1. ACTIVE SAFETY SYSTEMS

The three basic modes of vehicle motion—moving, turning and stopping—all depend on traction between the tires and the road surface. Depending on road surfaces and conditions, however, maintaining traction can be difficult. Vehicles traveling at high speed can easily exceed the traction allowances of an icy road, for example—and this can often cause accidents. To prevent loss of control, the vehicle needs to make maximal use of traction at all times without exceeding road and situational limits.

Toyota has developed active safety systems to help better control a vehicle in emergency situations where drivers of average ability would typically be unable to prevent the loss of traction. The Anti-lock Brake System (ABS) helps prevent wheel-lock during emergency braking. Traction Control (TRC) safety systems control the engine and brakes to prevent wheel-slip or engine-racing when accelerating.

Two more recently developed systems boost a vehicle's ability to make maximal use of traction during turning and emergency braking. Vehicle Stability Control (VSC) works to control lateral slip during cornering, while Brake Assist (BA) works in tandem with other systems such as ABS to extract maximum stopping power from the brakes.

Vehicle Stability Control (VSC)

Lateral slip can occur when drivers make a sharp turn to avoid something, or when they attempt to take a curve too fast or on a low-friction surface such as ice. The resultant loss of vehicle control is a major cause of serious traffic accidents.

VSC helps control lateral slip in situations that go beyond the abilities of average drivers. The system combines automatic operation of a throttle actuator, which controls engine output, with independent actuators on all four brakes. Sensors constantly monitor vehicle conditions such as speed, yaw rate and acceleration, and on the basis of this data the system adjusts engine output and operates the brakes on all four wheels to keep the vehicle within traction and control limits. The result is much higher cornering stability.

Front-wheel outward lateral slip can occur if a driver enters a bend too fast without cornering sufficiently. In this case, VSC applies the brakes on the inside-rear wheel and throttles the engine back. This has the effect of reducing the car's speed and increasing the inward moment on the vehicle (i.e. pushing the vehicle to the inside of the turn). The tires' grip on the road rises, and the vehicle is able to return to a safe course.

Alternatively, if the steering is too sudden on a curve, this can cause rear-wheel outward lateral slip, in which the vehicle enters a spin. In this situation, VSC applies the outside-forward brake and controls the engine's output to impart an outward moment to the vehicle. This stops the rear wheels from slipping and helps prevent the spin.

Brake Assist (BA)

The Brake Assist system detects emergency braking situations through sensors that measure the speed and force with which the driver depresses the brake pedal. If it detects an emergency situation, the Brake Assist system helps ABS and other braking systems extract maximal stopping power from the brakes.

Toyota's research into braking has shown that, in panic situations, even inexperienced drivers are generally able to depress the brake pedal quickly. However, they often cannot apply full power to the brake pedal and their emergency stopping distance is considerably longer than that of highly skilled drivers as a result.

Brake Assist adds extra braking force in these situations. It estimates the need for emergency braking, and boosts braking power even if the driver is not depressing the brake pedal strongly. This allows even ordinary drivers to stop in a similar distance to experienced drivers. Independent electronic control ensures that this extra force is not applied during non-emergency braking.

2. PASSIVE SAFETY SYSTEMS

Passive safety systems aim to minimize damage to the occupants of a vehicle in the event of an accident. Over the years, Toyota has worked to develop car bodies that can better absorb the impact of collisions from the front, side or rear, together with high-integrity passenger cabins that help to lessen the danger to vehicle occupants from the primary and secondary effects of a collision. In addition, Toyota has worked on a variety of safety measures designed to reduce the harm caused to pedestrians or riders of two-wheeled vehicles during accidents.

Toyota's development work typically divides into three phases. First, Toyota collects independent data from Japan and around the world on accidents. Second, based on this data, computer-aided engineering (CAE) techniques are employed to run computer simulations of different types of accidents on various vehicle bodies. Third, the company conducts numerous tests with full-size prototypes on around 1,000 vehicles per year to determine how well actual performance compares with simulation theory. Data from these tests is fed back into the CAE design stage.

Toyota Passive Safety Body (GOA*)

Toyota began introducing GOA into its vehicle line-up in December 1995. Since then, the company has been constantly working to improve the level of protection that the passive safety body affords vehicle occupants in a collision. Crumple zones and a high-integrity cabin help reduce deformation in full- and offset-frontal collisions, as well as impacts from the side and other directions. Bodies are also designed to help minimize damage to the passenger compartment, thereby protecting the occupants while facilitating escape and rescue.

Recently, Toyota has raised its own minimum passive safety standards in line with a move towards more stringent government regulations worldwide. The company's aim is to keep its standards higher than existing regulations, so that the new Toyota passive safety body is at the top level of passive safety effectiveness in every vehicle class.

Specifically, Toyota toughened the criteria used in its GOA tests during the development of the Vitz compact, which went on sale in Japan in January 1999. The new body passed offset frontal collision testing at 64 km/h, which involves an increase in collision energy of around 14% compared to the previous test speed of 60 km/h. It also passed tests for full-lap frontal and side collision impacts at 55 km/h—representing a 21% increase in impact energy compared to the previous test speed of 50 km/h. The Vitz body has also been fully tested for safety in 55km/h offset rear collisions.

Pillars and roof side rails are internally ribbed in the Vitz to help absorb the energy of a collision. Underbody and anchor-point configurations of the brake pedal were devised so that in the event of a frontal collision, occupants' legs are protected from injury by controlling the degree to which the brake pedal intrudes into the cabin. Additionally, rear seats have reinforced seat-back frames, hinges, and locks to help protect occupants if loads in the rear luggage space are thrown forward during a frontal collision.

* GOA, or Global Outstanding Assessment, is a domestic Toyota term denoting top-level passive safety concepts.

Seatbelts with pretensioners and force limiters

Pretensioners are designed to take up slack in a seatbelt the instant a collision is sensed. This increases the speed with which the belt can start restraining the chest's forward movement. A force limiter then restricts the force applied to the chest by the belt to a preset value, and maintains the force at that value once it is reached. This helps prevent the force on the chest from becoming damagingly high. Together, these two features help to lessen the impact of a collision on the chest compared with conventional seatbelts.

SRS Curtain Shield Airbag

When a sensor in the center pillar detects a side impact, the SRS curtain shield airbag deploys from the front pillar and the roof side downwards between the occupants and the side of the car. Toyota's SRS Curtain Shield Airbag helps to protect occupants' heads from injury due to severe impact with the vehicle's pillars or side windows, and outside obstacles such as utility poles.

WIL concept seats

Toyota has developed Whiplash Injury Lessening (WIL) concept seats to lessen the damage caused to an occupant's head and neck during rear-end collisions. Such whiplash damage is caused by sharp jerks of the head relative to the rest of the body. The new seats are designed so that the seat back and headrest impart the force of a collision to the torso and head simultaneously. This stops the two parts of the body from moving fast relative to one another, and thereby lessens the effects of whiplash.