GRBOOT
ECSS FLIGHT QUALIFIED BOOTLOADER PORTING TO RISC-V

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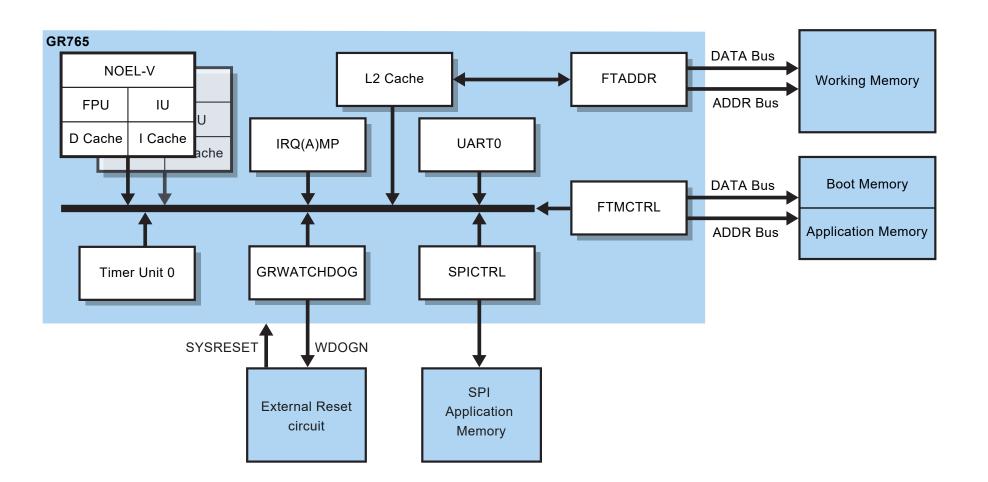daniel@gaisler.com

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Background

- GRBOOT was designed in based on the SAVOIR-GS-002 system boot specification to meet the requirements of an ECSS Category B bootloader. The STANDBY software extension point was also developed per SAVOIR-GS-002. Both GRBOOT and STANDBY are based on the boot software originally developed for the ESA JUICE mission.

- High criticality and reliability software is required for space missions where the ECSS standards ECSS-E-ST-40C and ECSS-Q-ST-80C define requirements to make software compliant to various high level system reliability and criticality requirements.

- The GRBOOT and STANDBY software have been developed for general mission use rather than for a specific mission. Consequently, the ECSS-E-ST-40C and ECSS-Q-ST-80C standard requirements have been tailored. Recommendations are provided to achieve full ECSS Category B compliance in accordance with both ECSS-E-ST-40C and ECSS-Q-ST-80C.
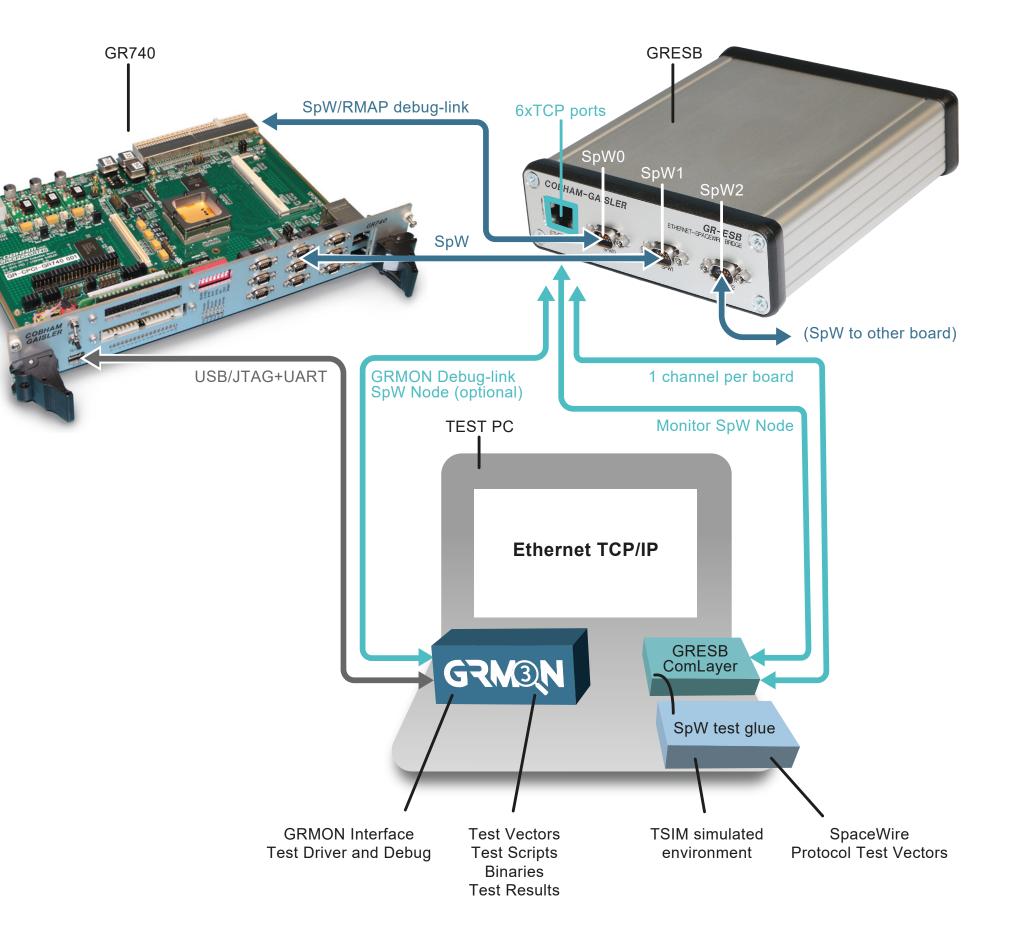
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Purpose of porting activity

- Previously the GRBOOT and STANDBY software supports the systems GR712RC, GR740 and the upcoming GR765 SoC in LEON5 mode. GRBOOT is also supported on the UT700.

- The RISC-V port of GRBOOT is being developed as part of a ESA project aiming to improve the hardware and software ecosystem for space. Porting GRBOOT to RISC-V provides a bootloader intended for space applications. Both GRBOOT and STANDBY software will be ported to support the NOEL-V processor.

- The project's objectives for GRBOOT and STANDBY include porting the existing qualified code, documentation, test systems, analyses, and reports (originally developed for the GRBOOT GR765 LEON5 port) to the GR765 NOEL-V version of GRBOOT.

- The development is carried out within the ESA actitivity RISC-V hardware and software ecosystem contract 4000143337/23/NL/CRS.
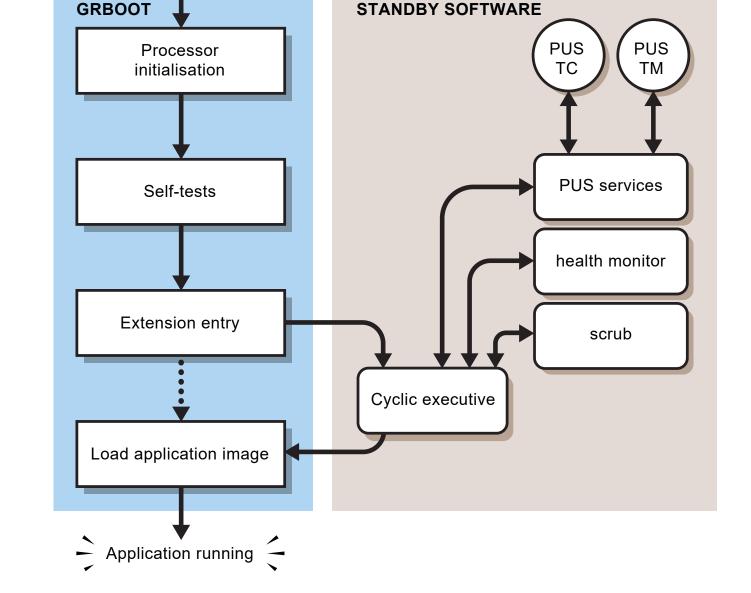

Findings and impact

- Porting of GRBOOT for GR765 LEON5 to GR765 NOEL-V allows for some flight qualified software to be reused between both configurations since the external interfaces are the same. This is particularity true for STANDBY, which is developed almost entirely in C.

- FPGA hardware platform used for testing and validation of the GRBOOT GR765 LEON5 port leveraged for the GRBOOT GR765 NOEL-V port before the ASIC is available, allowing for the same test setup to be reused and simplifying the porting effort.

- **The benefits of using GRBOOT with RISC-V/NOEL pertains to:**
  - Simpler register initialization as compared to SPARCv8/LEON.
  - Subsystem models such as UART/timer/Interrupt controller accessible within the NOEL core.
  - RISC-V provides a larger ecosystem support for different software tools and frameworks.

- GRBOOT is designed to execute at processor reset before software environments have been setup. Consequently, low level code is rewritten in assembly limiting the level of reuse.

- **The challenges of reusing GRBOOT for RISC-V processors includes:**
  - More restrictive implementation before C has been initialized compared to SPARCv8.
  - Protocol and format updates due to moving to 64-bit architecture which is little endian.
  - New hardware and less heritage is available compared to using LEON.

Boot sequence and extensibility

- GRBOOT software has been designed to execute at processor reset and perform early system initialization, self-testing of processor resources and external memories, and loading of applications from an application memory to working memory.

- Extension points are provided by GRBOOT that are executed as part of the boot process. The extension points provides a flexible way to tailor the initialization, self-testing, or application loading or a specific board configuration. In addition, GRBOOT also calls a standby extension point which is intended to support the implementation of the SAVOIR-GS-002 standby mode.

- The optional STANDBY software component to provide a software system with the capabilities described SAVOIR-GS-002 in regards to the standby mode. STANDBY supports patching of ASW images in flight, collection of error information, and general remote control of the system.