DoD Helicopter Mishaps FY85-05: Findings and Recommendations

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Statement of Accountability

This brief represents the position of the researchers. It does not represent the position of any other organization including the United States Air Force or the Department of Defense.

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**Background**

- This study describes all 917 U.S. DoD Class A-B Rotary Wing Mishaps from FY 85 to 05

- It studies 957 lost or severely damaged aircraft & over 3,800+ souls exposed to the mishap situations

- This data is based on a study of data archived in the mishap files of the Service Safety Centers

**Data Sets**

- USAF Data contains two sets:
  - AVSAS Data from FY 1993 through FY 2005
    - 13 Years, 359 Mishaps, Class A – C
  - Safety Reports from FY 1985 Through FY 2005
    - 21 Years, 88 Mishaps, Class A & B

- DON Data: 371 Mishaps, Class A & B, FY 85 – 05, 383 Vehicles

- USA Human Factor Mishap Data, Class A & B, FY 85 – 05, 251 Mishaps, 278 Vehicles

- USA Non-Human Factor Mishap Data, Class A & B, FY 85 – 05, 207 Mishaps, 207 Vehicles
Method

• Obtained & reviewed all available DoD Rotary Wing Aircraft Class A & B Mishap reports from FY 85 to FY 05 inclusive
• Created data bases for initial analysis
• No monetary value is associated with fatalities
• Major injuries resulted in approximately four weeks or more of lost duty time (5 days for DoN data)
• Minor injuries resulted in approximately less than four weeks of lost duty time (5 days for DoN data)

Outline

• Fleet Size, Service Mishap Rates & Utilization
• Mishaps by Service, Phase of Flight & Cause
• Fatality & Injury Patterns
  – DoN Water Fatalities
• Whiteout, Brownout, Night, IMC
• Experience, Recency, Training & Supervision (USAF Data)
• MDS Specific Data
• Mishaps & Injuries By Phase Of Flight
• Findings
• Recommendations
Fleet Size, Overall Mishap Rates & Utilization

Size of the Active Inventory by Service FY 85 – 05

- USA (5,891)
- DON (1,109)
- USAF (202)
**Fleet Size by Aircraft Type**

- U.S. Army
- USAF
- DON

**Class A & B Mishap Rate per 100Khrs by Service FY 85 – 05**

- USA (5,892)
- DON (1,109)
- USAF (202)
Hours per Aircraft-Year

Mishaps by Service, Phase of Flight & Cause
Fraction of Active USAF Inventory, FY 85 – 05, Involved in Class A or B HF Mishaps

- H - 1 = 6/62
- H - 53 = 24/36
- H - 60 = 20/104

Fraction of Active USAF Inventory, FY 85 – 05, Involved in Class A or B NHF Mishaps

- M/TAI
  - H - 1 = 8/62
  - H - 53 = 18/36
  - H - 60 = 4/104
**Fraction of Active USAF Inventory, FY 85 – 05, Involved in Class A or B Mishaps**

- **H - 1**: 14/62
- **H-53**: 42/36
- **H-60**: 24/104

**% of USA Inventory, FY 85 – 05, Involved in Class A or B HF Mishaps**

- **UH-1* (32)**
- **AH-1* (18)**
- **H-6* (8)**
- **H-47 (22)**
- **OH-58 (65)**
- **H-60 (73)**
- **AH-64 (58)**
- **TH-67 (2)**

* = Average/21 yrs
% of USA Inventory, FY 85 – 05, Involved in Class A or B NHF Mishaps

% Involved

N = 207

% of USA Inventory, FY 85 – 05, Involved in Class A or B Mishaps

% Involved

N = 207
% of DON Inventory, FY 85 – 05, Involved in Class A or B HF Mishaps

% of DON Inventory, FY 85 – 05, Involved in Class A or B NHF Mishaps
% of DON Inventory, FY 85 – 05, Involved in Class A or B Mishaps

- AH-1
- UH-1
- H-46
- H-53
- H-60

DoN ALL Rotary Wing - HF Cause Occupant Outcome by Phase of Flight

N = 992

- Take-off G/A: Uninjured 98, Minor 18, Major 9, Fatal 0
- Cruise: Uninjured 219, Minor 50, Major 6, Fatal 0
- Hover & Taxi: Uninjured 14, Minor 10, Major 0, Fatal 0
- Landing: Uninjured 33, Minor 6, Major 0, Fatal 0
- Ground: Uninjured 66, Minor 14, Major 0, Fatal 0
**DoN ALL Rotary Wing – NHF Cause Occupant Outcome by Phase of Flight**

- **Take-off Q/A**: 18 Uninjured, 26 Minor, 13 Major, 23 Fatal, N = 670
- **Cruise**: 59 Uninjured, 14 Minor, 5 Major, 10 Fatal
- **Hover & Taxi**: 62 Uninjured, 183 Minor, 88 Major, 88 Fatal
- **Landing**: 5 Uninjured, 18 Minor, 5 Major, 9 Fatal
- **Ground**: 7 Uninjured, 7 Minor, 7 Major, 7 Fatal

**USA HF Mishaps by MDS**

- TH-67 (2)
- UH-1 (28)
- AH-64 (53)
- H-6 (8)
- H-47 (20)
- OH-58 (61)
- H-60 (65)
- N = 251
USA NHF Mishaps by MDS

All USA NHF Mishaps Malfunction Categories

Engine Failure 82%
WX
Fuel System
Tail Rotor
Airframe
Flight Controls
Fire
Electrical
Main Rotor
Transmission
Weapons
FOD
Hydraulics

N = 207
Class A & B Mishap Rates/100Khrs by MDS

USAF HF Mishaps by Type & Phase

N = 53
**USAF NHF Mishaps by Phase**

- **T/O**: 41.9%
- **Cruise**: 32.2%
- **Hover**: 3.2%
- **Landing**: 22.6%

N = 32

**USA HF Mishaps by Type & Phase**

- **CFIT**: 84.46%
- **MIDAIRS**: 12.75%
- **Other Landing**: 2.8%

N = 251
USA NHF Mishaps by Phase of Flight
FY 85-05

Fatality & Injury Patterns
USA NHF Injury Rates/100K Hours by MDS

USA Injury Rates/100K Hours by MDS
USA HF Mishap Protection Factor

DoN HF Mishap Protection Factor

Cells with adequate power: p<0.05
USA NHF Mishap Protection Factor

DoN NHF Mishap Protection Factor

Cells with adequate power: p<0.05
**Location Of DoN Injuries**

- Head
- Lower Ext
- Chest
- Spine
- Upper Ext
- Abdomen
- Pelvis
- Lost/Drown

**Paired Pilot VS. Passenger & Crew**

*U.S. Army Rotary Wing Human Factor Mishap Fatalities & Injuries*

<table>
<thead>
<tr>
<th>MISHAP N = 112</th>
<th>PILOTS N = 232</th>
<th>PAX &amp; CREW N = 431</th>
<th>Δ% (p value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT INJURED</td>
<td># #</td>
<td>%</td>
<td>#</td>
</tr>
<tr>
<td>88</td>
<td>37.9</td>
<td>140</td>
<td>32.5</td>
</tr>
<tr>
<td>MINOR INJURY</td>
<td>67</td>
<td>28.9</td>
<td>113</td>
</tr>
<tr>
<td>MAJOR INJURY</td>
<td>22</td>
<td>9.5</td>
<td>70</td>
</tr>
<tr>
<td>DEAD</td>
<td>55</td>
<td>23.7</td>
<td>108</td>
</tr>
</tbody>
</table>
### Pilot vs. Passenger & Crew
**USA Non-HF Injuries & Fatalities**

<table>
<thead>
<tr>
<th>MISHAPS N = 207</th>
<th>PILOTS N = 409</th>
<th>PAX &amp; CREW N = 315</th>
<th>Δ%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
</tr>
<tr>
<td>NOT INJURED</td>
<td>218</td>
<td>53.3</td>
<td>132</td>
</tr>
<tr>
<td>MINOR INJURY</td>
<td>99</td>
<td>24.2</td>
<td>67</td>
</tr>
<tr>
<td>MAJOR INJURY</td>
<td>23</td>
<td>5.6</td>
<td>21</td>
</tr>
<tr>
<td>FATAL</td>
<td>69</td>
<td>16.9</td>
<td>95</td>
</tr>
</tbody>
</table>

### What the Navy did...

- Stroking seats in the cargo compartments of troop carrying helicopters for passenger use
- Instituted HEEDS: individual compressed air supply bottles for emergency escape
- Instituted anti-exposure suit availability policy for crew and passengers
- Required all crew and frequent passengers (selected fleet marine forces) to take and pass dunker training
- Maintained strict requirements for helmet wear for all passengers.
### DoN Fatality Rates
**Overall Decrease: FY 85-94 vs. FY 95-05**

<table>
<thead>
<tr>
<th>RR\textsubscript{1} = 1.84 \quad \text{(p &lt; 0.0000001)}</th>
<th>Fatalities</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 85 – 94 (1)</td>
<td>305</td>
<td>5,261,481</td>
</tr>
<tr>
<td>FY 95 – 05 (2)</td>
<td>140</td>
<td>4,439,551</td>
</tr>
</tbody>
</table>

### DoN Injury Rates
**Overall Decrease: FY 85-94 vs. FY 95-05**

<table>
<thead>
<tr>
<th>RR\textsubscript{1} = 1.83 \quad \text{(p &lt; 0.0000008)}</th>
<th>Injuries</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 85 – 94 (1)</td>
<td>206</td>
<td>5,261,481</td>
</tr>
<tr>
<td>FY 95 – 05 (2)</td>
<td>95</td>
<td>4,439,551</td>
</tr>
</tbody>
</table>
**DoN Fatalities & Major Injury Rates per 100,000 Flying Hours by Type**

- **AH-1**: Improved Fatality Rates
- **UH-1**: Improved Fatality Rates
- **SH-2**: Improved Fatality Rates
- **SH-3**: Improved Fatality Rates
- **CH-46**: Improved Injury Rates
- **CH-53**: Improved Injury Rates
- **TH-57**:
- **SH-60**:

**Improve Fatality Rates**

- * = p < 0.05
- + = p < 0.005
- ! = p < 0.0001

**Pilot vs. Passenger & Crew**

**DoN Injuries & Fatalities**

<table>
<thead>
<tr>
<th>MISHAP A/C</th>
<th>PILOTS N = 653</th>
<th>PAX &amp; CREW N = 1013</th>
<th>Δ%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT INJURED</td>
<td>392 (60.0%)</td>
<td>528 (52.1%)</td>
<td>+7.9 RR = 1.15 (p&lt;0.0015)</td>
</tr>
<tr>
<td>MINOR INJURY</td>
<td>38 (5.8%)</td>
<td>79 (7.8%)</td>
<td>-2.0 RR = 0.75 (p&lt;0.123)</td>
</tr>
<tr>
<td>MAJOR INJURY</td>
<td>63 (9.7%)</td>
<td>121 (11.9%)</td>
<td>-2.2 RR = 0.81 (p&lt;0.144)</td>
</tr>
<tr>
<td>FATAL</td>
<td>160 (24.5%)</td>
<td>285 (28.1%)</td>
<td>-3.6 RR = 0.87 (p&lt;0.102)</td>
</tr>
</tbody>
</table>
### Pilot vs. Passenger & Crew

**DoN Injuries & Fatalities**

**All Aircraft With Rear Occupants**

<table>
<thead>
<tr>
<th>MISHAPS N = 271</th>
<th>PILOTS N = 560</th>
<th>PAX &amp; CREW N = 1013</th>
<th>Δ%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percent</td>
<td>Count</td>
</tr>
<tr>
<td><strong>NOT INJURED</strong></td>
<td>339</td>
<td>60.5</td>
<td>528</td>
</tr>
<tr>
<td><strong>MINOR INJURY</strong></td>
<td>33</td>
<td>5.9</td>
<td>79</td>
</tr>
<tr>
<td><strong>MAJOR INJURY</strong></td>
<td>53</td>
<td>9.5</td>
<td>121</td>
</tr>
<tr>
<td><strong>FATAL</strong></td>
<td>135</td>
<td>24.1</td>
<td>285</td>
</tr>
</tbody>
</table>

**DoN Water Fatalities**
**USN Water Fatality Rates per 100,000 Hours**

- **Lost at Sea**: N = 133
- **Drowned**: N = 105
- **N = 28**

**DoN Water Fatality Numbers**

- **N = 133**
- Decreased Drownings/LAS: * < 0.05; + < 0.005; “ < 0.0005
**Drowning/Lost at Sea Rates**

*Overall Decrease: FY 85-94 vs. FY 95-05*

<table>
<thead>
<tr>
<th></th>
<th>D/LAS</th>
<th>Other Fatalities Hours</th>
<th>D/LAS:Total Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 85 – 94 (1)</td>
<td>119</td>
<td>186</td>
<td>39.0%</td>
</tr>
<tr>
<td></td>
<td>(2.26/100Khrs)</td>
<td>5,261,481</td>
<td></td>
</tr>
<tr>
<td>FY 95 – 05 (2)</td>
<td>14</td>
<td>126</td>
<td>10.0%</td>
</tr>
<tr>
<td></td>
<td>(0.315/100Khrs)</td>
<td>4,439,551</td>
<td></td>
</tr>
</tbody>
</table>

**RR<sub>Fatal1</sub>** = 3.85 (p<0.000001)

**RR<sub>Hours1</sub>** = 7.71 (p<0.00000001)

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**DoN Fatality Rates without D/LAS**

*Overall Decrease: FY 85-94 vs. FY 95-05*

<table>
<thead>
<tr>
<th></th>
<th>Fatalities</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 85 – 94 (1)</td>
<td>186</td>
<td>5,261,481</td>
</tr>
<tr>
<td>FY 95 – 05 (2)</td>
<td>126</td>
<td>4,439,551</td>
</tr>
</tbody>
</table>

RR<sub>1</sub> = 1.25 (p < 0.056)
Comparison USAF Rotary Wing Mishap Rates/100K Hrs by HF and Non-HF

FY 85 - 05

- Non-HF = 32
- HF = 53

Comparison USAF Rotary Wing Fatality & Injury Rates by HF and Non-HF

FY 85 - 05

- Non-HF = 32
  - Fatalities = 53
  - Injuries = 110
- HF = 53
  - Fatalities = 64
  - Injuries = 110
**USAF Rotary Wing # of Fatalities & Injuries, FY 85-05, By Flight Operation**

![Graph showing fatalities and injuries by flight operation]

**USAF Rotary Wing Landing Mishaps FY 85-05, By Mechanism**

![Graph showing mishaps by landing mechanism]
**USAF Rotary Wing # Landing Fatalities & Injuries, FY 85-05, By Mechanism**

- Fatalities
- Injuries

Note: Some Lat MRB due to droop

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**# USAF Rotary Wing CFIT Mishaps FY 85-05, By Phase of Flight**

- Hover
- Cruise
- T/O
- Landing
USAF Rotary Wing # CFIT Fatalities & Injuries, FY 85-05, By Type

Whiteout – Brownout
Night
Instruments
**USAF Human Factor Class A & B Rotary Wing Mishaps, FY 85 – 05, Reduced Visibility/Night**

![Bar chart showing mishap occurrences by day, night, IMC, and B/O for H-1, H-53, and H-60 A/C.](chart1)

**NOTE:** All IMC and B/O mishaps occurred at night in H-60 & H-53 A/C.

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**USA HF White/Brownout (& V-I) Prone Conditions**

![Pie chart showing mishap occurrences by day-brownout, day, night-brownout, and night.](chart2)

N = 117
USA HF WHITEOUT/BROWNOUT RATES (/100K Hours) BY SYSTEM

Relative Risk of Night USAF HF Class A & B Rotary Wing Mishaps, FY 85 – 05, By MDS
Mishaps were compared for additive risk of night operations and no increased risk was identified with the exception of UH-1 operations from 1985 to 1994.

- UH-1 night operations between FY 85 – 94 inclusive showed 2.51 times the relative risk of day operations for a mishap 95% CI (1.1-5.71) p = .024

- UH-1 night operations from FY 95 through FY 2005 had no increased risk.
Relative Risk of IMC USAF Class A & B Rotary Wing Mishaps, FY 85 – 05, By MDS

Experience, Recency, Training & Supervision (USAF Data)
Total Flying Time & HF Mishaps, USAF Rotary Wing Pilots (FY85 – 05)

- Mishap
- USAF

Score Test For Trend
P<0.00001

All Pilots = 745
Mishap Pilots = 104

RR 1.41
P=.049

RR 0.55
P = .012

90 Day Recent Flying Time & HF Mishaps
USAF Rotary Wing Pilots (FY85 – 05)

- Mishap
- USAF

All Pilots = 749
Mishap Pilots = 104
30 Day Recent Flying Time & HF Mishaps
USAF Rotary Wing Pilots (FY85 – 05)

Mishap

USAF

All Pilots = 742
Mishap Pilots = 104

MDS Specific Data
USAF Rotary Wing Fatality Rates/100K Hours
HF and Non-HF - By MDS + H-60

Non-HF > HF = Survival Design Deficiency
HF > Non-HF = Ops Design Deficiency

Comparison USAF & USA H-60 Rotary Wing Injury Rates/100K Hours by HF and Non-HF By MDS

Troop Seats in back
Gunner’s Harness Use
Consistent Non-HF + HF Rates ~5
USAF Fatality & Injury Rates/100K Hours By MDS FY 85-05

DoN AH-1
Occupant Outcome by Mishap Cause

N = 56
DoN UH-1
Occupant Outcome by Phase of Flight

N = 225

Take-off Q/A: Uninjured = 19, Minor = 2, Major = 2, Fatal = 12
Cruise: Uninjured = 42, Minor = 18, Major = 3, Fatal = 10
Hover & Taxi: Uninjured = 25, Minor = 44
Landing: Uninjured = 5
Ground: Uninjured = 5

DoN H-46
Occupant Outcome by Mishap Cause

N = 539

Engine Failure: Uninjured = 13, Minor = 4, Major = 6, Fatal = 2
Fuel System: Uninjured = 17, Minor = 3, Major = 8
Tail Rotor (N/A): Uninjured = 0, Minor = 4, Major = 10
Airframe: Uninjured = 0, Minor = 19, Major = 25
Flight Controls: Uninjured = 0, Minor = 4, Major = 30
Electrical: Uninjured = 0, Minor = 3, Major = 12
Main Rotor: Uninjured = 0, Minor = 6, Major = 11
Transmission: Uninjured = 0, Minor = 5, Major = 9
FCO: Uninjured = 0, Minor = 6, Major = 92
Hydraulics: Uninjured = 0, Minor = 2, Major = 12
HF: Uninjured = 0, Minor = 0, Major = 11
HF: CFTT: Uninjured = 0, Minor = 0, Major = 11
HF: Bio: Uninjured = 0, Minor = 0, Major = 11
HF: GDU: Uninjured = 0, Minor = 0, Major = 11
HF: VME/INC: Uninjured = 0, Minor = 0, Major = 11
HF: Wire Stress: Uninjured = 0, Minor = 0, Major = 11
HF: Other: Uninjured = 0, Minor = 0, Major = 11
DoN H-53
Occupant Outcome by Mishap Cause

N = 379

Engine Failure
Fuel System
Tail Rotor
Airframe Contacts
Electrical Main Rotor
Transmissions
POD
Hydraulics
HF - CFIT
HF - IFO
HF - SIGMET
HF - Wire Strike
HF - Other

Uninjured
Minor
Major
Fatal

DoN H-53
Occupant Outcome by Phase of Flight

N = 379

Take-off G/A
Cruise
Hover & Taxi
Landing
Ground

Uninjured
Minor
Major
Fatal
USAF HF Blackhawk CFIT

N = 17

<table>
<thead>
<tr>
<th>Mode</th>
<th>Cruise</th>
<th>Takeoff</th>
<th>Hover</th>
<th>Landing</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRUISE</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%

N = 105

Fatal | Injured | Uninjured

USAF HF Blackhawk Cruise CFIT

N = 8

- Day VMC Terrain
- Day VMC Aero
- Night VMC Wire
- Night IMC Terrain
USAF HF Blackhawk Slow CFIT

- Night T/O B/O: 2
- Night Hover: 1
- Night Hover B/O: 1
- Night Landing B/O: 1
- Night Landing: 3
- Day Landing: 1

N = 9

Army HF Blackhawk CFIT

- CRUISE: 26
- T/O & G/A: 9
- HOVER & TAXI: 6
- LANDING: 16

N = 57

<table>
<thead>
<tr>
<th></th>
<th>100%</th>
<th>90%</th>
<th>80%</th>
<th>70%</th>
<th>60%</th>
<th>50%</th>
<th>40%</th>
<th>30%</th>
<th>20%</th>
<th>10%</th>
<th>0%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fatal</td>
<td>Major</td>
<td>Minor</td>
<td>Uninjured</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRUISE</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>T/O &amp; G/A</td>
<td>37</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HOVER &amp; TAXI</td>
<td>17</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LANDING</td>
<td>34</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

N = 308
Army HF Blackhawk Cruise CFIT

N = 25

- Day VMC Terrain: 7
- Night VMC Terrain: 1
- Night IMC Terrain: 1
- Day VMC Wire: 3
- Day IMC Wire: 4
- Night VMC Wire: 1
- Night IMC Wire: 2

Army HF Blackhawk Slow CFIT

N = 32

- Day T/O B/O: 11
- Night T/O B/O: 2
- Night G/A B/O: 2
- Night G/A: 2
- Day Landing B/O: 2
- Night Landing B/O: 3
- Night Landing: 1
- Night Hover B/O: 1
- Night Hover IMC: 2
- Night Hover VMC: 1
DoN H-60
Occupant Outcome by Phase of Flight

N = 171

Army HF Kiowa Warrior CFIT

N = 53
N = 106
Army HF Kiowa Warrior MIDAIR

N = 8, All Clear Air

<table>
<thead>
<tr>
<th>CRUISE</th>
<th>T/O</th>
<th>LANDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 (AH-1E)</td>
<td>1 (hit parked AH-1F)</td>
<td>2 (hit parked A/C)</td>
</tr>
</tbody>
</table>

N = 32

Fatal  Major  Minor  Uninjured

100%  90%  80%  70%  60%  50%  40%  30%  20%  10%  0%

Day Cruise
Night Cruise
Night T/O
Day Landing
Night Landing

N = 8
Army HF Apache CFIT

N = 43

CRUISE 27
HOVER & TAXI 14
LANDING 2

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%

Fatal
Major
Minor
Uninjured

N = 86

Army HF Apache Cruise CFIT

N = 27

Day VMC Terrain
Twilight IMC
Night VMC Terrain
Night IMC Terrain
Day VMC Wire
Night VMC Wire
Night IMC Wire
Army HF Apache MIDAIR

N = 9

DoN Fatalities & Major Injury Rates per 100,000 Flying Hours by Type

Fatal
Major

AH-1 UH-1 SH-2 SH-3 CH-46 CH-53 TH-57 SH-60
Comparison of USA HF Class A & B Mishaps by Threats & Type

<table>
<thead>
<tr>
<th>MDS</th>
<th>CFIT</th>
<th>MIDAIR</th>
<th>B/O</th>
<th>TR</th>
<th>Night (Associated)</th>
<th>Cause Lost Lives</th>
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<td>UH-1</td>
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<td>#2 X</td>
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Pilot vs. Passenger & Crew DoN Injuries & Fatalities

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<th>PAX &amp; CREW N = 269</th>
<th>Δ%</th>
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<td>Count</td>
<td>Percent</td>
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<td>11.8</td>
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<tr>
<td>FATAL</td>
<td>33</td>
<td>30.0</td>
<td>111</td>
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<td></td>
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</tr>
</tbody>
</table>
Mishaps & Injuries
By Phase Of Flight

USAF HF Fatalities & Injuries
by Phase of Flight

- RR Fatal_{cruise} = 43.08
- RR F+I_{cruise} = 3.69
- P < 0.00000001

N = 336

- Uninjured
- Injured
- Fatal
**USAF NHF Fatalities & Injuries by Phase of Flight**

- Cruise: Uninjured (60), Injured (20), Fatal (10)
- Hover & Taxi: Uninjured (40), Injured (20), Fatal (10)
- T/O & G/A: Uninjured (20), Injured (20), Fatal (10)
- Landing: Uninjured (100)

- RR Fatal\(_{cruise} = 2.24\)
- RR F+I\(_{cruise} = 1.29\)
- \(P = 0.0074; .137\)

**USA HF Fatalities & Injuries by Phase OF Flight**

- Cruise: Uninjured (300), Minor (100), Major (70), Fatal (20)
- Hover & Taxi: Uninjured (100), Minor (100), Major (70), Fatal (20)
- T/O & G/A: Uninjured (20), Minor (20), Major (100), Fatal (20)
- Landing: Uninjured (100)

- RR Fatal\(_{cruise} = 14.24\)
- RR F+I\(_{cruise} = 1.42\)
- \(P < 0.00000001\)

\(N = 740\) of 974+
USA NHF Fatalities & Injuries by Phase of Flight

- Ground
- Landing
- Hover & Taxi
- Take-off
- Cruise

RR Fatal_cruise = 2.97
RR F+I_cruise = 1.29
P < 0.0000001 .00134

Uninjured
Minor
Major
Fatal

N = 725

DoN Helicopter Exposed Population by Outcome & Phase Of Flight

- Landing
- Hover & Taxi
- T/O & G/A
- Cruise

RR Fatal_cruise = 2.43
RR F+I_cruise = 1.67
P < 0.00000001

Uninjured
Injured
Fatal

N = 1,666
**DoD Fatalities & Injuries by Phase of Flight**

- **RR Fatal_cruise** = 3.61
- **RR F+I_cruise** = 1.59
- **P < 0.00000001**

N = 3,800

**USA NHF Ground Mishaps Malfunction Categories**

- Airframe
- Flight Controls
- Fire
- Engine Failure
- FOD
- Main Rotor
- Transmission
- WX

N = 14
USA NHF Ground Mishap Fatalities & Injuries

- Uninjured: 41
- Minor: 3
- Fatal: 1

N = 45

USA HF Landing Mishaps

- Day: 26
- Day - Low Vis.: 7
- Night: 9
- Night - Low Vis.: 10

N = 52
USA HF Landing Mishaps

- Tailwind
- Excess Sink
- Under
- TR
- Lat - MRB
- Slope - R/O
- Drift - R/O

- Day
- Day - Low Vis
- Night
- Night - Low Vis

N = 52

USA HF Landing Fatalities & Injuries

- Minor
- Uninjured
- Major
- Dead

All Fatalities and all major injuries except one occurred in B/O or IFR Visibility

N = 280
USA NHF Landing Mishaps
Malfunction Categories

- Engine Failure: 7
- WX: 6
- Tail Rotor: 4
- Fuel Systems / Starvation: 3
- Main Rotor: 2
- Flight Controls: 2
- FOD: 3

N = 24

USA NHF Landing Mishaps
Fatalities & Injuries

- Uninjured: 35
- Minor: 35
- Major: 8
- Fatal: 21

N = 99
USA NHF Landing Fatalities & Injuries by Malfunction Category

- Fuel System
- Tail Rotor
- WX
- Main Rotor
- Engine Failure
- FOD

N = 64

USA HF Hover/Taxi Mishaps

- Day
- Day - Low Vis.
- Night
- Night - Low Vis.

87% occur at night & 33% occur in low visibility

N = 46
USA HF Hover/Taxi Mishaps

- Lateral (MRB)
- TR
- Aero - Power
- Excess Sink
- Hit A/C
- Drift - R/O
- Not Spec.

Day
Day - Low Vis
Night
Night - Low Vis

N = 46

USA HF Hover/Taxi Fatalities & Injuries

- All Fatalities (10) and 42 Major Injuries (of 44 – 2 undet.) occurred at night & 16.7% (9) occurred in low visibility

- Of those uninjured or with minor injuries, 6 were day (3 low vis) and 129 were night (3 low vis)

N = 189
USA NHF Hover/Taxi Mishaps Malfunction Categories

- Engine: 8
- Airframe: 6
- Tail Rotor: 4
- Electrical: 2
- Fire: 2
- Flight Controls: 2
- Fuel: 2
- Hydraulics: 2
- Transmission: 2
- Weapons: 2
- WX: 2

N = 30

USA NHF Hover/Taxi Mishaps Fatalities & Injuries

- Uninjured: 67
- Minor: 16
- Major: 5
- Fatal: 5

N = 93
USA NHF Hover/Taxi Fatalities & Injuries by Malfunction Category

- Airframe: Minor - Major - Fatal: N = 26
- Tail Rotor: Minor - Major - Fatal: N = 26
- Engine: Minor - Major - Fatal: N = 26
- WX: Minor - Major - Fatal: N = 26
- Fuel: Minor - Major - Fatal: N = 26
- Flight Controls: Minor - Major - Fatal: N = 26
- Weapons: Minor - Major - Fatal: N = 26
- Hydraulics: Minor - Major - Fatal: N = 26

USA HF T/O & G/A Mishaps

- Whiteout, brownout and night are the largest HF risks for takeoff and go-around: N = 26
- Day
- Day - Low Vis.
- Night
- Night - Low Vis.

N = 26
USA HF T/O & G/A Mishaps

1. **Aero - PWR**: N = 26
   - Day
   - Night
   - Night - Low Vis

2. **Lat - A/C**: Day - Low Vis
3. **Lat - MRB**: Day
4. **Drift - R/O**: Day - Low Vis
5. **Wire**: Day

(NO HF FATALITIES OCCURRED DURING T/O & G/A)

- Minor: 10
- Uninjured: 29
- Major: 71

N = 110
USA NHF Take-Off Mishaps
Malfunction Categories

- Engine
- Flight Controls
- Fuel Systems
- WX

N = 13

USA NHF Take-Off Mishaps
Injuries

No Fatalities

- Uninjured
- Minor
- Major

N = 51
USA NHF Take-Off Fatalities & Injuries by Malfunction Category

Engine Failure
Fuel Systems
Flight Controls

Minor
Major
N = 19

USA HF Cruise Mishaps

Day
Day - Low Vis.
Night
Night - Low Vis.
N = 88
USA HF Cruise Mishaps

- **Terrain**: 19/48 Terrain CFITs and 70/162 fatalities. All but 3 were night events!
- **Wire**: 42/216 cruise fatalities and 22/63 major injuries
- **Midair**: 50/216 cruise fatalities and 10/63 major injuries
- **Aero-Bank**: Minor, Uninjured, Major, Dead

USA HF Cruise Fatalities & Injuries

- Cruise Fatalities and Major Injuries were the largest groups in any phase of flight

**USA HF Cruise Mishaps**

**USA HF Cruise Fatalities & Injuries**
USA NHF Cruise Mishaps
Malfunction Categories

- Engine Failure
- WX
- Fuel Systems
- Tail Rotor 84%
- Flight Controls
- Fire
- Electrical
- Transmission
- Airframe
- Main Rotor
- Weapons
- Hydraulics
- FOD

N = 126

USA NHF Cruise Mishaps
Fatalities & Injuries

- Uninjured
- Minor
- Major
- Fatal

N = 437
USA NHF Cruise Fatalities & Injuries by Malfunction Category

- Engine Failure
- WX
- Electrical
- Flight Controls
- Tail Rotor
- Main Rotor
- Fuel Systems
- Airframe
- Fire
- Weapons
- Hydraulics
- Transmission

Findings

N = 437
**Army Findings**

- Cruise flight is the most lethal and injurious
- Twin rotor aircraft & attack helicopters appear to be the most survivable
- The training pilots receive to deal with NHF mishaps improves protection factor by roughly 20%
- Cargo compartment crew are more likely to receive major injuries and die than pilots
- IMC is associated with the highest risk of mishap fatality
- Unforecast adverse weather accounts for 1/6 of NHF mishaps, engine failure is the leading NHF mishap cause
- Whiteout/brownout was the most common risk factor in mishaps below ETL
- Tail rotor strikes were common in AH & OH helicopters

**DoN Findings**

- The risk of fatality in cruise is 2.43 times greater than in flight below effective translational lift given an accident
- DoN has cut mishap fatalities and injuries in half since the period from FY 85 to 94
- Mandatory cranial use yields lower head fatality/injury ratio (2.8:1) compared to the Army (4.97:1)
- Pilots are more likely to be uninjured than cargo compartment occupants
- Twin rotor design & IP on TH-57 increased HF survivability
- DoN has greater likelihood of over water mishap yet water fatalities have been dramatically reduced
**USAF Findings**

- Class C USAF mishaps do not foretell Class A or B
- H-60 use in CSAR produces a high fatality rate not seen on the use of the H-60 by other services
- The H-53 & H-60 experience high mortality and morbidity compared to other services and the H-1
- Cruise CFIT was the most lethal and injurious phase of flight
- The wire strike and the midair were 100% lethal
- All brownouts and all but one IMC mishap occurred at night
- IMC imposed 20 to 30 times the risk of a mishap
- Mishaps are likely with low time aircraft commanders

**Recommendations**
Technology Recommendations
(Life Saving - Requirements)

• USA & USAF Helicopters would benefit from a system similar to TAWS
  – Militarize a COTS item to provide this for legacy aircraft
  – Use Navy TAWS when computer present
• Bring datalink weather data into all helicopter cockpits
• Provide COTS traffic warning technology to prevent midairs
  – TCAD
  – TCAS
  – ADSB (less practical due to coverage limits)
• All helicopters need wire detection technology
• Installation of wire cutters has value
• USAF H-60 CSAR mission needs new vehicle or Δ

Technology Recommendations
(Life Saving - Crashworthiness)

• Occupants of mishap helicopters above ETL cannot be protected, the only protection is mishap prevention
• Injuries and deaths in low speed mishaps can be mitigated
• All occupants should use lap and shoulder restraints
• Airbag use should be evaluated
• Crew positions should be designed to eliminate (minimize) the need for any crewmember to be out of a crashworthy seat below ETL
• All helicopter occupants should be carried in crashworthy seats capable of Gz mitigation with 4-point restraint
• Maximize use and acquisition of twin rotor designs
  – Move pilots out in front of forward rotor head
• Prevent occupancy beneath heavy components
Technology Recommendations
(Aircraft Saving)

- All helicopters need technology permitting safe flight and the maintenance of situational awareness in brownout/whiteout conditions, particularly at night:
  - Automated hover with instant availability
  - Automated landing systems
  - Sensor based systems
- All helicopters without rearward visibility (AH & OH) should be equipped with technology to prevent tail rotor strikes:
  - Warning systems that notify the pilot when an object is in the proximity of the tail rotor.
  - Automated systems permitting hover in a fixed position without drift.

Policy Recommendations

- Require all occupants of operating helicopters to wear a helmet at all times
- Require all passengers to remain strapped in position when operating below ETL until landing or in a stabilized hover
- VFR training should cease in IMC for all pilots
  - High Risk Mission, approve at O-6+ level
  - Supervisors should actively recall or direct the landing of any assets airborne on VFR missions if weather is forecast to fall below VMC or does
  - Capable aircraft/pilots should use IFR clearances
- Emphasize (Do Not Waive) IMC proficiency
**DoN Recommendations**

- Improve head protection for all crew members
- Continue to improve rear compartment seating
- Communicate effectiveness of water safety improvements to other branches of service and civil aviation
- Record type and details of helmet and restraint information into existing DoN safety database
- Improvement in numerator and denominator collection is required at the DoN Safety Center
  - Original reports should be kept
  - Populate all variables in the current database format
  - DoN needs to integrate denominator feeds to Center (A/C & Aircrew hours, night, IMC, # A/C, etc)

**Initiatives**

- **Occupant Protection**
  - DON SBIR on crashworthy passenger seating
  - USA Airbags in OH-58 (No stroking seat)
    - STWG white paper commissioned
  - USAF
    - SBIR on localizing crew functions in back
    - SBIR on crashworthy crew seating
    - SBIR on crashworthy passenger seating
- **Terrain, weather & traffic awareness**
  - DSOC Dem/Val program with GPS based data
  - Applies to USAF and USA Legacy Aircraft

* = unfunded
Needed

- Radar or Optical Wire Detection
- Tail Warning and/or automated hover for OH & AH aircraft (no rear visibility)
- Wireless Intercom for aft compartment crew (Navy)
- Collection of adequate data for analysis by all services
  - Flight hours by year & aircraft type
    - For Aircraft - Total, Instrument, Night, NVD, Overwater
    - For Aircrew - Total, Recency, Night, NVD & Instrument
  - Phase of flight exposure data (MFOQA)
    - Time in various altitudes & flight regimes
    - Man years of exposure
  - Mishap data (Incorporate MFOQA into Board Reports)

The material in this presentation represents the opinion of the author and should not be construed to represent the position of the United States Air Force, the Department of Defense or any other organization.

Questions?

Colonel Pete Mapes
DUSD(R)/PR&A
(703)604-0482
## DoN Rotary Wing Airframe Types

<table>
<thead>
<tr>
<th>Aircraft Category</th>
<th>Common Name</th>
<th>Mission</th>
<th>Models Included</th>
<th>Mishap Numbers</th>
<th>Mishap Rate /100,000 Hours</th>
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<td>Cobra</td>
<td>Attack</td>
<td>AH-1J/T/W</td>
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<td>UH-1N; HH-1N</td>
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<td>SH-2</td>
<td>Seasprite</td>
<td>Anti-submarine Utility</td>
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<td>Sea King</td>
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## Pilot vs. Passenger & Crew
### DoN Injuries & Fatalities

### SH-60

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<th>PILOTS N = 80</th>
<th>PAX &amp; CREW N = 89</th>
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<td>15</td>
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## USA HF Fatality & Injury Rates

### by MDS/100K Hours - Overview

![Bar chart showing fatality and injury rates by MDS/100K Hours for different aircraft models.](chart.png)
**DoN SH-2**  
**Occupant Outcome by Mishap Cause**  

![Graph showing mishap cause and occupant outcome.](image1)

**DoN SH-2**  
**Occupant Outcome by Phase of Flight**  

![Graph showing phase of flight and occupant outcome.](image2)
**DoN SH-3**

**Occupant Outcome by Mishap Cause**

- Engine Failure: 43
- Fuel System: 31
- Tail Rotor: 2
- Airframe: 2
- Electrical: 1
- Main Rotor: 7
- Transmission: 11
- POD: 10
- Hydraulics: 3
- HF: 14
- BF: 10
- HF - S000: 8
- HF - Misc: 0
- HF - Other: 0
- **N = 163**

**Uninjured**

- Engine Failure: 43
- Fuel System: 31
- Tail Rotor: 2
- Airframe: 2
- Electrical: 1
- Main Rotor: 7
- Transmission: 11
- POD: 10
- Hydraulics: 3
- HF: 14
- BF: 10
- HF - S000: 8
- HF - Misc: 0
- HF - Other: 0

**Minor**

- Engine Failure: 0
- Fuel System: 0
- Tail Rotor: 0
- Airframe: 0
- Electrical: 0
- Main Rotor: 0
- Transmission: 0
- POD: 0
- Hydraulics: 0
- HF: 0
- BF: 0
- HF - S000: 0
- HF - Misc: 0
- HF - Other: 0

**Major**

- Engine Failure: 0
- Fuel System: 0
- Tail Rotor: 0
- Airframe: 0
- Electrical: 0
- Main Rotor: 0
- Transmission: 0
- POD: 0
- Hydraulics: 0
- HF: 0
- BF: 0
- HF - S000: 0
- HF - Misc: 0
- HF - Other: 0

**Fatal**

- Engine Failure: 0
- Fuel System: 0
- Tail Rotor: 0
- Airframe: 0
- Electrical: 0
- Main Rotor: 0
- Transmission: 0
- POD: 0
- Hydraulics: 0
- HF: 0
- BF: 0
- HF - S000: 0
- HF - Misc: 0
- HF - Other: 0

**DoN SH-3**

**Occupant Outcome by Phase of Flight**

- Take-off G/A: 4
- Cruise: 45
- Hover & Taxi: 36
- Landing: 41
- Ground: 4
- **N = 163**

**Uninjured**

- Take-off G/A: 0
- Cruise: 6
- Hover & Taxi: 5
- Landing: 4
- Ground: 0

**Minor**

- Take-off G/A: 0
- Cruise: 7
- Hover & Taxi: 9
- Landing: 1
- Ground: 0

**Major**

- Take-off G/A: 0
- Cruise: 0
- Hover & Taxi: 0
- Landing: 0
- Ground: 0

**Fatal**

- Take-off G/A: 0
- Cruise: 0
- Hover & Taxi: 0
- Landing: 0
- Ground: 0
DoN TH-57
Occupant Outcome by Mishap Cause

N = 35

DoN TH-57
Occupant Outcome by Phase of Flight

N = 35
Complicated interactions in CH-46 injuries were found when stratified for the two time periods examined.

Minor injuries: In the second decade pilots were 4 times more likely than passengers to sustain MINOR injuries. ($p_{FE} = 0.049$)

Major injuries: Pilots were half as likely to sustain MAJOR injuries in the first decade. ($p = 0.056$)

Fatalities:
- After subtracting drowning and lost at sea fatalities from the first decade, pilots were found to be twice as likely as passengers to die. ($p = 0.0174$)
- Pilots were half as likely as passengers to die in the second decade. ($p = 0.03$) This difference was not affected by drowning and lost at sea data.