Developing a New System Safety Standard for U.S. Army Aviation

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Abstract

Several different helicopter programs managed and operating in the domain of U.S. Army Aviation all have their own system safety programs. These system safety programs were developed somewhat independently, over a wide span of time, under the flexible guidelines of MIL-STD-882 and applicable Army regulations. The considerable variations from program to program present significant challenges to the overarching Army management organizations. This paper presents background information, including descriptions of the existing standards and regulations, and the role they have played in creating the current situation. It also discusses in depth the challenges presented by such non-standard programs within the same Army domain. It then examines the opportunity for better standardizing the development, management, and execution of system safety programs for the variety of helicopter platforms within U.S. Army Aviation. A key aspect of the opportunity involves the current climate of standard-updating activities among system safety practitioners, both within the U.S. Department of Defense (DoD) community in general, and in DoD aviation circles in particular. Recommendations are summarized for developing a new system safety standard for U.S. Army Aviation.

Introduction

Before discussing the development of a standard for U.S. Army Aviation, it is necessary to summarize what the domain of U.S. Army Aviation consists of, and to briefly discuss how the included entities interact. The terms “U.S. Army” and “Army” are used interchangeably in this paper. The U.S. Army owns and operates over five thousand helicopters, fixed wing airplanes, and unmanned aerial vehicles (UAVs) – the largest fleet of aircraft in the world. A broad network of interrelated organizations, each with its specified roles and responsibilities, work together on a daily basis to manage and execute the Army’s aviation mission.

The majority of the Army’s helicopters are included in four helicopter programs: Chinook (CH/MH-47) Cargo Helicopters, Black Hawk (UH/MH-60) Utility Helicopters, Apache/Longbow (AH-64) Attack Helicopters, and Kiowa / Kiowa Warrior (OH-58) Scout Attack Helicopters. The alphanumeric designations of these helicopter programs were determined and assigned according to reference 1. These helicopter programs are all managed under the auspices of the U.S. Army Program Executive Officer for Aviation, or simply “PEO Aviation.” Each major Army Aviation program is managed by a program manager (PM) who reports to PEO Aviation. The “MH” designator used for Chinos and Black Hawks refer to helicopter variants used for special operations. The special operations aircraft are managed under the Technology Applications Program Office (TAPO).

A variety of different fixed wing aircraft are also flown by the Army. However, all of the Army’s fixed wing aircraft combined account for a relatively small percentage of its total aircraft fleet. Furthermore, all Army fixed wing aircraft are managed under a single Fixed Wing Product Manager’s Office, under the PEO Aviation’s PM for Aviation Systems. For these reasons, the Army’s fixed wing fleet is treated in this paper as a single program, unless noted otherwise.

In addition to conventional rotary wing and fixed wing aircraft, UAVs have become an increasingly more important asset to U.S. Army aviation. A separate PM under PEO Aviation manages the UAV fleet. Because of their unique nature, UAVs present special challenges to the standardization of system safety across Army Aviation.

The foundation of each Army Aviation program featuring a distinct aircraft design (Chinook, Black Hawk, etc.) is the aircraft manufacturer, or prime contractor. This original equipment manufacturer, or OEM, is contracted by the Army to provide the aircraft and all necessary after-market services, such as spare
and replacement parts, engineering analysis, and technical support.

The Army’s Research, Development, and Engineering Command (RDECOM) provides matrix engineering support to applicable Army programs. In the case of Army Aviation, this support is provided by RDECOM’s Aviation and Missile Research, Development, and Engineering Center (AMRDEC). Under AMRDEC, the Aviation and Engineering Directorate (AED) employs a number of engineering specialists in fields such as systems engineering, structural analysis, aircraft propulsion systems, and electromagnetic environmental effects (E3).

The aviation-related mission of the Army’s Aviation and Missile Command (AMCOM) includes supporting PEO Aviation and its PMs to enable the development, acquisition, and fielding of superior aviation and missile systems. AMCOM provides sustainment support, ensuring the readiness of aviation systems, and the integration of aviation technology for sustainment. By Army regulation (ref. 2), the AMCOM Commander is responsible for airworthiness of the Army’s aircraft fleet. AMCOM – more specifically its Safety Office – is considered the “gatekeeper” of various system safety processes affecting Army Aviation. For instance, AMCOM Safety issues safety of flight (SOF) messages and aviation safety action messages (ASAMs) to all Army units when it is determined that actions in the field, such as special inspections, part replacements, or even grounding of partial or entire fleets, are necessary to reduce safety risk. AMCOM Safety also coordinates and tracks all system safety risk assessments (SSRAs), which serve as the means for formalizing risk decisions, and obtaining and documenting the acceptance of risk. Finally, AMCOM Safety conducts reviews, from a system safety standpoint, of airworthiness releases (AWRs), engineering change proposals (ECPs), requests for deviation or waiver, safety analysis reports, test plans, and any of numerous other types of documents, and provides recommendations for concurrence or non-concurrence to AED, the PMs, or other requesting organizations.

The Army’s Developmental Test Command (DTC) operates the Aviation Technical Test Center (ATTC). Before approval is granted for full rate production of new aircraft, or before new aircraft systems can become part of any existing aircraft’s standard configuration, flight tests by ATTC test pilots are conducted in rigorously controlled test environments. A key output of an ATTC test is the safety confirmation recommendation (SCR) report.

The Army’s Combat Readiness Center (CRC), formerly known as the Army Safety Center, is responsible for conducting investigations of serious accidents involving Army aircraft. The CRC also maintains an extensive historical database of all Army Aviation accident reports. The Director of Army Safety, who also serves as the Commander of the CRC, is responsible for setting overall safety policy for the Army.

A meeting of the Army Safety Action Team (ASAT) is convened whenever senior Army leadership must discuss and resolve significant Army-wide safety issues, including any issues with potential impact on the safety of all, or significant portions of, the fleet of Army aircraft. The ASAT’s principal members include senior representatives from the offices of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology; the Deputy Chief of Staff, Operations and Plans; the Deputy Chief of Staff, Logistics (who serves as chairman); the Deputy Chief of Staff for Programs; the Director of Army Safety; PEO Aviation; and the Army Materiel Command.

For the most part, the existing DoD and Army documents that have anything to do with the application of system safety to Army Aviation only provide general requirements or guidance as to what is required. Currently, there is no specific standard or requirements document to ensure that the system safety discipline is applied consistently across all programs. Consequently, there are notable differences in the specifics of how system safety is applied to the several Army Aviation programs. A number of benefits could be realized by standardizing the application of system safety across all of Army Aviation. The goals of this paper are to identify and characterize the opportunity for realizing these benefits, and to provide recommendations for pursuing this opportunity.

Existing standards, regulations, and other pertinent documents are described in the next section, with emphasis on their generally limited provisions for standardization of system safety in Army Aviation. Next, the current situation and its challenges are described, primarily by comparing and contrasting the system safety attributes of each of the major Army Aviation programs. The next section provides a discussion of the opportunities to benefit from standardization. The paper concludes with a summary of recommendations to be considered for developing a new system safety standard for Army Aviation.
Existing Standards and Regulations

The highest level U.S. Government document ordinarily cited as directly requiring the application of system safety to DoD programs is DoD Instruction 5000.2. A single paragraph on Environment, Safety, and Occupational Health (ESOH), located in the Instruction’s Enclosure 7, on Human Systems Integration, requires the PM to “prevent ESOH hazards where possible, and … manage ESOH hazards where they cannot be avoided.” This same paragraph establishes four risk levels and identifies the component acquisition executive (CAE) as the acceptance authority for high risks, the PEO for serious risks, and the PM for medium and low risks, “as defined in the industry standard for system safety” (ref. 3).

The widely accepted “industry standard for system safety” mentioned in reference 3 is MIL-STD-882. This military standard was first published in 1969. Formally approved revisions have been published four times since – the most recent one being Revision D, published in 2000 (ref. 4). MIL-STD-882 has always been a “tailorable” document; that is, it has mandated only general requirements, while offering a wide range of more specific system safety program elements and aspects that may be selected as appropriate, depending on attributes of the acquisition program (cost, schedule, complexity, etc.). Revision D of MIL-STD-882, driven by national acquisition reform initiatives that started in the mid-90’s, considerably weakened the already somewhat loose guidelines of the standard by removing explicitly defined tasks that were present in earlier revisions. An improved Revision E, which will restore the tasks and make many other improvements, is currently under development and expected to be published by late 2005.

Army Regulation (AR) 70-1, the Army Acquisition Policy, requires that PMs integrate the ESOH risk management process into the systems engineering process. This document specifies that the steps of the risk management process are to “identify hazards, assess risks, make risk decisions, implement [means of eliminating or reducing risk], and supervise.” It also states that decisions to accept risks associated with hazards are to be made at a management level commensurate with the risk, and it provides “a risk decision authority matrix,” a representation of which is shown in Figure 1 below (ref. 5).

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**HAZARD PROBABILITY**

<table>
<thead>
<tr>
<th>SEVERITY</th>
<th>CATASTROPHIC</th>
<th>CRITICAL</th>
<th>MARGINAL</th>
<th>NEGLIGIBLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENT</td>
<td>F</td>
<td>E</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>OCCASIONAL</td>
<td>G</td>
<td>B</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>REMOTE</td>
<td>H</td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMPROBABLE</td>
<td>I</td>
<td>H</td>
<td>G</td>
<td>F</td>
</tr>
</tbody>
</table>

**RISK ACCEPTANCE BY:**

HIGH: AAE or designee.
MEDIUM: PEO or equivalent with concurrency of CBTDEV proponent CDR.
LOW: PM or equivalent.

Figure 1 – Risk Decision Authority Matrix from AR 70-1
The matrix from reference 5 is a typical risk assessment matrix, with four severity levels and five probability levels. However, the risk space contained in the matrix is divided into only three levels (high, medium, and low), which is inconsistent with DoD Instruction 5000.2 (ref. 3).

Army Regulation 385-16, “System Safety Engineering and Management,” (ref. 6) is the Army’s most explicit requirements document governing the application of system safety to Army programs in general. Programmatic responsibilities are outlined for levels ranging from the Assistant Secretary of the Army down to the PM. AR 385-16 requires the establishment of a “system safety working group (SSWG) to track hazards and ensure program coordination” for major Army program systems. An accompanying Department of the Army pamphlet, DA Pam 385-16, “System Safety Management Guide” (ref. 7), provides guidance on the composition and other characteristics of the SSWG. AR 385-16 specifies standard requirements for preparing and processing system safety risk assessments (SSRAs) to accept system safety risks at a level of management authority commensurate with the risk. A standard SSRA format is even provided.

PEO Aviation has drafted an updated policy memorandum to “provide current policy for System Safety Risk Management within PEO Aviation” (ref. 8). This document sets forth high level risk management policy to be followed by all Aviation PMs under PEO Aviation, and all agencies providing risk documentation support. In terms of standardizing the application of system safety to all Army Aviation programs, this document does the following:

- Outlines responsibilities of the PMs, AED, and SSWGs for all Army Aviation programs under PEO Aviation
- Requires use of a common system safety risk assessment decision authority matrix with numerical values, in terms of mishaps per 100,000 flight-hours for probability, and cost of property damage for severity (occurrence of a fatality is also a criterion for the highest severity level), for the upper and lower bounds of each cell of the matrix
- Specifies risk documentation requirements
- Requires hazard to be described using the source-mechanism-outcome convention

The documents described above all serve a worthwhile purpose; however, with the exception of the PEO Aviation policy memorandum (ref. 8), none are specific to Army Aviation. DoD Instruction 5000.2 (ref. 3) is very high-level and merely requires the application of system safety in the broadest sense; it does not provide for standard methodology or consistent practice. MIL-STD-882D (ref. 4) emphasizes tailorable and is weak in terms of any specificity, especially without the DIDs and tasks present in earlier revisions. AR 70-1 (ref. 5) formalizes the five elements of the risk management process, but provides little detail as to the subprocess included in each. It also provides a risk decision authority matrix, but presents it as more of an example to be considered, and without numerical upper and lower bounds of each matrix cell, leaves its use subject to a wide range of interpretation. Furthermore, the matrix is inconsistent with requirements of DoD Instruction 5000.2. AR 385-16 (ref. 6) effectively standardizes the SSRA process and requires all major programs to utilize SSWGs. Finally, the PEO Aviation policy memorandum (ref. 8) is directly applicable and specific to Army Aviation, and it does lay the groundwork for standardization of basic system safety processes across Army Aviation. However, as discussed in more detail in the next section, there are still opportunities for improved standardization of the application of system safety to all Army Aviation programs.

The Current Situation and its Challenges

Primarily because of the nature of the existing standards, regulations, and requirements documents, as summarized in the previous section, and because a number of different Army Aviation programs have developed and matured at different times over the past several decades, as the existing acquisition and system safety documents have evolved, there are some notable differences in the way system safety is applied to the different programs. The good news is that there are also some commonalities. In a discussion of the standardization of system safety across different programs, it is important to recognize these common features and understand the reasons for them. This section will compare and contrast the main points of the system safety programs and how system safety is applied to the various major Army Aviation programs.

Some common features among the various Army Aviation system safety programs result from deliberate attempts to make them uniform, such as the policy to be set forth in the draft PEO Aviation Policy Memorandum 05-14 (ref. 8), discussed in the previous section. Examples of these similarities are the consistent use of the SSRA process and ASAM/SOF messages. On the other hand, there are some similarities in the approaches to system safety and the treatment of Army helicopter hazards that owe their existence to the general nature of...
Army Aviation and helicopter design aspects, regardless of the actual aircraft platform involved. Many of these similarities have to do with the technical nature of certain general helicopter hazards, the identification and control of which are the goals of the respective system safety programs. For instance, the typical flight profile of many Army helicopters involves short duration, low altitude flight (as opposed to longer duration, high altitude flight of, say, commercial airliners). This means that safety considerations such as shorter times for reacting to in-flight anomalies or failures are common to all helicopters. The hazard of total engine failure, and the design capability of autorotating, or “coasting” to a safe landing, is a common concern among all helicopters. The basic operational concepts of flight control and rotor system mechanisms are common to most helicopters, particularly those used in Army Aviation. System safety programs that are standardized across all Army helicopter programs should account for and handle these common features and considerations in the same manner, regardless of the helicopter.

Another reason for similarities of safety program considerations from one helicopter to another is the fact that often, identical or similar weapon systems or auxiliary systems are installed in different helicopters. This creates the opportunity – or rather, the necessity – for consistent treatment, from one helicopter’s system safety program to another’s, of hazards involving those weapon systems or auxiliary systems.

However, just as there are similarities from program to program because of inherent similarities in missions and general design aspects, there are also differences in safety considerations from program to program because of expected and unavoidable differences in missions and designs. For instance, autorotation is more hazardous in a Kiowa helicopter, whose rotor blades have a lower mass than those of the larger Chinook or Black Hawk, and therefore, have less momentum to maintain autorotation to a safe landing in the event of complete engine failure. Additionally, Kiowas have only a single engine, while Chinooks, Black Hawks, and Apaches all have two. For another example, Chinooks can hold over 30 passengers, while an Apache will never bear more than its two crewmembers (with the exception of extremely rare rescue scenarios), and UAVs have no one on board. This means that, other than the case of an errant aircraft inflicting fatalities to one or more people on the ground after impact (which is a possibility for any of these aircraft), the worst severity Chinook mishap could entail more than an order of magnitude more fatalities than the worst severity Apache mishap, and a catastrophic mishap of either of these involves more potential loss of life than the worst severity UAV mishap. Many hazards to which fixed wing aircraft are exposed differ markedly from many rotary wing hazards. Guidelines for standardizing system safety application for multiple programs will need to be flexible enough to accommodate differences such as these.

Some differences between the system safety programs and processes for different aircraft programs are unrelated to differences in aircraft type, design, or mission, and these differences exist in spite of the Army’s best efforts to minimize or eliminate them. For instance, even though reference 8 requires the use of a single risk assessment matrix by all Army Aviation programs under PEO Aviation, there are often differences in interpretation that can cause variations in assessment of the same or similar risks. For instance, SCR reports issued by ATTC following the performance of an aircraft test have been known to contain assessment of risks for hazards identified in the report that differ significantly from the assessment that the same hazard would have received if performed by safety analysts from the PM or AMCOM Safety. This is likely due to the unique perspective from which ATTC views hazards and assesses their risks.

Even though they should be nearly identical, system safety program plans (SSPPs) vary considerably from one helicopter program to the next. Hazard tracking systems employed by each helicopter program also vary considerably.

The types of program differences discussed in the last two paragraphs offer the best opportunities for standardization. The next section provides a more complete discussion of the opportunities to benefit from standardization.

Many of the program similarities and differences discussed above in this section are summarized in Table 1 below.
Table 1 – Summary of Selected System Safety Program Aspects, Illustrating Similarities and Differences

<table>
<thead>
<tr>
<th></th>
<th>H-47 Chinook</th>
<th>OH-58 Kiowa/Kiowa Warrior</th>
<th>H-60 Black Hawk</th>
<th>AH-64 Apache</th>
<th>Fixed Wing</th>
<th>UAVs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk Matrix</strong></td>
<td>-- All are directed to use the matrix from reference 8 --</td>
<td>Run primarily by the PM, with assistance from OEM (Boeing); meets semi-annually; called SSWG (includes “Environmental”)</td>
<td>Run primarily by the PM; meets annually; co-chaired by AMCOM Safety</td>
<td>Run primarily by the PM; meets quarterly; co-chaired by AMCOM Safety</td>
<td>Run primarily by the PM; meets semi-annually at OEM’s plant; co-chaired by AMCOM Safety</td>
<td>A new, single SSWG is being organized for all Army FW programs; separate MANPRINT IPT (includes system safety) for ACS (a FW new development program)</td>
</tr>
<tr>
<td><strong>SSWG</strong></td>
<td>Run primarily by the PM, with assistance from OEM (Boeing); meets semi-annually; called SSWG (includes “Environmental”)</td>
<td>Run primarily by the PM; meets annually; co-chaired by AMCOM Safety</td>
<td>Run primarily by the PM; meets quarterly; co-chaired by AMCOM Safety</td>
<td>Run primarily by the PM; meets semi-annually at OEM’s plant; co-chaired by AMCOM Safety</td>
<td>Separate SSWG for each UAV program; SSWGs meet annually; attempting to coordinate meetings</td>
<td></td>
</tr>
<tr>
<td><strong>Hazard Tracking System</strong></td>
<td>HTSs for all programs are different.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SSRA Process</strong></td>
<td>Does not issue interim SSRAs; most SSRAs are issued for indefinite periods to accept residual risk.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Unique/Special Concerns</strong></td>
<td>Currently undergoing a major modification program.</td>
<td>Currently undergoing a major modification program.</td>
<td>Heavy production activity is currently in process.</td>
<td>Very FAA-oriented.</td>
<td>Many new and developing programs; formal processes still in transition</td>
<td></td>
</tr>
</tbody>
</table>

Rather than dwell on the challenges presented by the differences summarized above, the next section will deal with them in a more positive tone by discussing and summarizing the opportunities to benefit from standardization of system safety across Army Aviation.

**Opportunities to Benefit From Standardization**

In a recent presentation of improvements made to the new draft MIL-STD-882E, the goals of developing and promulgating consensus standards were explained in the context of fields of endeavor having a distribution of practices. In such a realm or field of endeavor, when a majority of practitioners – those in the consensus – operate in some middle ground (in terms of level of detail, accuracy, acceptability, “goodness,” etc.), one side of the distribution of practices will taper off to minimally acceptable practices, while the other side will taper off toward what may be considered exemplary, state-of-the-art practice, and even farther to the “cutting edge.” The goals of improved standardization are to (A) improve the mean practice and (B) decrease the spread of practices (ref. 9). These goals are depicted in Figure 2 below by the curve (A) moving to the right, and (B) getting taller and narrower.
Since there are Army leadership entities (for example, the ASAT) and matrix organizations that deal with all Army Aviation programs, it stands to reason that there would be considerable benefit in having more uniformity and consistency between the various programs. Simply put, a “I-C” hazard on one helicopter should connote the same risk level as a “I-C” hazard on another helicopter.

Another general benefit could be the enhanced agility of the work force. A more standard application of system safety to all the programs in Army Aviation would mean that personnel could move among the different programs more easily. Similarly, there would be more opportunity for sharing resources, such as hazard tracking system software, if all Army Aviation programs adhered to the same, explicit system safety standard.

Several specific opportunities for improvement to the practice of system safety in Army Aviation are discussed briefly in the following paragraphs. These opportunities constitute additional benefits to the development of a new system safety standard for Army Aviation.

Risk Summation: There has been recent, considerable interest in the idea of risk summation, when determining whether systems are safe enough. A Risk Summation Workshop held in Huntsville, AL in February 2005 drew over 30 participants, including some from as far away as Sweden. According to the concept of risk

**Figure 2 – The Goals of Consensus Standards**
summation, heretofore not widely practiced (in fact, a
good example of a “cutting edge” practice, as discussed
earlier), the risks associated with all individual system
hazards would be summed to determine the total system
risk, which would be presented to management for a
risk decision (ref. 10). A new system safety standard for
Army Aviation could include requirements, or at least
provisions, for determining and reporting total system
risk.

**Risk Matrix Modernization:** Recent years have seen
extensive work in the area of modernizing risk matrices
and their use. One example of an improvement being
made to risk matrices and the consistency of their use is
that more and more matrices are being displayed in true
Cartesian coordinate fashion – that is, with the matrix
oriented such that cells with the highest risk are up and
to the right. Another example of risk matrix
modernization is ensuring that severity and probability
categories are quantified and that the spans from
logarithmic upper and lower bounds of each cell are
uniform throughout the matrix. These and other
guidelines for using more modernized risk matrices are
being included in the improved draft Revision E of
MIL-STD-882 (ref. 9). Army Aviation would benefit
from having any new system safety standard providing
the same guidelines.

**Definitions:** A new standard would provide the ideal
opportunity for ensuring consistent verbiage is used
throughout Army Aviation. Currently, assessment of
risk associated with hazards might be geared toward the
“worst credible” mishap on one program, the “worst
possible” on another program, and the “most reasonable
credible” on yet another. These differences in verbiage
easily create differences in how hazards are assessed.

**Boilerplate SSMPs:** A new standard for system safety
in Army Aviation could provide a template for
boilerplate system safety management plans (SSMPs).
Ensuring consistency of SSMPs from program to
program would obviously improve the consistency of
many aspects of system safety across all Army Aviation
programs.

**Minimum Requirements for Hazard Tracking Systems:**
Standardizing the HTSs across all Army Aviation
programs would provide a number of specific benefits,
including easier sharing of hazard data from program to
program, easier use of hazard data by Army leadership
or matrix organizations that deal with multiple
programs, sharing of HTS software from program to
program, and so on.

**List of Generic Hazards:** Certain hazards generic to
many or all helicopter programs, such as brownout, wire
strikes, etc., could be identified and characterized in a
new system safety standard for Army Aviation. One
important source of generic hazards for Army Aviation
is database developed by the Aviation Safety
Investment Strategy Team (ASIST) (ref. 11).

**Lessons Learned:** Lessons learned are a vital tool in
any application of system safety. Better standardization
of system safety practice across Army Aviation will
improve the quality and availability of lessons learned
data.

**Online Access:** Significant benefits will be offered as
all Army Aviation programs begin to provide online
access to their HTSs, lessons learned databases, and
generic hazards, to name a few. A new standard could
address common concerns, such as security procedures.

**Concluding Recommendations**

The author recommends that a new standard be
developed for the application of system safety to U.S.
Army Aviation. All affected organizations should be
involved in the development and publishing process.
The standard should incorporate the specific
opportunities for benefits outlined in the previous
section. Once published, the standard should be
promulgated and enforced.

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