Integrating CCSDS Electronic Data Sheets into Flight Software

Jonathan Wilmot
Jonathan.J.Wilmot@NASA.gov

This is a non-ITAR presentation, for public release and reproduction from FSW website.
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

This is a non-ITAR presentation, for public release and reproduction from FSW website.
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)

This is a non-ITAR presentation, for public release and reproduction from FSW website.
Development and Operations Use Cases

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

This is a non-ITAR presentation, for public release and reproduction from FSW website.
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

This is a non-ITAR presentation, for public release and reproduction from FSW website.
EDS Use in NASA’s core Flight System (cFS) software

Free, open source, reliable flight software

This is a non-ITAR presentation, for public release and reproduction from FSW website.
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/

This is a non-ITAR presentation, for public release and reproduction from FSW website.
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

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

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

Application Support
- Data Link
- Physical

This is a non-ITAR presentation, for public release and reproduction from FSW website.
Current cFS View of SEDS  End to End

This is a non-ITAR presentation, for public release and reproduction from FSW website.
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.
Acronyms

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

This is a non-ITAR presentation, for public release and reproduction from FSW website.
Thank You.

Questions?