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Army Aircraft Icing

Lindamae Peck, Charles C. Ryerson, and C. James Martel

September 2002

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Abstract: Icing is among aviation's most serious weather hazards because it renders aircraft unflyable before flight and severely reduces aircraft performance within flight. Army aviation is vulnerable to icing, which occurs most frequently at lower altitudes, and which generally has the greatest impact upon small fixed-wing aircraft and helicopters that fly slowly and low. Icing causes mission delays during ground deicing of aircraft and mission cancellations and abortions because of forecast or actual in-flight icing. The common notion, however, is that icing is "not a problem" for Army aviators because they generally "do not fly in icing." This report assesses the effects of icing, both before and during flight, on the ability of Army aviators to accomplish their mission. Interviews with aviation commands, surveys to aviation commands worldwide, and assessment of Army aviation safety records demonstrate the affect of icing and snow on Army aviation.

COVER: A U.S. Army soldier from 1st Battalion, 501st Aviation Brigade, removes snow from an AH-64A Apache attack helicopter at Eagle Base Air Field Tuzla, Bosnia and Herzegovina, on 16 December 1997. (Department of Defense photo by Specialist Richard L. Branham, U.S. Army.)

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ABSTRACT

Icing is among aviation's most serious weather hazards because it renders aircraft unflyable before flight and severely reduces aircraft performance within flight. Army aviation is vulnerable to icing, which occurs most frequently at lower altitudes, and which generally has the greatest impact upon small fixed-wing aircraft and helicopters that fly slowly and low. Icing causes mission delays during ground deicing of aircraft and mission cancellations and abortions because of forecast or actual in-flight icing. The common notion, however, is that icing is "not a problem" for Army aviators because they generally "do not fly in icing." This report assesses the effects of icing, both before and during flight, on the ability of Army aviators to accomplish their mission. Interviews with aviation commands, surveys to aviation commands worldwide, and assessment of Army aviation safety records demonstrate the affect of icing and snow on Army aviation.

SUBJECT TERMS

Aviation, deicing, forecast, helicopters, icing, inflight, preflight, mission, safety, snow

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PREFACE

This report was prepared by Lindamae Peck, Research Geophysicist, Geophysical Sciences Branch; Charles C. Ryerson, Research Physical Scientist, Snow and Ice Branch; and C. James Martel, Environmental Engineer, Applied and Military Engineering Branch, U.S. Army Engineer Research and Development Center (ERDC), Cold Regions Research and Engineering Laboratory (CRREL), Hanover, New Hampshire.

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The authors thank Robert Redfield, Jimmy Huntington, and Tom Foster for their technical reviews, which contributed to the validity of the report; DCD-Aviation for reviewing the questionnaires and facilitating their distribution to aviation units; and the Army Safety Center for conducting database searches for icing-related incidents and accidents. The authors thank the organizers of the following conferences for their assistance: the 2000 Army Aviation Association of America Convention; the TRADOC System Manager Unmanned Aerial Vehicles Conference; and the Aviation Ground Support Equipment Users’ Conference. The authors thank the following Army organizations for their assistance in obtaining aviation information: the Directorate of MEDEVAC Proponency; PEO Robotics; the TRADOC System Manager for Unmanned Aerial Vehicles; the 160th Special Operations Aviation Combat Development, Systems Integration and Maintenance Office; and the 160th Special Operations Aviation Equipment Acquisition Office. Finally, the authors express their appreciation to the aviation units that responded to their questionnaires.

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1 INTRODUCTION

This report presents aircraft icing's impact on Army aviation, as reported in 2000/2001 by soldiers and civilians responsible for the Army's capabilities in the areas of general aviation, Special Operations aviation, medical evacuation, and unmanned aerial vehicles.

The U.S. Army's reliance on aviation has grown continuously since the inception of modern Army aviation on 6 June 1942 and the subsequent establishment of the Aviation Branch in 1983. The Army employs the versatility, deployability, and lethality of its aviation assets in its full range of missions. During conflicts the operational Army uses aircraft for attack, air assault, reconnaissance, transportation, combat search and rescue, and observation. In contingency operations Army aviation also conducts infiltration and evacuation. Given this diversity of functions, external factors that restrict aviation operations can be decisive in mission accomplishment.

The formation of ice on an aircraft is an obvious example of an external factor hindering aviation operations. In-flight ice accumulation on windscreens and instrument ports creates the situation of a pilot essentially flying blind, with limited or no visibility and unreliable instrument aids. The added weight of accumulated ice on the airframe reduces the aircraft's load capacity and increases fuel consumption. If helicopter rotor blades shed ice asymmetrically, the resultant imbalance causes severe vibrations that can force emergency landings and the potential for Foreign Object Damage (FOD). Most important, the shape of ice on rotor blades affects aerodynamics and increases drag, which reduces aircraft lift and controllability. Ground icing increases the time required to prepare aircraft for flight, with negative consequences for readiness and OPTEMPO. In addition, forecast of icing conditions in a planned flight profile cancels missions, or at best causes delays due to rerouting.

Despite obvious icing-related problems, there is debate as to the severity of icing's impact on Army aviation. One reason is that it is possible for career Army aviators to never be in the right place at the right time to experience in-flight or ground icing. The occurrence of low-altitude icing is restricted by season and geographic location. A second reason is that Army aircraft are restricted as to the severity of icing conditions in which they can be flown. An aircraft will not be scheduled for a mission if actual or forecast icing conditions exceed its rating (no, trace, or light icing), which leads Army aviators to state that icing does not negatively affect their mission. That reasoning sidesteps the basic point—that not being able to conduct aviation operations under all or most icing conditions significantly alters the Army commander's options for mission accomplishment. If icing deprives a commander of even part of his aviation assets for any of the roles listed above, from attack to evacuation, then his mission has been affected.

As a basis for assessing the impact of icing on Army aviation, the U.S. Army Engineer Research and Development Center's Cold Regions Research and Engineering Laboratory (CRREL) has queried Army aviators in the fields of general aviation, special operations, and medical evacuation. The CRREL aviation icing team has also investigated current and planned capabilities of Army's unmanned aerial vehicles (UAVs) under icing conditions. This report presents an analysis and synthesis of the information obtained. It also documents the nature and severity of icing-related problems experienced by aviation commanders and their flight operations and maintenance personnel, as well as the challenges weather support personnel face in forecasting icing conditions.

2 ARMY AVIATION OPERATIONS

Current and future operations

The following excerpts are from FM 1-100, *Army Aviation Operations* (U.S. Army 1997a). Aviation missions are summarized in Table 1. A brief description of the Army's rotary wing and fixed-wing aircraft is given in Appendix A.

Table 1. Aviation missions (FM 1-100, Figure 2-1).

Combat	Combat support	Combat service support
Reconnaissance	Command and control	Aerial sustainment
Security	Air movement	Casualty evacuation
Attack	Electronic warfare	
Air assault	Combat search and rescue	
Theater missile defense	Air traffic services	
Special operations	Aerial mine warfare	
Support by fire		

> Aviation, as a maneuver force, is the third-dimension centerpiece of the land force. Reconnaissance, attack, utility, and cargo helicopters complemented by special operations forces (SOF), fixed-wing and medical evacuation (MEDEVAC) aircraft, and air traffic service (ATS) units, comprise [aviation's] contribution to the fight for a global Army. [1-3.b]
>
> Army aviation greatly enhances the commander's ability to apply four fundamental principles of war—maneuver, mass, surprise, and economy of force. [1-5.a.(3)]
>
> Aviation's greatest contribution to battlefield success is the ability to apply decisive combat power at critical times, virtually anywhere on the battlefield. This may be direct fire from aviation maneuver units or the insertion of overwhelming infantry forces or artillery fires, delivered into combat via air assault. This versatility is the very essence of Army aviation. [1-5.c.(1)]
>
> Army aviation contributes to the following battlefield operating systems functions: maneuver; intelligence; fire support; air defense; mobility, countermobility, and survivability; logistics; and battle command. [1–6] Within the intelligence function, Army aviation

provides the commander with near-real-time intelligence throughout his battle space with its attack and cavalry aircraft and special electronic mission aircraft (SEMA). With the OH-58D Kiowa Warrior and AH-64 Apache, a single combat system can find, fix, and observe or destroy enemy assets across the depth of the battlefield. [1–6.b.(6)]

By placing combat aviation forces in the early entry phase of force projection, the ground commander has a force that can provide reconnaissance, security, and command and control over great ranges, in depth, at night; and increases his security capability during the critical phase of force buildup. [1–8.c.]

Aviation combat service support is the assistance provided by aviation forces to sustain combat forces. One aviation brigade can restore a mechanized battalion task force worth of combat power to a division each day through the expeditious movement of critical repair parts. Army aviation provides air movement of personnel, equipment, and supplies; and performs aeromedical evacuation and aviation maintenance. [2–5] Casualty evacuation (CASEVAC) can be performed by any Army aviation utility aircraft. MEDEVAC is the process of moving patients while providing them enroute care; most aviation units are not equipped or staffed to perform MEDEVAC. [2–5.b.]

In the future battle space, the Longbow Apache and Comanche helicopters will provide commanders with real-time intelligence and situational awareness. Their range and coverage will be extended by the use of UAVs that are digitally cued by Army airborne command and control system (A2C2S) UH-60 Black Hawks. The Comanche and Longbow Apache, the UAVs and the A2C2S UH-60 jointly become the command, control, communications, and intelligence (C3I) key facilitator for the future battlefield, helping to establish information dominance. [Future Doctrine]

Army aviation will rapidly project the force and build combat power in an immature theater. It then becomes the principal means to protect the forces on the ground as they become established. [Future Doctrine]

Army aviation will conduct armed reconnaissance and security missions to confirm the enemy's intentions, disrupt his tempo, deny his freedom of action, and get into his decision cycle. The Comanche and Longbow Apache will maneuver throughout the depth of the battle space to deliver precision fires with devastating lethality. [Future Doctrine]

> Army aviation will sustain the force and transition to future operations with combat support and combat service support provided by UH-60 Black Hawk and CH-47 Chinook aircraft, and by air assaulting forward-operating bases from which follow-on combat operations can be conducted. In the preparation for follow-up operations, Army aviation will continue to provide the reconnaissance, security, and attack helicopter support to sustain the fight and protect the force. [Future Doctrine]

Flight into icing conditions

By regulation, aircraft will not be flown into known or forecast severe icing conditions (Aviation Flight Regulations, AR 95-1 [U.S. Army 1997b]). The regulation also states that, if a flight is to be made into known or forecast moderate icing conditions, the aircraft must be equipped with adequate deicing or anti-icing equipment. The restrictions are stated in the operator's manual (the "dash 10" technical manual) for each aircraft.

Local commanders establish policies specifying when a Flight Weather Briefing, form DD 175-1, is required to be filed with form DD 175, Military Flight Plan (Reg 95-1). Weather information for DD 175-1 will be obtained from a military weather facility or, if a military forecaster is not available, the pilot in command will obtain a weather forecast per "DoD Flight Information Publication." Automated or computer-based systems may be used to obtain weather information if the system is approved by the U.S. Army Aeronautical Services Agency and the commander establishes a program to ensure aviators are thoroughly familiar with the system in use.

3 SOURCES OF PRIMARY INFORMATION

The information-gathering portion of this project was conducted in several ways.

Soldiers and Army civilians were contacted directly at three conferences, Quad A (Army Aviation Association of America, 29 March–1 April 2000), the TRADOC System Manager Unmanned Aerial Vehicles Conference 2000 (6–8 June 2000, Fort Huachuca), and the Aviation Ground Support Equipment User's Conference (5–6 December 2000, Fort Rucker).

Fact-finding discussions by telephone were held with the following: Directorate of MEDEVAC Proponency (Fort Rucker); PEO Robotics (Redstone Arsenal); the UAV training base (Fort Huachuca); the 160th Special Operations Aviation Combat Development—Systems Integration and Maintenance Office (Fort Campbell); and the 160th Special Operations Aviation Equipment Acquisition Office (Fort Bragg).

In association with the Directorate of Combat Developments (Army Aviation Center, Fort Rucker [DCD-Aviation]), four questionnaires (Appendix B) were developed to elicit information on icing's impact on aviation operations as experienced by commanders, flight operations officers, maintenance personnel, and weather support personnel. These questionnaires were mailed to 59 aviation units (Appendix C) selected by DCD-Aviation in August 2000; a second set of questionnaires was mailed to non-responding units in March 2001.

With the assistance of the Army Safety Office (Fort Rucker), its database of incidents and accidents was queried for icing-related entries.

Army Aviation Association of America (Quad A) Convention

A CRREL exhibit booth at the Quad A convention presented ongoing activity in preflight and in-flight deicing research and served as a focal point for obtaining information on icing problems from the Army aviation community. Among the information gained at the Quad A meeting is that aircraft flying near the ground by visual flight rules (VFR) must land, turn back, or follow instrument flight rules (IFR) upon encountering fog. In addition, in IFR flight the aircraft must climb in order to clear terrain by 1000–2000 ft, and so could encounter icing at altitude. Units such as the 160th Special Operations Aviation have radar to follow terrain in fog and so could encounter icing near the ground.

TRADOC System Manager Unmanned Aerial Vehicles (UAV) Conference

Ongoing work at CRREL on icing remote sensing was presented at the 2000 Unmanned Aerial Vehicles (UAV) Conference at Fort Huachuca, Arizona. The UAV Conference provided the opportunity to learn how icing affects UAV operations. This is particularly relevant because Army aviation's future doctrine, as cited above, incorporates reliance on the use of UAVs to extend the range and coverage of the Longbow Apache and Comanche helicopters that will be providing commanders with real-time intelligence and situational awareness in the future battle space.

Army planning involves UAVs as the primary means of obtaining intelligence to a radius of 50–100 km (scouts conduct reconnaissance out to 50 km; beyond 100 km it is covered by other assets). The number-one priority is the development of the brigade commander's tactical UAV (TUAV), which will operate line-of-sight with an electro-optical/infrared sensor payload, although adverse-weather payloads are being developed. Other possibilities include a micro-UAV for operation in urban environments, including building interiors; a small unit UAV that would be organic to reconnaissance elements and operated by a scout team; and an extended range/multipurpose UAV operated at division or corps level to obtain dedicated, non-line-of-sight reconnaissance out to 200–300 km, and conduct communications and nuclear, biological, and chemical (NBC) monitoring. Another priority is to establish manned/unmanned teaming between Longbow Apache helicopters and UAVs for target development. The 12- to 27-km increase in standoff identification distance over using just the helicopter would result in a significant increase in lethality and survivability. The Hunter (8.8-m wingspan) is the Army's interim TUAV for the brigade commander until the Shadow 200 (4-m wingspan) UAV is available. The Hunter's primary payload is a TV camera and forward-looking infrared sensor (FLIR). TUAV missions include reconnaissance, surveillance, and target acquisition (RSTA); target designation; battle damage assessment; communications relay; jamming; and NBC detection. These missions serve to keep soldiers out of harm's way, and to provide early warning, reaction time, and maneuver space. UAVs also have the advantages of being faster than helicopters and being able to spend more time on station. The main restrictions on UAVs are payload dimensions and weight.

Eight Hunter UAVs were deployed to Macedonia in 1999/2000 in support of NATO operations in Kosovo. They were operated in relay mode in order to have line-of-sight communications out of Macedonia, i.e., a Hunter flying inside Kosovo received/transmitted its communications with ground control via a second Hunter flying in Macedonia. Hunters in Kosovo flew at 10,000- to12,000-

ft altitude to collect video imagery; that altitude put the Hunter above most anti-aircraft artillery during Kosovo operations. Hunter operators learned to recognize the occurrence of icing on the aircraft by these events: the camera freezes over; rapid altitude loss; air speed loss; and/or porpoising (fluctuations in altitude). (Freezing [partial or complete] of the pitot tube results in erroneous airspeed feedback to the on-board computer. As the UAV tries to maintain airspeed, it porpoises up and down, and may even go into an intentional dive to regain airspeed. A Hunter UAV suffered extensive structural damage as a result of altitude fluctuations [Nascimento 2000].) Conference participants noted that even if the aircraft could fly in icing conditions, the camera could not obtain useful imagery because the camera faceplate would ice over.

Ironically, icing-related limitations on UAV operations are not known to the Army's general aviation community. Apache instructor pilots visiting CRREL advised that the enemy knows by the weather conditions when Apaches will and will not be flying. The pilots stressed that UAVs need to be flying in conditions that ground Apaches in order to provide intelligence and to suppress the enemy.

The CRREL presentation included results of a DARPA-funded study indicating that 58% of wintertime UAV flights in Kosovo would be affected by icing. The audience response was that 58% is too small a number given the actual experience of Hunters in Kosovo; one remark was that the icing problem was so severe that it is questionable whether Hunters should have been used. Even during the warmer months of April through October when the Hunters were flown in Kosovo, 25% of flights were adversely affected by icing or rainfall.

The United Kingdom UAV program's planned enhancements for its Phoenix UAV include an ice warning capability and protection of vital systems (carburetor, pitot tube) by heating them. The objective is to enable the Phoenix to escape icing, with the anti-icing system expected to "buy enough time" for Phoenix to fly elsewhere without first being overcome by the effects of ice forming on the aircraft.

The Air Force Predator, a medium-altitude (maximum 25,000 feet), 48-foot (14.65-m) wingspan, medium-endurance UAV, has a fielded deicing system consisting of a "weeping wing" system that continuously pumps a film of deicing fluid onto the wing. The Air Force's high-altitude, high-endurance UAV is the Global Hawk, which has a wingspan of 146 feet and flies as high as 65,000 feet. This aircraft has no airfoil ice protection system.

Although UAVs may be operated above icing conditions, they may have to ascend and descend through icing conditions. Since UAVs have a lower climb rate (about 150 feet per minute) than Army rotary- and fixed-wing aircraft, they are more susceptible to the formation of an ice layer sufficiently thick to destabilize the UAV's flight (Nascimento 2000). In addition, UAVs, as do all fixed-wing aircraft, generally descend more slowly than they climb out, thus exposing them to extended periods of icing during an aerodynamically critical phase of flight.

Aviation Ground Support Equipment User's Conference (AGSEUC)

The AGSEUC provided little new information about how Army aviation combats icing. A CRREL presentation brought little comment except that icing was a problem and work was encouraged in that area. Two types of deicing hardware were on display at the conference: the Buddy Start deicing nozzle and the Aircraft Cleaning and Deicing System (ACDS). The ACDS, which washes and deices aircraft, consists of a heated spray and recovery system, and a containment mat.

Directorate of MEDEVAC Proponency, Fort Rucker

The MEDEVAC component of a search-and-rescue task force has a unique on-board medical capability. MEDEVAC aircraft do not conduct combat search and rescue. Whether there are MEDEVAC flights in icing conditions depends on the restrictions placed on the airframe by the aircraft's operator's manual (referred to as the "dash 10" technical manual). In accordance with Technical Manual 1-1520-237-10 (U.S. Army 2001) for UH-60A, UL-60L, and EH-60A helicopters, these aircraft are permitted to fly into trace or light icing conditions if the following equipment is installed and operational: windshield anti-ice, pitot heat, engine anti-ice, engine inlet anti-ice modulating valve, and insulated ambient air sensing tube. Flight into light icing conditions, however, is not recommended without the blade deice kit. Flight into moderate icing requires that all the above cited equipment be installed and operational. Flight into heavy or severe icing is prohibited. Helicopters equipped with a blade erosion kit are prohibited from flight into icing conditions.

PEO Robotics, Redstone Arsenal

An electroexpulsive deicing system for the wings and tail of the Hunter UAV is being developed. Numerical modeling of ice accretion on the Hunter leading edge was conducted by CRREL, and a wing section with deicing system installed has been tested in an icing wind tunnel.

TRADOC System Manager for Unmanned Aerial Vehicles, Fort Huachuca

Army UAVs are not launched into known icing conditions, nor if icing is forecast in their flight plan. In Kosovo, prior to summer 2000, Hunters were flown only from April to October to avoid icing conditions. If there were an in-flight system for icing avoidance, then UAVs would be launched into icing conditions. The electro-optical/infrared sensor payload carried by the Hunter has the UAV's landing gear in its field of view. Since the landing gear usually ices first, its condition is monitored and used to assess the situation, i.e., whether the UAV has encountered unexpected icing.

160th Special Operations Aviation Combat Development: Systems Integration and Maintenance Office, Fort Campbell

Special operations aviation has the same restrictions as general aviation with regard to flight in icing conditions. Their Black Hawks are flown "quite a bit" in light or moderate icing conditions. There is interest in using X-band radar to detect icing conditions. The opinion expressed was that they "would like to have deicing equipment on their Chinooks." Other concerns are proper deicing of missile tubes and guns, and icing of the radomes of the multimode radar that supports flight at 100 feet in IFR. The 160th also operates off ships where parked aircraft can become iced by frozen spray. The 160th does occasionally use chemicals to deice its aircraft, but the type of chemical is unspecified.

160th Special Operations Aviation Equipment Acquisition Office, Fort Bragg

The Special Operations Aviation Regiment has no special icing-related requirements. It flies standard helicopters with mission-specific equipment. Deicing/anti-icing equipment determinations are in accordance with general aviation requirements.

4 CRREL/DCD-AVIATION ICING SURVEY

Purpose

The survey was designed to provide answers to the following questions:

- Is icing a problem for aviation units?
- To what extent does the severity of any icing problem reported by survey respondents depend on

  1) their geographic location

  2) their facilities (amount of hangar space; deicing techniques employed).
- Are a significant number of flights cancelled as a result of either ground or in-flight icing?
- Are a significant number of flights disrupted (aborted, redirected, etc.) as a result of unexpected in-flight icing?
- Is there any indication that the accuracy of icing forecasts is limiting winter aviation operations?
- What increase in mission accomplishment might result from technology innovations that reduce the time to deice an aircraft, that improve the accuracy or resolution of icing forecasts, or that display in-flight icing hazard warnings to pilots?

Survey results

A. Severity of icing impact on reporting aviation units.

1. Commanders' questionnaire.

Part A of the commanders' questionnaire elicits information on three measures of icing impact. They are a) the time required to deice aircraft before flight, b) aircraft damage due to deicing techniques, and c) the degree to which forecasted icing conditions in the mission flight path affect mission accomplishment. The questionnaire results are summarized in Tables 2–4; a compilation of results by unit is given in Appendix D, which includes commanders' written comments. Icing is considered to be a serious problem if at least 50% of the commanders in a location cite its effect on mission accomplishment as moderate or high.

a. Deice time.

By the 50% criterion, deice time is significant in Germany and Korea, and at Fort Drum, Fort Wainwright, and Fort Belvoir (Table 2). The commander of the 4-123rd Aviation Regiment at Fort Wainwright stated that all CH-47s are left on the ramp during winter, and that aircraft preparation is two hours with no ice and much more with ice. Although the commander of the 421st MEDEVAC Battalion, V Corps in Wiesbaden, Germany, rated deice time as a moderate impact on mission accomplishment, his written comment was that "time is critical when first-up aircraft require deice." The comments of commanders who rated deice time as a low impact on mission accomplishment indicate that their aircraft are usually hangared (Belgium) or are hangared in advance of icing conditions to avoid the necessity to deice (Germany, Korea, Indiana, Fort Eustis), especially where alert aircraft are involved. Mission impact is also low where icing conditions are uncommon (Germany, Korea, Fort Campbell). The commander of the 1-160th SOAR at Fort Campbell, who rated deice time as low impact, described it as not having been a "mission stopper"; deicing is accomplished by placing aircraft in a warm hangar followed by using deice fluid.

Table 2. Commanders' ratings (by location) of mission impact due to time currently required to deice aircraft.

Location	No. of low ratings	No. of moderate ratings	No. of high ratings	% of low ratings	% of moderate ratings	% of high ratings
Belgium	1	0	0	100	0	0
Germany	7	6	1	50	43	7
Korea*	3	3	1	43	43	14
Fort Drum, NY	0	1	2	0	33	67
Fort Campbell, KY	3	0	1	75	0	25
Fort Wainwright, AK	0	0	1	0	0	100
Fort Belvoir, VA	0	0	1	0	0	100
Fort Eustis, VA	1	0	0	100	0	0
USAR						
Fort Sheridan, IL	2	0	0	100	0	0
National Guard						
Indiana	1	0	0	100	0	0
Minnesota	1	0	0	100	0	0

* Two returned questionnaires from HQ, 17th Aviation Brigade, Seoul, Korea.

Note: The total number of ratings per location corresponds to the number of commanders' questionnaires returned from each location.

The commander of the 12th AVN Battalion at Fort Belvoir rates deice time as having a high impact on mission accomplishment, while the commander of the 1-222nd Aviation Regiment at Fort Eustis rates deice time as having a low impact because his aircraft are hangared before flight. That two commanders within 154 miles of each other can regard deice time so differently points out that location (frequency of occurrence of ground icing) and facilities (availability of hangars) jointly determine whether deice time is a significant factor in aviation operations.

b. Aircraft damage during deicing.

By the 50% criterion, aircraft damage due to deicing (improper techniques or inadequate training) is significant only at Fort Drum and Fort Belvoir (Table 3). Units that hangar aircraft in advance of ground icing events have minimal deicing-related damage unless aircraft become iced in flight, and so impact on mission is low. At the other extreme, units that often contend with deicing soon master the skills and procedures required to avoid damage during deicing. As the commander of the 4-123rd Avn Regt (Fort Wainwright) noted in rating deicing damage as having a low impact on mission accomplishment, “unfortunately, we have the chance to get the experience.” Similarly, the commander of the SHAPE Flight Detachment in Belgium commented that his unit flies in icing all the time and so is very familiar with proper procedures. The SHAPE aircraft would rarely be exposed to ground icing (vs. in-flight icing) because, as reported by the commander, the aircraft are hangared nearly all of the time when on the ground, even when deployed.

Deicing damage is most likely to occur with new personnel or when units without prior experience deploy to locations where they encounter ground icing. The commander of the 1-501st (Attack) of the 1st Armored Division in Hanau, Germany, rated deicing damage as a moderate impact on mission accomplishment, and noted that soldiers were inexperienced with deicing techniques and often tried to use brooms and other inappropriate tools to scrape ice. He commented that an educational process coupled with an in-depth training program would minimize such incidents. An alternative, used for fixed-wing aircraft, is to employ contract maintenance, as the 3rd MI BN (AE) does at Camp Humphreys, Korea. The commander of the 1-6 Attack unit (Camp Eagle, Korea) of the 6th Cavalry Brigade reported the loss of some seals and elastomeric bearings in rating deicing damage as moderate impact on his mission accomplishment; this unit moves alert aircraft into hangars to avoid having to deice them.

Table 3. Commanders' ratings (by location) of mission impact due to aircraft damage during deicing.

Location	No. of low ratings	No. of moderate ratings	No. of high ratings	% of low ratings	% of moderate ratings	% of high ratings
Belgium	1	0	0	100	0	0
Germany	11	2	1	79	14	7
Korea*	5	2	1	71	29	0
Fort Drum, NY	0	2	1	0	67	33
Fort Campbell, KY	3	0	1	75	0	25
Fort Wainwright, AK	1	0	0	100	0	0
Fort Belvoir, VA	0	0	1	0	0	100
Fort Eustis, VA	1	0	0	100	0	0
USAR						
Fort Sheridan, IL	2	0	0	100	0	0
National Guard						
Indiana	1	0	0	100	0	0
Minnesota	1	0	0	100	0	0

* Two returned questionnaires from HQ, 17th Aviation Brigade, Seoul, Korea.

Note: The total number of ratings per location corresponds to the number of commanders' questionnaires returned from each location.

c. Forecasted icing conditions in the mission flight plan.

By the 50% criterion, forecasted icing conditions in the flight plan have a significant impact on mission accomplishment in Belgium, Germany, and Korea, at Forts Drum, Wainwright, Belvoir, and Eustis, and in Indiana (Table 4). The SHAPE (Belgium) aircraft fly weekly to Germany and the United Kingdom, and in winter encounter light to moderate icing on almost every mission, and occasionally high-altitude unforecasted icing. The commander of the SHAPE flight detachment rated the impact of icing conditions in the flight path as moderate, however, perhaps because his aircraft are equipped with blade deicers as well as color weather radar and storm scopes. The 421st MEDEVAC Battalion, V Corps, in Wiesbaden, Germany, flies the same aircraft (UH-60A), but its experience with the deice/anti-ice equipment on its aircraft is less satisfactory, leading the 421st commander to rate icing conditions as having a high impact on mission accomplishment. He comments that icing forecasts generally are not very accurate, and that deice or anti-ice systems on his aircraft test fine on the ground but fail in flight.

Table 4. Commanders' ratings (by location) of mission impact due to forecasted icing in the mission flight path.

Location	No. of low ratings	No. of moderate ratings	No. of high ratings	% of low ratings	% of moderate ratings	% of high ratings
Belgium	0	1	0	0	100	0
Germany	6	4	4	42	29	29
Korea*	2	3	2	29	42	29
Fort Drum, NY	0	1	2	0	33	67
Fort Campbell, KY	3	1	0	75	25	0
Fort Wainwright, AK	0	0	1	0	0	100
Fort Belvoir, VA	0	0	1	0	0	100
Fort Eustis, VA	0	1	0	0	100	0
USAR						
Fort Sheridan, IL	1	1	0	50	50	0
National Guard						
Indiana	0	0	1	0	0	100
Minnesota	1	0	0	100	0	0

* Two returned questionnaires from HQ, 17th Aviation Brigade, Seoul, Korea.

Note: The total number of ratings per location corresponds to the number of commanders' questionnaires returned from each location.

The following commanders rated forecasted icing conditions as a moderate or high impact on mission accomplishment and also provided comments to support their ratings. The commander of the 11th Aviation Regiment of the 11th Aviation Brigade at Illesheim, Germany, rated forecasted icing conditions' impact as moderate, noting that operational deployments are affected. The commander of the 1-501st Aviation Regiment (Attack) of the 1st Armored Division, stationed in Hanau, Germany, noted that accurate forecasting is essential, and that in the mountainous terrain of the Balkans (where deployed) that is "sometimes a more difficult task." He rated forecasted icing condition impact as moderate. The commander of the 2-52nd Avn Regt (Camp Humphreys, Korea) of the 17th Aviation Brigade rated forecasted icing as moderate impact, noting that icing in IFR conditions in clouds is quite common. "Altitude icing" was also cited by the commander of the 1-222nd Avn Regt at Fort Eustis, Virginia; he rated the impact of forecasted icing as moderate, noting that his pilots always fly IFR and that altitude icing can impair missions. Forecasted icing conditions affect the HQ, US EUCOM Flight Detachment, based in Stuttgart, Germany, in that C-12F models are limited to 12,500 pounds during icing conditions. The commander rated this as a high impact on mission accomplishment. The 38th ID Avn Bde, an Indiana National Guard unit, flies UH-1H/V aircraft, which are rated for flight in trace and light icing, but the commander noted that his aviators avoid all icing when possible; consequently, he rated forecasted icing conditions as having a high impact on mission. The commander of the 4-123rd Avn Regt at Fort Wainwright also regarded forecasted icing conditions as a high-impact situation; he commented that his aviators' ability to fly in instrument meteorological conditions most of the year is restricted as a result of icing and the UH-60A's poor deicing capabilities. Finally, the commander of the 1-6 Attack Squadron (6th Cavalry Brigade) at Camp Eagle, Korea, rated forecasted icing conditions as high impact, stating that if his squadron with AH-64A aircraft had to fight during winter months from a field site, forecasted icing conditions would be a problem and would limit their ability to get in the fight.

2. Flight operations questionnaire.

Parts B, C, and D of the flight operations questionnaire elicit information on three measures of icing impact. They are a) the cancellation of scheduled flights as a result of ground icing, b) the cancellation of scheduled flights as a result of actual or forecast icing, and c) the disruption of flights (aborted, redirected, etc.) as a result of unexpected in-flight icing. The questionnaire results are summarized in Tables 5–7; a compilation of results by unit is given in Appendix E. The scale for assessing icing's impact in a given month is as follows: no impact (flights never affected), moderate impact (1–10% of flights affected), and severe impact (more than 10% of flights affected).

a. Cancellation of scheduled flights due to ground icing.

By the criterion that cancellation of more than 10% of scheduled flights in a given month is a severe impact on operations, the only aviation units severely affected are in Germany, Indiana, and Virginia (Table 5). Not surprisingly, ground icing is a severe problem in December, January, and February at these locations. The severely affected units are the 2-1st Avn Regt (GSAB) in Katterback, Germany; the 1-4 Cavalry Squadron in Schweinfurt, Germany (both in the 1st Infantry Division); the National Guard's 38th ID Avn Bde in Indiana; and the 1-222nd Avn Regt at Fort Eustis, Virginia. The majority of units in Germany typically have fewer than 10% of their flights in winter cancelled as a result of ground icing. None of the responding units in Korea are severely affected by ground icing.

Table 5. Flight operations reports (by location) of scheduled flights cancelled by ground icing.

Location		Oct	Nov	Dec	Jan	Feb	Mar	Apr
Belgium	No impact	1	1	1	1	1	1	1
	Moderate	0	0	0	0	0	0	0
	Severe	0	0	0	0	0	0	0
Germany	No impact	9	6	4	4	6	9	11
	Moderate	2	5	6	5	3	2	0
	Severe	0	0	1	2	2	0	0
Korea*	No impact	6	5	2	2	3	6	6
	Moderate	0	1	4	4	3	0	0
	Severe	0	0	0	0	0	0	0
Fort Drum, NY	No impact	2	1	1	1	1	1	3
	Moderate	2	3	3	3	3	3	1
	Severe	0	0	0	0	0	0	0
Fort Campbell, KY	No impact	3	3	1	1	1	3	3
	Moderate	0	0	2	2	2	0	0
	Severe	0	0	0	0	0	0	0
Fort Wainwright, AK	No impact	1	0	0	0	0	0	1
	Moderate	0	1	1	1	1	1	0
	Severe	0	0	0	0	0	0	0
Fort Belvoir, VA	Not reported	–	—	—	—	—	—	—
Fort Eustis, VA	No impact	0	0	0	0	0	0	0
	Moderate	1	1	0	0	0	1	1
	Severe	0	0	1	1	1	0	0
USAR								
Fort Sheridan, IL	No impact	0	0	0	0	0	0	0
	Moderate	1	1	1	1	1	1	1
	Severe	0	0	0	0	0	0	0

Table 5 (cont'd). Flight operations reports (by location) of scheduled flights cancelled by ground icing.

Location		Oct	Nov	Dec	Jan	Feb	Mar	Apr
National Guard								
Indiana	No impact	1	0	0	0	0	0	1
	Moderate	0	1	0	0	0	1	0
	Severe	0	0	1	1	1	0	0
Minnesota	No impact	1	0	0	0	0	1	1
	Moderate	0	1	1	1	1	0	0
	Severe	0	0	0	0	0	0	0

*Two returned questionnaires for 3rd MI BN at Camp Humphreys, Korea.

Key: No impact: Scheduled flights never cancelled as a result of ground icing.

Moderate impact: 1–10% of scheduled flights cancelled.

Severe impact: More than 10% of scheduled flights cancelled.

Note: The number of reports per month per location corresponds to the number of flight operations questionnaires returned from each location.

A more conservative criterion for assessing the impact of cancelled flights would be to regard as few as 1–10% of scheduled flights being canceled as significantly affecting aviation operations. Under this criterion, then flight cancellations due to ground icing affect operations by a majority of the aviation units in Germany and Korea and at Forts Drum and Campbell.

In all cases, the impact of ground icing on a unit depends on whether that unit's aircraft are exposed to icing conditions. Aircraft that are customarily hangared, or that are hangared in advance of specific ground icing events, remain operational. Aircraft that must undergo deicing prior to flight are more likely to be subject to flight cancellations in the immediate aftermath of a storm.

b. Cancellation of scheduled flights due to actual or forecast icing.

More aviation units are affected by actual or forecast in-flight icing than by ground icing. This is reasonable since all scheduled flights in winter are subject to cancellation if icing conditions are expected in the flight profile, but only aircraft that are not hangared are exposed to ground icing. Cancellations caused by actual or forecast icing conditions in the flight profile typically occur from December through February, but for some units the season for cancelled flights due to icing extends from November through March (Table 6). The F-159th (MHC) (12th Avn Bde) in Giebelstadt, Germany, experiences a severe impact on operations (more than 10% of flights cancelled) from October through April.

Table 6. Flight operations reports (by location) of scheduled flights cancelled as a result of actual or forecast icing.

Location		Oct	Nov	Dec	Jan	Feb	Mar	Apr
Belgium	No impact	1	0	0	0	0	1	1
	Moderate	0	1	1	1	1	0	0
	Severe	0	0	0	0	0	0	0
Germany	No impact	6	2	1	1	3	3	6
	Moderate	4	8	7	5	3	7	4
	Severe	1	1	3	5	5	1	1
Korea*	No impact	5	5	2	1	1	5	6
	Moderate	1	1	4	5	5	1	0
	Severe	0	0	0	0	0	0	0
Fort Drum, NY	No impact	2	0	0	0	0	0	2
	Moderate	2	3	1	0	0	3	2
	Severe	0	1	3	4	4	1	0
Fort Campbell, KY	No impact	3	3	0	0	0	3	3
	Moderate	0	0	3	3	3	0	0
	Severe	0	0	0	0	0	0	0
Fort Wainwright, AK	No impact	1	0	0	0	0	0	0
	Moderate	0	1	1	1	1	1	1
	Severe	0	0	0	0	0	0	0
Fort Belvoir, VA	Not reported	—	—	—	—	—	—	—
Fort Eustis, VA	No impact	0	0	0	0	0	0	0
	Moderate	1	1	0	0	0	1	1
	Severe	0	0	1	1	1	0	0
USAR								
Fort Sheridan, IL	No impact	0	0	0	0	0	0	0
	Moderate	1	1	1	1	1	1	1
	Severe	0	0	0	0	0	0	0
National Guard								
Indiana	No impact	1	0	0	0	0	0	1
	Moderate	0	0	0	0	0	1	0
	Severe	0	1	1	1	1	0	0
Minnesota	No impact	1	0	0	0	0	0	1
	Moderate	0	1	0	1	1	0	0
	Severe	0	0	1	0	0	1	0

*Two returned questionnaires for 3rd MI BN at Camp Humphreys, Korea.

Key: No impact: Scheduled flights never cancelled as a result of actual or forecast icing.
Moderate impact: 1–10% of scheduled flights cancelled.
Severe impact: More than 10% of scheduled flights cancelled.

Note: The number of reports per month per location corresponds to the number of flight operations questionnaires returned from each location.

Applying the criterion that cancellation of more than 10% of scheduled flights in a given month is a severe impact on operations, while cancellation of 1–10% is a moderate impact, the majority of units in Korea and Germany and at Fort Campbell experience at least a moderate impact on mission as a result of actual or forecast icing. Units in Belgium and Illinois and at Fort Wainwright also experience a moderate impact on mission. Severely affected units are in Germany, Indiana, and Minnesota, and at Forts Drum and Eustis.

The flight operations respondent for the 3-17th Cavalry Squadron of the 10th Aviation Brigade at Fort Drum commented that if icing is forecast the flights are always cancelled prior to departure if icing will affect the profile to be flown; this is because their aircraft, the Kiowa, is restricted to VFR. From the 11th Aviation Regiment in Illesheim, Germany, the comment is that only a minimal number of flights are canceled; rather, missions and mission times are adjusted. This difference in the way in which units react to icing in the flight profile (cancel vs. delay) indicates that the reported number of cancelled flights due to actual or forecast in-flight icing does not fully represent the difficulty of fulfilling missions in icing conditions. The mission ultimately may be accomplished in spite of in-flight icing, but on a schedule imposed by the presence or absence of icing conditions.

c. Flights disrupted due to unexpected in-flight icing.

Flights aborted or redirected are examples of disruptions. The occurrence of flight disruptions is a severe problem (more than 10% of scheduled flights affected) only for the 2-1st Avn Regt (GSAB), whose home station is at Katterback, Germany (Table 7). In December, January, and February, 11–25% of this unit's flights are disrupted as a result of unexpected in-flight icing. Flight cancellations due to ground icing or due to actual/forecast icing in the flight profile also severely affect this unit; 26–50% of scheduled flights are cancelled because of ground icing, with the same percentage of cancellations reported as a result of actual or forecast icing conditions. The unit commander, however, indicated in his questionnaire that forecasted icing conditions in the mission flight path have a low impact on mission accomplishment.

For the majority of units (62%), more flights are cancelled in midwinter as a result of actual or forecast icing than are disrupted by in-flight icing. This may reflect effective forecasting, such that pilots do not frequently encounter unexpected in-flight icing. Or, it may reflect conservative decisions with regard to canceling flights, i.e., flights are cancelled if there is even a small likelihood that icing would be encountered.

Table 7. Flight operations reports (by location) of flights disrupted as a result of unexpected in-flight icing.

Location		Oct	Nov	Dec	Jan	Feb	Mar	Apr
Belgium	No impact	1	1	0	0	1	1	1
	Moderate	0	0	1	1	0	0	0
	Severe	0	0	0	0	0	0	0
Germany	No impact	10	4	2	2	5	8	10
	Moderate	1	7	8	8	5	3	1
	Severe	0	0	1	1	1	0	0
Korea*	No impact	6	6	3	2	2	6	6
	Moderate	0	0	3	4	4	0	0
	Severe	0	0	0	0	0	0	0
Fort Drum, NY	No impact	3	1	0	0	0	1	2
	Moderate	1	3	4	4	4	3	2
	Severe	0	0	0	0	0	0	0
Fort Campbell, KY	No impact	2	2	0	0	0	2	2
	Moderate	1	1	3	3	3	1	1
	Severe	0	0	0	0	0	0	0
Fort Wainwright, AK	No impact	1	0	0	0	0	0	1
	Moderate	0	1	1	1	1	1	0
	Severe	0	0	0	0	0	0	0
Fort Belvoir, VA	Not reported	—	—	—	—	—	—	—
Fort Eustis, VA	No impact	0	0	0	0	0	0	0
	Moderate	1	1	1	1	1	1	1
	Severe	0	0	0	0	0	0	0
USAR								
Fort Sheridan, IL	No impact	0	0	0	0	0	0	0
	Moderate	1	1	1	1	1	1	1
	Severe	0	0	0	0	0	0	0
National Guard								
Indiana	No impact	1	1	0	0	0	1	1
	Moderate	0	0	1	1	1	0	0
	Severe	0	0	0	0	0	0	0
Minnesota	No impact	1	0	0	0	0	0	1
	Moderate	0	1	1	1	1	1	0
	Severe	0	0	0	0	0	0	0

*Two returned questionnaires for 3rd MI BN at Camp Humphreys, Korea.

Key: No impact: Scheduled flights never cancelled as a result of unexpected in-flight icing.
Moderate impact: 1–10% of scheduled flights cancelled.
Severe impact: More than 10% of scheduled flights cancelled.

Note: The number of reports per month per location corresponds to the number of flight operations questionnaires returned from each location.

3. Aircraft and ground maintenance questionnaire.

Part A of the aircraft and ground maintenance questionnaire elicits information on one measure of icing impact, the frequency of aircraft being grounded as a result of icing. Both ground icing (snow or ice on the aircraft before flight) and in-flight icing (actual or forecast) are covered by the one question. The questionnaire results are summarized in Table 8; a compilation of results by unit is given in Appendix F, which includes respondents' written comments.

The majority of units report that their aircraft are never or rarely grounded because of icing (Table 8). Within Germany, only three units out of 15 experience more frequent occurrences of aircraft being grounded; the units reporting monthly or weekly groundings are ones whose aircraft are not hangared. In Korea, two out of six units experience weekly (or bi-weekly) aircraft groundings; one of those units, however, is represented by two independent questionnaire responses, one of which indicates that aircraft groundings occur rarely, the other which indicates that they occur weekly. The frequency of groundings (rarely vs. monthly or weekly) at Fort Drum and at Fort Campbell depends on the unit reporting. There are weekly groundings at Forts Sheridan and Wainwright, and at the National Guard facility in Indiana.

Whether groundings occur frequently enough to be considered a problem depends jointly on the weather and the facilities at a location. In Korea, all units contend with insufficient hangar space to shelter all their aircraft from snow and ice events (Aircraft and ground maintenance questionnaire, Part B, "how are aircraft on the ground protected from the accumulation of snow or ice?"). It varies by unit whether aircraft parked on the flight line are protected with covers (e.g., canopy, blade). Although aircraft are exposed to ground icing, the icing events are either not numerous enough or not severe enough to cause more than occasional grounding in Korea.

If hangar space is not available, the effort to keep aircraft flyable during ground icing events is significant. The 421st MEDEVAC Battalion in Wiesbaden, Germany, typically moves its aircraft into the hangar the night prior to scheduled flights. Emergency response aircraft, however, are not hangared; they are continually brushed of accumulating snow and are sprayed with anti-ice fluid, if necessary. The unit notes that using anti-ice fluid is not the preferred method of keeping its aircraft free of ice because of potential damage to electrical components and other materials.

Table 8. Aircraft and ground maintenance reports (by location) of aircraft groundings due either to snow or ice on the aircraft before flight or to actual or forecast in-flight icing.

Location	Never	Rarely	Monthly in winter	Weekly in winter
Belgium	0	1	0	0
Germany*	2	12	1	2
Korea**	0	5	0	1- weekly, 1- biweekly
Fort Drum, NY	0	1	1	1 - daily
Fort Campbell, KY	0	3	1	0
Fort Wainwright, AK	0	0	0	1
Fort Belvoir, VA	0	1	0	0
Fort Eustis, VA	0	1	0	0
USAR				
Fort Sheridan, IL	0	0	0	1
National Guard				
Indiana	0	0	0	1
Minnesota	0	1	0	0

* Three returned questionnaires from the 421st MEDEVAC Battalion in Wiesbaden, Germany.

** Two returned questionnaires from the 2-2nd Avn Regt at Camp Stanley, Korea, and two returned questionnaires from the 1-52nd Avn Regt (CAB) at K-16, Seoul AB, Korea.

Note: The number of reports per month per location corresponds to the number of maintenance questionnaires returned from each location.

The reliance on hangaring aircraft to avoid aircraft icing is expressed by the 38th ID Avn Bde in Indiana as "we try to maximize the number of flyables stored in the hangar during winter." That unit also moves aircraft into a hangar temporarily on a daily basis to "defrost" during periods of snow and ice, with the result that missions are rarely cancelled due to icing. The 2-10th Avn Regiment (Assault) at Fort Drum also makes increased use of hangar space in winter. The unit has the organic capability to hangar 18 of its 38 UH-60 aircraft on a daily basis. In winter, the unit hangars 18 airframes each night, plus hangars an additional four to six units in an AVIM maintenance company's hangar. On average, 16 of the 2-10th's aircraft are left outside overnight in winter, thereby contributing to that unit experiencing daily groundings due to icing.

Hangaring aircraft to avoid icing or to expedite deicing is time-consuming and labor-intensive. The 2-10th Avn Regiment (Assault) at Fort Drum prepositions aircraft with next-day missions in the hangar overnight to keep the aircraft clear of ice or as part of the deicing process. The unit's standing operating procedure dictates a seven-man team requirement to maneuver aircraft in and out of its extremely congested hangar to avoid damaging the aircraft. One hour per workday is dedicated to maneuvering scheduled aircraft in and out of the hangar. However, if there were hangar space (uncongested) for all the aircraft of the 2-10th, then the difficulties associated with maneuvering aircraft would be reduced or even eliminated. As noted by a respondent from the 421st MEDEVAC Battalion in Wiesbaden, Germany, "hangaring aircraft prior to flight is undoubtedly the best method [to protect aircraft from icing] and keeping emergency response aircraft hangared continuously is also preferred." His recommendation is that funding intended for deice facilities be used to build larger, more spacious hangars. Another respondent from the 421st notes, however, that on deployments problems may accrue in environments without proper facilities [hangars].

Aircraft are deiced by several methods (Aircraft and Ground Maintenance questionnaire, Part D, "How is pre-flight deicing accomplished at your facility, and roughly how much time is required to deice each aircraft?"). Manual removal of snow, perhaps in conjunction with heated air, is the approach relied upon by most units. If hangar space is available, aircraft are moved inside so that deicing is assisted by the warmer air temperature within the building. The amount of time to deice an aircraft in a hangar ranges from one to four hours, and depends on the amount of ice coating the aircraft and on whether heat from an Auxiliary Ground Power Unit (AGPU) or Herman Nelson heater is used. The 7-159th Avn Regt (AVIM) in Illesheim, Germany, reports four hours to deice aircraft even when using a Herman Nelson heater. If the aircraft is deiced outside, the estimate from the F-159th (MHC) in Giebelstadt, Germany, is three to four hours to clear the rotor blades and two to three hours to clear the airframe, or approximately six to seven hours. Six hours also was reported by the 1-501st (ATK) in Hanau, Germany, for deicing aircraft in the hangar when deicing fluid and a heater "didn't work." At some locations, deicing an aircraft outside would be impracticable. The 2-10th Avn Regiment (Assault) at Fort Drum experiences extreme cold (–30°F) and intense periods of falling snow and high winds. The unit notes that its organic deice systems (AGPU) cannot adequately manage with the extreme cold experienced at Fort Drum.

On a scale of 1 (negligible) to 5 (significant), 75% of the respondents rated the amount of damage to aircraft caused by deicing techniques as negligible or none (respondents often added their own categories to the response selection on the questionnaire, in this case adding none or no damage). Altogether 92% of the respondents rated aircraft damage as a three or lower. The only units to rate the damage higher (five in both cases) were the 1-4th Cavalry Squadron in Schweinfurt, Germany, and 2-10th Avn Reg (Assault) at Fort Drum. The comment from the Schweinfurt unit is that the damage can be "up to five if someone isn't careful with AGPU heat," which can damage the leading edge material on the blade of its Kiowa aircraft. The comments from Fort Drum do not specifically address deicing damage, but rather the problems associated with aircraft left outside in extremely cold weather: control surfaces frozen, "PCL" levers frozen, and high pressures upon engine run-up that often affect sensitive pressure switches, valves, and seals. The Fort Drum respondent notes that the extreme cold affects the unit's ability to perform maintenance, which "degrade[s] the unit's ability to support training and mission requirements."

4. Weather support questionnaire.

The weather support questionnaire elicits information on three measures of icing impact. They are a) the number of days per month when ice or snow occurs as precipitation events (part A); b) the number of days per month on which in-flight icing is forecast or reported (part B); and c) the duration of forecast in-flight icing conditions (part C). The questionnaire results are summarized in Tables 9–11. A compilation of results by unit is given in Appendix G, which includes respondents' written comments.

a. Number of days per month with ice or snow precipitation events.

As expected, December, January, and February are the months with the most snow or ice events (Table 9). Fort Drum experiences as many as 19–25 days with snow or ice events in the winter months. In contrast, the majority of units in Germany report seven or fewer days with snow/ice events; the maximum number of days is 13–18, reported by the 1-501st (Attack) [1st Armored Division] in Hanau for January. The maximum number of days with snow or ice events in Korea is 8–12, as reported by the 2-2nd Avn Regt (ASLT) at Camp Stanley and the 1-52nd Avn Regt (CAB) at Seoul Air Base. Other units reporting 8–12 days with snow or ice events are the 2-228th USAR at Fort Sheridan and the 4-123rd at Fort Wainwright, although for the latter the months of October through December are the ones with the most snow/ice events. The 38th ID Avn Bde of the Army National Guard in Indiana experiences 13–18 days of snow or ice events in December and January. CONUS units, then, have the severest winter conditions in terms of number of days with snow and/or ice events.

Table 9. Weather support reports (by location) of days per month with snow or ice as precipitation events.

Location		Oct	Nov	Dec	Jan	Feb	Mar	Apr
Belgium	Not reported	—	—	—	—	—	—	—
Germany	Never	7	1	0	0	0	0	2
	1–3 days	2	7	3	2	3	6	6
	4–7 days	0	1	5	4	3	1	1
	8–12 days	0	0	1	2	3	2	0
	13–18 days	0	0	0	1	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
Korea*	Never	5	0	0	0	0	1	4
	1–3 days	1	5	3	3	1	4	2
	4–7 days	0	1	2	0	3	1	0
	8–12 days	0	0	1	3	2	0	0
	13–18 days	0	0	0	0	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
Fort Drum, NY	Never	1	0	0	0	0	0	0
	1–3 days	2	0	0	0	0	0	0
	4–7 days	0	2	0	0	0	0	3
	8–12 days	0	0	0	0	2	2	0
	13–18 days	0	1	2	2	0	1	0
	19–25 days	0	0	1	1	1	0	0
	26–31 days	0	0	0	0	0	0	0
Fort Campbell, KY	Never	1	0	0	0	0	0	1
	1–3 days	1	2	1	1	1	2	1
	4–7 days	0	0	1	1	1	0	0
	8–12 days	0	0	0	0	0	0	0
	13–18 days	0	0	0	0	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
Fort Wainwright, AK	Never	0	0	0	0	0	0	0
	1–3 days	0	0	0	0	0	0	0
	4–7 days	0	0	0	1	1	1	1
	8–12 days	1	1	1	0	0	0	0
	13–18 days	0	0	0	0	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0

Table 9 (cont'd).								
Location		**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
Fort Belvoir, VA	Never	1	0	0	0	0	0	1
	1–3 days	0	1	1	0	0	1	0
	4–7 days	0	0	0	1	1	0	0
	8–12 days	0	0	0	0	0	0	0
	13–18 days	0	0	0	0	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
Fort Eustis, VA	Never	1	1	0	0	0	1	1
	1–3 days	0	0	1	1	1	0	0
	4–7 days	0	0	0	0	0	0	0
	8–12 days	0	0	0	0	0	0	0
	13–18 days	0	0	0	0	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
USAR								
Fort Sheridan, IL	Never	0	0	0	0	0	0	0
	1–3 days	1	0	0	0	0	0	1
	4–7 days	0	1	0	0	0	1	0
	8–12 days	0	0	1	1	1	0	0
	13–18 days	0	0	0	0	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
National Guard								
Indiana	Never	0	0	0	0	0	0	0
	1–3 days	1	0	0	0	0	0	0
	4–7 days	0	1	0	0	0	0	1
	8–12 days	0	0	0	0	1	1	0
	13–18 days	0	0	1	1	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
Minnesota	Not reported	—	—	—	—	—	—	—

* Two returned questionnaires from 2-2nd Avn Regt (ASLT) at Camp Stanley, Korea.

Note: The number of reports per month per location corresponds to the number of weather support questionnaires returned from each location.

b. Number of days per month with in-flight icing forecast or reported.

In Germany in-flight icing, forecast or reported, is more of a problem for aviation operations than ice or snow precipitation events, in that in-flight icing conditions exist or are forecast for as many as 26–31 days per month (Table 10), vs. 13–18 days maximum for snow and ice precipitation events. Similarly, weather support for aviation units at Fort Campbell, Fort Sheridan, Fort Belvoir, and Fort Eustis, and the Indiana National Guard unit all report more days (maximum) with potential in-flight icing than days with snow or ice precipitation events.

In Korea in midwinter the number of days of actual or forecast in-flight icing ranges from few (1–3) to many (13–18) depending on location. The majority of units would have at least four–seven days when in-flight icing is a consideration, whereas one–three days of snow or ice precipitation events are likely.

At Fort Wainwright, in-flight icing events and snow or ice precipitation events are equally numerous through midwinter. Only in February, March, and April are days with in-flight icing likely to be more numerous.

The reports for Fort Drum differ appreciably, but both precipitation events (snow, ice) and in-flight icing can be as numerous as 19–25 days per month in midwinter.

In comparing the impacts of in-flight and ground icing on aviation operations, it is not only a greater number of days with potential for in-flight icing that makes that condition more detrimental. Another factor is that hangaring aircraft greatly reduces the impact of snow and ice events on a unit's flight schedule by minimizing or eliminating the time-consuming need to deice aircraft. There is no comparable "facility fix" for in-flight icing. If the predicted or encountered icing conditions exceed the rating of the aircraft, then the crew has no choice but to reroute or abort the flight. Aircraft are more likely to be grounded by a forecast of icing conditions than they are by ground icing (the aftermath of snow or ice events), especially at locations where the aircraft can be hangared in advance of snow and ice events.

Table 10. Weather support reports (by location) of days per month that in-flight icing is forecast or reported.

Location		Oct	Nov	Dec	Jan	Feb	Mar	Apr
Belgium	Not reported	—	—	—	—	—	—	—
Germany	Never	2	0	0	0	0	0	2
	1–3 days	4	1	0	0	0	1	3
	4–7 days	1	5	1	0	0	2	1
	8–12 days	1	2	4	1	1	4	2
	13–18 days	0	0	3	7	7	1	0
	19–25 days	1	1	0	0	0	1	1
	26–31 days	0	0	1	1	1	0	0
Korea*	Never	2	0	0	0	0	1	1
	1–3 days	1	3	1	1	1	2	3
	4–7 days	2	1	3	2	2	1	1
	8–12 days	1	2	2	2	2	2	1
	13–18 days	0	0	0	1	1	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
Fort Drum, NY	Never	0	0	0	0	0	0	0
	1–3 days	2	0	0	0	0	0	0
	4–7 days	1	2	1	1	1	1	3
	8–12 days	0	1	0	0	1	1	0
	13–18 days	0	0	1	1	0	1	0
	19–25 days	0	0	1	1	1	0	0
	26–31 days	0	0	0	0	0	0	0
Fort Campbell, KY	Never	0	0	0	0	0	0	0
	1–3 days	2	1	0	0	0	2	2
	4–7 days	0	1	2	1	2	0	0
	8–12 days	0	0	0	1	0	0	0
	13–18 days	0	0	0	0	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
Fort Wainwright, AK	Never	0	0	0	0	0	0	0
	1–3 days	0	0	0	0	0	0	0
	4–7 days	0	0	0	1	0	0	0
	8–12 days	1	1	1	0	1	1	1
	13–18 days	0	0	0	0	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0

Table 10 (cont'd). Weather support reports (by location) of days per month that in-flight icing is forecast or reported.

Location		Oct	Nov	Dec	Jan	Feb	Mar	Apr
Fort Belvoir, VA	Never	0	0	0	0	0	0	0
	1–3 days	0	0	0	0	0	0	0
	4–7 days	0	0	0	0	0	0	1
	8–12 days	1	0	0	0	0	1	0
	13–18 days	0	1	1	1	1	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
Fort Eustis, VA	Never	1	0	0	0	0	1	1
	1–3 days	0	1	0	0	0	0	0
	4–7 days	0	0	1	0	0	0	0
	8–12 days	0	0	0	1	1	0	0
	13–18 days	0	0	0	0	0	0	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	0	0	0	0	0
USAR								
Fort Sheridan, IL	Never	0	0	0	0	0	0	0
	1–3 days	0	0	0	0	0	0	0
	4–7 days	0	0	0	0	0	0	0
	8–12 days	1	0	0	0	0	0	1
	13–18 days	0	1	0	0	0	1	0
	19–25 days	0	0	0	0	0	0	0
	26–31 days	0	0	1	1	1	0	0
National Guard								
Indiana	Never	0	0	0	0	0	0	0
	1–3 days	0	0	0	0	0	0	0
	4–7 days	0	0	0	0	0	0	0
	8–12 days	0	0	0	0	0	0	0
	13–18 days	0	0	0	0	0	0	0
	19–25 days	1	1	1	1	1	1	1
	26–31 days	0	0	0	0	0	0	0
Minnesota	Not reported	—	—	—	—	—	—	—

* Two returned questionnaires from 2-2nd Avn Regt (ASLT) at Camp Stanley, Korea.

Note: The number of reports per month per location corresponds to the number of weather support questionnaires returned from each location.

c. Typical duration for forecast in-flight icing conditions.

The impact of forecasted in-flight icing on aviation operations in a given month is dependent on the number of hours for which in-flight icing is predicted to occur. The same number of "no fly" hours per month could result from a few in-flight icing forecasts of long duration as from more numerous icing forecasts of shorter duration. A unit's flight schedule determines which occurrence (many short-duration icing forecasts vs. fewer long-duration icing forecasts) is more disruptive to its operations, and so influences the statistics of the flight operations responses. Units contend with their aircraft's icing restrictions in creative ways to minimize cancellations in response to forecast in-flight icing. For instance, as reported on the Aircraft and Ground Maintenance questionnaire, the 34th Avn Bde of the Minnesota National Guard allows UH-1 aircraft to fly in forecast light icing only within a 25-km radius of its base of operations. The respondent noted that "if this rule did not exist, we would cancel a lot of flights in December and March–April timeframe."

The majority of units in Germany receive forecasts of in-flight icing with duration of at least 24 hours in December, January, and February (Table 11). The duration of in-flight icing forecasts for most units in Korea falls in the range of seven to 24 hours, although the 1-52nd Avn Regt (CAB) receives forecasts with a typical duration of more than 1.5 days throughout the winter (October through April). At Fort Wainwright, the forecast duration of in-flight icing is 19–24 hours throughout the winter. Fort Drum, Fort Campbell, and Fort Sheridan all are subject to forecast icing durations of more than 1.5 days.

A worthwhile activity would be the comparison of icing forecast duration with actual persistence of icing conditions. Such an analysis would indicate whether Army aircraft at a location spend an inordinate amount of time grounded because of forecast (vs. actual) icing conditions.

Table 11. Weather support reports (by location) of typical duration of forecast in-flight icing conditions.

Location		Oct	Nov	Dec	Jan	Feb	Mar	Apr
Belgium	Not reported	—	—	—	—	—	—	—
Germany	≤3 hrs	2	0	0	0	0	0	2
	3–6 hrs	3	3	1	0	0	1	4
	7–12 hrs	1	2	1	2	0	5	1
	13–18 hrs	3	2	2	2	4	1	1
	19–24 hrs	0	1	0	0	0	1	1
	1–1.5 days	0	1	3	3	3	0	0
	>1.5 days	0	0	2	2	2	1	0
Korea*	≤3 hrs	2	1	0	0	0	0	2
	3–6 hrs	0	1	2	0	0	2	0
	7–12 hrs	2	1	1	3	3	2	2
	13–18 hrs	0	0	0	0	0	0	0
	19–24 hrs	0	2	2	2	2	0	0
	1–1.5 days	0	0	0	0	0	0	0
	>1.5 days	1	1	1	1	1	1	1
Fort Drum, NY	≤3 hrs	0	0	0	0	0	0	0
	3–6 hrs	0	0	0	0	0	0	0
	7–12 hrs	1	0	0	0	0	0	1
	13–18 hrs	0	1	0	0	0	0	0
	19–24 hrs	1	1	1	1	1	1	1
	1–1.5 days	1	0	1	0	0	0	1
	>1.5 days	0	1	1	2	2	2	0
Fort Campbell, KY	≤3 hrs	0	0	0	0	0	0	1
	3–6 hrs	0	0	0	0	0	1	0
	7–12 hrs	1	0	0	0	0	0	0
	13–18 hrs	0	1	1	0	0	0	0
	19–24 hrs	0	0	0	0	0	1	0
	1–1.5 days	0	0	0	1	1	0	0
	>1.5 days	0	0	1	1	1	0	0
Fort Wainwright, AK	≤3 hrs	0	0	0	0	0	0	0
	3–6 hrs	0	0	0	0	0	0	0
	7–12 hrs	0	0	0	0	0	0	0
	13–18 hrs	0	0	0	0	0	0	0
	19–24 hrs	1	1	1	1	1	1	1
	1–1.5 days	0	0	0	0	0	0	0
	>1.5 days	0	0	0	0	0	0	0

Table 11 (cont'd).

Location		Oct	Nov	Dec	Jan	Feb	Mar	Apr
Fort Belvoir, VA	≤3 hrs	0	0	0	0	0	0	0
	3–6 hrs	1	0	0	0	0	0	1
	7–12 hrs	0	1	0	0	0	1	0
	13–18 hrs	0	0	1	1	1	0	0
	19–24 hrs	0	0	0	0	0	0	0
	1–1.5 days	0	0	0	0	0	0	0
	>1.5 days	0	0	0	0	0	0	0
Fort Eustis, VA	≤3 hrs			0	0	0		
	3–6 hrs			1	0	0		
	7–12 hrs			0	1	1		
	13–18 hrs			0	0	0		
	19–24 hrs			0	0	0		
	1–1.5 days			0	0	0		
	>1.5 days	—	—	0	0	0	—	—
USAR								
Fort Sheridan, IL	≤3 hrs	0	0	0	0	0	0	0
	3–6 hrs	1	0	0	0	0	0	0
	7–12 hrs	0	0	0	0	0	0	1
	13–18 hrs	0	1	0	0	0	0	0
	19–24 hrs	0	0	0	0	0	1	0
	1–1.5 days	0	0	0	0	0	0	0
	>1.5 days	0	0	1	1	1	0	0
National Guard								
Indiana	Not reported	—	—	—	—	—	—	—
Minnesota	Not reported	—	—	—	—	—	—	—

* Two returned questionnaires from 2-2nd Avn Regt (ASLT) at Camp Stanley, Korea.

Note: The number of reports per month per location corresponds to the number of weather support questionnaires returned from each location.

B. Potential increase in mission accomplishment from technology innovations.

Part B of the commanders' questionnaire elicited information on the potential increase in mission accomplishment that might be derived from four technology advancements. They are an aircraft deicing technique that would reduce the time to flight-ready aircraft to under 30 minutes; an environmentally friendly deicing fluid that is compatible with the entire aircraft; an improved icing forecast capability that would result in a 50% reduction in flight cancellations; and the capability to provide an advance icing hazard warning in-flight on a cockpit display. The questionnaire results are summarized in Tables 12–15; a compilation of results by unit is given in Appendix D, which includes respondents' written comments.

1. Aircraft deicing technique that can have aircraft flight ready in less than 30 minutes.

As cited in the discussion of the Aircraft and Ground Maintenance questionnaire, the amount of time to deice an aircraft in a hangar ranges from one to four hours, and depends on the amount of ice coating the aircraft and on whether heat from an AGPU or Herman Nelson heater is used. If the aircraft is deiced outside, the estimate is three–four hours to clear the rotor blades and two–three hours to clear the airframe, for a total of six hours. Reducing that task to a 30-minute effort would both greatly diminish the during- and after-storm consequences of snow and ice events (in terms of how long aircraft remain unflyable as a result of being iced), and also reduces the time that personnel must commit to deicing aircraft.

Not unexpectedly, commanders who considered that the time required to deice an aircraft (Commanders questionnaire, part A) has a moderate or high adverse impact on their mission also consider that a 30-minute deice technique would moderately or highly improve mission accomplishment. Surprisingly, however, the majority (61%) of commanders who rated the current deice time as having a low impact on their mission in turn consider that a 30-minute deice technique would have a moderate or high impact on their mission. This may reflect an appreciation of the future benefit of quicker deicing under other circumstances. A relevant comment from a respondent to the aircraft and ground maintenance questionnaire is that deicing is not necessarily a problem at a unit's home station, especially if aircraft are hangared, but that at a field site without hangars, it can be a "show stopper."

Of the units in Germany, 50% of the commanders rate a 30-minute deice technique as potentially having a high impact on their mission; 79% rate the potential impact as moderate or greater (Table 12). In Korea, 71% of the commanders consider that rapid deicing will significantly affect (high impact) their mission. All the responding commanders at Fort Drum rate a 30-minute deice technique highly; that is consistent with their situation of severe winter conditions with frequent snow and ice events and insufficient hangar space for their aircraft. Overall, 74% of the commanders responded that a 30-minute deice technique would have a moderate or high impact on their mission.

Table 12. Commanders' ratings (by location) of potential impact on mission of an aircraft deicing technique that allows aircraft to be flight-ready in less than 30 minutes.

Location	No. of low ratings	No. of moderate ratings	No. of high ratings	% of low ratings	% of moderate ratings	% of high ratings
Belgium	1	0	0	100	0	0
Germany	3	4	7	21	29	50
Korea*	2	0	5	29	0	71
Fort Drum, NY	0	0	3	0	0	100
Fort Campbell, KY	1	0	3	25	0	75
Fort Wainwright, AK	—	—	—	—	—	—
Fort Belvoir, VA	0	0	1	0	0	100
Fort Eustis, VA	1	0	0	100	0	0
USAR						
Fort Sheridan, IL	1	1	0	50	50	0
National Guard						
Indiana	0	0	1	0	0	100
Minnesota	0	1	0	0	100	0

* Two returned questionnaires from HQ, 17th Aviation Brigade, Seoul, Korea.

Note: The number of reports per month per location corresponds to the number of commanders' questionnaires returned from each location.

2. Environment-friendly deicing fluid that is compatible with the entire aircraft.

The primary method of deicing civil and military fixed-wing aircraft before flight is to spray them with heated ethylene or propylene glycol. Though helicopters are occasionally deiced with glycol, the practice is not recommended because glycol emulsifies greases, and thus washes lubricant from rotorhead bearings, causing corrosion and failure. In addition, glycol may damage some materials, and the odor has been reported to make soldiers sick. Ethylene glycol is toxic and must be recovered before entering the environment. Propylene glycol is not toxic, but does harm surface waters because it has a high biological oxygen demand that causes eutrophication of surface waters. Glycol recovery systems are economically viable only at airfields that use thousands of gallons per day. Military airfields do not consume large quantities of glycol because there are typically few flights. Since recovery systems are not economically viable, environmentally acceptable deicing fluids are needed for military applications. Army helicopter applications require deicing fluids that are environmentally acceptable and not damaging to aircraft bearings or materials.

Overall, 80% of the commanders responded that an environmentally friendly deice fluid would have either a moderate or high impact on their mission (Table 13). Most commanders (28 of 35) rate a 30-minute deice technique and an environmentally friendly deice fluid the same in terms of their potential impact on mission. Five commanders, however, rate the fluid higher than the technique: three are in Germany, one in Korea, and one at Fort Sheridan. Two commanders (one in Germany and one at Fort Campbell) rate a faster deicing technique higher.

Table 13. Commanders' ratings (by location) of potential impact on mission of an environmentally friendly deicing fluid that is compatible with the entire aircraft.

Location	No. of low ratings	No. of moderate ratings	No. of high ratings	% of low ratings	% of moderate ratings	% of high ratings
Belgium	1	0	0	100	0	0
Germany	3	3	8	21	21	58
Korea*	1	1	5	14	14	72
Fort Drum, NY	0	0	3	0	0	100
Fort Campbell, KY	1	1	2	25	25	50
Fort Wainwright, AK	—	—	—	—	—	—
Fort Belvoir, VA	0	0	1	0	0	100
Fort Eustis, VA	1	0	0	100	0	0
USAR						
Fort Sheridan, IL	0	2	0	0	100	0
National Guard						
Indiana	0	0	1	0	0	100
Minnesota	0	1	0	0	100	0

* Two returned questionnaires from HQ, 17th Aviation Brigade, Seoul, Korea.

Note: The number of reports per month per location corresponds to the number of commanders' questionnaires returned from each location.

3. Improved icing forecast resulting in a 50% reduction in flight cancellations.

In part A of the commander's questionnaire, 64% of the commanders responded that forecasted icing conditions in the mission flight path had either a moderate or a high impact on mission accomplishment. When asked in part B to rate how a 50% reduction in flight cancellations due to improved forecast icing would affect their mission, 80% of the commanders indicated it would have either a moderate or high impact on their mission. One commander with flight experience in the United States, Germany, and Korea stated that the forecast level of icing is rarely accurate for rotary wing aircraft. The support for an improved icing forecast is strong (rated moderate or high impact) everywhere except with the SHAPE flight detachment in Belgium and with a minority of commanders in Germany and Korea (Table 14).

Table 14. Commanders' ratings (by location) of potential impact on mission of an improved icing forecast resulting in a 50% reduction in flight cancellations.

Location	No. of low ratings	No. of moderate ratings	No. of high ratings	% of low ratings	% of moderate ratings	% of high ratings
Belgium	1	0	0	100	0	0
Germany	4	2	8	29	14	57
Korea*	2	0	5	29	0	71
Fort Drum, NY	0	1	2	0	33	67
Fort Campbell, KY	0	2	2	0	50	50
Fort Wainwright, AK	—	—	—	—	—	—
Fort Belvoir, VA	0	0	1	0	0	100
Fort Eustis, VA	0	1	0	0	100	0
USAR						
Fort Sheridan, IL	0	2	0	0	100	0
National Guard						
Indiana	0	0	1	0	0	100
Minnesota	0	0	1	0	0	100

* Two returned questionnaires from HQ, 17th Aviation Brigade, Seoul, Korea.

Note: The number of reports per month per location corresponds to the number of commanders' questionnaires returned from each location.

4. Capability to provide advance (km or greater) icing hazard warning in-flight on a cockpit display.

The support for an in-flight icing hazard warning system is strong (rated moderate or high impact) everywhere except at the SHAPE flight detachment in Belgium and with a minority of commanders in Germany and Korea (Table 15). Lack of experience with flying in icing conditions intensifies any problems; one commander refers to "apprehension of the unknown." As noted by one respondent who has flown Chinook helicopters in Italy, Korea, Alaska, and throughout CONUS, moderate icing builds very quickly and can be very disconcerting without deicing capability. Another points out that because there is no working deice system on AH64 helicopters, he has little actual flight experience in icing.

With four exceptions, commanders rated the icing hazard warning on a par with improved icing forecast. Two exceptions are commanders with the 11th Aviation Brigade in Illesheim, Germany; the commander of the 11th Aviation regiment considered that an icing hazard warning would more significantly affect his mission (moderate vs. low impact), while the commander of the 2-6 Cavalry Squadron (Attack) regarded an improved icing forecast as being more significant (high vs. moderate impact). The other two exceptions are the HQ, 17th Aviation Brigade in Seoul, Korea, which returned the commanders' questionnaire twice, completed by different individuals. One commander at the 17th Aviation Brigade rated an improved icing forecast as having high impact on his mission, while rating an in-flight icing hazard warning as low impact; the second commander rated the two technology advances exactly the reverse, i.e., the icing forecast as low impact and the in-flight icing hazard warning as high impact.

Table 15. Commanders' ratings (by location) of potential impact on mission of an icing hazard warning system in-flight with cockpit display.

Location	No. of low ratings	No. of moderate ratings	No. of high ratings	% of low ratings	% of moderate ratings	% of high ratings
Belgium	1	0	0	100	0	0
Germany	3	5	6	21	36	43
Korea*	2	0	5	29	0	71
Fort Drum, NY	0	1	2	0	33	67
Fort Campbell, KY	0	2	2	0	50	50
Fort Wainwright, AK	—	—	—	—	—	—
Fort Belvoir, VA	0	0	1	0	0	100
Fort Eustis, VA	0	1	0	0	100	0
USAR						
Fort Sheridan, IL	0	2	0	0	100	0
National Guard						
Indiana	0	0	1	0	0	100
Minnesota	0	0	1	0	0	100

* Two returned questionnaires from HQ, 17th Aviation Brigade, Seoul, Korea.

Note: The number of reports per month per location corresponds to the number of commanders' questionnaires returned from each location.

5 ARMY SAFETY CENTER DATA ANALYSIS

Introduction

The Army operates one of the largest, most comprehensive safety programs in the world. The program is designed to create safe air and ground operations and to promote safe practices by military and civilian personnel both on and off duty. The mission of the Army Safety Center, which is located at Fort Rucker, Alabama, is to enhance combat readiness through proactive risk management to prevent accidents. The Safety Center has staff responsibility for administering the Army Safety Program and helping commanders integrate risk management into all that the Army does. The Safety Center supports the Army commanders by providing them with timely, accurate information on hazards and risks that they can use to make informed decisions.

The Army Safety Office maintains a database of all Army aircraft accidents and incidents from FY1985 to the present. Information contained in this database was obtained from DA Form 2397-11-R, Technical Report of U.S. Army Aircraft Accident Part XII—Weather/Environmental Data, and DA Form 2397-AB-R, the Abbreviated Aviation Accident Report (AAAR). These forms must be filled out after each aircraft accident.

A search of this database turned up 255 icing-related accidents in the FY85–FY99 time period. The search was conducted by querying on Aircraft Icing (DA Form 2397-11-R, Block 10 and DA Form 2397-AB-R, Block 17c), or Significant Weather such as sleet and freezing rain (DA Form 2397-11-R, Block 8 and DA Form 2397-AB-R, Block 17b[1]). A review of this 255-icing-related-incident-and-accident dataset indicated that only 172 accidents were confirmed as genuine icing-related accidents by the narrative summary. However, icing could not be ruled out as a factor in the remaining accidents, so they were not eliminated from the icing related dataset.

The objective of this investigation was to analyze this dataset to see what it reveals about the nature and frequency of the Army aviation icing problem. A hindrance to quantifying the impact of icing on Army aviation is that the Aviation Safety Office's risk management information system does not contain information on missions cancelled because of icing (aborted missions are included in the database).

Results

The database was analyzed for several aspects of the icing problem, including in-flight vs. ground icing, aircraft type (Table 16), accident location (Table 17), and accident class (Table 18). Finally the icing accident data was compared to the total Army aviation accident data during the same time period.

A. In-flight vs. ground.

Out of the 255 icing-related accidents and incidents, 160 occurred in flight and the remaining 95 occurred on the ground. A common in-flight icing accident in helicopters was damage to a whip antenna. For example, an AH60A flying out of Grafenwohr AAF (Case No. 19981124009) reported the following:

"During instrument approach into Grafenwohr AAF, aircraft entered moderate icing condition. Ice accumulated on no heated surfaces. Suspected that ice accumulated on #1 whip antenna causing antenna to flex and eventually fracturing and fraying the antenna. Maintenance replaced antenna and released aircraft to flight."

A typical ground icing accident was inadequate deicing before takeoff. For example, this UH1 out of Fort Lewis WA (Case No. 19841212011) noted that

"Aircraft start, run up with no deficiencies noted. Aircraft lifted to hover for taxi to take off. Pilot noted severe 1:1 lateral vibration and returned a/c to parking and performed emergency shutdown procedures. Crew did not notice buildup of clear ice on main rotor blade during preflight inspection."

In several other cases, snow and ice that collected on the aircraft while on the ground later melted and refroze on control surfaces and other equipment.

B. Icing by aircraft type.

As shown in Table 16, helicopters account for two-thirds of the icing accidents and incidents. Of these, three-quarters were attributed to the UH-1 Huey and the UH-60 Black Hawk, which were the two largest fleets in the Army during the period of the study, and have many more flight hours. The Black Hawk fleet flies over 40% of the rotary wing flight hours annually. However, the most serious accident was the crash of an MH47E Chinook at Fort Campbell, Kentucky, on 7 March 1997. It resulted in five fatalities and loss of the aircraft, valued at $26,478,835. This cost represents 92% of the total damage cost due to icing over the FY85–FY99 time period. According to the accident report, the helicopter was flying through fog, gusty winds, snow, and moderate icing when it crashed. These weather conditions are suspected to be a cause of the crash.

Table 16. Icing accidents/incidents in FY85–FY 99 by aircraft type.	
Aircraft type	**Accidents/incidents**
OH-58 Kiowa	22
UH-1 Huey	64
UH-60 Black Hawk	64
AH-64 Apache	8
TH-67 Creek	2
CH-47 Chinook	10
Fixed wing	85
Total	255

C. Icing by location.

As expected, most of the icing accidents and incidents occurred in the United States (Table 17), and 24 of those occurred in Alaska. Although the frequency of occurrence was higher in northern tier states, e.g., Kansas, Washington, and Alaska, several icing accidents and incidents were reported in southern tier states, e.g., Louisiana, Alabama, and Texas. The Federal Republic of Germany (FRG) and Korea were second and third, respectively, in the number of accidents and incidents. This is not surprising considering the large presence of U.S. Forces in these areas.

Table 17. Location of icing accidents and incidents (FY85–FY99).	
Country	**Accidents/incidents**
U.S.	148
FRG	51
Korea	25
Panama	4
Belgium	1
Greenland	1
Japan	1
Italy	1
Yugoslavia	1
Hungary	1
Not recorded	21

D. Classification of icing accidents/incidents.

According to AR 385-40, Accident Reporting and Records, aircraft accidents and/or incidents are classified according to injury, and amount of damage (see Table 18).

Table 18. Aircraft accident classifications.

Accident classification	Extent of injuries	Amount of damage
Class A accident	Fatality or total disability	$1,000,000 or more
Class B accident	Permanent partial disability, or five or more personnel are hospitalized in single occurrence.	$200,000 to $1,000,000
Class C accident	Injury or illness that causes loss of time from work, or later disability.	$10,000 to $200,000
Class D accident	Nonfatal injuries/illnesses in conjunction with property damage.	$2,000 to $10,000
Class E incident	No injuries or fatalities. Mission (either operational or maintenance) is interrupted or not completed.	Less than $2,000
Class F incident	No injuries or fatalities.	Any amount due to foreign objects

During the FY85–FY99 time period, there was a total of 54,081 aircraft accidents/incidents according to Army Safety Office data. The vast majority (90%) of these accidents/incidents were in the Class E category. During the same period there were 255 recorded icing accidents/incidents, which represent only 0.5% of the total. Similarly, most of the icing accidents/incidents were in the Class E category. A breakdown of the total and icing-related accidents/incidents according to class is shown in Table 19.

Table 19. Comparison of icing accidents/incidents to total aircraft accidents/incidents according to classification.

Accident classification	Total in class	Total in class due to icing	Percent due to icing
A	399	1	0.3
B	188	1	0.5
C	1294	27	2.1
D	3047	25	0.8
E	48956	184	0.4
F	197	17	8.6
Total	54081	255	0.5

E. Icing accident/incident rate.

Table 20 shows the number of aircraft accidents/incidents and the accident/incident rate from FY85 to FY99. The total accident/incident rate ranged from 2.35 to 3.13 accidents/incidents per 1000 hrs, with the average being 2.66 accidents/incidents per 1000 hrs. The icing accident/incident rate was significantly lower, ranging from 0.00 to 0.03 accidents/incidents per 1000 hrs. The average was only 0.01 accident/incident per 1000 hrs, or one accident/incident every 100,000 flying hours.

Table 20. Aircraft accident/incident rates (FY85–FY99).

Fiscal year	Total accidents/ incidents	Icing accidents/ incidents	Total flying hours 000	Total accident/incident rate #/1000 hours	Icing accident/incident rate #/1000 hours
FY85	4636	24	1532	3.03	0.02
FY86	5091	27	1628	3.13	0.02
FY87	4931	32	1705	2.89	0.02
FY88	4783	20	1742	2.75	0.01
FY89	4494	8	1685	2.67	0.00
FY90	4355	17	1697	2.57	0.01
FY91	3272	13	1300	2.52	0.01
FY92	3502	9	1400	2.50	0.01
FY93	3327	7	1299	2.56	0.01
FY94	3244	8	1278	2.54	0.01
FY95	3219	24	1204	2.67	0.02
FY96	2672	28	1082	2.47	0.03
FY97	2320	17	953	2.43	0.02
FY98	2092	6	891	2.35	0.01
FY99	2143	15	913	2.35	0.02
Total	54,081	255	20,309	2.66	0.01

Army Safety Center data discussion and conclusions

The Army Safety Office data indicate that icing is not a high-frequency safety problem. However, it occurs remarkably often considering the strict regulations against taking off with ice on the aircraft or flying into icing conditions. It was the likely cause of over $28,000,000 in damage and the loss of five lives. Better in-flight icing detection and pre-flight deicing capabilities would help to mitigate the risks of icing-related incidents and accidents.

6 OVERCOMING ICING'S IMPACT ON ARMY AVIATION OPERATIONS

As indicated, one reason for the very low accident rate of Army aircraft in icing conditions is that strict regulations require that aircraft not fly in icing conditions beyond the rating of the aircraft. However, the accident rate may be potentially lowered, and Army's ability to fly more frequently in icing-prone weather could be improved by a variety of technological improvements.

In-flight icing

Only two Army helicopters, the Black Hawk and the Apache AH-64A, have blade deicing systems that allow them to fly in icing at the moderate severity level and below. The newer Apache Longbow AH-64D does not have blade deicing. The AH-64A deicing system was considered a maintenance headache, was costly to repair, and was not considered very effective in icing conditions according to interviews with pilots and aircrew. The Black Hawk deice system has been included on all models of the helicopter, and will likely be maintained on the upgraded UH-60M Black Hawk. It has been considered an effective system according to most pilots and aircrews participating in this study.

Despite the success of the Black Hawk deicing system, there is a need for improved blade deicing/anti-icing systems. The Black Hawk and Apache AH-64A blade deicing systems are electrothermal. Blade leading edges are heated by wires imbedded in the leading edge composite under the titanium wear strip. Wires burn out, and if controllers fail, leading edges can overheat, causing damage to composites and blade delamination. Leading edge damage from excessive heat has been a problem for the Apache AH-64A. Major airframe manufacturers, small businesses, and the National Rotorcraft Technology Center and Rotorcraft Industry Technology Association (NRTC/RITA) are actively seeking nonthermal solutions to helicopter blade deicing. However, it is unlikely that blade deicing systems will be developed that will allow helicopters to fly into any icing conditions with impunity. This is because other portions of the aircraft that cannot be easily anti-iced or deiced, such as antennas and weapons systems, will also ice. A helicopter that can fly in icing, but cannot prevent icing of its antennas and weapons to avoid their being rendered nonfunctional, becomes more susceptible to threats when arriving at the area of responsibility.

Traditionally, the most effective method of coping with icing conditions is to avoid them. This is accomplished by using guidance provided by weather forecasts, or by detecting icing conditions ahead of aircraft from pilot reports. Icing forecasts are the typical method pilots use for determining whether to launch and where and when not to fly in icing weather. However, icing forecasts are often in error with regard to timing, location, and intensity of icing conditions.

Forecasting icing conditions is difficult because icing conditions are typically not directly observed by weather observers, but are determined indirectly from other atmospheric parameters. Air temperature, which must be near or below 0ºC for ice to form, is measured directly. However, supercooled cloud liquid water content, the most important variable in addition to temperature for assessing in-flight icing conditions, is typically derived from other measurements, such as dew point or relative humidity. Modeling explicit cloud microphysics from temperature and relative humidity is difficult because upper air temperature and relative humidity measurements are made by radiosondes only twice per day, at locations hundreds of kilometers apart. Thus, predicting the location of icing clouds, which are transient in both space and time, is extremely difficult. Vertical atmospheric motion is enhanced or suppressed by warm or cold fronts, low pressure, or topography, and varies on temporal and spatial scales finer than the radiosonde observing network. For example, because of poorly understood dynamics, icing forecasts may under-forecast icing frequency in mountainous areas, increasing the possibility that aircraft will encounter dangerous conditions when forecasts indicate that it is safe to fly (Stanley et al. 2002). This is consistent with comments from the commander of the 1-501st (ATK), in the commander's questionnaire, that accurate icing forecasts are difficult to obtain in mountainous terrain of the Balkans. In addition, poorly understood processes can enhance or suppress in-cloud icing. For example, supercooled cloud droplets can exist indefinitely in their supercooled state. However, they can also spontaneously freeze, or glaciate, and cause their neighboring supercooled drops to also freeze. Therefore, liquid clouds can remain supercooled for many hours and present a hazard to aircraft for the entire period. Clouds that freeze to ice, or glaciate, are not generally dangerous to aircraft.

Older icing algorithms are based principally on radiosonde observations of temperature, humidity, wind speed, and wind direction with height. Because of the infrequent and spatially distant measurements, forecasters use models to simulate atmospheric physics, typically on a fine-scale grid a few tens to hundreds of kilometers across, at a 1- to 3-hour time frequency. This improves the temporal and spatial quality of icing forecasts. In addition, surface and satellite observations add information about the time and location of cloud cover and precipitation. Since icing avoidance can be accomplished by avoiding cold air, or by avoiding clouds and liquid precipitation, high resolution observations of these variables are a valuable asset to icing forecasters.

Though the oldest and most simple forecast techniques use only radiosonde information to predict icing conditions, newer models embellish this information by considering the location of pressure systems and fronts, and topography. One model, in use by the FAA, uses neural network derived statistical relationships between standard atmospheric measurements, such as made by a radiosonde, and pilot reports of icing, to make predictions. However, the most sophisticated model available, developed by NCAR and in operational use by the National Weather Service, is the Current Icing Potential (CIP), which combines output from a mesoscale forecast model, MM5, surface observations, satellite imagery, and NEXt generation RADar (NEXRAD) radar to determine the probable location and timing of icing. NCAR is developing the Forecast Icing Potential (FIP), which can use principally MM5 output, and potentially satellite and radar information from any location, to predict icing. FIP should be valuable for OCONUS military operations.

Icing forecast techniques are steadily improving, and provide forecasts today of higher spatial and temporal resolution than only a few years ago. However, they can be improved substantially as computing power allows model physics to be implemented on finer spatial and temporal scales, as the ability to interpret satellite observations improves, and as the understanding of cloud physics matures. At the very least, satellite imagery can tell us where there are no clouds, and thus no icing. However, despite needed improvements in spatial and temporal resolution, even more progress is needed to predict icing intensity, a difficult problem because it requires the amount of supercooled liquid water at a location to be predicted.

As a result of forecasting shortcomings, the National Aeronautics and Space Administration (NASA), the Federal Aviation Administration (FAA), the National Atmospheric and Oceanic Administration, (NOAA), the National Center for Atmospheric Research (NCAR), and the U.S. Army Corps of Engineers Engineer Research and Development Center Cold Regions Research and Engineering Laboratory (ERDC–CRREL) are developing technology for remotely detecting icing conditions ahead of aircraft in-flight (Ryerson et al. 2001). Remote sensing systems should provide more timely and detailed information about icing spatial extent and intensity.

Airframe icing typically does not occur until aircraft enter cloud or precipitation conditions containing supercooled drops. Remote sensing systems, therefore, must detect cloud microphysical conditions, such as droplets and their size and temperature, rather than ice. Remote sensing systems and information retrieval algorithms are being developed to allow radars or microwave radiometers located either near airfields on the ground, or on aircraft, to detect and map icing potential location and severity to at least 20 km ahead of an aircraft. This should provide pilots with sufficient time to interpret cockpit displays and avoid the conditions. NASA is evaluating a commercial, ground-based system built, in part, with Army funding. NOAA is constructing a ground-based radar and radiometer system. An airborne system would probably serve Army aviation best because the Army typically does not operate near airfields, especially in wartime environments. ERDC–CRREL is developing an aircraft-mounted radiometer system, and NASA is developing an airborne radar system. Prototype systems may be ready to fly within the next 5–10 years.

Preflight deicing

The questionnaires indicate that it can take up to six hours to deice Army helicopters before flight. The Army has not developed standardized methods of deicing entire helicopter airframes. As a result, if heated hangars are not available, units must use creative methods to prepare aircraft for flight after snow or ice events. Though often effective, these methods typically require a large amount of time, and have resulted in damage to airframe components and, most seriously, composite rotor blades. A summary of blade deice procedures is given in Appendix H.

ERDC–CRREL has been evaluating and developing improved methods for deicing Army helicopters before flight, with the goal of preparing a snow- or ice-covered aircraft for flight within 30–45 min. The two approaches to solving these problems being explored are improved deicing fluids and thermal deicing.

Fluids used to deice commercial aircraft and military fixed-wing aircraft are typically ethylene or propylene glycol-based. Ethylene glycol is toxic and is hazardous to the environment. Propylene glycol is not toxic and is used, for example, as a food additive and for skin care products. However, it is harmful to the environment because it has a high biological oxygen demand (BOD). That is, when it enters surface water supplies it degrades so rapidly that oxygen is depleted sufficiently to injure aquatic life, and to drive water bodies to eutrophication. In addition, glycols may harm composite materials and emulsify greases. Therefore, glycol deice fluids are banned by the Army for use on helicopter rotorheads where grease could be washed from bearings, thus causing failure.

Industry is developing an environmentally friendly, helicopter-acceptable deicing fluid that should be usable on Army helicopters, and which may not need recovery to protect the environment. A common, organic chemical, sorbitol, has been identified as the potential base stock for the new deicing fluid. Such a fluid, if successful, could be applied to aircraft with a garden-type sprayer if bivouacked, or applied with the Army’s ACDS.

CRREL has assessed thermal deicing methods as a substitute for fluids (Ryerson et al. 1999). These include infrared deicing and hot air deicing. Thermal methods are very effective deicers except, without proper control, they offer opportunities to overheat composite surfaces, especially rotor blades, and perhaps cause delamination. Another problem is that the epoxy matrix of composites thermally expands and contracts at a different rate than the glass or carbon fiber matrix. Thus, given sufficient heating and cooling cycles, composites could weaken internally. However, given proper control, aircraft composites may not be damaged by thermal methods.

Infrared deicing systems have the potential of rapidly deicing helicopters, perhaps in only 15–25 minutes, if the entire aircraft is heated at once (Ryerson et al. 1999). However, water does run into quiet areas on aircraft after snow or ice melts, and subsequently can refreeze during taxi or in flight. Prevention of this problem would require application of an appropriate anti-ice fluid after deicing. In addition, portions of rotor blades, for example, typically deice and dry before other portions. Areas that dry rapidly heat in the infrared energy, while those areas covered with ice or snow are 0°C or colder. If heating continues to melt all of the ice and dry the blade, then portions of the blade that dry first will have a tendency to overheat. The potential for blade overheating must be solved if infrared deicing is to become viable for helicopters.

Hot, forced air deicing is also a potential substitute for deicing fluids. Hot air may be taken from either an AGPU, or from an aircraft-mounted auxiliary power unit (APU). Both power units are operated by a small gas-turbine engine, and bleed air is used as the hot air source. Though bleed air pressure is often less than 35 psi, air flow can be 1500 cfs, and temperatures can be as high as 200°C. Though air temperature exiting the end of a 10- to 20-m hose on a cold day can be considerably cooler, the air is still too warm for rotor blade composites. If a deice nozzle is held close to a blade surface to heat the edge of an ice mass, dry areas of the blade adjacent to the ice or snow can dangerously overheat. With proper control, however, hot, forced air deicing systems could be very effective. An entire helicopter possibly could be deiced in about 90 minutes with a single, hand-held hot-air device.

There are a variety of options for deicing Army helicopters with non-glycol techniques. With relatively minor additional technical development the Army could have several effective deicing systems available for rotorcraft flight preparation.

7 DISCUSSION

The difficulty in definitively answering the question, "Is icing a problem for Army aviation units?" is captured in the following statement from a respondent to the aircraft and ground maintenance questionnaire: "When the weather is bad enough to require deicing, it is usually too bad to fly, so we don't need deicing." Because the Army limits aircraft flight in icing conditions according to each aircraft's performance envelope, the consequential restrictions on flying become the baseline for defining aviation capabilities. The concern is not what capability is lost because aircraft cannot fly in icing conditions, but instead how to be fully functional once aircraft finally are airborne. At the commander's level and below, this reasoning considers icing not as a problem to be solved, but as a limitation to be dealt with. At the same time, however, the Army is striving within budget constraints to increase the safe operational envelope for all its systems to provide a more robust, adverse weather capability to support national military requirements.

Contributing to the "icing is not a problem" attitude is the conviction that if Army aviators are not flying, opposing forces are not, either. One challenge, then, is to be the first back in the air. The side that can deice its aircraft most rapidly will resume executing its mission sooner. Icing may not be considered a problem at the commander's level, but the time required to deice an aircraft is. Similarly, the lack of deicing fluids that are both environmentally safe and non-damaging to aircraft is a problem because it contributes to the delays associated with deicing aircraft. For many aviation commanders, deicing is not a limiting factor in mission accomplishment because their aircraft either are hangared regularly or are moved into hangars when ground icing is expected. When hangars are not available, then the speed with which deicing can be accomplished determines the minimum time before aircraft are again flyable after ground icing events.

Another challenge is to have more accurate predictions of the occurrence and extent of in-flight icing conditions. If a flight line is experiencing moderate or heavy icing, then aircraft are grounded. If the local conditions are favorable (no or light icing), but more severe in-flight icing conditions are forecast in the mission area, then aircraft, including UAVs, can launch, but may not necessarily reach their objective. The problem becomes one of needing to know if there are, or will be, sectors with allowable weather conditions. The side that can exploit transient flight corridors where ambient conditions do not exceed the icing rating of its aircraft has the advantage.

A final challenge is to reduce the danger associated with aircraft encountering unexpected icing conditions in-flight. The capability to locate safe flying conditions would both protect aviators and also assist them in completing missions. As one commander noted, "the greater our ability is to accurately forecast and be warned of icing conditions, the safer and more effective we will be."

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APPENDIX A. ARMY AIRCRAFT

Approximately 97% of the total Army aviation inventory is rotary wing aircraft, with the remainder being C-12 and C-21 fixed-wing aircraft. The number of aircraft in Force Mod fleets and the number of hours flown from 1 January 1996 through 31 March 2002 are given in Table A1. The following statements are taken from or based on the aircraft section of the 2000–2001 Status Report on Army Weapons and Equipment (AUSA 2000).

Table A1. Army rotary wing aircraft and hours flown, 1 Jan 1996–31 May 2002 (courtesy PEO Aviation).

Aircraft	Number	Hours flown
AH-64A	480	526,664
AH-64D	258	62,888
CH-47D	392	320,444
OH-58D	363	417,838
UH-60A	866	773,337
UH-60L	515	482,464

Rotary wing aircraft

AH-1S Cobra attack helicopter

The Cobra is in reserve component attack aviation units of Army inventories. All AH-1 aircraft have been retired from Army inventory as of December 2001.

AH-6/MH-6 Little Bird (Cayuse) helicopter

The Cayuse is in service with the 160th Special Aviation Regiment (Airborne). Following service in Viet Nam, the Army's fleet of OH-6 light observation and command helicopters was reassigned to Army National Guard units. With their excellent roll-on/roll-off mobility and extremely high power-to-weight ratios, however, the aircraft subsequently were tapped for special operations applications in 1980.

AH-64A Apache helicopter

The Apache is the Army's primary attack helicopter, providing day, night, and adverse-weather attack helicopter capability. It is a quick-reacting, airborne weapon system that can fight close and deep to destroy, disrupt, or delay enemy forces. Approximately 800 Apaches have entered Army inventories since 1984. Its principle mission is to destroy high-value targets with the Hellfire missile.

AH-64D Longbow Apache helicopter

The Longbow Apache's mission is to conduct rear, close, and deep operations; perform deep precision strikes; and provide armed reconnaissance and security. The Longbow Apache is far more effective in defeating threat armored vehicles and more survivable in the threat air defense environment than the AH-64A due to its ability to engage targets in weather and obscurant conditions that preclude the employment of laser-guided weapons.

CH-47D Chinook helicopter

The Chinook is a tandem-rotor, medium transport helicopter for transporting weapons, equipment, troops, and other cargo in support of combat units and operations other than war. The MH-47E helicopter is a special operations variant of the Chinook, with added fuel capacity, an air-to-air refueling probe and specialized communications, navigation, avionics, and night-vision subsystems.

OH-58C Kiowa helicopter

The Kiowa is an obsolete Vietnam-era helicopter. It remains in the Army inventory, mostly in the ARNG.

OH-58D Kiowa Warrior helicopter

The Kiowa Warrior fills the armed-reconnaissance role for attack helicopter and air cavalry units. It is the only practical, armed-reconnaissance aircraft in the Army inventory. It is capable of performing reconnaissance, security, command and control, target acquisition/designation, and defensive air combat missions. The Kiowa Warrior adds armed-reconnaissance, light-attack, and multipurpose light helicopter capabilities that permit rapid deployment, troop lift, cargo, and casualty evacuation to the basic OH-58C Kiowa mission capabilities.

RAH-66 Comanche helicopter

The Comanche will be the Army's next-generation helicopter to perform the armed-reconnaissance and light-attack helicopter mission, with production beginning in 2008. The Comanche will perform the armed-reconnaissance mission for attack helicopter and air cavalry units, significantly expanding the

Army's ability to conduct reconnaissance operations in all battlefield environments, in adverse weather, and during the day or night.

UH-1H/V Huey (Iroquois) helicopter

The Huey remains in Army service in a variety of support and service support functions. It fills UH-60 shortages for general support, command, light utility, and assault missions. All UH-1s will be retired from inventory no later than FY2004.

UH-60/MH-60/EH-60 Black Hawk helicopter

The Black Hawk provides the Army with utility, air assault, and MEDEVAC helicopter capability. The EH-60 is the special electronic mission aircraft (SEMA) variant. The Black Hawk is the primary helicopter of air assault, general support, and aeromedical evacuation units. It has enhanced the overall mobility of the Army because of its dramatic improvements in troop capacity and cargo-lift capability over the UH-1H Huey, which it replaces. Troops can be transported faster and in most weather conditions. The MH-60 model is a variant of the UH-60 that is used in special operations applications. The UH-60L model has an upgraded power train (over the UH-60A).

Fixed-wing aircraft

C-12 King Air

The King Air is the Army's current short-range utility aircraft designed to fulfill air transportation requirements out to 800 nautical miles. It provides an efficient all-weather transport for commanders; staff; and low-volume, high-priority parts and equipment. The RC-12 configuration provides standoff communications intelligence, electronics intelligence, and intercept and location targeting to enhance corps commanders' war fighting capability.

C-20 and C-37 Citation

The Citation long-range/executive transport jets provide global transport and command and control support to senior executives from the Department of the Army staff, the commanders in chief, and other high-ranking government officials for flights up to 4,200 nautical miles.

C-23 Sherpa

The Sherpa aircraft provide troop and equipment transport, airdrop, and medical evacuation for cargo up to 7,820 pounds. Eight Sherpas are authorized per theater aviation battalion to provide the commander with the essential ability to move troops and equipment rapidly within the theater of operations. The Sherpa can operate from short, unpaved airfields.

UC-35A Cessna Citation Ultra/UC-35B Encore

This aircraft is an efficient, medium range (800–1,800 nautical miles), all-weather airplane that transports commanders and staff so that they can perform command, liaison, administration, and inspection duties. It also is to move high-priority personnel and cargo. Eight UC-35s are authorized per theater aviation company.

Unmanned Aerial Vehicles (UAVs)

Hunter

The Hunter short-range UAV provides corps and division personnel with reconnaissance, surveillance and target acquisition, and battle damage information in near-real time, day or night.

Shadow 200

The Shadow 200 UAV was selected in December 1999 to be the Army's tactical UAV.

APPENDIX B. FOUR QUESTIONNAIRES DISTRIBUTED TO ARMY AVIATION UNITS LISTED IN APPENDIX C.

Commander
AVIATION XXX

__________________________, Commander Date_______________
(name, rank)

_____________ ____
(telephone) (e-mail)

Aircraft flown by your command (type and model):____

Sir:

In cooperation with the Army Aviation Directorate of Combat Developments, the Army Corps of Engineers Cold Regions Research and Engineering Laboratory is assessing the impact of pre-flight and in-flight icing on Army aviation. Please respond to the following regarding your command.

A. As commander, how do you rate the following icing impacts on mission accomplishment (High, Moderate, Low)?

1) Time required to deice aircraft before flight (up to 4 hours reported in Bosnia) H M L
Comments:

2) Aircraft damage due to improper deicing techniques or inadequate training H M L
Comments:

3) Forecasted icing conditions in the mission flight path H M L
Comments:

B. Rate the potential impact (High, Moderate, Low) of the following technology advancements on your mission:

1) Aircraft deicing technique allowing flight ready in <30 minutes H M L

2) Environment-friendly deicing fluid that is compatible with the entire aircraft H M L

3) Improved icing forecast resulting in 50% reduction in flight cancellations H M L

4) Capability to provide advance (km or greater) icing hazard warning in-flight on cockpit display H M L

C. Your experiences with icing?

Flight Operations
AVIATION XXX

Date______________

____
(name, rank)

________________ ____
(telephone) (e-mail)

Types of aircraft flown by your unit:____

Sir:

In cooperation with the Army Aviation Directorate of Combat Developments, the Army Corps of Engineers Cold Regions Research and Engineering Laboratory is assessing the impact of pre-flight and in-flight icing on Army aviation. Please respond to the following questions and return this quetionnaire in the attached envelope.

A. On average, how many flights does your unit initiate each month, if there are no weather-related flight restrictions in effect?

October	November	December	January	February	March

B. How common is it that scheduled flights are cancelled due to ground icing?

	Never	1-5%	6-10%	11-25%	26-50%	>50%
October						
November						
December						
January						
February						
March						
April						

C. How common is it that scheduled flights are cancelled due to actual or forecast icing?

	Never	1-5%	6-10%	11-25%	26-50%	>50%
October						
November						
December						
January						
February						
March						
April						

D. How common is it that flights are disrupted (aborted, redirected, etc.) due to unexpected in-flight icing?

	Never	1-5%	6-10%	11-25%	26-50%	>50%
October						
November						
December						
January						
February						
March						
April						

E. Your experiences with icing?

Aircraft and Ground Maintenance
AVIATION XXX

______________________________ Date_______________
(name, rank)

____________________ ____
(telephone) (e-mail)

Types of aircraft flown by your unit:____

Sir:

In cooperation with the Army Aviation Directorate of Combat Development, the Army Corps of Engineers Cold Regions Research and Engineering Laboratory is assessing the impact of pre-flight and in-flight icing on Army aviation. Please respond to the following questions and return in the attached envelope.

A. Are aircraft at your activity grounded due to icing (from snow or ice on the aircraft before flight, or from actual or forecast inflight icing)?

Never Rarely Monthy in winter Weekly in winter

B. How are aircraft on the ground protected from the accumulation of snow or ice?

Hangars? Covers? Anti-ice fluids? Other:

C. Are aircraft deiced before flight at your facility, or are aircraft not flown until ice or snow disappears naturally? (If not deiced, go to question F)

D. How is pre-flight deicing accomplished at your facility, and roughly how much time is required to deice each aircraft?

E. Rate the amount of damage to aircraft caused by current de-icing techniques on a scale of 1 (negligible) to 5 (significant).

F. In your opinion, what would be the increase in flight readiness during the months listed below if a de-icing facility were available at your activity? (Check one per month)

	Low	Moderate	High
November			
December			
January			
February			
March			
April			

G. Your experiences with icing?

Weather Support
AVIATION XXX

To be completed by a person providing weather support to this unit.

__________________________ Date_______________

(name, rank)

_______________ ____

(telephone) (e-mail)

____

(location)

Sir:

In cooperation with the Army Aviation Directorate of Combat Developments, the Army Corps of Engineers Cold Regions Research and Engineering Laboratory is assessing the impact of pre-flight and in-flight icing on Army aviation. Please respond to the following questions and return in the attached envelope.

A. On average, how many days per month does ice or snow occur as precipitation events at AVIATION XXXX?

	Never	1-3 days	4-7 days	8-12 days	13-18 days	19-25 days	26-31 days
October							
November							
December							
January							
February							
March							
April							

B. On average, how many days per month is in-flight icing forecast or reported at AVIATION XXXX?

	Never	1-3 days	4-7 days	8-12 days	13-18 days	19-25 days	26-31 days
October							
November							
December							
January							
February							
March							
April							

C. On average, what is a typical duration for forecast in-flight icing conditions at AVIATION XXXX?

	≤3 hrs	3-6 hrs	7-12 hrs	13-18 hrs	19-24 hrs	1-1.5 days	>1.5 days
October							
November							
December							
January							
February							
March							
April							

D. Are records of in-flight icing forecasts and icing pireps retained? For how long are they retained?

E. Are records of ice and snow precipitation events at the surface retained? For how long are they retained?

F. Your experiences with icing?

APPENDIX C. ARMY AVIATION UNITS TO WHICH QUESTIONNAIRES WERE SENT

The number in the left column is the unit's identification number. It is used in appendices D–G to associate questionnaire entries with the responding unit.

Table C1. Aviation units that received questionnaires.

ID #	Organization	Mission	Aircraft	Location
1	SHAPE Flight Detachment	VIP transport (Supreme HQ Allied Powers Europe)	UH 60A	Cheves, Belgium
2	ODCSCPS			Heidelberg (Unit 29351) Germany
3	HQ US EUCOM FLIGHT DET.	VIP transport	C-12F, C-12K, UH-1	Stuttgart, Germany
11th Avn Brigade				
4	11th Aviation Regiment	HQ		Illesheim, Germany
5	2-6 Cavalry Squadron (ATK)	Attack		Illesheim, Germany
6	6-6 Cavalry Squadron	Reconnaissance		Illesheim, Germany
12th Avn Brigade				
7	12th Aviation Brigade	HQ		Wiesbaden, Germany
8	3-58th Avn Regt (ATC)	Air traffic services		Wiesbaden, Germany
9	5-158th Avn Regt (CAB)	Command Aviation Battalion: command and control a/c with special communications packages		Giebelstadt, Germany
10	F-159th (MHC)	Heavy lift	CH 47D	Giebelstadt, Germany
1st Armored Division				
11	4th Aviation Brigade, 1st AD	HQ	AH64, UH60, EH60, OH58D	Hanau, Germany
12	1-1 Cavalry Squadron	Reconnaissance		Buedingen, Germany
13	1-501st (ATK)	Attack		Hanau, Germany
14	2-501st Avn Regt (GSAB)	General Support Aviation Battalion: UH helicopters providing the division command and control, air transportation, and limited air assault. Primarily heavy divisions.		Hanau, Germany
15	127th ASB	Aviation Support Battalion	AH-64, UH-60, OH58D	Hanau, Germany

Table C1 (cont'd).				
ID #	**Organization**	**Mission**	**Aircraft**	**Location**
1st Infantry Division				
16	4th Combat Aviation Brigade	HQ		Ansbach, Germany
17	1-1st Avn Regt (ATK)	Attack		Katterback, Germany
18	2-1st Avn Regt (GSAB)	General Support Aviation Battalion: UH helicopters providing the division command and control, air transportation, and limited air assault. Primarily heavy divisions.		Katterback, Germany
19	601st Division Avn Spt Bn	Aviation support		Katterback, Germany
20	1-4 Cavalry Squadron	Reconnaissance	OH-58D	Schweinfurt, Germany
21st Theatre Command				
21	2-502 Aviation Battalion	VIP transport		Mannheim, Germany
USAREUR				
22	AFOD	Air Force Flight Operations Det.t		Heidelberg, Germany
23	HQ USAREUR DCSOPS AVN	VIP transport		Heidelberg, Germany
24	7th ATC Detachment	Air Traffic Control		Grafenwöhr, Germany
V Corps				
25	421st MEDEVAC Battalion	Medical evacuation	UH60A	Wiesbaden, Germany
26	1st Military Intelligence Battalion	Intelligence	Fixed-wing special electronics mission aircraft	Wiesbaden, Germany
27	V Corps Aviation G3 (AVN)	VIP transport		Heidelberg, Germany
28	7-159th Avn Regt (AVIM) (COSCOM)	Aviation Intermediate Maintenance Company	CH-47D, UH-60	Illesheim, Germany
2nd Infantry Division				
29	2nd Aviation Brigade (2nd Inf Div)	HQ		Camp Stanley, Korea
30	1-2nd Avn Regt (Attack)	Attack		Camp Page, Korea
31	2-2nd Avn Regt (ASLT)	Assault	UH-60 A/L, H-60A	Camp Stanley, Korea
32	4-7th Cavalry Squadron	Reconnaissance		Camp Garry Owen, Korea
8th Army				
33	HQ 8th US Army	HQ		Seoul, Korea
34	52nd Medical Evacuation Bn	Medical evacuation		Seoul, Korea

Table C1 (cont'd). Aviation units that received questionnaires.				
ID #	**Organization**	**Mission**	**Aircraft**	**Location**
35	**17th Avn Brigade**	HQ	Ch-47, OH-60, C-12, UC35	Seoul, Korea
36	164th ATS Group	Air Traffic Service (no a/c)		Yong-San, Korea
37	1-52nd Avn Regt (CAB)	Command Aviation Battalion: command and control a/c with special communications packages	H-60	k-16, Seoul AB, Korea
38	2-52nd Avn Regt (MHB)	Heavy lift	CH-47D	Camp Humphreys, Korea
39	**6th Cavalry Brigade**	HQ		Camp Humphreys, Korea
40	1-6 Attack	Attack	AH-64A	Camp Eagle, Korea
41	3-6 Cav	Reconnaissance		Camp Humphreys, Korea
INSCOM				
42	3rd MI BN (AE)	Intelligence	C-12, C-7	Camp Humphreys, Korea
10th Mountain Division				
43	**10th Avn Brigade**	HQ	UH 60 AK, OH 58D, UH-1V	Fort Drum, New York
44	1-10th Avn Regt (Attack)	Attack	OH58D(I)	Fort Drum, New York
45	2-10th Avn Reg (Assault)	Assault	UN-60AL, EH-60A, UH-1V	Fort Drum, New York
46	3-17th Cav Sqdn	Reconnaissance		Fort Drum, New York
160th Special Operations Aviation				
47	**160th SOAR (Airborne)**	HQ	AH-6, MH-6, MH-60K, MH-60L, MH-47E	Fort Campbell, Kentucky
48	1-160th SOAR (Airborne)	Assault	H-60, H-500	Fort Campbell, Kentucky
49	2-160th SOAR (Airborne)	Heavy Lift	MH 47 E	Fort Campbell, Kentucky
50	3-160th SOAR (Airborne)			Hunter AAF, Georgia
51	4-160th SOAR (Airborne)	Attack, lift	AH/MH-6, MH-60,MH-47	Fort Campbell, Kentucky
244th Avn Brigade (USAR)				
52	**244th Theater Avn Brigade (USAR)**	HQ		Fort Sheridan, Illinois
53	2-228th	VIP transport	C-12R, UC-35	

Table C1 (cont'd).				
ID #	**Organization**	**Mission**	**Aircraft**	**Location**
National Guard Aviation Brigades				
54	28th AD Avn Brigade	HQ		Annville, Pennsylvania
55	29th ID (Light) Avn Brigade	Lift		Aberdeen Proving Ground, Maryland
56	38th ID Avn Brigade	Lift		Shelbyville, Indiana
57	34th Avn Brigade	Lift		St. Paul, Minnesota
Other units				
58	4-123rd Avn Regt	Lift	CH-47, OH-60	Fort Wainwright, Alaska
59	12th AVN Battalion, MDW	VIP transport	C-12	Fort Belvoir, Virginia
60	1-222nd Avn Regt	Lift	UH-60A, UH-1H, UH-1V	Fort Eustis, Virginia

APPENDIX D. COMMANDERS' ASSESSMENT OF CURRENT MISSION IMPACT AND POTENTIAL MISSION ENHANCEMENT

Rankings and comments were provided by respondents to the commanders' questionnaire (Parts A, B, C). Each commander's unit is referred to by its identification number, which is the number that begins each listing.

Table D1. Commanders' rankings of mission impact and enhancement.

				Mission impact			Mission enhancement			
ID #	**Organization**	**Location**	**Aircraft**	**Deice time**	**Deicing damage**	**Forecasted icing**	**Quicker deicing**	**EQ deicing fluid**	**Better forecasting/fewer cancellations**	**In-flight icing hazard warning**
1	SHAPE Flight Detachment	Cheves, Belgium	UH-60A Commander-in-Chief Black Hawks	L	L	M	L	L	L	L
2	ODCSCPS	Heidelberg (Unit 29351) Germany								
3	HQ US EUCOM Flight Det	Stuttgart, Germany	C-12F, C-12K, UH-1	M	L	H	M	H	M	M
11th Avn BRIGADE										
4	11th Aviation Regiment	Illesheim, Germany	AH-64A	L	L	M	L	M	L	M
5	2-6 Cavalry Squadron (ATK)	Illesheim, Germany	AH-64A	M	H	M	H	H	H	M
6	6-6 Cavalry Squadron	Illesheim, Germany	AH-64A	L	L	L	H	H	H	H
12th Avn BRIGADE										
7	12th Aviation Brigade	Wiesbaden, Germany								
8	3-58th Avn Regt (ATC)	Wiesbaden, Germany								
9	5-158th Avn Regt (CAB)	Giebelstadt, Germany	UH-60A	L	L	M	M	M	L	L
10	F-159th (MHC)	Giebelstadt, Germany	CH-47D	M	L	H	H	L	H	H
1st Armored Division										
11	4th Aviation Brigade, 1st AD	Hanau, Germany								
12	1-1 Cavalry Squadron	Buedingen, Germany	OH-58D(I)	L	L	L	L	L	L	L

Table D1 (cont'd). Commanders' rankings of mission impact and enhancement.

				Mission impact			Mission enhancement			
ID #	**Organization**	**Location**	**Aircraft**	**Deice time**	**Deicing damage**	**Forecasted icing**	**Quicker deicing**	**EQ deicing fluid**	**Better forecasting/fewer cancellations**	**In-flight icing hazard warning**
13	1-501st (ATK)	Hanau, Germany	AH-64, UH-60, OH-58D, CH-47D	L	M	M	H	H	H	H
14	2-501st Avn Regt (GSAB)	Hanau, Germany								
15	127th ASB	Hanau, Germany	AH-64, UH-60, OH58D	M	L	L	H	H	H	H
1st Infantry Division										
16	4th Combat Aviation Brigade	Ansbach, Germany								
17	1-1st Avn Regt (ATK)	Katterback, Germany								
18	2-1st Avn Regt (GSAB)	Katterback, Germany	UH-60A/L/EH	L	L	L	M	H	M	M
19	601st Division Avn Spt Bn	Katterback, Germany								
20	1-4 Cavalry Squadron	Schweinfurt, Germany	OH-58D(I)	H	M	H	H	H	H	M
21st Theatre Command										
21	2-502 Aviation Battalion	Mannheim, Germany	UH-60	L	L	L	L	L	L	L
USAREUR										
22	AFOD	Heidelberg, Germany								
23	HQ USAREUR DCSOPS AVN	Heidelberg, Germany								
24	7th ATC Detachment	Grafenwöhr, Germany								

Table D1 (cont'd).

				Mission impact			Mission enhancement			
ID #	**Organization**	**Location**	**Aircraft**	**Deice time**	**Deicing damage**	**Forecasted icing**	**Quicker deicing**	**EQ deicing fluid**	**Better forecasting/fewer cancellations**	**In-flight icing hazard warning**
V Corps										
25	421st MEDEVAC Bn	Wiesbaden, Germany	UH-60A	M	L	H	H	H	H	H
26	1st Military Intelligence Battalion	Wiesbaden, Germany								
27	V Corps Aviation G3 (AVN)	Heidelberg, Germany								
28	7-159th Avn Regt (AVIM) (COSCOM)	Illesheim, Germany	UH-60A	M	L	L	M	M	H	H
2nd Infantry Division										
29	**2nd Aviation Bde (2nd Inf Div)**	Camp Stanley, Korea								
30	1-2nd Avn Regt (Attack)	Camp Page, Korea								
31	2-2nd Avn Regt (ASLT)	Camp Stanley, Korea	UH/EH-60	L	L	L	L	L	L	L
32	4-7th Cavalry Squadron	Camp Garry Owen, Korea								
8th Army										
33	HQ 8th US Army	Seoul, Korea								
34	52nd Medical Evacuation Bn	Seoul, Korea								
35	**17th Aviation Brigade**	Seoul, Korea	a: CH-47, UH-60, C-12, UC35	M	L	M	L	M	H	L
			b: not indicated	L	L	L	H	H	L	H
36	164th ATS Group	Yong-San, Korea								

Table D1 (cont'd). Commanders' rankings of mission impact and enhancement.

				Mission impact			Mission enhancement			
ID #	**Organization**	**Location**	**Aircraft**	**Deice time**	**Deicing damage**	**Forecasted icing**	**Quicker deicing**	**EQ deicing fluid**	**Better forecasting/fewer cancellations**	**In-flight icing hazard warning**
37	1-52nd Avn Regt (CAB)	k-16, Seoul AB, Korea		H	M	M	H	H	H	H
38	2-52nd Avn Regt (MHB)	Camp Humphreys, Korea	CH-47D	M	L	M	H	H	H	H
39	**6th Cavalry Brigade**	Camp Humphreys, Korea								
40	1-6 Attack	Camp Eagle, Korea	AH-64A	L	M	H	H	H	H	H
41	3-6 Cav	Camp Humphreys, Korea								
INSCOM										
42	3rd MI BN (AE)	Camp Humphreys, Korea	RC7/RC12	M	L	H	H	H	H	H
10th Mountain Division										
43	**10th Avn Bde**	Fort Drum, NY	UH-60L/A, OH-58D, UH-1	M	M	M	H	H	M	M
44	1-10th Avn Regt (Attack)	Fort Drum, NY	OH-58D(I)	H	M	H	H	H	H	H
45	2-10th Avn Reg (Assault)	Fort Drum, NY	UH-60A/L, EH-60A, UH-1V	H	H	H	H	H	H	H
46	3-17th Cav Sqdn	Fort Drum, NY								

Table D1 (cont'd).

				Mission impact				Mission enhancement		
ID #	Organization	Location	Aircraft	Deice time	Deicing damage	Forecasted icing	Quicker deicing	EQ deicing fluid	Better forecasting/fewer cancellations	In-flight icing hazard warning
160th Special Operations Aviation										
47	**160th SOAR (Airborne)**	Fort Campbell, KY	AH-6, MH-6, MH-60K, MH-60L, MH-47D, MH-47E	H	H	M	H	M	M	M
48	1-160th SOAR (Airborne)	Fort Campbell, KY	A/MH-6J, MH-60K/L	L	L	L	H	H	H	H
49	2-160th SOAR (Airborne)	Fort Campbell, KY	MH-47 E	L	L	L	H	H	H	H
50	3-160th SOAR (Airborne)	Hunter AAF, GA								
51	4-160th SOAR (Airborne)	Fort Campbell, KY	MH/AH-6, MH-47E, MH-60L/K	L	L	L	L	L	M	M
244th Avn Brigade (USAR)										
52	**244th Theater Avn Bde (USAR)**	Fort Sheridan, IL		L	L	L	M	M	M	M
53	2-228th	C-12R, UC-35		L	L	M	L	M	M	M
National Guard Aviation Brigade										
54	28th AD Avn Bde	Annville, PA								
55	29th ID (Light) Avn Brigade	Aberdeen Proving Ground, MD								
56	38th ID Avn Bde	Shelbyville, IN	UH-1H/V	L	L	H	H	H	H	H
57	34th Avn Bde	St. Paul, MN	UH-1, AH-1, OH-58	L	L	L	M	M	H	H

Table D1 (cont'd). Commanders' rankings of mission impact and enhancement.

ID #	Organization	Location	Aircraft	Deice time	Deicing damage	Forecasted icing	Quicker deicing	EQ deicing fluid	Better forecasting/fewer cancellations	In-flight icing hazard warning
Other units										
58	4-123rd Avn Regt	Fort Wainwright, AK	CH-47D [16], UH-60A [15], UH-60A (MEDEVAC) [6]	H	L	H				
59	12th AVN Battalion, MDW	Fort Belvoir, VA	UH-60, VH-60, UH-1	H	H	H	H	H	H	H
60	1-222nd Avn Regt	Fort Eustis, VA	UH-60A, UH-1H, UH-1V	L	L	M	L	L	M	M

Impact on mission accomplishment

A1. Time required to deice aircraft before flight

1. L. a/c stay hangared just about all the time, even when deployed.

3. M

4. L

5. M

6. L. Assessed as low due to reduced collective training OPTEMPO during winter due to preparation for Longbow turn-in, as well as weather in this region is quite moderate.

9. L

10. M

12. L

13. L. In Kosovo we experienced very few incidents of icing. The procurement of blade covers and the hangar availability allowed aircraft on R&S (reconnaissance and surveillance) and [illegible] to be hangared when inclement weather was forecasted.

15. M

18. L

20. H

21. L

25. M. Time is critical when 1st up a/c require deice.

28. M

31. L. Little icing in Korea.

35a. M

35b. L

37. H

38. M. In Korea, happens rarely, but can add up to one hour for preparation. Icing here is historically fairly light, even trace on the ground.

40. L. Never deiced a/c. We would move alert a/c into hanger to keep from deicing.

42. M

43. M

44. H

45. H. With more hanger space this becomes less of a problem.

47. H

48. L. Deicing has not been a mission stopper. We use a warm hangar followed by deice fluid.

49. L

51. L. Very seldom required.

52. L

53. L

56. L. We have so few flyable a/c we are able to hangar all of them during icing weather.

57. L

58. H. We have to leave all CH-47s out on the ramp during the winter at Fort Wainwright, Alaska. a/c prep time is two hours with no ice to warm up engines, etc., and much more with ice.

59. H

60. L. a/c hangared before flight.

A2. Aircraft damage due to improper deicing techniques or inadequate training.

1. L. Fly in icing all the time, so very familiar with proper procedures.

3. L

4. L

5. H

6. L. Assessed as low due to reduced collective training OPTEMPO during winter due to preparation for Longbow turn-in, as well as weather in this region is quite moderate.

9. L

10. L

12. L

13. M. Soldiers were inexperienced with deicing techniques and often tried to use brooms and other inappropriate tools to scrape ice.

An educational process coupled with an in-depth training program will minimize these incidents.

15. L

18. L

20. M

21. L

25. L

28. L

31. L. None.

35a. L

35b. L

37. M

38. L. (In Korea) most non-rated crew members are knowledgeable enough to not use the old hammer or screwdriver to remove ice. Sun, time, and deice fluid.

40. M. Have lost some seals and elastomeric bearings but once again very low due to not being able to use a/c if iced over.

42. L. Contract maintenance for our fleet minimizes this issue.

43. M

44. M

45. H

47. H

48. L. Have not experienced any damage due to improper techniques.

49. L

51. L

52. L

53. L

56. L. We have so few flyable a/c we are able to hangar all of them during icing weather.

57. L

58. L. "Unfortunately" we have the chance to get the experience.

59. H

60. L

A3. Forecasted icing conditions in the mission flight plan.

1. M. In winter encounter light-to-mod icing on just about every mission and have experienced high unforecasted on occasions. From Belgium fly IFR 7 to 9000 feet to the UK or Germany weekly for mission support. Have blade deice installed along with color WX radar and storm scope.

3. H. Limited to 12,500 lbs with the C-12F models during icing conditions.

4. M. Operational deployments impacted.

5. M

6. L. Assessed as low due to reduced collective training OPTEMPO during winter due to preparation for Longbow turn-in, as well as weather in this region is quite moderate.

9. M

10. H

12. L

13. M. Accurate forecasting is essential. Here in the Balkans with the mountainous terrain that is sometimes a more difficult task.

15. L

18. L

20. H

21. L

25. H. Icing forecasts generally are not very accurate. Plus deice or anti-ice systems on a/c test fine on the ground but fail in flight.

28. L

31. L. 95% of missions at 600 feet or below.

35a. M

35b. L

37. M

38. M (In Korea) icing at IFR altitudes in the clouds is quite common.

40. H. If we have to fight during winter months from a field site, this would be a problem or limit our ability to get in the fight.

42. H

43. M

44. H

45. H

47. M

48. L. Icing has not been a show stopper.

49. L

51. L

52. L

53. M

56. H. We avoid all icing when possible. Trace and light is all we are allowed to fly in per the UH-1-10.

57. L

58. H. Our ability to fly IMC most of the year is restricted due to icing and poor deice UH-60A capabilities.

59. H

60. M. We always fly IFR; altitude icing can impair missions.

Potential impact of technology advancements on mission.

B1. Deicing technique for flight ready in <30 minutes

1. L

3. M

4. L

5. H

6. H

9. M

10. H

12. L

13. H

15. H

18. M

20. H

21. L

25. H

28. M

31. L

35a. L

35b. H

37. H

38. H

40. H

42. H

43. H

44. H

45. H

47. H

48. H

49. H

51. L

52. M

53. L

56. H

57. M

59. H

60. L

B2. Environmentally friendly deicing fluid

1. L

3. H

4. M

5. H

6. H

9. M

10. L

12. L

13. H

15. H

18. H

20. H

21. L

25. H

28. M

31. L

35a. M

35b. H

37. H

38. H

40. H

42. H

43. H

44. H

45. H

47. M

48. H

49. H

51. L

52. M

53. M

56. H

57. M

59. H

60. L

B3. Improved icing forecast (50% reduction in flight cancellations)

1. L
3. M
4. L
5. H
6. H
9. L
10. H
12. L
13. H
15. H
18. M
20. H
21. L
25. H
28. H
31. L
35a. H
35b. L
37. H
38. H
40. H
42. H
43. M
44. H
45. H
47. M
48. H
49. H
51. M
52. M
53. M
56. H
57. H
59. H
60. M

B4. Cockpit display of in-flight icing hazard warning

1. L

3. M

4. M

5. M

6. H

9. L

10. H

12. L

13. H

15. H

18. M

20. M

21. L

25. H

28. H

31. L

35a. L

35b. H

37. H

38. H

40. H

42. H

43. M

44. H

45. H

47. M

48. H

49. H

51. M

52. M

53. M

56. H. Once we have a larger fleet B1 and B2 will definitely apply.

57. H

59. H

60. M

C. Comments (Respondent's experience with icing)

1. Commander and warrants fly into icing at least once a week in the winter. Has been commander for over two years; a warrant has flown in this environment for over three years.

3. Limiting the total aircraft weight to 12,500 during icing conditions hampers our ability to complete our mission.

4. Flights cancelled—routes diverted.

5. Limited. My primary concern is affordability and maintainability. As a troop commander in 1987, my AH64 a/c were modified with icing detectors and the anti-ice for main/tail rotors was functional. As a squadron commander in 1999–2001, all of the a/c have incomplete anti-icing capability. As replacement blades (not anti-ice capable), we lost a significant adverse weather capability. Key is a system that AMC can afford to upkeep with Single Stock Fund.

6. Limited to training in icing conditions (severe!) at Fort Riley, Kansas, in 84–86 with totally inadequate/non-existent deice capability. One rotation through JRTC at Fort Polk where icing stopped all training/flights/operations for 72 hours.

9. Moderate. I've flown in moderate icing on half a dozen occasions. Blade deice and other equipment have always worked as briefed.

12. Mission profile for OH-58Ds requires low altitude flight; very little impact on mission accomplishment due to icing.

13. As stated in Para A1., we have experienced icing only on a few occasions here in Kosovo. We have had several missions cancelled due to forecasted icing at altitude.

15. No experience with icing.

20. Experience: In-flight/on-ground icing during Bosnia/Kosovo deployments. Precautionary landing in Kosovo requiring NATO ground forces to deploy to provide aircraft security.

25. The a/c within the 421st command routinely fly in icing conditions during winter months. Functioning deice and anti-icing systems are a must. We routinely check our systems even in the summer to keep them functional; however, when this doesn't happen, systems tend to fail more, especially at the beginning of the cold/icing season.

31. Moderate—most experience at Fort Lewis, Washington.

35a. Experience: Missions cancelled last minute; apprehension of unknown; unexpected buildup causing mission cancellations; deice systems that do not work and you cannot make them; Europe/Korea/Fort Carson/Fort Hood.

37. IFR—United States/Germany/Korea. Deicing the aircraft takes a long time due to inadequate deicing capabilities. Forecast level of icing is rarely accurate for rotary wing aircraft.

38. While I have recently arrived in Korea for my second tour over here, I have flown CH-47s in Europe (Italy), Alaska, and throughout CONUS. I have experienced light icing numerous times and moderate icing (by definition in the Flight Information Handbook) only once. Moderate icing builds very quickly and can be very disconcerting without deicing capability. The above-mentioned advancements would be very beneficial to all units. The units who will be most troubled by icing are, of course, those who rarely have to deal with it.

40. Have flown C12 and U21 fixed-wing a/c and has not been a big problem. Because of the lack of <u>working</u> deice system on the AH64—I have very little <u>actual</u> flight experience. More experience at canceled flights due to forecasted icing.

42. Numerous missions flown in light and moderate icing conditions during my 2 tours to Korea—both MI assignments.

43. Bosnia

44. We live at Fort Drum—need I say more!

45. While assigned at Fort Drum I have had over 30% of missions during the winter months cancelled due to icing conditions or poor forecasting. Although the UH-60 is equipped with a deice capability the equipment is maintenance-intensive and crews do not have a high confidence level in its capability.

47. Limited experience due to the regions of world we are most often employed. Although we don't often encounter these conditions, we could. Need to have better procedures available when we do.

48. Overall, icing has not hindered mission success. However, any improvement in deicing capability can only enhance mission accomplishment.

49. I don't understand the high/med/low scale on question B. Obviously, I am in favor of all four advancements if they improve mission accomplishment. I have very limited experience with icing; my unit does not routinely operate in environments conducive to icing.

51. Usually don't plan to fly in any known icing conditions. Have experienced one UH60 that had damaged TR paddle from shedding ice. Once while flying UH60, experienced light icing conditions and MR/TR deicing worked.

52. Icing on UH-1 rotor while flying over water (Greece).

53. Substantial experience—both Army RW and FW, also civilian and commercial aviation.

56. I have had very little experience with icing as I generally avoid it. I have had a few crews in my company that have told me some "close call" incidents when they experienced greater than forecast icing. The greater our ability is to accurately forecast and be warned of icing conditions, the safer and more effective we will be.

57. Very little.

58. Flown up here IMC [instrument meteorological conditions]; IFR [instrument flight rules], and VMC [visual meteorological conditions] and have seen the effects of "LT Rime" ice quickly build up.

59. Our a/c are hangared everyday, so the impact of icing on our a/c is not all that great. However, having been assigned to units that have had icing problems, I feel there is a great impact to the mission.

60. Many flights in low icing, some in moderate.

APPENDIX E. OCCURRENCE OF FLIGHT CANCELLATIONS AND DISRUPTIONS

Flight cancellations and disruptions (by percentage) are shown as reported by respondents to the Flight Operations Questionnaire (parts B, C, and D). They are followed by respondents' comments. Each unit's identification number is used consistently throughout Appendices C through G.

Table E1. Flight cancellations and disruptions.

ID #	Organization	Location	Ground icing cancellations							Actual/forecast icing cancellations							Flight disruptions as a result of unexpected icing						
			0=never; 1=1–5%; 2=6–10%; 3=11–25%; 4=26–50%; 5=>50%																				
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1	SHAPE Flight Detachment	Cheves, Belgium	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1	1	0	0	0
2	ODCSCPS	Heidelberg (Unit 29351) Germany																					
3	HQ US EUCOM Flight Det	Stuttgart, Germany																					
11th Avn Brigade																							
4	11th Avn Regiment	Illesheim, Germany	0	0	0	0	0	0	0	1	2	1	1	2	1	1	0	1	0	0	1	0	0
5	2-6 Cavalry Squadron (ATK)	Illesheim, Germany	0	0	1	2	1	0	0	0	1	2	3	3	1	0	0	1	1	1	1	0	0
6	6-6 Cav. Squadron	Illesheim, Germany	0	0	0	0	0	0	0	0	0	0/1	0/1	0/1	0	0	0	0	0	0	0	0	0
12th Avn Brigade																							
7	12th Avn Brigade	Wiesbaden, Germany																					
8	3-58th Avn Regt (ATC)	Wiesbaden, Germany																					
9	5-158th Avn Regt (CAB)	Giebelstadt, Germany	0	0	1	1	0	0	blank	0	1	2	2	0	0	0	0	0	2	1	0	0	0
10	F-159th (MHC)	Giebelstadt, Germany	0	1	1	1	1	0	0	3	4	4	4	4	3	3	0	0	1	1	0	0	0
1st Armored Division																							
11	4th Avn Bde, 1st AD	Hanau, Germany																					
12	1-1 Cav. Squadron	Buedingen, Germany	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0
13	1-501st (ATK)	Hanau, Germany	0	0	0	0	0	0	0	0	1	2	2	2	1	0	0	1	1	1	1	0	0
14	2-501st Avn Regt (GSAB)	Hanau, Germany																					
15	127th ASB	Hanau, Germany																					

Table E1 (cont'd). Flight cancellations and disruptions.

			Ground icing cancellations							Actual/forecast icing cancellations							Flight disruptions as a result of unexpected icing						
			0=never; 1=1–5%; 2=6–10%; 3=11–25%; 4=26–50%; 5=>50%																				
ID #	Organization	Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1st Infantry Division																							
16	4th Combat Avn Brigade	Ansbach, Germany																					
17	1-1st Avn Regt (ATK)	Katterback, Germany																					
18	2-1st Avn Regt (GSAB)	Katterback, Germany	1	2	4	4	3	1	0	1	2	4	4	4	2	1	1	1	3	3	3	1	1
19	601st Div Avn Spt Bn	Katterback, Germany																					
20	1-4 Cavalry Squadron	Schweinfurt, Germany	1	2	1	3	3	1	0	1	2	2	3	3	2	1	0	1	1	2	2	1	0
21st Theatre Command																							
21	2-502 Avn Bn	Mannheim, Germany	previously submitted																				
USAREUR																							
22	AFOD	Heidelberg, Germany																					
23	HQ USAREUR DCSOPS AVN	Heidelberg, Germany																					
24	7th ATC Det.	Grafenwöhr, Germany																					
V Corps																							
25	421st MEDEVAC Bn	Wiesbaden, Germany	0	1	1	1	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0	0	0
26	1st Military Intelligence Bn	Wiesbaden, Germany																					
27	V Corps Aviation G3 (AVN)	Heidelberg, Germany																					
28	7-159th Avn Regt (AVIM) (COSCOM)	Illesheim, Germany	0	1	1	1	1	0	0	0	2	3	3	3	2	0	0	1	2	2	2	1	0
2nd Infantry Division																							
29	**2nd Avn Brigade (2nd Inf Div)**	Camp Stanley, Korea																					
30	1-2nd Avn Regt (Attack)	Camp Page, Korea																					
31	2-2nd Avn Regt (ASLT)	Camp Garry Owen, Korea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table E1 (cont'd).

ID #	Organization	Location	Ground icing cancellations							Actual/forecast icing cancellations							Flight disruptions as a result of unexpected icing						
			0=never; 1=1–5%; 2=6–10%; 3=11–25%; 4=26–50%; 5=>50%																				
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr
32	4-7th Cavalry Squadron	Camp Garry Owen, Korea																					
8th Army																							
33	HQ 8th US Army	Seoul, Korea																					
34	52nd Medical Evacuation Bn	Seoul, Korea																					
35	**17th Aviation Brigade**	Seoul, Korea	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0
36	164th ATS Group	Yong-San, Korea																					
37	1-52nd Avn Regt (CAB)	k-16, Seoul AB, Korea	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0
38	2-52nd Avn Regt (MHB)	Camp Humphreys, Korea	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0
39	**6th Cavalry Brigade**	Camp Humphreys, Korea																					
40	1-6 Attack	Camp Eagle, Korea																					
41	3-6 Cav	Camp Humphreys, Korea																					
INSCOM																							
	3rd MI Bn (AE)	Camp Humphreys, Korea	0	0	0	0	0	0	0	1	1	1	1	1	1	blank	0	0	0	0	0	0	0
42		B	0	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0
10th Mountain Division																							
43	**10th Avn Brigade**	Fort Drum, NY	0	1	2	2	2	1	0	0	2	4	4	4	2	0	0	1	2	2	2	1	0
44	1-10th Avn Regt (Attack)	Fort Drum, NY	1	1	2	2	2	2	1	1	1	1	4	4	3	1	0	0	1	2	2	1	1

Table E1 (cont'd). Flight cancellations and disruptions.

			Ground icing cancellations							Actual/forecast icing cancellations							Flight disruptions as a result of unexpected icing						
			0=never; 1=1–5%; 2=6–10%; 3=11–25%; 4=26–50%; 5=>50%																				
ID #	**Organization**	**Location**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
45	2-10th Avn Reg (Assault)	Fort Drum, New York	1	2	2	2	2	1	0	1-2	3	4	4	4	2	1	1	1	2	2	2	1	1
46	3-17th Cav Sqdn	Fort Drum, New York	0	0	0	0	0	0	0	0	1	3	3	3	2	0	0	1	1	1	1	0	0
160th Special Operations Aviation																							
47	**160th SOAR (Airborne)**	Fort Campbell, Kentucky	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0
48	1-160th SOAR (Airborne)	Fort Campbell, Kentucky	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0
49	2-160th SOAR (Airborne)	Fort Campbell, Kentucky	0	<1	<1	<1	<1	<1	0	0	<1	1	1	1	<1	0	1	1	1	1	1	1	1
50	3-160th SOAR (Airborne)	Hunter AAF, Georgia																					
51	4-160th SOAR (Airborne)	Fort Campbell, Kentucky																					
244th Avn Brigade (USAR)																							
52	**244th Theater Avn Bde (USAR)**	Fort Sheridan, Illinois																					
53	2-228th		1	1	2	2	2	1	1	1	1	2	2	2	1	1	1	1	2	2	2	1	1
National Guard Aviation Brigades																							
54	28th AD Avn Bde	Annville, Penn.																					
55	29th ID (Light) Avn Brigade	Aberdeen Proving Ground, Maryland																					
56	38th ID Avn Bde	Shelbyville, Indiana	0	1	3	4	4	2	0	0	3	5	5	4	2	0	0	0	2	1	1	0	0
57	34th Avn Bde	St. Paul, Minnesota	0	1	1	1	1	0	0	0	1	3	2	2	3	0	0	1	2	1	1	2	0

Table E1 (cont'd).

			Ground icing cancellations							Actual/forecast icing cancellations							Flight disruptions as a result of unexpected icing						
			0=never; 1=1–5%; 2=6–10%; 3=11–25%; 4=26–50%; 5=>50%																				
ID #	**Organization**	**Location**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
Other units																							
58	4-123rd Avn Regt	Fort Wainwright, Alaska	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	1	1	1	1	0
59	12th AVN Battalion, MDW	Fort Belvoir, Virginia	do not track																				
60	1-222nd Avn Regt	Fort Eustis, Virginia	1	2	3	3	3	2	1	1	2	3	3	3	2	1	1	1	1	1	1	1	1

Flight Operations Comments

Experience

4. Some flights cancelled (minimal); missions/mission times adjusted.

6. No in-flight icing experience.

10. I have over 10 years flying the CH47D (+1600 hours). This a/c is poorly equipped to handle any icing and is limited to light icing only.

12. Icing has little to no impact on operations in central Germany.

20. In-flight/ground. Homestation/Schweinfurt/Kosovo/Bosnia.

28. Icing is almost always prevalent during the winter months in Europe. Most of our flying is for maintenance test flights. We are mostly restricted by cloud heights/ceilings for our mission.

38. Occasional icing on windscreen, engine inlet screen, and blade tips.

42a. We are a fixed-wing unit flying at 20,000 plus with deice and anti-ice. Flights are cancelled in summer months during monsoon season.

44. Several PCs surveyed with at least three years of Fort Drum winters. [Included copy of 1-10 Avn weekly flight schedule trends.]

45. Have never flown in icing conditions.

46. Typically not a big factor because of our restriction on flying in icing conditions. If icing is forecasted, the flights are typically (always) cancelled prior to departure if the icing will affect the profile to be flown.

49. Minimal.

53. Ground icing issues are addressed by our host facility JRB NAS Willow Grove, PA. We could use portable aircraft deicing equipment. We try to hangar all of our a/c in winter, but hangar size is limited.

56. Experienced light–moderate icing during heavier-than-forecast IMC causing loss of a/c performance. Required ATC to give lower altitude to stop buildup. Experienced asymmetrical shedding and vibration. Another time, had to follow another a/c for navigation due to heavy snow and ice accumulation on windscreen.

59. Do not track missions cancelled or delayed by weather.

60. Do not fly; schedule a/c.

APPENDIX F. RESPONSES TO AIRCRAFT AND GROUND MAINTENANCE QUESTIONNAIRE

This information was provided by respondents to the aircract and ground maintenance questionnaire (Part F). Each unit's identification number is used consistently throughout Appendices C through G.

Table F1. Potential increase in flight readiness with availability of deicing facility.

				Increase in flight readiness with deicing facility					
ID #	**Organization**	**Location**	**Aircraft**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
1	SHAPE Flight Detachment	Cheves, Belgium	UH-60A Commander-in-Chief Black Hawks	L	L	L	L	L	L
2	ODCSCPS	Heidelberg (Unit 29351) Germany							
3	HQ US EUCOM FLIGHT DET.	Stuttgart, Germany	C-12 [3 ea], UH-1 [5 ea]	L	L	L	L	L	L
11th Avn Brigade									
4	11th Aviation regiment	Illesheim, Germany	AH-64A	L	N/A	M	M	L	L
5	2-6 Cavalry Squadron (ATK)	Illesheim, Germany	AH-64A	blank	L	L	L	blank	blank
6	6-6 Cavalry Squadron	Illesheim, Germany	AH-64A	L	L	L	L	L	L
12th Avn Brigade									
7	12th Aviation Brigade	Wiesbaden, Germany							
8	3-58th Avn Regt (ATC)	Wiesbaden, Germany							
9	5-158th Avn Regt (CAB)	Giebelstadt, Germany	UH-60A	L	L	L	L	L	L
10	F-159th (MHC)	Giebelstadt, Germany	CH-47D	H	H	H	M	L	L
1st Armored Division									
11	4th Aviation Brigade, 1st AD	Hanau, Germany	AH-64, UH-60, EH-60, OH-58D	L	L	L	L	L	L
12	1-1 Cavalry Squadron	Buedingen, Germany	OH-58D(I)	L	L	L	L	L	L
13	1-501st (ATK)	Hanau, Germany	AH-64, UH-60, OH-58D; no CH-47D	L	M	H	H	L	L
14	2-501st Avn Regt (GSAB)	Hanau, Germany							
15	127th ASB	Hanau, Germany							
1st Infantry Division									
16	4th Combat Aviation Brigade	Ansbach, Germany							
17	1-1st Avn Regt (ATK)	Katterback, Germany							
18	2-1st Avn Regt (GSAB)	Katterback, Germany	UH-60A/L, EH-60	H	H	H	H	M	M
19	601st Division Avn Spt Bn	Katterback, Germany							
20	1-4 Cavalry Squadron	Schweinfurt, Germany	OH-58D(I)	blank	L	L	L	blank	blank

Table F1 (cont'd).

				Increase in flight readiness with deicing facility					
ID #	**Organization**	**Location**	**Aircraft**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
21st Theatre Command									
21	2-502 Aviation Battalion	Mannheim, Germany	UH-60; OH-58 occasionally	L	L	L	L	L	L
USAREUR									
22	AFOD	Heidelberg, Germany							
23	HQ USAREUR DCSOPS AVN	Heidelberg, Germany							
24	7th ATC Detachment	Grafenwöhr, Germany							
V Corps									
25	421st MEDEVAC Battalion	Wiesbaden, Germany (a)	UH-60A (Medevac configuration)	L	L	L	L	blank	blank
		(b)	UH-60A (Medevac configuration)	blank	blank	blank	blank	blank	blank
		(c)		L	M	M	M	L	L
26	1st Military Intelligence Battalion	Wiesbaden, Germany							
27	V Corps Aviation G3 (AVN)	Heidelberg, Germany							
28	7-159th Avn Regt (AVIM) (COSCOM)	Illesheim, Germany	UH-60A, CH-47D	10%	10%	10%	10%	blank	blank
2nd Infantry Division									
29	**2nd Avn Brigade (2nd ID)**	Camp Stanley, Korea							
30	1-2nd Avn Regt (Attack)	Camp Page, Korea							
31	2-2nd Avn Regt (ASLT)	Camp Stanley, Korea (a)	UH-60A/L, EH-60A	H	H	H	L	L	L
		(b)	UH-60A/L, EH-60A	L	M	H	M	L	L
32	4-7th Cavalry Squadron	Camp Garry Owen, Korea							
8th Army									
33	HQ 8th US Army	Seoul, Korea							
34	52nd Medical Evacuation Bn	Seoul, Korea							
35	**17th Aviation Brigade**	Seoul, Korea	blank	L	L	M	L	L	L
36	164th ATS Group	Yong-San, Korea							

Table F1 (cont'd). Potential increase in flight readiness with availability of deicing facility.

				Increase in flight readiness with deicing facility					
ID #	**Organization**	**Location**	**Aircraft**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
37	1-52nd Avn Regt (CAB)	K-16, Seoul AB, Korea (a)	H-60	n/a	n/a	n/a	n/a	n/a	n/a
		(b)	UH-60A	L	M	M	M	L	L
38	2-52nd Avn Regt (MHB)	Camp Humphreys, Korea							
39	**6th Cavalry Brigade**	Camp Humphreys, Korea							
40	1-6 Attack	Camp Eagle, Korea	AH-64A	L	L	M	M	L	L
41	3-6 Cav	Camp Humphreys, Korea							
INSCOM									
42	3rd MI BN (AE)	Camp Humphreys, Korea	RC-7B, RC-12D/H	N/A	have deice facility				
10th Mountain Division									
43	**10th Aviation Brigade**	Fort Drum, New York							
44	1-10th Avn Regt (Attack)	Fort Drum, New York	OH-58D(I)	L	M	M	M	L	L
45	2-10th Avn Reg (Assault)	Fort Drum, New York	UH-60A/L	L	M	H	H	H	M
46	3-17th Cav Sqdn	Fort Drum, New York	OH-58D(I)	L	L	L	L	L	L
160th Special Operations Aviation									
47	**160th SOAR (Airborne)**	Fort Campbell, Kentucky	AH-6, MH-6, UH-60L, UH-60K, MH-47E	L	L	M	L	L	L
48	1-160th SOAR (Airborne)	Fort Campbell, Kentucky	MH-60K/L, A/MH-6J	M	M	M	M	M	M
49	2-160th SOAR (Airborne)	Fort Campbell, Kentucky	MH-47 E	L	L	L	L	L	L
50	3-160th SOAR (Airborne)	Hunter AAF, Georgia							
51	4-160th SOAR (Airborne)	Fort Campbell, Kentucky	MH/AH-6, MH-47E, MH-60L/K	L	L	L	L	L	L
244th Avn Brigade (USAR)									
52	**244th Theater Avn Bde (USAR)**	Fort Sheridan, Illinois							
53	2-228th		C-12R, CBE-20	L	M	M	M	L	L
National Guard Aviation Brigades									
54	28th AD Avn Brigade	Annville, Pennsylvania							

Table F1 (cont'd).

				Increase in flight readiness with deicing facility					
ID #	**Organization**	**Location**	**Aircraft**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
55	29th ID (Light) Avn Brigade	Aberdeen Proving Ground, Maryland							
56	38th ID Avn Brigade	Shelbyville, Indiana	**UH-60A**	M	H	H	H	M	L
57	34th Avn Brigade	St. Paul, Minnesota	UH-1, AH-1, OH-58	L	L	L	L	L	L
Other units									
58	4-123rd Avn Regt	Fort Wainwright, Alaska	CH-47D, UH-60A	L	M	H	M	L	L
59	12th AVN Battalion, MDW	Fort Belvoir, Virginia	C-12		H	H	H	blank	blank
60	1-222nd Avn Regt	Fort Eustis, Virginia	UH-60A, UH-1H, UH-1V	L	L	L	L	L	L

Table F2. Aircraft groundings due to ground or in-flight icing.

ID #	Never	Rarely	Monthly in winter	Weekly in winter	Comments
1		X			
3		C-12		UH-1	
4				X	
5		X			Ceiling and visibility are usually associated with this type of wx.
6		X			
9		X			
10			X		
11		X			
12		X			
13		X			
18		X			
20		X			
21		X			
25a		X			
25b	X				
25c	X				
28		X			
31a		X			
31b		X			
35		X			

Table F2 (cont'd).

ID #	Never	Rarely	Monthly in winter	Weekly in winter	Comments
37a		X			
37b				X	
40				Bi-weekly	
42		X			
44		X			
45					Daily
46			X		
47		X			
48			X		
49		X			
51		X			
53				X	
56				X	a/c are moved into the hangar daily to defrost during periods of snow, ice. Missions are rarely cancelled as a result of icing.
57		X			
58				X (Jan, Feb)	
59		X			
60		X			

Table F3. Protection from snow/ice accumulation for aircraft on ground.

ID #	Hangars	Covers	Anti-ice fluids	Other/comments
1	X			
3	UH-1	UH-1		
4	X			Very limited hangar space.
5	X	X		
6	X	X		
9	X	X		
10		X		Rotor head and engine inlet covers
11	X	X		
12	X	X		
13		X		
18	X	X		
20	X			
21	X			
25a	X	X		
25b	X			
25c	X	X	X	
28		X		
31a				Most are left outside.
31b	X			
35	X			Some hangars; most in the open.
37a				Not protected.
37b				Unprotected. Moored on flight line, no covers.
40	X	X		Canopy covers when available—blades are not covered. There is not enough hangar space for all our a/c.

Table F3 (cont'd).

ID #	Hangars	Covers	Anti-ice fluids	Other/comments
42			X	On-site deice truck operated/maintained by contractor. Anti-ice fluids prescribed by maintenance manuals per a/c manufacturer.
44	X			
45				The 2-10th Aviation Regiment is assigned 38 UH-60 a/c and has the organic capability to hangar 18 a/c on a daily basis. During winter months, 18 airframes are hangared each night, an additional 4–6 a/c are hangared in the C-10 Hangar (AVIM Maintenance Company), leaving an average of 16 a/c “outside" overnight.
46	X			
47	X			
48	X	X	X	AGPU and buddy hose for Black Hawks.
49		X		Head covers are installed.
51	X			If not in hangar, and it gets snow or ice, it must be brought inside for thawing or ice and snow removal
53	X			
56	X			We try to maximize the number of flyables stored in the hangar during winter.
57	X			
58	X	X		
59	X		X	
60	X			

Table F4. Are aircraft deiced?

ID #	Yes	No; snow/ice disappears naturally	Comments
1		X	
3		?	
4	X		Deiced in hangar.
5	X		
9	X	X	Combination of manual and natural deice, i.e., hand, broom, Buddy hose
10			Limited to hangar space w/in the unit
11		X	
12		X	
13	X		
18	X		All a/c are deiced prior to flight, by heated air.
25a	X		
25b			a/c stored in hangar
25c			a/c are typically moved into the hangar the night prior to their flight. For emergency response a/c, a/c are continually brushed of accumulating snow and are sprayed with anti-ice fluid if necessary. (Using fluid is not the preferred method because of potential damage to electrical components and other materials.)
28			Try to hangar a/c.
31a	X	X	
31b			A/C must deice in hangers.
35	X		
37a		X	

Table F4 (cont'd).

ID #	Yes	No; snow/ice disappears naturally	Comments
37b	X		
40	X		Manually deiced with snow removed by hand and melted via heat application.
42	X		Deiced if outside or pulled into hanger to deice.
45			a/c which remain outside have covers placed over the exposed flight controls as well as the mandatory fly away gear which protects sensitive openings on the a/c. Blade surfaces and the majority of the airframe remain exposed. Deice fluids are not used to deice airframes prior to flight.
48	X		
51			If not in hangar, and it gets snow or ice, it must be brought inside for thawing or ice and snow removal.
56	X		We do not use any deicing agents, just defrosted in the hangar.
57	X		In hangar.
58	X		
59	X		
60		X	Disappears naturally, or hangared.

Table F5. Pre-flight deicing, and time required.

ID #	
4	Deiced by hangaring a/c day prior.
5	2 hours.
9	Manually; 30–45 minutes.
10	Rotor blades 3–4 hrs and airframe 2–3 hrs, for a total of 6 hrs.
11	Not done.
13	Brought into hangar—6 hours (Fluid and heater didn't work.)
18	a/c are hangared prior to flight 12–24 hours. Pre-flight is accomplished in the hangar.
20	Naturally or with AGPU heat; depending on amount of ice, 1–4 hrs.
25a	30–45 min. using heat from AGPU.
25b	N/A
25c	a/c are typically moved into the hangar the night prior to their flight. For emergency response a/c, a/c are continually brushed of accumulating snow and are sprayed with anti-ice fluid if necessary. (Using fluid is not the preferred method because of potential damage to electrical components and other materials.)
28	Herman Nelson heater; 4 hours.
31a	In a/c hangars; at least 1 hour.
31b	a/c must deice in hangers, 2–3 hours.
35	a/c allowed to warm in hangars, approx 4 hours.
37b	Snow is swept from a/c with a broom. Ice is melted with Herman Nelson blowers.
40	Manual; AGPU exhaust; natural.
42	Aircraft maintenance contractor/ pilot preflight. 30–40 minutes.
44	Manual removal of snow. Natural removal (melting) of ice.
45	Routinely, a/c identified for next day missions are pre-positioned inside the hangar the night prior to allow adequate time for the a/c to heat soak, deice, and are pre-flighted prior to moving outside just prior to flight. A significant effort is required to hangar a/c. Our unit SOP dictates a seven-man team requirement to maneuver a/c in and out of our extremely congested hangar to avoid damaging a/c. 1 hour per workday is dedicated to simply maneuvering scheduled a/c into and out of the hangar each workday. Fort Drum experiences extreme cold weather conditions during the winter months. Icing conditions begin as early as October and remain late into April. During this time a/c outside are exposed to extreme cold (minus 30 F) and are exposed to intense periods of snowfall and high winds. Simple engine flush requirements in sub-zero degree weather become impossible maintenance events. Severe weather conditions at Fort Drum severely degrade the 2-10th Aviation Regiment's ability to perform maintenance operations and therefore degrade the unit's ability to support training and mission requirements. Use of organic deice systems (AGPU) cannot adequately manage with the extreme cold experienced at Fort Drum.

Table F5 (cont'd).

ID #	
48	Mostly heated hangar, 2 hours. Sometimes deice fluid when hangar isn't available.
51	If not in hangar, and it gets snow or ice, it must be brought inside for thawing or ice and snow removal.
53	Hangar a/c until snow or ice melts.
56	Depending on the amount of icing, anywhere from 1–3 hours, counting moving the a/c in and out.
57	In hangar.
58	Brooms, brushes and heaters; 2.5 hours.
59	Visual, once.

Table F6. Deicing damage to aircraft. [1=negligible, 5=significant]

ID #	Rating	Comments
4	2 to 3	Due to blade damage moving a/c in hangar.
5	1	
9	1	
10	2	
11	None	
12	1	
13	1	
18	1 to 2	Minor damage, usually due to cover damage.
20	5	Up to 5 if someone isn't careful with AGPU heat. It can damage the leading edge material on the blade.
25a	1	
25b	0	
25c	1	
28	1	
31a	1	
31b	None	
35	1	
37b	2.5	
40	2	Damage caused due to exposure in blades. Snow melts, water gets into blades, freezes, and expands.
42	None	
44	3	
45	5	The lack of hangar space seriously degrades the unit's ability to deice a/c. a/c that remain outside overnight often fail to pass preflight inspections due to severe weather conditions, control surfaces frozen, PCL levers frozen and upon run up high pressures often affect sensitive pressure switches, valves and seals. The extreme cold environmental conditions associated with Fort Drum significantly affect this unit's ability to perform unit level maintenance and affect the unit's overall readiness rates.
48	1	
51	1	

Table F6 (cont'd). Deicing damage to aircraft. [1=negligible, 5=significant]

ID #	Rating	Comments
53	1	
56	1	
57	1	
58	1	
59	1	

Comments on increase in flight readiness

4. Dec is N/A; no fly APZ.

5. Indicates no increase in readiness in Nov, Mar, Apr.

20. Indicates no increase in readiness in Nov, Mar, Apr. Note asks, What type of deicing facility?

25a. Indicates no increase in readiness in Mar and Apr.

25b. No entries.

28. Moderate increase is specified as 10%.

37a. No readiness entries; instead, comment that “Korea does not have ground ice problems.”

42. N/A–have a deice facility/equipment.

40. Hangar–anti-ice.

57. Low increase in readiness simply because we can hangar all a/c in our facility.

59. Indicates no increase in readiness in November, March, and April.

Respondents’ experience with icing

3. Very little as UH-1 has minimal deice capability we avoid icing whenever possible.

5. Some light icing conditions at Carson and Germany.

6. Ice rarely accumulates in this region. We have delayed a few flights due to icing on main rotor blades. It usually melts within a few hours.

9. Three years maintenance management in Germany.

10. CH47D rotor blades ice up, which takes a long time to remove. Also from state to state EPA will or will not let you use one or all the differing deicing fluids. Mostly each state has its own requirements even though the federal government [sic]. We in the field need something portable to take on deployments and a fixed base deicing machine like the civilian airline uses. I’ve seen in the past the Army try to buy something that works in the field but doesn’t work very well at a fixed base. There are a lot of off-the-shelf deicing machines that the Army could buy! I don’t think that one piece of equipment works best for every possible environmental condition. I would like to see a fixed base deicing

machine that could handle deicing 16 ALOT(?) a day and also a small portable deicing machine for deployments.

11. 1998: UH-60, Fort Monroe to Pentagon VIP flight. Had to abort between Richmond and DC. Return VFR to Monroe. Misforecast moderate to heavy rime icing in flight. All systems working, i.e., inlets, blades, windshield.

12. Icing has little to no impact on operations in Central Germany.

13. None.

18. The UH-60s in our flight have problems with in-flight icing conditions. The blade deice system is intermittent (?) and restricts operations from time to time. On ground, icing problems are time consuming, but have never been a grounding or no-flight result.

20. Missed missions in Kosovo; malfunctioning weapons; rockets frozen in the tubes.

25a. Significant icing during deployment from home station. Slowed down the OPTEMPO, but did not stop very many missions.

25b. 236th MED Co. At this time we have not experienced any situations here with deicing problems due to the fact that we have readily available hangar space to store the a/c during inclement weather. Though upon deployment, problems may accrue in environments without proper facilities.

25c. If deice equipment is turned on and checked with each 10-hour as a preventive measure (even in the summer months) and deice components are cleaned thoroughly prior to freezing each year (Aug/Sep), then deice systems on the UH-60 rarely fail. We practice this at the 45th. I find that covers are one of the least preferred methods since wet covers freeze to the airframe. Blade covers are very impractical. Windshield covers and engine covers are semi-helpful. I would recommend using moneys intended for deice facilities to build larger, more spacious hangars. Hangaring a/c prior to flight is undoubtedly the best method and keeping emergency response a/c hangared continuously is also preferred. The best field method is to continually clear accumulating snow from the a/c. However, this is very manpower intensive. [I have even begun work on a 2028 for the deice maintenance procedures—I believe Sikorsky has this method in the S-70 manual. I don't know why the Army hasn't adopted it.]

28. Damage to blades on CH47D.

31a. None.

31b. None in flight.

37a. Spent three years at Fort Drum—they need a deicer.

37b. Most damage occurs to windshields cracking where the F.A.T. gage protrudes and is often hit with broom sweeping snow off. Main rotor blades are also damaged when personnel try to break the ice on them by hitting the ice with their hand or another object. This dents the skin of the rotor.

40. Icing and elements are best dealt with through prevention, versus elimination. We have an extra hangar on post whose space is unavailable to us. Keeping airframes from unnecessary exposure to the elements is the best prevention for damage.

42. We experience icing weekly in the winter months in Korea. Our aircraft are flown within the aircraft operation manual constraints. On occasion we must exit icing conditions due to excessive buildup of ice, but it is not significant to readiness. Our deice facility/equipment is sufficient for continued operations.

44. Not a significant factor in garrison where our a/c are constantly hangared. Potential icing/snow accumulation inherent during field operations poses the greatest problem. Is there a piece of equipment that's field transportable, safe for the environment, and cost-effective to operate and maintain?

45. a/c which remain inside and are immediately flown upon being "pushed outside" perform well. The deice system on the UH-60 works well and as described in the operator's manual.

47. Very little here at Fort Campbell, Kentucky.

48. We deploy to many extreme cold environments. The primary method of deice is a warm hangar. After that we'll use deice fluid and then heat sources. Covers are used as a preventative method, however, we don't have any that cover the entire nose or aircraft. The in-flight icing drops our MH-6s and above mod icing for the MH-60s. A mobile deice unit would work best.

49. I think if the 47 fleet [MH-47E] had rotor blade deice/anti-icing capabilities like the UH60 fleet, it would enhance the fleet readiness. We never know where in the world we could be called to, prior prep is the answer.

51. When the weather is bad enough to require deicing, it is usually too bad to fly, so we don't need deicing.

53. Need portable a/c deicing equipment.

56. Our a/c are equipped with deice equipment; about 70% of these systems are operational. I look at these systems as backups to get me out of icing trouble if it is encountered and would not intentionally fly into known moderate icing. My experience has been that if you leave the deice equipment turned on long enough, something will fail.

57. Numerous. We allow UH-1 a/c to fly in forecast light icing within 25 km only of our base of operations. If this rule did not exist, we would cancel a lot of flights in December and March–April time frame.

58. In January cold weather stops us from flying due to –50 degrees F or lower.

59. 14 years airfield service. All personnel trained to deice a/c. Most a/c kept in hangars, approximately 3 to 4 a/c per year.

60. Some flights in icing, low to moderate.

APPENDIX G. RESPONSES TO WEATHER SUPPORT QUESTIONNAIRE (PARTS A THROUGH C), BY UNIT.

Each unit's identification number is used consistently throughout Appendices C through G.

Table G1. Occurrence and duration of actual or forecast icing events.

			Ice or snow as ppt events							In-flight icing forecast or reported							Duration of forecast in-flight icing *						
			0=never; 1=1–3 days; 2=4–7 days; 3=8–12 days; 4=13–18 days; 5=19–25 days; 6=26–31 days														*0=<3 hrs; 1= 3–6 hrs; 2=7–12 hrs; 3=13–18 hrs; 4=19–24 hrs; 5=1–1.5 days; 6=>1.5 days						
ID #	**Organization**	**Location**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
1	SHAPE Flight Detachment	Cheves, Belgium	USAF, Sembach Air Base, Germany																				
2	ODCSCPS	Heidelberg (Unit 29351) Germany																					
3	HQ US EUCOM Flight Det	Stuttgart, Germany																					
11th Aviation Brigade																							
4	11th Avn Regiment	Illesheim, Germany	0	1	2	2	2	1	1	0	2	4	4	4	2	0	3	5	6	6	6	6	3
5	2-6 Cavalry Squadron (ATK)	Illesheim, Germany	0	1	1	1	1	1	0	1	2	3	4	4	3	1	1	2	5	5	5	2	1
6	6-6 Cav Squadron	Illesheim, Germany	0	1	1	1	1	1	0	1	2	3	4	4	3	1	1	2	5	5	5	2	1
12th Aviation Brigade																							
7	12th Avn Brigade	Wiesbaden, Germany																					
8	3-58th Avn Regt (ATC)	Wiesbaden, Germany																					
9	5-158th Avn Regt (CAB)	Giebelstadt, Germany	0	1	2	2	2	1	1	1	3	4	4	4	3	3	3	4	5	5	5	4	4
10	F-159th (MHC)	Giebelstadt, Germany	0	1	2	2	2	1	1	5	5	6	6	6	5	5	2	3	6	6	6	3	2
1st Armored Div																							
11	4th Avn Bde, 1st AD	Hanau, Germany																					
12	1-1 Cav Squadron	Buedingen, Germany	No internal weather support																				
13	1-501st (ATK)	Hanau, Germany	0	0	2	4	3	3	1	0	1	3	4	3	1	0	0	1	3	3	3	1	0

Table G1 (cont'd). Occurrence and duration of actual or forecast icing events.

			Ice or snow as ppt events							In-flight icing forecast or reported							Duration of forecast in-flight icing *						
			0=never; 1=1–3 days; 2=4–7 days; 3=8–12 days; 4=13–18 days; 5=19–25 days; 6=26–31 days														*0=<3 hrs; 1= 3–6 hrs; 2=7–12 hrs; 3=13–18 hrs; 4=19–24 hrs; 5=1–1.5 days; 6=>1.5 days						
ID #	Organization	Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr
14	2-501st Avn Regt (GSAB)	Hanau, Germany																					
15	127th ASB	Hanau, Germany																					
1st Inf Div																							
16	4th Combat Aviation Brigade	Ansbach, Germany																					
17	1-1st Avn Regt (ATK)	Katterback, Germany																					
18	2-1st Avn Regt (GSAB)	Katterback, Germany	1	2	2	3	3	2	1	3	3	4	4	4	3	2	3	3	3	3	3	2	1
19	601st Division Avn Spt Bn	Katterback, Germany																					
20	1-4 Cavalry Squadron	Schweinfurt, Germany	1	1	3	3	3	3	2	1	2	2	3	4	2	1	1	1	1	2	3	2	0
21st Theatre Command																							
21	2-502 Avn Bn	Mannheim, Germany	"centralized"																				
USAREUR																							
22	AFOD	Heidelberg, Germany																					
23	HQ USAREUR DCSOPS AVN	Heidelberg, Germany																					
24	7th ATC Detachment	Grafenwöhr, Germany																					
V Corps																							
25	421st MEDEVAC Battalion	Wiesbaden, Germany	0	1	1	2	1	1	1	2	2	3	4	4	4	3	0	1	2	2	3	2	1
26	1st Military Intelligence Battalion	Wiesbaden, Germany																					

Table G1 (cont'd).

			Ice or snow as ppt events							In-flight icing forecast or reported							Duration of forecast in-flight icing *						
			0=never; 1=1–3 days; 2=4–7 days; 3=8–12 days; 4=13–18 days; 5=19–25 days; 6=26–31 days														*0=<3 hrs; 1= 3–6 hrs; 2=7–12 hrs; 3=13–18 hrs; 4=19–24 hrs; 5=1–1.5 days; 6=>1.5 days						
ID #	**Organization**	**Location**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
27	V Corps Aviation G3 (AVN)	Heidelberg, Germany																					
28	7-159th Avn Regt (AVIM) (COSCOM)	Illesheim, Germany																					
2nd Inf Div																							
29	**2nd Aviation Brigade (2nd Inf Div)**	Camp Stanley, Korea																					
30	1-2nd Avn Regt (Attack)	Camp Page, Korea																					
31	2-2nd Avn Regt (ASLT)	Camp Stanley, Korea (a)	1	2	2	3	3	2	1	2	3	3	4	4	3	2	0	1	1	2	2	1	0
		Camp Stanley, Korea (a)	0	1	2	3	3	1	1	0	1	2	3	3	1	1	none	0	1	2	2	1	0
32	4-7th Cavalry Squadron	Camp Garry Owen, Korea																					
8th Army																							
33	HQ 8th US Army	Seoul, Korea																					
34	52nd Medical Evacuation Bn	Seoul, Korea																					
35	**17th Aviation Brigade**	Seoul, Korea																					
36	164th ATS Group	Yong-San, Korea																					
37	1-52nd Avn Regt (CAB)	k-16, Seoul AB, Korea	0	1	3	3	2	1	0	3	3	3	3	3	3	3	6	6	6	6	6	6	6
38	2-52nd Avn Regt (MHB)	Camp Humphreys, Korea	0	1	1	1	2	1	0	1	1	2	2	2	1	1	2	4	4	4	4	2	2

Table G1 (cont'd). Occurrence and duration of actual or forecast icing events.

			Ice or snow as ppt events							In-flight icing forecast or reported							Duration of forecast in-flight icing *						
			0=never; 1=1–3 days; 2=4–7 days; 3=8–12 days; 4=13–18 days; 5=19–25 days; 6=26–31 days														*0=<3 hrs; 1= 3–6 hrs; 2=7–12 hrs; 3=13–18 hrs; 4=19–24 hrs; 5=1–1.5 days; 6=>1.5 days						
ID #	Organization	Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr
39	**6th Cavalry Brigade**	Camp Humphreys, Korea																					
40	1-6 Attack	Camp Eagle, Korea	0	1	1	1	1	0	0	0/1	1	1	1	1	0	0	blank	2	2	2	2	blank	blank
41	3-6 Cav	Camp Humphreys, Korea																					
INSCOM																							
42	3rd MI BN (AE)	Camp Humphreys, Korea	0	1	1	1	2	1	0	2	2	2	2	2	2	1	2	4	4	4	4	2	2
10th Mountain Division																							
43	**10th Aviation Brigade**	Fort Drum, New York																					
44	1-10th Avn Regt (Attack)	Fort Drum, New York	1	2	4	4	3	3	2	1	2	4	4	3	3	2	5	6	6	6	6	6	5
45	2-10th Avn Reg (Assault)	Fort Drum, New York	0	4	5	5	5	4	2	1	3	5	5	5	4	2	2	3	5	6	6	6	2
46	3-17th Cav Sqdn	Fort Drum, New York	1	2	4	4	3	3	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4
160th Special Operations Aviation																							
47	**160th SOAR (Airborne)**	Fort Campbell, Kentucky	1	1	2	2	2	1	1	1	2	2	3	2	1	1	2	3	3	5	5	1	0
48	1-160th SOAR (Airborne)	Fort Campbell, Kentucky																					
49	2-160th SOAR (Airborne)	Fort Campbell, Kentucky	0	1	1	1	1	1	0	1	1	2	2	2	1	1	blank	blank	6	6	6	4	blank
50	3-160th SOAR (Airborne)	Hunter AAF, Georgia																					

Table G1 (cont'd).

			Ice or snow as ppt events							In-flight icing forecast or reported							Duration of forecast in-flight icing *						
			0=never; 1=1–3 days; 2=4–7 days; 3=8–12 days; 4=13–18 days; 5=19–25 days; 6=26–31 days														*0=<3 hrs; 1= 3–6 hrs; 2=7–12 hrs; 3=13–18 hrs; 4=19–24 hrs; 5=1–1.5 days; 6=>1.5 days						
ID #	Organization	Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Jan	Feb	Mar	Apr
51	4-160th SOAR (Airborne)	Fort Campbell, Kentucky																					
244th Avn Brigade (USAR)																							
52	**244th Theater Avn Brigade (USAR)**	Fort Sheridan, Illinois																					
53	2-228th		1	2	3	3	2	1	3	4	6	6	6	4	3	1	3	6	6	6	4	2	
National Guard Aviation Brigades																							
54	28th AD Avn Bde	Annville, Pennsylvania																					
55	29th ID (Light) Avn Brigade	Aberdeen Proving Ground, Maryland																					
56	38th ID Avn Bde	Shelbyville, Indiana	1	2	4	4	3	3	2	5	5	5	5	5	5	5	blank	blank	blank	blank	blank	blank	blank
57	34th Avn Bde	St. Paul, Minnesota	n/a																				
Other units																							
58	4-123rd Avn Regt	Fort Wainwright, Alaska	3	3	3	2	2	2	2	3	3	3	2	3	3	3	4	4	4	4	4	4	4
59	12th AVN Battalion, MDW	Fort Belvoir, Virginia	0	1	1	2	2	1	0	3	4	4	4	4	3	2	1	2	3	3	3	2	1
60	1-222nd Avn Regt	Fort Eustis, Virginia	0	0	1	1	1	0	0	0	1	2	3	3	0	0	n/a	n/a	1	2	2	n/a	n/a

APPENDIX H. BLADE DEICE PROCEDURES (COURTESY OF DCD-AVIATION)

The following information was provided by Mr. Tom Foster, DCD, Fort Rucker, Alabama.

1. Purpose: The purpose of this memorandum is to answer unit questions about blade deice in cold climates. It is intended to review/increase awareness of current deicing procedures/issues.

2. Requests to use Air Force or commercial equipment, including Landoll deicer boom truck on rotary wing aircraft, are not authorized. Army M17 Sanator, lightweight decon system (NSN 4230-01-251-8702) is not approved. System operates at 100 psi through a high-pressure nozzle. These systems work on fixed-wing aircraft due to the wing design where bearing surfaces are not exposed to deice fluids. Helicopter bearings and their lubricant will experience damage due to high-pressure washing or thinning of the grease by the deice fluid. Other surfaces and components can be damaged by exposure to deice solutions. Read your specific manual for detailed instructions before attempting to deice any aviation equipment. No high-pressure systems of any type are authorized for this purpose.

3. Units have a great number of informational sources for advice on this subject. Your specific aircraft manual is the primary reference. It takes priority over general-use manuals and PS magazine articles. A PS magazine article dated November 1995 gives the following general references:

a. TM 1-1500-204-23-1, Section 10-2, for freezing weather maintenance information.

b. TM 1-1500-204-23-1, Section 1-86, which provides information about deicing fluids and heating instructions.

c. TM 1-1500-344-23, Table 3-2, for dilution instructions for use as a low-temperature cleaner.

d. TM 1-1500-344-23, paragraphs 3-5.3.7C and 3-5.3.7F, give instructions for heating detergent with deicing fluid for cleaning and deicing fluid for rinsing cleaning fluid from your aircraft.

4. General cautions

a. Anti-icing and deicing fluids are toxic. They can irritate skin, cause burns, and contaminate water sources. In case of contact flush skin or eyes with water for at least 15 minutes. Get medical attention for eye contact or suspected ingestion. Note: Use/runoff should not be allowed to contact water sources. A containment area should be utilized if possible.

b. Rapid oxidation and fire can occur when glycol solutions come in contact with a short or components carrying direct current (DC).

c. Heated deice fluids will damage plastic windows, covers, boots, bearings, and greases. Avoid all contact with these surfaces.

d. Do not allow isopropyl alcohol or other alcohol solutions to contact acrylic canopies.

e. Do not spray alcohol-based fluid on magnesium components.

f. TM 55-1520-240-23-10 (U.S. Army 1982), paragraph 1-86, and Chapter 10, Arctic Maintenance, address cold-weather operations beyond blade deicing, to include covering openings, removal of snow and ice from inlets, removal of bypass panels, freeing frozen compressor rotors, battery storage in low temperatures, avoiding damage to seals and moving shafts from ice and dirt, and ice removal from windshields. These procedures should be used in coordination with your specific aircraft instructions.

5. Summary of general options in order of preference

a. The (#1) preferred method for deicing aircraft is to avoid icing conditions by storing MEDEVAC, attack, and other critical mission aircraft in hangars or clam-shelter-type temporary facilities. When icing conditions are predicted, temporary covers over blades may be used to prevent accumulation.

b. The (#2) preferred method for deicing aircraft stored outside where ice has collected on them is to bring the aircraft inside a shelter or facility to thaw.

c. The (#3) preferred method for preventing ice buildup or deicing aircraft is to use an available heat source to direct warm air near the blades. Caution: This method poses risks to the aircraft components. Exposure to extreme variations in temperature can crack windshields and cause debonding problems with composite materials. Air should not be hot. Warm temperatures in the appropriate range will feel warm to a bare hand, but not be uncomfortable to a bare hand held in the airstream for extended periods of time. Commonly available sources of heat include "Herman Nelsons" used at a suitable distance from the aircraft, or an aviation ground power unit (AGPU) using a mixture of exhaust and fresh air.

d. The (#4) preferred method to deice aircraft is to avoid exposure to ice by using portable covers. Caution: This method can cause damage from abrasion produced by rubbing covers or tie-downs. Covers do not work well on damp or wet aircraft where they may actually freeze to the surface we are trying to protect. Do not use makeshift covers in areas with blowing grit or dust.

e. The (#5) method to prevent ice buildup on aircraft blades is to utilize glycol-type deicing fluid by saturating a rag or cloth and wiping the blade surfaces with deicing fluid. This should be done late at night before ice settles on the blades. Caution: Deicing fluid can be detrimental to aircraft wiring and avionics equipment. Read your specific aircraft manuals to fully understand which components and deicing fluids create problems for your systems. Note: This does not work for snow.

f. Use of low-pressure spray deicing procedures using equipment described in TM 1-1500-240-23-1, Chapter 10, is allowed on fixed-wing air craft. Note: This does not work for snow.

g. Spray deicing should not be performed on (in general) rotary wing aircraft. Those rotary wing aircraft without TM instructions shall not spray blades. Deicing of rotary wing aircraft is limited to specific procedures for the various systems. The list below offers a summary of the procedures addressed in the aircraft-specific manual, or additional permissive procedures identified below. Deicing using these procedures should be limited to operationally critical missions, not used for routine or training exercises. Note: This does not work for snow.

6. Aircraft-specific procedures, by systems

a. AH-1; TM 55-1520-236-23, paragraph 1-18, provides instructions for application by hand or using a low-pressure hand pump spray atomizer applied to blade surfaces only. Align each blade to be deiced over open ground or a catch basin. Do not spray over aircraft fuselage. All surfaces should be wiped and no fluid should drip off blade surfaces. Caution: Read specific manual cautions/ instructions. A wide range of damage may result from improper use.

b. AH-64A: No deicing utilizing spray methods. In extreme conditions a clean rag or cloth saturated in deicing compound may be utilized in conjunction with published cautions to wipe the blade surface to impede the formation of new ice. The cloth and blade shall not drip on other surfaces. Protect avionics, electrical connectors, wiring, plastic surfaces, bearings and/or grease-containing bearings from contact with deicing compound. Use physical barriers if needed. Rotation of the blades to minimize possible contact with these surfaces is strongly suggested.

c. CH-47-D: Method of choice is to cover heads and use plastic or other suitable covering for blades. Should blades remain uncovered wipe top surface with a clean rag or cloth saturated in the (glycol) deicing fluid. Should blades experience accumulations of ice, use (keep) rotor head cover in place, protecting head and controls. A low-pressure handheld pump (like a garden sprayer) may be used to spray windshield wiper solution methyl alcohol or deice solution. Start at the root end of the blade and work outward. It is desirable to work fluid under the ice, and allow it to travel down the (drooping) blade to the tip. This will provide the most effective removal of the ice. Cautions for use of alcohol products should be observed.

d. OH-58-C: TM 55-1520-228-23-1, paragraphs 1-15 through 1-20, give instructions for ice removal and cleaning. Deice fluid should be treated like cleaning liquids described in these paragraphs. No contact with sensitive surfaces should occur.

e. OH-58-D: TM 55-1520-248, paragraph 1-4-10, gives instructions for shaking blades to remove ice. Spray of deicing fluid is permitted with (per TM 1-1500-204-23) low-pressure spray or wiping. Aircraft should be watched to ensure immediate wipe-up of melting ice and deicing fluid before it melts and comes into contact with other surfaces. Caution: Read all cautions and instructions. A wide range of damage may result from improper use. Avionics and optics on the OH-58-D are particularly susceptible to damage during this process. Protect them with physical barriers as needed. Do not use alcohol-based solutions on these blades.

f. UH-1: No manual instructions are available. Limited application by hand with a clean saturated cloth as described for the AH-64 is permitted. Application of deice fluid with a low-pressure handheld spray pump as described for AH-1 should be limited.

g. UH-60: TM-1-1500-237-23-1, paragraph 1.15.6 and TM 1-1500-237-10 discuss use of the blade deicing system. Aircraft may utilize wipe or low-pressure spray application of deice fluids to rotor blade surface following the guidance in TM-1-1500-204-23-1 and these instructions. Caution: No bearings, electrical connectors, plastic or elastomeric components should come in contact with the deice fluid.

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14. ABSTRACT

Icing is among aviation's most serious weather hazards because it renders aircraft unflyable before flight and severely reduces aircraft performance within flight. Army aviation is vulnerable to icing, which occurs most frequently at lower altitudes, and which generally has the greatest impact upon small fixed-wing aircraft and helicopters that fly slowly and low. Icing causes mission delays during ground deicing of aircraft and mission cancellations and abortions because of forecast or actual in-flight icing. The common notion, however, is that icing is "not a problem" for Army aviators because they generally "do not fly in icing." This report assesses the effects of icing, both before and during flight, on the ability of Army aviators to accomplish their mission. Interviews with aviation commands, surveys to aviation commands worldwide, and assessment of Army aviation safety records demonstrate the affect of icing and snow on Army aviation.

15. SUBJECT TERMS

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Deicing	Helicopters	Inflight	Mission	Snow

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