



ABS keeps the vehicle steerable, even during an emergency braking –



under all road conditions



Contents

- Safety systems in vehicles
- Why do you need ABS?
- How does ABS work?
- What are the benefits of ABS?
- In which situations does ABS help?
- What is important when braking with ABS?
- The ABS success story
- Summary
- Attachment: Basics of driving physics





Safety systems in vehicles (1)

- Passive safety systems protect the passengers in case of an accident
 - Airbag
 - Seat-belt tightener

- Active safety systems help prevent accidents
 - Antilock Braking System ABS
 - Traction Control System TCS





Safety systems in vehicles (2)

- The benefits of the active safety systems ABS and TCS:
 - ABS and TCS act before a situation becomes dangerous: They actively contribute to the prevention of accidents
 - ABS prevents wheel lock-up during braking: The vehicle remains steerable even in case of all-out braking, independently of road conditions
 - TCS prevents the wheels from slipping during drive-off and acceleration: It ensures high driving stability and traction





Why do you need ABS? (1)

- Shortly hitting the brakes can be sufficient to cause wheel lock-up – even on a dry road
- Locked-up wheels cannot transfer lateral forces
- The consequence:
The vehicle doesn't react to the driver's steering input





Why do you need ABS? (2)

- ABS recognizes very early, if one or more wheels show a tendency to lock-up while braking. In this case ABS ensures that the braking pressure is kept on a constant level or reduced
- The wheels do not lock up and the vehicle remains steerable
- Thus the vehicle can be decelerated quickly and safely and an obstacle can be avoided

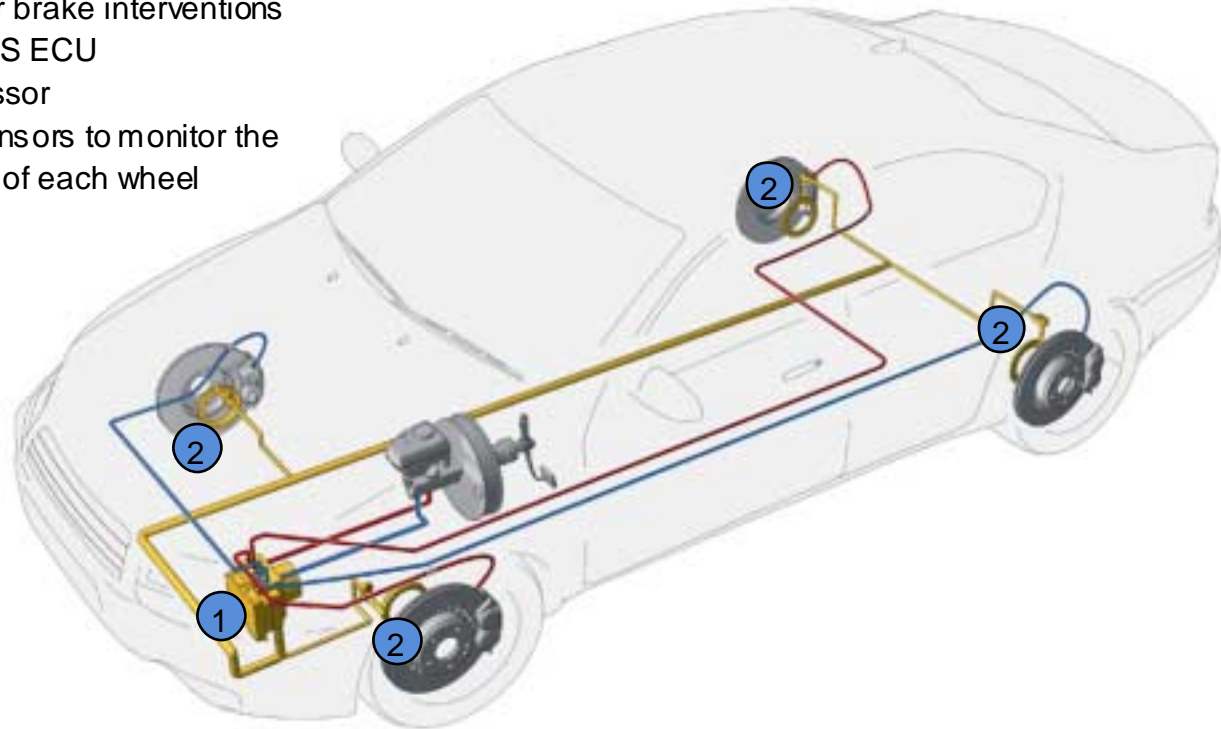




How does ABS work? (1)

The Bosch ABS components :

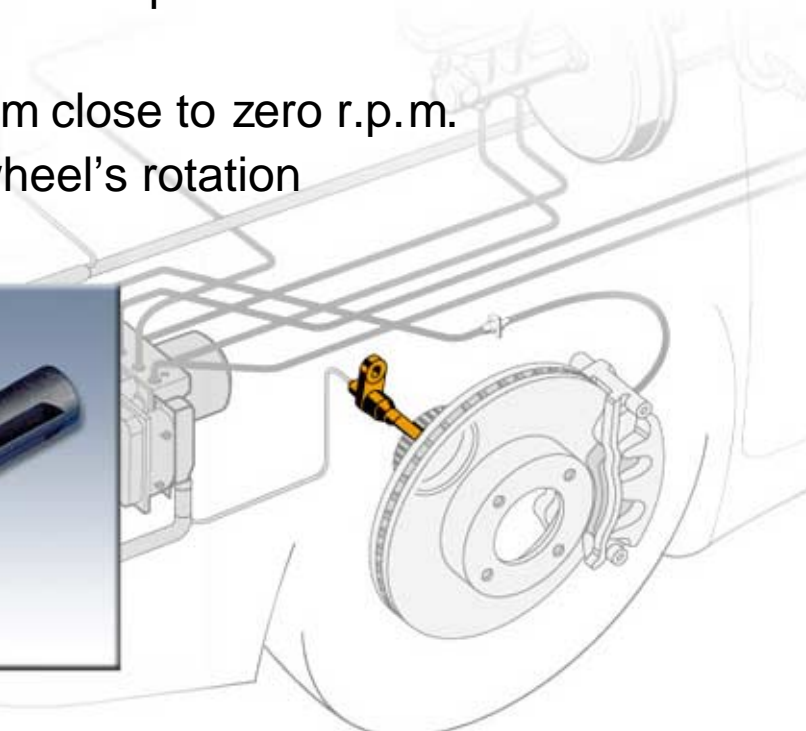
- 1 Hydraulic modulator:
Hydraulic unit for brake interventions
and attached ABS ECU
with microprocessor
- 2 Wheel-speed sensors to monitor the
rotational speed of each wheel





How does ABS work? (2)

- Wheel speed sensors
 - individually monitor each wheel's speed without physical contact
 - recognize wheel speeds from close to zero r.p.m.
 - detect the direction of the wheel's rotation

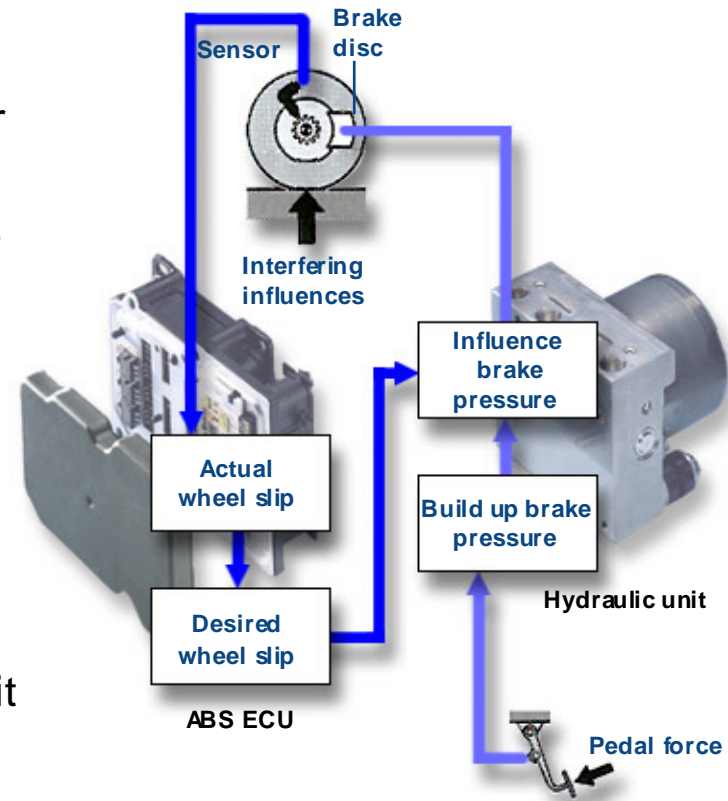




How does ABS work? (3)

→ The ABS closed-loop control:

- The driver hits the brake. Master cylinder and brake booster build up braking pressure
- The wheel-speed sensors provide the ABS ECU with information on the wheel speeds
- The ABS ECU calculates the wheel slip
- If the wheel slip exceeds a set value, the ECU influences the braking pressure via the solenoid valves of the hydraulic unit. Thus it prevents wheel lock-up





What are the benefits of ABS? (1)

- ABS prevents wheel lock-up
- ABS reduces the total stopping distance as far as possible
- ABS increases vehicle stability
- ABS maintains steerability even in case of all-out braking





What are the benefits of ABS? (2)

- ABS complies with complex demands:
 - Maximum utilization of the coefficient of slip between tires and road for minimum braking distances
 - Best-possible braking effectiveness, vehicle stability and steerability
 - on all types of road surface from dry to black ice
 - with different levels of grip on the left and right (μ -split)
 - with varying levels of grip during braking
 - throughout the vehicle's complete speed range down to as low as walking speed
 - when cornering



What are the benefits of ABS? (3)

- ABS complies with complex demands:
 - Improved braking force distribution between front and rear axle
 - Increased stability every time the driver hits the brake and shorter stopping distances on nearly all road surfaces
 - Self-monitoring when the vehicle is being driven, even when the system itself is not in operation
 - Freedom from maintenance, together with safety and reliability throughout the vehicle's useful life (millions of vehicles have been equipped with Bosch ABS)
 - Unlimited functionality, independent of operating status, road conditions, state of the tires, and vehicle-specific characteristics

(ABS)

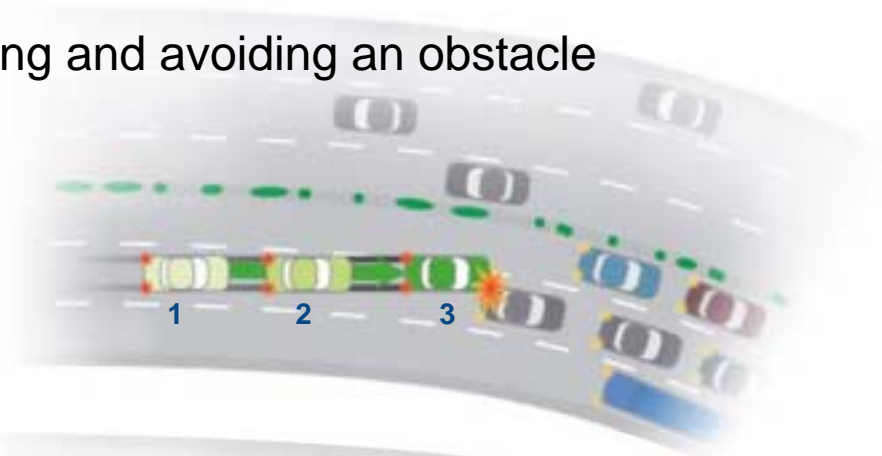


In which situations does ABS help? (1)

→ Example 1: Panic braking and avoiding an obstacle

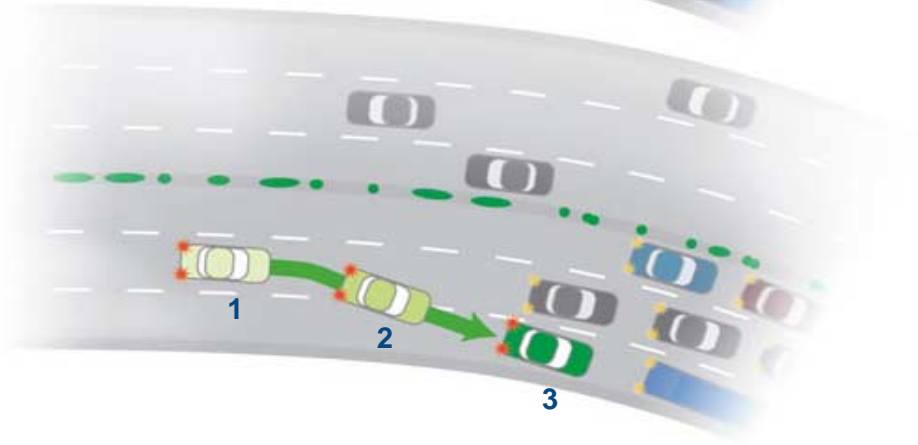
Without ABS

1. Driver recognizes danger and hits the brake
2. Driver tries to avoid obstacle
3. Vehicle doesn't respond to steering input



With ABS

1. Driver recognizes danger and hits the brake
2. Driver tries to avoid obstacle
3. ABS prevents wheel lock-up – steerability is maintained



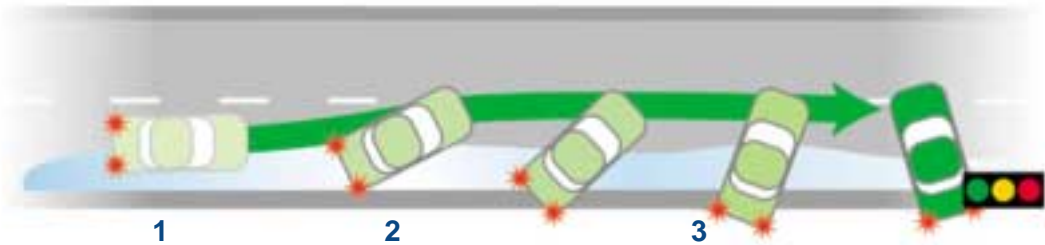


In which situations does ABS help? (2)

- Example 2: Braking on surface with different levels of grip (μ -split), e.g. snow, ice, leaves, oil

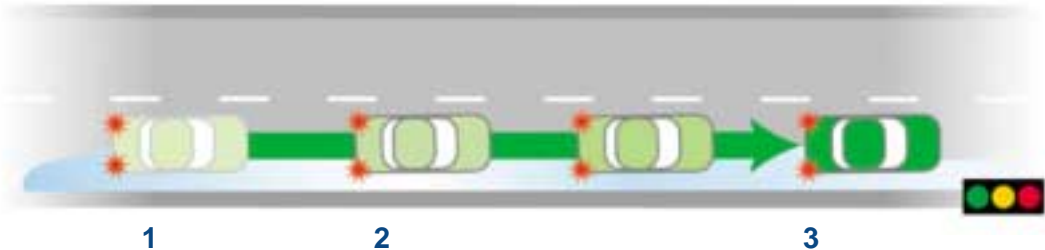
Without ABS

1. Driver hits the brake. Wheel lock-up on the right side
2. Driver tries to countersteer
3. Vehicle doesn't react to steering input and starts skidding



With ABS

1. Driver hits the brake. ABS recognizes the wheels' tendency to lock up
2. ABS prevents wheel lock-up
3. Vehicle remains on track





What is important when braking with ABS? (1)

- In order to fully benefit from the valuable extra safety it is important to keep the following in mind:
 - In case of an all-out braking hit the brake pedal with full power and keep it pressed down
 - The “pulsating” brake pedal is the signal that ABS is active and automatically setting the braking pressure to the possible maximum
 - The vehicle remains steerable: Obstacles can be deliberately avoided



What is important when braking with ABS? (2)

→ But:

- ABS cannot cross the boundaries of physics:
driving with foresight, a sufficient safety distance and
driving at an adequate speed are the best contributions
for more road safety



The ABS success story

- Due to its important contribution to active driving safety, ABS today is a standard feature in all vehicle classes in many countries

- Since 1978, about 100 millions of vehicles have been equipped with Bosch ABS

- Examples for the ABS equipment rate in 2002:
 - Western Europe 81 %
 - USA 78 %
 - Japan 74 %
 - South Korea 32 %





Summary

- ABS prevents wheel lock-up, thus keeping the vehicle steerable
- You can avoid an obstacle even during a panic braking
- ABS improves braking-force distribution resulting in reduced stopping distances and increased driving stability
- ABS increases the tires' service life (less and more even wear of the tire tread)
- ABS is proven millions of times





**The gas pedal is hot –
the brake pedal is cool**





Basics of driving physics (1)

- Each vehicle is subject to a number of different forces, independent of the vehicle movement:
 - Longitudinal forces (motive force, aerodynamic drag, rolling friction and others)
 - Lateral forces (i.e. steering power, centrifugal forces during cornering or through crosswind)

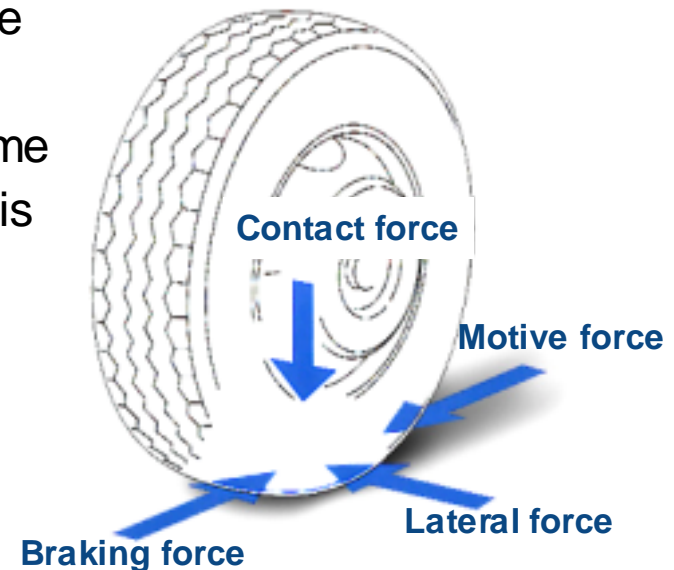




Basics of driving physics (2)

- The tires play a crucial role in transmitting the forces between the vehicle and the road surface: During braking and drive-off the power transmission depends on the slip between the rolling tire and the road surface
- Slip: A wheel with a circumference of 1.5 m should have passed a distance of 15 m after ten rotations.

The actual distance, however, is some centimeters shorter. This difference is called slip. The slip of a blocking or spinning wheel is 100 %





Basics of driving physics (3)

- As soon as the slip exceeds a defined value, the static friction decreases:
- During braking a wheel can lock within tenths of a second
 - During acceleration the increasing excess drive torque leads to a sudden increase of wheel speeds, that is, wheel spin of one or more wheels





TCS ensures stability and steerability – even when driving off and accelerating





Contents

- Why do you need TCS?
- What are the components of TCS?
- What are the benefits of TCS?
- In which situations does TCS help?
- Summary





Why do you need TCS?

- While driving off or accelerating the slip between tires and road surface can increase so far that one or more wheels start slipping
- Slipping wheels cannot transfer motive or steering forces onto the road
 - The vehicle becomes uncontrollable
- If the driver demands a drive torque exceeding that transferable to the road, TCS intervenes: In fractions of a second it adapts the slip of the driven wheels to the best possible level

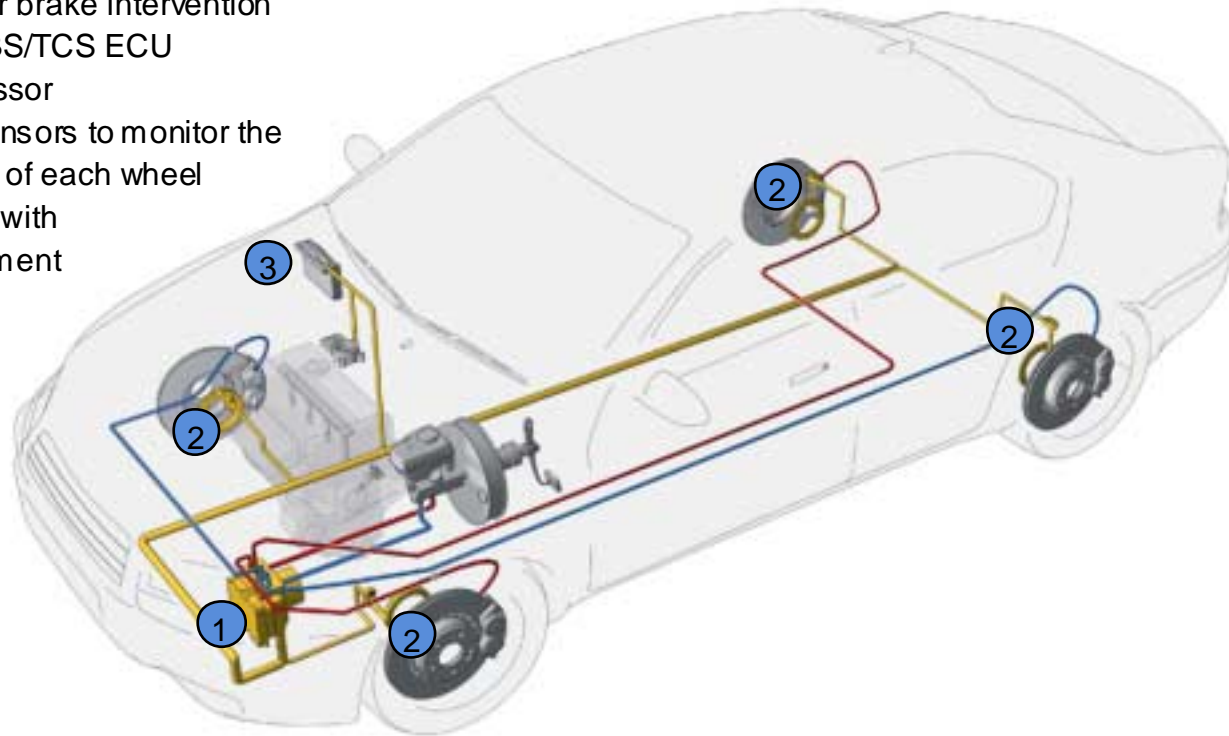




What are the components of TCS?

The Bosch TCS components:

- 1 Hydraulic modulator:
Hydraulic unit for brake intervention
and attached ABS/TCS ECU
with microprocessor
- 2 Wheel-speed sensors to monitor the
rotational speed of each wheel
- 3 Communication with
engine management





What are the benefits of TCS?

- TCS prevents wheel slip
- TCS increases driving stability
- TCS maintains steerability



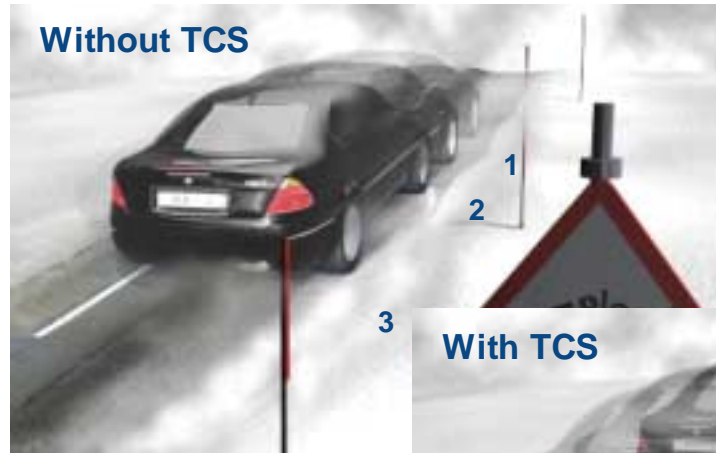


In which situations does TCS help? (1)

→ Example 1: Driving off uphill on a slippery road

Without TCS

1. Driver wants to drive off, wheels start spinning
2. The slipping wheels cannot transfer the motive force onto the road
3. The vehicle goes into an uncontrollable skid



With TCS

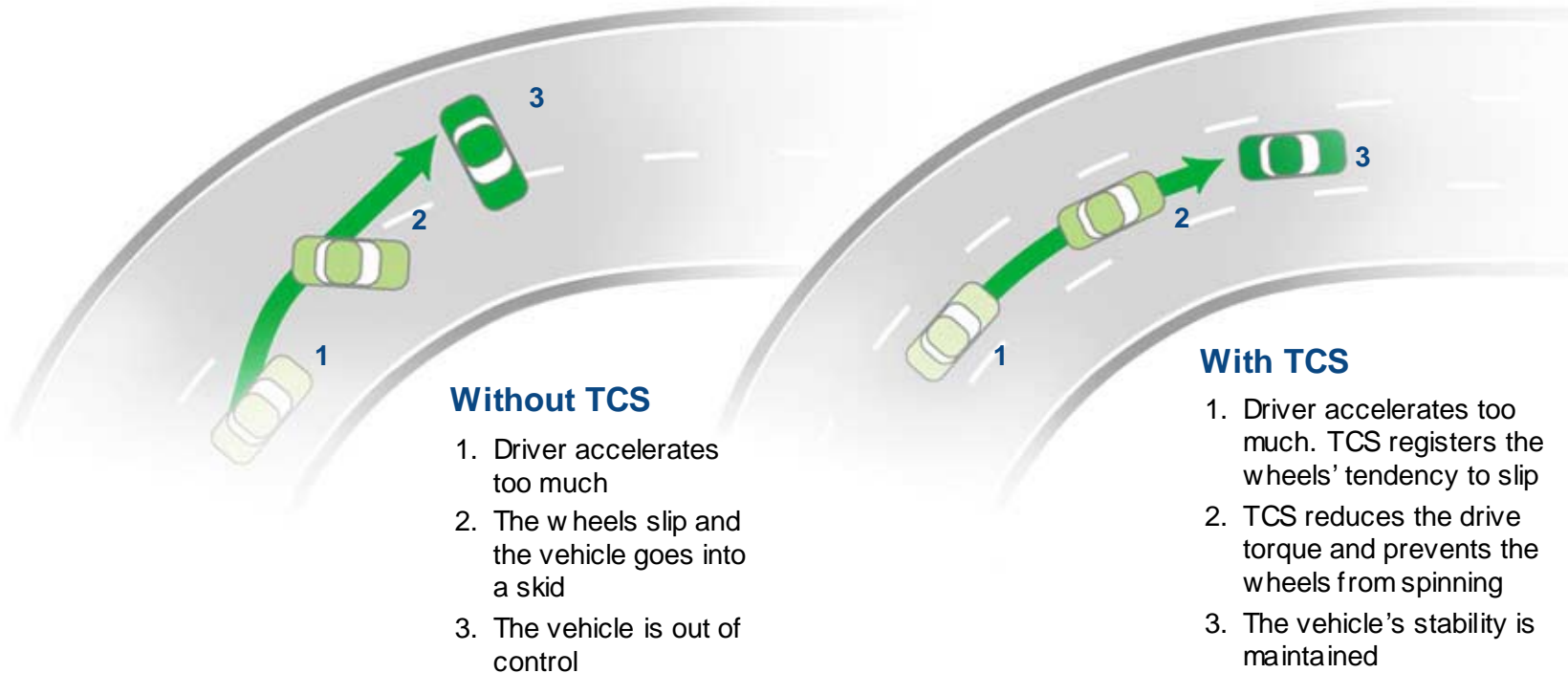
1. Driver wants to drive off, wheels threaten to spin
2. TCS individually reduces the wheels' drive torque
3. Stability is maintained while the vehicle drives off





In which situations does TCS help? (2)

→ Example 2: Accelerating while driving out of a bend





Summary

- TCS prevents wheel slip while driving off or accelerating, thus maintaining the vehicle's steerability
- The vehicle remains steerable even when driving off or accelerating on slippery roads
- TCS increases the tires' service life (less wear)
- TCS is proven millions of times





**Restraining your strength
often makes your progress faster**

