G-VECTORING CONTROL

PRESS EVENT ARTICLES

FOR INTERNAL USE ONLY

TABLE OF CONTENTS

Mazda busts a move so smooth you won't even notice

THE GLOBE AND MAIL

Mark Richardson

June 30, 2016

It's disconcerting to have a Japanese engineer in the back seat, studying your driving with a laptop. It's also frustrating to go to a racetrack to turn laps in the parking lot at 10 and 20 km/h.

The engineer didn't want me to drive any faster. The aim was for precision and consistency, because the squiggly lines on his screen were very subtle.

The graph's blue line showed my driving inputs with Mazda's new G-Vectoring Control (GVC) switched on in the CX-3, while the red line showed when it was switched off. The blue line was a little smoother, with fewer peaks and troughs. The back-seat engineer looked happy with this, and another engineer in the passenger seat explained it.

"Steering precision, and response, and stability – that's what the system is all about," said Kelvin Hiraishi. "You can feel it very subtly in the drive, but you can see it on these graphs."

GVC is nothing if not subtle. It's a system that will be embedded in the engineering of new Mazdas to help smooth out your drive, without you really noticing. The company says its hope is drivers will appreciate it without really thinking about it, and it'll help them love their cars. Maybe they'll stay with the brand without really knowing why.

It's best illustrated by a little band of tape at the top of the steering wheel. When you drive, you constantly correct to keep the car going in the direction you want, and you can see the tape jiggle left and right. With GVC, the car handles the constant tiny corrections automatically, with no change to the feel of the steering, and the tape jiggles less.

There's a video I was shown of a model, slightly puzzled in the passenger seat of a Mazda6, not really knowing why she was being filmed driving along a Japanese road. It's a split-screen video: the left side has her in a car with GVC active and the right side is without GVC. Her forehead jiggles less on the left-side screen.

Mazda says it achieved this by studying the way people walk, and recognizing that we dip our heads a little when taking strides. Following this, it tweaked the suspension on GVC-equipped cars to allow the front of the vehicle to dip a little to one side in a corner while the rear remains flat.

The clever stuff comes with the speed at which this happens. For it to be truly discreet, the

Mazda busts a move so smooth you won't even notice -Continued

automatic corrections need to take place more quickly than the driver can react, otherwise the driver will just do it and override the process. Most people have a reaction time of about a quarter of a second. For years, it wasn't possible to beat that time mechanically. The application of individual brakes in traditional torque-vectoring, for example, still needs the fluid to move in the lines and press against the calipers, and that just takes too long.

The breakthrough came when Mazda started work on an electric car. The instant response possible from the motor and circuitry provided the reaction needed to beat the human driver. Engineers developed a system that used the torque of the gas engine to regulate the speed of the car; response time now from input to result can be as quick as 50 milliseconds, or one-twentieth of a second.

Now, the SkyActiv system uses the gas engine to create deceleration G-forces, which will compress the front suspension, or acceleration G-forces, which will compress the rear. When it senses the steering wheel being turned, it will shift weight to the front to dig the turning tires in more firmly. If the driver maintains a constant steering angle, it'll move that weight to the back to dig in the rear tires and improve stability.

The idea is you don't even know it's happening – you just feel more confident in the vehicle, and it responds more predictably. The engine itself feels no different.

I was happy with the handling of Mazdas before GVC. Out on the open road, with an engineer turning the system on and off, I could see the little band of tape did seem to jiggle less, both on curves and straights. Did I feel more confident? No, but Mazda reckons this will be a subliminal thing.

The first car to get GVC will be the 2017 Mazda6, followed by the 2017 Mazda3. It'll be fitted as standard and there won't be an engineer to switch it off and on, so it will always be on. Apparently, it won't cost extra. Chances are, you'll never notice it, but Mazda hopes you'll appreciate it.

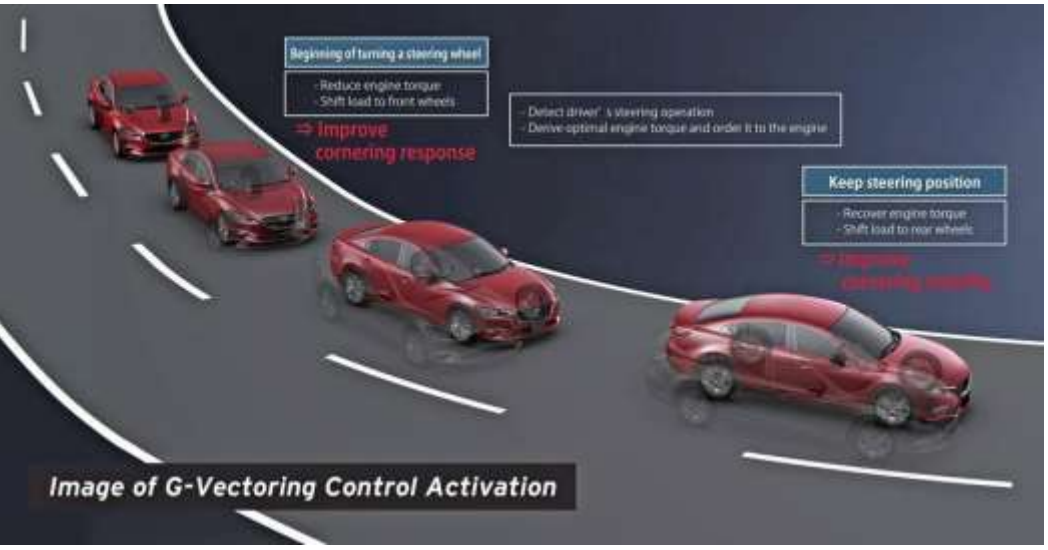


Image of G-Vectoring Control Activation

Latest Mazda SkyActiv technology is subtle but very effective

Richard Russell

June 29, 2016

MONTEREY, CA – I've taken and conducted a number of driving courses over the years, but none at a maximum speed of 30 km/h – until now. Mazda's SkyActiv Driving Academy, at nearby Laguna Seca Raceway, rigorously limited top speed through a number of exercises to experience the latest addition to its suite of SkyActiv technologies – G-Vectoring Control.

What makes Mazda unique among manufacturers of affordable cars is the practice of challenging conventional thinking, sweating the details. This has resulted in a widely recognized ability to produce cars with the best driving dynamics in their classes, from the Mazda3 and CX3 to the Mazda6, and the vehicle many believe offers the best driving dynamics of any class and price – the MX5. Mazda calls it the tireless pursuit of Jinba-Ittai, a feeling of oneness between driver and vehicle.

We gathered at Mazda Raceway Laguna Seca to sample the latest product of this "sweat the details" philosophy. Subtle and difficult to describe and experience, G-Vectoring Control is the next building block in the SkyActiv program.

G-Vectoring Control

SkyActiv is not so much a technology as a philosophy – an ongoing series of engineering efforts and resultant technologies designed to deliver superior fuel economy, lower emissions and a natural, intuitive response to driver input.

G-Vectoring Control (GVC) falls into the latter area. In essence the concept is simple – a subtle transfer of weight to the front wheels and contact patches at the first millisecond of steering input. The result is more accurate and smoother steering.

But the execution of GVC is anything but simple. It has taken eight years of R&D and a new generation of powerful and fast processors to reach the stage where it can be included in a production vehicle.

An in-depth technical session headed by Dave Coleman, a well-known Mazda Vehicle Development Engineer who is also a racer, explained the development of GVC, covering some pretty esoteric concepts. It all started with the continued pursuit of smooth transitions between G-Forces when braking, turning and accelerating.

Seat-of-the-pants feel

The development team began by studying the behaviour of the human body when subjected to movement. "We must tune our cars to please

Latest Mazda SkyActiv technology is subtle but very effective -Continued

the driver's subconscious. To do this we had to study the human body," Coleman said.

That undertaking led to issues like "minimizing jerk theory" – the rate of change of acceleration. It turns out the "seat of our pants' often referred to when describing our reaction to a vehicle is actually in our neck.

Studying head movement during dynamic situations from walking to driving or being a passenger allowed the engineers to develop a steering system that minimized vertical and lateral forces. Cameras, EKG sensors and various other technologies were used during development – and to effectively display the results – more on this point later.

Steering, brakes and engine involved

GVC involves not just the steering, but also the brakes, suspension and engine. Coleman says conventional brake systems and engines take too long to react, are too imprecise for GVC to work. The human brain can detect changes in G-forces within 250 milliseconds – one-quarter of a second. A new generation of faster and more powerful processors was required in order to put GVC into operation in a production vehicle.

"This latest generation of control computers allows more precise input, to combine a slight reduction in engine output at the first moment of steering input, shifting more weight unto the front tires. Everything has to happen within the first 50 milliseconds" Coleman said.

"The suspension was tuned so the front rolls slightly ahead of the rear and the inside goes down, rather than the outside going up. In tuning the steering, we want there to be direct feedback, the amount of turn or roll relating directly to the amount of steering input."

Subtle, yet effective

The result is very subtle and yet very effective. To experience GVC we drove a fleet of Mazda6 sedans equipped with the system and an on/off button. Cameras mounted at several points in the interior recorded upper body movement and steering wheel movement. Sensors monitored steering angle and lateral forces. An engineer riding in the rear seat gathered all these inputs on a laptop computer as we drove a number of courses, all at a top speed of 30 km/h.

That task was difficult on closed courses around pylons in the infield and darn near impossible on the actual full road course including the famous corkscrew. For that session we were told to forget the racing line, but rather follow the white line on the outside of the track as closely and consistently as possible.

Each exercise was performed twice, once with GVC enabled and once without. At the conclusion of each exercise, the engineer showed us the traces of our steering wheel movement and G-Forces – dramatically pointing out the efficacy of GVC! The number and degree of steering corrections was emphatically greater without GVC.

The last session was a half-hour drive over twisting secondary public roads with an engineer sitting in the front passenger seat turning GVC on and off at different points, allowing the driver to experience the difference. It was difficult to detect in some instances, all but impossible in others – perhaps because the driver was trying so hard to be smooth he

Latest Mazda SkyActiv technology is subtle but very effective -Continued

couldn't tell the difference!

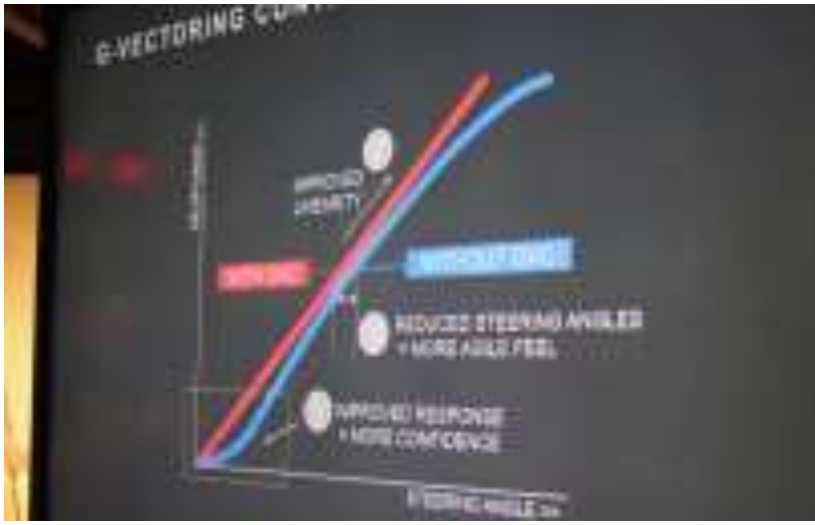
Most effective in poor conditions

Coleman and his crew said GVC will be most appreciated and effective in poor conditions. That certainly proved to be the case during the wet track and sandy-covered track exercises where it was obvious, by just watching the steering wheel movements that GVC smoothed things out considerably. I can't wait to experience it on snow and ice!

GVC will be rolled out in production vehicles as the various vehicle systems are upgraded and engine control computers updated, starting with the 2017 Mazda6 this fall, followed by the Mazda3 then the CX3.

"Mazda is nuts!" Coleman said in conclusion. "But in the right kind of way. Nobody else would go to such lengths with the driver/vehicle interface. But, the more satisfying we can make the driving experience, the more likely we are to attract new customers."

At the end of the day we were turned loose on the track with no restrictions in a fleet of bone stock Mazda3s and Mazda6s – proving just how good the current product is.



The ChronicleHerald

G-Vectoring control: Mazda offers upgrades to drive dynamics

Richard Russell

July 3, 2016

MONTEREY, CA — This is weird. Whoever heard of a 30-mph speed limit on one of the most famous racetracks in the world?

Yet, here I was driving around Mazda Raceway Laguna Seca ignoring the racing line and, instead, hugging the white line at the left of the track.

The cruise control was set at 30 mph and there was an engineer in the passenger seat watching my driving and another in the rear seat logging my steering inputs through a series of sensors and cameras connected to a powerful laptop computer.

This and numerous other exercises on dry, wet and sand-covered surfaces, all at low speeds and with a logging system on board, were designed to show the effectiveness of Mazda's latest SkyActiv technology — G-Vectoring Control (GVC).

Eight years of development has resulted in steering precision that the average driver will probably never appreciate, especially if they are familiar with Mazda products, which universally lead their classes when it comes to driving dynamics.

Dave Coleman, vehicle development engineer, said the development of GVC all started with the pursuit of smooth transitions between g-forces when braking, turning and accelerating.

The development team began with deep-dive research into the behaviour of the human body when subjected to the forces of motion.

"We must tune our cars to please the driver's subconscious. To do this we had to study the human body," Coleman said.

That led to 'minimizing jerk theory' — the rate of change of acceleration. It turns out the 'seat of our pants' often referred to when describing our reaction to a vehicle is actually in our neck.

Studying head movement during dynamic situations from walking to driving or being a passenger, allowed the engineers to develop a steering system that minimized vertical and lateral forces. Cameras, EKG sensors and various other technologies were used during development – and to effectively display the results — more on this in a few minutes.

Cameron told us how, by closely monitoring the speed of steering wheel inputs GVC, can signal the engine control computer to reduce power slightly.

This results in a slight shift of weight unto the outside front tire, tightening up everything in the suspension and improving steering response. All of this occurs in less than 50 milliseconds and is not consciously detectable by the average driver.

The numbers are extremely

The ChronicleHerald

G-Vectoring control: Mazda offers upgrades to drive dynamics -Continued

small: the deceleration is only 0.05g compared to 0.20 when you lift off the accelerator; engine torque is cut by a single digit percentage for only milliseconds. GVC mimics the weight transfer techniques used by racecar drivers around the world. This comes as no surprise since most of the engineer involved in the development, are weekend racers.

Mazda chose this simple method of improving steering precision and handling. The rest of the industry dabbles in something called torque vectoring which involves reducing engine output and applying the brakes to an inside wheel or adding power to the outside one, a process that Mazda engineers feel is too imprecise and takes too long.

The result is subtle and yet very effective. Each exercise was performed twice, once with GVC enabled and once without. At the conclusion of each exercise, the engineer showed us the traces of our steering wheel movement and G-Forces — dramatically pointing out the efficacy of GVC.

The number and degree of micro-corrections was emphatically reduced by GVC. With it disabled, the driver is likely to turn in too much or not enough, requiring corrections.

Coleman and his crew said GVC will be most appreciated and effective in poor conditions. That certainly proved to be the case during the wet track and sand-covered track exercises where it was obvious, by just watching the steering wheel movements, that GVC smoothed things out considerably. I can't wait to experience it on snow and ice.

What took so long? The precise control and instantaneous readings and signals required by GVC required a new generation of faster and more powerful processors.

"The latest generation of control computers allows more precise input, to combine a slight reduction in engine output at the first moment of steering input, shifting more weight unto the front tires. Everything has to happen within the first 50 milliseconds," Coleman said.

Those used for the demonstrations here were 2016 versions of the Mazda6. GVC will be rolled out in production vehicles as the various vehicle systems are upgraded and engine control computers updated, starting with the 2017 Mazda6 this fall, followed by the Mazda3 then the CX3.

G-Vectoring control is a modest but significant enhancement to driving dynamics. It improves handling, makes the driver better and passengers more comfortable — another sample of how this small company sweats the details.

All-New Mazda G-Vectoring Control Tested and Explained

Vincent Aubé

June 30, 2016

Self-driving cars seem to be all the rage among auto and tech companies right now, but luckily for us there are some that still care about having fun and enjoying total control behind the wheel.

Mazda, for instance, has long been known for building some of the best-driving and most exciting cars on the road. The Mazda3, Mazda6, and Mazda CX-5 (just to name a few) are arguably the most dynamic models in their respective categories, although that doesn't appear to be enough for many consumers if we look at the sales numbers in Canada and the U.S.

Feature content, technology, pricing, and even fuel economy seem to matter more to these people than simply having a good time driving. Today's cars are like pizzas with so many toppings you end up forgetting what you're eating in the first place.

G-Vectoring Control, a simple solution

Mazda North American Operations (MNAO) aims to change that with the upcoming introduction of a new driver-assist system. The 2017 Mazda6 will be the first vehicle to use it, followed by the Mazda3 in what will likely be the 2018 model year.

It's called "G-Vectoring Control," or GVC for short, and it has nothing to do with torque -vectoring systems found in a growing number of sporty cars. Spearheading the new SKYACTIV Vehicle Dynamics umbrella of technologies, it's designed to work on any vehicle and will actually become standard on all Mazdas once the necessary platform adjustments are made.

GVC software strives to enhance handling and reduce steering effort in corners while improving overall comfort. Requiring little to no modifications to a vehicle's hardware (suspension, brakes, chassis or other), it governs the throttle so quickly and minutely that no human driver can notice. Fed with a plethora of information such as vehicle speed, steering wheel rotation, and throttle position, GVC can react and adjust accordingly.

The principle is fairly simple as the system merely seeks to maximize the vertical load on the front wheels as you approach a corner by inducing a slight deceleration that

All-New Mazda G-Vectoring Control Tested and Explained -Continued

results in a forward pitch (longitudinal g-force). This puts more grip on the front tires and allows the car to get through the corner more easily. As you exit, weight shifts back to the rear axle, thus stabilizing the car.

In a telling video presented by the company, we see a pair of Mazda6 sedans changing lanes on a snow-covered road. The one blessed with GVC has a lot less tendency to slip and slide than the other that doesn't feature the new piece of technology. Watch:

https://www.youtube.com/embed/02tIMWI25K0

Another benefit of GVC is boosting the driver's confidence. By limiting steering corrections in corners, said steering starts to feel pleasantly heavier and you can manipulate the wheel with more assurance. While the technology is inspired from motorsports, it aims to make driving easier and more enjoyable for everyone, not just experts.

It's worth noting that GVC is constantly on, even in straight lines so as to provide more linear travel. No matter what the road conditions are, from bumps and potholes to slush and ice, the fact that steering corrections are minimized results in less driver fatigue at the end of the trip. Other passengers in the vehicle also enjoy a slightly more comfortable ride.

Blind test, sort of

As mentioned earlier, the effects of GVC can barely be detected as the system works so fast and so transparently, at the tiniest of levels. By the way, once integrated to the various Mazda vehicles it will be impossible to turn it off, unlike most stability control systems.

In an effort to demonstrate the virtues of their latest marvel, the good engineers at Mazda set up a series of tests that would increase our ability to perceive how GVC works. Alas, while we had been invited to the legendary Laguna Seca Raceway in California, almost all these driving exercises took place in the nearby parking lot, at speeds most auto journalists weren't used to.

The Mazda reps wanted us to really focus on what happens at ultra-low speeds. Circling around a loop with cruise

All-New Mazda G-Vectoring Control Tested and Explained -Continued

control activated while trying to stay very close to the inside cones forced us to pay attention to the car's slightest reactions and particularly the steering wheel's movements. While the difference was negligible, GVC did improve stability.

Added value

Research and development are already completed, but Mazda will keep doing homework after all future vehicles incorporate the technology. There's no going back now; SKYACTIV Vehicle Dynamics and GVC are coming soon. How will Mazda convince buyers that they need this sort of gadget? I sure would like to know.

Personally, after a full day of testing with GVC-equipped Mazda vehicles, I'm sold. Will it revolutionize modern cars? Certainly not, but it's another step toward optimized driving (rather than automated driving) and excellent news for all of us who refuse to believe that we're heading straight into a global wall of automatization. For many, driving is still fun!

Will it be enough?

While speaking with a few engineers during the presentation, I realized how much the culture and the mentality at the Hiroshima company is different from other, high-volume automakers. They firmly think that continuous improvements to the driving experience will have non-believers finally buy into what they're selling.

In their minds, a simple test drive is enough to change public perceptions about Mazda.

Mazda Will Use its Engines to Make its Cars Handle Better

AutoGuide.com

Sami Haj-Assaad

June 27, 2016

Mazda explained that how we drive is essentially three steps. The first step is making an input, whether it's steering, throttle or brakes. The second step is that the car responds to that action, and more often than not, it isn't 100 percent perfect. As a result, the driver has to make an adjustment, the third step. This is called the feedback loop. Sometimes you have to make big corrections, and depending on the speed of the vehicle, that adjustment may need to be done quickly. Those adjustments may even need finer and smaller inputs afterwards.

The result of all this is an unnatural, back and forth motion on the steering wheel, or jerky acceleration and braking. Sometimes this isn't very noticeable to the driver, but for other people in the car or objects, it's easy to see and feel. Additionally, all these extra inputs can reduce the driver's confidence and connection to the vehicle.

Mazda wants to change all of this. The idea is to reduce the time between input and making an adjustment. They also want the adjustments the driver makes to be smooth and not jerky. And of course, because this is Mazda and not a luxury company, it needs to be done without additional hardware that could make the car heavier.

Introducing G-Vectoring Control (GVC)

They've come up with something called G-Vectoring Control. It's software that can give the driver a good sense of what their initial action resulted in, and then needs a clear and very small adjustment afterwards. It's also one of the first processes that utilize the engine to enhance handling.

Here's how it works: when you make your steering input, the car will reduce the engine torque ever so slightly. This shifts the weight to the front wheels, giving them extra grip and a more responsive turn. From there the driver can make their minute adjustments, but if they maintain a steady steering angle, the car will then recover that reduced engine torque, which will shift weight towards the back of the vehicle, which improves stability through the turn.

Does it Work?

The effect is very subtle. We tested it thoroughly in a number of ways and needed to be extra sensitive to what we were doing and how it affected the driving process. As a passenger it was easier to see that the driver was "sawing" the steering wheel less with the system active. As a driver, it was hard to detect a significant difference until we drove the car in situations with limited grip, first wet pavement and

Mazda Will Use its Engines to Make its Cars Handle Better -Continued

then gravel. In those circumstances, it was clearer that the car required fewer inputs to keep steady despite the fear oflimited traction. It gives a better sense of confidence behind the wheel, and allows the driver to predict what the car will do with each input.

The engine only limits a small amount of torque, up to 15 lb-ft, which results in a difference of less than 0.01 g of force. It's not perceptible to the driver in the way that other brake-vectoring systems are. Mazda believes that those other systems are far less natural, while its process is more driver-focused.

Using the Engine to Improve Handling

In fact, Mazda's system is so unique because it uses engine braking instead of traditional brakes. The reason for that is because brakes are both less predictable and take too long to spring into action. The engine braking happens in about a quarter of a second, a delay that is hard to detect by human standards.

It's a uniquely Mazda thing to do, using the engine to enhance cornering and driving dynamics. This is the automaker that brings us the "Driving Matters" slogan and adheres to the philosophy of Jinba-Ittai: a feeling of unity between driver and vehicle. The automaker strives to have their cars become an extension of the driver, making them as natural and as fun to drive as possible. This makes sense with the more exciting and sport-focused Mazda MX-5 roadster, but the Japanese automaker wants to make even its mainstream products like the Mazda6 and Mazda3 engaging.

Coming Soon

The Mazda6 will be the first vehicle to get this software, as part of its 2017 Model Year changes. Mazda promises that the rest of the Mazda lineup will get this technology too.

In a time where automakers are investigating self-driving cars, semi-autonomous features and tons of driver assistance systems, Mazda is still introducing enhancements that improve the feeling of driving for the person behind the wheel.

Mazda's improved its steering, but you'll probably never notice

Jil McIntosh

July 9, 2016

SALINAS, California—Ever heard of "equilibrioception"? Or "minimum jerk theory"? That last one might sound like you're cutting down your Facebook friends list, but in reality, these things helped Mazda develop its latest technology, G-Vectoring Control (GVC).

It'll be gradually rolled out across most of Mazda's models, starting with the Mazda3 and Mazda6. But what's really unusual is that even if you buy a Mazda that has it, it's unlikely that you'll even realize it.

It makes such a subtle difference that I was only able to discern it by driving a specially-equipped model where it could be turned on or off (it'll be a default on production models, without a defeat switch). You just have the sensation of a car that handles really well.

The engineers extensively studied the human body during the process. Equilibrioception is your sense of balance, while minimum jerk theory is the fact that moving smoothly, such as when walking, is the most efficient and comfortable way.

In a vehicle, other than the fun of an occasional racetrack ride-along, most people are happiest when their heads are upright and they're not being jostled around. By smoothing out the motion when the car changes direction, GVC provides a more comfortable ride.

But it isn't only about passengers. That's actually more of a side benefit, since it's really about improving grip and steering response.

How it works seems deceptively simple. When you initially turn the steering wheel, GVC reduces the engine's torque. It's so slight and quick that it's impossible to detect, but that momentary deceleration transfers just enough weight forward onto the front tires – about five kilograms to each one – to better their grip and improve the steering response. As soon as you hold the wheel steady, the engine returns to normal.

The result is that, while you can't feel exactly what it's doing, it takes less effort to keep the car under control. In any vehicle, you're continually making little steering corrections to keep the car straight, especially on rougher roads. With GVC, you don't make as many, and the ones you do are smaller.

Even so, it's hardly noticeable, since you correct your steering so automatically that you seldom realize you're doing it. It was more obvious from the rear seat, where passengers are jostled more by steering movement along the car's length: with GVC on, the ride was smoother.

I most noticed what the car was

Mazda's improved its steering, but you'll probably never notice -Continued

doing on two courses, one water-soaked and the other loose gravel, where I had to make turns at 50 km/h. With GVC on, it was easier to keep the car tight in the curve and it better obeyed my steering input.

You can see in the video, taken on a dry course, that the difference is minimal (it's more noticeable on the second turn).

It's all done with software and needs no extra greasy bits. But it took eight years to develop, simply because everything has to happen so quickly and seamlessly. Braking was the obvious first choice for weight transfer, but even the fastest brake response produced a noticeable lag.

Engine management systems weren't quick enough at the time, and torque vectoring – applying power to individual wheels rather than cutting it back – didn't achieve what the engineers wanted.

Finally, because electric motors start and stop almost instantly, GVC was developed on an electric car. When Mazda began production of its new SkyActiv engines, which could handle the milliseconds of deceleration, it was able to proceed with a gasoline unit.

The roll-out across the lineup will be gradual because the system has to be dialled in for each vehicle's weight, size, steering and suspension, and will be added as models are updated.

So why come out with something so subtle that most drivers will never even realize what the car is doing? Mazda says it's simply an engineering improvement, just as if it adjusted damping rates or added different springs, which is why it can't be defeated and why it probably won't be advertised (plus it's really too complicated to explain in a 30-second commercial).

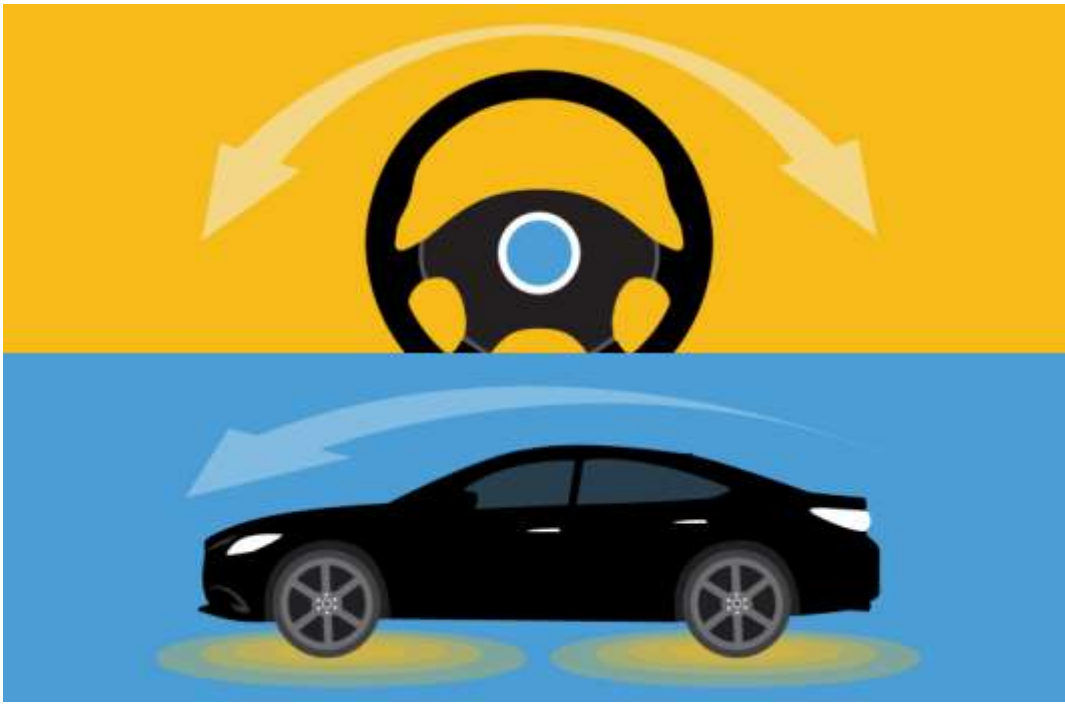
Overall, it smooths out the ride, reduces the need for wheel input, and on slippery surfaces, it reduces the slip angle for better control. It's not just subjective feel: the engineers even took electromyographs of passengers' necks to see how much they were jostled.

It's also the first of a series of technologies, all yet to be revealed, that will come under the name of SkyActiv Vehicle Dynamics. It's not a huge difference, but it's there, and that's exactly what Mazda intended.

How it works: Mazda's G-Vectoring Control steering

Jil McIntosh

July 13, 2016



SALINAS, CALIFORNIA – Whenever an automaker comes out with a brand-new technology, it usually shouts out to the heavens about it.

But even though Mazda spent more than eight years developing a new steering technology that it calls G-Vectoring Control (GVC), and which it will eventually put on most of its vehicles, you might never hear it advertised. And it's so subtle that when you drive a car with it, you might not even know it's there.

But as understated as it is, it does make a difference, and that's what Mazda's engineers set out to achieve.

GVC sounds pretty simple, at least on paper. A vehicle's weight shifts during acceleration and deceleration: to the rear when you take off, giving you that feeling of being "pushed back in your seat" in a powerful car, and to the front when slowing down, throwing your body forward when you brake hard. With weight shifted forward over them, the front tires have better contact with the asphalt, which in turn gives the driver more control.

When you initially turn the steering wheel on a car equipped with GVC, the system momentarily reduces the engine's torque. This, in turn, shifts the car's weight to the front wheels. The tires have more grip and the car responds better to your steering. It's only triggered by the initial movement, and once you're holding the wheel steady, the torque returns to normal. It's all software, with no extra mechanical bits required. It also differs from torque vectoring, which varies the amount of power sent to specific wheels, rather than reducing torque as GVC does.

Okay, so I can hear you already: "So my engine's going to cut out every time I turn the wheel?" Relax. It's so subtle that it's essentially imperceptible. I could only determine the difference when driving a specially-equipped Mazda6 where the GVC could be turned on or off.

Even so, I never did feel the reduction in torque. What I mostly noticed about the change in steering response was that I wasn't working as hard to keep the car under control. Drivers are constantly making corrections to the steering, but they're so small and so integral to driving that you seldom realize you're even moving the wheel. With the GVC engaged, I didn't have to correct as much, or move the wheel as far when I did, to stay on a straight path. Even then, it wasn't always obvious to me, because I make such corrections automatically

How it works: Mazda's G-Vectoring Control steering -Continued

without thinking about it. But when I sat in the back seat, where sideways movement is more noticeable along the car's length, the ride was much smoother with GVC on, since I wasn't jostled from side to side as much.

The most impressive difference, from a driver's perspective, was when I took the car around fairly tight turns at 50 km/h on a water-soaked course and then a gravel surface (the best Mazda could do to simulate a snowy road on a sunny California afternoon). Throughout each curve, the car tucked in much better around the turn with the GVC on. I simply felt that I had more control. The effect is also more pronounced on bumpy roads, where you usually have to make far more steering corrections to keep the car straight.

So if it all sounds so simple, why did it take eight years to figure it out? First, the engineers had to determine how to achieve the weight transfer in milliseconds. Braking shifts weight, but the time required to apply the brakes created a noticeable lag. Engine management computers at the time weren't quick enough to reduce torque. Finally, someone tried an electric motor, and GVC was initially developed on an electric car.

The engineers also had to extensively study human motion to determine how external forces act on the body. Most people walk or move with "minimum jerk," fine-tuning our motions so we move smoothly while keeping our heads upright for balance. By reducing wheel movement on turns and rough roads, GVC provides that same minimum-jerk standard, reducing fatigue for the driver and decreasing how much passengers are jostled around. Finally, the precise amount of weight transfer had to be dialed in, since too much on the front wheels would make the steering turn-in too abrupt.

Even though no mechanical parts are added, GVC has to be tuned specifically for each model's size, weight, steering geometry, damping rates and other factors. It will be rolled out gradually over the model range, starting with the Mazda3 and Mazda6. Drivers won't be able to turn it on or off; instead, it's just part of the overall steering system.

That's why, in all likelihood, Mazda won't advertise that it's there. It's too complicated to explain in a 30-second television spot, and quite frankly, it's so subtle that it's difficult to figure out exactly what it's doing unless you can directly compare it with a model that doesn't have it. Sometimes, a new technology doesn't have to be earth-shattering to really make a difference.

TORONTO STAR

How Mazda's G-Vectoring will improve handling

Jim Kenzie

July 16, 2016

Mazda, exhibits, latest, advance, in, vehicle, dynamics, at, Laguna, Seca

Mazda G-Vectoring — the next step in vehicle dynamics

LAGUNA SECA, Calif. — How much can you learn about a car's handling prowess at 35 km/h?

If you're talking a race car, not much.

A road-going car? A surprising amount.

Mazda has long cared more about the finer points of vehicle dynamics than any other mass-market manufacturer. Most experts agree that cars like the compact Mazda 3, mid-size Mazda 6, even the CX-5 crossover, have superior steering and road feel compared to their direct competitors, following on from the brilliant MX-5 Miata.

But even non-enthusiasts can feel this.

When my second daughter was only 18, she briefly drove the then-current Mazda Protege, and remarked, "This car handles really well!"

I asked her for more details.

She thought for a bit and said, "It has a CD player."

Obviously, that has nothing to do with handling. But she felt something, and just didn't have the vocabulary to describe what that something was.

So she reverted back to what was critical to a teenager at the time — a CD player — which was rare in a car in this price class back then.

Mazda calls the actual driving sensation "Zoom Zoom," for lack of a better phrase.

Now they have come up with new technology to further enhance the handling of their vehicles.

It's called "G-Vectoring," again for lack of a better phrase, because it's not to be confused with torque vectoring, which in effect is advanced directional stability control.

G-Vectoring began with Hitachi. Best-known over here as a supplier of consumer electronics, Hitachi is also a major supplier to the car industry.

Some bright guy at Hitachi understood that good drivers, notably race or rally drivers, know that when entering a corner, if they can add just a bit of weight to the front wheels, it will help the car turn into that corner. A brush of the brakes, even a mild lift off the throttle before turning the steering wheel, can make this work, because reducing torque output causes the car's weight

How Mazda's G-Vectoring will improve handling -Continued

TORONTO STAR

to shift ever so slightly to the front wheels, giving the front tires more grip.

But you need a deft hand at the wheel to pull this off. Reduce the torque too much and you just slow the car down.

Said bright guy figured that if he could get the car to do this automatically, it might make the car handle better, steer more accurately, and in effect make the driver seem like a better driver than they really are. Make your customers feel superior — that's a good marketing strategy.

Working with a Japanese university, they more-or-less had the math figured out — how much to reduce the torque to get the weight transfer they needed.

Turns out that was only 0.01 to 0.05 G, which is undetectable by humans, and it needed to be applied in less than 250 milliseconds — a quarter of a second.

Hitachi's plan was to use the braking system to create this weight transfer, but the brakes simply could not react quickly or precisely enough.

At some point, Mazda got involved. As they were developing their engine management computers to be ever more sophisticated in search of reduced consumption and emissions they thought maybe when the steering wheel is turned indicating the initiation of a cornering manoeuvre, they could have the engine reduce torque output just enough to achieve the needed weight transfer.

As usual, the devil is in the details, and it took some eight years of constant development to make this work to their satisfaction. How much torque reduction? How much steering input, and how quickly must it be applied to trigger the response?

So here we are in the infield of the famed Laguna Seca race track near Monterey, doing loops around pylons at 35 km/h, trying to detect what difference this makes.

Dave Coleman and Kelvim Hirashi are two development engineers at Mazda North America, and they are largely responsible for the fine-tuning of the suspension of Mazdas.

Suspension design is maybe 95 per cent science, and 5 per cent art. Anybody can figure out (or buy) the 95 per cent; getting those last few details — bushing stiffness, damper valving, minute adjustments to the geometry — that takes some finely calibrated seats-of-the-pants.

These two guys are all about that.

And they knew the challenge with G-Vectoring was going to be showing us, and subsequently the buying public, how it works and why it matters.

The exercises included driving around these oval loops, on dry pavement, on wet pavement and on loose gravel.

The technology gives the tires more initial bite, and the driver more confidence that the line they have chosen is correct.

The problem is that with the system operational, it just feels like the car is a good-steering car. And Mazdas are already good-steering cars.

So they rigged up some Mazda 6 sedans so that the G-Vectoring could be switched on or off at will.

And by gosh, even at 35 km/h, you could feel the difference. Turn-in was just more stable and required less fine-tuning of the steering to maintain the desired arc.

And the differences were more noticeable in poor traction conditions — wet pavement, loose gravel.

Lane-change manoeuvres at moderate speeds were also more easily done with the

How Mazda's G-Vectoring will improve handling -Continued

TORONTO STAR

system in operation.

Interestingly, the differences were almost more noticeable as a passenger sitting in the back seat as a colleague drove. You could easily see how many more minute steering corrections the driver was making when the system was disengaged.

These are the sort of corrections you make almost subconsciously — as a driver you are almost unaware you are doing it.

Videos showing passengers' reactions in corners showed significantly less body movement with G-Vectoring in action, as the car was more stable throughout the manoeuvre.

Further proof was made available to us with printouts from a computer that was measuring steering wheel movement as we ran these loops. With the system on, the traces were markedly smoother, with less jerkiness.

And remember — this was all at low, everyday driving speeds. It's a handling benefit that doesn't only help at or near the limit.

Mercedes-Benz and other European manufacturers now have what are in effect 'doziness meters'. If the car detects that the driver appears to be getting tired, it flashes a coffee cup symbol in the instrument panel, suggesting it's time to take a break.

What these systems actually measure is the increase in minute steering wheel motions, the sort of thing G-Vectoring reduces, suggesting that in addition to making drivers more confident and passengers more comfortable, it will also make drivers less fatigued. So there is a potential safety benefit here, although that will be hard to quantify.

G-Vectoring will be launched as standard equipment in the next-generation 2017 Mazda 6 some time next year, and it will flow into all product lines as they come up for renewal.

The changes are largely software-based, hence relatively inexpensive, although the suspension must be tuned to take best advantage of this.

At this point, Mazda is unsure of how best to market G-Vectoring. If they promote it specifically but the cars don't have the on-off switch like our testers did, then the consumer won't be able to really detect the difference.

Yet if they don't brag a little about it, how will anyone know they have advanced the art of vehicle dynamics?

Mazda's current marketing slogan is "Driving matters" and G-Vectoring is consistent with it, in that it is almost the direct opposite of autonomous driving. They want people to enjoy their time behind the wheel.

They also feel that once people do get into Mazdas, they will appreciate the difference, and want to stay with the brand.

Until recently, sales statistics have not backed up that supposition. Mazda's brand loyalty hasn't been markedly different than other brands.

But they do say that the current generation of Mazdas, those with the so-called SkyActiv technologies, are showing greater brand retention/re-purchase rates, so perhaps they are on to something here.

Will G-Vectoring help get consumers out of their Camrys and Accords and into Mazda 6s?

We will start finding out next year.

Mazda G-Vectoring Control: Cornering Without Effort

THE CAR GUIDE

Sylvain Raymond

July 21, 2016

A few years ago now, Mazda launched its SKYACTIV technology, which involved fine-tuning the chassis, engine, gearbox and body to reduce fuel consumption. For 2017, the manufacturer is extending this system's reach by taking aim at the vehicle's dynamics. The aptly named SKYACTIV Vehicle Dynamics is a much more complete package that supports Mazda's philosophy of making the driver one with the car.

While they're at it, Mazda is introducing G-Vectoring Control, which improves comfort, stability and steering performance. Since they're refreshing the 2017 Mazda6 anyway, they're going to equip it with this new system. The Mazda3 will follow suit once it goes under the knife sometime between now and next year. When all is said and done, the manufacturer will have endowed all its vehicles, including its SUVs, with this technology.

An assistant that perfects your driving

Mazda summoned us to the Monterey region and the legendary Mazda Raceway in Laguna Seca to meet the G-Vectoring Control system (aka GVC). One common mistake when going into a turn is needlessly destabilizing the car and accentuating weight transfers by jerking the steering wheel, constantly correcting the trajectory or abruptly hitting the brake and accelerator rather than transitioning smoothly. Not only is this behaviour detrimental from a performance standpoint, but it's very uncomfortable for the driver and, more importantly, for the passengers.

And that's exactly why the GVC has been developed. This system isn't aimed at optimizing vehicle handling on a track and shaving off a second per lap. Instead, its goal is to enhance the everyday driving experience.

All this by controlling engine torque

The engine is the heart of this technology. The engineers developed software that, coupled with a series of sensors, detects interactions with the steering. Thus, it can limit the torque sent to the wheels at the right moment and better control G forces. It manages to replicate precisely what a professional pilot would do when cornering: use 100% of the grip while reducing the roll and pitch of the chassis.

It takes years of practice to master this art and now Mazda is offering it to you without any effort on your part. Some bemoan the fact that this and other innovations are aimed at compensating for drivers' lack of skill, but that's a whole other debate. These days we rely on technology instead of driving ability.

Mazda G-Vectoring Control: Cornering Without Effort -Continued

THE CAR GUIDE

The GVC is very efficient. We put it to the test in a series of exercises and then deactivated to see the difference. The good news is that it's very smooth without any noticeable impact on the fun of driving. And that's just what we were afraid of: yet another system that deprives us of control or power in the name of safety. That is not the case here. In fact, we found ourselves wanting to leave it engaged at all times on a winding stretch of road since it produced superior precision and enhanced enjoyment.

Not only does the system help maximize the car's performance in turns, it also reduces the amount of effort you need to put into steering, thus staving off fatigue. This is a very attractive feature if you spend long hours at the wheel every day.

As soon as you enter into a turn, the most critical part (i.e. the delay between the moment where you turn the wheel and where the vehicle starts to change trajectory) is greatly reduced. We sensed extreme precision. The number of corrections required is also reduced. A camera and sensors recorded our driving on an oval section and the results were very convincing. The graphic was a lot less jerky once the system was engaged.

The system proved very effective on wet or slippery surfaces. We were able to negotiate curves much more efficiently and with better control. In short, the GVC helps reduce jerky movements to the bare minimum to maximize vehicle handling and passenger comfort.

Of course, this new technology is not going to prompt throngs of buyers to rush into Mazda dealerships, and few salespeople are likely to know how to explain it. Be that as it may, the G-Vectoring Control system will prove its worth to owners who use it daily and will add to what makes driving a Mazda so dynamic and fun. You'll probably like, although you may not really be able to describe it.