Stokes Basket Operations Using Aerial Devices

Montgomery County Fire Rescue
Driver Training
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Purpose of This Document

The purpose of this document is to demonstrate acceptable best practices and technical methods for removing patients from remote locations using stokes baskets attached to rope and aerial devices common to Montgomery County Fire Rescue.

Stokes Basket Aerial Operations Best Practices

- Work within aerial ladder device manufacturer specifications and use good judgment.
- Deploy your system in a way that minimizes the potential for overstressing and/or shock loading equipment.
- Movement of an aerial device for the purpose of raising, lowering, or rotating a stokes basket carrying a patient should be avoided. The hydraulic advantage created by the movement of the aerial device causes dynamic loads that could cause failure of important components of a rope system.
- Keep rope and stokes basket in line with ladder at all times. Avoid rotating the aerial device such that the suspended portion of the rope becomes "out-of-line" with the ladder.
- Avoid attaching a patient attendant to a suspended stokes basket whenever possible.
- Always select bombproof anchors over marginal approaches.
- Employ "Three Sets of Eyes" to inspect any system before applying live loads.
- If an anchor is bombproof it can anchor the main and belay lines.
- Do **NOT** focus single point anchors (W3P2- wrap 3 pull 2).
- Single point anchors should be bombproof anchors.
- Multi-point anchors **must** be focused in the direction of the load (a carabiner or other smooth and dull object can be placed in overhand knot used to focus the anchor, thus allowing the knot to be untied after it has been loaded. Do **not** attach anything to the carabiner placed in the overhand knot).
- All carabiners in anchors should be rated for general use.
- Carabiners should be oriented "down and down." This means that when the system is loaded the carabiner's gate will screw shut in the direction that gravity would pull, and the carabiner should be oriented so that the gate is facing down.

Types of Aerial Apparatus in Montgomery County

Pierce Mid Mount Tower

Gross Weight – 80,800 lbs
Height – 10 Feet 10 Inches
Width – 9 Feet 6 Inches
Length – 47 Feet 9 Inches
Ladder Length – 100 Feet
Bucket Capacity – 1000 lbs

Pierce Tractor Drawn

Gross Weight – 67,800 to 71,740 lbs
Height – 11 Feet, 1 ¼ Inches
Width – 9 Feet, 7 Inches (18 Feet with Outriggers Extended)
Length – 59 ½ Feet
Ladder Length – 100 Feet
Tip Capacity – 500 lbs

Pierce Rear Mount All-Steer Tower

Gross Weight – 72,000
Height – 11 Feet 8 ½ Inches
Width – 9 Feet 2 Inches (19 Feet 2 with Outriggers Extended)
Length – 46 Feet 11 Inches
Ladder Length – 100 Feet
Bucket Capacity – 1000 lbs

Seagrave Tractor Drawn

No Stokes Basket Evolutions Using This Truck. Tip Capacity is Only 250 Pounds.

Ladder Length – 100 Feet
Bucket Capacity – 250 lbs

Rope System Equipment

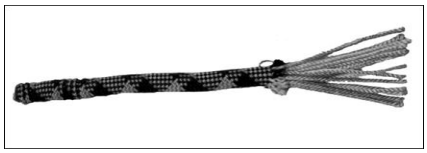
The following sections describe the equipment that is commonly used to assemble and execute an aerial stokes basket evolutions in Montgomery County.

This equipment includes:

- Rope,
- Carabiners,
- Webbing,
- Prusiks,
- Anchor Straps,
- Traverse 540 Belay and Triple Wrap Tandem Prusik Belay,
- Single Sheave Prusik-Minding-Pulleys,
- Rappel Racks, and
- Stokes Basket and Bridles.

Rope

Use ½ inch Static Kernmantle rope for both main and belay lines.



Kernmantle Rope

Montgomery County Life Safety Rope is ½ inch static kernmantle and is usually available in 100, 200, and 300 foot lengths. The rope is inspected and stored carefully in rope bags.

Rope Carefully Stored in a Rope Bag

Characteristics of ½ inch Static Kernmantle Rope

- Kern = Inner Core
- Mantle = Outer Sheath
- Static = Low Stretch (Used for Rescue Systems)
- Breaking Strength = 9000 lbs
- Safe Working Load = 600 lbs
  - Rescue systems require a 15:1 safety factor.
  - Safe for two-person load.

How Much is a Human Load (Per NFPA)
One Person Load = 300 lbs
Two Person Load = 600 lbs

$$\text{Safe Working Load} = \frac{\text{Breaking Strength}}{\text{Safety Factor (15)}} = \frac{9000 \text{ lbs}}{15} = \underline{600 \text{ lbs}}$$

Tag Line Attached to Stokes Basket

Braided nylon utility rope may be used as a tag line if an appropriate length of life safety rope is not available.

Utility rope is not suitable for supporting live loads and should not be used.

Braided Utility Rope

Carabiners

Properly Loaded Carabiner

Carabiners are metal connectors that link the several parts of a rope rescue system together. Carabiners in Montgomery County may be made out or aluminum or steel and have different rated strengths.

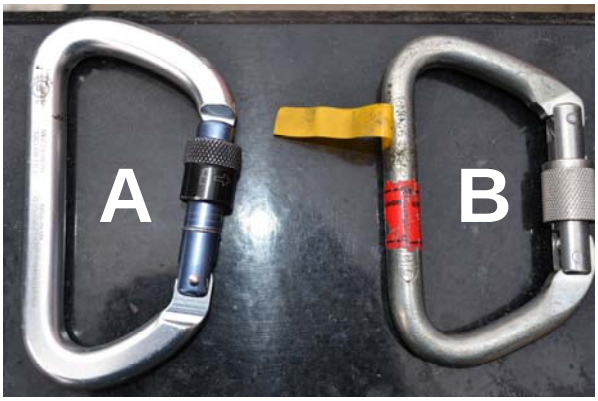
Characteristics of Carabiners

- Have a self-closing, or spring-loaded gate that allows them to close automatically
- Gates should be oriented in the "downward" position and locked before use
- Designed to be loaded on the spine side only
  - The spine is the long axis of the carabiner, or the side opposite the gate opening
  - Loading carabiners on any side other than the spine can cause failure of the carabiner at significantly less than the rated strength
- May be constructed of either aluminum or steel
  - Device strength is typically stamped on the carabiner spine (represented in kN or Kilonewtons)
  - 1kN = 224.8 lbs
  - Rating and use classification may be identified using letters G-General, L-Light, or T-Technical

NFPA 1983 2012 Edition identifies carabiners rated for 40 kN or greater as "General Use". General Use carabiners are used for "System" loads. General Use carabiners may be constructed of either steel or aluminum. There are now General Purpose Rated (G-Rated) aluminum carabiners strong enough to be used for "System" loads.

"Technical Use" carabiners are rated for at least 27 kN and should be used for "Personal Use". Look at the spine of the device to identify its rating. Personal rated carabiners in Montgomery County inventory will bear the letters "T"or "L" depending on when the device was manufactured. See the carabiner pictures below.

General Use Rated Carabiners (System)



Carabiner A
Material - Aluminum
Rating - 40 kN = 8992 lbs

Carabiner B
Material - Steel
Rating - 46 kN = 10,340.8 lbs

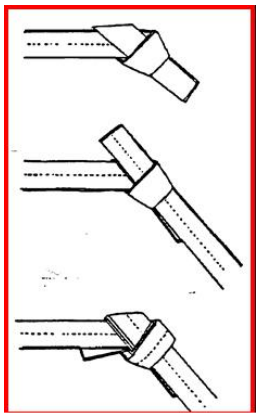
Technical Use Rated Carabiners (Personal)

Carabiner C
Material – Aluminum
Rating - 27 kN = 6069.6 lbs

Carabiner D
Material – Aluminum
Rating - 27 kN = 6069.6 lbs

Webbing

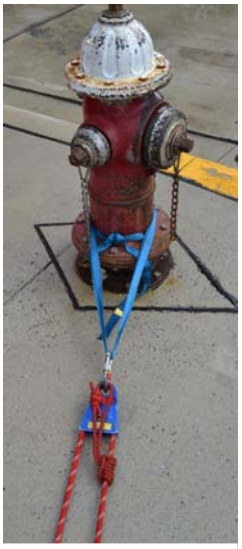
Webbing comes in many varieties. The most commonly used webbing in Montgomery County is 1inch in width and is usually "tubular" in construction.



Overhand Bend "Fisherman's Knot"

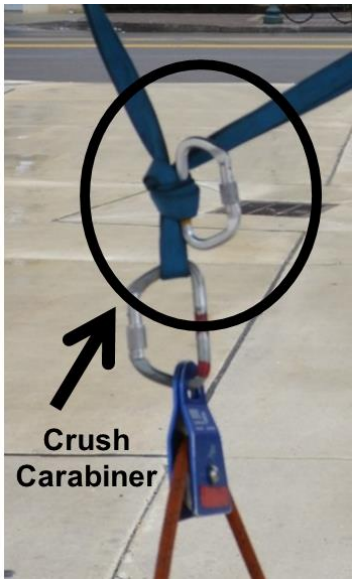
Characteristics of Webbing

- Breaking strength of 4000 lbs
- Multiple uses such as:
  - Anchors
  - Harnesses
  - Patient Lashing
- Can be damaged by sharp objects or corners
  - Use padding such as towels when wrapping webbing around abrasive or sharp objects
- When tying webbing into different configurations, the overhand family of knots should be used. This provides for the creation of a flat knot, which has greater holding power in webbing, and will provide a knot that can be untied after loading.
- Webbing can be most efficiently tied into fixed loops using an overhand bend, also known as the "Fisherman's Knot"/"Water Knot"
- Webbing is commonly used to make anchors using the "Wrap Three Pull Two" method
- Webbing can be used to make fixed focused anchors
- Carabiners may be inserted into overhand knots in webbing making it possible to un-tie a webbing knot after it has been subjected to weight or stress ("Crush Carabiners")



Wrap Three Pull Two Anchor

Webbing Used to Make a Fixed and Focused Anchor



One-Inch Webbing Wrapped Around Outrigger Using Protective Pad in Wrap-Three-Pull-Two Configuration

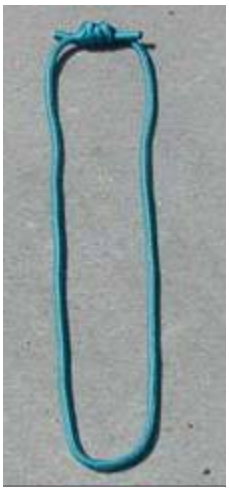
Overhand Bend "Fisherman's Knot"

Prusiks

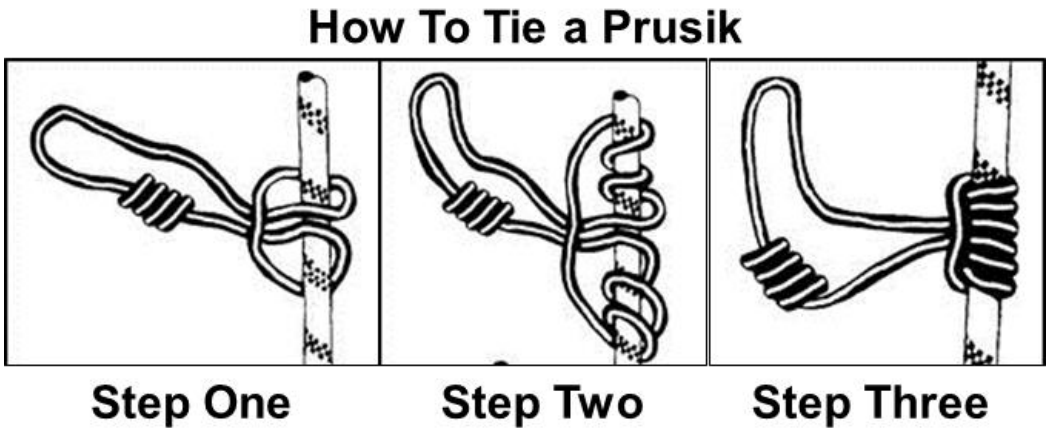
Prusik cords are fixed loops of accessory cord, tied together with a double overhand bend. Prusiks form useful devices that grip rope. Prusiks are wrapped twice around a host rope for personal applications, three times around the rope for system uses.

Characteristics of Prusiks

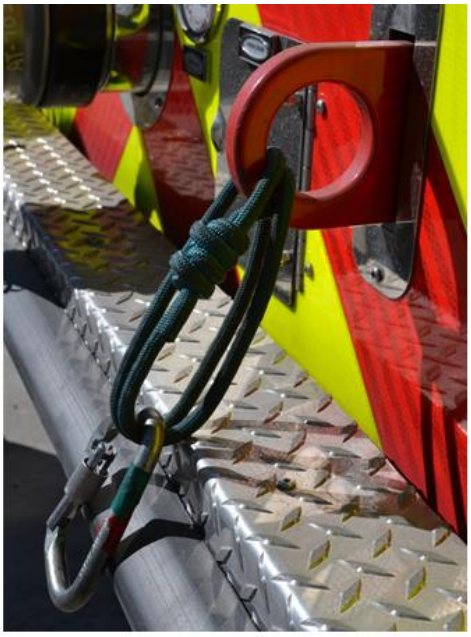
- Small diameter of kernmantle rope
- Found in diameters between 2 to 9 mm
  - Commonly found in 8 mm in Montgomery County
- Common uses include ascending, mechanical advantage systems, and belay systems



8mm Prusik



Tandem Triple-Wrapped Prusiks of Two Different Lengths Used to Create a Belay System



8mm Prusik in Basket Configuration Around Eyehook

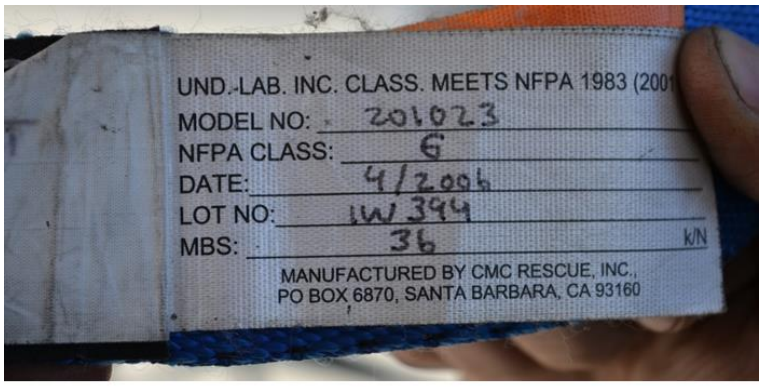
Anchor Straps

Anchor straps are nylon anchor devices that can have either sewn loops or metal attachments at each end.

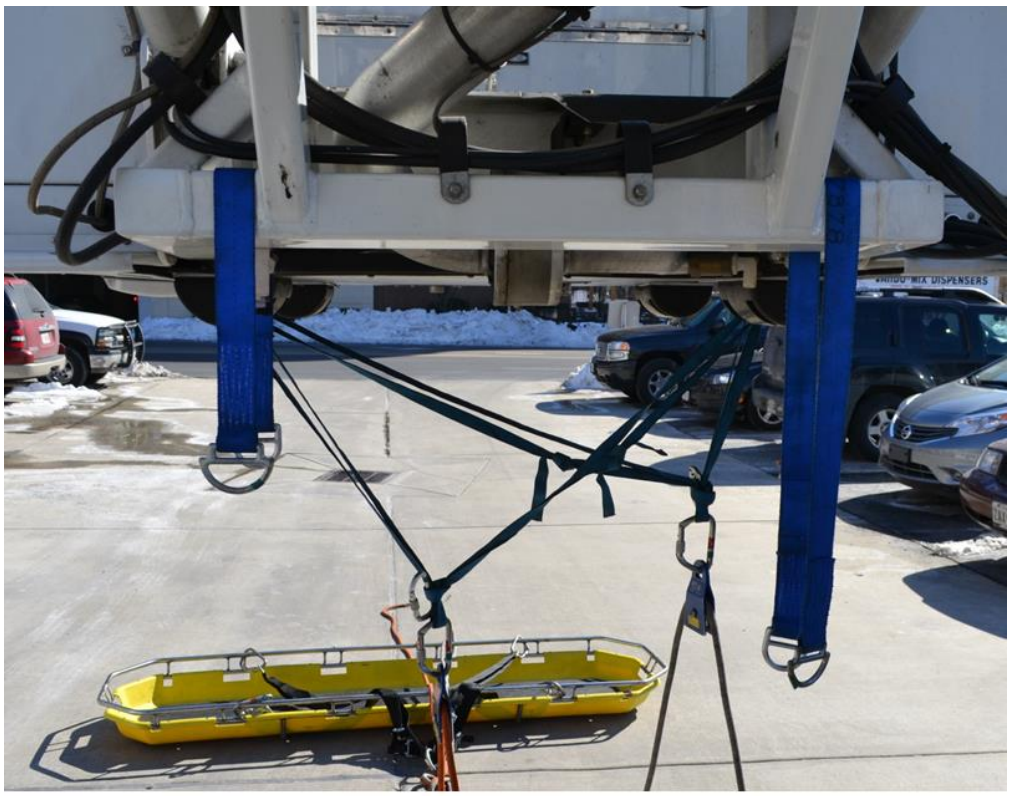
Characteristics of Anchor Straps

- May be assembled using straight, choker, or basket configurations
    - Each configuration has its own advantages and strength ratings
- Typically found in 1 ½ - 2 inch width and varying lengths
- Most straps will carry labels indicating their rated breaking strength in various configurations

Two Inch Anchor Strap



Anchor Strap Label – 36 kN = 8092.8 lbs



Anchor Straps Attached to Leveling Bracket

Belays

A belay system is a safety, or back-up system used in rope rescue. It is designed to stop or catch a falling load (rescuer, patient, etc.) in the event of a main line failure.

There are two very simple and reliable approaches to configuring belays commonly used in Montgomery County. There are other reliable belay mechanisms but these are simple to use and immediately available. These approaches include the use of:

- Traverse 540 Rescue Belay, and
- Tandem Triple-Wrapped Prusiks attached to a carabiner and belay line.

Characteristics of Belay Systems

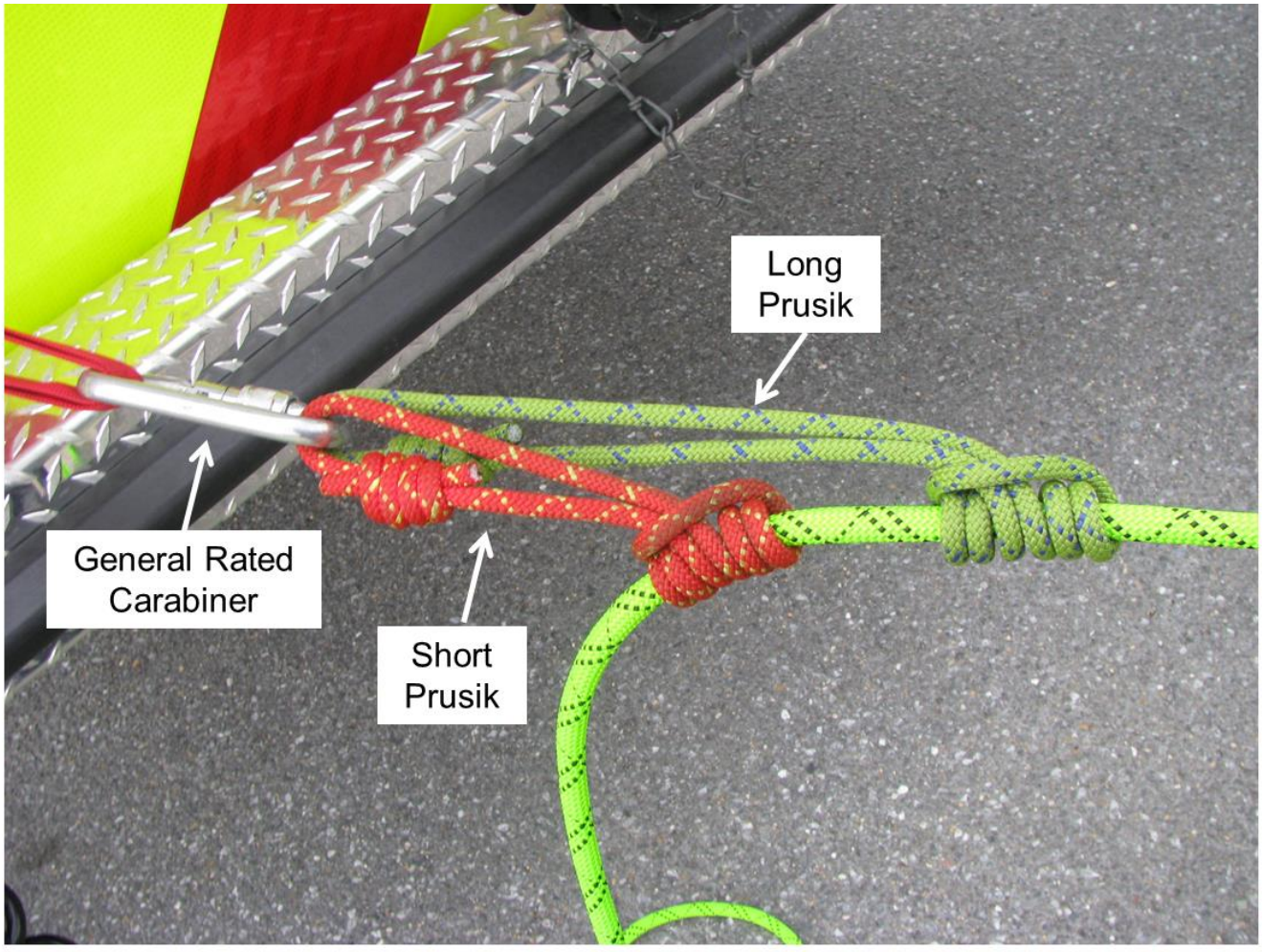
- Must be able to stop a load in motion or hold a load at rest
- Must survive an activation enough to allow further rescue
- Must minimize the shock load or Maximum Arrest Force (MAF)
- Must minimize the stopping distance of the load
- Must work in any environment
- Must activate automatically (must pass the whistle test)
- Must pass the critical point test

Traverse 540 Rescue Belay

Tandem Prusik Belay

How to assemble the tandem prusik belay

- Place two prusiks (one long one short) on the belay rope with three wraps
- Each prusik should be wrapped in the same direction around the rope
    - Prusiks wrapped in the same direction are easier to visually inspect and physically manage
- Make sure the prusiks are snug on the rope (Dress the Prusiks)
    - A good test of this is to pull rope through the prusiks and listen for the friction between the rope and the prusiks. If you can hear the friction, then the prusiks are tight enough
    - Also tug on the rope to make sure they grip
- Connect the prusiks to a carabiner attached to an anchor



Tandem Triple-Wrapped Prusiks of Two Different Lengths Used to Create a Belay System

Single Sheave Prusik-Minding Pulley

Pulleys are a multi-functional tool used in rope rescue. Their primary function is to change the direction of a rope while creating minimal friction.

Prusik Minding Pulley

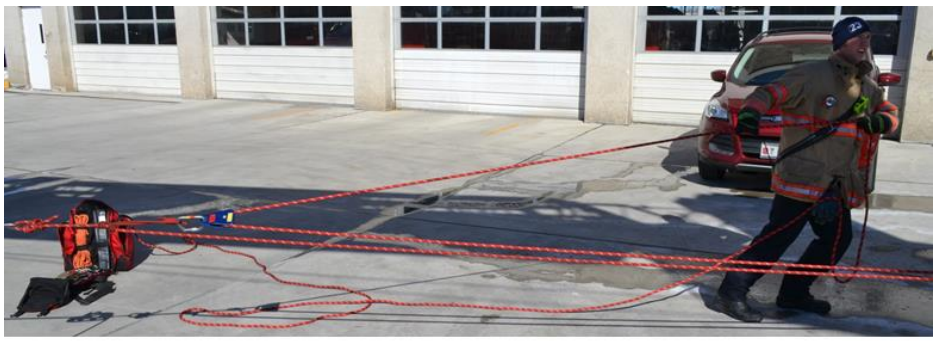
Characteristics of Prusik-MindingPulleys

- Designed to "mind" a prusik, or allow the rope to be pulled through the pulley with a prusik attached to one side
- Useful device when constructing mechanical advantage systems
- It is possible that the prusik can become jammed inside the pulley and restrict the passage of the rope

Important Considerations

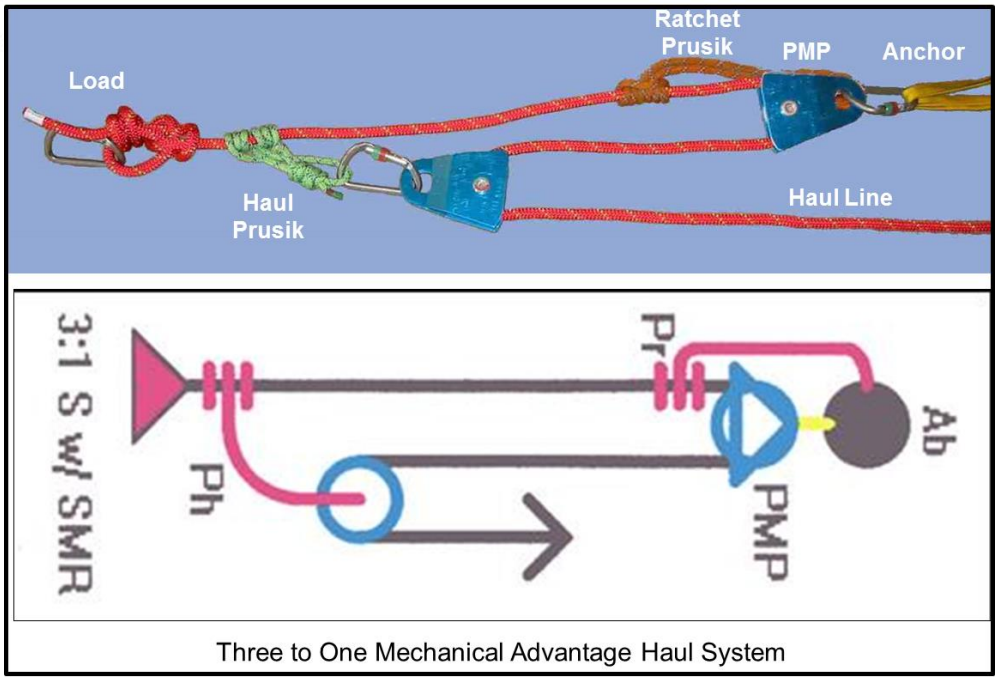
- Pulleys have an ability to multiply the load placed on their anchor
- The interior angle created by the legs of a marginal fixed and focused anchor must be less than 120 degrees (Critical Angle). It is ideal to keep this angle less than 90 degrees.

Pursik-Minding-Pulley Assembled with 8mm 3-Wrap Prusik for Progress Capture on 3:1 Haul System



Pulley Used In Hauling System

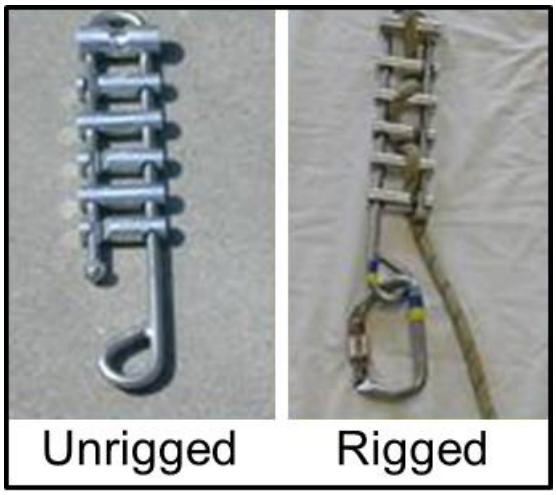
Pulley Used for Change of Direction



Three to One Mechanical Advantage Haul System

Rappel Rack

The Rappel Rack is a type of descent control device used in rescue. The rappel rack is considered the device of choice by many rescue teams. The device may be attached to a harness and used to descend, or rappel, and can also be attached to an anchor and used to lower other rescuers (or in this case a stokes basket).



Characteristics of Rappel Racks

- User-friendly device with significant advantages over the figure 8
- The biggest advantage of the rappel rack is the ability to vary the friction while the device is loaded
    - This is very important when "picking off" a victim while on descent
    - More bars means more friction
- Has good heat dissipation
- Does not twist the rope
- Easy to lock and unlock
- All six bars should be included when tying off rack

Rappel Rack Tied Into Haul System As the Load

Two Ways To Tie Off Rappel Rack

Rappel Rack Tied Into Pierce TDA Bottom Ladder Rung

Stokes Basket and Bridles

There are three basic types of stokes baskets:

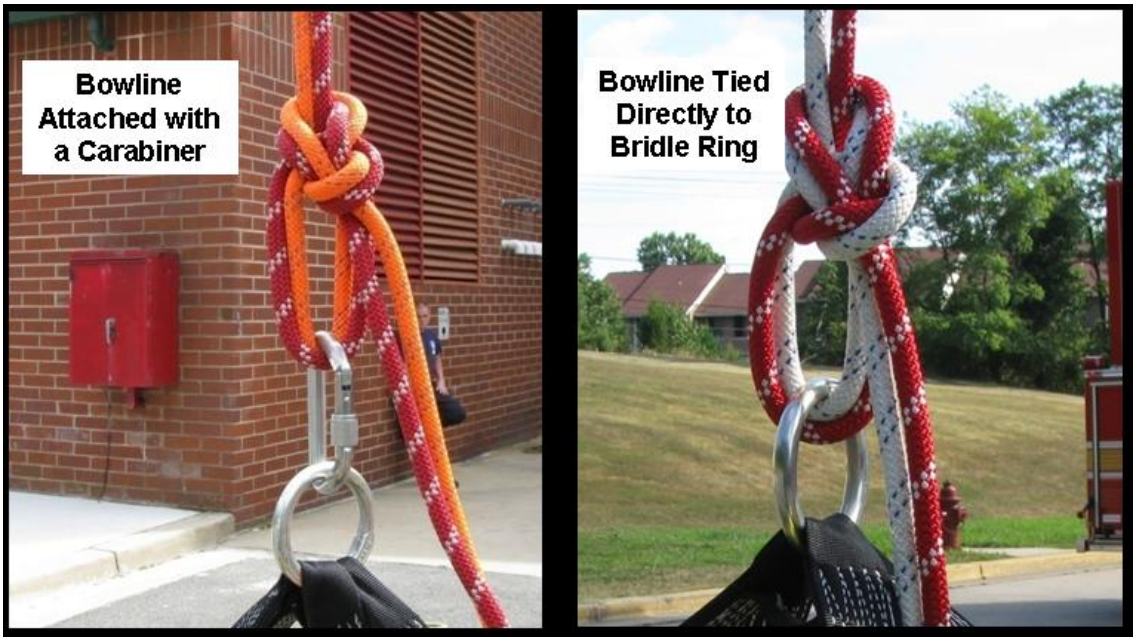
- Metal or wire basket,
- Plastic litter, and
- Combination.

No matter which basket is used, the patient packaging and lashing techniques are primarily the same. The biggest difference in the three types of baskets is the location that the lashing is tied off to.

Bridles may be made out of small diameter kernmantle rope (commonly fashioned into set-ups called Yosemite Rigs), or sewn webbing with adjustable attachments. They connect to a stokes basket using caribiners.

The Bridle will have a primary ring attachment that will attach the main and belay lines using a doubled-long-tail bowline.

The doubled-long-tail bowline may be tied directly into the bridle ring or attached using a general use-rated carabiner, either approach is acceptable. The doubled-long-tail bowline should be tied as to leave ample length (approximately 5 to 6 feet) tails to tie to the victim and any potential rescuer attendant.



Ladder Placement

The reliability and capacity of an aerial ladder used as a directional in raising and lowering live loads is dependent upon the following factors:

- Proper apparatus positioning relative to the target,
- Appropriate ladder working angle,
- Efficient and safe construction of a complimentary rope system,
- Proper loading of the ladder so forces are appropriately transmitted to anchors, and
- Ladder tip load rating.

The ladder turntable should be positioned to accomplish the following objectives:

- Close enough to the victim so that the ladder tip will reach directly over the victim,
    - The ladder angle will support the weight of the load,
    - There is room to set up the systems,
        - Need enough space for hauling system throw,
- Access to remote anchors for mechanical advantage systems, and
- There is enough room to potentially rotate the ladder and/or lower the basket and victim safely to stable ground.

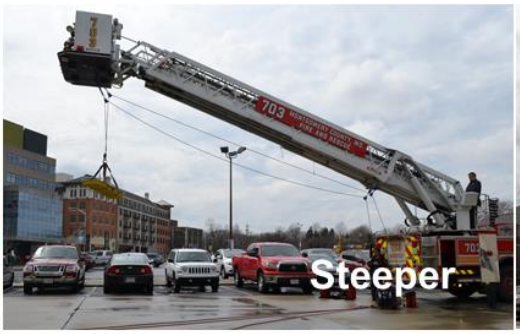
Ladder Angles

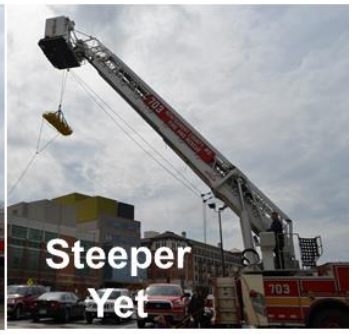
Larger ladder angles (measured from the horizontal) produce larger system capacities. Larger ladder angles also result in greater loads being generated by the rope system.

The inverse of this is also true: lower angles mean less capacity, but also generate lower forces in the rope system.

Driver/Operators must be knowledgeable of the load bearing capacity their aerial device at different elevations, angles, and in dynamic environmental conditions (Wind and Ice).

Ladder Angle	Corresponding Rope Angle	Load on Change of Direction Pulley as a percent of the load
0°	90°	1.41
30°	60°	1.73
45°	45°	1.84
60°	30°	1.93
80°	10°	1.99





Stokes Basket Evolutions Using Pierce All-Steer and E-One Towers

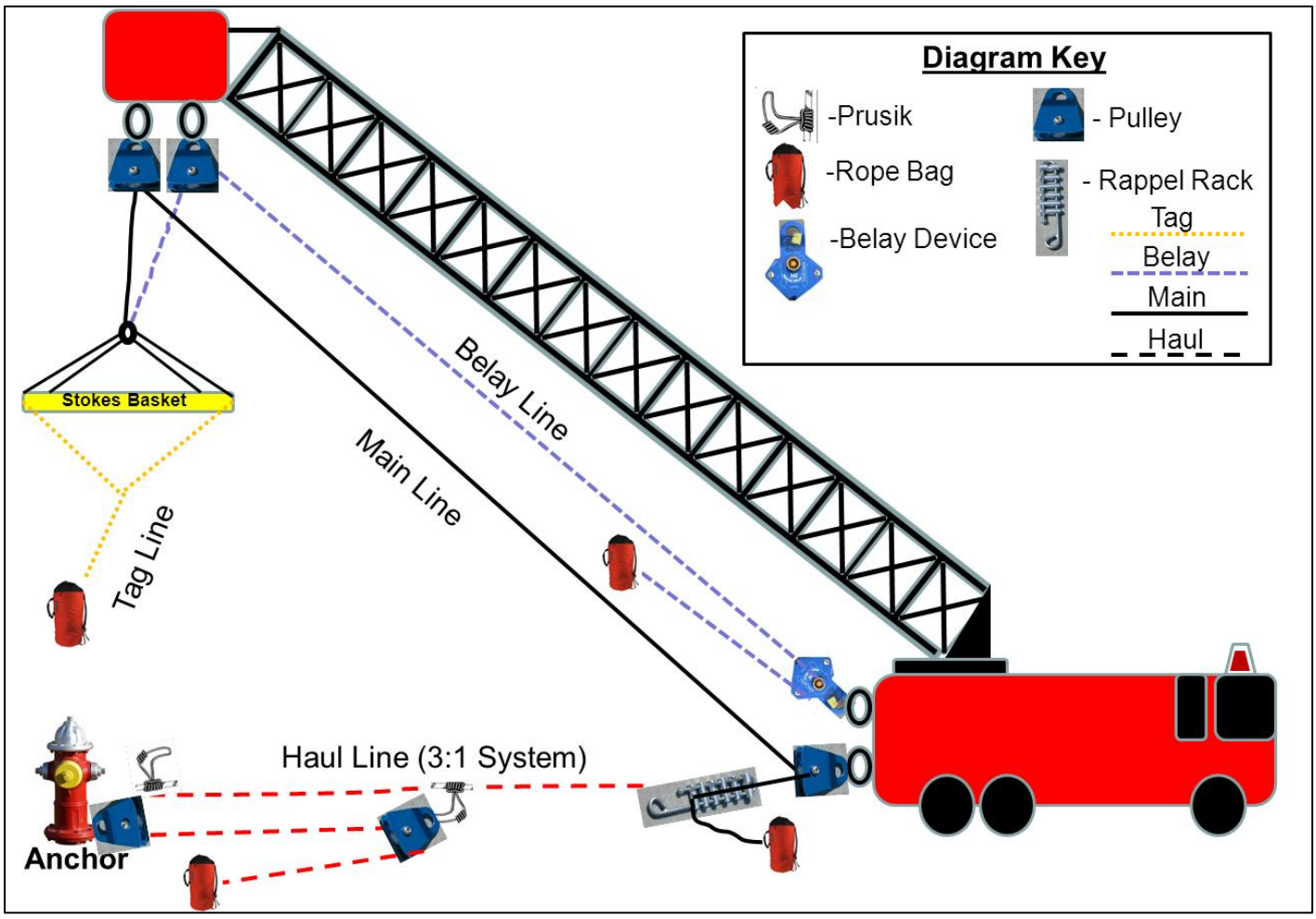
Most stokes basket evolutions can be accomplished using the conventional approach described in the following sections.

There are acceptable subtle variations to how a stokes basket evolution may be deployed using Montgomery County Tower Aerial Devices. Variations may be applied to mitigate unique operational circumstances and afford us the flexibility to adapt to unusual situations. These variations are acceptable provided they are justified in their purpose, satisfy safety guidelines, and do not place victims, rescuers, or equipment in unnecessary jeopardy. Most of the acceptable variations are identified in this document and observe the stokes basket evolution best practices listed on page two of this document.

The steps listed below describe the primary steps involving Aerial Tower Stokes Basket Evolutions:

1. Identify Victim Location – Determine Best Apparatus Position
2. Position Apparatus According to Plan – Set Up Aerial Device
3. Assemble Equipment and Distribute Tasks
    A. Set Up Anchor and Change of Directions for Main and Belay Lines on the Basket
    B. Set Up Stokes Basket
    C. Identify Anchors for Main Line and Belay
    D. Move the Basket to the Target for Patient Lashing
    E. Build Dynamic Raising and Lowering System
    F. Build and Complete Belay
    G. Ensure System is Safe – “Three Sets of Eyes” Principle
    H. Load System and Balance Stokes Basket
4. Operate System

Aerial Tower Stokes Basket Evolution Diagram



1- Identify Victim Location – Determine Best Apparatus Position

It is best practice to take a moment to formulate a strong plan and place the apparatus in the most advantageous position before committing any resources.

Take a few judicious moments to evaluate the scene and position the apparatus in a way that maximizes its useful capacities. Apparatus operators must know the capabilities of their aerial devices in various conditions. They must also be skilled at operating these devices to take advantage of a device's safe capabilities.

The apparatus should be positioned so that the end of the ladder will reach directly over the victim while allowing rope systems to remain in-line with the ladder.

Determine if you will work off the front, rear or side of the truck as this will influence your positioning and equipment selection.

Why Movement of the Ladder Should Be Minimized

This evolution sets the aerial device as a high directional. The position of that directional should not be altered unless there is a compelling reason to extend, retract, or rotate the aerial device. The haul and main line ropes must stay in-line with the ladder at all time. Movement of the ladder once there is a load placed on the system can create potentially dangerous dynamic stresses that may cause system elements to fail catastrophically.

2 - Position Apparatus According to Plan – Set Up Aerial Device

Set up the Aerial Tower in the most ideal possible method. Outrigger pads must be applied to the ground to spread out force and enhance the apparatus footprint.

All four outriggers should be maximally extended and well planted with safety pins installed. Abide by apparatus manufacturers technical specifications when short-jacking may be required, and do not override any safety mechanisms. Minimize lateral and horizontal slope as much as possible to obtain the best possible functional working range.

It is better to employ an alternative method of patient evacuation than to attempt to override safety interlocks and risk a ladder failure.

Ladder Failure Mundelin, IL – October 19, 1994

An 85 foot steel Seagrave midship aerial ladder collapsed onto the roof of the fire station during a high angle rescue team training exercise.

The ladder passed a 1914 NFPA ladder inspection one week prior to the incident. The ladder had been extended approximately 80 feet at an elevation angle of 60 degrees and had been rotated approximately 20 feet to the right from the front of the truck.

Firefighters were preparing to lift a stokes basket when the collapse occurred. The ladder was twisted to the right and a bending failure occurred in the second section of the ladder. The stokes basket was suspended from a rope that was passed over a pulley system. The pulley was attached to the top rung of the ladder and was offset approximately 18 inches from the centerline of the ladder.

The rope ran down from the pulley at the tip of the ladder to another pulley that had been attached to a tow hook on the front of the truck. This pulley system was rigged to raise and lower the stokes basket.

The investigator determined that the tip load had not been exceeded, but the ladder failed due to twisting force. The twisting force was induced by the rope running at an angle from the from tow hook to the tip of the ladder, and the offset of the pulley from the center of the top rung.

3 - Assemble Equipment and Distribute Tasks

The following equipment will be needed in varying quantities depending on the circumstances of the evolution:

- Rope (4 Bags – Main, Belay, Haul, and Tag Lines)
- Prusik Minding Pulley
- System Rated Carabiners
- Personal Rated Carabiners
- 1" Webbing
- Prusiks
- Anchor Straps
- Rappel Rack
- Stokes Basket and Bridle
- 540 Rescue Belay

Steps A-H may be distributed to a group of people. Some of the steps are interdependent, but many may be done simultaneously.

It is the responsibility of the Officer in Charge or Safety Officer to ensure that the system is safe to use and that "Three Sets of Eyes" have evaluated every component of the system before it receives a live load. The Aerial Tower Operator should be the first set of eyes that ensures the devices attached to their apparatus are applied properly in a way that can be safely supported by the aerial.

A - Set Up Anchor and Change of Directions for Main and Belay Lines on the Basket

There are a handful of safe and effective ways to anchor the Main and Belay line change of directions to the end of the aerial tower. Some of the safe options include:

- Applying 1-inch webbing arranged as a two-point fixed-and-focused offset anchor to the 500-pound-rated eye hooks fixed to the bottom of the aerial bucket (Figure 1),
- Anchor Straps Applied to tower bucket leveler bracket. Pulleys for the Load and Belay lines would be attached using caribiners (Figure 2), or
- Apply 1-inch webbing in Wrap-Three-Pull-Two configuration to tower bucket leveler bracket (Figure 3).


Figure 1 – Two-Point Fixed-And-Focused Anchors Attached to Eye Hooks

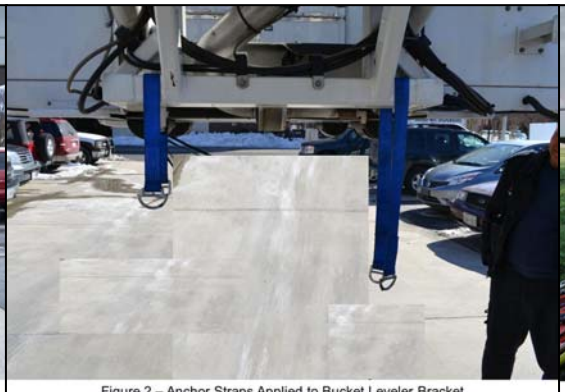


Figure 2 – Anchor Straps Applied to Bucket Leveler Bracket

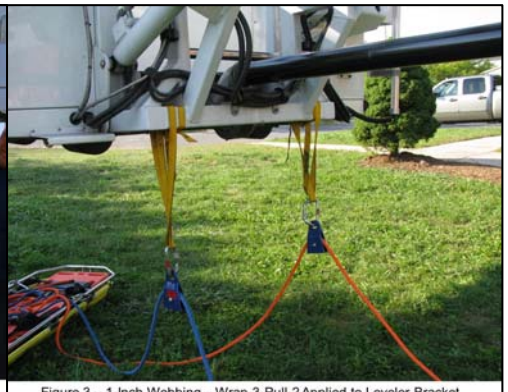


Figure 3 – 1-Inch Webbing – Wrap-3-Pull-2 Applied to Leveler Bracket

B - Set Up Stokes Basket

A knot called the “doubled long tail bowline” combines two ropes into a single bowline knot. For our purpose, the knot marries a Main Line and a Belay line into a single element.

The knot is tied using the same method as a conventional bowline knot with the addition of two long tails that exist from the knot to the end of the rope. This section of the rope is commonly referred to as the “Working End”.

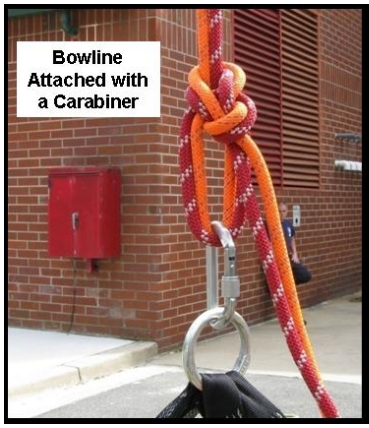
The long tails serve as attachment points to both the victim and a potential rescuer attendant. A direct connection to the stokes basket coupled with a connection to one of the long tails comprises two points of contact.

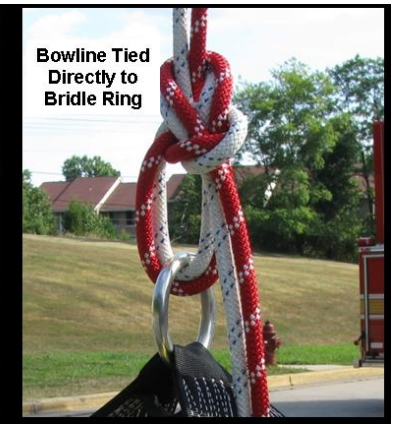
The Bridle attaches to the stokes basket using 4 system carabiners. Make sure to arrange the carabiners in the “Down and Down” position. “Down and Down” refers to the placement of a carabiner with the locking end down closest to earth and the locking collar down and applied.

Make sure to adjust the bridle so the stokes basket hangs close to level in the air, or with the side that will accommodate the patient’s head slightly elevated.

Remember to secure patient packaging equipment inside the stokes basket.

Double Long Tail Bowline





Stokes Basket Assembled With Tag Line and Doubled Long Tailed Bowline Attached to Bridle

Stokes Basket With Bridle

A tag line must be attached to the stokes basket to maintain directional control of the load. The tag line should be tied so the rope can grip the basket and have effective input control.

Two options for attaching the tag line include:

- ***Passing Through Rails Of Stokes Basket***
  - Pulling hard on a tag line affixed in this way may cause basket to pull out of level
- ***Connecting to Doubled Long Tail Bowline***
  - Pulls on attachment point of the system and does not alter leveling of basket in derogatory way while maintaining positive directional control

Tag Line Attached to the Basket

Tag Line Being Used to Move Basket Away From Building During Lowering Phase

Tag Line Attached to DLB Moving Basket During Lowering Phase

C – Identify Anchors for Main Line and Belay

Consider using the "bombproof" tow hook anchors mounted to the truck's frame when working off the rear of a Pierce All Steer. Belay assemblies and pulleys can be easily anchored to these points using an 8mm prusik in a basket configuration.

8mm Prusik in Basket Configuration

Tow Hook Anchors – Attachments Made With 8mm Prusiks

Make sure there are no sharp edges on the tow hooks that could compromise anchor attachment material (You do not want to cut into a prusik with a sharp edge).

Anchor Straps Applied to Bed Section Cross Member

Anchor Straps attached to change of direction pulleys with Carabiners are commonly applied to a ladder bed section close to the turntable on the Pierce Towers. This step was required by Pierce and helps the Main and Belay Lines better stay in line with the ladder. This step should be taken regardless the location of the Main and Belay line anchors.

The Main and Belay Lines may be placed on either the driver or officer side of the apparatus depending on circumstances. These lines should be anchored to outriggers if the ladder is intended to be used off the side of the truck.

Rope may be built in to the system as the devices are assembled.

Assembled Main and Belay Anchors

Main and Belays Anchored to Outriggers

Outriggers Used as Anchors

D – Move the Basket to the Target for Patient Lashing

The attached stokes basket may be moved to the target after the main and belay lines have been attached to the bucket using anchors and changes of direction. Rope attendants should run the main and belay lines through a carabiner attached to an anchor, and allow rope to gracefully pay out as the aerial device maneuvers the basket into position. Patient packaging equipment should be secured inside the stokes basket before the stokes basket is elevated into position.

This approach allows rescuers working with the victim to prepare the patient and stokes basket for evacuation while the ground crew completes the dynamic rope system.

Basket Being Delivered

Basket In Place at Target

E – Build Dynamic Raising and Lowering System

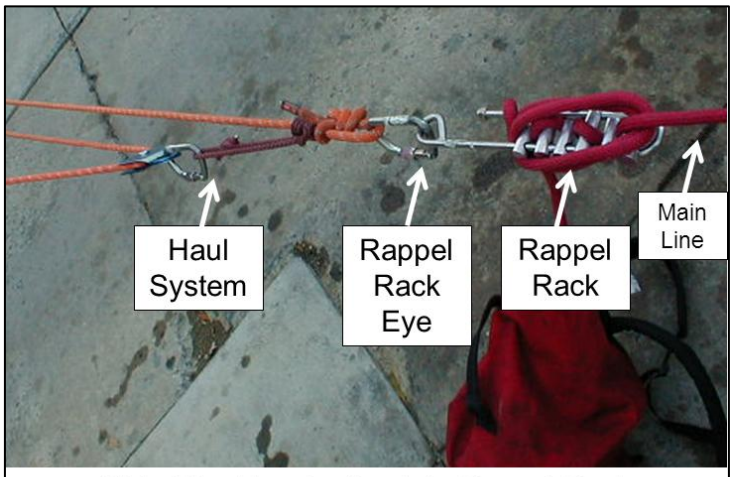
Step 1 - Set Up Main Line Change of Direction With Rappel Rack

The stokes basket will need to be both raised and lowered at some point during the evolution. The Main Line which is connected directly to the stokes basket terminates into a rappel rack. This configuration allows rescuers to lower the stokes basket by releasing rappel rack bars and allowing rope to pass through.

Main Line Moving Through Anchored Change of Direction

Change of Direction

The stokes basket will also need to be raised using a rope system during the evolution. To that end, the eye of the rappel rack is connected to a 3:1 haul system.



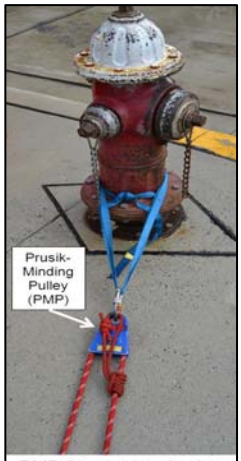
Main Line Terminating Into Rappel Rack

Main Line Connecting To Haul Line

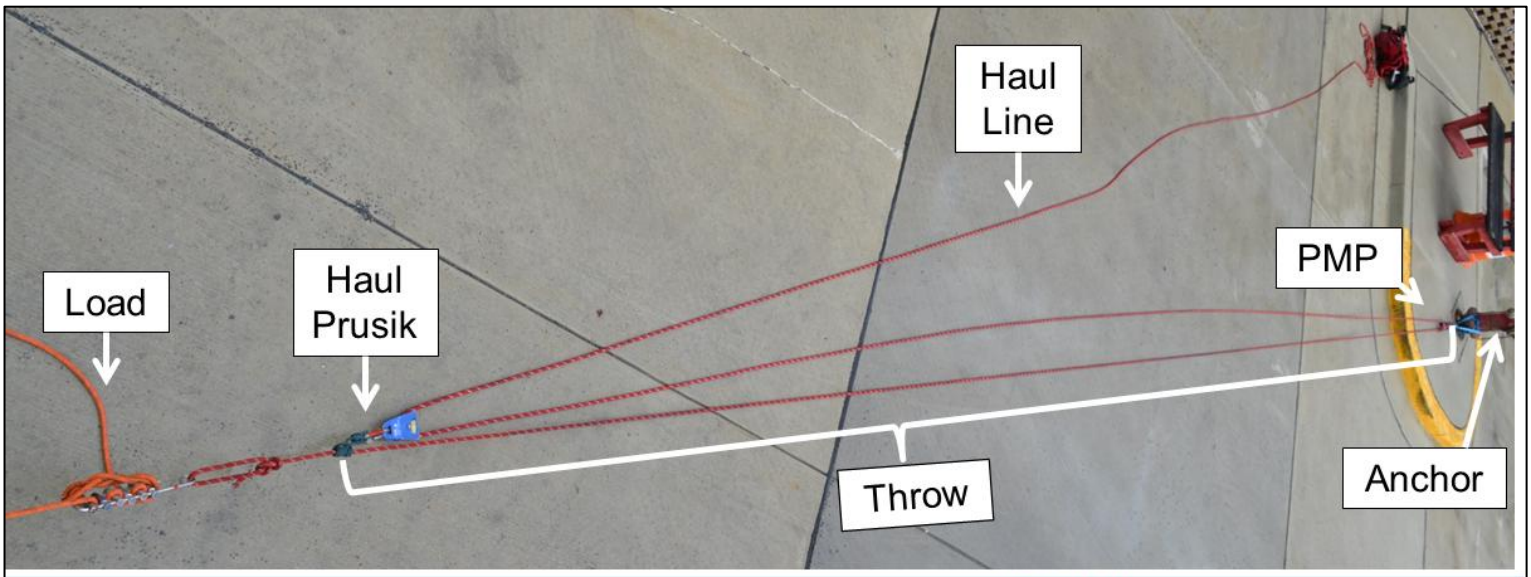
Step 2- Set Up Haul System Connected to Anchor

The stokes basket system contains a three-to-one (3:1) mechanical advantage hauling system used to raise the stokes basket's elevation with human power. This system is comprised of an additional life-safety quality rope, an anchor, connection devices, and pulleys.

The system is called a "three-to-one" because the components in the system must cumulatively travel three feet in order to raise the stokes basket one foot in elevation. In other words, the 3:1 system would have to travel 30 feet to raise the stokes basket 10 feet in elevation. "Throw" is the distance between the load and the anchor. In other words, the throw can be considered the maximum distance the haul system can travel.



PMP Attached to Anchor

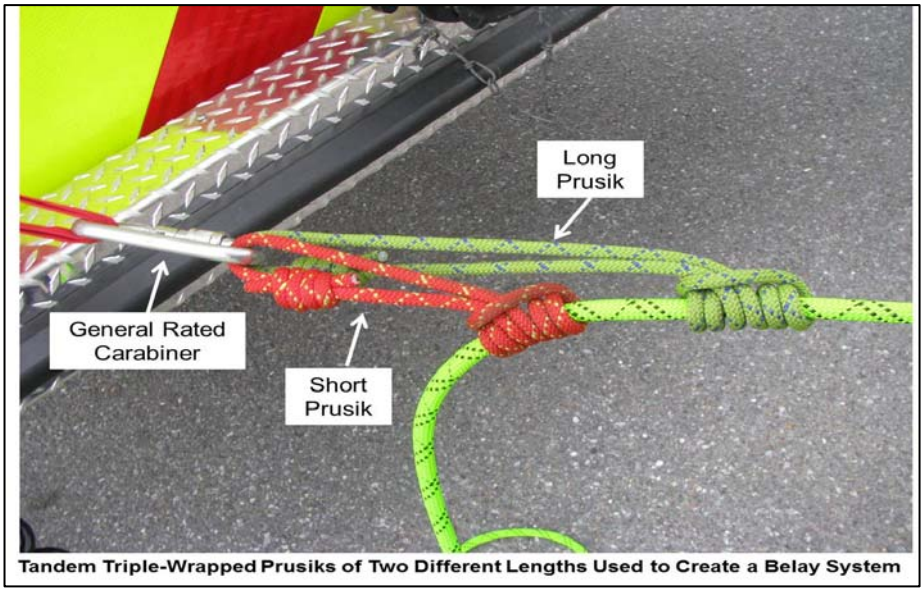


3:1 Haul System Attached to Main Line Rappel Rack

F – Build and Complete Belay

There are several types of belay devices found in rescue rope systems. The two acceptable belay assemblies in Montgomery County are the:

- Traverse 540 Rescue Belay, and
- Tandem triple-wrapped 8mm Short and Long Prusiks.



Tandem Triple-Wrapped Prusiks of Two Different Lengths Used to Create a Belay System

G - Ensure System is Safe – "Three Sets of Eyes" Principle

Everyone must take a responsible stake in the safety of the stokes basket operation. The Aerial Tower Operator must make sure that the system has been reviewed by "Three Sets of Eyes" before any load may be maneuvered. There will likely be Officers present, but the Aerial Tower Operator must be a subject matter expert on this evolution and shall be the first guardian of safety.

H – Load System and Balance Stokes Basket

Load the system after all elements of the aerial device stokes basket system have been assembled and evaluated for safety using "Three Sets of Eyes". Use the haul system to elevate the patient-laden stokes basket high enough that its weight is supported by the system and adjust the bridle to manipulate to leveling of the basket.

5 - Operate System

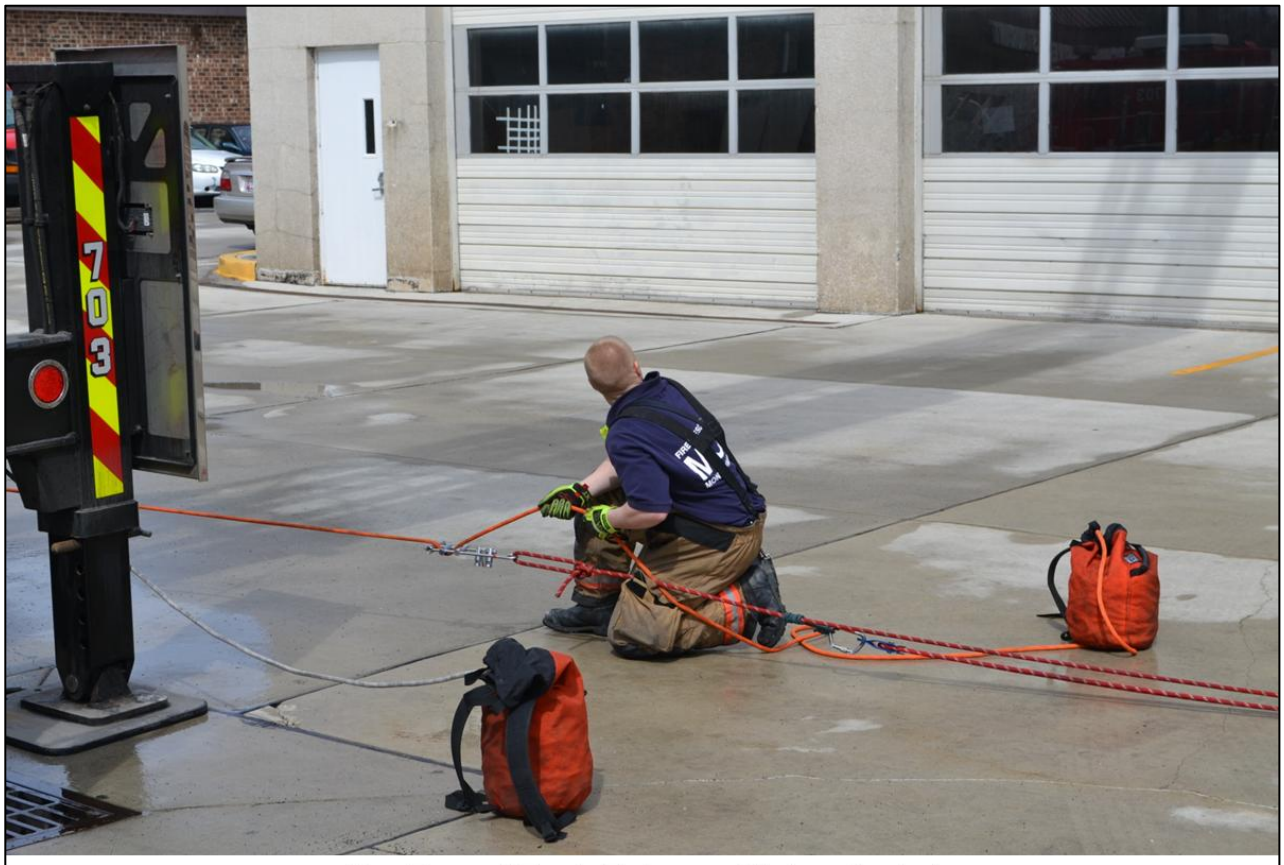
The following guidelines should be observed when conducting an Aerial Tower Stokes Basket Evolution:

- One person must be in charge of the evolution
  - This person takes input from all participants
  - Participants take action only on commands issued by the evolution leader. The only exception to this instruction is for safety-related observations
  - This person is the leader and calls all commands
- Use only standard rope rescue commands
- Place personnel in the following positions
  - Aerial Operator at Control Pedestal
  - Tag Line
  - Belay Line
  - Main Line/Haul Line (as many as appropriate)
  - Safety Spotters
- The aerial device may be moved into position over the patient after the high directional are rigged and the basket is attached to the doubled long tail bowline
  - Make sure to allow rope to move appropriately though devices as the ladder is moved
- Once the ladder is in place as a high directional, it should not be moved
  - Extension, Retraction, Raising, or Rotating of the ladder can damage system components and cause potential system failures
  - Never rotate an aerial tower during a stokes basket evolution in a way that causes the ropes to become out of line with the ladder
  - Use slow and feathered inputs if a ladder must be moved with a patient connected to the stokes basket
- Use the Hauling, Lowering, and Tag Line components to manipulate the stokes basket after the patient is installed
  - Use a Patient Attendant only if necessary for patient care and/or maneuvering a basket over a ledge

Maneuver Empty Stokes Basket Into Position

Place Stokes Basket Over Wall or Into Target

Engage Haul System to Raise Stokes Basket Away From Target



Use Rappel Rack To Lower Stokes Basket

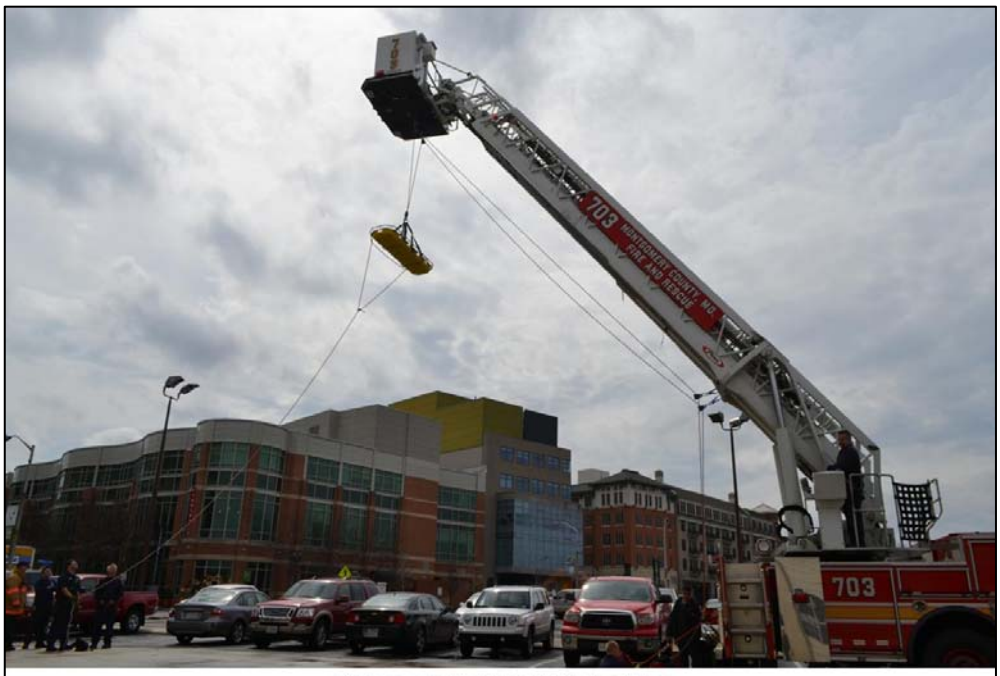
Use Tag Line To Maneuver stokes Basket During Lowering

Maintain Control of the Basket All The Way To The Ground

Manage the Belay During Lowering

Stokes Basket Is Safely Placed Onto The Level Ground

Example of Ropes In Alignment With Ladder



Ropes are In Line With Ladder

Ropes are in Line With Ladder

Example of Ropes Out Of Alignment With Ladder

Ropes Out of Alignment with Ladder – This Will Cause Dangerous Stresses

Stokes Basket Evolutions Using Pierce Tractor Drawn Apparatus – Lyfe Pulley System

The Lyfe Pulley System is the only manufacturer certified method of executing stokes basket evolutions using Pierce Tractor Drawn Aerials (TDAs). Use of any other approach is not certified by Pierce and is therefore not endorsed by the user Montgomery County. Deviation from the use of the Lyfe Pulley System when performing stokes basket evolutions involving Pierce TDAs could result in the following derogatory outcomes:

- Unsafe operating conditions for rescue personnel and equipment
- The aerial may not perform as expected preventing successful completion of the evolution
    - Aerial rope system techniques that are not endorsed by Pierce could exceed the design limits of the aerial device leading to catastrophic ladder failure
- Excessive or unnecessary damage to the Tractor Drawn Aerial device
- Voiding of aerial device warranty terms and conditions

The Pierce Lyfe Pulley method allows for 360 degree turntable rotation while maintaining alignment of ropes with the ladder. Elevation of the stokes basket is inputted by gentile extension and retraction of the aerial device.

Rotation, extension, and retraction of the Pierce Aerial device during the endorsed method of stokes basket evolution may still produce dynamic loads on the rope system components. Care should be taken to minimize or eliminate unnecessary movement of the ladder once a load has been applied to the high directional.

This method effectively uses the aerial device as a crane. Multiple simultaneous control inputs are required to raise and lower the vertical position of the loaded basket. It is possible to inadvertently cause simultaneous vertical, horizontal, and diagonal movement of the loaded basket if operator control is not properly coordinated.

The Pierce TDA Lyfe Pulley System is certified to support a maximum 500-pound distributed load. The system cannot support shock loads.

1- Identify Victim Location – Determine Best Apparatus Position

It is best practice to take a moment to formulate a strong plan and place the apparatus in the most advantageous position before committing any resources.

Take a few judicious moments to evaluate the scene and position the apparatus in a way that maximizes its useful capacities. Apparatus operators must know the capabilities of their aerial devices in various conditions. They must also be skilled at operating these devices to take advantage of a device's safe capabilities.

The apparatus should be positioned so that the end of the ladder will reach directly over the victim while allowing rope systems to remain in-line with the ladder.

Determine if you will work off the front, rear or side of the truck as this will influence your positioning and equipment selection.

Why Movement of the Ladder Should Be Minimized

This evolution sets the aerial device as a high directional. The position of that directional should not be altered unless there is a compelling reason to extend, retract, or rotate the aerial device. The haul and main line ropes must stay in-line with the ladder at all time. Movement of the ladder once there is a load placed on the system can create potentially dangerous dynamic stresses that may cause system elements to fail catastrophically.

2 - Position Apparatus According to Plan – Set Up Aerial Device

Set up the Tractor Drawn Apparatus in the most ideal possible method. Outrigger pads must be applied to the ground to spread out force and enhance the apparatus footprint.

Both outriggers should be maximally extended and well planted with safety pins installed. Abide by apparatus manufacturers technical specifications when short-jacking may be required, and do not override any safety mechanisms. Minimize lateral and horizontal slope as much as possible to obtain the best possible functional working range.

It is better to employ an alternative method of patient evacuation than to attempt to override safety interlocks and risk a ladder failure.

Full aerial operations can only be obtained when both level indicators are in the green area.

Ladder Failure Mundelin, IL – October 19, 1994

An 85 foot steel Seagrave midship aerial ladder collapsed onto the roof of the fire station during a high angle rescue team training exercise.

The ladder passed a 1914 NFPA ladder inspection one week prior to the incident. The ladder had been extended approximately 80 feet at an elevation angle of 60 degrees and had been rotated approximately 20 feet to the right from the front of the truck.

Firefighters were preparing to lift a stokes basket when the collapse occurred. The ladder was twisted to the right and a bending failure occurred in the second section of the ladder. The stokes basket was suspended from a rope that was passed over a pulley system. The pulley was attached to the top rung of the ladder and was offset approximately 18 inches from the centerline of the ladder.

The rope ran down from the pulley at the tip of the ladder to another pulley that had been attached to a tow hook on the front of the truck. This pulley system was rigged to raise and lower the stokes basket.

The investigator determined that the tip load had not been exceeded, but the ladder failed due to twisting force. The twisting force was induced by the rope running at an angle from the from tow hook to the tip of the ladder, and the offset of the pulley from the center of the top rung.

3 - Assemble Equipment and Distribute Tasks

The following equipment will be needed in varying quantities depending on the circumstances of the evolution:

- Rope (3 Bags – Main, Belay, and Tag Lines)
- Lyfe Pulley System Bracket
- System Rated Carabiners
- 2 Anchor Straps or 1-Inch Webbing
- Prusiks (If using a tandem-prusik belay)
- 540 Rescue Belay (If not using triple wrap tandem prusik belay)
- Rappel Rack
- Edge Protectors
- Stokes Basket and Bridle

Steps A-F may be distributed to a group of people. Some of the steps are interdependent, but many may be done simultaneously.

It is the responsibility of the Officer in Charge or Safety Officer to ensure that the system is safe to use and that "Three Sets of Eyes" have evaluated every component of the system before it receives a live load. The Tractor Drawn Apparatus Operator should be the first set of eyes that ensures the devices attached to their apparatus are applied properly in a way that can be safely supported by the aerial.

The steps listed below describe the primary steps involving Pierce TDA Lyfe Pulley Stokes Basket Evolutions:

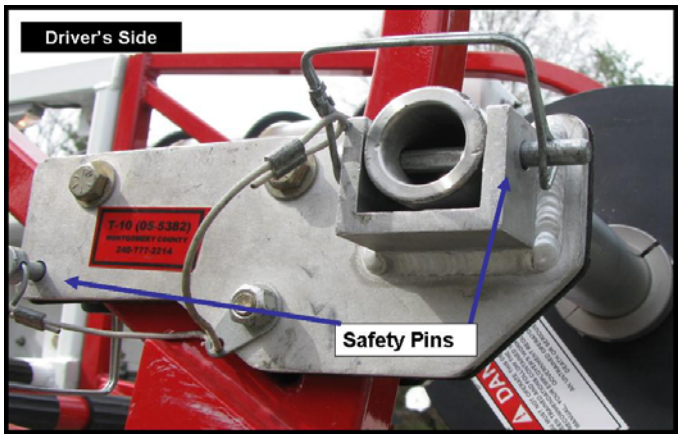
A- Perform "Dry Run" of Aerial Ladder Placement
B- Install Lyfe Pulley
C- Place Main and Belay Lines
D- "Dead-End" Main and Belay to Base of Aerial
E- Tie Double Long Tail Bowline and Attach Stokes Basket
F- Attach Tag Line

A - Perform "Dry Run" of Aerial Ladder Placement

Prior to performing the actual evolution the operator should complete a test run and determine exactly the amount of rope required and the length of ladder required to complete the task. While the operator is completing the test run, the remainder of the crew should be packaging the patient and preparing the stokes basket. Also, at this time it should be determined if an attendant will be needed.

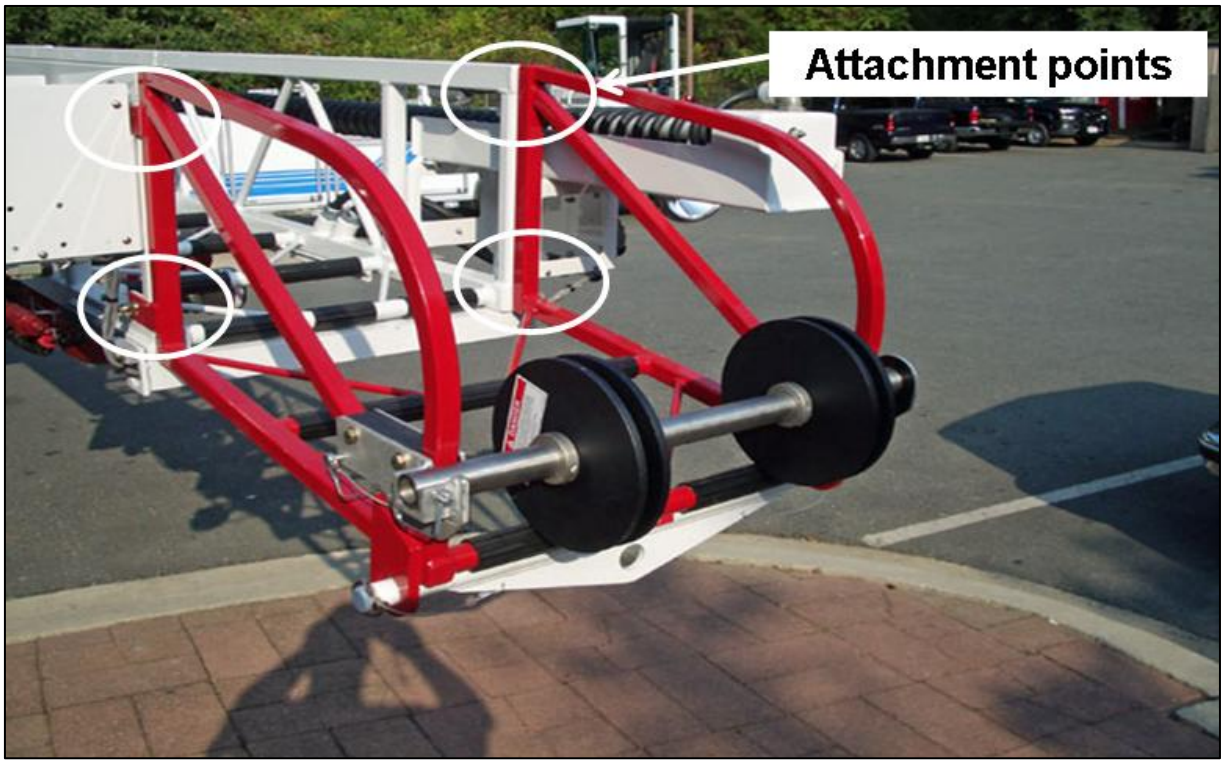
B - Install Lyfe Pulley

Install the Lyfe Pulley Brackets on the tip of the ladder, and then install the Pulley Roller.



Once the system is installed on the tip of the ladder it should look like the picture below.

It is imperative to inspect the integrity of the 4 bolts that hold the detachable tip in place. These bolts are circled in the picture.



C - Place Main and Belay Lines

The driver must now run both the main line and belay line through the pulleys after the pulley is in place and the bracket and anchor bolts pass inspection.

The lines should run from the turntable, up the ladder, through the pulleys, and to the basket. Make sure enough slack is left to tie the double long-tail bowline to the lifting bridle.

Main and Belay Lines Applied Over Pulley

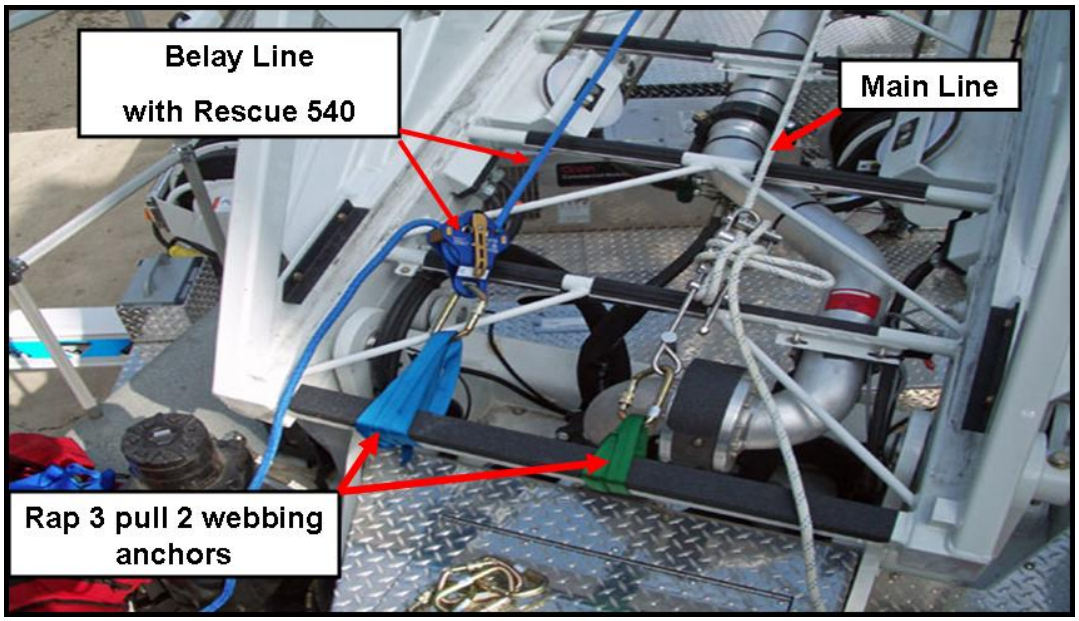
Main and Belay Lines Run Through Ladder

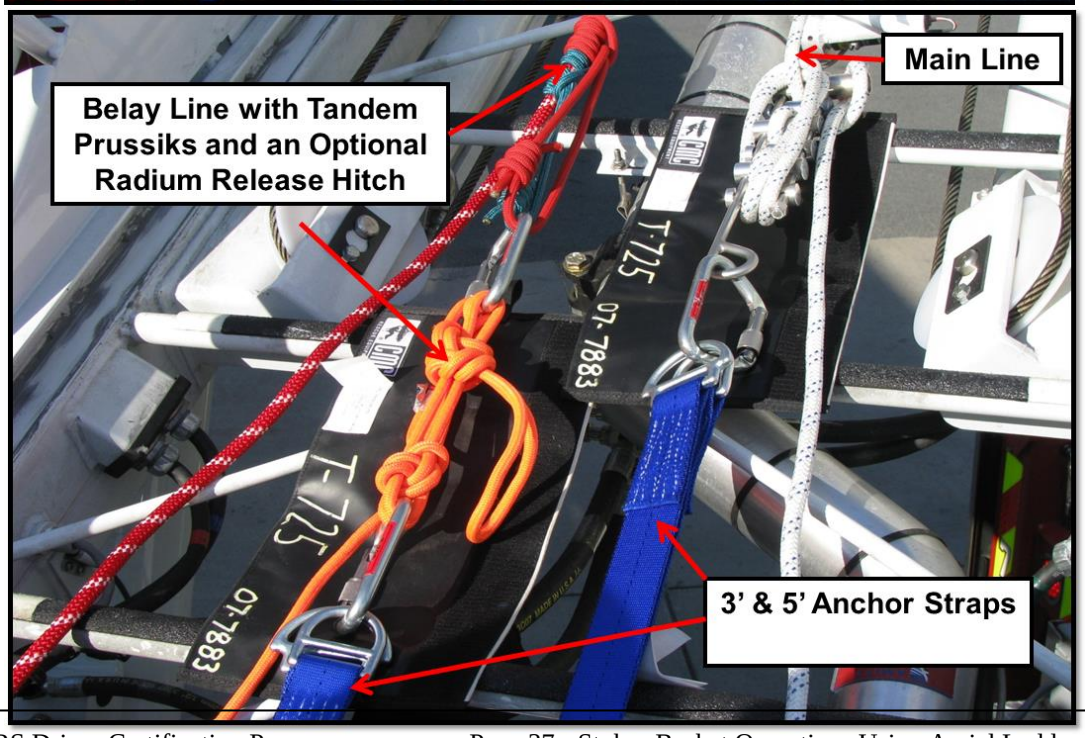
D - “Dead-End” Main and Bely to Base of Aerial

To achieve maximum capacity and rotation, the Pierce Lyfe Pulley system requires that all ropes be “dead ended” at the base of the aerial ladder.

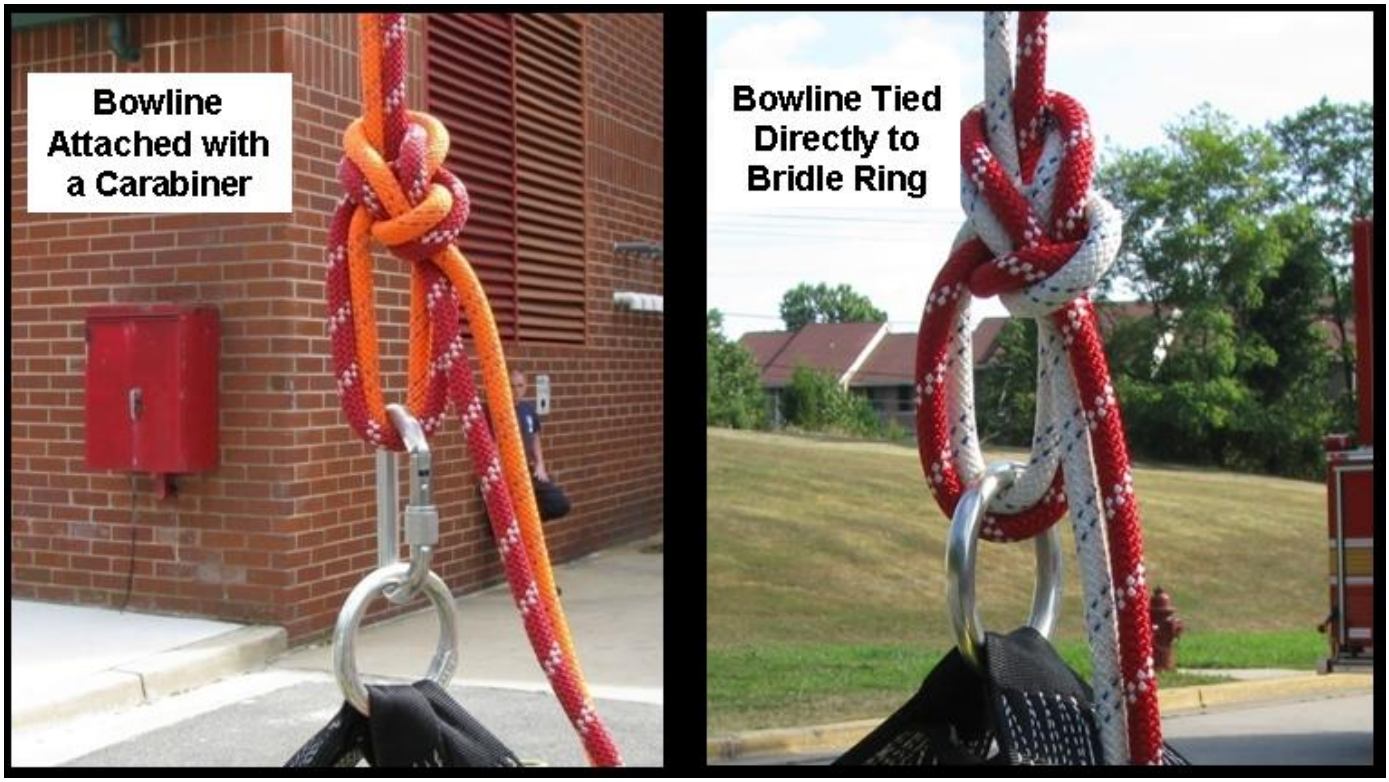
The picture below shows the use of wrap 3, pull 2 webbing anchors tied around the tubular aluminum at the base of the ladder. Anchor straps wrapped in basket configuration around the bottom rung produce an alternative acceptable anchor. ***Use edge protectors placed over ladder rungs treated with abrasive grip coverings. Ropes moving through rappel racks and belays may become damaged if they are not shielded from the abrasive rung coverings common to later model Pierce TDAs.***

The pictures below also demonstrate use of a rappel rack for the main line and a Traverse 540 Rescue Belay device. The use of tandem prusiks is also acceptable for the belay line.





E - Tie Double Long Tail Bowline and Attach Stokes Basket



F - Attach Tag Line

Attach a Tag Line tied with either figure eight follow through or bowline Note the method used to lace rope through the stokes basket allows the tag line to grip the basket and input directional control.

4 - Ensure System is Safe – "Three Sets of Eyes" Principle

Everyone must take a responsible stake in the safety of the stokes basket operation. The Aerial Tower Operator must make sure that the system has been reviewed by "Three Sets of Eyes" before any load may be maneuvered. There will likely be Officers present, but the Aerial Tower Operator must be a subject matter expert on this evolution and shall be the first guardian of safety.

5 - Operate System

The following guidelines should be observed when conducting an Aerial Tower Stokes Basket Evolution:

- One person must be in charge of the evolution
    - This person takes input from all participants
    - Participants take action only on commands issued by the evolution leader. The only exception to this instruction is for safety-related observations
    - This person is the leader and calls all commands
- Use only standard rope rescue commands
- Place personnel in the following positions
    - Aerial Operator at Control Pedestal
    - Tag Line
    - Belay Line
    - Main Line Line (as many as appropriate)
    - Safety Spotters
- The aerial device may be moved into position over the patient after system is set up
    - Make sure to allow rope to move appropriately though devices as the ladder is moved
- Once the ladder is in place as a high directional
    - Allow rope to pass through the rappel rack and belay to deliver stokes basket the final distance to the rescuers
    - Use slow and feathered inputs if a ladder must be moved with a patient connected to the stokes basket
    - Gently extend and raise the ladder (much like a crane) to elevate the stokes basket as needed
    - Carefully rotate the turntable and ladder as needed
    - Lower the patient laden stokes basket to the ground using the rappel rack, making sure to manage the belay line

Stokes Basket Lashing Evolution

Background

The purpose of this document is to adopt a standard method for lashing patients into a stokes basket. There are several different ways of lashing a stokes basket, many of which are considered safe or correct. The particular method chosen at any given time depends upon several factors, including, but not limited to, type of basket, available lashing equipment, type of operation being performed, patient condition, and rescuer knowledge/experience. By adopting a standard method of patient lashing, we can increase our operational efficiency; we reduce the number of training hours required, reduce the amount of equipment required, reduce equipment costs, increase the likelihood that personnel will remember the procedure, and eliminate differing opinions on the scene. Therefore, our goal is to adopt a single method of lashing that will meet all of our needs.

Technical Information

The goal of patient lashing is twofold. First, it prevents the patient from falling or sliding out of the basket, or moving within it. Second, it assists with spinal immobilization of the patient, whether or not he is already secured to a backboard or other device. One easy way to accomplish both of these goals is to utilize a two tiered lashing system that consists of “interior” and “exterior” lashing.

Interior lashing serves to prevent the patient from sliding within the basket, or out either end of it. This type of movement is most often caused by a tilting of the basket, which may be intentional or unintentional. An example of intentional tilting would be orienting the basket in a vertical position to negotiate a narrow opening. Unintentional tilting might occur if one end of the basket becomes caught on a stationary object and the rest of the basket continues to be lifted. This actually happened on a body recovery in Montgomery County. Due to poor lashing technique (including no interior lashing), the body slid out of the basket and fell 200’.

Exterior lashing prevents the patient from falling out of the basket. It also provides additional protection from moving within the basket, and therefore provides some spinal immobilization. As noted earlier, the basket may become tilted either partially or completely upside down. Without exterior lashing, the patient would be suspended in an awkward and uncomfortable position by the interior lashing. This creates an unsafe condition and will most likely be very painful. In addition, the patient could move or roll within the basket. Movement within the basket is not critical as long as the patient is secured to a secondary spinal immobilization device. However, in some cases, a backboard or other device is not used and some type of spinal immobilization will be required. Proper exterior lashing will prevent any patient

movement, and therefore provide some spinal immobilization, the degree of which depends upon the type of basket and the type of lashing.

In some cases, once the patient is lashed into the basket, the basket will be carried over land or in a vehicle to the EMS providers or hospital. However, many times the basket will be tied into some type of technical rope rescue system. If a rope system is used, then a belay system (safety or back-up system) must be used as well. In order to render our lashing system completely safe, we must ensure that the patient is incorporated into the belay system. ***This means the patient must be outfitted with a class three harness. If one is not available, this can be accomplished by using a class two harness and incorporating an improvised chest harness made of webbing, or by constructing a class three harness made completely of webbing.***

When using a standard "doubled long-tail bowline" yoke attachment, one of the tails would be connected to a double-wrapped prusik that and connected to the waist lashing. The tail of the doubled long tail bowline could also be tied directly to the patient's waist lashing.

Equipment

Typically there are two different types of stokes baskets in Montgomery County - an orange plastic litter or a combination metal/wire basket. Although there are differences between these two baskets, the lashing procedures are primarily the same. One important difference is the location that the lashing is secured to the basket. On the metal basket, it is secured to the metal cross members that span the basket from left to right (there are four). On the plastic basket, it is secured to an 8mm cord that encircles the basket, inside and out. This cord is divided into 20 sections inside the basket (ten on each side). *(Note: Most Ferno plastic baskets have seatbelt type straps attached to this cord. They can be used in addition to the lashing system, but not in place of it.)* Both stokes baskets have had a numbering system affixed to the inside of the basket. This system will simplify the lashing procedures as outlined in the following sections. Each structural member is labeled either "R" for right or "L for left, and with a number 1 through 10. The "R" and "L" indicators correspond to the patient's right and left.

The equipment required for lashing is minimal, and in a pinch can be found on most rescue squads and truck companies. All that is required is a minimum of five pieces of 1" tubular webbing, 12'-15' in length.

Procedure

This two tiered method works well for metal/wire baskets, plastic baskets, and combinations. It can be used for both horizontal and vertical basket orientations. As previously mentioned, it requires minimal equipment. It is very effective for accomplishing the above goals, and most importantly, it maintains a high degree of patient safety.

No matter which basket is used, the webbing should be tied to the basket in the same manner. First, wrap the webbing around the appropriate structural member/cord section two times, creating a round turn. Then, while maintaining tension on the webbing, secure it with two half hitches. This method will be used to secure all lashing. It is used in place of the split clove hitch because it allows tension to be maintained on the webbing while tying the knot and it is easier to untie.

Interior Lashing

The interior lashing system will be constructed first. The first piece of webbing will be used to construct a modified waist harness. Place the center of this piece of webbing under the patient's legs close to the groin area, with the ends laid out over the sides of the basket. Pull a bight of webbing up between the patient's legs. Place both ends of the webbing through the bight and pull them snug to their respective sides. Secure both ends with an overhand knot to prevent the webbing from cinching on the patient's legs. Finally, pull the ends toward the head of the basket on their respective sides and tie them off to the basket. For the metal basket, use ribs R4 and L4, and for the OPL use sections R6/L6 or R7/L7. Once secured, this will prevent the patient from sliding out of the foot end of the basket.

The second piece will be applied to prevent the patient from sliding out the head end of the basket. Depending on basket style, patient condition, and other factors, this can be done one of two ways. The first method is to construct an ankle hitch around both ankles and secure to the foot end of the basket. Start by finding the center of the piece of webbing. Place the center of the webbing under the patient's legs just above the ankles. Next, cross the ends over the top of the legs, so that the ends are facing out opposite sides of the basket. Using the section under the ankles, pull a bight up and over the standing part of the webbing and around the bottom of the feet. Tighten the hitch securely. Now, pass both ends between the feet and cross. Complete by tying off to ribs/rope sections R1/L1.

If injuries or other factors prohibit this, a second method may be used. This method uses a modified type of chest/shoulder harness secured toward the foot end of the basket. Start by placing the center of the webbing under the patient's back near the bottom of the shoulder blades. Next, bring the ends out under the armpits and make an "X" across the chest. Now, pull the ends around underneath the shoulders. Secure the loose ends by tying an overhand slipknot around the section of webbing under the

armpit. Last, snug everything up and tie the ends off to ribs R3/L3 or R4/L4 on the metal basket, or sections R5/L5 or R6/L6 on the OPL.

Chest Lashing, Step 1

Chest Lashing, Step 2

Chest Lashing, Step 3

Chest Lashing, Step 4

Exterior Lashing

The exterior lashing system will be constructed last. Each of the three (3) remaining pieces of webbing will be used to construct a series of X's across the patient. First, choose which side to start based on access, etc. For example, start by tying one end of the webbing to rib R2. Next, cross the legs diagonally and go around rib L3 on the opposite side. Next, cross the basket and go around rib R3 on the starting side. Finally, cross diagonally to rib L2 on the opposite side, snug up each section, and tie off securely. Repeat this procedure on ribs #3 and #4 for the waist, and ribs #4 and #5 for the chest. If the webbing crosses the patient's neck, reverse the order for the chest section, starting and ending on ribs R5/L5. For the Ferno OPL, utilize sections #3 and #4 for legs, #5 and #6 for waist, and #7 and #8 for chest. Because the patient is

crossed by nine (9) “separate” strands of webbing, just as in the Henley System, the patient is securely immobilized. In addition, the failure of one of the sections does not result in the total failure of the system, as in systems using only one (1) long piece of webbing.

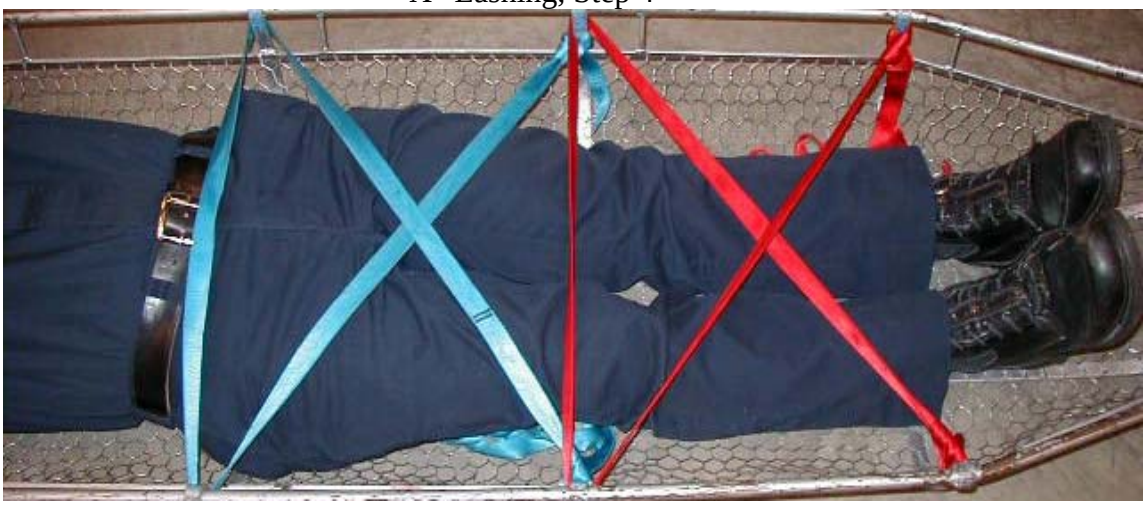
This completes the lashing system. The patient is now ready for transfer via rope rescue system, vehicle, or manpower.

“X” Lashing, Step 1

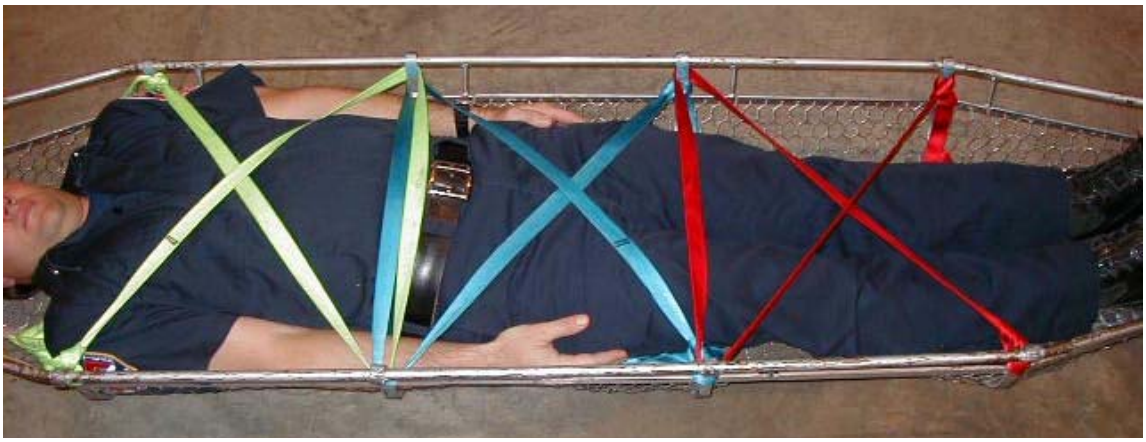
“X” Lashing, Step 2

"X" Lashing, Step 3

"X" Lashing, Step 4



"X" Lashing, Step 5



"X" Lashing, Step 6

"X" Lashing, Step 7 (and complete lashing system)