System Analysis

Spring 2011

Professor Kyongsu Yi

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

Introduction

Instructor: **Professor Kyongsu Yi**

301-1502

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

http://vdcl.snu.ac.kr

Lectures: **Mo/We 9:30-10:45 @301-305**

Office hours: **We 11:00 to 12:00 or by appointment**

Text:

1. System Dynamics, 2nd Ed., William J. Palm III, McGraw Hill, 2010.

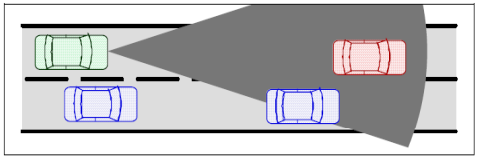
References:

1. System Dynamics, 4th Ed., K. Ogata, Pearson/Prentice Hall, 2004.

2. 동적시스템 및 제어공학**,** 김종식**,** 청문각

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: **Midterm Exam 30%, Final exam 45%**
Homework 15%, Class attendance 10%
(과제 제출일에 과제관련 10 minutes 퀴즈를 보고 퀴즈 성적으로 10%반영)

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.

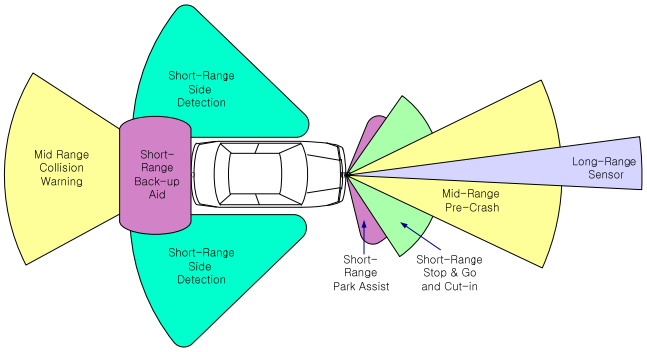
	주(기간)	강의내용
강의 계획	1주	Course overview, Key Concepts, Terminology, System dynamics, system analysis, design, synthesis
	2주	Laplace Transformation, LT Theorems
	3주	Mathematical Modeling of Dynamic Systems, mechanical systems, Friction, work, energy, and power
	4주	Transfer Function Approach to Modeling Dynamic Systems
	5주	State space Approach to Modeling Dynamic Systems, state equation and transfer function, vehicle systems
	6주	Electrical and electromechanical systems: Electrical elements, Circuit Examples
	7주	Electric motors, Motor systems, analysis of motor performance
	8주	Power dissipation, mechanical output power, Electric vehicle, Midterm Exam,
	9주	Fluid Systems and Thermal Systems: Liquid level systems, thermal systems
	10주	Hydraulic systems, Dynamic models of hydraulic systems
	11주	Time Domain Analysis of Dynamic Systems, First order/second order systems, Transient analysis
	12주	Solution of state equation, system ith additional poles and zeros, Analysis with MATLAB
	13주	Frequency Domain Analyses of Dynamic Systems: Bode plots
	14주	Vibration absorber, suspension, seismograph and accelometers
	15주	Review and Final Examination

Exam : 75-minute midterm exam

on April 13 (we) 9:30-10:45

120-minute final exam

on June 13 (mo) 9:30-11:30



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

hydraulic 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

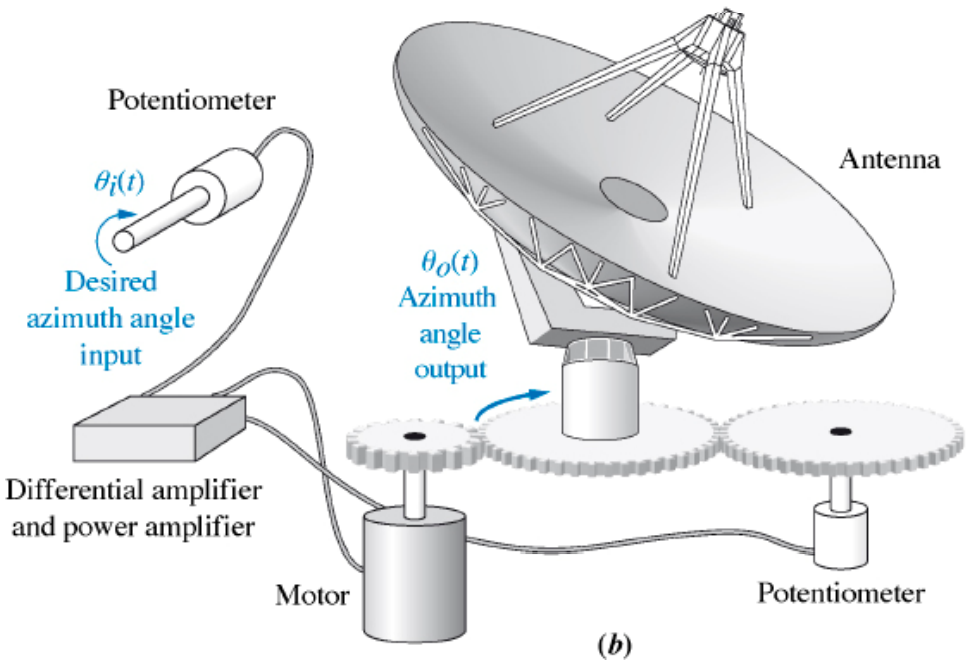
Analysis with MATLAB

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

Antenna azimuth position control system



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

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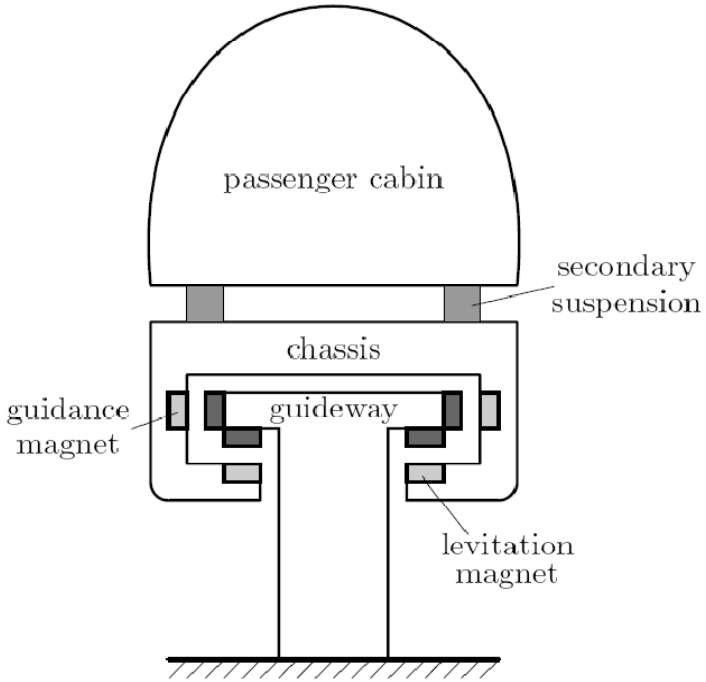
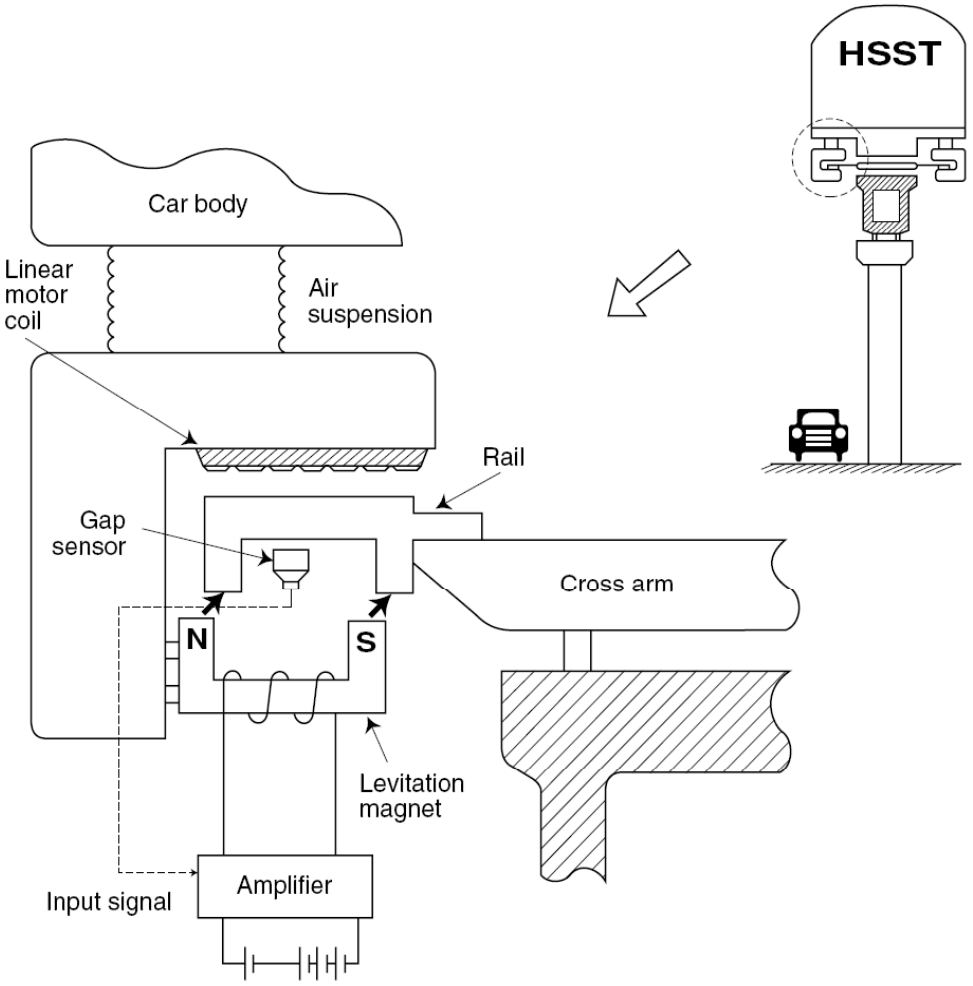
MAGLEV (Magnetic Levitation) Vehicle





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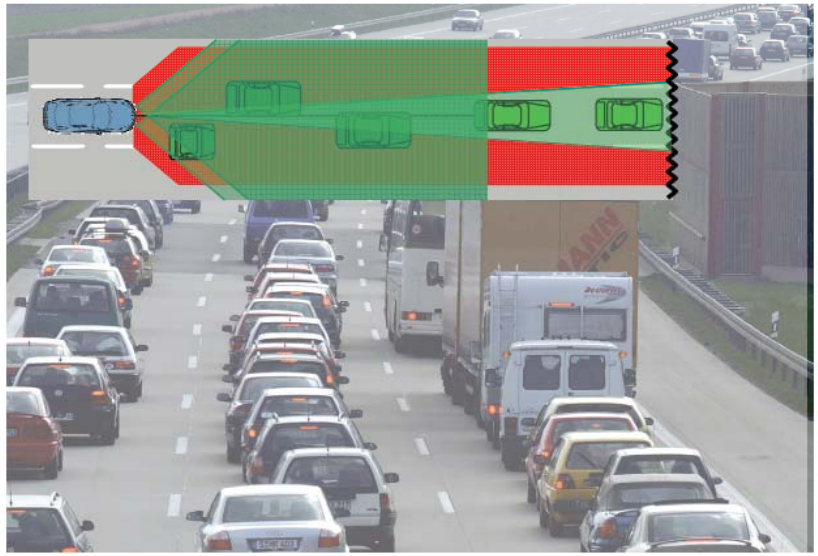
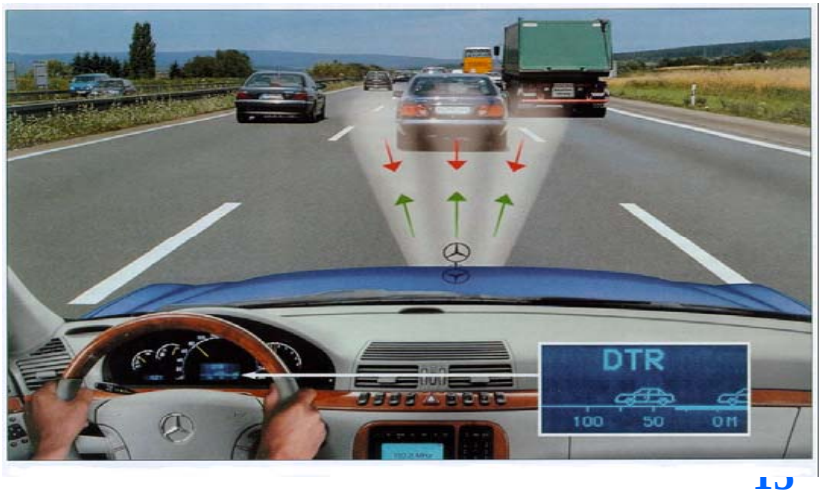
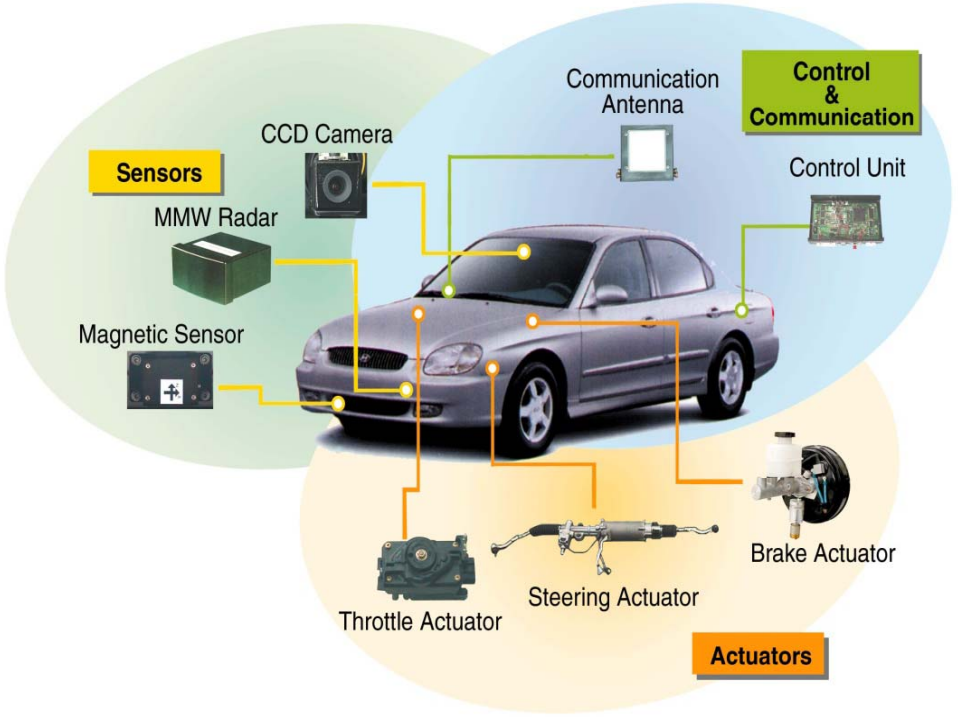
Full-range ACC/CA

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



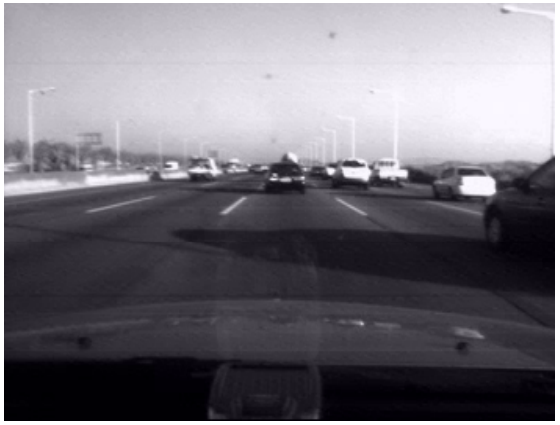


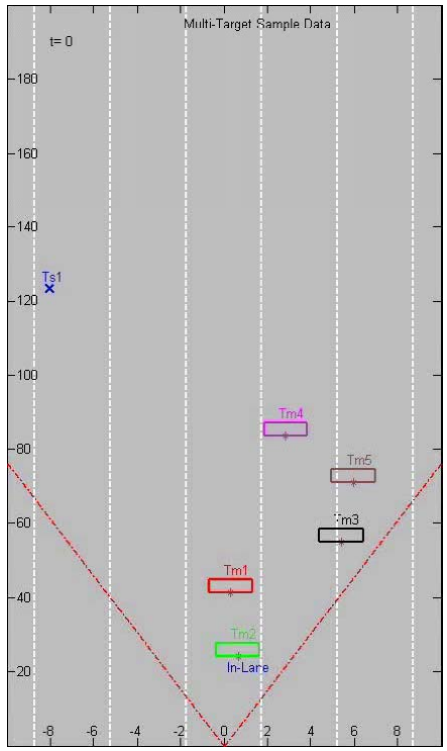


- **Autonomous Driving: Adaptive Cruise Control with Collision Avoidance**

ACC/CA Vehicle

Multi-Target Detection





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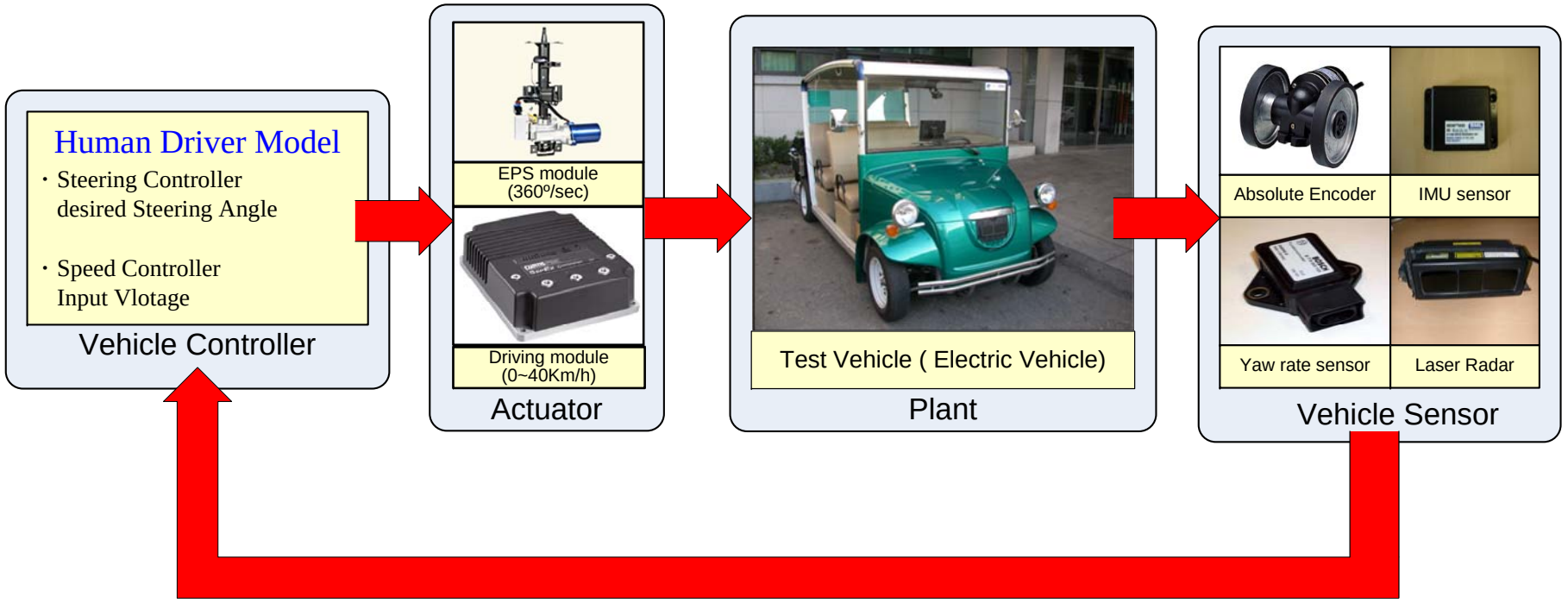
AUTOMATED HIGHWAY SYSTEMS (AHS)

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**



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Vehicle Tests

- Lane Following

- Lane Following + ACC

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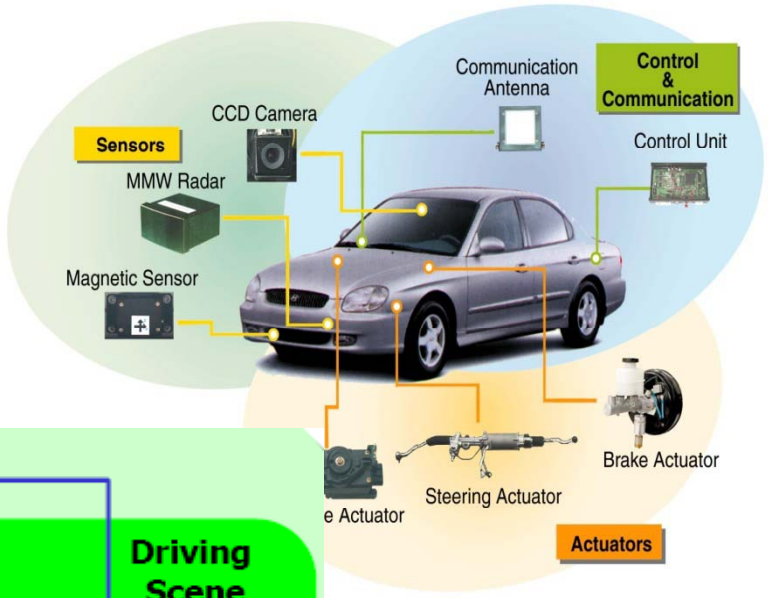
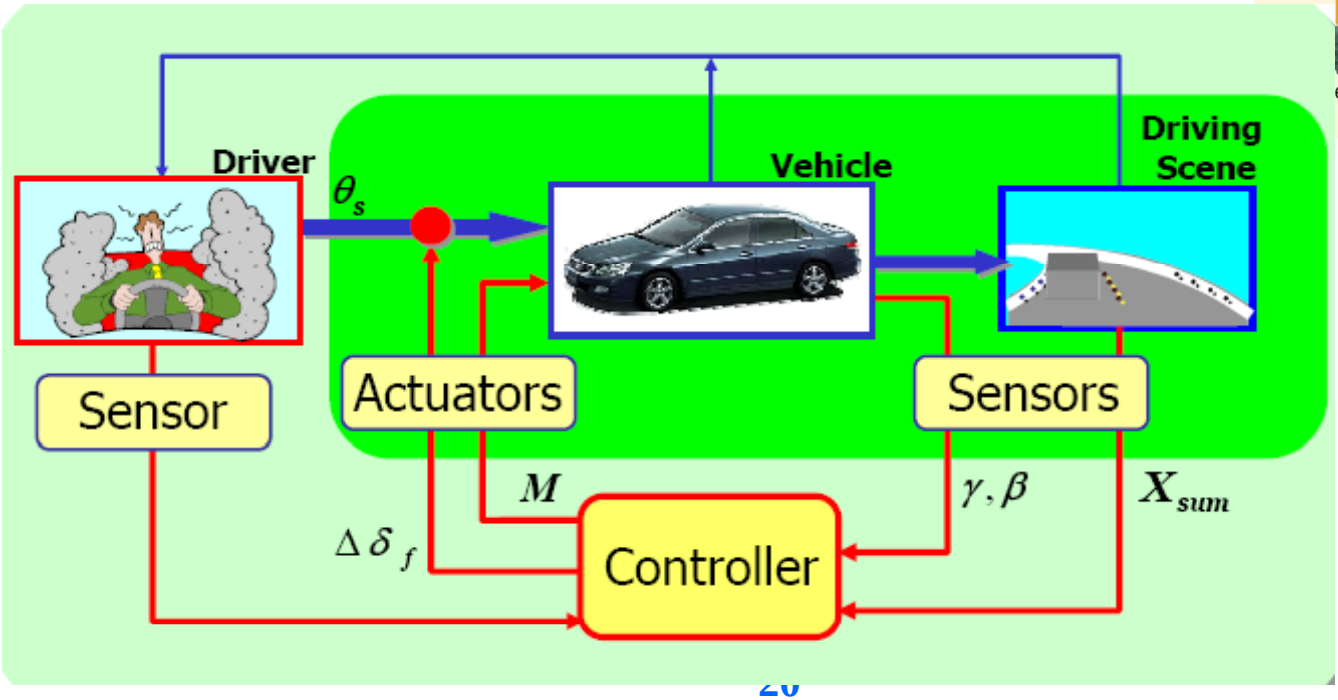
Vehicle Control Systems



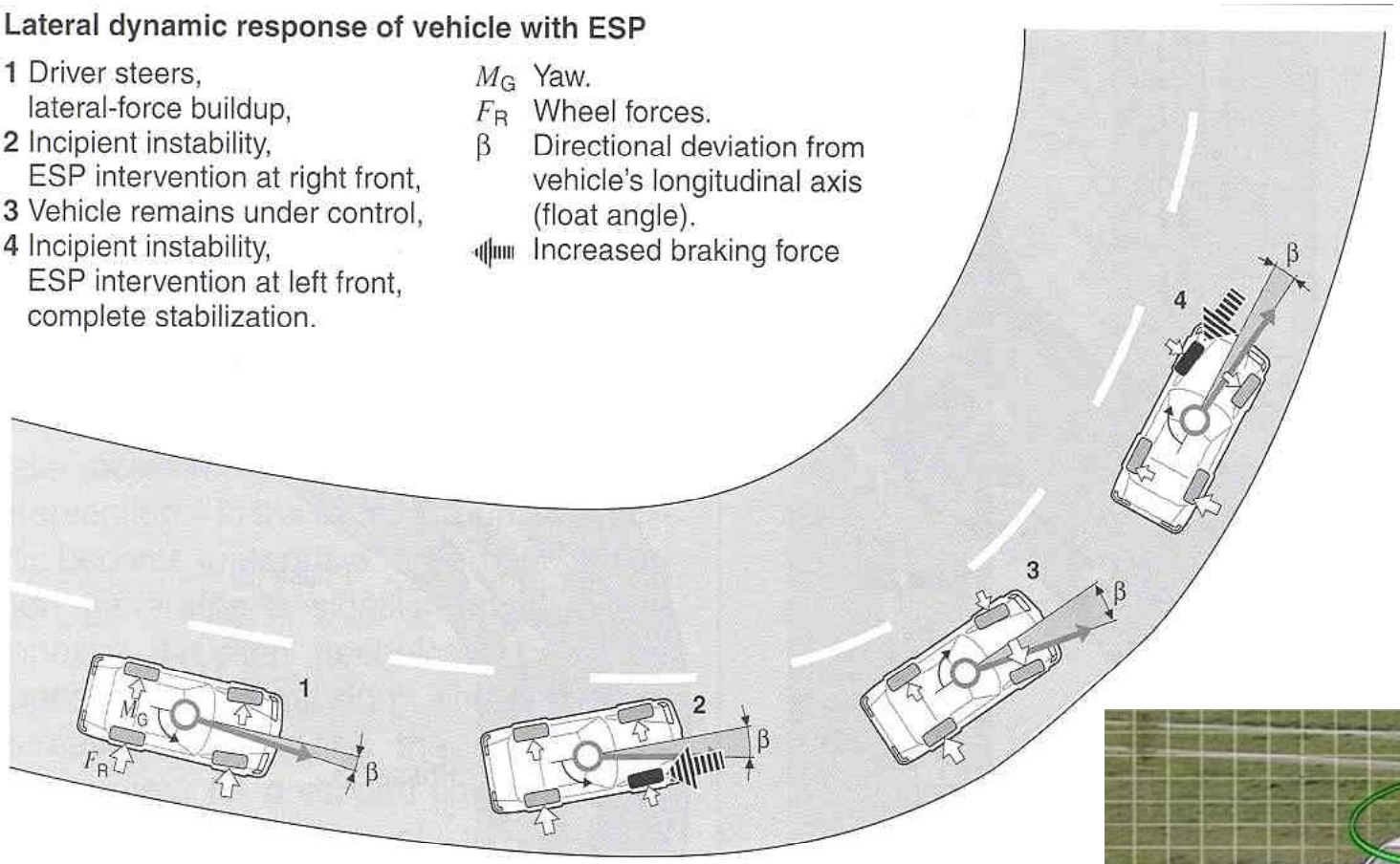


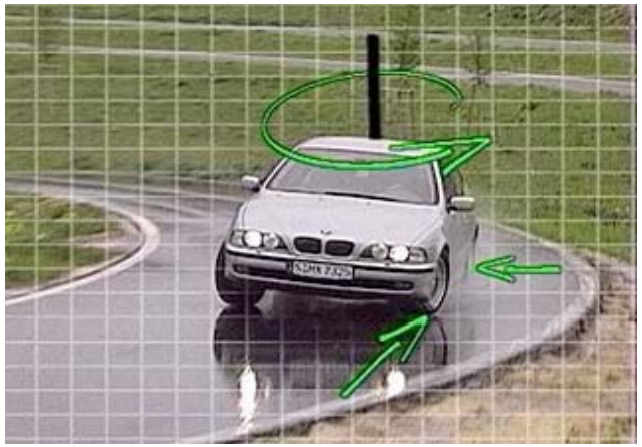
ESP (Electronic Stability Program)

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.

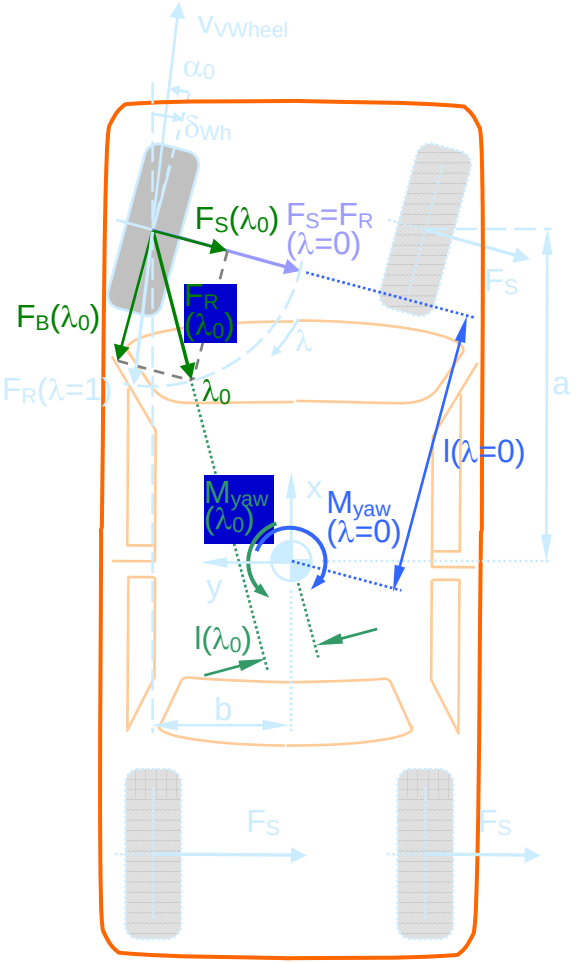
M_G Yaw.
F_R Wheel forces.
β Directional deviation from vehicle's longitudinal axis (float angle).
Increased braking force





Unified Chassis Control (UCC)

- Vehicle Lateral Motion (Dynamic Equations)



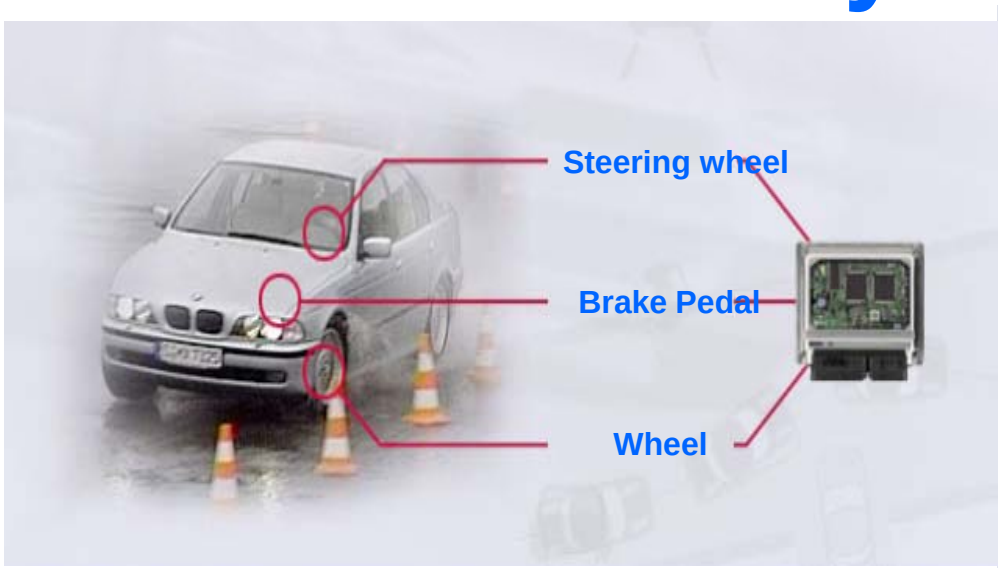
$$m(\dot{v}_x - \gamma v_y) = F_{xr} + F_{xf}\cos\delta_f - F_{yf}\sin\delta_f$$

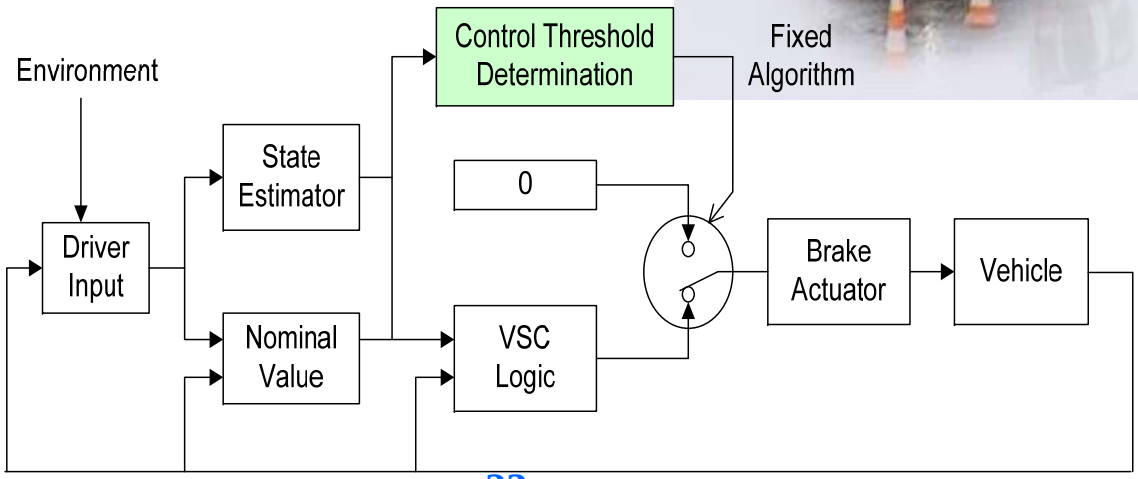
$$m(\dot{v}_y + \gamma v_x) = F_{yr} + F_{yf}\cos\delta_f - F_{xf}\sin\delta_f$$

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

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

Vehicle Stability Control Systems





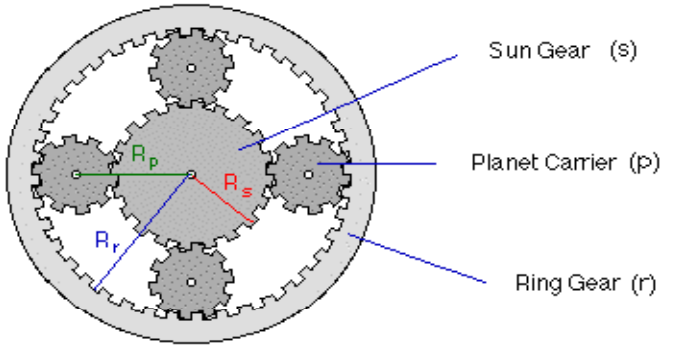
Electric Power Steering (EPS) / Active Front Steering (AFS)

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)

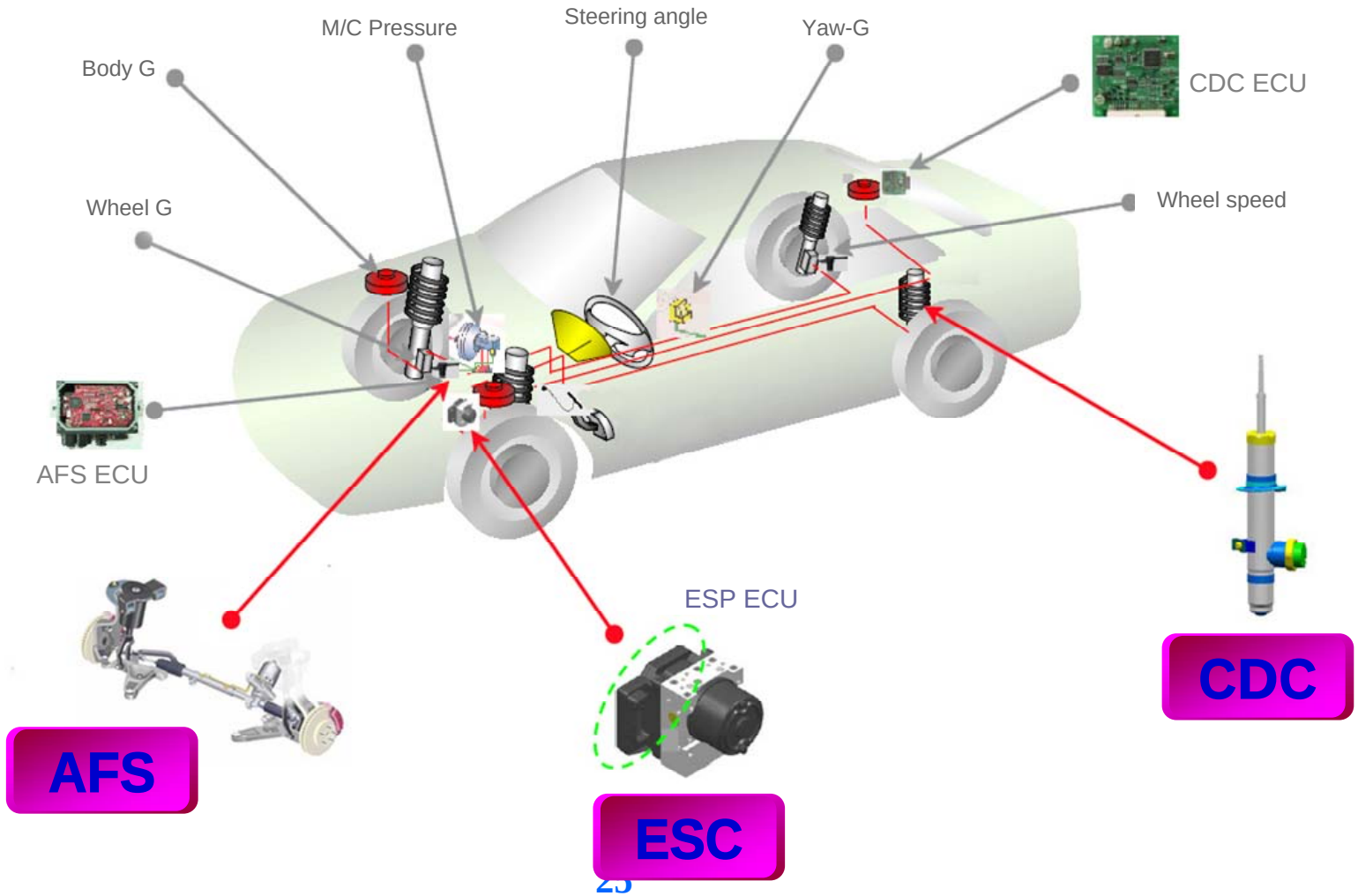


$$2R_p\omega_p = R_s\omega_s + R_r\omega_r$$

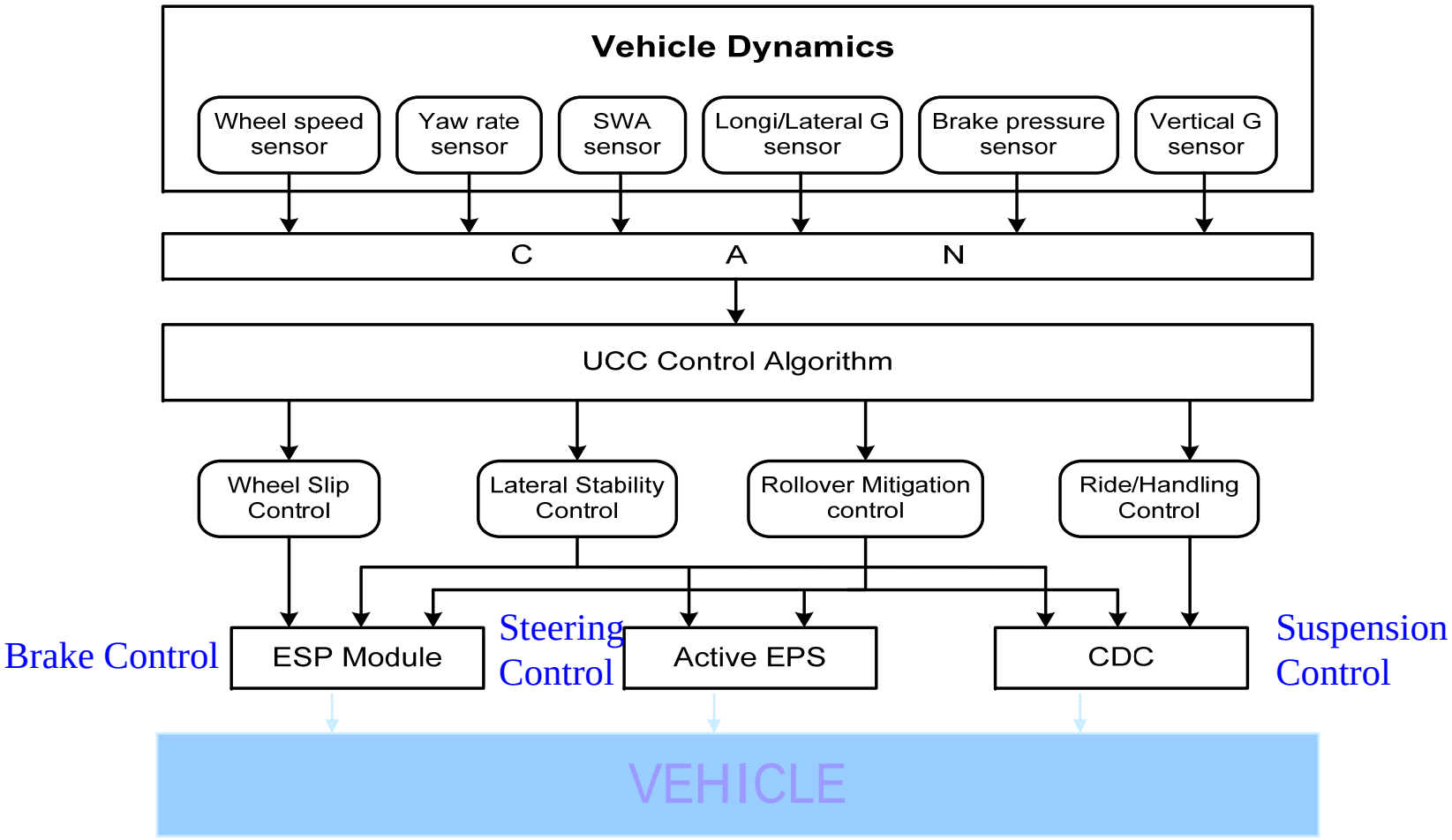
where R: Radius
ω: Angular Velocity

Vehicle Stability Control

Unified Chassis Control (UCC)

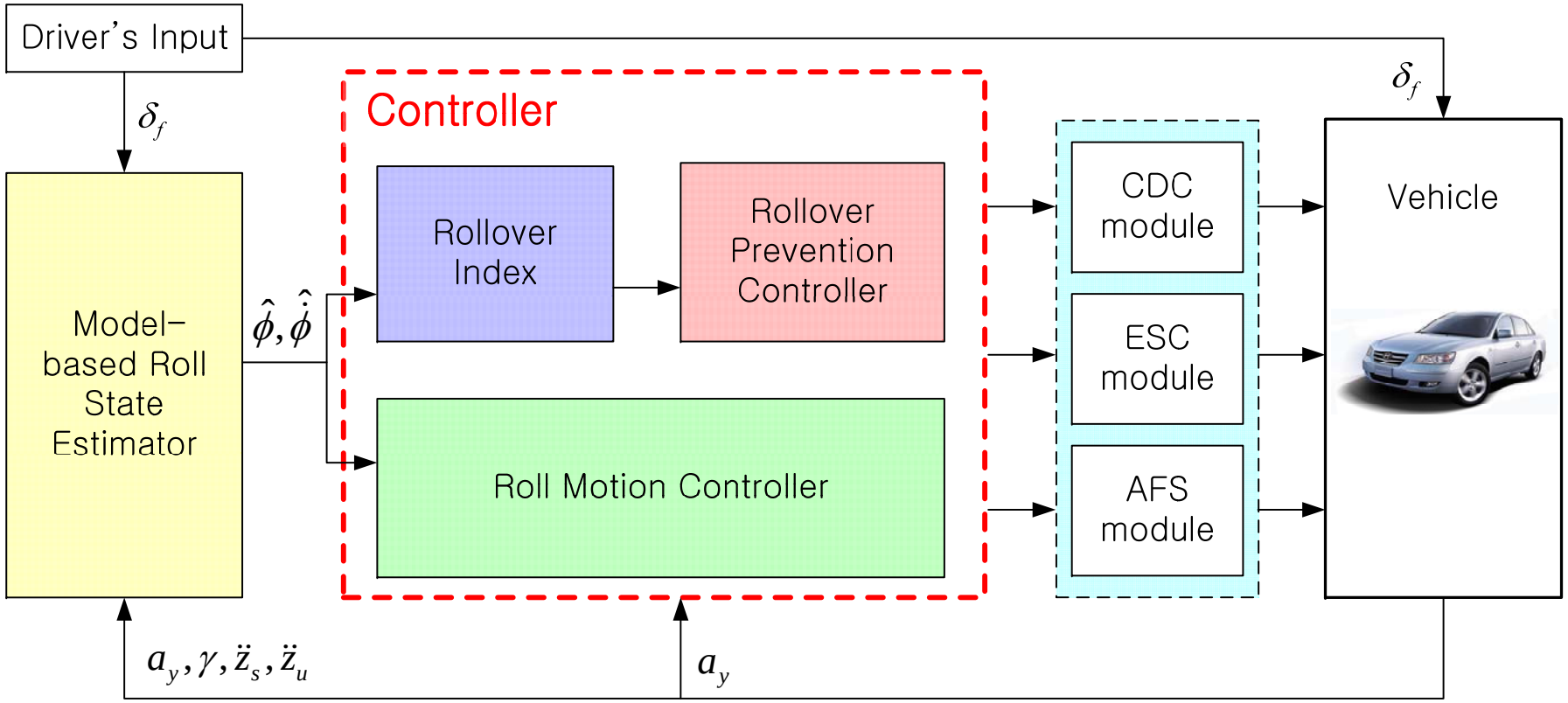


Integrated Chassis Control



Vehicle Rollover Mitigation

Schematic Diagram of RMC



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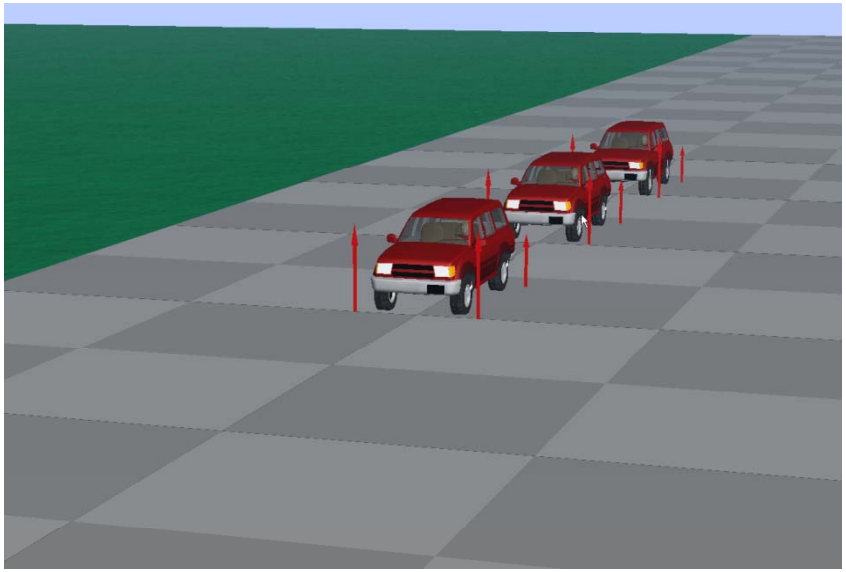
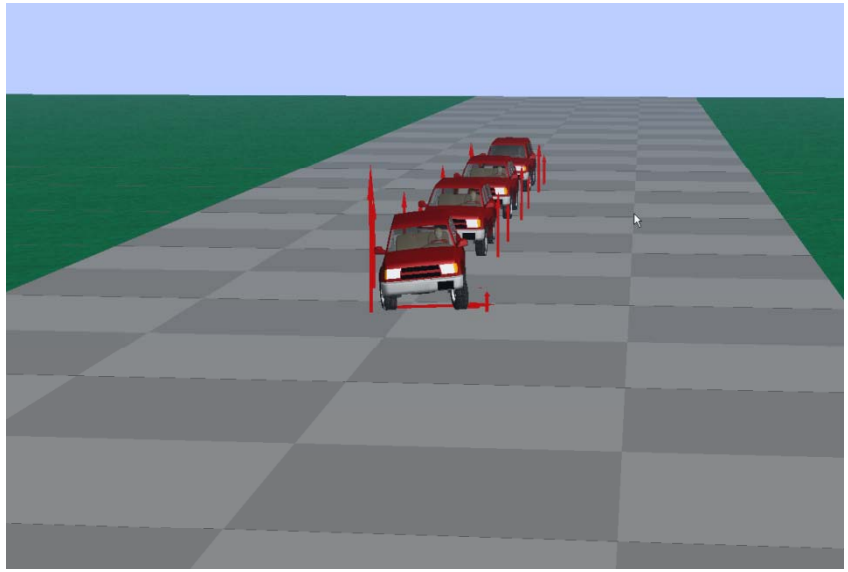
NHTSA fishhook Simulation (CARSIM & MATLAB)

- **Without RMC**



- **With RMC**



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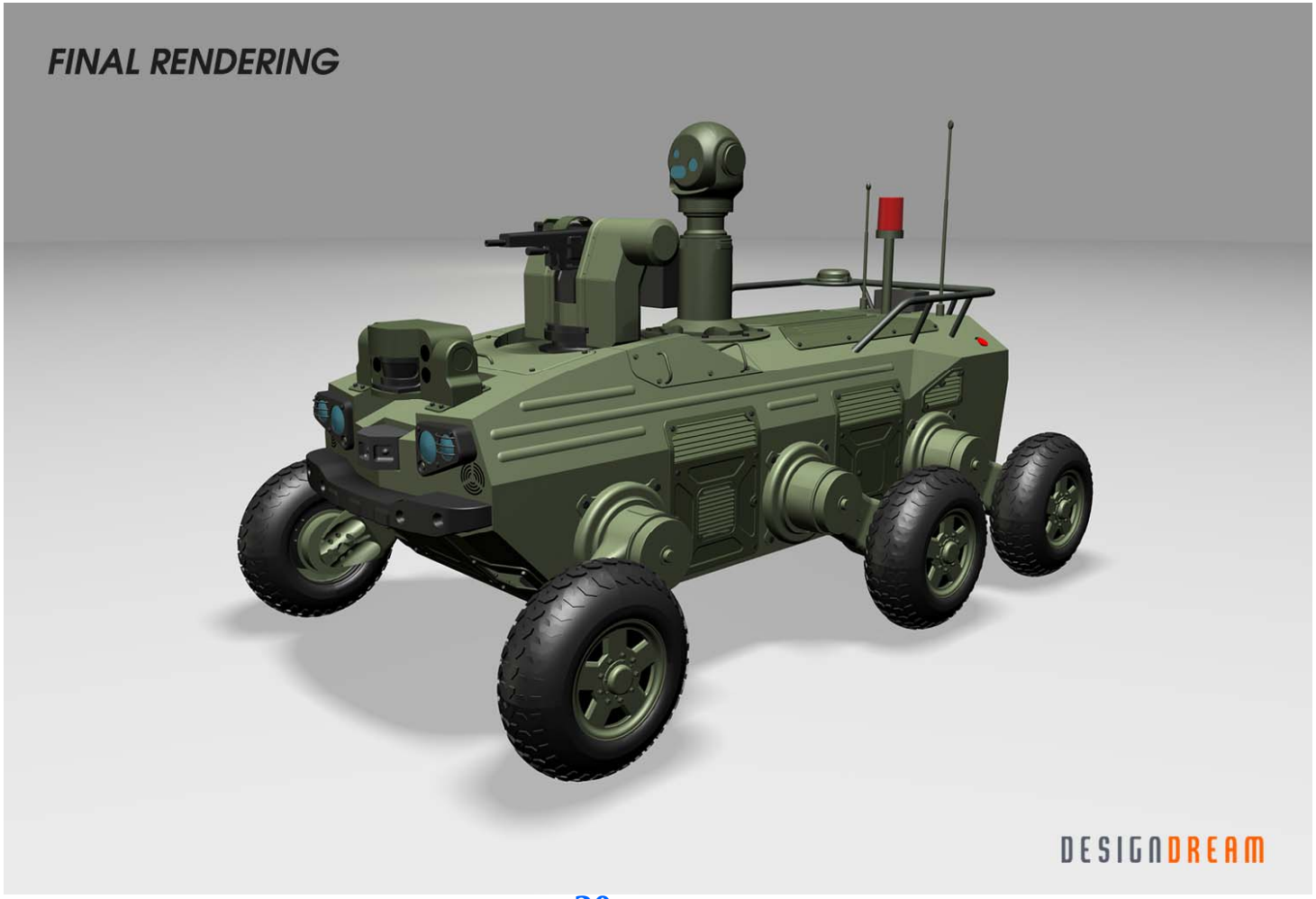
Military Robot : 견마로봇
(Autonomous Vehicle)



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.

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