinel 2 - MMFU

- Array Architecture
- 3 Flash Modules instead of 11 SDRAM Modules
- EQM delivered 2012
- PFM will be delivered in Jan. 2013



Next Generation "High Capacity" Unit

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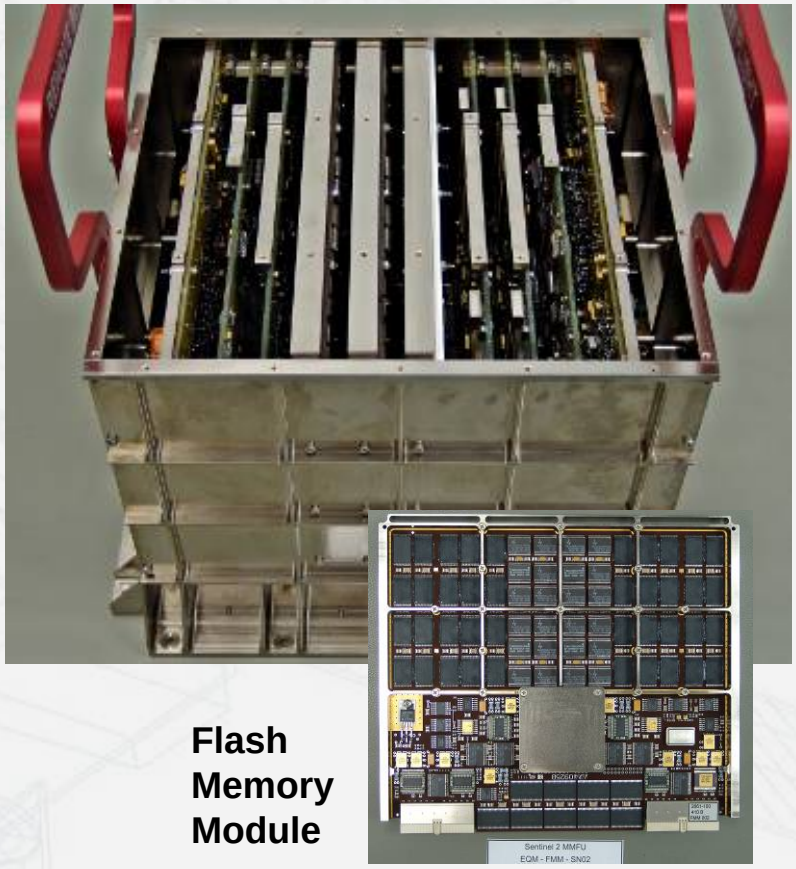
ESA Sentinel-2 MMFU, launch 2014

- Capacity 2400 Gbit (EOL) with Flash technology
- Input Data Rate 2x540 Mbps
- Mass 14 kg
- L: 302 x W: 345 x H: 240 mm
- Power consumption < 35W
- Simultaneous record and replay
- Flexible real-time SW based embedded File Management System with PUS services
- CCSDS conform output Data Formatting at a data rate of 2x280 Mbps
- 7.5 years lifetime in-orbit
- EQM delivery in June 2012 with FM delivery in 2013 Q1.

Sentinel-2 MMFU



Flash Memory Module

CoReCi "SSR with Compression" Unit

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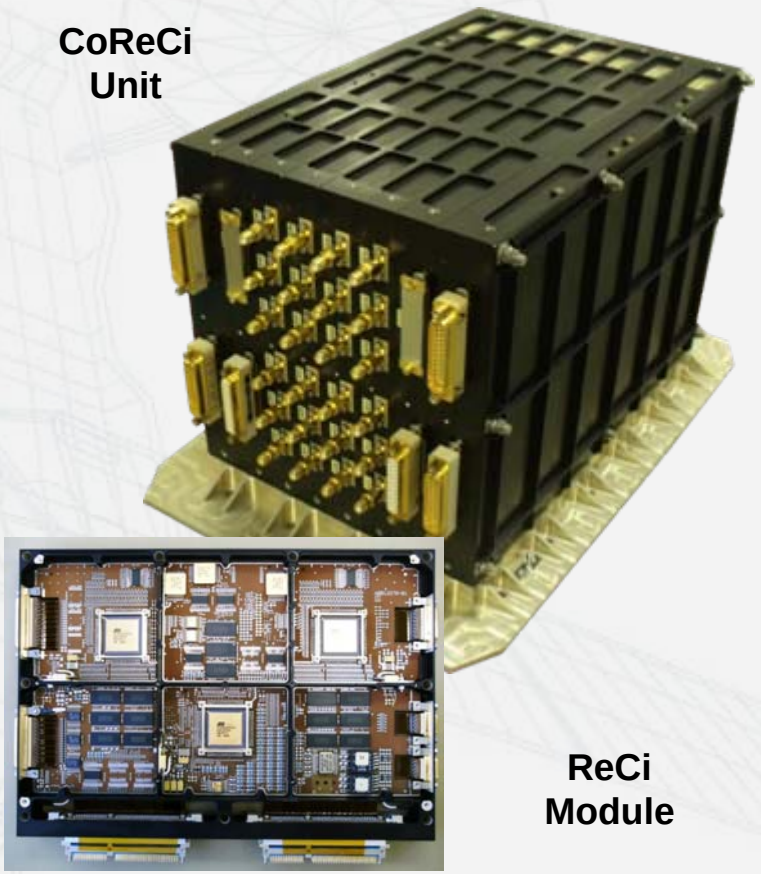
Astroterra (SPOT 6)

- Modular architecture adaptable to various data rates and capacities
- Input data rate up to 1.4 Gbps
- Capacity 850 Gbit (EOL) with Flash technology
- Embedded Wavelet Image Compression with MRCPB algorithm
- Ciphering based on AES algorithm with 127x128 bit ciphering keys
- Data Formatting acc. to CCSDS ESA Packet Telemetry Standard
- Mass 14 kg
- Power consumption 75 W during simultaneous data record / data compression / data replay
- PFM delivered in Jan 2012



CoReCi on Spot-6

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- Successful Spot-6 launch on 9th September 2012
- First commercial use of Flash storage technology in an on-board Payload Data Handling Unit
- First images obtained three days after launch:

Bora Bora

Gibraltar

SPOT 6 Launch in India

Innovation: NGMMA

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Future Mission Demands

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Future Mission Demands are mainly driven by

- Earth Observation (SAR, Hyperspectral) applications
  - high input data rates (up to 14 Gbit/s)
  - increased capacity (up to 10 Tbit)
  - enhanced downlink data rates (up to 5 Gbit/s)
  - communication via relay satellites

Answers are currently investigated in the frame of NGMMA

- Introduction of high speed serial links (SpaceFibre) for external and internal communication
- Evaluation and radiation tests of DDR3 devices
- Support for high speed downlink systems (Ka-Band, LCT)

Future Mission Demands

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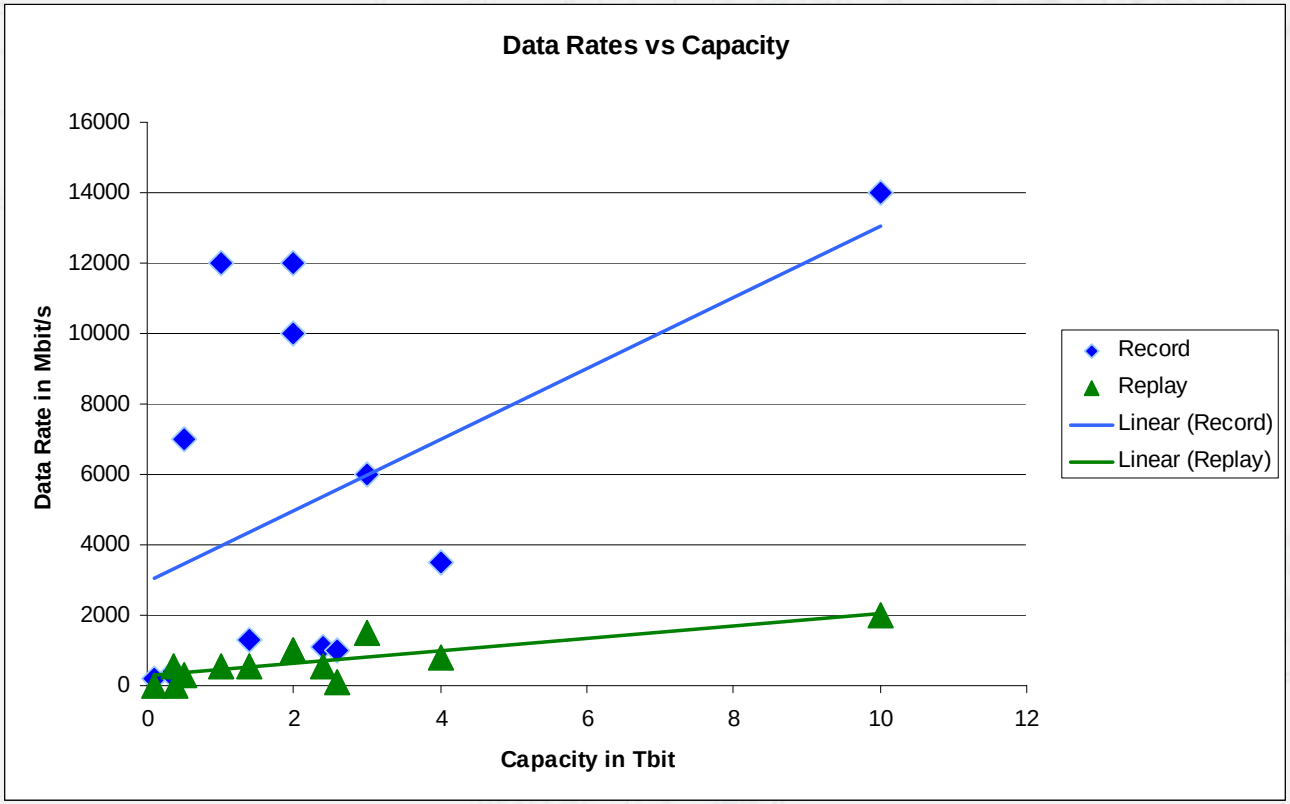
Data Rates vs Capacity



NGMMA Ring Architecture

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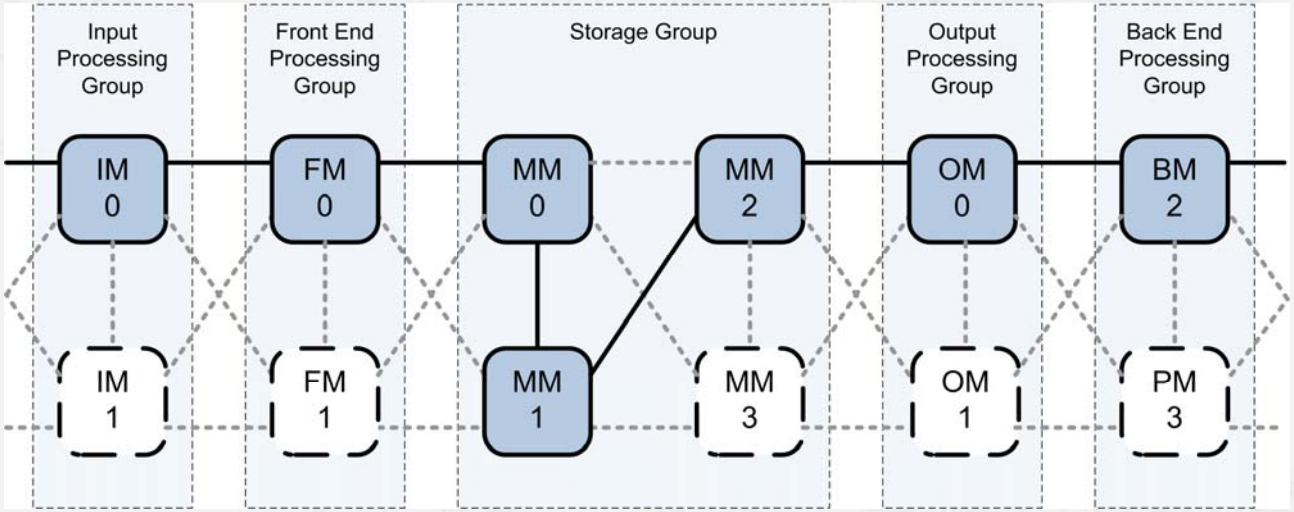
NGMMA Processing and Storage Ring Architecture

(internal basic interconnection scheme shown only)



- High Speed Communication Network based on SpaceFibre
- Each Module contains a Routing Function
- Highly modular in terms of number and type of modules
- High reliability due to cross-coupling between each processing and storage group

Communication - CFDP Support

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NGMMA and CFDP Support

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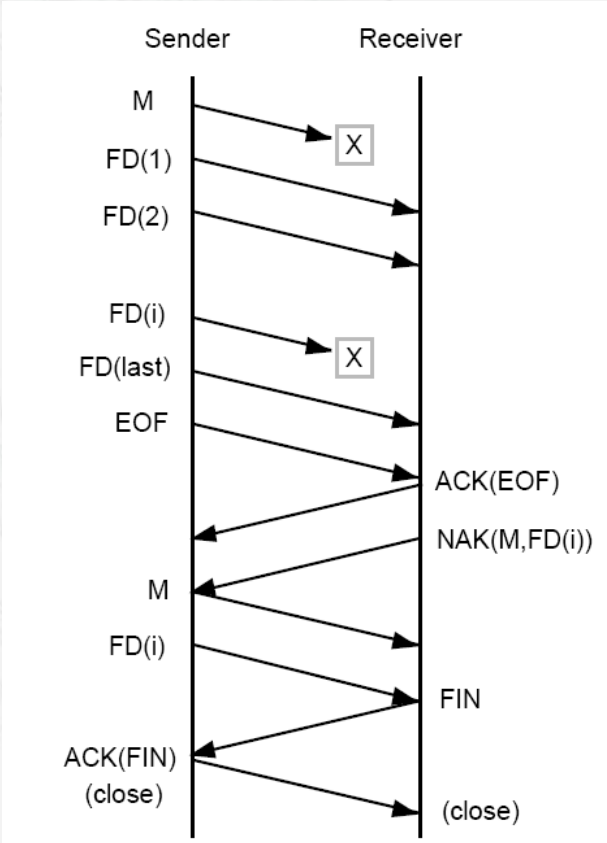
Proposed Implementation (under discussion):

- CFDP class 2 (reliable transfer) with deferred NAK Mode
- Principle CFDP Communication
  - high speed downlink interfaces
    - Meta Data (M)
    - File Data Segment (FD)
    - End of File (EOF)
  - TM/TC subsystem (PDU messages)
    - File Store Directives
    - Acknowledgement (ACK)
    - Negative Acknowledgements (NAK)
    - Finished (FIN)
- Protocol Data Units (PDU) exchanged with the OBC are assumed to be encapsulated in PUS structures.



NGMMA and CFDP Support

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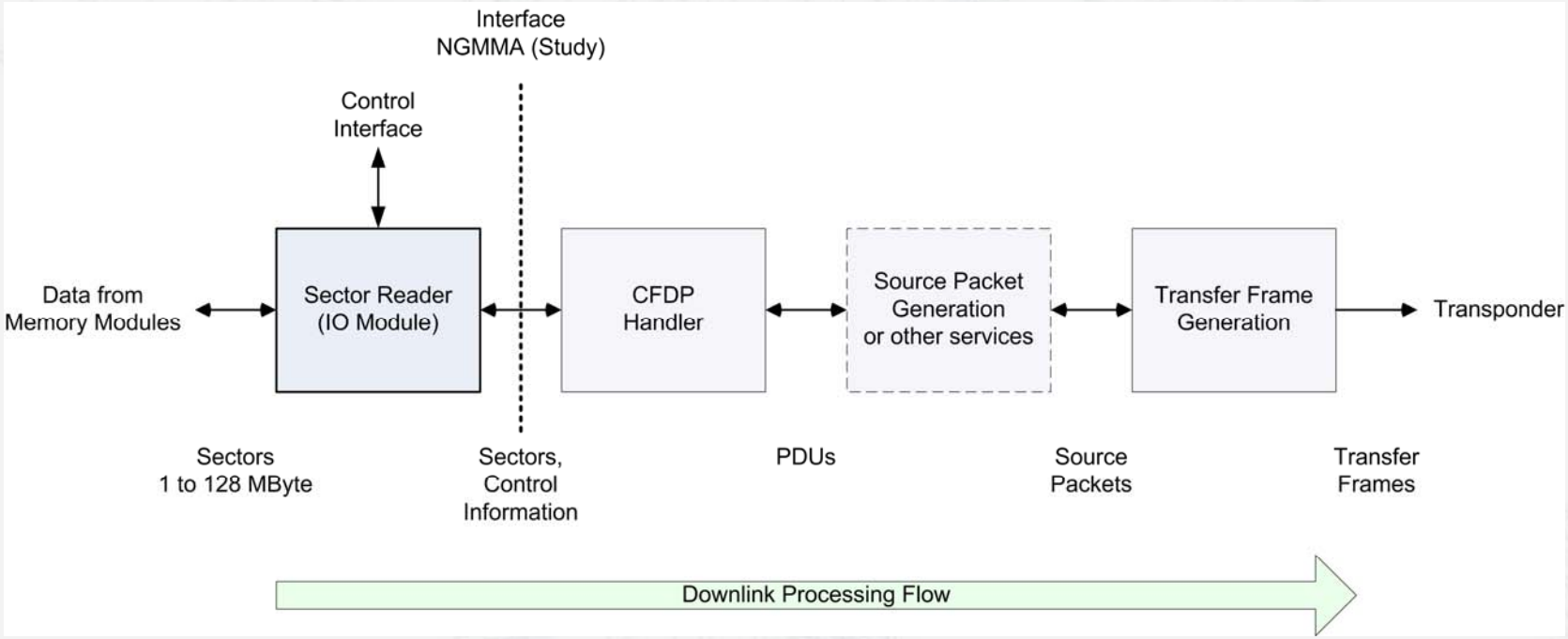

NGMMA and CFDP Support

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Proposed Implementation (under discussion):

- Transaction -> File Delivery Unit (FDU)
  - Delivery of one Sector which contains user data
  - A **Sector** represents the smallest entity which can be randomly accessed by the File System
  - **Sector** size depends on required access granularity, data rate and processor performance (1 Mbyte to 128 Mbyte)
  - FDU = Sector + Control Information (meta data)
- FDU is cut in File Data Segments (FD) by the CFDP Handler
- Optional Source Packet Generation or other Service
- Transfer Frame Generation (e.g. AOS)

NGMMA and CFDP Support

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Proposed Implementation (under discussion):

- CFDP Function needs hardware support
  - Downlink Data Rate: up to 5 Gbit/s
  - max. size of File Data PDU (FD): 64 Kbyte
  - CFDP Handler Interaction Frequency: ~10240 PDUs/sec
  - Software Interaction Frequency on Sector Level: > 1.5 ms per Sector (@ sector size: 1 Mbyte)
- Maximum File Sizes:
  - max. size of CFDP-File: 4 Gbyte
  - max. size of real file / packet store: up to completely available storage area (~Tbyte)
  - => a file needs to be delivered by several chunks (here: transactions)

NGMMA and CFDP Support

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Proposed Implementation (under discussion):

- File Types:
  - cyclic packet stores
  - non-cyclic packet stores

- Supported Services (NGMMA - high speed mass memory system)
  - File Access Service (FAS)
    - OPEN_FILE
    - CLOSE_FILE
    - READ (PACKETS)_FROM_FILE
    - WRITE (PACKETS)_TO_FILE
  - File Management Service (FMS)
    - CREATE_FILE
    - DELETE_FILE
    - MOVE_FILE
    - COPY_FILE

Concluding Summary

- **Astrium latest SSMM products with ESA qualified NAND Flash technology provide savings of more than 50 % in mass and power consumption over comparable SDR-SDRAM products. Flash SSMM units are fully qualified at component & unit level and successfully operating in space (Spot-6) since Sep 2012.**

- **R&D activities at both component and unit level are being performed to develop higher performance solutions with particular emphasis on DDR3 and SpaceFibre technologies.**

- **The implementation of the CCSDS File Delivery Protocol is supported by NGMMA. A useful configuration in the frame of NGMMA needs HW support to cope with the high speed demands. NGMMA and future support functions are under discussion.**

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The End

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