SpaceWire Test and Demonstration utilising the Integrated Payload Processing Module

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Short Paper

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Abstract

A demonstration platform called SpaceWire Test & Demonstration Platform (SpW TDP) is being set up in the Avionics/Data laboratory of the On-Board Data Systems Division at ESTEC. The TDP will be used to perform Onboard Data Handling related research and demonstrations with focus on SpaceWire network and protocols. The first version, TDP 1.0, will be tailored to resemble a simplified onboard data handling system which communicates with a simulated ground station for telemetry (both House Keeping and science TM) and telecommand. Its implementation will be based on the Integrated Payload Processing Modules (IPPM) and complementary demonstration equipment.

1 Introduction

A demonstration platform called SpaceWire Test & Demonstration Platform (SpW TDP) is being set up in the Avionics/Data laboratory of the On-Board Data Systems Division at ESTEC. The TDP will be used to perform Onboard Data Handling related research and demonstrations with focus on SpaceWire network and protocols. The first version TDP 1.0 will be tailored to resemble a simplified onboard data handling system which communicates with a simulated ground station for telemetry (both House Keeping and science TM) and telecommand.

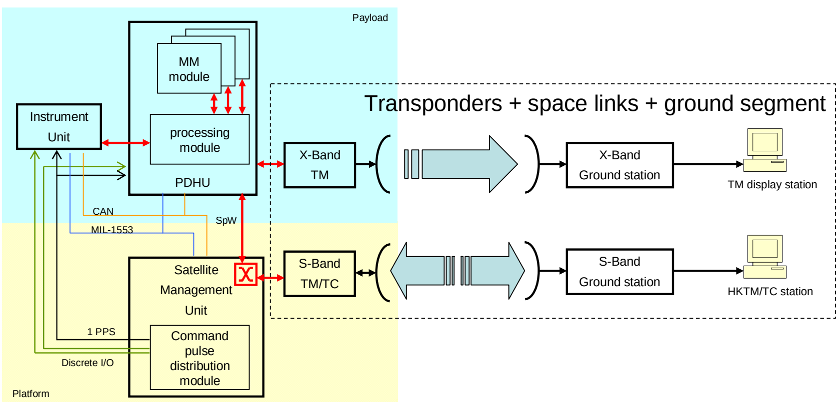

Figure 1: Functional overview of the OBDH demonstration (TDS 1.0).

2 ELEMENTS OF THE TEST & DEMONSTRATION PLATFORM 1.0

2.1 THE INTEGRATED PAYLOAD PROCESSING MODULE

A versatile onboard computer and storage system called IPPM [1], based on the Leon2-FT processor (AT697 ASIC), was developed in the frame of the ESA contract 18780/04/NL/LvH. The IPPM embeds a UoD-SpW-10X routing switch, supporting 8 high speed external SpW links while the two parallel links are connected to a Control and Communication FPGA. The support for the Remote Memory Access Protocol (RMAP) has been embedded in the Control and Communication FPGA, which allows for remote access of the IPPM I/O space over SpaceWire. For low medium rate applications such as for command and control, it also features redundant CAN and MIL-1553B links. The IPPM features, in addition, 262MB of on-board memory which is accessible via the Remote Memory Access Protocol (RMAP).

The IPPM provides the processing capability as well as all the standard interfaces to investigate the use of SpaceWire-based protocols with respect to current OBDH systems based on “classical” buses and protocols and on discrete lines.

2.2 RTEMS

RTEMS is an Open Source RTOS providing a powerful development and run-time environment that promotes the production of efficient real-time embedded applications. The current release 4.9 has been selected as the operating system to be used for each of the IPPM boards. Applications on each of the IPPM units are developed to conform to services defined in ECSS-E-70-41A. The selection of RTEMS is rooted firstly by its support by the European Space Agency related to the RTEMS Centre [10] and secondly by its use in several space projects. SMU’s used for the ESA missions such as Herschel, Plank and GAIA, to name a few, make use of RTEMS on SPARC architecture onboard computers.

Coupling RTEMS with SpaceWire related development activities on the TDP intends to identify requirements and constraints at both SW and HW level, as well as best practices for implementation.

2.3 PACKET UTILISATION STANDARD

The Packet Utilisation Standard (PUS), ECSS-E-70-41A, defines standard services for onboard components, which address the utilisation of telecommand and telemetry source packets. The ECSS-E-70-41A is a comprehensive standard which, in the frame of the development of the TDP 1.0, has been limited to include a sub-set of the services defined in Telecommand Verification Service, Device Command Distribution Service, Memory Management Service and Function Management Service.

PUS is an element of the TDP not only because it provides a standard application process layer and its extensive use in ESA missions, but also because it allows experiments to be performed when introducing newer SpW protocols on an RTEMS based onboard system.

3 ARCHITECTURE OF THE TEST & DEMONSTRATION PLATFORM 1.0

The demonstration platform is based on three IPPM boards. It includes complementary demonstration equipment to obtain Mass Memory functionality, and a TM/TC and Display unit that serves as a Ground Control Unit (GCU). The overall demonstration set-up aims at resembling a simplified onboard data handling system which communicates with a simulated ground station for telecommand uplink and HK and science telemetry downlink. Each of the three IPPM boards will have a dedicated role as an onboard data handling unit. One IPPM board will act as an Instrument Control Unit (ICU), while the other two boards act as Processing Module for the Payload Data Handling Unit (PDHU) and as Satellite Management Unit (SMU). Each IPPM board will be running RTEMS as Operating System (OS) as well as applications that support a subset of services in accordance with the Packet Utilisation Standard [6].

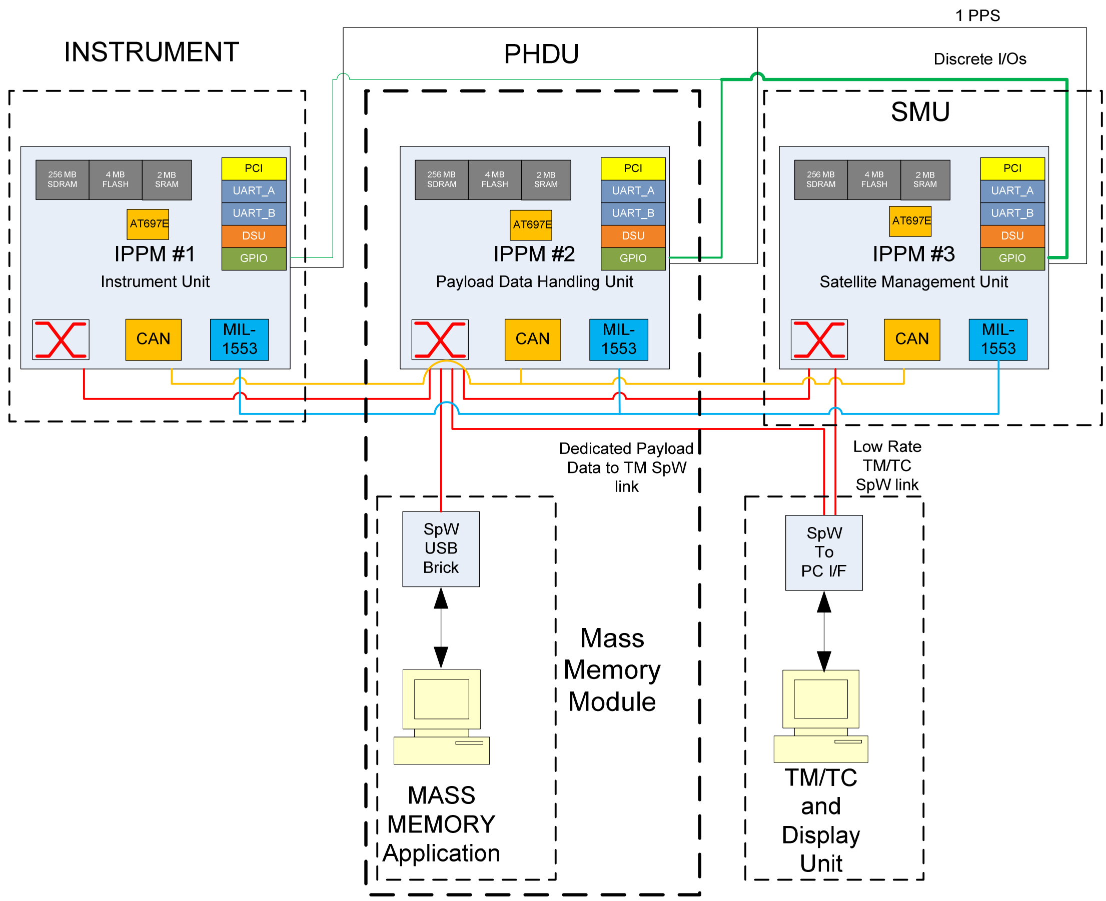

Figure 2: SpaceWire Demonstration Set-up baseline.

4 SPACEWIRE DEMONSTRATION SCENARIOS

4.1 TEST AND VALIDATE SPW NETWORK TOPOLOGIES AND SPW-ENABLED DEVICES

The features of the IPPM board will first and foremost be exploited in the demonstration baseline to identify best practices for SpaceWire network topologies e.g. redundancy schemes and use of current SpW networking protocols RMAP[9] and CCSDS Packet Encapsulation, defined in the soon to be released ECSS-E-50-11 standard [5]. Further, by inclusion of other units to the demonstration baseline, it will be used to establish and demonstrate best practices for current and near-coming use of SpW-enabled devices. To highlight some candidates one could mention e.g. general purpose processing SPARC/Leon2 nodes (SpW-RTC, ERC32, LEON-2 board), dedicated processing modules (compression, FFT, etc), and Non-intelligent nodes with no processing capabilities (sensors and instruments, I/O boards etc.). In essence, the demonstration baseline may be utilised to validate future SpW-enabled devices towards current SpW-based data handling systems.

4.2 INVESTIGATE SPW-BASED TIME DISTRIBUTION

The Pulse Per Second (PPS) signal is a common time distribution solution for onboard systems. As the IPPM features GPIO ports, the capability to distribute PPS is incorporated in the TDP 1.0 baseline. One demonstration scenario is to perform time distribution (for clock synchronisation), a pre-requisite for Command & Control protocols, using SpW time-codes, and to compare this “SpW time” with the “PPS time”. This demonstration scenario will take into account different network topologies and link failure scenarios. If the “SpW time” proves to satisfy Cmd&Ctrl application, SpW time codes could replace the PPS signal in OBDH systems.

4.3 PROTOTYPING AND VALIDATING SPW-BASED PROTOCOLS

At present, there are several parallel initiatives ongoing to develop standardised protocols, e.g. SpW PnP [2,3] and SpW-RT [7] to be used on top of SpaceWire. Utilising the IPPM for this purpose is beneficial as it embeds several of the most recent technology advances, such as the SpaceWire Router 10x, AT697E Leon2 processor and SpW RMAP support. Firstly, it will facilitate answering questions regarding not only how these protocols must be defined, but also if they are compatible with each other. Secondly, exercising these protocols from the IPPM will allow identifying requirements from a software point-of-view when utilising Real Time Operating Systems such as RTEMS.

Similarly, the SpaceWire, CAN and MIL-STD1553 bus interfaces in conjunction with its processing capabilities provided by the IPPM, make the IPPM good candidate for experimentation related to CCSDS Spacecraft Onboard Interface Services initiative (CCSDS SOIS) [8]. The primary objective of the CCSDS SOIS standard development activities is to radically improve the spacecraft flight segment data systems design and development process by defining generic services that will simplify the way flight software interacts with flight hardware and permitting interoperability and reusability both for the benefit of Agencies and Industrial contractors.

5 CONCLUSION

In this paper, the SpaceWire Test & Demonstration Platform 1.0 baseline has been discussed with view towards current and future SpaceWire related development activities. The features of the IPPM make it an ideal candidate for experimentation and validation of SpaceWire-enabled equipment, SpaceWire network topology and protocols as well as software applications for RTEMS aimed at conforming to the CCSDS SOIS recommendations and to the ECSS Packet Utilization Standard.

Future expansion of the basic set-up is foreseen to accommodate SpaceWire equipment based on the next generation of application specific standard products (ASSP) such as the SpW-RTC, which is an ideal candidate component for advanced instrument interfaces due to its Leon2-based architecture.

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