Snatch Strap Facts

Also known as tuggem or kinetic straps

by Mike Lauterbach

Recovery using snatch straps (snatching) is *extremely* dangerous if not done properly!. I will explain some fundamental physics involved, in an attempt to highlight the dangerous forces experienced.

During snatching, the momentum of the recovery vehicle is converted into strain energy, stored in the snatch strap. It's like we are using the recovery vehicle's engine to 'wind-up' the strap. What this means is that all the energy that the fire-breathing V8 recovery vehicle has produced in those few seconds of acceleration is now *stored in the rope* ready to be released at an instant.

The technique of snatch recovery is, in principle, very simple.

1. A snatch rope (normally a 50mm wide, 8ton capacity belt) is fastened between the recovery vehicle and the stuck vehicle.
2. The recovery vehicle is moved as close as possible to the stuck vehicle,
3. The recovery vehicle accelerates forwards, eg in 1st or 2nd gear, low range.
4. The slack of the snatch strap is taken up. The recovery vehicle will decelerate to a stop as the tension in the strap increases to the point where the stretched strap force equals the vehicle momentum force.
5. Hopefully, the induced force will be enough to extract the stuck vehicle. The driver in the recovered vehicle now applies his brakes to avoid smashing into the recovery vehicle.
6. If the recovery was unsuccessful, the procedure is repeated, with the recovery vehicle using more speed.

When to use it:

This technique should only be used as a last resort, as it is probably the most dangerous technique, and there have been some nasty, near fatal incidents. The pulling force that can be generated far exceeds that of any winch or conventional pulling - even if the recovery vehicle is on slippery ground.

Necessary Safety Precautions:

1. Only use proper robust recovery points on the vehicle. The lashing eyes on Land Rovers are not recovery points, and will rip off and become lethal projectiles!. Shackles used on the recovery points should be at least 4.75 ton rated bow shackles. Open the bow shackles half a turn to prevent them from binding under pressure.
2. In most instances, feed a bridle through the end of the strap, and attach the bridle to two recovery points. Do this on each vehicle, unless a recovery points has been specially fabricated to withstand these high forces.
3. Never connect two straps with shackles! If one of the straps breaks, the shackle becomes a lethal projectile. Rather use a light weight wooden stick (broom stick section) or even a rolled up newspaper. You can feed the two strap loops through each other, but under severe loads they will bind together,

making it very difficult to undo them again. Some experts maintain that this way undue forces are exerted in the entwined loops.

4. A nylon rope (about 5 to 6m long) should be tied around the the snatch strap close to the loop at the recovery point and wrapped a couple of times around the strap, and to another secure point on each vehicle. Do this on both vehicles. These two nylon ropes would then absorb some of the energy from the resultant recovery point missile, should one break off. Also, drape a blanket, tarpaulin, or something heavy and flexible over the centre of the strap, to absorb some of the strap energy should something break.
5. If at all possible avoid snatch towing a small light vehicle (eg. 1400 Nissan) with a much heavier vehicle (eg a Defender), and visa versa.
6. Make sure that the attachment points (eg shackles) do not have any sharp edges that may cut the strap.
7. Make sure that the strap is not twisted.
8. Only use rated snatch straps.
9. Everyone, apart from the two drivers, should stand at least twice the strap length away, to avoid flying missiles should the strap or an attachment break.
10. The drivers in the two vehicles *MUST* wear seat belts and preferably crash helmets.
11. The driver of the recovery vehicle should have some robust protection between himself and the snatch strap, such as a tyre.
12. The driver of the stuck vehicle should have the bonnet raised as a shield.
13. Because the two drivers can't see each other, a director needs to stand outside the danger zone, in a position where he can be seen and heard by both drivers.
14. The director coordinates the snatch, during which both drivers release their clutch in the same gear (eg 2nd low).
15. When the bogged vehicle is successfully extracted, same vehicle hoots to let the recovery vehicle know that he is free. The recovery vehicle stops, and the now released vehicle carefully reduces the gap between the two vehicles until there is slack in the snatch strap.
16. Only when the director declares that it is safe, may other helpers approach and help remove the recovery gear.

So why is snatching so dangerous?

As mentioned in the beginning, a huge amount of energy is stored in the snatch strap. The energy stored is half the vehicle mass multiplied by the square of the vehicle speed. Therefore, the forces exerted at say 20km/hr, are 4 times those exerted at 10km/hr! Our desire is to use all this stored energy to pull the bogged vehicle out of its mud-hole. But what if it doesn't?

The main dangers in order of magnitude are:

1. The worst that can happen is that the recovery point (or indeed a chunk of chassis) of one of the vehicles tears off. This piece of metal will now be accelerated by the tons of tension stored in the strap, in the direction of the other vehicle. This piece of metal can easily achieve speeds in excess of 700km/hr, depending on size (see calculations later). This projectile can cut a swath of destruction right though the vehicle. The best you can hope for is that no living soul is in its way! This missile could also strike a solid part of the

vehicle eg the winch, and bounce off at tremendous speed in an altered direction. This is why everyone, including the director (the two drivers excluded), should stand at least the extended length of the strap away.

2. If too much force is used at once, the bogged vehicle may come loose with the strap still having lots of stored energy to spare. This stored energy then makes your newly de-bogged vehicle accelerate faster than a Ferrari on steroids and literally go airborne only to come crashing down again (most likely onto the towing vehicle). Alternately, the recovery vehicle loses grip and is catapulted back into the bogged vehicle. The important thing is that you always start gently and *gradually* use more force at each attempt. But there are limitations, as the strap does not retract to its original length straight away. More on this later.
3. The snatch strap may break. This usually happens where it is in contact with the tow point, or where the webbing has come loose at the eyes. This results in a missile launch similar to when the tow point breaks except that this time only the rope is flying. Even the strap itself can be lethal. But you have protected the drivers with the open bonnet and tyre, and all the spectators are far away.

Some horror stories:

Some time back in SWA, now Namibia, an army tank attempted to snatch out a ldv. The result was that the chassis and axles stayed stuck, and the body was ripped off the stuck vehicle.

Then there was the story of a light vehicle (details are sketchy but I believe it involved a Suzuki), which tried to dislodge a Land Rover. He set off at pace, but was unfortunately catapulted back into the still stuck Land Rover, resulting in two broken vehicles, one which remained stuck!

I read a story of a Range Rover winching out a badly bogged vehicle. "The driver correctly insisted that his passenger leave the vehicle and stand well back. The winch cable was simply hooked over the tow ball of the stuck vehicle. At maximum stress the tow ball snapped and the cable with the round ball attached tore through the Range Rover, cutting through the roof and splitting the front passenger seat in two. The Range Rover was declared a write-off. Because of other precautions taken nobody was hurt. Tow balls are mild steel - not the correct material for high-stress pulling." This was winching, not snatching, which has higher forces!

Another story from the web: A Land Rover was stuck and no amount of winching would make the bogged landy budge. "Digging was impossible as the mud was too fluid and Hi-Lifting was impossible. So they went for snatch pulling. Even the most violent acceleration brought no results. They then decided to use two ropes (to double the length) with the result that the towing Landy reached speeds in excess of 60kph before the rope slack was taken up! Just as the Landy started to lose the battle against the increasing tension of the rope an appalling impact and what sounded like a rifle shot was heard. The tow rope seemed to have vanished. What had happened was that the towing point of the stricken Landy was pulled right out of the chassis and catapulted at awesome speed towards the towing landy. It went right through the rear door, the bulkhead and through the front windscreen, scattering bits of glass and aluminum all over the place. The towing point had actually passed within a few inches of the driver's head!! He was wearing a helmet but it is doubtful what protection that can afford against a 6 lb supersonic towook!"

A Land Rover was "de-bogging a Sammy. What happened this time was simply that maximum brute force was used right away. The Landrover accelerated about 20 feet to approx 20Mph before the rope started tensioning. All of a sudden the Sammy catapulted out of the ground, flew a distance of approximately 25 feet and then came crashing into the roof of the Landy just above the level of the tailgate. The only thing that prevented the driver of the Landy from getting killed was the substantial roll cage. What went wrong here was very simply that maximum brute force was applied first time. There was probably four times as much energy in the rope as was needed to de-bog the 'Zuki."

The bottom line is that snatching is a great way of recovering otherwise unrecoverable vehicles. If done with care, it is safe but if not, **can be lethal**. It is best to try winching, hi-lifting and digging first.

The Theory

Now let's have a look at the theory, now that we know what can happen:

Let's base the calculations on my Land Rover 110 tdi. It's weight is 2300kg, and can accelerate to 17km/hr within 9m in 2nd gear, low range.

8 ton snatch straps break more or less at 8 ton force (no safety factor! More of this later). The stretch factor of 20% is quoted at 50% force (4 tons for our example). Some snatch straps break at a lower, some at a higher force. The straps are 9m long. 20% relates to 1.8m, and assuming a linear spring constant in the elasticity of the strap, elongation, or stretch, will be 3.6m at a force of 8 tons.

Now F= k x s, where F = force (Newtons), s = distance (stretch) and k = spring constant.

Therefore k = F/s = 4000kg x 9.81 / 1.8m
==> *k = 21800N/m*

To calculate the stored energy and resultant forces in the snatch strap, we need to determine what the kinetic energy of the recovery vehicle is at the point where the snatch trap has enough force to stop it, ie at the point where the injected kinetic energy equals the stored potential energy in the strap.

The kinetic energy of the vehicle = 0.5 x m x v^2 (^2 = squared),
and the strain energy in the strap = 0.5 x F x s

Therefore, at v=17km/hr (4.72m/s), m=2300kg, and k=21800N/m,
the vehicle kinetic energy = 25644 Nm

Now, at this point, the strap strain energy = induced kinetic energy by the recovery vehicle

==> 0.5 x F x s = 0.5 x m x v^2

==> s = sqrt(m x v^2 / k) = 1.53m stretch

Therefore, the force exerted is
F = k s = 21800 x 1.53 = **3.41 tons**.

This does not sound too impressive though, as we were expecting something closer to 8 tons. This force assumes that the snatch strap has a 20% elongation at 50% load. Tests have shown that some snatch straps only have 15% elongation, which would mean that for these the exerted force would be 4.5 tons instead of the calculated 3.41 tons. If we add a V8 at the same vehicle mass with a higher speed to the equation, the forces will be much higher.

Now, 3.41 tons is "not a lot", only about 50% more than the vehicle mass. But what happens if an attachment point breaks off at this "low" force?

Let's take a pin and ball attachment, fitted with inferior low tensile bolts. The attachment weighs about 1.2 kg. If it gets ripped off the vehicle, how lethal will it be?

As determined above, the total stored strain energy = 25644 Nm.
Translating this into velocity, we get v = sqrt(2 x m) = sqrt(2 x 25644) = 226.5 m/s = **815 km/hr**!

Obviously this is a theoretical figure, derived from the assumption that the elasticity of the snatch strap is perfect at 100%. Let's be pessimistic, and assume that the strap is only a third efficient. This translates to a speed of **272km/h**r. Not all that fast, I hear you say.

Let's consider a cricket ball, weighing all of 155g, being bowled at 150km/hr by that Ozi wonder-boy, Brett Lee. The kinetic energy of this fast ball is 134Nm. Our 1.2kg loose projectile's energy is 25644/3=8548Nm! That's packing 64 times more punch than one of the fastest cricket balls the world has seen! We all know that this cricket ball is capable of bending and penetrating the protective screen on the helmet, and still fracture cheek bones behind it. Bearing this in mind It's not hard to imagine why that the broken vehicle attachment, now a projectile, can pierce firewalls, windscreens and seats. It will definitely be fatal to a passenger in its path!

Snatch Strap Forces (metric tons)

Speed km/hr	Vehicle Mass [kg]						
	1000	**1500**	**2000**	**2300**	**2500**	**3000**	**3500**
5	0.66	0.81	0.93	1.00	1.05	1.14	1.24
10	1.32	1.62	1.87	2.01	2.09	2.29	2.47
15	1.98	2.43	2.80	3.01	3.14	3.43	3.71
17	2.25	2.75	3.18	3.41	3.55	3.89	4.20
20	2.64	3.24	3.74	4.01	4.18	4.58	4.95
25	3.31	4.05	4.67	5.01	5.23	5.72	6.18
30	3.97	4.86	5.61	6.02	6.27	6.87	7.42

These figures should be used as guidelines only, as ideal situations are used in their calculations, such as assuming an even spring constant for the snatch straps in Hook's Law formula. Many straps also have less stretch than the "industry standard" of 20%. If the stretch is less, the resultant forces will be higher as a result of the increased de-acceleration of the recovery vehicle at the end of the pull.

This also applies to the the same strap being utilised more than once within a 6 to 8 hour period. Snatch straps need 6 to 8 hours, per 10% stretch, to fully contract again. Thus, for a full 8 ton pull, the stretch will be 40%, requiring up to 24hrs to retract fully! Also, with each pull, the strap loses some elasticity. Therefore, it will never contract back to its original length again. Check the manufacturers instructions, when to discard it as a snatch strap. The ball park figure is 10%, ie if the snatch strap does not recover its length to within 10% of the original length, discard it as a snatch strap. In most cases, these straps don't lose their strength, and can be used as pull straps. Just mark them accordingly and remember that they will still have some stretch in them!

For this reason, no snatch strap should be used more than once within 6 hrs, as the elasticity is different on successive pulls. This is not always possible though - only use the snatch strap more than once if the initial stretch was minimal, or if you are aware that the successive snatches will exert more force, since some elasticity was lost in the previous snatch(es)

When connecting a snatch strap, try and spread the load by using either a 10 ton lifting strap, or strong tree protector, attaching it to two jade rings on each side of the chassis. The snatch strap loop is then slipped over this strap. This way you are distributing the high forces to both sides of the vehicle, preventing possible recovery point damage and chassis deformation in severe conditions.

The reality of the situation is that many people use snatching as their primary method of extraction, and think nothing of it. It *can* be safe if done properly at reasonable speeds.   When you're using it, don't be in a hurry to use more power; start with slower tugs and build up speed gradually, with a new strap at each new attempt. Also make sure that you are only using rated recovery equipment on the vehicle, eg bow shackles. You should use at least a 6.5 ton rated bow shackle if the strap is to be connected to one recovery point, and 3.25t, preferably 4.75ton, bow shackles if two points are used.

Here is a summary of tests done on different snatch straps by Beaver Sales, at their Height Safety & Confined Space Testing Centre, Australia (see www.lizardlegs.com.au/blackrat/news.asp#1):

Snatch Strap Make	**Dry Test Breaking Force [kg]**	**Wet Test Breaking Force [kg]**	**Stretch Factor**	**Cost (Au$)**
ARB 8000	6803	7044	21%	$69
ARB 9000	8495	8966	22%	$94
Black Rat 8000	8277	7401	23%	$70
Bushranger 8000	8679	8281	15%	$65
Megastraps 8000	8981	7806	16%	$55
Megastraps 9000	8444	7835	23%	$79

Megastraps 11000	11319	9674	24%	$109
Kaymar 8000 (made by Spanset)	9288	8681	20%	$65
Mean Green 8000	9427	7927	15%	$69
Mean Green 10000	9759	9423	20%	$99
Repco Motogard 7500	6508	5902	18%	$59
Super Cheap Auto 8000 (made by Spanset)	8520	7790	19%	$70
Super Cheap Auto 9000	3798	3953	-----	$30
Don Kyatt Terrain Tamer 8000	7087	7048	18%	$55
Don Kyatt Terrain Tamer 11000	12022	10569	15%	$88
DJM-OX 8000	7036	7205	22%	$84

Whilst some consider a strap to be good if the breaking point is more than their quoted specification, I consider the stretch factor to be more important, then followed by the breaking force. eg some rate the Bushranger 8000 highly because of its strength, ignoring the fact that it has a poor stretch factor, inducing higher forces when snatching.

The article in the Australian 4wd Monthly used the above results to rate the straps as follows:
(I don't necessarily agree with their classification)

Winner	Kaymar 8000
Runner-up	Bushranger 8000
Highly recommended	Mean Green 8000
	Terrain Tamer 11000
	Megastrap 8000
	Super Cheap Auto 8000
	Black Rat 8000
Recommended	Megastrap 11000
	Mean Green 10000
Not Recommended	Terrain tamer 8000
	Ox 8000
	Repco Mortorguard 7500
	Megastrap 9500
	ARB 8000
	ARB 11000
	Super Cheap Auto 9000

What will be covered in the next section are safety factors. Here is a brief rundown:

Where lifting gear is used, a minimum safety factor of 5 is usually used. A 4.74 ton rated bow shackle was tested by the above mentioned Ozi crowd, and it broke at 33 tons! Legally, its minimal breaking force should be at least 5 times its rated force. This safety factor was born to protect the public, workers and equipment. Why so high? This is because material specifications cannot be guaranteed 100%, due to various uncontrollable manufacturing factors, which include material chemical compositions and heat treatment procedures.

When designing cars, weight is a major factor. To reduce excessive mass, the safety factor is reduced. To compensate, higher quality materials need to be used. In aircraft design, this is even worse, as the plane would not be able to fly at high safety factors of 5, or even 3. Here safety factors of 1.4 and 1.5 are used, but extremely high quality materials are used (which is the main reason for the high cost of aircraft)

Having digressed a bit, it can be seen that the lack of use of safety factors in 4x4 recovery gear is most worrying, and a reason why so many accidents happen. Let's hope that not too many lives will be lost because of this. The results of snatch straps investigation reveal that there are no safety factors employed with them. Most are rated at 8 tons, and most break at this force, some slightly less, and some more. Because the strap itself is not the most dangerous item when it breaks, I am actually glad that it will break at 8 tons, and not at 32 tons, the force needed if a safety factor of 5 had to be employed. This belt thus limits forces to about 8 tons, and if something breaks, we hope that it is the strap itself.

Not using safety factors on the attachment and recovery points can be fatal. This is where you don't want anything to break, especially if it can become a flying missile.

Happy snatching.....