ATP 4-31/MCRP 3-40E.1

Recovery and Battle Damage Assessment and Repair (BDAR)

November 2020

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Headquarters, Department of the Army

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1. A plus sign (+) marks new material.

2. ATP 4-31, 10 August 2021, is changed as follow.

Remove Old Pages	**Insert New Pages**
pages i through iii	pages i through iii
pages v through viii	pages v through viii
pages 1-2 through 1-6	pages 1-2 through 1-6
pages 2-2 through 2-3	pages 2-2 through 2-3
pages 3-3 through 3-4	pages 3-3 through 3-4
pages 5-6 through 5-21	pages 5-6 through 5-21
pages 5-26 through 5-29	pages 5-26 through 5-29
References-1 through References-2	References-1 through References-2

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Recovery and Battle Damage Assessment and Repair (BDAR)

Contents

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Figures

Tables

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+Preface

ATP 4-31/MCRP 3-40E.1, *Recovery and Battle Damage Assessment and Repair*, provides techniques on how recovery and battle damage assessment and repair (BDAR) are employed during operations.

The principal audience for ATP 4-31/MCRP 3-40E.1 is all members of the profession of arms. Commanders and staffs of Army headquarters serving as joint task force or multinational headquarters should also refer to applicable joint or multinational doctrine concerning the range of military operations and joint or multinational forces. Trainers and educators throughout the Army will also use this publication.

Commanders, staffs, and subordinates ensure their decisions and actions comply with applicable United States, international, and in some cases host-nation laws and regulations. Commanders at all levels ensure their Soldiers operate in accordance with the law of war and the rules of engagement. See FM 6-27/ MCTP 11-10C, *The Commander's Handbook on the Law of Land Warfare*.

ATP 4-31/ MCRP 3-40E.1 implements the following standardization agreements:

STANAG 2418, Edition 2, *Procedures for Expedient Repair, Including Battle Damage Repair (BDR).*

STANAG 2633 – *Maintenance Support of Land Operations*.

STANAG 4101 – *Towing Attachments*.

STANAG 4478 - *Towing and Recovery Facilities for Tactical Land Vehicle*.

ATP 4-31/MCRP 3-40E.1 uses joint terms where applicable. Selected joint and Army terms and definitions appear in both the glossary and the text. Terms for which ATP 4-31/MCRP 3-40E.1 is the proponent publication (the authority) are italicized in the text and are marked with an asterisk (*) in the glossary. Terms and definitions for which ATP 4-31/MCRP 3-40E.1 is the proponent publication are boldfaced in the text. For other definitions shown in the text, the term is italicized and the number of the proponent publication follows the definition.

ATP 4-31/MCRP 3-40E.1 applies to the Active Army, Active Marines, Army National Guard, United States Army Reserve, and Marine Corps unless otherwise stated.

+The proponent of ATP 4-31/MCRP 3-40E.1 is the United States Army Ordnance School. The preparing agency is the Combined Arms Center (CASCOM) G-3 Training and Doctrine Development Directorate. Send comments and recommendations on DA Form 2028 (*Recommended Changes to Publications and Blank Forms*) to Commander, United States Army CASCOM, ATTN: ATCL-TS (ATP 4-31), 2221 Adams Ave., Fort Lee, VA 23801; or submit an electronic Department of the Army (DA) Form 2028 by e-mail to: usarmy.lee.tradoc.mbx.leee-cascom-doctrine@mail.mil. United States Marine Corps readers of this publication are encouraged to submit suggestions and changes by email to doctrine@usmc.mil or by mail to the Commanding General, United States Marine Corps, Training and Education Command, ATTN: Policy and Standards Division, Doctrine Branch (C466), 1019 Elliot Road, Quantico, Virginia 22134-5010.

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Introduction

Soldiers, Marines, and officers who perform recovery operations and battle damage assessment and repair for their service perform a vital role of keeping units and personnel safe while maintaining and providing the effective operational readiness rates required to accomplish the mission. Recovery personnel, as identified in this publication, includes every person that plays a role in recovery operations or battle damage assessment and repair. This includes professional recovery personnel, such as maintenance control officers, warrant technicians and maintenance teams.

All personnel involved in recovery operations/battle damage assessment and repair need to understand the environment in which they operate. This manual provides information on recovery support to unit operations including operations within the Joint environment.

It is imperative for all personnel engaged in recovery operations or battle damage assessment and repair support operations to have an understanding of the various staff organizations that have a role in recovery planning and support. It will be necessary for a recovery support activity to contact the higher, lower, or adjacent headquarters (both sustainment and operational) to coordinate support, report status, request technical assistance, or request additional resources. This manual presents the roles and missions of the various recovery organizations to enhance coordination.

Readers should follow the guidelines in this publication as closely as possible within the constraints and restrictions of the tactical situation.

Army Techniques Publication (ATP) 4-31, *Recovery and Battle Damage Assessment and Repair (BDAR)*, is a revision of the 27 August 2014 publication. ATP 4-31 provides an overview of battlefield recovery, and battle damage assessment and repair for the fundamental purpose of returning combat assets to the battlefield as soon as possible. This publication presents the different types and methods used in recovery operations as well as guidance on the assessment and repair of battle-damaged equipment. This publication also reviews the rigging procedures and the utilization of mechanical advantage to accomplish recovery missions. This publication provides an overview of common recovery methods, techniques, and safety precautions for use by dedicated recovery personnel. The major change to ATP 4-31 from the previous version is the discussion of expedient repair and planning considerations for recovery operations and BDAR across all echelons.

ATP 4-31 is comprised of six chapters:

- **Chapter 1** provides an overview of two-level maintenance, expedient repair, battlefield recovery, and BDAR. It also discusses the importance of recovery and BDAR within the Army strategic roles.
- **Chapter 2** provides an overview of supporting organizations providing guidance and assistance within an area of operation. The chapter also provides information on units providing recovery and BDAR support.
- **Chapter 3** provides an overview of the planning process utilized in recovery operations. It also identifies the key personnel who plan for recovery and BDAR operations, the chapter also provides planning considerations for Marine Corps recovery and BDAR.
- **Chapter 4** explains rigging methods and techniques, and explains how to utilize mechanical advantage in recovery operations.
- **Chapter 5** identifies various examples of recovery techniques including those utilized by driver operators and those reserved for dedicated recovery personnel.
- **Chapter 6** clearly delineates the differences between technical manual (TM) repairs, expedient repairs, and BDAR, identifies examples of improvised repair procedure utilized to rapidly return disabled equipment to operational condition in wartime.

ATP 4-31 does not introduce, modify, or rescind any Army term or acronym.

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Chapter 1

Overview for Recovery and BDAR

Battlefield recovery and battle damage assessment and repair (BDAR) are separate and distinct subsets of maintenance. Both are the owning unit's responsibilities and both have a fundamental purpose of returning combat assets to the battlefield as soon as possible. The purpose of recovery is to rapidly free mired equipment or remove disabled equipment from the battlefield. The purpose of BDAR is to apply expedient repairs allowing the equipment to self-recover and continue the mission.

TWO LEVEL MAINTENANCE

1-1. The Army and Marine Corps both utilize a two-tiered maintenance structure. Both services emphasize fixing items forward.

ARMY

1-2. The Army utilizes a tiered, two-level maintenance system comprised of field and sustainment maintenance. Command teams, maintenance personnel, and planners must have a complete understanding of two-level maintenance fundamentals in order to properly plan and execute maintenance operations to include recovery and BDAR. Two-level maintenance provides the operating unit with more capabilities forward and the ability to respond rapidly.

1-3. Soldiers perform field-level maintenance as far forward as possible with the equipment being retained by or returned to the owning unit. Crewmembers, equipment operators and Ordnance trained maintainers perform field maintenance. All Army modification table of organization and equipment, commonly called MTOE, maintenance units perform field maintenance. Soldiers perform most recovery operations and BDAR under field level maintenance. For additional information on Army maintenance, see ATP 4-33, *Maintenance Operations*.

1-4. Sustainment maintenance is performed by the United States Army Materiel Command (USAMC) elements normally comprised of civilians and contractors who repair equipment to a national standard before returning it to the Army's overall supply system. When a unit sends equipment to a sustainment maintenance organization the owning unit, in most cases, removes the equipment from its property book. USAMC and Army Sustainment Command may provide forward augmentation through one or more Army field support brigade (AFSB) and Army field support battalion (AFSBn) to support maintenance actions in an area of operations. Chapter 2 discusses these organizations and their capabilities.

MARINE CORPS

1-5. The Marine Corps utilizes a two-level maintenance construct divided into field and depot maintenance. Crewmembers, operators, and maintainers perform field maintenance within Marine Corps organizations and activities. Approved commercial or contract sources can also perform field maintenance. Marine Corps maintenance categorize tasks performed within the field level of maintenance as organizational and intermediate. A unit may perform any field maintenance task the unit is manned, trained, and equipped to perform.

1-6. Organizational maintenance is the responsibility of the owning unit. Organization maintenance tasks include cleaning, servicing, inspecting, lubricating, adjusting and minor repairs.

1-7. Intermediate maintenance is field maintenance performed by designated agencies in support of the using unit. It also includes certain items of equipment used by specially authorized using units. Intermediate maintenance includes repair of secondary reparables.

1-8. Depot maintenance includes actions that are beyond field maintenance capabilities. Depots repair materiel or software involving the inspection, repair, overhaul, or the modification or reclamation (as necessary) of weapons systems, equipment end items, parts, components assemblies and subassemblies. Maintainers may also leverage depot maintenance to contribute to field maintenance efforts by providing overflow, on-site maintenance services, and technical assistance as appropriate to maintain enterprise materiel availability.

+RECOVERY

1-9. *Recovery* is actions taken to extricate damaged or disabled equipment for return to friendly control or repair at another location (JP 3-34). These actions typically involve extracting, towing, lifting, or winching. Towing is usually limited to moving equipment to a maintenance collection point (MCP). Crew, operator, or dedicated recovery personnel accomplish the recovery based on the mire level or the severity of battle damage.

1-10. Damaged and inoperable equipment on the battlefield can strain dedicated recovery resources. Dedicated recovery assets should be strategically placed within the area of operations to optimize battlefield recovery operations. Commanders must emphasize the use of self and like vehicle recovering methods to the greatest extent possible. These practices will minimize the use of dedicated recovery assets for routine recovery missions.

+1-11. Recovery operations, both on and off the battlefield, can be extremely hazardous. Safety must remain a top priority for each recovery mission. Leaders and Soldiers at all levels must conduct a continuous risk assessment throughout the recovery operation as some recoveries can take numerous hours, and risk factors regarding climate, Soldiers, and the situation can change significantly over that time. Proper maintenance of recovery vehicles and serviceability of authorized rigging and other equipment is essential to ensure safe recovery mission. For additional information on safety, refer to ATP 5-19, *Risk Management*, AR 385-10, *Army Safety Program* and DD Form 2977 *(Deliberate Risk Assessment Worksheet)*.

OPERATOR OPERATIONS

1-12. Crew and vehicle operators are limited to two types of recovery operations, self-recovery and like vehicle recovery.

Self-Recovery

1-13. Self-recovery starts at the location where the equipment becomes mired or disabled. The operator/crew use the basic issue item (BII) equipment and additional authorized list referred to as AAL or on-vehicle equipment to perform self-recovery.

1-14. When the equipment has a mechanical failure, the operator/crew will use the equipment's TM to perform troubleshooting procedures with the tools available in the BII and additional authorized list or on-vehicle equipment. When self-recovery fails, the operator/crew can request assistance from available like vehicles.

Like Vehicle Recovery

1-15. Like vehicle recovery is used when self-vehicle recovery fails. The principle is to use another piece of equipment "of the same weight class or heavier" to extract the mired, disabled, or damaged equipment by using tow bars, chains, and/or tow cables. When self-recovery and like-recovery are not practical or are unavailable, use dedicated recovery assets.

DEDICATED RECOVERY OPERATIONS

1-16. Soldiers and Marines possessing a recovery skill identifier conduct dedicated recovery operations as well as self and like vehicle recovery. These school-trained personnel can recover a wide range of vehicles and equipment. There are two types of identifiers for the Army, one for wheeled recovery and a second for tracked vehicle recovery. The school does not train specific techniques for all types of equipment. The skills taught in the recovery course allow graduates to apply known techniques to similar equipment. Commanders rely on school-trained graduates to safely conduct recovery operations on damaged equipment using a variety of equipment.

1-17. Dedicated recovery vehicles are those specifically designed and equipped for recovering other vehicles. Wheeled wreckers, such as the M984 and M1089, and tracked recovery vehicles, like the M-88A2, are examples. The military uses these vehicles when self-recovery or like vehicle recovery is not possible because of the severity of the situation, safety considerations, or the inability to use like vehicle assets. In general, wheel recovery vehicles should recover wheel vehicles and track recovery systems recover tracked vehicles. Wheel recovery vehicles may flat tow track vehicles less than their weight. Track flat-tow recovery of wheel vehicles should be avoided due to potential damage of wheel vehicle front steering components.

CAUTION

Do not flat tow wheeled vehicles using tracked recovery vehicles.

1-18. Recovery crews diagnose equipment and repair the equipment to a mission capable status. The crews, if authorized, may perform expedient repairs or BDAR to keep the vehicle or equipment available to perform the mission. If repairs are too extensive to fix on site, the team will recover the vehicle to a MCP.

1-19. Recovery managers and supervisors ensure recovery vehicles are used only when absolutely necessary. Units must return dedicated recovery vehicle as quickly as possible to a central location to support the maintenance missions. In addition to its recovery mission, maintainers often use this equipment for the heavy lifting required in maintenance operations. Recovery managers and supervisors must use all available resources carefully to provide sustained support.

EXPEDIENT REPAIR

1-20. Expedient repairs are non-conventional repair procedures performed by operators and maintainers that rate as low to medium risk. TMs do not direct these repairs and the repairs may be regarded as either permanent or temporary. Soldiers perform expedient repairs not only on the battlefield but also during training exercises. Expedited repairs can also reduce vehicle and equipment downtime incurred waiting for the delivery of spare parts.

1-21. Expedient repair is an important alternative repair process. It is vital Soldiers consistently record expedient repairs when used. The record accounts for the repair that falls outside of technical manual (TM) standards and defers the repair to a stated future date. Maintenance managers use their technical expertise to determine how long a repair might last during use and the risk associated if the repair fails. Commanders accept the limitations or constraints inherent with the use of vehicles when they authorize expedient repairs.

1-22. Expedient repair may utilize alternative parts that are similar in form, fit, function, and longevity to the part published in a TM. Soldiers document expedient repair parts used in a repair on a DA Form 5988E (*Equipment Maintenance and Inspection Worksheet*) or a manual DA Form 2404 (*Equipment Inspection and Maintenance Worksheet*). Units maintain these forms until they remove and replace the expedient part with the TM designated part.

BDAR

1-23. Maintainers rapidly return disabled equipment to the operational commander using BDAR procedures and field-expedient repair of components. *Battle damage assessment* is the estimate of damage composed of physical and functional damage assessment, as well as target system assessment, resulting from the application of lethal or nonlethal military force (JP-3-0). *Battle damage repair* is an essential repair, which may be improvised, carried out rapidly in a hostile environment in order to return damaged or disabled equipment to temporary service (JP 4-09).

1-24. BDAR restores the minimum essential combat capabilities necessary to support a specific combat mission or to enable the equipment to self-recover. Commanders must authorize the use of BDAR. Soldiers accomplish BDAR by bypassing components or safety devices, exchanging parts from like or lower priority equipment, fabricating repair parts, jury-rigging, taking shortcuts to standard maintenance, and using substitute fluids, materials or components (complete controlled exchanges in accordance with AR 750-1). Depending on the repairs required and the amount of time available, repairs may or may not return the vehicle to a fully mission-capable status. Operators/crew, maintenance teams, or recovery teams may perform BDAR.

1-25. Based on a unit's standard operating procedures and at the commander's discretion, anyone can perform BDAR depending on the extent of repairs required and operational variables. The commander decides whether to use BDAR instead of standard maintenance procedures. Expedient repairs may or may not return the vehicle to a fully mission-capable status.

1-26. BDAR procedures apply to field maintenance procedures only and depend on operational variables, the extent of damage, time allowances, and available personnel with required skills, availability of parts, tools, and materials. Personnel performing BDAR must act quickly to restore the vehicle to the combat-ready condition required to continue the mission or allow the vehicle to self-recover. BDAR procedures are non-standard maintenance practices.

1-27. Standard maintenance practice should always be considered first but, when BDAR is necessary, the following considerations should be made:

- Base decisions of using BDAR versus standard maintenance on the operational environment and situation.
- Provide an accurate assessment.
- Ensure economy of maintenance effort (use maintenance personnel only when necessary).
- Train multifunctional skills.
- Repair only what is necessary to regain combat capability.
- Remain flexible about repair priorities.

1-28. Commanders should address the use of BDAR in the logistics section of their operation order. The operation order provides a clear understanding of the risk level and authorization for the crews and maintainers to perform BDAR. Local command policy directs the degree of BDAR to apply.

1-29. Maintenance assets are in high demand on the battlefield. Because resources are limited (personnel, tools, and parts), it is imperative maintenance resources are not wasted because resources are limited (personnel, tools, and parts). Crewmembers must do repairs within their capabilities immediately rather than requesting maintenance personnel to do simple mechanical tasks.

1-30. Personnel shortages and battlefield casualties mandate maintenance team members have some knowledge of other skills needed to achieve critical repairs. A lack of key maintainers must not deter a team from doing repairs. Whenever possible, on-the-job training or cross training of personnel should be conducted.

1-31. On the battlefield, the objective is to return the system to an operational condition with enough combat capability to accomplish the mission. Cosmetic repairs are not necessary and are a poor use of time and resources. If a broken component does not affect the ability to shoot, move, or communicate, and does not pose a serious safety concern maintainers should defer repairs. When the unit returns equipment to maintenance, maintainers can perform standard repair procedures.

RECOVERY, EXPEDIENT REPAIRS, AND BDAR WITHIN THE ARMY STRATEGIC ROLES

1-32. The Army's primary mission is to organize, train, and equip its force to conduct prompt and sustained land combat to defeat enemy ground forces and seize, occupy, and defend land areas. Winning is the achievement of the purpose of an operation and the fulfillment of its objectives.

1-33. The Army supports the joint force in four strategic roles: shape operational environments, prevent conflict, prevail in large-scale combat, and consolidate gains. The Army wins when it successfully performs these roles during operations and meets all of its objectives. Maintenance plays a key role across all four strategic roles. Recovery and BDAR are elements of maintenance that directly enable the commander to preserve and rapidly restore combat power. For additional information about the Army's strategic roles see FM 3-0, *Operations* and FM 4-0, *Sustainment Operations*.

RECOVERY, EXPEDIENT REPAIR, AND BDAR SUPPORT TO OPERATIONS TO SHAPE

1-34. Operations to shape consist of various long-term military engagements, security cooperation, and deterrence missions, tasks, and actions intended to assure friends, build partner capacity and capability, and promote regional stability. Operations to shape typically occur in support of the geographic combatant commander's theater campaign plan or the theater security cooperation plan. These operations help counter actions by adversaries that challenge the stability of a nation or region contrary to United States (U.S.) interests.

1-35. Shaping activities include security cooperation and forward presence to promote U.S. interests, develop allied and friendly military capabilities for self-defense and multinational operations, and providing U.S. forces with peacetime and contingency access to a host nation. Regionally aligned and engaged Army forces are essential to achieving objectives to strengthen the global network of multinational partners and preventing conflict.

1-36. Recovery, expedient repairs, and BDAR are elements of maintenance operations supporting operations to shape. All units and their supporting sustainment elements need to train on vehicle recovery and practice implementing BDAR. Engaged leaders provide supervision and ensure safety and accountability. These efforts are part of an effective unit maintenance program, along with relevant Command Maintenance Discipline Programs, and timely test, measurement and diagnostic equipment calibration and maintenance programs all of which contribute to a positive organizational readiness rate. Standard battle rhythm events, such as brigade maintenance meetings, sustainment readiness reviews, and theater maintenance working groups, are effective for tracking readiness and prioritizing efforts. Senior leaders reinforce and verify maintenance practices by conducting periodic maintenance terrain walks. Refer to DA PAM 750-1, *Commander's Maintenance Handbook* for additional information regarding maintenance activities.

RECOVERY, EXPEDIENT REPAIR AND BDAR SUPPORT TO OPERATIONS TO PREVENT

1-37. The purpose of operations to prevent is to deter adversary actions contrary to U.S. interests. Government and military forces typically conduct these operations in response to activities that threaten unified action partners and require the deployment or repositioning of credible forces in a theater to demonstrate the willingness to fight if deterrence fails. Leaders tailor operations to prevent in scope and scale to achieve a strategic or operational level objective as part of crisis response or limited contingency operation. Leaders may conduct operations to prevent as a stand-alone response to a crisis, as in a non-combatant evacuation operation, or as part of a larger joint operation. The ability of an Army force to prevent stems from an adversary's realization further escalation would result in military defeat.

1-38. Concurrent with actions intended to confront and deter an adversary, the theater Army commander sets the theater to enable land power to exert its full capabilities. Recovery, expedient repair, and BDAR are especially important during reception, staging, onward movement and integration, commonly referred to as RSOI, to ensure vehicles reach their units.

Recovery, Expedient Repair, and BDAR Support to Prevail in Large-Scale Combat Operations

1-39. Large-scale combat operations executed through simultaneous offensive, defensive, and stability tasks require continuously generating and applying combat power, often for extended periods. *Combat power* is the total means of destructive, constructive, and information capabilities a military unit or formation can apply at a given time (ADP 3-0).

1-40. During large-scale combat operations, Army forces focus on the defeat and destruction of enemy ground forces as part of the joint team. Army forces close with and destroy enemy forces in any terrain, exploit success, and break their opponent's will to resist. Army forces attack, defend, conduct stability tasks, and consolidate gains to attain national objectives. Divisions and corps are the formations central to the conduct of large-scale combat operations, organized, trained and equipped to enable subordinate organizations. The ability to prevail in ground combat is a decisive factor in breaking an enemy's will to continue a conflict. Conflict resolution requires the Army to conduct sustained operations with unified action partners as long as necessary to achieve national objectives.

1-41. Armies go into battle with the forces they have available. Commanders rely on maintenance operations to provide the initial combat power and rapidly repair damaged weapon systems to help maintain combat power. Recovery, expedient repair and BDAR are key elements of maintenance. During combat operations maintainers recover and repair damaged platforms enabling them to shoot, move, and communicate and stay in the fight. Battle damage assessment and repair restores the minimum essential combat capabilities necessary to support a specific combat mission or to enable the equipment to self-recover.

Recovery, Expedient Repair, and BDAR Support to Operations to Consolidate Gains

1-42. Army operations to consolidate gains include activities to make enduring any temporary operational success and set the conditions for a sustainable environment, allowing for a transition of control to legitimate civil authorities. Commanders continuously consider activities necessary to consolidate gains and achieve the end state. Consolidation of gains is an integral and continuous part of armed conflict, and it is necessary for achieving success across the range of military operations. It is essential to retaining the initiative over determined enemies because it ultimately removes both the capability and will for further resistance.

1-43. The Army deliberately plans to consolidate gains during all phases of an operation. Early and effective consolidation activities are a form of exploitation conducted while other operations are ongoing, and they enable the achievement of lasting favorable outcomes in the shortest time span.

1-44. Maintenance support during operations to consolidate gains are similar to those in large-scale combat operations. Maintainers continue to maintain vehicles and equipment to provide and sustain combat power. Priorities may shift in some instances from repairing battle-damaged weapons systems to servicing equipment including rolling stock and generators required for stabilization efforts. Weapons systems returned to service utilizing expedient repair or BDAR techniques should receive an assessment to determine if the temporary repairs require permanent corrections. Units may also utilize maintenance assets to prepare equipment and vehicles for redeployment.

Chapter 2

Support and Maintenance Organizations

The nature of the modern battlefield demands a maintenance system that is flexible, responsive, and focused on returning systems to operational status quickly and as near as possible to the point of failure or damage. Maintenance assets move as far forward as the tactical situation permits to return inoperable and damaged equipment to the battle as quickly as possible. Recovery, expedient repair, and BDAR are crucial to success. They quickly return equipment to service when it becomes inoperable ensuring equipment reliability and availability.

STRATEGIC LEVEL

2-1. Most supporting organizations above the division level are concerned with the movement of parts, evacuation of equipment for sustainment level maintenance, and moving major end items into the theater. These organizations provide access to the strategic base and may push capabilities into theater to assist maintainers with recovery, expedient repair, and BDAR.

UNITED STATES ARMY MATERIEL COMMAND

2-2. USAMC is the main strategic partner for maintenance and plays a key role in maintenance operations and repair parts management. USAMC is the Army's sustainment maintenance process owner. USAMC equips, resets, and sustains the Army by leveraging its capabilities to include Logistics Readiness Centers on all major Army installations. While located in the United States, USAMC may project maintenance capabilities within subordinate commands into the theater in order to support the ground combatant commander.

LIFE CYCLE MANAGEMENT COMMANDS

2-3. The Assistant Secretary of the Army for Acquisition, Logistics, and Technology, known as ASA (ALT), program executive officers and product or project managers ensure support for fielded weapon systems and equipment throughout their entire life cycle. Materiel developer product directors ensure manufacturers develop nonstandard maintenance practices during equipment testing. They also place articles on nonstandard maintenance practices in equipment publications as directed by the current regulatory guidance. These actions permit training in the schoolhouse and at the unit level.

2-4. The various life cycle management commands manage and execute maintenance and supply programs for the USAMC. Inherently, many parts assembled and tested on each piece of equipment may not always be available for the entire lifespan of each piece of equipment.

2-5. USAMC and the life cycle management commands provide informed timely updates on parts availability. Changes to parts may require maintainers to utilize expedient repair. USAMC and the lifecycle management commands also provide guidance as necessary when parts suitability issues arise.

ARMY SERVICE COMPONENT COMMAND

2-6. The Army Service component command is the senior Army command aligned with a geographical combatant command. The Army Service component command maintains visibility of the maintenance and readiness posture of all Army units operating in an area of responsibility. It provides the necessary capability to support operations in the area of responsibility. This includes requirements for sustainment maintenance, additional echelons above brigade support maintenance companies, or contracted maintenance support.

ARMY SUSTAINMENT COMMAND

2-7. The Army Sustainment Command provides logistics support by synchronizing support from the strategic through the operational to the tactical level. The Army Sustainment Command facilitates reach back mission support across the USAMC. Army Sustainment Command and its subordinate AFSB and AFSBn, execute field maintenance missions. Maintenance supports both operational forces and the Army supply system. Unless prior planning occurs, USAMC subordinate elements typically enter after initial setting the theater tasks are completed.

PS Magazine

2-8. A subordinate command of Army Sustainment Command publishes the online monthly *PS Magazine Online, The Preventive Maintenance Monthly*. Commanders can use *PS Magazine* to enhance materiel readiness by having their Soldiers review the preventive maintenance, proper maintenance, and supply procedures presented in the online magazine.

Equipment Reports

2-9. Tank-Automotive and Armaments Life Cycle Management Command publishes the quarterly online *Equipment Reports*. These publications provide updates on field identified issues such as product deficiency, part unavailability, product change, or part list change. Technical manual authors incorporate these issues, as well as those identified in the *PS Magazine Online* in revisions of applicable TMs.

+ARMY FIELD SUPPORT BRIGADE

2-10. The AFSB is assigned to the Army Sustainment Command. When supporting a geographically aligned Army Service Component Command or Field Army the AFSB is under the operational control of the supported Command. An AFSB in support of a corps headquarters may deploy an element known as a Corps logistics support element within the supported corps headquarters. The Corps logistics support element is under the operational control of the Corps headquarters during the deployment. AFSBs in direct support to corps can deploy a corps logistics support element under the operational control of expeditionary corps and provides a direct link to USAMC capabilities at the corps level.

+2-11. The AFSB is typically placed under the operational control to the supporting theater sustainment command (TSC) or expeditionary sustainment command (ESC) as appropriate. As it pertains to maintenance activities, the AFSB has operational control of Life Cycle Management Command logistics assistant representatives. The AFSB commands and controls an AFSBn and logistics support elements supporting the tactical commander. For additional information see ATP 4-98, *Army Field Support Brigade*.

Army Field Support Battalion

2-12. The AFSBn is multi-tasked and responsible for home station and field maintenance support to include, reset management. Each division has an AFSBn in direct support at home station which can deploy a division logistics support element under the operational control of the division. It provides direct access to USAMC assets at the division level, to include a package of logistics assistance representatives tailored to division requirements. The division logistics support element, also called DLSE, may be further delegated the division sustainment brigade operational control. An AFSBn can provide integrated support by reaching back to the AFSB and/or national sustainment base when required.

Division Logistics Support Element

2-13. The mission of the division logistics support element is to synchronize and integrate USAMC capabilities at the division level to increase combat power. The division logistics support element's roles and responsibilities include—

- Providing logistics assistance representative technical expertise at the division level to assist in diagnosis and repair, determining battle damage, and disposition instructions.
- Assisting and coordinating with the assistant secretary of the Army for acquisition, logistics, and technology assistance called forward to support the division.

- Assisting in the coordination, synchronization, and resolution of system support contract and related logistics support program actions.
- Providing technical support capability for the division from the appropriate USAMC command.

2-14. The division logistics support elements are ad hoc organizations formed from the AFSBn structure to meet mission requirements. The division logistics support element may be led by the AFSBn commander, a centralized selection list select battalion commander, or the AFSBn executive officer or support operations officer depending to meet operational variables. The division logistics support element will also include Lead System Technical Representatives from each lifecycle management command.

2-15. The team assists the division in identifying and resolving systemic logistic problems. It also provides equipment technical expertise to aid in building and maintaining readiness. The number of logistics assistance representatives within a division logistics support element is dependent upon the equipment and technology densities within the supported unit. Typically, division logistics support activities work with divisions in the division support area.

+2-16. In addition to the AFSBn, USAMC can deploy elements from numerous national-level providers to augment a deployed AFSB. The actual size and composition (mixture Department of the Army Civilians and contractors) of these USAMC organizations varies from mission to mission. For additional information about USAMC support formations, see ATP 4-98.

Logistics Assistance Representative

+2-17. USAMCs' logistics assistance representatives, commonly known as LARs, provide weapon systems oriented supply and maintenance technical assistance to Army units. These representatives are normally assigned to an AFSBn or a division logistics support element, but can be assigned individually to a unit as needed. Logistics assistance representatives are experienced technicians and are able to provide information regarding maintenance, training, supply parts, and operational readiness. The logistics assistance representative takes an active role in educating and training Soldiers. In some instances, the logistics assistance representative may assist in resolving a maintenance issue. Logistics assistance representatives share information gained in the field with the appropriate Army sustainment command structure, their respective life cycle management command, and the project manager for the relevant system. In all cases, the life cycle management command maintains technical authority over their assigned logistics assistance representative. For additional information on logistics assistance representatives refer to ATP 4-98.

Equipment Support Activity

2-18. Equipment support activities provide sustainment maintenance and are ad hoc organizations normally formed from depot and arsenal capabilities and called forward to a designated operational area. An equipment support activity provides limited sustainment maintenance and augmented field maintenance support as needed. The team's sustainment mission focuses on the repair, overhaul, and modification of Army weapon systems. The equipment support activity performs this work through subordinate forward repair activities, combat vehicle evacuation teams and component repair teams. The equipment support activity's primary mission is to perform production and control scheduling of maintenance shop operations.

2-19. The equipment support activity is attached to an AFSB or designated AFSBn. It relies on the supported unit for logistics and force protection support. Command remains the responsibility of the AFSB.

Combat Vehicle Evacuation Team

2-20. Combat vehicle evacuation teams are task organized and called forward to the operational area to evaluate combat vehicles after major combat action or extended use in a sustained military operation. The teams evaluate combat equipment faults and damage; and make recommendations as to vehicle disposition based on the available logistics support, commander priorities, and the overall tactical situation. They prioritize repairs to return the maximum number of vehicles to an operational condition in a minimum amount of time.

2-21. Combat vehicle evacuation teams are normally attached to an AFSBn and work loaded by a designated equipment support activity or directly by the AFSBn. The team relies on the supported unit for logistics and force protection support. Command in all cases is the responsibility of the designated AFSB.

Forward Repair Activity

2-22. USAMC can deploy forward repair activities from select life-cycle management commands. Forward repair activities are task organized and designed to meet the specific requirements to accomplish repairs on specific types of equipment or components.

2-23. Forward repair activities perform sustainment maintenance and may augment the AFSBn or sustainment brigade's capabilities based on the operational commander's priorities and the need to surge maintenance capabilities to generate combat power. A forward repair activity may also help prepare tactical units for future missions or assist in their reconstitution after a major combat engagement.

2-24. Forward repair activities are attached to an AFSB or AFSBn. They are work loaded by a designated equipment support activity or directly by the AFSBn. The unit relies on the supported unit for logistics and force protection. Command remains the responsibility of the AFSB.

ARMY NATIONAL GROUND INTELLIGENCE CENTER

2-25. The Army National Ground Intelligence Center, also known as the NGIC, is the Army's center of excellence for attack scene investigation and battlefield vehicle forensics. Army National Ground Intelligence Center analysts and subject matter experts examine new or unusual combat damage suspected of being of intelligence value. The damage inflicted on Army ground combat vehicles by enemy weapons is a vital element in understanding the capabilities of those enemy weapon systems. Reports from maintenance and recovery personnel are often the first indication the enemy has introduced a new or modified enemy weapon. The Army National Ground Intelligence Center uses the analysis of combat damage to inform the development of design modifications and mitigating tactics, techniques and procedures for greater protection.

Reporting

2-26. Operators, crews, maintainers and recovery technicians should be aware of the importance of reporting new or unusual combat damage. The Army National Ground Intelligence Center collects enemy attack information from maintainers and recovery personnel as well as vehicle operators. These reports and accompanying photographs of battle damaged vehicles should include the following detailed information —

- 8-digit grid coordinate where the attack took place.
- Number and types of vehicles attacked.
- Theater of operations and unit attacked.
- A primary and alternate point of contact and contact information.
- Date of the attack and report.
- Indicate whether the report was prepared on-scene or post-recovery.
- Type of attack (such as direct fire, indirect fire, complex or improvised explosive device).
- Size and identification of enemy element and any unique tactics or techniques employed.

2-27. The report also requests a list of items of intelligence value found in or around the vehicle including—

- Fragments.
- Copper material.
- Steel material.
- Explosive residue.
- Weapon or munition components.
- Munition packaging (such as—dunnage, empty casings, shells, and launch tubes).
- Firing circuits.
- Photographs of the damage and materials recovered. Photographs should include a scale, ruler, or common item to identify scale to assist in analysis.

2-28. Soldiers report incidents to the Army National Ground Intelligence Center's Technical Forensics Branch. The report should reference all of the criteria noted in paragraphs 2-26 and 2-27.

Battlefield Vehicle Forensic Technicians and Combat Incident Response Team

2-29. The Army National Ground Intelligence Center deploys battlefield vehicle forensic technicians and combat incident response teams into theater to conduct detailed assessments, evidence collection, and analysis. The battlefield vehicle forensic technicians conduct analysis on recovered battle damage vehicles. The combat vehicle forensic technicians can rapidly deploy and conduct forensic collection and reporting on particularly critical vehicle battle damage. If a team is in the theater, maintenance and recovery personnel can request support from them through their brigade or battalion intelligence officer. The brigade or battalion intelligence officer can reach the Technical Forensics Branch through the National Ground Intelligence Center's web page on either the Secret Internet Protocol Router, known as SIPR, or Joint Worldwide Intelligence Communications System, also called JWICS. These are listed in the reference under websites, under Army National Ground Intelligence Center Technical Forensics Branch.

SUSTAINMENT AND MANUEVER UNITS

2-30. Maintenance formations at the division and below perform most recovery, expedient repair and BDAR operations that maintain maneuver forces combat power.

THEATER SUSTAINMENT COMMAND AND EXPEDITIONARY SUSTAINMENT COMMAND

2-31. A theater sustainment command is assigned to an Army Service component command. TSCs provide command and control, and decentralized execution of logistics operations throughout the theater. The fleet maintenance manager in the theater sustainment command is responsible for assessing and identifying maintenance capability requirements for the Army deployed in the theater. The theater sustainment command is also responsible for managing critical class IX supplies to support theater readiness requirements. The TSC must identify critical class IX shortages and pass this information to national level providers to fulfill the need. The maintenance section in the distribution management center's materiel management branch works closely with the AFSB to ensure effective sustainment-level maintenance support to the Army.

2-32. The expeditionary sustainment command typically focusses on sustainment within a theater. The maintenance section in the expeditionary sustainment command distribution management center's materiel management branch provides staff supervision over maintenance issues affecting force readiness. The staff determines requirements and manages the maintenance capabilities for supported units of the command. Within the staff there are personnel tasked to provide oversite of ground maintenance, electronic maintenance, and aviation maintenance. They conduct maintenance trend analysis, identify equipment maintenance issues, and coordinate resolutions.

SUSTAINMENT BRIGADE

2-33. A sustainment brigade is attached to a theater sustainment command or an expeditionary sustainment command to provide maintenance and class IX management support to the Army on an area basis. The sustainment brigade provides support to both corps and division subordinate formations. The sustainment brigade's coordination requirements differ from the expeditionary sustainment command and theater sustainment command. The sustainment brigade is the link from echelons above brigade sustainment to the brigade. The sustainment brigade executes maintenance support through one or more combat sustainment support battalion (CSSB). The support operations materiel readiness branch is responsible for assessing the current echelons above brigade maintenance capabilities and for making recommendations for additional maintenance capability if required.

COMBAT SUSTAINMENT SUPPORT BATTALION

2-34. The CSSB is a multifunctional logistics headquarters normally attached to the sustainment brigade. The role of a CSSB is to exercise command and control for task organized companies, teams, and detachments executing logistics operations. The Army designed the CSSB to employ and control up to seven company-sized units conducting logistics operations. The requirements for the number and type of units attached to a CSSB is mission dependent. The support operations maintenance management personnel provide oversight of the maintenance organizations attached to the CSSB. The support operations coordinate maintenance, class IX management and support within its supported area. The maintenance branch has a maintenance manager and a maintenance control sergeant to oversee maintenance workload, requirements, and to identify systemic maintenance problems. The CSSB headquarters company includes field maintenance capability that supports the headquarters' organic equipment.

CORPS AND DIVISION

2-35. Maintenance primarily falls under the responsibility of the corps and division assistant chief of staff, logistics officer, known as the G-4. At the corps level, the logistics officer serves as both the chief of the sustainment cell and the logistics coordinator. The logistics officer at division level recommends the allocation of critical logistics supplies and equipment to include recovery vehicles. The logistics officer may source heavy equipment transporters to supplement the division's recovery assets.

DIVISION SUSTAINMENT BRIGADE

2-36. The division sustainment brigade, also known as the DSB, is assigned to a division. The division sustainment brigade commander is the primary senior advisor to the division commander and the deputy-commanding general (support) for the sustainment warfighting function. The commander is responsible for the integration, synchronization, and execution of sustainment operations at echelon. The division sustainment brigade employs sustainment capabilities to create desired effects in support of the division commander's objectives. The division sustainment brigade has an organic division sustainment support battalion, known as the DSSB. The command and its subordinate units must be able to move and displace at the pace of large-scale combat operations.

DIVISION SUSTAINMENT SUPPORT BATTALION

2-37. The division sustainment support battalion is organic to a division sustainment brigade assigned to divisions. The division sustainment support battalion and its subordinate units must be able to move and displace at the pace of large-scale combat operations. The division sustainment support battalion commands and controls all organic, assigned, and attached units. Each division sustainment support battalion has an organic composite supply company, composite truck company, support maintenance company, and field feeding company. As directed by the division sustainment brigade commander, the division sustainment support battalion provides maintenance, transportation, supply, and distribution support to divisional brigade combat teams and other units operating in the division rear area. Other capabilities are task organized by the division commander in accordance with requirements.

Support Maintenance Company

2-38. The support maintenance company is organic to the division sustainment support battalion. Planners may also attach a support maintenance company to either a CSSB, or a sustainment brigade based on the projected maintenance workload of the supported unit. Support maintenance companies provide allied trades support, wheeled vehicle recovery, quality control, and maintenance for wheeled vehicles. The unit also provides communication, electronics, special electronic devices, ground support equipment, power generation equipment, utility equipment, and test measurement and diagnostic equipment, commonly called TMDE support. The support maintenance company has three platoons: an automotive/armament platoon, an electronic maintenance platoon, and a ground support equipment maintenance platoon. The company is able to task organic maintenance teams to provide support in multiple locations.

Maintenance Surge Team

2-39. Maintenance surge teams deploy into a theater to provide additional echelon above brigade maintenance capacity. Teams can be attached to a corps headquarters with an attached armor brigade combat team or Stryker brigade combat team or to a division with armor brigade combat teams or Stryker brigade combat teams. The maintenance surge team can be attached to any company-sized unit but will normally be attached to the support maintenance company in a division sustainment support battalion or CSSB. Commanders may employ the maintenance surge team to provide maintenance capability to support high demand maintenance on combat platforms or to mitigate risk based on geographic dispersion. Maintenance surge teams are highly tailorable and can include a combination of both track and Stryker capability if required and will include platoon headquarters and two to four maintenance sections of Abrams, Bradley or Stryker. Each section consists of two teams. Team equipment includes two system specific recovery vehicles and a special tools set. During reception, staging, onward movement and integration, the maintenance surge team may also address maintenance requirements to enable rapid port clearance and onward movement. The maintenance surge team is reliant on the support maintenance company, or supported unit to provide automation and logistic support.

BRIGADE SUPPORT BATTALION

2-40. The brigade support battalion (BSB) is an organic unit of the brigade combat team (BCT). Each BCT and most multifunctional brigades have a BSB designed to sustain the brigade. The BSB plans, coordinates, synchronizes, and executes logistics operations supporting brigade operations. The BSBs in all types of brigade combat teams have similar structure. A BSB contains a headquarters company, distribution company, field maintenance company (FMC), medical company, and up to six forward support companies.

FIELD MAINTENANCE COMPANY

2-41. FMCs are organic to the BSB within a BCT and most multifunctional brigades. The Army tailored the FMC's structure to the brigade's mission. The mission of the FMC is to provide field maintenance support to units in the brigade not supported by a forward support company (FSC). The FMC also provides specialized low-density field maintenance support to the entire brigade.

2-42. The BSB FMC provides lift capabilities for the repair shop, recovery of organic equipment, recovery to supported units, and support for maintenance evacuation of equipment requiring sustainment-level maintenance. The company also provides limited maintenance support to the FSCs for low-density commodities such as communications and electronic equipment and armaments. The FMC normally operates within the designated brigade support area.

FORWARD SUPPORT COMPANY

2-43. FSCs are organic to the BSB in a BCT and attached in most support brigades. The role of the FSC is to provide direct logistics support to include field maintenance to a maneuver battalion. The FSCs are the link from the BSB to the supported battalions. The FSC provides field maintenance teams as far forward as possible and does the bulk of its work no further back than the MCP though on occasions elements may move into the front lines.

2-44. The FSC's maintenance platoon performs both field maintenance on company vehicles and equipment, and maintenance management functions for the unit and supported battalion. The maintenance platoon leader coordinates all maintenance requirements with the FSC commander. The platoon consists of the platoon headquarters section, maintenance control section, maintenance section, recovery section and the field maintenance teams.

2-45. The maintenance control section is the management center for all maintenance actions in the FSC and supported battalion. The maintenance control section performs maintenance management functions, dispatching operations, and tracks scheduled services for the maneuver battalion and FSC. The maintenance control section also has a small supply section that provides class IX support including shop stock and bench stock for shop operations. It also provides exchange of reparable items. The maintenance control officer is the senior maintenance representative in the maintenance control section and manages the maintenance control section, maintenance section, service and recovery section, and the field maintenance teams. The maintenance control section also oversees execution of materiel management functions including supply planning, requirements determination, requirements verification, stock control, asset visibility, and asset reporting.

Field Maintenance Team

2-46. The field maintenance team (commonly known as FMT) provide field maintenance for all combat platforms in the supported unit. The field maintenance team s provide field maintenance to maneuver companies. Field maintenance team s utilize expedient repair and BDAR, when authorized, to return combat platforms to service. All or part of a field maintenance team typically travels with the company teams.

> ***Note.*** The Army tailored field maintenance teams to the requirements of the BCT they support. Infantry Brigade Combat Team and Stryker Brigade Combat Team FSCs does not have field maintenance teams.

2-47. The supported company commander and the maintenance control section establish the field maintenance team's priorities in accordance with the battalion commander's guidance. The field maintenance team's maintenance non-commissioned officer in charge supervises the field maintenance team, which operates under the operational control of the maneuver company. The maneuver unit fully integrates field maintenance team s into their operational plans.

2-48. Field maintenance team s perform field maintenance repairs as far forward as possible to return equipment to the battle quickly. The teams perform BDAR, diagnostics, and on-system replacement of line replaceable units. If the tactical situation permits, field maintenance team s focus on completing jobs on-site. Field maintenance team s carry limited on-board combat spares to facilitate forward repairs. The FSC's maintenance platoon provides reinforcing maintenance to the field maintenance team s when required.

Service and Recovery Section

2-49. Service and recovery sections are in the FMC, support maintenance company and armored brigade combat team FSC. Allied trades personnel and recovery specialists typically serve in this section. The section’s specialized equipment includes computer numerical control lathes, mills, and additive manufacturing printers for expedient and BDAR repairs. Allied trades personnel are subject matter experts for expedient repairs and BDAR.

MARINE CORPS ORGANIZATIONS

2-50. The Marine Corps developed distinct units to support the maintenance of ground-common and aviation-peculiar equipment. The Marine Corps designed these units to support the Marine air-ground task force, commonly known as a MAGTF.

MARINE AIR-GROUND TASK FORCE

2-51. The Marine air-ground task force is the principal Marine Corps organization for all missions across the range of military operations. The Marine air-ground task force is a task-organized force under a single commander capable of responding to contingencies across the globe. There are five types of Marine air-ground task force s including the Marine expeditionary force, Marine expeditionary brigade, Marine expeditionary unit, special purpose Marine air-ground task force, and air contingency Marine air-ground task force. All Marine air-ground task force have four core components: a command element, an aviation combat element, a ground combat element, and a sustainment element.

2-52. Logistics is a fundamental element of Marine air-ground task force expeditionary operations. The Marine air-ground task force has the logistic capability to initiate an operation, to sustain and to reconstitute the force for follow-on missions. The logistics staff officer is the commander’s principal assistant for logistics and the focal point for policy formation and overall logistical coordination. The logistics combat element, also known as a LCE, provides a wide range of tactical-level logistic capabilities including maintenance.

ORGANIZATION MAINTENANCE

2-53. Units owning equipment have organizational maintenance responsibilities. Proper maintenance is essential to sustain combat operations. The maintenance contact team is the centerpiece of organizational maintenance.

Maintenance Contact Team

2-54. The maintenance contact team consists of organizational maintenance personnel with tools, test equipment, and critical high-usage repair parts. These sustainers inspect, diagnose, classify, and repair equipment at forward sites. In addition, the maintenance contact team may include communications, engineer, motor transport, or ordnance repair personnel. The logistic officer determines the number of Marines and mixes of skills in the maintenance contact team. The maintenance contact team conducts recovery, evacuation and repair. The maintenance contact team will fix the item at the recovery site if possible. If the team cannot make the repair in place, they order required part and coordinate for an intermediate level maintenance support team from the logistics combat element, or supervise the evacuation of the item. The maintenance contact team is normally forward of the field trains where they can be most responsive to unit needs.

Maintenance Support Team

2-55. The maintenance support team is an intermediate version of the maintenance contact team. The maintenance support team has maintenance personnel with tools, test equipment, repair parts, and in most instances a wrecker or other maintenance vehicle. The team inspects, diagnoses, classifies, and repairs equipment at forward sites. The logistics combat element maintenance operations officer determines the number of Marines and mix of skills on each team. Maintenance contact teams generally moved forward to repair a specific item of equipment. Based on the input of the maintenance contact team the maintenance support team draws the required parts and tools for the job before moving to the site.

Logistics Combat Element Forward Maintenance Detachment

2-56. The logistics combat element forward maintenance detachment is the section of the logistics combat element that operates maintenance facilities and collection point forward. The forward support maintenance detachment—

- Evacuates inoperable equipment from supported units' collection points.
- Performs intermediate maintenance within its capabilities.
- Provides maintainers, tools, and test equipment to maintenance support teams.

Marine Logistics Group Intermediate Maintenance Activity

2-57. The Marine logistics group intermediate maintenance activity provides robust end item repair and component rebuild support to the Marine air-ground force. The Marine logistics group commander establishes a centralized intermediate maintenance activity in a sustainment area to perform complex time-consuming maintenance activities during sustained operations ashore. The logistics combat element commander forms multiple on-call maintenance support teams and during surge periods, sends them forward either to assist maintenance contact teams or to augment the logistics combat element forward maintenance detachments.

Aviation-Peculiar Maintenance Support Operations

2-58. The Marine aviation logistics support program and maritime prepositioning force programs provide aircraft support personnel with the skills to sustain all aircraft types within a Marine air-ground task force aviation combat element. These personnel are part of scalable support packages that include all of the maintenance personnel, tools and spare parts required to maintain the fixed or rotary aircraft assigned to the aviation combat element. There are three types:

- Fly in – provides organizational-level spare parts support that allows Marine aircraft to commence operations immediately on arrival in theater and continue operations up to 30-days.

- Contingency – augments the fly-in support package by adding common maintenance support items used by more than one Marine aviation unit and maintenance support items used for a specific aircraft or support equipment application. The Marines designed the contingent support package to extend sustainment up to 90-days.
- Follow on – Provide the aviation combat element with sustainment comparable to the support it would receive in garrison.

2-59. For additional information on Marine Corps maintenance formations refer to MCTP 3-40E, *Maintenance Operation.* MCTP 3-20A, *Aviation Logistics* covers maintenance for the aviation combat element in greater depth.

Chapter 3

Planning for Recovery and BDAR

Recovery operations and the use of BDAR are important sustainment functions that help maintain combat power during large-scale combat operations. Field maintenance capability must be adequate to repair and evacuate damaged equipment to meet the readiness requirements and the maneuver commander's intent. Planning for recovery and BDAR must be an integral part of overall maintenance planning.

MAINTENANCE PLANNING

3-1. Maintenance planners in an operational headquarters generally do not drive the planning process but their input must be fully integrated throughout the process. Maintenance planners use the commander's intent, planning guidance, and military decision-making process, commonly referred to as MDMP, to develop the maintenance concept of support. They derive the concept of support from running estimates developed using a variety of planning tools. These running estimates project casualty figures, maintenance requirements, software patches, and other sustainment requirements. See ADP 5-0, *The Operations Process* for additional information. Maintenance planners participate in all aspects of military decision-making process to ensure synchronization and unity of effort.

3-2. Effective maintenance plans balance three elements: identify requirements (the minimum number of available weapon systems required for mission success), identify available maintenance resources (what maintenance and repair parts capability is on hand to meet the mission), and manage the maintenance resources for maximum effect (establishing priorities, task organizing to support the main effort, posturing class IX, anticipating shortfalls). Commanders align maintenance resources to the unit with maintenance priority and the priority of work assigned to the key systems. Planners use prioritization to identify how to weight maintenance support for the mission. Figure 3-1 illustrates the maintenance planning process.

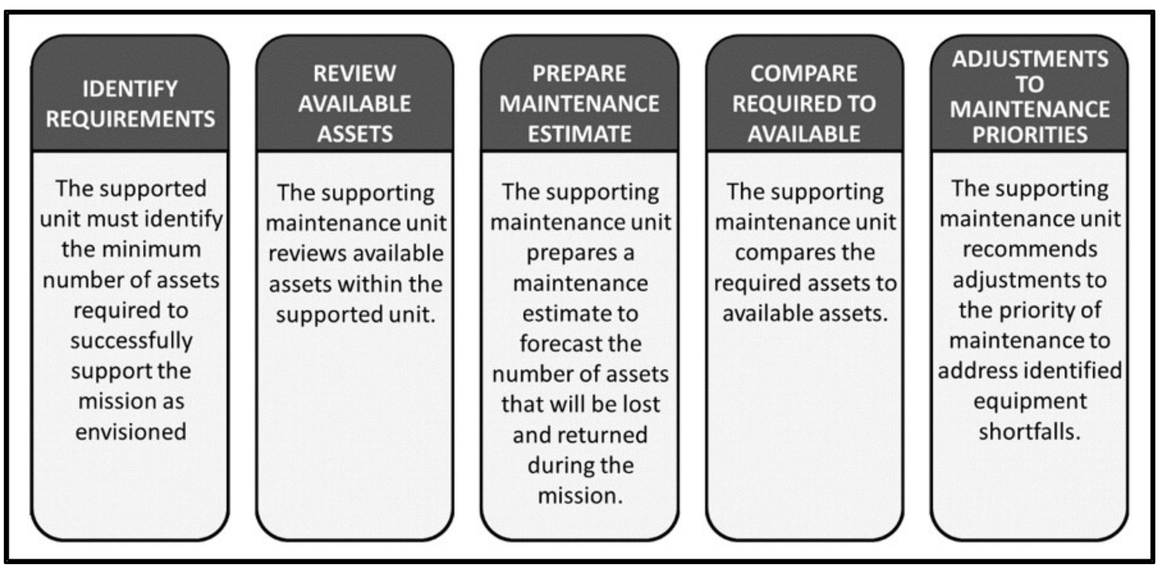

Figure 3-1. The maintenance planning process

3-3. As soon as the higher headquarters identifies a mission, the staff initiates maintenance mission specific planning. The operations officer initiates planning, identifies tasks, and priority of support. The operations section within the BCT has the added benefit of a dedicated logistician who is present to provide sustainment subject matter expertise. The maneuver commander establishes maintenance priorities based on the systems and units that are critical to the success of the operation.

3-4. Through task organization, commanders establish command or support relationships and allocate resources to the decisive operation or main effort. The concept of operations may also identify a main effort (if required); otherwise, the priorities of support go to the unit conducting the decisive operation. The *main effort* is a designated subordinate unit whose mission at a given point in time is most critical to overall mission success (ADP 3-0). The commander normally weights the main effort with the preponderance of combat power. Designating a main effort temporarily gives that unit priority of maintenance support. The commander sets the priority of support to ensure a subordinate unit has support in accordance with its relative importance to accomplishing the mission. Commanders may shift the main effort and priority of support during an operation and subsequently the priority of maintenance support will shift accordingly. Commanders shift resources and priorities to the main effort, as circumstances and the commander's intent require.

3-5. The staff planners calculate the minimum number of weapon systems required to complete the mission. The logistics officer, operations officer and maintenance planners work together to determine how many of the key systems identified are mission ready and then coordinate with the supporting maintenance organizations to repair systems to meet the minimum number required for the mission. The supporting maintenance organization prioritizes work around shortfalls in the key systems working from highest to lowest priority.

3-6. The staff wargames the operation and prepares an estimate of projected system losses and gains during each stage of the operation. Recovery and BDAR are important elements that should be included in the wargame as they are can return additional weapon systems to the fight. They then develop a maintenance estimate that identifies if or when the unit will drop below the minimum requirement of systems for success.

3-7. Commanders should strategically place dedicated recovery assets for optimum support throughout the operational area to support battlefield recovery operations. Commanders must emphasize the use of self and like vehicle recovery methods to the greatest extent possible. These practices will minimize the use of dedicated recovery assets for routine recovery missions. Recovery managers and supervisors must ensure recovery vehicles are used only when necessary. Only properly trained and certified recovery personnel will operate wheeled and tracked recovery vehicles. One or more additional skill identifier H8 certified maintainer must be present for a wheeled vehicle recovery mission. During tracked recovery missions, at least two recovery school trained maintainers with the correct additional skill identifier must be present. Commanders cannot substitute a recovery specialist with a wheeled recovery additional skill identifier for a Soldier with a recovery track additional skill identifier. For more information on tracked recovery operations, refer to TC 21-306, *Tracked Combat Vehicle Driver Training*.

3-8. Commanders determine whether to utilize BDAR on battle damaged equipment when standard maintenance repairs are not practical. The commander may also approve the use of controlled exchange or cannibalization to meet repair parts requirements. Controlled exchange is the removal of serviceable components with the commander's authorization in accordance with AR 750-1 from unserviceable but economically reparable equipment for immediate reuse in restoring another like item of equipment to combat serviceable condition. Cannibalization is the authorized removal of components from materiel designated for disposal. Units use cannibalization only during combat operations.

3-9. Commanders must clearly communicate the authority to use BDAR, controlled exchange, and cannibalization in the operation order. The commander may limit these actions to a specific operation or phase of an operation. The support operations staff can also task or attach maintenance assets to supported units and help expedite parts delivery by ground or air to speed repairs and equipment return to a supported unit.

3-10. Commanders at echelon can utilize fabrication to enable rapid replacement of critical repair parts or to enhance BDAR. Fabrication on the battlefield is a critical capability that utilizes many different technologies including additive and subtractive processes. Emerging additive manufacturing technologies can drastically reduce the amount of time it takes to obtain or make parts. This technology also enables the production of shapes that are impossible with traditional manufacturing processes. Subtractive manufacturing using computer numerical controlled mills and lathes enhance a Soldier's ability to fabricate and replicate items in an expeditionary environment.

3-11. Commanders position maintenance personnel and teams as far forward as possible to support maneuver units. The maintenance personnel and teams must have the necessary transportation, communication assets, tools, security, and repair parts to ensure rapid repair and return of non-mission-capable equipment to support the operation. These teams require reliable sustainment information system connectivity to rapidly replenish supplies and share maintenance information.

+OPERATOR LEVEL PLANNING

3-12. Brigade and below units are where most recovery operations, expedient repairs and BDAR are completed. Timely maintenance support is reliant on supported units providing critical information. This information includes unit locations, type of equipment requiring maintenance, type of fault, mobility status (can the equipment move on its own), parts required, number and status of supporting mechanics, and threat. Accurate reporting ensures commanders and maintainers have the information required to repair or recover a vehicle for repair. Units may pass information up the chain of command through communication systems but must also utilize a DA Form 5988-E to maintain a permanent record.

3-13. Commanders must ensure that a printed or electronically maintained copy of the appropriate TM accompanies each vehicle. Operators should refer to the appropriate TM for the vehicle and winch utilized. This will be sufficient for most like or self-recovery operations.

3-14. The preferred method is to repair a vehicle or piece of equipment without moving it back to a MCP. A recovery operation may be required if a vehicle cannot be repaired forward, is unable to self-recover, or like vehicle recovery is not an option.

3-15. A recovery operation is a combat logistics movement and requires preparation and planning. Before initiating the operation, leaders review the available information and determine if they have the correct equipment, tools, and trained personnel for the mission. A route is determined based on the most current intelligence, weather, and a route reconnaissance. At a minimum, leaders conduct a map reconnaissance and are prepared to navigate without the use of the global positioning system, also called GPS, in a denied, degraded, and disrupted operational environment.

+3-16. Leaders perform a risk assessment taking in all planning factors including speed, proper connections, and terrain grades traversed. Leaders identify hazards and controls to mitigate risk. See ATP 5-19 for additional information on risk management. A security element will accompany the recovery team to provide security from the enemy and secure the area. The element prevents others from entering the recovery area of operation, including local traffic, nonessential, untrained, unaware personnel. Particular consideration must be given to recovery operations occurring on or near roadways to mitigate potential unsafe situations.

MARINE CORPS RECOVERY AND BDAR PLANNING

3-17. The Marine Corps stresses the responsibility for recovery falls to the owning unit. If the owning unit has the capability and the tactical situation allows, the unit is responsible for retrieving immobile, inoperative, or abandoned materiel. A Marine air-ground task force must have a well-defined and understood recovery and evacuation process. In combat, recovery and evacuation may be the most difficult maintenance function. Units move recovered materiel to a MCP or main supply route.

3-18. Commanders should position their recovery capability forward. As a rule, the recovery vehicles and personnel are part of the maintenance contact team, also known as MCTs. The logistics combat element commander distributes maintenance assets to achieve a balance between economy and responsiveness.

3-19. Commanders should closely monitor and control recovery operations. Logistic officers establish recovery and evacuation priorities and allocate personnel and equipment to these operations. During combat operations, weapons and weapon's platform have a higher priority than other equipment. The extent of damage also influences recovery priority. If two or more of the same systems require recovery, the one requiring the least repairs receives higher priority. The logistics combat element evacuates equipment if neither the owning unit nor the logistics combat element can repair a recovered item. The following is a suggested recovery priorities list:

- Items immobilized by terrain.
- Items with failed or damaged components that require little repair.
- Damaged items that require significant expenditure of recovery and repair effort to return them to operation.
- Contaminated items that require significant recovery, repair, and decontamination effort.
- Salvageable items.
- Enemy material.

3-20. The Marine air-ground task force commander may authorize selective interchange. Selective interchange allows the logistics combat element to remove and use parts before evacuating an item. The strain of combat may dictate a greater reliance on selective interchange. The logistics combat element evacuates recovered equipment directly to a designated repair or disposal agency. If material is in danger of capture, the owning unit should recover all salvageable parts and components and destroy the remaining equipment. For additional information on United States Marine Corps recovery, see MCTP 3-40B, *Tactical-Level Logistics*.

Chapter 4

Rigging

Rigging is the process of assembling simple machines or tackle systems and using them to multiply the available force to overcome total resistance. Mechanical advantage is the product of these machines. This chapter describes individual rigging components, methods of rigging, and procedures for calculating mechanical advantage.

RIGGING EQUIPMENT

4-1. Humans have used rigging equipment using block and tackle for centuries to lift heavy objects. The increased mechanical advantage of using a pulley system aids in lifting heavy objects.

BLOCKS AND TACKLE SYSTEMS

4-2. Block and tackle is an arrangement of pulleys and rope that allows you to trade force for distance. A block is a wooden or metal case enclosing one or more pulleys with an attaching hook, eye, or strap. Tackle is a mechanism consisting of ropes, pulley blocks, hooks, or other equipment for lifting heavy items. A pulley is a sheave, a wheel with a grooved rim, used singly with a rope or chain to change the direction and point of application of a pulling force.

4-3. Rigging personnel primarily use blocks to reverse the direction of the rope in the tackle. Blocks take their names from the purpose for which they are used and the places they occupy. The number of sheaves in the block designate a block as either single or multiple. Figure 4-1 shows an array of typical pulley blocks and snatch blocks.

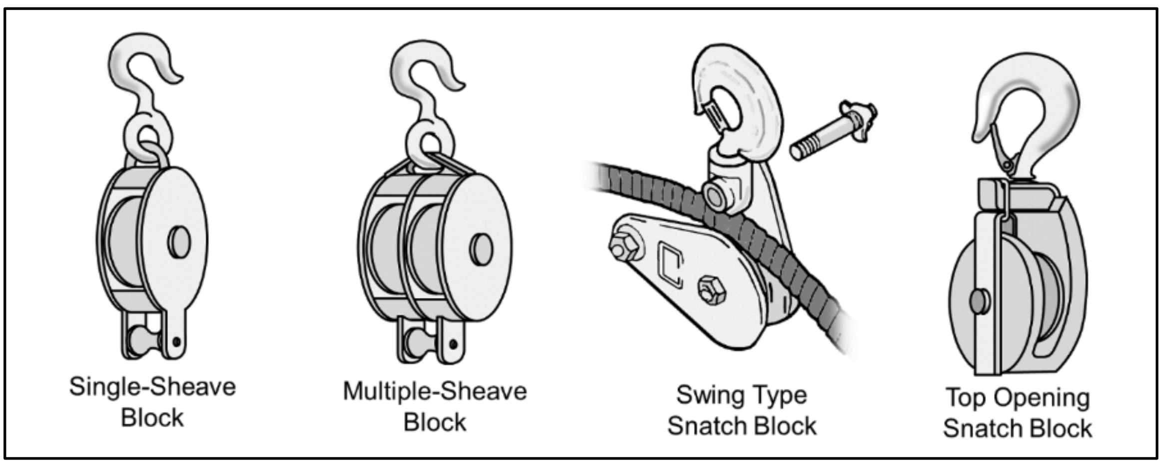

Figure 4-1. Typical pulley blocks and snatch blocks

Conventional Block

4-4. Rigging personnel typically use a conventional block where it will remain as part of a rigging system. On recovery equipment, the conventional block uses wire rope. Conventional blocks do not open. To form a tackle with conventional blocks Soldiers lay out the blocks, and thread or reeve the wire rope through the blocks. Figure 4-2 on page 4-2 shows an example of a conventional and snatch block.

Snatch Blocks

4-5. The snatch block is a single sheave block made so the shell opens on one side or pivots (swing block) at the center of the block to permit a rope to be slipped over the sheave without threading (reeving) the end of the rope through the block. The most common blocks used in rigging are snatch blocks because they are more flexible than fixed blocks. Recovery personnel refer to snatch blocks as fixed, running, or floating blocks depending on their location in the rigging.

4-6. Some snatch blocks have a hinge housing on one side allowing them to open. This enables a Soldier to place the rope over the sheave without disassembling the block. A major design advantage of this type of snatch block is it can remain attached to the rigging while removing or installing the rope. The major disadvantage of these hinged snatch blocks is their weight. Their weight increases as capacities and size increase.

4-7. The swing snatch block is a variant of the snatch block. On a swing snatch block, the housing swings in opposite directions on the sheave pin exposing the sheave to attach the rope. To close the block, a Soldier rotates both sides of the housing until the tackle openings on the block line up enclosing the rope. The major advantage of the swing snatch block is it is lightweight making it easier to handle and carry. A disadvantage is a Soldier must disconnect the swing snatch block from the rigging to enable the housing to swing open and insert the rope. Figure 4-2 shows conventional and snatch blocks.

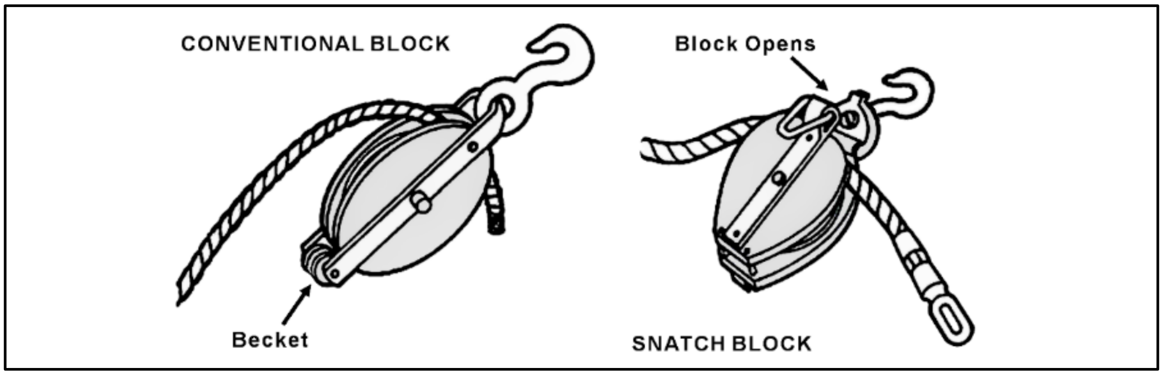

Figure 4-2. Block classifications

4-8. Conventional and snatch blocks may be classified as fixed, running or floating blocks:

- Soldiers attach a fixed block to a stationary anchor. They use a fixed block to change the direction of the wire rope. A fixed block does not provide a mechanical advantage with the exception of self-recovery utilizing a winch.
- An attached running block moves with the load. Soldiers run the cable from the source around the sheave and returns to the fixed bloc. This always provides a mechanical advantage.
- Soldiers use a floating block when the power force and load are not in alignment. Soldiers connect a tow cable to both tow hooks of the disabled vehicle. They then run the tow cable in the sheave of the floating block allowing the power force and load "to self-align." This equally distributes the load between tow hooks. A floating block does not provide a mechanical advantage.

Figure 4-3 depicts fixed, running and floating block configurations.

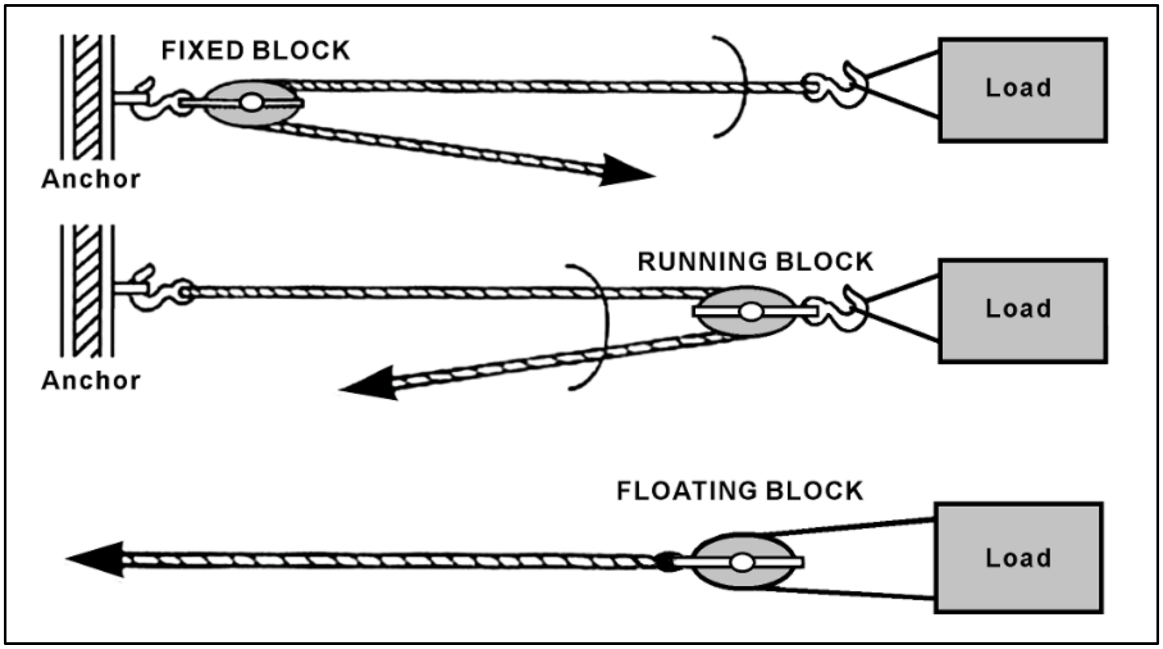

Figure 4-3. Fixed, running and floating blocks attached to a load.

CORDAGE

4-9. There are different types of cords and ropes used in the rigging. These include natural fiber rope, synthetic fiber rope, wire rope, and chains. The following paragraphs describe each.

Natural Fiber Rope

4-10. Soldiers use fiber rope in many rigging and lifting applications. In recovery, Soldiers use it primarily for handling tackle, securing rigging and loading items onto trucks. Manufacturers characterize fiber rope by its size, weight and strength. The most common types of natural fiber rope used are manila and sisal.

4-11. Fiber rope is identified by the size of its diameter until it exceeds 5/8 inch diameter. Manufacturers designate fiber rope with a diameter greater than 5/8 inch by the rope's circumference. Most tables provide both the diameter and circumference of fiber rope for this reason.

4-12. Weight of fiber rope varies due to several factors including, added preservatives, weather conditions and use. Strength of fiber rope depends on the type of properties that make up the fibers. The breaking strength is the greatest stress that a material is capable of withstanding without rupturing.

4-13. The minimum safety factor for fiber rope is four (4). To obtain the working load limit of fiber rope, divide the breaking strength by a minimum safety factor of 4. Soldiers can increase the safety factor by increasing the margin of safety when the condition of the equipment is in question. Table 4-1 on page 4-4 provides an example for computing a load limit for a specific fiber rope.

Table 4-1. Computing fiber rope load limit

Example:
A new 1-inch diameter, Number 1 Manila rope has a Breaking Strength of 9,000 pounds. To determine the rope's working load limit (WLL) divide the Breaking Strength (9,000 pounds) by a minimum safety factor standard of 4.
WLL = Breaking Strength/Safety Factor
WLL = 9000/4 = 2,250 pounds
WLL = 2,250
The result is a WLL of 2,250 pounds This means you can safely apply 2,250 pounds of tension to the new 1-inch diameter, Number 1 Manila rope in normal use.

4-14. Always use the safety factor. Repeated use and exposure to weather conditions reduces the breaking strength of rope. Shock loading, knots, sharp bends, and other stresses rope may have to withstand during use may reduce its strength by as much as 50 percent. When the condition of the rope is in doubt, the safety factor can be increased to 6 or 8 to minimize failures and maximize safety.

Synthetic Fiber Rope

4-15. Technological advances in materials and manufacturing processes led to the development of several strong synthetic fibers. The principal synthetic fiber used in earlier manufacture of synthetic rope was nylon, which has a tensile strength nearly three times that of Manila fibers. Manufacturers developed newer materials including Polyester, Kevlar, Spectra, Dynema, and others fibers. Kevlar and Dynema synthetic rope provide superior strength with minimal stretching and stored energy over the working load range when compared to other synthetic fibers, and wire rope.

4-16. Synthetic fiber rope has several advantages over natural fiber rope. These advantages include that synthetic rope is waterproof and has the ability to stretch and absorb shocks while maintaining its normal length. Further synthetic fibers resist rot, decay, and fungus growth. Synthetic rope is not without some disadvantages. Depending on the protective outer layer, synthetic rope's performance degrades through damage from abrasion, exposure to chemicals, high temperatures, and prolonged exposure to ultra violet radiation. The maritime industry commonly uses synthetic fiber rope in marine applications such as rigging equipment and winches. Some commercial vehicle winches also use synthetic fiber rope.

Wire Rope

4-17. Until recently, wire rope was the most common type of rope used on winches and cranes. The basic element of wire rope is the individual wire made of steel or iron and comes in various sizes. The wires are laid together to form strands, and strands are laid together to form rope. Manufacturers usually wind individual strands or lay individual strands together in the opposite direction of the lay of the strands. The strands are then wound around a central core that supports and maintains the position of strands during bending and load stresses. The main characteristics of wire rope are size, weight, and strength. See figures 4-4 and 4-5 for examples of wire rope characteristics and strand and wire arrangements in the rope.

CAUTION

Always wear leather gloves when handling wire or synthetic rope. Small frays in wire strands can cause severe lacerations to hands. Never slide rope through hands, even when wearing leather gloves. Use the hand-over-hand method when inspecting or handling wire ropes. Kinked, frayed, or unlayed wire ropes are unserviceable and will not be used.

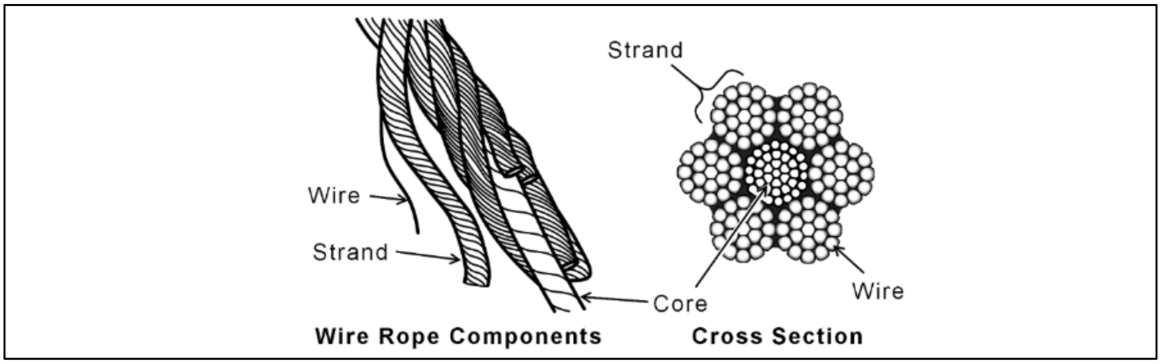

Figure 4-4. Wire rope characteristics

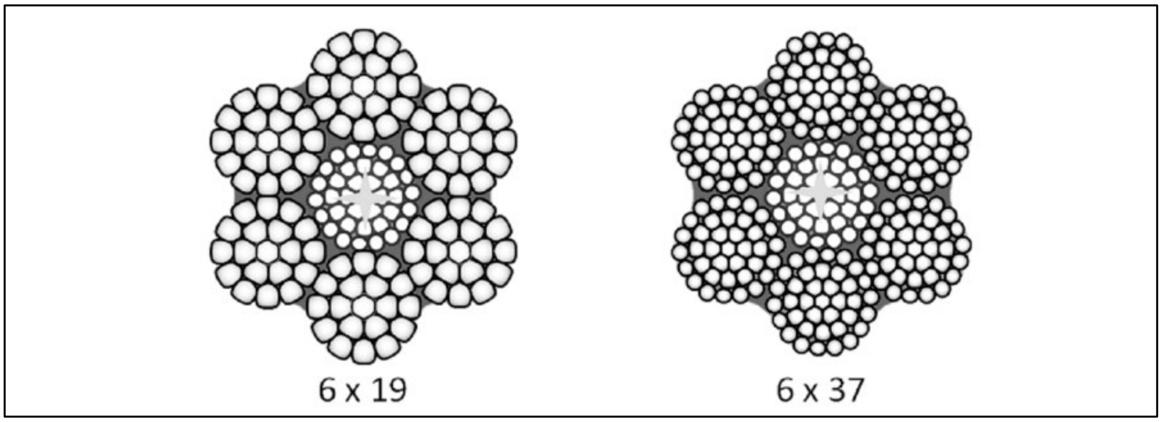

Figure 4-5. Strand and wire arrangements

4-18. Manufacturers designate wire rope size by its diameter in inches. To determine the correct size of wire rope, measure its greatest diameter. Figure 4-6 demonstrates how to measure rope diameter.

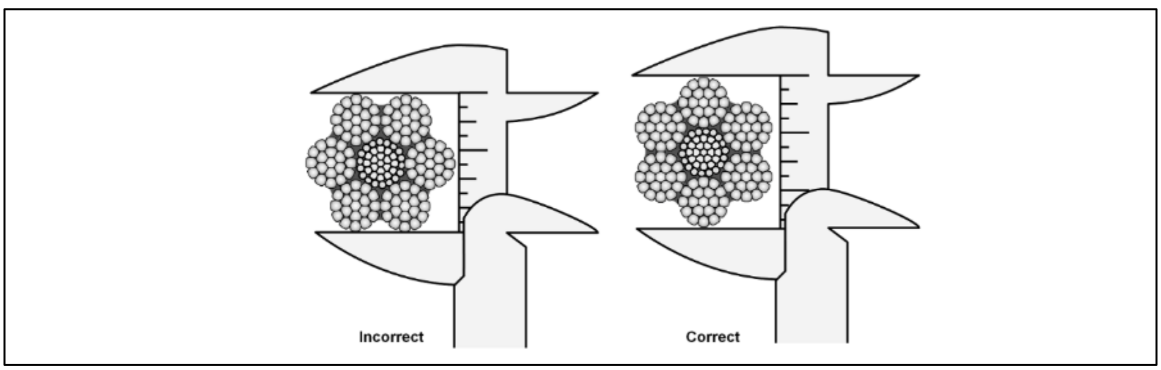

Figure 4-6. Measuring rope diameter

4-19. Due to various materials used in construction of wire rope, the weight varies with the size and the type of material. There is no rule of thumb for determining the weight of wire rope.

4-20. The size, grade and the method of fabrication determines the strength of wire rope. Manufacturers make the wire strands from various materials, including traction steel, mild plow steel, improved plow steel, and extra improved plow steel.

4-21. Soldiers must use a suitable margin of safety, similar to fiber and synthetic rope, when applying a load to a wire rope that has been in service for a considerable time. The user can increase the safety factor to provide an additional margin of safety where the rope has been in service for a considerable time. With wire rope, the safety factor varies depending on the application of the rope. Table 4-2 provides examples of minimum safety factors for various wire ropes.

Table 4-2. Wire rope safety factor

Types of Service	***Minimum safety factor***
Winch Cable	2.0
Track Cables	3.2
Guys	3.5
Miscellaneous Hoisting Equipment	5.0
Haulage (Towing) Ropes	6.0
Derricks	6.0
Small electric and air hoists	7.0
Slings	8.0

4-22. There are several contributing factors for wire rope failures. The following failures are the most common:

- Sizing, constructing, or grading it incorrectly.
- Allowing the rope to drag over sharp or abrasive obstacles.
- Improper lubricating.
- Operating it over drums and sheaves of inadequate size.
- Over winding or cross winding it on drums.
- Operating it over drums and sheaves that are out of alignment.
- Permitting it to jump sheaves.
- Subjecting it to moisture or acid fumes.
- Permitting it to untwist.
- Kinking.

CHAINS

4-23. Chains are some of the most flexible and practical pieces of recovery equipment. Soldiers use chains for extracting mired equipment, rigging applications, lifting overhead loads and securing loads for transport. Subjecting a chain to shock loads or over stretching by exceeding the rated load capacity can easily damage a chain. Only use commercially sourced chains with a verified safety factor and working load limit. The National Association of Chain Manufactures and certain government agencies can test and verify chains.

SAFETY CHAINS

Recovery personnel will use safety chains between towed vehicles and trailers to the towing vehicle. Safety chains are used in a straight line, without twist or knots to shorten, and are only crossed with tow bars/trailers. Safety chains will be 5/8” and grade 100 chains.

4-24. There are several types and grades of chains in use ranging from grade 30 through 100. Soldiers should only use 80 to 100 grade chains to ensure safe recovery operations. Soldiers should use grade 70 or higher chains to secure loads for transport. Soldiers should use grades 80 or 100 alloy chains for overhead lifting. Commercial manufacturers stamp chain grade on several links throughout the length of the chain. Figure 4-7 provides an example of chain markings. For chain and binder specifications refer to Title 49, Code of Federal Regulations, Part 392 (49 CFR 392) and 49 CFR 393.102.

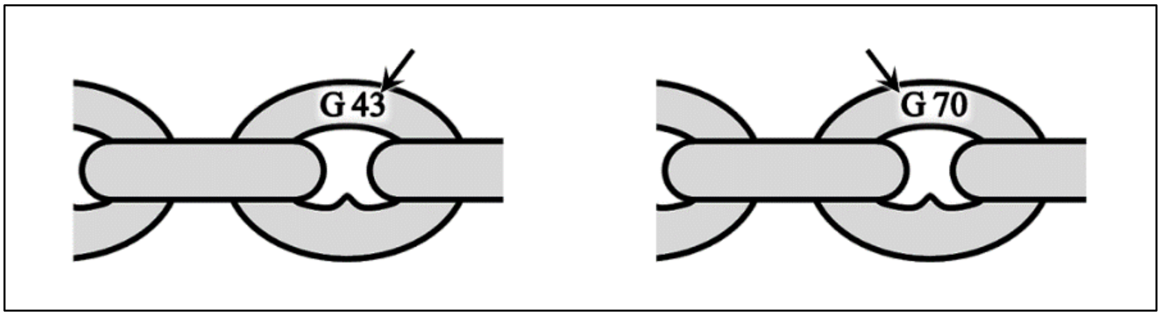

Figure 4-7. Typical chain markings

HOOKS, SHACKLES, AND LOAD BINDERS

4-25. Hooks, shackles, and load binders are essential for many rigging applications. They can differ widely in design, strength and capacity. See Figure 4-8 on page 4-8 shows examples of typical hoist and sling hooks.

Hooks

4-26. There are several types of hooks used with chains and slings. The most common in recovery are grab hooks, sling hooks, slip hooks, and J-hooks. Their application depends on which hooks are best suited for a particular task. Always select the proper hook and load rating for a specific task, and never exceed the working load limit of the hook or chain.

Grab hooks

4-27. Grab hooks are normally attached to chains and load binders. Grab hooks allow recovery personnel to adjust the chain length when needed by connecting to the chain links or to load binders for securing loads. New style chains equipped with grab hooks should have a safety clip or shackle attached that prevents the hook from disconnecting should the chain loosen during use.

4-28. Grab hooks are designed with a special narrow throat used to shorten or hold a length of chain used in overhead lifting applications. The throat engages between the links for quick non-slip handling.

Sling and Hoist hooks

4-29. Sling, or hoist hooks, are commonly found on material handling equipment blocks and lifting slings. Lifting slings may be made from natural or synthetic rope, fiber rope, or wire rope. Hoist or sling hooks are also equipped with safety clips and should not be used if they are damaged or missing.

4-30. Sling hooks are more common on chain bridles and other recovery rigging. The wide opening of these hooks allows for easy connections to shackles, skid plates or convenient locations on the equipment being recovered. The J-hook is a type of slip hook.

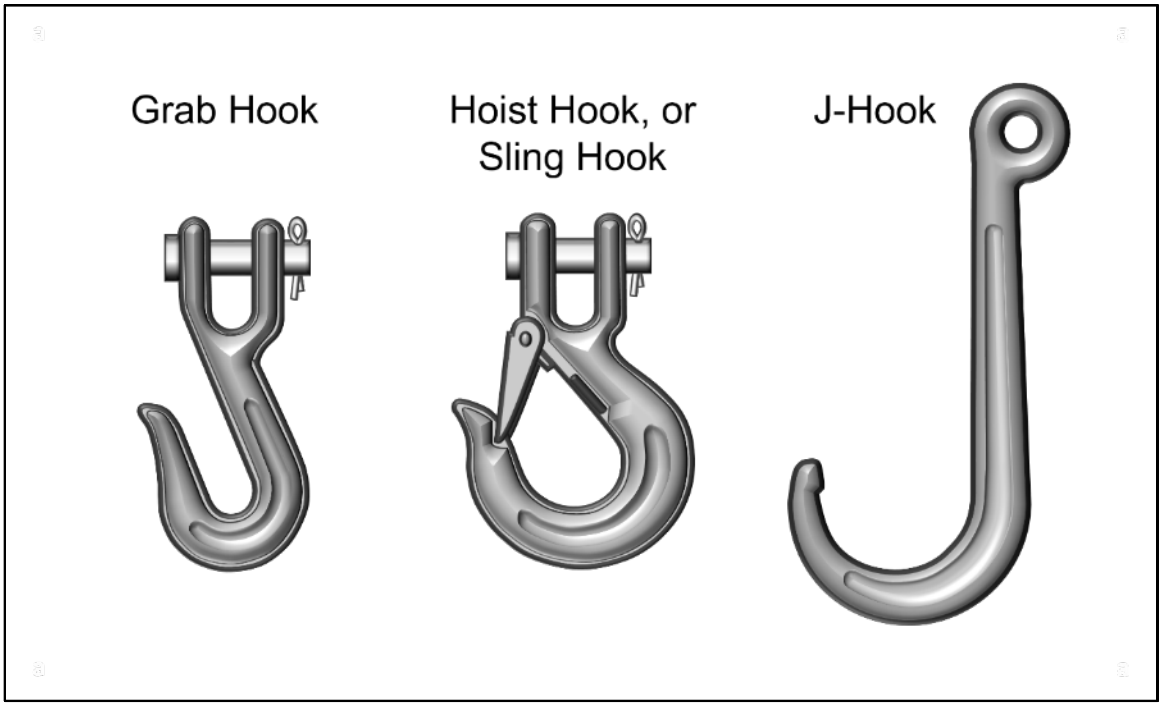

Figure 4-8. Typical hooks

Shackles

4-31. Shackles are another essential piece of equipment in recovery rigging. Shackles are available in various sizes and load ratings. Recovery shackles are normally rated in tons and like any other piece of recovery equipment; you must never exceed the working load limit. When in doubt use the next size shackle. There are two basic types of shackles: anchor shackles, and chain shackles.

Anchor Shackles

4-32. Anchor shackles are the most often used type of shackle and commonly found on recovery systems. These shackles have a rounded (wider) chain area that depending on the size of the shackle and chain can accommodate multiple chains. Anchor shackles are available in three classes based on the type of pin used. The three are—

- Class 1, round pin anchor shackle.
- Class 2, screw pin anchor shackle.
- Class 3, safety anchor shackle.

Figure 4-9 displays a variety of typical anchor shackles.

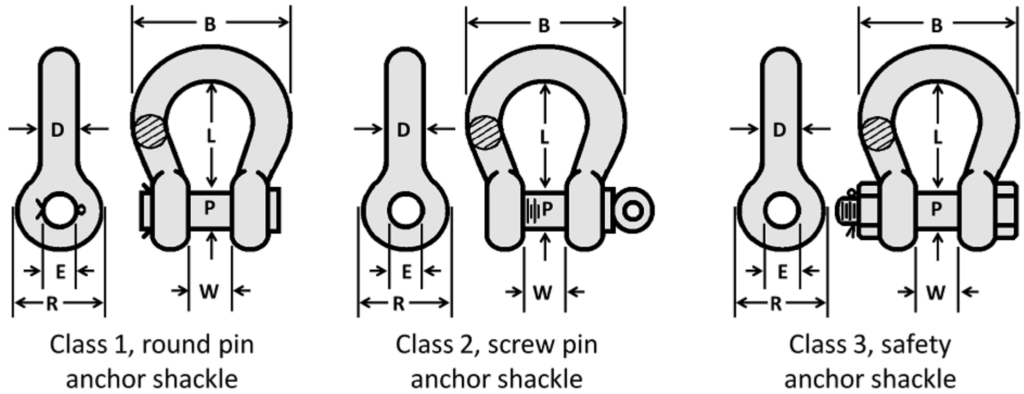

Figure 4-9. Typical anchor shackles

> **WARNING**
>
> **Always use chains in a straight line. Twisted or knotted chain can greatly reduce the safe working load.**

Chain shackle

4-33. Until recently, chain shackles were less common on recovery systems. These shackles have a less rounded (narrower) chain area and usually can only accommodate a single chain. They are available in three classes based on the type of pin used. The three types are—

- Class 1, round pin chain shackle.
- Class 2, screw pin chain shackle.
- Class 3, safety chain shackle.

Figure 4-10 depicts each of the types of chain shackle.

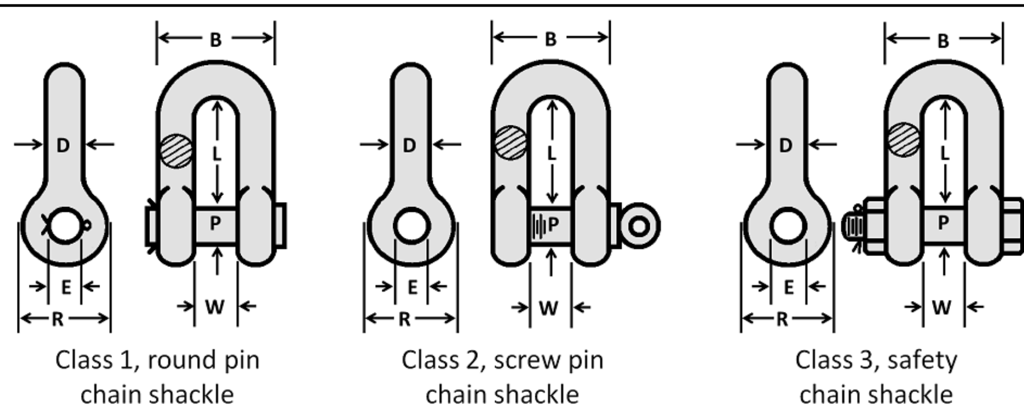

Figure 4-10. Typical chain shackles

SLINGS AND BRIDLES

4-34. Slings and bridles play a vital role during the rigging process. Without these important items, many recovery operations would be difficult if not impossible. This equipment makes rigging connections possible for lifting or recovering equipment. Manufacturers make slings and bridles from various materials including cordage, natural, synthetic or wire rope, and chains. They are available in single-leg, multiple-leg, or endless loop synthetic slings. Recovery personnel can also fabricate slings and bridles from the same materials.

4-35. Recovery personnel use slings or bridles during rigging as deadlines. They attach deadlines to the vehicle being recovered or to anchors. Manufactured endless synthetic slings are color coded with each color representing a working load limit. Only use slings and bridles rated to support the pulling force exerted on them during pulling or lifting a load. Table 4-3 provides capacity information on the endless loop slings and screw-pin shackles based on size and length.

Table 4-3. Endless loop slings and screw-pin shackles

Size/Length	***Sling color / Use shackle***	***Capacities in pounds***		
		Vertical	***Choker***	***Basket***
1" Alloy Shackle		***17,000***	***17,000***	***17,000***
4'	Yellow	8,400	6,720	16,800
6'	Yellow	8,400	6,720	16,800
1 ¼" Alloy Shackle		**24,000**	**24,000**	**24,000**
8'	Red	13,200	10,560	26,400
12'	Red	13,200	10,560	26,400
1 ½" Alloy Shackle		**34,000**	**34,000**	**34,000**
12'	Blue	21,200	17,000	42,400
16'	Blue	21,200	17,000	42,400
1 ¼" Alloy Master Link	**Alloy**	**36,200**	**36,200**	**36,200**

WINCHES

4-36. Soldiers accomplish most recovery operations to extract or recover immobile equipment with winches. Although there are some electrically driven winches on fielded equipment, the majority of recovery winches in use are hydraulically driven. Winch pulling capacities range from a few thousand pounds to several tons. There are two basic types of winches: constant pull capacity winches and variable pull capacity winches. Variable pull capacity winches are more common but are less desirable due to changing capacity.

4-37. Manufacturer designed constant pull winches provide a constant maximum pull with five wraps of rope around the power drum. Unlike variable pull types, constant pull winches have a rope storage drum. In addition to the constant pulling force, recovery personnel can increase the length of the rope by changing the capacity of the storage drum. The major advantage of this type of winch is that it does not require recalculating mechanical advantage as the operator reels in the rope and stores it in the drum. One disadvantage is the storage drum occupies additional space on the equipment. Figure 4-11 depicts typical constant pull winches.

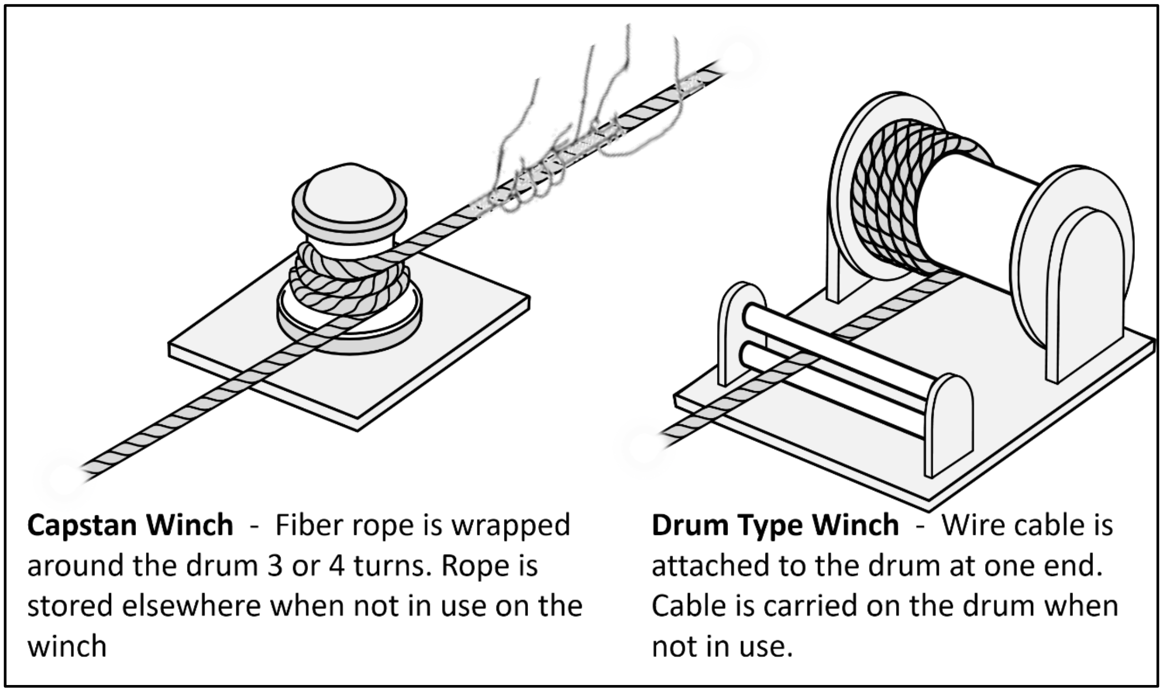

Figure 4-11. Typical constant pull winch

4-38. Winches can be very dangerous if personnel fail to maintain and operate them properly. Winch operation training is critical and must include operation of self-recovery winches. Always refer to the equipment operator's manual for proper operating procedures and maintenance.

4-39. All winches must have the cable stowed under tension. Use the rule "if it is not pretty - it is not right." Cable wound without tension will permit new cable layers to dig into the previous layer, and it damages cable, creates birds nest and may expand and damage winch drum and the winch drive end components. Figure 4-12 also shows an example of proper and improper tension.

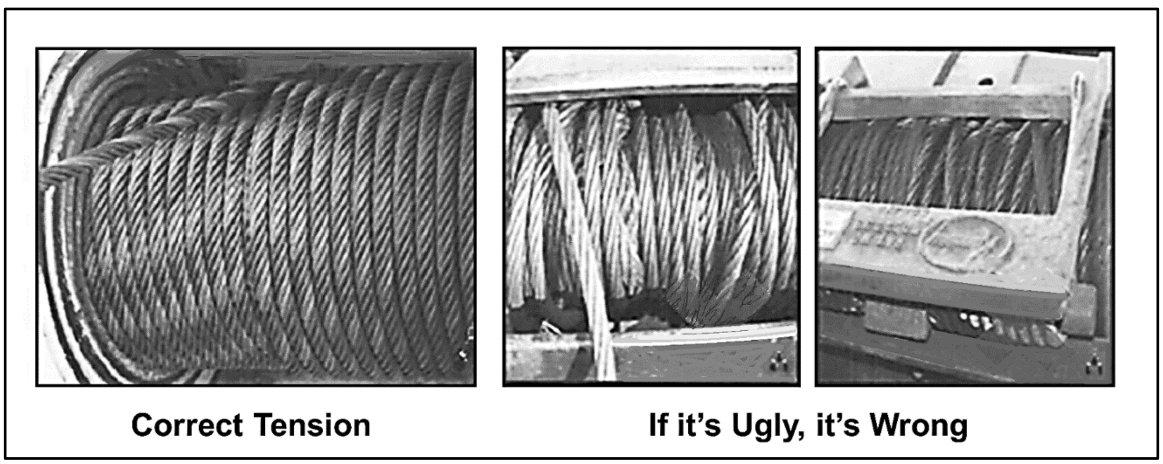

Figure 4-12. Proper and improper cable tensioning

WARNING:

Soldiers must maintain tension on a Main Winch Cable the entire time cable is being payed out. Tension is evident when cable being drawn remains taught and forms a near straight line. Failure to maintain tension will cause all cable layers on the Winch Drum to become loose. If the Main Winch is used with loose wraps on the drum, the winch line will bury down between wraps resulting in bird-nesting and damage to surrounding components.

4-40. Hydraulically controlled constant pull winches differ from Capstan type winches in design and capabilities. These winches do not have a rope storage drum. As the operator reels in the rope, it is stored on the power drum.

4-41. As illustrated in table 4-4, a 30-ton variable pull capacity winch loses nearly one third of its pulling force as the operator reels rope onto the fourth layer. When the pulling force is less than the total rolling resistance the winch usually stalls and repositioning of the recovery vehicle or re-rigging will be necessary. This is not a desirable option if the recovery operation is taking place on gradients or inclines and personnel have to change the rigging to increase mechanical advantage in the middle of the operation. Recovery specialists must consider these calculations during rigging.

Table 4-4. Variable pull capacity

Winch type	*Cable layer*	*Cable on drum (Feet)*	*Capacity (Tons)*
30 ton	1	0-55	30.00
	2	56-128	26.00
	3	129-208	23.00
	4	209-300	20.00

ANCHORS

4-42. Anchors provide solid points of attachment for rigging during recovery operations. There are three types of anchors: natural, vehicle, and constructed. Regardless of which type is used, anchors must provide a holding force equal to or greater than the resistance and the applied pulling force. Refer to TM 3-34.86 *Rigging Techniques, Procedures, and Applications* for additional information on anchors. The number of anchors required for a recovery operation depends on the specific rigging required for that task. Multiple anchors may be required to provide additional points of attachment to achieve the desired mechanical advantage. Whenever possible or practical, utilize natural anchors to expedite the rigging and recovery process. The number of anchors required for a recovery operation depends on the specific rigging required for that task. Figure 4-13 illustrates the symbol for an anchor.

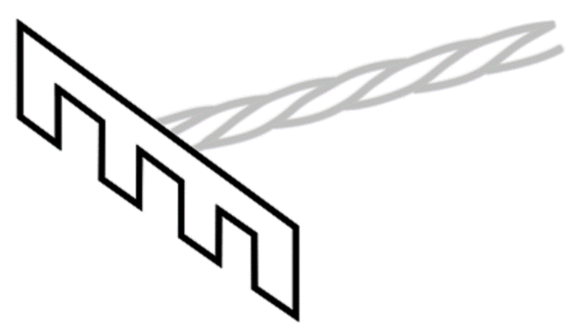

Figure 4-13. Anchor symbol

Natural Anchors

4-43. A natural anchor is one that does not have to be constructed. Examples of natural anchors are trees, tree stumps, and large rocks. Avoid dead or rotten trees or tree stumps, and examine rocks and trees carefully to make sure they are large enough and embedded firmly in the ground. Always fasten the anchor lines at a point as near to the ground as possible. The principal factor in the strength of most natural anchorage systems is the area bearing against the ground. Figure 4-14 shows an example of a constructed and natural anchor.

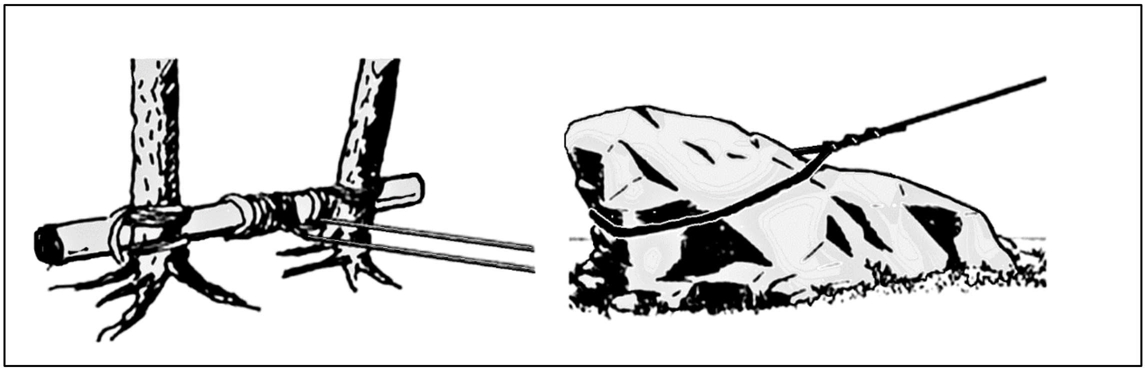

Figure 4-14. Examples constructed and natural anchors

Vehicle Anchors

4-44. Vehicles are the most readily available sources for anchors.

Single Vehicle anchor

4-45. Recovery personnel can use a vehicle as an anchor to assist in the recovery process as depicted in figure 4-15. To be effective, the selected anchoring vehicle must provide greater rolling resistance than the mired or disabled vehicle.

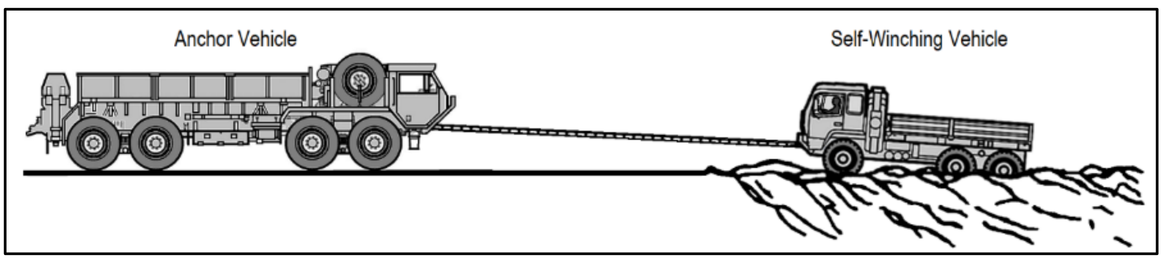

Figure 4-15. Single vehicle anchor self-winching

Tandem Vehicle Anchor

4-46. Recovery personnel can connect multiple vehicles in tandem to achieve the desired effect in situations where one vehicle does not provide the necessary resistance to affect recovery. Figure 4-16 on page 4-14 shows a tandem vehicle anchor self-winching. The connecting cables or chains used must have the appropriate rated capacity. Recovery personnel must connect the cables or chains to the towing lugs not the tow pintle or vehicle bumpers. When multiple vehicles are not available or connecting them in tandem is not practical, Soldiers use a manmade anchor.

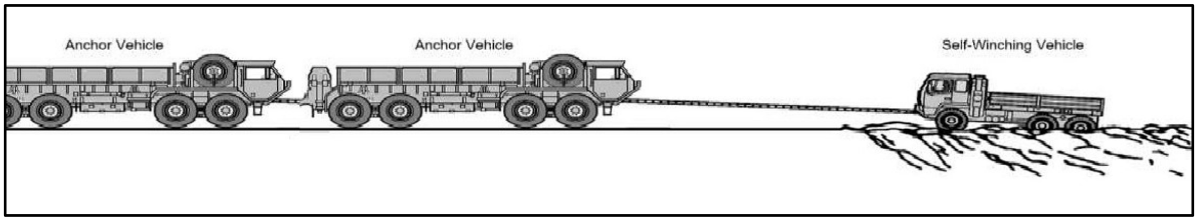

Figure 4-16. Tandem vehicle anchor

Manmade Anchors

4-47. When vehicles or natural anchors are not available, adequate or practical, it becomes necessary to construct anchors that are strong enough to enable recovery. Constructed anchors require time to build or to emplace. To build constructed anchors often requires tools or equipment that is not in the BII for the recovery equipment or disabled vehicle. However, some terrain or critical areas may require the use of constructed anchors to keep the recovery equipment stabilized.

4-48. Manmade anchors require time to construct therefore all operational variables must be carefully considered. The most common manmade anchors constructed include—

- Scotch anchors.
- Reusable anchors.
- Rock Anchors.
- Log Deadman.

Scotch Anchors

4-49. Soldiers may use a Scotch anchor to anchor a vehicle during winching operations when natural anchors are not available, adequate or practical. Scotch anchors are a good choice when it becomes necessary to construct anchors that are strong enough to enable recovery. Figure 4-17 shows a scotch anchor in use. A Scotch anchor is constructed as follows:

- Select a log or pipe at least 6 inches in diameter and 2 feet longer than the width of the vehicle.
- Dig a shallow trench (the length and width of the log and approximately 3 or 4 inches deep) parallel to the front axle, just ahead of the front wheels.
- Lay one or two chains across the center of the trench (width), place the log or pipe in the trench, and move the vehicle forward until both front wheels are against the log.
- Attach the ends of both chains to the towing/tie down lugs and remove all slack from the chains. The operator applies pressure to the winch, pulling the front wheels onto the log tightening the chains and anchoring the vehicle.

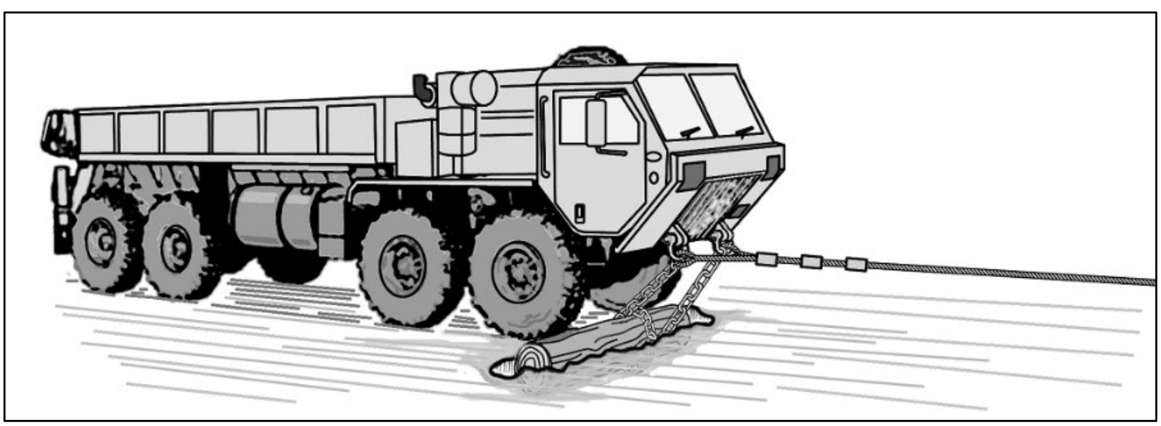

Figure 4-17. Typical Scotch anchor

Reusable Anchors

4-50. Recovery personnel may carry compact pre-fabricated reusable anchors on recovery vehicles for quick deployment in recovery operations. Manufacturers construct these anchors from thick metal or aluminum plates with holes drilled for metal pickets. Soldiers drive metal pickets through the holes into the ground. Personnel can connect the anchors in tandem for additional holding force when needed.

Rock Anchors

4-51. Rock anchors have an eye on one end, a threaded nut, an expanding wedge, and a stop nut on the other end. Construction considerations for a rock anchor include:

- Drill the holes for rock anchors 5 inches deep.
- Use an l-inch-diameter drill for hard rock and a 3/4-inch-diameter drill for soft rock.
- Drill the hole as neatly as possible so the rock anchor can develop the maximum strength.
- In case of extremely soft rock, it is better to use some other type of anchor because the wedging action may not provide sufficient holding power.
- The wedging action is strongest under a direct pull. In order to achieve this always set rock anchors so the pull is in a direct line with the shaft of the anchor.

Log Deadman

4-52. A log deadman is one of the best types of anchors for heavy loads. The log deadman consists of a log buried in the ground with the dead line connected to its center. Figure 4-18 shows a typical log deadman. A deadman is constructed as follows—

- Place the deadman where the direction of pull is as horizontal as possible. Take advantage of sharp banks or crests to increase the holding power with less digging.
- Dig a trench large enough for the deadman and as deep as necessary for good load bearing. When digging, slant the trench in the direction of the pull at an angle of approximately 15-degrees from the vertical. To strengthen the anchor, drive stakes in front of the deadman at each end.
- Dig a narrow inclined trench for the dead line at the center of the deadman.
- Tie the dead line to the center of the deadman, so the main or standing part of the line leads from the bottom of the deadman. This prevents the deadman from rotating out of the trench. If the dead line has a tendency to cut into the ground, place a small log under the line at the outlet of the trench. The strength of the deadman depends on the strength of the log and the holding power of the earth.

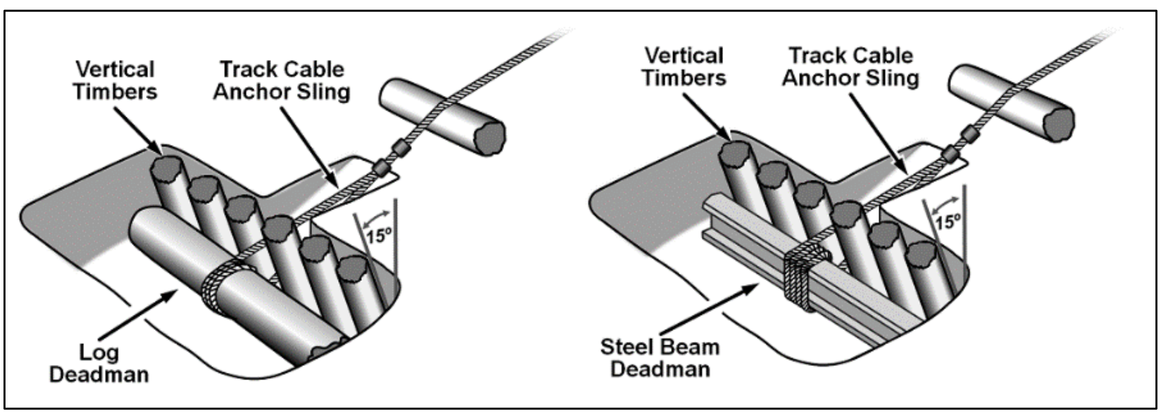

Figure 4-18. Typical log deadman

RESISTANCE

4-53. Resistance is opposition to movement. Terrain features such as mud, sand, water, or the recovery tackle itself, most often cause resistance during recovery operations. This section will focus on vehicles disabled by terrain conditions.

4-54. Two factors to help reduce resistance during recovery operations are direction of travel of recovery and power applied to tracks. (Applied reduction factors discussed in the following paragraphs do not apply to wheeled vehicles.) Once load resistance is determined, apply effort to affect recovery.

TYPES OF RESISTANCE

4-55. Five types of resistance may occur when recovering vehicles disabled by terrain conditions. They are mire, grade, overturning, water, and tackle.

Mire Resistance

4-56. Mud, snow, or sand impacted around the wheels, tracks, axle, gear housing, or hull of the vehicle creates mire resistance. Recovery operators categorize mire resistance as wheel/track, fender, or turret/cab depth. Figure 4-19 depicts the three types of mire resistance.

4-57. Wheel depth wheeled vehicles are mired up to the hub but not over the center of the hub. Wheel depth mired tracked vehicles are mired up to the road wheels but not over the top of the road wheels. Estimate wheel-depth resistance as equal to the weight of the vehicle plus cargo.

4-58. Fender depth wheeled vehicles are mired over the top of the hub but not over the fender. Fender depth mired tracked vehicles are mired over the top of the road wheels but not over the fender. Estimate fender-depth mire resistance as twice the total weight of the vehicle plus cargo.

4-59. Turret or cab depth wheeled or tracked vehicles are mired over the top of the fender. Estimate turret/cab depth mire resistance at three times the total vehicle weight plus cargo.

CAUTION

Make sure the mire is not deep enough to prevent the operation of the vehicle’s engine. Ensure both the air intake and exhaust are clear.

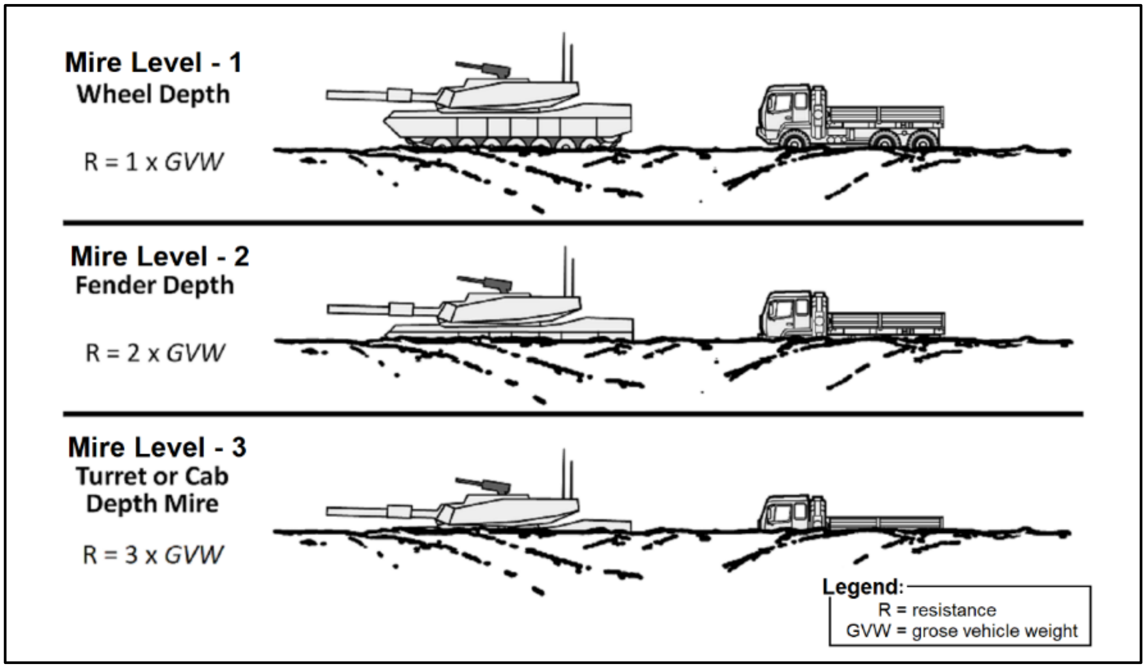

Figure 4-19. Mire factors

Grade Resistance

4-60. Grade resistance occurs when a vehicle moves up a slope. Figure 4-20 illustrates grade resistance. Estimated grade resistance (including nosed-in vehicles) is equal to the weight of the vehicle plus cargo. Even though actual grade resistance may be less than the weight of the vehicle, the most resistance encountered on a grade is the weight of the disabled vehicle plus cargo. Table 4-5 on page 4-18 shows how to calculate grade resistance.

Figure 4-20. Grade resistance

4-61. Surface drag is the single most significant factor in winching. Assuming the vehicle is in proper working condition, a flat surface will use approximately 4% of its total weight to initiate motion. In opposition, a restrictive surface can require as much as 50% of the vehicles total weight. Knowledge is power when it comes to winching. Tables 4-6 and 4-7 on page 4-18, along with figure 4-21 on page 4-19 provide information on determining gradient resistance.

Table 4-5. Surface drag coefficients

Surface Type	***Surface Drag***
Hard flat road	.04
Grass	.14
Sand (hard wet)	.17
Gravel	.20
Sand (soft wet)	.25
Sand (soft/dry/loose)	.25
Shallow mud	.33
Bog	.50
Marsh	.50
Clay (clinging)	.50
The values and calculations are approximate and for reference only.	

4-62. Example: If the surface is gravel, multiply the vehicle's total weight by .20. If the total weight is 50,000 pounds, then approximate rolling resistance is 10,000 pounds

(50,000 x .2 = 10,000 pounds)

Note. This equation is only applicable for flat surfaces. For all other surfaces, the calculation must include the gradient co-efficient.

Table 4-6. Determining gradient resistance in dedicated recovery operations

Gradient Resistance: For practical purposes, gradient resistance can be taken as 1/60th of the weight of the vehicle for each degree of the slope. Slope is defined as height versus horizontal distance.

Combining the weight of the vehicle, the type of surface to be traversed, and the gradient to overcome, use the following formula:

(weight of vehicle x surface drag) + (Gradient value x weight of vehicle) = Effort required

For example, if a vehicle weighing 4,500 pounds were winched up an incline dune that is 20 feet long and 10 feet tall of dry, loose, sand, then the above formula would be used as follows:

Where weight of vehicle = 4,500 pounds

Surface to be traversed = .25 (coefficient for soft sand)

Gradient to overcome = .44 (gradient value)

We have (4,500 pounds x .25) + (.44 x 4,500 pounds) =

1,125 pounds+ 1,980 pounds = 3,105 pounds of effort required to recover the vehicle

Table 4-7. Gradient values

Ratio		***Degree of Angle (ref.)***	***Gradient (G)***
Height (Feet)	**Distance (Feet)**		
1	1	45°	.75
1	2	27°	.44
1	3	18°	.31
1	4	14°	.23
1	5	11°	.19
1	6	9°	.16
1	7	8°	.14
1	8	7°	.12
1	10	6°	.10

Table 4-7. Gradient Values (*Continued*)

Ratio Height (Feet)	Distance (Feet)	*Degree of Angle (ref.)*	*Gradient (G)*
1	8	7°	.12
1	10	6°	.10
1	12	5°	.08
1	15	4°	.06
1	20	3°	.04
1	30	2°	.03
1	50	1°	.02

Overturning Resistance

4-63. Overturning resistance is weight of the vehicle that acts against the force exerted to bring it back on its wheels or tracks. This force is approximately one-half of the vehicle's weight. See figure 4-21.

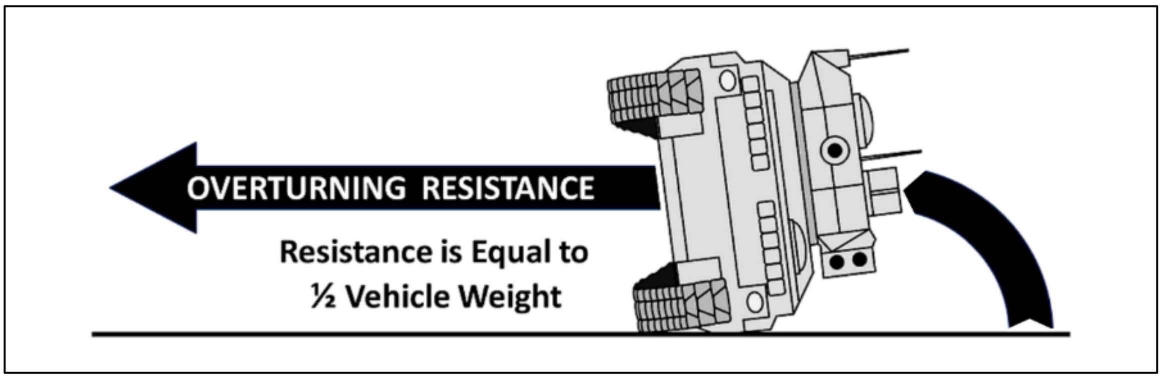

Figure 4-21. Overturning resistance

Water Resistance

4-64. Pulling submerged vehicles from water to land incurs water resistance. Estimating the amount of water resistance is similar to a land recovery. In some instances, the resistance to overcome is less than the rolling resistance of the same vehicle on land.

Tackle Resistance

4-65. Tackle resistance is that part of total resistance added to the recovery by friction in tackle. Tackle resistance is friction created by a sheave rotating in its pin, the rope flexing around the sheave, or the rope scuffing in the groove of the sheave, causing a loss in energy as the rope passes around the sheave. Tackle resistance must be overcome before the load resistance can be overcome. Each sheave in the rigging will create resistance. To determine tackle resistance, multiply 10 percent (.10) of the load resistance by the number of sheaves (not blocks) in the rigging.

CAUTION

Friction in tackle causes a loss in energy that must be overcome before the load resistance can be moved.

Resistance Reducing Factors

4-66. Situation and mechanical resistance affect the load resistance of mired vehicles. Only use resistance-reducing factors with tracked vehicles. Resistance reducing factors do not apply to wheeled vehicles.

4-67. If possible, recover a mired track vehicle in the opposite direction of its travel. Having the tracks pass through ruts made by the vehicle when going into the mire reduces estimated resistance approximately 10 percent. This is the preferred method of recovery.

Power Applied to Tracks

4-68. Applying power to the tracks of a mired tracked vehicle helps break the suction of mud against the belly of the vehicle. This reduces estimated resistance by approximately 40 percent. Before computing the 40 percent reduction, make sure the mire is not deep enough to prevent the operation of the vehicle's engine. Ensure both the air intake and exhaust are clear.

Total Load Resistance

4-69. Because tackle resistance must be overcome before the load resistance can be moved, the load and tackle resistance are added. The sum of the load and tackle resistance is the total load resistance. Total load resistance is the total amount of resistance the available effort must overcome.

Source of Effort and Winch Variable Capacities

4-70. Like vehicles are the quickest, most available sources of recovery effort. On dry, level hardstand in first gear or reverse, the average vehicle exerts a force equal to its own weight. Terrain conditions affect the towing capability of a vehicle. These conditions may require two or more vehicles to exert the same force one vehicle could under ideal conditions. Soldiers use a winch when the situation does not permit recovery by a like vehicle. (Most often, the approach to the disabled vehicle does not provide good traction.) A winch is a more positive source of effort since its towing capability does not depend on terrain conditions.

4-71. A variable winch exerts its greatest force when it pulls by the first layer or the layer next to the bare winch drum. Each successive layer of cable wound onto the winch drum increases the diameter and decreases winch capacity.

4-72. An exception is the constant pull winch found on the M88A2. The M88A2's winch force pull remains constant regardless of the cable layer. Table 4-8 provides a list of estimated winch variable capacities. Refer to the equipment operator's manual for specified capabilities.

Table 4-8. Estimated winch variable capacity

Winch Type	*Cable Layer*	*Cable on Drum (Feet)*	*Capacity (Tons)*
5 ton	1	0 – 39	5.000
	2	40 - 85	4.225
	3	86 – 138	3.670
	4	139 – 199	3.230
	5	200 – 266	2.890
10 ton	1	0 - 41	10.000
	2	43 – 93	8.850
	3	94 - 153	6.250
	4	154 – 220	4.250
	5	221 – 296	2.650
	6	297 – 380	1.400
30 ton	1	0 - 55	30.000
	2	56 – 128	26.000
	3	129 – 208	23.000

Table 4-8. Estimated winch variable capacity (Continued)

Winch Type	Cable Layer	Cable on Drum (Feet)	Capacity (Tons)
	4	209-300	20.000
45 ton	1	0 - 41	45.000
	2	42 - 91	38.000
	3	92 - 149	32.500
	4	149	28.500
Note: The 70-ton recovery vehicle has a constant capacity of 70 tons anywhere on the cable.			

Note. Reduction factors do not apply to wheeled vehicles due to lack of traction. However, power applied to wheels may reduce resistance. Reduction factors are only a guide and apply more to wheel depth than to either fender or turret depth mire situations.

OVERCOMING RESISTANCE

4-73. Applying effort to overcome resistance has always been a challenge. Modern machinery makes this evident. Energy released by burning small amounts of fuel in a modern engine provides the effort to move vehicles weighing thousands of pounds. The vehicle engine, with various mechanical devices, can move the vehicle from a standstill through a wide range of speeds.

LEVERAGE PRINCIPLE

4-74. Using levers is the most basic means to overcome resistance. A wrench handle and the gears of a truck overcome resistance by applying the principles of leverage. The simplest form of a lever is a rigid bar free to turn on a fixed pivot called a fulcrum. When a person exerts effort on one end of the bar, the bar rotates around the fulcrum. To increase mechanical advantage extend the distance between the point where effort is applied and the fulcrum.

Lever Classification

4-75. The location of the fulcrum with relation to effort and resistance determines the lever class. There are two classes of levers.

First-Class Lever

4-76. In a first-class lever, the fulcrum is located between the effort and the resistance. A crowbar is a good example of a first-class lever. Figure 4-22 illustrates how a first-class lever operates.

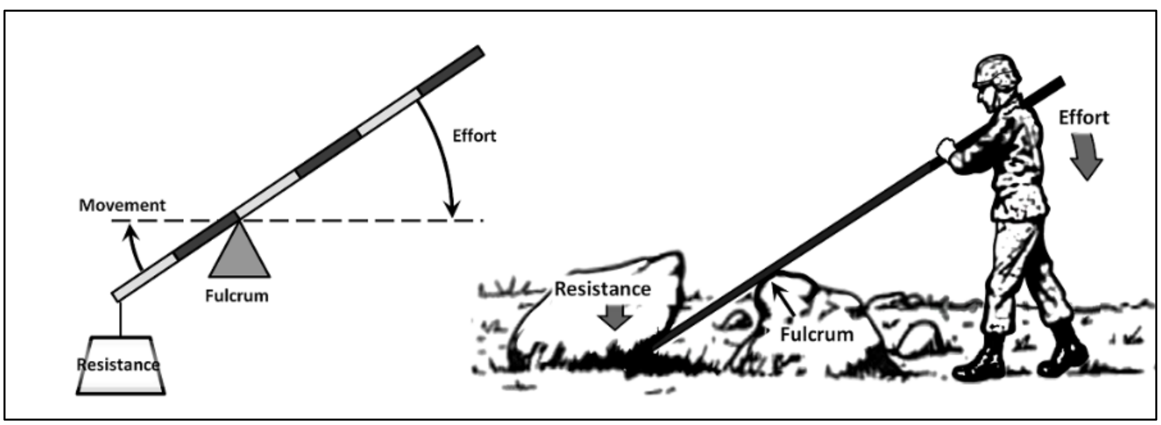

Figure 4-22. First-class lever

Second-Class Lever

4-77. In a second-class lever, the point of resistance is between the fulcrum and the effort. A wheelbarrow is a good example of a second-class lever. Figure 4-23 illustrates another type of second-class lever.

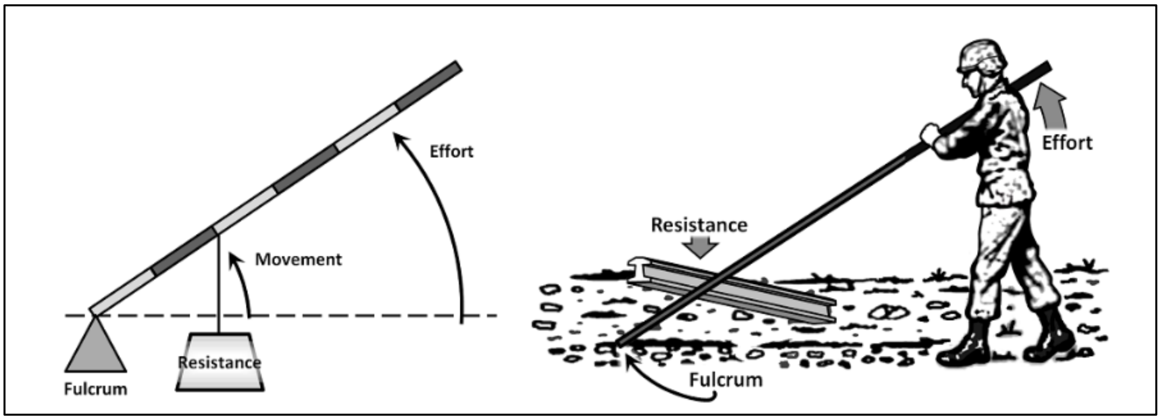

Figure 4-23. Second-class lever

Tackle Systems

4-78. Tackle is a combination of cables and blocks used to gain a mechanical advantage or to change the direction of pull. Recovery personnel classify tackle as either simple or compound.

Simple Tackle System

4-79. Simple tackle is one cable with one or more blocks. To determine the mechanical advantage of a simple tackle system, count the number of winch lines supporting the load. Figure 4-24 provides an example of a simple tackle system.

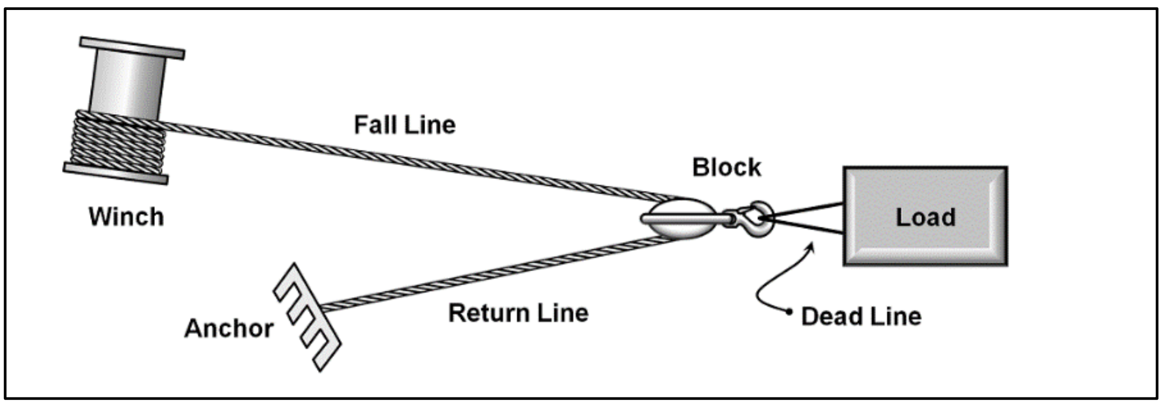

Figure 4-24. Simple tackle system

Compound Tackle System

4-80. Compound tackle is a series of two or more simple tackles working together providing a multiplication of force. The fall line force for the first simple tackle system becomes the load resistance for the second system. Most recovery operations use simple tackle because a winch has only one cable. To compute the mechanical advantage of a compound system, recovery personnel use the output of one simple tackle as the effort for the other. To compute the mechanical advantage of a compound system, multiply the sum of each simple system together. See figure 4-25 for an example of a compound tackle system.

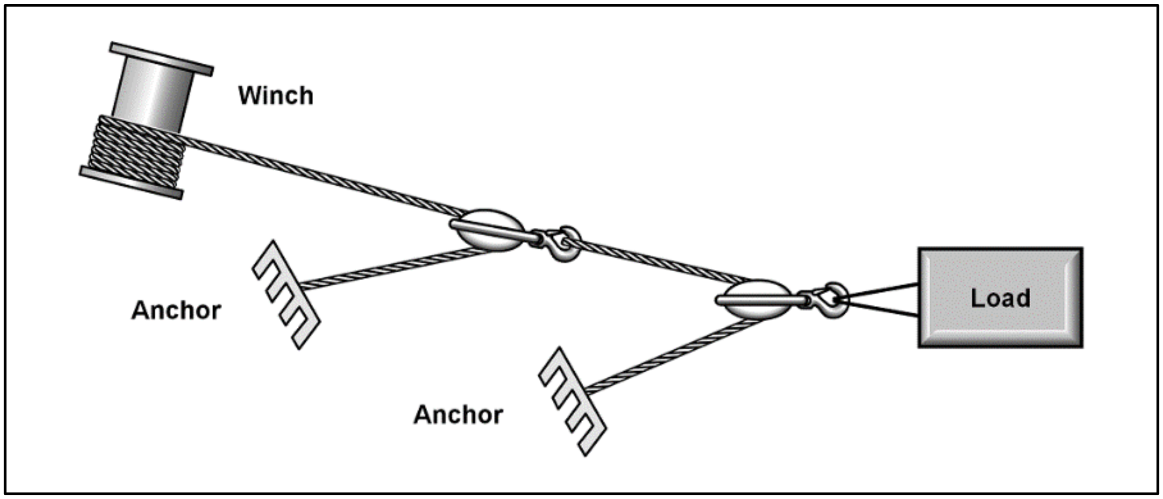

Figure 4-25. Compound tackle system

MECHANICAL ADVANTAGE

4-81. Mechanical advantage is a small amount of force applied over a long distance to move a heavy load a short distance. Recovery personnel need mechanical advantage whenever the load resistance is greater than the capacity of the available effort. To compute the mechanical advantage of a simple tackle system count the number of lines supporting the load. To compute the mechanical advantage of a compound tackle system multiply the sum of each simple system.

4-82. To determine the amount of mechanical advantage necessary in a recovery operation, divide the load resistance by the available effort and round any fraction up to the next whole number. Rounding up is required because only whole numbers can be rigged. See table 4-9 for an example of how mechanical advantage is calculated.

Table 4-9. Calculating required mechanical advantage

Load resistance = …………. 106,000 pound load
Available effort = ... 90,000 pound winch
Load resistance ÷ Available effort = 1.8
Round the fraction to the next whole number = 2
Required Mechanical Advantage = 2:1

4-83. Tackle provides the required mechanical advantage whenever the total load resistance is greater than the available effort. To obtain the amount of mechanical advantage required estimate by dividing the total load resistance by the available effort. Figure 4-26 on page 4-24 depicts how winch lines provide mechanical advantage

4-84. The mechanical advantage of any simple tackle system is equal to the number of winch lines supporting the load or when applying power to the winch, the number of winch lines that become shorter. Recovery personnel can attach the lines directly or indirectly through a block.

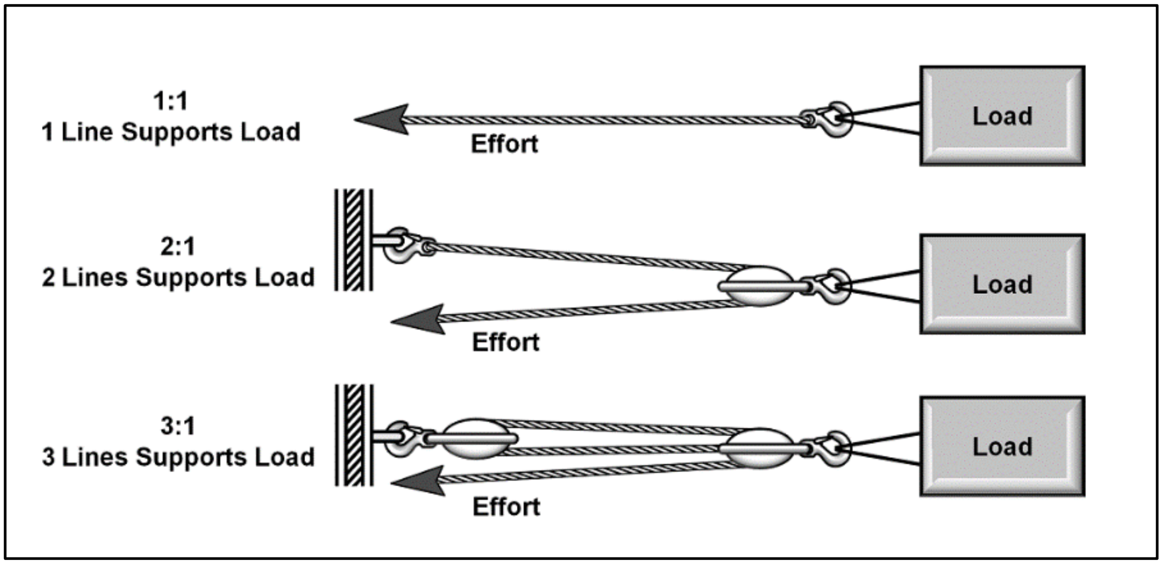

Figure 4-26. Mechanical advantage of tackle systems

4-85. Placement of the block is critical to gaining mechanical advantage. Recovery personnel must attach the block to the movable load and apply effort in the opposite direction to divide the effort equally over the two lines. The 1-to-1 ratio only changes the direction of effort. No mechanical advantage is gained in this configuration

DETERMINING LINE FORCES

4-86. The following paragraphs describe the methods to determine the line force.

FALL LINE

4-87. The fall line is the winch line that runs from the source of effort to the first block in the tackle. There is only one fall line in a simple tackle system. Recovery personnel must consider the amount of force exerted on the fall line relative to the available effort in every problem. The fall line force must be less than the capacity of the effort to accomplish the recovery. Figure 4-27 identifies the parts of a simple tackle.

4-88. To determine the fall line force, divide the total load resistance by the mechanical advantage of the tackle. Calculate as follows:

Note. Fall line force = total resistance / mechanical advantage of the tackle

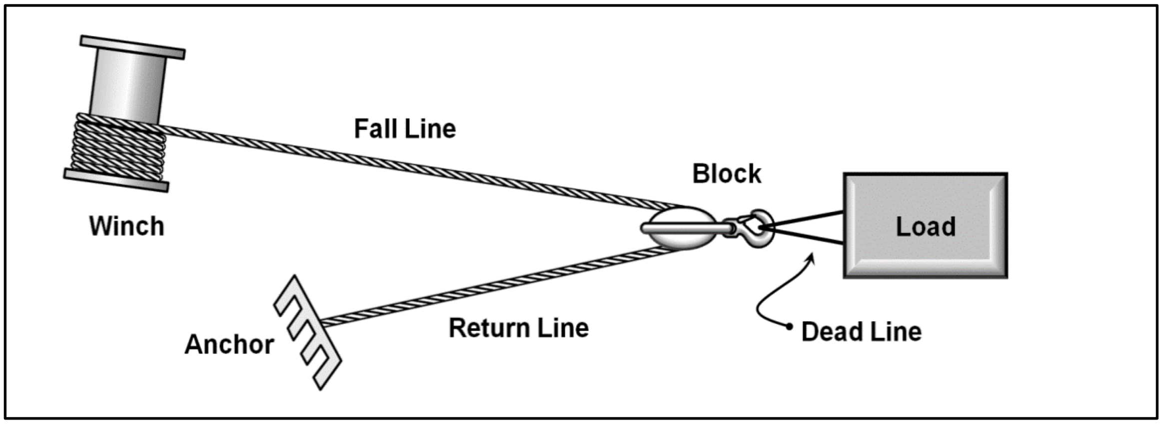

Figure 4-27. Terminology of simple tackle

RETURN LINE

4-89. A return line is a winch line rigged between the block or the winch line from the sheave of a block to the point where the end of the line attaches to (anchor). This force is always the same as the fall line force.

DEAD LINE

4-90. A dead line is a line used to attach blocks or other equipment to the load or to an anchor. To determine the dead line force, multiply the fall line force by the highest number of winch lines supported by the dead line.

FLEET ANGLE

4-91. The fleet angle is the angle between the drum centerline and the wire rope. Figure 4-28 provides examples of fleet angles.

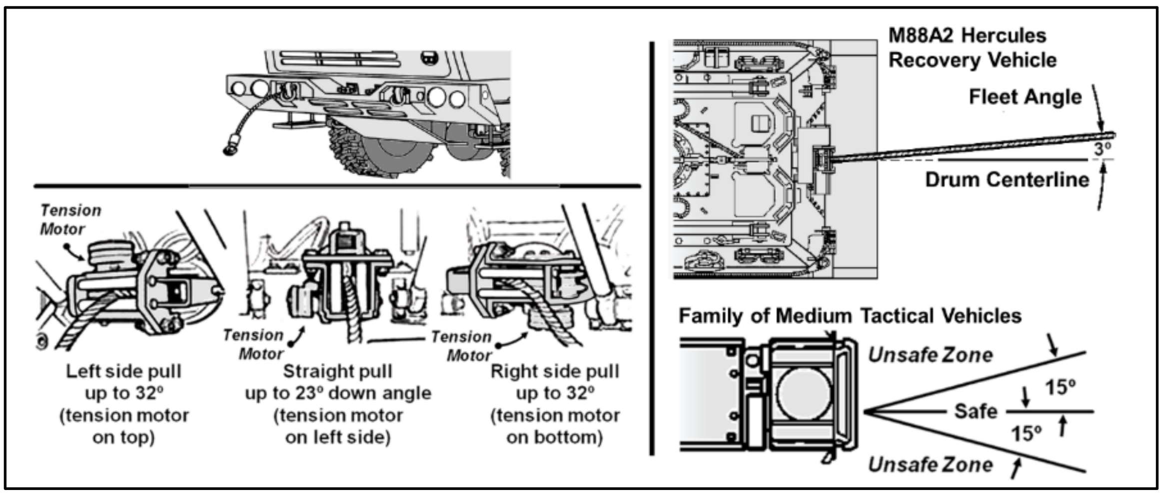

Figure 4-28. Examples of fleet angles.

4-92. Achieving even winding of the winch cable on the drum is important for wire rope life and winch operations. Working with the proper fleet anchor is the best way to accomplish this.

4-93. There are left and right fleet angles, measured to the left and right of the centerline of the sheave. The fleet angle should be restricted when wire rope passes over a fixed sheave and onto a drum. For the most efficient method and best service, the angle should not exceed 1½-degrees, for most vehicles. Refer to the equipment operator's manual for specific information on fleet angles.

> ***Note.*** Although many vehicles have winches that can safely operate at higher fleet angles, most achieve maximum stability and performance at lesser fleet angles. The M88A2 main winch fleet angle operates safely at a maximum 3-degrees to right, or 3-degrees to left. Exceeding the fleet angle will generate a warning light. If the warning light comes on the recovery personnel should cease winching, raise the spade, and power rearward until the operator regains a zero fleet angle. The operator can then lower the spade and resume winching operations.

FAIRLEADS

4-94. Fairleads are usually a combination of rollers and sheaves that maintain some alignment with the winch drum. Not all self-recovery winches or dedicated recovery winches are equipped with fairleads. With exception of a rope tensioner, many of them are open face drums without any sort of rope guides. Some self-recovery winches and dedicated recovery winches are equipped with some sort of fairleads or rope guide system. Operators must still maintain the fleet angle at less than 2-degrees with fixed fairleads.

POWERED FAIRLEAD SYSTEM

4-95. Some dedicated recovery winches have a powered rope feed and fairlead system. Because the distance between the winch drum and the fairlead system is great, the fleet angle remains constant. The power fairlead also maintains tension on the rope. Recovery vehicles equipped with power fairlead systems allow the winches to operate with a horizontal fleet angle between 30 and 32-degrees, and vertical fleet angle between 20 and 23-degrees.

4-96. Operators should never exceed these values. Always consult the operator's manual for the correct position of the fair lead system for right, left or vertical pulling angles. Again, not all recovery vehicle winches are equipped with fair lead systems.

RECOVERY MATH

4-97. Because tackle resistance must be overcome before the load resistance can be moved, the load and tackle resistance are added. Recovery personnel refer to this resistance as total resistance (the total amount of resistance the available effort [AE] must overcome). Table 4-10 lays out the formulas for recovery math.

> ***Note.*** Reduction factors do not apply to most wheeled vehicles due to lack of traction. However, power applied to wheels may reduce resistance. Reduction factors are only a guide and apply more to wheel depth than to either fender or turret depth.

Table 4-10. Recovery math

Recovery Math
Vehicle Weight + Cargo x Mire Factor = Pre Load Resistance – Reducing Factor = Load Resistance
Load Resistance / Available Effort = Mechanical Advantage (must round up to nearest whole number)
10% Load Resistance x Number of Sheaves = Tackle Resistance
Tackle Resistance + Load Resistance = Total Load Resistance
Available Effort must > Fall Line Force
Note: If fall line force is greater than the available effort, more mechanical advantage is required. Up the mechanical advantage by 1 and rework formula. This may be required multiple times. ***Note:*** The number of sheaves is one less than the mechanical advantage, unless you can look at a physical system or picture to count the actual number used.

EXAMPLE SCENARIO 1

4-98. The data in the example recovery math worksheet in figure 4-29 uses the information from scenario 1. Scenario 1: A tracked vehicle weighing 50,000 pounds with 1000 pounds of cargo is mired to the top of the fender. The vehicle runs and is capable to provide power to the tracks. The recovery asset has a 60,000 pounds winch. What is your fall line force?

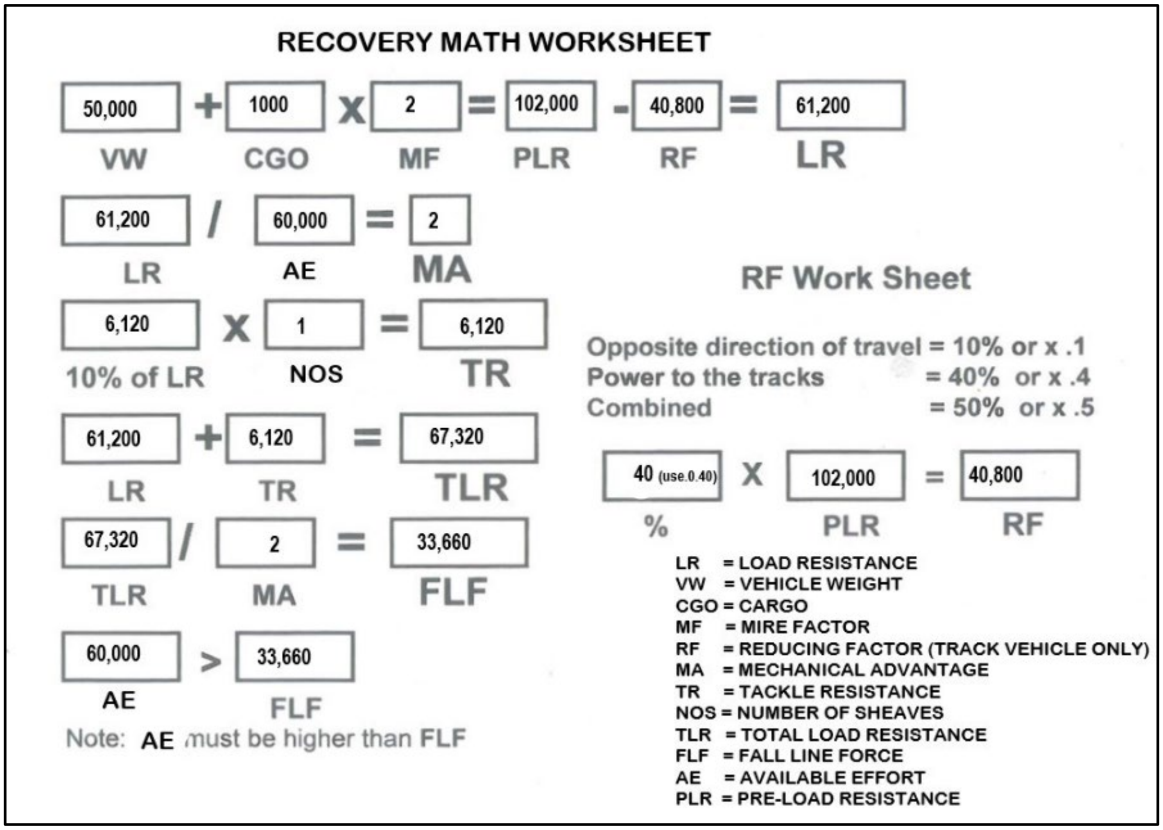

Figure 4-29. Example of a unit generated recovery math worksheet for example 1

Note. Double check: The fall line force is less than the winch capacity.

DETERMINING DEAD LINE FORCE

4-99. In order to determine dead line force for scenario 2 you first find the fall line force. In scenario 2, a disabled vehicle has a load resistance of 14 tons (28,000 pounds). A winch with a maximum capacity of five tons (10,000 pounds) provides the available effort.

EXAMPLE SCENARIO 2

4-100. Return line force is equal to fall line force. If a fall line force is equal to 9,100 pounds and each return line has the same weight as the fall line (9,100), then the dead line force would be equal to 9,100 pounds times the total number of winch lines supported by the dead line. Figure 4-30 on page 4-28 depicts a 4:1 mechanical advantage that could be utilized to solve this problem. Table 4-11 on page 4-28 identifies how to determine fall line force.

Table 4-11. Determining dead line force example scenario 2

Fall line force = 9,100 pounds
Return lines 1, 2, and 3 = 9,100 pounds each
Dead line force equals the number of support winch lines x the fall line force.)
Lines 1, 2, 3 (and fall line) = 9,100 pounds
Dead line I = 4 x 9,100 pounds = 36,400 pounds, Dead line II = 2 x 9,100 pounds = 18,200 pounds, Dead line III = 1 x 9,100 pounds = 9,100 pounds

Note. Ensure Y-slings used for deadlines and snatch blocks are rated to withstand the force applied at the point of attachment.

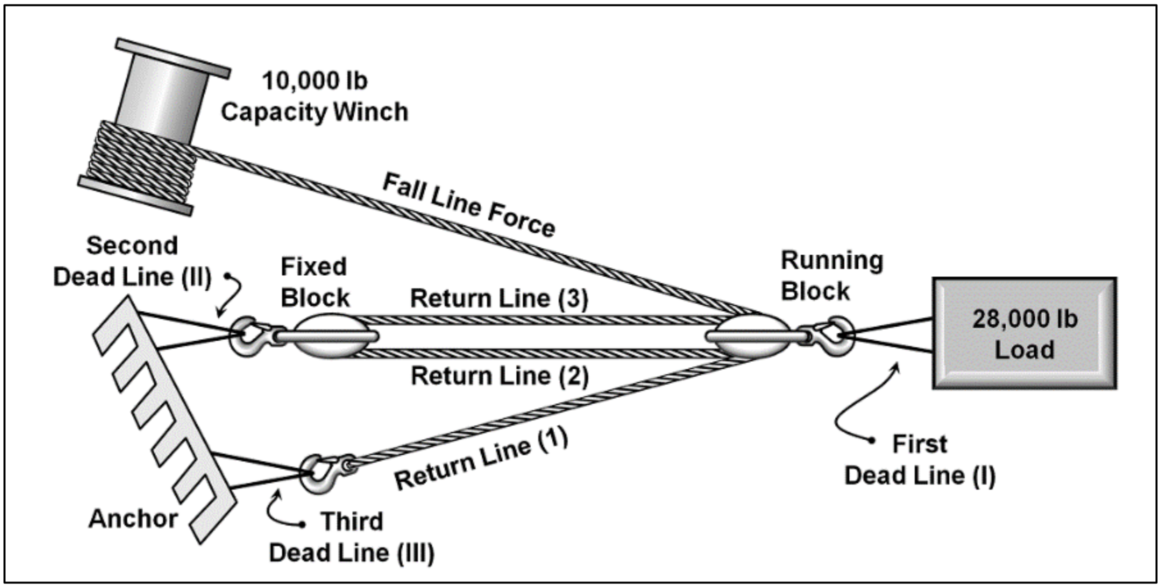

Figure 4-30. 4 to 1 mechanical advantage, with two snatch blocks for example scenario 2

Note. If utilizing field expedient slings as deadlines, refer to TM 3-34.86 to determine sling leg forces. Field expedient slings are constructed using materiel that is not part of the recovery vehicle's BII.

RIGGING TECHNIQUES

4-101. Rigging techniques used depend on terrain, the types of recovery and inoperable vehicle, the distance between the recovery vehicle and the casualty vehicle, and weight of the tackle. Manpower, backup, and lead methods are the most common used for rigging. All of the methods apply to both land and water recovery operations. Depending on the water depth, recovery operations may require specialized equipment to transport the heavy tackle to the recovery site, or the use of qualified divers to attach rigging to the submerged vehicle.

SAFETY

4-102. Rigging and tackle equipment can be extremely heavy, whenever possible deliver the equipment with the aid of vehicle power. When manhandling the heavy gear and equipment make sure multiple individuals assist in dragging or carrying the equipment to prevent injuries.

4-103. When rigging in water make sure at least three individuals are present to assist one another in the event a rigger becomes stuck in the mud or knocked-down by the current or the heavy gear. Always use the buddy system especially during water recovery operations.

TECHNIQUES OF RIGGING ON LAND

4-104. The following methods apply to both wheeled and tracked recovery vehicles: manpower method, backup method, and lead method.

Manpower Method

4-105. The manpower method is used when the winch cable and other rigging equipment are light enough to be carried by the recovery or casualty vehicle crew to where they are needed. This method depends entirely on the strength of the personnel.

Backup Method

4-106. Recovery personnel use the backup method when the recovery vehicle can be safely positioned within 20 to 25 feet of the disabled vehicle. Figure 4-31 shows a tracked recovery vehicle in position to perform the 2:1 lines winching operation using the following steps:

- For a 2:1 lines pull out enough line for a loop in front of the recovery vehicle.
- Attach the cable back to the recovery vehicle.
- Place the main winch snatch block in the loop of the cable and attach the block to the disabled vehicle.
- Slowly back up the recovery vehicle while paying out the main winch cable until it deploys sufficient cable to obtain maximum pulling force (variable capacity winch).
- For a 1:1 lines rigging, pull out enough main winch cable to attach to the casualty vehicle.

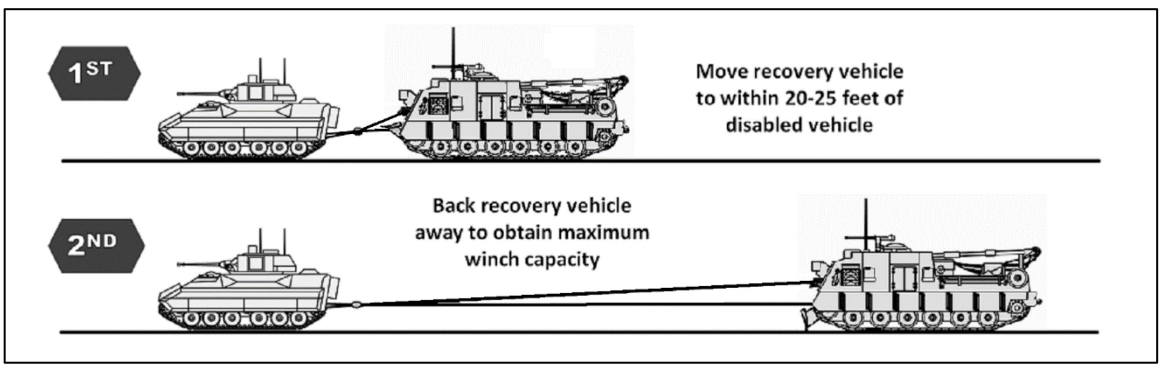

Figure 4-31. Backup method of rigging

Lead Method

4-107. Recovery personnel use the lead method when terrain conditions do not permit close access to the casualty vehicle. Because the hoist winch cable (M88A1) or auxiliary winch cable (M88A2) weighs less than the main winch cable, it is easier to carry (manpower) it to the disabled vehicle. Recovery personnel utilize a snatch block attached to the front casualty vehicle and the Hoist winch cable (M88A1) or auxiliary winch cable (M88A2) to drag the main winch cable and rigging to the casualty vehicle. Figure 4-32 on page 4-30 depicts the lead method of rigging.

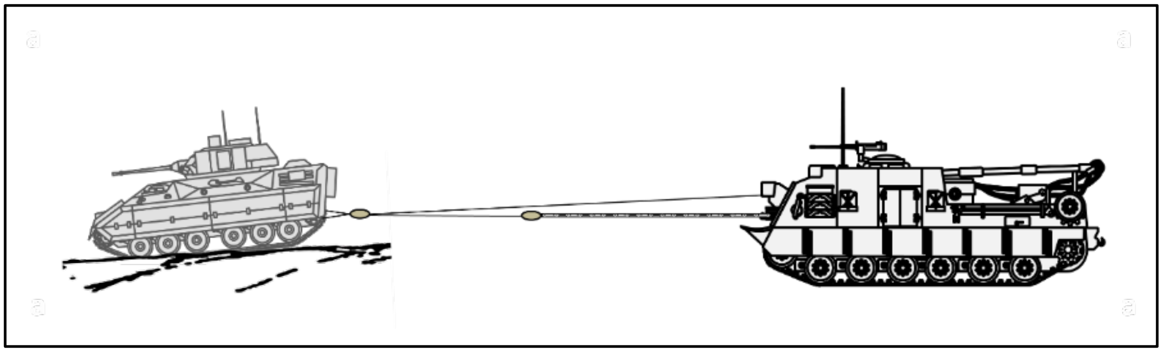

Figure 4-32. M88A2 lead method of rigging

TECHNIQUES OF RIGGING IN WATER

4-108. The rigging methods for underwater recovery are normally restricted to the manpower and/or lead methods. Towing from water is recommended only if the inoperable vehicle is located in very shallow water. The method of rigging depends on:

- The distance from the inoperable vehicle.
- The type of inoperable vehicle.
- The type of recovery vehicle available.
- The equipment available (floats, air bags, tackle).
- The condition of the inoperable vehicle.

4-109. When recovering submerged vehicles with water trapped inside, estimate 8 pounds per gallon factor, plus the curb weight and cargo weight when breaking the surface. It is recommended to open doors or hatches to remove the water inside or pump the water out after it breaks the surface.

Manpower Method

4-110. The manpower method is much the same regardless of whether it's on water or land. A best practice when performing a water recovery is to attach flotation devices to the rope cable every few feet or to snatch blocks and other tackle to aid in getting the rigging equipment to the inoperable vehicle.

Lead Method

4-111. The lead method of rigging is also performed the same in water as on land. If the water is deep, a boat or an amphibious vehicle can transport tackle to the inoperable vehicle. If the water is shallow, the manpower method can be used to carry the rigging and tackle to the inoperable vehicle.

ATTACHING TACKLE

4-112. In recovery operations, attach tackle in a manner that does not cause damage to an inoperable or mired vehicle or does not cause additional damage to a repairable battle damaged vehicle. Recovery personnel utilize only equipment (tackle, shackles, chains, cables or ropes) rated to handle the required force, pulling force and load they will be subject to during recovery.

Wheeled Vehicles

4-113. Always connect tackle to the front or rear towing lugs of a wheeled vehicle. When the towing lugs are not available, connect the rigging to tie down provisions only if rated the same as the towing lugs (see shipping data plate or vehicle TM). Otherwise, attach the rigging to solid mainframe structure. The lifting provisions, also known as eyes, are not designed to withstand the lateral pulling forces exerted during recovery. Always use a V chain, cable, or bridle to spread the load evenly to both attachment points during winching. A V chain is either a chain balanced in the center and held from a hook then connected at two points forming a "V" or two separate chains joined by a center or D-ring. A bridal is typically a cable set up in a "V" shape used with a floating block to help balance the load. A floating block requires the use of a cable but is an ideal method for maintaining an even pull during the entire recovery process.

4-114. Recovery personnel must never attach the rigging to bolt on vehicle components, suspension, or axles. These components may not support the force applied to them and can easily detach, fall or become dangerous flying objects. For additional information on wheeled vehicles recovery operations see TC 21-305-20, *Manual for The Wheeled Vehicle Operator*.

Tracked Vehicles

4-115. Recovery personnel always attach rigging on tracked vehicles to towing lugs at the front or rear of the vehicle. The lifting provisions/eyes are not designed to withstand the lateral pulling forces exerted during recovery.

4-116. When a disabled tracked vehicle does not require mechanical advantage it should be recovered by attaching the winch cable directly to a sling connected to both the towing lugs of the casualty vehicle. This distributes the load more evenly to the casualty vehicle. It is highly recommended the recovery vehicle use the two tow cables from the casualty vehicle to create the sling. This creates the proper angle of the cables and ensures sling leg force is spread evenly to the track vehicle.

4-117. The best method for maintaining even pulling force is with a floating block, as demonstrated in figure 4-33. As with both tracked and wheeled vehicles, this type of rigging provides better distribution of applied forces throughout the recovery operation, until it is possible to apply a tow bar. This hookup is easy to rig and uses tow cables found in BII. The floating block is rigged as follows—

- Attach the ends of the tow cable to the two tow hooks.
- Place the snatch block in the loop formed by the tow cable.
- Attach the winch rope to the snatch block.
- Ensure cables and attachments can withstand forces.

4-118. For additional information on recovering tracked vehicles, refer to TC 21-306.

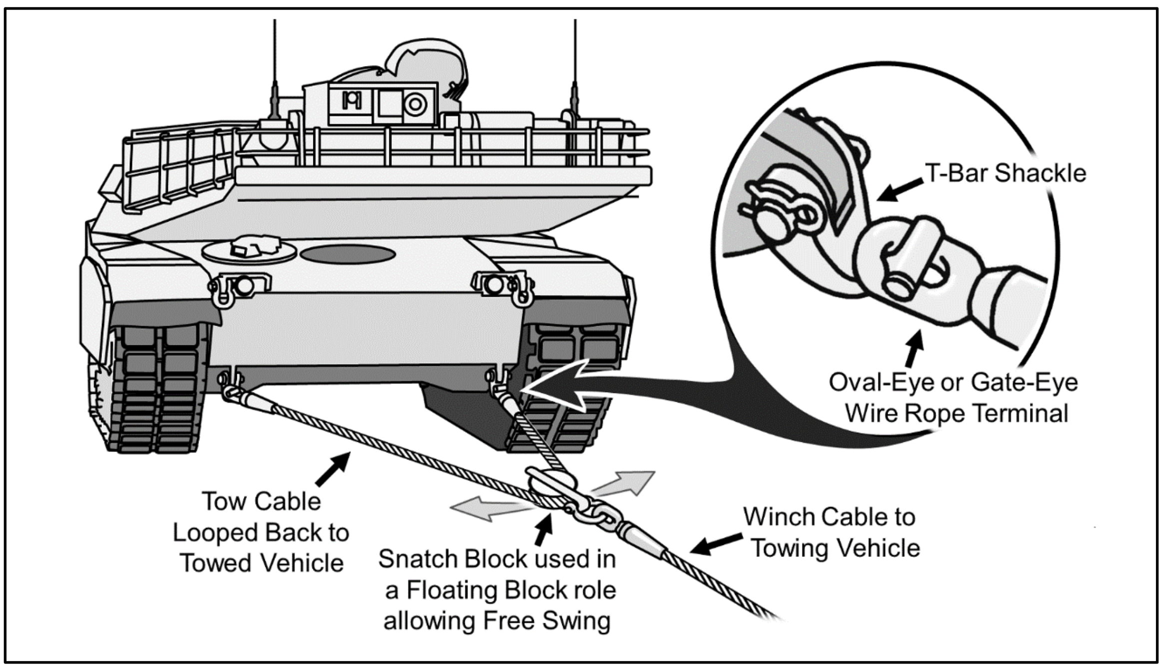

Figure 4-33. Floating block for recovery towing

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Chapter 5

Recovery

Recovery personnel regard a successful recovery operation as one completed quickly and safely. Care must be exercised when erecting and using equipment to prevent damage to vehicles and equipment and to prevent injury to personnel.

CAUTION

Think Safety

Recovery is a big job. Before any recovery operation, do calculations, inspect tackle, and keep rigging references handy. A haphazard approach to recovery can lead to damaged equipment.

WARNING

A haphazard approach to recovery can lead to dismemberment or death.

GENERAL SAFETY PRECAUTIONS

5-1. Recovery personnel must observe safety at all times during any recovery operation.

ACCELERATION IMPACT

5-2. Failure occurs when a weight falls a short distance and then stopped. A similar strong force occurs when recovery personnel engage power suddenly to recovery vehicles when connected to a towed or mired vehicle. The excessive strain on the equipment from shock loads may cause it fail. Figure 5-1 identifies unsafe areas during an angle pull.

WARNING

A winch line makes a deadly slingshot. Recovery personnel will designate safe areas for observers. If the dead line of a snatch block breaks, a 200-pound snatch block can travel as far as 300 yards in the air. All personnel observing should stand at least twice the cable length away from and opposite of the angle of pull or as determined by the winch operator when the cable is under stress. When wire rope is drawn taunt and then released suddenly by a break, its recoil (or backlash) may cut a person in two. Proper distance allows greater reaction time for personnel to move out of the path of flying objects if a cable or other attaching hardware breaks.

BACKLASH

5-3. The winch operator directs the safe distance and areas during recovery operations. Make every effort to stand clear of wire rope that is under tension. A winch line under load stretches like a rubber band and stores up tremendous potential kinetic energy. In fact, a steel winch cable weighing 50 to 500 pounds has more spring to it than rubber. Recovery personnel recommend a minimum distance twice the length of the payed out cable in straight-line recovery operations.

CROSSED CABLES

5-4. Make sure the rigging lines are not crossing each other before the winching operation is continued. Crossed rigging lines can rub against each other causing damage to the cable or an increased amount of tackle resistance.

GROUND GUIDES

5-5. Recovery personnel use two ground guides—one ground guide in the front and one in the rear during recovery operations. Only one ground guide gives the signals to the operator. The ground guides should stand apart from other personnel at the recovery site and be in a position where the vehicle operators can easily observe the signals. The vehicle operators must know the meaning of the signals and act only on those signals. All personnel should be aware of unsafe areas as depicted in figure 5-1.

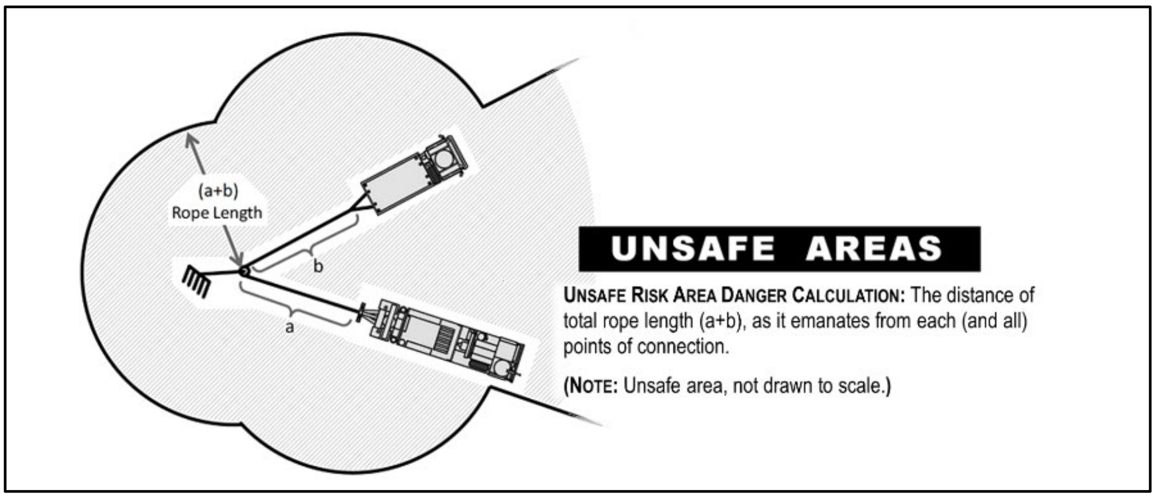


Figure 5-1. Unsafe areas during an angle pull

HOOK POSITIONS

5-6. During rigging operations, recovery personnel position the snatch block hook with the open part (throat) upward. This is a safety best practice. If the hook should straighten out from overload, the hook would be forced downward. If the hook is positioned with the open part (throat) down, the rigging would travel upward unrestricted with a real potential to cause injury to personnel or damage to vehicles. Figure 5-2 illustrates the correct and incorrect position of the hook.

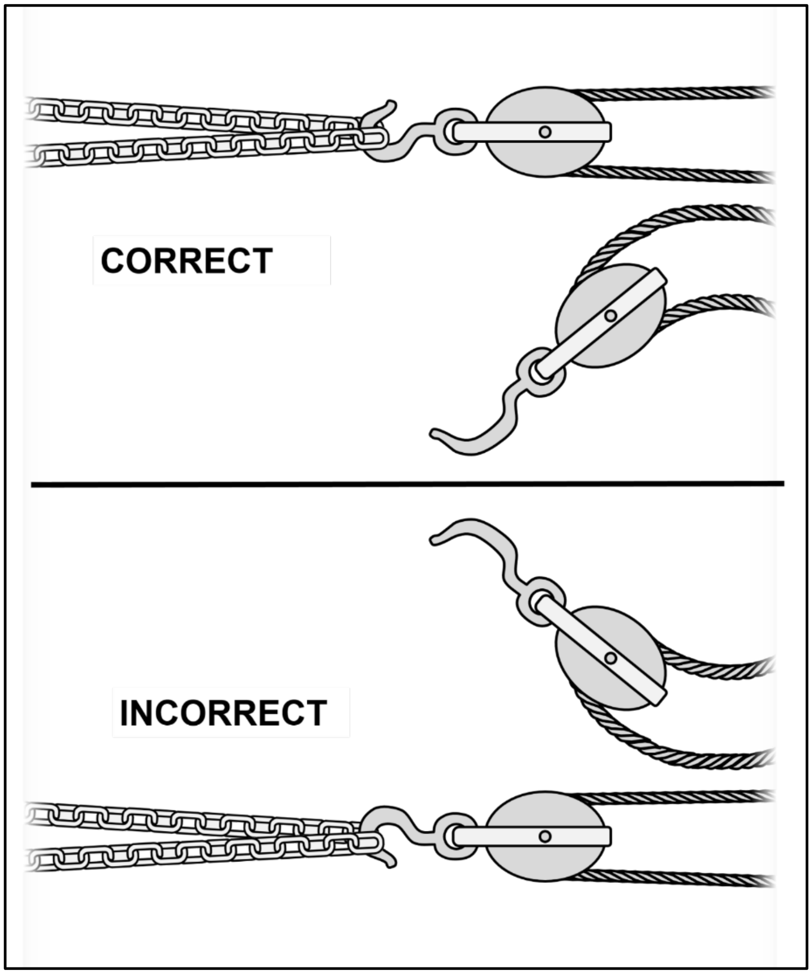


Figure 5-2. Hook positions (snatch blocks only)

HOLDBACK VEHICLES

5-7. Towing tracked vehicles may require using a holdback vehicle:

- Tow cables are only used for extraction, normally less than 50 feet.
- When a holdback vehicle or braking vehicle is necessary, use tow bar for the holdback vehicle. Use a holdback vehicle or braking vehicle if the recovery vehicle is lighter than the disabled vehicle. Recovery personnel as well as the commander need to complete a risk assessment.
- When towing up a grade over 15%, a tow bar on the holdback is required to enable the holdback M88A2 to push the M1. The M88A2 operator will use discretion when crossing ditches and wadis in rigorous cross-country terrain where the tow bar on the holdback M88A2 may contact the spade and damage tow bars. This two-vehicle recovery mitigation process is not a desired practice and will cease when an improved M88A3 regains single vehicle recovery. Modification table of organization and equipment or a table of distribution and allowances, commonly TDA, do not support two M88A2 recovery. Neither operators nor equipment is available, and the procedure is too slow for combat operations.

5-8. For additional information on towing tracked vehicles, see TC 21-306.

INSPECTING RIGGING

5-9. Inspect equipment thoroughly before the recovery operation starts. Direct the recovery vehicle operator to apply power to the winch to remove the slack from the rigging, and then stop the operation to inspect the rigging without endangering personnel. When inspecting the rigging, never place the hands or body between cables under tension.

CAUTION

Personnel inspect rigging thoroughly at every connection to ensure that safety pins are installed correctly and that proper shackles, pins, and hooks are used. Ensure tow cables are not crossed and are reeved correctly in the snatch block.

WARNING

Always step on winch cables not over them when rigging or inspecting rigging. Never cross an anchored cable.

OPERATOR/DRIVER SAFETY

5-10. Operators and other personnel, in both the recovery and disabled tracked vehicles, must keep their hatches closed during winching operations. Operators should use their periscopes to view hand and arm signals.

POSITIONING GUN TUBES

5-11. During tank or tracked howitzer recovery, position the main gun tube so it will not be damaged. If the gun tube of a disabled tank or tracked howitzer is involved in a collision (this might occur on a nosed or overturned tank), maintenance support personnel should always ensure the gun tube is clear before towing. Point tube away from recovery vehicle for movement. When towing a self-propelled howitzer the cannon tube must be in travel lock to the front of the howitzer or severe damage will be done to the elevation and traversing mechanisms. Tow self-propelled howitzer from the rear of the vehicle with the tube in travel lock in accordance with the appropriate TM.

RIGGING BETWEEN VEHICLES

5-12. While erecting rigging between vehicles turn off the engines and apply the brakes. This prevents possible injury to recovery personnel and/or damage to the vehicles. When riggings are erected using a recovery vehicle that must have its engine running to operate the equipment, position the spade or chocks, for a wheeled vehicle, and apply the brakes to prevent movement. The driver remains in position. Figure 5-3 depicts ways to chock or block wheeled vehicles.

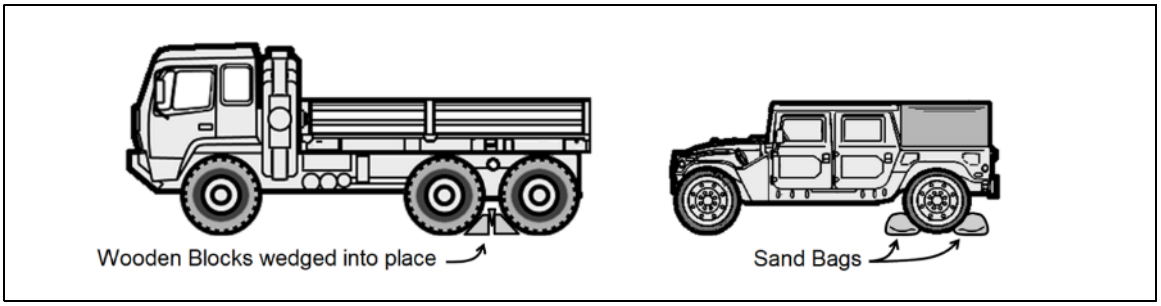


Figure 5-3. Chocking/blocking wheeled vehicles

Hooking up to a Vehicle

5-13. Before hooking up to a tow bar or before disconnecting the drive or parking brake, chock the vehicle wheels with blocks so it cannot move. Place a block of wood or other suitable object between the rear tires or in front of and behind one tire. Make sure the chock extends the full width of the tire.

Unhooking From a Vehicle

5-14. Before unhooking from a tow bar or before connecting the drive or parking brake, chock the vehicle wheels with blocks so it cannot move. Place a block of wood or other suitable object between the rear tires with blocks so it cannot move. Make sure the chock extends the full width of the tire.

CAUTION

Failure to remove the blocks could result in damage to the vehicle.

SAFETY KEYS AND SHACKLE PINS

5-15. Safety keys and shackle pins should be in place on all tow hooks and shackles as depicted in figure 5-4. Even though the safety key and shackle pin supports no great load, its absence can allow a pin to move which places excessive force on only a part of a connection. Some shackles use a threaded-type pin. If the pin is not completely inserted into the shackle threads, the shackle or pin can be bent or broken when force is applied.

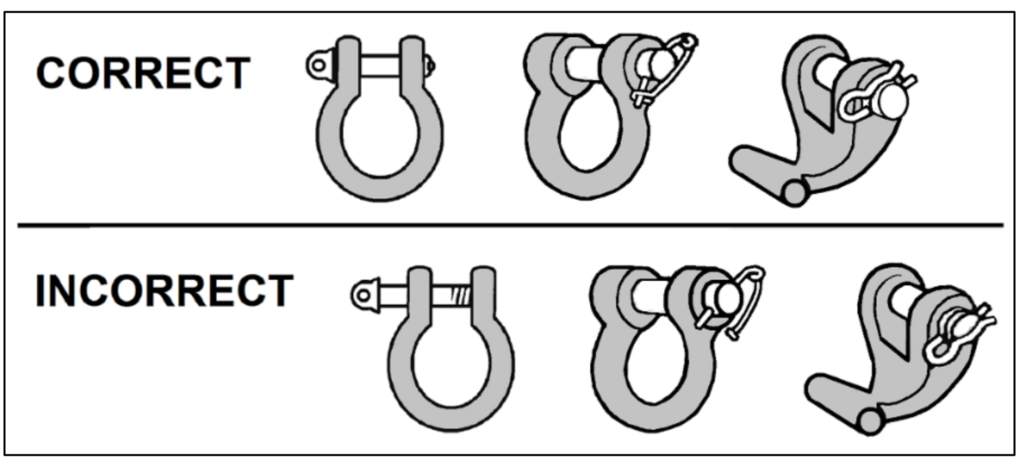


Figure 5-4. Safety keys and shackle pins

5-16. When using shackle pins with safety keys, such as the type used in tow bars, all shackle pins in a vertical plane should have their heads pointing upward. Should the safety key break or fall out, the shackle pins will remain in position if the load shifts.

SPEED

CAUTION

Maintain the correct speed when towing vehicles. Consider the terrain, weather and road conditions when determining speed. Personnel inspect rigging thoroughly at every connection to ensure safety pins are installed correctly and that proper shackles, pins, and hooks are used. Ensure that tow cables are not crossed and are reeved correctly in the snatch block.

+DEDICATED RECOVERY PROCEDURES

5-17. In any recovery operation use the following eight-step method listed in table 5-1:

+Table 5-1. Eight step recovery method

+Step 1. Reconnoiter area. Make sure the security element has secured the area and begin the risk assessment process. Consider all risks factors including the operational variables (mission, enemy, terrain and weather, troops, and support available, time available and civil considerations). Check the terrain for the best approach to the load, then determine the method of rigging and the availability of natural anchors. A recovery crew must know the problem before making decisions. Conduct a complete ground survey of the area, and then select the best route of approach to the disabled vehicle. Avoid approaches that might disable the recovery vehicle. When selecting the evacuation route, ensure the military route classification number will support the combination vehicle classification (recovery plus towed vehicles). Refer to ATP 3-34.81/MCWP 3-17.4 for further information.
Step 2. Estimate resistance. Estimate the resistance created by the load and determine the capacity of the available effort. For most recovery operations involving winching, the available effort would be the maximum capacity of the winch. In some recovery operations, the maximum distance between the winch and the disabled vehicle could be restricted. This makes the available effort as little as half of the winch capacity.
Step 3. Calculate ratio. Compute an estimated mechanical advantage for the rigging by dividing the resistance of the load (step 2) by the available effort.
Step 4. Obtain resistance. Compute the tackle resistance and total load resistance. Total available effort must be greater than the total load resistance (winch capacity multiplied by mechanical advantage). Multiply the percentage of the load resistance (as determined in step 2) by the number of sheaves in the rigging. The determined resistance of the tackle added to the load resistance equals the total load resistance.
Step 5. Verify solution. Compute line forces to compare with the winch and dead line capacities. Divide the total load resistance (step 4) by the mechanical advantage (step 3). The result is the fall line force. The fall line force must be less than the capacity of available effort. Therefore, this step of the recovery procedure is the key step to solving the problem. ***Note:*** When verifying the solution, if the computed fall line force is greater than the available effort, return to step 3 and increase the mechanical advantage. **Note:** No physical work has occurred up to this point. As a result, no time is lost moving equipment or having to re-erect rigging equipment. • Compute the dead line force. • Determine the required strength of equipment capacity, and choose the correct equipment to use as a dead line.

Table 5-1. Eight step recovery method (Continued)

Step 6. Erect rigging. Orient the crew, instruct them on assembling the tackle, and then move to a safe location. Advise the crewmembers of the plan, direct them to erect the tackle, and assign specific tasks for desired mechanical advantage. (Crewmembers that have finished their tasks should assist those who are having difficulty. The crewmembers can save time by having a thorough knowledge of the tackle to be erected and by helping each other.) Observe all safety precautions.
+Step 7. Recheck rigging. Make sure the tackle is rigged for proper and safe operation. Direct the operator to remove most of the slack from the lines and to inspect for correct assembly. If any corrections must be made, direct the crewmembers to make them. Supervise and evaluate all implemented risk mitigation controls and identify any possible new hazards during the operation. Apply additional controls to mitigate new risks as necessary. Explain the details of the operations to the operators of the recovery vehicle and the other vehicles involved. Direct operators to watch for signals and be prepared to act on them.
Step 8. You are ready. Signal the operators to apply winch power and recover the load. Be alert and ensure nothing obstructs the operations of the equipment and that all personnel on the ground remain at a safe location.

RECOVERY METHODS USING WHEELED RECOVERY VEHICLES

5-18. Qualified recovery personnel must perform recovery operations. Qualified recovery personnel use special purpose vehicles for recovery when methods used by the operator, crew, or platoon do not fit the situation or when their efforts have had no success. The methods of recovery performed with special purpose vehicles are winching, lifting, and towing. The following paragraphs describe the different methods of recovery using wheeled recovery vehicles.

Note. This section summarizes winching, lifting, and towing procedures. For more in-depth information, refer to the equipment operator's manual, which relates to the operation of the equipment and its specific capabilities.

Winching

5-19. During the recovery of a mired truck using a wrecker, consider the following factors: the resistance of the load, the approach to the load, and the distance between the wrecker and mired vehicle. Mired trucks may have a resistance greater than the winch capacity of the wrecker. In addition, the wrecker may not be able to align itself with the truck because of the terrain. If so, use a 2-to-1 mechanical advantage and a change of direction block as illustrated in figure 5-5.

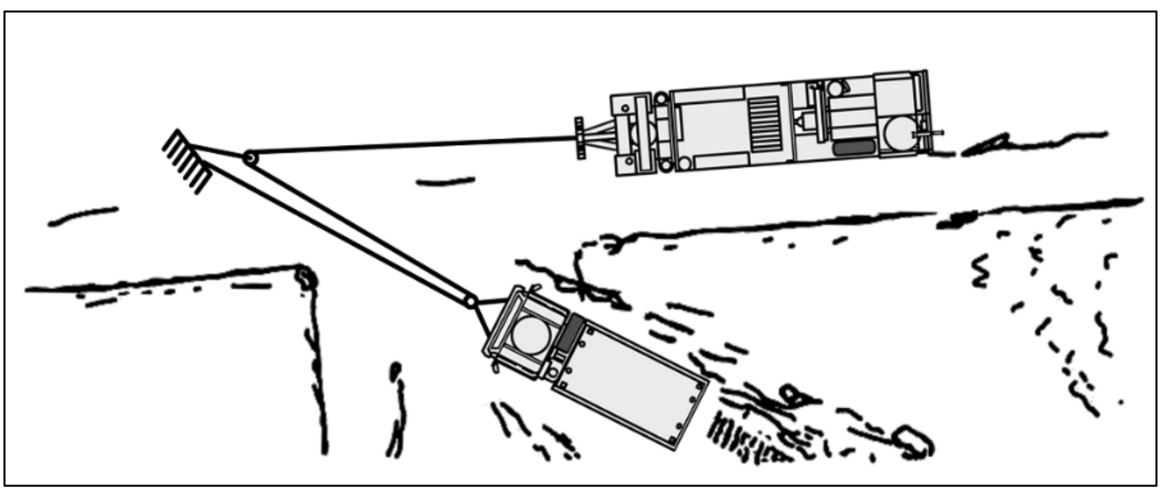


Figure 5-5. Winching using a 2-to-1 mechanical advantage and a change of direction block

Wheeled Towing

5-20. Recovery personnel will tow recovered vehicles to the nearest MCP where maintainers can perform repairs or other recovery, evacuation, or retrograde actions can take place. The method of towing used is situational dependent based on terrain, mechanical condition, and operational variables. A wrecker can conduct towing operations in either of two ways, flat tow or lift tow.

Like Vehicle Flat Tow

5-21. +To use a flat tow—

- Always refer to applicable TM, field manual, and/or Army techniques publication for proper towing procedures.
- Use the BII airlines to supply air from the wrecker to the towed vehicle for additional braking.
- Support the tow bar 1 inch above the tow pintle with a mattock handle and ground guide tow vehicle to tow bar lunette, ensuring no one is between moving tow vehicle and disable vehicle.
- Determine the terrain features and route prior to movement. If a hill will be encountered that requires the brakes to be used to reduce speed, shift into the next lower gear at the crest of the hill and use the engine compression to assist in slowing the vehicles.
- Take extreme care to prevent excessive engine speed while descending a hill. Determine the suitable gear and shift, if necessary, at the crest of the hill before speed has increased from downhill movement. Ordinarily the gear required to ascend a hill is proper to use to descend it. Refer to the vehicle operator's manual for additional information and see figure 5-6 depicts like vehicle flat towing.

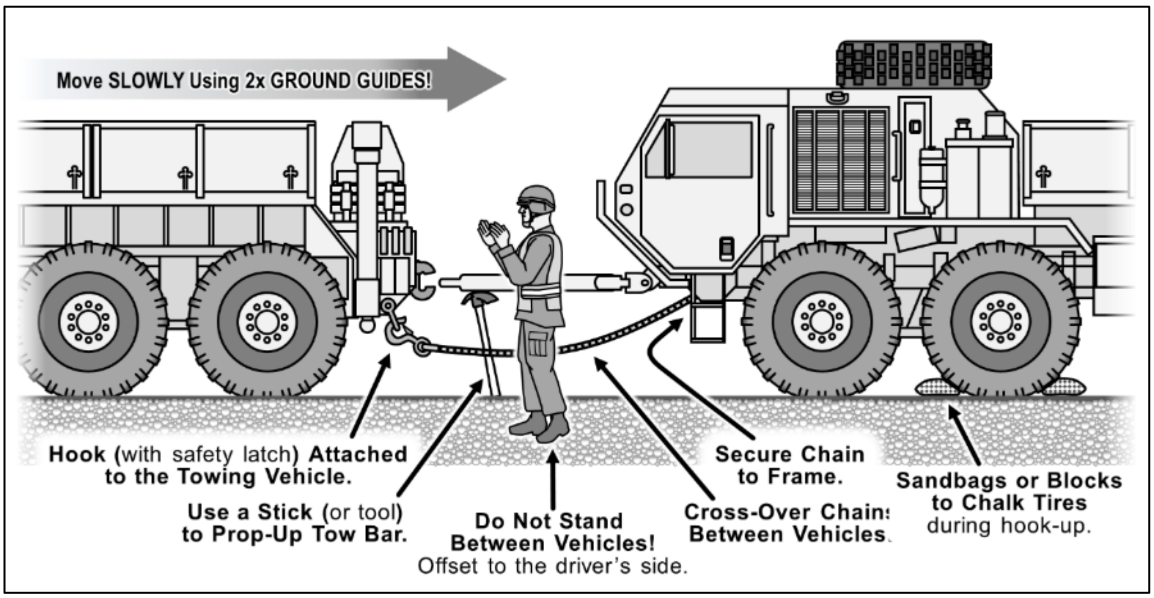


Figure 5-6. Like vehicles preparing for flat towing

CAUTION

Safety chains must be used in addition to the tow bar. Properly used, safety chains will retain a towed vehicle should the tow bar fail or become disconnected.

Cross the chains under the tow bar.

Fasten chains with a second shackle or latching hook to the shackles of the towing vehicle.

Secure the back end of the tow chain around a structural member or the underside of the vehicle to be towed.

Leave sufficient slack in the chains for turns, but not so much as to drag on the road surface.

WARNING

Front and rear ground guides are required when connecting wheel tow bars per AR 385-10 and TC 21-305-20.

WARNING

Vehicles that have caged brakes should not be towed by like vehicles; If in doubt, a wrecker should be used to tow vehicles with caged brakes.

Lift Tow

5-22. If damage to the front or rear of the vehicle requires the disabled vehicle be lifted, use the lift-tow procedure even when the disabled vehicle is being towed on the highway to include—

- Always refer to applicable TM, field manual, and/or Army techniques publication for proper lift towing procedures.
- Always use the retrieval system and multi-use adaptors provided in the BII of the wrecker to conduct lift tow operations. Exceptions include when the disabled vehicle's frame and tow lug damage make the multi-use adaptor use impossible. See figure 5-7 on page 5-10 for variations of cross-country towing.
- When possible, use the airlines in the BII to supply air from the wrecker to the towed vehicle for additional braking.
- Connect the adaptors to the towed vehicle and the retrieval device on the wrecker.
- Use 5/8 inch safety chains connected between the wrecker and the towed vehicle.
- Connect safety chains in a straight line. Do not cross them.
- Lift the towed vehicles high enough to provide enough clearance to keep the tires on the towed vehicle from coming into contact with the ground during movement. The actual height is terrain dependent but will typically be 12-18 inches.
- Refer to the wrecker operator manual for additional information.

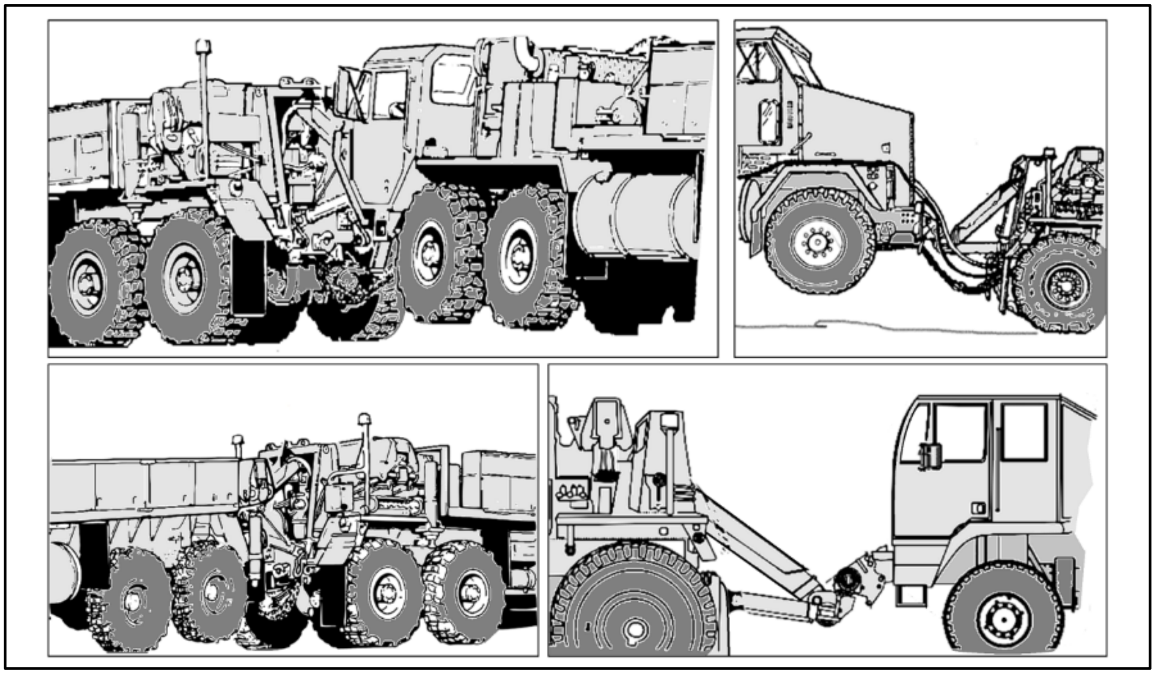


Figure 5-7. Cross-country towing

Multi-Use Adapters

5-23. Wrecker retrieval system multi-use adapters are designed for each recovery platform by weight class and used with all wheel recovery systems except the modular catastrophic recovery system (MCRS). The multi-use adapters are designed with multiple pin holes that align and allow the towed vehicle to be double pinned eliminating the need to use chains and single pin adapters for hooking up to the vehicle. Multi-use adapters permit faster and safer connections, but most importantly, multi-use adapters reduce wrecker weight because one adapter fits all wheeled vehicles.

> ***Note.*** Multi-use adapters used with two pins require only safety chains. Multi-use adapters with one pin adapter require the use of a recovery chain to compensate for the second pin. Operators must use safety chains in this configuration.

5-24. Recovery personnel utilize tow bars of the same weight class as the wheeled vehicle when performing like vehicle towing. Like vehicle, towing requires the towing vehicle's air lines be able to brake for both vehicles.

> ***Note.*** Do not use a tow bar with a working load limit less than the weight of the towed vehicle. Refer to GTA 55-01-001, *Tow Bar Smart Book,* for the correct tow bar to use according to the weight class of the vehicle. Recovery personnel should always utilize safety chains with tow bars on paved roads and as needed for cross-country towing.

WHEELED RECOVERY VEHICLE OPERATIONAL RISK ASSESSMENT

5-25. Dedicated recovery operators must keep a significant number of risks in mind. Utilization of a risk assessment worksheet to organize and evaluate terrain, weather and infrastructure techniques increases safety. A DD Form 2977 utilized for dedicated recovery operation using a wheeled recovery vehicles should include the following:

- Name of the unit, operator, and truck commander.
- Recovery vehicle bumper number and towed load weight.
- Date.
- Months of experience for both operator and truck commander and associated risk factor.
  - 0-6 months – 4.
  - 7-12 months = 3.
  - 13-24 months = 2
  - 25 or more = 1.
- Visibility and risk factor:
  - Night =2.
  - Day reduced visibility (rain, fog, or dust) = 1.
  - Clear = 0.
- Surface condition asphalt or concrete and risk factor
  - Wet = 2.
  - Dry = 1.
- Surface condition secondary roads (hard packed gravel) and risk factor:
  - Wet = 4.
  - Dry = 3.
- Surface condition loose condition (sand, dirt or loose gravel) and risk factor:
  - Wet = 4.
  - Dry = 0.
  - Surface condition mud or clay is automatically a risk factor = 5.
- Surface condition snow or ice automatically results in the recommendation to us a hold back vehicle.
- Slope and associated risk factor:
  - 0-5% = 1.
  - 6-10% = 2.
  - 11-14% = 3.
  - 15-19% = 4.
  - 20-22% = 5.
  - 23% or greater automatically results in the recommendation to use a hold back vehicle.
- Evaluation of total Risk (add up the relevant risk factors.):
  - Medium risk requiring either the platoon leader or platoon sergeant to sign off = 5-10 points
  - High risk requiring either the company commander or company executive officer to sign-off = 11-16 points.
  - Automatic recommendation of a hold back vehicle = 17 or more points.
- Signature of truck commander and approving authority.

RECOVERY METHODS USING TRACKED RECOVERY VEHICLES

5-26. Recovery using tracked recovery vehicles includes winching, towing and lifting of disabled tracked vehicles.

Winching

5-27. Recovering a mired tracked vehicle normally takes a single recovery vehicle. To prepare for winching, position the recovery vehicle in line as much as possible with the mired vehicle keeping in mind fleet angle.

Variable Winch

5-28. When recovering a mired tracked vehicle with a recovery vehicle that has a variable type winch, the operator gains maximum winching capacity when the full usable length of the cable is payed out. Always leave a minimum of five wraps of wire rope on the drum at the bottom layer to achieve a rated load. This is a safety feature that keeps the line from pulling completely off the winch drum. Leave seven wraps when using synthetic rope. Always refer to the operator's manual for guidance on achieving maximum winch effectiveness.

Constant Pull Winch

5-29. Position vehicles with a constant pull winch as close as practical to the mired vehicle. Always allow distance for the mired vehicle to get on solid ground. Testing has shown that the flat, smooth hull of the Abrams-series tank provides less resistance than expected. This should allow operators to recover most mired tanks using a single line pull. Recovery personnel only use two recovery vehicles when the load resistance of a mired tracked vehicle is so great that the calculated fall line force is more than the winch capacity of one recovery vehicle with a 3-to-1 mechanical advantage. Figure 5-8 depicts two M88A2 recovery vehicles winching a single M1 tank.

5-30. Recovery personnel position the recovery vehicles side by side to take full advantage of their winch capacities. This enables operators to use the same length of winch cable on both vehicles. Rig each recovery vehicle for a 2-to-1 mechanical advantage. Figure 5-9 shows the rigging for a 2-to-1 mechanical advantage. Attach each rigging snatch block to a tow lug on the mired vehicle. To synchronize winch speeds, both recovery vehicle operators should use the hand throttle to set the engine speed at the desired revolutions per minute and compensate with the winch control lever to maintain tension on cables.

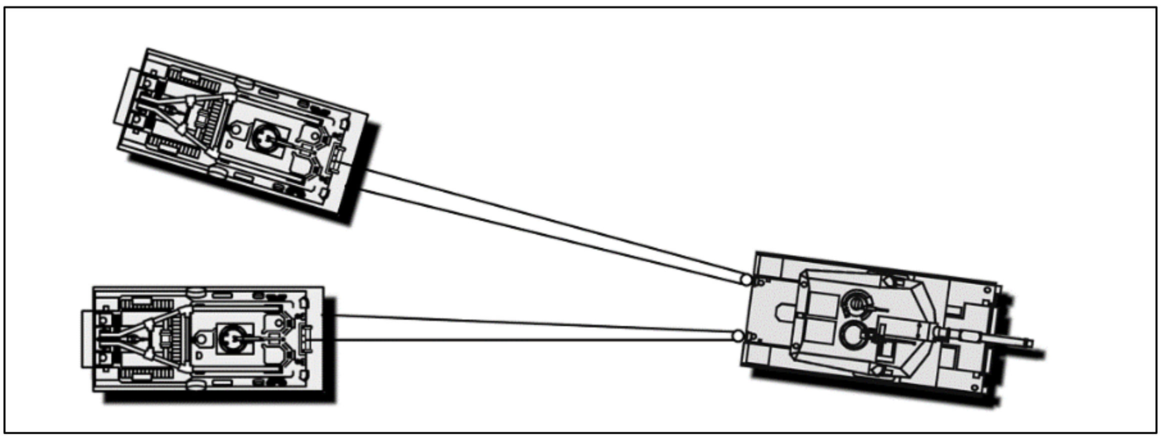


Figure 5-8. Winching with two recovery vehicles

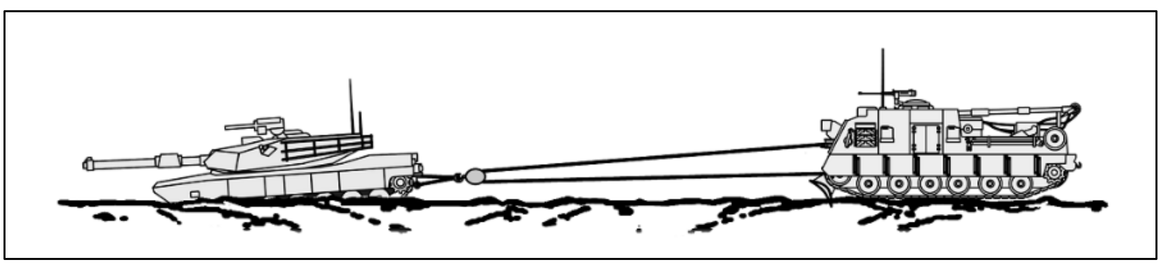


Figure 5-9. 2-to-1 mechanical advantage

Tracked Towing

5-31. Although units can tow disabled vehicles with similar vehicles, it is often necessary for a recovery vehicle to tow a disabled vehicle to the MCP. Once at the MCP maintainers can make repairs or evacuate the vehicle for sustainment maintenance.

Note. An observer will assist the operator during towing operations. The observer will be located on the recovery vehicle and will have direct communication with the operator. The observer's responsibilities are to verify the tow connection throughout towing operations and alert the driver of unsafe conditions of the towed vehicle, including but not limited to, disconnect and/or jack knife. This may require the recovery vehicle halt occasionally for the observer to exit the vehicle and examine the condition of the rigging. The observer will not, at any time during operations, ride on the exterior of the recovery vehicle or the towed vehicle during towing operations. The recovery operator must position the observer so the observer is visible in observation windows and rearview mirrors.

Towing with the M88A2

5-32. There are operational restrictions when towing an Abrams family of vehicles including—

- Without a holdback vehicle.
  - Use tow bars with same weight class vehicles for like vehicle towing. Like vehicle towing requires the towing vehicle to be able to control the braking for both vehicles.
  - Do not use a tow bar with a work-loading limit less than the weight of the towed vehicle. Refer to GTA 55-01-001, for the correct tow bar to use according to the weight class of the vehicle.
  - Communication is required between the towing and braking vehicle.
  - Use the tow bar provided with the M88A2 for the tow vehicle.
  - A driver or passenger is never in the towed vehicle.
- With a holdback vehicle.
  - Use braking or holdback vehicle M88A2 recovery vehicle or, if dictated by the operational risk assessment, use another Abrams family of vehicles.
  - Most units will have to request assistance for a second M88A2.
  - Use a tow bar as the method for attaching the braking or holdback vehicle when towing tracked vehicles.
  - Use the tow bar provided with the M88A2 for the tow vehicle.
  - Synchronize throttle and braking; operators should call out revolutions per minute (if two M88A2).
  - The braking vehicle must assist power on assents of grades greater than 15%. The braking vehicle provides traction and keeps the lead M88A2 from overheating.
  - Two vehicle towing speed is 4-7 miles per hour, factor completing a mile each 30 minutes for planning purposes.
  - Keep two vehicle-towing distances to the absolute minimum.
  - A driver or passenger is never in the towed vehicle.

5-33. If the recovery vehicle is lighter than the disabled vehicle, utilize a holdback vehicle of the same weight class as the disabled vehicle and tow bar so the towed vehicle will not overrun the recovery vehicle. Figure 5-10 on page 5-14 shows the holdback vehicle position.

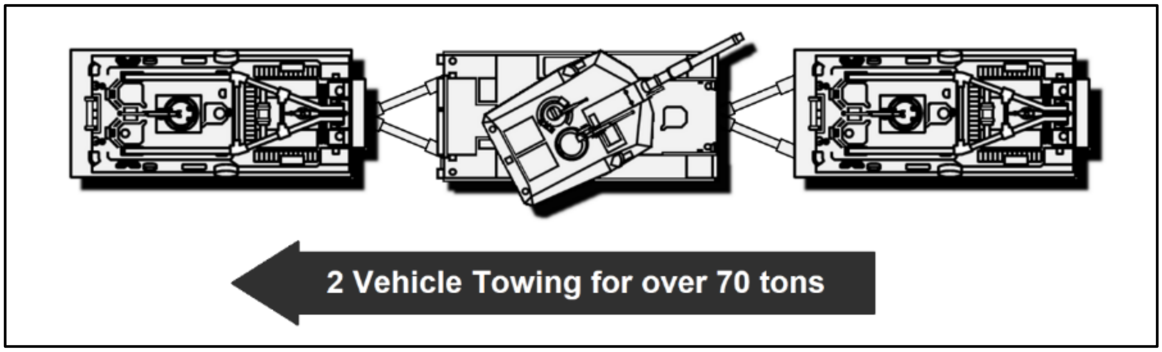


Figure 5-10. Tracked towing with holdback vehicle

Cross-Country Tow

5-34. Recovery personnel should utilize tow bars cross-country towing. Figure 5-11 shows an M88A2 towing a tracked vehicle.

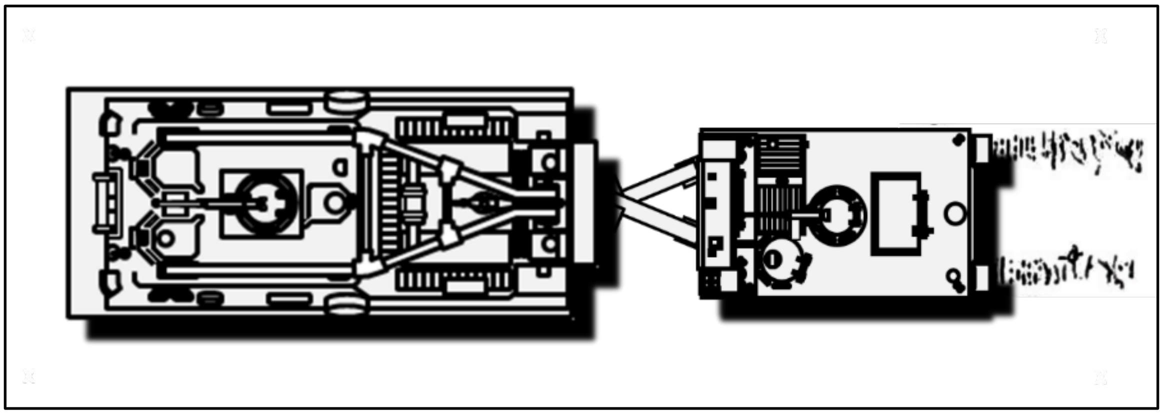


Figure 5-11. Tracked towing

Combat Tow

5-35. When the recovery vehicle and crew are under small arms fire, they perform a combat tow. Combat tows make a towing connection with the least possible exposure of personnel and observe the following—

- Attach the lifting V-chain to the recovery vehicle's tow pintle before moving it to the disabled vehicle. Wrap V-chain legs over tow bar.
- Move the recovery vehicle into the danger area.
- Recovery vehicle drivers back the towing vehicle up until making contact with the front of the disabled vehicle. (If possible, a crewmember in the disabled vehicle can connect the V-chain legs to the front tow hooks of the disabled vehicle).
- Move the recovery vehicle and the towed disabled vehicle out of the danger area.

TRACKED RECOVERY VEHICLE OPERATIONAL RISK ASSESSMENT

5-36. Dedicated tracked recovery operators must keep a significant number of risks in mind. These include:

- A risk assessment must be completed prior to 70-ton class vehicle towing operations.
- In conditions assessed as high risk, commanders may requires the use of a hold-back vehicle.
- The Ordnance Center and School have had trouble at 15% and greater slopes and under degraded soil conditions. A hold-back vehicle may be recommended.

- All slopes 15% and above must be signed off by the company commander.
- Cross-country tow with cable requires communication between towing vehicle and hold-back vehicle.

5-37. Combat tow does not require a hold-back vehicle.

5-38. Utilization of a risk assessment worksheet to organize and evaluate terrain, weather and infrastructure techniques increases safety. A DD Form 2977 utilized for dedicated recovery operation using tracked recovery vehicle should include the following:

- Name of the unit, operator, and track commander.
- Recovery vehicle bumper number and towed load weight.
- Date.
- Months of M88A2 experience for both operator and track commander and associated risk factor:
  - 0-6 months = 4.
  - 7-12 months = 3.
  - 13-24 months = 2.
  - 25 or more = 1.
- Visibility and risk factor:
  - Night = 2.
  - Day reduced visibility (rain, fog, or dust) = 1.
  - Clear = 0.
- Surface condition asphalt or concrete and risk factor:
  - Wet = 2.
  - Dry = 1.
- Surface condition secondary roads (hard packed gravel) and risk factor:
  - Wet = 4.
  - Dry = 3.
- Surface condition loose condition (sand, dirt or loose gravel) and risk factor:
  - Wet = 4.
  - Dry = 0.
  - Surface condition mud or clay is automatically a risk factor = 5.
  - Surface condition snow or ice automatically results in the recommendation to use a hold back vehicle.
- Slope and associated risk factor:
  - 0-5% = 1.
  - 6-10% = 2.
  - 11-14% = 3.
  - 15-19% = 4.
  - 20-22% = 5.
  - 23% or greater automatically results in the recommendation to use a hold back vehicle.
- Evaluation of total Risk (add up the relevant risk factors):
  - Medium risk requiring either the platoon leader or platoon sergeant to sign-off = 5-10 points
  - High risk requiring either the company commander or company executive officer to sign-off = 11-16 points.
  - Automatic recommendation of a hold back vehicle = 17 or more points.
- Track commander signature and verifying authority signature.

WARNING

- **Ensure proper lifting techniques are followed when removing or installing heavy components. Use assistant(s) and suitable lifting device when lifting heavy parts of components.**
- **Use extreme caution when moving vehicle into position. Ensure personnel stay out from between vehicles while towing vehicle is being positioned.**
- **When backing the vehicle, two personnel must guided operator. Both guides must stand to the same side of vehicle at a safe distance. Front guide must be visible to operator.**
- **Ensure disabled vehicle will not move after it is disconnected from the towing vehicle. Chock the track on the towed vehicle before moving between vehicles to disconnect tow bar.**
- **Failure to comply may result in personnel death, injury, or damage to equipment.**

TOW BAR HANDLING

5-39. Before attempting to tow a disabled vehicle, be familiar with the location, features, and operation of all components of the tow bar. (Some tow bars have operator's instruction decals mounted on them.) Recovery personnel must ensure they use the proper tow bar for the towed equipment. Operators can use a tow bar to tow any vehicle up to the gross weight of the tow bar towing capacity. Refer to GTA 55-01-001, for the tow bar's working load limit.

5-40. Before attaching a tow bar to a disabled vehicle, chock the wheels/tracks and/or set the emergency brake. After attaching the tow bar to a disabled vehicle and the towing vehicle, remove the chocks and/or release the emergency brake before moving.

CHOCKING A TRACKED VEHICLE

5-41. Before hooking up the tow bar or disconnecting the drive between the differential and final drive, chock the vehicle with blocks so it cannot move. Place a block of wood or other suitable object between the track guides and the two sets of road wheels or one in front of and one in the rear of the track as depicted in figure 5-12. Make sure the object extends the full width of both road wheels.

5-42. Follow the same process for chocking the vehicle before unhooking the tow bar or connecting the drive between the differential and final drive as utilized while hooking the vehicle up. Chock the vehicle with blocks so it cannot move.

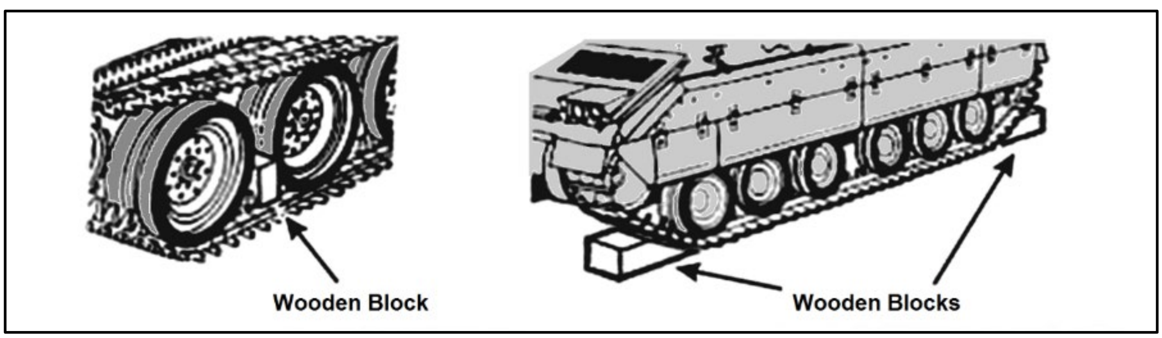


Figure 5-12. Chocking/blocking tracked vehicles

CAUTION

Failure to remove the blocks before moving could result in damage to the vehicle.

5-43. Refer to the disabled vehicle's TM for proper towing procedures, for example, automatic versus standard transmission. Recovery personnel ensure the proper pin assemblies are in the clevis holes, and properly secure the quick-release pins (which snap automatically).

+Towing Operations on Grades

5-44. Towing a disabled vehicle is never easy, but towing up or down a grade can be even more difficult and dangerous. While towing a disabled vehicle, do not attempt to negotiate a 15% grade (either up or down) before doing a risk assessment. The commander must sign off on the risk assessment.

Note. Use extreme care when lift towing or flat-towing disabled vehicles. Check the disabled vehicle's TM for vehicle preparation, precautions, and maximum vehicle speed.

WARNING

Under NO circumstances, negotiate a slope that is greater than 30 percent while towing a vehicle.

5-45. To know which grades to avoid, an operator must understand how grades are classified. Grades are defined in terms of percent or the amount of a grade's vertical height (rise) over its horizontal length (run). If a road gains 25 feet of height over 100 feet of length, it is classified as a 25 percent grade. See a graphic depiction of classifying a grade in figure 5-13.

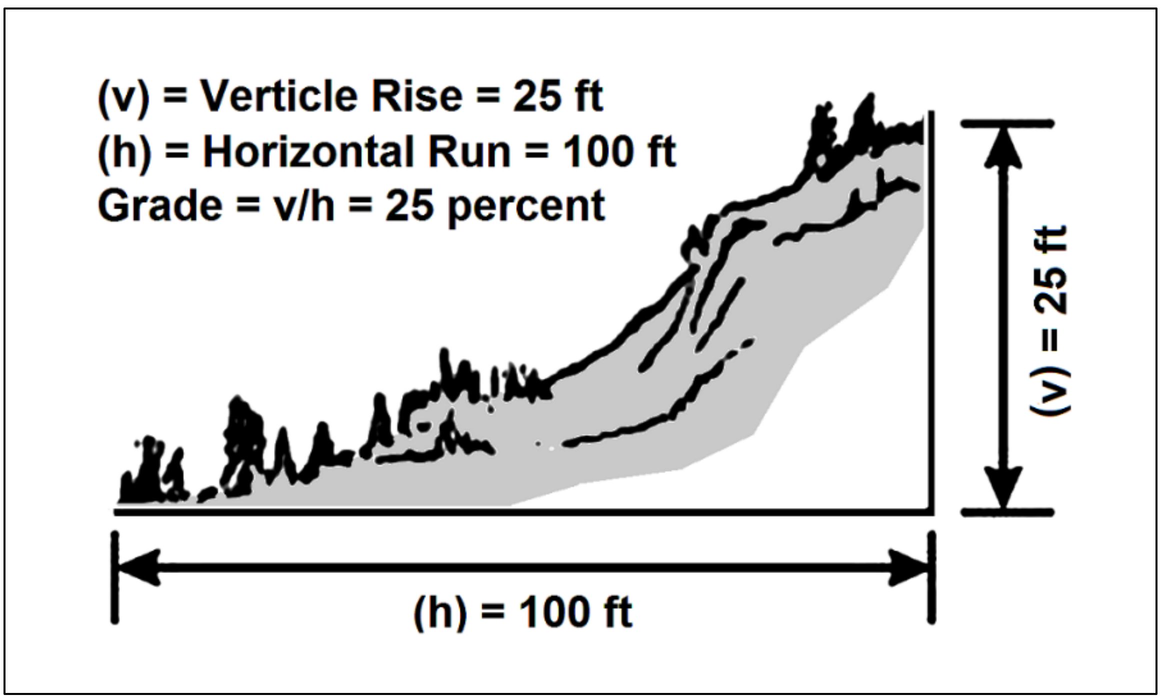


Figure 5-13. Classifying a grade

+5-46. The best way to classify a grade is with a surveying level, illustrated in figure 5-14, which is an item of BII for the M88A2 see TM 9-2350-292-10, *Operator's Manual for Recovery Vehicle, Full-Tracked: Heavy M88A2*. The operator stands at the top (or bottom) of the hill and chooses a point as close as possible to the bottom (or top) of the hill where the vehicles will be traveling. The operator then looks through the sight of the level at the chosen point and turns the level knob until the operator sees the level bubble centered between the witness marks. Then the operator reads the percent grade on the indicator. Figure 5-14 shows a surveying level.

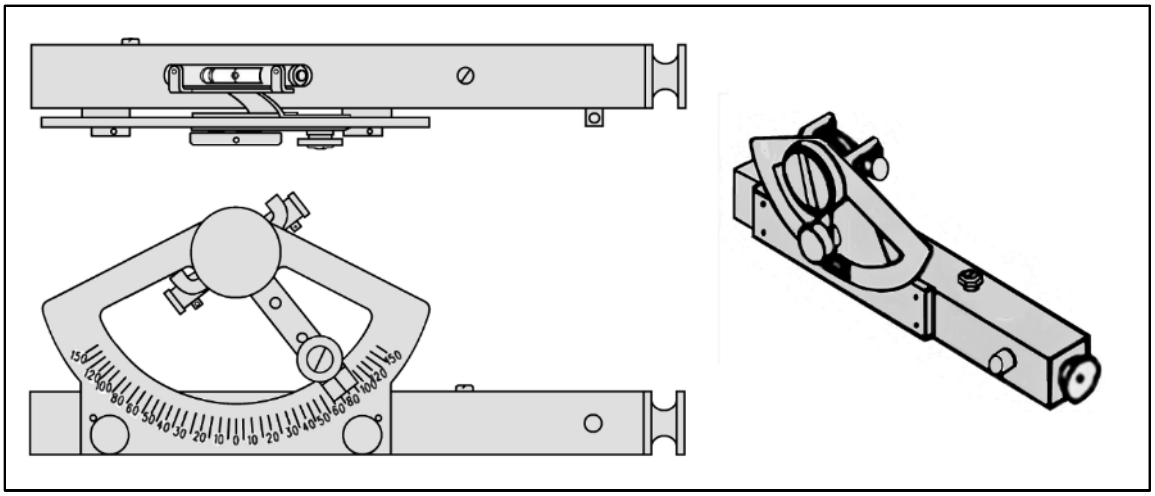


Figure 5-14. Slope surveying level

5-47. An improvised or field expedient method uses a small level, a 10-inch piece of flat wood, and a ruler:

- Lay the piece of wood on the steepest part of the grade, with the length of wood running up and down hill.
- Put the level on the piece of wood and start to raise the downhill side of the wood up, until the bubble in the level is between the witness marks.
- Measure the distance between the road and the bottom of the wood. If it is 3 inches, there is a 30 percent slope. If it is 2.5 inches, there is a 25 percent slope.

5-48. Another method is the eyesight and pace method shown in figure 5-15. The Soldier needs to know his height and the length of his stride. As an example - If a Soldier is 6 feet tall and his step is 2 feet long—

- The Soldier stands at the bottom of the hill and picks a spot on the hill that is the same height as his head.
- The Soldier then walks to that spot, counting his steps.
- Once the Soldier reaches that spot, the Soldier multiplies steps taken by the length his stride (2 feet) and then divides his height (6 feet) by that number multiplied by 100 and adds 1.

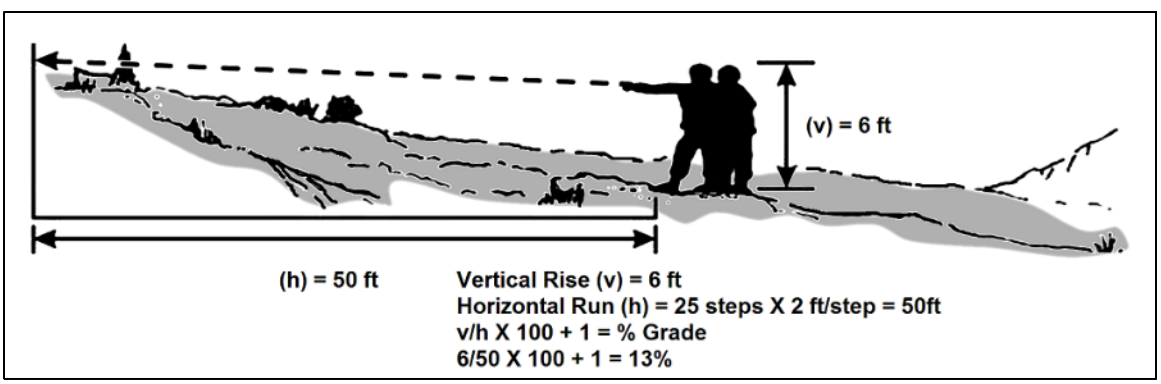


Figure 5-15. Eyesight and pace method

5-49. The following items must be considered while performing terrain analysis—

- Trails/grades with sharp curves mean additional control is needed while ascending and descending. There is no safety zone in case of a runaway load.
- Dry and dusty soil or wet and muddy soil can cause a loss in traction. Pay close attention to the soil conditions that may alter as weather conditions change.

Note. Inclement weather (rain, snow, ice) will naturally affect the road conditions, making loss of traction more probable.

5-50. If the operator has to shift into first gear to climb a grade, there is a good chance that it is too steep to descend with a towed load. Measure the downhill grade before attempting to descend any hill that required first gear to climb. Other options may include—

- Using a braking or holdback vehicle behind the towed load.
- Inching the disabled vehicle downhill, if possible.

5-51. Recovery personnel should look for detours to avoid steep grades. If no detour is available, notify the commander. Inform the commander of the grade percentage of the road, weather visibility, and road conditions (wet, dry, muddy, pavement). The recovery vehicle driver's experience and the type of towed load will play an important role in the commander's decision. If the driver does not feel confident in negotiating the grade, the driver must inform the commander. The best course of action may be to get the most experienced wrecker/recovery vehicle operator on the site to handle the mission.

5-52. In summary, conduct a good route reconnaissance on the way to the disabled vehicle's site. When possible, avoid all hills or roads with a grade of 25 percent or greater while towing a load. If not, notify your commander and take proper precautions. Ensure no one rides in a towed vehicle.

FIFTH WHEEL TOWING DEVICE

5-53. The fifth wheel towing device is a heavy-duty, under lift towing device that uses the fifth wheel coupling as a pivotal connection between the pulling tractor and the truck in tow. The fifth wheel towing device transfers the weight of the towed vehicle evenly to all axles of the towing tractor. The front axle of the towing tractor actually gains weight as the operator lifts the towed vehicle. Figure 5-16 depicts the use of a fifth wheel towing device.

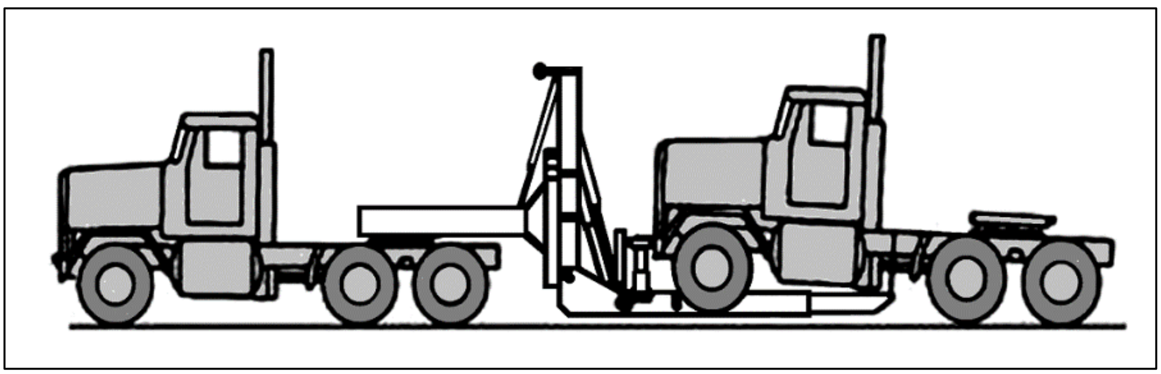


Figure 5-16. Fifth wheel towing device

5-54. Remember the following important safety considerations when using the fifth wheel towing device to transport or recover disabled vehicles:

- Towing a single vehicle with nonfunctioning brakes must be limited to not more than 25 miles per hour on the highways and 15 miles per hour off roads.
- Stopping distances greatly increase when the towed vehicle has nonfunctioning brakes.
- It is prohibited to tow a vehicle combination (tractor with trailer) with nonfunctioning brakes.

- Visibility from the prime mover is significantly reduced when backing, whether the fifth wheel towing device is loaded or not.
- All wheels remaining on the ground of the towed vehicle should be serviceable to increase system stability and reduce the risk of further damage.
- Never stand between the prime mover and fifth wheel towing device when the prime mover is backing up to the fifth wheel towing device. Serious injury or death may result.
- Proper procedures must be followed and extreme caution used when backing to prevent damage to equipment and injury or death to personnel. See operator's manual for additional cautions for the fifth wheel towing device.

5-55. Tables 5-2 and 5-3 list prime movers for the fifth wheel towing device and authorized towed vehicles.

Table 5-2. Vehicle weights

Prime Movers	***Gross Combination Weight Rating***
*M915, A1, A2, A3, A4	105,000 pound or 47,641 kilogram
M916, A1, A2, A3	120,000 pound or 54,446 kilogram
M920	120,000 pound or 54,446 kilogram
M1088	80,775 pound or 36,649 kilogram
M983	100,000 pound or 45,372 kilogram

Table 5-3. Prime movers for fifth wheel towing device

Authorized Towed Vehicles
M915s, M931 and M932 Models, family of medium tactical vehicles (FMTV) series, palletized load system (PLS) Series
M915s, M916s, M931 and M932 Models, FMTV series, palletized load system series
M915s, M916s, M920, M931 and M932 Models, FMTV series, palletized load system series
M915s, M916s, M920, M931 and M932 Models, M983, FMTV series, palletized load system series
Note: M1074 and M1075 (palletized load system series) can be transported only without a payload

THE MODULAR CATASTROPHIC RECOVERY SYSTEM

5-56. Recovery personnel utilize the MCRS, a heavy duty under lift towing and recovery device, for the retrieval and transportation of vehicles. The MCRS consists of three major components; the M983A4 Light Equipment Transporter with a 45,000 pounds winch, the XM20 Fifth Wheel Towing and Recovery Device (FWTRD) and the XM1250 Tilt Deck Recovery Trailer (TDRT) as depicted in figure 5-17. The MCRS supports a 70,000 pounds payload on primary, secondary and cross-country roads. The FWTRD is equipped with a 35,000 pounds and 18,000 pounds winch. The towing capacity gross combination weight is 151,000 pounds which nets a lift towing capacity of 86,400 pounds

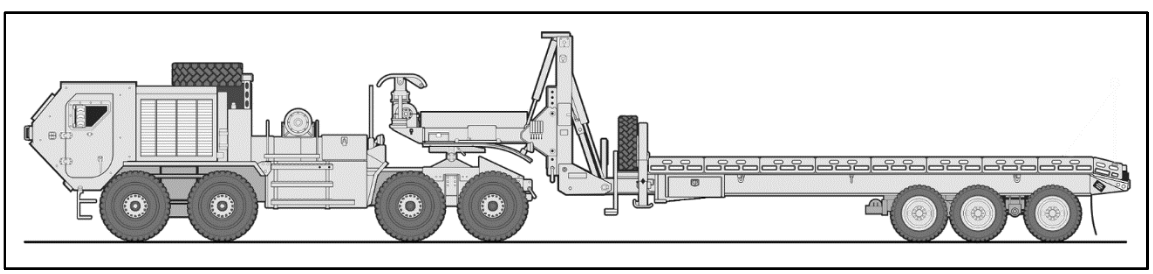


Figure 5-17. The modular catastrophic recovery system

5-57. The MCRS is capable of performing various recovery, evacuation and transportation missions. The primary function of this system is to recover and evacuate catastrophically disabled tactical wheeled vehicles in the forward battle area within its weight classification.

5-58. The MCRS has a 35,000 pounds winch kit attached to the FWTRD, increasing the versatility of the FWTRD by allowing it to pull from a 90-degree angle. This winch is in addition to the 45,000 pound winch on the M983A4 tractor. Recovery operators may use both winches for straight-line recovery over the FWTRD mast and for loading the TDRT. This permits leverage walking disabled equipment for better alignment during operations.

5-59. The FWTRD is capable of completing multiple recovery procedures, contingent upon the status of the vehicle that needs recovering or evacuation. MCRS operator may use the FWTRD to perform equipment up righting and overturns by cradle method for armored vehicles and winching overturns for wheel equipment.

5-60. The TDRT is self-supporting when detached from the FWTRD due to its vehicle support stands. The operator manually positions the legs and pin them as needed for operation. No crane or lifting device is required during attachment or detachment. When the operator deploys the pusher axle the TDRT has ability to tilt the deck up to a 10-degree angle for loading payloads up to 70,000 pounds. The TDRT also features drawer style pull-outs that allow the TDRT deck to expand from 102 inches (259 centimeters) to 114 inches (290 centimeters). This allows the TDRT to accommodate varied wheelbase configurations. The load capacity of the TDRT is 70,000 pounds. (31,751 kilograms).

5-61. Recovery personnel utilize the TDRT in conjunction with the FWTRD to transport recovered vehicles the FWTRD is unable to tow due to tire condition, unserviceable axles, or destruction due to battle. Procedures performed by the FWTRD consist of winch recovery, pre-picking, lift towing, loading, and transportation of the TDRT.

5-62. The TDRT gives the operator the ability to trailer transport vehicles that are inoperable or battle damaged. The TDRT engages the FWTRD, which serves as the fifth wheel connection. The TDRT features a three axle (one of which is an airlift axle) sliding carriage that, when slid forward, allows the TDRT deck to tilt to the rear for loading. This allows the operator to set up for loading without having to disengage from the FWTRD. Essentially, the TDRT will slide rearward over the axles, and form a loading ramp of less than 12-degrees to load equipment. After the damaged vehicle is loaded onto the TDRT, the operator brings TDRT forward over the axles for transport mode. The operator engages the axle-locking pin in loading and transport mode. The axle-locking pin is a safety feature that locks the sliding axles during transport. Figure 5-18 depicts the tilt deck recovery trailer tilted to winch a high mobility multipurpose-wheeled vehicle aboard.

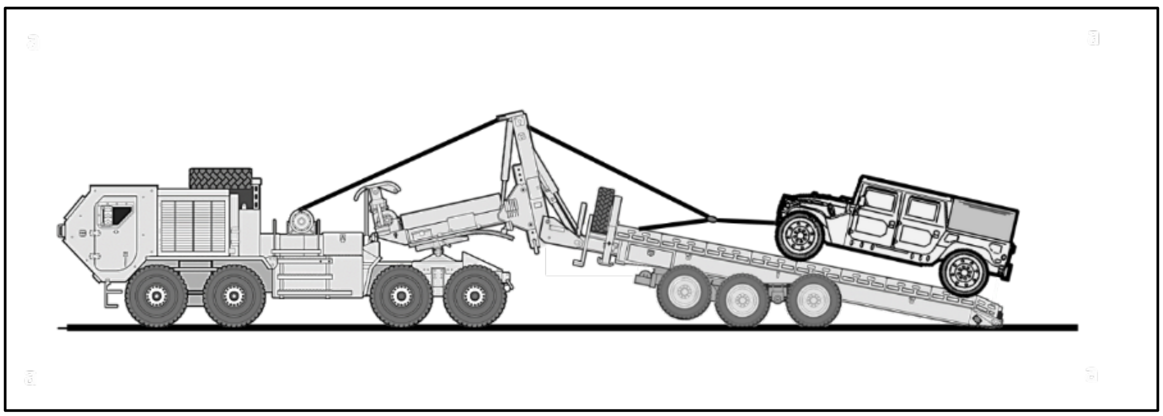


Figure 5-18. Tilt deck recovery trailer.

5-63. Split system operations: The MCRS is capable of deploying on a mission as a complete system or dropping the TDRT and deploying with just the FWTRD. Depending on the terrain where the downed vehicle is located, the recovery effort may require approaching as close as safety permits and dropping the TDRT. The FWTRD covers the remaining distance. Recovery personnel recover the downed vehicle with the FWTRD and bringing it back to the TDRT. They then load it onto the TDRT and evacuate it to a MCP.

5-64. Recovery personnel use tie down shackles to secure vehicles to trailers and recovery systems like the MCRS. Operators should use screw pin shackles with chains to secure vehicles and equipment to trailers. Using tie down shackles provide for three links on the chain. There is a 50% reduction in chain capacity if used on sharp edged corners without tie down shackles.

SPECIAL RECOVERY SITUATIONS

5-65. Nosed and overturned wheels, tracks, engineer, material handling equipment, and armored vehicles constitute special recovery situations. Determine if the resistance of the mired truck is greater than the winch capacity. If it does not exceed the winch capability, mechanical advantage is not required. Proceed as follows:

- Recovery personnel obtain the correct fleet angle by positioning the anchor vehicle in line with the mired vehicle.
- Free-spool the winch cable from the drum.
- Attach a sling or chain to both front lifting shackles of the anchor vehicle, and attach the winch cable clevis to the apex of the sling or the center of the chain. The angle of the Y-sling must be less than 30-degrees to reduce strain on the lifting shackles.

5-66. If mechanical advantage is required, proceed as follows:

- Attach a snatch block to the center of the chain or apex of the Y-sling and the winch cable routed through the snatch block back to the mired vehicle.
- Place the loop formed in the winch cable in the snatch block.
- Apply power to the winch to remove the slack from the cable.

5-67. Recovery personnel place wheel blocks, chocks, or natural material in front of the anchor vehicle's front wheels if the anchor vehicle must be anchored by more than just its weight.

NOSED TRUCK

5-68. The recovery of a nosed truck using a wrecker may require only a towing operation. However, some situations may require using all three of the wrecker's capabilities (winching, lifting, and towing) to complete the recovery.

5-69. Figure 5-19 shows an example of a cargo truck that is nosed off a narrow road and mechanically disabled. Although the apparent fleet angle of the winch cable in the figure is greater than 1½-degrees, the wrecker winch has a level winding device that offsets the difference. (Not all vehicles with winches have this device.) When possible, position the wrecker at the least possible fleet angle and on the most solid surface to improve stability.

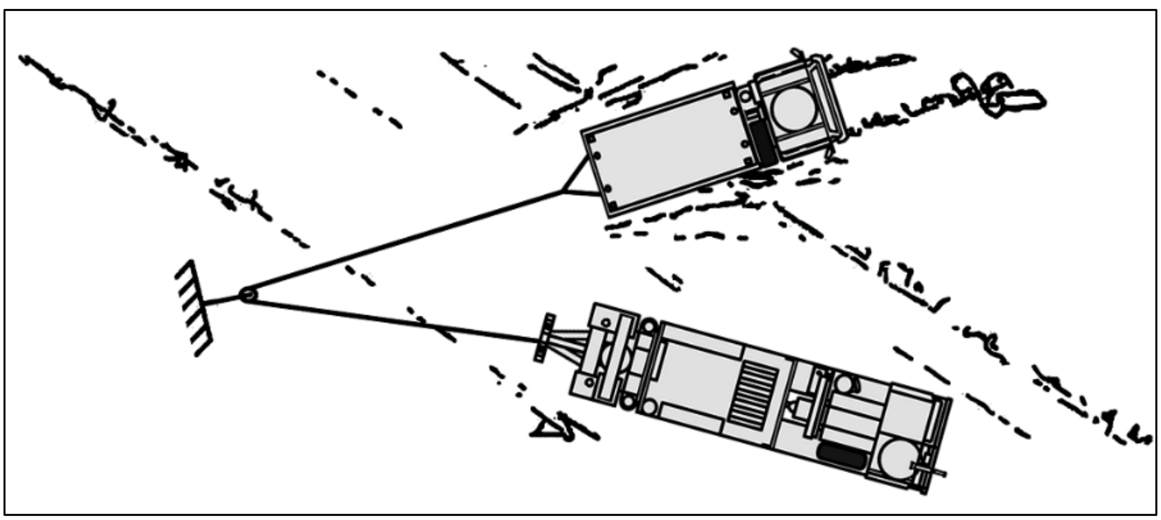


Figure 5-19. Recovery of a nosed-in cargo truck

5-70. To perform the recovery—

- Position the wrecker truck on the road so the front end of the nosed truck, when pulled back up on the road, will be in line with the rear of the wrecker truck.
- Make a change of direction pull, using the wrecker's rear winch to pull the truck onto the road.

- Lift the front of the truck with the wrecker's outriggers in place and turn the crane to place the truck directly behind the wrecker truck to prepare for towing.

OVERTURNED TRUCK

5-71. Recovery operators utilize a sling method of attachment to upright an overturned truck using the wrecker because a pulling force applied to only one point of the frame may result in a bent frame. A sling attachment is made of two utility chains. The personnel attach sling ends to the front and rear lifting shackles on the high side of the overturned truck. Then recovery personnel attach the winch cable to the center of the sling.

5-72. A holding effort will be required to prevent the overturned vehicle from crashing onto its wheels. (The holding force could be another vehicle, the wrecker boom, or a rope block and tackle with personnel.) The attachment for the holding force is a holding sling attached to the same points on the overturned truck as the pulling sling. The recovery operators attach the holding sling to the holding force with cable, rope, or chain. The personnel confirm the attachment of the holding force to the center of the sling. If a holding vehicle is not available, use the wrecker boom to hold the load.

5-73. Apply power gradually to the winch until the overturned truck is past the vertical position. Then, lower the truck on its wheels with the hoist winch. This method should make maximum use of the boom jacks and outriggers. Figure 5-20 depicts the recovery of an overturned truck with a wrecker.

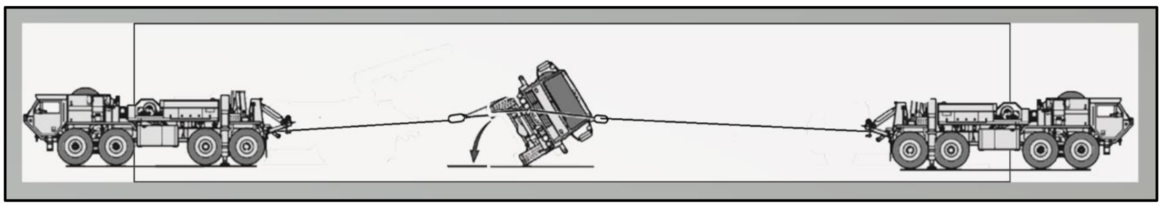


Figure 5-20. Recovery of overturned and upright with wreckers

> **WARNING**
>
> **Because of the danger of igniting spilled fuel and oil, smoking or open flames are not allowed near the overturned vehicle.**

OVERTURNED TRACKED VEHICLE

5-74. To upright an overturned tracked vehicle with a recovery vehicle, position the recovery vehicle so it is facing the bottom of the overturned vehicle. It should be at a distance equal to the width of the overturned vehicle, plus 2 feet for safety. Recovery personnel use two tow cables to form a sling. Pass the opposite ends of the sling under the track. Attach them to the front and rear tow hooks on the high side of the overturned vehicle. Figure 5-21 shows a tracked recovery vehicle righting an overturned track.

5-75. For the up righting source of power—

- Use a utility chain to attach the main winch cable to the center road-wheel arm support housing on the high side.
- Apply power to the main winch until the vehicle pulls past its point of balance and the hoist rigging supports the vehicle.
- Lower the hoist winch rigging slowly to lower the overturned vehicle onto its suspension system.

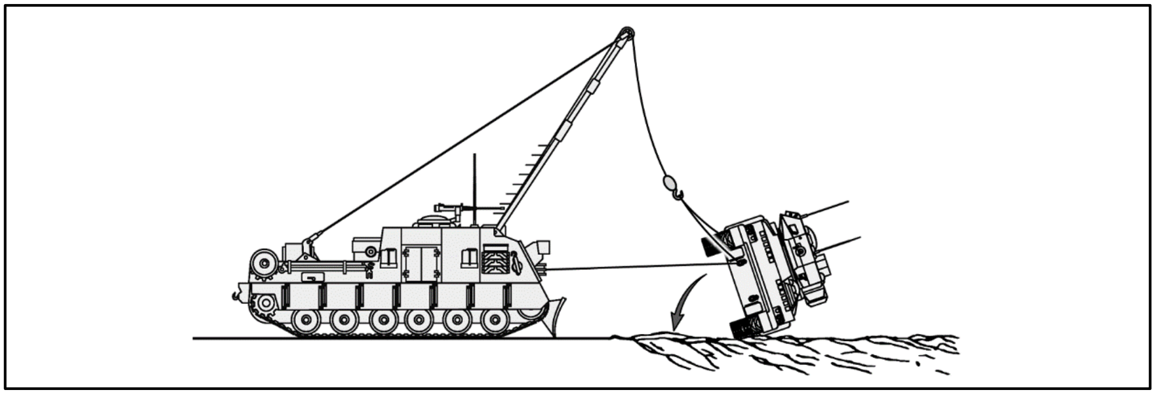


Figure 5-21. Recovery of overturned track vehicle

HOWITZER

5-76. When uprighting a howitzer, follow procedures similar to uprighting a wheeled vehicle—

- Attach the tow cable or chain to the lifting loops on the shoulder of the howitzer.
- Utilize a holdback vehicle to slowly lower the howitzer to the ground.

Note. If the prime mover is also overturned, disconnect the howitzer from the vehicle and upright the vehicle first. If the howitzer is positioned so the prime mover cannot be righted, upright the howitzer first.

FORKLIFTS

5-77. Only tow forklifts from the rear. Towing forklifts forward poses a serious overturn risk if the forks make contact with the ground and dig in. Refer to the equipment operator's manual for specific towing instructions. To upright an overturned or mired forklift, use the overturned vehicle recovery procedure or the mired-vehicle procedure.

ARMORED VEHICLE-LAUNCHED BRIDGE AND JOINT ASSAULT BRIDGE

5-78. Recovery personnel must utilize an armored vehicle-launched bridge using a hydraulic slave procedure to recover another armored vehicle-launched bridge. The M88 cannot remove a bridge because the M88 hydraulic system couplings differ in design. Once they remove the armored vehicle-launched bridge from the prime mover, recovery personnel should refer to the operator manual for towing and hookup procedures. Before recovery personnel can tow a joint assault with a tow bar, they must remove the bridge. This is due to spacing, recovery personnel must also utilize cross cables and a holdback-braking vehicle.

MINE PLOW AND MINE ROLLER

5-79. Recovery personnel cannot tow vehicles from the front with mine plows or mine rollers attached. Personnel can tow these vehicles from the rear with the rollers in "full float" or "free float" mode provided the terrain and situation permit. Once the recovery personnel determined how to tow the vehicle, they refer to the operator's manual for towing and hookup procedures.

CRANE, WHEEL-MOUNTED

5-80. Recovery personnel can tow the wheel-mounted crane, but they must first obtain information on road conditions and possible restrictions along the route. Take into account the following—

- Use a vehicle with an air brake system capable of producing 120 pounds per square inch in the system.

- Place the boom over the front; the most stable position for towing.
- If towing more than one-fourth of a mile, disconnect the propeller shafts from the front and rear axles.
- Operators must use caution when turning and traveling through towns.

ROAD GRADER

5-81. When towing the road grader for distances greater than half a mile, maintenance personnel must remove the tandem drive chains. If the distance is less than half a mile, it is not necessary to remove the tandem drive chains, but the driver must keep the speed below 5 miles per hour. If the recovery distance is greater than half a mile, and maintenance personnel are not available to remove the tandem drive chains, recovery personnel must use a trailer to recover the road grader.

SCOOP LOADER

5-82. Recovery personnel should not push or tow the scoop loader. A flatbed trailer must move this vehicle. In the event of an emergency where the scoop loader must be towed, the maximum distance the loader may be towed or pushed is half a mile—at a low speed not to exceed 5 miles per hour. Refer to the operator's manual for details.

M9 ARMORED COMBAT EARTHMOVER

5-83. Recovery personnel must tow the M9 armored combat earthmover from the rear. They first must disconnect the final drives to prevent damage to the steering unit. When turning with the armored combat earthmover in tow, turn in a wide arc to prevent undue strain on the suspension of the disabled vehicle and tow bar. Make sure the disabled vehicle is in the SPRUNG position. Refer to the operator's manual for additional towing information. The preferred recovery method for other bulldozers is also to tow them backwards.

STRYKER RECOVERY

5-84. The Stryker is a unique platform and can only be recovered with the MCRS using a suspended tow or trailering. Recovery personnel cannot lift tow a Stryker using the M984 Series Heavy Expanded Mobility Tactical Truck, known as a HEMTT, wrecker or any other wheeled wrecker. The Army does authorize personnel to flat tow a Stryker with a Heavy Expanded Mobility Tactical Truck or any vehicle that is in the same weight class and has the braking capacity. The Stryker -10 TM provides winch assistance guidance and procedures that do not require calculations. Maintainers must strictly follow the guidelines.

Note. The current Stryker two-piece tow bar can only be used to tow Strykers. Due to the length of the tow bar, and the width of the Stryker tow lug, the tow bar is not to be used with any other wheeled vehicle.

NOSED TRACKED VEHICLE

5-85. Recovery personnel consider various factors before recovering a tracked vehicle nosed in a deep trench or ravine. If the terrain behind the nosed vehicle is level, recover by towing. If the terrain is not suitable for towing, perform a winching operation. Figure 5-22 on page 5-26 shows a recovery vehicle performing winching operations. To perform a winching operation—

- Move the recovery vehicle to the opposite side of the trench or ravine (to the front of the nosed vehicle).
- Using the recovery vehicle's boom with its maximum mechanical advantage rigging, attach its hoist block to the front lifting eyes on the nosed tank with a V-chain.

5-86. In some circumstances, a nosed tracked vehicle will require lifting to recover the vehicle. Figure 5-23 on page 5-26 shows a lifting operation. In this example, recovery operators lift the vehicle to a horizontal position and then pull it to the opposite side of the ditch. Once the tank is on better ground recovery personnel either tow or use a winch to complete the recovery.

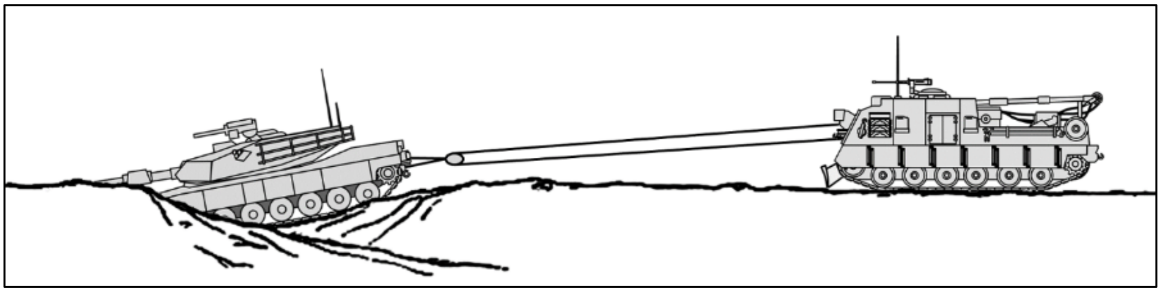


Figure 5-22. A recovery vehicle winching a nosed tracked vehicle

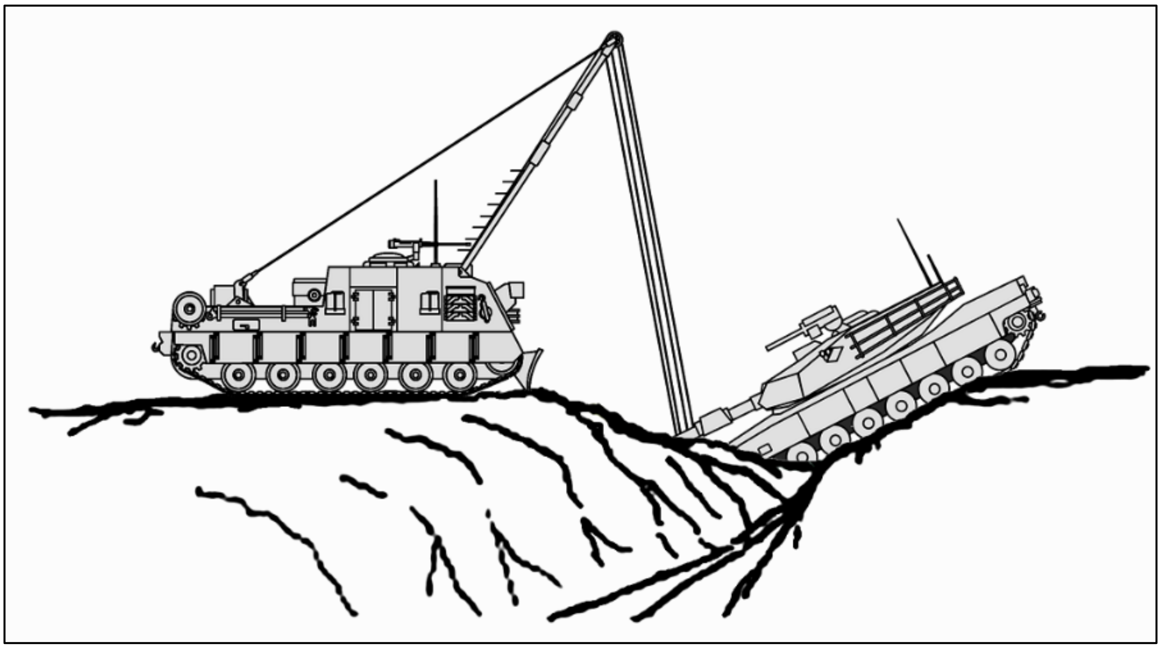


Figure 5-23. Lifting operation

Note. Recovery personnel can recover nosed vehicles utilizing towing, winching, or lifting operations. If the tow hooks are accessible on the nosed vehicle, use rigging to attach them to the winch. Recover the nosed vehicle with a combination of winching and hoisting. Control the weight and movement of the disabled vehicle during the entire recovery operation by coordinating the hoist winch and the main winch.

+SELF-RECOVERY AND LIKE VEHICLE RECOVERY

5-87. Drivers and crews should evaluate the situation and determine if they can safely self-recover the vehicle with the available resources or using a like vehicle before calling on support from a higher level.

SOURCE OF EFFORT

5-88. The amount and type of equipment used as the source of effort during any recovery operation depends on the level of recovery. Drivers and crews should evaluate the situation and determine if the crew can recover the vehicle before calling on support from a higher level. During combat, it may be imperative cargo reach its destination at a definite time, the personnel or cargo be picked up at a given time, or a combat vehicle be at a given place at a specific time.

5-89. Using like vehicles is usually the quickest method of recovery because they are readily available. Call for recovery support only when self-recovery or like vehicle recovery techniques cannot support the recovery operation. Personnel may recover a mired vehicle without a winch using recovery expedient measures discussed previously.

5-90. Combat vehicles, that need fuel, ammunition, or repairs not related to mobility (for example, a fire control malfunction), can tow disabled vehicles to the refuel, rearm, or maintenance site. Using combat vehicles for vehicle recovery, removes them temporarily from combat operations.

5-91. Use like-wheeled vehicles as the source of effort to perform recovery by towing and winching. (For vehicles not equipped with lifting shackles, attach a tow chain to the main structural members.) Before towing or recovering a disabled vehicle, check the vehicle's TM to ensure all physical and safety features are considered (for example, automatic transmissions, fail-safe braking systems, and articulation). Following these safety features prevents further damage to the disabled vehicle.

EXTRACTING A MIRED TRUCK

5-92. To recover a mired truck by towing with a like vehicle, use a tow chain, cable, or bar between the towing vehicle and the mired vehicle:

- Attach a tow chain, cable, or bar to one lifting shackle (both, if possible) of the mired vehicle and the tow pintle on the towing vehicle. If a greater working distance is required to enable the towing vehicle to get better traction, use the towing chains or other device from both vehicles.
- Apply power slowly to prevent placing an impact load on the towing device and lifting shackles. A chain, unlike a cable, does not stretch and impact loading can break the chain. If one towing vehicle cannot attain sufficient towing effort to overcome the resistance, use another towing vehicle in tandem with the first vehicle. Figure 5-24 depicts a tandem extraction of a mired truck. Upon mire extraction, stop and connect tow bar for like vehicle recovery if necessary.

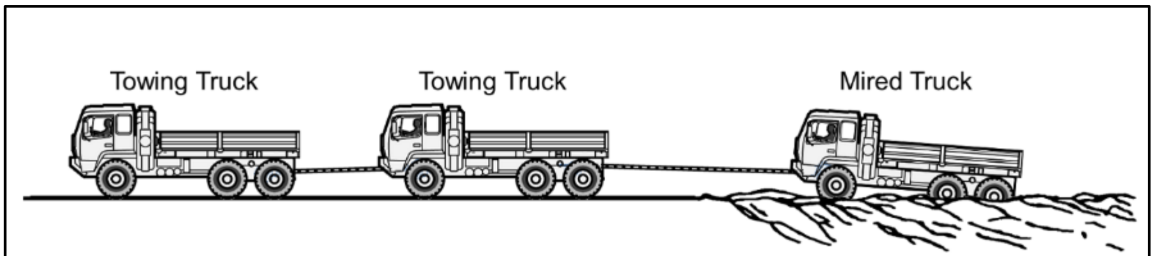


Figure 5-24. Recovery extraction of a mired cargo truck in tandem

> **CAUTION**
>
> Rigging should include a chain or Y-sling attached to both lifting shackles whenever possible to minimize damage and create an even pull effort. Using a second tandem vehicle increases the risk of tearing off lifting shackles, bending the rear cross member, or distorting the frame of a mired vehicle.

PROPER HOOKUP WITH A LIKE VEHICLE

To recover a mired cargo truck, use a truck of an equal or heavier vehicle class as an anchor vehicle. Use the winch (if equipped) mounted on the mired vehicle to perform the recovery assist winching operation. Use a snatch block in the rigging when possible. All winch equipped trucks are authorized a single sheave snatch block and one tow chain for rigging. When required, the self-winching truck applies power to wheels. See figure 5-25 for an example of winching with like or heavier class wheeled vehicle. Additionally see TC 21-305-20 for additional information on like-wheeled vehicle towing.

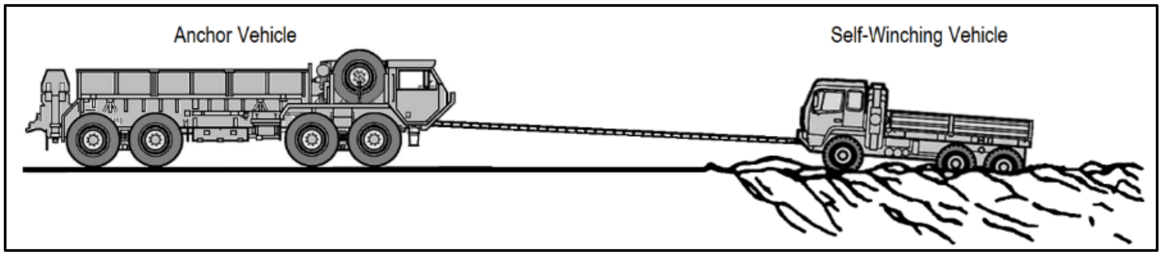


Figure 5-25. Winching with like or heavier class wheeled vehicle

> **CAUTION**
>
> Use extraction ropes for extraction operations. Do not use extraction ropes to tow a vehicle more than 50 feet under any circumstance.

SELF-RECOVERY

5-93. A winch-equipped, mired vehicle can perform self-recovery using an anchor. Attach the snatch block to a suitable anchor, and attach the free end of the cable to a chain sling connected to both of the mired vehicle's front lifting shackles. Use a fixed block to gain mechanical advantage when performing a self-winching operation. Figure 5-26 shows a vehicle performing a self-recovery operation.

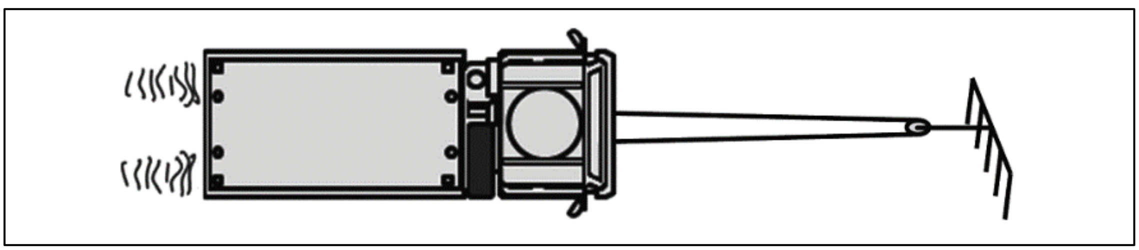


Figure 5-26. Self-recovery operation

USE OF LIKE-TYPE TRACKED VEHICLES FOR RECOVERY

5-94. The number of tracked vehicles required for a specific recovery depends on the resistance, extent to which the vehicle is disabled, and terrain conditions. To rig for recovery, attach the tow cables to the tow hooks of both vehicles. All main battle tanks carry two tow cables. Light-tracked vehicles carry one tow cable.

5-95. When a vehicle with a main gun cannon tube is recovered or towed, rotate or elevate the gun tube. This prevents serious damage if the rigging fails or the towed vehicle rams the towing vehicle.

5-96. Towing vehicles connected to disabled tracked vehicles with a tow bar. Use two tow cables between two vehicles for extraction. Vehicles can also use two tow cables in hasty combat evacuations (less than one grid square.) Follow the guidance from the disabled vehicle TM. Figure 5-27 depicts the recovery of a mired track using a like-type vehicle.

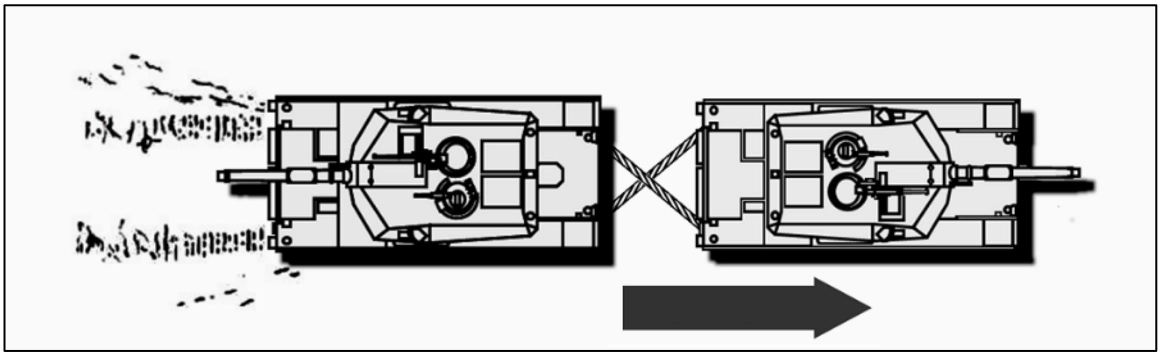


Figure 5-27. Recovery of a mired tank using one like vehicle

RECOVERING A TRACKED VEHICLE WITH LIKE VEHICLES

5-97. It may be necessary to use as many as three like vehicles to recover a nosed-tracked vehicle. This depends on the degree to which the vehicle is nosed and the terrain conditions on which the pulling vehicles must operate. In extreme instances, another resource may be required to lift the front of the nosed vehicle. Figure 5-28 shows a recovery operation using three like vehicles. To accomplish this type of recovery—

- Position the lifting vehicle to face the nosed vehicle.
- Position the gun tube to the side during the recovery procedure.
- Connect the cables of the pulling vehicles in the same way as for recovering a mired vehicle.
- Apply power to all assisting vehicles at the same time. The front of the nosed vehicle will rise and move toward the rear.
- Clean up any oil or fuel spills in the nosed vehicle before running the engine.

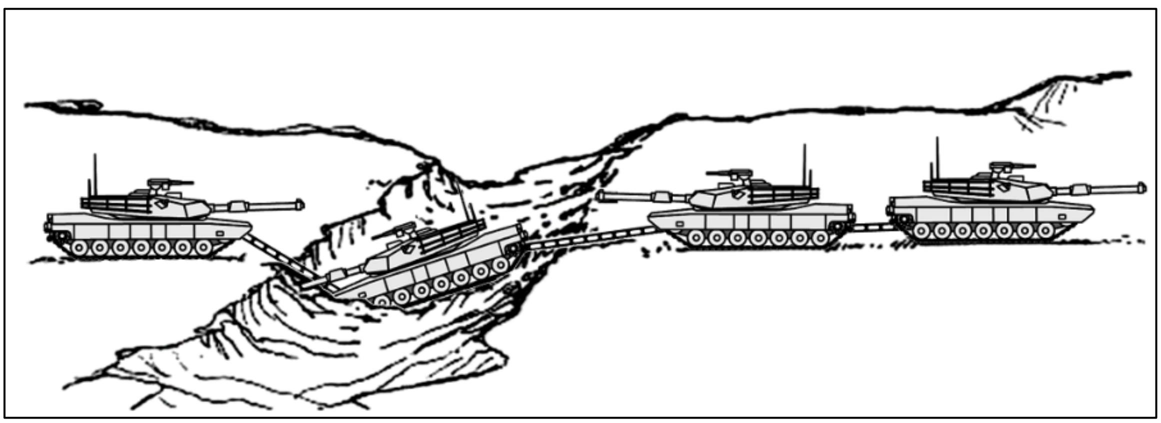


Figure 5-28. Recovering a nosed tracked vehicle with like vehicles

+RECOVERING AN OVERTURNED TRACKED VEHICLE WITH LIKE VEHICLES

5-98. An overturned tracked vehicle can be up righted using three like vehicles as shown in figure 5-29 on page 5-30. Use one vehicle to pull the overturned vehicle upright. Use the other two vehicles to hold and retard the fall of the overturned vehicle so it does not crash down on its suspension system and—

- Connect tow cables together in pairs to allow a safe working distance.
- Connect the cable used to upright the overturned vehicle to the nearest center road-wheel arm support housing on the upper side of the overturned vehicle. Never connect to any other part of the suspension system, turret, or the tie-down eyes.

- Position the two vehicles used for holding at a 30-degree to 45-degree angle from the overturned tracked vehicle, with their cables connected to the tow hooks on the high side of the overturned vehicle. Position the holding vehicles in this way to prevent damage to the cables, fenders, or lights of the overturned vehicle as it is righted.

5-99. Drivers of the holding vehicles must shift to low range. The pulling vehicle gradually applies power in reverse, while the holding vehicles move forward only enough to keep their cables taut until the overturned vehicle passes through the point of balance. As the overturned vehicle passes through the balance point, the holding vehicles move forward slowly, supporting the overturned vehicle and lowering it onto its suspension system.

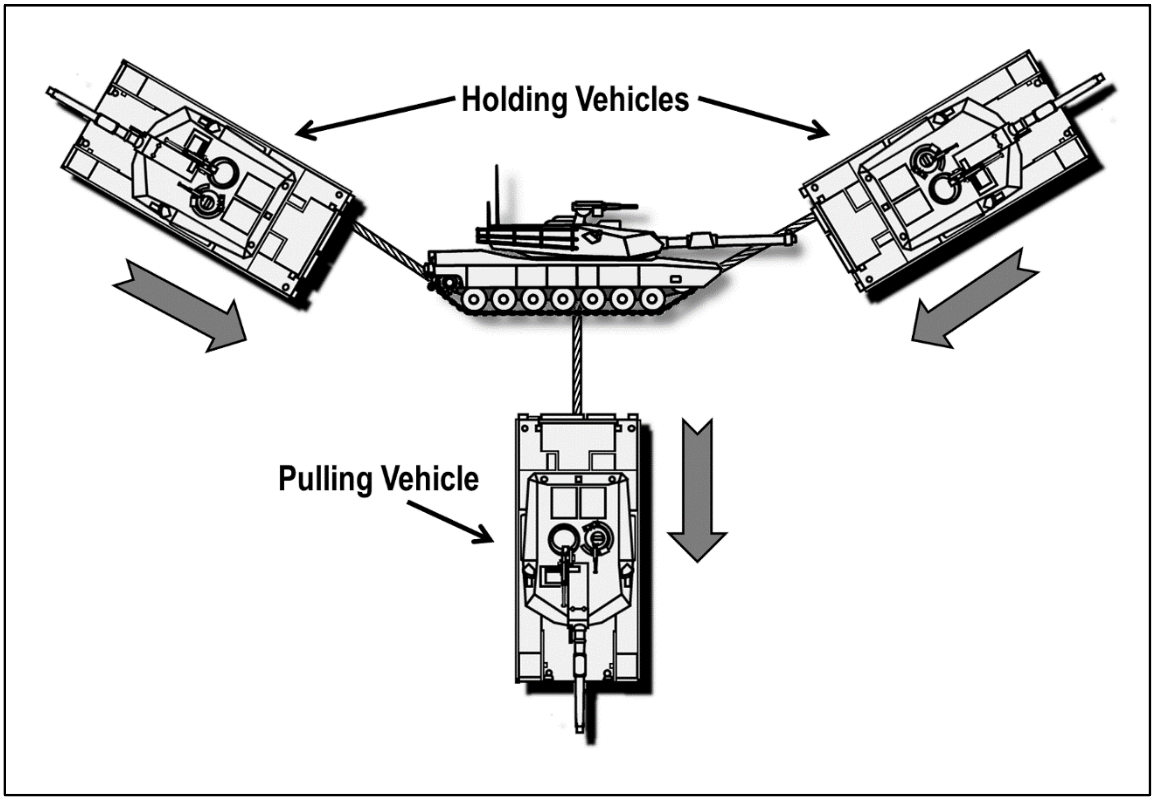


Figure 5-29. Recovering an overturned tracked vehicle with like vehicles

TOWING DISABLED TRACKED VEHICLES

5-100. Tow a disabled tracked vehicle with a like vehicle of the same weight class or heavier weight class with a tow bar. When using a tow bar on vehicles lighter than the 70-ton class, no holdback vehicle is required, unless the terrain interferes. A holdback vehicle will be used when—

- Tow cables are used.
- The towed vehicle is heavier than 70 tons.
- Terrain grades are more than 15 percent.

MARINE RECOVERY

5-101. Most vehicles ford. Some of these vehicles will fail while waterborne and will need recovery. Situations may be as simple as stalled, floating vehicles or as complex as submerged vehicles. The same methods of recovery apply to these situations but with a few unique considerations.

5-102. In the case of floating vehicles, swiftly moving currents can carry the vehicle and crew downstream. Water safety must be stressed to both vehicle and recovery crews. When operating on beaches or rivers with soft bottoms, time is critical. Recover the vehicle as quickly and safely as possible.

Fording Vehicle

5-103. Vehicles may become mired, nosed, or overturned during fording operations. As a result, estimate resistance in the same way by considering vehicle weight and type of disablement. For example, if a like vehicle is used for this operation—

- Attach its tow hooks to the lifting eyes.
- Cross the tow ropes and attach them to the lifting eyes before towing the disabled vehicle to shore. Using cables will prevent the quick disconnect of the towing vehicle if the towed vehicle begins to submerge.
- Once the vehicle is close to the shore and the tow lugs are exposed, move the tow cables to the tow lugs on both vehicles to pull the disabled vehicle ashore.

Submerged Vehicles

5-104. If a vehicle is flooded and submerged, determine the resistance on the river bottom in the same way as on land. Consider the weight of the vehicle, the cargo, and the river bottom, which may be sand, gravel, or mud. In addition, when pulling flooded vehicles from water to land, consider the weight of the water when determining the resistance. Recovery personnel estimate water weight to be equal to the vehicle's weight. For example, a tracked vehicle weighing 52,000 pounds sank. The vehicle mired to fender depth in the riverbed (mud). The effort required to retrieve it is 156,000 pounds (2 x 52,000 - pound mire factor + 52,000 – pound water weight). Estimate the number gallons and factor one gallon of fresh water weighs roughly 8 pounds, when calculating the amount of water.

5-105. The first problem in underwater recovery is locating the disabled vehicle in deep water. It may be easier to use dragging devices to locate the vehicle. Divers then determine the location of the vehicle rigging and mark the location of the vehicle using lines and floats. Special purpose vehicles, such as wrecker trucks and recovery vehicles are readily adaptable to recovery operations on submerged vehicles. In most situations, the winch cables of the recovery vehicles are long enough to allow winching operations from water to land.

WATER OPERATIONS

5-106. Most vehicles in the U.S. military's inventory have fording capability. Vehicles involved in fording operations may become disabled from mechanical or mobility malfunctions. A vehicle disabled during water operations must have power restored using BDAR or any other means available. Amphibious vehicles are at the mercy of the surf or river current if power is lost. If left afloat without power, vehicles are at risk of sinking, causing further damage to the vehicle and serious water contamination. If sinking does occur during non-combat operations, recovery personnel should make all practicable efforts to avoid environmental contamination. Contamination over 1 gallon should be reported through the chain of command. Should a vehicle sink out of sight, recovery personnel call qualified scuba personnel. Scuba personnel assist in locating, rigging and vehicle recovery.

Resistance in Water

5-107. Water resistance occurs when recovery vehicles pull a submerged vehicle to land. Estimated water resistance is equal to the vehicle weight. Therefore, a vehicle weighing 25 tons (including cargo) would require 50 tons of effort to winch it from the water. In the same situation, resistance would increase if the vehicle went down in the surf and the sand was partially covering the vehicle. Vehicles completely submerged, even for a short period, will usually be in a mired condition from sand, if in the ocean, or mud, if in a river. If in doubt, rig for the greater resistance and factor water weight at 8 pounds per gallon.

5-108. Whether the vehicle is upright or overturned will also be a factor in determining the total resistance. Qualified divers should locate and rig a vehicle for recovery. The divers will also be able to recommend direction of recovery, depending on obstacles. Following are some examples of resistance encountered when recovering floating-type vehicles:

- Amphibious vehicle afloat, minimal – 1/64th of vehicle weight.
- Amphibious vehicles completely submerged – equal to the weight of the vehicle. If the vehicle mired on a river or ocean bottom, calculate the additional resistance the same as for land mire.
- Amphibious vehicles completely submerged and filled with water, the submerged vehicle weight is the vehicle weight times two.

5-109. Fording-type vehicles that have become disabled must also be considered for weight of water but only an additional 1/8th of the vehicle weight; that is, a 70-ton tank would be calculated to weigh approximately 79 tons plus any mire encountered. Calculate the mire factor in this case is using 79 tons.

5-110. Qualified divers can place air bags or 55-gallon drums inside the submerged vehicle and inflate to provide buoyancy and decrease resistance during underwater recovery operations. Divers need to place the air bags or 55-gallon drums inside the vehicle in a location where they will not escape the vehicle or cause additional damage. Once the air bags or drums are in position, inflate to the recommended capacity.

Methods Of Rigging

5-111. The rigging methods for underwater recovery are normally restricted to the manpower and/or lead methods. Recovery personnel should only attempt to tow a disable vehicle from water if it is located in very shallow water. The method of rigging depends on the distance from the disabled vehicle, type of disabled vehicle, type of recovery vehicle available, equipment available (floats, air bags, tackle), and condition of the disabled vehicle.

Lead Method

5-112. The lead method of rigging is performed the same in water as on land. If in deep water, a boat or an amphibious vehicle can transport tackle to the disabled vehicle. If the water is shallow, personnel can carry the tackle to the disabled vehicle.

Manpower Method

5-113. The manpower method is much the same regardless of whether on water or land. Recovery personnel can attach flotation devices to the cable every few feet and to snatch blocks and other tackle to aid in getting the recovery equipment to the disabled vehicle.

Note. Underwater recovery is usually limited to the manpower or lead methods.

EXPEDIENT RECOVERY TECHNIQUES

5-114. An expedient measure involves completing a task with on-hand materials. For example, vehicles may be required to operate in remote areas where assistance in recovery operations is not readily available. Under these conditions, the operator or crew must attempt self-recovery by using methods similar to those described previously in this manual.

PRY BAR

5-115. A pole can be used to pry a lightweight truck out of a ditch by—

- Using the pole to lift the front end of the truck.
- Applying power to the truck while in reverse gear.

SUBSTITUTE JACKS TO REMOVE FRONT AND REAR WHEELS

5-116. To raise the front wheel of a cargo truck—

- Locate a timber (approximately 5 feet long) to use as a pry bar.
- Place the bottom of the timber in a shallow hole.
- Secure the timber to the front bumper at an angle with a chain or rope.

- Move the vehicle forward until the timber is in a vertical position and the wheel clears the ground.
- Set the brakes and chock the wheels.

WARNING

Do not use substituting jacks to remove front and rear tires on vehicles with aluminum front bumpers, such as the United States Marine Corps MK-23. If this method is used, it will damage the front end of the vehicle and possibly cause injury to personnel.

5-117. Another substitute jack is a piece of timber longer than the distance from the axle to the ground. To prepare this type of substitute jack do the following:—

- Place one end of the timber against the axle at an angle and the other end in a shallow hole.
- Drive the vehicle forward against the angled timber, which will cause the timber to stand straight up and lift the axle off the ground.
- Set the brakes and block the vehicle securely.

REMOBILIZING TRACKED VEHICLES

5-118. Tracked vehicles that run over obstacles are sometimes caught on stumps, rocks, dry ridges, or mire. This is called bellied (high-centered). A lack of traction immobilizes the vehicles.

ANCHORING TRACKS

5-119. To recover a bellied vehicle, obtain a log long enough to span the width of the vehicle and of sufficient diameter to support the vehicle weight. Figure 5-30 demonstrates how to anchor the log. To anchor the log do the following—

- Place the log against both tracks.
- Place a tow cable so that one end of the cable goes under the log and through the tracks from the inside.
- Place the other end of the tow cable underneath the log and connect the ends of the cable together with a tow hook on the outside of the track to make disconnecting easier.

5-120. Follow the same procedure to attach the log to the track on the opposite side of the vehicle. Take up the slack in the tow cable by gradually applying power to the tracks. This pulls the log underneath the tracks until it contacts the obstacle, thereby anchoring the tracks and causing the vehicle to move.

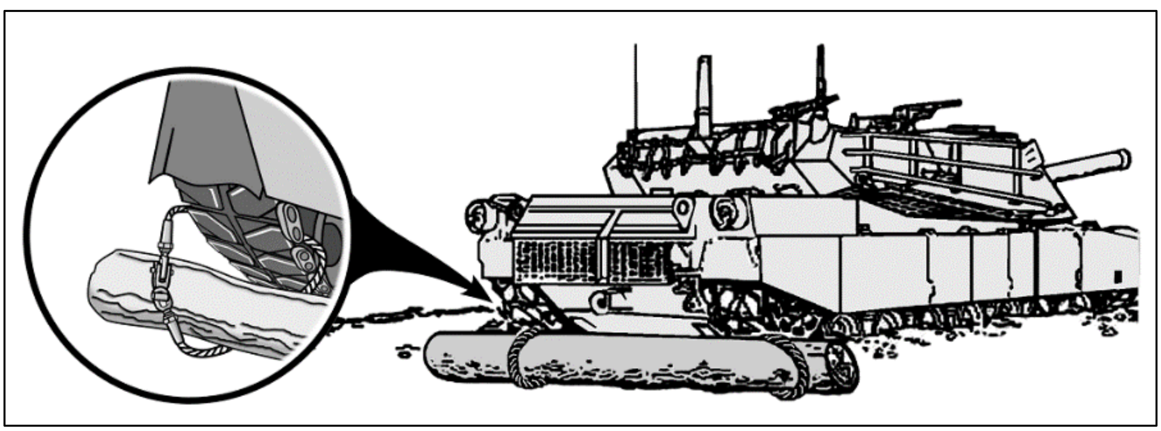


Figure 5-30. Using a log to anchor tracks

CAUTION

To prevent damage to the fenders and tow cables, stop the vehicle before the log reaches the fenders or the cable reaches the drive sprocket.

5-121. For a bellied disablement (other than mire), anchor the tracks by using two tow cables. See figure 5-31 for an example. Connect the tow cables together with a tow hook and attach the cables to both tracks by passing the ends of the cables through the tracks from the outside and attaching them to the standing parts of the cables with tow hooks. When operators apply power to the tracks, the cable will contact the obstacle and anchor the tracks.

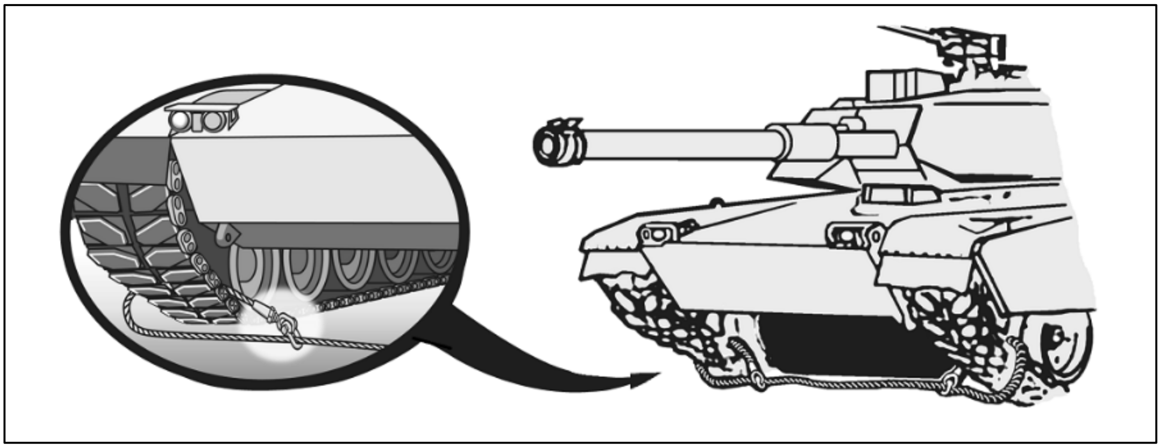


Figure 5-31. Cables used to anchor tracks

Moving a Vehicle With Both Tracks Broken

5-122. When a vehicle throws both tracks, the crew may need to separate the tracks before moving the vehicle to remount the tracks. Figure 5-32 shows one method of moving a tank with both tracks broken. To separate tracks—

- Break one track and attach a cable from the drive sprocket hub to an anchor. This will support the vehicle so that personnel can separate the other track.
- Chock the vehicle to keep it from rolling out of control.
- Apply engine and steering power to the drive sprocket attached to the cable. When the operator does this, the vehicle will move by the winching action of the drive sprocket hub.

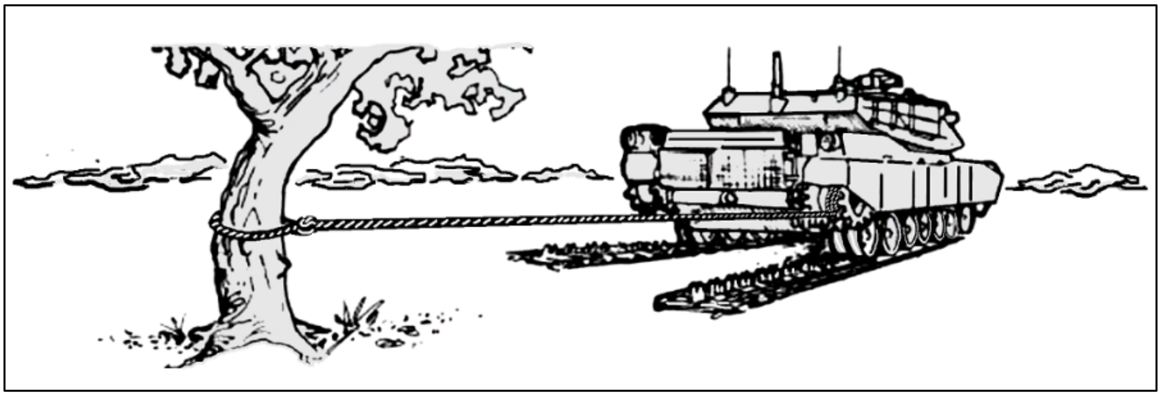


Figure 5-32. Moving a vehicle with both tracks broken

MOVING A VEHICLE ONTO A TRACK

5-123. Figure 5-33 provides one example of how to move a vehicle onto a track. Align the vehicle with the track and position a plank-type ramp on the end of the track. When a ramp is not available, dig a shallow ditch where the end of the track can lie.

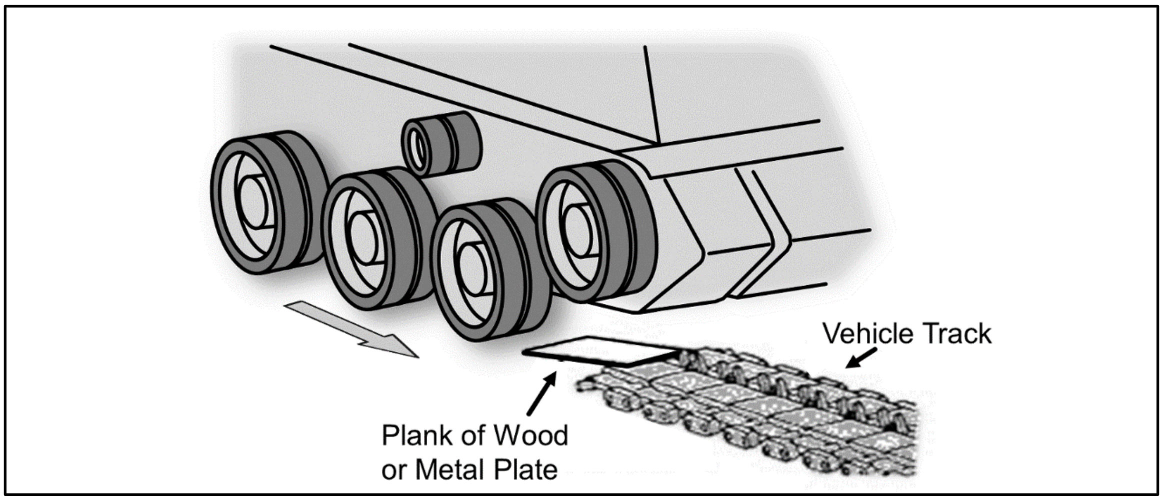


Figure 5-33. Moving a vehicle onto a track

INSTALLING A TRACK

5-124. To install a track—

- Align the track with the road wheels so that the center guide(s) will pass between the road wheels when the vehicle is moved. See Figure 5-34 for an example of installing a track.
- Stop the vehicle when the rear road wheel is resting forward far enough for the entire track to pass over the sprocket.
- Tie a rope to the center of the track pin on the rear track link.
- Pass the rope over the center guide groove of the sprocket hub, around and between the rear support roller wheels, and back around the sprocket hub, making two turns.

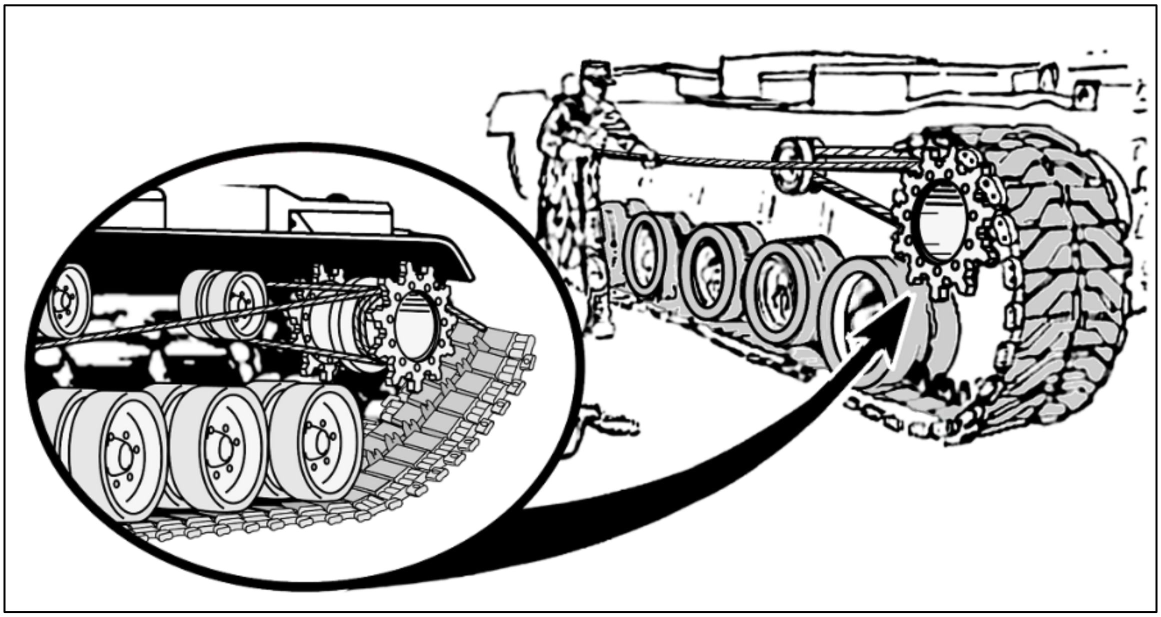


Figure 5-34. Installing a track

5-125. As the operator applies power to the sprocket, and the free end of the rope is held taut, the end of the track is pulled up to the sprocket. Once the sprocket has engaged a minimum of three track links do the following—

- Stop the sprocket, lock the brakes, and shut off the vehicle engine.
- Remove the rope from the sprocket hub and extend it forward over the compensating idler wheel.
- Restart the vehicle and move forward.
- When the end of the track has passed over the compensating idler, connect the track.

Chapter 6

Non-Standard Repairs

Expedient repair and BDAR are key enablers in maintaining military capability. Expedient repairs use basic common maintenance engineering skills and or non-conventional or improvised repair techniques. BDAR rapidly returns disabled equipment to operational condition in wartime by bypassing and restoring minimum functions to essential systems. Operator/crew and maintainers use both repair procedures to restore a vehicle to limited or full capability while operating within field-level maintenance. This chapter outlines expedient repairs and BDAR techniques and consideration.

UNIT RESPONSIBILITY

6-1. Commanders execute expedient repairs and BDAR repairs by designating maintenance leadership to publish and disseminate guidance on the use of expedient and BDAR capabilities. This guidance is unit specific and provides authorization for the application of expedient repair techniques by operators and field maintainers.

6-2. Expedient repairs and BDAR are non-standard repairs. Both are sets of simple, rapidly implemented repairs that return disabled equipment to an operational condition. Both methods restore minimum function to essential systems using minimal resources.

6-3. Commanders are responsible for ensuring all expedient repairs and BDAR are authorized and documented. They also ensure expedient repairs and BDAR are thoroughly inspected and validated for temporary or continued use. Each unit develops its own expedient repair and BDAR standards for training execution. Examples of unit level standards may include—

- Repair of electrical wires/cables, possibly including fiber optics and data-buses.
- Repair of pipes/hoses (metal, rubber and synthetic materials) for:
  - Coolant.
  - Fuel.
  - Lubricating Oil.
  - Hydraulic Fluid.
  - Air.
- Repair of non-pressurized liquid storage tanks (fuel, oil, water) or pressurized (air).
- Mechanical connections.
- Armor.
- Vehicle and equipment panels.
- Tires.

6-4. Expedient repairs are deferred faults. Maintainers must reassess the repair at a specific future date to validate its continued use. Expedient repairs must meet legal and safety requirements.

UNITED STATES ARMY MATERIEL COMMAND RESPONSIBILITY

6-5. The USAMC places predictable failures that fall under nonstandard repair actions along with identified corrective actions in equipment publications to update the field. This helps avoid second and third order damage to other equipment related parts that may occur in routine use, training, or combat. Examples of these include limp home features such as short tracking, wheel-station tie-up, and suspension preparation necessary for movement.

EXPEDIENT REPAIRS

6-6. Expedient repairs are temporary or semi-permanent in nature. Maintainers should perform repairs that are more reliable as soon as possible. Examples of expedient repairs include replacing a damage hose with a fabricated hose without national stock number, using alternative fully functional batteries, but not the national stock number stated in the TM, and sealing electrical wires to prevent electrical shorts when wet or contact to grounds or other wires.

EXPEDIENT MAINTENANCE

6-7. Commanders should incorporate expedient maintenance into training and practice the techniques during unit training exercises. During training, unit maintenance personnel apply all medium and high-risk repairs. Operators at the unit level, with approval of the commander, can apply low risk repairs during training and exercises. Senior maintenance supervisors must inspect all repairs and classify the risk level. The risk level determine whether the repair can remain until parts are available.

THREE CATEGORIES OF NON STANDARD REPAIRS

6-8. There are three categories of non-standard repairs. Table 6-1 provides examples of non-standard repairs. They range from expedient repairs through BDAR.

- **Type 1 Expedient repair.** An improvised, non-conventional repair that is of sufficient engineering quality and robustness to be considered permanent. This allows the continued use of the equipment. The repair does not require subsequent replacement. Maintainers review Type 1 repairs at a specific future date to validate continued use. This repair must meet any legal and safety requirements.
- **Type 2 Expedient repair.** An improvised, non-conventional repair that is considered only temporary in nature. Maintainers allow the equipment to complete the immediate mission or task, before replacing the work with a conventional repair. This repair should meet agreed legal and safety requirements.
- **Type 3 BDAR.** An improvised, non-conventional repair that rapidly returns the equipment for use. This repair is unlikely to be permanent and may not meet legal and safety requirements but is essential to maintain military capability in periods of conflict or war.

Table 6-1. Nonstandard repairs

Non Standard Repair	*Risk*	*Present on equip-ment in Peace time*	*Applied in Training*	*Applied in Battle*	*Permission Required*	*BDAR Kit used*	*MC Status*	*Deferred Length*	*MS Check*
Type 1	L	Yes	Yes	Yes	Yes	Yes	FMC	Maintenance supervisor dependent	Yes
Type 2	M	Yes	Yes	Yes	Yes	Yes	FMC	Maintenance supervisor dependent	Yes
Type 3	H	No	Yes	Yes	No	Yes	MC	No, must be corrected after the mission	Yes
Legend: L = low M = medium H = high BDAR = battle damage assessment and repair FMC = fully mission capable MC = mission capable MS = maintenance supervisor									

BATTLE DAMAGE ASSESSMENT AND REPAIR

6-9. On the battlefield, equipment damage can occur through various means. Enemy contact contributes to the majority of the equipment damage. Accidents are another source that may cause serious damage to equipment. Extensive use of equipment coupled with poor maintenance practices can lead to premature failures from fatigued and worn out components. During the battle damage assessment phase the extent of damage determines if the equipment is a BDAR candidate or requires recovery assets. Always consider the current tactical conditions before attempting expedient repairs.

6-10. Establish local security before conducting any battlefield assessment or repair. A disabled vehicle provides a lucrative opportunity target for an adversary. The security element provides early warning and initial reaction to a threat. Maintenance personnel anticipate having to suspend their assessment or recovery mission and respond to a ground or air threat using their individual and crew-served weapons.

6-11. The battlefield heavily taxes maintenance assets. Because resources are limited (personnel, tools, and parts), it is imperative maintenance resources are not wasted. Operators/crew must perform expedient repairs within their capabilities immediately rather than requesting maintenance personnel to perform simple mechanical tasks. Most expedient repairs are not found in TMs. Flexibility and ingenuity are the keys to successful expedient repairs.

6-12. On the battlefield, the objective is to return the system to combat with enough capability to accomplish the mission. Crew/operators repair only what is necessary to restore function. Cosmetic repairs waste time and resources. If a broken item does not affect the ability to shoot, move or communicate, and does not pose a serious safety concern, crew/operators ignore the issue until combat operations are over. Maintainers defer cosmetic repairs until the equipment returns to maintenance at which point they perform standard repair procedures.

6-13. BDAR in extreme operational environments requires an understanding of how temperatures affects the physical tendencies of rubber, plastic, petroleum products, and vehicle parts. Refer to TM 4-33.31, *Cold Weather Maintenance Operations* and ATP 4-33 for information on operational environment impacts.

6-14. BDAR procedures, according to AR 750-1, are for battlefield and training environments and used in situations where standard maintenance procedures are not practical or possible. These procedures ensure the vehicle and/or equipment is mission capable until maintainers can perform permanent repairs. BDAR does not replace standard maintenance procedures. After battle or completion of training, maintainers return the end item/system to full serviceable condition using standard repair procedures.

BATTLE DAMAGE ASSESSMENT

6-15. The first and most important phase of BDAR is battle damage assessment. A quick and accurate assessment is critical in determining the extent of the damage. Recovery personnel identify parts to make expedient repairs, BDAR or to recover the equipment. A poor battle damage assessment can result in overlooked secondary damage or unnecessarily result in the need for equipment recovery. Battle damage assessment must take place at the site of the breakdown if the area is safe and secure. An accurate battle damage assessment determines the extent of primary damage and secondary damage to the subsystems and components including the type of repair and the risks involved. The assessment should also include an estimate of required personnel, time and materials required to perform expedient repairs

6-16. Recovery personnel performing battle damage assessment on several pieces of damaged equipment use the equipment triage concept. This concept establishes the order of precedence for repair and whether spare parts acquisition through controlled substitution or cannibalization will be required. Major weapons systems should have top priority for repairs unless the immediate mission dictates otherwise.

BASIC RULES OF ASSESSMENT

6-17. Always consider the safety of the crew and personnel performing BDAR on a piece of equipment. The following safety checks are performed to identify any obvious hazards:

- Is there a round of ammunition in the gun tube?
- Is any ammunition in a critical state due to shock, fire, or physical damage?

- Have any combustibles such as fuel, hydraulic fluid, or oil accumulated?
- Does wiring appear to be safe? Could an arc occur to stored ammunition or leaking combustibles?
- Is the fire extinguishing system operational? If not, station a crewmember in the vehicle, prepared either to use a handheld fire extinguisher or to operate the onboard fire extinguishing system manually. Station a second crewmember outside the vehicle with an additional fire extinguisher.
- For systems with built-in self-test procedures, has the crew performed a functional/operator test on those systems that appear undamaged?
- Are any toxic fumes present?

6-18. Abandoned equipment, or equipment left unsupervised by friendly forces may have been booby-trapped. Booby traps and improvised explosive devices present unique challenges when conducting damage assessments or recovery of abandoned vehicles. To ensure the safety of individuals during BDAR/recovery operations, carefully inspect equipment for evidence of tampering before attempting to perform repairs or move the equipment. Personnel must request explosive ordnance disposal, also called EOD, support to render safe any unexploded ordnance to include improvised explosive devices or booby traps.

6-19. Soldiers should not disturb any unexploded ordnance in the immediate area, on top, or inside the equipment. Explosive ordnance disposal personnel must render safe and dispose of the ordnance prior to BDAR or recovery operations.

6-20. In areas where chemical, biological, radiological, and nuclear (CBRN) contamination might be present, recovery personnel adopt the proper personal protection equipment. Recovery personnel check the area and equipment for contamination. If they detect contamination, recovery personnel conduct contamination mitigation measures to minimize its spread. The Soldiers must decontaminate contaminated equipment at the designated decontamination site prior to evacuation to the MCP.

6-21. Several munitions and vehicle armor panels utilize depleted uranium. Depleted uranium poses a greater risk than radiation because it is a heavy metal poison. Soldiers must be aware of the hazard of depleted uranium and adopt appropriate contamination reduction practices. Sufficient measures to reduce particle ingestion and absorption include placing a piece of cloth over the nose and mouth, covering any open wounds, and practicing good personal hygiene. Soldiers must use a Radiac meter to determine if depleted uranium is present in damaged ammunition or vehicle armor panels.

6-22. Units and recovery personnel should attempt to move damaged equipment to a covered or concealed position away from enemy fire in the forward battle area. The distance moved will be determined based upon the current tactical situation. Be aware of loaded weapons, damaged ammunition, and damaged wiring which pose a safety hazard during battle damage assessment.

6-23. Familiarization with the operation of damaged equipment is extremely important to prevent further damage to the equipment or injury to personnel. During battle damage assessment and functional checks, only experienced individuals will operate the systems.

Chemical, Biological, Radiological, and Nuclear Impacts on Recovery Operations

6-24. CBRN contamination will add a significant degree of complexity and risk to recovery operations. Major CBRN considerations for recovery of battle-damage vehicles include the following:

- Commanders may decide to abandon vehicles and weapon systems with only minor or no conventional battle damage due to contamination.
- Environmental factors may cause decontaminated equipment to off-gas chemical hazards after previously indicating no hazards especially under colder or more humid weather conditions.
- Complex artillery strikes that integrate CBRN agents with conventional munitions are likely to target routes utilized by recovery assets.

6-25. CBRN personnel in units tasked with recovery operations will support recovery planning and execution to address the following actions:

- Assess decontamination requirements to support recovery; coordinate for thorough decontamination as required.

- Ensure subordinate units execute immediate and operational decontamination using organic assets to limit the spread of CBRN contamination.
- Recommend mission oriented protective posture, also known as MOPP, levels required for recovery personnel, and adjust as necessary.
- Template potential CBRN strikes in accordance with most current assessment of enemy capabilities and TTPs.
- Coordinate with CBRN reconnaissance units to confirm hazards in planned avenues of approach, providing clarity on the appropriate protective measures to take to protect the force.

6-26. For additional information regarding CBRN factors for battlefield recovery, refer to FM 3-11, *CBRN Operations*, ATP 3-11.32, *CBRN Passive Defense*, and ATP 3-11.36, *CBRN Planning*.

BATTLE DAMAGE INDICATORS

6-27. Battle damage indicators play an important role in battle damage assessment. Damage can occur as the result of enemy contact, accidents or mechanical failures. During an operation, it may not be possible to focus on what just happened. However, immediate recognition and attention by operators/crew members is important because some battle damage indicators may not be apparent once the equipment stops functioning. For example, if the operator notices engine oil pressure dropping rapidly due to a perforated oil pan, the operator can pull over and turn the engine off before it seizes from a lack of lubrication. Recovery personnel can expediently repair an oil pan. If the oil pan is accessible, it can be expediently repaired and the crankcase refilled. This action will return the asset to operational status instead of requiring recovery and replacement of the engine.

6-28. Battle damage indicators include smoke, fire, unusual odors, unusual mechanical noise, leaking fluids, warning lights and alarms, and loss of mobility or system function. Most fluids have distinct colors and odors. Familiarization with the characteristic of each type of fluid is extremely important to identify a damaged system. Other battle damage indicators include loss of power, system function, control, or degraded system performance

PERFORM AN ASSESSMENT

6-29. During combat operations the senior Soldier present decides if and when to utilize BDAR. The senior Soldier bases the decision on analysis of current operational variables and the appropriate risk repair level. In the forward battle area, the crew must attempt to move the vehicle to a covered or concealed position to prevent additional damage. The best technique is to move the vehicle at least one terrain feature or one kilometer away from enemy contact.

6-30. Recovery personnel should not attempt to operate systems or subsystems until the crew has performed an assessment. This crew assessment prevents further damage to equipment or personnel. For example in an assessment where the vehicle's circuit breakers are tripped, including the main circuit breaker, the assessment process should lead to determining the best method or sequence required to restore power to the vehicle. The system restart would happen after resetting the main circuit breaker followed by resetting the remaining circuit breakers one at a time.

6-31. If the vehicle is not self-recoverable, use any like or heavier class vehicle to recover the vehicle or to conceal it. If this is not possible, turn the turret or weapon system in the direction of engaging fire to limit damage and provide return fire capability.

6-32. To enable a systematic assessment, crews and maintenance personnel should use these basic steps to battle damage assessment. The basic steps are—

- Visually inspect interior and exterior for damaged parts and systems.
- Visually determine if vehicle main systems appear to be operable.
- Perform equipment self-test function using a built-in test, built-in test equipment, and a function test.
- Assess system performance (exercise each system if engine can be safely started).
- Determine which subsystems are affected.

- Determine if crewmembers can repair the damage. Are there enough crewmembers with the required skills available? Does the current tactical situation allow repairs at the current location?
- Estimate the repair time by either crew or by a maintenance team.
- Estimate the number and type of repair personnel needed and the associated risk. Ensure command approval to perform repairs.
- Determine what materials are required.
- Determine what the vehicle limitations will be after repairing using BDAR or standard repair.
- Determine the recovery status, self/like/dedicated.

BATTLE DAMAGE ASSESSMENT GUIDELINES

6-33. This section provides guidelines for battle damage assessment. Use these guidelines to rapidly assess battle-damaged equipment and systematically determine which subsystems are affected. The assessment includes the time, personnel, and materials required for repair.

6-34. These guidelines will also assist in performing "equipment triage." Recovery personnel base this determination on combat or sustainment equipment, time, urgency, materials, and personnel required to do the required repairs.

6-35. +Units can develop locally produced forms or checklists that best support authorized equipment and unit maintenance structure, and list personnel authorized by the command to approve BDAR actions based on the battle damage assessment. Commanders and maintenance supervisors can tailor these guidelines to fit a specific vehicle. These checklists should include the following:

- **System Assessment Summary:**
  - Determine vehicle status.
  - Can the vehicle shoot, move, and communicate?
  - Can the vehicle be repaired to shoot, move, and communicate?
  - Should the vehicle be self-recovered, towed, or transported?
  - Estimate the time and personnel needed.
- **Armament and Fire Control:**
  - Does the turret traverse and elevate with no oscillations either manually or by power.
  - Is the main gun capable of firing without damage to the recoil system?
  - Is the fire control device operational (primary or secondary)?
  - Is the electrical system: turret power, slip ring, circuit breaker, and wiring harness damaged?
  - Is the bore evacuator, gun tube, breech group, and main gun mount damaged?
  - Is the commander control handle and weapon sight, gunner primary and auxiliary sight, range finder, crosswind sensor, gunner control handle, stabilization system operational?
  - Is the auxiliary hydraulic pump, hydraulic fluid, and hydraulic reservoir intact or damaged?
- **Mobility:**
  - Is the engine, transmission, fuel system, electrical system, wheels and suspension, hydraulic system, armor operational? Can it be repaired or recovered? Are there any limitations?
  - Is the vehicle able to use normal braking/stopping from 15 mph and brakes must hold on slopes? Is the vehicle steering system operational?
- **Communications:**
  - Does the vehicle have intercom between commander and driver?
  - Are the radios able to communicate to next higher command?
  - Does the vehicle have a backup communication system?

6-36. BDAR may enable the equipment to either self-recover or continue the mission. The battle damage assessment will provide the commander with necessary information to make efficient decisions concerning whether to continue the fight or recover the equipment to the appropriate maintenance location. Always report battle damage as soon as possible. Report the damage according to the local standard operating procedure (SOP) and this publication.

BDAR TOOLS AND EQUIPMENT

6-37. One BDAR kit is available to support both crew and maintainers to perform BDAR with access to basic issue items and components of end items. To get general information about expedient repairs, GTA 01-14-001, *BDAR Smart Book*, BDAR kit and NSN review MilSuite's sustainment Ordnance community, maintenance management, and battlefield recovery operations pages. A common access card is required to enter the site. Personnel will find GTA 01-14-001 and other helpful documents on the battlefield recovery operations page. GTA 01-14-001 provides valuable information on the BDAR kit's capability including fuel, hydraulics, cooling, tires, electrical systems, and hull repair.

6-38. When possible, the vehicle crew should perform authorized BDAR tasks using the BDAR kit, BII, components of end-items, also known as COEI, and additional authorized list. Maintenance personnel will have access to the same items available to the crew/operator, to include additional resources and components. For reference to basic BDAR repair techniques use the BDAR Smart Book or the Platform BDAR technical manual.

6-39. The operator/crew prepares and provides the initial damage assessment and reports to the vehicle commander. They describe inoperable conditions, to include CBRN conditions and other circumstances. (When the inoperable equipment is subject to or in danger of hostile fire, another vehicle can recover it to a secure location.) The operator/crew assesses the situation and determines which type of maintenance support is required.

6-40. If directed, using the BDAR kit and *BDAR Smart Book* the crew will proceed to make any repairs possible. Usually these repairs will consist of restoring firepower, communications, and/or vehicle mobility within the limit of their skills and the availability of materials and tools. They must also consider repairing items to make the equipment self-recovery capable. If repairs are beyond crew capabilities, they request assistance per the unit's SOP.

6-41. The vehicle commander will report the results of the crew/operator damage assessment to the platoon leader. The vehicle commander will name the major known causes of the vehicle's immobility and/or lack of firepower and/or communication failures. If repairs by the crew are possible, the vehicle commander will report the appropriate risk repair level, a total estimated repair time, and a list of restorable functions.

6-42. The platoon leader will respond with directives and, if required, will call a maintenance team to the location of the damaged vehicle for assistance. If possible, the platoon leader will provide sufficient information to enable the maintenance team to bring any required repair parts, special tools, or recovery assets to the site.

6-43. Maintenance personnel will assess the equipment to verify the operator's/crew's damage assessment for accuracy or reconsideration of repair methods. Based on the maintenance assessment, the recovery personnel will decide to either attempt an on-site repair or request recovery assets to move the vehicle to a MCP. The current tactical situation will determine if on-site repair or evacuation is necessary.

6-44. The maintenance team will/can perform BDAR repairs if possible to regain functions, using the BDAR kit and any other field expedient material on hand. Because standard maintenance repairs usually offer the best repair, maintenance personnel will strive to perform standard repairs if the current tactical situation permits. Other courses of action include—

- When recovery vehicles are not available and the tactical situation permits, damaged equipment that is mobile may move disabled equipment. Like classed or heavier vehicles may recover disabled equipment.
- If the maintenance team can make all critical repairs with the skills, tools, and equipment on hand, they, assisted by the crew, should proceed with the on-site repair.
- If the vehicle is not reparable, the maintenance team will provide:
  - Recovery to the MCP for evacuation to the rear.

  - On site cannibalization, if approved by the commander and coordinated with support maintenance.
  - Other needed replacement parts.
- If the vehicle is contaminated, the maintenance team will mark the vehicle with the appropriate contamination markers and arrange for recovery to a decontamination site.

DETERMINING EQUIPMENT READINESS STATUS

6-45. Equipment readiness is often identified by a readiness status. Readiness status range from fully mission capable to combat emergency capable.

Fully Mission Capable

6-46. The term fully mission-capable refers to systems and equipment that are safe and have all mission-essential subsystems installed and operating as designated by applicable Army regulation. A fully mission-capable vehicle or system has no faults that are listed in the “not fully mission-capable ready if” columns of the TM XX–10 and XX–20 series preventative maintenance checks and services tables. It must also meet AR 385–10 provisions that apply to the vehicle and/or system or its sub-system required by AR 750-1.

6-47. The equipment, per AR 700-138, *Army Logistics Readiness and Sustainability*, must perform tactical and combat missions safely and without endangering the life of the operator or the crew. Once inspected and approved by the maintenance technician, BDAR expedient repairs may bring damaged equipment to a fully mission capable status (Type I and Type II BDAR repairs).

Not Mission Capable

6-48. The term not-mission capable means the damage to the equipment or failure of components rendered it inoperable (NOT READY/AVAILABLE) and expedient BDAR repair procedures will not restore the equipment to combat capable or combat emergency capable status requiring the application of standard maintenance and/or repair parts.

Combat Capable

6-49. The term combat capable means the equipment can operate in a combat environment with some limitations and meets the minimal function capability listed in the BDAR technical manuals (brakes, steering, forward and reverse capability) to continue the mission.

Combat Emergency Capable

6-50. This term indicates the equipment or vehicle meets the criteria for a specific mission but not all functions are fully operational (shoot, move communicate) and additional damage may occur if the equipment is operated. The commander must decide if these limitations are acceptable for that specific emergency.

RECORDING BATTLE DAMAGE REPAIRS

6-51. Recovery personnel record all expedient repair and/or BDAR performed on a piece of equipment. They begin the recording process at the site where repairs begin. The purpose for marking the component is to alert the crew and maintenance personnel that an expedient repair action was taken and needs to be inspected and repaired to 10/20 standards. Recovery personnel use a DD Form 1577 (*Unserviceable [Condemned] Tag-Materiel*) available in the BDAR kits or a suitable tag which identifies the damage, type of repair made, repairer and date. It is not necessary to complete the tag under emergency conditions. However, as soon as possible the recovery personnel should record the location and type of repair.

6-52. In some cases, it may be impractical to attach tags to repairs located on the outside of the vehicle. Recovery personnel can place the completed tag in the equipment record book/folder or in a conspicuous place in the driver’s compartment. When an expedient repair cannot restore full function and one or more systems are operating in a degraded mode, the tag must indicate the operation limitations and must be placed in the drivers and commanders area (where applicable) to alert them of limitations and cautions.

6-53. Recovery personnel must also record the BDAR repair on a DA Form 2404 (*Equipment Inspection and Maintenance Worksheet*). Personnel record BDAR actions on faults in block 10c with "BDAR APPLIED" marked across blocks 10c and 10d. Figure 6-1 provides an example of the DA Form 2404. If the computer generated DA Form 5988-E is used, personnel must write the acronym "BDAR" across the corrective action section in the lower right corner of the form. See figure 6-2 on page 6-10 for an example of the DA Form 5988.

EQUIPMENT INSPECTION AND MAINTENANCE WORKSHEET

For use of this form, see DA PAM 750-8; the proponent agency is DCS, G-4.

1. ORGANIZATION	2. NOMENCLATURE AND MODEL
B-9 // B Btry, 62nd ADA, Ft Hood, TX	M984A2R1, Try Wrecker

3. REGISTRATION/SERIAL/NSN	4a. MILES	b. HOURS	c. ROUNDS FIRED	d. HOT STARTS	5. DATE	6. TYPE INSPECTION
NSN: 2320014928233	3214				6 Apr 2019	After PMCS

7. APPLICABLE REFERENCE

TM NUMBER	TM DATE	TM NUMBER	TM DATE
TM 9-2320-279-10-1			

COLUMN a – Enter TM item number.
COLUMN b – Enter the applicable condition status symbol.
COLUMN c – Enter deficiencies and shortcomings.
COLUMN d – Show corrective action for deficiency or shortcoming listed in Column c.
COLUMN e – Individual ascertaining completed corrective action initial in this column.

STATUS SYMBOLS

"X" – Indicates a deficiency in the equipment that places it in an inoperable status.

CIRCLED "X" – Indicates a deficiency, however, the equipment may be operated under specific limitations as directed by higher authority or as prescribed locally, until corrective action can be accomplished.

HORIZONTAL DASH "(-)" – Indicates that a required inspection, component replacement, maintenance operation check, or test flight is due but has not been accomplished, or an overdue MWO has not been accomplished.

DIAGONAL "(/)" – Indicates a material defect other than a deficiency which must be corrected to increase efficiency or to make the item completely serviceable.

LAST NAME INITIAL IN BLACK, BLUE-BLACK INK, OR PENCIL - Indicates that a completely satisfactory condition exists.

FOR AIRCRAFT - Status symbols will be recorded in red.

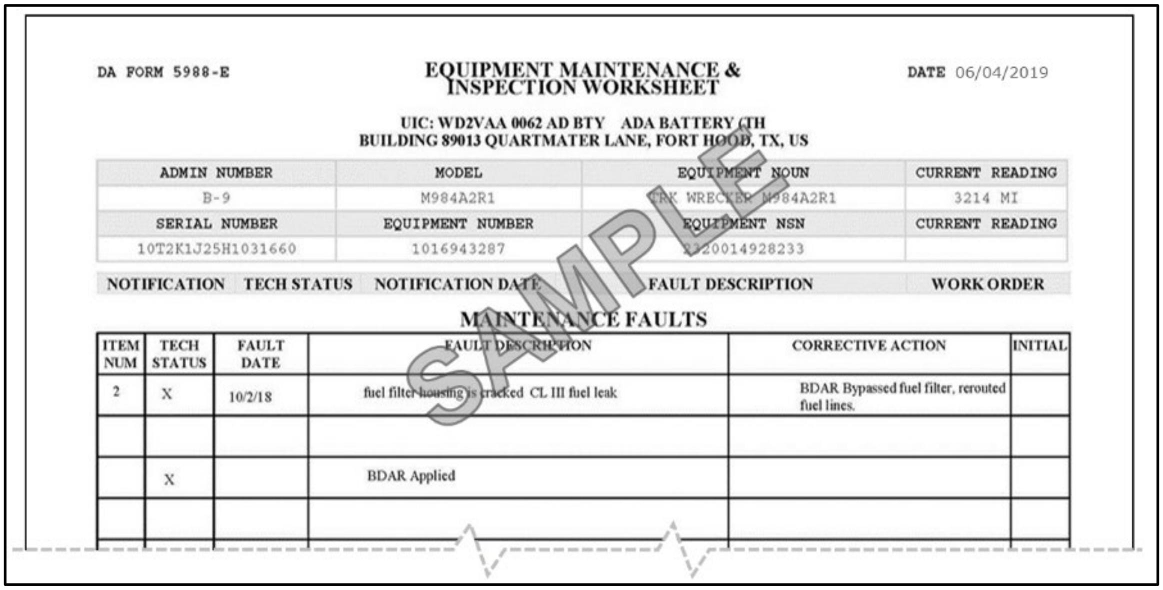
ALL INSPECTIONS AND EQUIPMENT CONDITIONS RECORDED ON THIS FORM HAVE BEEN DETERMINED IN ACCORDANCE WITH DIAGNOSTIC PROCEDURES AND STANDARDS IN THE TM CITED HEREON.

8a. SIGNATURE (Person(s) performing inspection)	8b. TIME	9a. SIGNATURE (Maintenance Supervisor)	9b. TIME	10. MANHOURS REQUIRED
Michael Anderson, SPC	1435hrs			

TM ITEM NO. a	STATUS b	DEFICIENCIES AND SHORTCOMINGS c	CORRECTIVE ACTION d	INITIAL WHEN CORRECTED e
9	X	Fuel Filter housing is cracked; CLIII fuel leak	BDRM Applied: Bypassed fuel filter by rerouting fuel lines. Parts ordered.	

SAMPLE

Figure 6-1. Example of a DA Form 2404



DA FORM 5988-E

EQUIPMENT MAINTENANCE & INSPECTION WORKSHEET

DATE 06/04/2019

UIC: WD2VAA 0062 AD BTY   ADA BATTERY (TH
BUILDING 89013 QUARTMATER LANE, FORT HOOD, TX, US

ADMIN NUMBER	MODEL	EQUIPMENT NOUN	CURRENT READING
B-9	M984A2R1	TRK WRECKER M984A2R1	3214 MI
SERIAL NUMBER	**EQUIPMENT NUMBER**	**EQUIPMENT NSN**	**CURRENT READING**
10T2K1J25H1031660	1016943287	2320014928233	

NOTIFICATION	TECH STATUS	NOTIFICATION DATE	FAULT DESCRIPTION	WORK ORDER

MAINTENANCE FAULTS

ITEM NUM	TECH STATUS	FAULT DATE	FAULT DESCRIPTION	CORRECTIVE ACTION	INITIAL
2	X	10/2/18	fuel filter housing is cracked CL III fuel leak	BDAR Bypassed fuel filter, rerouted fuel lines.	
	X		BDAR Applied		

SAMPLE

Figure 6-2. Example of computer generated DA Form 5988-E

Reporting Battle Damage Repairs

6-54. Recovery personnel must report all BDAR actions to the unit maintenance facility. When reporting a supervisor approved expedient repair or BDAR action, personnel list the details of the damage, the expedient repair or BDAR action taken and the success of the repair. All details should be annotated on DA Form 5988-E, and entered in Global Combat Support System – Army, also known as GCSS-Army. When recovery personnel perform expedient repair or BDAR actions on classified systems (or where aggregate Standard Army Management Information Systems, known as STAMIS, reporting is determined to be a classified risk) they should be reported as appropriate through SIPR transmission to recipients at the proper level. See AR 700-138 for additional guidance regarding equipment reporting. BDAR reporting documents provide valuable information which serve as examples that can be tested to prove principle and may be used to develop new reliable techniques for BDAR training and updating publications. Ensure all information provided is as accurate and detailed as possible.

SPECIAL OPERATING ENVIRONMENTS

6-55. Recovery personnel must train with other services on conducting recovery operations. They should also train in extreme weather conditions and different terrain.

BDAR in Multi Service Operations

6-56. Military units can expect to deploy as a component of a multi service task force. Maintenance personnel should work closely with other services to make collective use of tools and capabilities to perform BDAR. Despite differences in equipment and doctrine, the services have much in common. Navy Seabees, Air Force maintenance activities, and most Navy ships have machine shops and fabrication capabilities that will prove useful in supporting BDAR. The Army and Marine Corps should further develop existing multi-service agreements to use this capability between services. The military can develop the same cooperation with allied nations. Most armed forces in the North Atlantic Treaty Organization have a BDAR program under standardization agreement. Many of the allied tools, materials, and techniques are similar to those of the United States. In addition, some foreign countries use our equipment (especially vehicles) which provides a possible source for repair parts through controlled substitution or cannibalization. These actions require agreements and prior approval from allies or host nations. These agreements should identify which BDAR or other maintenance services are available and the procedures required for obtaining support.

BDAR IN EXTREME OPERATING ENVIRONMENTS

6-57. BDAR techniques may be more difficult in certain environments, such as extremely hot, dry or humid, and extremely cold or wet conditions. Rubber and plastic products become brittle in extremely cold environments and break easily. Fluids may gel and slow down the operation of systems. Fluids tend to expand in extremely hot environments resulting in low viscosity and overfull conditions. Metals also expand which can result in pressure losses in hydraulic and lubrication systems. During repairs for example, certain molecular compounds (polymers) may take longer to cure in a cold environment but may cure very rapidly in hot environments. These polymers may not be the best choice under these extreme conditions. GTA 01-14-001 provides instructions for best performance, limitations and application of these compounds.

BDAR AND EXPEDIENT REPAIR TRAINING

6-58. Commanders can incorporate training expedient and BDAR procedures into peacetime maintenance training in both field and training-base scenarios. Combat training centers and field training exercises provide excellent realistic training environments for BDAR. Approved battlefield damage repair BDAR kits will provide operators and maintainers the capability to accomplish damage repair or routine equipment failure repair on the battlefield. Maintainers will replace BDAR repairs with standard repairs at the first opportunity. In training settings, units may continue to operate equipment with BDAR based on the recommendation of qualified maintenance personnel, while awaiting parts. Maintainers will replace BDAR repairs with standard maintenance repairs at the first opportunity or deferred if appropriate.

6-59. Commanders ensure personnel train in various expedient and BDAR skills to prepare for wartime operations. Commanders should address both expedient and BDAR training in the logistics and maintenance section of their operation order. This will provide the crews and maintainers with a clear understanding of when and at what risk level the commander authorizes expedient repair and BDAR. Local command policy direct the degree of repair maintainers apply and when to use standard maintenance.

6-60. Maintenance assets will be heavily taxed on the battlefield. Because resources are often logistically limited (personnel, tools, and parts), it is imperative maintenance resources are not wasted. Operators/crew must perform expedient repairs within their capabilities immediately rather than requesting maintenance personnel to perform simple mechanical tasks. Soldiers will not find most expedient repairs in technical manuals. Training, flexibility and ingenuity are the keys to successful expedient repair and BDAR.

6-61. Personnel shortages and equipment readiness require maintenance team members have some knowledge of other skills needed to achieve critical repairs. A lack of key maintainers must not deter a team from doing repairs. Commanders should stress the importance of on-the-job training and cross training of personnel.

6-62. On the battlefield, the expedient repair and BDAR objective is to return the system to an operational condition with enough combat capability to get the mission accomplished. Cosmetic repairs on the battlefield are not necessary and are a poor use of time and resources. If a broken component does not affect the ability to shoot, move, or communicate, and does not pose a serious safety concern, maintainers can postpone maintenance. Maintainers will repair the equipment after operations are over and there is time to return the equipment for standard repair procedures.

6-63. Successes of expedient repair and BDAR actions depend entirely on the level of training individuals receive at the unit level. Individuals trained on multifunctional skills become valuable assets for the unit. Command emphasis on peacetime expedient repair and BDAR training is the key to success in wartime execution. Cross training and on the job training for operators/crew and maintenance personnel on expedient repair and BDAR techniques to support mission essential combat equipment is extremely important. Live-fire testing and evaluation has shown personnel without a maintenance background can learn effective expedient repair and BDAR skills with minimal training.

6-64. Unit commanders must develop sustainment training in which vehicle operators/crews and field maintenance mechanics conduct expedient repairs, BDAR and recovery training as outlined in AR 750-1 and ATP 4-33. Individual and collective training tasks identify the skills required to perform expedient repairs and BDAR.

6-65. AR 750-1 requires units conduct annual expedient repair and BDAR training. Commanders must incorporate expedient repair and BDAR training during annual unit training exercises. Operators and crew must be familiar with the concepts and techniques along with the components in the BDAR kit. This will enable many repairs which otherwise would not be possible. Each operator/crew member must also be familiar with the process for performing battle damage assessment on assigned equipment and reporting procedures.

BDAR AND EXPEDIENT REPAIR DEFINITIONS

6-66. **Short Cuts.** Shortcuts are inherent to BDAR. Shortcuts are when maintainers perform shortcuts as they remove, install and repair components out of the sequence or to a different standard outlined in a technical manual.

6-67. **Bypassing.** Bypassing consists of eliminating a device or component from the system in which it plays a role. For example, maintainers can bypass a damaged fuel filter allowing the fuel system to function in a degraded mode. In this situation, the fuel will not be filtered which could later lead to clogged fuel system components, but allow the weapon system to continue the immediate mission. Another example, is when an electrical switch is damaged it can be eliminated from the circuit by connecting the wires together to bypass the switch. In this case, the circuit will remain active and may deplete battery power when the vehicle is not in use. Before attempting to bypass any component an assessment of the repair must conducted to determine the risks associated with the procedure.

6-68. **Fabrication.** Fabrication involves using readily available materials and fashioning them by bending, cutting or welding them in the place of a damaged component. Examples include maintainers fabricating a radiator overflow reservoir to replace a damaged overflow tank using a suitable plastic container. A second example is maintainers welding metal stock or pipe to a broken suspension tie rod to affect a temporary repair.

6-69. **Substitution.** Maintainers can use parts serving a non-critical function on the vehicle to replace a critical component on the same equipment. These substitutions may require some modifications for the application to work and additional time to prepare.

6-70. **Controlled Exchange.** Maintainers may use battle damaged and inoperable equipment classified as economically reparable, with command authorization per AR 750-1, for controlled exchange when the needed part or component is not readily available through normal supply channels. Maintainers must report any part or component acquired through controlled exchange through the supply system to generate a parts demand. Regardless of the source used to acquire the repair parts, recorded Global Combat Support System – Army demands establish proper stockage demand levels in the supply system.

6-71. **Cannibalization.** Shortages of repair parts and spares to maintain equipment during wartime establishes the need for alternate parts sources. Maintainers code extensively damaged equipment that is not economically repairable as salvage. In spite of the damage, many serviceable parts and components are salvageable. Fully serviceable parts removed from cannibalized like items of equipment are considered repairs with alternative parts source and are regarded as standard repairs.

6-72. Cannibalizing destroyed equipment, whether friendly or captured, provides an alternate source of repair parts. AR 710-2, *Supply Policy below the National Level*, and ATP 4-33 outline the guidance for establishing and operating cannibalization points.

6-73. A serviceable part acquired through cannibalization from a salvage piece of equipment does not require an unserviceable part to replace the one removed. However, maintainers should record all repair parts needed to repair any piece of equipment to establish a parts demand through the supply system. This is applicable regardless of how the maintainer acquired the part. Documenting all repair part demands ensures the supply system will maintain needed items on hand. Replacing a serviceable part is not BDAR.

Appendix A
Multinational Recovery and BDAR Operations

Today's military missions increasingly call for multinational recovery and BDAR operations to be part of a multinational force. For BDAR managers and operators, there are many opportunities and requirements to recover multinational vehicles. This appendix provides guidance for coordinating and executing such operations.

COORDINATION CONSIDERATIONS CHECKLIST

A-1. When participating in an operation in which U.S. assets support multinational assets or vice versa, check the existing standardization agreement and SOP. Make contact with the affected multinational unit to exchange information. Although coordination at initial phases of a multilateral operation will start at the highest level, as the relationship matures, coordination or information exchanges should routinely occur at tactical unit levels. This should be encouraged until continuous information exchanged happens at the lowest level possible. The questions listed will become mission detractors if not clearly resolved before initiating BDAR missions. The following critical information should be exchanged, understood, and established during multinational operations:

- Clearly establish command and control. Does a U.S. element revert to multinational command and control for the duration of support to that multinational unit, or does the U.S. parent organization retain command and control?
- Identify who establishes priorities for BDAR assets in an area where more than one command exists.
- Determine who tows and where they tow recovered assets. Potential multinational supporting units need the location of U.S. MCPs. U.S. forces need the locations of other collection points established by the supported multinational unit.
- Identify the point of contact for questions and guidance. Multinational and U.S. forces both identify a point of contact.
- Establish the extent to which BDAR can be applied to multinational units.
- Identify specifics regarding the primary vehicles that each nation might recover for the other.
- Exchange technical information regarding towing, preferred hookup locations for winching or overturned vehicles, and any other information that would assist in avoiding unsafe or dangerous BDAR operations.
- Exchange information regarding special actions required to secure sensitive items, such as radios, maps, signal operating instructions, or high cost or scarce components.
- Determine what the multinational unit doctrine is concerning the use of the disabled crew on-site. Multinational doctrine may be different from U.S. doctrine, which requires crews to assist in BDAR operations, as well as provide local security.
- Ascertain which type of coordination will be required concerning the passage of lines, if required. Contact clearly established points of contact for such passages.
- Exchange operational plans and graphics to preclude inadvertent distracters to combat operations or placing U.S. assets in unnecessary danger.
- Clearly establish recognition signals. These signals include challenges and passwords, as well as identifying vehicle markings. Recognition markings are especially important in operations where multinational units and enemy forces use the same type of vehicle or in the case where the enemy may be using U.S. vehicles.
- Be aware of any special operational hazards, such as the use of minefields. As necessary and where possible, arrange for multinational guides or provide guides to U.S. supporting elements.

- If possible, provide multinational units with U.S. BDAR kits for effecting BDAR on U.S. vehicles.
- If time and situation permit, arrange for mutual training or orientation sessions with counterpart personnel.
- If translations are critical for ongoing BDAR operations, arrange to have translators available. A better arrangement would be to have a technical advisor available from the nation owning the equipment

EXECUTION CONSIDERATIONS CHECKLIST

A-2. The primary consideration is returning equipment to battle as quickly as possible while creating as little collateral damage as possible. Equally important is surviving to complete the mission. The following considerations involve approaching the site, local security, camouflage, and actions taken on contact:

- Obtain authorization and any necessary guidance before beginning recovery or BDAR operations on multinational vehicles.
- Attempt to locate a member of the crew or a technical representative to provide technical guidance.
- Before starting BDAR operations, obtain applicable manuals to determine proper BDAR actions. Even where language is a problem, pictures and diagrams may prove useful.
- Obtain technical information before beginning any operation. Acting too quickly or prematurely might cause damage.
- Report completion of the mission to the U.S. chain of command. The U.S. chain of command will pass that information to the command and control at the liaison officer level.

SECURITY OF SENSITIVE ITEMS AND SALVAGE OF DAMAGED EQUIPMENT

A-3. Only divisional or higher commanders have the authority to order the destruction of equipment. Divisional or higher commanders delegate this authority to subordinate commanders in operations orders. When recovery personnel destroy a piece of equipment, they must report it through proper command channels.

SAFETY CONSIDERATIONS

A-4. Hazards that exist on the battlefield will also be present during the demolition of equipment (for example, toxic fumes and spilled fluids). Safety is an important consideration. BDAR personnel must become completely familiar with all safety aspects of the equipment involved. Applicable equipment technical manuals provide necessary warnings, cautions, and hazards. Remove all classified documents, notes, and instructions from the vehicle before demolition. BDAR must render all remaining classified materials useless to the enemy.

Appendix B
Hand and Arm Signals

Visual signals are any means of communication that require sight used to transmit prearranged messages rapidly over short distances. This includes the devices and means used for recovery operations. Reference TC 3-21-60, *Visual Signals*.

VOICE CONTROL

B-1. Ground guides controlling all tracked vehicle recovery operations will use electronic voice means whenever available, supplemented by minimal hand and arm signals as the primary means of ground control during recovery and lift operations. Ground guides must also be familiar with recovery operations during hours of darkness—using a flashlight to augment hand and arm signals. Until a wireless system is developed, units will use clear voice capture cables to link the ground guide with the vehicle operator via the vehicle intercom system for operations within 30 feet of the recovery vehicle.

B-2. An alternative means, especially for operations in excess of 30 feet of the recovery vehicle, is to connect a digital non-secure voice telephone (using an optional headset for hands-free operation) to the control box via wire. Military personnel will use hand and arm signals if they are unable to establish voice communication.

B-3. Restrictions for using hand and arm signals are as follows:

- Units must acquire extended clear voice capture cables and/or other items needed in BDAR operations.
- Units are responsible for conducting familiarization training. During operations extended cable or field telephone wire can be cut or snag on obstacles. The ground guides must keep the cable or wire away from obstacles while moving. If movement of the components is required, disconnect the wire or cable and reconnected after the ground guides are in the new position.
- Leaders inform crew and ground guides if voice cannot be established or fails at any point they will utilize hand and arms signals.
- The clear voice capture cable assembly can be connected to any intercommunication control box in a vehicle, except for the driver's box.
- When using either clear voice capture cable or field telephone wire with winching operations, the length must be such that the ground guide can be located safely and sufficiently outside any hazard area as required.
- Voice communications between the operator and the ground guide will make for safer operations by removing the doubt associated with hand and arm signals. These communications are particularly safer and more effective for limited visibility and night operations. They also remove doubt as to who is controlling the operator.

HAND AND ARM SIGNALS

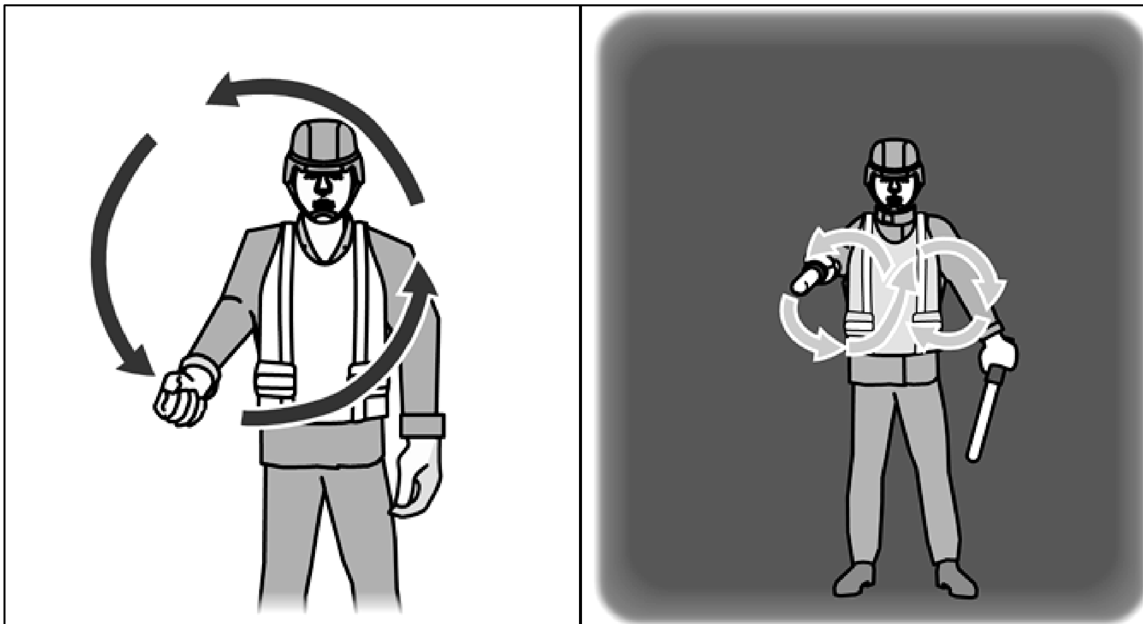
B-4. The most common types of visual signals are hand and arm (ground and crane), flag, pyrotechnic, and ground-to-air signals. TC 3-21.60 outlines some hand and arm signals. Soldiers are not limited to the types of signals discussed and may use whatever means available. Soldiers can use chemical light sticks, flashlights, and other items, provided all Soldiers and units working in the area understand their use. Figure B-1 on page B-2 to Figure B-42 on page B-23 depict common hand and arm signals useful for recovery operations.

Ground Guide Hand and Arm Signals

B-5. Military personnel use these signals to ground guide wheeled and tracked vehicles day or night.

	
ATTENTION: Raise and extend the arm overhead. Move it to the right and left. *(Do not make a circular motion; that is a different signal.)*	ATTENTION (Night): Raise and extend the arm overhead with the wand pointed up. Move it to the right and left. *(Do not make a circular motion.)*

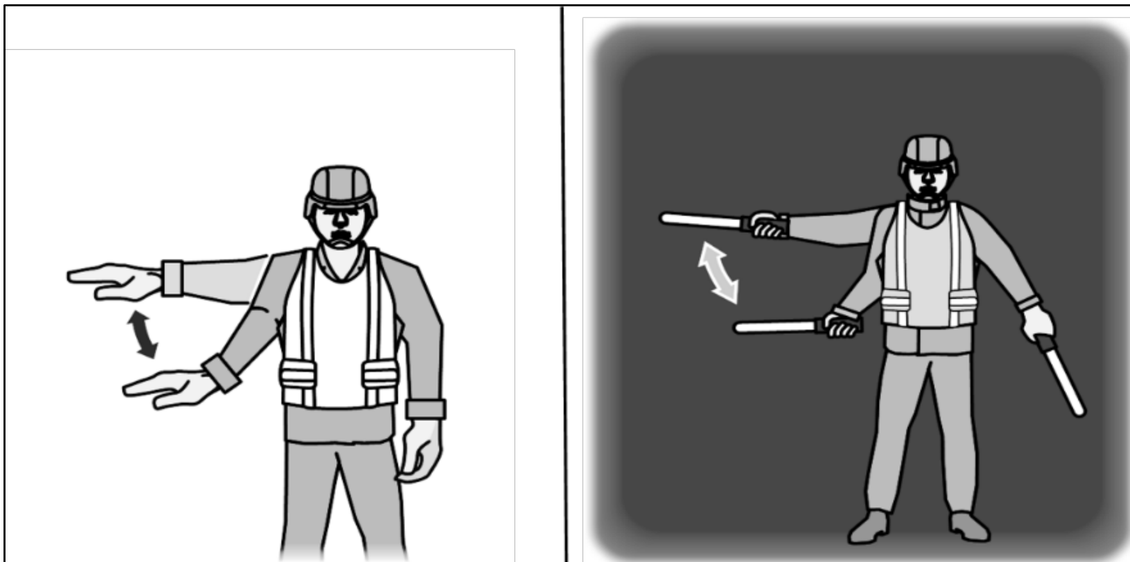
Figure B-1. Signal for attention



START ENGINES: Move the arm with fist in a large circular motion, simulating the motion of crank starting an engine.

START ENGINES (Night): Move the light in a horizontal figure 8, at waist level.

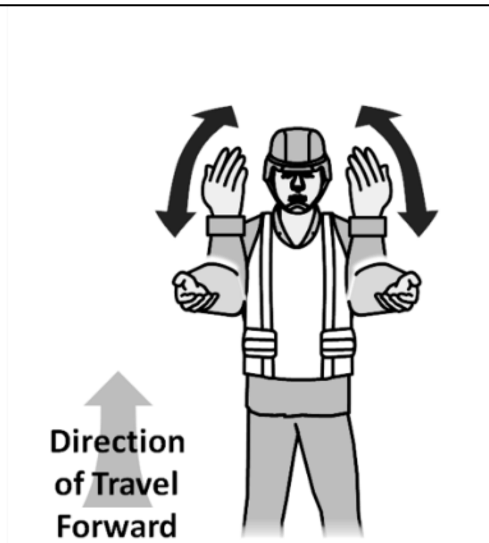
Figure B-2. Signal for start engine



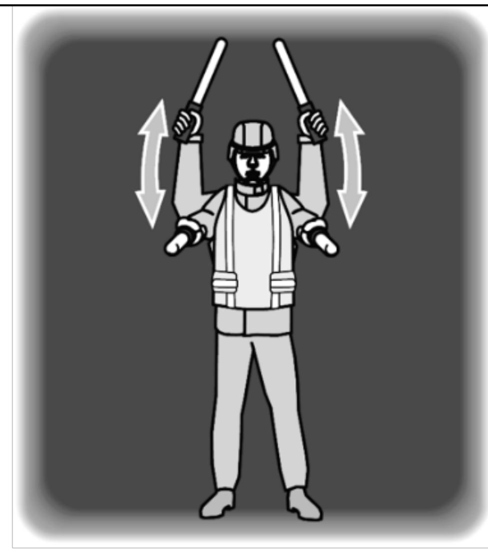
DECREASE SPEED, SLOW DOWN (Day): Extend the arm horizontally sideward, palm facing down, and wave arm downward several times, keeping the arm straight. (The arm is not moved above the horizontal plane.)

DECREASE SPEED, SLOW DOWN (Night): Face the vehicle, and hold the right wand out to the side, horizontal at shoulder level. Swing the wand to waist level, holding it horizontal. Repeat the swinging motion until the vehicle has slowed to the appropriate speed.

Figure B-3. Signal for decrease speed and slow down

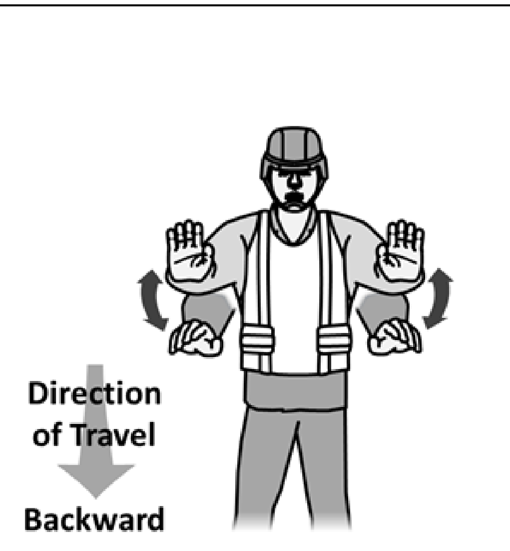


MOVE FORWARD (Day): With both hands, palm up, holding the arm horizontally to the front, point toward vehicle operator. Then beckon by repeatedly motioning upward, moving the hands to the side of the head.

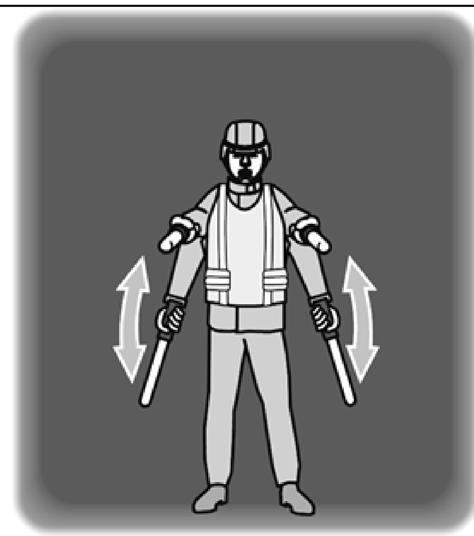


MOVE FORWARD (Night): Hold both wands in front of the body at shoulder level with tips pointed at the vehicle. Then beckon by repeatedly motioning upward, moving the wands to just above the side of the head.

Figure B-4. Signal for move forward

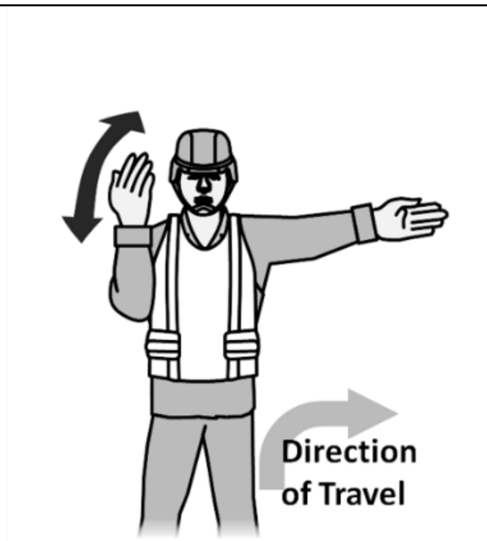


MOVE BACKWARD (Day): Raise the hands to chest level with elbows bent, the thumbs in and palms down. Repeatedly sweep the hands forward and down, in a pushing away motion.



MOVE BACKWARD (Night): Raise the wands repeatedly form sides to chest level. Swing the wands in a slight forward and back pushing motion.

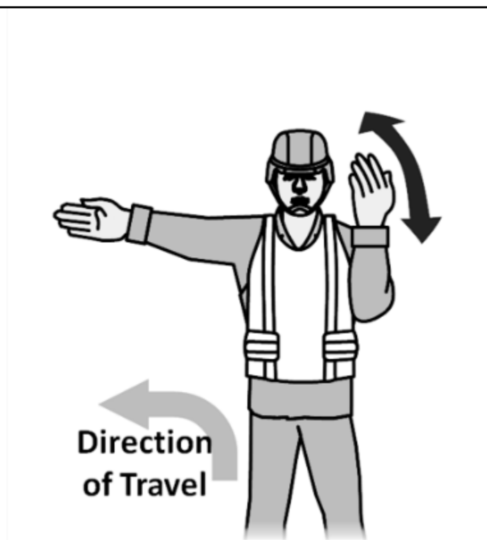
Figure B-5. Signal for move backward



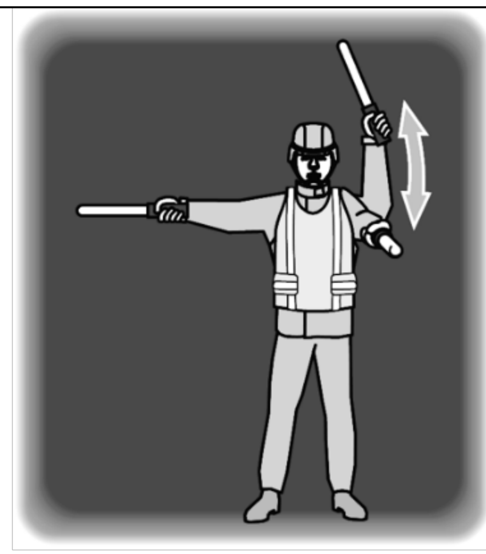
<u>TURN RIGHT (Day)</u>: Extend the arm closest to the direction of travel horizontally, palm towards traffic to the indicated which way to turn. With the other hand, make the Come Forward signal.

<u>TURN RIGHT(Night)</u>: Extend the arm closest to the direction of travel horizontally, with the wand pointed to indicate which way to turn. With the other wand, make the Come Forward signal.

Figure B-6. Signal for turn right

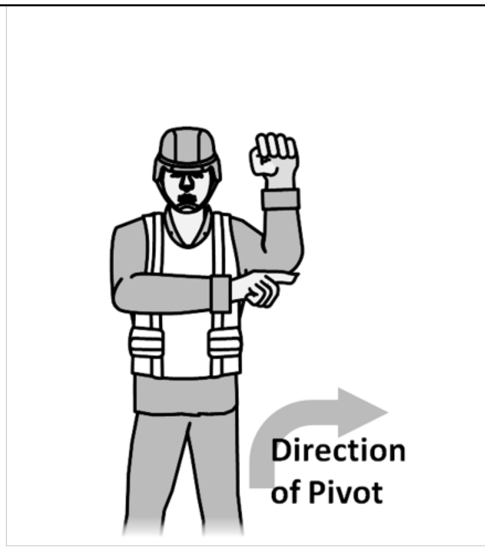


<u>TURN LEFT:</u> Extend the arm closest to the direction of travel horizontally, palm towards traffic to the indicated which way to turn. With the other hand, make the Come Forward signal.

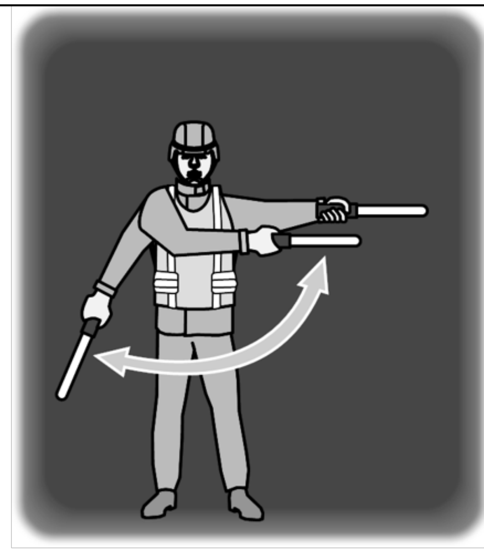


<u>TURN LEFT(Night):</u> Extend the arm closest to the direction of travel horizontally, with the wand pointed to indicate which way to turn. With the other wand, make the Come Forward signal.

Figure B-7. Signal for turn left

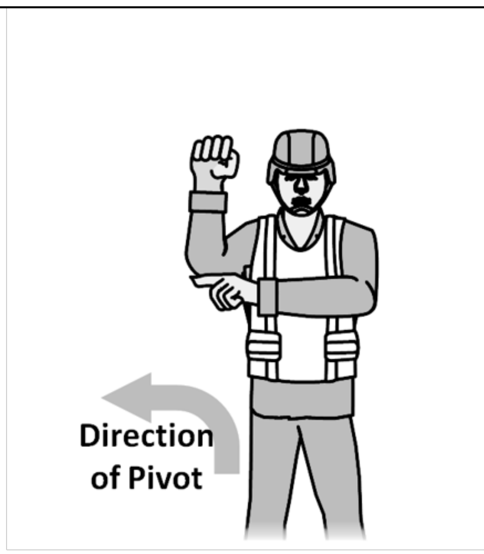


<u>PIVOT RIGHT, Track Vehicles:</u> Clench the left fist at head level, and point the index finger of the right hand in the direction of steer. *(Operator stops right track while the left track moves forward into the turn.)*

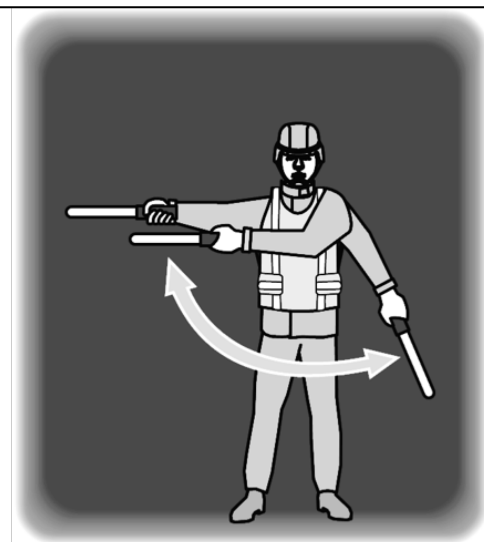


<u>PIVOT RIGHT, Track Vehicles (Night):</u> Extend the arm closest to the direction of travel horizontally, with the wand pointed to indicate which way to turn. With the other wand, make a repeated swing from the side of the leg to just under the extended wand.

Figure B-8. Signal for pivot right

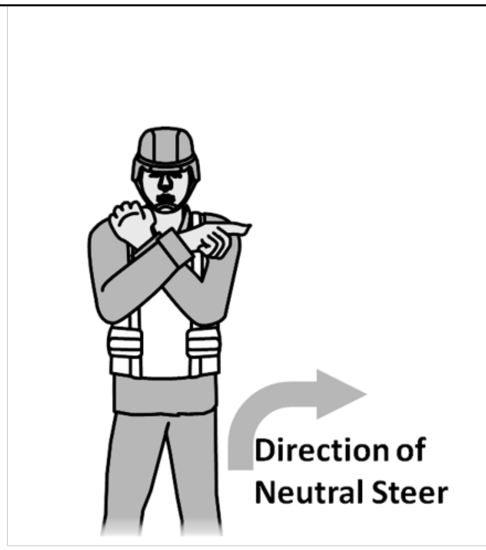


<u>PIVOT LEFT, Track Vehicles:</u> Clench the right fist at head level, and point the index finger of the left hand in the direction of steer. *(Operator stops left track while the right track moves forward into the turn.)*



<u>PIVOT LEFT, Track Vehicles (Night):</u> Extend the arm closest to the direction of travel horizontally, with the wand pointed to indicate which way to turn. With the other wand, make a repeated swing from the side of the leg to just under the extended wand.

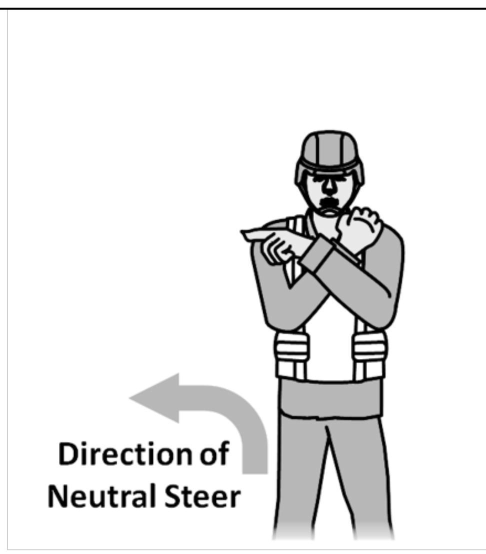
Figure B-9. Signal for pivot left



NEUTRAL STEER RIGHT, Track Vehicles: Cross the left wrists beside the neck with clenched fist. Point the index finger of the right hand toward the left.
(Operator moves the right track in reverse, while moving forward with the left track.)

NEUTRAL STEER RIGHT, Track Vehicles (Night): Place the left wand against the right side of the neck. Extend the right arm horizontally toward the direction of travel, with the wand pointed to indicate which way to turn.

Figure B-10. Signal for neutral steer right



NEUTRAL STEER LEFT, Track Vehicles: Cross the right wrists beside the neck with clenched fist. Point the index finger of the left hand toward the right.
(Operator moves the left track in reverse, while moving forward with the right track.)

NEUTRAL STEER LEFT, Track Vehicles (Night): Place the right wand against the left side of the neck. Extend the left arm horizontally toward the direction of travel, with the wand pointed to indicate which way to turn.

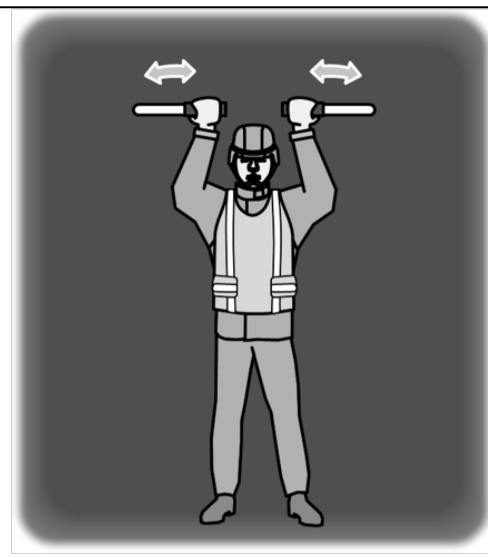
Figure B-11. Signal for neutral steer left

BUTTON-UP: Place both hands on top of the helmet, palms down, one on top of the other. Have the arms and elbows back on the same plane as the body.

BUTTON-UP (Night): Place both wands on top of the helmet, one on top of the other. Have the arms and elbows back on the same plane as the body.

Figure B-12. Signal for button-up

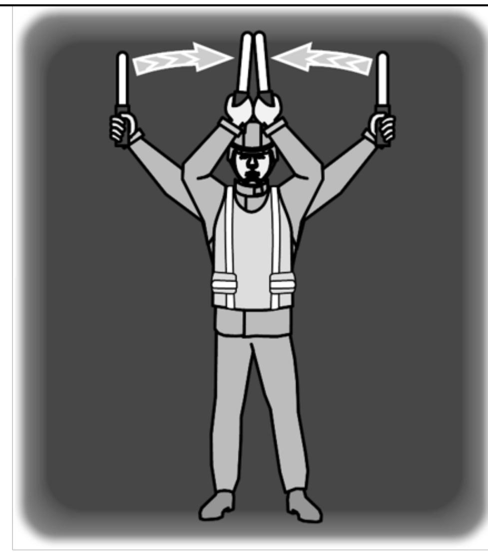
UNBUTTON: Start from the button-up signal; then separate the hands, moving them slightly back and forth in a slicing motion. Have the arms and elbows back on the same plane as the body. Repeat as needed to ensure having the driver's attention.



UNBUTTON (Night): Start from the button-up signal; then swing the wands outwards, moving them slightly back and forth in a slicing motion. Repeat as needed to ensure having the driver's attention.

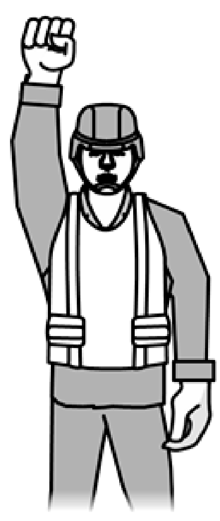
Figure B-13. Signal for unbutton

CLOSE THE DISTANCE & STOP: This Far To Go - Extend the forearms to the front, palms inward and separated (to about 3 or 4 feet of width). Bring palms together as the crane approaches the target stop point. The crane stops when palms come together.



CLOSE THE DISTANCE & STOP (Night): This Far To Go - Extend the wands over head, tips pointed upward and separated (to about 3 or 4 feet of width). Bring wands together as the crane approaches the stop point. The crane stops when wands touch, or flip to Stop signal.

Figure B-14. Signal for close the distance and stop



EMERGENCY STOP: Raise either arm with clenched fist. The other hand may point to the cause for the emergency. *(Only for use when the guide sees a safety issue or threat to the operation.)*

EMERGENCY STOP (Night): Raise either arm with wand held horizontally. The other hand may briefly point to the cause for the emergency. *(Only for use when the guide sees a safety issue or threat to the operation.)*

Figure B-15. Signal for emergency stop

STOP: Clasp hands together palm to palm just below the chin.

STOP (Night): Cross wands over the head.

Figure B-16. Signal for stop

STOP ENGINES: Extend an arm horizontal under the chin, hand open, palm down, and move the arm across the body in a throat-cutting action.

STOP ENGINES (Night): Hold a wand horizontal under the chin, and move the arm across the body in a throat-cutting action.

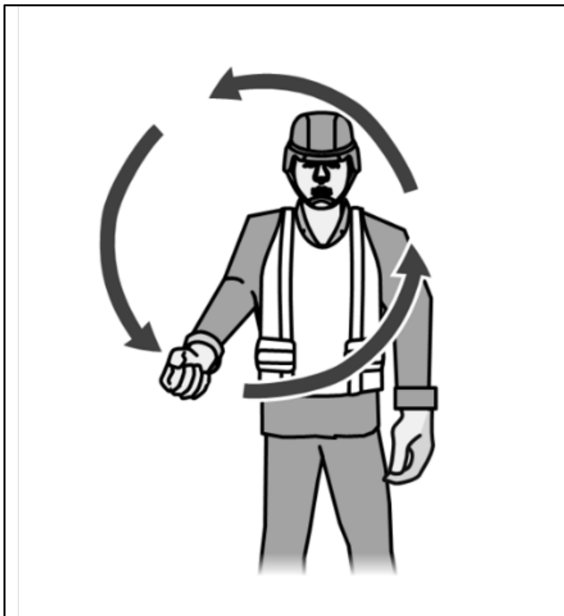
Figure B-17. Signal for stop engine

Mobile Crane Operation Guide Hand and Arm Signals

B-6. Military personnel may use these signals during crane operations day and night.

	
ATTENTION: Raise and extend the arm overhead. Move it to the right and left. *(Do not make a circular motion; that is a different signal.)*	ATTENTION (Night): Raise and extend the arm overhead with the wand pointed up. Move it to the right and left. *(Do not make a circular motion.)*

Figure B-18. Signal for attention

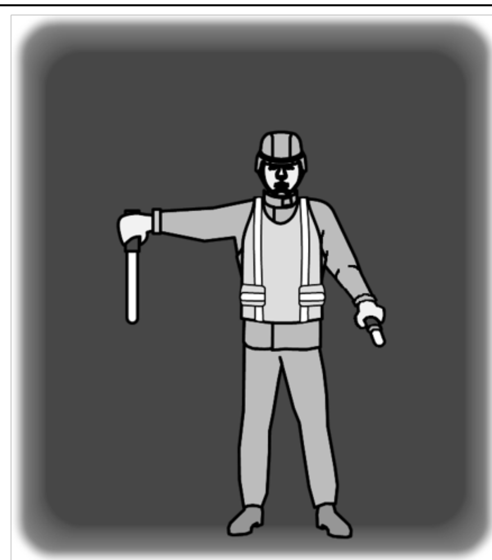


START ENGINES: Move the arm with fist in a large circular motion, simulating the motion of crank starting an engine.

START ENGINES (Night): Move the light in a horizontal figure 8, at waist level.

Figure B-19. Signal for start engine

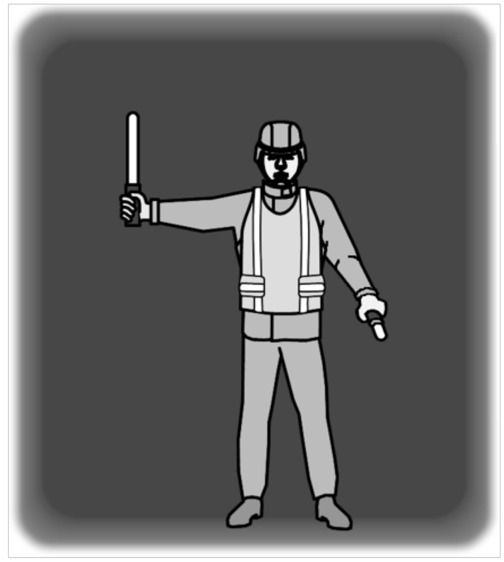
LOWER SPADE/OUTRIGGERS: First, point at the spade with the index finger of the left hand. Then, extend the right arm to the side, clenching a fist, and point the thumb downward.



LOWER SPADE/OUTRIGGERS (Night): First, point at the spade with the wand of the left hand. Then, extend the right arm to the side, and point the right wand downward.

Figure B-20. Signal for lower spade/outriggers

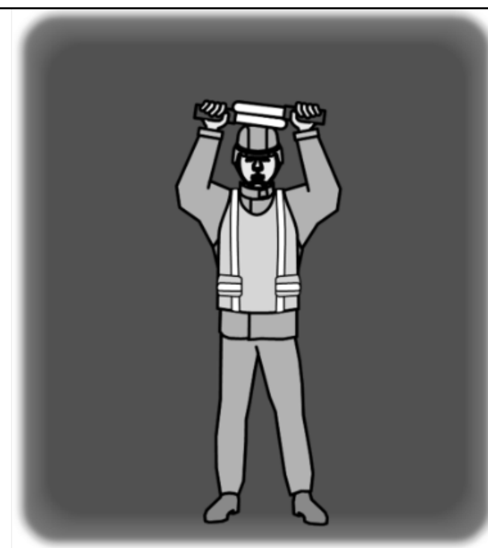
<u>RAISE SPADE/OUTRIGGERS</u>: First, point at the spade with the index finger of the left hand. Then, extend the right arm with the arm slightly bent upward at the elbow while clenching a fist, and point the thumb upward.



<u>RAISE SPADE/OUTRIGGERS (Night)</u>: First point at the spade with the wand of the left hand. Then, extend the right arm to the side, and point the right wand upward.

Figure B-21. Signal for raise spade/outriggers

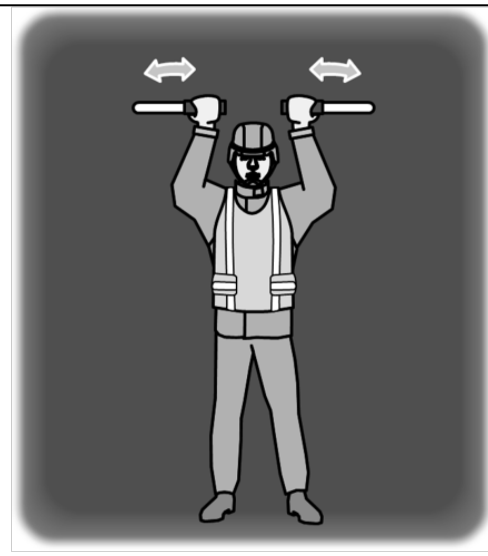
<u>BUTTON-UP:</u> Place both hands on top of the helmet, palms down, one on top of the other. Have the arms and elbows back on the same plane as the body.



<u>BUTTON-UP (Night):</u> Place both wands on top of the helmet, one on top of the other. Have the arms and elbows back on the same plane as the body.

Figure B-22. Signal for button-up

UNBUTTON: Start from the button-up signal; then separate the hands, moving them slightly back and forth in a slicing motion. Have the arms and elbows back on the same plane as the body. Repeat as needed to ensure having the driver's attention.



UNBUTTON (Night): Start from the button-up signal; then swing the wands outwards, moving them slightly back and forth in a slicing motion. Repeat as needed to ensure having the driver's attention.

Figure B-23. Signal for unbutton

PAYOUT THE WINCH CABLE: With the arm bent, bring the hand in front of the chest. Move the hand down and away from the body at belt level, circling back to the chest. The circular motion is continued until the stop signal is given.

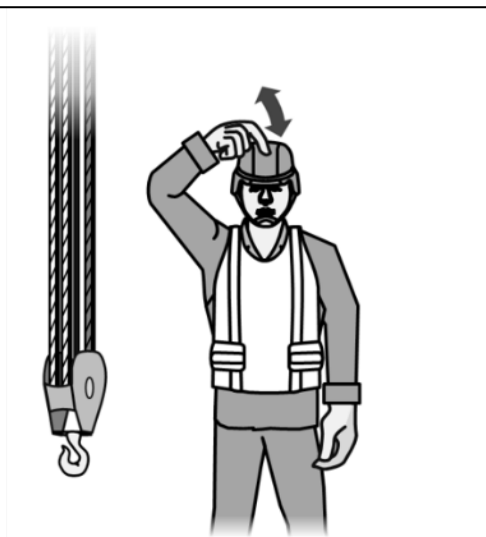
PAYOUT THE WINCH CABLE (Night): With the arm bent, bring the wand in front of the chest. Move the wand down and away from the body at belt level, circling back to the chest. The circular motion is continued until the stop signal is given.

Figure B-24. Signal for payout the winch cable

INHAUL THE MAIN WINCH CABLE: Point at the operator with the index finger and rotate the arm in circular motion.

INHAUL THE MAIN WINCH CABLE (Night): Point at the operator with the wand, and rotate the arm in circular motion.

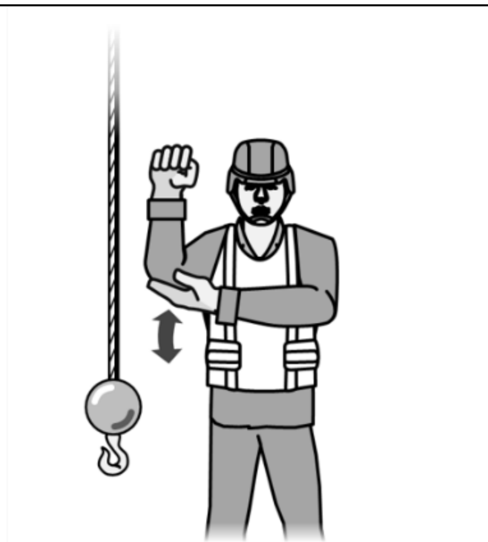
Figure B-25. Signal for inhaul the main winch cable



USE MAIN LINE: Tap the top of the helmet with the forefinger, three or four times.

USE MAIN LINE (Night): Tap the top of the helmet with the tip of the wand, three or four times.

Figure B-26. Signal for use the main line



USE WHIP LINE: Tap the elbow of the raised forearm, three or four times.

USE WHIP LINE (Night): Tap the elbow of the raised forearm, three or four times with the wand.

Figure B-27. Signal for use the whip line

RETRACT THE BOOM: Extended the index and center fingers upward, with the back of the hand facing the operator. Move the hand in toward and a way from the chest, bending the elbow slowly in a pumping action.

RETRACT THE BOOM (Night): Hold the wand against the chest, with the lighted end touching the chest. Move the wand away from the chest and back again, bending at the elbow slowly in a pumping action.

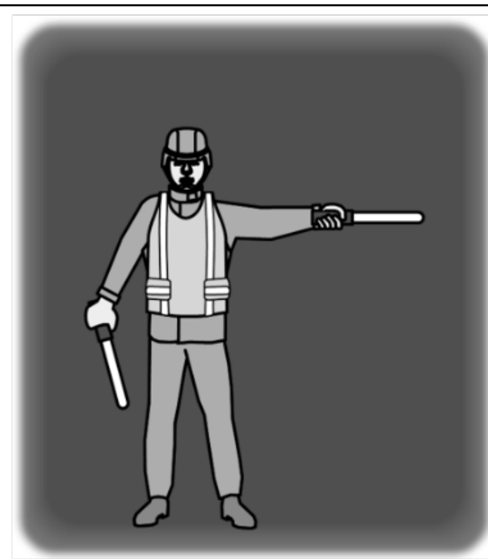
Figure B-28. Signal for retract the boom

EXTEND THE BOOM: Extend the index and center finger upward, with the palm of the hand facing the operator. Move the hand away from the chest and back again, bending at the elbow slowly in a pumping action.

EXTEND THE BOOM (Night): Hold the wand against the chest, with the lighted end pointing outward. Move the wand away from the chest and back again, bending at the elbow slowly in a pumping action.

Figure B-29. Signal for extend the boom

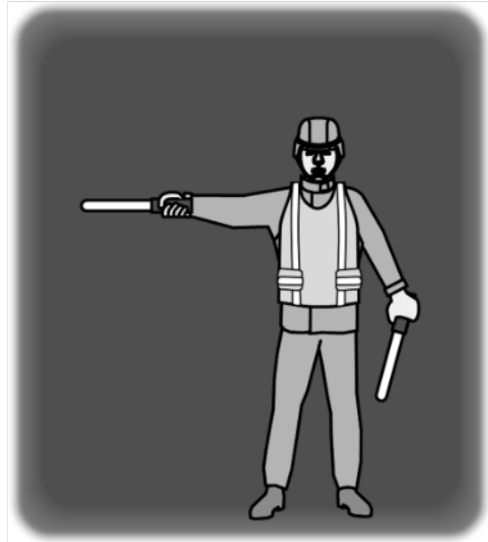
SWING BOOM, RIGHT: Extend the left arm to shoulder level, with the whole hand pointing in the direction that the operator must traverse.



SWING BOOM, RIGHT (Night): Extend the left arm to shoulder level, holding the wand horizontal in the direction that the operator must traverse.

Figure B-30. Signal for swing the boom to the right

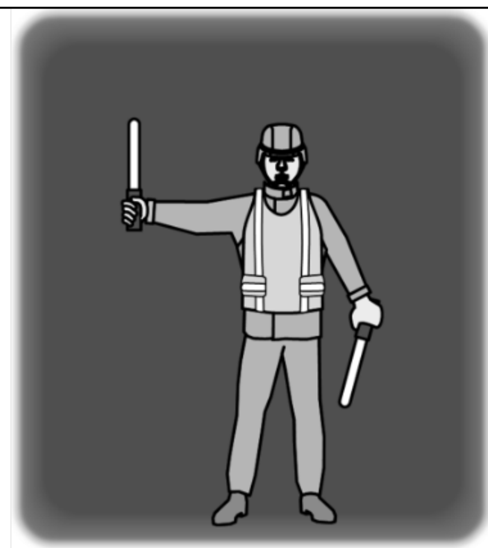
SWING BOOM, LEFT: Extend the right arm to shoulder level, with the whole hand pointing in the direction that the operator must traverse.



SWING BOOM, LEFT (Night): Extend the left arm to shoulder level, holding the wand horizontal in the direction that the operator must traverse.

Figure B-31. Signal for swing the boom to the left

RAISE THE BOOM: Extend an arm to the side, with the fist clenched, and point the thumb upward. This signal may be made with either hand.



RAISE THE BOOM (Night): Extend an arm to the side, with wand pointed upward. This signal may be made with either hand.

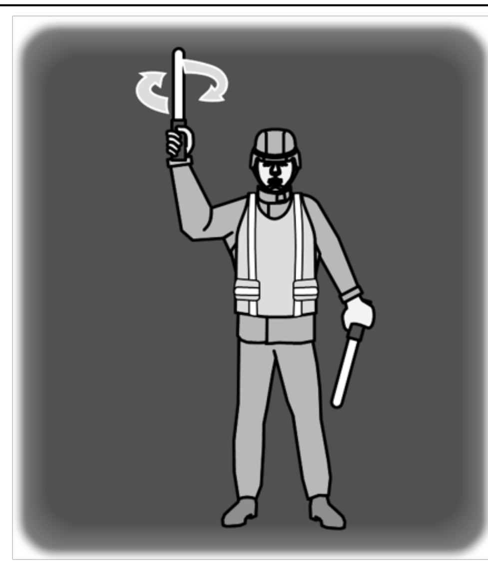
Figure B-32. Signal for raise the boom

LOWER THE BOOM: Extend the arm to the side, with the fist clenched, and thumb pointed downward. This signal may be made with either hand.

LOWER THE BOOM (Night): Extend an arm to the side, with wand pointed downward. This signal may be made with either hand.

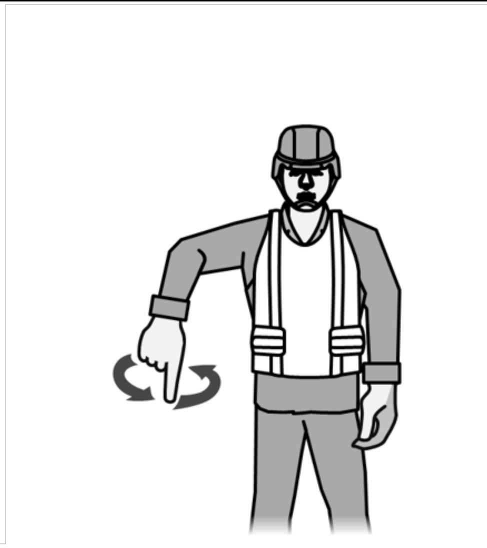
Figure B-33. Signal for lower the boom

RAISE THE HOIST CABLE: Hold out the arm to the side, bent upward at the elbow, and extend the index finger from a fist. Rotate the hand slowly. This signal may be made with either hand with rotation made in either direction.



RAISE THE HOIST CABLE (Night): Hold out the arm to the side, bent upward at the elbow, and point the wand upward. Rotate the hand slowly. This signal may be made with either hand with rotation made in either direction.

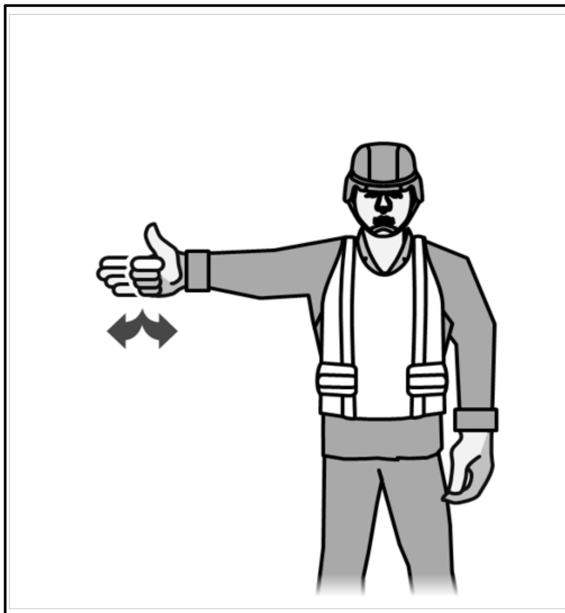
Figure B-34. Signal for raise the hoist cable



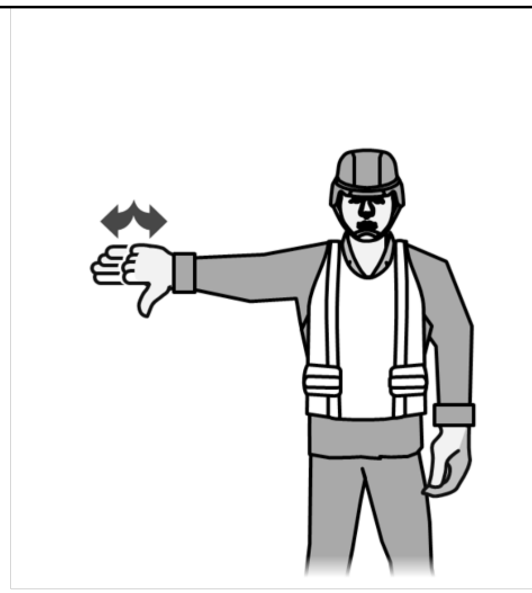
LOWER THE HOIST CABLE: Hold the arm downward and out slightly from the side, extend the index finger from a fist, and rotate the hand slightly. This signal may be made with either hand with rotation made in either direction.

LOWER THE HOIST CABLE (Night): Hold the arm downward and out slightly from the side, with the wand pointed down, and rotate the wand slightly. This signal may be made with either hand with rotation made in either direction.

Figure B-35. Signal for lower the hoist cable

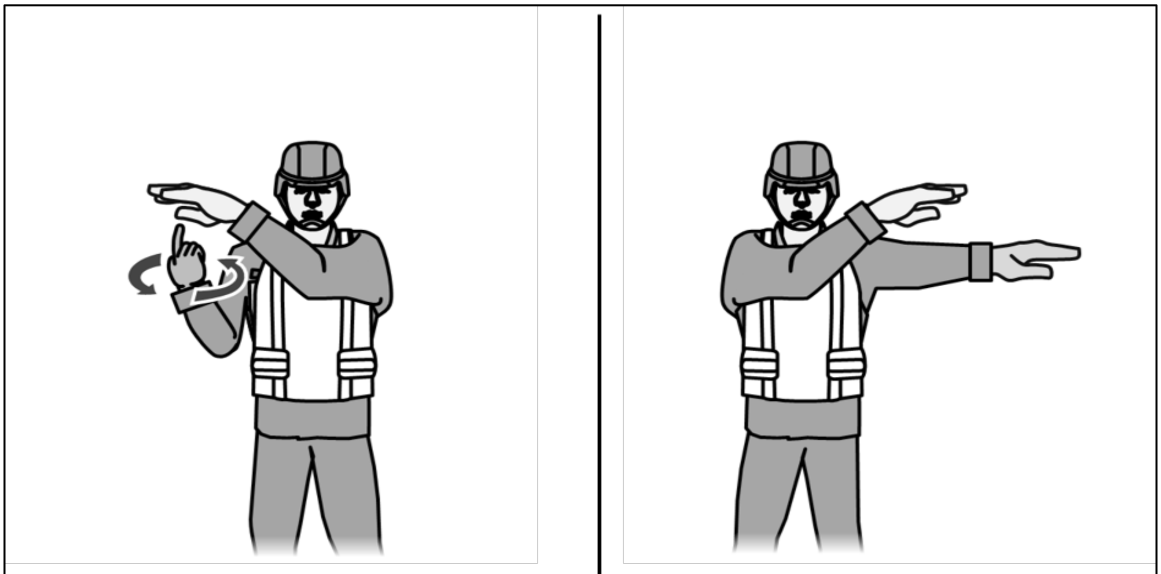


RAISE BOOM & LOWER THE LOAD: Extend arm, thumb pointed up, flex fingers in and out as long as load movement is desired. *(This moves the load horizontally toward the crane.)*



LOWER BOOM & RAISE THE LOAD: Extend arm, thumb pointed down, flex fingers in and out as long as load movement is desired . *(This moves the load horizontally away from the crane.)*

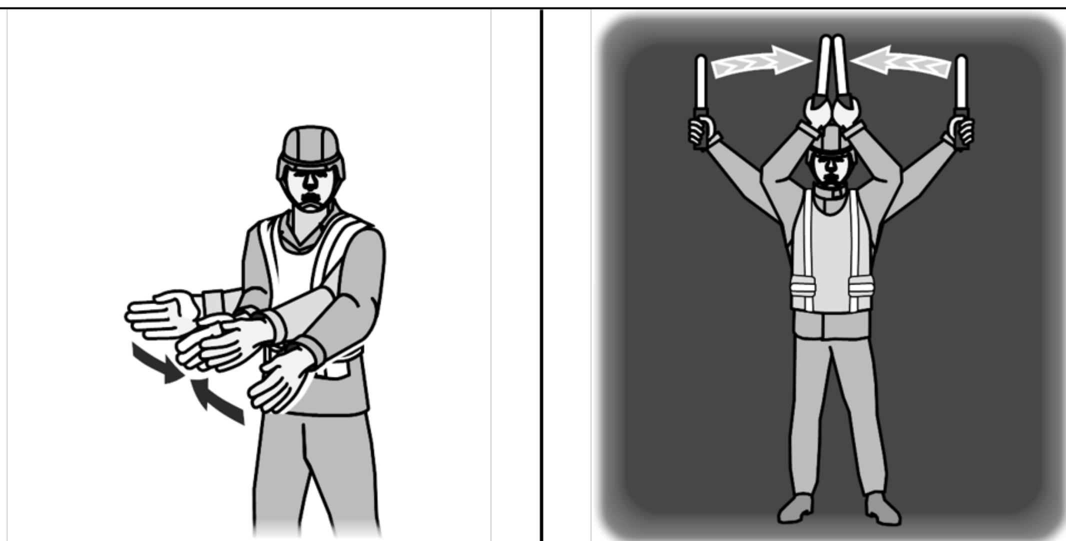
Figure B-36. Signal for raise boom, lower load & lower boom, raise load



MOVE SLOWLY: Use one hand to give any motion signal, and hold the other hand motionless palm down just above the signaling hand (e.g., Hoist UP - Slowly, and Swing Boom Right - Slowly).

(There is no night time conjoined signal for movement and move slowly.)

Figure B-37. Signal for move slowly



CLOSE THE DISTANCE & STOP: This Far To Go - Extend the forearms to the front, palms inward and separated (to about 3 or 4 feet of width). Bring palms together as the crane approaches the target stop point. The crane stops when palms come together.

CLOSE THE DISTANCE & STOP (Night): This Far To Go - Extend the wands over head, tips pointed upward and separated (to about 3 or 4 feet of width). Bring wands together as the crane approaches the stop point. The crane stops when wands touch, or flip to Stop signal.

Figure B-38. Signal for close the distance and stop

EMERGENCY STOP: Raise either arm with clenched fist. The other hand may point to the cause for the emergency. *(Only for use when the guide sees a safety issue or threat to the operation.)*

EMERGENCY STOP (Night): Raise either arm with wand held horizontally. Place the other hand with wand held diagonally across the chest. The other hand may briefly point to the cause for the emergency, but must repeatedly return to the chest.

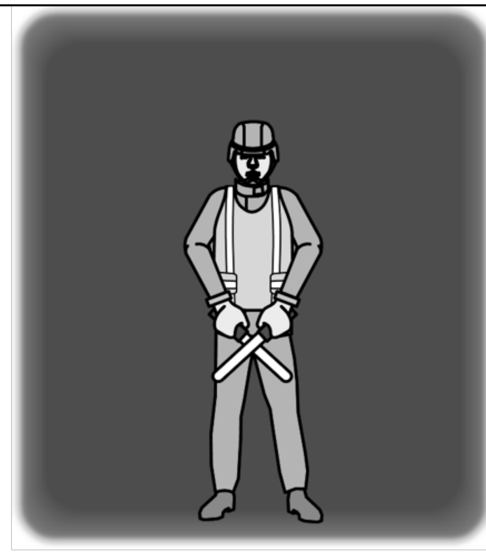
Figure B-39. Signal for emergency stop

STOP: Clasp hands together palm to palm just below the chin.

STOP (Night): Cross wands over the head.

Figure B-40. Signal for stop

DOG EVERYTHING: Clasp hands in front of the lower body. (Stop, shift to park, set breaks, and lock all other systems to prevent further movement. Turning off the engine or power is a separate signal.)



DOG EVERYTHING (Night): Cross wands in front of the lower body. (Stop, shift to park, set breaks, and lock all other systems to prevent further movement. Turning off the engine or power is a separate signal.)

Figure B-41. Signal for dog everything

STOP ENGINES: Extend an arm horizontal under the chin, hand open, palm down, and move the arm across the body in a throat-cutting action.

STOP ENGINES (Night): Hold a wand horizontal under the chin, and move the arm across the body in a throat-cutting action.

Figure B-42. Signal for stop engine

Note. Refer to TC 21-60 for more information on hand and arm signals and using flashlights during night operations.

Appendix C

Recovery Guidelines for Operators/Leaders

Mission success on the battlefield may be linked to a unit's ability to perform vehicle recovery, to return immobilized equipment to operation, and to continue with the mission. Commanders must take aggressive actions to retrieve damaged equipment and return it to use. Successful recovery operations require trained operators and leaders at all levels.

OPERATOR AND CREW

C-1. When the operator/crew detect disabled equipment, they assess the damage and initiate actions based on the results of their analysis and the tactical situation. The crew/operator informs the chain of command of the status of the disabled equipment. Unit standard operating procedures should prescribe notification based on the type of unit, equipment, communications, and location of equipment.

C-2. The operator/crew perform electrical soldering, self-recover, and like-recover on assigned equipment. They practice these skills during garrison and field training exercises as prescribed in the unit's SOP.

C-3. The operator/crew normally remains with the disabled equipment to provide local security and until assistance arrives. When the maintenance personnel arrive, the operator/crew assists with the repair or recovery and stays with the vehicle until it repaired or coded for sustainment maintenance.

C-4. The following is a list of key items the operator/crew should know before requesting recovery from support elements:

- Location, map coordinates, and type of terrain.
- Nature of the disability.
- Tactical situation.
- Can BDAR be applied?
- Has BDAR been applied?
- Repair parts required, if known.
- Alternate radio frequency.

RECOVERY PERSONNEL

C-5. Recovery equipment operators are usually highly trained mechanics and very familiar with the mechanical functions of equipment they must recover. These personnel must be skilled in the technical aspects of recovery, such as equipment rigging, towing, and righting procedures. They must also be skilled in related tasks — such as using the specialized BII on assigned equipment and operating in a tactical environment. Commanders assign recovery equipment operators to company maintenance teams and to the recovery support section of the maintenance platoon. Leaders train personnel participating in recovery operations to check for and clear or disarm weapon systems of supported equipment. The unit SOP should specify procedures for the disposition of contaminated equipment, contingency plans, and any special tactical or security.

C-6. Recovery personnel are mechanics who perform repairs when not engaged in recovery missions. The following is a list of key items recovery personnel must know:

- Oxygen and acetylene tank operations for welding.
- Cutting torches.
- .50-caliber machine guns.
- Communications (both radio, and hand and arm signals).

- Map reading, compass use, and correct global positioning system use.
- Chemical and biological agents.

C-7. Those conducting repair or recovery need to have a plan for recovery operations. The unit SOP will contain detailed checklists to assist in preparing for on-site support. Preparations should include—

- A verification of location and the status of disabled equipment.
- An update on the current tactical situation.
- A selection of primary and alternate routes.
- The availability of communications, to include communications checks, applicable call signs, and primary and alternate frequencies.
- Individual clothing and equipment, with emphasis on CBRN equipment.
- A basic load of rations and ammunition to support 24-hour continuous operation.
- A selection of appropriate support equipment, vehicles, and personnel required for the mission.

C-8. Recovery teams need to be aware of classified communications devices and components, and other classified materials. This will assist with maintaining proper security and reducing chances of compromise.

LEADERS

C-9. Platoon leaders and platoon sergeants coordinating recovery assets and assess labor requirements for recovering disabled equipment. Recovery personnel perform their mission simultaneously with the combat mission. If the recovery mission interferes with combat operations or in any way compromises security, it must be coordinated with the tactical commander.

C-10. Leaders should train on the same tactical procedures as recovery personnel so they can periodically check the rigging and equipment for proper hookups and adjustments. Weight and clearance limitations require special attention when using bridges or underpasses. The following is a list of factors that leaders should determine before supervising or requesting recovery support—

- Equipment identification.
- Alternate radio frequencies.
- Location (map coordinates if possible).
- Alternate routes (when possible).
- The condition of the disabled vehicle.
- On site repair capability.
- Repair parts required.
- The organic recovery capability.
- Tactical situation and security requirements, risk level.
- Cargo, road, and movement restrictions.

C-11. The recovery manager and leader must be alert to new situations and changing requirements. Planning and prior preparation are needed for continued effective recovery support. Specific leader mechanic and operator BDAR training should encompass the following—

- Group equipment.
- Suspension systems (short tracking).
- Electrical systems (bypassing components, wire repair).
- Fuel systems (patching holes, replacing or making lines sections).
- Hydraulic/oil systems (repair high-pressure lines, repair oil lines).
- Tire and track repair.
- Risk assessment procedures.
- BDAR assessment procedures.
- BDAR TM familiarization.
- BDAR kit familiarization.

Glossary

This glossary lists acronyms and terms with Army or joint definitions. Where Army and joint definitions differ, (Army) precedes the definition. Terms for which ATP 4-31 is the proponent publication with an asterisk (*) before the term. For other terms, it lists the proponent publication in parentheses after the definition.

SECTION I – ACRONYMS AND ABBREVIATIONS

AFSB	Army field support brigade
AFSBn	Army field support battalion
BCT	brigade combat team
BSB	brigade support battalion
BDAR	battle damage assessment and repair
BII	basic issue item
CBRN	chemical, biological, radiological, and nuclear
CSSB	combat service support battalion
FMC	field maintenance company
FSC	forward support company
FWTRD	fifth wheel towing and recover device
MCP	maintenance collection point
MCRS	modular catastrophic recovery system
SOP	standing operating procedure
TDRT	tilt deck recovery trailer
TM	technical manual
U. S.	United States
USAMC	United States Army Materiel Command

SECTION II – TERMS

battle damage assessment

The estimate of damage composed of physical and functional damage assessment, as well as target sytem assessment, resulting from the application of lethal or nonlethal military force. (JP 3-0)

battle damage repair

Essential repair, which may be improvised, carried out rapidly in a hostile environment in order to return damaged or disabled equipment to temporary service. (JP 4-09)

combat power

The total means of destructive, constructive, and information capabilities that a military unit or formation can apply at a given time. (ADP 3-0)

main effort

A designated subordinate unit whose mission at a given point in time is most critical to overall mission success. (ADP 3-0)

recovery

The actions taken to extricate damaged or disabled equipment for return to friendly control or repair at another location. (JP 3-34)

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Index

Entries are by paragraph number.

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18 November 2020

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