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Upon Closer Inspection...U.S. Naval Aviation Mishaps 1977-1992

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Abstract

The U.S. Navy/Marine Corps Class A flight/flight-related mishap rate has declined markedly since 1953. However, analysis of all Class A, B, and C naval aviation mishaps between January 1977 and December 1992 reveals that mishaps attributable to human factors have declined at a slower rate then those attributable to mechanical/environmental factors. Upon closer inspection of the data, marked differences were evident between single-piloted and dual-piloted aircraft. Global trends were primarily a function of single-piloted aircraft, particularly when phase of flight and time of day that a mishap occurred are considered. Previously reported improvements in aviation safety may be biased by global assessments that do not differentiate among mishap causal factors and single- versus dual-piloted aircraft.

Aviation in general, and military aviation in particular, is an inherently dangerous and unforgiving environment. Marked improvements have been realized through the use of safety programs and standardization of procedures, as well as improvements in design, maintenance and material. As evidence, the naval Class A aviation mishap rate has declined significantly since 1953 to a relatively stable rate of 1.9 to 3.4 mishaps per 100,000 flight hours (Yacavone, 1993).

On the surface, a reduction in the mishap rate from 55 Class A mishaps per 100,000 flight hours in 1953, to its present rate, represents a dramatic improvement. Unfortunately, these statistics are based upon *only Class A mishaps* and represent a summary of *all* naval aircraft without regard for mission. Many Class B and C mishaps are only seconds away from a Class A and are therefore equally important though less catastrophic. In addition, there is reason to believe that measurable differences exist between single- and dual-piloted aviation which may also influence the mishap trend. All single-piloted aircraft are involved with tactical missions and most engage in dynamic maneuvers (e.g., dog fighting, bombing, and close-air support). Moreover, single-piloted aircraft are frequently based aboard aircraft carriers or other naval platforms making landings the most difficult in naval aviation. In contrast, many dual-piloted aircraft engage in logistical missions, or those tactical missions devoid of dynamic maneuvers, and in most instances land on conventional runways rather than aboard naval vessels.

Despite efforts to the contrary, the mishap rate has remained relatively unchanged over the last decade. The majority of these efforts have focused on human factors such as: aircrew coordination, spatial disorientation, loss of situational awareness, and aircrew fatigue. However, efforts may need to focus on additional areas or selected aviation communities. The primary aim of this investigation was an attempt at the latter, an evaluation of all Class A, B, and C mishap trends since 1977 including any differences between single-piloted and dual-piloted aircraft.

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Method

A comprehensive review of U.S. Navy/Marine Corps Class A, B, and C aviation mishaps between January 1977 and December 1992 was conducted using database records maintained at the U.S. Naval Safety Center, Norfolk, Virginia. We considered only those mishaps where the causal factors were determined and not currently under investigation. Data included several variables applicable to the mishap. Of particular importance to this investigation were the type of aircraft involved, time of day and phase of flight during which the mishap occurred, and those causal factors which were identified as definite causes of the mishap. There were several other variables available but analysis of these were not complete at the time of this report.

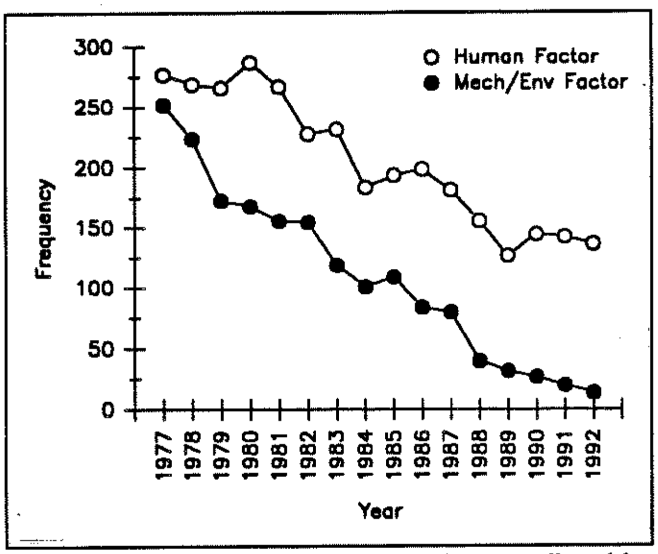

Figure 1. Frequency of aviation mishaps attributable to mech/env and human factors annually since 1977.

Results

A combined total of over 6700 Class A, B, and C were reported between January 1, 1977 and December 31, 1992. Consistent with previous reports of Class A mishaps alone, a decreasing trend toward fewer mishaps was observed from a high of 636 mishaps reported in 1977 to 161 mishaps reported in 1992.

All mishaps were categorized as being attributable to either mechanical/ environmental factors alone (mech/env) or to human factors. Mishaps attributable to mech/env factors and those attributable to human factors decreased annually but at different rates (Figure 1). In 1977 the frequency of mishaps attributable to mech/env and human factors was roughly equivalent (mech/env = 252 mishaps; human = 277 mishaps). However by 1992, while the total number of mishaps was dramatically reduced, the disparity between the two groups was much larger (mech/env = 14; human = 137). A significant relationship was obtained between aircraft type and year of this review ($X^2(15, N=5008) = 219.832$, $p < .001$).

Those mishaps attributable to human factors were examined further as a function of phase of flight and the time of day that the mishap occurred. The influence these two additional variables had on naval aviation mishaps is illustrated in Figure 2. Data were sorted into six 3 h blocks and one 6 h block. Due to the low number of mishaps occurring between 0001-0600, two 3-h blocks were combined. Within each 3-h block the percentage of mishaps during each landing phase were computed. Mishaps occurring during other phases of flight (e.g., autorotation), or those not incident to flight, were excluded. A significant relationship was observed between phase of flight and time of day (X^2 (12, N=2452) = 96.490, $p < .001$). The percentage of mishaps that occurred during takeoff remained relatively constant across time. The percentage of mishaps that occurred inflight peaked at 57 % between 0601-1500 but consistently declined to less than 35 % by 2400. In contrast, the percentage of mishaps that occurred during landing increased steadily throughout the day from roughly 21% between 0601-0900 to a high of 56 % by 2101-2400.

Although a significant relationship was obtained between mishap causal factor and year of this review for single-piloted (X^2 (15, N = 1724) = 148.803, p < .001) and dual-piloted aircraft (X^2(15, N = 3284) = 101.994, p < .001), an inspection of Figure 3 reveals some notable differences between aircraft types. First, the frequency of mishaps attributable to single-piloted aircraft is nearly twice that of dual-piloted aircraft. Second, it appears that the effect evident in Figure 1 can be attributed in large part to single-piloted aviation communities. Although the disparity between mech/env and human factors causes is evident in both single- and dual-piloted aircraft, the prominent downward trend is most apparent among single-piloted aircraft.

Unlike those effects observed for mishap causal factors, only single-piloted aircraft are influenced by both the time of day and phase of flight (Figure 4). A significant relationship was observed between phase of flight and time of day only for single-piloted aircraft (X^2 (12 N = 1580) = 134.678, p < .001). Even more than that observed for mishap causal factors above, nearly the entire effect seen in the global analysis (Fig. 2) can be accounted for by single-piloted aircraft.

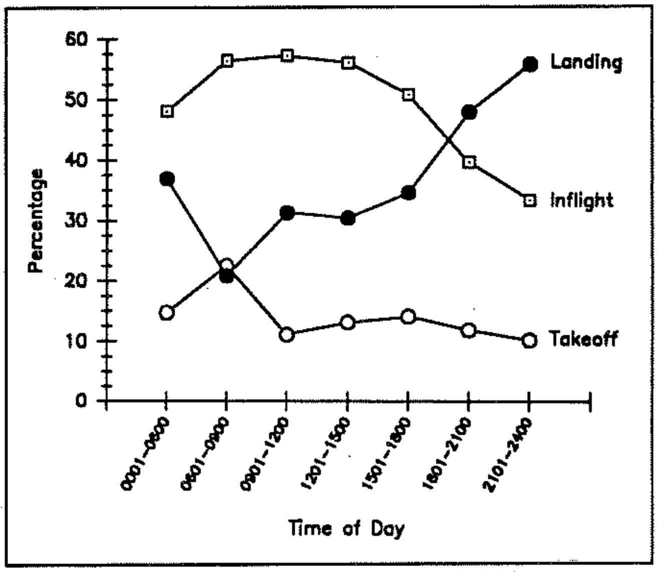

Figure 2. Mishaps attributable to human factors plotted as a function of time-of-day and phase-of-flight.

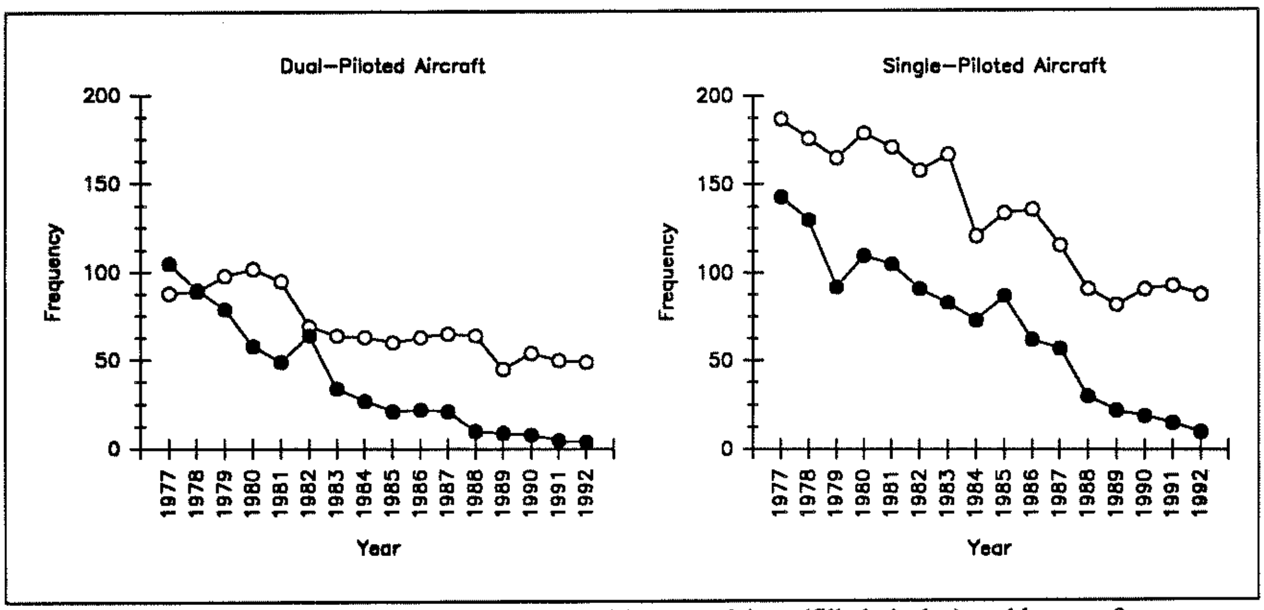

Figure 3. Frequency of aviation mishaps attributable to mech/env (filled circles) and human factors (open circles) since 1977 for dual- and single-piloted aircraft.

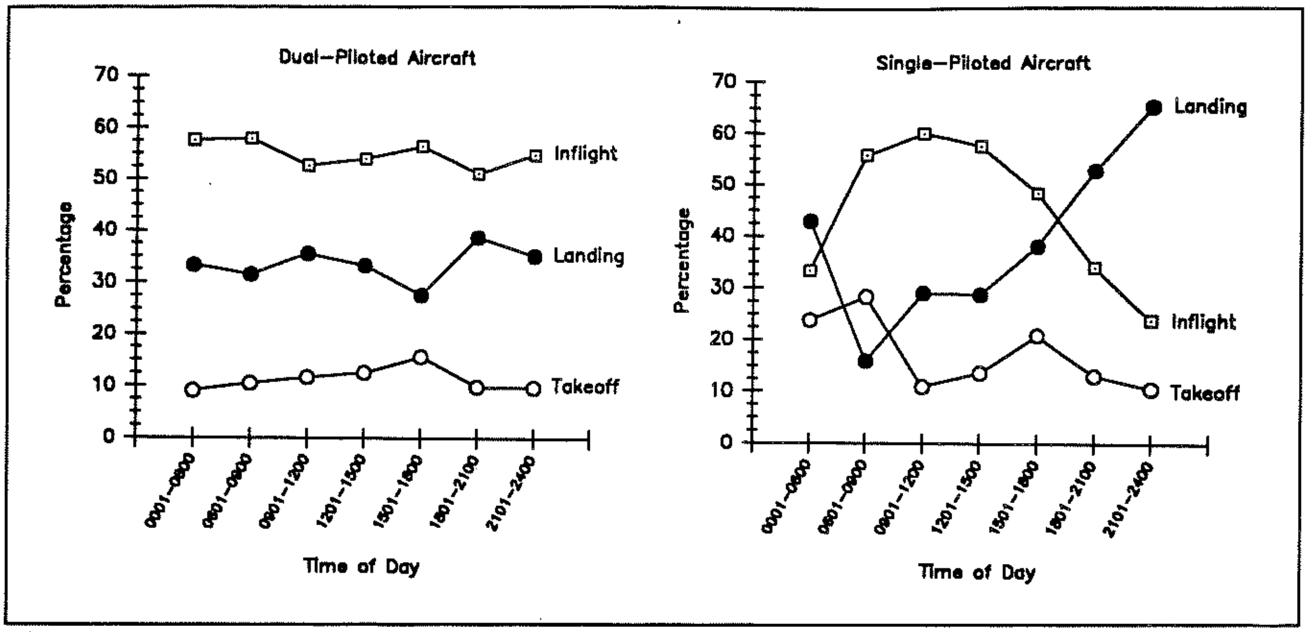

Figure 4. Mishaps attributable to human factors as a function of time-of-day and phase-of-flight for dual- and single-piloted aircraft.

Discussion

Naval aviation safety has improved considerably since 1953. Although fewer flights are being flown and flight hours have been reduced, the mishap rate has remained low and relatively stable (Yacavone, 1993). Like the Class A mishap rate reported by Yacavone, the frequency of Class A, B, and C mishaps combined has declined markedly since 1977. When mishap causal factors are considered, those attributable to mech/env and human factors have been dramatically reduced over the last 16 years. Notably, mishaps attributable solely to mech/env factors have been nearly eliminated. In contrast, while mishaps attributable to human factors have been reduced appreciably, the downward trend evident between 1977-1987 has stabilized at roughly 150 aviation mishaps annually. Clearly, if a significant reduction in the mishap rate is to be realized, primary attention should focus upon human factors.

Mishaps attributable to human factors exceeded mech/env factors for both single- and dual-piloted aircraft, thus identifying human factors as the number one cause of aviation mishaps, regardless of mission or differences among aircraft. Still, differences exist between single- and dual-piloted aircraft when mishap causal factors are considered. Not only were the frequency of mishaps in single-piloted aircraft double that of dual-piloted aircraft, but much of the difference observed between mech/env and human factors were evident in single-piloted aircraft. Although differences in raw frequencies may be attributable to a higher sortie rate in single-piloted aircraft, this explanation cannot account for the larger ratio of human factors to mech/env causes. Rather, the observed difference between aircraft types is likely a function of the type of mission flown, the number of pilots available to validate actions during emergencies, and other high workload situations.

Predicting when mishaps are likely to occur is paramount to aviation mishap prevention. Toward these ends, identifying which phase of flight (takeoff, inflight, or landing) is associated with the greatest percentage of mishaps, and at what time of day those mishaps are likely to occur, was a principal aim of this investigation. Furthermore, the differences between single-piloted and dual-piloted aircraft evident for mishap causal factors requires that any discussion of human factors include this discrimination. Nearly the entire effect seen in the global analysis can be accounted for by the single-piloted aircraft. There was no variability among dual-piloted aircraft in the percentage of mishaps occurring during any phase of flight with time of day. Not surprisingly, the largest percentage of mishaps occurred inflight for dual-piloted aircraft since the vast majority of their time is spent in transit, and most landings and takeoffs are unremarkable.

In stark contrast, the data obtained for single-piloted aircraft was quite remarkable and deserves particular attention. As anticipated, mishaps that occurred on takeoff were relatively infrequent and did not vary across time of day. During takeoff, aircrew fatigue is minimal and human resources optimal relative to the remainder of the flight. However, mishaps that occurred inflight and during the landing phase of flight varied significantly throughout the day and night. During the day, the percentage of mishaps occurring inflight exceeded those occurring during either the takeoff or landing phase of flight. The opposite was true at night. It is difficult to speculate why this difference manifested itself about the light/dark cycle. Conceivably, more dynamic inflight training occurs during the day, thereby increasing the risk of mishaps inflight. Or possibly, a sense of complacency may pervade the aircrew since visual cues and other conditions are usually better during the day. Both of these explanations deserve further attention.

Perhaps the most significant finding was that for single-piloted aircraft the percentage of mishaps during landing increased consistently throughout the day reaching a peak between 2101-2400. It is tempting to attribute this rise in landing mishaps to the lack of visual cues at dusk and at night. However, this hypothesis cannot explain the steady rise in landing mishaps evident during the day when visual cues are usually optimal. Conceivably, the increase in landing mishaps throughout the day and night is a function of increasing aircrew fatigue. Assuming that most aircrew sleep between 2300 and 0600, fatigue associated with the normal work/rest cycle should closely parallel normal circadian rhythms. However, the percentage of mishaps during the landing phase was not greatest during the circadian trough which typically occurs between 0200-0600. In fact, the greatest percentage of mishaps occurred during the 2101-2400 block, well before the circadian trough. Possibly the rise in landing mishaps is related to an increase in cumulative fatigue associated with extended work beyond a normal 8-10 h workday. Presumably, most naval aircrews, even when scheduled to fly a night mission, continue their present sleep/wake schedule (e.g. 0700 wake-up) and have been awake (perhaps even working) for well over 8 h by 1800. Aircrew engaging in missions beyond this time would be subject to cumulative fatigue, and landings naturally more hazardous. Moreover, the chances of flying more than one mission in a given day naturally increases with time of day. It is simply more likely that a given aircrew is flying their second mission of the day at 1600 than 0600. The cumulative fatigue associated with multiple combat missions and extended work has been well documented (Shappell and Neri, 1993). Still, cumulative fatigue would not necessarily be selective of phase of flight. However, in this review, only the landing phase of flight was adversely affected and the percentage of inflight mishaps were actually reduced. Clearly, no single explanation is sufficient to account for the consistent increase in the percentage of landing mishaps across time of day. Rather, it is probably some combination of visual cues, circadian factors, and cumulative fatigue associated with extended work schedules and normal activities.

The data presented here represent our initial investigation into naval aviation mishaps using the U.S. Navy/Marine Corps data base maintained at the Naval Safety Center. Future efforts will attempt to identify which mission types, and what human factors are most hazardous to naval aviation. Only through a better understanding of those factors associated with aviation mishaps can the current mishap rate be lowered and safety of flight improved.

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