Challenges in Implementing Medium & High Risk NASA Payloads

Kim Plourde
JPL/Caltech
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Agenda

• Review the NASA process for determining payload* risk classification
• Examine the implications of payload risk classification
• Discuss typical challenges at JPL with implementing payloads of varying risk classifications
• Observations/suggestions going forward

* - Payload- Any airborne or space equipment or material that is not an integral part of the carrier vehicle
• NASA* divides all airborne/space equipment into one of four risk classifications-

- Very Low Risk (Class A)
- Low Risk (Class B)
- Medium Risk (Class C)
- High Risk (Class D)

• Determining the risk classification for a particular payload is an *inexact*, iterative process
  – Classification is finalized prior to Preliminary Design Review through a combination of various NASA offices/organizations/councils

*- NPR 8705.4, “Risk Classifications for NASA Payloads”
## Risk Classification Considerations*

<table>
<thead>
<tr>
<th>Priority (Criticality to Agency Strategic Plan) and Acceptable Risk Level</th>
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*NPR 8705.4*
# Example - Deep Space Mission

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Example - Earth Orbiter (3 yr mission)

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Risk Classification Implications

For each of NASA’s four risk classes, there are companion guidelines/requirements in each of the following areas*-

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<th>Single Point Failures</th>
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<th>Maintainability</th>
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<td>Hardware (EM, Flight, Spares)</td>
<td>Materials</td>
<td>Quality Assurance</td>
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<tr>
<td>Test program (Qual, ProtoFlight, Acceptance)</td>
<td>Reliability</td>
<td>Software (assurance)</td>
</tr>
<tr>
<td>EEE Parts</td>
<td>Fault Tree Analysis</td>
<td>Risk Management</td>
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<tr>
<td>Reviews</td>
<td>Probabilistic Risk Assessment</td>
<td>Telemetry Coverage</td>
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With a few exceptions (noted in blue), the level of rigor and penetration required in each of these areas varies with classification, i.e. the expectations for low risk payload electronic parts are much greater than for a high risk payload.

* NPR 8705.4
Recap - It's a Two Step Process

**STEP 1**

Designate a Risk Class

- **Low**
- **Medium**
- **High**
- **Very Low**

**STEP 2**

Evaluate requirements associated with the designated risk classification*

**EEE Parts**

- Class A - NPSL Level 1
- Class B - NPSL Level 1/2
- Class C - NPSL Level 1/2/3
- Class D - NPSL Level 1/2/3

**Reliability**

- Class A - FMEA, Worst Case, Parts Stress Analysis
- Class B - Box level FMEA, Worst Case, Parts Stress
- Class C - Interface FMEA, Parts Stress
- Class D - Based on safety requirements

**Etc**

- Class A
- Class B
- Class C
- Class D

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* - per NPR 8705.4
IMPLEMENTATION CHALLENGES
Main Challenges

- At JPL, there are generally two challenges in dealing with NASA’s multiple payload risk classifications-
  1) Payloads with a lower risk posture than the JPL “low risk” Institutional baseline- i.e., “very low” risk missions
   - Meeting these guidelines requires a few add-ons to the way JPL typically performs work
     - Impact is largely programmatic- increases in cost and cycle time (full qualification & acceptance test programs, separate prototype and flight models, etc)
  2) Payloads that adopt a higher risk posture than the JPL “low risk” Institutional baseline- “medium/high” risk missions
   - In our experience, more effort (than expected) is required to actually execute a payload with less than traditional rigor and penetration
Medium/High Risk Payload Challenges

- The willingness to assume “additional” risk, versus normal practice(s), is typically uneven throughout an organization.

- “Medium/high risk is OK in other areas, but not mine”
Medium/High Risk Payload Challenges

- In some areas, there is no clear line of demarcation (based on current guidelines) between various risk postures- which leads to differences in interpretation
  - Examples
    
    **Spares***
    
    | Low Risk                          | Medium Risk                          | High Risk                                |
    |-----------------------------------|--------------------------------------|------------------------------------------|
    | "..Spare hardware as needed to avoid major program impact." | "..Limited flight spare hardware (for long lead flight units)." | "..Limited engineering model and flight spare hardware." |

    **Quality Assurance***
    
    | Low Risk                          | Medium Risk                          | High Risk                                |
    |-----------------------------------|--------------------------------------|------------------------------------------|
    | "… moderate surveillance"         | "… tailored surveillance"            | "… Based on applicable safety requirements" |
Medium/High Risk Payload Challenges

• There are corollary, unstated risks which need to be understood and communicated
  – Example
    • Medium/high risk payload guidelines allow the use of NASA Parts Selection List (NPSL) Quality Level 3 parts
      – **Unstated risk**-The radiation tolerance/hardness of NPSL Level 3 parts is typically not easily quantifiable
        » Little or no test data
        » Lot variability
        » Use of off-shore suppliers
      – **Result**- Projects choose between painful options, including-
        » Accept risk of a radiation-induced unrecoverable event (with an undefined likelihood of occurrence)
        » Spend funds to characterize the parts (typically considered an out-of-scope task)
High Risk Payload Challenges

• During implementation of high risk payloads, there is a tendency to stray from the guidelines and expand the boundaries of what is acceptable. Common signs of this trend include:
  – Best practices and lessons learned are overlooked/ omitted
  – Documentation rigor suffers
  – Success criteria becomes less well defined, leading to potential miscommunication/misunderstandings with the customer/spo

• Implementation of high risk payloads requires specialized, unique training.
  – For many, this seems to be counterintuitive
  – It is hard to clearly define the “dos” and “don’ts” for high risk baselines
High Risk Payload Challenges

• The human-rated safety requirements for International Space Station (ISS) payloads restrict “flexibility”-

<table>
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<tr>
<th>High Risk Approach*</th>
<th>Additional ISS Safety-related Requirement</th>
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<td>Single Point Failures</td>
<td>“…single string approaches may be used.”</td>
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<td>Test Program</td>
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• These additional requirements complicate the costing/planning process for technology development payloads, which are typically viewed as high risk

*- NPR 8705.4
Summary

• The advantages of early identification of an acceptable project risk posture for a NASA payload include-
  – Serves to baseline expectations and enhances communication among participants, as well as with customers and suppliers
  – Reduces the amount of time/expense required to justify deviations to normal practices

• Medium/high risk implementation approaches tend to move people out of their comfort zone
  – In our experience, more effort (than expected) is required to actually execute a payload with less than traditional rigor and penetration

• When working on high risk projects, training and adherence to guidelines are (still) two keys to success
BACK-UP
Definitions

• Payload- Any airborne or space equipment or material that is not an integral part of the carrier vehicle (i.e. not part of the carrier aircraft, balloon, sounding rocket, expendable or recoverable launch vehicle). Included are items such as free-flying automated spacecraft, Space Shuttle payloads, Space Station payloads, Expendable Launch Vehicle payloads, flight hardware and instruments designed to conduct experiments, and payload support equipment.

• NASA payload- Any payload for which NASA has design, development, test or operations responsibility.
## Example Missions

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<td>HST, Cassini, JWST</td>
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<td>ESSP, Explorer Payloads, MIDEX, ISS complex subrack payloads</td>
<td>SPARTAN, GAS Can, technology demonstrators, simple ISS, express middeck and subrack payloads, SMEX</td>
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Level 3 is the minimum product assurance class assigned to parts listed in this document. Level 3 contains many advanced electronic functions (from a space flight applications standpoint) and has been created to provide a technology insertion path into NASA flight projects. Parts listed are those produced by reputable manufacturers under a recognized quality assurance system (QML, QPL, ISO 9000) or their equivalent. Typically, only a limited amount of information is available to NEPAG for these parts and NASA has minimal visibility into the manufacturing and testing of Level 3 product. The parts are usually available commercially and have the capability to be used in space applications. The intent of Level 3 listings is to provide products that are newer, have greater functionality and enhanced performance characteristics, and provide higher levels of integration. Because the product has little or no heritage in space flight application and data is unavailable or scarce, these parts are considered higher risk than the Level 1 and Level 2 parts. While the price of these parts may be less than the traditional Levels, more engineering evaluation may be needed to qualify the part for the project’s application. The overall reliability and cost of ownership should be considered when selecting these parts. The Level 3 criteria is summarized as follows:

- The manufacturer has supplied and qualified parts for several NASA space projects within the past 2 years.
- The parts and manufacturers have been recommended by one of the following NASA programs.
  - PSAP
  - ASAP
  - ET
  - AIT
- A NASA, DoD, or other space agency procurement specification (e.g. ESA SCC or JAXA QPL/QML) exists.
- Available data on the manufacturer shows no significant problem trends such as GIDEP Alerts or NASA Parts Advisories, a low DPA rejection rate for the manufacturer’s products in general, and no significant failures attributable to product quality and/or reliability.