Next generation processors for space
ESA round table

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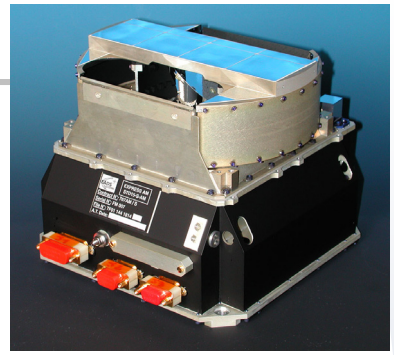
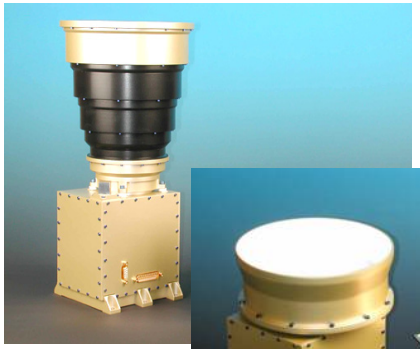
Agenda

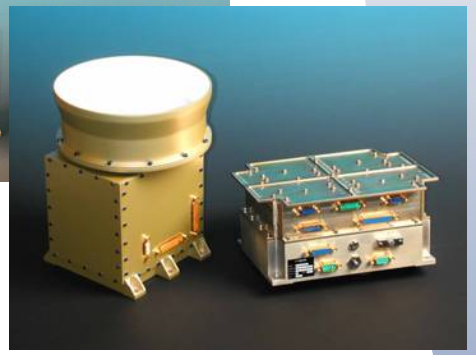
- Brief history of processors used at Sodern
- On going developments
- AT697E evaluation
- Requirement review for a next generation

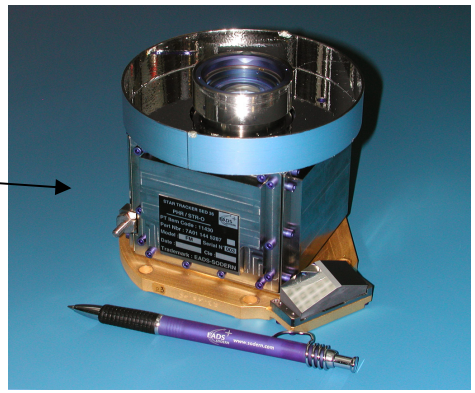
Status

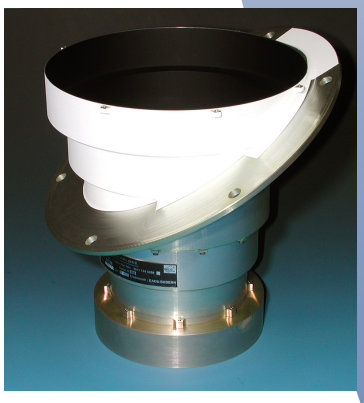
- **Brief history :**
- **Different processors used by Sodern for space equipments**
  - 80C32 (MHS) → STD15 earth sensor
  - F9450 (Fairchild) → for SED12 star tracker processing box for Helios II (software only)
  - RTX2010 (Harris) → STS02 earth sensor
  - Sparc Flame (Thalès / Honeywell) → SED16 star tracker and ATV videometer
  - Sparc TSC695F (Atmel) → SED26/36





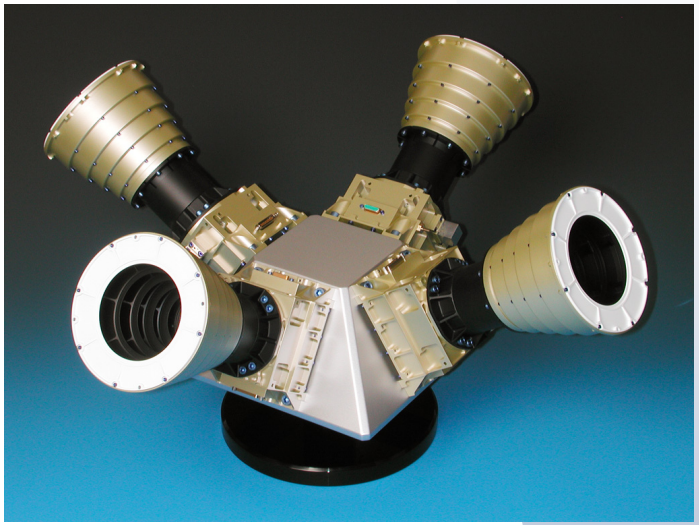


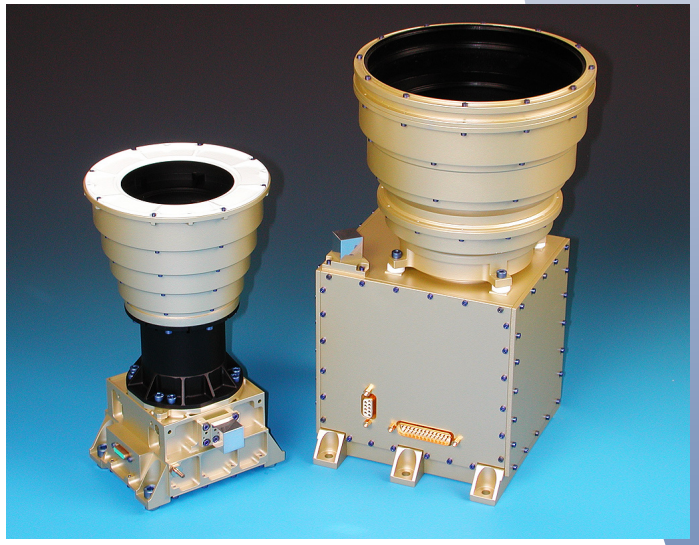




Status

- **On going developments**
  - Hydra star sensor system
  - Multiple optical heads and one (or two if redundant) processing unit
  - Processing unit will be based on the AT697F processor
    - 48MHz is the target frequency, higher frequencies are considered for other missions
    - 32Mbit SRAM + 16Mbit EEPROM
    - 3 SpaceWire Links
    - 1553 or AS16 AOCS link
  - The processing unit shall command and control the different optical heads and perform full attitude computations (pattern recognition, Quest, filtering, FDIR, …) and deliver output quaternions at 30Hz.





Results of AT697E evaluation

- **Tests on the Atmel Eval board**
- **On dedicated algorithms for determining the angular rate and attitude of a spacecraft**
- **The following points have been noticed**
  - Cache is mandatory to achieve higher performances than TSC695F (at the same frequency, with no cache, TSC695F is slightly faster than the AT697E) → cache usage has to be accepted among the software community
  - 8 bits boot capability is foreseen for our application : has been tested without EDAC but not tested with EDAC yet due to a limitation on our eval board
  - Average PCI performances (throughput) are OK for our application (PCICLK=24MHz). Latency still have to be evaluated (due to the PCI-AMBA bridge)
  - Most of the Leon2 registers are not reset to a defined state → must be initialized by the boot code
  - Sometimes, connection to DSU fails on our board. But DSU is a great improvement compared to TSC695
  - GRMON is the only software to enable use of DSU and integration in a high level IDE like Eclipse → works OK
  - RTEMS 4.6 runs flawlessly since few month (compiler and kernel)
  - On the wish-list : cache locking in order to achieve higher RT latency performances

Requirements for next generation

- **Driving application**
  - Attitude sensor (mostly star trackers)
    - Higher operating frequencies for attitude sensors
    - Higher robustness towards environments like high proton flux which generate a high number of false objects
    - Higher accuracy while embedding stronger corrections/filters
  - Any instrument that requires computing power
- **Requirement specific to space applications**
  - TID is not really an issue (300kRad for the AT697)
  - SEU, SEL : should be usable for LEO, GEO or planet exploration with some very harsh environments
  - Ability to fit different QA level from low cost LEO satellites to full QMLV
- **Processor architecture**
  - No precise requirement : the availability of support tools is the main criterion for us rather than a specific architecture. FPU is mandatory and a faster one than the Meiko could be helpful.
  - Integrated peripherals : why not including standard interfaces promoted by ESA (1553, SpW, CAN, …). It seems that different companies are developing their own SoC with more or less the same peripherals.

Requirements for next generation

- **SW development related needs**
  - Compilers maintenance is a big issue for older products (SUN Pro compiler used for Sparc flame for instance)
    - SUN Workstations are becoming obsolete
    - Compiler is proprietary → when not supported anymore, impossible to switch license token from one workstation to another
    - GNU C compiler are greatly appreciated for being much more platform independent, even if generated code may not be fully optimized (considered sufficient until now)
  - Operating System
    - RTEMS support is preferred since many investments have been done on this product (training)
  - Debugging tools
    - GDB based debugger is OK
  - Simulator
    - ISS is not widely used at Sodern. Usage is reserved for some timing measurements or software breadboarding
    - Test on target is preferred rather than using an ISS (unit testing possible on LEON with RT-RT)

Requirements for next generation

- **Performance target**
  - For star tracker (with multiple heads) LEON seem today sufficient with a rough margin factor of 2 (nominal operating frequency should be 48MHz)
  - For another instrument in development, LEON at 100MHz is considered as a minimum. FPU performance is the main limiting factor but not only.
- **Availability as a standard ASIC**
  - Yes. If standard, the processor can be widely used and get a strong heritage → validation
  - But should stay affordable !
- **Availability as an IP core**
  - Given the complexity of validation of such a device, hard IP is the preferred solution for targeting an ASIC (or even FPGA… if economically interesting).
  - In the case of LEON2, direct access to AMBA bus would enable higher performances
  - Soft core is useful for prototyping on FPGA

Requirements for next generation

- **SW compatibility with previous generation**
  - Is not a strict requirement (we always have to re-write low level software)
  - Is preferable because of the amount of know-how capitalized on the Sparc architecture
- **Price !**
  - AT697 is quite expensive !

Conclusion

- **In short, the processor that could ease future developments :**
  - Should have at least the same features than the AT697
    - 8 bit boot with EDAC protection
    - DSU / trace buffer
    - ...
  - and
    - Faster FPU
    - Cache locking
    - Protected DRAM (not presently used by Sodern)
    - Standard integrated peripherals (1553, CAN, SpW, …)
    - Dual boot management
    - Higher frequency