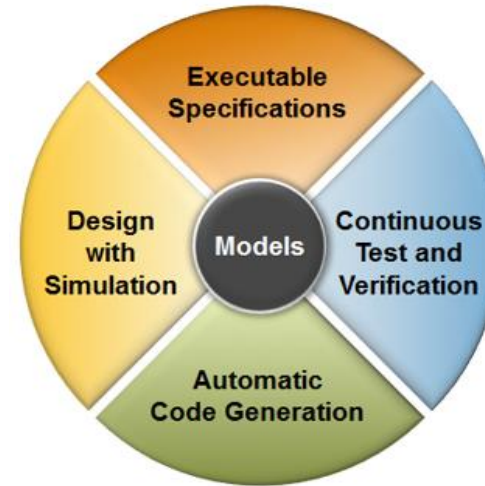


Physical Modeling as Enabler for Simulation-Based Design

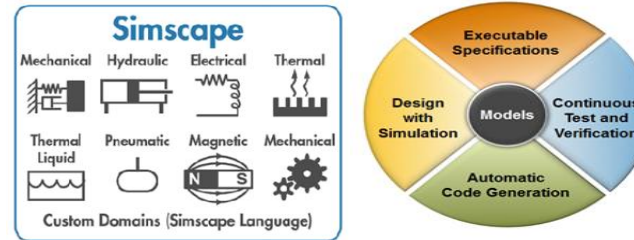
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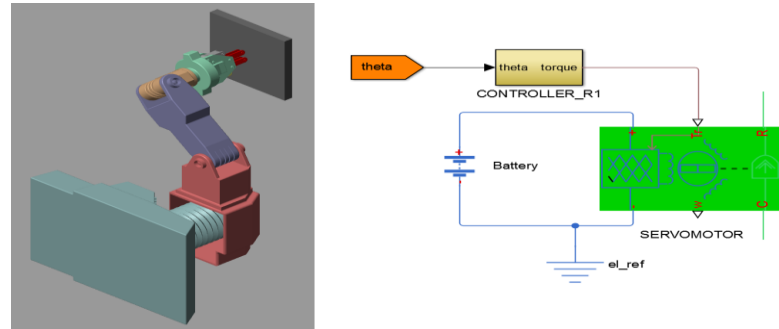
April 21st 2016 – Waterfront Congress Center (Stockholm)

Agenda

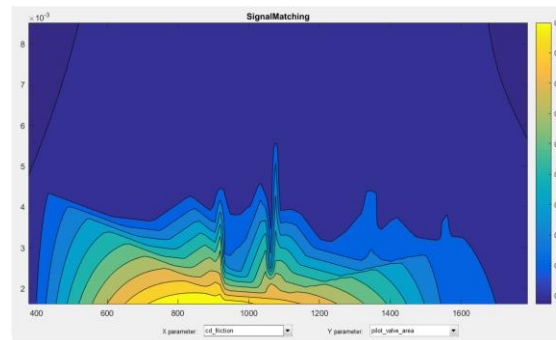
1. Physical modeling (simulation-based design)



2. Mechatronic design workflow

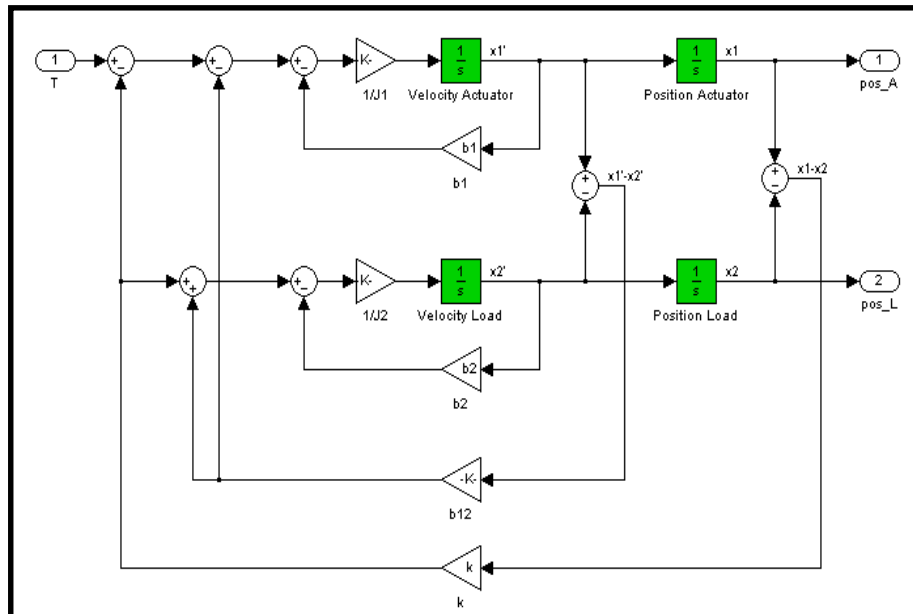


3. Design optimization



4. Conclusions

First Principles Modeling

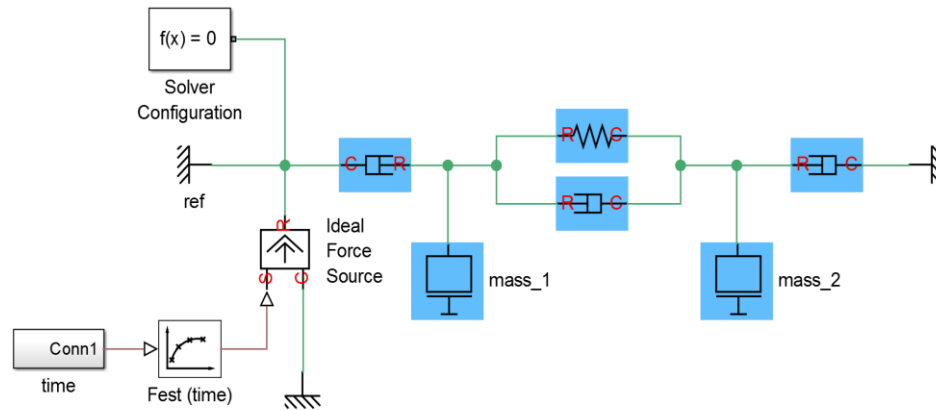


First principles (Simulink)

- ❑ suitable for simple systems
- ❑ common during 90s

Differential algebraic equations
created manually (blocks)

Physical Modeling



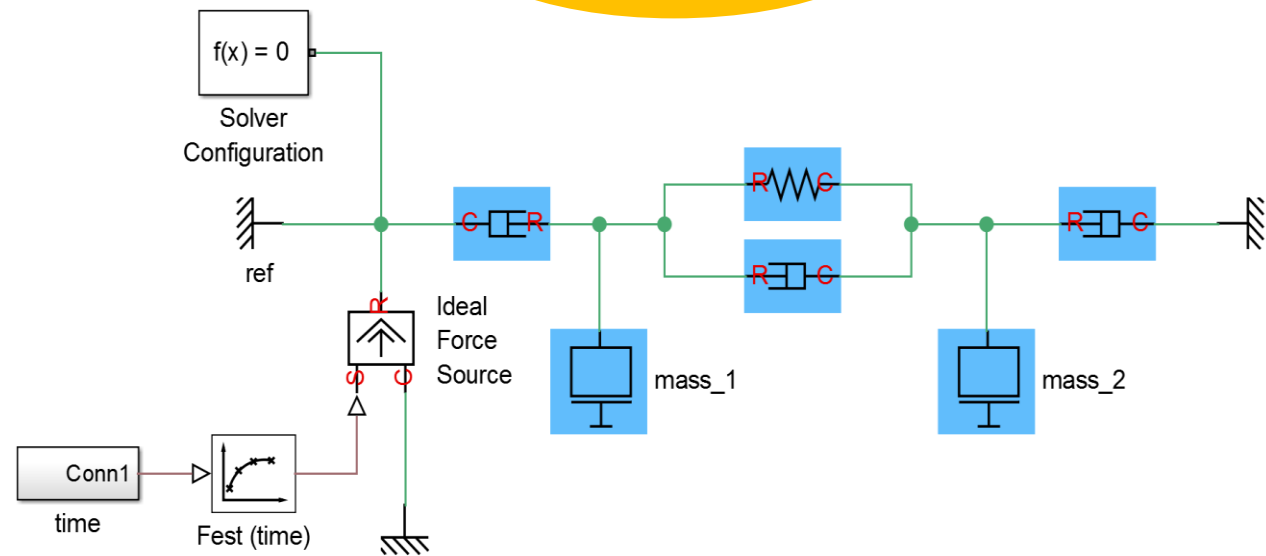
Physical Networks (Simscape)

- complexity & multi-domain
- solver flexibility (testing)
- proven (automotive, aerospace)
- high priority development

**Differential algebraic equations
automatically created (topology)**

Physical Networks (Simscape)

scalability
re-usability



Physical Modeling (requirements)

*system design
(integration, optimization)*

Physical Modeling (requirements)

*system design
(integration, optimization)*

*development of
control algorithms*

Physical Modeling (requirements)

*system design
(integration, optimization)*

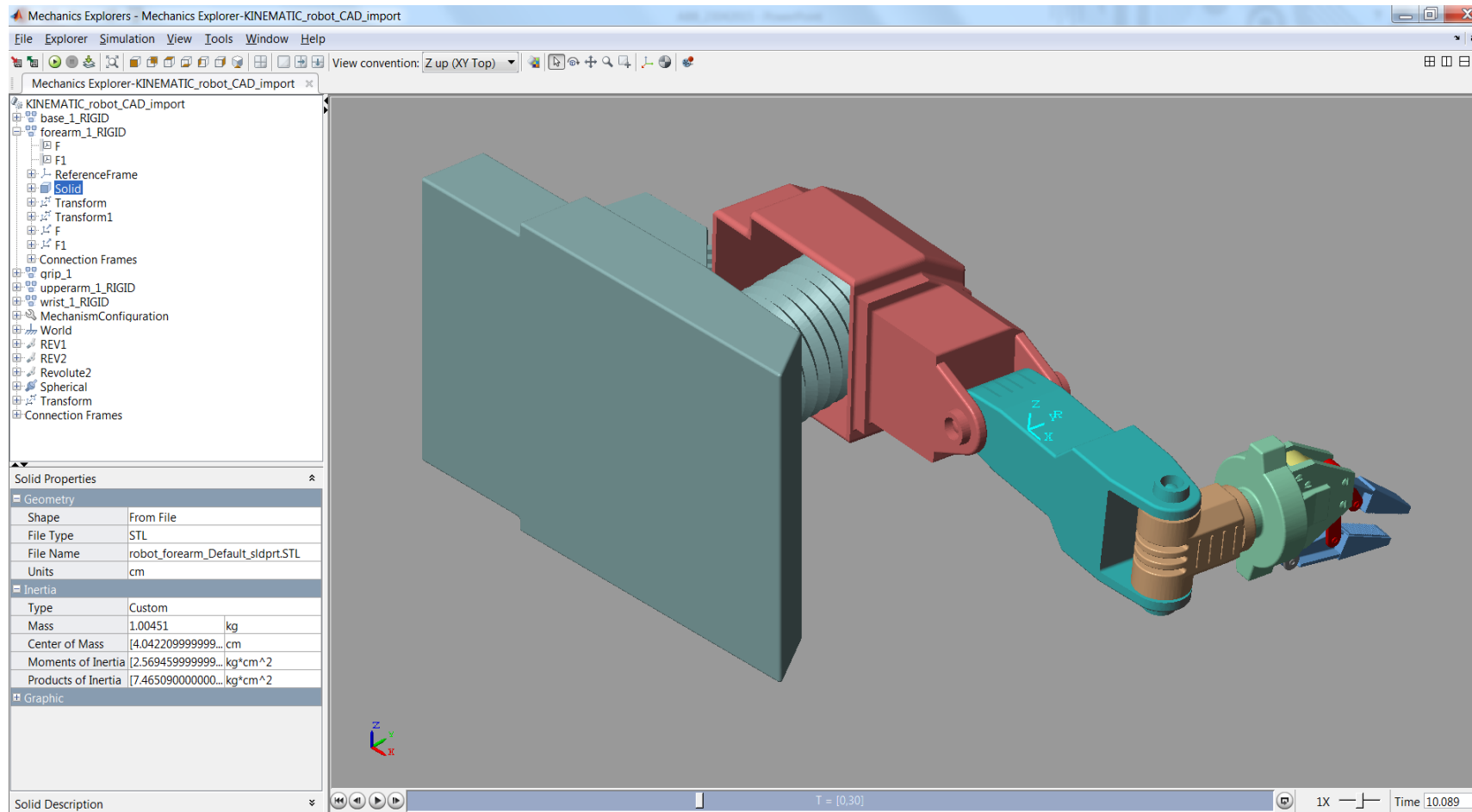
*development of
control algorithms*

*hardware-based
physical emulation
(real-time testing)*

Mechatronic Design (recommended workflow)

Mechatronic design – step 1

1. CAD import => 3D mechanical systems in Simulink



Mechatronic design – step 2

2. Kinematic Analysis

- imposition of a given kinematic movement (duty cycle)
- evaluation of required torque/forces

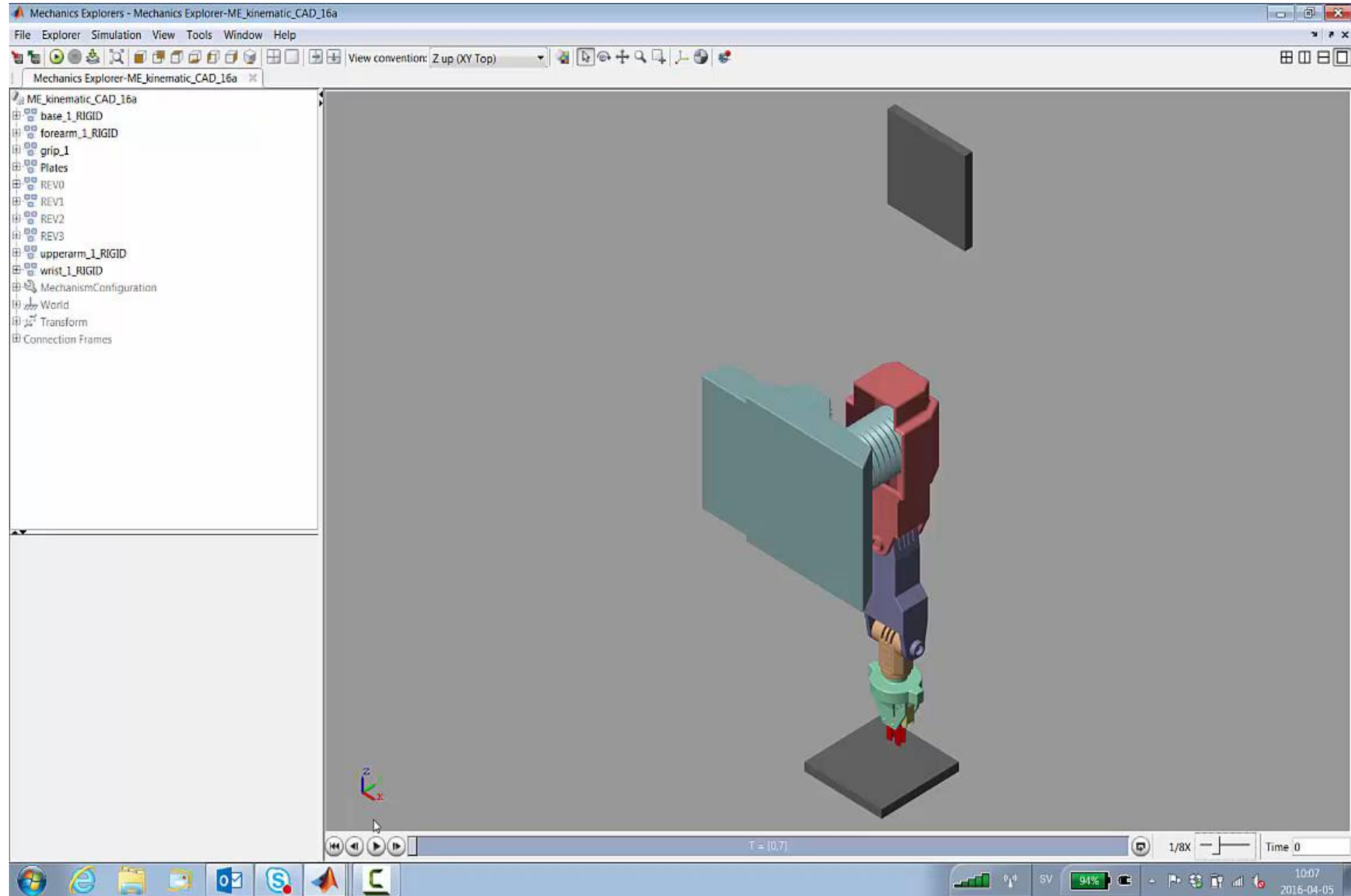
Mechatronic design – step 3



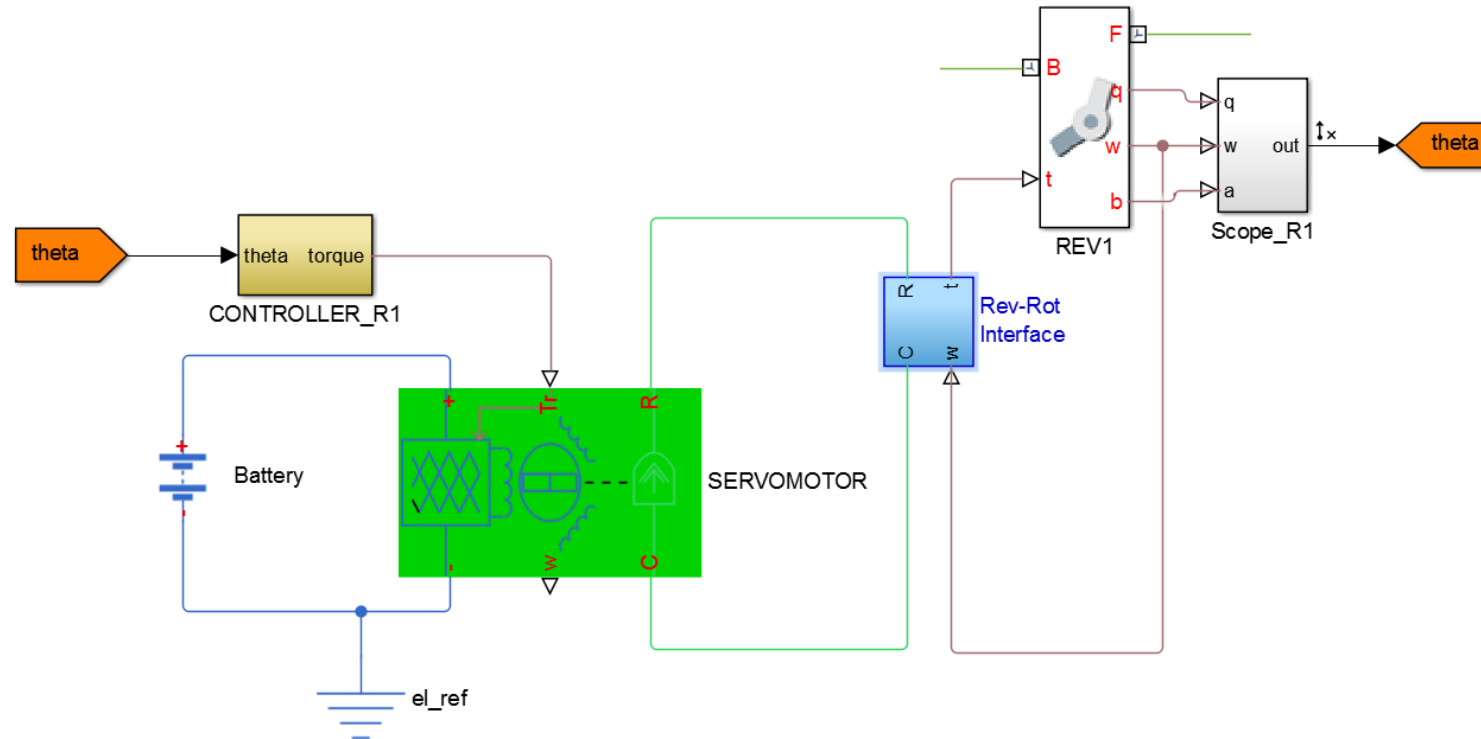
demo

3. Dynamic Analysis

- closed-loop motion control
- application of torque and/or force
- control design (tuning, stability)



Mechatronic design – step 4

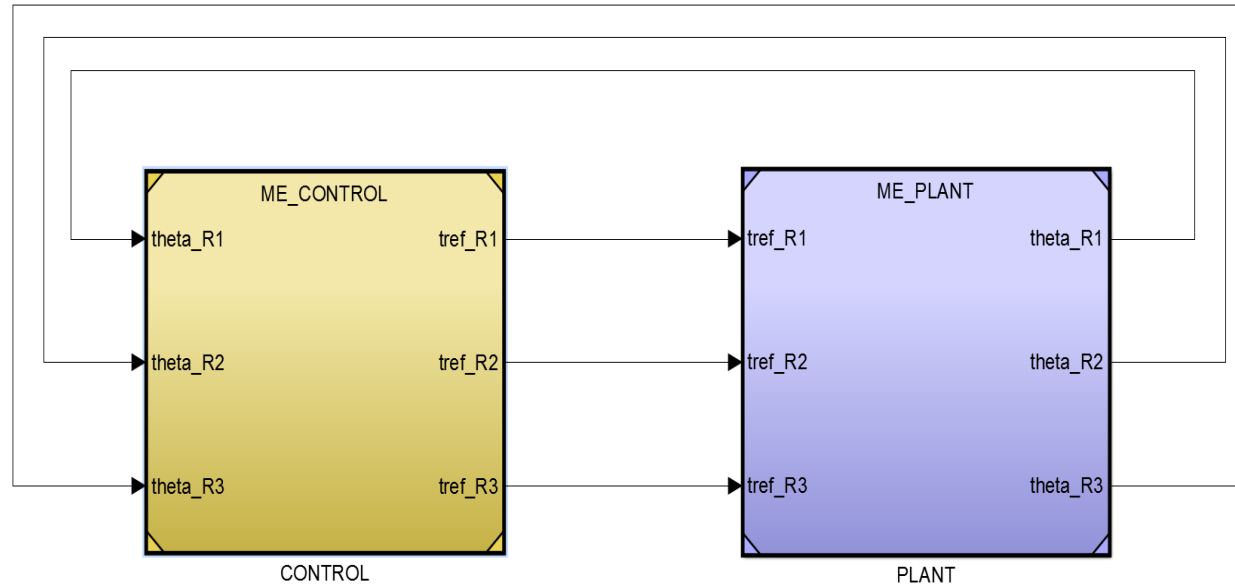


4. Actuator Design

- selection of actuator (PMSM, brushless...)
- optimal sizing (avoid overdimensioning)
- electric effects (network, battery, energy consumption...)

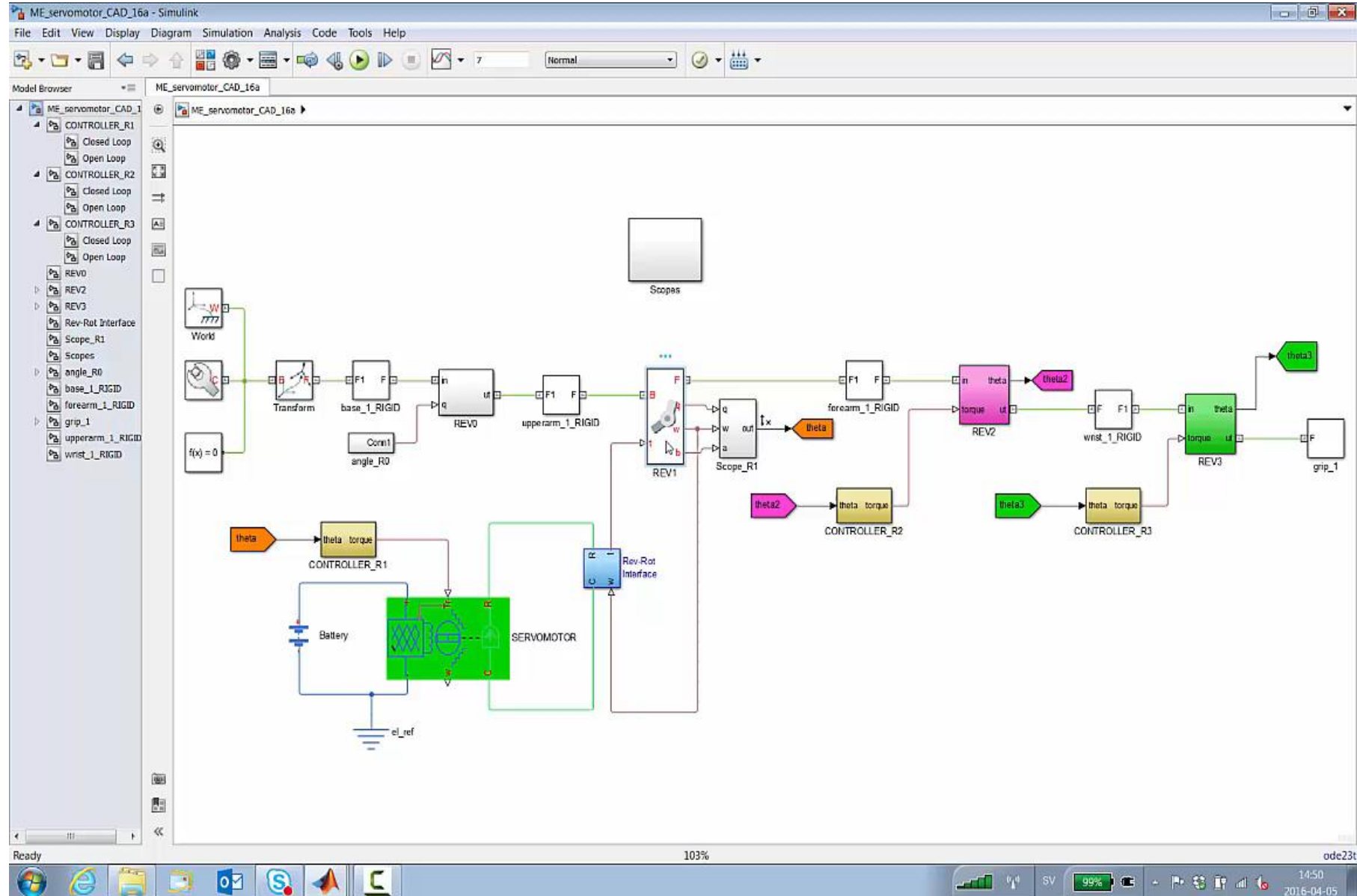
Mechatronic design – step 5

demo



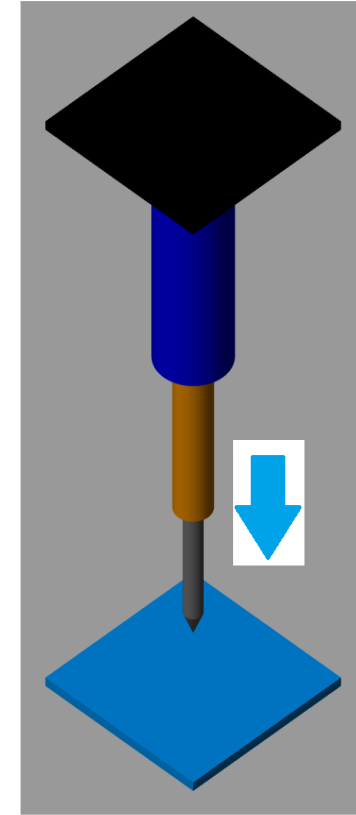
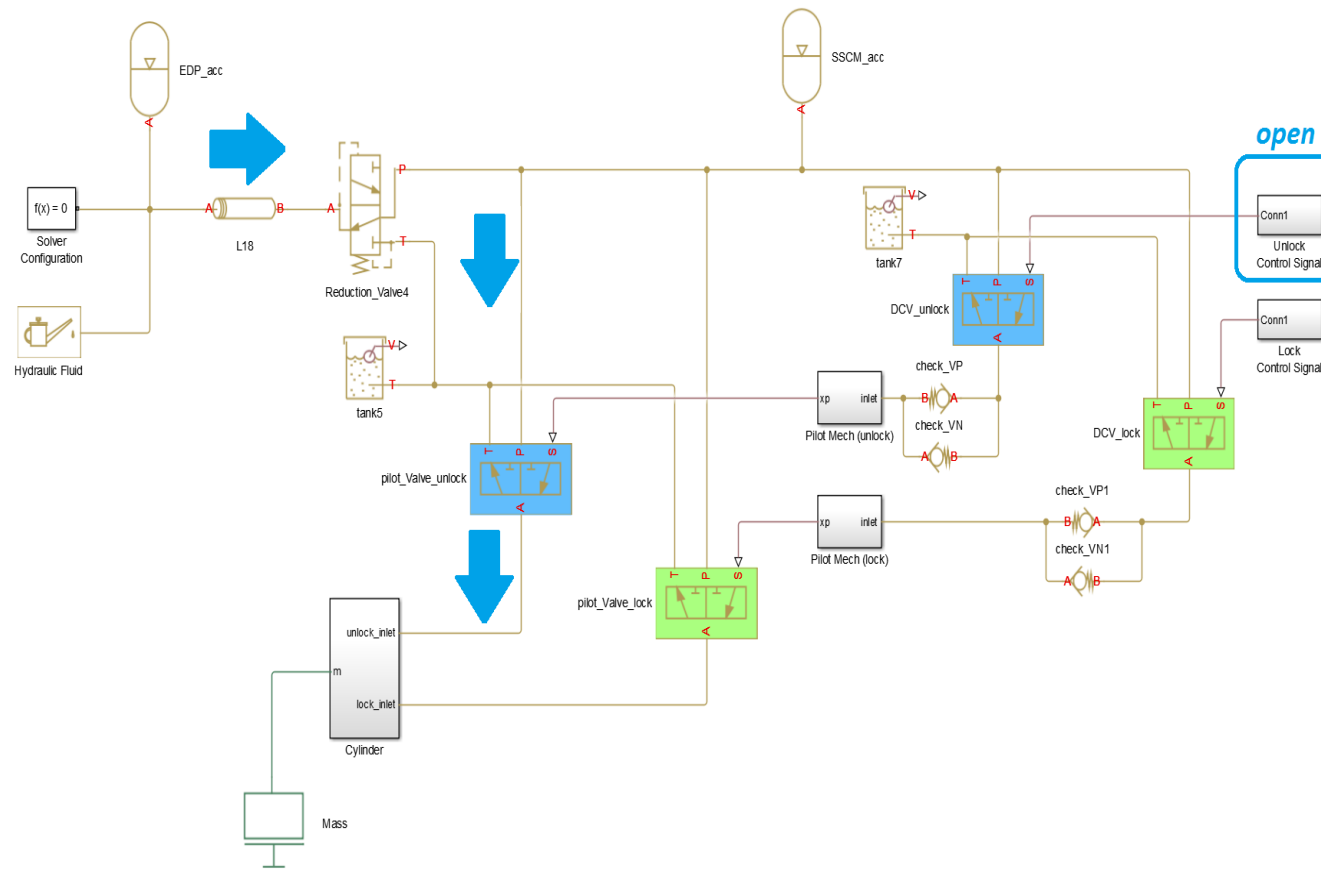
5. Model re-use for real-time testing

- discretization [solver, sample time]
- benchmark [fidelity vs. speed]
- code generation

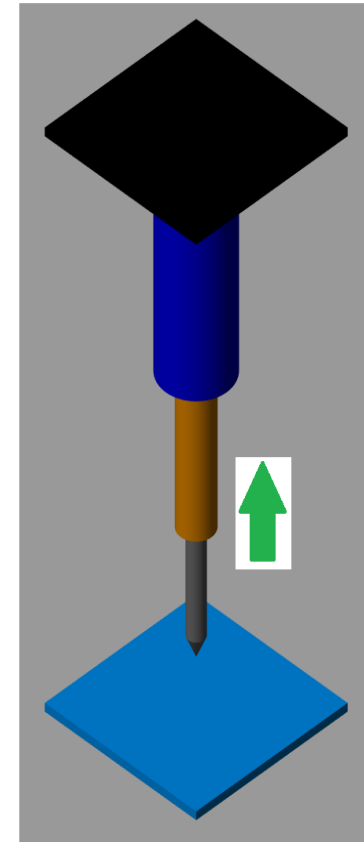
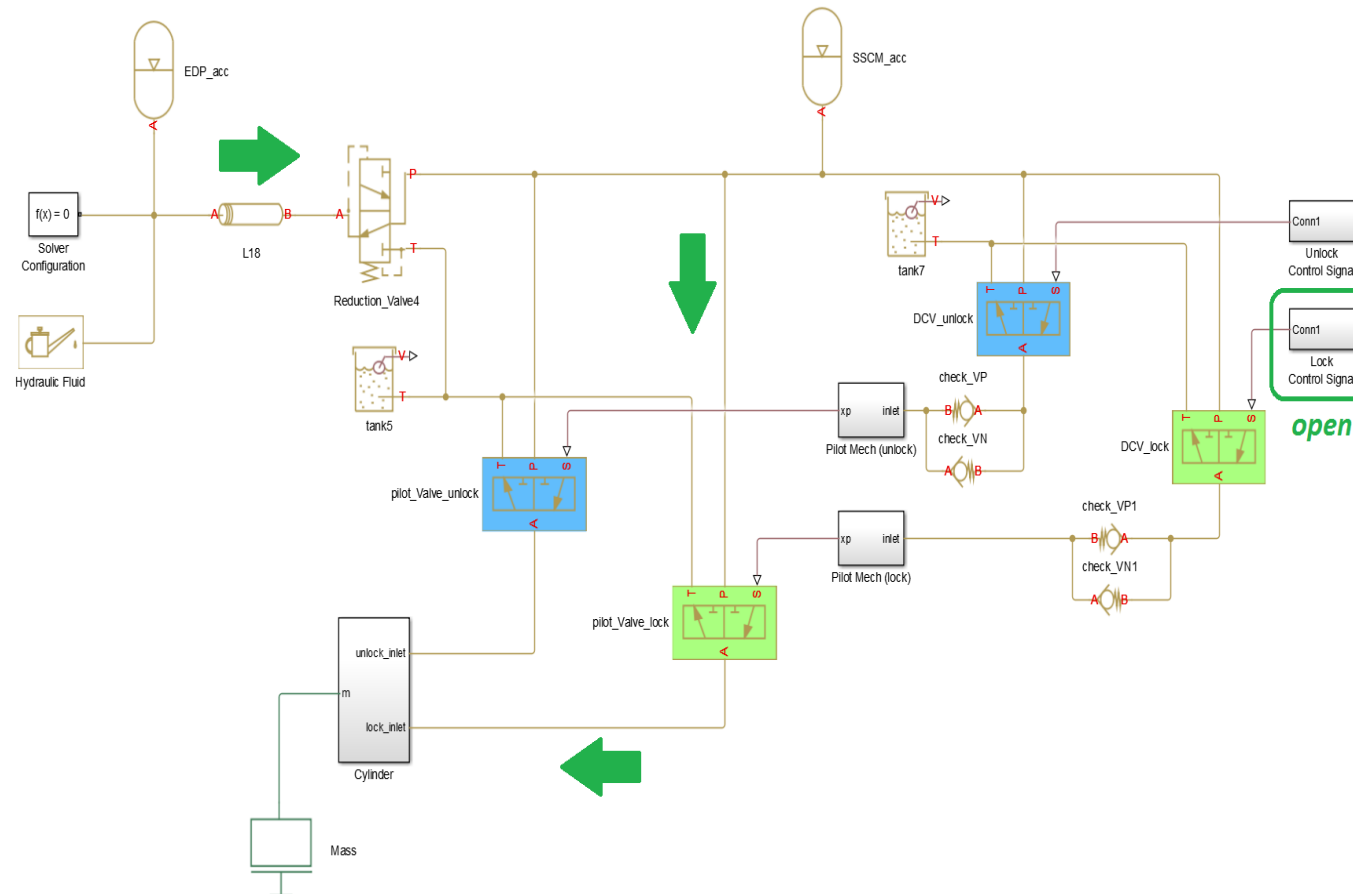


Design Optimization (based on physical model)

Hydro-mechanic drill mechanism (unlock)



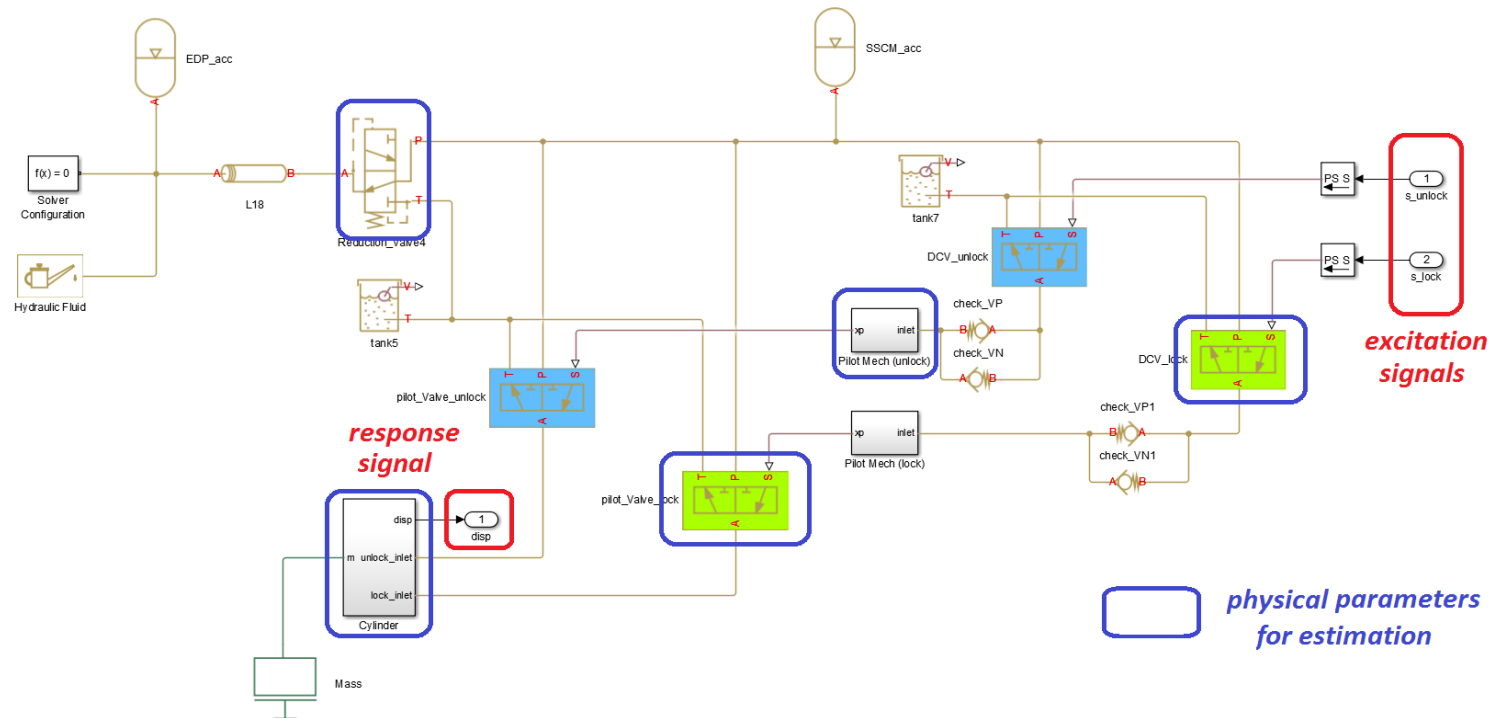
Hydro-mechanic drill mechanism (lock)



Design Optimization – task 1

1. Parameter Estimation (calibration)

- ❑ measurement signals to MATLAB workspace
- ❑ optimization-based method (iterative execution)

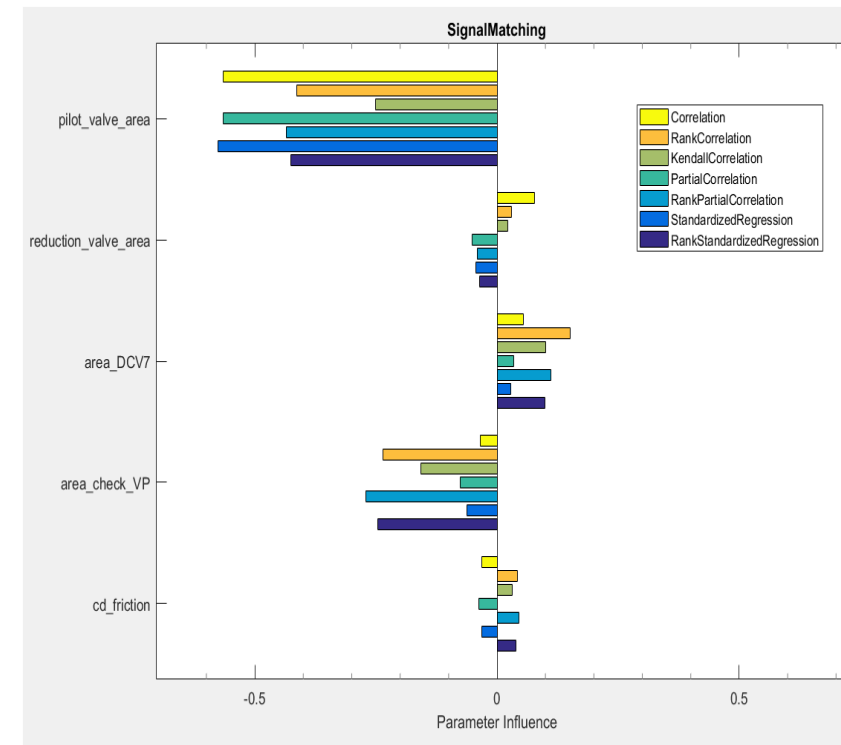
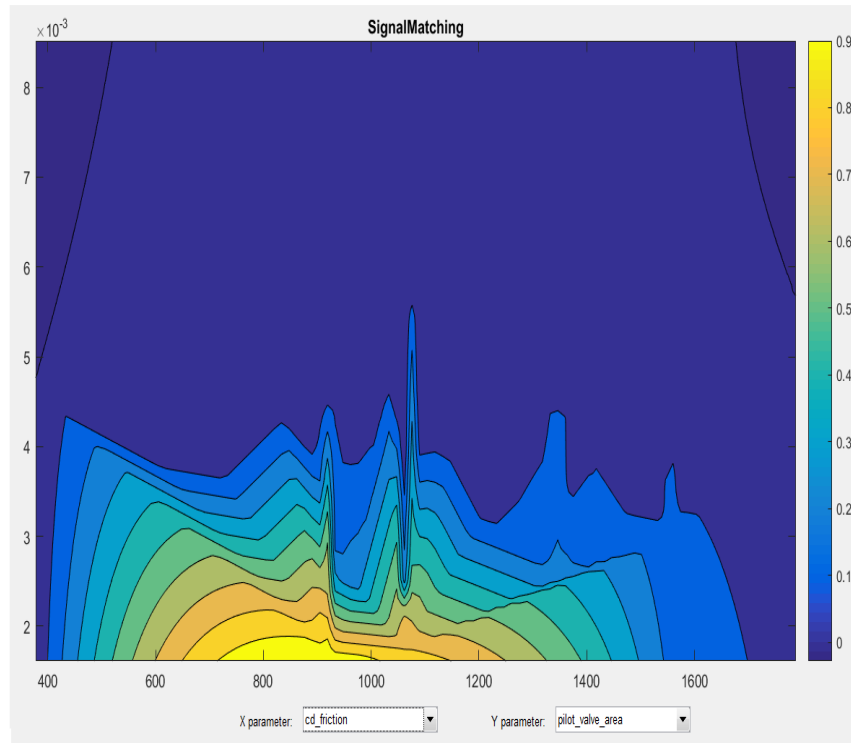


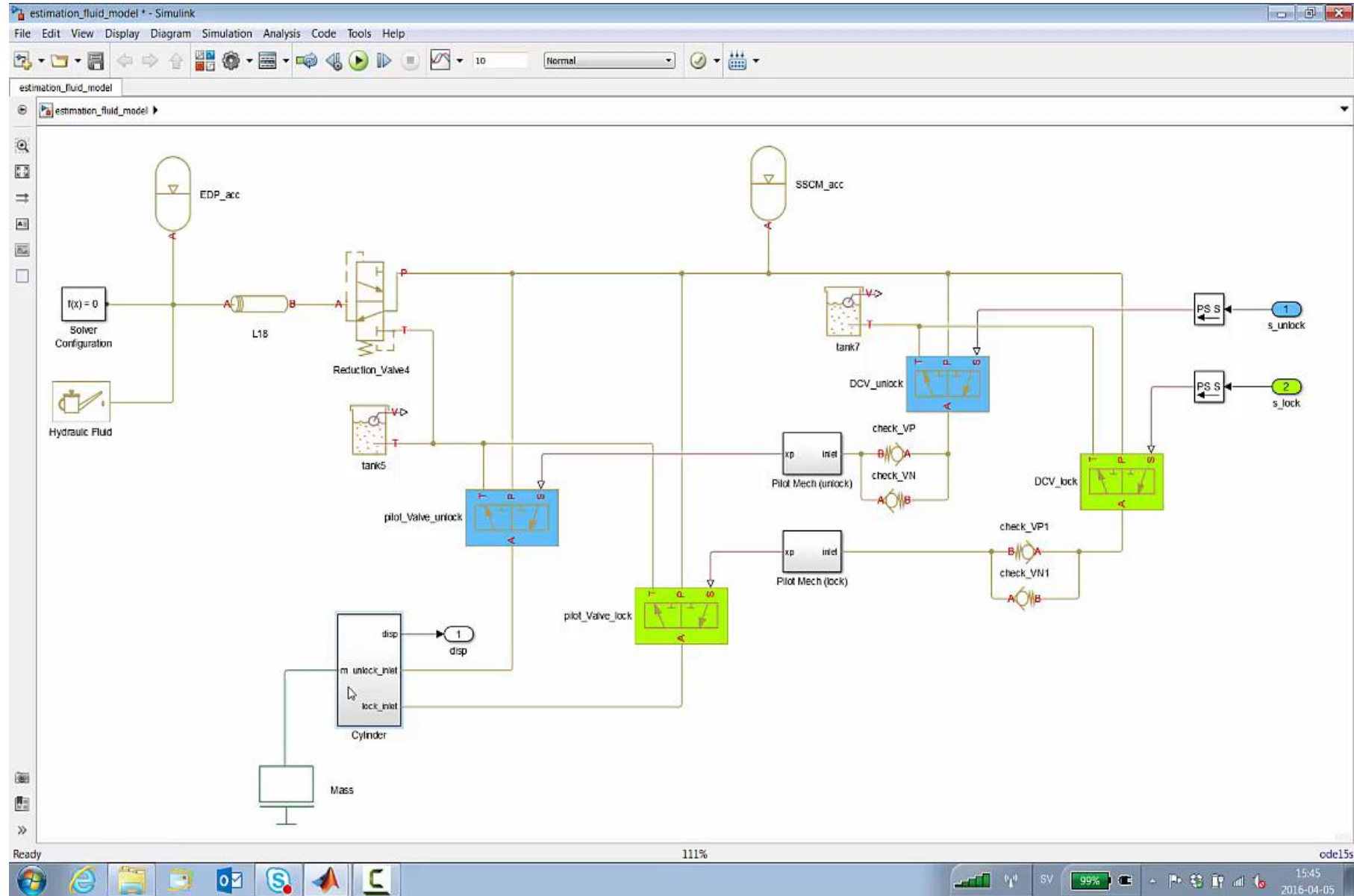
Design Optimization – task 2

2. Sensitivity Analysis (system insight)

- parameter sweep [MATLAB scripting]
- statistic methods [formal & systematic]

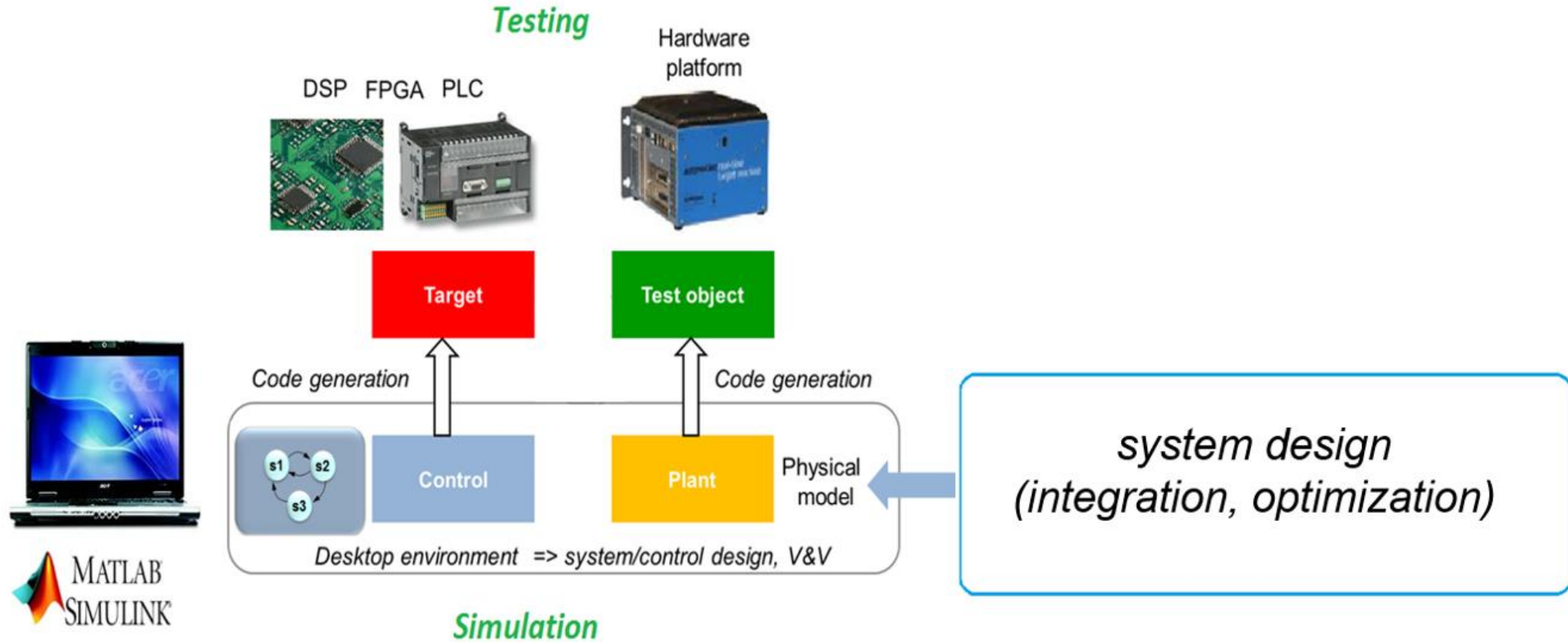
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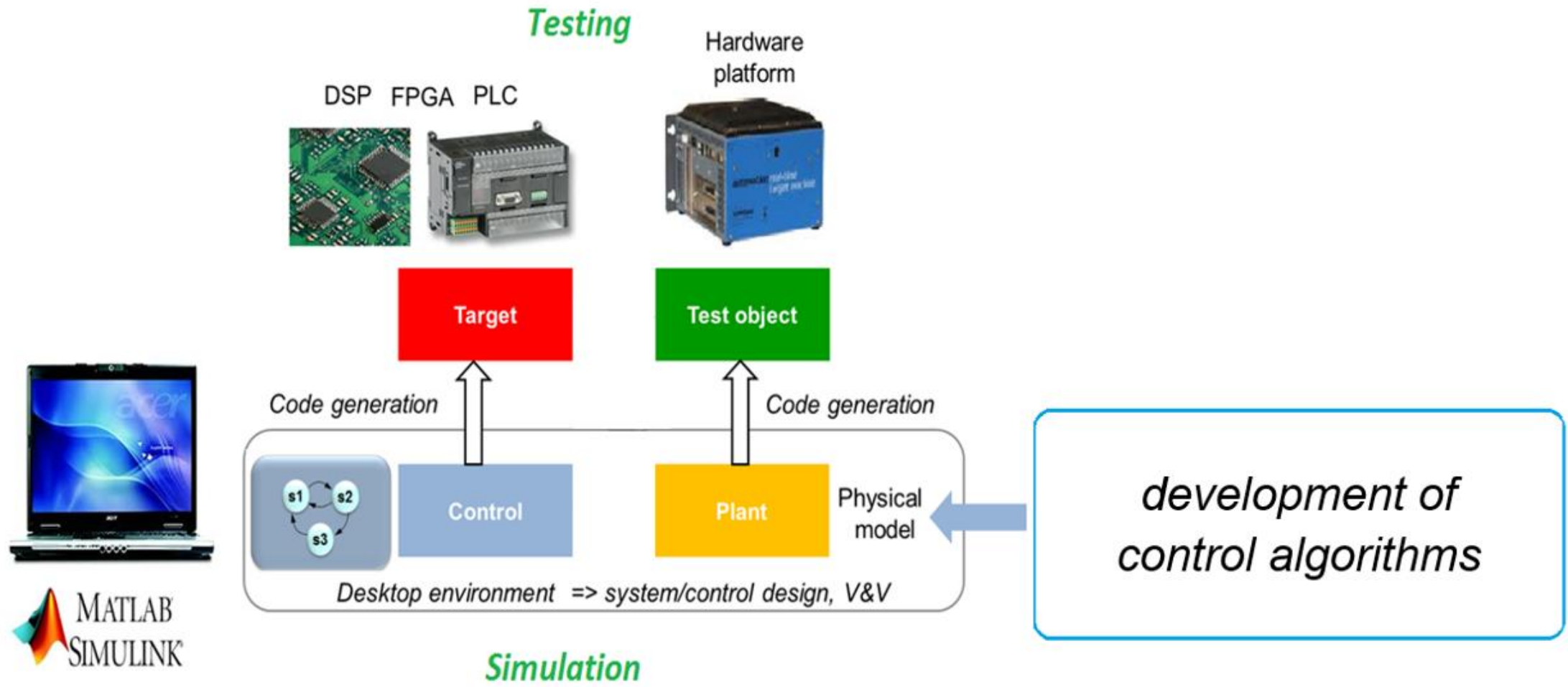


Conclusions

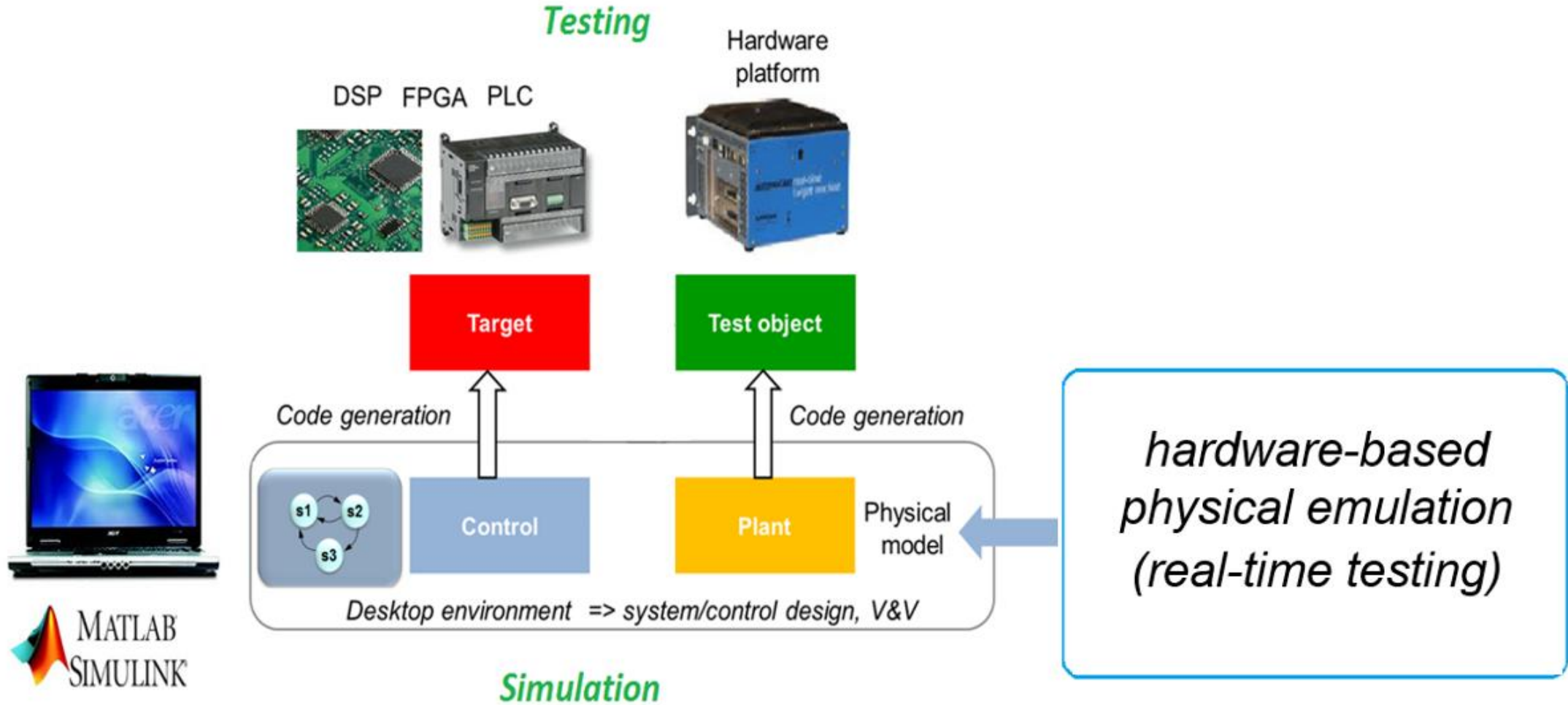
Simulation-based Design = System



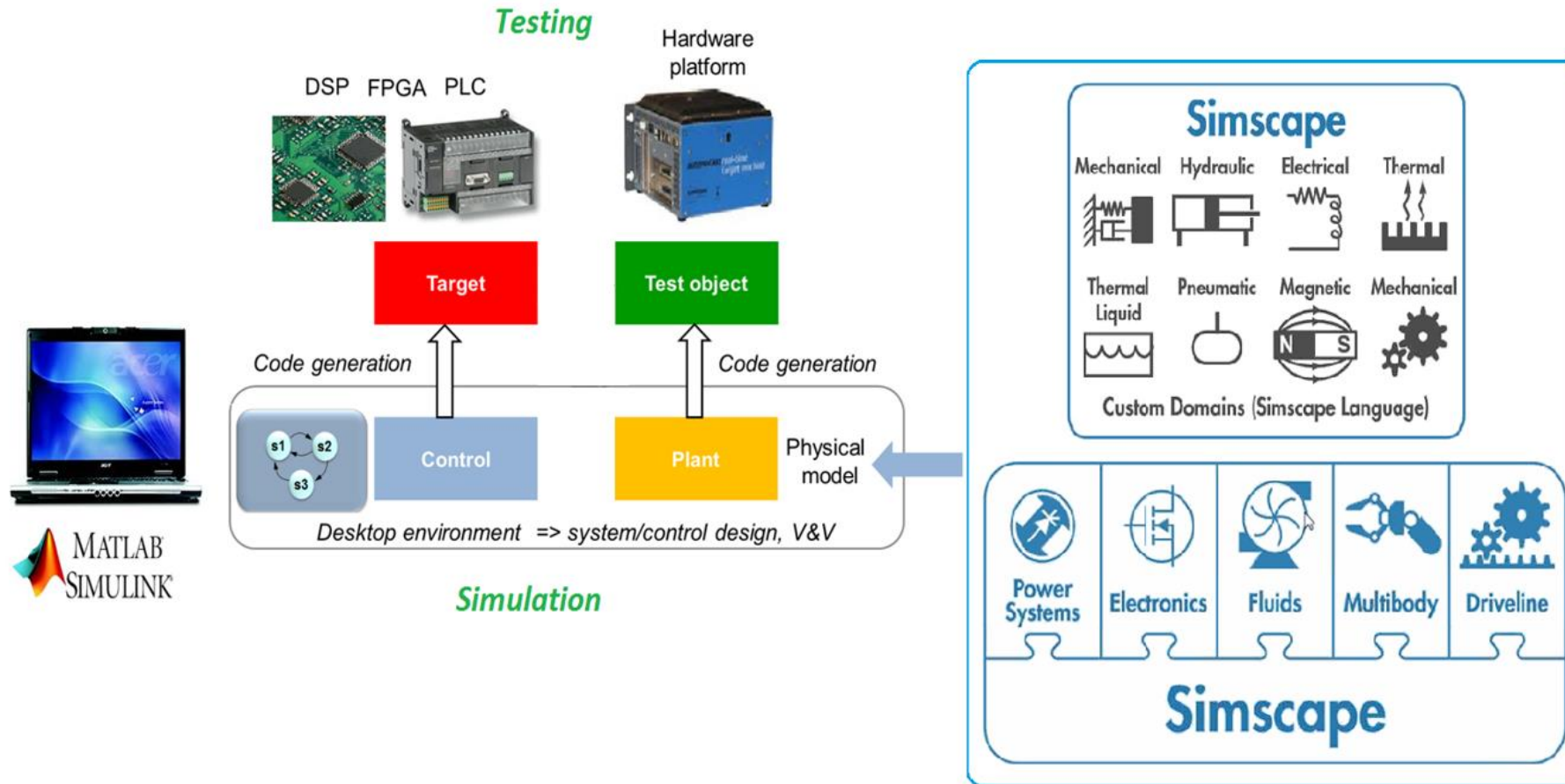
Simulation-based Design = Controls



Simulation-based Design = Testing



MATLAB/Simulink offers a unique environment for data analytics & embedded development



**Partnership with MathWorks
reduces risk and accelerates the adoption process**

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