RCP *Anchor Considerations*

KES

KARY ENVIRONMENTAL SERVICES INC.

"THE KEY TO YOUR ENVIRONMENTAL SOLUTIONS"

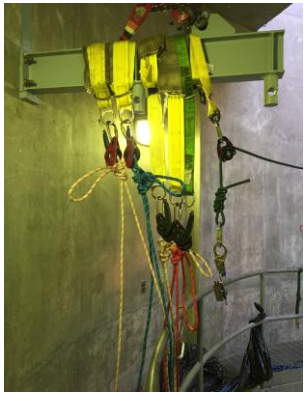
Anchor Stability *(static)*

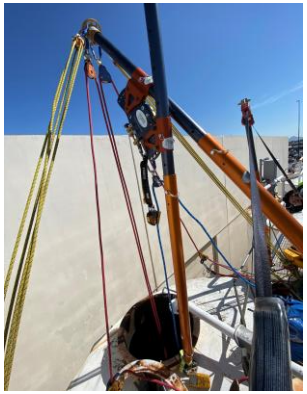
The key to any anchor system is to minimize movement (static) and when movement is needed, do so with a planned purpose in a highly controlled manner (dynamic).

Bombproof Anchor vs. Marginal Anchor Systems

What is a bombproof anchor and is there a number that we can attach to it? From the early history of rescue rigging, it was inferred that a 'bombproof' anchor was so strong that it would withstand a direct hit from a bomb. Also, it had to be agreed upon by the whole team that it is indeed BOMBPROOF…and then we all would be surprised when the *bombproof* tree would snap or the leaf springs of the *bombproof* axle of the fire truck would saw its way through the wrap 3/pull 2. The truth is…any anchor is only as 'bombproof' as we make it. When an anchor fails it is always due to human error.

Anchor Interpretations Based on Work Environments





Although rigging physics never changes, anchors used for rescue purposes versus anchors used for standby rescue and confined space entry and other industrial jobs seldom see eye-to-eye in regulations and standards. OSHA might give the rigger a pass during a life and death rescue situations whereas in the world of standby rescue rigging and rope access work anchor selection is becoming more of a target of OSHA and ANSI fall protection compliancy.

Debates of do's and don'ts/pros and cons of rescue anchor selection and rigging is relatively easy compared to anchor selection and rigging in the regulatory world of rope access and fall protection standards. To add some clarity to this rigging topic we can divided the following anchor environment summaries into five subdivisions:

1. Wilderness Rescue,
2. Urban/Industrial Rescue,
3. Pre-planned Rescue Standby,
4. General Industry Rope Access Anchors,
5. Construction Rope Access Anchors.

Each one of these five subdivisions have notable differences in their job application and the type of equipment used to rig the anchorage.

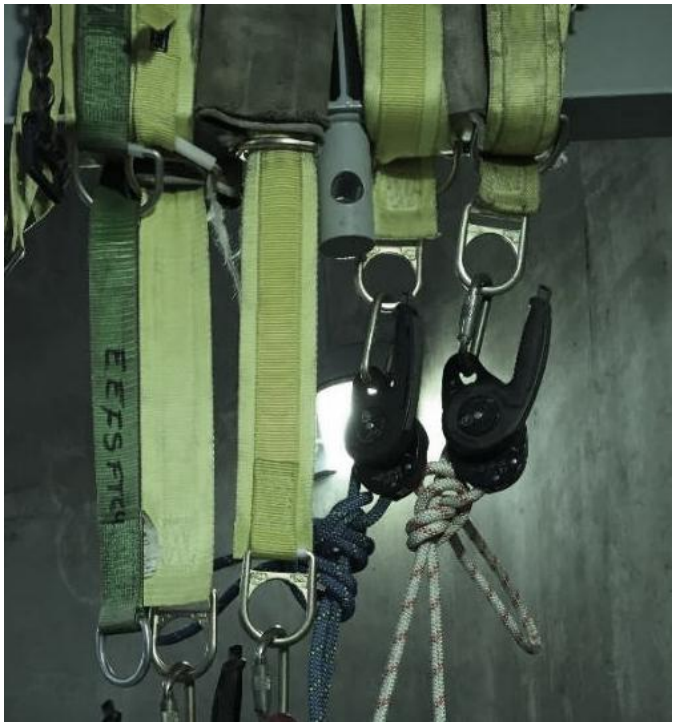
Wilderness Rescue Anchors

1. Light Weight Equipment – Typically one-inch webbing, or Dyneema slings, easy to backpack, and preferable for anchorage around trees and rock formations.
2. More Rigging Intensive – Wrap-three/pull-two webbing anchors, tensioned back-ties are more commonly used to stabilize marginal anchors.
3. Minimal governmental regulation unless it involves the jurisdiction of a municipal fire/rescue service.

Urban/Industrial Rescue Anchors

Includes structural steel environments such as towers and bridges.

1. Heavier OSHA fall arrest compliant equipment – Instead of one inch webbing that requires more time-consuming knot craft (This is a major reason for not using one inch webbing in high exposure tower/bridge environments.) urban/industrial locations are best served by pre-sewn slings and anchor straps with steel “D” rings.
2. Less rigging intensive – due to a greater abundance of structural support options, however, great care is needed for edge protection
3. More governmental regulation – typically falling under OSHA law and important standards such as NFPA-1983 and ANSI-Z359.



Pre-planned Rescue Standby

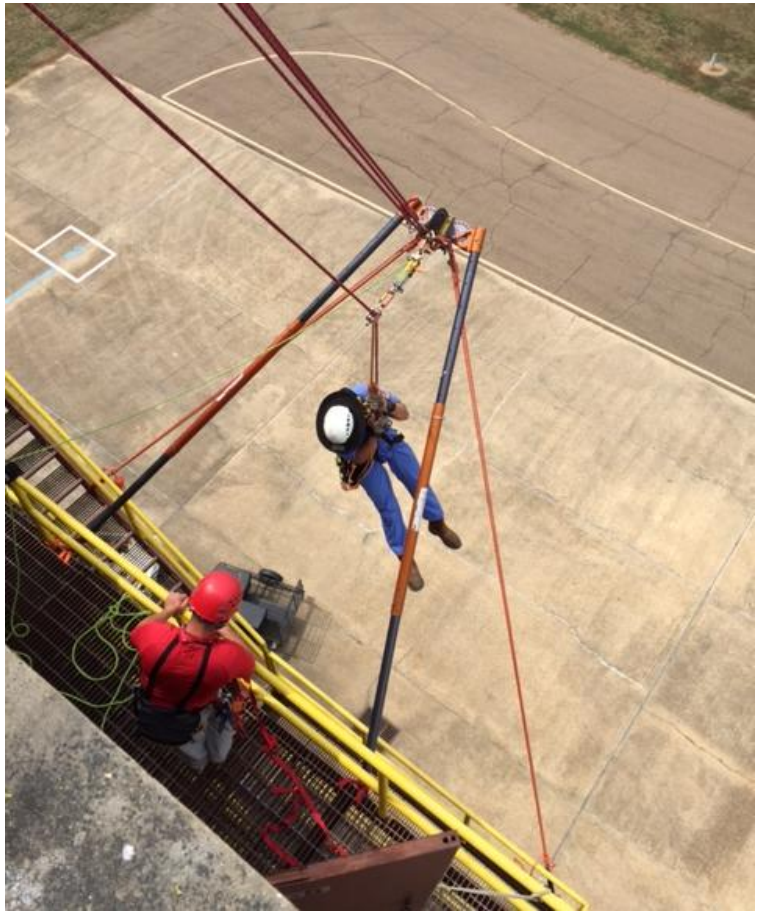
OSHA fall arrest compliant equipment – Hand-tied webbing anchors and untimely knot craft, is not the best practice during this application. Stay with pre-sewn slings and anchor straps with steel “D” rings.

1. As with most industrial settings, steel and heavy structure components are usually available. Great care is still needed for edge protection around sharper steel edges and concrete.
2. Substantial pre-planning is still required. Time to develop pre-plans is a distinct advantage when hired to provide standby rescue.
3. Anchors may be dynamically rigged to facilitate a rapid lowering or raising of a suspended victim.
4. Anchors should be approved by a qualified person. *(A qualified person is one who has been certified to make anchor decisions based on physics and structural evaluation.*
5. Standby rescue events are highly regulated by OSHA and are strongly driven by consensus standards.

General Industry Rope Access Anchors

Rope access anchorage is more reliant on the technical capabilities of the user. Even so, this anchor environment still falls under the regulatory control of OSHA.

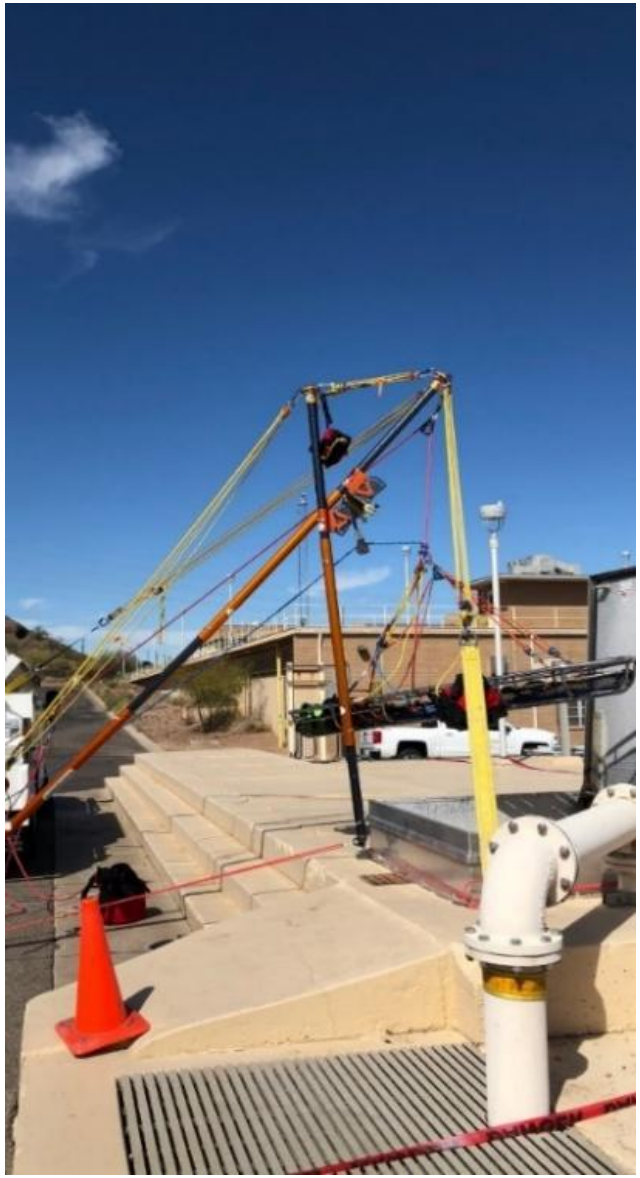
1. The need for rope access may require more intensive rigging skills due to the advance nature of these type of jobs.
2. More than ever, pre-planning is a must – this type of event demands whatever time is needed to make sure the anchor engineering is correct prior to the start of any work.
3. As with most industrial applications, dynamic anchor rigging to facilitate a speedy lowering or raising of a suspended worker should always be considered.
4. Anchors may need to be approved by a qualified person.
5. Substantial governmental regulation – OSHA fall arrest requirements are strictly followed.



Construction Rope Access Anchors

The theme of heavier OSHA fall arrest compliant equipment is still the same. However, because it a construction environment, OSHA does allow some latitude in trigger heights for fall protection and the type of anchorage that may be used.

1. Rigging may be challenging; edge protection is a potential issue that cannot be ignored.
2. Pre-planning is critical, however, stay alert to changing worksite conditions that seem to pop-up at construction sites.
3. Dynamically (ability to move and adjust in a highly controlled manner) rigged anchors are a strong consideration.
4. Improvised anchors must be approved by a qualified person.
5. Substantial governmental regulation – OSHA fall arrest requirements are strictly followed.

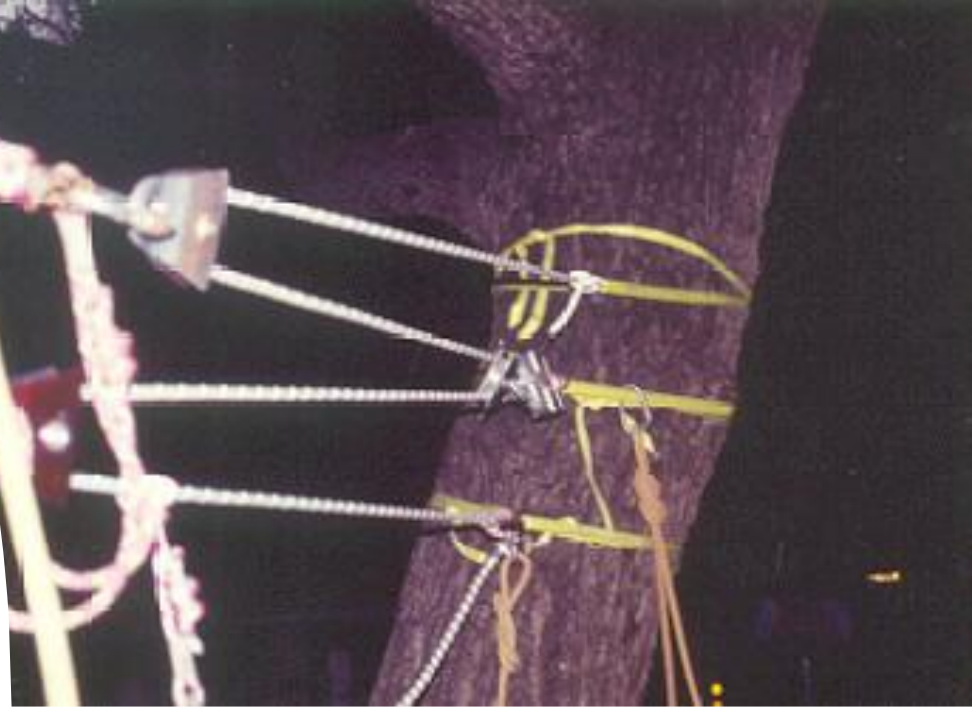


A Word on Substantial Anchors

The word ‘Substantial’ is often used in the discussion of anchors. Substantial anchors are those that seem to be strong and indeed look to worthy of calling Bombproof, however we might not be in total agreement or we’re not ready give it that absolute title of ‘Bombproof’. We come across this naming stalemate often in wilderness locations when we are just not sure about completely trusting a tree, or a rock formation or any number of natural anchors. So, the term Substantial becomes a useful compromise. This also means we are not going to rig our mainline and belay line to this anchor. We will find a suitable second anchor for the belay system.

Bombproof anchors continued…

Bombproof anchor construction might be the more appropriate phrase. The most critical aspect of a bombproof anchor is extremely high-quality rigging that pays attention to the smallest of details, makes no assumptions, and takes nothing for granted. In the final analysis, during a rescue we want our anchor system to be strong enough to support the predicted resultant force that it will see during the time of greatest stress during the operation. If we were to put a rating on our anchor selection it should be one that meets a realistic margin of safety of our intended load/resultant force. Example: For a 200kg load, we might want an anchor system capable of providing a 10:1 safety margin, or a 20kN rating. However, that same 200kg load may need to run through a directional pulley, either close to the ground or in the form of an artificial high directional (AHD). For this example, let's give our directional pulley a vector angle of 60°. That pulley and its associated anchor would then receive 173% of the load, or 346kg. Our directional anchor should probably be rigged with a 36kN pulley. With all physical factors considered, a 10:1 safety margin is a slippery target; the reality is that most of our rescue rigging is in the realm of a 6:1 or 7:1 safety margin.



Marginal Anchors

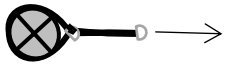
Marginal anchors are typically anything not considered bombproof. Collecting enough marginal anchors and make them into a usable, 100% reliable single collection point requires very advanced and experienced rigging skills in anchor construction. The best everyday practice should be, choose the point of the most advantageous location and make it bombproof by virtue of quality, low elongation back-ties connected to substantially strong anchor points that support the resultant force applied to the focused (forward) anchor.

Anchor Straps and pre-stitched slings (including stitched prusik loops) come in a variety of shapes, sizes, and lengths. These rigging tools are commonly used by the fire/rescue service and general industry alike . Anchor straps promote rapid attachments with minimal rigging knowledge required.

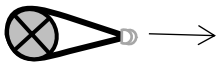
Anchor straps are typically rigged with three basic configurations:

Inline – 100% of the manufacturer's rating.

Choker – Approximately 60% to 70% of the manufacturer's rating.



Basket – Approximately 200% of the manufacturer's rating.



Wrap 3, Pull 2 Single Point Anchor

Based on the diameter of the anchor, select an appropriate length of webbing, wrap the webbing around the anchor 3 times, and tie an overhand follow through bend with its ends. Dress the wraps in a way that will position the bend on the first wrap and next to the anchor, pull the remaining two wraps and attach a carabiner. Attach the next link of the system to this carabiner.

Rope may be used in place of webbing. Be advised; when using rope tied around something like a bolder there is a tendency for the rope to roll up and over boulders that are tapered towards the top.

Tensionless Hitch

A Tensionless Hitch may be used when maximum strength of the rope is needed, i.e. highline operations.

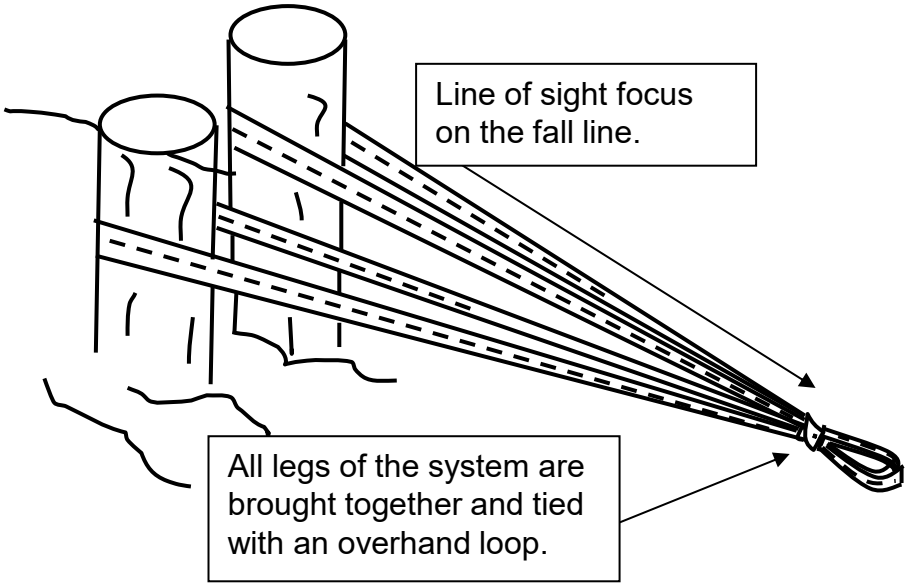
The Tensionless Hitch is made by wrapping the line enough times around a bombproof anchor to take the tension off the knot on the last wrap.

Tie a Figure 8 Follow-through or a Bowline on the working end of the rope and connect this knot to the standing rope just in front of the first wrap. A Double-Overhand Noose also works well for this application. Avoid making the last wrap too loose. The knot at the end should have only enough tension on the standing part of the rope (usually a highline) to keep the last wrap secure. The knot is still not loaded, which is the goal of the Tensionless Hitch.

As a rule of thumb for the Tensionless Hitch, avoid using anchors that are less than 3 inches in diameter, anything smaller threatens to defeat the purpose of the hitch and introduces unwanted stress in the fibers of the rope.

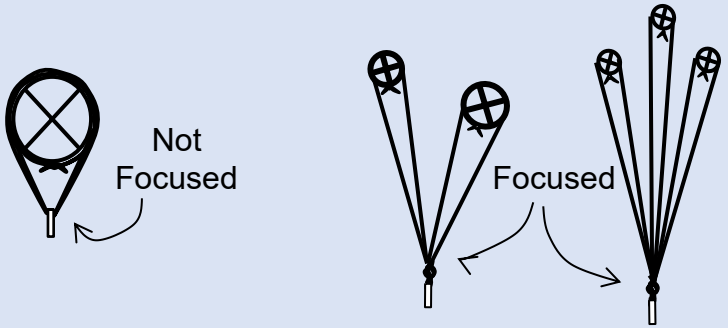
Fixed Multi-point (Load Sharing)

Like a self-equalizing system, load sharing is used to combine multiple marginal anchors to one focused point. In addition, load sharing is also useful in taking two solid anchors to focus a more desirable location for the fall line.



It seems at times, there is confusion in knowing what anchor systems are “focused”. (Bringing all the ends together in the direction of pull and tying an “Overhand on a Bight”) Remember, any time the apex of multiple anchors come together, they should be focused.

Wrap 3, Pull 2 single point anchors are meant to self-equalize, do not tie an overhand at the end of this type of anchor.



Back-ties

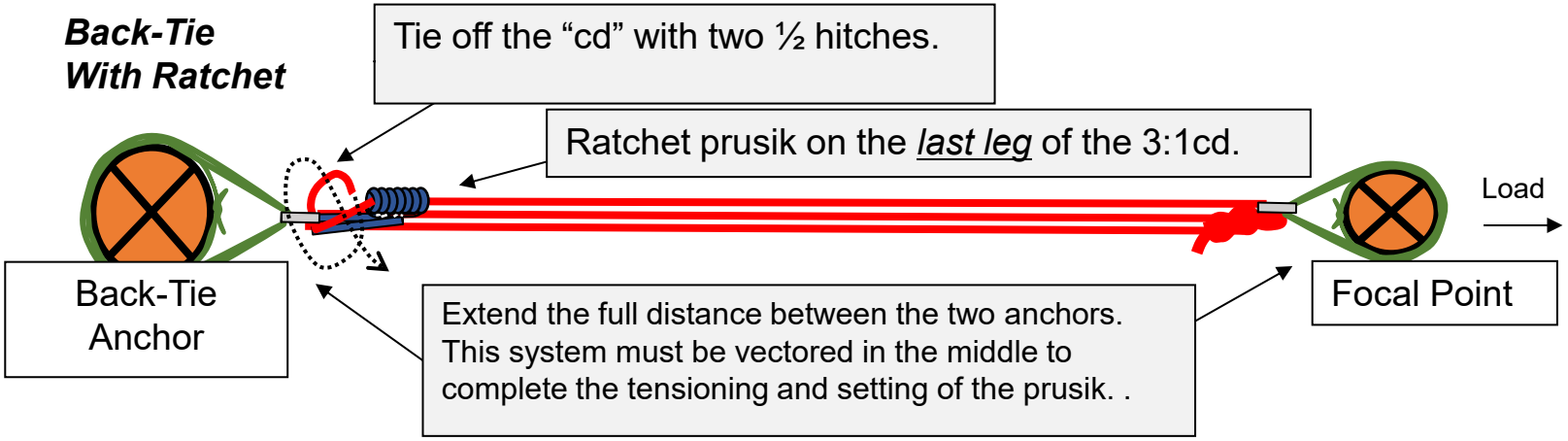
Back-tie skills require management of the elongation of the back-tie rope. Doubling, tripling, and even sometimes with smaller diameter cordelettes, quadrupling the legs of rope between the back-tie anchor and the point being supported greatly helps in mitigating the elongation of the back-tie, and may be needed to meet a specific system safety factors.

It should be noted that multiplying the legs of rope to prevent elongation is not an absolute rule all the time. Multipoint anchor systems of short length often can be rigged with single legs of rope. It is with longer systems that are required to stabilize a singular anchor point that is expected to receive a substantial resultant force we start to really focus on the elongation factor and the unwanted movement of the anchor system.

Back-ties typically connect the two anchors, the focal point and a substantial backup strong enough to meet the required safety margin of the intended load. Again, addressing the issue of rope elongation, when using a 3:1 mechanical advantage this MA typically extends the full distance between the front anchor and the back anchor. However, this is not an absolute rule given the distance and equipment availability.

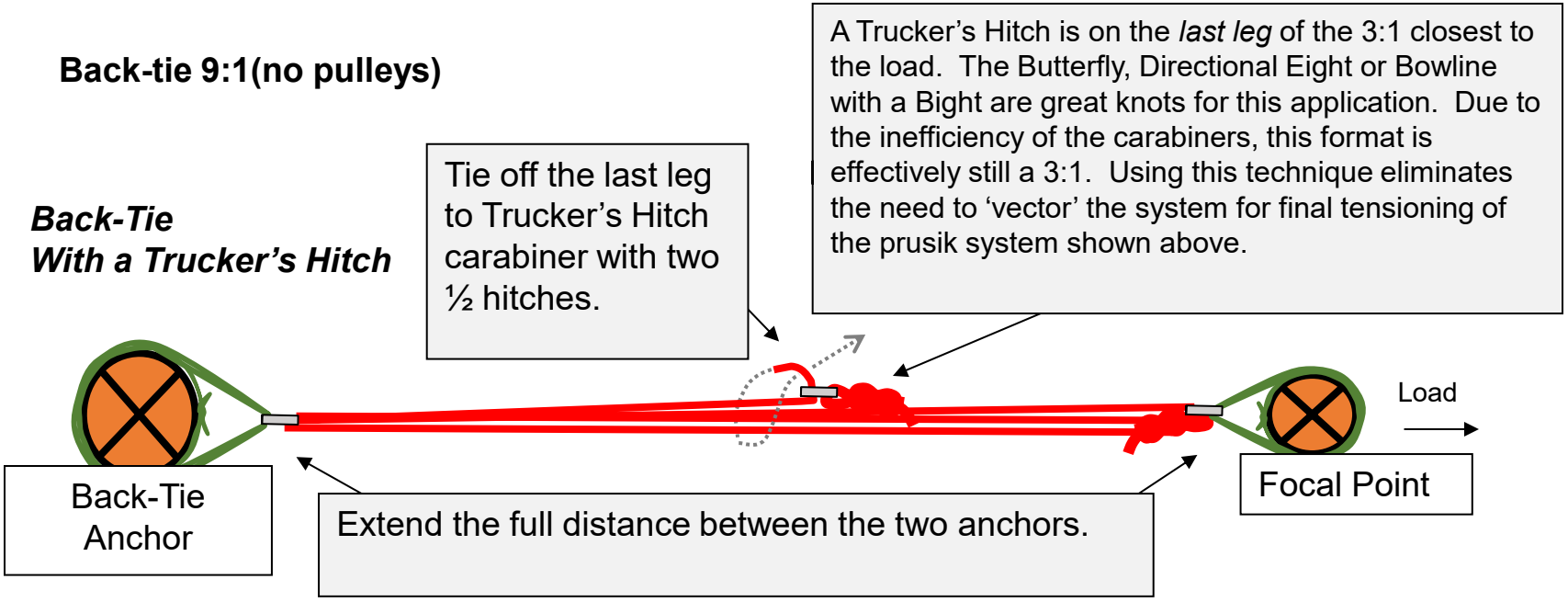
Back-tie 3:1 (no pulleys)

Back-Tie With Ratchet



Back-tie 9:1(no pulleys)

Back-Tie With a Trucker’s Hitch



Note: The ratchet prusik (top example) is applied to the last leg of the MA. *In a normal MA setup, the ratchet be would on the first leg, closest to the load*. By doing this, all three legs of the MA are tensioned for greater strength and minimal rope stretch. *In addition, because this is a “non-hauling” MA, carabiners should be used in place of pulleys.*

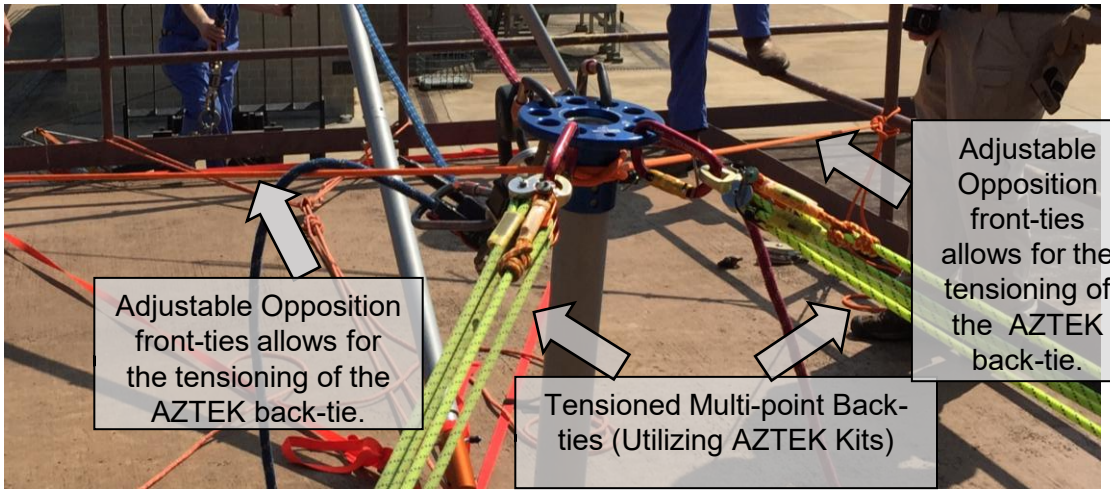
Back-tie, Opposition, Floating, and Elevated Anchors

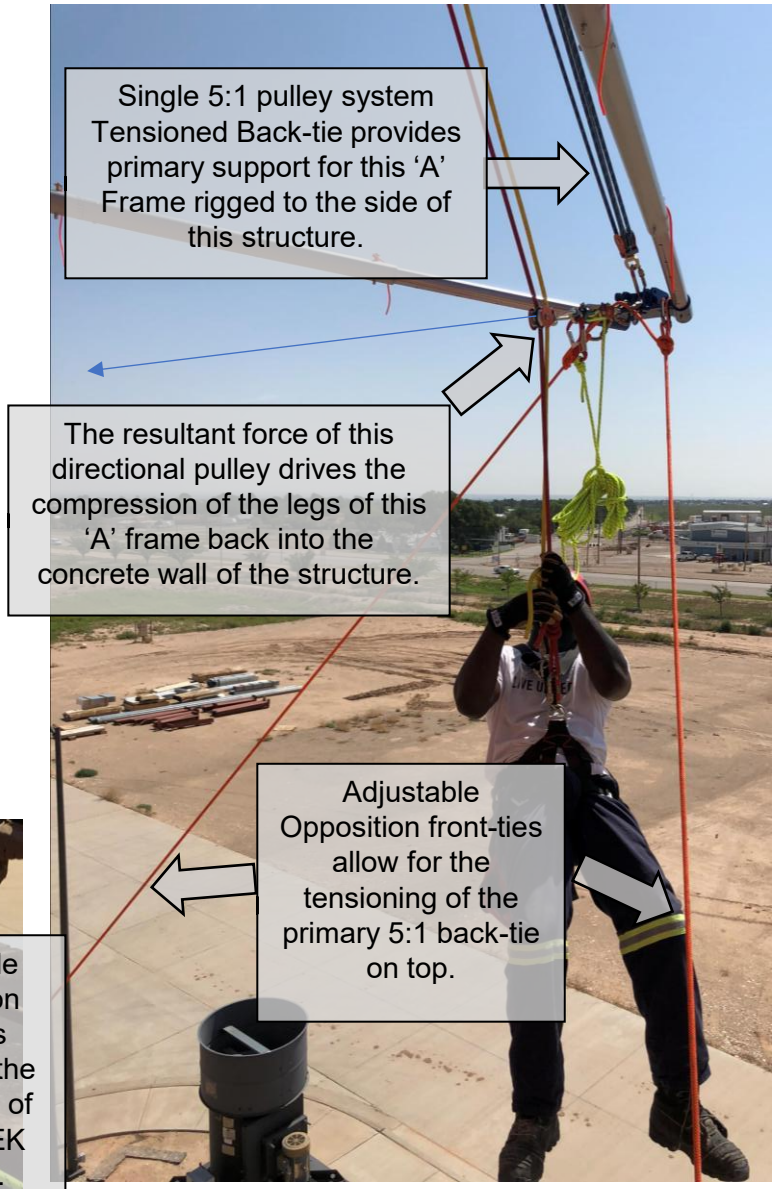
Opposition anchors

Opposition anchors do what their names imply, that is, they pull the opposite direction of the tension back-tie. Opposition anchors are often used to counter high directional tension guying/back-tie systems typical to “A” frames and “gin poles”. Opposition anchors are also important in supplying a forward force to “Floating Anchors”, allowing the floating anchor to hold position with no slack in the main anchor legs. This forward force continues until the force of the rescue operation becomes greater. When the increased force occurs, the opposition anchor system may become slightly slack; this flexing of the system is considered normal.

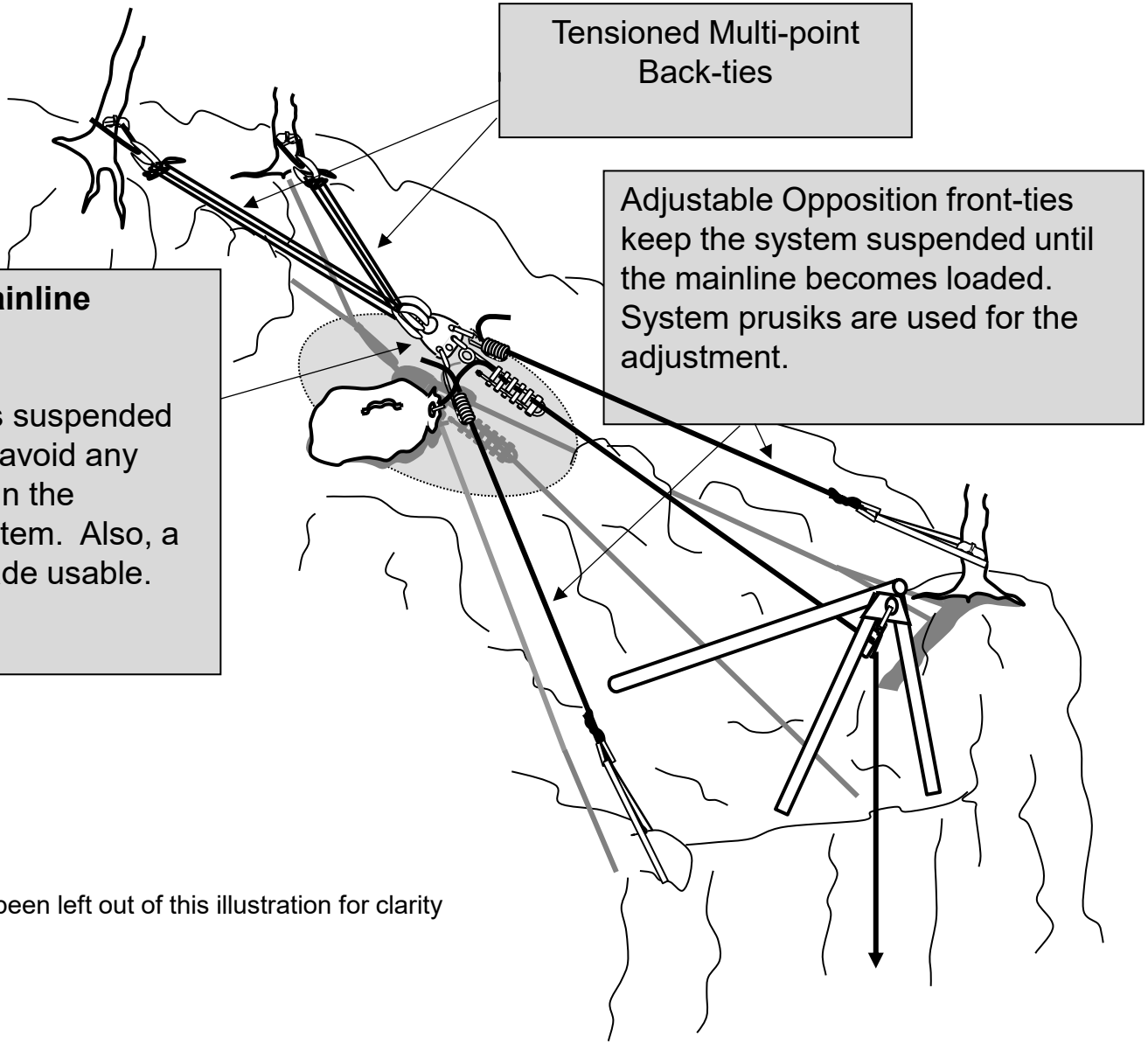
Floating anchors

Floating anchors are constructed in harmony with the combination of back-ties, and opposition anchors. Typically, these anchors are focused in a needed position where no natural anchors are to be found. In addition, floating anchors provide suspension where horizontal movement must be controlled.





Opposition Anchors and Floating Anchors, Continued…



Tensioned Multi-point Back-ties

Adjustable Opposition front-ties keep the system suspended until the mainline becomes loaded. System prusiks are used for the adjustment.

Focus point for mainline anchor system.

The entire system is suspended in such a way as to avoid any slack or movement in the mainline anchor system. Also, a difficult terrain is made usable.

Note:

The belay has been left out of this illustration for clarity purposes.

Floating Anchors, and Elevated Anchors Back-tie Systems

Floating anchors and elevated anchors are one in the same when it comes to back-ties used to stabilize a marginal ‘floating anchor versus back-ties used to rig stabilizing guy systems for elevated anchor points. Albeit each system can have a wide diversity of functions.

The angles between tensioned back-ties and the opposition front-ties are critical. When we get into the study specifically addressing Elevated Anchors these back-tying principals equally apply.

We can categorize back-tie techniques that are required for the stabilizing of floating anchors, as well as elevated anchors into three types:

1. Duel Back-ties (Usually associated with ‘A’ Frame guy systems.)
2. Delta Back-ties (Associated with Gin poles and floating anchors.)
3. Quad Back-ties (Associated with Gin Poles and floating anchors.)

Duel Back-tie Systems

Duel back-ties are a function of stabilizing a bi-pod (‘A’ Frame) elevated anchor system. This will be addressed in detail when we get to the anchor section on Elevated Anchor Systems. However, the methodology of tying the back-tie component is no different then what we’ve already addressed in this module. Usually for symmetrical ‘A’ Frames, the back-ties are directly opposite of each other. The tensioned components (the back-ties) spilt the space between the compression members of the ‘A’ Frame.

Duel back-ties may also be used as a 2 X 1 anchor system for the purpose of stabilizing a marginal anchor, i.e., a small diameter tree that is needed for a natural high directional.

Delta Back-ties

Delta (three back/front ties total), may be two back with one opposition, or one back with two opposition. At times, all three can be tensioned back-ties. What is tensioned and what is the opposition is 100% reliant on the direction and magnitude of the directional forces at play. The upcoming module on Elevated Anchors will address this in detail.

A Delta back-tie system must be symmetrical (120^{o} angle between each back-tie). This rule is rarely negotiable. This is a greatly mis-understood concept in rescue rigging. To the point that some rigging books and field operation guides wrongly depict three tensioned back-tie anchors closely clustered to the rear with a single opposition front-tie, this typically creates a dangerously wide angle between the rear cluster and the front-tie. This condition will offer zero stability of the anchor side to side. We will revisit this topic at the end of this discussion.

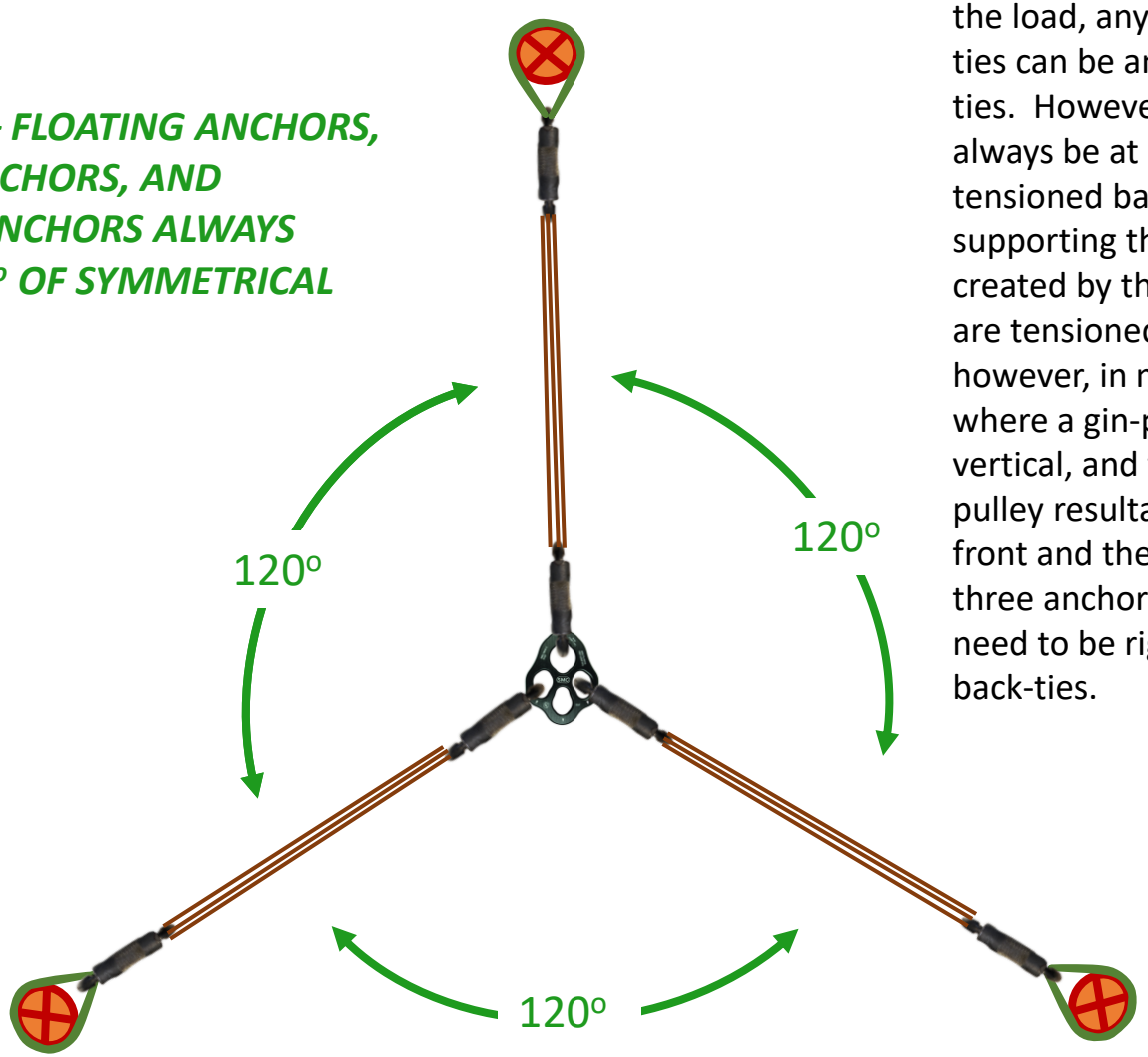
Quad Back-ties

Quad back-ties are easily the most stable and convenient method of securing a mono-pod (Gin-pole) high directional. Like the Delta back-tie systems, the Quads should be as close to symmetrical as possible, 90^{o} spacing between each back-tie. Whereas the Deltas must be right on 120^{o}, the Quads do allow for some 'fudging' on the spacing with any of the four back-ties not less the 30^{o} and not greater than 120^{o}. Once again, the engineering of these anchor configurations can become quite complex and typically requires substantial practice and experience to gain journeyman proficiency in this skill.

Further Discussion about Floating anchors

(Overhead View Schematics)

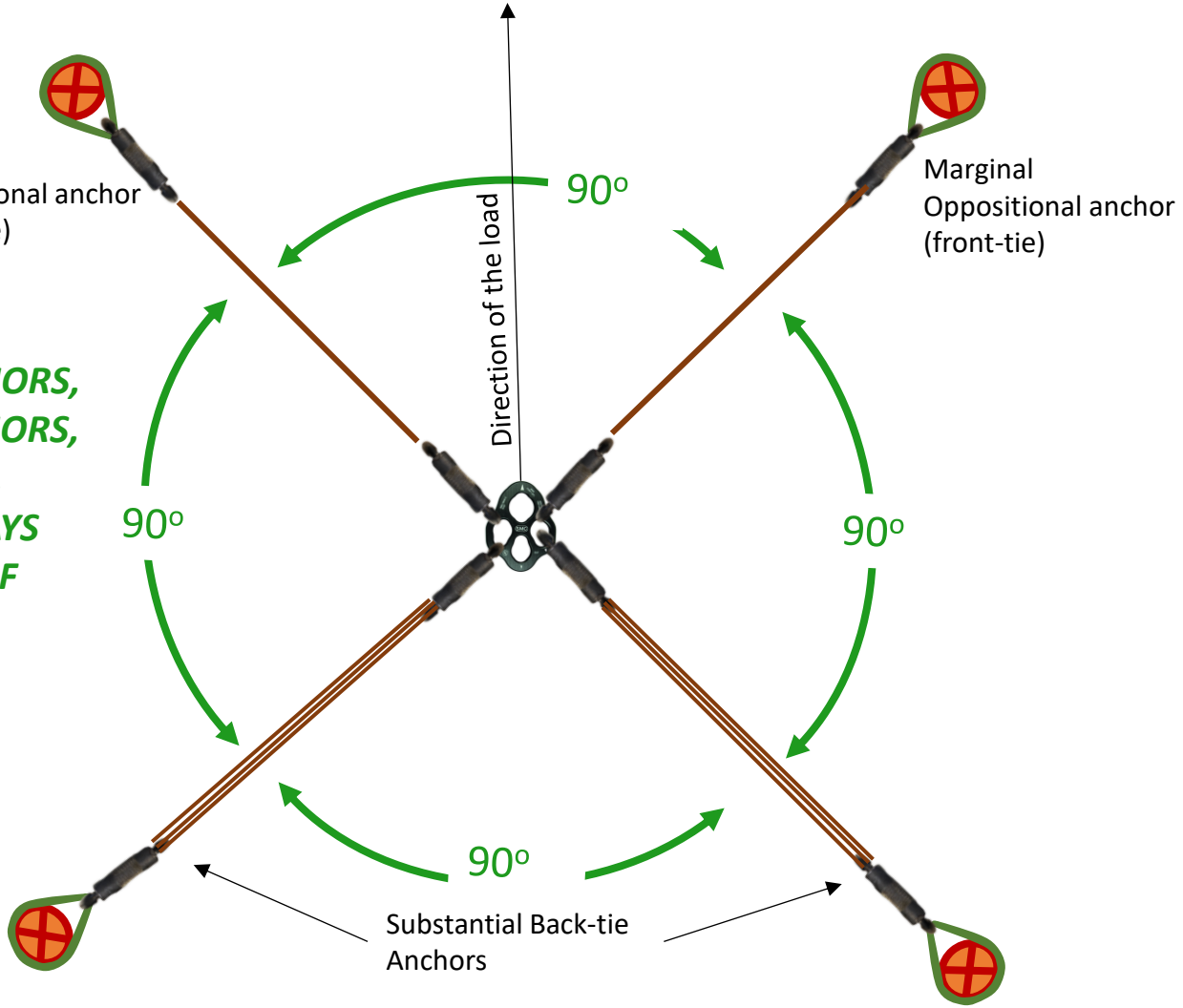
REMEMBER – FLOATING ANCHORS, ELEVATED ANCHORS, AND MARGINAL ANCHORS ALWAYS REQUIRE 360º OF SYMMETRICAL SUPPORT!



Depending on the direction of the load, any one of these back-ties can be an oppositional front-ties. However, there must always be at least one that is a tensioned back-tie that is supporting the intended forces created by the load. Usually two are tensioned back-ties, however, in many applications where a gin-pole is close to vertical, and the high directional pulley resultant can drift to the front and the back of the pole all three anchors may facilitate the need to be rigged as tensioned back-ties.

Further Discussion about Floating anchors

(Overhead View Schematics)



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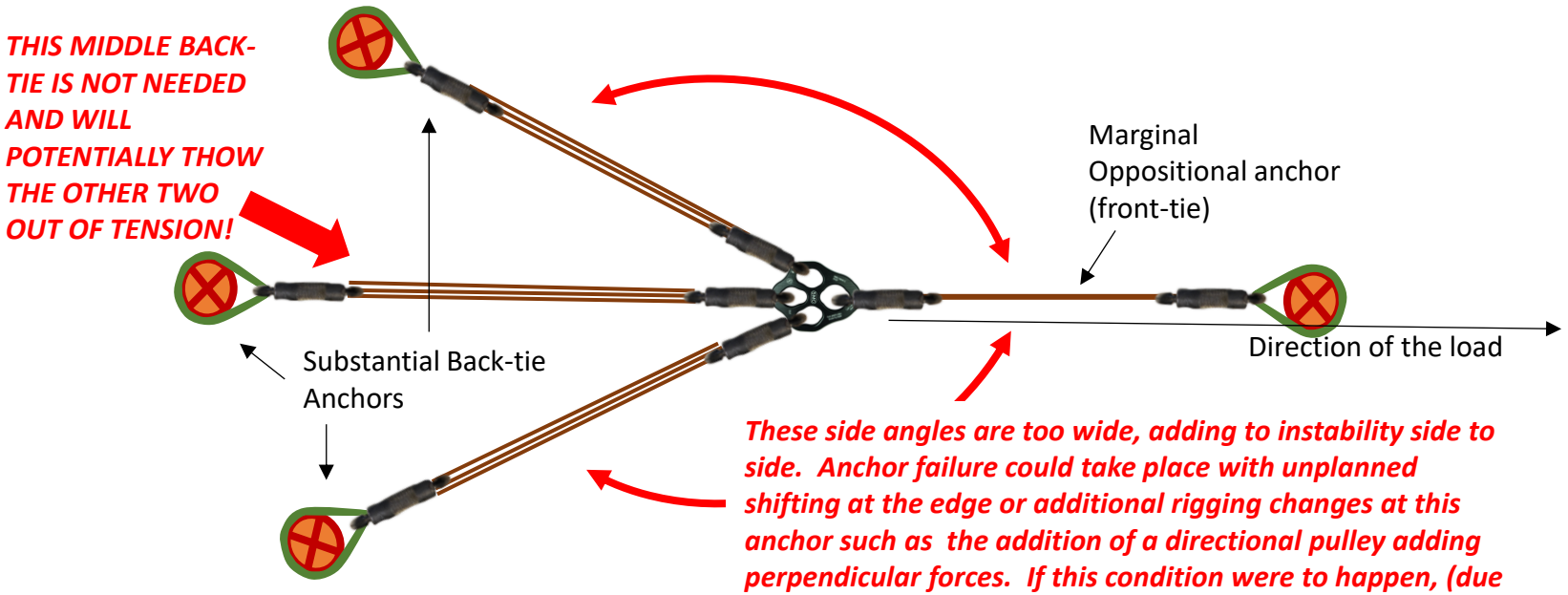
Further Discussion about Floating anchors

(Overhead View Schematics)

Why is this a poor rigging practice?

The prime directive of back-tying is to back-tie to substantial anchors, allowing that holding power to project forward to the floating anchor, or marginal anchor up front. When three tensioned back-ties are this close in proximity to each other, it becomes impossible to match equal tensioning to each anchor. One will always have more tension than the others. Given that these are bombproof anchors in the rear, there is simply no reason to have the middle back-tie in this scenario. This will typically throw the outer two back-ties out of balance.



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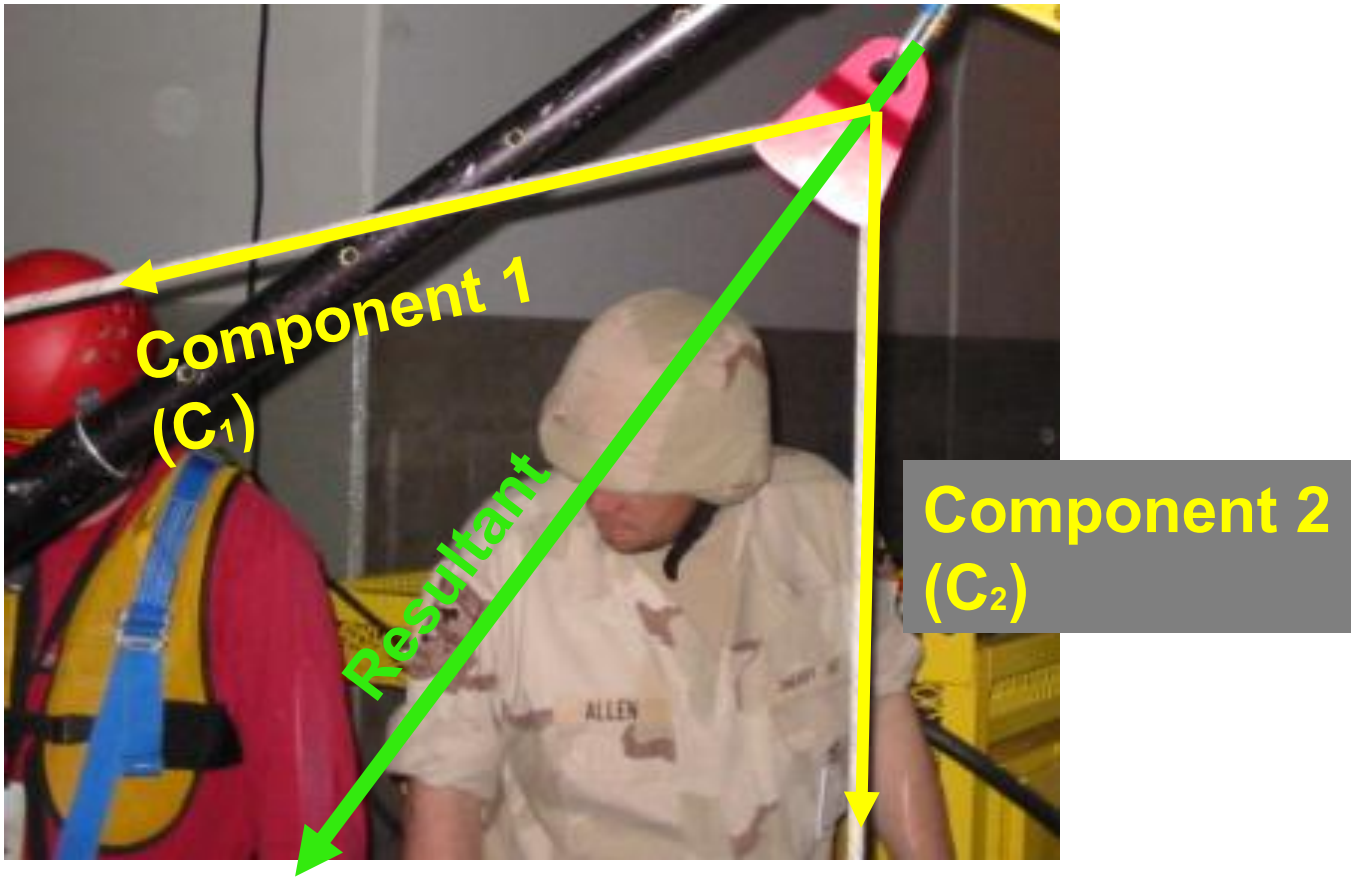
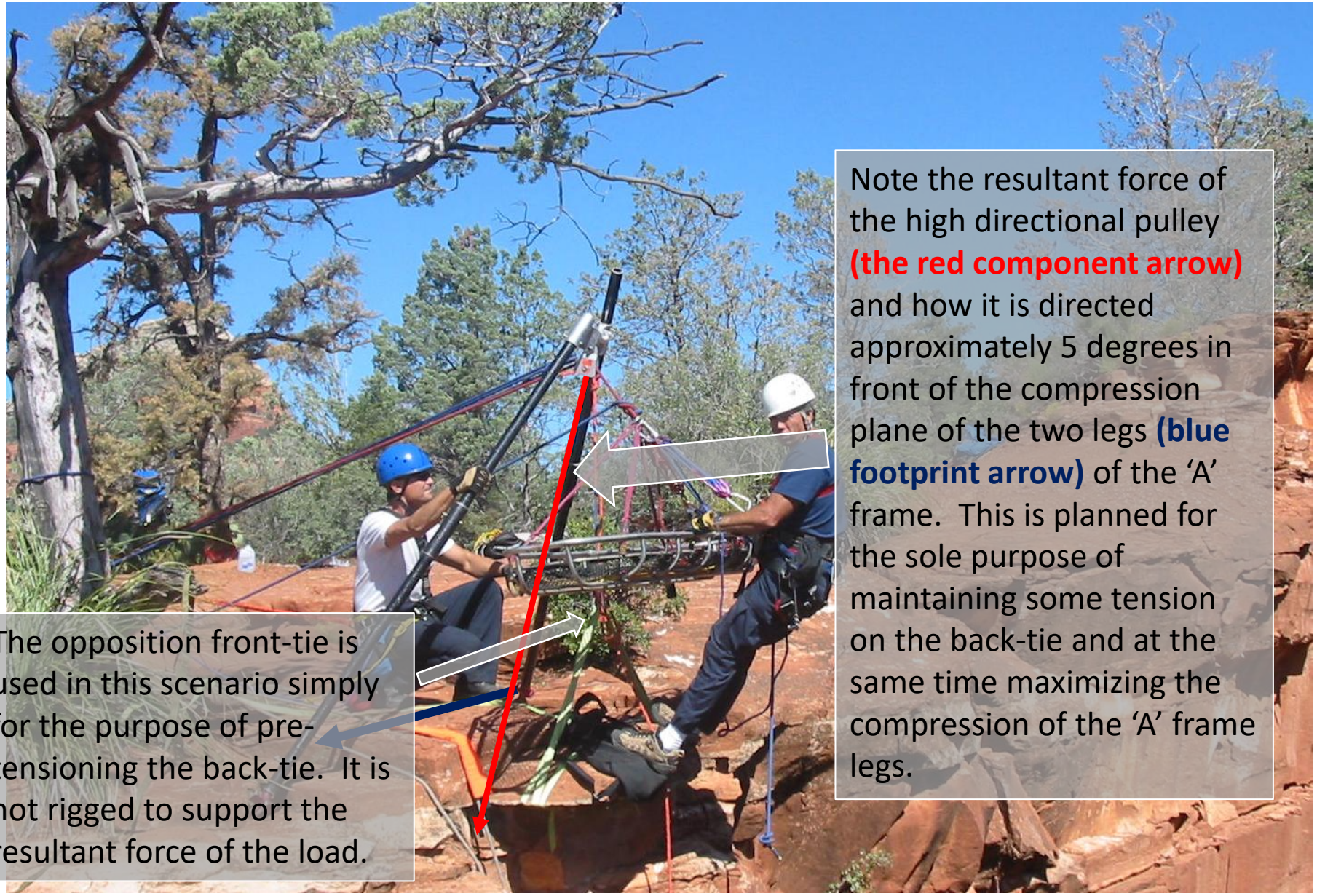
The direction indicated by the pulley while under tension, is <u>exactly</u> where the forces on the directional are going.



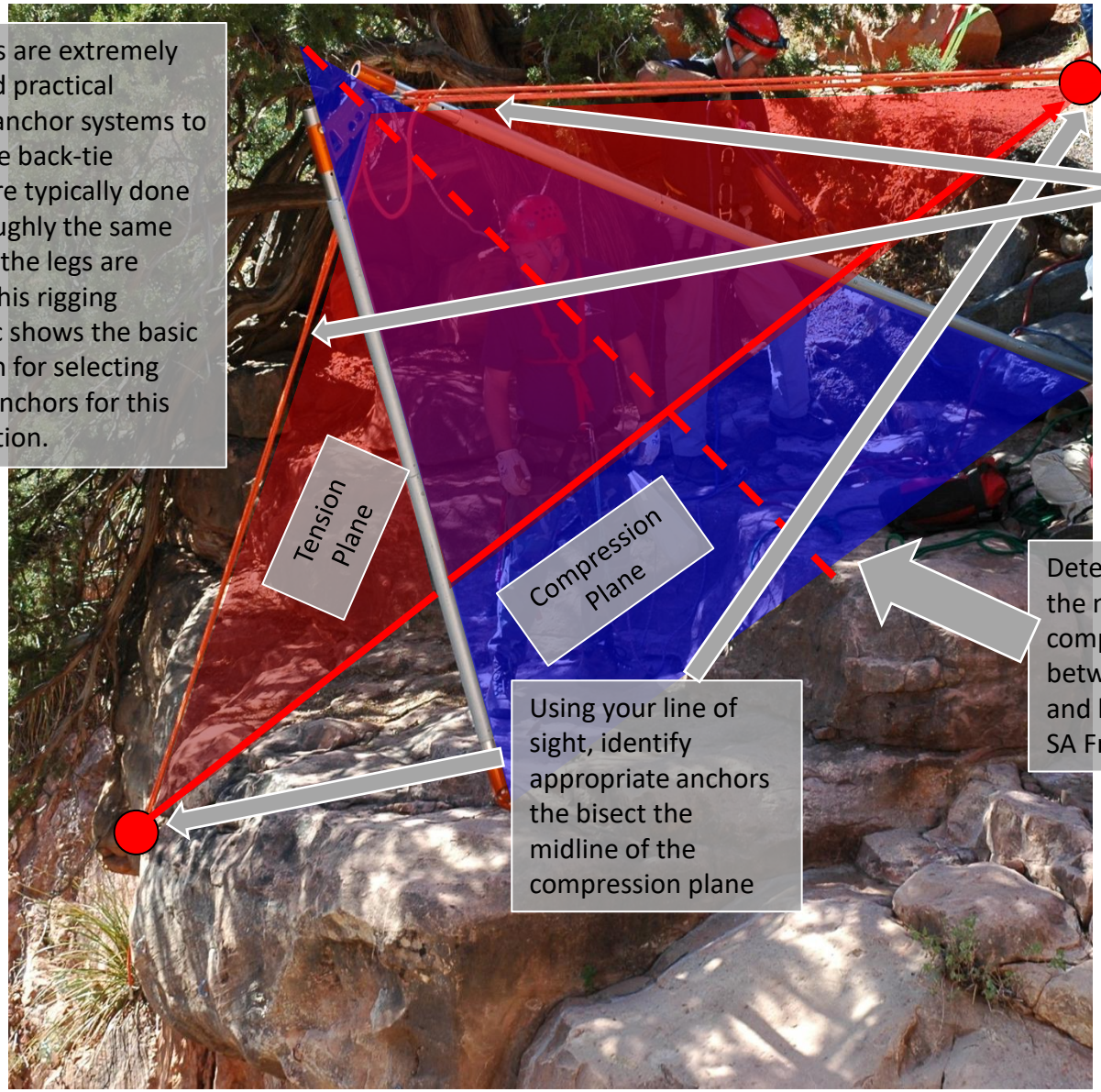


Note the resultant force of the high directional pulley **(the red component arrow)** and how it is directed approximately 5 degrees in front of the compression plane of the two legs **(blue footprint arrow)** of the 'A' frame. This is planned for the sole purpose of maintaining some tension on the back-tie and at the same time maximizing the compression of the 'A' frame legs.

The opposition front-tie is used in this scenario simply for the purpose of pre-tensioning the back-tie. It is not rigged to support the resultant force of the load.

Sideway ‘A’ Frame (SA Frame) Elevated Anchors

SA Frames are extremely useful and practical elevated anchor systems to rig. All the back-tie options are typically done on the roughly the same level that the legs are placed. This rigging schematic shows the basic game plan for selecting back-tie anchors for this configuration.

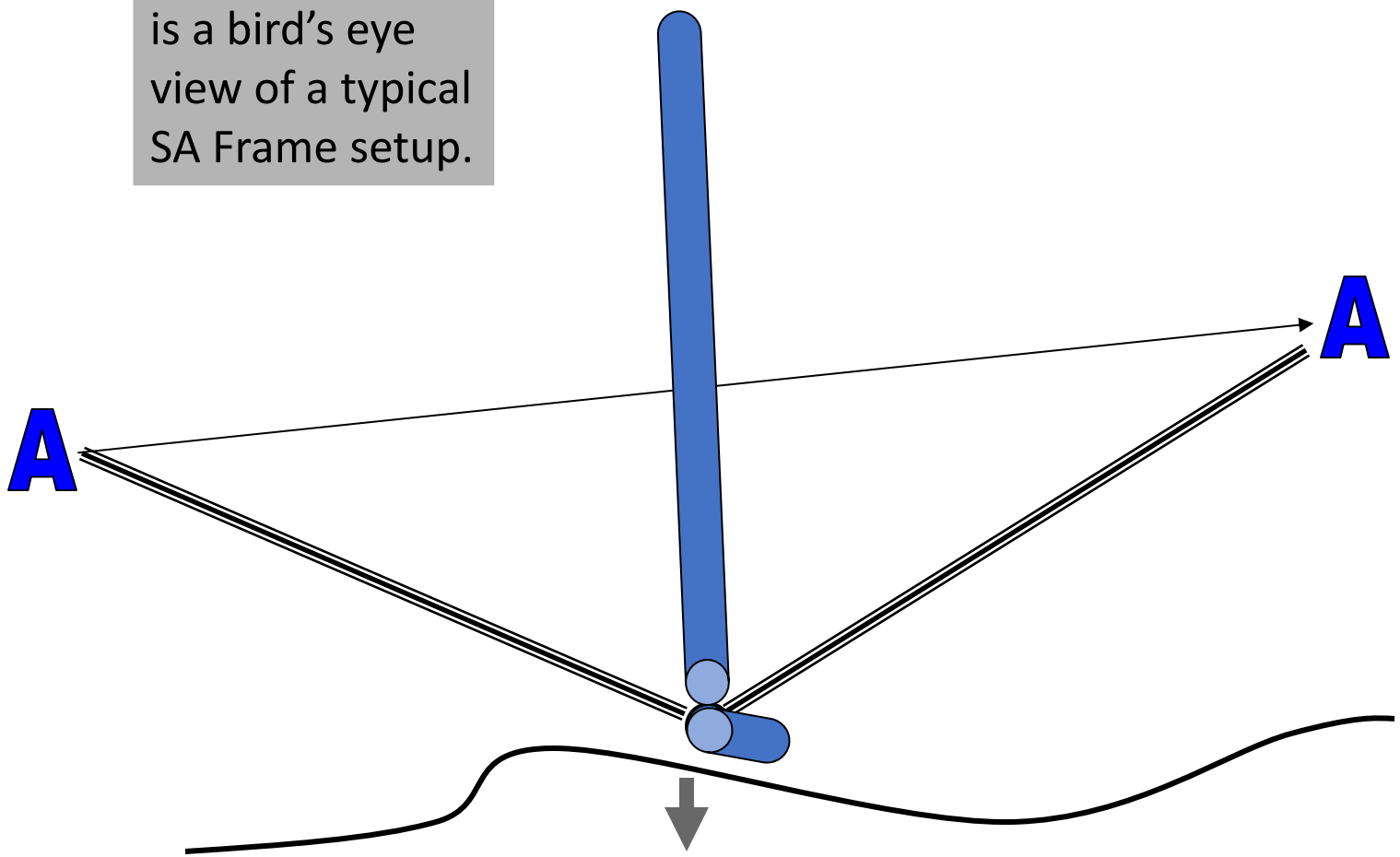


Rig the back-ties from the head of the elevated anchor to the selected back-tie anchors. This will render a tension plane creating four points of symmetrical support, two tensioned and two compression.

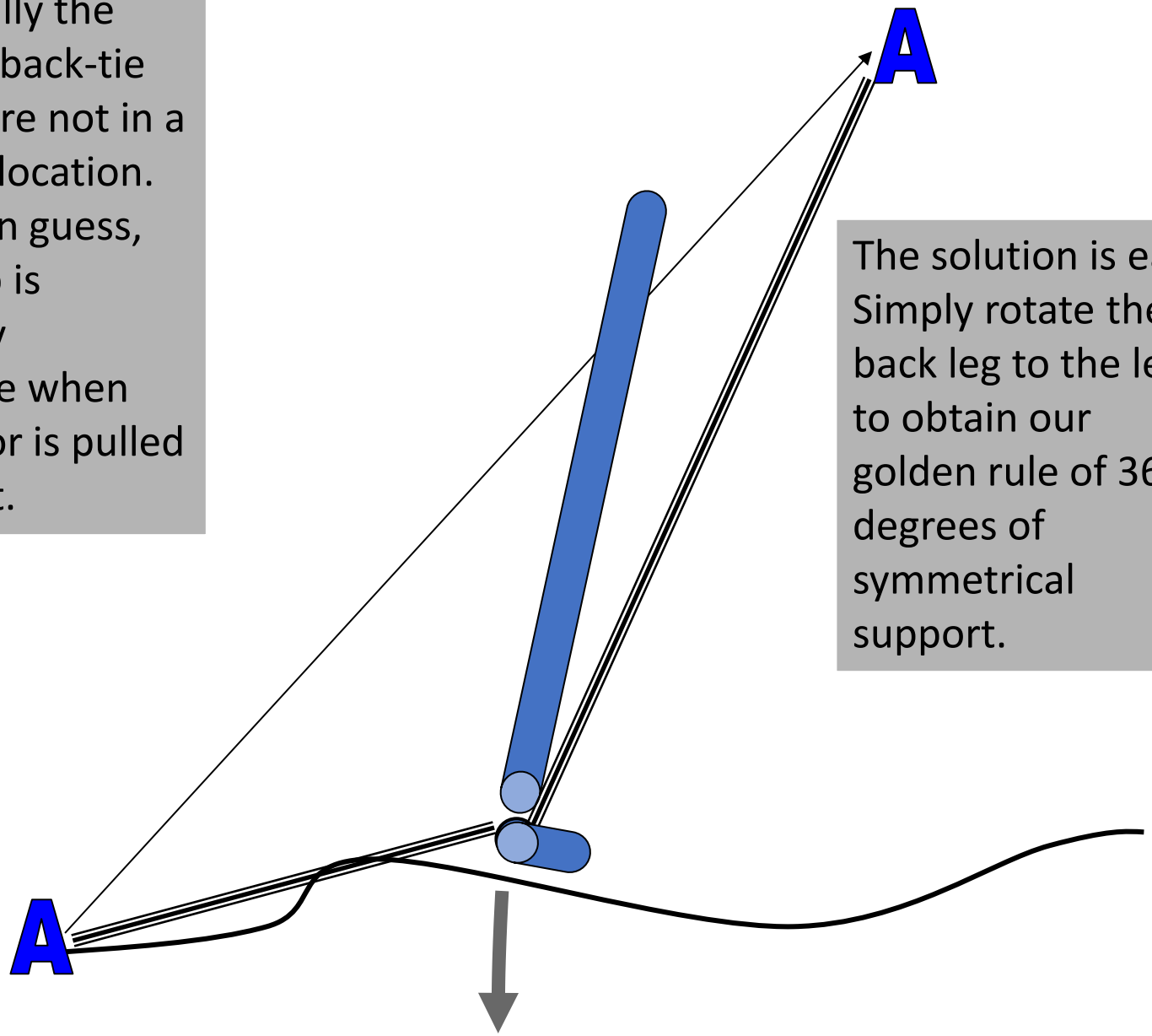
Determine roughly the mid-point of the compression plane between the front and back leg of the SA Frame

Using your line of sight, identify appropriate anchors the bisect the midline of the compression plane

This schematic is a bird's eye view of a typical SA Frame setup.



As is usually the case, our back-tie anchors are not in a textbook location. As you can guess, this setup is extremely vulnerable when the anchor is pulled to the left.



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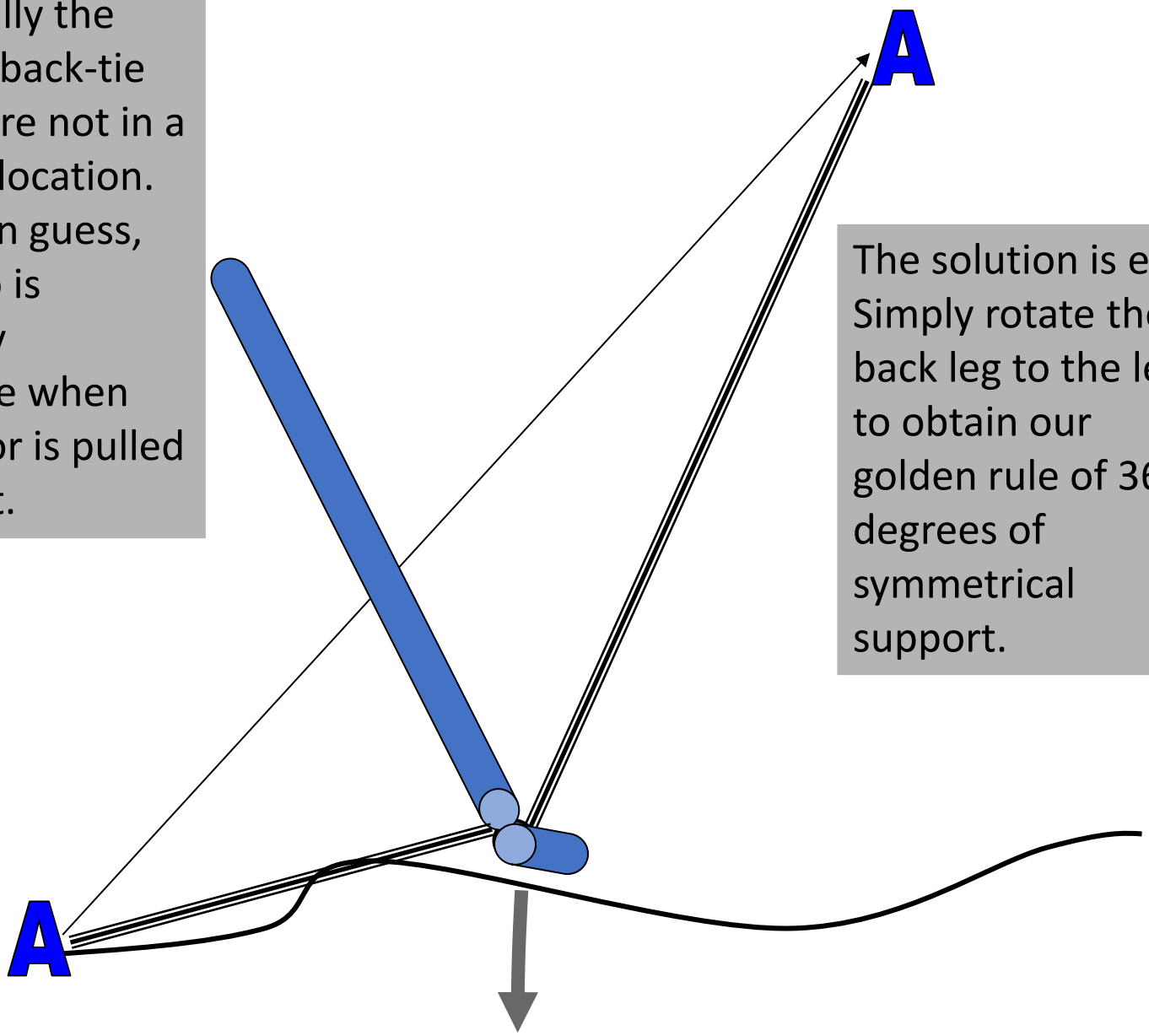
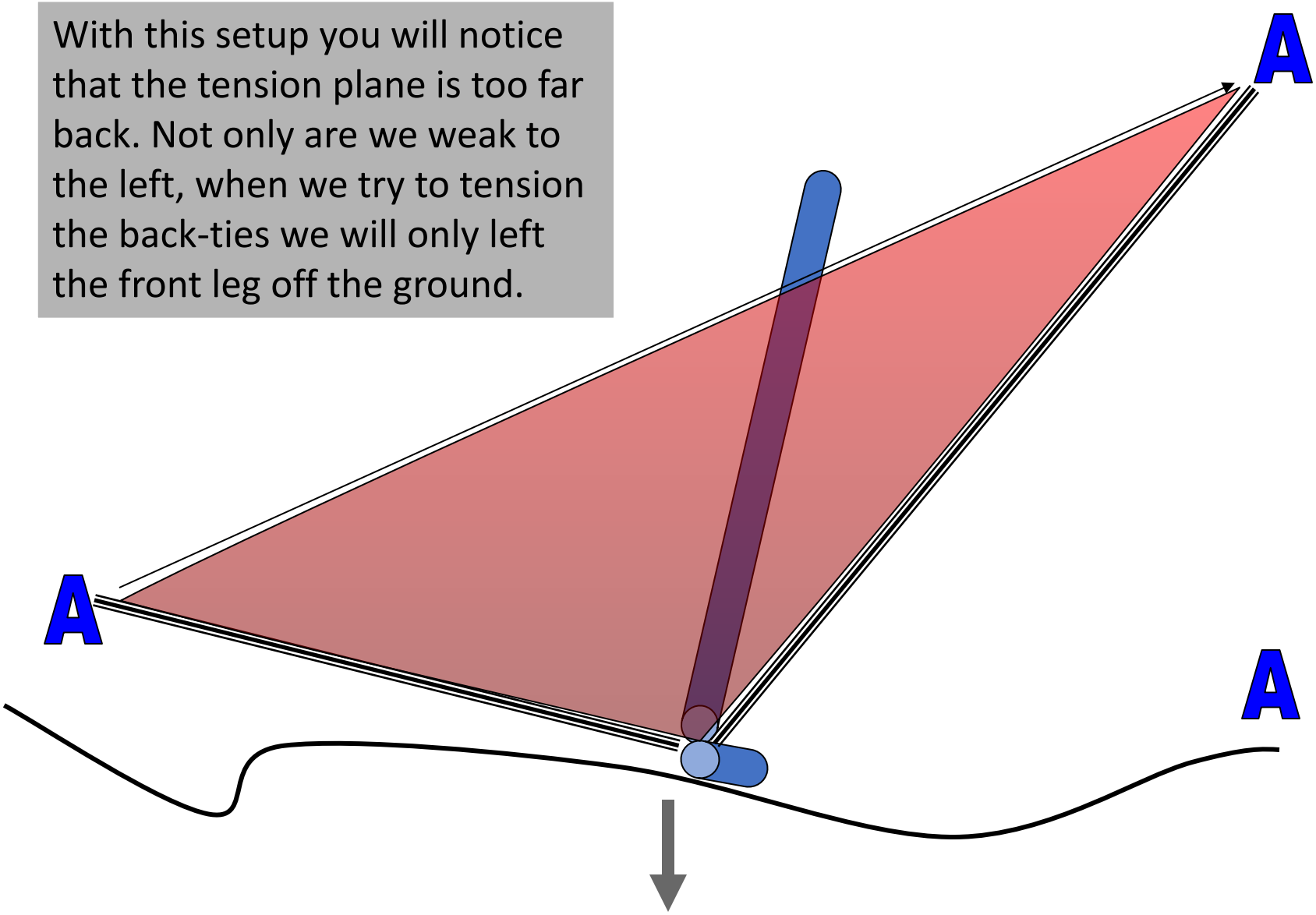


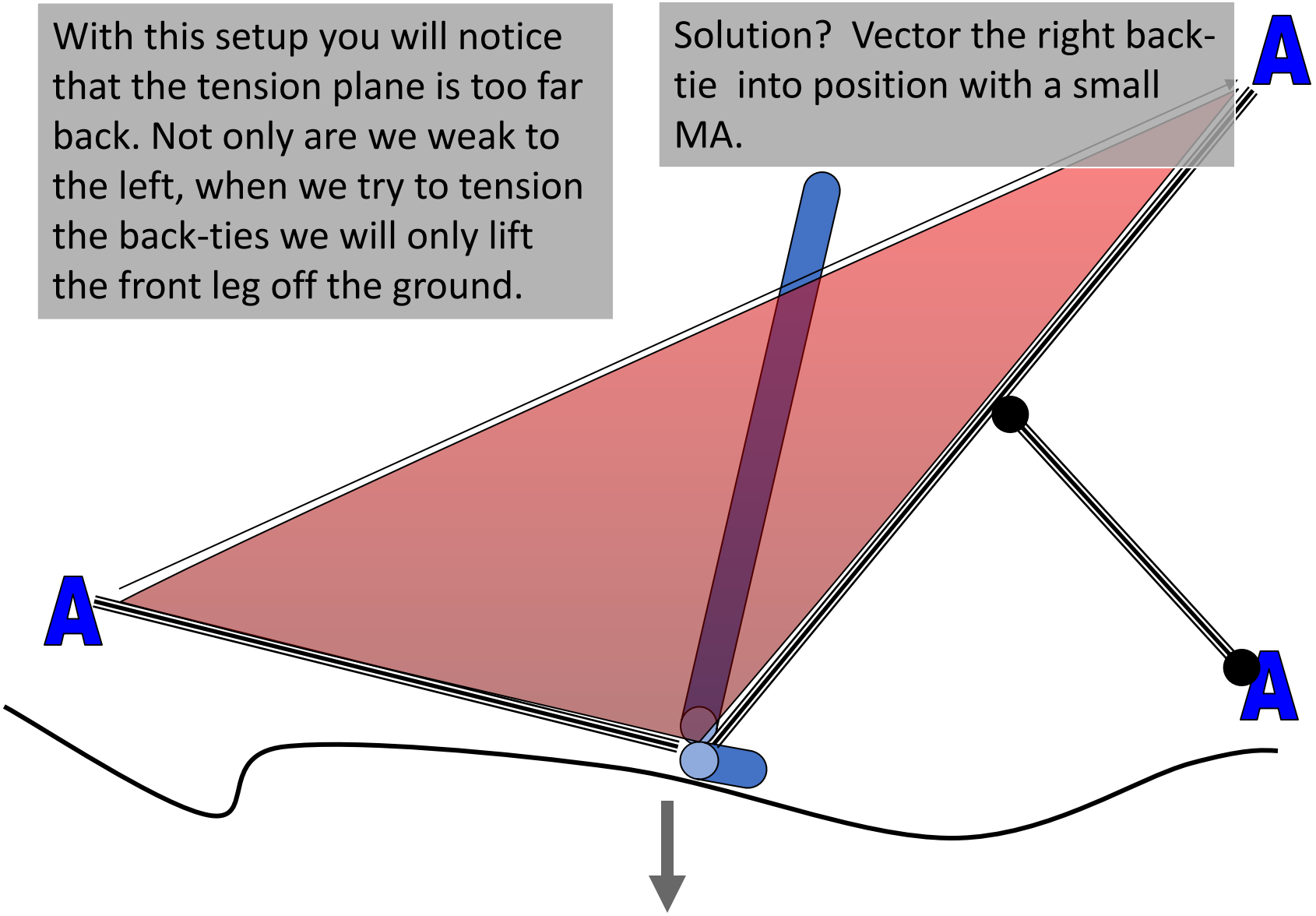
The solution is easy. Simply rotate the back leg to the left to obtain our golden rule of 360 degrees of symmetrical support.

With this setup you will notice that the tension plane is too far back. Not only are we weak to the left, when we try to tension the back-ties we will only left the front leg off the ground.



With this setup you will notice that the tension plane is too far back. Not only are we weak to the left, when we try to tension the back-ties we will only lift the front leg off the ground.

Solution? Vector the right back-tie into position with a small MA.



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