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WARNING: This manual is meant to supplement hands-on rescue training by competent instructors. It is not meant to be a complete set of instructions by itself. Technical rescue is inherently dangerous. Personnel could suffer serious injury or death through the use of improper techniques.

Tenth Edition (Revised March 2005)
Edited by Ken Phillips, Grand Canyon National Park, Arizona

Cover Photograph: National Park Service rescuers Donna Sisson and Kelley Confer during litter raising at Canyonlands National Park, UT.

Photo contributions provided by:

CMC Rescue, Inc., Santa Barbara, CA
Cascade Toboggan & Rescue Equipment Company, Sandpoint, ID
Conterra Technical Systems, Bellingham, WA
Ferno-Washington, Inc., Wilmington, OH
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Pigeon Mountain Industries (PMI), Inc., Lafayette, GA
Skedco, Inc., Portland, OR
Traverse Rescue, Kelowna, B.C.

BASIC TECHNICAL RESCUE

INTRODUCTION TO RESCUE OPERATIONS

1. PRE-PLANNING
   - Examine the SAR history of the area.
     - What incident types and severity happen or potentially could occur.
     - What locations generate incidents or have existing hazards.
     - Review the rescue tactics that are employed and recognize training deficiencies.
   - Inventory available equipment and resources, including skill levels. Is your team ready for your most difficult rescue?
   - Establish organization and train personnel.
   - Develop established procedures; organizational structure, communications, rescue techniques, safety practices, etc.
   - Review industry safety and agency standards (e.g. American Society For Testing And Materials [ASTM] F-32 Subcommittee on Search And Rescue, NFPA, OSHA, etc.).
2. NOTIFICATION

   Obtain an accurate initial report. Size-up information includes number of victims, distances involved, suspected injuries and anticipated hazards.
3. RESPONSE

   The elements of a SAR incident- **"LAST"** principle;
   - **L**ocate
   - **A**ccess
   - **S**tabilize
   - **T**ransport

National Park Service rescue personnel at Yosemite National Park (left and top right) and Grand Canyon National Park.

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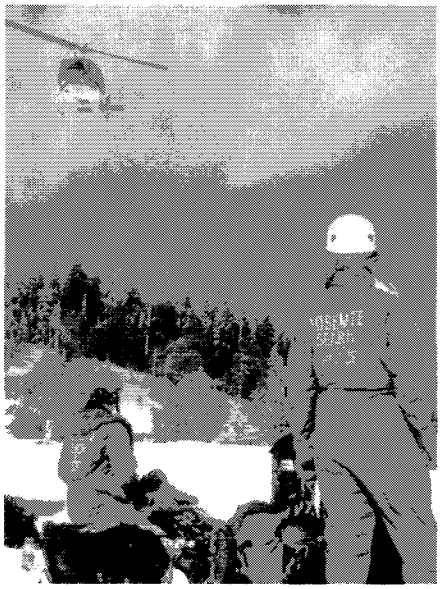
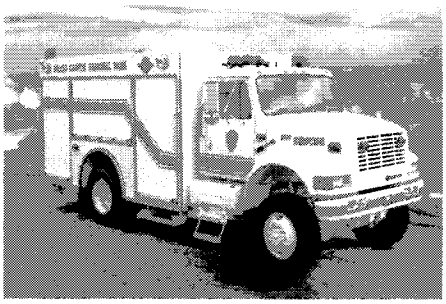
4. INVESTIGATION- Determine if any law enforcement investigative actions are required due to an associated crime or possible tort liability. Provide for thorough documentation of the scene and factors relating to an accident.
5. CISM- Provide for the Critical Incident Stress Management needs of involved personnel. Conduct defusing sessions when appropriate to provide for the mental health of emergency responders.
6. HOT DEBRIEF- Immediately review the operational efficiency with involved rescuers and focus on possible improvements for the next response.
7. INCIDENT REVIEW (*After-Action Review*)
   - A formal incident review is frequently scheduled for larger incidents to conduct an honest review of the incident with all involved agencies.
   - A moderator leads the review with a posted agenda to evaluate the operational safety, effectiveness and efficiency. Using a structured format for the review will assist in keeping it on track.
8. PSAR- Implement preventative search and rescue (PSAR) actions to mitigate potential accidents in advance. Seek effective strategies to provide information for the public that encourages safe behavior. Analyze accident statistics to understand where efforts should be focused.



Yosemite rescuers await helicopter transport from the summit of El Capitan following a rescue mission.

SAR Cache Pre-Planning-

- Consider efficient location(s) and mobility of your equipment in order to minimize response time.
- Equipment is stored ready for a rapid response.
- Assemble hasty packs with rapid deployment in mind. Construct packs to meet both initial medical and technical rescue functions. Weigh and label rescue packs with visible exterior markings showing contents.
- Protect gear from harmful ultraviolet damage by bagging ropes and storing equipment away from direct sunlight.



Dedicated emergency SAR apparatus to facilitate efficient response efforts.

INCIDENT MANAGEMENT

Utilizing the Incident Command System (or Incident Management System) during rescue operations permits efficient use of resources, ensures personnel accountability and promotes improved mutual-aid responses. Cross-training with outside agency responders will serve to eliminate deficiencies and maximize team concepts. The modular nature of ICS allows it to grow with the complexity and scope of the incident.

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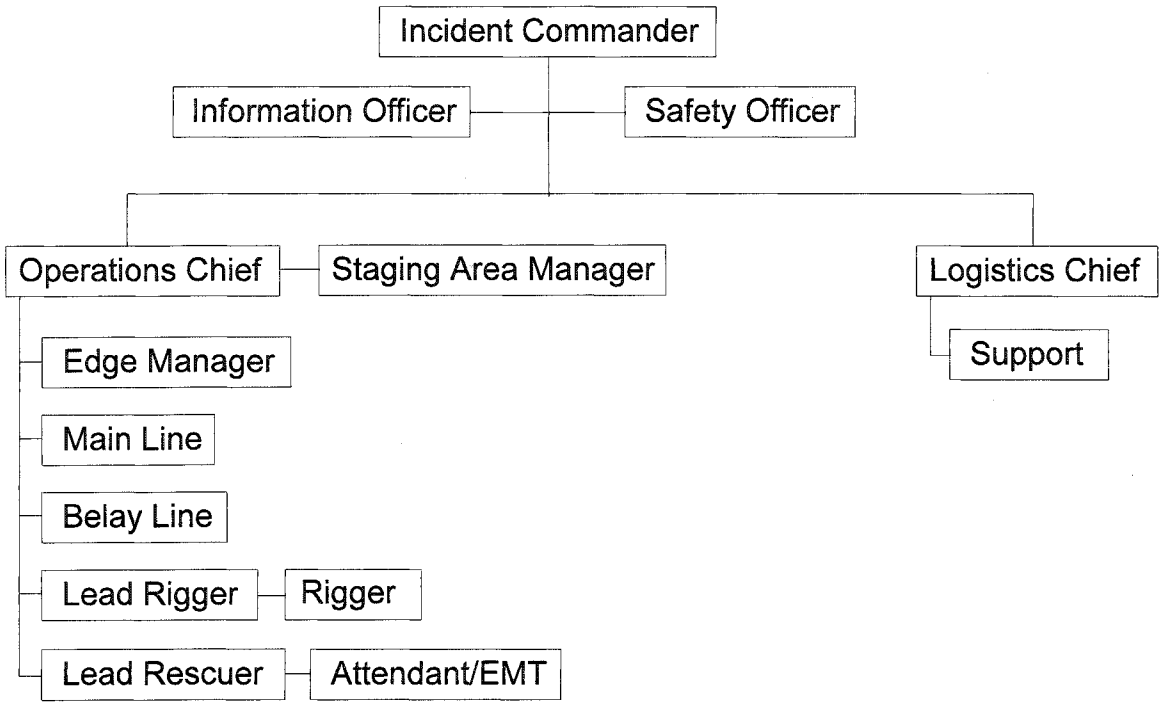
TECHNICAL RESCUE- INCIDENT ORGANIZATION



NOTE: The incident organization shown above is an example of the ICS structure for a small-scale technical rescue. The ICS structure of any incident is adapted to meet the specific needs and complexitiy of a particular rescue operation.

KEY POINTS TOWARD MAINTAINING AN ORGANIZED RESCUE

- Initiate a quick "size-up" of the incident to verify initial report.
- Organize an immediate initial response to reach and stabilize the victim.
- Utilize ICS (Incident Command System/Incident Management System) and identify positions (verbally on the radio & use of vests).
- Establish an accessible staging area for your equipment.
- Limit communications with the rescuer(s) to the Edge Manager or the Operations Chief (Control position).
- Stay ahead of the logistics curve. Plan and act now.... Be mentally prepared for a rescue to take longer than you expect.
- Keep rescue systems simple and **safe.** An overly complex system may compromise your efficiency.

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OPERATIONAL CONSIDERATIONS FOR MANAGING EFFICIENT SAR RESPONSES:

- Is the level of response appropriate?
- Have you selected the appropriate technique for the task?
- Are the correct initial actions being implemented immediately?
- Have alternative techniques been adequately evaluated?
- Has "command" been identified to involved personnel?
- Is there an adequate ICS organization in place?
- Are you deploying initial response team members who are prepared to provide EMS care?
- Are operations within equipment and personnel performance capabilities?
- Are adequate communications in place?
- Have thorough briefings of the mission been conducted for all involved personnel?
  - → In-person briefings are the most effective.
  - → Give clear instructions and be certain there is no misunderstanding.
- Can you locate any omissions or deficiencies in the plan?
  - → Are you staying ahead of the "power curve"?
  - → Anticipate and actively prevent possible delays to the mission.
  - → Insure sufficient timeliness of logistical support.
- Is there compliance with policy and operating procedures?
- Is safety truly being openly promoted?
- Are established policies and procedures known by involved personnel?
- Is staging of additional resources identified and being employed?
  - → Pre-stage EMS transport resources (e.g. ambulance, helicopter) for efficient patient transfer.
- Is Personnel accountability in place?
  - → Check-in, flight following, span of control, etc.
- Have you planned for rest & rehabilitation of involved personnel?
  - → Fatigue, stress and dehydration profoundly effect performance.
  - → Employ rotations of rested personnel.
  - → Provide for CISM (Critical Incident Stress Management) support.

SAFETY CONSIDERATIONS

Remember your priorities for operational safety...

- **YOU ARE NUMBER ONE!**
- Your fellow rescuers are your **SECOND** concern.
- The subject is your **THIRD** priority.

Safety is of paramount importance at all times. If you see any action that is unsafe it is your responsibility to speak up!
Remember that no one is infallible and that includes you!

*** The worst-case scenario is having a rescuer injured, resulting in two patients. Don't create an incident within an incident.**


Safety Officer Reviews Rigging

NOTES:

FORMAT FOR BRIEFING IN EMERGENCIES

1. **Here's what I think we face;**
2. **Here's what I think we should do;**
3. **Here's why;**
4. **Here's what we should keep our eye on;**
5. **Now, talk to me.**

Adapted from Dr. Karl E. Weicke. University of Michigan. 1995.
"SOUTH CANYON REVISITED: LESSONS FROM HIGH RELIABILITY ORGANIZATIONS."
Published in Proceedings of Wildland Firefighters Human Factors Workshop.

IMPORTANT SAFETY REMINDERS

- Do not rush! Maintain a sense of ***"controlled urgency."***
- Use well-trained, competent rescuers for the core of the team.
- Establish a marked safety perimeter.
- Be tied-in when working near an edge.
- Minimize the number of personnel working near an edge.
- Designate a Safety Officer, which might be a collateral role for a rescuer.
- Do a safety check prior use of a system. Recheck equipment when in use.
- Create a redundant system. Rescue systems have backups.
- Use standard communications terminology and techniques.
- Aggressively employ appropriate personal protective equipment (PPE) for all incident hazards, environments and tasks (e.g. gloves, footwear, helmet, harness, personal flotation device, hearing protection, Nomex clothing, safety goggles, sunscreen, etc.). Have spare equipment available.
- Establish safety lines where exposure places personnel at significant risk of injury.
- Secure loose gear in a cache adjacent to the rescue operations area.
- Keep a Prusik and trauma scissors with you.
- Be aware to prevent "cross-gate forces" and three-way forces on carabiners.

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SITUATIONAL AWARENESS

NOTE: Most climbing and rescue related accidents are not related to equipment failure, but instead "human error." ....How can we engineer and plan for the human factor on all rescue operations?

Aircrash investigators routinely attribute a loss of "situational awareness" as a contributing factor in serious accidents. The ability of an aviator to maintain an accurate perception of the external environment as well as detect and act on any problems encountered, is also a valuable asset for technical rescue personnel.

- Factors to be aware of that reduce situational awareness include:
  - Insufficient communication.
  - Fatigue/stress.
  - Task overload.
  - Group mindset.
  - "Press on regardless" philosophy.
  - Degraded operating conditions.
- Techniques to prevent the loss of situational awareness:
  - Actively question and evaluate your mission progress.
  - Update and revise your image of the mission.
  - Use appropriate assertive behaviors when necessary;
    - Make suggestions.
    - Provide relevant information without being asked.
    - Confront ambiguities in assignments.
    - State opinion on decisions and procedures.
    - Refuse unreasonable requests.

COMMUNICATION- Using Direct Statements:

Frequently emergency responders observe operational hazards on an incident but fail to speak up and get them corrected. During situations involving critical communication it is most effective to use **direct statements**. Although they appear rude, direct statements are difficult to ignore and very effective. The six components of direct statements include:

1. Use the person's name who you are addressing.
2. State; "I", "I think", "I believe" or "I feel".
3. State your message as clearly as possible.
4. Use the appropriate emotion for your message so that it is delivered as you intended.
5. Require a response by using such statements as "What do you think?" or "Don't you agree?"
6. Don't let it go. Don't disengage with the other person till an understanding is achieved.

Example: *"John, I think we need additional manpower for this rescue. Don't you agree?"*

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INCIDENT RISK MANAGEMENT PROCESS

STEP 1 Situation Awareness

Gather Information

- Objectives
- Communication
- Incident Organization
- Weather Forecast
- Local Factors/Terrain/Hazards

STEP 2 Hazard Assessment

Identify All Possible Tactical Hazards

STEP 3 Hazard Control

Mitigate Potential Hazards Through Safety Procedures & Protective Equipment

STEP 4 Decision Point

GO or **NO-GO** To Implement Planned Course Of Action

STEP 5 Evaluate

Self:
- Low experience level for activity?
- Distracted from primary task?
- Fatigue or stress reaction?
- Hazardous attitude?

Situation:
- What is changing?

AFTER ACTION REVIEW *-"HOT DEBRIEF"*

- **What Was Planned?**
- **What Actually Happened?**
- **Why Did It Happen?**
- **What Can We Do Next Time?**

Adapted from INCIDENT RESPONSE GUIDE (NFES #1077), NIFC, Boise, ID

COMMON HAZARDS

TECHNICAL RESCUE TACTICAL WATCH-OUTS

HAZARD	CORRECTIVE ACTION
Ineffective communications.	*Use in-person briefings and maintain disciplined incident communications.*
Failure to protect rope against sharp edges.	*Aggressively employ edge protection.*
Weld abrasion- nylon rubbing against nylon.	*Engineer rigging attentively.*
Misuse and inattention to equipment. Improperly tied rigging.	*Continually inspect in-use gear.*
Cross-gate forces on carabiners.	*Rig correctly and recheck rigging frequently.*
Carabiner gates unlocked or held open by webbing or rocks.	*Check rigging frequently.*
Loosely rigged Prusiks.	*Employ visual and tactile function checks.*
Failure to wear helmets or be tied in.	*Keep an eye on one another.*
Rescuer fatigue, thirst, boredom, & distraction.	*Change out the belayer and rehydrate often.*

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SAFETY FACTORS AND FORCES

SAFETY FACTOR

The *Static System Safety Factor* (SSSF) is the ratio between the equipment breaking strength and the maximum expected static force. When rigging a rescue system always consider the weakest link in your design. By applying the standard engineering principle of constructing a system to withstand a *"dynamic event"* it causes us to realize that such an event could produce a peak force on the system of twice the static force. Rescue systems are constructed with a 10:1 SSSF so that the relative worst case event would be less than the failure level (breaking strength or yield) of the equipment. The outcome of this practice is that rescue systems designed in this manner will have a 2:1 dynamic safety factor.

Currently mountain rescue groups consider a **10:1 safety factor** completely acceptable, while the fire service uses a 15:1 safety factor *(based upon the NFPA standard of 60 kN breaking strength for general-use life safety rescue rope)*. However, it is still important to understand that a system component safety factor of 15:1 can still be unsafe if the equipment is rigged in an improper manner.

STANDARD RESCUE LOAD DEFINITIONS:
***"Rescue Load"* = 200 kg** (440 lbs.) [Victim + Rescuer + Gear]
***"Heavy Rescue Load"* = 272 kg** (600 lbs.) [Victim + Two Rescuers + Gear]

KiloNewtons And The Technical Rope Rescuer

A kiloNewton (kN) is a measure of *force* and has much more relevance to rescuers than say a measure of just mass. A falling rescuer or climber is mass accelerating under the pull of gravity. Most rescue equipment manufacturers label their wares according to a specific kN rating for strength. A newton is the force required to accelerate one kilogram, one meter per second. 1 kN or 1000 Newtons is the force required to accelerate 1000 kilograms, one meter per second. For conversion purposes, ***1 kN is the force approximately equal to one rescuer plus gear, or 225 lbs. of force (lbf).***

RESCUE GRAMMAR & PHYSICS

Force- The term *"weight"* is considered ambiguous in rescue rigging. Weight essentially constitutes the force exerted on matter by the gravitational attraction of the Earth, and so it varies from place to place. Force is the action of one body on another body. Are you referring to a force acting on the rope or a mass suspended on it?

Mass- A measure of the amount/quantity of matter. By international agreement the standard unit of mass, with which the masses of all other objects are compared, is a platinum-iridium cylinder of one kilogram. In countries that favor the English system of measurement over the International System of Units (SI), the avoirdupois pound is used instead. Finally another unit of mass, one that is widely employed by engineers, is the slug, which equals 32.17 pounds. In contrast to *"weight"*, mass remains

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constant regardless of its location, under ordinary circumstances. A satellite launched into space for example, weighs increasingly less the further it travels away from the earth. Its mass, however, stays the same.

Tension- To refer to a *"load"* on a rope is another ambiguous use of terminology in rescue rigging. It is more accurate to say tension the rope, instead of load the rope.

Shock Force- The resulting tension in a system when a mass is transferred to a system in a catastrophic manner. The term shock force is more accurate than "shock load."

Newton- It is defined as that force necessary to provide a mass of one kilogram with an acceleration of one meter per second per second ($N=kg/s^2$). One newton is equal to a force of 0.2248 pound in the foot-pound-second (English, or customary) system. The newton was named for Sir Issac Newton, whose second law of motion describes the changes that a force can produce in the motion of a body.

1 kiloNewton (kN) = force of 225 lbs. of force (lbf)

It is important to understand that there is a distinction between force and mass;

	FORCE	MASS
US system	pound-force (lbf)	Slug
SI System (International System of Units)	Newton (N)	Kilogram (kg)

DYNAMICS:

Fall Factors and dynamics:

- The forces generated during fall arrests are referred to as *shock forces*. Forces on the system will increase with acceleration from longer falls. *Fall factor* is a measure of fall severity. A knotted low-stretch rope can fail from a tension below its rated strength by the dynamic forces of a falling mass, which puts too much stress on the rope too quickly. The potential associated with *dynamic forces* underscores the need to construct a rescue system ten times stronger than the greatest static force you plan to put on it.

- Fall ratings on dynamic ropes are determined from the number of UIAA test falls that a rope sustains prior to failure. The UIAA drop test involves a 2.8 meter section of rope anchored at one end. The anchored end is .3 meters away from a carabiner with a 80 kg mass on the remaining 2.5 meters of slack. The resultant fall of 5 meters generates a fall factor of 1.78.

Fall factor is calculated from the length of the fall divided by rope available for energy absorption. Typically a factor 2 fall is the highest encountered in a climbing situation, where the rescuer lead climbs above the belayer. This might involve falling 20 feet (6 meters) with 10 feet (3 meters) of rope available for energy absorption the shock. A fall factor 2 fall on low-stretch rope generates enough

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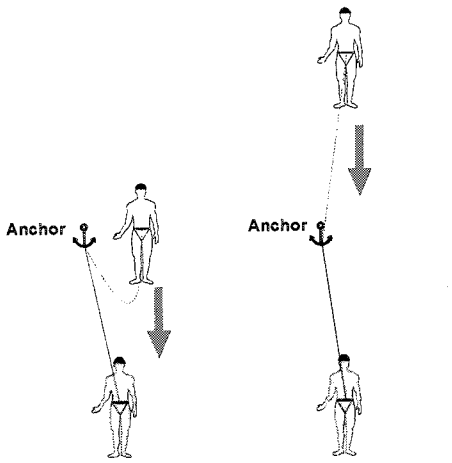
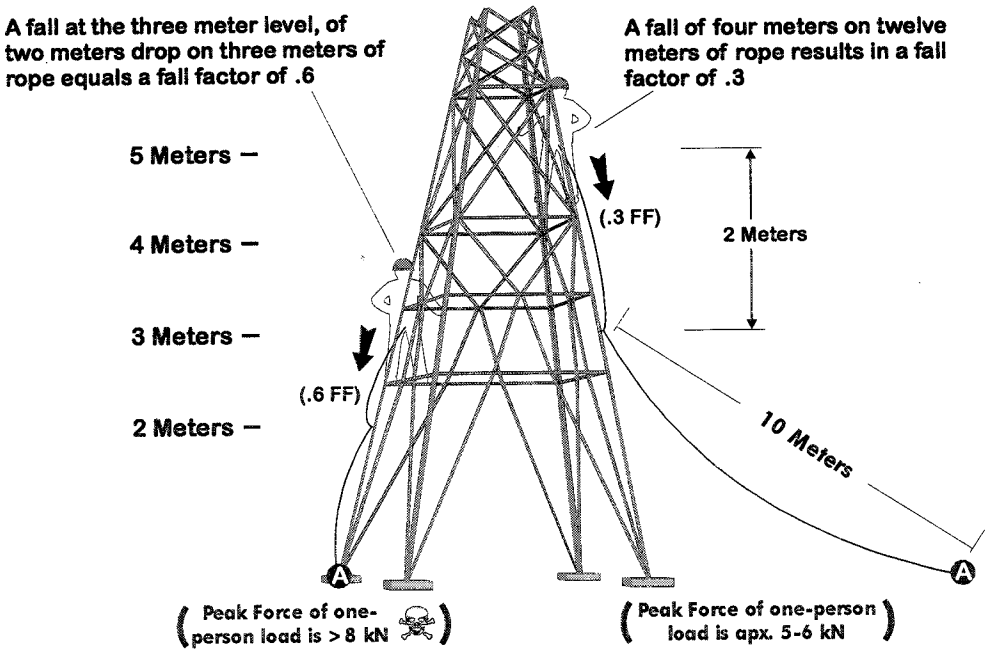
force to cause injury or death. However it is recommended that only a **maximum fall factor of 0.3 be permitted in a rescue system.** Keeping this principle in mind, one of the potential scenarios for generating the highest shock forces is right at the point of going over the edge of a cliff.



Knowledge regarding dynamic forces can be applied practically by rescuers in the field. As an extreme example, ask yourself how could you safely lead climb up a tower using low-stretch rope, while keeping the fall factor at an acceptable level? The solution is to increase the amount of rope available for energy absorption by moving the anchor out away from the base.

Fall Factor= $\dfrac{\text{Fall Distance}}{\text{Amount Of Rope For Energy Absorption}}$

Although lead climbing is commonly conducted with high-stretch rope, consider the following extreme example.. If the situation dictates lead climbing with low-stretch rope, the solution is to increase the amount of rope available for energy absorption. This is illustrated in the following situation with two rescuers on a steel tower. If the anchor is constructed away from the base, causing more rope to be used in the climbing system, the fall factor is reduced.



NOTE: A practical rule of thumb in this situation to keep the potential fall factor at a safe level, place a piece of protection every full body length (two meters) in height. **Maximum peak force survivability for humans is 10-15 kN.**

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For comparison, these are the UIAA limits of peak force for the following pieces of equipment;

- Anchors: 25 kN
- Carabiners: 20 kN
- Slings: 22 kN
- Harnesses: 15 kN

Note: The Belay Competence Drop Test method developed by British Columbia Council Of Technical Rescue (BCCTR) uses a one meter drop on 3 meters of rope with a 200 kg mass, which is only a fall factor 0.3. The peak force generated by this test using the Tandem Prusik Belay or the *540° ™ Rescue Belay* ***is <15 kN* (* Distributed to the individual mass in the system, such as the rescuer or victim, which does not result in such a peak force applied per person).***

Apply a standard engineering principle for designing systems to handle dynamic events by constructing it about twice as strong. Therefore if we build a system with a static system safety factor of 10:1, we will likely wind up with a 2:1 dynamic safety factor. This is for the relative worst case scenario of a one meter drop on three meters of rope. Looking at the example of the Belay Competence Drop Test above, we should attempt to achieve a constant goal of 20-24 kN strength (twice the amount seen in the peak force) in order to not exceed the yield point of equipment due to a dynamic event.

SYSTEMS ANALYSIS

• ***WHISTLE TEST***; examines what would happen to the rescuers and the victim if at any time during the operation everyone were to let go. This duplicates what would happen if rescuers were struck by lightning or if someone forgot to do his job. Does the system function automatically?

• ***CRITICAL POINT TEST***; examines what would happen to the rescuers and the victim if any single piece of equipment were to fail at any particular moment. Would there be anything to back it up? If there is no backup, then it is a "critical point."

A PRACTICAL METHOD FOR EVALUATING A SAFE RESCUE SYSTEM DESIGN:

1. Whiteboard Analysis.

- Critical Point Test.
  Examine every component of a system to locate any "critical points." If one fails will the system fail?
- Whistle Test.

2. Comparative Analysis.

- Field trials to evaluate system for practicality.
- Identify advantages/disadvantages to what technique you currently use.

3. Failure Analysis.

- Fail the primary system to see if backups actually perform in position of function.

Warning: Failure analysis is only conducted in a testing situation under controlled conditions.

NOTES:

STANDARDS AND INDUSTRY RATINGS:

Current industry ratings and standards relating to equipment labeling and technical rescue operations.

ASTM- American Society For Testing And Materials is one of the largest standards setting organizations in the world and a not-for-profit corporation. They provide a forum for development of voluntary test methods. All actions are conducted through full consensus of the membership. The F-32 Committee, is currently working on standards for search and rescue.

C.E.N.- European Economic Community Law has dictated that climbing equipment be subject to uniform C.E.N. (Comité Européen de Normalisation). Standards in order to be distributed in European Market Countries. C.E.N. has adopted common labeling, terminology, and strength ratings for all classes of products. Equipment is marked "**CE**" (Conformité Européenne).

D.I.N.- Deutsches Institut Fur Normung (DIN), the German Institute for Standardization, is a registered association, founded in 1917. Since 1975 it has been recognized by the German government as the national standards body and represents German interests at international and European level.

ISO - The International Organization for Standardization (ISO), established in 1947, located in Geneva, Switzerland is an association of approximately 149 national standards bodies. American National Standards Institute (ANSI) is the "member body" for the USA. ISO develops international standards including the ISO 9000 standards, specifically ISO 9001:2000 and ISO 9004:2000, which address quality management and quality assurance. In order for a manufacturer to qualify for ISO "certification" certain test methods, standard quality-control procedures, and documentation must be met. A product manufactured in an ISO 9000 factory can be traced back to a specific product "batch."

NFPA- The National Fire Protection Association, which develops standards and operating guidelines for the fire service, has several guidelines which relate directly to "technical rescue" operations.

- **NFPA 1006- Standard for Rescue Technician Professional Qualifications (2003 Edition).** Identifies the "requisite knowledge" and "requisite skills" for a rescue technician involved in rope rescue, surface water rescue, vehicle and machinery rescue, confined space rescue, structural collapse rescue, trench rescue, victim management, rescue site operations and rescue equipment maintenance. Example; *"Construct a belay system, given life safety rope, anchor systems, personal protective equipment, and auxiliary rope rescue equipment if available, so that the system is capable of arresting a fall, a fall will not result in system failure, the system is not loaded unless actuated, actuation of the system will not injure or render the belayer ineffective, the belayer is not rigged into the equipment components of the system, and the system is suitable to the site and is connected to an anchor system and the load."*
- **NFPA 1670- Standard on Operations and Training for Technical Rescue Incidents. (2004 Edition).** Addresses *Technical Rescue Standards* for fire service agencies in rescues involving structural collapse, rope rescue, confined space, trench and excavation, vehicle and machinery, water and wilderness search and rescue. This guideline identifies the specific operating

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procedures that organizations functioning within these disciplines need to have established (e.g. *"Procedures for the safe selection, construction, and use of a belay system"*). The guideline identifies three different proficiency levels for rescuers;

1. Awareness Level- minimally trained initial responder, without specialized training. Awareness trained personnel are capable of recognizing a rescue-related incident, preventing additional bystanders from getting injured as well as carrying out a non-complicated rescue, if possible.
2. Operations Level- fully functioning rescuer with specialized training who can participate in all operations, and usually does so under the supervision of a technician-level responder.
3. Technician Level- fully trained rescuer who coordinates, performs and supervises rescue activities.

- **NFPA 1983- Standard On Fire Service Life Safety Rope and System Components (2001 Edition).** This guideline covers high angle rescue equipment used on the structural fire ground. Rescue components, labeled by the manufacturer, as "Meets NFPA 1983" are also marked **"P"** for personal use (one-person load) or **"G"** for general rescue use (greater than one-person loads) in rigging applications. NFPA 1983 requires that general-use life safety rope (13 mm or 1/2 in. dia.) and carabiners for the fire service have a breaking strength of 40 kN (8992 lbf). NFPA 1983 considers a single person load mass to be 300 lbs (136 kg).

OSHA- Occupational Safety and Health Administration; Department Of Labor, Washington, D.C. Regulates workplace and employee safety through enforcement of applicable statutes. 29 CFR, part 1926, section 1926.500, subpart M, *"Fall Protection In Construction Workplaces."* These regulations apply to industrial fall protection in the workplace, but do not apply to emergency responders involved in technical rescue operations. However it is important to note that OSHA requires fall protection to be employed, where exposure is six feet or greater.

> ***29 CFR 1926.501 (b)(1)*** *Each employee on a walking/working surface (horizontal and vertical surface) with an unprotected side or edge which is* ***6 feet (1.8 m) or more*** *above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems.* [Refer to http://www.osha.gov]

U.I.A.A.- Union International D'Association D'Alpinisme, established in 1928, established the first standards for mountaineering and climbing equipment in the world. In 1964 the UIAA developed the first common test procedures and minimum standards for climbing rope. UIAA standards eventually included helmets, harnesses, ice axes, and carabiners. UIAA serves merely in an advisory capacity.

3 Sigma (3Σ)– Rating system derived from established accepted statistical principles and engineering practices in North America. The average, or mean value; e.g., breaking strength, is first calculated by a uniform test method along with the standard deviation. This deviation, sigma, indicates the range of variation in the test data, from the average value. If a manufacturer chooses to rate his products three deviations (3 sigma) less than the average breaking strength, statistics indicate that 99.87% of all product will exceed this value (e.g. a batch of 10,000 units would include 13 units which could fail below the reported strength). A three deviation rating standard is used by NFPA 1983 (2001 edition).

NOTES:

EQUIPMENT

ROPE

Important characteristics and properties of rope used in evaluating different rope materials:

- Strength.
- Abrasion resistance & durability.
- Flexibility, handling & knotability.
- Elongation (rope stretch).
- Shock (energy) absorption.
- Melting Point.

NYLON ROPE CONSTRUCTION:

LAID ROPE:

• This is one of the oldest and most familiar rope designs. These ropes are manufactured by twisting bundles of fiber around one another. They are commonly found in three strand twisted line. Provides good elongation, but twists when tension is applied. Best example of this type of rope is "Goldline" Rope (manufactured by New England Cordage). This type of rope construction fails readily under tension if one strand is suddenly cut.

BRAIDED:

• **Double Braid or Braid-on-Braid:** Very flexible handling characteristics. This rope accepts knots easily and coils readily. Utilized most commonly in marine applications.

• **Multi-braid:** This is a braid of fiber bundles lacking a core found in other rope types. Used primarily for utility work applications as well as being the type of rope used in conjunction with the Sky Genie descent device.

KERNMANTLE:

• Kernmantle construction is a braided style in which the kern, a high strength inner core, is covered by the mantle, an outer braided sheath.

• **High-Stretch Kernmantle Ropes:** Used for climbing purposes and are designed to absorb the force that is generated in a fall. A climbing rope should be stretchy enough to absorb the shock, but not stretch so much that the climber falls an excessive distance. High-stretch kernmantle ropes may stretch up to 40% or more at failure. These ropes have a place in rescue work, such as using on a lead climb to a victim, where a leader fall is possible (fall factor in excess of 0.3). UIAA impact force testing for these ropes involves an 80 kg (176 lbs) mass on a 2.8 meter length of rope dropped 5 meters. A "single" rope (9.8-11 mm) must hold five such falls.

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•**Low-Stretch Kernmantle Ropes:** The core fibers are parallel for minimum elongation. Manufactured by cavers beginning in 1966 (Bluewater) for the purpose of rappelling and ascending ropes that had little stretch (between 1% and 5% under working conditions) and did not spin in comparison to laid rope construction. Low-stretch rope should not be used when a leader fall is possible.

ROPE MATERIALS:

• **NATURAL FIBERS:** Hemp, sisal, manila and other natural fibers are no longer used in rescue applications. These materials rot, have less energy absorption and are weaker than modern synthetic fibers.

• **SYNTHETIC FIBERS:**

-Polypropylene (polyolefins)
- Floats (good for swiftwater rescue applications).
- Low melting point and abrades easily.
- Low ultraviolet light resistance.
- Low elongation and energy absorption (apx. 60% of nylon).
- Specific gravity= 0.91

-Polyester (*Dacron*- Dupont trade name)
- Low elongation and energy absorption (less than nylon and same as polypropylene).
- Resists abrasion well. Resists ultraviolet light.
- Dense- specific gravity 1.38.

-Kevlar ® (Dupont trade name for aramid fibers)
- High strength and resists high temperatures (e.g. decompresses at 800° F).
- Easily damaged by abrasion or when knotted.
- Low stretch and therefore poor shock absorbing qualities.
- Specific gravity= 1.44

-Spectra ® (Hybrid polyethylene fiber manufactured by Allied Chemical)
- Pound (kg) for pound (kg) is ten times stronger than steel cable.
- Spectra cordage can actually survive high shock forces.
- Low stretch, therefore poor energy absorption qualities.
- Too slippery to accept knots well- works best as a commercially sewn runner.
- Low melting point= 297 ° F. (Sticky point = 150 ° F).

-NYLON (Invented by Dupont in 1938, nylon ropes were used in W.W.II)
- -Nylon Type 6,6 is common ingredient in current rescue rope fibers.
- -"Perlon" (Nylon Type 6); used in high-stretch rope construction.
- -Nylon is lighter but slightly weaker than polyester.
- -Has good flexibility and abrasion resistance.
- -Disadvantage- loses up to 15% strength when wet.
- -Melts at 480-500 °F (248-260 °C), becomes sticky at 445 °F (229 °C), yellows at 300 °F (148 °C) after 5 hours exposure. [Source: Pigeon Mountain Industries, Inc. website]
- -Specific gravity = 1.14

NOTES:

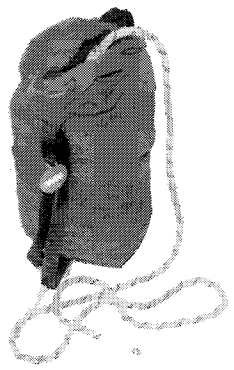
ROPE DIAMETER:

- *Mountain Rescue*- 7/16 inch or 11 mm. Apx. 30 kN (7,000 lbs.) Breaking strength.
- *Fire Service*- 1/2 inch or 12.5 mm. Apx. 40 kN (9,000 lbs.) Breaking strength.

ROPE LENGTH:

- Recreational climbing- typical 165' length (50 meters or one pitch).
- Mountain Rescue- 150' , 200' & 300' are some common lengths. This varies widely depending on the agency and area preferences based upon terrain.

CARE AND USE OF ROPE



- ***....Never step on a rope!***
- Ropes should be stored away from acids and sunlight.
- Petroleum products do not deteriorate a nylon rope- however they will attract dirt to it.
- Keep ropes away from oil and grease.
- Remove knots when storing a rope.
- Practice good rope management in the field;
  - * Become proficient at stacking, coiling, and throwing a rope.
  - * Bagging ropes for storage is the most preferred method.
  - * Identify individual ropes and document their history with a rope log.
  - * Clean dirty ropes with a rope washer or washing machine. Use low heat, mild soap and bag them or "chain" coil.

Rescue Rope Retirement Considerations:

1. Sheath wear- Penberthy Method; involves the evaluation of each "pic" (square of woven fibers in the sheath). If in each of these pics, over a majority of the rope, there are more than 50% of the strands broken, then the rope should be retired.
2. Following any excessive loading, rockfall or heavy wear.
3. Inspection that reveals soft spots or defects.
4. Chemical contamination.
5. Suspect or unknown rope history.
6. Age exceeding seven years in used rope. (See box below)
7. "When in doubt... Throw it out."

WHAT IS THE RETIREMENT AGE FOR A ROPE?

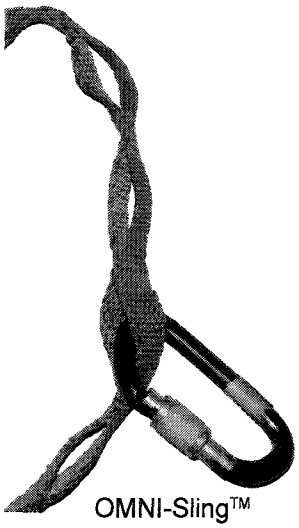
In order to calculate a deterioration rate for nylon rope Bruce Smith conducted pull testing of aged 11mm rope samples. He measured a 1.5-1.8% loss of strength per year in relatively unused PMI and Bluewater rope. This results in a 15-18% strength loss for unused rope after ten years. Citing a military ten-year retirement guideline for life safety support nylon products, he concluded that *"used rope would need to be discarded at approximately seven years if the same ten year new margins wish to be maintained."* *AGING ROPE- Study On Rope Aging,* Bruce Smith, Nylon Highway, Issue #25, January 1988, National Speleological Society (NSS).

NOTES:

WEBBING

- Styles include tubular and flat webbing.
- Types of nylon webbing construction:
  1. Needle loom (chain stitch) with seam along one edge.
  2. Shuttle loom or spiral stitch.
- One inch tubular nylon (shuttle loom) has been the most popular among mountain rescue teams. This is manufactured according to Mil-W-5625 specification, which requires a minimum breaking strength of 17.93 kN (4,000 lbs.). The equipment used to manufacture shuttle loom webbing is no longer being manufactured (Frank, CMC Rope Rescue Manual, 1998). As the product becomes less available on the market it will likely cause a shift to heavy duty flat or needle loom webbing.

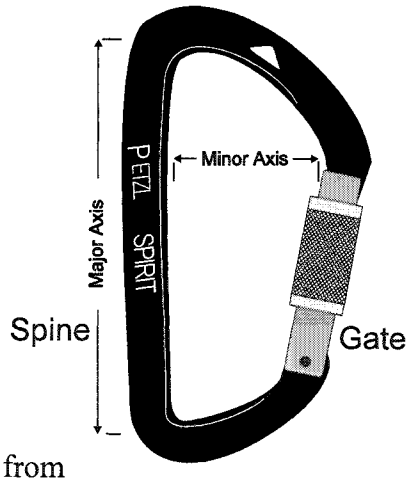
- Heavy duty one-inch Type 18 flat webbing is being increasingly utilized by rescue teams due to its increased strength and abrasion resistance over one-inch tubular webbing. Type 18 heavy duty flat webbing has a strength of 26.67 kN (6,000 lbs.) but it is bulkier than tubular webbing.


OMNI-Sling™

- Etriers, daisy chains, and anchor straps are common sewn webbing products.
  - OMNI-Sling™ manufactured by Rescue Systems, Inc. is nylon webbing with rigging pockets, which are woven directly in during the construction of the webbing. The rated strength of the OMNI-Sling™ webbing is 44.4 kN (10,000 lbs.) and strength of the individual slots is 20.4 kN (4600 lbs.). Be aware that the individual pockets may be difficult to clip with a carabiner when the entire sling is under tension.
- If Spectra® runners are employed, it is recommended that factory sewn units be used.

CARABINERS

Design: Non-locking, locking and spring loaded self-locking (kwik lock or auto lock).
Style: Oval, D-shaped, modified D, bent gate and pear shaped.
Anatomy: Spine, gate, latch and hinge.
Material: Aluminum and steel.



Locking D Carabiner

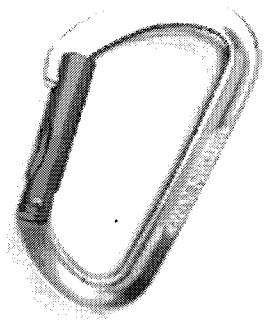
CARABINER REMINDERS:

[Rigging in the rescue environment]

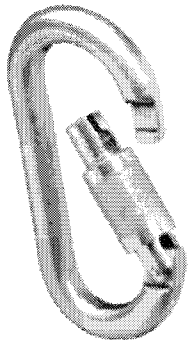
- For safety consider using one locking carabiner or two non-locking carabiners that are placed with their gates opposite and opposed.
- Tension along the major axis of a carabiner- be aware to prevent the primary force going onto or across the minor axis (cross-gate forces).
- Tension along the spine. Keep straps, lanyards, and carabiners away from the gate.

NOTES:

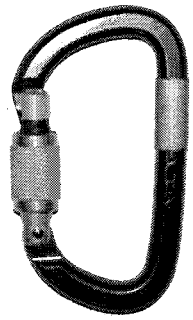
- A carabiner's gate-open strength is usually less than half of its gate-closed strength.
- Remember locking carabiners can unlock themselves! Recheck them during use.
- Do not over tighten a locking carabiner while it is loaded. After the tension is released it will be difficult to unlock. To unlock such a "stuck" carabiner it may be necessary to re-tension it in order to loosen the gate.



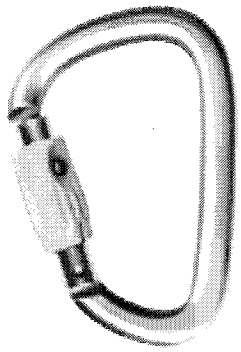
Petzl Spirit Non-Locking Straight Gate Carabiner



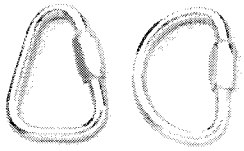
Petzl OK Locking Oval Carabiner



Petzl Am'd Offset D Locking Carabiner



Petzl William Pear Shaped Spinball Locking Carabiner

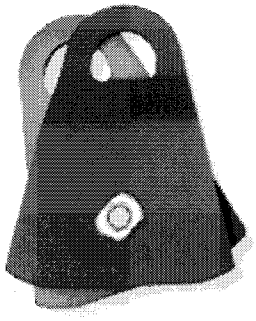


Triangular and Semi-Circular Screw Links

RESCUE PULLEYS

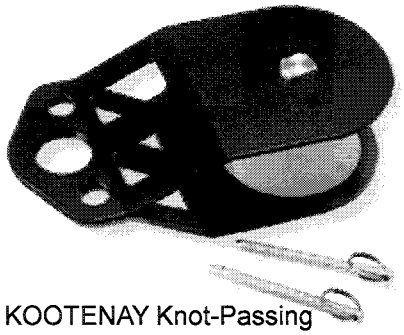
A rescue pulley has rotating side plates or "cheeks" and is constructed with a sheave (wheel) mounted on a bearing or bushing. The sheave width should be 10% larger than the rope going through it. Pulleys constructed with sealed bearings are superior and more efficient in handling rescue loads than those containing bushings. When using a pulley as a directional; keep in mind that the force on the pulley anchor may be twice the force on the rope!

* Optimum pulley size- For efficiency the rescue pulley size should be at least three times the diameter of the rope being used on it [e.g. 11 mm (7/16 inch) rope= two inch rescue pulley].

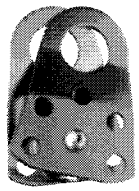


Petzl MINDER Prusik Minding Pulley

Petzl RESCUE Pulley



Petzl KOOTENAY Knot-Passing Pulley and Highline Carriage

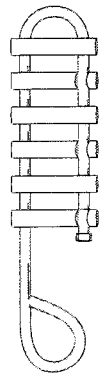


Petzl MINI Compact Prusik Minding Pulley

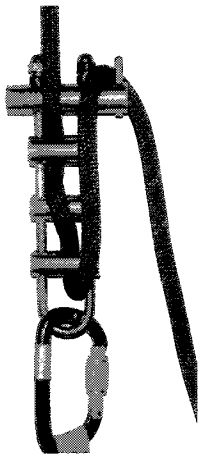
NOTES:

DESCENDERS

•**Rappel Rack;** Invented by John Cole in 1966 to allow variable friction during a descent. A very popular device among cavers and the most efficient tool for rescue loads. The rappel rack does not twist the rope during use as it applies friction in an "in-line" fashion. Two rappel rack styles include the standard inverted "U" shape ("open" style), which has attachment eye along one of the legs of the inverted "U" frame. The second popular style is the closed rack, which is also "U" shaped, but the base of the "U" serves as the attachment point. The rappel rack is the recommended tool of choice for many technical rope rescue applications including conducting pick-offs and lowering rescue loads.

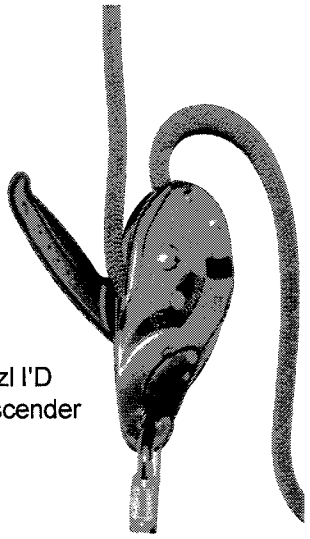


RAPPEL RACK

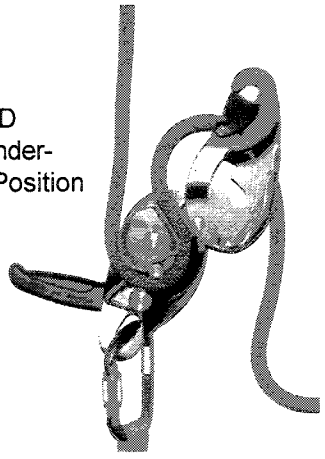


Mini Rappel Rack with Hyper Bar

• **Petzl I'D** (Industrial Descender). The I'D is similar in design to the smaller Petzl Grigri as a self-braking descender for single rope use. Descent is controlled by pulling on the control handle while keeping hold of the rope with the opposite hand. The I'D has a safety feature of an Off-On-Off range in the handle. If the user panics during descent and pulls too hard on the control handle the device automatically stops on the rope. Another safety feature of the I'D is the anti-error catch, which prevents use after threading a rope in reverse.



Petzl I'D Descender



Petzl I'D Descender- Open Position

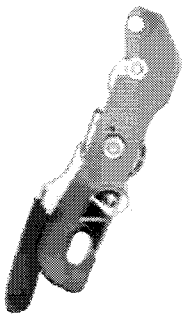
Although the "normal working load" for the I'D is listed as 30-150 kg (66-330 lbs), Petzl does state that; ***"In exceptional cases, accompanied descents, the maximum working load indicated by EN (European norm) 341 may be insufficient. Laboratory tests have shown that, with precautions taken in use (no impact force may occur), the I'D can be used with a load up to 250 kg (551 lbs)."*** Although the manufacturer permits the use of the I'D in controlled circumstances with a two person load- it should not be considered a two-person belay device for rescues. The weight of the I'D is 530 grams (1.17 lbs).

NOTES:

•**Figure Eight** ("Rescue Eight"); The ears prevent the rope from forming a girth hitch during a rappel. This device is efficient for a one person (personal use only) load, but it is not desirable for a rescue load. Although the figure eight can be double wrapped during setup to increase friction, varying friction with this device during a descent is difficult. Another disadvantage of the figure eight is that it twists the rope during use.

Figure Eight With Ears- "Rescue Eight"

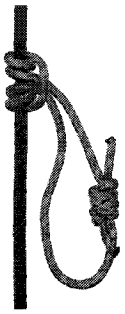
• **Petzl Stop;** A bobbin-style descender with squeeze ON and release OFF feature. Designed for personal loads and rappelling on a single rope. It brakes automatically as soon as the handle is released.



Petzl STOP Descender

• **SRT "Stop";** Australian-manufactured bobbin-style descender similar to the Petzl Stop. This heavier design will stop the rappeller if the handle is squeezed hard. Designed for personal load.

• **Alp Descender;** Bobbin-style descender manufactured by Troll (UK). Variable friction is permitted by adjustment of a wing nut control. Efficient for personal and rescue loads.



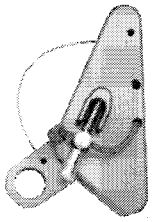
Double Wrap Prusik Hitch

ASCENDERS

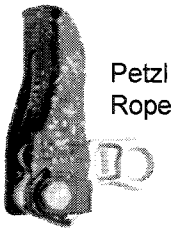
• **Prusik Hitch-** The original and simplest ascender device that is a hitch which is applied to a host rope. Dr. Karl Prusik of Austria first described the use of this hitch in 1931.

• **Cammed Ascenders-** Include Jumars, CMI, Petzl, Gibbs and Petzl (formerly Rock Exotica) Rescucender. Handled and non-handled models. ***Note: These were all designed for and rated by manufacturers for one-person loads only.***

HELMETS

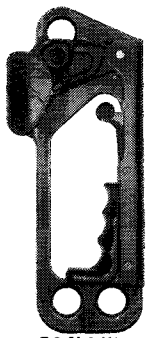


Petzl Rescucender Rope Grab

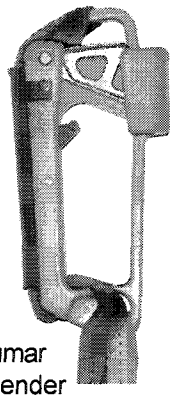


Petzl Shunt Rope Grab

Petzl Ascension Ascender



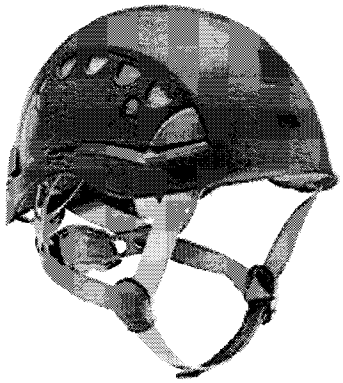
CMI Ultra Ascender



Jumar Ascender

NOTES:

Three or four-point strap suspension system is essential in any rescue helmet. Hardhats with a single chinstrap are not secure if struck by a rock and could pivot off the head. A good helmet should provide for air circulation and be suspended off the skull for impact protection. During off-trail carry-outs wear a helmet for protection from branches or other hazards. Manufacturers label their helmets as meeting ANSI Z89.1-2003, which is the national standard relating to the performance and testing of industrial helmets. Applicable European standards are EN 397 (industrial helmets) and EN 12492 (mountaineering helmets), which are referenced by European manufacturers.

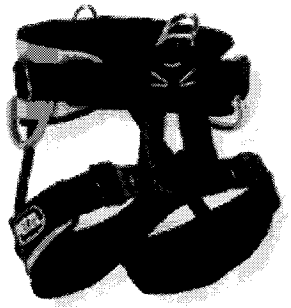


Petzl Vertex Vent Helmet

- Recommendations for helmet replacement:

[Prepared by Recreational Equipment, Inc.]

- After a significant hit.
- After any sign of damage.
- Every five years.



Petzl Navaho Vario Harness

HARNESSES

Features of a commercially-sewn rescue harness;

- Not designed for absorbing high shock forces.
- Key ingredient is rescuers comfort while hanging fully suspended.
- Typically have double back buckle design.
- Contain contrasting colored stitching to indicate thread wear.
- Ease of rigging and being able to don quickly is an important consideration.
- Know the manufacturer's directions to your harness and it's history.
- Be sure any seat harness is worn above your hips (pelvic bone).
- The gear loops on the side of a harness are not meant to be used as tie ins, only for hanging gear. This sounds simple but rescuer fatalities have occurred from this mistake.
- A properly sized and fitted harness allows all webbing ends to be doubled back through the buckle and have at least a two inch tail.
- Use a figure eight follow-through or bowline with a double overhand backup knot to attach the belay line directly to the harness, rather than clipping the belay line to harness with a carabiner.
- Retire a harness the same as you would other nylon products when it gets old and worn.

Wear And Retirement Information From Petzl;

- *In aging the strength of the (harness) fibers stays more or less the same, but their elasticity diminishes. This loss of elasticity has little effect on the harness because in comparison with the rope it has little energy absorption to do.*
- *The effect of UV light may be more destructive. It varies depending on the color of the webbing, and the quality of the anti-UV treatment it has received. Discoloration of the harness is frequently a sign of UV damage to the fibers. Chemical or corrosive products, among others, may degrade the webbing. Take care to avoid contact with acids (car batteries) and solvents.*
- *As the harness is used it gradually weakens. Repeated rubbing cuts the surface fibers and*

NOTES:

gradually reduces webbing strength. Abrasion on the stitching is even more dangerous and may rapidly lead to grave consequences. The harmful influence of earth or sand is not negligible: minute grains of sand which penetrate the webbing are tiny abrasion points where the fibers are cut when they are under tension. It can lead to breakage of the tape at a value much less than normal.

- *To limit this problem, a soiled harness should be washed, by hand or in a machine, with a powder for delicate textiles then rinsed in clean water (maximum temperature 30^0 C), and finally dried in a shaded cool ventilated place. Damp webbing, due to use in the wet or washing, shrinks slightly.*
- *It is thus more than advisable to inspect your harness regularly to check the condition of the webbing and stitching, as well as the proper functioning of the buckles. It is considered that a harness has a lifetime of the order of five years by "natural ageing."*

[Petzl-Rescue Harness Technical Information, www.petzl.com]

HARNESS INDUCED PATHOLOGY

- aka Suspension Trauma

• Remaining suspended motionless in a harness for an extended duration can quickly lead to a life-threatening condition known as *harness induced pathology*. Rescue personnel must be aware of this danger to a suspended victim and make every effort to get them to the ground as quickly as possible!

• When someone faints and falls to the ground their condition is normally self-corrected by their change to a horizontal position. While hanging, suspended in a harness, it is difficult to correct this problem and can lead to cardiac arrest.

• Signs and symptoms include near syncope, nausea, paraesthesia (feeling of pins and needles) in legs, increased respiratory rate, increased or decreased pulse rate and unconsciousness. As long as the patient's legs are lower than their heart and immobile they will be susceptible to injury.

• If a patient must be raised or lowered in a vertical orientation, attempt to minimize the time suspended in this orientation. Elevate their legs if warning signs develop.

• Having a conscious patient do leg contractions can assist with circulation in their legs.

• Suspension trauma has resulted in the death of relatively uninjured casualties, depending on the subject and their harness type, while suspended upright for as little as 10-30 minutes.

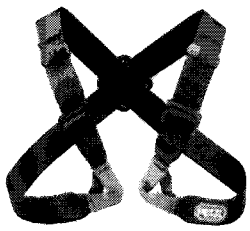
Sources:

- Greenfield, John. **Suspension Trauma- Who Is At Risk?** High Access Rescue Team, Glasgow, UK. Paper presented at Safe Working At Height Conference- October 2002, Birmingham, UK. http://www.remotemedics.co.uk/0069.htm
- Millar, Dr. Ian. **Suspension Induced Shock Syndrome**. Rescue Training Resource and Guide. 2002. http://www.alpineclub-edm.org/accidents/SuspensionInducedShockSyndrome.htm
- United States Air Force- Air Force Aerospace Medical Research Laboratory; **Fall Arrest and Post-Fall Suspension**. 1984. Wright-Patterson AFB, Dayton, OH.

NOTES:

Chest Harness- provides upright stability for rescuer when ascending when used with a seat harness. A chest harness is not meant to be used alone.

- A ***connector strap***, which creates a sliding link between the seat and chest harness, maintains an upright position of rescuer even if they lose consciousness. This connector strap should be incorporated when the main line and belay line are joined together somewhere above the rescuer (e.g. rescue litter master attachment point).



Petzl Voltige Chest Harness

- **Full Body Harness-** an alternative to seat/chest harness combination.
- **Hoisting Vest** "Screamer Suit"- military fishnet suit used for helicopter hoisting.
- **Petzl Rescue Evacuation Triangle** (Bermude or Pitagor)- fast device for pick-off situations.
- Improvised harnesses are very effective for stabilizing a stranded climber. These can be easily tied with practice from a webbing runner. Comfort is sacrificed with the lack of padding to the leg loops.

RELATIVE BREAKING STRENGTHS OF RESCUE EQUIPMENT

ITEM	AVG. BREAKING STRENGTH: kN/lbs.
4 mm Accessory Cord (Mammut Brand)	3 kN/720 lbs.
5 mm Accessory Cord (Mammut Brand)	5 kN/1,125 lbs.
5.5 mm Spectra™ Cord (Bluewater Spectra)	18 kN/4,005 lbs.
6 mm Accessory Cord (Mammut Brand)	8 kN/1,732 lbs.
7 mm Accessory Cord (Mammut Brand)	10 kN/2,250 lbs.
8 mm Accessory Cord (Mammut Brand)	15 kN/3,375 lbs.
11 mm Low-Stretch Rope (PMI Brand Max Wear)	**27 kN/ 6050 lbs.**
1 inch Mil-Spec Tubular Webbing	18 kN/4,000 lbs
1 inch *Type 18* Heavy Duty Flat Webbing	27 kN/6,000 lbs.
Climb Spec Webbing, 9/16" (Bluewater Brand)	10 kN/2,295 lbs.
Bluewater Spectra™ Sewn Runners, 9/16"	27 kN/6,075 lbs.
Petzl Prusik-Minding Pulley (P60)	36 kN/8,100 lbs.
Traverse Rescue 540° ™ Rescue Belay	40 kN/9,000 lbs.
RA/SMC Figure Eight With Ears	40 kN/9,000 lbs.
Maillon-Rapide Triangular Link, 10 mm, Plated Steel	44 kN/9,900 lbs.
Carabiners:	
SMC Aluminum Non-Locking Oval	21 kN/4,640 lbs.
SMC Aluminum Locking D	28 kN/6,190 lbs.
SMC Lite Stainless Steel	40 kN/8,946 lbs.
SMC Large Steel Locking D	51 kN/11,590 lbs.
Petzl Spirit, Locking	23 kN/5,175 lbs.
Petzl AM'D Locking Carabiner (M17)	28 kN/6,300 lbs.
Petzl FDC Extra Large Locking Carabiner (M27)	41 kN/9,225 lbs.
Spring Loaded Camming Devices (SLCD):	
Wild Country Technical Friends, sizes 0-4	10-15 kN
Black Diamond Camalots™, sizes 1-5	12-16 kN

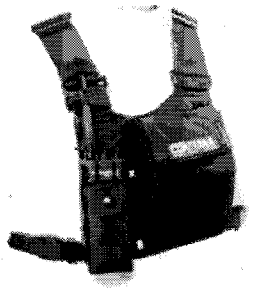
Petzl Bermude Evacuation Triangle

Note: 1 kiloNewton (kN) = force of 225 lbs

NOTES:

OTHER PERSONAL EQUIPMENT

Cutting Tool- a person wielding a sharp knife around tensioned ropes is dangerous . Trauma scissors or a rescue hook knife are recommended.
Eye Protection- sunglasses and goggles.
Headlamp- a durable and compact headlamp should be carried at all times.
Footwear- boots with a sole that provide adequate traction are essential.
Gloves- leather gloves provide excellent protection for rappelling, ascending and litter carries.
Radio Chest Harness- protect your expensive communications tool. Carry an extra radio battery.



Conterra Radio Chest Harness

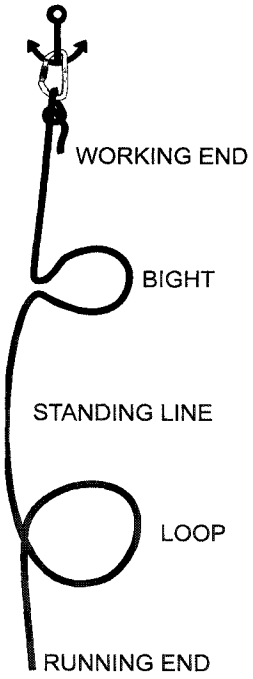
TIES: KNOTS, BENDS, AND HITCHES

Factors that make knots or other ties superior to others includes the ability of the knot to remain tied, the ease of untying and the relative strength. As a general rule of thumb, *a rescue knot reduces the strength of the rope by one third.* This is due to sharp bends in the rope created by the knot. The strength of the knot will be affected by the sharpness of these bends and the angle at which the rope leaves the knot.

Other important factors in knot tying are dressing knots so they are neat and also pre-tensioning or "setting" a knot. When appropriate a backup knot is tied with the excess tail using a double overhand knot. A half hitch does not make an acceptable backup knot.

Knot Terminology:

- ☐ WORKING END ; The anchored end of the rope.
- ☐ RUNNING END ; The end of the rope toward the load or the end that is not tied off. In a lead climbing situation this is often referred to as the "sharp end."
- ☐ STANDING LINE; All of the rope that is not fastened to a rigging point.
- ☐ BIGHT; A U-shaped bend formed in the rope by folding a section of the rope with one hand.
- ☐ LOOP; The rope forms a circle and crosses over itself.
- ☐ KNOT; A tie that intertwines within itself.
- ☐ BENDS; A tie that joins two rope ends.
- ☐ HITCHES; A tie that attaches a rope to another object in a way that if the object is removed, the hitch falls apart (the object is required for construction) e.g. clove hitch.
- ☐ SPLICES (not used in rescue); Joins two ropes by interweaving the strands.



NOTES:

Bowline-

This is a versatile knot that has unfortunately received a bad reputation in the past with regard to rescue rigging applications. The bowline is not significantly weaker than a figure eight knot. Although the bowline is a very efficient knot it has been known to work itself loose under repeated loadings, therefore it is best tie an overhand or double overhand backup with the tail for security. The bowline is easier to untie after being tensioned in use.

- **"It (bowline) is considered one of the preferred knots and a *"must know"* for rigging."**
  -Bruce Smith. *ON ROPE -Revised Edition.*

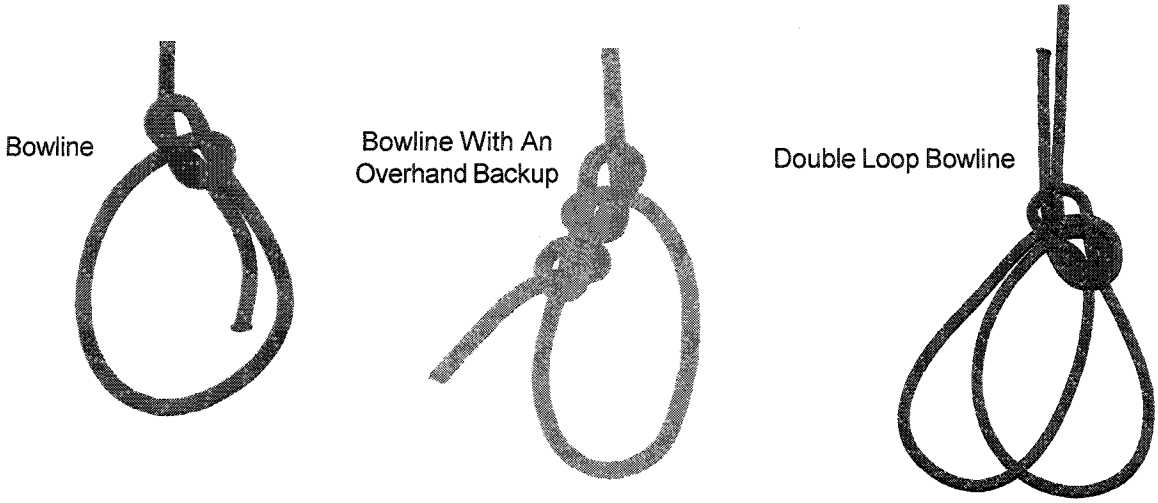
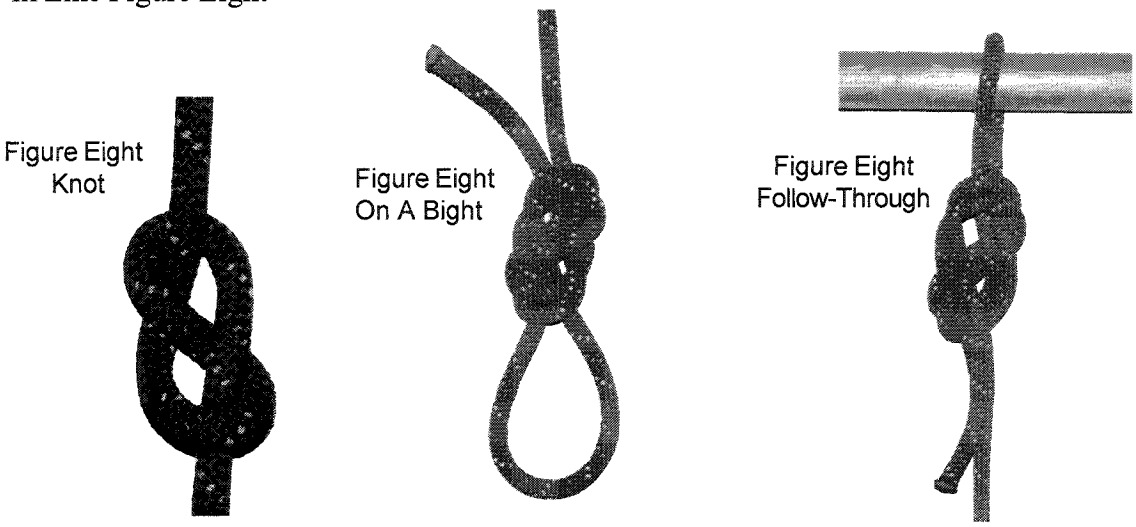


Figure Eight Family Of Knots-

A very versatile group of knots that are simple to tie and easily inspected.

- Figure Eight
- Figure Eight Follow Through Bend (Flemish Bend)
- Figure Eight On A Bight
- Double Loop Figure Eight
- In Line Figure Eight



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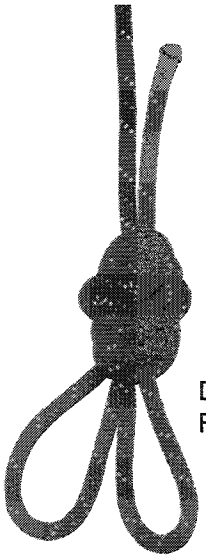


Double Loop
Figure Eight

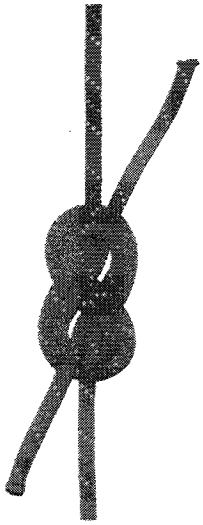
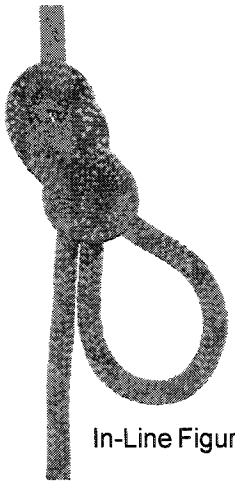


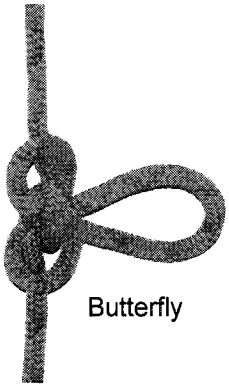
Figure Eight
Bend



In-Line Figure Eight

Other Useful Knots-

- Butterfly

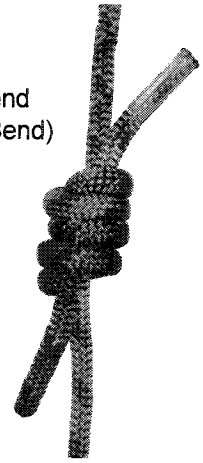


Butterfly

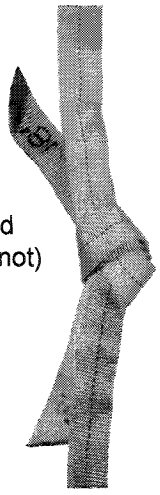
Bends-

- Double Overhand Bend (Double Fisherman's Bend).
- Ring Bend (Water "Knot", Overhand Follow-Through, Tape "Knot").

Double Overhand Bend
(Double Fisherman's Bend)



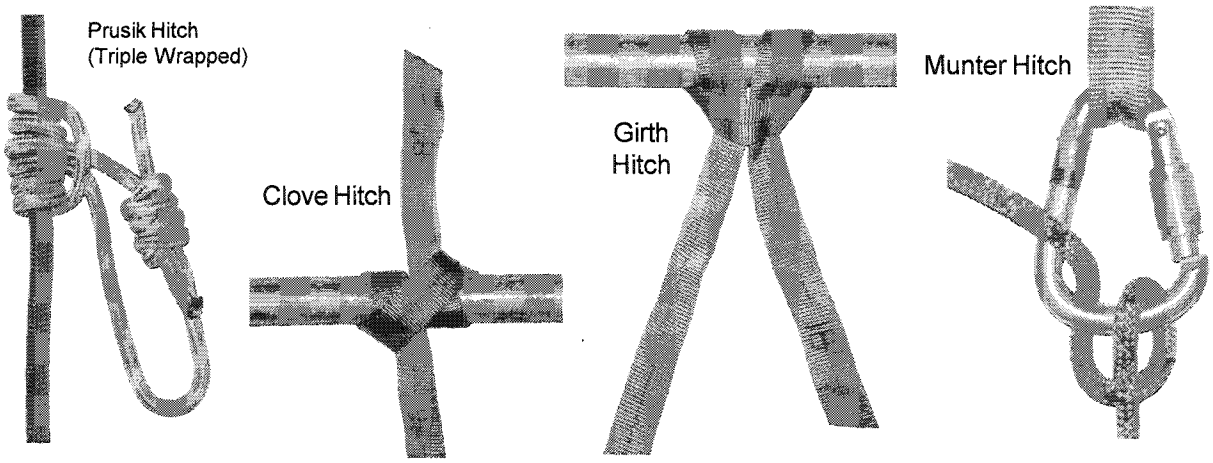
Ring Bend
(Water Knot)



NOTES:

Hitches-

- Prusik Hitch (two or three wrap depending on type of load and application)
- Clove Hitch
- Girth Hitch
- Münter Hitch (see rappelling section)



RELATIVE STRENGTH OF KNOTS (Varies With Rope Type)
Reduction in strength with knot

No Knot	100%
Figure Eight	75% - 80%
Bowline	70% - 75%
Double Overhand Bend ("Double Fisherman's")	65% - 70%
Ring Bend ("Water Knot")	60% - 70%
Clove Hitch	60% - 65%
Square Knot (Do Not Use!)	43% - 47%

Note: Remember these values are based upon static pull testing, not dynamic loading.

NOTES:

BELAYING TECHNIQUES

•**Belay-** The act of using a rope or backup procedure to prevent a person or load from taking a serious fall. In two rope systems, it is a separate, untensioned rope managed by someone other than the attendant.

•**Self Belay-** Protection against a fall is provided by a climber/rescuer moving their adjustable connection point along a fixed rope. This connection point remains untensioned unless a fall occurs.

•**Conditional Belay-** Fall protection is provided through the use of a rope, that is already under tension from part or all of the load, to hold the load should failure occur in some other part of the system (e.g. dual rope lowering system , bottom belay on rappel).

•**Conditional Self Belay-** Protection is provided against a fall through the use of a self belay that is managed by the climber/rescuer needing the protection.

•**Auto Belay-** A positive auto locking device (deadman) that does not require a positive action to engage it (e.g. Tandem Prusiks, auto-stop descender).

•**Pseudo Belay-** A belay that will not function properly if activated.

*-adapted from **Belay Definitions**, originally prepared by Arnör Larson, Rigging For Rescue.*

REQUIREMENTS OF A RESCUE LOAD BELAY:

• In 1982 the British Columbia Council of Technical Rescue (BCCTR) tested many standard belay devices, and found these techniques were unable to hold a zero fall factor with a rescue load mass (440 lbs or 200 kg) on a static line. The following techniques were unable to hold a static fall; Münter Hitch, Stitch belay plate, Figure Eight device, and the body belay.

• Rescue teams have previously employed a Gibbs Ascender as a rescue belay device. However, during drop testing, a Gibbs Ascender catching a rescue load dropping greater than 20 inches severed the rope. It is important to understand that a Gibbs ascender was only designed as a rope grab device to handle a single person load on an overhead fixed rope. The manufacturer does not endorse its use a rescue load belay device. Rescue personnel should always read and follow the manufacturer recommendations for the use of any commercial rope rescue product.

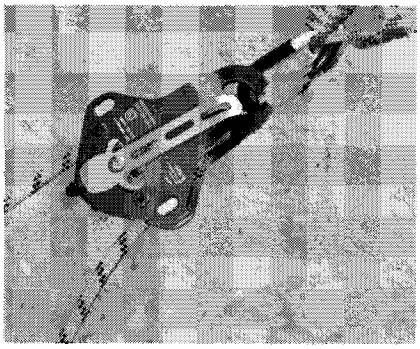
Characteristics Of A Good Rescue Belay: (developed by BCCTR)

1.) Be able to catch a fall without rescuer attending it.
2.) Catch a fall without damaging the line to the point of being useless.
3.) Stop a fall in the shortest distance possible, commensurate with an acceptable stopping force.
4.) Minimum capacity of handling a 440 lbs. "rescue load" (200 kg).

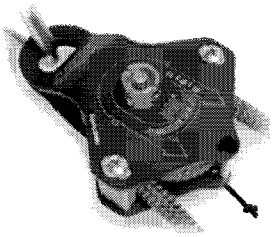
• Many rescuers cling to the misguided notion that a Figure Eight device is an appropriate belay device for a rescue load (400 lbs or 200 kg). This has been disproved in repeated drop testing experiments. **Currently the most consistently reliable techniques for belaying a rescue load are the Tandem Prusik Belay technique as well as the *540°™ Rescue Belay.***

NOTES:

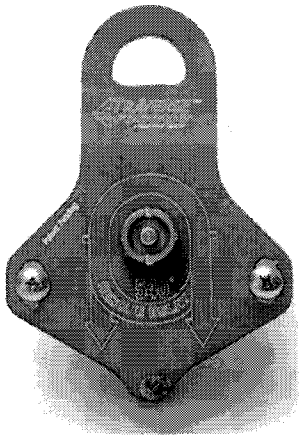
540°™ RESCUE BELAY

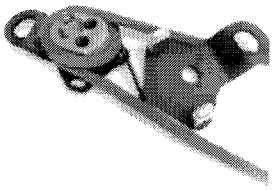


The 540°™ Rescue Belay was designed by Kirk Mauthner of Rigging For Rescue and is manufactured by Traverse Rescue, Kelowna, B.C. This self-locking device is capable of holding a falling rescue load quickly, while limiting the peak force applied to the rope. The device has a symmetrical internal design which permits bi-directional loading. A built-in release lever releases the tension on the belay rope, eliminating the need for a release hitch. UL Certified to NFPA1983 (1995 edition) "General Use" rating with a minimum rated breaking strength (MBS) 9,000 lbf (40 kN). Weight 1.5 lbs (680 grams).



"The 540°™ Rescue Belay passes the British Columbia Council of Technical Rescue's demanding Belay Competence Drop Test Criteria of being able to catch a 1 m drop of a 280 kg (617 lbm)[pounds of mass] rescue-sized load onto 3 m of 12.7 mm kernmantle rescue rope, within 1 m of additional travel (pre-rebound), and with less than 15 kN peak force."



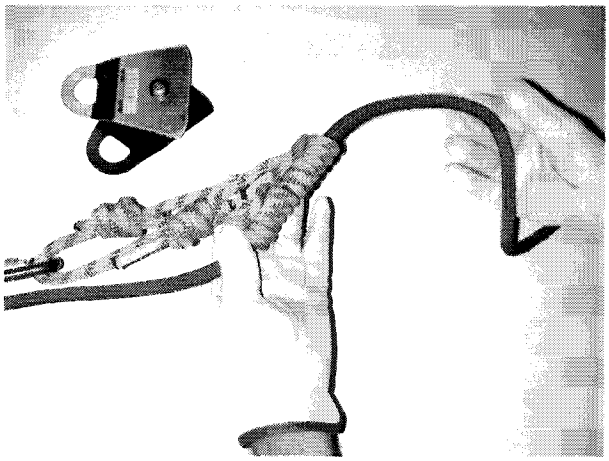


"For example, a sample test of 1 m drop on 3 m of 12.5 mm PMI EZ Bend rope with a 280 kg mass resulted in a peak force of 12.9 kN with only 62 cm of additional travel, pre-rebound, and only 24 cm of rope slippage through the 540°™ Rescue Belay." -Rigging For Rescue, Ouray, CO

[In comparison 8mm Tandem Prusiks generated a peak force of 17.3 kN]

TANDEM PRUSIK BELAY:

The Tandem Prusik Belay was developed as a field practical alternative in order to provide a reliable rescue load belay technique. During the tests, the Prusiks typically "settled in" and glazed the host rope. If they did slip, they melted slightly before holding the fall, but left the belay line intact. This technique utilizes two triple-wrapped Prusik Hitches attached between the belay anchor and the belay rope. These Prusiks are 8mm, triple wrapped, kernmantle construction, which are properly dressed and snug. The short Prusik of the pair will usually be the first one to catch and the longer one is available for redundancy in addition to providing better heat dissipation in the event of a sudden shock force

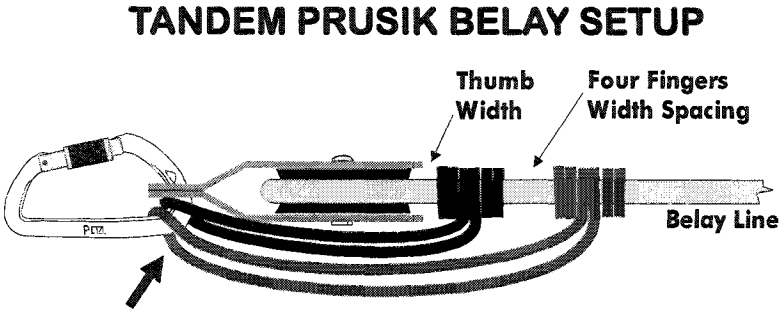


Tandem Prusik Belay (Rigged)

NOTES:

being applied. The Tandem Prusik Belay consistently held falls of 1 meter on 3 meters of rope without damage to the main line and almost no damage to the Prusiks (For further reference- *Are You Really On Belay?*, by John Dill, NASAR Response Reprint, Summer/Fall 1990).

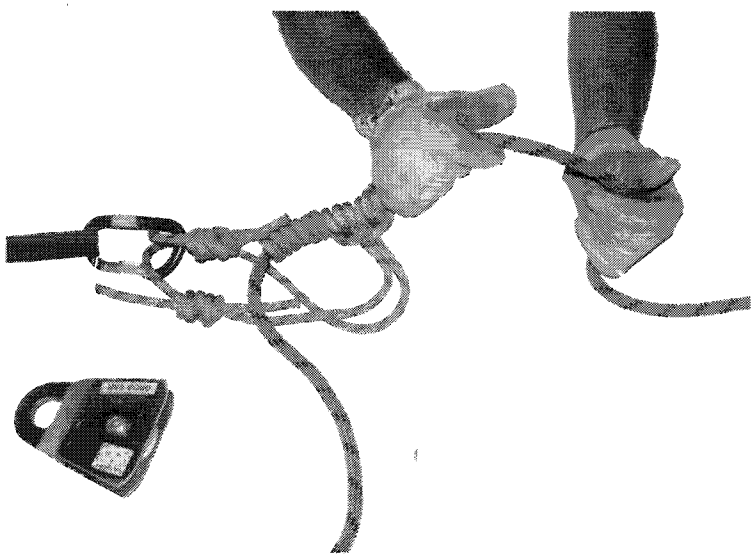
•To construct the most efficiently sized set of tandem Prusiks, the finished short Prusik Hitch should allow *one thumb width* in front of the Prusik-minding pulley (PMP) on the host rope and *four fingers width* of spacing between the two Prusik Hitches. This will allow adequate working distance from the pulley without excessive slack to create potential shock forces if activated. Start with 8 mm nylon kernmantle cordage cut to the following lengths; **53 inches (1.35 meters) and 65 inches (1.65-1.70 meters).** Keep in mind these sizes will vary according to brand and model of Prusik-minding pulley employed. Tie these with 1.25 inch (apx. 25-30 mm) tails. These must be three wrap Prusiks in order to catch a rescue load. **Prusiks need to be properly dressed and snug.**



Sequence Of Loading Carabiner Is Long Prusik First Against Spine, Followed By Short Prusik And Then Prusik-Minding Pulley.

•Be careful to not employ Prusik cord that is too stiff. **Check the Prusiks prior to the belay being put into service to be certain they will grab!** Use a "pinch test" for optimal cordage, that when pinched between two fingers in a bight will leave a gap 1/2 the diameter of the material.

•Tending the tandem Prusiks by hand during a lowering requires constant attention by the belayer to keep the Prusiks snug but free-running. An error in concentration could lead to accidental activation of the Prusik hitches by the belayer, which would require untensioning the belay line and unnecessarily delay the rescue operation. On a lowering, the belayer should hold both hitches with one hand and pull out some slack in the belay rope with the



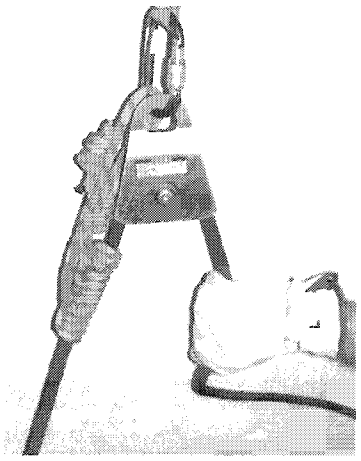
NOTE: For clarity in this photo the belayer's right hand has been intentionally moved to their left. Actual field technique involves the belayer holding their right hand around both Prusiks.

Tandem Prusik Belay Technique- Lowering

NOTES:

other hand as they attempt to "feel the load". As the load takes the slack, the hand rotates and slides back to pull another bight of slack. The Prusiks should be held (with fingers open in event belay activation) perpendicular to the plane of the belay line, which provides greater chance for the Prusik hitches to grab, as opposed to an in-line position. The belayer also coordinates their actions through the Edge Manager, who keeps the belay line taunt and provides feedback on slack in the system.

•During a raising operation, a Prusik-minding pulley may be incorporated to pull the belay line through it. Place the loop of the long Prusik into the carabiner first, so that it is against the carabiner spine, followed by the short Prusik loop and finally the Prusik-minding Pulley closest to the gate. The pulley aids in keeping the Prusiks and any shock forces they transfer against the spine, which is the strongest part of the carabiner.



Tandem Prusik Belay Technique- Raising Phase

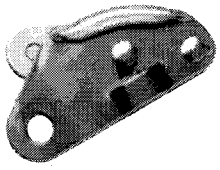
WARNING: Don't overlook the fact that the Prusiks must be <u>constantly</u> properly tended. Make certain they have not become too loose and will work in their intended manner of function.

PERSONAL LOAD BELAY:

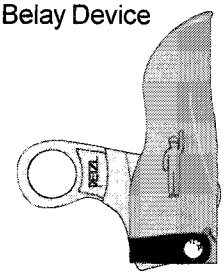
- Manual (body/hip belay): <u>Not used</u> for rescue applications. This is due to the fact that during rescue operations there exists the need to remain independent of your belay system for flexibility.

- Mechanical belay devices include; Sticht plate, Petzl Grigri, Petzl Reverso, Black Diamond ATC (Air Traffic Controller), Wild Country Varible Controller, Trango Jaws, Trango Pyramid, Figure Eight plate, Münter Hitch or Prusiks.

- Shunt Device (Spelean shunt or Petzl Shunt): Allows changeover while ascending or rappelling. This device is rated for a one person load only.



Petzl Grigri Mechanical Belay Device



PETZL SHUNT

GENERAL RULES OF BELAYING:

- Designate a "brake hand" and "guide hand"
- **WHEN USING A MANUAL BELAY, NEVER LET GO WITH YOUR BRAKE HAND!**
- Remain independent of the system and belay directly off an anchor instead of a rescuer.
- Belayer should be tied in when positioned near significant exposure.
- Belayer sits behind or to one side of the belay device for personal safety.
- In rescue work, keep a snug belay rope to avoid shock forces.
- Gloves should be employed by the belayer.
- Belay practice and proper technique is essential.

NOTES:

LOAD RELEASE DEVICE:

• A load releasing device is designed to loosen and extend it while under tension without having to raise the load. Useful when the belay Prusiks grab accidently during a lower or when the load becomes stuck during a raising (e.g. litter caught by an overhang). The release device can also be employed in knot passing techniques.

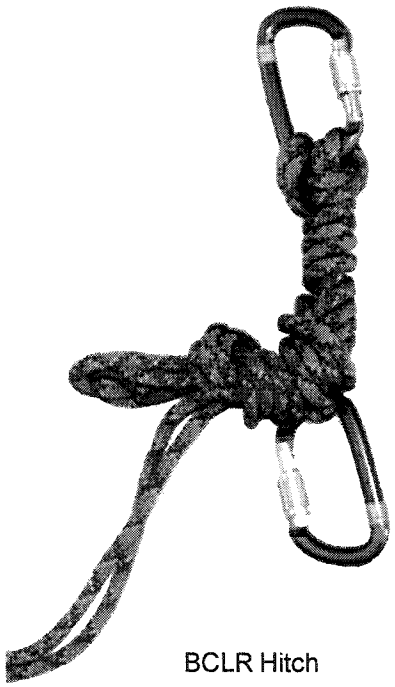
• CMC Hitch is one type of load release device that releases well, but does not absorb energy as well as the BCLR Hitch when stopping a fall. Additionally the release distance is inadequate.

• The BCLR Hitch (*after Arnör Larson*) releases well, but also *absorbs some of the shock forces* generated during a system failure. When used in conjunction with tandem Prusiks it was typically able to hold 2.5-3.0 meters (10') falls on 3 meters of rope.

• The ten meters of cordage length used in the BCLR Hitch allow it to accommodate a main line failure which results in 2.5 meters of stretch as the belay line is tensioned. Transferring the tension back to a new main line requires an additional 2.5 meters of extension. Many commercially manufactured load release devices do not permit this much extension.

• Construct a BCLR Hitch with 10 meters (33') of 8 mm low stretch kernmantle and tie a Münter Hitch with a doubled rope between two locking carabiners. Finish with wrapping the tail in a spiral around the cordage between the two locking carabiners with three wraps and incorporate a stopper knot at the end **(see illustration).**

• The BCLR Hitch is rigged into a system with the Münter Hitch end toward the anchor so if the belayer employs it, they are able to lower the load away from them without having to move from their position.

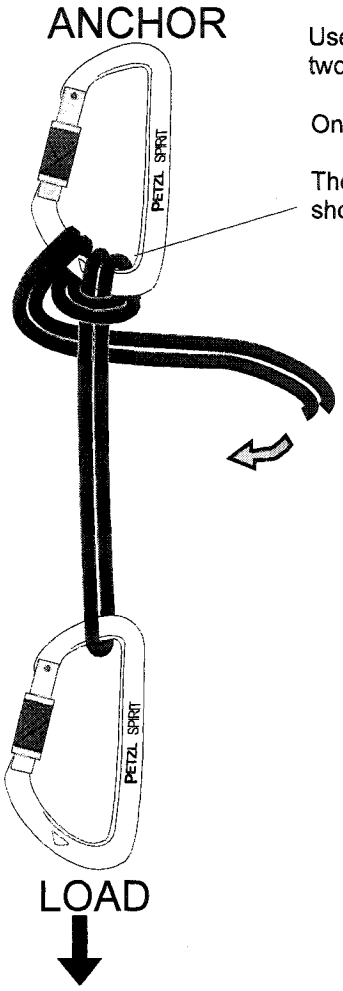


BCLR Hitch

• Radium Release Hitch is an alternative load-releasing hitch. The 3:1 mechanical advantage **Radium Release Hitch** which was developed by Rigging For Rescue. This hitch also uses ten meters of 8mm cord in its construction.

NOTES:

Load-Releasing Hitching (BCLR Hitch) (after Arnör Larson)



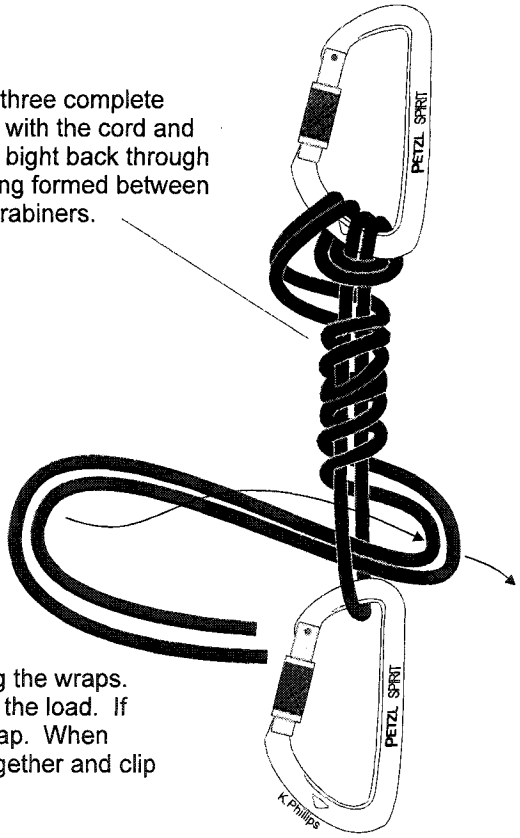
Use 10 meters (33 feet) of 8-mm low-stretch kernmantle cord and two locking carabiners.

On a doubled line tie a Münter Hitch.

The high (load side) of the Münter Hitch should be next to the carabiner spine.

Keep the BCLR Hitch as compact as possible. Allow just enough room between carabiners for at least three wraps and a securing knot.

Make three complete wraps with the cord and tuck a bight back through the sling formed between the carabiners.



Tie the ends in a manner that is secure yet allows the hitch to untied under tension. Secure the tails in two consecutive overhand knots. Construct secure wraps and overhand knots.

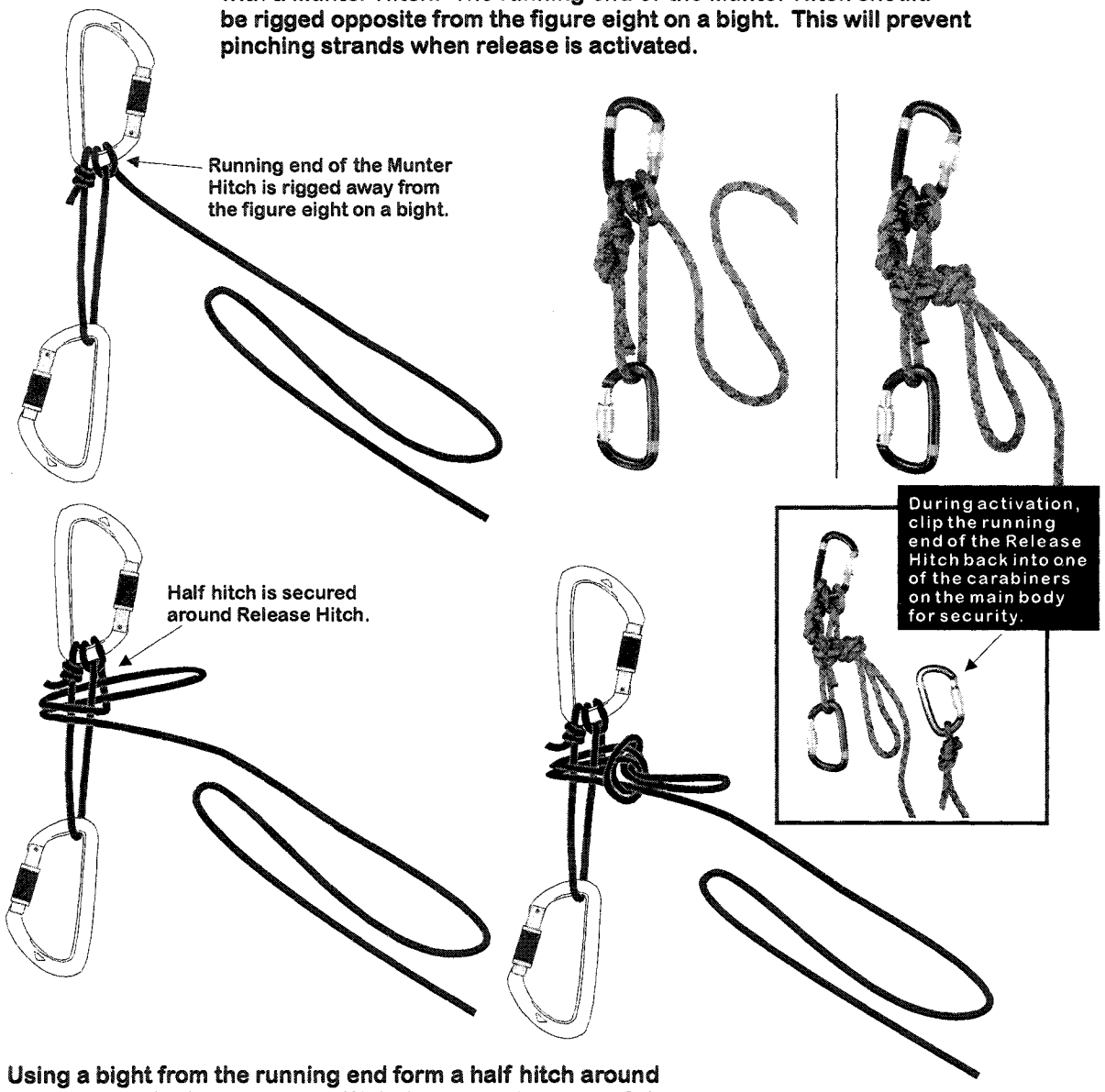
To lower the load, untie the knots while holding the wraps. Feed slack through the BCLR Hitch and lower the load. If too much friction is encountered, remove a wrap. When lowering to the limit of the hitch, tie the tails together and clip in a safety carabiner.

NOTES:

RADIUM RELEASE HITCH

-After Rigging For Rescue

Use ten meters of 8mm cord, which permits a five meter release. Begin at one end with a figure eight on a bight clipped into the upper carabiner and positioned close to the spine. Run the cord down through the lower carabiner and back to the upper carabiner with a Munter Hitch. The running end of the Munter Hitch should be rigged opposite from the figure eight on a bight. This will prevent pinching strands when release is activated.



Using a bight from the running end form a half hitch around the Release Hitch to secure it. With the remaining part of the bight, finish with an overhand knot around the tail for added security as a stopper knot.

Ken Phillips 03-99

NOTES:

Radium Release Hitch (3:1 variation) — *Rigging for Rescue®—Notes*

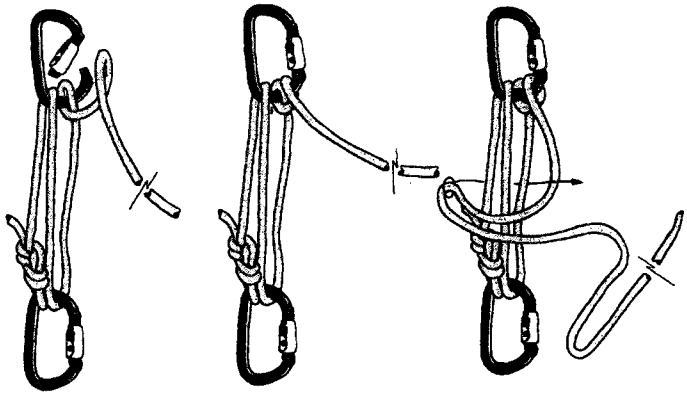
The Radium Release Hitch was developed by *Rigging for Rescue* (with input from Arnör Larson) as a result of the extensive comparative analysis of release devices[1] undertaken during 1997 through 1999.

Materials Required

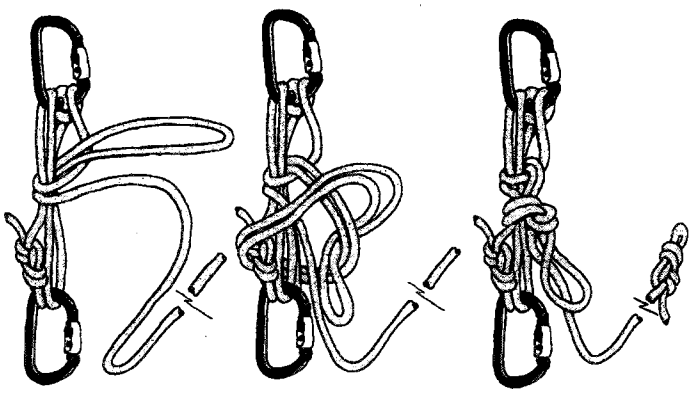
10 m of 8 mm nylon low stretch kernmantle cord and 2 locking carabiners

How to Tie

1. Tie a figure-of-8-on-a-bight and clip it into the load-side carabiner on its spine side.
2. Clip the standing part of the cord up through the anchor carabiner, back down through the load carabiner; bring back up to the anchor and tie a Münter Hitch onto that anchor carabiner on its gate side. Ensure that the Münter Hitch is in the release position with the in-feed rope towards the gate side of the carabiner. A reasonable length for the hitch is 10 to 15 cm.
3. Secure the Radium Release Hitch using a bight to tie a half hitch around the entire stem <u>below</u> the Münter Hitch, and then back it up with an overhand-on-a-bight knot, again around the entire stem.
4. Tie a figure-of-8-on-a-bight at the other end and clip it to a secure anchor if desired.



For illustrative purposes, the half-hitch and overhand tie-offs are not shown tied tight up against the Münter Hitch. In actual use, ensure that this is done.



Artwork courtesy of Rick Lipke.

[1] For additional information, please refer to the complete report "Release Devices: A Comparative Analysis" by Katie and Kirk Mauthner, *Rigging for Rescue* (December 1999).

NOTES:

STANDARD CLIMBING SIGNALS

Belayer	Climber/Rescuer	Meaning
	"On Belay"	You ready yet?
"Belay On"		Belay is ready.
	"Climbing"	Off I go.
"Climb"		Off you go.
	"Slack"	Give me rope.
"Thank You"		Understood.
	"Up Rope"	Take Up Slack.
"Thank You"		Understood.
	"Off Belay"	I'm secure.
"Belay Off"		Understood.
"Face Right"		Right side of cliff facing the rock.
"ROCK!"	**"ROCK!"**	Echoed By All.

ANCHORS

GUIDELINES FOR ANCHOR SYSTEM CONSTRUCTION:

-Considerations For Efficient Scene Management

1. Where do you need to go?

- Select an efficient fall line in order to reach the victim.
- Avoid rappelling down on top of victim, in a manner that causes rockfall injury.
- Lowering route selection should avoid additional hazardous terrain if possible.
- Is a *deviation* pulley required to redirect the fall line of the rope?
- What rescue tasks need to be accomplished (e.g. edge management, lowering, raising or a traverse)?

2. Where should the anchor "focal point" be located?

- Raising the focal point off the ground increases efficiency of belayer/attendant.
- Is a floating focal point necessary?
- Does the focal point require pretensioned back-ties or front-ties?
- Focal point prevents extension of an anchor point in load-sharing anchor system.

3. What anchor points should be used?

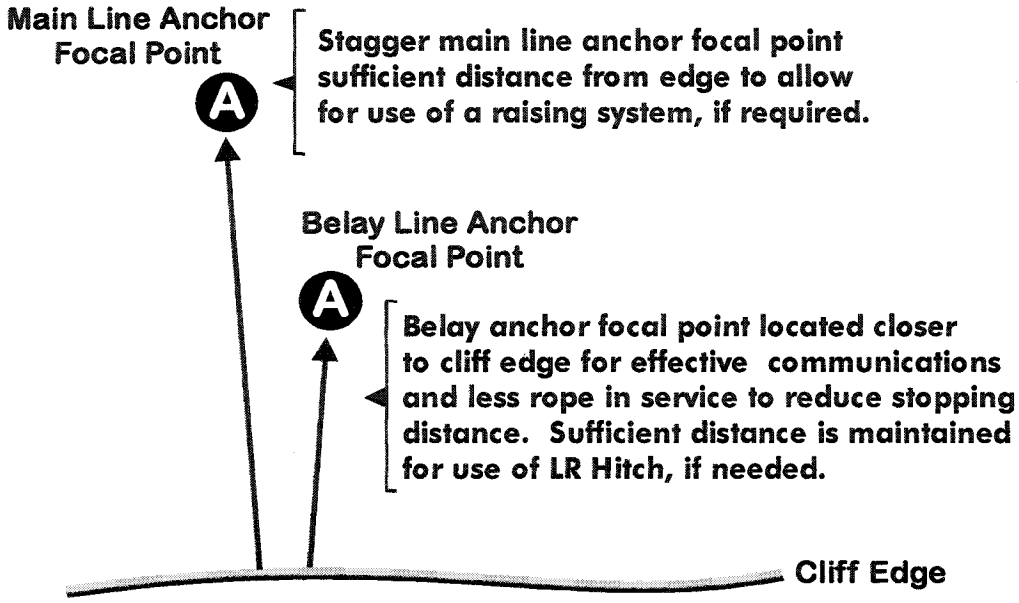
- Pad anchor points with sharp edges.
- Evaluate the integrity of the anchor points being utilized.
- Anchor point should not be hot to the touch or exposed rope to Haz-Mat.

NOTES:

- Use more than one anchor point for redundancy- avoid reliance on a single feature or placement of one piece of artificial protection (e.g. bolt or camming device).
- Attach at the base of an "anchor point" to prevent a leverage situation.

4. What directionals are available if needed?

- A directional may be needed for the use of certain anchor points.
- Is an artificial high directional needed at the edge?
- Rig the focal point high to take advantage of any natural high directionals (e.g. stair-stepped edge) and allow for more efficient edge management with a litter.



LOCATING BELAY AND MAIN LINE ANCHOR POINTS

ANCHOR CONSTRUCTION TERMINOLOGY:

☐ *Anchor Point*- Single connection point (e.g. tree, camming device, etc.).

☐ *Anchor System*- Multiple anchor points rigged together creating redundant system.

☐ *Deviation*- Redirects the natural fall line of the rope on the rock face. A deviation point is not meant to be subjected to the same force as the primary rig point.

☐ *Directional*- Rigging technique to change the natural lie of a rope with a carabiner or pulley attached to an alternative anchor.

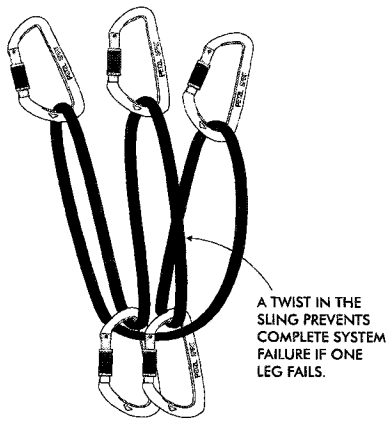
☐ *Focal Point*- A location, floating or fixed, where all rigging is directed for anchor points. This concept disciplines rescuers to construct rigging which joins together at an efficient point, rather than linking handy anchor points together and finding the end result lands in an awkward spot to manage rope handling tasks.

☐ *High-Strength Tie-Off*- Several wraps of rope around an anchor point (e.g. large tree or rock) that employs nearly the full strength of the rope by avoiding any knots or sharp bends in the line. This was formerly referred to as a tensionless anchor.

NOTES:

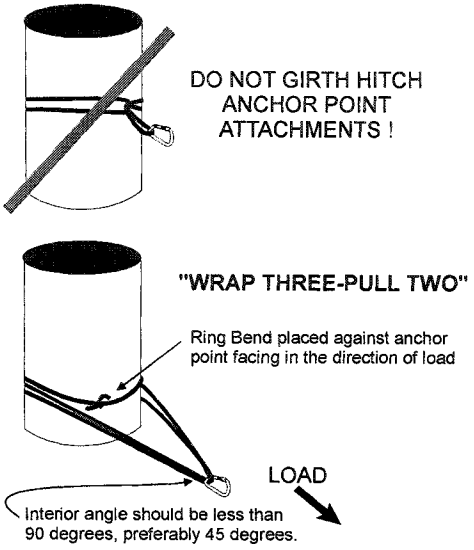
☐ *Load Distributing Anchor-* Incorrectly referred in the past as a "self-equalizing anchor" (SEA), due to the moveable/adjustable legs of the anchor system. In reality though anchor systems do not precisely distribute the load in an equal manner between all anchor points, hence the "load-distributing" label. **CAUTION: In the event one of the anchor points fails- there will be a shock force created by the sudden extension of the load-distributing anchor system.**

☐ *Load Sharing Anchor (aka Cordelette)-* Anchor system where the load is distributed between two or more anchor points, but not necessarily equally. The key distinction from a load-distributing anchor is that the legs of the anchor system are a fixed length and will not adjust once rigged. This advantage makes it a superior technique for rigging rescue anchor systems.

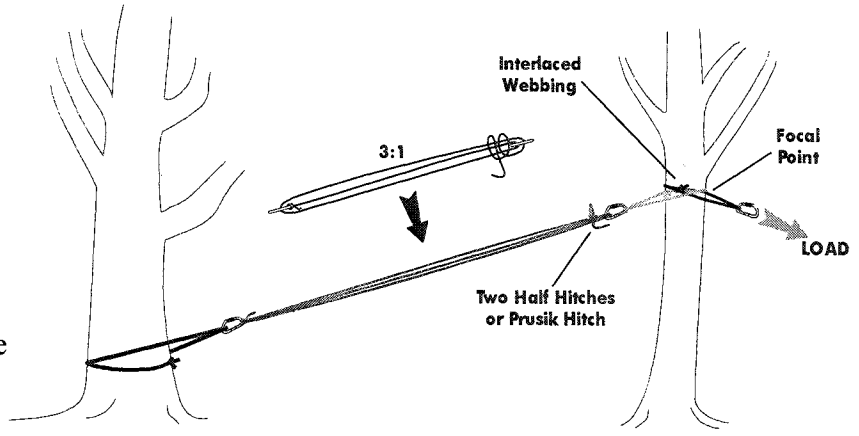


LOAD DISTRIBUTING ANCHOR SYSTEM

"WRAP THREE-PULL TWO"; Do not girth hitch anchor points. Wrap the rope or webbing loosely three times around anchor point and tie the ends with a ring bend ("water knot"). Pull two of the wraps away from the anchor point and allow the third wrap with the ring bend to cinch around the anchor point. The ring bend should be facing the direction of the load, which is primarily for ease of inspection. The friction in the remaining wraps will also prevent the ring bend, which is the weakest spot, from becoming significantly tensioned. The interior angle of the webbing is important to prevent excessive forces on the webbing. The strength of this anchor rigging can easily exceed 25 kN, which is obviously limited by the structural integrity of the anchor point itself.



PRETENSIONED BACK-TIE; The purpose of a pretensioned back-tie, constructed to backup anchor points, serves to prevent movement in the main anchor and provide for redundancy in the anchor system. The webbing wraps of the focal point need to be interwoven with at least one wrap of the webbing connecting to the back-tie connection in order to have integrity with the back-tie anchor point. A 3:1 mechanical advantage system is strung between the front

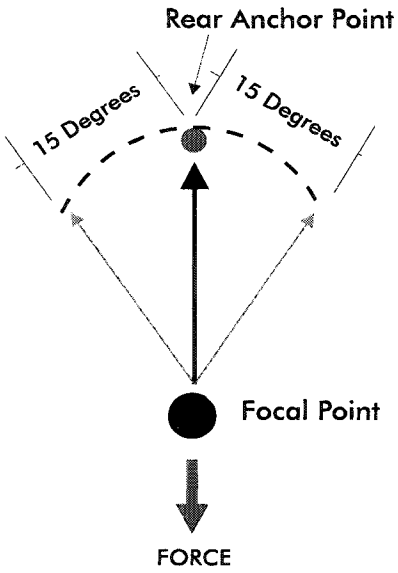


PRE-TENSIONED BACK-TIE

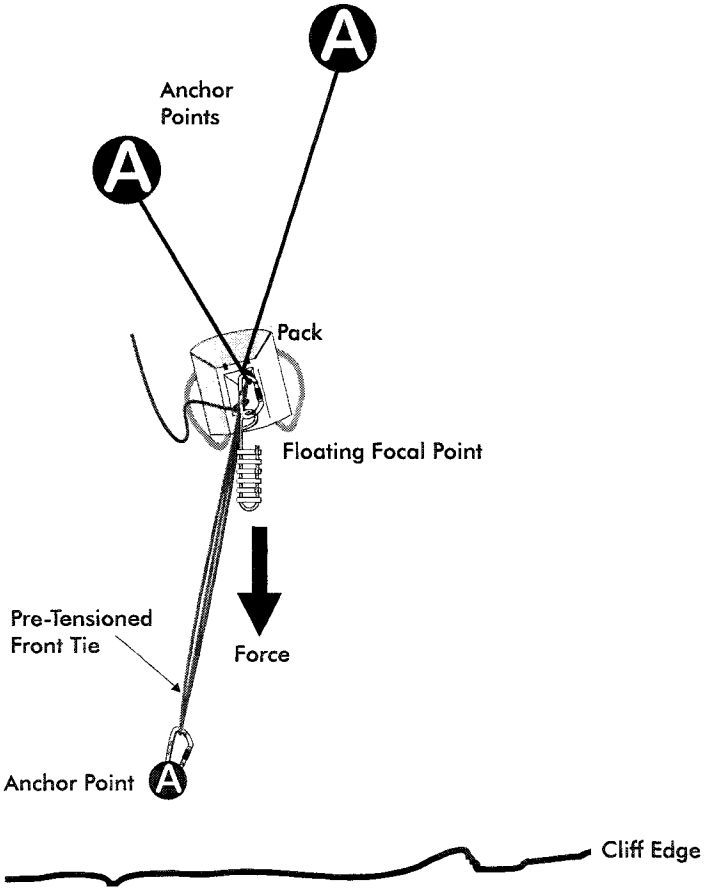
NOTES:

and rear anchor points using carabiners instead of pulleys. If the line is constructed with one end starting at the rear anchor, then the tie will be finished at the front anchor leaving the remaining line to be flaked nearby and available for the edge if needed.

To tension the back-tie the 3:1 hauling system is pulled tight by at least two people. After the bundle of strands is sufficiently tight, push sideways on the rigging to "vector" it for additional tensioning in order to get any remaining stretch out of the rope. The finishing tie is completed with slippery half-hitches to locked it off.



The alignment of the front and rear anchor point need to be within 15° either side of in-line to the fall line (30° total width). If the angle is greater than 30°, use two pretensioned back-ties to balance the offset forces. Two pretensioned back-ties can be constructed with a single line if the distances are not too great, by starting at the focal point and splitting the rope to use half the line rearward on each back-tie.



The Petzl *Paw* Rigging Plate Provides An Organized Means To Rig Anchor Systems Where Multiple Lines Are Joined At A Common Point.

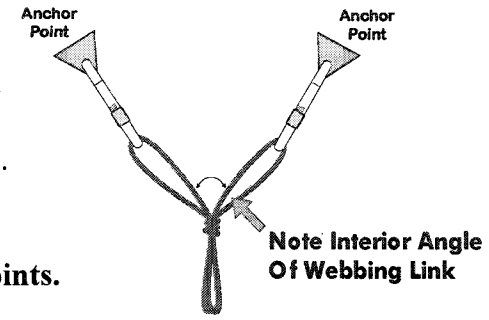
NOTES:

RELATIONSHIP OF ANCHOR TENSION AND LOAD:

-Refers to the load on each leg of an anchor created by force vectors.

When the angle is 0°; 50% of the load is on each leg.
When the angle is 90°; ≈70% of the load is on each leg.
When the angle is 120°; 100% of the load is on each leg.
When the angle is 170°; 1150% of the load is on each leg.

• ***NOTE: Less than 90° is essential and 45° is preferred.***



□ **A rescue anchor system should consist of <u>two</u> anchor points.**

•Anchor systems should pass both the whistle test and the catastrophic failure test. Make sure to have two separate equalized or redundant systems for both the primary anchor and belay anchor, even if you use the same anchor point.

□ **IMPORTANT: Extend your anchor points rather than extending the anchor system!**

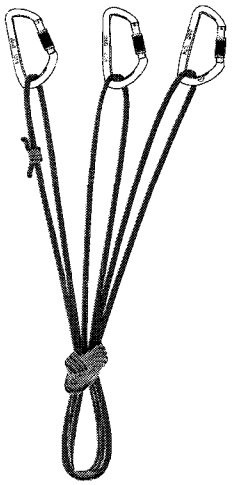
HIGH STRENGTH TIE-OFF (Formerly Tensionless Anchor):

An efficient method of attaching a line to an anchor point, which provides for most of the original rope strength to still be available. The end of the line is wrapped up to three times around the anchor point and then finally attached back to the main line at a 90° angle. The number of wraps is completely dependent upon the anchor point and the amount of friction provided by the surface. Canvas wrapped around a tree trunk can be used to protect the bark from damage and the line can be protected in this manner from sap on the tree. There is no advantage in using this high-strength technique if a knot is going to be tied into the running end of the rope and loaded, since the knot immediately lowers the strength of the system by one third.

LOAD-SHARING ANCHOR SYSTEM (*"CORDELETTE"*):

The load-sharing anchor system or "cordelette" is frequently constructed of a twenty foot (apx. 7 meters) length of 7 mm or 8 mm cord. It may also be constructed with nylon webbing or Spectra runners. Once all anchor points are clipped in and the load is distributed evenly, the middle of the load-sharing anchor is tied off with a figure eight knot or overhand knot.

NOTE: THE ADVANTAGE OF THE LOAD-SHARING ANCHOR SYSTEM IS THAT IT IF ONE LEG OF THE ANCHOR SYSTEM FAILS, THERE IS NO "EXTENSION" AND SHOCK FORCES ARE MINIMIZED ON THE REMAINING ANCHOR POINTS.

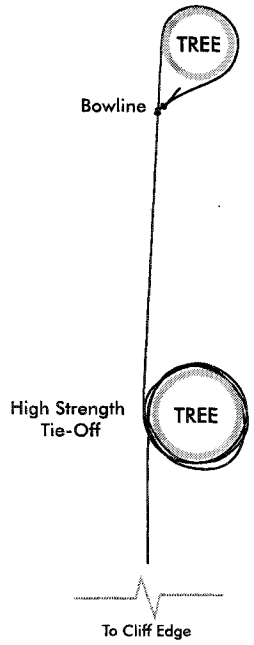


CORDELETTE ANCHOR

NOTES:

HASTY RESCUE ANCHOR:

To construct a hasty anchor for rappelling to a victim, locate two in-line anchor points with the fall line of the rappel. Construct a high-strength tie-off to the anchor point closest to the cliff edge by wrapping it at least three times with the rope. Plan accordingly and allow for an extremely long tail to reach the next anchor point. Using the tail, tie a bowline around the second anchor point to the rear. This has the advantage of redundancy over simply using a high-strength tie-off alone.



HASTY RESCUE ANCHOR SYSTEM

NATURAL ANCHORS;

• Natural anchors such as trees, boulders etc.; "BFT" and "BFR" (Big friendly trees and rocks). Make certain to pad the edges. **Do not trust only one anchor- be suspicious.** Question strength and integrity of boulders lying on slabs or partially buried in soil. Many trees appear huge but in reality have shallow root systems. Look for natural chockstones in cracks or chimneys which can be incorporated as anchor points.

ARTIFICIAL ANCHORS;

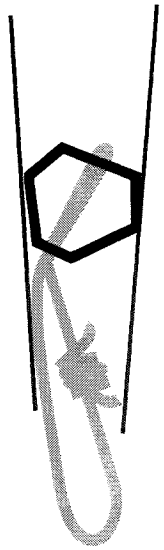
Includes chocks, nuts, bolts, pitons, camming devices, vehicles, or buildings.

•**Vehicles;** keep ropes away from hot or greasy parts. Block wheels, etc. Remove the keys from the vehicle's ignition. Do not use the vehicle for towing the litter up a cliff.

•**Pickets;** utilized in soil where no rocks or other natural anchors are available.

- Can be time consuming to set up.
- Optimum length of 4-5 foot metal post with 2/3 of the length driven into the ground.
- Driven into the ground at 15° angle away from the load.
- Lash top of front picket to the base of rear picket.
- Use a "Spanish windlass" to tension the connective webbing between pickets, by placing a smaller stake in strands of the webbing, twisting to provide tension and then driving the stake in the ground to secure it.

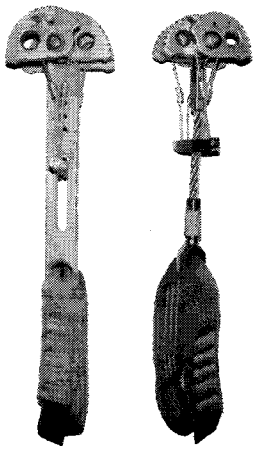
• **Nuts/Chocks;** Work well if you can find a constriction, but do not function as well in parallel cracks. They are very dependent on direction of force applied. The amount of surface area in contact with the rock is critical. Also look at the quality of the rock and likelihood that it will fail. Smaller sized nuts are not as strong due to the smaller surface area in contact with the rock and also the limitation on size of the sling or wire.



Black Diamond Hexentric

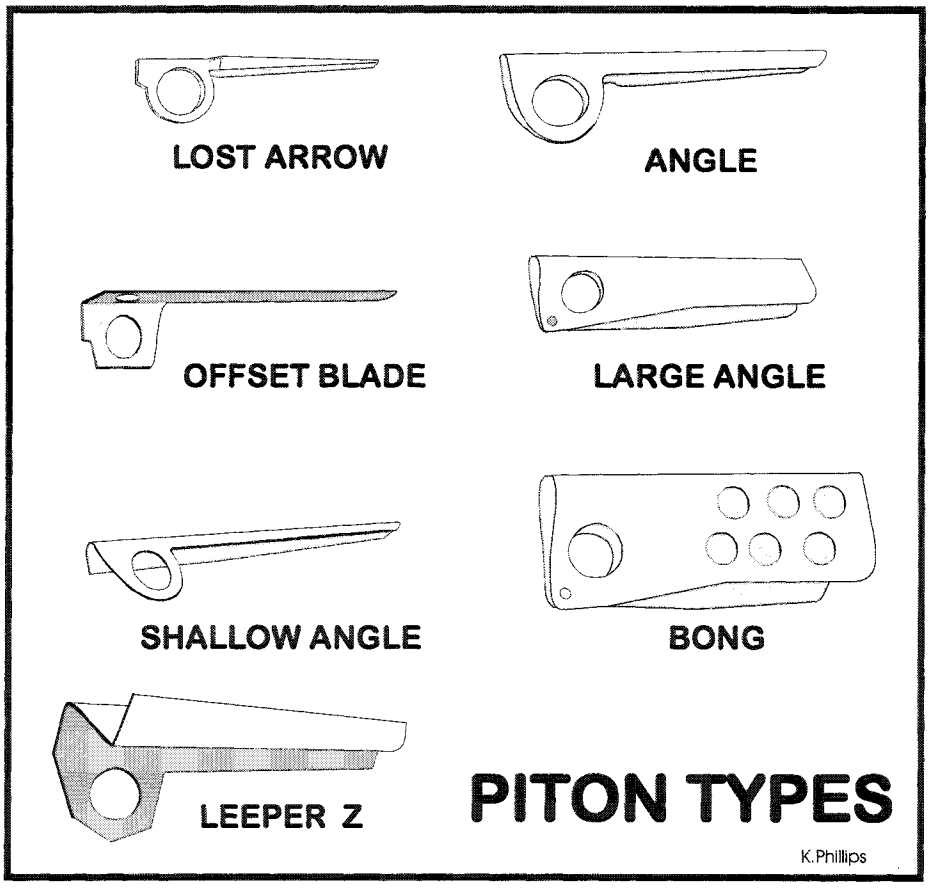
NOTES:

• **Spring Loaded Camming Devices (SLCD);** These are best placed in parallel sided cracks and less dependent on direction of pull. Be aware that they can walk themselves out of reach in a crack and become difficult to remove. SLCD can also walk to a wider spot in a crack and fall out. Ideal placement is with 10-50% of cam deployed. Never trust a placement with cams "tipped" (almost fully deployed), which allows little room for further expansion and stability is poor. Align in the direction of the load. In horizontal cracks, where the force will be applied downward, orient with the widest lobes on the bottom for better stability. Do not place a rigid-stemmed unit with the stem protruding over a lip.



Wild Country flexible Friends (right) shown with older rigid stem style.

• **Pitons;** Have limitations in soft sandstone and should be used with caution. Utilized best if the direction of force applied is perpendicular to the crack. Pitons may cause permanent impact on the resource. If driven too deep in a bottoming crack they will loosen. Listen to sound while driving the piton for a change to a higher pitch.



Yonomor Wall Hammer

NOTES:

•*Drilled Baby Angle Pitons-*

Drill a 3/8 inch hole for the length of the piton. Use a 1/2 inch baby angle piton. In soft rock, like sandstone, the piton may be hammered directly into the smaller sized hole. Drill the hole at a right angle to the load or slightly greater angle tilted away from the load. Make the hole deep enough so that the piton does not "bottom out" (hit the bottom of the hole). When these placements fail, the rock will often form a "dinner plate" around the piton. Do not place drill holes too close to one another to prevent losing more than one anchor point and avoid drilling near fracture lines in the rock.

BOLTING:

• Bolt placement results in permanent rock damage and remain in place after use, but are often the only safe option. These take more time to place but are very strong if installed properly. Many bolts are designed for industrial use and were not intended to have someone's life depend on it. They can fail well below rated strength. Some companies design bolts specifically for climbing use.

■ **BOLT TYPES:**

A. Expansion Bolts

I. Hammer-In

(Star Drive™ used to be the standard in sandstone but are now unacceptable.)

1. Compression (split shank) [hard rock only]
   a. Screw Top
   b. Buttonhead
2. Wedge
   a. Externally Threaded (stud type)
   b. Internally Threaded (sleeves)

II. Torque-In

1. Pull-Type; RAWL, Metolius
   -Sleeve type bolts (Rawl five piece) are the most popular on the market.
2. Push-Type
   -Torque bolts use a cone at tip which expands when hammered.

B. Chemical Bolts (glue-in). Inefficient for rescue work requiring time for the glue to dry.

• **Hangers-** various styles of commercial hangars are available for the attachment of a carabiner. Old, plain steel hangers may have cracks. Examine them closely and back them up for redundancy.

• **Power Drills-** A battery-powered rotary hammer (pneumatic drill) makes drilling bolt placements much quicker and easier. The Bosch 11225VSRH (24-volt) "Annihilator" and the Hilti 6-A (36-volt) are popular models on the market. The Bosch weighs in a little more than nine pounds and is rather expensive at $600. Although extremely variable a power drill can drill a

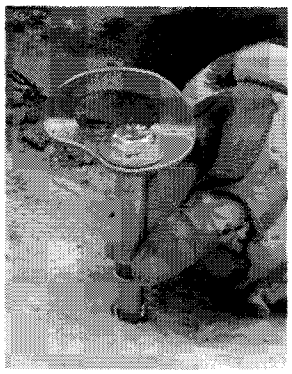
Bosch Bulldog Portable Rotary Hammer Drill

NOTES:

hole in hard rock in 50 seconds as compared to 15 minutes with a hand drill. Power drills accept the SDS style bits.

Hand Drilling Technique:

- Examine the rock before you drill:
  - Tap with hammer to test for hollowness (exfoliating rock).
  - Clean off surface of rock.
  - Don't place bolts too close together.
  - Avoid areas where there are cracks or corners.
  - Don't place where the hanger can lever bolt out of rock.

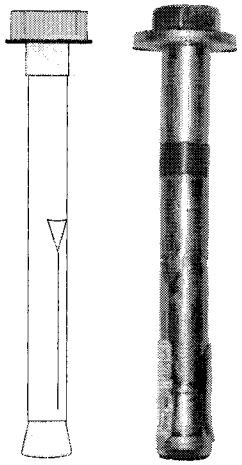


Placing A Bolt With Hanger Into Finished Hole

- Starting the hole is the critical stage in hand drilling. Crosshatch the rock with the bit to make an indentation for starting the hole. The bolt placement is stronger if the edge of the hole is straight.

- Hold the drill bit straight and pound deliberately to start the hole. Rotate the drill after every hit, otherwise it will bind in the hole. Clean the rock dust out of the hole periodically with a blow tube. If the bit begins to bind do not move the handle laterally or it may break the bit. Use the handle to rotate the bit with both hands. If you keep the tip of the bit a short distance from the bottom of the hole it will create a pneumatic effect and tend to keep the hole free of dust. Hold the handle loosely.

Powers (formerly RAWL) Power-Bolt™ 5-Piece Expansion Bolt; Does not matter if the hole is drilled deeper than the bolt. Place hanger on the bolt before you insert it into the hole. Make sure the bolt is snug but do not overtighten. Pound the bolt most of the way into the hole. Hand tighten again before it bottoms out, since it loosens itself as you pound on it. Tighten the bolt head with a wrench to approximately 35 pounds of torque (around 3-4 turns) for a 3/8" bolt. The manufacturer rated shear strength for a 3/8 inch X 3-inch bolt is 8155 pounds and a pullout strength of 5590 pounds. Field placements will always be less than these ideal laboratory values.



Powers Power-Bolt™ 5-Piece Expansion Bolt

RAPPELLING

Remember that rappelling is ***DANGEROUS!*** Rappelling accidents resulting in injury or death are frighteningly common. The original body rappel, known as the "Dulfersitz", ran the rope around the rappeller's body for friction.

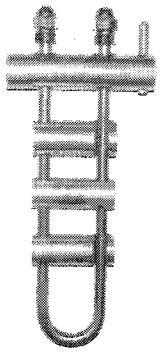
NOTES:

RAPPELLING SAFETY:

• In rescue work a separate belay line is *recommended* when ascending or descending. This should serve as a safety guideline rather than an absolute rule. There are exceptions that may dictate deviation from the use of a separate belay line. Rescuers need to practice good sound judgement in deciding what is warranted.

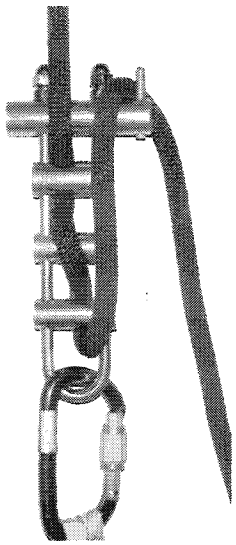
• Utilizing *single rope technique* (SRT) means there is not a separate rope as a belay. It is imperative that you pad and protect the rappel line. The situation may not provide for or allow available personnel to manage a separate belay line. Some situations where single rope technique might be employed include where a rescue team travelling past a slot canyon or pour-off that requires a short rappel and then pulling their rope, law enforcement tactical applications, helicopter short haul or rappel and swiftwater operations.

• **INCORPORATE THE USE OF A BACKUP:**
  - **•Bottom Belay;** person at base of rappel pulls down on the rope creating additional friction against the rappel device stopping the rappeller.
  - **•Top Belay;** separate belay line is utilized.
  - **•Conditional self belay;** requires tending by the rappeller (e.g. Petzl Shunt or Prusik).



Mini Rappel Rack

• Double check your harness, carabiners, and proper rigging prior to going over the edge.
• Always use a ***buddy check system*** to have any rigging inspected by other rescuers.
• Keep the brake hand below the descending device. NEVER LET GO!
• Keep hair and clothing away from the descending device.
• Carry a cutting tool for emergencies.
• Remember that a rope under tension cuts extremely easily.
• Do not bounce during a rappel! This action dangerously shocks the rappel anchor.
• Descend slow and avoid excessive heat buildup.
• Gloves are advised for long rappels, and should fit well or they become a safety hazard.



Mini Rappel Rack With Extended Bar In-Use For Additional Friction.

RAPPELLING TECHNIQUE- RAPPEL RACK:

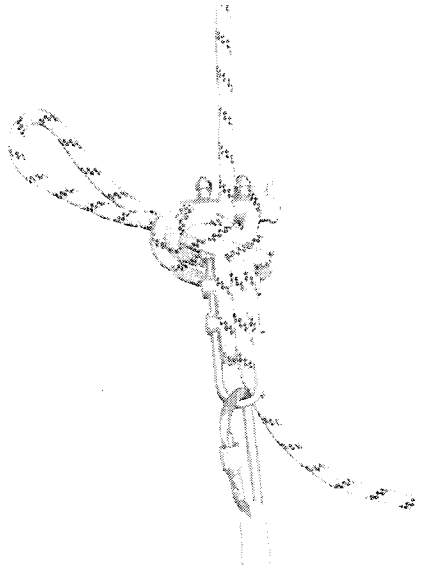
Equipment Note: <u>The rappel rack is the most versatile and efficient rappelling device for the technical rescuer.</u>

1. Attach one end of the rappel rope to a reliable anchor, allowing enough rope to reach your objective. Keep in mind that besides rappelling out of control, a frequent cause of rappelling accidents is due to the failure of inadequate anchors. Throw the rope by splitting the coil and tossing the uphill half first. The unused portion of the line is adjacent to the anchor

NOTES:

so that it could be incorporated as a hauling system if necessary. Verify the end of the rope reaches down to your destination.

2. Rig the rope into rappel rack with a minimum of four bars engaged, while it is attached to your harness. Make certain the attachment carabiner is locked.
3. It is always best to begin the rappel with more friction and then reduce it as necessary. The figure eight device does not allow the amount of friction to be varied during a rappel. More friction will be required towards the bottom of the rappel as the weight of the rope below you decreases.
4. Proper rappelling stance/technique involves leaning back perpendicular to the rock with feet spread and legs straight but flexible. Sit down to negotiate a sharp roof edge.
5. The hand on the rope below the rappel rack is the "brake hand" and must not be removed from the rope. The other hand is placed on the two lowest bars to assist with spreading the bars on the rack or adjusting the number of bars engaged in order to vary the friction.
6. Practice the lock-off technique for your rappel device.



Mini-Rack Locked Off With Overhand Knot For Security

WAYS TO DIE WHILE RAPPELLING

- Anchor collapses.
- Anchor sling severed.
- Rappel rope severed.
- Cross load carabiner.
- Clothing or hair jams.
- Slide off the end of the rope.
- Dislodge a rock.
- Rappel device unclips from unlocked carabiner
- Failure to rig a backup, e.g. Prusik, Shunt, etc. while dealing with a problem during a rappel.

ASCENDING

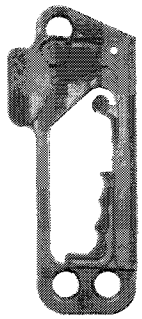
Many techniques exist for ascending a fixed rope. Depending on the situation, some are more efficient than others. It is best to learn one ascending technique well and feel confident in it's use, yet still be familiar with alternatives.

Single Rope Technique (SRT); Involves reliance on only one rope to support the load. This requires that the rope is thoroughly protected from edges and rockfall. Although the safest practice is a separate main line and belay line, it is not always practical to have separate belays for each person on a rescue. The decision to deviate and use SRT technique requires sound judgement on the part of rescuers.

NOTES:

There are many types of ascenders available, but these are the most common:

- Prusiks (Purcell Prusik System-see appendix)
- Closed Ascenders
  - Gibbs
  - Rock Exotic Rescucender
- Handled Ascenders
  - Petzl, CMI, Clog, ISC and Jumar



CMI Ultra Ascender

Handled ascenders have the advantage of being easily attached or removed from a rope. Jumars have a cast frame and should be backed up with a safety strap running from top to bottom. The safety catch on most handled ascenders will keep it from twisting off of the rope but be careful on horizontal traverses. They can be kept parallel to the rope during a traverse by attaching a carabiner from the rope to the ascender handle.

• TWO POINTS OF CONTACT- Ascending Systems

An ascending system should have ***"two points of contact at or above the waist"*** with the rope for redundancy in a safe design. These may include:

- Separate top belay.
- Third ascender incorporated into system.
- Prusik backup.
- Tie in "short"; tie a bight of rope into a loop from just below and clip it directly into climbing harness.

SAFE CLIMBING (ASCENDING) SYSTEM

"A common sense approach to vertical climbing"

Three essential criteria of any vertical ascending system:

1. a. If any one component fails the climber will not fall upside down or to the ground.
   b. If failure occurs a third "quick attachment system" (QAS) should be placed into service. This QAS involves a ready ascender with a tether strap attached to the harness.
2. System is regularly inspected and maintained.
3. Solid understanding and careful use of the system.

Developed by Bruce Smith, author of ***ON ROPE***

Yosemite Ascending System: The lengths of daisy chains and etriers are critical and worth adjusting them until they are at the most efficient length. The daisy chain to the upper ascender usually should be less than a full arm extension. The lengths of the etriers are also critical. Equipment includes; two ascenders, two etriers or foot straps, and two daisy chains. ***(See Appendix Illustration- Page 90)***

NOTES:

Mitchell Ascending System: Developed as a technique for cavers by Dick Mitchell in 1967. This ascending system incorporates the use of a chest harness, which requires less upper arm strength to operate and holds the rescuer in a more upright position. Many cavers also incorporate the use of a double roller chest box on the front of their chest harness for efficiency. Required equipment includes; two ascenders and one shunt with separate daisy chains and attachments to foot loops. ***(See Appendix Illustration- Page 91)***

- When passing bends in the rope or other obstacles you will have to remove the top ascender and replace above the bend. Then repeat the process with the lower ascender.

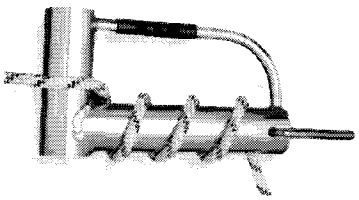
- Starting at the base of a climb or immediately after "tying in short" during and ascent there may not be enough rope weight to easily slide through the ascender. "Thumb" the ascender by depressing the cam as you move it up the rope.

Changeovers:
Changing over from ascending to rappelling back down, while part way up a rope, requires that the rescuer follow a sequence of steps to insure safety. Maintain two points of attachment during this procedures. A knot can be used in lieu of one of the ascenders. **Never undo the main attachment carabiner to the harness.** Use two harness attachment carabiners; one each for rappelling and ascending equipment.

RESCUE LOWERING SYSTEMS :

• **Figure Eight;** Difficult to vary the amount of friction during its use and it drastically twists the rope. It allows for a single or double wrap depending upon load. The figure eight can be an efficient device for low-angle scree lowering, otherwise it is considered a one-person load device only.

•**Brake Tube;** Bulkier and heavier than most other friction devices. It also twists the rope during use. The biggest advantage is that knots pass easily through this device. Based on original Mountain Rescue Association (MRA) Team design and is commercially manufactured by Petzl. Manages rescues loads efficiently and friction wraps can be adjusted during use.

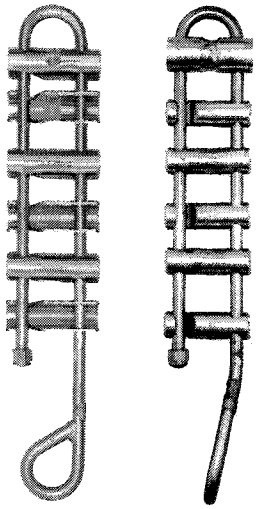


Petzl Tuba Brake Tube

•**Rappel Rack** (Brake Bar Rack); The most desirable method for high angle rescue operations. The amount of friction is completely adjustable during use and the device dissipates heat well. Disadvantage is that they are more complicated than other lowering devices. The friction bars are constructed of various metals. Aluminum bars have more friction but discolors rope and wear out more quickly. Stainless steel is heavier but wears better and provides less friction. Titanium bars are lightest and strongest, dissipate heat well, but are very expensive. The eye of the rack should be welded and not wrapped, which have begun to unravel at about 1000 lbf (4 kN) during tests.

NOTES:

"Aluminum bars provide the highest coefficient of friction, stainless steel the next highest, while titanium provides the lowest coefficient of friction." (Smith, ON ROPE, 1996). Thus aluminum bars will generate more heat during a rappel than either stainless steel or titanium. The first three bars on a rappel rack provide the majority of the friction generated during use.



Standard Six-Bar Rappel Racks Configured With U-Shaped Stainless Steel Bars (Left) & Solid Aluminum Bars (Right).

Rappel Rack- Points To Remember:

- •You may run either one or two ropes through the device.
- •The rope runs over the top bar and not between the bar and rack.
- •Take care to rig the rack so the rope is running correctly over the bars.
- •Always have a minimum of four bars in the system. Start with all bars incorporated and reduce the number of bars after getting past the edge.
- •The speed of descent and friction is controlled by;
  1. The number of bars in the system
  2. Sliding the brake bars together or pulling them apart to change friction
  3. Rappeller's brake hand pressing rope against their hip.

Rappel rack procedures include; setting up the rack, lowering, changing friction, passing bend, and tying off the load.

•Carabiner Brake; Older improvised technique that requires at least a minimum of five carabiners to construct this friction device. This is no longer employed on rescue operations due to the improper forces placed on carabiner gates. It is important to remember that **carabiners are not manufactured as rappel devices** and that using them improperly could lead to an accident.

EDGE MANAGEMENT:

The role of Edge Attendant is important for a number of reasons:

1. Secures cliff edges with padding and edge rollers. Protects the rope from damage and to reduce haul friction.
2. Assists with the litter at the edge where it is difficult to handle, and the load is not completely tensioning the system.
3. Relays communications between litter attendant and the rescuers on top. This is especially important in the event of radio failure. Also serves as an extra pair of eyes for the litter attendant.
4. Holds the belay line taunt.

NOTES:

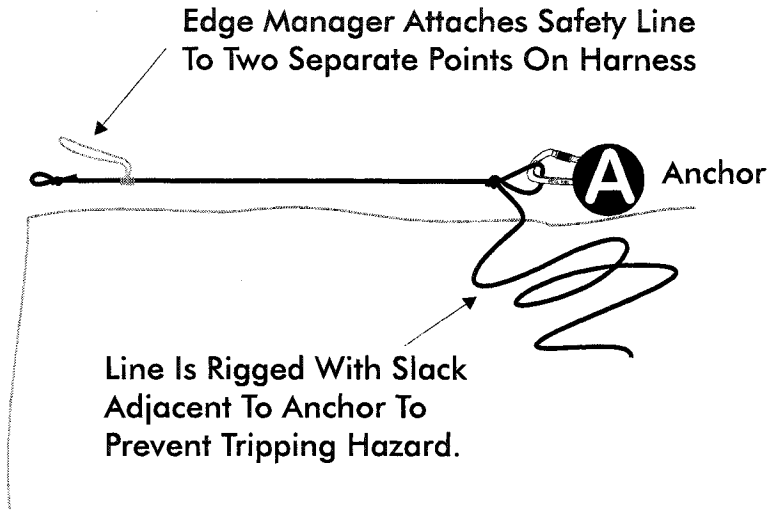
• More than one edge attendant may be needed for efficiency.

• The edge attendant must be tied in with a separate line when working near an exposed edge. An additional fixed safety line (not a belay line) should be used by the edge attendant if they are in a position where their support is completely dependent upon the line. If they are in a position to be working "over the edge" in the vertical environment, they need to be secured by a second line for redundancy in their personal safety system.

• The edge attendant must posses the strong rope skills to quickly move up and down the rope without compromising the operational efficiency. Halting all operations to wait while an edge attendant fiddles with their gear is less than optimum.

• The edge attendant's safety line should be clipped into a separate anchor from the main line anchor. The edge attendant should never tie into the main line for a safety. In the event of main line failure, the belay would catch the rescue load and the edge attendant would be catapulted forward.

• The edge attendant should attach their safety line to two separate points on their harness. This can be accomplished by clipping the line into their harness as well as placing a Prusik on the line close to this connection which is also clipped into the harness.

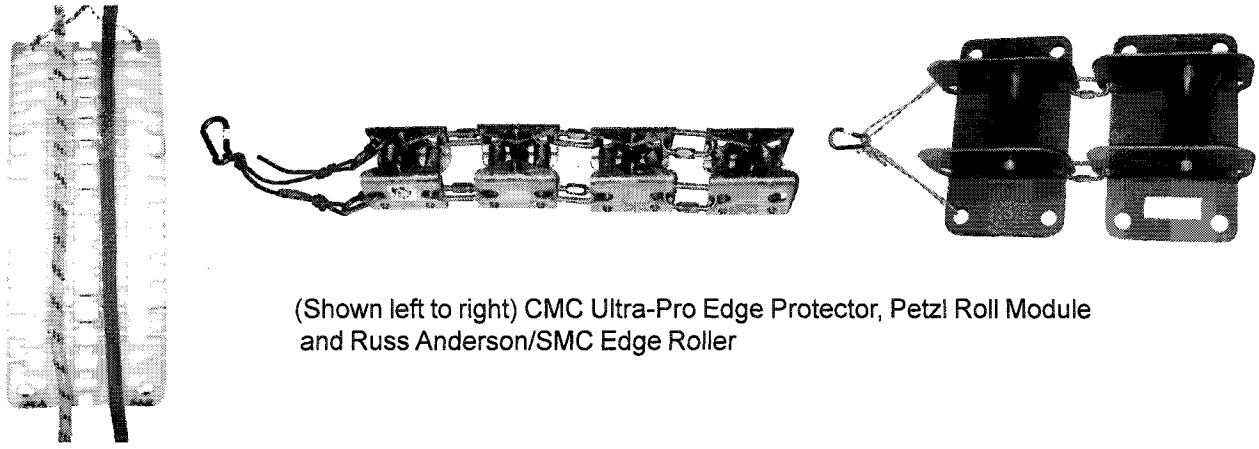


WARNING: A "tripping hazard" exists if the edge attendant's line has slack piled near the edge. The edge line should be rigged with just enough length for the attendant to work comfortably at the edge with excess rope out of the system behind their anchor.

• Protecting the rope: use of padding or edge rollers are the most common techniques. Edge rollers are more efficient for hauling but are heavier. Padding is lighter and usually available in some form (e.g. hoses, canvas, clothing, the patient's packs, etc.). A directional may be used to keep the ropes from encountering the edge. As a last resort you can reduce sharp edges by dulling with a hammer.

WARNING: If synthetic rope pads are utilized which are constructed with nylon components, they may melt when exposed to the friction of a running main line (e.g. carpet with nylon backing).

NOTES:

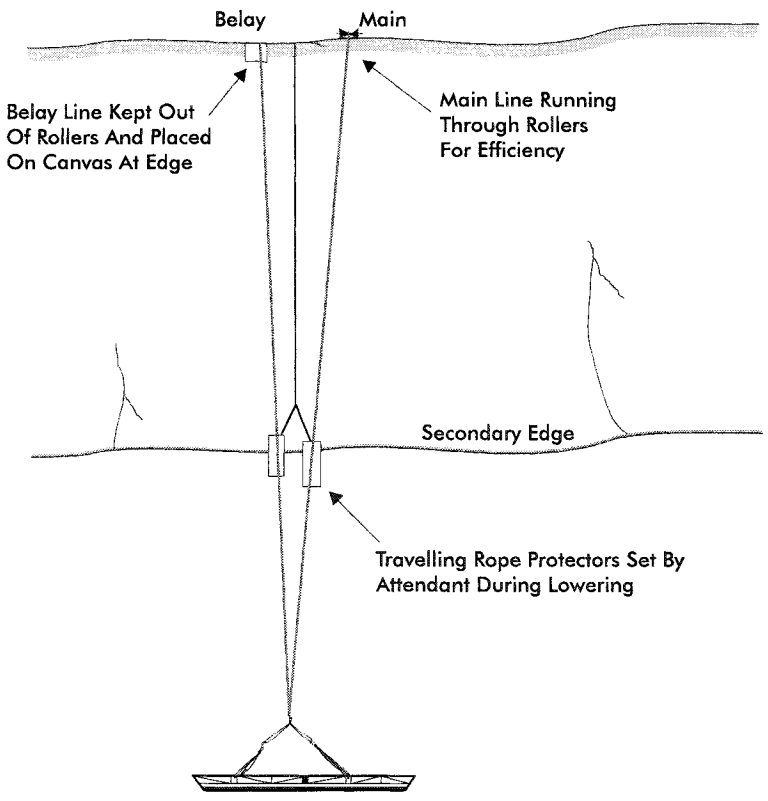


(Shown left to right) CMC Ultra-Pro Edge Protector, Petzl Roll Module and Russ Anderson/SMC Edge Roller

• Tie-in edge rollers and pads or Prusik them to a separate line so they are adjustable.

• **RIGGING NOTE:** The main line should go through the rollers, while the belay line is left out of edge rollers. This is to utilize friction in the event the belay is activated. Edge rollers can cause the belay device to actually receive higher peak forces and work harder. Friction at the edge reduces these forces. On a sharp edge, use padding for the belay line or finally go to the rollers if that doesn't work due to rope drag.

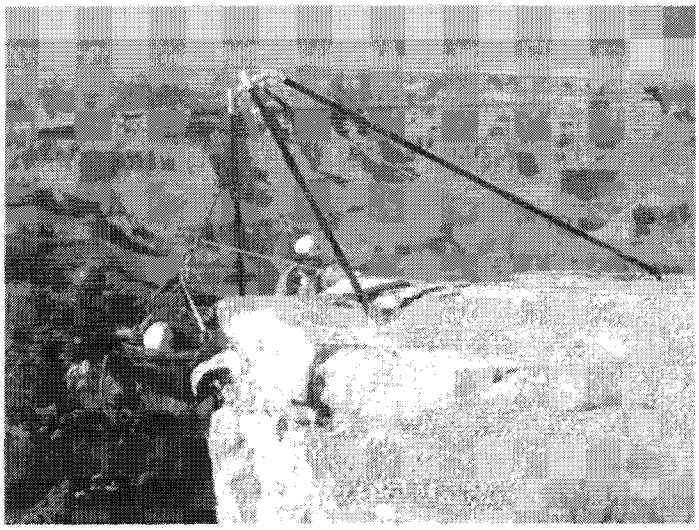
• Selection of anchor focal points for the belay and main lines can be staggered back from the edge. The belay is placed closer to the edge for reduced communications distance but still providing for the use of a load-releasing device if required. The main line anchor is placed further back to provide for working room that a hauling system might require.



• Travelling rope protectors can be placed on a "secondary edge" by the litter attendant during a lowering operation. These are secured to an independent line from above.

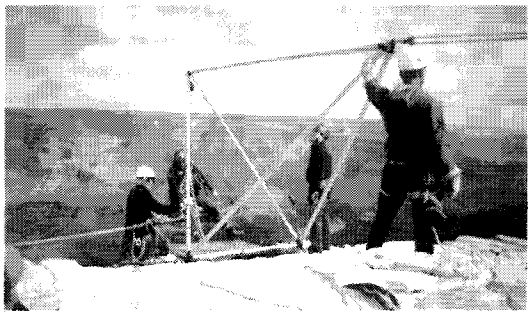
NOTES:

• Artificial directionals can be utilized for edge management including; A-frames, gin poles, Larkin Frame, and tripods. These devices can be more complex and time consuming yet will eliminate the "edge trauma" a patient might experience as a litter is brought over a cliff edge.



The *Arizona Vortex*, which is manufactured by Rock Exotic Inc., West Bountiful, UT. This extremely versatile artificial high directional was developed by Reed Thorne of ROPES THAT RESCUE in Sedona, AZ. Due in part to the adjustable length of the legs, it can be rigged in varying terrain to match the conditions of the rescue site.

Sideways A-frame artificial high directional constructed from wooden posts and secured with guy lines. Grand Canyon National Park.



Larkin Rescue Frame, manufactured by Splean Ltd, NSW, Australia, shown during rescue training session at Grand Canyon National Park.

MECHANICAL ADVANTAGE:

Mechanical advantage is produced through the use of hauling systems for raising rescue loads. Pulley systems, which serve as "force mutipliers", are one of the most common methods of accomplishing this task. Pulley systems can be rigged by either using the main line itself or using a separate line "ganged" onto the main line. In order to have a working knowledge of pulley systems, it is important to understand some basic principles that distinguish one system from another. The majority of pulley systems used in technical rescue are either simple or compound.

NOTES:

SIMPLE PULLEY SYSTEM- Identified as have one continuous rope flowing back and forth between the pulleys on the load and anchor, and all pulleys on the load side (known as travelling pulleys) travel toward the anchor at the same speed. All pulleys at the anchor remain stationary. Tension in the rope is constant throughout the pulley system.

COMPOUND PULLEY SYSTEM- Compound pulley systems are identified as one simple pulley system pulling on another simple pulley system. Travelling pulleys in the system travel towards the anchor at different speeds. Compound pulleys systems are useful because they can provide greater mechanical advantage than simple systems for the same number of pulleys.

RIGGING NOTE: The most efficient use of a number of pulleys to create the highest mechanical advantage is to construct a compound system of a 2:1 simple pulley system acting on a 2:1 simple pulley system, acting on a 2:1 and so forth.

• Ideal mechanical advantage (IMA) refers to mechanical advantage of a system without taking friction into account. Hauling systems should be employed considering practical mechanical advantage (PMA), which takes into account the friction generated by pulleys and edges.

• Obtain the greatest mechanical advantage in a hauling system by reducing as much friction as possible by rigging lines so they do not directly touch sharp rock edges or run directly along the ground.

• A change of direction pulley, which adds no mechanical advantage to a hauling system is frequently employed to orient the line in a position of convenience for hauling (e.g. pulling at a right angle from the main anchor).

• Keep mechanical advantage lines parallel for maximum practical mechanical advantage. A directional pulley may be used to achieve this if hauling is being directed away from the main pulley system.

• Prusiks (sometimes referred to as "soft safeties") are utilized as haul and ratchet rope grabs for rope connections that can handle shock forces without catastrophically failing a line. Mechanical ascenders, which had been employed in the past as haul and ratchet devices, can sever a rope with a rescue load if a shock force was applied.

•*Haul Prusik;* the Prusik in a pulley system that is closest to the load that attaches the pulley system to the main line going to the load.

•*Ratchet Prusik;* a Prusik employed in a hauling system to hold the mainline while the haulers reset the pulley system, so that progress is not lost. The ratchet allows movement of the line in one direction but not another. Sometimes this is referred to as a "progress capture device."

NOTES:

TYPICAL RESCUE HAULING PULLEY SYSTEMS:

2:1 Pulley System; "C-Rig"
3:1 Pulley System; "Z-Rig"
4:1 Pulley System; "Pig Rig"

STANDARD HAUL SYSTEM COMMANDS- ROLE CALL:

Command	Whistle Signal	Meaning/Action
"Haulers Ready?"		Team should be prepared to haul.
"Attendant Ready?"		Attendant is ready to be raised.
"Up", "Haul Slow"	Two Whistle Blasts	Team begins hauling.
"Set"		Team stops and resets the ratchet.
"Reset"		Team resets for a new bite of rope.
"Stop!"	One Whistle Blast	All movement stops and tension held.
"Down"	Three Whistle Blasts	Lower the load.

"Stop-Stop-Why Stop?" *-Used to alert personnel when a line will not move.*

• Communications during a raising evolution must be clearly understood by all personnel. Use common single syllable words. Have a single person giving the commands and restrict all excess bantering among topside personnel. The operation should work like a well-oiled machine.

• As a general guideline, the average haul person can pull about **20 kg (44 lbs.)**. This is useful to know in planning a raising system and determining how many haulers will be needed or what mechanical advantage system should be employed.

• A common error is pulling too hard, too fast- **VERY DANGEROUS!** The load can be jammed in a crevice or injure rescuers on the line.

• Generate a smooth raising effort on the line. Avoid a "heave-ho" pull on the haul system. This can cause the litter to bounce and create excess abrasion on the main line.

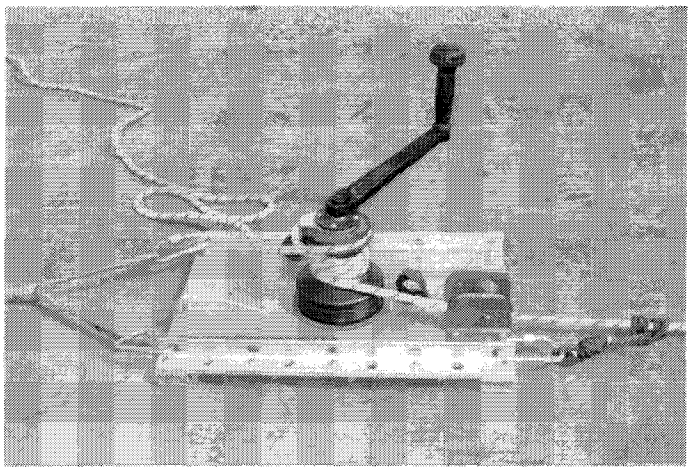
NOTES:

•MECHANICAL HAULING SYSTEMS:

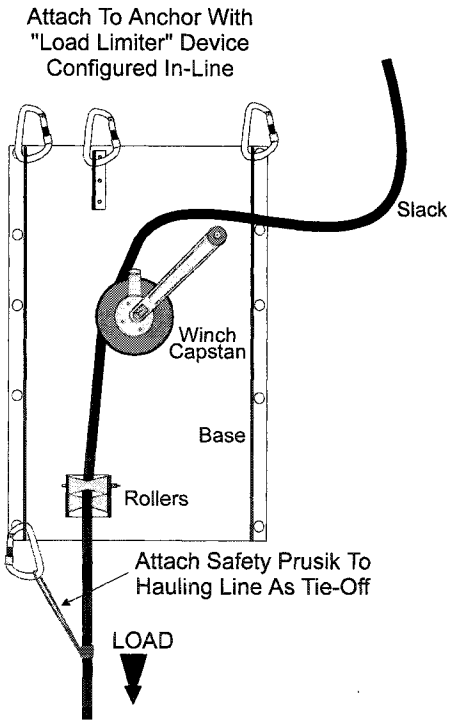
• **Motorized winches;** Frequently noisy and maintenance intensive equipment using two-stroke gas-powered engines. An innovative design is the motorized hydraulic powered Paillardet Winch, developed by in collaboration with the P.G.H.M. (High Mountain Constabulary) in Chammonix, France. This provides an efficient winch for technical rescue operations, which performs both lowering and raising functions. The unit weighs 10 Kg (22 lbs), handles a 300 Kg (660 lbs) working load and raises at a speed of 17 meters (56 ft) per minute.

Paillardet Rescue Winch

• **Modified sailing winch;** manufacturers include Russ Anderson Company, RSI (Rescue Systems, Inc.) and Kong Bonatti. Slow technique during long raising operations. Disadvantages include expense and weight of the device. It does provide for tremendous mechanical advantage in a relatively small space (two speeds on the Russ Anderson Winch are 12.5:1 and 40:1 mechanical advantage).



Russ Anderson Rescue Winch



Russ Anderson Rescue Winch

NOTES:

KNOT PASSING TECHNIQUE

Note: As with most rescue techniques, there are several acceptable methods for passing a bend during a lowering or raising operation.

LOWERING PHASE

1. **Attach LR Hitch and system Prusik.**
   Use a single Prusik (3 wrap, 8 mm) out beyond the friction device (approximately one foot) which is attached to the running end of the LR Hitch. The LR Hitch is then attached to the same anchor as the friction device. DO NOT construct a separate anchor. This Prusik will need to be minded during the lowering.
2. **Allow the LR Hitch to take the tension.**
   At the point where the incoming bend (knot in the main line) is about 12 to 16 inches away from the friction device, let the minded Prusik grab the rope by pushing it away from the anchor down the rope. At this point BOTH the friction device and the Prusik will have tension on them. Allow total slack onto the friction device and angle the rope between the Prusik and the friction device away from the LR Hitch. The tension is now on the LR Hitch.
3. **Move the friction device beyond the knot, reattach and lock off.**
   The rope will slide through the friction device and become slack. Remove the device completely and replace it onto the other side of the bend to be passed. Make sure the bend is as close as possible to the top of the friction device. The brake person should lock-off the friction device, ready to receive tension again.
4. **Lower the load with the LR Hitch until tension is on the friction device.**
   An assistant uses the LR Hitch to gently lower the load (extended out) back onto the readied friction device. As this happens, tension will again be on each system.
5. **Remove LR Hitch and system Prusik.**
   Angle the LR Hitch away from the friction device to slack for complete removal. After this is done the Prusik can be removed by an assistant to the brake person. The bend is now ahead of the friction device.

•*Repeat these steps, if needed, by retying the LR Hitch again and adding the Prusik to the moving rope beyond the friction device.*

ALTERNATE METHOD:

1. Lock off the lowering device (i.e. rappel rack) with the knot a short distance behind it.
2. Attach a Prusik beyond the original lowering device on a short length of rope (50') with a second lowering device from the anchor to the main line.
3. Unlock the primary lowering device and transfer the load to the secondary lowering device.
4. Remove the main line from the primary lowering device.
5. Lower the load till the knot is well past the primary lowering device.

NOTES:

6. Lock off the second lowering device.
7. Attach the primary lowering device back to the main line.
8. Transfer the load back to the primary lowering device and continue the lowering.

RAISING PHASE (3:1 Hauling System)

SLAMMA JAMMA KNOT PASSING TECHNIQUE:

Equipment Needed: Locking carabiner, ratchet Prusik and Prusik Minding Pulley.

1. Pass the approaching knot by the haul Prusik by reattaching beyond it during a haul rest.
2. Continue the raising and let the knot run into the ratchet Prusik and primary pulley.
3. Stop the raise and attach the new Prusik Minding Pulley and a ratchet Prusik with a locking carabiner to the line on the side of the knot closest to the load.
4. Continue to raise slowly. There will temporarily be less mechanical advantage in the haul system. As the line slacken clip the carabiner from the new Prusik Minding Pulley into the anchor focal point. Once it is attached stop the raise.
5. Disconnect the original Prusik Minding Pulley and ratchet Prusik. Continue with the raising operation passing the remaining pulley system pulleys as normal.

ALTERNATE METHOD:

1. During the raising, reset the haul Prusik below the knot.
2. Continue the haul until the knot reaches the ratchet Prusik.
3. Attach a temporary ratchet Prusik with a load releasing hitch on an extension sling from the anchor in front of the original ratchet Prusik well below the knot (leave adequate distance to accommodate the pulley and the original ratchet Prusik). This is attached to the anchor on a separate carabiner.
4. Transfer the load to the temporary ratchet Prusik. While manually tending the original ratchet Prusik to prevent it from grabbing, lower out the release hitch line thereby loading the temporary ratchet Prusik.
5. Relocate the pulley and original ratchet Prusik on the main line beyond the knot. Once the main is tensioned by the haulers, the temporary ratchet Prusik can be removed.
6. Continue the raising operation till the bend reaches the second pulley.
7. Set the safety ratchet Prusik to hold the load.
8. Disconnect and reattach the pulley on the other side of the knot. Continue with the hauling operation.

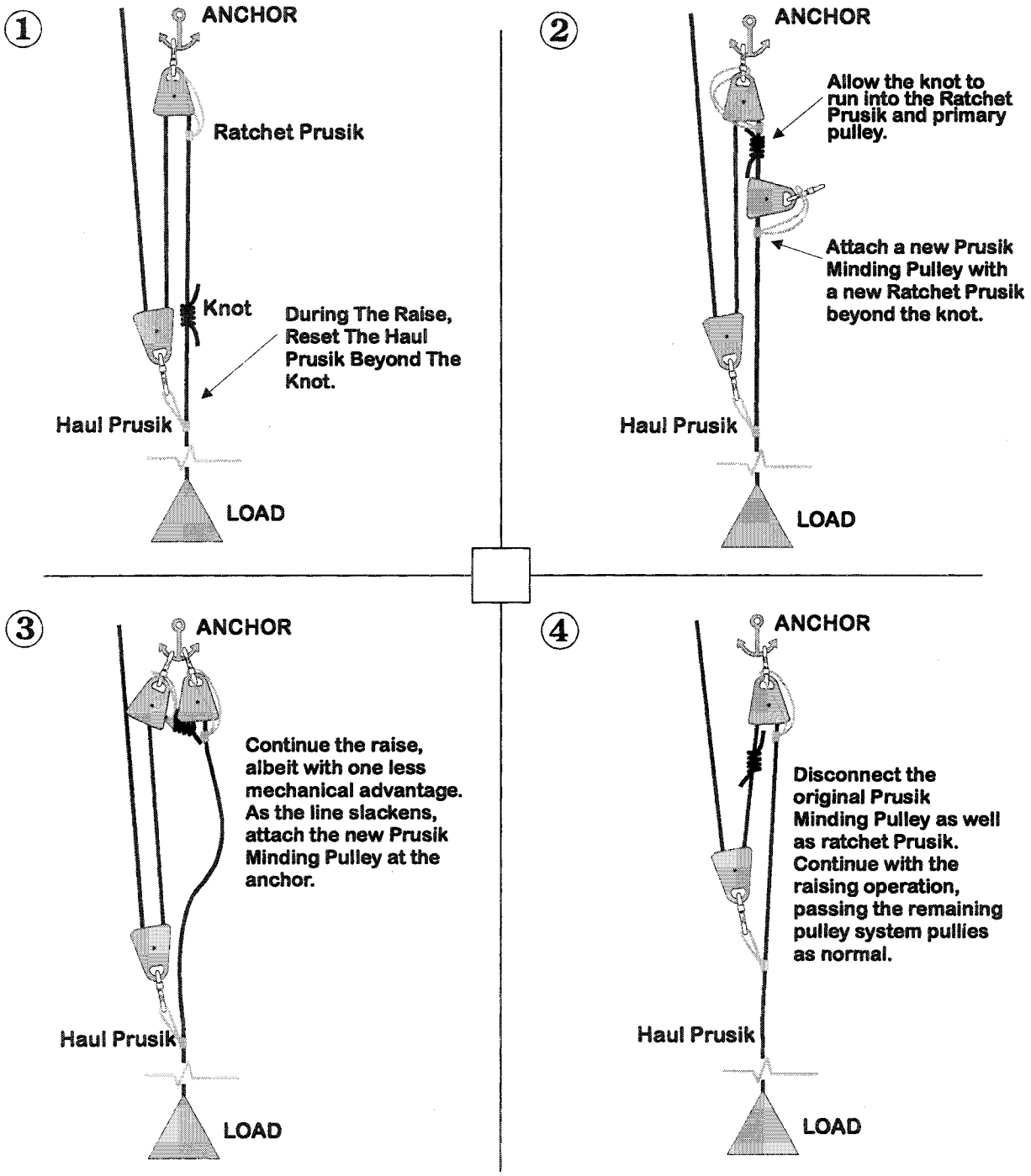
ADDITIONAL KNOT PASSING CONSIDERATION:

Attach a "ganged" hauling system (pulley system acting on the main line versus pulley system constructed from the mainline) to the main line from a separate anchor system further behind the primary anchor system. This permits hauling of the main line and knot until it is well above and out of the way of the primary hauling system. With adequate anchors and additional equipment this may be a more efficient technique.

NOTES:

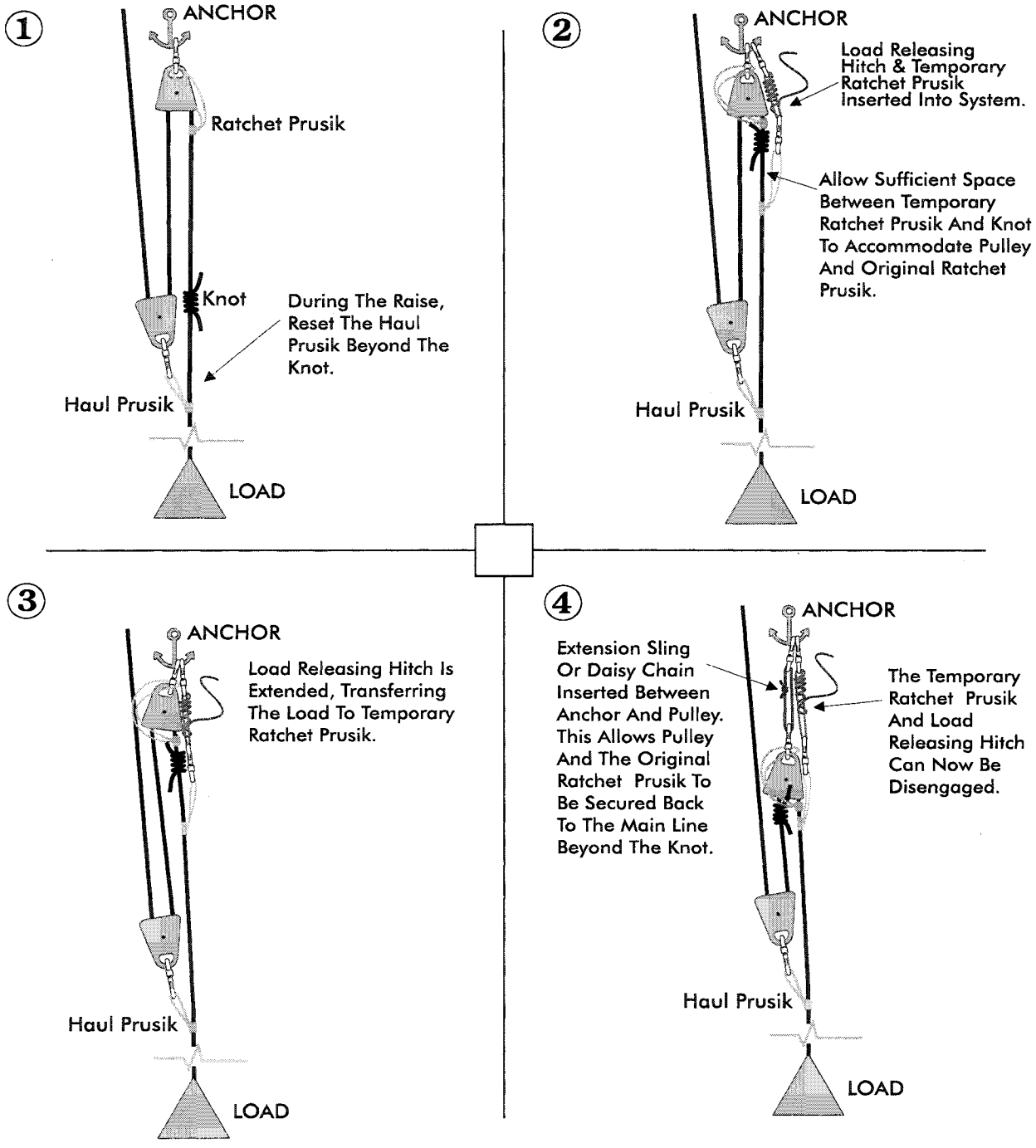
"SLAMMA JAMMA" KNOT PASSING TECHNIQUE (RAISING)

Provided by Billy Shott



NOTES:

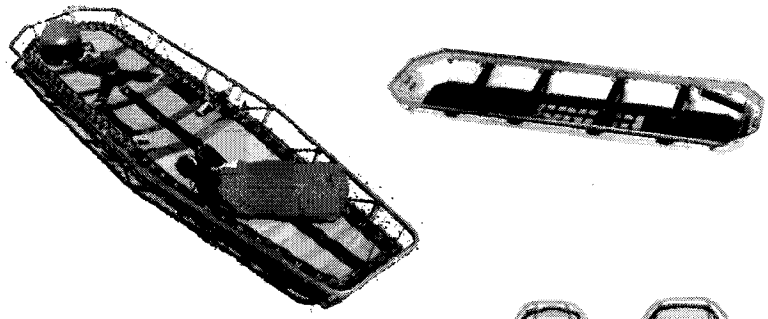
ALTERNATE KNOT PASSING TECHNIQUE (RAISING)

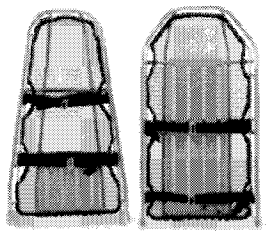


NOTES:

RESCUE LITTERS

Rescue litters permit the stable transport of a patient in a rugged environment without aggravating their injuries. A patient with minor injuries may not require the use of a litter to effect an evacuation, and instead may only need a harness.

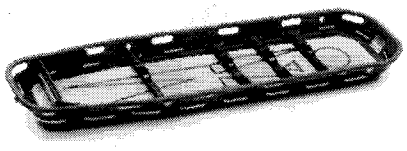




Junkin Military Basket Stretcher (above) rigged with a commercially sewn litter insert to facilitate patient packaging. Junkin Plastic Stretcher (aove right). Traverse Rescue Titan Litter (right) shown in break apart configuration.

Basket Stretcher- military basket style stretcher frequently referred to as "Stokes Litter" (named after original 1895 designer, Charles Stokes). The tubular steel frame with either welded aluminum plates or chicken wire to from the basket. There are several commercial models on the market that vary in dimensions and weight. The original "military-spec" model contains a leg divider, which becomes a severe hindrance in patient packaging. Manufacturers of open basket stretchers include; Colonial, Junkin, Traverse Rescue and Lifesaving Systems Inc. Purchase of a new basket stretcher should avoid selection of a model that contains a leg divider and it is recommended that a commercially available nylon litter insert be used to replace the wire mesh for increased patient comfort. Basket stretchers with a break-apart design facilitate backpacking the litter in to a remote accident site.

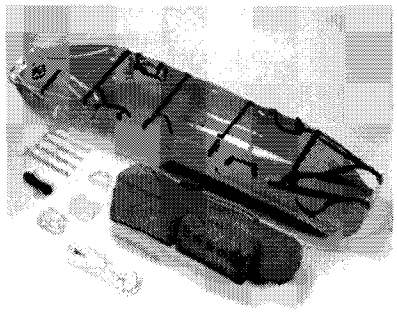
•Ferno-Washington Plastic Litter. Not as strong of a design compared with the Stokes-type litter, but works well for cliff rescue applications. It also slides easily over snow and scree because of the smooth bottom. When rigging this litter make sure to tie into the metal rail and not just the plastic material. Here again, the break apart design facilitates backpacking this litter. The Ferno-Washington litter comes with a 5 meter (16') piece of nylon rope woven around the side of the stretcher. It is recommended this piece of rope be replaced with 8 mm accessory cord that has a figure eight knot at each exposed section along the inside of the litter. The knot permits webbing, for patient packaging, being passed easily beneath it. Do not leave this litter (or any litter for that matter) exposed to harmful ultraviolet for extended periods. Plastic will deteriorate, fade and become brittle with this type of exposure.



Ferno Model 71 Basket Stretcher

NOTES:

• **Sked Litter.** A compact and lightweight plastic stretcher based on the same design as a game "drag sheet" used by hunters. Although this stretcher slides easily over obstacles and snow it provides no impact cushioning. Works well in confined space but provides limited patient protection and poor immobilization. The manufacturer (Skedco) recommends it be used in conjunction with their spinal immobilization device, known as the Oregon Spine Splint (OSS).

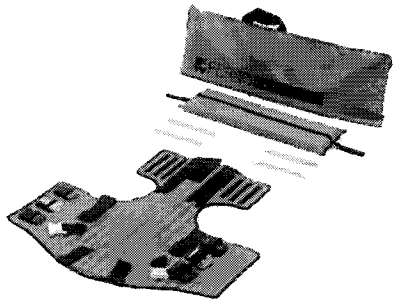


Skedco Sked Stretcher System

• **SSP (Smith Safety Products) Rescue Stretcher.** (Designed after the MIBS Stretcher of Great Britain) This lightweight device is constructed of Cordura material covering closed cell foam on polyethylene sheeting that rolls up compactly for storage. This design builds upon the lightweight design of the Sked Litter, while providing for significantly more patient padding from impacts and contact with the ground. The narrow profile permits use in confined space. The MIBS stretcher is used extensively by British Ministry of Defense as well as British Mountain Rescue.

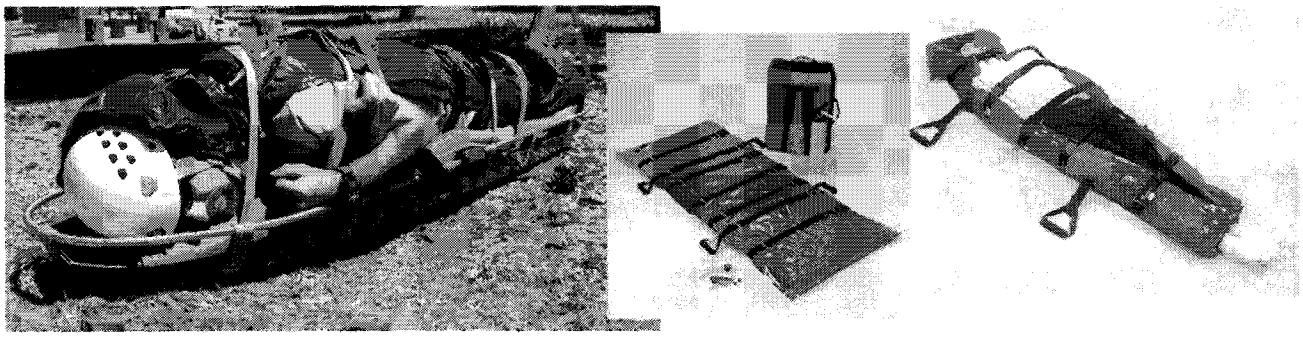
PATIENT PACKAGING CONSIDERATIONS-

- Advise the patient of your evacuation plan.
- It is critical to backup the break-apart joint in litters with webbing. Don't simply trust quick-release pins on a litter joint, which may fail.
- Use additional spinal immobilization if warranted.
- Secure patient tie-ins to lowest rail to securely wrap the patient.
- Avoid compression from webbing that could cause ***compartment syndrome.*** As with splinting, recheck the patient's circulation following packaging.
- Prevent patient heat loss and/or provide an outside heat source.
- Utilize adequate padding along with head and eye protection.
- **Think ⇒ AIRWAY!** Intubation or packaging a patient on their side may be the best means of protecting the airway of a patient you suspect may vomit during transport.
- A Ferno K.E.D. is very efficient for spinal immobilization in the vertical environment during technical rescues.
- For extended rescues requiring spinal immobilization a vacuum mattress splint is the tool of choice over a backboard. This is a more humane way of treating the patient and is easily secured sideways inside the litter for airway considerations.



Ferno K.E.D. immobilization device

NOTES:



A vacumn mattress is an excellent tool for spinal immobilization of a patient during prolonged transports. If necessary a patient with an unsecured airway can be packaged on their side to facilitate drainage. The MDI (Medical Devices International) EMS Imobile-Vac[tm] vacuum mattress is shown with storage case and pump.

LITTER RIGGING AND TRANSPORT:

• Litter Pre-Rig Spider (Bridle);
The litter spider permits rigging of the litter in a horizontal configuration for vertical raising operations with an attendant to guide the litter and provide limited patient care. Many commercial litter spiders are designed to be adjustable when tensioned. It is possible to change the head or foot end of the litter for terrain obstacles and patient care. In using an adjustable litter spider, it is easiest to start with the legs sucked up short and then lengthen them as needed. Connecting carabiners to the litter are rigged with the gates down and facing inward. A spider should not be improvised on scene, instead have it pre-rigged in advance for efficiency.

• Litter Attendant;
The preferred technique is to use a single attendant. The attendant is tied into two points of attachment, including the tail of one of the lines below the spider connection as well as an adjustable link such as a daisy chain or "Purcell Prusik." If two attendants are to be used, it is recommended that the second attendant be on independent lines and they can either ascend next to the litter or be raised from above.

• The tail of the remaining line is used as an attachment to the patient. The patient must be tied both into the litter and into the rope system in the event of litter failure.

• Dependent upon the injury, patient should be fitted with a harness, helmet and eye protection for safety. Consider shading, insulation, and padding of the patient. Special vigilance must be taken to maintain the patient's airway. The patient will be more secure in the litter if extra gear and clothing is used to pack around the body. Pad pressure points created by the tie-ins, since extreme cold in high altitude situations can quickly cause frostbite when circulation is compromised.

NOTES:

VAPOR BARRIER LINER (VBL) PATIENT PACKAGING:

A vapor barrier creates an environment of high humidity close to the skin, preventing the evaporation of sweat and thereby keeping a person warmer. A three layer patient packaging system, which incorporates a vapor barrier liner (VBL), can be used effectively in dry cold environments to package a patient for extended transport. This system includes the following three layers;

1. **Inner vapor barrier liner.** Placed against bare skin or undergarments (*e.g. plastic trash bags or Tyvek "haz-mat" suit).* If the patient wears a layer of undergarments with wicking properties it will pull the moisture away from their skin, leaving them more comfortable.
2. **Insulation layer.** A sleeping bag wrapped around the vapor barrier.
3. **Waterproof barrier.** A waterproof tarp placed on the outside.

LITTER RAISE/ LOWER TECHNIQUE

• Long-tailed interlocking bowlines are tied joining the main and belay lines together and then connected to the litter spider.

• The attendant uses their legs to push from the rock face and arms to pull the litter away from the face. The attendant should have sufficient clearance for their legs below the litter.
A proper height adjustment for the litter attendant allows them to reach the rock face with their legs and have minimal clearance of the litter above their thighs.

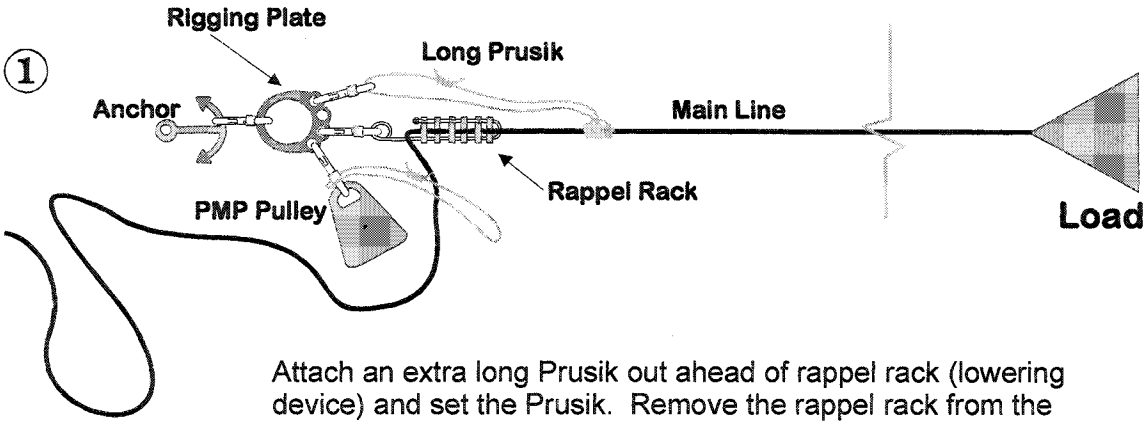
• An alternate technique for rigging the litter attendant is to have them attached by their harness connector strap into the apex of the litter spider, where they hang suspended above the patient. This "elevated attendant position" technique is less fatiguing on the rescuer, since their legs are doing the majority of the work, and overhangs during a raise are negotiated much easier. This technique is best applied in vertical faces and overhangs. Negotiating a cliff edge or on inclined slopes forces the attendant to change to the lower position, which is easily accomplished.

"Elevated Attendant Position" Being Used During A Litter Raising Training Session.

• Patient protection during rockfall- rescuer has a duty to protect patient, but not at the risk of personal sacrifice. Options are to jump on top of the patient if rescuer is wearing a backpack or roll the litter on the side and duck in as close as possible.

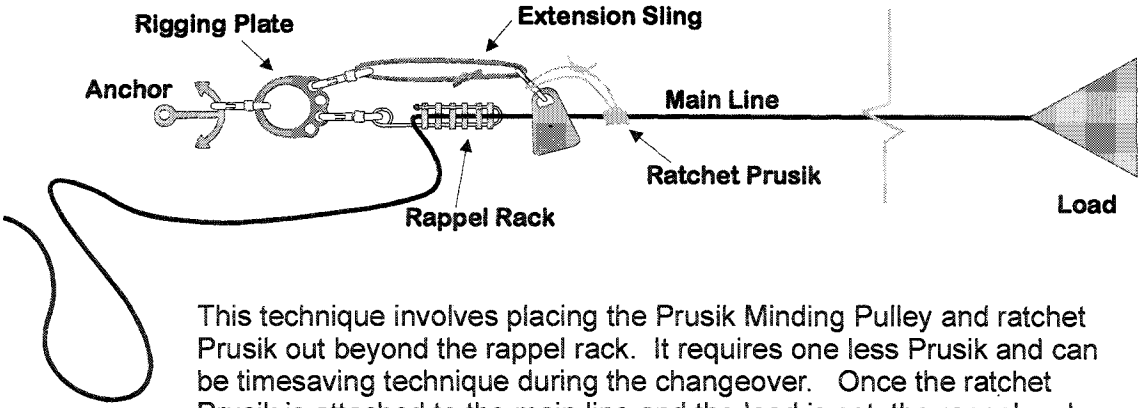
NOTES:

CHANGE OVER TECHNIQUE (LOWERING TO RAISING)



Attach an extra long Prusik out ahead of rappel rack (lowering device) and set the Prusik. Remove the rappel rack from the system. Attach the Prusik Minding Pulley and the ratchet Prusik to the main line. Finish constructing the remainder of the haul system. During the initial part of the raise, remove the long Prusik from the system. Continue the raising operation. Using a rigging plate to keep the rigging organized at the anchor focal point increases efficiency.

② ALTERNATE METHOD (By Kirk Mauthner, RFR)



This technique involves placing the Prusik Minding Pulley and ratchet Prusik out beyond the rappel rack. It requires one less Prusik and can be timesaving technique during the changeover. Once the ratchet Prusik is attached to the main line and the load is set, the rappel rack can then be removed from the system. Finish constructing the hauling system and begin the raise. If the Prusik Minding Pulley and ratchet Prusik are attached during the lowering to expedite the change-over, make certain that they are tended as rope is being feed out.

NOTES:

LOWERING EVOLUTION- ROLE CALL:

Operations/Control:	Response:	Operations/Control:
"Belay ready?"	"Belay Ready!"	
	"Standby!"	"Advise When Ready"
"Main Line Ready?"	"Main Line Ready"	
"Edge Ready?"	"Edge Ready"	
"Attendant Ready?"	"Attendant Ready"	
"Tension all lines"	(main line, belayer, edge manager and attendant tension lines)	
"Attendant, Approach Edge!"	(Final inspection is completed)	
"Attendant, stop!"	(Proper position at edge)	

■ High Directional Exists: *<Otherwise Omit Vectoring Commands>*

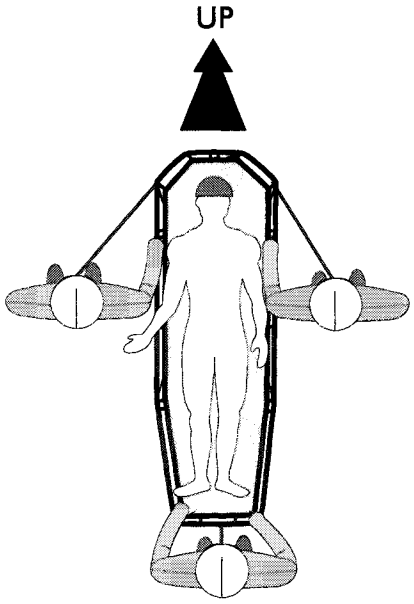
"Vector Main Line!"	(One or two persons deflect the main line upward and no rope is let through the brake device)
"Attendant Lean Back!	(Stretcher cleared of all obstructions)
"Edge Push Out!"	(Main line only and not the stretcher [which will tilt] or belay [which will generate slack])
"Release Vector!"	(Slowly initially, then quicker)

"Brake- Down Slow!" *[Three Whistle Blasts]*

LOW-ANGLE LITTER EVACUATION

Important considerations for a low-angle litter carry operation;

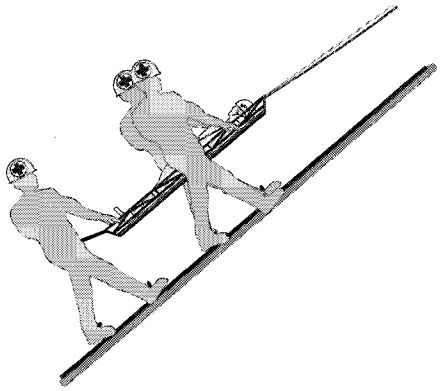
- Request adequate resources. Use a minimum team of 6-8 persons to provide for relief.
- Designate a lead medical attendant to be responsible for patient care.
- Decide on and flag the easiest route before evacuation. In an urgent situation designate a "route finder" in order to save time gaining access to the patient.
- Remind personnel to lift the load with their legs. **DON'T LIFT WITH YOUR BACK!**
- Use a shoulder strap or litter wheel to make the task more bearable.
- On rough terrain, where footing is hazardous, pass the litter between bearers using the "leapfrog technique." Personnel remain stationary as they pass along the litter and then bump forward as the litter is handed off.



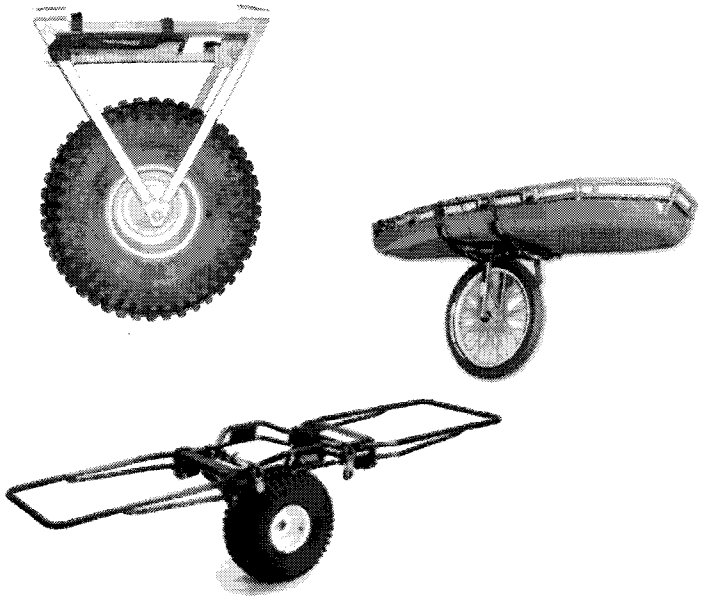
NOTES:

- Create belay stations for the litter on steep or exposed slopes. If multiple stations are needed, have additional personnel rig them in advance for efficient litter transport.
- Front personnel call out footing hazards that the rear members are unable to see.
- Switch sides of the litter frequently to prevent muscle fatigue.
- Extra pair of bearers "bump" into place for relief of fatigued personnel.
- Anyone can yell "Stop," but only the Team Leader says "Go."
- Tie-in to head of litter should be over a wide area in the event the litter rail fails. Consider patient injuries with regards to orientation of the litter during transport.

• **<u>On steep slopes</u> (20⁰ to 50⁰) <u>use a main line and belay line combination.</u>** ***SYSTEMS FOR LOW-ANGLE RESCUES CAN EASILY GENERATE EXTREME LOADS WITH THE COMBINED WEIGHT OF SEVERAL ATTENDANTS PLUS THE PATIENT!*** Since rescuers are not suspended and are standing on their feet, not all of their weight is placed on the rope system. Recognize what could happen in the event of catastrophic failure. Tether the litter bearer's harness to the main and belay with an adjustable Purcell Prusik to each line. Litter bearer's lean back, placing the load on harness. In the steeper terrain use only three bearers as shown for more efficient transport.



• A litter wheel, which reduces fatigue on rescuers, may be used with limited application on low-angle terrain or staged ahead for transport on flatter ground. Consider keeping a small handheld bike pump lashed to the side of the litter wheel in the event you need increase the air pressure in the field or install a solid rubber tire tube which won't go flat.



Litter Wheels (Top-Bottom).
1.) Russ Anderson/SMC Litter Wheel uses a large ATV-style tire and clamps to the bottom of the rescue litter.
2.) Advanced Rescue Wheel, manufactured by Cascade Toboggan Rescue Equipment Company, accomodates multiple litter designs, which are held in place with straps that cinch down hooks with a ratchet system.
3.) The Mule II Litter Wheel, manufactured by Traverse Rescue, is designed with adjustable handles. The unit collapses and stores inside itself. The handles allow fewer tenders and adjust in height for easier carrying.

NOTES:

STRANDED PATIENT PICK-OFF

A **Rappelling Pick-Off** can be employed to rescue a stranded climber or a subject with minor injuries that don't require the use of a stretcher. This technique involves the following sequence of actions;

• The rescue team rigs a main line and belay line.

• The end of the belay line is a attached through the rescuer's seat and chest harness independent of the connector strap.

• The rescuer rappels to just above the patient but within reach of the patient's waist or harness.

• If the patient is not wearing a harness, a baudrier *(see improvised techniques)* or other pick-off strap is secured immediately to the patient. The baudrier is then connected to the rescuer's descender attachment point to provide a safety for the patient.

• If the patient is not wearing a harness, an improvised or commercially sewn harness is put on the patient.

• The harness is secured to the rescuer's descender attachment point. Connecting directly to the rescuer's harness is to be avoided.

• A secondary connection is made from the belay line to the patient's harness with a Prusik on the belay line above the rescuer.

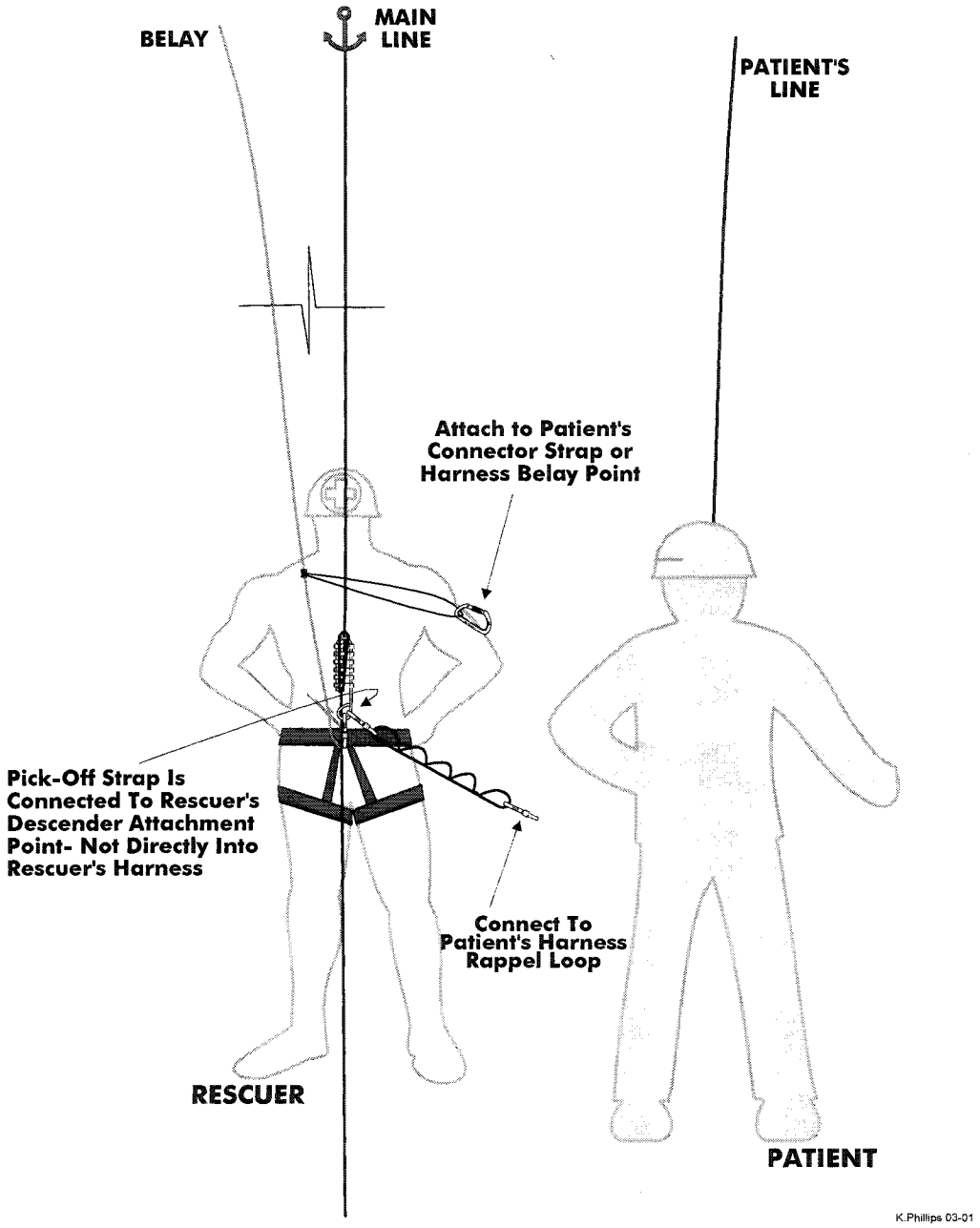
• The patient is removed from their original line if one is present. This may involve unloading their weight off their original line through the use of a jigger or simply cutting the patient's line.

• If the line is to be cut, use trauma scissors and avoid generating a shock force on to the rescuer's system by removing as much slack as possible between the patient and the rescuer's descent device.

• The rescuer continues to rappelling with the patient to the ground.

NOTES:

RAPPELLING PICK-OFF



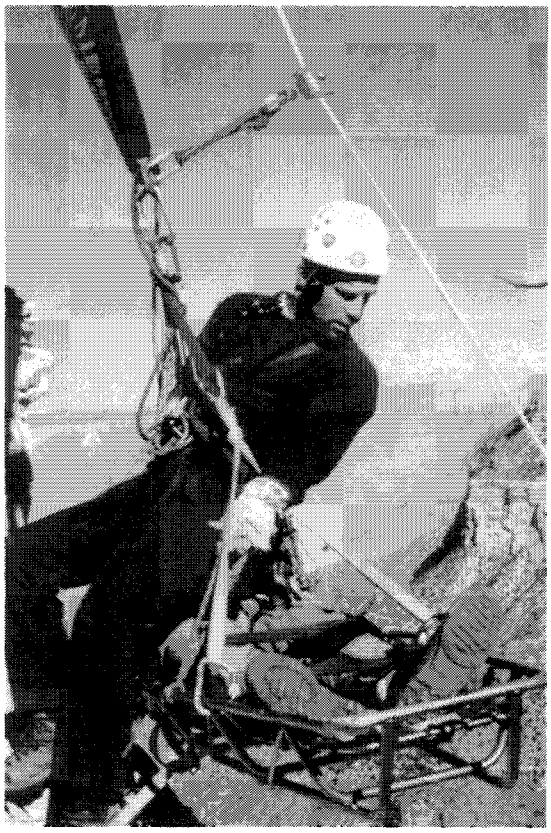
NOTES:

GUIDING LINE TECHNIQUE

A guiding line provides a very effective method for avoiding obstacles at the base of a cliff during a raise or lower and is not overly complex. The guiding line is more than a "tag line," which would attach beneath a litter to permit personnel below to provide tension and deflect the litter's path. The guiding line provides an independent ropeway for a guiding pulley, which is linked to the litter, to move along as a managed directional.

This technique can be viewed as a "low-tech highline", but it is important to understand that it is not designed to suspend loads a significant distance in the air. During transport with a guiding line the load should not be more that one meter away from the rock face or slope. This permits a very short pendulum into rock face if the guiding line fails. If there exists a significant potential for injury due to the height that the load is suspended, then another technique should be employed.

The upper anchor for the guiding line should be a high strength tie off. The belay and main are joined to a litter spider with long-tailed interlocking bowlines. The adjustment of the guiding line is performed with a 3:1 pulley system at the bottom end to tension or untension as necessary. The addition of a ground level directional pulley in front of the 3:1 pulley system will permit horizontal control of the pulley system.



Litter Attendant Shown During A Guiding Line Lowering Operation. Note The Webbing Connection Between The Guiding Line And Litter Spider.

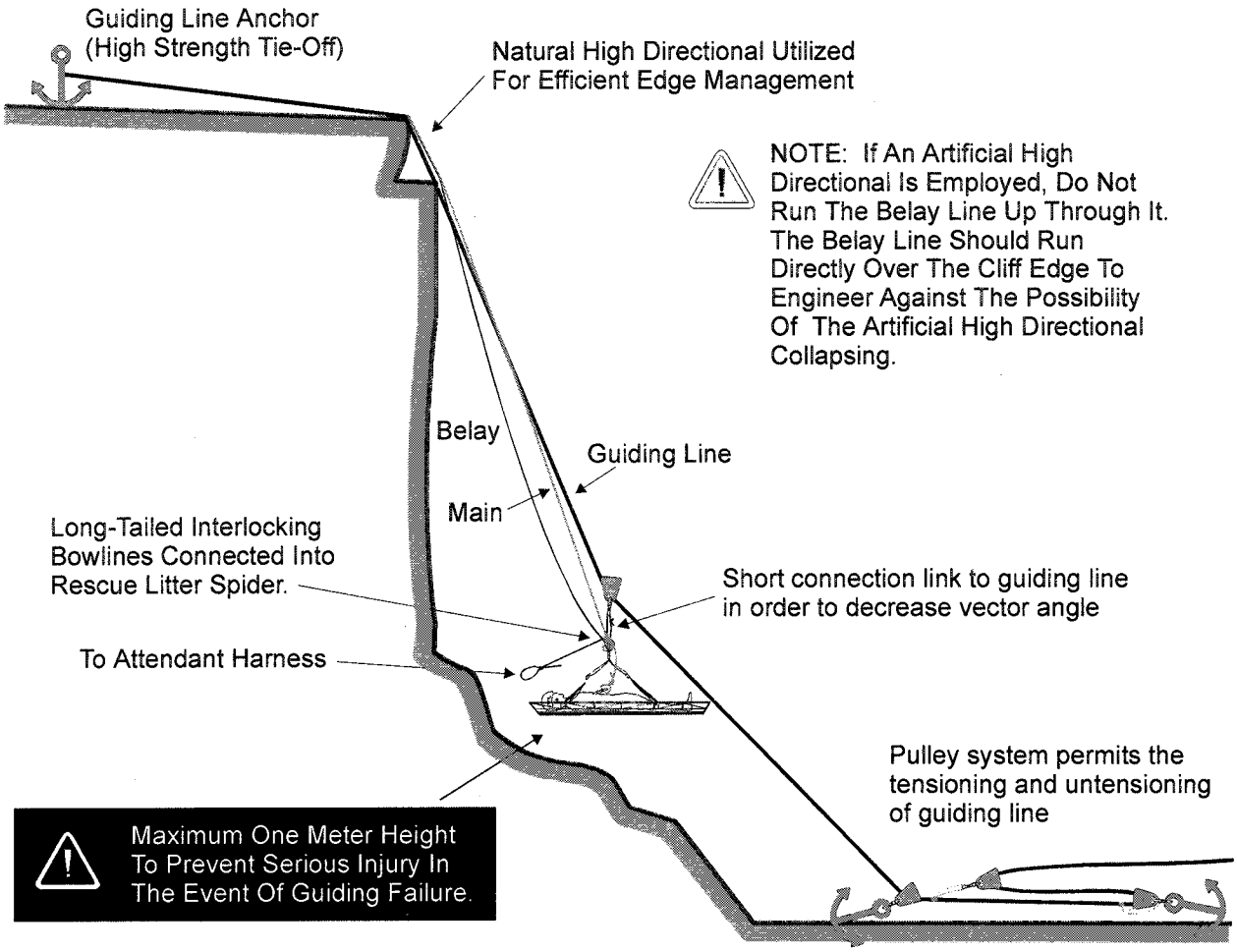
GUIDING LINE COMMUNICATIONS;

- **MAIN LINE:**
  - **"Main Line Up"**
  - **"Main Line Down"**
- **GUIDING LINE:**
  - **"Guiding Line In"** *(Toward cliff face)*
  - **"Guiding Line Out" (Away** *from cliff face)*

WARNING: If an artificial high directional (e.g. A-frame, gin pole, etc.) is employed it is critical that the belay line not run up through it. To engineer for the potential of the high directional collapsing, the belay line should run directly over the cliff edge against padding.

NOTES:

GUIDING LINE TECHNIQUE



NOTES:

EMS CONSIDERATIONS IN THE TECHNICAL ENVIRONMENT

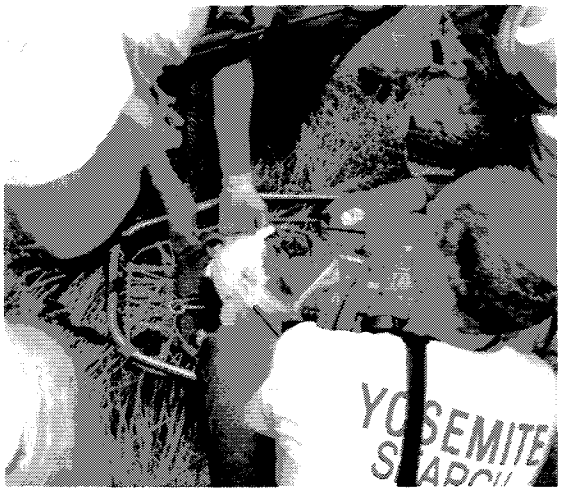
Compiled by Keith Lober, SAR Coordinator-Paramedic, Yosemite National Park

THE FOUNDATION- Here are some philosophies that you might want to ponder....

- If you expect to do it professionally, you must learn to do it recreationally. If you expect to be involved in high angle rescue, then spend a little of your recreational time climbing.
- A climber does not a rope rescuer make.....*but climbers <u>can</u> make the best rope rescuers.*
- When operating in the technical environment, the philosophy which I've found works the best is the ability to; **IMPROVISE, ADAPT and OVERCOME!**

ADVANCED LIFE SUPPORT PROVIDERS:

In the technical arena advanced life support (ALS) providers commonly won't be doing advanced procedures for a variety of reasons such as the environment, extreme cold, gravity, lack of space and the occasional ability to rapidly extricate a patient with a helicopter. This is not to suggest that the advanced level provider is not needed. The experience that an ALS provider brings to the call often determines what procedures can be diverted or delayed and which procedures cannot or should not. You may also find yourself as the sole provider with a critically injured person and it is not just the advanced skills in your bag of tricks but the experience that an advanced provider typically brings to the call that makes a difference.



Members of Yosemite National Park YOSAR stabilize a climber who sustained a head injury

<u>SIMPLE TRICKS OF THE TRADE:</u>

Some of these ideas you might find controversial. You will need to be able to justify any deviations from the normal standards of care and the protocols under which you function. This deviation is only as much as practical and of course driven by the incident.

• RATIONING: Commonly in the technical environment, the logistics "train" is slow or non- existent. Rationing of supplies is certainly less than desirable but there are some cost effective ways to do it.

• AIRWAY: Consider <u>not</u> using a non-rebreather mask on critical trauma and medical patients. A nasal cannula that delivers only two liters a minute will last longer than the face mask that requires a minimum of eight liters a minute. Simply put: you get more bang for your buck! It is better for a patient to receive two liters a minute throughout the rescue extrication rather than to have high flow oxygen for a short duration.

NOTES:

• ELECTRIC SUCTION: I'm really big on the portable electric suction devices. Although I carry them in my first line medical packs, my experience has been that the V-Vacs™ and other manual devices are just not as effective.

• IV: Try not to run IV solutions wide open in shocky patients. Instead, titrate IV rates to a substandard but survivable blood pressure. A steady systolic blood pressure of 70-80 mm Hg will have a better outcome than will raising the systolic to 120 mm Hg for a short duration followed by a precipitous drop. Current studies done in urban settings also suggest better outcomes with this technique, since raising blood pressure to a robust level blows out clots and precipitate blood loss.

• PROFESSIONALISM: In EMS it has been said that the client's first impression is their only impression of you. How you act, what you look like and what you bring to a call sets the stage. Never let them see you sweat! Your job at the very least is to remain calm and act in control even if you are not. A paramedic at a scene is comparable to the role of an "airline pilot."

> - Know what is in the bag you're carrying. Know the location of all crucial items in your EMS bags. When supplies have been carried around in a pack for years they begin to look like hell. Throw out tattered, soiled or water spoiled items.

• SHARPS SAFETY: Never allow care providers to place sharps of any kind into trash bags. Sharps containers must be provided with all IV kits. An empty water bottle that is well labeled will provide a safe repository for a contaminated sharp in an emergency.

• EQUIPMENT: I have total access to all of the EMS resources of Yosemite National Park. Because of this I actually have the luxury of two complete Paramedic level medical packs. One is dedicated to front-country uses but the one we will be reviewing here is my back country response pack.

> -I call it the "meat and potatoes" med-pack. I've thrown out all the cool gadgets and hoohaws that EMS providers, myself included, love to play with. As I've gotten older I've found it increasingly more difficult to keep up with the 25 year-old young bucks on the trail, and it's caused me to take a critical look at what we do carry.
>
> - My first goal with this pack was to minimize both weight and volume (bulk). To do this I've had to focus this pack toward my average target audience: adults between the ages of 16 and 40. Not that we don't get calls for older or younger age groups, but the incidence of these calls is significantly lower. The second goal was to modularize my medical packs. This allows me to grossly customize my packs for each call. You can definitely get burned by doing this, but good information gathering can mitigate this.

• SOFT RESTRAINTS: I use casting sock as a restraint, which is light and relatively easy to use. In a pinch situation I also used the patient's own socks. The patient's hands are then inserted up beyond the wrist and tape is applied to keep the sock in place. Lighter socks seem to work better.

NOTES:

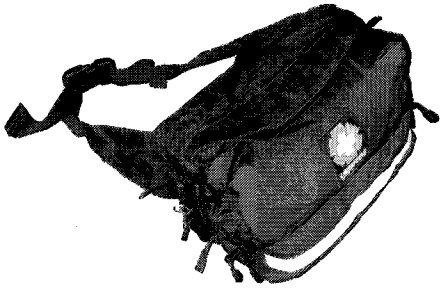
• MEDICATIONS: As a paramedic I was trained to administer over thirty different medications, but what I've found is that I use only about six medications with any regularity in the backcountry.

- 1 mg. vials Epinephrine 1:1000 (2)
- D50 (50% Dextrose) (1)
- 2 mg. vial Narcan (1)
- 10 mg. vial, Morphine (1)
- Nitroglycerin tablets
- Albuterol via small volume nebulizer (SVN) (1)

- I consider 1:1,000 Epinephrine to be the single most important medication of the lot. I will dilute it with normal saline in cardiac arrest situations. *Consult your local protocols.*

ADVANCED LIFE SUPPORT EMS PACK- YOSEMITE NATIONAL PARK

- Airway Module
- Intravenous (IV) Module
- Space Blanket, Disposable
- Stethoscope
- Blood Pressure Cuff
- Trauma Shears
- Clipboard with Run Sheets
- Gloves (large)
- Cervical Collar, adjustable (or improvised from a SAM Splint)
- Triangular Bandages- 2
- Cloth Tape, 2 inch- 2 rolls
- SAM Splint
- Kling- 2 rolls
- 4 X 4 Dressings
- Bio-Hazard Bags
- Sharps Container
- Start Triage Tags
- Micro-Sized Oxygen Bottle with regulator
- Nasal Cannula
- Non-Rebreather Mask
- Oxygen Supply Tubing
- Bag-Valve Mask



Conterra Infinity Pro backcountry modular EMS fanny pack. It can be worn as fanny pack or slipped inside a larger backpack during a rescue.

NOTE: To reduce weight and bulk, oxygen delivery equipment may adjusted depending on availability of additional manpower to deliver equipment to a scene as well as transport times. As a minimum, a BVM supplying ambient air to a patient should be available.

NOTES:

Basic Technical Rescue

☐ AIRWAY MODULE

- Endotracheal Tube, 5 mm to 8 mm- 1 set
- Syringe, 10 cc
- Tube Restraint
- Laryngoscope Handle (AA battery size- batteries interchangeable with headlamp)
- Laryngoscope Blades- 2-3 misc. sizes
- Intubation Stylet- 2
- V-Vac™ Suction
- Lidocaine Jelly
- BAMM Intubation Confirmation Whistle
- Neosynephrine
- Nasopharyngeal Airway
- Oropharyngeal Airway- set
- Soft Restraints

☐ IV MODULE

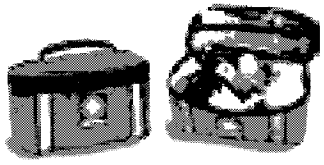
- Drip Tubing Set, Macro Size
- IV Solution, 2- 500 cc size (permits establishing two IV's)
- IV Catheters; 22, 20, 18 and 16 gauge- 2 each

  Note: 60 cc syringe with 16 GA angiocatheter can be employed for wound irrigation.
- Tourniquets- 2
- Alcohol Prep Pads
- Op-Site Dressing
- 4 X 4 Dressing- 2
- Adhesive Tape
- Latex Exam Gloves (1 pair large)

TECHNICAL RESCUE ALS MEDICAL PACK - YOSEMITE NATIONAL PARK

[NOTE: This kit fits in a small pouch measuring 7" H x 11" W x 7" D. It can easily be slipped inside a rescuer's personal SAR pack for field use.]

- Intravenous (IV) Start Kit with Solution Bag & Drip Set
- Airway Module
- Oxygen Supply Tubing
- Bag-Valve-Mask with Adult & Pediatric Mask
- Space Blanket, Disposable
- Stethoscope
- Blood Pressure Cuff
- Trauma Shears
- Clipboard with Run Sheets
- Glove Module (large plastic bag with over one dozen pairs)
- Cervical Collar, adjustable (or improvised from a SAM Splint)
- Triangular Bandages- 2



Conterra Responder I EMS Jump Kit

NOTES:

- Cloth Tape, 2 inch- 2 rolls
- SAM splint
- Kling- 2
- 4 X 4 Dressings
- Bio-Hazard Bags
- Sharps Container
- Pulse Oximeter (finger probe model)
- Headlamp
- Water Bottle & Food
- Pile Jacket & Wool Hat

NIGHT RESCUE OPERATIONS

Compiled by Kip Knapp, Grand Teton NP and Jim Schlinkman, Great Basin NP

Any rescue operation may easily end up taking much longer than projected. Be prepared to continue efficiently after nightfall if required. Evaluate what plan is in the best interest of everyone. Is it worth the risk to move through the night or is it better to sit it out? Brief the victim of your plan.

Hazards

- Increased likelihood of injury to rescue personnel.
- Nighttime temperatures often drop dramatically.
- Routefinding becomes more difficult. Consider chemical lightsticks to mark route.
- Obvious hazards become obscured by darkness (e.g. cliff edges and low hanging branches). Aggressively flag and rope off danger zones.

Night rescue training exercise. Canyonlands National Park.

Personal Preparedness

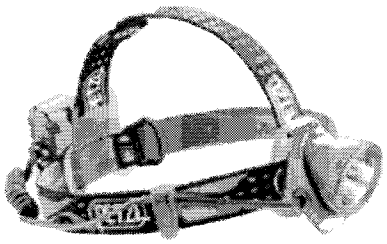
- Carry a headlamp even during day rescues [with extra bulb and batteries].
- Strobe lights are a very effective attraction device.
- A backup flashlight should be carried on your person.

Headlamps

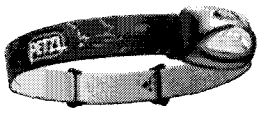
- The intensity of a headlamp lightbulb is measured in amperage, or amps. Gas bulbs, such as halogen, krypton or xenon burn brighter than a vacuum bulb but draw more battery power due to their amperage. The development of headlamps equipped with LED's *(light emitting diodes)* has been a significant improvement. An LED is illuminated by the movement of electrons in a semiconductor material through the process of *electroluminescence*. While not yet as bright as an incandescent bulb, an LED uses ten times less current and therefore will operate ten times longer with the same battery. An LED doesn't have a filament that will burn out, with a useful life span of 100,000 hours, which translates to an impressive 11.41 years of constant use.

NOTES:

• The three common types of dry-cell batteries are: alkaline, lithium and nicad (rechargeable). Alkaline have replaced carbon-zinc as the most common battery on the market and should be utilized at a constant amperage. If you change bulbs to alter your light's intensity it will result in a power loss. Lithium batteries out perform all other battery types in cold weather. In freezing weather most batteries have a shorter life (often by half), but Lithium batteries actually last longer. Lithium also has the advantage of a longer shelf life. Nicad or nickel-cadmium batteries are rechargeable and may require an adapter to operate in your headlamp. Carry spare alkaline or nicad batteries next to your body to keep them warm in cold weather.



Petzl MYO 5 (LED & Xenon Halogen Combo) Headlamp



Petzl Tikka Headlamp

• **Batteries can explode!** Basic safety guidelines for batteries include;
  • Don't use different types of batteries together (e.g. lithium with alkaline)
  • Don't try and recharge any battery except a nicad.
  • Don't put your batteries in a fire- they will explode!
  • Don't carry batteries loose in your pack or pocket (keep them wrapped in a bag).
  • Do check your batteries for corrosion. Discard any corroded batteries.

Other Considerations

• Drink water during night operations. It is very easy to overlook your personal hydration on an emergency operation.
• Evaluate the updated urgency of the incident- maintain your **"situational awareness"**;
  ° Can you stabilize the patient and wait till morning?
  ° Should the team hike in all night or wait until morning and hike or fly in?
  ° Provide relief personnel in the morning, after initial team has been out all night.
  ° Use less experienced rescuers on night operations? Have them provide backup support instead?
• Safety Officer function as well as buddy check inspections among peers is absolutely essential on night operations.
• The initial response team should travel as a group in the backcountry. Don't allow them to separate and get lost enroute.
• Scout and flag the access route with teams of two rescuers. Consider using reflective flagging or chemical lightsticks.
• Leave a rescuer at the bottom of the cliff as a spotter out of the danger of rockfall.
• Remember that extra food and supplies can't be flown in at night. Bring what you need.
• Conserve your radios. Not all of them need to be on at once.
• In cold temperature extremes keep your radio inside an insulating layer close to your body. This will help prevent power loss with a nicad battery.
• Rest the team as much as possible. Prevent unsafe levels of fatigue.
• Keep equipment organized. Prevent gear from allowing to scatter and get lost in the darkness.
• Be aware that voices carry further in the darkness.

NOTES:

BASIC SAR EQUIPMENT CHECKLIST

(Adapted from Mountain Tools, Carmel, CA)

*Necessities

24 hour search pack 2750-3800 cubic inches.

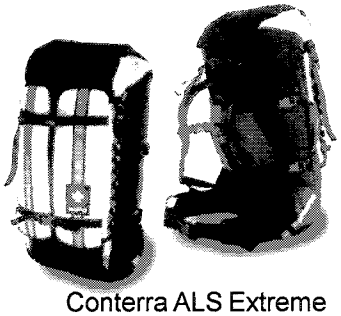
48 hour (overnight) pack internal frame 4500-5500 cubic inches.

Clothing Kit

- Climbing helmet.
- Hats: Wool, Polypro or Capilene balaclava, baseball cap, rain hat.
- Parka: Gore-tex, anorak, down, pile.
- Shirt: high visibility shirt, tee-shirt, wool outer shirt, pile sweater or down vest.
- Handwear: fingerless pile, Polypro liners, Dachsteins, overmitts.
- Pants: pile or wool pants, Thermax or Capilene underwear.
- Socks: Polypro liner, midweight Polypro, Capilene, wool socks, vapor barrier for winter or plastic mountaineering boots. Overboot liners.
- Footwear: Mountaineering boots or lightweight hiking boots.
- Rainwear: gaiters, rain jacket and rain/wind pants.

Communications & Transportation Kit

- Radio; extra battery, radio harness, long range antenna and remote microphone (also consider; ground-to-air radio, cellular telephone, or satellite telephone).
- Topographic Maps.
- Compass, altimeter and/or handheld GPS (global positioning system).
- Pencil and notebook.
- Signal mirror.
- Strobe.
- Chemical lightstick.
- Whistle.
- Smoke signal and night flares.



Conterra ALS Extreme Rescue Pack

Bivouac Kit

- Gore-tex bivy sack.
- Foam sleeping pad.
- Lightweight (2 pound) down bag.
- Lightweight ground sheet.

Miscellaneous

- Waterproof matches and disposable lighter.
- Knife; Swiss Army, Gerber or Leatherman Tool
- Trauma scissors.

NOTES:

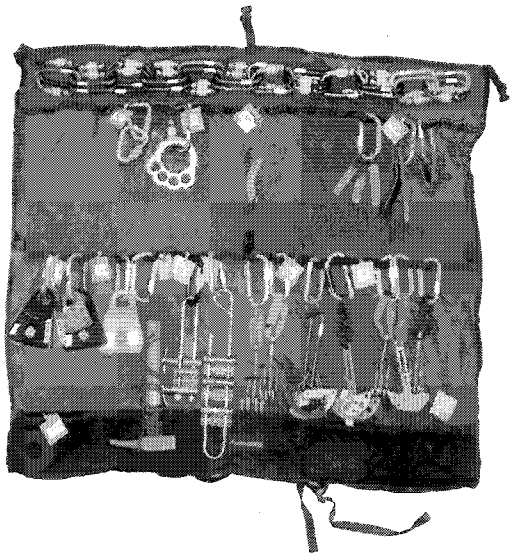
- Spoon.
- Headlamp with extra batteries and spare bulb.
- Large plastic trash bag.
- 100' parachute cord.
- Duct tape.
- Watch.
- Binoculars.

Personal Kit

- Sunglasses and case.
- Toilet paper (additional fire starter).
- Bandana.
- Sunscreen.
- Insect repellent.
- Lip balm.

First Aid Kit

- Personal EMS kit.



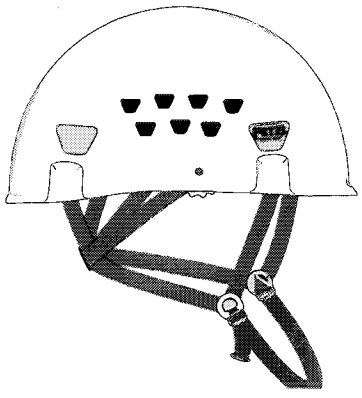
Mountain Tools "California Roll" Gear Organizer

Food/Fluids Kit

- Granola or endurance bars.
- Food for two days [no cooking required].
- Stove for winter use/ base camp.
- Water bottles (minimum of two).
- 2 feet of 3/8 inch plastic tubing (for water sources).
- Water filtration device.
- Electrolyte replacement mix.
- Cup.

"Houdini" Kit

- Seat and chest harness.
- 80'- 7 to 9 mm nylon cordage.
- 18' X 1 inch tubular nylon webbing.
- 12' X 1 inch tubular nylon webbing.
- 3- 6 or 7 mm Prusiks.
- 6- Oval Carabiners & 1 locking carabiners.
- Spectra runner.
- Sewn daisy chain (minimum two feet long).
- Prusik minding rescue pulley.
- Figure eight descender/belay device.



NOTES:

TECHNICAL GEAR:

Rock Gear

- 11 mm X 165 feet dynamic rope.
- Climbing Shoes.
- 1 set of Prusiks.
- 20 oval carabiners + five locking carabiners
- Runners: one inch webbing runners: 10- 4', 2- 8' and quickdraws, etc.
- Small sport rack: nuts, chocks, spring loaded camming devices, etc.
- Rappel rack.
- Etriers, pair.
- Handled ascenders, pair.
- Prusik minding rescue pulley.
- Leather gloves.
- Hammer with holster.
- Bolting kit and small pitons.

Snow and Ice Gear

- Avalanche Transceiver.
- Snow shovel.
- Snowshoes.
- Cross-country skis, boots and avalanche probe poles.
- Snow axe (60 cm).
- Rigid crampons.
- Deadman anchor.
- Ice hammer.
- Technical ice axe (50 cm).
- 5 ice screws, various length.
- Snow saw.
- Ice tool holsters

Conterra Magnum Rope Bag

"Rocky Mountain" Technical Rescue Pack

Adapted from Rocky Mountain National Park

Considerations:

- Have enough food and personal gear to be self sufficient on a complex overnight rescue operation, in cold wet weather. Plan for the worst case. Be prepared to stay in the field 48 hours!
- Have enough personal technical gear to perform a solo rope rescue, serve as litter attendant, and ascend or descend a rope safely.
- Have room in rescue pack to carry other gear from rescue cache, such as ropes, modules, etc.
- Have adequate gear to keep yourself and a victim warm, dry, and fed overnight.

NOTES:

Basic Technical Rescue

• Recommended Survival Gear:

1. Map (topographic quad of preferred area).
2. Compass (and a signal mirror, whistle, watch).
3. Headlamp (and extra batteries, bulb, candle).
4. Sunglasses (and Chums, sunscreen, lip balm, hat).
5. Waterproof matches (and toilet paper, plastic bags).
6. Knife (Swiss Army and/or Trauma scissors).
7. Food and water (water treatment capability?).
8. Lots of clothing (including yellow rescue vest and Gore-tex rain gear).
9. Overnight bivy gear (bivy sack, ground cloth, etc.).
10. First Aid Kit (with moleskin, flight medicine, space blanket).
11. Sturdy boots (extra laces).
12. Radio and Extra battery (radio chest harness & remote microphone).
13. Leather gloves with wrist straps.
14. Smoke grenades, flagging tape and ear plugs.
15. Pocket notebook and pen, EMS forms and Helicopter signals

Conterra Crag Alpine Rescue Pack

<u>Optional Survival Gear: (depending on conditions)</u>

Binoculars, Camera and film, Altimeter, Wind Gauge, Thermometer, Insect Repellant, Strobe Light, Foam Pad, Sleeping Bag, Climbing/Hiking Guide, Stove and cookset, Aerial Flares, Cyalume Chemical Lightsticks, Sven Saw, Ice Axe, Shovel, Avalanche Transceiver, Ski Goggles, Thermos with warm liquids. Repair Kit: pliers, duct tape, wire, screwdriver.

• Recommended Technical Rescue Gear:

1. Climbing Helmet.
2. Seat Harness (or 20' of one inch tubular webbing).
3. Chest Harness (or 10' of one inch tubular webbing).
4. Figure eight (preferably with ears) and Prusik.
5. Six locking carabiners and six regular carabiners.
6. Ascending System: (either Prusiks, Mitchell or Yosemite System).
   - ***Prusiks*:** Pre-rigged set of Purcell Prusiks.
   - ***Mitchell System*:** 2- handled ascenders, one with a long foot loop and one with a short foot loop, 1- Gibbs or Petzl Shunt & daisy chain.
   - ***Yosemite System*:** 2- handled ascenders, etriers, and a third attachment point (e.g. Gibbs, Prusik, tied loop) to the rope.
7. Four single runners (5' total length of one inch tubular webbing).
8. Two double runners (10' total length of one inch tubular webbing).
9. Two 20' runners (20' total length of one inch tubular webbing).
10. Daisy Chain.
11. Parachute cord (20').

• Optional Technical Gear:

Rope, Small sport rack, Pearbiner, Pulley, Rappel rack, Climbing shoes, Knee pads, Etriers, Chalk bag, Pitons, Hammer, Bolt Kit.

NOTES:

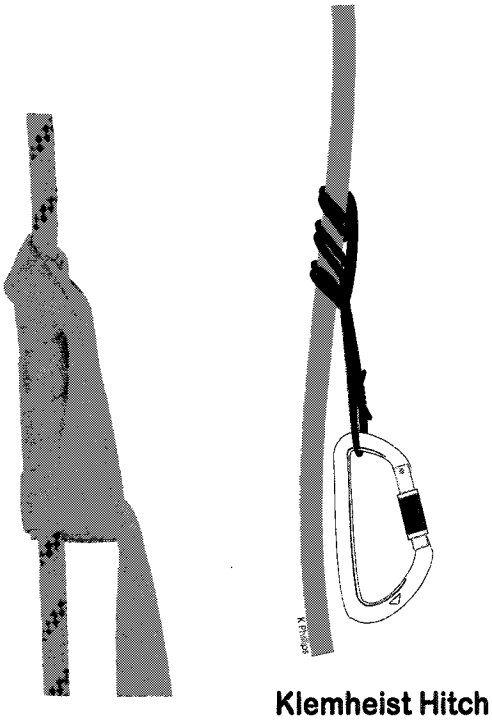
IMPROVISED TECHNIQUES

KLEMHEIST HITCH

The Klemheist Hitch is a "Prusik"- type hitch, which has the advantage in that it can be tied with either cordage or webbing.

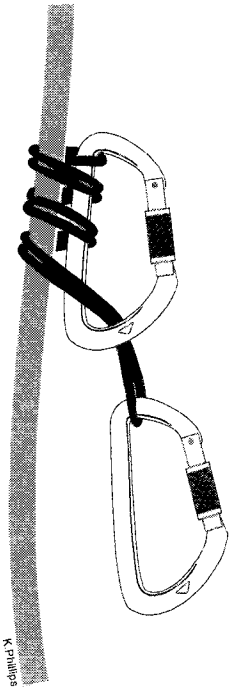
• The sling is wrapped around the host rope in a spiral fashion several times creating a short loop and a longer loop. Make certain that all the wraps lie parallel to one another. With the shorter loop at the top of the hitch, thread the longer loop through the shorter loop.

• When tying the Klemheist with webbing, a softer more supple brand of webbing will work more effectively. Ensure that the webbing lies flat throughout the knot as it is tied.



Klemheist Hitch

BACHMAN HITCH



Bachman Hitch

The Bachman Hitch, a semi-mechanical hitch, can be used for an improvised ascending technique. This hitch has certain limitations and may appear defective. The attached carabiner is not, as it may appear, a handle. If the hitch is raised by pulling on the carabiner the coils will squeeze together and jam. It will release itself when not under load but lock automatically when a load is applied. This hitch does not work on icy ropes!

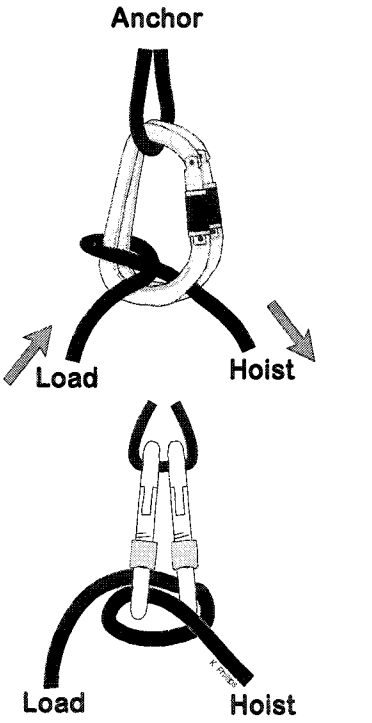
• Clip a carabiner into a sling. Wrap the sling at least three times around the standing rope and through the carabiner. If tied upside-down the hitch slips and will jam.

• Tension the loop coming out of the carabiner.

• An advantage of the Bachman Hitch is that it can be constructed with cordage or webbing.

NOTES:

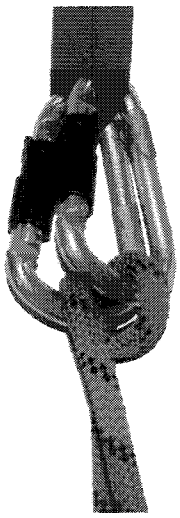
GARDA HITCH:



The Garda Hitch

• The Garda Hitch *(aka Alpine Clutch)* forms a one-way ratchet or autobloc which is a valuable technique when no prusiks are available. It is useful for constructing improvised hauling systems.

• The rope is clipped through two identical locking carabiners. Oval carabiners offer the most efficient performance. D-shaped carabiners are less efficient and tend to jam. Make a loop and clip into the carabiner closest to the load.

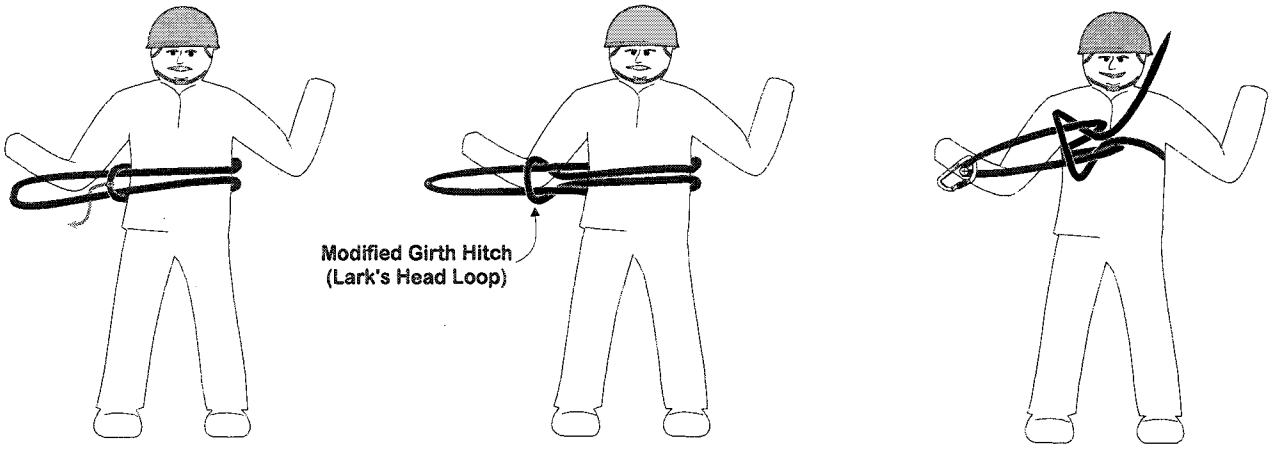


• When the hoist rope is pulled, the rope runs freely with friction. When the load rope is pulled, the hoist rope is pinned between the two carabiners, which are pulled together.

IMPROVISED CHEST HARNESS:

• The baudrier makes an excellent quick tie-off to utilize upon reaching a stranded subject who is not wearing a harness. The double larks head loop or modified girth hitch prevents the webbing from dangerously cinching around the subject's chest if they were accidently suspended in this rig.

• Following application and prior to tying off, one arm of the subject can be slipped into the rigging, thereby forming a chest harness.

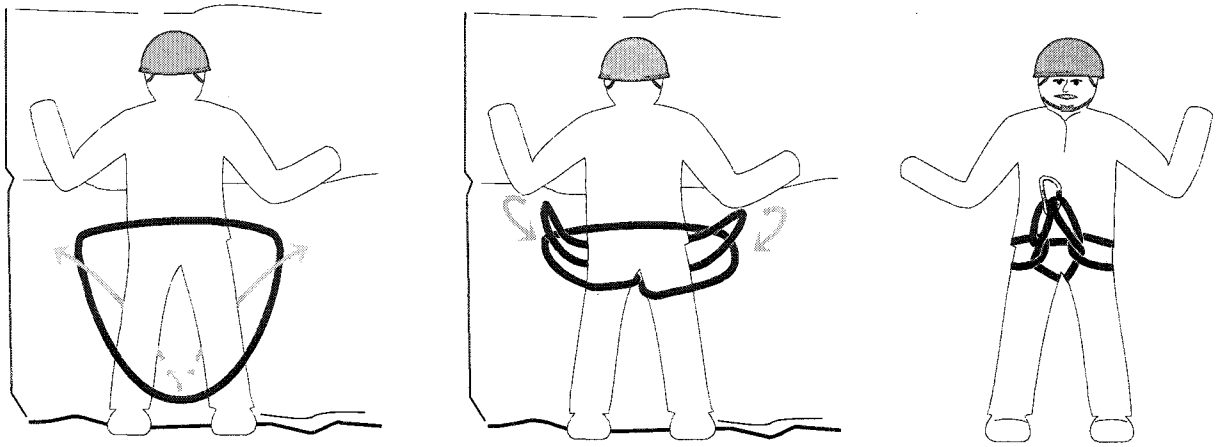


IMPROVISED CHEST HARNESS/BAUDRIER

NOTES:

PICK-OFF HASTY HARNESS:

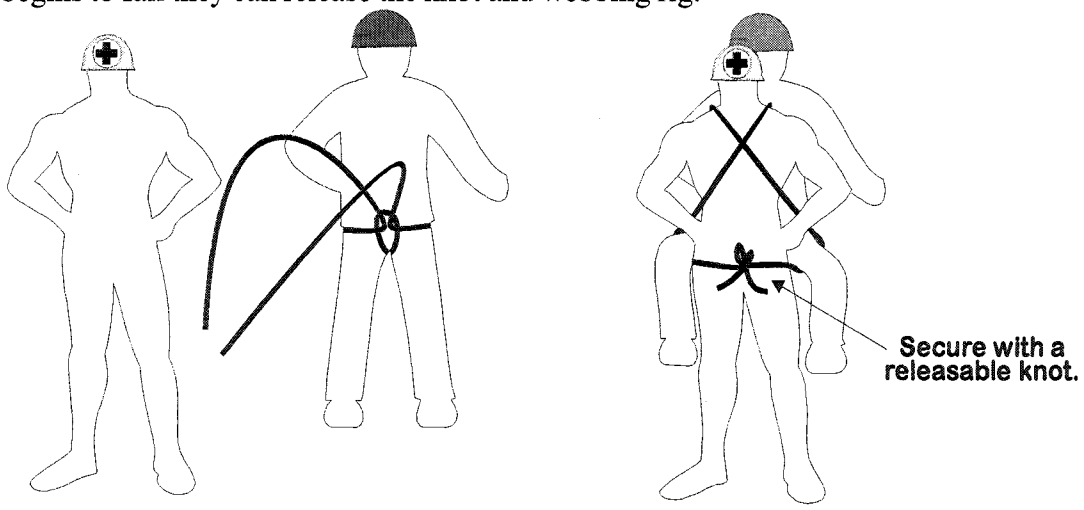
This rig may be quickly attached to a subject that is clinging to a rock face. Using a pre-tied eighteen foot webbing runner, simply drape it over the back of the subject. Reach around both their legs and grab the dangling webbing. Pull the webbing through the crotch and around to each waist forming two loops. Pull these two loops to the front of the subject and tension the harness. Attach a carabiner to the two loops and secure the subject.



PICK-OFF HASTY HARNESS

NYLON WEBBING CARRY:

To facilitate the evacuation of a subject with a minor injuries following a technical rescue, it may be useful to transport them using a nylon webbing carry. An eighteen foot webbing runner is recommended for this rig to prevent dealing with too short a piece of webbing. Once the rig is initially "tied" to the subject's waist, they get into a piggyback position on the rescuer's back. The rig is then secured around the subject's legs and finished with any quick release knot. In the event the rescuer begins to fall they can release the knot and webbing rig.



NYLON WEBBING CARRY

NOTES:

CONVERSION REFERENCES:

Metric		U.S.
1 mm	=	0.039 inches
2.54 cm	=	1 inch
25.4 mm	=	1 inch
30.48 cm	=	1 foot
1 meter (m)	=	39.37 inches or 3.3 feet
1.61 km	=	1 mile
1 gram	=	0.035 ounces
1 kilogram (kg)	=	2.2046 or 2.2 lbs

A newton is the force required to accelerate one kilogram, one meter per second. 1 kN or 1000 Newtons is the force required to accelerate 1000 kilograms, one meter per second. This is approximately equal to a 190 lb. person plus clothes, boots, and gear in a pack. Consider the equivalent that one big person equals about one kN of force hanging on a rope.

1 kN = 225 pounds of force (lbf)

TEST LOAD REFERENCES:

NFPA-

300 lbs.	=	1 person load
600 lbs.	=	2 person load

NASAR & British Columbia Council Of Technical Rescue (BCCTR)-

440 lbs.	=	Rescue Load
600 lbs.	=	Heavy Rescue Load

UIAA

80 kg	=	1 climber

STANDARD WHISTLE SIGNALS ("SUDOT" SYSTEM):

1 Blast	**S- STOP!**
2 Blasts	**U-** Up
3 Blasts	**D-** Down
4 Blasts	**O-** Okay; Off Rope
Sustained Blast	**T-** Trouble; Emergency!; Help!; Rock!

NOTES:

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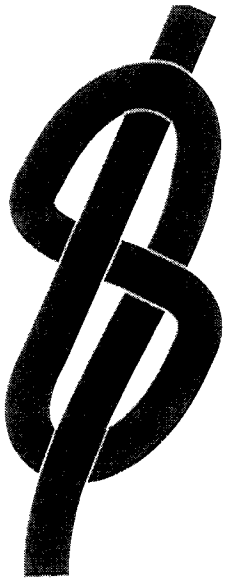


Figure Eight Knot

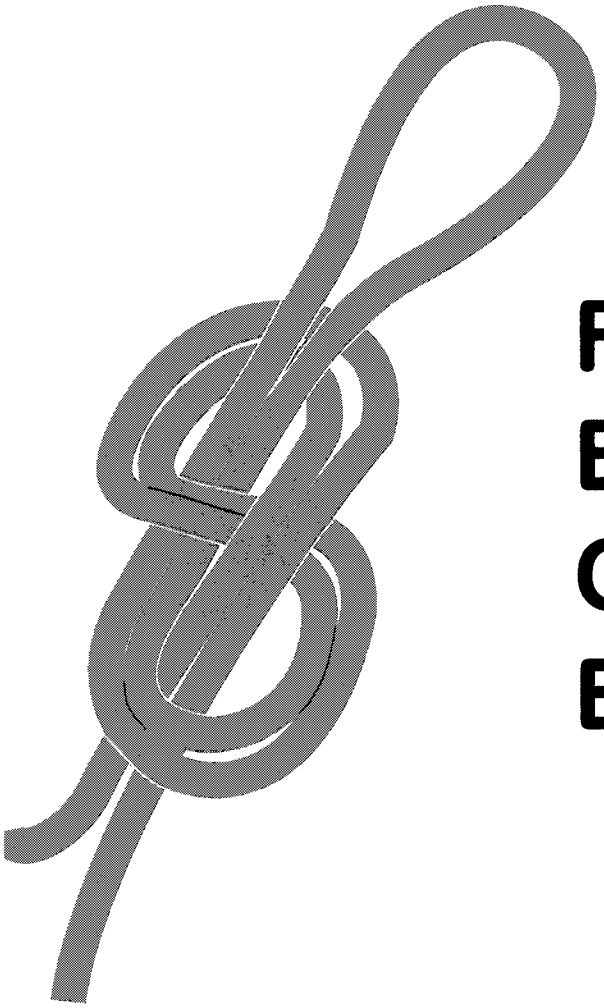


Figure Eight On A Bight

NOTES:

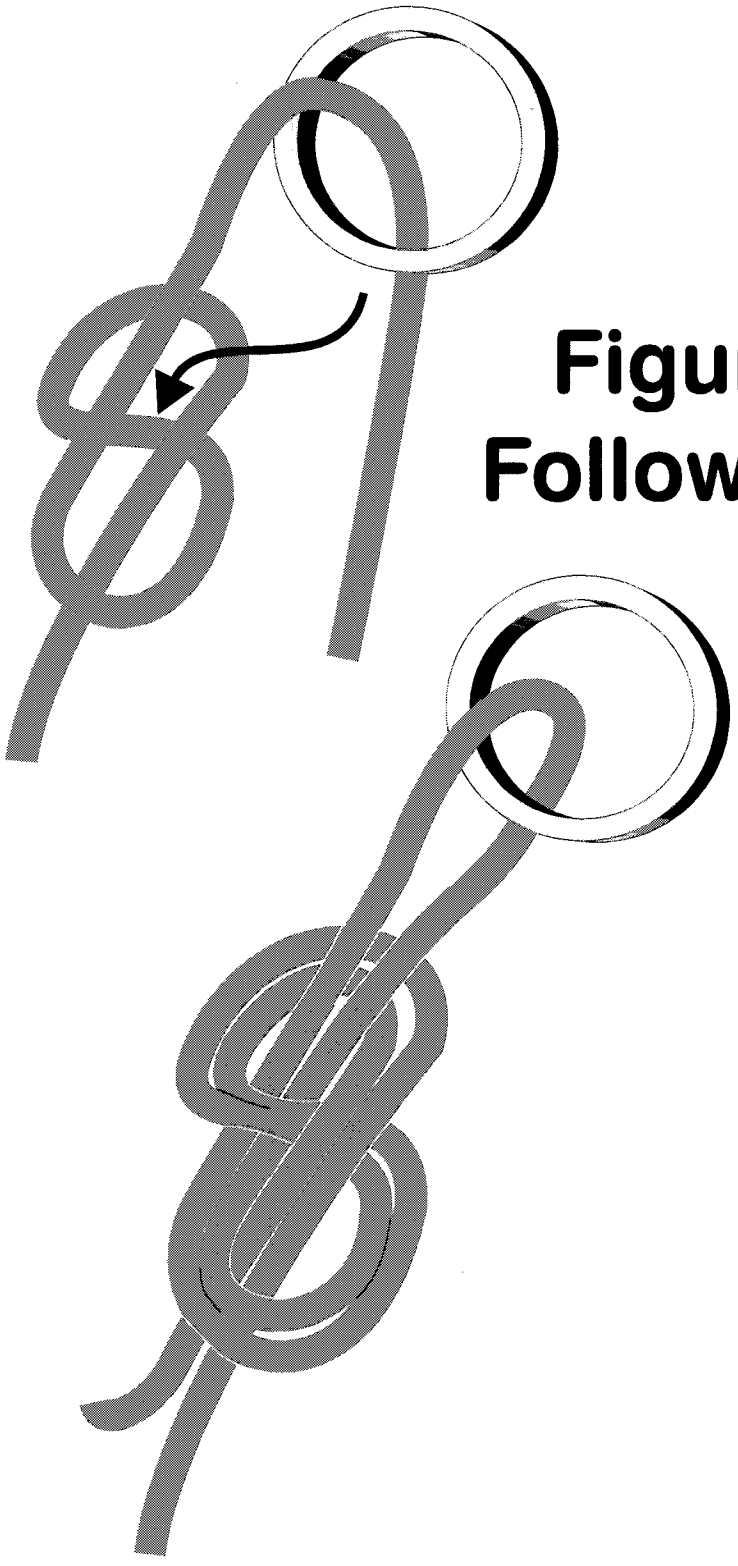
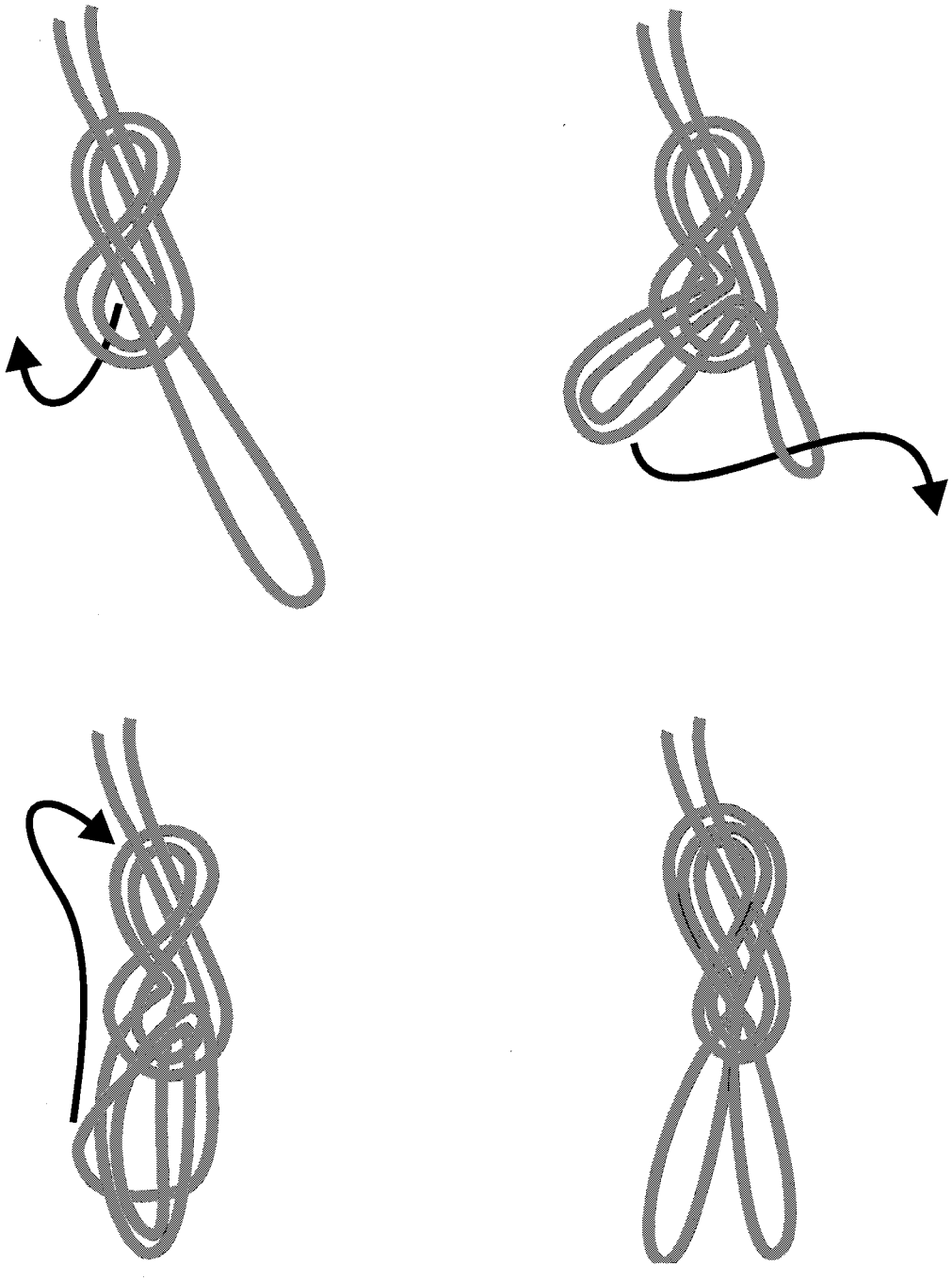


Figure Eight Follow Through

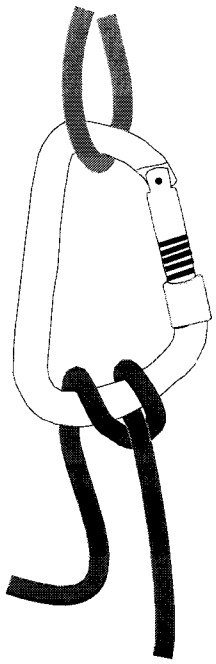
NOTES:

Double Loop Figure Eight

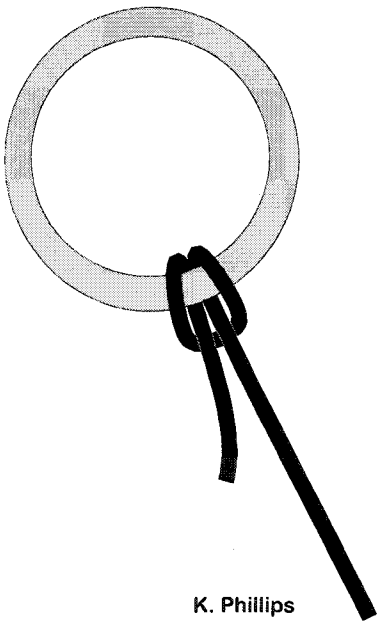


NOTES:

Münter Hitch

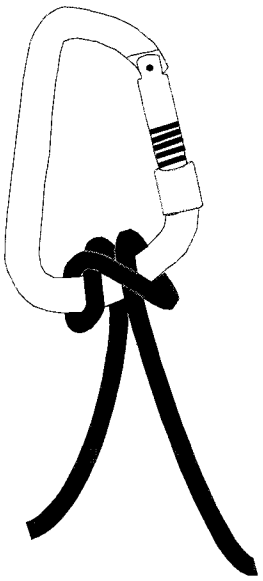


Girth Hitch



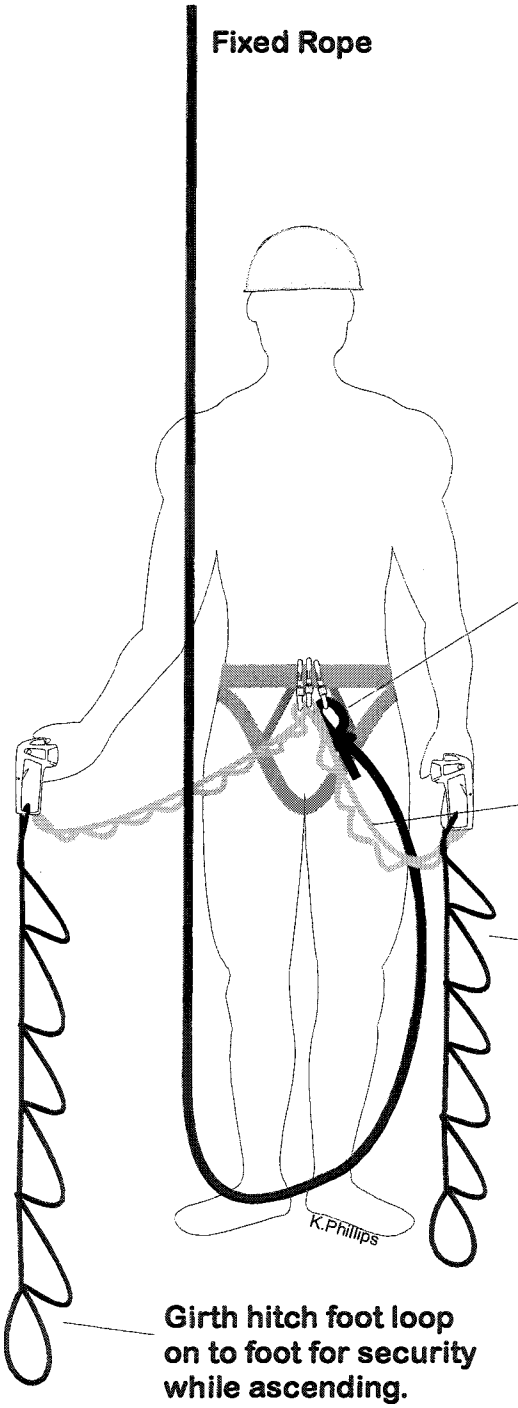
K. Phillips

Clove Hitch



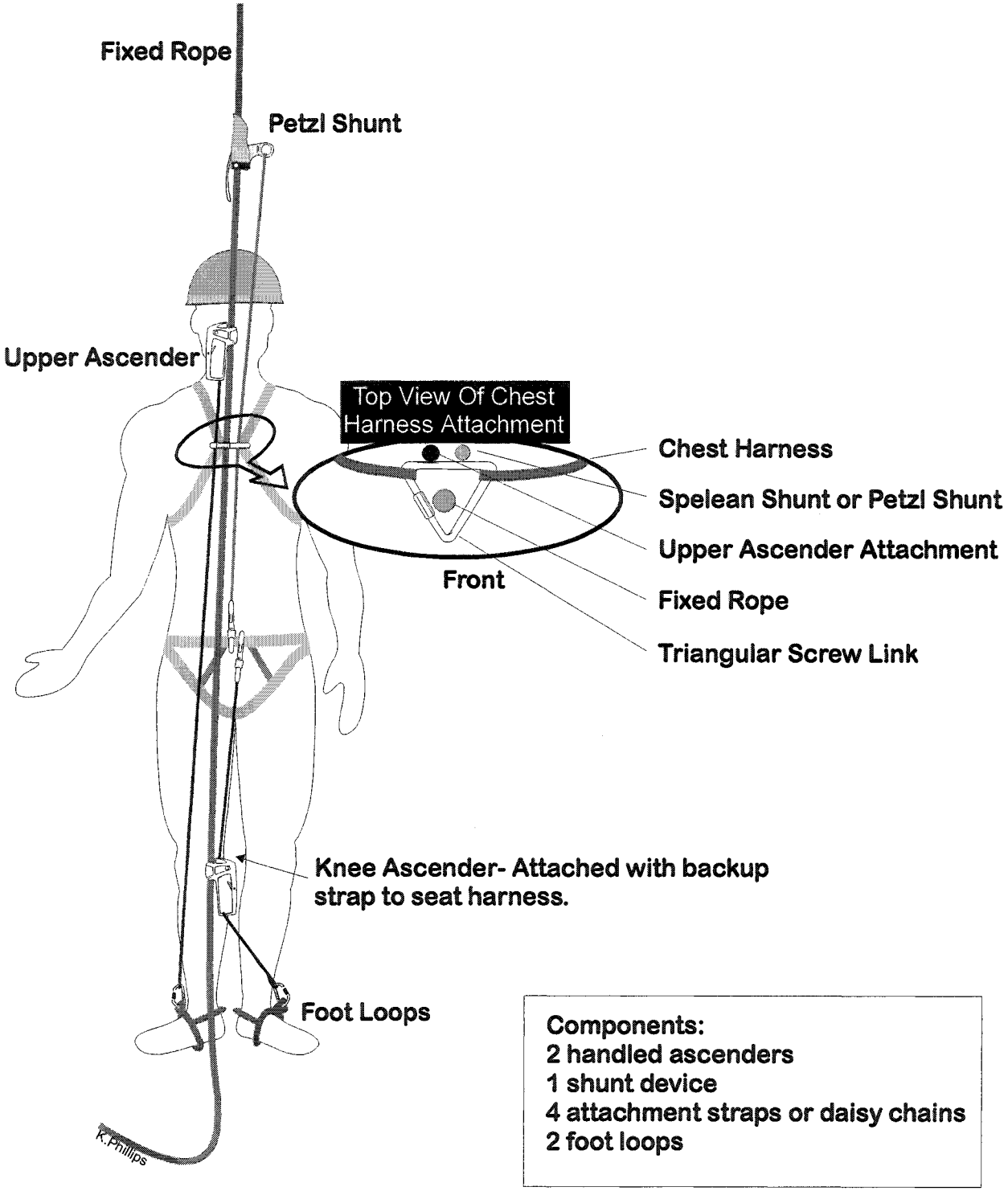
NOTES:

Yosemite Ascending System (Big Wall System)



NOTES:

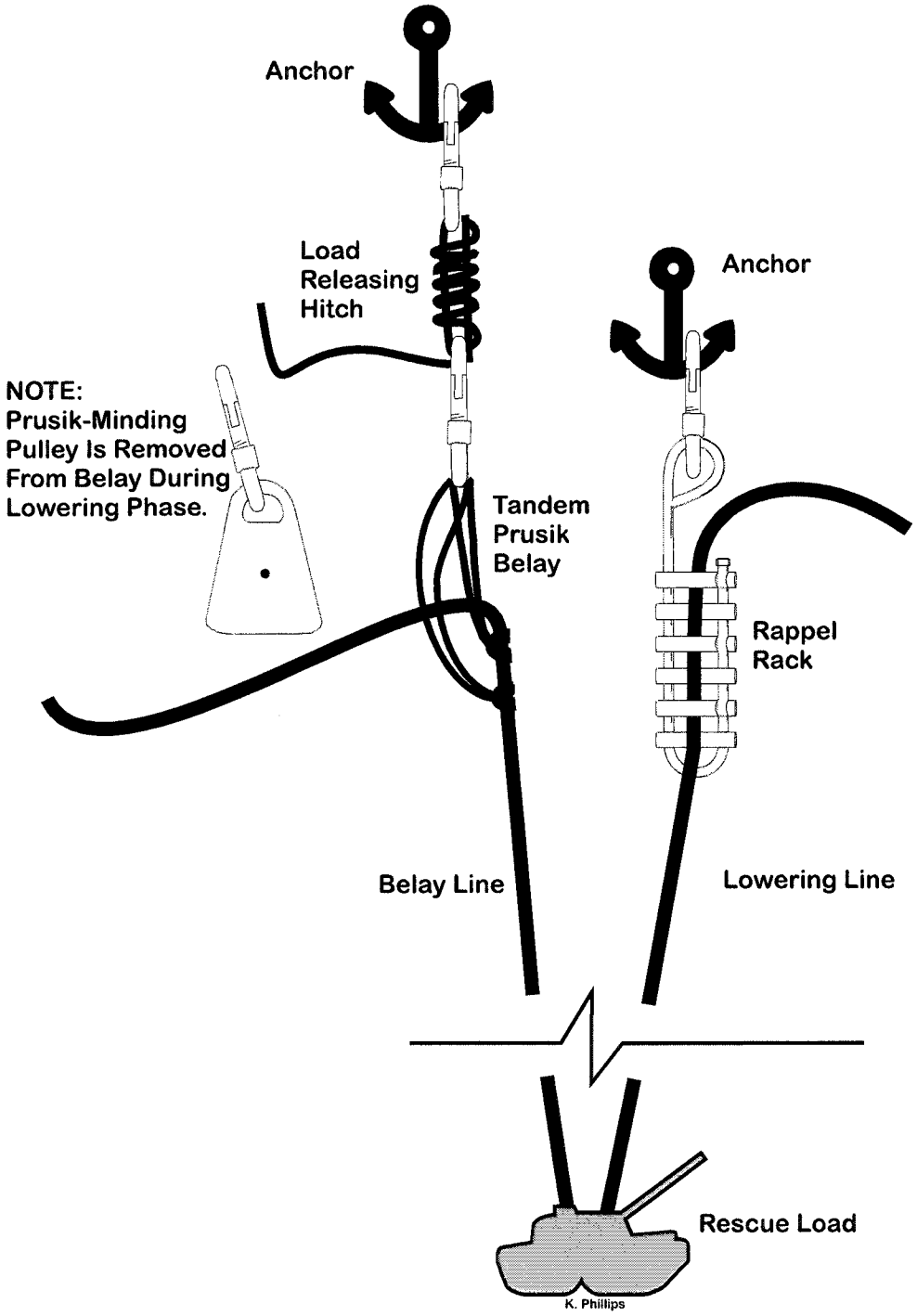
Mitchell Ascending System



Components:
2 handled ascenders
1 shunt device
4 attachment straps or daisy chains
2 foot loops

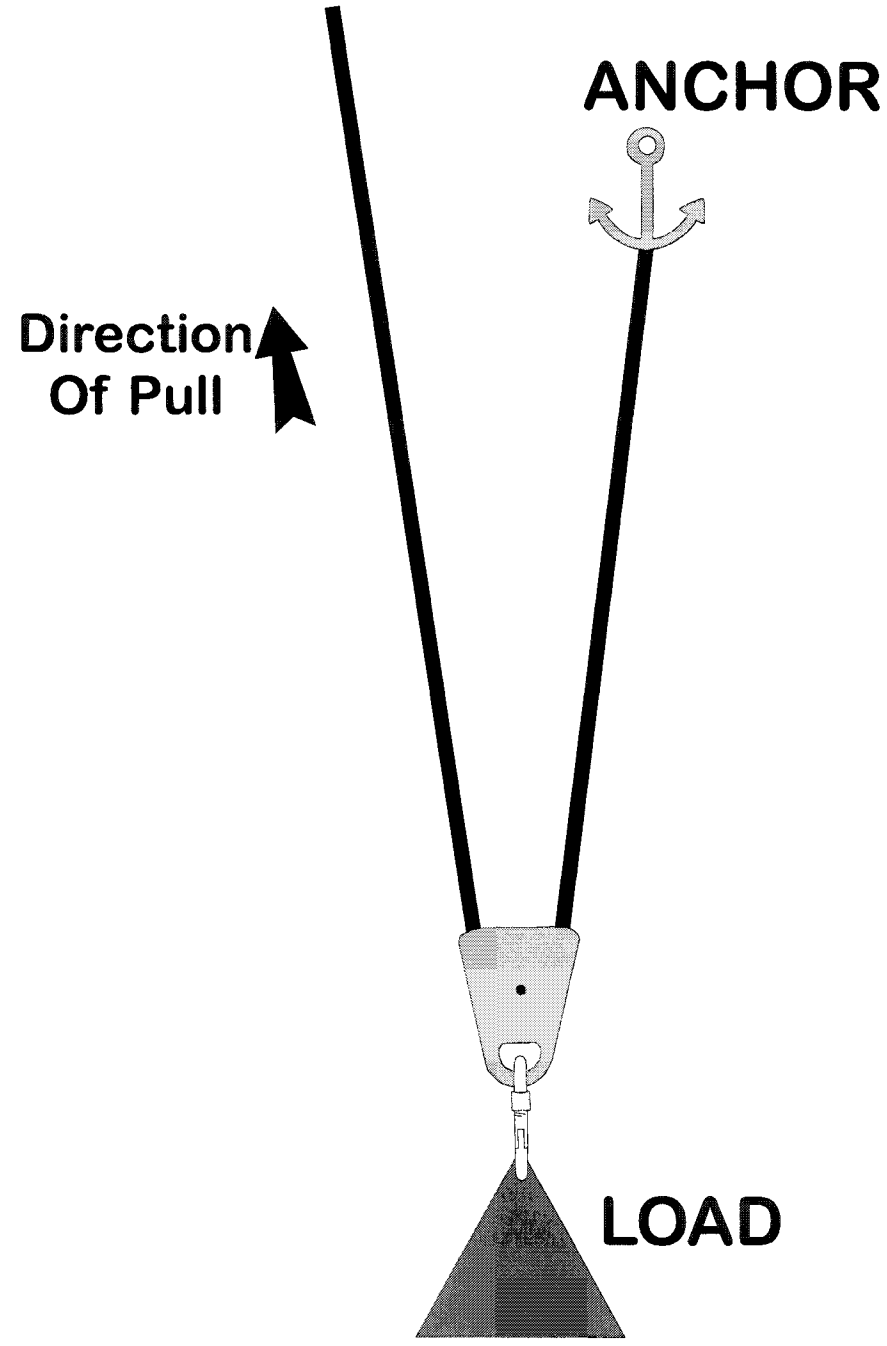
NOTES:

LOWERING SYSTEM- RESCUE LOAD



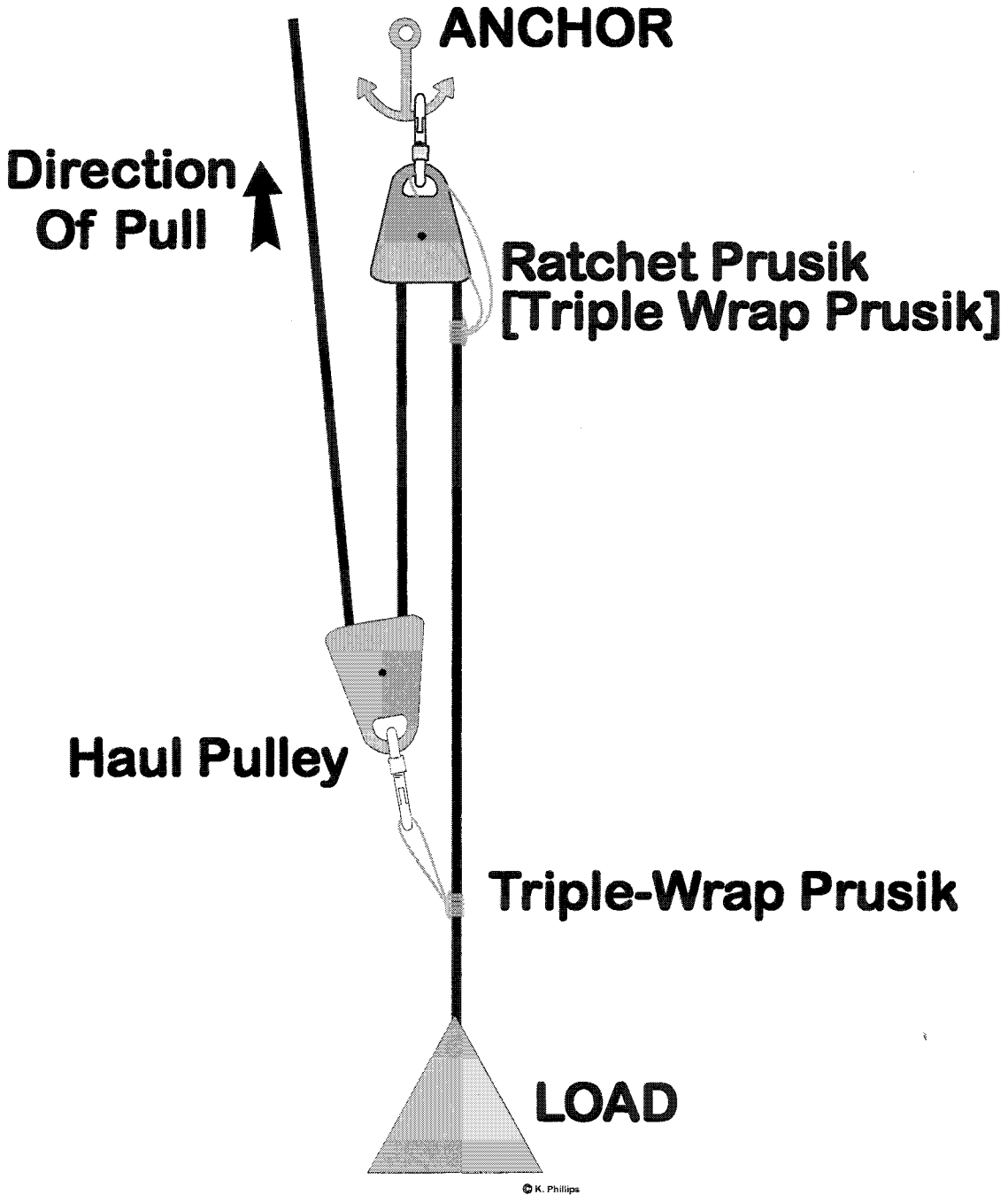
NOTES:

2:1 Mechanical Advantage Pulley System



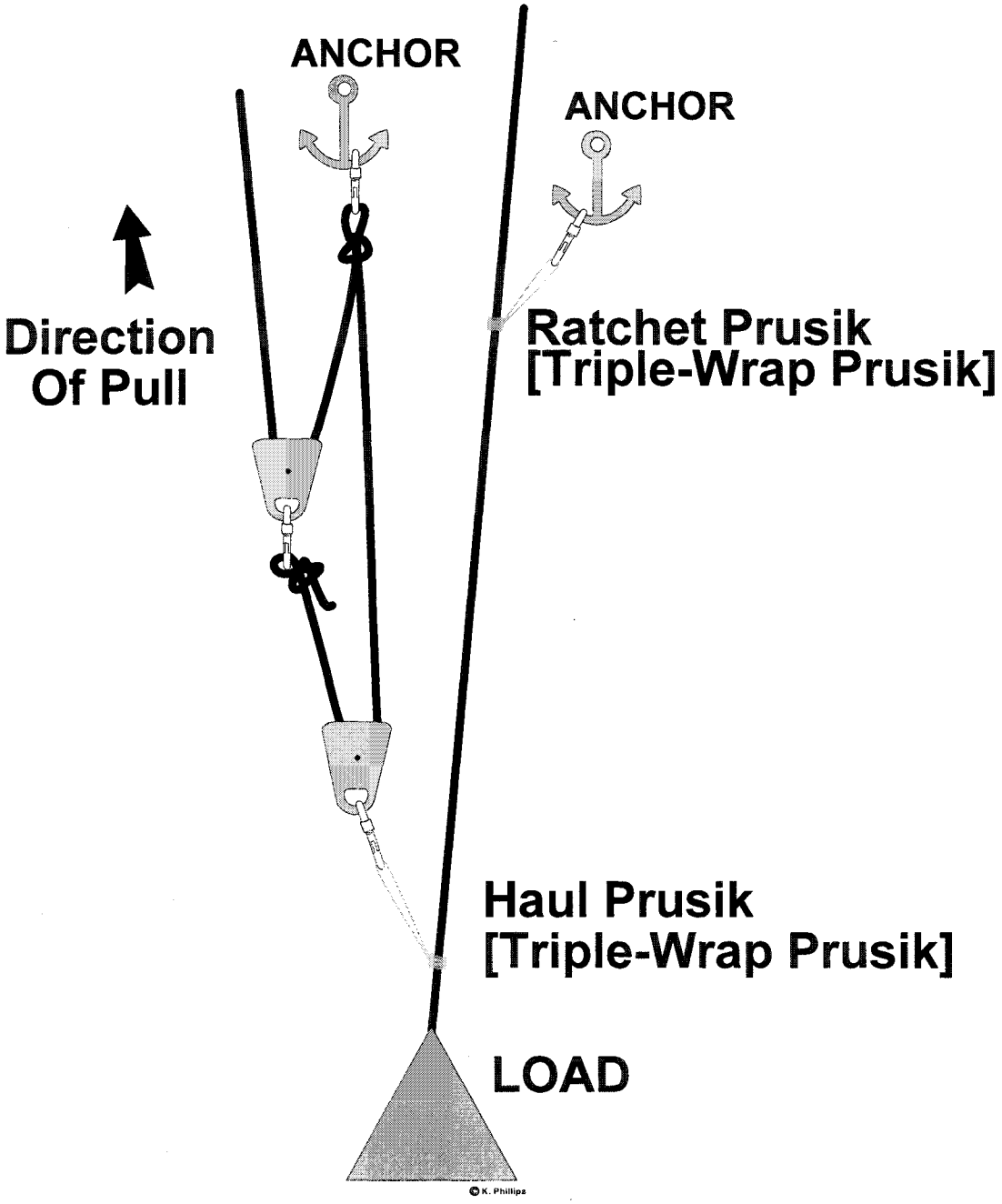
NOTES:

3:1 Mechanical Advantage Z-Rig Pulley System



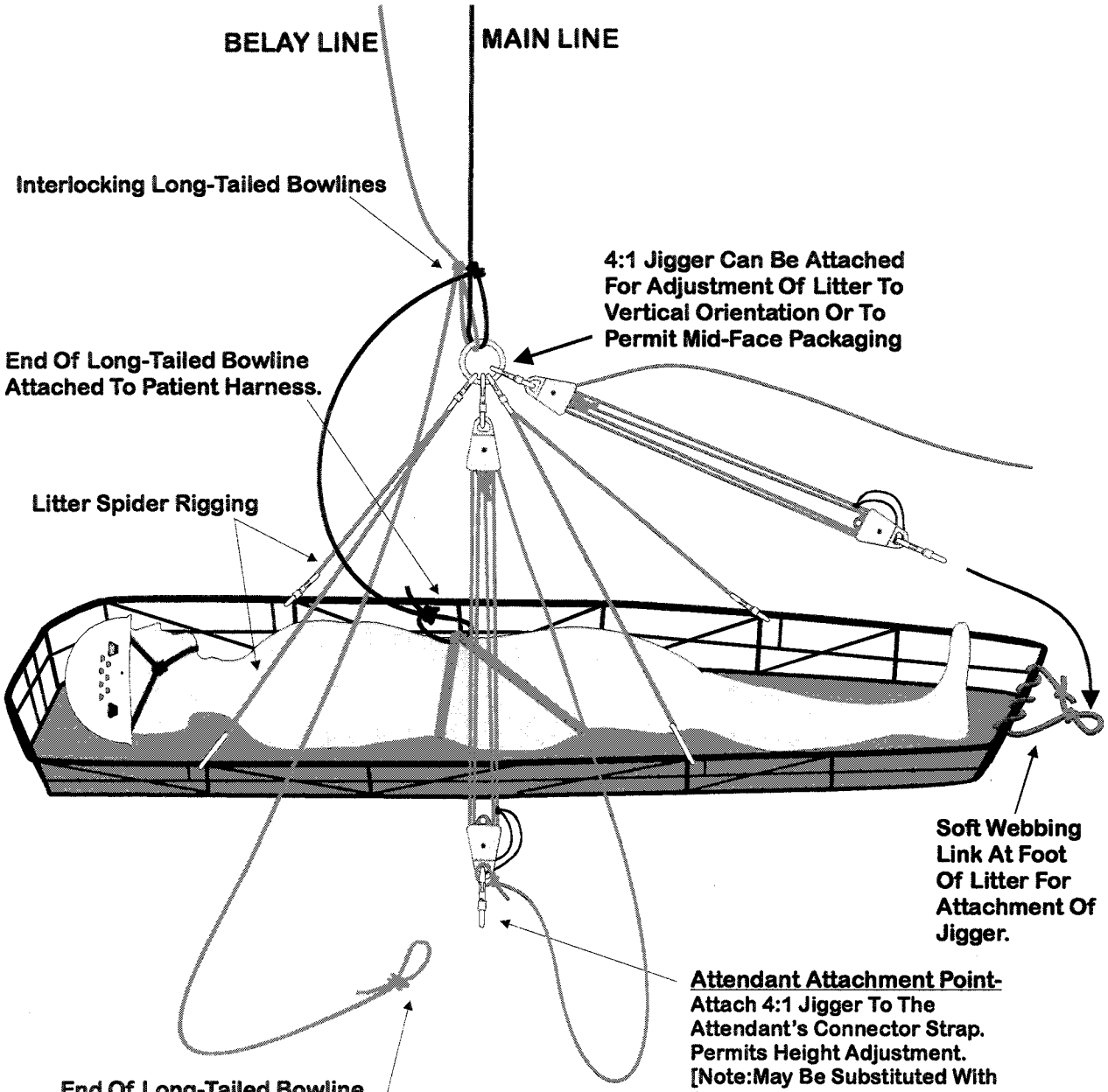
NOTES:

4:1 Mechanical Advantage Pig Rig System



NOTES:

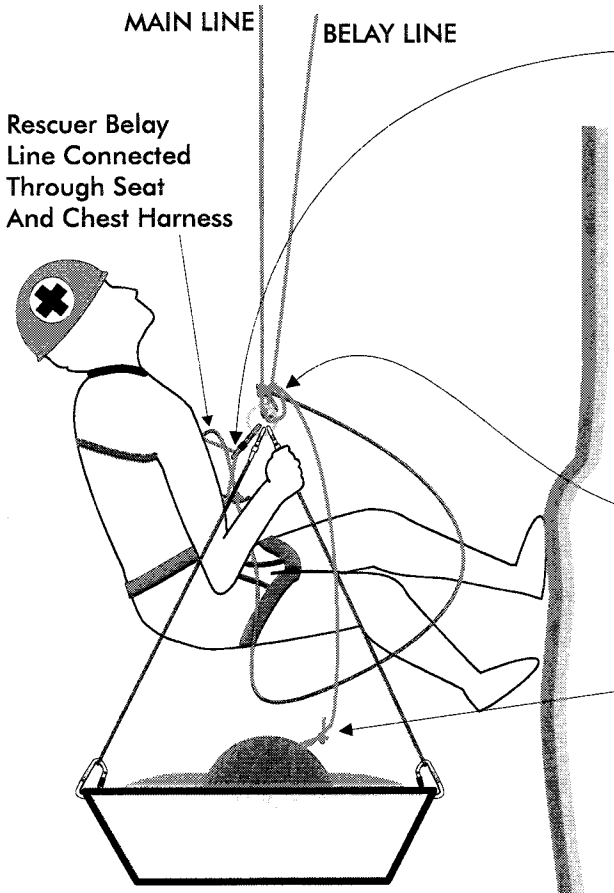
HIGH ANGLE RAISE/LOWER RIGGING



MEDICAL NOTE: For a patient with a compromised or unstable airway, who is not intubated, it is much safer to package the patient on their side, rather than attempt to roll the litter on its side with a "barf strap" if they vomit.

NOTES:

ELEVATED ATTENDANT POSITION FOR HIGH ANGLE RAISE/LOWER



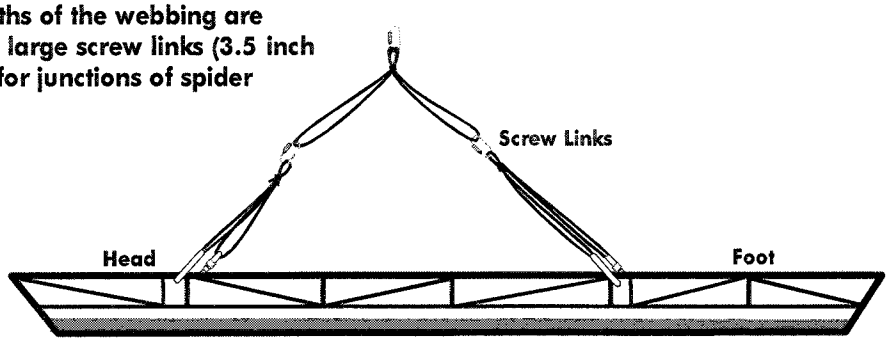
NOTE: This position works very well in vertical or over-hung terrain. It allows the attendant to use their legs to perform the majority of the task of keeping the litter away from the cliff face. However, when negotiating a cliff edge or inclined situations the attendant needs to transition into the traditional position below the stretcher.

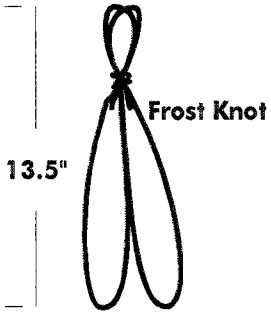
Employing The Elevated Attendant Position During A Litter Raising Evolution

NOTES:

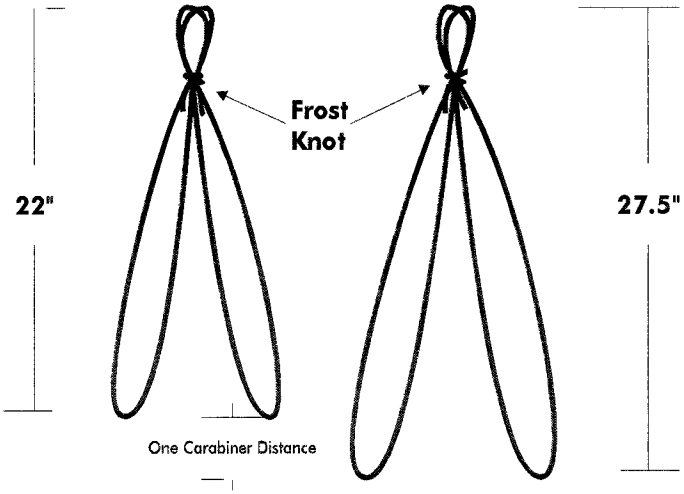
RFR FIXED LEG LITTER SPIDER

Fixed leg litter spider constructed with three pieces of one-inch tubular webbing. Dimmensions shown are sized for a standard size Junkin or Colonial brand Stokes stretcher. Cut lengths of the webbing are shown prior to knots. Use large screw links (3.5 inch length with 30 kN rating) for junctions of spider components.





(9' 8" Webbing)



(9' 10" Webbing) (12' 1" Webbing)

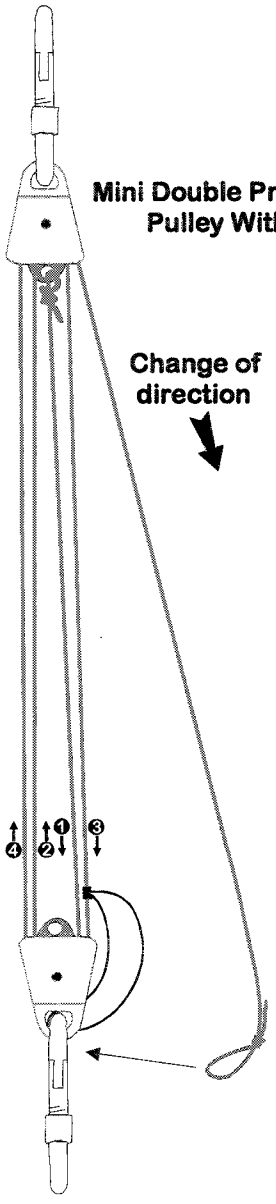
NOTES:

4:1 LITTER/ATTENDANT JIGGER SYSTEM

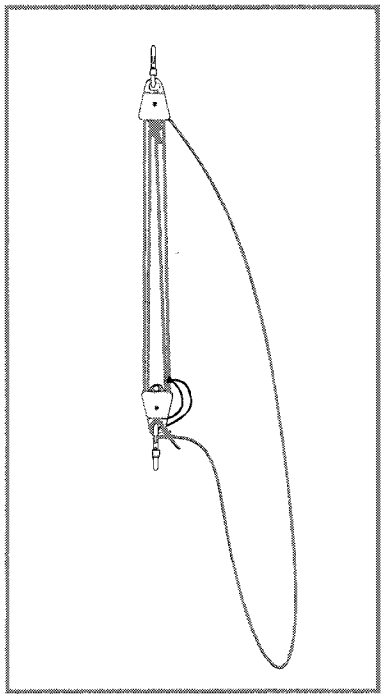
(Attachment To Litter Spider)

ANCHOR

The jigger is a simple 4:1 pulley system with a change of direction, which is constructed of 8mm accessory cord X 12 meters.



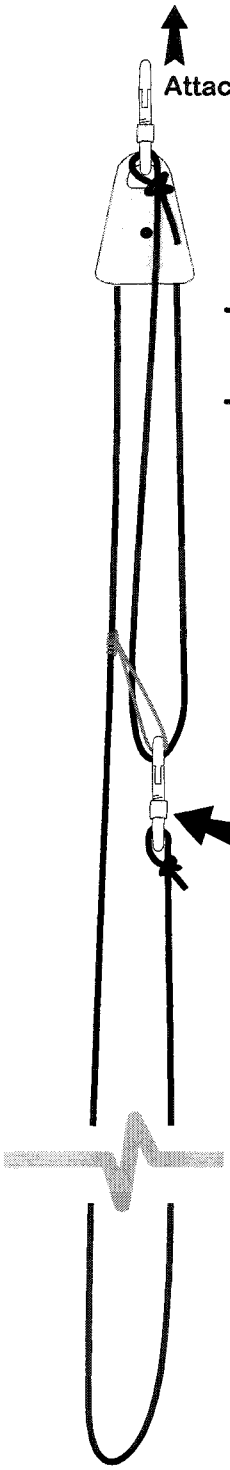
Tie a figure on a bight into end of cord and clip into the load carabiner. This provides good control when full extension of the jigger is reached.



(Depending upon application- attach to foot end of litter or to attendant)

NOTES:

Closed Loop 3:1 Personal Jigger



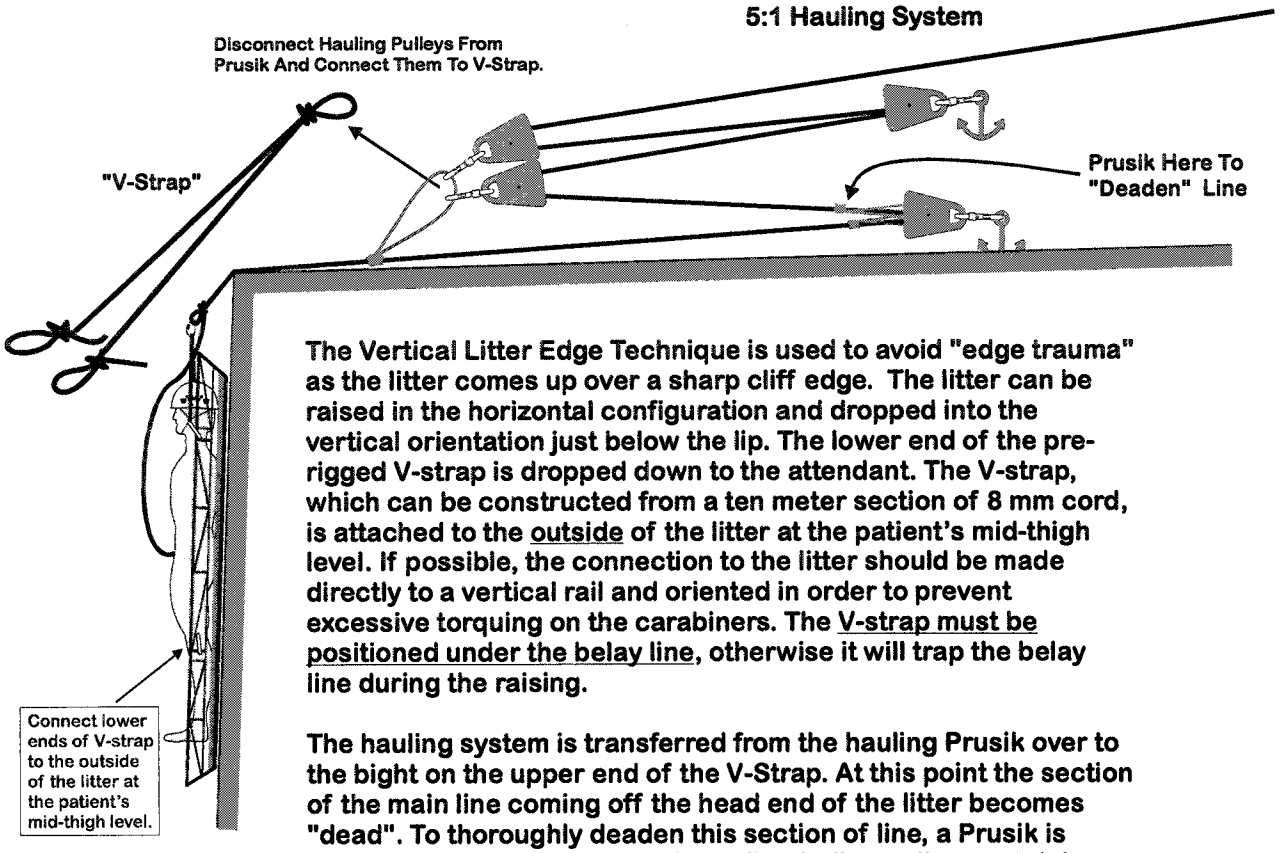
-Personal jigger for use by litter attendant to adjust working position.
-Construct with five meters of cord.

Excess cordage is flaked into loops and and tucked unsecured into a gear loop or carabiner on the attendant's seat harness to prevent a tripping hazard.

NOTES:

VERTICAL LITTER - EDGE TECHNIQUE

- aka "Pike & Pivot" Technique



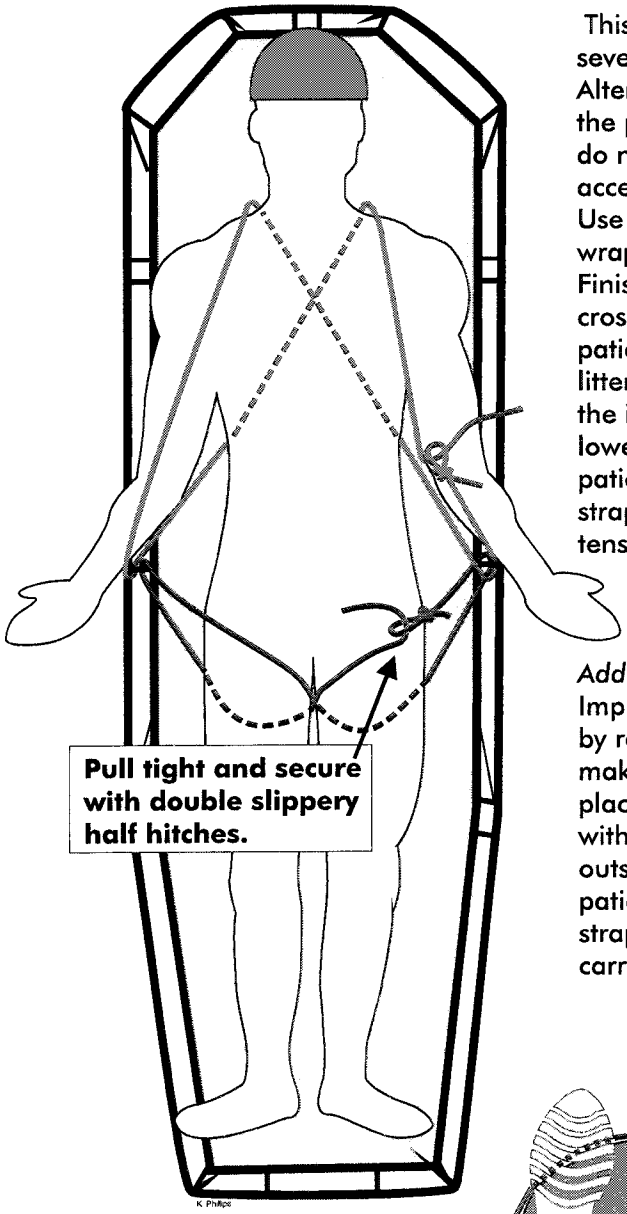
The Vertical Litter Edge Technique is used to avoid "edge trauma" as the litter comes up over a sharp cliff edge. The litter can be raised in the horizontal configuration and dropped into the vertical orientation just below the lip. The lower end of the pre-rigged V-strap is dropped down to the attendant. The V-strap, which can be constructed from a ten meter section of 8 mm cord, is attached to the outside of the litter at the patient's mid-thigh level. If possible, the connection to the litter should be made directly to a vertical rail and oriented in order to prevent excessive torquing on the carabiners. The V-strap must be positioned under the belay line, otherwise it will trap the belay line during the raising.

The hauling system is transferred from the hauling Prusik over to the bight on the upper end of the V-Strap. At this point the section of the main line coming off the head end of the litter becomes "dead". To thoroughly deaden this section of line, a Prusik is added on the opposite side of Prusik-minding pulley containing the ratchet Prusik. This action locks the main line in place in front of the hauling system. After the V-strap is connected, the attendant needs to move their attachment to a side rail of the litter or climb up to the top of cliff out of the way using the side rail supports as a ladder.

The hauling system, in this case a 5:1 simple system, becomes reconfigured to a 4:1 simple system. As the V-strap pulls upward on the litter it raises the head of the litter into the air above the cliff edge, causing it to "pike" into the air. The edge personnel then simply grab the head end of the litter and "pivot" it toward them. The litter is then on top without a struggle or trauma to the patient.

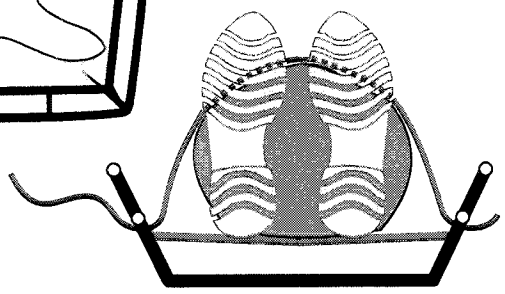
NOTES:

YOSEMITE PACKAGING TECHNIQUE



This patient packaging technique utilizes several nylon runners to secure the patient. Alternative packaging techniques, which lace the patient in with one extremely long runner, do not permit isolated adjustment or patient access without compromising the entire system. Use **two 18 foot runners** for the "figure eight" wraps through the groin and over the shoulders. Finish with several additional circumferential cross straps (12 foot runners), which secure the patient by locking them down in the rescue litter. These circumferential straps (not shown in the illustration to left) should be secured to the lower liter bar in order to prevent lateral any patient movement Avoid positioning cross straps directly over the knees or excessive tension that restricts patient breathing.

Additional Considerations:
Improvised patient padding can be constructed by rolling up sleeping pads by the long side to make "Tootsie Roll" pads. These are secured in place alongside the patient to prevent contact with the litter frame in rugged terrain carry-outs. Also consider padding between the patient's clavicle and the packaging shoulder straps for increased comfort during extended carry-outs.



END VIEW

NOTES:

APPENDIX

Rigging For Rescue Notes
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NOTES:

Pulley Systems | *Rigging for Rescue®—Notes*

The ability to raise loads with a rope is increased when the rope is used in conjunction with a pulley or pulleys. Combinations of fixed and moving pulleys create systems that multiply the force that rescuers are able to apply - making use of mechanical advantage to reduce required strength, at a trade-off of increased endurance. Said another way, mechanical advantage enables a rescuer to lift a load applying less force than the load itself, but over a longer distance.

Pulley Systems are just one method of obtaining mechanical advantage, and they are not new. As early as 350 BC Aristotle had left a record of a "sophisticated" pulley arrangement, showing how half the effort was required to lift the load[1]. Sometimes also referred to as "block and tackles", pulley systems are common to other fields such as seamanship, construction and even auto mechanics; most cranes and hoists use some kind of a block and tackle system.

The simplest example of a pulley system is shown in Figure 1. Here the fixed pulley provides no mechanical advantage (MA) but rather only changes the direction of pull. The force required to lift the load is approximately the same as the load itself and the same amount of rope is brought in for the distance that the load is raised.

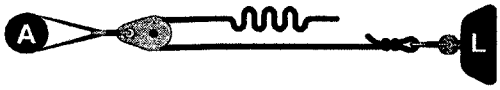
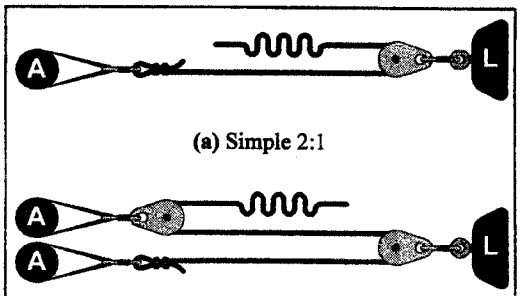


Figure 1: Simple 1:1 with a change of direction

The MA changes, however, if the same pulley is moved to a different location so that it is now a traveling pulley; one that moves toward the anchor as the load is raised (Figure 2a). Now only half as much effort is required, but over twice the distance. Even if a second pulley is added so that the direction of pull is reversed (Figure 2b), the fixed pulley does not affect the Ideal Mechanical Advantage (IMA), though in some cases it may make it more practical for the haulers to pull.

Mechanical Advantage is gained from the moving pulleys in exchange of effort for distance. If the last pulley in the system is fixed, it does not affect the IMA but may improve the practical use of the pulley system by changing the direction of pull (e.g. downhill instead of uphill). In both Figures 2a and 2b, twice as much rope is required on the pull side to raise the load a certain distance, although only half the force is required. This is referred to as a system with a MA of 2, or a "2:1" system.



(a) Simple 2:1

(b) Simple 2:1 with a change of direction

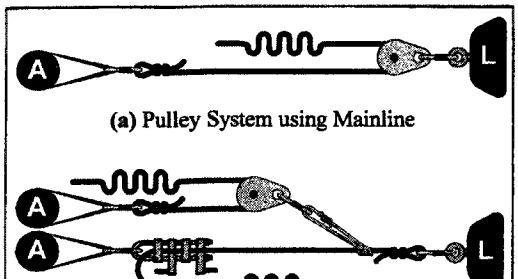
Figure 2:

A pulley system is just one of many ways to achieve MA (or, possibly mechanical disadvantage depending on how it is rigged). The key to learning pulley systems is understanding the basic concepts and principles that distinguish one system from another. All too often, rescuers are shown just one or two pulley systems and end up force fitting them to all rescue situations. Learning a few pulley systems by heart does not provide rescuers with the knowledge and flexibility to make the

[1]The How and Why of Mechanical Movements, Harry Walton 1968, p.45

best use of people and equipment. To be efficient, flexible and effective, rescuers need to have the ability to quickly decide which system is most appropriate for the given working conditions such as the amount of tension the load places in the mainline, the availability of equipment including rope, working (setup) room, friction points, and the number of haulers.

Pulley systems can be divided into three categories: simple, compound and complex. In addition, most pulley systems can be rigged either by using the mainline itself or using a separate rope, often referred to as 'acting on the mainline' (Figure 3). While most pulley systems used in rope rescue will be either simple or compound, rescuers still need to be able to recognize and understand the advantages and disadvantages of all types of pulley systems.

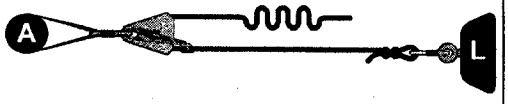


(a) Pulley System using Mainline

(b) Pulley System acting on the Mainline

Figure 3:

There are some components that can be added to a pulley system to make its operation practical during a rescue. The first is a 'self-minding ratchet'. Such a device enables the haulers to maintain lift distance gained without having to hold onto the rope at all times. One such device is the use of a Prusik and a Prusik Minding Pulley (Figure 4). Devices that act as ratchets (allow one way movement) also enable resets of the pulley system as they maintain the tension in the mainline while the pulley system is slackened and reset. This can also be accomplished by having a rescuer tend a device that will grab the rope when the pulley system needs a reset.



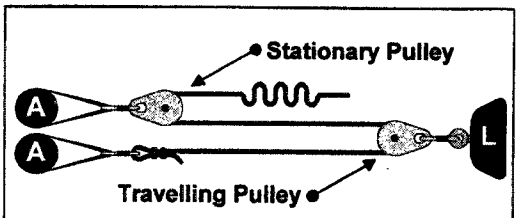
Ratchet Prusik

Figure 4:

Simple Pulley Systems are characterized by having one continuous rope flowing back and forth alternately between the pulleys on load and the anchor (or the anchor and the load), and all pulleys at the load side (referred to as travelling pulleys) travel towards the anchor at the same speed (Figure 5). All pulleys at the anchor side of the system remain stationary. The tension in the rope remains the same throughout the pulley system.

Summary of Simple Pulley Systems Principles:

- if the tied end of the rope is at the anchor, the IMA will be an even number (2:1, 4:1, 6:1, etc.). If the tied end of the rope is toward the load, the IMA will be an odd number (1:1, 3:1, 5,1 etc.).

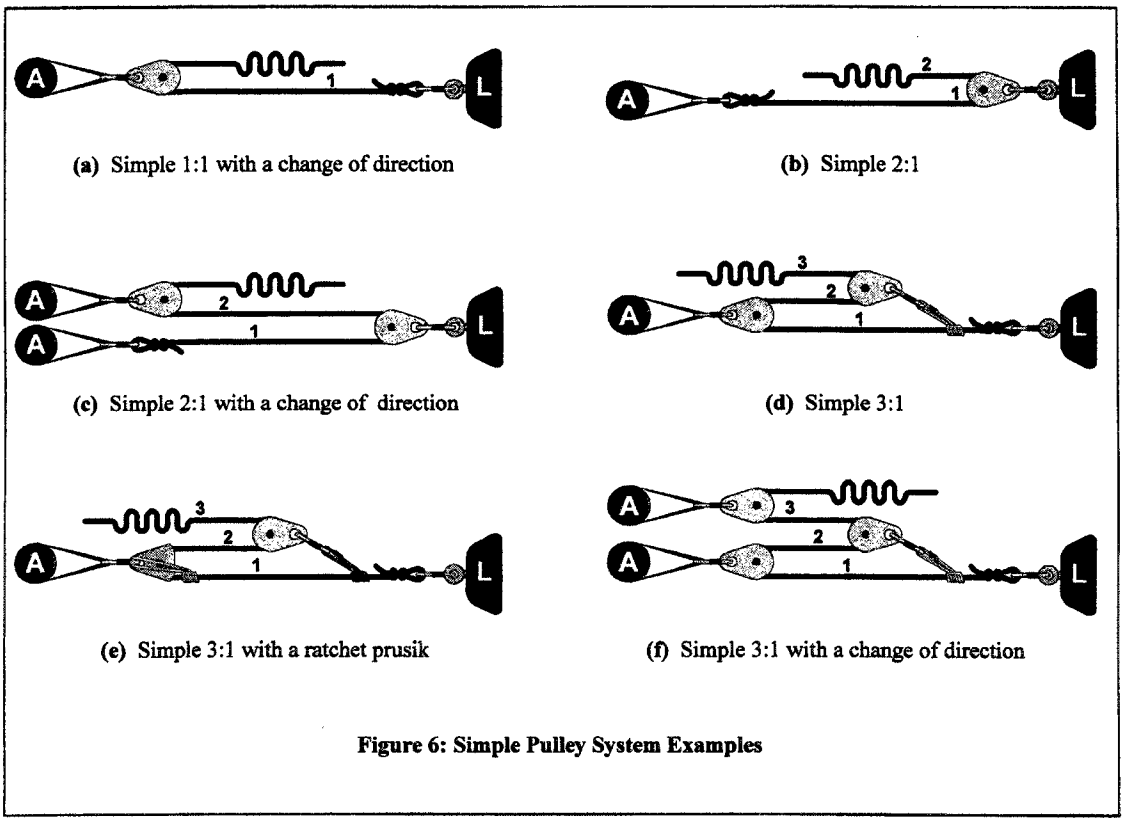


Simple Pulley System

Figure 5:

- if the last pulley in the system (one closest to the haulers) is at the anchor (fixed), it does not add MA, but just changes the direction of pull.
- the IMA of a simple system is determined by counting the number of ropes under tension at the load side of the pulley system.
- the number of pulleys required for a simple system (without a change of direction) is always the IMA minus one.
- to incorporate a 'self-minding ratchet' located at the anchor, the IMA of the simple pulley system must be an odd number.

Compound Pulley Systems are characterized as one simple pulley system pulling on another simple pulley system; the traveling pulleys travel towards the anchor at different speeds. Compound Pulley systems are useful because they can provide greater MA than simple systems for the same number of pulleys, thereby reducing overall friction loss for the same IMA.



(a) Simple 1:1 with a change of direction

(b) Simple 2:1

(c) Simple 2:1 with a change of direction

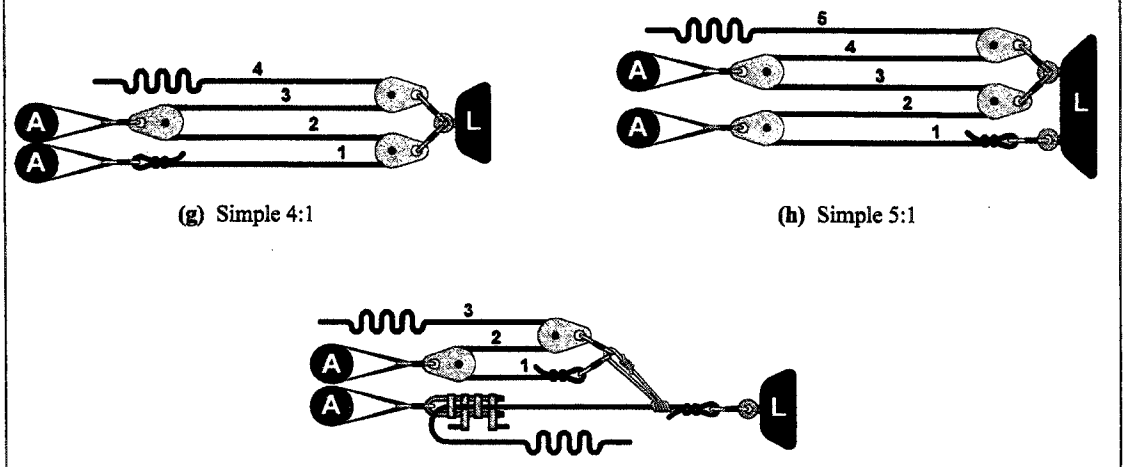
(d) Simple 3:1

(e) Simple 3:1 with a ratchet prusik

(f) Simple 3:1 with a change of direction

Figure 6: Simple Pulley System Examples

NOTES:



(g) Simple 4:1

(h) Simple 5:1

(i) Simple 3:1 acting on the Mainline

Figure 6: Simple Pulley Systems Examples cont...

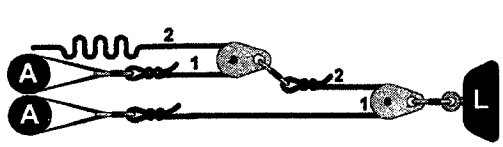
Summary of Compound Pulley System Principles:

- the IMA of a compound pulley system is determined by multiplying the IMA of each simple pulley system together. For example, a simple 3:1 pulling on a simple 2:1 becomes a compound 6:1 as 3 x 2 = 6; also note, however, that a simple 2:1 pulling on a simple 3:1. is also a compound 6:1 as 2 x 3 = 6 (see Figures 7b and 7c).

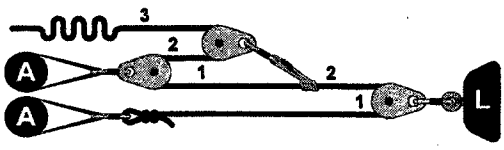
- if it is important to get the load up with the least number of resets and you are using a compound pulley system comprised of two dissimilar MA simple pulley systems, have the higher MA system pull on the lower MA system (e.g. have the 3:1 pull on the 2:1 in a compound 6:1). Recall, however, from the Simple Pulley System Principles, if you want to use a 'self-minding ratchet', you need an odd-numbered pulley system. You will have to decide which factor is more important or change your compound pulley system to another combination that can meet both those needs (i.e., a compound 9:1 or a simple 5:1).

- longer throw distances per reset can be achieved by positioning the anchor pulley(s) of the last (closest to the hauler) simple pulley system, far enough back to allow each simple pulley system to collapse at the same time. For example, for both simple 3:1's in a compound 9:1 to collapse at the same time, the last 3:1 must have three times the reset distance of the first simple 3:1.

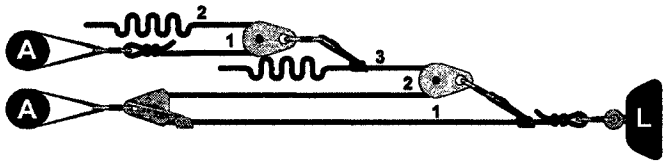
- This is due the fact the 3 times more rope will be pulled through the last simple 3:1 than the first simple 3:1.
- the highest MA with the least number of pulleys is achieved by repeatedly compounding a simple 2:1 on a simple 2:1.



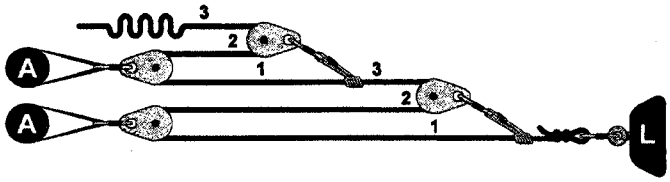
(a) Compound 4:1
(Simple 2:1 pulling on a Simple 2:1)



(b) Compound 6:1
(Simple 3:1 pulling on a Simple 2:1)



(c) Compound 6:1 with a ratchet
(Simple 2:1 pulling on a Simple 3:1)

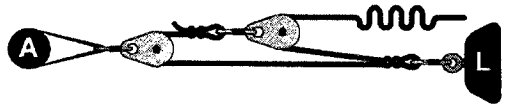


(d) Compound 9:1
(Simple 3:1 pulling on a Simple 3:1)

Figure 7: Compound Pulley System Examples

- when constructing a compound pulley system, always think of all the possible combinations that when multiplied together will equal your desired MA; then consider the advantages and disadvantages of each and determine which combination will best meet your needs given your available equipment and working constraints.

Complex Pulley Systems are characterized by being neither simple nor compound. There is no one definition that characterizes all complex systems due to their great diversity. With only 4 pulleys, over 100 combinations of pulley systems can be made, most of them being complex pulley systems. With the exception of a few common complex pulley systems such as the "Spanish Burton" shown in Figure 8, complex pulley systems are not often seen being used in rescue work. Typically, similar objectives can be met using Simple or Compound Pulley Systems that are easier for rescuers to recognize and are more flexible for modifications as required.



Complex 3:1 / Spanish Burton

Figure 8:

The IMA of a complex pulley system can be determined using either of two methods. While impractical in the field, the first method is to pull in a known length of rope and compare that distance to how far the load was raised. The second, more practical method, is the "T-method" which can be used to determine the IMA of any pulley system, and is covered in a separate handout.

Theoretical Mechanical Advantage

Theoretical Mechanical Advantage (TMA) is the estimated Actual Mechanical Advantage (AMA) that you calculate after taking into consideration factors that would affect IMA. These include several factors, the largest component of which is friction. Calculating the TMA is covered in a separate handout, but it is important to be note that with pulleys and/or carabiners within the pulley system, the TMA and AMA will always be less than the IMA.

Terminology in the Field

While most terms are defined at the end of this handout, there are a few special notes with respect to the use of terminology during rescues and practices. First, when referring to the construction of Pulley Systems, the IMA is most often used - "build a simple 3:1 or build a compound 6:1 with a change of direction and a self-minding ratchet". Practically, the team is aware that due to friction and other considerations, the AMA and the TMA will be less than the IMA.

In addition, better communication and understanding can be achieved by using terms and definitions that are more descriptive of the actual pulley system, such as, "simple 3:1" rather than "z-rig." The latter has led to a lack of understanding as it has been used to describe everything from a simple 2:1 with a change of direction, a simple 3:1, or even a simple 4:1. Being as descriptive as possible when describing pulley systems means that you are more likely to get the pulley system you want and not something else.

Conditions can change through the course of raising a load; steepness of terrain may change, more haulers may become available, more rope becomes available as the load is raised, or a knot may have to be passed. Efficiency is achieved by having the knowledge and skill to be flexible enough to recognize what practical and simple changes can be made during an operation when conditions change. Knowledge provides understanding, skill provides ability, practice provides proficiency, and from these, together with experience, comes judgment.

These notes provide a overview of three categories of pulley systems: simple, compound and complex, as well as 4 different categories of MA: IMA, PMA, TMA and AMA. A separate handout covers the application of the T-method for calculating the IMA of any pulley system. Neither of these summaries covers more advanced types of pulley systems such as pulley systems in series or parallel or the use of equalizing or differential pulleys. Refer to your notes from the Rigging for Rescue Seminar and additional handout materials for more information.

Pulley System Graphics created by Earl Fröm

Terms & Definitions

MECHANICAL ADVANTAGE (MA): The ratio of the load to the pull required to lift the load. For example if 1 kN of force is required to raise 2kN, the mechanical advantage said to be "2 to 1" or 2:1. Mechanical Advantage is gained at the expense of endurance. Even though, less force is required, it is required over a longer distance.

IDEAL MECHANICAL ADVANTAGE (IMA): The MA of a pulley system without taking into account friction and other factors.

ACTUAL MECHANICAL ADVANTAGE (AMA OR PMA): The actual observed and/or measured MA when the pulley system is being pulled on.

THEORETICAL MECHANICAL ADVANTAGE (TMA): The estimated actual (or Practical) MA that is calculated when friction losses are taken into account.

PULLEY SYSTEM: Combination of fixed and traveling pulleys and rope used to create MA.

TRAVELLING (MOVING) PULLEYS: Those pulleys in a pulley system that move toward the anchor when the Pulley system is pulled on.

STATIONARY (FIXED) PULLEYS: Those pulleys in a pulley systems that do not move when the pulley system is pulled on (usually those pulleys at the anchors).

EFFICIENCY: The measure of friction loss calculated as the input force over the output force, expressed as a percent. For example if 90 N is required on 1 side of a pulley to hold a 100 N load on the other side, the efficiency of the pulley is said to be 90% or 90/100. In pulley systems, this is typically the efficiency of pulleys and carabiners (if used).

RESET: As a pulley system is pulled on, it collapses to the point where 1 or more of the traveling pulleys meet the stationary pulleys. At this point the load cannot be pulled up any further. The term reset describes the act of re-expanding the pulley system to its original dimensions so that pulling may continue.

RESET OR THROW DISTANCE: the distance that a pulley system collapses between resets.

HAUL PRUSIK: the Prusik in the pulley system that is closest to the load that attaches the pulley system to the mainline going load.

RATCHET PRUSIK: A Prusik used to hold the mainline while the haulers reset the pulley system, so that progress is not lost.

'SELF-MINDING RATCHET': The use of a Prusik Minding Pulley to mind the ratchet Prusik and therefore eliminate the need for a rescuer to mind it.

NOTES:

The T-Method for Pulley Systems — *Rigging for Rescue®—Notes*

A pulley system's Ideal Mechanical Advantage[1] (IMA) is expressed as a ratio of the amount of output force to the amount input force (e.g. 6:1 or "6 to 1"). The input force is the tension you apply to the system, and it is always expressed as one. One method of calculating the IMA of any pulley system in the world is often referred to as the Tension Method, or T-Method.

Some basic physics principles need to be understood and applied to knowing how tension is distributed through a pulley system. Mechanical advantage in pulley systems is gained by increasing the number of times your initial one unit of tension is applied to the load. Recognize that there are many ways that this can be accomplished, or rigged, using simple, compound or complex pulley systems.

By assigning one unit of tension (called "T" in subsequent diagrams) to where you pull on the pulley system, then following the path of the rope through the pulley system to the load itself, the IMA can be determined by keeping track of how that initial unit of tension is distributed throughout the system. Simply compare the amount of tension the load receives to the initial input unit of tension.

The key to understanding the T-method is in recognizing what happens to the tension in the rope as it flows through the pulley system. Whenever there is a 'junction' in the ropes of the pulley system where either more than one rope acts on another rope, or one rope acts on more than one rope, then the tension on one side of the junction must be equal to the tension on the other side of the junction, and for each side of the junction, the tension must be distributed appropriately (not always equally) to each rope. For example, if a rope having one unit of tension makes a 180° change of direction through a pulley (a junction), then whatever that pulley is connected to receives two units of tension (Fig 1). In essence, two ropes each having a tension of one (for a total of two units of tension) are acting on (and being opposed by) what the pulley is connected to. Below are some illustrations of tension distribution in ropes at junctions:

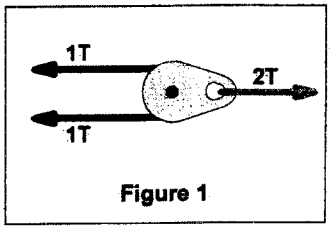


Figure 1

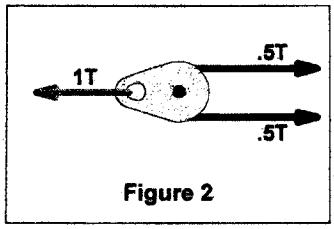


Figure 2

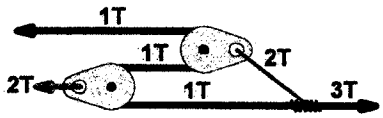


Figure 3

[1]Ideal Mechanical Advantage assumes that there are no losses in pulley system mechanical advantage due to factors such as pulley friction, or ropes rubbing, bending or unbending.
Pulley System Graphics created by Earl Fröm

NOTES:

The T-Method for Pulley Systems | *Rigging for Rescue®—Notes*

Summary of how to apply and use the T-Method to Calculate the IMA of any Pulley System:

1. Assign one unit of tension to where you pull on the pulley system.
2. Follow the rope through the pulley system and when you encounter a junction, apply the principles of tension distribution. Keep track of all units of tension through to the load.
3. Total all units of tension that reach the load; the Ideal Mechanical Advantage is the ratio between this total and the initial one unit of tension.

Examples of using the T-Method to Calculate the IMA of pulley systems:

Simple Pulley System:

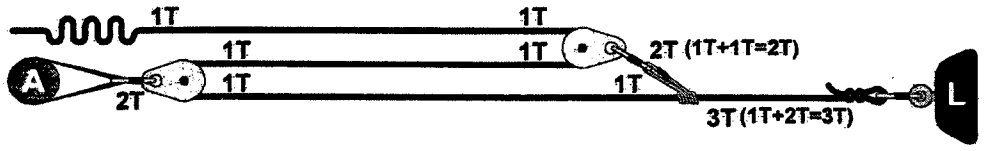


Figure 4: simple 3:1

Compound Pulley System:

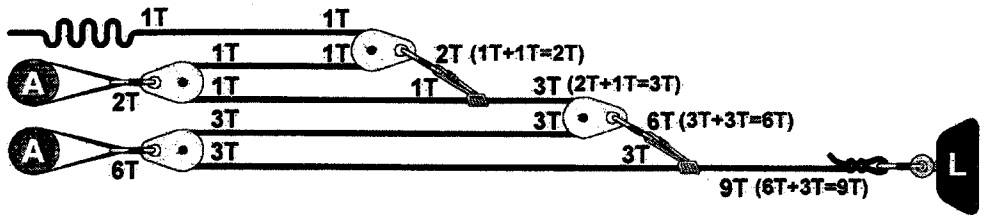


Figure 5: compound 9:1

Pulley System Graphics created by Earl Fröm

NOTES:

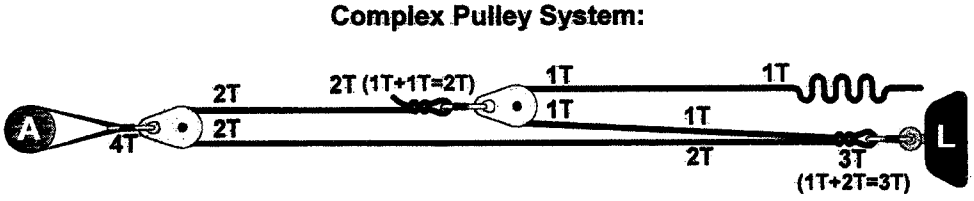


Figure 6: complex 3:1

Calculating the Theoretical Mechanical Advantage (TMA)

The TMA is the estimated Actual Mechanical Advantage (AMA) calculated after taking into account factors that affect IMA; the largest component of which is friction. The greatest friction losses occur as the rope comes into contact with the pulleys. Sometimes carabiners are used in place of pulleys which results in an even greater friction loss.

To calculate the losses due to friction, one must first know the efficiency of the pulleys and/or carabiners being used. Efficiency is the measure of friction loss calculated as the input force over the output force, expressed as a percent. For example if 90 N is required on 1 side of a pulley to hold a 100 N load on the other side, the efficiency of the pulley is said to be 90% or 90/100.

With efficiency information, the friction loss through the system can be calculated. Figure 7 shows the calculations for a pulley system with pulleys that have an efficiency of 0.90.

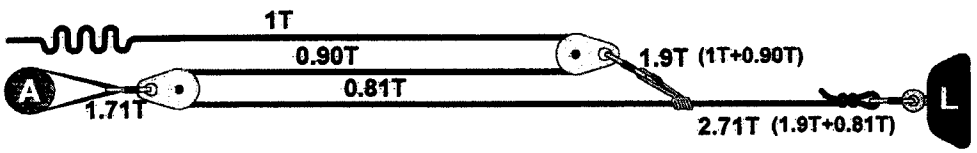


Figure 7: Simple 3:1 TMA

Pulley System Graphics created by Earl Fröm

NOTES:

The T-Method for Pulley Systems  ***Rigging for Rescue®—Notes***

Assuming that the pullers pull at the end of the pulley system with 1 unit of Tension (1T), only 0.90 T will be transferred past the first pulley. When that 0.9 T reaches the 2nd pulley, only 0.81T will be transferred on (0.9 * 0.9 = 0.81) as the friction loss is now compounded over two pulleys. Follow this process all the way through the pulley system. When you are finished, use the T-method to determine the final TMA, which in this example is 2.71:1.

If higher efficiencies pulleys are used (i.e. 0.95 efficiency), the TMA is increased to 2.85:1, which is closer to the IMA of 3:1. Also important to note, is that if you are using pulleys of different efficiencies, less losses occur if the most efficient pulley is placed closest to the pullers. This is because the loss at the 1st pulley is compounded throughout the system.

NOTES:

The Purcell Prusik System

Rigging for Rescue®—Notes

Ascending Considerations:

For self-reliance, safety and flexibility, a rescuer should always have the ability to either descend or ascend a rope. Therefore, while rappelling, being lowered or raised, or working an edge, rescuers should always have their ascending system with them and know how to competently use it. A rescuer should have a separate, untensioned belay rope as a back-up in case something happens to him/her, or if the main rope, anchors, or ascending system fails. This handout does not cover single rope technique considerations.

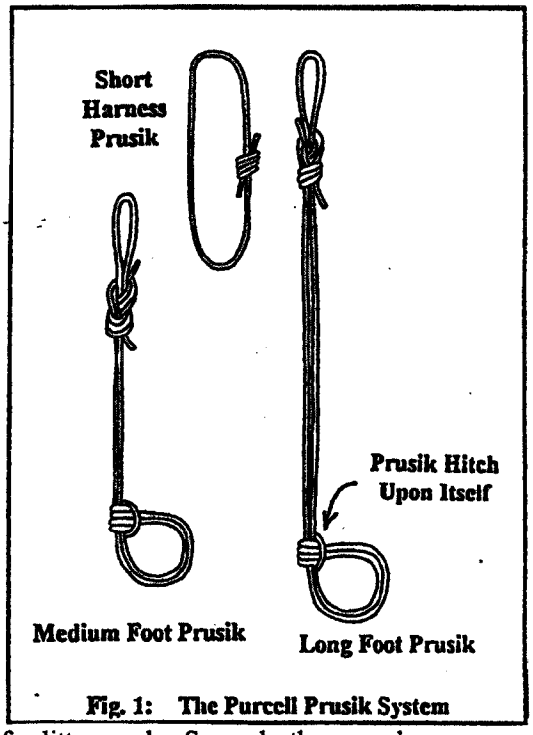


Fig. 1: The Purcell Prusik System

The Purcell Prusik System:

Many types of ascending systems exist. Some of these systems have been highly refined for special applications such as long free hanging ascents in caving. In rope rescue, however, there are strong arguments for equipment that has multi-purpose capabilities to increase efficiency, minimize equipment requirements and reduce cost. The Purcell Prusik System is an ascending system that was developed by members of the *Columbia Mountain Rescue Group* in British Columbia. It evolved from a need to combine equipment that would allow rescuers to ascend in either a free-hang or sloping environment, tie-in to an anchor system or edge/safety line, or have an adjustable tie-in link for litter work. Several other uses have come about since their introduction in the early eighties. The Purcell Prusik System (Fig. 1) incorporates the use of 3 Prusiks: 2 foot Prusiks and 1 harness Prusik. Two foot Prusiks allow easier movement in non-free-hanging terrain. Also, if one foot Prusik is being used as an adjustable tie-in (e.g. attendant tie-in), then the other can be used to ascend a short distance if required.

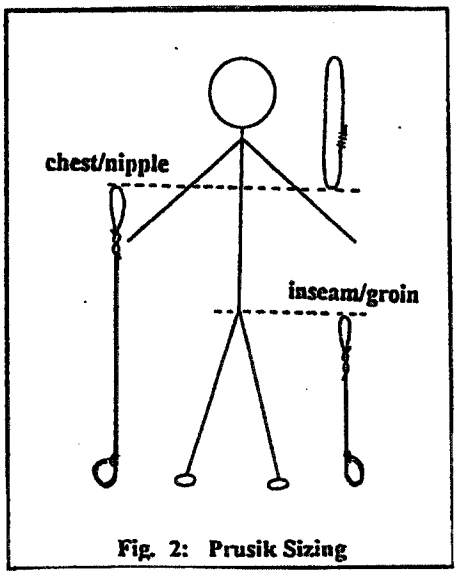


Fig. 2: Prusik Sizing

General Purcell Prusik Sizing:

The 3 Prusiks are different lengths: short, medium and long. With the long foot Prusik tightened over a boot, the top of the Figure of Eight on a Bight should reach the chest/nipple height of the rescuer, and the medium foot Prusik should reach the inseam/groin height. The short harness Prusik should reach from the chest/nipple area to a few centimetres (cm) above the top of the helmet (Fig. 2). The

NOTES:

reason for the different foot Prusik lengths is to allow enough room to comfortably advance them up the rope without having them bump into each other. The short harness Prusik length is long enough enable the rescuer to bypass a descent device (e.g. brakerack) if changing over from a rappel, but not so long that it is out of arms reach.

Placement on the Mainline:

Two wrap Prusik Hitches are used to attached the foot Prusiks to the mainline. A 3 wrap Prusik Hitch is used to attach the short harness Prusik as it is more secure. Three wrap Prusik Hitches may also be used for the foot Prusiks if the person ascending is very heavy, or if brand new Prusiks are being used on brand new rope. Three wraps allow the Hitches to grab better and provide more security, though at a cost of being more difficult to slide up the rope. A gentle loosening of the back of the Prusik Hitch before advancing it up the rope will make this easier.

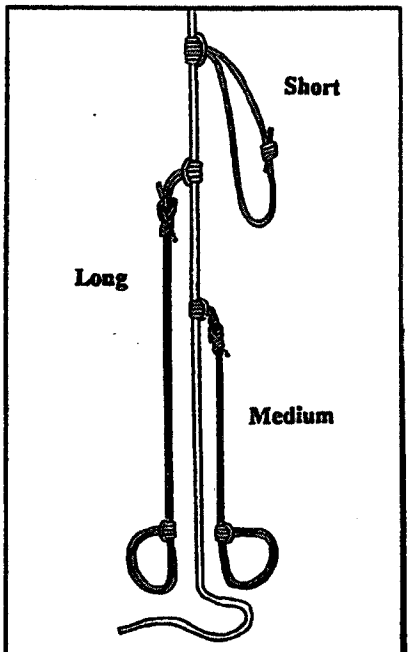


Fig. 3: Placement on the Mainline

From top down, the general order in which the Purcell Prusiks are placed on the rope are: short, long, medium (Fig. 3). The acronym SLM, or 'slim' helps to remember this. While this is the final order which the Prusiks should be on the mainline, it is recommended that they be put on from the bottom up: medium first, then long, then short. This way, the placing of each Prusik Hitch on the rope is not being hampered by any Prusiks dangling from above. While the medium and long Prusiks are used as foot Prusiks, the short Prusik is clipped to a special connector strap between the sit and chest harness of the rescuer. The proper tying of the harness connector strap is not covered in this handout.

Ascending Techniques:

Generally, there are two types of terrain in which a rescuer may have to ascend a rope. The first is a complete free-hang where no contact is made with the cliff or building face by the rescuer. The second type is on terrain which is less than vertical whereby the rescuer will have contact with the cliff or building face.

The free-hang technique resembles that of an inchworm. The long and medium foot Prusiks are moved up the rope to the point where both feet are the same elevation. The short harness Prusik is then advanced as the person smoothly stands up on the foot Prusiks. This process is repeated to ascend up the rope in a free-hang.

In less than vertical terrain, the technique used is referred to as the "toe-in technique," which more closely resembles the movements of climbing up a ladder. The body is kept vertical, and the long and medium foot Prusiks are advanced alternately between advancement the short harness Prusik.

Competent instruction should be sought in both the free-hang and toe-in techniques, as well as in techniques to pass knots, ascend over an edge, and/or change over from rappelling to ascending, or ascending to rappelling.

Constructing Purcell Prusiks:

Select a 10 metre (m) length of good quality 6 or 7 millimetre (mm) nylon kernmantle accessory cord with a manufacturers rated breaking strength of at least 7.5 kiloNewtons. The 10 m length will be sufficient to make all 3 Prusiks for people up to 2 m tall. To minimize waste, all three Prusiks can be tied before any cut is made to the cord.

1. To begin making the long foot Prusik, tie a Figure of Eight on a Bight at one end of the 10 m length of cord (Fig. 4). Make the bight approximately 20 cm long. The bight needs to be this length so that a 3 wrap (6 coil) Prusik Hitch could be tied onto the rope being ascended, even though a 2 wrap (4 coil) will most likely be used.

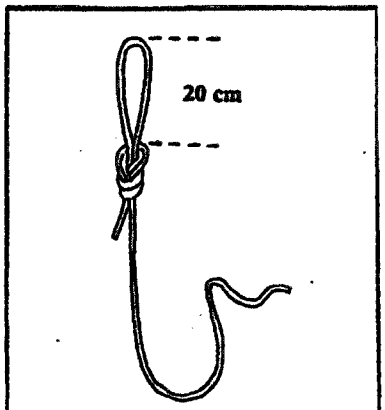


Fig. 4: Figure of Eight on a Bight

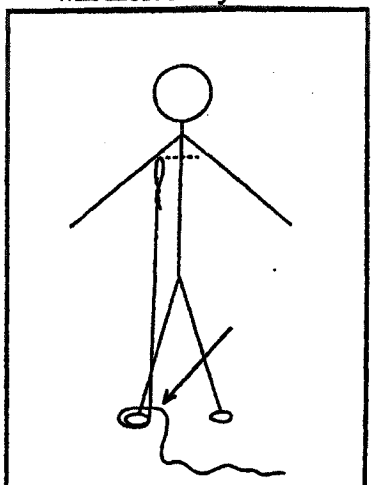


Fig. 5: Locating Back of Prusik

2. While standing, position the top of the Figure of Eight on a Bight at the chest/nipple landmark. From there, run the cord down to the ground and make one loop around your foot. Locate the point on the cord approximately 3-5 cm past where the loop crosses itself around your foot (Fig. 5). Pinch that point between your thumb and forefinger—being careful not to lose that location—and undo the wrap around your foot. This location on the cord will become the back, or bridge, of the Prusik Hitch upon Itself.

3. To make a Prusik Hitch upon Itself, the coils of the Prusik Hitch need to be made first, and then the standing parts of the Prusik Hitch are passed through the coils. With the back of the Prusik upon Itself identified (step 2), make the 4 coils of Prusik Hitch (Fig. 6), and then pass both standing parts—the long cord and the one with the Figure of Eight on a Bight— through the 4 coils. Dress the Prusik Hitch upon Itself (Fig. 7). This becomes the adjustable loop of your long foot Prusik. If this step was done

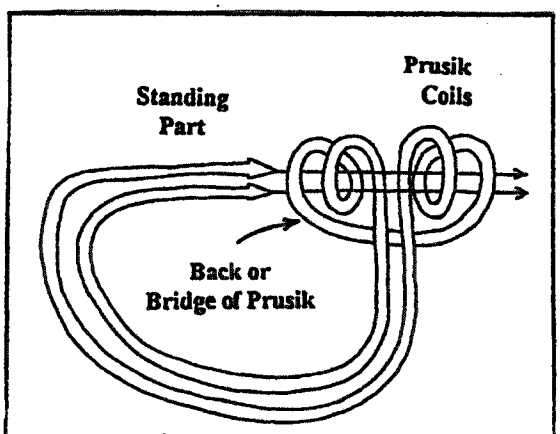


Fig. 6: Making the Prusik upon Itself

correctly, then when you slip the foot loop over your foot and cinch it down on top of your foot, the Figure of Eight on a Bight should reach your initial chest/nipple landmark. If not, make minor adjustments by either feeding cord into, or out of, the Prusik upon Itself until you have the correct landmark length.

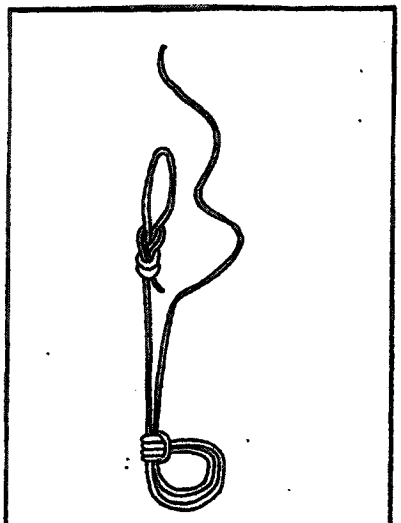


Fig. 7: Dressed Prusik Upon Itself

4. Trace the remaining length of cord through the Figure of Eight until the two cords exiting the Prusik Hitch upon Itself are the same length (Fig. 8). The remaining cord should exit the Figure of Eight towards the bight. Either cut the remaining cord off now (leave enough tail), or repeat steps 1-4 with the other end of the cord to make the medium foot Prusik, except this time, use your inseam/groin as your new landmark height (Fig. 2).

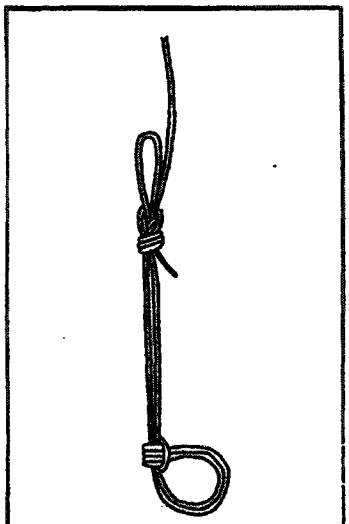


Fig. 8: Traced Figure of Eight

5. Once the two foot Prusiks are made, make the short harness Prusik with the remaining cord. Tie the loop of cord into a sling using a Double Overhand Bend. Size this sling from the chest/nipple landmark to only a few cm above your helmet (Fig. 2).

6. Once you have ascended a rope with your Purcell Prusik System using both the free-hang and toe-in techniques, you can make any minor adjustments—lengthen or shorten—or fine tuning you deem necessary.

NOTES:

Command & Communication — *Rigging for Rescue® — Notes*

Team Positions:

Team Leader – has overall responsibility of operation
Belay – manages belay line
Mainline – can be a brake, winch (for up or down) or a haul team (use one spokesperson for haul team)
Edge – may be 1 or more people; keep edge clean, place edge protection, assist load over edge
Attendant – manages handling of patient (with/without stretcher) and cleans/protects route if necessary
Vector – used in some lowering operations
Control – gives commands to lower or raise the load, especially during the critical edge phase

Briefing:

After 'size-up' the Team Leader briefs the team using a format found effective for emergencies[1]

1. Here's what I think we face;
2. Here's what I think we should do;
3. Here's why;
4. Here's what we should keep our eye on;
5. Now, talk to me

The briefing allows team members an opportunity to voice concerns or oversights, and achieves team consensus. After the briefing, the Team Leader assigns operational roles, and then and asks for "quiet on the set, over to control!" The Team Leader then roams around, checks rigging alignment, fine-tunes, checks people's operating techniques (e.g. belay, brake) and potential rope hang-ups, as well as thinks ahead and prepares for the next stage of the operation.

Ideally, to free up the Team Leader, and to reduce risk by having single-task roles, a separate Control person is used. He/she should be in a location where the edge transition can easily be seen, yet can still clearly communicate with the main and belay line operators. Communication can be achieved using strong voice commands, radios, whistle blasts, or the edge person can be used as a relay to maintain communications. Commands follow a format of 'who' first, then 'what do'.

Lowering Operations: There are four stages to lowering:

1. First Stage (role call);ensure everyone is physically and mentally ready & alert.
2. Second stage (positioning the load); position the attendant/patient to allow for a smooth transfer over the edge. The Edge people may need to help the Attendant carry the stretcher to the edge. To make this easier, the Control can ask for Slack in the mainline as required.
3. Third stage (pre-tensioning); pre-tension the system and transition the load over the edge. There are several ways of pre-tensioning a system; the appropriate technique is dependent on the number of available people and terrain, and must be briefed to the team by the Team Leader prior to 'role call'. Deciding which technique to use, is not within the scope of this handout. Commands during the 'critical edge transition must be very well timed so as to maximize the aerobic ability of the edge and attendant's strength. It can be very physical.
4. Fourth stage (attendant needs); commands specific to the needs of the attendant, such as speed, belay or edge protection requirements, and an indication of progress (i.e. how far from the objective).

Raising Operations: There are three stages to raising:

1. First Stage (role call); ensure everyone is physically and mentally ready & alert.
2. Second Stage (raising); use a pulley system or winch to raise the load; includes sets & resets.
3. Third Stage (edge transition); reset the haul system when the load is just below the edge, to ensure that the load can be cleanly and smoothly brought completely up over the edge without having to reset during the critical edge transition.

[1]Courtesy of Ken Phillips, US National Park Service (adapted from Karl Weick, South Canyon Revisited; Lessons From High Reliability Organizations)

NOTES:

Command & Communication — *Rigging for Rescue® — Notes*

Commands For Lowering:

Control:	**Response:**
First Stage (role call):	
Belay ready?	*Ready!* (belayer is physically & mentally ready; no belay slack) *Standby!* (if not ready); give indication of time
Advise when ready! (if hear "standby")	*Ready!*
Mainline ready?	*Ready!* (device is unlocked and ready to feed)
Edge (1 and/or 2) ready?	*Ready!* (in position to move the load, edge clean & protected)
Attendant ready?	*Ready!* (patient has been briefed; tie-ins properly adjusted)

Second Stage (position the load):
Attendant, approach the edge! (Edge people assist; slack mainline if necessary)
Attendant stop! (when at proper location near edge)
Mainline, load the brake! (given if brake friction was reduced during edge approach)

Edge Ready?	*Ready!* (edge protection placed & ready to push out)
Attendant Ready?	*Ready!* (patient briefed; hands on litter, ready for pre-tension)

Third Stage (pre-tensioning system):
– use the technique set out during the briefing

A. Vectoring the Mainline (used if a high directional exists)
Vector mainline! – 1 or 2 people deflect the mainline, and no rope is let through the brake
Attendant lean back! – if with stretcher, pull it away from all obstructions
Edge push out! – on mainline only, and not the stretcher (this can tilt it) or belay (will cause slack)
Release vector! – slowly at first, then quicker (most load movement occurs at the initial release)
Brake down slow! – prepare by barely breaking static friction at end of vectoring to allow for +'ve feed

B. No Vector (high directional may or may not exist) – just exclude the vectoring commands above

C. Jigger – where there is no room to vector, or with certain A-frame or tri-pod configurations

D. Edge Lift – used with overhead high directional: edge people lift the stretcher, slack is taken out of the mainline, and then the load is set back onto the mainline.

Commands For Raising:
First Stage (role call): – same as above for lowering.
Second Stage (raising):

Control	Attendant	Mainline (Haul Team)
Mainline (Haul Team) Ready?		Ready!
Attendant Ready?	Ready!	
Mainline Up!		Mainline Up! Set!
Set (to attendant), Reset!	Ready!	
Attendant Ready!		Ready!
Third Stage (edge transition):		
Stop, set, reset, last haul!	Ready!	Ready!
Mainline Up!		
Stop, stop, all stop!		

Additional Commands:
Stop! - this can be given by anyone; essentially it means 'freeze'
Stop, stop, why stop? - given by anyone if the load has stopped moving for an unknown reason
Down, Down - go down faster
Slow - self-explanatory
Up Rope - pull rope through the device and ensure there is no slack
Slack - too much tension, need more rope.
Whistle Commands: One Blast - Stop; Two Blasts - Up; Three Blasts - Down; Three Long Blasts - Help!

NOTES: