OBC Mass Memories
Final Presentation

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ESTEC, 6 December 2016

Study partners:

SCISYS

DSI Informationstechnik

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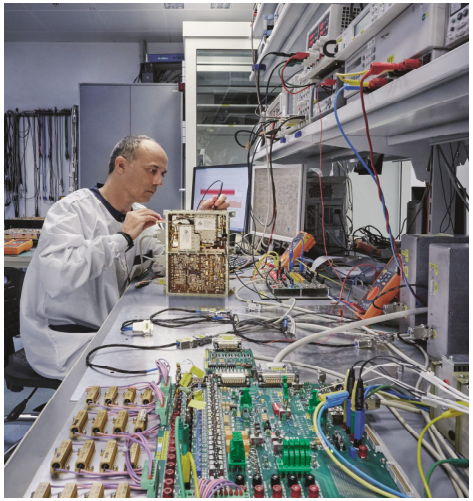
RUAG Space Product Areas

Launcher Structures & Separation Systems

- Launcher Fairings & Structures
- Payload Adapters & Separation Systems
- Sounding Rocket Guidance

Satellite Structures, Mechanisms & Mechanical Equipment

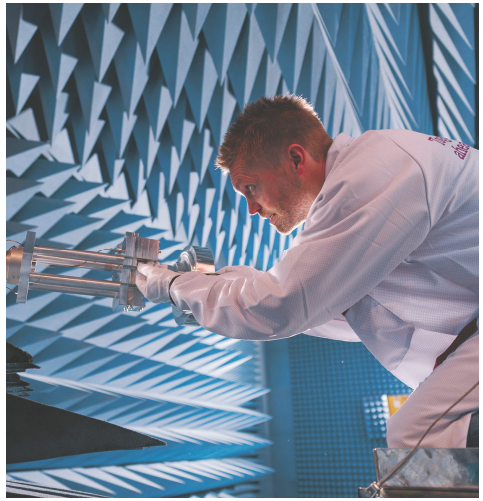


- Satellite Structures
- Satellite Mechanisms
- Sliprings
- Mechanical Ground Support Equipment
- Thermal Systems

Digital Electronics for Satellites and Launchers

- Satellite & Launcher Computers
- Navigation Receivers & Signal Processing

Satellite Communication Equipment



- Receivers & Converters
- Antennas

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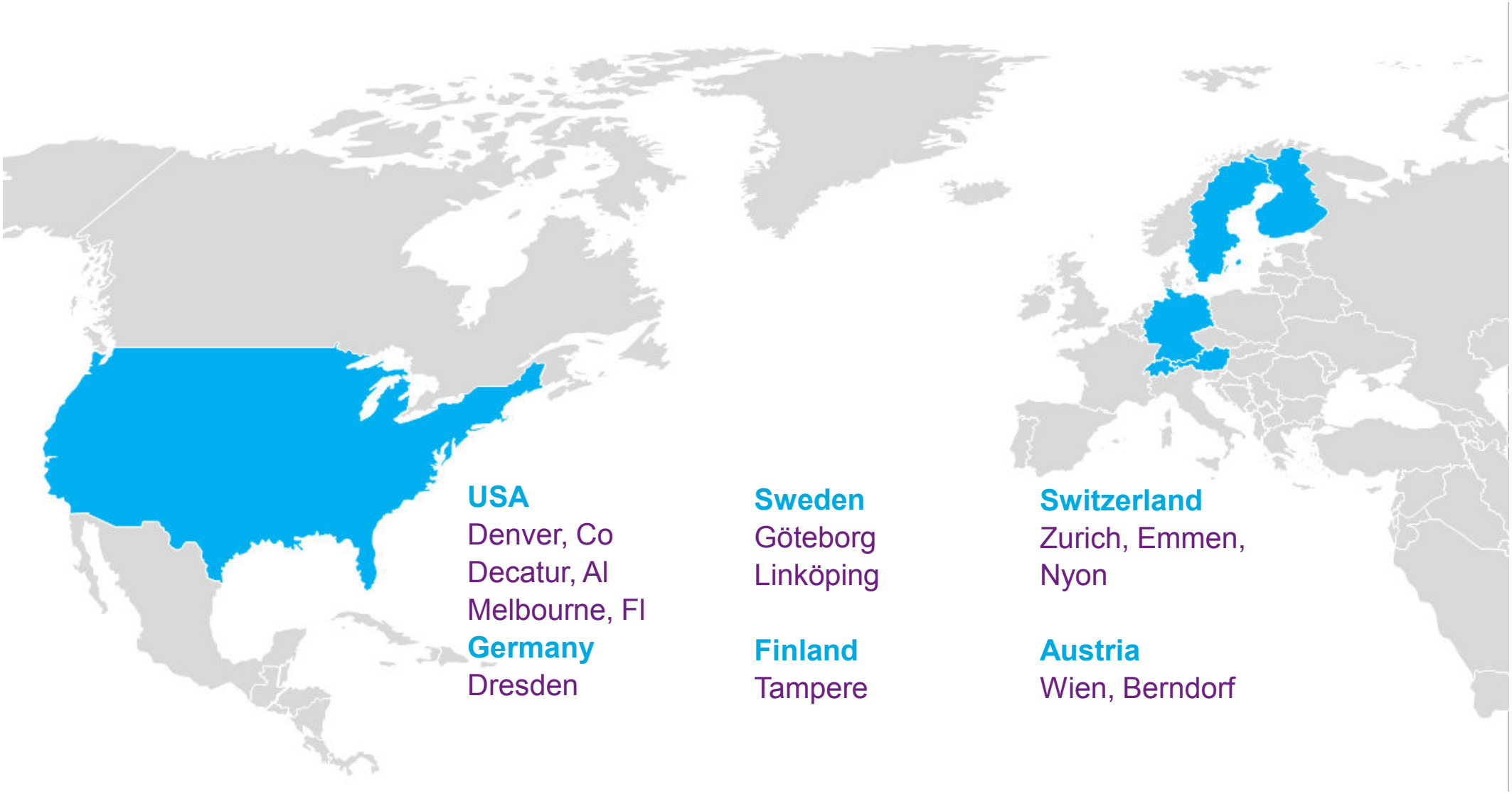
RUAG Space – 12 sites worldwide



USA
Denver, Co
Decatur, Al
Melbourne, Fl

Germany
Dresden

Sweden
Göteborg
Linköping

Finland
Tampere

Switzerland
Zurich, Emmen,
Nyon

Austria
Wien, Berndorf

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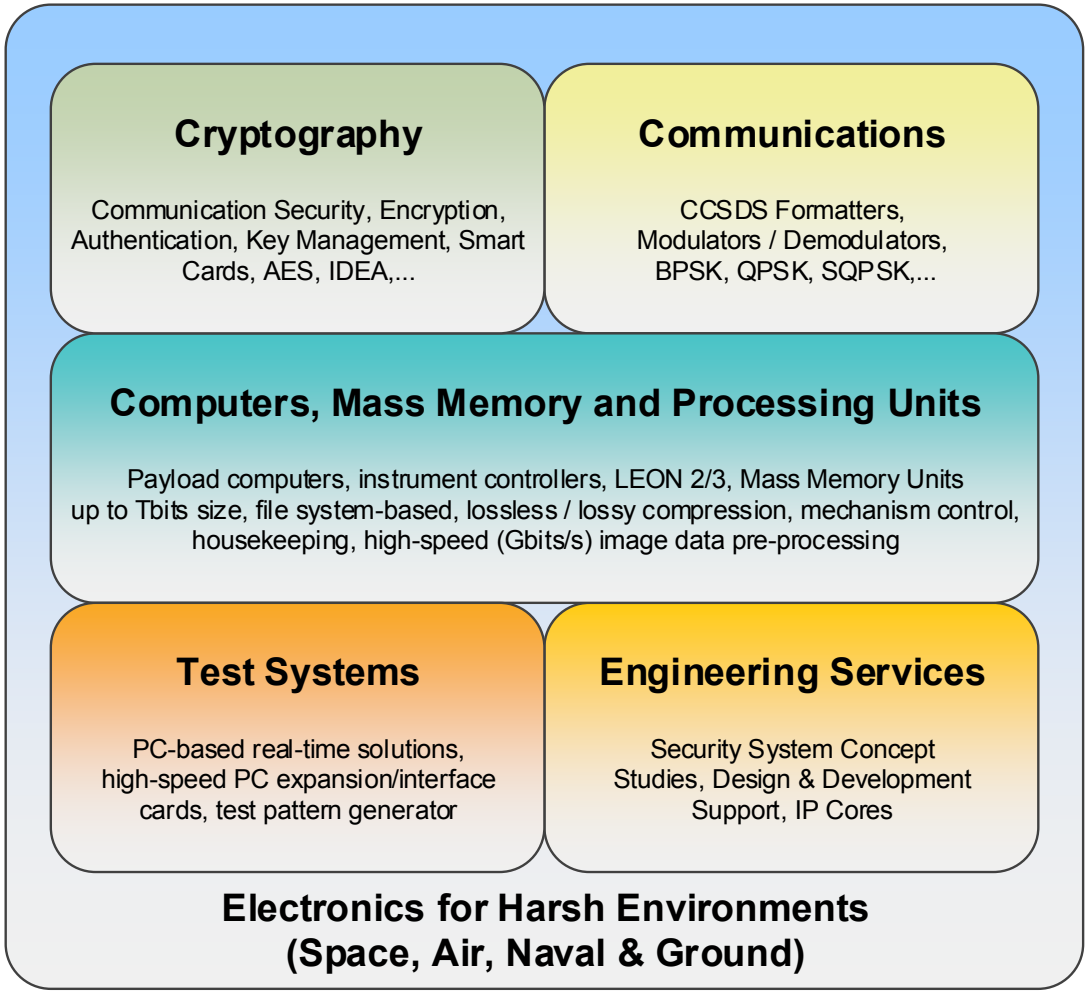
DSI Overview

DSI (Digital Signal Processing and Information Technology GmbH)
Bremen, Germany



SCISYS Overview

Sites in UK and Germany

Space - UK

- Satellite Control Systems
- On-board Software
- Modelling and Simulation
- Robotics

Space - Germany

- Payload Data Ground Segment
- Service Infrastructure
- Space Applications
- Mission Operations
- Flight Dynamics

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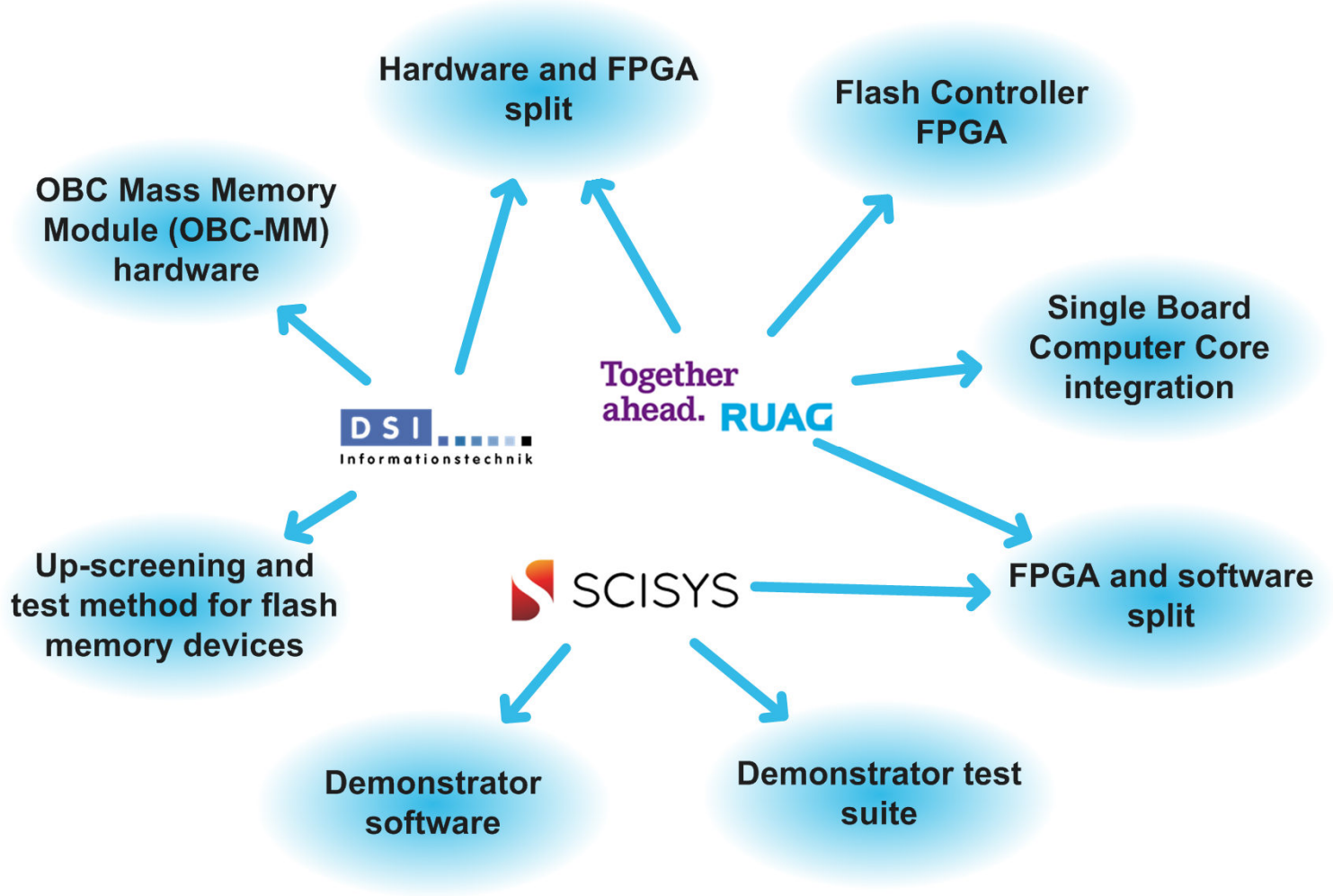
OBC Mass Memories Overview

Integrate a multi-user complex, file based, mass memory into the On-Board Computer (OBC) to facilitate a cost effective solution with high performance utilizing state-of-the-art solid state memory technologies while at the same time ensure the reliability and endurance for a mission in the harsh space environment.

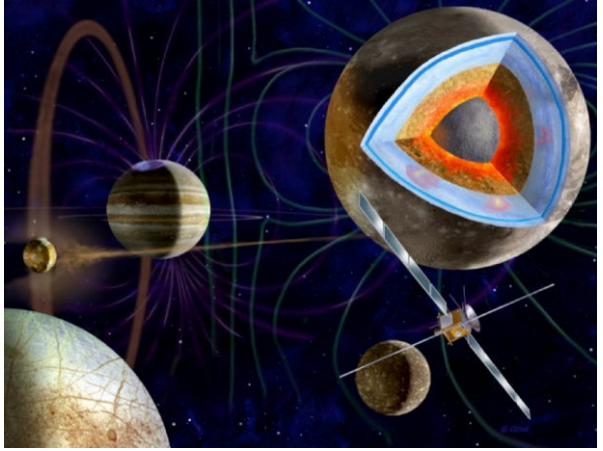


Integration of Mass Memory in the OBC

- Why integrate it?
  - Integrated modules instead of a complete standalone unit

- Missions with moderate storage needs
  - Total storage capacity: 0.5 – 2 Terabits
  - Total storage bandwidth: 100 Mbps
  - Total downlink bandwidth: 100 Mbps

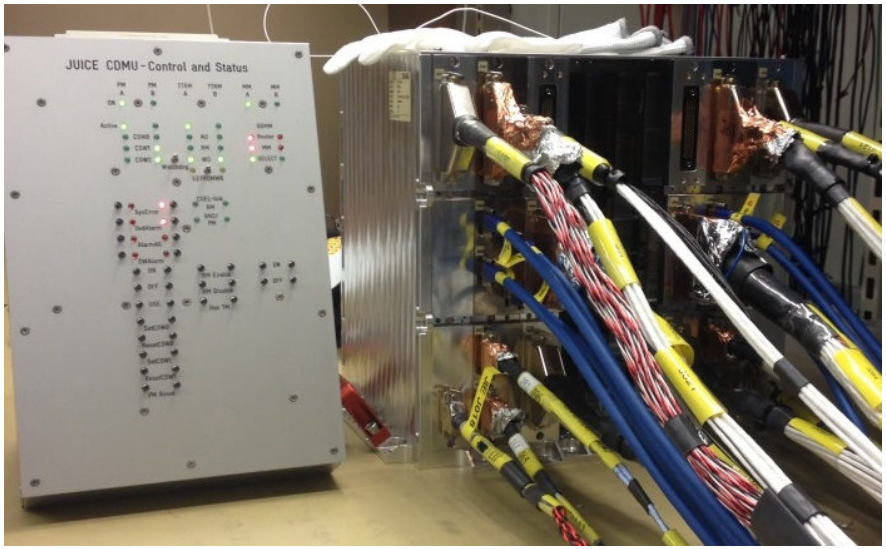
Target Applications for Integrated MM



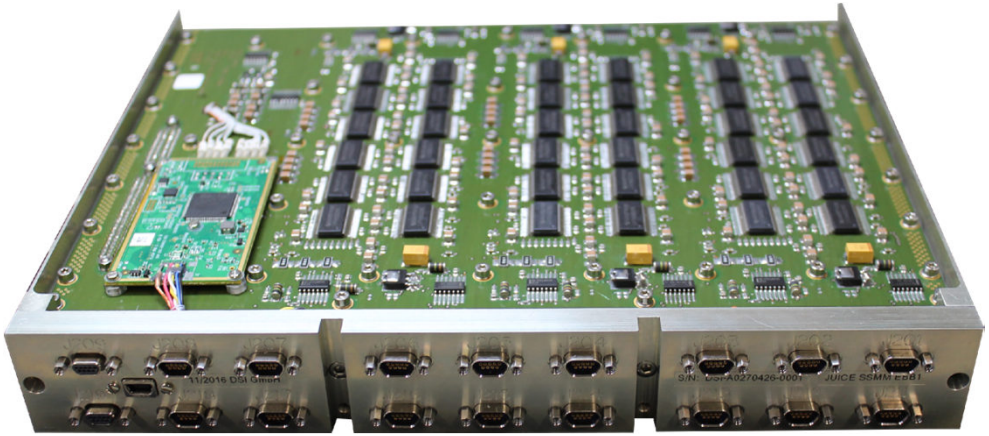
JUICE courtesy ESA

- Identified missions
  - JUICE
  - SMILE
  - PLATO
  - Small EO missions
  - Athena
  - M4

JUICE OBC



JUICE SSMM



RUAG Space

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Flash Memory Selection

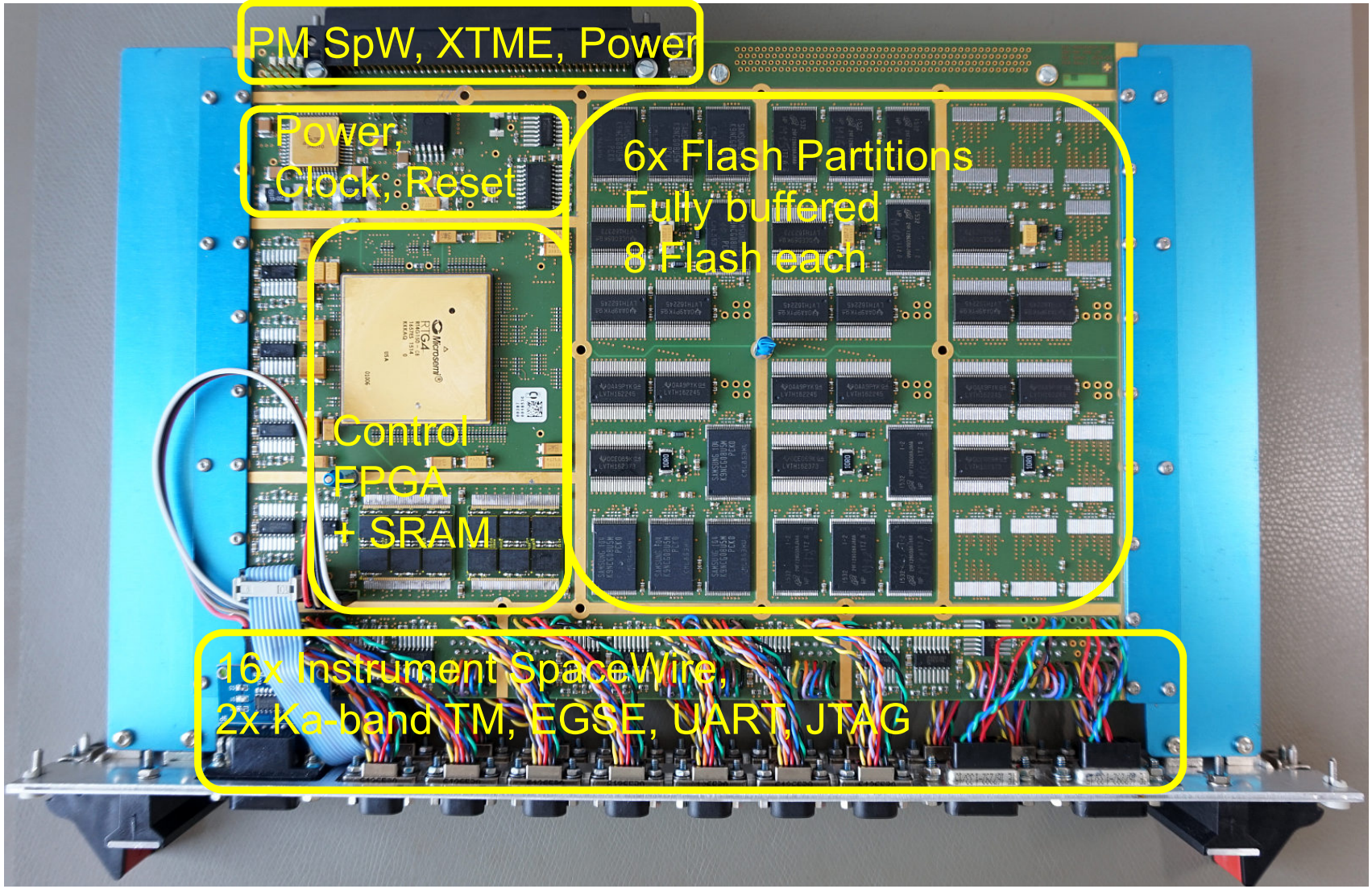
- Selected memory technology: Raw Planar SLC NAND Flash
  - Suitable for most space applications
  - High density (compact)
  - Non-volatility (low power)
  - Well known (flight heritage / qualification status)
  - Error mechanisms can be easily handled by
    - Hot redundancy (EDAC) to achieve data integrity
    - Cold redundancy to achieve EOL reliability / capacity
    - TID shielding
    - Other improving measures (wear levelling, scrubbing, power cycling)

- Used components in OBC MM EM:
  - Samsung K9NCG08U5M (51nm, 8-die, 8Gbit per die)
  - Micron MT29F128G08AJAAAWP (25nm, 4-die, 32Gbit per die)

Radiation Performance

- Powerful Flash EDAC
  - Future-proof (copes with increasing sensitivity of new NAND Flash)
  - High data integrity / reduced maintenance efforts
  - Inner ECC
    - (248,164) 11 bit Error Correcting BCH Code
    - Applied within Flash pages
    - To cope with distributed errors (TID, SHE, SEU, MBU)
  - Outer ECC
    - (8,6) Double Erasure Correcting Reed-Solomon Code
    - Applied across Flash word group
    - To cope with severe errors (SEFI)
  - Uncorrectable bit error rate << 10^{-20} (JUICE)

The Mass Memory Board (MMB)



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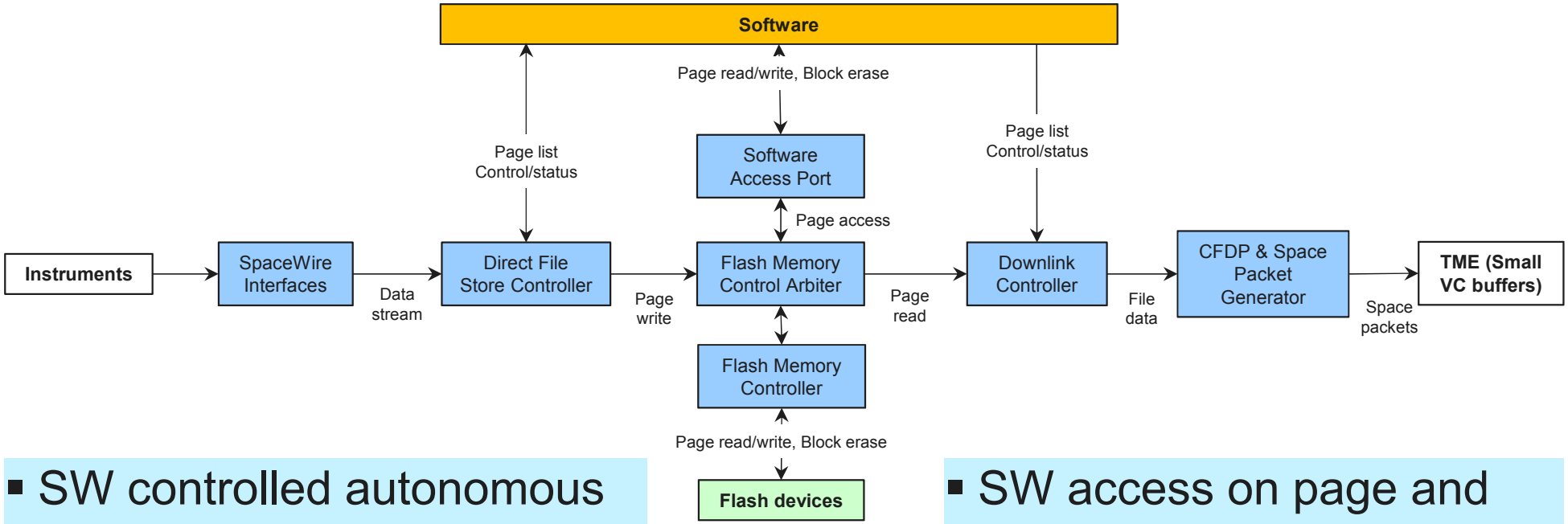
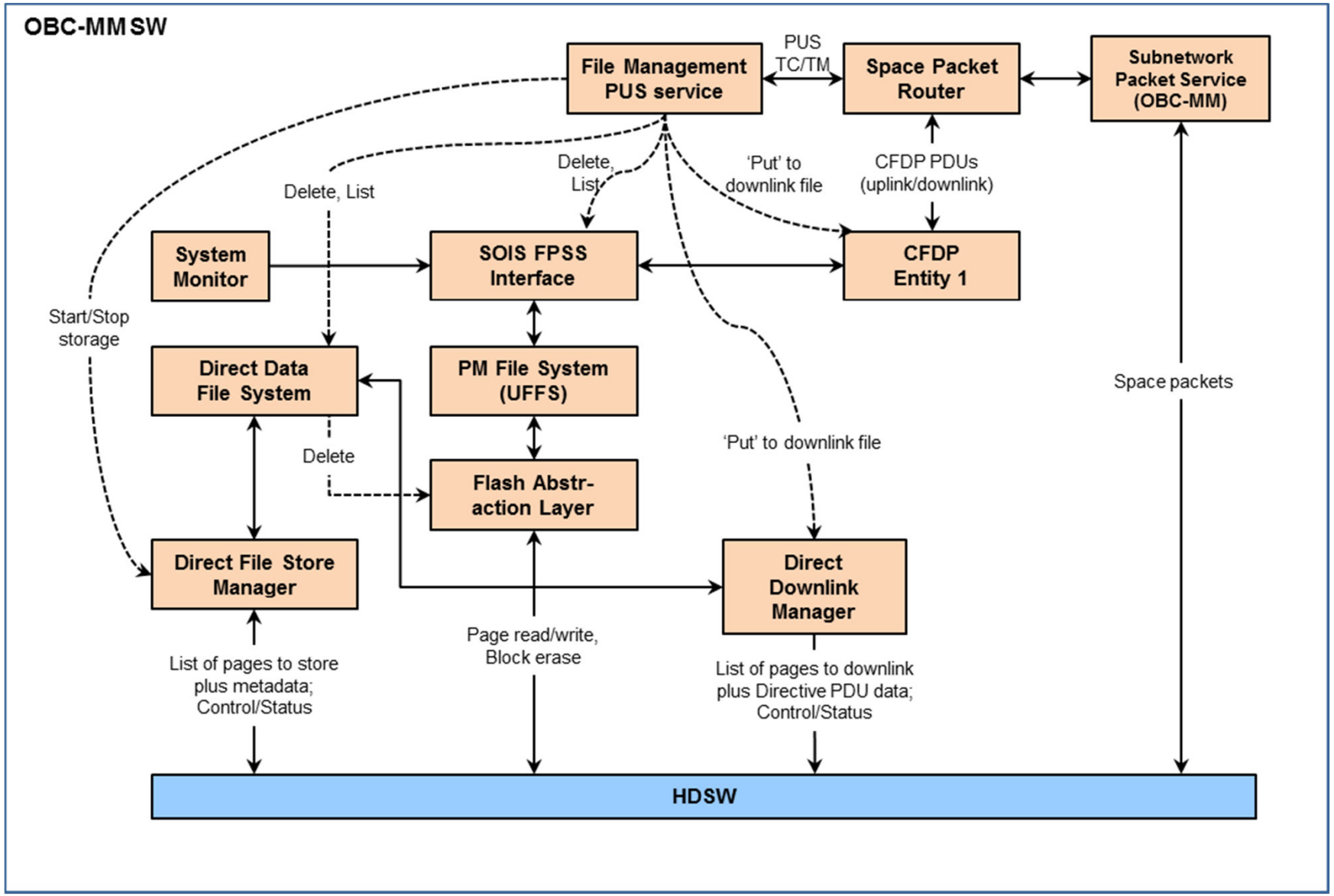
The Mass Memory Controller FPGA



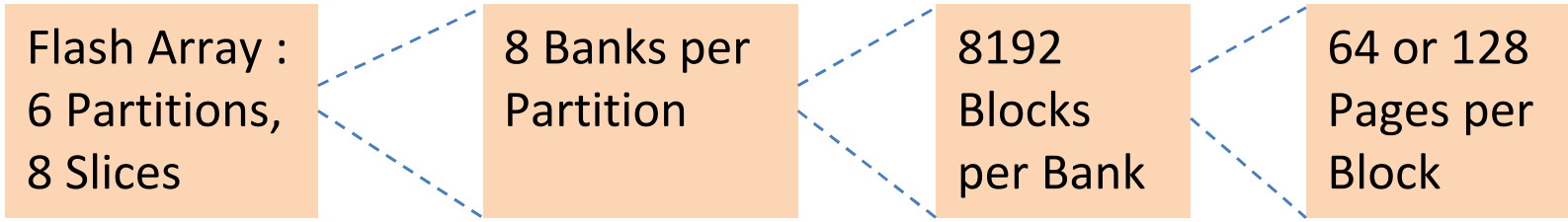
- SW controlled autonomous direct file storage
- SW controlled autonomous downlink
  - CFDP
  - Space Packets
- File and Packet store support

- SW access on page and block level
- Advanced error correction scheme
- Raw device access possible

Software Functional Overview



OBC Mass Memories File Systems



PMFS :

- Processor Module File System
- Supports Platform data stored via PM interface
- Implemented using UFFS
- Partition size configurable
- Mounted as /PM
- Multiple directories
- Block per file node
- Dynamic wear levelling

DDFS :

- Direct Data File System
- Supports Payload data stored directly by HW
- Bespoke implementation
- Partition size configurable
- Mounted as /DD
- Directory per data channel
- Configurable blocks per file
- Multiple parallel channels
- Dynamic wear levelling

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File Operations

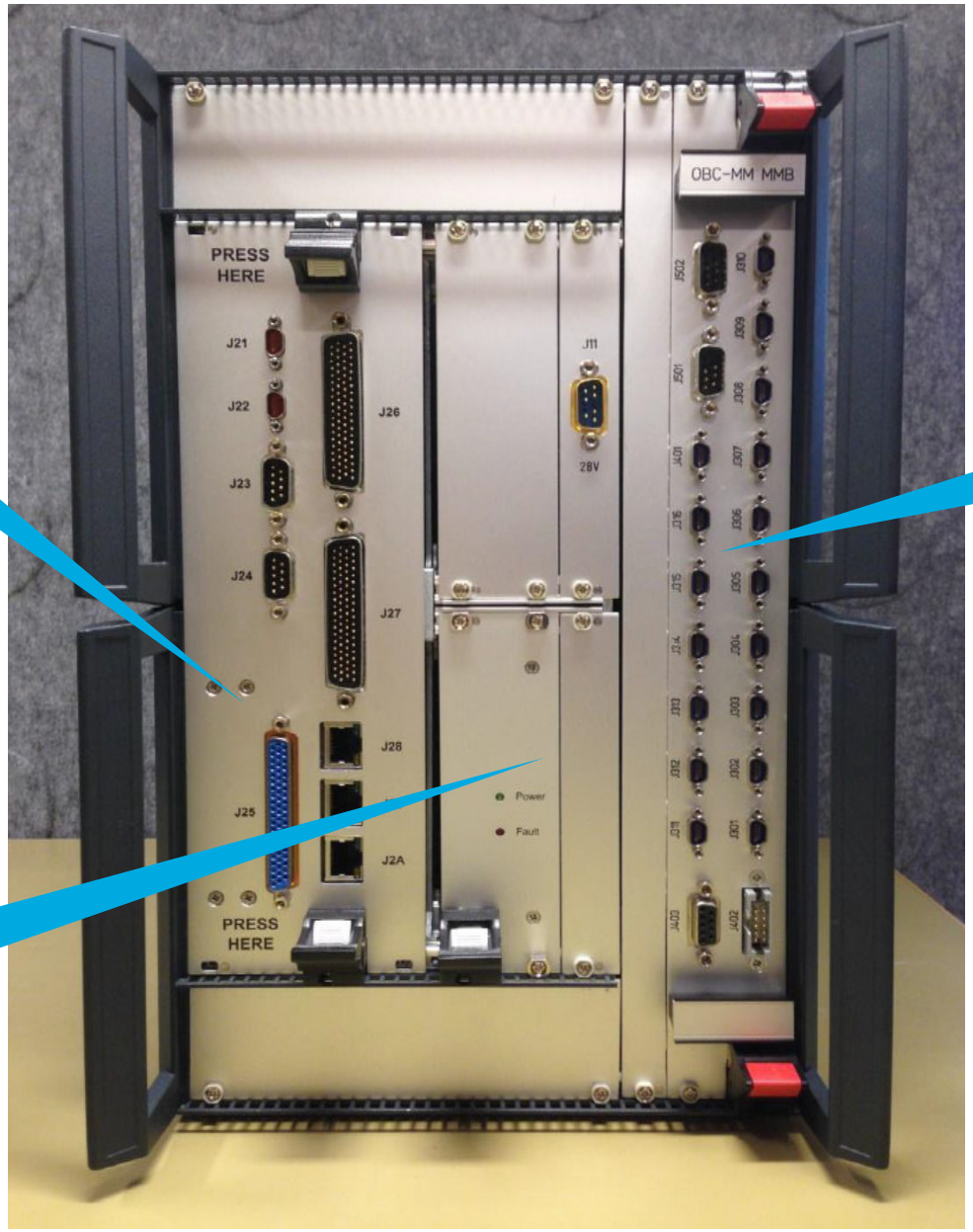
Mount Process

- Partition power switched by OBC-MM SW
- Bad Block Table
  - Bad blocks established at board manufacture
  - Stored in Block-0/Page-0 of each Rank
  - Whole array Bad Block Table created during mount
  - Bad blocks avoided when creating/extending files
- UFFS reads every block to build its internal node tree
- DDFS reads every block to build its Block Allocation Table

SW Interfaces to File Systems

- SOIS File Access & Management interface via ‘API’
- PUS service for file transfer initiation, list requests, deletion
- CFDP : Class 1 & 2 transfers; Uplink data is buffered

OBC-MM



Processor Module

Mass Memory Board

Power Supply

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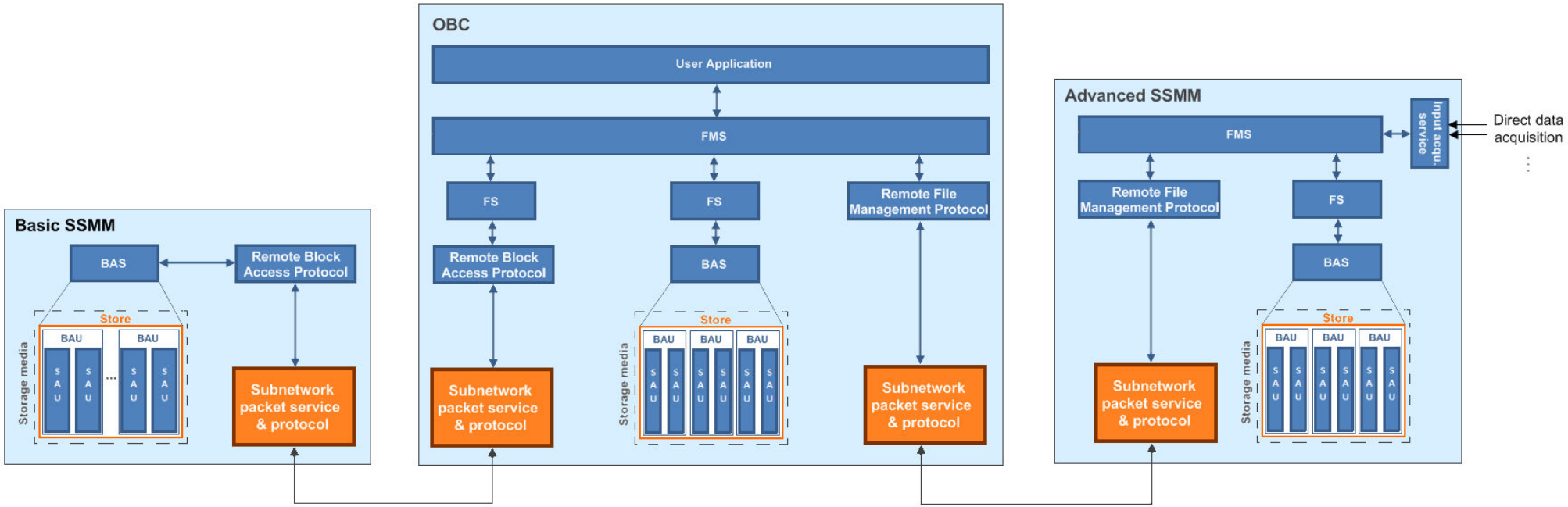
Programmatic Aspects

- Success factors:
  - Meet ESA needs
  - Control schedule and risk

- OBC Mass Memories schedule control:
  - Build up schedule margin before delays occur
  - When delay occurs allocate additional resources/intense control of subcontractors and introduce countermeasures to recover delay
  - Through rapid prototyping of the mass memory controller and instantiating it in the MFC/CREOLE board from the parallel Single Board Computer Core activity, SCISYS software development was decoupled from the HW design protecting it from late delivery of the MMB hardware
  - Contractual completion date met with some margin

SAVOIR-MASAIS
File Management Services Interface Standardization



- OBC-MM supports the FMSIS architecture
- OBC-MM defines Block Access Services (BAS) and a packet protocol similar to RMAP but page/block aware with ECC information and status

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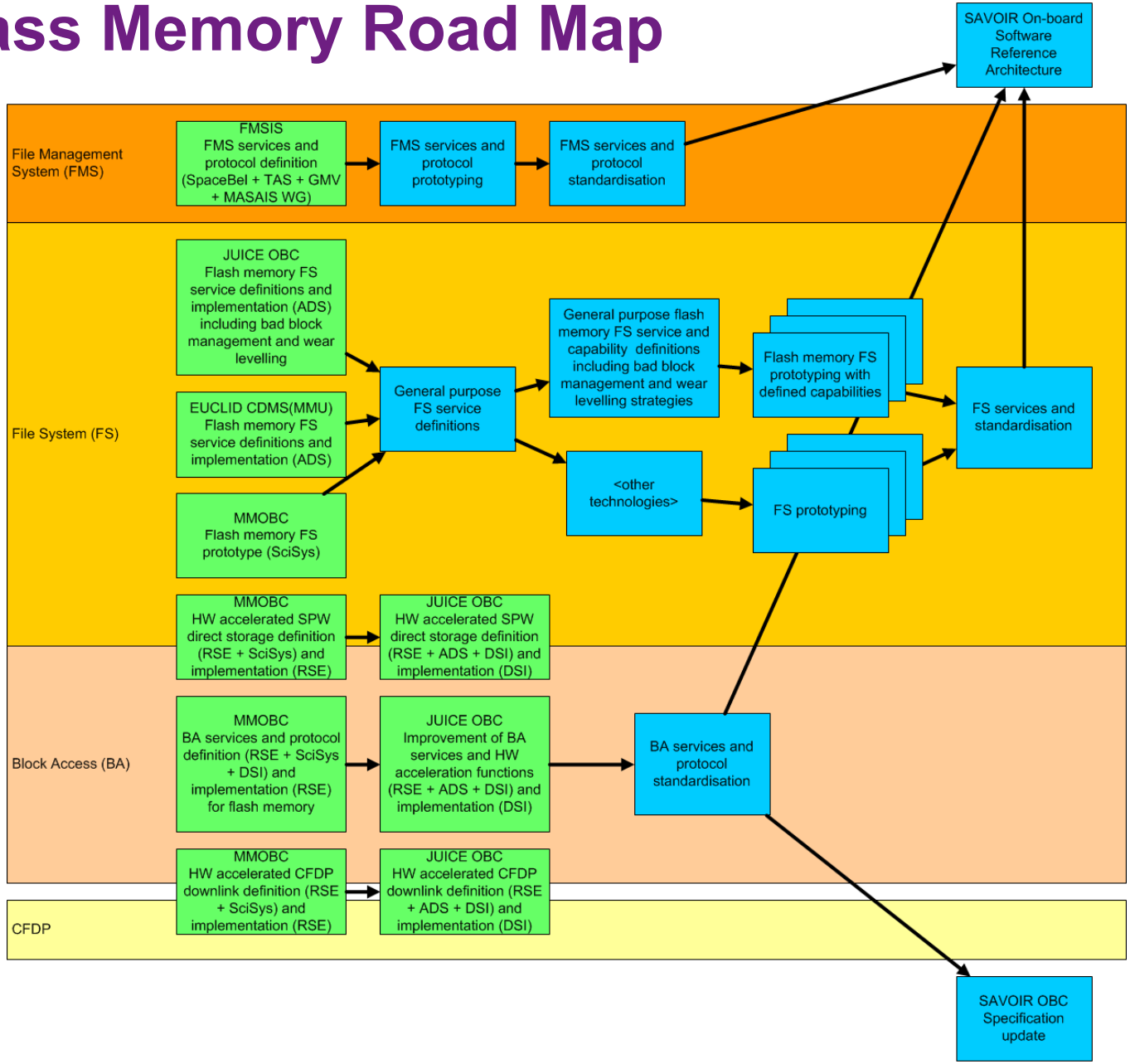
Mass Memory Road Map



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