Protocol Validation System (PVS) for On-Board Communications:

Extensions and Evolutions to EGSE Requirements

December 2015

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Presentation Contents

- 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 – ESA Contracts & Rationale**

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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 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.

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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

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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.

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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
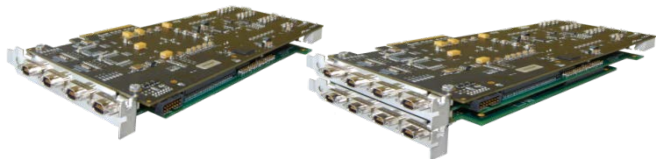
Quad/Octal SpaceWire PCIe NIC
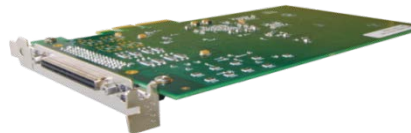
Dual 1553 1Mbit PCIe NIC

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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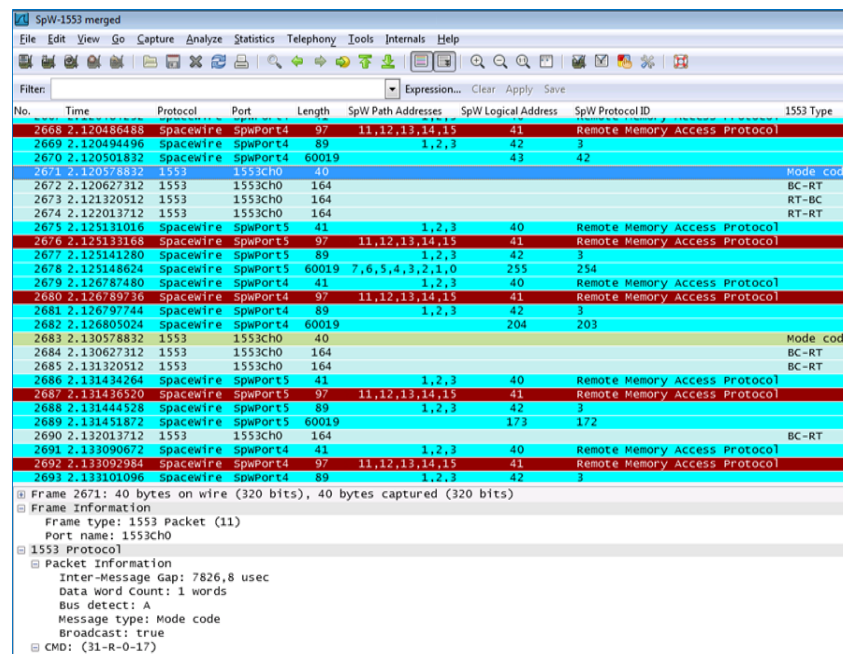
iSAFT SpW / MIL-STD-1553 / CAN Recorder

- 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.

CCS

EGSE SCOE Interface (Ethernet)

iSAFT Recorder

MIL-STD-1553

| Sensor 1 Nominal | OBC1 (Nominal) |
| Dual Redundant 1553 Bus 1 |
| Dual Redundant 1553 Bus 2 |
| Sensor 2 Redundant | OBC2 Redundant |

SpaceWire

SpW Switch

Processor Module
Memory Module
⋮
SpW Node x
⋮
Telemetry Module

SpW Switch

CAN

| Sensor 1 Nominal | Sensor 3 Nominal |
| CAN Bus Nominal | RTU |
| CAN Bus Redundant |
| Sensor 2 Redundant |

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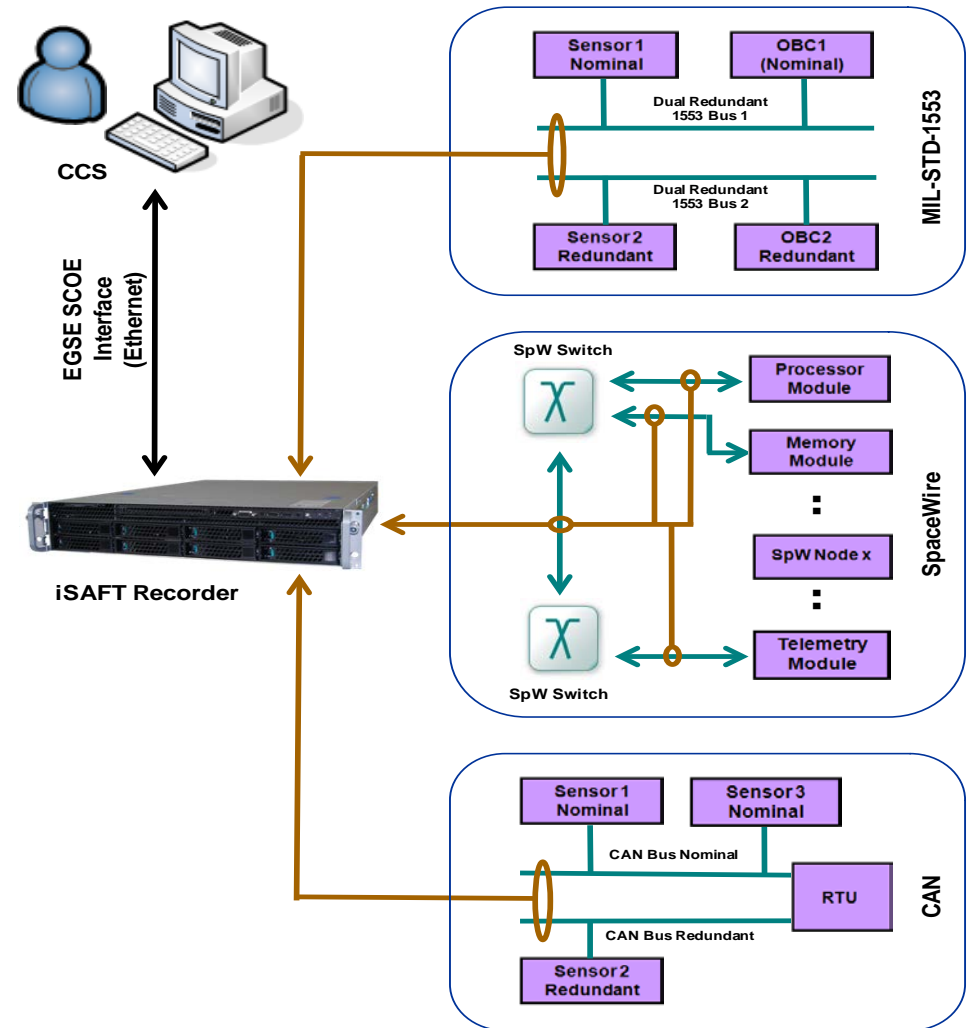
iSAFT SpaceWire Recorder

- 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.

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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.

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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

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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.).
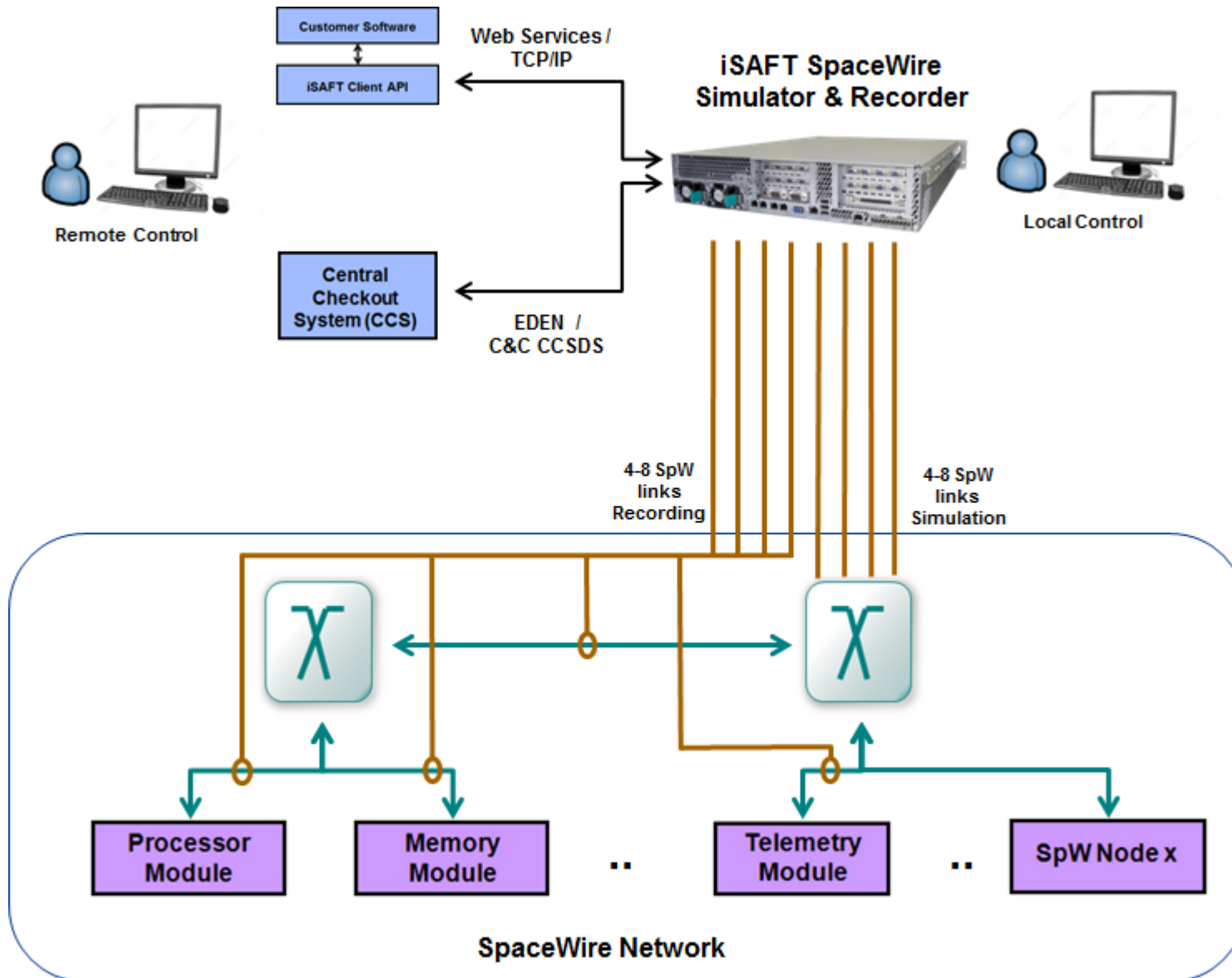
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Case Study: iSAFT SpaceWire Simulator

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.
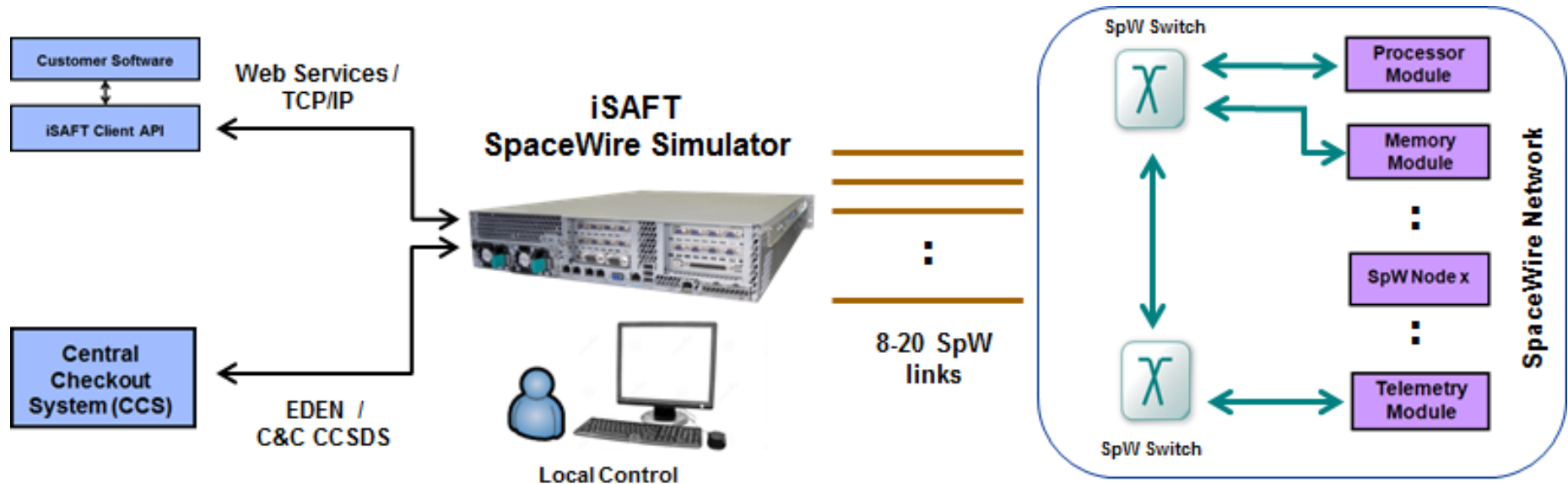
# Case Study: iSAFT SpaceWire Simulator & Recorder

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.

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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.
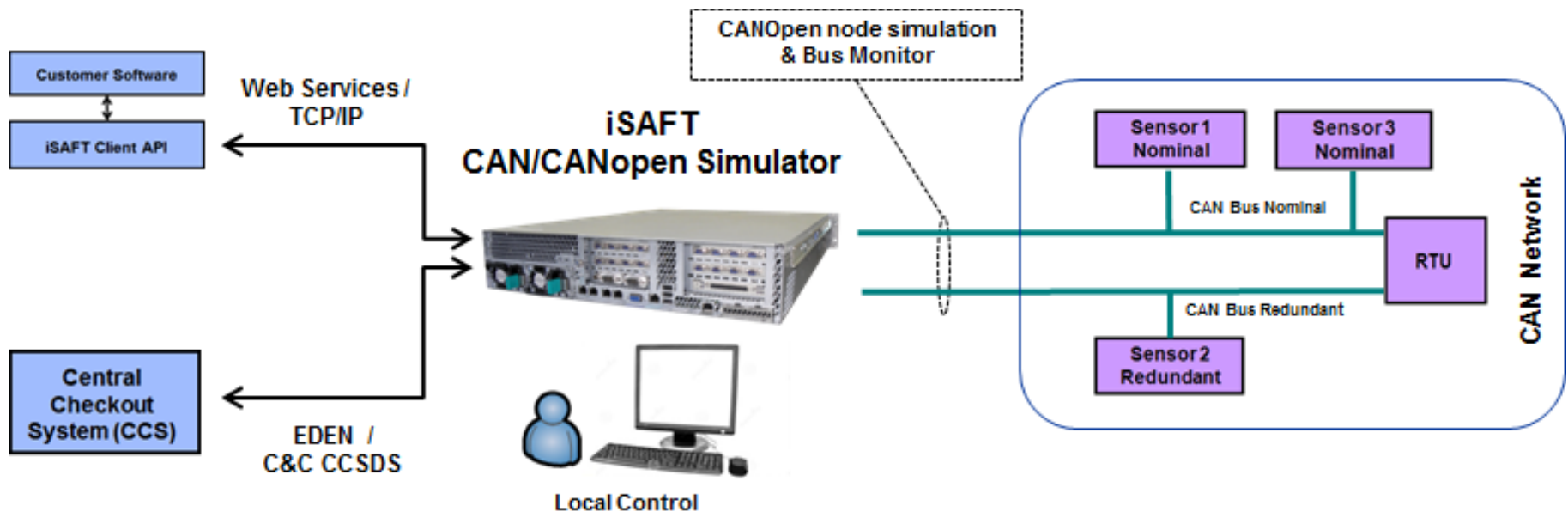

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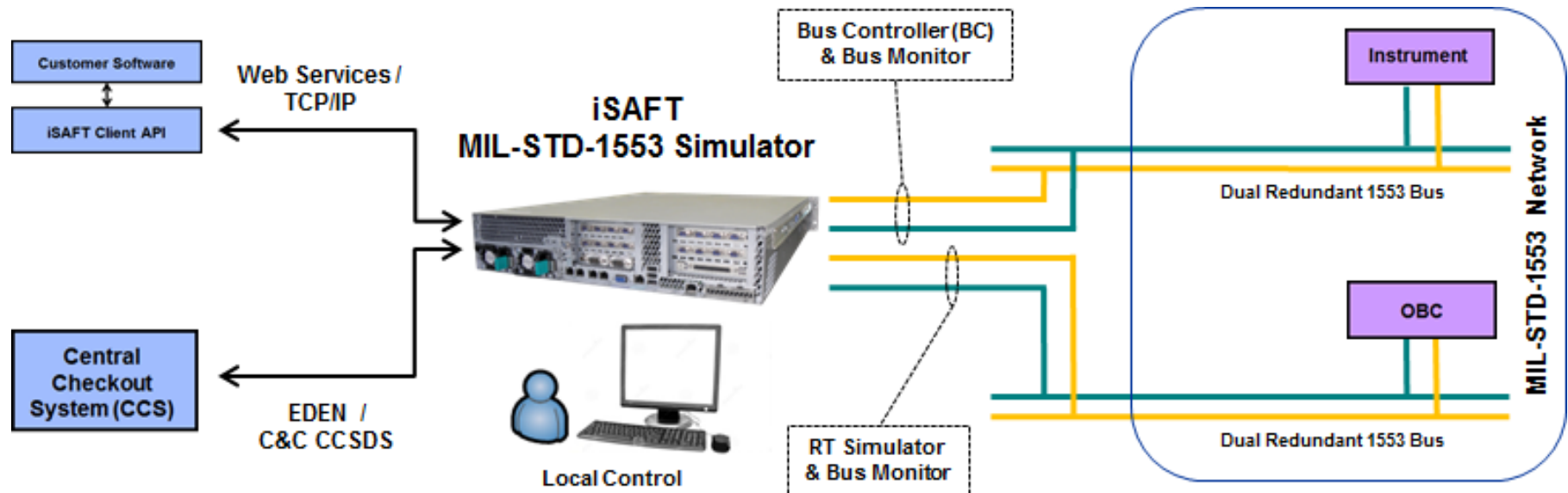
iSAFT CAN/CANopen Simulator

- 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.

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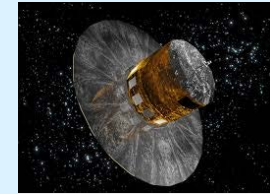
SpW/1553 Recorder & iSAFT SpW Simulator at the Solar Orbiter AIT testbed (Stevenage)

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

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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.

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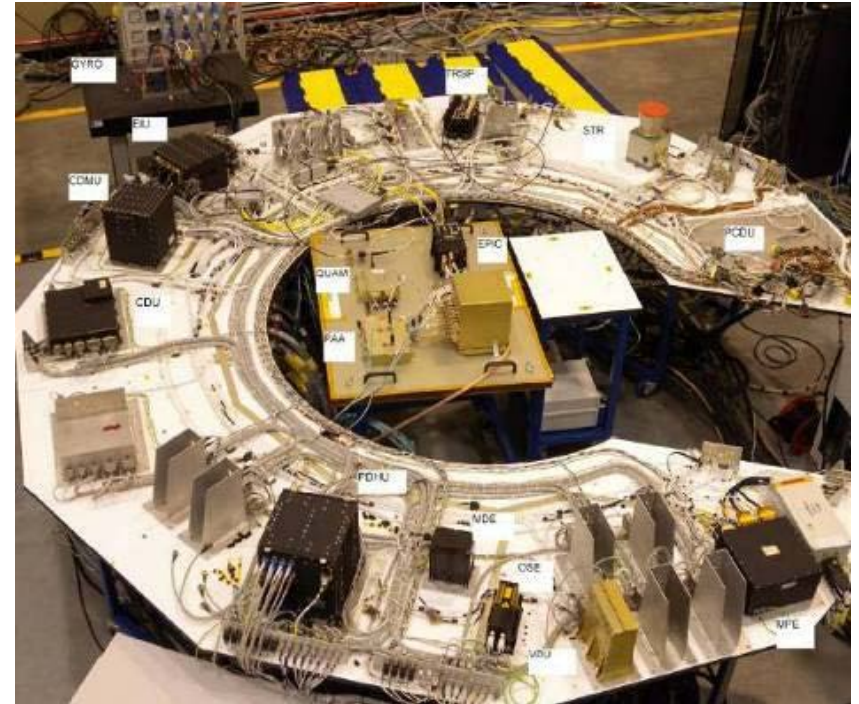
Validation at the Solar Orbiter AIT Testbed in Stevenage

- 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.

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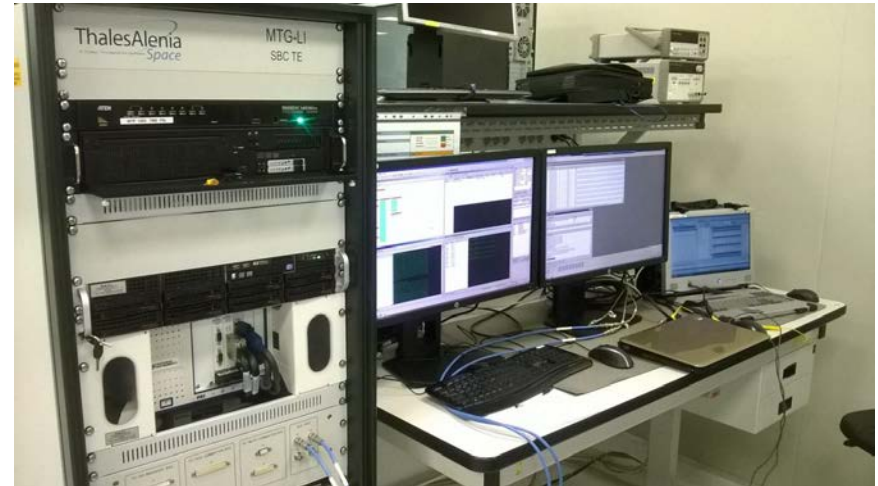
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The iSAFT PVS roadmap with respect to EGSEs and Technology includes:

■ **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.
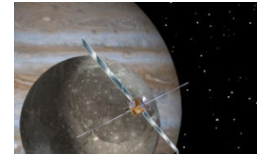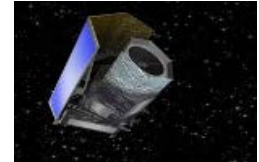
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