RT & RCP
CIntroduction
Mainline Systems

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Mainline Operations

When building a mainline system, consider the possibility of the need to convert from a lowering system to a raising system. There are numerous hidden factors that have caught many teams by surprise. By predicting these factors and pre-planning the Mainline life becomes much easier and safer when the time comes to convert to the raising system. Typically, lowering systems are safer than raising systems because we are cooperating with gravity. As soon as we go to a raising system, gravity becomes our prime enemy, and gravity's most powerful accomplice is friction. What we are talking about mostly is the friction coefficient or mainline contact with the surface between the mainline anchor and the rescue package. Yes, friction is working in our favor during the lowering process, and if we are going down only, then ground friction isn't that big of a deal (although we still keep a sharp eye out for rope abrasion and damage), but when it is known that a raising system is going to be employed, we must mitigate rope contact with the surface before the lowering system is put into action. This is best accomplished using a high directional.

The Theoretical Load Weight (TLW) is the weight of the load during a static state; the Practical Load Weight (PLW) is the actual weight of the load plus the effects of the friction coefficient. Unfortunately, this fact is many times overlooked. During a lowering with approximately 20 feet of rope contact with a rock surface, the PLW of a 450-pound two-person load may be only 150 pounds. During a raise with the same 20 feet of rope drag, the PLW will skyrocket to about 1100 pounds!

What does this mean to our anchor selection? With the use of a high directional, the unwanted friction is all but eliminated. Without the use of a high directional, our anchor system is very susceptible to this hidden weight and possibly prone to failure. Control of all the many aspects of friction during a rope rescue operation is a must.

Mechanical Advantage with Pulley Systems

There are three categories of mechanical advantages using pulleys: Simple, Compound, and Complex. A Simple MA consists of a pulley system that has a single haul connection between the load and the haul team. A Compound MA is a simple mechanical advantage system pulling on the haul line of another simple mechanical advantage. Multiplying the two systems will give the total advantage.

Here are five rules that can be used to determine simple and compound mechanical advantage systems.

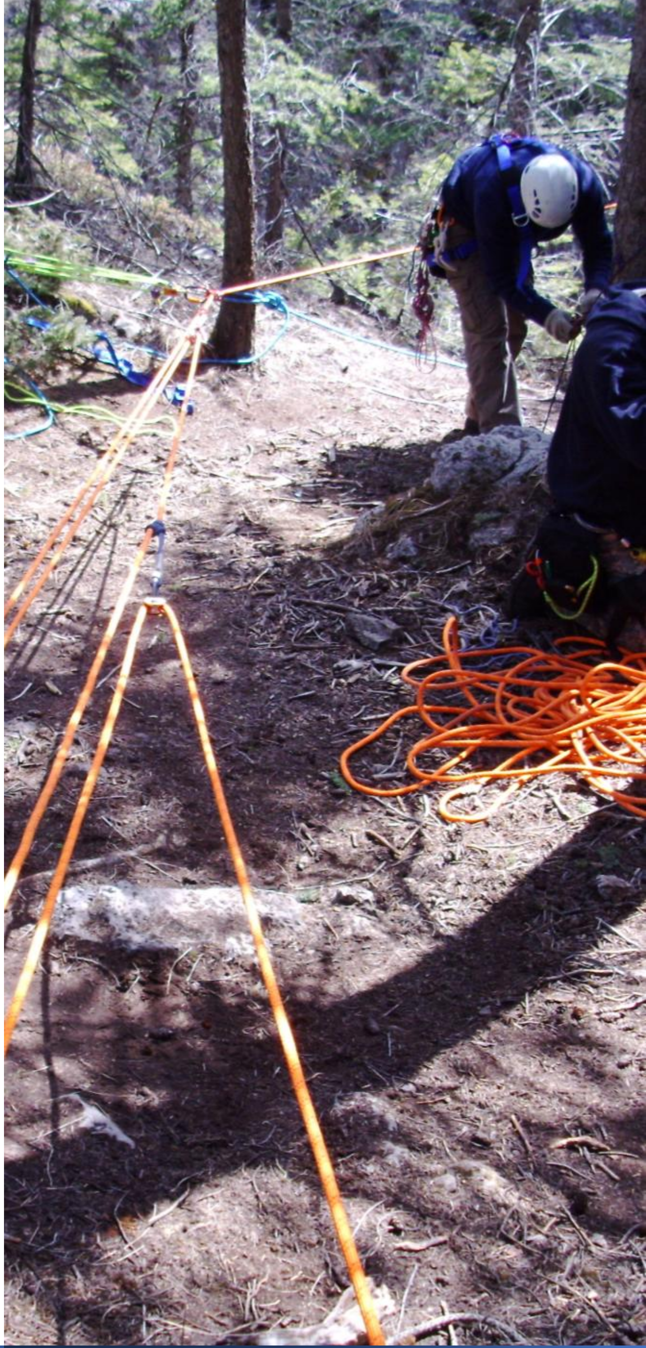
1. If the rope used in the pulley system is tied to the anchor, the theoretical mechanical advantage (TMA) will be EVEN (i.e., 2:1, 4:1. 6:1, etc.)
2. If the rope used in the pulley system is tied to the load, the theoretical mechanical advantage (TMA) will be ODD (i.e., 1:1, 3:1. 5:1, etc.)
3. The last pulley on the anchor where the rope feeds directly to the haulers is only considered a change of direction (cd). Same rule applies to ANY pulley system.
4. To determine the TMA of a simple pulley system, count the ropes between the anchor and the load. Do not count the ropes between two anchors.
5. A simple MA pulling on the haul line of another simple MA is called a compound MA system.

A Complex MA system is neither simple nor compound, and the above rules will not work in determining the system. The only way in determining the mechanical advantage of a complex MA system is by calculating the "tension units". The combinations of pulleys that can be incorporated in an MA system are infinite.

How many pulleys are needed, and what are the characteristics of a quality haul system? In general, the theoretical mechanical advantage (TMA) is the ratio between the distance the load moves and distances the haul team moves. In a 2:1 system the load will move 1' to every 2' of haul. However, this does not mean that lifting the load is twice as easy. The practical mechanical advantage (PMA), or simply put, the efficiency of the system, is the actual physical advantage the haul team ends up with. In short, based on the size of the haul team, try to build the MA system as small as possible. More pulleys create more friction, resulting in efficiency loss. Of course, when the haul team is small in numbers larger compound systems will need to be used.

Consider the hauling field - that is to say, configure the MA system in a way that maximizes that amount of ground area the haul team can operate. This will also minimize the number of re-sets of the haul system. Build the MA system clean. Avoid crossed or twisted lines, as this will add unwanted friction in the system.

When the haul prusik slips this is an indication that something is not right.   Do not add an additional prusik; correct the problem. A slipping haul prusik is like having a pressure relief device in the system; the haul prusik typically slips between 800 and 1200 pounds. Putting tandem haul prusiks in the MA is like replacing a 15-amp fuse with a 30-amp fuse; something could very well fail.

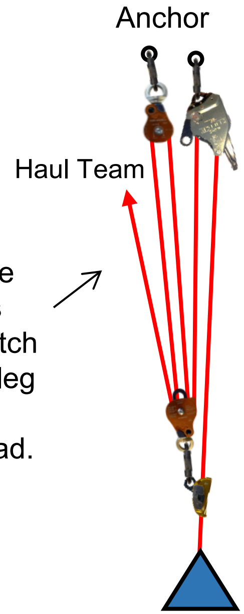


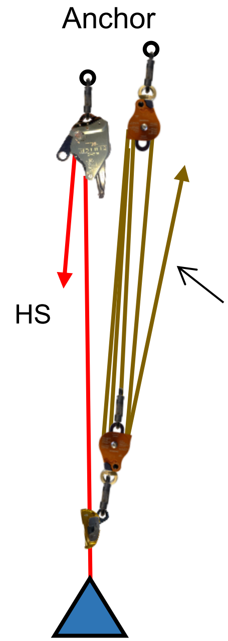
Placement of the Progress Capture Device (PCD)

Typically for the purpose of hauling and the ability to perform multiple resets of the pulley system we would rig the PCD on the leg of rope directly connected to the load as seen in examples 1 and 2. Example 1 is an integrated system (rigged with one rope) while example 2 is a ganged-on system (rigged with a different rope from the mainline).

1.

Integrated 5:1, constructed with one rope. The progress capture device (Clutch is shown) is on the leg of rope directly connected to the load.





2.

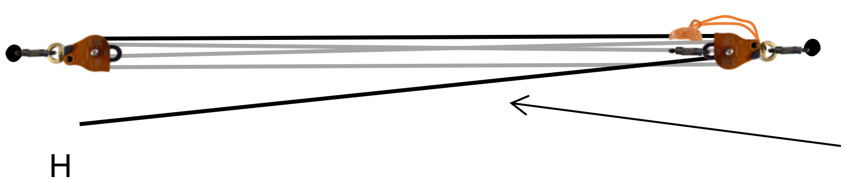
Ganged 5:1, rigged with a separate rope from the mainline.
The progress capture (Clutch) is still on the leg of rope directly connected to the load but in this example, it is the mainline (Clutch) and are not the hauling system. However, one member (Haul Slacker, HS) must be assigned to pull the slack through the Clutch during the hauling process.

3.

Mini Haul 5:1/4:1cd, is a variable direction system in that is readily used to go up and down. There are two options for the progress capture device (PCD) that is dependent on the location of the operator.

Example 3 is typically used for personal rigging, i.e. a solo pick-off or rope access when the operator is lowering/raising himself/herself. In this example the PCD is rigged on the 3rd leg in from the haul.

4.



Example 4 might be rigged on a tripod and operated from the top; this PCD is placed directly off the cd of this 4:1.

Other MA Factors

Equipment

Lack of proper equipment, namely, ropes and pulleys and the assorted adjuncts such as rope grabs, carabiners, anchor material, progress captures, haul prusiks and ratchet prusiks (for starters), is like going into battle against a powerful opponent who is vastly superior. The answer is straightforward; know the challenge at hand and make sure your team is properly equipped to get the job done.

Power

How many people do you have to haul versus the size of the pulley system? With pulley system mechanical advantages (MA), horsepower equals the number of haulers plus the size of the MA system. With a small team of one or two haulers, a 9:1 may be in order. However, with the 9:1 the load will move very slowly, only about 1 foot for every 9 feet of haul. A 9:1 with a very large haul team could be so powerful as to break something if the load were to hang up.

On the flip side of this coin, a 3:1 is going to be more effective with a large haul team of six as the load will move much faster than the 9:1 and the large number of haulers will more than compensate for the smaller system.

What about a 1:1 with a super team of haulers? This is a risky proposition in that the load could move so fast that it creates a trip hazard or a greater hang up potential for the rescue package. The 3:1 seems to be a good speed control for the larger haul team.

Other MA Factors
Continued…

Anchorage

When creating a hauling system, magnification of the hit on the anchor system may be substantial. An anchor that was chosen and rigged strictly for a lowering system may not be capable of absorbing the physical increase of a haul system. This is highly predictable. When we know we will be converting a lowering system to a raising system, we must pre-engineer our anchor to meet our time of greatest stress to the system. This time of greatest stress will always be during the initial onset of the hauling process.

Workspace

How much space have you been afforded to complete the job? We typically think of two issues with workspace for hauling; 1) the amount of space the haul team has to move, walk, and/or work; 2) the amount of space the pulley system has to contract before a re-set is needed. Obviously, more space is a good thing, however, sometimes the hand we're dealt is not always what we were hoping for. Maybe you're working on the confines of a structural tower, or in an enclosed space and your ideal space requirements are simply not available. Consider the use of change of direction (cd) pulleys to maximize your operating space. Small spaces usually equate to small haul teams. Can the haul line be re-directed to another location that could accommodate a larger team, i.e. on the ground of the tower, or outside of the enclosed space?