Space Shuttle Processing Simulation Model

Macro Level Simulation Model Of

Space Shuttle Processing

Developed under a NASA Space Act Agreement between the Kennedy Space Center and the University of Central Florida

“ST Day 2000: Reducing Risk for the Next Generations”
The simulation model encompasses the existing space shuttle ground processing Facilities, Ground-Support Equipment (GSE) infrastructure and Flight-Hardware elements to the level of detail that NASA retains management responsibility for; such as...

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<th>Flight Hardware</th>
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<td>Orbiter Transporter</td>
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<td>SSMEs</td>
<td>Engine Shop</td>
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<td>External Tanks</td>
<td>VAB</td>
<td>ET Transporter</td>
</tr>
<tr>
<td>SRM/SRB</td>
<td>MLPs</td>
<td>Crawler/Transporter</td>
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The simulation model logic is consistent with current Space Shuttle program ground rules and constraints such as...

- After 8 flights, the shuttle orbiter undergoes depot level maintenance (OMDP/OMMP) in California.
- Only one shuttle on orbit at any given time.

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Flow Diagram
Utilized commercial off-the-shelf Software

Rockwell Software* Arena
*Systems Modeling

Microsoft Project
Microsoft Excel
Microsoft PowerPoint
Microsoft Visio

Simulation Software

Project Schedule
Data Files
Knowledge Files & Presentations
Flow Diagrams

Averill M. Law &
Associates, Inc. ExpertFit

Distribution Fitting

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Space Shuttle Processing Simulation Model
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<th>Process Location</th>
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<td>MLP UCF Phase-</td>
<td>SSME Turnaround</td>
<td>OPF, VAB, Pad, Engine Shop</td>
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<td>MLP TA Days.xls</td>
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<td>Orbiter OMDP</td>
<td>OPF, Palmdale</td>
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<td>Omdpflows UCFRev A.xls</td>
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Knowledge Acquisition
Diagram at left is the SSME related portions of the model. Of interest from a modeling standpoint is:

- How long from OPF roll-in to SSME removal.
- Travel time between OPF and Engine Shop.
- Duration of Engine Shop activity.
- Minimum time between engines-out and engines-in.
- Duration between SSME installation and OPF roll-out.

Initial modeling assumptions and subsequent changes:

- The engine set (3 engines) stays together. (Changed to allow engines to be separated in the engine shop)
- There are 13 engines and thus four sets of engines plus one ready spare engine. (Changed to 21 engines or 7 sets to more closely reflect 1992-1997 time-frame)
- The engine shop can process one set of engines at a time. (Changed to any number of engines at a time)
- Any engine set can go in any orbiter on a first need, first served basis.
- Engine removal during a Pre-Palmdale OPF Flow is modeled the same as Normal OPF Flow.

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Space Shuttle Processing Simulation Model Knowledge Acquisition Excerpts from Introductory Briefings
Example of Probability Distribution Selection using ExpertFit: OPF Roll-in to SSME Removal

Density / Histogram Overplot

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Simulation Input Analysis
A functional probabilistic based simulation of space shuttle operations now exists and can be used for several applications:

- **Analysis of present Space Shuttle System**
  - Identify Facility & Flight Hardware Utilization percentages
  - Identify potential bottlenecks

- **Flight Rate Experiments**
  - Manipulate process-duration probability distributions to achieve 10 (or more) flights per year and analyze model outputs.

- **What-if questions can be analyzed such as:**
  - What is the expected impact on flight rate given the loss of a launch pad?
  - What is the expected impact on flight rate given the loss of one VAB Integration Cell?

- The current model offers an architecture that allows lower level detail to be modeled for system specific operational processes or events.

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Model Applications in current Shuttle Environment
♦ The existing model can serve as a First Generation RLV baseline for comparison
  • Aid in understanding and serve as a point of departure for new reusable Space Launch Initiatives

♦ New RLV specific models can be used to increase insight into reusable launch vehicle turnaround, operational processes and business case closure risk.
  • Demonstrate Flight Rate dependence on such factors as the RLV architecture, probabilistic processing times, launch scrubs, and ascent outcomes.

♦ Provide the government with a tool for analyzing and comparing competing architectures
  • Requires that each architecture be modeled using similar methodology.

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Model applications for future RLV’s