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EMS HELICOPTER INCIDENTS REPORTED TO THE NASA AVIATION SAFETY REPORTING SYSTEM

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The incorporation of aviation support services in Emergency Medical Service (EMS) programs has improved the timeliness of response to medical emergencies and increased access to major medical centers that provide specialized patient care facilities. The immediate availability of medical personnel in an on-scene emergency and the timely patient transport within the initial hours following traumatic injury appears to reduce mortality by 35-52% (Baxt & Moody, 1983; Moylan, et.al., 1988). Reflecting the growth in EMS aviation services, the number of aeromedical transports by helicopter has increased since the 1970's with annual rates for hospital based operations of 20,750 flight hours in 1980 to 134,912 in 1991 (Cleveland, et.al., 1976; Preston, 1992).

Although some emergency response programs provide both fixed-wing and rotary-wing capabilities, the helicopter has been recognized for its unique ability to reach remote areas, often in difficult terrain. However, this capability has not been without risks. After a series of fatal EMS helicopter accidents in 1985-1986, the safety record of EMS helicopter operations became a concern. The National Transportation Safety Board undertook a study of 59 commercial EMS helicopter accidents occurring between 1972-1986 (NTSB, 1988). Human error, directly or indirectly, was attributed as the cause of the majority of these accidents (Lauber & Kayten, 1989). Weather was the second most common cause of these accidents. Despite a dramatic reduction in accident rates since the NTSB study, the EMS helicopter remains a high-risk operation with rates higher than the overall U.S. civil helicopter fatal accident trend (Fig.1).

Aircraft accidents are generally poor indicators of trends in aviation safety due to their low rates of occurrence and to the limited information available for accident event re-creation. Due to pilot fatalities, accident investigations often cannot obtain complete information on the chain of events and precursors that led to the accident. This obstacle is even more prevalent in EMS accidents where it has been found that EMS helicopter occupants are more likely to be seriously or fatally injured compared to those occupants in non-EMS helicopters (Dodd, 1992). Therefore, there are advantages in expanding accident investigation results with aviation safety information from alternative perspectives.

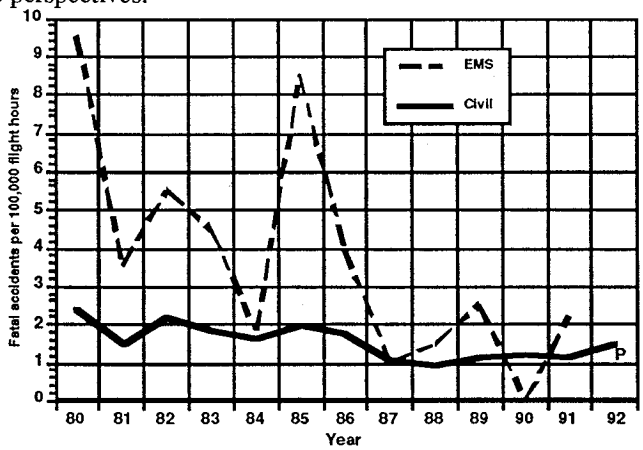

Figure 1. Fatal accident rate per 100,000 flight hours for EMS and civil helicopter operations (1980-1992). Based on data from HAI Helicopter Annual, Association of Air Medical Services, and Journal of Air Medical Transport.

One of these perspectives is the reporting of aviation-related incidents that did not lead to accidents. The NASA Aviation Safety Reporting System (ASRS) has the world's largest database on aviation incidents and is an important resource for this alternative perspective. In the current evaluation, the ASRS database was searched and reports related to EMS helicopter incidents were obtained. Eighty-one reports between 1986 and 1991 were obtained in full record form, which includes the reporter's narrative of the actual incident events. These reports, voluntarily submitted by pilots, air traffic controllers (ATC) and others, provide a rich collection of information on aviation-related incidents, including the crucial "chain of events" and the successful resolution of the event.

OBJECTIVES

The objectives of this evaluation were to:

- Identify the types of safety-related incidents reported to ASRS in EMS helicopter operations;
- Describe the operational conditions surrounding these incidents, such as weather, airspace, flight phase, time of day;
- Assess the contribution to these incidents of selected human factors considerations, such as communication, distraction, time pressure, workload, and flight/duty impact.

APPROACH

Eighty-one EMS helicopter incident reports were selected from the previous five full years available in the ASRS database.[1] The computer-aided search criteria included aircraft type (rotary-wing), operation (ambulance), and/or narrative key words (emergency, EMS, lifeguard). This original set of reports was screened and thirteen reports not relevant to this examination or not directly related to any specific safety incident were excluded from the evaluation.

The ASRS incident reports and narratives were evaluated according to several variables. These included incident variables (reporter category, pilot's qualifications/ratings, incident anomaly reported); operational variables (flight phase, weather, flight plan, time of day, and airspace); and human factor variables (communication, distraction, time pressure, workload, and flight/duty conditions). The inclusion of a reported incident in any of these categories was determined by coding provided in the ASRS record and/or by the content of the reporter's narrative.

The results of the present study are descriptive in nature. The ASRS database contains voluntarily submitted incident reports by people working in the National Airspace System. Therefore, there are inherent statistical limitations in the use of these data. Despite the limitations of a non-random sample and potential reporter and analyst biases, the information derived from actual accounts of incidents from the people directly involved can be compelling. Additionally, it is reasonable to assume that the reporting levels of events found in the ASRS database are probably the lower bound of their actual incidence in everyday flight operations. This study into contributions before, during, and after an aviation incident may help to establish potential patterns adversely affecting the safety of EMS helicopter operations, and thus, lead to further quantitative research.

RESULTS

Incident Variables

The reporters who submitted the sixty-eight ASRS incident reports included EMS helicopter pilots, air traffic controllers, and pilots of other aircraft. The majority of reports (72%) were from single-pilot helicopters. There were no multiple reports from two-pilot helicopters, i.e., only one pilot submitted a report on any one incident. Qualifications/ratings were available from the coded data on the EMS helicopter pilot reporters in both single- and two-pilot aircraft. Sixty-eight percent of the EMS pilot reporters were instrument rated. Whether their rating was current at the time of the incident cannot be determined from the coded data. However, 66% of the pilot reporters mentioned in the narrative account that they were IFR current at the time of the incident.

In the ASRS database all coded anomalies are entered for each incident. One incident report can potentially involve up to 6 anomaly entries. Therefore, the total occurences in each anomaly category cannot be considered independent of the other categories, i.e., not mutually exclusive. A summary of the incident anomalies from the EMS helicopter data are presented both for total number in each category and percentage of the total number of incidents (Fig. 2). Non-adherence to legal requirement/FAR was evident in 53% of these reports. This category includes all incidents in which a violation of a current Federal Air Regulation occurred and comprises a wide variety of information (e. g., violations of flight/duty limitations, maintenance requirements, or other coding incident categories). The third category in rank order is "Other", a category used to designate general problems not specifically addressed by other incident categories. Excluding these two general anomaly categories, the three most prevalent safety incidents found in rank order in this collection of ASRS incident reports were airspace violations, near mid-air collisions (NMAC), and in-flight encounter with instrument weather conditions.

Operational Variables

The operational descriptive variables include flight phase, weather conditions, type of flight plan, time of day, and type of airspace involved at the time of the incident. The EMS incidents occurred most frequently in the cruise phase of flight and during good weather. There were similar numbers of incidents on a VFR flight plan or no flight

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[1]Database records for 1992 are not yet complete.

plan. None of the reported incidents were during flights on an IFR flight plan, although 6% of the total reports did not include the type of flight plan in use. The time of day most often reported for these incidents was 12:01PM to 18:00PM (Fig. 3a - d). The reported incidents occurred in all types of controlled or uncontrolled airspace. The types of airspace involved in the three main incident anomalies are presented in Figure 4.

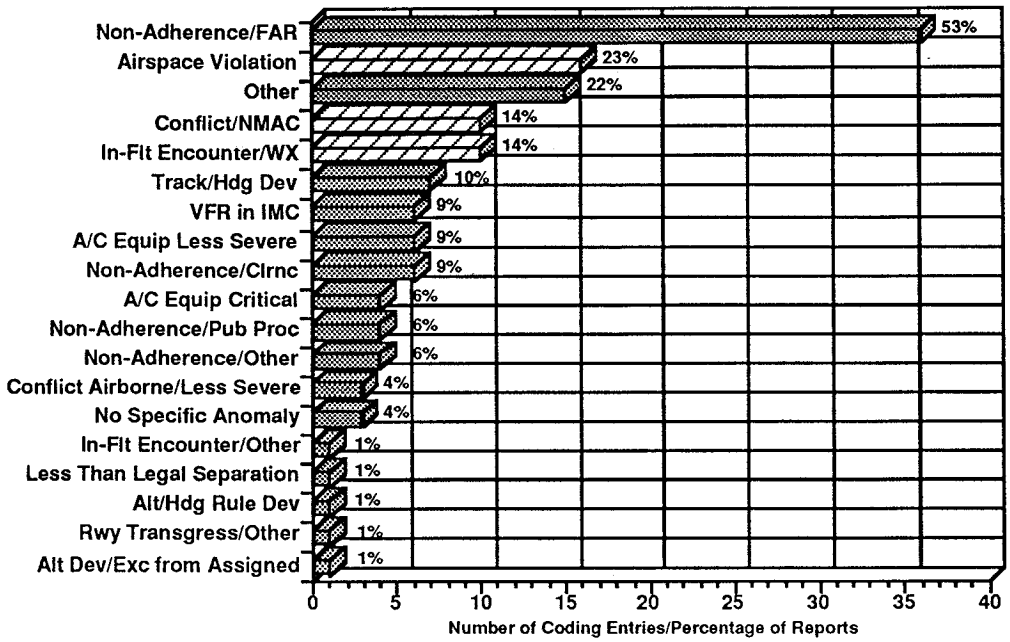

Figure 2. Total number and percentage for EMS helicopter incident anomalies (1986-91). Anomaly categories are not mutually exclusive. (n=68). Striped bars indicate top three main incident anomalies in rank order.

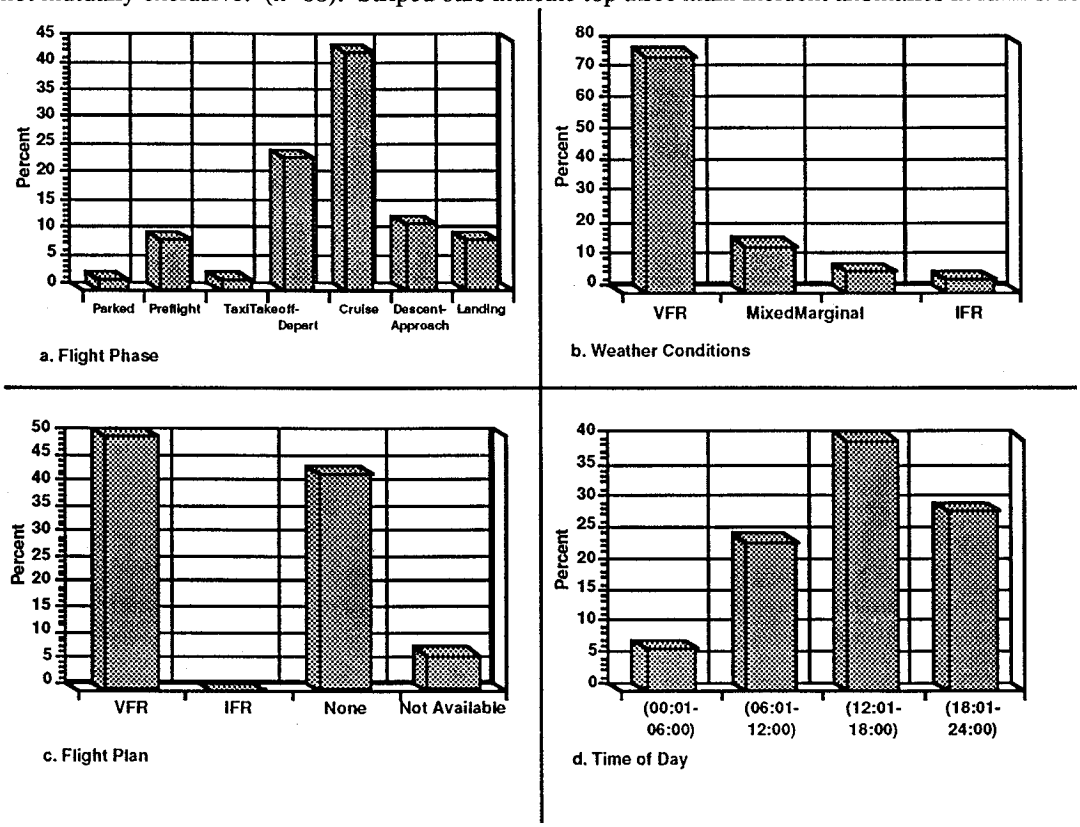

Figure 3. Percentage of incident operational variables for EMS data. (a.flight phase, b. weather conditions, c. flight plan, d. time of day.

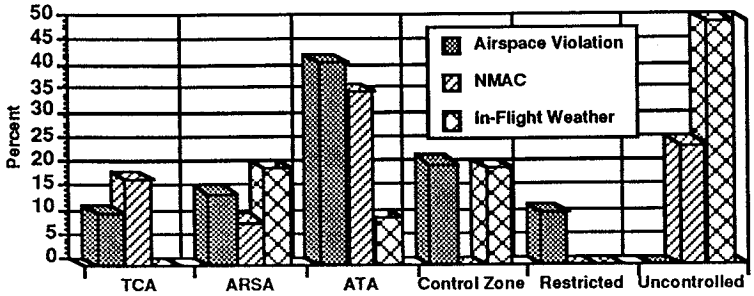

Figure 4. Percentages of reported types of airspace involved during EMS incidents for three main incident anomalies-airspace violation, NMAC, and in-flight encounter with weather.

Human Factor Variables

The categories used to describe the human factors variables are communication, distraction, time pressure, workload, and flight/duty conditions. The results are presented in Figure 5. Communication difficulties were reported in 78% of the EMS incidents. Of these incidents, pilot-ATC communications was mentioned most frequently (60%). The next highest proportion of these communication problems was pilot-weather services (13%), where ambiguous weather reports or lack of accurate weather information became a major contributor to in-flight encounters with instrument weather conditions. The third highest proportion of communication difficulties was between pilot-ground personnel, such as police, ground crew, and maintenance, where important information affecting the integrity of the EMS flight was not communicated to the pilot.

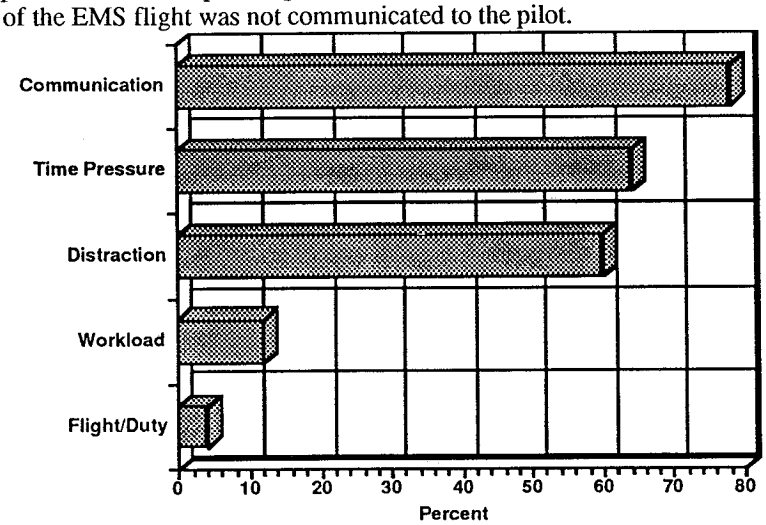

Figure 5. Percentage of contribution of human factor variables in EMS incident reports.

Time pressure, distraction, and workload followed communication as frequent contributors to incidents. Time pressure reflects the reporter's comments either directly or indirectly on lack of time as an important cause of or contribution to the incident. The comments concerning time pressure revolved around four events: patient condition, rapid mission preparations, the flight to an accident scene or patient pick-up, and low fuel situations. Whether a patient was present on the aircraft at the time of the incident varied, but patient condition was reported as the most major contribution to time pressure (44%). One Captain, ATP and instrument rated, was trapped above the clouds and forced to descend through the clouds in a non-IFR certified helicopter during the transport of a woman in high-risk labor.

> "EMS accidents are extremely high and I feel that many, if not most, are the result of operating VFR in an IFR environment....I allowed the patient's condition to influence my decision...Weather was not available at XXX...should have refueled at YYY so more options were open." (Report ACN# 58837)

Many external events were involved in creating situations leading to distraction. Examples of reporter comments contributing to distraction included aircraft equipment problems occurring in flight, monitoring of

multiple radio frequencies, traffic avoidance in high density traffic areas, radio frequency congestion, poor visibility due to haze or night operations, and noise interference from medical equipment on aircraft. Often events contributing to distraction would also be reported as time pressure situations (e.g., impending weather, low fuel concerns, and patient condition). The internal events commented on by some reporters that lead to distraction involved concerns over family members, anxiety of current situation, disorientation, and general inattention. Distraction substantially contributed to the occurrence of the three most prevalent incidents in the EMS incident reports.

The EMS helicopter incident reports were initially reviewed for comments related to workload. Constrained by a requirement that workload be explicitly referenced by the reporter, we found that the proportion of incidents mentioning workload was fairly low at 12%. The concept of workload is complex and includes a wide variety of influences on a human that potentially may lead to overload and the shedding of important tasks. One reporter aptly described the complexity of the EMS operational demands contributing to workload.

> "...I was coordinating with dispatcher, medic command (flight following/status reports), and emergency vehicle on scene and broadcasting position reports and intentions on Unicom...Approach Supervisor advised (me) that I entered his airspace and did not properly coordinate with his controller...I was working 4 frequencies and receiving conflicting coordinates from the ground while searching for the landing zone." (Report ACN# 181754)

The EMS incident reports were examined for narrative comments concerning flight/duty considerations (i.e., flight/duty length, crew rest, and number of duty days). Flight/duty conditions, although mentioned in a few reports, were not reported as a contributor to any actual safety-related incident. All of these reports were coded Non-Adherence Legal Requirements-FAR and directly related to actual violations of the FAR's regulating Part 135 rest, flight, and duty time limitations. There were no additional comments in these reports concerning any influence on performance. One reporter described a common reason why there are difficulties complying with duty time limits in EMS flight operations.

> "I overflew the duty time limits required under FAR 135.263d by 30 minutes.....We received a request for an EMS patient transfer that would normally have been completed in a time frame that would not have violated any crew duty times. Unplanned delay at the patient's originating hospital did not allow me to return in time to avoid working over my crew duty time..." (Report ACN# 112090)

The unpredictability of EMS operational demands among the EMS industry are reflected in these narratives. Some of these dilemmas of on-call emergency services are currently under investigation in a structured callback study[2] being conducted through the NASA Ames Research Center, Rotorcraft Human Factors Branch and NASA/ASRS.

DISCUSSION

The variables under examination in this collection of ASRS incident reports are important considerations related to aviation safety in emergency medical helicopter operations. Many of these variables are known to have a significant impact in other aviation environments and are common topics in aviation human factors research (Nagel & Weiner, 1989). The EMS helicopter reports from the ASRS incident database were examined as an initial exploration of "real world" events experienced by pilots, ATC operators, and others dealing with EMS flight operations.

Several common patterns emerged in the present study between airspace violations and NMAC's. Both types of incidents tended to occur in airport traffic areas (ATA) during midday. These results appear to reflect the complex airspace environment most commonly found around or near major medical centers, and a time of day when traffic density and interfacility patient transports would be expected to be high. Additionally, according to the EMS pilot

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[2] A structured callback is an interview conducted by specially trained ASRS or NASA personnel in which incident reporters are contacted by telephone before their ASRS report is de-identified, and asked to participate in a series of questions developed for a specific topic by interested researchers. A structured callback is voluntary and confidential, as are all of the ASRS incident reporting procedures.

reporters, the ATC response to the Lifeguard call sign appears to be unpredictable and inconsistent, often encouraging a pilot to maneuver around the edges of controlled airspace to avoid any delays.

Following cruise phase of flight, the second most frequent flight phase reported for NMAC incidents was descent/approach, a phase of flight when initial entry into a confined airspace occurs and workload increases. However, NMAC incidents additionally occurred in uncontrolled airspace. In these two situations, one of high traffic density and the other with lack of radio communication, the conditions increased the likelihood of conflict between two aircraft. The "see and avoid" concept taught to every pilot is never more crucial than in these two situations. Billings, et. al., (1980) state, "The highest level of pilot vigilance must be maintained to avoid midair collisions, regardless of the airspace in which operations are being conducted and regardless of the ATC services being utilized."

Degraded weather conditions and the decision to fly an EMS helicopter mission are extremely important considerations in safe flight operations. The NTSB investigation (1988) found unplanned entry into instrument meteorological conditions as the single most common factor in fatal EMS helicopter accidents, with most occurring at night (Lauber & Kayten, 1989). The findings of this ASRS incident study and those of the NTSB accident investigation were similar. These conditions reflect those found in the EMS in-flight weather incidents that did not end in an accident.

The differences between the successful resolution of in-flight weather encounter incidents and those unfortunate events leading to tragic accidents could possibly illuminate preventive strategies to be encouraged in the future. Although tentatively expressed, a comparison of these two studies may be instructional. The conditions of weather, airspace, and flight phase were similar in the two studies. The experience levels of the pilots were similar. The quality and interpretation of weather information was a concern in both the present study and the NTSB investigation. One difference, however, in the present study, is a 68% rate for ASRS-EMS pilots who were IFR rated and a 66% rate for these pilots in IFR currency at the time of the incident. In the NTSB study, 86% of the pilots were IFR rated, but only 6% (1 in 15) was current. Although this finding appears to be a compelling reason to advocate IFR currency for EMS pilots, additional research is necessary to reach this conclusion due to the comments expressed earlier concerning the limitations of the ASRS data. However, in these "real life" accounts, an IFR rating and currency were reported by these EMS reporters to be very helpful, if not invaluable.

Accurate pilot decisions appear to be complex and a pervasive contributor in the EMS helicopter flight environment. As stated by Lauber and Kayten (1989), "many factors can influence pilot judgment, such as the urgency of the mission, program competition, and management pressure (real or perceived)." In the EMS incident reports, time pressure and the influence of the patient's condition were frequent contributors to decisions to undertake a flight. There were no reports in these EMS incidents concerning management pressure. Most of the pressure related in these EMS incident reports arose from situational and self-imposed urgency.

Two influential factors in EMS helicopter operations, one present in the current EMS incident study, were addressed by the NTSB study (1988). These factors are the urgency of EMS mission requirements and the on-call nature of EMS operations contributing to fatigue (Lauber & Kayten, 1989). The contribution of time pressure to the EMS incidents in this study has been discussed and was present in all three major types of incidents, although to a lesser extent in NMAC incidents. Common reasons given by the pilots for increased feelings of time pressure was rapid mission preparation which led to errors and the condition of a critical patient creating a sense of maximum urgency.

The intense human response of pilots to injury and emergency was recognized in the NTSB study. One of the recommendations of the study was "to develop procedures to isolate flight operation decisions from medical decisions" (Lauber & Kayten, 1989). Whether this recommendation has been applied to the EMS operations from which this collection of incident reports has originated cannot be determined, but the pilots indicate a lack of "isolation from the medical decisions." The goal of isolation may not be realistic when a pilot is faced with the contagious nature of anxiety and expressions of urgency, both in speech and non-verbal gestures.

CONCLUSIONS

The EMS pilot is an integral member of the EMS team. The acknowledgment of the pilot's role and membership in this team is important in order to develop constructive mechanisms that incorporate realistic expectations among all participants of the EMS operation. The difficult balance between team membership, independent judgment, and decision-making authority is a skill to be developed. The application of Crew Resource

Management (CRM) principles, prevalent in air carrier operations, may be effectively applied to assist in team development necessary for the unique environment of EMS operations.

Additional recommendations emerging from this study are an acknowledgment concerning the unique demands placed on the EMS pilot that lead to distraction, time pressure, and workload. These demands in the EMS environment can erode the positive efforts toward good communication, thorough planning, cooperative team work, and safe flight during patient transport. The predominant findings of this study concern communication difficulties adding unnecessary burdens to the numerous tasks already occupying an EMS helicopter pilot; the priority handling of "Lifeguard" flights within the aviation system; incomplete pre-flight planning and accurate weather information; and the acknowledgment and development of mechanisms to deal with the detrimental influences of communication/information transfer problems, distractions, time pressure, workload, and the pilot's role in the overall EMS team.

All efforts need to proceed towards developing the solutions and preventive mechanisms within the National Airspace System, the EMS team, and each individual involved in these important emergency operations to improve communication and transfer of crucial information, decrease distraction, decrease time pressure to realistic levels, assist in workload management, and thereby, increase safety.

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