Developing Metrics in Systems Integration
(ISS Program COTS Integration Model)

Kathryn Lueders
COTS Integration Manager
International Space Station Program

August 22, 2007
System Integration Challenges

- In large systems, multiple managers manage key system components.
  - Products for parts feed in as inputs to others.
  - Parts of the system may have conflicting priorities.

- One challenge we have is matching our goals and metrics to complement our corresponding partners’ goals and metrics.

- The second challenge is to ensure that our goals and metrics are appropriate for the global organizational goals while supporting our needs.

- The following is a case study of how two programs within NASA try to develop and measure performance while meeting the encompassing organizational goals.
• To provide logistics services for the International Space Station (ISS).
  – Vision for Space Exploration to retire Space Shuttle by 2010 results in using remaining flights to complete ISS assembly.
  – Our International Partners are providing transportation with the ATV and HTV but there is still a need for further transportation capabilities.
  – Commercial transportation service is the preferred approach if proven reliable and cost effective.
• Current transportation provider pool is limited.
  – NASA developed the COTS Program as a method of “jump starting” market capability.
  – The ISS needs provide a tangible market for them.
ISS Transportation Concept

Orbital Vehicle

- ISS Verification and Manifest Interface
- ISS COTS Packing and Loads Analysis
- Physical Cargo Integration
- Packing and Orbiting Vehicle Integration Infrastructure
- Mission Design, Integration & Engineering
- Vehicle Production
- Launch Site Operations
- Launch Management
- Post Launch

Launch Vehicle

- Launch Management
- Post Launch

ISS On Orbit Mission Control Center Interface
- Proximity Operations
- Orbiting Vehicle Recovery
- Cargo Unpacking and Return

Keep Out Sphere
Identify Key Outcomes

• The Commercial Crew and Cargo Program Office (C3PO) was established to support the development of potential providers by providing funding, expertise, and advocacy.
  – Key Outcomes for C3PO are:
    • Enabling markets for future providers.
    • Developing measurable milestones for monitoring and tracking provider progress.
    • Fostering support for emerging providers.

• The International Space Station Program (ISSP) is responsible for safely managing and flying the International Space Station.
  – Key Outcomes for the ISS Program are:
    • Having the COTS vehicle safely approach and berth to the ISS vehicle.
    • Ensure that they are developing an integration template that matches the Partner’s design progress while allowing the Program enough time to perform their integration task.
**COTS Development Milestones**

<table>
<thead>
<tr>
<th>Year</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **SpX Project Milestones**
  - Demo 1
  - Demo 2
  - Demo 3

- **Rpk Project Milestones**
  - Demo 1
  - Demo 2
  - Demo 3

- **POC:**

  - COTS Development Milestones
    - The COTS Demo schedules were appropriate for incremental vehicle development and test milestones.
      - They allowed incremental growth and check out of the new vehicle.
        - First demo flights tested the rocket; later flights checked out prox ops and berthing to the ISS.
      - The development milestones were very aggressive.
        - The development schedule was driven by the ISS Resupply needs beginning in 2010.
        - The schedules only reflected the COTS developing providers schedules but didn’t take into account ISS Program and COTS integrated activities.
    - The C3PO and the COTS Partners’ milestones matched their objective of provider development.
Determine Appropriate Milestones

• The ISS had to develop their schedules that met the ISS Program’s integration and resource needs.
  – We needed to identify long lead activities and what work needed to be done by the COTS Partners to meet that.
    • Safety Review Panel assessment – drives comm data, design approval.
    • Software integration
    • Requirements and verification planning
    • Required integrated test requirements
  – But yet, we had to be aware of the schedule that the COTS Partners were committing to and only deviating from it in critical areas.
  – We had to look at the rest of our current activities and how these new tasks fit in our schedule.
  – We had to manage our resources to match to our integration dates.

• The ISS Program also has to understand how the elements and metrics tracked by their sister program fed into these key integration milestones
  – We needed to synergize the efforts of both programs.
  – We needed to insure that we minimized the impact of our requirements on the Partner.
Milestone Development

• In particular areas the ISS drove the schedule.
  – An example of this is the scheduling of the Space X Phase 1 and Phase 2 Safety Review Panel dates.
    • Under the COTS Demo schedules, these would have occurred in May 2008 and November 2009.
    • For Space X, the ISS requested that they occur in summer 2007 and spring 2008.
    • That provided the groundwork that they needed to begin critical ISS integration work (ops concepts, communication requirements, software concepts).
  – Other areas we drove the schedule were tied to our long lead integration templates.
    • Software development, integration and testing, and timing of uploads are a long lead process.
    • Critical integrated analysis and integration areas (overall loads, environments, thermal, and robotics analysis).
    • Crew training and operations planning.
    • PROX operations and planning activities.
ISS Program Milestone Development

COTS Milestones
- Demo 1
- Demo 2
- Demo 3

ISS Integration Milestones

Requirements Development
- Val1 Running @ SpaceX
- Provide Architecture & General Description of SpaceX FDIR
- Confirm w/NASA C&W/Safety Fulfill Caution & Warning Rqts

Software Development
- 1st level Testing @ JSC (Link Layer/Basic Comm)
- PROX Testing w/JAXA
- 2nd Level Testing @ JSC (Function/Cmmd & Warnings)

Stage Verification
- RpK Demo 2 MAPS Baseline (L-6mos)
- RpK Demo 2 Stage Verification Complete (L-5wks)
- RpK Demo 3 MAPS Baseline (L-6mos)
- RpK Demo 3 Stage Verification Complete (L-5wks)
- SpX Demo 3 MAPS Baseline (L-6mos)
- SpX Demo 3 Stage Verification Complete (L-5wks)
Keep Goals and Milestones Balanced

• Original ISS Program templates were tied to their development and sustaining templates and resources.
  – Typical timeline for software releases was two years.
  – Typical timeline for stage verifications and integrated analysis was over two years.
  – These templates allowed the teams to work the flights and perform work within their existing manpower.

• If ISS kept to their usual templates for development and integration they would never meet the overall goals of NASA (and ultimately our goals for having multiple resupply providers).
  – We had to adjust their timelines and change their processes to accommodate the new vehicles.
  – We had to push for critical data deliverables where they needed them to perform key long lead tasks.
  – We had to monitor the progress of the key sub elements of the other programs tasks.

• We had to balance the overall commercial model for development with our programmatic requirements.
Summary

• Understand how your piece fits in the overall system.
  – Have a clear vision of the overall goal.
  – Understand how your goals fit in with other organization’s goals.

• Ensure development, tracking, and measurement of milestones is appropriate for your specific role.
  • May require a re-negotiation of dependent organization’s milestones.
  • Critical to understand priority of the relating milestones.

• Keep an understanding of overarching goal and how to balance goals and milestones between them.