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Weather Craftsman

Volume 1. Military Operations and the Environment

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Author: MSgt Walter L. Chumney
335th Training Squadron
Joint Weather Training Facility
335TRS/UOAA
700 H. Street Bldg 4332
Keesler Air Force Base, Mississippi, 39534–2499
DSN: 597–0493
E-mail address: walter.chumney@us.af.mil

Instructional Systems Specialist: Kenith Isreal

Editor: Maxine Baldwin

Air Force Career Development Academy (AFCDA)
The Air University (AETC)
Maxwell-Gunter Air Force Base, Alabama 36118–5643

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WELCOME to the Weather Craftsman course! Your journey to becoming a 7-level is just beginning. Air Force Weather has developed a top-notch field-training program utilizing this course, and on-the-job training (OJT) to upgrade you to the 7-level. You have probably already begun the first phase of upgrade training, which is OJT. The second phase of training consists of self-study to gain additional career knowledge. This will be provided by a specially designed career development course (CDC). Using these carefully planned and prepared texts, you will acquire the necessary career knowledge with assistance from your supervisor.

CDC 1W071 provides additional weather management information and severe weather analysis necessary for you to compliment the OJT process and leads to eventual upgrade to AFSC 1W071 or 1W072. It enlarges and expands the knowledge you've already received at the 3 and 5 levels. This CDC is comprised of three volumes: Volume 1, *Military Operations and the Environment*, Volume 2, *Management of Weather Operations*, and Volume 3, *Severe Weather Techniques.*

Volume 1 has two units. The first unit deals with integrating weather into planning and operations. You will gain a deeper understanding of the different types of military planning and operations. The second unit explores the impacts that different types of weather have on operations.

A glossary is included for your use.

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This volume is valued at 12 hours and 4 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings, numbers, and page location. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

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Unit 1. Integrating Weather into Planning and Operations

ALL MILITARY OPERATIONS ARE influenced by the weather and the weather asserts constant influence on the readiness, morale, and effectiveness of military forces, the choice of military strategy, tactics, and the performance and useful life of military weapons systems. Therefore, weather must be considered in every facet of military planning, deployment and system design, and evaluation. In this unit, we explore how and why weather is an integral part of the overall decision making process, as well as the operational tactics we use and the areas of operation that we operate in. The lessons in the first part of this unit address planning, preparation of the battle space, and air tasking orders. The second part of the unit then moves to briefly acquaint you with operational tactics. Part three is the familiarization and tactical communication structure of the area of the world you're tasked to support. Let's begin by looking at military planning strategy.

1–1. Military Decision Making Process

Military decision making is performed at all levels within the Department of Defense (DOD). The military tiers are normally classified as strategic, operational, and tactical levels. Once military decisions are made, they're then filtered downward to the next lowest level. When it comes to administrative policies, it normally takes time for decisions to filter from the highest level downward. However, when it comes to decisions that directly affect national security and interests, time is critical. Air Force Weather (AFW) uses the three tiered structure as well, with an operations concept known as the "Forecast Funnel." At the Strategic Level the Strategic Weather Center is engaged in the creation of weather products on a world wide scale. The Operational Weather Squadron creates products on a regional basis and as the name implies is at the operational level of the Forecast Funnel. The Tactical level is covered by the weather flight (WF), which tailors products into decision-quality weather information for planners and operators.

001. Military planning strategy

Advanced planning ensures the rapid actions required of lower echelons for campaign and operations success. In short, this lesson covers the key planning necessary to support a military campaign or operation. It covers military planning at the strategic, operational, and tactical levels. Let's start by looking at strategic planning.

Strategic planning

The strategic level is the highest level of decision-making when planning for contingencies, war, or military operations other than war (MOOTW). Examples of MOOTW are national emergencies for natural disasters or humanitarian airlifts. With strategic planning, the scope and size of the military operation are normally factors that determine where the strategic planning takes place. Scope and size also influence the number of agencies involved in the strategic planning process.

Joint operations planning

Joint operations planning is conducted in the chain of command from National Command Authorities (NCA) to combatant commanders but is primarily the responsibility of the Chairman of the Joint Chiefs of Staff (CJCS) and the combatant commanders.

Campaign plans

Campaign plans are the centerpiece of planning and are normally created in the crisis-action planning phase but may be initiated in the deliberate phase. Campaign plans outline the plan of how to conduct the battle, conflict, or operation. They are the responsibility of combatant commanders. When developing campaign plans, the Joint Forces Commander (JFC) and component commanders, use the operations plan (OPLAN) or contingency plan (CONPLAN) as the core document.

Crisis action planning

Crisis action planning (CAP) differs from deliberate planning in that it's based on current events and conducted in time-sensitive situations and emergencies that use assigned, attached, and allocated forces and resources. Moreover, crisis-action planners base their plans on actual circumstances that exist at the time the planning occurs. They follow prescribed CAP procedures that parallel deliberate planning, but are more flexible and responsive to rapidly changing events.

Deliberate planning

Deliberate planning helps prepare for the most likely contingencies that may occur in the near term future. The planning relies heavily on assumptions regarding the political and military circumstances that will exist when the plan is implemented. Deliberate planning is conducted principally in peacetime to develop joint operation plans for contingencies identified in strategic planning documents.

Operation orders

Operation orders are prepared in the crisis-action planning phase. An operations order (OPORD) is a directive issued by a commander and directed to subordinate commanders for the purpose of executing an operation. OPORDs are normally derived from the OPLAN, which is considered by strategists to be a core-planning document.

Scope of joint operations planning

Joint operations planning involve planning for a full range of activities. Each mode of planning for mobilization, deployment, employment, sustainment, and redeployment is necessary in order for the operation's success. Although each type of planning deals specifically with one aspect of the operation, together, they complete the plans necessary to make the operation a success.

Employment planning

Employment planning involves the strategic, operational, or tactical use of forces within an operational area. In this type of planning, strategists define how to use existing and projected resources to attain military objectives. Some of the considerations made during this type of planning require assessments of the following:

- Evaluating enemy actions and capabilities.
- Devising and selecting courses of action (COA).
- Positioning of forces and resources.

By assessing these factors, military strategists can then create advantages to exploit opportunities that will allow forces to attain objectives, despite enemy resistance. Combatant commanders, through their component commands, normally develop employment-planning concepts. Employment planning provides the foundation and determines the scope of mobilization, deployment, sustainment, and redeployment planning. Once the foundation is laid, other planning can take place.

Mobilization planning

Mobilization planning is aimed at assembling and organizing national resources to support national objectives during a time of war or for operations other than war. This type of planning brings all armed forces of the United States to a state of readiness that meets the requirements of the contingency. Depending on the scope of the contingency, all or parts of Reserve components may also be used to help organize personnel, supplies, and material. Each of the services is responsible for mobilization planning.

Deployment planning

Deployment planning outlines how to move forces and the resources required to sustain the forces, from their original locations to specific operational locations. This planning encompasses the transportation of troops from the continental United States (CONUS), intertheater, and intratheater movement of forces. Combatant commanders, in close cooperation with the United States Transportation Command (USTRANSCOM), Scott Air Force Base, Illinois, are responsible for deployment planning.

For example, in a full-scale deployment such as Operation Enduring Freedom or Operation Iraqi Freedom, both military cargo aircraft (C–5s and C–17s) and civilian commercial airliners were used to transport troops from the CONUS to the Middle East Theater in Afghanistan and Iraq. Once in theater, intratheater transportation such as C–130 fixed wing aircraft and CH46/47 cargo helicopters were used to move troops from one location to another.

Sustainment planning

Once the troops are in place, military planners must have a strategy to maintain the levels of personnel, materials, and consumable goods that are required to sustain combat operations. When conducting sustainment planning, critical factors are the length of the anticipated deployment and the level of combat intensity. Combatant commanders, in close coordination with the service branches and defense agencies, are responsible for sustainment planning.

Once your unit and you are deployed, it may be months before supply inventories find your unit. Therefore, sustainment planning extends to all levels of the support force structure. When assigned to a WF, a carefully planned inventory of all of your tactical equipment and supplies is critical to the weather team’s success in providing weather support in a combat operations environment. Because it is so critical, personnel must inventory equipment before storage and before exercise/deployments. Considerations for spare parts kits, maintenance agreements, and a resupply of equipment parts are a must.

Redeployment planning

This type of planning is essentially the same as deployment planning, except in reverse order. Once combat operations are complete, detailed redeployment plans outline the phases and timelines to return forces to the CONUS. The overall responsibility lies with the combatant commanders in close cooperation with USTRANSCOM. Now that we’ve looked at these concepts of strategic level planning, let’s briefly look at the benefits and impacts of operational force planning.

Operational force planning

Operational force planning differs from strategic planning in that operational planning identifies how joint air operations will take place. Recall that with strategic planning, the focus was on the broader picture of deployment, mobilization, and redeployment plans. The next portion of the lesson briefly describes the five-phase planning of joint force air operations. The planning conducted here is necessary for campaign success. There are five areas of consideration for joint air operations to be successful. All are the responsibility of the Joint Forces Air Component Commander (JFACC).

Operational environmental research

This planning phase consists primarily of the intelligence preparation of the battlefield (IPB) and gathering in-depth knowledge of the operational environment in order to gain understanding of the theater of operations, the adversary, and friendly forces. During this phase, the JFACC, JFC, and staff military strategists use every available source to obtain as much information as possible. As with any major military operation, the gathering of intelligence is a critical first step to understanding how the battle should be conducted.

Objective determination

Objective determination defines and quantifies objectives that will contribute to the accomplishment of the JFC's operation or campaign objectives. Although the overall objective is identified here, a multitude of subordinate objectives that contribute to the overall objective(s), are also identified. For example, while the overall objective may be to end a dictator's aggression on a country incapable of defending itself, several subordinate objectives likely support the overall objective, especially with a large-scale campaign or operation. Examples of subordinate objectives in this case may include targeting: supply routes, command and control facilities, missile sites, radar sites, and so forth.

Strategic determination

The JFC and JFACC and their staff must define an air strategy statement that clearly defines and states exactly how the JFACC plans to exploit air capabilities and forces to support the JFC's objectives. Without such a statement, objectives may become blurred as the mission progresses. The purpose of the strategic statement is to maintain focus of the battle.

Centers of gravity identification

Centers of gravity (COG) are key targets that must be attacked in order to ensure operation and campaign success, as well as friendly COGs that must be defended. Identification of COGs, in the five-phase planning process, ensures that the JFC satisfies strategic, operational, and tactical objectives.

Joint air operations plan development

This phase of planning outlines the details of how joint air operations will support the JFC's operation or campaign plan. Planners integrate all of the above phases of planning to develop a comprehensive plan for the operation or campaign. When developing the Joint Air Operations Plan (JAOP), special consideration is made to identify all of the capabilities and forces required to achieve joint air operations objectives. In the final stages of developing a plan, planners make an assessment on sustainability and accurately outline the specific procedures for allocating, tasking, and exercising command and control (C2) of available air capabilities and forces. In short, the JAOP is one of the key planning documents that outline the details of the operation or campaign plan.

Up to this point, we've briefly looked at some key planning steps at both the strategic and operation level of the military force structure. In essence, the lessons evolve from the planning phases, to preparing the battle space, and then to the actual combat execution and tactics. However, before we can look at those concepts, let's turn our attention to the last type of planning that is necessary and conducted at the unit or tactical level. Planning at this level involves both team and individual efforts in order for a deployment to be successful.

Tactical deployment execution planning

Up to this point in the lesson, you've become familiar with differences in deliberate planning and crisis action planning and the types of plans that fall into each category. You've also become familiar with both the strategic and operational phases of planning necessary to ensure military campaign and operation success. This section of the lesson deals with some of the unit and individual considerations that you must understand before your deployment as a weather craftsman. Although not all inclusive, it outlines your weather flight's key responsibilities and key individual responsibilities that are necessary to deploy in support of a campaign or military operation.

Weather flight planning and responsibilities

All members of a WF share responsibilities for a deployment, but the overall responsibility lies with the unit commander. Military operations and campaign success depend on your unit's ability to deploy at a moment's notice. Preparation and planning are key elements to ensuring success during the deployment process. Without proper planning, your efforts during the deployment execution process are sure to fail. Let's take a look at some of the key planning that's necessary to ensure that your deployment flows smoothly.

Eligibility requirements and readiness

Prior to deployment, unit commanders have the responsibility to make sure that their personnel meet eligibility requirements. Commanders normally use the personnel data system (PDS) to make submissions and answer questions that arise over eligibility. The PDS has a series of rules regarding eligibility codes called deployment availability (DAV) codes. The DAV codes fall into the categories of legal, physical, time requirements, and administrative characteristics. DAV codes are used to identify personnel eligible for deployment. Once the commander has reviewed DAV codes for each member and made designations to deployable personnel, the selections are considered final, unless otherwise waived.

Skill level and training requirements

When selecting unit personnel for deployment status, commanders must consider skill level requirements. Enlisted personnel are tasked upon their Control Air Force Specialty Code (CAFSC) while officers are tasked based on their Duty AFSC (DAFSC). Grade and skill level substitutions for identifying deployable personnel are normally made only when all other resources have been exhausted. Commanders are given quite a bit of leeway in this area. For example, unless prohibited, an enlisted person possessing a 3–, 5–, 7–, or 9–skill level may satisfy a 5–skill level, deployment-tasking requirement.

Supervisors and trainers are responsible for ensuring that skill level upgrades for each member of the unit occur within the allotted time frame. This includes all in-garrison and tactical certifications that are required for deployable personnel. Untrained personnel may cause mishaps and unforeseen problems for the WF.

Training responsibility extends to subordinate weather units that may serve as augmentees to support a larger, tactical weather unit. Augmentees must have the required training as outlined by the gaining unit. Personnel found to be unqualified or who do not meet the specifications identified in the tasking are returned to home station at the expense of the assigned unit. When this occurs, the home station is still responsible for providing a person to fill the tasking.

Tactical training exercises help prepare WF members for the tasks they'll be required to perform. Documentation of the training you receive during the exercises ensures your readiness. Although supervisors and trainers bear some responsibility for your training, it's equally your responsibility to know which tasks you are certified to perform. Don't wait until you're in a deployment line to identify a shortcoming on your training.

Additional training requirements

Unit and squadron commanders hold the responsibility for making sure that deployable personnel have the required training and have their personal affairs in order. At a minimum, the following requirements must be met:

- Law of armed conflict training.
- Rules of Engagement training.
- Human Rights training.
- Trafficking in Persons Awareness training.
- Personal and family readiness briefings.

- Self-aid and buddy care training.
- Air Force antiterrorism/force protection training.
- Information assurance training.
- Explosive ordinance recognition training.
- Small arms training.
- Chemical, biological, radiological, nuclear, and high-yield explosive defense.

Deployment taskings

All deployment taskings for a particular contingency or exercise are consolidated into a single document called the deployment requirements manning document (DRMD).This document is a critical element in the deployment planning process and has the same level of importance as the OPLAN. Together, the DRMD and OPLAN provide the wing with all requirements for exercises and deployments. Both the base Manpower Office and the Personnel Readiness Unit process the documents during the wing deployment process.

Equipment and cargo preparation

WFs are tasked with maintaining a list of all deployable equipment and other cargo such as vehicles, and so forth. The overall responsibility lies with the senior leadership and team leaders in the weather unit. When planning for the shipment of equipment and cargo, the best method to plan the shipment of cargo is by using a priority-based sequence. Plan the sequencing of cargo shipment based on the timeline for the equipment or cargo need. Obviously, everything your unit needs to operate may not go on the same mode of transportation, especially with a large-scale deployment. Prioritize cargo in categories such as en route support, initial operating capability, and spare parts/replacement kits.

All cargo that is shipped is accompanied by a DD Form, or an approved substitute. The form used is determined by the local Logistics Readiness Squadron or Transportation Management Office. Placards are used for rolling cargo such as vehicles and identify your unit, weight, center of balance, and so forth. Hazardous material is labeled accordingly.

Load and pallet requirements

Although loadmasters load your pallets for shipment, they won’t palletize the equipment for you. Weather teams should practice palletizing equipment and cargo before the deployment occurs. There are strict guidelines and restrictions to the weight and size dimensions that each pallet of cargo must comply with (these guidelines vary from one aircraft to the next). When the guidelines aren’t met, the load obviously needs to be repalletized.

Sometimes metal containers called container expresses (CONEX) are used to ship cargo as well. These are normally shipped by sea on large cargo ships. In addition to practicing palletizing, weather unit personnel should be well versed on what goes inside and how to pack it. Moreover, understand that with large weather units involved in large-scale deployments, vehicles are shipped by sea. Weather units must have plans for personnel that take part in the convoy to get the vehicles to the central shipping port.

Squadron and unit commanders appoint key deployable personnel most familiar with cargo as members of a quick-fix team. When the final inspection of cargo takes place, quick-fix teams can make on-the-spot decisions to correct palletizing and cargo errors. Additionally, each weather unit must have an appointed person called an increment monitor to accompany the cargo through its final inspection. The increment monitor and the quick-fix team resolve any last minute cargo frustrations.

Individual planning and responsibilities

The unit commander (or a designated representative) must ensure that deployable personnel have all of their personal affairs in order prior to the deployment. Each of the responsibilities, once attended to, ensures your survival, health, and the well being of the family members you leave behind. The preparation actions you take before you deploy will ease your mind as you support our nation’s defense and interests. The individual responsibilities below are not all inclusive. For deployment preparations, use the checklists that your unit has provided for your use.

Medical issues

Each member is required to have all immunizations current within 30 days of being appointed to a deployment position. Any additional immunizations that are theater-specific are obtained in a deployment line prior to your departure. At a minimum, take a 90-day supply of prescription medications. If you wear eyeglasses or contact lenses, ensure that you have at least one spare pair of glasses and an ample supply of contact lens solutions, and so forth. Additionally, make sure that your prescription for your gas mask insert is current and that your gas mask fits properly.

Take an ample supply of hygiene products to cover the duration of the deployment. If the deployment lasts longer than anticipated, the sale of such items will be made available to deployed personnel. But don't take chances that such items are readily available after you deploy. Normally such sales centers take time to establish.

Family care plans, wills, and powers of attorney

All deployable personnel must have a plan for dependent family members before they deploy. When applicable, an Air Force Form 357, Family Care Certification, may be used to satisfy this requirement. After being assigned to a deployment position, start immediately on making plans on where your dependents will stay and who cares for them in your absence. Identify special needs of family members as appropriate. Additionally, make back-up plans that cover extended deployments.

Last will and testaments, powers of attorney, and living wills can all be accomplished at your servicing base legal office. Don't wait until you're notified of a deployment to take care of these matters, especially in the case of establishing wills. Wills take a considerable amount of time and thought to complete, whereas obtaining a power of attorney takes a short amount of time.

Make certain that your DD Form 93, Record of Emergency Data, is up to date. Also, ensure that your Servicemen's Group Life Insurance (SGLI) reflects the appropriate beneficiaries. If you make it a point to keep these records current, they'll be one less thing on your mind as you deploy.

Legal issues and financial obligations

Ensure that any matters with businesses, creditors, lease agreements, schools, and so forth, are taken care of before you deploy. Your absence for a deployment does not excuse you from these obligations. If terminations, cancellations, or suspensions can be applied, do so if necessary. Otherwise, make arrangements so that your legal and financial obligations are met.

ID tags and ID cards

Current ID tags and a current ID card are required prior to deployment.

Training records

Personnel in the grades of E–1 through E–6, who are deploying for more than 30 days, must take their AF Form 623, On-the-Job Training Record or an Air Force electronic Training Record (AFTR) printout. Supervisors and trainers use the records to determine certifications and skill levels, as well as document any additional training you received during the deployment.

From this lesson, you can surmise that there are significant differences in the levels and types of decision making and planning necessary in order to support a campaign of military operation. Nonetheless, without the planning conducted at each level, the real possibility of deployments to support military campaigns and operations could not exist. Thus, military planning, from the highest to the lowest echelon, is essential.

002. Joint intelligence preparation of the battle space

Once forces are in place for combat operations, commanders must conduct joint intelligence preparation of the battlefield (JIPB). This lesson briefly familiarizes you with some of the terms (and examples) that are necessary for combat operations success as they relate to the JIPB and air intelligence preparation of the battle space processes.

Joint intelligence implies that that joint forces use intelligence agencies from all forces to make intelligence assessments, estimates, and other intelligence products to support the JFC. The term intelligence itself applies to the gathering of information. When intelligence sources are pooled together, the amount of information acquired can be phenomenal. During the JIPB process, the goal is to enable joint forces commanders and their staffs to visualize the full spectrum of enemy capabilities. Once this information is revealed, commanders then decide upon a COA to use across all dimensions of the battle space. In the past, the term battleground was used, but battle space is now a more appropriate term, as battle space describes all air, sea, and ground dimensions where the campaign or operation takes place.

The primary purpose of the JIPB process, through intelligence gathering, is to provide the JFC, staff, and component commanders with the information required so they can make military decisions. Specifically, the JIPB process helps commanders make decisions on enemy COGs, critical vulnerabilities, capabilities, limitations, intentions, the most likely COA, and the COA most dangerous to friendly forces and mission accomplishment.

Supported military activities

Commanders use the JIPB process to support a wide range of military activities to counter our adversaries' war-making capabilities. Some of the broad activities are:

- Information operations.
- Targeting.
- Chemical, biological, radiological, and nuclear operations.
- Special operations.
- Rear area operations and logistics.
- Reconnaissance, surveillance, and target acquisition.
- Force protection.
- Civil–military operations.
- Counter air operations.

The JIPB process applies to strategic, operational, and tactical level activities. The distinctions of how the JIPB process is used at each level lies in the battle space focus. For example, at the strategic level, the battle space may range from several countries to the entire world depending on how the process is being used. At the operational level, the focus narrows to perhaps an AI such as the Middle East. Finally, at the tactical level, the JIPB process applies to the immediate battle space such as the area of operations (AO). Furthermore, when applying the JIPB process at the tactical level, as with any operations conducted at the tactical level, we must use a refined focus to detail.

JIPB is a four-step process that is continuous. Continuous implies that as new information is revealed about our adversaries, this information is included into the JIPB process. A failure to include any one of the four steps may lead to unpleasant surprises of enemy capabilities to commanders. Moreover, it may lead to the unnecessary expenditure of limited resources against enemy forces that do not exist. Let's examine each of the four steps.

Define the battle space environment

The first step of the JIPB process is to define the battle space environment. In this step, political and geographic boundaries are established, normally from the OPLAN or OPORD. This includes determining the full multidimensional spectrum of the battle space and any characteristics, limitations, and risks that are involved in operating within the battle space. Analysis of the battle space also includes making considerations for the amount of battle space needed for our adversary's allies. During this step, the JFC and component commanders must additionally establish the intent of the operation and identify the details required to operate within the battle space. Finally, intelligence analysts fill in any data gaps, and then collect any additional intelligence required before moving to the next step.

Describe the battle space effects

Before a military campaign or operation can take place, careful analysis of how the battle space environment may affect both friendly and adversary operations must take place. In this step of the JIPB process, environmental, geography, demographics, and meteorological and oceanographic (METOC) influences are analyzed. Technological influences such as electromagnetic and cyberspace environments are also considered.

Land dimension

The land dimension analysis focuses on any dimension that will affect ground forces and movements. Planners consider nearly every conceivable geography feature that may help or hinder ground maneuvers in the land dimension of the battle space. Let's take a look at some of the key considerations that are made when analyzing the land dimension.

Observation and fields of fire

The term observation applies to the ability to see or be seen by adversary forces either visually or by surveillance techniques. A field of fire is the area that a weapon or group of weapons may effectively cover with fire. Combined, these two considerations can either favor or hinder a specified area of the land dimension. Some factors that may hinder observation and fields of fire are:

- The height and density of vegetation and buildings.
- Relief features such as hills.
- Obstructions to specific lines of sight.
- Target acquisition and sensor capabilities.
- Precipitation and cloud cover.

Concealment and cover

Concealment means to protect a force from observation. This can be achieved by several means such as woods, underbrush, snowdrifts, tall grass, and cultivated vegetation. The term cover is protection from the effects of direct and indirect fire. Concealment and cover are the inverse of observation and fields of fire. Cover can be provided by such things as ditches, caves, tunnels, riverbanks, folds in the ground, shell craters, buildings, walls, and embankments. Areas with good concealment and cover favor both offensive and defensive COAs.

Obstacles

Obstacles are considered any obstruction, whether natural, manmade, or a combination of both. They are used to disrupt, fix, turn, or block the movement of an opposing force. Examples of obstacles include buildings, steep slopes, rivers, lakes, forests, swamps, jungles, cities, minefields, trenches, and military wire obstacles.

Key terrain

Strategists and analysts regard key terrain as any area that gives either friendly or adversary forces an advantage over the other. For example, an operational commander may consider as key terrain an urban complex that is an important transportation center, a road network providing passage through restrictive terrain, or a geographic area that provides critical agricultural, industrial, or natural resources.

Avenues of approach

An avenue of approach is the most likely route that a ground force will use to attack. Strategists consider how avenues of approach may be used for both friendly and enemy forces. During offensive operations, avenues of approach are evaluated based on the ease with which friendly forces can maneuver through them and the adversary's ability to withdraw from attack and reinforce. During defensive operations, the avenues are analyzed to determine how easily adversary forces may get through and how friendly forces may be able to withdraw or defend their positions with reinforcements. When analyzing avenues of approach, strategists must identify mobility corridors. Mobility corridors are areas free of obstacles that allow a force to capitalize on the principles of mass and speed (rapid movement of a military unit). While mechanized armor units often require large, open areas through which they can move, smaller dismounted infantry units, insurgents, and terrorists often prefer mobility corridors for the concealment and cover they provide

Terrain effects

The final step in analyzing the land dimension is to determine the overall use of the terrain and how it may help or hinder COAs. Examples of some of the COAs considered with terrain effects are ambush sites and battle positions. Concealment and cover and observation and fields of fire are key considerations made in this step.

Maritime dimension

The maritime dimension is any area where naval, amphibious, or sea control operations may take place. Littoral (adjacent coastal and wetland) areas are also included in this dimension. The maritime dimension differs considerably from the land dimension because concepts such as concealment and cover are difficult to practice. Let's look at some of the key considerations of this dimension.

Maneuver space and choke points

Maneuver space defines the area that sea-going vessels have to turn and navigate. Surface ships compensate for their size by using their ability to maneuver to avoid attack. Thus, the more confined the sea space is, the less able a ship is to maneuver; placing it at an increased risk for attack. The same holds true for the ship's proximity to land. The closer it is to a shoreline, the more susceptible it is to being attacked by antiship weaponry. Ships close to shorelines also experience a significantly shortened warning advance to incoming antiship fire.

Straits and narrows in a seaway are considered choke points and are considered extremely hazardous areas because they severely limit a ship's ability to maneuver. Strategists evaluate both maneuver space and choke points especially when considering the effect of task force (close-up formations) operations. An equally important consideration is the effective use of sea-mines that can be greatly enhanced in confined waters.

Natural harbors and anchorage

Strategists and intelligence analysts focus a great deal of attention on the ability to exploit natural harbors and anchorages. Some harbors and anchorages may offer limited camouflage and concealment for friendly forces; however, when practical, near-by choke points can be used as a stranglehold. Both offensive and defensive strategies are considered.

Manmade infrastructure

Manmade infrastructures such as civilian ports, naval bases, airfields, and occupied or unoccupied antiship missile sites need considerable analysis as well. In short, any manmade facility that may interfere with or be advantageous to friendly forces is considered.

Ocean surface characteristics

METOC data is particularly important when it comes to analyzing ocean surface characteristics. Important considerations include the effects of wind and temperature. Storms and weather patterns affect tides, wave formation, roughness of the ocean surface, and the sea state. Normally, analysts compile as much historical data as possible to help their evaluation of ocean surface characteristics.

Ocean subsurface characteristics

Subsurface characteristics are critical to the operation of submarines, antisubmarine and mining operations. Specifically, sonar capabilities can be significantly affected by the composition of the sea bottom, saline content and water temperatures at various depths, the presence of ocean currents and eddies, and the ambient noise in various areas of the ocean.

Ocean depth is another equally important characteristic that is vital to naval operations. For example, shallow water is advantageous when using ocean bottom mines, but its impact on sensors and weapons makes undersea warfare more difficult. Contrarily, deep water allows greater three-dimensional maneuver room for submarines, but has less impact on undersea warfare and weapons. Lastly, ocean depth may affect the thickness of ocean ice. The thickness of ocean ice may severely restrict a submarine's vertical maneuvering room.

Littoral characteristics

The gradient and composition of coastal areas, coastal terrain features, tides and currents, are all critical factors that may affect amphibious operations. For example, naval gunfire has a flat trajectory. If coastal ridgelines that run parallel to the shore exist, this amplifies the effects of terrain masking to offer protection from the naval gunfire.

Good amphibious landing sites depend on the beach composition. Equally important is the landing sites' proximity to coastal roads and highways. Once the landing takes place, how rapidly the force can get to the transportation infrastructure may make the difference between success and failure. Lastly, a historical database of METOC data is also compiled to analyze the use of amphibious operations.

Maritime effects

The final step in analyzing the maritime dimension is to determine the overall use of the maritime environment and determine what COA to use. The analysis includes an evaluation of various bodies of water and littoral areas to determine if they constitute key geography. For example, the control or denial of a body of water near an amphibious landing site, or adjacent avenue of approach running along a coastal plain, may be critical to either friendly or adversary joint operations.

Air dimension

The air dimension of the battle space is the environment where military air and counter air operations take place. Fixed-wing, rotary-wing, air defense systems, unmanned aerial vehicles (UAV), cruise missile, and ballistic missiles operate in the air dimension. Air power and operating in the air dimension is unique when compared with the other dimensions. Air power characteristics allow approach from almost any azimuth or altitude, with great rapidity and flexibility. Moreover, air power often allows little advanced warning and can be conducted from great distances, directly into the heart of an adversary's territory. Following are some of the key considerations strategists and planners make when analyzing the air dimension.

Target characteristics and configuration

During target analysis, both adversary and friendly targets are identified. Some of the most likely targets are identified, but are not limited to: airfields; air defense sites; ballistic and/or cruise missile sites; C2 facilities; adversary forces; transportation nodes; supply depots; naval bases; chemical, biological, radiological, nuclear, and high yield explosive (CBRNE) production and storage areas; and logistic infrastructure. Targets are normally grouped into packages to determine whether they support an adversary's offensive or defensive air posture. For example, adversaries normally allocate a portion of their available aircraft to defend their own high-value facilities; such facilities would therefore constitute an adversary's "defensive" air posture target set.

Targets are also categorized as hard or soft targets. Hard targets are considered those that are deep underground. In order for friendly forces to acquire these targets, deep penetrators must be dropped from high altitudes. Soft targets are surface based targets that don't require such efforts. In addition, analysts must consider nearby air defenses and the surrounding terrain when evaluating targets. Depending on the fortification of adversary air defenses, the presence of air defense systems may drive the attack profile to low, medium, or high profile. Once target characteristics and configurations have been identified, the focus is then directed toward determining air attack headings and profiles for each target or group of targets.

Airfields and support infrastructure

When examining the air dimension of the JIPB process, each existing and potential airfield must be analyzed. This analysis includes abandoned airfields that may be capable of rapid modification to support air operations. Considerations that are part of the analysis are runway length, width, weight-bearing capacity, elevation, lighting, navigation aids, and potential for expansion. The proximity of the airfield to logistic centers is also considered.

Missile launch sites

When analyzing potential or existing missile launch sites, maximum range arcs are drawn for all cruise and ballistic sites. Nearby terrain is also analyzed to determine any presurveyed sites, and hide and reload capabilities. Possible reload and hiding areas for forward deployed missile units are forested areas with good access to highway underpasses and warehouses. Lastly, friendly missile sites that are within range of the adversary are analyzed to determine counterstrike and defensive measures.

Potential aircraft carriers, submarine and sea launched cruise missiles

Analysts should determine whether adversaries have sea-based, air strike capabilities. Of the three, aircraft carriers are most easily identified because they normally operate in open waters with adequate sea room for maneuvers. Submarine and sea launched platforms are more problematic and require extensive intelligence gathering.

Air avenues of approach

Air avenues of approach differ significantly from ground avenues because air avenues are three-dimensional and often unconstrained by geography. For the most part, instead of geography considerations, air avenues of approach focus on aircraft over flight restrictions, aircraft performance characteristics, counter air capabilities, early warning radar coverage, and locations of air defense forces.

Depending on the aircrafts' vulnerability to detection, terrain may be used to mask the approach and conceal the aircraft from radar. Terrain with minimal contrast to the aircraft may also be used to protect low flying aircraft from lookdown and shoot-down radar systems.

Evaluation of air dimension effects

The final step in evaluating the air dimension is to evaluate the overall effects of the air environment to both friendly and adversary forces. In this step, all militarily significant characteristics of the surface and air environments that may constrain or facilitate air operations are analyzed and presented to the JFC and component commanders.

Space dimension

The space dimension starts at the lowest altitude at which a space object can orbit the earth (approximately 93 miles) and extends to approximately 22,300 miles. The space dimension affords forces that use this medium a wide array of options and advantages. The capability of tracking and monitoring friendly and hostile forces is necessary for a complete understanding of the battle space environment. Suffice it to say that space-based gathering systems, when used, offer friendly and hostile forces a huge advantage to intelligence gathering.

Electromagnetic dimension

Analysis of the electromagnetic dimension of the battle space includes all portions of the electromagnetic spectrum to include radio, radar, laser, electro-optical, and infrared equipment.

Within this dimension, analysts consider how both solar anomalies and electronic warfare devices may affect communications and electronic equipment. Use of this spectrum in warfare is controlled by a variety of factors ranging from international agreements on frequency usage to the physical characteristics of electromagnetic waves. Because each of the principles analyzed requires a strong background in electromagnetic principles to understand the effects, it's not appropriate to teach you the principles in this forum.

Briefly, some of the elements of the electromagnetic spectrum that strategists and analysts consider are:

- Military use of infrared band.
- Multispectral and hyperspectral imaging.
- Radio wave directionality.
- Radio wave attenuation.
- Skip zones and skip distances.
- Evaluate the effects of the electromagnetic environment.

When analyzing the electromagnetic spectrum, strategists may focus on solar and space anomalies that may interfere with communications and equipment. Extensive knowledge on the effects of anomalies may be used as advantages by either friendly or hostile forces. Additionally, atmospheric weather may adversely impact communications and the operation of electronic equipment. Clearly, taking advantage of either event may give friendly forces an offensive or defensive upper hand.

Cyberspace dimension

The cyberspace dimension encompasses the world of information systems to support military operations. In the cyberspace environment, the possibility for computer network attacks (CNA) is a real threat that exists daily. To counteract this ever-increasing threat, computer network defense, among other individual precautions, is a critical to our military and civilian computer networks. CNA can be directed against any of the means of accessing the cyberspace environment. The following major areas of concern are computer hardware, networks, computer software, data, procedures, and human operators.

Computer hardware

Computer hardware consists of sophisticated electronic circuitry that is extremely vulnerable to high temperatures, as well as to electrical power fluctuations and interruptions. Power surges, whether manmade or natural (lightning), may also cause significant damage to components and severely degrade performance. With this threat, operators must consider the vulnerability especially if replacement parts and chips cannot be readily obtained.

Another concern is the possibility that hardware malfunctions may be induced by intentional or nonintentional malfunctions as the hardware is manufactured. An important concept is that CNA may be designed to physically destroy or temporarily degrade computer performance. In the case of degradation, the act may appear as something other than blatant sabotage. Both types of attack require the operators to have detailed knowledge of the hardware used, network nodes, and the vulnerabilities of supporting infrastructure.

Networks

Information networks are vulnerable to the same type types of attack that an adversary my conduct on C2 systems. Examples of threats are jamming, physical destruction, and intrusion. Because military systems are increasingly linked with civilian telecommunications systems, the threat is magnified considerably. Without adequate safeguards, adversaries can gain unauthorized access to network links, information systems, and databases. Additionally, because some network systems are worldwide, adversaries may gain access by channeling through networks located nearby to third world countries.

Computer software

Computers rely on software ranging from operating systems to programs designed to manipulate highly complex data. Thus software is extremely vulnerable to computer viruses that may seriously degrade performance or, in the worst case, cause a loss of entire databases. Viruses can enter computer systems through a variety of means, such as floppy disks, documents in word processors with advanced macro languages, binary programs or documents transferred through electronic mail, or commercial and government off-the-shelf software. Barriers to viral attack include frequent antivirus scans, training operators to recognize the symptoms of infection, and securing the network against the downloading of potentially infected software.

Data

Data is information that when altered may become inaccurate. Data is subject to attack either before or after it is entered into a computer system. For example, one country may be able to manipulate another country’s intelligence analysis by waging a successful camouflage, concealment, and deception effort. Thus an adversary’s campaign of deception may result in the entry of erroneous information into another country’s automated databases. Attacks against data that already reside in automated systems are more complex, with a higher payoff to adversaries. Once access is gained, adversaries have the option to read, change, or erase data.

Procedures

Information system procedures are normally set up to ensure that data maintenance is performed at certain times, and that it’s performed in a rational sequence. Procedures also ensure that only authorized users have system access. The very nature of the predictability of procedures may make it possible for adversaries to discern and exploit vulnerabilities of established schedules used with procedures.

Human operators

The human dimension consists of a large list of categories such as sociological, cultural, demographic, and psychological characteristics of both friendly and adversarial leaderships and populace. Because of the broad range of potential threats, conducting information operations often involves psychological operations (PSYOPS) and military deception techniques.

Evaluating the human dimension is a two-step process. Step 1, identifies and assesses all human characteristics that may impact the behavior of the populace as a whole, military rank and file, and senior military and civilian leaders. Step 2, evaluates the effects of these human characteristics on military operations.

Evaluate the effects of the cyberspace environment

Analysts evaluate the effects of the cyberspace environment by first identifying the threats, then setting priorities for information systems deemed most important. The more critical an information system is, the greater the impact will be; especially when ripple effects may last for days, weeks or months. In the end analysis, planners must present vulnerability assessment reports for leaders and commanders.

Analysis of weather effects

Climate and weather conditions can have a significant effect on the battle space. Weather affects the battle space in two ways: (1) it can interact with and modify the environmental characteristics of the battle space; or (2) it can have a direct effect on military operations regardless of the battle space dimension.

Visibility

Low visibility is beneficial to offensive and retrograde operations because it allows the concealment of forces. This greatly enhances the element of surprise to defending forces. Contrarily, low visibility hinders forces on defensive positions because cohesion and control are lost. Low visibility also impacts surveillance capabilities and the ability to acquire targets. Poor visibility adversely affects air operations. The exceptions are those missions that are not dependent upon visual references and flying under instrument flight rules.

Winds

Combat effectiveness is degraded when winds are strong enough to result in blowing dust, smoke, sand or precipitation. In such cases, the upwind force normally has better visibility and the advantage. The same holds true in case where CBRNE weapons are used.

Strong winds and turbulence can limit aircraft performance and airborne and theater missile operations. Winds and turbulence also affect airdrops and landing operations. Yet, other considerations that analysts examine are aircraft fuel consumption, munitions trajectories, and the effect of windblown matter on weapons and radar systems.

Precipitation

Precipitation typically affects visibility and many infrared systems, electro-optical sensors, and radar and communication systems. Additionally, heavy precipitation that occurs for long durations may affect the quality of supplies in storage, the accuracy and effects of munitions, and the state of the ground. When the terrain becomes impassable, troop movements inevitably come to a halt.

Cloud cover

Heavy cloud cover may degrade the effectiveness of target acquisition systems as the cloud cover conceals military forces. Moreover, when cloud cover is significant enough, it may affect surface temperatures, thereby lessening the effectiveness of heat seeking systems. Infrared systems rely on temperature contrast between the target and the earth's surface. Low ceilings may prevent aircraft from departing from or landing at an airfield, conducting low level missions, employing weapons, and conducting airdrops.

Temperature and humidity

Extreme temperatures and humidity values have debilitating effects on personnel. Extremes also reduce the life span and effectiveness of equipment and chemical and biological weapons. For example, high surface temperatures increase the evaporation rate of chemical weapons. Humidity increases the effects of mustard and nerve agents. Thermal target acquisition systems are degraded when temperature crossover occurs. This means that the target and background temperatures are nearly equal. When this happens, the target blends with the background and isn't identified by the acquisition system. The length of crossover time depends on air and surface temperatures, surface composition, vegetation, cloud cover, and other variables.

Evaluate the effects of weather on the battle space

In the final analysis of weather factors that may affect the battle space, strategists must establish critical values for each weather element and weapons system. Weather thresholds can then be used to establish favorable, marginal, or unfavorable effects on specific types of equipment and operations. Weather effects summaries generally paint an overall picture of how weather may affect the battle space.

Other characteristics of the battle space

In addition to the battle space dimensions you've learned about so far, strategists also consider the effects of time, political and military constraints, environmental and health hazards, and the infrastructure within the theater.

Time

An adversary's decision and reaction time directly affects how well an adversary can employ resources and tactics in a specific situation. For example if friendly forces act and react more rapidly than adversary forces, we may be able to constrain the adversary's ability to reinforce or redeploy military units in time to counter the operation.

Political and military constraints

Matters such as rules of engagement, no-fly zones, maritime defense zones, territorial waters, excessive maritime claims, and air defense identification zones all have an impact on friendly forces and an adversary's abilities to ensue battles over certain areas. Strategists must identify such matters when analyzing the battle space.

Environmental and health hazards

Another factor that cannot be overlooked when analyzing the battle space is the presence of communicable diseases, locations of epidemics, methods of disease transmission, and the location and types of pollutants within the battle space.

Infrastructure

Lastly, analysts must identify sources of potable water, transportation systems (road, rail, and waterways), communication nodes, power production facilities, and power transmission grids. Some of the infrastructure elements may be used to help friendly forces, while others, when denied to the adversary, seriously degrade an adversary's abilities.

It's evident from the length of this section that step 2, *define the battle space effects*, requires a large amount of analysis, planning and decision making to assess nearly every possible dimension that may affect the campaign or operational area. Having briefly looked at some of the key considerations, now, let's turn our attention to the remaining three steps of the JIPB process.

Evaluating the adversary

When strategists and analysts evaluate the adversary, they are, in essence, studying the adversary's strongholds, strengths, weakness, and overall capabilities. Once the adversary's threats are analyzed, models are created to accurately portray how the adversary normally executes operations. Adversary capabilities are normally identified as broad COAs that the adversary may use to accomplish a mission. For example the adversary's postures are identified in order to anticipate their next course of action. Any failure to identify an adversary's capabilities may result in unexpected surprise or result in unnecessary expenditure of limited resources for forces that do not exist.

Identify adversary centers of gravity

Centers of gravity are analyzed to determine how critical each COG is to adversary strategy. Truly critical COGs are analyzed to determine the mechanics and links that give the COG strategic strength. Once identified, these COGs are incorporated into friendly forces' joint campaign strategy, OPLANs, and targets.

Update/create adversary models

Adversary models depict how an opponent conducts operations under ideal conditions. Models are based on detailed study and are completed prior to deployment. Models consist of three major parts:

- Graphical depictions of doctrine or patterns of operations.
- Descriptions of preferred tactics and options.
- Identification of high-value targets.

Once these models are completed, analysts run every conceivable scenario to predict what action adversaries may use during a campaign.

Determine the current adversary situation

In this sub step, every available intelligence source, method, and database is used to exploit and analyze current adversary's capabilities. The main focus is to analyze and stay updated on adversary air, naval, special operations, and ground forces that are deployed within the area of interest (AOI). The current adversary situation is based on each unit's composition, disposition, strength, tactics, logistics, and so forth. In other words, "What is the current state of affairs for the adversary?"

Identify adversary capabilities

Once the adversary's situation is assessed, their capabilities are determined by comparing the current situation to previous adversary models that are already created. Capabilities are then evaluated to determine true capabilities as strengths and identify vulnerabilities as weaknesses. Analysts then summarize by completing a capability statement that identifies the overall capabilities (strengths) and vulnerabilities (weaknesses).

Determine adversary potential COAs

The last major step in the JIPB process is to determine the adversary's COA. In other words, what COA is the adversary most likely to adopt, and which COAs are most dangerous to friendly forces?

Determine adversary's likely objectives and end state

Analysts identify the adversary's likely objectives and end state by analyzing the current military and political situation, strategic and operational capabilities, and characteristics of the country the adversary is operating within. In most cases, due to insufficient analysis information, objectives are most likely to be assumptions rather than fact. Once assumptions (or facts) are established, analysts, again, focus on COAs.

Identify COAs available to the adversary

At this point, a full list of all potential COAs is developed. When listing adversary COA's analysts, ensure that each COA meets the five criteria of suitability, feasibility, acceptability, uniqueness, and is consistent with doctrine. Suitability implies that the adversary has the ability to accomplish the COA to an end state. Feasibility implies that the adversary has ample time, space, and resources to accomplish the COA. The question of acceptability infers that the adversary is willing to accept the risks associated with the COA. The level of risk that an adversary accepts is determined by analyzing the past actions and psychological profiles of the adversary. The term uniqueness applies in a sense, that if a COA is not significantly different from other COAs, it's then considered a variation of a COA, rather than a distinct COA. Finally, each adversary COA must be consistent with adversary doctrine. However, analysts must use caution when making these assumptions and have a high degree of certainty. For example, just because an adversary has never used biological weapons in the past does not guarantee that the adversary won't use such weapons to gain the element of surprise.

Evaluate and prioritize each COA

Once the COAs are identified, analysts must then evaluate and prioritize each COA according to the most likely order of adoption by the adversary. Moreover, each COA is analyzed in terms of the danger it poses to friendly forces. The overall goal of this prioritization is to provide JFCs with a starting point for developing OPLANs and OPORDs.

Develop COAs in detail

The next sub step in determining the adversary's COA potential is to develop each COA into as much detail as possible. COA complexity and the amount of time available are the two biggest factors that play into detailed portrayals and depictions. The details of COAs should, at a minimum, identify phases and timelines for COA execution and high-value target locations.

Identify initial collection requirements

Finally, once the adversary's COAs have been developed, analysts begin to identify intelligence data requirements. Now that the predictions of potential COAs are made, intelligence analysts can focus efforts on named areas of interest (NAI), as opposed to a shot-in-the-dark approach.

003. Air tasking cycle

Up to this point, you've learned about military planning strategies and how strategic, operational, and tactical planning takes place. You've also become familiar with the steps of JIPB. Both concepts are extremely important to predeployment and deployment processes and are very necessary for campaign or military operation success. This portion of your CDC provides equally important concepts regarding the execution of the air tasking cycle and air tasking orders. After completing this section, you'll have a much better understanding of the military decision processes, the air tasking cycle, and air tasking orders.

Background information

The terms *targeting* and *tasking* are closely related when speaking of air tasking orders (ATO). Targeting is the process of selecting targets and measuring the results or response of the target selection. A complex target selection process is always conducted before an air tasking order is made. Like the intelligence preparation of the battlefield process, the targeting process must be applied at the strategic, operational, and tactical levels of command. Because targeting occurs at all levels of command in a joint operation, special care must be taken to avoid duplication of target acquisitions. Instead, planners and commanders must carefully synchronize and sequence targeting so that all components and levels of command achieve a common goal with minimal casualties or wasted resources. Once the joint forces commander and staff select targets, a tasking for the target then follows suit. This is typically called an ATO. Let's look at the process that leads to the development of an ATO.

Notional air tasking cycle

In the notional air tasking cycle, the term *notional* means that the air tasking cycle is theoretical and may not necessarily occur exactly as outlined. This is because, in reality, there are too many variables that may cause deviations to the cycle. Moreover, whenever a notional process is developed, understand that the scale of the battlefield and the order in which events unfold is normally the cause for deviations to any process. For example, with military planning, strategists normally plan for the worst-case scenario of a full-scale battle. If, as is often the case, a large-scale planning model is used for a smaller-scale battle, then conditions may warrant that not every part of the process be used exactly as outlined in the plan. The notional air tasking cycle is a six-phase process. The notional air tasking cycle normally takes place over a 30- to 72-hour period. Although this seems like a short time frame for such a complex process, it's possible only because parts of the targeting process are already outlined in the CONPLAN and OPLANs that you learned about from previous lessons.

Phase 1: JFC/component coordination

In the first phase of the notional air tasking cycle, the JFC coordinates with the component commanders to assess the war-fighting efforts and discuss strategic direction and operations plans. A key result of these discussions is making air apportionment decisions. Air apportionment means that the JFC and the component commanders identify the total effort required by mission-type, percentage of forces, priority of targets, geographic areas, and time. In short, apportionment allows the JFC to ensure that the weight of the joint air effort is consistent with campaign phases and objectives. When prioritizing the air effort, mission-types may be categorized as strategic attack, interdiction, counter air, maritime support, close air support, and so forth.

Phase 2: Target development

The objectives analyzed in phase 1 are used to focus on target development. The JFC, joint staff, unified commands, and component commanders take part in target development. Specific targets are selected based on joint target lists (JTL), component commander requests, intelligence recommendations, electronic warfare inputs, and requirements of the current situation. The focus is to develop a list of prioritized targets. In reality, this list is often developed in the predeployment phases of planning you learned about in previous lessons. Ideally, target planning takes place in the deliberate planning phase, when the CONPLAN and OPLAN are being developed.

The JTL contains target categories that prioritize targets into categories such as C2, airfields, and lines of communication. Planners simply can't wait for an AI to become a real world threat. If and when the OPLAN is executed, target development continues to refine and update the JTL as necessary. Once all targets are finalized, the final product is called a joint integrated prioritized target list.

Phase 3: Weaponeering/allocation

Once target development is complete, planners must quantify the expected results of lethal and nonlethal weapons. To quantify the expected results, planners analyze the details of the destruction capabilities of each target. This step involves using target weaponeering worksheets to determine factors such as aim points, recommended number and type of aircraft and weapons, fusing, target description, attack objectives, target area threats, and probability of destruction. Once the details are finalized, planners then incorporate the prioritized targets into the master air attack plan (MAAP). The MAAP is developed with guidance from the JFC and JFACC, and becomes the key document that outlines the details of target selection and aircraft allocations. The MAAP is sometimes called air employment plan or joint tasking order shell.

After all target and aircraft allocation decisions are made, the JFC/JFACC and staff then translate the MAPP content into the total number of aircraft sorties and weapons that are required to support each operation. Once these decisions are finalized, each air capable component then prepares allocation requests (ALLOREQ) for the JFC and JFACC. Normally, ALLOREQs are sent within 24 hours of the air-tasking day. ALLOREQ messages must include:

- The number of joint air sorties that will be flown during the air-tasking day. The sorties are categorized by mission and aircraft type.
- Excess sorties not required by the air-capable component. Excess sorties may then be used in other combat applications.
- Requests for additional air support beyond the capability of the air-capable component.

Phase 4: Joint ATO development

This phase of the air tasking cycle requires additional detailed planning and coordination. Through JFC and JFACC guidance, target worksheets, the MAAP, and component requirements are used to develop three documents called the ATO, aerospace control order (ACO), and special instructions (SPINS).

The ATO provides specific instructions that include call signs of aircraft, targets, controlling agencies, and so forth, as well as general instructions for target acquisition. The ACO provides the details of aerospace control and safety control measures. The third of the documents, SPINS, are updates that are created daily, weekly, and monthly and are also included in the ACO. They indicate instructions and changes that have been made throughout the process. Together, the ATO, ACO, and SPINS provide operational and tactical directions and detail for the multiple bases and components that are involved in the joint operation. When multiple bases and components commanders are involved in joint operations, a greater level of detail must be applied to the ATO and ACO. With any large-scale operation, JFC and JFACC must be sure that targeting duplication is avoided and aerospace control is maintained. By contrast, much less detail is required when missions and targets are tasked to a single component commander.

Phase 5: Force execution

Once all of the coordination from phases 1 through 4 has taken place, the JFC or JFACC executes the ATO. The execution phase normally occurs in a 24–hour period. During the execution phase, the JFC and JFACC must be responsive to any required changes during the execution. For example, in-flight reports and initial battle damage assessments (BDA) may cause the JFC/JFACC to redirect joint air forces before making a subsequent launch. Additionally, if BDA is less than expected, then retargeting may occur. In this case, if targets are prioritized, the first set of targets must be acquired before subsequent targeting can take place. Each occurrence of redirection in the targeting must be carefully coordinated.

Phase 6: Combat assessment

Combat assessment is performed at all levels of the joint force. During this process, the JFC and JFACC continuously evaluate the results of the joint air operations. Combat assessments include evaluating BDA, munitions effects, and reattack recommendations. Additionally, the JFC/JFACC staff evaluates future adversary COAs and remaining combat capabilities. Once the assessment is complete, the JFC then determines the overall campaign success and recommends changes in COAs. Although combat assessment marks the end of the air tasking cycle, the results are used for future targeting development.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

001 Military planning strategy

1. What two factors influence the number of agencies involved in the strategic planning process?

2. What type of planning considers positioning of forces and resources?

3. In which types of planning is USTRANSCOM responsible for planning?

4. Who is responsible for making sure their personnel meet eligibility requirements for deployment?

5. What codes identify deployment availability?

6. What helps prepare WF personnel for the tasks they'll be required to perform?

7. What two documents provide the Wing with all requirements for exercises and deployments?

8. What do all personnel with dependents require after being assigned to a deployment position?

002. Joint intelligence preparation of the battle space

1. What is the goal of the JIPB?

2. What do you call the most likely route that a ground force will use to attack?

3. Why are air avenues of approach different from ground avenues of approach?

4. When analyzing the electromagnet dimension of the battle space, on what do strategists focus?

5. How does weather affect the battle space?

003. Air tasking cycle

1. Which comes first, targeting or tasking?

2. What's the timeframe of the notional air tasking cycle?

3. In what timeframe does the execution phase normally occur?

4. What marks the end of the air tasking cycle?

1–2. Operational Tactics

Now that you have a sound background on the military decision-making process, the second part of this unit examines the aerospace and land operational tactics used during wartime. As a weather forecaster, you provide a variety of meteorological products and services to a diversified customer. Since Air Force weather (AFW) supports Air Force, Army and joint operations, your products and services are used to enhance military capability in aerospace and land operational tactics. This section explores some of the aerospace and land operational tactics used by the Air Force and Army.

004. Aerospace operational tactics

Before you start learning about aerospace operational tactics, let's begin with some background information on the levels of war. This information helps you understand how and why air and space functions are employed.

Airman's perspective of the levels of war

Warfare is typically divided into three levels: strategic, operational, and tactical. The focus at a given level of war is not on the specific weapon used or on the targets attacked, but rather on the desired effects. A given airplane, dropping a given bomb, could compromise a tactical or strategic mission depending on the planned results.

Strategic level

Effects at the strategic level of war include destruction or disruption of the enemy's COGs or other vital target sets, including command elements, war-production assets, and key supporting infrastructure that impairs the enemy's ability or will to wage war or carry out aggressive activity. At this level the NCA, sometimes as a member of a group of nations, determines national or multinational (alliance or coalition) security objectives and guidance and develops and uses national resources to accomplish these objectives. These national objectives in turn provide the direction for developing overall military objectives, which in turn are used to develop the military objectives and strategy for each theater. In general terms, the strategic level of war addresses the issues of WHY and WITH WHAT we will fight and WHY the enemy fights against us.

Tactical level

At the other end of the spectrum lies the tactical level of war, where individual battles and engagements are fought. To the Airman, the distinction between this level and higher levels of war is fairly clear cut; we tend not to fight “battles” with aerospace power, but focus at the tactical level on the individual engagement. The tactical level of aerospace warfare deals with how these packaged forces are employed and the specifics of how engagements are conducted and targets attacked. In short, the tactical level of war deals with HOW we fight.

Operational level

Between the strategic and tactical levels of war lies the operational level of war. At this level of war, campaigns and major operations are planned, conducted, and sustained to accomplish strategic goals within theaters or areas of operations. These activities imply a broader dimension of time or space than do tactics; they provide the means by which tactical successes are exploited to achieve strategic objectives. Operational effects such as theater air superiority, C2 decapitation, and battlefield isolation are the tools with which the operational air commander supports the overall strategy. In terms of aerospace operational employment and targeting, planning at the operational level of war determines WHAT we will attack, in WHAT order, and for WHAT duration.

Employing air and space power

The Air Force’s basic functions are the broad, fundamental, and continuing activities of air and space power. They are not necessarily unique to the Air Force; elements of other services may perform them or similar activities to varying degrees, but together they do represent the means by which the Service forces accomplish the missions assigned to the JFCs.

Counter air

Counter air consists of operations to attain and maintain a desired degree of air superiority by the destruction or neutralization of enemy forces. Counter air’s two elements—offensive counter air (OCA) and defensive counter air (DCA)—enable friendly use of otherwise contested airspace and disable the enemy’s offensive air and missile capabilities to reduce the threat posed against friendly forces. The entire offensive and defensive counter air effort should be controlled by one air officer under the centralized control, decentralized execution concept in order to assure that concentration of effort and economy of force requirements are met. Air and space superiority normally should be the JFC’s first priority for air and space forces.

OCA

Because air and space forces are inherently offensive and yield the best effect when so employed, OCA is often the most effective and efficient method for achieving the appropriate degree of air superiority. This function consists of operations to destroy, neutralize, disrupt, or limit enemy air and missile power as close to its source as possible and at a time and place of our choosing. OCA operations include the suppression of enemy air defense targets, such as aircraft and surface-to-air missiles or local defense systems, and their supporting C2. OCA operations protect friendly forces and vital interests by destroying or neutralizing enemy offensive air and missile threats before they bring their effects to bear against us. This is freedom from attack that enables action by friendly forces—freedom to attack.

DCA

DCA concentrates on defeating the enemy’s offensive plan and on inflicting unacceptable losses on attacking enemy forces. DCA is synonymous with air defense and consists of active and passive operations to defend friendly airspace and protect friendly forces, materiel, and infrastructure from enemy air and missile attack. It entails detection, identification, interception, and destruction of attacking enemy air and missiles and normally takes place over or close to friendly territory.

Counter space

Counter space involves those operations conducted to attain and maintain a desired degree of space superiority by the destruction or neutralization of enemy forces. The main objectives of counter space operations are to allow friendly forces to exploit space capabilities, while negating the enemy's ability to do the same. Air, space, land, sea, or special operations forces can conduct the operations. Counter space operations include both offensive and defensive components.

Offensive counter space

Offensive counter space (OCS) operations destroy or neutralize an adversary's space systems or the information they provide at a time and place of our choosing through attacks on the space, terrestrial, or link elements of space systems. OCS operations are conducted to achieve five major goals: deception, disruption, denial, degradation, or destruction of space assets or capabilities. These operations may include military operations such as surface-to-surface and air-to-surface attacks against space support facilities or space payloads before they are placed in orbit, as well as jamming of enemy satellite uplink and downlink frequencies. Counter space operations initiated at the onset of hostilities can result in an immediate advantage in space capabilities and in early space control. Continued suppression of the space threat may be required in conjunction with other offensive actions under way within the joint area of operation.

Defensive counter space

Defensive counter space (DCS) operations consist of active and passive actions to protect our space-related capabilities from enemy attack or interference. The objective of active counter space defense measures is to detect, track, identify, intercept, and destroy or neutralize enemy space and missile forces. The objective of passive counter space defense is to reduce the vulnerabilities and increase the survivability of friendly space forces and the information they provide. These may include operations such as designing survivability features into satellites, satellite maneuver, emission control, and decoys. Defense Support Program (DSP) satellites are a key part of North America's early warning systems.

Counter land

Counter land involves those operations conducted to attain and maintain a desired degree of superiority over surface operations by the destruction or neutralization of enemy surface forces. The main objectives of counter land operations are to dominate the surface environment and prevent the opponent from doing the same. Although normally associated with support to friendly surface forces, counter land is a flexible term that can encompass the identical missions without friendly surface-force presence. This independent or direct attack of adversary surface operations by air and space forces is the essence of asymmetric application and is a key to success during operations to decisively halt an adversary during initial phases of a conflict. Specific traditional functions associated with air and space counter land operations are interdiction and close air support.

Interdiction

Interdiction is a form of air maneuver. Interdiction consists of operations to divert, disrupt, delay, or destroy the enemy's surface military potential before it can be used effectively against friendly forces. Air interdiction's ability to delay and disrupt may have a devastating impact on the enemy's plans and ability to respond to the actions of friendly forces, even before friendly surface forces appear in the battle space. Interdiction attacks enemy C2 systems, personnel, materiel, logistics, and their supporting systems to weaken and disrupt the enemy's efforts and may achieve tactical, operational, or strategic objectives. Although nontraditional in the classic sense, information warfare may also be used to conduct interdiction by intercepting or disrupting information flow or damaging/destroying controlling software and hardware. For example, electronic warfare could be used to prevent further enemy incursions by disrupting C2 of advancing enemy forward-deployed forces through jamming of communications relays. The F–16 Fighting Falcon is one the Air Force's principle fighter aircraft for air interdiction operations.

Through interdiction operations, a commander can exploit airpower's ability to concentrate firepower quickly at any point throughout the theater. Depending on the JFC's overall campaign plan, air interdiction can have a variety of target sets, such as C2 systems, logistics, movement networks, or follow-on forces. It can also achieve objectives by destruction, blockage, channelization, disruption, or by inducing systemic inefficiencies. Interdiction and surface-force maneuver can be mutually supporting. Surface-force operations can support interdiction operations by forcing the enemy to consume supplies at an accelerated rate and to move forces to meet emerging threats. These movements and resupply efforts then become targets or objectives for air and space forces. Interdiction can also support surface operations by forcing the enemy to react to friendly interdiction, thereby exposing vulnerabilities to surface-force maneuver forces. Additionally, attacks on enemy C2 systems interfere with an adversary's ability to effectively mass, maneuver, withdraw, supply, and reinforce his surface forces.

Close air support

Close air support (CAS) consists of air operations against hostile targets in close proximity to friendly forces; further, these operations require detailed integration of each air mission with the fire and movement of those forces. CAS provides direct support to help friendly surface forces carry out their assigned tasks. Commanders can build on the tactical effects of CAS by orchestrating it with other surface and air operations to produce operational-level effects. In fluid, high-intensity warfare, the need for tight control, the unpredictability of the tactical situation, and the proliferation of lethal ground-based air defenses make CAS especially challenging.

CAS produces the most focused but briefest effects of any counter land mission; by itself, it rarely achieves campaign-level objectives. However, at times it may be the more critical mission by ensuring the success or survival of surface forces. CAS should be planned to prepare the conditions for success or reinforce successful attacks of surface forces. CAS can halt attacks, help create breakthroughs, cover retreats, and guard flanks. To be most effective, however, CAS should be used at decisive points in a battle and should normally be massed to apply concentrated combat power and saturate defenses. The A–10 Thunderbolt II more commonly known as the "Warthog" is one of the Air Force's prime aircraft for CAS.

Counter sea

Counter sea is a *collateral mission*, defined by Joint Pub 1–02, *Department of Defense Dictionary of Military and Associated Terms*, as "a mission other than those for which a force is primarily organized, trained, and equipped, that the force can accomplish by virtue of the inherent capabilities of that force." Counter sea functions are an extension of Air Force functions into a maritime environment. The identified specialized collateral functions are sea surveillance, antiship warfare, protection of sea lines of communications through antisubmarine and antiair warfare, aerial mine laying, and air refueling in support of naval campaigns. Many of these collateral functions translate to primary functions of air and space forces such as interdiction, counter air, and strategic attack. As with the air and space functions, counter sea operations are designed to achieve strategic-, operational-, or tactical-level objectives in the pursuit of joint force objectives. In addition, as with counter air, counter land, counter space, and counter information, the objective is to gain control of the medium and, to the extent possible, dominate operations either in support of naval forces or independently.

Strategic attack

Strategic attack is defined as those operations intended to directly achieve strategic effects by striking at the enemy's COGs. These operations are designed to achieve their objectives without first having to necessarily engage the adversary's fielded military forces in extended operations at the operational and tactical levels of war. In classic theater warfare, those objectives typically centered on destruction or disruption of the enemy's COGs, which were the characteristics, capabilities, or localities from which a force derived its freedom of action, physical strength, or will to fight. This was the objective during both World War II and Desert Storm. In modern operations the adversary may be a large nation state with a highly sophisticated political, economic, and military structure or a nonstate terrorist group that relies on clandestine support. Regardless of the opponent, it is the operation's direct impact on assigned strategic objectives that are important. Strategic attack objectives often include producing effects to demoralize the enemy's leadership, military forces, and population, thus affecting an adversary's capability to continue the conflict. This function may be carried out in support of a theater combatant commander (CCDR) or as a stand-alone operation by direction of the NCA. One of the Air Force's principle aircraft for strategic attack is the F–22 Raptor advanced fighter.

Strategic attack may also be conducted against fielded forces. For example, strategic attack may be conducted against identified COGs such as major reserves or politically significant military formations, space launch and support elements, or forces used for strategic nuclear attack. Strategic attacks can be conducted independently by air and space forces or in conjunction with friendly land and naval forces and often overlaps into a "gray area" with other functions such as interdiction and counter air. However, the determining factor is that strategic attack should affect the enemy's entire effort rather than just a single action, battle, or campaign. Another Air Force aircraft that performs strategic attack mission is the B–2 Spirit stealth bomber.

Strategic attack should produce effects well beyond the proportion of effort expended in their execution. It is the effect of a relatively few well-placed systems, weapons, or actions on a few targets or target sets of extreme value that distinguishes strategic attack from other functions, especially when compared to the forces typically needed for tactical- or operational-level actions. If properly applied, strategic attack is the most efficient means of employing air and space power. It provides the theater commander with the option of creating decisive, far-reaching effects against an adversary while avoiding loss of life and expenditure of treasure.

Strategic attack is a function of objectives or effects achieved, not forces employed. It is not limited to nuclear operations, heavy bombers and intercontinental ballistic missiles (ICBM), or total devastation of an enemy's war-making capacity. In fact, many strategic actions tend to be nonnuclear conventional or special operations against more limited war or contingency operations objectives, and will increasingly include attack on an adversary's information and information systems. The means, methods, and aim of strategic attack can be tailored to the objective or objectives being sought. Strategic attack can be a practical and potent option and can utilize a variety of weapons, forces, tactics, or warfare to attain the desired "strategic objectives or effects."

Normally, one of the key target systems is the enemy's C2 system. Regardless of the nature of the adversary, disrupting the ability to communicate can be a critical step toward achieving strategic paralysis and disunity by cutting off the enemy's political/military leadership from the civilian populace (or in case of nonstate adversaries, their clandestine base of support) and fielded force. Whether one uses aircraft, missiles, or information attack, the enemy's C2 should always be a target of particular focus in strategic attack.

Counter information

Counter information seeks to establish information superiority through control of the information realm. Counter information creates an environment where friendly forces can conduct operations without suffering substantial losses, while simultaneously denying the enemy the ability to conduct their operations. The focus of the effort is on countering the enemy's ability to attain information advantage. Counter information, like counter air and counter space, consists of both offensive and defensive aspects.

Offensive counter information

Offensive counter information (OCI) includes actions taken to control the information environment. The purpose is to disable selected enemy information operations. OCI operations are designed to destroy, degrade, or limit enemy information capabilities and are dependent on having an understanding of an adversary's information capabilities. Examples of OCI include jamming radars and corrupting data acquisition, transformation, storage, or transmissions of an adversary's information; psychological operations; deception; and physical or cyber attack.

Defensive counter information

Defensive counter information (DCI) includes those actions that protect our information, information systems, and information operations from the adversary. DCI programs, such as operations security (OPSEC), information security (INFOSEC), and counterintelligence assess the threat and reduce friendly vulnerabilities to an acceptable level. Improving security procedures designed to safeguard equipment and information can prohibit unintentional and unwanted release of information.

Command and control

Command is the art of motivating and directing people and organizations into action to accomplish missions. Control is inherent in command. To control is to regulate forces and functions to execute the commander's intent. C2 includes both the process by which the commander decides what action is to be taken and the system that monitors the implementation of the decision. Specifically, C2 includes the battle space management process of planning, directing, coordinating, and controlling forces and operations. C2 involves the integration of the systems of procedures, organizational structures, personnel, equipment, facilities, information, and communications designed to enable a commander to exercise command and control across the range of military operations. Air and space forces conduct the command and control mission to meet strategic, operational, and tactical objectives.

Airlift

Airlift is the transportation of personnel and materiel through the air and can be applied across the entire range of military operations in support of national objectives. Airlift provides rapid and flexible options allowing military forces to respond to, and operate in, a wider variety of circumstances and time frames. A key function of the Air Force, airlift provides global reach for US military forces and the capability to quickly apply strategic global power to various crisis situations worldwide by delivering necessary forces. The power-projection capabilities that airlift supplies are vital since it provides the flexibility to get rapid-reaction forces to the point of a crisis with minimum delay. Accordingly, airlift is viewed as a foundation of US national security at the strategic level and as a crucial capability for operational commanders within a theater. Therefore, airlift is not only a vital component of US defense policy but is critical to the support of overall national policy and objectives. Air Force airlift can be classified as strategic (intertheater), theater (intratheater), and operational support. These classifications depend on the mission the airlift asset is performing, not on the type of airframe itself.

Intertheater airlift

Intertheater airlift provides the air-bridge that links theaters to the CONUS and to other theaters, as well as airlift within the CONUS. The forces responsible for executing intertheater airlift missions are under the combatant command of the Commander, US Transportation Command (USTRANSCOM/CC). Due to the global ranges usually involved, intertheater airlift is normally composed of the heavy, longer range, intercontinental airlift assets, but may be augmented with shorter-range aircraft when required. The C–17 Globemaster III is the most flexible airlift aircraft in the Air Force's inventory.

Intratheater airlift

Intratheater airlift provides the air movement of personnel and materiel within a CCDR's area of responsibility. Assets designated to provide intratheater airlift are either assigned or attached to that geographic CCDR. Aircraft capable of operation under a wide range of tactical conditions, including small, austere, unimproved airfield operations generally fulfills this classification of airlift. The Air Force's C–130 Hercules is especially adept at this.

Operational support airlift

Operational support airlift is airlift provided by assets that are an integral part of a specific service, component, or major command (MAJCOM) and that primarily support the requirements of the organization to which they are assigned. These airlift assets are not common user assets and normally only serve in that role by exception. Operational support airlift operations provide for the timely movement of limited numbers of critical personnel and cargo for the assigned user.

Air refueling

Air refueling, along with airlift, fulfills the Air Force's contribution to the joint mobility role. Air refueling is an integral part of US airpower across the range of military operations. It significantly expands the employment options available to a commander by increasing the range, payload, and flexibility of air forces. Therefore, aerial refueling is an essential capability in the conduct of air operations worldwide and is especially important when overseas basing is limited or not available. Air Force air refueling assets are employed in five basic modes of operation: (1) support of the nuclear Single Integrated Operation Plan (SIOP), (2) support of long-range conventional strategic attack missions, (3) deployment of air assets to a theater, (4) support of an airlift line of communication or air bridge, and (5) support of combat and combat-support aircraft operating within a theater. The Air Force's KC–135 Stratotanker is capable of refueling airborne jet fighters, thereby increasing their range and effective payload.

Space lift

Space lift projects are powered by delivering satellites, payloads, and materiel into or through space. During a period of increased tension or conflict, the space lift objective is to launch or deploy new and replenishment space assets as necessary to achieve national security objectives. To satisfy this requirement, space lift must be functional, flexible, and capable of meeting the nation's full range of launch requirements from placing small space systems in low orbits to large space systems in high, geostationary orbits. Equally important, space lift must be timely and responsive to the user's needs.

Launch to deploy

These are launches required to initially achieve a satellite systems designed operational capability. In this approach, space systems are launched on a predetermined schedule.

Launch to sustain

These are launches to replace satellites that are predicted to fail or abruptly fail. They may be scheduled well in advance or may require unscheduled operations.

Launch to augment

These are launches to increase operational capability in response to contingency requirements, crisis, or war. Unscheduled launches or payload adjustment on scheduled activity will likely be required.

Special operations employment

Special operations employment is the use of airpower operations (denied territory mobility, surgical firepower, and special tactics) to conduct the following special operations functions: unconventional warfare, direct action, special reconnaissance, counter terrorism, foreign internal defense, psychological operations, and counter proliferation. To execute special operations, Air Force Special Operations Forces (AFSOF) are normally organized and employed in small formations capable of both independent and supporting operations, with the purpose of enabling timely and tailored responses across the range of military operations. Special Operations Weather Teams (SOWT) are included in the Special Tactics (ST) portion of AFSOF.

Uniquely distinctive from normal conventional operations, AFSOF may accomplish tasks at the strategic, operational, or tactical levels of war or other contingency operations through the conduct of low-visibility, covert, or clandestine military actions. AFSOF operations are usually conducted in enemy-controlled or politically, sensitive territories and may complement or support general-purpose force operations. AFSOF are part of a joint Special Operations Forces (SOF) team that provides combatant commanders with a synergistic capability to accomplish specialized tasks.

Special operations differ from conventional operations in degree of physical and political risk, operational techniques, mode of employment, degree of covertness, independence from friendly support, and dependence on detailed operational intelligence and indigenous assets. That setting is one often dominated by high risk and political, environmental, and operational constraints. In addition, governments often view the use of SOF as a means to control escalation in situations in which the use of conventional forces is unwarranted or undesirable. Accordingly, theater CCDRs may choose to utilize special operations forces, working either independently or in support of conventional forces, to operate in rear areas to exploit enemy weaknesses or collect intelligence that would not otherwise be available. However, it must be emphasized that SOF can also operate as a strategic force independent of theater CCDRs. However, such employment should be carefully coordinated to prevent conflict with other operations. The mission of the MC–130H Combat Talon II is to provide global, day, night, and adverse weather capability to airdrop and air land personnel and equipment in support of US and allied special operations forces.

Intelligence

Intelligence provides clear, brief, relevant, and timely analysis on foreign capabilities and intentions for planning and conducting military operations. The overall objective of intelligence is to enable commanders and combat forces to "know the enemy" and operate smarter. It helps commanders across the range of military operations by collecting, analyzing, fusing, tailoring, and disseminating intelligence to the right place at the right time for key decision making. Intelligence provides indications of enemy intentions and guides decisions on how, when, and where to engage enemy forces to achieve the commander's objectives. It assists in combat assessment through munitions effects assessment and bomb damage assessment.

Intelligence organizations integrate technical and quantitative assessments with analytical judgments based on detailed knowledge of the way the enemy thinks and operates. Intelligence personnel also must maintain an independent perspective. Commanders anticipate that even the best intelligence may not provide a complete picture, especially when the enemy is practicing deception or when the intelligence is derived from a single source. Still, intelligence gives commanders the best available estimate of enemy capabilities, COGs, and courses of action. An example intelligence asset is the MQ–1 Predator UAV. Over the years, it has proven itself to be a valuable instrument for the gathering of intelligence information.

Surveillance

Surveillance is the function of systematically observing air, space, surface, or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means. Surveillance is a continuing process, not oriented to a specific "target." In response to the requirements of military forces, surveillance must be designed to provide warning of enemy initiatives and threats and to detect changes in enemy activities. Air- and space-based surveillance assets exploit elevation to detect enemy initiatives at long range. For example, its extreme elevation makes space-based missile launch detection and tracking indispensable for defense against ballistic missile attack. Surveillance assets are now essential to national and theater defense and to the security of air, space, subsurface, and surface forces.

Reconnaissance

Reconnaissance complements surveillance in obtaining, by visual observation or other detection methods, specific information about the activities and resources of an enemy or potential enemy; or in securing data concerning the meteorological, hydrographic, or geographic characteristics of a particular area. Reconnaissance generally has a time constraint associated with the tasking. Collection capabilities, including airborne and space-based systems that are manned and unmanned, and their associated support systems are tailored to provide the flexibility, responsiveness, versatility, and mobility required by the strenuous demands of fluid, global taskings. Intelligence critical to the prosecution of current combat operations is evaluated and transmitted in near real time to those elements having a need for that information. Reconnaissance forces such as SOWT possess multiple and diverse capabilities. Because these capabilities are valuable across all levels of war, their specific employment at any one level should consider possible effects on other levels. Intelligence, surveillance, and reconnaissance must operate together, enabling commanders to preserve forces, achieve economies, and accomplish campaign objectives. They are integral to gaining and maintaining information superiority.

Combat search and rescue

Combat search and rescue (CSAR) is an integral part of US combat operations and must be considered across the range of military operations. CSAR consists of those air operations conducted to recover distressed personnel during wartime or MOOTW. It is a key element in sustaining the morale, cohesion, and fighting capability of friendly forces. It preserves critical combat resources and denies the enemy potential sources of intelligence. Although all US Air Force weapon systems have the inherent capability to support CSAR operations, certain forces such as Pararescue and Special Forces medics are specifically dedicated for search, rescue, and recovery operations.

Navigation and positioning

The function of navigation and positioning is to provide accurate location and time of reference in support of strategic, operational, and tactical operations. For example, space-based systems provide the Global Positioning System, airborne-based systems provide air-to-surface radar, and ground-based systems provide various navigation aids. Navigation and positioning help air forces by: accurate rendezvous for air refueling; synchronization of effort via a common timing capability; and position, location, and velocity for accurate weapons delivery, ingress/egress, as well as search and rescue. Navigation and positioning are key elements of information superiority and global awareness.

Weather services

Weather services provided by the Air Force supply timely and accurate environmental information, including both space environment and atmospheric weather, to commanders for their objectives and plans at the strategic, operational, and tactical levels. It gathers, analyzes, and provides meteorological data for mission planning and execution. Environmental information is integral to the decision process and timing for employing forces and planning and conducting air, ground, and space launch operations. Weather services also influence the selection of targets, routes, weapon systems, and delivery tactics, and are a key element of information superiority.

005. Army background information

The Army’s primary mission is to organize, train, and equip forces to conduct prompt and sustained land combat operations. It is the Army’s ability to react promptly and to conduct sustained land combat operations that make it decisive. The Army is competent in many areas, such as nation assistance, counter-drug operations, security assistance, deterrence, and stability operations that combine with other elements of national power to achieve strategic effects favorable to US interests around the world. The Army’s capabilities provide the nation a diverse, deployable, and sustainable set of options that include strategic and operational logistics and communications capabilities. Before we begin looking at the Army’s operational tactics, otherwise called combat functions, let’s go over some background information on the Army’s organization structure. This information will assist you in providing weather support for the land operational tactics that your Army customer employs.

Army’s organizational structure

The Army’s organizational structure is divided into many different types of formations. As you read through this section, please note that the symbol is displayed with the information for each organizational level in the US Army.

Theater

There are six major Army commands (MACOM) and one Army ground component command, which is part of a multination Combined Forces Command (CFC), designated as *Theater* commands.

US Army Forces Command

US Army Forces Command (FORSCOM) is the Army's largest major command. Headquartered at Fort Bragg, North Carolina, and consisting of more than 750,000 active Army, US Army Reserve and Army National Guard soldiers. FORSCOM's mission is to train, mobilize, deploy and sustain combat ready forces capable of responding rapidly to crises worldwide. FORSCOM trains and equips forces for all Unified Combatant Commands.

US Army Central

US Army Central (USARCENT) headquartered at Shaw AFB, SC commands Army forces in the area of responsibility of the US Central Command (USCENTCOM). USARCENT covers 21 different countries, and has been the busiest of the Army MACOM's with a consistent deployed force in place since 7 August 1990.

US Army in Europe

US Army in Europe (USAREUR) headquartered at Campbell Barracks in Heidelberg, Germany commands Army forces in the area of responsibility of the US European Command (USEUCOM). USAREUR was involved in the planning, implementation, and provision of troops for operations in Macedonia, Hungary, Bosnia, and Croatia.

US Army Pacific

US Army Pacific (USARPAC) serves as the Army Component Command to Commander, US Pacific Command (USPACOM/CC), less the geographical area of Korea, and for matters of Commander of US Navy, Pacific Fleet concern beyond the exclusive authority or transcending the geographical area of Commander, Eighth US Army. USARPAC commands and supports assigned and attached active US Army and US Army Reserve units, installations, and activities in Alaska, Hawaii, Japan, and in possessions and trust territories administered by the United States in US Pacific Command (USPACOM).

US Army South

US Army South (USARSO), headquartered at Fort Sam Houston, Texas is a MACOM serving as the United States Southern Command's (USSOUTHCOM) Army component with an area of operation that encompasses 19 Latin American nations from Guatemala to Argentina. This area of operation is roughly 22 percent of the earth's land surface. As the US Army's smallest MACOM; USARSO's missions are among the most challenging in military operations.

US Army Africa

US Army Africa (USARAF), headquartered at Vicenza, Italy is a MACOM serving as the United States Africa Command's (USAFRICOM) Army component. The area of operation includes 52 African States, more than 800 ethnic groups, over 1000 languages, and a diverse geography three and a half times the size of the continental United States. Established in 2008, it is our newest regional combatant command.

US Forces Korea

US forces and Republic of Korea (ROK) forces are partners in operating the Republic of Korea (ROK)/US CFC. The integrated headquarters established by the two governments is responsible for planning the defense of the ROK and, if necessary, directing the ROK/US combat forces to defeat enemy aggression. US Forces Korea (USFKO) is the joint headquarters through which American combat forces would be sent to the CFC's fighting components by ground, air, naval and marine forces component commands. Major USFKO elements include Eighth US Army, US Air Forces Korea, and US Naval Forces Korea.

Army

Normally, the senior tactical headquarters of the Army in the field is the corps. However, under certain circumstances, a tactical headquarters may be required above the corps. Such circumstances might include the following:

- Commitment of a sizable number of corps on a large land mass.
- A wide dispersion of forces.
- Instances where political or geographical conditions dictate wide variation in the nature of operational functions leaving responsibility for logistics, administration, and area control in the hands of the theater Army commander.

When circumstances like these arise, Army forces are combined into a numbered *Army*, such as the Fifth US Army or the Eighth US Army.

Corps

Corps is the Army's largest tactical unit, the instruments with which higher echelons of command conduct maneuver at the operational level. Corps is tailored for the theater and mission for which they are deployed. Once tailored, however, they contain all the combat, combat support (CS) and combat service support (CSS) capabilities required to sustain operations for a considerable period. Lieutenant generals command corps.

A corps plans and conducts major operations and battles. They synchronize tactical activities including the maneuver of their divisions, the fires of their artillery units and supporting aerial forces, and the actions of their CS and CSS units. While corps normally fights as part of a larger force, they may also be employed alone, either as an independent ground force or as the Army or land component of a joint task force (JTF). When employed alone, they may exercise operational as well as tactical responsibilities.

Corps may be assigned divisions of any type required by the theater and the mission. They possess organic support commands (Corps Support Command—COSCOM) and are assigned combat and CS organizations based on their needs for a specific operation. Armored cavalry regiments, field artillery brigades, engineer brigades, air defense artillery brigades, and aviation brigades are the nondivisional units commonly available to the corps to weight its main effort and to perform special combat functions. Separate infantry or armor brigades may also be assigned to corps. Signal brigades, military intelligence (MI) groups, and military police groups are the usual CS organizations present in a corps. Other units such as psychological operations battalions, Army special operations forces, and civil affairs units may be assigned to corps when required.

The corps staff is concerned with CS, and CSS functions. Primary emphasis is on planning and coordinating combat and CS command. The organization of the coordinating staff group parallels five broad fields of interest. Coordinating staff officers are designated as follows:

1. Assistant chief of staff (ACOFS), G1 (Personnel).
2. ACOFS, G2 (Intelligence).
3. ACOFS, G3 (Operations).
4. ACOFS, G4 (Logistics).
5. ACOFS, G5 (Civil-Military Operations).
6. ACOFS, G6 (Communications/Information Systems).

At the corps level, weather support is aligned with Army G2. G2 staff and WF work together to provide corps command staff with military intelligence and weather information.

Divisions

Major generals normally command divisions. They are fixed, combined arms organizations of 8 to 11 maneuver battalions, 3 to 4 field artillery battalions, and other combat, CS, and CSS units. Capable of performing any tactical mission and designed to be largely self-sustaining, divisions are the basic units of maneuver at the tactical level. Divisions possess great flexibility. They tailor their brigades and attached forces for specific combat missions. These CS and CSS battalions and separate companies may be attached to or placed in support of brigades for the performance of a particular mission.

Divisions perform major tactical operations for the corps and can conduct sustained battles and engagements. They almost never direct actions at the operational level (campaigns or major operations), but corps may use them to perform tasks of operational importance. These may include exploiting tactical advantages to seize objectives in depth, moving to gain contact with enemy forces, or moving by air to seize objectives behind an enemy force.

The Army’s organizational concept embraces six types of divisions—infantry, light infantry, mechanized infantry, armored, airborne, and air assault. Adding a varying number, forms the divisions and mixtures of combat maneuver battalions-infantry, light infantry, mechanized infantry, tank, airborne, or air assault to a common division base. The division base, which is essentially the same in all types of divisions, includes the command and control, reconnaissance, CS such as artistry, air defense, intelligence, aviation, signal, engineers, and combat service support element (CSSE). Among the command and control elements are brigade headquarters, which control the tactical operations of several attached maneuver battalions as determined by the division commander.

A Division Support Command (DISCOM) provides combat service support. It provides supply, transportation, field maintenance, medical support, and administrative services to the division. DISCOMs are organized differently to best satisfy the support needs of each division. Divisions are supported administratively and logistically by COSCOMs, which are responsible for the centralized management of supplies, maintenance, and movement of personnel and materiel beyond the capability of the divisions.

The theater Army, combining several principles of modern service management and automatic batch processing, completes the functional organization at all levels. This ensures the maximum degree of responsiveness, efficiency, and economy in providing combat service support. The Army maintains four active corps headquarters, 10 active divisions (six heavy and four light), and two active armored cavalry regiments. Light forces—airborne, air assault, and light infantry divisions—are tailored for forcible-entry operations and for operations on restricted terrain, like mountains, jungles, and urban areas.

Heavy forces—armored and mechanized divisions equipped with Abrams tanks, Bradley fighting vehicles, Apache attack helicopters, and the Paladin field artillery system—are trained and equipped for operations against armies employing modern tanks and armored fighting vehicles. Light and heavy forces can operate independently or in combination, providing the mix of combat power needed for specific contingencies.

The organization of division staff is similar to corps (G1, G2, G3, and etc.). Also like the corps, WFs are aligned with the division G2 for staff weather support.

Brigades

Brigade-sized units are normally commanded by colonels but may, as in the case of separate brigades, be commanded by brigadier generals, who control two or more battalions. Their capabilities for self-support and independent action vary considerably with the type of brigade. Maneuver brigades are the major combat units of all types of divisions. They can also be organized as separate units.

While separate brigades have a fixed organization, division commanders establish the organization of their brigades and change their organizations as frequently as necessary for mission accomplishment. The only permanent unit assigned to a brigade is its headquarters and headquarters company (HHC). They can employ any combination of maneuver battalions and are normally supported by field artillery battalions, aviation units, and by smaller combat, CS, and CSS units. Brigades combine the efforts of their battalions and companies to fight engagements and to perform major tactical tasks in division battles. Their chief tactical responsibility is synchronizing the plans and actions of their subordinate units to accomplish a single task for the division or corps.

The primary mission of the brigade is to deploy on short notice and destroy, capture, or repel enemy forces, using maneuver and shock effect. Armored and mechanized brigades are organized to fight successful engagements in conventional and various MOOTW activities. Brigades also conduct various MOOTW activities, independently or as part of a joint or multinational headquarters in peacetime and conflict environments. They are subordinate commands of a division and corps and perform major tactical operations as part of a division or corps operation.

Other combat, CS, and CSS brigades are organized to control nondivisional units for corps and larger units. Engineer, air defense artillery, signal, aviation, military police, and transportation brigades are typical of such units. They may also be the building blocks of large unit support such as corps support commands and of CS commands such as engineer commands. Divisions are supported by an organic brigade-sized support command of mixed CSS battalions and companies.

The staff organization of a brigade remains similar to corps and divisions except instead of a “G” in front of the number; an “S” is used. The staff organization is as follows:

1. Personnel officer, S1.
2. Intelligence officer, S2.
3. Operations and training officer, S3.
4. Logistics officer, S4.
5. Civil-military operations officer, S5.
6. Communications officer, S6.

WF personnel at the brigade level are aligned with the S2. WFs, in general, do not deploy with Army echelons below the brigade level. In most circumstances, levels of command below the brigade level will coordinate with the brigade S2 and WF for weather support they require. There are times when weather personnel will deploy with units below the brigade level; however, this is generally in support of Army special operations.

Group/regiment

Below the brigade level are groups and regiments. A group is a brigade-sized unit normally commanded by a colonel. Colonels, who control two or more battalions, normally command regiments.

Groups

CSS brigades and groups are organized to control nondivisional units for corps and larger units. Engineer, air defense artillery, signal, aviation, military police, Special Forces and transportation brigades are typical of such units. They may also be the building blocks of large unit support such as corps support commands and of CS commands such as engineer commands. Divisions are supported by an organic brigade-sized support command of mixed CSS battalions and companies. There are two types of Army groups, area support groups and combat equipment groups.

Regiments

Their capabilities for self-support and independent action vary considerably with the type of regiment. Armored cavalry regiments, which have a fixed organization, combine the efforts of their battalions and companies to fight engagements and to perform major tactical tasks in division battles. Their chief tactical responsibility is synchronizing the plans and actions of their subordinate units to accomplish a single task for the division or corps. Aviation and armored cavalry regiments can be used to reinforce corps or divisions and can be shifted from unit to unit to tailor forces for combat. Regiments are usually employed as integral units when attached to corps or divisions.

Battalion/squadron

Below groups and regiments are battalions and squadrons. Battalions consist of two or more company-sized units and a headquarters. Cavalry squadrons consist of two or more company-sized units and a headquarters.

Battalions

Most battalions are organized by branch, arm, or service and, in addition to a typical compliment of three to five operational companies, contain a headquarters company that gives them the ability to perform some administrative and logistic services.

Combat arms battalions are designed to perform single tactical missions as part of a brigade’s tactical operations. Battalions attack, defend, delay, or move to assume new missions. Field artillery battalions fire in support of any of these missions. Maneuver battalions can be reinforced with other combat and CS companies to form task forces for special missions, to tailor the force to match the mission. Field artillery battalions can be reinforced with batteries of any kind to form artillery task forces.

Engineer, air defense artillery (ADA), and signal battalions assigned to or supporting divisions normally operate throughout the division area of operations. Their commanders also perform additional duties as division special staff officers (for example, the military police battalion commander is also the division provost marshal). CS and CSS battalions vary widely in type and organization. They may be separate divisional or nondivisional battalions but, in any case, they normally perform functional services for a larger supported unit within that unit’s area of operations.

All battalions, regardless of type, have at least two things in common: they are capable of at least limited, short-term self-defense and they are all generally commanded by lieutenant colonels. The maneuver battalions have similar organizational structures that vary only to fit their individual roles. The battalions are tactically self-sufficient and each battalion is of essentially one combat arm (e.g., infantry in the mechanized infantry battalions).

The battalions are capable of cross-attachment of companies of different types to form battalion-level task forces for particular missions. The number and type of maneuver battalions vary with the nature of the divisions. Normally, an armored division will have more tank battalions than mechanized infantry battalions, while a mechanized infantry division will have a greater proportion of mechanized infantry battalions. An infantry division consists predominantly of infantry battalions with some tank battalions and mechanized infantry battalions, as required. Any division, however, could have all three types of battalions if the mission and operational environment so required.

The battalion is the lowest echelon at which firepower, maneuver, intelligence, and support are combined under a single commander. Battalions normally fight enemy forces they can see and engage—this defines an area of operations extending from less than 100 meters in forests, urban areas, or close terrain, out to about 5 to 6 kilometers from the battalion’s direct and indirect fire weapon systems.

During the offense, the battalion task force is expected to defeat a defending enemy company. During the defense, the battalion task force is expected to defend against and defeat a threat regiment. The battalion has no deep fight, but may be charged with the execution of the fight against follow-on enemy battalions. The battalion normally designates a company-size reserve as a counterattack force.

A tank or mechanized infantry battalion consists of pure companies under the command of a battalion headquarters. The capability of the tank and mechanized infantry battalions is increased through task organization. Based on an estimate of the situation, the brigade commander task-organizes tank and mechanized infantry battalions by cross-attaching companies between these units. As a rule, cross-attachment is done at battalion, because battalion has the necessary command and control and support capabilities to employ combined arms formations. The brigade commander determines the mix of companies in a task force.

Squadrons

Most squadrons, in addition to a typical compliment of three to five operational companies, contain a headquarters company that gives them the ability to perform some administrative and logistic services.

The cavalry squadron conducts detailed ground reconnaissance and surveillance within and as necessary to the front, flanks, and rear of the division on a mission basis. It facilitates command and control for the division commander, reporting information in an electronic countermeasure or nuclear, biological, and chemical environment that is essential in order to maintain a positive command link between the division commander and brigade commanders. It conducts internal surveillance and reconnaissance to facilitate rear battle operations, as well as planning to conduct these operations, and conducts continuous radiological monitoring and survey and chemical detection.

The aviation cavalry (CAV) squadron, which serves as the eyes and ears of the division, is a unit of the aviation brigade that is common to all heavy and light active divisions throughout the Army. The CAV conducts reconnaissance, screens, and command and control enhancement missions. The squadron consists of a headquarters and headquarters troop, two ground cavalry troops, and two air reconnaissance troops.

Company/battery/troop

Below groups and regiments are companies, batteries, and troops.

Companies

Captains normally command company-sized units. They consist of two or more platoons, usually of the same type, a headquarters, and, in some cases, a limited self-support capability. Companies are the basic elements of all battalions. They are also assigned as separate units of brigades and larger organizations (for example, the brigade or division headquarters company). All close combat companies can fight massed or by separate platoons.

In infantry, armor, and attack helicopter battalions, companies normally fight as integral units. Attack helicopter companies more frequently fight with their platoons in separate zones, sectors, or areas. Company-sized close combat units are capable of fighting without additional reinforcements but they are normally augmented with such units as short-range air defense (SHORAD) teams. They may also be reinforced with maneuver platoons of the same or different types and with engineer squads or platoons to form company teams. The formation of company teams allows tailoring forces for a particular mission. Combat engineer companies control three or four engineer platoons. Their own battalion may employ them in a variety of tasks or they may support maneuver brigades or battalions. Separate brigades and regiments usually have an assigned combat engineer company. Most other CS and CSS units are formed as companies.

Batteries

Field artillery batteries are the basic firing units of field artillery battalions. They are normally commanded by captains, and are organized with a firing battery, a battery headquarters, and limited support sections. They may fire and move together or by platoon. Normally, batteries fight as part of their parent battalion. In some cases, however, they respond directly to a maneuver battalion or company. Multiple launch rocket, lance, and pershing batteries will more often operate independently than cannon artillery batteries. Armored cavalry squadrons have organic howitzer batteries. Air defense artillery batteries operate as the fighting elements of air defense artillery (ADA) battalions or, if they are SHORAD batteries, in direct support of maneuver brigades or battalions. Separate SHORAD batteries exist in separate brigade-sized organizations.

The focal point of the field artillery is the line of metal—the firing batteries of field artillery battalions. Firing platoons, commanded by field artillery lieutenants, and firing batteries, commanded by field artillery captains, and run by their lieutenant executive officers, are the delivery units for an impressive array of artillery munitions. All other efforts of the field artillery team, fire support, target acquisition, and fire direction elements serve but one purpose—to help the firing units place responsive, accurate, and lethal fires on target. Such fires can impact from just in front of friendly troops to more than 100 miles into hostile territory. The howitzers and rockets are the muscle of the field artillery—the hard-hitting hardware of fire support.

Troops

Cavalry troops are company-sized units, normally commanded by captains. They consist of two or more platoons, usually of the same type, a headquarters, and, in some cases, a limited self-support capability. Cavalry troops are the basic elements of all squadrons. Cavalry troops frequently fight with their platoons in separate zones, sectors, or areas. Cavalry troops are capable of fighting without additional reinforcements but they are normally augmented with such units as SHORAD teams. They may also be reinforced with maneuver platoons of the same or different types and with engineer squads or platoons to form teams. The formation of teams allows tailoring forces for a particular mission.

Platoon/detachment

The next level down is platoons and detachments.

Platoons

Platoons consist of two or more squads, sections, or crews. In armor, a platoon consists of five tank crews, in infantry; a platoon consists of three rifle squads and a weapons squad or section. Lieutenants lead most platoons, and the second-in-command is generally a sergeant first class.

The light armor platoon consists of four M8 light tanks and 12 personnel organized into two sections of two M8s each. Although the light armor platoon is an integral part of the light armor company, it is capable of detaching from the company and then operating with a light infantry battalion. When the platoon operates with its parent light armor company, its fundamental employment is similar to that of an armor platoon.

Detachments

Detachments are platoon-sized units that are normally commanded by lieutenants. The long-range surveillance detachment (LRSD) is organized as a detachment organic to the MI battalion at division level. The LRSDs are organized into a headquarters section, communications section (two base radio stations), and six surveillance teams. (Light division LRS detachments only have four surveillance teams.) The leaders are airborne and ranger qualified. All other personnel in the detachment are airborne qualified.

Squads/sections

Squads and sections are generally the smallest organizations in tactical units. While size can vary greatly, most range from 10 or 12 soldiers, as in a rifle squad or mortar section. Generally, staff sergeants are the leaders of squads and sections.

Now that you have an understanding of the organization of the Army, let’s move on to the land operational tactics they employ.

006. Land operational tactics

In this section on land operational tactics, you’ll learn about the range of military operations and how the Army functions on the battlefield.

The range of military operations

The United States seeks to achieve its strategic objectives in three diverse environments—peacetime, conflict, and war—using all the elements of national power.

Peacetime and conflict

The Army classifies its activities during *peacetime* and *conflict* as military operations other than war. During *peacetime*, the United States attempts to influence world events through those actions that routinely occur between nations. *Conflict* is characterized by hostilities to secure strategic objectives.

War

The last environment, that of war, involves the use of force in combat operations against an armed enemy. Often the Army will operate in all three environments at once. Whichever environment the Army conducts operations; a commander uses a variety of combat functions to build and sustain combat power. The Army employs its lethal combat power in the land battle.

The land battle

The land battle is an extended, integrated battle involving the use of all available Army forces, both air and land forces. It is extended because the battle is fought from the rear boundary out to the range of available weapons as a single, continuous battle. It is integrated in that nuclear and chemical weapons are merged with electronic and conventional weapons in all operations and plans. The use of nuclear and chemical weapons depends on the tactical situation and requires a release from the NCA.

Inherent to the battlefield is the simultaneous fighting of deep, close in, and rear operations. The need for deep attack emerges from two key conditions. They are:

- The nature of our potential enemy’s doctrine. An enemy’s doctrine encompasses how they fight. If the enemy is free from deep attack, they remain at full strength and can attack the United States according to their doctrine.
- The need for numerical superiority. By destroying the enemy’s forces deep in the battlefield, the Army can achieve a numerical superiority.

In all three types of operations—deep, close in, and rear—the Army’s objectives in battle are to:

- Gain a degree of manipulative control over enemy follow-on forces.
- Destroy enemy combat power before they can join in the close-in operations in the defense.
- Carry the battle to the enemy’s depth through bold but calculated offensive operations.

Army commanders on the battlefield achieve these three objectives.

The battlefield

Commanders consider the battlefield in terms of the time and space necessary to defeat the enemy force or to complete the assigned mission. Time is the first consideration and must be related to a battlefield area so commanders can direct their reconnaissance, surveillance, and target acquisition resources to identify targets and threats. In terms of space, commanders view the battlefield as two distinct areas, which are the AO and AI. The AO, as you may recall from earlier reading in this unit, is a geographical area assigned to commanders for which they have responsibility and for which they have authority to conduct military operations. The AI is an area of concern to the commander that encompasses adjacent areas and areas occupied by enemy forces that could jeopardize the mission.

Army component responsibilities

Each echelon of command in the Army has a range of responsibilities while fighting in the rear, close in, and/or deep operations at its own level. Weather support requirements are different at each level and must be tailored to meet the scale and time for the AO and AI.

Echelons above corps

If you recall from reading the earlier background information, there are times when an Army headquarters exists between the theater and the corps echelon. This may occur when:

- Several corps are employed.
- There is a dispersion of forces.

- Political or geographical conditions dictate wide variations in the nature of operations.

The echelons above corps (EAC) commander directs the operational level of warfare. Overcoming the enemy's initial numerical advantage must begin at the highest level. EAC is responsible for skillful employment of long-range assets, including:

- Airpower.
- Movement of reinforcing forces into the battle area.
- CSS activities supporting the operations of deployed corps.

Enemy forces and their nuclear delivery systems must be located and destroyed before they can affect close-in operations. EAC commanders must see the enemy forces that will affect friendly operations up to 96 hours and beyond. To see the battlefield enables commanders to make timely decisions to effectively employ friendly forces and long-range weapon systems.

Several operational work centers may exist to support EAC responsibilities. The EAC structure depends on the theater and level of conflict. Geographically separated C2 centers may exist at EAC main, rear, alternate, and EAC intelligence centers (EACIC). The EACIC is the hub of theater intelligence and normally is part of the EAC MI brigade.

In terms of weather support, EAC commanders need to know the following:

- Current and forecast weather condition effects and impacts in their AO and AI and logistical points of embarkation and debarkation.
- A general overview of weather effects on subordinate commands and the weather impacts on tactical air support and tactical and strategic airlift.
- Seasonal conditions and climatology that affects their campaigns across the theater.
- The plan for the next season and how the combination of terrain and weather will limit or enhance their capabilities. Historical climatological studies for the theater of operations to ensure operations plans include general weather effects on weapon systems, maneuver, logistics, personnel, and the use of aviation and CAS assets.

Corps

The corps is the highest tactical echelon. The corps directs, coordinates, and allocates resources for operations in its AO up to 72 hours in the future. Corps generally conducts offensive operations by:

- Massing fires or forces against enemy flanks, gaps, or rear.
- Seeking to avoid enemy strength.
- Going against enemy weak areas.
- Using economy of force in areas from which forces have been drawn.

While divisions normally attack first- and second-echelon defenses, corps plans and conducts operations against deeper defensive echelons, reserves, and reinforcing forces. Corps interdicts second-echelon enemy divisions of first-echelon armies to delay and disrupt those forces before they can join the battle. Corps directs the air land battle and provides security for the rear area.

In terms of weather support, corps commanders require interpretation on how weather affects engaging forces in the AO during the next 72 hours. In addition, corps commanders need to know current observed weather conditions and forecasts for their AI out to 96 hours in order to:

- Judge the weather affects on the enemy plans and movement.
- Assess the effects on their systems and tactic.
- Adjust their planning.

Corps commanders also need forecasts of conditions limiting ground and air movement from aerial and sea points of debarkation to support logistical efforts. These same type forecasts are provided to divisions, but for corps, the forecasts is expanded in time and space to support corps combat operations such as artillery and aviation assets.

Divisions

Divisions are the basic units of maneuver at the tactical level. They possess great flexibility and tailor their brigades for specific missions. Designed to be largely self-sustaining, portions of their CS and CSS battalions and separate companies may be attached to or placed in support of brigades for the performance of a particular mission. At the direction of the corps, divisions perform major tactical operations and conduct sustained battles and engagements.

Significant planning activities take place at the division level to direct subordinate brigades against first-echelon regiments; this is done while interdicting enemy second-echelon regiments and follow-on divisions with long-range artillery, maneuver, and aviation assets. Normally, there are three separate battle-planning centers at each division:

1. The current close-in operation is supervised at the forward tactical command post (CP) under the supervision of the assistant division commander for maneuver.
2. Rear operations are supervised at the division rear CP under the supervision of the assistant division commander for support.
3. Deep operations and planning for sustained division operations are conducted at the division main CP.

The division planning staff needs tailored weather forecasts and current observations for synchronizing the combat power components into a comprehensive plan for battle. Detailed, accurate weather information and the effects of the environment on weapon systems, tactics, and logistics are required to conduct and direct operations and to plan for future operations.

Division artillery requires observations and forecasts for the tactical fire (TACFIRE) direction computer system. In compliment with the division's cannon artillery is the multiple launch rocket system (MLRS). MLRS is a versatile weapon system that supplements traditional cannon artillery fires by delivering large volumes of firepower in a short time against critical, time-sensitive targets. These targets often include enemy artillery, air defense systems, mechanized units, and personnel. MLRS units can use their system's "shoot and scoot" capability to survive while providing fire support for attacking maneuver elements.

Within the division, there are many sections that will use the weather information provided by WFs. Chemical teams need data for chemical and nuclear support planning. All divisions need illumination forecasts for night vision devices.

Many divisions require more tailored weather information, such as heavy divisions. Heavy divisions are especially concerned with weather affecting trafficability, thermal sights, laser range finders, and aviation.

Air assault divisions are mostly concerned with weather affecting aircraft operations. Light infantry divisions are more concerned with visibility and illumination as well as weather conditions affecting the individual soldier and mobility on foot. Some divisions have areas of specialization such as cold weather, desert, and mountain operations that require tailored support.

As a weather journeyman in support of Army forces, you provide weather services to the three major categories of Army divisions. They are as follows:

- Heavy division (armored or mechanized).
- Airborne division.
- Infantry division (motorized).

Heavy divisions (armored or mechanized)

Heavy divisions are a mixture of tank and mechanized infantry battalions. Armored divisions have six tank battalions and four mechanized infantry battalions. Mechanized divisions have a mix of five tank and five mechanized infantry battalions. The mission of the M1A2 Abrams main battle tank (MBT) is to close with and destroy enemy forces using firepower, maneuver, and shock effect.

Heavy divisions have large amounts of mobile, armor-protected firepower. Because of mobility, survivability, and firepower, the heavy divisions are normally employed where battles are fought over wide areas against a threat with similar capabilities. During offensive operations, heavy divisions move rapidly, concentrate overwhelming combat power against the threat, break through the threat's defenses, and then strike deep to destroy the threat's field artillery. The heavy divisions operate best in open terrain where they can move quickly and can use their long-range direct fire weapons to their best advantage. The heavy divisions are not designed to operate in jungles, dense forests or mountains; generally, infantry is most often used in these areas. Large cities or towns and built-up areas also restrict operations of heavy divisions; although in Europe, these divisions operate in built-up areas from time to time.

Airborne division

The airborne division is organized to be rapidly deployed anywhere in the world to:

- Secure critical installations or facilities.
- Reinforce allied forces and us.
- Conduct a show of force.

This division can conduct a parachute assault in the threat's rear to secure terrain or to interdict routes of resupply or threat withdrawal. It can also conduct air assault operations as well as other missions normally assigned to infantry divisions

Airborne operations are most often joint operations with the US Air Force, which provides the airlift, close air support, and aerial resupply for the airborne forces. Normally, units participating in an airborne operation are assigned to a JTF. Naval air and naval gunfire may support airborne operations, if the operational area is within range. Airborne operations are generally executed in two phases: assault and defense. In the assault phase, Air Force aircraft transport division units to the operational area to conduct a parachute assault. Before and during the assault, close air support, naval gunfire, or both deliver supporting fires. After the parachute assault, units assemble and seize assault objectives. Artillery begins providing fire support as soon as possible after landing. Close air support continues with priority to armor and forces beyond artillery range. Additional units are air landed as landing zones are secured. The defense phase begins when assault objectives are seized. An all-ground defense is organized when the force is in threat-occupied territory. The division masses and then conducts operations in the same manner as the infantry division. Airborne operations usually end on linkup or extraction of the division.

Infantry division (motorized)

The infantry division (motorized) was organized to meet the security demands of the dynamic and potentially volatile international environment, and to be highly flexible and strategically responsive across a broad spectrum of conflict. It is organized, equipped, and trained for combat in desert and arid mountainous areas and it retains the utility to respond to appropriate missions from North Atlantic Treaty Organization (NATO) or to provide increased mobility and firepower in a low-intensity conflict.

The infantry division (motorized) is a lethal, flexible, and versatile fighting force capable of responding quickly to crisis situations. The division is organized for responsive deployment, immediate combat operations upon arrival in any conflict environment, and quick retrieval from the operational area after the mission is completed. To meet a worst-case armored threat, the division is organized around combined arms battalions equipped with a substantial number of long-range antiarmor weapons. These weapons can be maneuvered quickly about the integrated battlefield using organic air and ground mobility. Whether on foot or mounted in vehicle, the Army's infantry is a lethal force on the battlefield.

The division maintains the capability to see far enough into the battlefield to execute operations and influence the air land battle. It achieves maximum combat effectiveness including survivability through force mobility, system agility, distribution of C2, and force-oriented tactics emphasizing indirect approaches and standoff attacks. The division also operates widely dispersed and relies on deception to mask its location and intentions. Such dispersion and the nature of the maneuver battle requires that motorized units be organized on a combined arms basis and deploy in conjunction with heavy divisions. The division can also accept air assault, airborne, infantry, and armor units with appropriate CS and CSS slices.

All Army divisions, including the three different types of infantry divisions described here are made up of division maneuver brigades.

Division maneuver brigades

Division maneuver brigades are the major combat units of all types of divisions. They control two or more battalions. Capabilities for self-support and independent action vary with the type of brigade. It is in the brigade AO where friendly forces must gain the initiative and destroy enemy forces. Brigades direct, coordinate, and support operations against enemy first-echelon regiments and interdict second-echelon battalions of first-echelon regiments.

Brigades are concerned primarily with current weather conditions and weather that will affect operations during the next 12 hours. Current and near-term conditions are more important to today's battle; the outcome will play a major role in future planning. Division WFs ensure brigade commanders are updated on current weather observations and provided timely weather forecasts.

Separate brigades and armored cavalry regiments

Separate brigades and armored cavalry regiments (ACR) can be used to reinforce corps or divisions and can be shifted to tailor forces for combat. They are employed as units when attached to corps or divisions. Separate brigades provide corps commanders with the assets to execute several missions, especially deep operations. ACRs engage in the battle early in the covering force area (CFA) and are very mobile. ACRs have assigned aviation assets that magnify the scope of operations they can perform.

ACRs and separate brigades require dedicated weather support similar to divisions because they operate as corps assets. Their AO and AI vary with their missions but normally coincide with that of a division or brigade, depending on how they are employed.

SOF

SOF is normally employed at the direction of EAC. They may deploy before announced hostilities and often operate in a stand-alone mode. Large distances may exist between the group headquarters and subordinate battalions at forward operating bases (FOB). Battalions may deploy teams over continent-sized operational areas for special missions deep in enemy territory. Most SOF operations will have SOWT personnel assigned. The assigned SOWT will handle all WX requirements but will likely coordinate with the WF on generalized and nonspecific forecasts. SOWT coordination is general and nonspecific because of classification issues.

The SOF requires independent, direct weather support for long-range planning, mission execution, and resupply operations. Support must be tailored to:

- The unique weapon systems.
- Particular mission objectives.
- Aviation requirements.
- Infiltration, exfiltration, and resupply operations.

Time and space considerations are often similar to the EAC AO and AI with particular attention to specific geographical points and routes.

Aviation brigades

Aviation brigades are part of each corps and division. Operations are similar for corps and division aviation brigades, except the division's AO planning timeframe is shorter. Deep, close, and rear operational missions include:

- Direct attack.
- Air insertion or extraction.
- Resupply.
- Reconnaissance.

Aviation brigades receive mission taskings from their respective corps or division to employ support or attack aircraft. However, they independently plan and execute their missions. Single and multiple aircraft missions will also be flown in conjunction with ground and joint operations. Each brigade will have a tactical operations center (TOC) that will be geographically separated from the corps or division TOC. Normally a WF will deploy with the aviation brigade and provide weather support directly from the TOC.

Aviation brigades are especially susceptible to weather factors. Direct, dedicated weather support is required to ensure the optimum employment of these highly technical, weather-sensitive systems. Weather support for aviation brigades should coincide with the corps or division AO and AI versus that of a nonaviation brigade.

Army airspace command and control

Air traffic control (ATC) facilities control supporting rotary wing resupply efforts moving from the corps rear to the forward areas. The main corps WF provides forecasts and observations to the corps airfield, which then relays them to mobile ATC facilities. Careful coordination between ATC and the Space Weather Operations is required to ensure latest forecasts are provided. Weather forecasts made at lower echelons (for example, divisions, ACRs, and separate brigades) are transmitted to the corps WF. The corps WF then passes them to the corps airfield and into the Army airspace command and control (A2C2) system. The WF coordinates to ensure the communications for this linkage are included in communications annexes and all aviation support annexes to the war plans.

Battalions

Battalions fight what they can see and shoot. Their AO normally covers out to about 5 kilometer (km) from the forward line of own troops (FLOT) to meet objectives over the next 3 hours. Battalion commanders need near real-time weather information for their AO and for planning operations for their AI. Normally, battalions will receive their weather information through communication channels down from the division or brigade WF. The Air Force may be organized to provide direct support at Aviation Battalions and Special Operations Battalions headquarters, though this is not required. Rarely do battalions have their own WF assigned.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

004. Aerospace operational tactics

1. What are the three levels that typically divide warfare?

2. At what level are campaigns and major operations planned?

3. With what is defensive counter air synonymous?

4. What are the two functions of counter land?

5. What are the three classifications of airlift?

005. Army background information

1. Normally, what is the Army's largest tactical unit?

2. With who are WF's normally aligned at the brigade level?

3. What is the lowest echelon at which firepower, maneuver, intelligence and support are combined under a single commander?

006. Land operational tactics

1. With what timeframe of weather information are brigades primarily concerned?

2. With what Army unit does a WF normally deploy?

3. Where do WF's normally work when they are deployed with the Army?

1–3. Areas of Operation

Providing weather services for DOD forces requires an extraordinary amount of knowledge and skills. Once you become familiar with the day-to-day routine required at your location, you'll feel comfortable at performing your job. Sometimes your level of comfort may leave you feeling unchallenged. This is especially true when our nation experiences long stretches of peacetime operations. But, what happens when your unit is suddenly tasked for a mobility commitment that you've practiced for, but this time it's for real? Are you going to be tasked with providing weather support for an area unfamiliar to you? Hopefully not! Throughout this unit, you'll learn some of the measures that WFs take to prepare for any crisis that may unfold.

Typically, weather personnel assigned to an operational weather squadron (OWS) are responsible for providing weather support to the WFs that fall within their realm of responsibility. With this in mind, consider how the following lesson applies to both the OWS and WF, but especially the WF.

If you're assigned to an OWS, your unit's role varies significantly from those assigned to a WF. OWS personnel will be deployable and have a deployment window timeframe, but not normally a deployment tasking (except for occasional, small mobility cell). Therefore, the following lessons apply more specifically to responsibilities of the WF.

Familiarization of the area of the world you’re tasked to support determines your success as a deployed weather forecaster. Moreover, your level of success directly relates to your ability to accurately support your customer and contribute to mission success. Let’s take a closer look at the specifics of battlefield area familiarization.

007. Area of operations and interest

Before we can look at areas of interest (AI) or areas of operations (AO), we must first understand the bigger picture and the definition of each term. An AI is a political or geographic region of national interest. An AO is an area or geographic theater where military operations occur. A third term, area of responsibility (AOR) refers to the geographic area that falls under a military unit’s realm of responsibility. The major distinction between an AI and an AO is that an area of interest is a possible location that your unit may deploy to, whereas an area of operations is the area, where once deployed, your supported customer and your deployed unit operates within. Each OWS has an AOR for which they provide support during exercises, contingencies, air and space expeditionary forces (AEF), and wartime operationsMC3. For example, at Shaw AFB, the 28th OWS has an AOR that covers the countries depicted in figure 1–1, known as US Central Command (USCENTCOM). As you can see from figure 1–1, the oversea AOR of the Middle East is quite extensive.

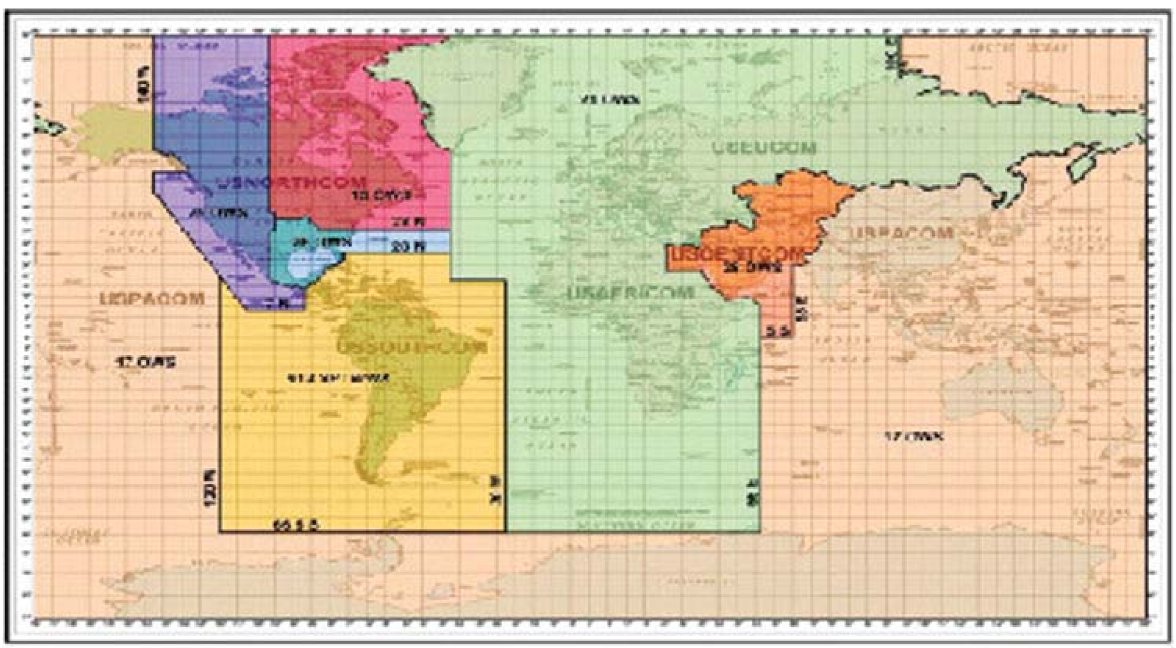

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Figure 1–1. Shaw AFB, CENTCOM AOR.

Within the USCENTCOM AOR, the 28th OWS and each subordinate WF has a specific AI within the CENTCOM AOR. Areas of interest are normally considered areas, countries, or portion of countries where political issues or turmoil are occurring or expected to occur. When the political issues intensify, this sometimes leads to possible military action in the near- or medium-term future within the AI. Keep in mind, as political climate changes over the years, the areas of interest change also. Our national interests are influenced by the policies, doctrine, and perceived threats that a potential adversary may exhibit—and not by our own strengths, weaknesses, or capabilities.

For example, prior to the deployment of forces to Kuwait and the Persian Gulf for Operation Iraqi Freedom, the nation of Iraq was merely an AI. However, as we invaded Iraq in March of 2003, the AI quickly changed to an AO.

Responsibilities

In order to guarantee any level of operational success, all deployable weather personnel must be familiar with the areas of interest and potential areas of operations that they'll most likely support during training exercises, contingencies, AEFs and wartime operations. Familiarization includes becoming familiar with the geography, climate, meteorology, and weather support infrastructure for the area requiring support.

AI/AO familiarization package

Normally, unit commanders and supervisors prepare an AI/AO familiarization package for each location where a unit deploys. In addition, WF's have a requirement to do familiarization packages on the AO's they cover. For effective training, the AI/AO package is incorporated into initial and recurring tactical training. While training for forecasting weather is most effective when "realworld" data is used, consider the fact that frequent requests for that data may divulge information about our interests in the area, especially if nonsecure networks are used. Because of this problem (also cost), "canned data" works best. Therefore, when developing training scenarios to train for the weather regimes in a deployed area, trainers often use canned weather data.

AO/AI packages are a necessary part of any deployment planning. Imagine for a minute if you won a vacation to southern Australia. However, the rules of the sweepstakes state that you're not allowed to look at a map or any information about your prized vacation spot. How enjoyable will your vacation be if you show up ill-prepared for the vacation spots' weather, terrain, and climate? If you show up with Bermuda shorts and t-shirts only to find that it's the Southern Hemispheres' winter, you're not going to be the least bit happy, not to mention comfortable. Similarly, AI/AO familiarization packages help prepare you for the weather climate and patterns, functionality of equipment, and creature comforts that you deal with during and long after your deployment.

Geography familiarization

A major part of the AO/AI familiarization package includes background information on the geography of the area your unit will support when they deploy. At a minimum, geography information should describe the terrain over the deployed area and how the terrain influences the weather patterns for that region. Features such as mountains, vegetation, and bodies of water all have an impact on the overall climate for an area, and may impact synoptic and tertiary weather patterns. In addition, the geography synopsis should also inform you of the living conditions that deployed troops could encounter. Realize that there's a significant difference in the type and amount of planning required for a deployment to the desert versus one to a marshy, wetland area.

Climate familiarization

Today, most climatology (nicknamed climo) data is accessed through 14th Weather Squadron's climate services website. Ideally, your tactical unit should prepare by obtaining whatever climo data is necessary for a worldwide or regional deployment. Never underestimate the uses for climo data, especially when all other communication for new weather information has failed. When such ill-fated events occur, climo data is an excellent starting point for limited-data and short-term forecasting.

Study the climate for the AI/AO, as well as surrounding areas or adjacent countries. For example, it's possible that if you're on an extended deployment, your unit could move long distances. By nature, vast changes in distance by either geography or latitude have significant changes in climate and weather. Never sell yourself on the idea of staying put, especially if you support an Army unit.

Meteorology (weather regime) familiarization

Effective AI/AO packages describe the weather regime for deployed locations. Once developed, this section of information describes every known weather pattern that may affect the area. When WFs are preparing this data, the OWS's have the overall responsibility to assist in the development and review of any AOR-specific data that the WF requires.

Temporary location identifiers (KQ identifiers)

Temporary location (aka KQ) identifiers are necessary to tell others where you unit is. Although the AI/AO packages do not have a list of identifiers for deployed locations, you still need to understand how to obtain KQ identifiers.

Fixed weather units have permanent identifiers that never change (e.g., Fort Bragg is KFBG, Scott AFB is KBLV). Temporary identifiers, however, are normally issued to WFs prior to deployment. The Air Force Weather Agency (AFWA) manages the database and distribution of KQ identifiers to the unified commands or designated service representatives (Army, Air Force, etc.). From there, the identifiers are then issued to deploying units. Once your unit obtains the KQ identifiers, your location and latitude/longitude are then given to the unified command or service representative, and finally is given to HQ AFWA. When the exercise or deployment ends, the KQ identifier goes back in the database.

So far, it’s obvious that preparing for a WF deployment involves quite a bit of planning. Hopefully, you can clearly see that in order to succeed, preparation and AI/AO familiarization is very necessary. Once in place, your unit fine-tunes the familiarization by focusing on your AOR. More importantly, realize that once the political climate at an AI evolves to a real-world threat, your unit inevitably obtains even more AOR-specific data from your OWS.

At this point, you may be wondering just how many AI/AO packages a WF should have and what document specifies the “hot-spots” in the world for which your supported organization is responsible. In the next lesson, we’ll briefly look at a document called an operations plan (OPLAN) and some derivatives that explain details of deployment requirements.

008. Operations plans

An OPLAN is an official document that outlines how each operational unit and its’ supporting subunits align and deploy during a contingency or war. The contents of an OPLAN are broken down into annexes. Each annex contains the different aspects and military units necessary to deploy to the battlefield or contingency area and conduct combat operations. The OPLAN maps out the details of the general nature of how the combat will be conducted. For example, the type of combat may be described as ground, air, or sea operations; deception; psychological operations (PSYOPS); and even nuclear operations, when applicable.

Background information

In order to understand the intent of OPLANs you must understand why they are created. Earlier, you learned that the political climate within an area of responsibility is a factor that determines what specific regions are of interest to our national security. Does that mean that an OPLAN exists for every location in the world? No. It’s a little bit more complex than that.

Joint Operations Planning and Execution System

Joint military planning for national security is conducted under the Joint Operations Planning and Execution System (JOPES). Using JOPES, national security strategists divide national security issues into one of two broad categories; either deliberate planning or crisis action planning. These two categories of planning are also an umbrella for the types of contingency documents that fall under the categories.

Deliberate planning

OPLANs are developed under the deliberate planning process of JOPES. By the term deliberate, the focus is to have a plan of action for predetermined threats to, or interests of the United States. Once military strategists perform a detailed analysis of conceivable threats and interests that may affect our national security, they then determine whether or not an OPLAN is required.

Crisis action planning

The crisis action planning process of JOPES deals with national security issues and reactionary emergencies that arise suddenly and require a time-sensitive plan of action. One of the main documents developed using crisis action planning are documents called operation orders (OPORD), which are developed from the OPLAN. Unlike the OPLAN, an OPORD is a directive issued from a commander to a subordinate commander to execute a military operation. Crisis action planning and the subsequent creation of an OPORD may sometimes take place in the very short time frame of one to three days. Because the OPORD is time-sensitive, strategists use the already existing OPLANs as the source document to develop the OPORD (fig. 1–2).

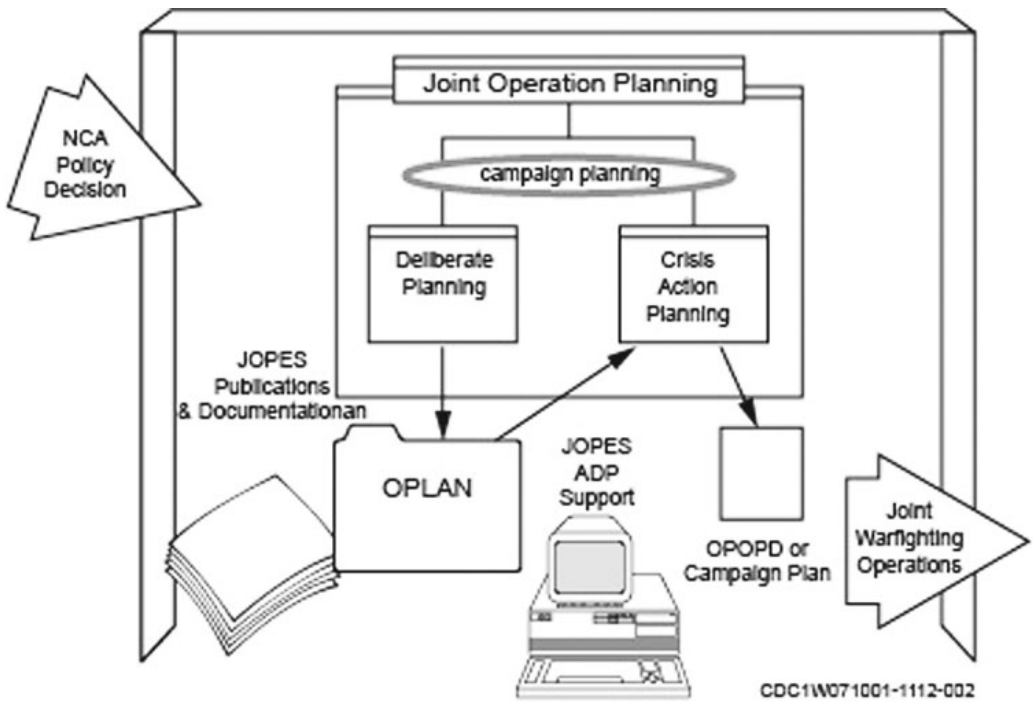

Figure 1–2. Joint Operations Planning and Execution System.

OPLAN requirements

Because the JOPES process takes time, military strategists from both the National Command Authorities (NCA) and the Joint Chiefs of Staff (JCS) create OPLANS only when a threat to national security or our national interstates exist. OPLANs are normally created when the following conditions exist:

- The contingency has a compelling national interest and is critical to national security.
- The nature (large scale) of the contingency requires detailed prior planning for complex issues.
- Detailed planning contributes to deterrence.
- Detailed deterrence is required to multinational planning.
- Detailed planning is necessary to determine specific force and sustainment requirements.

OPLAN contents

The OPLAN is a complex document mainly because it contains such a large amount of detailed planning information. OPLANs identify all of the units and actions that are required for a deployment to take place. The document is divided and categorized through annexes, appendixes, and tabs with weather falling in annex H.

Annexes and tabs

Some of the annexes that make up an OPLAN are listed in the table below:

Annex	Tab
ANNEX A	TASK ORGANIZATION
ANNEX B	INTELLIGENCE
ANNEX C	OPERATIONS
ANNEX D	LOGISITCS
ANNEX E	PERSONNEL
ANNEX H	WEATHER OPERATIONS
ANNEX J	COMMAND RELATIONSHIPS
ANNEX K	COMMAND, CONTROL, AND COMMUNICATIONS SYSTEMS
ANNEX L	ENVIRONMENTAL CONSIDERATIONS
ANNEX M	MAPPING, CHARTING, AND GEODESY
ANNEX N	SPACE OPERATION
ANNEX P	WARTIME HOST NATION SUPPORT
ANNEX Q	MEDICAL SERVICES

Depending on the complexity and detail of each annex, some of the more detailed annexes have a very detailed list of appendixes and tabs.

Annex H, Weather Operations

Annex H of the OPLAN will be of the most important for the WF. Like all of the other annexes in the OPLAN, the document is broken down into different categories, each requiring a detailed description of the how, who, what, where, and when. The annex must describe both primary and alternative plans of action that will be employed. Sometimes, WFs that provide Army support may not have an Annex H in the OPLAN. When this is this case, Army support units' responsibilities may fall under the same annex, appendix, and tab as the Army's G–2, Intelligence unit, Annex B.

Security classification

Information contained in an OPLAN normally has a security classification that requires the OPLAN to be kept in a security container or safe. Sometimes, just parts of the OPLAN are classified; however the portion of the OPLAN with the highest classification determines the level of security for the entire document.

The originating agency that creates the OPLAN uses a classification guide to determine the level of protection the information requires. The classification/declassification guide is also listed in the forward section of the OPLAN. As with any classified document, the declassification is done by the document originator.

Large weather units that have more than one area of interest often have several OPLANs (at least one OPLAN for each AI). Each member of the WF who is on deployment or mobility status should know that the OPLANs exist, but more importantly, they should know for which area of interest the OPLAN was written. More importantly, once you know what area of the world the OPLAN(s) is/are for, remember to safeguard the information. This means that if the classification is CONFIDENTIAL or higher, you're not to discuss the OPLAN with anyone, not even close friends or family. Additionally, even when such information is UNCLASSIFIED, parts of the information may be sensitive. Refer to operations security (OPSEC) and communications security (COMSEC) references for additional further guidance.

Unit readiness

Your WFs' readiness as a unit directly relates to your ability to comply with everything listed in Annex H (or the Army support equivalent). A shortfall in any one area of Annex H will seriously degrade the ability to deploy with the unified or specified command that your unit supports.

Now that you've been introduced to the concepts of areas of operation and OPLANs, hopefully you've gained an understanding of the necessity of preparing for a war or contingency. In the truest sense, preparedness directly relates to readiness. It's readiness that that sets the stage for success on the battlefield or in the air.

009. Tactical communications

In an ever changing world of technology, our ability to communicate is continuously evolving. Because of this, it would be impossible for us to believe that the way we communicate today will be the way we communicate tomorrow. Whether we need an upper-air chart or the latest surface observation we rely on technology to deliver and create the products that enable us to support the warfighter. There are many different ways to deliver these products to the field, then in turn to our customer. In a tactical environment, reliable communication is key to enabling Air Force Weather to quickly and accurately relay critical data.

Tactical networks

A tactical network is simply a communication system that provides weather data to all echelons of tactical operations. This may include non-deployed as well as deployed weather personnel. The deployed weather team receives and transmits weather data using phone lines, military and non-military computer networks, satellites, and military radios.

Phone line

Phone lines can be used to provide both voice and computer communications. Because data flow is typically slower than other communication methods, use of a phone line for data transfer would be better suited as a back-up alternative. The type of phone service you have at your location is dependent upon many factors. In some cases, a forward deployed location may not have phone capability, unless you have a satellite phone. However, most established weather facilities will have access to a DSN phone line.

Computer networks

You may use computers to access and download weather charts and images in a tactical location. Depending on location, there are several tactical computer networks available to the WF and SOWT member. These networks are usually maintained by communications personnel. The networks we use include a limited function internet and a military communication network.

Satellites

WF and SOWT members can receive weather data by standard ground receivers. These can be large-scale systems with multiple antennas or a single antenna and a laptop computer. Currently Air Force weather uses the Tactical Very Small Aperture Terminal (T-VSAT) for receiving weather data. In a deployed environment T-VSAT may be the only weather data link the WF and SOWT member have to weather products.

Radios

Radio transmissions transfer data using high frequency (HF) and frequency modulation (FM) radios. Long range communications (over 30 miles) are conducted between different echelons of support using HF radios. For example communications between a tactical forecast unit and a weather team is usually long-range. Short-range communications (within 30 miles) are conducted within a single echelon of support using FM radios. Single echelon communication includes forward area observers relaying observations from the "front-line" to the deployed weather team. Another example of how radio transmissions are used is the Pilot-to-Metro Service used by pilots to communicate with ground weather personnel.

Tactical communications equipment

As you can see there are many different ways weather personnel communicate. However, communication would not be possible without the use of proper equipment. In many cases, these separate components work together to form one tactical system. The following tactical equipment are examples of what a weather team might use in a field environment.

Integrated Meteorological System (IMETS)

The IMETS is an Army-furnished and maintained system operated by weather team personnel. It provides timely and accurate weather and environmental effects forecasts and decision aids to multiple command elements at all echelons supported by weather teams. IMETS software employs programs that ingest, analyze, and integrate weather data in a deployed or garrison environment. Data collected and generated in IMETS is fed to an Army network for commanders to use as a decision making tool.

Weather effects workstation (WEW)

The WEW ingests weather data from various sources. Some are automated while others require manual operator input. The WEW uses the Battle Forecast Model, an Army mesoscale forecast tool, to provide a detailed, 24-hour forecast of weather conditions displayed on a map of the warfighters AO. The WEW is used in tandem as a part of the IMETS.

Mobile subscriber equipment (MSE)

The MSE system provides both voice and data communications. The system supports both mobile and wire subscribers with the means to exchange communications, data, and intelligence information in a dynamic tactical environment.

Tactical-Very Small Aperture Terminal

The T-VSAT is used for transporting large volumes of weather data from the Air Force Weather Agency (AFWA), a strategic weather center, or an Operational Weather Squadron (OWS) to deployed WF. T-VSAT was originally designed to provide a “first-in” stand-alone weather system to provide WFs with current AOR weather data. Through technical innovation, T-VSAT now interfaces with multiple combat weather systems such as the deployable N-TFS and the IMETS Weather Effects Workstation for both training in garrison and in the tactical environment. An advantage of T-VSAT, is its ability to quickly receive data. It’s capable of providing near real-time data to a WF. The data includes, but is not limited to, satellite imagery, radar images, upper air soundings, and surface observations. T-VSAT users can view weather products through a web client graphic user interface.

Iridium Satellite Phones

Iridium is a constellation of 66 polar-orbiting satellites that provide global coverage for voice and data using a Motorola phone handset and antenna. The maximum data rate is approximately 10 kbps. The Iridium Satellite phone set includes the 9505a handset, battery, subscriber identity module (SIM) card, secure sleeve and mobile antenna. The secure sleeve provides voice encryption to ensure communications security. SOWT personnel utilize the secure sleeve when they carry the Iridium Satellite Phone as a backup while forward deployed or on tactical missions. A working satellite phone is an invaluable tool for communication when tactical radios fail.

In addition to the equipment previously mentioned, some tactical weather equipment can provide its own network. For example, the Tactical Meteorological Observing System (TMOS) has the ability to use a modem and RF transmitter to transmit data to locations in the near vicinity. This equipment uses a stand-alone network to rapidly transmit meteorological data to agencies such as air traffic control. The TMOS modem network is an excellent method for providing these agencies with the most current weather conditions.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

007. Areas of operations and interest

1. Name three events that require WFs support during exercise.

2. Match the definitions in column A with the terms in column B. The terms in column B may be used once, more than once, or not at all.

Column A	*Column B*
____ (1) Defines the area that tactical units will operate within.	a. Area of interest
____ (2) Identifies a potential location where future deployments may occur.	b. Area of operations
____ (3) The area for which a weather flight must provide forecast weather support.	c. Area of responsibility
____ (4) The geographic theater where military operations occur.	

3. Explain the intent of AI/AO familiarization packages?

4. When AOR-specific weather regimes are developed, which weather unit has the responsibility to help develop and review the package?

5. Which agency manages issuance of temporary KQ identifiers?

008. Operations plans

1. Name three types of combat that an OPLAN may describe.

2. Name the two categories of planning used in JOPES

3. What DOD planning system outlines the process for creating an OPLAN?

4. What is one of the main documents developed using crisis action planning and from which core document is it is derived?

5. Name two requirements that must exist in order for an OPLAN to be developed.

6. How are OPLANs organized and what portion of the OPLAN pertains to Air Force Weather operations?

7. If a portion of the OPLAN is classified as CONFIDENTIAL with another portion of the OPLAN classified as SECRET, what level of protection should the OPLAN receive?

009. Tactical communications

1. What types of communications systems do deployed weather personnel use?

2. Pilot-to-Metro Service (PMSV) is an example of what type of network?

3. Match the tactical equipment in column B with the characteristics in column A. Each item in column B may be used once, more than once, or not at all.

Column A	*Column B*
____ (1) Uses Battlefield Forecast Model to display 24-hr forecast on map of AO.	a. IMETS.
____ (2) Used for transporting large volumes of weather data from AFWA to WF's.	b. WEW.
____ (3) Uses 66 polar-orbiting satellites for voice and data communication.	c. MSE.
____ (4) Data is fed to an Army network for commanders to use as a decision making tool.	d. T-VSAT.
____ (5) Used to exchange data in a dynamic tactical environment.	e. Iridium Satellite Phone.

Answers to Self-Test Questions

001

1. Scope and size.
2. Employment planning.
3. Deployment and redeployment planning.
4. The unit commander.
5. DAV.
6. Tactical training exercises.
7. DRMD and OPLAN.
8. Family Care Certification.

002

1. Enable commanders and their staff to visualize the full spectrum of enemy capabilities.
2. Avenues of approach.
3. Because they are three dimensional and often unconstrained by geography.

4. Solar and space anomalies.
5. It can interact with and modify the environmental characteristics and it can have a direct affect on operations regardless of the dimension.

003

1. Targeting.
2. 30–72.hours.
3. 24 hours.
4. Combat assessment.

004

1. Strategic, operational, and tactical.
2. Operational.
3. Air defense.
4. Interdiction and close air support.
5. Intertheater, intratheater, and operational.

005

1. Corps.
2. S2.
3. Battalion.

006

1. The next 12 hours that affect operations.
2. Aviation Brigade.
3. TOC.

007

1. Contingencies, AEFs, and wartime operations.
2. (1) b.
   (2) a.
   (3) c.
   (4) b.
3. AI/AO familiarization packages help prepare you for the weather climate and patterns, functionality of equipment, and creature comforts that you deal with during, and long after your deployment.
4. OWS.
5. HQ AFWA.

008

1. Combat may be described as ground, air, or sea operations; deception; PSYOPS; and even nuclear operations.
2. Deliberate planning and crisis action planning.
3. OPLANs are developed under the deliberate planning process of JOPES.
4. OPORDs and it is derived from the OPLAN.
5. Any two of the following: when the contingency has a compelling national interest and is critical to national security; when the nature (large scale) of the contingency requires detailed prior planning for complex issues; when detailed planning contributes to deterrence; when detailed deterrence is required to multinational planning; and when detailed planning is necessary to determine specific force and sustainment requirements.
6. The document is divided and categorized through annexes, appendixes, and tabs. Weather falls under Annex H, Weather Operations.
7. SECRET; the level of the highest classification.

009

1. Phone lines, military and non-military computer networks, satellites, and military radios.
2. Radio.
3. (1) b.
   (2) d.
   (3) e.
   (4) a.
   (5) c.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (001) During military planning, the strategic level is
   a. the only level of the military echelon that uses strategy planning.
   b. the lowest level of decision making when planning for contingencies.
   c. the highest level of decision making when planning for contingencies.
   d. the second largest group of military strategists within the war planning echelon.

2. (001) Joint operations planning is *primarily* the responsibility of the
   a. Commander in chief (CINC).
   b. deployed forces commander.
   c. Chairman of the Joint Chiefs of Staff (JCS).
   d. ranking group-level expeditionary commander.

3. (001) Crisis action planning differs from deliberate planning in that it’s based on
   a. input from the staff weather officer (SWO).
   b. the inputs of weather and intelligence personnel.
   c. current and past events, without regard to data sensitivity.
   d. current events and conducted in time-sensitive situations and emergencies.

4. (001) For what does deliberate planning help to prepare?
   a. All types of natural disasters that accurate forecasts can prevent.
   b. The types of contingencies that are recognized as long term threats.
   c. The most likely contingencies that may occur in the near term future.
   d. Weather related products that could prevent lost operating hours during deployments.

5. (001) What type of planning is aimed at assembling and organizing national resources to support national objectives during a time of war or for operations other than war?
   a. Deliberate Planning.
   b. Mobilization Planning.
   c. Crisis Action Planning.
   d. Joint Operations Planning.

6. (002) Commanders use the joint intelligence preparation of the battlefield (JIPB) process to support all of the following except
   a. targeting.
   b. special operations.
   c. natural disaster relief.
   d. counter air operations.

7. (002) To what level(s) does the joint intelligence preparation of the battlefield (JIPB) process apply?
   a. Tactical.
   b. Strategic and Operational.
   c. Operational and Tactical.
   d. Operational, Strategic, and Tactical.

8. (002) What is the last major step in the joint intelligence preparation of the battlefield (JIPB) process?
   a. Define the battle space environment.
   b. Describe the battle space effects.
   c. Determine the adversary potential course of actions (COA).
   d. Determine the current adversary situation.

9. (003) What is targeting, with respect to the air tasking cycle?
   a. Identifying those persons or objects needing removal.
   b. The process of eliminating targets from controlled operational air space.
   c. The process of engaging all unfriendly targets within the area of operations.
   d. The process of selecting targets and measuring the results or response of the target selection.

10. (003) Over what period of time does the Notational Air Tasking Cycle take place?
    a. About 30 days.
    b. 30 to 72 hours.
    c. One to two weeks.
    d. Seven duty days.

11. (003) What must be completed before moving into Phase Three of the Notational Air Tasking Cycle?
    a. Target development phase.
    b. Target engagement phase.
    c. Target recognition phase.
    d. Target elimination phase.

12. (004) Effects at the strategic level of war include
    a. destruction of all enemy assets.
    b. control of all weather reporting sites.
    c. infiltration of the enemy’s intelligence branch.
    d. destruction or disruption of the enemy’s center of gravity (COG).

13. (004) At what level of warfare are individual battles or engagements fought?
    a. Tactical.
    b. Global.
    c. Strategic.
    d. Operational.

14. (004) At what level of war are campaigns and major operations planned, conducted, and sustained?
    a. Tactical.
    b. Global.
    c. Strategic.
    d. Operational.

15. (004) Planning at the operational level of war determines all of the following *except*
    a. what we will attack.
    b. exactly when we will attack.
    c. in what order we will attack.
    d. for what duration we will attack.

16. (005) The Army's primary mission is to organize, train, and equip forces to
   a. conduct prompt operations.
   b. add support to units calling air strikes.
   c. conduct prompt operations in foreign lands.
   d. prompt and sustained land combat operations.

17. (005) What is the Army's largest major command?
   a. US Army Pacific.
   b. US Army in Europe.
   c. US Army Forces Command.
   d. US Army South.

18. (005) What is the US Army Forces Command (FORSCOM) mission?
   a. To deploy and sustain air forces capable of responding rapidly to crises worldwide.
   b. To enhance combat ready forces capable of responding rapidly to crises worldwide.
   c. To train, mobilize, deploy and sustain air forces capable of responding rapidly to crises worldwide.
   d. To train, mobilize, deploy and sustain combat ready forces capable of responding rapidly to crises worldwide.

19. (005) What rank of Army officer normally commands divisions?
   a. Major generals.
   b. Brigadier generals.
   c. Colonels and above.
   d. Colonels or brigadier generals.

20. (006) In what environment(s) does the US seek to achieve its strategic objectives?
   a. War.
   b. Conflict.
   c. War and conflict.
   d. Peacetime, conflict, and war.

21. (006) How does the Army classify its activities during conflict?
   a. War.
   b. Peacetime battle.
   c. Real world exercise.
   d. Military operations other than war.

22. (006) What does the US attempt to do during peacetime?
   a. To influence world events by introducing actions that might unsettle nations.
   b. To influence world events through actions that break apart unfriendly nations.
   c. To influence world events through those actions that rarely occurs between nations.
   d. To influence world events through those actions that routinely occurs between nations.

23. (006) According to the US Army, what is war?
   a. The use of ground troops in operations.
   b. The use of ground troops in operations in hostile areas.
   c. The use of force in combat operations against an armed enemy.
   d. The use of force in combat operations against an enemy, armed or otherwise.

24. (006) In what terms do commanders consider the battlefield?
   a. The time necessary to defeat the enemy force.
   b. The space necessary to complete the assigned mission.
   c. The space necessary to defeat the enemy force or to complete the assigned mission.
   d. The time and space necessary to defeat the enemy force or to complete the assigned mission.

25. (007) Once deployed, a tactical unit works within the
    a. Area of Interest (AI).
    b. Area of Operations (AO).
    c. Area of Responsibility (AOR).
    d. Area of Tactical Responsibility (ATR).

26. (007) Regarding US military forces, the changing of one area of interest to another is most likely influenced by
    a. equipment shortfalls.
    b. personnel shortfalls.
    c. enemy intelligence.
    d. political climate.

27. (007) Who is responsible for maintaining and managing the database for temporary location (KQ) identifiers?
    a. HQ Air Force Weather Agency (AFWA).
    b. Unified Commands.
    c. Armed service representative.
    d. The tactical unit's supporting Operational Weather Squadrons (OWS).

28. (008) Under which phase of the joint operational execution and planning system (JOPES) is an operation plan (OPLAN) created?
    a. Deliberate planning.
    b. Crisis action planning.
    c. Emergency action planning.
    d. Psychological operations (PSYOPS) planning.

29. (008) Which statement best describes the relationship between an operational plan (OPLAN) and an operational order (OPORD)?
    a. OPLANs are usually derived from the OPORD.
    b. An OPLAN is more time sensitive than an OPORD.
    c. An OPORD is a directive to execute a military operation.
    d. Weather units sometimes maintain more than one OPRORD.

30. (008) Which of the following documents pertains to weather operations and is maintained in the weather unit's security container?
    a. Annex H of the joint operational execution and planning system (JOPES).
    b. Annex H of the operational plan (OPLAN).
    c. Appendix H of the operational order (OPORD).
    d. Appendix H of the OPLAN.

31. (008) What agency and action determines the security classification of an operation plan (OPLAN)?
    a. The custodian of the document classifies the OPLAN as TOP SECRET.
    b. The originator of the document classifies the OPLAN as TOP SECRET.
    c. The custodian of the document classifies the OPLAN at a level commensurate with the highest classified portion of the document.
    d. The originator of the document classifies the OPLAN at a level commensurate with the highest classified portion of the document.

32. (009) Radio transmissions transfer data using?
    a. Low frequency (LF) and frequency modulation (FM) radios.
    b. High frequency (HF) and frequency modulation (FM) radios.
    c. Ultra low frequency (ULF) and frequency modulation (FM) radios.
    d. Ultra high frequency (UHF) and amplitude modulation (AM) radios.

33. (009) Which tactical communication device employs programs that ingest, analyze, and integrate weather data in a deployed or garrison environment?
    a. Iridium Satellite Phone.
    b. Mobile subscriber equipment (MSE).
    c. Weather effects workstation (WEW).
    d. Integrated Meteorological System (IMETS).

34. (009) Tactical Meteorological Observing System (TMOS) can transfer data to locations in the near vicinity using?
    a. A modem and high frequency (HF) transmitter.
    b. A modem and radio frequency (RF) transmitter.
    c. A secure modem and high frequency (HF) transmitter.
    d. A secure modem and radio frequency (RF) transmitter.

35. (009) The Iridium Satellite phone set includes?
    a. 9505a handset, battery, secure sleeve and Radio Frequency (RF) antenna.
    b. 9505a handset, battery, secure sleeve and Ultra High Frequency (UHF) antenna.
    c. 9505a handset, battery, Subscriber Identity Module (SIM) card, secure sleeve and fixed antenna.
    d. 9505a handset, battery, Subscriber Identity Module (SIM) card, secure sleeve and mobile antenna.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Weather Impacts to Operations

ALL MILITARY OPERATIONS ARE influenced by the weather, both terrestrial and space. Weather asserts constant influence on readiness, morale, effectiveness of military forces, the choice of military strategy, tactics, and the performance and useful life of military weapons systems. Therefore, weather must be considered in every facet of military planning, deployment and system design, and evaluation.

2–1. Impacts of Terrestrial Weather

Weather impacts a large range of military operations. Because the list of operations is so lengthy, only an overview of aerial, ground, and maritime operations are presented here. Moreover, with the increasing number of joint operations that weather flights may support, it's nearly impossible to list every operation from the service branches that you may support. First, let's look at some of the principles and terms that are used when describing military operations.

010. Air and space weather doctrine and principles

Air Force Weather (AFW) personnel provide information on the past, present, and future states of the air and space environments within which weapon systems and their supporting infrastructure operate. They function as an integral part of combat operations. Their most important role is to provide the war fighter tailored weather information that enhances combat effectiveness. Together, with the war fighter, they perform this role by understanding the effects of weather; seeing the opportunities they offer and anticipating when they come into play. Successfully accomplishing this role allows the commander to set the terms for battle to maximize his performance while taking advantage of limitations on enemy forces. Additionally, AFW personnel provide information critical to peacetime operations, personnel safety and resource protection, and provide a vital link in the development of new equipment, weapons systems, combat tactics, and effectiveness analysis.

The following principles are the cornerstone of AFW in all military operations. By applying these principles, AFW is better prepared to enhance and sustain military operations.

Accuracy of data and information

Commanders depend on accurate weather information to plan and direct their operations. Inaccurate information can cost lives, undermine the successful execution of an operation/mission, waste resources, and impair readiness. This is true anytime—whether at peace or war. The complexity of the mission, the amount of detail that is required, the capability to collect data, the ability to model and forecast the weather, the perishable nature of weather data, and human error all affect accuracy. Therefore, weather information is never totally accurate. These factors must be explained to decision makers so they may weigh them in making decisions.

Timeliness of data and information

AFW is most effective when a commander receives accurate weather information in time to consider its impact on the decision to be made. Weather information that could influence an operation or program is worthless whenever the commander receives it after an opportunity has passed, an irreversible decision has been made, or an operation is complete. Communication links are vital to support and sustain the timely dissemination of weather information and are the key to the overall capability of AFW.

Relevance to the operational user

AFW provides the user an understanding of the weather situation through information that is directly relevant and applicable to the responsibilities of each echelon of the supported command. It impacts the echelon's current, planned, and alternative courses of action. Weather personnel tailor the information for specific applications so the user can quickly identify and apply relevant information without additional analysis or manipulation. Attaining this principle requires AFW personnel understand operational user needs and implies a user's responsibility to communicate specific requirements for content, form, medium, presentation, timeliness, and frequency of delivery.

Unity of effort

Weather information that influences a commander's decision usually cannot be derived from data obtained from a single source. Instead, weather data from many sources must be assembled into a database that contains a complete and interrelated summary of weather over an extended region and time encompassing the area of interest to the commander. Within a theater of war, or for a particular joint operations area, a unity of effort ensures the weather database is as complete and accurate as possible. To accomplish this task, weather organizations at all levels require clearly defined functions that eliminate duplication, maximize sharing of information, and are mutually supportive of the overall weather concept. The responsibilities of each AFW organization must be clear, explicit, and understood by all.

Readiness

It is essential that weather forces, databases, products, and equipment be responsive to the requirements of commanders and their forces. Weather resources oriented to areas where there is a high probability of military operations must be maintained in a degree of readiness that ensures immediate employment capability. Readiness is most often achieved through weather forces and service components participating in training exercises. During the training exercises, units must identify any limitations to communications equipment. Realistic training scenarios provide the best indicators of readiness. Joint exercises ensure interoperability and identify the feasibility of communications and the operations plan (OPLAN).

Measure of effectiveness

The overall effectiveness of AFW is based on the successful and effective accomplishment of specific military operations. Each weather organization directs its actions towards this goal. This requires weather organizations at all levels to be fully integrated into all operations. Such interaction leads to mutual understanding and trust between the weather sources and other war fighting forces.

011. Weather functions

The primary weather functions required to enhance military operations are collection, analysis, forecasting and tailored application, dissemination, evaluation, and integration. These functions need to be performed in full recognition of the fundamental weather principles outlined earlier.

Collection

AFW depends on the collection of high-quality weather data. As an example, observations from land and ship, upper-air sounding devices, meteorological satellites, weather radars, lightning detection systems, atmospheric profilers, solar telescopes, ionospheric sensors, buoys, and aircraft set the foundation for AFW to enhance operational missions. These are the essential components of regional and worldwide databases from which weather services and products are derived. Because of the rapidly changing nature of the aerospace environment, these observations are extremely perishable and continuously updated and available to military operations.

Analysis

After collection of available data, AFW develops a coherent picture of the current state of the air and space environment as a result of performing analysis—a critical function that better enables accurate forecasts of future states of the aerospace environment.

Forecasting and tailored application

Through the evaluation and interpretation of collected and analyzed weather data, specific forecast products are developed to enhance military operations and to satisfy user requirements. Forecast products can be developed for the near or far term and on a scale ranging from global in size to pinpoint locations in the battle space. For example, generalized, long-range planning forecasts are required from several days to several weeks before an operation. Specific mission planning and execution forecasts are needed at the start and during execution of a mission. A key function in AFW's ability to enhance theater military operations lies in their ability to apply tailored forecast products and information to assist the decision-making process of commanders. By applying weather information to operating limitations of weapon systems and associated tactics, techniques, and procedures, commanders can identify favorable, marginal, and unfavorable weather-effects information.

Dissemination

Weather information is of no operational use unless it reaches the user in time to be of operational or planning value. Therefore, AFW functions need to process and disseminate weather information to users by the fastest means available. Weather personnel and the users of weather information determine what information merits distribution, to whom, when, and the format and media required. They must have a common understanding of the impact of timeliness on operations. Mutual efforts by weather personnel to promote their capabilities and by users to state their requirements must be accomplished. This ensures the user receives the information needed for the task at hand rather than be inundated with unneeded products or not receive a key product.

Evaluation

AFW evaluations by operational users and weather personnel ensure the effectiveness of the weather information. Evaluations based on established standards identify shortfalls in the value of various types of products, the responsiveness of the weather products to the user, and techniques used to provide them. Implementing timely corrective actions enhances the overall effectiveness of AFW.

Integration

AFW extends beyond the functions identified above. It is essential that weather personnel actively participate in staff actions involving planning for or assessing the effectiveness of an operation or weapon system. Integration of weather information as decision aids into the planning process allows commanders to make informed decisions about the design and operation of a plan. For example, early integration of information from weather studies developed from climatological databases can aid the long-range planning of military operations, or the research, design and development of equipment and weapon systems. Integration of weather information during the process of assessing the effectiveness of weapons with electro-optical (EO) sensors can help war fighters obtain maximum combat benefit from precision-guided munitions (PGM). Weather information integrated with other sources of information affect the enemy's probable course of action due to the enemy's ability or inability to perform in given weather conditions.

012. Weather impact terms

Normally, when combat weather personnel support a customer, the customer must identify the thresholds for the operation in categories as favorable, marginal, or unfavorable. These thresholds apply to both current and forecast conditions. The term favorable implies that there is little degradation to the mission based on the impact of weather elements for that particular operation. Favorable conditions are denoted on weather matrix slides by using the color green, which signifies that conditions are a "go." The term marginal implies that some degradation may occur based on the current or forecast weather conditions. Marginal conditions are denoted by an amber color. Unfavorable conditions imply that weather elements will seriously degrade the ability to conduct the operation. Unfavorable conditions are symbolized by the color red, signifying that conditions are "no/go."

Aerial operations

Just a few examples of aerial operations that you may support are aerial reconnaissance, paradrop operations, air refueling, flight operations, and close air support. Like ground operations, weather can also have a favorable, marginal, or unfavorable impact on the success of each operation.

Your role is to support each operation by creating the products that meet your customer's needs. In order for your weather flight to fully support your customer, it's imperative that you understand the limitations and capabilities of each airframe and the scope of the operation. This concept applies not just to aerial operations, but also for all types of military operations. For example, there are generally three levels of aerial reconnaissance: strategic, above 25,000 feet; high, from 8,000 through 25,000 feet; and low, below 3,000 feet. Cloud cover and visibility are two significant weather parameters that impact reconnaissance operations.

With paradrop operations, however, winds are the more important parameter and have a strong influence on the target zone. The bottom line is, the more you know about the operation you're supporting; the better able you'll be to focus on the weather parameters that are most important for each operation. The following table lists some examples of parameters that affect each operation and are some sensitivities you may focus on as you create your weather products. Keep in mind, that no specific airframe is specified.

Operation	Favorable (green)	Marginal (amber)	Unfavorable (red)
Aerial reconnaissance	< 2/8 cloud cover Visibility > 8000m	2/8–4/8 cloud cover Visibility 4,800–8000m	> 4/8 cloud cover Visibility < 4,800 m
Paradrop	Wind < 13 knots	Winds 13–18 knots	Winds > 18 knots
Air refueling	No clouds at flight level No thunderstorms	Scattered to broken clouds at flight level Few thunderstorms	Overcast clouds at flight Level Scattered thunderstorms
Flight operations	Ceiling > 3,500 ft.	Ceiling 1,000 - 3,5000 ft	Ceiling < 1,000 ft
Close air support	Ceiling > 2,000 ft.	Ceiling 1,000 - 2,000 ft	Ceiling < 1,000 ft

Ground operations

Ground operations are affected by all of the weather elements. Some examples of ground operations that your weather flight may provide weather briefings and support for are trafficabilty, bridging, armor gun sights, personnel, and ground reconnaissance. Trafficability operations refer to the state of the ground to include river/stream crossings—in other words, the ability for ground forces to maneuver and traverse across terrain.

The major concerns with weather in trafficability terms are normally precipitation and temperatures. Bridging operations rely on favorable wind conditions in order to construct bridges. Armor gun sights operations rely on good visibility in order to see the targets. While gun operators may be able to make trajectory adjustments for wind conditions, it’s difficult at best to operate armored weapons when the targets aren’t visible. Personnel are affected by nearly all weather elements, but precipitation is the biggest factor that affects performance in combat conditions. Lastly, ground reconnaissance, which often occurs at night, also relies on visibility. Listed in the following table are some examples of the thresholds for each.

Operation	Favorable (green)	Marginal (yellow)	Unfavorable (red)
Trafficability	No precip	Moderate precip	Heavy precip
Bridging	Wind < 10 knots	Wind 10–34 knots	Wind > 34 knots
Armor Gun Sights	Visibility > 2000m	Visibility 1000–2000m	Visibility < 1000m
Personnel	No precip	Light precip	Moderate precip
Reconnaissance	Visibility > 3000m	Visibility 1000–3000m	Visibility < 1000m

Maritime operations

During joint operations, you may be tasked to support maritime operations. Like aerial operations and ground operations, each maritime operation may be affected by some weather parameters more than others. The following table lists some examples of weather sensitivities that impact antisurface warfare, one of many aspects of maritime operations.

Operation	Favorable (green)	Marginal (amber)	Unfavorable (red)
Antisurface warfare			
Over-the –horizon targeting	None to light precip	Moderate precip	Heavy precip Temperature > 103F
Seas	< 6ft	6–8ft	>8ft Winds > 60 knots

013. Atmospheric effects on electro-optical systems

You may recall from high school chemistry and physics that all matter is composed of discrete charges: electrons and protons. These charges are in constant motion with respect to each other. The oscillation (or acceleration) of these charges leads to electromagnetic (EM) radiation, which is emitted in nearly all directions from all matter. We are most familiar with visible light, because that is the EM radiation our eyes detect.

However, visible light represents only a very narrow band in the entire spectrum of EM. Other common examples of EM radiation are microwaves, radio waves, and ultraviolet radiation. The only difference between the different categories is their wavelength; that is, the distance between successive crests/troughs in the waves. All electromagnetic radiation travels at the speed of light; in the vacuum of outer space this speed is 186,000 miles per second (mps), or 300,000 kilometers (km) per second. Let’s look at the different sources of radiation.

Radiation sources

The sun is the primary source of EM energy in the atmosphere. The peak emission from the sun happens to lie in the visible part of the spectrum. We see other objects, such as this text you are reading, because of scattered radiation. This page does not emit visible radiation; if it did, it would be too hot for you to hold. You can read this because it is illuminated by a source of visible radiation; for example, the sun or a light bulb, and that light is scattered from the page to your eyes. It is important to distinguish the difference between emitted and scattered radiation.

You do emit radiation—infrared (IR) radiation. If you had an instrument that allowed you to detect EM radiation near the ten-micrometer (μm) wavelength, you could see other people, even at nighttime, without the aid of moonlight or starlight. In fact, we have instruments that detect IR radiation, and we use them for nighttime navigation and targeting of weapons systems. For a better understanding of radiation sources, let’s review a few basic radiation laws.

Radiation laws

Several classical physical principles are available to quantify some radiation ideas covered thus far. However, we first introduce the assumption that all objects here are considered black bodies; that is, they are perfect absorbers and perfect emitters. Planck's law relates the amount of energy (radiation) emitted by a black body to the temperature of the object. It also reveals how much radiation at each wavelength is emitted.

With Actual EM radiation emitted from the sun, few wavelengths would not be classified as a black body. This is because the sun is not a true black body; however, it is still a good assumption. We'll continue to make this assumption for all objects through the rest of this section.

Next is Wien's displacement law, which relates the temperature of an object with the wavelength of maximum emission. In simple terms, it allows you to determine that wavelength (in micrometers) by dividing the number 3,000 by the temperature (in degrees Kelvin). For example, the maximum wavelength emitted by the earth (–300°K) is 10µm.

The last two principles that we'll briefly mention are Stephan-Boltzman's law and Kirchoff's radiation law.

Stephan-Boltzman's law simply says that the energy emitted by a black body is proportional to the fourth power of its temperature. In other words, if the temperature of an object is raised only 20 percent, the amount of energy emitted from that object more than doubles. The temperature of an exercised tank is quite a bit warmer than its surrounding. If not properly cooled or diffused, the engine compartment sticks out like a sore thumb to an IR sensor because of the amount of IR energy emitted. In simple terms, Kirchoff's law requires that the absorptivity of a body at a given wavelength and temperature equals its emissivity at that wavelength and temperature.

In operational terms, if two objects are identical in every physical way, except emissivity, the object with the higher emissivity heats or cools faster than the other. These laws provide us the understanding we need to model the radiative properties of matter.

The thermal characteristics of an object help determine the radiative temperature of the object. Radiative temperature is the temperature that an object appears to have based on the amount of energy it emits. Besides the absorptivity/emissivity that determines how efficiently the object absorbs or emits energy, we need to know something about the thermal conductivity and thermal capacity. The thermal conductivity is a measure of how rapidly heat travels through an object. Metals have a high thermal conductivity. When mixing soup on a stove, the handle of a metal spoon heats up quicker than a wooden spoon. The thermal capacity is a measure of the amount of heat an object holds.

For example, although a truck and tank are made of the same material, the tank's mass is greater; however, the truck would heat up or cool off quicker than the tank. Combinations of absorptivity/emissivity, thermal conductivity, and thermal capacity, are used to determine the radiative temperature of the object.

Radiative extinction

Consider a source of EM radiation and a detector, such as a light bulb and a camera. Assume that you are in a smoke-free room with no windows or other sources of visible radiation and you are pointing the camera at the light. When you fill the room with a cloud of fine particles, less radiation reaches the camera lens. What happens to the radiation that does not reach the camera? When EM radiation encounters matter, it is either absorbed or scattered. The sum of scattering and absorption is called extinction. Less radiation reaches the camera because of extinction. Extinction is very similar to attenuation that affects radar beams.

Without more information about the composition of a cloud, we do not know if the extinction is a result of scattering, absorption, or both. If the cloud is composed of black soot, then most of the extinction is due to scattering. As you can now begin to appreciate, an accurate characterization of the conditions of the intervening atmosphere is essential for determining the amount of EM radiation that is transmitted from a target to the weapons system. Now we need to take a closer look at scattering and absorption.

Scattering

The nature of scattering by matter depends on the relative size between the wavelength of the EM radiation and the object. The relative size is usually presented as the size parameter, X, which is essentially the ratio of the radius of the particle (r) to the wavelength (λ) of the radiation.

$$X = \frac{2\pi}{\lambda}$$

Rayleigh

When the size parameter is much less than one, the scattering falls in the category of Rayleigh scattering. Of particular interest in this regime is the wavelength dependence of the scattering; that is, the shorter wavelengths are scattered more efficiently. For example, the molecules in the atmosphere scatter blue light more efficiently than red light. The blue sky is a result of the preferential scattering of the shorter wavelengths of sunlight

Geometric

When the size parameter is greater than ten, the scattering falls in the category of geometric scattering or reflection. In this regime we can discuss the reflectivity or albedo of a material. For example, a ground cover of new snow reflects over 80 percent of the incident visible sunlight. Actually each individual snow grain scatters the incident light but for simplicity we are considering the snow as one large object.

Mie

The last category, Mie scattering, considers the particles whose sizes are on the same order of the wavelength of light (the size parameter approximately equals one). A characteristic of Mie scattering is that the scattering is independent of the wavelength of light. For example, on a hazy day the hydroscopic particles in the sky have grown because of condensation. The size of the haze particles is slightly larger than, but still approximately the same as, the wavelength of visible light. Since the light from the sun is white, the light scattered to us by the haze remains white. This is why the sky is whiter, or a more washed-out blue, on hazy days.

The most important aspect to remember about the size parameter is that it is a ratio of two values: particle size and wavelength. When asked for the size parameter of a cloud drop, you also must be told the type of radiation that it is scattering. A cloud drop falls in the category of Rayleigh scattering for microwave radiation, Mie scattering for IR, and geometric scattering for ultraviolet. Similarly, different sized particles scatter differently for a single wavelength.

An interesting question is which scattering regime offers the best visibility. Consider visible light. There are many molecules in the atmosphere (Rayleigh scattering), yet on a clear day you can see forever. There are fewer, but larger fog droplets (Mie scattering), on a day when the visibility is less than a quarter mile. Finally, there are still fewer, but even larger raindrops (geometric scattering), on a day when the visibility may exceed several miles. By this example, it appears that as the size of the scatterers gets larger and larger, visibility decreases, but then increases. The answer to the question about visibility is that you need more information than just the size parameter of the scatterers. This is a complex issue about the apparent size (scattering cross section) and number (concentration) of scatterers. It is even more difficult to guess what may happen at wavelengths different from visible light. This is especially true for absorption.

Absorption

Dust, smoke, cloud particles, molecules, etc., absorb part of the solar radiation passing through the atmosphere. Collectively, they absorb some fraction of nearly every wavelength of solar radiation. For example, ozone absorbs ultraviolet light, water vapor absorbs IR and some larger wavelengths, and carbon dioxide absorbs IR radiation. Absorption by dust depends on the composition of the particle; for example, quartz has several absorption bands in the IR. Radiation in parts of the EM spectrum passes through the atmosphere with little or negligible absorption. These regions of the EM spectrum are called atmospheric windows; the most important lie in the visible, near-IR (NIR), and far-IR (FIR).

NOTE: The separation of IR into categories of near, mid, far, and so forth, are arbitrary and vary between publications.

The atmospheric windows are important for weapons systems. Most of our current IR sensors are designed to operate in the 8 to 12µm window. Night vision goggles operate in the visible to near-IR window. One popular laser operates at 1.06µm, a wavelength that has no appreciable absorption. Finally, some microwave windows of interest lie in the millimeter-length part of the spectrum.

You should not be lured into thinking that absorption for any particular substance is constant across the EM spectrum. While a bed of freshly fallen snow reflects over 80 percent of incident, visible, solar radiation, it absorbs over 80 percent of IR radiation.

Electro-optical systems

The three systems we discuss are visible, infrared, and microwave systems. Before going into the detail of these systems, Let us review how the different types may operate and some characteristics and ideas that are similar to all of them.

The three ways an EO system may operate are: passive, active, or semiactive. A passive system does not radiate any of the energy it attempts to detect. It is designed to detect either directly emitted or reflected radiation. An example of a passive sensor is a television camera. An active sensor radiates energy and is designed to detect that energy that is reflected back to the sensor. Radar is an example of an active sensor. A semiactive sensor is a two-part system. One part emits the energy, such as a laser designator. The other part receives the energy reflected off the target such as a laser Maverick.

To detect an object, it must stand out from the background scene. We refer to the difference between the object and the background as the contrast. With our eyes we can detect contrast by color or brightness; for black and white systems, only brightness.

Contrast

Contrast can be broken down into subcategories; three are described here: inherent, apparent, and threshold contrast. Consider the thin blue lines (target) on a sheet of white paper (background). The inherent contrast is the measured contrast between lines and the paper. As you move away from the paper, the contrast between the lines and the paper decreases. The contrast measured or perceived at some distance from the target is called the apparent contrast. Finally, at some distance from the paper you can barely distinguish the lines on the paper. This distance is synonymous with the threshold contrast, which is the minimum contrast that your eyes can detect.

Apparent contrast is always less than or equal to the inherent contrast due to scattering and/or absorption of the radiation. The apparent contrast is also a function of the distance from the target. The difference between the apparent and inherent contrast depends on the transmission of the radiation through the atmosphere. We could use a scientific law, Beer's law, to explain the effect of transmission to you but we won't. Instead, we will tell what Beer's law means in layman's terms. At a distance of zero, the transmission of radiation has a value called unity, which means no loss of signal. At the distance of zero the apparent contrast will equal the inherent contrast. At a very large distance, there is a large signal loss and the apparent contrast becomes small. The bottom line is that as the distance from the sensor to the target increases, the apparent contrast decreases. The rate at which the apparent contrast decreases with distance depends on the appreciable scattering and/or absorption of radiation by the atmosphere. When there is more scattering and absorption, the apparent contrast decreases quickly and the distance to the threshold contrast is less than if there were smaller amounts of scattering and absorption.

Recalling that extinction is composed of effects from scattering and absorption, let's examine some environmental effects on the different weapons systems. First, the effects of each environmental/meteorological condition can be broken down into scattering and absorption components. Additionally, each of these can be subdivided into contributions from molecules and aerosols. The extent of the extinction processes for each wavelength category is shown for various weather conditions. Note how the effects of scattering become more significant for larger particles and smaller wavelengths. The variation of absorption effects appears more random because of the nonlinear relationship between absorption and size parameter.

Consider when a sensor is too far to see the target or anything else in the area where the target is expected to be. In other words, the apparent contrast is less than the threshold contrast. As the sensor approaches the target, objects in the field of view become apparent. At this point we have reached detection range. Coming closer, we can eventually distinguish the target from other objects. This is called recognition. Finally, we get close enough for the target system to lock-on to the target. There are more subtle steps in the target acquisition cycle, but these will suffice for this discussion.

Environmental effects

Is it easier to detect a white target on a black background or a black-on-white? Experience may already tell you that it is easier to see white-on-black. Why is this so? Recall that extinction is the sum of scattering and absorption. Absorption removes radiant energy from the beam. On the other hand, scattering is merely the redirection of the energy. Sometimes, radiation can be scattered into your line of sight. When a white background surrounds a black target, the chance of stray radiation being scattered into your line of sight and blurring your vision of the black object is greater than when a white target is surrounded by a black background. This is why it is easier to see white-on-black. The scattering of light or radiation into your line of sight is called path radiation. This is important only for visible sensors.

Optical turbulence is an atmospheric phenomenon that degrades weapons system performance, especially the shorter wavelength sensors (visible and near-IR). It is the blurring and shimmering of images that are caused by uneven heating of the air. This is the image distortion you see as you drive down an asphalt highway in the summer or look through the heated air above a fire or barbecue grill. The effects of optical turbulence are more pronounced near the ground.

Battlefield-induced contaminants (BIC), such as dust, smoke, or debris from explosions, obscure the target from view. This category of environmental effects also includes manmade obscurants that have been manufactured to purposely degrade the effectiveness of the weapons system. These obscurants, such as fog oil or burning phosphorous, can be used defensively to screen our field maneuvers from the enemy's vision. Other environmental effects include icing, ablation or erosion, lightning, and triboelectrification. Icing can render a weapon system useless by covering the sensor. Hail, sand, or other large particles can pit (cause indentations) the sensor cover. Lightning or static discharges from electric charge buildup (triboelcetrification) can cause transient currents that can reduce system effectiveness or even destroy some electronic circuitry.

Visible systems

Examples of visible systems are TV Maverick, PAVE SPIKE TV, and night vision goggles (NVG). The term "Direct View Sensors" also refers to the category of visible sensors and includes equipment such as telescopes and binoculars. The most common visible sensor, the human eye, has the highest resolution and is best at discriminating target-to-background contrast. Because direct view sensors operate at or near visible wavelengths, the same environmental conditions that affect your vision, affect the effectiveness of these sensors.

Every radiative extinction process except molecular absorption significantly affects the performance of visual sensors somewhat. However, depending on your location and the season of the year, visual sensors may be very effective most the time. This includes nighttime. On a cloudless and moonless night, the stars provide enough visible radiation for using NVG.

Infrared systems

Infrared sensors are less sensitive than visible sensors to some environmental conditions. One type of weapons system operating in the NIR is the 1.06µm laser. Examples of IR sensors operating in the far-IR (8 to 12 µm) are the IR Maverick and Pave Tack FLIR (forward looking infrared), recall that the laser operates as semiactive system, and the FIR systems are passive.

These systems are less affected by molecular scattering, but more by molecular absorption. This is especially true for passive IR systems when the absolute humidity is high due to absorption by water vapor. These systems also perform better than visible systems in hazy, dusty, or foggy conditions.

Thermal contrast

IR systems operate by sensing thermal contrast. Thermal contrast is the difference between the thermal energy of the target and that of the background (terrain) that the target lies. The thermal energy that a target emits is closely related to the temperature. Thus, when the difference between the temperatures of the target and the temperature of the background is small, the thermal contrast is low, meaning that the target is difficult to detect. Inversely, when the difference between the target temperature and the background temperature is large, the thermal contrast is high, making the target easier to detect.

Thermal crossover

Thermal crossover refers to the moment when the target and the background are at the same temperature. This is usually due to diurnal variations in temperature and differences in emissivity. For instance, an unexercised tank is colder than the ground during the night and hotter during the day. Twice during each 24-hour period the temperatures of the tank and the background are equal. Theoretically, at thermal crossover the target is invisible. In actuality, the tank is not uniformly the same temperature. Different parts (facets) of the tank warm and cool at different rates. Therefore, these facets will still be visible against the background.

Sometimes, using multispectral imaging, which is to view the target in at least two different bands of the EM spectrum, can lessen the poor detection that occurs at thermal crossover. For example, the target can be imaged simultaneously in the far-IR and the mid-IR (3 to 5µm). How does multispectral imaging help detect a target? Recall that the radiation laws reviewed earlier are for black body radiation. In reality, the targets are not black bodies, and their emissivity varies across the EM spectrum. For example, while the background and target may have an apparent of 300°K in the far-IR, their apparent temperatures may be different in the mid-IR. This increases the possibility that the target might be visible in one part of the spectrum despite being invisible in another. In the future, multispectral imaging may become an important technological improvement in our weapons system inventory.

Thermal clutter

Some target scenes may be filled with multiple hot and cold objects, making detection of the target difficult. This phenomenon is called thermal clutter. When the scene is cluttered with many objects of many temperatures, and the temperature of the target falls within the range of the surrounding objects, it is difficult for the weapons system to remain locked-on to the target.

Millimeter/microwave systems

These systems operate in the longer wavelength regions of the EM spectrum. Examples of millimeter/microwave (mm/MW) systems are the Navy's Harpoon, anti-ship missile, and high-speed antiradiation missile (HARM) and other anti-radiation missiles. These systems can be either passive or active.

As we saw a decrease in the effects of aerosol scattering as we increased the operational wavelength from the visible to the IR, the effects decrease further in the mm/MW region

Only precipitation and thick clouds offer any significant degradation to mm/MW systems. On the other hand, absorption effects remain significant when moisture is present, even as water vapor. You should already be aware that water absorbs microwaves, which is the basis of operation of a microwave oven. This is why mm/MW sensors are designed to operate in one of several water vapor absorption windows: 19, 37, or 94 gigahertz (GHz).

Refractivity

Have you ever noticed how a straw in a glass of water appears to bend at the air/water interface? This bending of the EM energy is called refraction. It is a form of scattering due to the EM radiation entering a medium of different density (technically, a medium of a different refractive index). Recall that light travels 186,000 miles per second in a vacuum. Its speed is slightly slower in our atmosphere, and even slower in water. The relative difference in speed is what makes the straw in the water appear to bend.

In a similar way, mm/MW and radar are refracted in the atmosphere. This is a result of strong temperature and/or moisture lapse rates. These lapse rates can cause a substantial change in the refractive index of the atmosphere through the region that a radar beam is propagating. Depending on the conditions, the beam can be bent upward or downward; this leaves a large gap in coverage we call ducts. The radar operator may observe aircraft and report them further, closer, higher, or lower than they actually are. If you are aware of ducting, you can enter a duct and approach the radar virtually invisible.

How do you forecast ducts? The Advanced Refractive Environmental Prediction System (AREPS) is a Navy software program used to analyze the refractive structure of the atmosphere and assess the impact this structure has on EM system performance. The program is available for download from the Navy. Just contact one of the regional Naval Meteorological and Oceanography Centers to gain access to the program.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

010. Air and space weather doctrine and principles

1. What is the most important role of AFW personnel?

2. Why is weather information never totally accurate?

3. What weather principle requires AFW personnel to understand the operational user needs?

4. Where are weather resources orientated?

011. Weather functions

1. What are the primary weather functions?

2. Why is weather data perishable?

3. What does applying weather information to operational limitations allow commanders to do?

4. How is the effectiveness of weather information assessed?

012. Weather impact terms

1. What are the terms we use to identify the threshold categories?

2. What are the colors used on weather matrix slides and what do they mean?

3. What are the three levels of aerial reconnaissance?

4. What's another term for "Trafficability?"

5. What's the biggest weather factor that affects performance in combat?

013. Atmospheric effects on electro-optical systems

1. How fast does EM waves travel?

2. State the primary source of EM energy in the atmosphere.

3. What kind of radiation do humans emit?

4. What does scattering by matter depend on?

5. Name the different types of scattering.

6. Name the three types of EO systems discussed in the text.

7. What are the different subcategories of contrast? Explain each.

8. List and discuss why some of the environmental effects reduce EO sensor performance.

9. What is thermal crossover?

10. What is thermal clutter?

11. What is the bending of EM energy called?

12. What can cause a radar or millimeter/microwave EO system to be refracted?

2–2. Impacts of Solar Weather

From the Department of Defense's (DOD) practical standpoint, space weather refers to disturbances in the near-earth space environment that can degrade or disrupt military systems that operate in or through space. As shown in figure 2–1, the near-earth space environment encapsulates the region of space around the earth. The space weather regime extends out 93-million miles to the sun, the ultimate source of energy for every living thing and mechanical process on our planet. The origin of space environmental impacts on radar, communications, and space systems lies primarily with the sun. The sun continuously emits electromagnetic (EM) energy and electrically charged particles. Superimposed on these normal (or background) emissions are transitory enhancements in the EM radiation (particularly at X-ray, extreme ultraviolet (EUV), and radio wavelengths) and in the energetic charged particle streams emitted by the sun. These solar radiation enhancements have a significant potential to impact DOD operations.

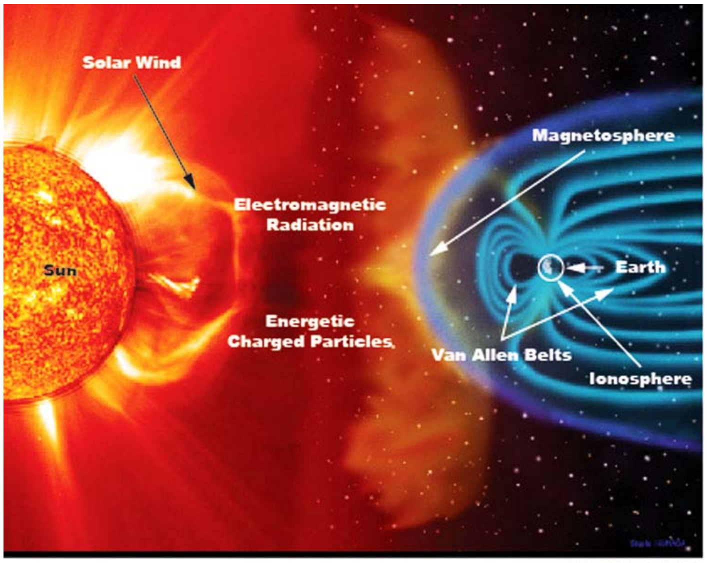

Figure 2–1. The near-earth space environment.

014. Background on solar emissions

The sun emits radiation over the entire EM spectrum. The distribution of energy is such that the most intense portion of this radiation falls in the visible part of the spectrum (which is why we see in visible light). Substantial amounts also lie in the near ultraviolet and infrared (IR) portions. Less than one percent of the sun's total emitted EM radiation lies in the EUV/X-ray and radio wave wings. However, we still have a two-fold problem: first, solar activity can cause the amount of emitted EUV and X-ray energy to be enhanced by a factor of up to 100 or more and radio wave energy by a factor of tens of thousands over the normal solar output at these wavelengths. Second, it is exactly these wavelengths to which radar, communications, and space systems are most vulnerable.

In addition to the emission of EM radiation, there is a continuous out-flow of energetic charged particles (protons and electrons) from the sun called the "solar wind." There is also an "interplanetary magnetic field (IMF)" emanating from the sun, which has a spiral structure near the plane of the earth's orbit caused by the fact that the sun rotates every 27 days.

The spiral IMF guides the outward motion of the charged particles in the solar wind. On the average, solar wind particles travel at over 400 kilometers per second, with a density of about 5 particles per cubic centimeter. Several types of solar activity can cause energetic particle streams to be superimposed on this background solar wind. The resultant enhancements and discontinuities in solar wind particle speed and/or density can disturb the earth's "magnetosphere" as they sweep by.

The magnetosphere is that volume of space where the earth's own magnetic field can exclude the sun's IMF and control the motion of charged particles. The pressure of the outward flowing solar wind causes the distorted shape of the magnetosphere. Its geomagnetic field lines are compressed on the sunward side and drawn out in the antisunward direction. While the magnetosphere does provide some shielding from solar charged particles (except at the funnel-like cusps over the polar caps), the shielding is not enough to avert some unpleasant impacts on radar, communications, and space systems operating in or through the near-earth environment.

Solar cycle

Western sunspot records start with the first telescopic observations by Galileo in 1611. Since that time, the number of sunspots has been found to follow a roughly 11-year cycle, called the "Sunspot or Solar Cycle" (figs. 2–2 and 2–3). Sunspot cycles in the past have been as short as 8 years and as long as 15 years, but most cycles are very close to the average of 11.1 years. There is also a 22-year solar cycle. Every 11 years, the overall magnetic polarity of the sun's northern and southern hemispheres reverses. A return to the original polarity requires another 11 years—hence the 22-year cycle.

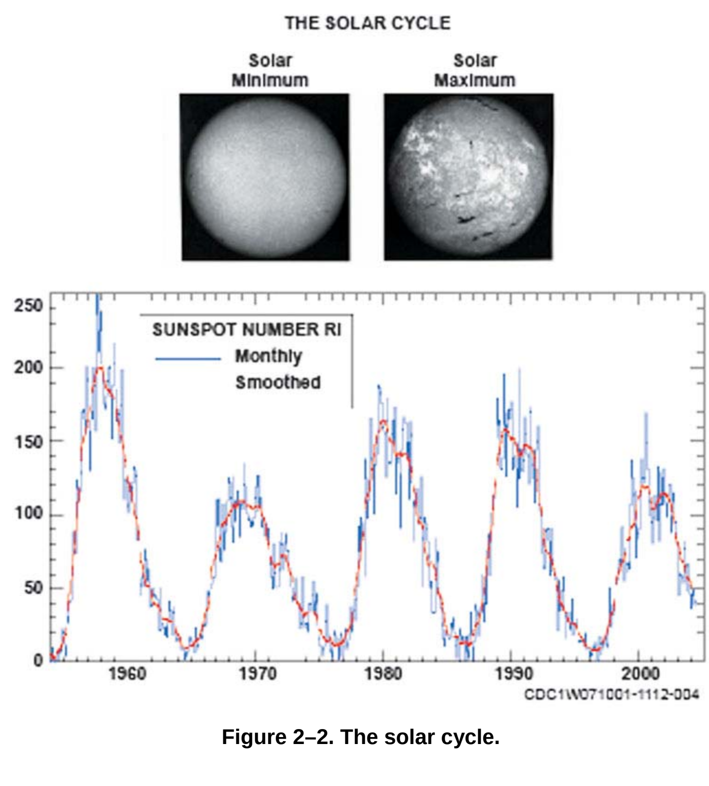

Figure 2–2. The solar cycle.

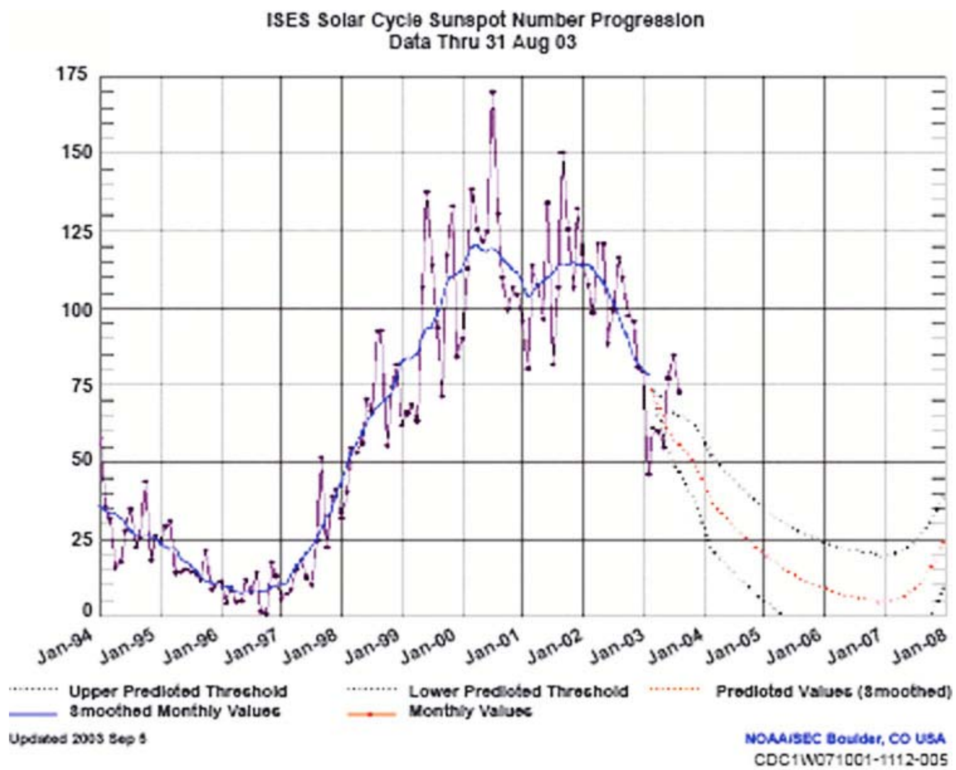

Figure 2–3. Solar cycle number progression.

Solar cycle characteristics

Generally, cycles show a rapid, roughly 4-year rise to a “Solar Maximum,” followed by a gradual 7-year decline to a “Solar Minimum.” Since solar activity is closely correlated with the number of sunspots, solar events and operational impacts also tend to follow an 11-year cycle. Predicting the time and magnitude of future sunspot cycles is a relatively difficult, uncertain process, normally involving the use of a variety of statistical and precursor methods. However, the real operational problem with the Solar Cycle is that Solar Minimum tends to lull system designers, operators, and users into a state of complacency, and then the rapid rise to Solar Maximum creates some unexpected and unpleasant surprises.

The cyclic nature of solar activity

Operators should not be fooled into thinking they are “out of the woods” when a Solar Maximum has passed. The greatest potential for large solar flares is actually during the 2 to 3 years immediately following a Solar Maximum. The reason for this situation is that a decline in the number of sunspots and active regions (or plage) permits solar magnetic fields in those regions that exist to build in intensity and complexity without being prematurely disturbed by neighboring flare events.

Furthermore, solar and geophysical activity can and does occur even during Solar Minimum. That is because not all solar activity (and thus system impacts) is solar flare induced. Flares are only the primary cause, other causes include: coronal mass ejections, disappearing filaments (also known as eruptive prominences), solar wind sector boundaries, high-speed particle streams emanating from coronal holes, and cosmic rays of nonsolar origin. Not all of these phenomena are directly tied to sunspots and plage; in fact, some (like coronal holes and nonsolar galactic cosmic rays) are actually more common problems during Solar Minimum.

Solar flares

The prime cause of solar activity is the solar flare, which is an explosive release of energy, both EM and charged particles, within a relatively small (but greater than earth-sized) region of the lower solar atmosphere (fig. 2–4). While the energy released during a flare is very substantial, it represents at most 1/100,000th of the total solar output. Consequently, our daily lives appear to be unaffected. However, a flare's enhanced X-ray, EUV, radio wave, and particle emissions are sufficient to adversely impact radar, communications, and space systems operating in or through the near-earth environment.

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Figure 2–4. Solar flare.

Flare occurrence

Flares usually occur in the vicinity of sunspots or their precursors, bright active regions called plage. The reason is that the energy released by a flare is the energy stored in the intense, complex magnetic fields which produce those plage and sunspots. Flares are also one triggering mechanism for eruptive prominences or disappearing filaments, which are outward ejections of material (charged particles) previously suspended cloudlike in the solar atmosphere. Unfortunately, on a case-by-case basis, it is almost impossible to predict exactly when a large flare will occur. However, their close correlation with sunspots and plage do permit reasonable forecasts of the likelihood of flare occurrence and probable flare characteristics (size, duration, X-ray and particle emissions, and etc.). The strength of a flare, and thus its potential to cause system impacts, is often correlated with the size and complexity of the associated sunspot group or plage active region.

Flare classification

Flares are classified according to their optical or X-ray characteristics. Two of the features we discussed are optical flare and x-ray flare classifications.

Optical flare classification

The optical (as seen in Hydrogen-alpha light) classification of a flare is made using a two-character designation based on flare area and brightness Example: a 1B designation indicates a "brilliant" intensity flare covering a corrected area between 100 and 249 millionths of the solar hemisphere as shown in the following table. Flare areas are corrected for geometric foreshortening caused by projection of a spherical object on a flat viewing plane. The table below shows their characteristics:

Size Category	Corrected Flare Area (Millionths of the Solar Hemisphere)	Typical Duration	Percentage of All Flares
0	10 to 99	Several minutes	75
1	100 to 249	Tens of minutes	19
2	250 to 599	An hour	5
3	600 to 1200	An hour or more	Less than 1
4	Greater than 1200	An hour or more	Less than 1
Brightness Categories F: Faint N: Normal B: Brilliant			

X-ray flare classification

Flares are also classified by the peak X-ray energy flux emitted in the 1 to 8 Angstrom wavelength band, as measured by a geosynchronous satellite. These measurements must be made from space, since the earth's atmosphere absorbs all solar X-rays before they reach the earth's surface. Example, a M3 flare emitted an X-ray flux of 3 x 10–2 ergs/cm2/second as depicted in the table below:

Class	X-Ray Peak Flux
A	Greater than or equal to 10–5 but less than 10–4 ergs/cm2/sec
B	Greater than or equal to 10–4 but less than 10–3 ergs/cm2/sec
C	Greater than or equal to 10–3 but less than 10–2 ergs/cm2/sec
M	Greater than or equal to 10–2 but less than 10–1 ergs/cm2/sec
X	Greater than or equal to 10–1 ergs/cm2/sec

Features on the solar disk

Let's look at some of the features we might find on the solar disk. The features on the solar disk we discuss area sunspots, plage, filaments, and prominences.

Sunspots

Sunspots are regions of intense, localized magnetic fields on the sun's surface (also known as the photosphere). These magnetic fields cause sunspots to be cooler than the rest of the photosphere, so they appear dark compared to the hotter, brighter surrounding surface. Since sunspots are regions of intense magnetic fields, solar flares and other solar activity tend to occur near sunspots. Sunspot groups are categorized according to size, configuration, and magnetic complexity. The number and intensity of operationally significant solar events is positively correlated with the total number of sunspots.

Plage

Plages are areas of strong, localized magnetic fields in the sun's lower atmosphere (also known as the chromosphere). These magnetic fields cause the material in a plage to be somewhat denser, hotter, and thus brighter than in the areas surrounding the plage. Plage can best be observed through a filter that passes only the monochromatic red light of the Hydrogen-alpha wavelength (6563 Angstroms).

Growth in plage area and brightness can significantly increase the total output of portions of the solar EM spectrum, particularly EUV radiation and radio waves with frequencies near 2800 megahertz (MHz). Since plage can be produced by lower magnetic field strength than required to produce sunspots, plage are a precursor of sunspots and will persist longer than any related sunspots. Most solar flares will occur in the vicinity of these "active" regions.

Filaments and prominences

"Filaments" occur in the upper chromosphere and/or lower corona (the sun's outermost atmospheric layer). The material in a filament is supported by strong magnetic field lines that are horizontal (or parallel) with respect to the sun's surface. This filamentary material has a higher density and lower temperature than its surroundings and so tends to form dark, ribbon like features when observed in Hydrogen-alpha light against the brighter underlying solar disk. Filaments are called "prominences" when they are observed on the limb of the sun, where they will appear as bright features in contrast to the dark, non-Hydrogen-alpha emitting corona. Occasionally, a solar disturbance causes the supporting magnetic field lines to fling the material (charged particles) in a filament or prominence outward from the sun. This rapid eruption of a filament (observed as a "disappearing filament") or a prominence (called an "eruptive prominence") can result in a geomagnetic disturbance in the near-earth environment when the ejected particles arrive approximately 72 hours after the eruption, if the earth happens to be in the portion of its orbit where the particles cross.

The solar wind

Another source of space environmental activity, which can strike at anytime during the solar cycle, is enhancements or discontinuities in the outward flow of the energetic charged particles that make up the solar wind (fig. 2–5). The heliosphere is a bubble of magnetism springing from the sun and inflated to colossal proportions by the solar wind. Every planet from Mercury to Pluto and beyond is inside it. The heliosphere is our solar system's first line of defense against galactic cosmic rays. High-energy particles from black holes and supernovas try to enter the solar system, but most are deflected by the heliosphere's magnetic fields.

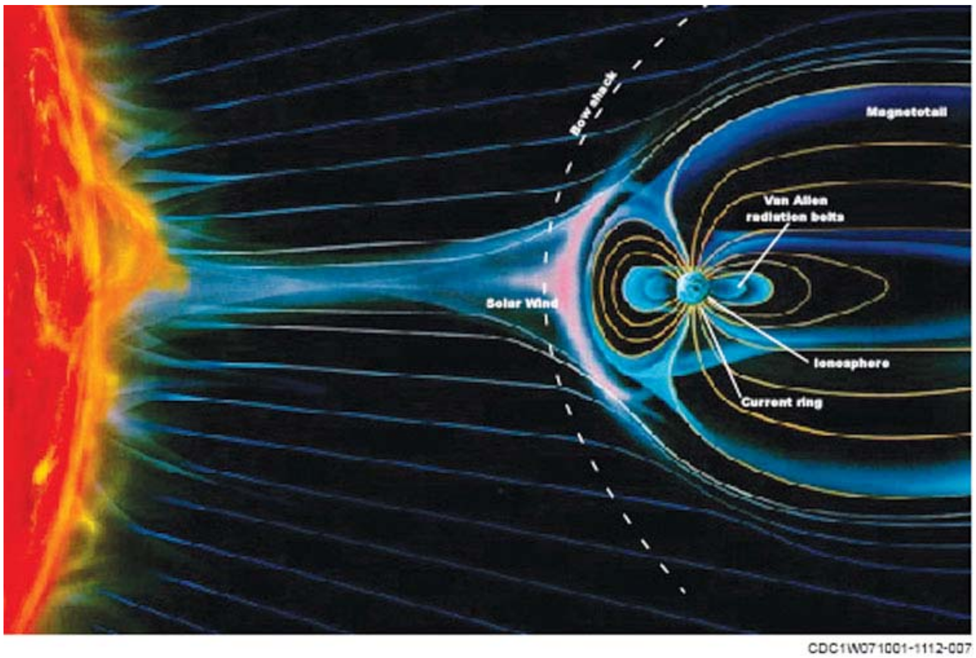

Figure 2–5. The solar wind.

IMF

The IMF emanating from the sun normally has 4 to 6 sectors of alternating positive (+) and negative (-) polarity, and a spiral structure near the plane of the earth's orbit due to the 27-day rotation period of the sun. Charged solar wind particles are guided by the IMF. Those particles in one IMF sector do not normally penetrate into another sector. Since particles tend to move faster in the forward portion of a sector than in the tailing portion, particle density tends to increase and be irregular just behind a "solar sector boundary (SSB)," leading to a "high speed stream (HSS)" of particles.

HSSs of particles can also exist within a sector because there are regions in the sun's atmosphere (called coronal holes) where magnetic field lines are open to space and do not impede the outward flow of charged particles. These coronal holes are most effective in causing HSSs near the plane of the earth's orbit and during solar minimum periods.

Both SSB and HSS enhancements and discontinuities can disrupt the earth's magnetosphere as the sun's rotation causes them to sweep past the earth. The sun rotates on its axis once every 27 days. The coupled solar wind and IMF inherit this angular motion. Consequently, the solar wind and IMF can be thought of as a rotating pin wheel, any point on which will sweep pass the much slower moving Earth, which requires 365 days to revolve around the sun, roughly once a month.

Geomagnetic and ionospheric storms

What is the mechanism by which charged solar particle streams (whatever their origin) disrupt our magnetosphere and adversely affect radar, communications, and space operations? Except for the funnel-like cusps above the polar caps, solar particles do not have direct access to the near-earth environment. Instead, when a particle stream enhancement (whatever its solar source) or discontinuity in the solar wind sweeps pass the earth, its impact sends a shockwave rippling through the magnetosphere. Out in the magnetosphere's tail, drawn-out magnetic field lines reconnect and (like a snapping rubber band) shoot trapped particles toward the earth's night side.

Some of these particles stay near the equatorial plane and feed into the Van Allen Radiation Belts (fig. 2–6); others follow geomagnetic field lines and penetrate into the high northern and southern latitudes (or auroral zones). The results are disturbances called "geomagnetic and ionospheric storms." Later, the trapped particles in the magnetotail are replenished by the slow diffusion of solar wind particles into the magnetosphere's tail. This nightside particle injection mechanism makes sense when one looks at where DOD system impacts occur. The majority of radar, communications, spacecraft, and satellite problems occur in the night sector, not the daylight sector!

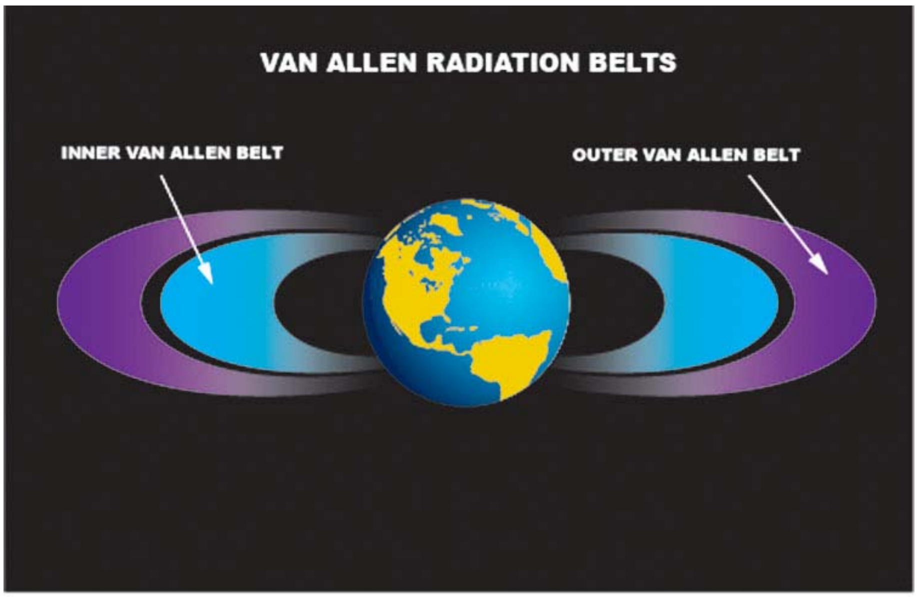

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Figure 2–6. Van Allen Radiation Belts.

Geomagnetic storms

Geomagnetic disturbances are rapid variations in the earth's magnetic field as measured by ground-based or space-based magnetometers. A geomagnetic storm tends to occur about 24 to 72 hours after its causative solar event (flare, disappearing filament, and eruptive prominence) or in response to the passing of a discontinuity in the solar wind (a sector boundary or high speed stream). A typical geomagnetic storm normally is composed of alternating periods of disturbed and relatively undisturbed conditions, and can last up to around three days. The following table lists the six levels of geomagnetic activity, based on the most commonly used indices of global geomagnetic conditions: the 3-hour Ap index and 24-hour Ap index. These indices are obtained from a network of ground-based magnetometer stations as presented in the table below:

Level	ap or Ap Index	Potential for Impacts
Quiet	0 to 7	Low
Unsettled	8 to 15	Low
Active	16 to 29	Moderate
Minor Storm	30 to 49	Moderate
Major Storm	50 to 99	High
Severe Storm	Greater than 100	Very High

Ionospheric disturbances

Ionospheric disturbances occur when a portion of the earth's ionosphere (generally between 50 and 400 kilometers altitude) experiences a temporary, irregular fluctuation in its degree of ionization (either unusual enhancements or depletions in the number of ions/electrons observed). These fluctuations can be caused by the motion of charged particles within the ionosphere or by the ionizing effect of particle bombardment or solar X-ray and EUV EM radiations.

Ionospheric storms

The term "ionospheric storm" is normally used when referring to ionospheric disturbances that occur in response to a geomagnetic storm. Like a geomagnetic storm, an ionospheric storm tends to occur about 24 to 72 hours after its causative solar event (flare, disappearing filament, and eruptive prominence) or in response to the passing of a discontinuity in the solar wind (a sector boundary or high-speed stream). It is also normally composed of alternating periods of disturbed and relatively undisturbed conditions and may last up to around three days. Ionospheric storms are associated with strong auroral activity (the northern and southern lights), degraded high frequency (HF) and satellite radio communications, and errors in spacetrack and missile detection radar observations.

Sudden ionospheric disturbances

Variations in the influx of solar X-ray and EUV radiation can also produce fluctuations in the ionosphere's degree of ionization. However, these fluctuations tend to occur immediately after the onset of the solar flare which produced the enhanced X-ray/EUV emission, affect only the sunlit hemisphere of the earth, and persist only for a few tens of minutes to several hours (i.e., as long as the flare continues to produce the enhanced EM radiation). Such disturbances are normally referred to as "sudden ionospheric disturbances (SID)," rather than ionospheric storms. The best known example of a SID is a short wave fade (SWF), an event that can hamper HF radio propagation by causing severe signal absorption. Other types of SIDs can cause deviations in signal frequency, phase, and/or amplitude.

High energy proton events

The polar cusps in the magnetosphere can provide direct access to the earth's upper atmosphere for energetic solar protons that are sometimes emitted by the larger solar flares.

Forecasting proton events

These high energy protons are normally sufficiently energetic to cut across the solar wind and IMF, and can reach the earth within a quarter hour to several hours after the causative flare. Fortunately, few flares are capable of producing these high energy protons. Additionally, the earth represents a rather small target 93 million miles from the sun; so many proton streams miss the earth entirely. However, an unfortunate consequence of the rarity of these proton events is that they are very difficult to forecast. The forecaster must determine whether such particles were produced, whether they will arrive at the earth, when they will arrive, how long they will persist, and what energy ranges they will be in.

Proton event system impact

These high-energy protons represent a direct radiation danger to astronauts and high-altitude aircraft crews (e.g., U–2 or supersonic transport (SST)). They can also produce direct collisional electrical charging on satellites or spacecraft. These impacts are most frequently observed near the earth's polar caps, where the "polar cusps" in the magnetosphere provide direct access to low altitudes in the earth's atmosphere. HF "polar cap absorption (PCA)" events occur when the high-energy protons penetrate into the polar ionosphere's lowest region (called the "D-layer"), roughly 50 to 90 kilometer (km) in altitude.

As these protons collide with atmospheric atoms and molecules, they will cause significantly increased levels of ionization, resulting in severe absorption of HF radio waves used for communication and some radar systems. This phenomenon sometimes referred to as a "polar cap blackout," can last for several days and is often accompanied by widespread geomagnetic and ionospheric disturbances as lower energy solar protons and electrons arrive. Since the ionosphere's base tends to lower during PCA events, concurrent errors on low frequency (LF) navigational systems are also normally observed.

015. Electromagnetic versus solar particle effects

Every solar event is unique in its exact nature and the enhanced emissions it produces. Some solar events cause little or no impact on the near-earth environment because their enhanced particle and/or EM (X-ray, EUV, and/or radiowave) emissions are too feeble, or their particle streams may simply miss hitting the earth. For those events that do affect the near-earth environment, there can be both immediate and delayed effects depending on the exact type of enhanced radiations emitted (fig. 2–7).

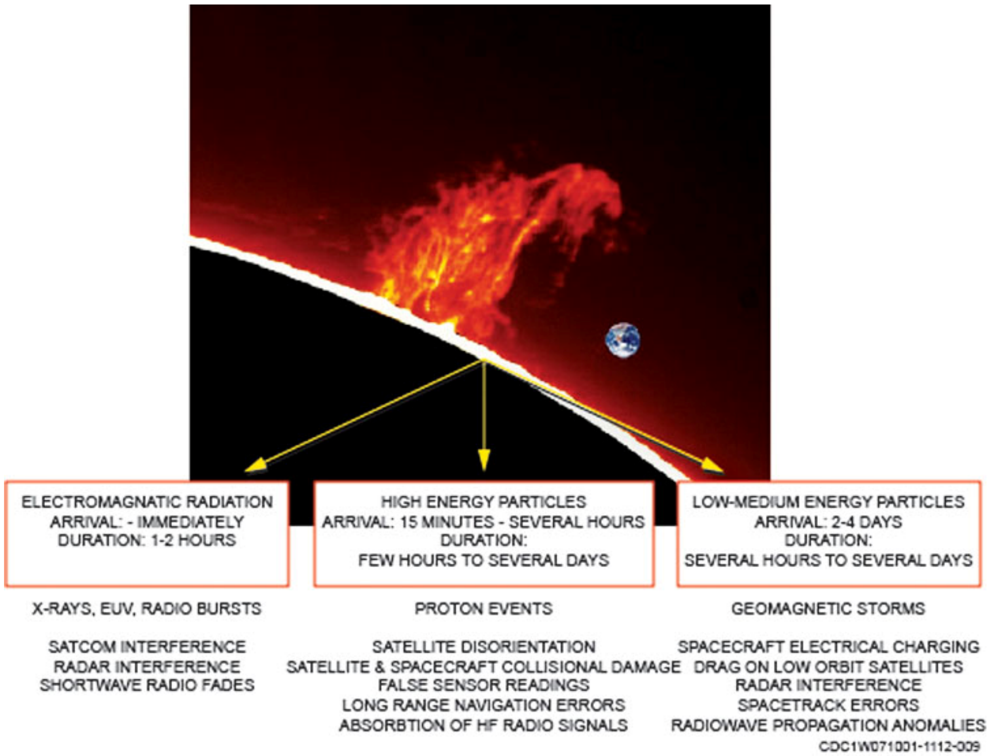

Figure 2–7. Solar flare effects and impacts.

EM radiation

We detect flares by the enhanced X-ray, ultraviolet, optical, and/or radio waves they emit. All of these wavelengths travel to the earth at the speed of light (in about 8 minutes); so by the time we first observe a flare, it is already causing immediate environmental effects and DOD system impacts. These impacts are almost entirely limited to the earth’s sunlit hemisphere. Since the enhanced EM emissions cease when the flare ends, their effects tend to subside shortly after the flare ends. As a result, these effects tend to last only a few tens of minutes to an hour or two. Sample system effects include: satellite communications (SATCOM) and radar interference (specifically, enhanced background noise), Longe Range (LORAN) navigation errors, and absorption of HF (3–30 MHz) radio communications.

High energy particles

These particles (primarily protons, but occasionally cosmic rays) can reach the earth within 15 minutes to a few hours after the occurrence of a strong solar flare—if they arrive at all. Not all flares produce these high-energy particles, plus the earth is a rather small target 93 million miles from the sun, so predicting solar proton and cosmic ray events is a difficult forecast challenge. The major impact of these protons is felt over the polar caps, where the protons have ready access to low altitudes through funnel-like cusps in the earth’s magnetosphere. The impact of a proton event can last for a few hours to several days after the flare ends. Sample impacts include: satellite disorientation, collisional damage on satellites and spacecraft, false sensor readings, LORAN navigation errors, and absorption of HF radio signals.

Low to medium energy particles

Particle streams (composed of both protons and electrons) may arrive at the earth about 2 to 4 days after a flare. Such particle streams can also occur at anytime due to other, nonflare solar activity. These particles cause geomagnetic and ionospheric storms which can last for hours to several days. Typical problems include: spacecraft electrical charging, drag on low orbiting satellites, radar interference, spacetrack errors, and radiowave propagation anomalies. These impacts are most frequently experienced in the nightside sector of the earth.

016. Short wave fade impacts

The first of the specific DOD system impacts we discuss is the SWF, which is caused by solar flare X-rays. The second impact is SATCOM and radar interference caused by solar flare radio bursts. These EM (or immediate) impacts occur simultaneously with the solar flare that caused them, tend to persist only a bit longer than the flare, and are almost entirely limited to the earth's sunlit hemisphere.

SWF events

The HF, 3–30 MHz radio band is also known as the short wave band. Thus a SWF refers to an abnormally high fading (or absorption) of a HF radio signal.

HF radio communications

The normal mode of radiowave propagation in the HF range is by refraction using the ionosphere's strongest (or F) layer for single hops, and by a combination of reflection and refraction between the ground and the F-layer for multiple hops (fig. 2–8). The "ionosphere" is defined as that portion of the earth's atmosphere above roughly 50 km where ions and electrons are present in quantities sufficient to affect the propagation of radio waves.

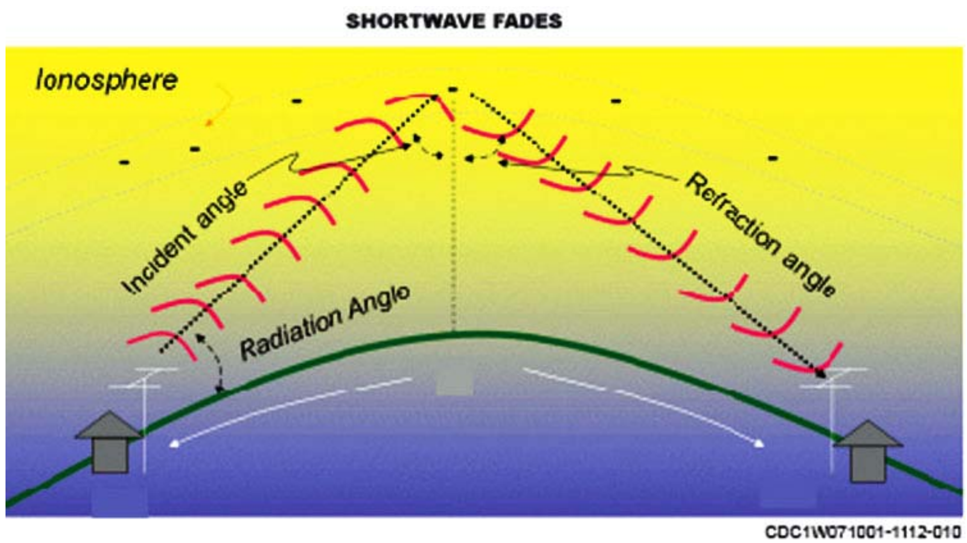

Figure 2–8. Shortwave fades.

Maximum useable frequency

The portion of the ionosphere with the greatest degree of ionization is the F-layer (normally between about 200 and 400 km altitude). The presence of free electrons in the F-layer causes radiowaves to be refracted (or bent), but the higher the frequency the less the degree of bending. As a result, surface-to-surface radio operators use medium or high frequencies (300 kHz to 30 MHz), while SATCOM operators use very too extreme high frequencies (30 MHz to 300 GHz). The maximum useable frequency (MUF) is that frequency above which radio signals encounter too little ionospheric refraction (for a given take-off angle) to be bent back toward the earth's surface (i.e., they become transionospheric). Normally the MUF lies in upper portion of the HF band.

Lowest useable frequency

The lowest layer of the ionosphere is the D-layer (normally between 50 and 90 km altitude). At these altitudes, there are still a large number of neutral air atoms and molecules coexisting with the ionized particles. As a passing radiowave causes the ions and free electrons to oscillate, they will collide with the neutral air particles, and the oscillatory motion will be damped out and converted to heat. Thus the D-layer acts to absorb passing radiowave signals. The lower the frequency, the greater is the degree of signal absorption. The lowest useable frequency (LUF) is that frequency below which radio signals encounter too much ionospheric absorption to permit them to pass through the D-layer. Normally the LUF lies in lower portion of the HF band.

HF propagation window

The HF radio propagation window (fig. 2–9) is the range of frequencies between a LUF (complete D-layer signal absorption) and a MUF (insufficient F-layer refraction to bend back the signal). This window varies by location, time of day, season, and with the level of solar and/or geomagnetic activity. HF operators choose propagation frequencies within this window so their signals will pass through the ionosphere's D-layer and subsequently refract from the F-layer. As seen in figure 2–9, typical LUF/MUF curves show a normal, daily variation. During early afternoon, incoming photoionizing solar radiation (X-rays, but mostly ultraviolet) is at a maximum, so the D- and F-layers are strong and the LUF and MUF are elevated. During the night, the removal of ionizing sunlight causes all ionospheric layers to weaken (some layers disappear altogether), and the LUF and MUF become depressed.

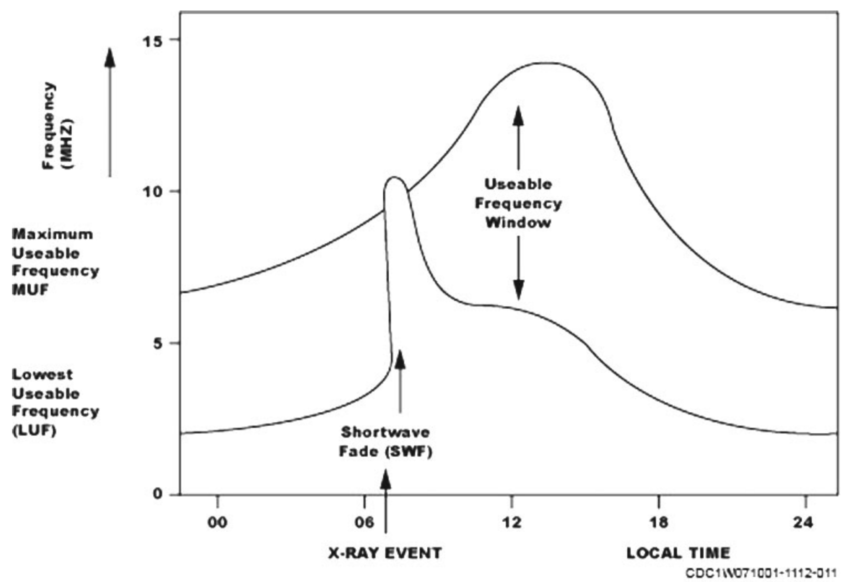

Figure 2–9 MUF and LUF.

The short wave blackout

X-ray radiation emitted during a solar flare can significantly enhance D-layer ionization and absorption (thereby elevating the LUF) over the entire sunlit hemisphere of the earth. This enhanced absorption is known as a SWF, and may at times be strong enough to close the HF propagation window completely (called short wave blackout). The amount of signal loss depends on a flare's X-ray intensity, location of the HF path relative to the sun and design characteristics of the system.

A SWF is an "immediate" effect, experienced simultaneously with observation of the causative solar flare. As a result, it is not possible to forecast a specific SWF event. Rather forecasters can only predict the likelihood of a SWF event based on the probability of flare occurrence determined by an overall analysis of solar features and past activity. However, once a flare is observed, forecasters can quickly (within 7 minutes of event onset) issue a SWF warning which contains a prediction of the frequencies to be affected and the duration of signal absorption. Normally SWFs persist only for a few minutes pass the end of the causative flare; that is, for a few tens of minutes to an hour or two.

017. SATCOM and radar interference

Solar flares can cause the amount of radiowave energy emitted by the sun to increase by a factor of tens of thousands over certain frequency bands in the very high frequency (VHF) to super high frequency (SHF) range (30 MHz to 30 GHz). These radio bursts can produce direct radio frequency interference (RFI) on a SATCOM link, or a missile detection or spacetrack radar, if the sun is in the field of view of the receiver and if the burst is at the right frequency and intense enough. Knowledge of a solar radio burst can allow a SATCOM or radar operator to isolate the RFI cause and avoid time consuming investigation of possible equipment malfunction or intentional jamming (fig. 2–10).

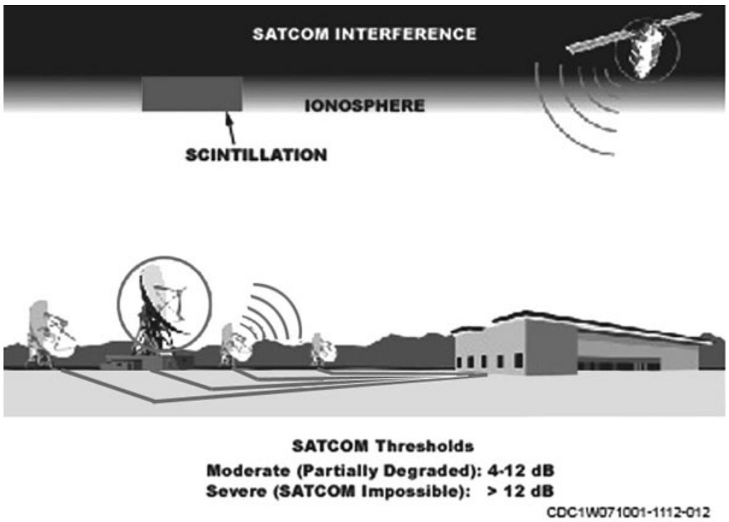

Figure 2–10. SATCOM interference.

Solar radio bursts

Radio bursts (fig. 2–11) are another "immediate" effect, experienced simultaneously with observation of the causative solar flare. Consequently, it is not possible to forecast the occurrence of radio bursts, let alone on what frequencies they will occur and at what intensities. Rather, forecasters can only issue rapid warnings (within 7 minutes of event onset) that identify the observed burst frequencies and intensities. Radio burst impacts are limited to the sunlit hemisphere of the earth. They will persist only for a few minutes to tens of minutes, but usually not for the full duration of the causative flare.

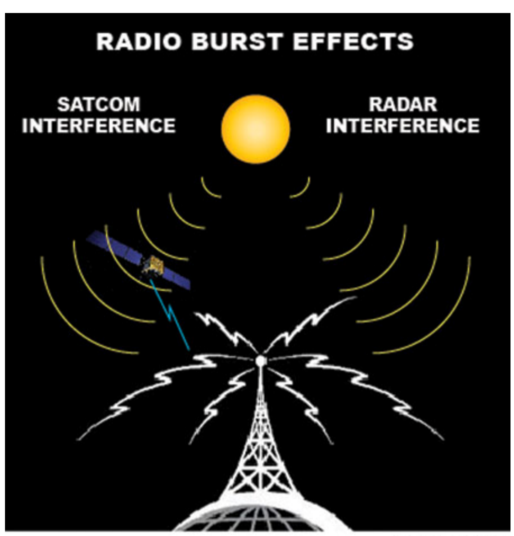

Figure 2–11. Radio burst effects.

Solar conjunction

There is a similar geometry-induced affect, called "solar conjunction," which accounts for why geosynchronous communication satellites will experience interference or blackouts (e.g., static or "snow" on TV signals) during brief periods on either side of the spring and autumn equinoxes. This problem does not require a solar flare to be in progress, but its significance is definitely greatest during Solar Max when the sun is a strong background radio emitter.

Solar radio noise storms

Sometimes a large sunspot group will produce slightly elevated radio noise levels, primarily on frequencies below 400 MHz. This noise may persist for days, occasionally interfering with communications or radar systems using an affected frequency.

Particle (delayed) effects

We continue the discussion of specific DOD system impacts with the major delayed (or charged particle induced) system impacts. The "delayed" impacts tend to occur hours to several days after the solar activity that caused them, persist for up to several days, and be mostly felt in the nighttime sector (since the particles that cause them usually come from the magnetosphere's tail), although they are not limited to that time or geographic sector.

Particle events

The sources of the charged particles (mostly protons and electrons) include: solar flares, disappearing filaments, eruptive prominences, and SSBs or high-speed streams (HSS) in the solar wind. Except for the most energetic particle events, the charged particles tend to be guided by the IMF which lies between the sun and the earth's magnetosphere. The intensity of a particle-induced event generally depends on the size of the solar flare, filament, or prominence, its position on the sun, and the structure of the intervening IMF. Alternately, the sharpness of a SSB or density/speed of a HSS will determine the intensity of a particle-induced event caused by these phenomena.

Recurrence

One important factor in forecasting particle events is that some of the causative phenomena (like SSBs and coronal holes, the source region for HSSs) persist for months, while the sun rotates once every 27 days. As a result, there is a tendency for these long lasting phenomena to show a 27-day recurrence in producing geomagnetic and ionospheric disturbances.

018. High frequency absorption events

We discussed high frequency SWFs over the sunlit hemisphere (caused by solar flare X-rays enhancing D-layer absorption) earlier. There are similar HF absorption events at high geomagnetic latitudes (above 55 degrees). However, at high latitudes the enhanced ionization of D-layer atoms and molecules (which produce signal absorption) is caused by particle bombardment from space. Another difference is that these high latitude absorption events can last for hours to several days, and usually occur simultaneously with other radio transmission problems like nongreat circle propagation and multipath fading or distortion.

Polar cap absorption events

For a polar cap absorption (PCA) event, the enhanced ionization is caused by solar flare protons that gain direct access to low altitudes (as low as 35 km) by entering through the funnel-like cusps in the magnetosphere above the earth's polar caps.

Auroral zone absorption events

For an auroral zone absorption (AZA) event, the enhanced ionization is caused by particles (primarily electrons) from the magnetosphere's tail, which is accelerated toward the earth during a geomagnetic storm and is guided by magnetic field lines into the auroral zone latitudes. These are the same ionizing particles that cause the aurora or northern/southern lights (fig. 2–12).

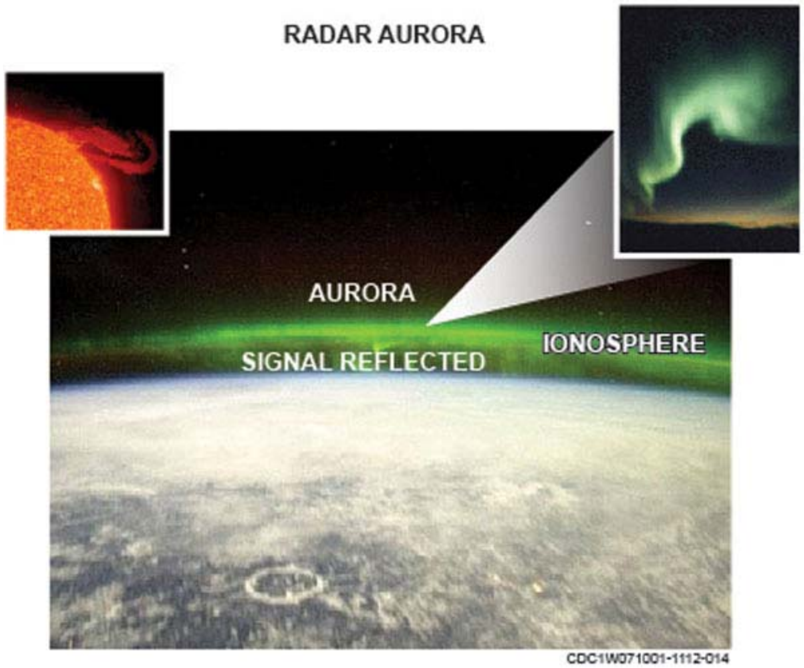

Figure 2–12. RADAR aurora.

019. Ionospheric scintillation

The intense ionospheric irregularities found in the auroral zones are also one cause of ionospheric "scintillation," at least at high geomagnetic latitudes. Scintillation of radiowave signals is the rapid, random variation in signal amplitude, phase, and/or polarization caused by small-scale irregularities in the electron density along a signal's path (fig. 2–13 to fig. 2–15). Ionospheric radiowave scintillation is very similar to the visual twinkling of starlight or heat shimmer over a hot road caused by atmospheric turbulence. The result is signal fading and data drop outs on satellite command uplinks, data downlinks, or on communications signals. Scintillation tends to be a highly localized effect. Only if the signal path penetrates an ionospheric region where these small-scale electron density irregularities are occurring will an impact be felt. Low latitude, nighttime links with geosynchronous communications satellites are particularly vulnerable to intermittent signal loss due to scintillation. In fact, during the Persian Gulf War, allied forces relied heavily on SATCOM links, and scintillation posed an unanticipated, but very real operational problem.

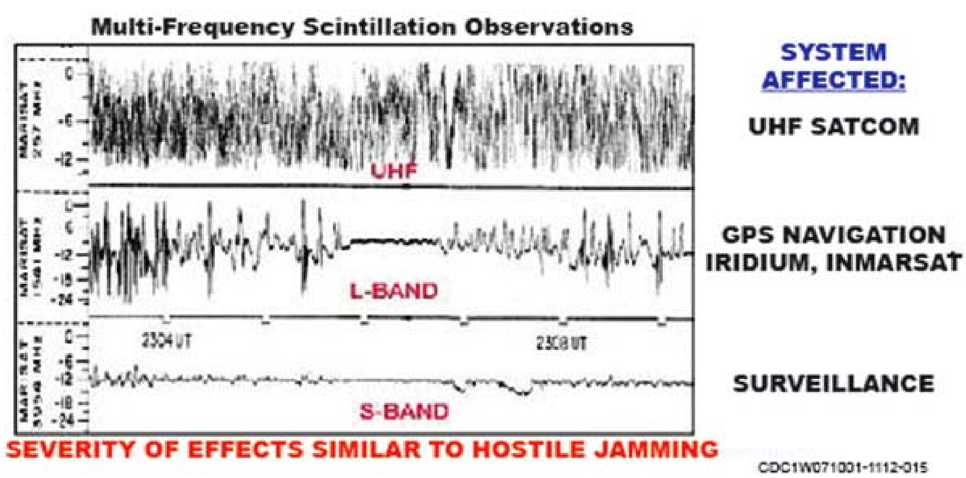

Figure 2–13. Scintillation.

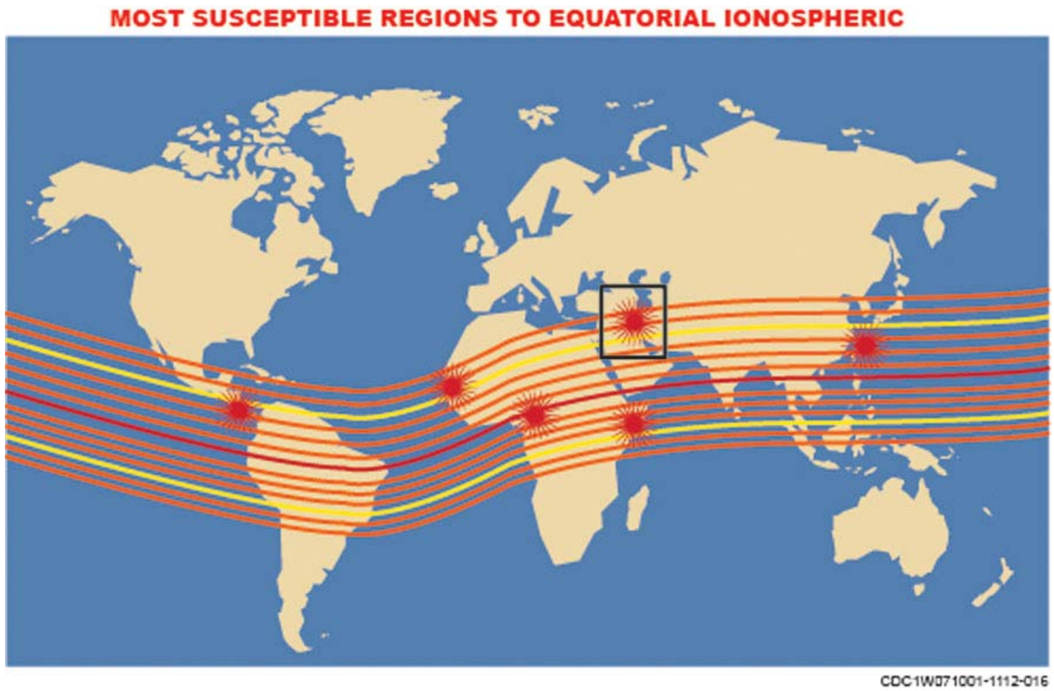

Figure 2–14. Susceptible regions.

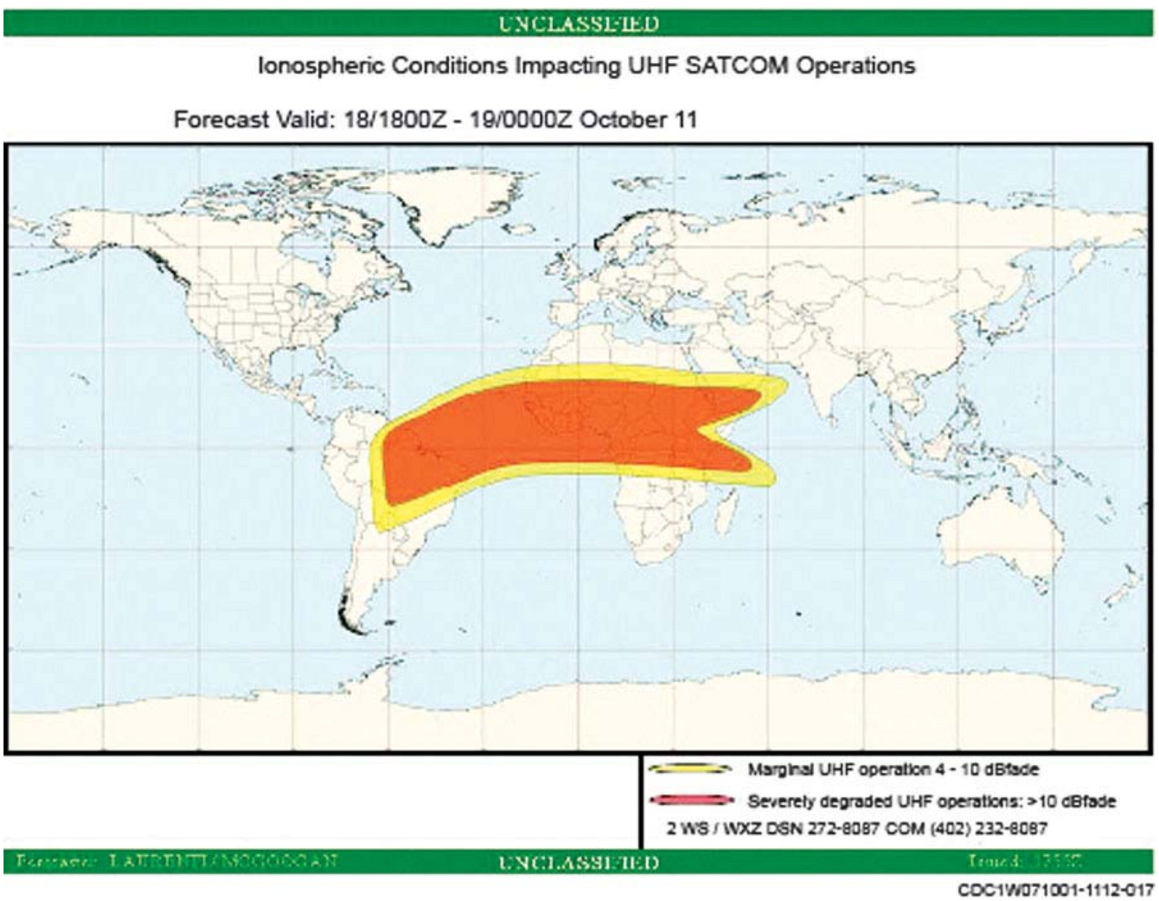

Figure 2–15. SATCOM interference.

Global Positioning System and scintillation

Global Positioning System (GPS) satellites, which are located at semisynchronous altitude, are also vulnerable to ionospheric scintillation (fig. 2–16). Signal strength enhancements and fades, as well as phase changes, due to scintillation can cause a GPS receiver to lose signal lock with a particular satellite. The reduction in the number of simultaneously useable GPS satellites may result in a potentially less accurate position fix. Since scintillation occurrence is positively correlated with solar activity and the GPS network has received widespread use only recently (during a quiet portion of the 11-year solar cycle), the true environmental vulnerability of the GPS constellation is yet to be observed.

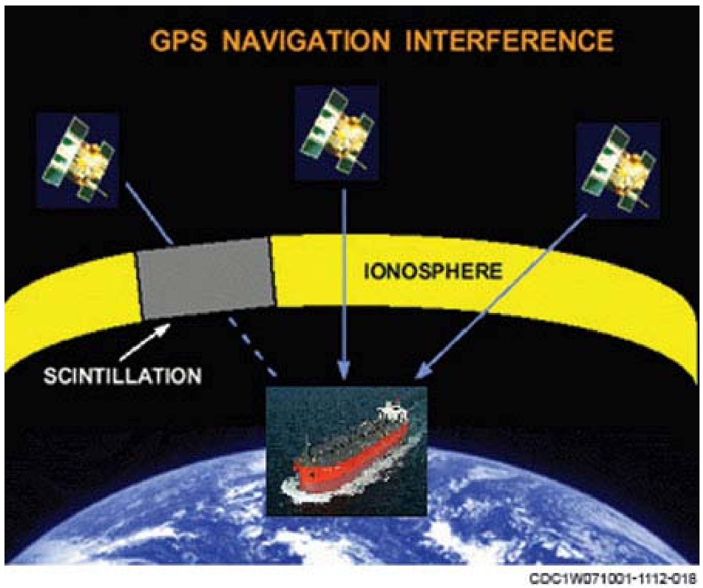

Figure 2–16. GPS interference.

GPS and total electron content

The total electron content (TEC) along the path of a GPS signal can introduce a positioning error. Just as the presence of free electrons in the ionosphere caused HF radiowaves to be bent (or refracted), the higher frequencies used by GPS satellites will suffer some bending (although to a much lesser extent than with HF radiowaves). This signal bending increases the signal path length. In addition, passage through an ionized medium causes radiowaves to be slowed (or retarded) somewhat from the speed of light. Both the longer path length and slower speed can introduce up to 300 nanoseconds (equivalent to about 100 meters) of error into a GPS location fix—unless some compensation is made for the effect.

The solution is relatively simple for two-frequency GPS receivers, since signals of different frequency travel at different speeds through the same medium. Measuring the difference in signal phases for the two frequencies allows computation of the local phase delay for a particular receiver and elimination of 99 percent of the error introduced in a location fix. Unfortunately, this approach will not work for single-frequency receivers. For them, a software algorithm is used to model ionospheric effects based on day of the year and the average solar untraviolet (UV) flux for the previous few days.

This method produces a gross correction for the entire ionosphere. But, as we've already stated, the ionosphere varies rapidly and significantly over geographical area and time. Consequently, the algorithm can eliminate at best about 50 percent of the error, and a far smaller percentage of the error in regions where an enhanced degree of ionization is found—such as in the auroral latitudes and near the magnetic equator during evening hours.

Scintillation occurrence

Because there is no fielded network of ionospheric sensors capable of detecting real-time scintillation occurrence or distribution, presently space environmental forecasters are heavily dependent on its known association with other environmental phenomena (such as aurora) and scintillation climatology. Scintillation is also frequency dependent; the higher the radio frequency (all other factors held constant), the lesser is the impact of scintillation. Statistically, scintillation tends to be most severe at low latitudes (within plus or minus 20 degrees of the geomagnetic equator) due to ionospheric anomalies in that region. It is also strongest from local sunset until just after midnight, and during periods of high solar activity. At high geomagnetic latitudes (the auroral and polar regions), scintillation is strong, especially at night, and its influence increases with higher levels of geomagnetic activity. Knowledge of those time periods and portions of the ionosphere, where conditions are conducive to scintillation, permit operators to reschedule activities and/or to switch to less susceptible radio frequencies or satellite links.

020. Effects of atmosphere drag

A major source for space object positioning errors is either more or less atmospheric drag than expected on low orbiting objects (generally at less than about 1000 km altitude). Energy deposited in the earth's upper atmosphere by EUV, X-ray, and charged particle bombardment heats the atmosphere, causing it to expand outward. Low earth-orbiting satellites and other space objects then experience denser air and more frictional drag than expected. This drag decreases an object's altitude and increases its orbital speed. The result is the object will be some distance below and ahead of its expected position when a ground radar or optical telescope attempts to locate it. Conversely, exceptionally quiet solar and/or geomagnetic conditions will cause less atmospheric drag than predicted, and an object would be higher and behind where it was expected to be found (fig. 2–17).

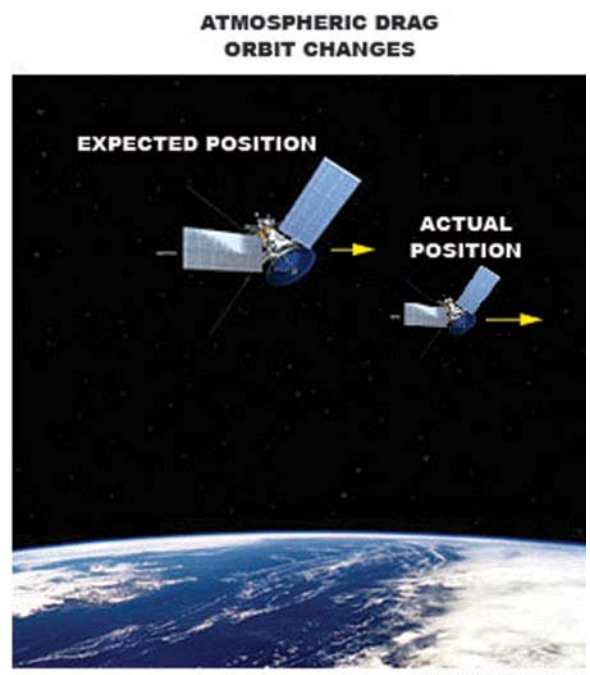

Figure 2–17. Drag.

Impacts of atmospheric drag

The consequences of atmospheric drag include: (1) inaccurate satellite locations can hinder rapid acquisition of SATCOM links for commanding or data transmission, (2) costly orbit maintenance maneuvers may become necessary, and (3) de-orbit predictions may become unreliable. A classic case of the later was Sky Lab. Geomagnetic activity was so severe, for such an extended period, that Sky Lab de-orbited and burned-in before a planned Space Shuttle rescue mission was ready to launch.

Contributions to drag

There are two space environmental parameters used by current models to predict the orbits of space objects. The first is the solar "F10 index." Although the F10 index is a measure of solar radio output at 10.7 centimeters (or 2,800 MHz), it is a very good indicator of the amount of EUV and X-ray energy emitted by the sun and deposited in the earth's upper atmosphere. There is clearly a 27-day periodicity caused by the sun's 27-day period of rotation and the fact that hot, active regions are not uniformly distributed on the sun's surface. The second parameter is the geomagnetic "Ap index," which is a measure of the energy deposited in the earth's upper atmosphere by charged particle bombardment. This index shows strong spikes corresponding to individual geomagnetic storms (fig. 2–18). Since it takes time for the atmosphere to react to a change in the amount of energy being deposited in it, the impact of drag first tend to be noticeable about 6 hours after a geomagnetic storm starts, and may persist for about 12 hours after the storm ends.

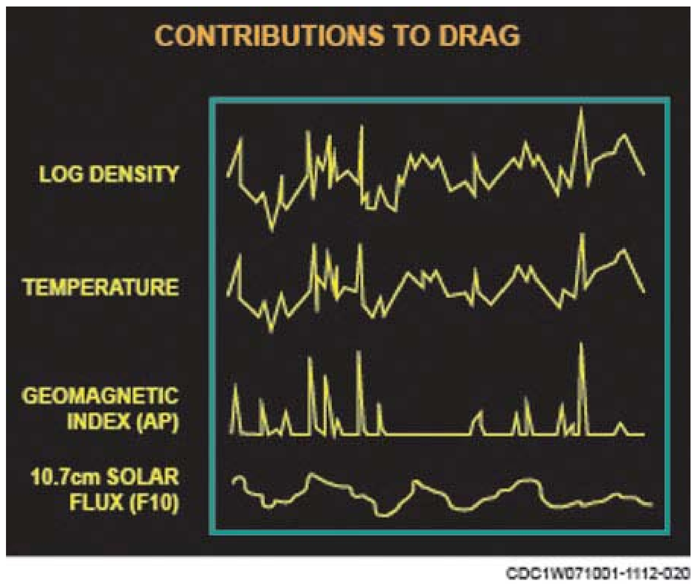

Figure 2–18. Contributions to drag.

021. Radiation hazards

Despite all engineering efforts, satellites are still quite susceptible to the charged particle environment; in fact, with the newer microelectronics and lower voltages, it will actually be easier to cause electrical upsets than on the older, simpler vehicles. Furthermore, with the perceived lessening of the man-made nuclear threat, there has been a trend to build new satellites with less nuclear radiation hardening. This lost hardening also protected the satellites from space environmental radiation hazards. Both low and high earth-orbiting spacecraft and satellites are subject to a number of environmental radiation hazards, such as direct collisional damage and/or electrical upsets, caused by charged particles. These charged particles may be: (1) trapped in the "Van Allen Radiation Belts," (2) in directed motion during a geomagnetic storm, or (3) protons/cosmic rays of direct solar or galactic origin.

Van Allen Radiation Belts

The Outer and Inner Van Allen Radiation Belts are two concentric, toroid (or donut-shaped) regions of stablely trapped charged particles that exist because the geomagnetic field near the earth is strong and field lines are closed. The inner belt has a maximum proton density near 5,000 km above the earth's surface, and contains mostly high energy protons produced by cosmic ray collisions with the earth's upper atmosphere. The outer belt has a maximum proton density near 16,000 to 20,000 km, and contains low to medium energy electrons and protons whose source is the influx of particles from the magnetotail during geomagnetic storms.

Geosynchronous orbit

Geosynchronous orbit (35,782 km or 22,235 statute miles altitude) is commonly used for communication satellites. Unfortunately, it lies near the outer boundary of the outer belt, and suffers whenever that boundary moves inward or outward. Semisynchronous orbit (which is used for GPS satellites) lies near the middle of the outer belt (in a region called the "ring current"), and suffers from a variable, high density particle environment. Both orbits are particularly vulnerable to the directed motion of charged particles that occurs during geomagnetic storms. Particle densities observed by satellite sensors can increase by a factor of 10 to 1,000 over a time period as short as a few tens of minutes.

Geomagnetic storms

As we mentioned earlier, charged particles emitted by the sun, cause problems primarily on the night side of the earth. The reason is the arrival of solar particles causes a shockwave to ripple through the magnetosphere, magnetic field lines out in the magnetosphere's tail recombine, and previously stored particles are shot toward the earth's nightside hemisphere. Some of these particles stay near the plane of the equator and feed the ring current in the Outer Van Allen Radiation Belt, while other particles follow magnetic field lines up (and down) toward auroral latitudes.

Those particles from the nightside magnetosphere (or magnetotail) which stayed near the plane of the equator will feed the ring current in the Outer Van Allen Belt. The electrons and protons, since they are oppositely charged, tend to move in opposite directions when they reach the ring current. Furthermore, the protons and electrons have about the same energy, but the electrons (since they are 1,800 times lighter) move 40 times faster. Finally, the electrons are about 10 to 100 times more numerous than the protons. The result of all these factors is that electrons are much more effective at causing collisional damage and electrical charging than the protons. This fact explains why the preponderance of satellite problems occurs in the midnight to dawn (00 to 06 Local) sector, while the evening (18 to 00 Local) sector is the second most preferred location for problems. This explanation is well supported by the large number of satellite anomalies actually observed in the midnight to dawn sector.

022. Electrical charging

One of the most common anomalies caused by the radiation hazards we discussed above is spacecraft or satellite electrical charging. Charging can be produced by: (1) an object's motion through a medium containing charged particles (called "wake charging"), which is a significant problem for large objects like the Space Shuttle or a space station; (2) directed particle bombardment, as occurs during geomagnetic storms and proton events; or (3) solar illumination, which causes electrons to escape from an object's surface (called the "photoelectric effect"). The impact of each phenomena is strongly influenced by variations in an object's shape and the materials used in its construction.

Surface vs. deep charging

An electrical charge can be deposited either on the surface or deep within an object. Solar illumination and wake charging are surface charging phenomena. For directed particle bombardment, the higher the energy of the bombarding particles, the deeper will be the charge that can be placed. Normally electrical charging will not (in itself) cause an electrical upset or damage. It will deposit an electrostatic charge, which will stay on the vehicle (for perhaps many hours) until some triggering mechanism causes a discharge or arcing. Such mechanisms include: (1) a change in particle environment, (2) a change in solar illumination (like moving from eclipse to sunlit), or (3) onboard vehicle activity or commanding.

Charging impacts

Generally, an electrostatic discharge can produce: (1) spurious circuit switching; (2) degradation or failure of electronic components, thermal coatings, and solar cells; or (3) false sensor readings. In extreme cases, a satellite's life span can be significantly reduced, necessitating an unplanned launch of a replacement satellite. Warnings of environmental conditions conducive to spacecraft charging allow operators to reschedule vehicle commanding, reduce onboard activity, delay satellite launches and deployments, or reorient a spacecraft to protect it from particle bombardment.

Should an anomaly occur, an environmental post analysis can help operators determine whether the environment contributed to it, and the satellite function can be safely reactivated or reset, or whether engineers need to be called out to investigate the incident. An accurate assessment can reduce downtime by several days. Charging occurs primarily when solar and geomagnetic activity is high, and on geosynchronous or polar-orbiting satellites (fig. 2–19).

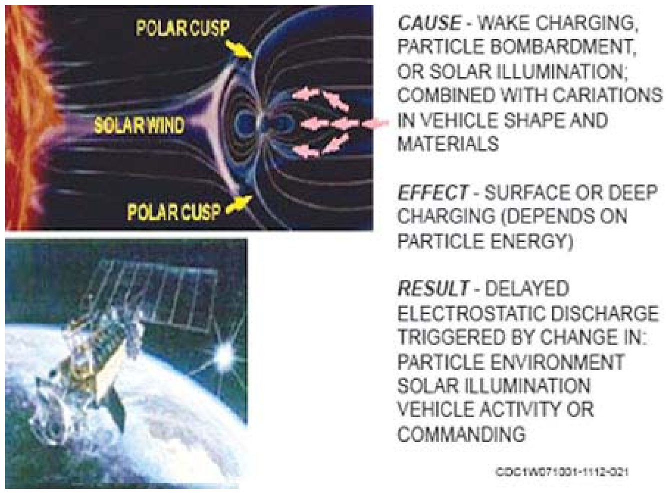

Figure 2–19. Spacecraft charging.

023. Single event upsets

Very high-energy protons or ions (either from solar flares or the Inner Van Allen Belt) or cosmic rays (either from the very largest solar flares or from galactic sources outside our Solar System) are capable of penetrating completely through a satellite. As they pass through, they will ionize particles deep inside the satellite. In fact, a single proton or cosmic ray can (by itself) deposit enough charge to cause an electrical upset (circuit switch, spurious command, or memory change or loss) or serious physical damage to onboard computers or other components. Hence, these occurrences are called "single event upsets" (SEUs) (fig. 2–20 to fig. 2–23).

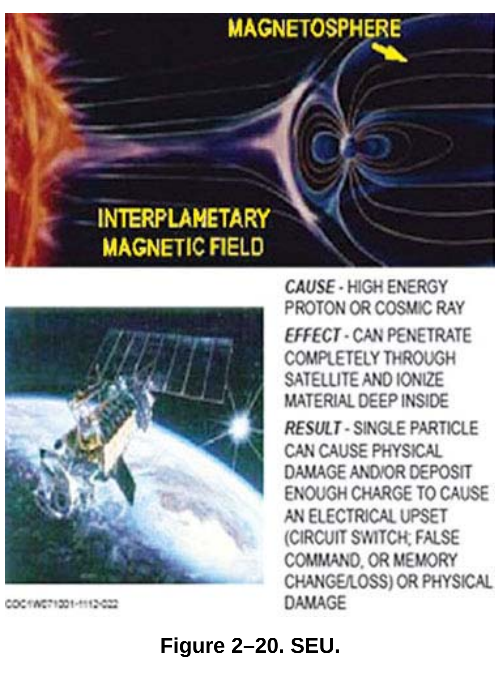

Figure 2–20. SEU.

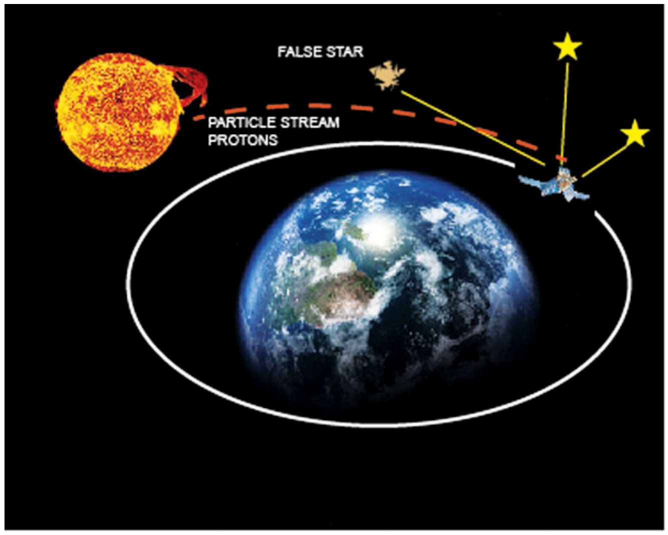

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Figure 2–21 Satellite disorientation.

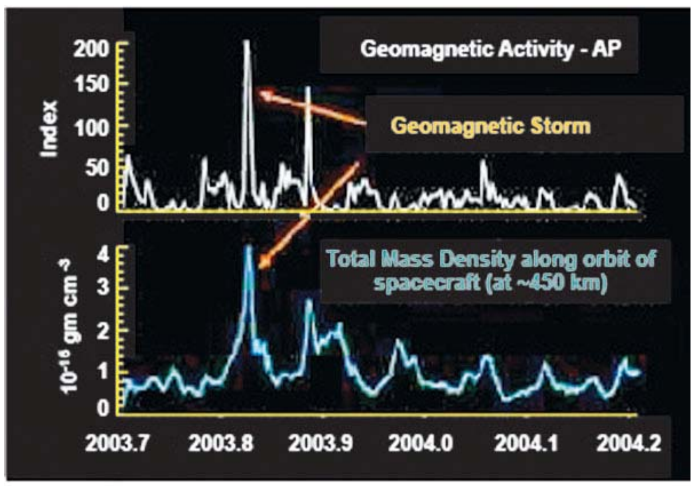

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Figure 2–22. Geomagnetic storm impact on orbit changes.

- Worldwide HF Radio Blackouts and SATCOM Interference
- AF Satellite Control Network Interference
- LORAN Navigation Problems
- Missile Warning Radar Interference
- Lost Imagery and Communications on GOES Satellites
- GPS errors and interfenence proventing lock-on
- Permanent Loss of Command Circuitry on Communications Satellites
- Commercial Satellites Require Manual Operator Interventions to Maintain Orientation
- Power Outages
- Loss of Space Object tracking
- Compass Alignment Errors

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Figure 2–23. Example of system impacts from a large solar flare.

SEUs are very random, almost unpredictable events. They can occur at any time during the 11-year solar cycle. In fact, SEUs are actually most common near Solar Minimum; when the IMF emanating from the sun is weak and unable to provide the earth much shielding from cosmic rays originating outside the Solar System.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

014. Background on solar emissions

1. Where does the most intense portion of the sun's EM energy fall?

2. What is the outflow of energetic charged particles from the sun called?

3. How long does it take the sun to make one revolution?

4. On average, how fast do solar wind particles travel?

5. What is the magnetosphere?

6. What's the average sunspot cycle?

7. What's the average sunspot solar cycle?

8. How many years does it normally take to go to Solar Maximum from Solar Minimum?

9. How many years does it normally take to go to Solar Minimum to Solar Maximum?

10. What is the prime cause of solar activity?

11. What is a solar flare?

12. Where do solar flares usually occur?

13. What’s more intense, a 0F or 4B flare?

14. What’s a geomagnetic storm?

15. What’s an ionospheric disturbance?

015. Electromagnetic versus. solar particle effects

1. How long does it take for EM radiation to reach the earth after a solar flare occurs?

2. How long does it take for high-energy particles to travel to the earth after a solar flare?

3. How long does it take low to medium particles to reach the earth after a solar flare?

016. Short wave fades impacts

1. What is a short wave fade?

2. Where is the greatest degree of ionization in the ionosphere?

3. What is it called when the HF propagation window is completely closed?

017. SATCOM and radar interference

1. What accounts for why geosynchronous communication satellites experience interference or blackouts on either side of the spring and autumn equinoxes?

2. Where does the interplanetary magnetic field lie?

018. High frequency absorption events

1. How do protons gain entrance to cause polar cap absorption events?

2. Where do the particles that cause auroral zone absorption events come from?

019. Ionospheric scintillation

1. What is scintillation?

2. Is scintillation a broad or localized effect?

3. Statistically, at what latitudes is scintillation most severe?

020. Effects of atmosphere drag

1. What is the result of atmospheric drag?

2. What are the two space environmental parameters used to predict the orbits of space objects?

3. When does the impact of drag first tend to be noticed?

021. Radiation hazards

1. On what side of the earth do charged particles primarily cause problems?

2. What particle is most effective at causing collisional damage?

3. What sector shows the preponderance of satellite problems?

022. Electrical charging

1. Where can electrical charging be deposited?

2. When does charging primarily occur?

023. Single event upsets

1. How predictable are SEU?

2. When are SEU most common?

Answers to Self-Test Questions

010

1. Provide the warfighter tailored weather information that enhances combat effectiveness.
2. Because our ability to collect the data, model and forecast the weather and the perishable nature of weather data is all affected by human error.
3. Relevance to the operational user.
4. Where there is a high probability of military operations.

011

1. Collection, analysis, forecasting and tailored applications, dissemination, evaluation and integration.
2. Because of the rapid changing nature of the aerospace environment.
3. Allows them to identify favorable, marginal, and unfavorable weather effects.
4. Through AFW evaluations by operational users.

012

1. Favorable, marginal, and unfavorable.
2. Green–Go Amber–Marginal Red–No/Go.
3. Strategic, high, low.
4. State of the ground.
5. Precipitation.

013

1. EM radiation travels at the speed of light—186,000 mps or 300,000 km/sec.
2. The sun.
3. Infrared radiation.
4. It depends on the relative size between the wavelength of the EM radiation and the object.
5. Rayleigh, geometric or reflection, and Mie.
6. Visible, infrared, and microwave.
7. Inherent, apparent, and threshold contrast. Inherent contrast is the measured contrast between lines on a piece of paper and the paper. Apparent contrast is the contrast measured or perceived at some distance from the target. Threshold contrast is the minimum contrast that your eyes can detect.
8. Optical turbulence degrades weapons system performance, especially the shorter wavelength sensors (visible and near-IR). The effects of optical turbulence are more pronounced near the ground. BIC such as dust, smoke, or debris from explosions obscure the target from view. Manmade obscurants have been manufactured to purposely degrade the effectiveness of the weapons system, such as fog oil or burning phosphorous, used to screen field maneuvers from the enemy's vision. Other environmental effects include icing, hail, sand or other large particles, lightning or static discharges from electric charge buildup (triboelectrification).
9. It is the point in time when a target and its background are at the same temperature.
10. When some target scenes are filled with multiple hot and cold objects making detection of the target difficult.
11. Refraction.
12. A strong temperature and/or moisture lapse rate.

014

1. The visible part.
2. Solar Wind.
3. 27 days.
4. 400km per second.
5. The volume of space where the earth's own magnetic field can exclude the sun's IMF and control the motion of charged particles.
6. 11 years.
7. 7 years.
8. 4 years.
9. 2–3 years after Solar Max.

10. Solar flares.
11. An explosive release of energy within a relatively small region of the lower solar atmosphere.
12. In the vicinity of sunspots and plage.
13. 4B.
14. Rapid variations in the earth's magnetic field.
15. An irregular fluctuation in its degree of ionization.

015

1. Approximately 8 minutes.
2. 15 minutes to a few hours.
3. 2–4 days.

016

1. An abnormally high fading or absorption of an HF signal.
2. F layer.
3. Shortwave blackout.

017

1. Solar conjunction.
2. Between the sun and the earth's magnetosphere.

018

1. Funnel-like cusps in the magnetosphere above the polar caps.
2. The magnetosphere tail.

019

1. The rapid, random variation in signal amplitude, phase, and/or polarization.
2. Localized.
3. Low.

020

1. It decreases an object's altitude and increases its orbital speed.
2. F10 Index and Ap Index.
3. About 6 hours after a geomagnetic storm starts.

021

1. Night side.
2. Electrons.
3. Midnight to dawn.

022

1. Either on the surface or deep within an object.
2. When solar and geomagnetic activity is high.

023

1. Almost unpredictable.
2. Solar Minimum.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

36. (010) What is the most important role of the AF weather (AWF) personnel?
    a. To help the war fighter understand the effects of terrestrial and space weather.
    b. To ensure that the accuracy of weather forecasts take precedence over timeliness of data.
    c. To provide the war fighter tailored weather information that enhances combat effectiveness.
    d. To collect and analyze terrestrial and space weather data without respect to war fighter relevance.

37. (010) Air Force Weather (AFW) is most effective when a commander receives
    a. accurate weather forecasts covering a global scale.
    b. accurate and relevant weather forecasts in a timely manner.
    c. timely weather forecasts for all operations regardless of accuracy.
    d. accurate and relevant weather forecasts regardless of actual timeliness.

38. (010) Weather personnel tailor the information for specific applications so the war fighter can
    a. quickly identify and correct any erroneous weather analysis.
    b. manipulate the weather data further to ensure relevancy to the war fighter.
    c. quickly identify and apply relevant information without additional analysis.
    d. continue to manipulate and correct the data to ensure accuracy and timeliness.

39. (010) The overall effectiveness of Air Force Weather (AFW) is based on the
    a. successful and effective accomplishment of specific military operations.
    b. war fighter’s ability to understand the weather’s affects on the current mission.
    c. the specific degree to which the forecast is or is not accurate and relevant to the user.
    d. how many times the weather forecast must be amended or corrected before the mission ends.

40. (011) Air Force Weather (AFW) develops a coherent picture of the current state of the air and space environment as a result of performing
    a. forecasting and tailored application.
    b. dissemination.
    c. integration.
    d. analysis.

41. (011) Weather information is of no operational use unless
    a. it is accurate, no matter how long it takes to reach the user.
    b. it is relevant to the mission at hand, regardless of timeliness.
    c. it is in keeping with climatological values for known events.
    d. it reaches the user in time to be of operational or planning value.

42. (011) Integration of weather information as decision aids into the planning process allows commanders to
    a. use the appropriate software application to obtain forecasts.
    b. ask the weather forecaster to make changes to the weather data.
    c. make informed decisions about the design and operation of a plan.
    d. create hard and fast war plans that will not require changes due to adverse weather.

43. (012) The term marginal implies that the impact of weather elements will cause
    a. large degradation to the mission.
    b. a cancellation of any planned missions.
    c. no degradation to the mission of any kind.
    d. the occurrence of some degradation to the mission.

44. (012) What must you understand in order for your weather flight (WF) to fully support aerial operations?
    a. The limitations and capabilities of each airframe and the scope of the operation.
    b. The physical geography of the regions your customer will operate in and around.
    c. The necessity of intelligence gathering operations performed by your customer.
    d. The experience level of your customer and how long they need for acclimatization.

45. (012) The ability for ground forces to maneuver and traverse across terrain refers to
    a. trafficability.
    b. bridging capability.
    c. operations capability.
    d. reconnaissance capability.

46. (013) In operational terms, what can be expected if two objects are identical in every physical way except emissivity?
    a. Lower emissivity heats or cools faster than the other.
    b. Higher emissivity heats or cools faster than the other.
    c. Lower radiative temperature heats or cools faster than the other.
    d. Higher radiative temperature heats or cools faster than the other.

47. (013) What term is used to express the difference between the thermal energy of the target and that of
    the background?
    a. Thermal crossover.
    b. Inherent contrast.
    c. Thermal contrast.
    d. Thermal clutter.

48. (013) The moment when the target and the background are at the same temperature is referred to as
    a. thermal crossover.
    b. thermal contrast.
    c. inherent contrast.
    d. thermal clutter.

49. (013) Why does a beam of light traveling through air bend once it hits water?
    a. Speed of light is faster in water.
    b. Speed of light is slower in water.
    c. Apparent contrast of water is lower than air.
    d. Apparent contrast of water is higher than air.

50. (014) The greatest potential for large solar flares is
    a. during the solar maximum.
    b. during the solar minimum.
    c. two to three years immediately following a solar maximum.
    d. two to three years immediately following a solar minimum.

51. (014) What is associated with strong auroral activity, degraded high frequency (HF) and satellite radio communications, and errors in spacetrack and missile detection radar observations?
    a. Proton events.
    b. Ionospheric storms.
    c. Geomagnetic storms.
    d. Sudden ionospheric disturbances.

52. (014) What represents a direct radiation danger to astronauts and high altitude aircraft crews and may produce direct collisional electrical charging on satellites or spacecraft?
    a. Proton events.
    b. Short wave fades.
    c. Geomagnetic storms.
    d. Sudden ionospheric disturbances.

53. (015) A flare is already causing immediate environmental effects and DOD system impacts by the time we first observe it because
    a. current technology for detecting solar flares is limited.
    b. the flare detection equipment network operates on an 8 minute delay.
    c. very little climatology concerning initial stages of solar flares is available.
    d. the X-ray, ultraviolet, optical, and radio waves flares emit travel at the speed of light.

54. (015) When do the effects of solar flares tend to subside?
    a. Shortly after the flare ends.
    b. At the same time the flare ends.
    c. During the onset of the next solar maximum.
    d. Several hours to a few days following the flare.

55. (015) The impact of a proton event can last for
    a. a few hours to several days after the flare ends.
    b. a few minutes to one hour after the flare ends.
    c. several weeks to one month after the flare begins.
    d. until the effects are broken by the onset of another flare.

56. (015) What effect in not caused by proton events?
    a. False sensor readings.
    b. Satellite disorientation.
    c. Absorption of high frequency (HF) radio signals.
    d. Omnidirectional antenna failure.

57. (016) To what does a short wave fade (SWF) refer?
    a. The ionosphere's strongest (or F) layer.
    b. An abnormally high fading of a high frequency (HF) radio signal.
    c. The normal mode of radiowave propagation in the high frequency (HF) range.
    d. The portion of the ionosphere with the greatest degree of ionization.

58. (016) Surface-to-surface radio operators use medium or high frequencies (MF or HF), while SATCOM operators use very high frequencies (VHF) to extreme high frequencies (EHF) because
    a. the higher the frequency the less the degree of refraction cause by the F-layer.
    b. surface based operators use the normal mode of radiowave propagation by default.
    c. it has been determined that extreme high frequencies (EHF) cause radio interference on the earth.
    d. the F-layer continually disrupts the use of very high (VHF) and extreme high frequencies (EHF) on the earth.

59. (016) What is a short wave blackout?
    a. The range of frequencies between a lowest useable frequency (LUF) and a maximum useable frequency (MUF).
    b. An immediate effect experienced with the observation of a solar flare.
    c. A short wave fade (SWF) event that is strong enough to close the high frequency (HF) propagation window completely.
    d. That frequency threshold signaling too much absorption, preventing signal passage through the D-layer.

60. (017) Solar radio bursts are
    a. not possible to forecast due to model bias.
    b. best forecast using climatology and persistence.
    c. best forecast by collaborative effort with civilian counterparts.
    d. not possible to forecast since they are experienced simultaneously with observation of the solar flare.

61. (017) What causes geosynchronous communication satellites to experience interference or blackouts during brief periods on either side of the spring and autumn equinoxes?
    a. Solar radio bursts.
    b. Solar conjunctions.
    c. Solar radio noise storms.
    d. Particle delayed effects.

62. (017) Which system impacts tend to occur hours to several days after the solar activity that caused them, persist for up to several days, and are mostly felt in the nighttime sector?
    a. Particle delayed effects.
    b. Solar radio noise storms.
    c. Geomagnetic delayed events.
    d. Ionospheric delayed effects.

63. (017) Particle events and associated geomagnetic disturbances often show a 27-day recurrence because
    a. the sun rotates once every 27 days.
    b. they are influenced by the lunar cycle.
    c. climatology shows that solar flares occur in 27-day cycles.
    d. they can only be detected during lunar darkness.

64. (018) What causes the enhanced ionization of D-layer atoms and molecules which produces signal absorption at high latitudes?
    a. Particle bombardment from space.
    b. Interaction of particles with aurora.
    c. The enhanced influences of the polar caps.
    d. The extreme nature of seasonal day and night lengths.

65. (018) The enhanced ionization caused by solar flare protons enter through the funnel-like cusps in the magnetosphere above the earth's polar caps is called
    a. a short wave fade event.
    b. a polar cap absorption event.
    c. an auroral zone absorption event.
    d. a geomagnetic or ionospheric storm event.

66. (018) What causes auroral zone absorption events?
   a. The aftermath of geomagnetic storms.
   b. Particles from the magnetosphere’s tail.
   c. Polar cap absorption events and solar flares.
   d. Extremely long and persistent short wave fade events.

67. (019) What causes ionospheric scintillation at high geomagnetic latitudes?
   a. Rogue particles from the magnetosphere’s tail.
   b. The extreme variation of sun angles near the polar caps.
   c. Intense ionospheric irregularities found in the auroral zones.
   d. The immediate nature of effects produced by solar radio bursts.

68. (019) Scintillation of radiowave signals is
   a. relatively uncommon in polar regions.
   b. relatively common in equatorial regions.
   c. intense geomagnetic irregularities found in the ozone.
   d. the rapid, random variation in signal amplitude, phase, and/or polarization.

69. (019) What tends to occur as a result of scintillation?
   a. A sudden influx in apparent satellite network traffic.
   b. Signal fading and data drop outs on satellite uplinks and data downlinks.
   c. Increases in signal strength to the degree which satellite data is unreadable.
   d. False readouts on radar, satellite, and geological sensors in the mid latitudes.

70. (019) Impacts of scintillation will only be felt if
   a. a radio signal is not in use in or around the affected region.
   b. radio signals are traveling close enough to the region to intercept it.
   c. the signal is strong enough to avoid excessive refraction by the F-layer.
   d. the signal penetrates an ionospheric region where electron density irregularities are occurring.

71. (019) During what event did scintillation pose an unanticipated, but very real operational problem?
   a. Operation Desert Storm.
   b. Operation Deny Hope.
   c. Vietnam War.
   d. World War II.

72. (020) A major source for space object positioning errors is
   a. radio signal failure.
   b. solar radio bursts.
   c. unexpected auroral activity.
   d. miscalculated atmospheric drag.

73. (020) Atmospheric drag
   a. decreases an object’s altitude and increases its orbital speed.
   b. increases an object’s altitude and increases its orbital speed.
   c. decreases an object’s altitude and decreases its orbital speed.
   d. increases an object’s altitude and decreases its orbital speed.

74. (020) What is not a consequence of atmospheric drag?
   a. Satellite mechanism failures.
   b. Inaccurate satellite locations.
   c. Unreliable de-orbit predictions.
   d. Costly orbit maintenance maneuvers.

75. (020) The solar F10 index is used to
    a. forecast the necessity of navigational alterations.
    b. compare solar activity to tropospheric changes.
    c. predict the impact of short wave fade events.
    d. predict the orbits of space objects.

76. (021) The Outer and Inner Van Allen Radiation Belts are
    a. the extreme ends of the known radiation belts.
    b. the only detectable radiation belts presently known.
    c. actually composed of three regions of trapped charged particles.
    d. two concentric, donut-shaped regions of trapped charged particles.

77. (021) The Outer Van Allen Radiation Belt contains mostly
    a. low energy electrons high.
    b. energy protons and electrons.
    c. low to medium energy protons and electrons.
    d. medium to high energy protons and electrons.

78. (021) Geosynchronous orbit suffers whenever the Outer Belt moves inward or outward because
    a. it lies near the outer boundary of the Outer Belt.
    b. it lies near the inner boundary of the Outer Belt.
    c. it lies near the inner boundary of the Inner Belt.
    d. it lies near the outer boundary of the Inner Belt.

79. (021) Why do semisynchronous orbit suffers from a variable high density particle environment?
    a. It lies near the middle of the Inner Belt.
    b. It lies near the middle of the Outer Belt.
    c. It lies along the inner boundary of the Inner Belt.
    d. It lies just outside the outer boundary of the Inner Belt.

80. (021) Radiation belt electrons are
    a. about 1 to 5 times more numerous than protons.
    b. about 5 to 10 times more numerous than protons.
    c. about 10 to 100 times more numerous than protons.
    d. about 100 to 1000 times more numerous than protons.

81. (022) All of the following can produce spacecraft electrical charging except
    a. solar illumination.
    b. lunar illumination.
    c. motion through a medium containing charged particles.
    d. directed particle bombardment during geomagnetic storms and proton events.

82. (022) Solar illumination and wake charging are examples of
    a. unexpected solar events.
    b. surface charging phenomena.
    c. electrical and radiation hazards.
    d. core sector charging phenomena.

83. (022) What is not produced by an electrostatic discharge?
    a. False sensor readings.
    b. Spurious circuit switching.
    c. Failure of onboard modeling sensors.
    d. Failure of electronic components, thermal coatings, and solar cells.

84. (023) What is the source for cosmic rays which compliment single event upsets' (SEU)?
   a. Rather small, unnoticed solar flares?
   b. The middle of the Outer Van Allen Belt.
   c. Various sources that is rather difficult to forecast.
   d. Very largest solar flares or galactic sources outside our Solar System.

Student Notes

Glossary of Terms, Abbreviations, and Acronyms

Terms

Absorptivity—The ratio of absorbed radiation by an object to the absorbed radiation by a black body at the same wavelength and temperature.

Air and space expeditionary forces (AEF)—An organizational structure composed of force packages of capabilities that provides warfighting combatant commanders (CCDRs) with rapid and responsive aerospace power. AEFs are tailored to meet specific needs across the spectrum of response options and will deploy as aerospace expeditionary wings, groups, or squadrons. An AEF, by itself, is not a deployable or employable entity.

Air Force weather (AFW)—All Air Force activities which function together in a system to produce worldwide weather services for the Air Force, Army, unified commands, national programs, and other military and government agencies. It includes base and post weather stations; staff functions; centralized weather, climatology production facilities; and communications systems serving AFW.

Airspace Control Authority—The commander responsible for the aerospace control system within the airspace control area.

Algorithm—A procedure for solving a mathematical problem. Basically, it is a formula.

Allocation—Distribution of limited resources.

Ap index—A 24-hour planetary amplitude index representing the degree of geomagnetic activity on a worldwide scale.

Apparent contrast—The contrast measured or perceived at some distance from the target.

Aurora—Intermittent radio, infrared, visible, or ultraviolet emission from earth's upper atmosphere. Aurora occurs simultaneously at high northern and southern latitudes, and are sometimes called the northern or southern lights.

Auroral oval—A roughly elliptical band around either geomagnetic pole in which aurora occurs at a particular time.

Avenue of approach—Route or path taken to a specific point or target

Battalion—An Army or Marine unit equivalent to an Air Force squadron. Referred to as ODC or operational detachment charley in Army Special Forces.

Black body—A theoretically perfect absorber and emitter of radiation.

Center of gravity (COG)—The characteristics or localities that provide a military force the freedom of action, physical strength, or the will to fight.

Close air support—The act of expending ammunition, missiles, rockets or dropping bombs from airframes in close proximity to ground troops engaged against the enemy.

Combatant command—A unified or specified command with a broad continuing mission under a single commander who is designated by the Secretary of Defense.

Combined—Between two or more forces or agencies of two or more allies.

Company—An Army or Marine unit made up of multiple platoons or teams. Referred to as ODB or operational detachment bravo in Army Special Forces.

Contingency—An emergency involving military forces caused by natural disasters, terrorists, subversives, or by required military operations. Due to the uncertainty of the situation, contingencies require plans, rapid response, and special procedures to ensure the safety and readiness of personnel, installations, and equipment.

Contrast—The difference between the object and background.

Coronal Hole—A region of open magnetic field lines in the sun's outermost atmosphere (or corona).

Cosmic Rays—Very high energy particles that permeate interstellar space.

Course of action (COA)—A plan or scheme adopted to accomplish a mission.

Division—A level of command in the US Army that includes multiple battalions or brigades. Divisions are the basic unit of tactical maneuvers and are self sustaining.

Doctrine—Fundamental principles by which military forces or elements thereof guide their actions in support of national objectives. It is authoritative but requires judgment in application.

Echelon above corps (EAC)—A generic term used to describe any echelon above the corps echelon.

Emergency Close Air Support—Close air support procedures followed when a JTAC is not available and there is no other option to endure safety of the team.

F10 Index—The 10.7 cm (2800 MHz) solar radio flux observed daily at local noon.

Field Operating Agency (FOA)—A subdivision of the Air Force, directly subordinate to a Headquarters US Air Force functional manager. The mission of an FOA does not fit into the mission of any of the major commands (MAJCOM). An FOA performs field activities beyond the scope of any of the major commands. AFWA is a FOA reporting to the chief of staff, USAF, through the HQ USAF Directorate of Weather.

Filament—A mass of relatively high density, low temperature gas suspended in the mid-to upper-solar atmosphere by magnetic fields. It is seen as a ribbon-like absorption feature, in single wavelength observations, against the solar disk—also, see Prominence.

Flare—A sudden, short-lived release of electromagnetic and particle radiation from a small region in the sun's lower atmosphere.

Force structure—Numbers, size, and composition of the units that comprise our defense forces; for example, divisions, ships, air wings.

Geomagnetic field—The magnetic field observed in the neighborhood of earth.

Geomagnetic storm—A widespread disturbance in earth's geomagnetic field, which results when an enhanced stream of solar particles strikes the magnetosphere. Geomagnetic storms are caused by particle emissions from solar flares and disappearing filaments (or equivalently eruptive prominences), or by enhancements and discontinuities in the solar wind associated with solar sector boundaries in the interplanetary magnetic field or high speed streams from solar coronal holes.

Geosynchronous orbit—The orbit of any equatorial satellite with an orbital velocity equal to the rotational velocity of earth, and thus a period of 23 hours, 56 minutes. Geosynchronous altitude is near 35,782 kilometers, 22,235 statute miles, or 19,321 nautical miles, above earth's surface. To also be geostationary, the satellite must satisfy the additional restriction that its orbital inclination be exactly zero degrees. The net effect is that a geostationary satellite is virtually motionless with respect to an observer on the ground.

High frequency (HF)—The 3 to 30 MHz radio wave band; normally used for long distance communication by refraction in the ionosphere's uppermost (or F) layer.

High speed stream (HSS)—A high speed, energetic stream of charged particles superimposed on the normal (or background) solar wind. The primary source for HSS' is coronal holes in the upper solar atmosphere, where magnetic field lines are open and do not impede the outward flow of charged particles.

Infrastructure—A term generally applicable to all fixed and permanent installations, fabrications, and facilities for the support and control of military forces.

Interplanetary magnetic field (IMF)—A magnetic field that originates on the sun's surface and extends into interplanetary space. The IMF typically has four to six sectors where the magnetic field is directed either away from or toward the sun. A sector boundary in the IMF is normally narrow, being convected past the earth in minutes or hours, compared to days to a week or so required for passage of the sector itself. The IMF strongly influences the motion of charged particles in the solar wind—also, see Solar Sector Boundaries.

Intelligence—The act of, or resulting product obtained by collecting, processing, integrating, analyzing, evaluating, and interpreting information.

Interoperability—The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together.

Ionosphere—The portion of earth's upper atmosphere where ions and electrons are present in quantities sufficient to affect the propagation of radio waves. Normally, the ionosphere extends down to about 50 km altitude, but at certain times and locations it can reach as low as about 35 km.

Ionospheric storm—A disturbance in the ionosphere that may follow the onset of a geomagnetic

Iridium—Satellite telephone used as a backup tactical communication device.

Joint—Indicates activities, operations, organizations, and so forth, in which elements of more than one service of the same nation participate.

Joint Chiefs of Staff (JCS)—The Chairman, Vice Chairman, Chief of Staff of the Army, Chief of Naval Operations, Chief of Staff of the Air Force, and Commandant of the Marine Corps.

Joint Doctrine—Fundamental principles that guide the employment of forces of two or more services in coordinated action toward a common objective.

Joint environment—Consists of forces from each military service and in some cases other government agencies.

Joint Force—A general term applied to a force composed of significant elements, assigned or attached, of the Army, the Navy or the Marine Corps, and the Air Force; or two or more of these services operating under a single commander authorized to exercise operational control.

Joint Force Meteorological and Oceanographic Forecast Officer (JMO)—Officer designated to provide direct meteorological and oceanographic support to the joint task force commander.

Joint Force Meteorological and Oceanographic Forecast Unit (JMFU)—A flexible, transportable, jointly supported collective of meteorological and oceanographic personnel and equipment formed to provide the joint task force commander, and joint force METOC officer with full meteorological and oceanographic services.

Joint Forces Commander—A general term applied to a combatant commander, subunified commander, or joint task force commander authorized to exercise combatant command (command authority) or operational control over a joint force.

Joint team—Combinations of personnel from different services brought together as a team to accomplish a specific mission set.

Law of Armed Conflict—A set of humanitarian rules, laws, and guidelines pertaining to military combat.

Lowest useable frequency (LUF)—The lowest frequency that allows reliable long range high frequency (HF) radio communication between two points on earth's surface by ionospheric refraction. It depends on the ionosphere's lowest (or D) layer absorption, transmitted power, receiver sensitivity, and other equipment parameters.

Magnetosphere—The magnetic cavity surrounding earth in which the geomagnetic field dominates and prevents, or at least impedes, the direct entry of solar wind particles.

Magnetotail—The portion of the magnetosphere in the antisunward direction, where geomagnetic field lines are drawn out to great distances by the flow of the solar wind passing earth.

Maximum useable frequency (MUF)—The highest frequency that allows reliable long range high frequency (HF) radio communication between two points on earth's surface by ionospheric refraction. It depends on the electron density in the ionosphere's strongest, uppermost (or F) layer at the point of refraction and the angle of incidence with which a radio wave enters the ionosphere. Frequencies higher than the MUF do not suffer sufficient refraction to be bent back toward earth and are transionospheric.

Megahertz—A measure of frequency equal to a million cycles per second.

Meteorological Watch (METWATCH)—The concept of watching for changes in weather conditions.

Military capability—The ability to achieve a specified wartime objective (win a war or battle, destroy a target set). It includes four major components: force structure, modernization, readiness, and sustainability.

National Command Authorities (NCA)—The President and the Secretary of Defense, or their duly deputized alternates or successors

National Imagery and Mapping Agency (NIMA)—The DOD's source for maps, topography, and geography materials; headquartered at Bethesda, Maryland.

Numerical Weather Prediction—Computer model with advanced equations and techniques that can forecast as much as two weeks.

Oceanography—The study of the sea, embracing and integrating all knowledge pertaining to the sea and its physical boundaries, the chemistry and physics of sea water, and marine biology.

Optical turbulence—An atmospheric phenomenon that degrades weapons system performance

OSINT—Open source intelligence that is available to the general public.

Outer Van Allen Radiation Belt—The ring current is produced by the drift (eastward for electrons and westward for protons) of trapped charged particles. The ring current is greatly enhanced during geomagnetic storms by the injection of particles from the magneto-tail**.**

Paradrop—Operations involving dropping cargo using parachutes.

Path radiation—The scattering of light or radiation into your line of sight

Plage—A region in the sun's lower atmosphere where material is concentrated by intense magnetic fields. Plages are denser, hotter, and brighter than surrounding areas. Nearly all flares occur in the vicinity of plages.

Planck's law—This law says the amount of radiation emitted by a black body at a given wavelength is proportional to its temperature.

Platoon—An Army, Navy SEAL or Marine unit made up of multiple fire teams or boat teams.

Polar cap absorption (PCA)—A significant increase in ionospheric absorption of high frequency (HF) radio waves in the polar regions. Some energetic solar flares emit protons that can gain direct access to the polar caps via funnel-like cusps in the magnetosphere. These protons can penetrate to low altitudes before colliding with atmospheric gases and producing an increase in ionization which, in turn, causes enhanced absorption of HF radio waves crossing the polar caps.

Polar cusps—Funnel-like features in the magnetosphere over each geomagnetic pole. High energy solar particles can be deflected by Earth's geomagnetic field and guided in through the polar cusps, allowing the particles direct access to low altitudes over the polar caps.

Principle—A comprehensive and fundamental law, doctrine, or assumption. (A doctrine is a generalization based on sufficient evidence to suggest that a given pattern of behavior will probably lead to the desired result. Doctrine is what is officially believed and taught to be the best way to conduct military affairs).

Prominence—A mass of relatively high density, low temperature gas suspended in the mid to upper solar atmosphere by magnetic fields. It is seen as a bright, ribbon-like emission feature, in single wavelength observations, against the dark of space beyond the visible solar limb—also see Filament.

Proton—A positively charged subatomic particle (equivalent to a hydrogen atom nucleus) with a mass 1,836 times that of an electron.

Psychological operations—Planned operations to convey information and indicators that will influence an enemy's emotions, motives, objective reasoning, and ultimately their behavior.

Radar Aurora—Radar signal returns reflected off ionization produced by particle precipitation in the Auroral Oval. (Radar aurora is distinctly different from auroral emissions at radio, or radar, wavelengths).

Radio burst—A short-lived enhancement of solar radio emission over background levels, normally associated with an active region or flare.

Radiative temperature—The temperature that an object appears to have based on the amount of energy it emits.

Readiness—The ability of forces, units, weapon systems, or equipment to deliver the outputs for which they were designed (includes the ability to deploy and employ without unacceptable delays).

Reconnaissance—A mission to obtain, by visual observation or other methods, any information about enemy activities and resources. Missions are also conducted to obtain meteorological, hydrographic, or geographic characteristics of a particular area.

Reflectivity—The ratio of the total amount of radiation reflected from the object to the total amount of incident radiation.

Refraction—The bending of an electromagnetic wave (for example, a ray of visible light or a radio wave) as it passes from one medium to another medium with a different index of refraction.

Resolution—The smallest individual element a sensor can detect.

Scintillation—A rapid, random variation in the amplitude, phase, and/or polarization of a radio signal passing through the ionosphere. Scintillation is caused by abrupt variations in electron density anywhere along the signal path.

Senior Meteorological and Oceanographic Officer—Meteorological and oceanographic officer responsible for assisting the combatant commander and staff in developing and executing operational meteorological and oceanographic service concepts. Also called SMO.

Short wave fade (SWF)—An abrupt decrease in the strength of high frequency (HF) radio signals observed over transmission paths in the sunlit hemisphere. A SWF is due to increased signal absorption in the lower

SIGINT—Intelligence derived from communications, electronics and instrumentation signals.

Single event upset (SEU)—An electrical upset caused by a cosmic ray or high energy proton passing through a satellite. Each single particle has sufficient energy to deposit enough charge deep in the satellite to cause an electrical upset hence the name SEU.

Solar cycle—A roughly 11-year variation in the general level of solar activity—also, see Sunspot Cycle).

Solar Maximum (or Solar Minimum)—The activity peak (or minimum) in the 11-year solar or sunspot cycle—also, see Sunspot Cycle).

Solar sector boundaries (SSB)—Boundaries within the interplanetary magnetic field (IMF) that separate regions of opposite magnetic polarity (either toward or away from the sun). A sector boundary in the IMF is normally narrow; being convected past earth in minutes or hours, compared to days to a week or so required for passage of the sector itself—also, see IMF).

Solar wind—The continual outward streaming of solar particles into interplanetary space. The interplanetary magnetic field strongly influences the motions of these charged particles. Solar activity events often lead to increases in the solar wind's particle density and velocity.

Space weather—A term used to describe the environment and other natural phenomena occurring above 50 kilometers altitude.

Specified command—A command that has a broad, continuing mission, normally functional, and is established by the President through the Secretary of Defense with the advice and assistance of the Chairman of the Joint Chiefs of Staff. It normally is composed of forces from only one military department—also called specified combatant command.

Staff weather officer (SWO)—A weather officer, qualified in forecasting, that commands a weather team. An SWO can be a lieutenant or a colonel depending on the Army unit supported. Some SWOs serve without a weather team as members of a meteorological and satellite sensing information (METOC) support level.

Standard weather system—A weather capability required by more than one major command.

Sunspot Cycle—A mostly periodic variation in the number of observed sunspots. The cycle exhibits an average period of 11 years, but past cycles have been as short as 8, or as long as 15 years. Generally, there is a 4-year rise to a solar maximum, followed by a gradual 7-year decline to a solar minimum. The overall level of solar activity, and resultant DOD system impacts, tend to follow the same 11-year cycle.

Sunspots—Relatively dark regions on the solar surface. Seen in white light, they appear dark because they are cooler than the surrounding gases. Sunspots are characterized by strong magnetic fields and are closely related to the overall level of solar activity.

Sustainment—The art and science of developing and using political, economical, psychological, and military forces as necessary during peace and war, to afford the maximum support to policies, to increase the probabilities and favorable consequences of victory and to lessen the chances of defeat.

Tailored mission products—Mission specific products developed after obtaining mission details and battlefield factors.

Targeting—The process of selecting targets.

Tasking—Assigning responsibility and accountability for a military action to an allied force.

Theater—An area outside of the United States that is the responsibility of a combatant commander.

Thermal capacity—A measure of the amount of heat an object holds.

Thermal clutter—Occurs when some target scenes may be filled with multiple hot and cold objects making detection of the target difficult.

Thermal conductivity—A measure of how rapidly heat travels through an object.

Thermal contrast—The difference between the thermal energy of the target and that of the background.

Thermal crossover—The moment when the target and the background are at the same temperature.

Threshold contrast—The minimum contrast that your eyes can detect.

Time-phased force and deployment data—A separate, yet detailed database used by joint planners. It includes sequencing data, routes of forces to be deployed, non-unit related cargo movements, personnel movements, and other pertinent deployment data.

Unified Command—A command with a broad continuing mission under a single commander and composed of significant assigned components of two or more military departments. It is established by the President, through the Secretary of Defense with the advice and assistance of the Chairman of the Joint Chiefs of Staff-also called unified combatant command.

Total electron content (TEC)—The total number of free electrons in a unit area column from the ground to the top of the ionosphere.

USASOC—Army Major Command component of USSOCOM.

USASFC—Army command that oversees all 7 Special Forces groups.

USSOCOM—A unique combination of a unified combatant command and unified support command with oversight of AFSOC, MARSOC, NAVSPECWARCOM and USASOC.

Van Allen Radiation Belts—Regions near earth consisting of stably trapped charged particles that are produced by the presence of strong, closed geomagnetic field lines. The source and distribution of the trapped particles led to a division of this region into two belts: the Inner and Outer Van Allen Belts.

Warning order—A first look at the details of an upcoming mission.

Weather thresholds—Go/No go mission thresholds used for personnel, vehicles and systems.

Wien Displacement Law—This law says the wavelength of the maximum irradiance of a black body depends on its temperature.

X-rays—Electromagnetic radiation with wavelengths shorter than, and energy content greater than, ultraviolet radiation.

Glossary of Terms Abbreviations and Acronyms

A2C2	Army Airspace Command and Control
ACO	Aerospace Control Order
ACOS	assistant chief of staff
ACR	armored cavalry regiment (Army)
ADA	air defense artillery
AEF	air and space expeditionary force(s)
AFSOF	Air Force special operations forces
AFTR	Air Force electronic training record
AFW	Air Force Weather
AFWA	Air Force Weather Agency
AI	area of interest
ALLOREQ	allocation requests
AO	area of operations
AOI	area of interest

AOR	area of responsibility
AREPS	Advanced Refractive Environmental Prediction System
ARTYMET	artillery meteorological
ATC	air traffic control
ATO	air tasking order(s)
AZA	auroral zone absorption
BDA	battle damage assessment
BIC	Battlefield-induced contaminants
C2	command and control
CAFSC	control Air Force specialty code
CAN	computer network attacks
CAP	crisis action planning
CAS	close air support
CAV	cavalry
CBRNE	chemical, biological, radiological, nuclear, and high yield explosive
CCDR	combatant commander
CFA	covering force area
CFC	Combined Forces Command, Korea
CJCS	Chairman of the Joint Chiefs of Staff
CNA	computer network attacks
COA	course of action
COG	centers of gravity
COMSEC	communications security
CONEX	container express
CONPLAN	contingency plan
CONUS	continental United States
COSCOM	corps support command
CP	command post
CS	combat support
CSAR	combat search and rescue
CSS	combat service support
CSSE	Combat Service Support Element
DAFSC	duty Air Force specialty code
DAV	deployment availability code
DCA	defensive counterair
DCI	defensive counter information

DCS	defensive counter space
DISCOM	division support command (Army)
DOD	Department of Defense
DRMD	deployment requirements manning document
DSN	Defense Switched Network
DSP	Defense Support Program
EAC	echelons above corps (Army)
EACIC	Echelons Above Corps Intelligence Centers
EM	electromagnetic energy
EO	electro-optical
EUV	extreme ultra violet
FALOP	Forward Area Limited Observation Program
FLIPS	flight information publications
FLIR	forward-looking infrared
FLOT	forward line of own troops
FM	frequency modulation
FOB	forward operating base(s)
FORSCOM	United States Army Forces Command
GHz	gigahertz
GPS	Global Positioning System
HARM	high-speed antiradiation missile
HF	high frequency
HHC	headquarters and headquarters company
HSS	high speed streams
ICAO	International Civil Aviation Organization
ICBM	intercontinental ballistic missile
IMETS	Integrated Meteorological System
IMF	interplanetary magnetic field
INFOSEC	information security
IPB	Intelligence Preparation of the Battlefield
IR	infrared
JAOP	Joint Air Operations Plan
JCS	Joint Chiefs of Staff
JFACC	joint force air component commander
JFC	joint force commander
JIPB	Joint Intelligence Preparation of the Battlefield

JOPES	Join Operations Planning and Execution System
JTF	joint task force
JTL	joint target lists
km	kilometer
KQ ID	tactical location identifier; temporary location
LF	low frequency
LORAN	long range
LRSD	Long Range Surveillance Detachment
LUF	lowest useable frequency
MAAP	master air attack plan
MACOM	major command (Army)
MAJCOM	major command (USAF)
METOC	meteorological and oceanographic
MHz	megahertz
MI	military intelligence
MLRS	multiple launch rocket system
mm	micrometer
mm/MW	millimeter microwave
MOOTW	military operations other than war
mps	miles per second
MSE	Mobile Subscriber Network
MUF	maximum useable frequency
NAI	named area of interest
NATO	North Atlantic Treaty Organization
NCA	National Command Authority
NVG	night vision goggles
OCA	offensive countera Air
OCI	offensive counter information
OCS	offensive counter space
OPLAN	operations plan
OPORD	operations order
OPSEC	operations security
OWS	operational weather squadron
PCA	polar cap absorption
PDS	Personnel Data System
PGM	precision-guide munitions

PMSV	Pilot-to-Metro Service
PSYOPS	psychological operations
RFI	radio frequency interference
ROK	Republic of Korea
SATCOM	satellite communications
SEU	single event upset
SGLI	Servicemen's Group Life Insurance
SHF	super high frequency
SHORAD	short -range air defense
SID	sudden ionospheric disturbances
SIM	subscriber identity module
SIOP	Single Integrated Operation Plan
SOF	special operations forces
SOWT	special operations weather team
SPINS	special instructions
SSB	solar sector boundary
SST	super sonic transport
ST	special tactics
SWF	short wave fade
TACFIRE	tactical fire
TEC	total electron content
TMOS	Tactical Meteorological Observing System
TOC	tactical operations center
T-VSAT	tactical very small aperture terminal
UAV	unmanned aerial vehicle
UHF	ultra high frequency
USAFRICOM	US Africa Command
USARAF	US Army Africa Command
USARCENT	US Army Central Command
USAREUR	US Army European Command
USARPAC	US Army Pacific Command
USARSO	US Army Southern Command
USASFC	United States Army Special Forces Command
USASOC	United States Army Special Operations Command
USCENTCOM	United States Central Command
USEUCOM	United States European Command

USFKO	United States Forces Korea
USPACOM	United States Pacific Command
USPACOM/CC	United States Pacific Command/CC
USSOCOM	United States Special Operations Command
USSOUTHCOM	United States Southern Command
USTRANSCOM	United States Transportation Command
USTRANSCOM/CC	United States Transportation Command Commander
UV	ultra violet
VHF	very-high frequency
WARNORD	warning order
WEW	weather effects workstation
WF	weather flight

Student Notes

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