Go to Table of Contents

MTMCTEA Pamphlet 70-1

Transportability for Better Deployability

Go to Table of Contents

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TRANSPORTABILITY FOR BETTER DEPLOYABILITY

September 1999*

MILITARY TRAFFIC MANAGEMENT COMMAND
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NEWPORT NEWS, VA 23606

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Table of Contents

Chapter

Go to Table of Contents

Introduction

Properly applied transportability engineering is essential to the deployment of military equipment. An item of equipment is of little value if it cannot be transported rapidly and efficiently to where it is needed. This publication is a guide to transportability. It is intended for everyone interested in transportability: decision makers, materiel developers, combat developers, equipment designers and users, logisticians, and transporters. It is not designed to make you an instant transportability expert, but to help you understand the Engineering for Transportability program and the various transport modes. Transportability criteria are given in Interface Standard **MIL-STD-1366**. This publication covers the following areas of transportability and deployability:

Transportability Definition

This pamphlet provides insight into the Engineering for Transportability program, transport modes and limitations, and the definition of a transportability problem item. It will answer the following questions:

What is transportability?
Why is it important?
What are the limits and restrictions of the transportation infrastructure and assets?
What qualifies as a transportability problem item?

Transportability In Acquisition

This pamphlet explains how transportability fits into the materiel acquisition cycle. It will answer the following questions:

When should MTMCTEA become involved in a program?
How should transportability requirements be determined and how are they written?
What is transportability approval and how is it obtained?
How can modeling and simulation be used during acquisition?
What types of tests are required?

Deployability

This pamphlet will explain how new or modified equipment can affect force deployability.

Transportability Lessons Learned

This pamphlet shows some examples of lessons learned from past deployments and exercises.

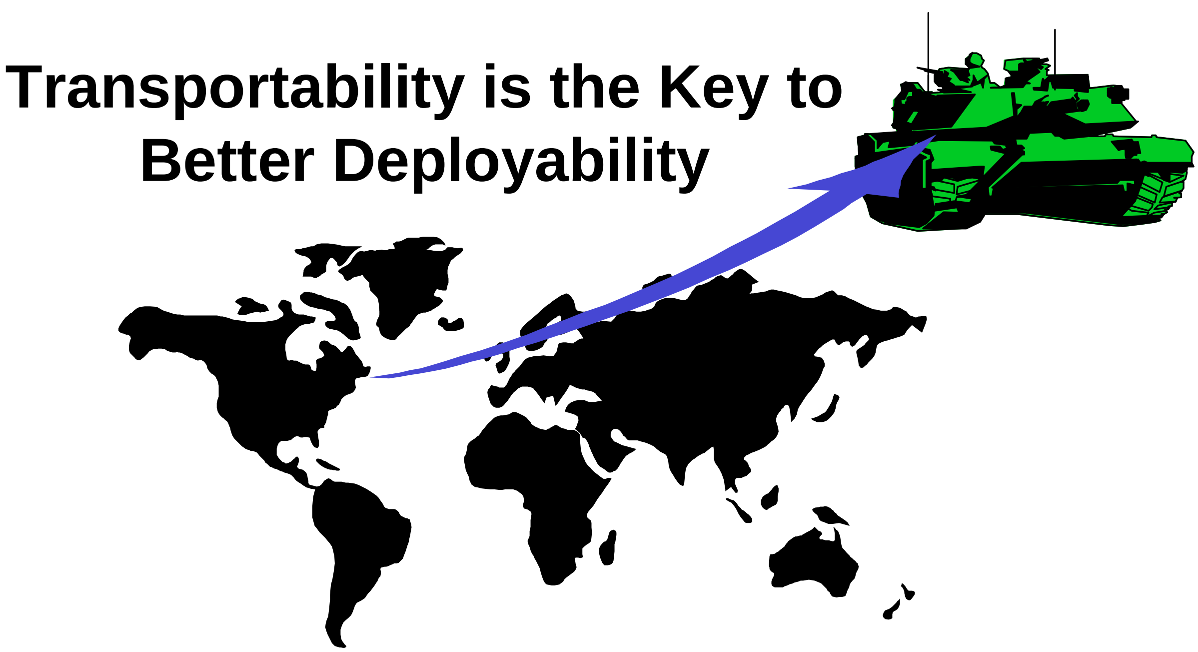
Go to Table of Contents

1 Background

Transportability and Deployability Questions

What is it?

Transportability is the inherent capability of military materiel and units to be moved efficiently by existing or planned transportation assets. Deployability is the capability of the force, people and equipment, to be moved within CONUS, intertheater and intratheater to support a given military operation. Deployability depends on the interplay among transportability, the available transportation equipment, and the supporting infrastructure: installations; world wide road, rail, waterway and air networks; air and sea terminals and other transshipment points.



Go to Table of Contents

Why do it?

The end of the Cold War and the retraction of most U.S. military power to the CONUS base have enormously increased the scale and complexity of force projection. Our forces once manned positions at a handful of flash points around the world, with massive forward deployed units ready to counter attacks by a small number of aggressor states in well developed theaters. Today, we have relatively sparse tripwire forces in scattered danger points, with the vast preponderance of our power concentrated at home in CONUS. The threats are asymmetric, and the probable battlefields lie in areas surrounded by rugged terrain and served by fragile transportation infrastructure. Reaching the battle, and arriving within the highly compressed time frames required to achieve decisive combat success, is a major technical and operational challenge. It is often necessary to balance combat effectiveness against transportability. Materiel developers and force designers are fully aware that the most sophisticated and capable weapon system is useless if it cannot be moved swiftly to its place of business, and that minimizing the total force movement requirement, the logistical footprint, is vital to effective force projection. The requirement to ensure transportability is therefore imposed by policy and regulation: it is crucial to the Nation's capability to respond and survive in a historically unique period of uncertainty and danger.

Who does it?

Every official involved in the development, procurement and acquisition of military hardware must consider transportability and deployability as essential features. Project managers are key players.

When is it done?

Transportability engineering begins by concept exploration or earlier, and continues throughout the procurement cycle. The modes of transportation required for the item and the impact of transportability on total force deployability should be determined by the "Approval to Conduct Concept Studies" acquisition milestone. Transportability characteristics of developmental items must be forwarded to MTMCTEA no later than 90 days prior to each milestone.

Where are the directives and guidance?

AR 70-1, *Army Acquisition Policy* and **AR 70-44/OPNAVINST 4600.22B/AFR 80-18/MC) 4610.14C/DLAR 4500.25**, *DOD Engineering for Transportability*, establish the DOD Engineering for Transportability program. **AR 70-47**, *Engineering for Transportability*, supplements **AR 70-44**. **AR 70-44** is under revision and will replace **ARs 70-44** and **70-47**. Henceforth, in this publication we will use **AR 70-44/47** to designate the current and revised versions of these documents. **MIL-STD-1366**, *Interface Standard for Transportability Criteria*, lists criteria for all modes of transport.

Go to Table of Contents

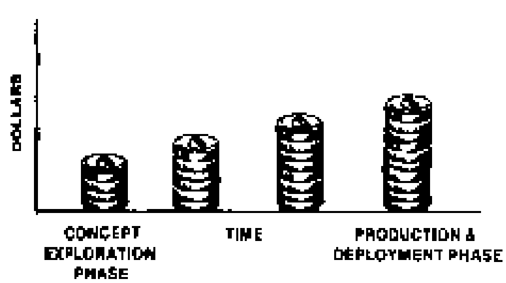
How does transportability analysis influence design?

Transportability is both an Integrated Logistic Support (ILS) element and a design element. The influence of transportability analysis on the design is greatest, and most effective, at the beginning of the acquisition cycle, because the costs for design changes are minimal during conceptual design. Once the conceptual design is converted to hardware, modification costs increase dramatically. The design engineer should therefore incorporate transportability elements into the item design as early in the cycle as possible.

Equipment items normally enter the inventory with a train of associated support items. The transportability of all these items must also be planned for as early as possible. Early coordination with MTMCTEA transportability engineers is the best way to ensure that the equipment and its associated support items will meet their deployability requirements.

Showing that a proposed weapon system can improve the deployability of the mission force is a powerful justification for proceeding with development and fielding. Transportability considerations are therefore crucial in advanced technology demonstrations and conceptual studies, where tomorrow's military power is first sketched and shaped. The lives of our soldiers and our Nation's success on future battlefields demand no less.

COST OF CHANGE TO MEET TRANSPORTABILITY REQUIREMENTS



Go to Table of Contents

2 Modes and Limitations

Transportability is the inherent capability of materiel and units to be moved efficiently by existing or planned transportation assets. This chapter provides insight into the transport modes and assets. It also includes a discussion of transport limitations and their impacts.

Air (Fixed Wing)

Air transport by fixed wing aircraft is the most important transport mode in terms of rapid strategic mobility. This mode has the greatest demand and the most limited assets. The need for equipment to be transportable by the C-130 and C-141, in addition to the larger C-5 and C-17, cannot be overemphasized.

Air transport has definite cargo size and weight limitations that must be met in the design and acquisition of military equipment. To ensure worldwide strategic transport, an aircraft range of 3,200 nautical miles is required. The fixed wing aircraft available for transporting military equipment are the U.S. Air Force C-130, C-141, C-17, and C-5 and the Civil Reserve Air Fleet (CRAF). All of these aircraft except the C-141 are expected to remain in service until well into the 21st century. The USAF plans to retire all C-141s by 2006. The data in this section are general. Specific requirements are in **MIL-HDBK-1791**, *Designing for Internal Aerial Delivery in Fixed Wing Aircraft* and **MIL-STD-1366**, *Interface Standard for Transportability Criteria*.

C-130

Go to Table of Contents

The C-130, a four-engine, high-wing aircraft, is used mainly as a tactical, intratheater aircraft. It is not intended for use as a long-haul aircraft to strategically deploy military equipment. It is not capable of air refueling. The C-130 is loaded through an aft cargo door.

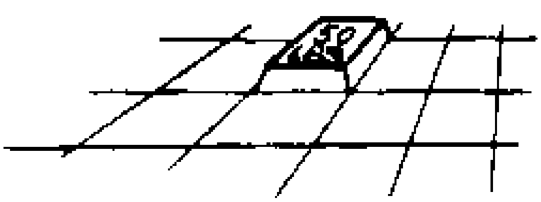
The dimensional design limits for the C-130 cargo compartment are:

Height: 102 inches
Width: 107 inches
Length: 480 inches

The item length must allow space for restraint to the aircraft deck. These design limits allow for 6 inches of safety clearance between the equipment being loaded and the aircraft ceiling and sidewalls.

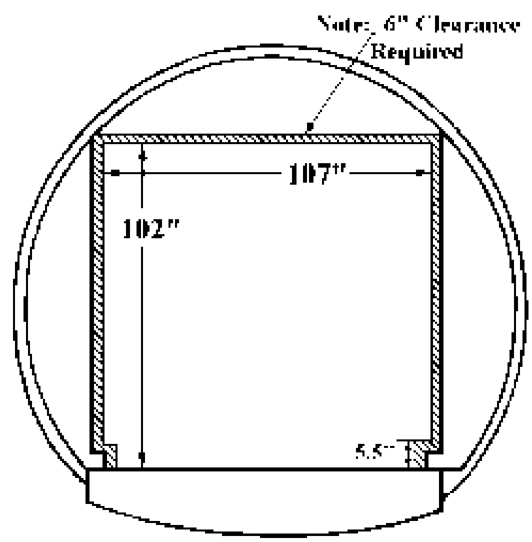
The C-130 has a permanently installed rail system that limits the available floor width. To a height of 5.5 inches, the width is 105 inches. Because of this, the practical maximum floor widths for roll-on/roll-off operations of wheeled and tracked vehicles are 102 and 100 inches, respectively. For tracked vehicles with a track contact length exceeding 110 inches, a track width no greater than 98 inches may be required to prevent interference with the permanently mounted rail system.

The maximum concentrated load for bulk cargo on the floor of a C-130 is 50 pounds per square inch (psi).



While the maximum payload for the C-130 is 42,000 pounds, the aircraft range is severely limited. Payload is also limited when operating from unimproved airfields or when refueling at the delivery point is not available. The C-130 must carry sufficient fuel to reach a recovery airfield, so the delivery range is reduced.

An adequate safety aisle is required so that, during flight, the aircraft loadmaster can move from the forward to the aft end of the cargo compartment. Safety aisle dimensions should be 14 inches wide by 72 inches high or 30 inches wide by 48 inches high (includes 6 inch safety clearance).

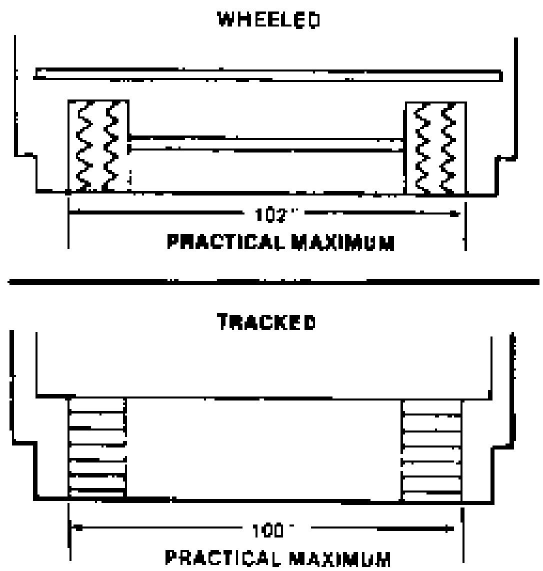


ALL VEHICLES THAT REQUIRE C-130 TRANSPORT MUST BE CAPABLE OF ROLL-ON/ROLL-OFF LOADING AND UNLOADING IN AN OPERATIONAL CONFIGURATION.

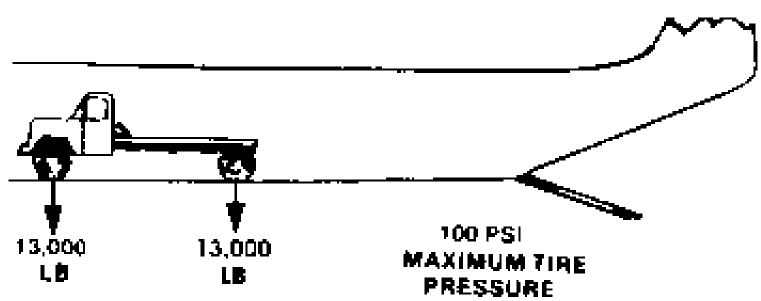
Go to Table of Contents

Wheeled vehicles:
The C-130’s 35-inch-wide treadways are rated at 6,000 pounds (axle-load) for pneumatic tires, provided the tire pressure is less than 100 psi. In the central part (28.75 feet) of the aircraft (fuselage station 337 to 682) the treadway axle-load limit increases to 13,000 pounds. The allowable load on each tire (and each treadway) is half the axle-load rating.

Tracked vehicles:
Treadways are rated at 2,800 pounds per linear foot (1,400 pounds per side). In the central part of the aircraft (FS 337 to 682) the treadway-limit increases to 6,000 pounds per linear foot (3,000 pounds per side). Loading is based on linear length of track in contact with the floor.



$$\text{Pounds Per Linear Foot} = \frac{42.000\ \text{lb}}{7\ \text{ft}}$$
$$= 6.000\ \text{lb/ft maximum}$$



Go to Table of Contents

C-141

The USAF C-141, a high, sweptback wing jet aircraft, is mainly used as a strategic, intertheater aircraft. The USAF plans to retire all C-141s by 2006 so this aircraft should not be a critical transportation requirement.

The C-141 is loaded through an aft cargo door. The dimensional design limits for the cargo compartment in the C-141 are:

Height:	103 inches
Width:	111 inches
Length:	1,090 inches

These design limits allow for 6 inches of safety clearance between the equipment being loaded and the aircraft ceiling and sidewalls.

The maximum payload of the C-141 is 68,600 pounds. However, aircraft operating weight and range must also be considered. Without refueling, the C-141 will be limited to a payload of 60,000 pounds (for a range of 3,200 nautical miles).

ALL VEHICLES THAT REQUIRE C-141 TRANSPORT MUST BE CAPABLE OF ROLL-ON/ROLL-OFF LOADING AND UNLOADING IN AN OPERATIONAL CONFIGURATION.

The maximum concentrated load for bulk cargo on the floor of the C-141 is 50 psi on and outboard of the treadways and 25 psi between the treadways.

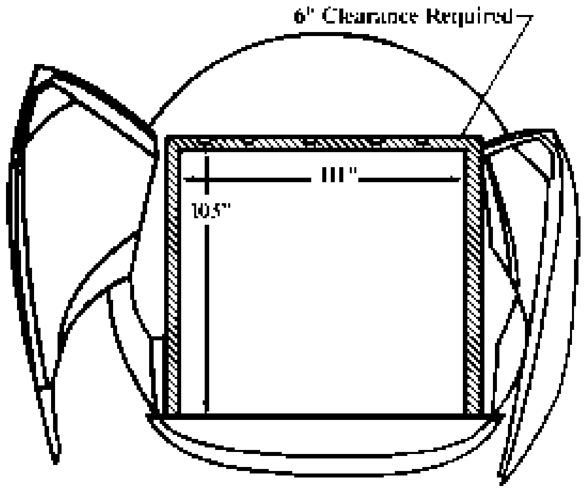
Wheeled vehicles:
The C-141's 34-inch-wide treadways are rated at 10,000 pounds (axle-load) for pneumatic tires, provided the tire pressure is less than 100 psi. In the central part (26.7 feet) of the aircraft (fuselage station 678 to 998) the treadway

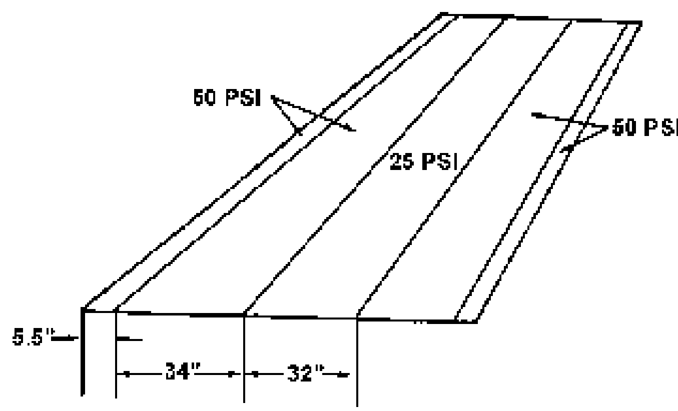
Go to Table of Contents

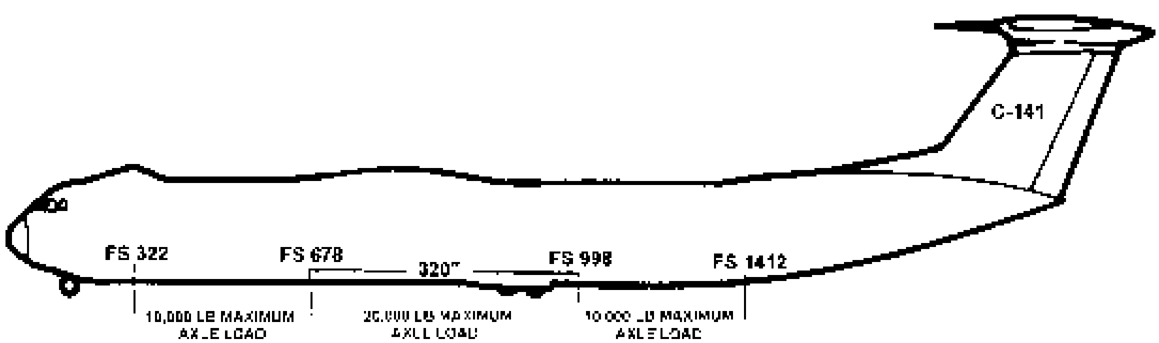
axle load increases to 20,000 pounds. The allowable load on each tire (and each treadway) is half the axle load rating. When the tire size is less than 14 x 17.5, the maximum wheel load is 5,000 pounds on any part of the treadway.

Tracked Vehicles:
The maximum practical weight for C-141 transport of tracked vehicles is 44,000 pounds. Tracked vehicles with snubbed, chained-down, or nonarticulating ("beam") suspension that exceed 32,500 pounds must be straight-in loaded/unloaded from/onto a loading bed (K-loader or M870 semitrailer). The maximum roadwheel weight of a tracked vehicle is 5,000 pounds; however, 3 inches of shoring will be required.

If no shoring is to be used, the maximum roadwheel weight of a tracked vehicle is 2,500 pounds for tracks with pads.







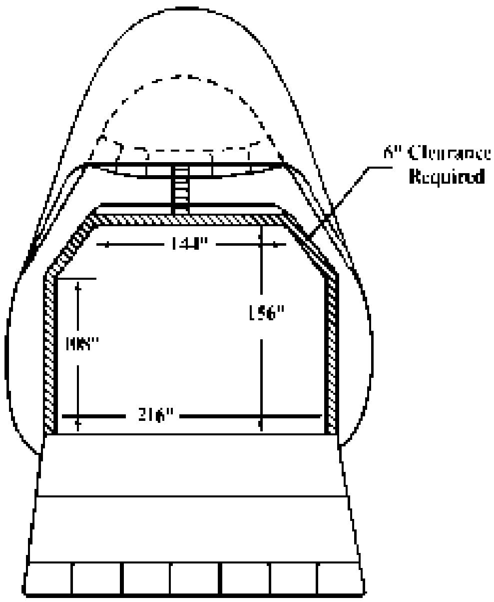
Go to Table of Contents

C-5

The USAF C-5, a high-speed, high-capacity, long-range jet aircraft, is mainly used as a strategic, intertheater aircraft for transporting cargo and troops. The C-5 can be loaded through either a forward visor door or an aft door under the tail. Both doors come equipped with cargo ramps. The dimensional design limits for the cargo compartment in the C-5 are:

Height:	156 inches
Width:	144 inches (216 inches if height is less than 108 inches)
Length:	1,454 inches

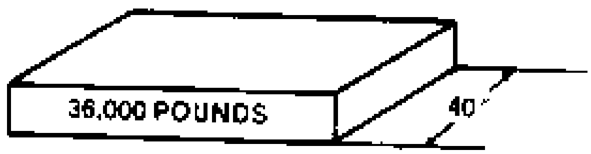
These design limits allow for 6 inches of safety clearance between the equipment being loaded and the aircraft ceiling and sidewalls.



Go to Table of Contents

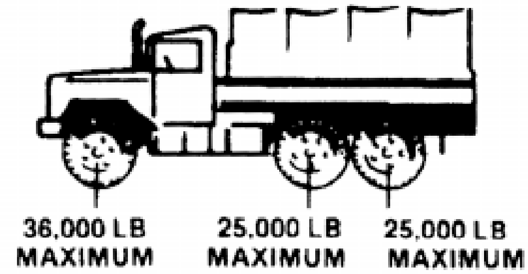
The maximum payload of the C-5 is 265,000 pounds (range at this payload is 1,600 nautical miles). A more typical payload, considering fuel weight, is 178,000 pounds (range at this payload is 3,200 nautical miles).

The strongest portion of the C-5 floor is capable of supporting loads of 36,000 pounds in any 40-inch longitudinal length of floor.

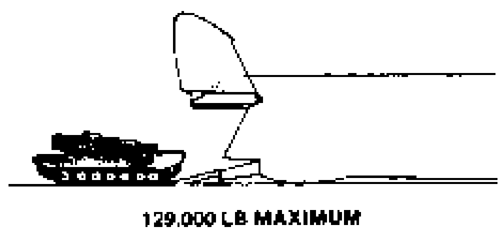


The maximum single axle load allowed on the C-5 is 36,000 pounds.

The maximum tandem axle load allowed on the C-5 is 25,000 pounds per axle.



The maximum tracked vehicle weight for the C-5 is 129,000 pounds.



Go to Table of Contents

C-17

The C-17, a high-speed, high-capacity, long-range jet aircraft, can transport outsize and overweight cargo from origins in the United States to forward airfields overseas. Therefore, the C-17 can function as a strategic, intertheater aircraft and as a tactical intratheater aircraft. The C-17 is loaded through an aft cargo door.

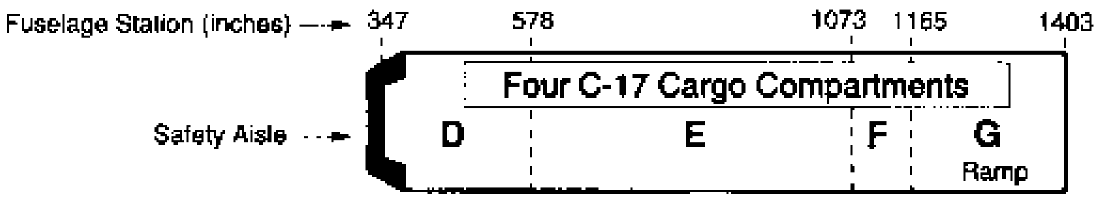
The design limits for equipment to be transportable in the C-17 are:

Height:	142 inches
Width:	196 inches (204 inches if height is less than 136 inches)
Length:	784 inches (cargo deck) 238 inches (ramp)

These design limits allow for 6 inches of safety clearance between the equipment being loaded and the aircraft ceiling and side walls. The actual C-17 fuselage contours are shown in the following figures. The maximum payload of the C-17 is about 170,000 pounds. The maximum tracked vehicle limit is 135,000 pounds. However, the maximum payload for a range of 3,200 nautical miles is 130,000 pounds. The C-17 cargo compartment width is designed for the side-by-side loading of two 96-inch-wide wheeled vehicles (such as 5-ton vans). Wheeled vehicles should not exceed 96 inches in width to take full advantage of the capability of the C-17.

The following table gives general floor load limits for the C-17. More detailed limits may apply to specific systems.

Go to Table of Contents



C-17 Floor Load Limits

<table>
<tr><th colspan="3">Cargo Compartment</th><th>D</th><th>E</th><th>F</th><th>G
ramp</th></tr>
<tr><td colspan="3">Maximum allowable in each compartment (lb) (total weight not to exceed 169,330 lb)</td><td>72,000</td><td>169,330</td><td>35,000</td><td>40,000</td></tr>
<tr><td colspan="3">Maximum allowable pneumatic tire inflatable pressure (psi)</td><td>100</td><td>100</td><td>100</td><td>100</td></tr>
<tr><td colspan="3">Maximum allowable weight per linear foot (lb)</td><td>6,200</td><td>8,670</td><td>6,200</td><td>6,200</td></tr>
<tr><td rowspan="4">Vehicles (lb)</td><td rowspan="3">Vehicle centerlines more than 8 inches from aircraft centerline (single or double row)</td><td>Single equal-weight axles side-by-side</td><td>13,000</td><td>20,000</td><td>13,000</td><td>13,000</td></tr>
<tr><td>Single axles beside 4,500-lb axles</td><td>22,000</td><td>27,000</td><td>22,000</td><td>22,000</td></tr>
<tr><td>Bogies (tandem) side-by-side
42-inch axle spacing</td><td>23,000</td><td>40,000</td><td>23,000</td><td>23,000</td></tr>
<tr><td colspan="2">Vehicle centerline within 8 inches of aircraft centerline. Vehicle single-axle weights, single-row</td><td>27,000</td><td>36,000</td><td>27,000</td><td>27,000</td></tr>
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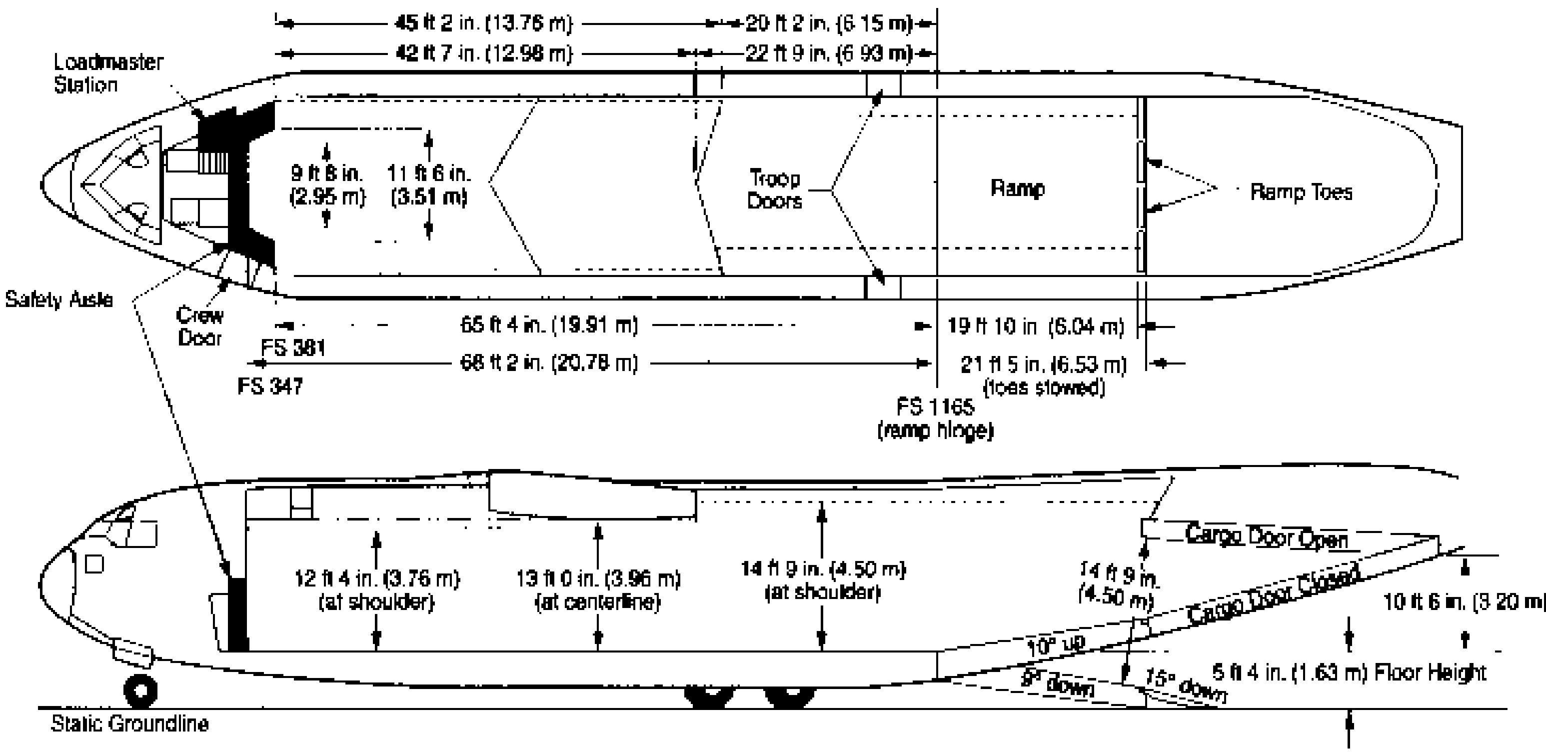
Go to Table of Contents

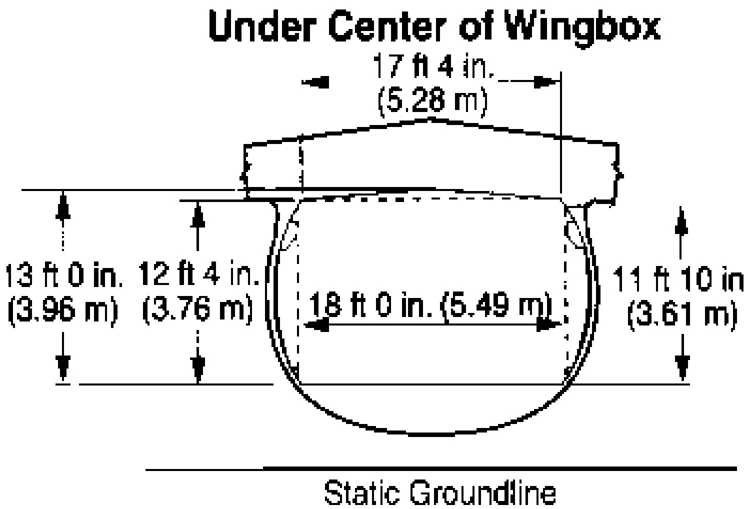


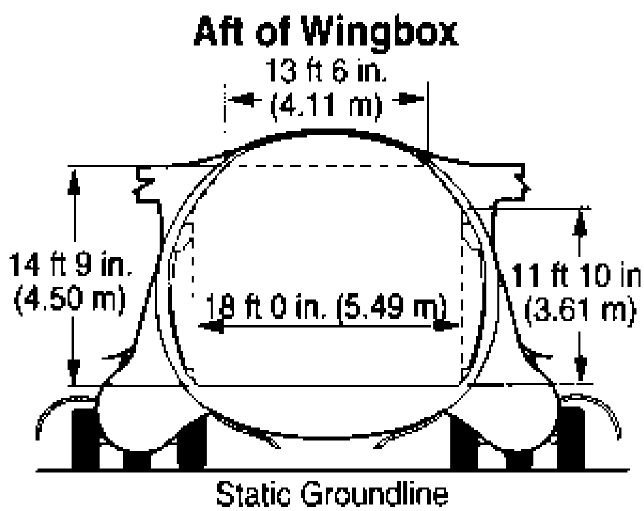
Note: These figures do not include the reduction for 6 inches of safety clearance.

Go to Table of Contents

CARGO COMPARTMENT

Dimensions





Note: Six inch clearances should be maintained between items being loaded and aircraft structure.

Go to Table of Contents

Civil Reserve Air Fleet (CRAF)

The Civil Reserve Air Fleet (CRAF) represents about 50 percent of the USAF total strategic wartime airlift capability. It consists of U.S. civil air carriers that have contracted to provide support personnel, equipment, and aircraft to the USAF. This represents 90 percent of air passenger movement and 30 percent of cargo movement when stage II CRAF is employed (primarily palletized cargo).

For materiel transport, the CRAF aircraft with the greatest utility is the B-747 wide-body aircraft. Aircraft cargo capabilities differ not only between carriers but also within carrier fleets, according to the specific needs at the time it is ordered from the manufacturer. Many freight aircraft are modified passenger aircraft replaced by more modern passenger aircraft. The specific carrier is the approving authority for loads.

The maximum load that may be placed on a pallet is 10,000 pounds. This loading is available for only a portion of the aircraft and pallet loads may be 6,000 pounds or less, according to the aircraft received. A wide-body aircraft compatible cargo loader is required for all cargo loadings/offloadings. For military equipment, a pallet subfloor is required for load distribution, with shoring used to fill pallet voids.

Military equipment will normally be loaded using 463L pallets. Two connected pallets (two-pallet train) is the greatest length that can be side-door loaded for any commercial aircraft. After the equipment and pallet train is maneuvered onto the aircraft it is then placed in its stow position, or if the equipment is a vehicle it can be driven across the pallet subfloor to the stow position.

Because outsized equipment loads must enter in a lateral aircraft direction and be maneuvered to a longitudinal direction, there is a width-to-length relationship for determining cargo loadability. The longer the item, the narrower it must be. This is driven by the barrel shape of the aircraft fuselage, which causes greater restriction at increased heights. For the B-747, an item 96 inches high and 110 inches wide can be no longer than 232 inches. For the MD-11/DC-10, an item of the same width and length can only be 80 inches high.

For the B-747s equipped with a nose cargo door, the maximum cargo height through this door is 94 inches, plus the 2-inch pallet thickness. Width varies with item height, with a minimum width of 96 inches. Length is limited by the cargo loader when equipment is driven into the aircraft. Equipment loaded on pallet trains may also be restricted by the aircraft's roller system.

Go to Table of Contents

Airdrop

Airdrop is used to support two types of military operations: mass assault and resupply. In a mass assault operation, a large quantity of personnel, supplies, and equipment are airdropped into the opposing forces' territory to establish a position. In a resupply operation, items such as rations, equipment, ammunition, water, fuel, and medical supplies are airdropped into an area held by friendly forces to replenish dwindling stocks. (This procedure takes place when aircraft landing is impossible.) When possible, items should be airdropped in their operational configurations.

The C-130, C-141, and C-17 are the primary USAF aircraft used for low-velocity airdrop. The C-5 is available but limited, for now, to a small number of aircraft.

Before heavy vehicles or equipment are airdropped, each item is secured to an airdrop platform. Energy-dissipating material is placed between the item and the airdrop platform to absorb the impact shock when the platform strikes the ground.

The dimensional limits of a rigged load (airdrop platform, energy-dissipating material, and the item to be airdropped) are:

	C-130/ C-141 (in.)	***C-5 (in.)***	***C-17 (in.)***
Height*:	100	105	118
Width:	108	108	126

*The height is further restricted forward of the rigged item's center of gravity to allow extraction under a malfunction condition (that is, extraction parachute fails to fully deploy).

The maximum airdrop height for vehicles with rubber tires and vehicles with suspension systems is:

C-130/C-141	90 inches
C-5	95 inches
C-17	108 inches

The maximum airdrop height for all other equipment is:

C-130/C-141	84.5 inches
C-5	89.5 inches
C-17	102.5 inches

The maximum airdrop capability (in pounds) of each aircraft for fully rigged loads is as follows:

C-130	*C-141*	*C-5*	*C-17*
42,000	38,500*	60,000	60,000

*May be increased to 42,000 pounds for the C-141 during contingencies (wartime) with USAF approval.

The maximum gross rigged weight (GRW) of an item to be airdropped is estimated based on the following formula:

GRW = 1,600 pounds + (1.18 x item weight for airdrop)

The maximum item weights for each aircraft, which depend on the rigging requirements, are about 34,200 pounds for the C-130, 31,270 for the C-141, and 49,500 for the C-5 and C-17.

Note: At present, the airdrop hardware that is available can only be used for a maximum GRW of 42,000 pounds or less. This is an airdrop hardware limitation and not an aircraft limitation. The weights given above are aircraft limitations.

Go to Table of Contents

Air (Rotary Wing)

Rotary wing aircraft are used mainly for short-range, tactical transport missions. These aircraft have the ability to transport essential equipment directly to a forward area without having to contend with enroute terrain obstacles or damaged road or railroad systems. The five common types of military helicopters that are used to transport cargo are the UH-1 and UH-60 utility helicopters and the CH-46, CH-47, and CH-53 cargo helicopters. In 2001, the MV-22 will be operational and will be able to carry cargo. All six aircraft are capable of external lift operations. The CH-47 and CH-53, however, are the only helicopters with cargo compartments large enough to carry a significant amount of cargo.

Each helicopter has a maximum payload rating; however, the lift capability and range of each helicopter differ for each mission. The temperature, altitude, and fuel carried in a helicopter must be considered for each mission.

Helicopters can rarely fly at their maximum payload rating. If a requirement exists for helicopter lift, the mission (weight and distance) requirements must be known.

The maximum external loads (pounds) that can be lifted by some common helicopters appear in the table below. Note the dramatic decrease in helicopter payload capability with increasing temperature and altitude. Also, the CH/MH-53 has wide variations in capability depending on the precise model. Other CH/MH-53 models have different capabilities.

All vehicles that require CH-47 and/or CH-53 internal transport must be capable of roll-on/roll-off loading and unloading in the operational configuration.

Maximum External Loads for Helicopters

Mission Scenario	UH-1H	UH-60A	UH-60L	CH-46E	CH-47D	CH-53D	CH-53E	MV-22 [1]
Sea Level, 60 F, 30 Nautical Miles (NM)	2,585	7,843	9,000	5,915	23,324	14,700	34,770	13,320
2,000 ft, 70 F, 30 NM	2,624	7,302	9,000	5,480	23,396	13,900	28,300	9,330
4,000 ft, 95 F, 30 NM	1,169	4,700	6,630	3,780	16,644	7,860	18,200	7,500

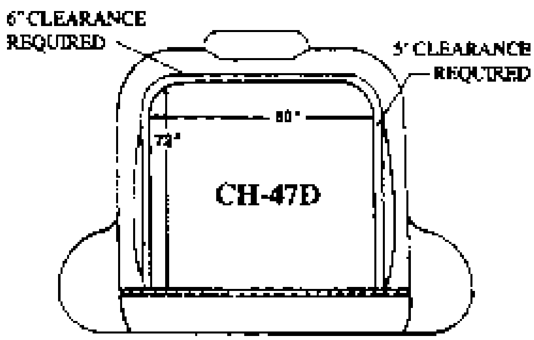
[1] In service after 2001.

Go to Table of Contents

The dimensional design limits for equipment to be internally transported by CH-47 are:

Height: 72 inches
Width: 80 inches
Length: 331 inches

These design limits allow for safety clearances of 6 inches between equipment and the aircraft ceiling and 5 inches at the sidewalls.



The maximum internal loads (pounds) that can be lifted by some common helicopters appear in the table below. Internal helicopter payload capability can decrease significantly with increasing temperature and altitude. Also, the CH/MH-53 models have wide variations in capability depending on the precise model. Other CH/MH-53 models have different capabilities. You can find payload capacitites for other helicopters in **MIL-STD-1366**.

Maximum Internal Loads for Helicopters

Mission Scenario	CH-46E	CH-47D	CH-53D	CH-53E
Sea Level, 60 F, 30 Nautical Miles (NM)	6,000	23,300	14,770	34,990
2,000 ft, 70 F 30 NM	5,600	23,350	13,970	28,600
4,000 ft, 95 F, 30 NM	3,890	16,900	7,910	18,600

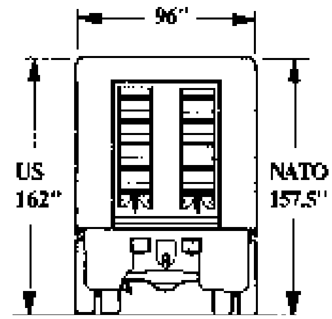
Go to Table of Contents

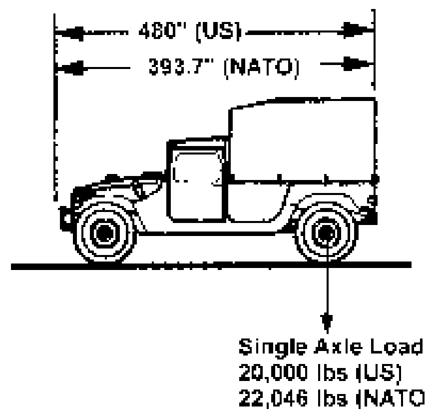
Highway

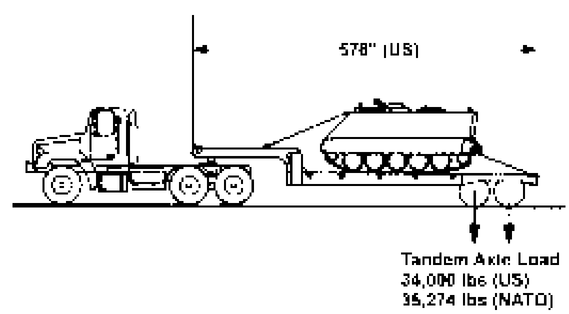
GENERAL

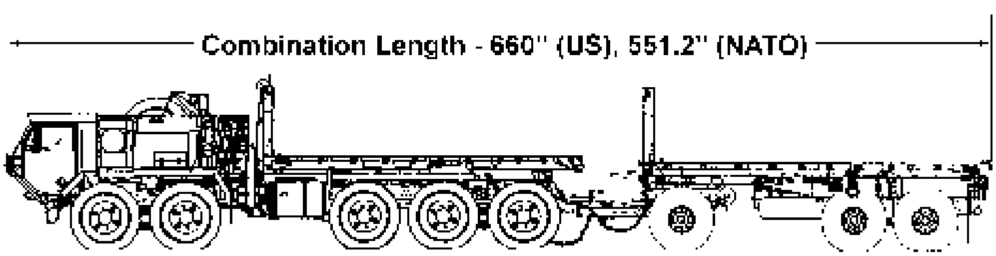
Highway is the most common transport mode. It is essential for both strategic and tactical deployment, as well as day-to-day operations. Military equipment usually is not located at its strategic deployment port of embarkation, such as ports or airfields. Highway transport can be used to reach these points of embarkation especially if they are less than 400 miles from the origin of the deployment. For tactical deployment, this mode allows the item to be delivered as close as possible to the point where it is needed. This mode is also the most flexible of the surface transport modes. Maximizing the efficiency of the highway network requires that vehicles and vehicular combinations be capable of unrestricted movement. This movement is possible if vehicles or vehicular combinations do not exceed legal size and weight limits imposed by the Federal Government, States, and foreign countries. If the dimensional and weight limits shown in the figures are not exceeded, movement will be generally unrestricted in most States and NATO countries.

There are Federal weight limits on the Dwight D. Eisenhower System of Interstate and Defense Highways, or more commonly known as the "Interstate" system, which can depend on the number and spacing of axles on the vehicle. As a general guide, the gross vehicle weight limit for the Interstate is 80,000 pounds. There are Federal length and width limits on the Interstate and other primary highways. State highway authorities cannot be more restrictive than these limits, but can set forth their own limits, including height restrictions. More detailed information is available in the American Trucking Association's *Summary of Size and Weight Limits.*







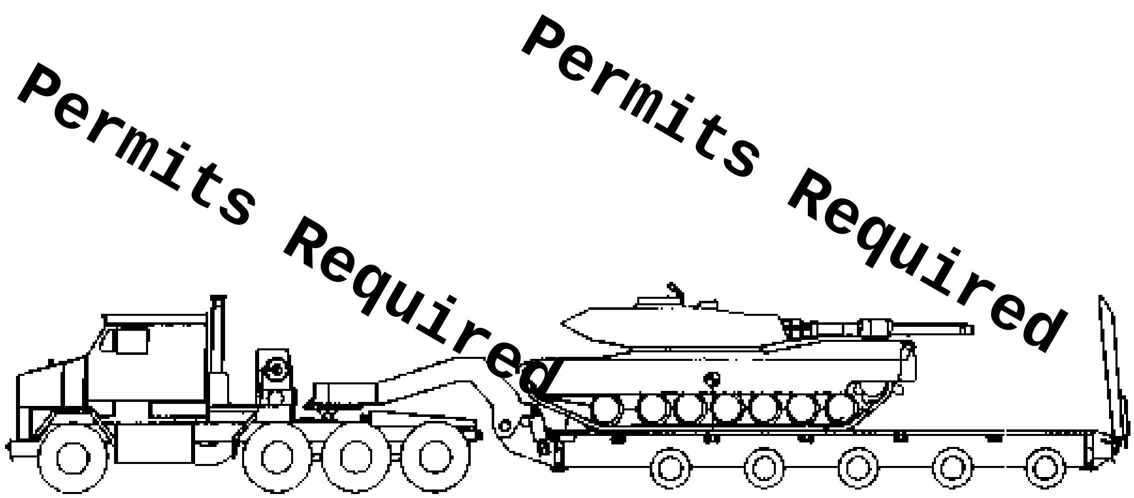


Go to Table of Contents

Highway Permits

Vehicles and vehicular combinations that exceed the legal highway limits will require permits for highway transport. The difficulty in obtaining these permits depends on the State's policy and the amount that the legal limit is exceeded. Circuitous routing, resulting in transport delays, may be required as a condition of the permit. Permits for vehicles that exceed the legal width and length limits are not as difficult to obtain as those for vehicles that exceed the legal height and weight limits. In general, States will not issue permits for reducible or divisible loads. **DOD 4500.9-R**, *Defense Transportation Regulation (DTR), Part III* explains the procedures for obtaining highway permits.

Many States are reluctant to grant permits for overweight cargo vehicles with divisible loads, since these vehicles can be brought within normal legal limits simply by reducing the payload. In some cases, a vehicle with a high empty weight may have a very limited legal payload.



THE STATES AND LOCAL GOVERNMENTS OWN AND CONTROL ALL PUBLIC ROADS WITHIN THEIR BOUNDARIES, INCLUDING LOCAL, STATE, U.S., AND INTERSTATE ROUTES. THEY DO NOT HAVE TO GRANT A PERMIT IF THEY FEEL THE VEHICLE OR LOAD IS TOO LARGE OR TOO HEAVY FOR SAFE TRANSPORT.

Go to Table of Contents

Certification as Essential to National Defense

During an emergency or if state permits are denied, a highway movement may be declared as essential to national defense. The following requirements must be met for an item to be certified as essential to national defense:

- The item must be essential to mission completion or unit readiness.
- The item cannot be reduced or moved by commercial transporters to conform with the limits.
- There is no alternative to highway transport.

Movement for routine training, maintenance, or equipment displays will not be considered essential to national defense. The shipment must be eligible for highway movement in accordance with the provisions of **DOD 4500.9-R**. If all these requirements are met, the commander of the transporting installation will request the major commander of the shipping activity to certify the shipment as essential to national defense. The local installation commander cannot certify a shipment as essential to national defense. The *Directory of Highway Permit and MOBCON Officials*, published by MTMCTEA, lists the individuals authorized to determine essentiality to national defense. It also lists military officials authorized to request, and State officials authorized to grant permits for oversize, overweight, or other special military movements on public highways.

Certification as essential to national defense is not a guarantee that State highway officials will allow the shipment. The States have complete authority over their highway network, and their determination is final.

Pavement and structures have a practical load limit. Certification as essential to national defense, followed by the State's permission, does not ensure the load can be transported safely and without damage to the roadway. Pavement and structure analysis may be required at DOD's expense before transporting extremely heavy items. If roadways are damaged, DOD may have to reimburse the State for the cost to repair the damages.

CERTIFICATION AS ESSENTIAL TO NATIONAL DEFENSE IS NOT A GUARANTEE THAT STATE HIGHWAY OFFICIALS WILL ALLOW SHIPMENT

Go to Table of Contents

Rail

Rail transport is essential for the shipment and deployment of oversize and overweight equipment. Oversize and overweight equipment is that equipment which cannot meet legal highway transport limits. Rail transport is also essential for the land deployment of all equipment transported farther than 400 miles. When many items are to be shipped, rail transport is often cheaper than highway transport.

Rail transport of tactical vehicles reduces the time the vehicles must operate during deployment and, thus, places them on the front lines in top operational condition. Rail transport reduces wear and tear on tactical vehicles, minimizes the requirements for en route support, and reduces maintenance requirements. Presently, there is a slight risk of vandalism to equipment during rail shipments.

Although oversize and overweight equipment is routinely transported by rail, there are still maximum limits and restrictions to rail transport. These restrictions are given in clearance diagrams. When railcar-mounted equipment exceeds the clearance diagrams, it possibly could be transported by rail but may require special routing and special provisions.

Rail transport on standard-gauge rail lines in North America and in Europe is more important than rail transport in other areas of the world to military planners, because rail networks are extensive in these areas. Korea also has a standard-gauge rail network. The five rail clearance diagrams of greatest interest are:

North America:
Association of American Railroads (AAR) outline diagram for single loads, without end overhang, on open-top cars
DOD clearance profile for the Strategic Rail Corridor Network (STRACNET)

Europe:
Gabarit International de Chargement (GIC)
Envelope B

Korea:
Korean clearance diagram

The AAR diagram applies to rail lines in North America. Equipment that is mounted on 50-inch-high railcars and falls within the limitations of the AAR diagram will be cabable of unrestricted movement on almost all rail lines.

The DOD STRACNET clearance profile accommodates 96 percent of DOD types of equipment and 99 percent of individual pieces of equipment in the DOD inventory. However, it is only valid for selected routes and sometimes only at severely restricted speeds. Other special conditions may also apply.

The GIC applies to rail lines in European countries. Equipment that is mounted on 51.4-inch-high railcars and falls within the limitations of the GIC gauge will be capable of essentially unrestricted movement worldwide on standard-gauge rail lines.

Equipment Envelope B applies to rail lines in NATO countries on the European continent. Envelope B rail network is not as extensive as the GIC equipment network, but comprises 85 percent of the rail lines.

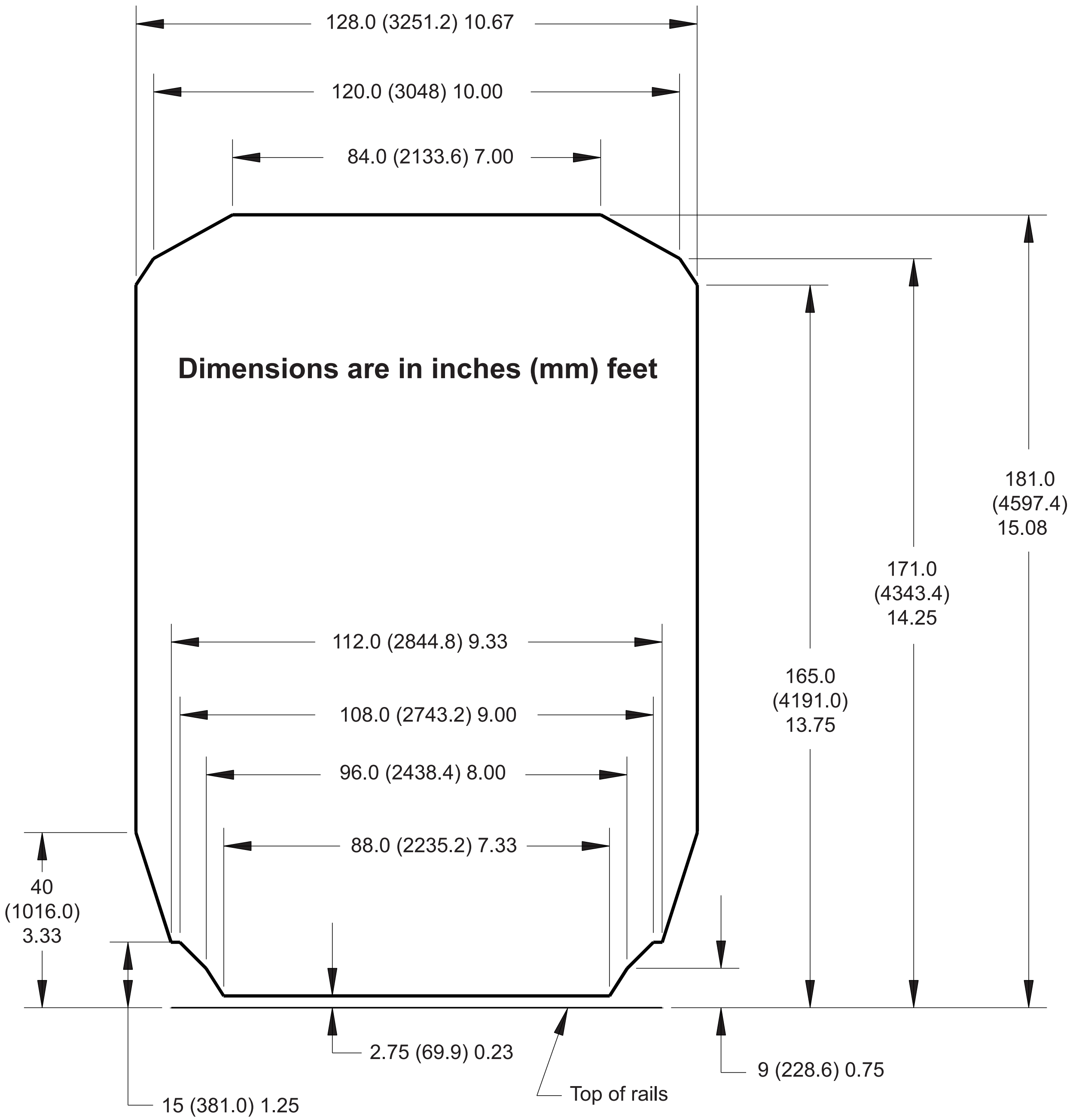
The Korean clearance diagram applies to the major rail lines in Korea for equipment secured to a flatcar. Korean railcars are 47.2 inches high for up to 110,200 pounds or 55.1 inches high for heavier loads such as heavy tracked vehicles.

If equipment exceeds the clearance diagrams, it still may be transported by rail; however, special routing and provisions may be

Go to Table of Contents

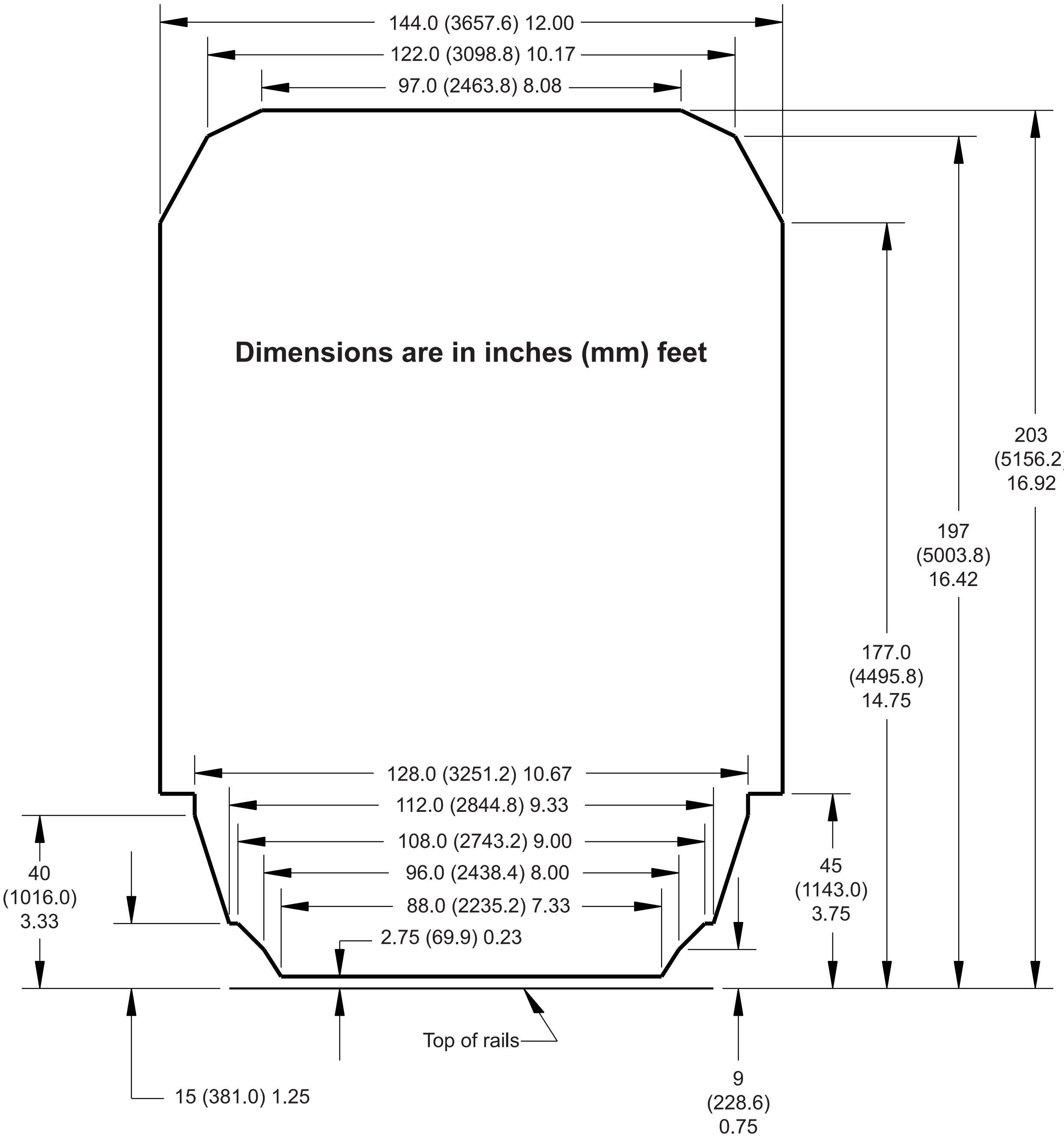
required. This special treatment will add to the transport time - a luxury not available when rapid deployment is essential.

Rail transport can subject equipment to the greatest longitudinal shock loads of any transport mode during rail humping and other train handling. Rail humping is a procedure used in rail classification yards to asssemble separate railcars into trains. A railcar is pushed over a hump and is allowed to roll into and couple with the train being assembled. During coupling, the normal speed is usually under 4 mph, but speeds can go as high as 8 mph.



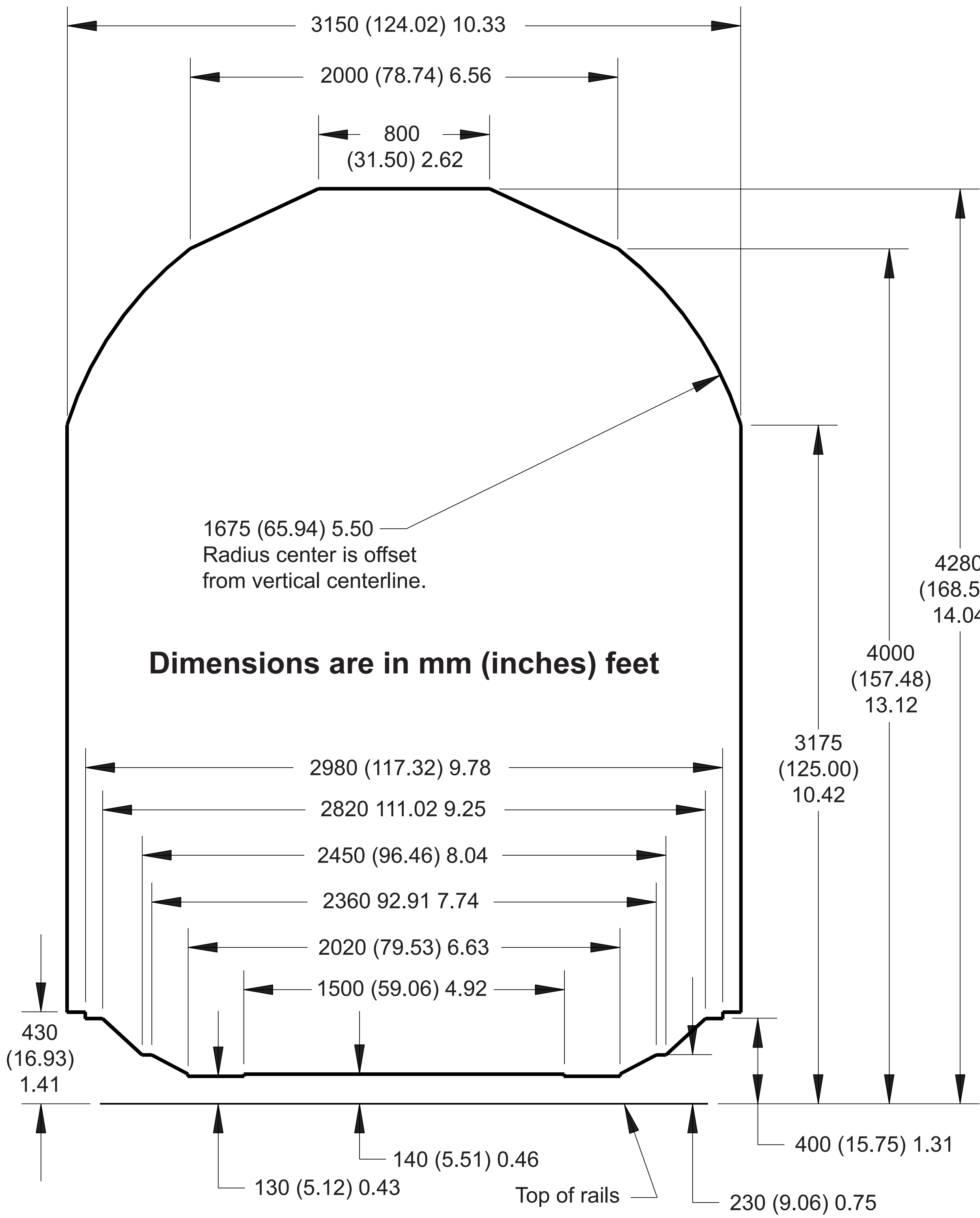
AAR Outline Diagram of Single Loads, Without End Overhang, On Open-Top Cars

Go to Table of Contents

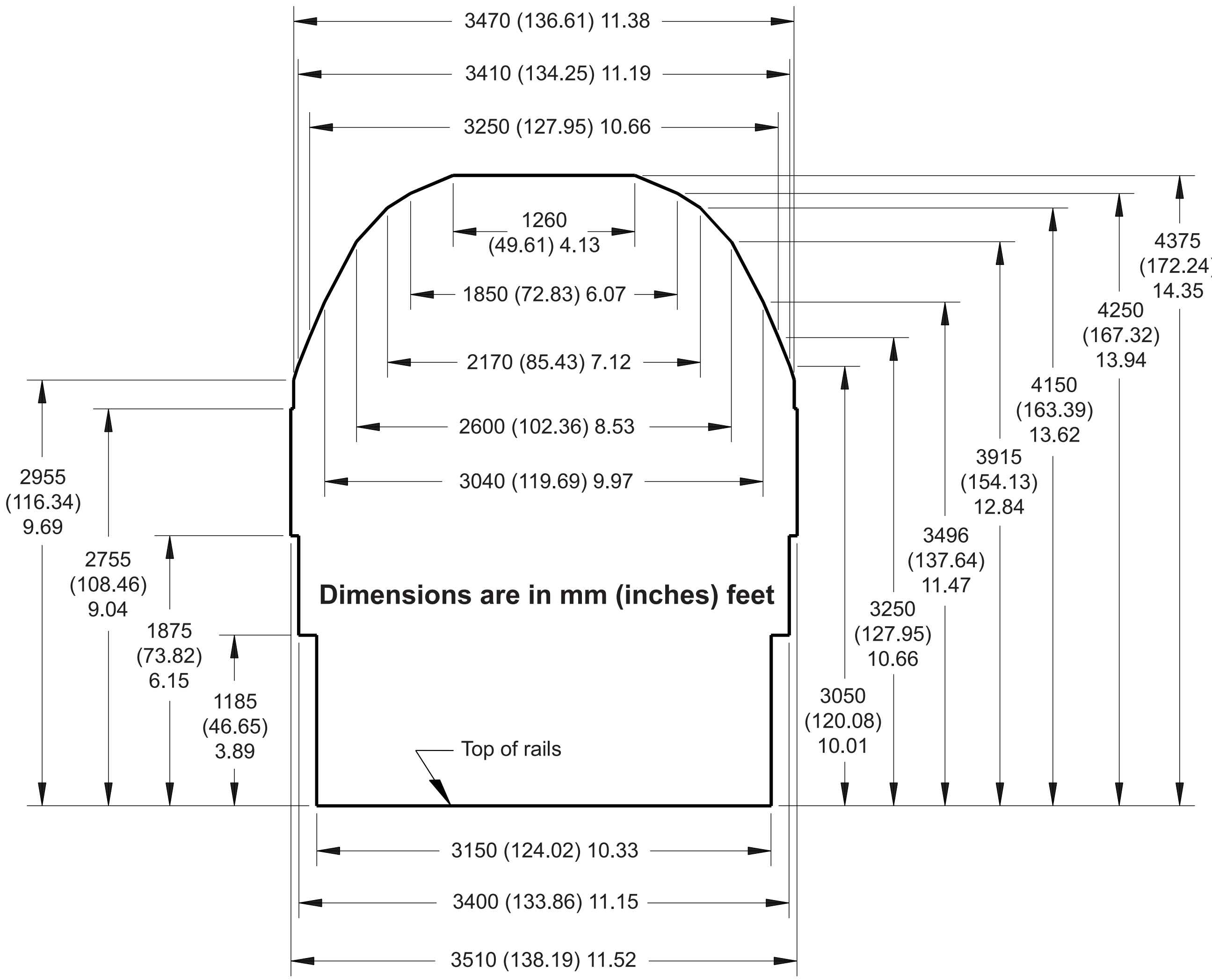


DOD Rail Clearance Diagram

Go to Table of Contents

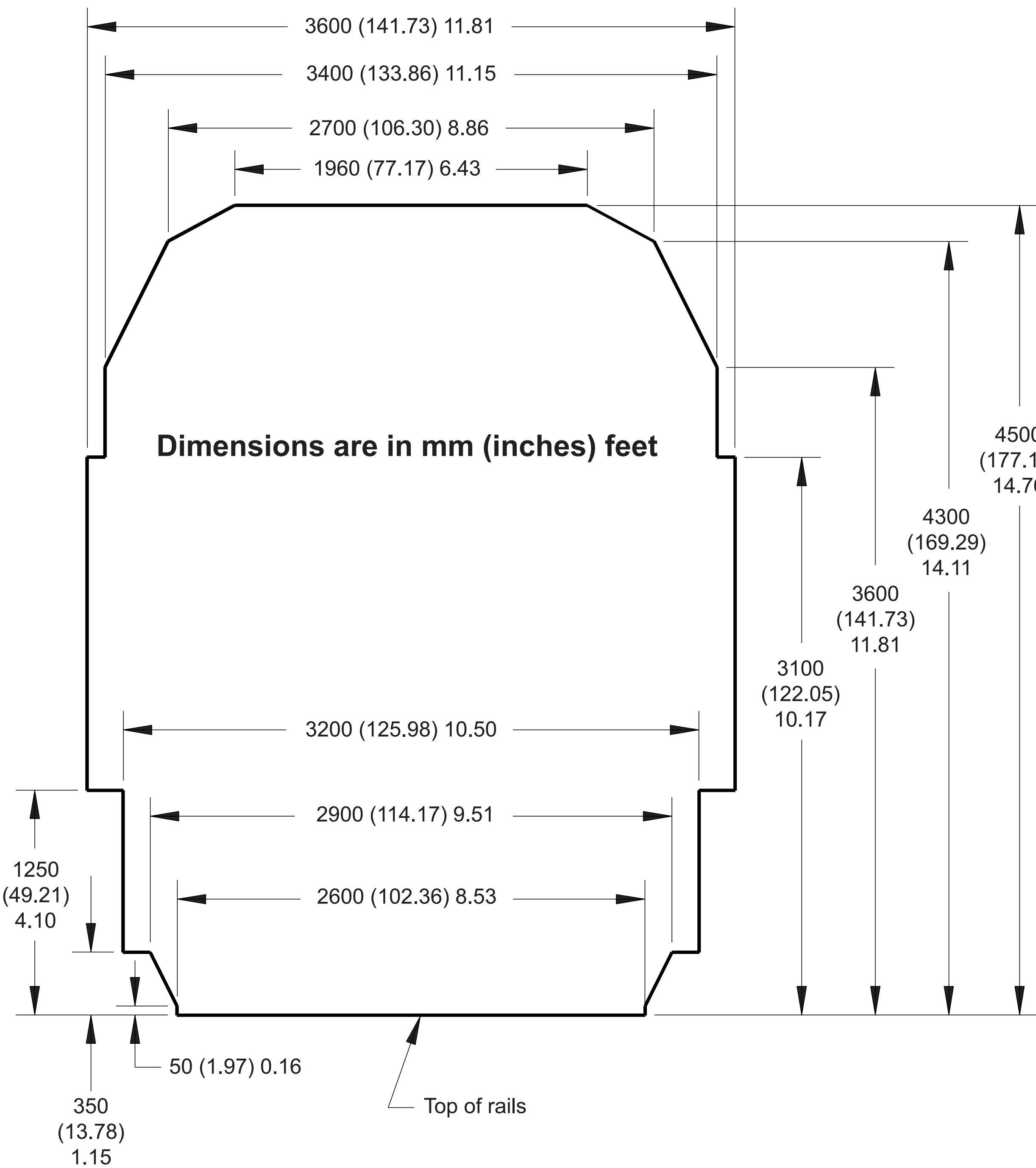


GIC Diagram



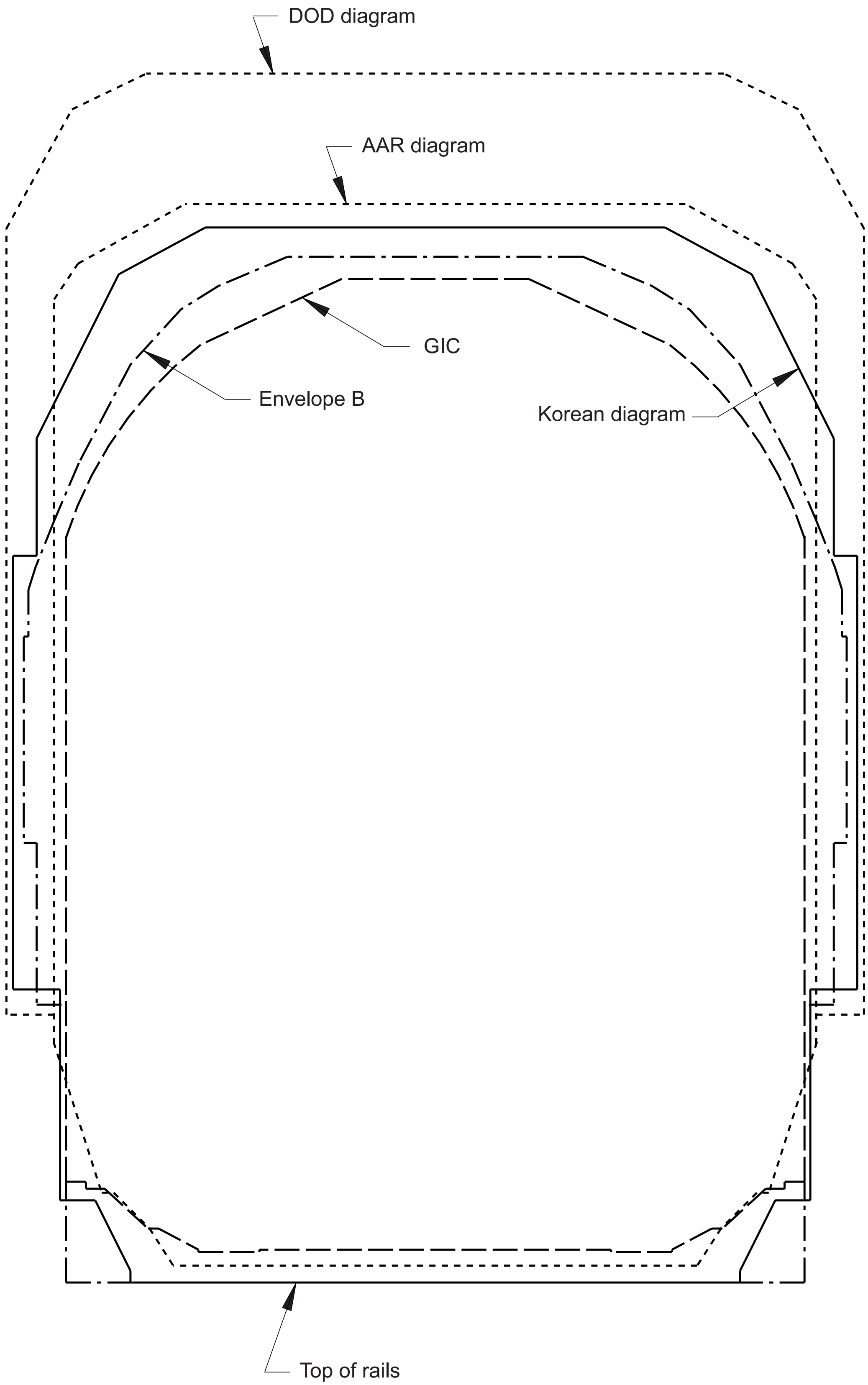
NATO Envelope B

Go to Table of Contents



Korean Rail Clearance Diagram

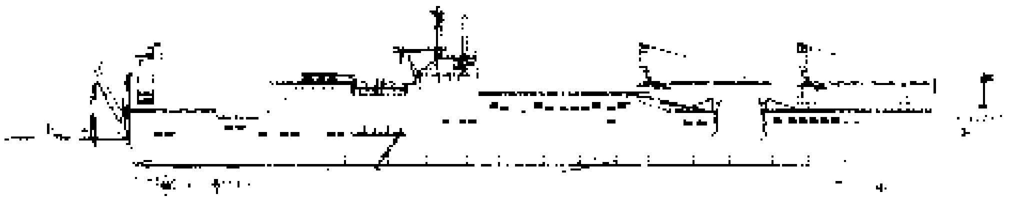
Go to Table of Contents



Comparision of Loading Diagrams

Go to Table of Contents

Marine



Water transport is used for both strategic and tactical deployments. During strategic deployment, most military equipment will be transported by ship. The types of ships that will be used include breakbulk (general cargo), container, roll-on/roll-off (RORO), and barge-carrying (LASH and SEABEE) ships. In general, almost all items of equipment can be transported by ship without major problems or restrictions.

Equipment must have good, accessible lifting and tiedown provisions. Equipment too heavy for lift by shipboard cranes requires dockside cranes. Such equipment is also limited to improved ports. Equipment to be delivered to unimproved ports or underdeveloped areas must be light enough to be lifted by shipboard cranes.

Commercial marine transport increasingly relies on container ships for cargo movement. When commercial marine transport is a requirement, compatibility with intermodal containers or flatracks is essential. See page 32 for design guidance.

Logistics-over-the-shore (LOTS) operations are used when developed ports are not available, or damage prevents their use. The lighters listed below accomplish LOTS operations.

USA, USMC, and USN Lighterage

	Cargo Deck Length (ft, m)	Cargo Deck Width (ft, m)	Cargo Capacity (short tons, lb, kg))	Bow ramp Capacity (short tons, lb, kg)	Bow Ramp Width (ft, m) [1]	Bow Height Limit (ft, m) [1]	Stern Ramp Capacity (short tons, lb, kg)	Stern Ramp Width (ft, m) [1]	Stern Height Limit (ft, m) [1]
LARC-LX	42.25’ 12.9	13.83’ 4.2 [2]	60.0 120,000 54 431	60.0 120,000 54 431	13.83 4.2	N/A	N/A	N/A	N/A
LCM-8	42.75’ 13.0	14.50’ 4.4	60.0 120,000 54 431	65.0 130,000 58 967	14.50 4.4	N/A	N/A	N/A	N/A
LCU-1466	75.50’ 23.0	29.50’ 9.0	168.0 336,000 152 407	-	14.33 4.4	N/A	N/A	N/A	N/A

Go to Table of Contents

USA, USMC, and USN Lighterage (Cont)

	Cargo Deck Length (ft, m)	Cargo Deck Width (ft, m)	Cargo Capacity (short tons, lb, kg))	Bow ramp Capacity (short tons, lb, kg)	Bow Ramp Width (ft, m) [1]	Bow Height Limit (ft, m) [1]	Stern Ramp Capacity (short tons, lb, kg)	Stern Ramp Width (ft, m) [1]	Stern Height Limit (ft, m) [1]
LCU-1646	110.00’ 33.5	28.00’ 8.5	179.2 358,400 162 568	112.0 224,000 101 605	14.00 4.3	N/A	97.5 195,000 88 451	18.00 5.5	N/A
LCU-2000	108.00’ 32.9	38.75’ 11.8	350.0 700,000 317 515	224.0 448,000 203,209	16.00 4.9	30.00	N/A	N/A	N/A
LSV	256.00’ 78.0	60.00’ 18.3	2,016.0 4,032,000 1 832 727	560.0 1,120,000 508 023	28.00 8.5 [3]	43.50 13.3	N/A	25.00 7.6	21.50 6.6
LCM Mk. 6 [4]	37.50’ 11.4	10.83’ 3.3	34.0 68,000 30 844	65.0 130,000 58 967	10.83 3.3	N/A	N/A	N/A	N/A
LCM Mk. 8 Mod. 2 (Steel)	42.00’ 12.8	14.00’ 4.3	60.0 120,000 54 431	65.0 130,000 58 967	14.50 4.4	N/A	N/A	N/A	N/A
LCM Mk. 8 Mod. 2 (Aluminum)	42.00’ 12.8	17.00’ 5.2	65.0 130,000 58 967	65.0 130,000 58 967	14.50 4.4	N/A	N/A	N/A	N/A
LCU-1646 [4]	100.00’ 30.5	12.75’ 3.9	200.0 400,000 181 437	112.0 224,000 101 605	14.50 4.4	N/A	97.5 195,000 88 451	18.00 5.5	N/A
LCAC [5]	67.00’ 20.4	27.00’ 8.2	27.0 54,000 24 494	75.0 150,000 68 039	28.33 8.6	N/A	75.0 150,000 68 039	14.83 4.5	N/A

[1] Values given are actual dimensions. For design purposes, subtract 12" (.3 m) from the width and 6" (.15.m) from the height limitations for ramps to ensure adequate clearance.

[2] Width is restricted to 12.91’ (3.9 m) so that the item is within the inside tiedown rings.

[3] For wheeled and tracked items, the width of the ramp itself is 19’ (5.8 m). Therefore, the maximum width, width from outside-of-tire to outside-of-tire or outside-of-track to outside-of-track is 19’(5.8 m) minus 1’ (.3 m) to ensure adequate clearance on the LSV bow ramp.

[4] The LCMs 6 and 8 and LCU 1646 are USMC landing craft. The cargo deck width of the LCU 1646 varies from 12.75’(3.9 m) to 25.00’ (7.6 m) throughout the vessel. For design purposes, use the 12.75’ (3.9 m) worst case value.

[5] The Landing Craft, Air Cushioned (LCAC) is a Navy landing craft. The cargo deck contact-area pressure limit is 80 psi (552 kPa). Areas used for loading or unloading cargo, such as ramps, are restricted to wheel or track loads equal to a vertical load factor of 1.5g of the vehicle weight. The cargo capacity listed for the LCAC is at its overload weight (maximum cargo capacity). The **normal** capacity load is 60.0 tons (120,000 lb, 54 431 kg).

Go to Table of Contents

Containers and Flatracks

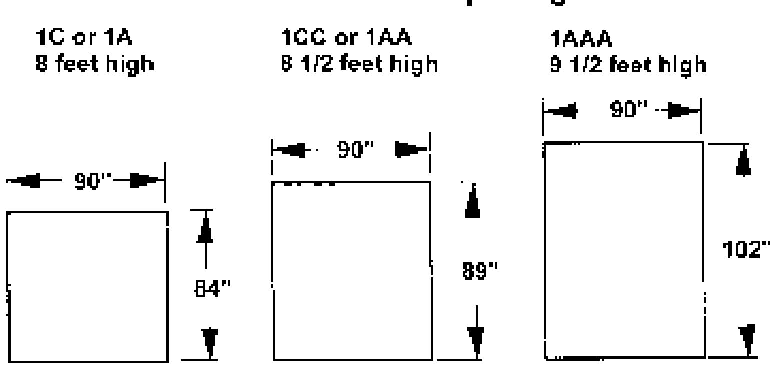
Cargo containers and flatracks are transport equipment designed and constructed to facilitate the international and intermodal exchange of goods. They are designed to be used repeatedly and to provide security during transport. Also, their fittings readily permit handling and transfer from one transport mode to another. A very strong trend exists for commercial ocean carriers to equip their fleets predominantely with ships that have standardized container cells and to withdraw breakbulk ships from service. Thus, force deployability will be improved if many pieces of individual military equipment can be containerized or placed on flatracks for movement in commercial containerships. Designing for container/flatrack transport effectively increases the strategic sealift assets available for deploying the force.

Military materiel should be transportable in 8.5-foot-high by 8-foot-wide by 20-foot-long American National Standards Institute/International Organization for Standardization (ANSI/ISO) containers or flatracks, where practical, to take full advantage of the intermodal benefits of containerization. Other common containers for military transport are the ANSI/ISO 9-foot-6-inch-tall containers and the ANSI/ISO 40-foot-long containers. When C-130 transport is required the container height is limited to 8 feet.

For rail, truck, and ocean transport, a 20-foot container or flatrack is limited to a gross weight of 52,900 pounds and a 40-foot container to a gross weight of 67,200 pounds. For air transport, lower maximum weights apply. The weight of the containers alone is generally less than 6,000 and 9,000 pounds for 20- and 40-foot containers, respectively.

The door openings of 8-foot-high ANSI/ISO containers are 90 inches wide and 84 inches high. The door openings of 8-1/2-foot-high ANSI/ISO containers are 90 inches wide and 89 inches high. Interior widths and heights are subject to slight variations, but are always larger than the door openings. Items being designed for containerization should be no more than 85 inches wide and no more than 85 inches high (80 inches high if designed for 8-foot-high containers and MILVANs.) Commercial 8-1/2-foot-high ANSI/ISO containers/flatracks are now so common that, if military equipment fits within them, it will be readily container/flatrack transportable, at least on the ocean leg of its journey. The interior lengths of 20- and 40-foot containers are at least 231 and 472 inches, respectively. However, consideration must also be given to restraining the item in the container.

ISO Container Door Openings



Go to Table of Contents

Shelters

Many communications, support, and weapons systems require the use of shelters. When shelters are used, they should be made the same size and equipped with the same fittings as ANSI/ISO containers, or standard shelters such as the S-250, S-280, Standardized Integrated Command Post System (SICPS), or S-788 Lightweight Multipurpose Shelter (LMS) should be used. ***The use of nonstandard shelters should be avoided!*** Developers must take care not to overload shelters and their prime movers. As the following table shows, overloading a system prime mover is possible even if the maximum theoretical shelter payload is not exceeded. When calculating shelter weight, do not forget to include basic issue items (BII), camouflage nets, ladders, manuals, cable reels, and any other items that will be carried on the shelters.

Allowable Shelter Payloads on Different Prime Movers [1]

Shelter	Shelter Tare Weight/ Payload (lb)	HMMWV M1037 (lb) [2] *(max payload = 3,331 lb)*	Heavy HMMWV M1097 (max payload) (lb) [2] *(max payload = 4,401 lb)*	Expanded Capacity Vehicle M1113 (lb) [2] *(max payload = 5,120 lb)*	2.5 Ton Truck (lb) [3] *(max payload = 5,000 lb)*	5 Ton Truck (lb) [3] *(max payload = 10,000 lb)*
S-250 [4]	770/2,530	1,995	2,530	2,530	2,530	2,530
LMS (Type I) S-788 [5]	630/ 3,300	2,135	3,205	3,300	3,300	3,300
S-280/G, A/G, B/G [6]	1,380/ 5,000	N/A [7]	N/A [7]	N/A [7]	3,620	5,000
S-280C/G	1400/7,100	N/A [7]	N/A [7]	N/A [7]	3,600	7,100

[1] Shaded areas are limited by vehicle payload; unshaded areas limited by shelter payload.

[2] Two-man crew and gear at 566 lb and shelter tare weight deducted from allowable payload. If the HMMWV pulls a trailer, the pintle load must be deducted from the above figures.

[3] Shelter tare weight deducted from allowable vehicle payload.

[4] Payloads shown are unshielded; for EMI shielding, deduct 12 lb from these payloads. Tare weight does not include mounting cradle (82 lb).

[5] Tare weight does not include mounting kit (88 lb) and pintle extension (50 lb).

[6] Payloads shown are unshielded; for EMI shielding, deduct 10 lb from these payloads.

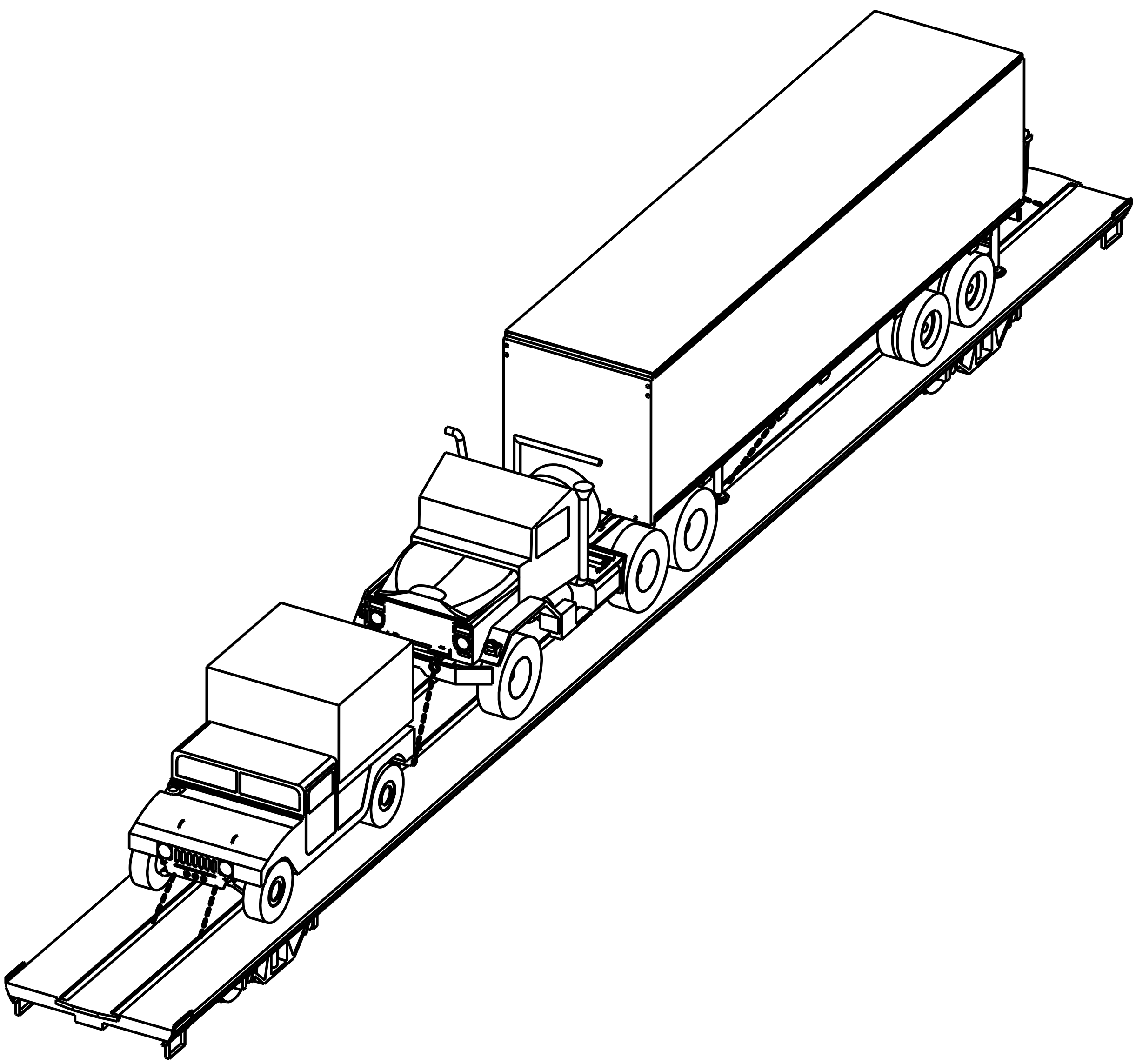
[7] Shelter incompatible with vehicle or would overload it empty.

Go to Table of Contents

Lifting and Tiedown Provisions

ADEQUATE LIFTING AND TIEDOWN PROVISIONS ARE ESSENTIAL TO EFFICIENT TRANSPORT. Equipment without adequate provisions is a logistic burden during deployment, especially when time is critical. Inadequate designs create restraint and handling problems during transport, especially transport by rail and marine modes. In addition, inadequate designs can cause damage to equipment and be dangerous to personnel.

All items of military equipment must have adequately designed lifting and tiedown provisions. Vehicles must have provisions designed for the gross vehicle weight (fully loaded vehicle) because vehicles are deployed with unit equipment in their cargo beds. Lifting and tiedown provisions should be integral to the equipment. Shackles and other provisions that can be removed are prohibited. See **MIL-STD-209**, *Interface Standard for Lifting and Tiedown Provisions* for specific requirements.



Go to Table of Contents

3 Transportability Problem Item

What is a Transportability Problem Item?

A piece of equipment is considered a transportability problem item when any of the following conditions apply:

a. The item is wheeled or tracked, and is to be towed, hauled, or self-propelled on or off highway.

b. The item increases the physical characteristics of the designated transport medium.

c. The item requires special handling or specialized loading procedures.

d. The item has inadequate ramp clearance for ramp inclines of 15 degrees.

e. The item exceeds any of the following conditions:

(1) Length - 20 feet

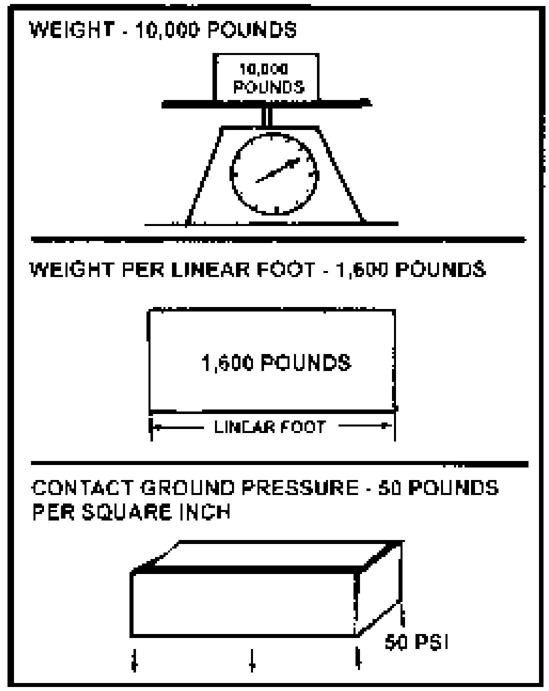
(2) Width - 8 feet

(3) Height - 8 feet

(4) Weight - 10,000 pounds

(5) Weight per linear foot
- 1,600 pounds/foot

(6) Floor contact pressure
- 50 psi



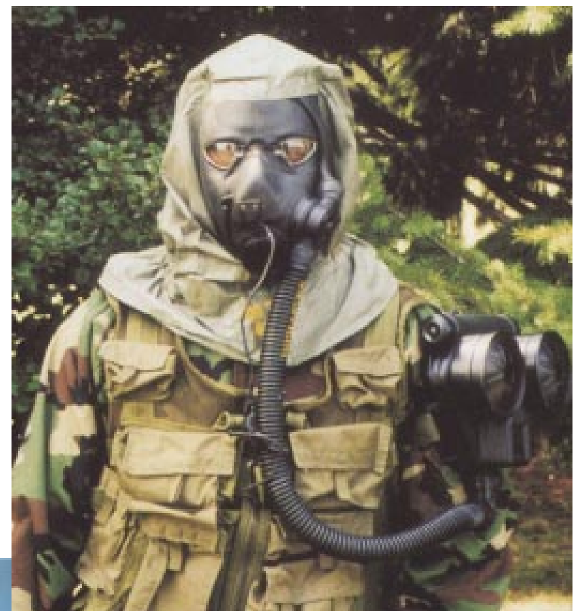
All items that qualify as a transportability problem item are required to have transportability approval prior to each major milestone decision.

Note: Items that are not on military units' tables of organization and/or equipment (TOE or T/E) and do not have a strategic deployment requirement are not considered transportability problem items and do not need transportability approval.

Go to Table of Contents

What is a Non-problem Item?

When an item does not qualify as a transportability problem item, it is termed as a "non-problem item." Non-problem items are not required to have transportability approval at each major milestone and MTMCTEA's involvement throughout the acquisition cycle is not required. It is the program manager's responsibility to determine if an item qualifies as a transportability problem item. If desired, a non-problem item statement will be provided by MTMCTEA, however, it is not necessary and this type of request is handled through email only and not through official correspondence. Sometimes a program manager has the desire to subject a system that does not qualify as a transportability problem item to transportability testing. In this case, the program manager should coordinate directly with the testers. MTMCTEA involvement is not required.



Go to Table of Contents

4 Acquisition Process

General

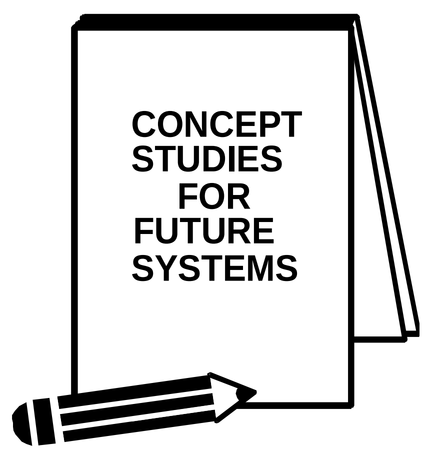
Transportability and Deployability must be a design consideration for all systems that meet the definition of a transportability problem item. This is regardless of the acquisition category or acquisition strategy, including modifications to existing equipment. Equipment being reprocured must be updated to reflect changes to the defense transportation system and to correct past deficiencies. Transportability and deployability must be addressed throughout the acquisition process to ensure maximum benefit for the fielded system. This chapter provides a discussion of how and where transportability fits into the acquisition process.

While transportability and deployability may be thought of as an integral part of system design in preparation for fielding, it is never too early to consider these issues as potential materiel solutions are being conceived. Both are an important part of the process of translating operational needs into stable, affordable programs. Size and weight constraints for transport should be a part of the earliest analyses of equipment alternatives. Delaying consideration will result in lost time and increased costs for later design changes.

Concept Studies

In today's environment of limited procurement budgets and changing threats, there is an increased emphasis on comprehensive analyses prior to the decision to initiate an acquisition program. Concept studies at this time should include the potential for meeting transportability and deployability mission needs, and how alternatives can best improve the utilization of transportation resources to improve force transport and deployment. These improvements should be a part of the decision supporting initiation of a new acquisition program.

With this in mind, MTMCTEA has developed modeling and simulation tools that provide the capability to address transportability and deployability throughout the acquisition process. These analysis tools result in improved up-front analyses and give concept developers the ability to conduct multiple analyses on different concepts and technologies in a timely manner. See Chapter 7, *Virtual Proving Ground - Transportability,* and Chapter 9, *Deployability,* for information on these analysis tools.



Go to Table of Contents

Equipment Acquisition

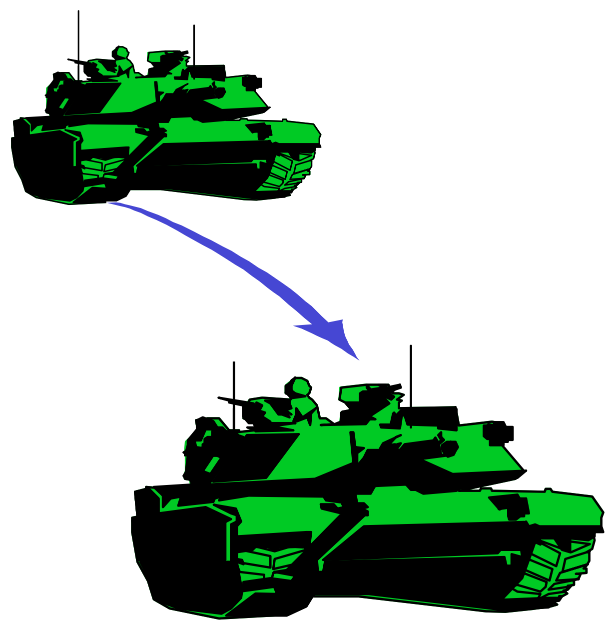
With the decision to initiate a new acquisition program, the transportability and deployability lessons from concept studies provide the basis to produce a system enhancing force transport and deployment. Transportability and deployability actions take place throughout the acquisition cycle. Each input and action is important to assure that the equipment being procured, as well as the associated support items of equipment, is capable of efficient transport and deployment. The omission of transportability and deployability at any time in the acquisition process, or tradeoff decisions that do not consider the full implications on transportability and deployability, can negate all previous efforts and advances made during the early stages of procurement.

While applicable throughout acquisition, the transportability and deployability status of an item should be updated prior to each milestone decision. However, this is too late to correct shortcomings prior to the milestone. This will determine corrections that must be made during the next acquisition phase. Considering transportability and deployability throughout the process will prevent shortcomings from being identifed at the milestone decision, as they are determined and the best correction implemented as a part of the development process.

Transportability approval establishes that the item of equipment meets transportability requirements established in the systems requirements document. Approval is required prior to the production decision for an item. Concurrence is also required in support of materiel release. This release ensures any modifications incorporated into the produced item have not adversely affected item transport and deployment.

Design Considerations

Many combat systems increase in weight during their life as product improvements are incorporated. This growth can adversely affect transport and deployment during the equipment's life by eliminating transport vehicles or increasing assets required for deployment. Consideration of potential improvements and allowing for them in the initial design can mitigate future transport degradation.



Acceptance of equipment sectionalization for transport should be closely considered. While it may be expedient to accept sectionalization as a means of accomplishing difficult design requirements and promoting a program, it adversely affects the receiving units when the required equipment preparation significantly increases their deployment and employment preparation. An item of equipment that can deploy in the configuration in which it will be employed should always be the goal in designing equipment for transport and deployment.

Go to Table of Contents

5 Requirements

General

Transportability requirements must be provided in all requirement documents for transportability problem items. Determining and then writing these requirements are essential to achieving the level of transport required of the item to perform its mission. The meaning of different transportability requirements and the limitations associated with each requirement are explained in this chapter.

Transportability Requirements

AR 70-1 states that transportability characteristics will be identified for all modes that could possibly be used to transport a new type of equipment. **AR 71-9**, *Materiel Requirements*, states that transportability must be included in all requirement documents. Simply including transportability, however, is not enough. The transportability requirements of an item to be procured must reflect the mission requirements of that item. For example, if an item has a rapid-deployment-type mission, it must be air transportable by C-130 in an operational configuration. The mission requirements must be known when the original need for the item is developed. Once these requirements have been developed, the determination of transportability requirements is simple. The options available for each mode when a transportability requirements statement is needed are explained in detail in this section.

Go to Table of Contents

Highway

Almost every item of military equipment, be it a self-propelled vehicle, a trailer, or cargo, uses the highway mode. All equipment (with the possible exception of aircraft and large marine craft) must be capable of highway transport. This is especially true of equipment with a rapid-deployment-type mission, since highway transport is essential to the delivery of equipment to the port of embarkation for deployment as well as within the theater of operations.

The optional statements for the highway portion of the transportability requirements statement for wheeled vehicles are provided below. Tracked vehicles and skid-mounted (or other) equipment must be included in the prime mover combination when highway transport restrictions are discussed.

The item must:

1. Meet U.S. and NATO countries' highway legal limits

The choice of this option means that highway transport would be almost unrestricted. This is the most restrictive, practical highway transport statement. The vehicle or loaded prime mover combination would have to be within both the U.S. and NATO size and weight limits listed in chapter 2.

2. Meet U.S. highway legal limits

The choice of this statement means that the vehicle or loaded prime mover combination could have the maximum dimensional and weight characteristics listed under the U.S. highway limits in chapter 2. Highway transport in the United States would be almost unrestricted, with only isolated States requiring permits for highway transport.

3. Be within the maximum permit limits established by the individual States

The choice of this statement means that vehicles or loaded vehicle combinations could exceed the legal limits for highway transport by obtaining permits for each move but could not exceed the maximum permit limits established by the States. This statement should be used only when the available prime movers already exceed the legal limits and only when there are no alternatives. The use of this statement will put an added logistic burden on the user.

Go to Table of Contents

4. Be highway transportable

This requirement provides no dimensional or weight restrictions for design as almost anything can be highway transported, given enough time and money. The choice of this statement means that a contractor could design a vehicle or have a loaded prime mover combination that exceeds established permits limits, and require certification as essential to national defense (chap 2). Highway transport that requires certification as essential to national defense at best severely limits highway transport, and does not ensure highway transport will be allowed. This statement should be used only when highway transport is desired but is not critical to mission accomplishments. Instead, requirements that place specific limits on design based on past experience and knowledge of planned operating areas should be used, as in the following statement.

5. Be highway transportable, with a turning radius of [50 feet], a maximum gross weight of [130,000 pounds], a maximum single axle load of [25,000 pounds], and a maximum tandem axle load of [45,000 pounds]

Note: Tailored to meet specific operating restrictions.

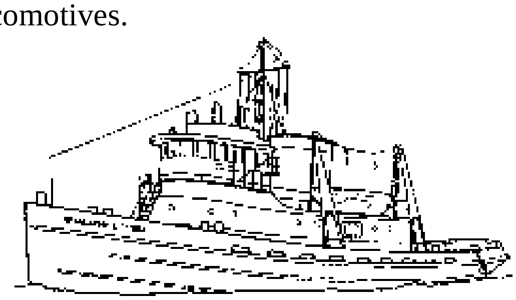
The choice of this statement means that a contractor could design a vehicle or have a loaded prime mover combination that exceeds established permit limits and may require certification as essential to national defense (chap 2). However, the design is more constrained than if Statement 4 were used. This statement should be used only when other requirements make it impossible to design equipment that meets highway permit limits and it is known that the equipment will be based at a specific installation and deployed through a specific port. Then the equipment can be designed to meet the constraints of a specific highway route. However, it may not be readily transportable on other highways if future operational plans change.

6. Be transportable on/by *(specify)* transport vehicle

The choice of this statement means that the size and weight of the item of equipment would be limited to the dimensional and weight capabilities of a specific transport vehicle.

7. Highway transport not required

This statement should be used only when the item of equipment will never require highway transport. This statement should apply only to extremely large items, such as barges or locomotives.



Go to Table of Contents

Rail

The rail mode, like the highway mode, is used to transport almost every item of military equipment (except aircraft). During deployment, most military equipment will be transported by rail from installations to ports of embarkation and from ports to inland areas once the theater of operations has been reached. Therefore, rail transport is essential to deployment.

The optional statements for the rail portion of the transportability requirements statement are provided below. Only standard-gauge rail transport is covered by this example. Verification of suitability for rail transport may be required through testing, modeling and simulation, or analysis.

The item must:

1. Meet the GIC (Gabarit International de Chargement) outline diagram

The choice of this statement means that rail transport on standard-gauge rail lines will be almost unrestricted worldwide (chap 2).

2. Meet the Envelope B outline diagram

The choice of this statement means that rail transport in Europe will be possible, but with limitations. These rail lines generally connect major population centers and most locations important for DOD use. Envelope B is slightly higher and wider than the GIC outline diagram (chap 2).

3. Meet the AAR (Association of American Railroads) outline diagram

The choice of this statement means that rail transport in North America will be almost unrestricted. The AAR outline diagram is higher and slightly narrower than the Envelope B outline diagram (chap 2).

4. Meet the DOD clearance profile

The choice of this statement means that rail transport in the United States will be limited to the Strategic Rail Corridor network (STRACNET) and a limited number of other rail lines. STRACNET provides rail service to all U.S. locations important for DOD use. Even on these rail lines, surcharges, operations at restricted speeds, and other limitations may be necessary. Transportation over foreign rail lines may not be possible. The DOD clearance profile is higher and wider than the AAR outline diagram and Envelope B outline diagram (chap 2).

5. Be rail transportable

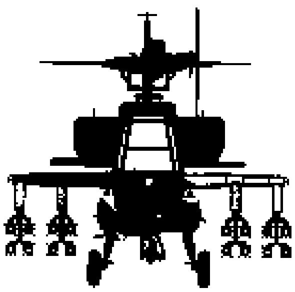
The choice of this statement means that a contractor could design an item of equipment that would always require special routing or special provisions for rail transport. Rail transport might not even be possible over the rail lines that would actually have to be used in a contingency. Therefore, this statement should not be used, because it provides no limits for rail transport. Rail transport is very likely to be

Go to Table of Contents

impractical for items that do not meet the DOD clearance profile.

6. Rail transport not required

This statement should be used only when the item of equipment will never require rail transport. This should apply only to extremely large items, such as watercraft, or to very sensitive or delicate equipment, such as aircraft.



Marine

All military equipment (except self-deploying aircraft) must be capable of water transport because most equipment in a strategic deployment will be transported by ship. Equipment must be capable of transport on barges and tactical watercraft. This capability will ensure the equipment can be deployed in LOTS (logistics-over-the-shore) operations.

The optional statements for the water portion of the transportability requirements statement are as follows:

The item must:

1. **Be marine transportable on** *(choose the smallest lighterage required to transport the item: LARC-LX, LCM-8, LCU-1646, or LCU-2000)* **and larger vessels/ships.**

The LARC-LX has the same payload capability as the LCM-8, but the cargo area is slightly smaller. Therefore, requirements documents should usually require items to be marine transportable on the LARC-LX and larger vessels.

The choice of this statement specifies the smallest watercraft on which the item of equipment must be capable of being transported and covers all larger vessels/ships.

2. **Be transported by commercial ships**

With the commercial emphasis on intermodal transport, effective transport on commercial ships requires compatibility with intermodal containers and flatracks (chap 2).

3. **Marine transport not required.**

This statement can only be used if marine transport will never be required. Since all military equipment must be capable of marine transport, the only equipment that would not require marine transport would be self-deploying aircraft and marine vessels or towed barges/vessels.

Go to Table of Contents

Air (Rotary Wing)

Rotary-wing aircraft are used primarily for short-range tactical transport missions. The rotary wing mission requirements and estimated weight of the equipment should be known before specifying rotary wing transport. This is because the lift capability of helicopters depends on several factors, including temperature, altitude, and amount of fuel in the aircraft.

The optional statement for the rotary wing portion of the transportability requirements statement is provided below.

The item must be transportable in/by the:

a. UH-1 *(externally)*
b. UH-60 *(externally)*
c. CH-47 *(specify internally, externally, or both; if externally, specify by single-point or dual-point lift or both.)*
.... and meet MIL-STD-913 ***(when*** *external air transport is a requirement).*

These are the only rotary-wing aircraft in the active Army that can routinely transport equipment. Other rotary wing aircraft in the inventory of the Department of Defense that can transport equipment are the CH-46, CH-53, and MV-22 (operational after 2001) cargo helicopters.

Transport must be accomplished in the: (*specify scenario, see chap 2)***.**

The “high-hot” scenario provides the greatest flexibility in operations and should be selected unless the operational mission of the equipment limits its use only to areas meeting either of the other scenarios.

Go to Table of Contents

Air (Fixed Wing)

Fixed-wing aircraft transport is the most important mode in terms of rapid strategic mobility. The four U.S. Air Force (USAF) prime mission cargo aircraft are the C-130, C-141, C-17, and C-5. The C-130 is a tactical (intratheater) aircraft; the C-141 and C-5 are strategic (intertheater) aircraft. The C-17 can support tactical or strategic missions; however, it is unlikely to be used to transport items into landing fields that would place the aircraft at risk. Equipment with a rapid-deployment-type mission must be air transportable in an operational configuration in the C-130 aircraft. The optional statements for the fixed-wing air portion of the transportability requirements statement are provided below.

The item must:

1. **Be air transportable in the** *(choose as many as required)*

   a. **C-130**
   b. **C-141** *(this aircraft will be retired in 2006)*
   c. **C-5**
   d. **C-17**
   e. **CRAF (Civil Reserve Air Fleet)** *(choose the aircraft required to transport the vehicle: B-747, DC-8, DC-10, MD-11, L-1011)*

This statement specifies which aircraft are required. It is essential that the aircraft required are listed in the requirements document (see chap 2 for aircraft limitations).

2. **Meet MIL-HDBK-1791**

MIL-HDBK-1791 is the military standard that states the requirements for air transport in USAF cargo aircraft. This statement must be added if C-130, C-141, C-5, or C-17 transport is required.

3. **Be air droppable from** *(choose the required aircraft: C-130, C-141, C-5, C-17)* **aircraft and meet MIL-HDBK-669 and MIL-STD-814**

This statement should be used when airdrop from USAF aircraft is required (see chap 2 for limitations).

4. **Be air transportable without the need for load spreading or approach shoring**

This statement should be used when vehicles must be loaded and unloaded in a roll-on/roll-off operational configuration for quick-reaction-type forces. Load spreading and approach shoring add both time and logistic burdens to air transport requirements and should be avoided whenever possible.

Go to Table of Contents

5. At least *(specify number of items)* **shall be capable of worldwide strategic transport in one** *(specify model of aircraft)*

6. *(If equipment is a system):* **Be capable of worldwide strategic transport by no more than** *(specify number and model of aircraft)* **sorties**

This statement means that a limitation is set on a number of sorties required to transport a system, thereby restricting the total size of the system.

7. Be reduced/disassembled to transport configuration in *(specify)* **minutes by** *(specify)* **personnel**

8. Be reassembled to operational configuration in *(specify)* **minutes by** *(specify)* **personnel**

These two statements set maximum times and personnel requirements for assembly and disassembly required for transport. Setting these maximums limits the amount of disassembly required for transport, thereby ensuring that the equipment will be capable of transport and be capable of operation shortly after disassembly or assembly begins. This eases the logistic burden on the deploying unit as well as decreases the time required to deploy. (Disassembly, however, introduces the possibility that parts may be lost during transport, thus preventing reassembly at the final destination.)

9. Be reduced/reassembled from/to operational configuration without disconnecting flight control surfaces or requiring a maintenance test flight

This statement minimizes helicopter assembly and disassembly required for air transport. It eliminates the requirement for a maintenance test pilot at the port of debarkation, easing the logistic burden on the deploying unit as well as decreasing the time required to deploy.

10. Air transport is not required

This statement should be used only when the item of equipment will never require air transport. This should apply only to extremely large or heavy items that could be deployed only by ship.

Go to Table of Contents

Containers

Military equipment should be transportable in ANSI/ISO containers or flatracks where practical so that the intermodal benefits of containerization can be realized and container ships can be more effectively used to support deployments. The following would be the container portion of the transportability requirements statement.

- **The item must be transportable in ANSI/ISO containers/flatracks** *(specify size, see chap 2).*

Lifting and Tiedown Provisions

All equipment must have adequate lifting and tiedown provisions since these provisions are essential to efficient transport. Vehicles must have provisions designed for the gross vehicle weight (fully loaded vehicle). All transportability requirements statements must contain the following lifting and tiedown statement.

- **The item must have lifting and tiedown provisions that meet the requirements of MIL-STD-209.**

If external air transport (EAT) is required, the item's lifting provisions must also comply with **MIL-STD-913**.

Go to Table of Contents

General Requirements

Other general transport requirement statements that could be included in the transportability requirements statement are listed below.

The item must:

- Reduce/not increase deployment transport requirements of the receiving military unit(s).

The choice of this statement dictates that an item (or system) must not be larger or heavier than the item (or system) it replaces.

- Be transportable at its maximum gross vehicle weight (GVW) during *(choose mode(s))* **- highway, air, rail, marine, or all-mode transport.**

The choice of this statement ensures that the equipment can be transported at its maximum operational weight by all or by specific modes. All equipment should be capable of all-mode transport at its GVW.

In certain situations, other statements may be specified to ensure transportability.

Go to Table of Contents

6 Transportability Approval

General

Transportability approval is required by **AR 70-1 and AR 70-44/47**. This chapter provides a discussion on which items need transportability approval, how approval is requested and obtained, and what data are required for approval.

Transportability Approval

Developing efficiently and economically transportable equipment and combat resources will be an integral part of the acquisition process. Transportability is a critical element of strategic and tactical deployment. When strategic and tactical deployment is a system requirement, transportability will be a primary system selection and design factor.

The required type of transportability (worldwide highway, rail, air, marine) together with any special requirements for contingency forces, airdrop, helicopter lift, and tactical transport will be explicitly stated in the requirements documents, purchase descriptions, and specifications. MTMCTEA will review requirements documents for systems classified as transportability problem items (see chap 2).

Throughout the acquisition process, MTMCTEA monitors equipment that qualifies as a transportability problem item and concurs at major milestone decisions if the equipment meets its transportability requirements.

AR 70-44/47 requires transportability approval before major milestone decisions. The procedures and requirements for this approval are explained in **AR 70-44/47**, *DOD Engineering for Transportability.* This chapter briefly explains how approval is requested and obtained, and what data are required for MTMCTEA to conduct a transportability engineering analysis.

Go to Table of Contents

How is Transportability Approval Requested and Obtained?

The materiel developer requests transportability approval from the service transportability agent (MTMCTEA for Army systems). A transportability report containing the characteristic data required by **AR 70-44/47** should be sent to MTMCTEA at least 90 days before approval is needed. MTMCTEA then will perform a transportability engineering analysis of the item to determine if the requirements have been met. If they have been met, approval will be granted.

Transportability Report

What is a Transportability Report?

It is a report listing all the characteristic data for a transportability problem item. The transportability report provides all information necessary to perform a comprehensive transportability engineering analysis of problem items. This report is submitted to MTMCTEA by the materiel developer (or a field unit). The following information and format (taken from **AR 70-44/47**) is required in a transportability report. This information may be obtained by invoking data item description **DI-PACK-80880A**, *Transportability Report*, in contracts.

Format for Transportability Report

(1) Title. TRANSPORTABILITY REPORT.

(2) Contractor name and location.

(3) Date of transportability report.

(4) Official nomenclature.

(5) National stock number (if assigned).

(6) Line Item Number (if assigned).

(7) Brief description.

(a) Intended use.

(b) List whether commercial, modified commercial, non-developmental, developmental, reprocurement, or modified equipment.

(c) Specify type of military units that will use or transport the item.

(d) State whether for worldwide use or for specific theater of operations. List specific theater of operations in priority order.

(8) Modes of transportation. Provide the transportability requirements from the Operational Requirements Document or Purchase Description, or answer paragraphs (8)(a)-(8)(f).

(a) Highway. Specify if item is:

1. Self-propelled.

2. Towed.

3. Transported by truck or semitrailer. Give model numbers of required transporter(s) (for example, M920/M870, M1070/M1000, M1097).

(b) Rail. State if item will require rail transport in the United States and overseas areas. State foreign country, or countries, where rail transport is required.

(c) Ocean and waterways. State if item will require transport by ocean or waterways and provide the following information:

1. State if items will be shipped overseas in volume (unit) movements.

2. State if on-deck storage is permissible.

3. State type(s) of ship(s) (for example, breakbulk, container, roll-on/roll-off, LASH, SEABEE, waterway barge or boat).

(d) Lighterage. State the smallest lighter to be used if item is used in the logistics-over-the-shore (LOTS) environment.

(e) Air. State if item will require transport by air and provide the following information:

1. State the type(s) of fixed-wing aircraft transport required. (Air Force aircraft are C-130, C-141, C-17, and C-5.) (Civil Reserve Air Fleet (CRAF) cargo aircraft are B-747, DC-8, DC-10, MD-11 and L-1011.)

2. State the model number(s) of cargo helicopter(s) required. (Army utility/cargo helicopters are the UH-1, UH-60, and CH-47.) (Marine Corps helicopters are the CH-46 and CH-53).

3. State if internal or external helicopter airlift (or both) is required. External airlift includes aerial recovery of damaged and undamaged items of equipment (vehicles or aircraft).

4. State the helicopter mission requirements (time and distance of mission, atmospheric condition requirements - 95° F at 4,000 feet, 60° F at sea level, and so forth).

5. State if internal or external airlift (or both) is required by tiltrotor aircraft (Marine Corps MV-22 will be operational after 2001). External airlift includes aerial recovery of damaged and undamaged items of equipment (vehicles or aircraft).

(f) Intermodal containers. State the following information:

1. Length of the container(s) required (for example, 10, 20, 24, 30, 35, 40, or 45 feet).

2. American National Standards Institute/International Organization of Standardization (ANSI/ISO) designation of container(s) required.

(g) Specialized service and MHE to support movements. State if special railcars, highway vehicles, or materials handling equipment are required (bilevel or trilevel railcars, shock mitigation system, spreader bars, slings, forklifts, cargo loaders, and so forth).

(h) Planned quantity. State item acquisition quantity by fiscal year.

Go to Table of Contents

(i) Hazardous materials. For each item classified as hazardous material, state:

1. The class of hazardous material as specified in: *Title 49, Code of Federal Regulations* (49 CFR), Parts 100-179, *Transportation;* **AFJMAN 240-204**, *Preparing Hazardous Materials for Military Air Shipments;* International Maritime Organization (IMO), *International Maritime Dangerous Good (IMDG) Code*; or the United Nation's *Recommendation on the Transportation of Dangerous Goods.*

2. DOT proper shipping name.

3. Net explosive weight (DOT class A or B explosives only).

4. Venting requirements.

5. Grounding requirements.

6. Any other than above.

(j) Sectionalization. State if the item can be sectionalized, folded, or reduced for transport. All data specified in this report that are required for the operational problem item are required for each component(s) or subassembly that exceeds the criteria outlined in paragraph 4.4 of **MIL-STD-1366** (see chap 3 of this pamphlet). Provide the additional information in paragraphs (j)1-(j)2 for all components or subassemblies that meet the criteria of a transportability problem item. Provide the length, width, height, and weight of each sectionalized component that does NOT meet the criteria for a transportability problem item.

1. Time and personnel required to disassemble at departure site and reassemble at destination (Time: in work and clock hours).

2. Special equipment or tools required for sectionalization (for example, cranes, forklifts, wrecker trucks, pallets, nitrogen, hand tools, calibration equipment, or fixtures).

(k) Modeling and simulation (when required). Provide computer aided design (CAD) models of the equipment to support structural, kinematic, and dynamic analyses of the transportation environment, or provide results of CAD transportation analyses performed by the contractor. See **MIL-STD-209** and **MIL-STD-1366** for modeling and simulation requirements.

(l) Transportability tests. A copy of test report(s) (or test plan and scheduled date(s) if not completed) shall be included as a part of this report, when available.

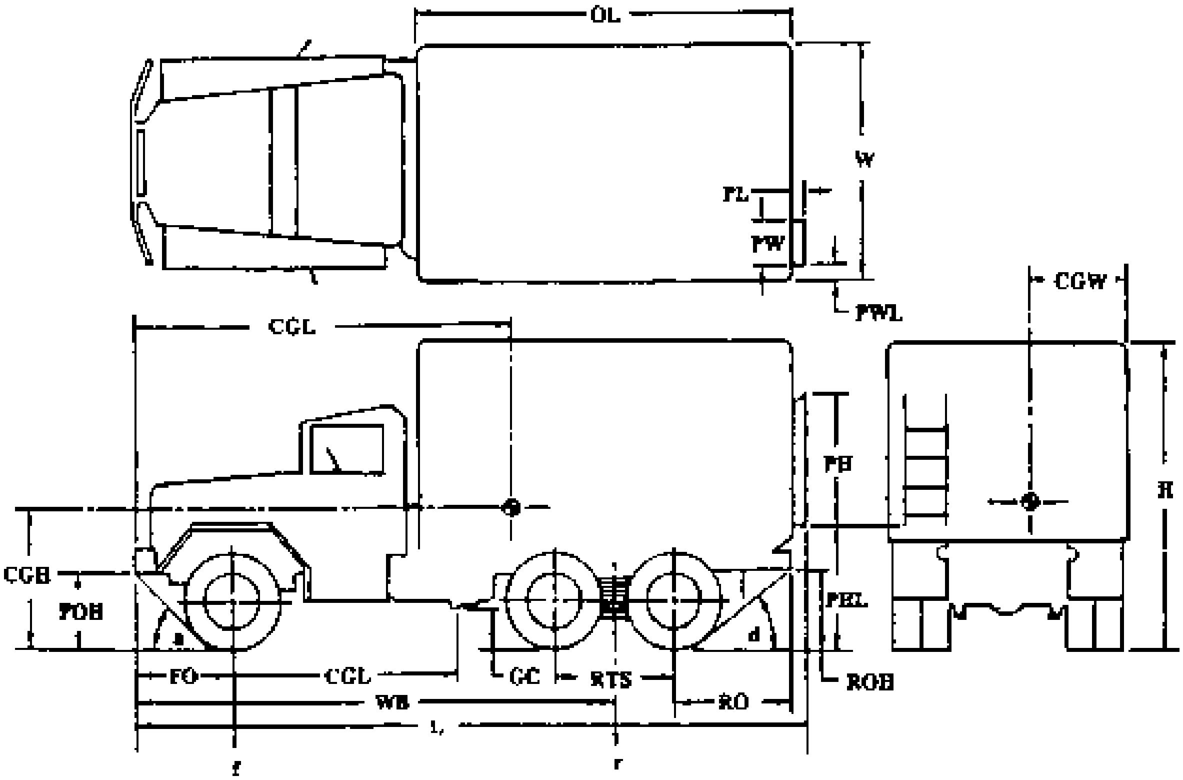
(m) Speed requirements. State self-propelled or towed speed limits.

(n) Shipping data. A paper copy of shipping data plate that will be secured to the vehicle shall be included with this report, when available (see **MIL-STD-209**).

(o) Transport configuration for wheeled vehicles, tracked vehicles, and skid-mounted equipment. Two sets of data are required: one for the fully operational configuration (includes fuel, lubricants, water, and so forth), and one for the shipping (reduced or sectionalized) configuration.

1. Drawings (required if CAD models are not provided (see (k))). Indicate top, plan, side, and end view configurations on a **MIL-DTL-31000** or similar engineering drawing(s). Hardcopy or electronic files are acceptable. Drawings must include all data as shown in figure 1, 2, or 3 (length, width, height, and location of Center of Gravity (CG)) on all three views).

Go to Table of Contents

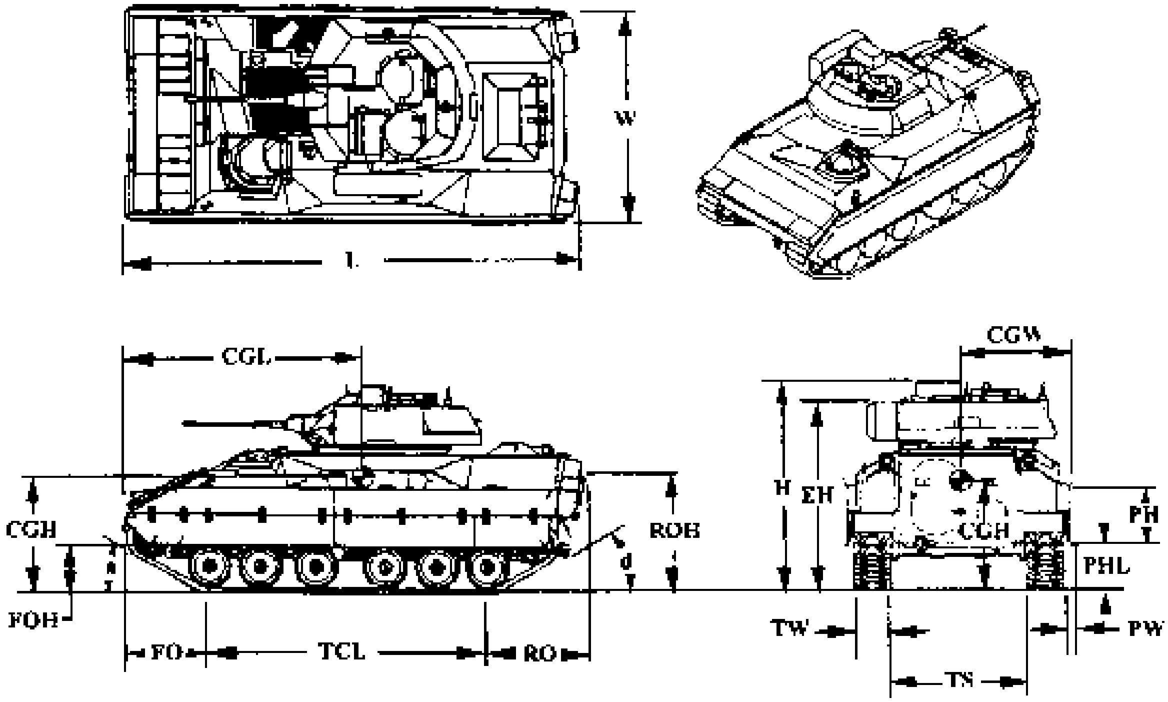


OL - Overall Length Body
W - Overall Width
PW - Projection Width
PWL - Projection Width Location
PH - Projection Height
PHL - Projection Height Location
PL - Projection Length
H - Overall Height
L - Overall Length
CGL - Center of Gravity Length
CGW - Center of Gravity Width
CGH - Center of Gravity Height

WB - Wheel Base
FO - Front Overhang
FOH - Front Overhang Height
RO - Rear Overhang
ROH - Rear Overhang Height
GC - Ground Clearance
GCL - Ground Clearance Location
RTS - Rear Tire Separation
a - Angle of Approach
b - Angle of Departure
F - Front Axle Load
r - Rear Axle Load

Figure 1. Wheeled Vehicle Dimensions

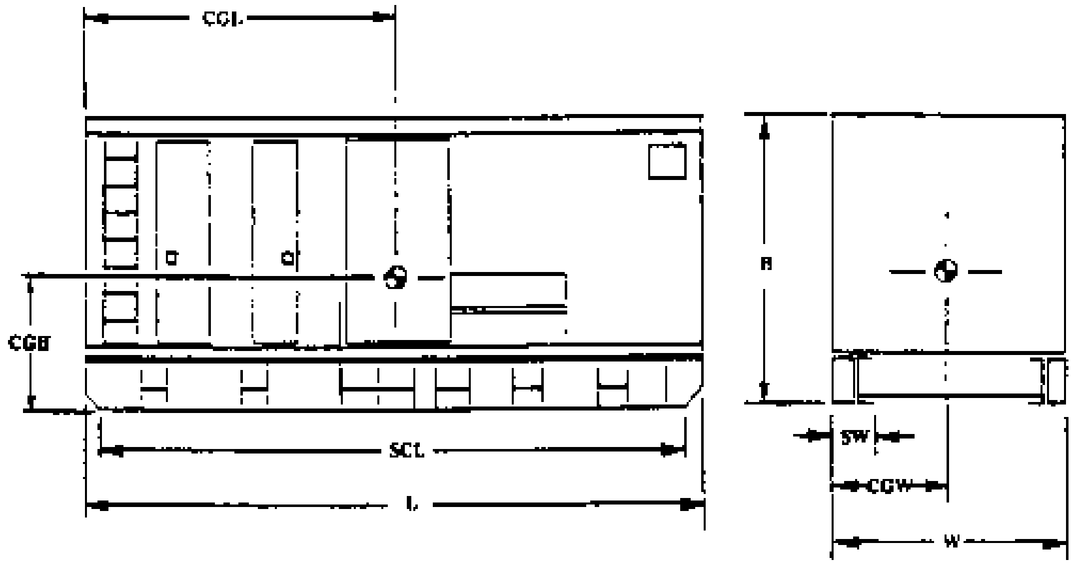
Go to Table of Contents



H - Overall Height	ROH - Rear Overhang Height
W - Overall Width	TW - Track Width
L - Overall Length	PH - Projection Height
CGL - Center of Gravity Length	PW - Projection Width
CGW - Center of Gravity Width	PHL - Projection Height Location
CGH - Center of Gravity Height	TS - Track Separation
TCL - Track Center Line	EH - Edge Height
FO - Front Overhang	a - Angle of Approach
RO - Rear Overhang	D - Angle of Departure
FOH - Front Overhang Height	

Figure 2. Tracked Vehicle Dimensions

Go to Table of Contents



SCL - Skid Chamber Length
SW - Skid Width
L - Overall Length
W - Overall Width
H- Overall Height
CGL - Center of Gravity Length
CGW - Center of Gravity Width
CGH - Center of Gravity Height

Figure 3. Skid-Mounted Item Dimensions

2. Weight. State curb weight and maximum gross weight, and any other intermediate weights for special configurations required to meet specific transport requirements (that is, fixed-wing air transport or helicopters in transport).

3. Lifting and tiedown provisions. State the number, location, and strength (yield and ultimate) of lifting (including aerial recovery) and tiedown provisions for the item and major components removed for transport. Identify the location of hardpoint lifting provisions provided for aerial recovery (if required). State if the lifting provisions meet criteria of **MIL-STD-209** and interface with all standard aerial recovery and sling components. Dimensional location of lifting and tiedown provisions (with respect to the CG) shall be shown in each view required in figure 1, 2, or 3.

4. Projections. State the dimensions and locations of any significant projections (for example, environmental control units, ladders, antennas, shelters, and so forth).

5. Load classification number. State the military load classification number (see **FM 5-170**):

a. Load classification number - curb weight.

b. Load classification number - maximum gross weight.

(p) Additional information required for **wheeled** vehicles.

1. Weight ratings. Specify the gross vehicle weight rating (GVWR).

Go to Table of Contents

2. Tires. State the number, size(s), number of plies, load rating(s), locations, and inflation pressure of tires.

3. Axle loads. State the axle loads for each axle for the following:

a. Empty vehicle.

b. Loaded vehicle.

4. State axle ratings for each axle.

5. Suspension ratings. State load ratings for each suspension.

6. Crest angle. State the angle (in degrees) connecting two horizontal surfaces that the vehicle can pass (crest) without interference (fig 4).

7. Tire footprint area. State the locations and dimensions of all tire footprint areas actually in contact with the ground in the fully loaded condition (fig 5).

8. Axle tracking width. State the tracking width of each axle (fig 6).

9. Vehicle turning diameter. State the vehicle turning diameter for the following:

a. Wall-to-wall.

b. Curb-to-curb.

(q) Additional information required for **tracked** vehicles.

1. Track pads. State the area and number of track shoe pads actually in contact with the ground (fig 7).

2. Ground pressure. Specify the ground pressure created by the heaviest pad (pounds per square inch). State the weight supported by each road wheel.

(r) Additional information required for **skid-mounted** equipment.

1. Skids. Information on skids shall include the following:

a. Number of skids.

b. Dimensions of all skid areas actually in contact with the ground.

(s) Subsystems or Modifications. For subsystems, support equipment, and modifications identified in paragraph (7)(b) above, this report shall contain all information pertaining to the applicable subsystem and identification of the primary system(s) affected.

(t) Identification. Include the name, title, organization, or department of individual preparing the report and the date of preparation.

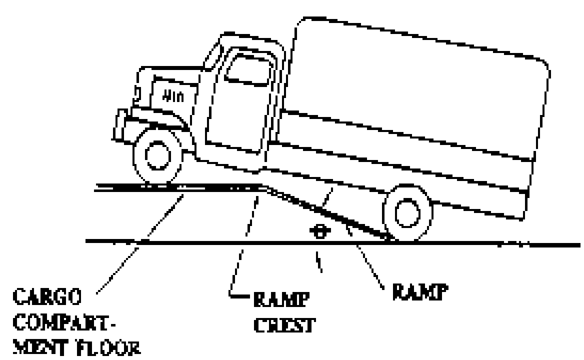
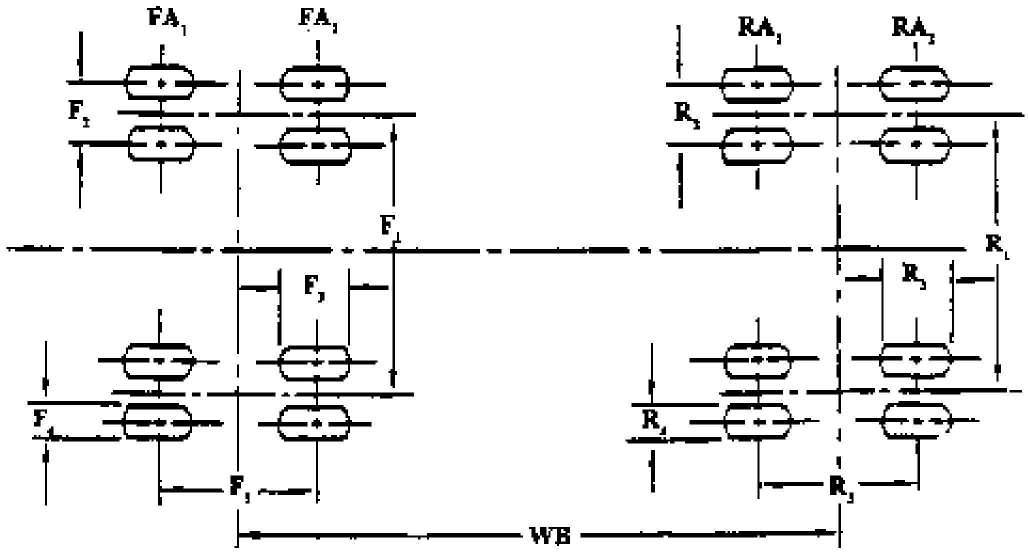


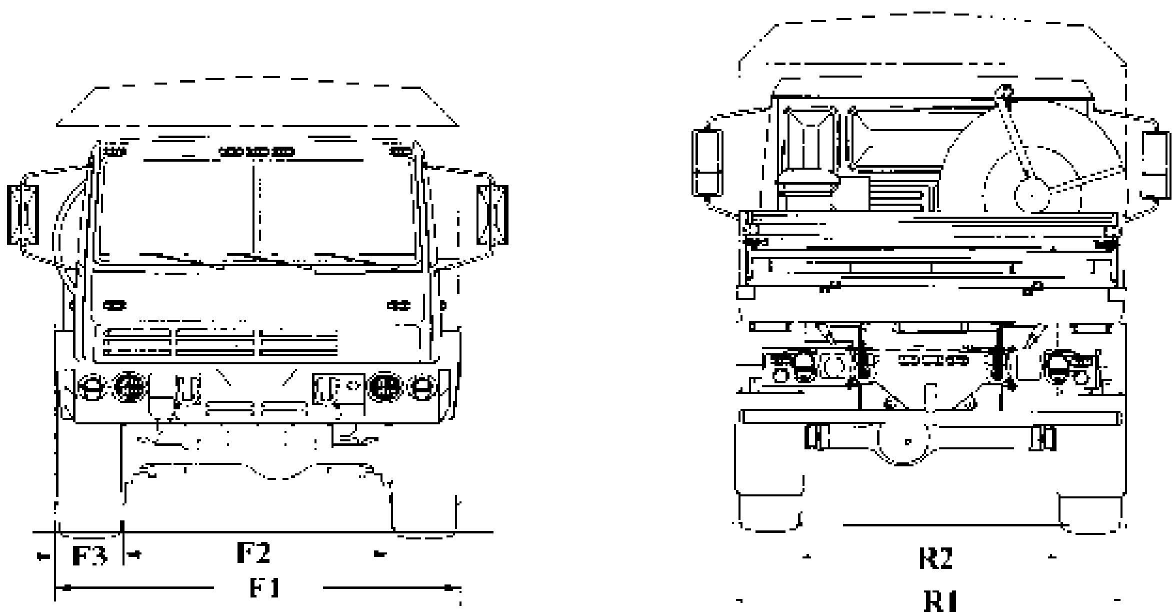
Figure 4. Ramp Crest Angle

Go to Table of Contents



FA - Front Axle
RA - Rear Axle
WB - Wheel Base

Figure 5. Tire Footprint Locations and Dimensions



F1 - Outside Distance F2 - Inside Distance
F3 - Tire Width R1 - Outside Width
R2 - Inside Distance

Figure 6. Tracking Width

Go to Table of Contents

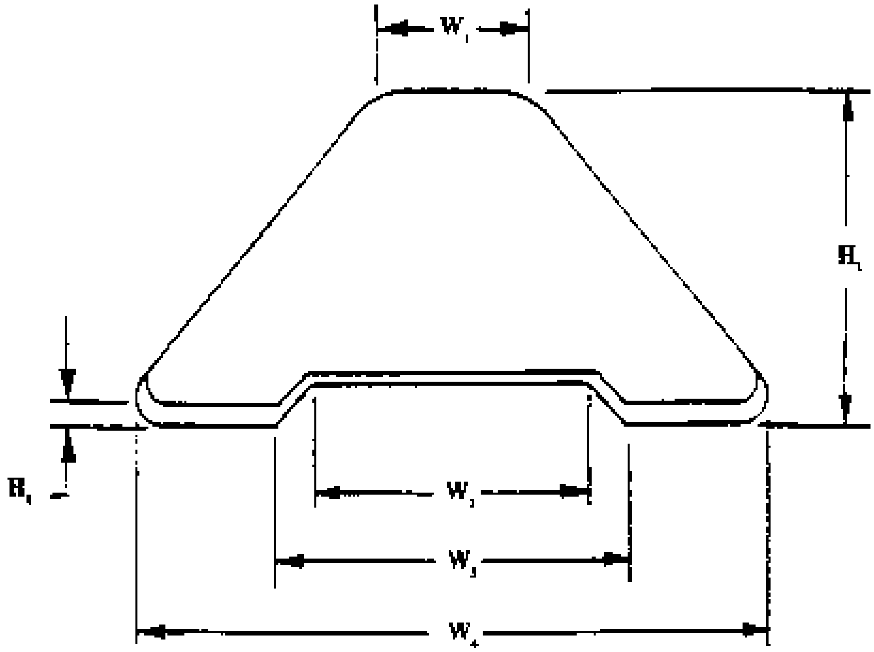


Figure 7. Track Shoe Pad Dimensions (footprint data)

Go to Table of Contents

7 Virtual Proving Ground - Transportability

Due to the rapid growth in computer technology and decreasing Department of Defense (DOD) resources, modeling and simulation (M&S) is becoming more prevalent. To provide better transportability engineering support, MTMCTEA has implemented the Virtual Proving Ground for Transportability (VPG-T) analysis. VPG-T is a combination of Computer-Aided Engineering (CAE) modeling tools implemented by commercial software, and linked to the U.S. Army Test and Evaluation Command's (TECOM) Virtual Proving Ground concept. MTMCTEA engineers use VPG-T to simulate and analyze military equipment in various transportation scenarios and test environments. Conducting transportability testing and analysis in software early in the acquisition process facilitates successful design for transport, thus reducing costly test failures and redesign cycles. The result is better equipment design at reduced costs, risks and schedules. Three functional areas of the program are described in the following sections.

Three-Dimensional (3D) Modeling

Engineers use 3D modeling software to model transportation configurations of military equipment (for example, cargo aircraft density loadings, rail tiedown configuration, lift configurations, and so forth.) The engineers can quickly and accurately determine cargo-transporter incompatibilities and provide design guidance and alternatives. Advanced visualization and video capabilities provide an informative means of illustrating results, such as transport procedures and interference issues.

Multibody Dynamic Analysis

Engineers use multibody dynamics to simulate the motion and forces experienced by mechanical systems in shock and vibration and other load-intense transportation environments. Available models include rail impact testing, crane lifting, and aircraft loading. Predicted forces and accelerations from rail impact and crane lift simulations provide design criteria, and can be applied to vehicle structural models to assess strength compatibility. Aircraft loading simulations apply motion to 3D equipment and cargo hold models to animate the loading processes and provide detailed analysis of clearances.

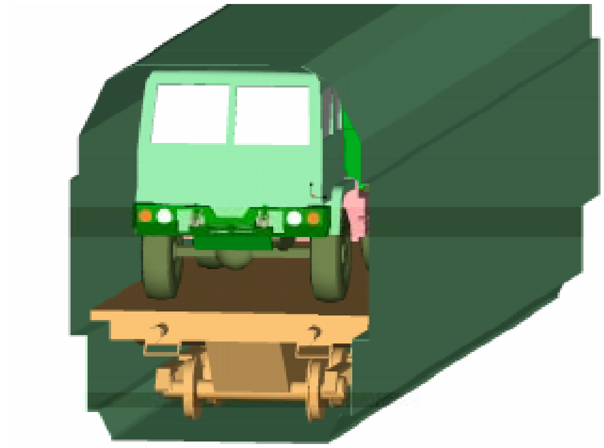
Structural Analysis

Engineers create detailed models of equipment and parts to analyze their structural integrity under various loading scenarios using commercial Finite Element Analysis (FEA) software. Our focus has primarily been on lifting and tiedown provisions but includes all aspects of the equipment, as well as feasibility studies. This capability provides a means to identify potential problem areas and provide corresponding workable solutions. By analyzing transport loading scenarios, MTMCTEA is able to facilitate successful equipment and part design very early in the process, reducing the number of failed field tests and actually eliminating the need to test in certain cases.

Go to Table of Contents

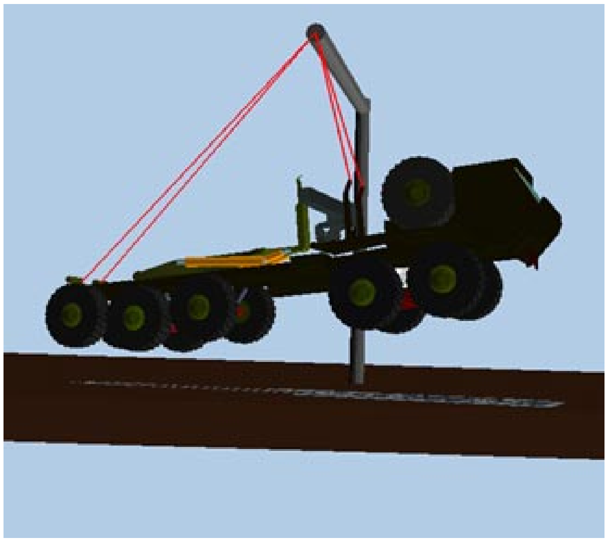
Typical Applications

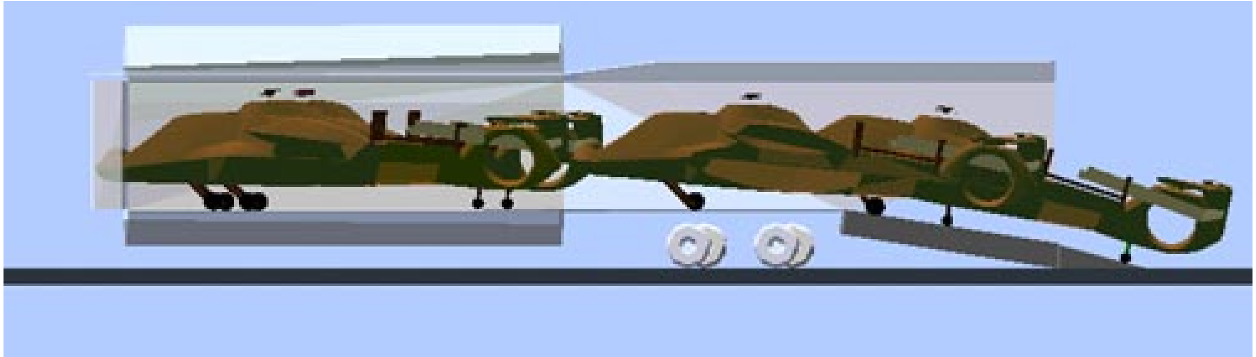
Rail Clearance Analysis - Use of 3D Modeling to compare a vehicle's dimensional characteristics to various rail envelope profiles and railcars for strategic rail lines used in deployment.



Aircraft Loading Analysis - Use of 3D modeling and kinematic simulation to evaluate clearance and suitability of loads and loading procedures. High-precision models of each aircraft (C-130, C-5, and C-17) are used for aircraft loading analyses. These aircraft models were created from digitized data of the interior of each type of aircraft. By using these high-precision aircraft models, we have a higher degree of confidence in the accuracy of our analyses since these models represent the true interior of the aircraft and are not based on published clearance drawings.

Lifting and Tiedown Analysis - Use of 3D modeling and dynamic simulation to evaluate for interference and determine actual sling and contact loads of lifted items. Structural analysis is used to evaluate the ability of equipment to withstand actual lift or contact loads, as well as the **MIL-STD-209** test requirements for lifting and tiedown provisions.





Go to Table of Contents

Rail Impact Analysis - The rail impact test is a severe, shock-intensive test that ensures military equipment is sufficiently designed for safe and efficient rail transport. This test is normally reserved for the last test in the test plan, as it frequently results in damaged equipment. Personnel at MTMCTEA, the Army's transportability agent, have developed a highly refined multibody dynamic model of this test. This model is a validated tool in the Army's Virtual Proving Ground concept.

Engineers use the rail impact test model to simulate loads and accelerations experienced during rail transport and in support of the rail impact test. The loads generated from the rail impact test are then applied to the equipment using structural analysis to evaluate integrity of the equipment.

Other - 3D modeling and structural analysis is also used to resolve field transport issues, such as the design and evaluation of a platform container, rail ramp and container ramp for loading and transporting military equipment.

To obtain transportability simulation support, including rail impact simulation, tiedown and lifting design/evaluation, and aircraft loading simulation, please contact your MTMCTEA Transportability Engineer.

Go to Table of Contents

Model Requirements for Analysis in the Virtual Proving Ground for Transportability (VPG-T)

The following paragraphs describe the system models required for conducting typical VPG-T simulations. Files can be transferred to MTMCTEA via file-transfer-protocol (ftp), CD or magnetic tape.

3D Modeling

To conduct transportability clearance and transporter compatibility analyses for a vehicle or other item of equipment we require three-dimensional computer-aided design (3D CAD) models. Preferred format is the current commercial version of Pro-Engineer from Parametric Technology, Inc. We also accept Initial Graphic Exchange Specification (IGES) translations. In absence of 3D CAD models we can build models from engineering drawings of the equipment.

Structural Analysis

To conduct a structural analysis of **MIL-STD-209** provision pull testing and **MIL-STD-810** rail impact loading we require detailed design information (3D CAD model or engineering drawings) of the tiedown and lifting hardware and supporting structures. We also require material property data including Poisson's ration, minimum yield strength, and tensile strength. Structural analyses performed by outside sources must be submitted for review to verify loading and constraint validity to meet the requirements of **MIL-STD-209**.

Multibody Dynamics

To conduct a **MIL-STD-810** rail impact test simulation or other dynamic simulations we require a multibody dynamic vehicle/system model including chassis and suspension, and appropriate mass and inertial properties of related components, and locations of vehicle tiedown and lifting provisions. Preferred format is the current commercial version of DADS (Dynamic Analysis and Design System) software from LMS CADSI, Inc. using the "INCHES" system of units. In the absence of a DADS model, we can build a model from stereolithography (.slp) files or engineering drawings and specifications. Data required to build the dynamic model include masses, CGs, inertial properties, locations and dimensions of rigid bodies, joint locations and suspension data (type, dimensions, mass properties, spring and damping characteristics, and constraints).

3D Model Database

MTMCTEA maintains a 3D Model Database that contains detailed models of military and commercial equipment used for transportability and deployability simulations and analyses. These can be downloaded from our web page at www.tea.army.mil/dpe/3dmodels.htm.

The files available for downloading have an extension of .prt or .igs. The .prt file is a Pro/Engineer CAD part file of the model. The .igs file is an IGES file for importation into other CAD packages.

Go to Table of Contents

8 Transportability Testing

General

Transportability testing may be required during the acquisition cycle as a part of Developmental Testing (DT). Simulated testing, as described in Chapter 7, may be substituted for some physical testing. However, if the simulated test results indicate that the equipment will fail or marginally pass the test, a physical test will be required (if design changes are not made to the equipment). If physical testing is required, test procedures should be coordinated with MTMCTEA at least 30 days before the test date. MTMCTEA should be notified of the exact test time and location at least 5 days before the tests. Transportability tests should be witnessed by MTMCTEA or other approved Government personnel. The ability of an item to withstand the rigors of transport may be demonstrated by:

- Lifting and tiedown provision strength test
- Helicopter lift test (internal and/or external)
- Air Force aircraft test loading
- Airdrop test
- Rail impact test

Lifting and Tiedown Provision Strength Test

The lifting and tiedown provisions on all items of equipment must be tested to the limits specified in **MIL-STD-209**. The provision must be tested **AFTER** it has been installed on the equipment. A dynamometer pull test on each provision, to include the provision's connection to the structural frame of the item, is the simplest way to test the strength of each provision. Equipment with a requirement for airdrop must also be tested to the requirements of **MIL-STD-814** for suspension, tiedown, and extraction provisions. Equipment with a requirement for external air transport must also be tested in accordance with **MIL-STD-913.**

Helicopter Lift Test (Internal and External)

The helicopter internal transport test determines fit and the feasibility of tiedown procedures. This test usually is required only when the fit is expected to be close. The helicopter external lift test (in accordance with **MIL-STD-913**) determines the ability of the item to be lifted, the stability of the item in flight, the speed at which the item can be flown, and the rigging procedures for lifting the item. All items with a helicopter external lift requirement must pass a helicopter flight test.

Go to Table of Contents

Air Force Aircraft Test Loading

An aircraft test loading determines the fit, and loading and tiedown procedures. Also, it ensures that none of the aircraft design limitations (axle loads and ramp hinge loads) are exceeded. This test loading is conducted only when required by the Air Force. Failure to pass an aircraft test loading will negate air transport. Validation loadings are less expensive than test loadings and may be required when mathematical calculations indicate that fit will be tight.

Airdrop

The airdrop test determines the adequacy of rigging procedures and the ability of the item to survive the landing impact. This test shall be performed in accordance with **MIL-STD-814** and **MIL-HDBK-669.** After this test, the item must be undamaged and operable.

Rail Impact Test

Rail transport subjects the item to the most severe longitudinal impacts of any transport mode. The rail impact test, therefore, is the most severe transportability test. The rail impact test in **MIL-STD-810** tests the integrity of the item and the adequacy of the rail tiedowns and tiedown procedures. Any item that passes the **MIL-STD-810** rail impact test should be capable of rail transport without damage to the item or the tiedowns.

Go to Table of Contents

9 Deployability

Introduction

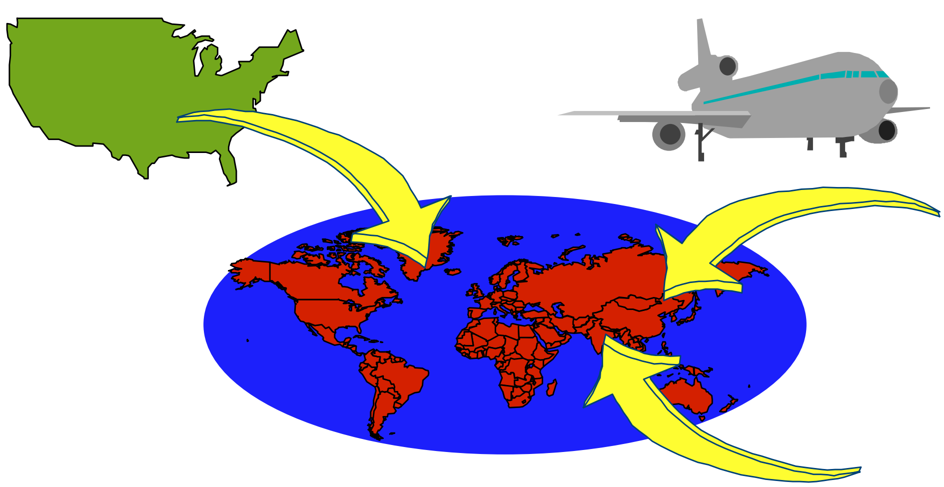
Deployability is the capability of an entire force (personnel and cargo) to be moved intraCONUS, intertheater (strategically), and intratheater (tactically) to support a military operation. The Army has shifted from a forward-deployed force to primarily a CONUS-based force. As defined in the Army Posture Statement '99, "Our national military strategy requires flexible power projection forces. They must be capable of rapidly deploying to any area of the world and generating decisive force across the full range of military operations".

To successfully meet the requirements of deploying a CONUS-based force, the deployment scenario must be evaluated at an early stage to accurately assess whether or not a new piece of equipment enhances or encumbers deployment. It is possible that from a transportability standpoint, the equipment is sufficient, but from a deployability standpoint (for example, a substantial logistics tail) could be a hindrance to force closure. A determination of the impact from both the transportability and deployability standpoints must be made to field a system that will enhance both.

Products of the Deployability Analysis

A deployability analysis typically consists of several key elements: sortie count, throughput analysis, closure profile, and infrastructure assessment.

Sortie Count: Given the gross dimensions and weight characteristics, along with the assumed force structure, a sortie assessment can be made for the C-130, C-17, and C-5, and also mixtures of each of the aircraft can be determined at a very high-level of confidence.



Go to Table of Contents

This information can be used to compare current force size with projected force size, with the new system incorporated into the force structure.

Throughput Analysis: Given specific contingency scenarios, the capability of a particular airfield, and/or port can be assessed with the known force size. Typically, the throughput assessment is based on the physical structure of the airfield or port. The short tons per day figure that is inherent in each airfield/port is the direct determinant for the throughput capabilities of the force.

Infrastructure Assessment: The CONUS and OCONUS-based scenarios and the movement of equipment through the contingency areas are dependent on successful maneuvering through the roads and bridges. This analysis is performed using the geographic information system (GIS) desktop software package that analyzes the force size and weight in conjunction with the imposed roadway limits. In many instances, the routes must be altered to successfully negotiate the necessary roadways.

Closure Times: The capability of a force to close in a certain amount of time is directly dependent on the sortie count, throughput analysis, and the infrastructure assessment. Using the data from these analyses, the closure profile for the force can be determined and compared with that of a current force. In many instances, there is a time requirement for the force to close within and these limits can be used to analyze what assets would be required to close in that timeframe. Ultimately, this is the gauge by which the deployment scenario is measured.

Example #1

There is a proposal to replace an existing 60-ton tracked vehicle with a 64-ton tracked vehicle. Since most military vehicles are not deployed singly but as part of a military unit, we would perform an analysis of two separate unit deployments, one with the existing vehicles and one with the proposed replacement vehicles. Based on the differences in aircraft missions, heavy equipment transporters (HETs), railcars, and closure time, we can draw conclusions about the proposed replacement vehicle's deployability.

For instances where we have information on the combat support and combat service support force structure required for the replacement vehicle, the differences between the two scenarios for this type of equipment would be accounted for in our analysis also. However, in this example, only the replacement of the primary vehicles is considered.

First, we would determine the notional unit standard requirement code (SRC) as well as the existing vehicle's line item number (LIN). Depending on the proposed fielding plan (1 new vehicle for 1 old vehicle, 1 new vehicle for 2 old vehicles, 2 new vehicles for 1 old vehicle, and so forth), we would develop a notional unit SRC reflecting the new vehicles.

Air: In this example, total aircraft missions would increase despite the fact that you can only load one of each type of vehicle in the airlifter. Aircraft payload limits require that sustainment and support equipment will be reduced when transporting a heavier vehicle, therefore, increasing total aircraft missions. Increased aircraft sorties will result in an increased closure time.

Marine: Increasing the vehicle weight will not significantly impact existing strategic marine transport vessels; however, it would reduce the available lighterage for in-stream discharge. The new vehicle will reduce the unit's ability to perform LOTS operations.

Rail: Increasing the vehicle weight will reduce the number of vehicles that can be loaded on DODX railcars. Whereas the railcars can be loaded with two 60-ton vehicles, they can only be loaded with one 64-ton vehicle. This will increase the railcar requirement as well as the time required to move the unit from the fort to the port; therefore, increasing unit closure time.

Highway: Since both vehicles are tracked, they cannot self-deploy via the existing highway system and will require HETs. Increasing the vehicle weight from 60 tons to 64 tons, however, will eliminate the unit's ability to use current HETs. This will increase the unit's requirement for newer and/or commercial HETS.

As we can see from this example, increasing the weight from 60 tons to 64 tons degraded both the vehicle's transportability and deployability.

Example #2

There is a proposal to replace existing S-280 shelter/2.5-ton M35 prime mover combinations with S-788 shelter/M1097A2 HMMWV combinations. The fielding plan calls for each existing S-280/M35 combination to be replaced by three S-788/M1097A2 combinations.

Again, we need to remember that HMMWV/shelter combinations are usually deployed as part of a unit, not singly. Therefore, we will base our deployability analysis on a notional unit deployment. The differences in combat support and combat service support force structure required for the primary vehicle combinations being analyzed is not considered in this example.

Air: Both combinations can be transported on C-17s and C-5s; however, the S-280/M35 combination cannot be transported on the C-130. Based on this fact, the proposed equipment replacement is more transportable than the existing equipment. However, the total length for the three M1097A2 combinations is over twice as much as a single M35A2 combination. This will increase the C-17/C-5 missions required to deploy the unit and increase unit closure time.

Marine: The M1097A2 combination is able to be moved by more ship/lighterage types than the M35 combination; therefore, it is more transportable. However, again the total square footage for the three M1097A2 combinations is more than twice the amount for the original M35 combination. This may increase the shipping/lighterage required to deploy a unit, increase ship load/unload time and increase unit closure time.

Rail: Both the M1097A2 and M35 combinations are transportable by rail without significant restrictions. However, more railcars may be required to deploy the new unit with three S-788/M1097A2s from the fort to the port.

Highway: Both combinations are self-deployable by highway without significant restrictions.

As we can see from this example, although the HMMWV/shelter combination is undoubtedly more transportable than the original M35/shelter, the vehicle replacement ratio decreases the unit's deployability.

Go to Table of Contents

10 Lessons Learned

When the military is developing or buying a system, one of the key considerations for combat and materiel developers should be transportability. If the ability to move the system is not carefully considered while the system is being designed or purchased, the result may be transportation problems that reduce the system's operational effectiveness. Strategic deployability and tactical mobility are based on good transportability engineering. Developers must understand the impact of deployment, payload, and mobility requirements on the systems they intend to field.

Efficient transport is not something that evolves by itself. The equipment designer must make a conscious effort to ensure that the equipment has design features that will allow it to be efficiently transported. Developers must consider what types of units will receive the system, and what their deployment and operating requirements are. They must also consider whether a system will operate in a combat, combat support, or combat service support role. Transportability by helicopter, good off-road mobility, and airdrop capability are generally most important for systems that are primarily oriented toward a combat or combat support role. Compliance with CONUS and host nation legal limits, while always important, becomes particularly important for combat service support vehicles at the corps and echelons-above-corps levels.

Airborne, air assault, and light infantry divisions have mission requirements that dictate that their equipment be highly deployable to and within the theater of operations. Recent exercises and low-intensity conflicts have shown a need for these units to have equipment that is transportable by helicopter and airdrop.

Overall, a CONUS-based force requires equipment that is more easily transported. For most, if not all, future weapons systems, transportability will be a critical design element.

Why Transportability Matters

On the following pages are some examples as to why transportability matters in equipment design. Although not all examples are military equipment, each example could have been prevented if the infrastructure and transportation asset limitations had been taken into account during equipment design and transport.

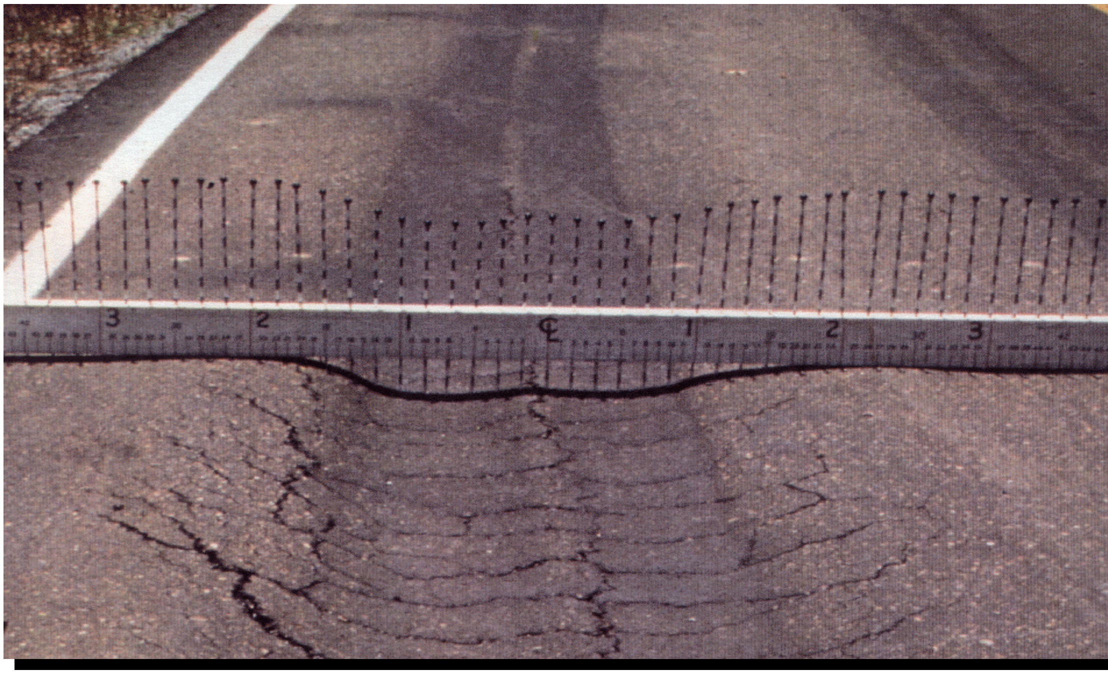
[Go to Table of Contents]

Trailing vehicle, rail transport overhead clearance accident

CUCV damaged during lifting accident

Go to Table of Contents

Road damage from overweight vehicles



Antenna mounts strike the door of a C-5

Go to Table of Contents

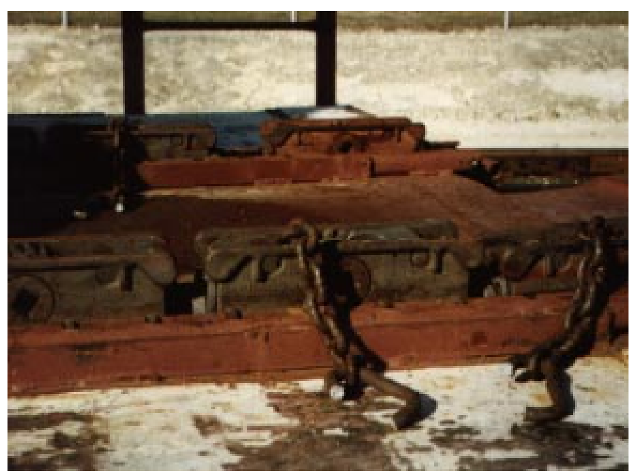
Ship ramp too short

Fatal accident when load was too high

Go to Table of Contents

Cargo that broke loose during rail transport

Chains breaking during rail transport



Tractor trailer that overloaded a bridge

Tight fit on a ship...little room for error

Go to Table of Contents

Locomotive struck by a tank turret

Tank that struck locomotive

Go to Table of Contents

References

Department of Defense Regulations

DOD 4500.9-R	*Defense Transportation Regulation, Part III, Mobility*

Army Regulations

AR 70-1	*System Acquisition Policy and Procedures*
AR 70-44	*DOD Engineering for Transportability*
AR 70-47	*Engineering for Transportability*
AR 71-9	*Materiel Requirements*

Military Standards

MIL-STD-209	*Interface Standard for Lifting and Tiedown Provisions*
MIL-STD-810	*Environmental Test Methods and Engineering Guidelines*
MIL-STD-814	*Requirements for Tiedown, Suspension, and Extraction Provisions on Military Materiel for Airdrop*
MIL-STD-913	*Requirements for the Certification of Externally Transported Military Equipment by Department of Defense Rotary Wing Aircraft*
MIL-STD-1366	*Interface Standard for Transportability Criteria*
MIL-STD-1472	*Human Engineering Design Criteria for Military Systems, Equipment and Facilities*

Military Handbooks

MIL-HDBK-669	*Loading Environment and Related Requirements for Platform Rigged Airdrop Materiel*
MIL-HDBK-759	*Human Factors Engineering Design for Army Materiel*
MIL-HDBK-1791	*Designing for Internal Aerial Delivery in Fixed Wing Aircraft*

Military Specifications

MIL-DTL-31000	*Technical Data Packages, General Specification For*

Go to Table of Contents

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FM 5-170	*Route Reconnaissance and Classification*
TM 5-31	*Military Fixed Bridges*

Air Force Pamphlets and Manuals

AF PAM 10-1403	*Air Mobility Planning Factors*
AFJMAN 24-204/ TM 38 250/NAVSUP PUB 505/ MCO P 4030.19/DLAI 4145.3	*Preparing Hazardous Materiels for Military Air Shipments*

Standardization Agreements

STANAG 2021 ENGR	*Computation of Bridge, Ferry, Raft, and Vehicle Classifications*
STANAG 2175 VF	*Classification and Designation of Flat Wagons Suitable for Transporting Military Vehicles and Equipment*
STANAG 2832	*Restrictions for the Transport of Military Equipment by Rail on European Railways*

Other Publications

Summary of Size and Weight Limits, American Trucking Association

Limits of Motor Vehicle Sizes and Weights, International Road Federation

Code of Federal Regulations, Title 49 Transportation, U.S. Government Printing Office

Code of Federal Regulations, Title 23 Highways, U.S. Government Printing Office

Directory of Highway Permit Officials and Mobilization Movement Control (MOBCON) Coordinators, Military Traffic Management Command Transportation Engineering Agency

Field Manual for AAR Interchange Rules, Association of American Railroads

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Go to Table of Contents

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International Maritime Dangerous Goods Code, International Maritime Organization

Recommendation on the Transportation of Dangerous Goods, United Nations

Go to Table of Contents

Contact Information

Please contact us directly or visit our web site if you need transportability assistance of any kind.

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Transportation Engineering Agency
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(800) 722-0727

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