October 17, 2011

Dear Madam, Sir

Our company RUAG Space AB in Gothenburg, Sweden , develops digital & microwave electronics and antennas for satellite and launcher programs. For science missions, we deliver C&DH and payload computers and S/X/Ka-band antennas. For the requested NASA program, maybe our new Instrument Control Unit with processing/IO functions and DC/DC could be of interest to lower the costs. It can be adapted to "any" instrument with built in FPGA and flexible number of IOs.

If the mission is of interest for Sweden, we could apply for funding from the Swedish National Space Board to adapt our unit for this NASA mission.

We participate in most ESA missions, telecommunication programs around the world, and missions like LCROSS, LDCM, SMAP and JWST.

Please find attached two different documents on ICU (short form) and a more detailed C&DH and ICU description (only first pages to comply with length requirement). Should there be an interest in these products, or antennas, please let me know and we can provide more detailed information.

Sincerely,

Hans Fritz

Director, Marketing and Sales
Advanced Programs

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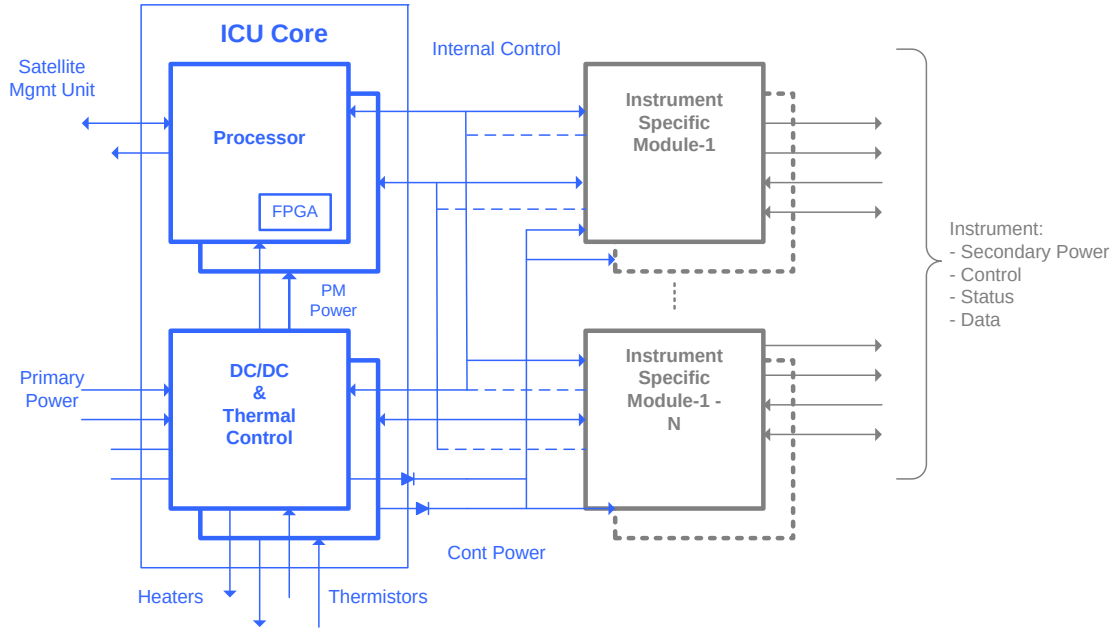
Generic ICU Concept

RUAG Space AB has long experience in the field of radiation tolerant Instrument Control Units (ICUs) for space applications. Our heritage dates back to Meris and Gomos ICUs on ENVISAT. In order to be able to deliver a competitive ICU in terms of price and performance a Generic ICU concept has been developed. The concept includes a Core part with a processor and a thermal control module. The Generic ICU is available either as a complete unit, with or without application software, or as ICU building blocks allowing a specific ICU to be created by the instrument developer.



Instrument Control Unit Building Blocks

The Generic ICU includes the following building blocks:

- Processor board based on the radiation hard COLE ASIC developed by RUAG Space AB. The COLE includes a Leon SPARC processor and a number of standard interfaces. The board has an FPGA for implementation of additional interfaces, logic functions and signal processing functions.
- Thermal Control board with interface for acquisition of temperatures via thermistors and heater drivers for switching of heaters. A DC/DC converter supplying the ICU core also included.
- Boot, Hardware Driver Software package for interfaces and Packet Utilisation Software Library.
- Cole Tools for software development and debugging.

Processor Board

Key characteristics:

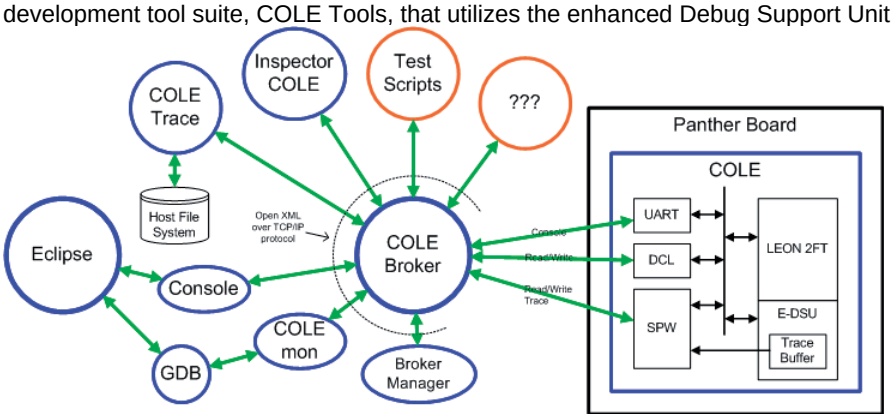
The processor is a SPARC® Version 8 processor, Leon-2 FT, especially designed for critical space applications. A high-performance built-in IEEE-754 floating-point unit is included. At 80 MHz the performance is about 57 MIPS and 22 MFLOPS. A dedicated Enhanced Debug Support Unit (E-DSU) is provided to be able to put the processor in debug mode, allowing access to all processor registers and cache memories. The E-DSU also contains a trace buffer which stores executed transfers on the COLE internal bus. The board has: 512 MByte SDRAM / 64kByte PROM / 4 MByte EEPROM. Additional interfaces and logic functions can be added in an RTAX2000S FPGA, which is connected to the processor via a bus.

Interfaces:

- Two dual-redundant MIL-STD-1553B buses with Bus Controller and Bus Monitor capabilities. One of the buses can act as a Remote Terminal.
- Two Controller Area Network (CAN) buses, which can be used in a redundant bus system.
- Up to eight SpaceWire (ECSS-E-50-12A) point-to-point links with LVDS interfaces, providing high-speed serial connections at up to 200 Mbps.
- Three high speed UART interfaces with transfer rates from 150 baud to 1.2 Mbaud
- One MIL-STD-1553B Bus Controller or OBDH Central Terminal with digital interfaces, available via the backplane connector.
- Twelve general-purpose inputs or outputs, indented for interrupt or status inputs/outputs.
- Additonal standard (IP blocks available) and specific interfaces via the PM FPGA. The FPGA has 36 LVDS/SDI Outputs and 8 LVDS/SDI inputs in external connectors. 100 I/O pins are connected to the backplane for ICU internal functions.

Software Development Environment – Cole Tools

The GNU cross compiler (GCC) suite can be used for development in C and C++ for the COLE target. Support for the RTEMS operating system is available in terms of a COLE BSP. A host platform independent COLE specific development tool suite, COLE Tools, that utilizes the enhanced Debug Support Unit is available.



The core of the COLE Tools is the COLE Broker, which allows multiple clients, connected via TCP/IP sockets, to share the same links (SpaceWire and UARTs) towards COLE.
Together with the clients the following functions are available:

- Eclipse together with GDB, COLEmon and Console provide possibilities to perform source level debugging. Star/stop executions, set breakpoints.
- With Cole Trace it is possible to dump filtered trace of the software execution in real time. The trace can be filtered on different types of instructions being executed.
- With Inspector COLE it is possible to view and modify internal COLE registers and memory. It is also possible to identify which bit that was last updated and when.

DC/DC and Thermal Control Board

Key characteristics:

The thermal control board has thermistor and heater drivers that can perform a thermal control loop by a PWM implemented in the processor FPGA and the regulation loop implemented in software. In order to minimize EMC disturbance the PWM performs the switching of the heater in a scheme that minimizes simultaneous switching of the heaters and with a controlled slope. The heaters are supplied directly from a dedicated power bus without any additional regulation. The thermal control board also includes the DC/DC converter supplying the Core part.

Interfaces:

- Thermistors: 30
- Heater channels: 30
- Primary Power 28 & 50 V Bus

Instrument Specific Boards

The instrument specific boards will be developed for the specific ICU application and is not part of the generic ICU core. Typically these boards can control CCD arrays and will in such cases include FPGAs for control and data processing. In some applications the instrument itself will do the data processing and the ICU interface the instrument with e.g. SpaceWire links. Heritage exists also on these parts and design blocks can be provided depending on the needs.

For use in instrument specific boards or instrument modules an Instrument DC/DC converter has been developed. This building block gives a reliable and radiation tolerant interface to a spacecraft power bus.

Instrument DC/DC Power Converter Module

Key characteristics:

The Instrument DC/DC converter will supply the instrument with a basic set of secondary voltages. The design allows for additional secondary regulators if lower voltages are required. The converter is able to deliver 10W secondary power. It includes overvoltage protection on all voltages and can start on command or directly when power is applied.

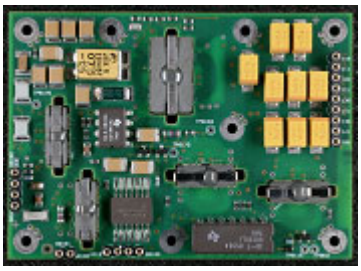
- Dimensions: 60mm x 83mm x 12.5mm
- Mass: <85g

Primary input:

- 20-55 V input voltage range with galvanic isolation between primary and secondary side

Secondary Outputs:

- 5V 2A
- 4,5V 2,2A
- 3,5V 2,9A
- 13V 50mA



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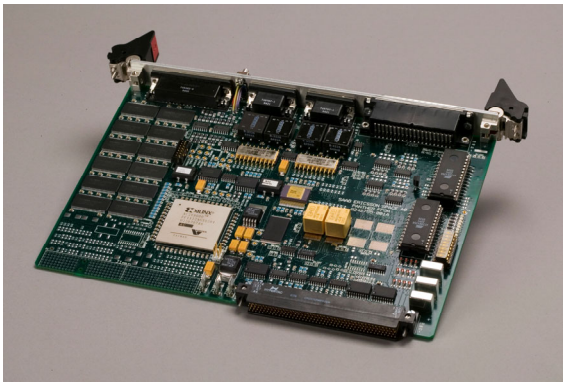
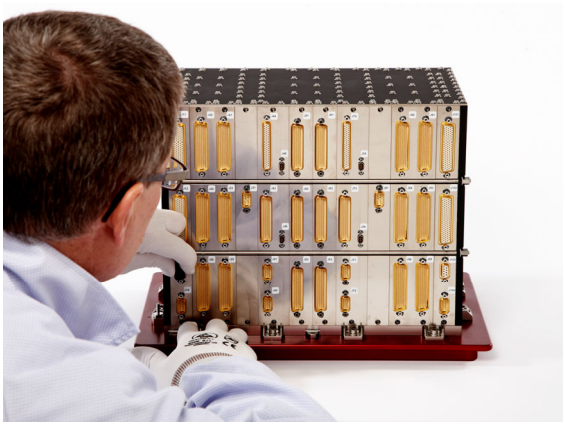
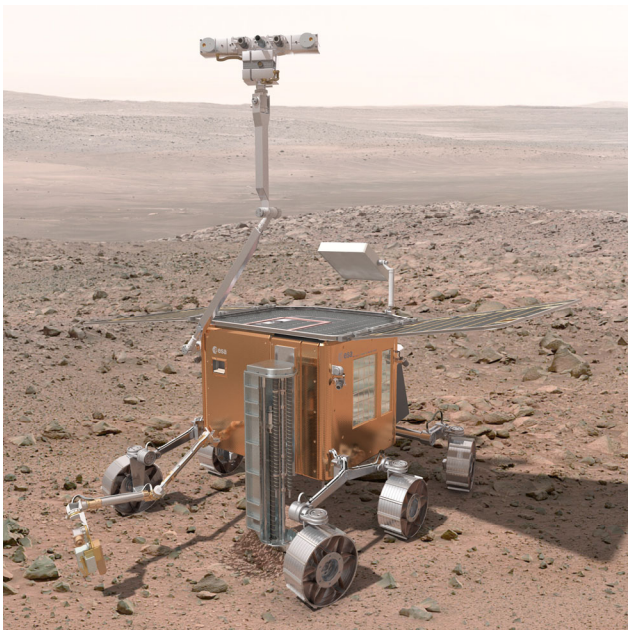
RUAG Space shows the way forward for efficient space computer system development







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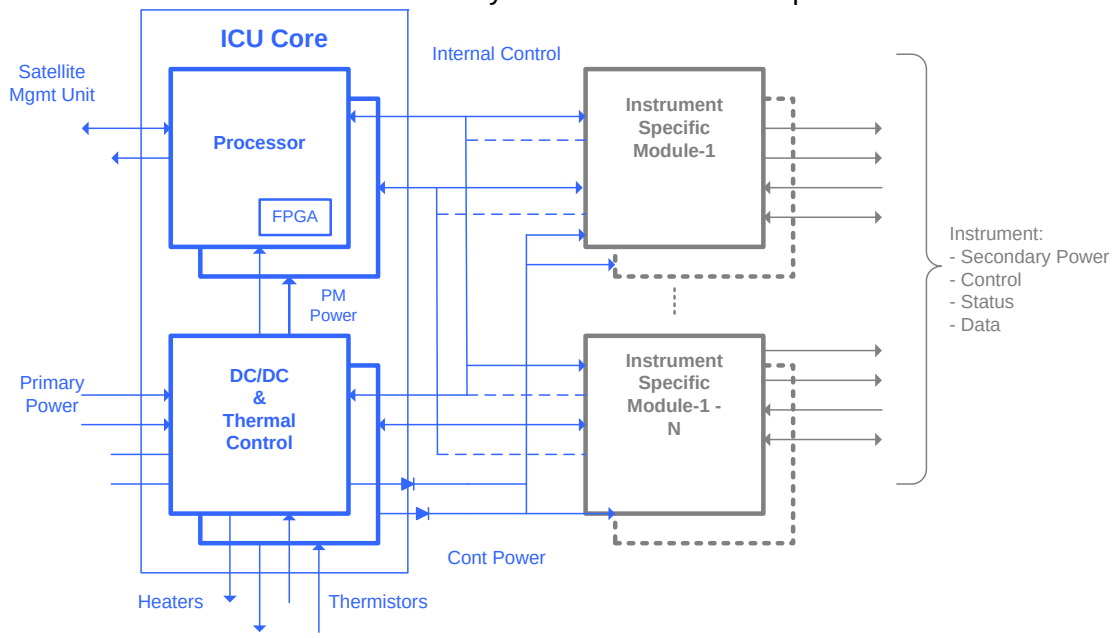

1 INTRODUCTION

RUAG Space is a major supplier of hardware and software for spacecraft command and control applications. The products range from launcher control computers via satellite control computers to instrument control computers. The latest addition to the family is the control computer for the ESA ExoMars Rover vehicle, currently in development.

The objective of this paper is to briefly describe the satellite control computers and instrument control computers and focus on the processor boards with associated software and software development tools as they can be used separately from the flight hardware in diverse applications.

2 PROCESSORS FOR COMMAND & DATA HANDLING UNITS

2.1 C&DH Unit Overview

The C&DH computer is in control of all spacecraft operations including the autonomous spacecraft Fault Detection, Isolation and Recovery (FDIR). A typical European satellite platform architecture is shown in a simplified form in Figure 1.

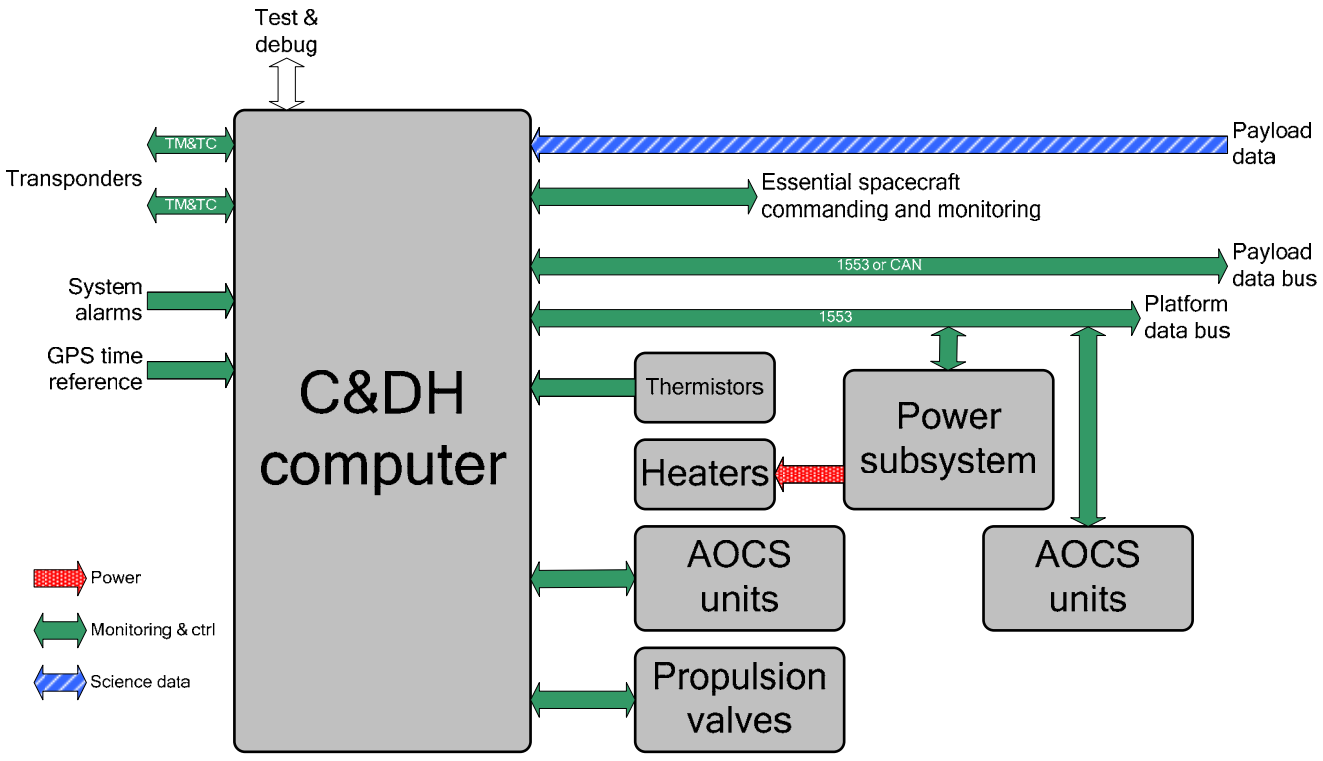

Figure 1 Typical European satellite platform architecture

The functions of the C&DH computer are:

- On-board satellite telecommand functions such as decoding, validation, authentication, decryption and distribution of commands
- On-board satellite telemetry functions including telemetry data acquisition or generation, formatting, encoding and transmission to transponders
- Maintenance and distribution of on-board time and synchronization signals
- Processing resources for application software
- On-board surveillance and reconfiguration functions including the operation control modes of the unit
- Direct control and monitoring of some AOCS units
- Communication with the payload and other platform units through direct, standard interfaces and two dual redundant MIL-STD-1553B buses
- Control and monitoring of propulsion valves
- Mass memory function for payload and housekeeping data