FM 34-81-1

FIELD MANUAL
FM 34-81-1

DEPARTMENT OF THE ARMY
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BATTLEFIELD WEATHER EFFECTS

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PREFACE

This manual provides some of the more common critical weather (and environmental) effects data and applies that information to specific operations, systems, and personnel. Inclement weather degrades battlefield operations, affects weapons and other systems, and plays a major role in the effectiveness of troops in the field.

This data is intended to support the brigade and battalion S2 and staff. It is applicable to combat, combat service, and combat service support units and is intended for use by Active Component (AC), Reserve Components (RC), and Army National Guard (ARNG) units in both training and combat situations.

Use of these lookup tables and data is a three-step process. For additional information on how this is accomplished, see Appendix A. The three steps are--

- Using current weather observations and forecasted conditions, you look for weather extremes. That is, those conditions that will be too hot, too cold, too windy, too overcast, too wet, or too humid for normal operations.
- Turning to the lookup tables, you then identify specific operations, systems, and personnel that will be impacted.
- And finally, bringing any impacts and constraints you have identified to the attention of your commander and the rest of the staff.

The critical values presented here, together with current weather observations or future forecasts mentioned above, will provide you with the basic tools needed to perform these three steps. Data are presented in the form of simple lookup tables called weather tactical decision aids (WTDAs). These WTDAs are designed to point you toward your briefing of the commander and staff. Appendixes B through O are tailored toward specific types of units.

This manual does not make you an expert in all facets of weather and the total impact that inclement weather might have on an army in the field. Instead, it allows you to quickly understand the potential impact specific current and forecasted weather elements could have on your unit's plans today.

Not all weather and environmental data parameters impacting Army systems and operations are addressed. A listing of the weather and data parameters

INTRODUCTION

ACT 3, SCENE 2. Location: Second floor of 3d Army Headquarters Building, European Theater of Operations, Germany. Date: December 1944. Players: General George Patton and Army Chaplain Colonel James H. O'Neill. Patton speaks . . .

"Chaplain, write me a weather prayer."

This prayer was subsequently issued, along with a Christmas card, to all 3d Army troops on December 22, 1944. In part, it read:

"Almighty and merciful Father . . . restrain these immoderate rains . . . grant us fair weather for battle . . . "

And, of course, as history has so well recorded, "December 23 dawned bright and sunny. " A miraculous 5-day break of clear weather followed, which permitted the Allied forces to take maximum advantage of their air superiority. This tremendously successful air support effort was one of the key factors that led to the German failure to attain its major objectives in the Battle of the Bulge.

Other historical accounts state that General Patton actually ordered his Chaplain to write this prayer in support of an earlier operation against the Siegfried Line. Nevertheless, it wasn't used until December 22, 1944.

This dramatic acknowledgment of the importance of weather on military operations is from the book <u>Lucky Forward - The History of Patton's Third U.S. Army</u> by Colonel Robert S. Allen (Vanguard Press, New York, 1947).

A half century later the same urgent concern about weather is reflected in FM 100-5 where weather is listed among the imperatives of battlefield operations. In addition, FM 100-5 states that weather and visibility conditions create advantages and disadvantages for combat forces. To fight effectively, commanders must acquire weather information about their entire areas of operations (AO) and areas of interest (AI).

As the S2, that is your job. Because we cannot count on a weather prayer to always supply this essential information to the commander, we need procedures that will provide accurate, timely, and tailored weather data to the commander.

Since we cannot control the weather, the best alternative is to develop a thorough understanding of weather effects and their impact on friendly and threat military operations. Then we use this knowledge and information to our advantage.

Chapters 1, 2, and 3 provide background information on weather and its effects on Army systems and operations. Chapter 4 explains the use of the WTDAs contained in Appendixes B through N.

currently identified as impacting Army operations, systems, or personnel is at Appendix O.

If you determine that a weather element may have a severe or moderate impact on operations, systems, or personnel (friendly or threat), you alert the commander and staff to this potential impact. This allows your commander to--

- Request additional information.
- Modify his plans.
- Continue as originally planned, but aware of potential weather problems.

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This manual does not implement any International Standardization Agreements.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

CHAPTER 1

COMBAT ENVIRONMENT

Weather, terrain, and the time of day constitute the basic environmental setting for all military operations. These physical conditions affect operations, systems, and personnel and act as constraints on the combat options available to your commander. Part of your job is to alert your commander and the staff of the implications adverse weather may have on both friendly and threat tactics, techniques, and procedures (TTP).

WEATHER AND THE COMMANDER

FM 100-5 states that terrain and weather affect combat more than any other physical factors. Weather not only affects battlefield operations, weapons, and electronics systems but also affects the soldiers that make it all work. Commanders cannot control the weather, but they must be sensitive to the effects inclement weather has on their unit.

In your role as the brigade or battalion staff officer with primary responsibility for weather intelligence and planning, you may not be Patton's chaplain. But you have an even more important task than writing a weather prayer--that of keeping your commander informed of adverse weather problems. And in order to do this, you need to be familiar with weather terminology and the collection, forecasting, and reporting available to your command.

Separate and aviation brigades, armored cavalry regiments (ACRs), special forces groups (SFGs), and divisions and above have a United States Air Force (USAF) staff weather officer (SWO) and weather team (WETM). Their job is to collect, analyze, and advise the senior intelligence officer (SIO) of current and forecasted weather conditions which will affect operations.

At maneuver (and other) brigades and battalions, you have no SWO. It is therefore very important that you familiarize yourself with the observations, forecasts, and other services provided by SWOs and WETMs at higher echelons. You need a general working knowledge of meteorology and an understanding of this manual. The simple WTDAs presented here help you in putting several pieces of the weather puzzle together. They then aid you in translating weather information into a format understandable to your commander and staff.

BATTLEFIELD ENVIRONMENT

Battlefield environmental conditions play a major role in the application of TTP. Some of the environmental factors evaluated in this manual are--

- General weather conditions.
- Terrain effects.
- Battlefield-induced contaminants (BIC).
- Illumination.
- Background signatures.
- Hazardous or severe conditions.

Evaluation of each of these factors is essential during your commander's decision-making process. All must be considered together in your analysis because they all impact each other--and friendly and threat TTP. See Chapter 2 for an explanation of weather factors and their interplay with each other. Chapter 3 helps you translate current weather conditions and future forecasts into valuable intelligence.

WEATHER ELEMENTS AND CRITICAL VALUES

Weather elements, and their associated impacts on battlefield operations, are the primary focus of this manual. Only the more commonly known, observed, or derived weather and environmental elements are discussed. A working knowledge about these elements is essential. Even more important is knowing when, and to what degree, these elements act as constraints on specific systems or operations.

These thresholds (or amounts) are called critical values and listed for each weather or environmental element. They are based on input from battlefield functional area (BFA) proponents, available data from third-party sources, Army field manuals, and the systematic analysis of weather-induced degradation of operations, systems, and personnel.

Weather and environmental data elements, in addition to those discussed here, may impact Army systems and operations. But the capability to collect and process them, or to technically define their impact, is presently limited. We are developing automated initiatives to identify and collect more weather and environmental data. These findings will be incorporated into subsequent iterations.

WEATHER TACTICAL DECISION AIDS

WTDAs provide tailored decision information to the user. They may be a simple two-sided matrix or lookup tables (as used in this manual), or complex software algorithms requiring computer processing. These tables assist you in matching a particular inclement weather condition with its associated impact on the battlefield. This correlating process is helped along by the WTDAs.

Lookup tables show the impact of critical weather and environmental elements on battlefield operations, systems, and personnel. Remember that these examples do not cover every battlefield situation, condition, or system. You may have to add others to cover any unique items in your unit.

If you are tasked to provide information for weather parameters not normally provided by the WETM, first determine what the critical values are for the system or operation. Your S3 should be able to assist you in analyzing the equipment and determining weather effects GO, NO-GO thresholds. Your nearest SWO (probably at division) can provide the additional weather data support.

You need to keep in mind that much computer-driven automation is coming to the battlefield. Some of these initiatives will affect the collection, processing, and dissemination of weather forecasts and weather effects predictions. They include the All-Source Analysis System (ASAS), the Integrated Meteorological System (IMETS), the Digital Topographic Support System (DTSS), and the Army Tactical Command and Control System (ATCCS). These initiatives will result in more precise data being quickly passed to the users so weather considerations will keep pace with the decision-making cycles of commanders.

THE BATTLEFIELD AND THE ENVIRONMENT

FM 100-5 is the umbrella concept for combat operations and the baseline document that describes warfighting doctrine. All other specific mission operations manuals spring from FM 100-5. It describes how the Army fights and wins on the battlefield. It lists three different types of battlefields on which the Army must be prepared to fight: high-intensity conflict (HIC), mid-intensity conflict (MIC), and low-intensity conflict (LIC).

DISPERSED OPERATIONS

FM 100-5 describes these conflicts as being characterized by dispersed operations employing sophisticated, longer range, and more lethal weapons systems. The scope of the battle is dramatically increased because of these systems and results in improved battlefield surveillance, more effective target acquisition sensors, and flexible communications links.

Command and control (C^2) is critical to success. Interruption of communications with higher headquarters and adjacent units can destroy synchronization and control. The effective control of airspace is a leading factor in the outcome of battles. High consumption of supplies, rapid movement, and long (therefore vulnerable) lines of communication (LOC) will challenge communicators and logisticians.

Overlaid on all of these concerns is the major constraint the environment plays on the battlefield. These are serious environmental constraints which, in turn, influence your commander's ability to apply maximum combat power at the right time and place.

A good example of using inclement weather effects to an advantage was demonstrated by the Soviets during World War II. They used weather to maximize firepower. Whenever heavy precipitation was expected, they moved their artillery to defilade positions close to the front lines.

After the storm, mobility was usually impossible and the Russians delivered rapid and accurate indirect fire on the immobilized Germans.

PROTECTION OF THE FORCE

Protection of the force against adverse effects of weather is paramount to maintaining maximum warfighting capability--and one of your biggest and most important tasks.

Protection of the force and understanding the impact of adverse weather can be quickly illustrated by an incident from the Korean War in early 1951. A battalion-sized relief-in-place was planned for late afternoon. The location was on the top of a 1,500-meter hill. The temperature at the time of the relief was nice and warm and the operation was conducted by troops wearing summer-like clothing. No plans had been made to issue winter clothing that evening because no one took the time to look at the weather forecast.

During the night a cold front forced temperatures below freezing. Cold weather injuries to 75 percent of the personnel made the unit completely ineffective. Intelligent planning, including a weather forecast, could have avoided the injuries and maintained full warfighting capability.

The protection of your force requires that you understand and identify inclement weather impacts on friendly and threat capabilities for the commander. It is your responsibility to inform him, and other staff planners, of current or forecasted weather conditions that endanger unit success. Accurate weather effects information is a major key to successful military operations.

CHAPTER TWO

WEATHER ELEMENTS AND SUPPORT

A working knowledge of various weather elements identified here is essential to your ability to provide your commander with a complete picture of potential adverse weather effects on the battlefield. But, you are not alone in your mission. Help is available from a variety of sources.

INTERACTION OF BATTLEFIELD ENVIRONMENT ELEMENTS

Weather conditions, terrain, BIC, illumination, and background signatures are some of the primary conditions that will be found in a battlefield environment. Table 2-1 defines some of the more common weather elements discussed.

A weather element generally is an atmospheric variable that is measured in a weather observation. A weather parameter is derived from one or more weather elements. For example: density altitude is a weather parameter derived from the elements barometric pressure and temperature.

You must remember that weather conditions such as wind, precipitation, and clouds can impact or can be influenced by the other conditions of the battlefield (terrain, BIC, illumination, and background signatures). All of these conditions are interdependent to a certain degree and must be considered as a whole, and not each in isolation.

WEATHER EFFECTS AND TERRAIN

Terrain features affect such weather elements as visibility, temperature, humidity, precipitation, winds, and clouds. The most common example of terrain affecting weather is that on the windward side of high terrain, such as mountains, the rainfall rate will be greater than on the leeward (opposite) side.

On the other hand, weather conditions such as temperature, winds, and precipitation have a definite effect on the terrain and can enhance or limit military operations, such as trafficability, watercrossing (fording), and the first-round accuracy of supporting field artillery fires. The responsibility for determining mobility and counter-mobility is given to the terrain team at division.

Table 2-1. Common weather elements.

ATMOSPHERIC PRESSURE: Atmospheric pressure is the pressure exerted by the atmosphere at a given point and measured by a barometer in inches of mercury (Hg) or in millibars (Mb).

Pressure Altitude:	This is indicated in an altimeter when 29.92 is set in the barometric scale window. High pressure altitude is critical to the lift capability of fixed wing aircraft.
Density Altitude:	This is a place in the atmosphere corresponding to a particular value of air density. High pressure is critical to helicopter operations.

CLOUDS: The amount of sky covered by clouds is usually described in eighths. Overcast (8/8ths), broken (5 to 7/8ths), or scattered (1 to 4/8ths). Cloud conditions are described by the amount of cloud cover and the height of the base of the cloud above ground level. A cloud ceiling is the height of the lowest broken or overcast layer, and is expressed in feet. A higher layer of several scattered layers of clouds is designated as a cloud ceiling when the sum of the coverage of the lower layers exceeds 4/8ths.

DEW POINT TEMPERATURE: Dew point is the temperature to which the air must be cooled for the air to become saturated and allow dew, and probably fog, to form.

HUMIDITY: This is the state of the atmosphere with respect to water vapor content. It is usually expressed as:

Relative Humidity:	This is a ratio between the air's water content and the water content of saturated air.
Absolute Humidity:	This is a measure of the total water content in the air. It is high in the tropical ocean areas and low in the arctic.

PRECIPITATION: Precipitation is any moisture falling from a cloud in frozen or liquid form. Rain, snow, hail, drizzle, sleet, and freezing rain are common types. The intensity of precipitation is described as light, moderate, and heavy.

Light Rain:	Drops are easily seen, very little spray, and puddles form slowly, and accumulation is a trace to 0.10"/hour.
Moderate Rain:	Drops are not easily seen, spray noticeable, puddles form rapidly, and accumulation rates are 0.11" to 0.30"/hour.
Heavy Rain:	Drops are not seen, rain comes in sheets with heavy spray, puddles form quickly, and the rate is more than 0.30"/hour.
Light Snow:	Visibility is equal to or greater than 5/8 miles, or 1,000 meters in falling snow; and a trace to 1 inch/hour accumulates.
Moderate Snow:	Visibility is 5/16 to 1/2 statute miles, or 500 through 900 meters in falling snow with 1 to 3 inches/hour accumulation.
Heavy Snow:	In heavy snow, visibility is cut to less than 1/4 statute miles, or 400 meters, with more than 3" accumulation/hour.

TEMPERATURE: Temperature is the value of heat or cold recorded by a thermometer normally at 6 feet above the ground at the observation site. Temperatures are normally given in both Fahrenheit and Celsius values. It is sometimes referred to as the ambient air temperature.

VISIBILITY: A measurement of the horizontal distance at the surface or aloft that the unaided human eye can discern a large object or terrain feature. Visibility is reported in meters or fractions of a mile, and is reported as a prevailing value of the visibility in all directions. Thus, a visibility report of 1,600 meters may not reveal that fog is diminishing visibility to 400 meters in the northwest if the observer has good visibility in other directions. However, such an event would typically be carried in the weather observation's remarks section.

WIND SPEED AND DIRECTION: These two measure the rate of movement of the air past a given point and the direction from which the wind is blowing. A gust is a rapid fluctuation in wind speed with a variation of 10 knots or more between peak and lull. Gust spread is the instantaneous difference between a peak and a lull and is important for helicopter operations.

Examples of terrain products that are normally prepared and available from the division terrain analysis team for use in the intelligence preparation of the battlefield (IPB) are discussed later in this chapter in the terrain analysis team support section.

BATTLEFIELD-INDUCED CONTAMINANTS

During combat operations, visibility can become severely reduced by BIC. These contaminants are either induced directly by combatants or occur as by-products from battlefield operations.

Two significant sources of battlefield contaminants are dust produced by high explosive (HE) artillery or mortar rounds and deliberately employed smoke. HE rounds used in a pre-attack barrage may not only kill enemy forces, but also may restrict the visibility of your own troops by dust caused by the HE if the direction of the wind is not taken into account. Smoke produced by smoke generators, vehicle exhaust emission systems, smoke pots, indirect fire, and smoke rounds also obviously produce battlefield contaminants.

Wind speed and direction are critical to maintaining an effective smoke screen. Rain can remove BIC quickly. Weather inversions over valley areas can sustain airborne contaminants for long periods of time.

Other sources of BIC that will lower visibility in the AO are clouds of dust from vehicle traffic or smoke from fires. These types of contaminants not only blind you but also may help your adversary in detecting troop movements and pinpointing your location.

A unique BIC, affecting visibility, occurs in very cold conditions when temperatures are in the range of -30° C or -22° F or colder. Whenever a source of moisture or water vapor is released into the cold air by internal combustion engines, artillery fires, or launching of self-propelled munitions, visibility can be reduced to zero when the moisture freezes instantly and changes into ice fog.

Ice fog may restrict visibility across a whole valley and, once created, can linger for hours. Ice fog crystals permit ground objects to be seen from above while severely restricting visibility on the ground--an advantage for aerial reconnaissance.

On airfields an ice fog created by fixed-wing aircraft may cover an entire runway. Visibility can be reduced so that other aircraft cannot take off or land if the wind is calm. Besides reducing visibility, the ice fog draws attention to the airfield location.

Launching missiles such as the tube-launched, optically tracked, wire-guided (TOW) in very cold air can create an ice fog. As the TOW moves to the target, the exhaust blast exits into the air where it condenses and creates the ice fog. If the wind is calm, this fog follows the trajectory of the missile and reduces launch point visibility to such an extent that the operator loses sight of the target. Also, the launch point can be identified by threat forces from the condensation trail of the missile.

ILLUMINATION

Natural light is critical in planning operations where night vision devices (NVD) are used or in operations timed to use only available light. Natural light values vary as a function of the position of the sun, moon, stars, and clouds. Light data are available from your SWO for any time, period, and place. These data are particularly important for determining first and last light, moonrise, and moonset, and are most effective for planning use of NVD.

Appendix F provides more detail on the impact of illumination on electro-optical (E-O) devices. Variables such as altitude, cloud cover, terrain-produced shadows, visibility, and direction of vehicle or aircraft movement in relation to the sun or the moon can also affect light level availability.

Artificial light is intended to increase visibility, but, under certain weather conditions, this does not always occur. For example: Low cloud ceilings will limit the area covered and effective time of flares. Rain, snow, or fog can reduce flare effectiveness. However, under the right conditions, cloud cover can enhance the effects of artificial light due to cloud base reflection. Snow or sand covered terrain also reflect both natural and artificial light.

BACKGROUND SIGNATURES

Temperature, wind, and precipitation have a major influence on your ability to pick out a target from the background in the infrared spectrum. They also affect seismic (sound and acoustic) signatures. Detection of objects in the infrared spectrum depends on a temperature contrast between the object and its surrounding environment. This difference is known as the background signature.

A more detailed explanation on how the background signature is affected and changed by weather is also in Appendix F. Snow, rain, and wind influence the background signature because they can change the surface temperature of objects. These elements lower object temperatures and thus reduce the differential between a target and its background.

A heavy layer of snow produces a washout during any part of the day since it causes both the object and the background to exhibit the same temperature.

Precipitation also degrades seismic sensors through the introduction of background noise (rain), while a snow-covered surface will dampen sound and the movement of troops.

OTHER WEATHER PHENOMENA

Although we have discussed such elements as clouds, temperature, and precipitation, other phenomena should not be overlooked. For example: In the desert, strong winds produce dust storms that can last for hours or even days.

Any wind, during cold weather, causes loss of heat from the body and increases the danger of freezing. This is discussed in Appendix L. Thunderstorms, with their associated lightning, strong winds, and heavy rains affect the battlefield environment. Owing to their short-lived ferocity and unpredictability over a given time and location, thunderstorms are difficult to assess in planning. But when they occur, they definitely disrupt intelligence gathering and affect personnel movement, equipment function, and target identification.

Atmospheric pressure is essential information for aircraft operations. High humidity and temperature affect aircraft lift and significantly reduce a soldier’s ability to work and fight.

WEATHER PRODUCTS

There are four types of weather information products that are available:

- Weather Observations.
- Weather Forecasts (to include severe weather warnings).
- Climatology.
- WTDAs.

All of these products are vital in preparing a complete weather picture of the battlefield, and showing critical weather impacts on your unit’s systems and operations.

WEATHER OBSERVATIONS

There are two types of weather observations normally collected on the battlefield: surface and upper air. Surface weather observations are taken by both Army and USAF personnel. Army intelligence personnel take weather observations under the Forward Area Limited Observing Program (FALOP) as outlined in FM 34-81/AFM 105-4.

Participating Army personnel (usually someone on your staff) will be taking a limited number of abbreviated surface observations, using a small, manual belt weather kit (BWK). The BWK is scheduled for replacement by an automated meteorological sensor system.

WETMs take and disseminate hourly observations as well as special observations when critical changes occur. Weather observations within the division AO might be available from a USAF mobile observing team (MOT). The MOTs are organic to the division WETM and are deployed at the direction of the SWO after coordination with the G2. If the G2 decides against employing a MOT below the division main command post (CP), the only immediate source of weather observations at the maneuver brigade and battalion are from the FALOP.

Regardless of the source of weather observations, they reflect current conditions and could be used, if the weather is stable, as an indicator for up to 1 to 3 hours. Remember that as the quality and quantity of observations diminish, their value, as even near-term trend indicators, also diminishes.

It is the Army's responsibility to provide upper-air data to support field artillery as needed. These upper-air observations may be taken as frequently as every 2 hours, or only twice daily. Field artillery meteorological (ARTYMET) sections also take valuable limited surface observations. Upper-air data primarily supports field artillery operations, but other mission areas use it routinely. These surface and upper-air meteorological messages should be quickly transmitted to WETMs. The WETM combines the ATYMET data with other meteorological information to support aviation, NBC, engineers, and other consumers.

WEATHER FORECASTS

Weather forecasts are prepared by WETM forecasters and normally cover periods from 1 hour out to 48. Outlooks extend from 3 days to 7 days. Several factors determine the accuracy of the forecast. These factors include--

- The length of time in advance that the forecast is required.
- The area for which the forecast is made.
- The quality and quantity of weather observations available to the forecaster.
- The quality and availability of communications.
- The availability of USAF-provided weather data base.

Forecast accuracy normally diminishes as the forecast period increases. A 24-hour forecast is more accurate than a 72-hour outlook. Although extended outlooks may not predict cloud base heights or exactly when the rain will start, they can show expected movement of weather systems with associated cloud and precipitation areas.

Forecasts and extended outlooks are the building blocks you use to determine the effect of the weather on planning. The shorter time period and the greater the number of observations in the forecast area, the higher the confidence you can have in the accuracy of your analysis.

CLIMATOLOGY

Weather information required beyond the extended outlook (7 days) is based upon historical climatological data. This information is important for long-range planning, especially if you are to deploy to an unfamiliar AO. Climatology data gives the commander average weather conditions and the weather extremes that can be expected in the field. This assists in planning--

- Future operations.
- Types of systems, equipment, and supplies.
- Personnel strengths.

You will need to work with your SWO while still in garrison to collect and process climatology data.

SOURCES OF WEATHER SUPPORT

Weather support to Army tactical units is provided in two ways. The WETMs provide all forecasts and supplemental weather information received from national and local sources, together with surface observations taken at each WETM location. Some division WETM MOTs may be deployed forward (by direction of the division commander) to supplement surface observations taken by Army personnel. The Army is responsible for taking surface and upper-air observations forward of the division command element and in direct support of Army weapon systems and operations.

USAF TACTICAL WEATHER SUPPORT

FM 34-81/AFM 105-3 states Army doctrine and our requirement for weather support. The USAF Directorate of Weather assigns weather forecasters and observers, comprising WETMs, or special operations weather teams (SOWTs), to tactical Army units to meet this need.

USAF forecasters are at the main CP at--

- Echelons above corps (EAC).
- Corps.
- Divisions.
- Separate brigades.
- ACRs.
- Division and corps aviation brigades.
- Ranger regiments.
- SFG headquarters and forward operating bases (FOBs).

Observers are assigned to the same locations listed above and assist forecasters by taking surface weather observations. Limited observing functions may exist at the SFGs, FOBs, and ranger regiments. MOTs may also be deployed to selected tactical airfields and landing zones (LZs). Size and composition of WETMs vary from as few as 4 observers and forecasters to teams with as many as 14 observers and forecasters plus 2 officers.

At EAC, corps, and division the senior weather officer is the tactical unit's SWO. Although the SWO is a member of the special staff, he normally works with the G2 and with the operations and plans sections. The SWO commands all the WETMs at his tactical level and is under the operational control of the Army commander.

Each SWO ensures that his WETM supports the commander's needs. For this reason, it is important that you outline your specific requirements to your supporting SWO. Weather support requirements must be validated (by the SWO and the SIO) prior to deployment so that the WETM can make the necessary preparations. If new requirements surface in the field, or changes are required, you notify your SWO. Give him enough lead time to allow for production changes.

ARMY WEATHER SUPPORT

By joint regulation, AR 115-10/AFR 105-3, USAF responsibility for surface weather observations ends at the division main CP. The Army's responsibility is to take observations from the CP forward, and in direct support of Army weapons systems anywhere in the AO.

As discussed earlier, the FALOP and ARTYMET data partially satisfy this requirement. Weather satellite imagery will play a larger role as new systems are designed to capture this data.

HOW G2 OR S2 RECEIVE WEATHER SUPPORT

It is your responsibility to provide weather and weather effects information to your commander and supported or subordinate units. Methods may vary from unit to unit and echelon to echelon. At higher echelons, the SWO has primary responsibility for providing weather support. There, the G2 simply contacts the SWO, states requirements, and receives the needed weather support.

If you have no SWO, you must pass the request up the chain of command to a level where one is assigned. Once your requirements have been validated, weather support products flow back over the same path. In addition to weather forecast products, the SWO can provide specialized weather effects products. You must provide the threshold values used in developing these products.

Figure 2-1 summarizes this flow. The SWO support to the brigade is shown with an asterisk because only separate and aviation brigades have direct weather support.

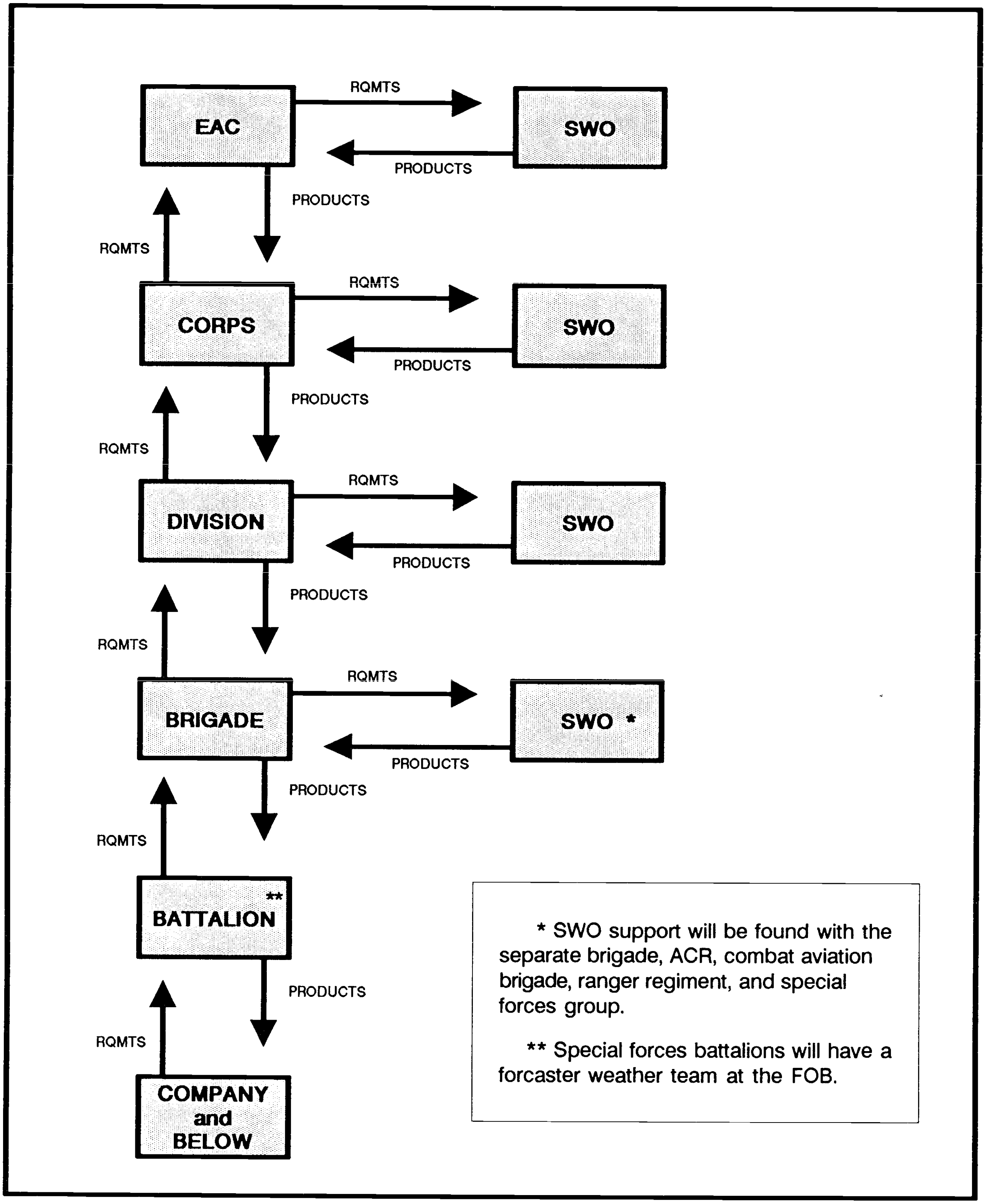


Figure 2-1. Weather requirements and production flow.

TERRAIN ANALYSIS TEAM SUPPORT

Combat intelligence is composed of weather, enemy, and terrain; sometimes called the WET trilogy. Below division, where a terrain team is not assigned, the intelligence analyst working order of battle (OB) has the added responsibility for terrain analysis. Your OB specialist relays the unit's requirements, through channels, to the terrain team supporting the division. He also does whatever limited local analysis is needed.

Once in the field, terrain and weather analyses in support of the intelligence preparation of the battlefield (IPB) are based on locally updated terrain data bases and the current weather forecast for the AO.

Terrain teams are responsible for analyzing the division geographic AI and providing recommended courses of action based upon effects of weather under current and forecast weather conditions. They produce graphical tactical decision aids (TDAs) that help the commander and staff understand the effects of weather on division operations. These IPB templates are available to you at either brigade or battalion upon request.

The principal user of IPB templates is the divisional G2 staff, but terrain teams will service needs of brigade and battalion S2s as priorities allow.

Separate brigades and other corps or EAC units obtain the same support via the corps or theater G2. Lead time must allow production of tailored products, and attached elements can expect to compete with other G2 and engineer priorities.

Many standard products will already be available from the division's team. See Table 2-2. The more you exercise terrain teams, the more responsive they will be as they understand and learn to anticipate the needs of brigades and battalions.

In the field, new or updated terrain analysis products may be obtained electronically or via courier.

USE OF INTELLIGENCE PREPARATION OF THE BATTLEFIELD TEMPLATES

IPB templates provide an integrated graphic portrayal of enemy doctrine and the effects of weather and terrain in the AO and AI. Development of IPB products, while still in garrison, based on climatology (provided locally by the WETM) gives you a general idea of what average seasonal weather conditions will be in the AO.

Table 2-2. Terrain analysis products.

• Observation, field of fire	• DZs and LZs
• Concealment and cover	• Maneuver (mobility and trafficability)
• Obstacles	• Key terrain
• Cross-country movement	• LOS, terrain perspectives
• LOC and MSRs	• Barriers and fortifications
• Ground avenues of approach	• Weapon sites
• Air avenues of approach	• Surface drainage
• EW sites	• Soil analysis
• Beach, river embankment studies	

Once deployed, IPB products must be updated based on--

- Current weather observations.
- Periodic weather forecasts.
- Environmental effects products produced by the terrain team.

By comparing the weather forecasts or current observations to the climatology used in preparing the IPB templates, you can keep the commander informed on trends.

Two examples illustrate how garrison-prepared IPB products can be updated in the field. You have prepared IPB templates depicting mobility or counter-mobility based on a climatic average of 2 inches of precipitation. Then the SWO reports that the rates are higher than anticipated. You quickly modify the templates and brief the commander.

Then, if you have prepared air mobility corridor templates based on the general low-level cloud ceilings (climatology) and high mountainous terrain, these can be modified to determine the best and worst air corridors based on either weather observations or forecasts.

You can obtain weather IPB overlays by asking for them from your higher G2. The G2 will then task the SWO to produce the weather portion of the overlays. Overlays may be used with either climatology for long-range planning or with forecasts for a specific time. Combinations of several critical threshold values and weather elements may be depicted on one overlay. This way a specific weapon systems effectiveness can be briefed as a sum of the various weather elements involved.

Remember that for long-range planning a climatology review and data extraction is a time-consuming process. The more lead time you can give the G2 and the SWO, the more thorough the research and the higher quality of the finished product. Use Appendixes B through O as guides to develop weather overlays. The weather elements contained in Table 2-3 may not address all of your unit's weather needs. Other weather overlays that may be of interest are--

- Atmospheric pressure and density altitude for helicopters.
- Areas where thermal sight target signatures will be reduced.
- Time periods when thermal crossover will occur.
- Areas where heat and humidity will exceed mission oriented protective posture (MOPP) 4 survivability for time periods over 2 hours at hard work.
- Long-range surveillance unit (LRSU) high altitude, high opening (HAHO) infiltration corridors based on upper-air weather conditions.
- Weapon system performance capabilities based on combined weather effects threshold values.

By combining climatology, terrain data, and the IPB process while still in garrison, you get an idea of what to expect in the field. Then you use current forecasts and local terrain data to update the weather and terrain analysis steps of IPB.

Table 2-3. IPB weather overlay criteria.

WEATHER ELEMENTS	THRESHOLD VALUES	IMPACTED SYSTEMS
VISIBILITY	1.0 km	DRAGON, Machine guns.
	3.0 km	Main gun, TOW, CAS, thermal viewers.
CLOUDS	500 ft	Nap-of-the-earth operations, Airborne, helicopter target acquisition.
	1,000 ft	CAS
	1,500 ft	COPPERHEAD engagements.
	5,000 ft	Visual reconnaissance, ADA target acquisition.
SURFACE WIND	6 kn	Chemical.
	13 kn	Airborne - round parachute.
	18 kn	Military free fall -- ram air parachutes, artillery smoke loses its effectiveness, artillary fire accuracy.
	30 kn	Helicopter maneuver.
TEMPERATURE	GT 32°C	Helicopter lift capabilities.
	LT 0°C	NVG (PVS-5).
WINDCHILL	LT -10°C	Personnel survival.
PRECIPITATION	Moderate	Ground maneuver, chemical, laser systems, GSR.
	Freezing	Ground maneuver.

LEGEND: GT= Greater than LT= Less than

CHAPTER 3

COMMANDER'S WEATHER INFORMATION REQUIREMENTS

Here we address the commander's weather requirements. And while the unit's weather needs flow from the commander, it is your job to articulate and convey these needs to the SWO. You do this either through your G2 or directly, depending upon local custom.

But before you can be totally effective, you need to understand how the SWO works and what kind of support he can provide. Plus, there are other factors you must consider before asking the SWO for forecast support.

FORECASTS, OUTLOOKS, AND REPORTS

Every commander views his battlefield as having two distinct areas that can be expressed in terms of distance and time. These are the AO and the AI. It is impossible to be specific about distances here because different types of units will travel at different speeds. And while distances may vary, time stays relatively constant. Examples of time applied to both the AO and AI are shown in Table 3-1.

Table 3-1. Areas of operations and interest.

LEVEL OF COMMAND	TIME OF AO	TIME OF AI
BATTALION	Up to 3 hours	Up to 12 hours
BRIGADE	Up to 12 hours	Up to 24 hours
DIVISION	Up to 24 hours	Up to 72 hours
CORPS	Up to 72 hours	Up to 96 hours
EAC	Up to 96 hours	More than 96 hours

The AO is an area of conflict necessary for military operations. It is a geographical area assigned to a commander for which he has responsibility and in which he has authority to conduct military operations. Commanders are assigned an AO based on the mission, enemy, terrain, troops, and the time available (METT-T).

The action of the threat forces, the trafficability, and the weather conditions in the AI are also of great concern to the commander. The AI includes the AO plus adjacent friendly areas and areas occupied by threat forces that could jeopardize the mission. The AI time span may be significantly increased over that of the AO because of possible threat ground and air operations. Since the battlefield is fluid, the land mass encompassing the AO and AI should be measured by the times shown in Table 3-1. This is important because the SWO will satisfy your weather support requirement by time sequencing weather forecasts for the geographical AO and AI.

ESTABLISHING REQUIREMENTS FOR FORECASTING SUPPORT

Weather forecasts, like any other intelligence information, must be keyed to those areas that encompass the commander's AO and AI planning horizons. The geographic area covered by the forecast is directly related to the military operations at each tactical level. For example: At battalion level, the commander's concern revolves around how far his soldiers can travel or shoot in 12 hours. Table 3-1 can be used to determine the geographic coverage required for any forecast and each echelon by factoring in distance.

PERIODS OF FORECAST AND OUTLOOKS

While it is critical for the commander to have a weather forecast covering current operations, it is not the only weather requirement he has. He must also be aware of tomorrow's weather and how it may affect his unit's continuing operations.

Therefore, instead of thinking only about current and forecasted weather for the next 3 to 12 hours, his weather concern envelope may extend out several days. This approach expands as you go up the tactical chain of command.

An EAC commander must be concerned with a 7- to 10-day weather outlook. Table 3-2 summarizes this concept. In every instance, the degree of detail varies, and you must tell the SWO the forecast length required and, in turn, put this information into the unit's tactical standing operating procedures (SOPs).

Generally, the commander needs detailed forecasts of selected weather elements for the first 24 hours, in increments as short as 6 hours. Forecast intervals beyond the first 24 hours are going to be longer.

Table 3-2. Determining lengths of forecasts and outlooks.

LEVEL OF COMMAND	LENGTH OF FORECAST/OUTLOOK OF PRIMARY INTENT	LENGTH OF FORECAST/OUTLOOK FOR PLANNING
BATTALION	12 to 24 hours	48 hours
BRIGADE	24 hours	48 hours
DIVISION	24 to 36 hours	3 to 5 days
CORPS	1 to 3 days	5 to 7 days
EAC	2 to 4 days	7 to 10 days

FREQUENCY OF UPDATE

After deciding the geographic coverage and length of the forecast period, you can then consider the frequency of forecast updates. Generally, an update every 6 to 12 hours is sufficient for the first 24-hour period. Asking for forecast updates more frequently than every 6 hours is counterproductive because the only new data available would be unevaluated observations.

Forecasts extending beyond 24 hours should be revised daily. These forecasts are based on hemispheric computer models that run every 12 to 18 hours. Table 3-3 summarizes the recommended frequency for weather forecast updates.

Table 3-3. Update frequency.

LENGTH OF FORECAST/OUTLOOK	FREQUENCY OF UPDATE
0 to 12 hours	Every 6 hours
0 to 24 hours	Every 6 to 12 hours
24 to 72 hours	Every 24 hours
More than 72 hours	Every 24 to 72 hours

SELECTING WEATHER ELEMENTS

Each weather forecast contains the standard weather elements observation the battlefield. You must identify those elements that are most important to you. Table 3-4 identifies several common battlefield applications and those weather elements that play a role in their operations.

Using a table like this, and discussions with your SWO, you can determine the precise weather elements that are most important to your unit. Based on your operation, systems, and personnel, there will be several weather effects threshold values that you will want the SWO to be aware of. He records your needs as standing requirements and will automatically report conditions that meet the criteria.

For example: The height above ground level (AGL) of the base of clouds that form a ceiling is important to the COPPERHEAD missile. If 600 meters is the critical threshold value, you must tell the SWO so the WETM will spend extra time trying to determine when, or if, that value will be reached.

Gusting surface winds over 35 knots are critical to air assault operations, and parachutists require at least 1,000 feet of visibility AGL to visually see and aim for a specific landing site within the drop zone (DZ). You must make sure the SWO is informed of these values so he can concentrate his forecasting capabilities on those thresholds that are critical to your unit.

CRITERIA FOR CHANGE

You have told the SWO when and how often you need a forecast. But what happens if conditions change (weather forecasters change forecasts occasionally)? What do you tell him about being notified? You will know, if you can answer this question: What weather elements with specific thresholds are important to my mission?

For example: In support of aviation your commander may specify that for cloud ceilings under 500 feet he wants to receive a new updated forecast whenever the ceiling changes (deteriorates or improves) by 100 feet from the original forecast.

Since precipitation is important for ground maneuvers, a commander may want to know when the forecast changes from no precipitation to rain or rain showers.

Table 3-4. Weather applications and criteria for changes.

BATTLEFIELD APPLICATION \ WEATHER EFFECTS	CLOUD DATA	FOG	HUMIDITY (1),(2)	LIGHT DATA	PRECIPITATION (2)	PRESSURE	SEVERE WEATHER	SNOW/ICE COVER	SURFACE WINDS	STATE OF GROUND	TEMPERATURE	VISIBILITY
OBSERVATION and FIELD OF FIRE	X	X		X	X		X	X				X
ARTILLERY FIRES	X	X	X	X	X	X	X	X	X	X	X	
CONCEALMENT	X	X		X	X		X	X	X	X		X
CAMOUFLAGE	X	X	X	X	X		X	X	X	X	X	X
GROUND AVENUES OF APPROACH		X		X	X		X	X		X	X	X
AIR AVENUES OF APPROACH	X	X	X	X	X	X	X	X	X	X	X	X
CROSS-COUNTRY MOVEMENT		X		X	X		X	X	X	X	X	X
FORDING SITES		X		X	X		X	X	X	X	X	X
AIR DROP ZONES	X	X		X	X	X	X	X	X	X	X	X
HELIMOBILE LZ/PZ	X	X	X	X	X	X	X	X	X	X	X	X
LOC AND MSRs		X		X	X		X	X		X	X	X
NBC OPERATIONS	X	X	X	X	X	X	X	X	X	X	X	X
RADIO/RADAR					X		X		X			
REMBASS EMPLACEMENT					X		X	X	X	X	X	
INFILTRATION ROUTES	X	X		X	X	X	X	X	X	X	X	X

LEGEND: (1) Density altitude quality affects aircraft lift capability.
(2) For laser-guided weapons.

SEVERE OR HAZARDOUS WEATHER

In addition to your continuous need for forecast updates for general weather elements, you need non-forecasted or unanticipated severe or hazardous weather warnings. These weather phenomena adversely impact your operational capability. WETMs normally issue severe weather warnings and advisories. Check for the values at which each weather element becomes known as severe. Severe weather conditions are listed below. (As a working aid you might add the exact critical values for your unit's operations, systems, and personnel in place of the X in Table 3-4.) When forecast (and especially when not forecasted), you will be concerned with such conditions as--

- Tornadoes.
- Thunderstorms producing winds in excess of 45 knots and hail greater than 3/4 of an inch.
- Hurricanes and typhoons.
- Precipitation (rain or snow) when X inches fall in Y hours.
- Surface winds in excess of X knots.
- Maximum and minimum temperatures; when a forecast value misses the actual temperature by X degrees.

You want to know that an earlier forecast for light snow was amended to a forecast of a 16 inch accumulation within the next 12 hours. We cannot over emphasize that you need to work with your next higher headquarters S2 or G2 and the SWO so that your needs are realistically stated and can be supported. All of your weather support needs should be reviewed every 6 months in garrison and as required in the field.

LIGHT DATA

Another weather-related element that your commander needs is light data. The introduction of NVD and night vision goggles (NVG) have made many night operations feasible. Your SWO provides official times for sunrise and sunset, beginning and ending of civil twilight (BMCT and EECT), beginning and ending of nautical twilight (BMNT and EENT), length of absolute darkness, moonrise, moonset, lunar phase in percent, and time periods for using NVD and NVG. Light data to support NVD is needed because there are times when there is not enough moon or star light to use them.

Civil twilight is sufficient for conduct of combat operations while nautical twilight permits most ground movements without difficulty. Nautical twilight allows a general visibility of up to 400 meters (1 ,320 ft) and lets you distinguish silhouettes from the background.

The actual duration of light varies considerably with latitude and time of year. For example, in the vicinity of 35 to 40 degrees north latitude, civil twilight generally occurs 30 to 45 minutes before sunrise and after sunset. In the tropics, twilight is much shorter.

Once light requirements are determined, relay them to your next higher SIO and SWO. This information is important for your commander because he needs to know not only when he can begin friendly military operations (day or night), but also when threat operations could begin.

OTHER CONSIDERATIONS

Although high frequency (HF) radio wave propagation forecasts are not normally available to the SWO, he can make arrangements before he deploys to receive these forecasts. When available, they should be given to every signal and intelligence organization. The signal officer should know that when HF is not effective, it may be because of solar activity rather than enemy jamming.

The USAF Global Weather Central can routinely provide solar forecast products to the SWO even in the field. Other data, such as tidal information and sea state conditions, can be obtained from the SWO but are normally only provided to specific Army units, and then upon special request.

RECEIPT OF FORECASTS

Every tactical echelon should receive the weather forecast prepared and briefed to the commander at the next higher echelon. With no SWO at a maneuver brigade, you receive both the forecast briefed at division covering the division AO and the forecast made by the division SWO specifically for your brigade. Each forecast message received should be worked by you to discover the direct weather impacts on your unit.

A commander wants the weather forecast. He also needs the effects and impacts of the forecasted weather interpreted for his specific operations, systems, and personnel. Table 3-5 provides a matrix of the kind of data and weather forecasts that Army units might need. Remember to schedule your forecasts so they arrive in time for you to prepare your commander’s briefing.

Table 3-5. Typical support requirements.

WEATHER DATA \ USERS	AIR DEFENSE	ARTILLERY	CAB/AIRBORNE	CHEMICAL	COSCOM	ENGINEER	HQ STAFF	MEDICAL	PORT HANDLERS	REAR/ALT CP	SIGNAL	S2	TERRAIN ANALYSTS
FORECAST (0 to 48 HOURS)	X	X	X	X	X	X	X	X	X	X	X	X	X
EXTENDED FORECAST (3 to 7 DAYS)	X	X	X	X	X	X	X	X	X	X			X
AVIATION FORECAST	X	X	X	X	X		X	X		X		X	X
LIGHT DATA	X	X	X	X	X	X	X		X	X		X	X
SEA STATE DATA						X			X				X
LOW-LEVEL WINDS	X	X	X	X	X		X	X		X			X
UPPER-LEVEL WINDS	X	X	X	X	X		X	X		X			X
DEEP ATTACK WEATHER	X	X					X			X			X
PRECIPITATION FORECAST	X	X	X	X	X	X	X			X	X	X	X
SEVERE WEATHER	X	X	X	X	X	X	X	X	X	X	X	X	X
HF PROPAGATION	X		X				X			X	X		
E-O DATA	X	X	X				X			X		X	
INVERSIONS			X	X							X		
VISIBILITY	X	X	X			X	X			X		X	X

CHAPTER 4

WEATHER TACTICAL DECISION AIDS

As your commander's weather interpreter, you are familiar with weather and its effects on operations, systems, and personnel. History provides many examples where weather, properly taken into consideration, contributed to the successful accomplishment of the mission. Conversely, when weather has not been properly considered, the consequences have been disastrous. To gain the maximum benefit from the data provided here, you must know the weather effects critical threshold values for the operations, systems, and personnel in your unit. Specific BFA-associated WTDAs located in the appendixes will be helpful.

EXPLANATION AND PRESENTATION

Conduct of the battle within the AO is influenced by the effects of weather. You advise and alert the commander on how, when, where, and why the battlefield dynamics will change because of weather. The key is to learn to exploit opportunities offered by weather while reducing or minimizing the adverse effects.

The geographical layout of the battlefield is important to you because the times and distances across the AO and AI vary with the size, type of unit, and mission. These constraints affect the type of weather forecasts needed in terms of time and area. The duration of the forecast must meet or exceed the planning and execution cycles.

The following are some operations affected by critical weather extremes.

- Poor visibility degrades target acquisition and engagement, C^2, troop and vehicle mobility, maneuver options, and air operations.
- High and low winds affect chemical weapons and smoke employment, air operations, antenna setup and employment, personnel (windchill), target tracking devices, and accuracy of artillery fire support systems.
- Temperature extremes impact troop safety and performance, trafficability, maintenance, aircraft limits, optical systems, employment of chemical weapons and smoke, and accuracy of fire support systems.

- Precipitation degrades mobility, trafficability, nuclear and chemical weapons, smoke, the effective use of laser-guided munitions, maneuver options, air operations, target acquisition, and tactical ballistic missile (TBM) employment and launching.
- Cloud cover affects all types of air operations. Cloud cover also can limit or enhance the effects of nuclear weapons, smart weapons, and smoke.
- Severe weather conditions (such as blizzards, hailstorms, thunderstorms, strong winds, and freezing rain) impact almost every battlefield operation.

Even the best weather information or intelligence will not necessarily be the decisive factor in winning the battle. However, it can be a force multiplier when applied during planning. It will almost certainly affect the degree of success you have. Weather may not be the sole determining factor as to the GO, NO-GO decision, but it will surely influence a commander's decision on how best to use combat power.

SOURCE OF WEATHER VALUES

Most of the critical weather values used here are a compilation of validated values taken from a variety of military publications including system technical manuals, other FMs, and proponent requirements. Some subjective values (based on personal experience and usually not validated) are also included. You will probably find that you will add values of your own based on practice and experience. (These insights, forwarded to the proponent office, will be valuable in updating the contents of future iterations of this manual.)

USE OF THE APPENDIXES

Time is in short supply in the field and, in some cases, higher priority tasks will permit you very little time to develop weather information for the commander's briefings. Appendixes B through N have been developed to help you quickly identify critical weather values and their effects on the operations, systems, and personnel of the unit. These WTDAs allow you to swiftly turn weather forecasts and observations into meaningful weather effects information. Practicing this skill in garrison will be a great help in the field.

CONTENTS OF APPENDIXES

Appendix A contains a step-by-step guide through the process of translating adverse weather conditions into force impacts. In addition, it features quick references tables to identify critical value ranges of five basic weather elements. For each weather element, the critical value ranges are shown impacting Army BFAs, E-O, and threat systems. The five elements evaluated are cloud ceilings, reduced visibility, surface wind, temperature, and precipitation. These references apply to critical values shown in Appendixes B through N.

Appendix O contains a current list of weather and environmental elements or parameters identified by BFA proponents and other Army agencies. The impacts of some of these are not fully known and data may not presently be collected.

Appendix P contains useful conversion factors. An expanded list of weather terminology is presented in the glossary.

Weather data and impacts reflected in these appendixes are predicated on normal unit configuration.

THE WEATHER BRIEFING

This section contains an example that will help you visualize how the WTDA charts and tables can be used to develop and present a comprehensive weather and weather effects briefing. For this exercise you are the S2 of a battalion task force (TF) located in North Korea in January. Your TF consists of two companies of M-1 tanks and two companies of Mechanized Infantry equipped with the M-2 infantry fighting vehicle (IFV). The TF has a fire support team from a direct support 155-mm self-propelled artillery battalion. The TF is conducting defensive operations as part of a brigade operating in the main battle area. You have just received the weather forecast from brigade headquarters as illustrated in Figure 4-1.

FROM: BRIGADE
TO: BATTALION
SUBJECT: WEATHER FORECAST
LOCATION: PUNGSAN AREA - 40,49N 128,09E (OR USE UTM GRID)

VALID PERIOD: 121200Z TO 131200Z JAN 92

Clear skies, surface winds northerly at 10 knots gusting to 20 knots, visibility will be unlimited except occasionally 1 to 2 miles in blowing snow. Low temperatures expected to dip to between -20 and -25 degrees F, warming to a high near 0 degrees F.

OUTLOOK: 131200Z TO 151200Z:

Increasing cloudiness, chance of heavy snow and temperatures warming to near 10 degrees F.

LIGHT DATA: BMNT 122147Z, BMCT 122221Z, SR 122251Z, SS 130820Z, EECT 130851Z, EENT 130925Z, MR 1924Z, MS 0819Z

NIGHT VISION GOGGLE USE PERIOD: 0149Z TO 0532Z

NOTE: Because blowing snow conditions are produced as a result of the combination of strong winds with loose snow on the ground, "blowing snow" is not listed as a separate weather condition in this manual. However, you need to be aware that such conditions will seriously degrade visibility. Similar conditions occur with blowing sand and blowing dust.

Figure 4-1. Example of a weather forecast.

Based on this forecast, you quickly scan the tables in Appendix A. You find that forecasted temperatures may have a critical impact on several TF systems. Turning to the Armor and Mechanized Infantry sections of Appendixes C and J, you identify actual systems that are impacted by the latest weather forecast. In addition, you also review Appendixes F and L and identify any additional impacts on E-O systems and personnel.

You alert your commander and the staff about the adverse impact of the forecasted weather. You prepare two simple charts to be used during your commander's stand-up briefing. You may want to leave these charts posted in the CP throughout the day for continued reference.

Remember to update the charts when a new forecast is issued by the WETM. Methods used in briefing your commander during the morning and evening briefings may vary greatly from command to command. The formats illustrated should be used as a guide and, of course, modified to suit your particular situation.

The first chart presented to your commander is a standardized chart containing the important elements of the weather forecast. Figure 4-2 illustrates how the weather elements and parameters contained in the forecast might be displayed on the board. Blown up to poster size and covered with acetate, this chart can be updated easily.

Figure 4-3 shows color codes as one way to display potential weather impacts on operations, systems, and personnel in your unit.

Another way would be to write the words "moderate" and "severe" in those blocks affected. Do not list all the equipment or systems, but have the list available to answer questions posed by the commander or staff. Stress those critical systems during the verbal portion of your briefing.

If the weather conditions change significantly during the period covered by the SWO's forecast (see Figure 4-1), then an updated impact chart will have to be prepared. Because a brigade or battalion's AI is small, the SWO's forecast is likely to be uniform across the AI.

WEATHER FORECAST

VALID FOR 121200Z to 131200Z

LOCATION: PUNGSAN

24-HOUR FORECAST:

SKIES: CLEAR MORNING AND NIGHT, PARTLY CLOUDY IN THE AFTERNOON, BASES 3,000 FEET.

VISIBILITY: UNLIMITED, OCCASIONALLY 1 TO 2 MILES IN BLOWING SNOW DURING AFTERNOON.

WINDS: NORTH TO NORTH WEST, 10 TO 15 KNOTS, OCCASIONAL GUSTS TO 25 KNOTS IN AFTERNOON.

TEMPERATURES: MAX: 10°F MIN: -20°F

72-HOUR OUTLOOK:

CLOUDY SKIES, SNOW FLURRIES DURING AFTERNOON HOURS LOWERING VISIBILITY TO 2 TO 4 MILES.

TEMPERATURES: MAX: 20°F MIN: -5°F

LIGHT DATA

BMNT:	1247Z	MOONRISE:	1924Z
BMCT:	2221Z	MOONSET:	0819Z
SUNRISE:	2251Z		
SUNSET:	0820Z	NIGHT VISION	
EECT:	0851Z	GOGGLE USE:	
EENT:	0925Z	0149Z TO 0532Z	

Figure 4-2. Example of a weather forecast chart.

WEATHER IMPACT CHART

PERIOD 121200Z to 131200Z

IMPACTED ITEMS	CLOUDS	PRECIPI-TATION	WIND	VISIBILITY	TEMPER-ATURE
NBC DEFENSE	GREEN	GREEN	GREEN	GREEN	RED
NIGHT VISION DEVICES	GREEN	GREEN	GREEN	AMBER EXCEPT 02 to 05Z	AMBER
CSS	GREEN	AMBER	AMBER	AMBER	AMBER
TOW/DRAGON	GREEN	GREEN	AMBER	GREEN	RED
M-1/M-2	GREEN	GREEN	GREEN	GREEN	AMBER
SMOKE/ CHEMICAL	GREEN	GREEN	AMBER	GREEN	GREEN
GROUND RADAR	GREEN	GREEN	AMBER	GREEN	GREEN
PERSONNEL	GREEN	GREEN	RED	GREEN	RED
THREAT	GREEN	GREEN	GREEN	AMBER	GREEN

NO IMPACT	GREEN
MODERATE IMPACT (Normal effectiveness reduced 25 to 75%.)	AMBER
SEVERE IMPACT (Normal effectiveness reduced to 0 to 25%).	RED

Figure 4-3. Example of a weather impacts display chart.

APPENDIX A

HOW TO USE THE TABLES AND TYPE UNIT REFERENCE TABLES

This appendix explains how to use the individual BFA appendixes. Appendix A is your starting point. Figures A-1 through A-5 provide a quick look at potential weather conditions that might impact on your unit. Forecasts specify cloud bases, visibility, surface winds, temperature, and precipitation.

If forecasted values exceed the thresholds shown in the figures, you have a weather impact. You then take a closer look at Appendixes B through N to determine which unit-specific operations, systems, and personnel are involved.

Step 1. Using the latest weather forecast received from the WETM, or a current observation from your AO, note the numeric values listed for cloud bases, visibility, surface winds (including gusts), high and low temperatures, and precipitation. (See Table 2-1 for relationship between precipitation intensity and accumulation.)

Step 2. Go to Figures A-1 to A-5. These display the five weather conditions reported in the forecast. For example, suppose visibility is forecast to be 3,000 meters (or 1.9 statute miles). Referring to Figure A-1, look for the horizontal dotted line representing 3,000 meters. You see that it intersects solid vertical lines for special operations, mechanized infantry, IEW, light infantry, aviation, artillery, armor, and air defense.

If you serve in one of these type units, you have a weather, impact. To see just exactly what kind and how severe the impact is, you look in the appendix devoted to that type of unit.

Note that in some figures, the solid vertical lines extend both up from the bottom and down from the top of the graph. This means there are two ranges of impact for the same weather element. As an example, temperatures can be too hot or too cold.

Step 3. Using the data in Figures A-1 to A-5, check the functional areas affected by the forecast or observation. Look to see which, if any, are involved in current or near-term operations during the time of the forecast. A quick look planning guide can be prepared (similar to Table 2-3) that will help you in preparing your weather briefings, charts, and IPB analysis.

Remember, these tables consider the effects of only five of the most common weather elements on units (except Special Forces). There are other weather elements and parameters that affect Army operations, systems, and personnel. As their critical values and impacts are qualified, they will be added to future iterations of this manual. Appendix O lists a variety of these elements and parameters together with the functional area affected.

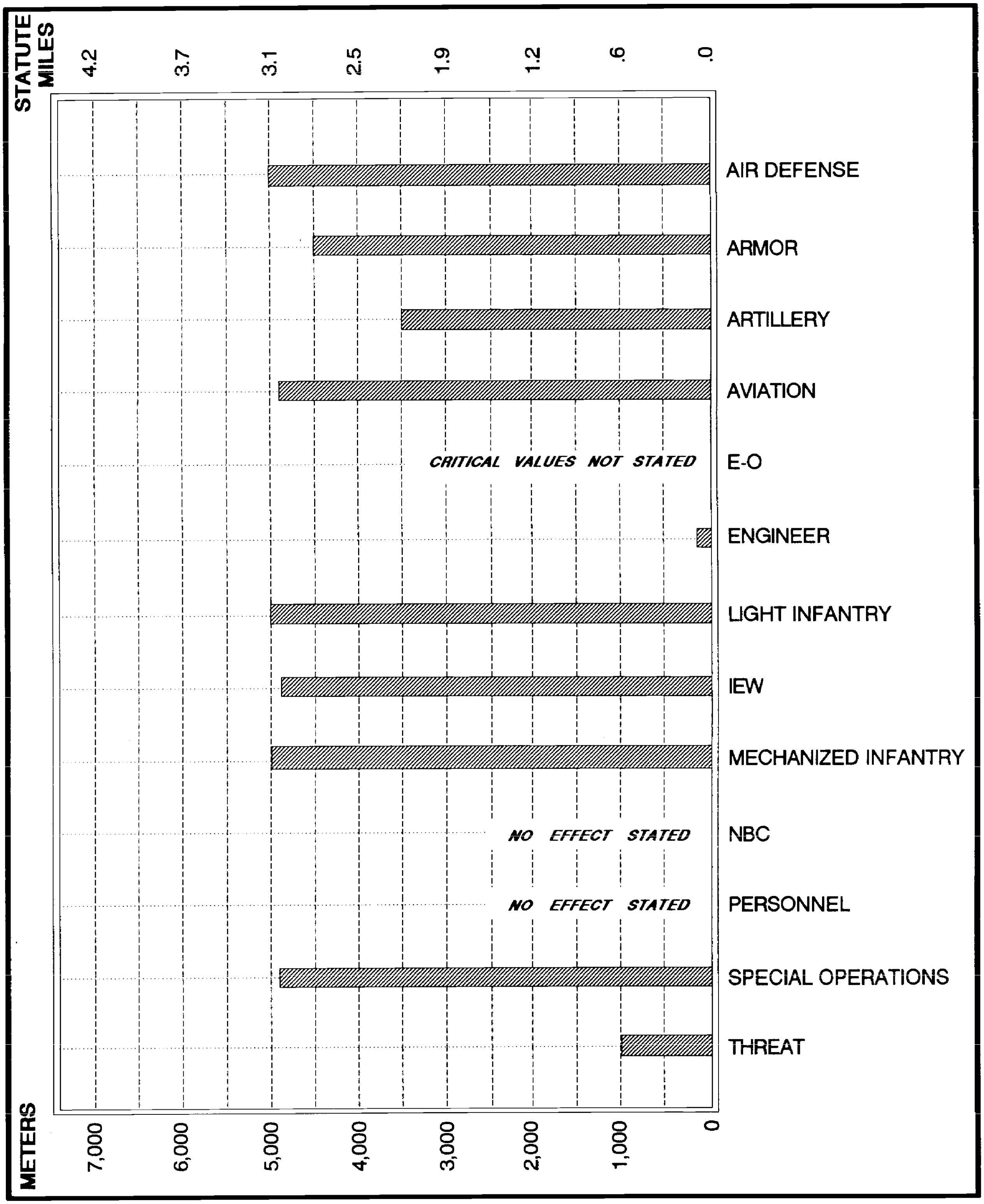


Figure A-1. Weather effects from reduced visibility.

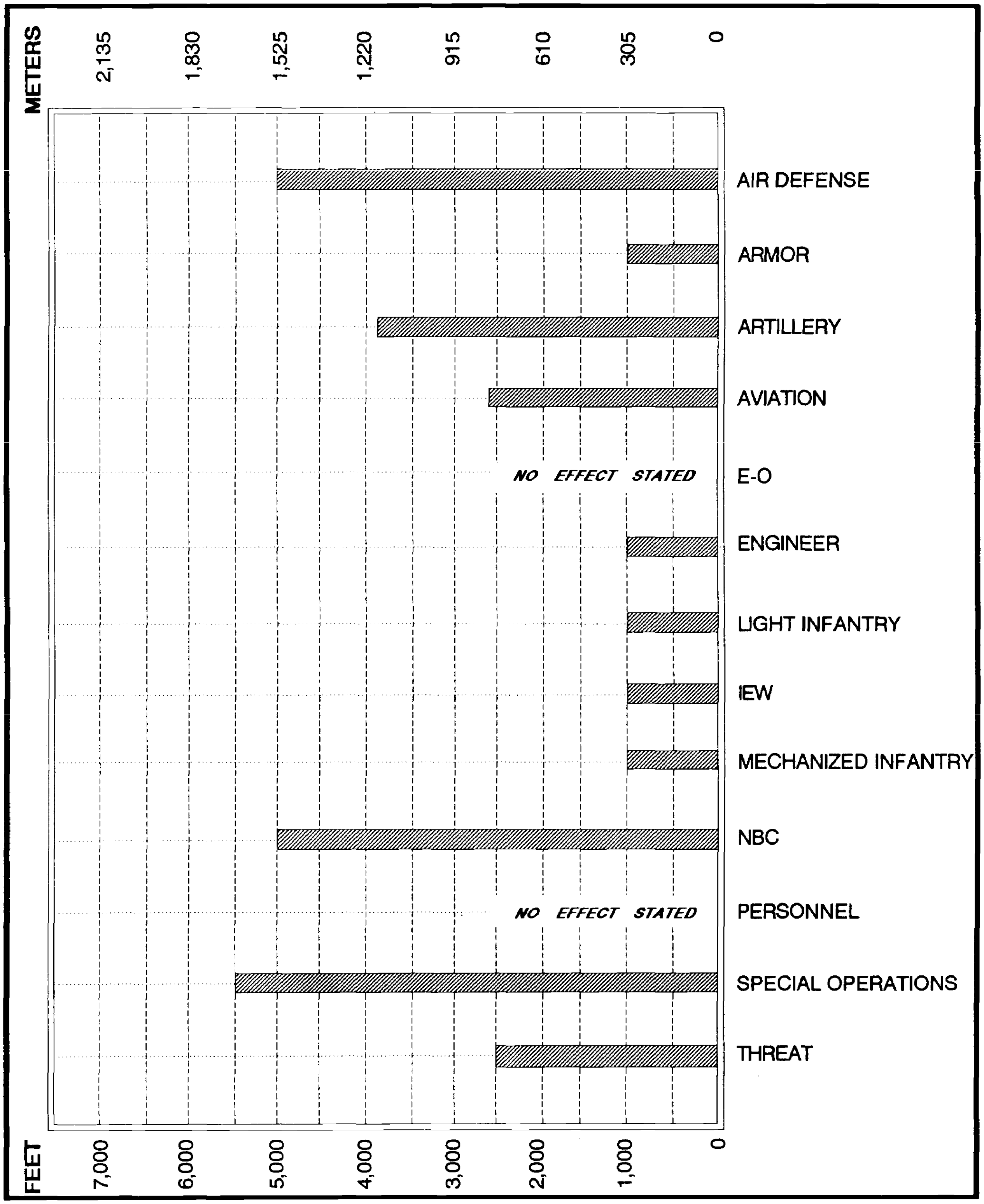


Figure A-2. Weather effects from clouds.

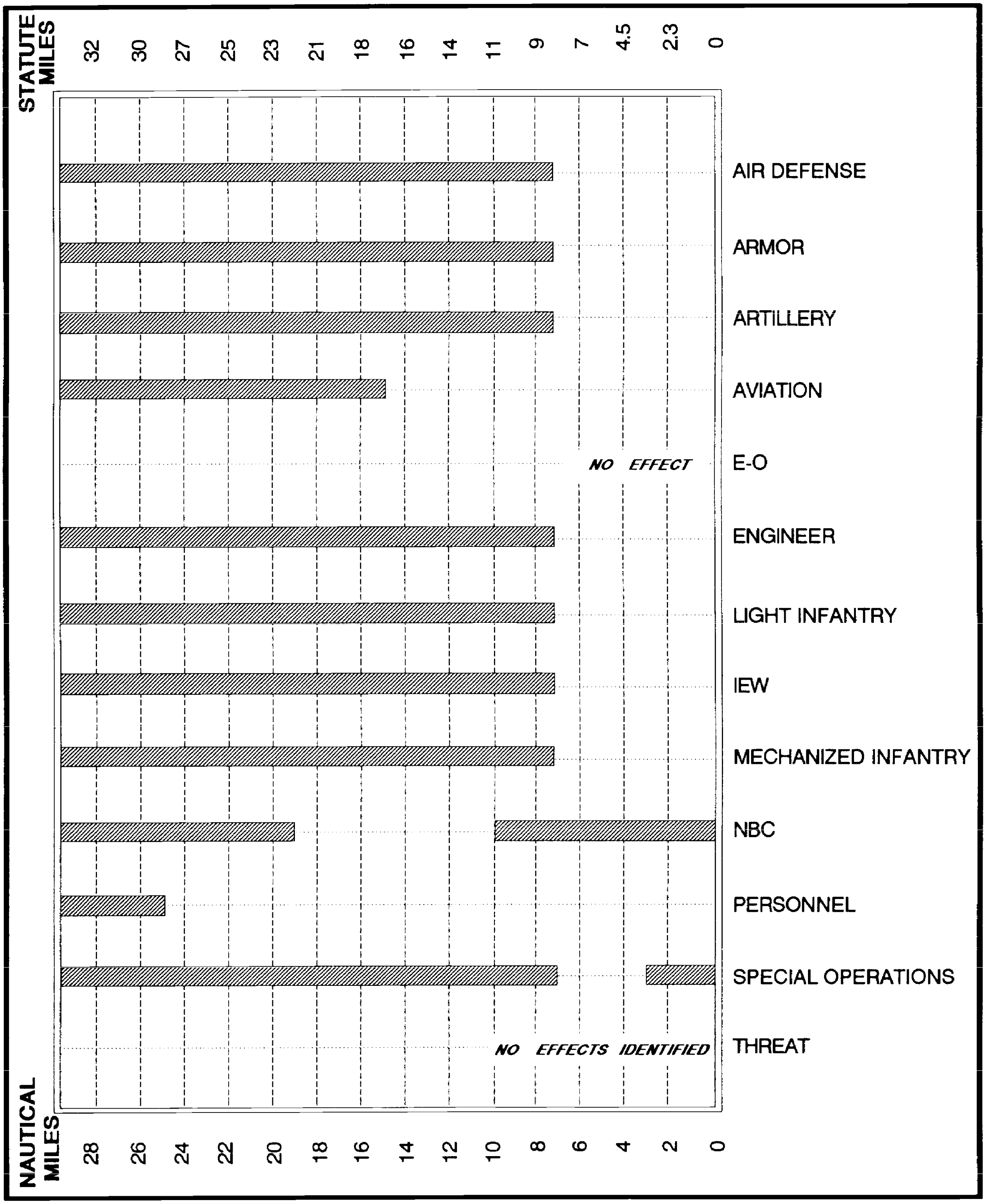


Figure A-3. Weather effects from surface winds.

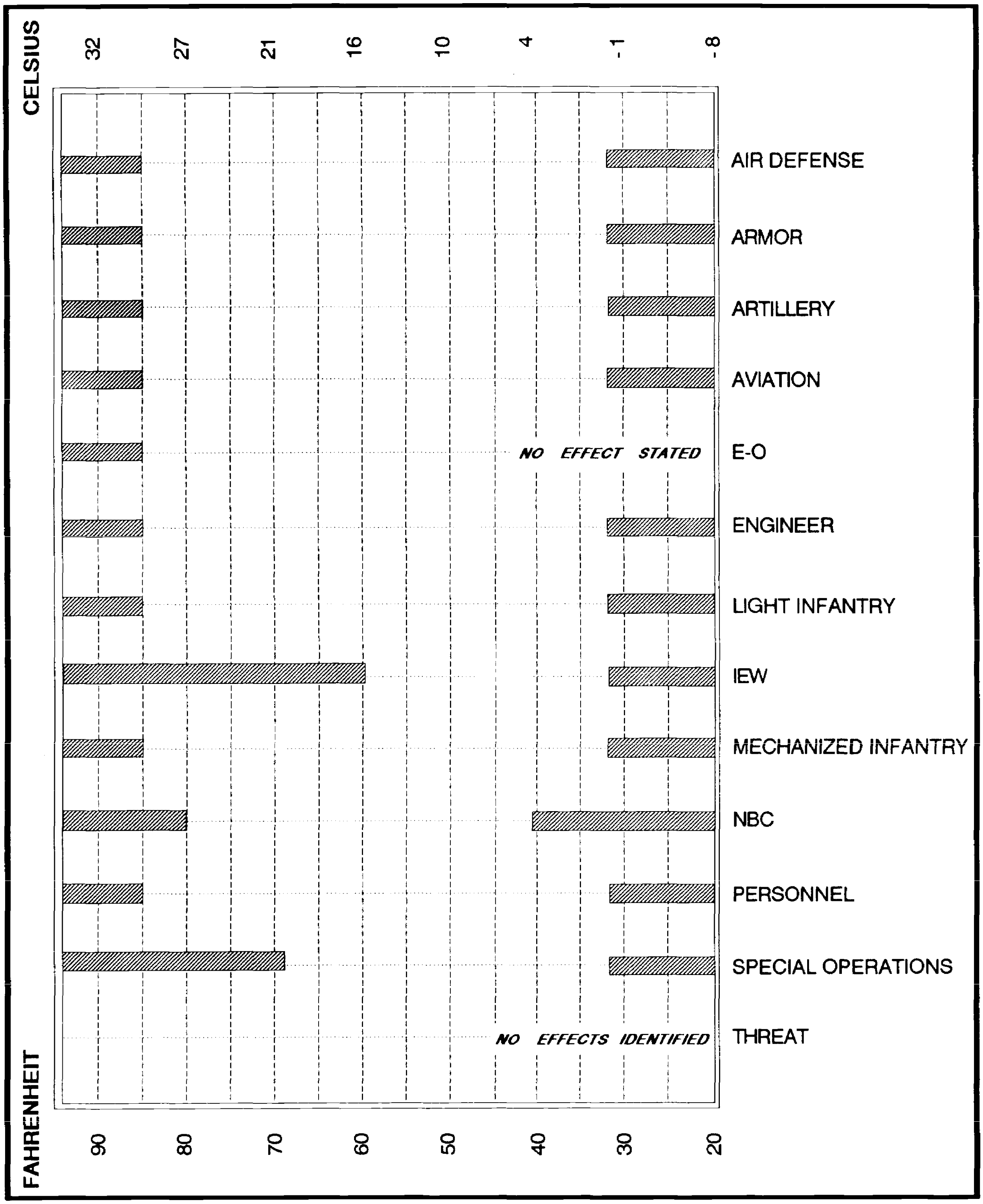


Figure A-4. Weather effects from temperature.

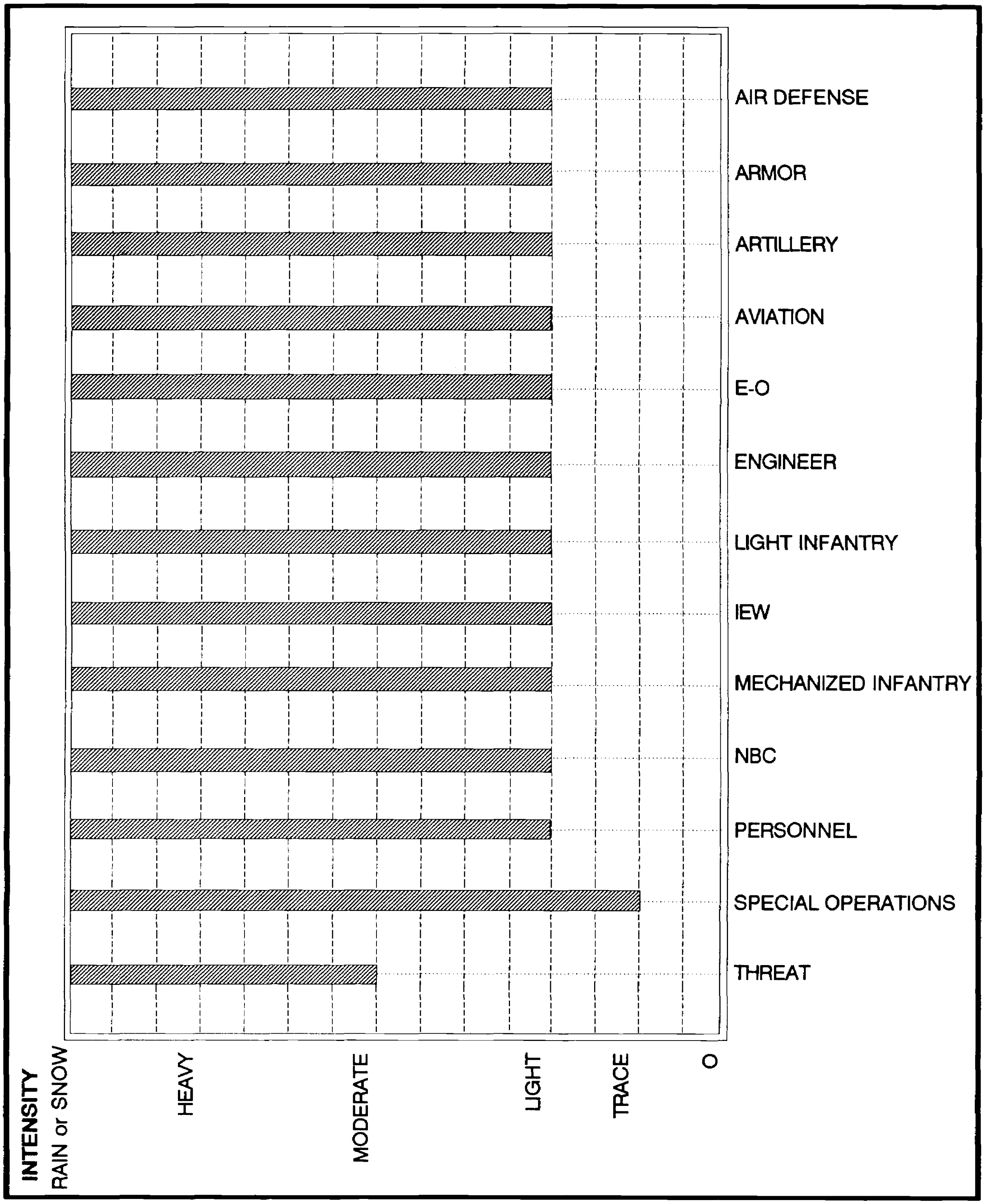


Figure A-5. Weather effects from precipitation.

APPENDIX B

WEATHER EFFECTS ON AIR DEFENSE ARTILLERY

Air defense artillery (ADA) requires weather information for both deployment and employment. Deployment requires climatological data, trafficability, and severe weather forecasts. Weather conditions affecting employment vary according to the type of weapon system used. When missle systems require radar surveillance, elements such as refractive index and precipitation must be known. Other systems require visual target acquisition. Listed below are weather effects for ADA that are not contained in the WTDA tables.

CLOUDS AND SKY COVER. Overcast skies degrade visual acquisition and tracking. Low overcast limits the effectiveness of aerial illumination devices. Clouds limit the use of NVD by blocking natural light from the moon and stars.

HUMIDITY. Moisture in the air affects the refractive index and may degrade radar effectiveness.

ILLUMINATION. Most NVD require about a quarter (23 percent) of the moon, 30 degrees above the horizon, scattered clouds, and the sun more than 5 degrees below the horizon. Detailed products dealing with the use of E-O devices are available from the SWO.

PRECIPITATION. Rain, sleet, or snow prevents visual target acquisition and tracking. Precipitation attenuates radar signals and degrades or prevents infrared homing.

REFRACTIVE INDEX. This index (see glossary for a description) degrades target acquisition and tracking radar.

SURFACE WIND. Strong surface winds produce blowing dust, sand, or snow and may cause computers to malfunction.

TEMPERATURE. High temperatures can degrade the effectiveness of electronic systems, and very low temperature may affect mechanical devices. Extreme cold produces detectable ice-fog exhaust trails from certain weapon systems and vehicles.

THUNDERSTORMS AND LIGHTNING. Intense electrical storms will probably mean that electronic systems will be out of service.

VISIBILITY. Low visibility decreases the effectiveness of visual collection systems.

Table B-1. Weather effects from cloud ceiling.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 500			Weapon selection	Type weapon
LT 1,000			Army aviation operations	See app E
LT 2,500	Visual detection/ identify aircraft			
LT 5,000			Visual detection, identify aircraft	

Table B-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 200			NVG (PVS-5)	
LT 400			NVS (PVS-2)	
LT 600			NVS (PVS-4)	
LT 1,200			NVS (TVS-2, TVS-5)	
LT 2,000			NVS (TVS-4)	
LT 3,000			VULCAN CHAPARRAL	
LT 5,000			STINGER REDEYE	

Table B-3. Weather effects from surface wind.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
GT 7			GSR	Increased noise
GT 20	GSR	Increased noise	Communications antennas NOE operations	
GT 25			Personnel	
GT 35	HAWK acquisition radar HAWK support system Illumination radar (MPQ-57)			
GT 40	Personnel			
GT 50	Communications antennas			
GT 65	HAWK launcher			

Table B-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT -25/-32	HAWK missile system Dry cell battery Personnel	 Only 20% effective	Generators	wo Arctic kit
LT -20/-28			Maintenance	Takes five times longer
LT -0/-18			Wheeled vehicles Dry cell battery 20-mm ADA gun	wo winter kit Only 40% effective Uses cold precaution
LT 32/0			Personnel	See app L for windchill
GT 85/29			Personnel	See app L for water consumption
GT 90/32	HAWK missile system			
GT 95/35	Personnel	See app L for water consumption	Dry cell battery	Will not hold charge
GT 120/49	REDEYE STINGER			
GT 125/52	Generators			

Table B-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION SYSTEM/EVENT	SEVERE DEGRADATION REMARKS	MODERATE DEGRADATION SYSTEM/EVENT	MODERATE DEGRADATION REMARKS
Light rain or snow			Mortar operations Wheeled vehicles	Sight glass fogs up
Moderate rain or snow	Wheeled vehicles		LOS communications Personnel movement Laser systems Target acquisition Equipment storage	
Heavy rain or snow	Mortar operations Personnel movement LOS communications Target acquisition Laser systems			
Thunder-storm/ lightning	HAWK (within 1.2 miles)		Ammunition Radar system (within 1.2 miles) Refueling operations Communications Equipment storage	Safety Interference
Light freezing rain			Personnel Wheeled vehicles	
Moderate freezing rain	Personnel Wheeled vehicles		Missile launching	
SNOW DEPTH (INCHES)				
GT 3			Personnel movement	
GT 6	Personnel movement		Wheeled vehicles	
GT 12	Wheeled vehicles			
GT 20			Tracked vehicles	
GT 30	Tracked vehicles			

APPENDIX C

WEATHER EFFECTS ON ARMOR

Armor operations are influenced primarily by those weather elements that degrade trafficability and visibility. Although the effect may be more pronounced for armor operations, weather elements have generally similar types of impacts on other units. Listed below are weather effects for armor that are not contained in the WTDA tables.

BAROMETRIC PRESSURE. The weight of the air affects gunnery computations and ballistic performance.

CLOUDS AND SKY COVER. Low overcast clouds limit the effectiveness of aerial illumination devices. Overcast clouds tend to limit heating of inactive targets and lower target detection ranges for thermal sights. NVD are limited by clouds blocking natural light from the moon and stars. Close air support (CAS) and aerial resupply missions are degraded by low clouds.

HUMIDITY. Coupled with high temperatures, high humidity decreases crew effectiveness in closed vehicles.

ILLUMINATION. Best use of most NVD requires about a quarter (23 percent) of the moon, 30 degrees above the horizon, scattered clouds, and the sun more than 5 degrees below the horizon. Detailed products dealing with the use of E-O devices are available from the SWO.

PRECIPITATION. Rain and snow degrade trafficability and limit visibility. They also degrade target acquisition and NVD.

SURFACE WIND. Trajectory projections and first round hit capability affected by high crosswinds.

STATE-OF-THE-GROUND. Frozen ground improves mobility and significantly increases the time available to prepare fighting positions. Deep snow slows movement of tracked vehicles. Frozen ground and mud affects munitions, sensors, and indirect fire.

TEMPERATURE. Temperatures influence the type of lubricants to be used, engine warm-up periods, and sustained rates of fire for weapons. High temperatures decrease the time personnel can remain in vehicles. High temperatures cause gun tube droop.

shimmering, mirages, and vehicle exteriors to be too hot to touch. Extremely high temperatures increase water consumption. Low temperatures degrade the ballistics of main guns and require frequent starting of engines and may increase maintenance problems and possible detection by the enemy. Extremely low temperatures reduce personnel effectiveness and decrease the availability of water because of freezing. Temperatures changing from above to below freezing can freeze stationary tracks into the mud.

VISIBILITY. Visibility affects visual acquisition, degrades laser range finding and target acquisition systems.

WINDCHILL. Winds affect the apparent temperature in which soldiers must operate. The windchill table must be consulted to determine the actual effective temperature.

Table C-1. Weather effects from cloud ceilings.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 300	CAS	See app E		
LT 1,000			Army aviation	See app E

Table C-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 100	Forward Observer (FO)		M-1 Tank	Speed
LT 200			LAW NVG (PVS-5) Infrared aiming light (PAQ-4)	
LT 400			NVS (PVS-2)	
LT 500	DRAGON		FO	
LT 600			NVS (PVS-4)	
LT 800	Tracked vehicle (day operation)			
LT 1,000	TOW		DRAGON DRAGON thermal sight (TAS-5) 106-mm recoilless rifle M-60 machine gun 7.62-mm coaxial machine gun	
LT 1,200			NVS (TVS-2 and TVS-5)	
LT 1,600	CAS	See app E	60-mm mortar (non-HE round) Tracked vehicle (day operation) .50-cal machine gun	
LT 2,000			NVS (TVS-4)	
LT 3,200			CAS M-60 main gun 25-mm chain gun M-1 main gun TOW thermal sight (UAS-12) Handheld thermal viewer (PAS-7) Thermal night observing device (UAS-11) 60-mm mortar (HE round)	See app E
LT 4,500			107-mm mortar	

Table C-3. Weather effects from surface wind.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION SYSTEM/EVENT	SEVERE DEGRADATION REMARKS	MODERATE DEGRADATION SYSTEM/EVENT	MODERATE DEGRADATION REMARKS
LT 25			Incendiaries	
GT 7			GSR	Increased noise
GT 10			Chemical emplacement	Less effective
GT 13			Airborne DZ limit	Less effective
GT 15			Acoustic sensors	Less effective
GT 15 Cross-winds			TOW, DRAGON	Impacts tracking/ reduces range
GT 20	GSR	Increased noise	Communication antennas NOE operations	
GT 25			Personnel	
GT 30	Helicopter operations	May cancel mission See app E		
GT 40	Personnel Radar (PPS-5)	 Antenna breaks		
GT 45	Acoustic sensors	Less effective		
GT 50	Communications antennas			

Table C-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT -25/-32	TOW DRAGON Handheld thermal viewer (PAS-7) Dry cell battery Personnel	 Only 20% effective	Generators M-1 Tank CFV, M3 Laser infrared observation set (GVS-5)	wo Arctic kit wo winter kit wo winter kit wo external power
LT -20/-28			NVS (PVS-4 and TVS-5) Maintenance Tanks, M-1, M-60	wo low temp adapter Five times longer Accuracy
LT 0/-18			Wheeled vehicles Dry cell battery	wo winter kit Only 40% effective
LT 20/-6			Thermal night observing device (UAS-11) Platoon early warning system (TRS-2) DRAGON	wo Arctic kit wo BA3090 battery wo low temp adapter
LT 32/0			NVG (PVS-5) Small arms and machine guns Personnel	wo Arctic kit Functions affected See app L for windchill
GT 85/29	Personnel	See app L	Dry cell battery	Will not hold charge
GT 125/52	All NVS Generators Laser infrared observation set (GVS-5) WP rounds	Operations deteriorate Operations deteriorate Operations deteriorate Special care for storage		

Table C-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
Light rain or snow			M-1 Laser range finder Wheeled vehicles	Fake ranging returns
Moderate rain or snow	Wheeled vehicles		LOS communications Personnel movement Target acquisition GSR Equipment storage	
Heavy rain or snow	Personnel movement LOS communications Target acquisition			
Thunder-storm/ lightning			Ammunition storage Refueling Communications Equipment storage	Safety Interference
Light freezing rain			Personnel Wheeled vehicles	
Moderate freezing rain	Personnel Wheeled vehicles			
SNOW DEPTH (INCHES)				
GT 3			Personnel movement	
GT 6	Personnel movement		20-mm and 40-mm ammunition Wheeled vehicles	
GT 12	Wheeled vehicles			
GT 20			Tracked vehicles	
GT 30	Tracked vehicles			

APPENDIX D

WEATHER EFFECTS ON ARTILLERY

Artillery in the field is heavily weather dependent. Not only must you contend with those weather effects common to all other units but you must also compensate for a number of special effects in the area of target acquisition and aiming. Listed below are weather effects for artillery operations that are not contained in the WTDA tables.

BAROMETRIC PRESSURE. Air pressure affects projectile trajectory, barofuzing, and fire control calculations.

CLOUDS AND SKY COVER. Low ceilings affect target acquisition systems and terminally guided munitions. Low overcast clouds will limit the effectiveness of aerial illumination devices.

DENSITY. The thickness of the atmosphere (heavy air) affects fire control. The greater (heavier) the density, the shorter the range.

HUMIDITY PROFILE. This scale is used to compute virtual temperatures for ballistic firing data.

ILLUMINATION. The best use of most NVD require about a quarter (23 percent) of the moon, 30 degrees above the horizon, scattered clouds, and the sun more than 5 degrees below the horizon. Additional weather products dealing with the use of E-O devices are available from your SWO.

PRESSURE PROFILE. Barometric pressure profiles are essential in both baroarming and barofuzing. They are required for calculating densities for ballistic firing data.

REFRACTIVE INDEX. This index affects radar, laser, and infrared distance measurements.

SURFACE WINDS. Trajectory data and first round hit capability are degraded by high crosswinds. Winds affect the accuracy of rocket fire and Firefinder radar trajectory computations.

SURFACE TEMPERATURE. Frozen ground increases the time a crew has to stabilize their weapon. Extreme cold affects gun accuracy and fuse functioning. High temperature affects stability of ammunition such as white phosphorus (WP). It also reduces rate of fire greatly because of crew heat fatigue.

TEMPERATURE PROFILE. This is another condition that affects calculations of ballistic artillery firing. The profile is used to compute virtual temperatures for artillery firing. Extreme cold affects gun accuracy and fuse functioning.

THUNDERSTORMS AND LIGHTNING. Electrical storms restrict the use of some munitions and fuse types.

VISIBILITY. This affects visual target acquisition, fire adjustment, and E-O target designation. Reduced visibility affects the placement of forward observers (FO) and fire support teams.

WINDS ALOFT. Strong winds aloft impact all ballistic projectile aiming calculations. Accurate and timely meteorological data can compensate for the problem.

WIND PROFILE. Wind profiles play a major role in ballistic wind compensations for artillery firing.

Table D-1. Weather effects from cloud ceilings.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 500	ATACMS	Target acquisition		
LT 600	COPPERHEAD	Target acquisition		
LT 800	SADARM	Target acquisition		
LT 1,000			ATACMS Army aircraft	Target acquisition See app E
LT 1,500			COPPERHEAD	Target acquisition
LT 3,300			SADARM	Target acquisition

Table D-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 200	FO		NVG (PVS-5) Infrared aiming light (PAQ-4)	
LT 400			NVS (PVS-2)	
LT 500	DRAGON		FO	
LT 600			NVS (PVS-4)	
LT 1,000	TOW		DRAGON thermal sight (TAS-5)	
LT 1,200			NVS (TVS-2, TVS-5)	
LT 2,000			NVS (TVS-4)	
LT 3,000			TOW thermal sight (UAS-12) Handheld thermal viewer (PAS-7) Thermal night observing device (UAS-11)	
LT 3,500			AFO	

Table D-3. Weather effects from surface wind.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
GT 7			GSR	Increased noise
GT 20	GSR	Increased noise	Communications antennas	Setting up
GT 25			Personnel	
GT 30	Meteorological processor (GMD-1)	Inhibits balloon launch	Meteorological data system (TMQ-31) Meteorological measuring set (TMQ-38)	
GT 35	Artillery detection radar (TPQ-36)	Stow antenna	155-mm how	
GT 40	Personnel			
GT 50	Communications antennas	Setting up		

Table D-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT -25/-32	TOW DRAGON Rocket launcher (M202A1) Handheld thermal viewer (PAS-7) Dry cell battery Personnel	Only 20% effective	Generators	wo arctic kit
LT -20/-28			NVS (PVS-4) Maintenance	wo low temp adapter 5 times longer
LT 0/-18			Wheeled vehicles Dry cell battery	wo winter kit Only 40% effective
LT 20/-6			Thermal night observation device (UAS-11) Platoon early warning system (TRS-2) DRAGON	wo arctic kit wo BA3090 battery Need low temp adapter
LT 32/0			NVG (PVS-5) Personnel Small arms and machine guns	wo arctic kit See app L for wind-chill Effective-ness reduced
GT 85/29			Personnel	See app L for temp/ humidity index
GT 95/35	Personnel	See app L for water consumption	Dry cell battery	Will not hold charge

Table D-4. Weather effects from temperature (continued).

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
GT 125/52	All NVS Generators 155-mm how (M198) ammunition 105-mm how TACFIRE Laser infrared observation set (GVS-5) LANCE WP artillery rounds	Become unstable		

Table D-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION SYSTEM/EVENT	SEVERE DEGRADATION REMARKS	MODERATE DEGRADATION SYSTEM/EVENT	MODERATE DEGRADATION REMARKS
Light rain or snow			Mortar operations Wheeled vehicles	Sight glass fogs up
Moderate rain or snow	Wheeled vehicles		LOS communications Personnel movement Target acquisition Platoon warning system (TRS-2) GSR Acoustic systems Equipment storage Laser systems	
Heavy rain or snow	Mortar operations Personnel movement Laser systems LOS communications Target acquisition			
Thunder-storm/ lightning			Ammunition Refueling Communications Equipment storage	Safety Interference
Light freezing rain			Personnel Wheeled vehicles	
Moderate freezing rain	Personnel Wheeled vehicles			
SNOW DEPTH (INCHES)				
GT 3			Personnel movement	
GT 6	Personnel movement		20-mm and 40-mm ammunition Wheeled vehicles	
GT 12	Wheeled vehicles			
GT 20			Tracked vehicles	
GT 30	Tracked vehicles			

APPENDIX E

WEATHER EFFECTS ON AVIATION

Army aviation operates over the length and breadth of the battlefield. Missions are varied and include both fixed-wing and rotary-wing aircraft. Battlefield aviation assets play a role in a host of missions including mobility, countermobility, survivability, C^2, fire support, maneuver, air defense, IEW, combat service, and combat service support. Weather support is critical and impacts both planning and execution.

Aviation planners must include weather conditions in takeoff areas, employment routes, engagement zones, PZs, and LZs to list just a few. Aviation commanders must consider all weather conditions both favorable and unfavorable. Accurate forecasts in the AO and AI are more critical to air operations than most land operations. This is especially true for the deep battle missions.

Listed below are weather effects for aviation that are not contained in the WTDA tables.

CLOUDS AND SKY COVER. Clouds are always a major consideration for aviation operations. Low overcast clouds will limit the effectiveness of aerial illumination devices. Overcasts tend to limit heating of inactive targets and lower target detection range for thermal sights. NVD are limited by clouds blocking natural illumination from the moon or the stars. CAS and aerial resupply missions are degraded by low clouds.

DENSITY ALTITUDE. This is a critical measurement that determines if an aircraft has enough lift capabilities and performance to get off the ground. Too much density altitude limits fuel, weapons, and passenger loads.

DEWPOINT. The dewpoint (see the glossary for an explanation) serves as a warning of possible fog formation or icing conditions. It is a key measurement in computing density altitude (see above).

ICING. Ice on lifting surfaces affects the aerodynamics of the aircraft. Even a little ice is a big problem.

ILLUMINATION. NVD are most efficient with about a quarter (23 percent) of the moon, 30 degrees above the horizon, scattered clouds, and the sun more than 5 degrees below the horizon. Detailed products dealing with the use of E-O devices are available from the SWO.

INFRARED CROSSOVER. This is a temperature condition that affects target acquisition. Your SWO will tell you when this is expected to occur.

PRECIPITATION. Rain and snow affect visibility and the safety of both crew and airframe. In some instances, precipitation may cause predetonation of munitions.

PRESSURE ALTITUDE. This computed figure affects all aircraft engine performance.

SNOW DEPTH. Snow compounds ground handling problems. Light, powdery snow may interfere with helicopter hover operations.

STATE-OF-THE-GROUND. Ground conditions impact on the effectiveness of serially delivered munitions.

SURFACE WINDS. Strong winds, especially cross-winds, affect aircraft control near the ground during take-off and landings. They also affect ground speed for low-level frights.

TEMPERATURE. High temperatures reduce lift capability. Cold temperatures increase maintenance requirements and the time needed to accomplish each task. The number of personnel that can be carried on a flight is reduced due to the weight of cold-weather gear.

THUNDERSTORMS AND LIGHTNING. Extreme weather that includes thunderstorms and lightning is very hazardous to inflight operations, refueling, and rearming operations.

TURBULENCE. Severe weather and clear air turbulence is a critical condition affecting all aviation assets and missions. It may cause aircraft structural damage or even crashes during take-offs and landings. Severe turbulence may cancel all operations.

VISIBILITY. The lack of good visibility affects landings and take-offs, visual reconnaissance, target acquisition, E-O target designation, terminally guided munitions, and the ability to distribute scatterable mines.

WINDS ALOFT. Winds at flight altitudes always affects navigation and fuel consumption.

Table E-1. Weather effects from cloud ceilings.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 300	NOE Day target acquisition, flat terrain		Day, flat terrain	AR 95-1
LT 500	Night target acquisition, flat terrain Day target acquisition, mountain terrain		NOE day, mountain terrain Night, flat terrain	AR 95-1 AR 95-1
LT 1,000	Night target acquisition mountain terrain Military free-fall HAHO	Minimum base of cloud over DZ	Army aviation, aerial observations CAS	
LT 1,100	HELLFIRE	Low angle approach		
LT 2,600	HELLFIRE	High angle approach		

Table E-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 200	NVG (PVS-5)		LAW Infrared aiming light (PAQ-4)	
LT 400	NOE operations NVS (PVS-2)			
LT 600	NVS (PVS-4)			
LT 800	Target acquisition		Helicopter, day, flat or mountain NOE	AR 95-1
LT 1,000	TOW		DRAGON DRAGON thermal sight (TAS-5) M-60 machine gun	
LT 1,200	NVS (TVS-2, TVS-5)			
LT 1,600	KIOWA (OH-58)	Target acquisition	Helicopter, night, flat or mountain .50-cal machine gun	AR 95-1
LT 2,000			Aerial target acquisition Night vision sight (TVS-4)	
LT 2,500	Military free-fall HAHO	Minimum altitude for RAP		
LT 3,200			TOW TOW thermal sight (UAS-12) Handheld thermal viewer (PAS-7) Thermal night observation device (UAS-11) Fixed wing, night, flat terrain operations, target acquisition	AR 95-1
LT 3,800			7.62-mm coaxial aerial machine gun	

Table E-3. Weather effects from surface wind.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
GT 15			Acoustic sensors	Less effective
GT 15 Cross-wind component	MOHAWK (OV/RV-1D)	Grounded, max for takeoff or landing	TOW	Impacts tracking
GT 15 Gust spread	Two-bladed helicopter			
GT 20			Communications antennas NOE operations Forward area refueling point Two-bladed helicopter	
GT 25			COBRA (AH-1) rocket launcher Personnel	2.75 inch rockets degraded
GT 25 Cross-wind component	UTE (U-21) HURON (C-12)	Grounded, max for takeoff or landing		
GT 30	Two-bladed helicopter COBRA (AH-1) CHINOOK (CH-47) IROQUOIS (UH-1)		Four-bladed helicopter	
GT 40	COBRA (AH-1S) CAYUSE (OH-6) SEMINOLE (U-8) Personnel			
GT 45	Acoustic sensors Four-bladed helicopter KIOWA (OH-58) BLACKHAWK (UH-60) APACHE (AH-64)	Less effective		
GT 50	Communications antennas SKY CRANE (CH-54)			
GT 60	MOHAWK (OV/RV-1D) HURON (C-12) UTE (U-21)			

Table E-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT -29/-34	BLACKHAWK (UH-60)	Ice fog will limit/halt visual flight	BLACKHAWK (UH-60)	wo special service
LT -25/-32	TOW Dry cell battery Personnel	 Only 20% effective	Generators	wo arctic kit
LT -20/-28			NVS (PVS-4 and TVS-5) Maintenance	wo low adapter Takes five times longer
LT 0/-18			Wheeled vehicles Dry cell battery	wo winter kit Only 40% effective
LT 32/0			NVG (PVS-5) Personnel	wo arctic kit See app L windchill
GT 85/29			Personnel	See app L temp, humidity index
GT 90/32	MOHAWK (OV/RV-1D), IROQUOIS (UH-1)	Above 4,000 ft	UTE (U-21), MOHAWK (OV/RV-1D), HURON (C-12), IROQUOIS (UH-1), BLACKHAWK (UH-60)	Lift
GT 95/35	Personnel	See app L for water consumption	Dry cell battery COBRA (AH-1)	Will not hold charge Lift/flight time
GT 119/49	HURON (C-12)	At sea level		
GT 125/52	All NVS Generators			

Table E-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
Light rain or snow			Wheeled vehicles	
Moderate rain or snow	Wheeled vehicles		LOS communications Personnel movement Target acquisition Equipment storage Laser systems	
Heavy rain or snow	Artillery detection radar (TPQ-36) Personnel movement LOS communications Target acquisition Laser systems		Rocket firing SLAR Radar systems	Predetonate
Thunder-storm/ lightning	MOHAWK (OV/RV-1D)	Imbedded thunder-storms	Ammunition Aircraft Refueling Communications Equipment storage SLAR	AR 95-1 Safety Interference
Light freezing rain	Aircraft (wo deice)	AR 95-1	Personnel Wheeled vehicles	
Moderate freezing rain, ice	Personnel Wheeled vehicles	AR 95-1	Rocket firing Aircraft (with deice)	Predetonate AR 95-1
Heavy freezing rain, ice	Aircraft (with deice)	AR 95-1		
SNOW DEPTH (INCHES)				
GT 3			Personnel movement All fixed-wing aircraft	
GT 6	Personnel movement All fixed-wing aircraft	Propeller clearance, braking	20-mm and 40-mm ammunition Wheeled vehicles	
GT 12	Wheeled vehicles			
GT 20			Tracked vehicles	
GT 30	Tracked vehicles			

APPENDIX F

WEATHER EFFECTS ON ELECTRO-OPTICAL SYSTEMS

Army battlefield capabilities have improved significantly in recent years due, in part, to the development and deployment of E-O systems. A great variety of these systems are in the Army's inventory and more are being programmed. Basically, E-O systems enhance the Army's battlefield reconnaissance, target acquisition, and target destruction capabilities.

They enable ground and aviation units to see better and accurately strike the enemy day or night even during limiting weather conditions. Since the weather parameters affecting E-O devices are numerous and the use of E-O systems is so widespread, they deserve special attention as a separate category of tactical systems.

CLASSIFICATION OF ELECTRO-OPTICAL SYSTEMS

E-O systems are classified as active (overt) or passive (covert). Active systems emit a detectable wavelength signal, while a passive system senses emitted or radiated energy. E-O systems include image intensifiers, infrared imagers, laser designators, and low-level-light (LLL) television (TV). To fully understand how weather impacts these systems, we need to know their basic operating principles.

NVG are an example of passive image intensifiers. They use extremely LLL sources (starlight), and amplify that light so that objectives are visible. These systems operate in the visual and near-infrared wavelengths.

LLL TV is a passive system and is capable of picking up targets at light levels below those usable to the human eye. This TV electronically enhances the video signal and makes it visible to the operator. Night sights, heat seeker munitions, and infrared detector munitions are examples of passive infrared imaging systems.

These systems are characterized as near infrared (short wavelength) or far infrared (long wavelength). For infrared imagers to function properly, there must be a temperature or thermal contrast between target and background area (signature). They can tell the difference between target "hot spots" and the rest of the target itself, like a warm engine in a cold truck.

Laser designators are active systems. They are used with smart munitions capable of receiving reflected laser light. The designator "pings" a target with a laser beam at a specified wavelength. The receiver in the munitions recognizes the reflected beam and homes in on the designated target. These designators do not emit light in the visible spectrum and, therefore, cannot be easily seen or detected.

When combined with E-O guided munitions, the transmitted laser beam reflecting off the target greatly enhances the delivery accuracy over conventional delivery techniques. However, the E-O guided munitions must receive the reflected beam in time to make course changes prior to hitting the target. If the beam is not reflected off the target or transmitted, or reception is disrupted, a miss will probably result.

Figure F-1 illustrates the portion of the light spectrum used by the different categories of systems employed by the Army.

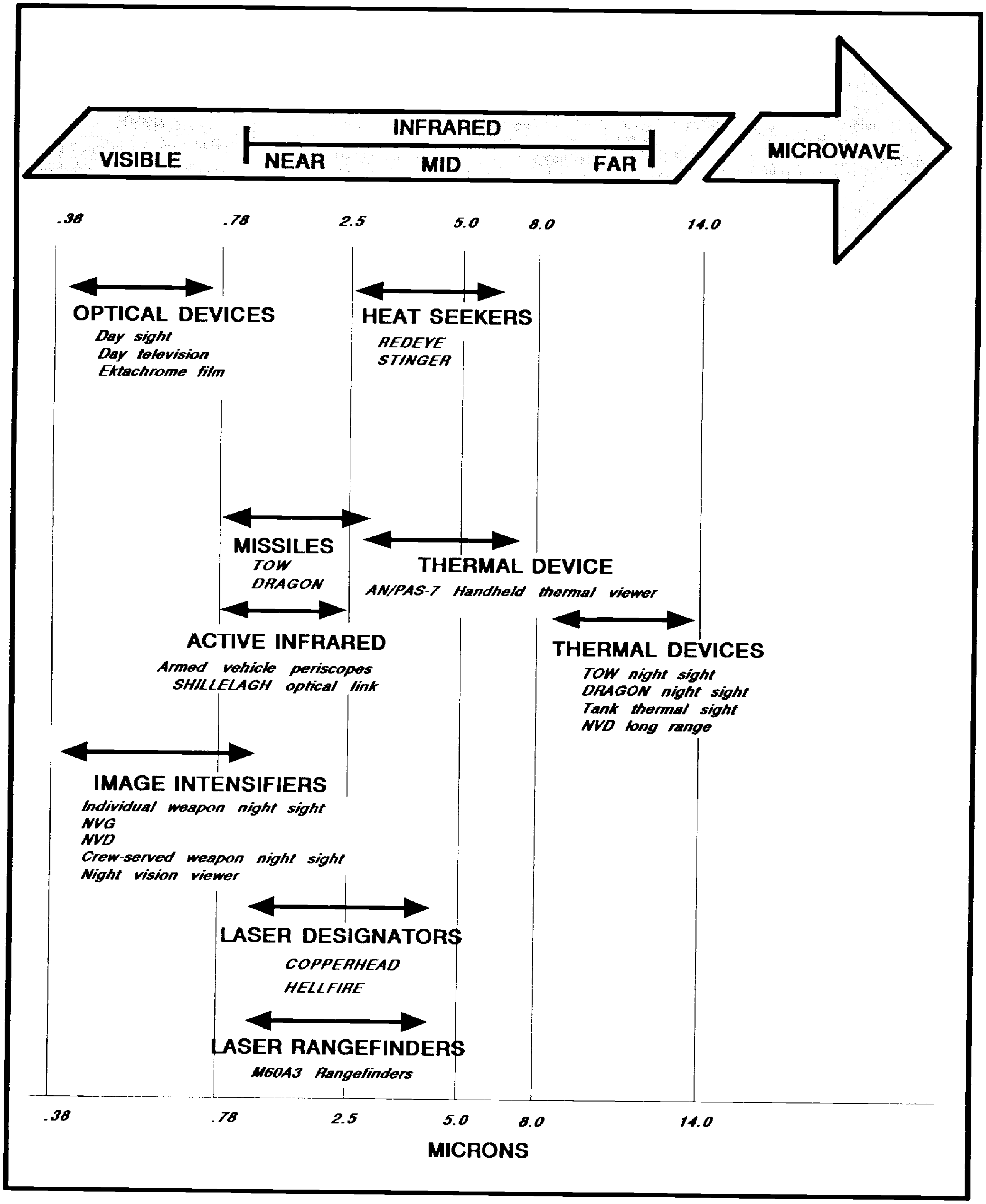


Figure F-1. Microwave ranges of selected Army E-O systems.

ENVIRONMENTAL IMPACT

The performance of E-O systems depends on three basic factors:

- E-O characteristics of the target and its background on the battlefield.
- The atmosphere between the E-O system and the target and its background.
- The sensitivity of the E-O detector system (to include human operator performance).

Weather conditions affect the first two factors, both directly and indirectly and are summarized in Table F-1. The most fundamental environmental conditions inhibiting E-O signals are--

- Attenuation or reduction of the signal by atmospheric moisture such as clouds, precipitation, fog, and high humidity.
- Temperature affecting atmospheric refraction near the surface.
- Temperature contrast between the surrounding environment and the target.
- Winds kicking up dust and sand.
- LLL.

Table F-1. Weather effects on E-O devices.

	SEVERE DEGRADATION				MODERATE DEGRADATION			
ENVIRONMENTAL PARAMETERS	VISIBLE	INFRARED			VISIBLE	INFRARED		
		NEAR	MID	FAR		NEAR	MID	FAR
CLOUDS								
ALL TYPES	X	X	X				X	X
FOG	X	X	X	X				
PRECIPITATION								
LIGHT TO MODERATE RAIN OR SNOW					X	X	X	X
HEAVY RAIN OR SNOW	X	X	X	X				
AEROSOLS (SMOKE, DUST, SAND)								
MODERATE DENSITY	X	X					X	X
HEAVY DENSITY	X	X					X	X
WATER VAPOR								
HIGH HUMIDITY (GT 80 PERCENT AND NEAR A SOURCE OF WATER)	X	X					X	

In addition to TV and binoculars, visible light systems include the TOW day sight and image intensifiers such as the individual-served weapon sight and the tank gunner's periscope. Systems that use available light are the easiest to defeat with obscurants such as haze, smoke, dust, and precipitation because visible light has a short wavelength and can be more easily attenuated.

As the wavelength of the light spectrum used by an E-O system increases, the less it is affected by obscurants. However, the long wavelength E-O system provides less target resolution. Near infrared systems like the handheld thermal viewer can penetrate some light fog oil and diesel oil smokes. Far-infrared systems, such as thermal sights for the Apache helicopter, Ml tank, TOW, and DRAGON, use longer wavelengths of the spectrum and can penetrate low densities of WP smoke and other obscurants that defeat both visible and near infrared.

In addition to attenuation from an obscurant, E-O devices are also affected by atmospheric refraction. Basically, the sun's heating of the surface air creates sufficient vertical motion or turbulence to cause this effect. A mirage is caused by this heating and can make a building appear to move or even cause a target to disappear altogether. Such apparent displacements can lead to target misses.

Although these refractive conditions are associated with periods of high heat, this condition has been observed over a snow cover when the air temperature was 25 degrees below zero Fahrenheit. The higher you are from the surface, the less likely you will encounter mirages.

Other parameters that impact on many E-O systems are weather conditions affecting the level of illumination. Although the level of light affects all devices operating in the visible spectrum, image intensifiers are influenced the most. Too much or too little light adversely affects the use of NVD.

On relatively clear nights with a near full moon, you can normally operate without the aid of NVD. With less than a full moon, there may still be too much light.

Too much light, when amplified by NVD, saturates the viewing area as seen through the device and makes the device unusable because light and dark contrasts are no longer possible. When illumination is limited, NVG must be used. For partial or heavy overcast skies with little moonlight, even these light levels may be too low to use NVG.

Additionally, terrain influences on available illumination must be considered. Even though illumination may be adequate to support the use of NVD, flying in a valley with shaded areas may end disastrously.

CLOUDS

"Smart" weapons such as COPPERHEAD and the air-launched HELLFIRE have critical cloud ceiling values. If these weapons pass into a cloud, they will lose "lock on" and miss their laser-designated target. Another system affected by low clouds is SADARM. Using E-O detectors, SADARM searches in a circular pattern at a fixed angle. As these munitions descend, the area they see becomes smaller. Low cloud ceilings drastically reduce their target search areas and time.

THERMAL CONTRAST

Millimeter wave and infrared E-O devices require a temperature difference between the target and its background. Bad weather can limit system performance. As the contrast diminishes, a condition is reached where the target is no longer discernible from the background and target acquisition becomes a problem.

Thermal imagers produce images of targets in scenes, somewhat similar to those seen on ordinary TV. The major difference is that, instead of observing light (visible energy) in the scene, thermal imagers observe heat (infrared energy) emitted, reflected, or generated by the objects in the scene.

The amount of infrared energy is determined principally by the object's temperature, its surface reflectivity, and its structural properties. Natural infrared energy is produced when objects absorb sunlight. Winds can change the image contrast by making target and background closer to the same temperature.

Man-made energy, particularly in vehicles, results from the heat of fuel combustion and the friction of moving parts. Infrared energy is not as greatly diminished at night as is visible energy. Thermal imagers tend to function as well or better during nighttime than during the day. For this reason, they are often used as night sights.

A target may be acquired with a thermal imager only if the amount of infrared energy of the target is sufficiently different from that of the background. This difference, called thermal contrast, is the difference between the temperatures of the target and its background.

Wind, rain, snow, humidity, and clouds reduce the temperature contrast between target and its background and even cause thermal reversal where instead of a "hot" target against a "cold" background, you find a cold target against a hot background. This can occur in the early morning and late afternoon when a thermal sight encounters a condition where some inactive targets without an internal heat source will warm up or cool off to the same temperature as the background.

In this instance, thermal devices will not be able to see targets because the difference in temperature is not enough to be detected. The sensitivity of the thermal device to the difference in temperature and the rate at which a target is heating or cooling will determine how long this "thermal crossover" will occur.

Most metal targets heat up or cool off faster than the ground and vegetation in the background. At night a metal target appears to be colder than the background, but with the sun shining on it, the target appears to be hot compared to the relative coolness of a background of trees or bushes.

In bright sunshine, the thermal crossover period may be just a few seconds. On cloudy days, however, the thermal crossover period may be a number of minutes. When this happens, optical sightings must then replace the infrared devices. Listed below are weather elements effecting thermal contrast at crossover time.

CLOUDS. Clouds will reduce the thermal contrast. Lower and thicker clouds have a stronger influence than higher or thinner clouds.

SURFACE WIND. Wind causes the temperatures of both the target and background to become closer to the air temperature, and as a result, closer to each other.

HUMIDITY. Moist air does not enhance the rate of cooling as much as dry air. With high humidity and a moist background, the thermal contrast would be minimal between target and background. If the air was dry, the cooling influence on the moist background would cause a greater thermal contrast.

PRECIPITATION. Falling rain and snow have cooling effects that bring target and background temperatures closer together. In the case of operating vehicles, the temperature contrast may be increased since the precipitation will have little effect on the heat generated in the engine compartment and the exhaust.

The relationship between weather effects and E-O systems is very complex since the result is a function of the precipitation particle size and the wavelength of the E-O system.

ELECTRO-OPTICAL SUPPORT PRODUCTS

You obtain E-O support from the SWO. These products identify periods of time during which NVG can be effectively used. In addition to E-O, your SWO has other predictive products that you might need. Check with him for a list.

APPENDIX G

WEATHER EFFECTS ON ENGINEERS

Engineer operations are influenced by past, current and future weather conditions. The interaction of weather with terrain produces a greater impact on engineer operations than previously understood. A source of help in identifying weather and terrain impacts is the terrain analyst team at division. Below are some weather effects on engineer operations that are not contained in the WTDA tables.

CLOUDS AND SKY COVER. Low clouds can limit the effectiveness of aerial illumination devices.

FREEZE AND THAW DEPTH. The frost line impacts site selection, construction, excavation, and trafficability.

HUMIDITY. Extreme humidities affect handling, storage, and use of building materials. When coupled with high temperatures, humidity affects personnel and significantly increases the time to perform physical work.

ILLUMINATION. Optimum use of most NVD requires about a quarter (23 percent) of the moon, 30 degrees above the horizon, scattered clouds, and the sun more than 15 degrees below the horizon. See Appendix F for further information on E-O devices.

PRECIPITATION. High rainfall rates influence river currents, water depth, and bridging operations. It complicates other construction or maintenance jobs, affects flooding, river-crossings, soil bearing strength, and explosives.

SNOW DEPTH. Snow affects site selection, construction, and flood prediction.

STATE-OF-THE-GROUND. Ground conditions impact mining operations, trenching, and any excavation job. Snow cover can impact the emplacement of scatterable mines.

SURFACE WINDS. Ground level winds affect river crossings, port management, and all watercraft. Construction projects in chronic wind areas may need to recalculate structural strength figures.

TEMPERATURE. High temperatures impact trafficability, influence flood control, and dictate the use of certain construction materials. Cold weather influences ice thickness and river crossings, Ice flow problems affect bridges. For example, armored vehicle launched bridges (AVLBs) are affected by warming if they were set up on frozen ground. Alternating freezing and thawing (frost heaves) may destroy the effectiveness of emplaced mines.

THUNDERSTORM AND LIGHTNING. Electrical storms, and the associated rain and wind, affect electronic systems in general and antennas, shelters, and mobility in particular.

SEA STATE. This condition affects site selection and the operations of port and beach facilities.

Table G-1. Weather effects from cloud ceiling.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 1,000			Army aviation	See app E

Table G-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 150			River crossings	Reduced speed

Table G-3. Weather effects from surface winds.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
GT 7			GSR	Increased noise
GT 20	GSR	Increased noise	Communications antennas River crossings Crane operations	 Reduced speed Increases fuel consumption, reduces lift
GT 25			Personnel	
GT 30	Crane operations	Terminates		
GT 35	Medium girder bridge		Float bridging	Waves
GT 40	Personnel			
GT 50	Communications antennas			

Table G-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT -25/-32	Dry cell battery Personnel	Only 20% effective	Generators Mine detectors	wo Arctic kit wo Arctic kit, short battery life
LT -20/-28			Maintenance	Takes five times longer
LT 0/-18			Wheeled vehicles Dry cell battery Military explosives	wo winter kit Only 40% effective
LT 32/0			Personnel	See app L for wind-chill
GT 85/29			Personnel	See app L for temp/ humidity index
GT 95/35	Personnel	See app L for water consumption	Dry cell battery	Won't hold charge
GT 125/52	Generator-type blasting machines Demolition kits Mine detectors Generators			

Table G-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION SYSTEM/EVENT	SEVERE DEGRADATION REMARKS	MODERATE DEGRADATION SYSTEM/EVENT	MODERATE DEGRADATION REMARKS
Light rain or snow			Mortar operations Wheeled vehicles Target acquisition	Sight glass fogs
Moderate rain or snow			LOS communications Personnel movement Ground emplaced mines scattering system Target acquisition Equipment storage Wheeled vehicles	
Heavy rain or snow	Mortar operations Mines (snow) Personnel movement LOS communications Target acquisition Construction/bridging	Sight glass fogs up	Mines	Rain
Thunder-storm/ lightning			Ammunition Aircraft Refueling Communications Equipment storage	Safety Interference
Light freezing rain			Personnel Wheeled vehicles	
Moderate freezing rain	Personnel Wheeled vehicles			
SNOW DEPTH (INCHES)				
GT 3			Personnel movement Mines	
GT 6	Personnel movement Mines		20-mm and 40-mm ammunition Wheeled vehicles	
GT 12	Wheeled vehicles			
GT 20			Tracked vehicles	
GT 30	Tracked vehicles			

APPENDIX H

WEATHER EFFECTS ON LIGHT INFANTRY

Infantry operations are influenced primarily by those weather elements that degrade trafficability and visibility. The effect may be significant for infantry operations, but weather elements have similar impacts on other units. The following contains other weather effects that are not contained in the WTDA tables.

CLOUDS AND SKY COVER. Low overcast clouds limit the effectiveness of aerial illumination devices. Overcast clouds limit heating of inactive targets and lower target detection range for thermal sights. NVD are limited by clouds blocking natural moonlight or starlight. CAS and aerial resupply missions are hampered by low clouds.

HUMIDITY. When coupled with high temperatures, humidity decreases the effectiveness of crews in closed vehicles.

ILLUMINATION. The use of most NVDs requires about a quarter (23 percent) of the moon, 30 degrees above the horizon, scattered clouds, and the sun more than 5 degrees below the horizon. See Appendix F for weather products dealing with E-O devices.

PRECIPITATION. Rain and snow degrade trafficability, limit visibility, and affect certain target acquisition and NVD.

STATE-OF-THE-GROUND. Ground state affects trafficability and movement rates. Frozen ground improves mobility and will increase the time available for preparing fighting positions.

SURFACE WIND. Trajectory data and first round hit capability are degraded by high crosswinds.

TEMPERATURE. High and low temperatures influence the type of lubricants used, engine warm-up periods, and sustained rates of fire for weapons. High temperatures decrease the time soldiers can remain in vehicles and increase water consumption. Low temperatures degrade the ballistics of main guns, require frequent starting of engines, increase maintenance problems, and increase possible detection by the enemy. Extreme low temperatures reduce personnel effectiveness, and decrease availability of water due to freezing.

VISIBILITY. Poor visibility affects visual sighting, laser range finding, and E-O target acquisition systems. Poor visibility increases the survivability of infantry units.

WINDCHILL. See Appendix L for a discussion on windchill.

Table H-1. Weather effects from cloud ceilings.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 300	CAS	See app E		
LT 500			CAS	See app E
LT 1,000	High altitude parachute operations		Army aviation	See app E

Table H-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 200	FO		LAW NVG (PVS-5) Infrared aiming light (PAQ-4)	
LT 400			NVS (PVS-2)	
LT 500	DRAGON		FO	
LT 600			NVS (PVS-4)	
LT 1,000	TOW		DRAGON DRAGON thermal sight (TAS-5) 106-mm recoilless rifle M-60 machine gun	
LT 1,200			NVS (TVS-2 and TVS-5)	
LT 1,600	CAS	See app E	60-mm mortar (non-HE round) .50-cal machine gun	
LT 2,000			NVS (TVS-4)	
LT 3,200			TOW thermal sight (UAS-12) Handheld thermal viewer (PAS-7) Thermal night observation device (UAS-11) CAS 60-mm mortar (HE round)	See app E
LT 4,500			81-mm mortar	
LT 5,000			120-mm mortar	

Table H-3. Weather effects from surface wind.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 25			Incendiaries	
GT 7			GSR	Increased noise
GT 10			Chemical emplacement	Less effective
GT 13			Airborne DZ limit	Less effective
GT 15			Acoustic sensors	Less effective
GT 15 cross-wind			TOW	Impacts tracking
GT 18	RAP			
GT 20	GSR	Increased noise	Communications antennas NOE	
GT 25			Personnel	See app L
GT 30	Helicopters	May cancel mission See app E		
GT 40	Personnel	See app L		
GT 45	Acoustic sensors	Less effective		
GT 50	Communications antennas			

Table H-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION SYSTEM/EVENT	SEVERE DEGRADATION REMARKS	MODERATE DEGRADATION SYSTEM/EVENT	MODERATE DEGRADATION REMARKS
LT -25/-32	TOW DRAGON Rocket launcher (M202A1) Handheld infrared thermal viewer (PAS-7) Dry cell battery Personnel	Only 20% effective	Generators	wo arctic kit
LT -20/-28			NVS (PVS-4) Maintenance	wo Low temp adapter Takes five times longer
LT 0/-18			Wheeled vehicles Dry cell battery	wo winter kit Only 40% effective
LT 20/6			Thermal night observation device (UAS-11) Platoon early warning system (TRS-2) DRAGON	wo Arctic kit wo BA3090 battery Need low temp adapter
LT 32/0			NVG (PVS-5) Personnel Small arms and machine guns	wo Arctic kit See app L for wind-chill Effective-ness reduced
GT 85/29			Personnel	See app L for heat effects
GT 95/35	Personnel	See app L for water consump	Dry cell battery	Will not hold charge

Table H-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION SYSTEM/EVENT	SEVERE DEGRADATION REMARKS	MODERATE DEGRADATION SYSTEM/EVENT	MODERATE DEGRADATION REMARKS
Light rain or snow			Mortar operations Wheeled vehicles	Sight glass fogs up
Moderate rain or snow	Wheeled vehicles		LOS Personnel movement Target acquisition Platoon warning system (TRS-2) GSR Acoustic systems Equipment storage Laser systems	
Heavy rain or snow	Mortar operations Personnel movement Laser systems LOS communications Target acquisition			
Thunder-storm/ lightning	GSR		Ammunition Refueling Communications Equipment storage	Safety Interference
Light freezing rain			Personnel Wheeled vehicles	
Moderate freezing rain	Personnel Wheeled vehicles			
SNOW DEPTH (INCHES)				
GT 3			Personnel movement	
GT 6	Personnel movement		20-mm and 40-mm ammunition Wheeled vehicles	
GT 12	Wheeled vehicles			
GT 20			Tracked vehicles	
GT 30	Tracked vehicles			

APPENDIX I

WEATHER EFFECTS ON INTELLIGENCE AND ELECTRONIC WARFARE

Intelligence operations, primarily sensors, are influenced by weather. Collection and dissemination may be hindered by weather. All-source processing requires evaluation of all weather conditions as they impact enemy and friendly operations and systems. Listed below are other weather effects for IEW operations that are not listed in the WTDA tables.

CLOUDS AND SKY COVER. Overcast skies with low cloud bases reduce the effectiveness of infrared and photographic collection systems, and may restrict the use of UAVs.

ICING. In addition to icing conditions associated with aircraft, ice is also a problem with electronic systems that depend on ice-free antennas for optimum operation.

ILLUMINATION. NVD require about a quarter (23 percent) of the moon, 30 degrees above the horizon, scattered clouds, and the sun more than 5 degrees below the horizon. See Appendix F for further information.

PRECIPITATION. Even moderate amounts of rain and snow will obstruct vision and degrade photographic and infrared collection systems. Heavier amounts of rain can generate background electronic noise that reduces the efficiency of GSR.

SURFACE WIND. Strong winds may damage or prevent erection of system antennas.

TEMPERATURE. Frozen soil increases the difficulty of grounding equipment. At extreme cold temperatures cables snap and wire is unmanageable. Extreme cold also shortens battery life and may put systems requiring a good source of battery power out of service.

VISIBILITY. Low visibility decreases the effectiveness of visual, photographic, infrared, and E-O collection systems. However, LRSU's may benefit from restricted visibility and increase their infiltration success. This condition may affect visual, laser range finding, and target acquisition systems.

Table I-1. Weather effects from cloud ceilings.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 50	NOE UAV, any terrain	Flight operations		
LT 300	IROQUOIS (EH-1H), flat terrain	Below VFR minimums	NOE UAV, flat terrain	Flight operations
LT 500	MOHAWK (OV/RV-1D) and BLACKHAWK (EH-60A), mountain terrain or night, flat terrain	Below VFR minimums	NOE UAV, flat or mountain terrain	Target requirements
LT 1,000	IROQUOIS (EH-1H), mountain terrain	Below VFR minimums	NOE UAV, mountain terrain Army aviation	Flight operations See app E

Table I-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 800	BLACKHAWK (EH-60A) and IROQUOIS (EH-1H), daytime, flat or mountain terrain	Below VFR minimums		
LT 1,000	Engagement, collection plans, photographic missions			
LT 1,600	Aircraft daytime, flat terrain	Below VFR minimums		
LT 2,000	UAV		Engagement, collection plans, photographic missions	
LT 3,200	Aircraft nighttime, flat terrain	Below VFR minimums		
LT 4,800	Aircraft nighttime, mountain terrain	Below VFR minimums		

Table I-3. Weather effects from surface winds.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
GT 7			Radars (PPS-5 and PPS-15)	Increased noise in tall grass
GT 13			Radio receiver (TRR-20)	Antenna must be guyed
GT 15			Acoustic sensors MRDFS (PRD-10), MANPACK (PRD-11) Radars (PPS-5 and PPS-15)	Less effective DF degraded, antennas degraded, can't set up Heavy vegetation moved by wind degrades
GT 15, with heavy rain	MRDFS (PRD-10), Man portable radio receiving set (TRQ-30), MANPACK (PRD-11)	Exceeds system operating limits		
GT 17, in sand/dust	HEXJAM (PLT-1A)	Exceeds operating limits		
GT 20			Communications antennas, radar (PPS-5)	Antennas degraded
GT 21 in heavy rain	Radio receiver (TRR-20)	Exceeds antenna operating limits		
GT 25	Radar (PPS-15)		TACFIX (TRQ-37)	DF degraded
GT 30	SASS TEAMMATE (TRQ-32)	Cannot operate Antenna hard to erect	TACJAM (MLQ-34) PIRANHA (OG-181), TACFIX (TRQ-37)	Antenna performance Antenna erection

Table I-3. Weather effects from surface winds (continued).

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
GT 35	Countermeasures system (GLQ-3B), TEAMPACK (MSQ-103C)	Antenna mast cannot be fully extended	TEAMMATE (TRQ-32(V)) Countermeasures system (GLQ-3B) PIRANHA (OG-181), TEAMPACK (MSQ-103C) GUARDRAIL (USD-9),	DF degraded Antenna extending Antennas should not be erected Antenna operations
GT 40	Personnel Radar (PPS-5)	Antenna breaks		
GT 45	Acoustic sensors IEW antenna systems BLACKHAWK (EH-60A)	Less effective Exceeds limits	TEAMMATE TRQ-32(V)), TRAILBLAZER (TSQ-114B(V))	DF degraded
GT 50	Communications antennas, PIRANHA (OG-181), TEAMMATE (TRQ-32(V)), REMBASS (GSQ-187) Countermeasures set (TLQ-15)	Antenna should not be erected Affects antenna perfor-mance	REMBASS (GSQ-187) PIRANHA (OG-181) Radio receiver set (TRR-20)	Antenna perfor-mance Antenna should not be erected Antenna damage
GT 60	Fixed-wing aircraft DRAGONFIX (TSQ-164), TRACKFINDER (TSS-11)	May cancel mission (see app E) Exceeds antenna limits		
GT 78	TRAILBLAZER (TRQ-114B(V))	Exceeds antenna limits		

Table I-3. Weather effects from surface winds (continued).

GT 90	GSM (TSQ-168), antenna	Cannot endure winds above 100 kn. Weather warning required at 90 kn.		

Table I-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT -25/-32	QUICK LOOK II (ALQ-133) Countermeasure system (GLQ-3B), TACJAM (MLQ-34), HEXJAM (PLT-1A) TEAMPACK (MSQ-103C) PIRANHA (OG-181) Personnel	Exceeds aircraft limits Exceeds generator operating limits Exceeds battery operating limits Requires arctic kit	Radar (PPS-5) Radar (PPS-15) TRAILBLAZER (TSQ-114B(V))	wo shelter wo generator, arctic kit Carrier requires several heater kits to operate
LT -20/-28			Maintenance	Takes five times longer
LT 0/-18	Radio receivers (TRR-20, TRR-33A)	Antenna rotor won't operate	Wheeled vehicles Dry cell battery Radar (PPS-15)	wo winter kit Only 40% effective Battery 5598 required
LT 17/-9			Radars (PPS-5 and PPS-15)	
LT 20/-6			Platoon early warning system (TRS-2) OUTS	wo BA3090 battery Env system cannot sustain personnel
LT 32/0	TACFIX (TRQ-37)		Personnel	See app L for wind-chill
Between 60/16 and 100/38			TRAFFICJAM (TLQ-17A)	Transmit no longer than 15 continuous minutes

Table I-4. Weather effects from temperature (continued).

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
GT 68/20			MANPACK (PRD-11)	Degrades receiver accuracy
GT 80/27			GSM (TSQ-168), shelter	Requires internal temp remain between 65°F-80°F
GT 85/29	QUICKFIX (ALQ-151(V)) MANPACK (PRD-11)	Affects lift Affects receiver accuracy	Personnel	See app L for temp/ humidity index
GT 95/35	Personnel	See app L for water consumption	Dry cell battery	Will not hold charge
GT 100/38			TRAFFICJAM (TLQ-17A)	Transmit no longer than 5 continuous minutes
GT 120/49	QUICKFIX (ALQ-151), GUARDRAIL (USD-9), TACJAM (MLQ-34), TRAILBLAZER (TSQ-114B(V)), TACFIX (TRQ-37)	Exceeds limits		
GT 125/52	Generators, REMBASS (GSQ-187), TEAMPACK (MSQ-103C), PIRANHA (OG-181), TEAMMATE (TRQ-32(V)), TRAILBLAZER, (TSQ-114B(V),) HEXJAM (PLT-1A) Man portable radio receiving set (TRQ-30), Radars (PPS-5 and PPS-15)	Exceeds limits BB-622 battery degraded		

Table I-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
Light rain or snow			Wheeled vehicles	
Moderate rain or snow	Wheeled vehicles		LOS communications Personnel movement Laser systems Target acquisition Equipment storage Platoon early warning system (TRS-2)	
Heavy rain or snow	Laser systems Personnel movement LOS communications HEXJAM (PLT-1A) TEAMPACK (MSQ-103C) Target acquisition		REMBASS (GSQ-187) SLAR Radars (PPS-5 and PPS-15) GSM (TSQ-168), antenna	Infrared detection People detection Must be drained when exposed to heavy moisture
Heavy rain with 15 kn or more surface wind	MRDFS (PRD-10) Man portable radio receiving set (TRQ-30) MANPACK (PRD-11)		GSM (TSQ-168)	Must move if rainfall exceeds 4 inches/ hour
Thunderstorm/ lightning			Ammunition Radar (PPS-15) Aircraft operations Refueling operations Communications Equipment storage	AR 95-1 Safety Interference
Light freezing rain	Aircraft wo deice	AR 95-1		
Moderate freezing rain	Personnel movement		Aircraft with deice	AR 95-1

Table I-5. Weather effects from precipitation (continued).

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
Heavy freezing rain	Aircraft with deice	AR 95-1		
SNOW DEPTH (INCHES)				
GT 3			Personnel movement	
GT 6	Personnel movement		Wheeled vehicles	
GT 12	Wheeled vehicles			
GT 20			Tracked vehicles	
GT 30	Tracked vehicles			
HAIL (INCHES)				
Large hail GT .5	GSM (TSQ-168)	Must be protected from hail		

APPENDIX J

WEATHER EFFECTS ON MECHANIZED INFANTRY

Mechanized infantry operations are also influenced by those weather elements that degrade trafficability and visibility. Indeed, the weather effects impacting mechanized infantry units will include most of the conditions that play a role in both armor and regular infantry. Although the effect may be more pronounced for mechanized infantry, armor, and cavalry operations, weather elements have generally similar impacts on other units. Listed below are weather effects for mechanized infantry that are not contained in the WTDA tables.

CLOUDS AND SKY COVER. Low overcast clouds will limit the effectiveness of aerial illumination devices. Overcast clouds tend to limit heating of inactive targets and, therefore, lower target detection range for thermal sights. NVD are limited by clouds blocking natural light from the moon and stars. CAS and aerial resupply missions are hindered by low clouds.

HUMIDITY. When coupled with high temperatures, humidity decreases effectiveness of crews in closed vehicles.

ILLUMINATION. NVD require about a quarter (23 degrees) of the moon, 30 degrees above the horizon, scattered clouds, and the sun more than 5 degrees below the horizon. Detailed products dealing with the use of E-O devices are discussed in Appendix F.

PRECIPITATION. Rain and snow degrade trafficability, limit visibility, and degrade the effectiveness of certain target acquisition and NVD.

STATE-OF-THE-GROUND. Wet grounds play an important role in the effectiveness of chemical agents and smoke munitions. They can also affect trafficability and movement rates. Frozen ground improves mobility and significantly increases time available for preparing fighting positions. Deep snow slows movement of tracked vehicles. Frozen ground affects systems such as mines, sensors, and indirect fire.

SURFACE WIND. Trajectory data and first round hit capability are degraded by high crosswinds. Wind, or in some cases the lack of it, affects smoke and indirect fire illumination missions and increases the number of indirect fire rounds used.

TEMPERATURE. Too cold or too hot conditions dictate the type of lubricants to be used, engine warm-up periods, and sustained rate of fire for weapons. High temperatures decrease the time personnel can remain in vehicles. Extremely high temperatures increase water consumption. Low temperatures degrade the ballistics of main guns. Extreme low temperatures reduce personnel effectiveness, and decrease the availability of water because of freezing. Temperatures changing from above to below freezing can freeze stationary tracks into the mud. High temperatures cause gun tube "droop," shimmering, mirages, and vehicle exteriors to be too hot to touch.

VISIBILITY. Poor visibility affects visual, laser range finding, and target acquisition systems. Poor visibility increases the survivability of infantry units.

WINDCHILL. See Appendix L.

Table J-1. Weather effects from cloud ceilings.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 300	CAS	See app E		
LT 1,000			Army aviation, CAS, UAV	See app E

Table J-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 200	FO		LAW NVG (PVS-5) Infrared aiming light (PAQ-4)	
LT 400			84-mm recoilless rifle (AT-4) NVS (PVS-2)	
LT 500	DRAGON		VIPER FO	
LT 600			NVS (PVS-4)	
LT 800	Tracked vehicle, day operation			
LT 1,000	TOW		DRAGON DRAGON thermal sight (TAS-5) M-60 machine gun 7.62-mm coaxial machine gun	
LT 1,200			NVS (TVS-2 and TVS-5)	
LT 1,600	CAS	See app E	Tracked vehicle, day operation .50-cal machine gun	
LT 2,000			NVS (TVS-4)	
LT 3,200			25-mm chain gun M-60, M-1 main gun TOW thermal sight (UAS-12) Handheld thermal viewer (PAS-7) Thermal night observation device (UAS-11) CAS	
LT 4,500			81-mm mortar	
LT 5,000			107-mm mortar (4.2 in)	

Table J-3. Weather effects from surface winds.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 25			Incendiaries	
GT 7			GSR	Increased noise
GT 15			Acoustic sensors	Less effective
GT 15 Cross-winds			TOW, DRAGON	Impacts tracking/ reduces range
GT 20	GSR	Increased noise	Communication antennas NOE	
GT 25			Personnel	
GT 30	Helicopters	May cancel mission See app E		
GT 40	Personnel			
GT 45	Acoustic sensors	Less effective		
GT 50	Communication antennas			

Table J-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT -25/-32	TOW DRAGON Rocket launcher (M202A1) Handheld thermal viewer (PAS-7) Dry cell battery Personnel	Only 20% effective	Generators Laser infrared observation set (GVS-5) INF/CFV (M2/M3)	wo arctic kit wo external power wo winter kit
LT -20/-28			NVS (PVS-4 and TVS-5) Maintenance Tanks (M-1, M-60)	wo low temp adapter Takes 5 times longer Accuracy
LT 0/-18			Wheeled vehicles Dry cell battery	wo winter kit Only 40% effective
LT 20/-6			Thermal night observation device (UAS-11) Platoon early warning system (TRS-2) DRAGON	wo arctic kit wo BA3090 battery wo low temp adapter
LT 32/0			NVG (PVS-5) Personnel Small arms and machine guns	wo arctic kit See app L for wind-chill Reduces effective-ness
GT 85/29			Personnel	See app L
GT 95/35	Personnel	See app L	Dry cell battery	Will not hold charge
GT 125/52	All NVS 81-mm mortar Generators 90-mm recoilless rifle Laser infrared observing set (GVS-5) WP rounds	Ammunition Storage, use		

Table J-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
Light rain or snow			Mortars Wheeled vehicles	Sight glass fogs
Moderate rain or snow	Wheeled vehicles		LOS communications Personnel movement Target acquisition Platoon warning system (TRS-2) GSR Acoustic systems Equipment storage	
Heavy rain or snow	Mortars Personnel movement LOS communications Target acquisition Laser systems			
Thunder-storm/ lightning			Ammunition Refueling Communications Equipment storage	Safety Safety Interference
Light freezing rain			Personnel Wheeled vehicles	
Moderate freezing rain	Personnel Wheeled vehicles			
SNOW DEPTH (INCHES)				
GT 3			Personnel movement	
GT 6	Personnel movement		20-mm and 40-mm ammunition	
GT 12	Wheeled vehicles			
GT 20			Tracked vehicles	
GT 30	Tracked vehicles			

APPENDIX K

WEATHER EFFECTS ON NUCLEAR, BIOLOGICAL, AND CHEMICAL OPERATIONS

NBC operations are extremely sensitive to environmental conditions that affect the transport and diffusion of CB agents. Humidity, air temperature, ground temperature, wind direction and speed, low-level temperature gradient, precipitation, cloud cover, and sunlight are a few of the critical elements to consider when planning NBC operations. The degree of impact depends upon the synoptic situation and the local influence of topography, vegetation, and state-of-the-ground.

The low-level stability of the atmosphere is an important factor in determining whether there will be a good horizontal transport of radioactive or CB clouds. However, stability is not measured directly but is calculated by considering the above weather elements. The WETM or SWO will assist you in making a stability determination. Listed below are weather effects for NBC operations that are not contained in the WTDA tables.

CLOUDS AND SKY COVER. persistent overcast low clouds usually indicate a neutral (favorable) condition, while broken low clouds indicate an unstable (unfavorable) condition during the day and a moderately stable (favorable) condition at night.

HUMIDITY. Humidity has little effect on most chemical agents; however, high humidity destroys some chemical agents such as lewisite and phosgene because of rapid hydrolysis. High humidity increases the effectiveness of HC and phosphorous smokes, some chemical agents, and both wet and dry forms of biological agents. High humidity improves the effectiveness of wet aerosols by reducing evaporation while low humidity assists agent aerosols. High humidity, combined with high temperatures, reduces time in which troops in MOPP gear are effective.

PRECIPITATION. Rain and snow will effect the persistence of chemical agents and may produce radioactive rainout and hot spots. Snow may cover and neutralize certain liquid agents. Rain may even work as a decontaminate. On the other hand, some agents may be very persistent on snow.

STATE-OF-THE-GROUND. Soil conditions impact the effectiveness of chemical agents. Bare, hard ground favors short-term effectiveness and high-vapor concentrations. If the surface is porous, such as sand, the liquid agent quickly soaks in. Vegetative cover reduces exposure to ultraviolet light and favors the survival of wet aerosols. Wet soil degrades the effectiveness of smoke munitions.

SUNLIGHT. A bright sun will shorten the lifespan of biological agents. Sunlight also plays a role in temperature gradients, winds, and temperature (stability).

TEMPERATURE. Some agents are more persistent at low temperatures. Vaporization may be a problem with higher temperatures. Normal atmospheric temperatures have little direct effect on a biological agent aerosol. Sub-freezing temperatures make water-based decontamination methods ineffective.

THUNDERSTORMS AND LIGHTNING. Severe electrical storms will restrict munitions handling because of safety.

WINDS. Winds play a significant role in CB agent dispersion, chemical agent persistence, and aerial delivery methods. Very light and strong winds degrade effectiveness of smoke and NBC operations. Wind direction is considered for fallout pattern determination.

Table K-1. Weather effects from cloud ceilings.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 600			Nuclear burst	Absorbs/ scatters 90% of thermal energy
LT 5,000			Nuclear burst Nuclear burst	Burst above clouds reduces thermal and EMP effect Burst below clouds enhances thermal effect

Table K-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
	NO VALUES IDENTIFIED			

Table K-3. Weather effects from surface wind.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
Calm	Chemical agents Smoke employment			
LT 2			Chemical agents	
LT 5			Smoke employment	
LT 10			Smoke employment, chemical agents	Wind direction more critical
GT 19	Smoke employment	Wind direction more critical		
GT 25			Personnel	See app L
GT 30	Chemical agents	Wind direction more critical		
GT 40	Personnel	See app L		

Table K-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT -25/-32	Chemical detection	Becomes ineffective		
LT -20/-28			Protective mask	wo winter kit
LT -15/-25	Chemical decontamination (DS-2) Detector (battery operated)	Solution becomes ineffective		
LT +32/0			Chemical detection Chemical decontamination	
LT 40/3	Nerve agent antidote	Protect against low temp		
GT 80/26	Personnel	See app L for MOPP4		
GT 95/35			Chemical evaporation	
GT 110/39			Chemical decontamination	
GT 120/48	Smoke generator			

Table K-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
Light rain or snow			Chemical agents Nuclear burst	Wash into low areas Absorb/ scatter up to 90% thermal energy
Moderate rain or snow			Engine-generated smoke	
Heavy rain or snow	Chemical agents Nuclear burst Engine-generated smoke	Wash into low areas Absorb or scatter up to 90% thermal energy		
Thunder-storm/ lightning	Chemical Smoke			
SNOW DEPTH (INCHES)				
GT 3	WP smoke rounds			

APPENDIX L

WEATHER EFFECTS ON PERSONNEL

Weather has a great impact on the soldier, particularly extreme temperatures. It may have a more immediate impact on the human body than on systems and equipment. Each soldier is unique because of differences in physical conditioning or a higher tolerance to hot and cold temperatures.

Regardless of physical differences, temperature, surface wind speeds, and relative humidity affect everyone to a degree. This is particularly true for physical activity, personal protection, and water consumption.

The products and information you develop as part of this appendix should be included in all weather effects briefings prepared for the commander and staff.

COLD WEATHER ENVIRONMENT

A soldier's greatest concern in extreme cold is survival. Soldiers spend much of their time trying to keep warm and protecting exposed skin from frostbite. Cold temperatures and wind speed create a windchill factor which has a definite effect on the soldier.

Your weather forecast includes temperatures in degrees Fahrenheit and wind speed in nautical miles-per-hour (knots). Table L-1 lets you use temperatures in Fahrenheit and wind speed either in statute miles or knots to determine windchill values and effects.

Extreme cold results in an increase of water consumption by soldiers. This is due to working outdoors in heavy clothing and the dry air that usually accompanies cold weather.

Wind and cold effects on military free-fall parachutists must be taken into account when planning these kinds of operations.

AMBIENT AIR

Ambient air temperatures at high altitudes can be calculated using the standard temperature lapse rate of 2°C (3°F) for every thousand feet increase AGL. For example, a military free fall jumpmaster spotting an aircraft at 25,000 feet AGL where the ground temperature is 50° F would be jumping into an air temperature of -25° F (calculated at 50 °F-(25 x 3°F)).

WINDCHILL FACTOR

The windchill caused by the speed of the aircraft (130 kn) increases the problems for the jumpmaster. Parachutists in free fall attain a terminal velocity of 120 mph. Parachutists conducting HAHO operations can be under canopy for as long as 35 to 40 minutes, and be exposed to bone-numbing cold temperatures as they descend. To succeed, they must be equipped to withstand these harsh conditions.

Table L-1. Windchill chart.

WIND SPEED (KNOTS)	WIND SPEED (MPH)	LOCAL TEMPERATURE (°F) 32	23	14	5	-4	-13	-22	-31	-40	-49	-58
		EQUIVALENT TEMPERATURE (°F)										
	CALM	32	23	14	5	-4	-13	-22	-31	-40	-49	-58
4	5	29	20	10	1	-9	-18	-28	-37	-47	-56	-65
9	10	18	7	-4	-15	-26	-37	-48	-59	-70	-81	-91
13	15	13	-1	-13	-25	-37	-49	-61	-73	-85	-97	-109
17	20	7	-6	-19	-32	-44	-57	-70	-83	-96	-109	-121
21	25	3	-10	-24	-37	-50	-64	-77	-90	-104	-117	-127
26	30	1	-13	-27	-41	-54	-68	-82	-97	-109	-123	-137
30	35	-1	-15	-29	-43	-57	-71	-85	-99	-113	-127	-142
35	40	-3	-17	-31	-45	-59	-74	-87	-102	-116	-131	-145
39	45	-3	-17	-31	-45	-59	-74	-87	-102	-116	-131	-145
43	50	-4	-18	-33	-47	-62	-76	-91	-105	-120	-134	-148
		LITTLE DANGER FOR PROPERLY CLOTHED PERSONS		CONSIDERABLE DANGER			VERY GREAT DANGER					
		DANGER FROM FREEZING OF EXPOSED FLESH										

HOT WEATHER ENVIRONMENT

In hot weather the important factors are temperature and relative humidity. The Soldiers' primary concerns are physical exhaustion and dehydration. You must consider both because a common work task will take longer and additional water may have to be transported during hot weather. The following hot weather concerns play a role in the employment of soldiers.

WATER ADEQUACY. Water supplies and the enforcement of its intake before, during and after physical activity is critical for survival.

WORKLOAD CORRELATION. Workload or training activities must be adapted to environmental heat stress conditions.

REST PERIODS. Adequate break time must be provided for physically active personnel in a hot environment.

CHILLED DRINKING WATER. Soldiers will often reject warm drinking water even when they are significantly dehydrated.

ADJUST PHYSICAL ACTIVITY. Soldiers' introduction to physical exertion in a hot climate upon arriving from a temperate one should be as gradual as circumstances allow. They will need 1 to 2 weeks' time to physiologically adjust to the new climate. Lighten physical activity during this period to ensure optimum performance.

SALT. Sodium intake must be maintained in hot weather. Two good meals a day normally provide enough salt for most soldiers.

HUMIDITY. This can be tricky. A low WBGT index (for example, in the morning) may not be a totally safe indicator if the humidity is high. High humidity retards cooling by evaporation of sweat, and decreases the urge to drink sufficient water.

WATER SPRAY. A water mist will cool a person off. But it should never be substituted for adequate consumption of water before, during, and after strenuous activities in the heat.

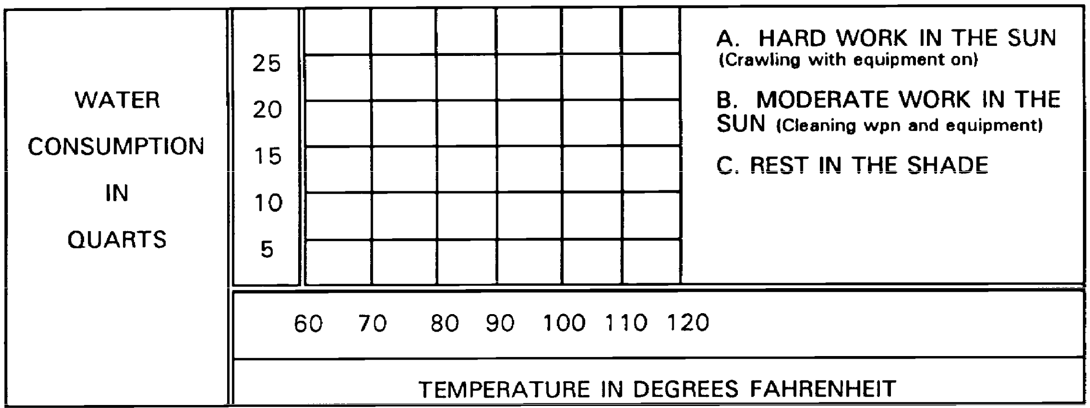
Tables are provided that use a temperature measurement (or temperature forecast) and a relative humidity calculation. The SWO can routinely provide you with temperature and relative humidity forecasts. If you need air temperature values measured at your particular location, use the thermometer included in the FALOP BWK.

HOT WEATHER WATER REQUIREMENTS

Table L-2 shows the water needs (in quarts per day) for soldiers at 3 activity levels over an 8-hour work period. To determine soldiers' average water needs, you have to know the air temperature and decide the level of activity the troops will be doing. For example, if a soldier is doing 8 hours of hard work in the sun (curve C) when the average temperature for the day is 100°F, his water requirements for the day will be around 15 quarts.

This amount of water can be converted into extra weight the soldier must carry. One quart is equal to 2 pounds so the 15 quarts of water would weigh 30 pounds.

Table L-2. Daily water consumption requirements for three levels of activity.



HOT WEATHER WORK TIME LIMITS

Table L-3 shows the time limits during which work can be safely performed in hot weather. In computing the time limits, both air temperature and relative humidity are considered. The values are based on a sitting soldier in BDUs doing light work.

The table gives an estimate of the length of time continuous work should be performed. For moderate work a technical manual on the PATRIOT missile system recommends that you sue on-half the values contained in the table. You should not consider these tables as absolute limits--especially since light, moderate, or heavy work are difficult to quantify. Table L-4 indicates work time in hot weather based on the WBGT index.

Table L-3. Work time in hot weather operations.

TEMPERATURE		RELATIVE HUMIDITY (%)					
(°C)	(°F)	10	30	50	70	90	100
60	140	1 HR	.25 HRS				
54	130	2 HRS	.5 HRS	.25 HRS	NO WORK RECOMMENDED		
49	120	4 HRS	2 HRS	.5 HRS	.25 HRS		
43	110	12 HRS	4 HRS	2 HRS	.5 HRS	.25 HRS	
38	100	NO LIMIT	12 HRS	4 HRS	2 HRS	1 HR	.5 HRS
32	90	WITH PRECAUTIONS			12 HRS	6 HRS	4 HRS

Table L-4. Wet bulb globe temperature index (light work).

HEAT CONDITION/ CATEGORY *	WET BULB GLOBE TEMPERATURE INDEX (DEGREES F)	WATER INTAKE QUARTS/HOUR	WORK/REST CYCLE (MINUTES)
1	78.0 to 81.9	AT LEAST 1/2	CONTINUOUS
2	82.0 to 84.9	AT LEAST 1.2	50/10
3	85.0 to 87.9	AT LEAST 1	45/15
4	88.0 to 89.9	AT LEAST 1 1/2	30/30
5 **	90.0 and ABOVE	MORE THAN 2	20/40

* MOPP GEAR OR BODY ARMOR ADDS AT LEAST 10 DEGREES F TO THE WPGT INDEX.

** SUSPEND PHYSICAL TRAINING AND STRENUOUS ACTIVITY. IF OPERATIONAL (NON-TRAINING) MISSION REQUIRES STRENUOUS ACTIVITY, ENFORCE WATER INTAKE TO MINIMIZE EXPECTED HEAT INJURIES.

APPENDIX M

WEATHER EFFECTS ON SPECIAL OPERATIONS FORCES

Special operations forces (SOFs) consist of Special Forces (SF), Rangers, special operations aviation, psychological operations (PSYOP) and Civil Affairs (CA), as well as signal and support. These operations are influenced by many of the same elements and thresholds as their conventional counterparts. However, special tactics and capabilities can make SOF operations more weather sensitive than conventional operations.

SOF optimal use is in deep operations at the strategic or operational level. These operations are significantly affected by both weather and environmental conditions, and make extensive use of climatology. The following are some of the more significant weather effects for SOF operations.

CLOUDS AND SKY COVER. Low clouds improve SOF mobility due to decreased chance of detection. Low clouds may degrade target acquisition. Employment of E-O systems (both) infrared and laser) may be degraded.

HUMIDITY. Moist air degrades sound propagation while dry air improves it. Prolonged exposure of sensitive equipment (C-E and medical) affects maintenance requirements and the useful life of supplies.

ILLUMINATION. Poor light conditions enhance surreptitious operations but hinder visual observation of targets, troop movement, and both land and sea navigation. Special operations aviation generally operates at night.

PRECIPITATION. Rain or snow may improve surreptitious ground mobility if threat patrols seek shelter. Aircraft and watercraft can "hide" in, or be masked by, precipitation to avoid radar detection. Wet weather improves crowd control, but during prolonged precipitation may increase populace restlessness. Heavy rain or snow affect CA operations. Moderate rain dampens sound during loudspeaker operations. Variations from normal precipitation can alter the speed of river stream flow and estuary currents.

REDUCED VISIBILITY. poor visibility complicates target surveillance. Surreptitious movement is enhanced. The ability to navigate and fly at night is degraded. Selected E-O systems are degraded (see Appendix F). Restricted visibility aloft affects flight operations.

SOLAR AND IONOSPHERIC DISTURBANCES. High sun spot activity degrades long-haul communications and PSYOP radio and television broadcasts.

SURFACE WIND. Wind speed and direction forecasts (both surface and aloft) are critical to leaflet dissemination. Wind also cuts down on loudspeaker sound propagation. Moderate winds can degrade or enhance waterborne operations, depending on situation. Winds are a major cause of turbidity in shallow water. Winds affect CA operations according to each particular type mission.

TEMPERATURE. Both high and low temperatures may affect crowd and population control. Extreme cold may improve surreptitious mobility if threat guards and patrols seek shelter. Cold air allows better sound propagation than warm air.

TIDES AND CURRENTS. Infiltration and exfiltration route planners must consider timing and height of tides. Infiltration at low tide results in more exposure while moving up the beach and may require avoiding obstacles in shallow water. In both inland and open waters, currents may vary widely and require careful study.

Table M-1. Weather effects from cloud ceilings.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 200	R&S	Target acquisition		
LT 300	Ground	Target acquisition		
LT 1,000	Airborne, CAS HALO Infiltration Amphibious Aviation Ground	Aircraft fast movers Minimum base of cloud over DZ CAS Target acquisition CAS	Aviation Ground, R&S	See app E Target acquisition
LT 3,000			Airborne Amphibious Aviation Ground	Aircraft CAS Target acquisition CAS
LT 3,500			CAS	Depends on tactics--fast movers
LT 4,500	HERCULES (AC-130)			
LT 5,000	NBC	Blast effect	MAVERICK	Depends on tactics

Table M-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 1,600	Airborne Amphibious Aviation R&S NBC	Aircraft operations Target acquisition Target acquisition Target acquisition Target acquisition		
LT 4,800			Airborne Amphibious Aviation R&S NBC	Aircraft operations Target acquisition Target acquisition Target acquisition Target acquisition

Table M-3. Weather effects from surface winds.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
SURFACE WINDS				
LT 3			NBC	Agent dispersal
GT 7			Amphibious NBC Balloon launch for leaflet dissemination	Sea state Agent dispersal
GT 10	NBC	Agent dispersal		
GT 13			Static line (infil)	Chute limitation
GT 15			Airborne Loudspeaker broadcasts	Jump release
GT 18	RAP	Chute limitation		
GT 20	Airborne	Jump release		
GT 25			Aviation Signal	Aircraft Antenna stability
GT 30	Aviation	Aircraft		
GT 35	Amphibious	Sea state		
GT 49	Signal	Antenna stability		
GUST SPREAD				
GT 15	Aviation	Aircraft		

Table M-3. Weather effects from surface wind (continued).

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
UPPER AIR WINDS				
GT 15			Airborne	Jump release
GT 20	Airborne	Jump release		

Table M-4. Weather effects from temperature.

WEATHER VALUE (°F/°C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT -25/-37	Signal	Exposure		
LT 0/-18			Signal	Exposure
LT 25/-4	Amphibious Logistics	Exposure Exposure		
LT 32/0			Amphibious Signal	Exposure Exposure
GT 68/20			NBC	Dispersal persis-tence
GT 95/35	NBC	Dispersal, persis-tence	Signal	Heat stress
GT 105/41	Signal	Heat stress		
GT 122/50	Logistics	Storage		

Table M-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
RAIN (INCHES)				
Any	NBC	Agent persistence		
Light rain (trace - .1/hour)			Airborne Amphibious Ground R&S	Fall rate Beach state Trafficability Trafficability, target acquisition
Moderate rain (.11 to .3/hour)	Airborne Amphibious Ground R&S	Fall rate Beach state Trafficability Trafficability, target acquisition		
LT .5/hour			Signal	Attenuation
GT .5/hour	Signal	Attenuation	Aviation	Target acquisition
Freezing precipitation	Aviation Signal	Aircraft icing Antenna stability		
SNOW DEPTH (INCHES)				
Trace			Ground R&S Logistics	Trafficability Trafficability Trafficability
1			Aviation	Targeting, vertigo
GT 1	Aviation	Targeting, vertigo		
2	Logistics	Trafficability		
GT 24	Ground R&S	Trafficability Trafficability		

Table M-6. Weather effects from miscellaneous causes.

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
THUNDER-STORMS				
LT 5 km distance	Airborne Aviation R&S Logistics NBC Signal	Aircraft Aircraft Ground Storage Munition storage System safety, ground operations		
GT 5 km distance			Airborne Aviation R&S Logistics NBC Signal	Aircraft Aircraft Ground operations Storage Munition storage System safety, ground operations
EFFECTIVE ILLUMI-NATION (MILLILUX)				
LT 2.5	Airborne Amphibious Aviation R&S Signal	NVG NVG NVG NVG NVG		
RELATIVE HUMIDITY				
GT 70%	Logistics	Storage		

Table M-6. Weather effects from miscellaneous causes (continued).

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
DENSITY ALTITUDE (FEET)				
4,000			Airborne, Aviation	Aircraft lift
6,900	Airborne, Aviation	Aircraft lift		
SEA STATE (FEET)				
Tide GT 6	Amphibious	Boat safety		
Swell-height GT 3	Amphibious	Boat safety		
Surf height GT 4	Amphibious	Boat safety		
AIRCRAFT ICING				
Trace			Aviation	Aircraft safety
Light or greater	Aviation	Aircraft safety		
AIRCRAFT TURBU-LENCE				
Light			Aviation	Aircraft safety
Moderate	Aviation	Aircraft safety		
LAPSE RATE				
Inversion	Signal	Fading, ducting	NBC	Agent persis-tence

Table M-6. Weather effects from miscellaneous causes (continued).

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
Stability change	NBC	Agent persistence		
IONOSPHERIC DISTURBANCE				
Any	Signal	Frequency use		

APPENDIX N

PART I

WEATHER EFFECTS ON THREAT SYSTEMS

MILITARY ASPECTS OF WEATHER

Because of recent significant political and military changes in the former Soviet Union, US Forces will have to be prepared to fight in a variety of climatic conditions on short notice. One major key to accomplishing our missions under these circumstances is understanding how weather affects both friendly and threat forces and their operations, systems, and personnel.

Current weather conditions and weather forecasts for the AO and AI are analyzed to determine the effects on friendly and enemy operations. This is especially significant when threat forces have the capability to employ NBC weapon systems.

THREAT EQUIPMENT

Some of the major arms producers and sellers in the world today are the former Soviet Union, Sweden, Brazil, Britain, Germany, France, Italy, and the United States. However, the major arms purchasers continue to be the undeveloped or Third-World countries in the Middle East, Latin America, and Asia.

The types of threat equipment that we may encounter on future battlefields will vary considerably from artillery and mortars produced during World War II to the Austrian-produced GHN-45, a 155-mm towed gun with a range of 39,600 meters (using extended-range full-bore-base bleed (ERFB-BB) technology). Almost all of the Third-World countries have bought or made their own versions of Soviet-produced tanks, APCs, artillery, antiaircraft artillery (AAA), and assorted surface-to-air (SAM) and surface-to-surface missile (SSM) systems.

CRITICAL WEATHER FACTORS

The following are major critical weather factors that can enhance or degrade combat operations, systems, and personnel.

LOW VISIBILITY. Low visibility (less than 3 km) can be beneficial to both threat and friendly forces. It conceals the center of gravity and maneuver of offensive forces and increases the possibility of achieving surprise. Some disadvantages of low visibility are that it hinders C^2 and reduces the effectiveness of R&S and target acquisition--especially during the defense.

SURFACE WINDS. Strong winds can reduce the effectiveness of downwind forces by blowing dust, smoke, sand, rain, or snow on them. The upwind force generally has better visibility and can advance faster and easier. Strong winds also limit airborne and aviation (primarily helicopters) operations. Winds in excess of 35 knots can cause personal injury, damage materiel and structures, create false radar returns, and reduce visibility because of blowing sand, dust, and other battlefield debris.

PRECIPITATION. Precipitation is significant because it affects trafficability, visibility, personnel effectiveness, and a wide variety of tracked and wheeled military equipment. Heavy rains can make some unsurfaced, low-lying, and off-road areas impassable. In addition, both rain and snow can drastically reduce personnel effectiveness by limiting visibility, causing discomfort, increasing fatigue, and creating other physical and psychological problems.

CLOUD COVER. The type and amount of cloud cover and the altitude of cloud bases and tops influence aviation operations. CAS employing fixed-wing aircraft would like a ceiling of at least 2,500 feet (762 m), but can be employed with ceilings as low as 500 feet. Threat CAS rotary-wing aircraft and aerial resupply missions require a minimum ceiling of 300 feet (100 m). Cloud cover affects ground operations by reducing illumination and visibility, or, in some instances, by enhancing the effects of artificial light.

TEMPERATURE AND HUMIDITY. Together, these elements have a direct impact on personnel and vehicle performance. Excessively high temperatures cause heat-related injuries to personnel and vehicle engine wear that leads to equipment failure. Very low temperatures increase cold weather injuries, cause damage to vehicle cooling systems and engines, decrease the effectiveness of vehicle lubrication, and create excessive logistics requirements.

Table N-1. Weather effects from cloud ceilings.

WEATHER VALUE (FEET)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 1,000			SA-9 SAM SA-14 SAM	
LT 2,500			ZU-23 ZSU-23-4 SA-13 (Contrast mode) SA-16 SA-19	

Table N-2. Weather effects from reduced visibility.

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 200			RPG-18 (rocket launcher) AKM/AKMS (7.62-mm) TKN-1T infrared periscope	ATW Rifle E-O device
LT 500	SA-14 GREMLIN SAM SA-13 SAM SA-16 SAM SA-19 (FSU) SAM		OU-3GK White infrared search light RPG-7 (Grenade launcher) PT-76 (5.45-mm) AK-74	E-O device ATW AG/LT Rifle
LT 600			ERYX	
LT 750	SA-9 GASKIN SAM			
LT 800	AT-2 SWATTER AT-3 SAGGER AT-6 SPIRAL	ATGM ATGM ATGM	ASU-85 BMD (73-mm) BMP (73-mm) Sniper rifle, SVD RPK-74, squad MG AGS-17, grenade launcher RPG-16, grenade launcher	AG/LT LAV LAV Rifle MG
LT 1,000	All Types	ATGM	SPG-9 (73-mm recoilless rifle) SD-44 (85-mm) 14.5-mm KPU hvy MG 7.62-mm PKT MG DShK NSV/NSVT PK Series MT-LB 7.62-mm coaxial machine gun for all tanks	ATW ATW AA AA AA MG MG LAV MT

Table N-2. Weather effects from reduced visibility (continued).

WEATHER VALUE (METERS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
LT 1,500			7.62-mm MG 15.5-mm heavy MG gun BTR-50,-60,-70 (14.5-mm) KPVT ACRV M1974 DShK NSV/NSVT T-54, T-55, T-62 (main gun)	 AA/LAV AA LAV MG MG MT
LT 2,000			T-12, MT-12 (100-mm) KPVT BRDM-2 (14.5-mm) T-80, T-72, T-64 (main gun) MATHOGO MILAN 2 RBS-56 SPIGOT	ATW MG LAV MT
LT 2,500			SA-7 GRAIL ZU-23 ZSU-23-4	FSU SAM AA AA
LT 3,000			RED ARROW 73 RED ARROW 8 SUSONGP'O AT-3 SAGGER	
LT 4,000			SA-9 GASKIN HOT 2 SWINGFIRE AT-2 SWATTER AT-5 SPANDREL AT-8 SONGSTER AT-10 STABBER SA-13 (Contrast Mode)	 FSU SAM FSU SAM
LT 4,500			MAPATS	
LT 5,000			NIMROD AT-6 SPIRAL AT-11 SNIPER SWIFT (SF)	ATGM
LT 6,000			120-mm, M-1943 S-60 (57-mm)	MO AA
LT 8,000			160-mm, M-160	MO

Table N-3. Weather effects from reduced surface wind.

WEATHER VALUE (KNOTS)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
	NO CRITICAL VALUES IDENTIFIED			
	SEE INTRODUCTORY PARAGRAPH			

Table N-4. Weather effects from temperature.

WEATHER VALUE (F/C)	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
	NO CRITICAL VALUES IDENTIFIED			

Table N-5. Weather effects from precipitation.

WEATHER CONDITION	SEVERE DEGRADATION		MODERATE DEGRADATION	
	SYSTEM/EVENT	REMARKS	SYSTEM/EVENT	REMARKS
Light rain			LOW BLOW (fire control) STRAIGHT FLUSH (12 gHz) (Tracking) THIN SKIN (Height finder)	SAM radar SAM radar SAM radar
Moderate rain			STRAIGHT FLUSH (Acquisition)	SAM radar
Heavy rain			LOW BLOW (Fire control) THIN SKIN (Height finder)	SAM radar SAM radar
	ALSO SEE INTRODUCTORY PARAGRAPH			
	NOTE: The list of air defense radars on this page should be considered as a representative sample of the various other types of threat radars associated with EW operations and tactical and strategic SAM systems. Not listed are a large variety of threat combat equipment (wheeled and tracked) affected by moderate or heavy rain and snow.			

PART II

COMPARISON OF WEATHER EFFECTS ON US AND THREAT SYSTEMS

The following tables illustrate how similar capabilities of weapon systems may be compared. For example, Figure N-1 shows the T-series tanks' acquisition capabilities are more limited. Obviously, the advantage lies with the friendly tanks. Under similar weather conditions, the M-1 and M-60 tanks can acquire targets up to 3000 meters.

Figure N-2 shows similar visibility comparisons of friendly and threat anti-tank guided missile systems.

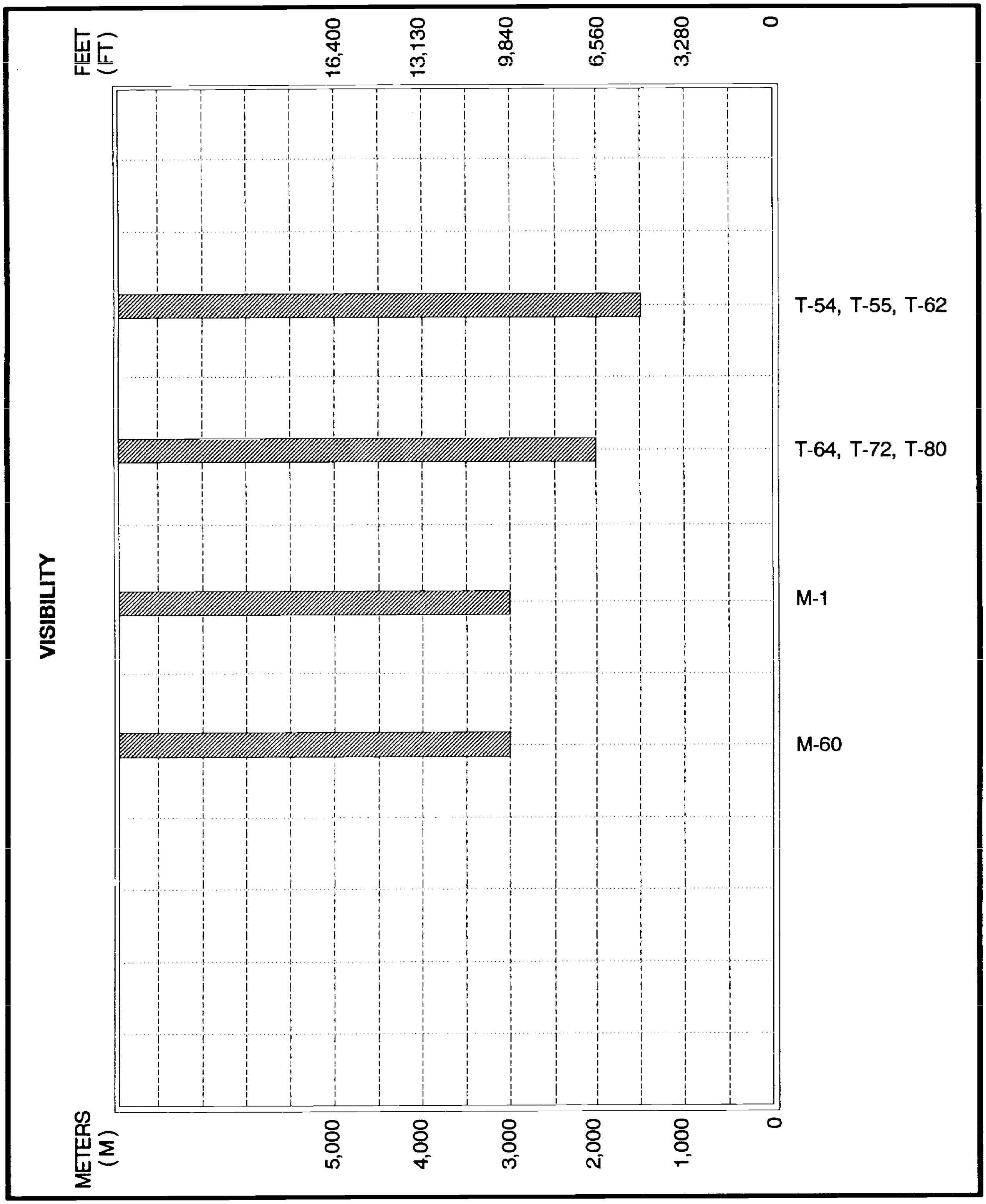


Figure N-1. Comparison of US and threat tanks.

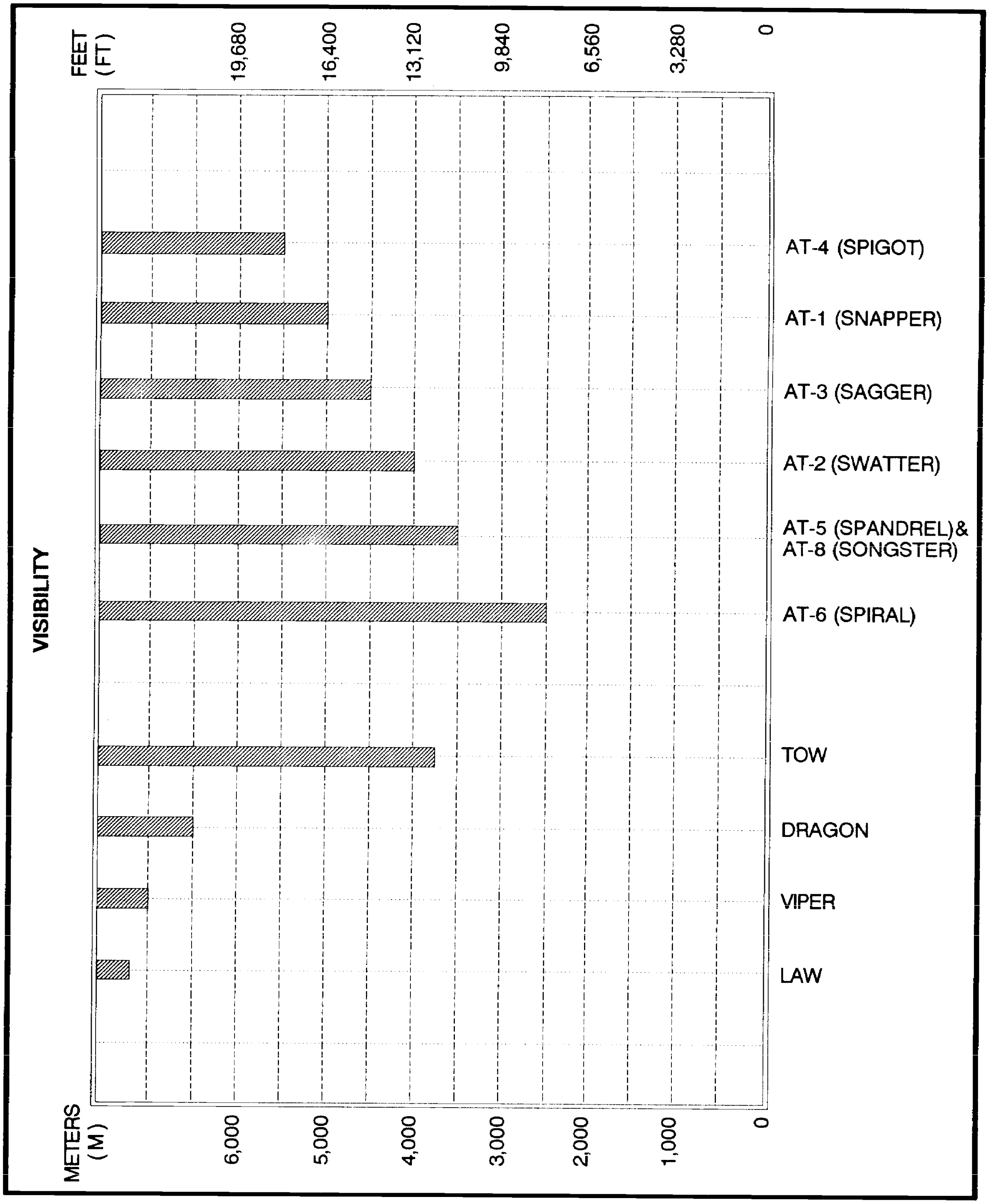


Figure N-2. Comparison between US and threat anti-tank guided missiles.

APPENDIX O

WEATHER AND ENVIRONMENTAL ELEMENTS AND PARAMETERS IMPACTING ARMY SYSTEMS AND OPERATIONS

The data elements and parameters listed in this appendix are from a study conducted by the US Army Intelligence School as part of the IEW Mission Area Analysis (IEWMAA). Each TRADOC branch was asked to survey the impact of weather and environmental elements on their operations, systems, and personnel. They ranked these impacts as either essential (E) or desired (D). Other Army agencies also submitted their weather data element requirements which are incorporated here.

To be listed as E, some positive action had to be taken by the user based on severe current or forecasted weather conditions. Weather conditions, elements, or parameters listed as D were identified as having some impact, but the degree of impact is uncertain or not mission-threatening.

Note that for each element or parameter listed, at least one responder identified it as essential for one or more of their operations, systems, or personnel.

Some data elements and parameters are known to have an impact, but exact critical thresholds have not been determined. Others cannot be measured or sensed with present technology. But identifying these data elements or parameters now allows for further research in how to collect the raw data (where applicable), determine the frequency of collection, establish data accuracy, and learn other supporting information.

Just prior to this printing, 10 of the 24 agencies stating requirements submitted updates to their original needs. Ninety two new essential requirements and 22 new desired requirements were added. Additionally, 9 desired requirements were upgraded to essential, and 11 essential requirements were downgraded to desirable. Four existing requirements were deleted.

These updated data requirements are reflected in Figure O-1. As users and planners continue to learn more about weather and environmental impacts, the misconception there is such a hypothetical thing as an Army "all-weather" system or operation fades. New values and impacts will be added to this manual as the information becomes available.

WEATHER AND ENVIRONMENTAL DATA ELEMENTS IMPACTING ARMY SYSTEMS/OPERATIONS

A = AIR DEFENSE
B = ADJUTANT GENERAL
C = ARMOR
D = AVIATION
E = CHAPLAIN
F = DEFENSE AMMUNITION CENTER
G = ENGINEER
H = FIELD ARTILLERY
I = FINANCE
J = HEALTH SERVICES
K = INTELLIGENCE
L = INFANTRY
M = JUDGE ADVOCATE
N = MILITARY POLICE
O = CHEMICAL
P = ORDNANCE
Q = ORDNANCE M&M
R = PUBLIC AFFAIRS
S = QUARTERMASTER
T = SIGNAL
U = SPECIAL FORCES
V = SOLDIER SUPPORT
W = TRANSPORTATION
X = JOINT READINESS TRNG CENTER

REQUIREMENT DESIGNATORS: **E** = ESSENTIAL SUPPORT NEEDS **D** = DESIRABLE SUPPORT NEEDS

SPECIAL GROUP CATEGORIES: [GS] = GROUND STATE [SS] = SEA STATE [SW] = SEVERE WEATHER CRITERIA

DATA ELEMENT	CATEGORY	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1. ALTIMETER SETTING					E						E	E										E			
2. ATMOSPHERIC CONTAMINANTS					E	D	D	E	D		E	E							D			D			
3. ATMOSPHERIC DENSITY									E			E										E			
4. ATMOS. TRANSMISSION COEFFICIENT									E																
5. BAROMETRIC PRESSURE		D		E	E				E		E	E										E			E
6. CLOUD COVER AMOUNT		D		E	E		E	E	E		E	E	E		D	E			D			D	E	E	E
7. CLOUD BASE HEIGHT		E			E		E	E	E		E	E	E	D		E						E		E	E
8. CLOUD TOP HEIGHT					E						E	E										D			
9. DAMAGING WINDS	[SW]	E	E	E	E	E	D	E	E	E	E	E	E	E	E	E	D	E	E	E	E	E	E	E	E
10. DENSITY ALTITUDE					E						E	E										E			E
11. EXTINCTION COEFFICIENT									E			E										D			
12. EXTREME HEAT/COLD	[SW]	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	D	E	E	E	E	E	E	E	E
13. FLOODING, RIVER STAGE	[GS]	E	E	E	E	E		E	D	E	E	E	E	E	E	E	D	E	E	E	E	E	E	E	E
14. FREEZE/THAW DEPTH	[GS]	D		E	E			E	D		E	E	E		E	D	E	E		E	E	D			E
15. FREEZING PRECIPITATION	[SW]	E	E	E	E	E		E	E	E	E	E	E	E	E	E	D	E	E	E	E	E	E	E	E
16. HEAVY RAIN/SNOW	[SW]	E	E	E	E	E	D	E	E	E	E	E	E	E	E	E	E	D	E	E	E	E	E	E	E
17. HUMIDITY, ABSOLUTE		D			E			E			E	E				E						E			E
18. HUMIDITY, ABSOLUTE, PROFILE		D			E			E			E	E				E						E			E
19. HUMIDITY, RELATIVE							E	E	D		E	E				E				E		D	E	E	E
20. HUMIDITY, RELATIVE, PROFILE									E													D			
21. HURRICANES/TYPHOONS	[SW]	E	E	E	E	E		E	E	E	E	E	E	E	E	E	D	E	E	E	E	E	E	E	E
22. ICE/SNOW DEPTH/COVER	[GS]	D		E	E			E	D		E	E	E		E	D	D	E		E	E	D			E
23. ICING, FLIGHT	[SW]				E						E	E	E									E			E
24. ILLUMINATION		E		E	E			E	E		E	E	E		E		D			D		E	E	E	E
25. IR TARGET/BACKGROUND CONTRAST				E	E				D		E	D										E			E
26. IR THERMAL CONTRAST X-OVER TIME				E	E				D		E	E										E			E
27. IONOSPHERIC DISTURBANCES					D						D	E									E	E			
28. LIGHT DATA		E		E	E		D	E	D		E	E	E		D	D				D	D	E		D	D
29. LIGHTNING/THUNDERSTORMS	[SW]				D		E	E	E		D	E								E		E			E
30. LITTORAL CURRENT	[SS]				D		D	E			D	D	E									E			
31. PRECIPITATION, ACCUMULATION			D	E	E	D	D	E	D	D	E	E	E		E	D	E		D	E	E	E	E	E	D

Figure O-1. Weather and environmental data elements impacting Army systems and operations.

DATA ELEMENT	CATEGORY	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
32. PRECIPITATION, RATE		E	D		E	D		E	E	D	E	E	E	D	E	E	D		D	E	E	E	E	E	E
33. PRECIPITATION, HAIL SIZE		E			E			E	D		E	E			E		E			E		D			
34. PRECIPITATION, TYPE		E	D	E	E	D		E	E	D	E	E	E	D	E	E	D		D	E	E	E	E	E	E
35. PRESSURE ALTITUDE					E						E	E	E									E			E
36. REFRACTIVE INDEX		E		E	E				D		E	E			D										
37. RESTRICTION TO VISIBILITY					E			E	D		D	E			E	E				E	E	E			E
38. SEEABILITY (MILLIMETER WAVE, INFRARED, ULTRAVIOLET)		E		E	E			E	E		E	E	E		E	D						E		E	D
39. SEVERE WEATHER CONDITIONS	[SW]	E	E	E	E	E		E	E	E	E	E	E	E	E	E	D	E	E	E	E	E	E	E	E
40. SNOW STATE CONDITION	[GS]	D		E	E			E	E		E	E	E		E	D	D	E		E	E	D			E
41. SNOW DRIFT DEPTH	[GS]	D			D			E	D		D	E	E		E		E			D	E	E			E
42. SOIL/GROUND MOISTURE	[GS]	D		E	E		D	E	D		E	E	E		E	D	D	E		D	E	D			E
43. SOIL/GROUND TEMPERATURE	[GS]	D		E	E		D	E	D		E	E	E		E		E		D	D		E	E	E	E
44. SOLAR RADIATION							E				D	D										E			
45. STABILITY INDEX							E					E				E									E
46. STANDING WATER/POOLING	[GS]	D		E	E	D		E	D		E	E	E		E	D	D	E	D	E	E	D			E
47. STATIC ELECTRICITY POTENTIAL					E						E	E													
48. SURF HEIGHT	[SS]				D			E			D	D	E									E		E	
49. SWELL DIRECTION/HEIGHT	[SS]				D						D	D	E									E		E	
50. TEMPERATURE, AIR, SURFACE		E	E	E	E	E	E	E	E	E	E	E	E		E	E	D	E		D	E	E	E	E	E
51. TEMPERATURE, AIR, PROFILE					E		E		E		E	E										D			
52. TEMPERATURE, AIR, UPPER AIR					E				E		E	E										D			E
53. TEMPERATURE, DEWPOINT				E	E				D		E	E										E			E
54. TEMPERATURE, DEWPOINT, PROFILE					E				E		E	E										D			
55. TEMPERATURE, WINDCHILL FACTOR			D		D	D		E	D	D	E	E	E	D	E		E		D	E		E	E	E	
56. TEMPERATURE, INVERSION LEVEL(S)					E		E		E		E	E				E						D			E
57. TEMPERATURE, SEA SURFACE	[SS]				D			E			D	D	E									E		E	
58. TEMPERATURE, WATER, INLAND	[GS]				D			E			D	E	E									E		E	
59. TEMPERATURE, WBGT					D			E	D		E	E			E	E	E			E		E			E
60. TORNADO	[SW]	E	E	E	E	E		E	E	E	E	E		E	E	E	D	E	E	E	E	E	E	E	E
61. TURBULENCE, FLIGHT					E						E	E										E			
62. TURBULENCE, OPTICAL				E	E			E	E		E	D										E			
63. VISIBILITY, VISIBLE SPECTRUM, ALOFT					E				E														E		E
64. VISIBILITY, VISIBLE SPECTRUM, SFC		E			E			E	E		E	E	E		E	E	D			E		E	E		E
65. WAVE PERIODICITY	[SS]				D						D	D	E									E		E	
66. WAVE DIRECTION/HEIGHT	[SS]				D						D	D	E									E		E	
67. WIND, PROFILE					E				E		E	E										E			
68. WIND, PROFILE, TARGET, AGL - 3KM					E				E							E									
69. WIND, SHEAR					E						E	E										E			E
70. WIND, SURFACE, SPEED/DIRECTION		E		E	E		E	E	E		E	E	E		E	E	D	E	D	D	E	E	E	D	E
71. WIND, SURFACE, GUST SPEED				E			D	E	E		E	E	E		D						E	E			E
72. WIND, SURFACE, GUST SPREAD					E				E		E	E										E			E
73. WIND, UPPER AIR, SPEED/DIRECTION		E			E				E		E	E				E						E			E

Figure O-1. Weather and environmental data elements impacting Army systems and operations (continued).

APPENDIX P

CONVERSION FACTORS

TEMPERATURE

TO CONVERT:	TO:	USE:
Degrees F	Degrees C	°C = 5/9 (°F - 32)
Degrees C	Degrees F	°F = (9/5 °C) + 32

DISTANCE

TO CONVERT:	TO:	MULTIPLY BY:
Kilometers	Miles	0.62
Kilometers	Nautical Miles	0.54
Kilometers	Feet	3,280.80
Miles	Kilometers	1.61
Miles	Nautical Miles	0.87
Miles	Yards	1,760.00
Miles	Feet	5,280.00
Nautical Miles	Kilometers	1.85
Nautical Miles	Miles	1.15
Meters	Feet	3.28
Yards	Feet	3.00

SPEED

Kilometers/Hour	Miles/Hour	0.62
Kilometers/Hour	Knots (Nautical Miles/Hour)	0.54
Miles/Hour	Kilometers/Hour	1.61
Miles/Hour	Knots	0.87
Miles/Hour	Feet/Second	1.467
Knots	Kilometers/Hour	1.85
Knots	Miles/Hour	1.15
Meters/Second	Feet/Second	3.281
Meters/Second	Miles/Hour	2.237

PRESSURE

Inches of Mercury (Hg)	Millibars	33.86395
Millibars (Mb)	Inches of Mercury	0.295299

LENGTH

Feet	Meters	0.3048
Feet	Centimeters	30.48
Inches	Meters	0.0254
Inches	Centimeters	2.54
Meters	Yards	1.094
Yards	Meters	0.9144

GLOSSARY

PART 1 - ACRONYM LIST

AA	antiaircraft gun
AAA	antiaircraft artillery
AAM	antiaircraft missile
AC	Active Component
A/C	air conditioning
ACR	armored cavalry regiment
ADA	air defense artillery
adapt	adapter
AF	See USAF
AFM	air force manual
AFO	aerial forward observer
AFR	air force regulation
AGL	above ground level
AG/LT	assault gun/light tank
AI	area of interest
alt	altitude
ammo	ammunition
AMSS	automated meteorological sensor system
AO	area of operations
APC	armored personnel carrier
app	appendix
AR	Army Regulation
ARNG	Army National Guard
arty	artillery
ARTYMET	artillery meteorological team
ATACMS	Army tactical missile systems
ASAS	All-Source Analysis System
ATCCS	Army Tactical Command and Control System
ATGM	antitank guided missile
ATW	antitank weapon
AVLB	armored vehicle launched bridge
avn	aviation
AWS	Air Weather Service (USAF)
bde	brigade
BDU	battle dress uniform
BFA	battlefield functional area
BIC	battlefield-induced contaminants

BMCT	beginning of morning civil twilight
BMNT	beginning of morning nautical twilight
bn	battalion
BWK	belt weather kit
C	Celsius (Centigrade)
C^2	command and control
C^3	command, control, and communications
CAB	combat aviation brigade
cal	caliber
cap	capacity
CAS	close air support
CB	chemical biological
CFV	cavalry fighting vehicle
CG	Commanding General
comm	communications
consump	consumption
COSCOM	corps support command
CP	command post
CS	combat support
CSS	combat service support
D	desired
DF	direction finding
dir	direction
div	division
DOD	Department of Defense
DTSS	Digital Topographic Support System
DZ	drop zone
E	essential
EAC	echelons above corps
ECB	echelons corps and below
EECT	end of evening civil twilight
EENT	end of evening nautical twilight
effect	effective
EMP	electromagnetic pulse
encl	enclosure
env	environmental
E-O	electro-optical
EW	electronic warfare

F	Fahrenheit
FALOP	forward area limited observation program
fc	footcandle
FDC	fire direction center
FLIR	forward looking infrared
FLOT	forward line of own troops
FO	forward observer
FOB	forward operating base
frz	freezing
FSU	fire support unit
ft	feet
gHz	gigahertz
GSM	ground station module
GSR	ground surveillance radar
GT	greater than
HAHO	high altitude, high opening
HALO	high altitude, low opening
HC	hexachloroethane
HE	high explosive
HF	high frequency
Hg	inches of mercury
HIC	high-intensity conflict
how	howitzer
hq	headquarters
hr	hour
hvy	heavy
IEW	intelligence and electronic warfare
IFV	infantry fighting vehicle
IMETS	Integrated Meteorological System
in	inch
in/hour	inches per hour
inf	Infantry
inter	interference
IPB	intelligence preparation of the battlefield
IR	Information requirement
Khz	kilohertz
km	kilometers
kn	knot (speed measurement)

LAV	light armored vehicle
lgt	light
LIC	low-intensity conflict
LLL	low-light-level
LOC	lines of communication
LOS	line of sight
LRSU	long-range surveillance unit
LT	less than
LZ	landing zone
m	meter
MACOM	major Army command
max	maximum
Mb	millibars
MDT	moderate
MECH	mechanized
met	meteorological
METT-T	mission, enemy, terrain, troops, and time available
MFF	military free fall
mg	machine gun
MIC	mid intensity conflict
min	minimum
MLRS	multi-launcher rocket system
mm	millimeter
MOPP	mission-oriented protective posture
MOT	mobile observing team
mph	miles per hour
MR	moonrise
MS	moonset
MSL	mean sea level
MSR	main supply route
MT	medium tank
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, and chemical
nmi	nautical mile (distance)
NOE	nap-of-the-earth
NV	night vision
NVD	night vision devices
NVG	night vision goggles
NVS	night vision sights

OB	order of battle
obsn	observation
op	operation
qty	quantity
plt	platoon
PZ	pick-up zone
RAP	ram air parachute
R&S	reconnaissance and surveillance
RC	Reserve Component
recce	reconnaissance
REMBASS	Remotely Monitored Battlefield Sensor System
rqmts	requirements
rqr	required
SAM	surface-to-air missile
SF	Special Forces
SFG	special forces group
SIO	senior intelligence officer
SLAR	side looking airborne radar
SOF	special operations forces
SOP	standing operating procedure
SOWT	special operations weather team
SP	self-propelled
spt	support
SR	sunrise
SS	sunset
SWO	staff weather officer
tac	tactical
TAS	tactical air support
TBM	tactical ballistic missile
TDA	tactical decision aid
temp	temperature
TF	task force
TOW	tube-launched, optically tracked, wire-guided
TRADOC	US Army Training and Doctrine Command
TTP	tactics, techniques, and procedures
TV	television
UAV	unmanned aerial vehicle
UGDF	uniform gridded data field

US	United States
USAF	United States Air Force
USAR	United States Army Reserve
VFR	visual flight rules
VHF	very high frequency
VT	variable time (fuse)
WA	weather advisory
WET	weather, enemy, and terrain
WETM	weather team
WGT	wet globe temperature
wo	without
WP	white phosphorus
WTDA	weather tactical decision aid
WW	weather warning
X	an unknown quantity
Y	an unknown amount of time

PART 2 - DEFINITIONS

absolute humidity	A ratio of the quantity of water vapor present per unit volume of air, usually expressed as grams per cubic meter or grains per cubic foot.
Air Weather Service	An Air Force field operating agency reporting directly to the Air Staff. AWS operates centralized weather support and provides technical advice and assistance to USAF weather units in support of USAF and Army missions worldwide.
altitude	The height measured from MSL.
altostratus	Clouds that are relatively uniform gray to blue sheets that cover the entire sky. When thin, the sun or moon may be visible as a "bright spot." Cloud bases range from 6,500 to 20,000 feet AGL.
atmospheric pressure	The pressure exerted by the atmosphere as a consequence of gravitational attraction exerted upon the column of air laying directly above any point.
barometric pressure	The measure of atmospheric pressure by a mercurial or aneroid barometer. Changes in pressure are significant in weather forecasting. The normal pressure at sea level is 29.92 inches of mercury or 1013.3 millibars. Rising pressures usually indicated improving weather conditions; falling pressures may reflect impending inclement weather. Barometric pressure is used in aircraft altimeter settings to tell pilots how far above ground level the aircraft is. This is critical for landing during obscured conditions and NOE flying.
battlefield environment	A phrase used to describe the combination of weather, terrain, BIC, illumination, and background signatures that occur on a battlefield.
belt weather kit	A small kit with simple equipment, used originally by the US Forest Service, and now employed by S2 personnel at maneuver brigades. The BWK equipment measures temperature, dewpoint, pressure, and wind speed and direction. It is slow and does not meet the

	accuracy standards necessary to support the Army's battlefield weapon systems. The BWK will be replaced by an automated meteorological sensor system (AMSS).
blizzard	A violent, intensely cold wind of 30 kn or greater with considerable falling or blowing snow causing visibility to drop to .5 miles or less.
ceiling (cloud)	The height above the earth's surface of the lowest layer of clouds. This layer is reported as broken, overcast, or obscured and not classified as thin or partial. See cloud cover for details.
Celsius	A temperature scale (formerly called centigrade). The temperature interval between waters ice and steam points is divided into 100 parts (or degrees) with 0° Celsius at the freezing or ice point and 100° at the boiling or steam point. Used commonly worldwide.
cirrocumulus	Clouds that are high and thin which appear as small white flakes or patches of cotton. Cirrocumulus clouds are sometimes called a mackerel sky. The bases of cirrocumulus clouds are above 16,000 feet AGL.
cirrostratus	Clouds that are thin and whitish layers appearing like a sheet or veil. The ice crystals composing these clouds may produce a halo effect around the sun or moon. The bases of cirrostratus clouds are above 16,000 feet AGL.
cirrus	Clouds that are thin, feather-like ice crystal clouds in patches or narrow bands. Cirrus clouds are sometimes called mares tails. The bases of cirrus clouds are above 16,000 feet AGL.
climatology	The historical records of weather conditions measured or observed at a specific location is knows as climatology. Some data go back over 100 but generally a 10- to 25-year history is more common. Climatology is useful in planning operations beyond 5 to 7 days. It usually describes the average (or mean) conditions such as high and low temperatures and extremes.

clouds	A visible aggregate of minute water and ice or just ice particles in the atmosphere above the surface of the earth. Clouds differ from fog only by definition--fog is in contact with the surface of the earth.
cloudburst	A sudden and extremely heavy downpour of rain.
cloud cover	The amount of clouds over, or at, a given location. Cloud conditions are expressed as cloud bases or ceiling, the amount of cover (stated in eighths--1/8 to 4/8 described as scattered; 5/8 to 7/8, broken; and 8/8, overcast), and cloud tops. Several layers of scattered clouds added together may result in a broken or overcast condition Low clouds impact many battlefield operations, especially the use of smart weapons.
cumulonimbus	Clouds that are large, dense, and towering with cauliflower-like tops. The top portion of the cloud is often flattened into an anvil shape. Cumulonimbus clouds are also known as thunderstorms.
cumulus	Billowy, individual cloud masses that often have flat bases. Bases range from near the surface to 6,500 feet AGL.
density altitude	The height above MSL at which the existing density of the atmosphere would be duplicated in the standard atmosphere; atmospheric density expressed as height according to a standard scale. Extremely important in flight operations.
dew	Water condensed onto grass and other objects near the ground. Occurs when the temperature has fallen below the dewpoint of the surface air (due to radiational cooling during the night) but is still above freezing. If the temperature falls below freezing after dew has formed, the frozen dew is known as white dew.
dewpoint	The temperature to which a given weight of air must be cooled at constant pressure and constant water-vapor content in order for saturation to occur. When this temperature is below 0°C, (32°F) it is sometimes called the frost point.

diurnally	Having a daily cycle.
drizzle	Fairly uniform precipitation composed exclusively of fine drops of water falling very close to one another.
dry-bulb temperature	The temperature measured by the dry bulb of a psychrometer; ambient air temperature.
effective illumination	The level of light available for night operations.
effective wind speed	The combined effect of actual (meteorological) wind and other motion caused by the moving of an object or a person through air. Also caused by moving equipment such as aircraft propellers or rotors.
elevation; station elevation	The measure of height with respect to another point on the earth's surface; usually MSL.
Fahrenheit	A thermometer scale on which the boiling point of water is at 212° and the freezing point is at 32° above zero point. Used primarily in the US.
FALOP	A program implemented in the 1970's to supplement battlefield observations taken by USAF AWS WETMs. FALOP is employed by S2 personnel at maneuver brigades and battalions. The BWK is used by the S2 to make limited measurements of weather conditions. Additionally, the S2 provides estimates of other weather and environmental conditions he observes. His report is encoded and forwarded to the closest WETM.
fallout	The precipitation to earth of particulate matter from a nuclear cloud; also applied to the matter itself, which may or may not be radioactive.
fog	A cloud with its base at or very near the earth's surface.
footcandle (fc)	A unit of illumination equal to 1 lumen ft^{-2}. Full sunlight with zenith sun produces an illuminance of the order of 10,000 fc on a horizontal surface. Full moonlight provides an illuminance of about 0.02 fc. Adequate

	illumination for steady reading is about 10 fc. Close machine work required about 30 to 40 fc.
forecast units	USAF WETMs and centers at higher Army echelons that produce support forecasts for planning and operations.
frost	A feathery deposit of minute ice crystals or grains upon a surface or object, formed directly from vapor in the air; the process by which such ice crystals are formed; any temperature at which frost forms. Frost often forms when the close-lying air is above 0°C (32°F), especially in calm, clear air when radiation or evaporation reduces a surface temperature to or below the freezing point.
frostbite	The freezing or partial freezing of some part of the human body.
frost heaves	Also frost thrusting; frost lifting. The upward or sideways movement of surface soils, rocks, and vegetation through expansion caused by freezing subsurface moisture, soil, and gravel.
gust	Rapid fluctuations in wind speed with a variation of 10 knots or more between peaks and lulls.
hail	Hail is observed precipitation in the form of small balls or pieces of ice (hailstones), falling either separately or agglomerated into irregular lumps. Hail falls during heavy thunderstorms.
high	In meteorology it is synonymous with "area of high pressure" and refers to a maximum of atmospheric pressure in two dimensions--closed isobars in the synoptic surface chart; or a maximum of height (closed contours) in the constant-pressure chart. Since a high is, on the synoptic chart, always associated with anticyclonic circulation, the term is used interchangeably with anticyclone.
humidity	A measure of the water vapor content of air.
hypothermia	Excessive lowering of body temperature generally caused by prolonged exposure to cold or when the body

	has become wet. Hypothermia can occur at temperatures well above freezing as easily as at temperatures below freezing.
icing	In general, any deposit or coating of ice on an object; a mass or sheet of ice formed on the ground surface during the winter by successive freezing of sheets of water that may seep from the ground, a river, or a spring.
instrument flight rules	An aircraft operational term indicating that the weather conditions have deteriorated to the point that navigational instruments on board the plane must be used in flying from one place to another.
inversion (stable) condition	An increase in air temperature with an increase in height. The condition is called stable because there is usually little vertical movement of air.
knot	The unit of speed or distance in the nautical system. One nautical mile per hour. See conversion factors in Appendix P.
lapse (unstable) condition	A decrease in air temperature with an increase in height. The condition is called unstable because it is accompanied by vertical air movement.
light and illumination data	Battle planning requires accurate timing based on available light. Light tables have been computed for any location that tell sunrise, sunset, moonrise, moonset, and moon phase. Illumination is a measure of sunlight, moonlight, starlight, and air glow. Illumination is a critical factor in the considered of NVD, cloud cover, and terrain masking.
low	An area of low pressure referring to a minimum of atmospheric pressure in two dimensions. Since a low is, on a weather chart, always associated with cyclonic circulation, the term is used interchangeably with cyclone.
mesoscale	Smaller scale weather features that exist for minutes or hours. Examples of mesoscale atmospheric phenomena are thunderstorms, tornadoes, and land-sea breezes.

meteorological products	Processed information derived from basic meteorological data which is collectively referred to as meteorological products. Such information can be in the form of forecasts, specific data, or WTDAs. WTDAs may correlate one or more data elements impacting a system with critical values, timing, system limitations, and other modifying factors.
moderate weather impact	A subjective measure of weather conditions impacting a system or operations that require alternative actions to be considered. Moderate impacts limit the effectiveness of the system or operations from 25 to 75 percent.
nimbostratus	A gray or dark massive cloud layer accompanied by continuous rain or snow.
precipitation rates	The measured, or estimated, rate of rainfall or snowfall during a given period. Precipitation rates are essential to predict ground moisture, flooding, river crossings, and other trafficability factors. Precipitation rates also affect visibility.
refractive index	A measure of the amount of "refraction," or bending, of an energy wave (visual light, infrared, radio and others) passing from one density to another in a medium such as air or water. The apparent bending of a stick when placed in a pool of water is an example.
relative humidity	Ratio, usually expressed as a percentage of air's water vapor content, to its water vapor capacity at a given temperature and pressure.
sea state	Also state-of-the-sea. Describes wind-generated waves on the surface of the sea.
seeability	Distance at which a sensor is able to see, to recognize, or to lock onto a target. Seeability is dependent on the condition of the atmosphere, the contrast between the target and the background, the direction and type of illumination, and the characteristics of the sensor.
semidiurnally	A cycle occurring approximately every half day.

sky conditions	The amount of sky covered by clouds or the amount obscured by surface-based phenomena. This information is derived from standard charts.
slant-range visibility	The distance a pilot can distinguish objects that are both forward and beneath his aircraft. For example, looking down at an angle as he approaches a target or a runway.
sleet	A term sometimes used for ice pellets, a mixture of precipitating rain and snow, or glaze.
snow	Precipitation composed of white or translucent ice crystals, chiefly in complex branched hexagonal form and often agglomerated into snowflakes.
soil trafficability	The capacity of a soil to withstand traffic, especially the traffic of military vehicles.
specific humidity	The ratio of the mass of water vapor to the total mass of air (including water vapor).
state-of-the-ground	A standardized surface observation that describes the condition of the ground surface. Basically, state-of-the-ground is characterized as dry, moist, wet, frozen, and ice or snow covered.
staff weather officer	A USAF AWS officer, qualified in forecasting, that usually commands a WETM. He may be a lieutenant or a colonel depending on the Army unit he is attached to. Some SWOs, assigned to Army commands, serve without a WETM. The SWO, a member of the Army commanders special staff, works under the direction of the G2 or S2.
steering wind	Winds that are winds measured at 50 feet (16 m), although they may extend as high as 2,500 feet. They are used in smoke operations where the moving air is measured far enough above the ground to be free of disturbances caused by local terrain variations. They establish the speed and direction of a smoke cloud. Steering winds also play a role in the direction that weather systems move.

stratocumulus	Clouds having large globular masses or rolls which look like balls of dirty cotton. Stratocumulus form from the breaking up of a stratus layer or from the spreading out of cumulus clouds. Bases range from near the surface to 6,500 feet AGL.
surface observations	Weather and environmental observations measured or estimated on the land or water surface, and usually reflecting surface conditions. Cloud cover is an exception.
surface winds	Wind speed, direction, and gust speeds measured over the land or water. Technically measured at 10 meters above the surface.
synoptic scale	Large-scale atmospheric features that exist for days or weeks. An example of synoptic scale is the analysis of weather fronts, highs, and lows over the continental US.
temperature	A measure of the hotness or coldness of the air near the surface (surface ambient temperature), the ground (surface or ground temperature), or the upper atmosphere (air temperature). Measured by a thermometer or other instrument.
temperature gradient	The change in temperature per unit of distance between one point and another.
temperature-humidity index	An indicator of the effect of temperature and humidity upon individuals. Sometimes called the misery index by television weatherpersons. An example is the WBGT index.
temperature inversion	See inversion condition
thaws	A weather condition occurring when the temperature rises above the freezing point and ice and snow melt.
tidal current	The alternating horizontal movement of water associated with the rise and fall of the tide. In relatively open locations, the direction of tidal currents rotates continuously through 360 degrees diurnally or

semidiurnally. In coastal regions, the nature of tidal currents is determined by local topography as well.

tide	The periodic rising and falling of the oceans, large lakes, and the atmosphere. It results from the tide-producing forces of the moon and sun acting upon the rotating earth. This disturbance actually propagates as a wave through the atmosphere and through the surface layer of the oceans.
turbulence	A condition of the atmosphere in which air currents vary greatly over short distances. Turbulence may occur at any altitude, and the intensity may vary rapidly over short distances. See wind shear.
twilight	The periods of incomplete darkness following sunset (evening twilight) or preceding sunrise (morning twilight). Twilight is designated as civil, nautical, or astronomical, as the center of the sun travels 6, 12, or 18 degrees below the celestial horizon, respectively. In general, civil twilight precedes nautical twilight by 2 hours.
visual flight rules	In aviation a set of regulations that must be adhered to when piloting in calm, clear weather where the pilot can move from one point to another using ground features for navigational aids.
USAF tactical weather support	As directed by AR 115-10/AFR 105-3, the USAF AWS provides part of the Army's tactical weather support. This includes the collection of surface weather data up to the division command elements and the production of forecasts and climatic data. The Army has the greater role in its own weather support. The Army collects surface weather forward of the division command elements, and all upper air weather data needed to support its tactical operations. Additionally, the Army provides the USAF WETM the communications paths and equipment to pass weather information to the Army users.
visibility	The greatest distance that prominent objects can be seen and identified by the unaided, normal eye. When

NVG or other infrared devices are used to increase visual distance, "seeability" is used instead of visibility.

weather advisory (WA) — A special WETM notice when an established weather condition that could affect operations is occurring or is expected to occur.

weather briefing — Information concerning the current and forecast weather conditions impacting an AO. The SWO, or a member of the WETM or the G2 or S2 may provide weather briefings. Suggested formats are included in Chapter 4.

weather effects — The impacts, favorable or unfavorable, weather conditions have on tactical systems, operations, personnel, and logistics. Weather effects become highly significant information when they can be cross-checked with specific critical values, reaction leadtimes, and other operational considerations. There are always weather effects that will have an impact on systems or operations. There is no such thing as an all-weather system.

weather elements — Weather elements (such as wind speed and temperature) are generally benign. Only when they fall below or exceed certain pre-established thresholds do they have an adverse impact on operations, systems, and personnel. These pre-established thresholds are known as critical values. Critical values change by type of operations, sensitive (or complexity) of systems, and the amount of exposure of personnel to the elements. S2s must know the critical weather values for their unit's operations, systems and personnel and advise the commander and staff when these values are (or will be) reached or exceeded.

weather forecast — A prediction made by USAF WETMs for periods as short as 3 hours to as long as 96 hours for specific Aos and Ais. Forecasts are correlated with WTDAs to provide tailored products for the supported command's planning. The accuracy of a weather forecasts depends on the timeliness, accuracy, and resolution of the data it is taken from. The longer the period of time a forecast covers the less accurate it becomes. Forty-eight to 96-

	hour forecasts are considered "outlooks"--or very general forecasts. Beyond 96 hours, climatology is used.
weather forecaster	A USAF AWS officer or NCO trained in meteorology and forecasting. He uses general area forecasts produced by USAF AWS weather centers, and fine tunes them for his own AO. The forecaster need timely, accurate data from the supported unit's AO and AI to do this fine tuning.
weather observer	A USAF AWS officer or NCO trained in meteorology and weather observing. Many AWS NCOs are dual qualified as observers and forecasters and are called weather technicians. The training of an AWS weather observer is technical. S2s are instructed by AWS observers on how to take weather observations. But the observations may fall short of the AWS standard and are, therefore, characterized as "limited."
weather tactical decision aids	These refer to the manual lookup tables and matrices in this manual, or are computer-driven algorithms by which such a product is generated. These tables provide the critical thresholds that effect operations, systems, and personnel adversely. The tables, together with a current forecast, are used to brief the commander and staff.
weather warning (WW)	A special notice from the supporting WETM when an established weather condition of such intensity as to pose a hazard to property or life is occurring or is expected to occur. Protective action must be taken.
weather watch	A special WETM notice alerting the command of the potential for tornadoes, severe thunderstorms, or a winter snow with heavy snow, freezing precipitation, or blizzard conditions.
wet bulb globe temperature index	A measure of heat stress potential. It is calculated by using a formula which considers relative humidity, radiant heat, air temperature, and air movement.

whiteout
Also known as milky weather. A condition in the polar regions in which no object casts a shadow, the horizon becomes indistinguishable, and light-colored objects are very difficult to see. A whiteout occurs when there is complete snow cover, and the clouds are so thick and uniform that light reflected by the snow is about the same intensity as that from the sky.

windchill factors
These factors are revised temperature values based on the effect of wind and temperature combined on exposed skin. This windchill temperature is the effective temperature for troops. The effect of windchill differs individually because of body chemistry, but is an acceptable operating standard.

winds aloft
The flow of air, measured in speed and direction above the surface. There is no distinct demarcation between winds aloft and surface winds, although winds above 100 meters are usually referred to as winds aloft.

wind shear
The rate of change of wind velocity (speed or direction) with distance. Eddies and gusts form in areas of wind shear, thus producing turbulent flying conditions. Wind shear may occur in either the vertical or horizontal plane.

wind speed
The rate of movement of air flow. Wind speed is normally reported in nautical miles per hour, or knots. Wind speed is affected by terrain and obstacles such as buildings and trees.

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DOCUMENTS NEEDED

These documents must be available to the intended users of this publication.

READINGS RECOMMENDED

These readings contain relevant supplemental information.

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