Complementary Validation for SCOC3 BSW in TEC/S Lab

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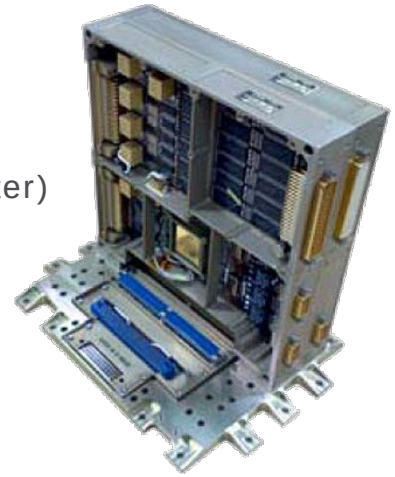
Introduction

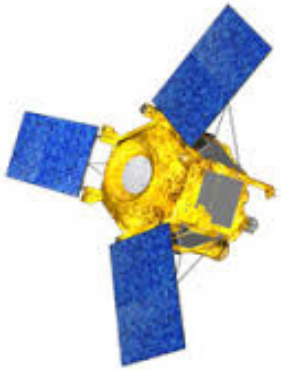
- SCOC3 ASIC in a nutshell
- Why use SCOC3 BSW
- SCOC3 BSW Development & Validation
    - Development and Validation on STARKIT
    - Complementary Validation on KERTEL
- Validation Plan & Results
- Conclusions

SCOC3 in a nutshell

- SCOC3 is an standard product, commercially available to all users:
  - http://www.scoc3.com
- Developed by Astrium with ESA and CNES funding
  - Used in OSCAR (Astrium Observation and Telecomm On-Board Computer)

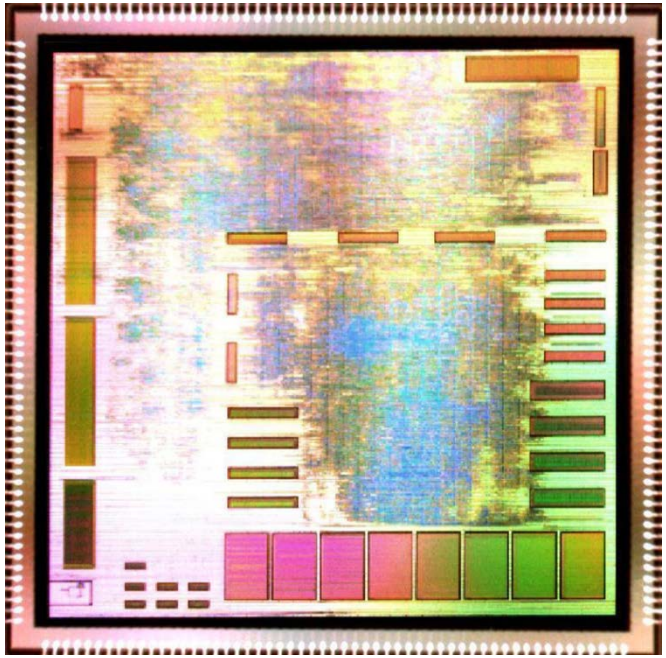


  - It is flying on board of SPOT6 since 2012/09/09
  - Since then it has been selected as flight computer for SEOSAT, SPOT7, Sentinel 5…



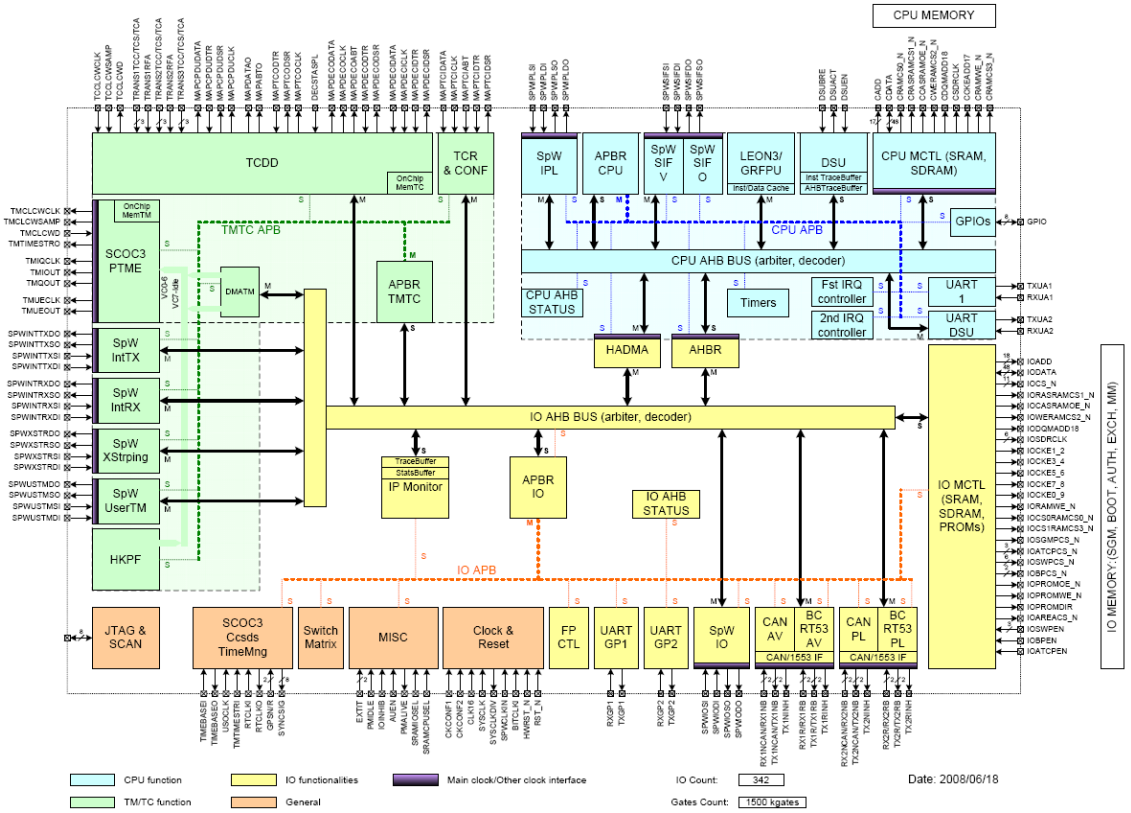
SCOC3 Features

- SCOC 3 is: LEON3-FT plus Comm IPs (1553 x 2, CAN x 2, SPW x 7) & CCSDS TM/TC
  - Up to 80 Mhz (60 MIPS)
  - Compatible with SDRAM and SRAM
  - 100 krad total dose. SEU < 10^{-5} per day (for LET > 30 MeV·cm²/mg)
  - Latchup free (LET up to 80 MeV·cm²/mg)



SCOC3 Architecture

- IPs in SCOC3:
  - Astrium IPs: BCRT53 (x2), HADMA, TCDD, STME, MAPTCR, IPMON, etc.
  - Gaisler IPs: Leon3-FT, GRFPU, GRGPIO, IRQMP, ICTL2, AHB, APB, DSU, etc.
  - ESA IPs: SpW-RMAP (x7), CAN (x2), SCTM

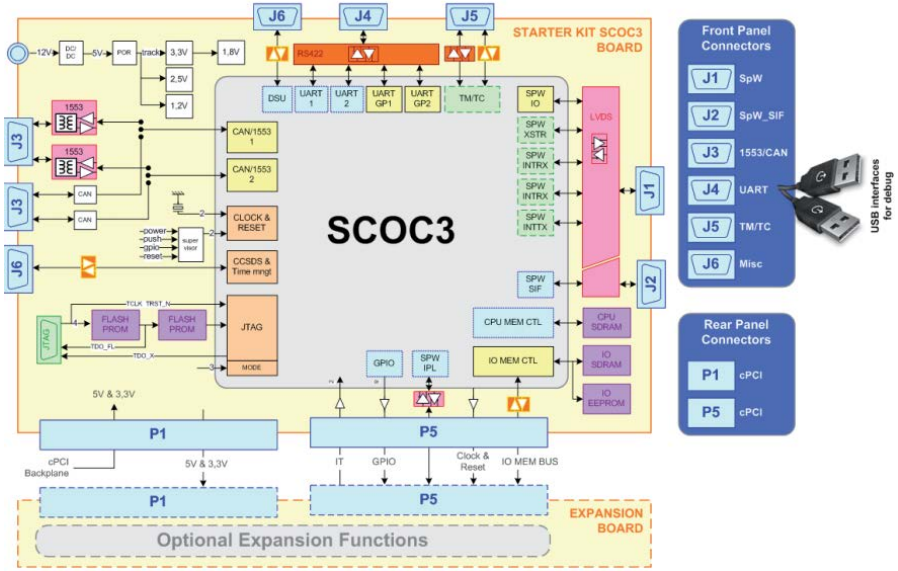


SCOC3 BSW

- The purpose of the SCOC3 BSW is to provide a layer between any hardware compatible with the SCOC3 hardware functions and the ESA-qualified version of RTEMS software layer, according to ECSS standards as CAT-B software.
- The development was carried out under ESA/ESTEC Contract #4000104797 by the DELTA Consortium
- The DELTA Consortium is formed by DELTA Technologies Sud-Ouest, TELETEL and M3 Systems
- The HW used by TELETEL for validation was the STARKIT development board

STARKIT

- The starter kit SCOC3 system (STARKIT) provides a scalable and easy-to-use platform for early development and rapid prototyping. It has been specifically developed to enable the implementation of designs using the SCOC3 ASIC
- Its cost is about 20-25K depending on the HW options, the included harness…
- The STARKIT board is provided with the following interfaces:
  - CCSDS TM/TC & Time management
  - 2xMilbus 1553
  - 2xCAN
  - 7xSpacewire/RMAP
  - GPIO
  - UART & DSU (RS-422)

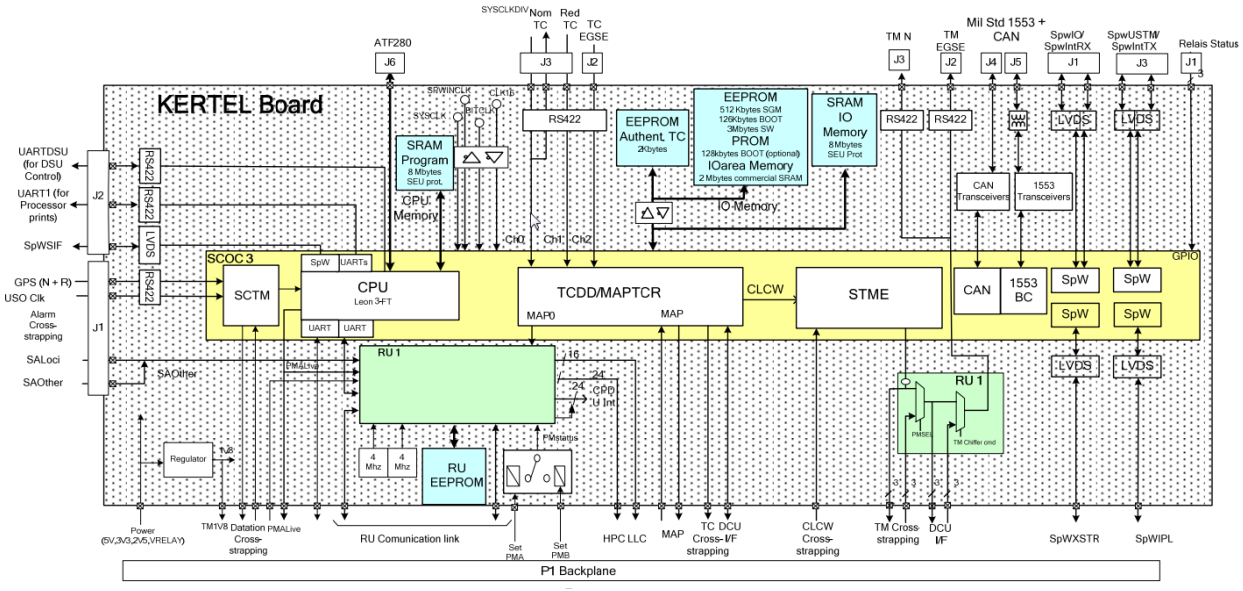


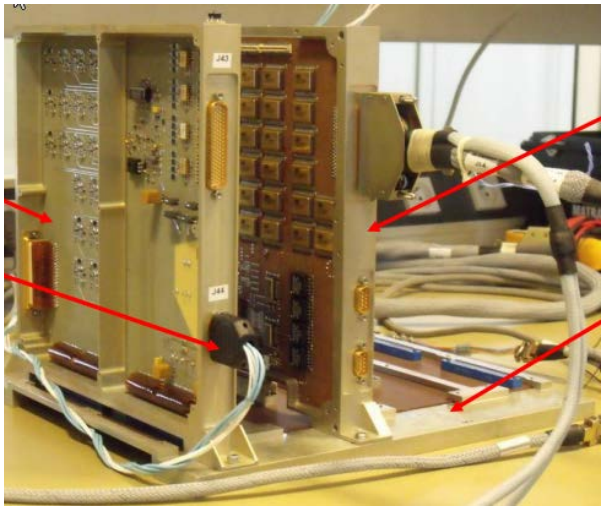
Why Complementary Validation?

- TELETEL has performed a validation for the SCOC3 BSW on STARKIT board with success.
- However, the STARKIT board is a development and prototyping board with the following limitations:
  - Clock speed limited to 32 Mhz
  - SCOC3 IP implemented in a FPGA
- The KERTEL board developed by AirbusDS implements the SCOC3 ASIC and can run up to 80 Mhz
- TELETEL had no access to this equipment, so ESA has taken the responsibility for this complementary validation, the task 5 of this TRP

KERTEL BOARD

- KERTEL is a board designed and manufactured specifically for SCOC3 validation and it is intended also to be used for SCOC3 user evaluation and prototyping.
- It contains the SCOC3 ASIC interfaced with SRAM and EEPROM memories and transceivers for all its communication links. The interfaces are the same as STARKIT.





Summary KERTEL vs. STARKIT

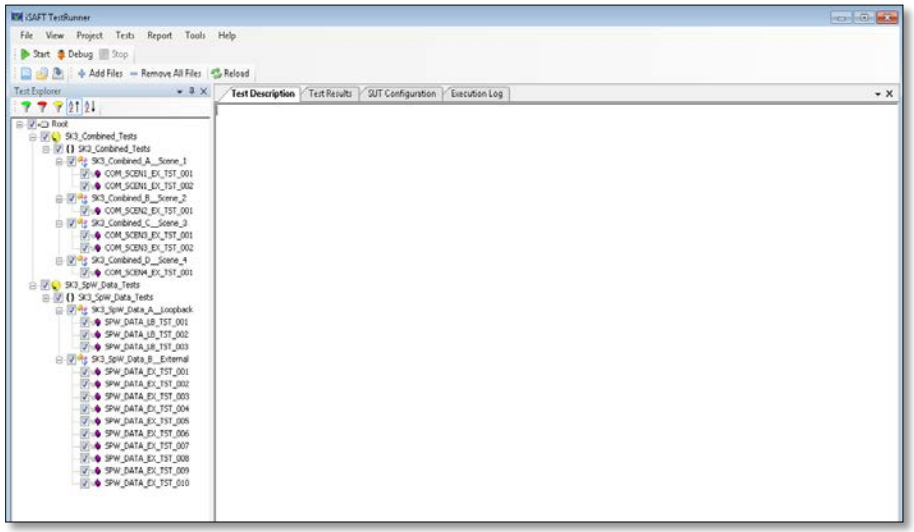
- Both implement the SCOC3 processor and make available the same type of interfaces. However, there are some differences:
  - The maximum CPU clock speed on STARKIT is 32MHz. KERTEL supports up to 80MHz
  - GPIO ports are in the KERTEL backplane, therefore externally inaccessible
  - Two SpW interfaces (SpWXSTR,SpWIPL) are in the KERTEL backplane, so they are also inaccessible
  - The KERTEL Spacewire transceivers cannot work beyond 80Mbps

SCOC3 BSW Features

- The Basic Support Software comprehends two parts:
  - Boot SW library: low-level, RTOS independent software in charge of HW register initialization and trap handler configuration
    - Provides a library of functions (checksum, edac, ramtest) that are intended to be adapted for each project
  - Driver SW: software layer between HW and RTEMS OS. It consists of:
    - **Libcpu** library stores low-level functions to initialize CPU registers with its internal units like IU, FPU, MMU, and CACHES.
    - **Libchip** stores low-level functions to initialize internal HW components other than the CPU chip located in the SCOC3 (IP cores like: MEM with EDAC Controller, Interrupt controller, SpW, CAN, 1553, TM/TC, UART, GPIO, TIMER, WDOG, AMBA, SWMA, SCTM) and to initialize external HW components like RAM/IO chips if any.
      - Note: By design decision, libchip does not use RTEMS primitives
    - **Libbsp** stores high-level functions to initialize HW units located on the StartKit board through RTEMS device drivers. It provides synchronization and resource arbitration by means of RTEMS primitives

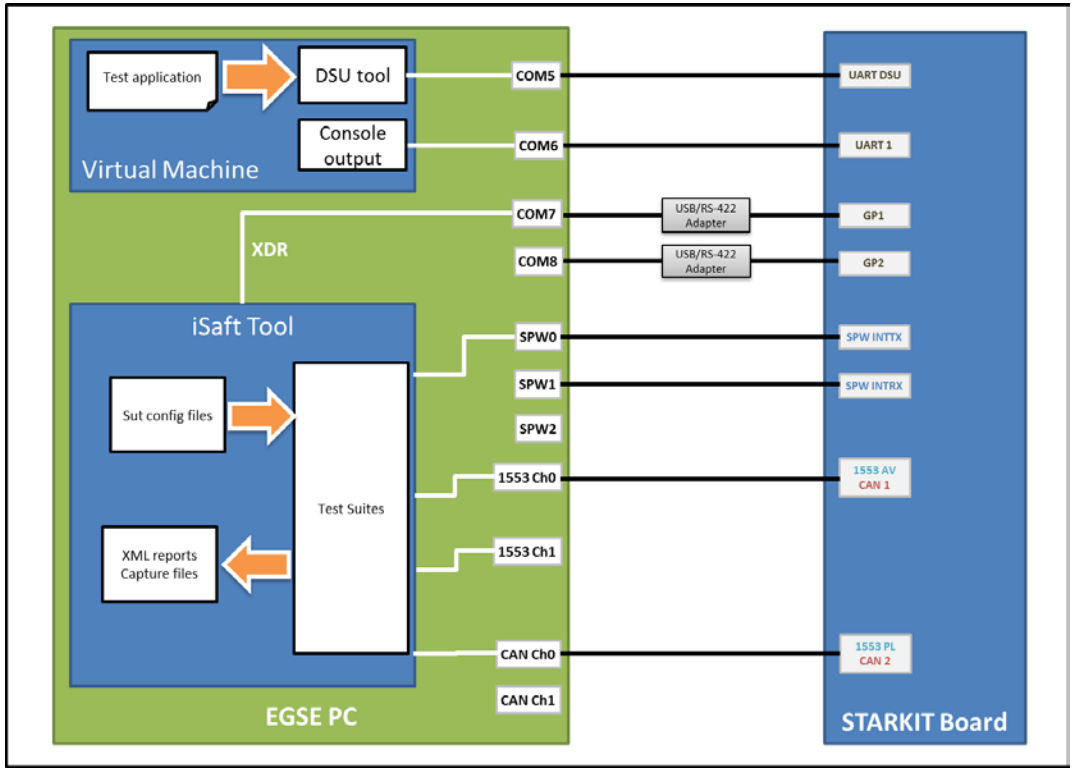
Validation Test Suite: iSaft

- iSaft is the validation test framework used by TELETEL
- It follows a client-server approach. The server is loaded in KERTEL and executes the test steps required by the Windows client
- The test cases to executed are commanded by the iSaft tool through the XDR interface (nominally using the GP1 port)
- iSaft provides also an interface displaying the step by step execution test report
- iSaft requires a HW license key



Test Scenario Configuration: STARKIT

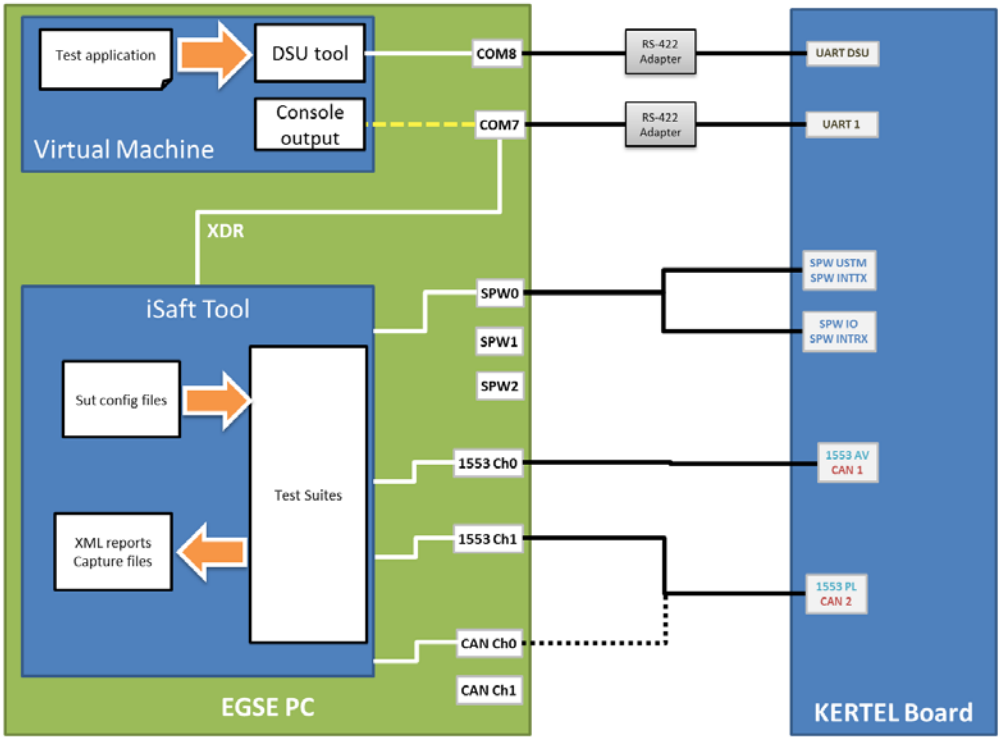
- The STARKIT board makes available:
- The DSU interface (program loading, DSU ≈ grmon,
- The UART1 for console output
- The GPIO1 for XDR communication with the windows test bench (iSaft)



Test Scenario Configuration: KERTEL

- The **GP1** interface is unavailable in the **KERTEL** board, so the test application is modified for using the **UART1** as **XDR** port for communication with the **iSaft** tool
- There are two configurations used in this scenario: **Full 1553** and **Half 1553-CAN**

- The ESA tests use the console output, so the unmodified version of the test application was used



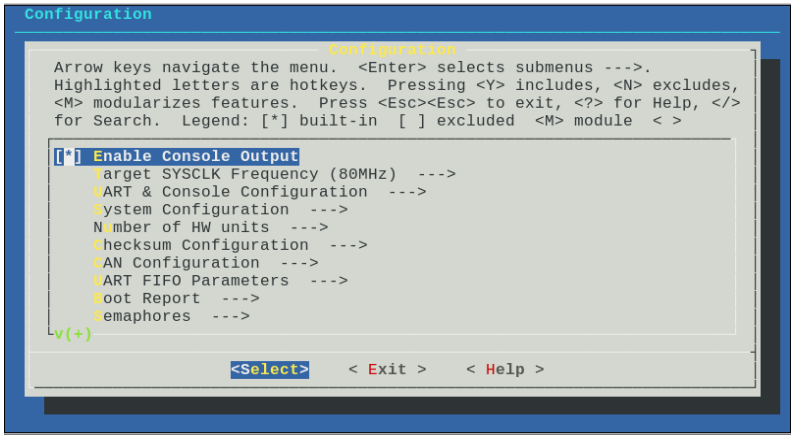
Configuration of SCOC3 BSW for KERTEL

- Since the GPIO ports are not accessible in KERTEL, the XDR communication with the iSaft tool has to be done through the UART1, usually enabled for console output. Therefore, the console support is disabled when the iSaft tool is used

- The CPU clock speed has to be configured also on the BSW for running at 80MHz

- There are tests that require that BSW is configured with different values for the same parameter (e.g. CAN SW FIFO size), so there were generated several versions of the BSW

- The build system has been improved in order to make easier the maintenance and manipulation of the BSW configuration files. This system is now based on the **mconf** tool used in the Linux kernel builds, among others



Test Selection Criteria

- A representative set of tests are selected from the validation suite used by TELETEL, following these directives:
    - All the main interfaces are tested (1553, CAN, SpW)
    - Test at different speeds (CAN, SpW)
    - Test SpW attached to CPUIO AHB Bus, IO AHB Bus
    - Test SpW in DATA mode, RMAP mode
- Some tests not performed because:
    - Interfaces not available (GPIO)
    - Console output is not available when iSaft is used
    - Some considered redundant

- In addition, a few more tests are developed by ESA for evaluate some concerns and interesting features

- Changing the 1553 + CAN configuration is a “risky” operation, so group test execution to minimize the number of changes:
    - Configurations used are Full 1553 and Half CAN-1553

Selected tests

- The validation tests (iSaft test bench) selected for the complementary validation were:
    - **34** SpaceWire Data and RMAP tests, testing send, reception and throughput with all the Spacewire interface at different speeds ranging from 2Mbps to 75Mbps
    - **9** Mil-Bus-1553 tests with both interfaces AV and PL for reception/send and throughput
    - **14** CAN tests within the CAN 2 interface (Half 1553–CAN) for reception/sending, throughput and different FIFO configurations
    - **8** combined tests (Spacewire + 1553 + CAN) with different Spacewire interfaces
- Test spec doc is

TEC-SWE/14-740/DS SCOC3 BSW Complementary Validation Test Specification on KERTEL

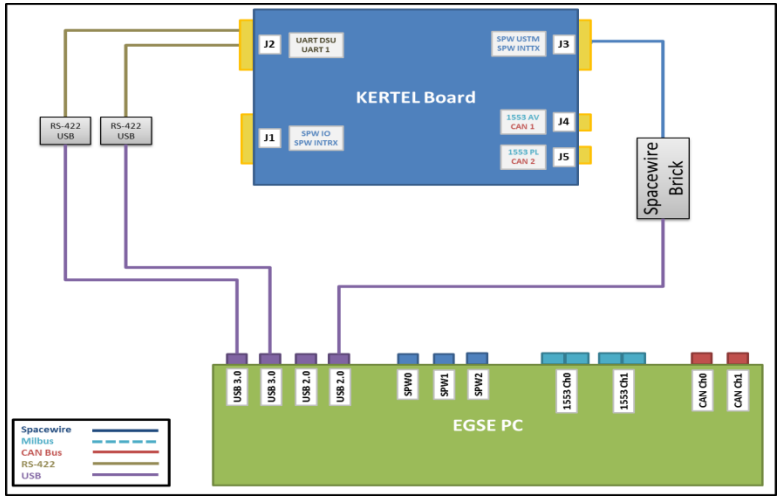
- (Available in Alfresco SCOC3 BSW web site)

ESA tests

There were 3 tests developed by ESA:

- A simple test for check the correctness of the port to KERTEL and parameters such the CPU speed or UART configuration

- Two tests for checking the correct implementation of the Spacewire driver and the throughput



Notes about test campaign

- The adaptation of the test bench to the particularities of the KERTEL board took some time to understand and resolve.

- A slight modification of the iSaft server program was needed to workaround the unavailable GPIO1
    - Still some instability on iSaft when acquiring test results through CONSOLE port instead GPIO1

- The change of HW configuration (2 x1553, 2 x CAN or multiplexed) is an operation that shall be done with great care. It is easy to “corrupt” the configuration:
    - The configuration is based a list of pairs of (address, values) written into a configuration EEPROM
    - The order of the pairs on the list depends on the particular board (STARKIT, KERTEL) so it has to be changed with extreme precaution
    - Very detailed instructions included in Annex A of the Validation Report

- Once the previous problems were resolved, test campaign was straightforward

Finally: Spacewire Test results

- The Spacewire tests were OK with the exception of two tests because of iSaft exception when conducting the test
- Failed test will be repeated when time available

Test	Kertel Result	SPR	STARKIT Result	Execution Notes
SPW_DATA_EX_TST_003-1	OK		OK	
SPW_DATA_EX_TST_003-2	OK		OK	
SPW_DATA_EX_TST_003-3	OK		OK	
SPW_DATA_EX_TST_003-4	OK		OK	
SPW_DATA_EX_TST_003-5	OK		OK	
SPW_DATA_EX_TST_003-6	OK		OK	
SPW_DATA_EX_TST_003-7	OK		OK	
SPW_DATA_EX_TST_003-8	OK		OK	
SPW_DATA_EX_TST_003-9	OK		OK	
SPW_DATA_EX_TST_003-10	OK		OK	
SPW_DATA_EX_TST_003-11	OK		OK	
SPW_DATA_EX_TST_003-12	OK		OK	
SPW_DATA_EX_TST_003-13	OK		OK	
SPW_DATA_EX_TST_003-14	OK		OK	
SPW_DATA_EX_TST_003-15	OK		OK	
SPW_DATA_EX_TST_003-16	OK		OK	
SPW_DATA_EX_TST_007-1	OK		OK	
SPW_DATA_EX_TST_007-2	OK		OK	
SPW_DATA_EX_TST_008-1	OK		OK	
SPW_DATA_EX_TST_008-2	OK		OK	

Test	Kertel Result	SPR	STARKIT Result	Execution Notes
SPW_RMAP_EX_TST_001-1	OK		OK	
SPW_RMAP_EX_TST_001-2	OK		OK	
SPW_RMAP_EX_TST_002-1	FAIL		OK	Alternative test with IO (PION-A) worked fine
SPW_RMAP_EX_TST_002-2	OK		OK	
SPW_RMAP_EX_TST_003-1	FAIL		OK	This test was successfully executed at 100Mbps on STARKIT
SPW_RMAP_EX_TST_003-2	OK		OK	
SPW_RMAP_EX_TST_004-1	OK		OK	
SPW_RMAP_EX_TST_004-2	OK		OK	
SPW_RMAP_EX_TST_009-1	OK		OK	
SPW_RMAP_EX_TST_009-2	OK		OK	
SPW_RMAP_EX_TST_010-1	OK		OK	
SPW_RMAP_EX_TST_010-2	OK		OK	
SPW_RMAP_EX_TST_011-1	OK		OK	
SPW_RMAP_EX_TST_011-2	OK		OK	

1553 Test Results

- A few 1553 tests fail because:
  - TST_009-1 & -2: sync transmitted at 4Hz instead 8Hz. Probably a test setup problem
  - TST_009-18-1: sync transmitted at 4Hz instead 8Hz. Load reach only 50%. Probably a test setup problem
  - TST_022-1: Erroneous test setup.
- Failed tests will be repeated when time available

Test	Kertel Result	SPR	STARKIT Result	Execution Notes
MIL_BUS_EX_TST_009-1	FAIL		OK	The PVS BM statistics Frequency 247136.8 of port MilCh0 is smaller than the minimum 7. Investigation by TELETEL suggests that iSaft was not configured properly for 1553
MIL_BUS_EX_TST_009-2	FAIL		OK	The PVS BM statistics Frequency 247136.7 of port MilCh1 is smaller than the minimum 7. Investigation by TELETEL suggests that iSaft was not configured properly for 1553
MIL_BUS_EX_TST_010-1	OK		OK	Only one 1553 port available in STARKIT
MIL_BUS_EX_TST_010-2	OK		OK	Only one 1553 port available in STARKIT
MIL_BUS_EX_TST_008-1	OK		OK	
MIL_BUS_EX_TST_017-1	OK		OK	
MIL_BUS_EX_TST_018-1	FAIL		OK	Investigation by TELETEL suggests that iSaft was not configured properly for 1553
MIL_BUS_EX_TST_019-1	OK		OK	Only one 1553 port available in STARKIT
MIL_BUS_EX_TST_022-1	FAIL		OK	Investigation by TELETEL suggests that iSaft was not configured properly for 1553

CAN Tests Results

- CAN bus tests OK except
  - Tests TST_003, _004 fail the throughput criteria : too optimistic expectations about throughput
  - Test TST_006, required 2 CAN. Executed in half CAN by error.
  - Test TST_009 should have been not executed. The required error condition cannot be injected
- Failed tests will be repeated when time available

Test	Kertel Result	SPR	STARKIT Result	Execution Notes
CAN_BUS_EX_TST_001	OK		OK	
CAN_BUS_EX_TST_002	OK		OK	
CAN_BUS_EX_TST_003	FAIL		OK	The test fails due to low performance of the CAN BUS which is a known issue
CAN_BUS_EX_TST_004	FAIL		OK	The test fails due to low performance of the CAN BUS which is a known issue
CAN_BUS_EX_TST_005	OK		OK	
CAN_BUS_EX_TST_006	FAIL		OK	The test was incorrectly identified as suitable for being executable with Half 1553-CAN configuration.
CAN_BUS_EX_TST_007	OK		OK	
CAN_BUS_EX_TST_008	OK		OK	
CAN_BUS_EX_TST_010	OK		OK	
CAN_BUS_EX_TST_011	OK		OK	
CAN_BUS_EX_TST_012	OK		OK	
CAN_BUS_EX_TST_013	OK		OK	
CAN_BUS_EX_TST_014	OK		OK	

Combined Tests Results

- The tests based in the first scenario (2x1553 + 1 SpW–IO/USTM at 10 Mbps/64Mbps) were passed with no problem

- SCEN2: 2 CAN, 1 SpW
  - COM_SCEN2_EX_TST_001: Not run with the right configuration. Full CAN was needed

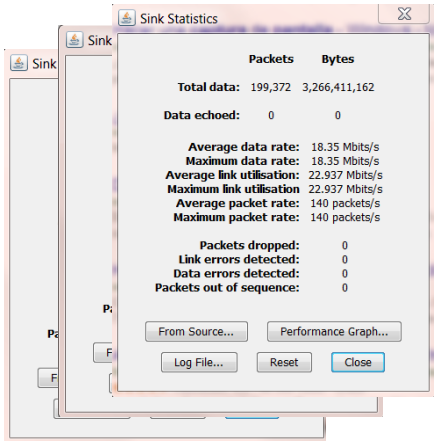
- SCEN3: 1 CAN, 1553, 1 SpW.
  - COM_SCEN3_EX_TST_001: (4 Sept). Timeout on CAN get port stat
  - COM_SCEN3_EX_TST_002: (4 Sept). ISaft exception

- SCEN4: 1 CAN, 1553, 1 SpW + FPU stress test
  - COM_SCEN4_EX_TST_001: Exception start SpW task. It is under investigation

Test	Kertel Result	SPR	STARKIT Result	Execution Notes
COM_SCEN1_EX_TST_001-1	OK		OK	
COM_SCEN1_EX_TST_001-2	OK		OK	
COM_SCEN1_EX_TST_002-1	OK		OK	
COM_SCEN1_EX_TST_002-2	OK		OK	
COM_SCEN2_EX_TST_001	FAIL		OK	The test was incorrectly identified as suitable for being executable with Half 1553-CAN configuration.
COM_SCEN3_EX_TST_001	FAIL		OK	Timeout on CAN get port stat
COM_SCEN3_EX_TST_002	FAIL		OK	ISaft exception
COM_SCEN4_EX_TST_001	FAIL		OK	The test was incorrectly identified as suitable for being executable with Half 1553-CAN configuration.

ESA tests Results

- ESA-CONSOLE-010: the test executes successfully the implemented traces for validate the port
- ESA-SPW-ECHO-020-1: the test has showed an abnormal behavior, when sending packets that are not multiple of 4
- ESA-SPW-ECHO-020-2: the SpaceWire throughput showed similar performance with respect to iSaft tests



Finally: Test Campaign Conclusions

- The test campaign has been executed with success
- Test report doc is

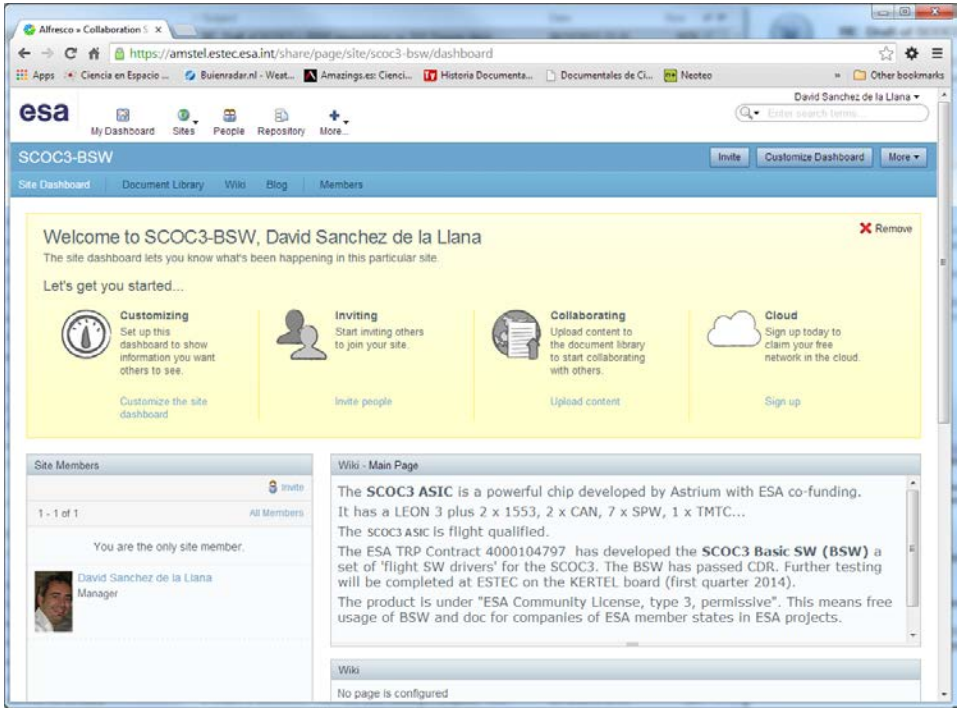
TEC-SWE/14-739/DS SCOC3 BSW Complementary Validation Report on KERTEL

(Available in Alfresco SCOC3 BSW web site)

- Some tests executed with erroneous setup will be repeated when time is available
- No differences have been found between the behavior of the SCOC3 BSW when executing on the STARKIT board (FPGA based) and on the KERTEL (ASIC based) ➔ No Hardware NCR are reported :-)
- 2 SPR concerning UART and Spacewire interface have been identified:
  - SCOC3-BSW-SPR-23 (Minor) : Port configuration shall be adapted when running at 80 MHz
  - SCOC3-BSW-SPR-24 (major): SpW driver truncates sending and receiving packets to module 4. Workaround: send packets with length multiple of 4 bytes
- Added as limitation of use to the UM. Will be solved in the next version of the SCOC3 BSW

SCOC3 BSW Distribution

- Documentation and SW available to registered users in Alfresco web site: https://amstel.estec.esa.int/share/page/
- ESA Community License type 3, permissive (SW free to use for companies of member states in European projects)
- Contact for getting an user: David.Sanchez.de.la.Llana@esa.int



Questions - .... .- -. -.- -.-- --- ..- -.-

THANK YOU!