IV&V project assessment
process validation

Method: map the Space Launch System
SRR/SDR IV&V findings to
IV&V PBRA
IV&V RBA
IEEE 1012-2004 Scorecard

*Reference: All graphics from
SLS Industry Day
IV&V project assessment
Process Validation Presentation

• Presenters
  – Stephen Driskell
  – Team Members for Questions

Study support from
• Rich Wolf, HEO ESD IV&V Deputy Project Manager
• Christina Moats, HEO ESD IV&V Project Manager
**NASA IV&V SLS Topic & Participants**

- **Abstract**: The Space Launch System (SLS) will launch NASA’s Multi-Purpose Crew Vehicle (MPCV). This launch vehicle will provide American launch capability for human exploration and travelling beyond Earth orbit. SLS is designed to be flexible for crew or cargo missions. The first test flight is scheduled for December 2017. The SLS SRR/SDR provided insight into the project development life cycle. NASA IV&V ran the standard Risk Based Assessment and Portfolio Based Risk Assessment to identify analysis tasking for the SLS program. This presentation examines the SLS System Requirements Review/ System Definition Review (SRR/SDR), IV&V findings for IV&V process validation correlation to/from the selected IV&V tasking and capabilities. It also provides a reusable IEEE 1012 scorecard for programmatic completeness across the software development life cycle.

- **Two teams performed separate concurrent assessments**
  - **IV&V Participants in the SLS SRR/SDR**
    - Melvin Rother, Bimal Patel, Vaughn Harvey, Stephen Driskell, Thomas Marshall, Gary Barber, James Chamberlain, and Noble Nkwocha,
  - **IV&V Participants in the RBA and PBRA**
    - Van Casdorph, John Bradbury, Rodger Barrington, David Frazier, James Dell, Richard Wolf, and Kimberly Mittelsted,
SLS Missions Summary

Exploration Missions For Earth and Moon to Asteroids Mars & Mars Moons

Initial Capability 70 mt in 2017 to Evolved Capability 130 mt Cargo
SRR/SDR IV&V results

- IV&V team submitted 33 Pre-RIDs, of which 7 became stand-alone RIDs and 4 were combined into other RIDs. All of the information submitted by the IV&V team (whether on a RID or not) was provided to the SLS personnel in that area to be incorporated into the program.
- All of these Pre-RIDS and RIDS fall into one of three categories:
  - IV&V issues Accepted as RIDS 7
  - SLS Program Combined IV&V comments with other reviewers RIDS 4
  - SLS Program comments to documents and “future work” 22

IV&V project assessment validation results

- PBRA - there is a GOOD correlation from SRR/SDR IV&V RIDs and Pre-RIDS to the Portfolio Based Risk Assessment.
- RBA - there is a GOOD correlation from SRR/SDR IV&V RIDs and Pre-RIDS to the Risk Based Assessment.
- IEEE 1012 - there is a GOOD correlation from SRR/SDR IV&V RIDs and Pre-RIDs to the SRR/SDR Software Life Cycle to the IEEE 1012 Software Validation and Verification Standard - 2004
SLS Affordability Tenets & Options

Boosters, Stages, Engines, Spacecraft & Fairings, Advanced Development + Existing Capabilities

Many Solutions Considered
### PBRA Map to IV&V SRR/SDR Results

<table>
<thead>
<tr>
<th>ID</th>
<th>RIDs only</th>
<th>Pre-RIDs</th>
<th>Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLS1</td>
<td>1</td>
<td>2</td>
<td>SLS.Provide Health &amp; Status data</td>
</tr>
<tr>
<td>SLS2</td>
<td></td>
<td></td>
<td>SLS.Provide Caution &amp; Warning data</td>
</tr>
<tr>
<td>SLS3</td>
<td></td>
<td></td>
<td>SLS.Provide Fault Detection</td>
</tr>
<tr>
<td>SLS4</td>
<td></td>
<td></td>
<td>SLS.Provide Fault Isolation</td>
</tr>
<tr>
<td>SLS5</td>
<td></td>
<td></td>
<td>SLS.Provide Fault Recovery</td>
</tr>
<tr>
<td>SLS6</td>
<td>7</td>
<td>8</td>
<td>SLS.Perform Vehicle State &amp; Mode Management</td>
</tr>
<tr>
<td>SLS7</td>
<td>1</td>
<td>4</td>
<td>SLS.Provide GNC</td>
</tr>
<tr>
<td>SLS8</td>
<td></td>
<td></td>
<td>SLS.Manage Subsystem Power</td>
</tr>
<tr>
<td>SLS9</td>
<td>1</td>
<td></td>
<td>SLS.Manage Flight Termination System</td>
</tr>
<tr>
<td>SLS10</td>
<td></td>
<td>5</td>
<td>SLS.Perform Required Abort Sequence</td>
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<tr>
<td>SLS11</td>
<td></td>
<td></td>
<td>SLS.Control Boosters</td>
</tr>
<tr>
<td>SLS12</td>
<td></td>
<td></td>
<td>SLS.Control RS-25 Engines</td>
</tr>
<tr>
<td>SLS13</td>
<td>2</td>
<td></td>
<td>SLS.Control iCPS Engine</td>
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<tr>
<td>SLS14</td>
<td>1</td>
<td>2</td>
<td>SLS.Control CPS Engine</td>
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<tr>
<td>SLS15</td>
<td>1</td>
<td>4</td>
<td>SLS.Control J-2X Engines</td>
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<td>SLS16</td>
<td>1</td>
<td>3</td>
<td>SLS.Track Ascent Operations</td>
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<td>SLS17</td>
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<td></td>
<td>SLS.Provide CMD Validation &amp; Acceptance</td>
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<td>SLS18</td>
<td></td>
<td></td>
<td>SLS.Provide onboard command history</td>
</tr>
<tr>
<td>SLS19</td>
<td>1</td>
<td></td>
<td>SLS.Provide Data to Ground</td>
</tr>
<tr>
<td>SLS20</td>
<td>1</td>
<td></td>
<td>SLS.Provide Data to MPCV</td>
</tr>
<tr>
<td>SLS21</td>
<td></td>
<td></td>
<td>SLS.Provide stage break-up and sinking upon impact</td>
</tr>
</tbody>
</table>

Total: 11 33
RBA To IV & V SRR/SDR

N – Not evaluated in SRR/SDR
### IV&V SLS Results MAP to IEEE 1012-2004

- SRR/SDR IV&V findings
- Mostly Requirements
- Some Findings on
  - Architecture
  - Verification
  - CONOPS
SRR/SDR IV&V results

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WRAP UP

• NASA IV&V Process for RBA and PBRA supports the capabilities for selecting analysis targets to support SMA and national objectives for the SLS Innovative New Business Model

• Based on the SRR/SDR Findings IV&V will revisit the PBRA/RBA rationale for
  – Perform Required Abort Sequence
  – Track Ascent Operations
  – Flight Safety System
  – Provide Health and Status Data

• Study shows good validation for the PBRA and RBA priorities established by the NASA IV&V IPEP process

• Study shows good validation for the SLS NASA life cycle activity with accepted RIDS on Launch Vehicle (LV):
  • Launch Vehicle to SW Functional Allocations Missing
  • Safety Critical SW not identified
  • V&V Testing and Risk Criteria not complete