The Science is Clear

Smoother is Faster

SPECIALIZED SCIENCE CLUB

Deutsche Sporthochschule Köln
German Sport University Cologne

Suspend the Rider, Proven.

Diverge STR System

Heaven above, hell below.

It has long been clear to the team at Specialized that making the rider more comfortable translates into a better ride. Athletes perform at peak levels longer when they can tame the terrain and focus on power. But how do you create compliance without compromising performance?

You suspend the rider, of course. Separating the rider from impacts and vibration has long involved suspension forks, multi-pivot frame designs, and lots of heavy components.

The Specialized Science Club — a combination of all of Specialized's different Ride Science teams, and a unique celebration of science geekery for over fifty years — knew we could do better; in 2016, the Specialized Science Club sealed themselves in the lab to devise an evidence-based, performance-first solution to power-robbing bumps and chatter. FutureShock, which soaked up vibration and impacts at the front of the bike with a revolutionary and lightweight compliance design, was born.

But we knew we had to go further and balance the compliance in the rear of the bike, too. Those bunson-burner-baddies in the Specialized Science Club got to work scheming the fastest, most dialed, efficient, and comfortable system they could imagine. And in 2022, Rear FutureShock was born.

Our riders know already that keeping them comfortable improves their ride, keeps their bodies fresher longer, and allows them to perform at their peak without distraction. It's hard to argue with seven Paris-Roubaix wins, after all. But some riders were skeptical. They said comfort's nice, but that requires compromise to preserve performance.

They called us crazy. We love it when they call us crazy.

To prove that suspending the rider over the chatter and chunder beneath them did indeed improve ride quality without sacrificing any performance, we sent a Diverge STR to the German Sport University Cologne's Institute for Biomechanics and Orthopedics. This third-party testing would prove — or disprove — with hard data whether STR improved ride quality while maintaining or improving performance.

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The data is in. Are we crazy? Is it all just hype? Not according to the numbers. The study showed Diverge STR is every bit as efficient as a rigid bike, and it's a significant improvement when it comes to rider comfort.

But the big news? Smoother is, truly, faster. The numbers prove it: the STR-equipped bike decreases rolling resistance created by external forces.

In other words, STR is a big win — by a comfortable margin.

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Innovation lies at the heart of every Specialized bicycle. As the needs of the rider change, we innovate to solve the rider's problems, and also transcend the performance baseline to create technical performance benefits for the discerning rider.

For nearly a decade, it has been clear to the minds at Specialized Science Club that smoother is faster. That ethos led engineers to STR, giving them the opportunity to rise above the noise—both figuratively and literally.

That meant isolating the rider from the harsh impacts that can slow them down without sacrificing any performance aspects of the bike itself. Enter FutureShock, the foundation upon which STR is built.

FutureShock and Rear FutureShock suspend the rider, vastly reducing the amount of impacts that reach the body. By incorporating front FutureShock above the head tube, your frame and fork remain rigid, maintaining efficiency and sharp handling. The suspension then absorbs vertical movement between the frame and the rider, keeping the rider more comfortable.

On top of that, FutureShock increases handling accuracy by ensuring the front wheel stays in contact with the ground longer.

Rear FutureShock operates on a similar principle: maintaining the structural rigidity of the frame for efficiency benefits, while separating the rider from jarring impacts — above the frame itself.

The result is a system that eliminates fatigue-inducing impacts on the rider while maintaining structural stability and responsiveness that defines the Specialized ride.

1990	FutureShock development and implementation on Specialized mountain bikes
2004	Zertz elastomer inserts integrated into road bike frames and forks to dampen vibrations
2005	Tom Boonen wins Paris-Roubaix on a Zertz-equipped Specialized
2016	Front FutureShock released to the world on the S-Works Roubaix
2018	Peter Sagan wins Paris-Roubaix on board a FutureShock-equipped S-Works Roubaix

2021	Ian Boswell and Laurens Ten Dam go 1-2 at Unbound on Future Shock Equipped Diverge
2022	Specialized introduces Rear FutureShock on the Diverge STR, delivering the ultimate expression of our Suspend The Rider philosophy
2023	Laurens Ten Dam takes the Elite Men's 200-mile second place at Unbound Gravel on the Diverge STR; Sarah Sturm finishes in third place in the women's Elite 200-mile race

German Sport University Cologne's Institute for Biomechanics and Orthopedics

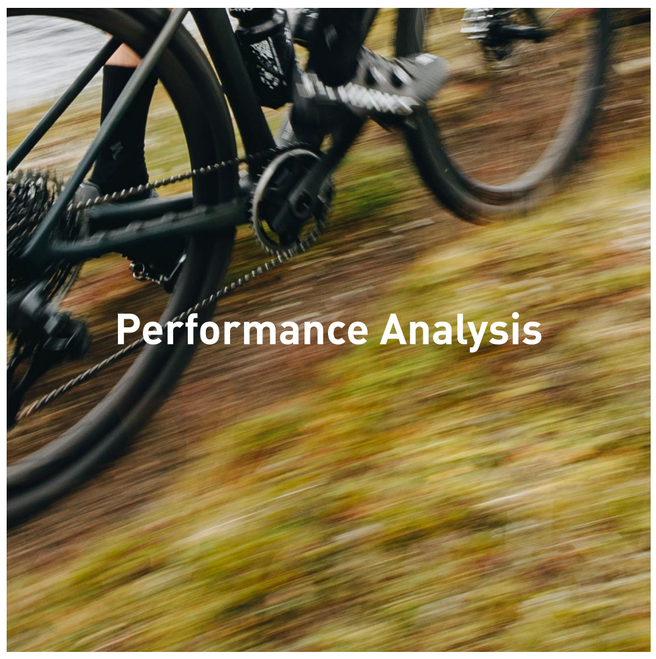
Deutsche Sporthochschule Köln
German Sport University Cologne

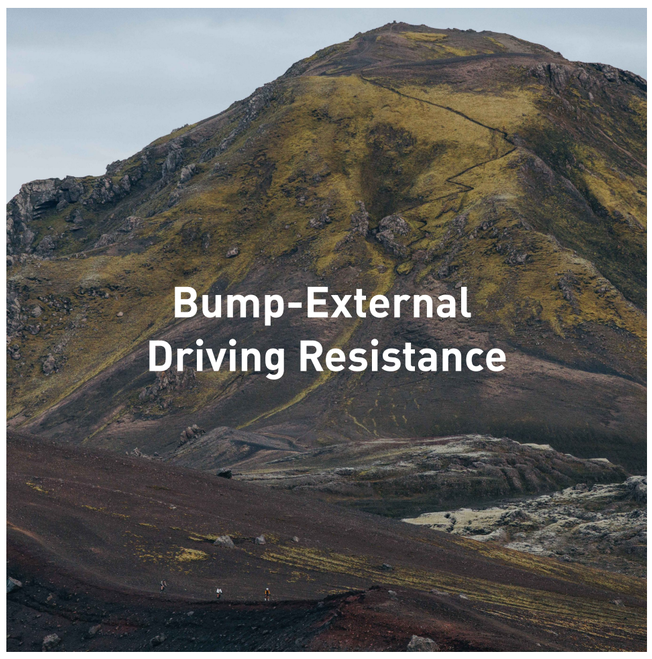
The independent STR validation study was conducted by Dr. Josef Viellehner and Professor Dr. Wolfgang Potthast of the Institute for Biomechanics and Orthopedics at the German Sport University Cologne.

The stated goal of the study was to "understand if and how vibrations and a damping system influence the rider's performance."

Two Specialized Diverge STR bicycles were used in the testing: one Diverge STR set up with fully-active FutureShock components, and one Diverge STR with fully locked-out, inactive FutureShock components.

20 riders were tested during the course of the study, which ran for six months. 17 male and 3 female riders were tested. Each rider was tested on three separate occasions. The riders tested were representative of the Diverge STR rider: strong, competitive, non-pro racers.





During each module, each rider's cadence, heart rate, power, and Rate of Perceived Exertion (RPE) were recorded and analyzed.

PERFORMANCE ANALYSIS

STR does not adversely affect power output.

PERFORMANCE ANALYSIS TAKEAWAY

Study results concluded that FutureShock does not rob the rider of any power output. This was determined by comparing each rider's average power over the five intervals conducted in testing.

Vibration reduces power output by around 3% over the entire testing on both a rigid bike and an STR bike.

Results indicated that there was no difference between power output on the fully active (damped) Diverge STR versus the locked-out (non-damped) Diverge.

Notably, no significant differences in heart rate were uncovered throughout the intervals. This indicates that activating STR has no negative effect on power.

Interval 4 is a notable exception; RPE dropped on the fully-active STR bike during interval 4, possibly due to riders 'settling in' to the testing protocol.

On average, RPE was significantly lower on the fully-active STR system throughout intervals.

METHOD

1. Goal was to achieve highest possible average power output per interval
2. Testing took place within eight days, with at least one day of rest in between
3. Performed on vibration machine with no vibration; then, with vibration active on both the fully-active bike and the fully-locked-out bike

During each module, each rider's cadence, heart rate, power, and Rate of Perceived Exertion (RPE) were recorded and analyzed.

STR significantly increases rider comfort both objectively and subjectively.

OBJECTIVE MEASUREMENT

The results from accelerometer data show that the Diverge STR with FutureShock fully active significantly reduced impact and other movement at the hands, neck, shoulders, and low back, as compared to the Diverge STR with FutureShock completely locked out.

STR vibration exposure reduction at each 3D accelerometer:

Hands = 46.3%
Shoulders = 28.7%
Head and neck = 23.2%
Low back = 11.4%

Damping also reduced impact on the low back most notably at low and medium cranking intensities. Legs were largely unaffected by STR, since most vibrations the legs will experience are transmitted through the pedals and cranks, which are not decoupled from the bike.

RIDER PERCEPTION

Riders reported that they felt the Diverge STR with fully active FutureShock was notably more comfortable than the Diverge STR with FutureShock completely locked out. Riders also noted lower RPE throughout testing on the fully-active FutureShock bike.

That's because impact absorption reduces stresses on the body, as well as muscular activation that leads to fatigue. Less fatigue leads to a perception of increased comfort.

This facet of the study is notable because it is rare for rider perception and objective data to line up almost exactly, as it does in this case.

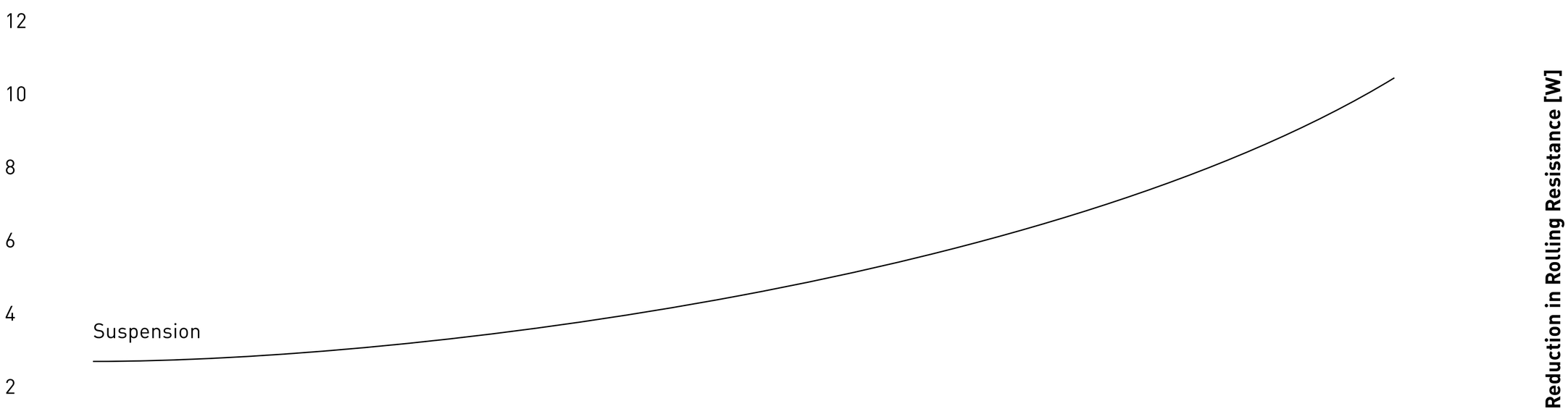
Rider perception of STR vibration reduction:

Seating area (saddle) = 28.5%
Hands = 43.9%
Head = 46.0%
Feet = 14.0%

METHOD

1. Three bike and vibration combinations were tested at three different pedaling intensities.
2. Riders maintained cadence between 85-90 RPM and power was normalized to body weight.
3. After warm-up, measurements were started as power and cadence stabilized
4. Three measurements were taken: exposure to vibration, perception of vibration, and muscle activation.
5. Tests were randomized on the no-vibration setting, the fully-active damping setting, and the locked-out damping setting.

Estimated Performance Gain of the STR System



Comparing the reduction of rolling resistance of the Diverge STR (blue line) and a non-suspended bike. The Diverge STR significantly reduces rolling resistance (measured as watts saved) as bumps become more frequent; the non-suspended bike does not reduce rolling resistance, regardless of bump spacing.

STR decreases rolling resistance created by external driving forces.

BUMP ANALYSIS TAKEAWAY

The results of the test show that the rider moves faster with less effort when braking impulses are mitigated.

- Testing concluded that STR reduces speed loss per bump by 4%
- The wattage savings of the STR system depends on the number of bumps encountered during a specific timeframe.
- The study concludes that when a bump is encountered every 10 meters (or 2 seconds), the rider saves 3.4 watts.
- The study concludes that when a bump is encountered every 3 meters (or 0.8 seconds), the rider saves 11.3 watts.

Riders noted a significant reduction (3.2%) in the effort required to complete maximal power tests. This, combined with comparable power production, suggests that STR lowers the effort required to pedal over bumps.

METHOD

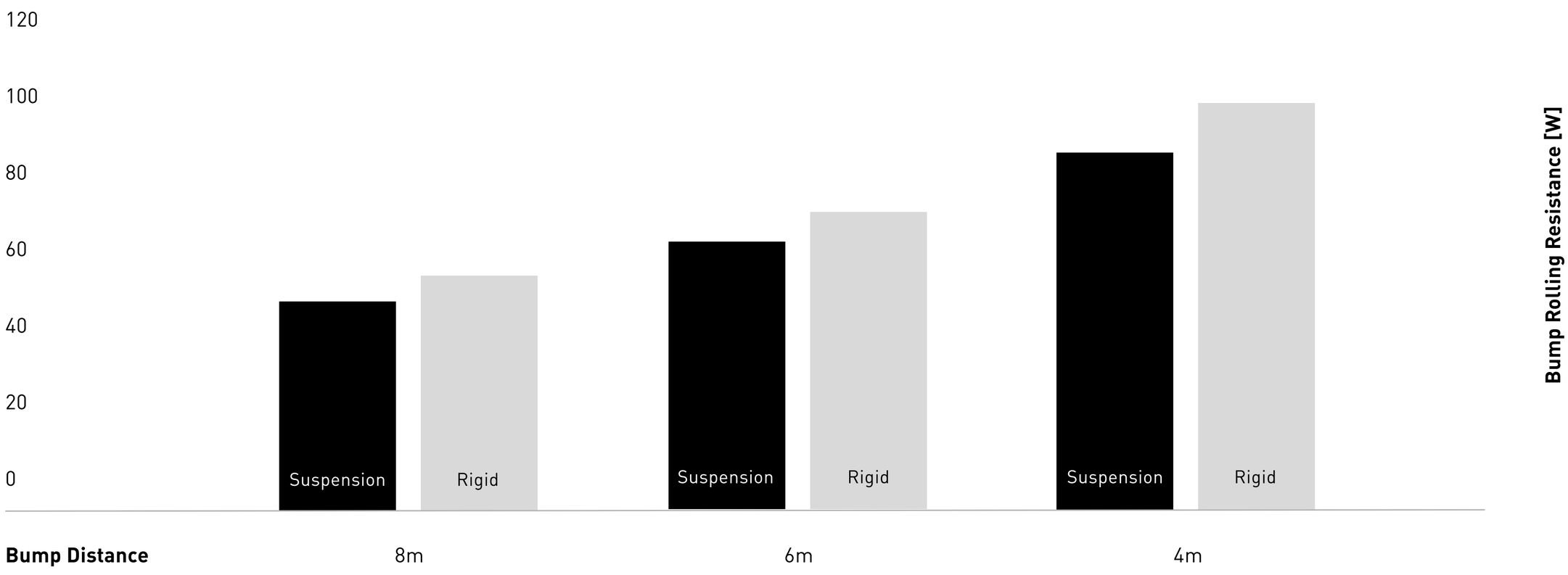
A bump study was conducted to measure deceleration on both the front and rear wheels. A 4cm x 4cm bump was mounted to a force plate to simulate a large impact a bicycle is likely to encounter in regular riding scenarios.

The force plate then measures ground reaction forces. When combined with the amount of time the wheel hits the bump, the resulting measurement defines external driving resistance — known as an impulse. Forces were measured horizontally — known as braking forces — as well as vertically.

Impacts were measured when the front wheel hit the bump, and when the rear wheel hit the bump. The cumulative effect on braking impact equals total impulse. The forces from the front and rear wheels are not averaged; rather, the forces are added as a total sum.

When the bicycle encounters a bump, the result is a reduction in driving forces. In order to regain that driving force, the rider has to input more power.

Rolling Resistance for Bumps @ 5 m/s



The Diverge STR's wattage savings over a non-suspended bicycle. While traveling at five meters per second, the Diverge STR reduced rolling resistance at bump distances of 8 meters, 6 meters, and 4 meters. The most significant savings occurred at shorter bump distances; this illustrates that the advantages of the Diverge STR increase as the terrain gets bumpier.

The lab data concluded that there are concrete benefits to STR. But what about in real world conditions? The Specialized Science Club got to work once the lab results were in to see if they would translate to real rides outside.

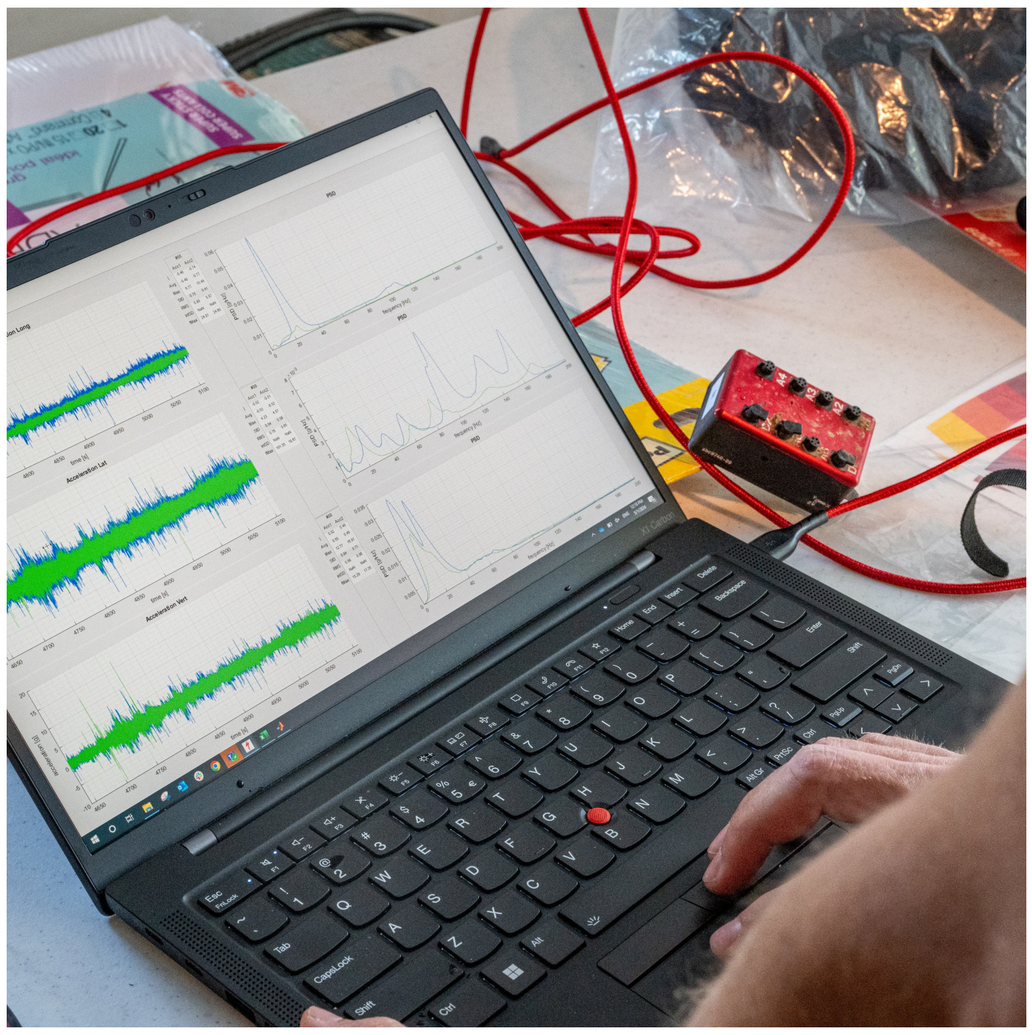
BUMP ANALYSIS TAKEAWAY

The results of the outdoor testing mirrored that of the lab testing. Of note, STR reduces bump-induced rolling resistance by 8% (6.1 watts), giving the rider a total performance benefit of around 3%.

The data is broken down according to rider type: Super Strong Rider, Strong Rider, and Normal Rider. Each rider was tested on Rough Road and Moderate Roughness Road, with time savings calculated over 10km of Rough or Moderate Roughness road.

METHOD

- A test run was constructed with a series of bumps that measured 37mm (2 x 2 inches). This is smaller than the lab bump so the Specialized Science Club could create a testing ground with a series of bumps the rider would encounter quickly.
- Riders pedaled over the bumps
- The test course was slightly inclined so the rider had to pedal in order to maintain speed
- Riders needed to maintain a constant speed over test runs, within a quarter-second variability
- Wind data was recorded; the wind speeds were the same for all bikes and riders tested.
- While a force plate was used in the lab, outdoor testing required the use of the rider's power meter to identify how much power was required to ride through the series of bumps.



FIELD TESTING

	Super Strong Rider 360 W at 70 kg (+10kg bike)	**Strong Rider** 240 W at 70 kg (+10kg bike)	**Normal Rider** 240 W at 70 kg (+10kg bike)
Rough Road			
Diverge	27.6 kph / 00:21:45	24.3 kph / 00:24:39	20.7 kph / 00:29:02
STR	28.3 kph	25.0 kph	21.4 kph
Time Saved over 10km	34.3 Seconds	43.7 Seconds	58.8 Seconds
Moderate Roughness Road			
Diverge	34.7 kph / 00:17:18	31.6 kph / 00:19:00	28 kph / 00:21:27
STR	34.9 kph	31.9 kph	28.3 kph
Time Saved over 10km	7.8 seconds	9.8 seconds	13.1 seconds

On a **moderately rough road** with small but frequent obstacles a super-strong rider will save nearly 8 seconds on the Diverge STR, and a normal rider will save just over 13 seconds. The Diverge STR benefits increase most for riders who need it most.

On a **rough road** with frequent and significant obstacles the Diverge STR will save a super strong rider nearly 35 seconds, and a normal rider will save almost a full minute, according to real-world testing conducted by the Specialized Science Club. The Diverge STR benefits increase as the course gets harder.

Ultimately, the Diverge STR reduces external driving resistances, which proves the notion that STR increases rider performance through enhanced comfort and lower rolling resistance.

Improved Rider Comfort

Movement analysis revealed STR improves rider comfort. Vibrations activate some muscle groups, thereby contributing to fatigue and discomfort. Vibrations can also reduce the rider's power output slightly and systematically during repeated short-term high-intensity efforts.

Subjective Vibration Reduction

The study concluded that damping systematically reduced the vibration exposure of certain muscle groups in the upper body, as well as in the hands and arms.

Objective Vibration Reduction

Rider perception also noted reduced vibration exposure in line with the objective data. This means that the STR system improves rider comfort both objectively and subjectively.

Reduction in Rolling Resistance

Real-world testing conducted by the Specialized Science Club corroborate lab testing results. STR reduces bump-induced rolling resistance by 8%. That's around 6.1 watts.

Reduction in External Driving Forces

Bump analysis revealed The STR system positively affected bike-surface interaction. External driving forces were reduced when passing over small bumps. Braking and vertical impulses generated by the front and rear wheels during the rollover testing were significantly reduced. The STR system therefore reduces rolling resistance over bumpy terrain.

No Adverse Impact to Power Output

Performance analysis revealed STR does not adversely affect power output. The performance of the riders on the fully-active Diverge STR and the locked-out Diverge STR was comparable. Damping had no detrimental effect on performance. While damping vibration does not enable more rider power output, it does not rob the rider of power, either.