NASA Space Rocket Logistics Challenges

Chris Bramon, Presenter; James R. Neeley, James V. Jones, Dr. Michael D. Watson, Sharon K. Inman, Loraine Tuttle; NASA Marshall Space Flight Center/EO and Kennedy Space Center/GP

SpaceOps2014, May 5-9, 2014, Pasadena, California, USA
Abstract

• The Space Launch System (SLS) is the new NASA heavy lift launch vehicle in development and is scheduled for its first mission in 2017.

• SLS has many of the same logistics challenges as any other large scale program. However, SLS also faces unique challenges.

• This presentation will address the SLS challenges, along with the analysis and decisions to mitigate the threats posed by each.
Design Architecture

SLS Architecture Reference Configuration

- Launch Abort System
- Orion
- Interim Cryogenic Propulsion Stage (ICPS)
- Interstage
- Core Stage
- Upper Stage with J-2X Engines
- Solid Rocket Boosters
- Advanced Boosters
- RS-25 Engines

SLS-10002 DAC1
SLS-21002 DAC1
Traditional Approach for “Logistics”

- Concepts and processes of Integrated Logistics Support (ILS) provide a significant opportunity to minimize life cycle cost of ownership of a system.
- Traditional application of ILS during the design, development, test and evaluation (DDT&E) of a system typically consists of two different, but highly related processes:
  - Designing a supportable system.
  - Developing a reasonable, responsive and cost effective support solution.
ILS During System Development

Integrated Logistics Support

Supportability Analysis
- Focus on: Design Characteristics, Testability, Reliability, Accessibility, Maintainability, Standardization, Human Factors, Obsolescence

Create a better design solution

Create a cost effective support solution

Minimize Cost of Ownership

Maintenance Task Analysis
Tailoring ILS

- A simple comparison of traditional ILS concepts and processes with the unique circumstances of the SLS Program (SLSP) indicates that application of ILS must be drastically different to be effective.
- SLSP is performing a comprehensive, but non-traditional ILS program that will contribute to the program goals.
- Specific details of SLS challenges and ILS tailoring are addressed in the remaining charts
Supply Chain Impacts Due to Multiple Projects, Contractors, and Vendors
# NASA SLS Common Challenges and Threats

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration of multiple geographically separated programs</td>
<td>Stakeholder communication, conflicting schedules, lack of commonality, gaps in requirements and funding</td>
</tr>
<tr>
<td>Integration of multiple geographically separated projects within a program and multiple contactors</td>
<td>Stakeholder communication, conflicting &amp; complex schedules, lack of commonality, gaps in requirements, different goals, lack of flowed down requirements</td>
</tr>
<tr>
<td>Funding constraints</td>
<td>Increased risk</td>
</tr>
<tr>
<td>Challenge</td>
<td>Threat</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Low manifest rates and frequencies (Up to four years apart)</td>
<td>Costly logistics solutions, increased risk for availability of skilled personnel resources</td>
</tr>
<tr>
<td>Architecture Block upgrade approach</td>
<td>Delay for operational phase, increased cost for changing support solutions: LSA, resources, sparing philosophy</td>
</tr>
<tr>
<td>Mixed new and heritage hardware</td>
<td>Obsolescence, parts marking, commonality</td>
</tr>
<tr>
<td>Multiple projects (elements) with individual milestone reviews</td>
<td>Limited personnel resources, design interface issues</td>
</tr>
<tr>
<td>Dictated flat funding constraints, no inflation allowed</td>
<td>Increased risk for adequate logistics support</td>
</tr>
</tbody>
</table>
## NASA SLS Common Threats and Analysis

<table>
<thead>
<tr>
<th>Threat</th>
<th>Analysis/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Programs: Stakeholder communication, conflicting schedules, lack of commonality, gaps in funding.</td>
<td>Cross-Program Logistics Integration Team (LIT) established to provide communication and work concerns/issues</td>
</tr>
<tr>
<td>Multiple Projects: Stakeholder communication, conflicting schedules, lack of commonality.</td>
<td>SLSP ILS Team established for integration of Elements’ schedules, data, and analysis.</td>
</tr>
<tr>
<td>Multiple prime contractors: Different goals, lack of flowed down requirements.</td>
<td>Contractors included in SLSP ILS Team activities, tailored Data Requirements Descriptions (DRDs) implemented.</td>
</tr>
<tr>
<td>Schedules: Conflicts, complexity.</td>
<td>SLS Integrated Master Schedule (IMS) established with inter-relationships. Logistics Support Date (LSD) concept implemented.</td>
</tr>
<tr>
<td>Funding: Increased risk.</td>
<td>Implemented engineering bottoms-up life cycle cost (LCC) and identified program risks for mitigation.</td>
</tr>
</tbody>
</table>
## NASA SLS Unique Threats and Analysis

<table>
<thead>
<tr>
<th>Threat</th>
<th>Analysis/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block upgrade approach: Delay for operational phase, increased cost for changing support solutions: LSA, resources, sparing philosophy.</td>
<td>Risk assessments.</td>
</tr>
<tr>
<td>Hardware: Obsolescence, parts marking, commonality.</td>
<td>Materials assessment, sustaining engineering planning.</td>
</tr>
<tr>
<td>Milestone reviews: Individual project element reviews, limited personnel resources, design interface issues.</td>
<td>Integrated reviews. Element supportability reviews.</td>
</tr>
<tr>
<td>Funding: Increased risk for adequate logistics support.</td>
<td>Identification of budget risks.</td>
</tr>
</tbody>
</table>
Element Analysis Types and Data

- SLS Program Data Requirements Description (DRD) for “Element Logistics Support Data”:
  - Maintenance Significant Items (MSI)
  - Provisioning Requirements
    - Long Lead Items, Interim Support Items
  - Line Replaceable Units (LRUs)
  - Maintenance Task Analysis (MTA)
  - Level of Repair Analysis (LORA)
  - Logistics Support Resources
Lessons Learned from Ares 1-X

- Supply chain responsibilities not clear between contracts.
- Supply Support process issues.
  - Material quantities uncertain, real time demands constant.
  - No processes ready to transfer material between programs.
  - Inventory management was resource intensive: multiple databases, no accountability identified for parts.
- Material distribution issues.
  - Mystery shipments caused delays, processing received expedited shipments time-consuming and degraded intent.
- Receiving inspection issues, confusion over requirements.
Applying Lessons Learned

- Progress has been made to apply several Lessons Learned from Space Shuttle, Constellation Ares/Ares 1-X, and Space Station.
  - Established an engineering bottoms-up Life Cycle Cost capability.
  - Established a Program ILS Team that includes Elements, contractors, and collaboration with launch site.
- Cross-Program Logistics Integration Team (LIT) includes the three NASA Exploration Programs.
Applying Lessons Learned (continued)

- Reliability, Availability, Maintainability, Supportability. Cost, and Testability considered.
- LRU remove and replace analysis.
- Collaboration on-going with launch site for streamlined shipping and receiving processes, common warehouse, and improved inventory management.
- Flight and ground hardware transfer points, processes, and procedures being addressed.
- Launch processing requirements for materials, fluids, etc., being worked, to include plans to fund the launch site to provide these items.
Applying Lessons Learned (continued)

- Clarifying Supply Chain Management (SCM), subject matter expert study in-progress.
- Commonality (Standardization) included as evolving consideration for materials and parts.
- Supportability Engineering exists as a discipline of Systems Engineering and Integration (SE&I) at Program level.
- Sustaining Engineering part of early planning.
- Maintenance planning and analysis included.
- Technical Performance Metrics (TPMs) include Launch Availability and Maintenance Down Time.
Initiatives

- Established and implemented SLSP ILS Team, includes Elements and contractors.
- Performed Program supportability assessments of Elements’ ILS and LSA plans and execution.
- Established PowerLOG-J as common LSA Record (LSAR) database with launch site.
- Modification of existing water barge for large item transport, avoidance of major new design effort.
Initiatives (continued)

- Supportability applied to Ground Support Equipment (GSE) along with flight hardware.
- Proposed efforts to evolve current integrated vehicle fault management (IVFM) model capability to include isolation capability to ambiguity group of 4-5 LRUs.
- Logistics Support Date (LSD) approach that addresses readiness of support infrastructure.
Decisions - Drivers

- **Policy Drivers**
  - Maximize use of contractor Best Practices.
  - Limited Program-imposed management and control plans.
  - Architecture Block upgrade approach.
  - SE&I Program Oversight and Insight with Elements.
- **Key target is initial launch in December, 2017.**
- **Risk-based approach to affordability.**
Decisions (continued)

- **Process tailoring**
  - Ensure the vehicle support infrastructure is adequate, has everything we need….nothing we don’t.
  - Ensure the design is successful within cost constraints.
  - Integrate ILS efforts across the Elements for support of vehicle assembly and integration activities.
  - Perform Logistics Support Analysis (LSA) under systems engineering to integrate an economical support approach.
Decisions (continued) for SLS Supportability Implementation
Decisions (continued)

- SLSP ILS Team Insight and Oversight
  - Functional team within the SE&I Operations Discipline Lead Engineering (ODLE) organization.
  - Includes capability to perform integration analysis and collaboration with the SLS Elements and launch site
- SLSP LSD is April 15, 2017.
- Identify and mitigate risks for Block 1.
- Implement life-cycle logistics support.
Conclusion

- SLSP is applying modified traditional and innovative concepts for supportability and logistics engineering.
- SLSP is applying lessons learned where possible.
- Path Forward:
  Ensure hardware availability for the first two test-oriented flights in 2017 and 2021 and work toward design-in-supportability and ILS for maturing designs for a thirty-year program.