Intervention: Filling the Holes in the Cheese

Safe Decisions

Safe Supervision

Preconditions for Safe Acts

Safe Acts


<table>
<thead>
<tr>
<th>Sample of the Types of Human Error Typically Found</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aircraft Control Not Maintained</strong></td>
</tr>
<tr>
<td>Procedures/Directives Not Followed</td>
</tr>
<tr>
<td><strong>Aborted Delayed</strong></td>
</tr>
<tr>
<td><strong>Airspeed (VREF) Not Maintained</strong></td>
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<tr>
<td><strong>APU Selected</strong></td>
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<tr>
<td><strong>Proper Touchdown Point Misjudged</strong></td>
</tr>
<tr>
<td><strong>Airspeed Above V1 Improper</strong></td>
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<tr>
<td><strong>Airspeed (VMC) Not Maintained</strong></td>
</tr>
<tr>
<td><strong>Autopilot Improper Use Of</strong></td>
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<td><strong>Compacency</strong></td>
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<td><strong>Control Interference Inadvertent</strong></td>
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<tr>
<td><strong>Crew/Group Coordination Not Maintained</strong></td>
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<td><strong>Proper Touchdown Point Not Attained</strong></td>
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<td><strong>Airspeed Not Maintained</strong></td>
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<tr>
<td><strong>Airspeed (VR) Improper</strong></td>
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<td><strong>Autopilot Inadvertent Deactivation</strong></td>
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<td><strong>Circuit Breaker Selected</strong></td>
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<td><strong>Compensation for Wind Conditions Not Possible</strong></td>
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<tr>
<td><strong>Flare Improper</strong></td>
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<tr>
<td><strong>Unsafe/Hazardous Condition Not Identified</strong></td>
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<tr>
<td><strong>VFR Flight Into IMC Attempted</strong></td>
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<td><strong>Flight Into Adverse Weather Continued</strong></td>
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<tr>
<td><strong>Hydraulic System Not Selected</strong></td>
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<tr>
<td><strong>Inadequate Surveillance of Operation</strong></td>
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<td><strong>Proper Touchdown Point Not Possible</strong></td>
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<td><strong>Aborted Takeoff Delayed</strong></td>
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<td><strong>Airspeed (VLOF) Not Attained</strong></td>
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<td><strong>Altimeter Setting Not Obtained</strong></td>
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<td><strong>Crew/Group Coordination Not Performed</strong></td>
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<td><strong>Flaps Improper Use Of</strong></td>
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<td><strong>Flight into Known Adverse Weather Initiated</strong></td>
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<td><strong>Go-Around Not Performed</strong></td>
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<td><strong>Identification of Aircraft Visually Delayed</strong></td>
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<td><strong>Inadequate Substantiation Process</strong></td>
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<td><strong>Visual Separation Not Maintained</strong></td>
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<td><strong>Minimum Descent Altitude Not Maintained</strong></td>
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<td><strong>Wheels Up Landing Inadvertent</strong></td>
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<td><strong>Aircraft Preflight Not Performed</strong></td>
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<td><strong>Aircraft Weight and Balance Misjudged</strong></td>
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<td><strong>Altimeter Not Used</strong></td>
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<tr>
<td><strong>Checklist Inaccurate</strong></td>
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<tr>
<td><strong>Compensation For Wind Conditions Inadequate</strong></td>
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<td><strong>Descent Excessive</strong></td>
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<tr>
<td><strong>Distance Misjudged</strong></td>
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<td><strong>Flare Delayed</strong></td>
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<td><strong>Ground Loop/Swerve Intentional</strong></td>
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<td><strong>Remedial Action Delayed</strong></td>
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<tr>
<td><strong>VFR Flight Into IMC Initiated</strong></td>
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<td><strong>Visual Lookout Not Maintained</strong></td>
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<td><strong>Airspeed Above V1 Performed</strong></td>
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<td><strong>Compensation for Wind Conditions Improper</strong></td>
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<td><strong>Directional Control Not Maintained</strong></td>
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<td><strong>Ice/Frost Removal From Aircraft Inadequate</strong></td>
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<td><strong>IFR Procedure Improper</strong></td>
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<td><strong>Aircraft Control Not Possible</strong></td>
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<td><strong>Stall Inadvertent</strong></td>
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<td><strong>Inadequate Visual Lookout</strong></td>
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<td><strong>Lack of Total Experience in Type of Aircraft</strong></td>
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<td><strong>Lowering of Flaps Performed</strong></td>
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<td><strong>Communications Not Understood</strong></td>
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<td><strong>Inadequate Weather Evaluation</strong></td>
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<td><strong>Nose wheel Steering Excessive</strong></td>
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<td><strong>Procedure Inadequate</strong></td>
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<td><strong>Airspeed (VS) Not Maintained</strong></td>
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<td><strong>Gear Extension Not Performed</strong></td>
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<td><strong>Touchdown Inadvervent</strong></td>
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<td><strong>Preflight Planning/Preparation Improper</strong></td>
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<td><strong>Proper Descent Rate Not Maintained</strong></td>
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<td><strong>Checklist Not Used</strong></td>
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<td><strong>Anti-Ice/Deice System Not Used</strong></td>
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<td><strong>Inadequate Monitoring</strong></td>
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<td><strong>Someone Goofed</strong></td>
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<td><strong>Proper Descent Rate Not Attained</strong></td>
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<td><strong>Ice/Frost Removal From Aircraft Not Performed</strong></td>
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<td><strong>Flight Controls Improper Use Of</strong></td>
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<td><strong>Altitude/Clearance Not Maintained</strong></td>
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<td><strong>Maneuver Performed</strong></td>
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<td><strong>Preflight Planning/Preparation Poor</strong></td>
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<td><strong>Proper Altitude Not Maintained</strong></td>
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<td><strong>Flare Initiated</strong></td>
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<tr>
<td><strong>Flight Advisories Not Followed</strong></td>
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<tr>
<td><strong>Altitude/Clearance Inadequate</strong></td>
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<td><strong>Distance/Altitude Misjudged</strong></td>
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<td><strong>Rotation Improper</strong></td>
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<td><strong>Unsuitable Terrain or Takeoff/Landing/Taxi Area</strong></td>
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<td><strong>VFR Procedures Inadequate</strong></td>
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<td><strong>Proper Alignment Not Possible</strong></td>
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<td><strong>Remedial Action Improper</strong></td>
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<td><strong>Flare Misjudged</strong></td>
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<tr>
<td><strong>Proper Alignment Delayed</strong></td>
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<td><strong>Missed Approach Not Performed</strong></td>
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<td><strong>Proper Alignment Not Attained</strong></td>
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<tr>
<td><strong>Lack of Total Experience in Type Operation</strong></td>
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<td><strong>Minimum Descent Altitude Below</strong></td>
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<tr>
<td><strong>Miscellaneous Equipment Initiated</strong></td>
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<tr>
<td><strong>Proper Alignment Not Maintained</strong></td>
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<tr>
<td><strong>Supervision Improper</strong></td>
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<tr>
<td><strong>Gear Down and Locked Not Verified</strong></td>
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<td><strong>Wind Information Misjudged</strong></td>
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<td><strong>Aircraft Weight and Balance Exceeded</strong></td>
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<td><strong>Aircraft Control-Uncontrolled</strong></td>
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<td><strong>Crew/Group Coordination Not Attained</strong></td>
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<tr>
<td><strong>Checklist Not Followed</strong></td>
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<tr>
<td><strong>Clearance Not Maintained</strong></td>
</tr>
</tbody>
</table>
USN/USMC Methodology

- Analyzed all Class A Mishaps between FY91-99 associated with human error (n=178)
- Analyses included all human causal factors as identified in the original investigation and endorsed by the Chain of Command
- **NO** new causal factors were identified
- Raters
  - 2 Aerospace Psychologists
  - 2 Flight Surgeons
  - Airframe Rated Pilot/NFO Subject Matter Experts
- Consensus rating
## Number and Percentage of Mishaps Associated with Each HFACS Causal Category (FY 91-99)

<table>
<thead>
<tr>
<th></th>
<th>USMC n=73</th>
<th>USN n=105</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count (%)</td>
<td>Count (%)</td>
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<tr>
<td><strong>Organizational Influences</strong></td>
<td></td>
<td></td>
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<tr>
<td>Resource Management</td>
<td>17 (23)</td>
<td>32 (30)</td>
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<tr>
<td>Organizational Climate</td>
<td>0 (0)</td>
<td>1 (1)</td>
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<tr>
<td>Organizational Process</td>
<td>19 (26)</td>
<td>39 (37)</td>
</tr>
<tr>
<td><strong>Unsafe Supervision</strong></td>
<td></td>
<td></td>
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<tr>
<td>Inadequate Supervision</td>
<td>18 (25)</td>
<td>27 (26)</td>
</tr>
<tr>
<td>Planned Inappropriate Operations</td>
<td>9 (12)</td>
<td>11 (10)</td>
</tr>
<tr>
<td>Failed to Correct a Known Problem</td>
<td>4 (5)</td>
<td>10 (10)</td>
</tr>
<tr>
<td>Supervisory Violations</td>
<td>8 (11)</td>
<td>11 (10)</td>
</tr>
<tr>
<td><strong>Preconditions for Unsafe Acts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adverse Mental States</td>
<td>57 (78)</td>
<td>79 (75)</td>
</tr>
<tr>
<td>Adverse Physiological States</td>
<td>18 (25)</td>
<td>27 (26)</td>
</tr>
<tr>
<td>Physical/Mental Limitations</td>
<td>7 (10)</td>
<td>11 (10)</td>
</tr>
<tr>
<td>Crew Resource Mismanagement</td>
<td>40 (55)</td>
<td>69 (66)</td>
</tr>
<tr>
<td>Personal Readiness</td>
<td>2 (3)</td>
<td>5 (5)</td>
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<tr>
<td><strong>Unsafe Acts</strong></td>
<td></td>
<td></td>
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<tr>
<td>Decision Errors</td>
<td>36 (49)</td>
<td>64 (61)</td>
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<tr>
<td>Skill-based Errors</td>
<td>38 (52)</td>
<td>57 (54)</td>
</tr>
<tr>
<td>Perceptual Errors</td>
<td>23 (32)</td>
<td>28 (27)</td>
</tr>
<tr>
<td>Violations</td>
<td>22 (30)</td>
<td>33 (31)</td>
</tr>
</tbody>
</table>
Violations

Decision Errors

Skill-Based Errors

Perceptual Errors

VIOLATIONS

- Violation of Orders/Regulations/SOP
  - Failed to Inspect ACFT after In-Flight Caution Light
  - Violated Squadron SOP Restricting Flight Below 500’
  - Failed to Comply with NATOPS During Streaming
  - Conducted Night Training and Ops Mission with PAX
  - Elected to File VFR in Marginal Weather Conditions
  - Failed to Use Radar Advisories from ATC
  - Inadequate Brief and Limits on Mission
  - HAC Knowingly Accepted Non-Current Crew

- Failed to Adhere to Brief
- Not Current/Qualified for Mission
- Improper Procedure
Intervention Strategy

- Professionalism
- Accountability
- Enforcing the Rules
Percentage of Human Error Mishaps Associated with Violations (FY 91-99)

Data-driven Intervention

Previous U.S. Navy/Marine Corps Mean
UNSAFE ACTS

Errors
- Decision Errors
- Skill-Based Errors
- Perceptual Errors

Violations
- Routine
- Exceptional

SKILL-BASED ERRORS
- Breakdown in Visual Scan
- Failed to See and Avoid
- Poor Technique
- Omitted Checklist Item
- Inadvertent Operation of Control
- Improper Use of Flight Controls
Percentage of Human Error Mishaps Associated with Skill-based Errors (FY 91-00)
TACAIR In-Model Flight Hour Distribution vs TACAIR Skill-Based Errors (FY 91-01)

TACAIR Pilot Flight Hour Distribution

- 2001+: 18%
- 1501-2000: 13%
- 1001-1500: 18%
- 501-1000: 29%
- Less 501: 22%

% Skill-Based Error Mishaps (n=98)

- Less 501: 48%
- 501-1000: 30%
- 1001-2000: 4%
- 1501-2000: 9%
Helo In-Model Flight Hour Distribution vs Helo Skill-Based Errors (FY 91-01)

HELO Pilot Flight Hour Distribution

- 1001 - 1500: 14%
- 501 - 1000: 24%
- 1501 - 2000: 15%
- 2001 +: 12%
- Less 501: 35%

% Skill-Based Error Mishaps (n=30)

- 1001 - 1500: 20%
- 1501 - 2000: 3%
- Less 501: 47%
- 501 - 1000: 30%
Preliminary Intervention Strategy

- Improve instrument scan
- Prioritizing attention
- Recognizing extremis situations
- Refine basic flight skills (Stick-and-Rudder)
- Practice procedures
- Review the mishap database!
U.S. Air Carrier
Methodology

- Analyzed all FAR Part 121 and 135 Scheduled Air Carrier Accidents occurring between FY90-96 associated with human error (n=119)*
- Analyses included all human causal factors as identified by the NTSB
- NO new causal factors were identified
- Raters
  - 2 Aerospace Psychologists
  - 1 NASA Engineer
  - 1 Commercially Rated Pilot
- Independent rating (Inter-rater reliability K=.71)
- All human causal factors were accommodated by HFACS
- Few instances of supervisory or organizational influences
- No instances of Readiness Issues or Supervisory violations
FAR Part 121 & 135 Scheduled Carriers:
Aircrew-related accidents involving Skill-based Errors

Percentages do not add up to 100%
FAR Part 121 & 135 Scheduled Carriers:
Aircrew-related accidents involving Decision Errors

Percentages do not add up to 100%
FAR Part 121 & 135 Scheduled Carriers: Aircrew-related accidents involving CRM Failures

Percentages do not add up to 100%
FAR Part 121 & 135 Scheduled Carriers: Aircrew-related accidents involving Violations

Percentages do not add up to 100%
FAR Part 121 & 135 Scheduled Carriers: Aircrew-related accidents involving Supervisory/Organizational Factors

Percentages do not add up to 100%

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U.S. AIR TAXI

AVIATION ACCIDENT DATA

Methods

- Analyzed all accidents that involved FAR Part 135 Nonscheduled air carriers between 1990 and 1997.
  - Only fixed wing aircraft were analyzed (no helicopters)
  - Reports only used if investigation was completed and cause determined
- A total of 559 accidents were identified for analysis. Of these, 403 (72.1%) were aircrew related.
- The 403 aircrew related accidents were associated with 653 human causal factors.
- These human causal factors were classified into HFACS causal categories independently by four certified pilots.
- No new cause factors were created during the coding process and consensus between coders was achieved on all classifications.
The Human Factors Analysis and Classification System (HFACS) is a theoretically based tool for investigating and analyzing human error associated with aviation accidents and incidents. Previous HFACS research performed at both at the University of Illinois and the Civil Aerospace Medical Institute (CAMI) has been highly successful and has shown that HFACS can be reliably used to analyze the underlying human factors causes of both commercial and general aviation accidents. Furthermore, these analyses have helped identify general trends in the types of human factors issues and aircrew errors that have contributed to civil aviation accidents. Key members of the FAA (e.g., AFS-800) and several committees chartered to address general aviation safety (e.g., Aeronautical Decision Making (ADM) JSAT and the General Aviation Data Improvement Team (GADIT)) have acknowledged the added value and insights gleaned from these HFACS analyses. However, these individuals and committees have directly requested that additional analyses be done to answer specific questions about the exact nature of the human errors identified, particularly within the context of general aviation. The purpose of the proposed research project, therefore, is to address these questions by performing a more fine-grained HFACS analysis of the individual human causal factors associated with fatal GA accidents and to assist in the generation of possible intervention programs.
## Execution Plan

Perform a comprehensive and systematic analysis of the individual human causal factors associated with fatal GA accidents.

- How important is each error type, or how often is each error type the “primary” cause of an accident?
- Do accidents that occur in different geographical regions or training facilities within the U.S. have different error patterns or trends?

### Questions
- What are the exact types of errors committed within each error category?
- How do the different error types relate to one another, or with other HFACS variables?
- What can be done to intervene given the information that is now available, and what more might be done with the additional refined data?

### Additional “pop-up” requirements will be addressed on a year-to-year basis, such as:
- Are there differences in the pattern of human error associated with controlled flight into terrain (CFIT) and other GA accidents?
- What differences exist between Alaska and the rest of the U.S. with regards to the pattern of human errors associated with GA accidents?

### Questions
- What are the human factors associated with air tour/sightseeing accidents and how do they compare with other GA and commercial aviation accidents?
- What are the specific types of human error associated with EMS helicopter accidents and how do they compare with other fixed- and rotary wing operations?
- Transition HFACS database to field
How important is each error type, or how often is each error type the “primary” cause of an accident?
Methods

- Analyzed all (over 20,797) FAR Part 91 – “GA accidents” occurring between 1990 and 2000
  - Eliminated:
    - 14 CFR Part 91 F (Ferry flight)
    - 14 CFR Part 137 (Agricultural Flights)
    - 14 CFR Part 91 (Blimps, balloons, ultra-lights, gliders)
  - Remaining 18,531 accidents were then screened for aircrew error

- The remaining 14,631 accidents were associated with over 34,000 human causal factors, as reported by the National Transportation Safety Board (NTSB).

- The NTSB human causal factors were classified into HFACS causal categories independently by seven GA pilots.
  - All were certified flight instructors
  - Mean flight hours = 3,530
Methods

- Each pilot-rater was assigned 1/3 of the accidents for a given year and independently coded the cause factors as identified by the NTSB (no new cause factors created).
- Each pilot-rater was then randomly paired with a second pilot who coded the same set of accidents to compare codes and achieve consensus.
- Pilot-raters were then assigned another 1/3 of the accidents for a particular year and randomly paired with another pilot-rater.
- This process continued until all the accidents had been coded.
- We continue to update the database annually (we generally run about 2 yrs behind due to the large number of incomplete investigations in more recent years)
Pilot-raters agreed 85% of the time
- 29,676 agreements
- 4,474 disagreements

Where disagreements existed the pilots were called into the laboratory to reconcile their differences and a consensus classification was included in the database
Our efforts have focused on the bottom tier of HFACS: The Unsafe Acts of Operators

- **Errors**
  - Decision Errors
  - Skill-Based Errors
  - Perceptual Errors

- **Violations**
  - Routine
  - Exceptional
技能为基础的错误 | 决策错误 | 违反 | 视觉错误

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百分比不相加为100%
FAR Part 91 - General Aviation: Fatal Aircrew-Related Accidents

- Skill-based Errors
- Decision Errors
- Perceptual Errors
- Violations

Year

Percentage of Accidents

Percentages do not add up to 100%
FAR Part 91 - General Aviation: Non-Fatal Aircrew-Related Accidents

Skill-based Errors
Decision Errors
Violations
Perceptual Errors

Year

Percentage of Accidents

Percentages do not add up to 100%
FAR Part 91 - General Aviation: Fatal vs. Non-Fatal Accident Comparison

Skill-based Errors

Decision Errors

Perceptual Errors

Violations

©Shappell & Wiegmann, 2003
FAR Part 91 - General Aviation: Fatal Aircrew-Related Accidents
Seminal Event Analysis

- Skill-based Errors
- Decision Errors
- Violations
- Perceptual Errors

Year: 1990-2000
Percentage of Accidents
FAR Part 91 - General Aviation: Non-Fatal Aircrew-Related Accidents
Seminal Event Analysis

Skill-based Errors
Decision Errors
Violations
Perceptual Errors

Percentage of Accidents

Year

Percentages do not add up to 100%
Do accidents that occur in different geographical regions or training facilities within the U.S. have different error patterns or trends?

Specifically, what differences exist between Alaska and the rest of the U.S. with regards to the pattern of human errors associated with GA accidents?
## Decision Errors

<table>
<thead>
<tr>
<th>Error</th>
<th>Alaska</th>
<th>RoUS</th>
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<tbody>
<tr>
<td>In-flight Planning/Decision</td>
<td>58 (14.1%)</td>
<td>857 (18.8%)</td>
<td>915 (18.4%)</td>
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<tr>
<td>Unsuitable Terrain</td>
<td>159 (38.7%)</td>
<td>221 (4.8%)</td>
<td>380 (7.6%)</td>
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<tr>
<td>Refueling</td>
<td>13 (3.2%)</td>
<td>321 (7%)</td>
<td>334 (6.7%)</td>
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<tr>
<td>Planning/Decision</td>
<td>20 (4.9%)</td>
<td>302 (6.6%)</td>
<td>322 (6.5%)</td>
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<tr>
<td>Go-around</td>
<td>16 (3.9%)</td>
<td>295 (6.%)</td>
<td>311 (6.3%)</td>
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<tr>
<td>Remedial Action</td>
<td>12 (2.9%)</td>
<td>280 (6.1%)</td>
<td>292 (5.9%)</td>
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<tr>
<td>Accidents with at least one</td>
<td>411 (100%)</td>
<td>4560 (100%)</td>
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<tr>
<td>Decision Error</td>
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<td>187 (18.8%)</td>
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<td>1993 (12.2%)</td>
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<tr>
<td>Aircraft Control</td>
<td>51 (5.1%)</td>
<td>1227 (7.9%)</td>
<td>1278 (7.7%)</td>
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<tr>
<td>Airspeed</td>
<td>56 (5.6%)</td>
<td>1166 (7.5%)</td>
<td>1222 (7.4%)</td>
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<tr>
<td>Compensation for Wind Conditions</td>
<td>145 (14.6%)</td>
<td>886 (5.7%)</td>
<td>1031 (6.2%)</td>
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<td>993 (100%)</td>
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FAR Part 91 - General Aviation: Perceptual Errors

Percentage of Accidents

AK
RoUS

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FAR Part 91 - General Aviation: Violations

Percentage of Accidents

- Red: AK
- Blue: RoUS

Years: 1990-2000

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## Violations

<table>
<thead>
<tr>
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<td>27 (25%)</td>
<td>304 (13.8%)</td>
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<tr>
<td>Procedures/Directives</td>
<td>14 (13%)</td>
<td>244 (11.1%)</td>
<td>258 (11.2%)</td>
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<tr>
<td>Operating with Known Deficiencies</td>
<td>6 (5.6%)</td>
<td>234 (10.7%)</td>
<td>240 (10.4%)</td>
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<tr>
<td>Flight into Adverse Weather</td>
<td>10 (9.3%)</td>
<td>186 (8.5%)</td>
<td>196 (8.5%)</td>
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<tr>
<td>Fuel Supply</td>
<td>4 (3.7%)</td>
<td>163 (7.4%)</td>
<td>167 (7.3%)</td>
</tr>
<tr>
<td>Aircraft Weight and Balance</td>
<td>12 (11.1%)</td>
<td>127 (5.8%)</td>
<td>139 (6%)</td>
</tr>
<tr>
<td>Design Stress Limits of Aircraft</td>
<td>3 (2.8%)</td>
<td>118 (5.4%)</td>
<td>121 (5.3%)</td>
</tr>
<tr>
<td>Accidents with at least one Violation</td>
<td>108 (100%)</td>
<td>2195 (100%)</td>
<td>2303 (100%)</td>
</tr>
<tr>
<td>Violation</td>
<td>Alaska</td>
<td>RoUS</td>
<td>Total</td>
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</table>
No major differences between Alaska and Rest of U.S. with regard to overall pattern of human error

- If anything, slightly more decision errors were associated with Alaska accidents along with fewer skill-based errors, perceptual errors, and violations

However, when looking deeper, differences were revealed in the specific types of errors and violations committed by those flying in Alaska

- Twelve (12) times more likely to take-off or land on unsuitable terrain
- Almost two times as likely to experience a loss of directional control and almost three times as likely to inadequately compensate for wind conditions.
- Almost twice as likely to continue VFR flight into IMC weather
Perform a comprehensive and systematic analysis of the individual human causal factors associated with fatal GA accidents.

- How important is each error type, or how often is each error type the “primary” cause of an accident?
- Do accidents that occur in different geographical regions or training facilities within the U.S. have different error patterns or trends?

- What are the exact types of errors committed within each error category?
- How do the different error types relate to one another, or with other HFACS variables?
- What can be done to intervene given the information that is now available, and what more might be done with the additional refined data?

Additional “pop-up” requirements will be addressed on a year-to-year basis, such as:

- Are there differences in the pattern of human error associated with controlled flight into terrain (CFIT) and other GA accidents?
- What differences exist between Alaska and the rest of the U.S. with regards to the pattern of human errors associated with GA accidents?

- What are the human factors associated with air tour/sightseeing accidents and how do they compare with other GA and commercial aviation accidents?
- What are the specific types of human error associated with EMS helicopter accidents and how do they compare with other fixed- and rotary wing operations.
- Transition HFACS database to field
HUMAN ERROR ASSOCIATED WITH
GENERAL AVIATION
CONTROLLED FLIGHT INTO TERRAIN

Douglas Wiegmann, Ph.D.
University of Illinois

Scott Shappell, Ph.D.
Civil Aerospace Medical Institute

So what is “controlled” flight into terrain?

After all, it seems inconceivable that a pilot would fly an aircraft into the ground while it was still controllable.

While individual definitions of CFIT may vary, most would agree at some level that CFIT occurs when an airworthy aircraft, under the control of a pilot, is flown into terrain (water or obstacles) with inadequate awareness on the part of the pilot of the impending disaster (FAA, 2000).
In 1998-99 the JSAT examined 195 CFIT accidents that occurred between 1993 and 1994 under a variety of operations. Using root cause analysis, the team selected 10 interventions that considered to be the most effective and feasible to implement.

- Increase pilot awareness of accident causes.
- Improve the safety culture within the aviation community.
- Promote the development and use of low-cost terrain clearance and/or look ahead devices.
- Improve pilot training (i.e., weather briefing, equipment, decision-making, wire and tower avoidance, and human factors).
- Improve the quality and substance of weather briefs.
- Enhance the Biennial Flight Review (BFR) and/or instrument competency check.
- Develop and distribute mountain flying technique advisory material.
- Standardize and expand the use of markings for towers and wires.
- Use high-visibility paint and other visibility enhancing features on obstructions.
- Eliminate the pressure to complete the flight where continuing may compromise safety.
Methods

- CFIT is used only for accidents occurring during airborne phases of flight.
- CFIT includes collisions with those objects extending above the surface (for example: towers).
- CFIT can occur during either Instrument Meteorological Conditions (IMC) or Visual Meteorological Conditions (VMC).
- This category includes instances when the aircrew is affected by visual illusions (e.g., black hole approaches) that result in the aircraft being flown under control into terrain, water, or obstacles.
- If control of the aircraft is lost (induced by crew, weather, or equipment failure), do not use this category.
- Do not use this category for occurrences involving intentional flight into terrain (i.e., suicide).
- Do not use this category for occurrences involving runway undershoot/overshoot.
Data

➢ “General Aviation” data obtained from the NTSB and FAA accident databases.

<table>
<thead>
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<th>Type of operation</th>
<th>Frequency</th>
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<tr>
<td>14 CFR Part 91F</td>
<td>8</td>
</tr>
<tr>
<td>14 CFR Part 103</td>
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<td>14 CFR Part 133</td>
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<td>1,288</td>
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<tr>
<td>Public Use</td>
<td>51</td>
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<tr>
<td><strong>Totals</strong></td>
<td><strong>17,994</strong></td>
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</tbody>
</table>

➢ After eliminating undetermined, incomplete, and non-human related accidents this left us with 14,086 accidents.

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HFACS Analysis

- The NTSB human causal factors were classified into HFACS causal categories independently by five GA pilots.
  - All were certified flight instructors
  - Mean flight hours = 3,530
- Each pilot was assigned 1/3 of the accidents for a given year and independently coded the cause factors as identified by the NTSB (no new cause factors created).
- Each pilot was then randomly paired with a second pilot who coded the same set of accidents to compare codes and achieve consensus.
- This process continued until all the accidents had been coded.
Results

CFIT = 1,407
Non-CFIT = 12,679
Results

PRECONDITIONS FOR UNSAFE ACTS

- Substandard Conditions of Operators
  - Adverse Mental States
  - Adverse Physiological States
  - Physical/Mental Limitations

- Substandard Practices of Operators
  - Crew Resource Mismanagement
  - Personal Readiness

UNSAFE ACTS

- Errors
  - Decision Errors
  - Skill-Based Errors
  - Perceptual Errors

- Violations
  - Routine
  - Exceptional
Results

PRECONDITIONS FOR UNSAFE ACTS

Substandard Conditions of Operators
- Adverse Mental States
  - CFIT: 171 (12.2%)
  - Non-CFIT: 576 (4.5%)
- Adverse Physiological States
  - CFIT: 52 (3.7%)
  - Non-CFIT: 317 (2.5%)
- Physical/Mental Limitations
  - CFIT: 182 (12.9%)
  - Non-CFIT: 2392 (18.9%)

Substandard Practices of Operators
- Crew Resource Management
  - CFIT: 102 (7.2%)
  - Non-CFIT: 1397 (11.0%)
- Personal Readiness
  - CFIT: 89 (6.3%)
  - Non-CFIT: 206 (1.6%)

UNSAFE ACTS

Errors
- Decision Errors
  - CFIT: 471 (33.5%)
  - Non-CFIT: 4472 (35.3%)
- Skill-Based Errors
  - CFIT: 1074 (76.3%)
  - Non-CFIT: 9286 (73.2%)
- Perceptual Errors
  - CFIT: 176 (12.5%)
  - Non-CFIT: 911 (7.2%)

Violations
- Routine
  - CFIT: 445 (31.6%)
  - Non-CFIT: 1574 (12.4%)
- Exceptional

Shaded (p<.001)
Results

PRECONDITIONS FOR UNSAFE ACTS

Substandard Conditions of Operators
- Adverse Mental States
  - Clear: 66 (9.6%)
  - Impoverished: 103 (14.8%)

- Adverse Physiological State
  - Clear: 9 (1.3%)
  - Impoverished: 40 (5.8%)

- Physical/Mental Limitations
  - Clear: 65 (9.5%)
  - Impoverished: 115 (16.5%)

Substandard Practices of Operators
- Crew Resource Management
  - Clear: 20 (2.9%)
  - Impoverished: 82 (11.8%)

Personal Readiness
- Clear: 36 (5.3%)
- Impoverished: 53 (7.6%)

UNSAFE ACTS

Errors
- Decision Errors
  - Clear: 216 (31.5%)
  - Impoverished: 241 (34.7%)

- Skill-Based Errors
  - Clear: 573 (83.6%)
  - Impoverished: 480 (69.1%)

- Perceptual Errors
  - Clear: 101 (14.7%)
  - Impoverished: 74 (10.6%)

Violations
- Routine
  - Clear: 91 (13.3%)
  - Impoverished: 346 (49.8%)

Shaded (p<.001)
Results

PRECONDITIONS FOR UNSAFE ACTS

Substandard Conditions of Operators
- Adverse Mental States
  - Terrain/Water Obstacles: 73 (12.6%)
- Adverse Physiological States
  - Terrain/Water Obstacles: 12 (2.1%)
- Physical/Mental Limitations
  - Terrain/Water Obstacles: 71 (12.2%)
- Crew Resource Mismanagement
  - Terrain/Water Obstacles: 35 (6.0%)
- Personal Readiness
  - Terrain/Water Obstacles: 38 (6.5%)

Substandard Practices of Operators

UNSAFE ACTS

Errors
- Decision Errors
  - Terrain/Water Obstacles: 172 (29.6%)
- Skill-Based Errors
  - Terrain/Water Obstacles: 477 (82.1%)
- Perceptual Errors
  - Terrain/Water Obstacles: 53 (9.1%)

Violations
- Routine
  - Terrain/Water Obstacles: 163 (28.1%)
- Exceptional
  - Terrain/Water Obstacles: 282 (34.1%)

Shaded (p<.001)
CFIT Joint Safety Implementation Team

Recommendations

- Streamline equipment installation.
- Enhance pilot training for CFIT awareness and prevention.
- Establish General Aviation Safety Council.
- Increase pilot awareness on CFIT accident causes.
- Develop education, awareness, and training modules for CFIT prevention.
- Standardize and expand requirements for enhancing the visibility and detection of wires, support structures, and towers.
- Develop routes for GPS waypoints for mountain passes.
- Enhance digital user access terminals (DUATS) to provide density altitude advisories.
Conclusions

Simply by increasing a pilot’s awareness of the hazards associated with excessive risk-taking and other causes of CFIT we can begin to reduce the number of violations and personal readiness failures committed by GA pilots.

Consistent with previous work in the area (Jensen and Benel, 1998; Hunter, in press; O’Hare, 1990), the data presented here suggest that any training aimed at the reduction of CFIT should also focus on adverse mental states like overconfidence, self-induced pressure, and a variety of other hazardous attitudes.
Conclusions

While terrain displays and other warning systems would might address some of the problems associated with spatial disorientation at night or in the weather, only 74 (10.6%) CFIT accidents involved a perceptual error during visually impoverished conditions. Another 101 or 14.7% of the perceptual errors occurred during broad daylight where presumably the errors were simply misjudging airspeed and altitude or simply not seeing obstacles due to inherent limitations in the visual system. What may help in these instances would be the use of high visibility paint and other enhancing features on obstructions combined with improved visual scan and safety awareness.

Finally, the CFIT JSAT recommended the development of mountain flying advisory materials. While on the surface this makes sense (i.e., the perception that pilots are simply flying into mountains), not all CFIT occur in mountainous terrain. For that matter, a number of accidents are not even controlled flight into “terrain” in the classical sense. That is, 581 (41%) were actually controlled flight into “obstacles.” This issue needs to be examined further.
Introduction

- HFACS has now been used to analyze aircrew-related accidents within U.S. military and civil aviation operations.
- This has lead to the unprecedented ability to answer fundamental questions about the types of human errors that cause aviation accidents:
  - What are the types and frequencies of unsafe acts that cause aviation accidents?
  - Are the types of unsafe acts that cause accidents across aviation operations truly different?
Methods

- Gathered and compiled HFACS data for over 12,800 aircrew-related accidents in the US

**US Military Aviation (n=332)**

- US Navy/Marine Corp TACAIR FY90-98 (n = 138)
- US Navy/Marine Corp Helo FY90-98 (n = 60)
- US Air Force TACAIR FY91-97 (n = 72)
- US Army Helo FY92-98 (n = 62)

**US Civil Aviation (n=12,501)**

- FAR Part 121 & 135 Scheduled Air Carriers CY90-98 (n = 165)
- FAR Part 121 & 135 Nonscheduled Air Carriers CY90-98 (n = 452)
- FAR Part 91 General Aviation CY90-98 (n = 12,033)
Methods

- All HFACS data had been previously coded by multiple independent raters who had expertise within the particular type of flight operation.
- The same “rules of engagement” were used to code each set of data.
  - No new causal factors were created.
  - Consensus was required for each HFACS classification.
U.S. Aviation Comparison

Military Aviation

General Aviation

Commercial Aviation
Skill-based Errors

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage of Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Naval TACAIR</td>
<td>60%</td>
</tr>
<tr>
<td>US Naval Helo</td>
<td>50%</td>
</tr>
<tr>
<td>USAF TACAIR</td>
<td>40%</td>
</tr>
<tr>
<td>US Army Helo</td>
<td>30%</td>
</tr>
<tr>
<td>Commercial Scheduled</td>
<td>20%</td>
</tr>
<tr>
<td>Commercial Non-sched.</td>
<td>10%</td>
</tr>
<tr>
<td>General Aviation</td>
<td>0%</td>
</tr>
</tbody>
</table>

Military

Civilian
Decision Errors

Percentage of Accidents

0 10 20 30 40 50 60 70 80 90 100


Military

Civilian
Violations

The chart illustrates the percentage of accidents for different categories of aviation, comparing Military and Civilian sectors. The categories include:

- US Naval TACAIR
- US Naval Helo
- USAF TACAIR
- US Army Helo
- Commercial Scheduled
- Commercial Non-sched.
- General Aviation

The Military sector shows a significantly higher percentage of accidents compared to the Civilian sector.
### Human Error
- Errors occur less frequently.
- Safety programs are effective at preventing the occurrence or consequences of these errors.

### Accident Investigation
- Sophisticated techniques and procedures
- Information is qualitative and quantitative
- Focus on both “what” happened and “why”

### Accident Database
- Designed around a well-known human error framework
- Well-defined variables
- Organization and structure easy to understand

### Database Analysis
- Traditional human factors analyses are much less onerous due to well-defined variables and error database
- Analyses can now be performed to identify human factors safety issues

### Research Sponsors
- FAA, DoD, NASA, & Airlines provide funding for safety research programs.
- Research programs are needs-based and data-driven. Interventions are therefore very effective.

---

**Feedback**

**Human Error**
- Errors occur less frequently.
- Safety programs are effective at preventing the occurrence or consequences of these errors.

**Data-Driven Research**
- Few safety programs are effective at preventing the occurrence or consequences of these errors.
- Lack of good data leads to research programs based primarily on interests and intuitions. Interventions are therefore less effective.

**Research Sponsors**
- FAA, DoD, NASA, & Airlines provide funding for safety research programs.
- Research programs are needs-based and data-driven. Interventions are therefore very effective.

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**HFACS**

### Accident Mitigation
- Fad-Driven Research
- Data-Driven Research
- Effective Intervention and Prevention Programs

### Accident Investigation
- Sophisticated techniques and procedures
- Information is qualitative and quantitative
- Focus on both “what” happened and “why”

### Accident Database
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**HFACS**

### PRECONDITIONS FOR UNSAFE ACTS
- Environmental Factors
  - Physical Environment
  - Mental/Adverse States
- Technological Environment
- Personal Readiness
  - Physical/Mental Limitations
- Crew Resource Management
- Organizational Process
- Organizational Climate
- Resource Management
- Inadequate Supervision
- Supervisory Violations
- Planned Inappropriate Operations
- Failed to Correct Problem
- Adverse Physiological States
- Adverse Mental States
- Mental Limitations
- Environmental Factors

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**Feedback**

**Human Error**
- Errors occur less frequently.
- Safety programs are effective at preventing the occurrence or consequences of these errors.
Factors Affecting the Validity of a Taxonomy

- Comprehensiveness
- Diagnosticity
- Reliability
- Usability
HFACS can be applied anywhere!

Flightdeck (HFACS)  Maintenance (HFACS-ME)

Medicine (HFACS-MD)  ATC (HFACS-ATC)
“Whenever we talk about pilots who have been killed in a flying accident, we should all keep one thing in mind. They made a judgment. They believed in it so strongly that they knowingly bet their lives and those of their passengers on it. That their judgment was faulty is a tragedy. Many of us here today had the opportunity to influence their judgment, so a little bit of all of us goes with everyone we lose.”
Anonymous as modified by Shappell and Wiegmann (2000)