

Toyota's Tacoma Pickup Isn't Just an Off-Road Monster, It's an Active Safety Stalwart

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Advances in sensors, software and computing power have led to a revolution in the capability of vehicles to process what's happening outside – and to help drivers mitigate collisions with other cars, bicyclists, and pedestrians. Toyota has been honing its crash-avoidance features for years and has packaged many of its latest active safety features in its Toyota Safety Sense (TSS) technology suite.

For consumers new to TSS, the all-new 2024 Toyota Tacoma is a great opportunity to understand the role these advanced driver-assistance features have on the driving experience.

TSS has consistently evolved since its first iteration in the 2016 model year. As TSS was rolled out, the safety package was initially offered as TSS-C for small cars and TSS-P for larger cars, SUVs, and trucks like the Tacoma. Since then, Toyota has rolled out TSS 2.0, 2.5 and 2.5+, and recently 3.0.

The new Tacoma shows how TSS capabilities have grown to a suite of eight safety or convenience features that are embedded in the vehicle's DNA.

“It's part of the driving experience now,” said Derek Caveney, senior executive engineer at Toyota Motor North America (TMNA) Research and Development. “More and more people are incorporating these active safety support and convenience systems into their driving. It's one of the top five features people are shopping for.”

As with most Toyota vehicles, TSS comes as a standard feature on Tacoma. TSS 3.0 has added functionality in certain situations and is designed to complement and support drivers' natural styles. Under certain scenarios, TSS may add steering or braking when it's needed to help mitigate or avoid a collision or avoid drifting out of a lane or going off the pavement. Drivers should always keep in mind that these active safety systems have limitations and are not a substitute for safe and attentive driving. The driver remains responsible for controlling the vehicle.

The engineers' hard work on the Tacoma was recently recognized by the Insurance Institute for Highway Safety, which bestowed its TOP SAFETY PICK award to the 2024 Toyota Tacoma crew cab.*

Under ideal operating conditions, TSS 3.0 now includes the capability to help avoid crashes with preceding vehicles at slightly higher speeds and may be able to detect oncoming cars in left-hand turns, and activate automatic braking for pedestrians, bicyclists, and motorcyclists. There are limitations to system performance, and each specific situation is unique, which means that system functionality will vary based of the unique conditions that are present.

Driver annoyance is an important consideration. If the systems feel obtrusive, drivers may choose to turn the features off — and all of the engineering and equipment added on for safety won't have any real-world impact. Toyota's engineers have attempted to strike a balance between the functionality of the system and the perceived annoyance of the notifications provided to the driver.

The 2024 Tacoma takes TSS 3.0's safety capabilities a step further, delivering unique driving capabilities never seen before on a body-on-frame Toyota pickup. For towing, Toyota has tuned its adaptive cruise control and blind spot warning systems so that they operate in a way that takes into account the presence of certain trailers.

Tacoma engineers studied the physics of jackknifing and how truck drivers behave in emergency situations, said Joe Conners, a senior engineering manager who worked on the truck upgrades. The engineering teams used computer simulations for applying the Pre-Collision System (PCS) in different driving scenarios based on the truck drivers' experience to help determine a set of boundaries for system operation. They also enabled trailer brakes to function in tandem with the Tacoma's braking system, a feature also available on the new generation Tundra.

“We did a number of these different scenarios and simulations, with steering angles and different speeds,” Conners said. “We design these active safety and convenience systems to work cooperatively with the driver, lining up the boundaries with naturalistic driving behaviors with the goal of ensuring that any intervention is seamless.”

Like owners of sporty vehicles, truck owners like to personalize their vehicles. Even when used for rugged work, drivers still want the support of safety systems while on the road. Tacoma can now be ordered with a Toyota-built lift kit, to give more ground clearance. In another Toyota first, Tacoma’s TSS features continue to properly function when the Toyota Genuine lift kit is installed at the factory, Caveney said. It’s a statement about the evolution of safety features on the pickup.

“These safety systems are specifically tuned now for trucks, even if they are raised with a Toyota lift kit,” Caveney said. “If you’re towing, we support better performance of those features. The market is showing us that even truck customers want this kind of support from their vehicles.”

Aside from the camera utilized by TSS, Tacoma is available with seven other cameras employed for some cool truck-specific features. Four surround cameras are used to generate a 360-degree birds-eye view for parking. One camera allows the driver to monitor the cargo in the truck’s bed. Another camera is available for an electronic inner mirror, and the final camera is available within a wireless camera system that can be attached to the rear of a trailer for sending images to the multimedia display or electronic inner mirror when towing.

More than that, the four surround cameras have been used in the Tacoma to generate the multi-terrain monitoring (MTM) view. The cameras keep track of what they’re seeing to generate an image of the terrain the truck is passing over. This can help avoid damage to the differential and other parts of the undercarriage. The panoramic view can also be used when the truck is off road, generating a birds-eye image of surrounding landscape when moving at slower, off-road speeds.

The way Lane Departure Alert with Steering Assist works in TSS 3.0 is a good illustration of how the technology has evolved. With LDA with Steering Assist, if the vehicle has detected the edges of its travel lane, the vehicle will attempt to correct steering if it senses the driver is drifting out of a lane. In older versions of TSS, drivers intentionally changing lanes without first putting on a turn signal would engage against steering assist, which would provide mild resistance to the driver’s initial steering input. With TSS 3.0, the system attempts to detect and interpret that intentional action and likely won’t intervene in this driving scenario.

“If you crossed a lane marking, the previous system would generally try to correct it,” said Jarod Duncan, senior principal engineer at TMNA’s integrated vehicle systems division. “Now, it’s programmed in a way that is more ‘aware’ of what you were doing before the move. It understands steering torque.”

Another example of TSS’s evolution to more natural driving styles can be seen in Dynamic Radar Cruise Control. It comes with a defined setting for maintaining a pre-set distance from the vehicle in front, and drivers can now choose from four following gaps. Through market research, Toyota determined many customers would prefer a shorter trailing distance, added Caveney.

The latest capabilities of TSS and other systems such as MTM were made possible by advances to sensors like cameras, radar, and sonar. For example, TSS 3.0 includes an upgraded forward-facing camera with higher resolution and wider angles, and an improved radar sensor for a longer and wider field of view. It’s the secret sauce that makes advanced driver assist systems operate at higher speeds and in more scenarios when the system must decide whether to engage in a fraction of a second.

“The system’s performance has improved to allow for more flexibility,” Caveney said. “We’re more confident the system will behave or react more naturally, and we can support safely shorter headway distances.”

For additional natural and confident support of driving, TSS 3.0 includes the new Proactive Driving Assist (PDA) feature. When conditions are met, PDA provides gentle braking when driving into curves or gentle braking and/or steering to help support other driving tasks, such as distance control between the driver's vehicle and a preceding vehicle, pedestrian, or bicyclist. PDA can also provide greater space margins to other road users to reduce the likelihood or severity of subsequent crash-imminent scenarios.

The engineering team behind TSS is also looking at trends in the crash data to help inform their next area of focus. In recent years, there have been spikes in U.S. crashes involving bicyclists and pedestrians, especially at night. And TSS 3.0 showcases better capabilities in detecting those kinds of road users. But these advances were assisted because of innovative research that started years ago at Toyota's Collaborative Safety Research Center (CSRC) in Ann Arbor, Michigan.

CSRC helped increase the range and field-of-view for front sensing at intersections. It reduced the times to warn drivers about impending collisions and activate emergency braking. These specifications were generated from several datasets of large crash and near-crash incidents as well as naturalistic driving studies in the U.S. CSRC's research focused on the two most frequent types of intersection crashes: vehicles coming straight across a driver's path and left turns in the opposite direction. For nighttime detection of pedestrians, CSRC developed a detailed method of testing by recreating illuminations from real world conditions on the test track.

CSRC has also worked for years to develop materials that could substitute for different surfaces in the real world that are found besides roads, which vary greatly throughout the world and in different climates. From this data, advanced driver assist systems have been trained to function in less than perfect road conditions, and especially on roads that may not have clearly marked lanes. It adds up to a higher functioning active safety system.

Further, CSRC's research impact stretches to the mannequins developed for the test track. Some were later adopted as standard by the Society of Automotive Engineers – influencing designs across the auto industry.

“It is extremely fulfilling to see the results of CSRC research projects to help prevent or mitigate crashes and make roadways safer,” said Rini Sherony, senior principal engineer at CSRC. “Other road users are benefitting as well. It's helping to make people's life safer and better.”

*Insurance Institute for Highway Safety 2024 ratings, small pickup/crew cab pickup class. 2024 Toyota Tacoma Crew Cab tested. For details on 2024 Top Safety Pick Awards, see www.iihs.org.