SpaceWire

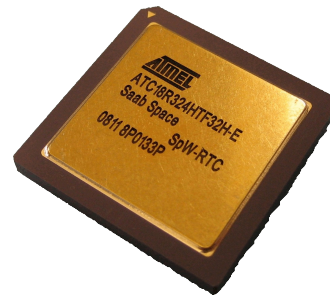# *Remote Terminal Controller*
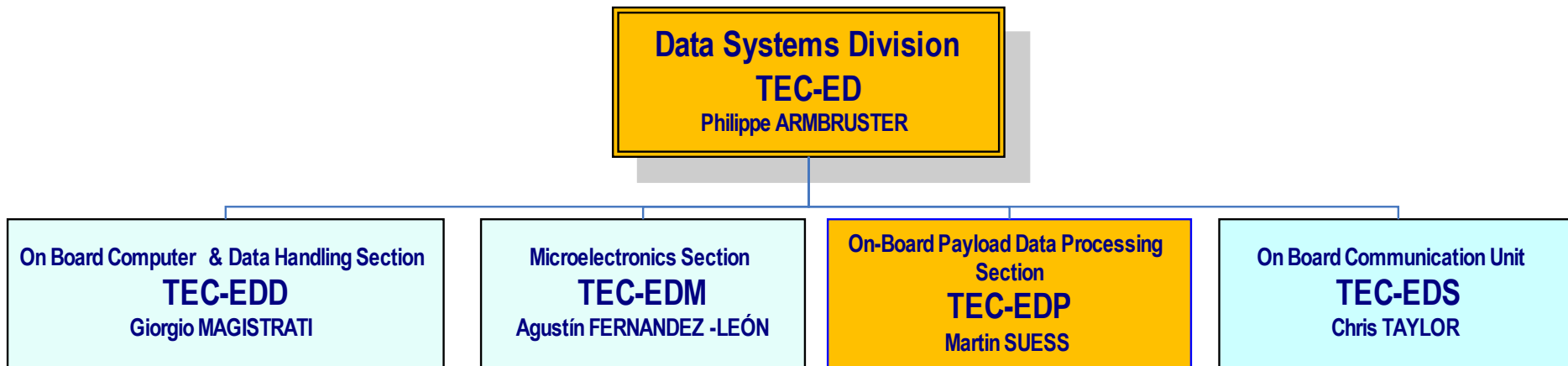
AT7913E

J. Ilstad

Onboard Payload Data Processing section (TEC-EDP)

ESA/ESTEC

TEC-ED: Sections and association

```
                    ┌─────────────────────────┐
                    │  Data Systems Division  │
                    │         TEC-ED          │
                    │   Philippe ARMBRUSTER   │
                    └─────────────────────────┘
```

On Board Computer & Data Handling Section **TEC-EDD** Giorgio MAGISTRATI	Microelectronics Section **TEC-EDM** Agustín FERNANDEZ -LEÓN	On-Board Payload Data Processing Section **TEC-EDP** Martin SUESS	On Board Communication Unit **TEC-EDS** Chris TAYLOR

Responsibilities:
Technical Officer SpW-RTC Development
Support to payload processing developments
Project support to ongoing missions
SpaceWire Components Support

Overview

- **Introduction**

- **ESA Strategy for Payload Developments**

- **SpW-RTC Description**

- **SpW-RTC and Onboard Data Handling**
  - **Application Areas**

- **Performances**

- **SpW-RTC Development Suites**

- **Usage in Missions**

- **Status and Availability**

European Space Agency

ESA strategy for payload developments

- Development of **Application Specific Standard Products** (ASSP)
  - Devices capable of answering most onboard computing needs for the coming decade.

- Adopt upcoming ASIC developments to use **similar device architectures** based on **pre-validated ESA IP cores** for the purpose of reducing development time and recurring costs.

- Ensure SpW nodes developed by ESA to be **easily integrated** in ESA On-Board Distributed Computing and Control System.
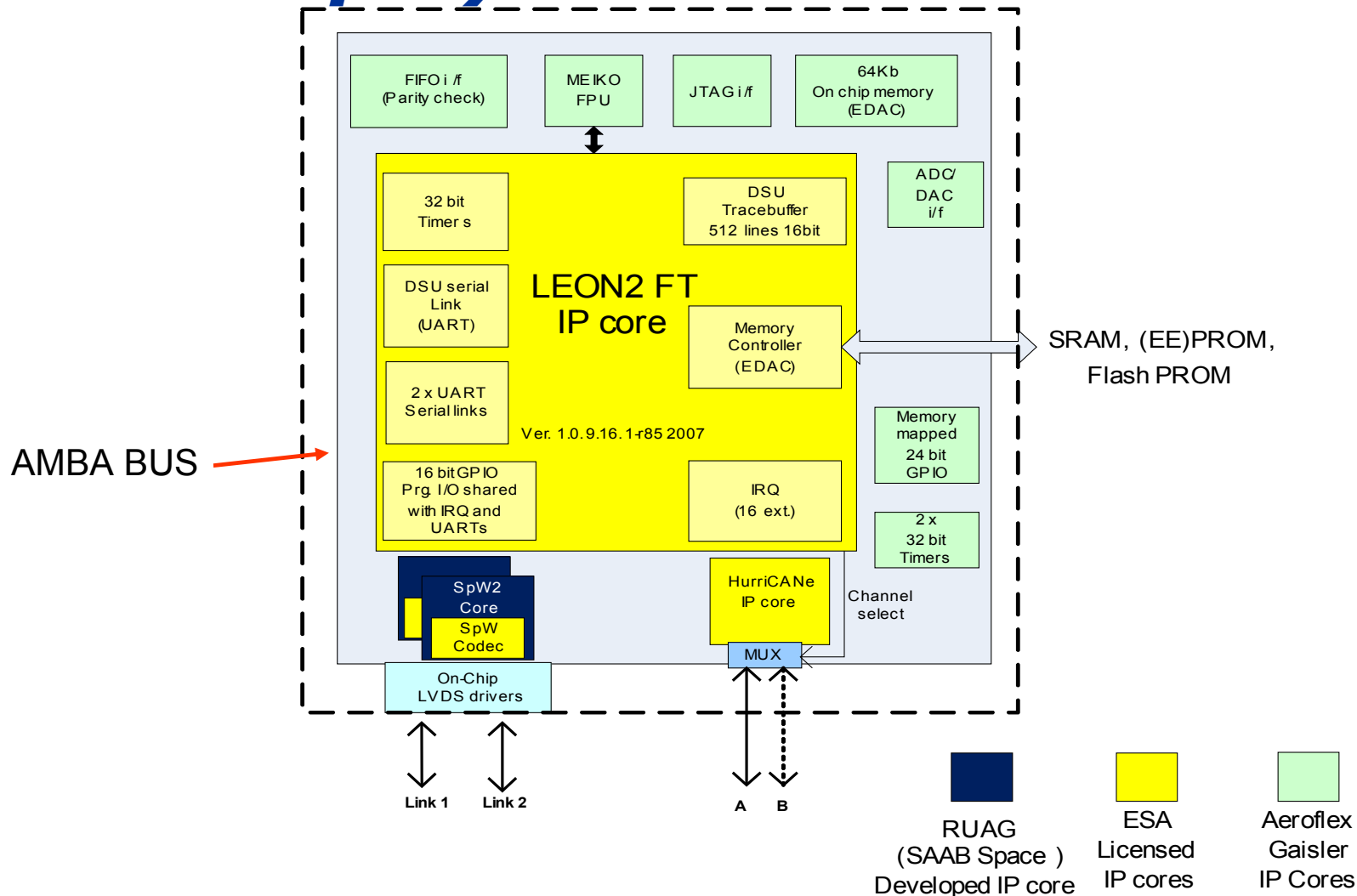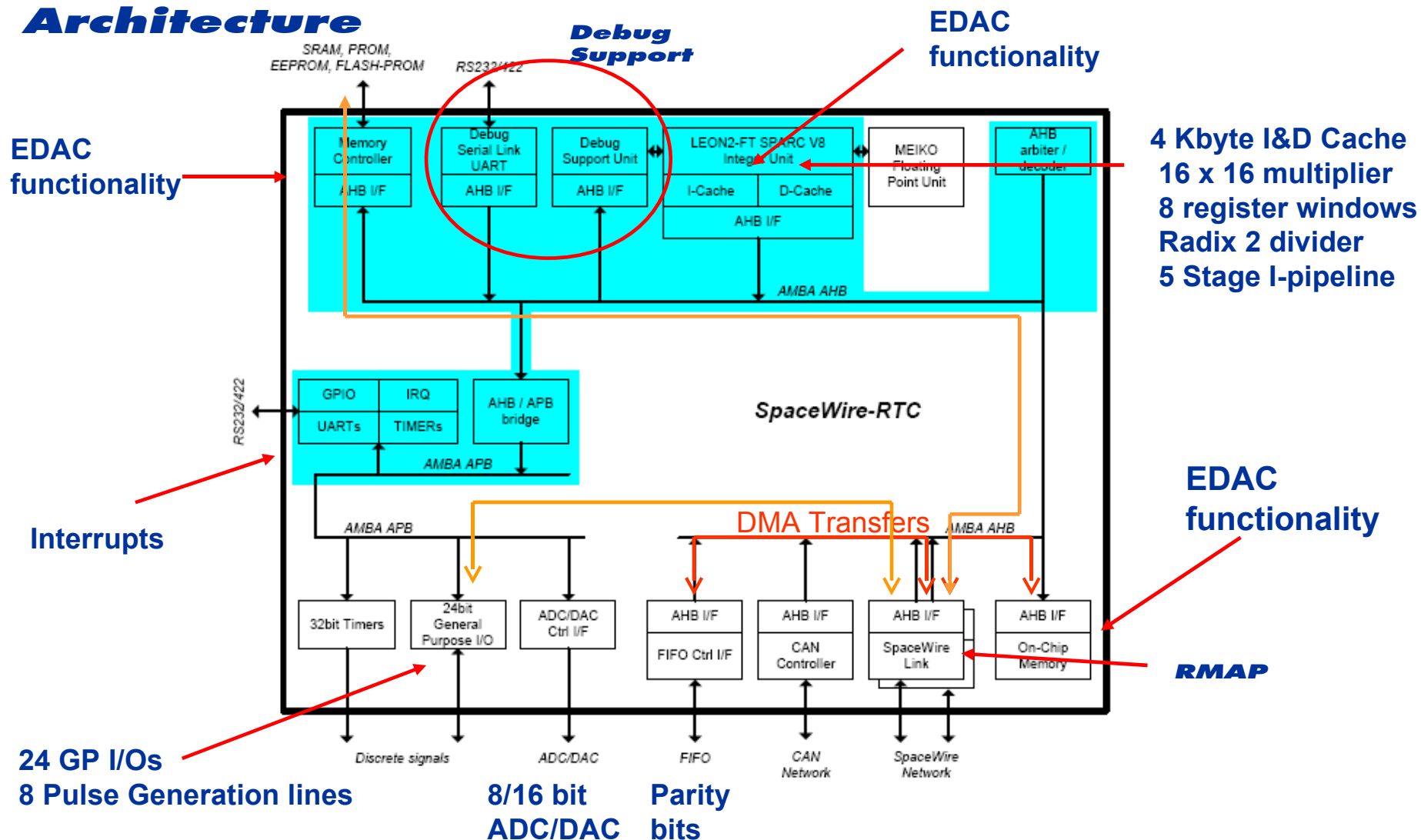
SpW-RTC Description

Device

- SpW Remote Terminal Controller contains
  - **Leon2 FT and FPU**,
  - CAN-Bus (N&R selectable)
  - 2*SpW,
  - SRAM, FIFO, ADC, DAC, UART, Parallel etc. interfaces
- SpW link speeds 200MBit/s
- System-on-Chip for compact RT implementation
- SW can be uploaded via SpW link (RMAP compatible)
- Direct Memory and IO Access via SpW RMAP
- LGA 349
- Power consumption: **~0.7W@50MHz**
- **1.8V** core, **3.3V** I/O
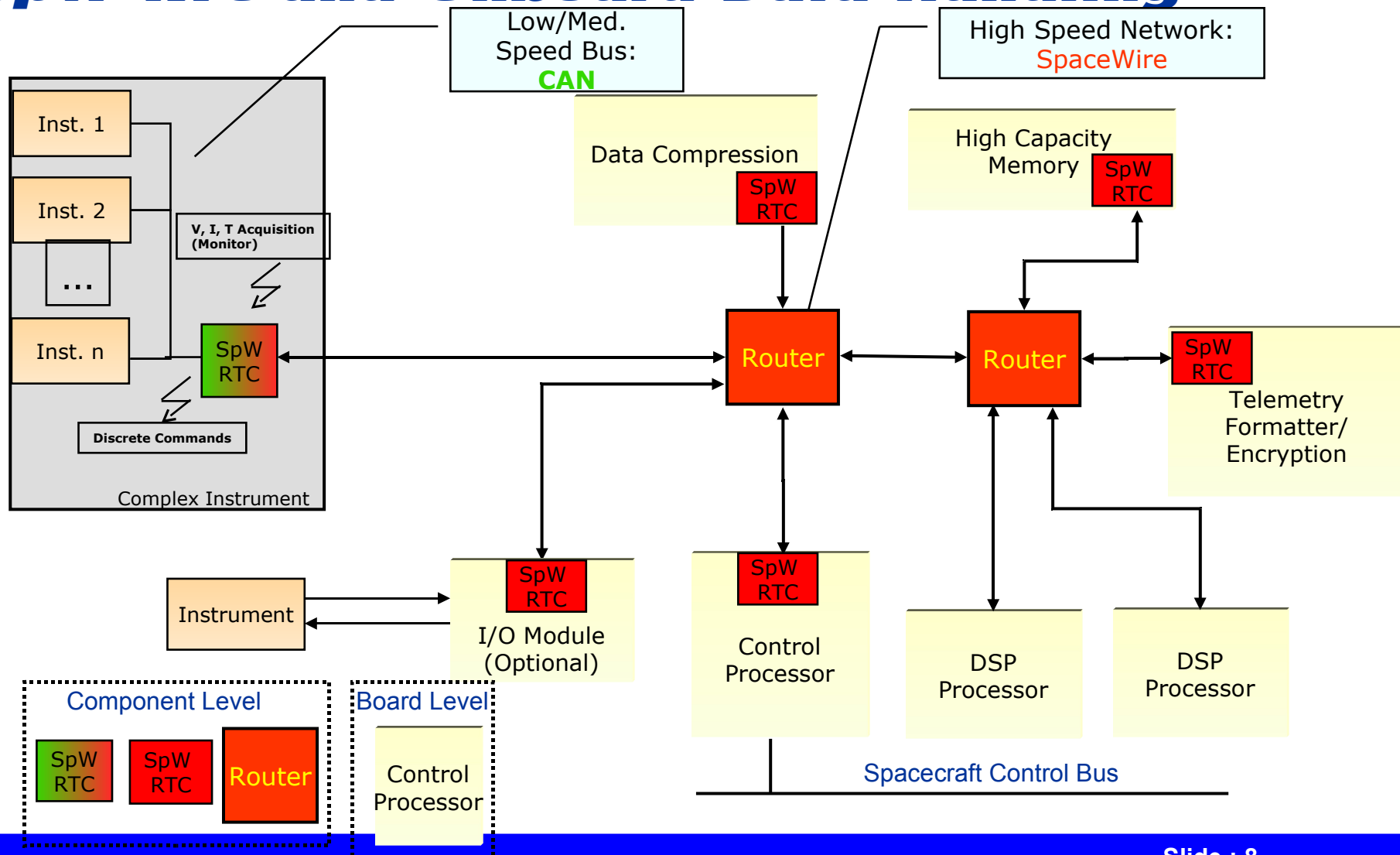- RT CMOS Technology: **ATC18RHA** (0,18 µm)

System on Chip Layout

The diagram shows the System on Chip Layout with the following components:

- FIFO i /f (Parity check)
- MEIKO FPU
- JTAG i/f
- 64Kb On chip memory (EDAC)
- ADC/DAC i/f

LEON2 FT IP core containing:
- 32 bit Timers
- DSU Tracebuffer 512 lines 16bit
- DSU serial Link (UART)
- Memory Controller (EDAC)
- 2 x UART Serial links
- Ver. 1.0.9.16.1-r85 2007
- 16 bit GPIO Prg. I/O shared with IRQ and UARTs
- IRQ (16 ext.)

- Memory mapped 24 bit GPIO
- 2 x 32 bit Timers
- SpW2 Core / SpW Codec
- HurriCANe IP core
- Channel select
- MUX
- On-Chip LVDS drivers

AMBA BUS

SRAM, (EE)PROM, Flash PROM

Link 1   Link 2   A   B

Legend:
- RUAG (SAAB Space) Developed IP core
- ESA Licensed IP cores
- Aeroflex Gaisler IP Cores

Architecture

EDAC functionality

EDAC functionality

Debug Support

EDAC functionality

**4 Kbyte I&D Cache
16 x 16 multiplier
8 register windows
Radix 2 divider
5 Stage I-pipeline**

EDAC functionality

Interrupts

DMA Transfers

RMAP

**24 GP I/Os
8 Pulse Generation lines**

8/16 bit ADC/DAC

Parity bits

SpW-RTC and Onboard Data Handling

Low/Med. Speed Bus: **CAN**

High Speed Network: SpaceWire

Complex Instrument
- Inst. 1
- Inst. 2
- ...
- Inst. n

V, I, T Acquisition (Monitor)

SpW RTC

Discrete Commands

Data Compression — SpW RTC

High Capacity Memory — SpW RTC

Router ↔ Router

Telemetry Formatter/ Encryption — SpW RTC

Instrument

I/O Module (Optional) — SpW RTC

Control Processor — SpW RTC

DSP Processor

DSP Processor

Component Level: SpW RTC | SpW RTC | Router

Board Level: Control Processor

Spacecraft Control Bus

Performances; CPU

The SpW-RTC ASIC processor performance (@ 50MHz)

- Dhrystone 2.1 benchmark
  - 34,4 MIPS

- Stanford benchmark
  - 91 integer composite
  - 138 float composite

- GNC benchmark

  (68,6 million instructions,16.6% prosent FP instructions):
  - 2,4 MFLOPS

Performances; Application Example

- Description of application:
  - executes **Dhrystone benchmark** via of chip SRAM
  - data transfers from **on-chip memory via loop backed SpaceWire links** (full duplex)
  - data transfers from **on-chip memory to external FIFO and back again**
  - 12bit value to **DAC and read back via ADC** interface
  - **GPIO pulse generation**
  - **CAN bus traffic** to external test equipment

Performances; Application Example

GPIO Pulse generation:
784 per second

FIFO throughput:
295 Mbit/s, 1,35 clock per byte

DAC/ADC conversions:
784 per second

Dhrystone Benchmark:
27.9 MIPS
(compared to 34,4 MIPS)

ASIC Power Consumption:
342mW (1.8V Core)
230mW (3.3V I/O)

11.44 mW/MHz

CAN communication:
208 kbit/sec

SpaceWire loopback:
587 Mbit/s (full duplex)

SpW-RTC Development Suites

Aeroflex Gaisler Products

Hardware

- ASIC Development board with housing and power supply
  - SpW-RTC prototype ASIC
  - RTEMS drivers for SpaceWire, CAN and FIFO
  - GRMON debug monitor

Software

- Bare-C compilation system (BCC)

- RTEMS – drivers and BSP

- Wind River VxWorks – drivers and BSP (sold separately)

Additional Tools

- GRESB – Ethernet SpaceWire bridge w. IP tunnel

- GRMON – debug monitor (debugging over RMAP)

- TSIM2 – instruction simulator with SpW-RTC loadable module

European General Purpose Microprocessors

SpW-RTC Development Suites

 Aerospace

 Microelectronics

CAEN Aerospace / Aurelia Microelettronica Products

Hardware

- **A1493A** PCI-SpW/CAN
- **A1494** RTC Test-Bed
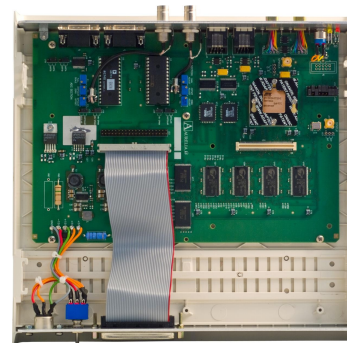
Software

- Linux based GUI control application.
- Uses SpaceWire RMAP to control, program and debug the SpW-RTC chip.

Tools

- Compatible with GRMON tool which can be obtained from Aeroflex Gaisler

Usage in Missions

- Implemented in Bepi Colombo instrument
  - MERMAG
    - Magnetometer
  - SIMBO-SYS
    - Spectrometer and Imag... ...grated package
- Solar Orbiter
  - Base lined for several instruments to form a common payload interface.
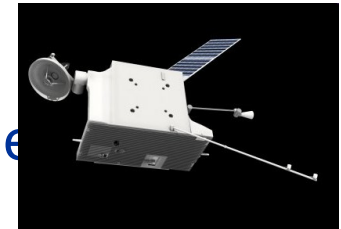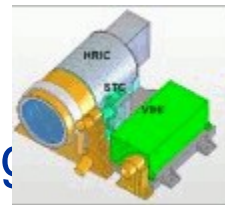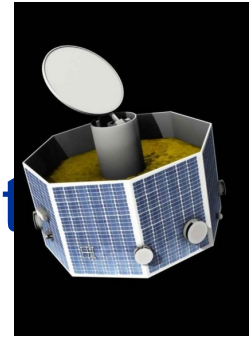
Status and Availability

- Prototypes available W7 2009 (**done**)

- Prototype approval foreseen W12 2009 (**done**)

- AT7913E Atmel Standard Product (Q4 2009)

- Availability: EMs (early Q1 2010), FMs (Q3 2010)