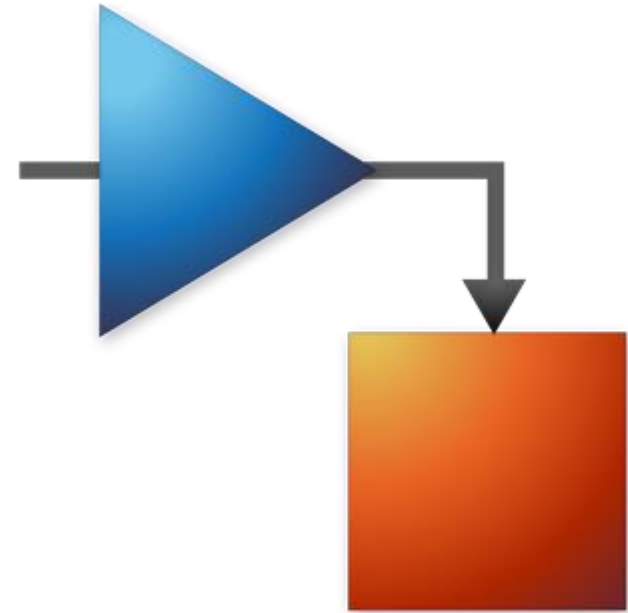


Introduction to Simulink

Mughees Asif

3rd Year Aerospace Engineering

QMUL MathWorks Student Ambassador



Outline

What is Simulink?

Working with Simulink

How Simulink works

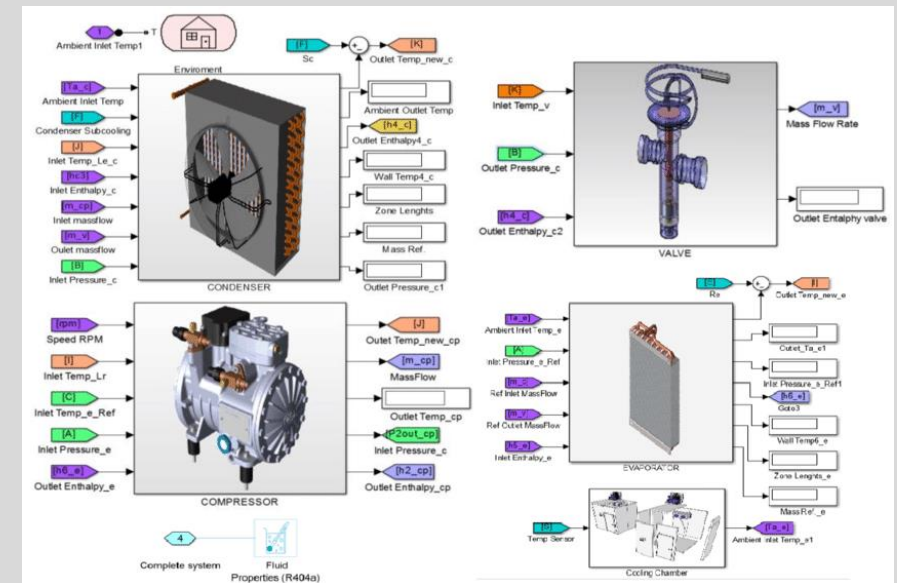
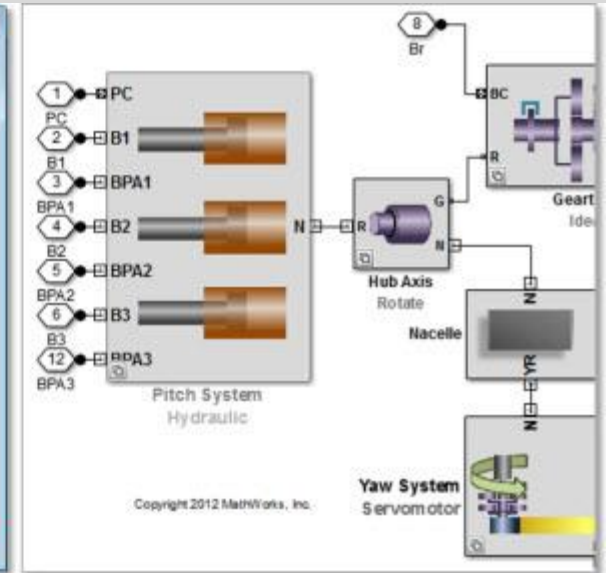
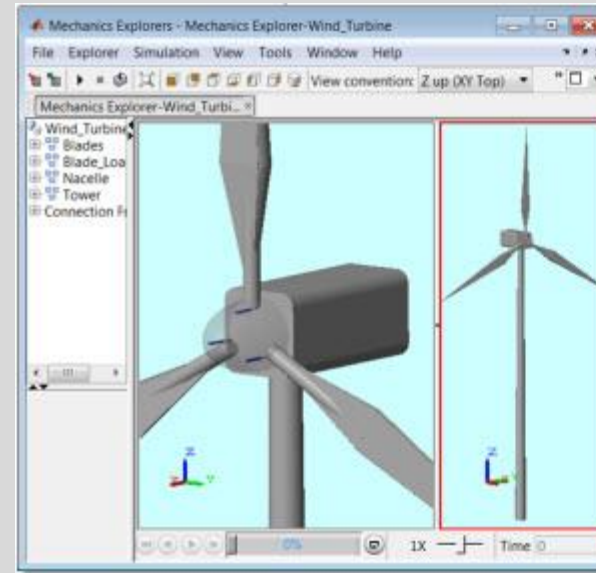
Decoupling models

Continuous and discrete models

Simulink

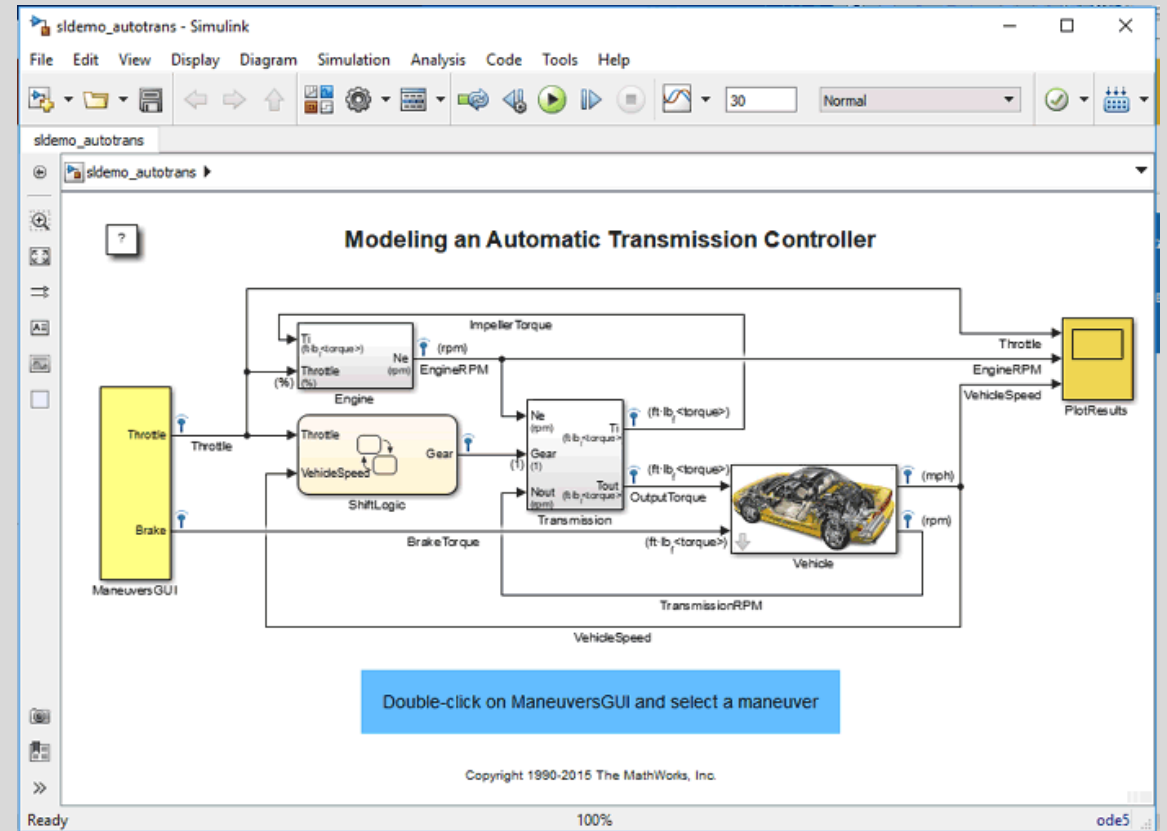
Simulink is a software package for modeling, simulating, and analyzing dynamic systems:

- 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



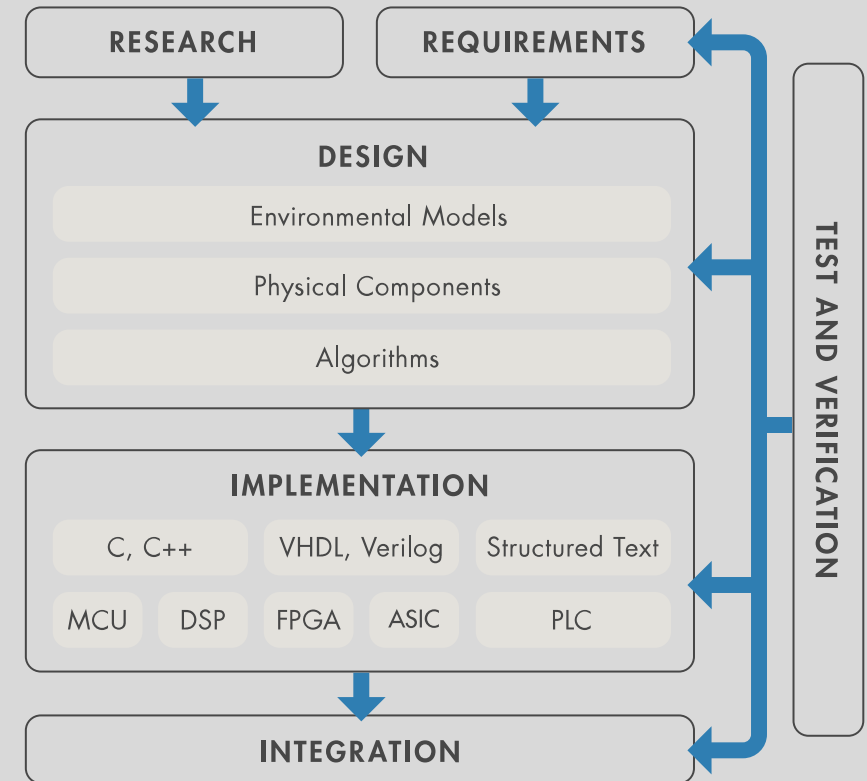
Simulink

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

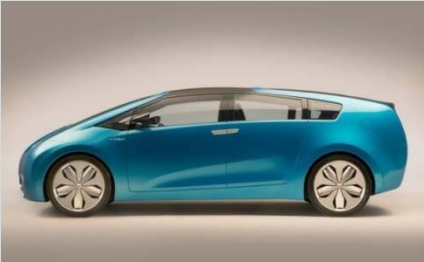


Model Based Design with Simulink

- **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

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

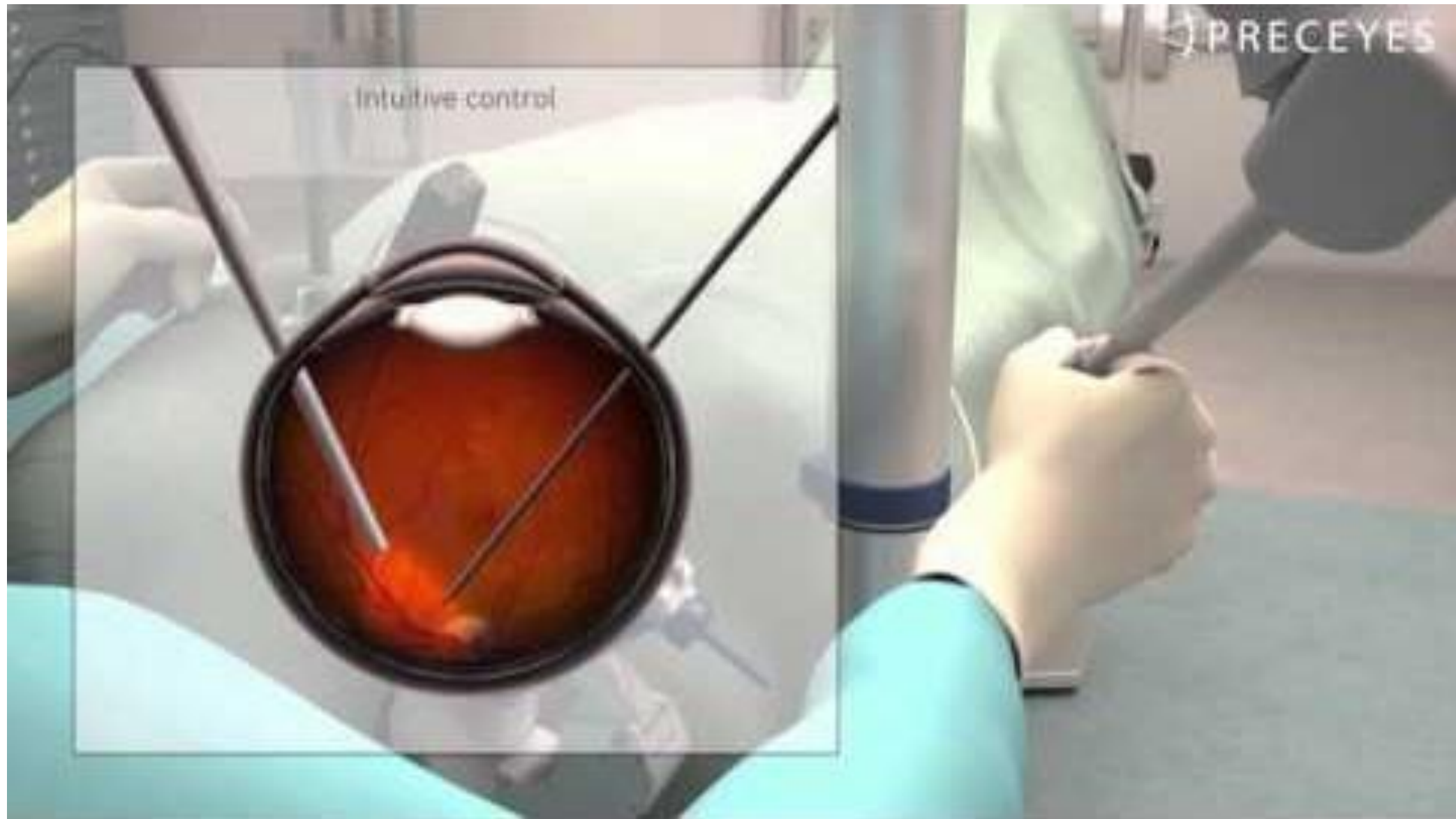


The BA609, flying in airplane mode.

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

Challenge

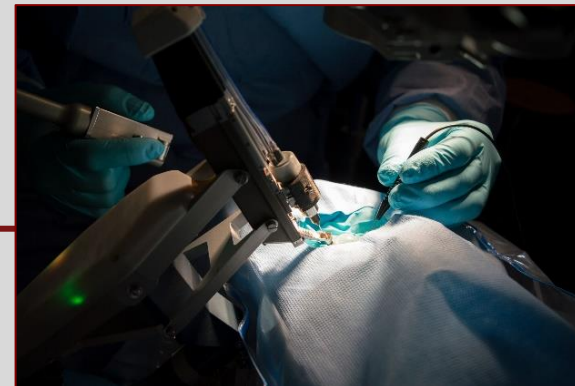
Develop a real-time control system for robot-assisted surgical procedures performed within the human eye

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?

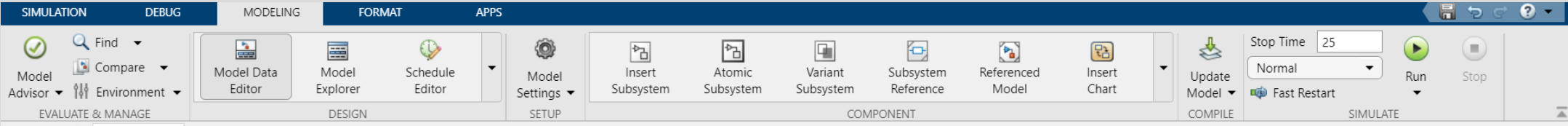
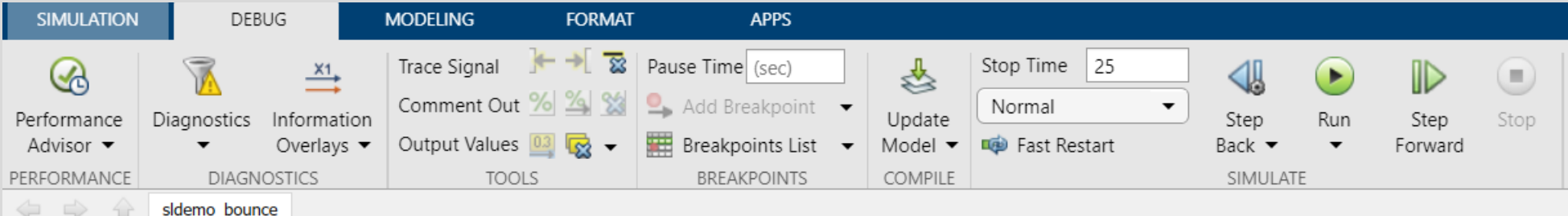
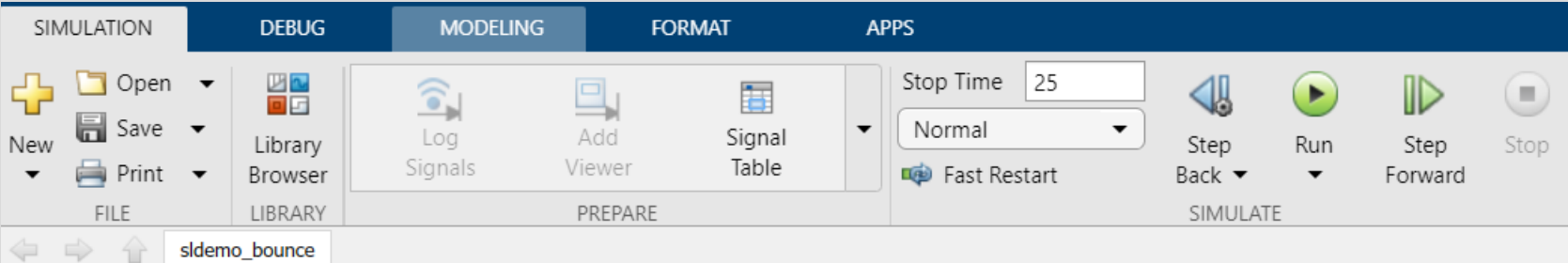
Working with Simulink

How Simulink works

Decoupling models

Continuous and discrete models

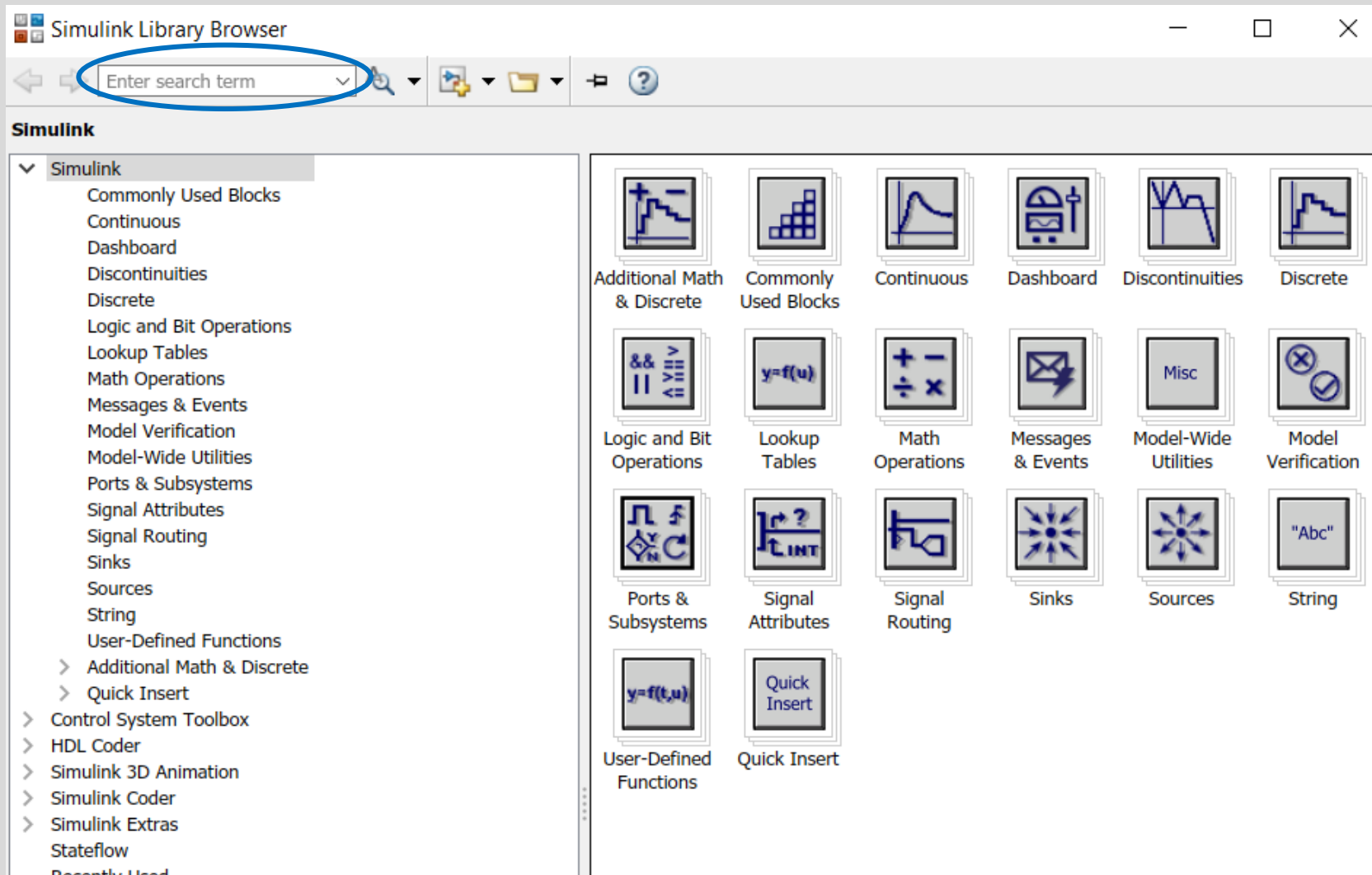
Simulink Toolbar



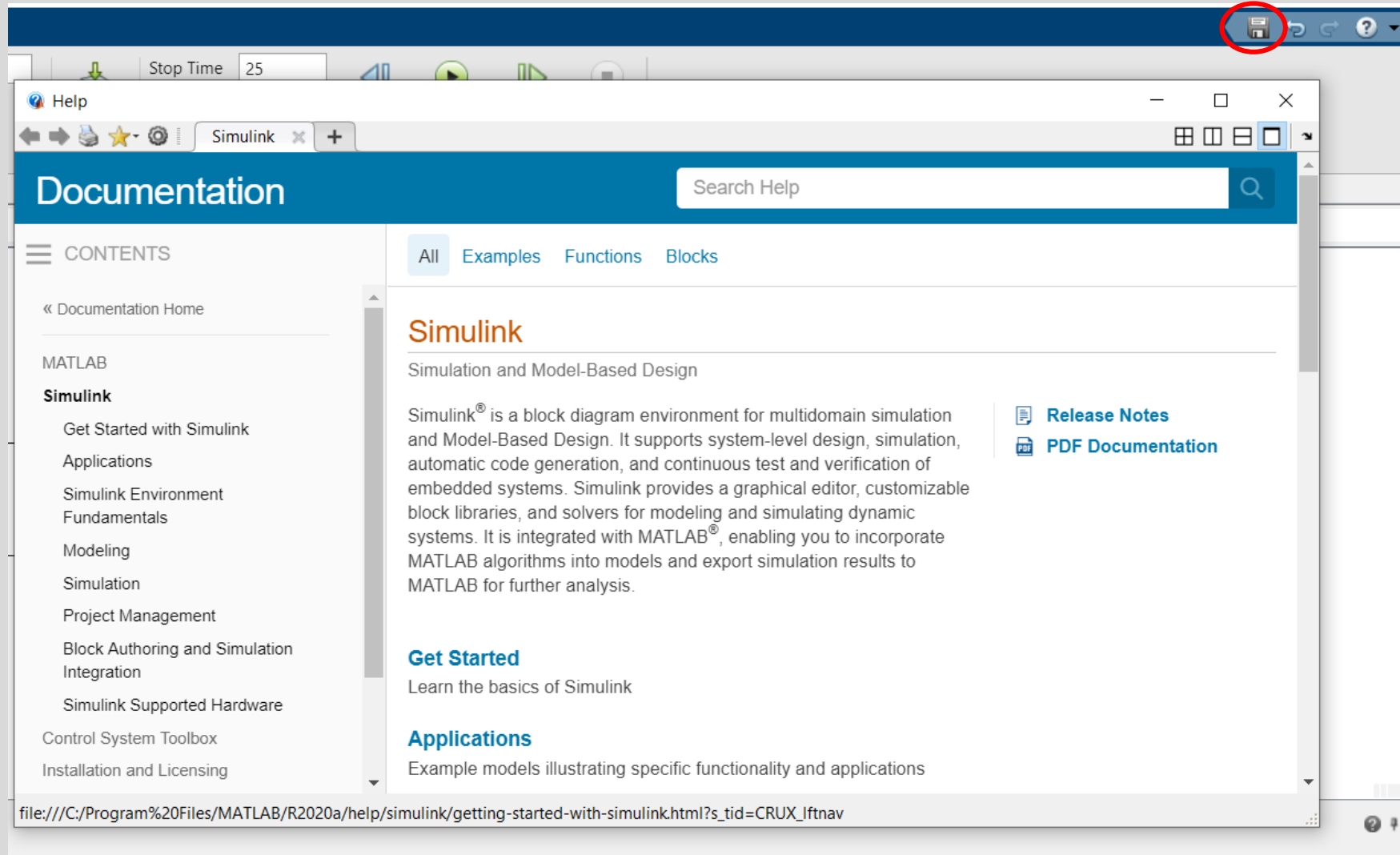
Overview of the library

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
Continuous	Integrator, Derivative
Discrete	Unit delay, Discrete Derivative
Logical and Bit operations	Compare to Zero, Logical operators

Finding Blocks



Getting Help



The screenshot shows the Simulink software interface with the Help window open. The Help window title is "Help" and it contains a "Documentation" page for Simulink. The page has a search bar and navigation tabs for "All", "Examples", "Functions", and "Blocks". The main content area displays the Simulink logo and a description: "Simulation and Model-Based Design. Simulink® is a block diagram environment for multidomain simulation and Model-Based Design. It supports system-level design, simulation, automatic code generation, and continuous test and verification of embedded systems. Simulink provides a graphical editor, customizable block libraries, and solvers for modeling and simulating dynamic systems. It is integrated with MATLAB®, enabling you to incorporate MATLAB algorithms into models and export simulation results to MATLAB for further analysis." There are also links for "Release Notes" and "PDF Documentation". A "Get Started" section with the text "Learn the basics of Simulink" and an "Applications" section with the text "Example models illustrating specific functionality and applications" are also visible. The left sidebar shows a "CONTENTS" menu with categories like "MATLAB" and "Simulink". The status bar at the bottom of the window shows the file path: "file:///C:/Program%20Files/MATLAB/R2020a/help/simulink/getting-started-with-simulink.html?s_tid=CRUX_lftnav". A red circle highlights the help icon in the top right corner of the Simulink interface.

Outline

Why Simulink?

Working with Simulink

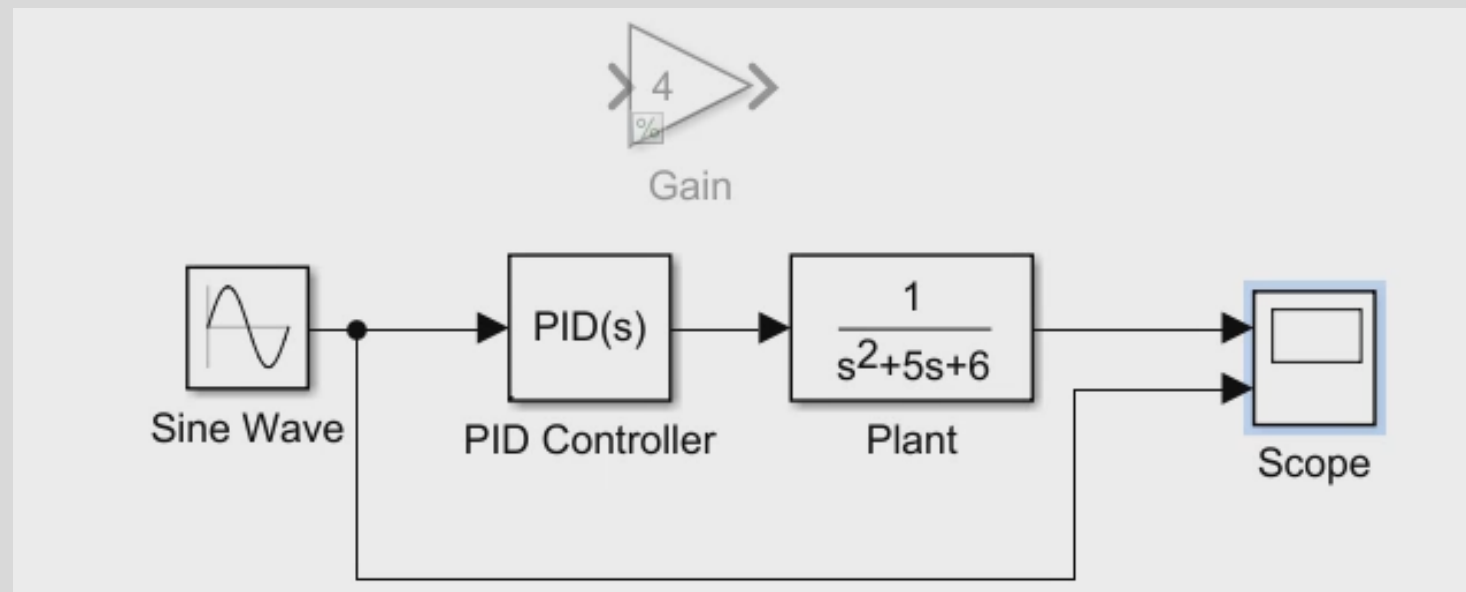
How Simulink works

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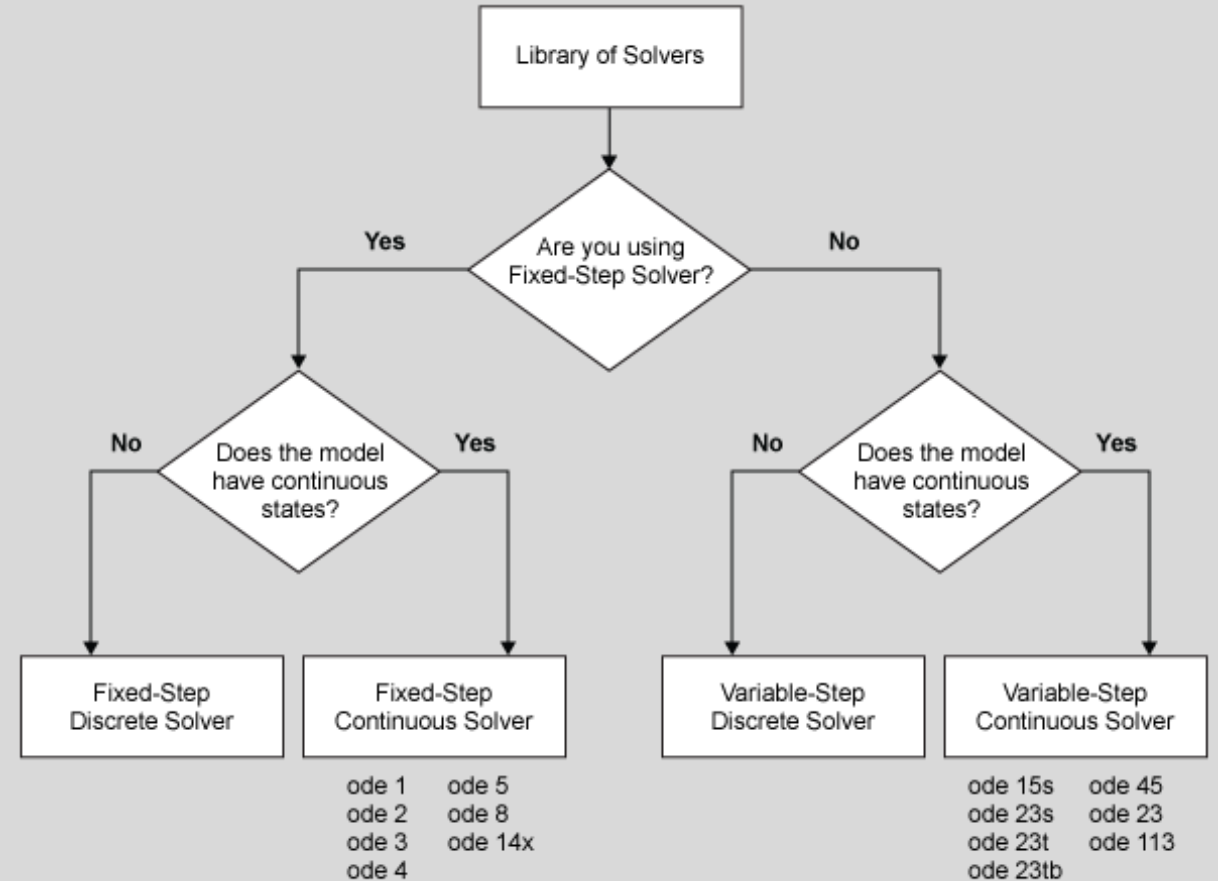
How Simulink Works

- 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



Outline

Why Simulink?

Working with Simulink

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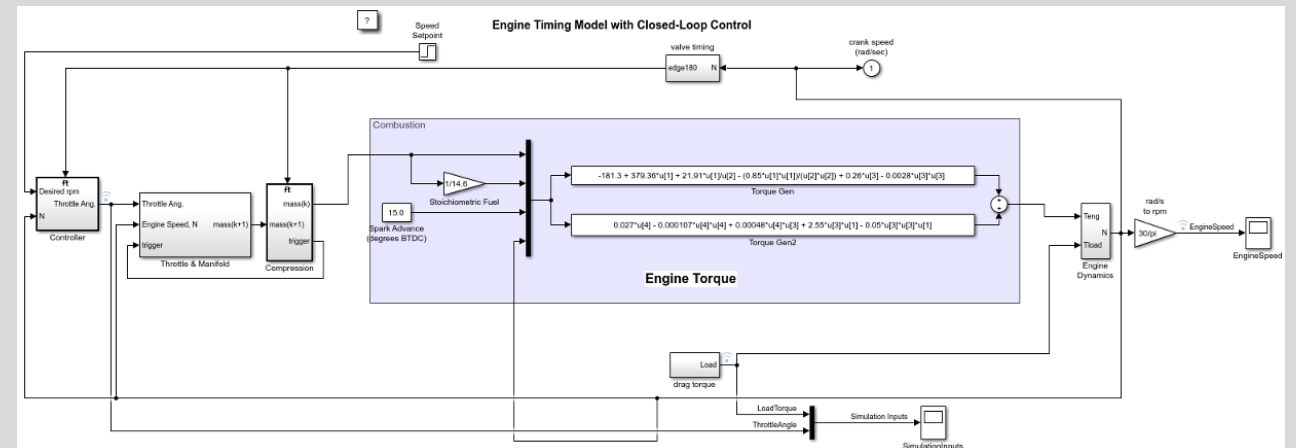
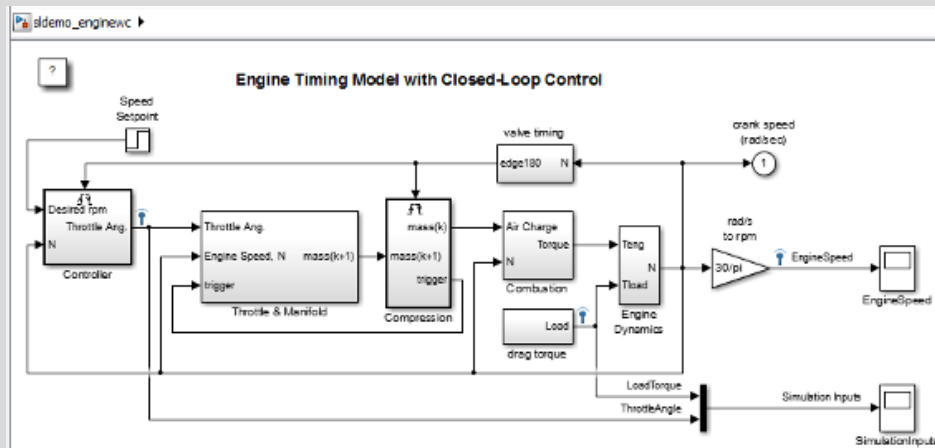
Continuous and discrete models

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.

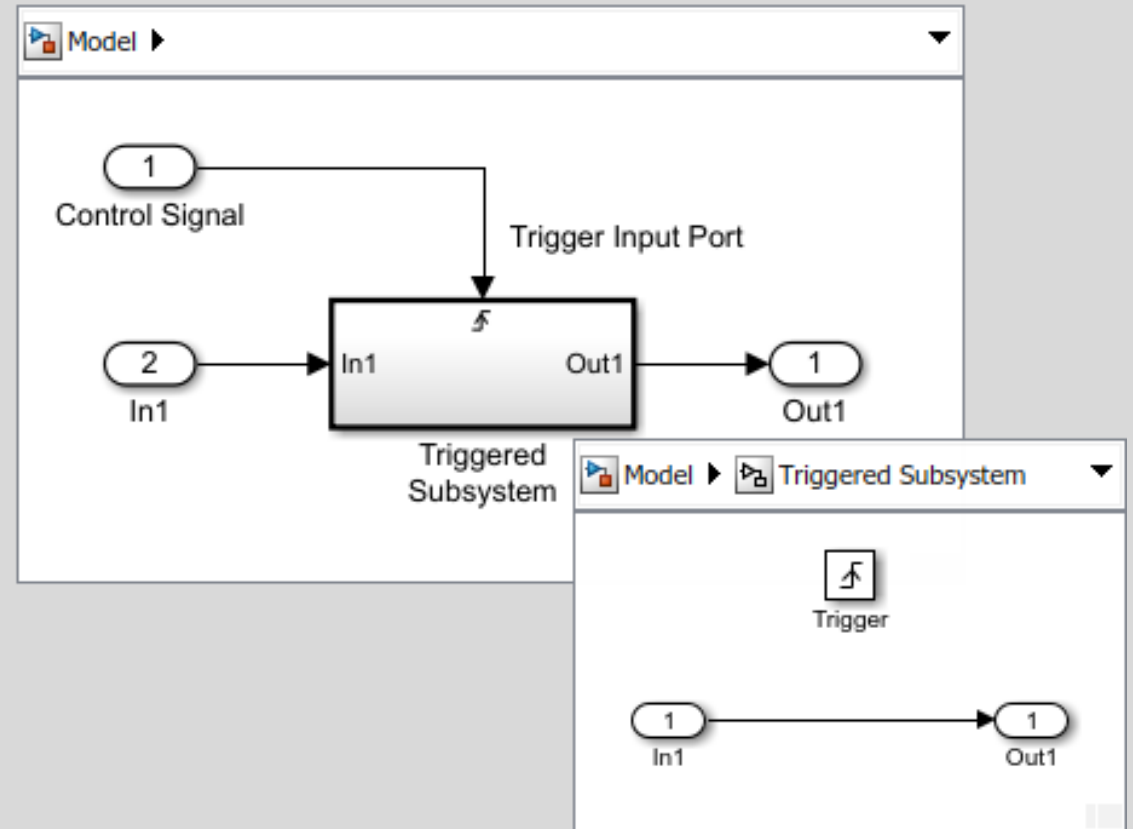
Creating Subsystems

- 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



Outline

Why Simulink?

Working with Simulink

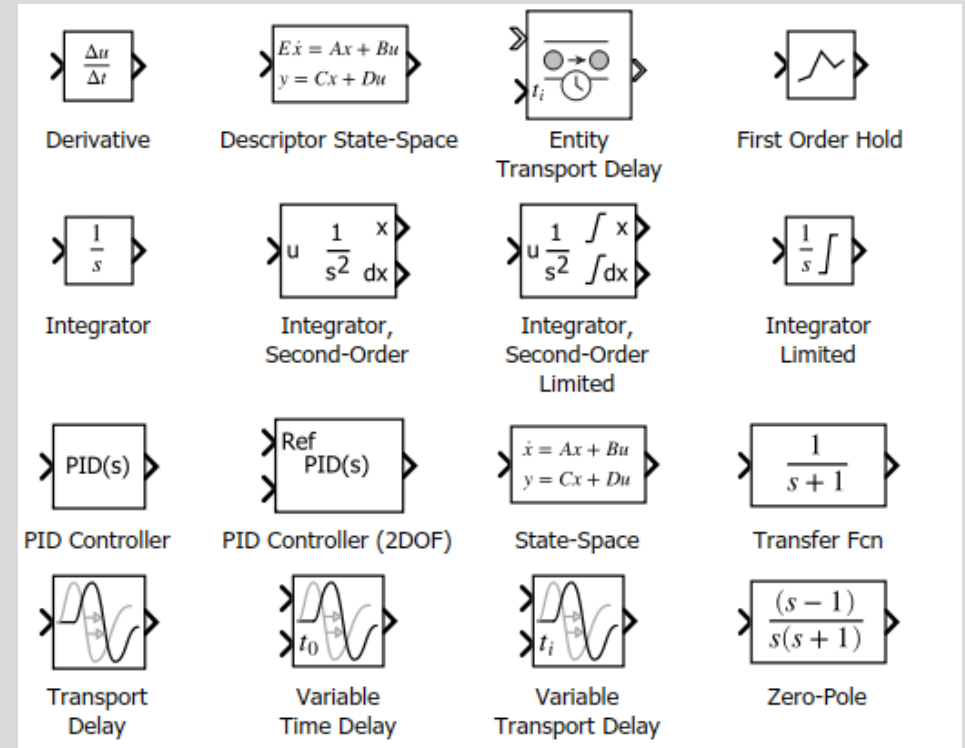
How Simulink works

Decoupling models

Continuous and discrete models

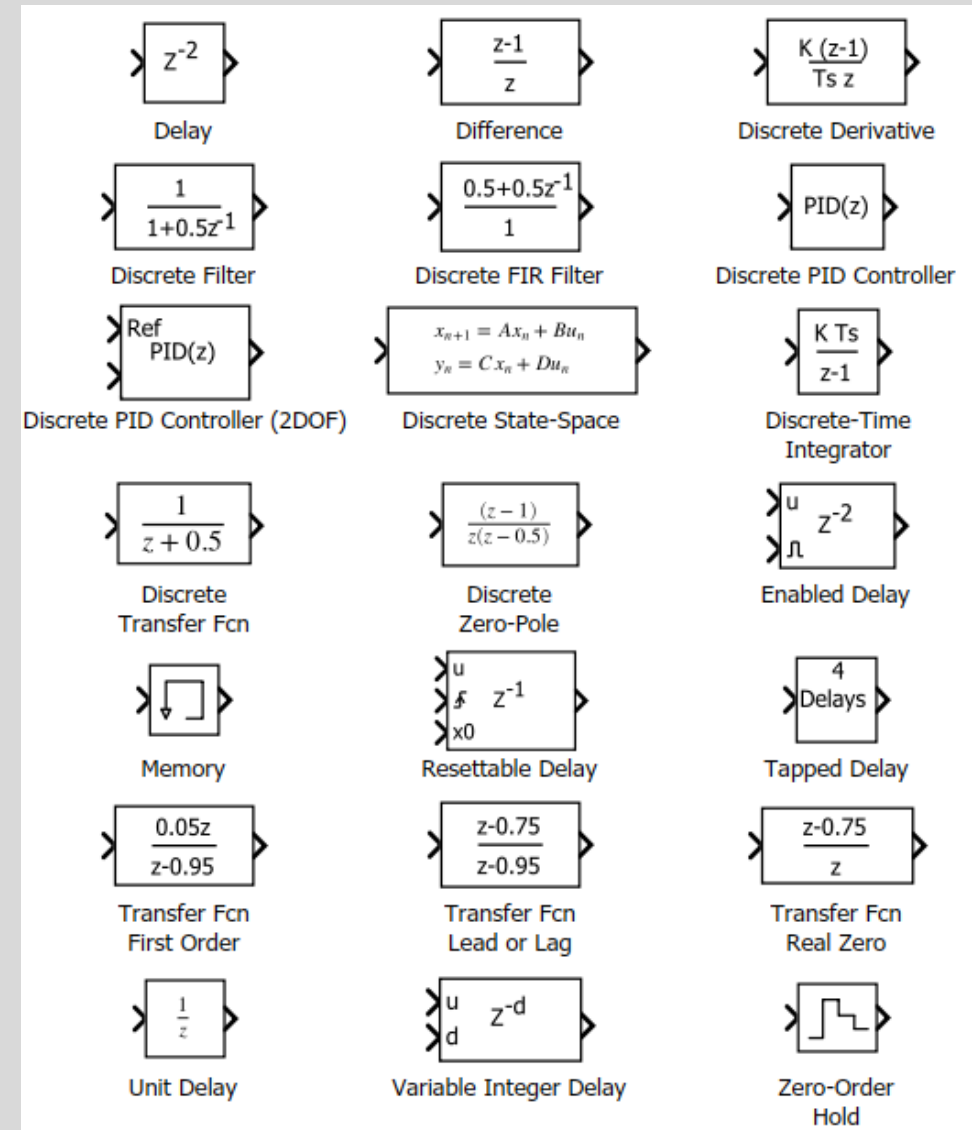
'Continuous' Library

- 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

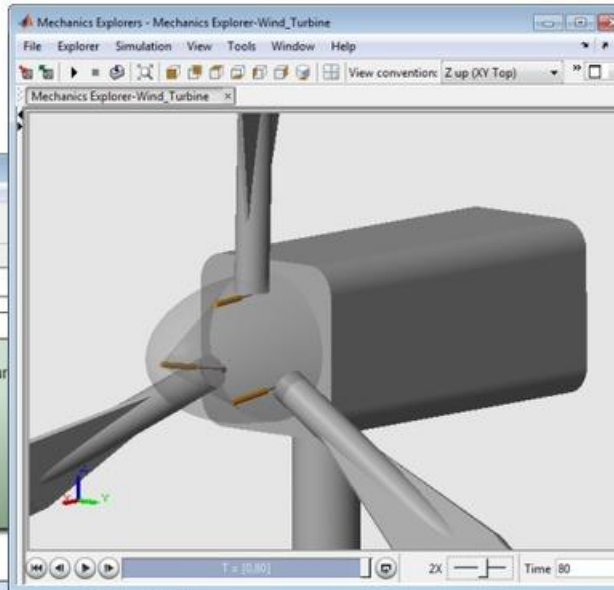
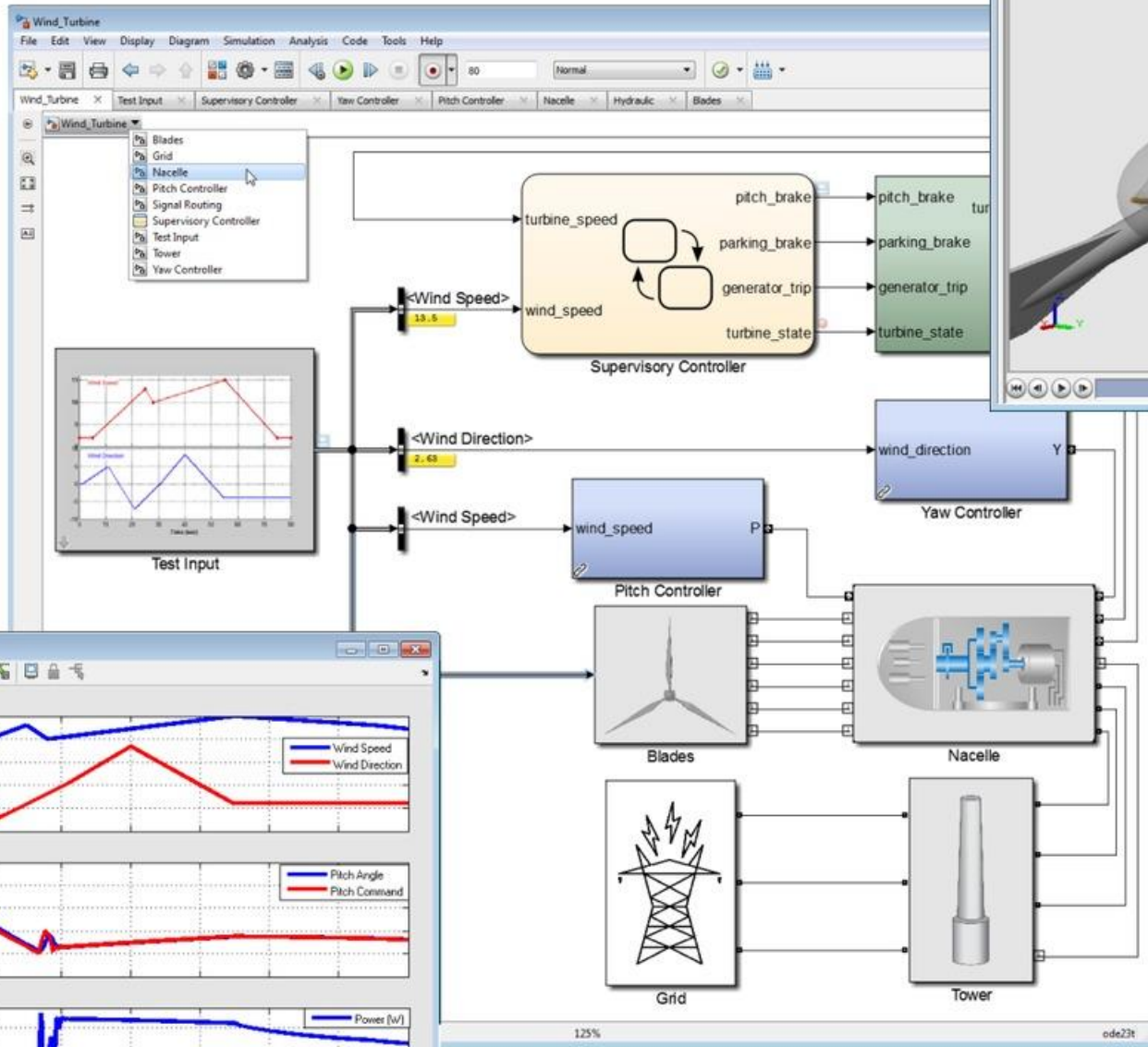
Why Simulink?

Working with Simulink

How Simulink works

Componentizing models

Continuous and discrete models



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