JCL Implementation On A Human Spaceflight Program

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Outline

- What is JCL Analysis
- SLS Program
- SLS JCL Architecture & Modeling Example
- SLS JCL Implementation
- Future SLS JCL Considerations
What is JCL Analysis?

Joint Confidence Level (JCL) analysis focuses on the integration of traditionally stove-piped programmatic components (schedule, cost and risk) to establish projected resource and schedule requirements at various confidence levels and to identify programmatic cost and schedule risk drivers.
NASA’s Human Spaceflight Program: Space Launch System (SLS) Program

**INITIAL CAPABILITY, 2017–21**

- **Orion Multi-Purpose Crew Vehicle (MPCV)**
  - Lockheed Martin

- **Launch Abort System**

- **Interim Cryogenic Propulsion Stage**
  - Early flight certification for Orion
  - Flexible for a range of payloads
  - Boeing

- **5-Segment Solid Rocket Boosters**
  - Upgrading Shuttle heritage hardware
  - ATK

- **Core/Upper Stage**
  - Common design, materials, & manufacturing
  - Boeing Avionics
    - Builds on Ares software
    - Boeing

**EVOLVED CAPABILITY, Post-2021**

- **Upper Stage**
  - Commonality with Core Stage
  - Optimized for Mission Capture

- **Advanced Boosters**
  - Competitive opportunities for affordable upgrades
  - Risk-reduction contracts awarded in FY13

- **Fairings (27.5’ or 33’)**
  - Right-sized for the payload
  - Received industry input in FY13

- **Core Stage Engines**
  - Using Space Shuttle Main Engine inventory assets
  - Building on the U.S. state of the art in liquid oxygen/hydrogen
  - **Initial missions**: Pratt & Whitney Rocketdyne
  - **Future missions**: Agency is determining acquisition strategy

**Evolutionary Path to Future Capabilities**

- Minimizes unique configurations
- Allows incremental development
- Advanced Development contracts awarded in FY13
SLS Integration Complexity

- SLS Program consists of multiple Prime Contractors managed by independent SLS Elements which are integrated using SE&I and Program Management.

- SLS further integrates with GSDO and MPCV through ESD integrated working groups.
Monte Carlo Simulation Analysis

- Schedule
  - Uncertainty
  - Duration (Low, High)
  - Cost loading of selected WBS/schedule Line items

- Cost
  - TD, TI
  - Uncertainty (Low, High)
  - Cost (Low, High)

- Risks
  - Probability of Occurrence
    - Schedule Impact
      - Uncertainty (Low, High)
    - Cost Impact
      - Uncertainty (Low, High)

Each Discrete Risk Linked to One or More Schedule Line Items

SLS Summary Schedule

Analysis Schedule (JCL backbone)
**Summary Task**

- **Assignment Cost:** $73 M
- **Duration:** 600 days
- **Rate:** $58.4 M / 600 = $97,333/day

**Subtask A**

- **Assignment Cost:** $154 M
- **Duration:** 250 days
- **Risk:** No risks assigned

**Subtask B**

- **Assignment Cost:** $0 M
- **Duration:** 350 days
- **Risk:** Multiple risks assigned
  - Risk 1: $10 M impact
  - Risk 2: 42 day impact
  - Risk 3: 42 day impact

**Notional Gantt View**

**Total Cost:** $227 M
### Input

#### Summary Task
- **Total Duration:** 600 Days
- **Rate:** $97,333/day
- **Total Cost:** $227 M
- **No Risks assigned**

#### Subtask A
- **Total Duration:** 250 days
- **Assigned Cost:** $154 M
- **No Risks assigned**

#### Subtask B
- **Total Duration:** 350 Days
- **Assigned Cost:** $0 M

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### Output

#### Summary Task
- **TI:** $14.6 M
- **TD:** $722 * Rate = $70.3 M
- **Subtask:** $154 M
- **Risks:** $10 M
- **Total Cost:** $248.9 M
- **Calculated Duration:** 600 + 122 = 722 Days

#### Subtask A
- **TI:** $154 M
- **TD:** 0
- **Assigned Cost:** $154 M
- **Duration:** 250 days

#### Subtask B
- **TI:** 0
- **TD:** 0
- **Assigned Cost:** 0
- **Risk 1:** $10 M
- **Risk 2:** 42 days
- **Risk 3:** 42 days
- **Calculated Duration:** 472 days

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*Increase due to external logic links*
SLS JCL Implementation

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On-going Data Collection & Analysis

SLS Polaris Implementation and Analysis

TD

TI

Cost data

Data Source #1

TD

TI

SLS JCL Data

Risk data

Delphi Assessment

SRB Update #1

JCL Data

SRB Update #2

SLS JCL Team Feedback

Benchmarking (Risk Plus, Primavera)

SRB Update #3

Polaris V1.XX

Polaris V1.3

Polaris V1.2

JCL Analysis Schedule

Cost data

Data Source #2

Data Source #3

Delphi Data

SRB Data Source

SRB Data Source

SRB Data Source

Update #1

Update #2

Update #3

Update #3

Update #1

Update #2

Update #3
Although the JCL analysis returns a projected cost and schedule at a selected confidence level, the real benefit of the analysis is the ongoing communication and interaction across the organization, that is needed to properly establish the right inputs and to tune the model.

The JCL data gathering and analysis process has led to data exchange, integration and communication between cost, schedule, and risk data owners within each Element/SE&I as well as between Elements/SE&I and the SLS Program Manager.
Potential use of JCL as a Management Tool

SLS Polaris Implementation and Analysis

JCL Analysis Schedule

SLS JCL Team Feedback

Notional SLS Monthly Management Review JCL metrics

Polaris V1.2
Polaris V1.3
Polaris V1.X
Large Scale Programs

- Large Scale programs require multiple levels of schedule cost and risk
  - 4 JCL team analysts
  - 6 resource managers
  - 6+ risk managers
  - 6+ schedulers
  - 10+ Integration team (risk managers, schedule team resource management)
  - Cross program working groups
  - 6-8 months of JCL data collection, evaluation, analysis and documentation
  - Education of large audience on JCL input parameters requirements

Smaller Scale Programs

- Smaller Programs require less time and resources, but can follow similar process as large scale programs.
  - 1 JCL Analyst
  - 1 resource manager
  - 1 risk manager
  - 1 Scheduler
  - Minimal integration team
  - Working groups integrated in existing organizations
  - Minimal education on JCL parameter requirements
  - 1-2 months data collection analysis and documentation
Lessons Learned

- Organizational top down support for JCL implementation makes a SIGNIFICANT difference.
  - We had it on SLS
  - Time is needed to educate risk “owning organizations” on how the JCL works

- Communication of initial model results, in conjunction with SLS Management emphasis on JCL importance, led to enhanced organizational interest and desire to refine their inputs

- Start the JCL analysis early
  - It takes time to collect the data, normalize the data, educate the organization, conduct the analysis, refine the analysis, and understand the results.

- Do not expect the right “JCL answer” on the first pass
  - It requires on-going tuning of parameters

- The JCL “story telling” is not an easy thing to do
  - Leave time to prepare presentations that document JCL process and results to a variety of audiences
  - Don’t fall into the trap of presenting too much “modeling detail”

- Be prepared to deal with cost, schedule and risk data that is undergoing constant change
  - Patience is needed