System Analysis

Spring 2008

Professor Kyongsu Yi

Vehicle Dynamics Control Laboratory
Department of Mechanical and Aerospace Engineering
Seoul National University

Introduction

Instructor: Professor Kyongsu Yi

301-1204

Tel: 880-1941 Email:kyi@snu.ac.kr

http://vdcl.snu.ac.kr

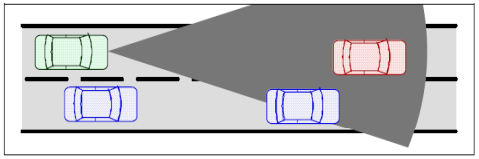
Lectures: Tu/Th 10:30-11:45 @301-105

Office hours: We 2:00 to 3:00 or by appointment

Reference: System Dynamics, Fourth Ed., Ogata, 2004 Pearson Prentice Hall

Objective: To provide basic concepts, an overview of dynamic system, modeling, analysis methods and applications to engineering systems

Mathematical model, analysis in the frequency and time domains and prediction of the dynamics of systems



Grading: Homework 15%, Class attendance 10%

Midterm Exam 30%, Final exam 45%

Students absent in a class without instructor's permission prior to the class would be failed.

Homework: Students will turn in before the end of the class on the due date.

Late homework will not be accepted.

All homework assignments are to be completed on your own.

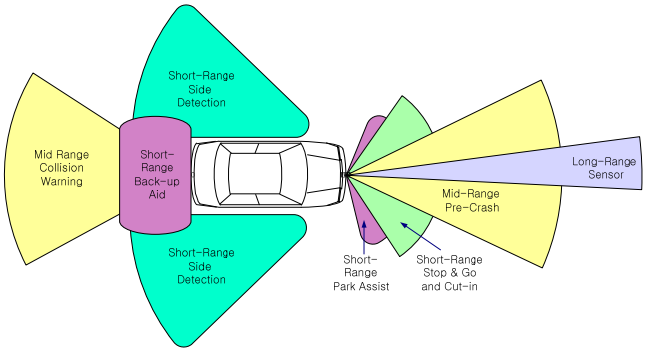
You are allowed to consult with other students during the conceptualization of a problem but all written and programming work are to be generated by yourself.

Exam : 75-minute midterm exam

on April 22 (Tu) 10:30-11:45

90-minute final exam

on June 10 (Tu) 10:30-12:00



Major Course Contents

Part 1: *Introduction*

Introduction, Concepts, Terminology

Part 2: *Laplace Transform*

Laplace Transform

Part 3: *Modeling*

Mathematical Model of Dynamic Systems

Transfer Function Approach to Modeling Dynamic Systems

State space Approach to Modeling Dynamic Systems

Electrical Systems

Fluid Systems and Thermal Systems

Major Course Contents (contd.)

Part 4: *Analysis*

Time Domain Analysis of Dynamic Systems

First Order / Second Order Systems

Transient Analysis

Analysis with MATLAB

Frequency Domain Analysis of Dynamic Systems

Understanding the underlying physics and being able to construct models of dynamic systems to analyze (and,) predict (and control) engineering systems

Systems

Aircraft

NASA x-29 forward swept wing aircraft

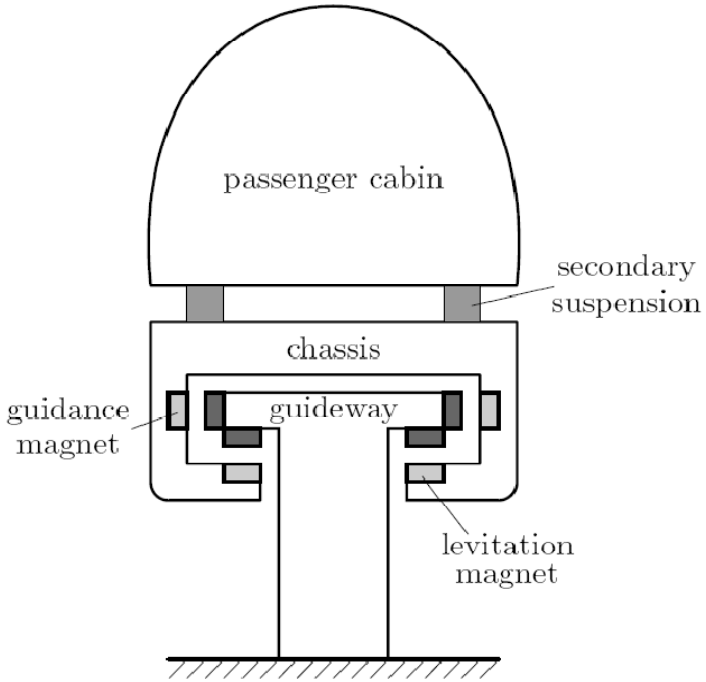
Airbus A320

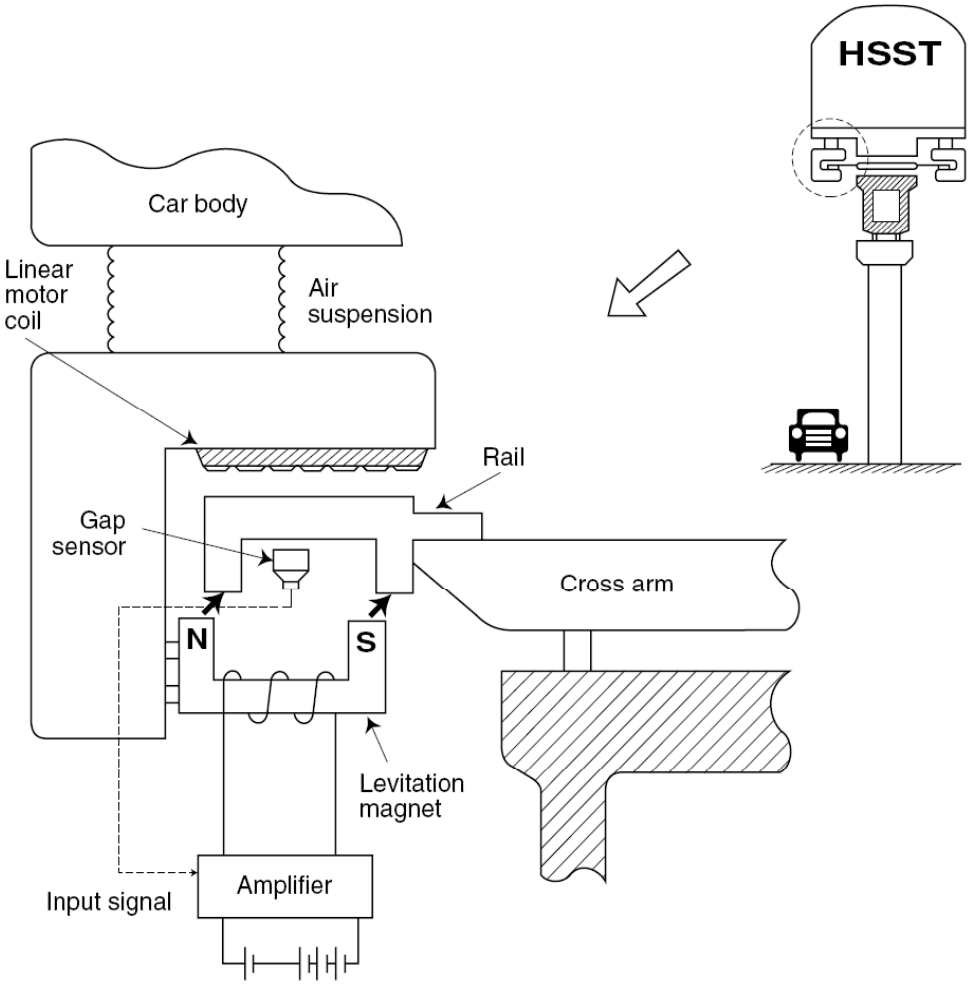
Unstable

Figure 1. *Gripen JAS39 prototype accident on 2 February 1989. The pilot received only minor injuries.*

MAGLEV (Magnetic Levitation) Vehicle

MAGLEV (Magnetic Levitation) Vehicle

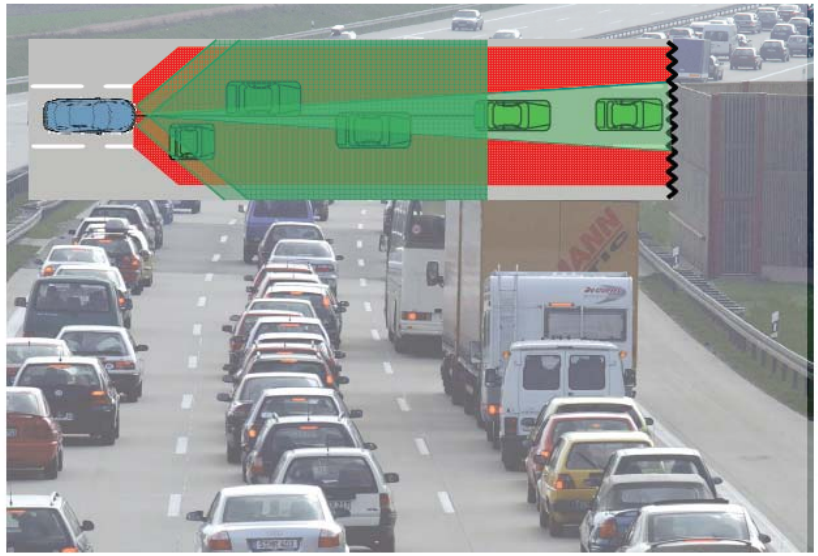


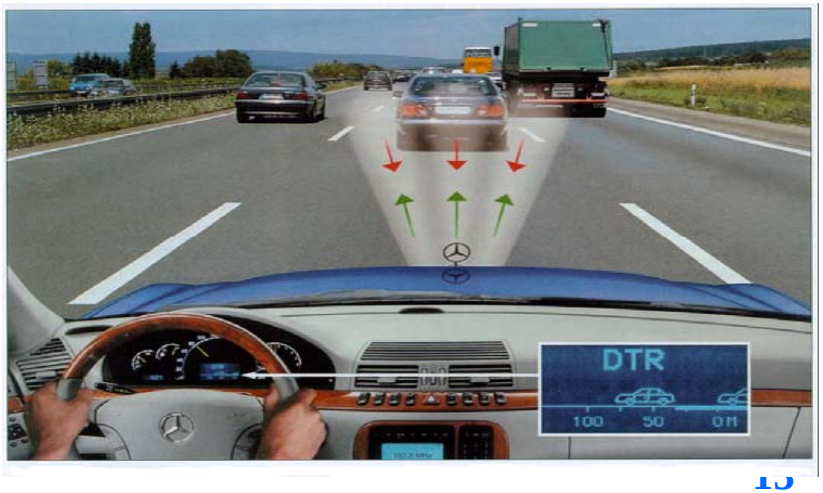


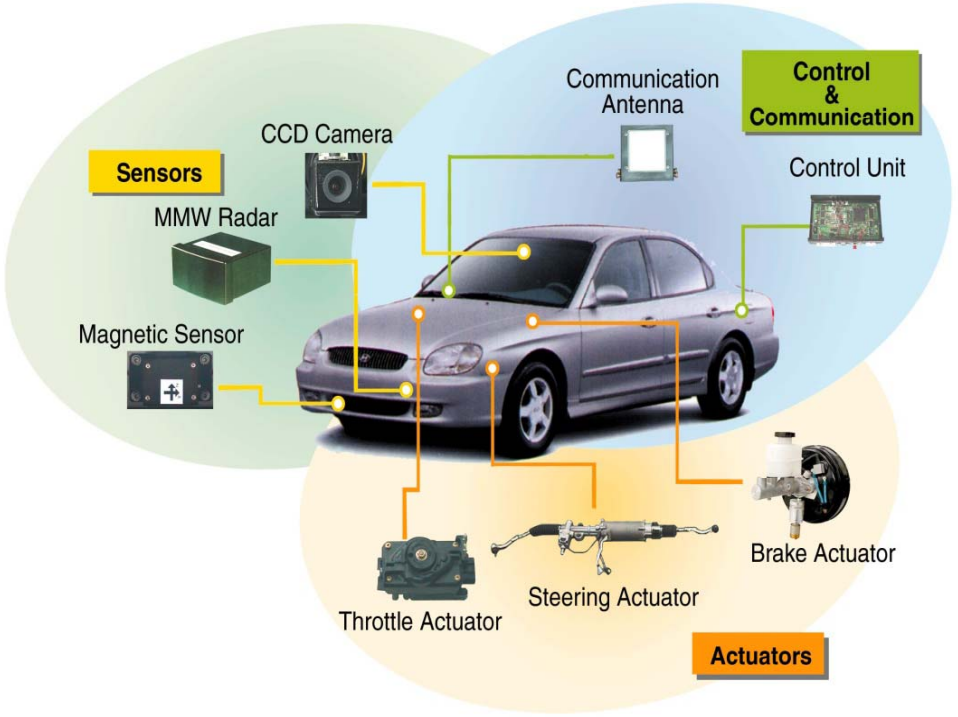
12

Full-range ACC/CA

Adaptive Cruise Control with Stop & Go:
ACC S&G.



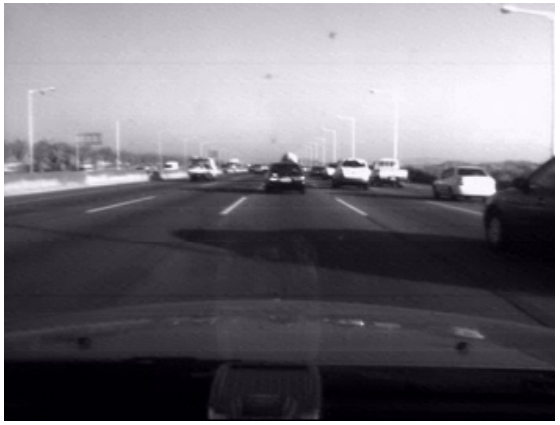


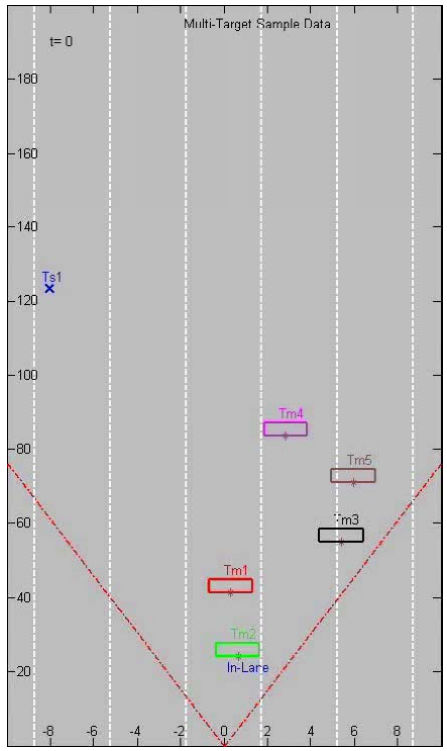


- **Autonomous Driving: Adaptive Cruise Control with Collision Avoidance**

ACC/CA Vehicle

Multi-Target Detection





14

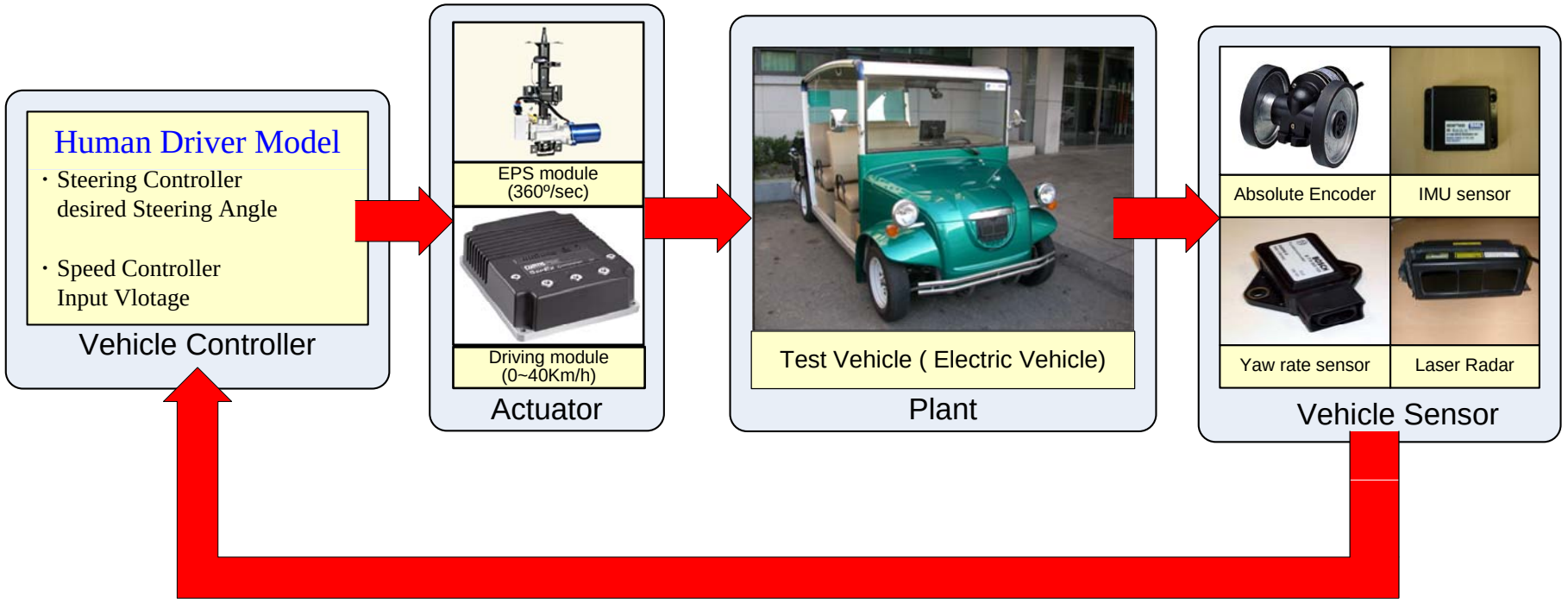
AUTOMATED HIGHWAY SYSTEMS (AHS)

AHS lanes will have three times the capacity of regular highway lanes - Vehicles will travel together in closely-packed “platoons”.

Dedicated to automated vehicles - regular passenger cars will have to be specially instrumented to travel on AHS lanes.

EV Autonomous Driving using Human Driver Model

- **System Configuration**



16

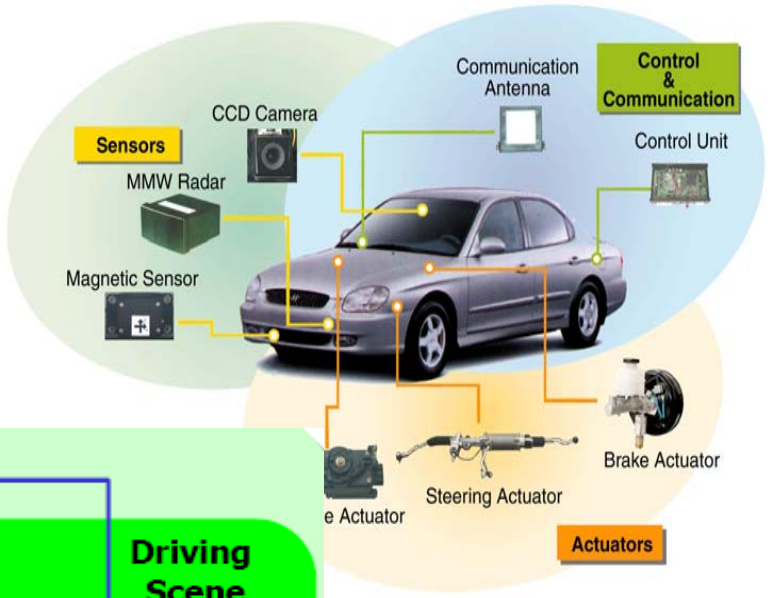
Vehicle Tests

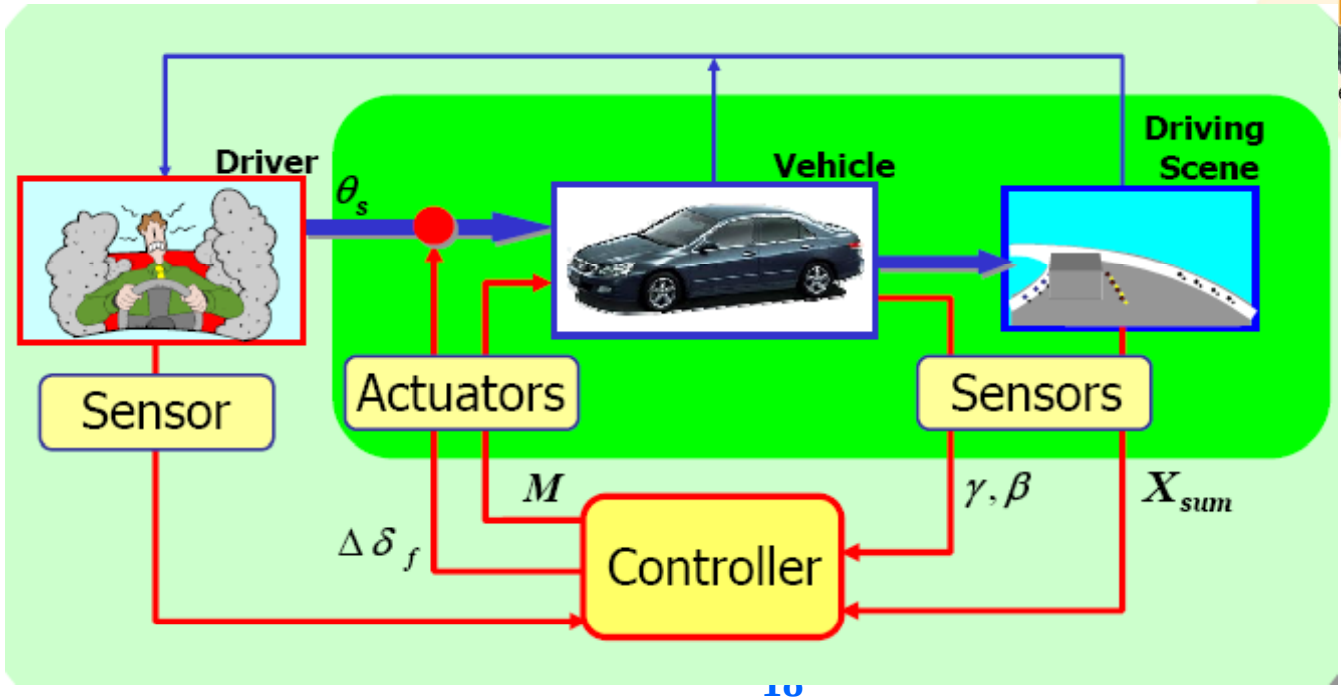
- Lane Following

- Lane Following + ACC

17

Vehicle Control Systems



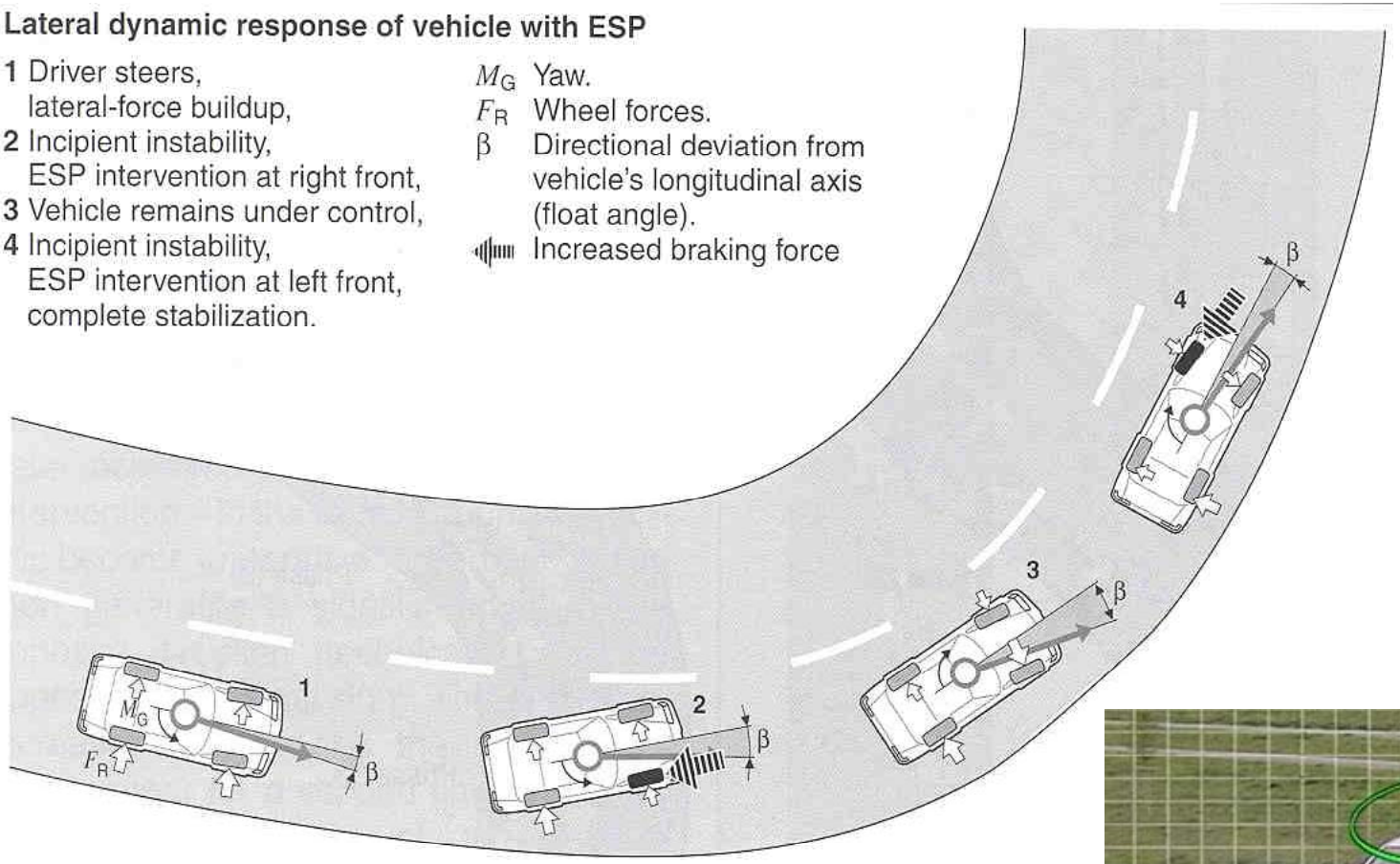


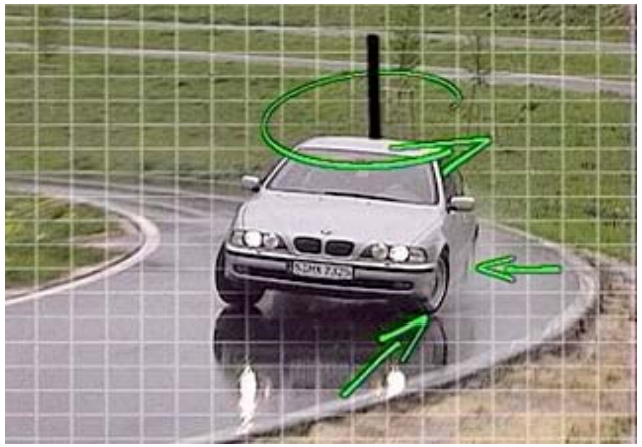
ESP (Electronic Stability Program)

Lateral dynamic response of vehicle with ESP

1 Driver steers, lateral-force buildup,
2 Incipient instability, ESP intervention at right front,
3 Vehicle remains under control,
4 Incipient instability, ESP intervention at left front, complete stabilization.

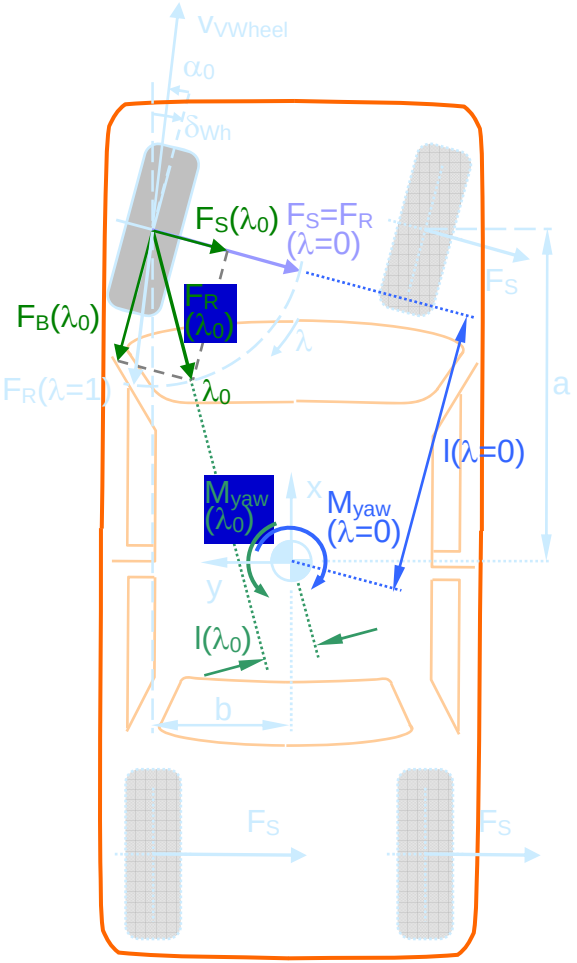
M_G Yaw.
F_R Wheel forces.
β Directional deviation from vehicle's longitudinal axis (float angle).
Increased braking force





Unified Chassis Control (UCC)

- Vehicle Lateral Motion (Dynamic Equations)

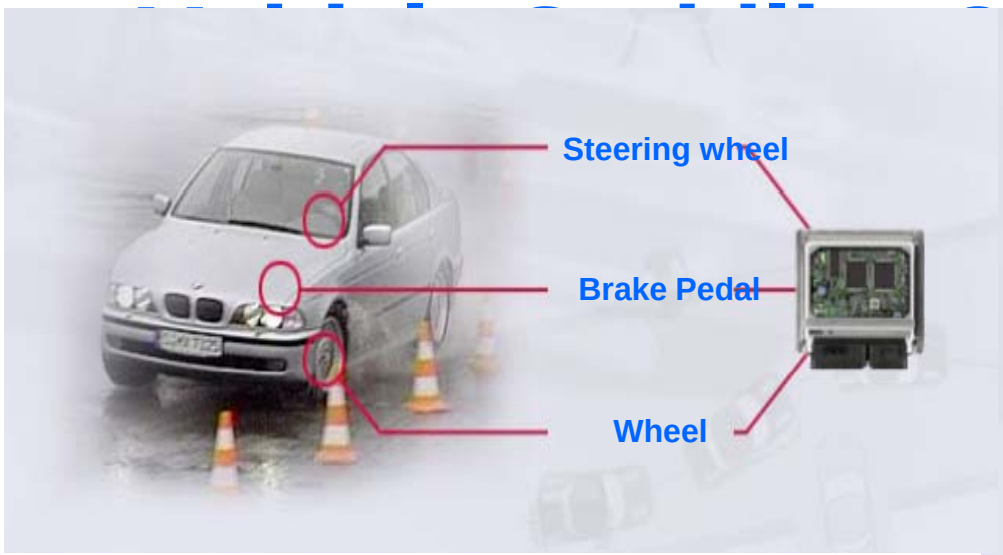


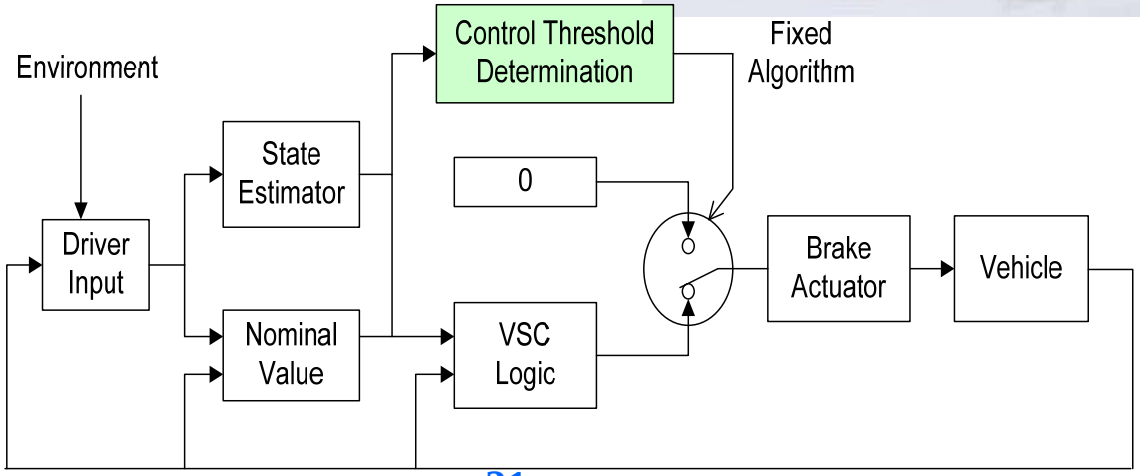
$$m(\dot{v}_x - \gamma v_y) = F_{xr} + F_{xf}\cos\delta_f - F_{yf}\sin\delta_f$$

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

$$I_z\dot{\gamma} = l_f F_{yf}\cos\delta_f - l_r F_{yr} - l_f F_{xf}\sin\delta_f \ldots$$

$$+\frac{d}{2}(\Delta F_{xr} + \Delta F_{xf}\cos\delta_f)$$


Steering wheel
Brake Pedal
Wheel


Environment
Control Threshold Determination
Fixed Algorithm
State Estimator
0
Driver Input
Brake Actuator
Vehicle
Nominal Value
VSC Logic

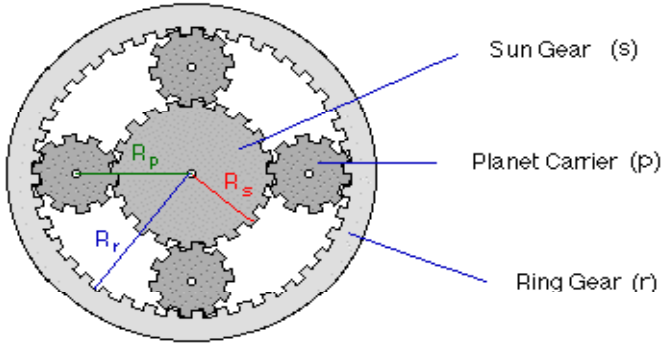
Electric Power Steering (EPS) / Active Front Steering (AFS)

Electric Power Assist Steering

Active Front Steering AFS (control motor / Planetary Gear)

: Delphi AFS-a prototype for Cadillac CTS

: New BMW 5 series '04 (by ZF Lenksysteme)

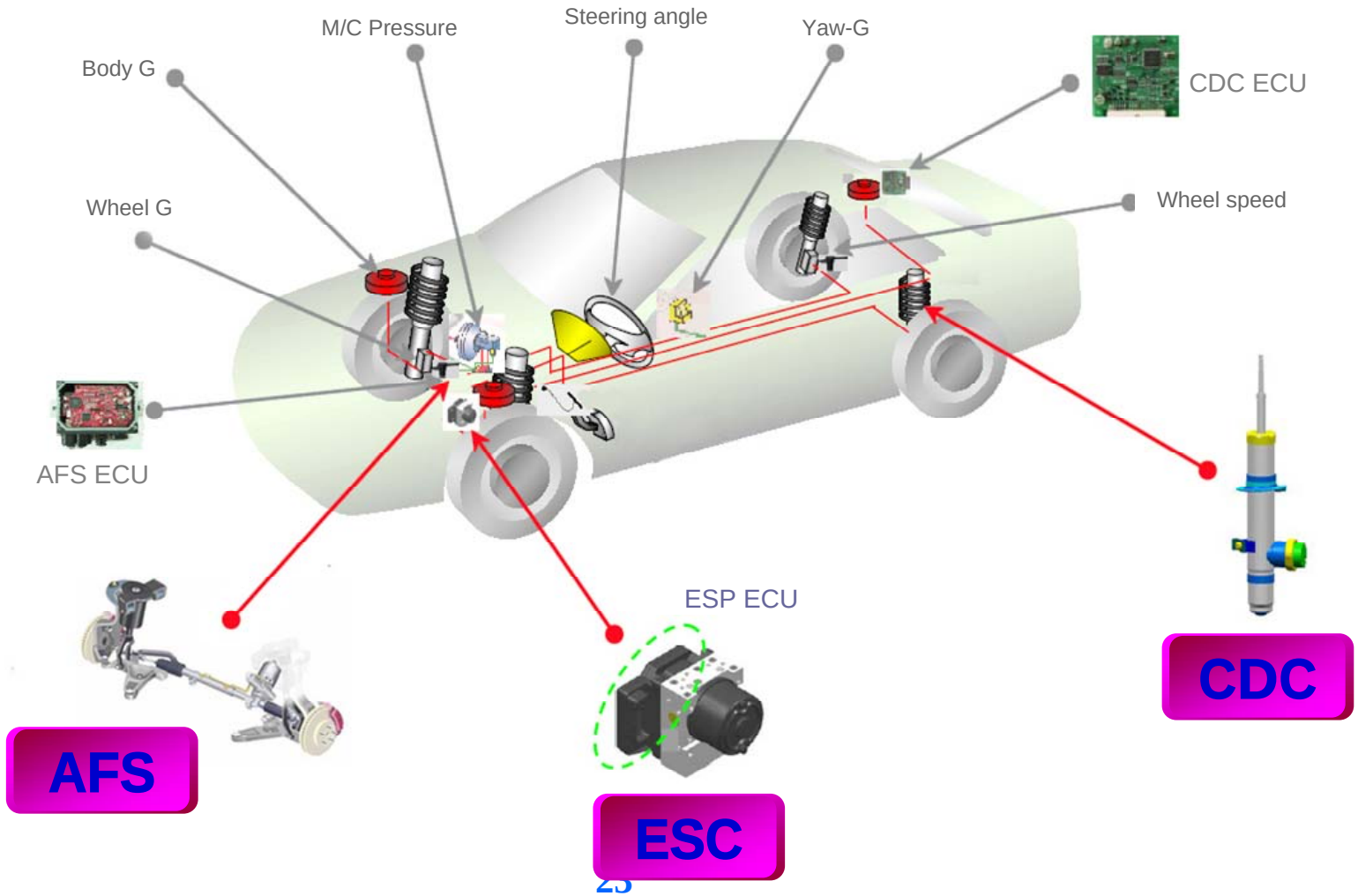


$$2R_p\omega_p = R_s\omega_s + R_r\omega_r$$

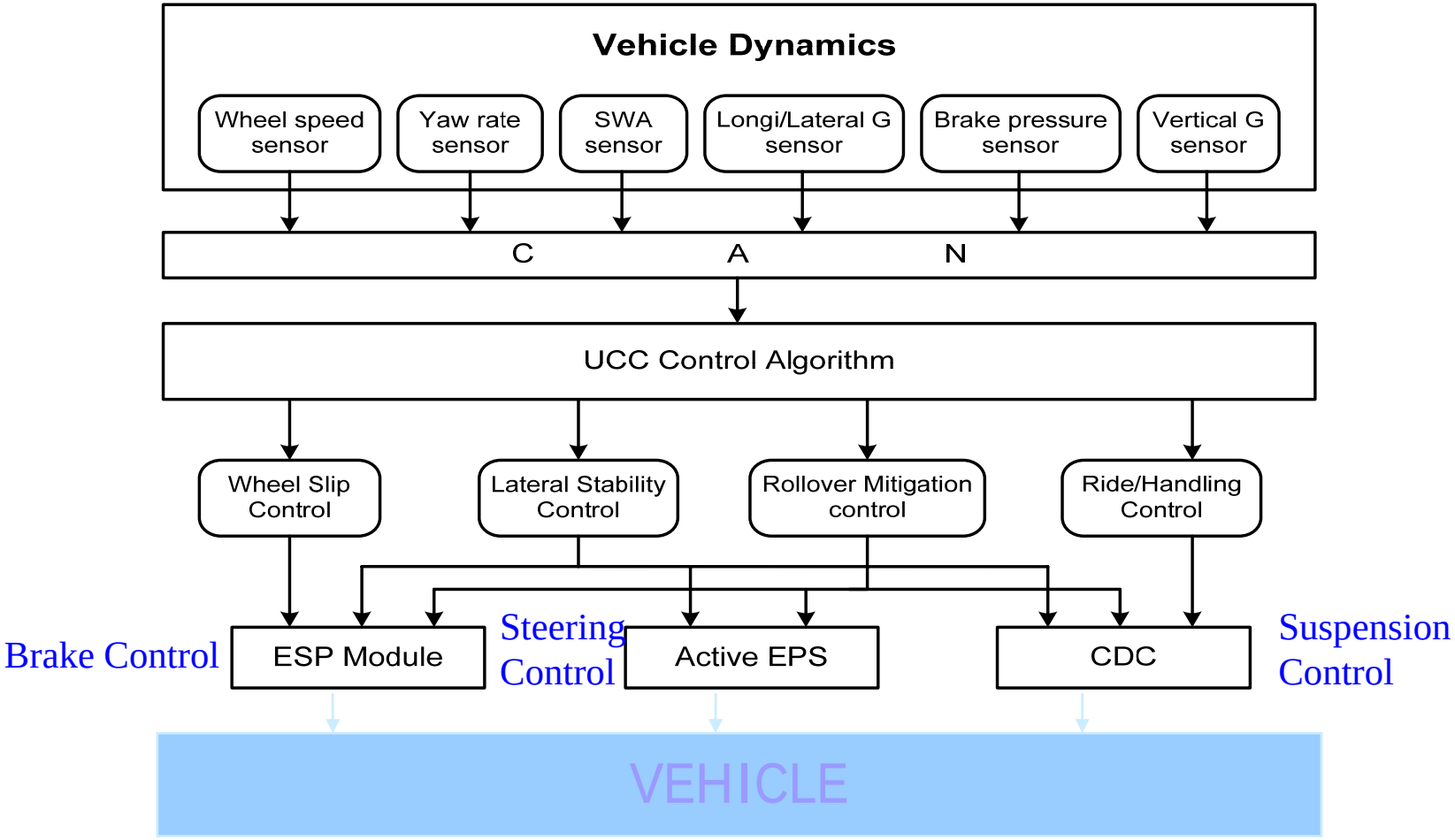
where R: Radius
ω: Angular Velocity

Vehicle Stability Control

Unified Chassis Control (UCC)

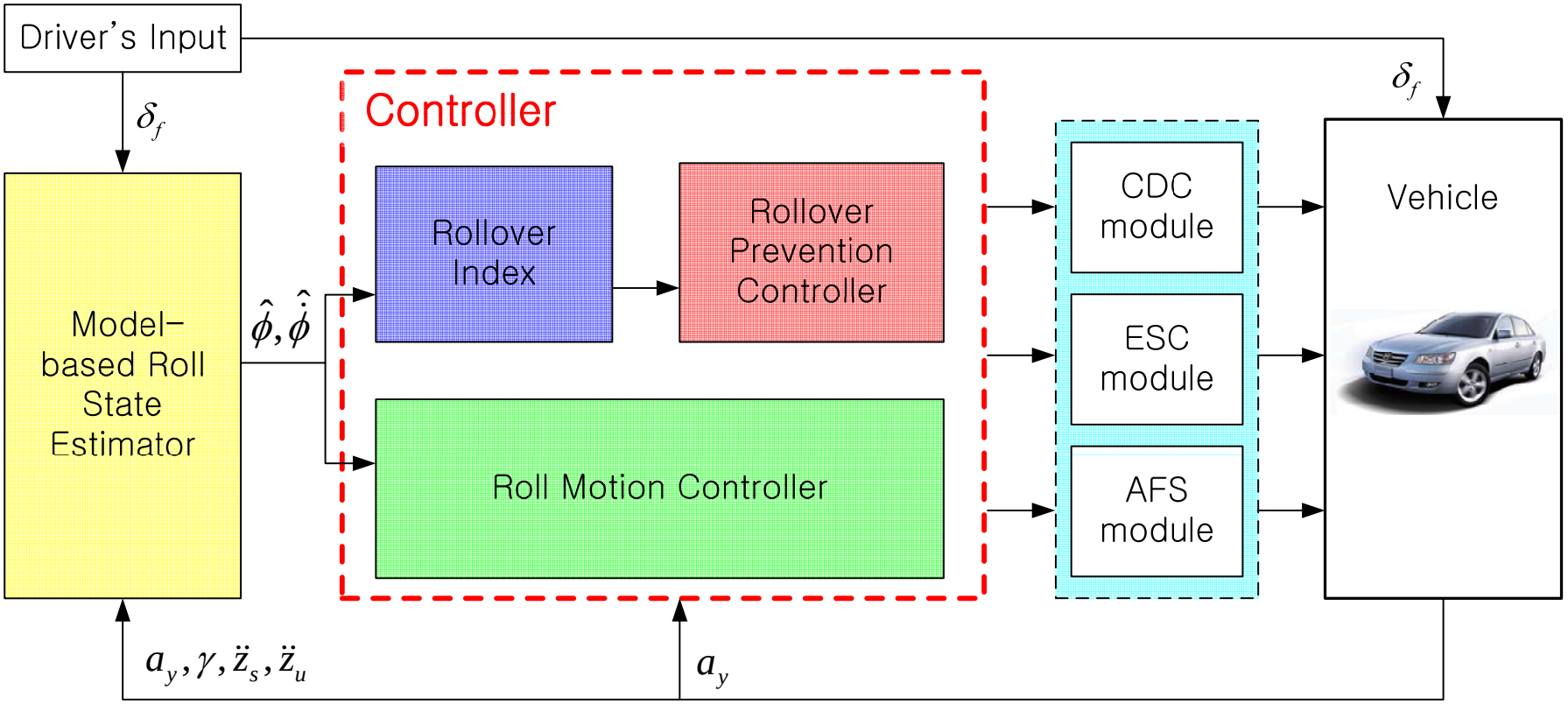


Integrated Chassis Control



Vehicle Rollover Mitigation

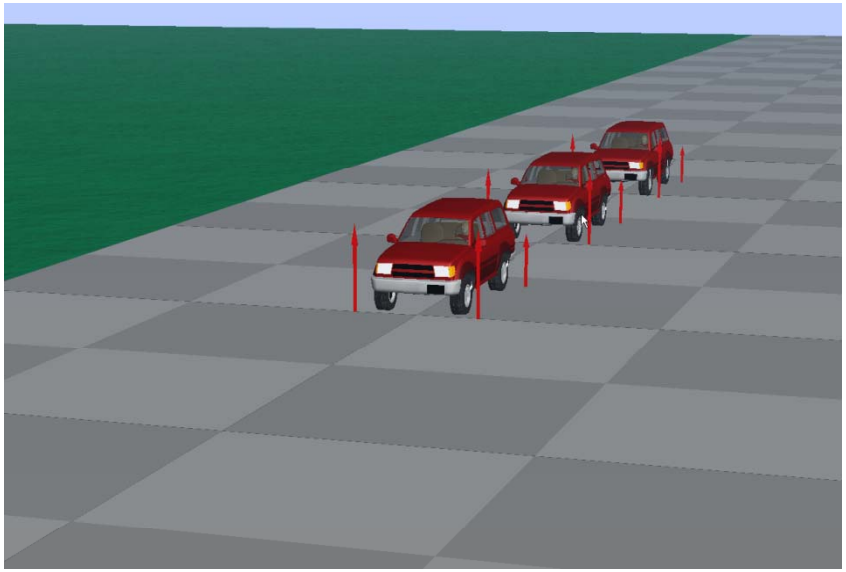
Schematic Diagram of RMC



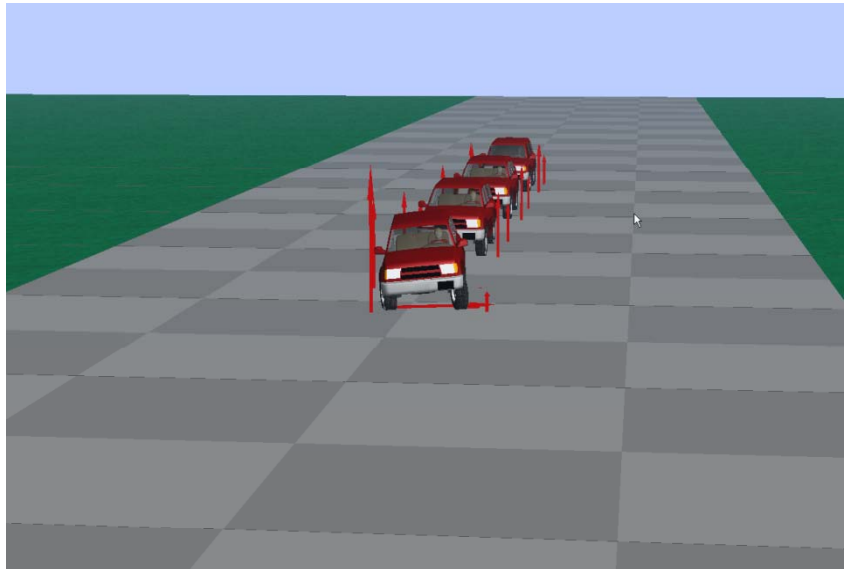
26

NHTSA fishhook Simulation (CARSIM & MATLAB)

- **Without RMC**

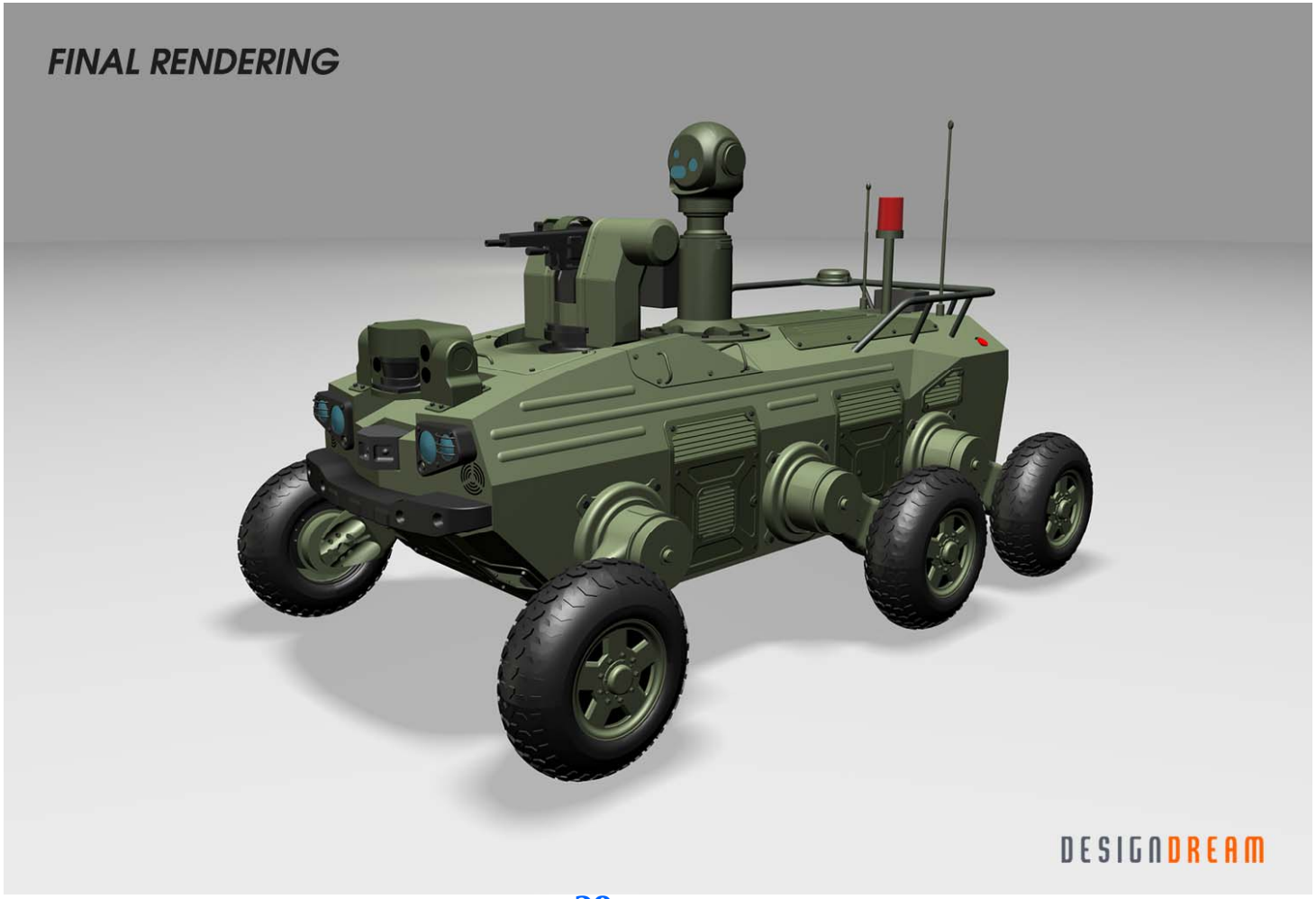


- **With RMC**



27

Military Robot : 견마로봇
(Autonomous Vehicle)



Systems

An aircraft
A head positioner for a computer hard disk
A vehicle
An engine/transmission/brake/ steering/ suspension systems
An electric rice cooker
An excavator
A room air conditioner
A refrigerator
Electric power plant
Robots
Chemical and Manufacturing Process Control: temperature; pressure; flow rate; concentration of a chemical; moisture contents; thickness.

.....