DIGITAL ASSURANCE

Empowering Decision Makers in the Digital Age

9 Aug 16

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Addressing Spacecraft Costs – What options do we have?

- Reduce spacecraft development costs and timelines by reducing costs and complexity in each section of the program.
- Key changes:
  - Reduce complexity and improve adaptability through standards, particularly MOSA.
  - Minimize schedule to keep management and labor costs down.
  - Increase use of COTS components.
  - Minimize customized components.
  - Use OM to reduce AI&T costs.

Ways to Reduce Cost & Development Time:

- Reduce complexity
- Shorten schedule
- COTS
- Bulk buys
- Reduce complexity
- Standardize
- Reuse not redesign
- Flexible / adaptable
- MOSA
- Pre-tested
- Flexible / adaptable
- Standardize
- MOSA
- OM
- Standardize

- Management & Systems Engineering
- Parts and Materials
- Non-recurring Engineering
- Mission-specific Engineering
- Assembly, Integration, and Test
What if we target improved Mission Assurance?

- **Digital Assurance (DA):**
  - Digital Assurance (DA) is the automated application of proven scientific, engineering, quality, and program management principles towards the goal of achieving mission success.
  - DA is implemented through the manipulation of relevant data presented to appropriate decision makers in **near-real-time**.
  - Validate the ability of **autonomous** digital techniques to provide Mission Assurance
  - Achieved through **Continuous Custody**

**Ways to Reduce Cost & Development Time**

- **Reduce complexity**
- **Shorten schedule**
- **COTS**
- **Bulk buys**
- **Reduce complexity**
- **Standardize**
- **Reuse not redesign**
- **Flexible / adaptable**
- **MOSA**
- **Pre-tested**
- **MOSA**
- **Reduce complexity**
- **Flexible / adaptable**
- **Standardize**
- **MOSA**
- **OM**
- **Standardize**

**Management & Systems Engineering**

**Parts and Materials**

**Non-recurring Engineering**

**Mission-specific Engineering**

**Assembly, Integration, and Test**
Key Technology #1: Continuous Custody
Key Technology #2: Graph Database
Key Technology #3: Machine Vision

Applied Minds Satellite Assembly #1

Mystery PCB Stack 01
Digital Assurance Interface

Real Time Assembly

Mission Assurance

Footer: displays current active assembly information
Real-Time Alerts

Error alert messaging: displays real-time error as they occur

ORS  Project

△ SPECIFIC ERROR MESSAGE

Real Time Assembly

Mission Assurance

2014.04.15 // 10:30 AM
Assembly: SAT 4
Reference Number: 13615801-2
Current OP: 0010
Step Number: 1
Workstation: NGHS
Work Order Number: 10014787
Operator: John Doe  Sign out
Situational Awareness View

<table>
<thead>
<tr>
<th>ORS</th>
<th>Project: Continuous Custody</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Situational Awareness</td>
</tr>
<tr>
<td>BUILD</td>
<td>RECEIVING</td>
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<td>SAT 1</td>
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<td>SAT 9</td>
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</tr>
</tbody>
</table>

- **Continuous Custody Review**
  - Part and assembly status as relates to Continuous Custody

**Situational Awareness**

<table>
<thead>
<tr>
<th>BUILD</th>
<th>RECEIVING</th>
<th>LEARNING</th>
<th>ASSEMBLY</th>
<th>TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAT 1</td>
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<td>SAT 9</td>
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</table>

**Error instance**

- **2015:04:15 // 10:30 AM**
- **Assembly**: SAT 4
- **Reference Number**: 13615801-2
- **Current OP**: 0010
- **Workstation**: NGHS
- **Work Order Number**: 10014787
- **Operator**: John Doe
- **Sign out**

---

**SmallSat**
Continuous Custody Review
part and assembly status as relates to Continuous Custody

<table>
<thead>
<tr>
<th>QRS</th>
<th>Project: Continuous Custody</th>
</tr>
</thead>
</table>

**Situation Awareness** | **Assembly and Testing** | **Part Tracking**

<table>
<thead>
<tr>
<th>BUILD</th>
<th>RECEIVING</th>
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<th>ASSEMBLY</th>
<th>TESTING</th>
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**Pop-up window with detailed info**

GPS Antenna
Date: 2015-01-23
Time: 09:13:45
Issue: Arrived broken

2015.04.15 // 10:30 AM
Assembly: SAT 4
Reference Number: 1385801-2
Current OP: 0010
Step Number: 1
Workstation: NGHS
Work Order Number: 10014787
Operator: John Doe
Sign out
Drill Down to Supporting Documentation

Continuous Custody Review
part and assembly status as relates to Continuous Custody

For performance video in Receiving
and Learning

ORS  Project: Continuous Custody

<table>
<thead>
<tr>
<th>BUILD</th>
<th>SAT 1</th>
<th>SAT 2</th>
<th>SAT 3</th>
<th>SAT 4</th>
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<th>SAT 6</th>
<th>SAT 7</th>
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<th>SAT 9</th>
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2015.04.15 // 10:30 AM
Assembly: SAT 4
Reference Number: 13615801-2
Current OP: 0010
Step Number: 1
Workstation: NGHS
Work Order Number: 10014787
Operator: John Doe    Sign out
Continuous Custody – Parts Tracking

ORS  Project: Continuous Custody

Continuous Custody Review
part and assembly status as relates to Continuous Custody

Part Tracking

Rollover state
with detail info regarding part

ORS  Project: Continuous Custody

Situational Awareness  Assembly and Testing

PARTS  RECEIVING  LEARNING

ADCS
Avionics Stack
Back Plate
Base Plate
Battery
BeagleBoard
Bolts
GPS Antenna
Part A
Part B
Part C
Part D
Part E
Part F
Part G
Part H
Part I

2015.04.15 // 10:30 AM
Assembly: SAT 4
Reference Number: 12615801-2
Current OP: 0010
Step Number: 1
Workstation: NGHS
Work Order Number: 10014787
Operator: John Doe
Sign out

Green bar indicates status in Continuous Custody
Parts received, learned and logged into system
Parts expected to be seen later in Assembly and Testing

Avionics Stack
Workstation: Learning
Date: 2015-01-23
Time: 09:13:45
Continuous Custody – Drill Down

### Situational Awareness

<table>
<thead>
<tr>
<th>PARTS</th>
<th>RECEIVING</th>
<th>LEARNING</th>
<th>ASSEMBLY</th>
<th>TESTING</th>
</tr>
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<tbody>
<tr>
<td>ADCS</td>
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<tr>
<td>Avionics Stack</td>
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<tr>
<td>Back Plate</td>
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<td>Base Plate</td>
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<tr>
<td>Battery</td>
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<tr>
<td>BeagleBoard</td>
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<tr>
<td>Bolts</td>
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<tr>
<td>GPS Antenna</td>
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<tr>
<td>Part A</td>
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<tr>
<td>Part I</td>
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</tbody>
</table>

- **Parts list**: Parts received, learned and logged into the system.
- **Parts expected to be seen later**: Parts expected to be seen later in Assembly and Testing.
- **Continuous Custody**
- **Continuous Custody Review**: Part and assembly status as relates to Continuous Custody.
- **Part Tracking**: On click state forensic video for receiving and learning.

**Timeline Information**
- **Assembly**: SAT 4
- **Reference Number**: 13515801-2
- **Current OP**: 0010
- **Step Number**: 1
- **Workstation**: NGHS
- **Work Order Number**: 10014787
- **Operator**: John Doe
- **Sign out**

**Timeline Data**
- **2015.04.15 // 10:30 AM**
- **Learning 2015-01-23 09:13:45**
Continued Interrogation to Operations Review
# DA – Requirements Verification

## ORS Project: Requirements

<table>
<thead>
<tr>
<th>Situational Awareness</th>
<th>Requirement Categories</th>
<th>Requirement Verification</th>
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<tbody>
<tr>
<td><strong>ASSEMBLY</strong></td>
<td>SPACECRAFT DESIGN REQUIREMENTS</td>
<td>TESTING REQUIREMENTS</td>
</tr>
<tr>
<td>SAT 1</td>
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<td>SAT 2</td>
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<td>SAT 5</td>
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</tbody>
</table>
| SAT 6                 |                        | Radio  
  Workstation: Assembly  
  Date: 2015-01-23  
  Time: 00:13:45  
  Exceeded Mass |
| SAT 7                 |                        |                         |
| SAT 8                 |                        |                         |
| SAT 9                 |                        |                         |

2014.04.15 // 10:30 AM  
Assembly: SAT 4  
Reference Number: 13615801-2  
Current OP: 0010  
Step Number: 1  
Workstation: NGHS  
Work Order Number: 10014787  
Operator: John Doe  
Sign out  

Pop-up window with detailed error info  
Pop-up toaster messaging for error alerts
# DA Requirements Thumbnail

**ORS** Project: Requirements

<table>
<thead>
<tr>
<th>Situational Awareness</th>
<th>Requirement Categories</th>
<th>Requirement Verification</th>
<th>Selected assembly</th>
<th>Progress icons</th>
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<tbody>
<tr>
<td>3.1 System Level Requirements</td>
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<tr>
<td>3.2 Structure and Mechanisms</td>
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<tr>
<td>3.3 Attitude Determination Control Subsystem</td>
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<tr>
<td>3.4 Electrical Power Subsystem</td>
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<tr>
<td>3.5 Cabling and Harness</td>
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<tr>
<td>3.6 Thermal Control Subsystem</td>
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<tr>
<td>3.7 Telemetry, Tracking, and Commanding</td>
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<td>3.8 Command and Data Handling</td>
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<td>3.9 On-board Flight Software</td>
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<td>3.10 Payload Accommodation</td>
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<td>4.1 Automated System Test Capability</td>
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<td>4.2 Random Vibration</td>
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<td>4.3 Acoustics</td>
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<td>4.4 Shock</td>
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<td>4.5 Thermal</td>
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<td>4.6 Electromagnetic Interference and Control</td>
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<tr>
<td>4.7 Week in the Life Testing</td>
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**2014.04.15 // 10:30 AM**

- **Assembly:** SAT 4
- **Reference Number:** 13815901-2
- **Current OP:** 0010
- **Step Number:** 1
- **Workstation:** NGHS
- **Work Order Number:** 10014787
- **Operator:** John Doe
- **Sign out**
## DA – Requirements Drill Down

### ORS Project: Requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>CATEGORY</th>
<th>DESCRIPTION</th>
<th>NOTES</th>
<th>SOURCE</th>
<th>STATUS</th>
<th>VERIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR-0390</td>
<td>Solar Input Power</td>
<td>The solar input power shall be a minimum of 40W EOL at full sun illumination.</td>
<td></td>
<td>Self-imposed (support use cases in section 2.3)</td>
<td>OP.0020 Test</td>
<td></td>
</tr>
<tr>
<td>SCR-0400</td>
<td>Power Storage</td>
<td>The spacecraft battery storage capacity shall be ≥100 Watt x hours.</td>
<td></td>
<td>Self-imposed (support use cases in section 2.3)</td>
<td>Test</td>
<td></td>
</tr>
<tr>
<td>SCR-0410</td>
<td>Power Storage</td>
<td>The maximum allowable battery depth of discharge shall be 40%.</td>
<td></td>
<td>Self-imposed (engineering judgment)</td>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>SCR-0420</td>
<td>Power Storage</td>
<td>The spacecraft shall be capable of being in an unpowered state for 90 days without requiring battery recharge.</td>
<td>This allows for the SV to be installed for a period of time in the CSD prior to launch.</td>
<td>Self-imposed (engineering judgment)</td>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>SCR-0430</td>
<td>Power Storage</td>
<td>The spacecraft shall be capable of being in a powered state, charging batteries, and communicating via the CSD connector, while in the CSD.</td>
<td>The CSD connector would be optional and removable if not used for the mission.</td>
<td>Self-imposed (engineering judgment)</td>
<td>Test</td>
<td></td>
</tr>
<tr>
<td>SCR-0440</td>
<td>Voltage Regulation and Switching</td>
<td>The EPS shall supply a switched unregulated 11V ± 2V DC battery voltage to the spacecraft.</td>
<td></td>
<td>Self-imposed (engineering judgment)</td>
<td>Test</td>
<td></td>
</tr>
<tr>
<td>SCR-0450</td>
<td>Voltage Regulation and Switching</td>
<td>The switched unregulated voltage shall be inhibited when the battery voltage is below 7.5 V and remain inhibited until the battery voltage returns to 9.6 V. These values are default.</td>
<td></td>
<td>Self-imposed (engineering judgment)</td>
<td>Test</td>
<td></td>
</tr>
</tbody>
</table>

**2014.04.15 // 10:30 AM**

- **Assembly:** SAT 4
- **Reference Number:** 13816801-2
- **Current OP:** 0010
- **Step Number:** 1
- **Workstation:** NGHS
- **Work Order Number:** 10014787
- **Operator:** John Doe
- **Sign out**

Linked supporting documents for requirements verification
All Data Searchable
Ground Truth Program Reviews
This is You!