AIR FORCE DOCTRINE PUBLICATION 3-59

WEATHER OPERATIONS

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AIR FORCE DOCTRINE PUBLICATION (AFDP) 3-59 WEATHER OPERATIONS

INTRODUCTION TO WEATHER OPERATIONS

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Air Force weather operations directly support conventional and special operations forces of the Department of the Air Force (DAF) and Army.[1] When designated, DAF weather forces also support joint, multinational, and other national agency operations. Weather operations provide a critical piece of situational awareness when a commander is building battlespace awareness of the assigned operational area, throughout the competition continuum. Though information about environmental conditions and its effects (referred to throughout this AFDP as weather and weather effects information) can be applied throughout theater and across the range of operations, weather forces to the military operation being executed, whether at the strategic, operational, or tactical level, should always be tailored.

For the purposes of DAF doctrine, weather is defined as **the physical conditions of the terrestrial and space environment. These conditions include any environmental factors from the surface of the earth up to the ionosphere and outward into space.** Examples include volcanic ash, dust, icing, turbulence, solar flares, and coronal mass ejections**.** This definition was adapted from Joint Publication 3-59, *Meteorological and Oceanographic Operations*.

The enduring principles of weather operations are **accuracy, consistency, relevancy, and timeliness.** Effective weather operations are executed through these overarching principles, along with the functions and processes depicted in the "conceptual model of weather operations." The top half of the figure shows how weather forces **analyze and forecast** the environment through the **collection, analysis, and prediction** of weather data from both Department of Defense (DOD) and non-DOD sources. This weather data and information, used to predict the future state of the environment, are stored in net-centric repositories accessible through end-user systems and web-based interfaces.

[1] Direct weather support to the Army was established via inter-service support agreement based on the National Security Act of 1947. See Air Force Instruction 15-157 / Army Regulation 115-10, *Weather Support and Services for the US Army*.

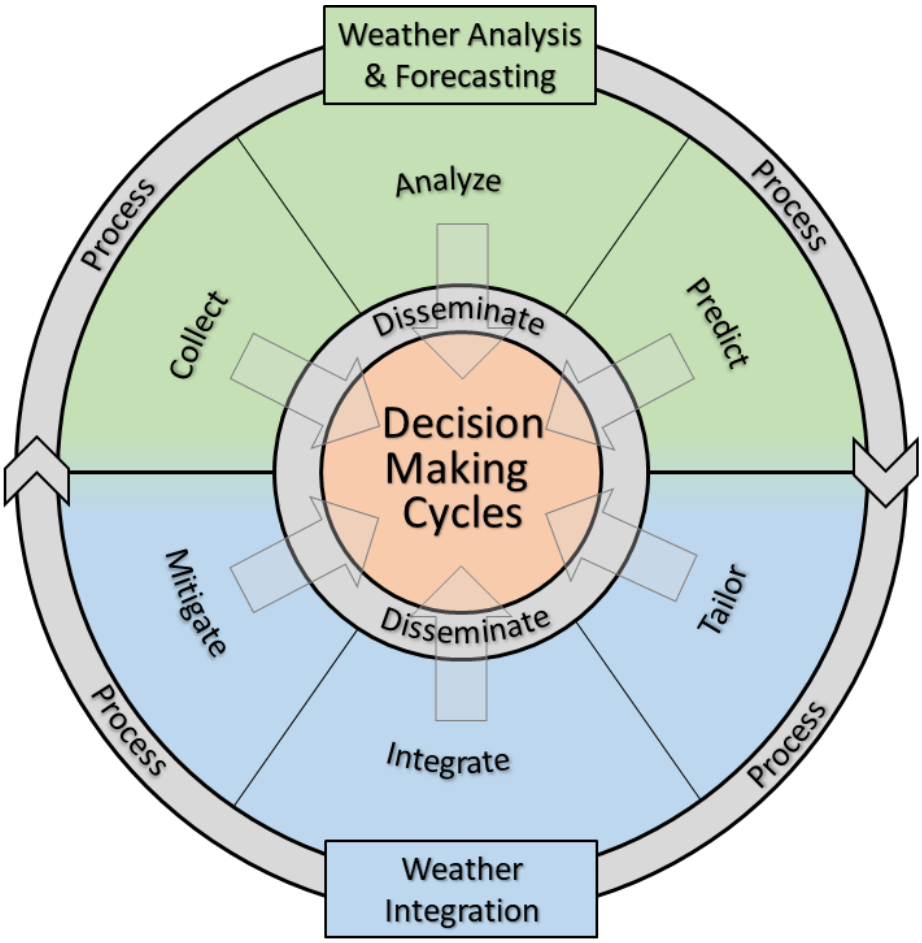

Figure 1. Conceptual model of weather operations

The bottom half of figure 1 depicts how the weather community **tailors** and **integrates** information from a net-centric data repositories into decision-making processes at the strategic, operational, and tactical levels. Weather personnel, either through reachback or being embedded with operational units, command and control facilities, and intelligence centers, use tailored weather information to advise decision makers on how to **mitigate** and exploit the effects of weather for friendly forces. Throughout weather operations, weather data and information undergoes **processing** and **dissemination**. These processes culminate into the **integration** of environmental effects of decision-making cycles, allowing leaders to make effective decisions to exploit the effects of weather.

DAF weather forces and those supporting Army operations deploy under the air expeditionary task force construct. DAF weather personnel provide support through a combination of on-site and reachback operations. Supported forces include air operations centers, Air Force expeditionary units, Army modular force echelons, Air Force and Army special operations forces, unmanned aircraft systems, and joint force headquarters.

Information on environmental effects should be integrated into the planning, execution, and assessment of all military operations. Environmental support is most effective when weather personnel know unit mission, organization, capabilities, plans, doctrine, and procedures. To the greatest extent possible, Air Force weather forces “train like they fight,” performing the same tasks in garrison as when deployed.

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WEATHER EFFECTS ON AIR OPERATIONS

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Weather has a profound effect on flight operations. Even on a clear day, the impact of something as simple as the speed and direction of the wind can significantly affect operations. Severe weather such as large hail, high winds, and heavy rains can halt flying operations and damage unprotected aircraft on the ground. Communication within the air domain is also susceptible to space weather effects such as ionosphere scintillation. This phenomenon affects the air operator's ability to effectively communicate with other airborne assets, ground forces, and can alter the effect of other services such as position, navigation, and timing (PNT).

Weather support to air operations focuses on three broad areas: protecting air assets, personnel, and base infrastructure from hazardous weather; maximizing aircraft performance and the effectiveness of the aircraft's weapons systems; and assisting during mission planning and execution.

PROTECTING AIR ASSETS, PERSONNEL, AND BASE INFRASTRUCTURE

Helping protect personnel, equipment, and base infrastructure from the effects of hazardous weather is a continuous responsibility of all-weather personnel. Weather personnel monitor weather conditions and alert the installation's personnel when hazardous weather is forecast or occurring. Depending upon the type and intensity of weather conditions and the installation's mission assets, commanders may exploit decision-grade weather information by directing a series of actions to mitigate risk ranging from moving, tying down, or sheltering aircraft to a full-scale evacuation of aircraft and personnel.

Aircraft are susceptible to hazardous weather. For example, the sudden onset of a thunderstorm could require aircraft to change their route of flight or divert to an alternate base. Weather personnel routinely monitor weather along planned flight routes, alerting decision makers to the onset of hazardous weather conditions such as turbulence, icing, and thunderstorms.

MAXIMIZING AIRCRAFT AND WEAPON SYSTEM PERFORMANCE

During short-term mission planning (one to three days) and execution, weather personnel play a vital role in helping maximize aircraft and weapons system performance based on observed and forecast weather. Airborne intelligence collection platforms; for example, are uploaded with appropriate sensor packages and plan their flight routes based on cloud cover and flight-level wind forecasts. Weather personnel use sophisticated computer models that help aircrews choose the best approach to their targets or provide a simulated picture of what a target might look like through a specific targeting pod based on environmental factors. Terminal aerodrome forecasts providing detailed forecast take-off and landing conditions can assist aircrew with choosing suitable alternate recovery locations. Flight-level wind forecasts help air planners determine the range and optimized flight routes for aircraft, potentially saving precious time and fuel by exploiting favorable winds. Drop zone forecasts help enable airdropped cargo and personnel to land safely on the target area. These weather products, as well as many others, help decision makers exploit terrestrial and space environmental conditions to maximize aircraft and weapons system performance, giving aviators a relative advantage over their adversaries.

Space Weather Effects

Space Weather. Having the proper understanding of space weather is critical when planning and conducting military operations. It also helps contribute to good space domain awareness, which is crucial when air and ground operators experience interference and degradation to radio signals, satellite communications, Global Positioning System signals, or radar operations. Knowledge of the space environment can help personnel mitigate the effects of space weather, and help differentiate between equipment malfunctions, natural interference, and man-made interference (intentional and unintentional). Being able to distinguish between intentional interference and natural sources of interference on space systems (whether on the ground or in space) enables the commander, Air Force forces, the commander, Space Force forces (if one is appointed), and the Combined Space Operations Center to identify threat trends to better protect US and partner nation space centers of gravity.

ASSISTING IN PLANNING AND EXECUTION

Weather information, integrated at every decision point during the planning, execution, assessment, and sustainment of military operations, is a key enabler of airpower. Weather forces directly support air planning and execution at the strategic, operational, and tactical levels. Well before hostilities begin, they provide weather effects analyses, forecasts, long-range outlooks, and climatological assessments that help shape future operations. Weather information such as historical crosswind trends and low ceiling information can affect decisions regarding aircraft deployment and staging operations. Persistent heavy cloud cover can hamper intelligence collection efforts, possibly driving major changes to a proposed campaign plan.

An example of the effectiveness of integration during planning is the contribution of the air operations center's weather personnel. These personnel can provide target area weather forecasts, predictions of weather effects on precision-guided munitions, and assessments of weather effects on intelligence, surveillance, and reconnaissance sensors. In addition, they provide weather-effect decision aids, including electro-optical and space weather effects guidance to planners during master air attack plan and air tasking order development. These products are vital in determining the timing of operations and selection of the appropriate weapons system to meet the joint force commander's objectives.

WEATHER EFFECTS ON SPACE AND CYBERSPACE OPERATIONS

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Just as weather affects air operations, weather can directly impact space systems and the services they provide, such as navigation; communications; and intelligence, surveillance, and reconnaissance. Similarly, weather affects the ability to leverage the electromagnetic spectrum (EMS), leading to impacts in the cyberspace domain.

ATMOSPHERIC WEATHER EFFECTS ON SPACE OPERATIONS

Atmospheric weather affects space supporting ground sites and launch and recovery of space assets. For example, severe weather approaching a launch range can cause delay or damage to critical launch infrastructure and global space mission operations. Rain may cause signal attenuation (due to absorption of radio signals by water vapor), hindering satellite communications (SATCOM) in higher frequency ranges.

SPACE WEATHER

Space weather is described as, “the conditions and phenomena in space and specifically in the near-Earth environment that may affect space assets or space operations” (Joint Publication 3-59, *Meteorological and Oceanographic Operations*). The Department of the Air Force (DAF) is responsible for conducting space environmental (space weather) operations in support of all elements of the Department of Defense (DOD) and the intelligence community.

Specially trained DAF weather personnel continuously monitor the space environment from the sun to near-earth space environment. Space-based satellites and ground-based systems that observe the sun and space environment assist forecasters in their analysis, forecasting, and integration of solar activity and other space weather effects information in the planning and execution of military operations.

Space Weather Effects. Space weather has a direct impact on space systems and the capabilities provided to operations. Space weather, such as a proton event (high-energy charged particles released from the sun) or spacecraft charging event (accumulation of energetic electrons), can disable satellite subsystems or even an entire spacecraft (temporarily or permanently). By extension, a great deal of cyberspace mission data

transits the space domain; therefore, space weather interference on space systems affects operations in the cyberspace domain. Additionally, weather can have a significant impact on the ability to transmit data through the EMS. These effects directly impact operations in the cyberspace domain and the operations that require use of EMS.

WEATHER EFFECTS ON LAND OPERATIONS

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Like operations conducted in the air, space, and cyberspace, operations in the land domain are highly susceptible to impacts from the natural environment. Air Force weather forces integrate current and predicted environmental impacts across the Army warfighting functions to enhance commanders' situational understanding, risk management, and decision making to defeat the enemy.

Specially trained Department of the Air Force personnel attached to Army units integrate environmental effects, including hydrology and space weather, into the intelligence preparation of the battlefield, the military decision-making process, and throughout operational planning and execution. Air Force forces, while in garrison and deployed, are resourced to integrate weather support into Army service component commands, corps, divisions, brigade combat teams (to include airborne), security force assistance brigades, combat aviation brigades, aviation battalions, military intelligence brigades (with aviation), and military intelligence aviation battalions.

MAXIMIZING THE ARMY'S ELEMENTS OF COMBAT POWER

Weather information should be integrated at every decision point during the planning, execution, assessment, and sustainment of ground-based military operations. Weather forces directly support the land component commander's planning and execution at the strategic, operational, and tactical levels by providing weather effects analyses, forecasts, long-range outlooks, and climatological assessments that help shape current and future operations. Visibility and precipitation forecasts can affect decisions regarding the tempo and timing of ground operations, including decisions on when to conduct sustainment operations and where to set up logistics support areas. Persistent fog can reduce visibility, limiting the ability to locate nearby enemy ground forces. Fog can provide cover for friendly forces seeking to maneuver, resupply, or reinforce. An example of weather integration during planning for ground operations are the contributions of division weather personnel during a wet gap crossing. These personnel can shape the division commander's courses of action by: determining environmental effects to rotary wing operations, targeting, traffic ability near the bridgehead, and enemy chemical operations. These environmental assessments are critical to determining the timing of operations, the types of forces, and support assets required to meet the joint force commander's objectives.

WEATHER OPERATIONS PRINCIPLES

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ACCURACY

Department of the Air Force (DAF) weather operations provide information to commanders to exploit environmental factors and mitigate weather effects during planning and through mission execution. Gaps in weather sensor coverage, limitations on the accuracy of weather observing systems and prediction models, and the complexity of atmospheric processes can all reduce accuracy. The DAF weather community constantly strives to overcome or lessen impediments. The supported community, including operators, should assist weather personnel by actively providing feedback and first-hand observations regarding the latest mission area weather conditions. For instance, post-strike inflight reports and post-mission debriefings should include target area and other relevant weather information. Mission reports, imagery, and ground observations (including augmentation of automated observation sensors), allow the weather community to improve the accuracy of weather and weather effects information for follow-on missions.

CONSISTENCY

DAF weather operations should provide consistent information on weather and its effects to all forces at all levels and echelons, resulting in “one operation, one forecast.” To achieve this result, weather personnel should derive products using the same basic data from designated analysis and forecasting sources to ensure consistent weather exploitation products. Weather information provided to decision makers and end-users should therefore be spatially and temporally consistent across the operational environment and provide a common operating environmental picture. Coordination and collaboration on an integrated, predictive weather product is required when many military units are operating in the same geographic area (e.g., the same airfield, air refueling routes, military operating areas, or drop zones). Coordinated weather operations ensure commanders at every level receive consistent weather information.

RELEVANCY

Weather information must be relevant for it to provide benefit to military operations. Air Force weather personnel ensure decision makers receive information on weather parameters that have the potential to degrade or enhance any mission prior to mission execution. Commanders should assess expected performance of assets in light of weather effects to determine the proper combination of delivery systems, munitions, platforms, and other resources to create desired effects. DAF weather operations are most relevant when integrated from the beginning of the planning process and when there is access to mission and platform data and parameters. Weather applies directly to planning, executing, assessing, and sustaining operations. DAF weather personnel should cultivate a two-way flow of information in which operators provide relevant mission data that enhances the applicability of weather information to operations.

Based on the mission requirements, weather personnel should consider the strengths, limitations, and time factors associated with specific missions and tailor weather products accordingly. For instance, weather that could negatively affect air refueling operations, such as excessive turbulence or cloud cover above 18,000 feet, may not appear to be relevant to Army helicopters operating below 500 feet, but could affect other platforms supporting the same mission objective. Thus, weather personnel possessing a detailed understanding of operations and mission profiles can ensure that weather information is relevant.

TIMELINESS

Weather information is perishable; therefore, it should be derived from the latest available data, disseminated quickly, and integrated at the appropriate time into the planning and execution of military operations. DAF weather operations should also be vigilant and responsive, informing commanders of potential weather effects on proposed and ongoing military operations in a timely manner.

A significant aspect of timeliness is how weather information is disseminated to the warfighter. Net-centric data repositories, using machine-to-machine dissemination, improve the chances that critical weather information and its impact on operations will reach decision makers in time to capitalize on time-sensitive opportunities. For instance, real-time information sent to an aircraft (such as images of targets affected by the weather and accounting for particular targeting sensors) enhances situational awareness for newly received time-sensitive targets. Similarly, space domain awareness requires timely integration of accurate and relevant space weather information into military space operations to help protect friendly forces, analyze and predict space system anomalies, differentiate between intentional and unintentional interference, and exploit adversary vulnerabilities. Weather entities and decision makers should maintain communication with one another to support and sustain the timely dissemination of weather information.

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WEATHER OPERATIONS FUNCTIONS

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The two functions of weather operations are **analysis and forecasting** and **mission integration**. Analysis and forecasting describe past, present, and future weather conditions. Integration enables decision makers to adjust and maximize operations based on weather and weather effects information. Figure 2 compares the main features of analysis and forecasting, and integration as used by weather forces.

Analysis and Forecasting	Mission Integration
• Produces actionable weather information primarily for the weather community • Usually produced by fixed locations • Usually a reachback provider • Requires data processing • Geographic focused	• Produces actionable weather information primarily for operational decision-makers • Usually mobile, deployable • Usually a reachback user • Requires information processing • Operator focused

Figure 2. Comparison between weather functions

ANALYSIS AND FORECAST PROGRAM

The analysis and forecast program (AFP) is a systematic and consistent approach to weather forecasting. The AFP identifies techniques and tools used to forecast individual weather elements, describes requirements for locally prepared work charts/composites, and explains refinements and application of centralized products.[1] AFP represents the ability to collect and process data into usable information to produce a coherent and accurate picture of the past, present, or future

[1] Air Force Manuals 15-129, *Air and Space Weather Operations*

state of the atmosphere and space environment. AFP encompasses the weather process of *collection*, as well as elements of the processes of *analysis*, *prediction*, and *tailoring*. Department of the Air Force weather operations provide actionable situational awareness to commanders covering past, present, and future states of the atmosphere and space environment to improve operational outcomes. Air Force weather operations collect and analyze atmospheric and space environmental data using satellites, and through the employment of a complex network of ground-based, airborne, and maritime sensors. The spatial and temporal measurements received from these sensors are processed to predict the future state of the atmosphere and space environment by applying the science of meteorology and by using complex, physics-based computer models.

MISSION INTEGRATION

Mission integration entails the ability to understand mission platforms, equipment, and systems capabilities/sensitivities, as well as mission processes (e.g., the joint planning process for air and the joint air tasking cycle) and inject the right information at the right time every time, enabling mitigation of environmental threats as early as possible in the mission planning process, ultimately optimizing mission execution.[2] Mission integration injects weather effects into planning and execution to minimize or mitigate any negative effects of the environment on friendly forces while capitalizing on conditions that maximize the operational advantage over enemy forces. It requires weather personnel to analyze, tailor, and integrate weather data that mitigates adverse effects. Knowledge of the weather and how it affects both friendly and adversary operations is a key component of battlespace awareness. Accurate, consistent, and relevant analysis and forecasting of the weather, integrated into operational planning in a timely manner, can provide friendly forces with the meteorological knowledge necessary to anticipate and exploit the best window of opportunity to plan, execute, support, and sustain specific operations.

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[2] Air Force Manual 15-129, *Air and Space Weather Operations*

WEATHER OPERATIONS PROCESSES

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Department of the Air Force (DAF) weather personnel execute eight processes—**collection**, **processing**, **analysis**, **prediction**, **tailoring**, **dissemination**, **integration, and mitigation**—to analyze and forecast the natural environment and integrate environmental effects information.

COLLECTION

Weather collection is the process of gathering and storing raw data in databases from which weather products are later derived. The data includes surface, air, and space-based observations, including meteorological satellite imagery and weather radar data from military, civilian, government, and commercial sources. Since each collection capability has limitations, DAF weather operations seek an optimal blend of measurements from land, sea, air, and space-based sensors. Although the Department of Defense owns many of these sensors, international data is obtained via data-sharing agreements with other countries, to include freely shared data under the auspices of international organizations such as the World Meteorological Organization and International Civil Aviation Organization.

Commanders should include nontraditional weather collection efforts throughout planning and operations to ensure receipt of adequate weather information in a timely manner. Nontraditional weather data sources, such as intelligence, surveillance, and reconnaissance platforms and unmanned aircraft systems can significantly enhance the quality and quantity of theater weather data collections. Inadequate sources or availability of weather data causes problems in regions where military operations occur. The DAF maintains the capability to deploy weather personnel and tactical sensors with joint and coalition forces to establish weather support for military operations.

A single piece of accurate weather information, regardless of the source, may provide the critical piece of information pivotal to mission success. Therefore, continuous collection of weather information and cooperation with outside sources are needed to ensure the optimal accuracy of weather products.

PROCESSING

Weather processing is the act of converting raw data into usable weather information. Collected weather data flows into a net-centric repository where much of it is processed into usable information. Usable information can be in the form of gridded data for weather personnel, or as tactical decision aides for decision makers. Observed conditions are first input into predictive weather models. High-speed computers run empirical and physics-based simulations of the environment and develop outputs representing the spatial and temporal evolution of the environment. The processed data serves as the basis for other processes: *analysis*, *prediction*, *tailoring*, *integration*, and *mitigation*. Data and information may be further processed and repeatedly refined to support military operations.

ANALYSIS

Weather analysis is the process of interpreting, fusing, and evaluating collected and processed environmental data and information to develop forecasts and recommendations in support of decision-making processes. It entails building a coherent, integrated depiction of the past and current state of the natural environment over a specified region. An effective analysis of collected weather data helps ensure the accuracy of the weather forecast provided to decision makers. It enables identification of weather features and conditions requiring subsequent study and monitoring. The analyzed data is processed and disseminated to net-centric databases to provide inputs that weather personnel use in building specification and forecast products to support decision-making.

PREDICTION

Weather prediction is the process of describing the future state of the atmosphere and space environment using analyzed weather information, sophisticated numerical models, and human judgment. Weather operations leverage collected environmental data as well as processed and analyzed weather information to predict how future weather conditions (such as temperature, cloud cover, and ionospheric scintillation) may affect operations. Prediction accuracy is highly dependent on the timeliness, accuracy, and quality of the initial input. Weather personnel rely on constant feedback from updated weather collections of actual conditions and continually adjust and assess prediction information to improve their forecasts.

TAILORING

Weather tailoring is the process of transforming relevant weather data and information into actionable, decision-grade information by aligning it with weapons systems' environmental sensitivities and details about planned operations. Weather information should be tailored to unique operational requirements. Weather personnel match products against mission, system, and platform requirements.

Weather products should be customized based on specific environmental sensitivities of, and effects on, operations and systems. Some examples of tailored weather products include decision aids, weather effects matrices, terminal aerodrome forecasts, drop zone forecasts, and target-area depictions.

DISSEMINATION

Weather dissemination is the process of delivering weather data and information to users in a suitable form. Dissemination occurs across other weather processes and ensures that products created through the collection, analysis, prediction, and tailoring processes are received by the appropriate end-user. These users may be weather personnel or decision makers, depending upon which output product is being used. Processed weather data may be disseminated to weather personnel for use in analysis or prediction products. Tailored forecasts may be disseminated to operators for use in the decision-making cycle so that leaders can act based upon the information. Because of its importance to other weather processes, dissemination should occur in a timely, reliable manner. Interruption of the process of dissemination at any stage can disrupt the flow of accurate and relevant data to the decision makers, significantly affecting their ability to integrate weather information.

INTEGRATION

Weather integration is the process of infusing tailored decision-grade weather and weather effects information into planning and decision-making cycles. Effective integration enables decision makers to maintain battlespace awareness and optimize the employment of military capabilities while marginalizing the benefit of the environment to the enemy, thereby creating an advantage for friendly forces. Informed with timely, relevant, and accurate information, decision makers can anticipate the weather's effects on planned operations and exploit those conditions to help facilitate achievement of the commander's objectives. Timeliness is critical to effective integration, and commanders should ensure weather effects information are fully integrated into decision-making processes and command and control (C2) systems in time to inform the appropriate decision makers. Likewise, weather personnel should be proactive and place great importance in reaching out to supported units to ensure integration occurs early in decision-making cycles. DAF weather operations use a net-centric repository of weather and operational effects information to facilitate such integration. A net-centric repository allows weather personnel to fuse relevant weather effects information with other operational information into an operational picture tailored to the mission.

Some C2 systems allow decision makers to extract mission-specific weather information from a net-centric weather data repository through machine-to-machine interfaces without consulting weather personnel and without knowing if the information was tailored by weather personnel. Because decision makers or other end-users may lack a thorough understanding of the strengths and weaknesses of the available weather

information, it is critical that weather personnel remain integrated in all phases of the planning and execution processes.

MITIGATION

Weather mitigation is the process of providing decision makers with options and courses of action, based on tailored and integrated weather information, so they can adjust operational plans and exploit weather effects to operations. Large-scale weather events can have strategic impacts that can be devastating to military operations. Weather personnel provide this information to commanders, enabling them to determine the best employment packages and courses of action for those weather conditions. When leaders use weather information to effectively mitigate environmental impacts, they can adjust plans and achieve optimal mission effectiveness. The process of mitigation gives decision makers options on beddown of forces, desired operational capabilities, and resource protection actions. Weather personnel should articulate their level of confidence in predictions to decision makers to be of value when leaders assess and manage risk in an operation. Weather personnel who are properly integrated and have established a relationship of trust and relevancy with their supported decision makers have greater influence in the mitigation process.

PRESENTATION OF WEATHER FORCES

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Weather forces provide integrated environmental support to a diverse set of consumers including, but not limited to, national agencies, combatant commanders or other level joint force commanders (JFC), service or functional components, multinational partners, and unit-level decision makers. Department of the Air Force (DAF) weather forces provide this support using three core mission areas: mission weather integration, staff and installation weather integration, and airfield weather services. These mission areas are supported by weather personnel assigned to centralized weather analysis and forecast centers operating at the strategic and operational levels. DAF weather operations present forces to the joint task force for joint and combined operations according to these distinct mission areas.

When a combatant commander (CCDR) or other JFC requires in-person weather operations, weather forces deploy as part of an air expeditionary task force (AETF) using the request for forces process. For support to the Army, weather forces deploy as part of the AETF and use a direct support relationship with the supported Army unit. Weather forces supporting the Army should train with their supported unit through all phases of the sustainable readiness model, participate in training center rotations and mission readiness certifications, and deploy with the unit.

Some weather capabilities, such as numerical weather prediction, climate services, and space weather operations remain centralized because of their strategic nature and the computing resources required. CCDRs request capabilities from Air Combat Command through their Air Force service component using the orders process (see Chairman of the Joint Chiefs of Staff Instruction 3810.01F, *Meteorological and Oceanographic Operations*).

MISSION WEATHER INTEGRATION

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Units conducting mission weather integration operations perform the weather *integration* function, primarily using the *analysis, prediction, tailoring, integration,* and *mitigation* processes. Mission weather integration is most effective when the supporting weather teams are located with their supported units, allowing weather personnel to develop relationships and learn how the natural environment affects operations. Department of the Air Force (DAF) weather forces providing mission weather integration should deploy with their home station units to deliver the same support in an expeditionary environment that they provide in garrison. DAF weather forces provide mission weather integration to the combat air forces (CAF), mobility air forces (MAF), and the US Space Force.

CAF AND MAF INTEGRATION

Air Force weather forces integrate tailored environmental data and information into the mission profiles of supported CAF and MAF units. This support includes mission-tailored weather products necessary for planning and executing specific operations, and inherently requires full integration into the supported unit, including clearances to access classified mission requirements. In-garrison support is provided to nuclear bombers and intercontinental ballistic missiles (ICBM) employed from home station. ICBM support includes the entire missile field and encompasses weather support to numerous unique operations: convoy operations, armed over watch, quick reaction force, and maintenance activities.

CAF. Though weather integration personnel are usually assigned to the operations support squadron at home station, they work day-to-day within the supported flying squadrons. In the expeditionary environment, weather forces providing in-person support to deployed CAF squadrons fall under the attached expeditionary fighter or bomber squadrons.

MAF. MAF aircraft are supported in-person or via reachback by assigned or deployed Airmen, or by the 618th Air Operations Center (AOC) (Tanker Airlift Control Center) for missions where US Transportation Command retains operational control of the aircraft. MAF weather integration personnel are usually assigned to the operations support squadron at home station, though they reside within the supported flying squadrons.

Weather forces deployed to support expeditionary MAF squadrons usually force pool with other deployed MAF weather Airmen at either the AOC or the central location where command and control (C2) of MAF operations takes place, allowing them to integrate weather impacts either in-person or via reachback. For a detailed explanation of how the MAF operates in an expeditionary environment, see AFDP 3-36, *Air Mobility Operations*.

AOCs

DAF weather personnel integrate environmental support into AOCs via assigned weather specialty teams (WST). These WSTs are typically aligned under the combat operations division but integrate environmental effects information across all AOC divisions and operations. While airfield weather services are responsible for the five nautical mile ring around the airdrome, the WST is responsible for shared operations area outside the airfields, such as target weather forecasts, aerial refueling tracks, drop zones, and military operating areas. The WST is focused on integration across the AOC divisions, and normally reaches back for a significant portion of weather data products needed to support AOC operations; including staff weather briefings, flight weather briefings, target and enroute weather forecasts, and mission-scale meteorological watch (MISSIONWATCH) support.

The size of the WST in some AOCs is not large enough to provide in-person support across the AOC divisions during contingency operations. When additional manpower is required for expanded operations, the AOC submits a request for forces to receive augmentation from an operational weather squadron (OWS). In both peacetime and wartime postures, the WST and its associated personnel should remain in close coordination with other weather teams supporting aircraft tasked by the AOC. They are responsible for producing all forecasts for air refueling tracks, military operating areas, drop zones, and targets which allows other mission integration weather teams to leverage central products, avoid duplication of effort, and ensure all forecasts are consistent.

UNMANNED AIRCRAFT SYSYTEM (UAS) GROUPS AND WEATHER SUPPORT

UASs are classified into five groups, based on their physical and performance characteristics of weight, operating altitude, and airspeed, with lower numbered groups being smaller and lighter or lower and slower flying, to the largest UASs with enduring, higher-altitude flights (groups four and five). Weather support to groups one and two UASs typically consists of information and products already available from supporting weather organizations and does not require specialized planning or mission weather support products or forecasts. Groups three through five receive direct weather support from the home station weather organization and require mission-tailored planning and mission execution weather products.

Launch and Recovery Element (LRE) Weather Support[1]

UASs are launched and recovered in-theater from established LREs. Weather forces at an LRE perform the weather *analysis and forecasting* function, primarily using *collection*, *analysis*, *prediction*, and *dissemination* processes. Weather forces conducting LRE weather operations produce terminal airdrome forecasts, observed and forecast weather watches, warnings and advisories, and the local airfield observation that may be used by other weather organizations supporting UAS operations. LRE weather support is provided from launch to hand-off to the mission control element (MCE), if there is one, and from the MCE hand-off back to the LRE for aircraft recovery.

MCE Weather Support

MCE weather operations include mission planning and execution weather along with MISSIONWATCH. Depending upon the UAS type, this is typically accomplished from a static location within the continental US. MCE weather operations has lead coordination responsibility with other organizations providing weather support, such as home station or deployed weather personnel supporting the LRE, if one exists, or the supporting OWS.

When an organization is established to provide operational-level C2 of UAS missions, the weather organization directly supporting that organization should be designated as lead weather unit (LWU). The LWU is responsible for producing the controlling mission weather product and providing operational-level weather recommendations to C2 decision makers.

LRE and MCE Coordination and Handoff

For UAS groups four and five (sometimes group three), there will typically be an LRE and an MCE. There are pre-determined distance and rule sets for providing a hand-off from the LRE to the MCE, and again from the MCE back to the LRE based upon UAS type. Since the weather unit supporting the MCE (if one exists) is typically the LWU, its responsibility is to coordinate weather support for the mission and the handoff transitions to ensure one mission, one forecast.

CONVENTIONAL ARMY OPERATIONS

Detailed, accurate, environmental information and the effects of the environment on friendly and adversary weapon systems, tactics, and logistics are required to conduct, direct, and plan for future operations. DAF weather personnel assigned to weather squadrons (WS) supporting Army operations should be fully integrated with the Army unit they support so that they understand the unique weather requirements for the assigned mission. DAF weather operations support Army commanders by effectively

[1] Weather operations at an LRE are provided by Airmen in the airfield weather services mission area but are discussed here for continuity.

integrating weather information and knowledge within mission command, operations process, warfighting functions, and operational framework to enable successful prosecution of the Army's operational doctrine. DAF weather personnel provide Army commanders and their staffs an estimate of the confidence level for all weather analytical assessments and weather knowledge integrated into the Army's operational structure.

DAF weather personnel supporting the Army integrate weather effects knowledge across warfighting functions, enabling commanders to optimize and synchronize forces at a decisive time and place on the battlefield to achieve the desired effects and win decisively. The capability of commanders and their staffs to anticipate, integrate, and mitigate weather effects to the employment of friendly and adversary combat power is important to achieving asymmetric advantage and defeat of the adversary. Weather effects information and knowledge are critical to commanders' situational understanding and decision making and enhance lethality when integrated into the Army's planning process, including intelligence preparation of the battlefield, fires, targeting, protection, risk management, and information collection. While WSs supporting the Army are focused primarily on the weather *integration* function, they perform the weather *analysis and forecasting* function when required.

Conventional Army weather support is integrated through support WSs, positioned under an air support operations group or weather group, which may belong to an air-ground operations wing under a numbered Air Force or with an air component commander. These WSs are comprised of personnel trained in basic soldier skills who deploy with and provide direct support to Army echelons and units.[2] Habitually aligned weather personnel should seamlessly integrate weather effects information within the Army service component command, corps, division, aviation brigade or battalion, brigade combat team, security force assistance brigade, and other supported unit battle rhythms. In addition, weather personnel coordinate, establish, and maintain weather-reporting networks within their respective operational areas to increase battlespace awareness and for use during operational planning and execution for the joint force. Weather personnel are trained and equipped to operate for extended periods in austere conditions that are removed from traditional airbase logistics support. Additionally, select DAF weather personnel receive special training and equipment to support forcible entry operations (e.g., airborne and air assault) as part of a brigade, division, or corps assault command post.

Because of its diverse mission, a conventional Army support WS is organized to maximize training efficiencies in functional skills, combat survival, and tactical equipment operations. Each WS is attached with specific Army echelons or units and provides Air Force C2 of subordinate detachments and operating locations that are co-located with the supported Army unit they are habitually aligned to support.

[2] "Basic soldier skills" refers to training mandated and provided by the Army for weather personnel embedded in Army units in accordance with Army Soldier Training Publication 21-1-SMCT, *Soldier's Manual of Common Tasks, Warrior Skills, Level 1* (common access card required).

The squadron manages the centralized control and decentralized execution of environmental support to these echelons and units. The squadrons are resourced to integrate support into specified Army units in both garrison and expeditionary environments via a direct support command relationship. The weather forces supporting these echelons provide general support to subordinate Army echelons, if required.

When deployed to support conventional Army operations, DAF weather personnel are typically assigned to an expeditionary weather squadron (EWXS) comprised of deployed mission-ready weather personnel supporting their habitually aligned Army units. The EWXS is normally a subordinate unit within an expeditionary air support operations group.

When appropriate, the EWXS commander tailors conventional Army weather support to forward deploy in support of their habitually aligned Army modular force echelons. These forward-deployed weather personnel leverage analysis and forecasting information from centralized weather organizations via a combination of reachback and distributed operations to integrate mission-tailored weather and weather effects information essential to planning and executing operations. The air component commander retains operational control and administrative control of conventional Army weather support units and provides those units in direct support of Army operations. As an alternative, the joint force commander may attach with specification of tactical control either the EWXS or its subordinate units to the land component commander when needed.

AIR FORCE SPECIAL OPERATIONS COMMAND

Air Force Special Operations Command provides weather support to DAF and Army special operations forces (SOF). Support is provided by assigned weather flights at the installation level. In some cases, SOF weather flights may leverage information provided by reachback weather organizations in support of home station and deployed special operations missions.

STAFF AND INSTALLATION WEATHER INTEGRATION

Last Updated: 28 October 2020

Units conducting staff and installation weather integration perform both weather functions. They primarily execute the *prediction*, *tailoring*, *integration*, and *mitigation* processes, but may often use *collection*, *analysis*, and *dissemination* processes.

Staff and installation weather integration include staff weather support to Department of the Air Force (DAF) and Army installation leadership and environmental services for all functions of an established or expeditionary base, including the emergency management office and other mission support and medical group functions. The staff and installation weather integration mission area is usually executed by a weather flight under the operations support squadron.

DAF personnel performing the staff and installation weather integration mission at an individual installation are usually required for minimum home station support. Deployed personnel performing this mission for expeditionary installations fall under expeditionary operations support squadrons and are usually deployed from an operational weather squadron.

AIRFIELD WEATHER SERVICES

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Units conducting airfield weather services perform the weather *analysis and forecasting* function. They primarily execute *collection*, *analysis*, *prediction*, and *dissemination* processes.

Airfield weather services include the local airfield observation, terminal airdrome forecast, and required weather watches, warnings, and advisories. For Department of the Air Force (DAF) installations, this capability usually exists within a weather flight under the operations support squadron. For Army installations, this capability usually exists within a weather squadron or a detachment under the air support squadron. Launch and recovery elements for unmanned aircraft systems provide airfield weather services.

Airmen performing airfield weather services at an individual DAF or Army installation are usually required for minimum home station support. Locations requiring airfield weather services without assigned DAF weather forces should request reachback support. When deployed, airfield weather services personnel fall under the expeditionary operations support squadron.

CENTRALIZED WEATHER ANALYSIS AND FORECASTING CENTERS

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Weather operations require significant amounts of data and complex information technology infrastructures to ingest, process, and disseminate data. Numerical weather prediction models also require large and expensive high-performance computing centers. These requirements drive the need to centralize certain weather capabilities, including climate services and space weather analysis and prediction. Centralized weather analysis and forecasting centers perform the weather *analysis and forecasting* function primarily using the *collection*, *processing*, *analysis*, *prediction*, *tailoring*, and *dissemination* processes.

NUMERICAL WEATHER PREDICTION

Department of the Air Force (DAF) numerical weather prediction support includes traditional, physics-based environmental models used to simulate and predict the total atmosphere, including the near-Earth space environment as well as specialized models to predict operationally significant parameters such as clouds, land surface, and volcanic ash. This capability requires the use of a sophisticated high-performance computing center to process terabytes of raw environmental observations and run computationally intensive numerical weather prediction schemes to deliver forecast data and products. The size and cost of this computing center precludes operating multiple centers at forward locations.

CLIMATE SERVICES

DAF weather climate support is the authoritative source for climate data for the Department of Defense and other US Government agencies and produces specialized climate studies and assessments used to optimize military and intelligence operations and planning. Like numerical weather prediction, this capability often requires the use of sophisticated high-performance computing centers to process terabytes of raw environmental observations received daily. Climate services are available to weather operators and other DOD users via reachback operations.

AIR FORCE WEATHER WING

DAF weather delivers worldwide weather information to joint warfighters, combatant commands, and national programs through a specialized mission wing (referred to hereafter as the Air Force weather wing), and subordinate weather groups, which act as the primary production centers for the weather *analysis and forecasting* function of DAF weather operations. Due to extensive processing systems, data storage capacity, and communications requirements, the weather *analysis and forecasting* function is generally performed by centralized weather analysis and forecasting centers. The Air Force weather wing is responsible for leveraging service capabilities to collect atmospheric and space weather data from commercial, civil, and military sources. The data is processed, analyzed, and used to create a four-dimensional representation of the natural environment, which are then available for use by subordinate weather units or other operational units such as air operations centers (AOC).

Operational Weather Squadrons (OWS). The OWSs form the backbone of regionally focused, centralized weather analysis and forecast operations, providing a variety of weather products and support to Air Force, Army, Air National Guard, Air Force Reserve forces, US Space Force, and other users as directed in their respective operational areas. The OWSs provide airfield weather services via reachback for locations without assigned weather personnel. OWSs' areas of responsibility are aligned with the Unified Command Plan's geographic combatant commands. Generally, the OWS focus on analysis and forecasting, delivering products for use by an AOC and weather organizations integrated at Army and Air Force locations.

Space Weather Support. Weather personnel providing space weather support to the DOD use space weather data collections from a global network of ground and space-based sensors to provide mission-tailored analyses, forecasts, warnings, and strategic level products. These products are used for mission planning and environmental situational awareness.

Space Launch and Test Operations Support. Weather squadrons (and units below squadron level) supporting space launch and test operations provide upper air observations, forecasts, launch probabilities of violation, and additional unique or specialized weather support as required. These units provide general weather information for launch sites, specified ranges, and abort landing sites as well as dedicated weather team integration with range operations crews. Units supporting tests provide staff meteorologists to perform or support basic research, development, acquisition, and testing of DAF weapon systems and capabilities through identifying, documenting, and helping resolve environmental sensitivity issues to support acquisition programs.

National Intelligence Community Support. Environmental support to the national intelligence community is provided using data collected from various sensors and sources across all enclaves to provide mission-tailored forecasts and impacts to operations. These weather products are used for mission planning and environmental situational awareness.

AIR FORCE DOCTRINE PUBLICATION (AFDP) 3-59 WEATHER OPERATIONS

PRESENTATION TO JOINT AND MULTINATIONAL OPERATIONS

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Department of the Air Force (DAF) weather capabilities should be integrated with those of other services and nations to provide coherent and structured weather operations to joint and multinational forces. DAF weather personnel may be tasked to fill joint weather positions supporting a combatant commander (CCDR), air component commander, or land component commander.[1]

AIR FORCE COMPONENT STAFF LEVEL

In a joint or multinational operational environment, the air component commander, executing under Title 10 commander, Air Force forces (COMAFFOR) authorities, exercises operational control (OPCON) and administrative control of all assigned and attached conventional Air Force weather personnel deployed to a theater.

The CCDR's senior meteorological and oceanographic officer (SMO) coordinates the weather capability needed to support a joint task force (JTF). In addition, the air component commander should have weather personnel on the operations (A3) staff and embedded in the air operations center (AOC). Weather personnel support the CCDR's intelligence (A2) staff, are involved in contingency planning, and ensure the air component commander's weather requirements are met.

The senior DAF weather representative to the air component commander is designated the staff weather officer (SWO). The SWO monitors and coordinates DAF weather resources in theater, including those supporting conventional land and special operations forces. The SWO advises the air component commander's A-staff on all matters related to employing weather resources and coordinates DAF and Army requirements with the appropriate joint and coalition meteorological and oceanographic entities.

The SWO should coordinate closely with counterparts on other JTF and component staffs. Like the SWO, staff weather officers of other components have functional support responsibilities and should coordinate their respective component requirements directly with their joint counterparts to deconflict responsibilities and ensure unity of effort.

[1] See Joint Publication 3-59, *Meteorological and Oceanographic Operations*, for details on joint weather operations.

Air Expeditionary Task Force (WX). Weather forces performing mission weather integration; for example, those supporting the Army, should deploy with their strike mission design series flying squadron(s) or other supported Army units as part of an air expeditionary task force (AETF). The theater air component commander retains OPCON of weather personnel supporting Army units at all echelons. Weather personnel and equipment from other units, including National Guard or Reserve forces, may be tasked to augment AETF weather forces.

DAF weather capabilities that support air expeditionary wing-level operations, to include airfield weather services, staff and installation weather integration, and mission weather integration, are normally organized, commanded, and employed as a weather flight in an expeditionary operations support squadron. In some instances, it may be best for weather personnel performing mission weather integration to be directly attached to a flying squadron to provide more tailored and specific environmental information in support of operations.

DAF weather personnel assigned or attached to an AETF normally obtain data required for the weather analysis and forecasting function from centralized weather analysis and forecasting centers such as operational weather squadrons. Reliable communications are critical to providing data and information required for weather operations conducted forward on the battlefield.

Weather Systems Support Cadre (WSSC). The WSSC is a service-retained asset that is manned, equipped, and trained in accordance with combatant command requirements. When requested and deployed to a theater, the WSSC is normally attached with specification of OPCON to the theater CCDR who will delegate OPCON to their air component commander, under their COMAFFOR authorities. The WSSC serves as a subject matter expert, offering recommendations and performing sensor operations, maintenance, troubleshooting, site surveys, and set-up and tear-down procedures in support of all meteorological and oceanographic forces in the designated theater of operations. The WSSC works with combatant command-aligned subject matter experts and senior SWOs to synchronize maintenance and logistics actions necessary to support the approved theater sensing strategy for forward deployed tactical weather sensors.

WEATHER OPERATIONS PLANNING, EXECUTION, AND ASSESSMENT

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The natural environment affects planning and execution across the joint force. Joint Publication (JP) 3-59, *Meteorological and Oceanographic Operations*, and the *Joint Meteorological and Oceanographic (METOC) Handbook*, are excellent references when planning, executing, and assessing weather operations. Environmental effects information should be integrated into the planning, execution, and assessment of all military operations. Environmental support is most effective when weather personnel know the mission, organization, capabilities, plans, doctrine, and procedures of the supported unit.

WEATHER OPERATIONAL PLANNING

In any planning process, weather should be considered at the earliest possible stage of planning. A combatant commander's planning staff should consider climatology, weather effects, and weather force lay-down during planning. METOC planners aid commanders by integrating their experience and knowledge of METOC conditions and effects, thereby allowing the commander to visualize adverse impacts and assess any potential risks when arranging operations. Weather operational planning includes METOC activities: identifying information gaps, prioritizing capability requirements, developing collections plans, assessing capabilities to identify shortfalls, and developing mitigation strategies to address shortfalls.

Weather forces should be co-located with key command and control elements to inject weather and weather effects information throughout the planning process. These forces should be fully integrated into supported units in order to understand the mission profiles, routes, ordinance, tactics, techniques, and procedures to be employed in an operation. With this understanding, METOC planners can better communicate where environmental effects will help or hinder operations and how best to mitigate potential negative effects.

Planners should use the guidance provided in the weather annex of the *Air Force War and Mobilization Plan, Volume One,* to request the weather capabilities required to meet the combatant commander's intent. Weather forces deployed forward should be properly trained and equipped to handle communications outages which may preclude

the transmission of weather data and products from centralized weather analysis and forecast centers. Air Force weather personnel should be assigned or attached to each Air Force, Space Force, and Army component staff and integrated into the staff functions to ensure the proper weather capabilities are requested.

During plan development, the Army should provide their requirements for weather support and services to the Department of the Air Force (DAF) for validation. In coordination with the DAF, the Army includes and synchronizes Army-provided equipment used to support Air Force weather capabilities in the time-phased force deployment database.[1]

WEATHER OPERATIONS EXECUTION

DAF weather operations help predict when weather could affect friendly and adversary operations, possibly offering friendly force commanders an exploitable asymmetric advantage. DAF weather operators persistently monitor, assess, and report weather conditions during execution.[2]

WEATHER OPERATIONS ASSESSMENT

To assess operational effectiveness and technical performance, weather personnel assess their ability to accurately predict the weather (technical performance) and its impact on operations (operational effectiveness). In general, weather personnel providing airfield weather services and staff and installation weather integration focus on evaluating analysis and forecasting products for their technical assessment while personnel providing mission weather integration evaluate the integration of products on their operational effectiveness. These assessments are used to modify or create new techniques, procedures, products, and services.

Additionally, weather personnel should reference the joint lessons learned information system during the planning process, archive weather planning and execution data, and documents weather lessons learned in accordance with the joint lessons learned program.

[1] Army Regulation 115-10, *Weather Support and Services for the US Army* (common access card required).
[2] AFDP 3-0, *Operations and Planning*.

Operation EAGLE CLAW: A Hard Lesson to Learn

Top-secret planning for what would be one of the most complicated and ambitious raids in American history, the Iranian hostage rescue attempt of 1980, lasted over five months but it fell short of fully considering an incorrigible foe: the weather.

Historical records pointed to winter as the optimal time for a mission of this type, as limited moonlight and suitable temperatures and densities represented favorable conditions for night RH-53D operations. Nevertheless, the mission was set for late April, introducing additional weather challenges such as suspended dust, which proved to be a factor in the subsequent mishap. This mission-impacting information was never briefed to JTF planners and decision makers.

Recommendations to use a WC-130 weather reconnaissance aircraft as a scout in advance of the RH-53Ds were discounted based on assumed favorable weather conditions and for security reasons. Additionally, it was determined that pilot reports from accompanying C-130s, flying the same route, could provide advance notice of unfavorable weather as needed. However, the C-130s ended up arriving at the destination, Desert One, well ahead of the helicopters and were unable to relay up-to-the-minute weather data to the RH-53D crews.

Weather operations personnel were excluded from planning and rehearsal exercises at the JTF training areas, eliminating their ability to work with the aircrews

Furthermore, mission execution weather briefings, developed by weather operations personnel, were presented by J-2 intelligence officers who had little, if any, formal weather training or experience. Aircrew feedback was provided in the same indirect way. Pilots were thus unaware of the possibility of encountering suspended dust and were unprepared to handle it. Integration of weather information, a vital contributor to mission success, never occurred.

—Paul B. Ryan
The Iranian Rescue Mission: Why It Failed