Mission Operations Services by the CCSDS: a step towards the future

CCSDS Spacecraft Monitor & Control Working Group (SM&C)
Mario Merri (ESA), Chair
Presentation Motivations and Agenda

□ Communicate and promote our standardisation effort
  ➔ Share SM&C approach with decision makers for future missions
  ➔ Dissipate unjustified fears (e.g. re-use of legacy systems, pre-defined system architecture, prescribed functionalities)
  ➔ Share benefits of application-level services and not only communication protocol standardisation

□ Agenda covers main SM&C WG responsibility, i.e. standardisation in the context of:
  ➔ Spacecraft Monitoring & Control (SM&C)
    ➔ Status, strategy and outlook
    ➔ Overview
    ➔ Prototype
  ➔ XML Telemetric and Command Exchange (XTCE)
    ➔ Very brief status and outlook
SM&C in Numbers

3 year lifetime
(started in Dec 2003)
10 active Space Agencies
1 partner standardization organization
7 CCSDS workshops
40 telecons

ASl: C Labonia
BNSC: R Thompson (deputy chairman), B Harnett
CNES: B Béhal, E Poupard, R Soumagne
CSA: P Melanson
DLR: H Hoffman
ESA: M Merri (chair), M Schmidt, A Ercolani, I Dankiewicz, S Cooper
FSA: L Kudrin
INPE: PG Milani, AM Ambrosio
JAXA: T Yamada
NASA/ GSFC: DC Lokerson, F Johnson, JK Marguart, JS Gal-Edd, C Fatig, R Jones, K Rice
NASA/ JPL: A Oyake, P Shames, J Moholt
OMG: G Simon (Lockheed Martin), B Kizzort (Harris Corp.)
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- 2 Agencies Reviews (XTCE)
- 2 internal Reviews (SM&C)
- 3 advanced draft HP SM&C RBs

- Mission Operations Service Concept, CCSDS 520.0-G-2, August 2006
  - [http://public.ccsds.org/publications/archive/520x0g2.pdf](http://public.ccsds.org/publications/archive/520x0g2.pdf)
  - Web hits: 158 in Feb 06; 259 in Jan 07

- XML TELEMETRIC AND COMMAND EXCHANGE (XTCE), CCSDS 660.0-G-1, July 2006
  - [http://public.ccsds.org/publications/archive/660x0g1.pdf](http://public.ccsds.org/publications/archive/660x0g1.pdf)
  - Web hits: 303 in Feb 07; 445 in Jan 07

- SM&C Message Abstraction Layer (ESA)
- SM&C Common Service (ESA)
- SM&C Core Service (ESA)
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4 initial draft SM&C RBs

- SM&C Time Service (CSA)
- SM&C Remote Software Management (BNSC)
- SM&C Automation Service (CNES)
- SM&C Planning Service (BNSC)

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Spacecraft Monitoring and Control

- **What it is**
  - Comprises application level services that are needed to monitor, control and operate a remote system including:
    - Classical TM monitoring
    - TC generation (manual, pre-planned, automatic, time-tagged, …)
    - Remote software management
    - Time management
    - Mission product data management
    - Mission planning and automation
    - Orbit, Attitude and Position determination
    - Standard interaction with the operator
    - … more to come

- **What it is not**
  - Does not prescribe the system architecture and functionality
    - service provider/consumer may be located differently depending on the specific deployment
    - No predefinition of applications’ implementation, but only of their management interfaces
  - Does not prescribe the technology to be used

- **Must allow expansion to accommodate future needs**

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What Do we Want to Achieve?

- **Prepare for the future**
  - Future missions will be more complex and require more collaboration across organisations
    - Better interoperability between systems (e.g. X monitoring its lander via Y’s orbiter, Z submitting planning requests for its payload on W’s S/C, ...)
    - Scalability
  - Expandable systems
    - Difficult to predict now what will be needed tomorrow
  - Protect from technology evolution
    - Replace implementation technology without major system redesign

- **Reduce cost (i.e. schedule, risks, ...) of**
  - [On-board and Ground-based] system development
    - Facilitate availability of generic software infrastructure
    - Facilitate availability of new, state-of-the-art, plug-in [commercial] components
    - Re-use components (including legacy systems)
  - ... and mission operations
    - Re-use operational concepts across missions
    - Increase operational commonality across components (less training costs)
How Can Standardisation Help?

- **Standardisation of interfaces for SM&C**
  - Reduce cost of Flight Components and Ground Segment Infrastructure
  - Enable “plug and play” architecture with components from different Agencies, systems and suppliers

- **SM&C Framework technology keywords**
  - Service Oriented Architecture
  - Plug & Play
  - Layering
  - Isolation and Grouping of generic and common services
  - Publish/Subscribe
  - Technology Adapters (e.g. integration of legacy systems)
Why Application-Level Service Standardisation?

- **Protocol-Level standardisation**
  - is necessary (allows communication), but not sufficient for seamless plug-in of components and interoperability
  - some commercial world examples:
    - Bluetooth/Infrared
    - USB
    - Internet (HTTP and TCP/IP)

- **Application-Level service standardisation**
  - allows seamless plug-in of components and interoperability
  - Examples
    - Calendar/Contacts/To do List/… management
    - Plug & Play of modern memory sticks
    - e.g. tailor-made holidays package (Expedia, LastMinutes, …)
Integrated Systems vs. Modular Components
Service-Oriented Architecture: Plug-in Components
Benefits of the SOA Approach

- Components exchangeable for others supporting same Service Interfaces
  - Plug-and-play interoperability of MCS components

- Common Service Framework
  - Re-use of common infrastructure across multiple systems
  - Independence of mission configuration data and history from system implementation

- Infrastructure Implementation can be changed without change to core Applications
  - Independence of core application software from underlying implementation technology – platform and communications

- Components rapidly deployable in different combinations
  - Reduced mission-specific deployment costs

- Extensible: easy to add new components
  - Scope to evolve a system, by replacing components or changing underlying technologies

- Success is dependent on the Granularity of the service architecture selected
End-to-End Services and Layering
SM&C Service Layering (a)

MO Domain Specific Applications

SM&C: Mission Operations Services

SM&C: Message Abstraction Layer
Message Exchange; File Transfer; Mail

SM&C: Common Services

Technology Adaptors

Infrastructure Services
Message Exchange; File Transfer; Mail

Communications Services

Interoperable Protocol (PDUs)
## Identified SM&C MO Services

<table>
<thead>
<tr>
<th>Name</th>
<th>Service Objects and Operations</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Monitoring &amp; Control</td>
<td>Parameters: publish status; set Actions [Commands]: publish status; invoke/send Alerts [Events]: notify; raise</td>
<td>1</td>
</tr>
<tr>
<td>Time</td>
<td>Time: report; set; correlate; notify</td>
<td>2</td>
</tr>
<tr>
<td>Software Management</td>
<td>On-board Software: load; dump</td>
<td>2</td>
</tr>
<tr>
<td>Planning Request</td>
<td>Planning Request/Goal: request; response</td>
<td>3</td>
</tr>
<tr>
<td>Scheduling</td>
<td>Schedule: distribute; edit; control; progress reporting</td>
<td>3</td>
</tr>
<tr>
<td>Automation</td>
<td>Procedure/Function: control; progress reporting</td>
<td>2</td>
</tr>
<tr>
<td>Data Product Management</td>
<td>Data Product [Payload Data File]: directory; transfer</td>
<td>3</td>
</tr>
<tr>
<td>Location</td>
<td>Position: tracking, ranging, onboard positioning</td>
<td>3</td>
</tr>
<tr>
<td>Flight Dynamics</td>
<td>Orbit/Attitude/Predicted Events: determination, propagation, manoeuvre preparation</td>
<td>4</td>
</tr>
<tr>
<td>Operator Interaction</td>
<td>Message/Alarm/Query: notify; operator response</td>
<td>4</td>
</tr>
<tr>
<td>Remote Buffer Management</td>
<td>Buffer: catalogue; retrieve; clear</td>
<td>4</td>
</tr>
</tbody>
</table>
SM&C Common Services

MO Service Consumer

MO Service Directory

Common Services Directory
Authentication
Session Control

LOOKUP

PUBLISH

INVOKE

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SM&C Service Layering (b)

MO Domain Specific Applications

Consumer Application

Provider Application

Plug-in Applications

SM&C: Mission Operations Services

SM&C: Common Services

SM&C: Message Abstraction Layer

Message Exchange; File Transfer; Mail

Technology Adaptors

SM&C: Message Abstraction Layer

Infrastructure Services

Message Exchange; File Transfer; Mail

Technology Specific Infrastructure

Communications Services

Interoperable Protocol (PDUs)
Message Abstraction Layer (1)

- **Generic Interaction Patterns (IP)**
  - limited set used by MO services in the SM&C framework
  - Each operation of a service uses one IP

![Diagram of SEND IP](show/diagram.png)

SEND IP

![Diagram of PROGRESS IP](show/diagram.png)

PROGRESS IP
Message Abstraction Layer (2)

- Generic Interaction Patterns (IP)

- Other features:
  - Multiplicity of services (Session, Domain, Network Zone)
  - Security and access control
  - Quality of Service

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Message Abstraction Layer (3)

- Interoperability (language and encoding/transport)

![Diagram of Message Abstraction Layer (3)]

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SM&C CCSDS Books

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Conclusions and Outlook

- The Mission Operations Services will provide a framework for development of
  - Interoperable systems (across and within Agencies)
  - Re-usable components
  - Systems-of-Systems

- At the last CCSDS workshop (Jan 07), NASA agreed to increase support to the SM&C effort while continuing to identify the candidate enabling technologies for the future Constellation Programme

- Target plan
  - SM&C Message Abstraction Layer - end 2007
  - SM&C Common Service - Q2/2008
  - SM&C Core Service - Q2/2008