Motion Imagery and Robotics Application Project

(MIRA)

8 October 2010
Background

- NASA Digital TV organization will deploy 3 cameras on the Exposed Facility (the “porch”) of the ISS JEM Module
- At request of CCSDS MIA WG (R. Grubbs) and SM&C WG
  - JSC Standards started investigating the use of CCSDS Mission Operations Spacecraft Monitor & Control
  - SM&C Conjecture – The SM&C SOA can provide a standards based methodology to control and status Robotic objects
    - CCSDS SM&C is a proposed integrated ground and space-based SOA
      - Specs are in various stages of CCSDS Red Book
    - Goal to mature MO SM&C SOA standards specs for Robotic Control
      - First time use of the SM&C standard
      - Develop Ops concepts for DTN + SM&C SOA
      - Cameras are a sub-class of Robotic Class of objects
    - Parameter, Action, and Alert services will be used to manage space-based Motion Imagery camera systems
SM&C is an application Service that can integrate many lower layer services to provide a consistent set of interfaces to mission development and Ops teams

- Use AMS and DTN protocols

Standardizing robotic operations leads to easier integration of various robot types and thus potentially lowers costs.

An SM&C SOA approach provides capabilities for plug and play, software reuse, self identification, self configuration and discovery, and cross-agency policy based robot capability sharing.

Ops Concept Review

- Identify architecture, of level of effort and cost, high level technical issues, etc. (Equal to NASA Mission Concept Review)
Contributors to Date

- Rodney Grubbs/Walter Lindblom – CCSDS MIA/NASA Digital TV
- Robert L. Pitts, Mike Kearney, Kelvin Nichols – MSFC HOSC
- CU/K. Gifford - CU DTN project concepts
- Dave Wagner – JPL Mission Data System
- JSC Engineering – Laura Hood
- NASA CCSDS Standards Group
Japanese Experiments Module (JEM) “Kibo” Module

- Pressurized Module (PM)
- Exposed Facility (EF)
- “Porch” or “Terrace”
- Inter-orbit Communication System (ICS)
- Experiment Logistics Module – Pressurized Section (ELM-PS)
- Remote Manipulator System (JEMRMS)
- Airlock
- Experiment Logistics Module – Exposed Section (ELM-ES)
Key Operations Concepts

• Hi-definition cameras will be deployed, plug-n-play
• IP will be used to monitor video from the cameras
• IP and serial links will be used to control and monitor the cameras
• Pan/tilt/roll capability will be included
  – The P/T/R capability will be commandable via IP
  – The P/T/R unit may be integrated with a camera or a separate gimbal unit
• CCSDS standards will be used where possible (SM&C, DTN and others)
• SM&C MIRA services will manage interaction between the user and the camera within a Service Oriented Architecture
• CCSDS packets will carry IP traffic between ground and ISS
• Nodes at termination points will implement DTN protocols in order to demonstrate MIRA/SM&C/DTN
• Minimize flight crew impacts for installation, configuration and maintenance
MIRA Service
MIRA Service Concept

• MIRA Services
  – Control and monitor cameras
  – Control and Monitor of IP encoders

• Design the Services to be expandable to full robotic manipulation

• JSC Data Standards and MIRA are the technical authority for the implementation of the services
Example Camera Features

- Zoom lens
- Controllable Pan/Tilt/Roll unit
- Pan/Tilt/Zoom/Focus (P/T/Z/F) functions are single speed
- Camera has automatic and manual exposure capability
- Different preset color balance settings (i.e. Daylight, Tungsten) can be remote commanded
- Manual black balance capability
- Integrated lighting system
- Heating unit

Example Services

- Power control
- Heater control
- Pan/Tilt/Roll control
- Zoom control
- Toggle Auto / Manual Iris
- Iris control (when in manual)
- Perform Black Balance
- Perform Color Balance
- Recall Preset White Balance 1/2
- Recall Camera Setup 1…n
- Light control
- Upload preset file
Example Encoder Features

- Power On/Off
- Inputs Connections (BNC, etc.)
- Output Ports
- Encoding Algorithm
  - At minimum, supports H.264/AVC/MPEG-4 Part 10
- Data Bit Rate
- Frame Rate
- Chroma Subsampling
- Multiple Group Of Pictures (GOP) Settings
- IP-Assignable and Discoverable
- Browser-Based Management Console
- Load Pre-set Configuration
- Save Configuration
- Upload Configuration

Example Services

- Power On/Off
- Select Algorithm
- Set Bit Rate
- Set Frame Rate
- Set Chroma Subsampling
- Set GOP
- Save Configuration
- Load Saved Configuration
- Upload Configuration
Software Architecture
High Level Architecture

Interfaces
PC, Mac, Touch screen, Joy-stick

MIRA/SM&C Client and Provider Services
(MIRA/SM&C connects any interface to any camera)

SM&C Robotics Client
SM&C Robotics Client
SM&C Robotics Client

SM&C Transport (MAL)

DTN

SM&C Provider Service (MAL)
Action Alert Parameter

Adapters
Adapters
Adapters

Cameras and Adapters
Software Architecture Baseline

User Interface

CCSDS State Based Camera Control Service

SM&C Client

AMS/DTN

Protocol Converter

CCSDS State Based Camera Control Service

SM&C Provider Service

SM&C Provider

AMS/DTN

JSC/MSFC Standards Development

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JSC State Based Camera Control Service

System Under Control (Camera)

Protocol Converter (provider Business Logic)
Action, Parameter, Alert SM&C Providers 1/Camera

Action, Parameter, Alert Client
Camera Control SM&C Provider

Parameter
Action

Service Application Layer
C++

Common Services
Core Services

Common Object Model
Message Abstraction Layer

Encoding
AMS/DTN Transport

User Interface (Client)

Service Layer Over Network (Provider)

*Control System
Elaboration, Projection, & Scheduling

State Variables
Intent
OK?

Knowledge

SM&C Client

SM&C Provider Service

SM&C Client Service

Parameter
Action

Service Application Layer
C++

Common Services
Core Services

Common Object Model
Message Abstraction Layer

Encoding
AMS/DTN Transport

DTN Integration

*Leverages JPL Mission Data System (MDS) State Model Based Control Systems
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# Camera Service Software Architecture

*Intra-Process Communications*

<table>
<thead>
<tr>
<th>Camera Service Consumer</th>
<th>Remote Camera Service Provider</th>
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<tbody>
<tr>
<td><strong>User Application</strong></td>
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<tr>
<td>Camera Service SPI Consumer</td>
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<tr>
<td>Camera Service SPI Provider</td>
<td>Camera Service Provider Application</td>
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<tr>
<td>MAL</td>
<td>MAL</td>
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<tr>
<td>Binary Encoding</td>
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<tr>
<td>TCP Transport</td>
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<td></td>
<td>DTN Transport</td>
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<thead>
<tr>
<th>Camera Service Consumer Application</th>
<th>Remote Camera Service Provider Application</th>
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<tr>
<td>Mission Data System</td>
<td>Camera Adapter Service Consumer</td>
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<tr>
<td>Action, Parameter and Alert Consumers</td>
<td>Action, Parameter, Alert Consumers</td>
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<tr>
<td>MAL</td>
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<tr>
<td>Binary Encoding</td>
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<tr>
<td>IPC Transport*</td>
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</table>

Camera Service Configuration (Goals)

TCP Transport

Remote Camera Service Provider

Mission Data System

Action, Parameter and Alert Consumers

Camera Adapter Service Consumer

Action, Parameter, Alert Consumers

Camera Adapter Service Provider

IPCTransport*

Protocol Converter

TCP Transport

MAL

Binary Encoding

DTN Transport

Remote Camera Service Provider Camera Service Consumer
External Interfaces, Data Flows

Defining external interfaces requires coordination and collaboration with the owners of “the other end of the wire”. Documentation (IRDs, ICDs, other) will be jointly developed and negotiated.

On-Board

MIRA Service

Commands, Telemetry selection, CM products up

Telemetry and Video products down

Ops Metadata, Electronic Procedures

CMD & TLM Data Products, Onboard Displays Caution & Warning Data, Configuration Data

MIRA Services

On-Board

ISS On-Board Command Data and Telemetry Data

Kibo ISS Camera

On-Ground

MSFC (HOSC)

JSC + Others

CU-Boulder (POC)

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Software Areas

• Reuse SM&C Provider, Client, Directory Services and Broker Applications (DTN Pub/SUB)
  – Alert, Parameter, Action Services
  – MAL (re-implement the transport layers for DTN)
  – Encoding – (Reuse – binary)
  – Directory Services (Reuse)
  – Publish/Subscribe
  – Ground Client
  – Provider

• Camera adapters

• Client Apps
  – New GUI
    • n-tier, using SM&C to communicate between GUI and ground client) Give GUI developers a MAL
Development Camera Candidate
AW-HE100 PTZ Control

Video Out
BNC Connector
Serial Digital Interface (Video Out)

Camera Status & Control
Cat-5 Connector
RS-422
AW-HE100 PTZ Control

- Multiple Panasonic controllers available
  - AW-RP555/655
  - AW-RP400 + AW-CB400 + AW-IF400
- Controllable by other manufacturer control systems
- AW Series Protocol
  - Panasonic proprietary but available
  - RS-422 communications over IP cable (i.e. CAT 5/5e/6 w/RJ-45 connector, not IP protocol)
    - Up to 1000’ from Panasonic controller to camera
Communications
On-board Communication Trade 2

Source: Kevin Gifford/CU-Boulder

- **Payload LAN**
  - DTN Laptop
  - CGBA-5
  - CGBA-4

- **Ops LAN**
  - OCA Laptop
  - DTN Laptop

- **Video Store**
  - MSFC HOSC
    - HOSC DTN gateway
    - ISS HD Camera Control
  - JSC MCC
    - MCC DTN gateway
    - ISS HD Camera Control

- **Internet**
  - SM&C Service Provider Option 1
  - SM&C Service Provider Option 2

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Options 2: Payload Downlink Path

TDRSS

Payload MDM

ISS

Payload LAN

JEM

Porch

10BASE-T Cable
RS422/IP for Control/Status

BNC Y/C-YPB

Ku-band (150 Mbps today, 300 Mbps in FY 2012)

White Sands

JSC/OTF

IDEA

FEPS

NISN

Telemetry Processor

MSFC/HOSC

HOSC Payloads

White Sands

Ku-band (150 Mbps today, 300 Mbps in FY 2012)
Forward Plans
10/8/2010
Phasing

- Phase 1 – Ground Demonstration Test
  - Monitor and Control real cameras on the ground
    - Using standards (CCSDS SM&C over DTN)
    - CCSDS Spring 2011 Berlin demo around April 30, 2011
    - Multi-center collaboration (JSC, MSFC, JPL, CU-Boulder)
- Phase 2 – ISS Communication Test
  - Round trip monitor and control of an on-board ISS camera emulator on running a laptop
    - Using standards (CCSDS SM&C over DTN)
  - Complete by 08/2011
  - CCSDS Fall 2011 meeting demo around October 30, 2011
  - Multi-center collaboration (JSC, MSFC, JPL, CU-Boulder)
- Phase 3 – Final Development and Deployment
  - Monitor and control cameras real cameras on the ISS
    - Using standards (CCSDS SM&C over DTN)
  - Cost and Date is TBD
Phase 1 Minimum Demo Requirements

- Berlin Demo Highlights
  - Connectivity to Berlin DIN
  - Berlin trough 4G connection (ATT)
- Berlin Demo minimum functionality shall include
  - Pan, tilt, zoom, focus, iris control, recall presets
  - White balance preset, scenes
  - Return status (Confirmation), limit on pan, tilt, temperature sensor
  - Supporting GUI will need to be created
- USE MCCX type secure remove access
- Use Extended Voice for ground coordination