VT Prusik for Rescue Belays - Abstract

Rope rescue teams typically operate redundant two-rope systems with inclusion of a fail-safe mechanism for fall arrest. Examples include the MPD, 540° Rescue Belay, Petzl I'D, and Tandem Prusiks to name a few. Teams operating in remote environments with longer ingress/egress distances often favor lighter weight, multi-purpose systems and devices as part of their overall *mission profile.* In 2013, Rigging for Rescue began examining the Bluewater VT Prusik (configured as a Schwabisch 'Max over One' hitch) as an alternative to the Tandem Prusik Belay. In 2014, this author presented at ITRS quick look tests considering a variety of Aramid fiber friction hitches and configurations. Initial results for the VT Prusik were favorable and thus additional testing was warranted. Further testing was conducted in 2017 and 2019. The purpose was to critically examine the capabilities and limitations of the VT Prusik as a device suitable for managing fall arrest on a rope rescue system while lowering or raising a 200kg mass.

Since the 2014 ITRS presentation, three primary areas of inquiry include:

- The British Columbia Council on Technical Rescue – Belay Competence Drop Test Method (BCCTR BCDTM)
- Human operators using a snug top-rope while lowering
- Raising scenarios with a snug top-rope and human operators

Additionally, tests were conducted with the tensile testing machine on drop test sample ropes and Prusiks.

The laboratory style tests (i.e. BCCTR BCDTM) demonstrated favorable results that were within industry acceptable performance criteria for:

- Maximum arrest force
- Stopping distance
- Integrity of the device and rope system

The human operated tests we conducted produced results that compared favorably to other tests we have either witnessed or been made aware of utilizing Nylon TPB (with human operators).

Mechanical devices with purpose-built fail-safe mechanisms will undoubtedly prove more reliable for fall arrest versus a user-configured system such as Tandem Prusiks or the VT Prusik. However, for teams with specific mission profiles that place a high value on lightweight, multi-purpose equipment, the single VT Prusik configured as a Max over One, appears to be a superior alternative to the traditional Nylon Tandem Prusik Belay.

VT Prusik for Rescue Belays

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In 2013, Rigging for Rescue began testing the VT Prusik on the drop tower and the tensile testing machine in order to better understand the device qualities and performance limits. Our primary curiosity was to assess the VT Prusik as an alternative to the Nylon Tandem Prusik Belay system (TPB). Through a combination of laboratory style testing, human operated test scenarios, and anecdotal use, we have developed a clearer picture of the capabilities and limitations of the VT Prusik as it compares to the TPB. Our assessment is that the VT Prusik utilized with a specific configuration is a suitable and perhaps superior alternative to the TPB.

Mountain rescue teams operating in remote environments tend to favor lightweight systems that include versatile, multi-function components. However, despite employing more improvised systems and devices, risk management principles for the rope rescue systems being utilized in the backcountry still include criteria common to front-country approaches. Examples include: Reliable fall arrest, redundancy, usability, independence, and strength.

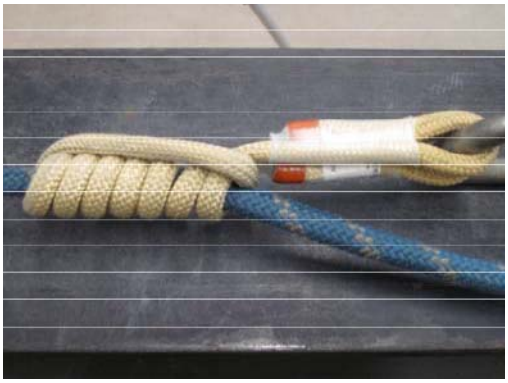
In seeking to meet these principles, backcountry SAR teams utilize devices such as the slot-style ATC descent control device, Italian Hitch (aka Münter Hitch), Prusik hitches as both rope grabs and backup systems, as well as independently rigged two-rope systems, and robust safety factors, just to name a few. Despite differences in devices and approaches across the industry, the end goal for all rope rescue teams is the same: devise a means of acceptably safe access to the patient's location and then transport them smoothly and reliably to definitive care.

In 2011, Rigging for Rescue began experimenting with the Bluewater VT Prusik in rope rescue systems. At that time, use of the VT Prusik as a tool for ropework was largely limited to the canyoneering community and arborists. Anecdotally, the VT performed well in commonly used friction hitch locations such as rappel back-up, mainline rope grab, and rope interface for knot-passing techniques. At ITRS 2014, this author presented initial findings from a small sample set of drop tests with the VT Prusik as the fall arrest device; the results appeared favorable. In the five years since that presentation, Rigging for Rescue principals have conducted a number of follow-up drop testing examinations – many of which have included human operators.

What is a VT Prusik?

The VT Prusik is manufactured by Bluewater Ropes and was originally designed by Rich Carlson of Canyons & Crags. The design is based on similar user-configured hitches from the arborist trade. The VT utilizes a kernmantle construction of a Technora sheath around a Nylon core. The terminal ends are bar tacked and rated to approximately 19kN. Because of the open-end construction of the VT (i.e. not a loop), a number of unique hitches can be configured. The VT testing conducted by Rigging for Rescue has largely focused on the Schwabisch hitch. The Schwabisch is an asymmetrical Prusik hitch that utilizes several wraps on the standing end side of the host rope and only one wrap on the running end. The colloquial term we have adopted for a VT configured by wrapping the entirety of the available material around the host rope as a Schwabisch hitch, is Max over One (i.e. Max/1).

VT Max/1
(6/1 on 11mm rope)



Testing Methods

The test methodologies utilized for examining the VT Prusik were as follows:

- The British Columbia Council on Technical Rescue, Belay Competence Drop Test Method (BCCTR BCDTM) using:
  - 11mm rope (7/16")
  - 9.5-10mm rope (3/8")
- Human operators managing a raising system in:
  - Dual tension mode {i.e. Two Tensioned Rope System (TTRS)}
  - Single tension mode {i.e. Single Main, Separate Belay (SMSB)}
- Human operators managing a lowering system in:

    - Dual tension mode
    - Single tension mode
- Tensile testing of drop test samples (i.e. slow pull), assessing for degradation from rated breaking strength

BCCTR BCDTM – 11mm host rope

In 2014, we conducted 13 drop tests using three different rope make/models to the BCDTM criteria with the fall arrest device as a VT 6/1 Schwabisch Hitch (i.e. Max/1). All tests passed the BCDTM examination parameters. In 2015, we conducted additional BCDTM tests focusing on slippage through the VT Prusik on heavily used ropes (Appendix 1; no force measurements recorded). Tests conducted with the VT configured as a symmetrical 3/3 Prusik hitch as well as an asymmetrical 4/1 Schwabisch hitch produced longer stopping distances. In fact, on four of the drop tests the test mass hit the ground. The results for VT Prusik configurations that deviate from a Max/1 Schwabisch hitch are highly variable relative to stopping distance. We observed similar long stop distances on 3/3 VT hitches in the 2014 test series presented at ITRS that year. As a result of the tests we have conducted to date, we do not recommend the VT Prusik as a symmetrical 3/3 hitch or as a 4/1, 4/2, etc. for use with a rescue load (i.e. 200kg or more); with rescue loads that could be subjected to any sort of dynamics, the VT should only be used as a Max/1 Schwabisch hitch.

Configured as a 5/1 or 6/1 on used PMI and New England ropes, the VT had a 100% catch rate over 10 drop tests. We chose to not collect force data during the 2015 drop test series. Previous tests with force data collection on BCDTM drops, indicated values well under the 15kN threshold for passing the examination. We were more interested in assessing fall arrest reliability on ropes that were heavily worn than on documenting force values. It should be noted that there is some variability in VT length from the manufacturer. As a result, some configurations of Max/1 on 11mm host rope utilize a 6/1 and some a 5/1. Based on testing we have conducted to date, the 5/1 appears to have slightly longer stop distances (Appendix 1).

BCCTR BCDTM – 9.5-10mm host rope

A number of mountain rescue teams whose Mission Profile includes longer ingress/egress distances to the patient's location, elect to use smaller diameter rescue ropes. Coupled with lighter weight hardware and devices, the smaller loads on responder's backs can aid in minimizing response time, rescuer fatigue, and affordability of other important PPE such as food, clothing, and shelter. The Ouray Mountain Rescue Team has been successfully conducting backcountry mountain rescues with 9.5mm host rope since the mid-2000s.

It is worth noting that the BCDTM was originally designed for 11mm host rope with a 200kg mass (2-person mountain rescue mass) and 12.5mm host rope with a 280kg test mass (2-person fire service mass). To our knowledge, no test parameters have been previously published with respect to changes in mass or fall factor when using smaller diameter rope such as 9.5mm. The designed fall event of a 1m drop on 3m of rope-in-service in a BCDTM examination is meant to simulate a severe scenario whereby the primary support rope fails during the initial edge transition in combination with minimal rope-in-service for arresting that fall (i.e. industrial setting with limited space available for increasing rope-in-service). The falling test mass is then arrested by the 3m of belay rope and the backup device affixed to that rope. An argument could be made that a true BCDTM test is well beyond the most severe event one would likely encounter in a mountain rescue setting utilizing 9.5mm ropes. However, due to the absence of an alternative test method and despite the low probability of ever encountering such a scenario in a backcountry setting, we elected to still utilize the BCDTM with a 200kg test mass in our testing of the VT Prusik on 9.5-10mm rope.

In August, 2019, we conducted BCDTM drop tests using 9.5-10mm host rope. In total, we utilized five different make/model combinations from three different manufacturers. All ropes utilized indicated a 3/8" equivalence in USA measurement despite the differences in tenths of mm. All ropes were brand new, unused. All VTs were brand new, unused as well. However, we elected to recycle VT Prusiks in the test series instead of conducting only one test per VT. Appendix 2 log sheet includes a column indicating the Belay Device Unit #; when that unit number repeats, it is an indication that the VT has been used previously.

Because of the diameter difference from 11mm to 9.5mm, a VT configured as a Max/1 provides for one additional wrap on 9.5mm rope. Depending on the exact VT length as well as the exact diameter (i.e. 9.5mm vs 10mm), we were able to rig either a 7/1 or 6/1 hitch. A total of five drop tests were conducted per rope make/model resulting in 25 tests in the data set. All tests passed the BCDTM criteria. The highest force recorded was 11.04kN (using a new rope with a VT that had been subject to two previous BCDTM drop tests). One of the tests resulted in a partial sheath rupture of the host rope. That rope sample was later tested on the slow pull tensile testing machine and the rope broke at the terminal knot as opposed to the damaged portion of the rope (Appendix 3).

<u>BCDTM as a rescue system litmus test</u>

Since the 1980s, the BCDTM has been the standard test methodology for evaluating rescue belay systems. It is a severe examination. Because of the combination of rigid mass of steel plates (200kg), no edge in the system, a steel overhead I-beam as the fall arrest anchor, and the high fall factor of 1/3, only a select few rescue belay systems successfully pass the examination with commonly used rope make/models. As such, different devices and systems that fail to pass the strict parameters of the BCDTM often end up being discarded by the rescue community as worthwhile alternatives. It is likely that there are other systems with high degrees of usability, ease of training, and adequate margins that could be suitable alternatives to currently used systems; but such systems are potentially underutilized due to perceptions of inadequacy as it pertains to BCDTM performance criteria.

It is the opinion of this author that the BCDTM is largely a mechanical engineering litmus test; one that focuses on a designed event meant to examine a very high force and low probability scenario. A worst-case event, if you will – from the standpoint of force generation. The general overriding philosophy of the BCDTM appears to be: if the system can pass this scenario, it seems reasonable to conclude it can pass all other scenarios. That may be somewhat true from a materials science/engineering point of view, but the omission of the BCDTM as a decision-making tool for rescue backup systems is that it does not include human operators. At Rigging for Rescue, we have evolved in our own decision-making insofar as what we deem to be valuable testing information. The BCDTM has a place in rescue backup system testing, but that place is not a "go vs. no go" as far as acceptance or rejection of a given system. We are much more interested in examining systems under more authentic operational conditions with human operators running the respective devices/systems.

<u>Raising systems with human operators</u>

In May 2019, we conducted 10 tests addressing raising systems with the VT Prusik as the fall arrest device. Three tests utilized dual tension raising systems and seven involved hand-tight backup belays with a single tension mainline. The test set-up involved a team of operators hauling on a mechanical advantage system(s) to raise a 200kg test mass. During the raising process we used a pre-rigged quick release mechanism to fail:

- One of the two dual tension systems
- The single mainline system, thereby transferring the weight to the remaining hand-tight belay system

Measurements were then recorded for fall arrest stopping distance. Some of the tests did utilize an alternative hitch to the Max/1 VT; we conducted three of the ten tests with the VT Prusik configured as a Distel hitch Max/1. All of the tests resulted in a successful fall arrest as well as short stopping distances (Appendix 5).

<u>Lowering system with human operators – TTRS; SMSB; SMSB Hybrid</u>

In June 2017, we conducted 108 drop tests of rescue lowering systems safeguarded by a VT Prusik and incorporating human operators (Appendix 4). Three primary styles of lowering systems were examined:

- TTRS – both systems rigged and operated similarly in load-sharing descent control
- SMSB – one system as the primary descent control (aka Main) and the backup as a hand-tight operation (aka Belay)
- SMSB Hybrid – both systems operated in load-sharing descent control, but the rigging/operation for the fall arrest system may not be identical to the failed system

In addition to the primary categories, there were numerous combinations of devices (e.g. ATC, Scarab), VT Prusik locations (e.g. running end of DCD or standing end of DCD), and Prusik minding technique (e.g. Hitchhiker grip or fingertip scissoring). Our objectives were to examine the VT Prusik with:

- A variety of devices

- A variety of locations relative to those devices
- A variety of rope management styles

In doing so, we cast a wide net. And therefore despite 108 lowering drop tests, we did not examine any one system or device combination & VT location to a robust degree. One fascinating human factor phenomenon was that we observed individual operator technique improve as the test series unfolded. When a device operator experienced a longer stop distance, they seemed to mentally catalog that event and then made subtle changes to their technique - often resulting in shorter stop distances on subsequent tests. The feedback loop for feeling what it is like to catch (or fail to catch) a falling rescue load appears to be a powerful learning tool for fine-tuning tactile methods.

For TTRS drop tests, we randomized which line was failed as both systems were being operated similarly. For SMSB tests, we always failed the primary descent control line leaving the hand-tight backup as the fall arrest system. For SMSB Hybrid tests, we always failed descent control system #1 and had fall arrest occur on descent control system #2. The name SMSB Hybrid implies that all of the tension at the start of the operation is on the mainline and the belay is operated hand tight. Then, once the initial edge transition was completed and consistent rope tension was achieved, the original belay system added a descent control device for the balance of the lower – essentially becoming a TTRS at that point. Despite the fall arrest portion of the test coming at a point whereby TTRS rope management methods were in place, we elected to always fail system #1 and have fall arrest occur on system #2 when examining SMSB Hybrid.

We did not conduct a robust number of Nylon Tandem Prusik Belay (TPB) tests to compare directly to VT Prusik performance. However, there have been a number of human operator TPB test series that have been presented at ITRS previously (e.g. Gibbs, ITRS 2007, Rescue Belays Long Lowers; Rocky Henderson/Dave Clarke, Portland Mountain Rescue, ITRS mid-2000s; Koprek, ITRS 2015) as well as others that we have been made aware of through correspondence (e.g. South Africa Mountain Rescue Association, 2014). The test results from these various examinations seem to indicate considerable variability due to differences in operator techniques as well as material qualities.

The nature of a friction hitch backup device is that in order to initiate and continue a lowering operation, the operator must mind (i.e. defeat) the hitch. It stands to reason that if a hitch can be minded, it can also be improperly minded. Of particular concern are techniques of Prusik-minding that rely on a specific action by the operator to initiate fall arrest. The fallibility of all friction hitch belay systems has undoubtedly led certain teams to adopt mechanical belay devices for their operations. However, mechanical devices have their own features and qualities that have to be well managed to ensure reliable results with human operators– particularly on a lowering operation while defeating the fail-safe mechanism of the device. Mechanical devices do not match the Mission Profile of many teams due to weight, cost, singularity of function, rope diameter tolerances, and a host of other variables. It is this author's suspicion that friction hitch backup systems for organized rope rescue will continue to be utilized for quite some time. Therefore, we need to continue to rigorously examine these systems in order to better understand their capabilities and limitations as well as optimize their overall reliability.

The 108 human factor VT drop tests we conducted in June 2017 - utilizing a variety of system configurations – produced results that compared favorably to other tests we have either witnessed or been made aware of utilizing Nylon TPB and human operators.

Tensile Testing

When we conduct drop testing to the BCDTM criteria, we inspect the host rope sample (after the drop test) for imperfections, excessive glazing, core shots, and the like. If we find damage, we note that on the log sheet. The sample is then taken to the tensile tester (slow pull) and examined end-to-end for knotted breaking strength. The objective is to assess if the damaged portion of the host rope has contributed to decreased tensile strength (i.e. degradation).

Appendix 3 outlines some 'quick look' tests from the 9.5-10mm host rope BCDTM test series conducted in August 2019. Two rope samples that had visible damage from drop tests with the VT were slow pulled to failure. Neither test resulted in failure of the rope in the damaged section; both tests resulted in failure in one of the end knots. And the strength values of these tests were similar to the baseline tests we conducted with new rope end-to-end and knotted.

Additionally, we pulled to failure a few of the VT Prusiks used in the drop test series. The VT sample with the lowest recorded strength broke at 16.2kN end-to-end, which is 85% of MBS. That particular VT had been subjected to three severe drop tests. It was a small slow pull data set, but there were no notable results indicating host rope or belay device degradation beyond acceptable parameters (i.e. BCDTM criteria).

Observations and Recommendations

As rope rescue trainers, the instructor cadre at Rigging for Rescue is afforded a unique opportunity to observe participant techniques as well as device/system qualities in action on any given training iteration. Based on our observations of friction hitch backup systems, we would categorize inherent risks into three broad categories:

1. *Human Factor* – poor technique associated with Prusik minding method; poor situational awareness of Prusik requirements for reliable fall arrest
2. *Equipment Factor* – fiber memory; lack of suppleness in fiber or construction; tends to spring open when configured as a Prusik hitch; poor friction interface with host rope
3. *Environmental Factor* – obstacles situated in front of Prusik(s) preventing fall arrest (e.g. an edge, rock mass); muddy, icy, wet conditions

Based on a combination of anecdotal observations in the field as well as drop test series incorporating human operators, it appears that the operator technique and the material quality are the most critical factors to proactively manage. Our own observations would lead us to conclude that the *Equipment Factor* is the easier of the two to reliably manage. Select a friction hitch system that:

- Is adequately robust in tensile strength (e.g. system safety factor)
- Can successfully arrest a severe dynamic event (i.e. BCDTM examination)
- Acts as a suitable heat sink for dissipating heat energy
- Utilizes supple cordage and a reliable configuration that consistently remains snug on the host rope

The equipment factor is largely a rigging consideration versus an operational consideration. Select high quality materials suitable for the task at hand. After that it is a matter of operating those materials within their design limits – a *Human Facto*r.

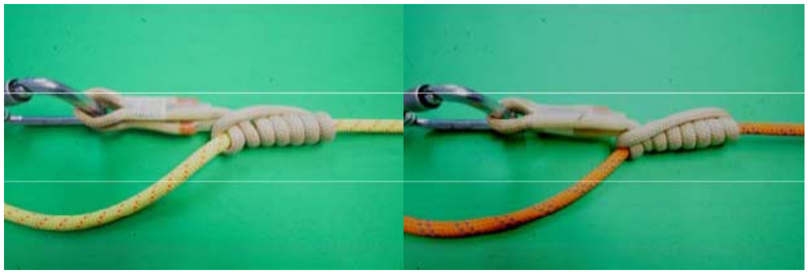
The human factors associated with managing a reliable friction hitch belay are numerous. Some are more critical than others. Three key considerations when operating a friction hitch belay are:

- The hitch should maintain a snug constriction around the host rope. Without a snug friction interface, the hitch becomes unreliable as a fall arrest device
- The operator should employ a technique that eliminates (as much as is reasonably possible) a specific action to initiate fall arrest. If we have to recognize a threat (i.e. rope acceleration) and then choose an action (e.g. let go of Prusik), the live cargo has already traveled an unacceptably far distance
- All of the anchor rigging material supporting the belay device should be taut prior to fall arrest. Semi-slack anchoring material introduces unnecessary stopping distance due to system elongation in fall arrest

In evaluating the capabilities and limitations of a VT Prusik Max/1 friction hitch belay versus a traditional Nylon TPB, the following considerations favor the VT Prusik:

- Only one device is required versus two in a TPB
    - simpler to rig/manage
- Same number of coils grabbing the standing part of the host rope with VT 6/1 as a TPB (which also grabs with 6 coils – 3 from each symmetrical triple-wrap Prusik hitch), accomplished with one device
- Aramid fiber sheath
    - abrasive fiber contributing to increased friction interface
    - heat resistant for withstanding a dynamic event
- Consistent suppleness of material from the manufacturer
    - We have yet to encounter a VT Prusik sample that lacks suppleness
    - Nylon Prusik material is highly variable across manufacturers (as well as batches within a given manufacturer) with respect to material suppleness. Cordage that is too stiff exhibits a tendency to spring open as a Prusik hitch and compromise the friction interface with the host rope
- Ability to use the same device across different rope diameters (i.e. 11mm and 9.5mm)
    - For teams that cache two rope diameters for front country (11mm) versus backcountry (9.5mm) operations, it is highly beneficial to only have to cache/train on one belay device

- For 11mm rope, a 6/1 VT is used. For 9.5mm rope a 7/1 VT is used



VT 6/1 on 11mm Rope **VT 7/1 on 9.5mm Rope**

- Rated MBS and not user-configured insofar as device construction (granted, user-configured when hitching on to host rope)
- As a Max/1, the sewn eyes of a VT present flush up against the bridge of the Prusik hitch

  - This is a *critical* quality to prevent loosening of the hitch while the host rope passes through - both on the lower and the raise
  - Nylon TPB presents a number of challenges in hitch loosening due to excessive material available for cycling into the coils of the hitch – this is of particular concern on a raising operation with a poorly sized TPB to PMP combination (i.e. excess material can cycle into the coils and loosen the Prusik hitch during the raising operation)

Limitations and/or cons of the VT versus the Nylon TPB include:

- Cost. The VT is more expensive than a user-configured set of Prusik loops made from generic 8mm Nylon cord

- Asymmetrical Max/1 configuration requires additional training and inspection criteria. The VT rigged backwards as a 1/Max configuration would only have one coil of cord gripping the standing part of the host rope
- A VT used in conjunction with a Prusik Minding Pulley (PMP) requires specific geometry in the rigging. A PMP with long side plates cannot occupy the same carabiner as the VT Max/1 without causing binding issues
    - The sewn eye terminations also add bulkiness to the carabiner clip when used in conjunction with a PMP. A larger HMS style carabiner is recommended
    - Additionally, splitting the sewn terminal ends to either side of the PMP seems to aid in properly lining up the VT during a raising operation. However, this does require pre-rigging the PMP to the VT carabiner prior to suspending a live load on the system (i.e. on a lower to raise scenario)

- Bluewater Ropes has some production variability in the overall length of the VT. Manufacturing lengths seem to deviate by as much as 6-7cm. A shorter VT may only allow a 5/1 configuration with 11mm rope whereas a longer VT may provide for enough length to configure a 7/1 on 11mm rope. Our experience is that a 7/1 is excessive friction with 11mm rope and operators have a difficult time managing rope travel through the VT. A 5/1 appears to be acceptable as a Max/1 (based on BCDTM test results) if there is inadequate material for configuring a 6/1 due to a shorter length VT

Our responsibility as rope rescue practitioners is to effectively identify and manage risks in our operations. We are charged with the safety of the patient as well as all of the responders. The systems and devices we elect to utilize all play a role in the overall success of the operation.

Having observed hundreds of rope rescue iterations as a trainer and responder, I have developed skepticism of the reliability of the Nylon TPB. On far too many occasions I have witnessed Prusiks that are too loose, too stiff, and/or improperly managed by the operator. I sometimes wonder whether or not we are “on belay”. That doubt is further buttressed by TPB human operated testing results from other researchers in addition to our own examinations (Rocky Henderson/Dave Clarke, Portland Mountain Rescue, ITRS mid-2000s; Koprek, ITRS 2015; Gibbs, ITRS 2007; South Africa Mountain Rescue Association, 2014). Simultaneously, I recognize that organizations with specific mission profiles will trend towards selecting lighter weight backup systems that do not include mechanical belay devices. Compared to the traditional Nylon TPB, the VT Max/1 appears to do a better job of mitigating some of the inherent risks in a friction hitch belay system. The most critical of those factors is that the VT Max/1 maintains a snug constriction around the host rope.

At Rigging for Rescue, our current recommendation is that if your team operates a traditional Nylon TPB, consider trying the VT Max/1 as an alternative. Properly configured, the VT will remain snug on the host rope. We believe it to be a superior choice to the TPB by virtue of not only testing results that we have observed, but also anecdotal evidence in the field of use by practitioners. The VT almost grips the host rope too well, but at least that contributes to it failing safe and arresting the fall. Additionally, we have never once observed a VT Max/1 fail to pass the BCDTM criteria with either 11mm or 9.5mm Nylon/Polyester host rope.

Special Thanks to the following:

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- Rocky Mountain Fire and Colorado Springs Fire Dept. for use of their fire training towers for drop testing
- Bluewater, Sterling, New England, and CMC for rope donations utilized in drop testing
- All of the device operators who participated in the drop test examinations

Test #	Start Time	Belay Device	Device Configuration	Rope Type: size, make, model	Initial Rope Length (cm)	Mass (kg)	Drop Height (cm)	FAS[1] Extension (cm)	Slide Distance @ Belay Device (cm)	Maximum Arrest Force (kN)	Comments
D062315-01	10:40	VT Prusik	3 over 3	used PMI EZ Bend - 11mm - Nylon	300	200	100	362.5	28.5	MNT[2]	heavy glazing on host rope
D062315-02	10:50	VT Prusik	3 over 3	used NE KMIII - 11mm - Nylon/ Poly Blend	300	200	100	Ground	148.5	MNT	rope slid through VT glazing all the way - Test Mass hit ground
D062315-03	11:05	VT Prusik	3 over 3	used NE KMIII - 11mm - Nylon/ Poly Blend	300	200	100	480	156	MNT	Bounced off ground - Load suspended at rest - Glazed rope all the way down
D062315-04	11:16	VT Prusik	3 over 3	Heavily used NE KMIII - 11mm Nylon/Poly Blend	300	200	100	Ground	MNT	MNT	glazing on rope
D062315-05	11:23	VT Prusik	3 over 3	used PMI EZ Bend - 11mm - Nylon	300	200	100	355	29.5	MNT	glazing on rope
D062315-06	11:34	VT Prusik	4 over 1	used PMI EZ Bend - 11mm - Nylon	300	200	100	396	35.5	MNT	heavy glazing on host rope
D062315-07	11:42	VT Prusik	4 over 1	Heavily used NE KMIII - 11mm Nylon/Poly Blend	300	200	100	473	135.5	MNT	Bounced off ground - Load suspended at rest - Glazed rope all the way down
D062315-08	11:51	VT Prusik	4 over 1	used NE KMIII - 11mm - Nylon/ Poly Blend	300	200	100	416	88	MNT	glazing on rope
D062315-09	12:02	VT Prusik	4 over 1	Heavily used NE KMIII - 11mm Nylon/Poly Blend	300	200	100	MNT	MNT	MNT	Bounced off ground - Load suspended at rest - Glazed rope all the way down
D062315-10	12:08	VT Prusik	4 over 1	used NE KMIII - 11mm - Nylon/ Poly Blend	300	200	100	413.5	88	MNT	glazing on rope
D062315-11	12:21	VT Prusik	5 over 1	used NE KMIII - 11mm - Nylon/ Poly Blend	300	200	100	416	75	MNT	glazing on rope
D062315-12	12:29	VT Prusik	5 over 1	Heavily used NE KMIII - 11mm Nylon/Poly Blend	300	200	100	405.5	65	MNT	glazing on rope
D062315-13	12:37	VT Prusik	5 over 1	used PMI EZ Bend - 11mm - Nylon	300	200	100	341.5	13.5	MNT	glazing on rope
D062315-14	12:45	VT Prusik	5 over 1	Heavily used NE KMIII - 11mm Nylon/Poly Blend	300	200	100	432.5	88.5	MNT	glazing on rope
D062315-15	12:55	VT Prusik	5 over 1	used NE KMIII - 11mm - Nylon/ Poly Blend	300	200	100	402	61	MNT	glazing on rope
D062315-16	1353	VT Prusik	6 over 1	used NE KMIII - 11mm - Nylon/ Poly Blend	300	200	100	381	41	MNT	glazing on rope
D062315-17	14:01	VT Prusik	6 over 1	Heavily used NE KMIII - 11mm Nylon/Poly Blend	300	200	100	381	38.5	MNT	heavy glazing on host rope
D062315-18	14:08	VT Prusik	6 over 1	used PMI EZ Bend - 11mm - Nylon	300	200	100	337	12	MNT	
D062315-19	14:21	VT Prusik	6 over 1	Heavily used NE KMIII - 11mm Nylon/Poly Blend	300	200	100	408.5	69	MNT	heavy glazing on host rope
D062315-20	14:29	VT Prusik	6 over 1	used NE KMIII - 11mm - Nylon/ Poly Blend	300	200	100	366.5	67	MNT	

[1] Fall Arrest System
[2] Measurement Not Taken

Test #	Start Time	Belay Device	Device Configuration	Belay Device Unit #	Host Rope: Make, Model, Color	Host rope fibers (sheath/core)	Initial Rope Length (cm)	Mass (kg)	Drop height (cm)	Slide distance @ Belay Device (cm)	FAS[1] extension (cm)	Maximum Arrest Force (kN)	Comments
D-081219-01	1140	VT Prusik	7 over 1	1	Bluewater, Safeline, Blue/Yellow	Polyester/ Nylon	300	200	100	60	386	MNT[2]	Moderate glazing
D-081219-02	1158	VT Prusik	7 over 1	2	Bluewater, Safeline, Blue/Yellow	Polyester/ Nylon	300	200	100	56	380	7.66	Moderate glazing
D-081219-03	1221	VT Prusik	7 over 1	3	Bluewater, Safeline, Blue/Yellow	Polyester/ Nylon	300	200	100	50	376	8.18	Moderate glazing
D-081219-04	1231	VT Prusik	7 over 1	4	Bluewater, Safeline, Blue/Yellow	Polyester/ Nylon	300	200	100	44	374	8.84	Moderate glazing
D-081219-05	1243	VT Prusik	7 over 1	5	Bluewater, Safeline, Blue/Yellow	Polyester/ Nylon	300	200	100	49	374	7.74	Moderate glazing
D-081219-06	1254	VT Prusik	7 over 1	6	NE, KMIII, Blue/White	Polyester/ Nylon	300	200	100	43	372	8.24	Partial sheath rupture near middle of glazed section - moderate glazing
D-081219-07	1300	VT Prusik	7 over 1	7	NE, KMIII, Blue/White	Polyester/ Nylon	300	200	100	38	356	8.26	Moderate glazing
D-081219-08	1308	VT Prusik	7 over 1	8	NE, KMIII, Blue/White	Polyester/ Nylon	300	200	100	42	363	7.98	Moderate glazing
D-081219-09	1316	VT Prusik	7 over 1	1	NE, KMIII, Blue/White	Polyester/ Nylon	300	200	100	52	367	7.26	Moderate glazing
D-081219-10	1324	VT Prusik	7 over 1	2	NE, KMIII, Blue/White	Polyester/ Nylon	300	200	100	65	383	7.32	Couple pics of the VT sheath are blown out
D-081219-11	1425	VT Prusik	6 over 1	9	Sterling, WorkPro, White/Orange/Black	Polyester/ Nylon	300	200	100	57	374	6.42	Very mild glazing - noticeably less than previous drops
D-081219-12	1434	VT Prusik	6 over 1	10	Sterling, WorkPro, White/Orange/Black	Polyester/ Nylon	300	200	100	64	388	6.5	Very mild glazing - noticeably less than previous drops
D-081219-13	1440	VT Prusik	7 over 1	3	Sterling, WorkPro, White/Orange/Black	Polyester/ Nylon	300	200	100	40	366	7.76	Moderate glazing just under the final VT position
D-081219-14	1447	VT Prusik	7 over 1	4	Sterling, WorkPro, White/Orange/Black	Polyester/ Nylon	300	200	100	34	357	7.86	Small spot with sheath close to rupture
D-081219-15	1454	VT Prusik	7 over 1	5	Sterling, WorkPro, White/Orange/Black	Polyester/ Nylon	300	200	100	41	369	8.42	Moderate glazing
D-081219-16	1500	VT Prusik	7 over 1	11	Sterling, SuperStatic2, White/Black	Nylon/ Nylon	300	200	100	17	344	9.34	Inverted the hitch - mild glazing to Moderate glazing under the hitch
D-081219-17	1513	VT Prusik	6 over 1	12	Sterling, SuperStatic2, White/Black	Nylon/ Nylon	300	200	100	20	349	9.8	Capsize the bridge of VT to be non-releasable post drop
D-081219-18	1523	VT Prusik	7 over 1	6	Sterling, SuperStatic2, White/Black	Nylon/ Nylon	300	200	100	36	359	MNT	No capsize - easier to break the VT loose - Moderate glazing
D-081219-19	1531	VT Prusik	7 over 1	7	Sterling, SuperStatic2, White/Black	Nylon/ Nylon	300	200	100	15	343	10.32	No capsize of bridge - easier to break - mild glazing on standing - moderate glazing under hitch
D-081219-20	1537	VT Prusik	7 over 1	8	Sterling, SuperStatic2, White/Black	Nylon/ Nylon	300	200	100	33	356	8.94	Moderate glazing
D-081219-21	1545	VT Prusik	6 over 1	13	Sterling, HTP, White/Blue	Polyester/ Polyester	300	200	100	46	358	8.48	Moderate glazing
D-081219-22	1551	VT Prusik	6 over 1	14	Sterling, HTP, White/Blue	Polyester/ Polyester	300	200	100	51	365	7.66	Moderate glazing - easy to break
D-081219-23	1557	VT Prusik	7 over 1	1	Sterling, HTP, White/Blue	Polyester/ Polyester	300	200	100	33	348	9.74	Harder to break hitch - moderate glazing
D-081219-24	1602	VT Prusik	7 over 1	2	Sterling, HTP, White/Blue	Polyester/ Polyester	300	200	100	34	346	9.94	Slight rain starting to fall - easy to break (due to no capsize?) - moderate glazing
D-081219-25	1608	VT Prusik	7 over 1	3	Sterling, HTP, White/Blue	Polyester/ Polyester	300	200	100	22	338	11.04	Light rain during test
D-081319-01	947	VT Prusik	7 over 1	4	Bluewater, Atlas, Toughline		300	200	50	18	328	9.24	Capsized the bridge of hitch
D-081319-02	959	VT Prusik	7 over 1	5	Bluewater, Atlas, Toughline		300	200	100	87	397	7.34	
D-081319-03	1109	VT Prusik	7 over 1	6	Sterling, SuperStatic2, White/Black	Nylon/ Nylon	300	200	60	3	334	9.04	Approx. 90 degree edge in system (wood w/ 4 layers canvas)
D-081319-04	1149	VT Prusik	7 over 1	7	Sterling, SuperStatic2, White/Black	Nylon/ Nylon	300	200	60	14	342	8.94	Approx. 90 degree edge in system (wood w/ 4 layers canvas) -
D-081319-05	1205	VT Prusik	7 over 1	8	Sterling, SuperStatic2, White/Black	Nylon/ Nylon	300	200	60	12	336	8.18	Approx. 90 degree edge in system (wood w/ 4 layers canvas) -
D-081319-06	1212	VT Prusik	6 over 1	9	Sterling, HTP, White/Blue	Polyester/ Polyester	300	200	60	20	329	9.12	Approx. 90 degree edge in system (wood w/ 4 layers canvas)
D-081319-07	1221	VT Prusik	6 over 1	10	Sterling, HTP, White/Blue	Polyester/ Polyester	300	200	60	29	345	8.06	Approx. 90 degree edge in system (wood w/ 4 layers canvas)
D-081319-08	1230	VT Prusik	7 over 1	1	Sterling, HTP, White/Blue	Polyester/ Polyester	300	200	60	5	316	10.6	Approx. 90 degree edge in system (wood w/ 4 layers canvas)
D-081319-09	1329	VT Prusik	7 over 1	2	Sterling, WorkPro, White/Orange/Black	Polyester/ Nylon	300	200	60	5	335	8.7	Approx. 90 degree edge in system (wood w/ 4 layers canvas)
D-081319-10	1334	VT Prusik	7 over 1	3	Sterling, WorkPro, White/Orange/Black	Polyester/ Nylon	300	200	60	5	334	8.54	Approx. 90 degree edge in system (wood w/ 4 layers canvas)
D-081319-11	1338	VT Prusik	6 over 1	11	Sterling, WorkPro, White/Orange/Black	Polyester/ Nylon	300	200	60	39	369	6.84	Approx. 90 degree edge in system (wood w/ 4 layers canvas)

[1] Fall Arrest System

[2] Measurement Not Taken

Test #	Start Time	Test Sample Configuration	MBS [1](kN)	Cordage Type: size & brand	Host Rope: Make, Model, Color	Breaking force (kN)	Comments
SP-081319-01	1428	New knotted breaking strength - fig 8 to fig 8	29		Sterling, WorkPro, White/Orange/Black	20.04	Knotted strength = 70% of MBS
SP-081319-02	1456	New knotted breaking strength - fig 8 to fig 8	30.1		Bluewater, Safeline, Blue/Yellow	19.78	Knotted strength = 65.7% of MBS
SP-081319-03	1459	New knotted breaking strength - fig 8 to fig 8	27		NE, KMIII, Blue/White	15.06	Knotted strength = 55.7% of MBS
SP-081319-04	1504	New knotted breaking strength - fig 8 to fig 8	23		Sterling, SuperStatic2, White/Black	19.64	Knotted strength = 85.4% of MBS
SP-081319-05	1509	New knotted breaking strength - fig 8 to fig 8	26.6		Sterling, HTP, White/Blue	21	Knotted strength = 78.9% of MBS
SP-081319-06	1516	D-081219-14 - Overhand to Overhand	29		Sterling, WorkPro, White/Orange/Black	17.6	Broke at overhand knot - did not break at the damaged section. Knotted strength = 60.7% of MBS
SP-081319-07	1522	D-081219-06 Overhand to Overhand	27		NE, KMIII, Blue/White	15.42	Broke at the knot - not at the damaged section. Knotted strengt = 57.1% of MBS
SP-081319-08	1526	D-081219-04 Overhand to Overhand	30.1		Bluewater, Safeline, Blue/Yellow	17.76	Knotted strength = 59% of MBS
SP-081319-09	1529	D-081219-18 Overhand to Overhand	23		Sterling, SuperStatic2, White/Black	16.68	Knotted strength = 72.5% of MBS
SP-081319-10	1531	D-081219-22 Overhand to Overhand	26.6		Sterling, HTP, White/Blue	18.86	Knotted strength = 70.9% of MBS
SP-081319-11	1542	D-081319-02	19	VT #5 from drop test		MNT [2]	
SP-081319-12	1545	VT #1. End-to-end	19			17.06	
SP-081319-13	1549	VT #3. End-to-end	19			19.46	Identified most abraded portion from drop test with sharpie & it started to rupture the sheath at that location during test
SP-081319-14	1552	VT #2. End-to-end	19			16.2	Identified most abraded portion from drop test with sharpie & it started to rupture the sheath at that location during test

[1] Minimum Breaking Strength

[2] Measurment Not Taken

Test #	Test Configuration	System #1 Operator #	System #1 - Device (running/standing) (Red system)	Rope Type: size, make, model	System #2 Operator #	System #2 - Device (running/standing) (Blue system)	Rope Type: size, make, model	Rope in Service	Mass	Fall Arrest System	Stop Distance	Comments from operator and/or system technique description	RfR comments
HF-062517-02	SMSB				1	VT 6 over 1	11mm, NE, KMIII	680 cm	200kg	VT	150cm		technique coaching
HF-062517-05	SMSB				2	VT 6 over 1	11mm, CMC, Lifeline (Red)	680cm	200kg	VT	134cm		
HF-062517-08	SMSB				3	VT 6 over 1	11mm, CMC, Static Pro (Blue)	680cm	200kg	VT	Long	"felt like it was in the middle of the pull NOTE: test mass tapped the groun during FAS extension. Final resting position was off the ground, but FAS extensio was a few meters. We basically ran out of drop tower before fall arrest was complete	n appeared to fail as the operator was pulling rope through anchor side hand - operator appeared to hesitate with anchor side hand more inline with the direction of pull - minor glazing of the host ro
HF-062517-11	SMSB				4	VT 6 over 1	11mm, NE, KMIII	680cm	200kg	VT	134cm	"this would be tiring over long lower"	
HF-062517-15	SMSB				5	VT 6 over 1	11mm, NE, KMIII	680cm	200kg	VT	118cm	"Similar to TPB. More simple due to less material to manage"	
HF-062517-16	SMSB				6	VT 6 over 1	11mm, CMC, Lifeline (Red)	680cm	200kg	VT	174cm	"snaps the fingers"	
HF-062517-20	SMSB				7	VT 6 over 1	11mm, CMC, Lifeline (Red)	680cm	200kg	VT	175cm	"felt like there was more of a threat to bodily harm"	
HF-062517-23	SMSB				8	VT 6 over 1	11mm, NE, KMIII	680cm	200kg	VT	186cm	"more to remember with hitch technique" "i feel like the failure occurred on my upstroke"	failure appeared to occur on upstroke
HF-062617-01	TTRS	5	ATC / VT	11mm, CMC, Lifeline (Red)	6	ATC / VT	11mm, CMC, Static Pro (Blue)	680cm	200kg	#2	132cm		Catch - no hitch activation - noticeable acceleration through operator's hands - operators instructe peg the VT against the device
HF-062617-03	TTRS	5	VT / ATC	11mm, CMC, Static Pro (Blue)	6	VT / ATC	11mm, NE, KMIII	680cm	200kg	#1	147cm	"started to fall, I had to think to let go."	catch - VT actuated
HF-062617-04	TTRS	3	ATC / VT	11mm, NE, KMIII	5	ATC / VT	11mm, CMC, Lifeline (Red)	680cm	200kg	#1	197cm	"Felt easy to defeat." "My instinct as a climber is to pull back on the rope."	catch - Reacted to acceleration of rope - appeared to pull back then forward
HF-062617-06	TTRS	3	VT / ATC	11mm, CMC, Lifeline (Red)	5	VT / ATC	11mm, CMC, Static Pro (Blue)	680cm	200kg	#1	117cm	"conscious effort to release prusik." "reaction to go both hands on brake"	Catch - hitch engaged
HF-062617-07	TTRS	2	ATC / VT	11mm, CMC, Static Pro (Blue)	3	ATC / VT	11mm, CMC, Lifeline (Red)	680cm	200kg	#1	102cm	"reminder to grab running end seemed to help"	Catch - no activation of hitch -
HF-062617-09	TTRS	2	VT / ATC	11mm, CMC, Lifeline (Red)	3	VT / ATC	11mm, NE, KMIII	680cm	200kg	#1	174cm	"I felt it sliding through fingers on my side" "Wasn't forced out of my fingers"	Catch - not auto actuating
HF-062617-10	TTRS	4	ATC / VT	11mm, CMC, Static Pro (Blue)	2	ATC / VT	11mm, CMC, Lifeline (Red)	680cm	200kg	#2	107cm		catch - operator appeared to make conscious effort to grab running end - VT grabbed
HF-062617-12	TTRS	4	VT / ATC	11mm, CMC, Lifeline (Red)	2	VT / ATC	11mm, NE, KMIII	680cm	200kg	#2	97cm	"i'm conditioned to hearing the drop."	Catch - quickly going to break strand post drop
HF-062617-13	TTRS	8	ATC / VT	11mm, CMC, Static Pro (Blue)	4	ATC / VT	11mm, CMC, Lifeline (Red)	680cm	200kg	#2	101cm	"I watched 6-12 inches slide before i grabbed it."	catch - not auto actuating
HF-062617-15	TTRS	8	VT / ATC	11mm, CMC, Lifeline (Red)	4	VT / ATC	11mm, NE, KMIII	680cm	200kg	#1	119cm		catch - no auto actuation - pulled operator toward re-direct biner
HF-062817-01	SMSB Hybrid	13	Main	11mm, NE, KMIII	14	VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	81cm	"Hitchhiker grip" TPB technique	"Hitchhiker grip" TPB technique. - Appeared to auto actuate
HF-062817-02	SMSB Hybrid	3	Main	11mm, CMC, Lifeline (Red)	4	VT / Scarab	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	81cm	"Hitchhiker grip" TPB technique	Hitch appeared to be "locking" just prior to the catch
HF-062817-03	SMSB Hybrid	14	Main	11mm, CMC, Static Pro (Blue)	18	VT / ATC	11mm, NE, KMIII	1415cm	200kg	#2	99cm	"Hitchhiker grip" TPB technique	no auto actuation
HF-062817-04	SMSB Hybrid	14	Main	11mm, NE, KMIII	18	VT / Scarab	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	118cm	"Ripped out of my hands."	"Hitchhiker grip" TPB technique
HF-062817-05	SMSB Hybrid	18	Main	11mm, CMC, Lifeline (Red)	19	VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	58cm	"Finding balance between good technique."	appeared to be more auto actuating
HF-062817-06	SMSB Hybrid	18	Main	11mm, CMC, Static Pro (Blue)	19	VT / Scarab	11mm, NE, KMIII	1415cm	200kg	#2	98cm	"hard to keep up with the lower"	
HF-062817-07	SMSB Hybrid	19	Main	11mm, NE, KMIII	20	VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	73cm	"Hitchhiker grip" TPB technique	less auto actuating
HF-062817-08	SMSB Hybrid	19	Main	11mm, CMC, Lifeline (Red)	20	VT / Scarab	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	65cm	"faster actuation."	appeared to be more auto actuating
HF-062817-09	SMSB Hybrid	20	Main	11mm, CMC, Static Pro (Blue)	21	VT / ATC	11mm, NE, KMIII	1415cm	200kg	#2	61cm	"Hitchhiker grip" TPB technique	appeared to auto actuate
HF-062817-10	SMSB Hybrid	20	Main	11mm, NE, KMIII	21	VT / Scarab	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	117cm	"Hitchhiker grip" TPB technique	less auto actuating
HF-062817-11	SMSB Hybrid		Main		18	VT / ATC	11mm, CMC, Lifeline (Red)	1115cm	200kg	#2	95cm	"felt good, grabbed hard."	Appeared to fail right before the pull phase of technique
HF-062817-12	SMSB Hybrid		Main		19	VT / Scarab	11mm, CMC, Lifeline (Red)	1115cm	200kg	#2	80cm	"hard to maintain technique"	"Hitchhiker grip" TPB technique
HF-062817-13	SMSB Hybrid	16	Main	11mm, NE, KMIII	15	VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	71cm	"Hitchhiker grip" TPB technique	appeared to auto actuate
HF-062817-14	SMSB Hybrid	16	Main	11mm, CMC, Static Pro (Blue)	15	VT / Scarab	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	238cm	"Hitchhiker grip" TPB technique	no auto actuation - hand position appeared to be in-line with loading direction
HF-062817-15	SMSB Hybrid	22	Main	11mm, CMC, Lifeline (Red)	23	VT / ATC	11mm, NE, KMIII	1415cm	200kg	#2	66cm	"Hitchhiker grip" TPB technique	some auto actuation
HF-062817-16	SMSB Hybrid	22	Main	11mm, NE, KMIII	23	VT / Scarab	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	82cm	"Hitchhiker grip" TPB technique	
HF-062817-17	SMSB Hybrid	23	Main	11mm, CMC, Static Pro (Blue)	24	VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	459cm	"Hitchhiker grip" TPB technique	no auto actuation - operator simply lowered the load on the ATC
HF-062817-18	SMSB Hybrid	23	Main	11mm, CMC, Lifeline (Red)	24	VT / Scarab	11mm, NE, KMIII	1415cm	200kg	#2	111cm	"Hitchhiker grip" TPB technique - "I could feel the event"	appeared to be no auto actuation
HF-062817-19	SMSB Hybrid	24	Main	11mm, NE, KMIII	13	VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	69cm	"Hitchhiker grip" TPB technique	no auto actuation
HF-062817-20	SMSB Hybrid	24	Main	11mm, CMC, Static Pro (Blue)	13	VT / Scarab	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	155cm	"Hitchhiker grip" TPB technique - "Felt it more" - "Still had to let go"	no auto actuation
HF-062817-21	SMSB Hybrid	17	Main	11mm, CMC, Lifeline (Red)	25	VT / ATC	11mm, NE, KMIII	1415cm	200kg	#2	150cm	"Hitchhiker grip" TPB technique- "felt heavier"	no auto actuation
HF-062817-22	SMSB Hybrid	17	Main	11mm, NE, KMIII	25	VT / Scarab	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	121cm	"Hitchhiker grip" TPB technique	more auto actuating - 2 lock ups prior to release
HF-062817-23	SMSB Hybrid	25	Main	11mm, CMC, Static Pro (Blue)	16	VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	68cm	"Hitchhiker grip" TPB technique	appeared to be more auto actuating
HF-062817-24	SMSB Hybrid	25	Main	11mm, CMC, Lifeline (Red)	16	VT / Scarab	11mm, NE, KMIII	1415cm	200kg	#2	118cm	"Hitchhiker grip" TPB technique	appeared to be more auto actuating
HF-062817-25	SMSB Hybrid	24	Main	11mm, NE, KMIII	22	VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	101cm	"Hitchhiker grip" TPB technique - "ripped out of my hands"	auto actuating - operator just pulled a new bight when failure occurred
HF-062817-26	SMSB Hybrid	24	Main	11mm, CMC, Static Pro (Blue)	22	VT / Scarab	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	153cm	"Hitchhiker grip" TPB technique	appeared to be auto actuating
HF-062817-27	SMSB Hybrid	14	Main	11mm, CMC, Lifeline (Red)	17	VT / ATC	11mm, NE, KMIII	1415cm	200kg	#2	76cm	"Hitchhiker grip" TPB technique - "I have to be willing to let it out of my hand."	
HF-062817-28	SMSB Hybrid	14	Main	11mm, NE, KMIII	17	VT / Scarab	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	95cm	"Hitchhiker grip" TPB technique	appeared to be more auto actuating
HF-062817-29	TTRS	26	Scarab / VT	11mm, CMC, Static Pro (Blue)	27	re-direct / ATC / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	57cm	Scissor technique for Prusik minding	no auto actuation
HF-062817-30	TTRS	26	re-direct / VT / Scarab	11mm, CMC, Lifeline (Red)	27	re-direct / VT / ATC	11mm, NE, KMIII	1415cm	200kg	#1	349cm	"slipped 2-3 inches before I realized it was going" "didn't like minding the Prusik backward"	This technique requires the operator to pull toward the load on the running end with one hand and against the loading direction with the VT minding hand.
HF-062817-31	TTRS	27	Scarab / VT	11mm, NE, KMIII	28	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#1	62cm		appeared to be more auto actuating - possible visual/ audible cue regarding release
HF-062817-32	TTRS	27	re-direct / VT / Scarab	11mm, CMC, Static Pro (Blue)	28	re-direct / VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#1	62cm	"no huge difference with VT in front or back"	
HF-062817-33	TTRS	28	Scarab / VT	11mm, CMC, Lifeline (Red)	29	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	45cm	"felt like I let it ride a ways"	
HF-062817-34	TTRS	28	re-direct / VT / Scarab	11mm, NE, KMIII	29	re-direct / VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	58cm	"felt like I made a conscious effort to grab running end"	Operators were briefed to grab running end upon failure
HF-062817-35	TTRS	29	Scarab / VT	11mm, CMC, Static Pro (Blue)	30	re-direct / ATC / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#1	70cm		Scarab was on 3 horns pre-drop - system #1 appeared to be carrying a majority of the load pre-dro p
HF-062817-36	TTRS	29	re-direct / VT / Scarab	11mm, CMC, Lifeline (Red)	30	re-direct / VT / ATC	11mm, NE, KMIII	1415cm	200kg	#2	97cm	"had to pull my hand away"	less impulse - not as auto actuating
HF-062817-37	TTRS	30	Scarab / VT	11mm, NE, KMIII	31	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#1	80cm		appeared to be a less conscious effort to remove minding hand
HF-062817-38	TTRS	30	re-direct / VT / Scarab	11mm, CMC, Static Pro (Blue)	31	re-direct / VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#1	73cm	"you can feel it passing through your hands"	
HF-062817-39	TTRS	31	Scarab / VT	11mm, CMC, Lifeline (Red)	33	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	43cm	"saw hers drop so I just let go"	appeared to auto actuate
HF-062817-40	TTRS	31	re-direct / VT / Scarab	11mm, NE, KMIII	33	re-direct / VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	31cm	"I'm just watching main" - "it doesn't rip out of my hand"	

HF-062817-41	TTRS	33	Scarab / VT	11mm, CMC, Static Pro (Blue)	34	re-direct / ATC / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#1	MNT [1]	"conscious effort to allow hitch to grab"	Incorrectly tied asymmetric Prusik (6:1) - Distel hitch instead
HF-062817-42	TTRS	33	re-direct / VT / Scarab	11mm, CMC, Lifeline (Red)	34	re-direct / VT / ATC	11mm, NE, KMIII	1415cm	200kg	#2	173cm		operator used more of a 'Pointer Technique' - single finger minding the Hitch
HF-062817-43	TTRS	34	Scarab / VT	11mm, NE, KMIII	32	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#1	326cm	"I think the burning in my running end hand cased me to let go of VT."	no auto actuation
HF-062817-44	TTRS	34	re-direct / VT / Scarab	11mm, CMC, Static Pro (Blue)	32	re-direct / ATC / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	187cm	"I was expecting the Prusik to get pulled from me"	conscious effort to let go by operator
HF-062817-45	SMSB Hybrid	32	Main	11mm, CMC, Lifeline (Red)	38	ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	107cm	"Hitchhiker grip" TPB technique - "right as I pulled a loop"	
HF-062817-46	SMSB Hybrid	32	Main		38	Scarab / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	221	"Hitchhiker grip" TPB technique	operator minded the VT - did not pull a loop - inched along the lower
HF-062817-47	SMSB Hybrid		Main		37	Scarab / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	173cm	"Hitchhiker grip" TPB technique	no auto actuation
HF-062817-48	SMSB Hybrid		Main		37	ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	99cm		Appeared to auto actuate - operator pulled smaller bights with technique this time
HF-062817-49	SMSB Hybrid		Main		30	ATC / VT (low friction)	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	82cm	"felt like high friction"	
HF-062817-50	SMSB Hybrid		Main		36	ATC / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	212cm		anchor side hand not perpendicular at time of drop
HF-062917-10	TTRS	17	re-direct / ATC / VT	11mm, NE, KMIII	38	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#1	73cm	"felt like the catch was on the running end"	both operators coached to focus on running end
HF-062917-11	TTRS	46	Tailer / re-direct / VT / ATC	11mm, CMC, Static Pro (Blue)	45	Tailer / re-direct / VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#1	38cm		no hitch actuation at all - load caught on DCD - appeared to be quick action on behalf of Rope Tailer
HF-062917-12	TTRS	46	Tailer / re-direct / VT / Scarab	11mm, CMC, Lifeline (Red)	45	Tailer / re-direct / VT / Scarab	11mm, NE, KMIII	1415cm	200kg	#2	65cm		Hitch actuated
HF-062917-14	TTRS	45	re-direct / VT / ATC	11mm, CMC, Static Pro (Blue)	41	re-direct / VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	79cm		slight hitch actuation - appeared to be mostly caught by DCD
HF-062917-15	TTRS	45	re-direct / VT / Scarab	11mm, CMC, Lifeline (Red)	41	re-direct / VT / Scarab	11mm, NE, KMIII	1415cm	200kg	#2	38cm		hitch actuated
HF-062917-16	TTRS	41	re-direct / VT / ATC	11mm, NE, KMIII	47	re-direct / VT / Scarab	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#1	28cm		hitch actuated
HF-062917-22	TTRS	53	re-direct / ATC / VT	11mm, NE, KMIII	49	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	23cm		no hitch actuation at all - load caught on DCD
HF-062917-24	TTRS	49	re-direct / ATC / VT	11mm, CMC, Lifeline (Red)	52	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	19cm		no auto actuation -caught on DCD
HF-002917-26	TTRS	52	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	50	re-direct / ATC / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	55cm	"here it comes"	no hitch actuation at all - load caught on DCD - operators appear to be anticipating the drop - increasing running end tension & decreasing the rate of descent during the lower
HF-062917-28	TTRS	50	re-direct / ATC / VT	11mm, NE, KMIII	51	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	16cm		no hitch actuation at all - load caught on DCD - both operators used reverse grip - no priming of technique
HF-062917-30	TTRS	51	re-direct / ATC / VT	11mm, CMC, Lifeline (Red)	54	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	21cm		no hitch actuation at all - load caught on DCD - both operators reverse grip - bouncy lower
HF-062917-32	TTRS	54	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	55	re-direct / ATC / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	57cm		VT actuation
HF-062917-34	SMSB Hybrid	56	re-direct / ATC	11mm, NE, KMIII	55	VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	77cm	"slow release"	"Hitchhiker grip" TPB technique - appeared to be a slow and gentle actuation of the VT
HF-062917-35	TTRS	56	Scarab / VT (2 Horns)	11mm, CMC, Static Pro (Blue)	59	Scarab / VT (2 Horns)	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	170cm		2 horns each Scarab - no auto actuation
HF-062917-37	TTRS	59	Scarab / VT	11mm, NE, KMIII	57	Scarab / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	73cm		Slight auto actuation - Arrest system appeared to be carrying less of the load during lower
HF-063017-01	TTRS	63	Scarab / VT	11mm, CMC, Lifeline (Red)	60	Scarab / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	58cm		VT actuated
HF-063017-02	TTRS	63	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	60	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	49cm		no hitch actuation
HF-063017-03	SMSB Hybrid	63	Main	11mm, NE, KMIII	60	VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	122cm		less auto actuating - operator appeared to be feeding rope in liberally
HF-063017-04	TTRS	60	Scarab / VT	11mm, CMC, Lifeline (Red)	61	Scarab / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	55cm		VT actuated
HF-063017-05	TTRS	60	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	61	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	57cm		VT actuated
HF-063017-06	SMSB Hybrid	60	Main	11mm, NE, KMIII	61	VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	67cm		slower VT actuation
HF-063017-07	SMSB Hybrid	61	Main	11mm, CMC, Lifeline (Red)	64	VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	47cm	"that was not violent"	
HF-063017-08	TTRS	61	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	64	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	45cm		VT actuated
HF-063017-09	TTRS	61	Scarab / VT	11mm, NE, KMIII	64	Scarab / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	78cm	"I minded that, right there."	
HF-063017-10	TTRS	64	Scarab / VT	11mm, CMC, Lifeline (Red)	65	Scarab / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	219cm		operator minded hitch
HF-063017-11	TTRS	64	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	65	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	90cm		operator appeared to mind the hitch some
HF-063017-12	SMSB Hybrid	64	Main	11mm, NE, KMIII	65	VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	136cm		appeared to auto actuate - operator has hitch elevated well above fall line
HF-063017-13	SMSB Hybrid	65	Main	11mm, CMC, Lifeline (Red)	62	VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	68cm		subtle hitch actuation
HF-063017-14	TTRS	65	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	62	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	116cm		Hitch actuated - This system appeared to be carrying far less tension during the lower
HF-063017-15	TTRS	65	Scarab / VT	11mm, NE, KMIII	62	Scarab / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	59cm		Hitch actuated
HF-063017-16	TTRS	66	Scarab / VT	11mm, CMC, Lifeline (Red)	63	Scarab / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	26cm		no hitch actuation - operator defiantly anticipated the drop
HF-063017-17	TTRS	66	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	63	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	67cm		catch on ATC - no hitch actuation - the arrest operator had almost no tension during the lower
HF-063017-18	SMSB Hybrid	66	Main	11mm, NE, KMIII	63	VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	151cm		appeared to auto actuate - operator pulled huge bight during the lower - the arrest system appeared to have very little tension during the lower
HF-063017-19	SMSB Hybrid	68	Main	11mm, CMC, Lifeline (Red)	67	VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	58cm		auto actuated
HF-063017-20	TTRS	68	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	67	re-direct / ATC / VT	11mm, NE, KMIII	1415cm	200kg	#2	115cm		hitch actuated - operator appeared to mind the hitch
HF-063017-21	TTRS	68	Scarab / VT	11mm, NE, KMIII	67	Scarab / VT	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	58cm		hitch actuated
HF-063017-22	TTRS	67	Scarab / VT	11mm, CMC, Lifeline (Red)	68	Scarab / VT	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	169cm		operator to mind the hitch
HF-063017-23	TTRS	67	re-direct / ATC / VT	11mm, CMC, Static Pro (Blue)	68	re-direct / ATC / VT	KMIII	1415cm	200kg	#2	137cm	"I had to physically let go."	Conscious effort on part of arrest system operator to stop minding the Hitch
HF-063017-24	SMSB Hybrid	67	Main	11mm, NE, KMIII	68	VT / ATC	11mm, CMC, Lifeline (Red)	1415cm	200kg	#2	168cm		failure occurred as the operator was taking an aggressive pull of rope - large bight
HF-063017-25	SMSB Hybrid	67	Main	11mm, CMC, Lifeline (Red)	45	VT / ATC	11mm, CMC, Static Pro (Blue)	1415cm	200kg	#2	92cm	"not violent"	

[1] Measurment Not Taken

Test #	Time	Test Configuration	System #1	Friction Hitch	System #2	Friction Hitch	Rope in Service (cm)	Mass (kg)	Arrest System	FAS [4] Extension	Comments	Other
HF-050219-01	844	Dual Raise	3:1 with COD [1]		3:1 with COD		1576	200	MNT [3]	MNT	3 ppl pulling on independent 3:1 with CODs	No video - no distance measurement taken. Dialing in test set-up
HF-050219-02	900	Dual Raise	3:1 with COD		3:1 with COD		1576	200	MNT	MNT	6 ppl pulling on two 3:1 with CODs	No video - no distance measurement taken. Dialing in test set-up
HF-050219-03	924	Dual Raise	3:1 with COD		3:1 with COD		1576	200	MNT	MNT		No video - no distance measurement taken. Dialing in test set-up
HF-050219-04	935	Dual Raise	3:1 with COD	VT	3:1 with COD	VT 6/1	1576	200	#1	17 cm		
HF-050219-05	943	Dual Raise	3:1 with COD	VT	3:1 with COD	VT 6/1	1576	200	#2	29 cm		
HF-050219-06	953	Dual Raise	3:1 with COD	VT as Distel 6/1	3:1 with COD	VT as Distel 6/1	1576	200	#1	17 cm		
HF-050219-07	1014	SMSB Raise	5:1	VT	Belay w/ PMP [2]	VT 6/1	1576	200	#2	84 cm		
HF-050219-08	1026	SMSB Raise	5:1	VT	Belay w/ PMP	VT 6/1	1576	200	#2	73 cm		
HF-050219-09	1036	SMSB Raise	5:1	VT	Belay w/ PMP	VT 6/1	1576	200	#2	77 cm		
HF-050219-10	1046	SMSB Raise	5:1	VT	Belay w/ PMP	VT 6/1	1576	200	#2	70 cm		
HF-050219-11	1056	SMSB Raise	Complex 9:1	VT	Belay w/ PMP	VT as Distel 6/1	1576	200	#2	87 cm		
HF-050219-12	1106	SMSB Raise	5:1	VT	Belay w/ PMP	VT as Distel 6/1	1576	200	#2	90 cm		

[1] Change of Direction

[2] Prusik Minding Pulley

[3] Measurement Not Taken

[4] Fall Arrest System

