



Oprogramowanie
Naukowo-Techniczne
sp. z o.o.

Poznań, 23.03.2023 r.

MATLAB i Simulink jako narzędzia w dziedzinie elektromobilności

Konrad Grzybowski, Młodszy Inżynier Aplikacji, ONT

Agenda

1. Elektryfikacja
2. Model-Based Design
3. Możliwości MATLAB&Simulink
4. Simscape
5. Warsztaty

Elektryfikacja

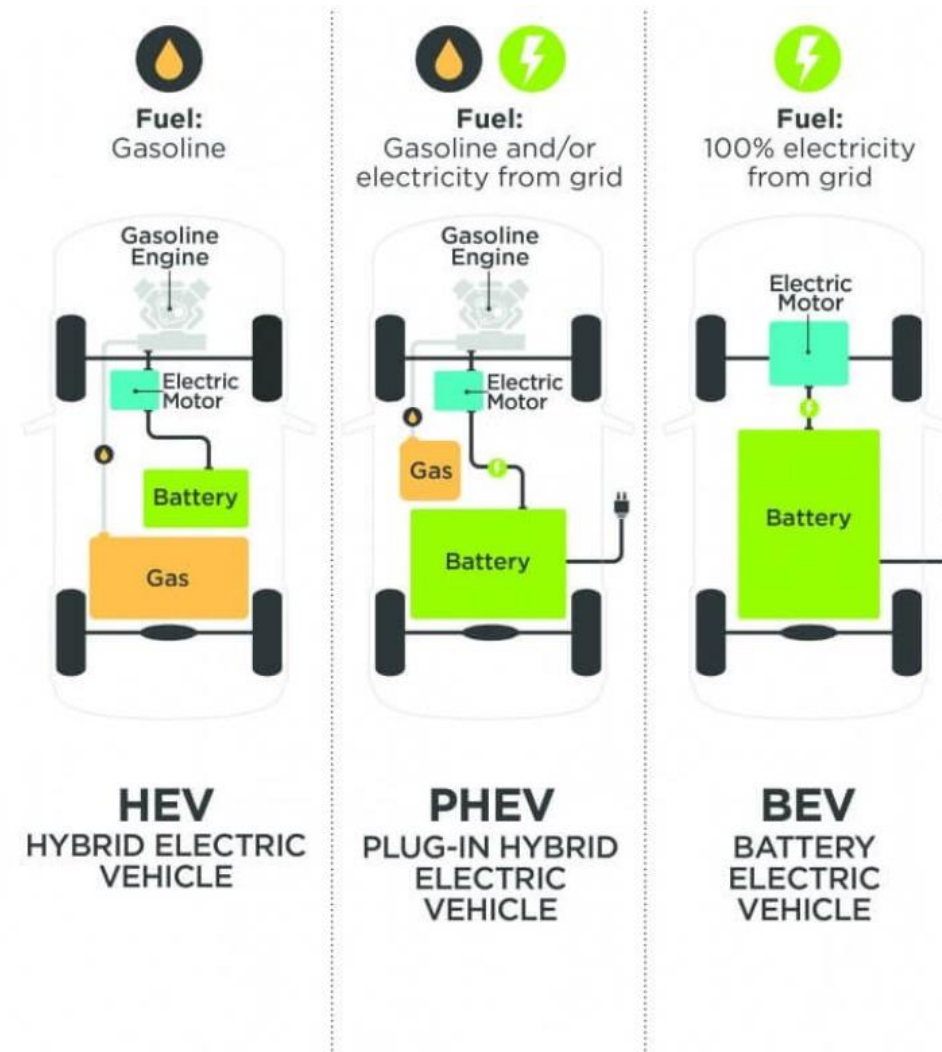


Elektromobilność



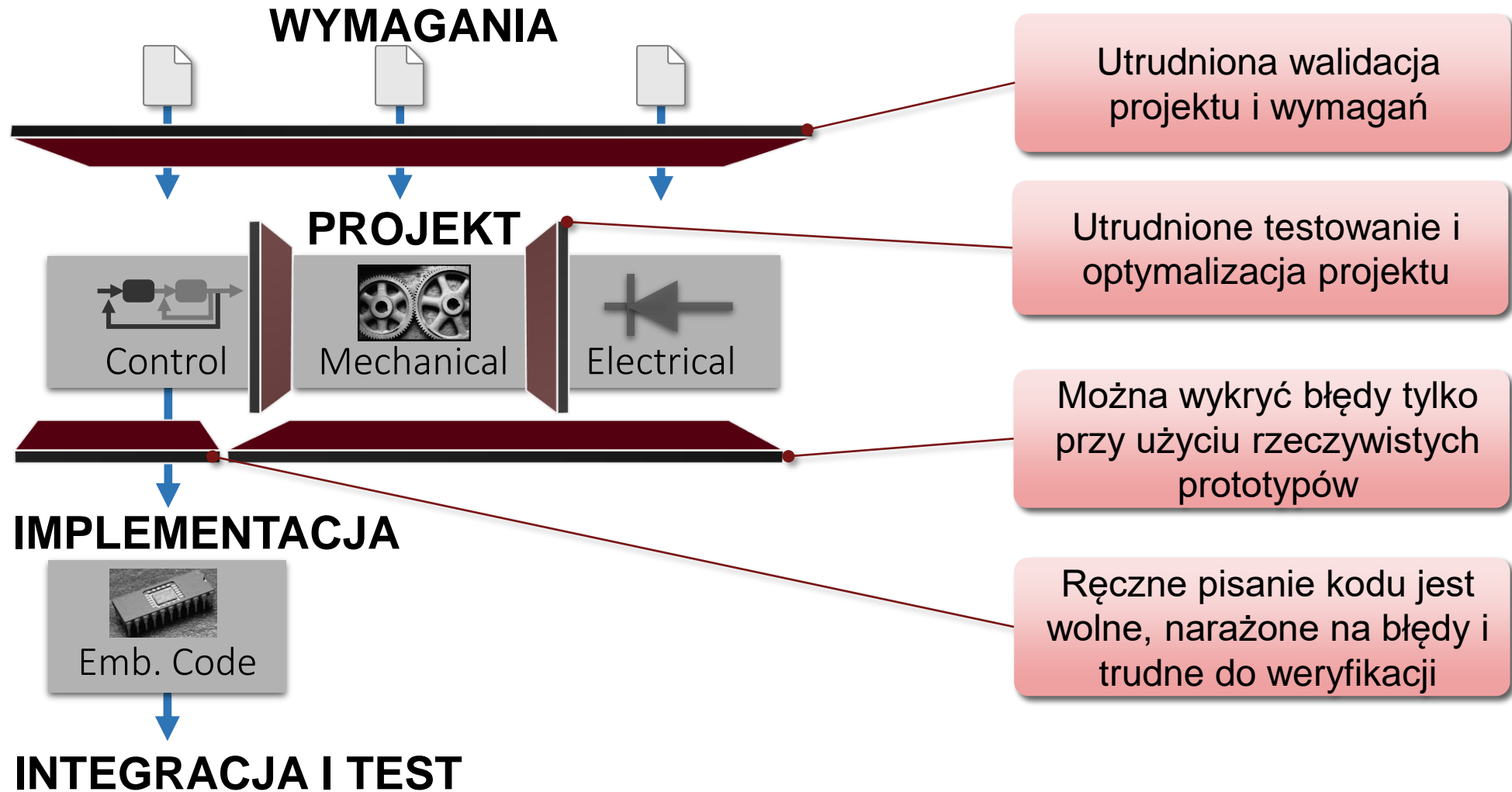
Zelektryfikowane pojazdy samochodowe

- Hybrid Electric Vehicles (HEVs)
- Plug-In Hybrid Vehicles (PHEVs)
- Battery Electric Vehicles (BEVs)

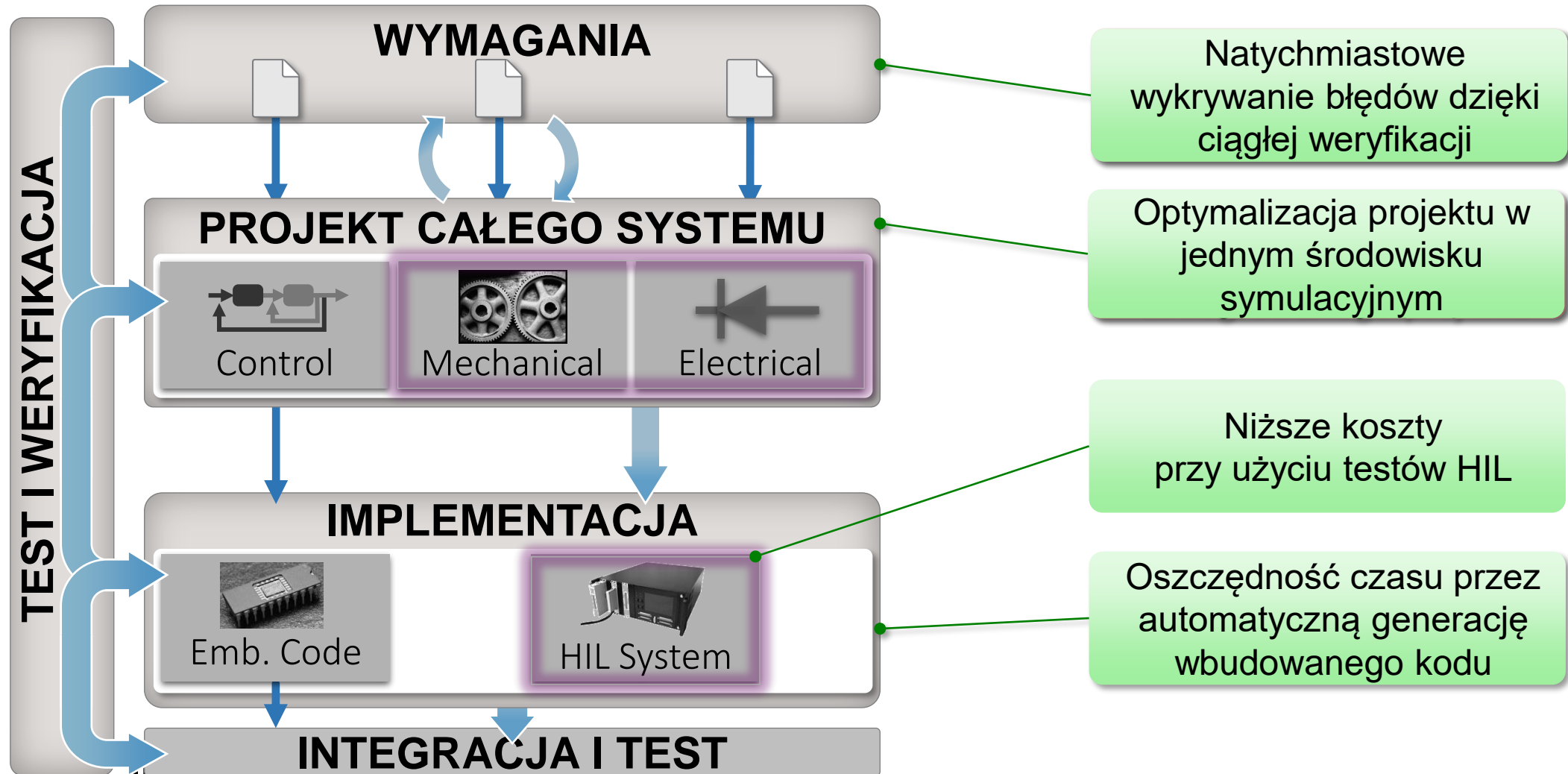


Źródło: Abhishek Sharma „MATLAB model of an electric car”

Tradycyjne podejście projektowe

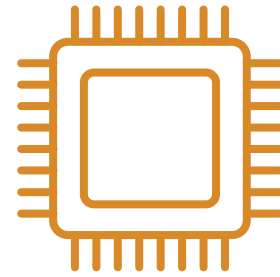


Model-Based Design

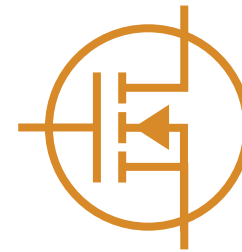


Produkty MathWorks

MATLAB



Simulink

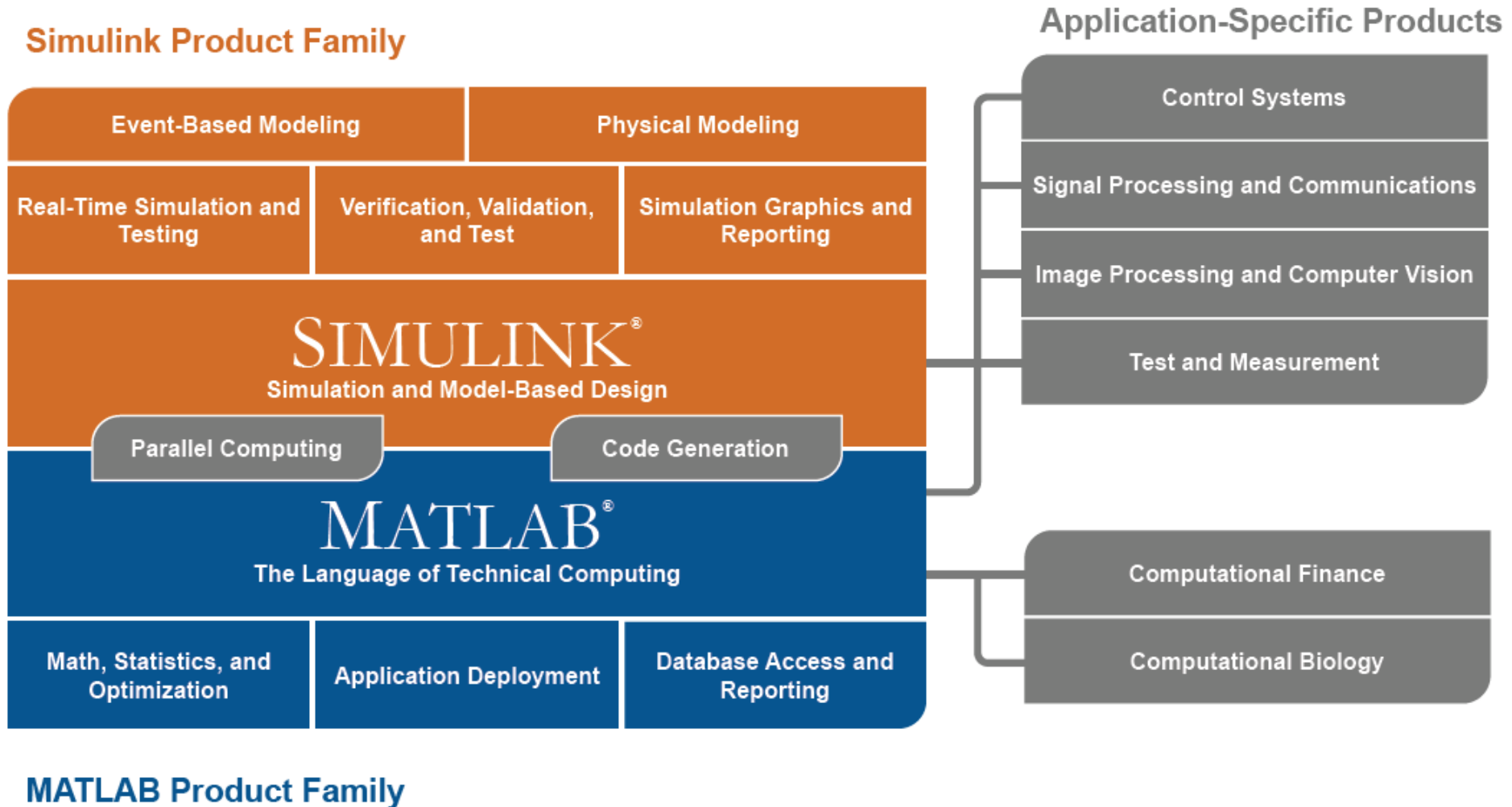


Simscape



Stateflow

Produkty MathWorks



Dokumentacja i przykłady użycia



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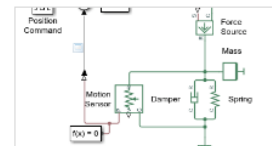
Category

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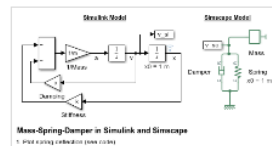
Trial Software Prodi

Mechanical Models – Examples



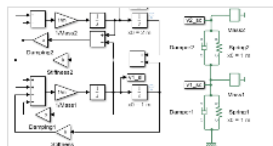
Mass-Spring-Damper with Controller
 1. Plot forces in system and mass position (see code)
 2. Plot time simulation results using Simscape Results Explorer
 3. Learn more about this example

Mass-Spring-Damper with Controller
 A controlled mass-spring-damper. A controller adjusts the force on the mass to have its position track a command signal. The initial velocity



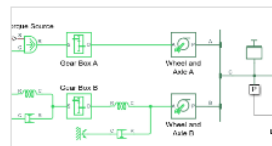
Mass-Spring-Damper in Simulink and Simscape
 1. Plot forces in system and mass position (see code)
 2. Plot time simulation results using Simscape Results Explorer
 3. Learn more about this example

Mass-Spring-Damper in Simulink and Simscape
 Two models of a mass-spring-damper, one using Simulink® input/output blocks and one using Simscape™ physical networks.



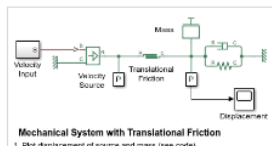
Double Mass-Spring-Damper in Simulink and Simscape
 1. Plot forces in system and mass position (see code)
 2. Plot time simulation results using Simscape Results Explorer
 3. Learn more about this example

Double Mass-Spring-Damper in Simulink and Simscape
 Two models of a double mass-spring-damper, one using Simulink® input/output blocks and one using Simscape™ physical networks.



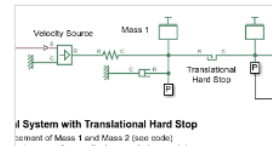
Simple Mechanical System
 1. Plot forces in system and mass position (see code)
 2. Plot time simulation results using Simscape Results Explorer
 3. Learn more about this example

Simple Mechanical System
 A model of a system that connects a rotational and translational motion. A summing lever drives a load consisting of a mass, viscous



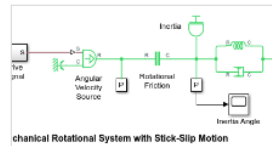
Mechanical System with Translational Friction
 1. Plot displacement of mass and mass force (see code)
 2. Plot hysteresis curve due to friction effect (see code)
 3. Choose simulation results using Simscape Results Explorer
 4. Learn more about this example

Mechanical System with Translational Friction
 A mass attached to a spring and a viscous damper. The mass is driven by an ideal velocity source through a friction element. The motion profile



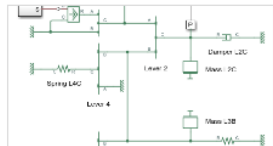
Mechanical System with Translational Hard Stop
 1. Plot forces in system and mass position (see code)
 2. Plot time simulation results using Simscape Results Explorer
 3. Learn more about this example

Mechanical System with Translational Hard Stop
 Two masses connected by a hard stop. Mass 1 is driven by an Ideal Velocity Source. As the velocity input changes direction, Mass 2 will stay



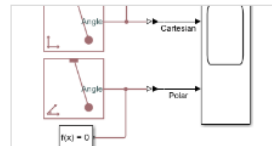
Mechanical Rotational System with Stick-Slip Motion
 1. Plot angle of inertia and inertia force (see code)
 2. Plot time simulation results using Simscape Results Explorer
 3. Learn more about this example

Mechanical Rotational System with Stick-Slip Motion
 A mechanical rotational system with stick-slip friction. An inertia is connected to a fixed point by spring and damper. The inertia is driven by



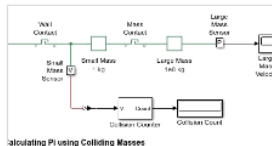
Linkage Mechanism
 1. Plot forces in system and mass position (see code)
 2. Plot time simulation results using Simscape Results Explorer
 3. Learn more about this example

Linkage Mechanism
 The use of the Simscape™ Lever block in a linkage mechanism. Lever 1 and Lever 4 are first class levers with the fulcrum at the end. Lever 3



Pendulum in Cartesian and Polar Coordinates
 1. Set parameters (see code)
 2. Plot comparison of pendulum angle (see code)

Pendulum in Cartesian and Polar Coordinates
 Two different implementations of a planar pendulum.



Calculating Pi using Colliding Masses
 1. Plot velocity and position of the two masses (see code)
 2. Plot time simulation results using Simscape Results Explorer
 3. Learn more about this example

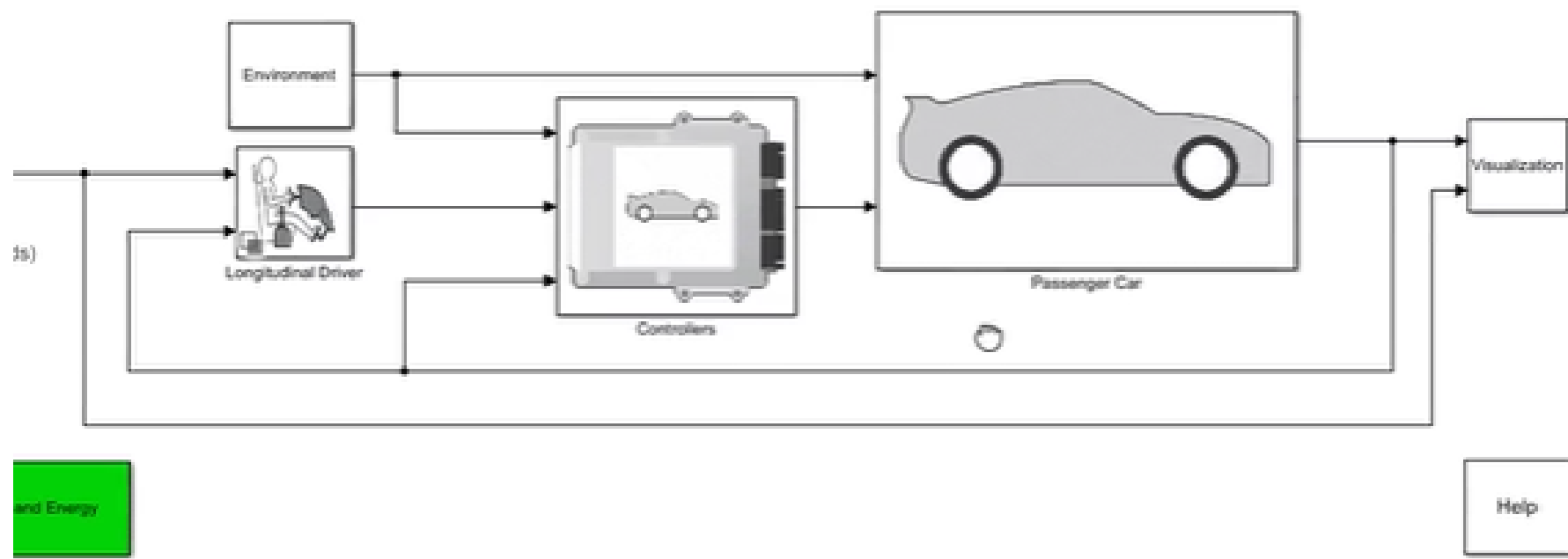
Calculating Pi Using Colliding Masses
 Uses a well-known physics problem to demonstrate solver performance by capturing tens of thousands of instantaneous events that occur in

Możliwości MATLAB/Simulink w elektromobilności

Model-Based Design

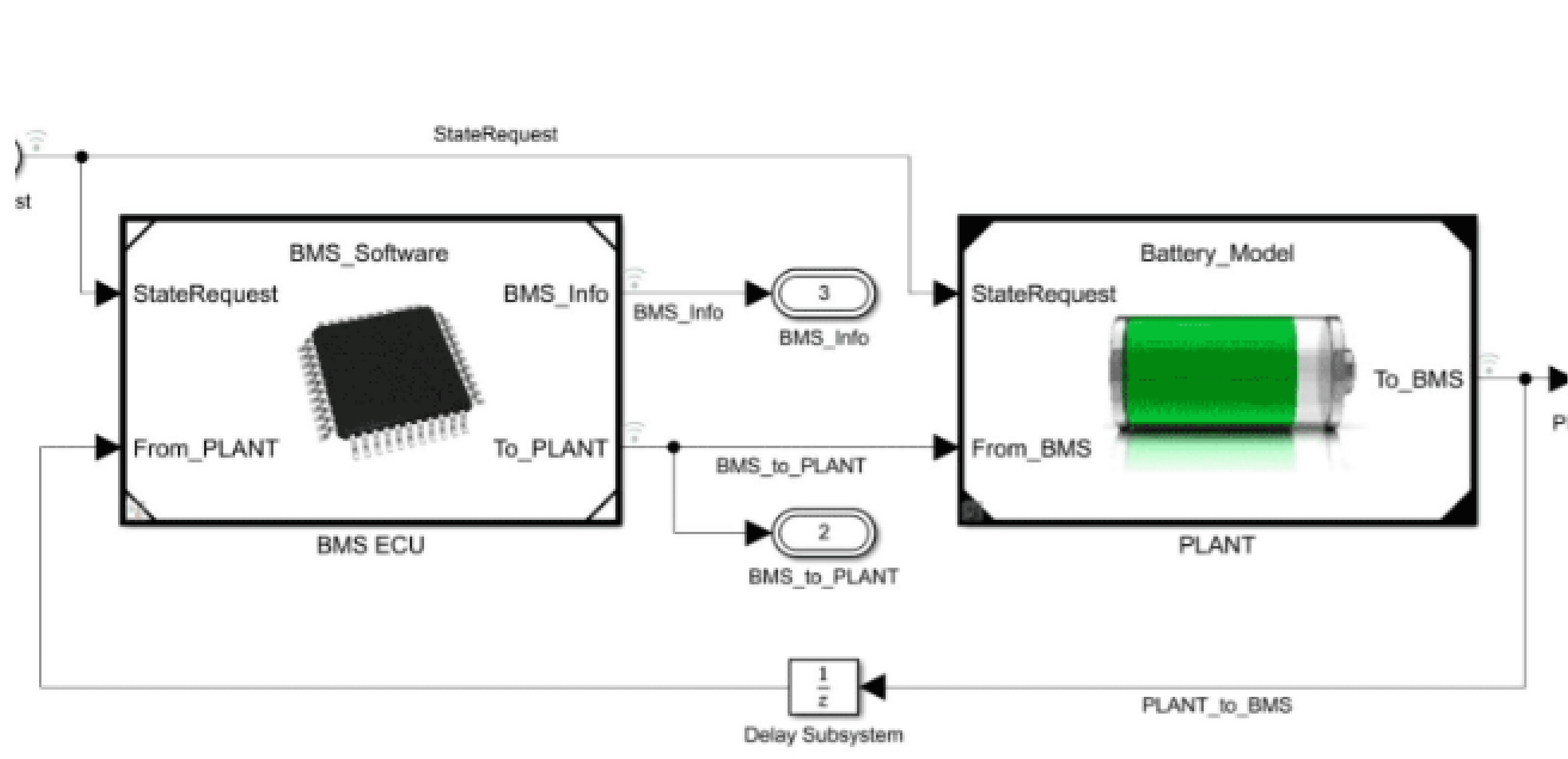
- Tworzenie architektur EV i optymalizacja systemów
- Modelowanie baterii i BMS
- Modelowanie ogniw paliwowych
- Modelowanie silników trakcyjnych i jednostek sterujących
- Sterowanie
- Sztuczna inteligencja

Tworzenie architektury systemu

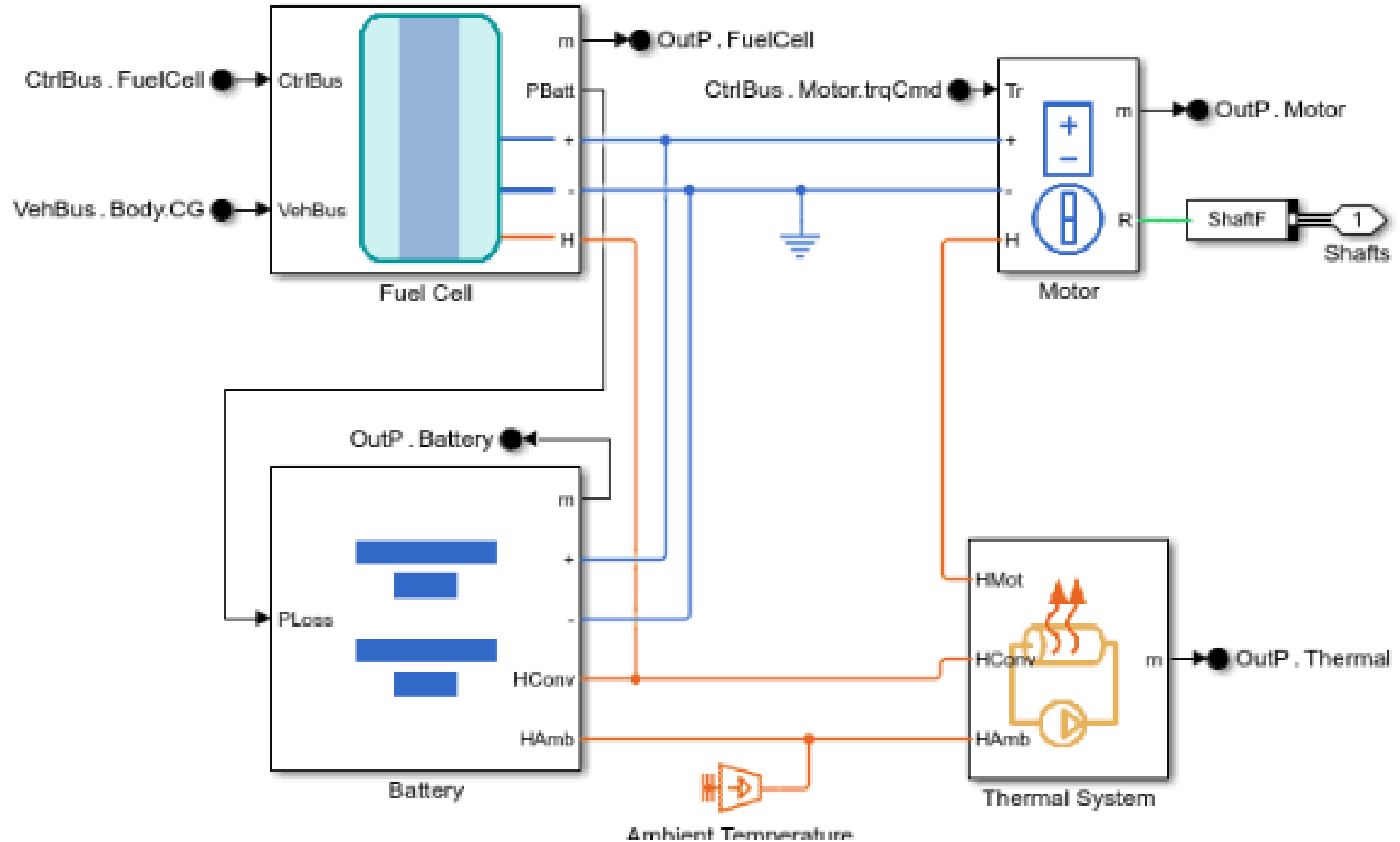


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Modelowanie baterii i BMS



Modelowanie ogniw paliwowych



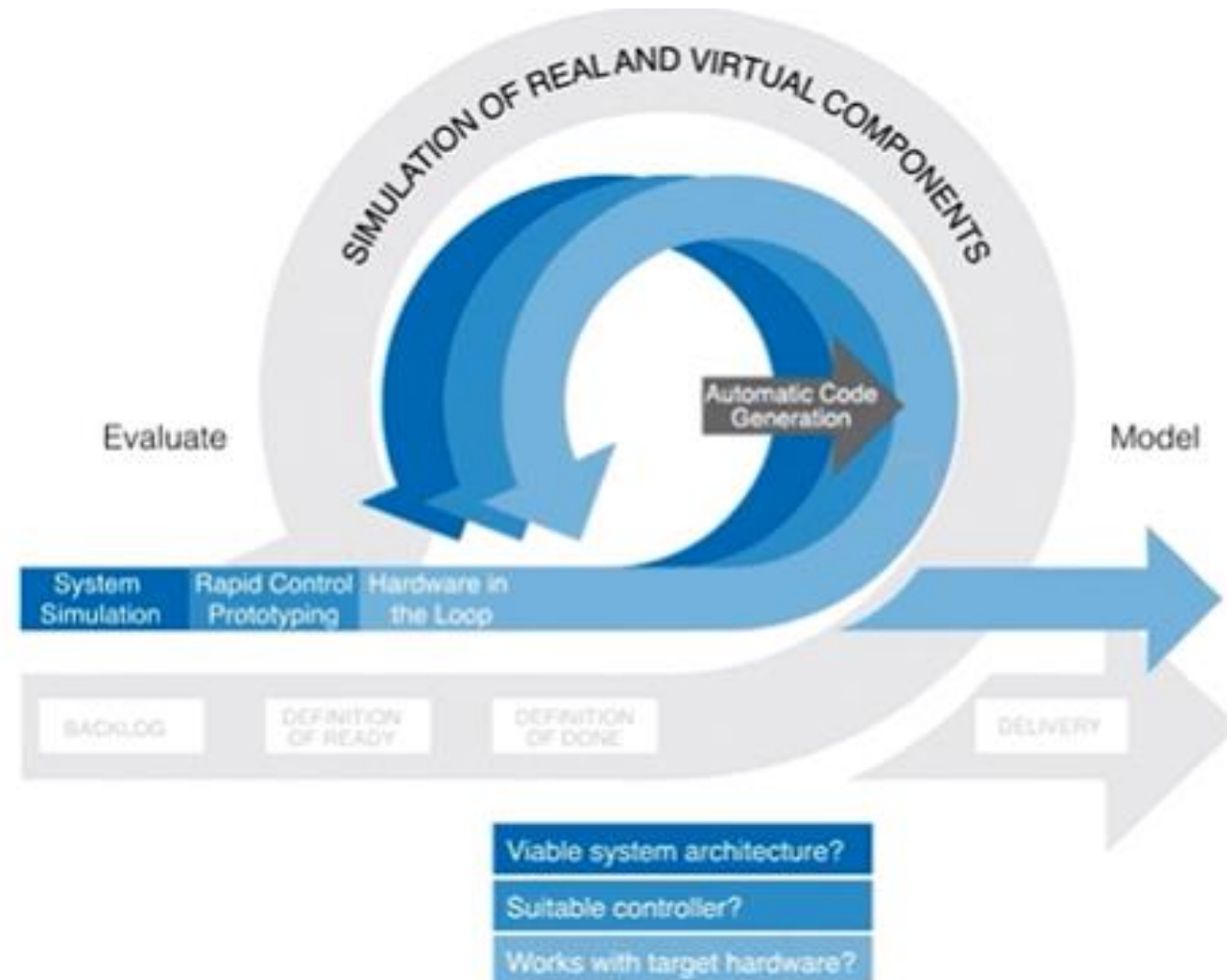
Modelowanie silników trakcyjnych i ich sterowania

The image displays the MATLAB/Simulink environment for an electric motor control application. The main window is titled "Electric Motor Control Panel" and includes the following components:

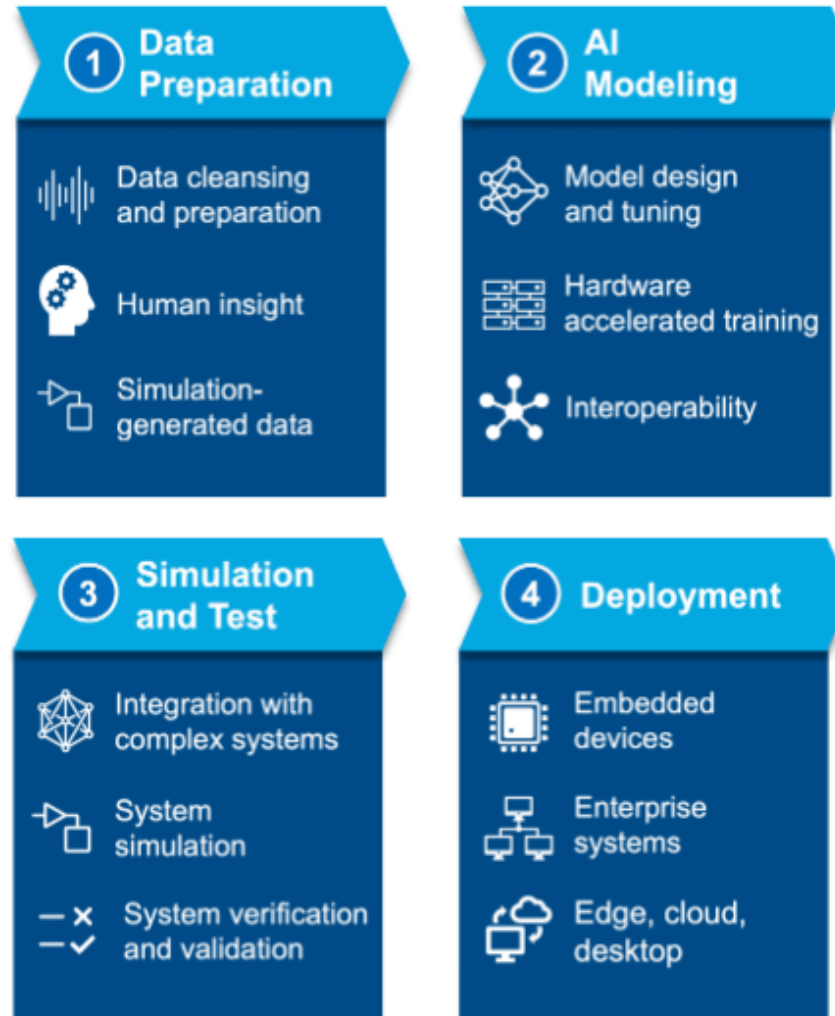
- Launch Application on Target:** A sidebar with buttons for "Open Model", "Connect to Target", "Build Simulink Model", "Download Application", "Start Application", and "Stop Application".
- Electric Motor Control:** A central control panel with a "Variant" dropdown set to "RCP", "Open Model", "Connect to Target", "Build Simulink Model", "Download Application", "Start Application", and "Stop Application" buttons. It also features a "Command Type" selector (Open Loop, Closed Loop), a "Motor mode" selector, and a "Motor Status" indicator.
- Real-Time Visualization:** A gauge for "Rotor Speed (rad/s)" ranging from -200 to 200, and a "Speed" plot showing speed in rad/s over time in seconds.
- Target Status:** A section indicating "Target connection established" with fields for "Sample Time" (5e-05), "Stop Time" (inf), and "Simulation Time" (0).

Below the control panel, a Simulink block diagram is visible, showing a "MotorDrive" block connected to an "OutputBus" block. The diagram includes a "DAC" block and a "MotorDrive" block. The "OutputBus" block is connected to the "MotorDrive" block. The "DAC" block is connected to the "OutputBus" block. The "MotorDrive" block is connected to the "OutputBus" block. The "OutputBus" block is connected to the "MotorDrive" block. The "OutputBus" block is connected to the "MotorDrive" block. The "OutputBus" block is connected to the "MotorDrive" block.

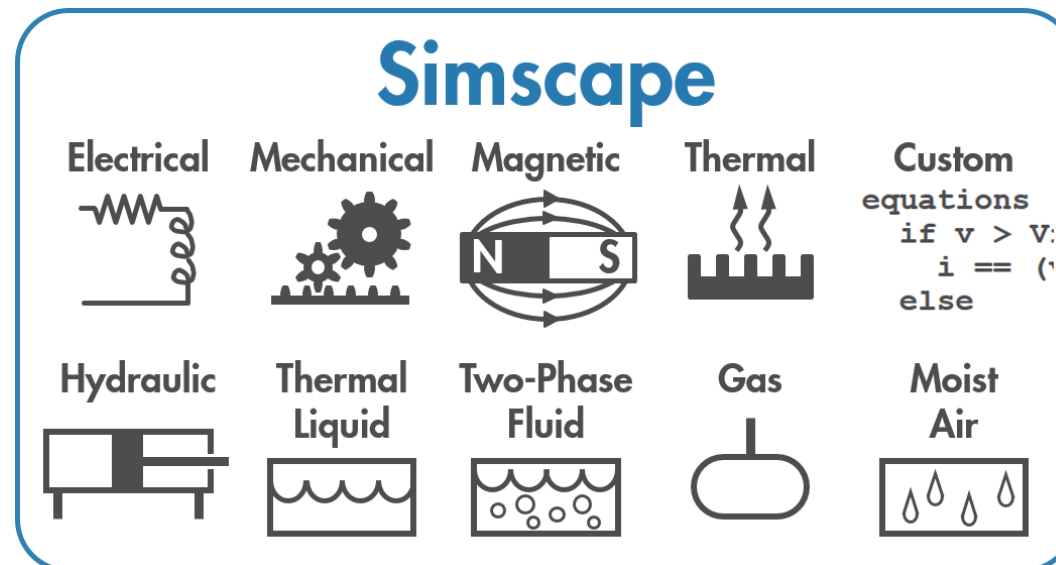
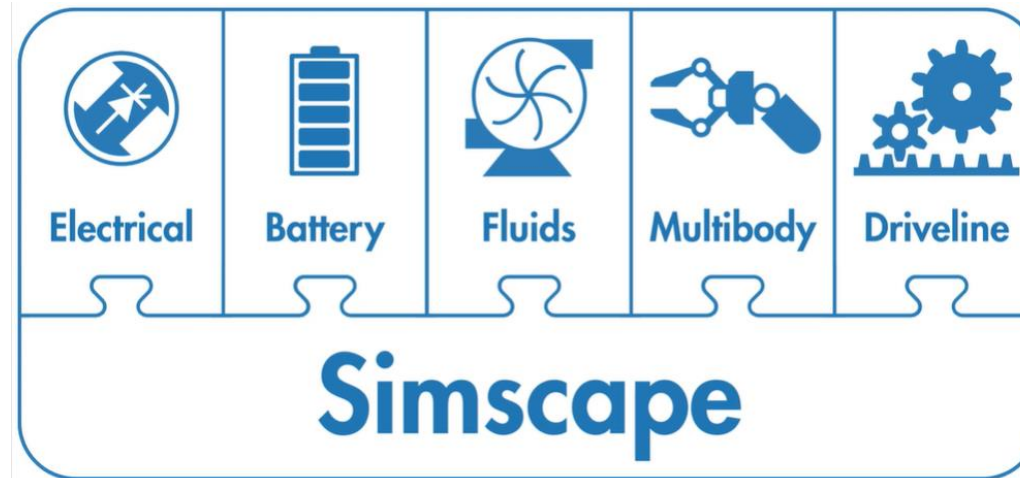
Algorytmy sterowania



Sztuczna Inteligencja

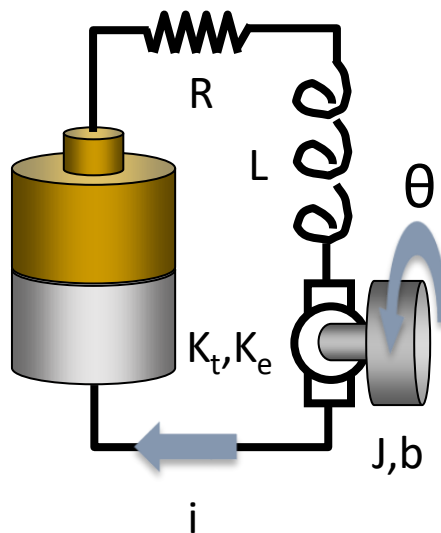


Moduły w środowisku Simscape



Simulink vs Simscape

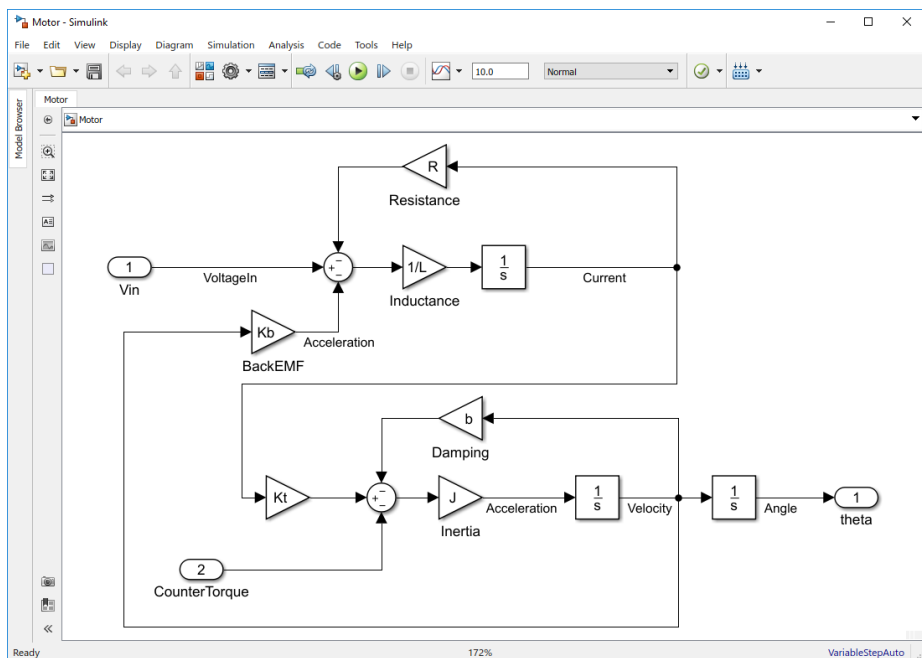
DC Motor



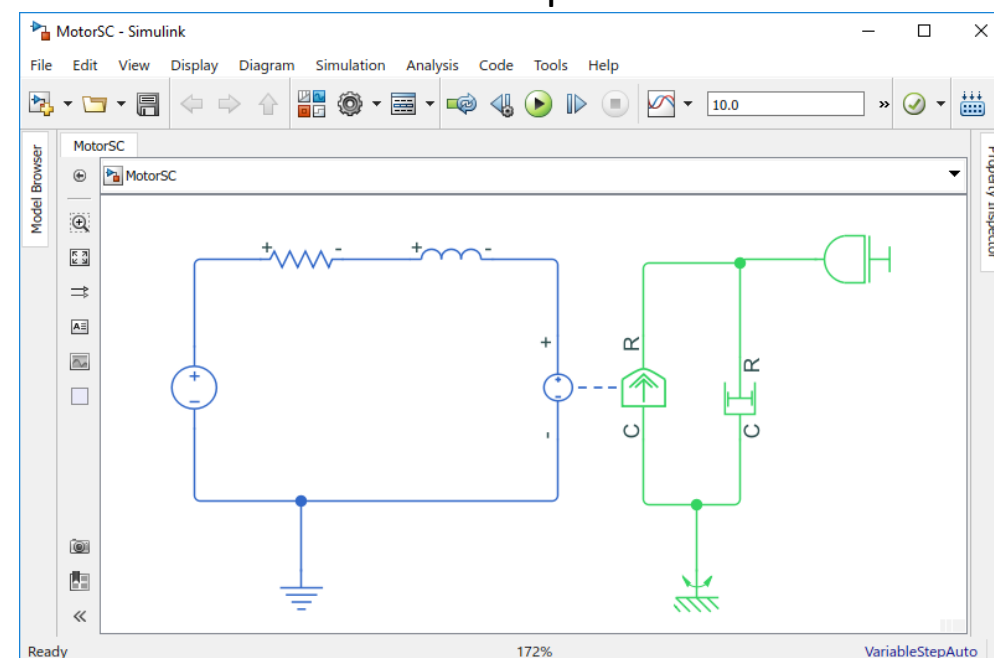
$$v = K_e \omega + i_m R_{wind} + L_{wind} \frac{di_m}{dt}$$

$$T = K_t i_m - D \omega - J \frac{d\omega}{dt}$$

Simulink

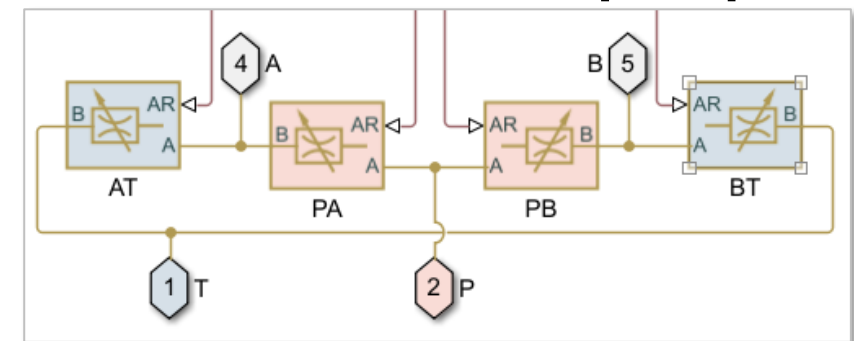
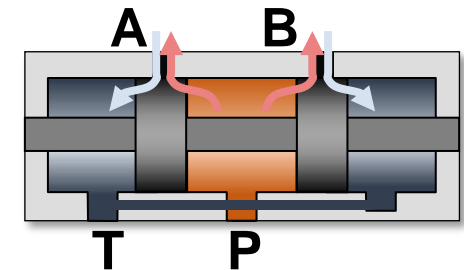
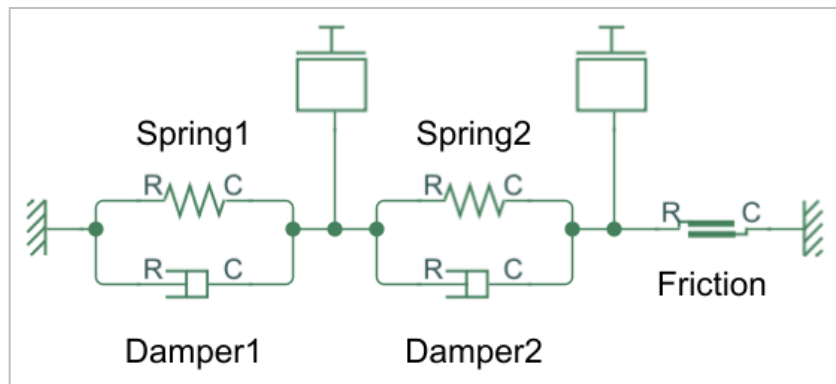
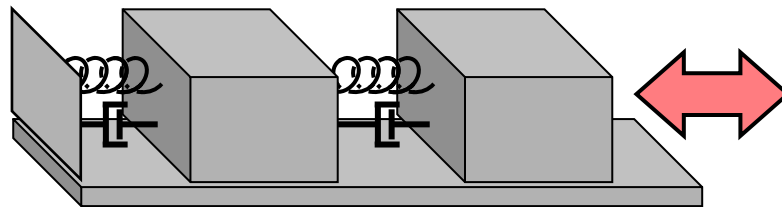
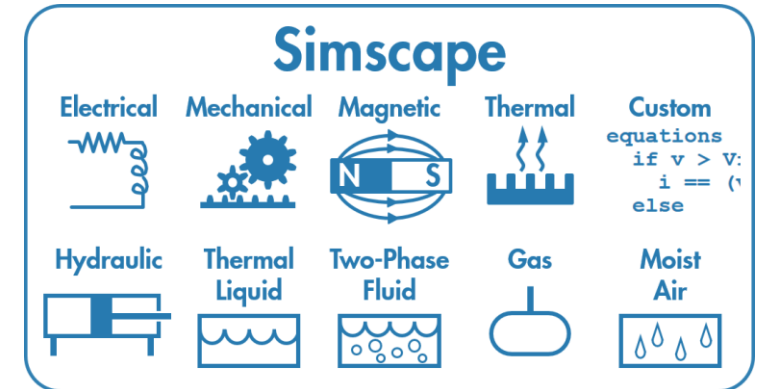


Simscape



Przewaga modelowania Simulink/Simscape

- Modelowanie fizyczne w ponad 10 różnych domenach fizycznych
- Tworzenie własnych komponentów
- Importowanie modeli CAD
- Wsparcie dla generowania kodu C



Bloczki Simscape

Simscape Line Styles Legend

Color	Name	Path
	Electrical Domain	foundation.electrical.electrical
	Three-Phase Electrical Domain	foundation.electrical.three_phase
	Gas Domain	foundation.gas.gas
	Hydraulic Domain	foundation.hydraulic.hydraulic
	Isothermal Liquid Domain	foundation.isothermal_liquid.isothermal_liquid
	Magnetic Domain	foundation.magnetic.magnetic
	Mechanical Rotational Domain	foundation.mechanical.rotational.rotational
	Mechanical Translational Domain	foundation.mechanical.translational.translational
	Moist Air Domain	foundation.moist_air.moist_air
	Moist Air Source Domain	foundation.moist_air.moist_air_source
	Thermal Domain	foundation.thermal.thermal
	Thermal Liquid Domain	foundation.thermal_liquid.thermal_liquid
	Two-Phase Fluid Domain	foundation.two_phase_fluid.two_phase_fluid
	Physical Signals	-
	3-D Mechanical (Belt-Cable)	-
	3-D Mechanical (Frame)	-
	3-D Mechanical (Geometry)	-

Help



Gear Box



Convective Heat Transfer



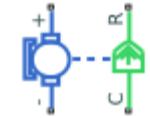
Capacitor



PS-Simulink Converter



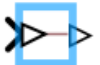
Reluctance



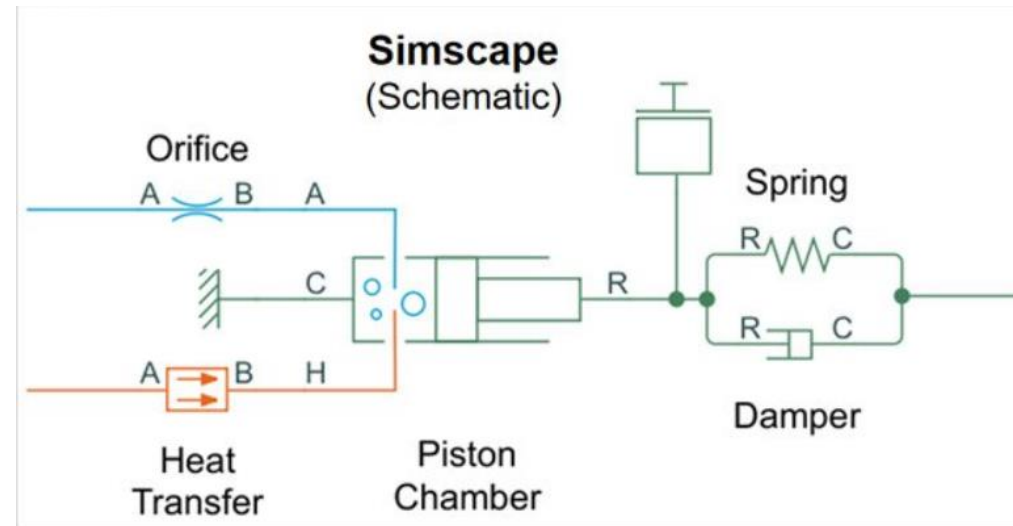
DC Motor



Pipe (TL)

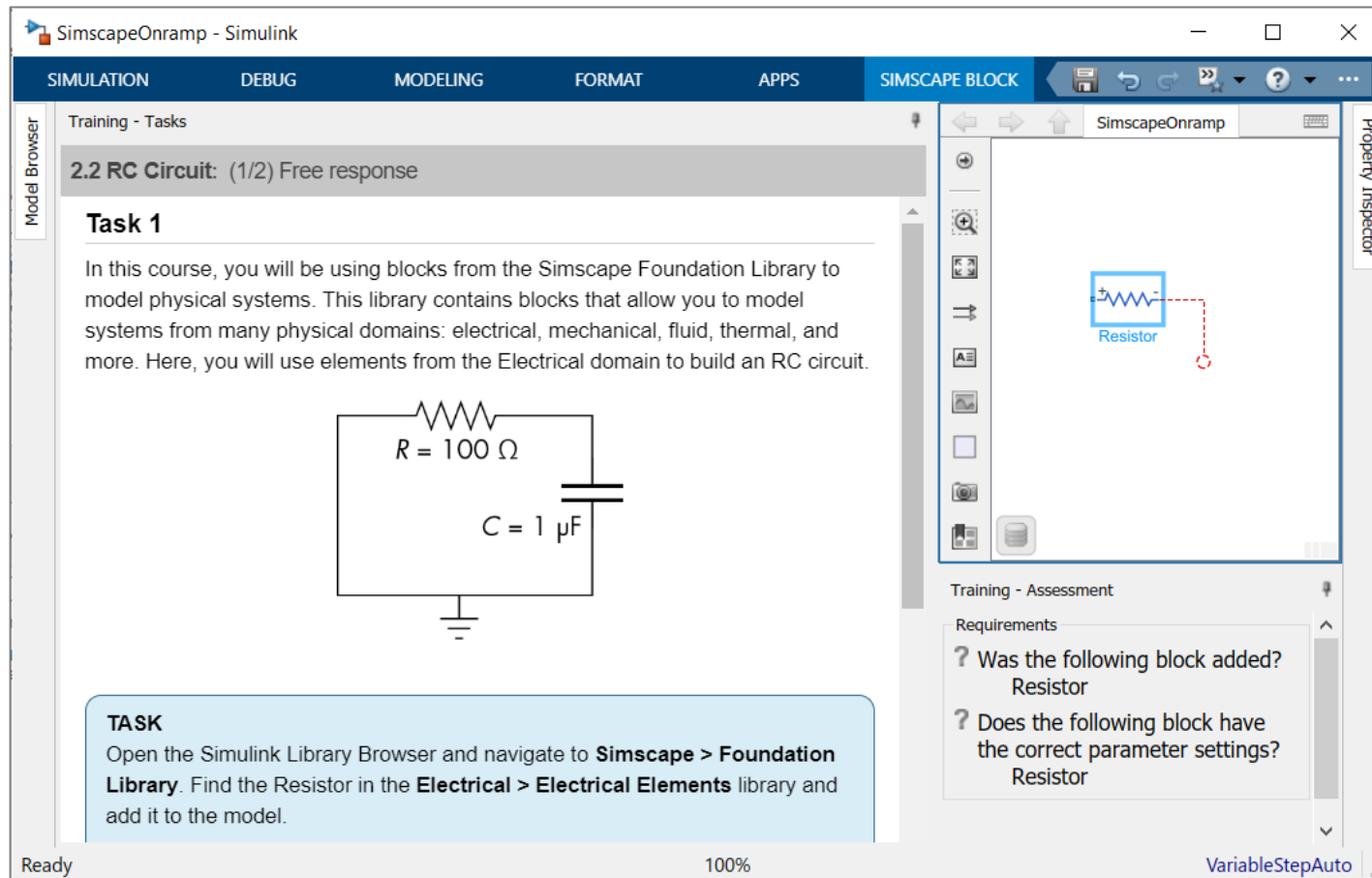


Simulink-PS Converter



Simscape Onramp

Interaktywny tutorial wprowadzający do pracy w środowisku Simscape

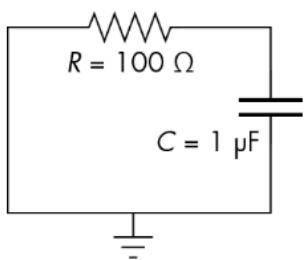


Training - Tasks

2.2 RC Circuit: (1/2) Free response

Task 1

In this course, you will be using blocks from the Simscape Foundation Library to model physical systems. This library contains blocks that allow you to model systems from many physical domains: electrical, mechanical, fluid, thermal, and more. Here, you will use elements from the Electrical domain to build an RC circuit.



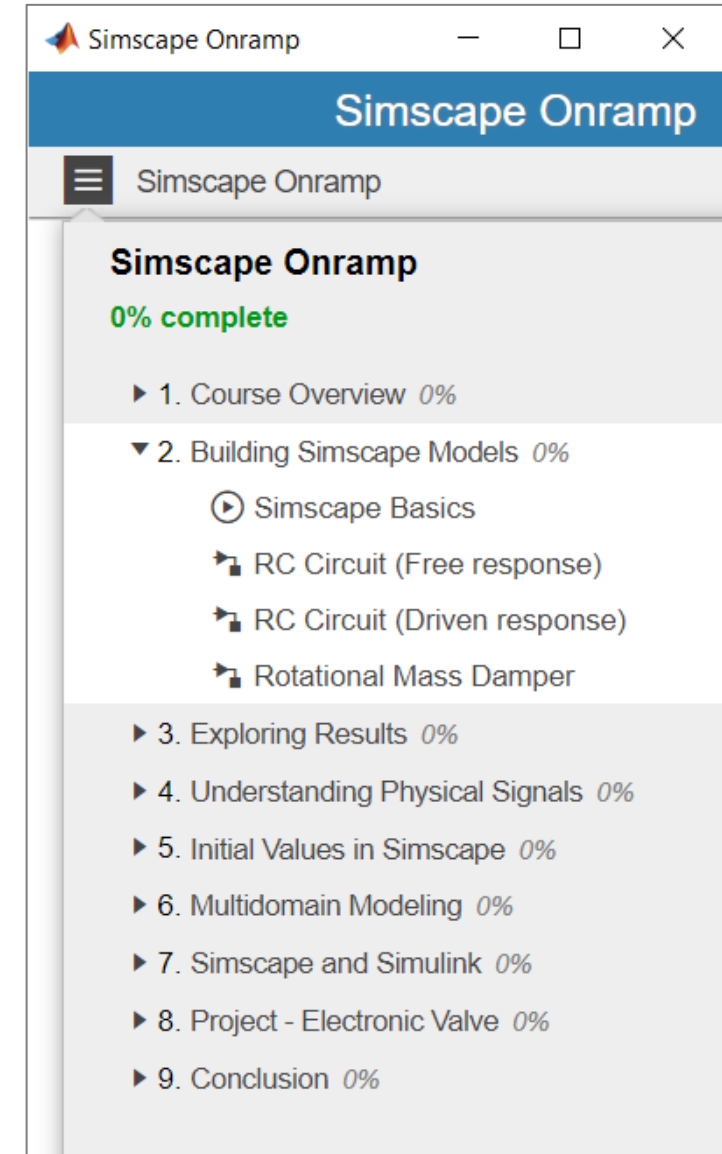
TASK
 Open the Simulink Library Browser and navigate to **Simscape > Foundation Library**. Find the Resistor in the **Electrical > Electrical Elements** library and add it to the model.

Training - Assessment

Requirements

- ? Was the following block added?
Resistor
- ? Does the following block have the correct parameter settings?
Resistor

Ready 100% VariableStepAuto



Simscape Onramp

Simscape Onramp

Simscape Onramp

0% complete

- ▶ 1. Course Overview 0%
- ▼ 2. Building Simscape Models 0%
 - ▶ Simscape Basics
 - ▶ RC Circuit (Free response)
 - ▶ RC Circuit (Driven response)
 - ▶ Rotational Mass Damper
- ▶ 3. Exploring Results 0%
- ▶ 4. Understanding Physical Signals 0%
- ▶ 5. Initial Values in Simscape 0%
- ▶ 6. Multidomain Modeling 0%
- ▶ 7. Simscape and Simulink 0%
- ▶ 8. Project - Electronic Valve 0%
- ▶ 9. Conclusion 0%

Zastosowania Simscape



Ellio opracowało rower elektryczny z napędem na dwa koła za pomocą Simulinka/Simscape Driveline



Koncern GM opracował układ napędowy Two-Mode Hybrid przy pomocy Model-Based Desing.



Toyota usprawniła swoje układy napędowe dzięki zastosowaniu oprogramowania firmy MathWorks, a w szczególności Simscape



Zalety modelowania w Simscape

Wielodomenowe
modele Simscape

Gotowe bloki ze
specjalistycznymi
funkcjami

Łatwa obserwacja
wyników
symulacji

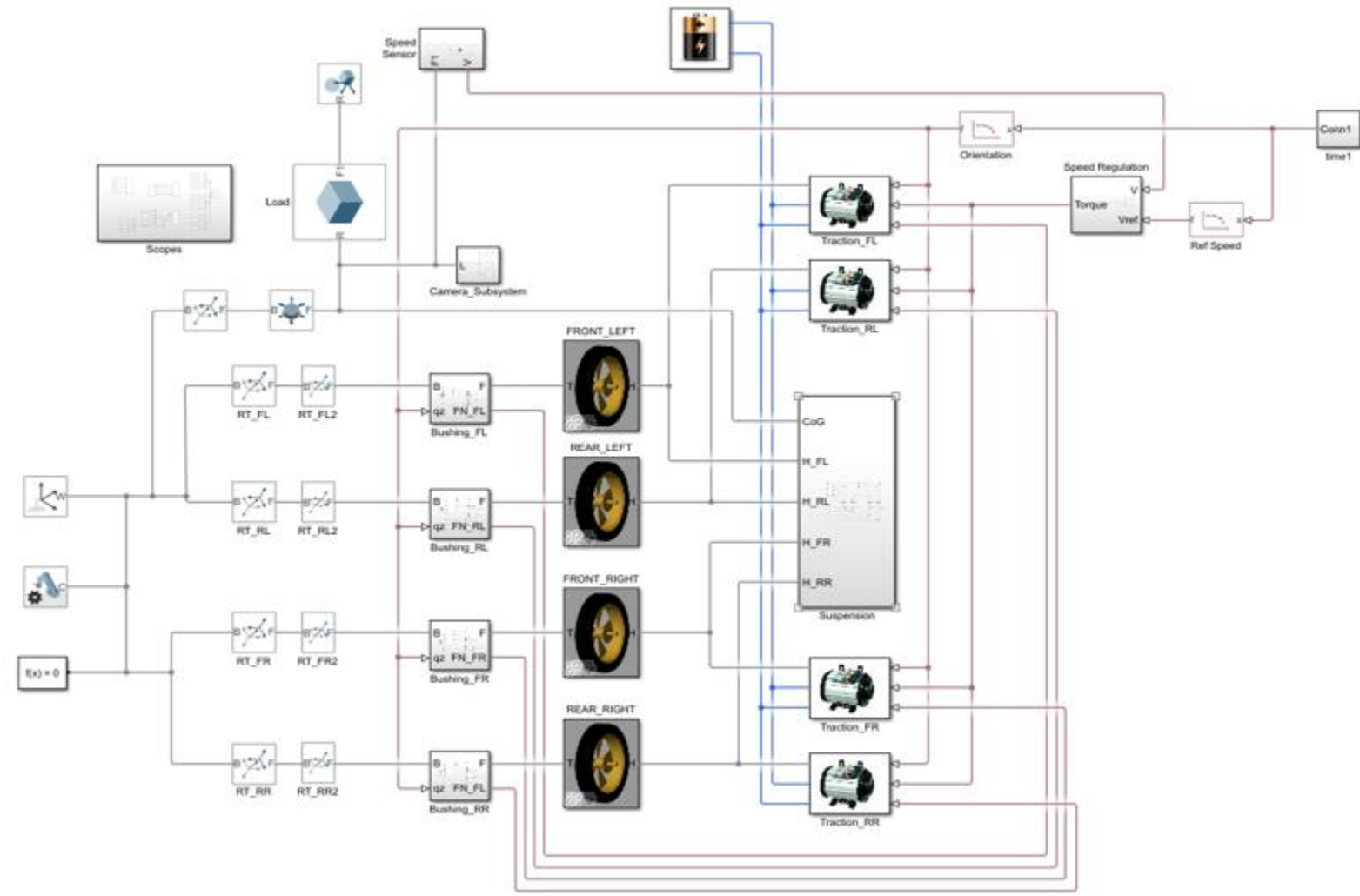
Modelowanie w
jednym
środowisku

Dostęp do
szerokiej bazy
dokumentacji

Zadania warsztatowe

- Ćwiczenie 1: Spring-damper
- Ćwiczenie 2: Electric Drivetrain
- Ćwiczenie 3: Battery Management
- Ćwiczenie 4: Vehicle Dynamics

Warsztaty



Objectives of the workshop

- Exercise 1: Spring-damper
 - Gain familiarity with physical network modeling
- Exercise 2: Electric Drivetrain
 - Build a physical model gradually
- Exercise 3: Battery Management
 - Enable supervision of a critical system i.e. Battery
- Exercise 4: Vehicle Dynamics
 - Introduce vehicle dynamics concepts with Simscape Multibody/Driveline



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ONT MATLAB

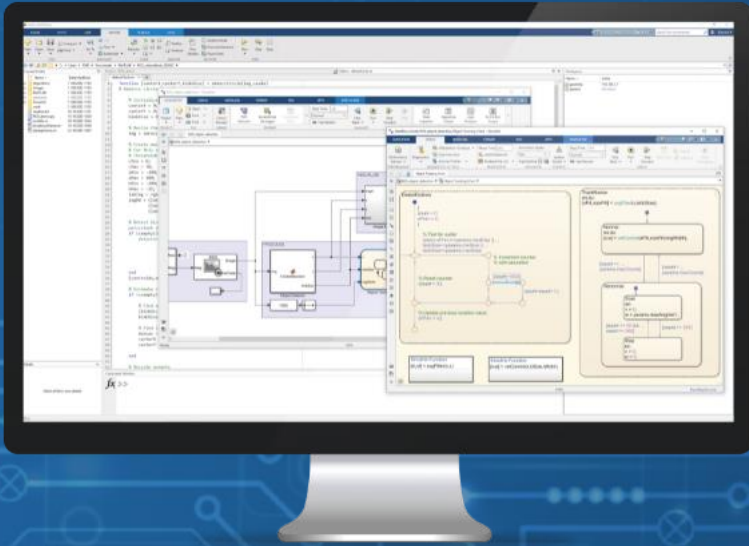


Konrad Grzybowski

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OBSZARY ZASTOSOWANIA



- ▶ Automatyka i robotyka
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- ▶ Pojazdy autonomiczne
- ▶ Inżynieria biomedyczna
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- ▶ Systemy elektroenergetyczne
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