NASA ARMSTRONG FLIGHT RESEARCH CENTER
AIRWORTHINESS AND FLIGHT SAFETY REVIEW PROCESS OVERVIEW

Bradford Neal - AFRC Chief Engineer
Bradley Flick - AFRC Director of Research and Engineering

AIAA Aviation 2017
Denver, CO
06 June 2017
OBJECTIVES

• Communicate the purpose of the AFRC airworthiness and flight safety review process

• Understand the operation of the AFRC airworthiness and flight safety review process
ARMSTRONG AFSR PROCESS APPLIED

One Process Many Applications
IMPLEMENTATION

• Per NASA Procedural Requiremnt 7900.3 - Aircraft Operations Management

  – “NASA maintains the level of airworthiness and aircraft/UAS operating standards that will ensure the safe operation of aircraft/UAS missions.”

  – “Center Directors shall establish airworthiness, flight safety, mission readiness, and configuration control review processes and procedures to identify any hazards, to manage the risks associated with flight programs, to ensure safe flight operations, to manage and thoroughly document aircraft configurations, and to ensure that flight objectives satisfy programmatic requirements.”
GOAL

• Provide a flexible, risk management based review system that...

  – Provides an airworthy vehicle that can be operated safely with the highest probability of mission success
  – Assesses, Communicates and Accepts the residual risks of vehicle test and operation
FAILURE CAN BE AN OPTION: SAFETY VS RISK

- Safety and risk are often used interchangeably, but in the flight research world they mean different things.
- Our primary motivation is to do everything we can to ensure mission success, but with no compromise to human safety
  - Public/non-participants
  - Ground personnel
  - Flight Crew
- But technical risk can be acceptable
  - Failure to meet mission objectives
  - Some system failures
  - RTB and live to fly another day
EXPERIMENTAL FLIGHT RISK

• Experimental flight often carries a higher technical risk than operational flight...
  – Less system maturity/demonstrated reliability,
  – Single-string elements,
  – Reused systems/components...

• But, experimental flight can allow mitigations that aren’t available to operational flight
  – Real-time system health and performance monitoring (control room)
  – Flight envelope and other mission-specific operating limits – rely on procedure to stay out of trouble
APPLICATION OF STANDARDS

• It’s important to evaluate not just the airplane, but the entire system when assessing risk.
• Design standards are essentially risk mitigations based on lessons learned over time, and they should be strictly applied to the development of operational systems.
• In an experimental flight application, however, the previously mentioned mitigations should be considered as potential rationale for deviation or relaxation of design standards. Tailor as appropriate for the application.
PROJECT TEAM RESPONSIBILITIES

- Select appropriate standards to design and build hardware, software and systems.
- Develop systems, test, procedures and documents, that will allow the project to meet its technical objectives.
- When the project believes it has accomplished sufficient validation in preparation for flight, it presents its plans and rationale for flight readiness to the appropriate reviewing body.
“The AFSRB is tasked with performing certain review processes in order to ensure the flight safety of all projects conducted at Armstrong Flight Research Center.”

G-7900.3-001
Airworthiness and Flight Safety Review

Armstrong Center Director

Airworthiness and Flight Safety Review Board

Flight Readiness Review Committee

Totally independent team of disciplinary specialists chartered to assess project’s overall readiness for flight, categorization of hazards, probability of mission success, and flight/ground/range safety procedures

Project Team

Responsibility for design, development, integration, verification and validation, hazard analyses, risk management, flight qualification, flight test, flight operations

Director considers AFSRB recommendations; either approves platform for flight or directs project team to provide additional risk mitigation

AFSRB formulates a recommendation letter to the Center Director documenting flight safety risks

Standing board of Armstrong senior managers chaired by the Armstrong Chief Engineer

FRR prepares written report of findings/recommendations and briefing to AFSRB

Comprehensive review of technical analyses, operational procedures, documentation, hazard/risk management, qualification test results, and flight/ground/range safety
PROCESS TAILORABILITY

Project Team and Center Chief Engineer Review plans and preparations

Complexity, Criticality, Risk Scale

Low High

Review Level

Chief Eng. Review
Chief Eng. Review with small group of experts
AFSRB Review
Indep. Flight Readiness Rvw.

Approved to fly with tech brief
Approved to fly with crew brief
Approved to fly with operational readiness review

FLY
• Flight Readiness Review (FRR) Board
  – An Ad Hoc committee chartered by the Center Chief Engineer to evaluate the systems, activities, procedures, and documents developed by the project, assessing the approach and implementation in regards to public, ground, flight, and range safety
  – The FRRB examines the project generated hazard analyses in detail, verifying that proper mitigations have been implemented and that reasonable residual risk has been identified
  – The Board’s findings and conclusions are presented to the Airworthiness and Flight Safety Review Board (AFSRB)
  – Membership is independent of the project under review, consisting of lead or journeyman level individuals assigned to other projects
  – Membership includes representation from the technical disciplines critical to the project
AFSR ROLES AND RESPONSIBILITIES

• Airworthiness and Flight Safety Review Board (AFSRB)
  – A standing board of Armstrong senior managers (Engineering, S&MA, Flight Ops, Test Systems, Projects), chaired by the Center Chief Engineer
  – Receives the FRR Committee’s findings and conclusions
  – Receives the project’s response to the FRR findings, as well as the project’s plans to close remaining work prior to flight
  – The AFSRB deliberates on the material presented and formulates a consensus-based recommendation to the Center Director regarding the project’s readiness for flight and the acceptability of residual risk
  – If consensus can not be reached, a majority based recommendation is presented to the Center Director along with the minority opinions.
  – The AFSRB Chair formulates a recommendation letter to the Center Director regarding the adequacy of the project’s preparation. Special attention is given to quantifying the residual risk, with Accepted Risk hazards clearly identified
• Purpose

– Closes out all open items for flight
– Provide for peer review of goals and plans
– Current assessment of project risks
– Final briefing to management to gain approval for flight
– Ensure safe and efficient conduct of a specific mission (or set of missions)
SUMMARY

• Get Off the Stage Chart
QUESTIONS?
Back up Charts
AFSR Roles and Responsibilities

• Center Chief Engineer
  – Chairs AFSRB and Tech Brief Committee
  – Determines the appropriate level of independent review based on project complexity and risk
    • Center Chief Engineer only
    • Center Chief Engineer with consultation from SME’s
    • Project brief to AFSRB
    • Independent Flight Readiness Review brief to AFSRB
  – Communicates AFSRB recommendation to Director
  – Communicates residual risk to Director
AIRWORTHINESS AND FLIGHT SAFETY PROCESS ROLES AND RESPONSIBILITIES

• Center Director

  – Considers the recommendation of the AFSRB and assesses the identified residual risk, including any Accepted Risk hazards
  – The Center Director’s signature on the AFSRB letter indicates a formal approval of the recommendation and acceptance of any Accepted Risk hazards, thereby permitting the project team to proceed toward the planned flight activity
WHO IS THE AFSRB?

- Airworthiness and Flight Safety Review Board
  - AFRC Chief Engineer (Chair)
  - Deputy Center Director (Alternate Chair)
  - Director, Research and Engineering (R)
  - Director, Flight Operations (O)
  - Director, Mission Information and Test Systems (M)
  - Director, Programs (XP)
  - Appropriate Projects Mission Director
    - Aeronautics (PA), Exploration (PE), Reimbursable (Z), Science (PS)
  - Director, Safety and Mission Assurance (S)
  - Chief Pilot (OF)
  - Aviation Safety Officer
  - Other Outside Organizations as Required

  - (Quorum = Chair, O, R, S, ASO*, Pilot*, RSO**)
Disagreement resolution

If the project team disagrees with an FRR recommendation, it can present an alternative to the AFSRB for consideration.

If the project team is still dissatisfied with the AFSRB’s disposition of the issue or with the Armstrong Director’s decision, it can appeal through the appropriate Mission Directorate.

If the project appeals to the Mission Directorate, then the Armstrong Director and the Associate Administrator attempt to resolve issue, in consultation with OCE and OSMA.

If the Armstrong Director and Associate Administrator fail to resolve issue, final disposition is taken to the NASA Associate Administrator.

Armstrong’s Directors for Engineering, Flight Operations, and Test Systems are members of the AFSRB and are also responsible to OCE at HQ on technical engineering matters … can appeal directly to OCE in the event of a disagreement with an AFSRB recommendation.

Armstrong’s Director for Safety and Mission Assurance is a member of the AFSRB and is also responsible to OSMA at HQ on safety related reviews … can appeal directly to OSMA in the event of a disagreement with an AFSRB recommendation.
### HUMAN SAFETY HAZARD ACTION MATRIX

<table>
<thead>
<tr>
<th>Injury Severity Classifications</th>
<th>Probability [Pr] Estimations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A: Expected to occur ((Pr &gt; 10⁻¹))</td>
</tr>
<tr>
<td></td>
<td>B: Probable to occur ((10⁻¹ &gt; Pr &gt; 10⁻²))</td>
</tr>
<tr>
<td></td>
<td>C: Likely to occur ((10⁻² &gt; Pr &gt; 10⁻³))</td>
</tr>
<tr>
<td></td>
<td>D: Unlikely to occur ((10⁻³ &gt; Pr &gt; 10⁻⁶))</td>
</tr>
<tr>
<td></td>
<td>E: Improbable to occur ((10⁻⁶ ≥ Pr))</td>
</tr>
</tbody>
</table>

| I: Catastrophic                  |                                                                                             |
|                                 |                                                                                             |
| II: Critical                    |                                                                                             |
| III: Minor                      |                                                                                             |
| IV: Negligible                  |                                                                                             |

#### AFRC Policy: Human Safety Primary Risks are NOT Accepted at the Center level.
When considered, risk acceptance requires Center Director approval and will normally require higher authority approval. These are **Accepted Risks** only by exception.

Risk acceptance requires Center Director approval. These are **Accepted Risks**.

Risk acceptance requires Project Manager approval.
# LOSS OF ASSET/MISSION HAZARD ACTION MATRIX

<table>
<thead>
<tr>
<th>Asset/Mission Severity Classifications</th>
<th>A: Expected to occur ((Pr &gt; 10^{-1}))</th>
<th>B: Probable to occur ((10^{-1} &gt; Pr &gt; 10^{-2}))</th>
<th>C: Likely to occur ((10^{-2} &gt; Pr &gt; 10^{-3}))</th>
<th>D: Unlikely to occur ((10^{-3} &gt; Pr &gt; 10^{-6}))</th>
<th>E: Improbable to occur ((10^{-6} &gt; Pr))</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Catastrophic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II: Critical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III: Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV: Negligible</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Primary Risk acceptance requires Center Director approval and may require higher authority approval. These are “Accepted Risks”.

Risk acceptance requires Center Director approval. These are “Accepted Risks”.

Risk acceptance requires Project Manager approval.
TECHNICAL BRIEFING

• Mandatory attendance (cancel if not represented)
  – 1. Project Manager
  – 2. Project Pilot
  – 3. Center Chief Engineer (Chairs the Tech Brief meeting)
  – 4. Director for Engineering
  – 5. Director for Aerospace Projects
  – 6. Director for Flight Operations
  – 7. Director for Safety & Mission Assurance
  – 8. Director for Test Systems

• Flight Request Signatures
  – The “Directors for”, Director for S&MA, and the Center Chief Engineer are required to sign the Flight Request to signify approval to fly.