Integrating CCSDS Electronic Data Sheets into Flight Software

Jonathan Wilmot
Jonathan.J.Wilmot@NASA.gov

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CCSDS Electronic Data Sheet Definition

• An Electronic Data Sheet (EDS) is a formal specification of a device, system, or software interface in a machine readable format
  – Unambiguous and machine verifiable specification
  – Delivered with the device, system, or software
  – It is not an Interface Control Document (ICD) in that it does not specify how a system or mission will use the device or software

• EDS specifies black box view of interfaces
  – Data formats, conversions, limits, exchange protocols, and state machines, ...

• A CCSDS Spacecraft Onboard Interface Services (SOIS) EDS (SEDS) is an EDS defined using the SOIS Dictionary of Terms and the SOIS EDS XML schema
  – Electronic Data Sheets and Common Dictionary of Terms - Overview and Rationale (Green 870.1)
  – XML Specification for Electronic Data Sheets for Onboard Devices and Software Components (Magenta 876.0)
  – Specification for Dictionary of Terms for Electronic Data Sheets for Onboard Components (Blue 876.1)
  – SEDS schema and dictionary of terms are keep in SPACE ASSIGNED NUMBER AUTHORITY(SANA) REGISTRY http://sanaregistry.org/r/sois/sois.html
Device and Software Component EDS

Vision: device manufactures provide an EDS with each component

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Use in Early Mission Design

• Automated tools used for device selection based on mission parameters
  – Orbit, lifetime, performance...
• Automated tools can generate system specs and cost estimates
• Mission designers review specs and cost estimates and adjusts mission parameters
• US Air Force Research Lab (AFRL) created prototype tools for this use case, Spacecraft Plug and Play (SPA)
Development and Operations Use Cases

System Models
  - Component (software) EDS
  - Device EDS
  - Designer and/or tools
    - Flight SW components
    - Models
    - Simulators
  - Test/Simulation tool/consoles
    - Test procedures
  - Ground Systems
    - Ground System Database(s)
    - Operations procedures
    - Page Displays

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Existing and Upcoming/proposed Tools

- EDS
- C headers
- ESA TASTE Models
- Device Drivers
- COSMOS Database
- ASIST Database
- XTCE
- JSON
- Simulink Data interfaces
- Flight Software
- ITOS Database
- LUA Scripts
- JSC Cmd/Tlm CCDDT
- Component tests
- ITOS Page Displays
- Models Based Systems Engineering tools
- Onboard Control Procedures

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EDS Use in NASA’s core Flight System (cFS) software

Free, open source, reliable flight software

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cFS Overview

- Layered Architecture
- Pub/Sub Messaging
- Common Services
  - Executive
  - Time
  - Message Bus
  - Events
  - Tables
  - Files
- Distributed systems
- Time/Space Partitions

Applications and libraries can be stopped, restarted, removed, and reloaded dynamically at run-time

Go get it at  https://cfs.gsfc.nasa.gov/

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cFS Software Component

- Each cFS component will have an associated SEDS
  - cFS AppStore will include both
  - Include in next release (TBR) of cFE and selected applications

- SEDS specifies the data formats, conversions, limits, commands, telemetry, and exchange protocols in terms of the cFS Software Bus
  - Protocols are in terms of command and response state machines

- The SEDS will be included in the component directory structure and be Configuration Managed with the component
EDS Is In Reference To What?

• An EDS is in reference to the “on the wire” spec from the point of view of the publisher
  – The publisher should be able to DMA the in memory representation to the network interface
  – A CFS Component EDS is written in terms of Big (Network) Endianness
    • Tools must be developed to convert to other architectures
### Standardization along Communication Stack

#### EDS Described
- Hardware or squirrels
- Comm. Cntrl.
- Connector
- Electrical I/F

#### EDS Referenced
- Comm. Protocols
- Cable

#### Application(s)
- Message Transfer Service
- Device Virtualization Service
- Device Access Service

#### Function | Example
--- | ---
Software tasks communication (software architecture specific) | publish/subscribe, etc.
Data representation (EDS describes) | Counts to units conversion
Software drivers (EDS describes) | Hardware-to-software I/F
Box-to-Box comm. Protocols (EDS reference) | SpaceWire; 1553, etc.
Conn./cable & electrical I/F | 9 pin MDM, Cat5, LVDS

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Current cFS View of SEDS  End to End

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Components and Build Time Parameters

• Each device and software component includes an associated SEDS
• SEDS specifies the data formats, conversions, limits, commands, telemetry, and exchange protocols in terms of the message bus and/or hardware interface
• Some parameter values in the message packet EDS are determined at build time
  – The original component EDS author does not know these values
  – Values are defined in mission deployment files
  – The values will be set by a tool that reads the mission files and creates a software component header file at build time
  – The EDS Schema has mechanisms for this
CCSDS SOIS EDS provides a standard mechanism to exchange interface & data definitions and automate many aspects of system development.

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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AFRL</td>
<td>Air Force Research Lab</td>
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<tr>
<td>ASIST</td>
<td>Advanced Spacecraft Integration and System Test</td>
</tr>
<tr>
<td>CCDDT</td>
<td>cFS Command &amp; Data Dictionary Tool</td>
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<tr>
<td>CCSDS</td>
<td>Consultative Committee for Space Data Systems</td>
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<tr>
<td>cFS</td>
<td>Core Flight System</td>
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<tr>
<td>COSMOS</td>
<td>Ball Aerospace User Interface for Command and Control of Embedded Systems (not a acronym)</td>
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<tr>
<td>EDS</td>
<td>Electronic Data Sheet</td>
</tr>
<tr>
<td>ESA</td>
<td>European Space Agency</td>
</tr>
<tr>
<td>ITOS</td>
<td>Integrated Test and Operations System</td>
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<tr>
<td>JSON</td>
<td>JavaScript Object Notation</td>
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<tr>
<td>Lua</td>
<td>embeddable scripting language (not a acronym)</td>
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<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<tr>
<td>SEDS</td>
<td>SOIS Electronic Data Sheet</td>
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<td>SOIS</td>
<td>Spacecraft Onboard Interfaces Services</td>
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<td>SPA</td>
<td>Space Plug and Play Avionics</td>
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<tr>
<td>TASTE</td>
<td>The Assert Set of Tools for Engineering</td>
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<tr>
<td>XML</td>
<td>eXtensible Markup Language</td>
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<tr>
<td>XTCE</td>
<td>XML Telemetric &amp; Command Exchange</td>
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<tr>
<td>xTEDS</td>
<td>extensible transducer electronic data sheets</td>
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Thank You.

Questions?