Introduction

• Mission Operations
  – Primary goal is to increase level of interoperability among Agencies
Project Goals

• Demonstrate the use of Mission Operations standards to implement Directory and Action Services
• Investigate Mission Operations language neutrality
• Investigate C3I XML interoperability concepts
• Integrate applicable open source technologies in a Service Oriented Architecture
Project Benefits

- Investigate the viability of the Mission Operations standards
- Provide feedback to the Mission Operations Working Group and NASA management
- Concrete implementation of a Service Oriented Architecture (SOA)
- Multi-center cooperation
  - GSFC: MAL Implementation
  - JPL: AMS (Asynchronous Message Service) Transport Layer
- Introduction of new technologies
Project Scope

- Does not address security concerns
- Does not implement Common Model operations
- Implements minimum MAL capabilities
Project Definition

- Mission Operations Interoperability Constraints
  - Directory Service
    - A. Language Mapping: C, C++, Java and Python
    - B. MAL Specification: July 2007 Red Book
    - C. Service Specification
      - Common Services: September 2007 Red Book
    - D. Transport Mapping: HTTP Transport / XML encoding
  - Action Service
    - A. Language Mapping: C++ and Java
    - B. MAL Specification: July 2007 Red Book
    - C. Service Specification:
      - Common Services: April 2008 Red Book
      - Core Services: May 2008 Red Book
    - D. Transport Mapping: AMS Transport / XML Encoding
Methodology

- Created XML schemas for MAL, Common and Core constructs
- Used XML tool kits to generate object to XML (OXM) mapping code from schemas
- Implemented the most common execution paths with reasonable error checking
Directory Service Provider

• Implemented Methods
  – Lookup: Consumer searches for qualifying services
  – Publish: Provider advertises availability
  – Withdraw: Provider indicates service is no longer available

• Java Application

• Integrated Open Source Projects
  – Spring Web Services: www.springframework.org/spring-ws
  – Tomcat Servlet Container: tomcat.apache.org
  – Derby embedded database: db.apache.org/derby
  – iBatis Object Query Mapping (OQM): ibatis.apache.org
  – JAXB Object XML Mapping (OXM): jaxb.dev.java.net
  – JUnit: www.junit.org
    • Automated unit and regression tests
Directory Service Clients

• Java Client
  – Wicket Web Framework: wicket.apache.org
  – Spring Web Services: www.springframework.org/spring-ws
  – JAXB OXM: jaxb.dev.java.net

• C / C++ Client
  – gSOAP OXM: www.cs.fsu.edu/~engelen/soap.html

• Python Client
  – Zolera Soap Infrastructure OXM: pywebsvcs.sourceforge.net
Directory Service Interfaces

Demonstration
Action Service Provider

- **invokeAction**
  - Execute actions (commands)
  - Implemented only actions without arguments

- **preCheckAction**
  - Boolean return indicating if action would succeed
  - Not implemented
    - Not supported by COTS Command and Telemetry System
    - No MCC equivalent capability for Command
Action Service Provider

• C++ Application

• Integrated Open Source Projects
  - OMNIORB CORBA ORB: omniORB.sourceforge.net
  - ACE TAO CORBA ORB: www.cs.wustl.edu/~schmidt/TAO.html
  - gSOAP OXM: www.cs.fsu.edu/~engelen/soap.html
  - Boost C++ Libraries: www.boost.org

• Dependencies
  - L3 InControl Command Server
    • Vendor permitted continued evaluation after trade study
  - AMS (Asynchronous Message Service)
  - JAMS (JSC Front End to AMS)
Action Service Client

- Browser Based User Interface
- Integrated Open Source Projects
  - Java Language
  - Tomcat Servlet Container: tomcat.apache.org
  - JAXB OXM: jAXB.dev.java.net
  - Web Application Framework: wicket.apache.org
  - SWIG C/C++ Wrapper: www.swig.org

- Dependencies
  - AMS (Asynchronous Message Service)
  - JAMS (JSC Front End to AMS)
Action Service Interfaces
Action Service Proxy
Action Service Client

Web Browser

- Action Service Client UIF
- HTML / Java Script

HTTP

Tomcat Servlet Container

- Action Service Client
- Wicket Web Framework
- Common Services
- Action Service
- MAL
- JAMS/SWIG
- HTTP
- JAXB-XML
- AMS
- JAXB-XML

HTTP/JAXB-XML
- MAL
- Directory Service
- Directory Service Provider
Demonstration Architecture

- Command Gateway
- Command Emulator
- MAESTRO
- In Control Command Server
- In Control Command Client
- Exceed on Demand Server
- JSC VPN
- Exceed on Demand Client
  - Remote In Control Client Display
  - Remote DSIL Client Display
- Storm Command API
- Action Service Provider
- Tomcat https://lance:8444
- Action Service Client
- mod_proxy
- OTF Apache Web Server
  - https://otf.jsc.nasa.gov/smc
- Web Browser
- Action Service Client UIF

lance : XDMCP Enabled
Demonstration Flow

1. Publish Service
2. Login
3. Lookup Service
4. Invoke Action
5. Acknowledgment
6. Execute Command
7. Command Callback
8'. Progress
11. Response
9. Send Command
10. Command Response
Results

• Identified modifications to implement manned spaceflight requirements (separate presentation)
• Eighteen (18) RIDS against Directory Service
• Seven (7) RIDS against Action Service
• Validated MO interoperability in regards to language neutrality
• Validated C3I XML interoperability concepts
Results Continued

• Specification defers many data format issues to the service configuration which is outside the scope of the documents
  – No discovery mechanism for the available commands with parameters
  – Interface for command uplink provides only an argument list for parameter values.
    • No parameter type
    • No engineering units
    • No operational limits
Results Continued

• Service Oriented Architecture (SOA) requires long term investment
  – Interfaces must be negotiated and designed for reuse
  – Software developer training

• Mission Operations does an excellent job defining the interfaces and service specifications
  – Provides business requirements to drive the architecture
  – Potential to absorb up front cost of interface design
  – Specifies defendable and versionable interfaces
MO Lessons Learned

• Necessary to write a blue book specifying the schemas for the Mission Operations data structures
  – The consumer and provider schema must be in agreement for interoperability
XML Lessons Learned

• Sufficient tool support for XML encoding

• Support varies by language
  – C/C++ require large amounts of generated code
  – C/C++ require hand written memory allocation logic
  – Java / Python have basic XML support available as libraries or packages
XML Lessons Learned

• Investigation to determine bandwidth issues for large amounts of XML data is necessary
• Schemas to define data formats must be defined and agreed upon for C3I to succeed
Conclusions

- Additional commanding capabilities are needed for manned space flight
- Validated MO interoperability in regards to language neutrality
- Validated C3I XML interoperability concepts
  - Contingent upon schema definition
- SOA is a long term investment
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• Project Sponsor
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Thank You

• Questions
### SOA SLOC Matrix

<table>
<thead>
<tr>
<th>Components</th>
<th>Language</th>
<th>SLOC Count</th>
<th>COCOMO Estimate (Months)</th>
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<td>Directory Web Service</td>
<td>Java</td>
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<td><strong>Generated Components</strong></td>
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Directory Service RIDS

- Distributed nature of directory service is not hidden from the clients
  - Client performs iterative lookup to resolve URI
  - Client performs addition of external links
- Publish service is not specify action to take if node does not exist
- Extra information attribute not used to aid problem resolution for errors
Action Service RIDS

- Information mismatch between progress updates and data archived in the Common Model
- Time triggered actions not specified
- Extra information attribute not used to aid problem resolution for errors
CCSDS Mission Operations
Directory Service Demonstration

Screen Shots
1. Directory Service Home Page
2. Directory Service Lookup

Spacecraft Monitor and Control - Directory Service

Service Entry

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<thead>
<tr>
<th>Domain</th>
<th>Network Zone</th>
<th>GROUND</th>
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<td>gov.nasa.jpl.na.ssl</td>
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<td>Session Type</td>
<td>Source Session Type</td>
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<td>Service Type</td>
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<tr>
<td>Service ID</td>
<td>Provider Name</td>
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<td>$</td>
<td>ActiveStatus</td>
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Service Occurrence

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<td>Priority Level</td>
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<td>Data URI</td>
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<tr>
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(Operation Technology Facility SMBC Prototype OFF)
3. Directory Service Filter

Spacecraft Monitor and Control - Directory Service

Service Entry

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<td>Service Version</td>
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Service Occurrence

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<th>Supported Capabilities</th>
<th>Supported QoS Levels</th>
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<tbody>
<tr>
<td>Priority Levels</td>
<td>Service URI</td>
</tr>
<tr>
<td>Data URI</td>
<td>Data Name</td>
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</tbody>
</table>

Operation/Technology Facility SMBI Prototype OFF
4. Directory Service Withdraw