Vehicle Dynamics and Simulation

Introduction

Modelling and Simulation

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TTC066 Overview

- Modelling and Simulation
  - Differential Equations
  - Numerical Integration
  - Linearity and State Space
- Ride Dynamics
- Eigenvalues and Eigenvectors
- Drivetrain Dynamics (MB)

Computer Based Test (40%)

- Engine Modelling
- Drivetrain Modelling
- Parameter Tuning
- Vehicle and Engine Testing
- MIRA preparation and experimentation

MIRA Coursework (60%)

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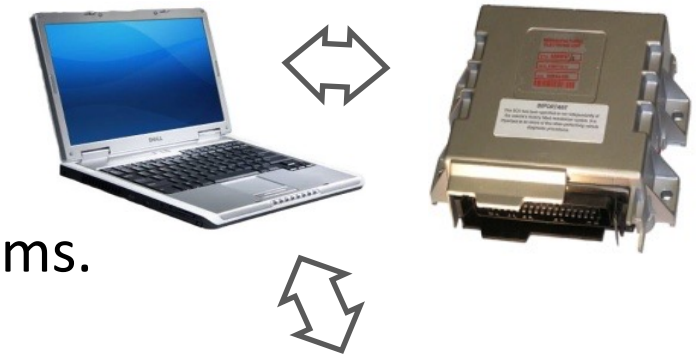
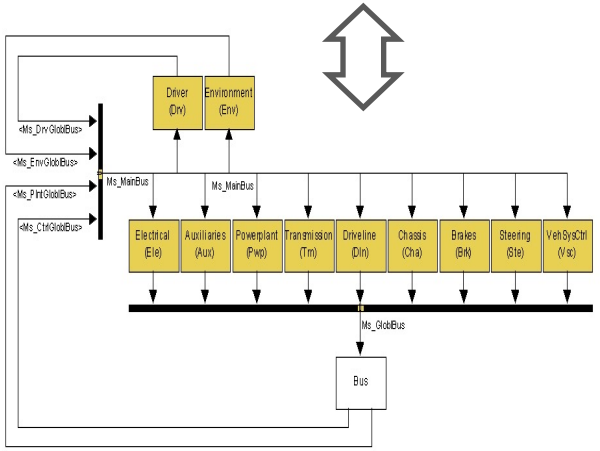
Overview

- Model based development for vehicle systems.
  - What is it?
  - How it is used for vehicle development.
- SiL, HiL & RCP
  - The various steps of the ‘controller’ development
- Real time simulation
- Concluding remarks





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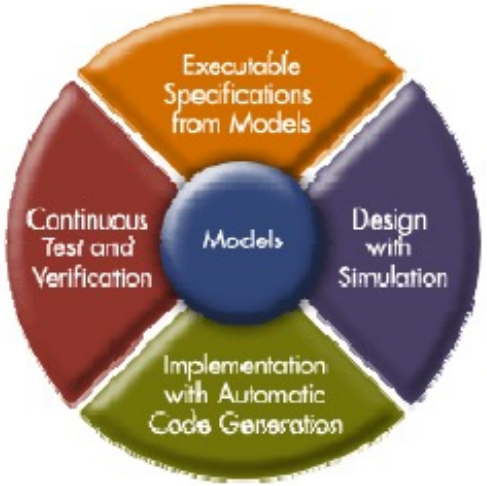
Definitions

- Simulation based design/development
  - Covers all use of dynamic (time varying) models for hardware and software development/optimisation/testing.
- Plant & controller
  - Plant = controlled hardware
  - Controller = control (embedded) hardware + control algorithm.



Features of SBD

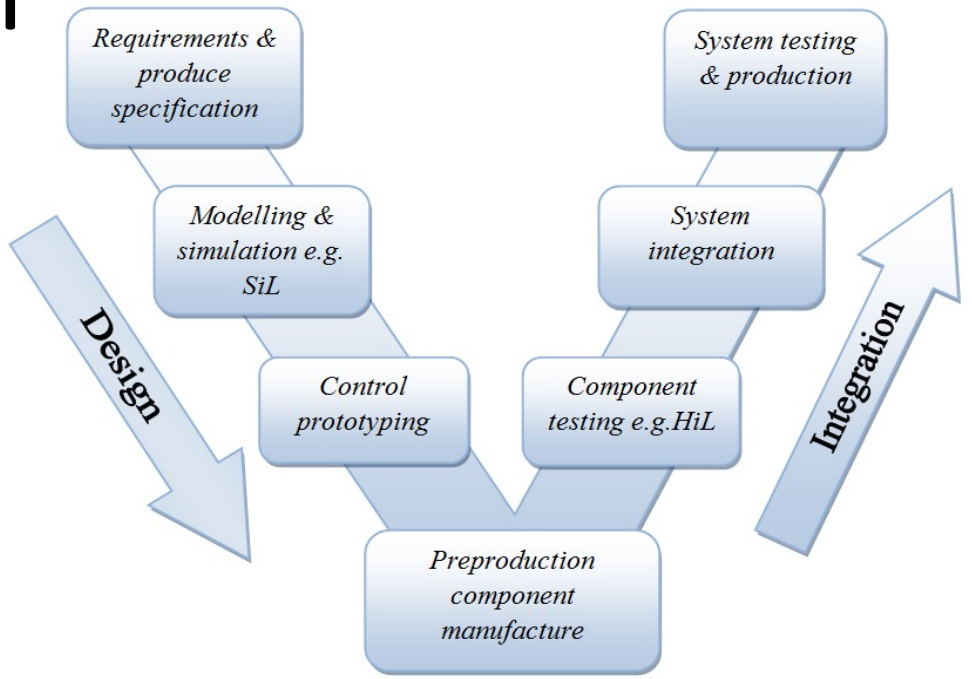
- Dynamic model employed for defining engineering specifications (executable – it can be run), design, simulation (early prototyping), prototype development, integration, etc
- Model forms the engineering specification.
  - More specific/descriptive
  - Engineers can interact with the model
  - Model can be used for testing
- Model is refined/improved as the process is undertaken.

Why use SBD?

- Optimise design
  - Reduce weight
  - Improve controller
  - Minimise emissions / weight / energy use
- Comprehensive testing before production
  - Greater test coverage
- Evaluate concepts
- Reduce time to market & costs associated with development.

Simulation based design

- A model serves as the definition of the system.
- Real time simulation techniques are used SiL/HiL/CiL.
- More hardware is included ‘in Loop’ as further fidelity increase is required/for integration.



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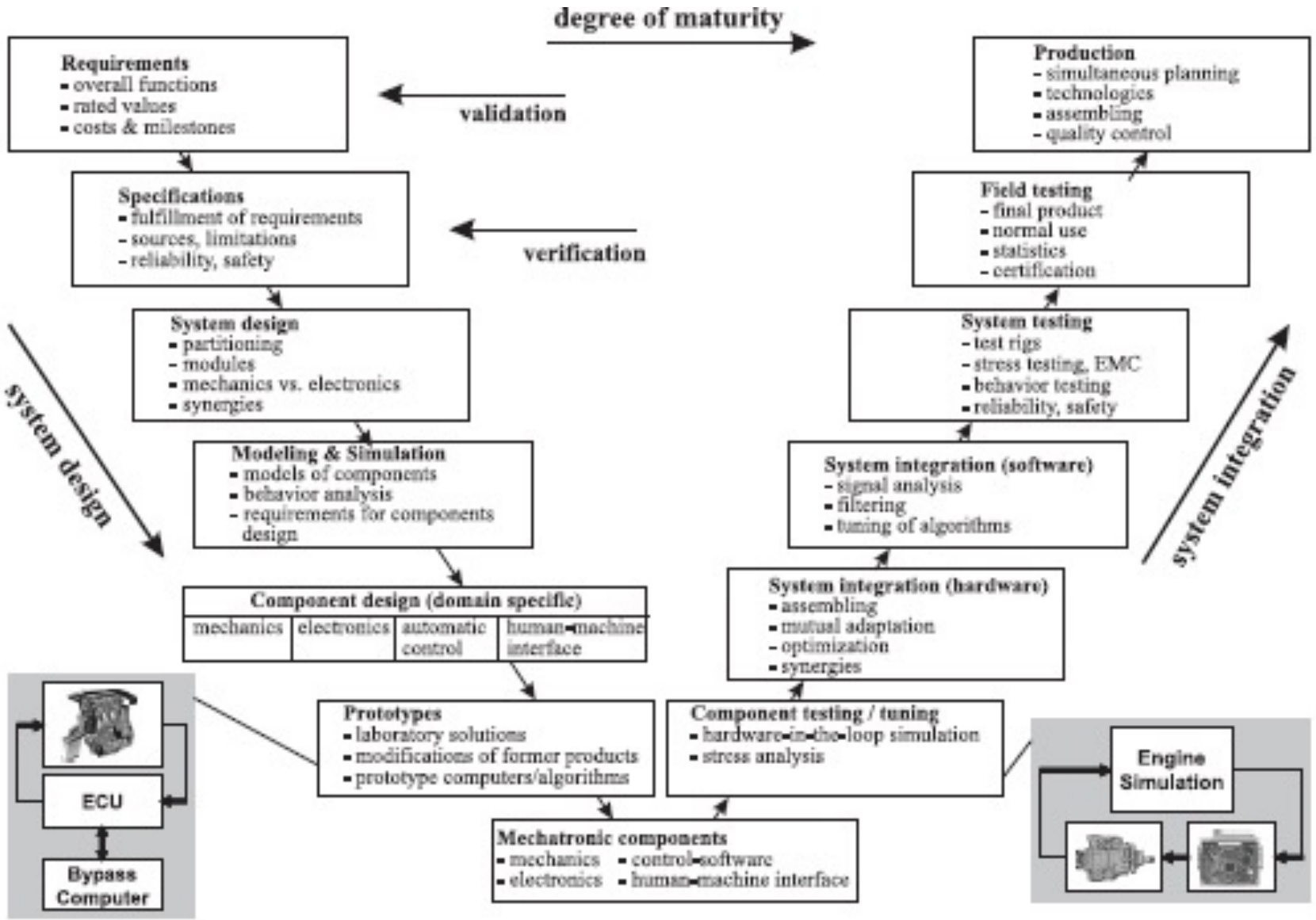
Design process



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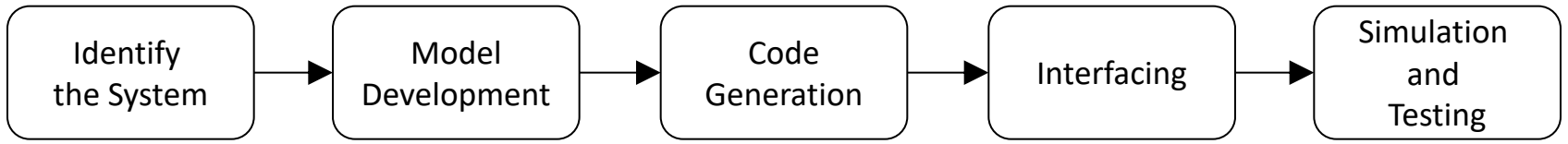
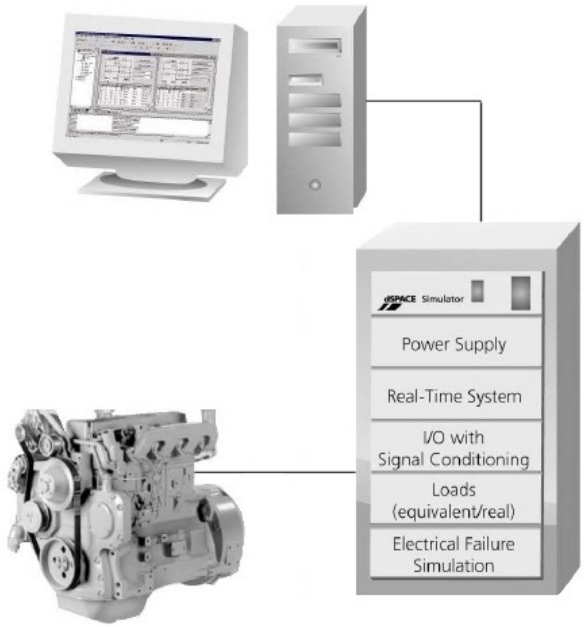
Real time Simulation for Controls Development



- Purpose of study/selection of hardware.
- Realtime models cycle time typically 1 msec consider overruns and queuing.
- Real Time Workshop generates C-code for the realtime platform.
- Model-hardware interaction i.e. delays in data exchange.
- Interface using breakout box or other connector.



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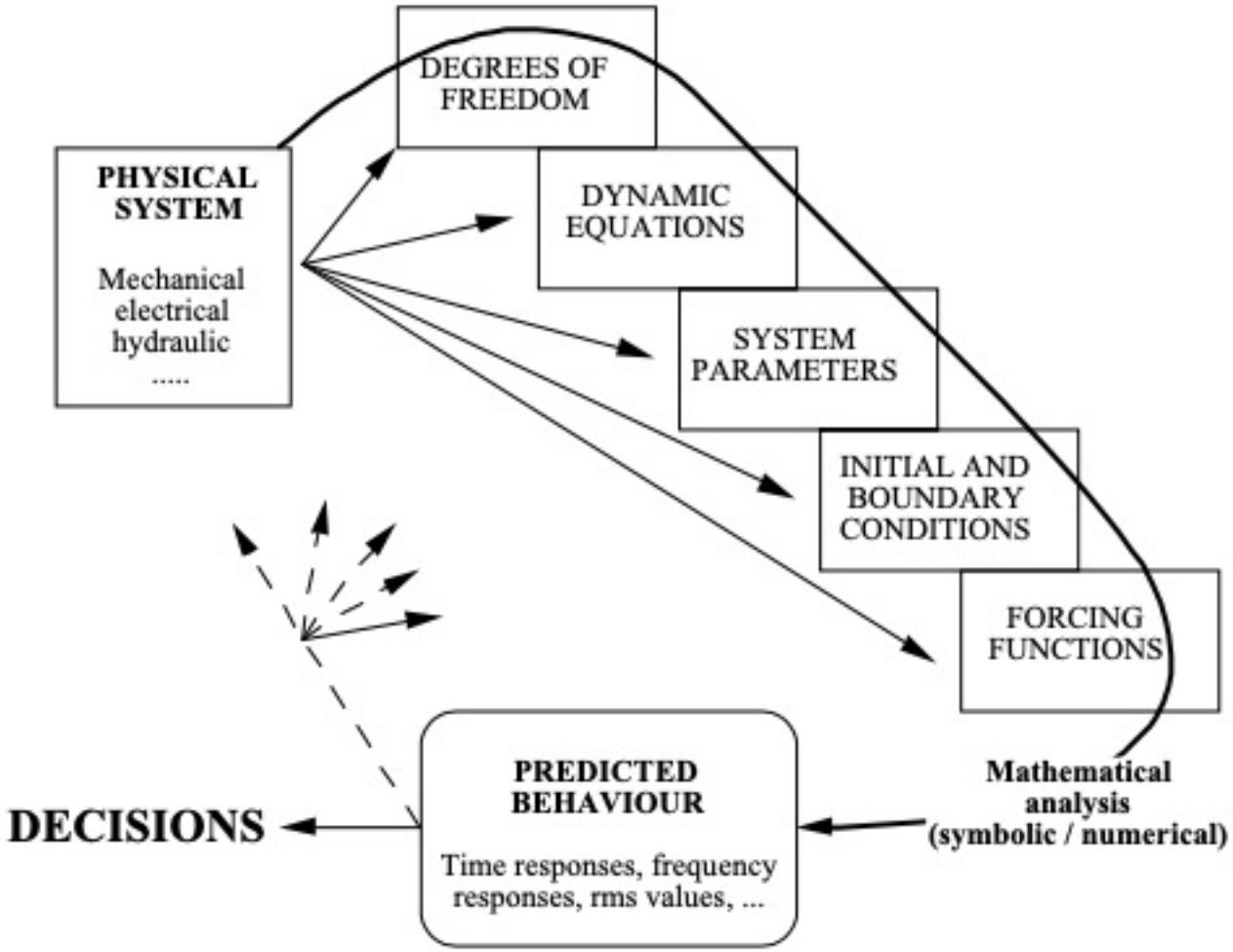
System Modelling



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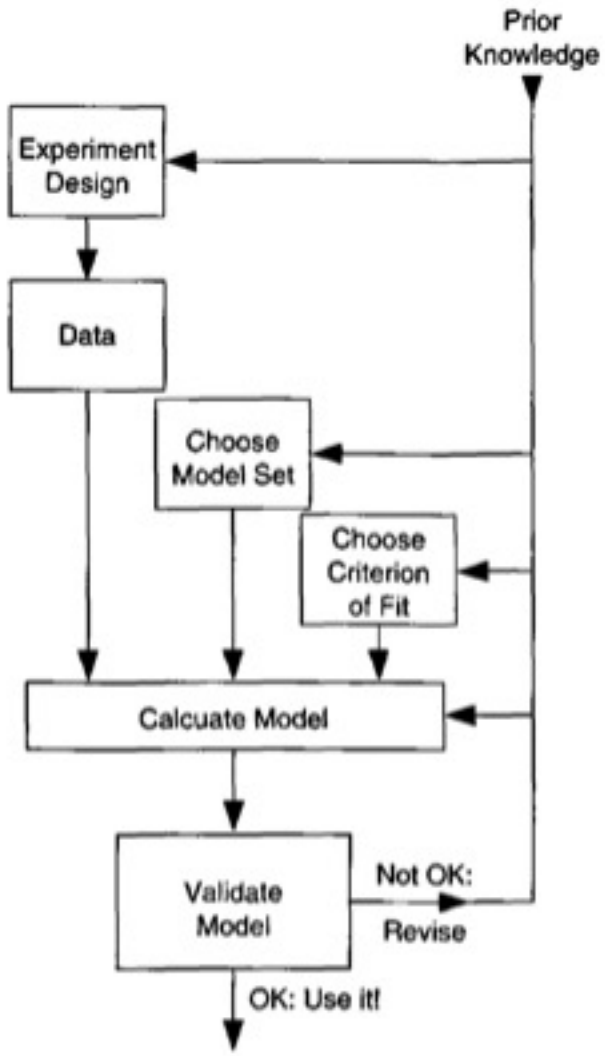
Source: Ljung, System Identification

System Identification

- System identification is the process by which a system is described in terms of equations
- Empirical models – make use of test data.
- Physical models – make use of prior system knowledge and established physics
- Both require some prior knowledge to determine the model mathematical structure and parameters



Concluding Remarks

- Realtime simulation one second simulation = one second reality. Hardware/user/environment interaction.
- Automotive realtime use increasing, controls development (ECU), component testing, pre-calibration/calibration, failure testing.
- Reduced time to market and development costs. Increased inter design group interaction at early stages. Testing prior/parallel to full prototype development.