



RCP and RQP  
Rope Technician  
Mainline Considerations

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**KES**

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"THE **KEY** TO YOUR **ENVIRONMENTAL SOLUTIONS**"

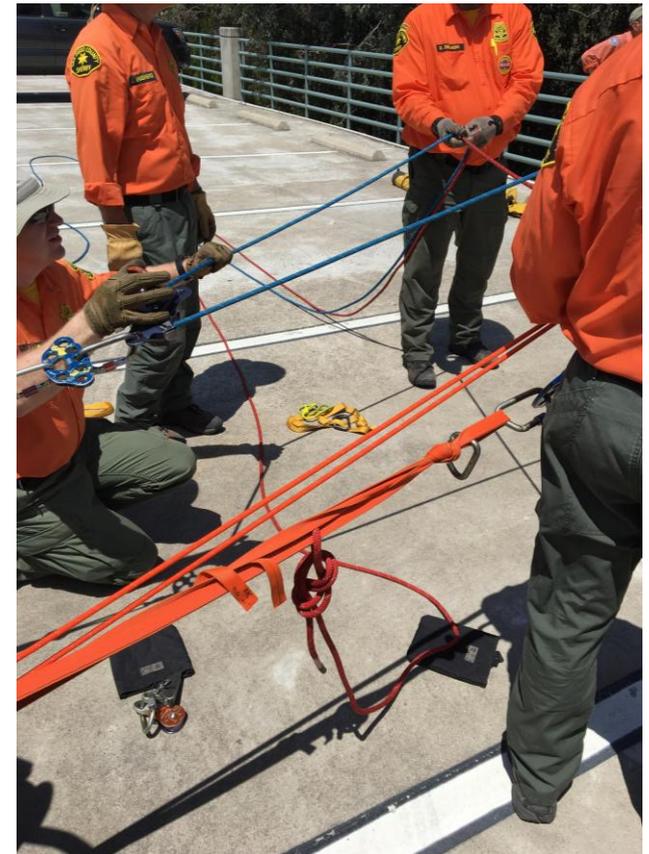
# Technician Level Mainline Considerations



The mainline is the primary rope system used by the team to lower, and/or raise the load. In comparison, the belay line is the secondary backup rope system. The belay system is synonymous with fall protection. Although some roping activity requires only a single rope system, the vast majority of time most rescue and rope access teams, as well as all regulatory bodies require a redundant primary and secondary rope systems. The mainline and belay line work in absolute harmony with each other. As such, it is impossible to discuss one without talking about the other.

# Proactive Rigging for Future Movement of the Load

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.



# Mainline Anchor Factors

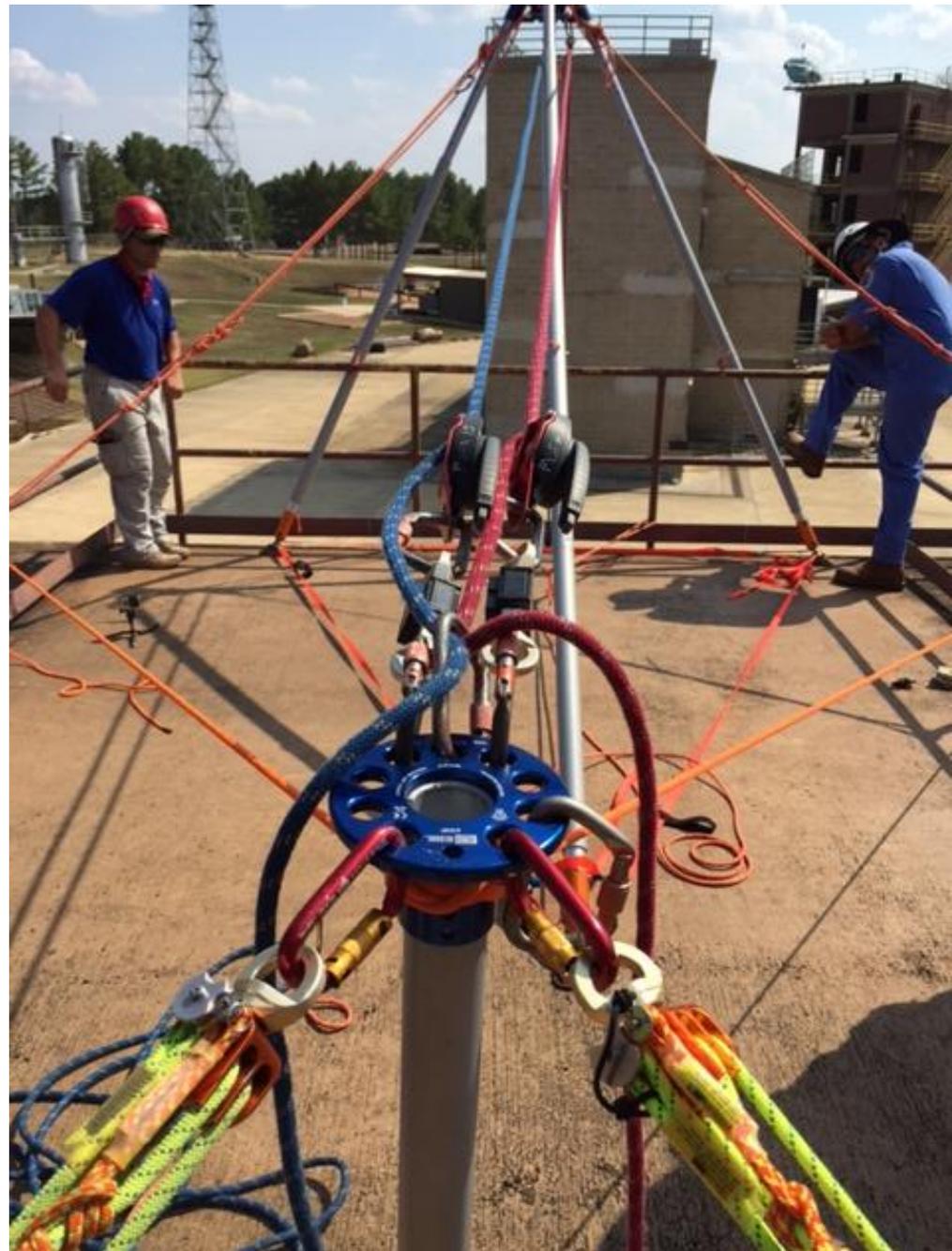
The Theoretical Load Weight (TLW) is the weight of the load during a static state; the Practical Load Weight (PLW) is the actual weight of the load plus the effects of the friction coefficient. Unfortunately, this fact is many times overlooked. During a lowering with approximately 20 feet of rope contact 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.



# TTRS – Twin Tensioned Rope System

*Two Tensioned Rope System, Twin Tensioned Rope System, Mirrored Rope System...* the concept of two ropes sharing or supporting some percentage of the load has evolved into different names and subtle differences. Nonetheless, the commonality of these systems is that there must be a highly controlled sharing of the load between the two ropes, (and typically two operators). In mitigating circumstances, a single operator may be capable of controlling two descent devices such as the Petzl I'Ds in this photo. However, this technically removes the redundancy of a two-rope system since only one person is solely responsible for the mainline and the belay line. As we know all too well, human action is not 'Bombproof'!



# TTRS continued...

## **Pros:**

### ***Mitigating Elongation:***

A two tensioned rope system has a lot of merit when dealing with extreme lengths. Or, arguably more often; short lengths combined with questionable clearance between the load and some obstacle below. The big positive factor here is the mitigation of rope elongation.

### ***Mitigating Shock force:***

By virtue of some amount of weight on both lines, if and when one line fails, the remaining line is less likely to receive a substantial shock load.

### ***Hauling:***

Two tension ropes systems works extremely well when hauling...especially during steep angle operations. Each rope is rigged with an MA. The MAs can be smaller and more efficient. For steep angle operations this will lessen the amount of rope contact with the ground.

# TTRS continued...

## **Cons:**

### ***Two Operators:***

Most often two tensioned rope systems are employing two separate operators. These two individuals cannot and will not ever operate their respective systems at the same rate of speed and balance. This is most noticeable during the lowering phase, and is radically magnified the longer the distance. As a result, most of the time one or the other of these two ropes experience multiple moments of slack.

This Russian roulette with slack tends to bounce back and forth between the two operators as they attempt to find the happy balance in their life of tension management. During the perfect storm; one operator is feeding a bit more rope (tension) back over to the other operator and the rope under tension fails. This potentially dumps 100% of the load over to the operator who is in a moment of slack. Remember, a moment is equal to a lifetime in the world of gravity. No human reaction is fast enough, and at the least, the load will drop several feet before the catch can happen.

### ***Counter Intuitive Devices:***

Some devices are counter intuitive during the act of catching a load. Devices like the MPD require the operator to let go of the T handle to fully complete the belay process. When the load is dropping the natural reaction is to grab...not let go. Again, a moment of hesitation equals several feet of freefall.

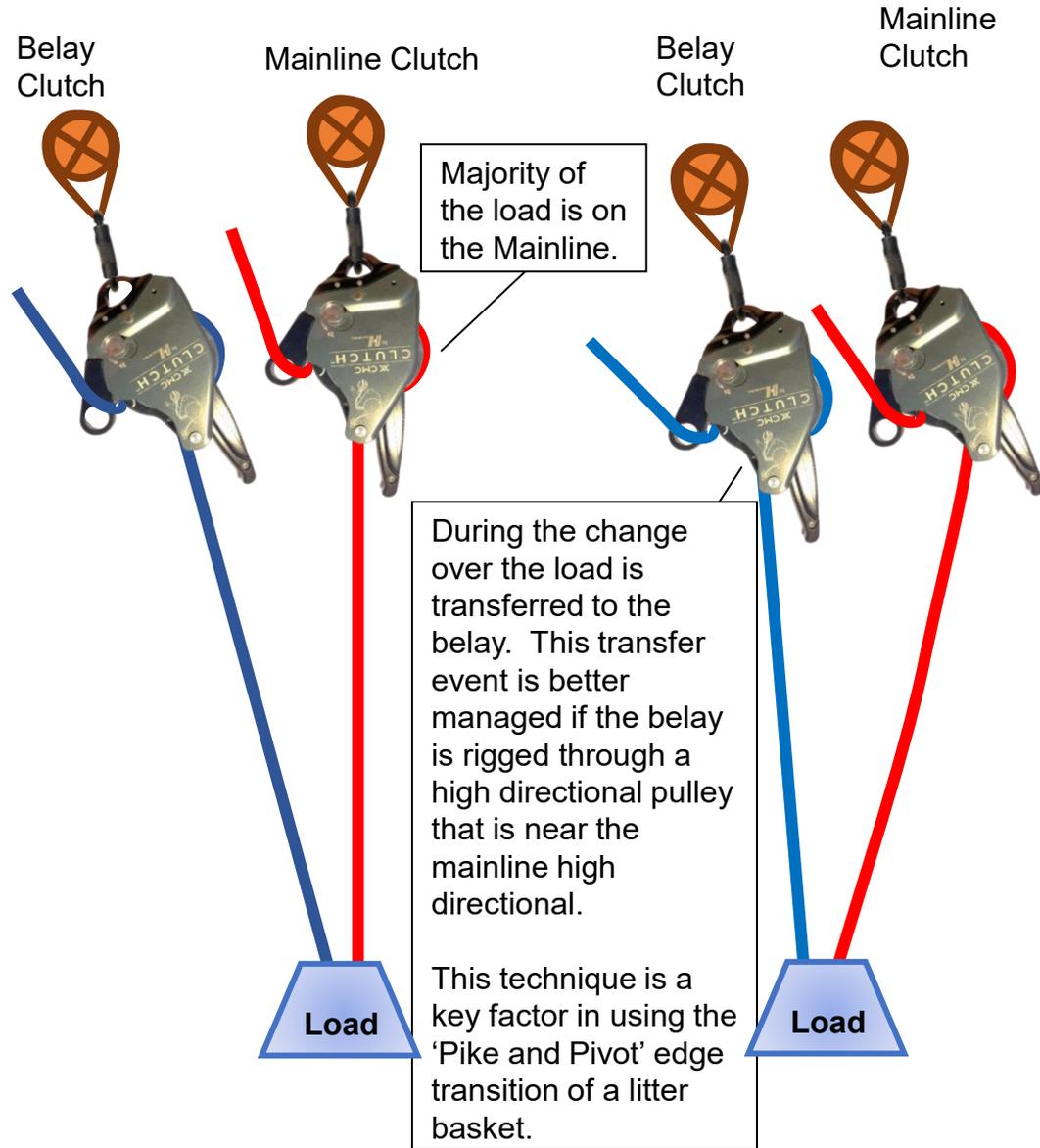
Other devices such as the Petzl I'D is more intuitive to the human tendency to hold on. Grab hard on the ID handle and the device goes into the panic mode and locks the load in place.

### ***Fluctuation of Mirrored Resultants:***

Usually overlooked; what is the effects of the Russian roulette tension game of two operators on the directional pulleys of each system? Are both ropes running through high directional pulleys at the edge? How stable is the high directional anchor system at the edge? Is the high directional anchor dependent on the stability of the resultant force of the HD pulleys? All of these questions come into play all the time. However, it becomes even more critical when attempting a two tension rope system.

# The Descent Device (Petzl I'D or Clutch): Using the Belay Line for Loaded Change Overs

Using the belay Clutch, (or I'D) to facilitate a loaded change over for the purpose of unloading the mainline Clutch from the system is completely acceptable providing the mainline and belay line edge resultant forces are near each other. Transferring the weight of the load between the two different lines will influence the loading and unloading of any directional pulley in front of these devices, i.e., high directional pulleys attached to a portable anchor at the edge.



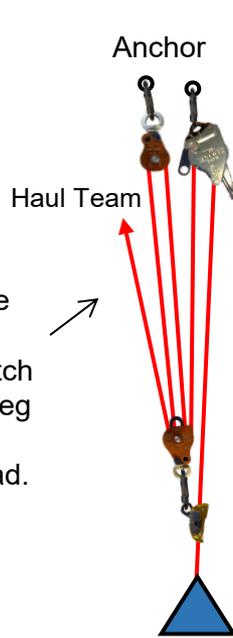


# Pulley Systems

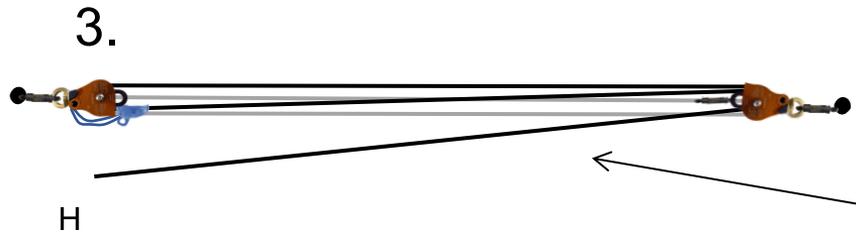
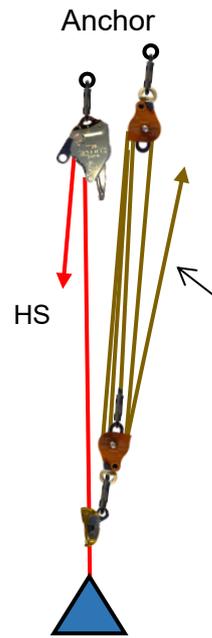
There are three categories of mechanical advantages using pulleys: Simple, Compound, and Complex. A Simple MA consists of a pulley system that has a single haul connection between the load and the haul team. A Compound MA is a simple mechanical advantage system pulling on the haul line of another simple mechanical advantage. Multiplying the two systems will give the total advantage. The Theoretical Mechanical Advantage (TMA) is the advantage the haul team has not taking into account the efficiency loss due to friction within the system. The Practical Mechanical Advantage (PMA) is the real advantage the haul team has which includes taking into account the efficiency loss due to friction in the system.



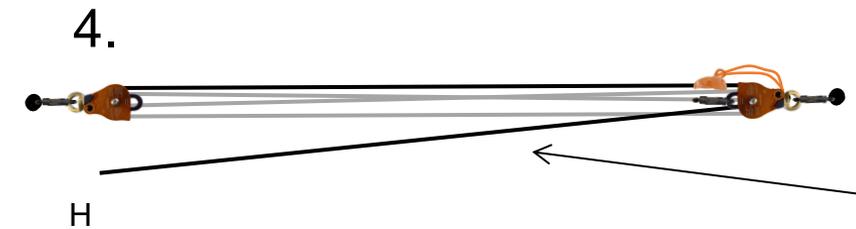
1. **Integrated 5:1**, constructed with one rope. The progress capture device (Clutch) is on the leg of rope directly connected to the load.



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.



**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 3<sup>rd</sup> leg in from the haul.

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*

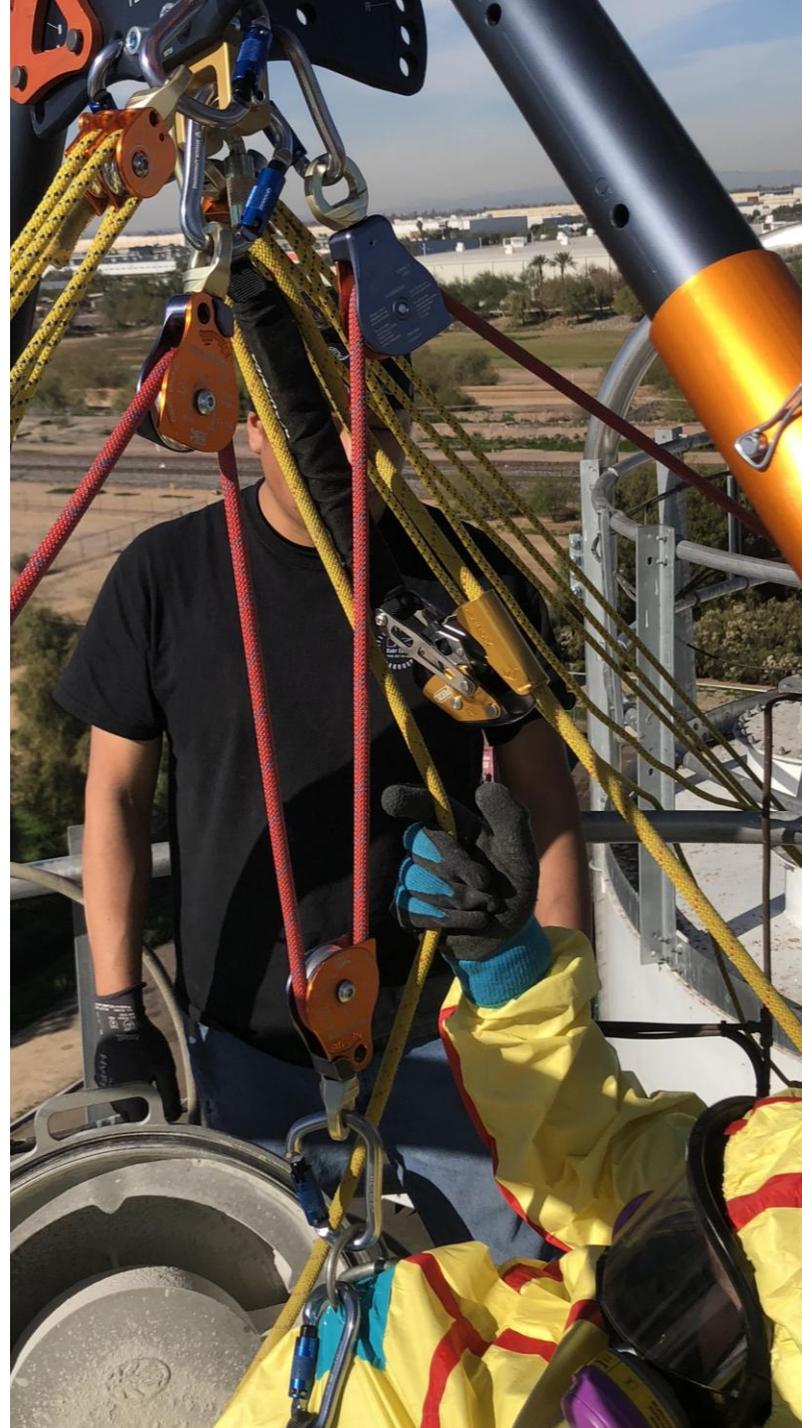
Lack of proper equipment, namely, ropes and pulleys and the assorted adjuncts such as rope grabs, carabiners, anchor material, progress captures, haul prusiks and ratchet prusiks (for starters), is like going into battle against a powerful opponent who is vastly superior. The answer is straightforward; 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?