Introduction to Simulink

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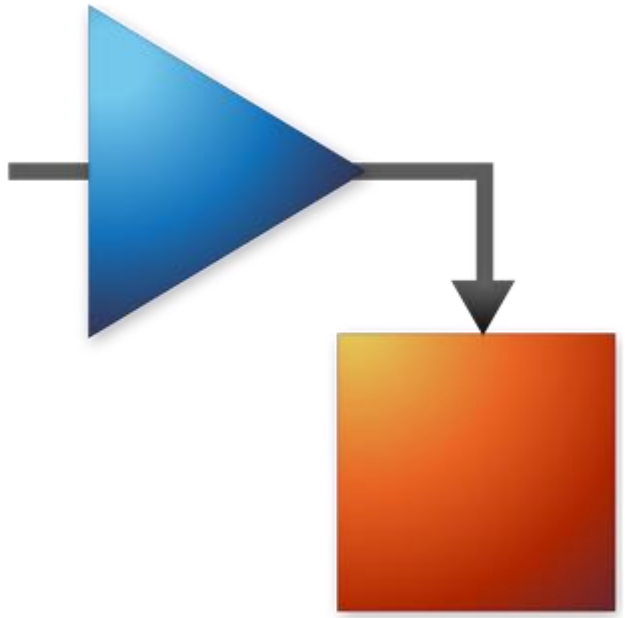


Outline

What is Simulink?

Working with Simulink

How Simulink works

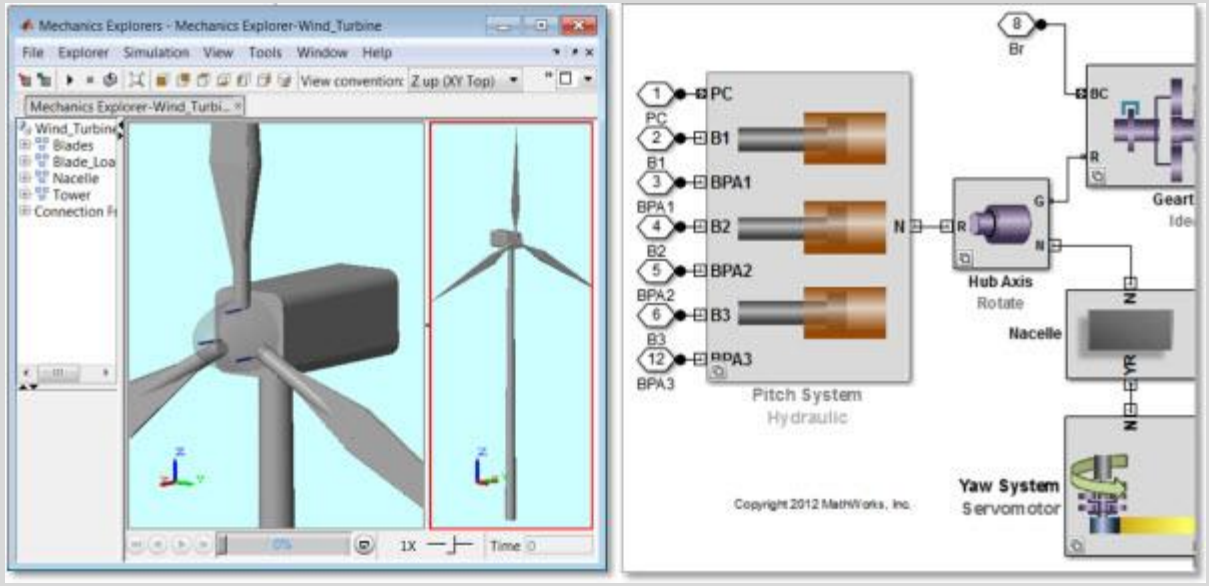
Decoupling models

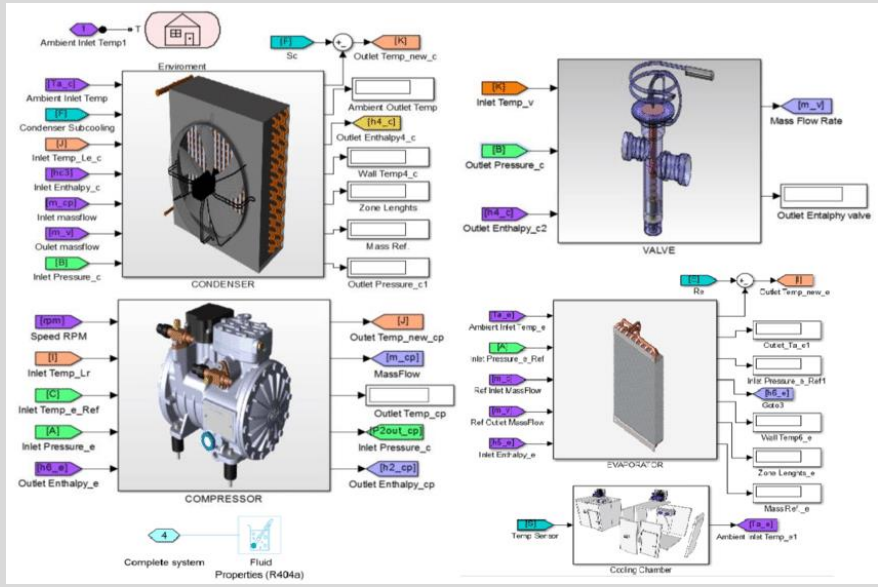
Continuous and discrete models

Simulink

Simulink is a software package for modeling, simulating, and analyzing dynamic systems:

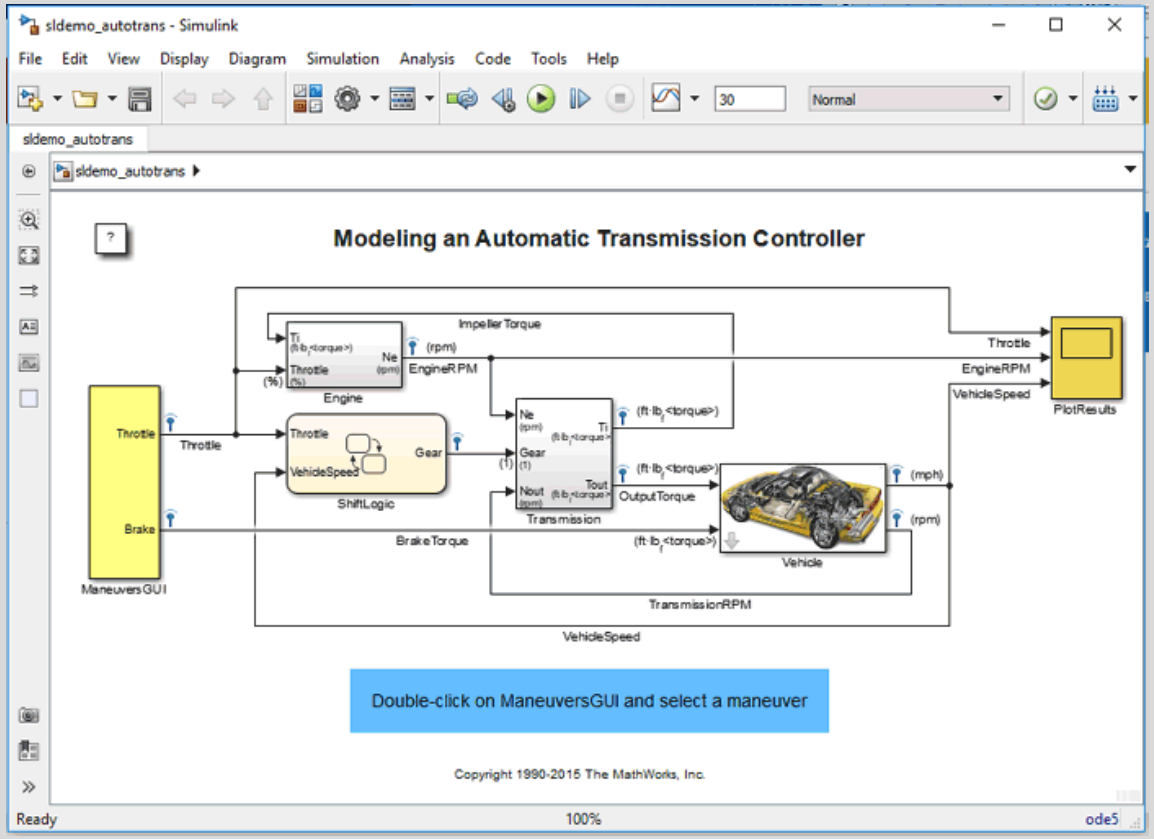
- Block diagram editing
- Non-linear simulation
- Hybrid (continuous and discrete) models
- Asynchronous (non-uniform sampling) simulation
- Fully integrated with MATLAB → MATLAB toolboxes and block sets





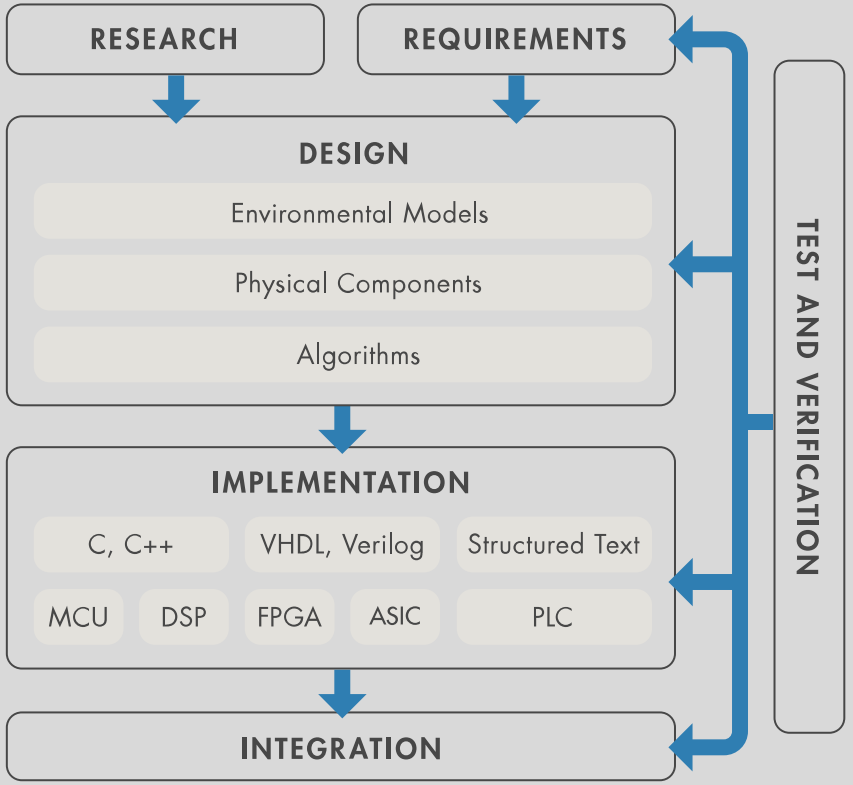
Simulink

- **Accurately design, implement, and test**:
  - Control systems
  - Signal Processing systems
  - Communications systems
  - Embedded systems
  - Physical systems
  - other Dynamical systems

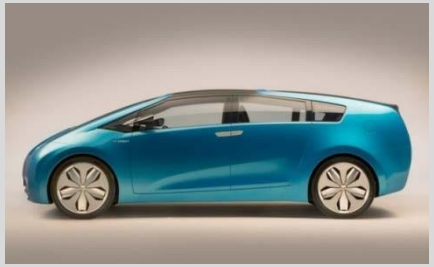


Model Based Design with Simulink

- **Definition:**
  - A *model* is defined as a representation of a system for the purpose of studying the system.
- **Types:**
  - Static vs. dynamic
  - Deterministic vs. stochastic
  - Discrete vs. continuous
- **Implementation:**
  - Automatic code generation
  - Rapid prototyping for HIL, SIL
  - Verification and validation



Simulink Applications



Bell Helicopter Develops the First Civilian Tiltrotor, Using Model-Based Design

The BA609, flying in airplane mode.

Challenge

To design and build the BA609, the first and fastest commercially available tiltrotor aircraft in the world

Solution

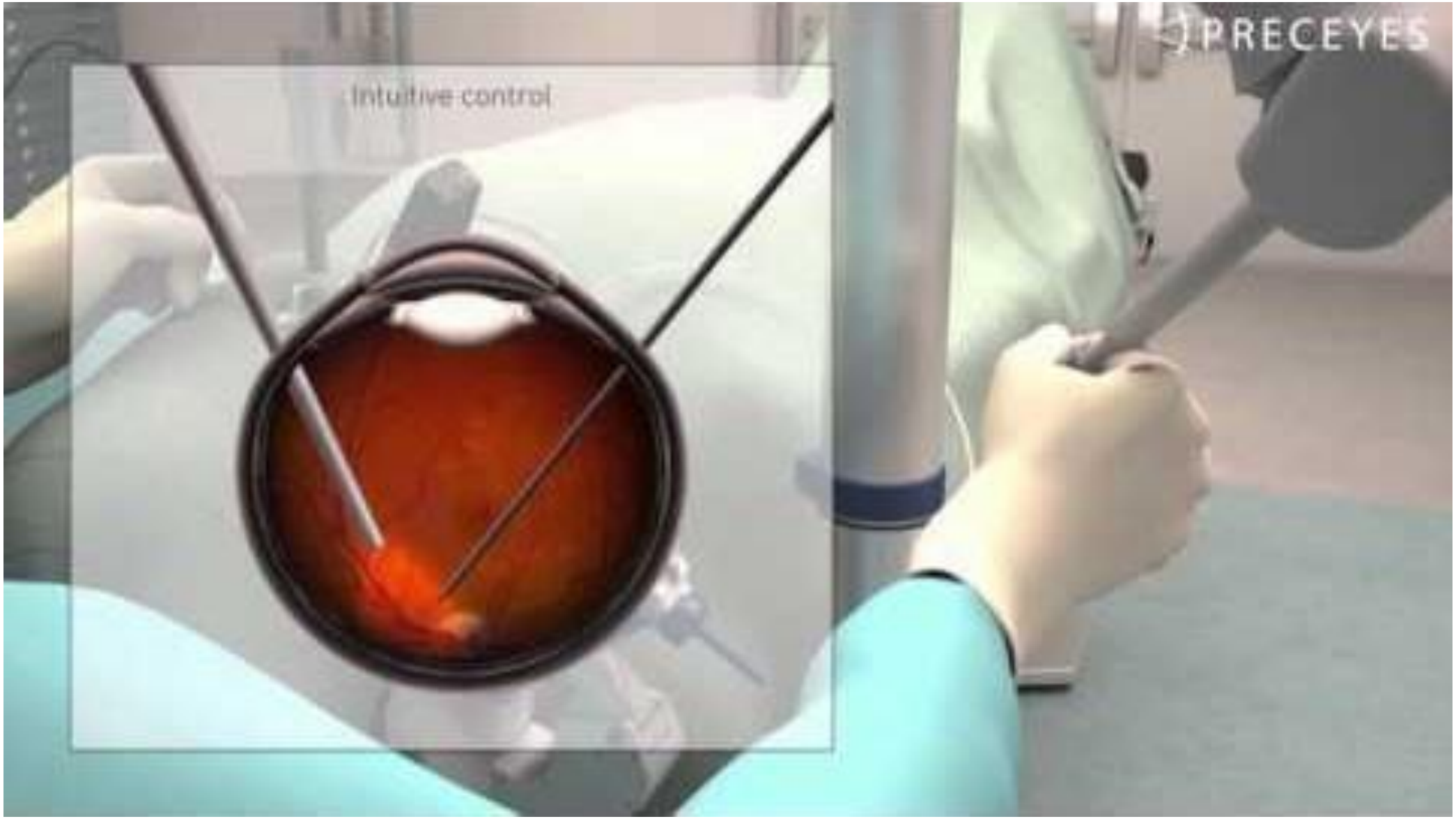
Use Model-Based Design with MATLAB, Simulink, and Real-Time Workshop software to model, simulate, test, and verify designs

Results

- Full collaboration with suppliers via Simulink models
- Flight control system code generated automatically from models
- 40% improvement in design and development time
- Flawless first flight, which went exactly like the simulation

"Simulations and a rapid, iterative approach enabled us to minimize the unknowns and ensure that we had established enough margin that when we ran into a surprise we could continue to have a safe flight test program—and run it with unprecedented efficiency."

David King
Bell Helicopter


intuitive control
PRECEYES

PRECEYES Accelerates Development of World's First Eye-Surgery Robot Using Model-Based Design

Challenge

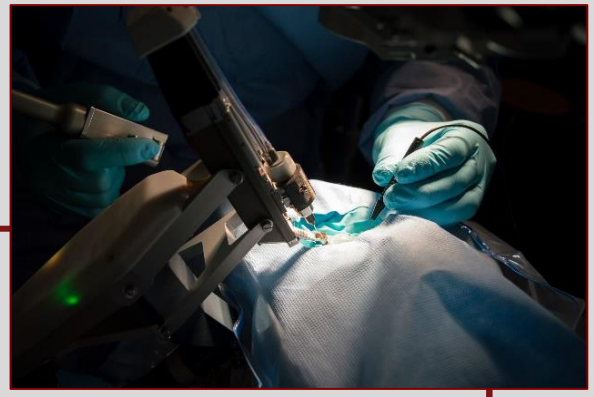
Develop a real-time control system for robot-assisted surgical procedures performed within the human eye

Solution

Use Model-Based Design with MATLAB and Simulink to model and simulate the control system and use Simulink Coder and Simulink Real-Time to deploy it to a real-time target

Results

- Core controller developed by one engineer
- Patient safety assured
- Road map to industrialization set



The PRECEYES Surgical System

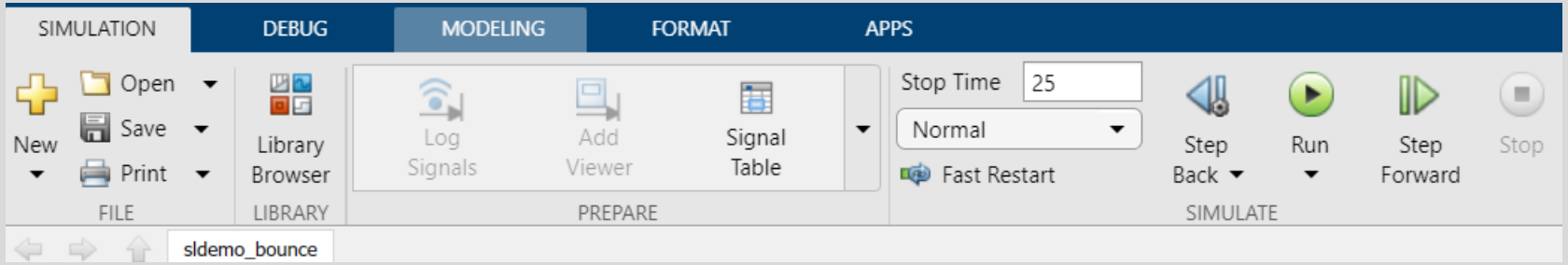
"MATLAB and Simulink provided a single platform that supported our complete workflow and all the components and protocols we needed for our robotic system. That enabled us to quickly develop a safe, real-time device, ready for clinical investigation."

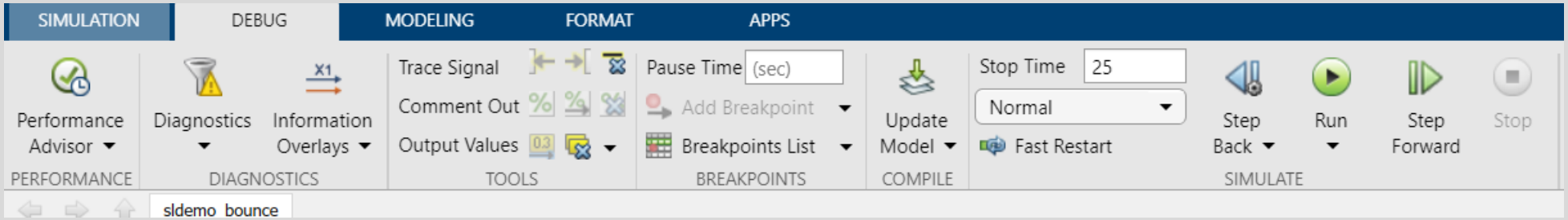
Maarten Beelen, PRECEYES

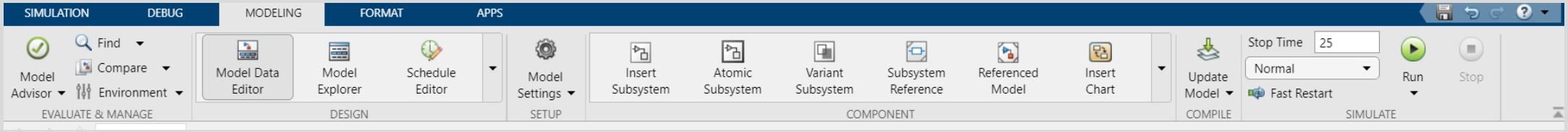
Outline

- Why Simulink?
- **Working with Simulink**
- How Simulink works
- Decoupling models
- Continuous and discrete models

Simulink Toolbar



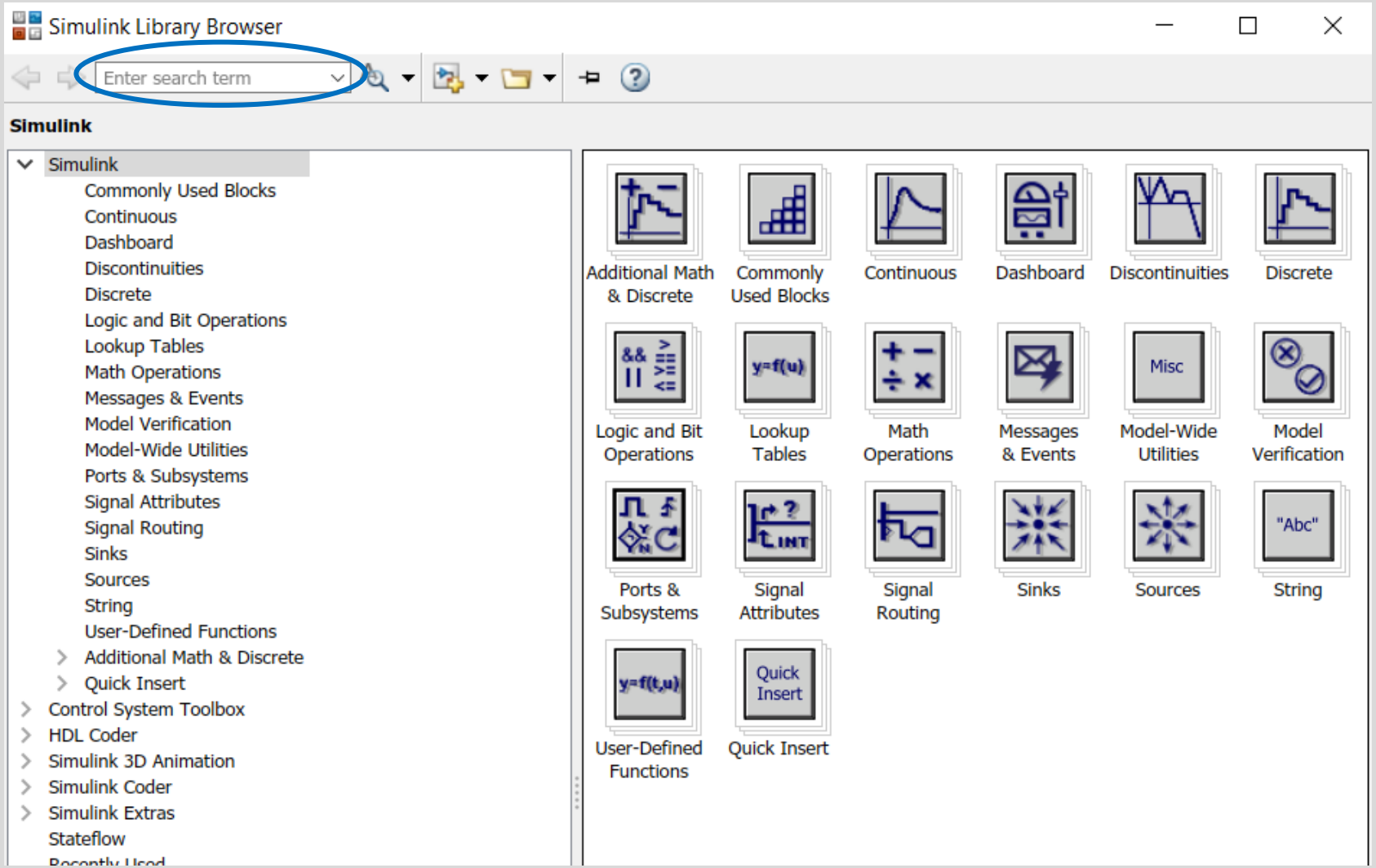




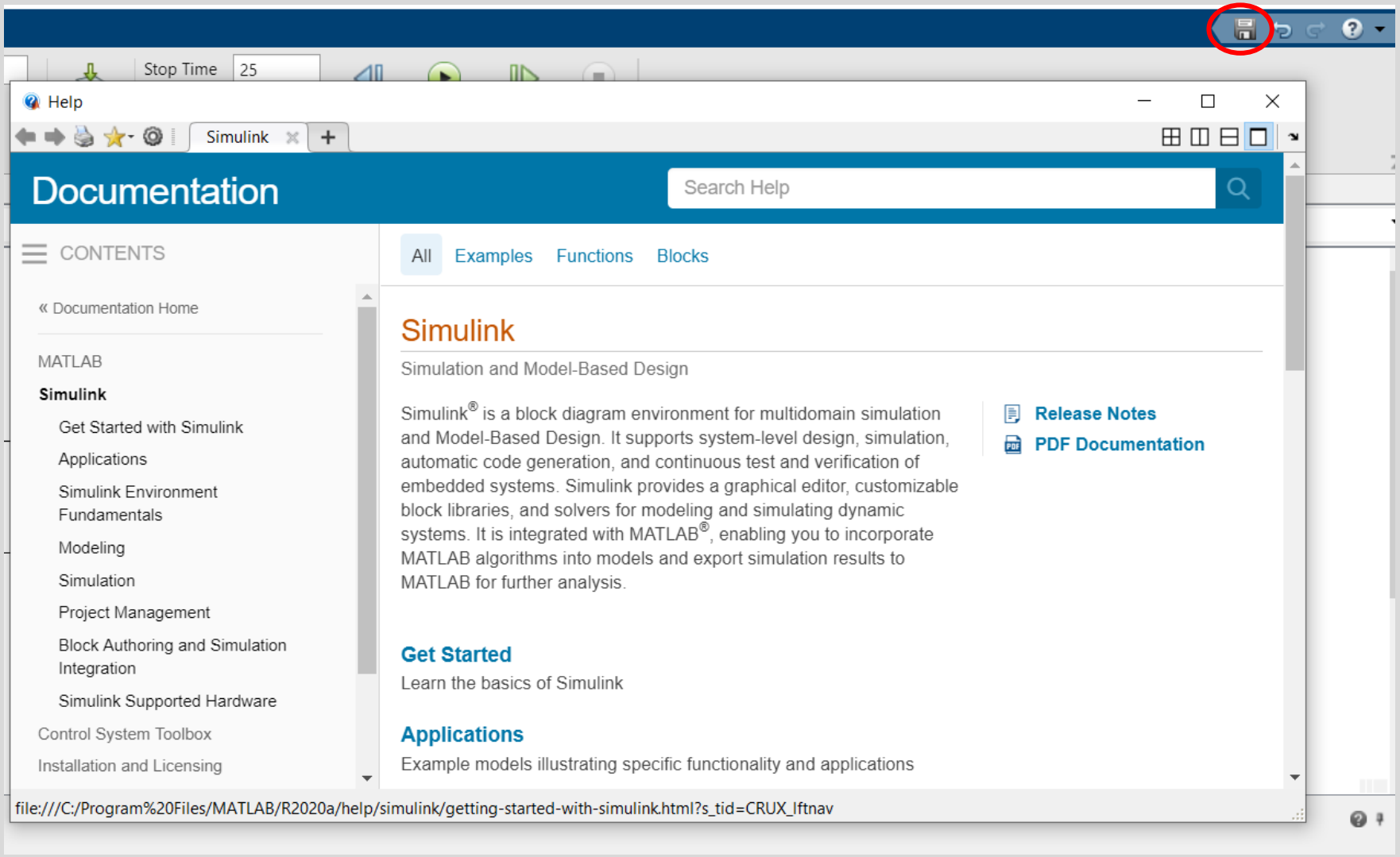
Overview of the library

Library Name	Examples
Sources	Constant, Sine Wave, Steps
Sinks	Scope, XY Graphs
Math operations	Add, divide, absolute
Ports & subsystems	Subsystem, Enable port, Inputs and Outputs: In1 and Out1
User defined functions	Fcn, MATLAB Fcn
Lookup tables	1D Lookup table
Signal Routing	Mux, BusCreator, Goto, Switch
Continouse	Integrator, Derivative
Discrete	Unit delay, Discrete Derivative
Logical and Bit operations	Compare to Zero, Logical operators

Finding Blocks



Getting Help



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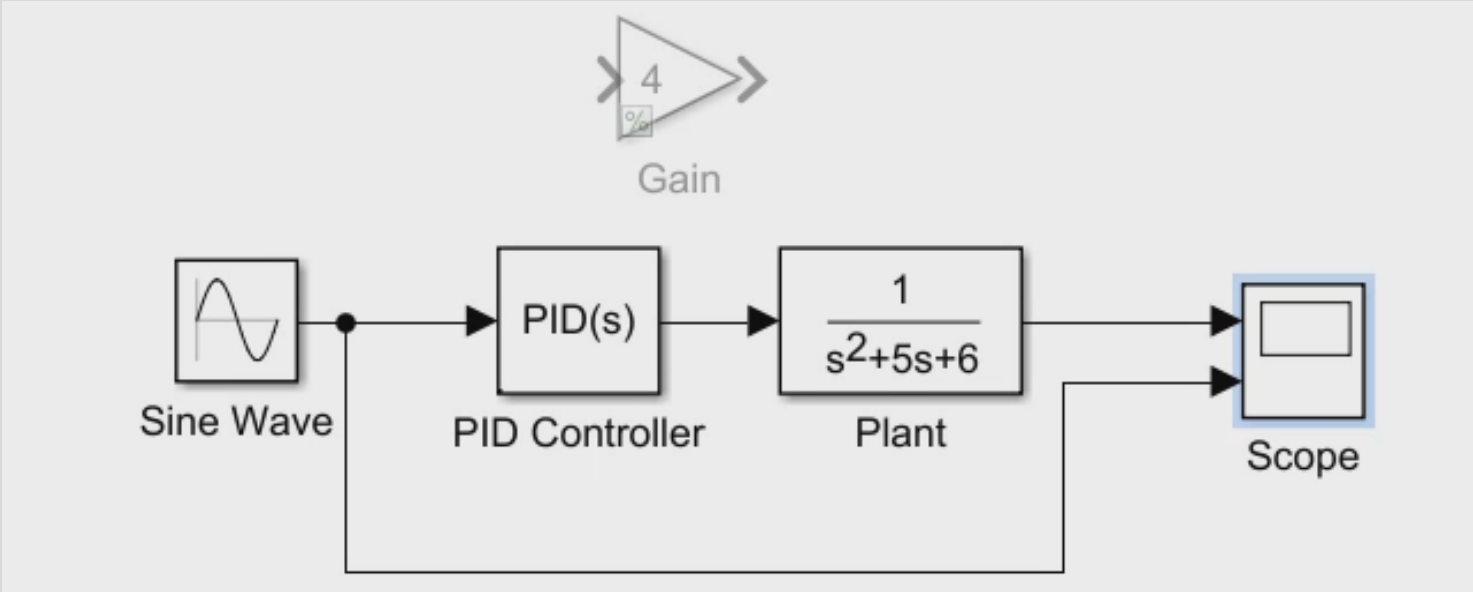
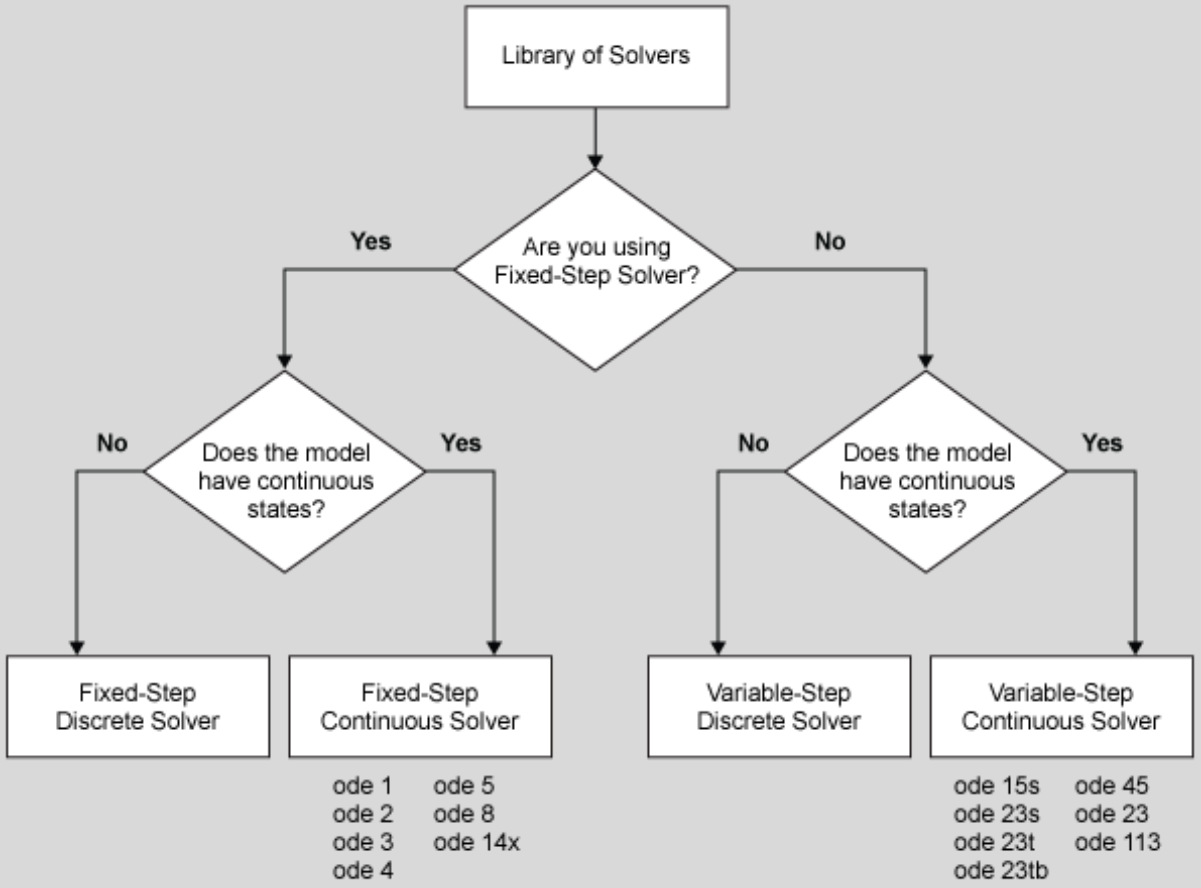
How Simulink Works

- Engine provides variable-step and fixed-step ODE solvers
- Block diagram representation of dynamic systems
- Blocks define governing equations
- Signals are propagated between blocks over time



Simulink Solvers

- **Solver**:
  - Determines solution at current time step
  - Determines the next simulation time step
  - MATLAB naming convention: *ode*
- **Selection Criteria**:
  - System dynamics
  - Solution stability
  - Computation speed
  - Solver robustness



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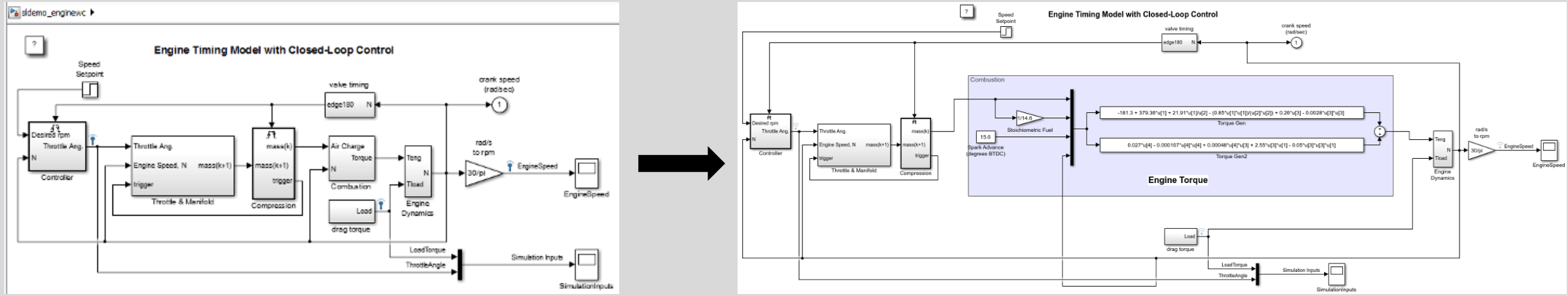
- Continuous and discrete models

Subsystems

- Group blocks into functional subsystems, ***create model hierarchy***.
- As a model increases in size and complexity, you can simplify it by grouping blocks into subsystems. A subsystem is a set of blocks that you group into a single Subsystem block.
- **Using subsystems**:
  - Establishes a hierarchical block diagram, where a Subsystem block is on one layer and the blocks that make up the subsystem are on another.
  - Keeps functionally related blocks together.
  - Helps reduce the number of blocks displayed in your model window.
  - Establishes an interface with inputs and outputs.

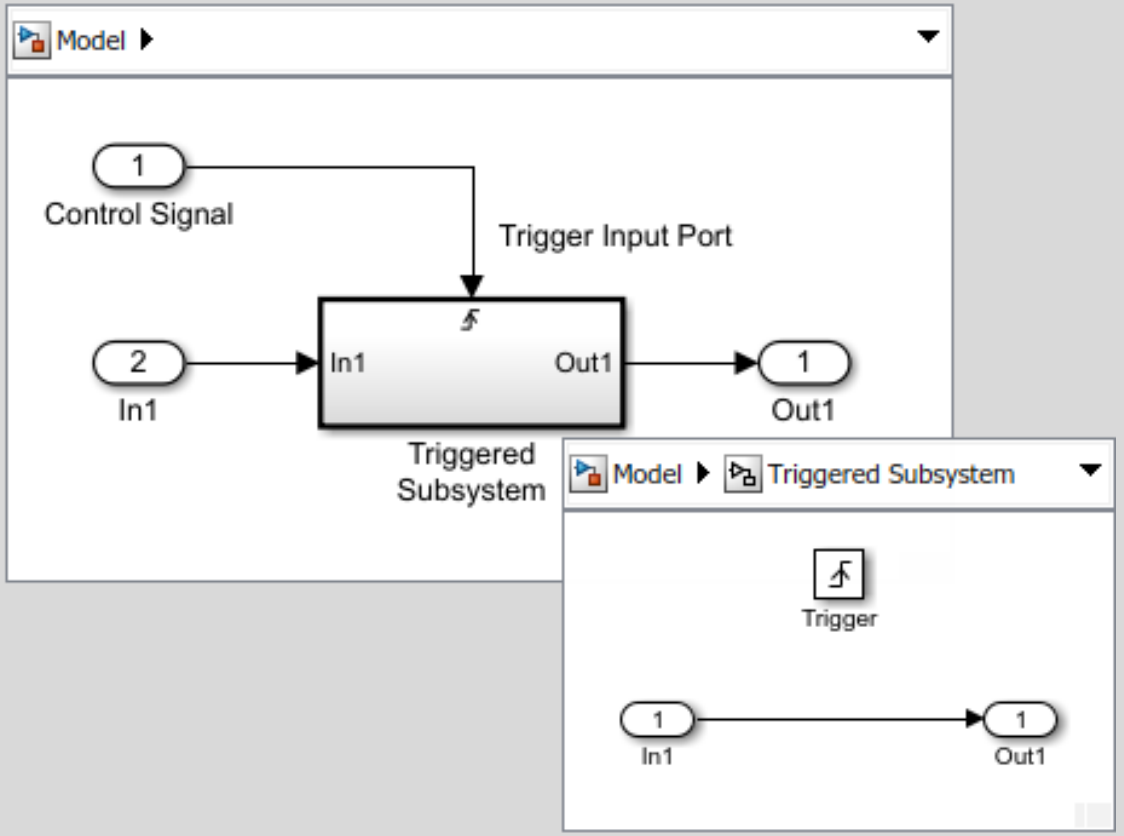
Creating Subsystems

- **To create a subsystem, you can:**
  - In the Simulink Editor, double-click and start typing the subsystem type, then select the corresponding block from the menu.
  - In the Simulink Editor, drag a selection box to outline the subsystem that you want to create, then select the subsystem type.
  - Drag a Subsystem block from the Library Browser.
  - Copy and paste a Subsystem block from a model.



Model Referencing

- One model in another – ***parent and referenced model***
- **Advantages**:
  - Modular development
  - Model protection
  - Inclusion by reference
  - Incremental loading
  - Accelerated simulation
  - Incremental code generation
  - Independent configuration sets



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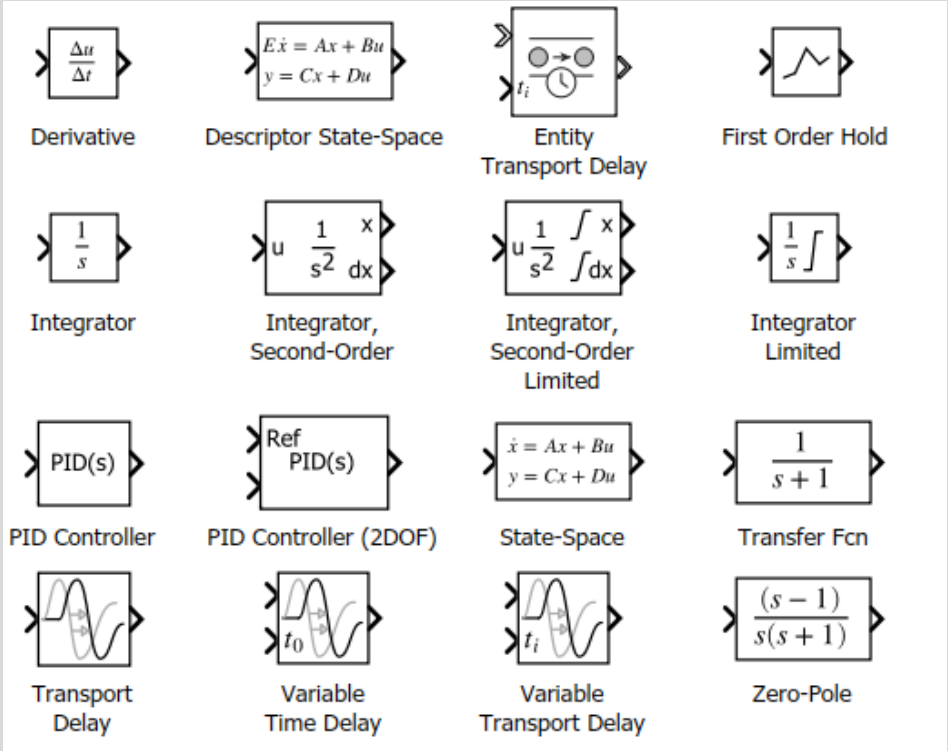
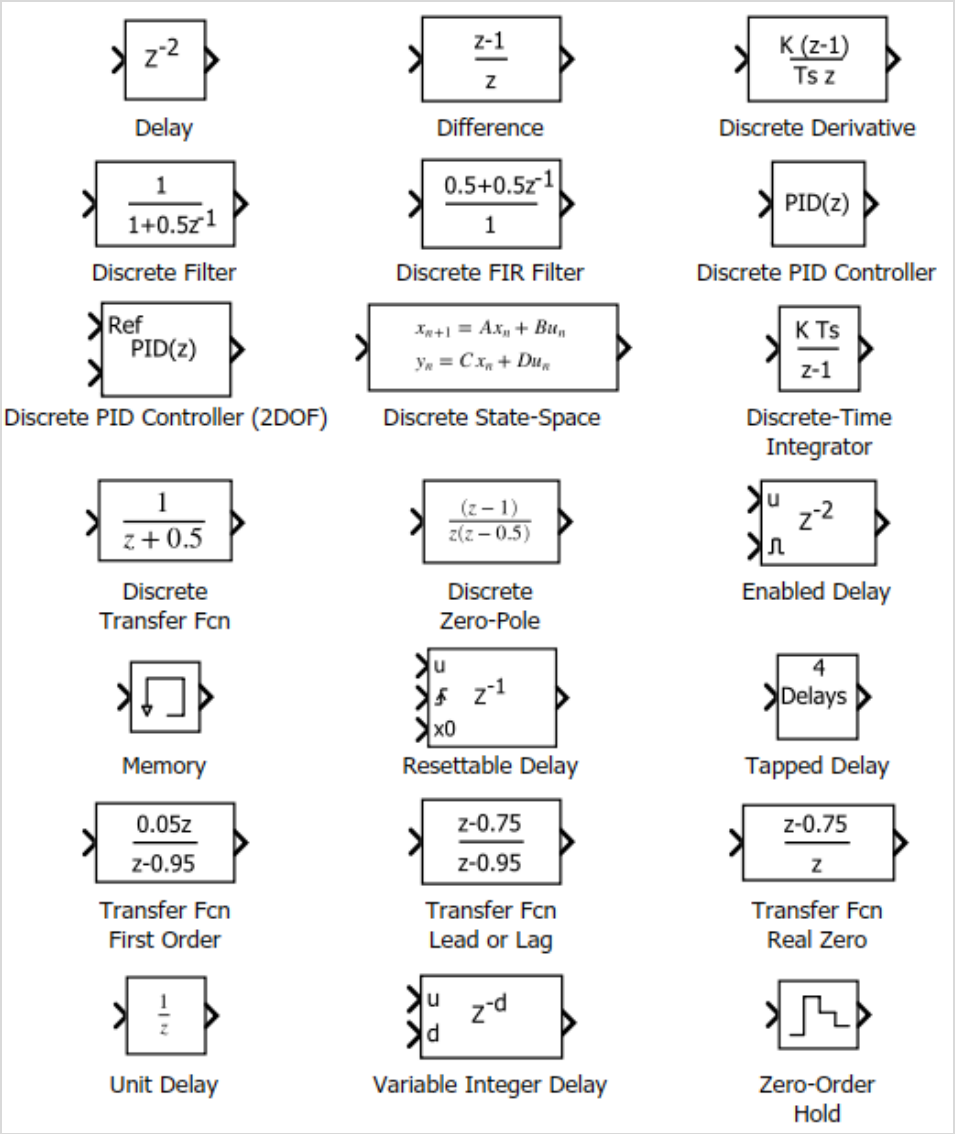
‘Continuous’ Library

- Use blocks from the Continuous library to model ***differential equations***.
  - Time derivative of a signal.
  - Integrate or delay a signal.
  - Model PID controllers and linear systems using transfer function or state-space representations.



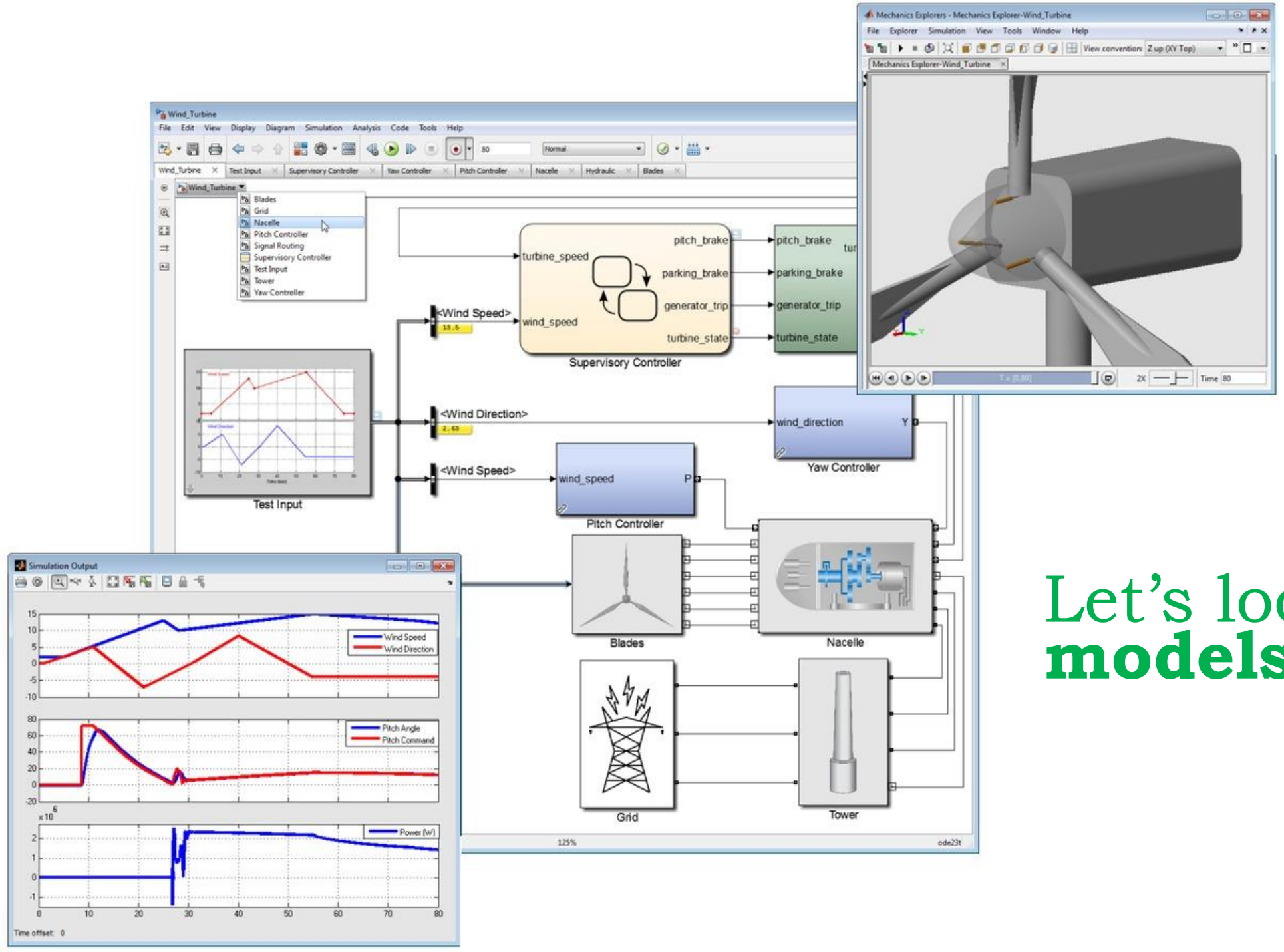
‘Discrete’ Library

- Use blocks from the Discrete library to model ***recurrence equations***.
- Discrete time function blocks such as Unit Delay.



Summary

- Why Simulink?
- Working with Simulink
- How Simulink works
- Componentizing models
- Continuous and discrete models



Let's look at some **models** now!

Developer Student Clubs

Queen Mary, University of London

- Work in a team of 17 students, in collaboration with Google
- Leveraging Google products to solve local community challenges
- Check out the team and for future updates, do **join the chapter**: https://dsc.community.dev/queen-mary-university-of-london/

KAHOOT! Challenge

Will post all prizes by next day

All sizes available

First	1 x ***t-shirt*** 1 x ***baseball cap*** 1 x ***sunglasses*** 10 x ***pens***
Second	1 x ***drawstring bag*** 1 x ***baseball cap*** 10 x ***pens*** 20 x ***stickers***
Third	10 x ***pens*** 10 x ***stickers***

Thank you!

MATLAB® & SIMULINK®

Join the FB group to stay up to date with future events:

https://www.facebook.com/groups/196042678284982

The presentation can be downloaded from:

https://github.com/mughees-asif/matlab-qmul#queen-mary-matlab-tutorials