CHAPTER 2
AIR TRANSPORT

Airlift is a flexible and essential element of the defense transportation system. This chapter contains information on a broad range of military and commercial aircraft used to accomplish the air transport mission.

Section I
ORGANIZATION AND OPERATIONS

ARMY AVIATION

Army aviation units support theater army, corps, and division requirements. They also support unified or specified commands, military assistance advisory groups, mission operating detachments, and separate brigade operations.

Army Aviation Units

The aviation brigade is the Army's primary aviation unit. It is a versatile organization found at division, corps, and EAC. It may include observation, attack, utility, and cargo helicopters and a limited number of fixed-wing C^2 aircraft.

Division. Each division has an aviation brigade designed, configured, and tailored to meet the tactical requirements of that type division. Brigade aircraft move troops, supplies, and equipment. The utility helicopter, either the UH-1 or UH-60, is the brigade's primary asset.

Corps. Each Army corps has an aviation brigade tailored to meet its specific mission requirements. The corps aviation brigade supports the corps scheme of maneuver by planning, coordinating, and executing aviation and combined arms operations. In its CSS role, the brigade moves forces, supplies, and equipment needed to support the battle. The corps commander should routinely allocate sufficient sorties for CSS air movement missions. The corps aviation brigade uses a combination of UH-1, UH-60, and CH-47 helicopters.

EAC. EAC aviation brigades are tailored and configured to meet the needs of the theater. They may be organized with attack, utility, and/or cargo aviation assets. EAC utility and medium helicopters reinforce corps CSS air movement requirements.

Mission

Army logistic aviation units airlift personnel and cargo for CSS and CS operations. Missions assigned to aviation units are usually similar to the mission as stated in the TOE.

Objective

The objective of aviation unit missions is to assist the land force in accomplishing its mission.

Authority

When an aviation company supports a ground unit, the ground unit commander assigns tasks to the aviation commander. To accomplish these tasks, the aviation commander retains the authority to issue orders to elements under his command.

Tables of Organization and Equipment

The TOE of each military unit prescribes its normal mission, organizational structure, and personnel and equipment authorization. Users who need detailed information on a specific aviation unit should use the TOE of that unit. See Appendix A for the TOE of aviation companies that provide logistic support.

AIRLIFT OF MATERIEL

Army air transport was never intended to compete with Air Force airlift. Its purpose is twofold:

- To provide rapid response transport for high-priority personnel, supplies, and equipment to locations inaccessible by other transportation modes.
- To supplement the lift capability of other Army transportation modes.

Areas of Operations

Army air transport is essential to the logistic support of Army operations. It rapidly moves passengers, cargo, and equipment without regard to terrain restrictions. However, there are limitations to the capabilities of airlift.

Communications zone. The aviation brigade provides Army airlift in the COMMZ. Army aircraft move high-priority cargo and personnel to and from Air Force terminals. Also, they rapidly deploy rear area protection forces. Based on the theater movement program, helicopters are positioned where they can best fulfill preplanned requirements. Helicopters are used when speed is essential or the use of other modes is not practical or possible.

Theater of operations. Army airlift is often the link between theater air and ocean terminals and receiving supply activities, receiving units, or TTPs. This air movement may be preplanned or immediate. For example, the MCA may task the COMMZ aviation brigade to transport high-priority cargo daily from theater air terminals forward to the supply activity. Either the supply activity issues the cargo, or the MCA pulls the preplanned commitment and issues a higher priority immediate commitment.

There are both advantages and limitations to Army air transport in a theater of operations. Advantages include flexibility, speed, internal or external transport of cargo or equipment, and immunity to surface or terrain conditions. Limitations include vulnerability to enemy air action; vulnerability to air defense weapons and other ground fire; susceptibility to adverse weather; inherent decrease in lift capability as air density decreases due to changes in altitude, temperature, or humidity; higher maintenance per operating hour than other modes; and dependence on logistical support.

Corps. The MC battalion manages Army air transport originating in the corps, controlling and directing which logistic support missions the helicopters will fly. Its CSS helicopters come from the corps aviation brigade. MC battalion management of all corps logistic transportation assets is essential to ensure the best mode is used to accomplish the mission.

Helicopters are a highly mobile and responsive means for moving equipment and supplies. Air transport units move troops, ammunition, repair parts, POL, engineer material, artillery, special weapons, disabled aircraft and vehicles, and other large or heavy items. Helicopters also augment surface transportation to meet increased transportation demands in surge operations, overcome terrain obstacles, and meet time-sensitive requirements.

Single-ship, independent operations generally characterize helicopter logistic missions. Helicopters do not routinely operate forward of the brigade support area. However, the trend to position more units forward and to dedicate aircraft for weapons system resupply requires the increased forward employment of helicopters. Aircraft may operate as close as 5 to 7 kilometers from the forward edge of the battle area.

They may also operate beyond the FLOT to support deep operations. Logistic support of the covering force justifies added cargo helicopter commitments in the forward area to support maneuver units. Both external loads at high altitudes and internal loads are used, coupled with nap-of-the-earth flying. Division utility helicopters provide most of the intradivision air transport support.

Preplanned and Immediate Air Movement Requests

Requirements for air movement operations are characterized as either preplanned or immediate. See FM 55-10 for more information on coordinating preplanned and immediate air movements.

Preplanned requests. Preplanned airlift involves matching movement requirements against airlift capability. Movement planners determine in advance that air is the best or most effective mode based on the urgency of the requirement and characteristics of the personnel, supplies, or equipment to be moved. Preplanned air movements are generally (but not necessarily) carried out over established routes.

Immediate requests. Immediate airlift missions result from unanticipated, urgent, or priority movement requirements. Movement planners must quickly determine if air is the best and most effective mode based on the urgency of the requirement and characteristics of the personnel, supplies, or equipment to be moved. Examples include:

- Unplanned requirements for resupply or repositioning of existing supplies.
- Emergency movement of personnel and equipment.
- Assistance to aeromedical air ambulance units.
- Prevention of congestion at an air or ocean terminal.

Request procedures must be responsive and flexible to support rapidly changing situations. Immediate airlift may or may not be carried out over the established air lines of communications.

Employment Considerations

Optimum use of airlift is attained by using Air Force transport aircraft to move materiel from a COMMZ depot directly to the user. However, in a tactical situation this is often impracticable. There is generally a point at which wholesale airlift is terminated and Army aviation elements undertake retail deliveries to the user.

Wholesale airlift. Certain factors must be considered when determining the point at which to terminate wholesale airlift. These include the following:

- Airfields – suitable airfields must be available at point where materiel is to be airlanded by Air Force transport aircraft.
- Enemy action – The enemy may be capable of limiting or denying the use of forward areas for airlanding by transport aircraft.
- Receiving unit capability – combat units in forward areas have a limited capability to receive, store, protect, and redistribute materiel airlanded in wholesale lots by transport aircraft.
- User requirements – the user may be a unit of company size or smaller that requires resupply in retail quantities only.

Efficiency. The efficient use of Army aviation is based on the factors of economy of use and ready availability. Aircraft should not be used to transport cargo when surface transportation is equally effective. Since there are seldom enough aviation assets to satisfy all requirements, most aviation support is allocated on a priority basis. The ability to respond rapidly increases the value of airlift to commanders. While aircraft are capable of supporting units located throughout a wide area, ready availability is enhanced when aviation units are located close to supported units. The intelligent scheduling of operational aircraft and programming of required maintenance further enhances ready availability.

Operational Considerations

Several elements bear directly on the conduct of airlift operations. These influence operational efficiency as well as the safety of personnel and equipment.

Air density. Unlike surface transportation where the payload of a particular vehicle is relatively fixed, aircraft payloads are affected by air density. Denser air gives greater lift to an aircraft's wing or rotor blade, increasing the weight-lifting performance of the aircraft. Temperature, altitude, and humidity all affect air density.

Temperature. An increase in temperature causes a decrease in air density. The amount of air that occupies 1 cubic inch at low temperatures will expand and occupy 2 or 3 cubic inches as the temperature rises. The payload of a particular aircraft can change, depending on the time of day a flight is scheduled. In general, early morning temperatures favor operations, and warmer noonday temperatures cause a decrease in the efficiency of the aircraft.

Altitude. An increase in altitude causes a decrease in air density. This is especially important when conducting operations from areas high above sea level. During these times it is necessary either to decrease the aircraft weight or to increase the length of takeoff and the landing strip.

Humidity. An increase in humidity causes a decrease in air density. Air always contains some moisture (water vapor), but the amount varies from almost 0 to 100 percent. We refer to this water vapor as humidity. As humidity increases, water particles displace the air, causing a decrease in air density and reducing the performance efficiency of the aircraft.

Distance. The distance to be flown is especially important because the allowable load is computed after the amount of fuel, plus reserve, is determined. When the maximum payload is desired, aircraft must carry less fuel with a relative reduction in distance flown. The payload must be reduced when the maximum distance is desired.

Weather. Weather impacts Army aviation operations. While low ceilings and limited visibility restrict operations, such conditions also shield the aircraft from enemy observation. However, adverse weather generally reduces efficiency of Army airlift operations. Although Army transport aircraft can operate under instrument flight conditions, commanders should establish weather minimums to preclude scheduling flights that jeopardize the safety of aircraft and personnel. The following factors should be weighed when establishing weather minimums:

- Pilot experience.
- Type of aircraft.
- Urgency of mission.
- Navigational aids available.
- Flight route terrain.
- Time of operation.

Enemy situation. The location and capabilities of enemy forces must be considered before finalizing flight routes for Army air transport operations. Avoid areas where suspected enemy antiaircraft weapons or known enemy ground fire exist. Prepare prearranged evasive-action flight plans for aviation units in case enemy aircraft are encountered.

Terrain. Terrain features should be considered with regard to their possible effects on each operation. Terrain influences the following:

- Location of takeoff and landing sites.
- Flight routes.
- Identification of prominent landmarks for navigational purposes.
- Location of navigational aids.
- Location of emergency landing sites.

Flight routes. Combat operations generate many demands for the use of airspace. Employment of US military aircraft, artillery, drones, and missiles must be coordinated to ensure adequate safety, proper identification, and operational efficiency. Army aviation unity ensures that flight routes are properly coordinated and approved by the appropriate air traffic control facility before beginning CSS or CS operations.

Communications. CSS and CS airlift operations require that adequate communications be established before a mission. Voice communication is necessary among Army air transport and command units, supported organizations, inflight aircraft, and takeoff and landing sites.

Support Requirements

Primary support requirements are the availability of POL, ammunition, and aircraft maintenance support.

Petroleum, oils, and lubricants. Aircraft use large quantities of fuel, and POL requires special handling. For these reasons, refueling facilities should be readily available.

Ammunition. Because the ammunition used in Army aircraft may be expended rapidly, resupply facilities must be located near the area of operations. This avoids the time penalty involved in resupply.

Aircraft maintenance. The sustained performance of aircraft operations depends on efficient aircraft maintenance. Maintenance of aircraft begins with AVUM and extends through AVIM to depot maintenance. The continuing availability of aircraft requires close coordination among the aviation unit commander, the ground combat commander, and the supporting maintenance unit commander. Proper scheduling of aircraft for maintenance is mandatory to prevent excessive downtime.

Section II
LANDING SITE SELECTION AND PREPARATION

SITE SELECTION

The selection of a PZ or LZ is extremely important. Logistical and tactical considerations must be analyzed to ensure that the PZ or LZ is correctly placed to support the mission. The area must be accessible to the aircraft that will use the site. The supported/ receiving unit commander – in coordination with the aviation unit liaison officer, if available – will select and prepare the PZ. The aviation unit liaison officer makes the final decision concerning minimum landing requirements.

Dimensions

The size of the landing site depends on the number and size of the landing points within it and the dispersion required between the landing points as the tactical situation dictates (Figure 2-1, page 2-6). The minimum size of a landing point for each size helicopter is shown in Table 2-1, page 2-6. Many factors, including the following, determine the size of the landing points:

- Helicopter type.
- Unit proficiency.
- Nature of the load.
- Climatic conditions.
- Day or night operations.

If this data is not available through the aviation unit, a size 5 landing point should be prepared. The minimum recommended distance between landing points within the LZ, where no consideration is given to dispersion, is the same as the minimum diameter of that size helicopter's minimum diameter; only measure from the center of one landing point to the center of the other (Figure 2-2, page 2-7).

Surface

The surface of the center of the landing point must be level and sufficiently firm to allow a fully loaded vehicle (1/4-ton truck for size 1 or 2 helicopters and a 3- to 5-ton truck for size 3 to 5 helicopters) to stop and start without sinking. Clear the entire landing point of loose material, piles of dust, or sand that could be blown up by the aircraft's rotor blades. Stabilize landing points with a sandy or dusty surface. Clear away all trees, brush, stumps, or other obstacles that could cause damage to the main or tail rotor blades or to the underside of the aircraft. Pack or remove snow to reveal obstacles and to reduce the amount of loose snow blown over the area. In a snow-covered LZ, a marker panel is essential to provide a visual reference for the pilot's depth perception and to reduce the effect of whiteout.

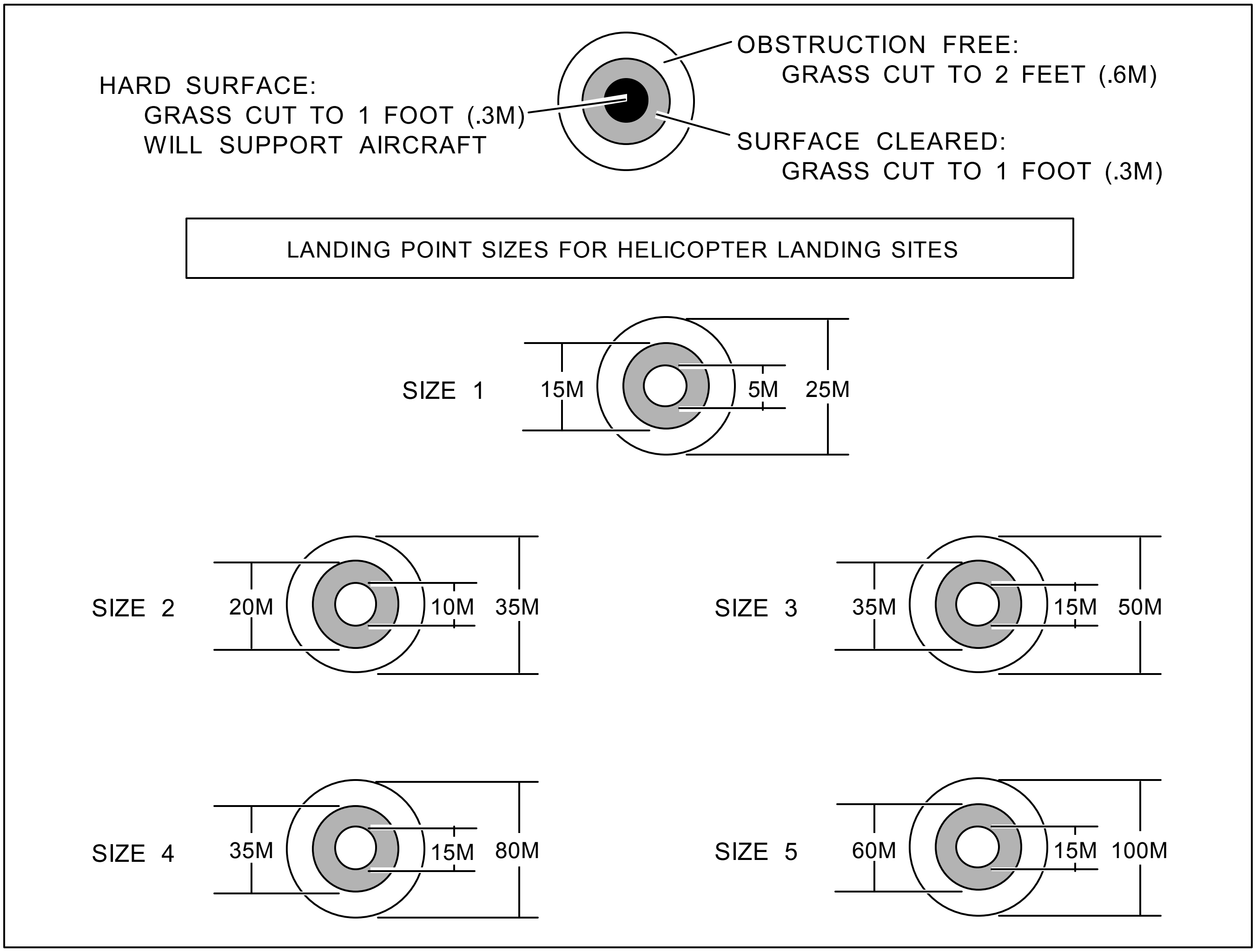


Figure 2-1. Helicopter landing sites

Table 2-1. Size helicopter for landing point

HELICOPTER SIZE	MINIMUM DIAMETER OF LANDING POINT	TYPE HELICOPTER
1	80 feet (25 meters)	OH-6, OH-58
2	125 feet (35 meters)	UH-1
3	160 feet (50 meters)	UH-60
4	264 feet (80 meters)	CH-47, CH-53, CH-54
5	328 feet (100 meters)	To be developed

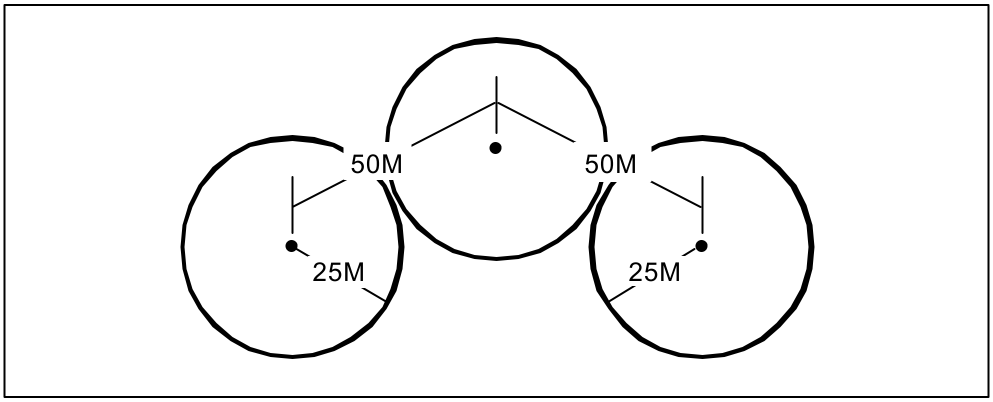


Figure 2-2. Size 3 aircraft landing zone for V-formation

Slope

Ideally, the ground at the landing point should be level. Where a slope is present, it should be uniform. If the helicopter is to land during a daylight approach, the slope should not exceed 7 degrees (1 in 8). A greater slope may be acceptable for hover operations. During a night approach, a reverse slope as viewed from the approach path is generally not acceptable. A forward and/or lateral slope should not exceed 3 degrees (1 in 19). If these criteria cannot be met, use of the landing point must be confirmed by the aviation unit (Figure 2-3, page 2-8).

Approaches

Ideally, there should be an obstruction-free approach and exit path into the wind. Approaches that do not meet the following minimum requirements may be acceptable depending on the nature of the operation. However, when these criteria cannot be met the aviation unit must be consulted.

Daytime. Within the selected approach and exit paths, the normal maximum obstruction angle to obstacles during daylight hours should not exceed 6 degrees, as measured from the center of the landing point to a distance of 1,640 feet (500 meters). The maximum obstacle height at the 1,640-foot mark is 171 feet (52 meters) (Figure 2-4, page 2-9).

Nighttime. The selected approach and exit paths should contain a sector of not less than 16 degrees in azimuth measured from the center of the landing point. The width of the approach and exit path should not be less than the width of the area in the landing point cleared to 2 feet (.6 meters) in height. Less than 164 feet (50 meters) is not acceptable; more than 328 feet (100 meters) is not necessary. Within the selected approach and exit path, the maximum obstruction angle should not exceed 4 degrees as measured from the center of the landing point to a distance of 9,843 feet (3,000 meters). The maximum obstacle height at the 9,843-foot mark is 689 feet (210 meters) (Figure 2-5, page 2-9).

Density Altitude

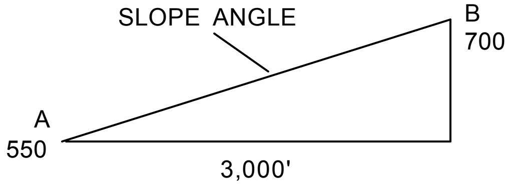
Density altitude is determined by altitude, temperature, and humidity. As density altitude increases, the size of the LZ must be increased proportionately. Hot and humid conditions at a landing site decrease the lift capabilities of helicopters using the site. A large area and better approach and/or departure routes are required more for fully loaded helicopters than for empty or lightly loaded ones. This is because most helicopters cannot climb or descend vertically when fully loaded.

Concealment

A PZ/LZ near the FLOT should be masked whenever possible. Base the selection of approach and exit routes on the availability of good masking features.

GROUND SLOPE EXPRESSED IN DEGREES

The approximate slope angle may be calculated by multiplying the gradient by 57.3. This method is reasonably accurate for slope angles under 20°.



VD	B	A	150
HD		3,000	

DEGREE OF SLOPE $= \dfrac{150 \text{ X } 57.3}{3{,}000}$

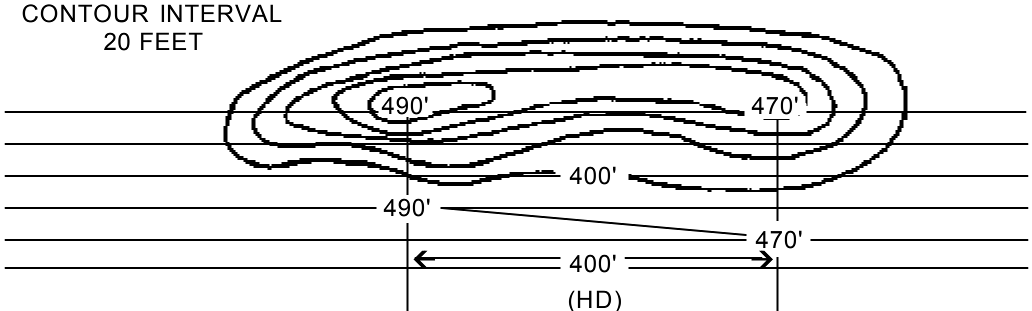
$\dfrac{8{,}595}{3{,}000}$ = Approximately 3° of Slope

GROUND SLOPE EXPRESSED AS PERCENTAGE

To determine the percent of ground slope, divide the vertical distance (VD) by the horizontal distance (HD) and multiply by 100.

$$\text{PERCENT SLOPE} = \frac{VD}{HD} \text{ X } 100$$

Vertical distance is the difference in field elevation between the two ends of the landing site. Always round number up to the next whole number.



490	400 ⟌ 20.00 = .05	.05
- 470	20.00	x 100
20 (VD)		05.00 = 5 PERCENT SLOPE

SLOPE LANDING RULES

Utility and observation aircraft will not be landed on slopes exceeding 7 degrees. Large utility and cargo aircraft will be given an advisory if ground slope is between 7 to 15 degrees.

CORRECT SIDESLOPE

AVOID LANDING AIRCRAFT UPSLOPE OR DOWNSLOPE

Figure 2-3. Determining ground slope

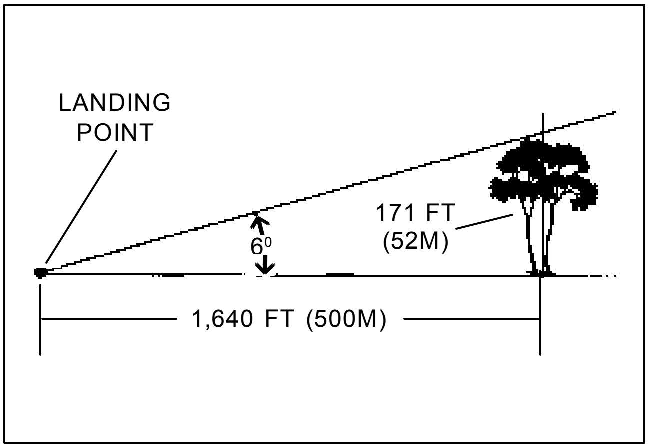


Figure 2-4. Maximum angle of approach (daytime)

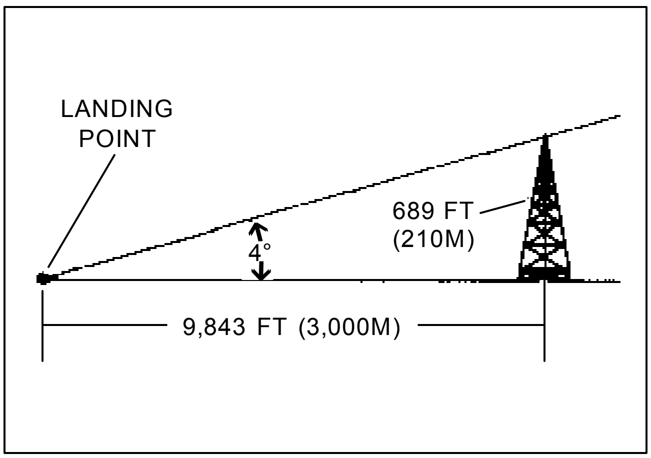


Figure 2-5. Maximum angle of approach (nighttime)

SITE PREPARATION

Once the site has been selected, the ground crew must prepare the PZ/LZ for safe, efficient operations.

Receiving Flight Formations

In large tactical relocations or resupply missions, helicopters will usually fly in formation. The PZ/LZ and the ground crew must be prepared to receive them. Helicopters should land in the same formation in which they are flying. However, planned formations may require modification for helicopters to land in restrictive areas. If a modification in flight formation is required for landing, use the change requiring the least shift of helicopters and notify the flight leader as soon as radio contact is made (Figure 2-6, page 2-10).

Many times, size 4 helicopters will not fly in standard flight formations and will be received one or two at a time. In such cases, each aircraft approaches and hovers at the Y and then is guided to its cargo pickup point by the signalman.

Marking the Landing Site

During daylight operations, the landing site is marked with colored smoke. It is also marked by the ground guide who holds both arms straight up over his head or holds a folded VS-17 signal panel, chest-high. Although the landing site can be marked with signal panels, these are seldom used because the helicopter's rotor wash may tear the panels from the ground and create a hazard.

CAUTION

When using colored smoke to mark the PZ/LZ, be sure the canister is far enough away from the landing point so the rotor wash does not pick up the smoke and obstruct pilot vision.

During night operations, amber beacon lights mark the landing point for the lead aircraft. The single point landing site – or the landing point for the lead aircraft, if the aircraft are in formation – is marked with either an inverted Y or T (Figure 2-7, page 2-10). The aircraft will touch down or hover on the midpoint of the legs of the Y and to the left of the stem if the T is used. The landing points for the other aircraft in the formation are also marked with lights. For size 1 through size 3 helicopters, a signal light is used to mark the landing point; size 4 and 5 helicopters have two lights spaced 10 meters apart to mark the landing point. The aircraft lands to the left of the lights. Whenever the size of the LZ/PZ permits, landing points should be increased to the next larger size. This provides an extra margin of safety for night operations.

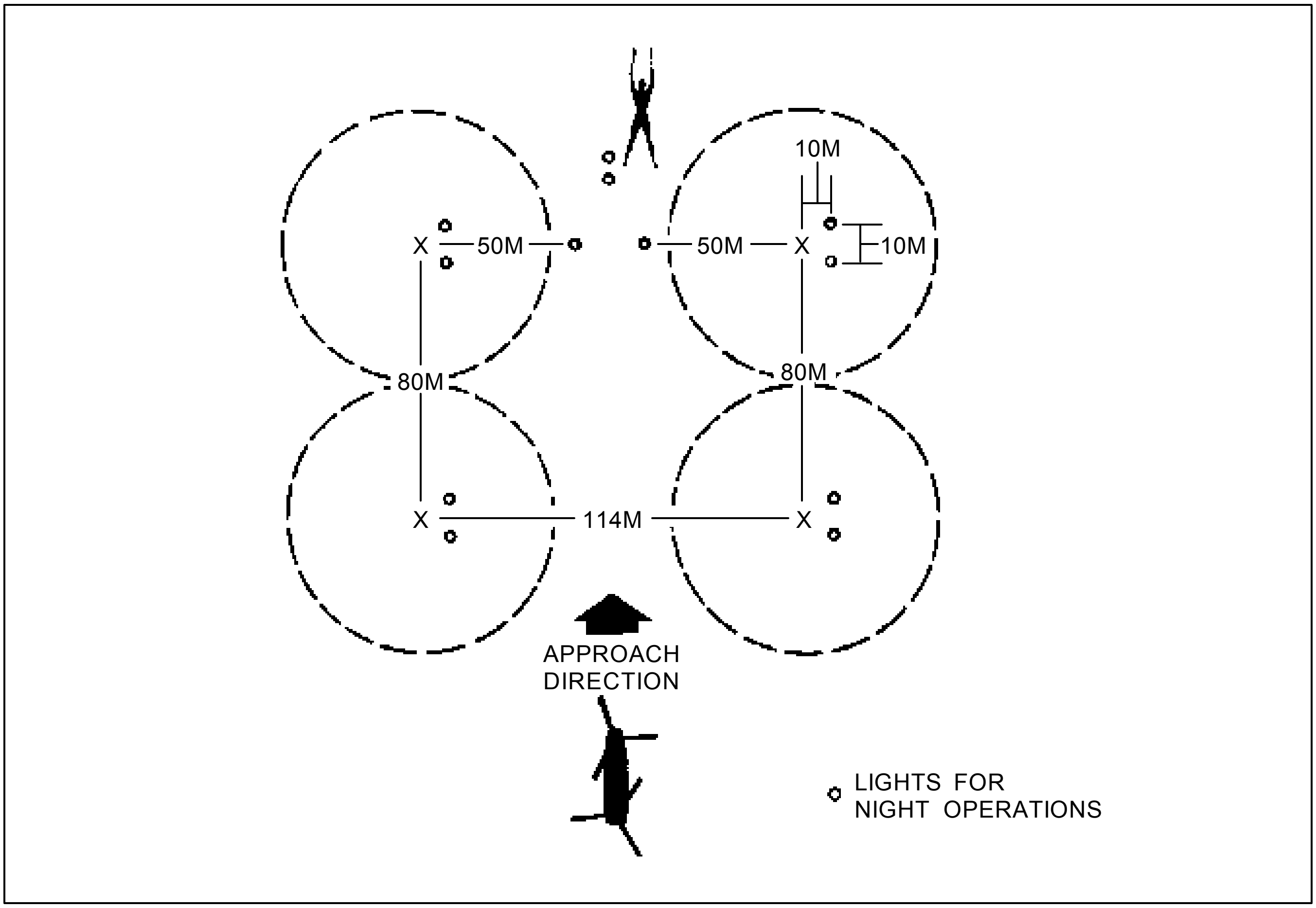


Figure 2-6. Landing zone/pickup zone landing formation for size 4 helicopters

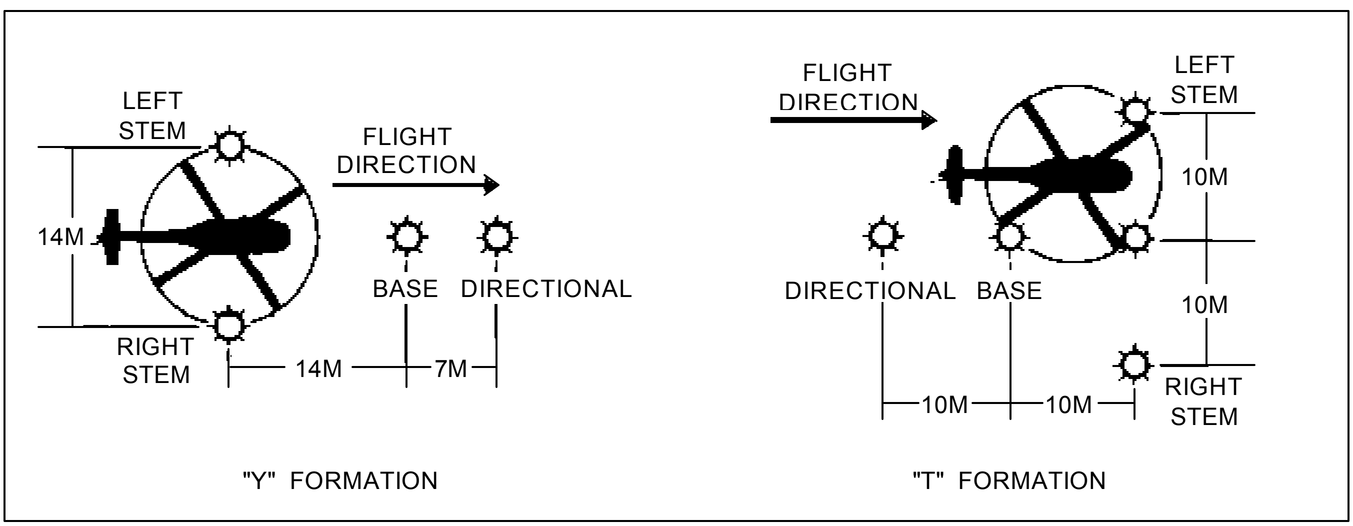


Figure 2-7. The Y- and T-formations for single-point formation landing sites

Marking Obstacles

During daylight operations, obstacles that may be difficult to detect or impossible to remove – such as wires, holes, stumps, and rocks – are marked with red panels or by other easily identifiable means. Devices used to mark obstacles must be colored red. During night operations, red lights are used to mark all obstacles that cannot be easily identified. In most combat situations, the need for security prohibits the use of red lights to mark the tops of trees on the approach and departure ends of the LZ. In training or in a rear area landing site, however, red lights should be used whenever possible. If obstacles or hazards cannot be marked, fully advise aviators of existing conditions by radio.

Section III
CARGO-CARRYING AIRCRAFT

EXTERNAL TRANSPORT HELICOPTERS

Helicopter transport can overcome many obstacles that hinder other modes from completing the mission. However, all aspects – advantages, disadvantages, and unit responsibilities and functions – must be considered when planning air cargo movements.

Advantages

External transport helicopters rapidly move heavy, outsize, or "needed now" items directly to their destinations. Damaged or congested highways, destroyed bridges, and most en route terrain obstacles have little impact on cargo transport. The helicopter may use different flight routes to provide a diversion and maintain security of the unit on the ground.

Also, cargo may be rapidly moved into or taken out of an area, which helps the ground unit obtain items of equipment when and where they are needed. On a rapidly changing battlefield, the helicopter can place fire power where it is needed and then relocate it. A PZ/LZ can be relocated to avoid detection and thus aid in ground security.

Disadvantages

The disadvantages to using external transport helicopters appear when the size, weight, and flight characteristics of the cargo fall outside of the aircraft design limits. When suspended beneath the aircraft, cargo that is too light or too bulky will not ride properly. If the cargo is too heavy, the aircraft cannot lift it.

Generally, restrictions that apply to helicopters also apply to sling-load operations or routine training flights. The following factors should be considered to ensure that aircraft are used wisely:

- Limited aviation assets.
- Maintenance downtime.
- Mission priority.

Weather conditions and the PZ/LZ terrain can present natural obstacles to the use of aircraft. These factors are especially critical during external sling-load missions. When operations are planned during hours of darkness or under reduced visibility, the size of the PZ/LZ must be increased to give the pilot more room to maneuver.

Responsibilities

There are usually three elements involved in a sling-load mission: the supported unit (requests the mission), the aviation unit (provides the aircraft), and the receiving unit (receives the cargo). Sometimes, such as during a unit relocation, the supported and receiving units are the same. The responsibilities and functions of each unit are discussed below.

Supported unit. The supported unit selects, prepares, and controls the PZ (pathfinders can be of great assistance in this area) and requisitions all equipment needed for sling-load operations. Needed equipment includes slings, A-22 cargo bags, cargo nets, and containers. Other supported unit responsibilities include:

- Storing, inspecting, and maintaining all sling-load equipment.
- Providing a sufficient number of trained ground crews for rigging and inspecting all the loads, guiding the helicopters, hooking up the loads, and clearing the aircraft for departure. (While the supported unit is responsible for ensuring that the load is properly rigged, the pilot has the right to refuse the load if he notices a rigging error while approaching the load or if the load does not ride properly when first picked up to a hover.)
- Securing and protecting sensitive items of supply and equipment.
- Providing load derigging and disposition instructions to the receiving unit.
- Providing disposition instructions to the receiving and aviation units for the slings, A-22 cargo bags, cargo nets, and containers.

Aviation unit. The aviation unit establishes coordination with the supported and receiving units and appoints a liaison officer. The liaison officer should be thoroughly familiar with the capabilities and limitations of the assigned aircraft. Aviation unit responsibilities also include:

- Advising the supported unit on the size and weight limitations of the loads that may be rigged.
- Advising the supported and receiving units on the suitability of the selected PZ/LZ.
- Providing assistance for the recovery and return to the PZ of the slings, A-22 cargo bags, cargo nets, and containers, as required by the supported unit. (The supported unit is still responsible for packaging and providing disposition instructions to the aviation unit.)
- Arranging for the aircraft to be at the PZ/LZ on schedule.
- Establishing safety procedures that ensure uniformity and understanding of the duties and responsibilities between the ground and flight crews. For example, determining the direction of the ground crew's departure (from beneath the helicopter) after hookup. If the ground crew moves from the aircraft in the same direction as the aircraft, injury could result. Each PZ has a different shape and obstacle. In an emergency, the pilot must know in which direction to set down the aircraft to avoid hitting the ground crew.

Receiving unit. The receiving unit selects, prepares, and controls the LZ. It also provides trained ground crews to guide in the aircraft and derig the load. Other receiving unit responsibilities include:

- Coordinating with the supported (sending) unit for the control and return of the slings, A-22 cargo bags, and other items that belong to the supported unit, and returning them as soon as possible.
- Preparing, coordinating, and inspecting back loads – such as slings, A-22 cargo bags, and so forth – and having them ready for hookup or loading.

Methods

There are three approved methods of external air transport. These methods employ slings, cargo nets, or cargo bags.

Slings. Figure 2-8 shows the 10,000- and 25,000-pound capacity slings used in external air transport operations.

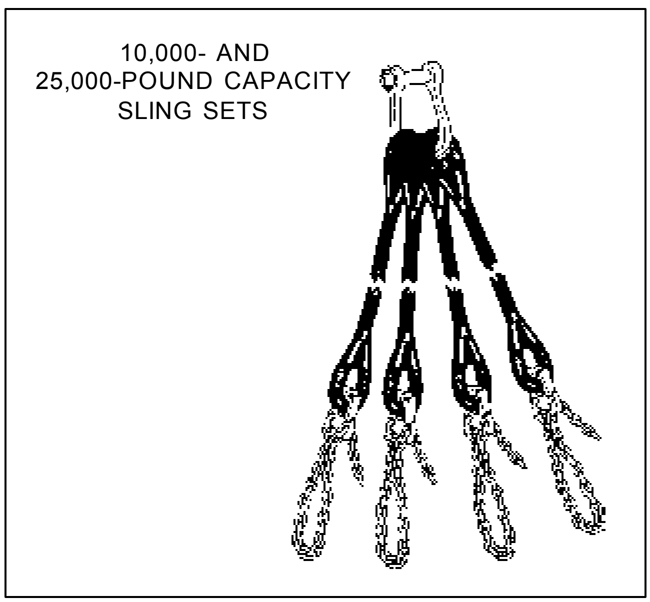


Figure 2-8. External air transport slings

Cargo nets. Figure 2-9 shows the 5,000- and 10,000-pound capacity cargo nets used in external air transport operations.

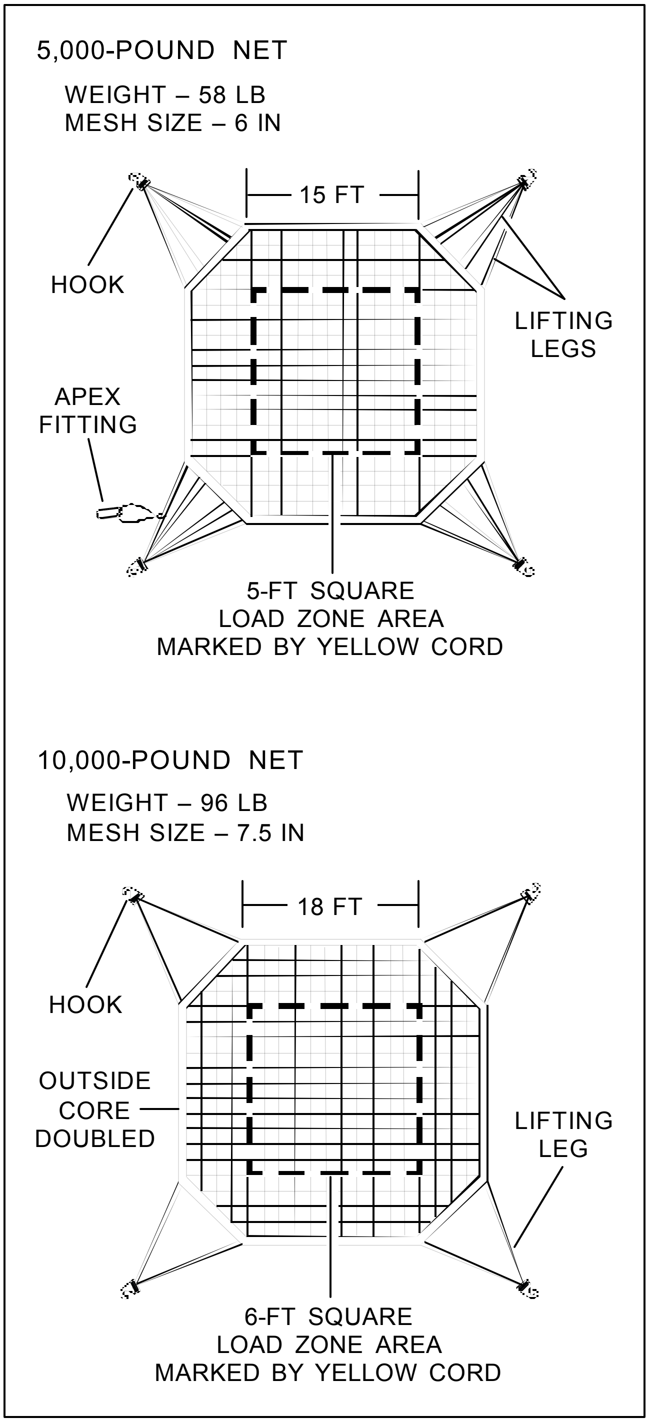


Figure 2-9. Cargo nets

Cargo bag. The A-22 cargo bag (Figure 2-10) is an adjustable cotton duck cloth and webbing container. It has a sling assembly, cover, and four suspension webs. This external carrying device can transport up to 2,200 pounds, including any standard palletized load, loose cargo, or oil drums. It can be rigged with or without the cover.

Personnel

The number of personnel in a ground crew depends on the situation, type of cargo, and size of the pickup zones. Generally, however, three people make up the ground crew: the signalman, the hookup man, and the static wand man. The unit commander decides how many crews to train. The commander also provides local security for the operation. (This task is not a responsibility of the ground crew.)

More than three people may be needed to prepare large items of equipment for sling-loading. For example, bridge sections or towers may need as many as eight people to manhandle them into place. Although each member of the crew has specific duties during the operation, each person should be cross-trained to perform all duties.

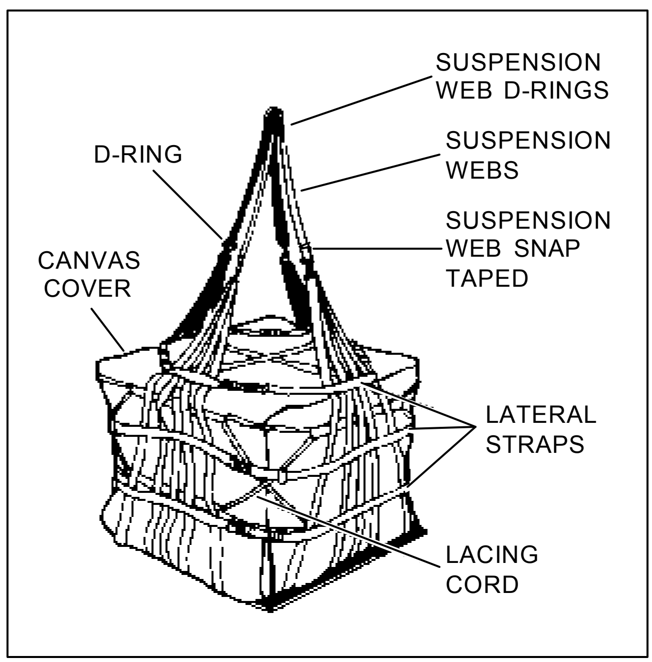


Figure 2-10. A-22 cargo bag

Equipment

If they are to conduct safe and efficient sling-load operations, ground crews must have the right equipment in sufficient supply.

Rigging and hookup. Besides weapons, radios, and operational equipment, each ground crew needs a separate and complete issue of rigging and hookup equipment. This is because there may be several PZs or LZs, and they may be spread over a large area. See FM 55-450-3, -4 and -5 for the proper method of rigging loads for external air transport.

Protective. Ground crews involved in helicopter operations are exposed to the hazards of noise and rotor downwash caused by the helicopter. Therefore, ground crew members must wear protective equipment while they perform their duties.

Pickup zone/landing zone. At a minimum, the equipment needed to operate the PZ/LZ includes helmets, goggles (or protective masks), snap-ring pliers, ear plugs, gloves, smoke grenades, a T33 tool kit (pliers and pocket knife), and static electricity discharge probe.

Static electricity discharge. In flight, a helicopter generates and stores a charge of static electricity. When the helicopter lands, this charge is grounded out. While the helicopter is flying, the charge remains stored unless a path is provided for it to be channeled into the earth. A ground crew member provides this path by touching the helicopter cargo hook when it is positioned over a cargo hookup point. This charge may not cause an electrical burn. However, if the crew member is on unsure footing, it can cause a muscular reaction that may result in injury from a fall. An individual shocked by the electricity may also suffer delayed discomfort from muscular cramps or spasms.

To prevent a ground crew member from being shocked, a discharge probe is used to ground the cargo hook. This probe channels the electricity from the helicopter directly into the ground. The probe consists of an insulated plastic tube with a metal hook on one end and a wire attached to a ground rod on the other end (Figure 2-11). Because contact will cause severe shock, the entire length of wire must be insulated. In use, the ground rod is driven into the earth and the contact rod is held by a ground crew member. As the helicopter hovers over the load, the static wand man holds the contact rod against the cargo hook load beam, thus grounding out the stored electrical charge. Meanwhile, the hookup man places the clevis (apex) on the cargo hook.

WARNING

Contact between the discharge probe and the cargo hook must be maintained until the clevis (apex) is placed on the cargo hook. If contact between the probe and the cargo hook is not maintained, the ground crew may receive a serious shock. This does not mean the ground crew should rig a spring clip to hook directly to the aircraft. If contact between the probe and cargo hook is broken, then contact must again be made before touching the cargo hook.

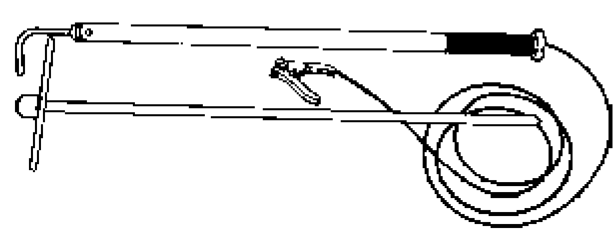


Figure 2-11. Static electricity discharge probe

INTERNAL TRANSPORT HELICOPTERS

Like external air transport, internal transport helicopters offer a viable, expedient alternative to surface modes. In a crisis, helicopter transport may be the only solution.

Advantages

Helicopters rapidly and directly move personnel and materiel to their destination. Damaged or congested highways, destroyed bridges, and most en route terrain obstacles have little affect on cargo transport. The helicopter may use different flight routes to provide a diversion and to maintain security of the unit on the ground. Helicopters move cargo rapidly into or out of an area, a distinct advantage for ground units that get equipment when and where they need it. Helicopters also move combat troops and weapons to locations where they are needed and then quickly relocate them in a rapidly changing battlefield situation. An LZ can easily be moved to avoid detection and ensure security.

Disadvantages

When the size and weight of the cargo exceeds the design of the aircraft, the disadvantages of transporting cargo internally by helicopter become clear. Restrictions that apply to helicopters in general also apply here, whether for internal load operations or a routine training flight. Also, aviation assets are limited; maintenance downtime and priority of missions must be considered to ensure that aircraft are used wisely. Bad weather may affect operations and the LZ terrain present natural obstacles. As is the case with external sling-load missions, these factors may severely restrict internal load missions.

Responsibilities

There are three separate elements involved in an internal load mission: the supported unit (requests the mission), the aviation unit (provides the aircraft), and the receiving unit (receives the cargo).

Supported unit. The supported unit selects and controls the pickup zone (pathfinders can be a great help in both tasks) and ensures that advanced coordination is conducted within the aviation unit. Other responsibilities of the supported unit include the following:

- Before equipment is prepared, ensuring the careful review of all loading, tie-down, and unloading procedures; tie-down diagrams; and tie-down data tables.
- Preparing supplies and/or equipment for air transport with technical supervision and assistance from the appropriate field support units.
- Ensuring that cargo loaded on vehicles is restrained in the vehicle and that all loose equipment in the vehicle is secured.
- Loading the vehicle into the helicopter, tying it down, and unloading it from the helicopter, once the helicopter commander, flight engineer, or crew chief gives approval.
- Ensuring that loads are properly prepared and do not exceed weight or size limitations imposed by the transporting helicopter.
- Providing all personnel involved in or near the loading operations with appropriate safety equipment.
- Policing the pickup zone.

Aviation unit. The aviation unit establishes coordination with the supported and receiving units and appoints a liaison officer. The liaison officer should be thoroughly familiar with the capabilities and limitations of the assigned aircraft. Other aviation unit responsibilities include:

- Advising the supported unit on size and weight limitations of the loads that may be lifted.
- Advising the supported and receiving units on the suitability of the selected PZ/LZ.
- Becoming familiar with the security, safety, and technical peculiarities of the loads that may adversely affect air transport.
- Providing all components of the 5,000- and 10,000-pound tie-down assemblies used for internal transport in helicopters. (The supported unit is still responsible for packaging and providing disposition instructions to the aviation unit.)
- Arranging for the aircraft to be at the PZ on schedule.
- Establishing safety procedures that ensure uniformity and understanding of duties and responsibilities between the ground and flight crews.

Receiving unit. The receiving unit selects and controls the LZ and provides trained ground crews to guide in the aircraft. Receiving unit responsibilities also include:

• Coordinating with the supported (sending) unit for retrograde of items that belong to the supporting unit.

• Preparing, coordinating, and inspecting back loads and having them ready for loading when the aircraft arrives.

Tie-Down Rings

Several types of cargo restraint devices can be used to tie down cargo. Tie-downs must be correctly attached to prevent cargo from shifting. Each tie-down has a rated strength to prevent cargo from shifting.

UH-1 Iroquois. The tie-down rings in the floor of the UH-1 have a rated holding capacity of 1,350 pounds in the vertical direction and 500 pounds in the horizontal direction. The restraint criteria are 4 g's forward, 2 g's aft, 2 g's vertical, and 1.5 g's lateral. Table 2-2 shows cargo compartment dimensions by model. Figure 2-12 shows the tie-down fittings of a UH-1.

Table 2-2. Dimensions of cargo compartments by model

	UH-1C/M	UH-1D/H
Height of floor above ground	26 in	32 in
Cargo compartment		
Length	60 in	92 in
Width	80.5 in	96 in
Height	56 in	52 in
Cargo door		
Width	48 in	92 in
Height	48 in	49 in

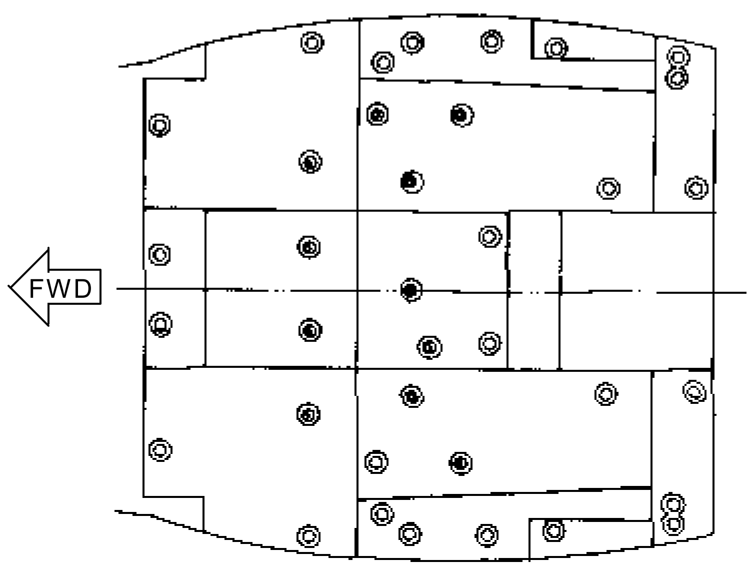


Figure 2-12. UH-1 tie-down rings

UH-60 Blackhawk. The tie-down rings in the floor of the UH-60 have a rated capacity of 5,000 pounds in any direction. The cargo restraint net rings on the walls and ceiling are rated at 3,500 pounds. The restraint criteria are 12 g's forward, 3 g's aft, 3 g's vertical, and 8 g's lateral with troops and cargo; 2 g's in the lateral criterion with cargo only. Table 2-3 shows internal cargo loading specifications. Figure 2-13 shows the tie-down fittings of a UH-60.

CH-47 Chinook. The CH-47 has eighty-seven 5,000-pound capacity tie-down rings (83 in the fuselage and 4 on the ramp) and eight 10,000-pound capacity tie-down rings in the cargo compartment. The restraint criteria are 4 g's forward, 2 g's aft, 4 g's down, 2 g's up, and 1.5 g's lateral. Figure 2-14, page 2-18 shows the tie-down fittings of a CH-47.

Table 2-3. UH-60 internal cargo loading specifications

SECTION	MAXIMUM CAPACITY (lb)	MAXIMUM LB/ SQ FT	SQUARE FEET
Forward cabin	5,460	300	18.2
Center cabin	8,370	300	27.9
Aft cabin	8,370	300	27.9

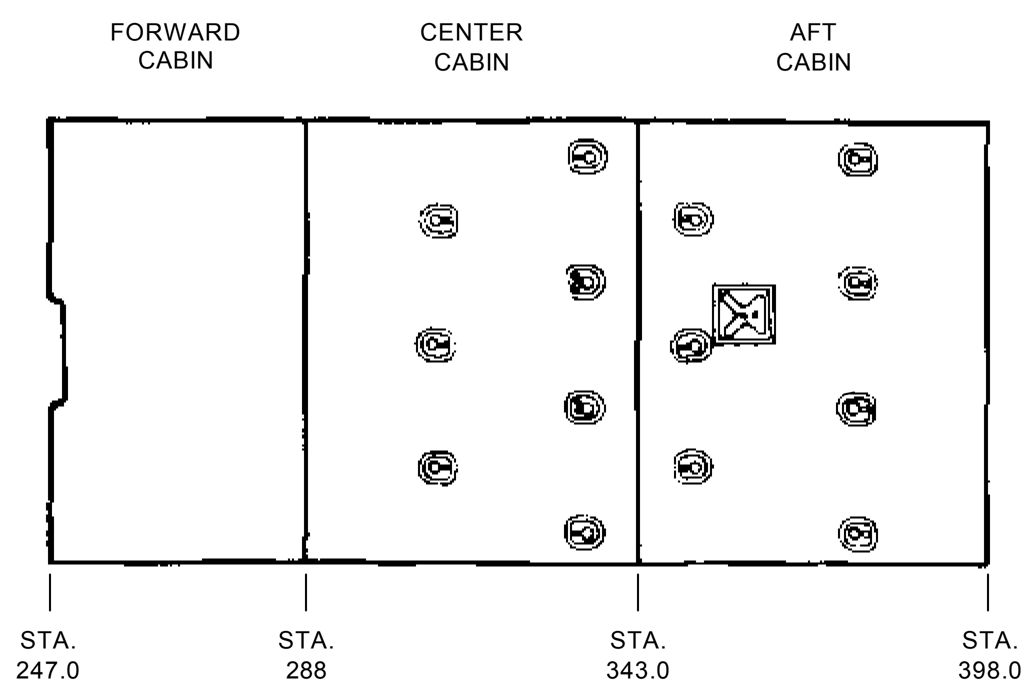


Figure 2-13. UH-60 tie-down rings

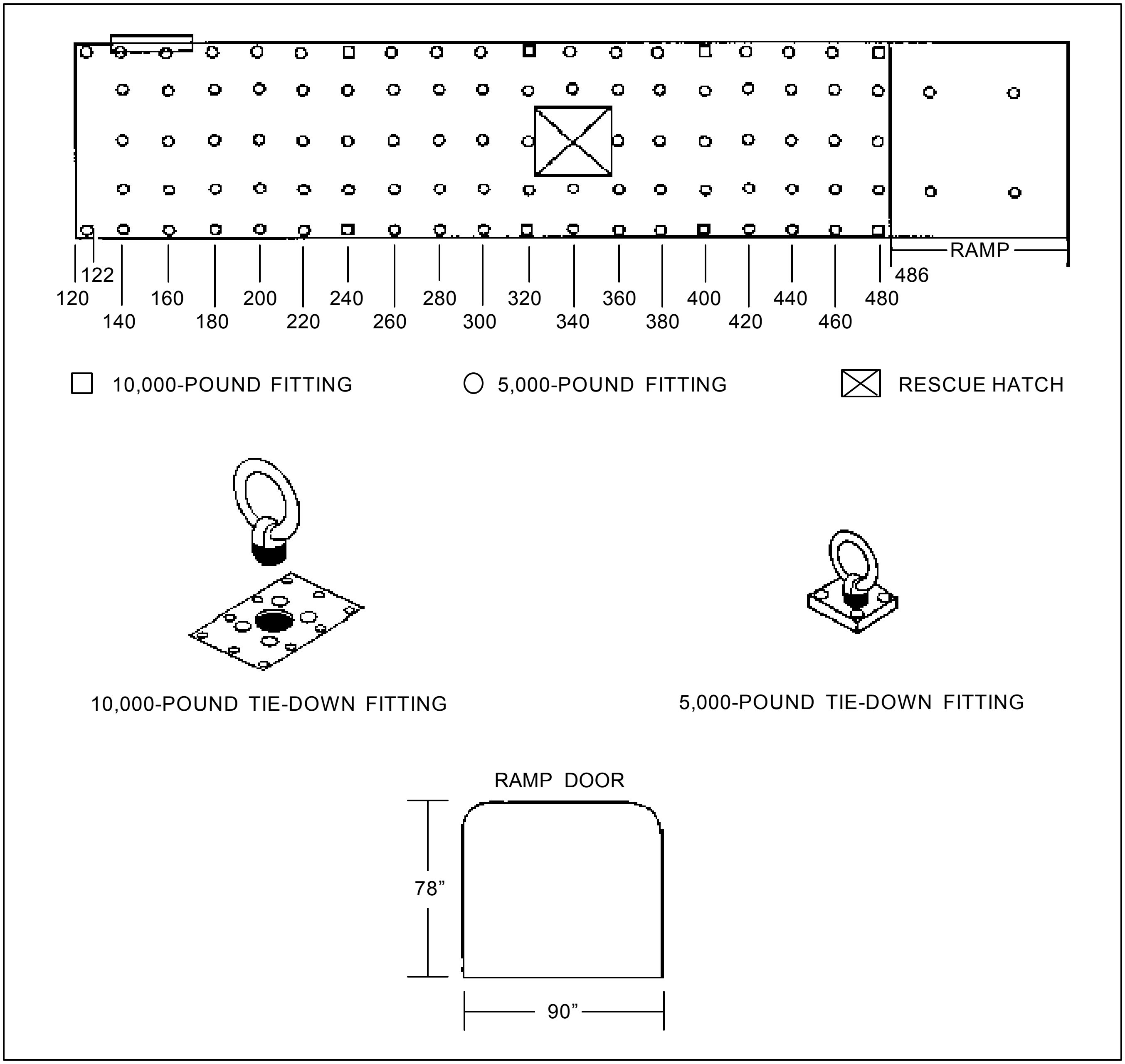


Figure 2-14. CH-47 tie-down rings

Loading/Unloading System

The HICHS is a roller system designed for the CH-47 helicopter (Figure 2-15, page 2-19). This system expedites the loading and unloading of 463L Air Force pallets and other modularized cargo. With the HICHS installed, a CH-47 can carry three (88- by 108-inch) 463L pallets or 12 (40 by 48-inch) standard warehouse pallets. The height of all loads is restricted to 54 inches. The HICHS can be installed by four men in 45 minutes and removed in 20 minutes.

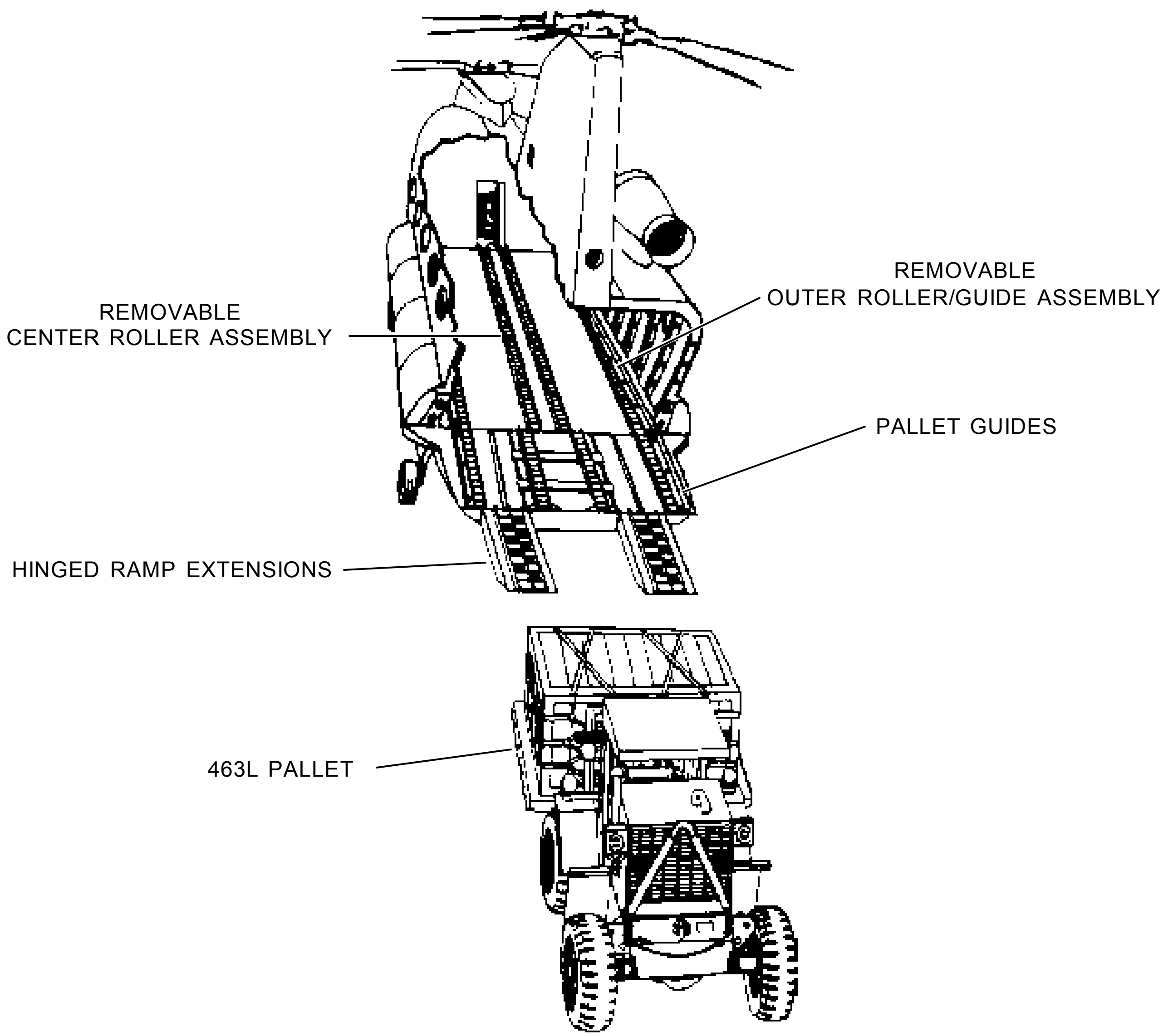


Figure 2-15. HICHS installed in a CH-47 helicopter

Equipment Deployment and Storage Systems

EDSS are standardized unit deployment/storage systems capable of strategic and tactical delivery by both surface and air transport. The QUADCON is the ground dominant system and the ISU the air dominant system.

The ISU is a weather resistant box with a 463L pallet bottom. It is certified for helicopter internal/external lift, transport on AMC aircraft, and combat off-load. The two versions of this system are the ISU-60 (60 inches high) and the ISU-90 (90 inches high). ISU characteristics are as follows:

- Base – 88- by 108-inches.
- Capacity – 5,000 pounds, internal helicopter lift; 10,000 pounds, airlift or helicopter external lift.
- Usable cubic feet – 225 (ISU-60), 400 (ISU-90).
- Double doors on both 108-inch sides.
- Adjustable shelves and dividers.
- Two-high stackable.
- Two-way forkliftable.
- Completely intermodal.

Figure 2-16 shows characteristics of both the 60-inch and 90-inch ISU. The QUADCON is discussed in Chapter 5 of this manual.

AIR MOBILITY COMMAND AIRCRAFT

Personnel who prepare load plans must be familiar with the types and characteristics of available airlift aircraft. Most significant of these are the C-130, C-141B, C-5, KC-10, and C-17. All are primarily transport aircraft. Their cargo compartments can be configured to accommodate general bulk or palletized cargo, vehicles, troops, paratroopers, and cargo rigged for airdrop. All have long-range mission capability, roller-conveyor systems for using the 463L pallet system, and hydraulically activated ramp systems for ease in loading and off-loading. The broad capabilities of these aircraft allow great flexibility in moving troops and equipment. See FM 55-9 for detailed loading guidance and schematics.

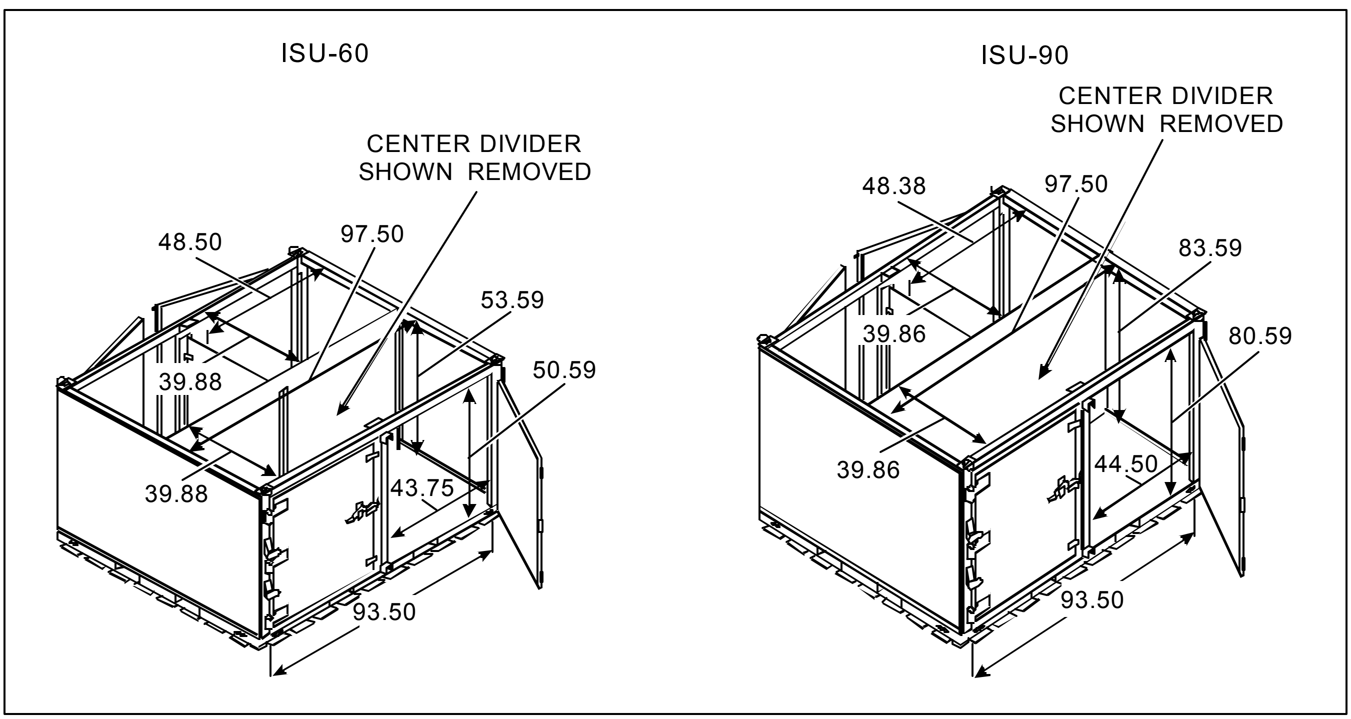


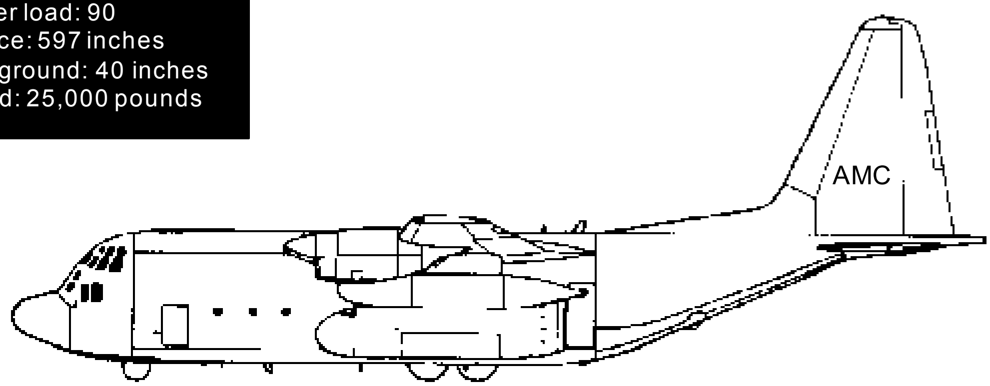
Figure 2-16. ISU characteristics

C-130E/H Hercules

The C-130E/H series Lockheed aircraft is a high-winged, four-engine, turbo-prop medium-range assault transport designed for tactical/theater-type missions. It is the primary aircraft used by Air Mobility Command for tactical missions.

The C-130 does not have a separate passenger compartment. When using side-facing seats, plan for a maximum of 29 passengers. The C-130 can carry up to 90 passengers (80 over water based on life raft capacity). See Figure 2-17 for C-130 characteristics.

- Maximum passenger load: 90
- Usable loading space: 597 inches
- Floor height above ground: 40 inches
- Allowable cabin load: 25,000 pounds



DIMENSIONS

	Cargo Compartment	Troop Door	Aircraft Ramp
Length	624 inches	—	132 inches
Height	108 inches [1]	72 inches	—
Width	23 inches	36 inches	—

PALLETIZED CARGO RESTRICTIONS

Pallet Position	Maximum Weight	Maximum Height
1-4	10,355 pounds	96 inches [2]
5	8,500 pounds	96 inches [2]
6	4,664 pounds	76 inches

NOTE: C-130E/H aircraft can carry six 463L pallets.

RESTRAINT FACTORS

Forward	3.0 g's
Aft	1.5 g's
Vertical	2.0 g's
Lateral	1.5 g's

[1] Only 106 inches of usable floor space is available when the Dual Rail System is installed.

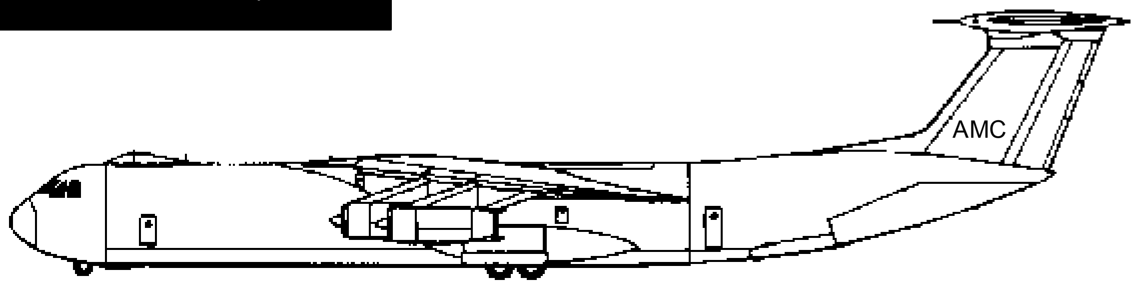
[2] Maximum cargo weight on a single pallet secured with nets stacked above 96 inches (not to exceed 100 inches) shall not exceed 8,000 pounds.

Figure 2-17. Characteristics of C-130E/H aircraft

C-141 Starlifter

The C-141 series Lockheed aircraft is a high-swept-wing, turbo-fan-jet airplane designed for strategic, intertheater-type missions. Like the C-130, the C-141 does not have a separate passenger compartment. When using side-facing seats, plan for a maximum of 98 passengers. The C-141 can carry a maximum of 200 passengers (160 over water based on life raft capacity). See Figure 2-18 for C-141 characteristics.

- Maximum passenger load: 200
- Usable loading space: 1,215 inches
- Floor height above ground: 50 inches
- Allowable cabin load: 50,000 pounds



DIMENSIONS	Cargo Compartment	Troop Door	Aircraft Ramp
Length	1,253 inches	—	133 inches
Height	109 inches	72 inches	—
Width	123 inches	36 inches	—

PALLETIZED CARGO RESTRICTIONS

Pallet Position	Maximum Weight	Maximum Height
1	10,355 pounds	76 inches
2-12	10,355 pounds	96 inches[1]
13	7,500 pounds	76 inches

NOTE: C-141 aircraft can carry thirteen 463L pallets

RESTRAINT FACTORS

Forward	3.0 g's
Aft	1.5 g's
Vertical	2.0 g's
Lateral	1.5 g's

[1] Maximum cargo weight on a single pallet secured with nets and stacked above 96 inches (not to exceed 100 inches) shall not exceed 8,000 pounds.

Figure 2-18. Characteristics of C-141 aircraft

C-5 Galaxy

The Lockheed C-5 is a high-winged, long-range, heavy-lift transport aircraft. It is used for strategic global, intertheater operations. Its primary function is to transport cargo that is outsized or overweight for C-130 or C-141 aircraft. Features unique to the C-5 include the forward cargo door (visor) and ramp and the aft cargo door system and ramp. These features allow drive-on/drive-off loading and unloading as well as loading and unloading from either end of the cargo compartment. The C-5's kneeling capability also facilitates and expedites these operations by lowering the cargo compartment floor by about 10 feet to 3 feet off the ground. This position lowers cargo ramps for truck bed and ground loading and reduces ramp angles for loading and unloading vehicles. The C-5's floor does not have treadways. The "floor-bearing pressure" is the same over the entire floor. As shown in Figure 2-19, page 2-24, however, the C-5 does have weight restrictions. See Figure 2-19 for C-5 characteristics.

The C-5A/B can carry up to thirty-six 463L pallets. The troop compartment is located in the aircraft's upper deck. It is self-contained with a galley, two lavatories, and 73 available passenger seats (CB at FS 1675). Another 267 airline seats may be installed on the cargo compartment floor (maximum combined total of 329 troops including air crew over water).

Passenger Computation Example Problem:

73 troops at 210 pounds each

73 troops x 210 pounds = 15,330 pounds

Center of balance of troop compartment = Fuselage Station 1675 (constant)

Weight x Distance = Moment

15,330 x 1675 = 25677750

KC-10A Extender

The KC-10A series aircraft is a swept-wing, wide-body tri-jet that both air-refuels military aircraft and airlifts cargo and support personnel. Fuel tanks are contained in the lower compartments of the fuselage. Troops, palletized and mixed cargo, vehicles, and logistics equipment are carried on the unobstructed upper deck. The KC-10A can carry up to 69 passengers over water. It accommodates up to twenty-seven 463L pallets. Normally, a maximum of 25 pallet positions are authorized. Besides being equipped to air-refuel military airplanes requiring either a boom or hose drogue, the KC-10A may be refueled from another KC-10A or KC-135 tanker. See Figure 2-20, page 2-25 for KC-10A characteristics.

C-17

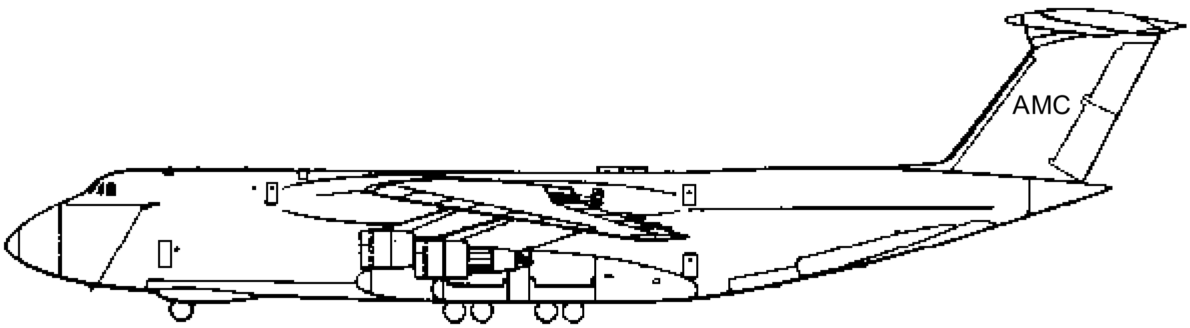
The C-17 is a high-winged, long-range, heavy-lift four-engine turbofan transport aircraft. It is designed to replace the aging C-141 fleet as airlift workhorse, combining the best attributes of today's airlift aircraft with proven modern technology to support tomorrow's battlefields effectively. The C-17 will provide worldwide airlift of US forces.

The C-17 wingspan is about the same as that of the C-141, but with twice the payload. It is capable of delivering the same outsize equipment as the C-5 into small austere airfields previously restricted to the C-130. Its ability to land on short runways with payloads up to 172,200 pounds will make possible the delivery of equipment to forward areas without intermediate transshipment. The C-17 can airdrop or LAPES outsize equipment (single items up to 60,000 pounds, total weight up to 110,000 pounds). It can also provide aeromedical airlift and augment special operations.

The C-17 accommodates up to eighteen 463L pallets. Although it does not have a separate passenger compartment, it has 54 side-facing seats permanently installed in the cargo compartment. With centerline seats installed on the cargo floor, the C-17 can carry a maximum of 102 passengers. See Figure 2-21, page 2-26, for C-17 characteristics.

- Maximum passenger load:
  - 73 normal contingency
  - 267 cargo compartment
- Usable loading space: 1,726 inches
- Floor height above ground: (variable):
  - Aft: 73 to 105 inches
  - Forward: 36 to 70 inches
- Allowable cabin load:
  - Peacetime – 150,000 pounds
  - Wartime – 150,000 pounds
  - Max design ACL – 291,000 pounds

Weight Restrictions
- Maximum axle load: 1884 and 1971: 20,000 pounds
- Maximum tracked vehicle weight: 129,000 pounds
- Floor limitations: maximum axle weight(s) per 40-inch longitudial area between fuselage stations:
  - 517 and 724: 20,000 pounds
  - 724 and 1,884: 36,000 pounds
  - 1,884 and 1,971: 20,000 pounds



DIMENSIONS

	Cargo Compartment	Troop Door	Aircraft Ramp
Length	1,736 inches	—	116 inches (fwd) 155 inches (aft)
Height	162 inches	72 inches	—
Width	228 inches	36 inches	—

PALLETIZED CARGO RESTRICTIONS

Pallet Position	Maximum Weight	Maximum Height
1-2	7,500 pounds	96 inches
3-34	10,355 pounds	96 inches
35-36	7,500 pounds	70 inches

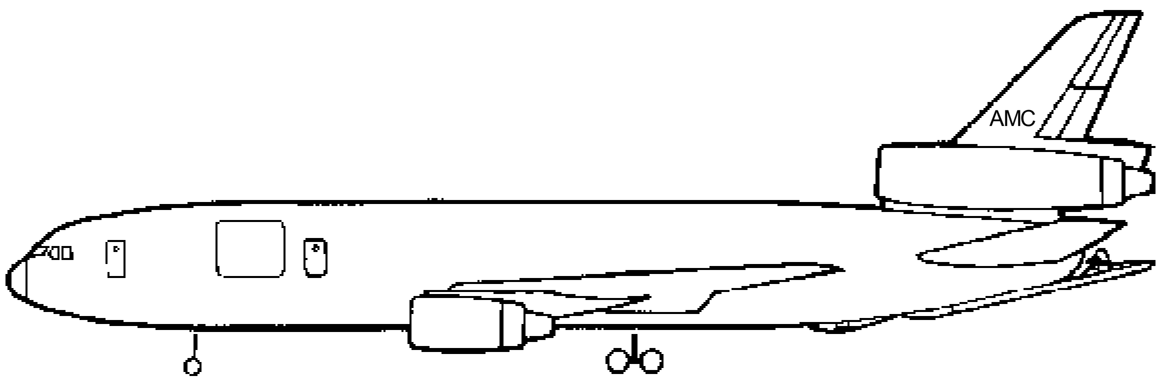
NOTE: C-5 aircraft can carry up to thirty-six 463L pallets.

RESTRAINT FACTORS

Forward	3.0 g's
Aft	1.5 g's
Vertical	2.0 g's
Lateral	1.5 g's

Figure 2-19. Characteristics of C-5 aircraft

- Maximum passenger load:
  - without seat kit: 16
  - with seat kit: 75
- Usable loading space: 1,058 inches
- Floor height above ground: 15 feet 10 inches
- Allowable cabin load: Because of the many types of load configurations (troops, cargo, and fuel) possible, the ACL varies significantly. Contact your local TALCE to get the ACL for the load you wish to transport.

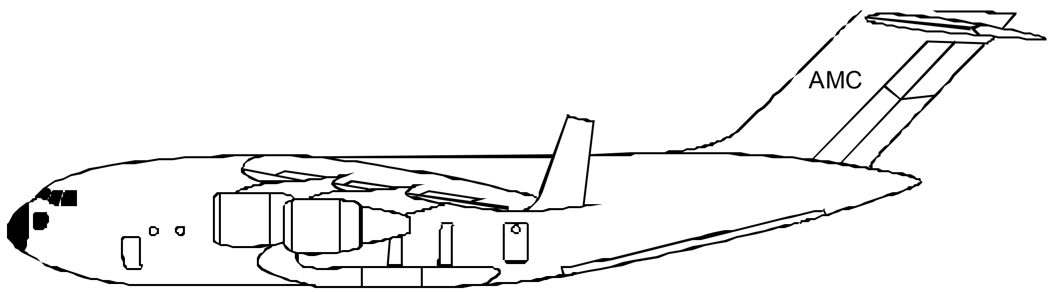


DIMENSIONS

	Cargo Compartment	Troop Door	Aircraft Ramp
Length	1,508 inches	—	—
Height	95 - 131 inches (variable)	76 inches	102 inches
Width	144 inches	42 inches	140 inches

Figure 2-20. Characteristics of KC-10A aircraft

- Troop Configuration (102 total seats)
  - 54 integral side seats
  - 48 center seats
- Usable loading space: 1,022 inches
- Double-row logistics system: eighteen 463L pallets
- Single-row aerial delivery system: eleven 463L pallets
- Constant strength flow: no treadways
- Tie-down ring capacity: 25,000 pounds
- Maximum floor cargo capacity: 172,200 pounds
- Maximum takeoff weight: 580,000 pounds
- Aeromedical evacuation capacity: 48 litters
- LAPES single platform capacity: 60,000 pounds
- LAPES multiple platforms capacity: 110,000 pounds
- CDS capacity: 40 containers at 2,350 pounds total rigged weight each
- Onboard winch system: high-capacity variable-speed
- Landing capability: 2,700 feet long runway with maximum payload of 167,000 pounds



DIMENSIONS

	Cargo Compartment	Troop Door	Aircraft Ramp
Length	1,056 inches	238 inches	—
Height	148-162 inches (variable)	128 inches	80 inches
Width	216 inches	216 inches	43 inches

RAMP LIMITATIONS

	Weight	Height
Pallet	10,355 pounds [1]	96 inches
Vehicle	27,000 pounds per axle	122 inches

[1] Not to exceed a combined total ramp weight of 40,000 pounds.

Figure 2-21. Characteristics of C-17 aircraft

CIVIL RESERVE AIR FLEET AIRCRAFT

The Civil Reserve Air Fleet is made up of US civil air carriers who are committed by contract to providing operating and support personnel for DOD. The CRAF program is designed to quickly mobilize our nation's airlift resources to meet DOD force projection requirements. CRAF airlift services are divided into four operational segments:

- Long-range international-strategic intertheater operations.
- Short-range international theater operations.
- Domestic CONUS-DOD supply distribution.
- Alaskan-Aerospace Defense Command support.

Capability

The CRAF airlift capability can be activated in three stages. These stages are as follows:

Stage I. Stage I may be activated by the USCINCTRANSCOM,[1] to perform airlift services when the AMC airlift force cannot meet simultaneously both deployment and other traffic requirements.

Stage II. Stage II is an additional airlift expansion identified for an airlift emergency which does not warrant national mobilization but may be activated by authority of the SECDEF.[1]

Stage III. Stage III makes available the total CRAF airlift capability when required for DOD operations during major military emergencies involving US Forces. The SECDEF[1] issues the order to activate CRAF stage III only after a national emergency has been declared by the President or Congress.

Description

Table 2-4, page 2-28, gives the dimensions and Table 2-5, page 2-29, gives the capabilities for Boeing B747 series aircraft; Tables 2-6, page 2-30, and 2-7, page 2-31, give the same data for the Douglas DC-10 and Lockheed L-1011 series aircraft; and Tables 2-8, page 2-32, and 2-9, page 2-33, give like data for the Douglas DC-8 and Boeing B707 series aircraft. Figure 2-22, page 2-34, shows profiles of CRAF aircraft; Figure 2-23, page 2-35, shows profiles of CRAF pallets.

Boeing B747. The Boeing B747 is a wide-body aircraft. The cargo-carrying versions have a planning cargo weight of about 180,000 pounds. The main deck can hold either 32 to 36 military or 28 commercial pallets. The passenger version carries about 364 passengers (only 237 on the B747SP).

Douglas DC-10 and Lockheed L-1011. The Douglas DC-10 and Lockheed L-1011 are wide-body aircraft. The cargo-carrying version of the DC-10 has an average cargo weight of about 120,000 pounds. The main deck can hold either 30 military or 22 commercial pallets. The passenger version of the DC-10 can carry about 242 passengers. The L-1011 passenger version has a capacity of 246 to 330 seats.

Douglas DC-8 and Boeing B707. The Douglas DC-8 and Boeing B707 are narrow-body aircraft. The DC-8 cargo version has a planning cargo weight that varies from 52,000 to 82,000 pounds. The main deck accommodates 14 to 18 pallets, depending on the aircraft series. The cargo version of the B707 has a planning cargo weight of about 60,000 pounds, and the main deck can carry 13 military or commercial pallets. The passenger DC-8 carries 165 to 219 passengers, and the B707, approximately 165 passengers. CRAF aircraft are neither designed nor intended to carry litter patients.

NOTE: Unit load plans or request for specific type aircraft is not necessarily the type of aircraft you will receive. Type aircraft received is controlled and driven by the total commitment of tonnage and passengers to be moved and specific airline type aircraft available.

[1] SECDEF memo indicates USCINCTRANSCOM activates all three stages with approval of the SECDEF.

Table 2-4. Dimensions of B747 series aircraft

	AIRCRAFT DESIGNATION				
	B747SP	B747-100/200	B747-100F	B747-200C	B747-200F
Floor height					
Main deck	188-196 in	193-201 in	193-210 in	186-204 in	186-204 in
Lower deck	108-122 in	109-121 in	109-121 in	109-121 in	109-121 in
Main deck cargo compartment					
Length	NA	NA	NA	NA	NA
Width	NA	NA	NA	NA	NA
Height	NA	NA	NA	NA	NA
Lower Lobe (fwd)					
Length	315 in	315 in [1,5] 504 in [6]	504 in	504 in	504 in
Width	125 in [2]	125 in [2]	125 in [2]	125 in [2]	125 in [2]
Height	66 in [3]	66 in [3]	66 in [3]	66 in [3]	66 in [3]
Lower Lobe (aft)					
Length	120 in	251 in [4,5] 436 in [6]	240 in	240 in	436 in
Width	125 in [2]	125 in [2]	125 in [2]	125 in [2]	125 in [2]
Height	66 in [3]	66 in [3]	66 in [3]	66 in [3]	66 in [3]
Door Sizes					
Visor door	104 in w x 98 in h				
Main cargo door	122 in w x 120 in h				

[1] Pallets will not be planned for use in lower lobe forward compartment of American/United Airlines B747-100 passenger aircraft.

[2] Floor width, 125 inches or 190 inches wall-to-wall; however, all cargo must be on pallets or shoring.

[3] Measured from top of rollers to ceiling.

[4] Use 251 inches for American/United Airlines B747-100.

[5] With galley installed in lower lobe.

[6] Without galley installed in lower lobe.

Table 2-5. Capabilities of B747 series aircraft

	AIRCRAFT DESIGNATION				
	B747SP	B747-100/200	B747-100F	B747-200C	B747-200F
Max auth gross weight					
Takeoff	670,000 lb	750,000/ 775,000 lb	750,000 lb	775,000 lb	820,000 lb
Landing	465,000 lb	585,000/ 564,000 lb	575,000 lb	833,000 lb	833,000 lb
Operating	326,000 lb	375,000/ 369,820 lb	327,000 lb	367,000 lb	349,000 lb
Zero fuel	425,000 lb	526,000/ 526,500 lb	545,000 lb	590,000 lb	590,000 lb
Restraining factors					
Forward	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's
Aft	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's
Vertical	2.0 g's	2.0 g's	2.0 g's	2.0 g's	2.0 g's
Lateral	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's
Passenger capacity	266[1]	364[1]	2	364[1]	2
Planning ACL	NA	NA	89.9 STONs	96.9 STONs[2]	99.1 STONs
463L pallet capacity	NA	NA	32[3]	32[3]	32[3]
Max pallet height	NA	NA	118 in	94 in[5]	118 in[4] 94 in[5]

[1] Maximum passenger capability will vary according to carrier configuration.

[2] Since this is a convertible aircraft, figures are based on cargo or passenger loads.

[3] Some aircraft may be configured to a 36-pallet configuration.

[4] Side door.

[5] Visor door.

Table 2-6. Dimensions of DC-10 and L-1011 series aircraft

	AIRCRAFT DESIGNATION				
	DC-10-10CF	DC-10-30CF	DC-10-40	L-1011-100	L-1011-500
Floor height					
Main deck	189 in	189 in	189 in	182-186 in	182-186 in
Lower deck	103-118 in	103-118 in	103-118 in	105-112 in	105-112 in
Main deck cargo compartment					
Length	1,414 in [1]	1,414 in [1]	NA	NA	NA
Width	218 in	218 in	NA	NA	NA
Height	84-95 in [2]	84-9 in [2]	NA	NA	NA
Lower Lobe (fwd)					
Length	491 in [3]	216 in [4]	491 in [3]	500 in [5] 254 in [6]	394 in
Width	125 in [7]	125 in [7]	125 in [7]	125 in	
Height	66 in [8]	66 in [8]	66 in [8]	64 in	64 in
Lower Lobe (aft)					
Length	241.5 in	241.5 in	241.5 in	250 in	190 in
Width	125 in [7]	125 in [7]	125 in [7]	125 in [7]	125 in
Height	66 in [8]	66 in [8]	66 in [8]	64 in	64 in
Lower lobe (aft, bulk compartment)					
Length	179 in	179 in [9]	179 in [9]	167 in	167 in
Width	125 in [10]	125 in [10]	125 in [10]	125 in	125 in
Height	66 in [10]	66 in [10]	66 in [10]	64 in	64 in [10]
Door Sizes					
Main cargo door	140 in w x 102 in h				
Forward and center door	70in w x 66 in h				
Aft door	44 in w x 48 in h				

[1] Length from FS 523 to 1937. A barrier net is located at FS 495. Usable cargo space is based on pallet surface.
[2] Max height of 84 inches at pallet positions 1 and 15; 88 inches at positions 2 through 14; 95 inches at the forward half of the cargo door.
[3] Length from FS 604.5 to FS 1095.5.
[4] Length from FS 879.5 to FS 1095.5.
[5] Without galley installed in lower lobe.
[6] With galley installed in lower lobe.
[7] Wall-to-wall distance is 164 inches.
[8] Measured from top of rollers to ceiling.
[9] Aircraft with an extended aft cargo compartment will have a 126-inch aft bulk cargo area and a cargo door 30 inches wide by 36 inches high.
[10] Dimension decrease toward aft of cargo compartment.

Table 2-7. Capabilities of DC-10 and L-1011 series aircraft

	AIRCRAFT DESIGNATION				
	DC-10-10CF	DC-10-30CF	DC-10-40	L-1011-100	L-1011-500
Max auth gross weight					
Takeoff	440,000 lb	572,000 lb	570,000 lb	466,000 lb	510,000 lb
Landing	363,500 lb	424,000 lb	403,000 lb	368,000 lb	368,000 lb
Operating	247,000 lb	237,591 lb	367,800 lb	246,000 lb	245,000 lb
Zero fuel	335,000 lb	401,000 lb	368,000 lb	320,000 lb	330,000 lb
Optimum load CG at fuselage station	1,323	1,323	1,323	NA	NA
Restraining factors					
Forward	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's
Aft	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's
Vertical	2.0 g's	2.0 g's	2.0 g's	2.0 g's	2.0 g's
Lateral	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's
Passenger capacity	242[1]	242[1]	242	273	238
Planning ACL	55.2 STONs[1]	75 STONs[1]	NA	NA	NA
463L pallet capacity	30	30	NA	NA	NA
Max pallet height	78-82 in	78-82 in	NA	NA	NA

[1] Figures on CFs are for ACLs or passengers, depending on the mode of aircraft use.

Table 2-8. Dimensions of DC-8 and B707 series aircraft

	AIRCRAFT DESIGNATION					
	DC-8-33F	DC-8-50CF	DC-8-61CF	DC-8-62F	DC-8-63F/CF	B707-300C/F
Floor height						
Main deck	126-135 in	126-135 in	128-132 in	126-130 in	126-131 in	119-126 in
Lower deck	68-92 in	68-97 in	75-98 in	73-100 in	76-98 in	54-63 in
Main deck cargo compartment						
Length	1,176 in [1]	1,176 in [1]	1,622 in [2]	1,265 in [3]	1,622 in [2]	1,176 in [4]
Width	127.2 in	127.2 in	127.2 in	127.2 in	127.2 in	126 in
Height	86 in [5]	86 in [5]	86 in [5]	86 in [5]	86 in [5]	87 in [6]
Lower lobe (fwd)						
Length	330 in [7]	330 in [7]	437 in	370 in	437 in	298 in
Width	100 in	100 in	100 in	100 in	100 in	
Height	51 in [8]	51 in [8]	51 in [8]	51 in [8]	51 in [8]	54 in [9]
Door size						
Main cargo door	140 in w x 85 in h					134 in w x 91 in h

[1] Length from FS 302 to FS 1478.

[2] Length from FS 62 to FS 1684.

[3] Length from FS 262 to FS 1527.

[4] Length from FS 242 to FS 1418.

[5] Measured from floor to ceiling.

[6] Measured on centerline to ceiling.

[7] Measurement for entire forward cargo compartment.

[8] Lowest point in cargo compartment to ceiling.

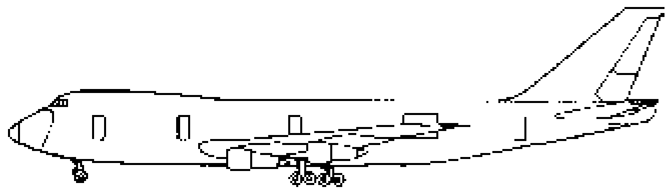
[9] Height of aft cargo compartment 54.5 in for the first 80 in, then tapering down.

Table 2-9. Capabilities of DC-8 and B707 series aircraft

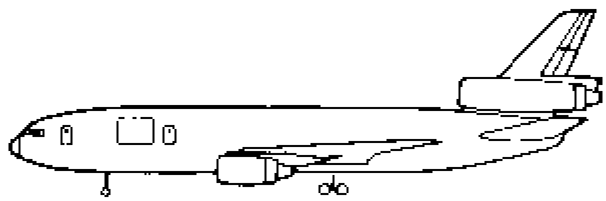
	AIRCRAFT DESIGNATION					
	DC-8-33F	DC-8-50CF	DC-8-61CF	DC-8-62F	DC-8-63F/CF	B707-300C/F
Max auth gross weight						
Takeoff	315,000 lb	315,000 lb	325,000 lb	350,000 lb	355,000 lb	336,600/ 333,100 lb
Landing	207,000 lb	240,000 lb	250,000 lb	250,000 lb	275,000 lb	247,000/ 247,000 lb
Operating	128,000 lb	131,600 lb	147,506 lb	140,000 lb	147,000 lb	355,000/ 132,174 lb
Zero fuel	192,140 lb	224,000 lb	234,000 lb	230,000 lb	261,000 lb	230,000/ 230,000 lb
Optimum load CG at fuselage station	860.0	860.0	828.0-889.0	836.1-883.8	833.9-883.8	838.3-843.7
Restraining factors						
Forward	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's
Aft	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's
Vertical	2.0 g's	2.0 g's	2.0 g's	2.0 g's	2.0 g's	2.0 g's
Lateral	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's	1.5 g's
Passenger capacity	2	165[1]	219[1]	170[1]	219[1]	165
Planning ACL	26.0 STONs	29.9 STONs[1]	47.3 STONs[1]	32.1 STONs[1]	41.4 STONs[1]	29.9 STONs[1]
463L pallet capacity	13	13	18	14	18	13
Max pallet height (in inches)	62-80[2]	62-80[2]	62-80[2]	62-80[2]	62-80[2]	74-80[2]

[1] Figures on CF are for ACLs or passengers, depending on mode of aircraft use.

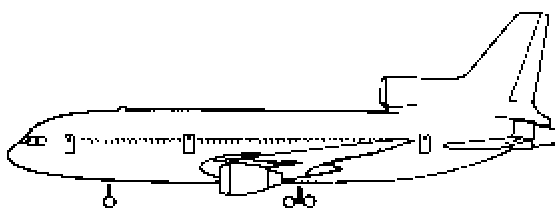
[2] For actual maximum height, see CRAF pallet profiles (Figure 2-23); a general planning height of 76 inches can be used.



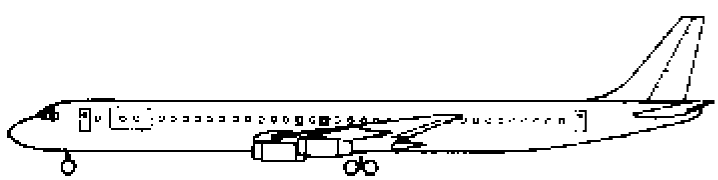
BOEING: B747



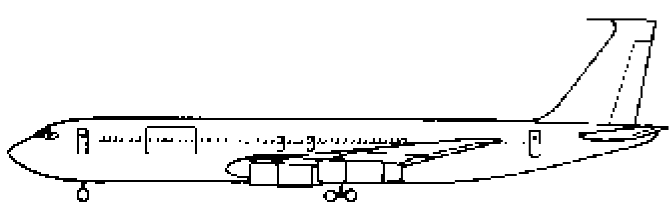
DOUGLAS: DC-10



LOCKHEED: L-1011



DOUGLAS: DC-8



BOEING: B707

Figure 2-22. CRAF aircraft profiles

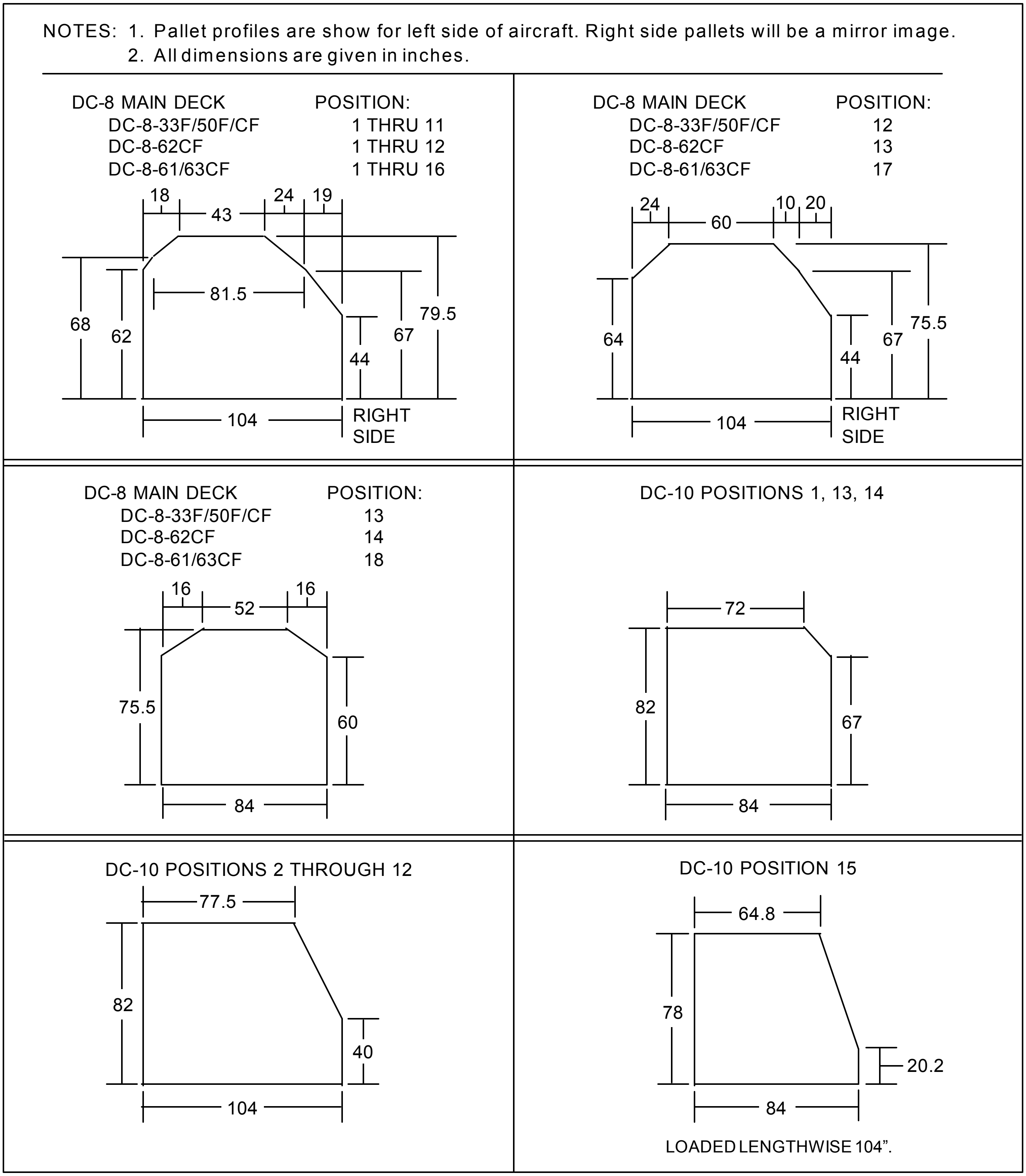


Figure 2-23. CRAF pallet profiles (measurement of pallet surface)

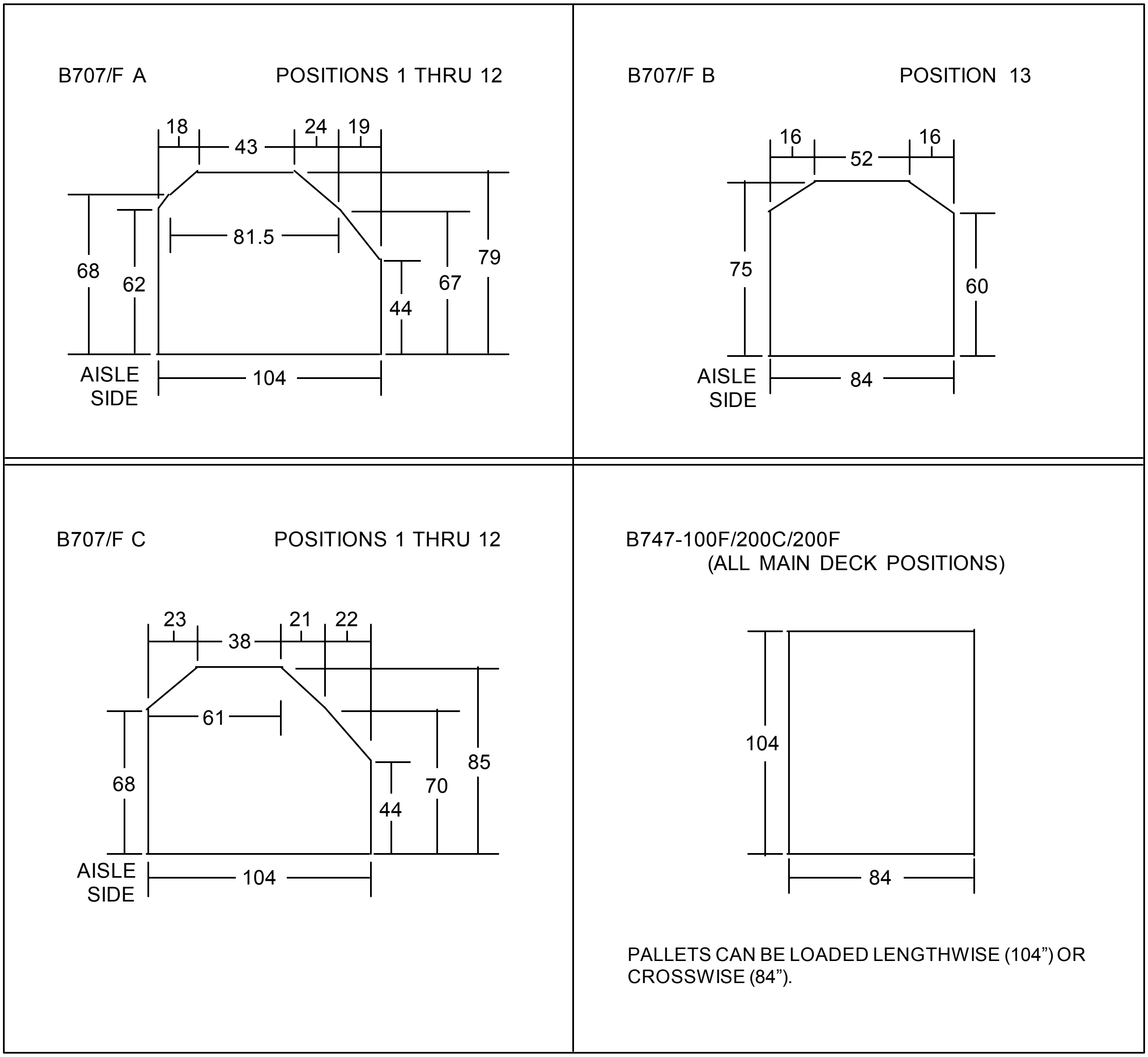


Figure 2-23. CRAF pallet profiles (measurement of pallet surface) (continued)

CHARACTERISTICS OF STANDARD ARMY AIRCRAFT

Tables 2-10 through 2-16, pages 2-37 through 2-44, give data on standard Army aircraft. Tables 2-10 and 2-11, pages 2-37 and 2-39, give capabilities and dimensions for fixed-wing aircraft. Tables 2-12 and 2-13, pages 2-41 and 2-42, give the same data for rotary-wing aircraft. Tables 2-14 through 2-16, pages 2-43 through 2-44, list speed and range factors, preparation times, and sortie capacities. Figure 2-24, page 2-44, shows profiles of Army aircraft.

Table 2-10. Dimensions of Army fixed-wing aircraft
(U-1A, U-10A, and T-41B not included due to their low density)

	UNIT	C-12A	C-12C	C-12D	U-21A	U-21D	U-21F	U-21G
Fuselage length [1]	ft-in	43'10"	43'10"	43'10"	35'10"	35'10"	39'11"	35'10"
Blades								
Length unfolded	ft-in	NA	NA	NA	NA	NA	NA	NA
Length folded	ft-in	NA	NA	NA	NA	NA	NA	
Width folded	ft-in	NA	NA	NA	NA	NA	NA	NA
Tread width	ft-in	17'2"	17'2"	17'2"	12'9"	12'9"	13'0"	12'9"
Extreme height	ft-in	15'5"	15'5"	14'9"	14'2"	14'2"	15'4"	14'2"
Rotor diameter								
Main or fwd	ft-in	NA	NA	NA	NA	NA	NA	NA
Tail or rear	ft-in	NA	NA	NA	NA	NA	NA	NA
Wing span	ft-in	54'6"	54'6"	55'6.5"	45'11"	45'11"	45'11"	45'11"
Cargo door								
Width x height	in	27.7 x 51.5	27.7 x 51.5	52.0 x 52.0	50.5 x 53.0	50.5 x 53.0	17.0 x 51.7	50.5 x 53.0
Location vs fuselage	(left/right front/rear)	left rear	left rear	left rear	left	left	left	left
Cargo floor								
Hgt from ground	in	47"	47"	42"	48"	48"	45"	48"
Usable length	in	128"	128"	128"	110.5"	110.5"	11"	110.5"
Usable width	in	54"	43"	54"	55"	55"	54"	55"
Unobstructed hgt	in	57"	57"	57"	55"	55"	57"	55"
Max cgo space	cu ft	306.5	306.5	306.5	230	230	306	230

[1] Dimension from nose to end of tail.

Table 2-10. Dimensions of Army fixed-wing aircraft
(U-1A, U-10A, and T-41B not included due to their low density) (continued)

	UNIT	U-21H	RU-21A	RU-21B	RU-21C	RU-21D	RU-21H	RU-21J
Fuselage length [1]	ft-in	35'10"	35'10"	35'10"	35'10"	35'10"	35'10"	35'10"
Blades								
Length unfolded	ft-in	NA	NA	NA	NA	NA	NA	NA
Length folded	ft-in	NA	NA	NA	NA	NA	NA	NA
Width folded	ft-in	NA	NA	NA	NA	NA	NA	NA
Tread width	ft-in	12'9"	12'9"	12'9"	12'9"	12'9"	12'9"	12'9"
Extreme height	ft-in	14'2"	14'2"	14'2"	14'2"	14'2"	14'2"	14'2"
Rotor diameter								
Main or fwd	ft-in	NA	NA	NA	NA	NA	NA	NA
Tail or rear	ft-in	NA	NA	NA	NA	NA	NA	NA
Wing span	ft-in	50'11"	50'11"	45'11"	45'11"	45'11"	50'11"	55'6"
Cargo door								
Width x height	in	50.5 x 53.0	50.5 x 53.0	50.5 x 53.0	33.0 x 51.5	50.5 x 53.0	50.5x 53.0	50.5 x 53.0
Location vs fuselage	(left/right front/rear)	left	left	left	left	left	left	left
Cargo floor								
Hgt from ground	in	48"	48"	48"	48"	48"	48"	42"
Usable length	in	110.5"	110.5"	110.5"	110.51"	110.5"	110.5"	128"
Usable width	in	55"	55"	55"	55"	55"	55"	54"
Unobstructed hgt	in	55"	55"	55"	55"	55"	55"	57"
Max cgo space	cu ft	158	158	158	158	158	158	306.5

[1] Dimension from nose to end of tail.

Table 2-11. Capabilities of Army fixed-wing aircraft
(U-1A, U-10A, and T-41B not included due to their low density)

	UNIT	C-12A	C-12C	C-12D	U-21A	U-21D	U-21F	U-21G
Normal crew	per acft	2	2	2	2	2	2	2
Passenger cap								
Troop seats	ea	8	8	8	10	10	10	10
Normal cap	ea	8	8	8	6	6	7	6
Total w/crew	ea	10	10	10	12	12	12	12
Litters/ambt	ea	NA	NA	NA	3/3	3/3	3/3	3/3
Operational cap [1]								
Max auth gross wt	lb	12,500	12,500	12,500	9,500	9,500	11,568	9,650
Basic wt	lb	7,869	8,084	8,084	5,383	5,383	7,012	5,434
Useful load	lb	2,131	4,416	4,416	4,117	4,117	2,756	4,216
Normal payload	lb	2,000	2,000	2,000	2,000	2,000	1,800	2,000
Fuel cap [2]								
Internal	lb/gal	2,470/386	2,470/386	2,470/386	2,457/378	2,457/378	2,405/370	2,457/378
External	lb/gal	NA	NA	NA	NA	NA	NA	NA
Fuel usage [2]	lb/gal per hr	350/538	456/70	456/70	450/72	450/72	450/72	450/72
Normal cruise speed	knots	240	260	260	210	210	220	210
Endurance at cruise	hr + min	6 + 30	5 + 15	5 + 15	5 + 00	5 + 00	4 + 45	5 + 00
(+ 30 min reserve)		NA	NA	NA	NA	NA	NA	NA
Fuel grade	octane	JP4/5	JP4/5	FP4/5	JP4	JP4	JP4	JP4
External cargo								
Max auth load [3]		NA	NA	NA	NA	NA	NA	NA
Rescue hoist	lb		NA	NA	NA	NA	NA	NA
Cgo winch cap	lb	NA	NA	NA	NA	NA	NA	NA
Weapons type		NA	NA	NA	NA	NA	NA	NA

[1] All data was computed at standard conditions at sea level but is subject to change with developmental testing. Detailed weight computations and characteristics were taken from current 55-series TMs.

[2] Aviation gas was figured on 6 lb/gal JP4 computed on 6.5 lb/gal.

[3] The maximum load the aircraft is able to lift.

Table 2-11. Capabilities of Army fixed-wing aircraft
(U-1A, U-10A, and T-41B not included due to their low density) (continued)

	UNIT	U-21H	RU-21A	RU-21B	RU-21C	RU-21D	RU-21H	RU-21J
Normal crew	per acft	2	4 (2 pilots & 2 op)	4 (2 pilots & 2 op)	4 (2 pilots & 2 op)	4 (2 pilots & 2 op)	4 (2 pilots & 2 op)	4 (2 pilots & 2 op)
Passenger cap								
Troop seats	ea	10	NA	NA	NA	NA	NA	NA
Normal cap	ea	6	NA	NA	NA	NA	NA	NA
Total w/crew	ea	12	4	5	4	4	4	4
Litters/ambt	ea	3113	NA	NA	NA	NA	NA	NA
Operational cap [1]								
Max auth gross wt	lb	9,650	10,200	10,900	10,900	9,650	10,200	12,500
Basic wt	lb	5,434	5,450	5,945	5,945	7,170	6,814	8,084
Useful load	lb	4,216	4,750	4,945	4,945	2,480	3.386	4,416
Normal payload	lb	2,000	1,845	1,845	1,845	0	962	2,000
Fuel cap [2]								
Internal	lb/gal	2,457/378	2,405/370	2,574/396	2,574/396	2,405/370	2,405/370	2,470/386
External	lb/gal	NA	NA					
Fuel usage [2]	lb/gal per hr	450/72	580/89.2	580/39.2	580/89.2	580/89.2	580/89.2	456/70
Normal cruise speed	knots	210	205	205	205	205	205	260
Endurance at cruise	hr + min	5 + 00	3 + 45	5 + 00	4 + 15	3 + 45	3 + 45	5 + 15
(+ 30 min reserve)		NA	NA	NA	NA	NA	NA	NA
Fuel grade	octane	JP4	JP4/5	JP4/5	FP4/5	JP4/5	JP4/5	JP4/5
External cargo								
Max auth load [3]		NA	NA	NA	NA	NA	NA	NA
Rescue hoist	lb		NA	NA	NA	NA	NA	NA
Cgo winch cap	lb	NA	NA	NA	NA	NA	NA	NA
Weapons type		NA	NA	NA	NA	NA	NA	NA

[1] All data was computed at standard conditions at sea level but is subject to change with developmental testing. Detailed weight computations and characteristics were taken from current 55-series TMs.

[2] Aviation gas was figured on 6 lb/gal JP4 computed on 6.5 lb/gal.

[3] The maximum load the aircraft is able to lift.

Table 2-12. Dimensions of Army rotary-wing aircraft

	UNIT	CH-47D	UH-1C/M	UH-1D/H/V	UH-60
Fuselage length[1]	ft-in	51’0”	42’7”	40’7”	50’7.5”
Blades					
Length unfolded	ft-in	99’0”	52’10”	57’1”	64’10”
Length folded	ft-in	51’0”	NA	NA	40’4”
Width folded	ft-in	12’5”	NA	8’7”	9’8.1”
Tread width	ft-in	11’11”	8’7”	8’7”	9’8.1”
Extreme height	ft-in	24’5”	12’8”	14’6”	17’6”
Rotor diameter					
Main or fwd	ft-in	60’0”	44’0”	48’0”	44’0”
Tail or rear	ft in	60’0”	8’6”	8’6”	11’0”
Wing span	ft-in	NA	NA	NA	NA
Cargo door					
Width x height	in	90 x 78	48 x 48	74 x 48	68 x 54
Location vs fuselage	(left/right front/rear	rear	left and right	left and right	left and right
Cargo floor					
Hgt from ground	in	NA	22.5”	22.5”	31.2”
Usable length	in	NA	39”	39”	360”
Usable width	in	NA	50”	50”	90”
Unobstructed hgt	in	NA	50”	50”	78”
Max cargo space	cu ft	NA	20	20	1,474

[1] Dimensions from nose to end of tail.

Table 2-13. Capabilities of Army rotary-wing aircraft

	UNIT	OH58C	CH47D
Normal crew	per acfts	1 + (obs)	4
Passenger cap			
Troop seats	ea	4	33
Normal cap	ea	4	33
Total w/crew	ea	4	37
Litters/ambt	ea	2	24
Operational cap [1]			
Max auth gross wt	lb	3,200	50,000
Basic wt	lb	1,898	22,499
Useful load	lb	1,302	27,501
Normal payload	lb	837 [2]	20,206
Fuel cap [3]	lb/gal	465/71.5	6,695/1,030
Fuel usage [3]	lb/gal	175/27	2,600/400
Normal cruise speed	knots	120	145
Endurance at cruise (+30 min reserve)	hrs + min	3 + 00	2 + 30
Fuel grade	octane	JP4	JP4
External cargo			
Max auth load [4]	lb	NA	28,000
Rescue hoist cap	lb	NA	600
Cargo winch cap	lb	NA	3,000
Weapons type [5]		NA	M24

[1] All data computed at standard conditions at sea level, but subject to change with developmental testing. Detailed weight computations and characteristics taken from current 55-series TMs.

[2] Does not meet 200 NM range requirement of normal mission definition.

[3] JP4 was computed on 6.5 lb/gal.

[4] The maximum load the aircraft can lift.

[5] Type of weapons the aircraft can carry.

Table 2-14. Aircraft speed and range factors [1]

AIRCRAFT TYPE	AVERAGE CRUISE SPEED (KN) [2]	FERRY RANGE (NMS)
AH-1	141	381
AH-1S	130	338
CH-47B	114	1,090
CH-47C	111	1,226
CH-47D	136	1,070
CH-54B	100	226
OH-6A	102	330
OH-58	102	260
UH-IC/M	92	300
UH-IH/V	111	276
EH-1H/X	111	276
UH-60A	143	960
C-12A	222	1,177
U-8F	127	1,220
U-21A	180	1,249
OV-1C	200	1,081 [3]

[1] Source is FM 101-20; factors are for ferry mission configuration.
[2] True airspeed under no-wind conditions.
[3] With two 150-gallon external fuel tanks.

Table 2-15. Aircraft preparation times and sortie capacities for airlift [1]

TYPE AIRCRAFT LOADED	AF AIRCRAFT REQUIRED	DISASSEMBLY TIME PER AIRCRAFT		REASSEMBLY TIME PER AIRCRAFT		AIRLIFTED AIRCRAFT PER SORTIE
		Man-Hours	Elapsed Hours	Man-Hours	Elapsed Hours	
AH-LG	C-5	8	2	12	3	12
AH-IS [2]	C-5	8	2	12	2	6
CH-47	C-5	174	32	225	36	3
CH-54	C-5	180	16	225	36	3
OH-6A	C-5	6	3	6	3	26
	C-141A	6	3	6	3	6
	C-130	6	3	6	3	3
OH-58	C-5	1.5	0.5	2	1	13
	C-141A	7.5	1.5	10	3	4
UH-IC/D/H/M/V	C-5	12	3	18	5	8
EH-IH/X	C-5	12	3	18	5	8
UH-6OA [3]	C-5	9	1.5	9	1.5	6
	C-141A	9	1.5	9	1.5	2
UX-8/RU-8	C-5	16	4	32	8	4
U-21	C-5	16	4	32	8	4
OV-IB/C/D	C-5	305	38	750	94	3

[1] Data take n from FM 10 1-20 for minimum disassembly required for air shipment.
[2] AH-IS Cob ras are usually shipped with stub wings on due to excessive reassembly time and boresighting of the TOW system.
[3] UH-60A data taken from TM 55-1520-237-23-4.

Table 2-16. Aircraft preparation times and barge capacities for sealift [1]

AIRCRAFT TYPE	CREW MAN-HOURS	ELAPSED SIZE	HOURS	AIRLIFTED AIRCRAFT [2] SEABEE Barge	LASH Lighter
AH-1G[3]	6.0	3	2.0	144	8
AH-1S	6.0	3	2.0	6	5
CH-47[3]	18.0	6	3.0	Note 4	—
OH-6A[5]	6.0	3	2.0	27	15
OH-58[3]	4.0	3	1.5	14	8
UH-1	5.0	3	2.0	94	6
UH-60A[6]	9.0	6	1.5	6	4
U-2IA[7]	16.0	4	4.0	4	—

[1] Based on minimum disassembly. Preparation times include disassembly, preservation, and crating, as required. Times are rounded off to the next higher 0.5 hours (MTMC Report 74-19).

[2] TM 55-1520-400-14.

[3] MTMC Report 74-19.

[4] SEABEE has capability of loading the following numbers of aircraft on the lower deck if 12 barges are displaced: 48 CH-47s, 3 AH-1GS, 19 UH-lHs.

[5] Estimated by MTMCTEA from TM 55-1520-214-5 and FM 101-20.

[6] Estimate based on information in TM 55-1520-237-23-2 and TM 55-1520-237-23-4.

[7] Estimated by MTMCTEA from TM 55-1500-200-5 and FM 101-20.

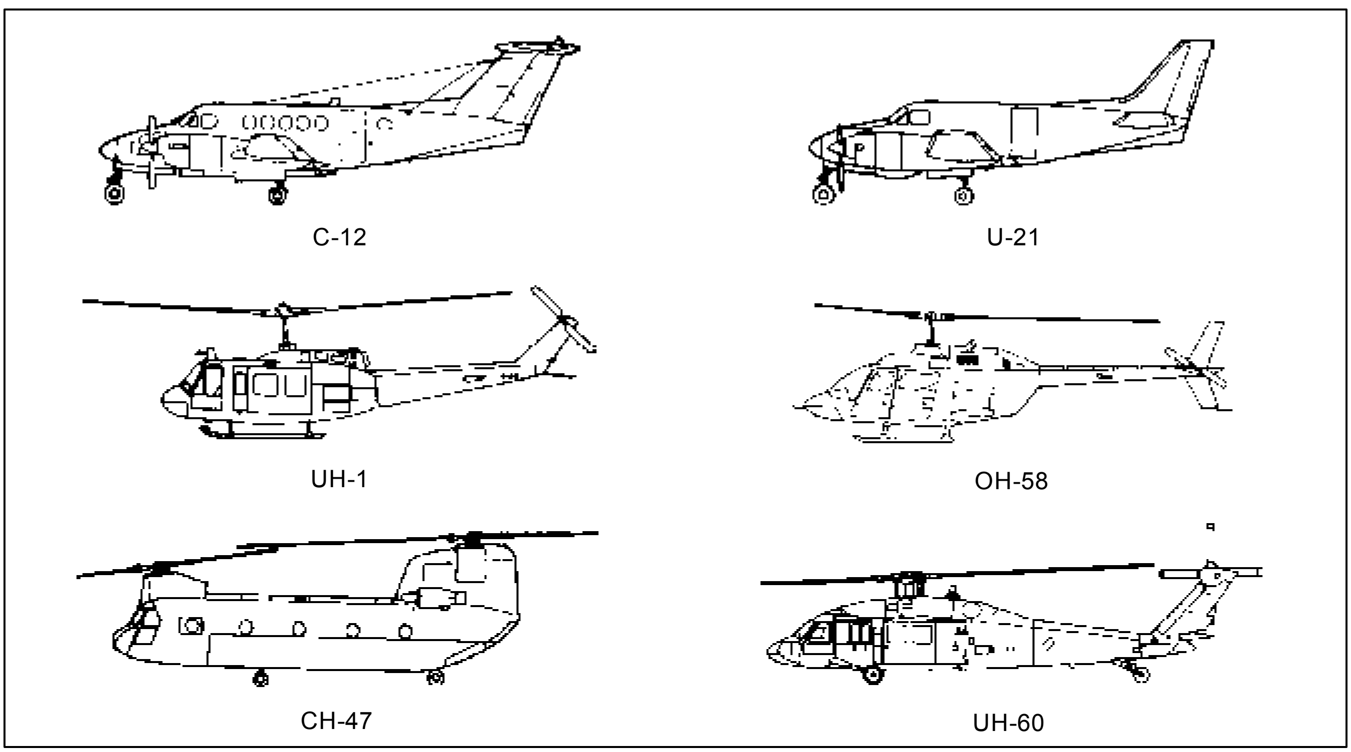


Figure 2-24. Profiles of Army aircraft

Section IV
RESTRAINT CRITERIA

DETERMINING THE CENTER OF GRAVITY

To determine the CG location of a loaded aircraft, you must first know the weight of the aircraft ready for loading, then calculate the weight times the arm to determine the moment.

Arm = the horizontal distance in inches from the reference datum line to the center of gravity of an object.

Moment = the product of the weight of an item multiplied by its arm. Moment may be expressed in pounds-inches; for example, 2 pounds (weight) x 10 inches (arm) = 20 pounds-inches (moment).

The procedures for computing the center of gravity of a loaded aircraft are as follows:

- Calculate for moment. Weight times are = moment.
- List aircraft ready-for-loading weight times the ready-for-loading CG = moment.
- List weight times the arm of each cargo item = moment.
- Add all the weights and enter the total.
- Add all the moments and enter the total.
- Divide the total moments by the total weight; round off any decimals.

This number is the station number at which the aircraft is balanced. If the number does not fall within the safe flight limits, the load or a part of it must be relocated and the aircraft balance recomputed.

Sample Problem (C-141 aircraft)

The C-141 aircraft is loaded with three M35, 2 1/2-ton trucks, each weighing 13,700 pounds, and six passengers (1,800 pounds). All trucks are positioned facing the rear of the aircraft with the CG of truck 1 at station 630, the CG of truck 2 at station 920; the CG of truck 3 at station 1200; and the CG of the six passengers at station 930. The weight of the aircraft ready for loading is 271,000 pounds, with its CG at station 915.

- Weight x arm = moment
- Weight of aircraft ready for loading x CG of aircraft ready for loading
- Weight of one truck x station 630
- Weight of one truck x station 920
- Weight of one truck x station 1200
- Weight of passengers x station 930

271,000	x	915	=	247,965,000
13,700	x	630	=	8,631,000
13,700	x	920	=	12,604,000
13,700	x	1200	=	16,440,000
1,800	x	930	=	1,674,000
313,900 (total weight)				287,314,000 (total moment)

$$\frac{\text{Total moment}}{\text{Total weight}} = \frac{287{,}314{,}000}{313{,}900} = 915.3 \text{ or } 915$$

Station 915 is the CG of the loaded aircraft. The CG limits safe for flight for the C-141 are 906.7 to 948. The aircraft balanced at station 915 is safe for flight.

SECURING CARGO

Tie-down devices secure cargo against forward, rearward, lateral, and vertical movement during takeoff, flight, and landing. To determine the number of devices needed to safely secure any given item of cargo, it is necessary to know the weight of the cargo, restraint criteria for the aircraft, strength of the tie-down devices and fittings, and angles of tie to be used.

Restraint Factors

Restraint factors vary for different aircraft. They are influenced by acceleration during takeoff, stability during flight, deceleration during landing, and the type of landing field (improved or unimproved) for which the aircraft is designed.

Tie-Downs

The effective holding strength of a device (or fitting) is determined by the rated strength of the item and manner in which it is employed. Anchor all tie-downs to a tie-down fitting. The fitting must be as strong as the tie-down. If a tie-down is stressed to its breaking point, the fitting is stressed an equal amount up to the full rated strength of the tie-down. Figure 2-25, page 2-47, shows a typical tie-down correct pull-off.

Number required. There is one basic formula for figuring the restraint for an item of cargo:

WT	=	Weight of cargo
R(g's)	=	Restraint required (g's)
RSD	=	Rated strength of device
% of	=	Percent of angle of tie-down
FTBR	=	Force to be restrained
EHSD	=	Effective holding strength of device

$$\frac{\text{WT} \times \text{R(g's)}}{\text{RSD} \times \text{\% of}} = \frac{\text{FTBR}}{\text{EHSD}} = \text{Total number of devices required}$$

Example:

WT	=	1,000 pounds
R(g's)	=	4
RSD	=	5,000 pounds
% of	=	74.9
FTBR	=	4,000 pounds
EHSD	=	3,745

$$\frac{1{,}000 \times 4}{5{,}000 \times 74.9} = \frac{4{,}000}{3{,}745} = 2 \text{ devices}$$

The weight of the cargo times the restraint force of g's equals the force to be restrained. The rated strength of the tie-down devices times the percent of angle of tie equals the effective holding strength of the tie-down. Use tie-down devices in pairs. If the total number of tie-downs is an uneven number of a decimal, it should be rounded off to the next higher even number.

If the cargo's weight is not marked on a particular item, refer to TB 55-46-1 for its weight and dimensions. The g forces for each direction are found in the applicable aircraft -10 manual. The rated strength of each device is given in Chapter 3 of this manual.

Angle. The percentage of the angle of tie-down is in relation to where the load is tied in the aircraft. See Figures 2-26 and 2-27, page 2-47, for examples of where to figure the angles. For a 30/30 angle of tie, measure from B to C (Figure 2-26) and go one and two-thirds of CB to A; then split the corner angle of DE. For a 45-degree angle, measure one length from B to C, one length to A, then right or left one length.

The recommended angle of tie is the 30/30 angle, as this is the best compromise of tie-down device-holding strength and angle. This tie-down is effective up to 75 percent of its rated strength forward (or aft) to 50 percent vertically and to about 43 percent lateral. Tie-downs secured at a 45-degree angle to the cargo floor and in line with the expected thrust will hold approximately 70 percent of their rated strength against forward, aft, or vertical movements. Tie-downs secured in this manner will hold against movement in two directions. Tie-downs secured at a 45-degree angle to the longitudinal axis of the aircraft prevent cargo movement in three directions: forward (or aft), vertical, and lateral.

These tie-downs will hold about 50 percent of their rated strength against forward (or aft) and lateral movements and 70 percent of their rated strength against vertical movements. To calculate the percentage of angle of tie-down, see Figure 2-28, page 2-48.

Angles across the top are those formed between the tie-down device and the cabin floor. Angles down the side are those formed between the tie-down devices and the longitudinal axis of the aircraft. Vertical restraint is related only to the angle between the tie-down device and the cabin floor. The lateral angle has no bearing on it. The unshaded area indicates the "best compromise" position.

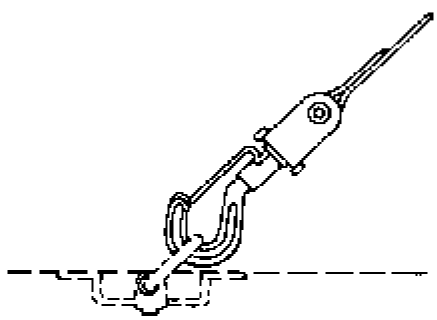


Figure 2-25. Correct pull-off

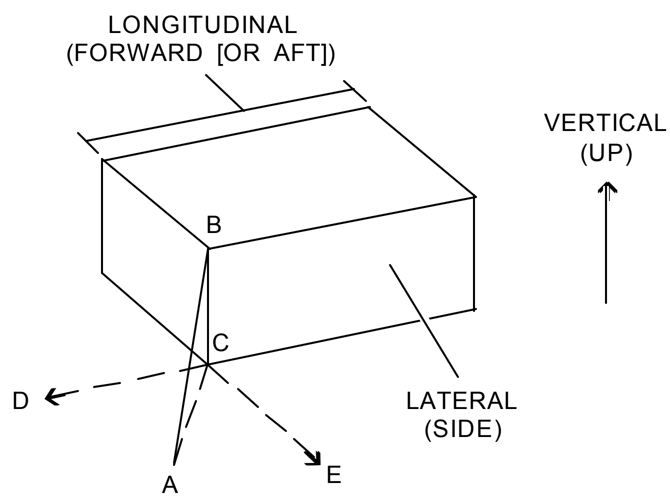


Figure 2-26. Longitudinal angle of tie-down

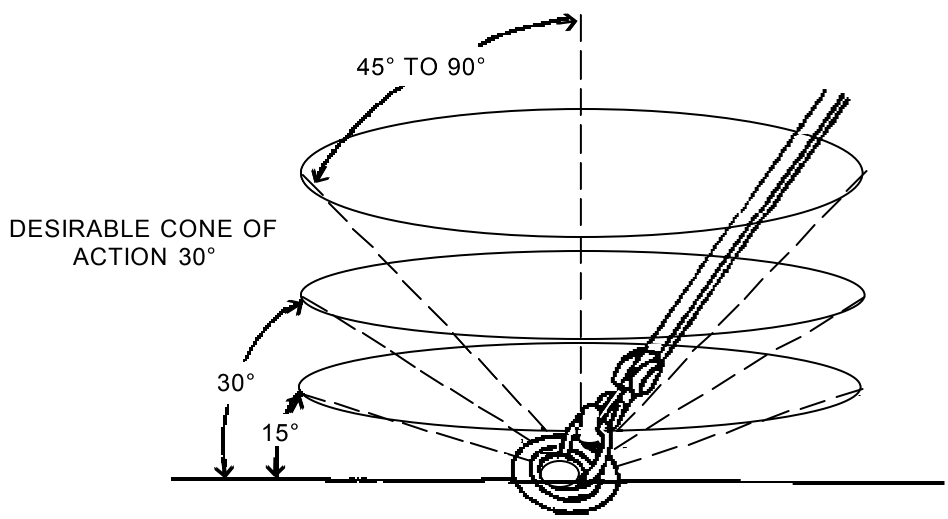


Figure 2-27. Vertical angle of tie-down

		5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°
	VERTI-CAL	8.7	17.4	25.9	34.2	42.3	50.0	57.4	64.3	70.7	76.6	81.9	86.6	90.6	93.9	96.6	98.5
5°	LONG	99.2	98.1	96.2	93.6	90.2	86.3	81.6	76.3	70.4	64.0	57.2	49.8	42.1	34.1	25.8	17.3
	LAT	8.7	8.6	8.4	8.2	7.9	7.5	7.1	6.7	6.2	5.6	4.9	4.4	3.7	2.9	2.3	1.5
10°	LONG	98.1	97.0	95.2	92.6	89.2	85.3	80.7	75.5	69.9	63.3	56.5	49.3	41.7	33.7	25.5	17.1
	LAT	17.3	17.1	16.8	16.6	15.8	15.1	14.3	13.3	12.3	11.2	9.9	8.7	7.4	5.9	4.5	3.0
15°	LONG	96.2	95.2	93.3	90.8	87.5	83.7	79.1	73.9	68.3	62.1	55.4	48.3	40.9	33.0	25.0	16.8
	LAT	25.8	25.5	25.0	24.3	23.5	22.4	21.2	19.8	18.3	16.7	14.9	12.9	10.9	8.9	6.7	4.5
20°	LONG	93.6	92.6	90.8	88.4	85.2	81.4	76.9	72.0	66.5	60.4	53.9	47.0	39.8	32.1	24.3	16.6
	LAT	34.1	33.7	33.0	32.1	30.9	29.6	28.0	26.2	24.2	21.9	19.6	17.1	14.5	11.7	8.9	5.9
25°	LONG	90.2	89.2	87.5	85.2	82.1	78.5	74.2	69.4	64.1	58.3	52.0	45.3	38.3	30.9	23.5	15.8
	LAT	42.1	41.7	40.9	39.8	38.3	36.6	34.6	32.4	29.9	27.2	24.3	21.2	17.9	14.5	10.9	7.4
30°	LONG	86.3	85.3	83.7	81.4	78.5	74.9	70.9	66.3	61.2	55.7	49.7	43.3	36.6	29.6	22.4	15.1
	LAT	49.8	49.3	48.3	47.0	45.3	43.3	40.9	38.3	35.4	32.2	28.7	25.0	21.2	17.1	12.9	8.7
35°	LONG	81.6	80.7	79.1	76.9	74.2	70.9	67.1	62.7	57.9	52.7	47.0	40.9	34.6	28.0	21.2	14.3
	LAT	57.2	56.5	55.4	53.9	52.0	49.7	47.0	43.9	40.6	36.9	32.9	28.7	24.3	19.6	14.9	9.9
40°	LONG	76.3	75.5	73.9	72.0	69.4	66.3	62.7	58.7	54.2	49.3	43.9	38.3	32.4	26.2	19.8	13.3
	LAT	64.0	63.3	62.1	60.4	58.3	55.7	52.7	49.3	45.5	41.3	36.9	32.2	27.2	21.9	16.7	11.2
45°	LONG	70.4	69.6	68.3	66.5	64.1	61.2	57.9	54.2	49.9	45.5	40.6	35.4	29.9	24.2	18.3	12.3
	LAT	70.4	69.6	68.3	66.5	64.1	61.2	57.9	54.2	49.9	45.5	40.6	35.4	29.9	24.2	18.3	12.3
50°	LONG	64.0	63.3	62.1	60.4	58.3	55.7	52.7	49.3	45.5	41.3	36.9	32.2	27.2	21.9	16.7	11.2
	LAT	76.3	75.5	73.9	72.0	69.4	66.3	62.7	58.7	54.2	49.3	43.9	38.3	32.4	26.2	19.8	13.3
55°	LONG	57.2	56.5	55.4	53.9	52.0	49.7	47.0	43.9	40.6	36.9	32.9	28.7	24.3	19.6	14.9	9.9
	LAT	81.6	80.7	79.1	76.9	74.2	70.9	67.1	62.7	57.9	52.7	47.0	40.9	34.6	28.0	21.2	14.3
60°	LONG	49.8	49.3	48.3	47.0	45.3	43.3	40.9	38.3	35.4	32.2	28.7	25.0	21.2	17.1	12.9	8.7
	LAT	86.3	85.3	83.7	81.4	78.5	74.9	70.9	66.3	61.2	55.7	49.7	43.3	36.6	29.6	22.4	15.1
65°	LONG	42.1	41.7	40.9	39.8	38.3	36.6	34.6	32.4	29.9	27.2	24.3	21.2	17.9	14.5	10.9	7.4
	LAT	90.2	89.2	87.5	85.2	82.1	78.5	74.2	69.4	64.1	58.3	52.0	45.3	38.3	30.9	23.5	15.8
70°	LONG	34.1	33.7	33.0	32.1	30.9	29.6	28.0	26.2	24.2	21.9	19.6	17.1	14.5	11.7	8.9	5.9
	LAT	93.6	92.6	90.8	88.4	85.2	81.4	76.9	72.0	66.5	60.4	53.9	47.0	39.8	32.1	24.3	16.6
75°	LONG	25.8	25.5	25.0	24.3	23.5	22.4	21.2	19.8	18.3	16.7	14.9	12.9	10.9	8.9	6.7	4.5
	LAT	96.2	95.2	93.3	90.8	87.5	83.7	79.1	73.9	68.3	62.1	55.4	48.3	40.9	33.0	25.0	16.8
80°	LONG	17.3	17.1	16.8	16.6	15.8	15.1	14.3	13.3	12.3	11.2	9.9	8.7	7.4	5.9	4.5	3.0
	LAT	98.1	97.0	95.2	92.6	89.2	85.3	80.7	75.5	69.6	63.3	56.5	49.3	41.7	33.7	25.5	17.1

Figure 2-28. Percentage restraint chart

Section V
AIRDROP

DELIVERY OPERATIONS

Airdrop is a method of delivering supplies and equipment from an aircraft to ground elements. As a rule, airdrop is a joint effort between Army and Air Force elements. Air Force aircraft transport items to the target area and airdrop them. Both Air Force and Army personnel support operations on the ground.

The Army is responsible for providing air-dropped supplies and equipment and airdrop equipment and ground vehicles used in recovering the items. Army divisions and separate brigades possess varying capabilities to support airdrop operations. Normally, airborne or air assault divisions have organic equipment support elements. Armored, infantry, mechanized divisions, and separate brigades require support from corps or theater air delivery units.

Advantages

There are many advantages to airdrop delivery. Supplies and equipment can be delivered directly to units, to otherwise unreachable areas, behind enemy lines, or to special operations units. Airdrop takes less handling and shipping time and reduces exposure of the aircraft to enemy fire. Also, items programmed for emergencies can be prerigged and stored.

Airdrop reduces the need for forward airfields or LZs, congestion during airfield off-loading, and MHE requirements. Airdrop increases aircraft availability and allows greater dispersion of forces.

Disadvantages

Disadvantages to the airdrop method of delivery include the need for specially trained personnel and appropriate airlift aircraft. Each aircraft's capacity and range determine the amount of cargo and number of personnel an aircraft can deliver. Other factors affect the performance of the aircraft, including bad weather and high wind. Helicopters are vulnerable to enemy aircraft and ground fire. Drop zones must be secured to keep items from falling into enemy hands. They require special preparation for LAPES. Also, the bulkiness and weight of equipment rigged for airdrop affect how much an aircraft can carry. Lastly, there is the possibility of loss or damage to equipment.

TYPES OF AIRDROP

Four types of airdrop are used: freedrop, high-velocity, low-velocity, and halo. Factors considered in selecting the appropriate method include threat, type of material to be airdropped, and circumstances of the operation.

Freedrop

No parachute or retarding device is used for freedrop. Energy-dissipating material can be used around the load to ease the shock when the load hits the ground. The load descends at a rate of 130 to 150 feet per second. Fortification or barrier material, clothing in bales, and other such items may be free-dropped.

High-Velocity

Ring-slot cargo, cargo-extraction, and pilot parachutes are used to stabilize loads for high-velocity airdrop. During the decent, the parachute has enough drag to hold the load upright at 70 to 90 feet per second. Items to be air-dropped are placed on energy-dissipating material and rigged in an airdrop container. Subsistence, packaged POL products, ammunition, and other such items may be high-velocity air-dropped.

Low-Velocity

Cargo parachutes are used for low-velocity airdrop. Items are rigged on an airdrop platform or in an airdrop container. Energy-dissipating material is put beneath the load to ease the shock of the load hitting the ground. Cargo parachutes attached to the load reduce the rate of descent to no more than 28 feet per second. Fragile material, vehicles, and artillery may be low-velocity air-dropped.

Halo

The halo is used to air-drop supplies and equipment at high altitudes when aircraft must fly above the threat umbrella. The rigged load is pulled from the aircraft by a stabilizing parachute and free-falls to a low altitude. A cargo parachute then opens to allow a low-velocity landing.

RELEASE METHODS

Loads to be air-dropped may be released by either the extraction, door load, or gravity method.

Extraction

The load and the platform on which it is rigged are pulled from the cargo compartment by an extraction parachute.

Door Load

The load is pushed or skidded out through the paratroop door.

Gravity

The aircraft is flown in a nose-up attitude. The restraint holding the load inside the aircraft is released, and the load rolls out of the cargo compartment.

LOW ALTITUDE PARACHUTE EXTRACTION SYSTEM

LAPES is a method of delivery that uses ring-slotted extraction parachutes to extract palletized loads from low-flying airlift aircraft. It is used to air-drop supplies and equipment from an aircraft flying about 5 to 10 feet above the ground. Energy-dissipating material is put under the load, and the load is rigged on a LAPES airdrop platform. Webbing and load binders hold the load to the platform. The rigged load is pulled from the aircraft by extraction parachutes, which also help slow the platform and load as it slides across the DZ. An airfield or DZ may require special preparation for a LAPES delivery. Vehicles, artillery, ammunition, supplies, equipment, and water may be delivered by LAPES. See Table 2-17 for weight limitations.

Concept of Employment

The LAPES may be the preferred method of delivering supplies or equipment under the conditions specified in this section.

Adverse weather conditions. LAPES should be used when surface or altitude winds exceed drop limitations or ceilings are low and preclude airdrop of equipment in visual meteorological conditions.

Table 2-17. Weight limitations for cargo parachute and aerial delivery container

PARACHUTE	*SUSPENDED WEIGHT IN POUNDS Minimum	Maximum
G-11A	2,270	4,250
G-11B	2,270	5,000
G-12C	501	2,200
G-12D	501	2,200
G-12E	501	2,200
G-13	200	500
T-7A	100	500
CONTAINER	**MAXIMUM WEIGHT (16)**	
A-7A	500	
A-21	500	
A-22	2,200	

* Suspended weight is the total rigged weight less the weight of the cargo parachutes and their riser extensions.

Surface conditions. LAPES should be used in restricted terrain where accuracy is required because of cliffs, mountains, ravines, or other obstacles or when an airfield or assault LZ has been cratered and adequate repair equipment is not available.

Tactical conditions. LAPES should be used when enemy air defense capabilities pose an unacceptable threat to aircraft at normal drop altitudes. Other instances where the use of LAPES may be advisable include:

- When hostile ground fire would pose a threat to an aircraft on the ground.
- When reduced aircraft radar signature is required.
- During clandestine resupply operations, where large loads and increased accuracy are required.

Extraction Zone

Selecting the proper site for an EZ depends on a number of conditions. To ensure safe operation, use specific standards in physically locating and marking an EZ. AMCR 3-3 describes appropriate criteria.

GROUND-AIR EMERGENCY SYMBOLS

The symbols shown in Figure 2-29 can be made with strips of fabric or parachute, pieces of wood or stone, or by tracking in the snow. To be clearly visible from the air, the symbols should be 8 feet or more in length and 10 feet apart. They should also contrast significantly with the background.

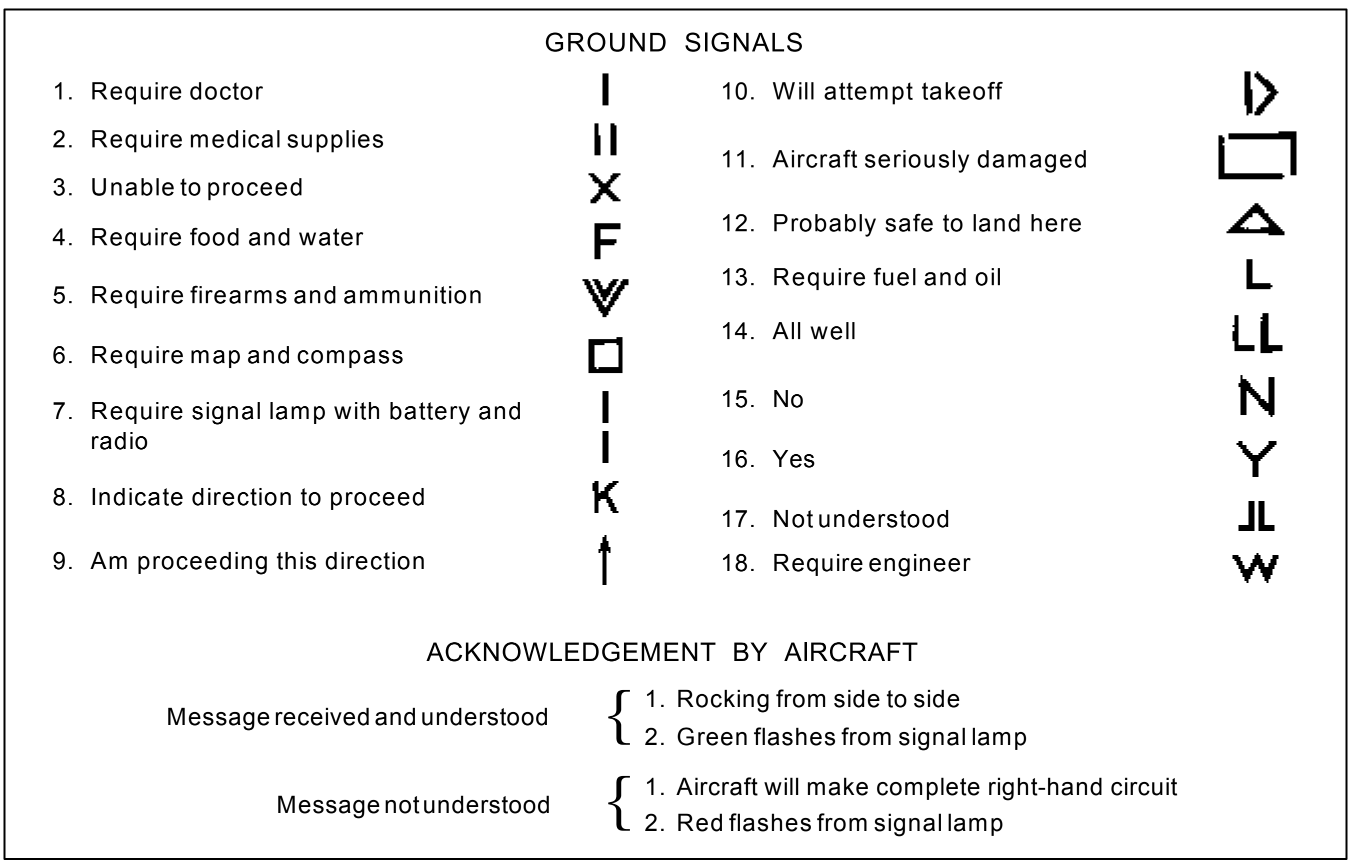


Figure 2-29. Ground-air emergency symbols