Mission Operations Assurance

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Mars Climate Orbiter Recommendations (1999)

- Revise JPL mission assurance policies and procedures to require an independent Mission Assurance representative during the operational phase of every flight project.

- Require all flight projects to report and track post-launch anomalies on ISAs. Project management should rigidly enforce this requirement and maintain a disciplined disposition, tracking, and resolution process.
Integrate the mission operations assurance function into the flight team providing:

- value added support in identifying, mitigating, and communicating the project’s risks and,
- being an essential member of the team during the test activities, training exercises and critical flight operations.
Mission Operations Assurance Requirements

- Independently assess project risks throughout mission operations.

- Independently assess the project’s operational readiness to support nominal and contingency mission scenarios.

- Implement the project’s problem/failure reporting system to comply with JPL’s Anomaly Resolution Standard.

- Provide training on problem reporting for the flight team.
Mission Operations Assurance Implementation

- **Risk assessment**
  - Captures the residual mission risks as the project transfers from the development to the operational phase of the mission.
  - Assesses residual risks throughout the post-launch risk review process and integrates them into an overall risk assessment.
  - Provides an independent risk assessment of the Project’s risk posture in preparation for critical events.

- **Operational Readiness**
  - Participates in Operational Readiness Tests (ORTs) to assess if the test objectives were met; and that residual liens are identified, tracked, and resolved.

- **Problem Reporting**
  - Manages the problem failure reporting system for flight operations including the system setup; as well as the initiation, processing and closeout of Incidents, Surprises, Anomalies (ISAs).

- **Operations Training**
  - Oversees/conducts the problem/failure reporting function training to the flight team.
  - Assesses the adequacy of the flight team operations position training and overall system level flight team training program.
Mission Operations Assurance Implementation

- **Operational Requirements**
  - Works with the MAM, PSE, and MOS engineer to assure operational requirements are implemented into the flight hardware, software, and operations design.
  - Participates in operations peer reviews and the Operational Readiness Review (ORR) to assess resolution of integration issues between development and operations.

- **Project Planning**
  - Assesses Mission Change Requests (MCRs) to ensure appropriate review has been completed, and provides independent risk assessments, as appropriate.

- **Flight Rules**
  - Reviews waivers to flight rules and makes recommendations to the project.

- **Reporting**
  - Briefs independent risk assessments at Mission Management Reviews (MMRs), Project Status Reviews (PSRs), Quarterly Reviews, Office of Safety and Mission Success (OSMS) monthly reviews, and Critical Events Readiness Reviews (CERR).

- **Interfacing with other Quality/Operations Assurance Function**
  - Coordinates Software Quality Assurance support for in-flight software development, flight software modifications, and the resolution of flight software anomalies.
  - Coordinates with industry partners to assure an integrated mission operations assurance program is in place.
Backup
Example
Post-Lauch
Residual Risk Assessment
Example Post-Lauch Residual Risk Assessment

- Performed an independent review and assessment (JPL and Contractor) of the Project’s pre-launch residual risk items with implications to earth return.
  - Reviewed and assessed all pre-launch residual risk items including single point failures, spacecraft design risks, mission design risks, red flag PFRs, unverified failures, and major waivers.

- Performed an independent review and assessment (JPL and Contractor) of the Project’s ISAs and operational waivers with implications to earth return.
  - Reviewed all Criticality 1 and 2 ISAs
  - Reviewed all Spacecraft ISAs
  - Reviewed Remaining Criticality 3 & 4 ISAs

- Captured residual risks from the Project’s post-launch risk review process.

- Participated in Flight team rehearsals and Operational Readiness Tests.

- Reporting on the risks with specific critical event applicability followed by generic risks applicable throughout the mission.
Example Post-Launch Residual Risk Assessment

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Consequence to sample return</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Very low - Very unlikely</td>
<td>1 Minimal or no impact to mission</td>
</tr>
<tr>
<td>2 Low - Unlikely</td>
<td>2 Small reduction in mission return</td>
</tr>
<tr>
<td>3 Moderate - Significant likelihood</td>
<td>3 Moderate reduction in mission return</td>
</tr>
<tr>
<td>4 High - More likely than not</td>
<td>4 Significant reduction in mission return (Significant delay in returning samples)</td>
</tr>
<tr>
<td>5 Very high - Almost certain</td>
<td>5 Mission failure (Loss/contamination of samples or violation of entry safety criteria)</td>
</tr>
</tbody>
</table>

Likelihood Scale:
- 1: Very low - Very unlikely
- 2: Low - Unlikely
- 3: Moderate - Significant likelihood
- 4: High - More likely than not
- 5: Very high - Almost certain

Impact Scale:
- 1: Minimal or no impact to mission
- 2: Small reduction in mission return
- 3: Moderate reduction in mission return
- 4: Significant reduction in mission return (Significant delay in returning samples)
- 5: Mission failure (Loss/contamination of samples or violation of entry safety criteria)
# Example Post-Launch Residual Risk Assessment

<table>
<thead>
<tr>
<th>Risk #</th>
<th>Risk Rating</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4x1</td>
<td>Thruster failure causing switch to backup thruster string</td>
</tr>
<tr>
<td>2</td>
<td>3x1</td>
<td>Reboot/side swap resulting in unplanned delta V</td>
</tr>
<tr>
<td>3</td>
<td>4x1</td>
<td>Spacecraft loss of attitude knowledge</td>
</tr>
<tr>
<td>4</td>
<td>5x1</td>
<td>DSN ground station uplink capability lost</td>
</tr>
<tr>
<td>5</td>
<td>4x1</td>
<td>DSN ground station downlink capability lost</td>
</tr>
<tr>
<td>6</td>
<td>5x1</td>
<td>FPGA in Pyro Initiation Unit (PIU) pyro card fails</td>
</tr>
<tr>
<td>7</td>
<td>5x1</td>
<td>Safe mode at end of autonomous sequence recovery window</td>
</tr>
<tr>
<td>8</td>
<td>5x1</td>
<td>SRC cable cutters fail</td>
</tr>
<tr>
<td>9</td>
<td>5x1</td>
<td>SRC Separation Mechanism (SSM) predicted to be 8 degrees C above flight allowable at release</td>
</tr>
</tbody>
</table>
6. FPGA in PIU Pyro Card
   • Description
     • FPGA in PIU Pyro Card Fails
   • Mission Risk
     • Impact: 5
     • Likelihood: 1
Example
Risk Trade Study
Risk Balance Trade
Nighttime vs Daytime Entry

• Approach
  • To provide an independent Safety & Mission Assurance assessment of the Stardust daytime vs nighttime entry decision

• Review the following areas to identify major risk Items:
  • Spacecraft Operations
  • Ground Impact Hazard Assessment
  • STRATCOM Tracking
  • SRC Design Margin
  • Ground recovery Operations
  • Backup Orbit Considerations

• Recommend an option based on the major risk drivers
## Risk Balance Trade

### Nighttime vs Daytime Entry

<table>
<thead>
<tr>
<th>Risk Drivers and Rankings</th>
<th>Risk Trade Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk Driver</strong></td>
<td><strong>Nighttime</strong></td>
</tr>
<tr>
<td></td>
<td>Human Safety</td>
</tr>
<tr>
<td>Earth Hazard Avoidance</td>
<td>Major</td>
</tr>
<tr>
<td>Ground Impact Hazard Assessment</td>
<td>Major</td>
</tr>
<tr>
<td>SRC Design Margin</td>
<td>Major</td>
</tr>
<tr>
<td>Ground Station Coverage</td>
<td>Major</td>
</tr>
<tr>
<td>SRC Processing Time - Anomalous</td>
<td>Major</td>
</tr>
<tr>
<td>Backup Orbit Duration</td>
<td>Minor</td>
</tr>
<tr>
<td>SRC Release Downlink Data Rate</td>
<td>Minor</td>
</tr>
<tr>
<td>STRATCOM Tracking</td>
<td>Minor</td>
</tr>
</tbody>
</table>

✔️: Lower Risk Option
Risk Balance Trade
Nighttime vs Daytime Entry

• Major Risk Drivers
  • The major risk drivers are:
    • Earth avoidance strategy - favors a nighttime entry
    • Ground impact hazard assessment - favors a nighttime entry
    • Redundant ground station coverage - favors a nighttime entry
    • The SRC design margin - favors a nighttime entry
    • The recovery processing time for a breached SRC - favors a daytime entry

• Safety and Mission Assurance Recommendation
  • On risk balance, preserving the SRC design margin by coming in at night and accepting a longer SRC processing time in the event of a breached SRC is recommended.