Review of Significant Incidents and Close Calls in Human Spaceflight from a Human Factors Perspective

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Agenda

• Significant Incidents in Human Spaceflight Overview
• Assumptions and description of analysis of Significant Incidents Tool
• Human Factors Classification
• Recommendations for Significant Incidents and Preventive Measures
• Government Documents Review
• Next Steps
• Acknowledgments and References
Analysis of Significant Incidents in Human Spaceflight Overview

Objectives:

• To perform a deep-dive analysis of significant incidents
• Classify them by human factors and human error during flight operations
• Verify that requirements address those incidents in current governing documents

Assumptions:

• Although everything can be contributed to human error at some point, this classification focuses on human error at the operational level, and whether it was a design-induced error
• Human error considered was for cases when the errors led to an incident/close call
• This analysis does not account for human error having its source in organizational factors, processes, etc.
• Medical evacuations and EVA incidents were excluded from analysis
Human Factors Classification

Product:

Human Factors Classification of Significant Incidents and Close Calls in Human Spaceflight Tool divided into 6 tabs
Sections of Human Factors Classification

- Incident Description
- Human Errors (Classification)
- Human Factors Design
- HSI Discipline Responsible
- Recommendations
- Review of Documents

Full list available in the paper

Analysis of Significant Incidents in Human Spaceflight Tool
Government Documents Review

  - Used by Shuttle and ISS programs
- NASA-STD-3001 Space Flight Human Systems Standards:
  - Volume 1 focuses on Crew Health
  - Volume 2 focuses on Human Factors, Habitability & Environmental Health
- NASA/SP-2010-3407 Human Integration Design Handbook
  - Details different HSI requirements developed from lessons learned in past human spaceflight missions.
  - Process is required by NPR 8705.2B Human-Rating Requirements for Space Systems, and NPR 7120.11 Health & Medical Technical Authority Implementation
- MPCV 70024 Human Systems Integration Requirements (HSIR)
  - Orion has addressed human errors in the HS7066 Crew Interface Usability, HS7080 Crew Cognitive Workload, and HS7003 Handling Qualities.
- NASA Human Factors Analysis and Classification System (HFACS)

Specific Program Documents Reviewed for Analysis:
MPCV 70024 HSIR   CCT-REQ-1130
Example of Analysis Results:
Apollo ASTP: 7/24/2975, Crew injury

- Earth Landing System Auto/Manual Switch to Auto
- Not Flagged as Human Error
- Proposed to change to “Yes”
  - Design-induced (interfaces) – primary cause, and
  - Operational error (human error) – contributing factor
- Poor human factors design decision leading to error-prone system or not facilitating crew making the right choices:
  - Spacecraft displays didn't have an obvious visual cue for the pilot to realize that he was still operating in manual mode
  - Procedures may have not had a step for commander to remind pilot to switch back to auto

- NASA HSI Domains:
  - Human Factors Engineering, Safety, Training, Operations Resources

- Causes synergistic in causing failure:
  - Displays may have not account with good visual cue to alert pilot of current state
Recommended Updates for Interactive Tool:

Divide description in 3 parts: Brief description of incident, Reason/causes/consequences, and Solutions

What could have been done during design/operational/training phase to prevent incident?

Procedures to include buddy system (confirmation by fellow crewmember) for callout to change to auto/manual as needed

Have redundant systems to human, e.g. alarms, colors in text or activation of flashing mode

Recommendation for all documents:

Add a requirement that explicitly explains that second crewmember should acknowledge verbally prior to execution of first crewmember.

HSIR: it has a requirement for manual control (HS7004 Manual Control) but doesn't specify it is required when automation is used, like in the other docs
Example of Analysis Results:

**Apollo ASTP:** 7/24/2975, Crew injury

Review of Documents:

- **NASA-STD-3001 Volume 2:** Needs additional requirement
  10.7.3.12 Software System Recovery,
  10.6.1.5 Automation Levels [V2 10104]
- **SP-2010-3407:** Needs additional requirement
  10.10.2.4 Levels of Automation
- **MPCV 70024 HSIR:** Needs additional requirement
  HS7010A Two-Crew Operations, HS7004 Manual Control
- **CCT-REQ-1130:** Needs additional requirement
  3.8.5.1.4 Tolerate Inadvertent Action during Failure, 3.2.6.1
  Manually Override Software, 4.3.2.6.1 Manually Override Software

Recommendation for two-crew operations: Add a separate requirement
that states commands/actions should be confirmed verbally by fellow
crewmember (or ground control) before executing
Recommendations for Tool

• For each incident, it would be good to divide the description in 3 parts:
  • Brief description of incident
  • Reason/causes/consequences
  • Solutions (methods in place resulting from incident investigations, if any)

• Recommend dividing classifications in Main Page into three sections:
  • **Classification 1 - Incidents**
    Keep classification for:
    - Loss of Crew
    - Crew Injuries
    - Related or Recurring Events
    Add: Close Calls
  • **Classification 2 - Various**
    Make another box or section (maybe by color) of second classification:
    - Space Vehicles
    - Country (not sure you need this but ok)
    - Systems (see comment 3, maybe rename to "technical system")
  • **Classification 3 - Human Factors**
    Make another classification just for Human Factors Errors (maybe it's called HSI) [also distinguish from other classifications by color or box]:
    Suggested Classification:
    - Human Factors Design-Induced Errors
    - Operational Errors/Factors
    - Design Errors/Factors
    - Organizational Errors/Factors

Full list of recommendations available in the paper

Analysis of Significant Incidents in Human Spaceflight Tool
Next Steps

• Share recommendations for tool updates with Safety and Mission Assurance group

• Compare information with mishap reports in:
  • NASA Lessons Learned Database (currently being reorganized)
  • NASA Human Factors Analysis and Classification System (HFCAS)

• Discuss topics in Standards meeting (assess if issues are/should be addressed as requirements in governing documents or in procedures at the operational level)

• Discuss with other Center organizations
Acknowledgments

• NASA Johnson Space Center
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• Human Health and Performance Directorate
• Safety and Mission Assurance Directorate

Thank you for your attention!
References


23. CxP 72242 Rev A Orion Display Format Standards, 8 September 2010