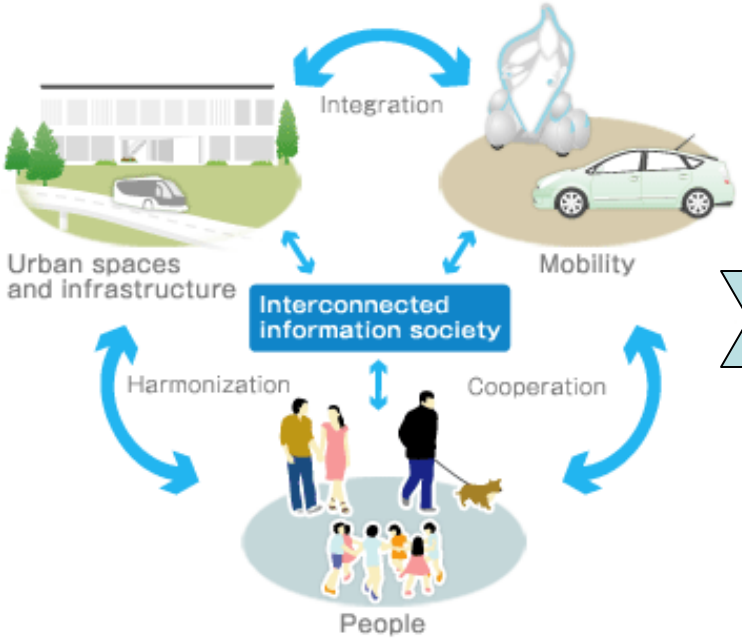
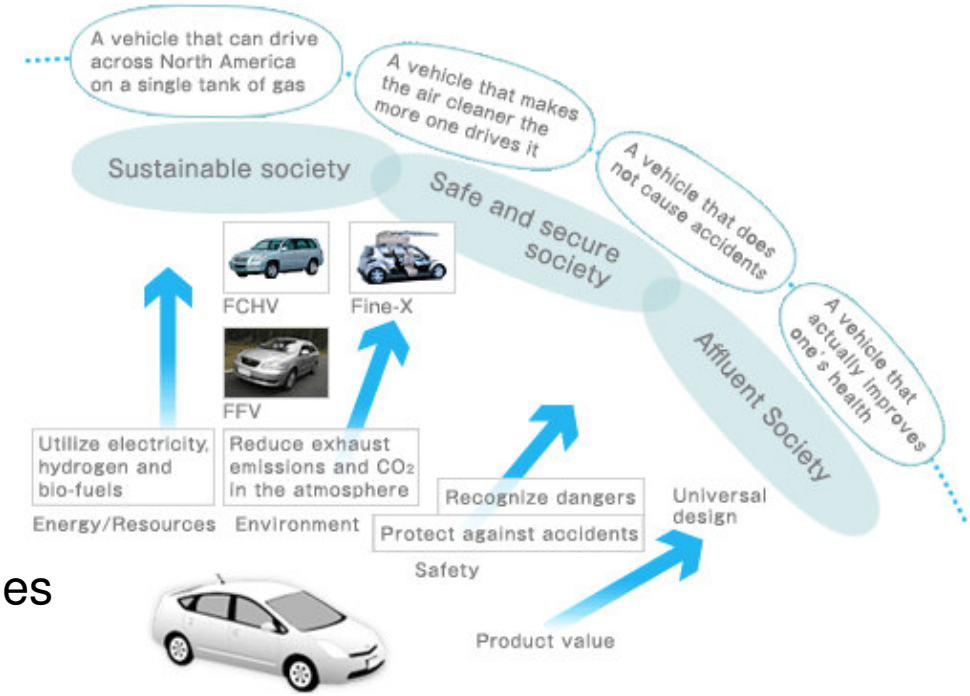
Control, Electronics, Communication, and Embedded Software

Infrastructure integration



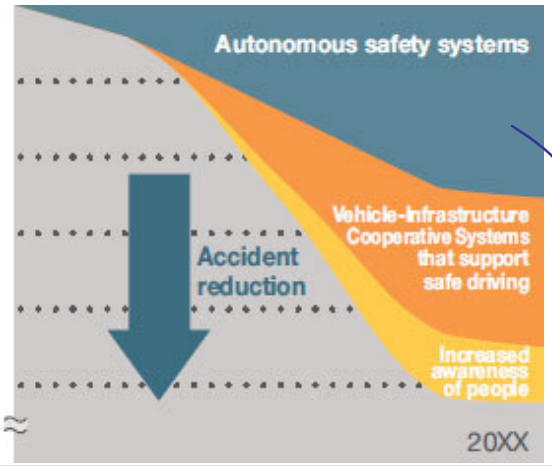


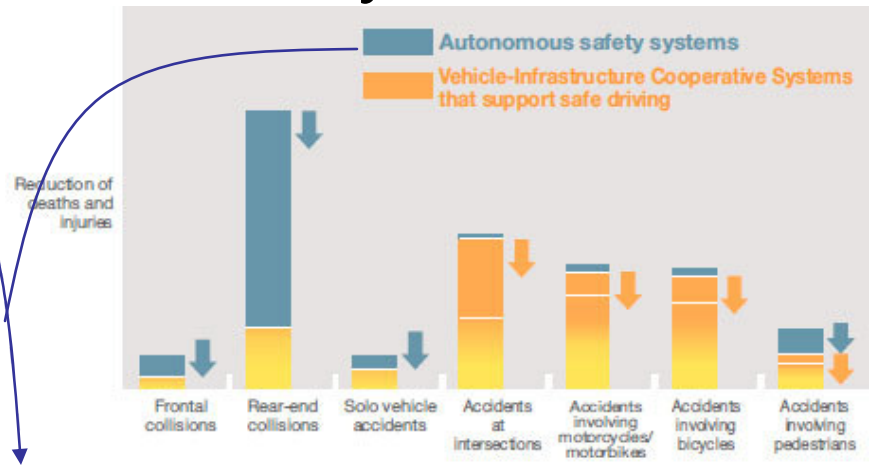
Vehicle technologies

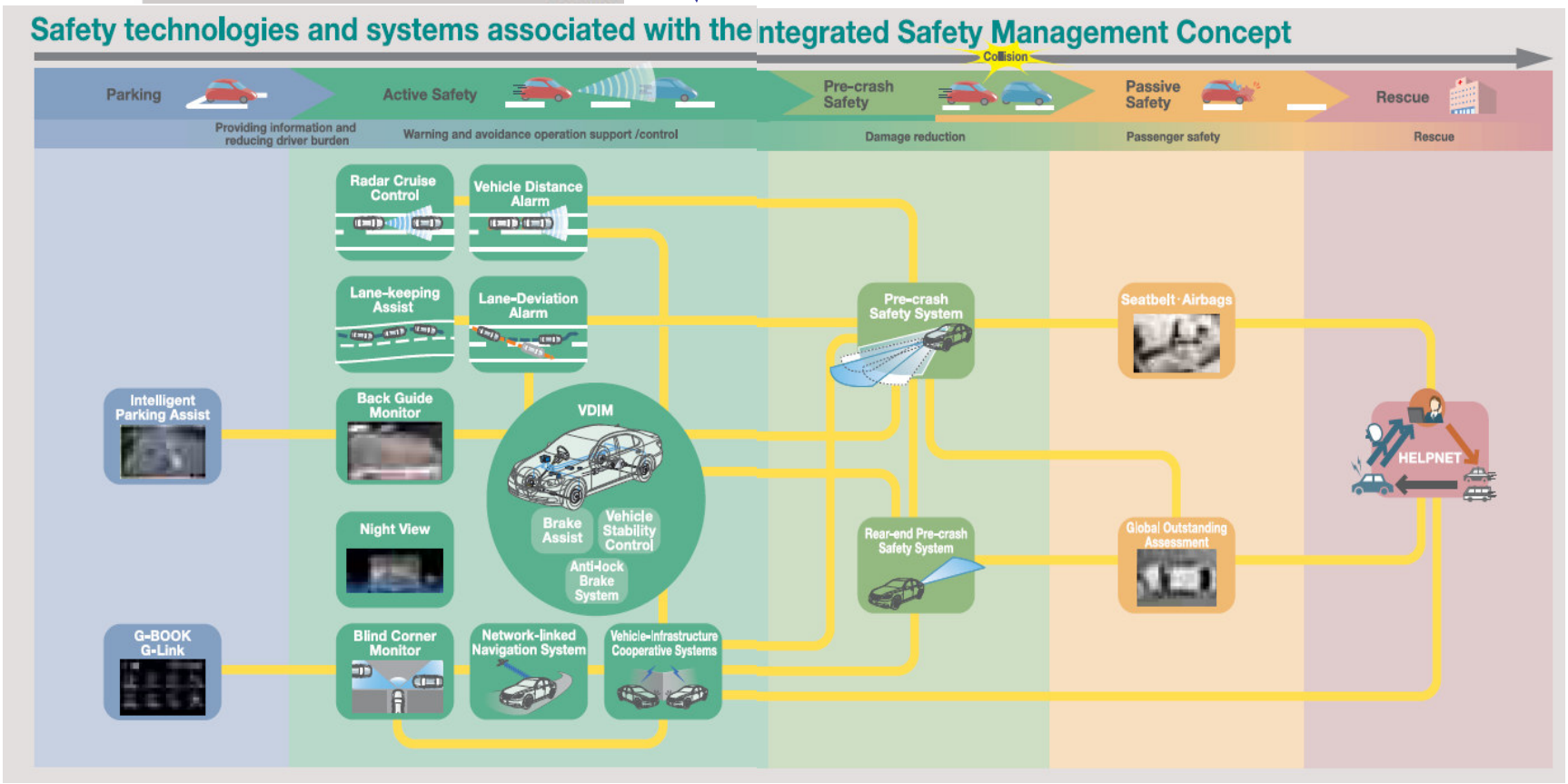
Presentation Flow

1. Control, Electronics, Communication, and Embedded Software: Enabled Products and Features
2. Development Complexity and Mitigation
3. Future Development Challenge: Cyber-physical systems

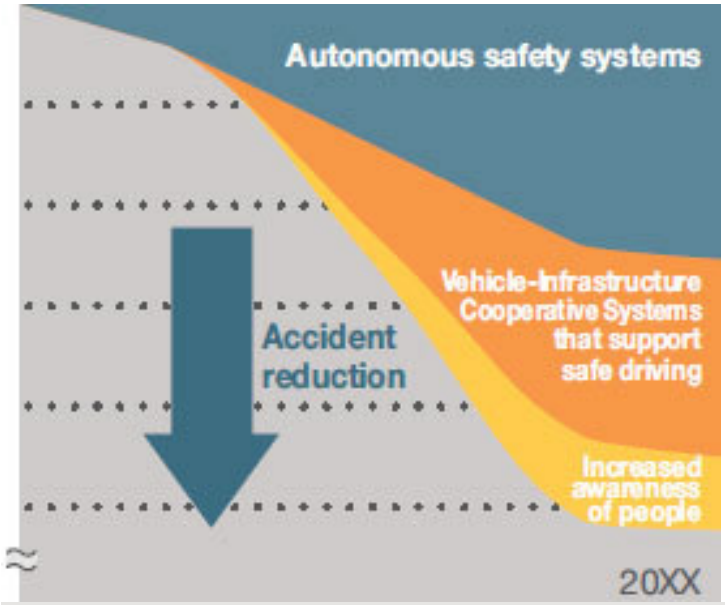
Vehicle - Safety

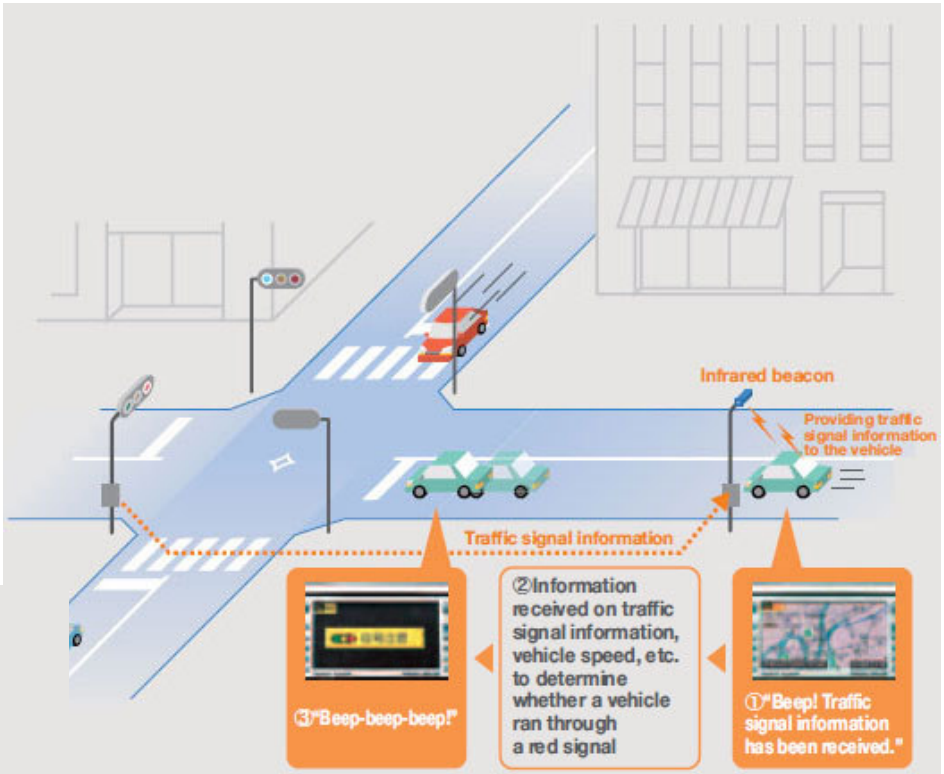


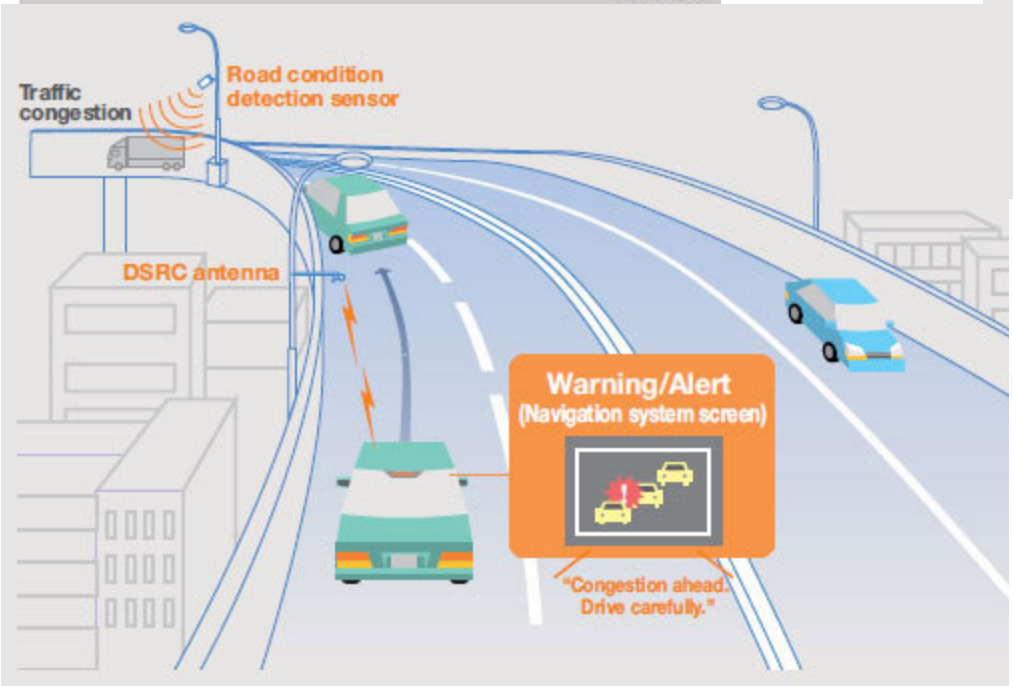


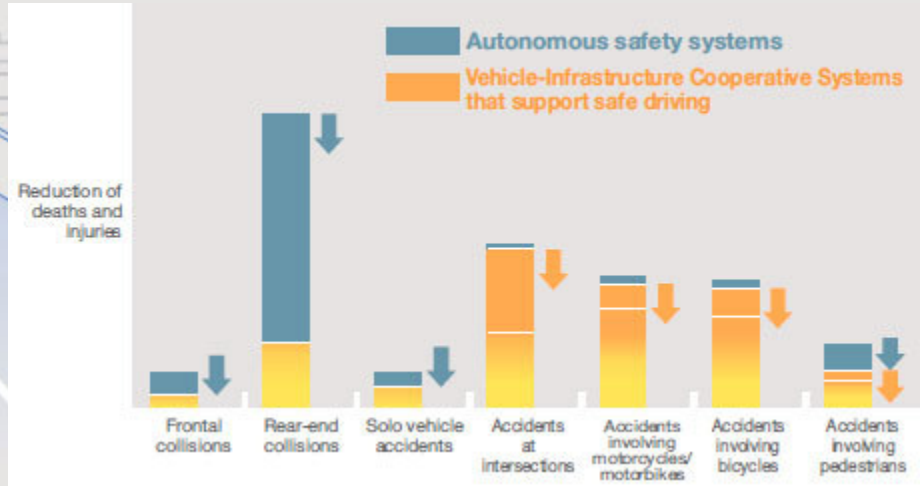


Vehicle – Infrastructure - Safety

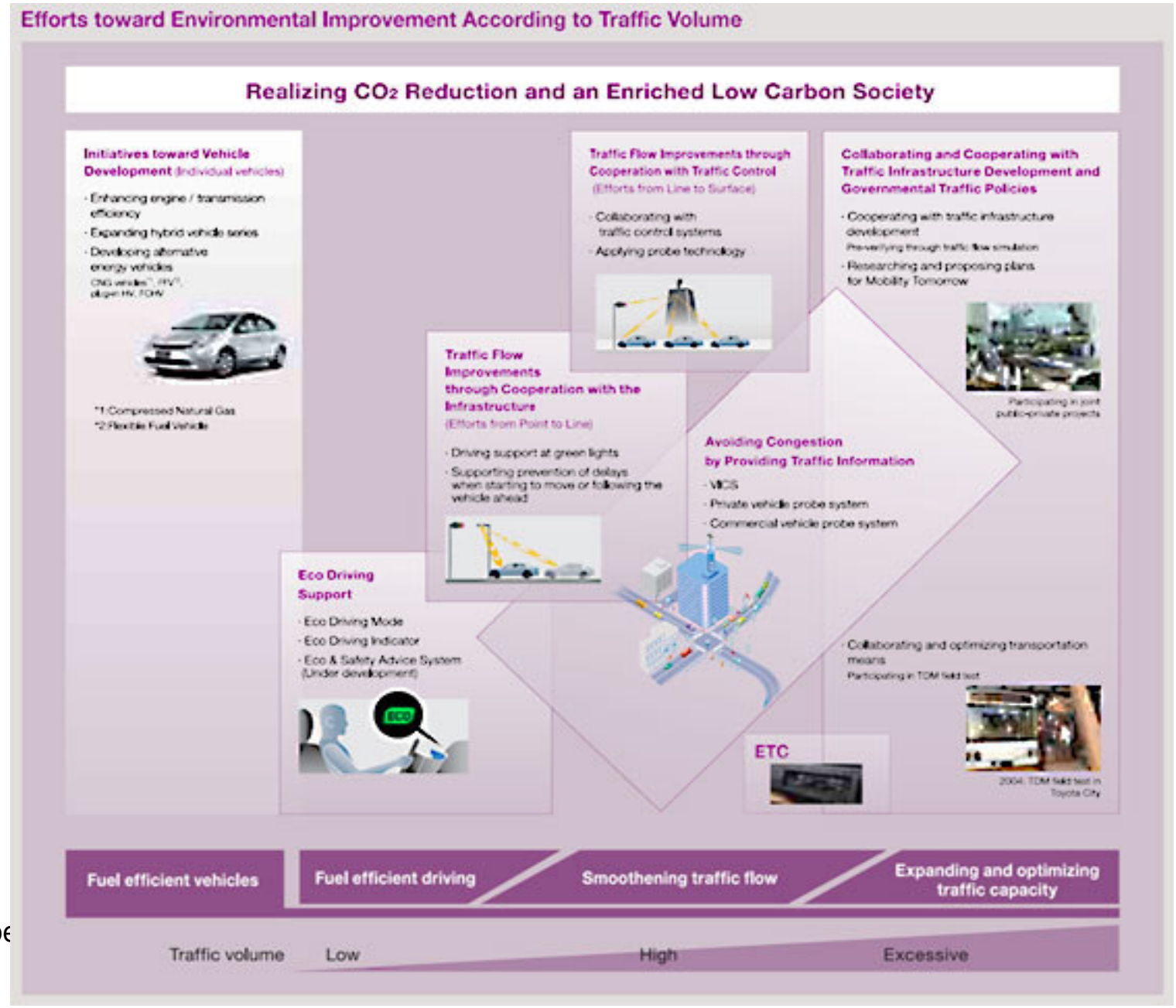




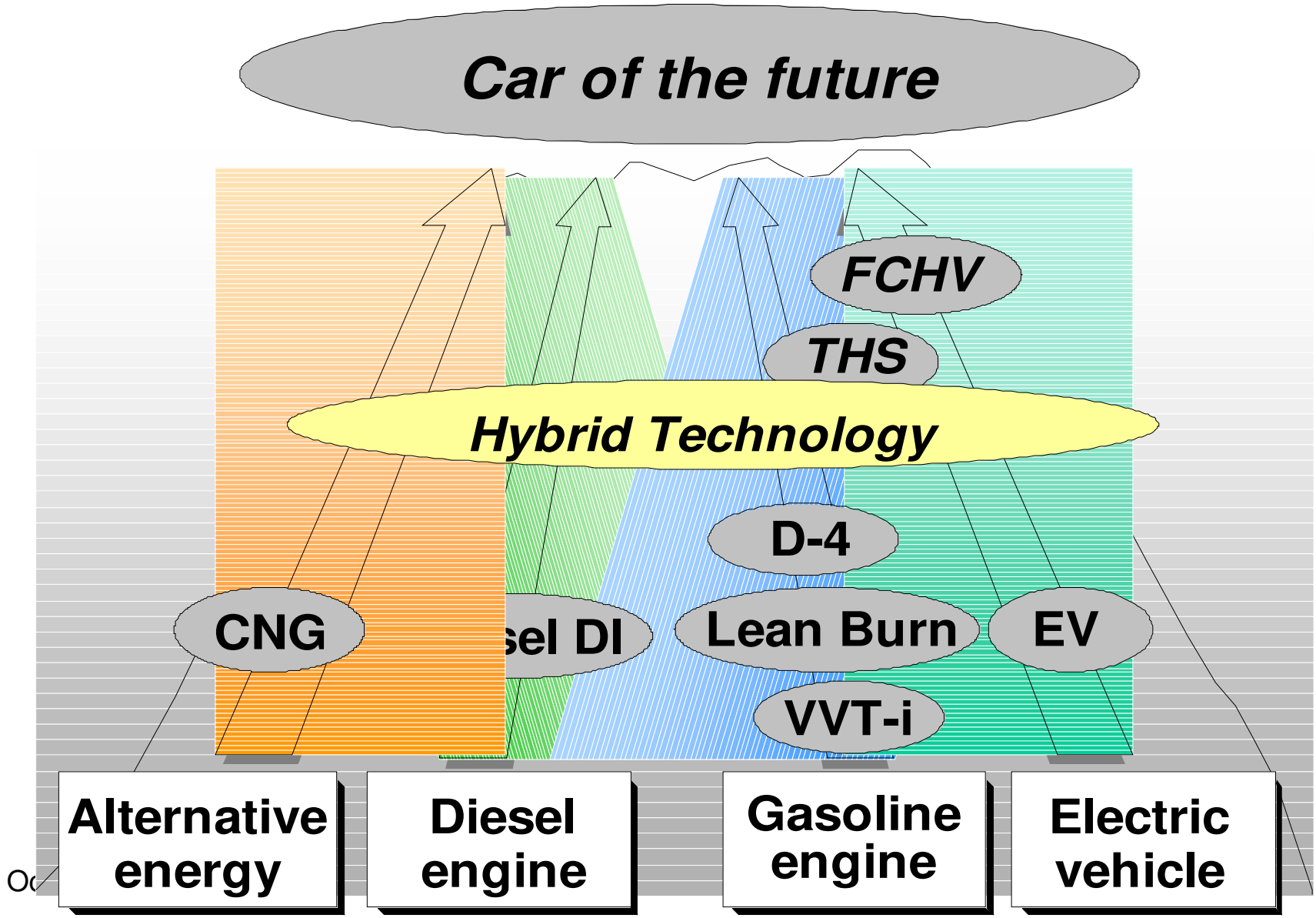




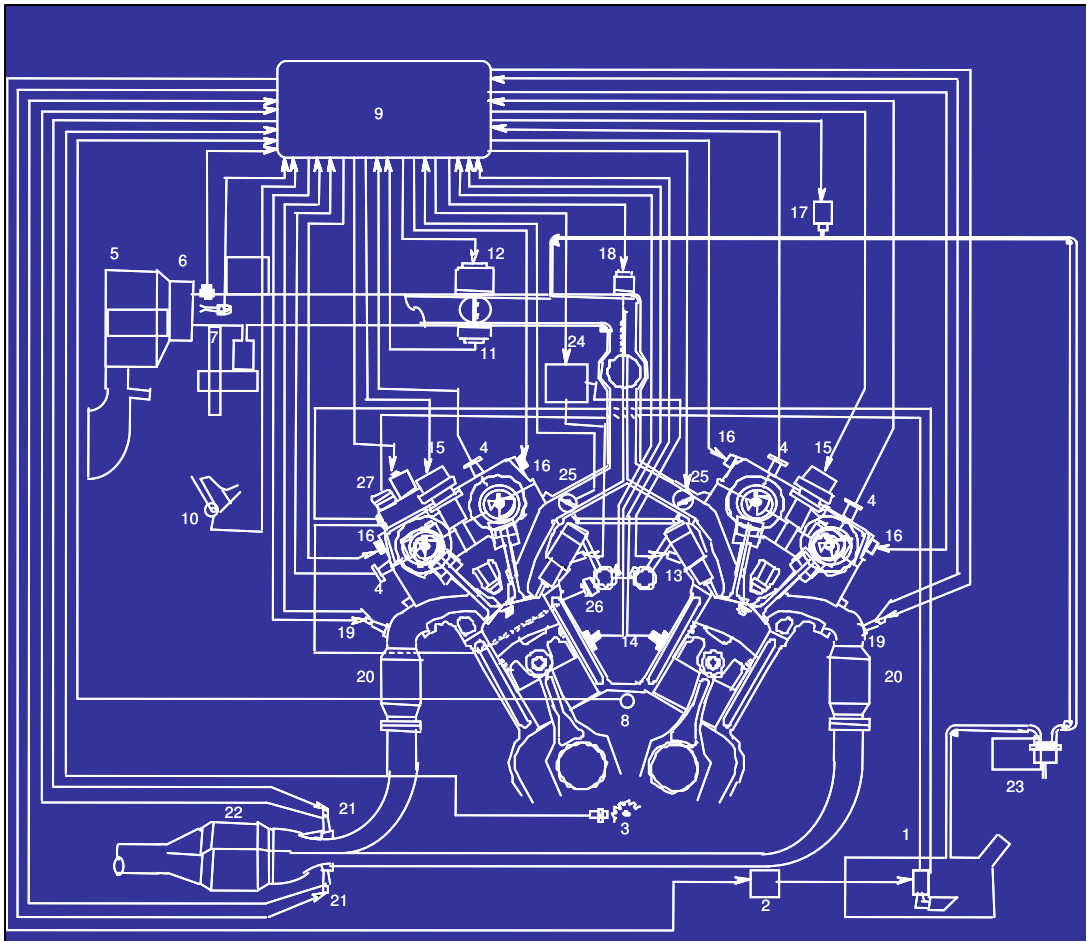
Traffic flow management - Environment



Environment - Powertrains



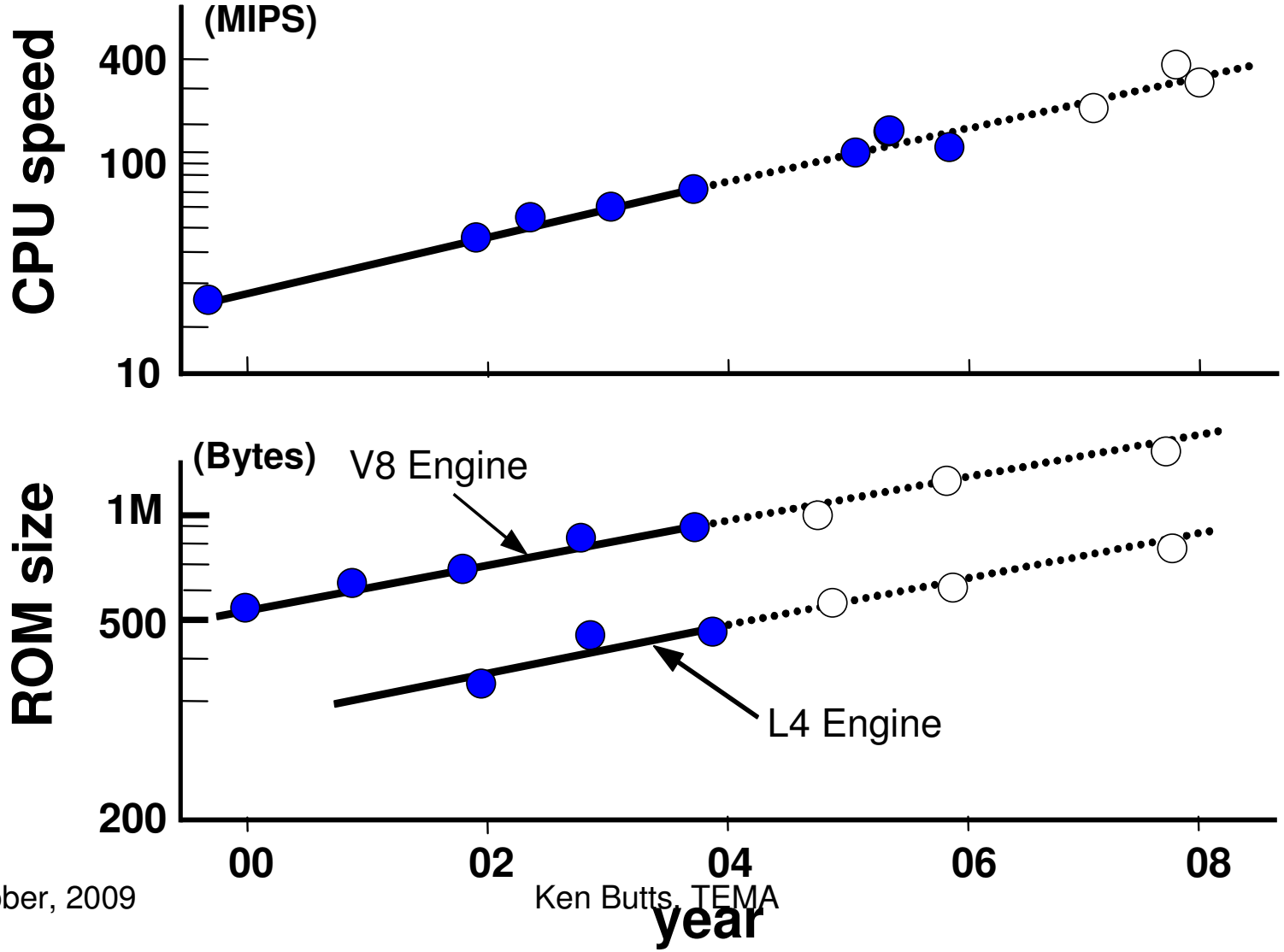
Modern Gasoline engine control



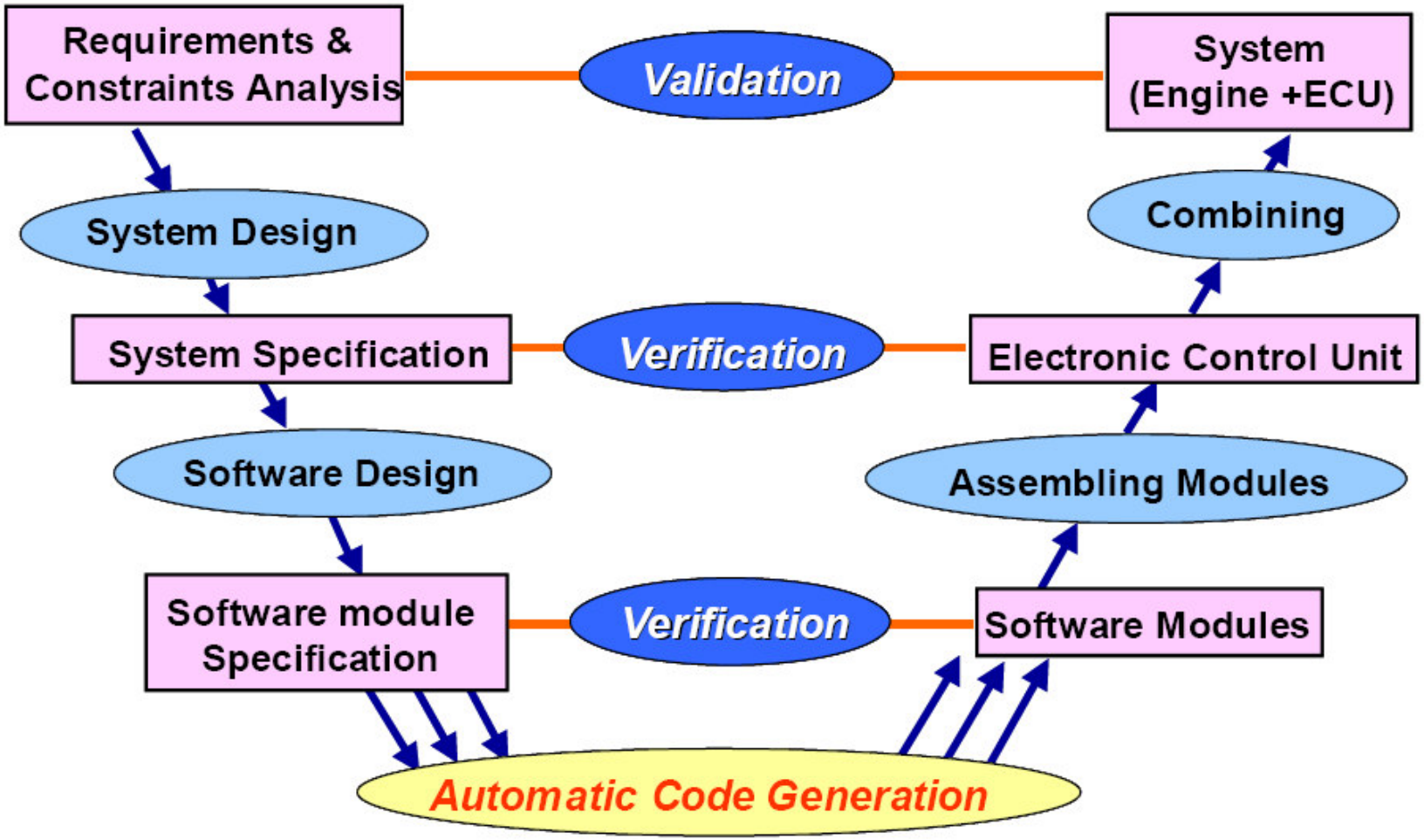
1.Fuel Pump
2.Fuel Pump Register
3.Crank Angle Sensor
4.Cam Angle Sensor
5.Air Cleaner
6.Intake Air Temp.Sensor
7.Air Flow Meter
8.Water TempSensor
9.32bit ECU
(Electronic Control Unit)
10.Accelerator Pedal Position Sensor
11.Throttle Position Sensor
12.Throttle Controller
13.Injector
14.Knock Sensor
15.Electronic Ignition
16.Oil Control Valve
(for VVT-i Control)
17.VSV
(for EVAP. Purge Control)
18.Rotary Solenoid Valve
(for Acoustic Control Induction System)
19.A/F Sensor
20.Three-way Catalytic Converter
21.Oxygen Sensor

22. Three-way Catalytic Converter 23.Charcoal Canister 24. EDU(Electric Driver Unit)
25.SCV(Swirl Control Valve) 26.Fuel Pressure Sensor 27.High Pressure Fuel Pump

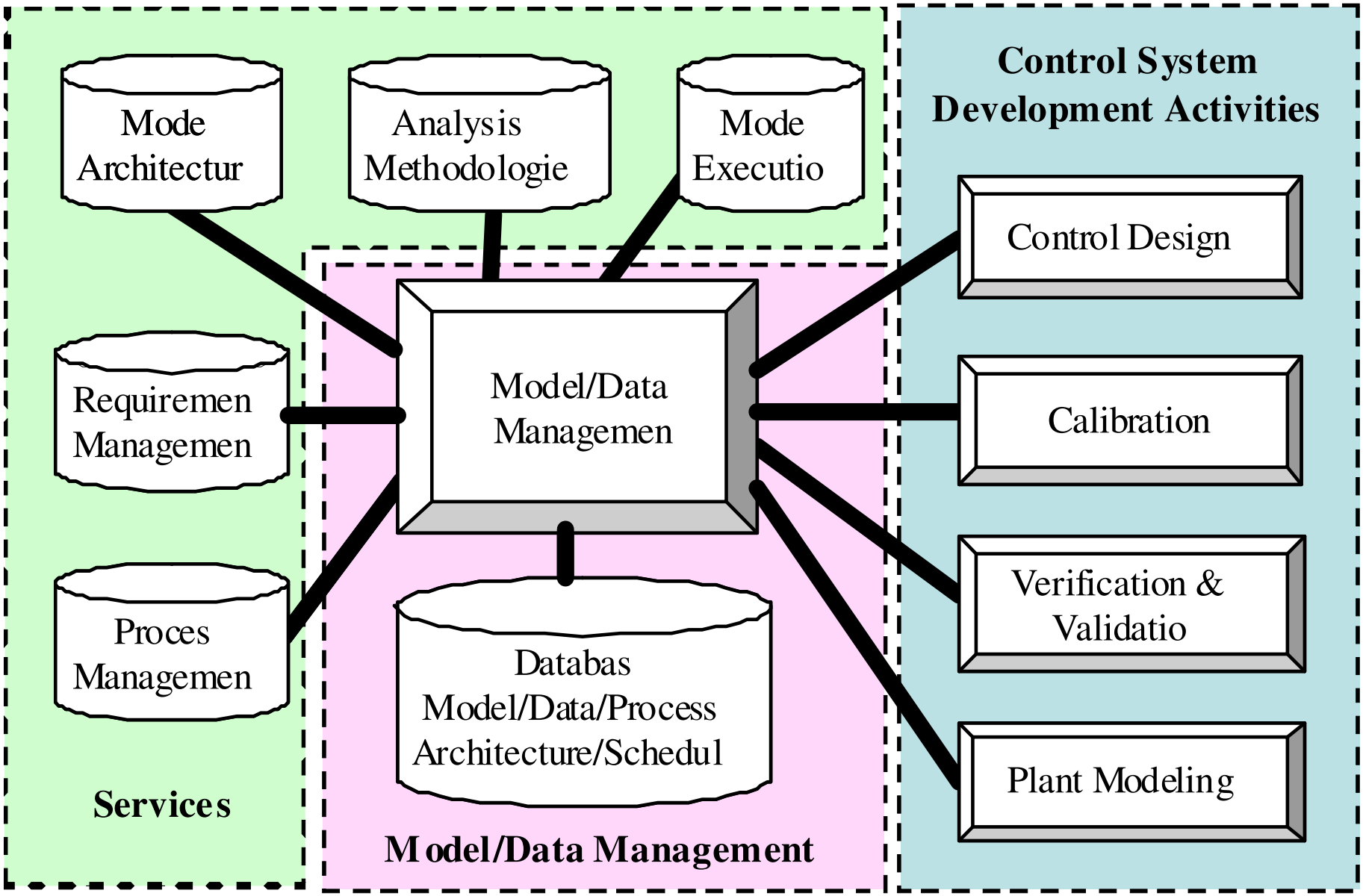
Engine Controller Complexity



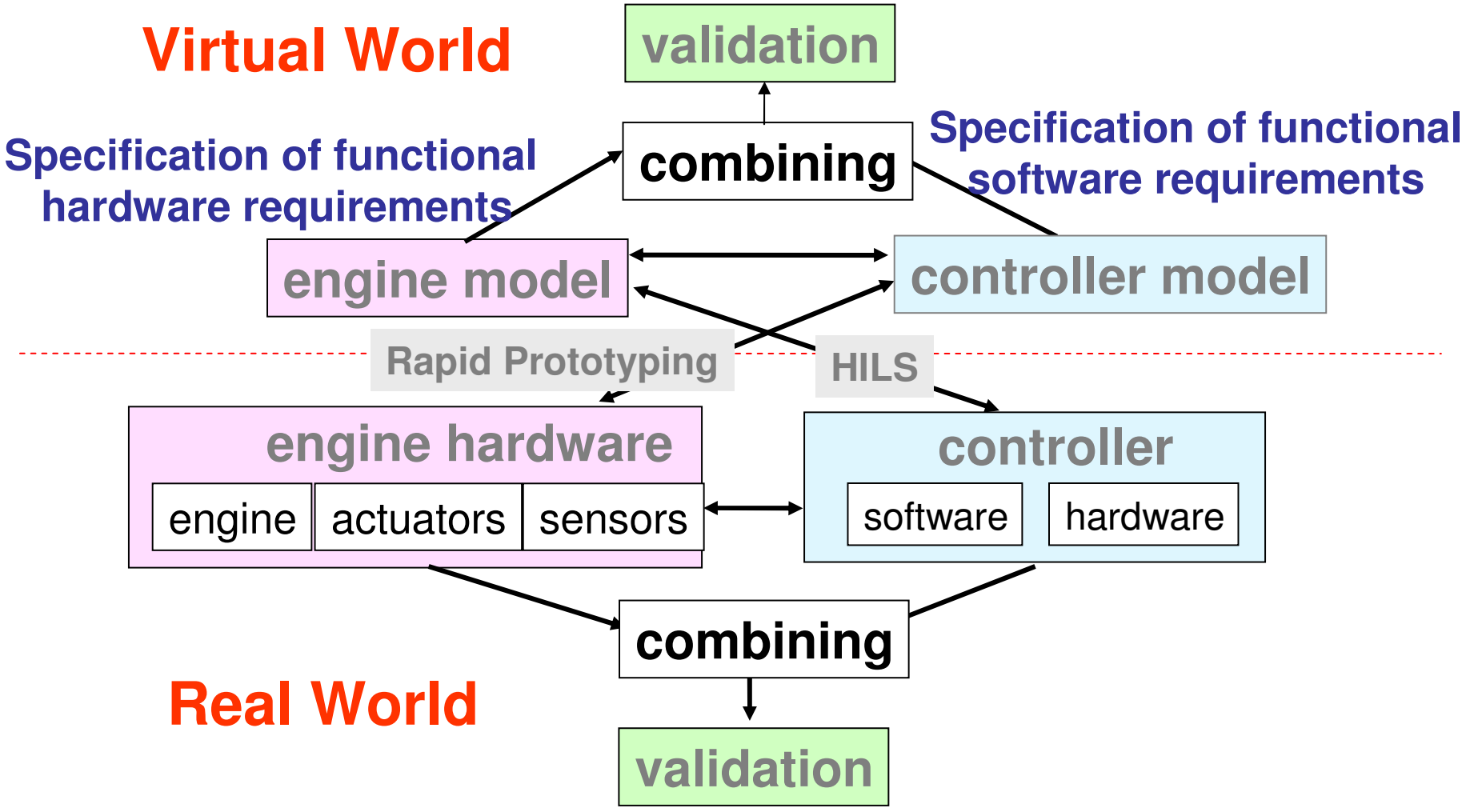
Process View – Traditional 'Systems V'



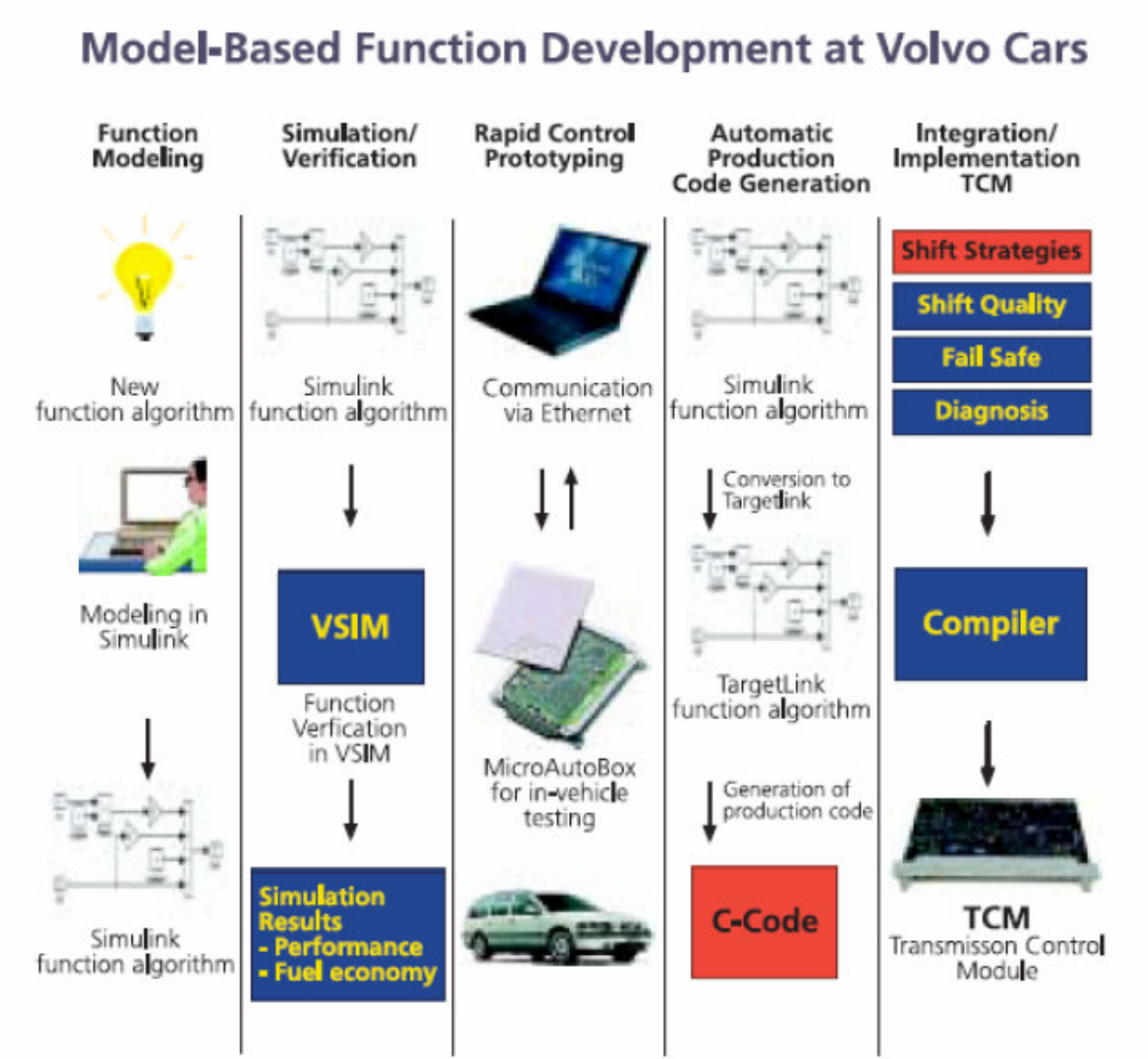
Complexity Mitigation – Process and Information Management



Complexity Mitigation – Model-based Development



Complexity Mitigation – Model-based Development

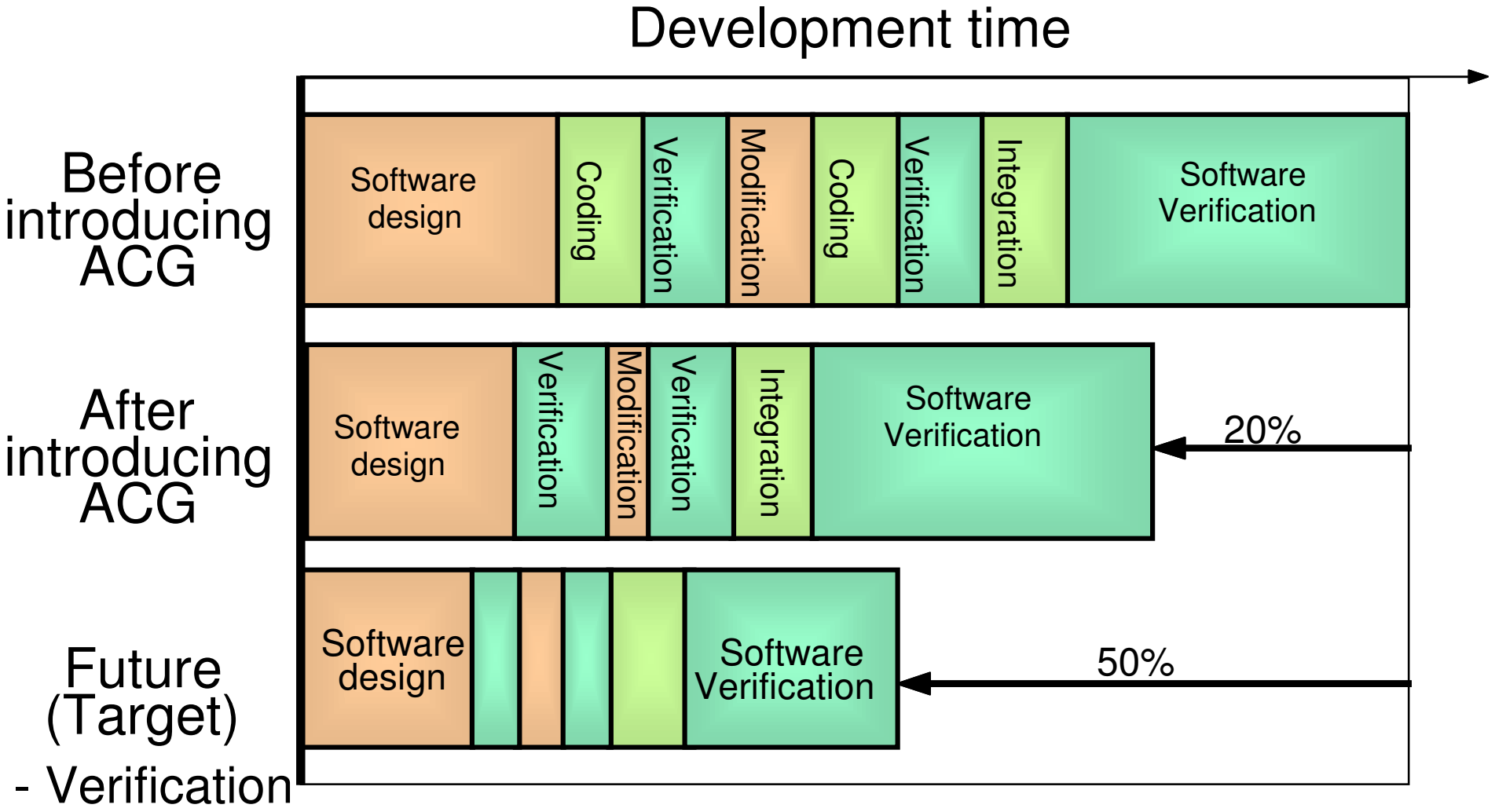


Goal:
Use models for

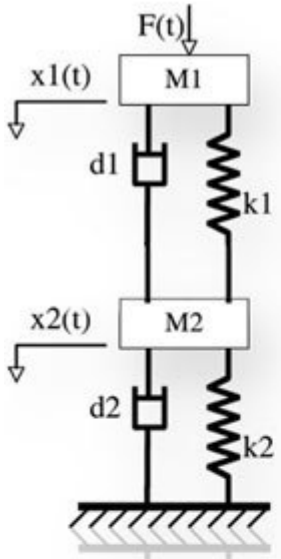
- requirements
- design
- verification
- test case generation
- modification
- documentation
- code generation
- run-time monitoring
- etc.

dSpace News, Jan. 02

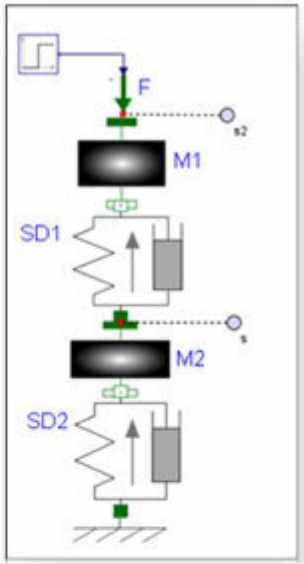
Complexity Mitigation – Automatic Code Generation (ACG)



Complexity Mitigation – Plant Modeling Productivity



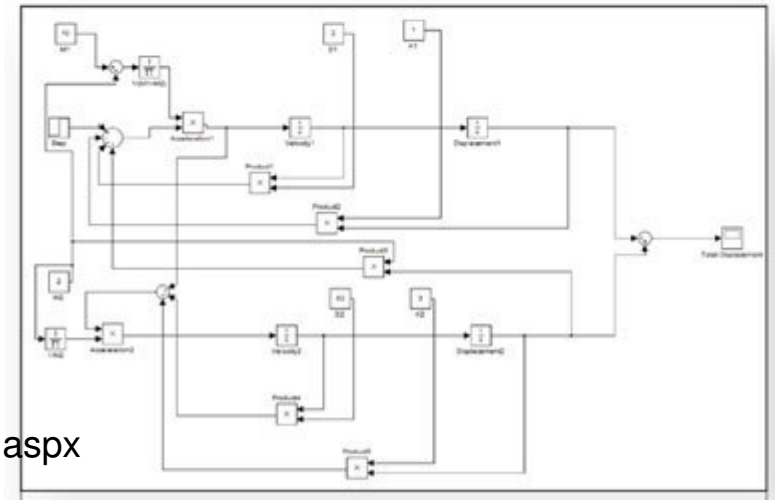
System diagram



MapleSim model

Acausal, component based modeling*

- Model diagrams map directly to the physical system
- Multi-domain modeling
- Symbolic system equations are generated automatically
- Multiple stages of symbolic model optimization

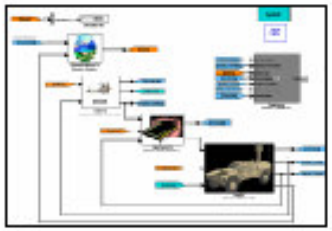

Traditional model

*http://www.maplesoft.com/products/maplesim/advantage.aspx

Complexity Management – Architecture Driven Rapid Modeling

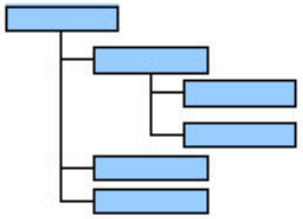
www.emmeskay.com

Architecture Description Language

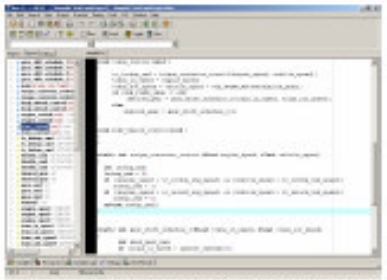


Simulink: Powertrain (MoVE) Architecture – Plant and Controls

Dymola: Vehicle Modeling Architecture (VMA) – Plant and Controls



PowerPoint: Systems Level specification of Architecture – Plant and Controls



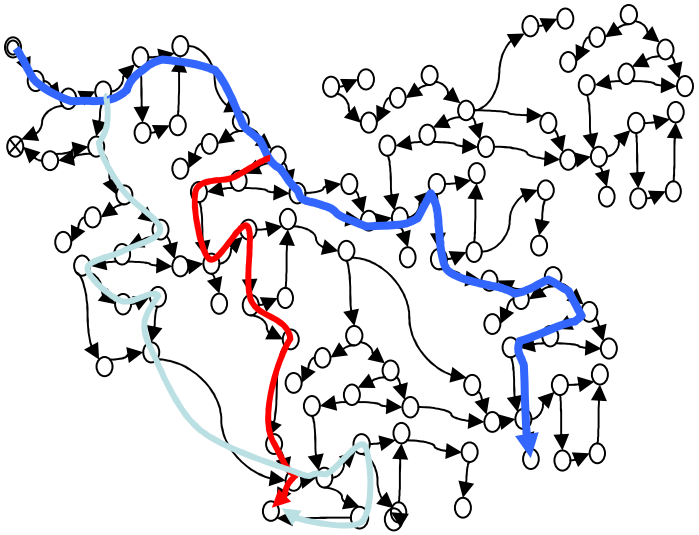
C Code: Legacy Controls Code

- Many possibilities for describing an architecture
  - AADL (Architecture Analysis and Design Language) - SAE standard
  - SysML – An OMG initiative
  - Modelica – A subset of Modelica could potentially be extended for this purpose
  - VHDL-AMS – A subset of VHDL-AMS could be potentially extended for this purpose
  - SADL (System ADL)
    - An immediate set of constructs that is being developed/used by Emmeskay for its tool IME
    - Will potentially be reconciled with one or more of the standard languages in the future

Models and Architectures in Other Tools, Domains, Lanuages (e.g. VHDL-AMS)

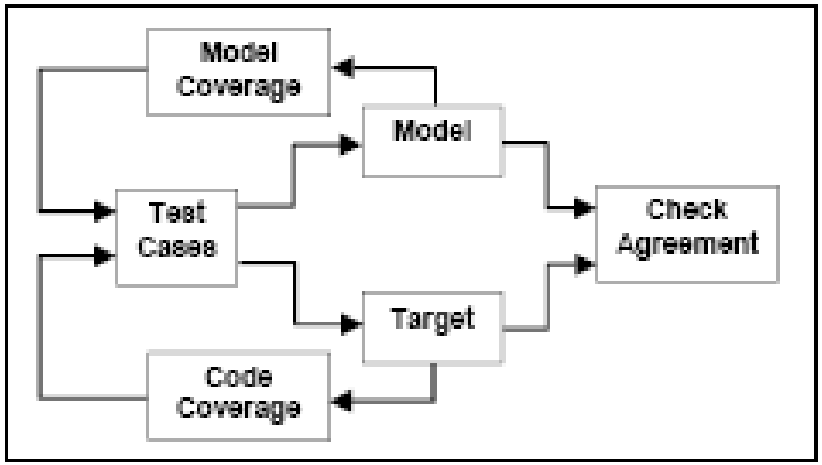
EMMESKAY, INC.
Advanced Technology Solutions

Complexity Mitigation – Verification and Validation



Automated test case generation
(path (model or code) structural coverage)

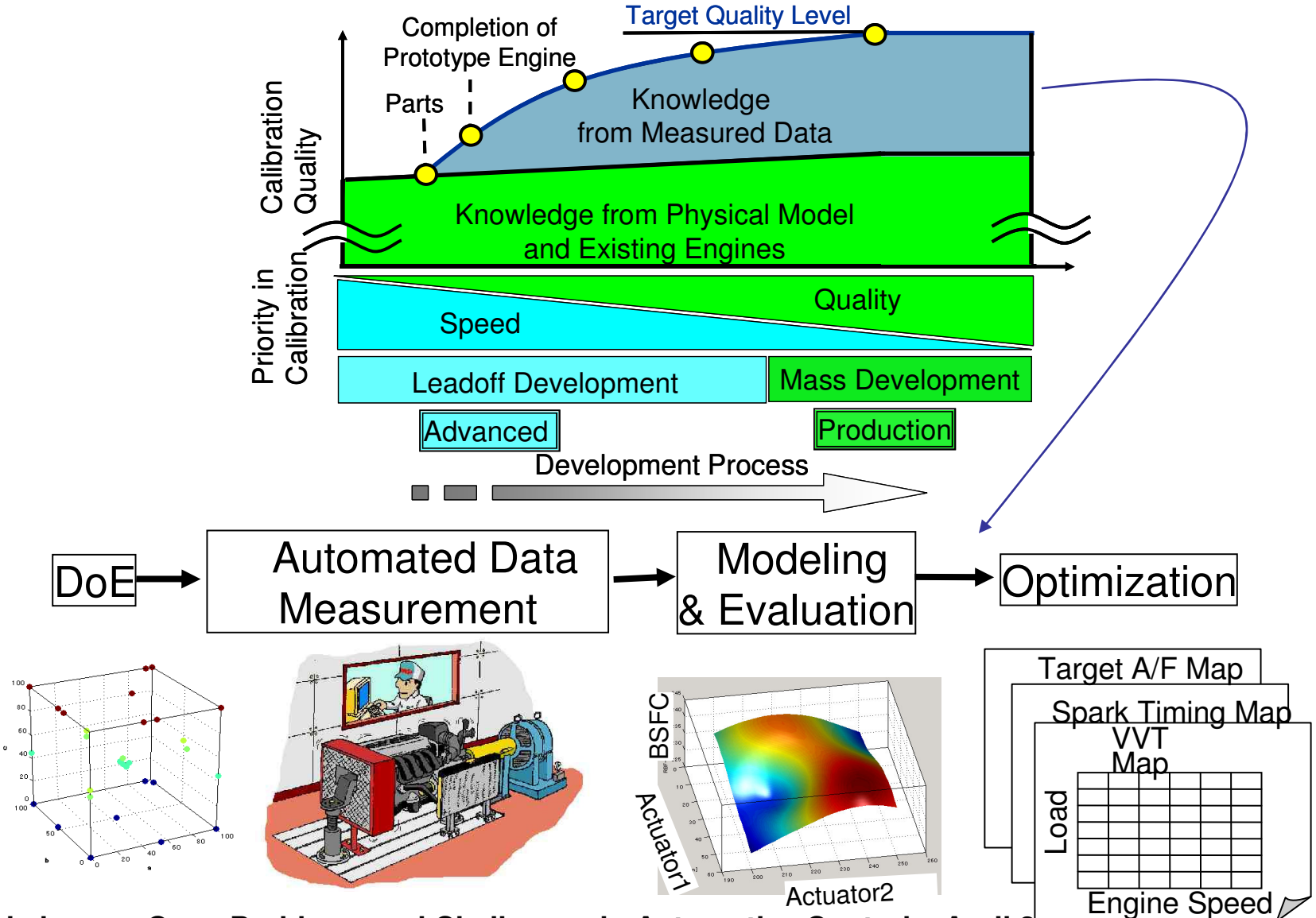
- **Style / Rules compliance checking**
- **Defect pattern detection**
- **Property checking**
- **Sensitivity / robustness evaluation**
- **Dependency analysis**
- **Model / code slicing**



Model / Code equivalence checking*

* Coverage Analysis for Model Based Design Tools, William Aldrich, The MathWorks, Inc.

Complexity Mitigation – Model-based Calibration

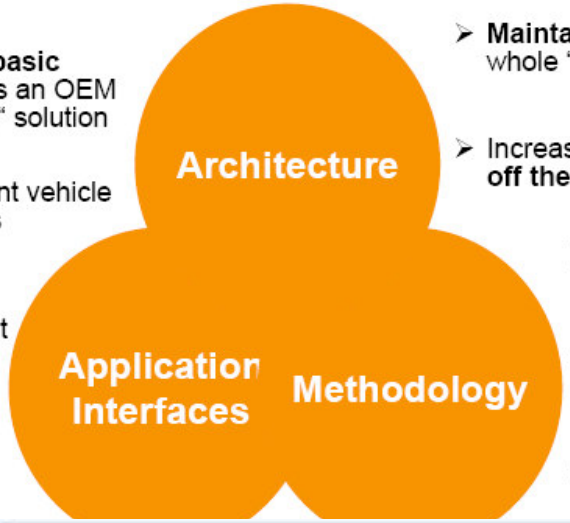


Complexity Mitigation
- AUTOSAR ECU standards*

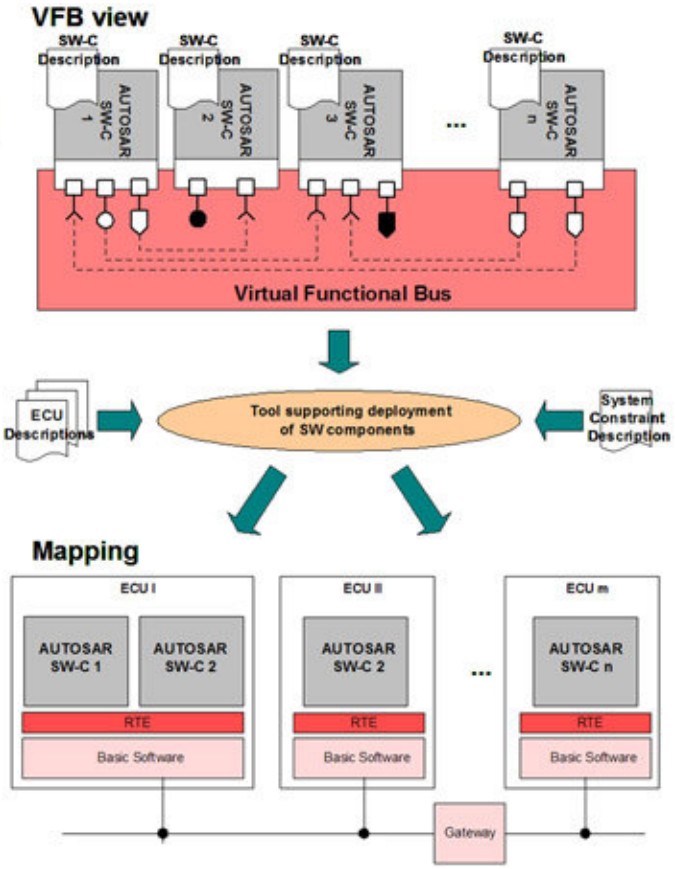
AUTOSAR

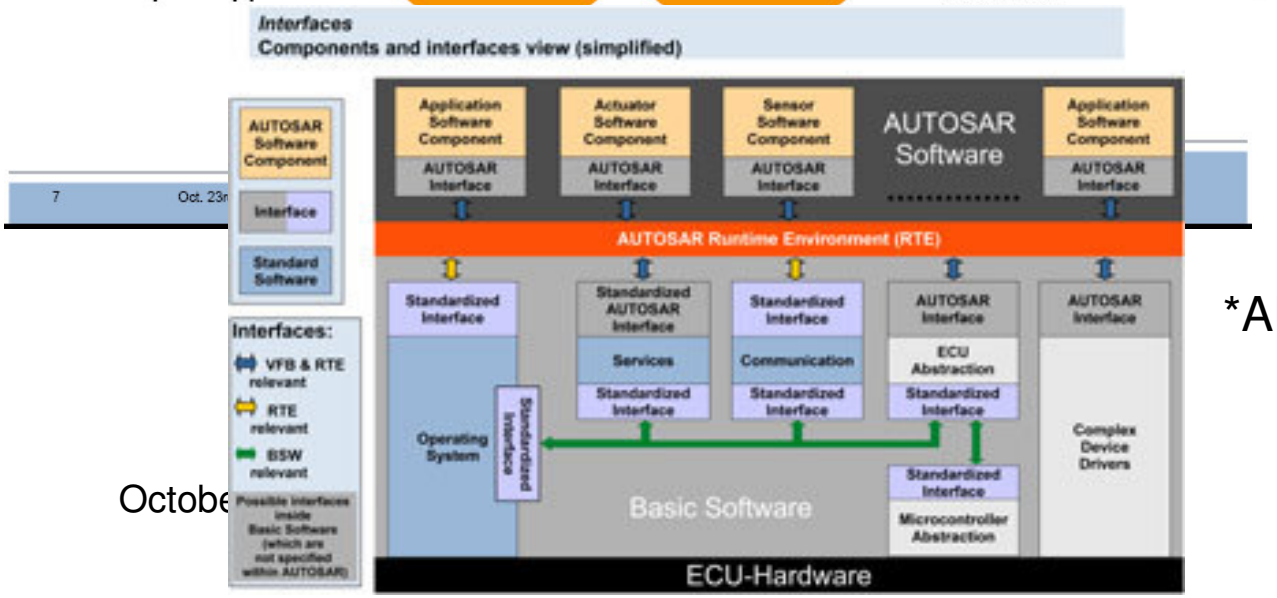
AUTOSAR
Project Objectives and Main Working Topics

- Implementation and **standardization of basic system functions** as an OEM wide "Standard Core" solution
- **Scalability** to different vehicle and platform variants
- **Transferability of functions** throughout network
- **Integration** of functional modules from **multiple suppliers**



- **Maintainability** throughout the whole "Product Life Cycle"
- Increased use of **"Commercial off the shelf hardware"**
- **Software updates** and upgrades over vehicle lifetime
- Consideration of availability and **safety** requirements
- **Redundancy** activation

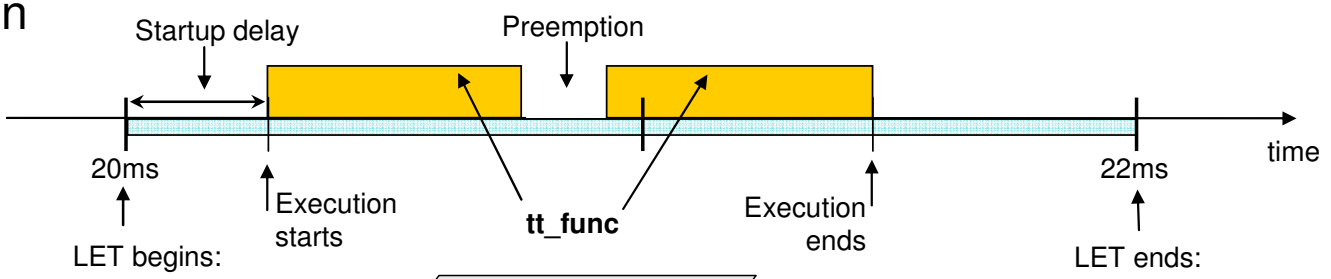


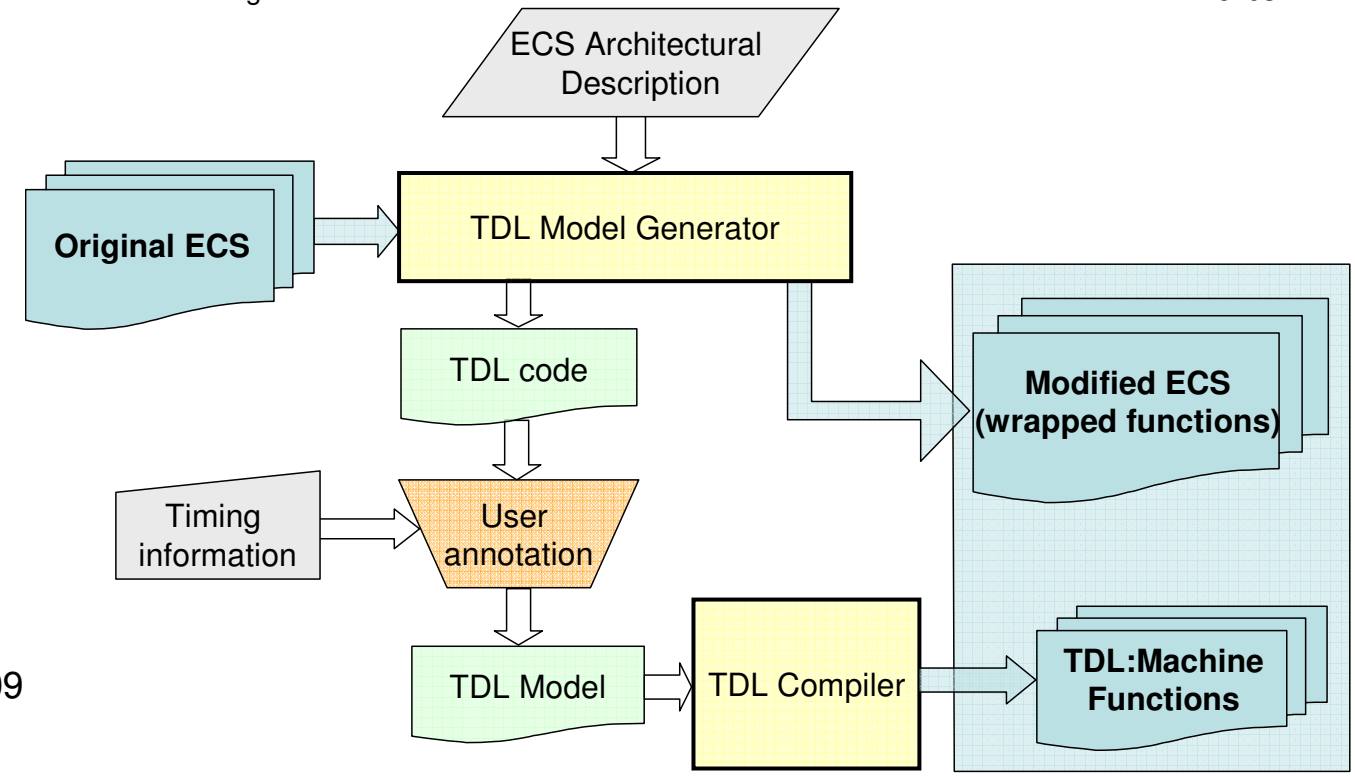


*AUTOSAR Tutorial, Oct. 2008

Complexity Mitigation
Robust real-time software architecture

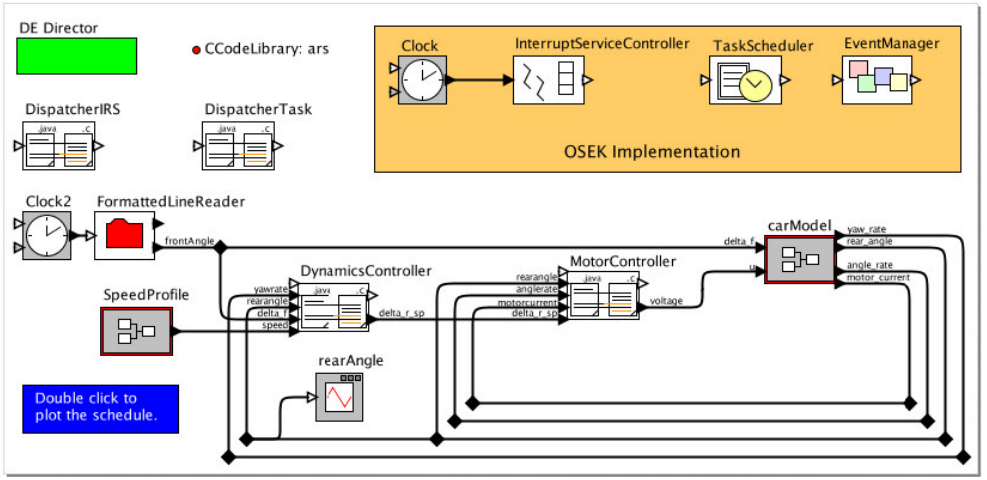
- Timing Definition Language (TDL) --> Robust real-time software behavior regarding:
  - Implementation architecture
  - Function reordering / redesign / addition / subtraction
  - Pre-emption

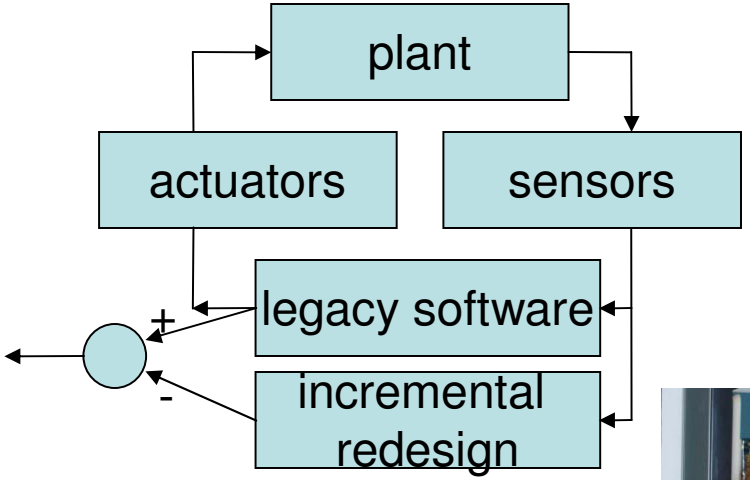


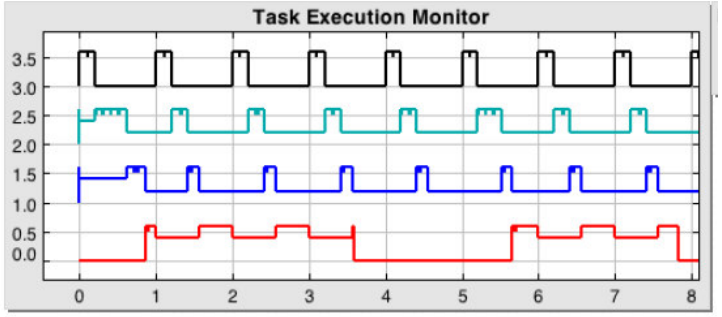


Complexity Mitigation
Code-based Legacy -- > Model-based Development

- Innovative Software Simulator to bring modeling and simulation capabilities to legacy design environments (CHESS)
  - Incremental model-based development
  - Mixed code and model components → system level analysis
  - Real-time software behaviors: Software execution time
    - latency, jitter, schedulability
    - pre-emption
  - ECU platform services model



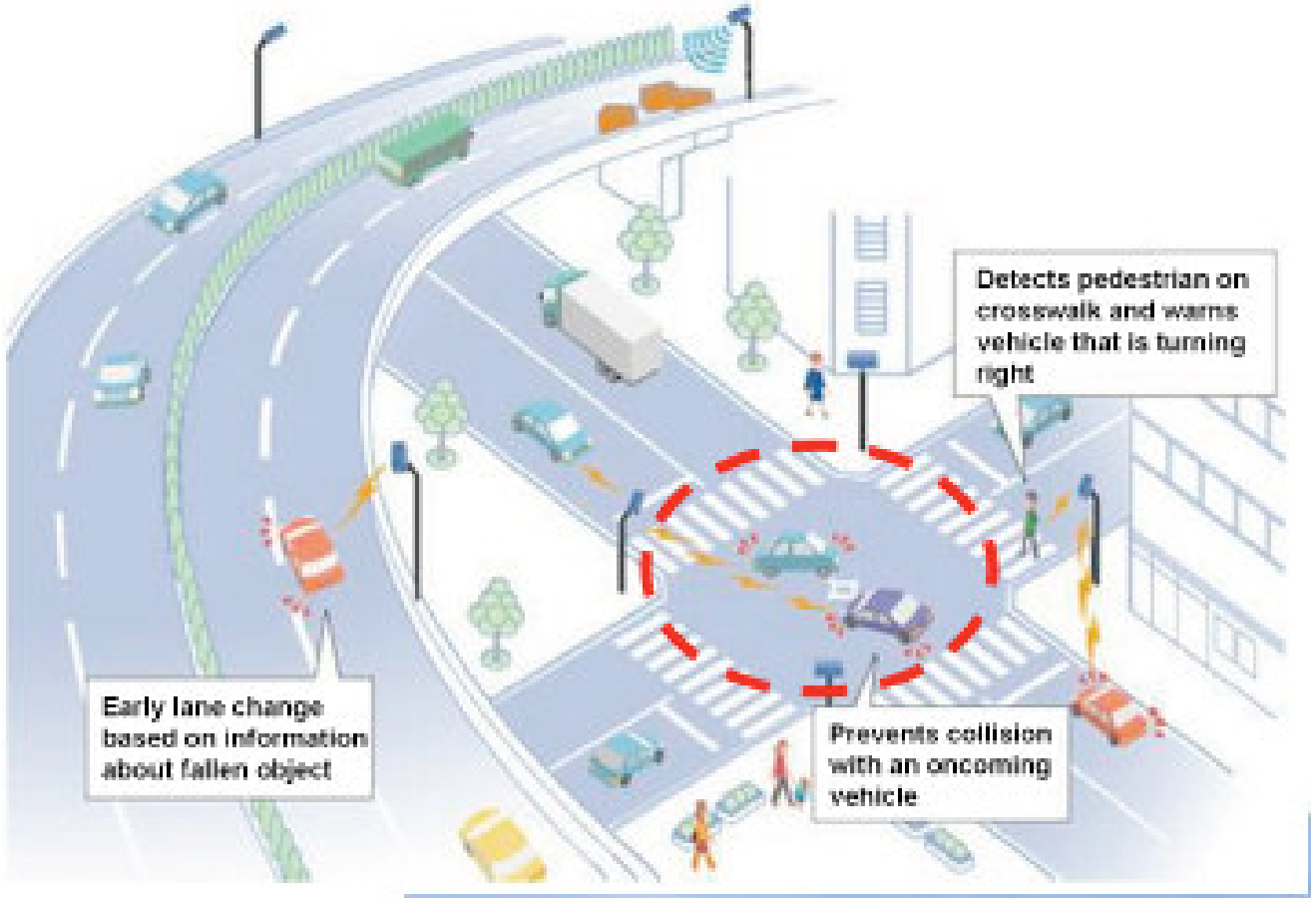




+ Daniel …

Methods Gap - Cyber-physical systems (e.g. collision avoidance)

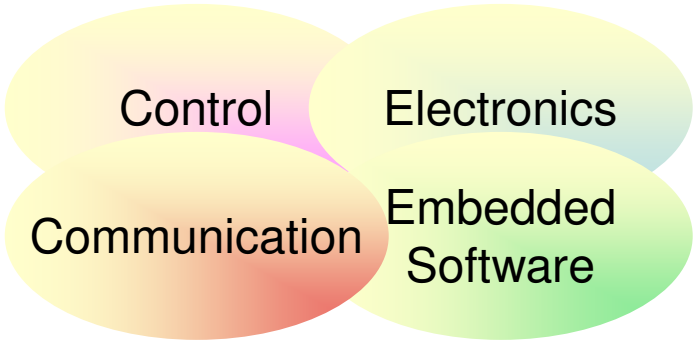
- Heterogeneous modeling – hybrid dynamics, wireless networking, dynamic agent scenarios
- Abstractions and refinements for synthesis and analysis – hierarchical systems structures
- Component composability and consistency – systems integration, rapid development
- Verification (within and across) design and implementation



Take-aways

- Automotive industry is considering people, society, sustainable mobility, and infrastructure
- Automotive industry is increasingly exciting and dynamic due to Control, Electronics, Communication, and Embedded Software
- Cyber-physical systems are of great interest to society: Europe, Japan, U.S.
  - Aerospace
  - Light rail
  - Automotive
  - Smart grid
  - Biological and Medical systems
  - Process and Manufacturing
  - Environmental management ….

Ken Butts' view:
October 15, 2009



→ ***What a great time to be an engineer / computer scientist !***

Karl Astrom's view:
Impact of Control, October 19, 2009