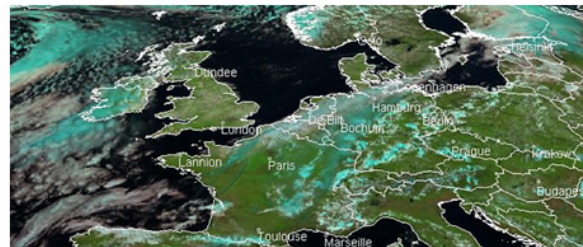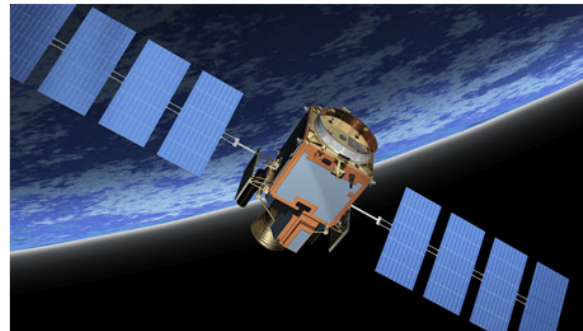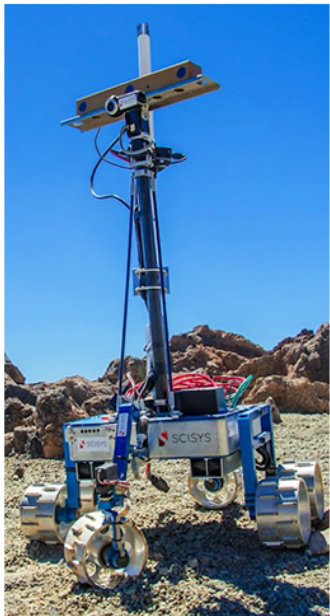# Progress on the Definition of Electronic Data Sheets for Onboard Devices
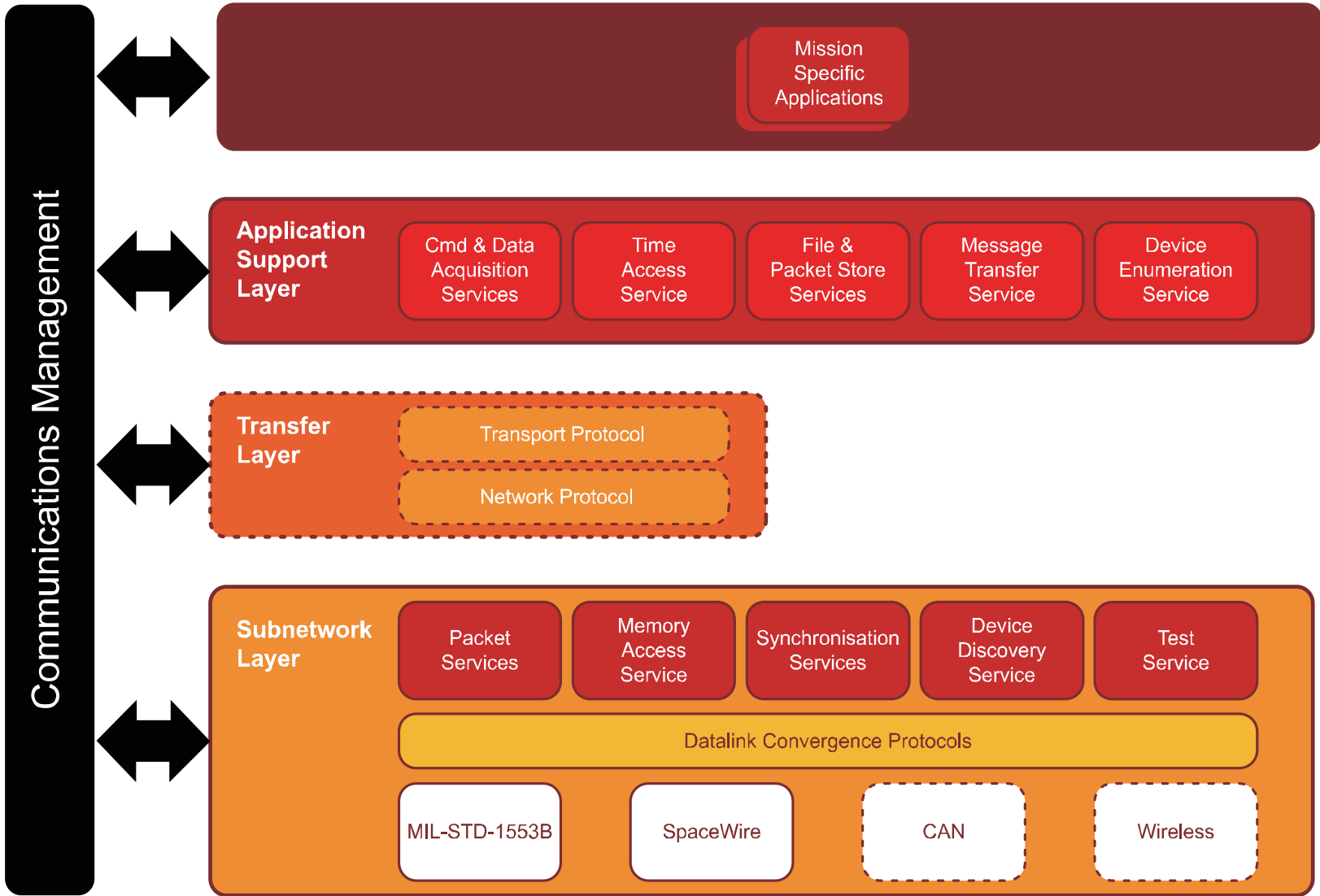
CCSDS SOIS WG and ESA TRP Project

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23rd October 2012

Introduction

- The CCSDS SOIS area was formed to improve the standardisation of the onboard avionics
- Originally, this was restricted to onboard buses and interfaces to payloads, but has evolved to align with the similar goals of the SAVOIR initiative

- There are now a suite of SOIS service specifications either published or in agency review
- All SOIS publications will be adopted as ESA standards

- Having defined a set of services and logical interfaces, emphasis is now being placed on the use of electronic data sheets (EDS) to further support the standardisation process
- The use of EDS is not restricted to the SOIS domain and there is now general interest in using electronic definitions to supplement the more traditional paper definitions

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CCSDS SOIS Reference Communications Architecture

Communications Management

Mission Specific Applications

Application Support Layer
- Cmd & Data Acquisition Services
- Time Access Service
- File & Packet Store Services
- Message Transfer Service
- Device Enumeration Service

Transfer Layer
- Transport Protocol
- Network Protocol

Subnetwork Layer
- Packet Services
- Memory Access Service
- Synchronisation Services
- Device Discovery Service
- Test Service

Datalink Convergence Protocols

- MIL-STD-1553B
- SpaceWire
- CAN
- Wireless

CCSDS SOIS Standards – Current Status

- Informational Report (Green Book)
  - » Issue 1 published June 2007
  - » Issue 2 agreed by CCSDS to be published

- Subnetwork Services
  - » Packet, Memory Access, Synchronisation, Device Discovery and Test Services all published as Magenta Books December 2009

- Application Support Services
  - » Time Access Service published as Magenta Book January 2011
  - » File and Packet Store Services published as Magenta Book September 2012
  - » Device Access, Device Data Pooling and Message Transfer Services under publication
  - » Device Virtualisation and Device Enumeration Services in process of being put out for 1st agency review

- Published Standards
  - » http://public.ccsds.org/

- Latest Draft Standards
  - » Please contact: stuart.fowell@scisys.co.uk (WG chair)
    chris.taylor@esa.int (Area lead)

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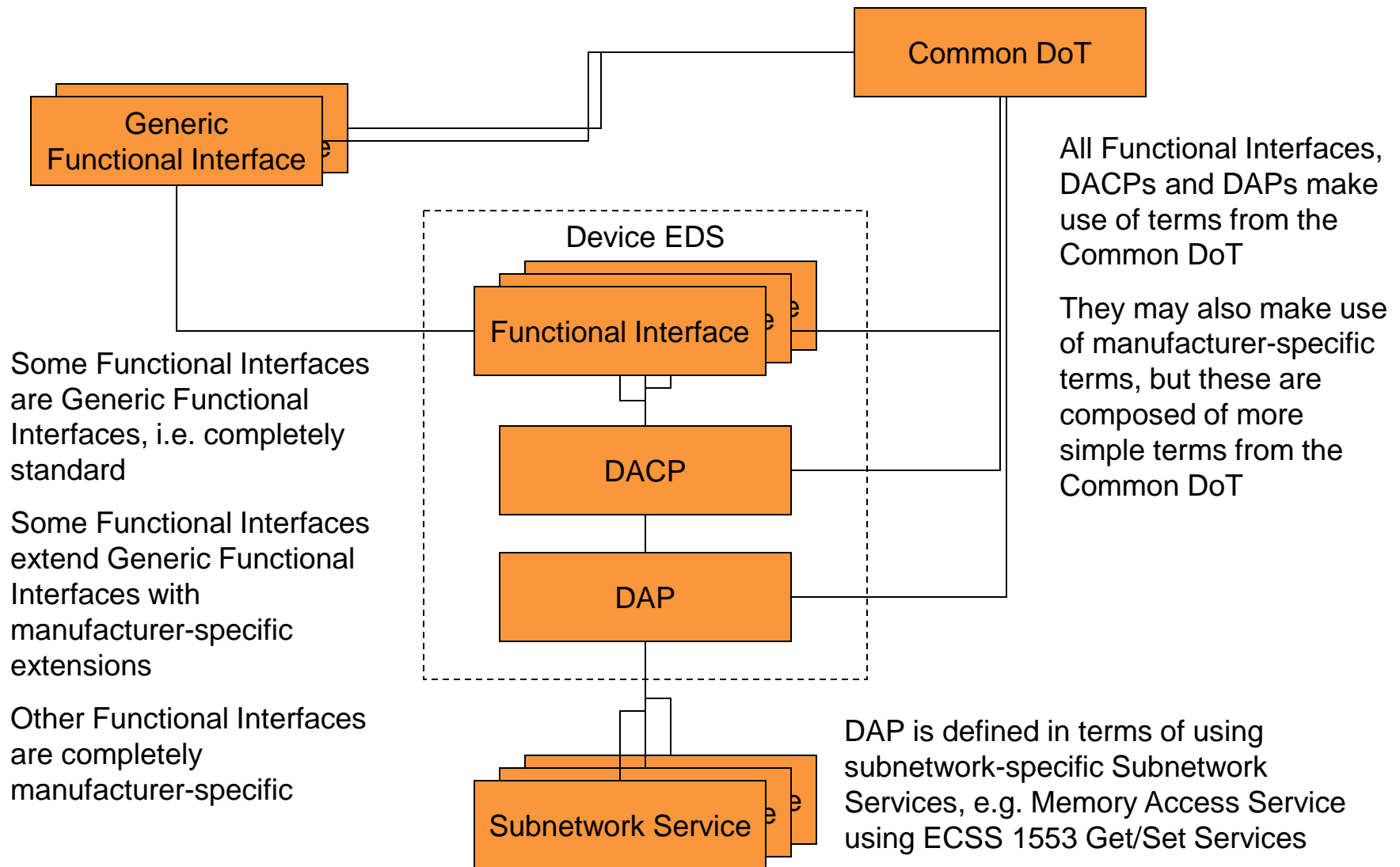# SOIS Device Commanding and Data Acquisition
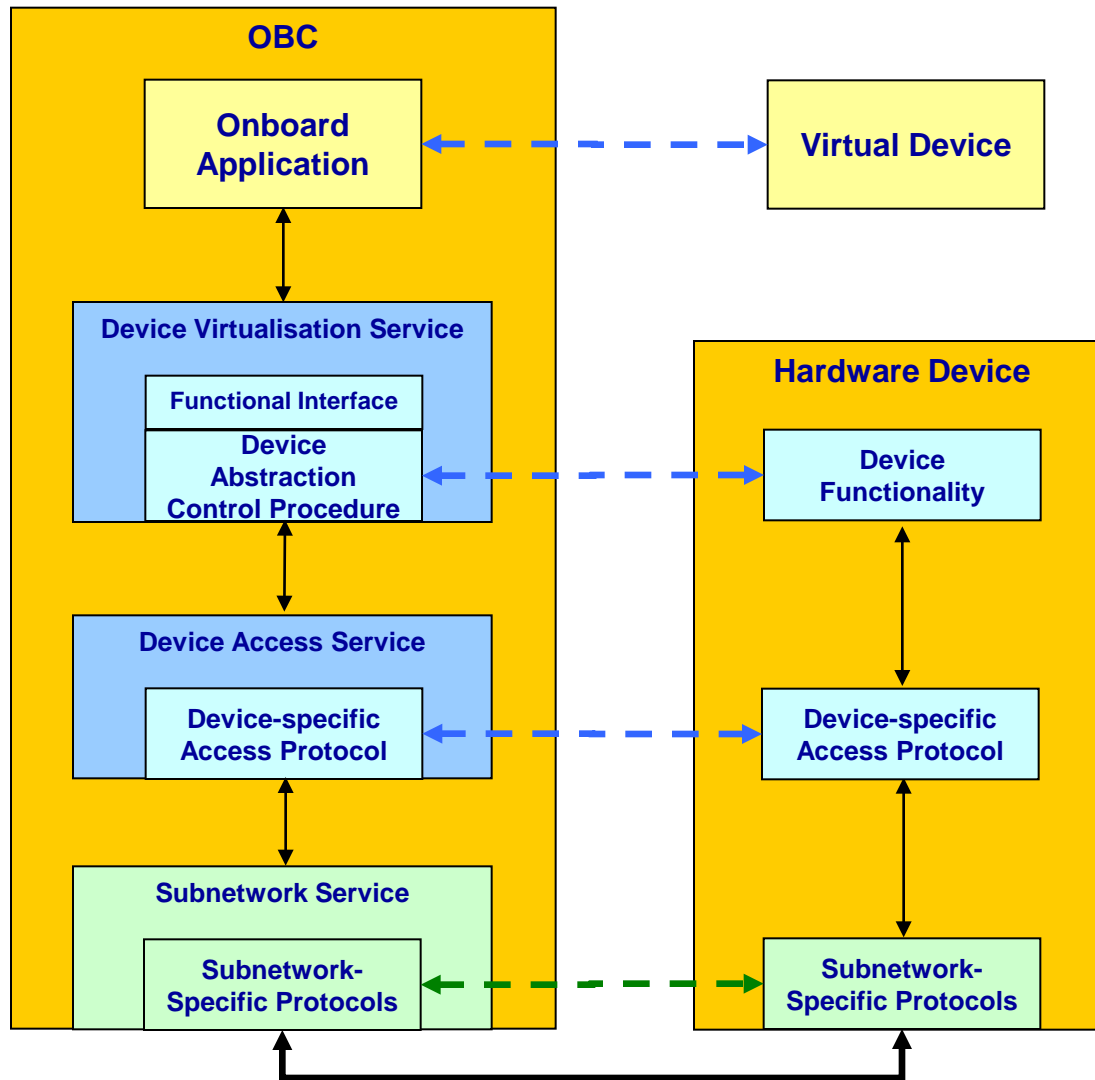
- Generic Functional Interface
  - » Functionality common to a device type
- Device Abstraction Control Procedure
  - » Type conversions, operations, state-machine
  - » How the Functional Interface is mapped onto the device-specific access protocols
- Device-specific Access Protocol
  - » How to command and acquire raw data for specific devices using subnetwork-specific protocols, e.g. packet structures
  - » State machine
- Subnetwork-specific Protocol
  - » How to transfer data to/from device across subnetwork
  - » QoS: ack, retransmit, priority etc.

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Electronic Data Sheets replacing Device ICDs

- Such information for a device is typically provided within an ICD
  - » Paper document
  - » Different formats from different organisations
  - » Potentially different levels of documentation
  - » Testable for inconsistencies with implemented device?
  - » Manual translation of ICDs
    - > OBSW development
    - > Spacecraft databases
    - > Simulators
    - > Mission Control System databases
    - > Others?

- Define Electronic Data Sheets to replace ICDs
  - » Capture electronically all information
  - » Check that all information provided
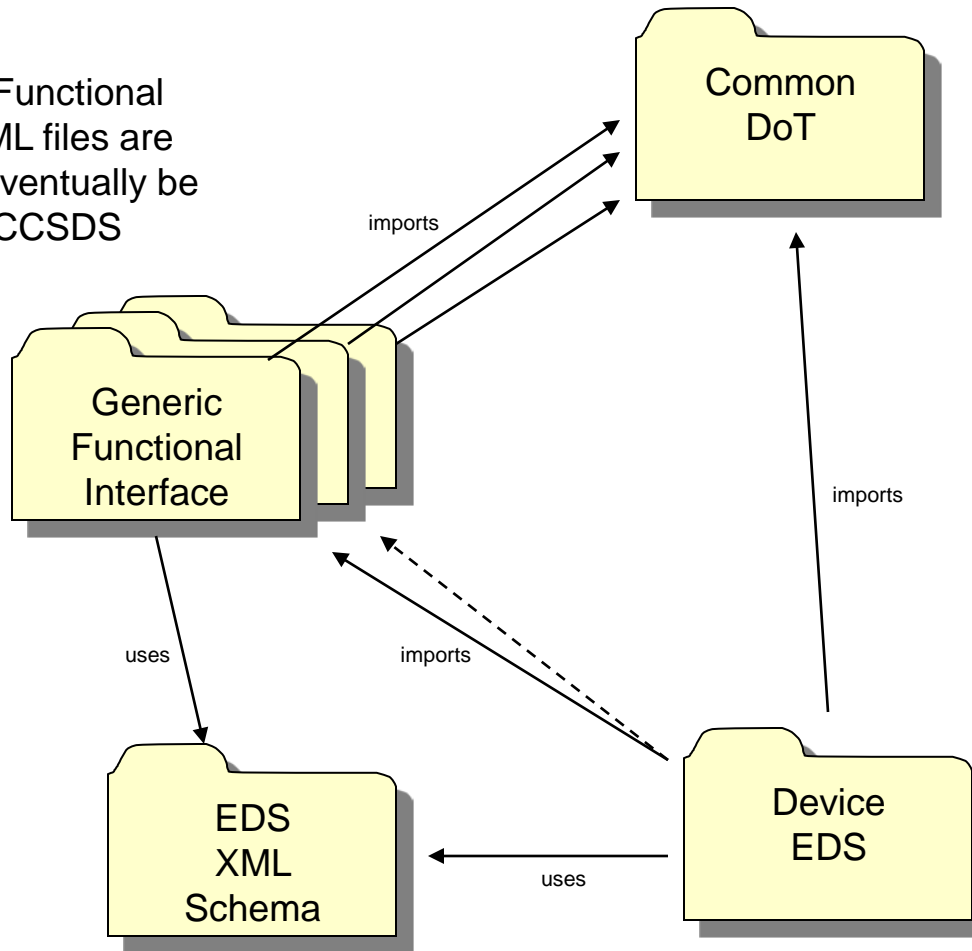 - » Auto-generation of OBSW, test harnesses, databases, ICDs, etc.

EDS and Common DoT Relationships and Structure

Common DoT

Generic Functional Interface

Device EDS

Functional Interface

DACP

DAP

Subnetwork Service

All Functional Interfaces, DACPs and DAPs make use of terms from the Common DoT

They may also make use of manufacturer-specific terms, but these are composed of more simple terms from the Common DoT

Some Functional Interfaces are Generic Functional Interfaces, i.e. completely standard

Some Functional Interfaces extend Generic Functional Interfaces with manufacturer-specific extensions

Other Functional Interfaces are completely manufacturer-specific

DAP is defined in terms of using subnetwork-specific Subnetwork Services, e.g. Memory Access Service using ECSS 1553 Get/Set Services

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XML Representation

The Generic Functional Interfaces' XML files are expected to eventually be managed by CCSDS SANA

The Common DoT XML file is managed by CCSDS SANA

Common DoT

Generic Functional Interface

imports

imports

Each device has it's own EDS

An EDS may be incomplete, e.g. a device EDS supplied by a manufacturer need not have any Functional Interfaces. Conversely an EDS used for device simulation in software testing may only have a Functional Interface

uses

imports

The EDS XML Schema file is managed by CCSDS SANA

EDS XML Schema

Device EDS

uses

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CCSDS SOIS Electronic Data Sheets Work Plan

- Electronic Data Sheets for Onboard Devices
  - » Specification – Magenta Book
  - » XML Schema
  - » Led by ESA from TRP Activity
- Common Dictionary of Terms
  - » Specification – Magenta Book
  - » Online dictionary managed by CCSDS SANA
  - » Led by NASA from SPA Ontology
- Not covered by SOIS but possible future work
  - » Generic Functional Interface per Device Class

- Work Plan:
  - » 1st complete draft of Books and XML Schemas for Spring 2013 meeting
  - » Prototyping example device EDS with device-specific functional interfaces
  - » Refine Books and XML Schemas for Fall 2013 meeting
  - » Possible prototype device EDS with generic functional interfaces
  - » 1st Agency Review of Books and XML Schemas for Spring 2014 meeting
  - » CESG Poll for publication of Books and XML Schemas for Fall 2014 meeting
  - » Publish Books and XML Schema End of 2014

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Relationship with Avionics Architectures

- SAVOIR
  - » SOIS Command and Data Acquisition Services part of the SAVOIR-FAIRE Execution Platform
  - » Functional Interface mapping onto Pseudo-Components in Component Model
  - » Auto-generation of DAS/DVS from Device EDS fits within auto-generation of Execution Platform

- AIAA SPA & NASA GSFC cFE
  - » Hardware and software components interact with publish-subscribe patterns to OBSW and TM/TC interface to ground segment
    - > Software-based Device Adaptors (different names used in each architecture) provide publish-subscribe interface
  - » Auto-generate Device Adaptor interfaces, published data structures and mission control system databases from EDS Functional Interface

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View of Differing Uses of SOIS EDS
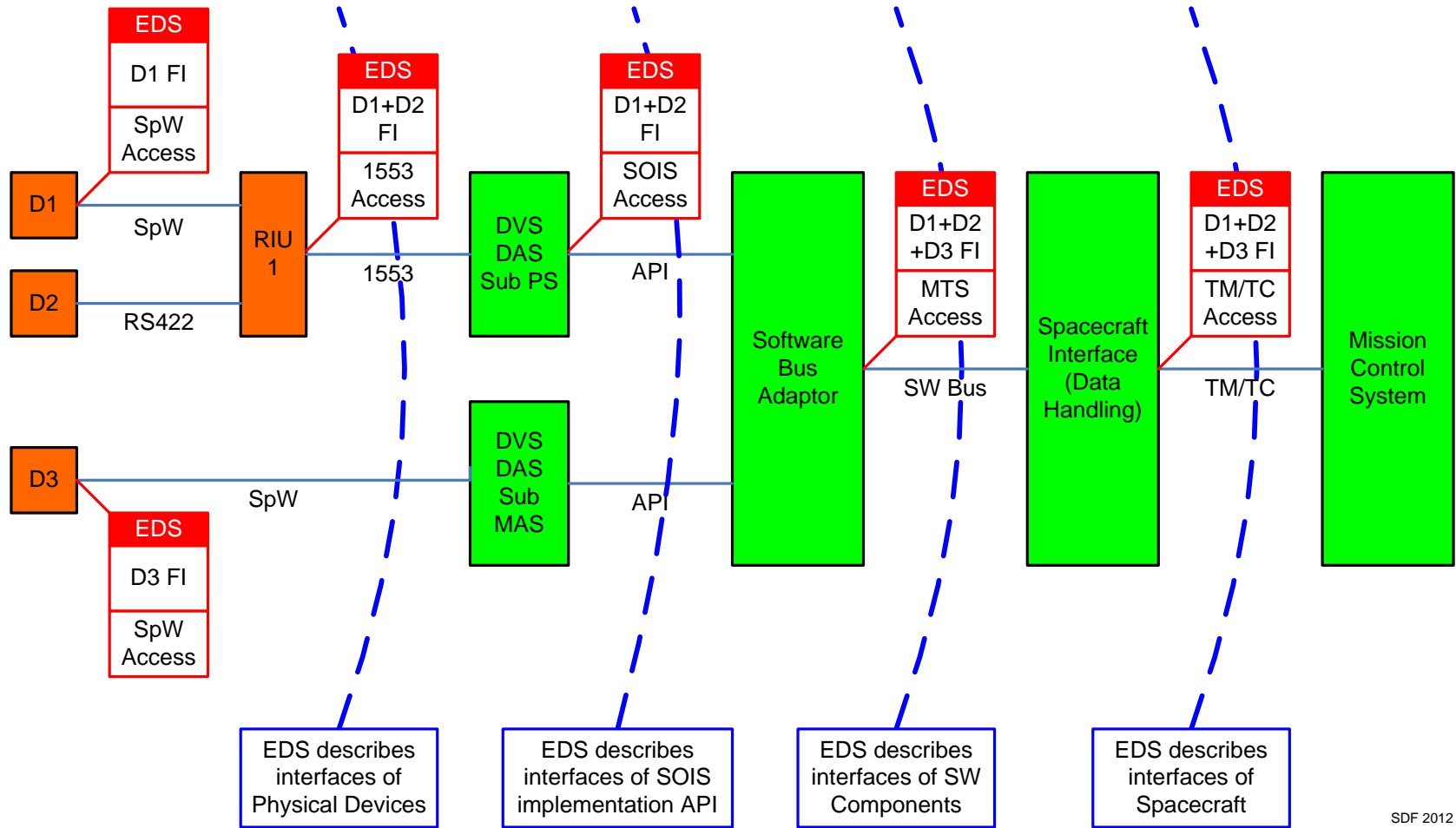
Adoption of Electronic Data Sheets and Device Virtualisation of Onboard Devices

- Project
  - » SCISYS supported by Astrium (F) and TAS-F
  - » 15 month TRP study, kicked on September 2012
- Objectives
  - » EDS Use Cases Capture and resulting Requirements
  - » Definition of EDS XML Schema and Specification
  - » Test with defining EDS from real-world ICDs
  - » Proof of Concept demonstration of code generation from EDS
- Outputs
  - » EDS XML Schema & EDS Specification draft SOIS standard
    - > In cooperation with CCSDS SOIS WG and SAVOIR
  - » Example Functional Interfaces for selected real-world devices
    - > Use of draft Common Dictionary of Terms
  - » Example EDS for selected real-world devices
  - » Proof of Concept Demonstration on RASTA
    - > EDS Editor
    - > SOIS Device Virtualisation and Device-specific Access Protocol auto-code generation
    - > ICD document generation
    - > Demonstration of OBSW using auto-generated SOIS to interface to simulated real-world devices
      - - Based on SOIS Proof of Concept software
- Current status
  - » Requirements Capture
  - » ICDs for Real-world Devices collected & being assessed
  - » Early extraction of Functional Interfaces using embryonic SOIS Common DoT

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SOIS Standards Reduce Spacecraft Costs

SOIS Overview

The Consultative Committee for Space Data Systems (CCSDS) Spacecraft On-board Interface Services (SOIS) standards are focused on radically improving the spacecraft flight segment data systems design and development process. This is achieved by defining interface services that simplify the way flight software interacts with flight hardware and will permit future missions to operate together and support the use of reuseable components for the benefit of Agencies and Industrial contractors.

Problem

Although missions often vary only slightly from each other in terms of requirements and architectures, they nevertheless develop completely new avionic hardware and software solutions. These must be developed, validated, qualified and integrated so adding costs, schedule delay and risk. The production of standard solutions that can be re-used across missions must be a more logical way to move forward.

Details

SOIS is a flexible communications architecture of protocols and services that is mapped onto a number of avionic buses typically used in spacecraft (MIL-STD-1553B, SpaceWire, CAN, etc. that are standardised by ECSS. Beyond the basic electrical interfaces provided by avionic buses, it standardises:

- subnetwork level protocols, providing packet transfer, memory access, time synchronisation, device discovery and test services
- at the higher level, it standardises services provided to flight software applications, isolating them from communication issues: device commanding and data acquisition, file and packet store access, messaging, on-board time access

Solution

SOIS Reference Communications Architecture

Reference Implementation

SCISYS has led a number of activities for ESA developing a reference implementation of the SOIS Services. This has been deployed on ESA's RASTA Test Facility in the Avionics Laboratory at ESTEC providing communication across both MIL-STD-1553B and SpaceWire. In addition, it is being used to demonstrate the use of the services in a reference avionics subsystem in the MARC system.

MARC Demonstration System

The CCSDS are developing the Spacecraft Onboard Interface Services (SOIS) set of standards to addresses this problem, by:

- **Increasing reuse of avionic components**
  - through a standard yet flexible interface, addressing multiple mission requirements rather than just a narrow single-project focus (not "re-inventing the wheel")
  - achieving higher quality components through a better design (clean separation of interface and implementation) with less likelihood of esoteric bugs (as they are discovered through multiple use)
- **reducing risk of integration**
  - through a better architecture of hardware and software building blocks with well-designed and specified interfaces
  - components designed & tested against a standard interface
  - shorter integration through less bugs being discovered in interpretation of interfaces
- **enabling more capable missions**
  - allows introducing more capabilities building on standard services, for example:
  - dynamic reconfiguration for different spacecraft modes through use of plug-and-play components, reducing the need for complex offline configuration and build processes or online FDIR and mode control
  - complex applications such as onboard autonomy through the use of software buses
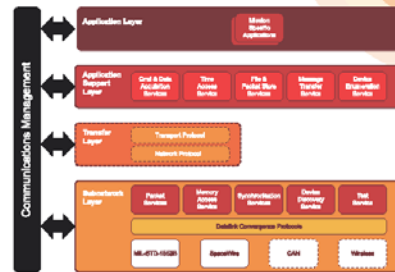
Further Information

The SOIS standards are published by the CCSDS and can be found on their website (www.ccsds.org). The CCSDS SOIS Working Group (sois@mailman.ccsds.org) is responsible for the on-going development of these. For further information of SOIS standards and the reference implementation, please contact SCISYS using the details below.