

Automotive Stability Enhancement Systems

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1. Scope—The purpose of this SAE Information Report is to describe currently known automotive active stability enhancement systems, as well as identify common names which can be used to refer to the various systems and common features and functions of the various systems. The primary systems discussed are:

- a. ABS—Antilock Braking Systems
- b. TCS—Traction Control Systems
- c. AYC—Active Yaw Control Systems

The document is technical in nature and attempts to remain neutral about specific manufacturer designs, and automobile producer features.

2. References—There are no referenced publications specified herein.

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3. **Definitions**—There are many automotive stability enhancement systems on the market today, with more arriving almost daily. These systems each have an acronym unique to their design, performance or marketing features. This document attempts to be current through the date of publication in describing the systems currently known. Some of these names and acronyms are trade names of the system or vehicle manufacturers. See Table 1.

TABLE 1—CURRENTLY KNOWN ACRONYMS

Antilock Braking Systems	Traction Control Systems	Active Yaw Control Systems
ABS (Antilock Brake System)	ASC (Automotive Stability Control)	ABC (Active Brake Control)
RWAL (Rear Wheel Antilock)	ASR (Automatic Stability Regulation)	AH (Active Handling System)
SCS (Stop Control System)	Brake Only Traction	Active Safety
	ETS (Enhanced Traction System)	Advance Trac
	TCS (Traction Control System)	ASMS (Automotive Stability Management System)
	TCB (Traction with Brake Intervention)	CBC (Cornering Brake Control)
	TRAC (Traction Control System)	DSC (Dynamic Stability Control)
	EDS (Electronic Differential-lock System)	DSTC (Dynamic Stability and Traction Control)
		ESP (Electronic Stability Program)
		ICCS (Integrated Chassis Control System)
		IVD (Integrated Vehicle Dynamics)
		PCS (Precision Control System)
		PSM (Porsche Stability Management)
		SCS (Stability Control System)
		StabiliTrac
		STC (Stability and Traction Control System)
		Traxxar
		VDC (Vehicle Dynamics Control)
		VSA (Vehicle Stability Assist)
		VSC (Vehicle Stability Control)
		YCS (Yaw Control Stability)

4. System Descriptions—In this section, the minimum criteria of each system are listed. In addition, a brief description of a typical implementation and the advantages of each system are provided. This description is not intended to limit innovations such as development of alternate sensors, etc., but represents the current state-of-the-art. In addition, it should be noted that performance of the systems might vary somewhat from manufacturer to manufacturer and from vehicle to vehicle as the systems are calibrated to satisfy the needs of a specific vehicle and target customer.

4.1 Antilock Braking Systems (ABS)

4.1.1 A system is defined as an Antilock Braking System if it:

- a. Is computer controlled.
- b. Has a means to determine if any wheel is about to lock.
- c. Has the capability of regulating the brake torque at the wheels to limit wheel lock.
- d. Controls the brake torque to each of the front wheels independently and the rear wheels either independently or as a pair.

4.1.2 DESCRIPTION AND ADVANTAGES—ABS systems monitor the vehicle wheel speeds and regulate the brake forces to control the slip between the tire and the road surface. By avoiding wheel lock, vehicle stability is improved and the driver retains the ability to steer the vehicle. On most surfaces, the stopping distance of a vehicle with ABS is improved when compared to the same vehicle without ABS. Whether the rear wheels are controlled individually or as a pair depends on the specific characteristics of the vehicle including load distribution and inherent vehicle stability, and the target market for the vehicle.

4.2 Rear Wheel Antilock (RWAL)

4.2.1 A system is defined as a Rear Wheel Antilock System if it:

- a. Is computer controlled.
- b. Has a means to determine if a rear wheel of the vehicle is about to lock.
- c. Has the capability of regulating the brake torque at the rear wheels to limit wheel lock.

4.2.2 DESCRIPTION AND ADVANTAGES—RWAL systems monitor the vehicle's wheel speeds and limit the rear wheel brake torques to limit rear wheel lock-up. By avoiding rear wheel lock-up, the vehicle stability is improved. This system does not control the vehicle's front wheels and does not provide steering or stopping distance improvement.

4.3 Engine and Brake Traction Control Systems (EBTCS)

4.3.1 A system is defined as an Engine and Brake Traction Control System if it:

- a. Is computer controlled.
- b. Has a means to determine if a drive wheel is spinning.
- c. Has the capability of applying brake force individually to the drive wheels to limit wheel spin.
- d. Has the capability of controlling engine torque to reduce the brake torque needed to limit wheel spin.

4.3.2 DESCRIPTION AND ADVANTAGES—Traction Control Systems monitor the wheel speeds and apply brake torques and/or control engine torque to the drive wheels as necessary to control spinning during acceleration. By controlling wheel spin, the vehicle stability, steerability, and acceleration are improved. Also since the brakes can be applied to the drive wheels individually, engine torque can be transferred through the differential from one wheel to another. This can improve vehicle mobility and acceleration on surfaces which have non-uniform frictions (such as a condition where one drive wheel is on a slippery surface and another is on a higher-friction surface). The capability for controlling engine torque allows the system to minimize use of the brakes by reducing engine torque.

4.4 Brake Traction Control Systems (BTCS)

4.4.1 A system is defined as Brake Traction Control System if it:

- a. Is computer controlled.
- b. Has a means to determine if a drive wheel is spinning.
- c. Has the capability of applying brake force individually to the drive wheels to limit wheel spinning.

4.4.2 DESCRIPTION AND ADVANTAGES—Brake Traction Control Systems monitor the wheel speeds and apply brake torques to the drive wheels as necessary to control spinning during acceleration. By controlling wheel spin, the vehicle stability, steerability, and acceleration are improved. Also since the brakes can be applied to the drive wheels individually, engine torque can be transferred through the differential from one wheel to another. This can improve vehicle mobility and acceleration on surfaces which have non-uniform frictions (such as a condition where one drive wheel is on a slippery surface and another is on a higher-friction surface.) Since the Brake Traction Control Systems do not have the capability of reducing engine torque, the duration of their activation must be limited, especially at high speeds. These systems may be de-activated at high speeds and may include algorithms to estimate brake temperatures and disable the system if the temperatures exceed some limit.

4.5 Engine Only Traction Systems (ETS)

4.5.1 A system is defined as an Engine Only Traction System if it:

- a. Is computer controlled.
- b. Has a means to determine if a drive wheel is spinning.
- c. Has the capability of controlling engine torque to limit wheel spin.

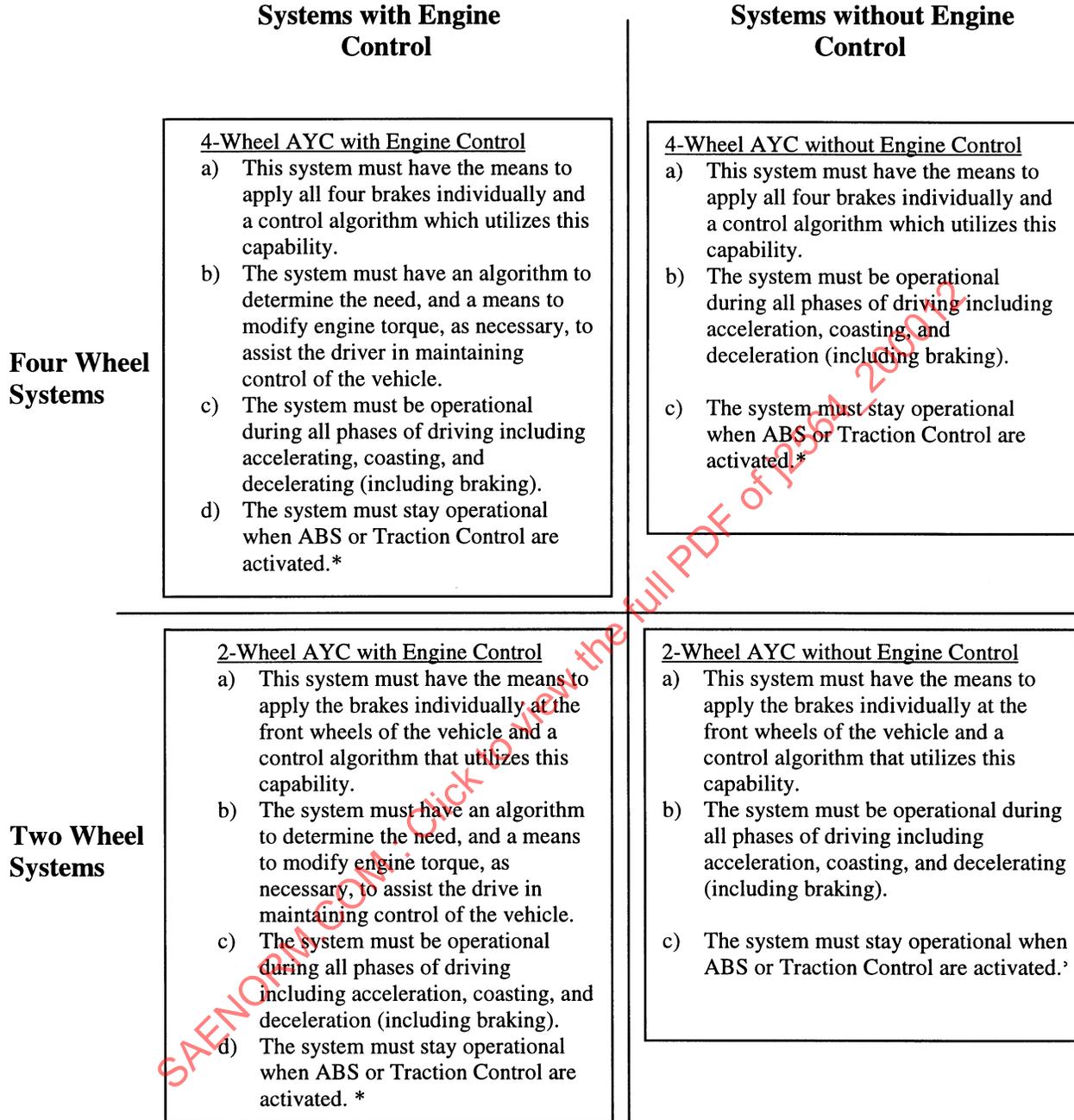
4.5.2 DESCRIPTION AND ADVANTAGES—Engine Only Traction Systems monitor vehicle wheel speeds to determine if a drive wheel is spinning during acceleration, and reduce engine torque to control spinning. Controlling wheel spin can improve vehicle stability, steerability, and acceleration capability. No brake applications are used with this system and it does not have any ability to transfer torque from one wheel to another.

4.6 Active Yaw Control Systems (AYC)

4.6.1 A system is defined as an Active Yaw Control System if it:

- a. Is computer controlled and the computer contains a closed-loop algorithm designed to limit understeer and oversteer of the vehicle.
- b. Has a means to determine vehicle yaw velocity and side slip.
- c. Has a means to monitor driver steering input.
- d. Has a means of applying and adjusting the vehicle brakes to induce correcting yaw torques to the vehicle.
- e. Is operational over the full speed range of the vehicle (except below a minimum speed where loss of control is unlikely).

4.6.2 Active Yaw Control Systems in use today can be divided into four categories (see Figure 1).



*Some systems may have limited Yaw Control performance during ABS or Traction Control activation.

FIGURE 1—THE FOUR CATEGORIES OF AN ACTIVE YAW CONTROL SYSTEM

4.6.3 All Active Yaw Control Systems are assumed to include ABS. The vehicles may also include other brake-related or stability enhancement features such as:

- a. Traction Control to control wheel spin during acceleration.
- b. Dynamic Brake Proportioning to control the vehicle front/rear brake balance.
- c. Engine Drag Control to prevent excessive wheel slip due to throttle lift-off or down shifting.
- d. Other computer-controlled features which can activate or modify vehicle braking.
- e. Other computer-controlled stability enhancement features.

If any of these features is included on the vehicle, the Active Yaw Control System must be capable of coordinating their activities to aid the driver in maintaining control of the vehicle and to prevent undesirable interactions.

4.6.4 DESCRIPTION AND ADVANTAGES—Active Yaw Control Systems use various sensors (typically wheel speed sensors, steering angle sensors, yaw rate sensors, and accelerometers) to monitor the dynamic state of the vehicle and the driver's commands. They then apply the vehicle's brakes (and adjust engine torque) to make appropriate adjustments to the rotational moment about the vehicle's vertical axis and correct the path of the vehicle to the driver's intended path. These systems improve the vehicle's stability, the driver's control of the vehicle, and correct understeer and oversteer conditions that occur.

The type of Active Yaw Control used on a specific vehicle is the decision of the vehicle manufacturer. Factors affecting this decision may include handling characteristics of the vehicle, vehicle weight distribution, powertrain size and type, intended vehicle use, size, cost, and targeted customer.

4.7 Other Stability Enhancement Features—While the emphasis of today's Yaw Control Systems is placed on control of the brake forces, the broader objective of such systems is to control the forces between the tire and the road by any actuation mechanism. In addition to the brakes, other systems are capable of effecting the wheel forces and thereby influencing the vehicle's dynamic behavior. These systems include the suspension, steering, and drivetrain.

4.7.1 CONTROLLED SUSPENSIONS—These systems have the ability to manage vertical wheel loads and thus influence the longitudinal and lateral force capability of each tire. The actuation may be through the active control of any or all of the following:

- a. Damping coefficients
- b. Spring rates
- c. Anti-roll bar rates
- d. Other suspension components

4.7.2 CONTROLLED STEERING—These systems have the ability to actively adjust the steered angle or the camber angle of any or all the wheels to influence the longitudinal and lateral forces of the tire.

4.7.3 DRIVETRAIN CONTROLS—These systems have the ability to adjust the engine torque applied to each of the wheels to influence the longitudinal and lateral forces of the tire. This may be accomplished by a combination of engine torque adjustment and control of differentials to manage the torque across axles.

4.8 Integrated Vehicle Systems—Vehicle Dynamics Control (VDC), Integrated Chassis Control System (ICCS), Electronic Stability Program (ESP), Dynamic Stability Control (DSC)—These systems combine vehicle stability features such as ABS, Traction Control, Electronic Brake Distribution (Dynamic Rear Proportioning), Active Yaw Control Systems, Suspension Controls, and Steering Controls on one vehicle. Each manufacturer may package and name these combinations to suit their specific vehicle and customer. These names may be trademarks of individual manufacturers.