Safety Management Systems and Aviation Technologies in the Helicopter Emergency Medical Services Industry

Aviation Human Factors and Safety Management Systems Wings Seminar

Real-World Flight Operations and Research Progress

July 23-24, Dallas Texas, Frontiers Of Flight Museum
Presentation Agenda

Introduction
- Background
- Research Problem
- Research Questions & Hypotheses
- Purpose
- Significance

Research Method and Design

Data: Collection, Processing, and Analysis

Findings

Implications, Recommendations, and Conclusions

Questions
The first practical use of civilian air medical rotor-wing service in the U.S. began in 1970s (McGinnis et al., 2007)

In 1980, there were 40 HEMS operators in existence and operations consisted of two to three pilots (FAA Accident Task Force, 2004)

Association of Air Medical Services indicated there are 658 EMS operators in the U.S. flying over 400 aircraft and 300,000 patients each year (McGinnis et al., 2007)

In 1980, there were 32 HEMS programs flying 17,000 patients a year In 1987, there was a 400% increase in the number of operations. Ten years later, 231 helicopter services with 400 aircrafts were flying over 203,000 patients each year (McGinnis et al., 2007)

In 1995, there were 293 aircrafts operating. In 2006, the industry had grown to 792 aircraft, with the majority of that growth between 2001 and 2006 (NTSB, 2011)
Background

- Studies have shown that the risk of Emergency Medical Services (EMS) helicopter accidents have more than tripled (Jenabzadeh & Warner, 2007)

- HEMS helicopters in the United States fly approximately 400,000 flight hours annually

- Escalation in the frequency of air-medical helicopter accidents has occurred (Jenabzadeh & Warner, 2007)

- The rate of fatal HEMS accidents in 2008 was distinguished that year as the deadliest on record (NTSB, 2011)
Part 121 accident rate increased from 3.53 accidents per 100,000 flight hours in 1992 to 4.56 accidents per 100,000 flight hours between 1997 and 2001 (McGinnis et al., 2007)

Commercial air carrier aviation accident rates were 0.146 accidents per 100,000 flight hours in 1992 to 0.309 accidents per 100,000 flight hours (NTSB, 2011)

In 2011, accident rates and fatality rates for 14 CFR, 121 operations were 0.159 and 0.006, respectively

Compared to other aviation career categories, HEMS fatality rates have been higher than all others combined (Jenabzadeh & Warner, 2007)
Problem

The problem has been that while studies have been conducted on empirical efficacy strategies to mitigate the high rate of HEMS accidents

- It remains unknown whether an increased focus on safety systems and technologies will result in fewer HEMS accident rates
Research Questions

- Q1. What associations exist among frequency of accidents at HEMS organizations and implementation of safety management systems?

- Q2. What associations exist among utilization of aviation technologies and frequency of HEMS accidents rates?
Purpose

The purpose of this quantitative correlational study was to investigate whether associations exist among safety management systems implementation, aviation technologies utilization (predictor variables), years of experience, and the frequency of HEMS accident rates (criterion variable) within HEMS organizations.
Significance

- HEMS accidents rates have been disproportionate compared to other commercial air carrier aviation accident and fatality rates (Jenabzadeh & Warner, 2007)

- No research on the relationships among the use of safety management systems, available aviation technologies, and frequency of HEMS accident rates

- It is known that most HEMS accidents are caused by pilot errors (NTSB, 2011)
Historical Data

- Human error has been shown to account for about 60% to 85% of all accidents (Shappell et al., 2007)
- Human factors have been shown to account for 42.2% of operational errors. 40.8% of those operational errors were errors of decision-making or judgment (Jenabzadeh & Warner, 2007)
- Human error has been cited as a major contributing factor in accidents, and incidents and surveys have attributed 70% of incidents to crew error (Masys, 2008)
- Researchers suggested there is a potential correlation between effective HEMS transportation of patients and implementation of safety management systems (Ringburg et al., 2009)
- Researchers maintained that the utilization of safety management systems and aviation technologies can help in the transformation of organization safety (Iani & Wickens, 2007)
Historical Data

During a 22-year period from 1983 to 2005, 71 accidents (39% of all accidents) resulted in fatalities. The first decline in the frequency of accidents occurred in 2006 with 2 (1%) less than in 2005, while the number of aircraft increased by 39 (5%) in the same year.

Through a series of preventive safety programs initiated by the FAA, the accident trend reversed itself. By the mid to late 1990s, however, the accident trend began to rise again.

NTSB records have revealed several alarming statistics regarding helicopter EMS crashes over a 22-year period where these crashes resulted in one or more deaths. Of the 182 crashes that occurred during this period, 71, or 39%, resulted in a fatality.

In 1987, the FAA initiated a series of HEMS operator base inspections, consisting of intensive reviews of field standard operating procedures, aircraft, personnel, and records. Several data points were identified, including training, safety, and standardization.
Research Design and Method

➢ The quantitative correlational study investigated whether associations existed among safety management systems implementation, aviation technologies utilization, and the frequency of HEMS accident rates within HEMS organizations.

➢ National EMS Pilot’s Association (NEMSPA) announced the study to its membership database and provided a link to the survey on a section of the NEMSPA website that was available to HEMS pilots.

➢ Curt Lewis and Associates also distributed the announcement via it’s membership database.
Research Design and Method

- There are approximately 4,000 HEMS pilots in the United States.

- The study employed convenience sampling as its sampling method.

- 800 emails were distributed, and 147 (18.2%) participants responded to the survey.

- The survey included a list of all possible aviation technologies, and which technologies were utilized.
Research Design and Method

- Correlational method assessed the associations among the study variables
- Nature of relationships and dependence on multiple linear regression methodology were explored
- SMS and aviation technologies (predictor variables) and HEMS accidents (criterion variable) rates in the HEMS industry were analyzed
- Study employed a convenience sampling methodology to select a group of subjects
Data Analysis

- Pearson R correlation analysis
- Linear multiple regression model
- SPSS Version 20 was used for data processing and analysis
- Multivariate regression was used to determine if any of the predictor variables significantly predicted accident rates
Findings

- The majority of participants were
  - Male (97 %), age 51-60 (54%)
  - Thirty-nine were within the age group of 41-50 years (27%)
  - Sixty-four participants reported years of experience in the HEMS industry as 10 or more years (43.5%). Followed by 7-9 years (26%), and
  - 4-6 years (17.7%)
# Findings

## Years Experience

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>3</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>1-3</td>
<td>15</td>
<td>10.2</td>
<td>10.2</td>
</tr>
<tr>
<td>4-6</td>
<td>26</td>
<td>17.7</td>
<td>17.7</td>
</tr>
<tr>
<td>7-9</td>
<td>39</td>
<td>26.5</td>
<td>26.5</td>
</tr>
<tr>
<td>10 or more</td>
<td>64</td>
<td>43.5</td>
<td>43.5</td>
</tr>
</tbody>
</table>
Findings

- $H_{1_0}$. There is no relationship between the frequency of accident rates at HEMS organizations and the level of safety management systems implementation

- $H_{1_a}$. There is a significant relationship between the frequency of HEMS accident rates at HEMS organizations and the safety management systems implementation
Findings

- Results from Pearson R correlation coefficient analysis confirmed and identified three significant positive relationships between the variables:
  - HEMS years of experience had a high significant positive relationship with Accident Rate ($r=.90$, $p<.05$)
  - SMS had a moderate significant positive relationship to NVG ($r=.38$, $p<.05$), and
  - SMS had a slight significant positive relationship with TAWS ($r=.234$, $p<.05$)

- The null hypothesis was rejected and support existed for the alternative hypothesis
Findings

- H2₀. There is no relationship between the frequency of accidents at HEMS organizations and the level of implementation of aviation technologies

- H2ₐ. There is a significant relationship between the frequency of accidents at HEMS organizations and the level of implementation of aviation technologies
Findings

- The regression analysis suggested that:
  - HEMS years of experience explained a significant percentage of the variance in accident rate scores ($R^2 = .814$, $F(2, 127) = 139.209$, $p<.05$)
  - HEMS years of experience was also found to be a significant predictor of accident rates ($b = .894$, $t(129) = 23.281$, $p<.05$)

- The regression model was statistically significant HEMS years of experience, accounted for most of the variance, while NVG and TAWS accounted for a minimal level of variance.

- The regression model was significant ($p<.05$) to explain 81.4% of the variance of accident rate

- The null hypothesis was rejected and support existed for the alternative hypothesis
## HEMS Accident Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Hrs</th>
<th>Total Accidents</th>
<th>Accident Rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>302,192</td>
<td>9</td>
<td>2.978</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>17.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>296,191</td>
<td>13</td>
<td>4.389</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>15.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>250,187</td>
<td>14</td>
<td>5.595</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>13.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>261,085</td>
<td>12</td>
<td>4.596</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>11.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>305,105</td>
<td>19</td>
<td>6.227</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>10.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>54,965</td>
<td>13</td>
<td>3.44</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>11.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>63,265</td>
<td>13</td>
<td>2.609</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>9.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>46,700</td>
<td>13</td>
<td>2.435</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>5.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>56,699</td>
<td>11</td>
<td>3.68</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>47,986</td>
<td>10</td>
<td>2.386</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>9.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>34,379</td>
<td>9</td>
<td>2.94</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>11.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>41,551</td>
<td>11</td>
<td>2.353</td>
</tr>
<tr>
<td>% Std. Error</td>
<td>9.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Accident rates are defined as the number of accidents divided by the total number of flight hours.
Implications

- The study results indicated evidence to suggest that a statistically significant relationship existed with HEMS years of experience, NVG, and TAWS in HEMS accident reduction.

- The findings of this study also showed that the level of organizational safety culture and level of SMS implementation are possibly related to the reduction of HEMS accidents.

- The results indicated that even though one variable, HEMS years of experience was statistically significant predictor of accidents rates, NVG and TAWS were at best slight to moderate significant predictors.
Implications

- The regression model was statistically significant for HEMS years of experience and slightly and moderately significant for NVG and TAWS respectively.

- This finding implied that in HEMS accidents and years of experience, NVG and TAWS were statistically significant and related to each other.

- These results implied that further research was needed to explore the influence these variables would have on the reductions of accidents in the HEMS industry.
Recommendations

- Further inferential research is recommended to ascertain whether SMS and aviation technologies utilization in the HEMS industry can influence HEMS accident reduction

- Recommend the HEMS industry adopt the current ICAO framework and existing FAA regulatory guidance for implementation of SMS programs

- Recommend the FAA support the HEMS industry by publishing the remaining NTSB recommendations

- Recommend HEMS organizations continue to re-evaluate their current and future operational strategies
Recommendations

- Additional research to confirm these findings is recommended.
- Recommend additional research be conducted utilizing the current variables in this study to include the same data collection instrument.
- Final recommendation for the FAA and NTSB to continue to work collaboratively within the industry to develop regulatory provisions.
- Comprehensive understanding of how HEMS operator’s perspectives can differ in their approach to aviation safety culture.
Recommendations

- Recommend that alternative variables be included in future research and analyzed to explore the influences and applicability of these variables

- Future additional research to ascertain if HEMS pilots can actually perceive NVGs, TAWS, and SMS as risk mitigation tools

- Recommend that additional quantitative studies involving a larger population sample could be useful to assess and further explain the large variance in this study
# FY 13 – U.S. Registered Rotorcraft Accidents

**Cumulative Rotorcraft Accidents – 113 (29 Fatal Accidents, 59 Fatalities)**

Same period previous FY: 89 Total Helicopter Accidents (12 Fatal Accidents, 26 Fatalities)

<table>
<thead>
<tr>
<th></th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accidents</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>113</td>
</tr>
<tr>
<td><strong>Fatal</strong></td>
<td>16</td>
<td>11</td>
<td>11</td>
<td>12</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td>29</td>
</tr>
<tr>
<td><strong>Fatalities</strong></td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>59</td>
</tr>
</tbody>
</table>

Data Source: FAA, NTSB Databases. Includes only events classified as accidents and does not include incidents. The accident numbers for each month of the Fiscal Year may vary from the previous monthly briefing based on analysis between FAA and NTSB databases for the specified month. The NTSB database may include accidents that were not reported to this office resulting in slightly different numbers.

## Accident Operations Summary (Cumulative)

<table>
<thead>
<tr>
<th></th>
<th>EMS 91/135</th>
<th>GOM 91/135</th>
<th>Part 133</th>
<th>Part 135 Other</th>
<th>Air Tour 135/136</th>
<th>Part 137</th>
<th>ENG 91/135</th>
<th>GA 91</th>
<th>N Reg Outside U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accidents</strong></td>
<td>9</td>
<td>4</td>
<td>4*</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>83*</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Fatal</strong></td>
<td>5</td>
<td>2</td>
<td>1*</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>17*</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Fatalities</strong></td>
<td>12</td>
<td>4</td>
<td>1*</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>29*</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

*Includes 1 fatal Utilities Patrol accident with human external load

†Includes 1 fatal Aerial Application Part 91 frost control flight, 1 fatal Aerial Application Public Use grass seeding flight

**Acronyms:** EMS = Emergency Medical Services, ENG = Electronic News Gathering, GA = General Aviation, GOM = Gulf of Mexico
U.S. Registered Rotorcraft Accidents: FY13 Comparison to FY12
FY 13 – Total FATAL Accidents by Industry (Oct 2012 – June 2013)

Due to rounding each Industry percentage, the overall total may not equal 100%.

Percentages include 3 Public Aircraft accidents in the following sectors: Aerial Application (1) and Law Enforcement (2)
FY 13 – Total Accidents by Industry (Oct 2012 – June 2013)

- Personal/Private: 23%
- Law Enforcement: 12%
- Aerial Application: 9%
- Emergency Medical Services: 9%
- Aerial Observation: 6%
- Instructional/Training: 19%
- Commercial: 6%
- Air Tour/Sightseeing: 4%
- Business: 4%
- Offshore: 4%
- External Load: 3%
- Utilities: 3%
- Patrol/Construction: 3%

Due to rounding each Industry percentage, the overall total may not equal 100%.

Chart includes 13 Public Aircraft accidents: Aerial Application (1), Aerial Observation (1), Law Enforcement (11)
Questions and Comments