



Protocol Validation System (PVS) for On-Board Communications: Extensions and Evolutions to EGSE Requirements

December 2015



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- iSAFT PVS – ESA Contracts & Rationale
- Product Instance: iSAFT PVS SpaceWire/MIL-STD-1553/CAN Recorder
- Product Instance: iSAFT PVS SpaceWire/MIL-STD-1553/CAN Simulator (Data Front-End)
- iSAFT PVS Integration & Validation in Primes Testbeds
- iSAFT PVS Roadmap



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iSAFT PVS Rationale

During the last 6 years, TELETEL in cooperation with ESA and Space Primes is developing an EGSE platform (iSAFT PVS) for the validation of spacecraft/satellite on board data networks validation.



- iSAFT PVS is based on over 20 years of experience in the area of protocol testing and validation in telecommunications sector and is currently targeting the validation of SpW, ECSS-E-ST-50-13C (1553), ECSS CAN on-board networks.
- iSAFT PVS is considered as a base platform, on top of which specific EGSE instances can be provided.



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iSAFT PVS Overview

iSAFT PVS is an advanced, integrated powerful HW/SW platform for the simulation, validation & monitoring of satellite/spacecraft on-board data networks.

- It supports simultaneously a wide range of protocols (RMAP, CPTP, ECSS 1553, ECSS CAN, CANopen, TM/TC management etc.) & network interfaces (SpaceWire, MIL-STD-1553, CAN).
- It is highly modular, thus easily expandable to support new network interfaces & protocols and it is based on the iSAFT powerful graphical tool chain (Protocol Analyser / Recorder, TestRunner, Device Simulator, Traffic Generator, etc.).
- It can be used for rapid prototyping & evaluation of new network protocols/features, for functional testing and stress testing. Moreover it can be used for device simulation (SSMM, RTU, etc.) as well as for protocol analysis & recording.



ESA contracts overview for iSAFT PVS

iSAFT PVS has been developed and industrially validated in the context of the following ESA contracts. The main purpose of this presentation is to provide details with respect to the relevant achievements.

- Protocol Validation System for On-Board Communications – Phase II (ESTEC Contract No. 4000105444/12/NL/CBI)
 - Duration: November 2013 – June 2015
 - Subcontractors: AIRBUS D&S FRANCE, AIRBUS D&S UK

- Extension of PVS with EGSE Functionality (ESTEC Contract No. 4000111156/14/NL/CBI/)
 - Duration: May 2014 - August 2015
 - Subcontractors: THALES ALENIA SPACE - ITALY

- PVS Evolution to EGSE requirements – Phase I (ESTEC Contract No. 4000112726)
 - Duration: November 2014 – December 2015



iSAFT PVS Applications Areas

iSAFT PVS can be used as a standalone testing and validation system as well as part of integrated EGSEs.

■ Standalone EGSE (Simulator DFE, Recording Equipment)

- Local or remote control through network APIs.
- Support of interfaces with CCS (EDEN/CCSDS) and APIs for integration with 3rd party SW.



■ Part of integrated EGSEs

- EGSE Controller.
- Data Front End (SpaceWire / MIL-STD-1553 / CAN).



■ Platform for experimentation and ESA studies

- Prototyping of new protocols over SpaceWire.
- Validation of CCSDS lossless compression IP core.
- New network paradigm for the on-board reference architecture.



iSAFT PVS HW Platforms / Network Interface Cards (NICs)

iSAFT PVS can be provided in different heavy duty hardware platforms with high processing power. They can host multiple physical interfaces in any combination and they also provide multi-Gbytes storage capacity.



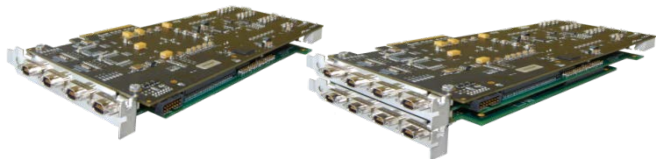
Server Based Site
Rackmount System (2U)



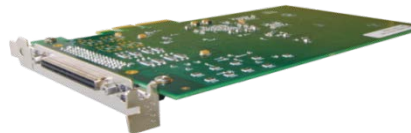
Site Rackmount System (3U)



Portable System



Quad/Octal SpaceWire PCIe NIC



Dual 1553 1Mbit PCIe NIC



Dual CAN PCIe NIC



iSAFT PVS Instances (examples)



iSAFT SpW/1553/CAN Recorder



iSAFT SpW/1553/CAN Simulator -
Data Front-End



iSAFT based EGSEs



iSAFT based Instrument Simulator



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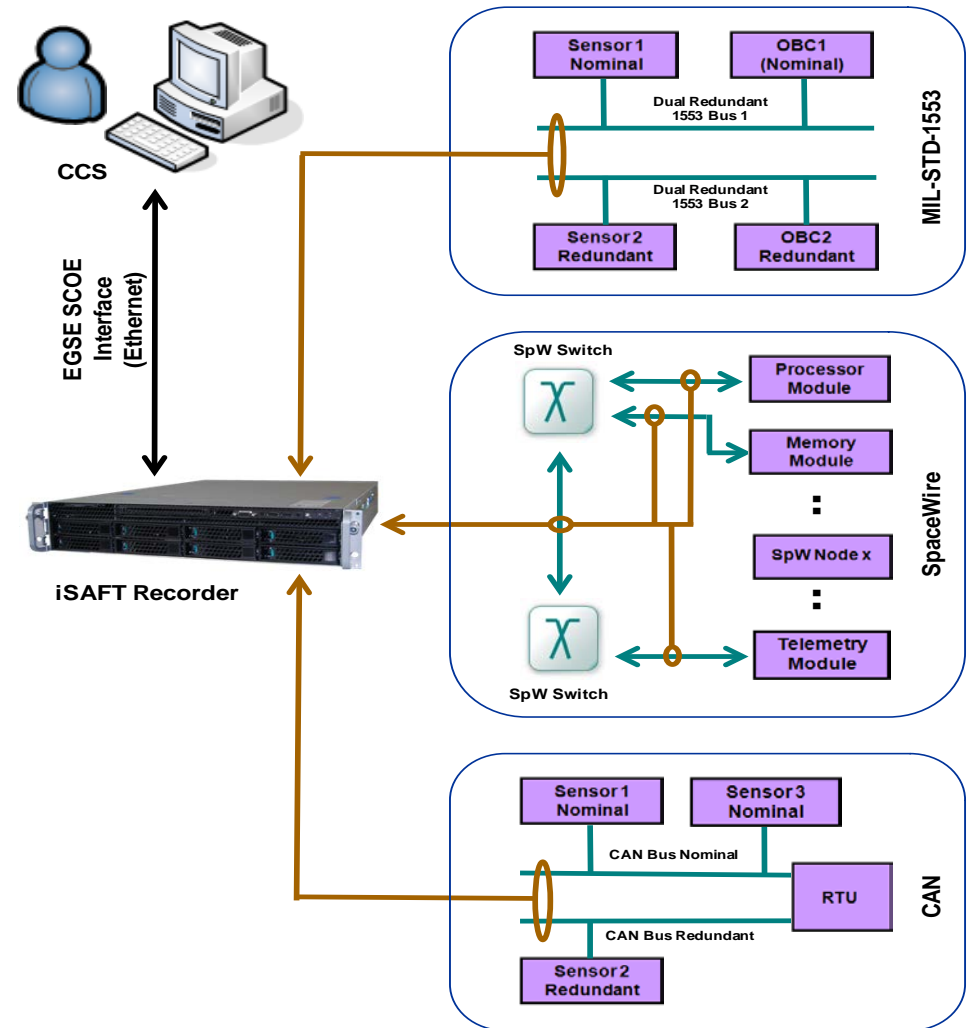
- iSAFT PVS Integration & Validation in Primes Testbeds

- iSAFT PVS Roadmap



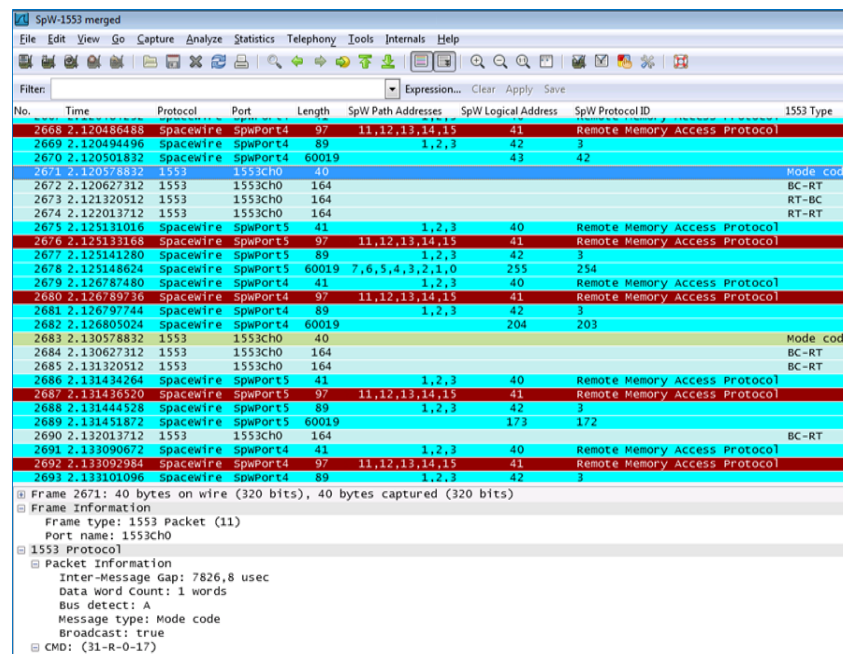
iSAFT SpW / MIL-STD-1553 / CAN Recorder

- Advanced, integrated, high performing, modern network traffic capture, recording and analysis tool for the validation of satellite/spacecraft on-board data networks.
- Traffic capturing on multiple SpW links, MIL-STD-1553 and/or CAN buses, time stamping, recording, and delivering them to a powerful Protocol Analyzer for further processing and analysis.
- One station for SpW, 1553, CAN recording, recording files management, interface to CCS, IRIG synchronisation, etc.



iSAFT SpaceWire Recorder

- Unobtrusive link monitoring (8-16 ports, 4-8 links).
- Continuous real-time capture from 2 to 250 Mbps per port.
- Enable/disable traffic capture per port.
- User selectable capture triggers/filters.
- Down to 8 nsec Timestamp Resolution.
- Raw and decoded packets display.
- IRIG generator or receiver operation.
- Packet/Character monitoring modes per port, including erroneous characters.
- Decoding of SpW, RMAP, CPTP, CCSDS Space Packet protocols.
- Truncation of packets exceeding a user programmable size.



The screenshot displays the iSAFT SpaceWire Recorder software interface. The main window shows a list of captured packets with columns for No., Time, Protocol, Port, Length, SpW Path Addresses, SpW Logical Address, SpW Protocol ID, and 1553 Type. The list includes various protocols such as Remote Memory Access Protocol and Mode code. Below the list, there is a detailed view of a selected packet (No. 2671) showing frame information, packet information, and command details.

No.	Time	Protocol	Port	Length	SpW Path Addresses	SpW Logical Address	SpW Protocol ID	1553 Type
2668	2.120486488	SpaceWire	SpwPort4	97	11,12,13,14,15	41	Remote Memory Access Protocol	
2669	2.120494496	SpaceWire	SpwPort4	89	1,2,3	42	3	
2670	2.120501832	SpaceWire	SpwPort4	60019		43	42	
2671	2.120578832	1553	1553cho	40				Mode code
2672	2.120627312	1553	1553cho	164				BC-RT
2673	2.121320512	1553	1553cho	164				RT-BC
2674	2.122013712	1553	1553cho	164				RT-RT
2675	2.125131016	SpaceWire	SpwPort5	41	1,2,3	40	Remote Memory Access Protocol	
2676	2.125131168	SpaceWire	SpwPort5	97	11,12,13,14,15	41	Remote Memory Access Protocol	
2677	2.125141280	SpaceWire	SpwPort5	89	1,2,3	42	3	
2678	2.125148624	SpaceWire	SpwPort5	60019	7,6,5,4,3,2,1,0	255	254	
2679	2.126787480	SpaceWire	SpwPort4	41	1,2,3	40	Remote Memory Access Protocol	
2680	2.126789736	SpaceWire	SpwPort4	97	11,12,13,14,15	41	Remote Memory Access Protocol	
2681	2.126797744	SpaceWire	SpwPort4	89	1,2,3	42	3	
2682	2.126805024	SpaceWire	SpwPort4	60019		204	203	
2683	2.130578832	1553	1553cho	40				Mode code
2684	2.130627312	1553	1553cho	164				BC-RT
2685	2.131320512	1553	1553cho	164				BC-RT
2686	2.131434264	SpaceWire	SpwPort5	41	1,2,3	40	Remote Memory Access Protocol	
2687	2.131436520	SpaceWire	SpwPort5	97	11,12,13,14,15	41	Remote Memory Access Protocol	
2688	2.131444528	SpaceWire	SpwPort5	89	1,2,3	42	3	
2689	2.131451872	SpaceWire	SpwPort5	60019		173	172	
2690	2.132013712	1553	1553cho	164				BC-RT
2691	2.133090872	SpaceWire	SpwPort4	41	1,2,3	40	Remote Memory Access Protocol	
2692	2.133092128	SpaceWire	SpwPort4	97	11,12,13,14,15	41	Remote Memory Access Protocol	
2693	2.133101096	SpaceWire	SpwPort4	89	1,2,3	42	3	

Frame 2671: 40 bytes on wire (320 bits), 40 bytes captured (320 bits)
Frame Information
Frame type: 1553 Packet (11)
Port name: 1553cho
1553 Protocol
Packet Information
Inter-Message Gap: 7826,8 usec
Data Word Count: 1 words
Bus detect: A
Message type: Mode code
Broadcast: true
CMD: (31-R-0-17)



iSAFT MIL-STD-1553 Recorder

- Recording of Fully Loaded Buses for Long Durations.
- 20 nsec Timestamp Resolution.
- Triggers to Start Monitoring on specific Events.
- Online Filters for Selective Capture or Offline Filters for Post Processing.
- Statistics Logging for Offline Analysis.
- Decoding of standard MIL-STD-1553 Messages, ECSS-E-ST-50-13C Services' Message over 1553 Buses.
- Decoders can display any Protocol Field and Messages Timing Information.
- Real Time Analysis of Recorded Messages and Detailed Statistics View.



The screenshot shows the 'Monitoring' window of the iSAFT MIL-STD-1553 Recorder. It displays a table with columns for 'Default Station', 'F:\Recordings', 'Captured', 'Valid', and 'Errors'. The table lists several monitoring points, including SpWBoard1 and MilBoard0, with their respective ports and monitoring status.

Default Station	F:\Recordings	Captured	Valid	Errors
SpWBoard1		119.100	119.100	0
SpWPort4	Packet	59.550	59.550	0
SpWPort5	Packet	59.550	59.550	0
SpWPort6	Character	0	0	0
SpWPort7	Character	0	0	0
MilBoard0		0	0	0
MilCh0	Bus Monitor	0	0	0
MilCh1	Bus Monitor	0	0	0
test19000	F:\Recordings			



iSAFT CAN/CANopen Recorder

■ General Features

- Recording and decoding of standard ECSS-CAN / CANopen messages over CAN Buses.
- Continuous real-time capture of 2 - 4 channels.
- Down to 63 ns Timestamp Accuracy.
- ECSS-E-50-15C TIME messages monitoring and decoding.
- Can support EDS and DCF files import enabling decoding and automatic interpretation of CANopen PDO frame values & parameters.

■ Filters & Triggers

- CAN frame type.
- Specific errors.
- Specific CAN Ids / COB-Ids.

■ Statistics

- CAN bus statistics (Bus load, Total number of received messages, Remotes frame statistics).
- CANopen statistics (SDO response times, TPDO response times, Heartbeat event times, Node Guarding response times, Bootup time statistics).



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iSAFT SpW / MIL-STD-1553 / CAN Simulator (Data Front-End)

- Advanced EGSE platform with traffic generation capabilities that simulates SpaceWire / MIL-STD-1553 / CAN devices or instruments, enabling S/C integration tests before the availability of Flight Models.
- Provides an 8 – 20 port SpaceWire interface with advanced traffic generation and asynchronous transmission capabilities and/or a 2 - 4 channel MIL-STD-1553 interface with BC and multiple RT simulation and Bus Monitoring capabilities and/or a 2-4 channel CAN interface for simulation with bus monitoring capabilities.
- One station for SpW, 1553 and CAN simulation, interface to CCS, IRIG synchronisation, etc.

Data Bus Front End

Instrument Simulation

OBC Simulation (PLM EGSE)

Suitable for various EGSEs

AIT/AIV, FMEA, CE



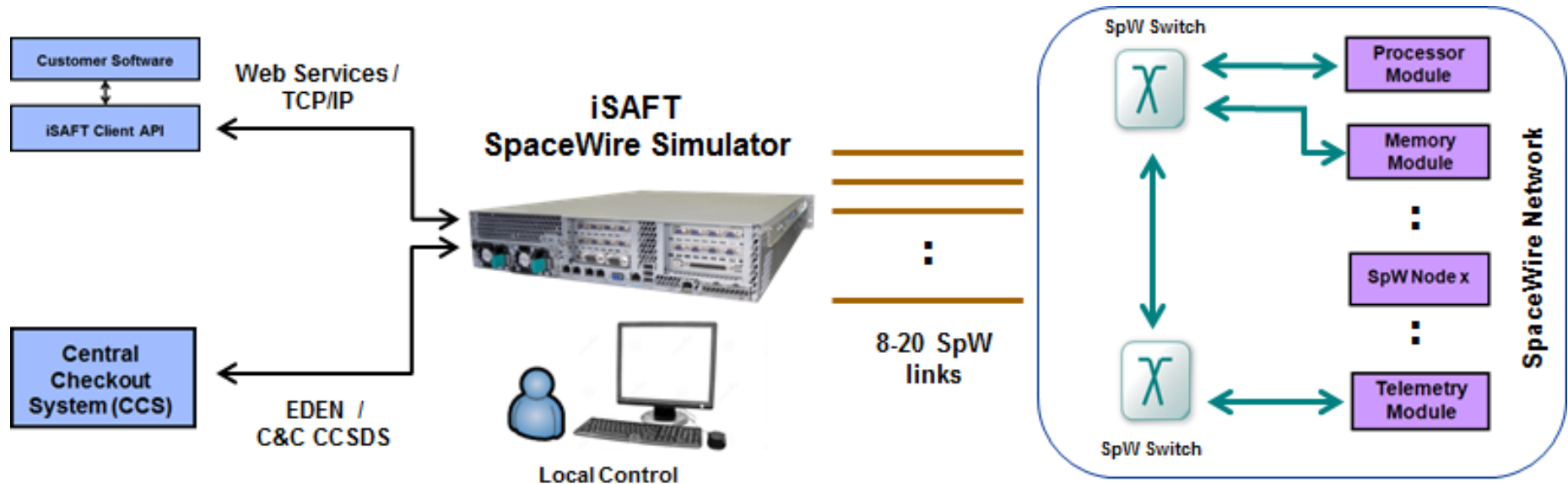
iSAFT SpaceWire Simulator

- Eight to twenty (8-20) SpaceWire ports, external triggers per port.
- Link speed from 1 - 400 Mbps with 1 Mbps granularity, independently programmable per port.
- Transmission of user packets unconditionally or upon the detection of programmable trigger event.
- Programmable packet truncation on received packets.
- Bulk traffic generation, transmission of Linked-listed packets & repetitive packets/sequences, with microsecond accurate traffic shaping capability through independent transmission triggers per packet.
- Hardware packet sinking for connected device transmission performance evaluation.
- Trigger port event generation upon packet transmission/reception or link status event (connect, disconnect etc.).

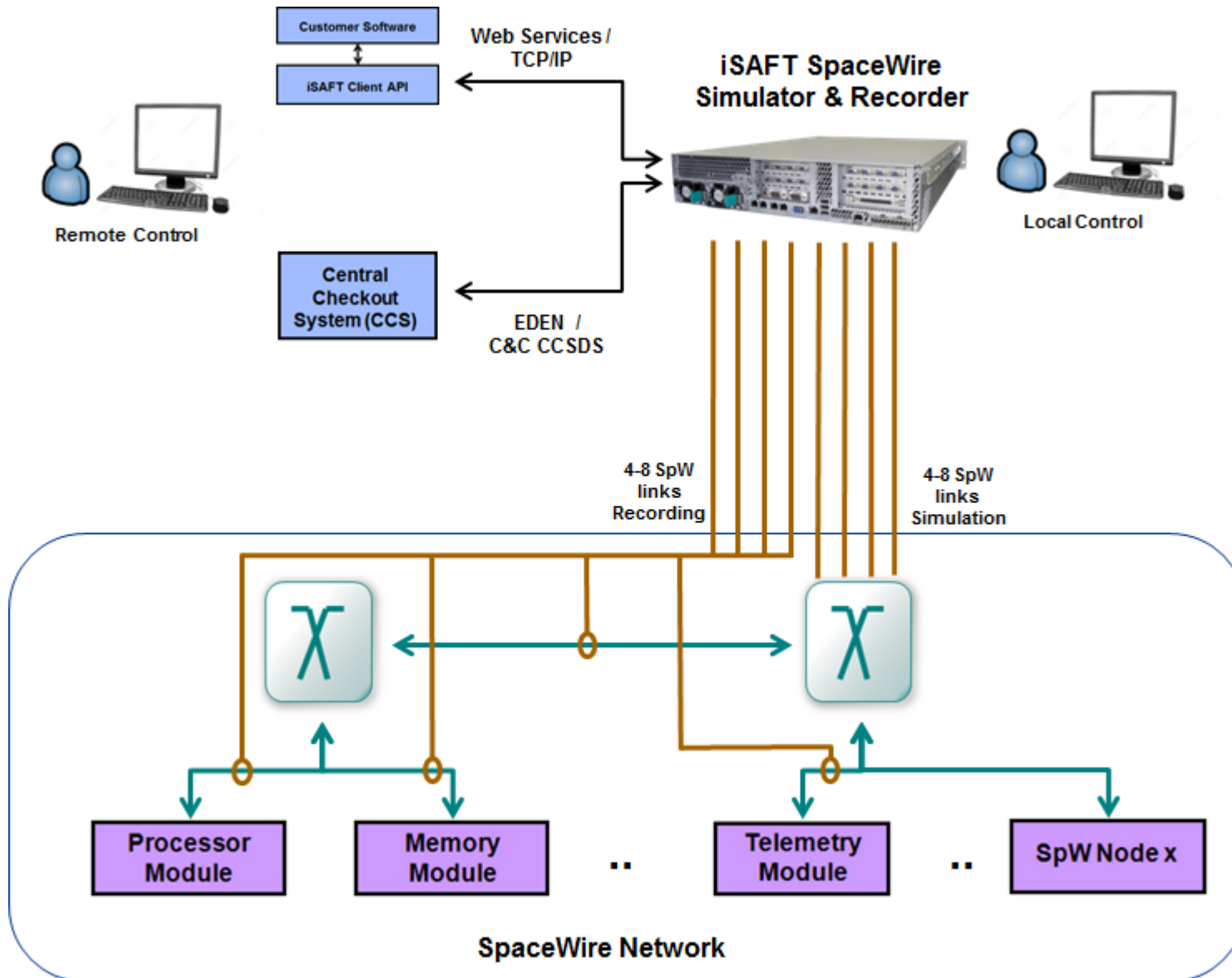


Case Study: iSAFT SpaceWire Simulator

The iSAFT PVS SpaceWire Simulator can be used for early validation of SpaceWire devices / instruments in a testbed. It provides a GUI for complete local operation (iSAFT PVS graphical toolchain). Remote control & operation is also possible through CCS.



Case Study: iSAFT SpaceWire Simulator & Recorder



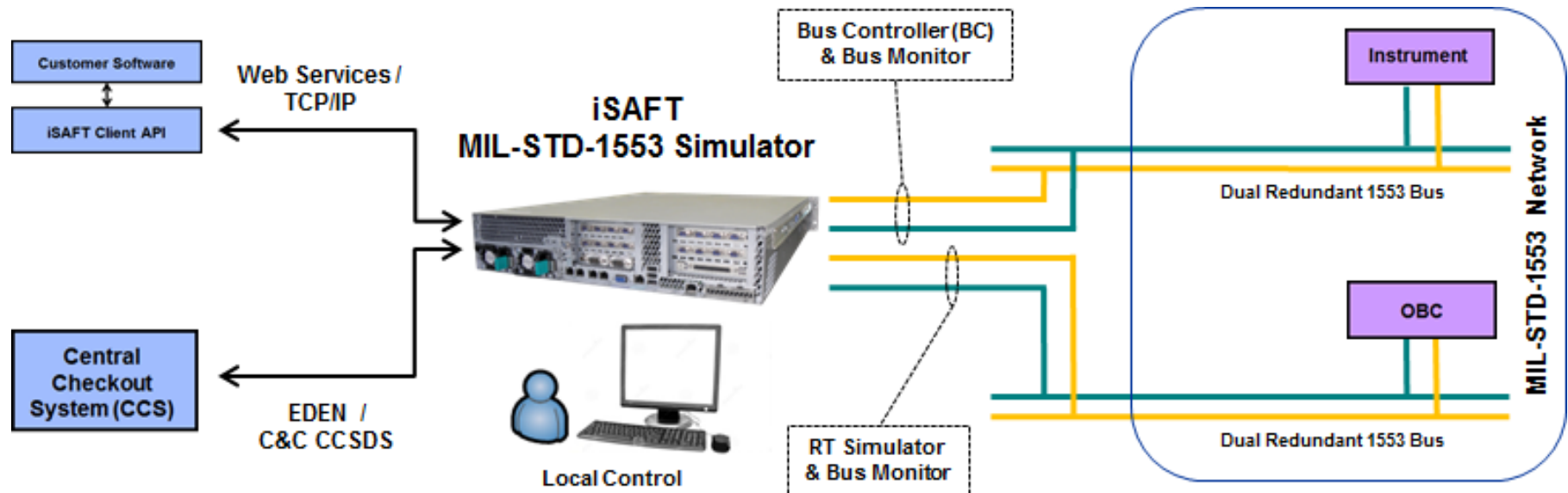
iSAFT MIL-STD-1553 Simulator

- One to four (1-4) independent, dual redundant MIL-STD-1553 channels.
- 1553A and 1553B support.
- Full function operation BC, BM and multiple RTs (1-31) simultaneously.
- BC and RT simulation fully compliant with MIL-STD-1553B Notice II & IV.
- Support of ECSS-E-ST-50-13C services during BC and RT simulation (time distribution, communication synchronization, get/set data, data block transfer and terminal management services).
- Full BC and RT Data Block Transfer services implementation supporting all QoS (Best-Effort or Verified Length) and sub-addressing modes (Deep or Flat).
- Statistics for ECSS-E-ST-50-13C services.
- Full error injection and detection capabilities (at MIL-STD-1553B or ECSS-E-ST-50-13C services level).
- Legal and reserved Mode Codes support.
- Variable voltage option.



Case Study: iSAFT MIL-STD-1553 Simulator

The iSAFT PVS MIL-STD-1553 Simulator can be used for early validation of MIL-STD-1553 devices / instruments in a testbed. It provides a GUI for complete local operation (iSAFT graphical toolchain). Remote control & operation is also possible through CCS.



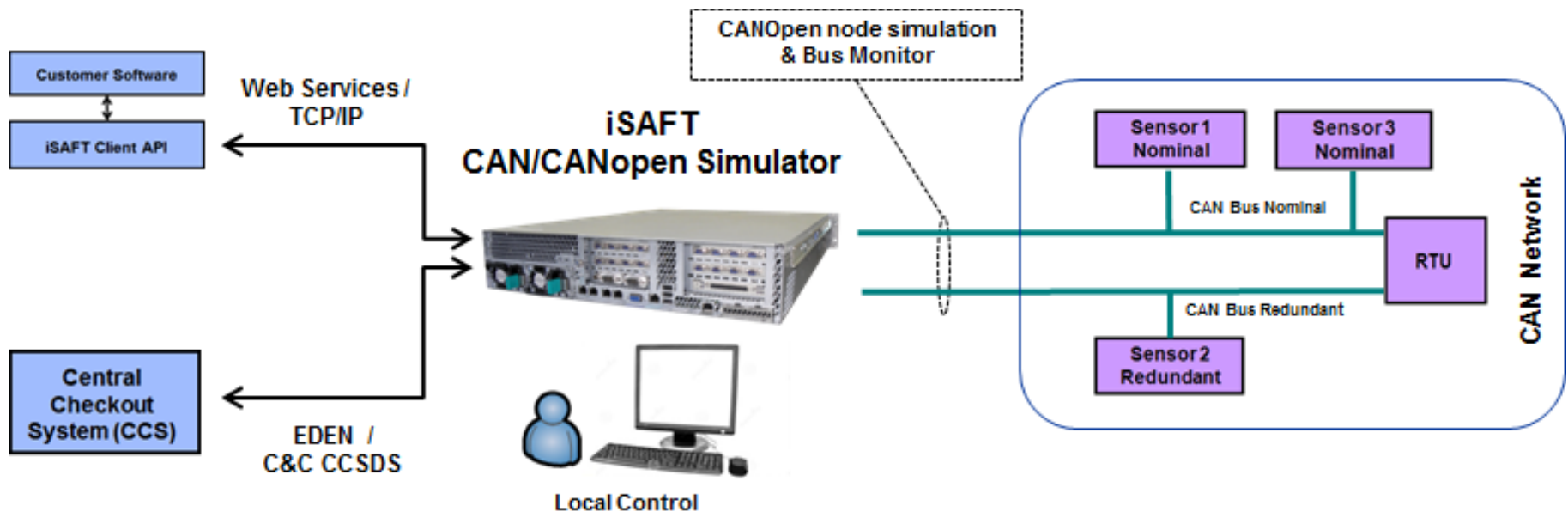
iSAFT CAN/CANopen Simulator

- CAN/CANopen simulation support for 1-4 channels, in CAN bus standard or dual redundant mode (based on ECSS-E-50-15C) in one system.
- Capturing and recording of large volumes of traffic from multiple CAN channels.
- GUI for complete local operation.
- Full error injection (at physical & protocol level) and error detection capabilities.
- Transmission triggers and statistics support (CAN bus statistics, CANopen statistics).
- IRIG support for synchronization.
- Support of interfaces with CCS (EDEN / C&C CCSDS) for remote control and operation.



Case Study: iSAFT CAN/CANopen Simulator

The iSAFT PVS CAN/CANopen Simulator can be used for early validation of CAN/CANopen devices / instruments in a testbed. It provides a GUI for complete local operation (iSAFT graphical toolchain). Remote control & operation is also possible through CCS.



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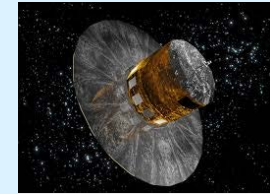


PVS Validation at LSI Testbeds

iSAFT PVS products have been completely industrially validated at LSI Testbeds.



iSAFT 1553 RT Simulator & iSAFT Recorder at the GAIA avionics test bench (AVM) (Toulouse)



SpW/1553 Recorder & iSAFT SpW Simulator at the Solar Orbiter AIT testbed (Stevenage)

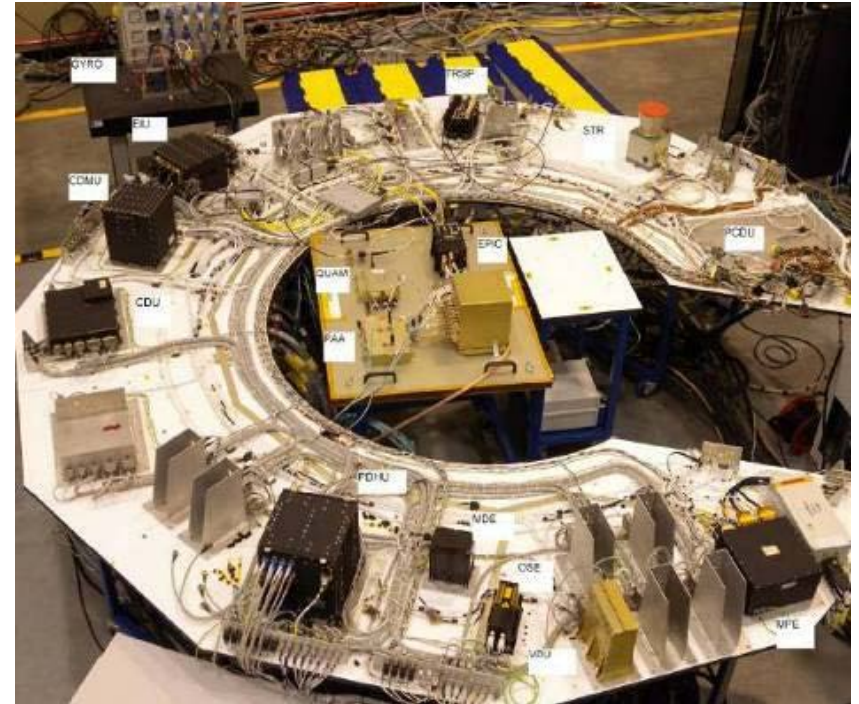


iSAFT 1553 BC Simulator and iSAFT SpaceWire / MIL-STD-1553 Recorder at the MTG-LI TE testbench (Milano)



Validation at the GAIA avionics test bench (AVM) in Toulouse

- Simulated a real avionics equipment with respect to other avionics units at MIL-STD-1553B bus level.
- Simulated at data bus level one of the seven Video Processing Unit (VPU) of the Gaia payload with respect to the Central Data Management Unit (CDMU), the main computer of the spacecraft.
- Monitored the MIL-1553B bus traffic.
- All the test scenarios were executed successfully and all tests have passed.



Validation at the Solar Orbiter AIT Testbed in Stevenage

- Validation of PVS SpaceWire Recorder (Solar Orbiter SimFE and CCS)
- Validation of PVS SpaceWire Simulator (simulation models execution)
- Validation of PVS SpaceWire SIIS (payload instrument simulation model execution and PUS-based telecommands based on SCOS 2000)
- The relative test scenarios were executed successfully and all tests have passed.

The screenshot displays the TSC software interface. The main window is titled 'TSC' and contains several panes:

- Commands:** A table listing various telecommands with their IDs, names, and parameters.
- Manual Commands:** A text area containing manual test commands.
- Log:** A list of execution events with source, time, and message.

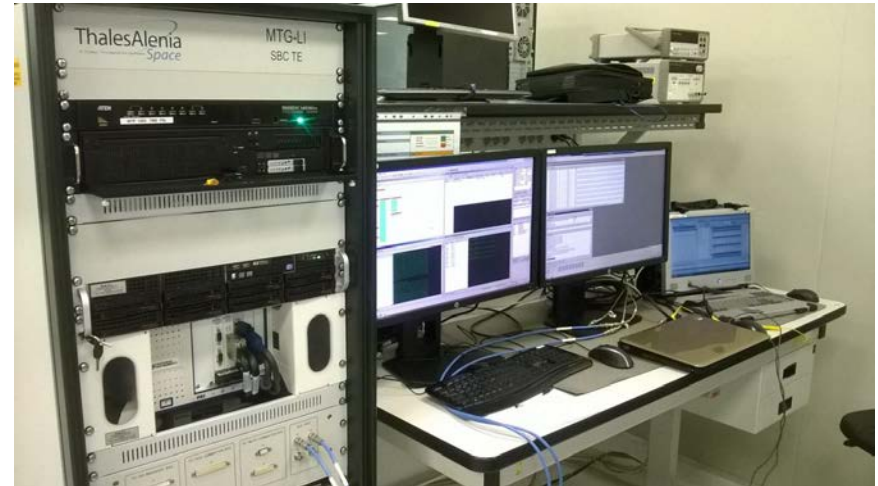
ID	Info	Raw	Eng	APID	Type	Subtype
ZIC00330	MODE_GOTO_SAFE			1372	255	18
ZIC00335	HVPS_ENABLE			1372	255	200
ZIC00340	HVPS_DISABLE			1372	255	201
ZIC00345	SCALE_TOGGLE_LVDT			1372	255	148
ZIC00350	SFM_UNLATCH			1372	255	149
ZIC00355	MCP_SET_OPS_HV			1372	255	202
ZIC00360	MCP_SET_ENG_HV			1372	255	203
ZIC00365	MEM_COPY			1372	255	19
ZIC00370	SCIENCE_SWITCH_APID			1372	255	20
ZIC00375	MARKER_SET_STEP			1372	255	21
ZIC00380	SFM_DRIVE_OFF			1372	255	150
ZIC00385	PARAMETER_UPDATE			1372	255	22
ZIC01000	HK_ENABLE_REPORT			1372	3	5
ZIC01005	HK_DISABLE_REPORT			1372	3	6
ZIC01010	HK_UPDATE_INTERVAL			1372	3	129
ZIC0C000	CONNECTION_TEST			1372	17	1
ZIC0M000	MEMORY_LOAD			1372	6	2
ZIC0M005	MEMORY_DUMP			1372	6	5
ZIC0M010	MEMORY_CHECK			1372	6	9

The Log pane shows the following messages:

```
TSC 2015-06-19T09:36:37.645 TCD loading C:/Users/LocalUser/Documents/TESTENV/data/ASCIITcd.dat
TSC 2015-06-19T09:36:37.645 readTCD definition: 1372, 0x8800, D"
TSC 2015-06-19T09:36:37.645 TCD read 1 line(s)
TSC 2015-06-19T09:36:37.645 EDEN: loaded data-source MIB data/ASCII"
TSC 2015-06-19T09:36:37.647 EDEN: EGSE Server started listening on port 10000, supporting 1 client(s)
TSC 2015-06-19T09:36:37.708 EDEN: 0x8800 socket disconnected"
TSC 2015-06-19T09:36:43.808 EDEN: 0x8800 socket host "192.168.30.61" lookup...
TSC 2015-06-19T09:36:43.823 EDEN: 0x8800 socket connecting (port=8123)...
TSC 2015-06-19T09:36:43.839 EDEN: 0x8800 socket connected"
TSC 2015-06-19T09:36:53.063 EDEN: TC with id '2' acknowledged with status '0"
```

Validation at the TAS-I MTG-LI TE testbench in Milano

- The integration of iSAFT PVS in the TAS-I MTG-LI TE testbench in Milano was performed successfully and no issues or technical difficulties were encountered.
- The remote command and control of iSAFT PVS from the Echo TCC via EDEN protocol was successful and no problems at TC/TM exchange or at TCP communication level were encountered.
- The communication at the 1553 bus and the operation of iSAFT PVS as BC simulator and Recorder was successful and no errors or issues were encountered at the 1553 bus exchange level.



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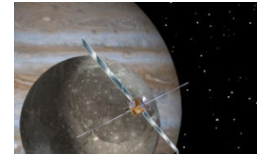
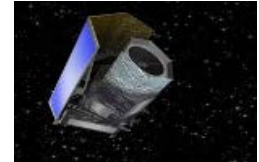
The iSAFT PVS roadmap with respect to EGSEs and Technology includes:

■ iSAFT PVS Roadmap - EGSE related

- iSAFT products will form the heart of a high complexity EGSE for the EUCLID mission, involving multiple Spacewire, MIL-STD-1553, power, discrete I/O interfaces.
- Participation in bids for Science Missions, Earth Observation Missions, Other Commercial EGSE.

■ iSAFT PVS Roadmap – Technology related

- Support for TTEthernet.
- Support for SpaceFibre.
- Support of TM/TC FEE processing functionality.
- Scripting Languages and APIs support.





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