Lessons Learned from Mishap Investigations

USAF Processes and Space Mishap Tabletop Exercise
Why investigate mishaps?

...to prevent future mishaps!!!
Different DoD Boards

- Interim Safety Board
- Safety Investigation Board
- Accident Investigation Board
Overview

• Planning ahead
• Day 1
• Investigation Process & Tools
• Tabletop Exercise
Planning Ahead
Planning ahead

- Site Emergency Action Plan (EAP)
  - Exercise plan
- Interim Safety Board (ISB)
- Have a ‘to go’ kit ready
  - Applicable Instructions
  - Supplies
- List of ideal team members per position
- Checklist per position
“Day One” of a Mishap Investigation
Overview

- Preliminary Reporting
- Mishap Site Actions
- Mishap Investigation Arrival Preparation
- Interviews
Preliminary Reporting
Preliminary Reporting

• Preliminary Message (Safety/Interim Safety Board)
  • “Just the facts”
  • 24hr for aviation, occupational, weapons, and space IAW AFI 91-204 Table 6.1

• Initial Public Affairs news release (PA)
  • Fully releasable
  • Facts from non-privileged sources
Mishap Timeline ...

Day 1
+3
+45

Mishap, ISB Actions, Prelim Message
Arrival
Finish (Message, Final Report, Briefing)
Brief Convening Authority
Mishap Site Actions (ISB)
When To Take “Control” of Site?

- Every situation is different
- After site is declared “Safe” by senior fire official
- With no fatalities
  - Fire safe
  - Explosive Ordinance safe
  - Security cordon
  - Other hazards
    - Pressure vessels
    - Environmental hazards
    - Bioenvironmental hazards
# Priority Considerations

## Responders
- “Safe” the site
- Human remains
- Survivor recovery
- Initial site survey (stakes)
- Site logistics
- Establish communications
- Site security
- Weather observation
- Secure classified

## ISB
- SV recorders*
- Witnesses/Survivor statements
- SLV fluids*
- Impound records
- Preservation of perishable evidence
- Photography*
For USAF, Following a Mishap

- The Commander (IC) of the nearest active duty AF base to a mishap will (IAW AFI 91-204 2.7):
  - Respond to the mishap - activate the disaster response force
  - Appoint an incident commander
  - Appoint an interim safety board (ISB) to preserve evidence
  - Conduct toxicology testing as required
  - Make appropriate military and civilian notifications
  - For occupational mishaps WG/SE will likely fill ISB role
  - Likely be initial host for SIB
  - Bottom Line: IC owns the site, SIB owns the asset(s)

Some mishaps may require 2 ISBs
Mishap Site Actions

- Initial walk through
- Photograph mishap site
- Preserve perishable on site evidence
  - Protect wreckage -- consider weather
  - Ground markings/impacts
- Witness identification
  - Locate and interview transient witnesses
- Preliminary diagram of major components
Mishap Site Actions

- Don’t trample the site
- Don’t move wreckage needlessly
- Don’t put fractured parts back together
- Don’t stick your hands in dark places
- Don’t pick it up if you didn’t drop it
- Do identify parts and diagram mishap site
- Do know the site hazards and use proper PPE
- Do preserve site evidence to max extent possible
- Do ensure all wreckage and ground scars are photographed from all angles
- Do take engine, fuel, hydraulic and LOX samples
- Do establish a personnel roster to limit access
Initial Walk Through
Staking the Wreckage

- Visible stakes
- Color coding
  - Paint
  - Ribbons

Tags
- What to stake?
- What to diagram?
Potential Hazards

- Sharp edges
- Gases & fumes from fire
- Pressures - explosion
  - Accumulators, etc.
- Explosives
- Radioactive materials
  - Depleted uranium
- Liquids
  - Hydrazine, hydraulic fluid, fuel
Mitigating the Hazards

- EOD (Explosive Ordnance Disposal)
  - Obviously Bombs & Bullets + explosive bolts, etc.
  - Let EOD secure/remove
- Hazardous Materials [HAZMAT]
  - Burned Composites
  - Spilled Fuel, etc., etc.
  - Let HAZMAT do it – they have the training/equipment
- Mental and Emotional
Personnel Safety

- Hazard Control
- Scene Control
  - Badges, Hats, Vests, etc.
  - Access Lists
  - Escorts
- Safety Awareness
- Personal Protective Equipment
  - Surgical Gloves
  - Leather Gloves
  - Exposure Suits

Expect hazardous materials/situations
DON’T BE IN A HURRY
Follow the experts
Photography

- **Purpose**
  - Documents the mishap
  - Educates people who could not observe the scene firsthand
  - Enhances understanding in briefings
- **Rules of thumb**
  - Over shoot
  - **Document each photograph!!!**
- **Control of pictures**
  - Unauthorized cameras
Photography … What is it?

Document each photograph!!!
Photography

- “Perishable” to “Non Perishable”
- Generic time-sensitive list:
  - Medical evidence
  - Potentially significant evidence
    - Ground scars, etc.
  - Aerial photography
  - Wreckage inventory
  - Damage to private property
  - Witness point-of-view shots
Mishap Team Arrival Preparation
Mishap Team Arrival Preparation

- Lodging arrangements for Mishap Team
- Transportation requirements to/from mishap site
- Determine work locations for Mishap Team
  - On-Base / On-Site
  - 24/7 computer support – 10 GB “Shared Drive”
  - Communications support
Mishap Team Arrival Preparation
Getting Started - White Boards

- You can not have enough White Boards
  - Timeline determination
  - Determining evidence
  - etc
- Butcher Paper also very useful
Lessons Learned

• ISB PRIMARY OBJECTIVES:
  • Initial reporting
  • Preservation and gathering of evidence
  • Initial witness interviews
  • Prepare for the arrival of the SIO

DON’T TRY TO DO THE ANALYSIS!!!
Safety Investigation Board
Interim Board Hand-off

- ISB President conducts the hand-off briefing
  - Overview of all known facts
  - Actions accomplished to date
  - Local orientation/safety brief
  - Site hazards
• Satellite failed to achieve intended orbit – 2010
  • Board President – Col
  • Board Vice President – GS-14 (Senior Systems Engineer)
  • Investigating Officer – Maj
  • AFSEC Rep – Maj and Lt Col (trainee)
  • Space Acquisition/Material Officer – GS-13
  • Space Environmental Officer – Capt
  • Space Operations Officer – Maj
  • Space and Missile Center SE Recorder – GS-11
  • Space and Missile Center – Secretary - Lt
  • HQ AFSPC Human Factors Member – GS-13
  • HQ AFSPC Rep – GS-13 (Chief of Orbital Safety)
Mishap Team Functions

- Who is doing what in a Mishap Investigation
  - **BP** – “chairing” daily meetings, working on briefing, supervisory interviews, MAJCOM & Wing liaison for problems, working with OSC for mishap site issues
  - **IO** – running daily investigation, keeping SIB focused
  - **Primary SIB members** – conducting interviews, QC interviews, reviewing/analyzing “data,” writing report
  - **Contractor/Tech Reps** – teardowns of equipment, preparing reports on results of teardowns
  - **AFSEC Rep** – helping IO run/manage investigation
  - **Recorder/Secretary** – keeping the admin side running smoothly, ensure interviews are being transcribed, etc.
Investigating Officer
“THE COORDINATOR”

- Manages the investigation
  - Shoulders the majority of the responsibility for the “day-to-day” Mishap Team activities
- Directs and coordinates activities of other board members
- Works with AFSEC Rep to “manage” Mishap Team
- Writes the majority of the Final Report
Technical/Process Assistance

- Engineering analysis group
  - Independent of SIO; may observe, but NOT direct
  - Provides factual (non-privileged) engineering analysis to SIO & industry
- Technical Advisors
  - Contractor Representative
  - Aerospace/Federally Funded Research & Development Center (FFRDC) Contractor
- Air Force Safety Center
  - Representatives to SIO; privilege & report writing guidance
Time Management of the Board

- Determine battle rhythm early …
  - One or two meetings a day?
- Other members take their lead from you
  - If you come in early, everyone comes in early
  - Take a lunch break
  - Take a PT break
- First several days are “anti-climactic”
  - Don’t burn out the first 10 days with artificially long hours …
- Work only a half day on Sunday … holidays?
Interviews
Interviews

- ISB accomplishes initial interviews with:
  - Mishap participants (Ops, Mx) and eye witnesses
- ISB interviews are simple:
  - “TELL ME WHAT HAPPENED”
  - As a generalization leave detailed questioning for Mishap Team ...
- Interviews can be written or verbal
- Anonymous Surveys can be used to resolve questions or gray areas
Interviews

• **Foot stompers ...**
  • Develop listing of who was interviewed and when to turn over to Mishap Team
  • “Tell me what happened ...”
  • For recorded interviews let them tell their stories uninterrupted
  • Make sure recording devices are adequate and work
  • Consider using two recorders
Release of Information ...

• Who Can the SIO Release Information To?
  • The MAJCOM/CC – Depends
    • You Are Working For The CA
    • CA can approve release
  • AFSEC - Yes
  • What About Mishap Wing/CCs/other Directorates?

NO!
Interviews - Problem Areas:

- Not starting transcriptions early enough
- Transcribers
- Transcribing/Reviewing testimony will be most time-consuming, labor intensive duty of clerical support (7 to 1 ratio)
- Not practicing interview questions
- Not practicing mock interviews
- Too many folks interviewing
- Incorrect folks interviewing
Questions ...
Investigation Process
Overview

- Getting to the why?
- Tools
- Human Factors
- Factors or Causes
- Report
Why investigate mishaps?

...to prevent future mishaps!!!
• Investigate sequentially and consistently...

• Do not draw conclusions too early!

• Do not concentrate on any one area too early to the exclusion of other areas

• Ensure the facts lead to the conclusion, rather than the other way around!
Getting to the Why... Tools

• Timeline
• Process Flow
• Fishbone
• 5 ‘why’s’
• Fault Tree
• What we know or KNOT
Apr 2000
Class A mishap due to turbine blade failure

Apr 2003
Testing of new turbine blades

Feb 2005
Blades installed in engine at ALC
Per TCTO
Tail #9965

Nov 2009
Engine compressor overhauled for operating time, no work in turbine section

11 Jan 2011
Pilot reports vibration, engine failure and ejects

Jun 2002
Engine Turbine Blade Redesign Finalized

Nov 2003
Lot of "Blades" with design flaw manufactured

Aug 2006
Engine inspected for potential compressor stall no damage to turbine noted

Jan 2010
Engine installed in tail #2397

21 Jan 2011
Engine teardown reveals liberated 2nd stage HPT blade
## Process Flow Symbols

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>MEANING</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Start or Stop Symbol" /></td>
<td>START or STOP</td>
<td>*Receive Tasking&lt;br&gt;*Begin Trip&lt;br&gt;*Open Checklist or Tech Order</td>
</tr>
<tr>
<td><img src="image" alt="Activity Symbol" /></td>
<td>ACTIVITY</td>
<td>*Mission / Activity Planning&lt;br&gt;*Start Car&lt;br&gt;*Step #1 in Checklist or Tech Order</td>
</tr>
<tr>
<td><img src="image" alt="Decision Point Symbol" /></td>
<td>DECISION POINT</td>
<td>*Yes / No&lt;br&gt;*Approve / Disapprove&lt;br&gt;*Pass / Fail</td>
</tr>
<tr>
<td><img src="image" alt="Fork / Split Symbol" /></td>
<td>FORK / SPLIT&lt;br&gt;(Other Considerations for Activity)</td>
<td>*Preposition Vehicles and Supplies&lt;br&gt;*Release Clutch and Press Accelerator&lt;br&gt;*Observe Flight Controls While Moving Stick</td>
</tr>
</tbody>
</table>
Process Flow Example

The flow diagram can be used as an RM planning tool. Indicate RM actions in connection with each activity block.

Start

- Intelligence Taskers

Gather Initial Intelligence

- Dispatch Advance Team

Deployment Planning

- Initial Mission Planning

Plans Complete

Contingency Planning

Get RM Data

Protect the Team
SCENARIO:
The supervisor of an aircraft maintenance operation has been receiving reports from Quality Assurance regarding tools left in aircraft after maintenance. Each case has involved a different individual and spot checks indicate “good” compliance with tool control procedures. The following cause and effect diagram will help the supervisor consider all possible sources of the problem.

CAUSE
- Low morale
  - No incentives
  - Motivation
- Weak procedures
  - Training
- Many places to lose tools
  - Aircraft
- Few spot checks
  - Supervision
  - Light direct mgt.
- Guidance
  - Incomplete Ots
- Tools
  - No tool board cutouts
  - Many small, hard to see tools

EFFECT
- Tools left in aircraft after maintenance performed
5 Why’s

• Without finding “The Why,” the failure will occur over and over
• Keep asking “Why” until reaching a dead end
  – Aircraft Crashed – Why?
  – Elevator Fell Off … Why?
    – Bolt Failed … Why?
    – Improperly Installed … Why?
  – Instructions Wrong … Why?
  – Not Field Tested … Why?
  – No Requirement to Field Test … Bingo!
Fault Tree Analysis (FTA)

• Starts with the significant event
• List possible causes at next level
• Each cause now becomes a significant event with analysis listed below
• For each potential cause, list probability
• When probability nears zero, you are done in that direction
• Visually shows logic
• Brainstorm all possible causes
FTA Example

Plane fails to recover from spin
Pilot does not eject - Fatality

- Pilot Incapacitation
  - Analysis:
    - On controls impact
    - CVR
  - Stop

- Ejection Seat Failure
  - Analysis
    - Handles down
    - Actuators unfired
  - Stop

- Flight Control Failure
  - Analysis
    - Actuators functional
    - Control continuity ok
  - Stop

- Improper Recover Procedure
  - Most Likely Direction To Continue
• **What we know:**
  – Verified facts

• **What we believe:**
  – Presumptions not yet confirmed, but necessary to proceed
  – Also called mini-hypotheses

• **What we need to know:**
  – Facts required to proceed
  – Evidence needed to prove / disprove beliefs
Organizing data...

- Know: Credible Data
- Need To Know: Data that is required, but not yet fully available
- Opinion: May be credible, but needs an action item to verify and close
- Think We Know: May be credible, but needs an action item to verify and close

## KNOT Chart

<table>
<thead>
<tr>
<th>Specific Item</th>
<th>Know</th>
<th>Need</th>
<th>Opinion</th>
<th>Think</th>
<th>Actions</th>
</tr>
</thead>
</table>
| Procedures to clean fuel line joining point a & b (see diagram) |      |      | Procedures difficult to understand |              | • View execution of procedure  
• Conduct survey   |
| Etc....                                            |      |      |                                  |              |                                              |
FACTORS
Factors

A “Factor” is any unusual, out-of-the-ordinary, or deficient action or condition contributing to the eventual outcome

Most mishaps involve multiple factors
  • Human Factors

Examples of factors (not all inclusive)

- Supervision
- Qualifications
- Weather
- Experience
- Tech Order
- Crew Rest

- Maintenance Qualifications
- Maintenance Documentation
- Mission Planning
- Depot (contractor) Quality Assurance
Factors

• Three Types of “Factors”
  • Factors: Those areas that are significant/influential to the outcome of the mishap
    • They can be causal or non-causal in the mishap sequence
  • Non-factors: Those areas considered but ruled out as influential to the outcome of the mishap
  • Non-Factors Worthy Of Discussion (NFWOD)
Scenario – Ex A/C Factors

• Unit leadership failed to correct unauthorized low level flights

• Pilot hit a telephone wire at 50’
  • Main rotor blade separation

• The helicopter was not equipped with the Wire Strike

• Factors?
Scenario – EX A/C Factors?

- Trainer aircraft has an unrecoverable in-flight engine shutdown
- IP inadvertently pulls the throttle to cutoff at low altitude while reducing the power to idle
- Poor throttle finger lift design allowed the possibility of inadvertent shutdown of engine
- After ejection the pilot was unable to contact SAR due to survival radio battery failure
Non-Factors Worthy of Discussion

• Issues discovered during the investigation with the potential to cause future mishaps but did not influence the outcome in this mishap

• For example:
  • Failure of survival radio batteries
  • Documentation errors noted in maintenance training records
Report Outline

- Tab A – Safety Investigator Information
- Tab D – Maintenance Report
- Tab F – Weather Records
- Tab G – Personnel Records
- Tab H – Impact & Crashworthiness Analysis
- Tab I – Deficiency Reports
- Tab J – Releasable Tech Reports
- Tab K – Mission Records & Data
- Tab L – Data from On-Board Recorders
- Tab M – Data from Ground Radar/Other
- Tab N – Transcripts of Voice Communications
- Tab O – Add’l Substantiating Data & Reports
- Tab P – Damage Summary
- Tab Q – AIB Transfer Documents
- Tab R – Releasable Witness Testimony
- Tab S – Releasable Photos, Videos, Diagrams
- Tab T – Investigation, Analysis, & Conclusions
- Tab U – Witness Testimony (Privileged)
- Tab V – Other Supporting Privileged Products
- Tab W – Tech Reports (Privileged)
- Tab X – Privileged Photos, Videos, & Diagrams
- Tab Y – Life Sciences & Medical Report
- Tab Z – SIB Proceedings and BP Comments
- AFSAS Final Message
- Briefing for Convening Authority
Objective of Report

- Objective is to show ...
  - Areas investigated
  - Factors accepted with rationale
  - Potentially relevant factors considered and rejected, with rationale

- Use illustrations to clarify if required ...
  - “A picture is worth a thousand words …”
• A superbly written report can not do much to overcome a bad investigation … but a poor report can definitely ruin a good investigation!

• Rightly or wrongly, the report is the Investigation’s “Report Card”
Questions ...
Tabletop Exercise