Lecture 8-2 Hydraulic Systems Vehicle Stability Control Systems

2014 SP

New thinking New possibilities

Real life cars

Driver Distraction

Driver Distraction is Not New, but Temptation has Increased

➔ **Common Factor in Driver Distraction is the Driver!**

*Source: ITS America, View on driver distraction, Roderick MacKenzie, Chief Technology Officer,ITS America






Rear-end Collisions/Side Crashes

Rear end collision

Side Crashes

Blind Spot/Loss of lateral Control

Accident in Expressway

Collision avoidance, Loss of lateral Control, Lane departure

-2011년 1월 26일 인천 신공항고속도로 Accident in Expressway

Vehicle Control Systems

1. Vehicle Stability Control
2. AEBS (추가할 것)

1. Vehicle Stability Control

1.1 Electronic Stability Program (ESP)

1.2 Vehicle Stability Control Algorithm

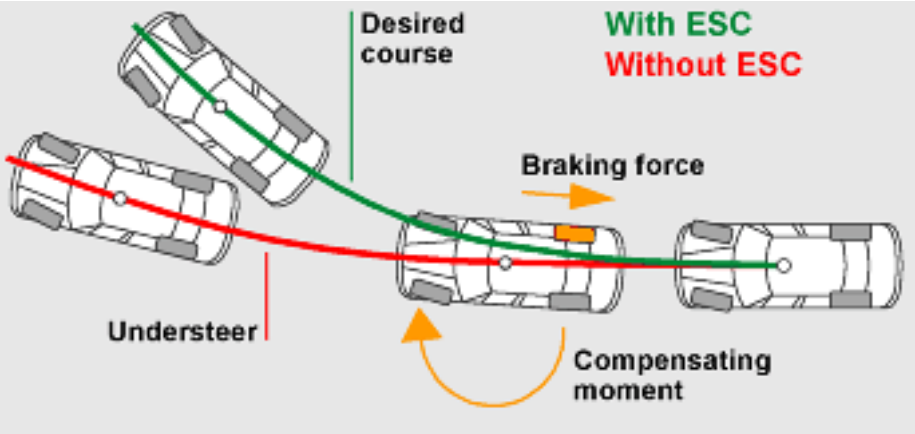
1.1 Electronic Stability Program (ESP)

- Why is ESP ?
  - An innovative safety system
  - Actively supporting the driver
  - Enhanced driving stability in situations with critical vehicle dynamics
  - Functions of ABS and TSC are integrated

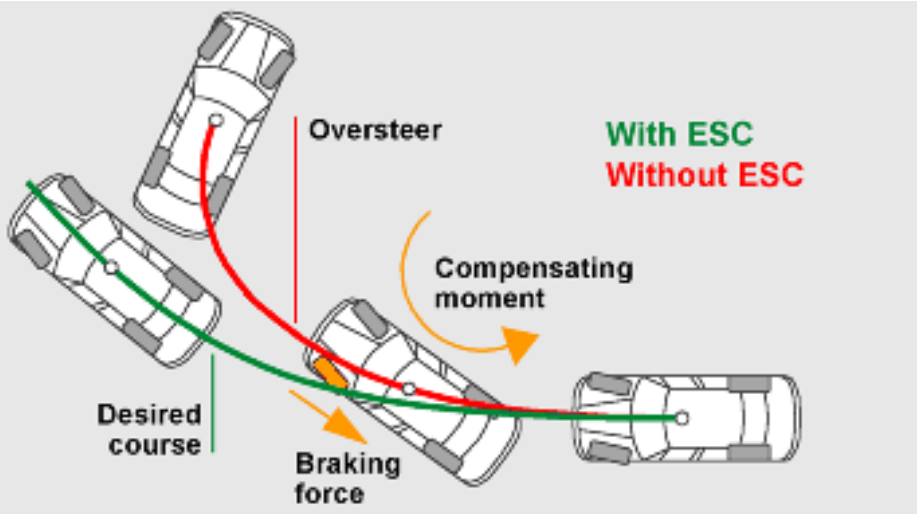
• What does ESP do ?

- ESP actively enhances vehicle stability
- (staying in lane and in direction)
  - Through interventions in the braking system or the motor management
  - To prevent critical situations, i.e., skidding, from leading to an accident
  - To minimize the risk of side crashs

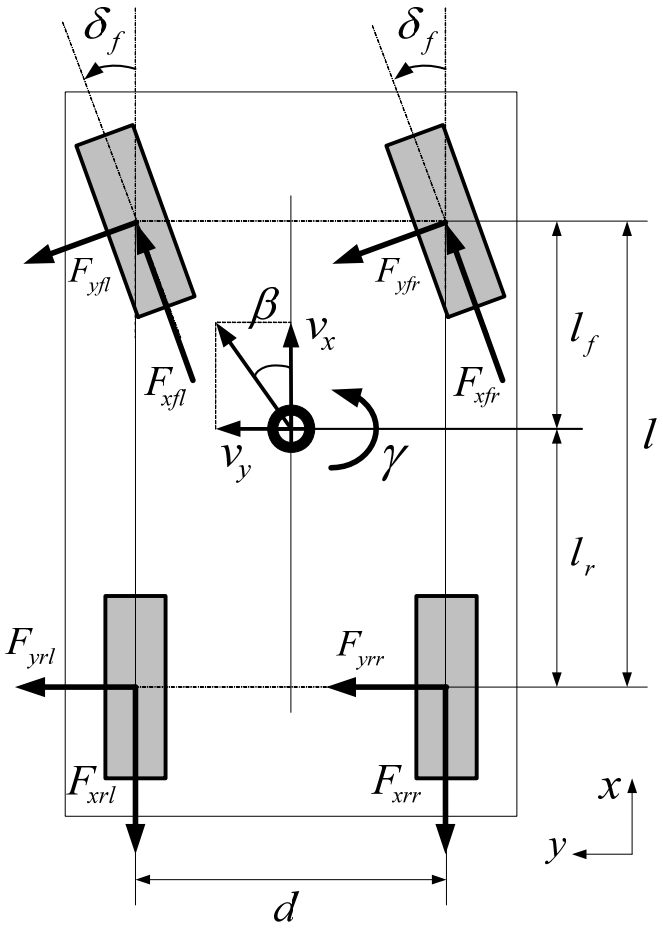
▪ Under Steer



▪ Over Steer



3 DOF Vehicle Planar Motion Model



[Top View]

$$F_{xf} = F_{x1} + F_{x2} = F_{xfl} + F_{xfr}$$
$$F_{yf} = F_{y1} + F_{y2} = F_{yfl} + F_{yfr}$$
$$F_{xr} = F_{x3} + F_{x4} = F_{xrl} + F_{xrr}$$
$$F_{yr} = F_{y3} + F_{y4} = F_{yrl} + F_{yrr}$$

$$m(\dot{v}_x - \gamma v_y) = F_{xr} + F_{xf}\cos\delta_f - F_{yf}\sin\delta_f \qquad (1)$$

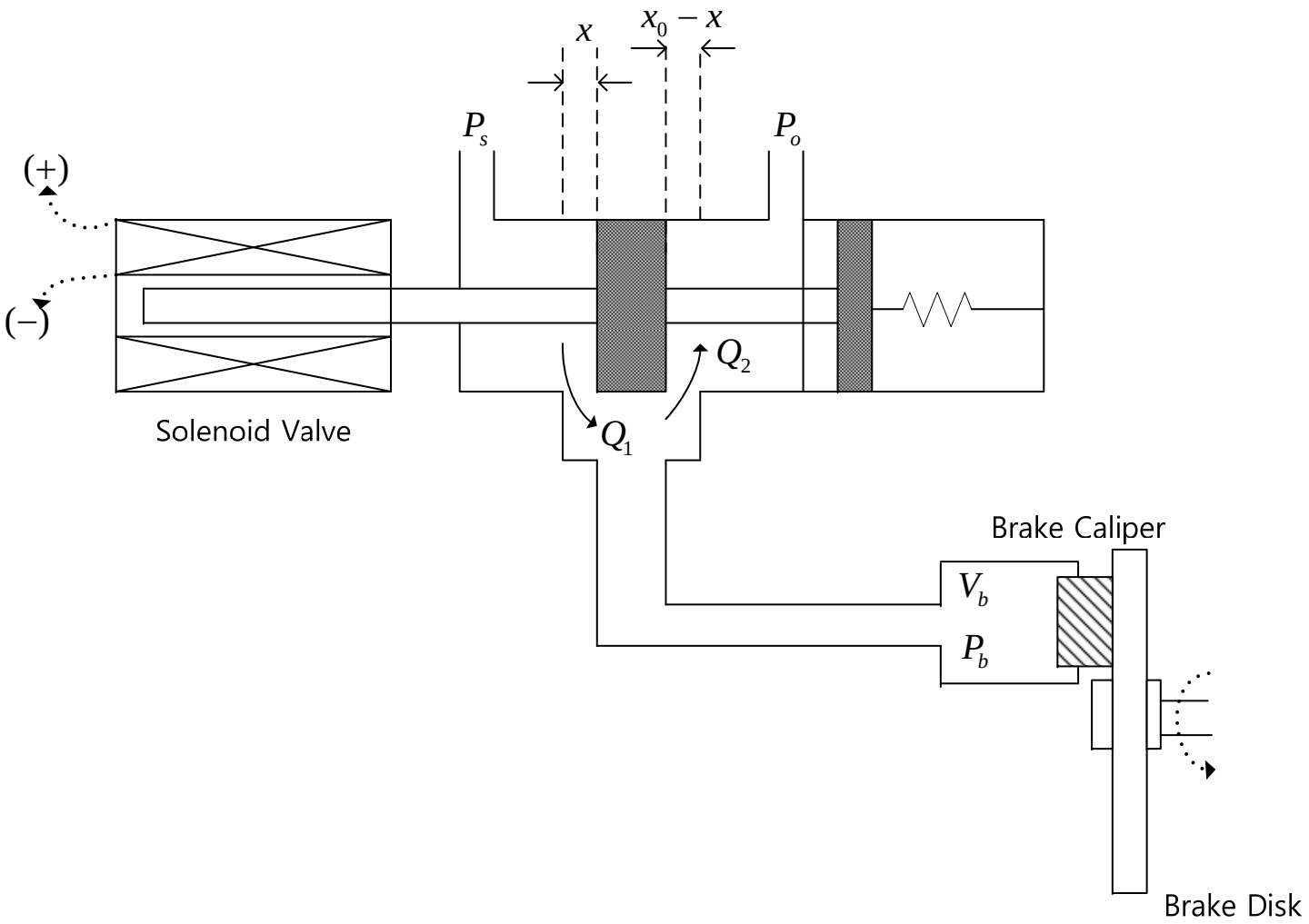
$$m(\dot{v}_y + \gamma v_x) = F_{yr} + F_{yf}\cos\delta_f - F_{xf}\sin\delta_f \qquad (2)$$

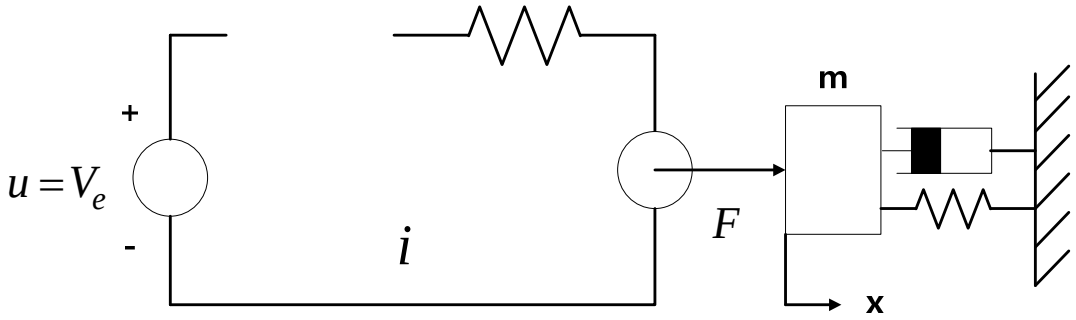
$$I_z\dot{\gamma} = l_f F_{yf}\cos\delta_f - l_r F_{yr} - l_f F_{xf}\sin\delta_f + \frac{d}{2}(\Delta F_{xr} + \Delta F_{xf}\cos\delta_f) \qquad (3)$$

- Solenoid valve-actuator-disk brake systems

- L-r circuit/force
- Valve mass eq of motion
- flow equation
- Pressure equation

Electro hydraulic systems : Break Pressure

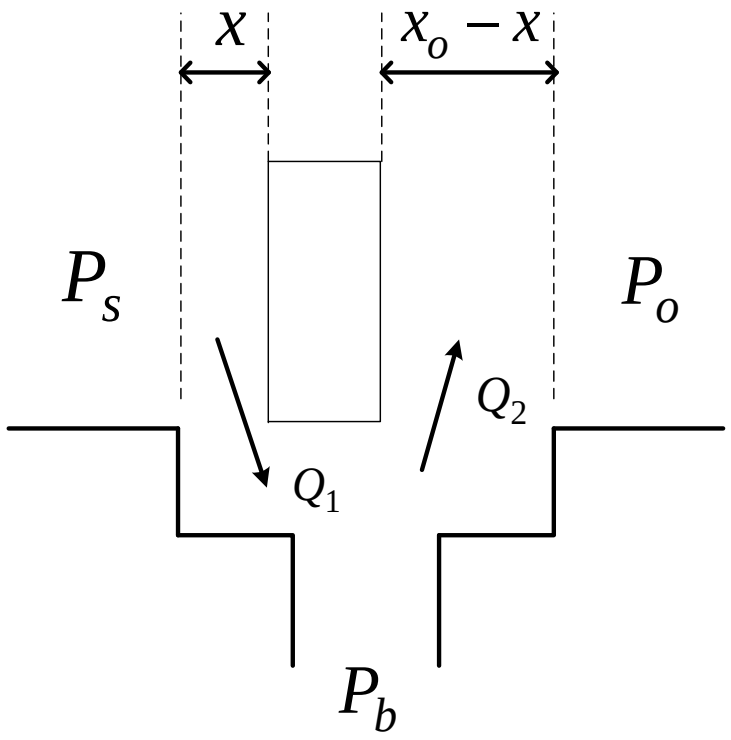




Solenoid *Spool*

$$u = L\frac{di}{dt} + Ri + K_b\frac{dx}{dt}$$

$$m\frac{dx^2}{dt^2} + b\frac{dx}{dt} + Kx = K_F i = F$$



$$Q_1 = C_d a x \sqrt{\frac{2}{\rho}\left(P_s - P_b\right)}$$

$$Q_2 = C_d a \left(x_o - x\right) \sqrt{\frac{2}{\rho}\left(P_s - \cancel{P_b}\right)}$$

$$= C_d a \left(x_o - x\right) \sqrt{\frac{2}{\rho} P_s}$$

$$\frac{dP_b}{dt} = -K_b \frac{1}{V_b}\left(Q_2 - Q_1\right)$$

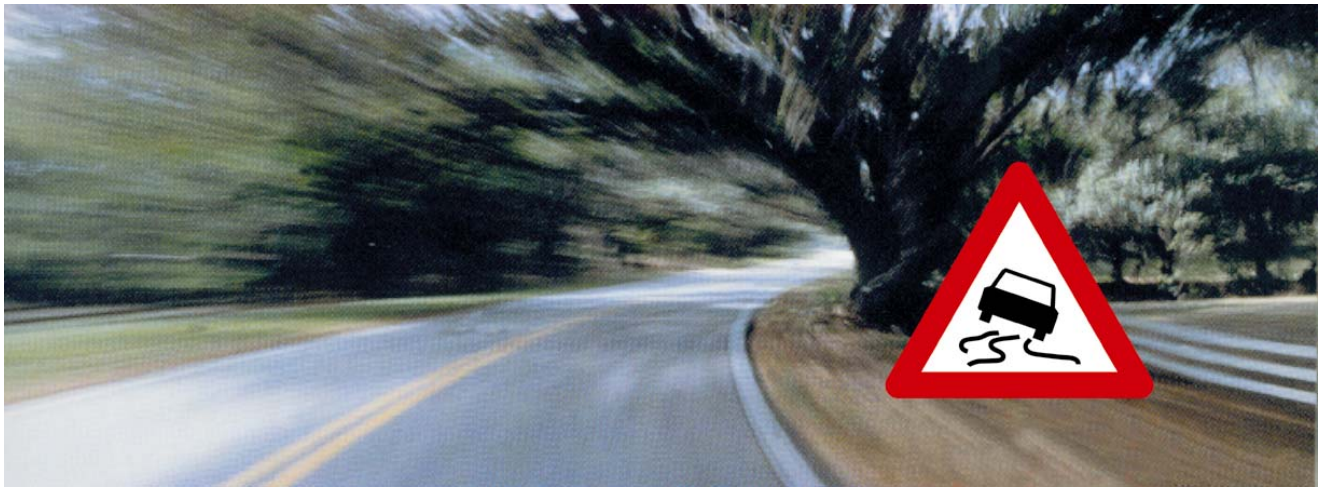
- What is so special about ESP ? (1)

ESP watches out:

– surveys the vehicle's behavior
(longitudinal and lateral dynamics)

– watches the vehicle-operator commands
(Steering angle, brake pressure, accelerator-pedal travel)

– is continuously active
in the background



- What is so special about ESP ? (2)

ESP knows:

– recognizes critical situations – in many cases before the driver does

– considers the possible ways of intervening:

  - Wheel-individual brake application
  - Intervention in the motor management

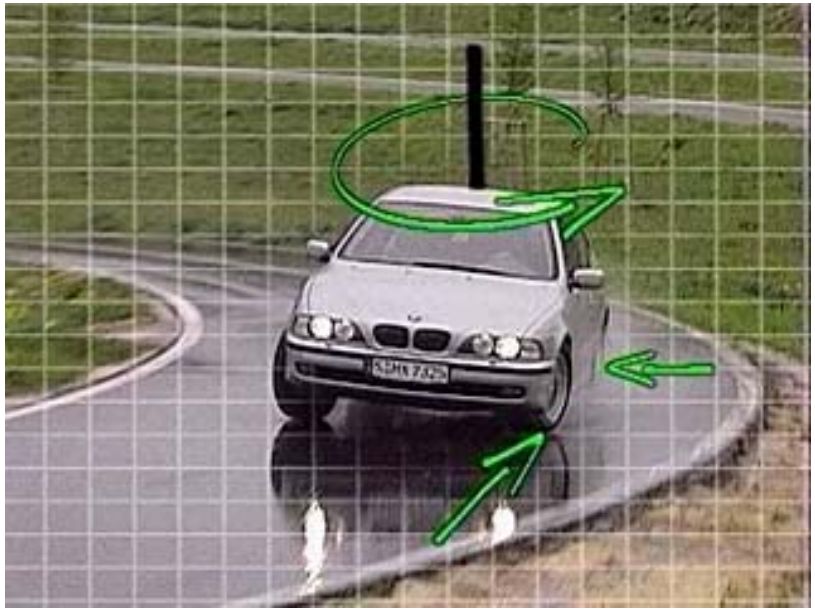
- What is so special about ESP ? (3)

  ESP acts as quick as lightning:

  – without reaction time

  – calculated intervention in the brakes or the motor anagement

  – reduces risk of skidding



Why is ESP so important ? (1)

Frequent cause for accidents:

The driver loses control of his vehicle.

I.e. Through

- speeding
- misinterpretation of the course or the road condition
- sudden swerving

ESP helps prevent accidents

Why is ESP so important ? (2)

28% of all accidents involving personal injury happen

- without prior conflict with another road user
- through loss of control of the vehicle followed by a collision with another car

60% of all accidents with fatal injuries are caused by side crashs

- These side crashes are mainly caused by skidding because of excessive speed, driving errors or excessive steering movements

(Source: RESIKO-Survey of GDV – Gesamtverband der deutschen Versicherungen – General Association of German Insurance Companies)

ESP helps prevent side crashes

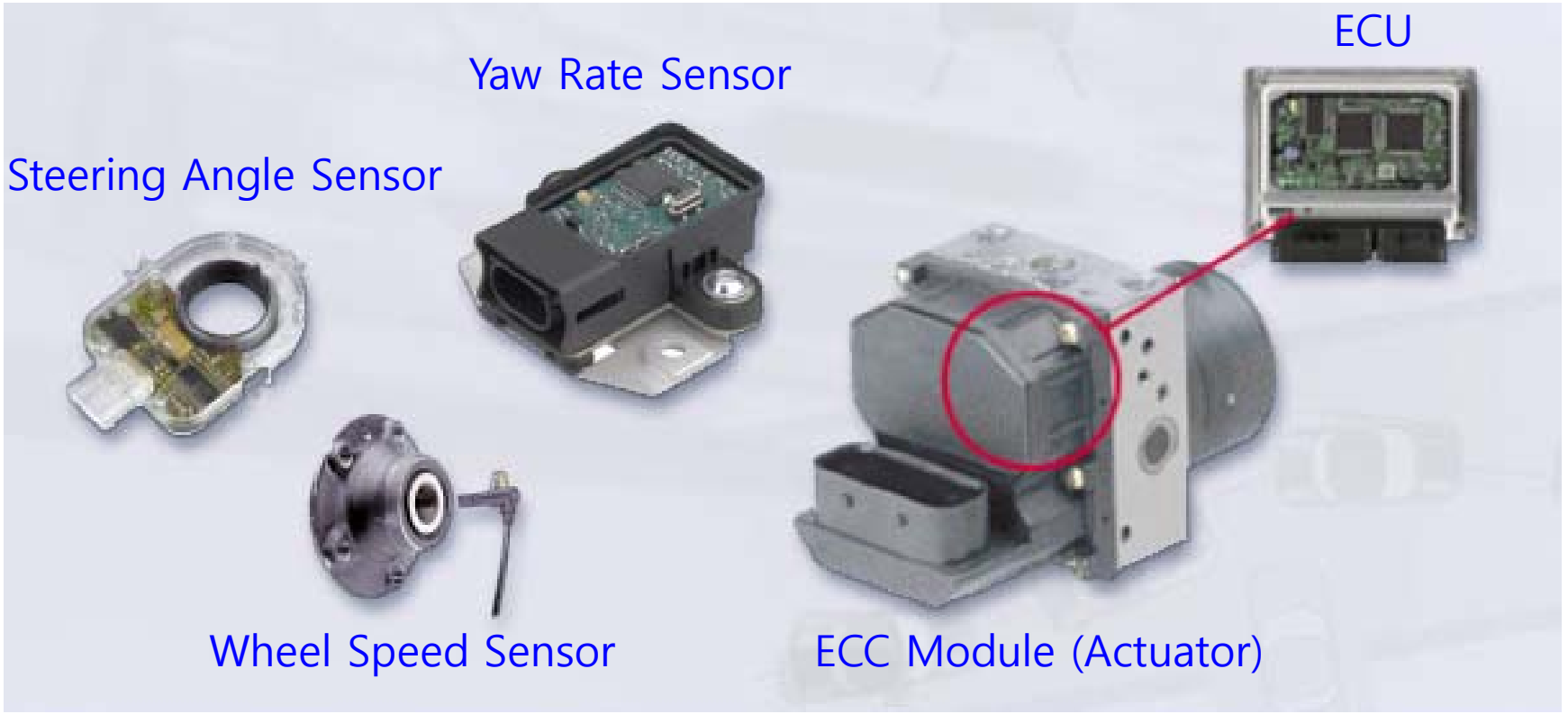
Why is ESP so important ? (3)

Recommendation of the General Association
of German Insurance Companies

" Practice shows that vehicle dynamic control systems like ESP are capable of making skidding avoidable or at least increase control. With their widespread introduction a substantial decrease in the number of serious accidents could be expected."

(Source: RESIKO-Survey of GDV –
Gesamtverband der deutschen Versicherungen –
General Association of German Insurance Companies)

- What are the components of ESP ?
  - Sensors for monitoring vehicle-state and driver-inputs
  - ESP-ECU with micro processor
  - Hydraulic unit for stabilizing brake-application



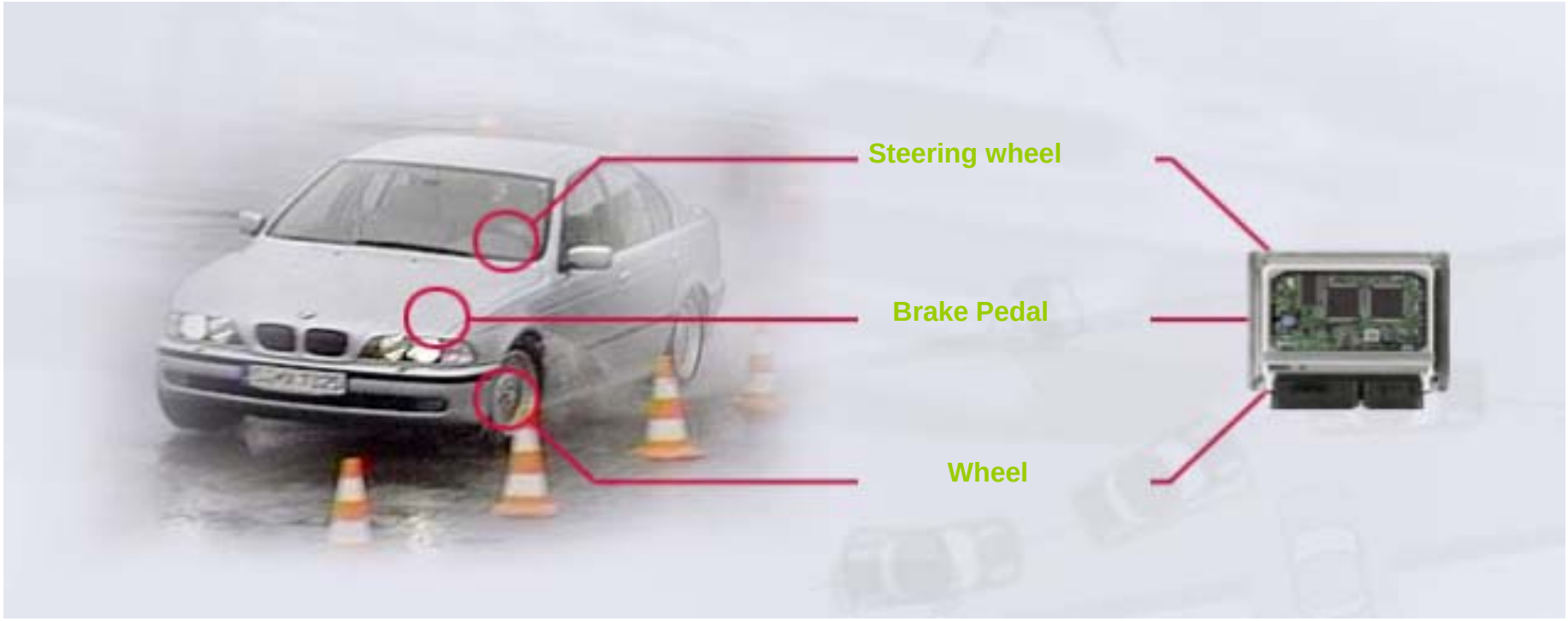
How does ESP work ? (1)

ESP analyzes:

What is the driver's intention?

Position of the steering wheel
+ wheel speed
+ position of the accelerator
+ brake pressure

= ECU recognizes driver's intention



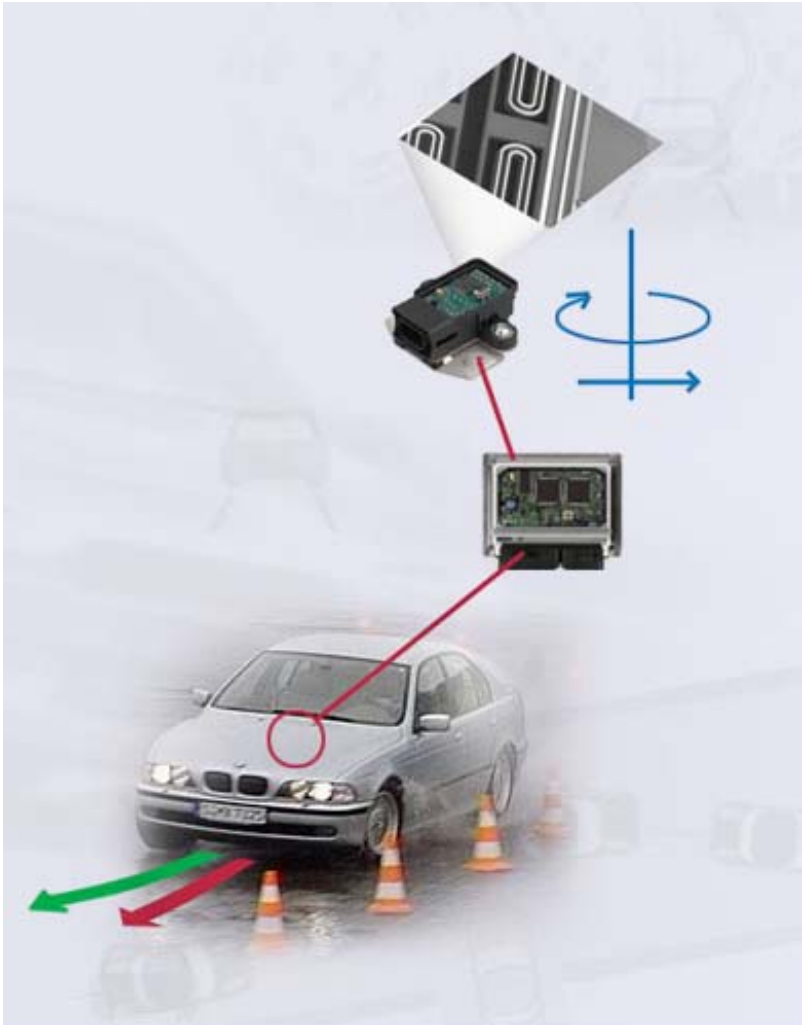
How does ESP work ? (2)

ESP examines:
How does the vehicle behave?

Yaw speed
+ lateral forces

= ECU calculates the vehicle's behavior

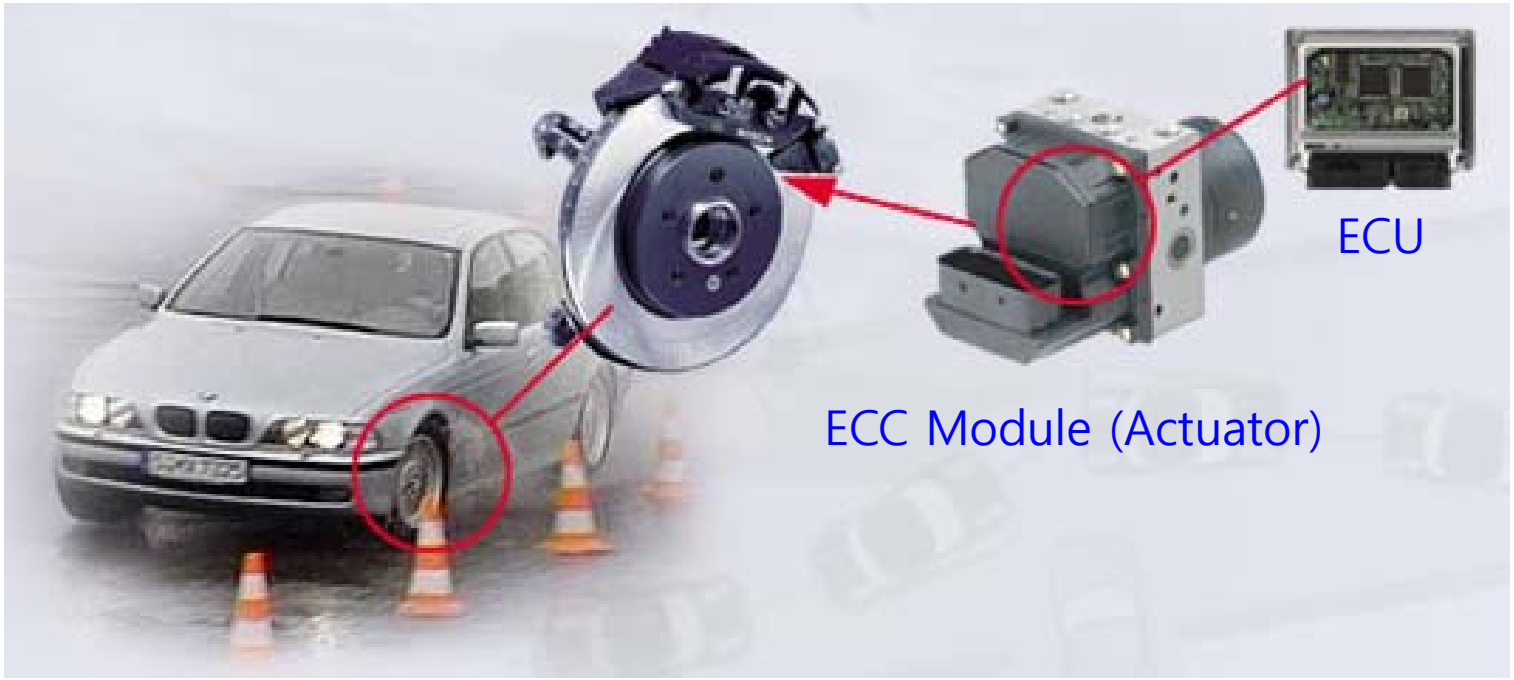
ESP's ECU compares vehicle behavior and driver's intention : It recognizes any deviation from the set course



How does ESP work ? (3)

ESP acts: It "steers" through brake-application

- The ECU calculates the required measures
- The hydraulic unit quickly and individually supplies the brake pressure for each wheel
- In addition, ESP can reduce the engine torque via connection to the motor management



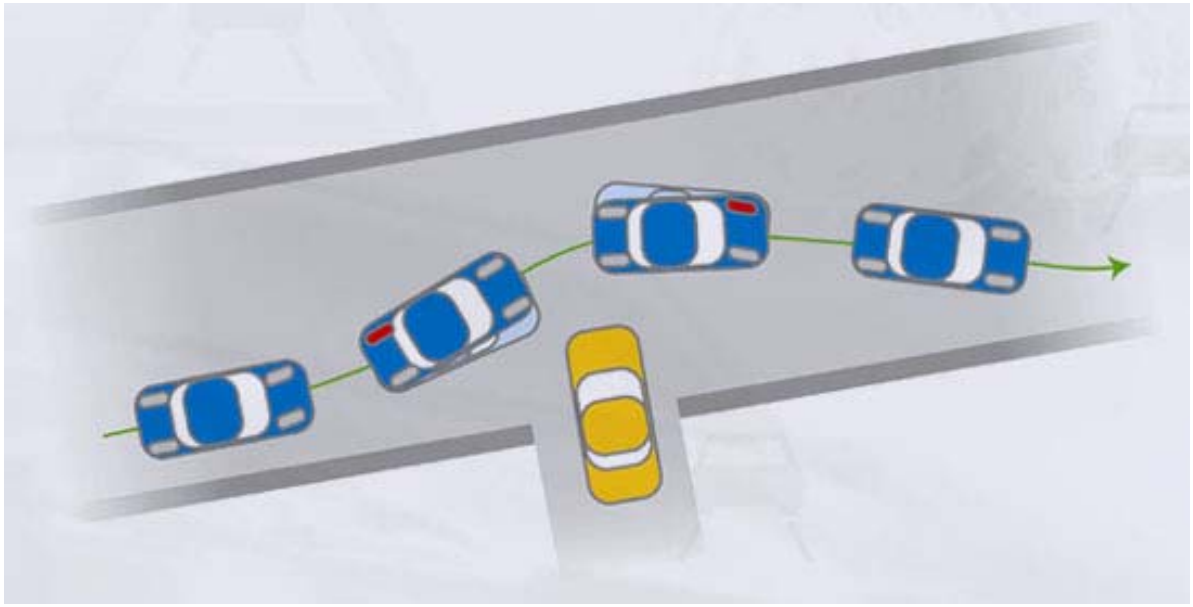
In what situations is ESP needed? (1)

Examples:

- Avoiding an obstacle
- Sudden wrenching of the steering wheel
- Driving on varying road surfaces
  (Longitudinal and/or lateral changes)

In what situations is ESP needed? (2)

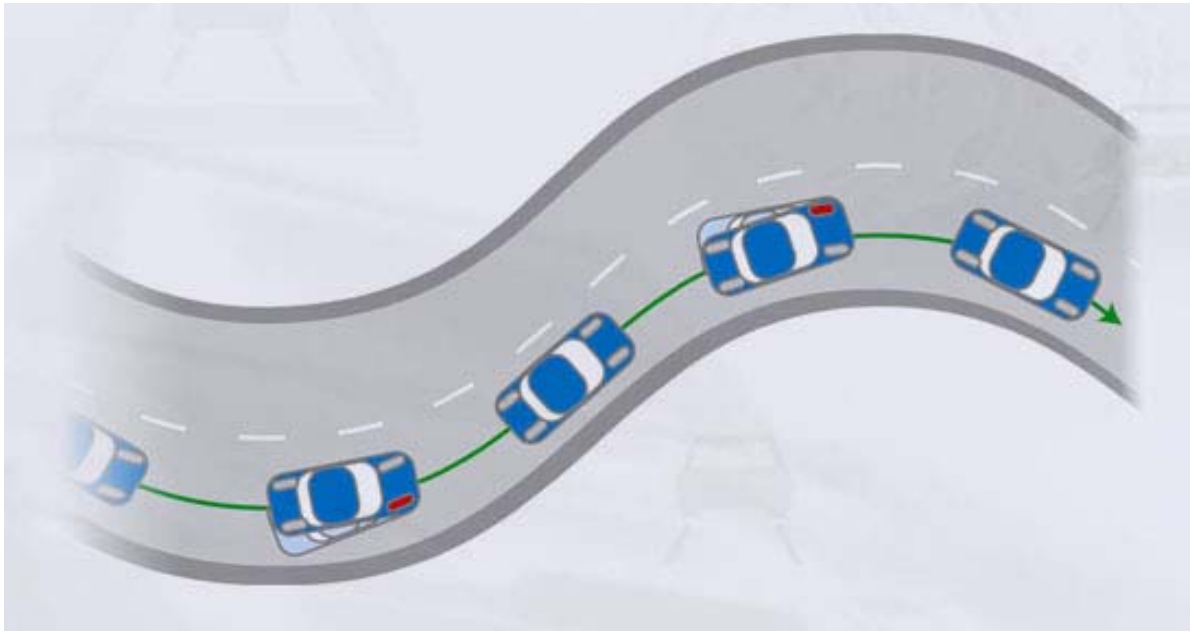
Avoiding an obstacle



1) Hit the brakes, wrench the steering wheel:
   Vehicle tends to understeer
2) ESP brakes the left rear wheel, vehicle obeys steering-wheel input
3) Reverse steering input:
   Vehicle tends to oversteer, ESP brakes the front right wheel
4) Vehicle becomes stable again

In what situations is ESP needed? (3)

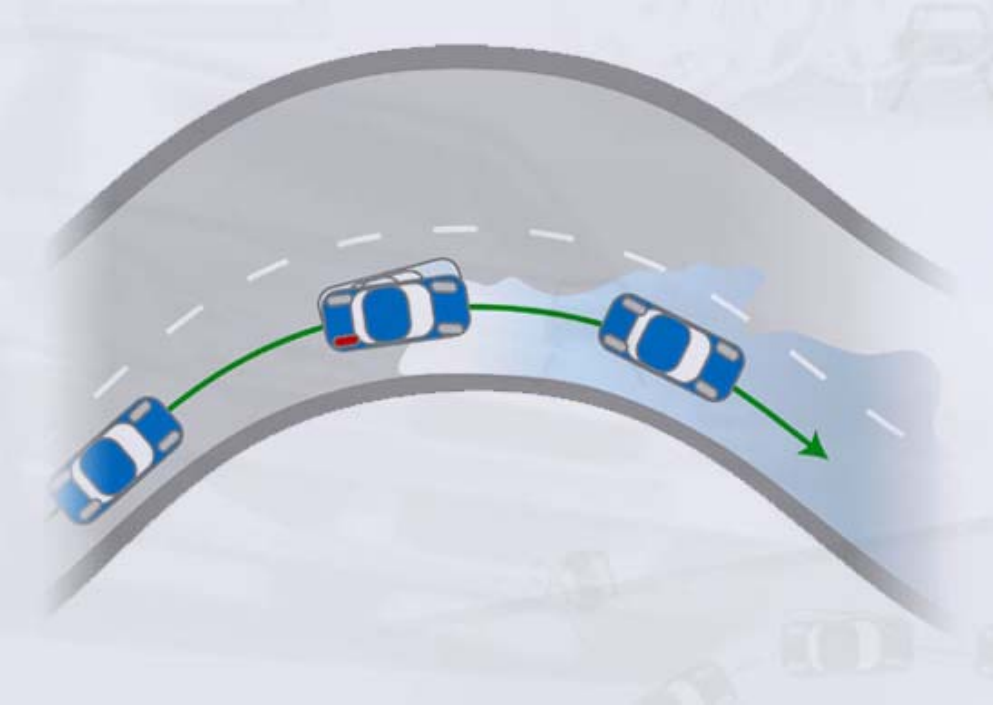
Sudden wrenching of the steering wheel



1) Vehicle tends to break away.
   Automatic breaking-pressure rise at the front right wheel
2) Vehicle is stable
3) Vehicle tends to break away.
   Automatic breaking-pressure rise at the front left wheel
4) Vehicle is stable

In what situations is ESP needed? (4)

Driving on varying road surfaces



Vehicle tends to break away (understeer):

– ESP intervenes and brakes the right rear wheel while at the same time reducing engine torque

1. Vehicle Stability Control

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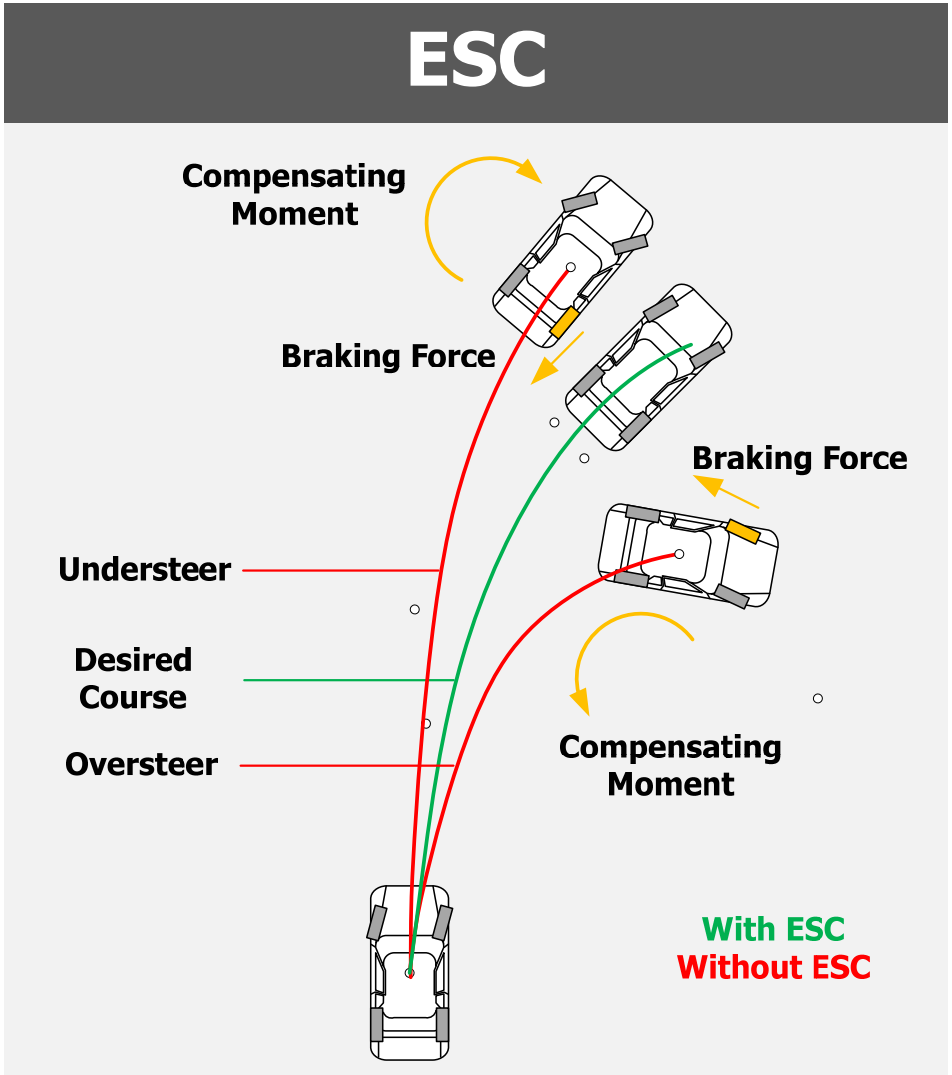
Vehicle Stability Control



The Canadian Association of Road Safety Professionals
http://www.carsp.ca

End of lecture 8 Hydraulic systems