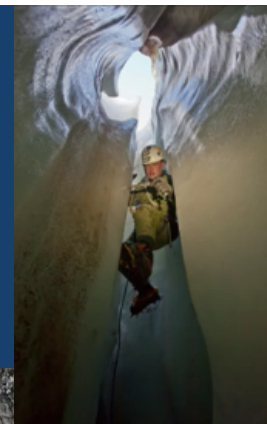




Small Party Assisted Rescue (SPAR) Cave Rescue applications for Alpine Rescue Situations

Minimal gear solutions for high urgency alpine incidents



ICAR 2019 Zakopane



Eddy Cartaya



SPAR: Small Party Assisted Rescue

A philosophy and set of techniques designed for a small team to resolve an unplanned technical rescue problem quickly, without any outside intervention or special rescue gear, using only the gear on their harness and the one rope available to them.



Originally conceived and popularized for cave expeditions, where the likelihood of a rescue is minimal, or the response would take too long to save the patient.

This presentation will cover 3 small party techniques and concepts that can be applied to crevasse rescue, pit rescue, and cliff rescue venues.

Relevancy to Mountain Rescue

SPAR techniques were designed to perform vertical rescues of 1 or 2 persons with:

- very few people
- very light weight gear and thinner ropes
- much less gear
- techniques putting less load forces on potentially dubious, unplanned anchors
- faster set up time... faster rescue time
- less overall team effort to haul
- & Maximizing **safety factors** in lieu of spending gear and time for intensive **redundancy**.

So why wouldn't we want to apply these methods for full call out mountain rescue operations?

Cave rescue systems often discounted by surface rescue due to lack of understanding or recognition of applicability.

SRT and cave type systems used daily by arborist (chainsaws, falling timber), tactical / military, mountain guides, canyoning rescue, many mountain rescue units, etc.

Common Misconceptions that SPAR techniques are:

- Extreme
- Dangerous
- Lack enough safety or redundancy
- Too hard to understand
- Require too much single rope technique (SRT) skill
- “That’s just for cavers!”

Differences:

- Mountain rescue most often performs lowers and rappels. (safe area is **DOWN** to bottom of mountain)
- Cave rescue most often involves hauls and climbing (safe area is **UP** out of cave)
- Cave anchors usually more dubious. Edges usually rock.
- Mountain anchors on snow or ice. Edge typically snow or ice (easier on rope)

Same:

Gravity is the same

Physics are the same

Haul system basic concepts the same

Consequences of failure are the same

Golden hour for patient is the same

Characteristics of SPAR Techniques

- Typically uses one rope – the rope in play, or the rope with the small team
- Only the hardware carried on the responder's harness and SRT kit is available
- Can be accomplished with 2 or 3 rescuers
- *Internally engineered* redundancy and safety mitigations
- Sharing load on multiple strands of rope
- Minimizing or completely avoiding edge friction
- Reliant on good SINGLE ROPE TECHNIQUE skills, counterweight, closed loop, and over the edge rigging

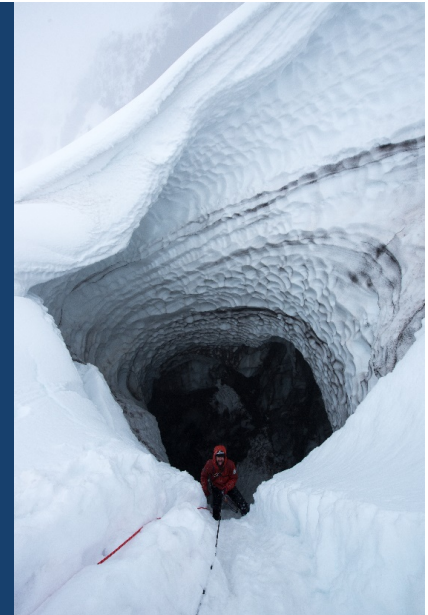
Who can use these techniques?

- Alpine hasty rescue teams
- Ready teams patrolling a mountain
- Initial response team delivered onsite via helicopter to high urgency mission
- Search team that finds subject in a compromising or critical condition (crevasse fall, etc.)

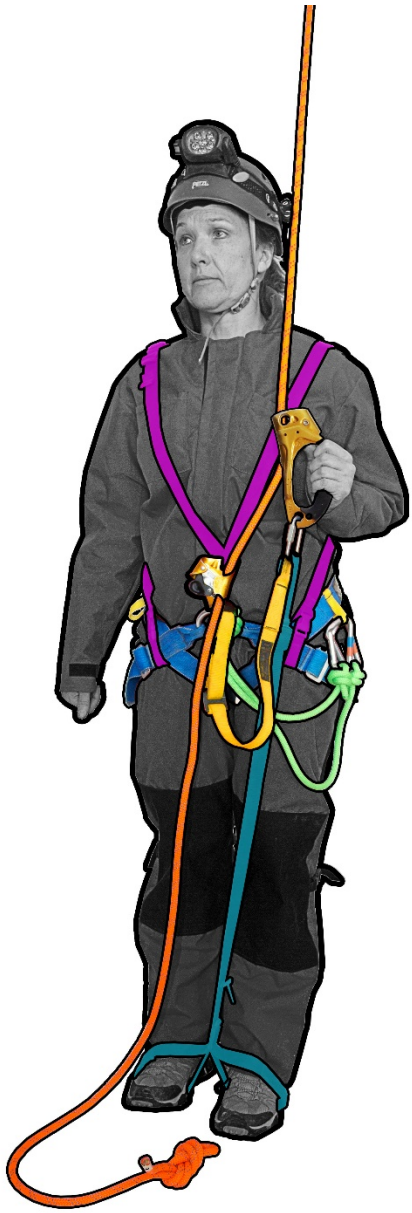


Use static rope

- Many mountain rescuers respond only with dynamic.
- Haul systems, counterweight systems, and single rope technique suffer with dynamic lines.



- If doing vertical problems and rescue systems in deep crevasses or glacier caves, you need GOOD SRT devices.
- Avoid Prusiks. Even ONE small mechanical ascender makes a BIG difference. Petzl Croll or Basic!



What's the environment?

Crevasse & Glacial Moulin or Caves

- Often bridged and concealed
- Often tight near the bottom
- Cold traps
- Wet



Crevasse and Fumarole / Glacier Cave Rescue / Extractions

Four patient extrication possibilities:

- A: Roped Patient that can assist and follow commands (**typical glacier travel punch through**)
- B: Roped Patient injured or unresponsive (**serious glacier travel fall**)
- C: Unroped patient that can assist and follow commands (**classic AT skier punch through**)
- D: Unroped patient injured or unresponsive (**typical fumarole cave fall**)

Unroped unresponsive patient the most committing and dangerous rescue... requires entry to connect to patient!

ALL are HIGH URGENCY extractions!

A responsive patient that can follow commands and assist with rigging is VALUABLE!

Do not let a cooperative patient become unresponsive due to unnecessary delay.

SPAR does not replace full on mountain rescue rigging and team responses!

If you have the team, time, and equipment, USE IT!

But if you **don't** have this...

...you can **STILL** do this!

...and still be just as safe!



When Lightweight / SPAR / minimal gear rescue systems are Recommended

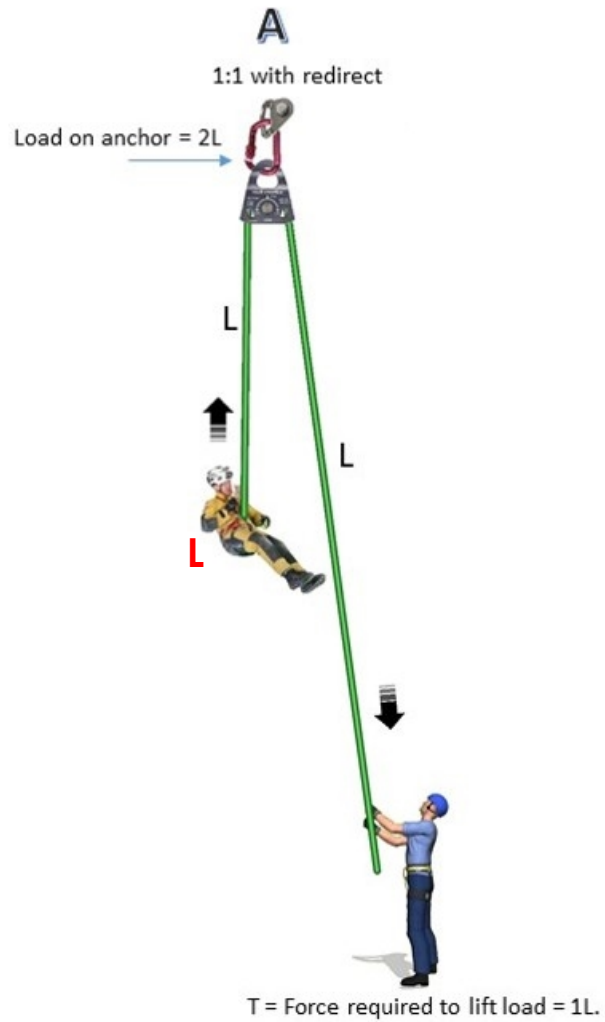
- High urgency rescue... waiting for a full call out not in patient interest.
- Biggest threat is ENVIRONMENT. Best treatment is REMOVAL.
- Lingering in area putting responders at higher risk to environmental hazards (rock fall, avalanche, hypothermia, etc.)
- Minimal manpower present – but rescuers are skilled!
- Minimal gear present

Workhorse Techniques for Small Party, minimal gear, minimal manpower missions:

1. Closed Loop / diminishing loop (**sharing load on multiple strands**)
2. Counterweight Systems (CW) (**using gravity & your own weight**)
3. Traveling hauls (**under the edge mechanical advantage**)

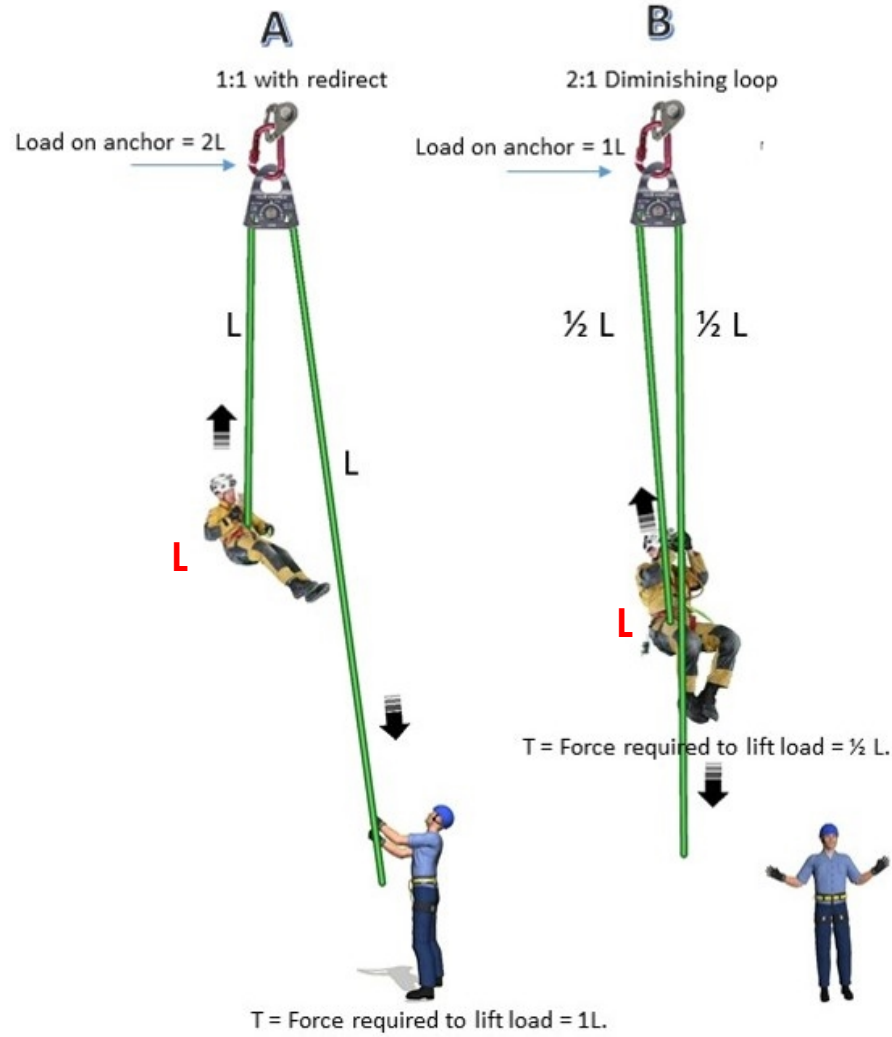
Concept 1: Closed Loop System Advantage

Load (L) = 200 pounds



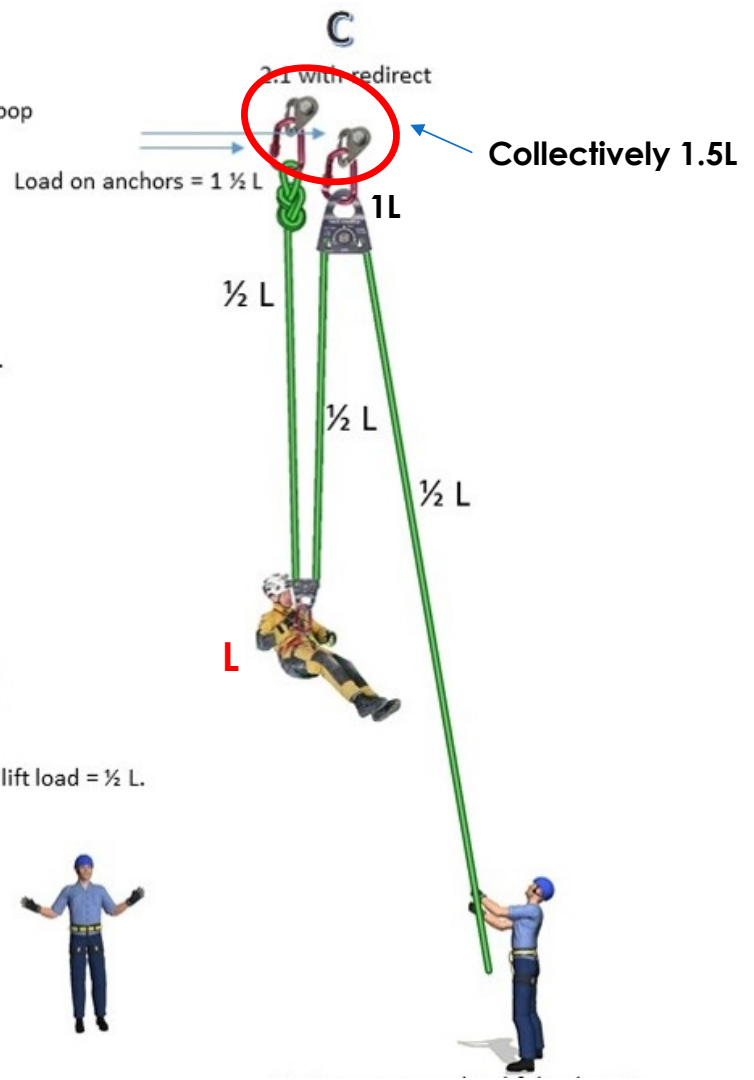
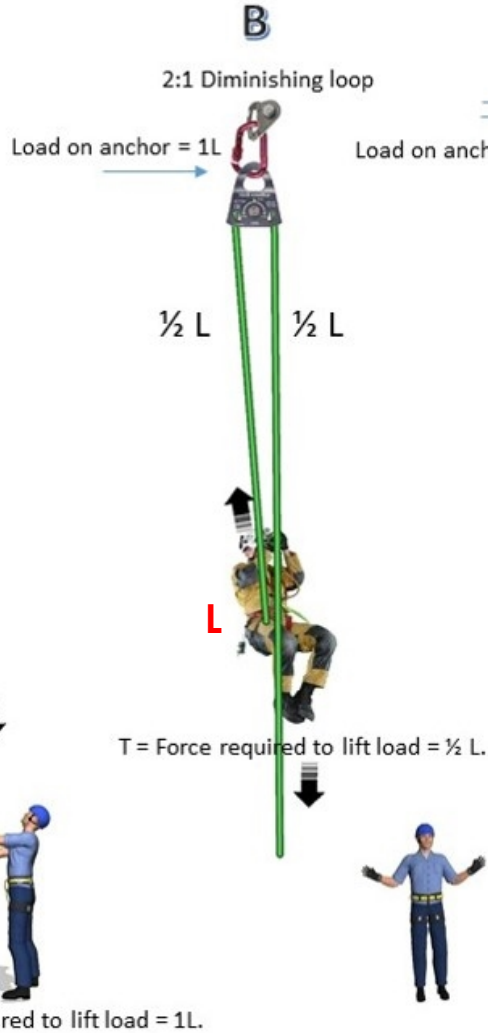
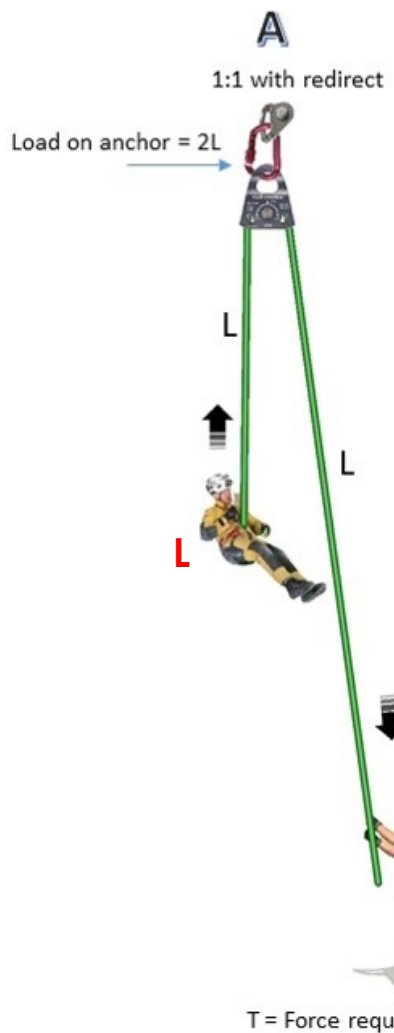
Closed Loop System Advantage

Load (L) = 200 pounds



Closed Loop System Advantage

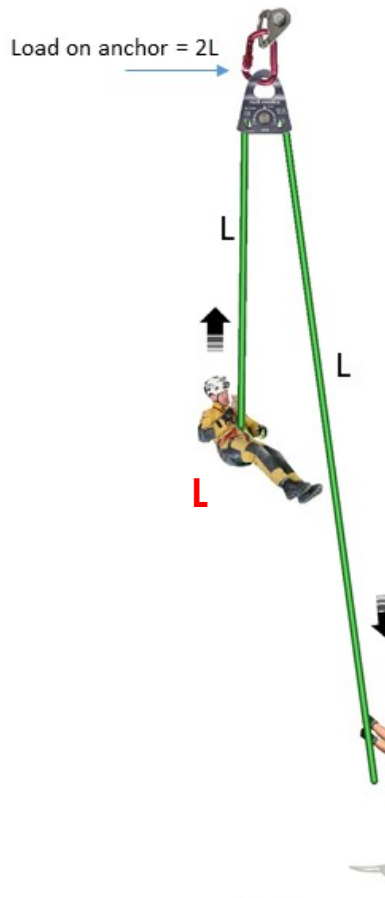
Load (L) = 200 pounds



Load (L) = 200 pounds

Closed Loop System Advantage

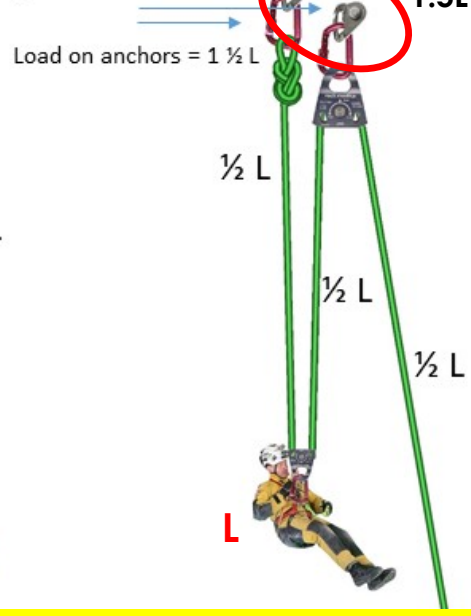
A
1:1 with redirect



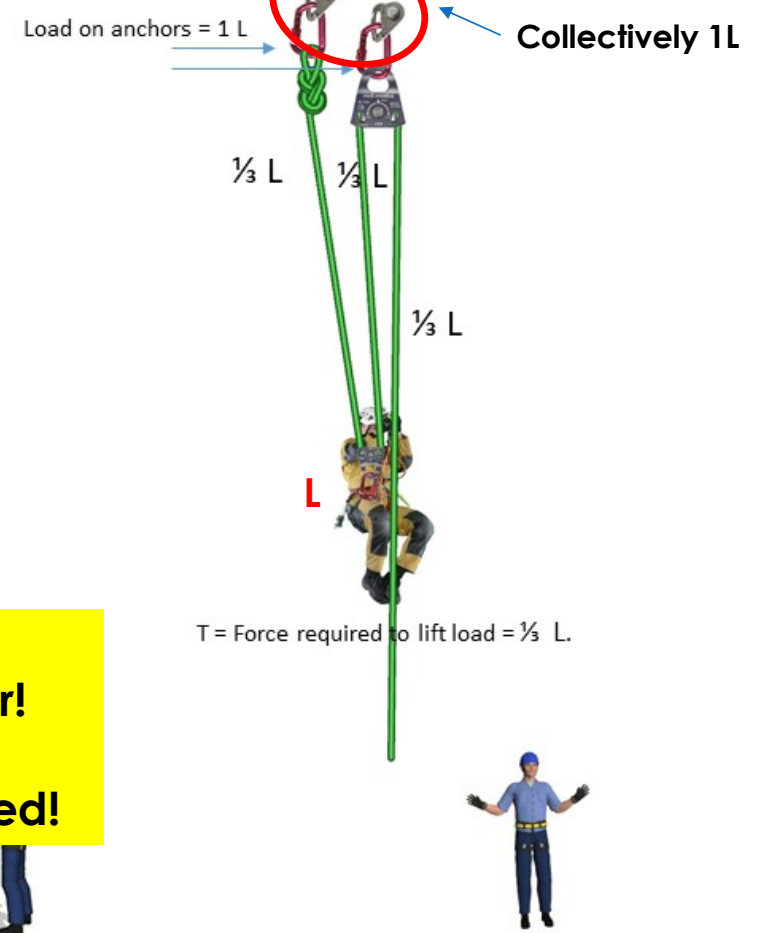
B
2:1 Diminishing loop



C
2:1 with redirect



D
3:1 Diminishing loop



Closing the loop =

- Less force on anchor!
- Less effort needed!
- Fewer people needed!

Loop formed by patient and rescuer on opposite sides of CW line connected by tether.

Pros:

- Good for patient care and management.

Cons:

- Within kicking range with crampons
- Harder to haul through confined space like narrow crevasse



No Progress capture at pulley.

RESCUER is the progress capture!

NOTE: Need 2X the pitch length!

Top anchor must be rescue strength...2KN or more!



Diminishing loop formed entirely with rescuer, similar to arborist 2 line technique.

Pros:

- Patient out of kicking range.
- Can piggy back system onto another rope.

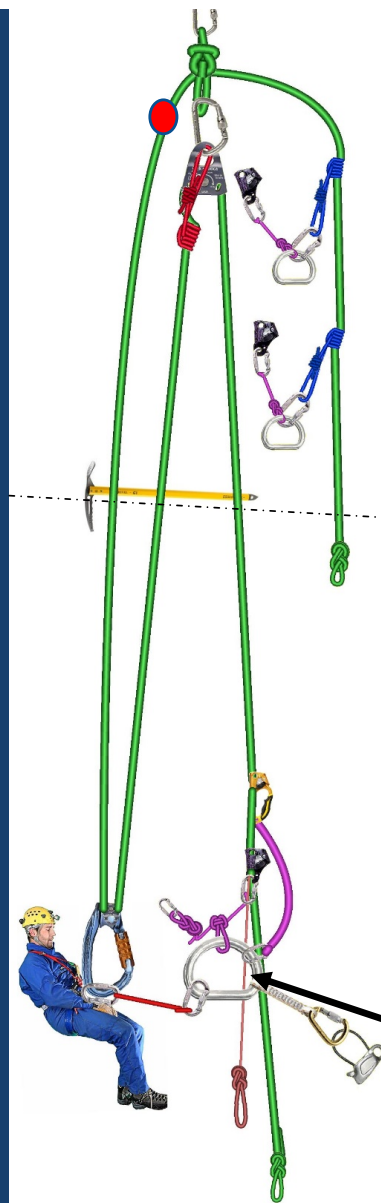
Cons:

- No access to patient once you start climbing.
- More committing as patient hangs from you.

Both formats can be rigged with the 3 to 1 diminishing loop too.

Pulley / roller carabiner clips to patient and rescuer climbs opposite line. Both connected via tether.

If Rappelling this way, your device will only feel 1/3 the collective load!



3:1 Diminishing loop



$T = \text{Force required to lift load} = \frac{1}{3} L.$

Rescuer master point



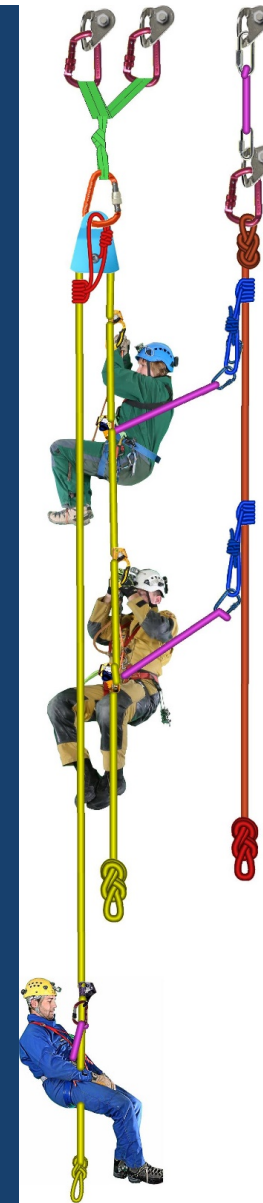
Counterweight Systems

Rappelling Counterweight System

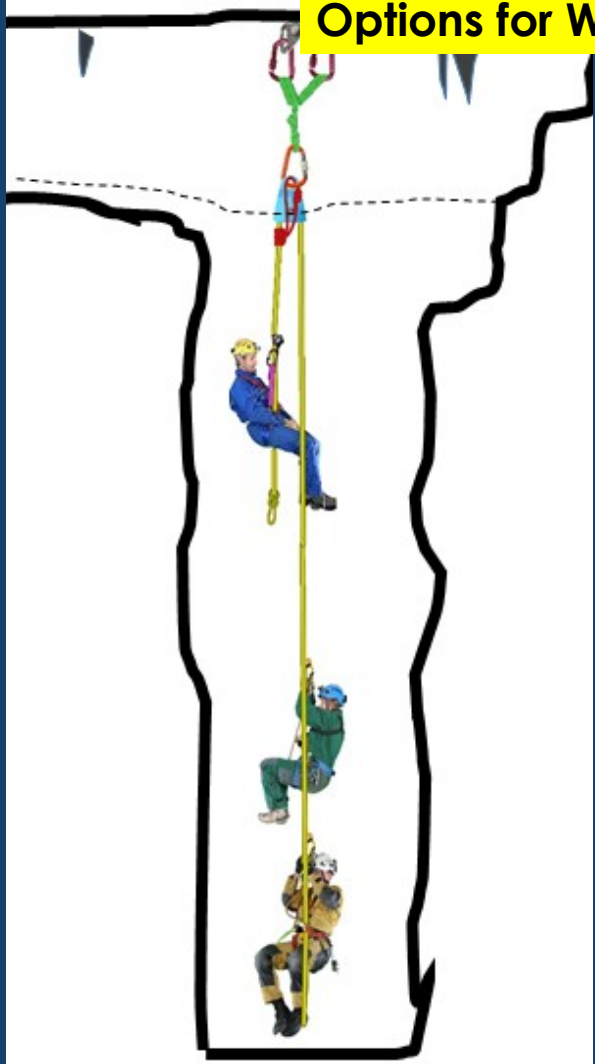
- Basic system involves 2 rescuer counterweights rappelling down as patient travels up.

Climbing Counterweight System

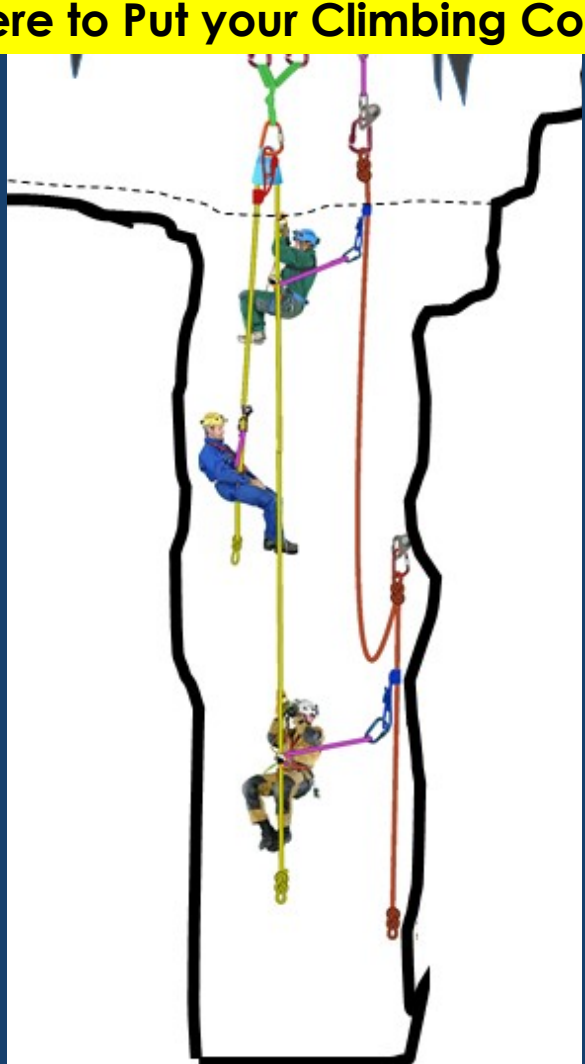
- Basic system involves 2 rescuer counterweights climbing in place using a separate position line.



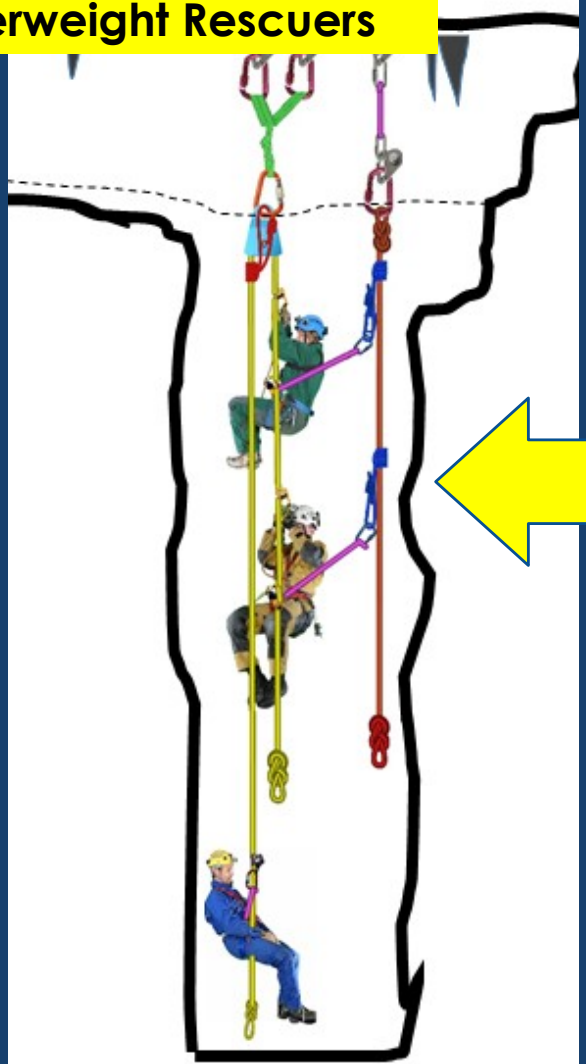
Options for Where to Put your Climbing Counterweight Rescuers



Both counterweights at bottom



Counterweights spread apart



Both counterweights at top!

Can you use this for mountain rescue?

3 Questions to ask yourself when faced with a high urgency extraction rescue

1. Does it Work?
2. Is it efficient / quick to save an urgent patient
3. Is it safe ENOUGH? **No system is 100% risk free!**

Does it Work?

Doesn't have to be pretty!

Is it EFFICIENT / fast to set up?

Speed can be a significant risk reduction factor!

The ENEMY of GOOD is BETTER!



Is it Safe Enough?

Debate about using Small Party Rescue techniques for a mountain rescue!

Can your team balance speed and safety for a high urgency rescue?

- What is the skill of your team? (**small & skilled!**)
- Do they have SRT climbing skills / proper gear?
- Are they trained in SPAR techniques?
- What gear do they have NOW? What are it's load limits?
- Do they understand the forces on their gear and anchors in the configurations they set up?
- Can they engineer safety and sufficient redundancy to mitigate PROBABLE modes of failure using the gear they carry?



Based on your on-scene specific risk assessment, what are you protecting against?

What is the worst case scenario that could REASONABLY happen?

- Anchor failure? (add an additional node)
- Getting stuck / jammed in a slot at the lip?
(rig a new line or drop loop versus using the patient's fall rope)
- Shock load if lip collapses? (Probe and groom lip... use closed loop rigging)
- Hit by rocks and snow in the entrance area? Less time involved equals less exposure!
(Rig rapid solutions with minimal gear to minimize time in hot zone)
- Responder going into the hole loses control (human error)? (Rig autolocks into systems)

“Possible” but not historically *probable* modes of failure

- A. Rope “snaps” and breaks. Ropes virtually never “Break”... they can get CUT.
What on scene can CUT the rope?
- B. Meteor strikes and kills - something immobilizes entire surface team
- C. Litter vaporizes
- D. Tree vaporizes



“Not so much.”

What exactly is Rigging Redundancy?

Is it 2 of everything? It CAN be!

OR is redundancy “internally engineered” – redundant by design?

More is not always better...and in some situations creates more friction and complexity, and can reduce the safety of the system.

(two ropes twisting when free hanging, more friction, etc.)

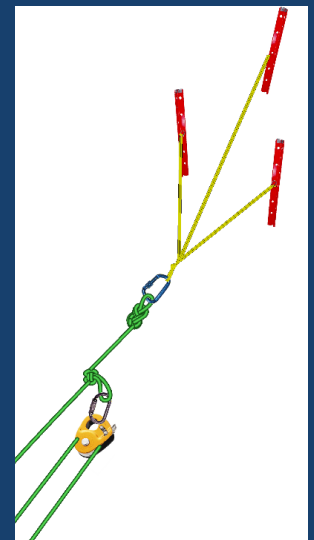
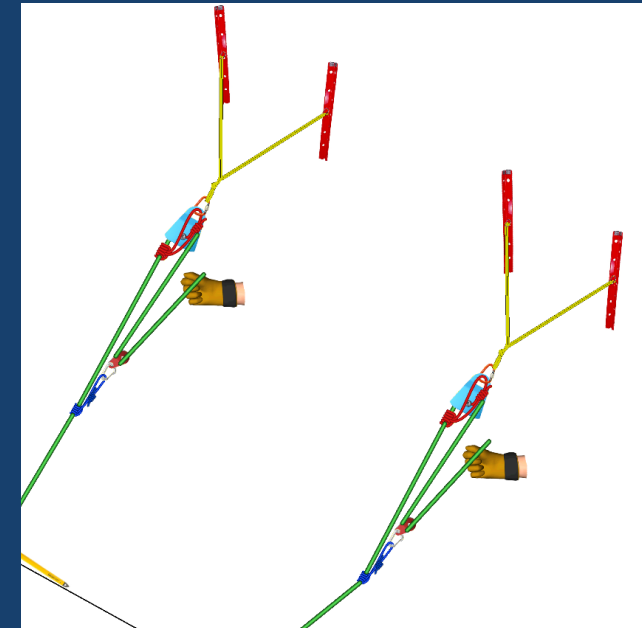
Think situational based redundancy versus dogmatic redundancy!

Safety factor v. redundancy

Conduct a risk assessment... based on REAL RISK probability, not IMAGINED **PROBABILITY VERSUS CONSEQUENCES... endless number of “what if’s?”**

Rig redundancy **as needed** for what is most likely to actually happen

CONSCIOUS decision based on training, experience, and risk assessment

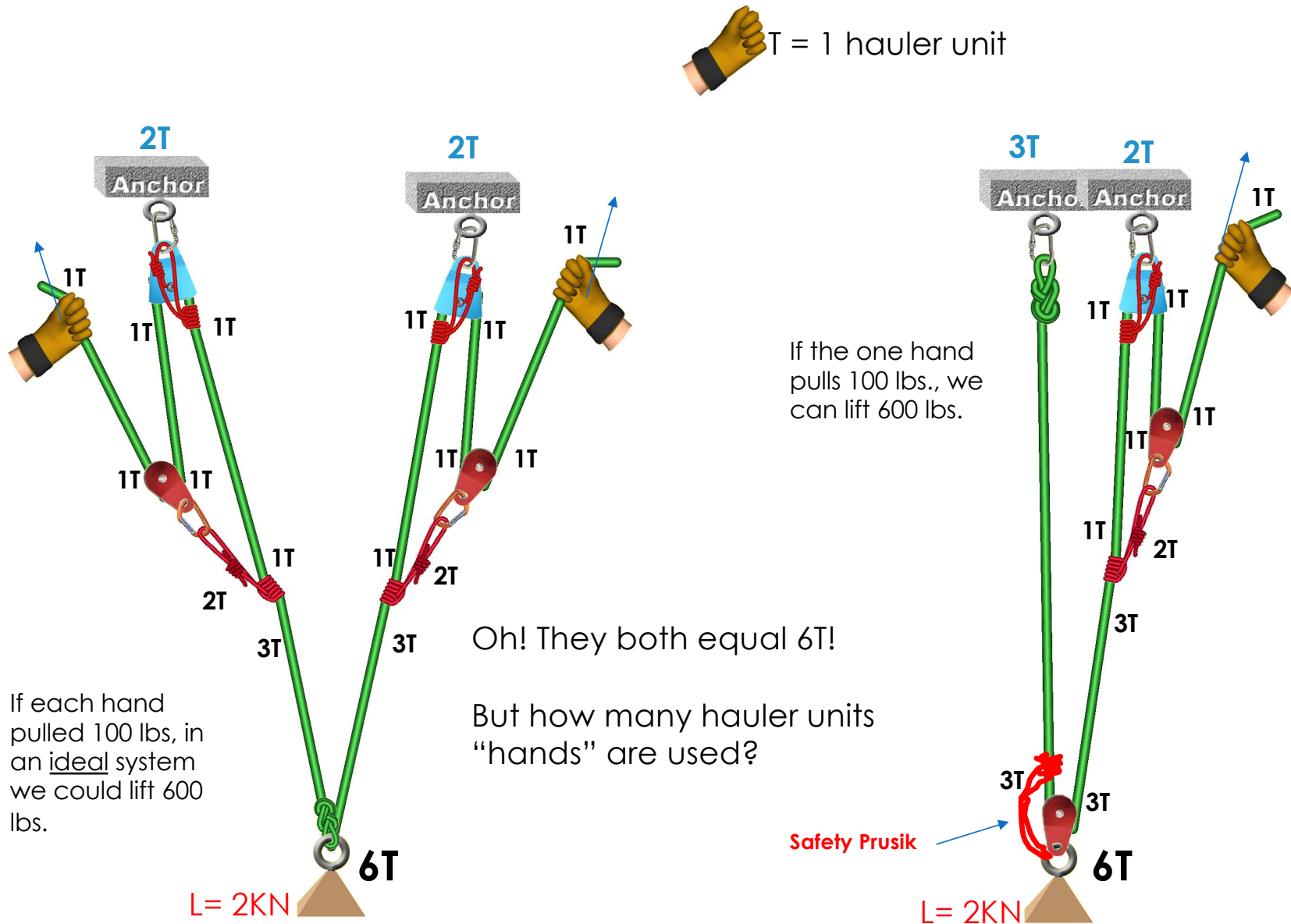


Are two side by side 3:1 hauls the same as a single 6:1 haul?

Assume no edge and frictionless pulleys.

Each HAND = 1 hauler unit, be that 1 strong person, or a haul team.

Let's look at T analysis, starting with the hands pulling tension and working towards the load.




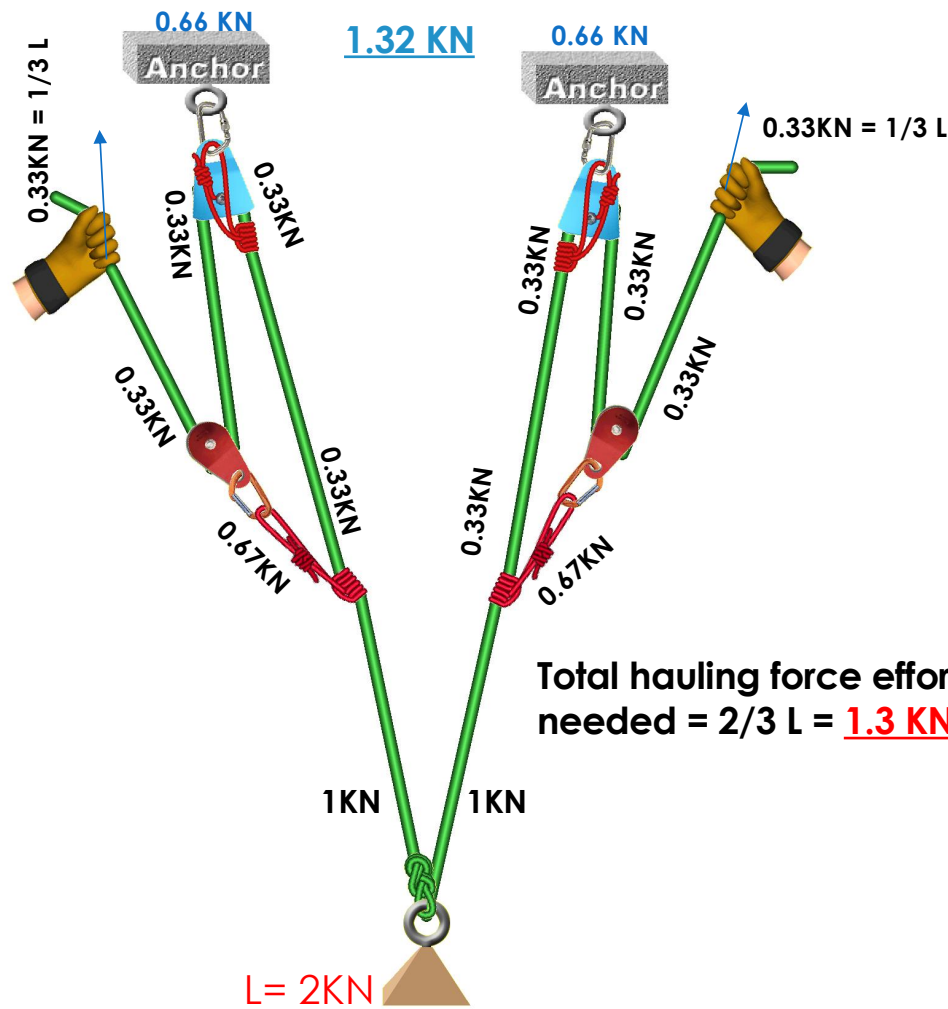
If each hand pulled 100 lbs, in an ideal system we could lift 600 lbs.

Now try it with the L analysis... starting at the load and working backwards.

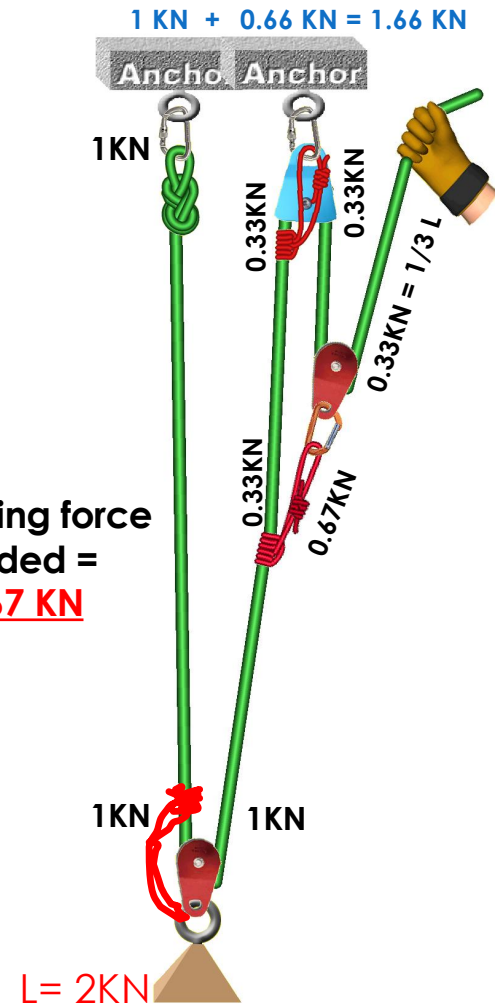
Obviously a 50% savings on haul force effort with the drop loop system, but an "apparent" additional 21% increase on anchor forces?

Bad?
But we ignored friction!

 = 1 hauler unit



Total hauling force effort needed = $1/3 L = 0.67 \text{ kN}$



But friction is real!

Friction is your friend going down, or holding something up.

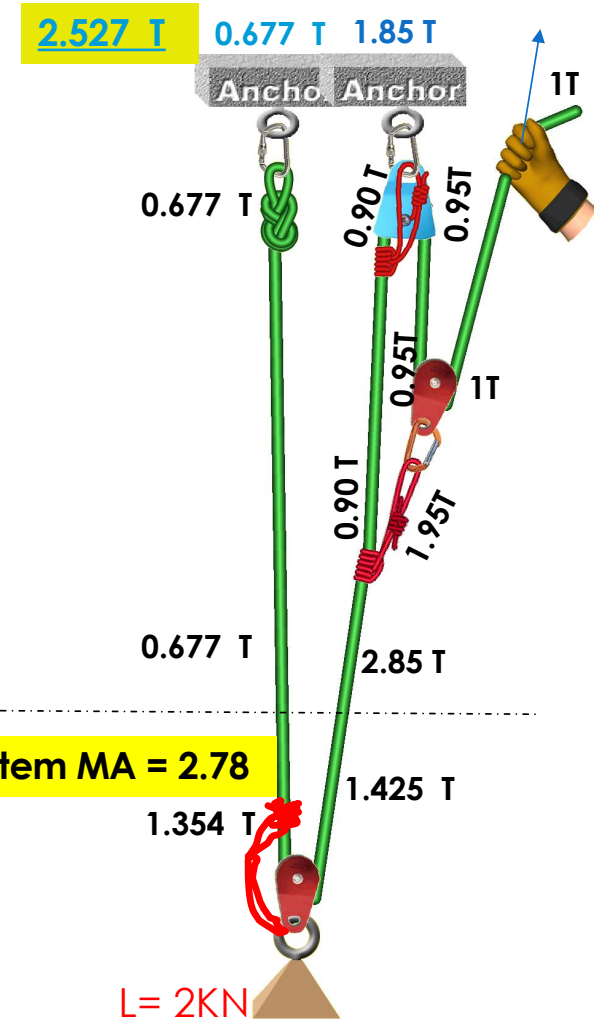
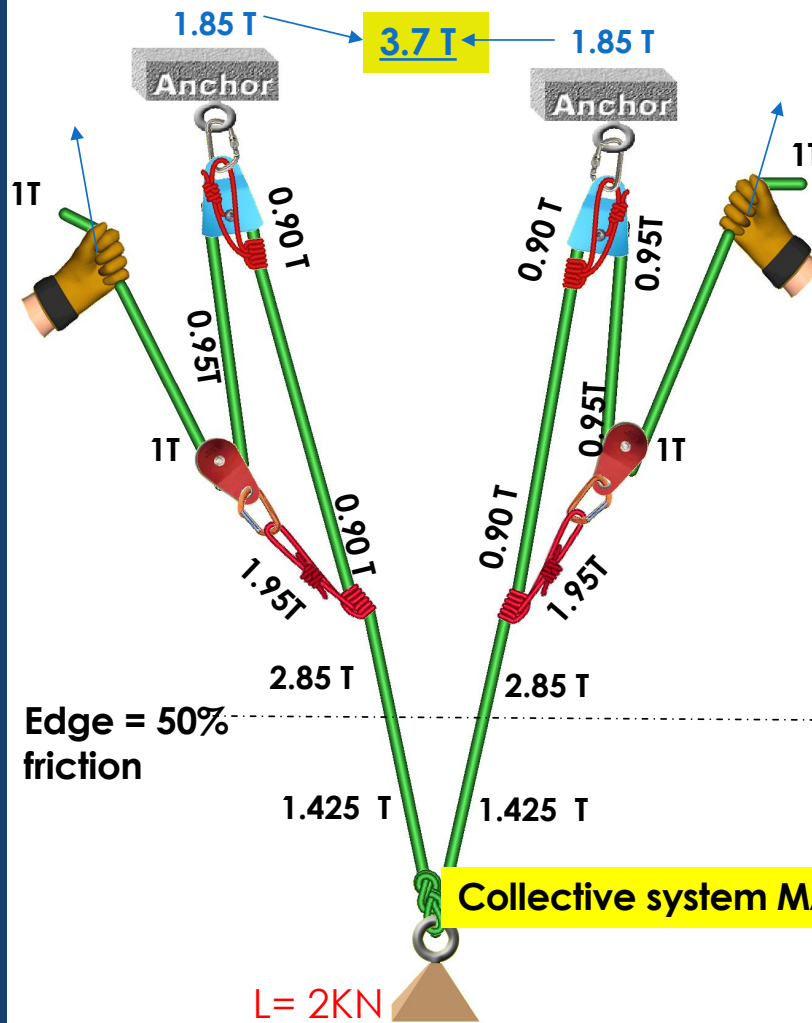
It is your foe going up!

Assume every pulley is 95% efficient.

Edge is 50% efficient

Try a T analysis with friction this time...

Looks like the TTRS has more MA, but puts more collective force on the anchor... but...



One more L analysis accounting for friction this time!

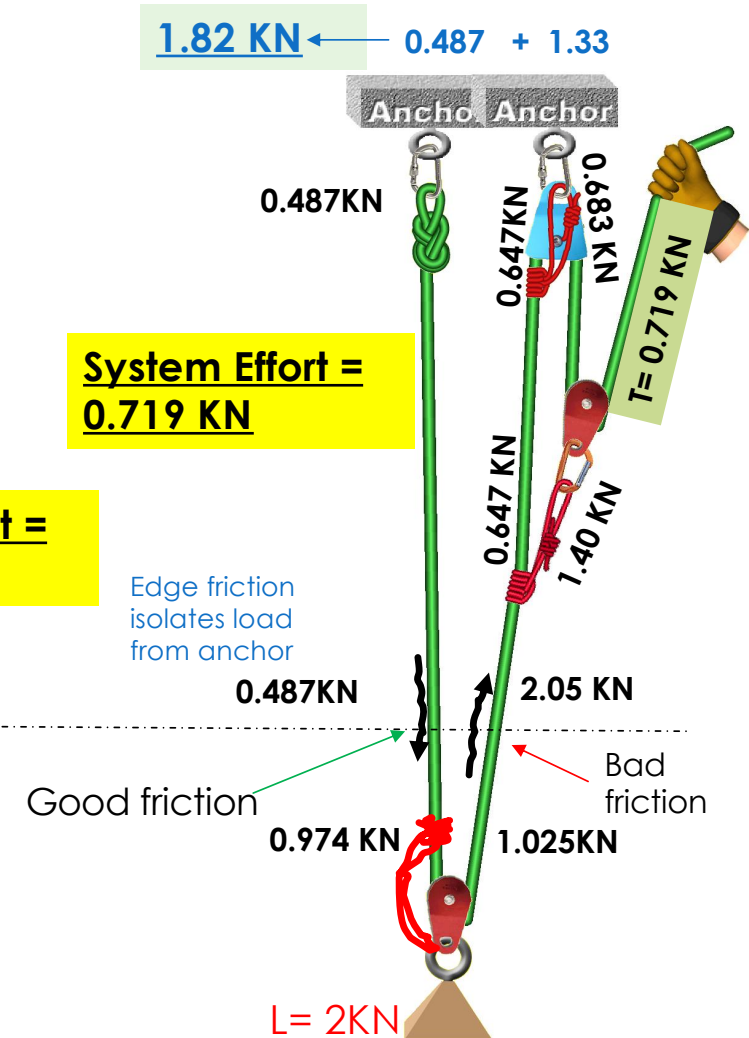
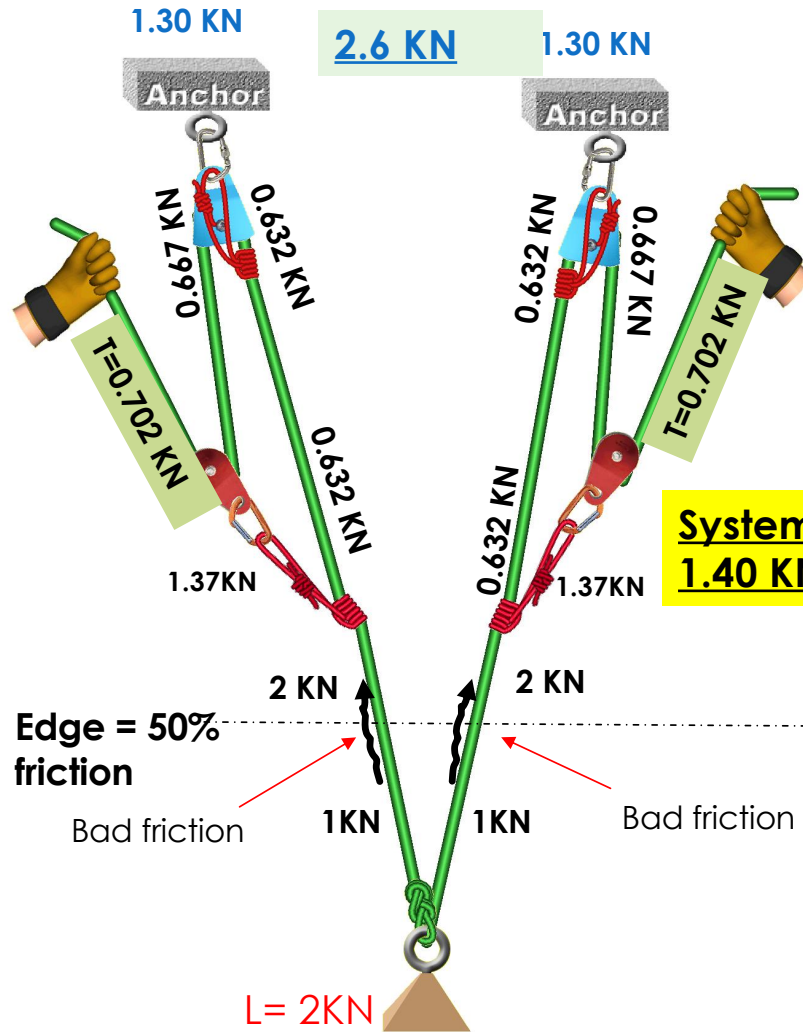
Assume every pulley is 95% efficient.

Edge is 50% efficient.

TTRS has 4 pulley losses and 2 moving line losses.

Drop loop has 3 pulley losses and 1 moving line loss.

Drop Loop system has 30% less force on anchor with no shock load potential, and requires 48.6% less haul effort.



Generic Two Tension Rope System (TTRS)

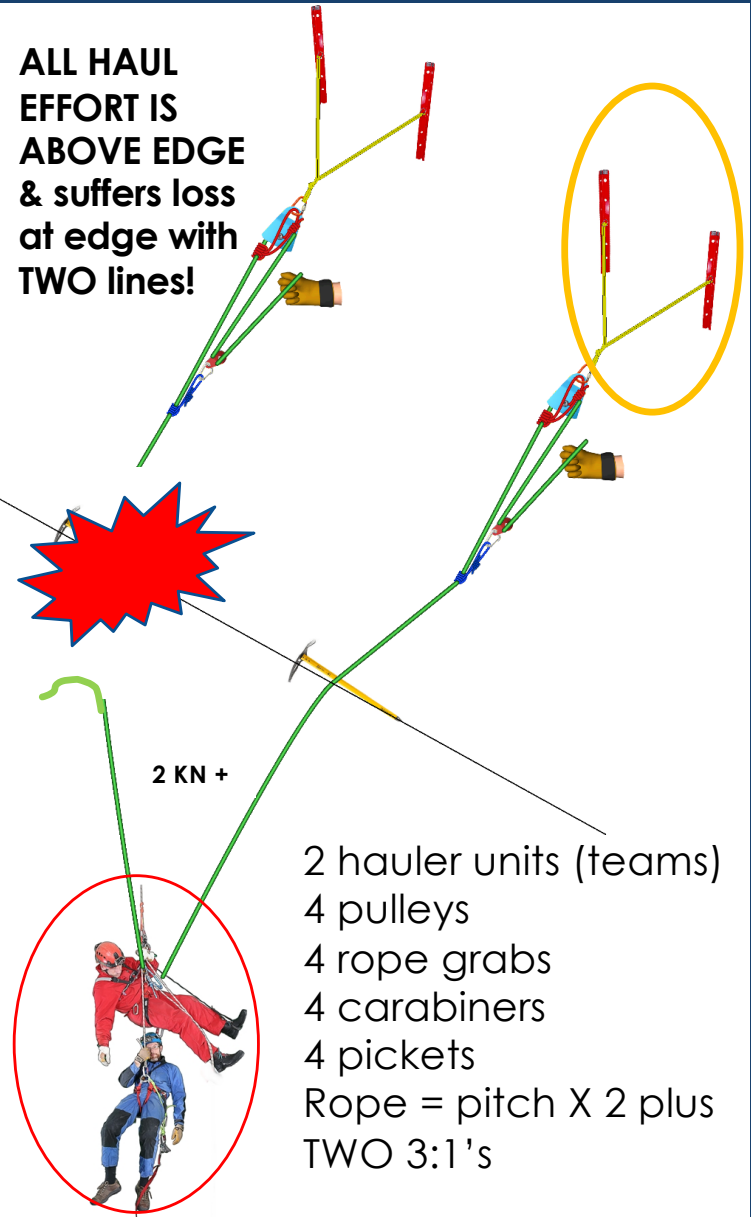
Each side of TTRS has 2 pickets. Total of 4 to make redundant system

If one line fails, entire load goes to 2 pickets and WILL have at least some **shock** load as remaining line inherits $\frac{1}{2}$ the load and stretches. (TTRS never truly 50/50)

2 Pickets MUST be enough to hold **L plus** shock or it is not truly redundant.

Load (L) = 2KN

ALL HAUL EFFORT IS ABOVE EDGE & suffers loss at edge with TWO lines!



6:1 Canadian Drop Loop / C+3

2 pickets holding the same load that one side of a TTRS would have to hold plus shock if one side failed.

If you “internally engineer redundancy” with a 3rd picket, that is still faster than rigging 4, and stronger / safer than the TTRS contingency system.

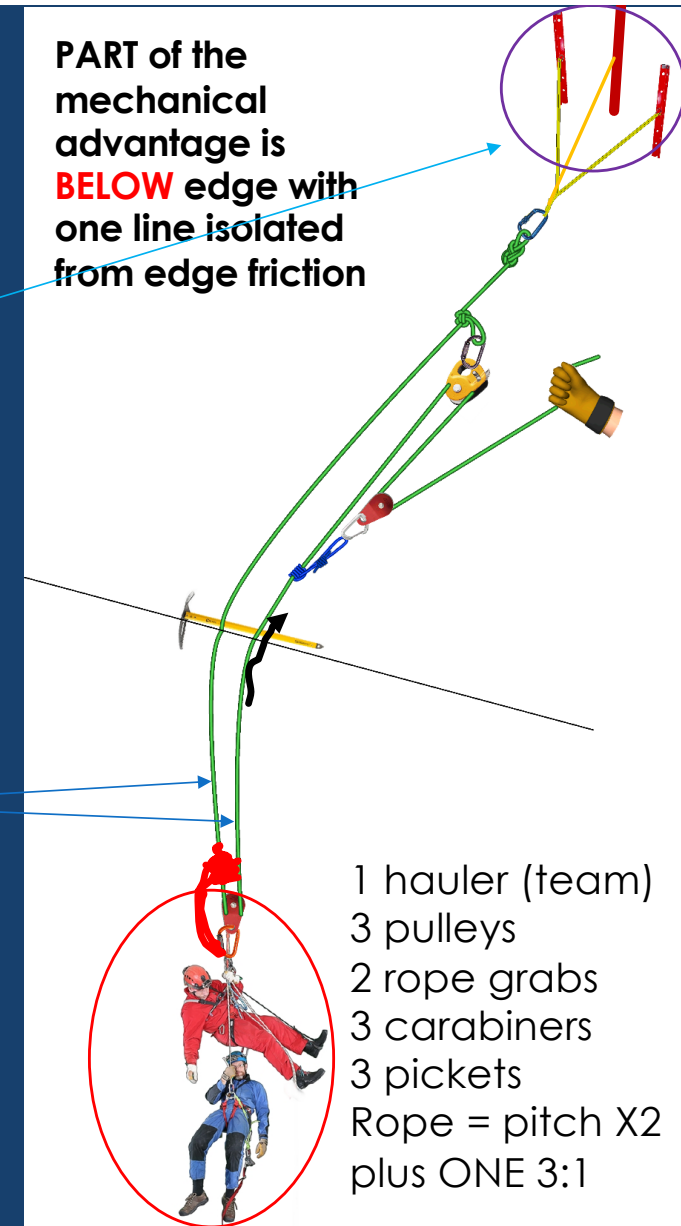
Less gear, faster rig, more haul efficiency, edge friction isolation, & more anchor redundancy.

One moving line holding 1 KN moving over lip generating friction.

Each line “sharing” load, roughly $1/2L$, or 1 KN each

Load (L) = 2KN

PART of the mechanical advantage is **BELOW** edge with one line isolated from edge friction



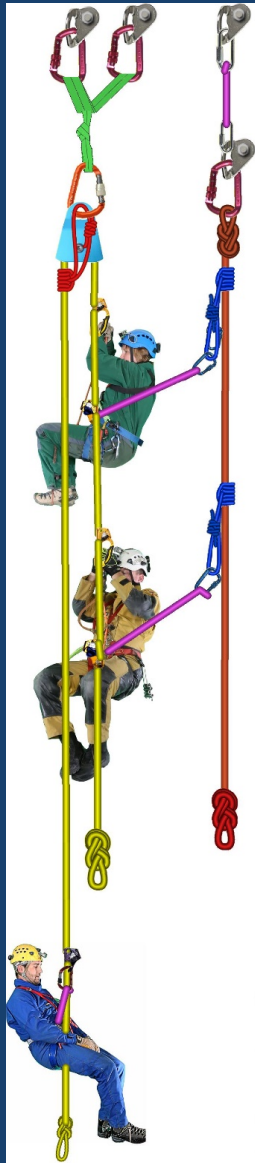
D

3:1 Diminishing loop

Force = 1 L

$\frac{1}{3} L$ $\frac{1}{3} L$ $\frac{1}{3} L$

T = Force required to lift load = $\frac{1}{3} L$.



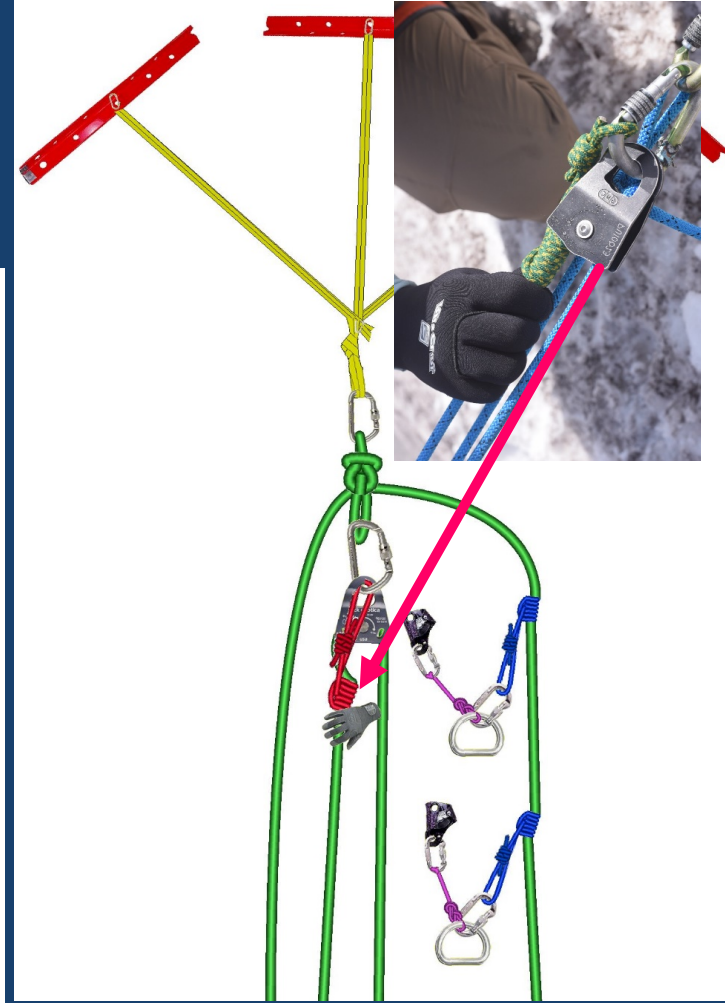
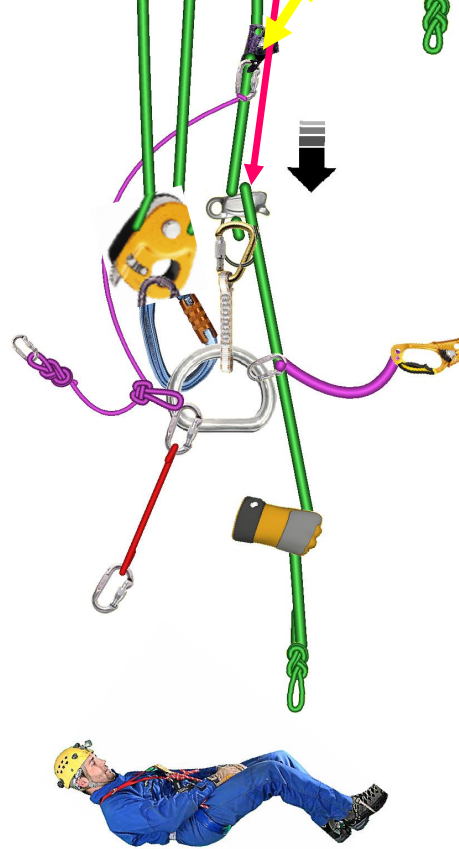
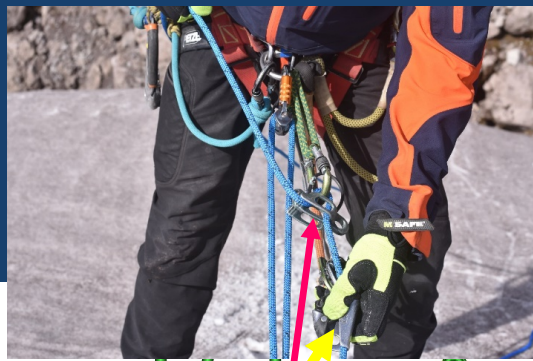
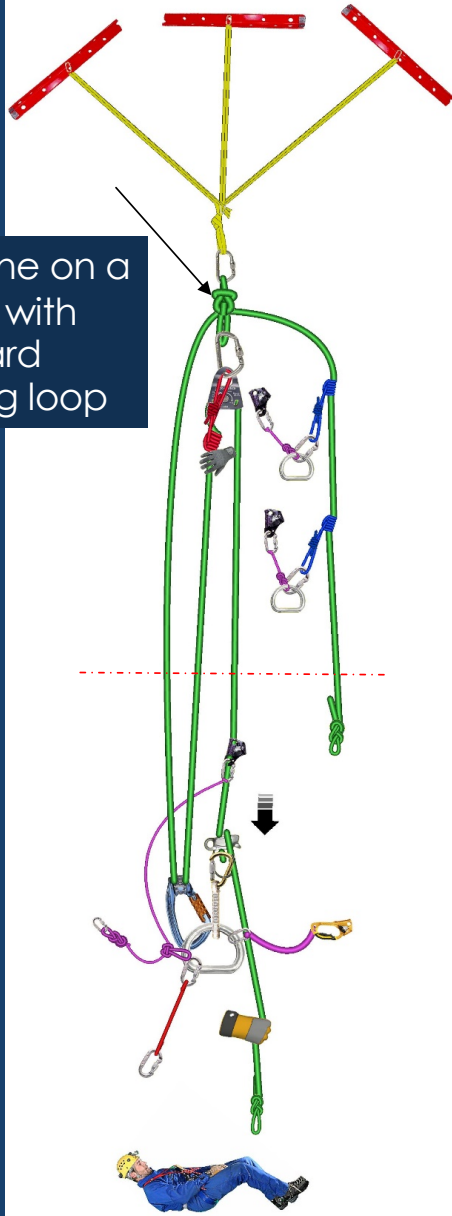
• A hybrid combination of the 3:1 diminishing loop rig and the top based climbing counterweight rig.

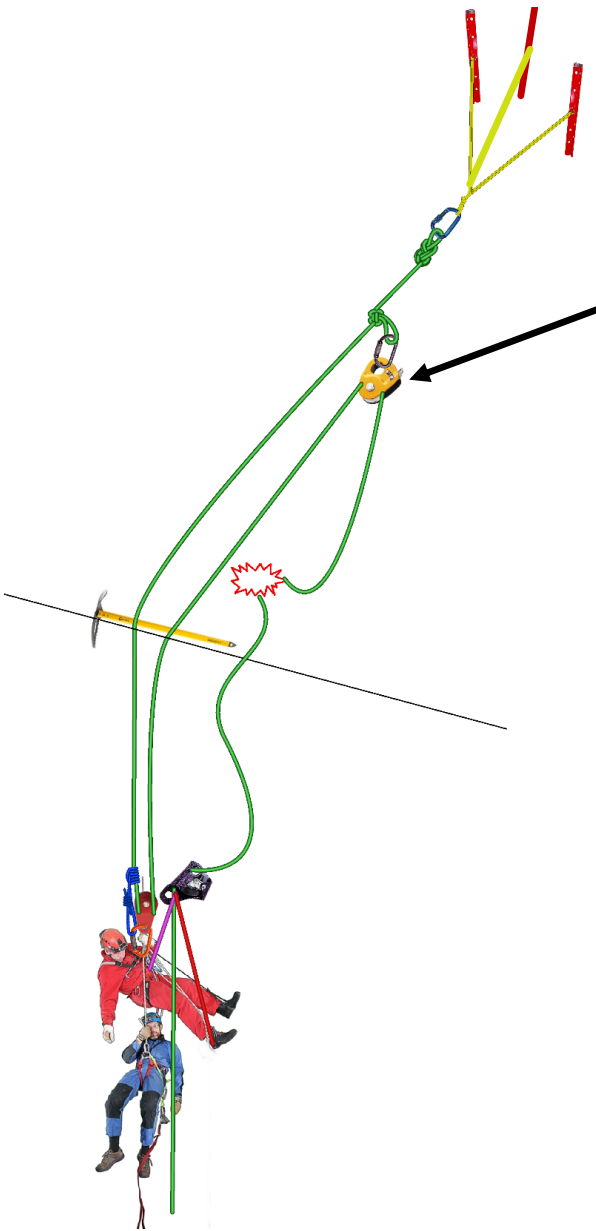


Rescuer harness master point



Bowline on a bight with forward facing loop





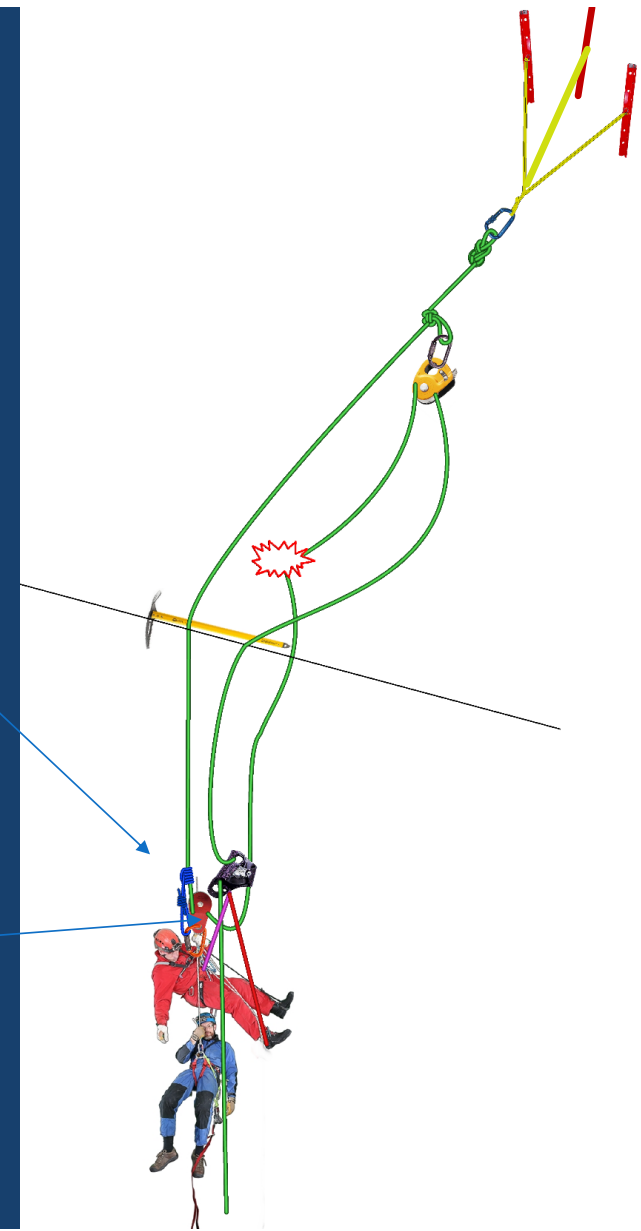
Internal Redundancy on moving lines

If rescuer climb / rappel line is cut, PCD at anchor traps a closed loop. Remaining 2 lines go from $\frac{1}{3} L$ each to $\frac{1}{2} L$ each, but anchor still feels 1 L...no shock load.

If the 2:1 moving line is cut, Prusik on static line holds the load. Remaining line now goes from $\frac{1}{3} L$ to 1 L, but anchor feels 1 L as before.

Replace drop loop pulley with ratchet pulley and you have protection for all 3 lines.

Anchor does not feel shock due to due to “black box / closed loop” rigging.



Edge Solutions

- Edge friction is your BIGGEST loss of haul efficiency... not your pulleys!
- You MUST have an edge plan! Especially with counterweight solutions, where there are 2 moving lines over edge...each moving in opposite directions.
- This can create drag in two lines, just as it does with a TTRS.
- Friction going down is your friend. Do NOT use high help for the static leg of a drop loop! Friction is holding some of the load for you!
- Friction is your enemy coming up!
- If you have a 2nd teammate, one solution is a human bipod. Static leg of a drop loop can be an edge attendant line.



Inline Traveling Haul

A classic and powerful cave SPAR technique

Utilizes downward pull / counterweight in conjunction with a classic C rig.

Disregards edge friction since **ENTIRE** haul effort is below lip.

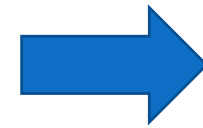
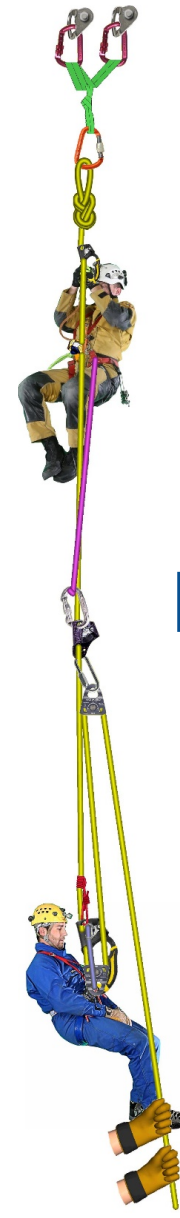
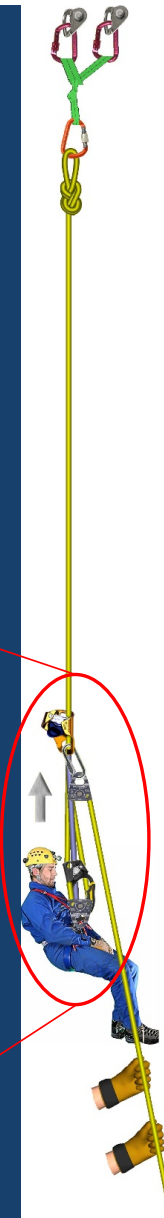
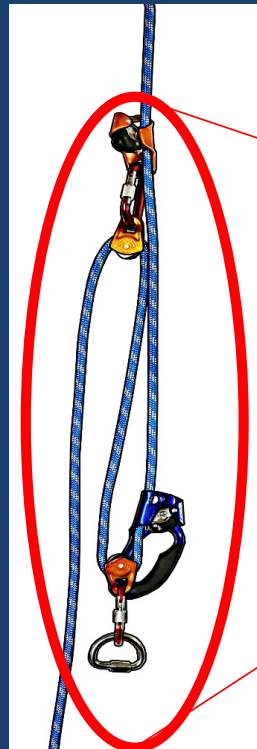
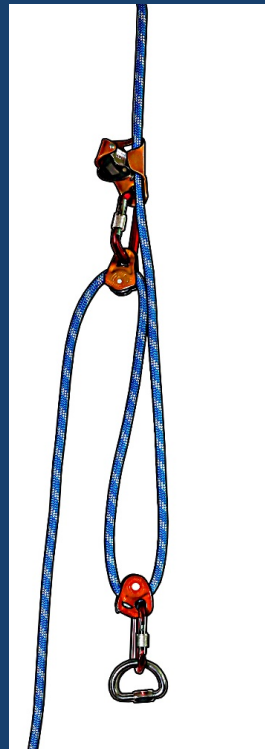
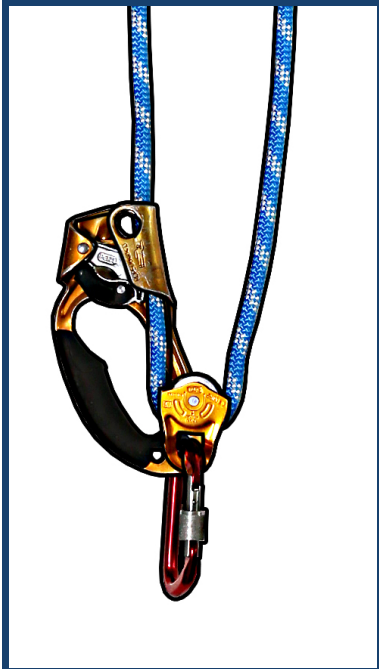


Illustration created using vRigger

Illustration created using vRigger

Traveling Haul under lip solution (2-part rescue)

Pulley=95%
Edge @ 1KN=50%
T = force needed to raise 1KN load

2KN

1T

1 KN

0.9025T 0.95T

1 KN

1.8525 T

Zero edge friction
plus rescuer can
use their own
weight!

Under lip
Haul effort = $1 \text{ KN} \div 1.8525 = \underline{0.54 \text{ KN}}$

Easy for rescuer to
raise via
counterweight!

1 KN

Rescuer then climbs SRT
over lip on the loaded line
(which will be awkward)

Now use same gear from
traveling haul to add the
3:1 to the existing C, and
haul with a 6:1.

Static leg of C used as
edge attender line.

Line will be loaded!

95%

1T

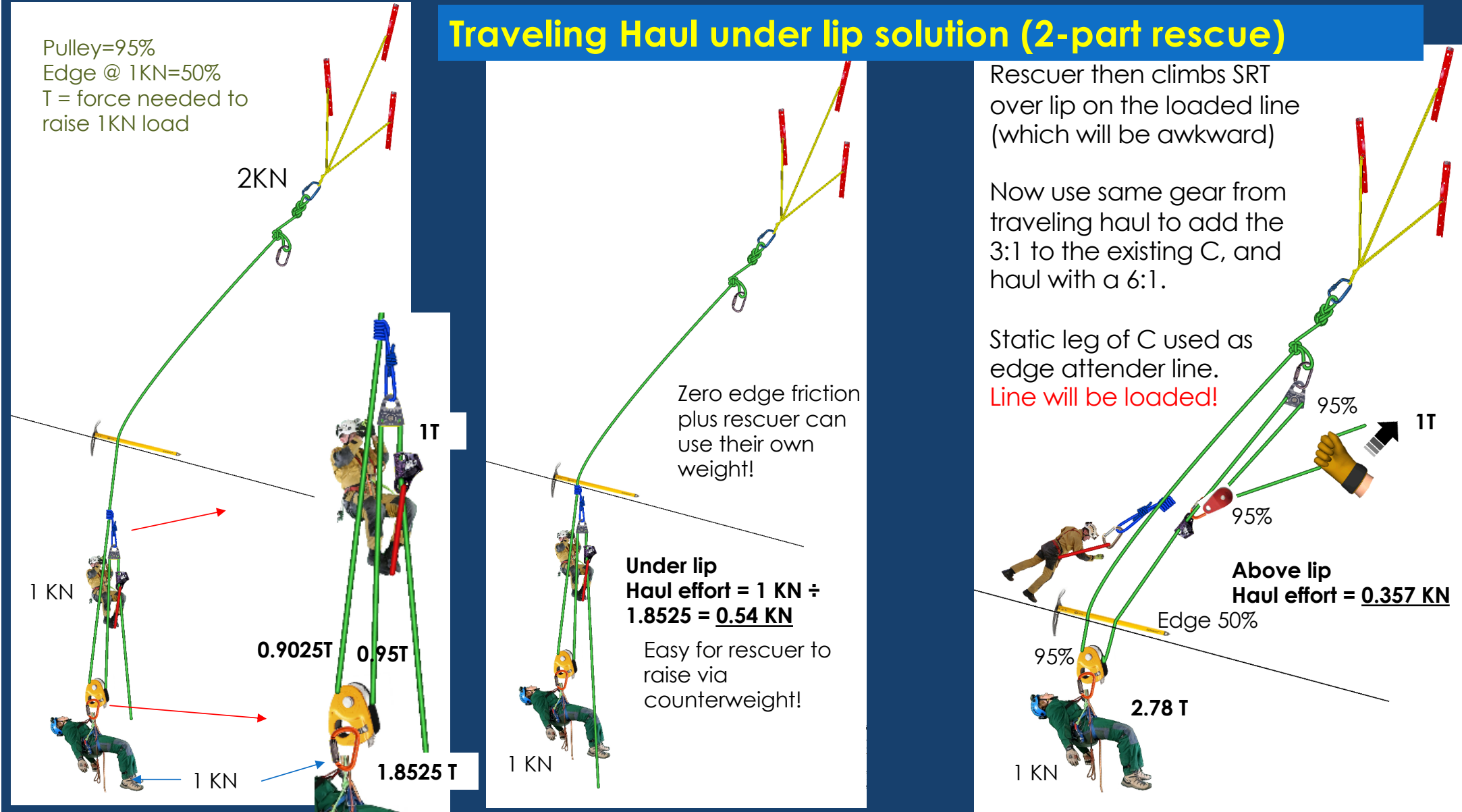
Above lip
Haul effort = 0.357 KN

Edge 50%

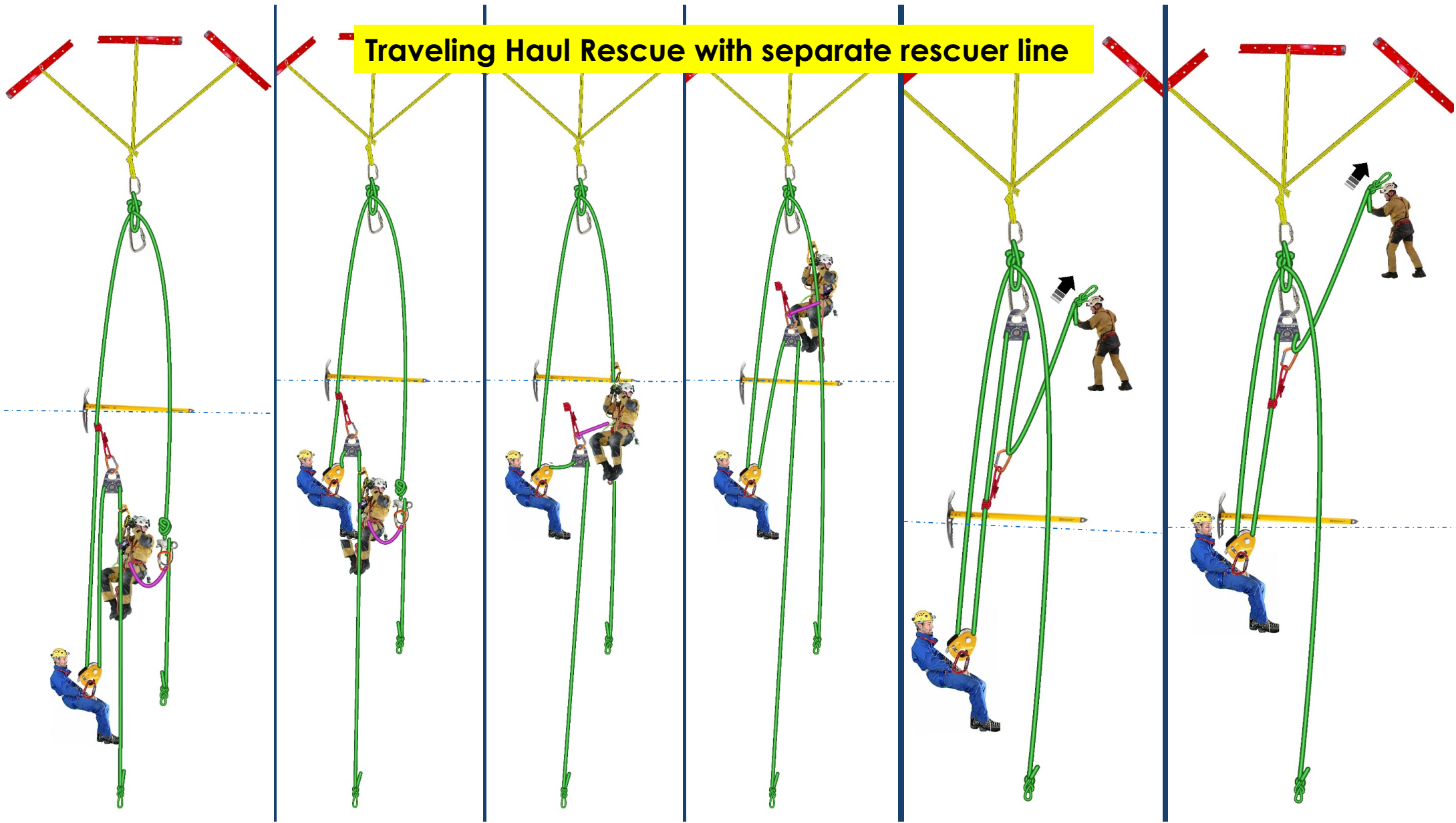
95%

2.78 T

1 KN



Traveling Haul Rescue with separate rescuer line



Summary / Key Points

- When time, gear, and personnel are scarce, and the patient injury or condition is critical, SPAR techniques can enable a team of 1 to 3 responders to remove patient from deadly environment.
- Speed often = safety for a patient in a deadly environment, and for rescuers in a high risk area.
- Closed loop rigging adds a mechanical advantage of 1 to any haul system, and with embedded PCD's can remove shock load potential if one line fails (black box rigging).
- Use gravity to your advantage... it is ALWAYS there. Counterweight hauls use this force to your advantage.
- The edge friction is your BIGGEST loss of haul efficiency... which you cannot afford in small team operations. Let friction help you in lowers and holding static legs of drop loops.
- Putting haul components BELOW the edge isolates that component from edge friction losses.
- Understand forces and **LIKELY** modes of failure, and engineer internal redundancy for the most likely occurrences **BASED ON YOUR RISK ASSESSMENT**. **Train** personnel to understand different systems and how they allocate forces.
- Redundancy is not always TWO of everything... it can be accomplished by sharing load on multiple strands, reducing friction, removing chance for shock loads, and adding anchor nodes.

Questions?

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