Component Technology Needs for AOCS / GNC Sensors

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Technology Needs For AOCS/GNC Sensors

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Purpose and Scope

- Purpose
  - To highlight the key EEE component issues affecting AOCS hardware suppliers and development
  - To draw attention to the difficulties caused by EEE components
  - To hope to encourage more European space component development, qualification and long term supply security
  - To hope to encourage an increase in the number of parts on the EPPL
- Scope
  - Generalisations made across units and manufacturers
  - Presentation mainly from an industrial equipment providers point of view
  - Only common issues reported – not specific issues for 1 product (although examples are given)
  - Only main issues reported - numerous minor issues are not discussed
  - Only AOCS equipments are discussed
    - Mainly: STR, Gyro, IMU, Reaction wheels
    - Also: New miniature sensors, accelerometers, MTM

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Introduction

- Background
  - EEE components are the key cost driver (typically 30 to 50% of the equipment price) and schedule driver for many AOCS equipments.
  - Rapidly changing ITAR rules and component obsolescence issues are the primary cause of NRE and re-design activities (after customer custom interface requests) and cause continuous investment need to maintain a product
  - The range of EEE components available as fully qualified products for space use is shrinking which limits equipment design.
  - Defending and justifying the use of EEE components not on the EPPL is now almost universal for every product and project and is expensive and time consuming.

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ITAR Issues

- Impacts
  - Reduced market potential
    - 30 - 40 % of European AOCS hardware sales need to be ITAR free. It is these sales that maintain the ability of European industry to be profitable. Without them we would certainly lose EU competence and capability. EU industry needs ITAR free parts to survive!
    - US components are all at risk of being made ITAR restricted (see Intersil)
    - Often major design impacts to remove ITAR parts due to no alternatives
  - Increased lead time and schedule risk
    - Delivery schedule risk is increased (especially when ITAR rules change): desired signature to delivery times for equipments are reducing though
    - Can get prolonged additional delays, especially for launches in India and Russia
  - Increase procurement cost and overhead.
    - Increase ITAR paperwork and schedule chasing adds further cost, typically between 4K and 6K Euro per part type!!
  - Less flexibility to move unit around (e.g. for testing)

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Main ITAR parts concerns 1

- Mosfets (all equipments)
  - NMOSFET & PMOSFET (e.g. from International Rectifier)
  - Often no alternatives, EU versions (from STM) in development but still not available
- PROMs (mainly STR, navigation cameras and RDV sensors)
  - Typically Aeroflex or Intersil parts
  - 32K * 8bit, 3.3V most needed (STRs mainly)
  - Very small capacities also useful (<8k*8bit – cal parameter storage)
  - No alternatives (see UT28F256LVQLE or HS-6664RH as example)
- 1553 RT and Transceivers (STR, wheels and gyros)
  - E.g. alternative to Aeroflex 3.3V transceiver or DDC 'all in one' soln.
- DC-DC convertors (most AOCS equipments)
  - No European convertors suitable for small and low power applications (e.g. <5W, < 10*10*10cm units).

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Main ITAR parts concerns 2

- Multiplexers
  - Multiplexers (8 input and 16 input, high-Z on power off)
    - Used in gyros and also many other equipments for HK TM capture
    - e.g. Intersil HS1840
- FPGA (many equipments)
  - No alternatives for US high performance/ high gate count components from Actel
    - Difficulties with Atmel MH1RT ASICs make this more acute
    - See later slides

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Examples of issues with ITAR

- Example 1:
  - During MAIT (between procurement and delivery of the component) a 1553 transceiver became ITAR restricted resulting in 4 month delay and >200KEuro additional costs to adapt the design for a different part.
- Example 2:
  - Between PDR and CDR of an equipment, the TEC (Thermo-Electric Cooler) and 1553 RT became ITAR restricted. These issues resulted in the need for a new custom ASIC and were the major contributor to a 2 year delay.

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Obsolescence, Single Source, Qualification and Long Lead Issues

- Commercial electronics developments moving at ever increasing rates and diverging away from typical space procurement and testing requirements. At the same time the commercial world market volume is huge and consolidations in the component manufacturing industry leads to fewer suppliers.
- Commercial component life cycles are very short whereas space development for the equipments using them can be very long (typically >5 years) and product life even longer >15years
  - → Perceived little interest from manufacturers in space
  - → Higher and faster rates of obsolescence, fewer options, fewer suppliers
- Obsolescence and excessive (often unexpected) long lead times lead to constant redesign and NRE
- Move to mixed signal ASICs is also bringing lower availability for relatively simple parts (e.g. multiplexers, DACs etc)

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Obsolescence: the key concerns

- There are a number of key common concerns regarding Obsolescence and single source or obsolescence risk. They are almost universal amongst all AOCS hardware:
  - MH1RT ASIC technology from Atmel (major issue for STR & Gyros)
    - 0.35um no longer supported
    - Increasing cost, lead time and yield issues at Atmel
    - Alternatives currently have high batch qualification costs
  - EEPROM (& PROM) (e.g. 58C1001)
    - Single source for dies
    - Old die, virtually single source, probably not available much longer (RENESAS)
    - Some equipments only need very small EEPROM (a few kbits! 4K *8bit), others need a large EEPROM (512K *16bit)
    - (Note Atmel provide an EEPROM 1Mb (AT28C010 - 4Mb in development) for FPGA support but long term availability is currentl too uncertain).
  - Sample and holds
    - Commercial and military use fallen dramatically
    - Availability difficult and package sizes are large
    - NSC and Intersil seem to be living off stock wafers and are US

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Obsolesence: Example

- One manufacturer asked to supply same equipment for two spacecraft, the first in 2001 and the second in 2006. Five key parts went obsolete in this intervening period including FPGA, Buffers, SRAM, ADC and an OpAmp. The impact resulted in VHDL code change, significant circuit and PCB layout changes and all associated re-verification, re-analyses and re-qualification leading to a 1 year additional delay and had a major cost impact.

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Long Lead Issues: The key concern

- A number of components and component types suffer from excessive lead times. The dominating component that seem to continually cause problems with respect to this and for all units are diodes:
  - Power Diodes (e.g. IN5811, 6626, 5822…)
  - Zener Diodes (Mostly in 5 to 10V range but also up to 70V, e.g. IN5622, 4622)
  - Small Signal Diodes (e.g. IN6642)
  - Microsemi are most used, IR are more expensive, still US and some are ITAR.
- Examples:
  - Microsemi diodes, quoted lead time 48 weeks but regularly taking up to 68 weeks to deliver!
    - This is incompatible with most delivery schedules for equipments.

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Component developments needed for future equipment development and competitivity.

- Component developments are needed in the future for:
  - Miniaturisation
    - Package types etc
  - Increased functionality and flexibility
    - Microcontrollers, FPGAs, IP cores
  - Improved performance
    - ADCs
    - DACs
    - Active Pixel Sensors
    - RAM

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Component developments needed for future equipment development and competitivity: Miniaturisation

- Qualification of small SMD passives packages (e.g. 0603 and 0402 format capacitors and resistors)
  - Needed for miniaturisation
- SMD packaged crystals and/or cheaper SMD oscillators (especially 10, 20, 48 and 80MHz, 3.3V)
  - Current components have typically have very large footprint (and often through hole pin style – especially crystals)
  - Current oscillators can be very expensive (up to 2KEuro/piece)
  - These are especially needed for miniaturised and lower cost units

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Component developments needed for future equipment development and competitivity: Increased functionality

- European ITAR free rad hard FPGAs
  - Needed for future STR, navigation camera, RDV/Docking sensors
  - Real alternatives for RTAX2000, RTAX4000
  - Requirements:
    - Integrated rad hard RAM (the more the better!)
    - 250K to >500K gates
    - > Qualified associated IP core library (DSP, Processor, PLL, 1553 RT etc)
    - Rad hardness similar to rad hard ASICs (Hard flip flops, harden clock trees, etc.)
    - Antifuse preferred (even though new dev plans are all SRAM-based)
- RAM
  - Obsolescence risk due to rapidly moving commercial market
  - Compatibility issues (timing) with respect to space qualified FPGAs for DRAM
  - Component footprint vs memory size far too big
  - Need >=512K * 32bit and 16bit, 20ns access time, low upset rate, single chip
  - Examples: UT9Q512E, AT60142H/HT

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Component developments needed for future equipment development and competitivity: Increased functionality

- Space qualified Microcontrollers
  - Useful for increasing functionality in small reaction wheels and enabling cost effective miniaturisation of gyros, IMUs and MTMs
  - Example potential requirements:
    - Core requirements (TBC):
      - 16bit micro controller, 8-16MIPS, Integrated RAM (256kbyte), Integrated NVM (16kbyte)
      - Integrated serial data bus drivers – preferably RS-422, CAN and SpW
      - EDAC, Watchdog
      - Low Power
    - Optional peripherals
      - Integrated ADC + DAC, 12 bit 96ksps
      - Clock generators, POR, PWM
      - Optional 1553 RT

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Component developments needed for future equipment development and competitivity: Increased performances

- ADCs
  - Needed mainly for IMUs and gyros, must be ITAR free
  - Requirements:
    - 12 bit, 16bit and 18bit versions
    - 10 – 20 Msps, low power, <1LSB INL
    - Also IP core versions would be useful for some applications
- DACs
  - No EU options for 16bit (and higher) resolution
- Active Pixel Sensors
  - Currently world leaders but technology moving fast due to consumer market
  - Need to have best sensors in world to maintain STR, Navigation camera and RDV sensor market.
  - Stable, dependable long term supply guarantees

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Contributors

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  - Rockwell Collins (RW)
  - SEA (Gyro, accelerometers + electronic units)
  - Selex Galileo (STR, ES, Miniaturised units)
  - Terma (STR)
  - ESA TEC-EXX and TEC-QXX (various people)

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Final Thought

- Component issues can sometimes be solved by system design/ specification changes – not just new components
  - E.g. Issues with 1553 EEE components could be solved by using other interfaces
  - E.g. Issues with DC-DC convertors (and some mosfets and diodes) could be solved or eased with different power supply architectures.
  - E.g. Issues with radiation hard RAM may be solved with larger amounts of softer RAM

- These system solutions may not always be practical or attractive but system engineers need to consider parts issues when designing and writing specifications.