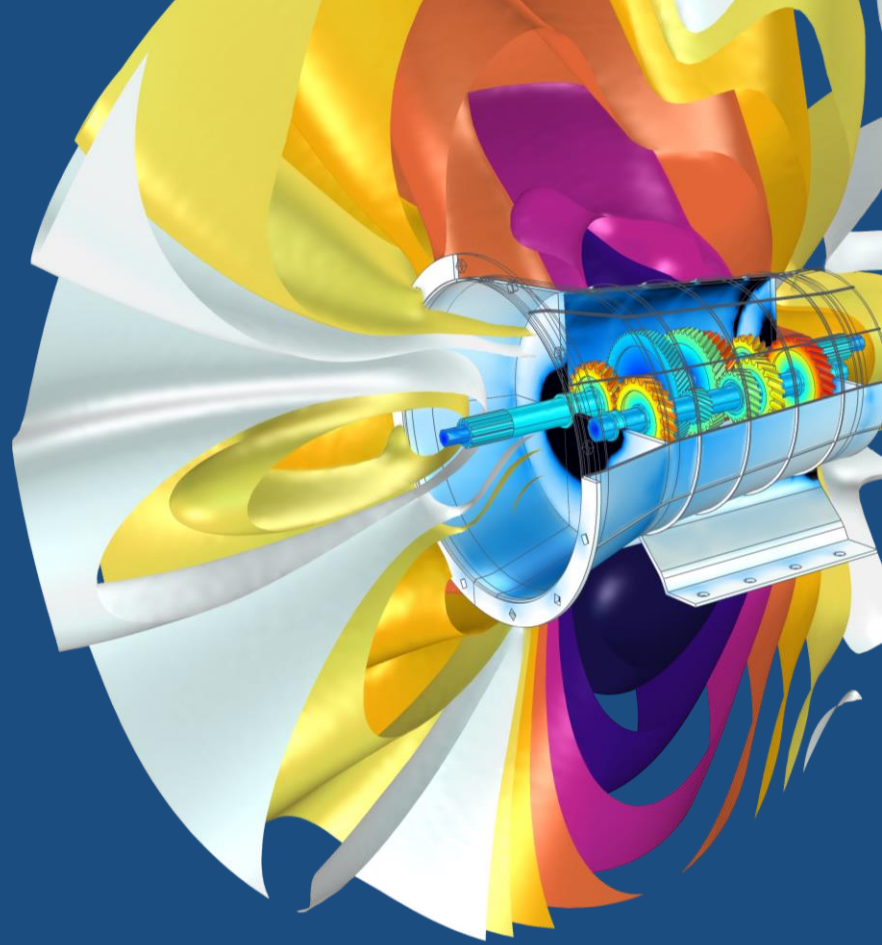


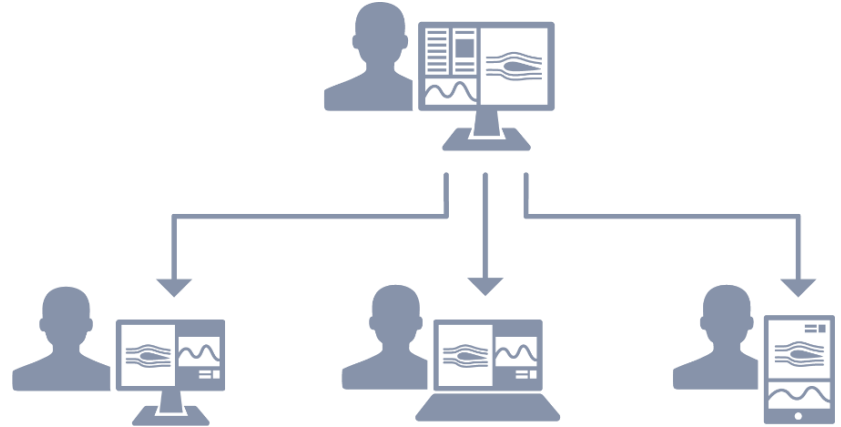
The Future of Modeling

Phil Kinnane, COMSOL, Inc.

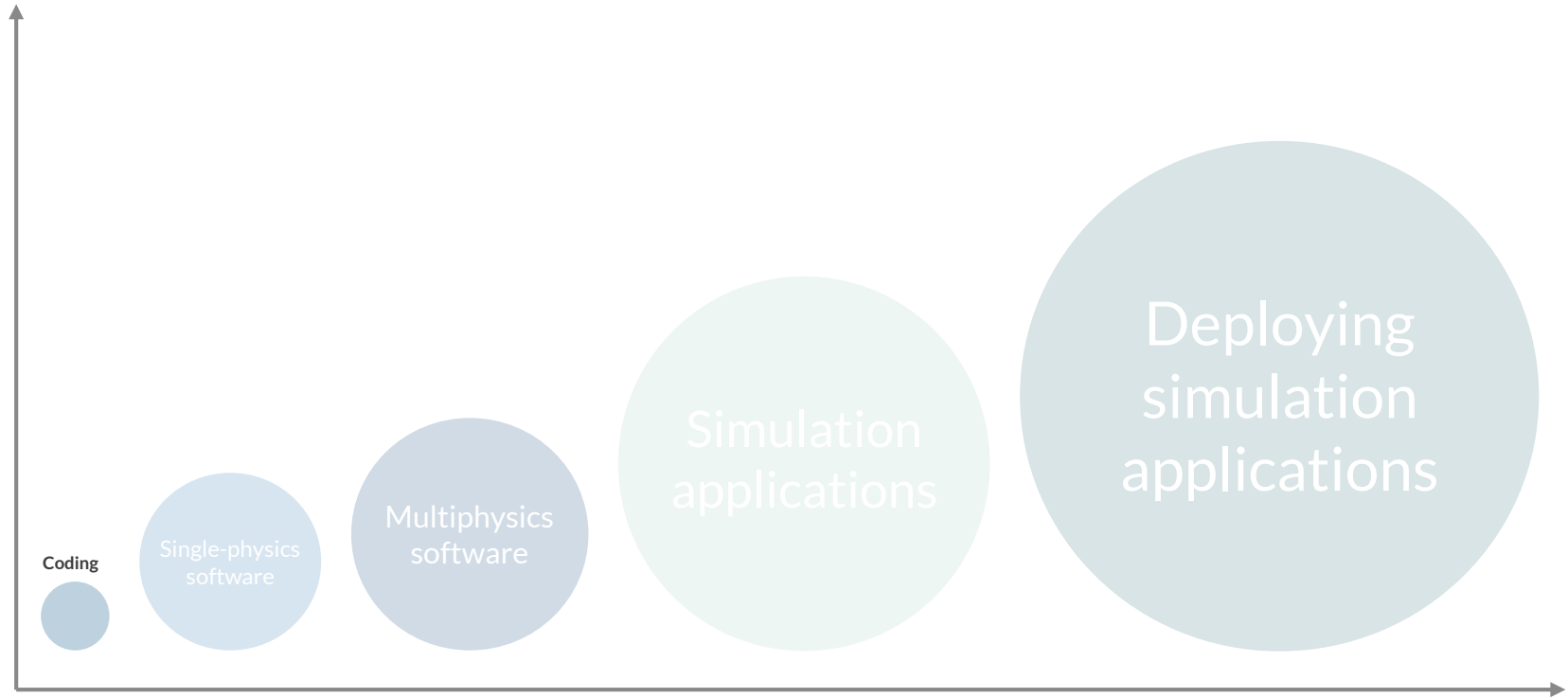


The Future of Modeling

- Democratization of Simulation
 - Transfer the power of simulation from the expert to the person actually using the results
 - Simplify models and design them to a specific audience
 - Efficiently deploy these models to this audience



Origins of Modeling: Coding



Coding

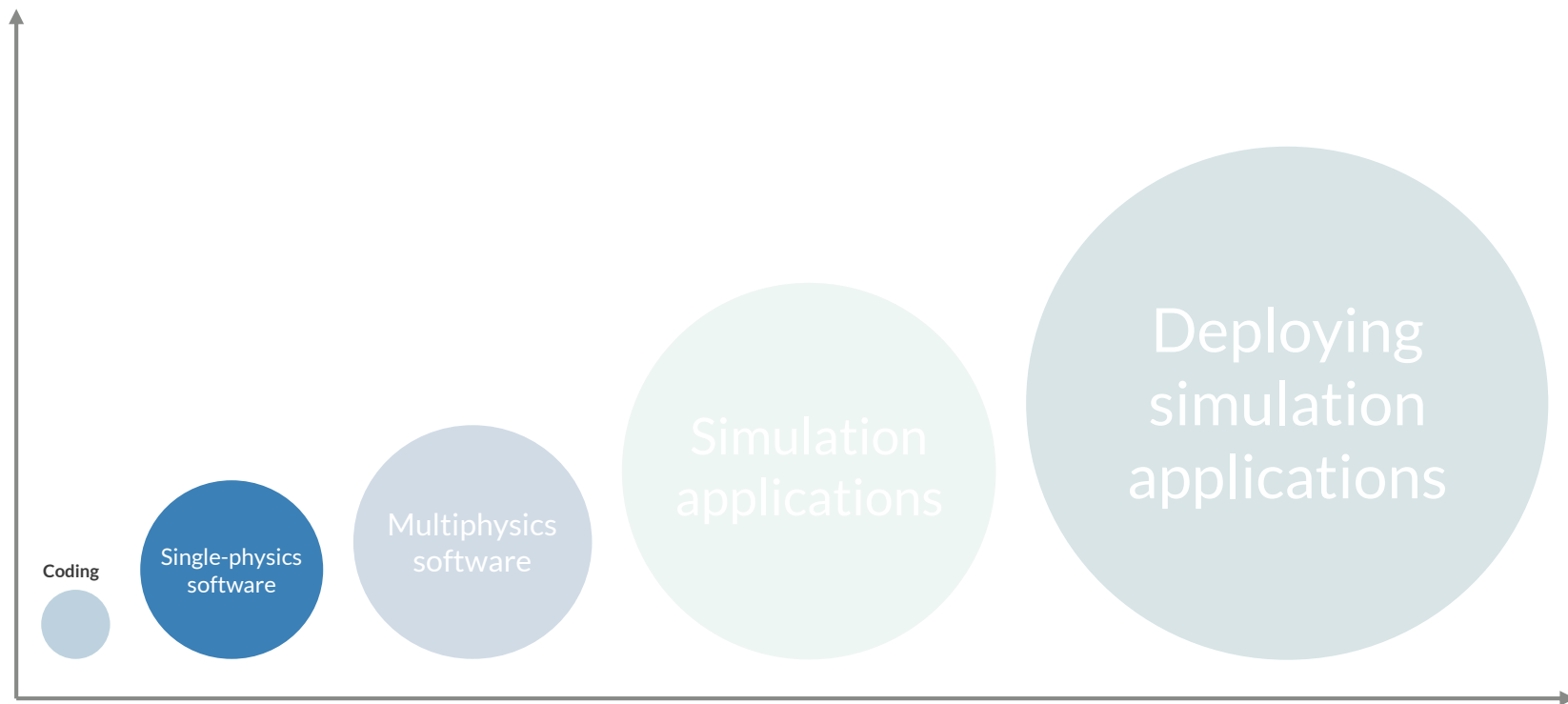
- Benefits:

- Predict the behavior of a physical process or object to the surrounding environment

- Barriers:

- Expertise in physics, numerical methods, and coding
- Time and effort
- Which method? Which language?
- Understanding other peoples' code
- Which hardware and operating system?

Commercialization: Single-Physics Software



Single Physics (Built-In Multiphysics) Software

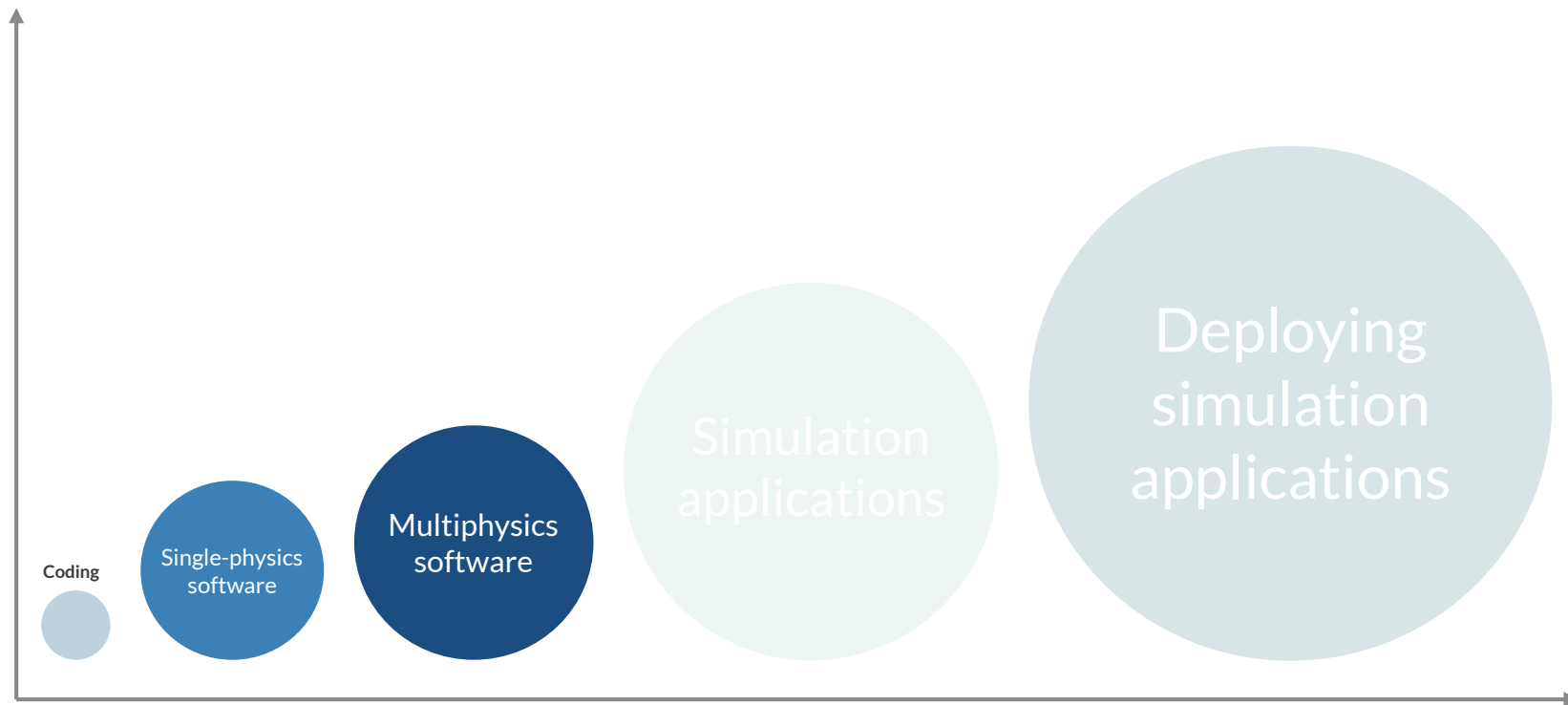
- Benefits:

- Less time and effort to set up models
- No coding required
- Standardized hardware and operating system(s)

- Barriers:

- Different numerical methods: FEM, FVM, FDTD, MoM
- Expertise in the physics, numerical methods, and the software
- Different user interfaces, model-building workflows, and syntax
- Different model formats
- Different vendors

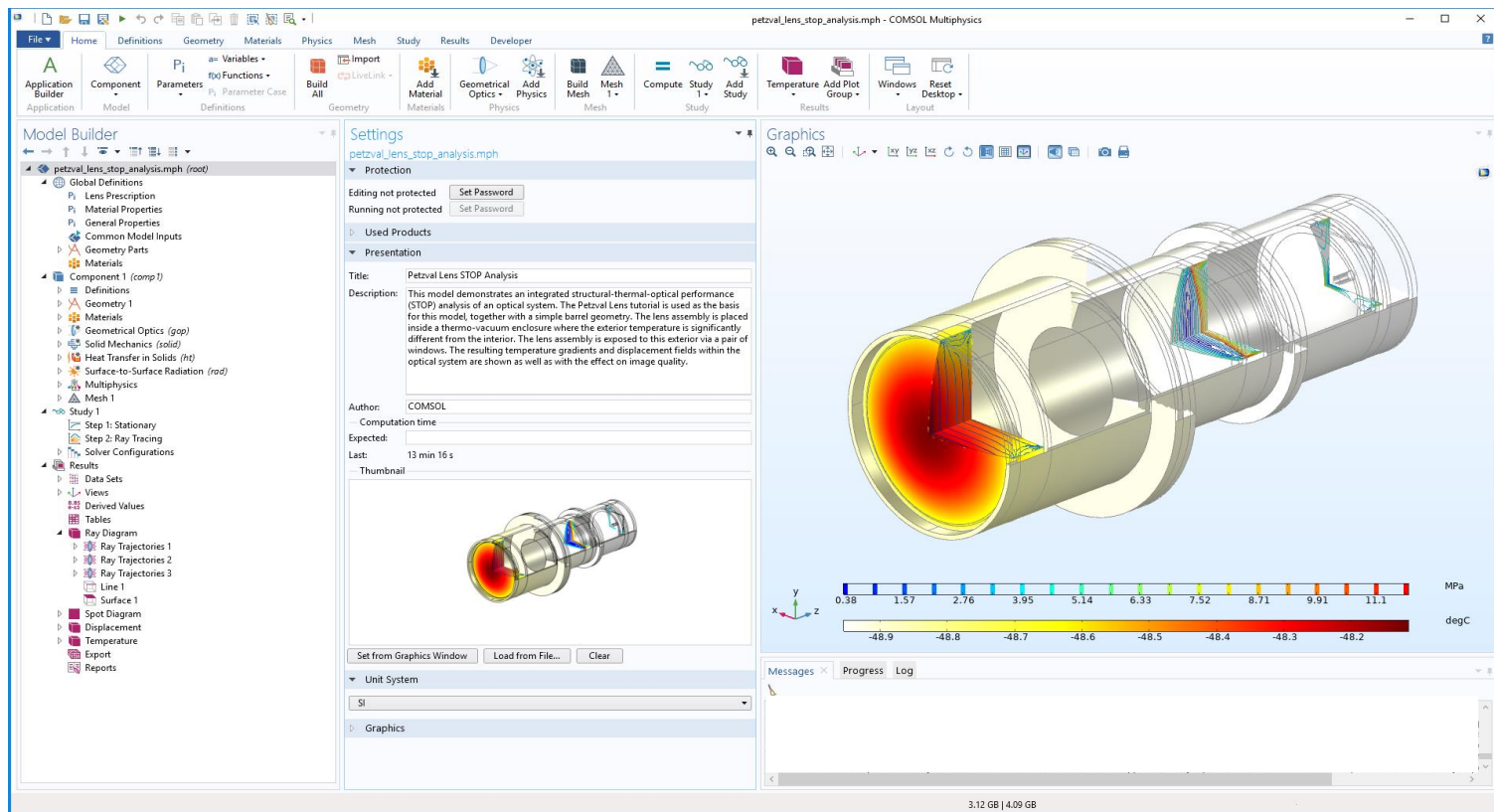
Unification: Multiphysics Software



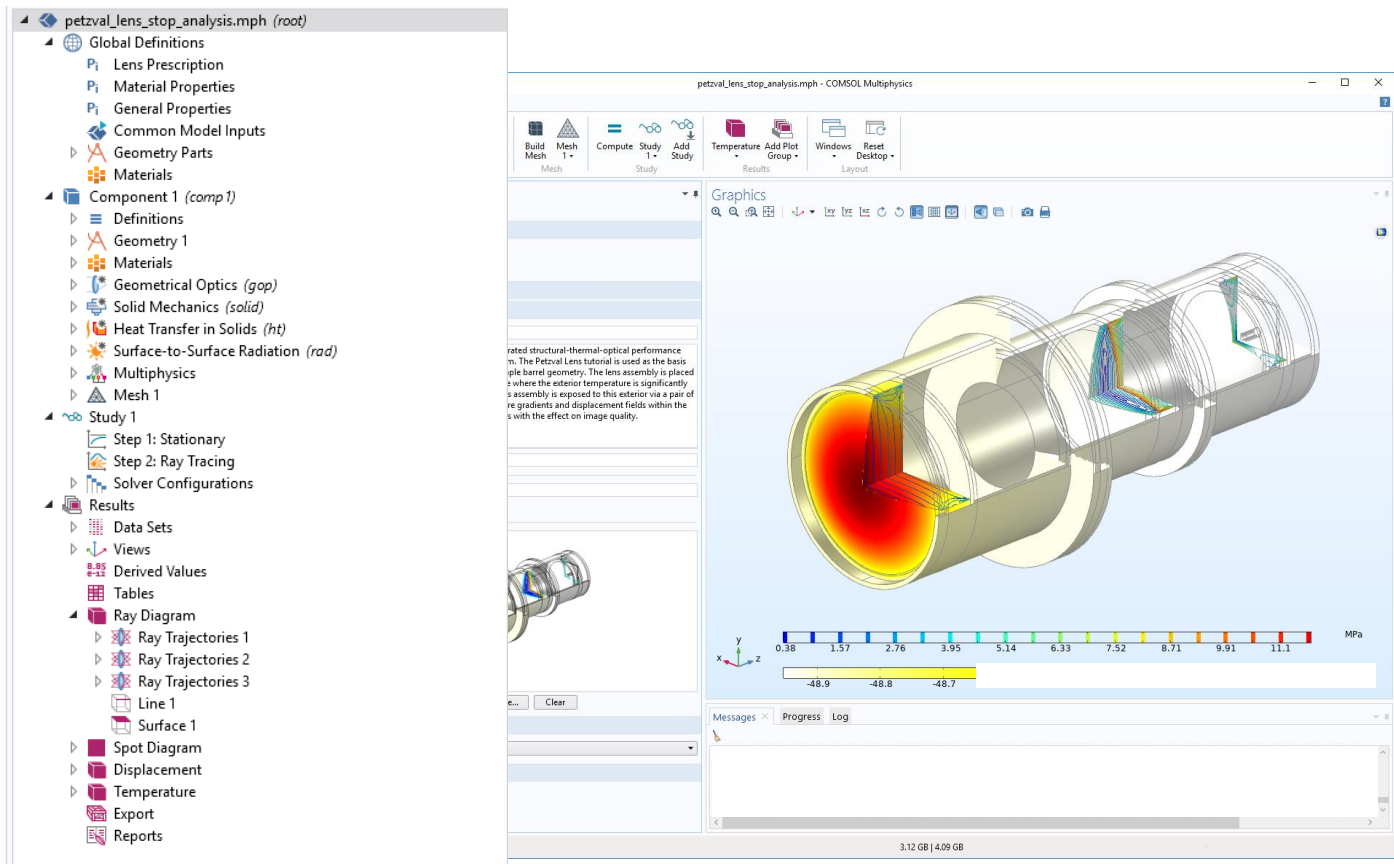
Multiphysics Software

- Benefits:
 - Same user interface, model-building workflow, and syntax in multiphysics

Unification: User Interface














Unification: User Interface





















Unification: Multiphysics

AC/DC

-  Electric Currents (ec)
-  Electric Currents, Layered Shell (ecls)
-  Electrical Circuit (cir)
-  Electrostatics (es)
-  Electrostatics, Boundary Elements (esbe)
-  Magnetic Field Formulation (mfh)
-  Magnetic Fields (mf)
-  Magnetic Fields, No Currents (mfnc)
-  Magnetic Fields, No Currents, Boundary Elements (mfncbe)
-  Magnetic and Electric Fields (mef)
-  Rotating Machinery, Magnetic (rmm)

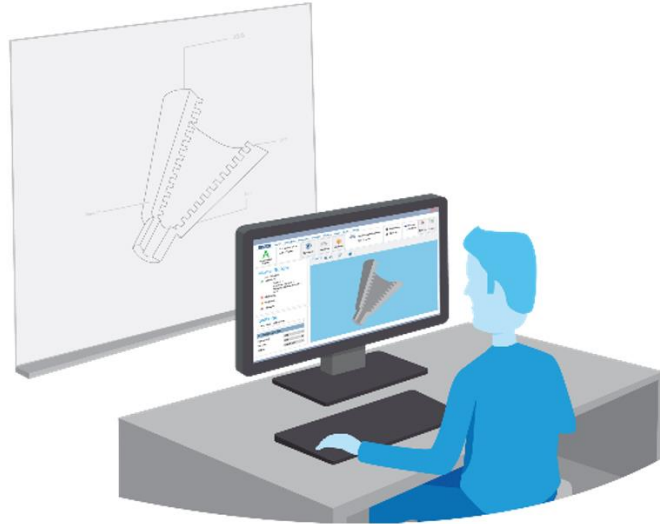
Fluid Flow

- ▲  Single-Phase Flow
 -  Creeping Flow (spf)
 -  Laminar Flow (spf)
 - ▷  Turbulent Flow
 - ▷  Large Eddy Simulation
 - ▷  Rotating Machinery, Fluid Flow
- ▷  Thin-Film Flow
- ▲  Multiphase Flow
 - ▷  Bubbly Flow
 - ▷  Mixture Model
 - ▷  Euler-Euler Model
 - ▷  Two-Phase Flow, Level Set
 - ▷  Two-Phase Flow, Phase Field
 - ▷  Three-Phase Flow, Phase Field
 - ▷  Phase Transport (phtr)
- ▷  Porous Media and Subsurface Flow
- ▷  Nonisothermal Flow
- ▷  High Mach Number Flow

Multiphysics Software

- Benefits:
 - Same user interface, model-building workflow, and syntax
 - Same model format
 - Same vendor
 - Streamlined numerical methods
 - Greater accuracy
- Barriers:
 - Expertise in the physics and the software

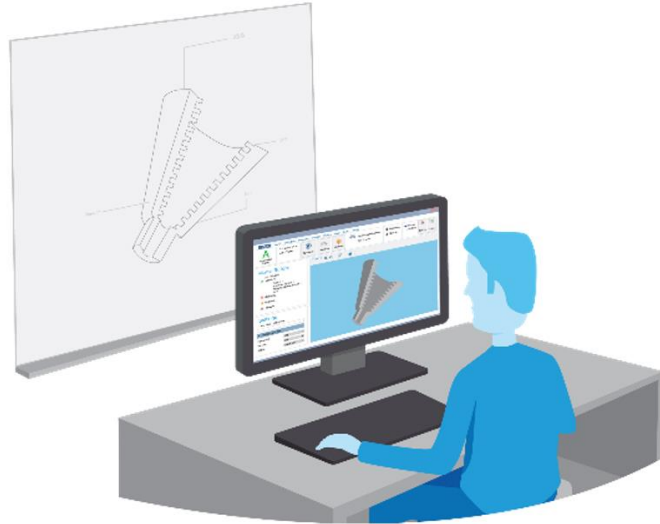
The Modeling Expert



MODEL

*Reports and data
Operating conditions
Design parameters
Complex understanding*

The Model User



MODEL

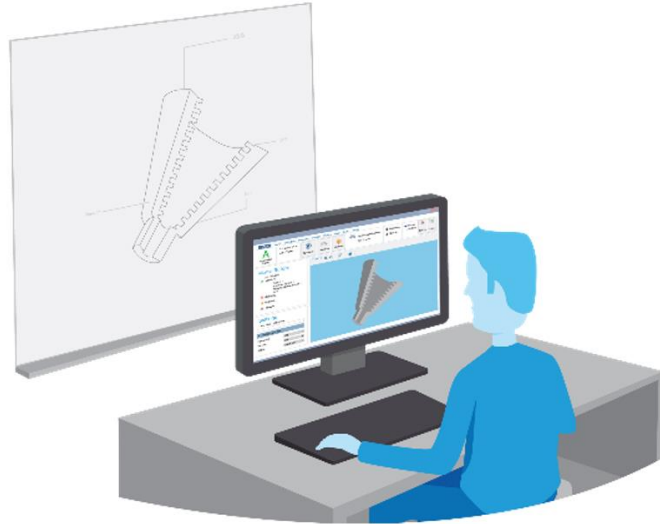
*Reports and data
Operating conditions
Design parameters
Complex understanding*



MODEL USE

*Project feasibility and QA
Process decisions
Optimized designs
Complex understanding*

The Feedback



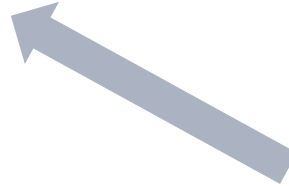
MODEL

*Reports and data
Operating conditions
Design parameters
Complex understanding*

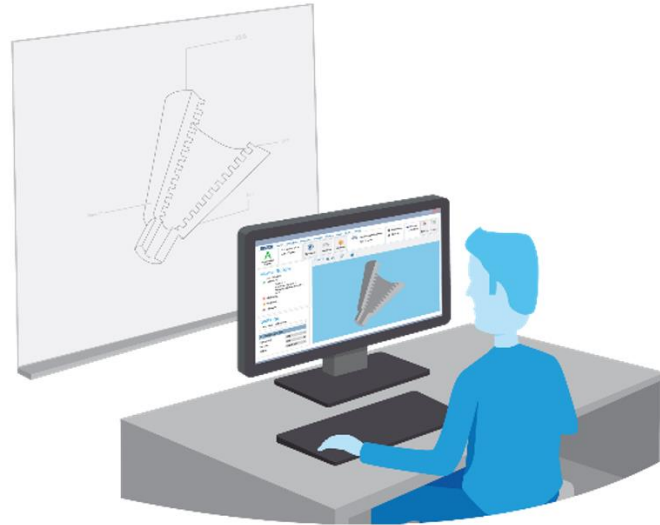


MODEL USE

*Project feasibility and QA
Process decisions
Optimized designs
Complex understanding*



The Bottleneck



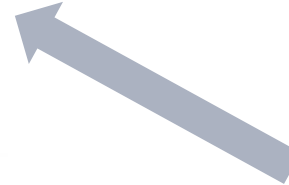
MODEL

*Reports and data
Operating conditions
Design parameters
Complex understanding*

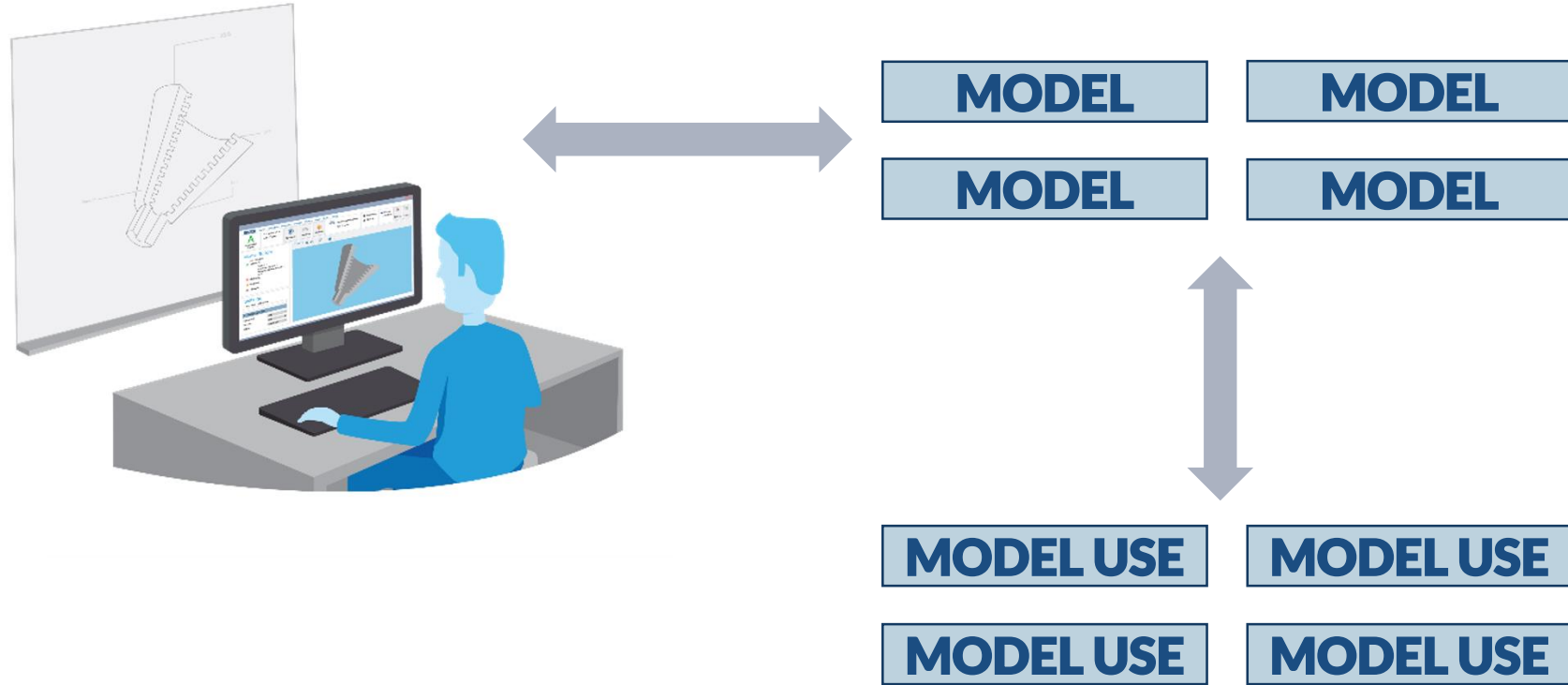


MODEL USE

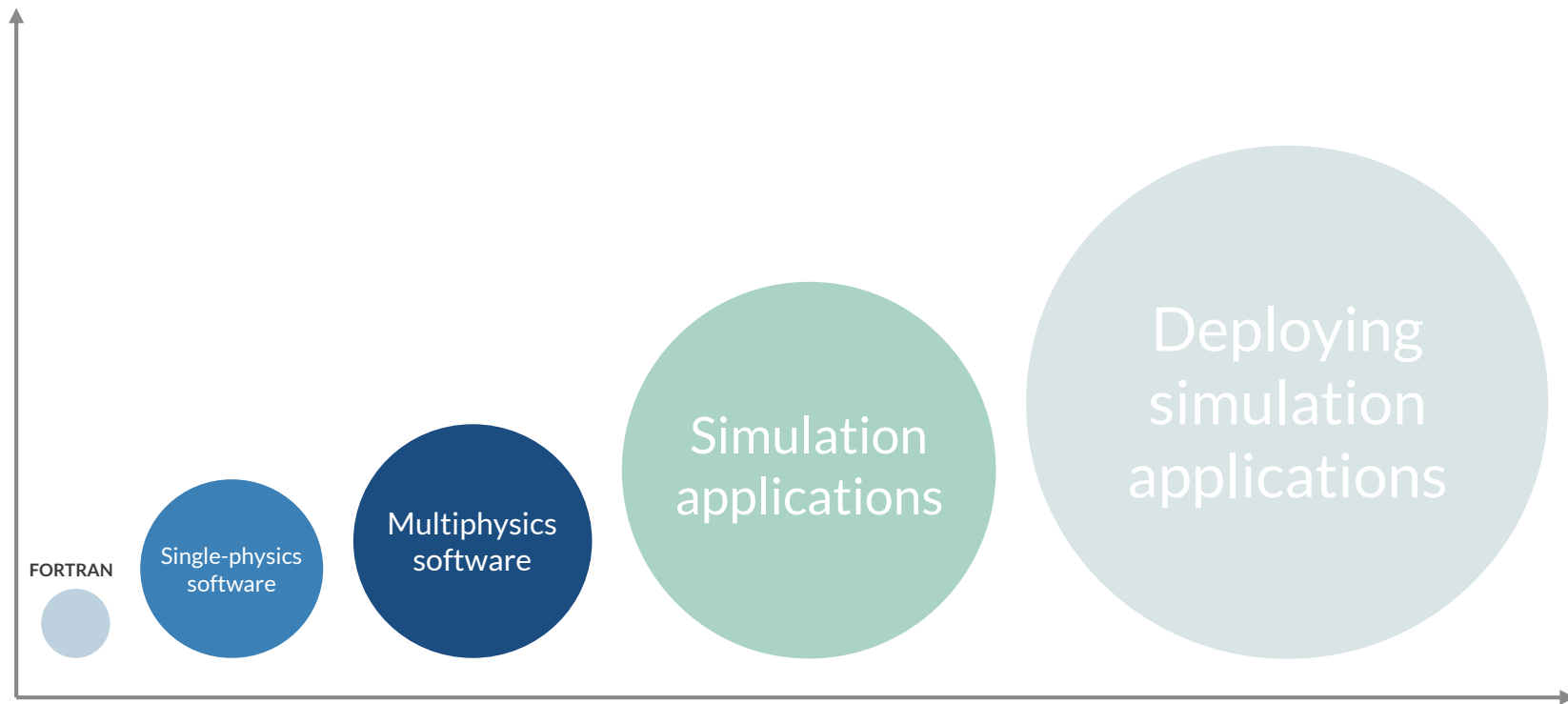
*Project feasibility and QA
Process decisions
Optimized designs
Complex understanding*



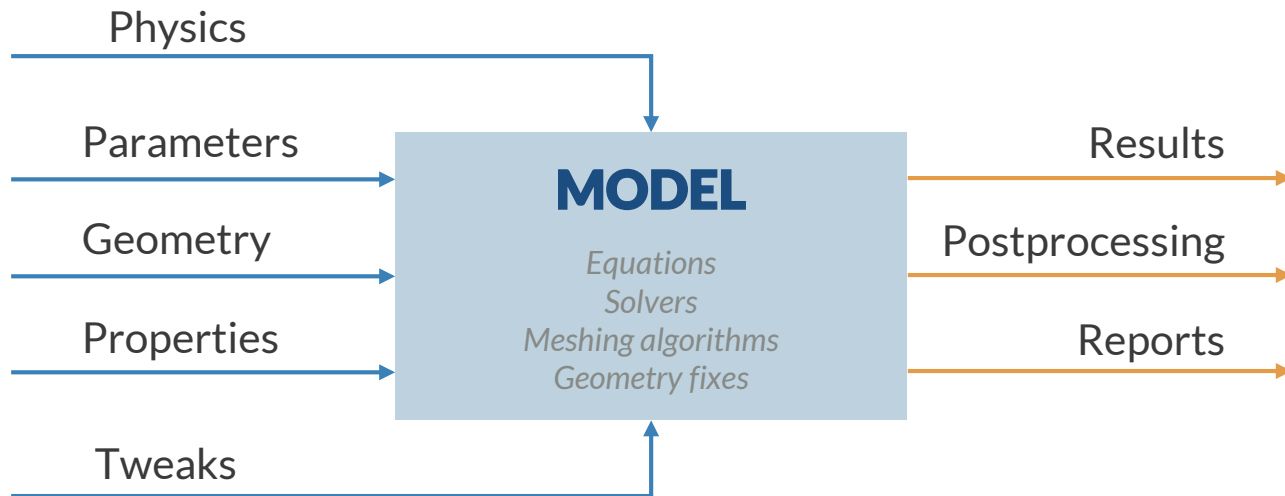
The Model Expert, Model User, and Feedback



Democratization: Simplification



Inputs/Outputs in a Model



Inputs/Outputs in a Model

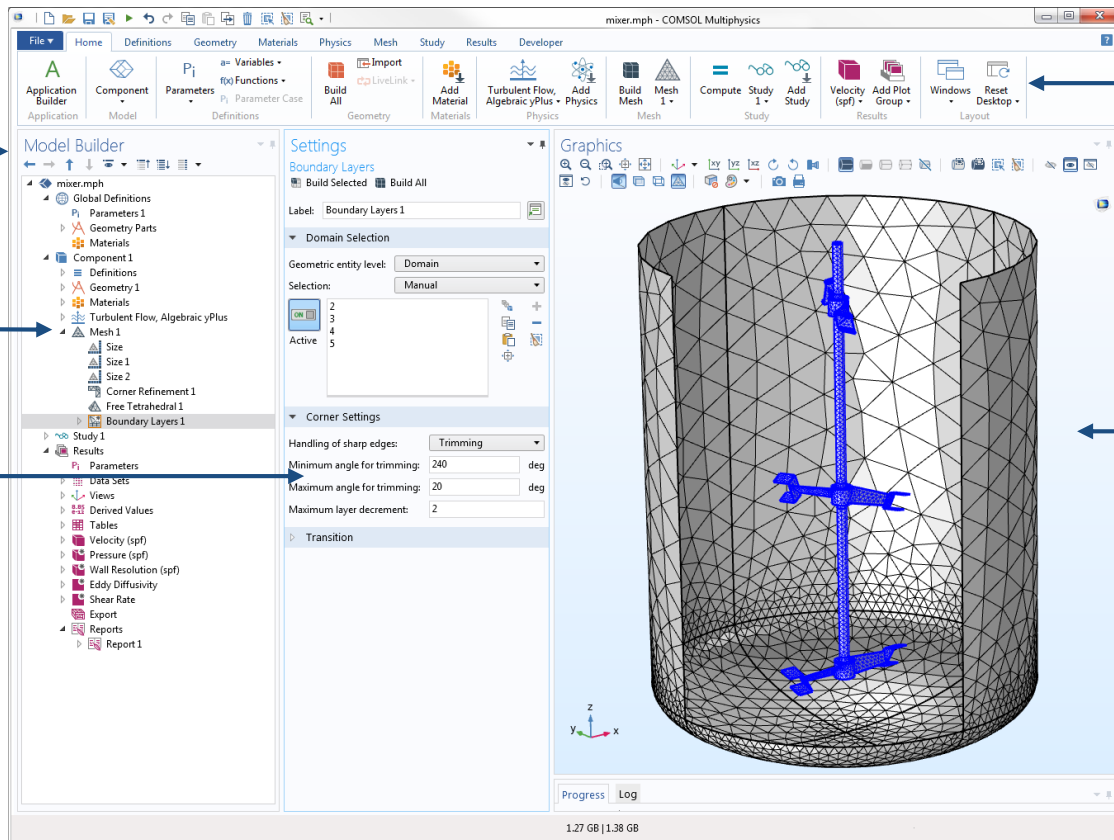
Model Builder

Nodes & subnodes

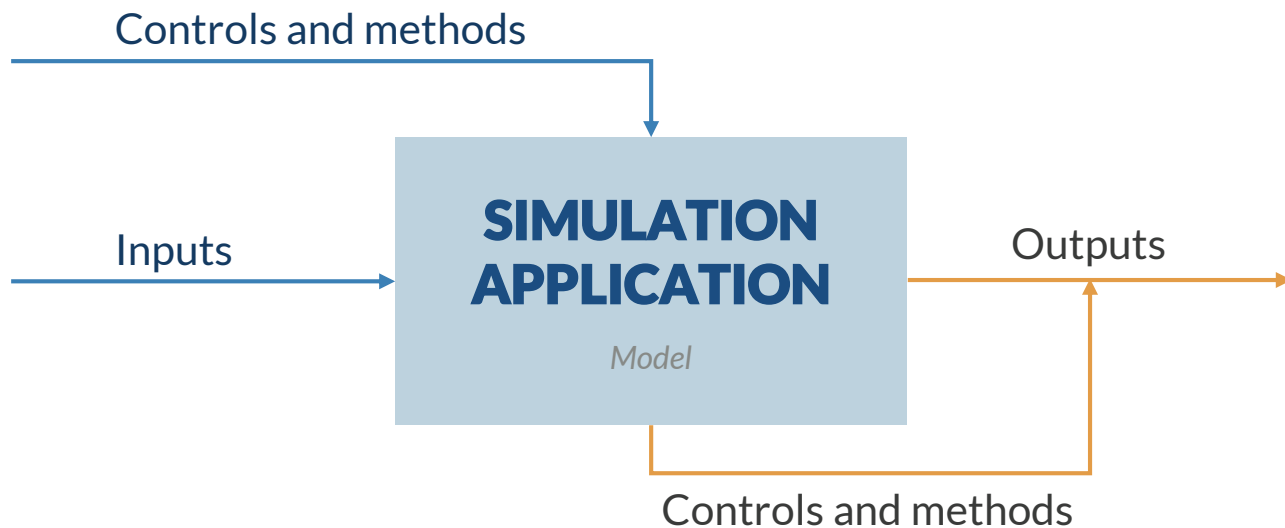
Settings fields

Menu items

Model graphics



Inputs/Outputs in a Simulation Application



Inputs/Outputs in a Simulation Application

Menu items

Nodes & subnodes

Settings fields

Model graphics

Example of a Simulation Application

- Lightweighting with aluminum: corrosion applications
 - Advance aluminum adoption in automotive lightweighting by designing galvanic, corrosion-resistant multimaterial assemblies
 - Optimized multimaterial assemblies for resistance to galvanic corrosion
 - Utilize simulation applications to deploy to NRC colleagues and ALTec members
 - *COMSOL News 2018: Danick Gallant, NRC, Canada.*

Galvanic Corrosion Behavior of a Complex Multi-Materials Assembly

NRC-CNRC

Corrosion Applications

Step 1. Components

Identify components in the corresponding tab. Select among: AA7075, AA6022, AA5083, AA6061, AA7072, AA5056, AA6111, SS304, SS201, ZnPh, steel, CFRP, Sn, Ti64, Almac, Zn, Mg

Step 2. Electrolyte thickness

Thickness mm

Step 3. Electrolyte movement

Adjust the convection level

Quiescent Maximum

Step 4. Temperature

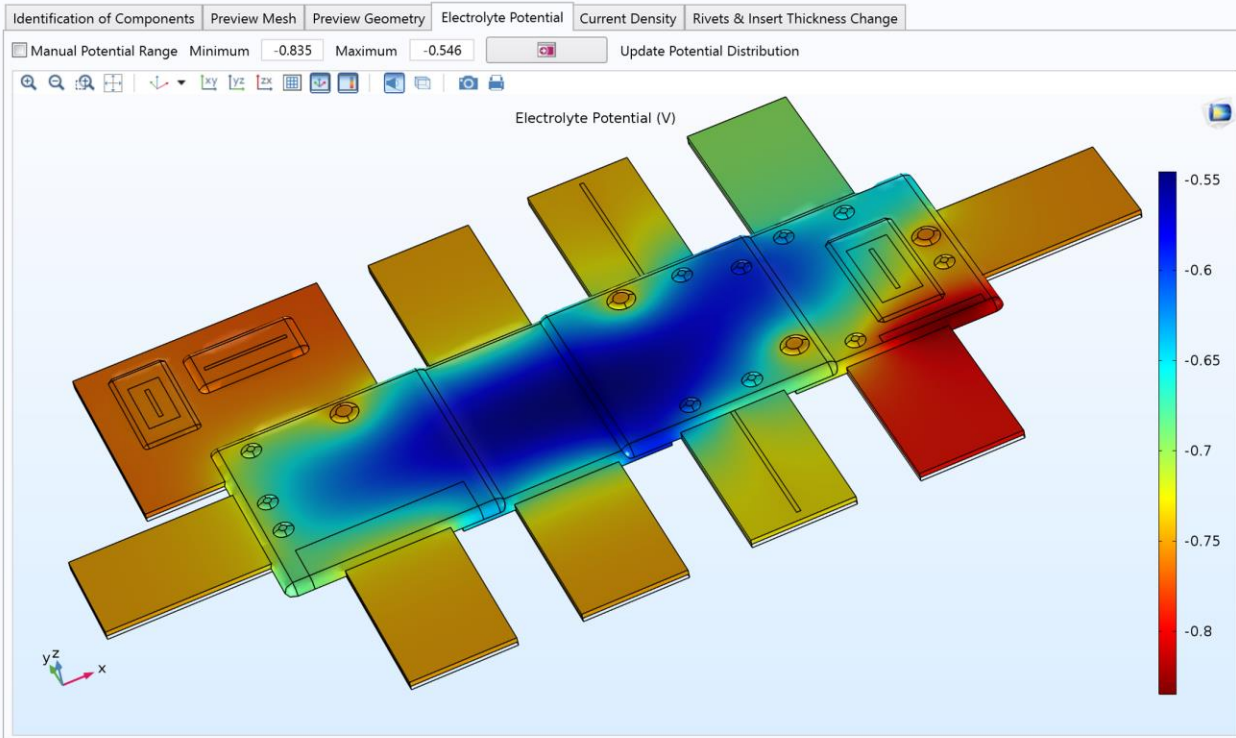
Temperature influences electrolyte conductivity & efficiency of cathode in reducing oxygen. Expected maximum service temperature is:

Temperature (C)

Step 5. Compute results

Step 6. Export global galvanic current

Export global currents for each component in GALM_17 file & plot results using MATLAB

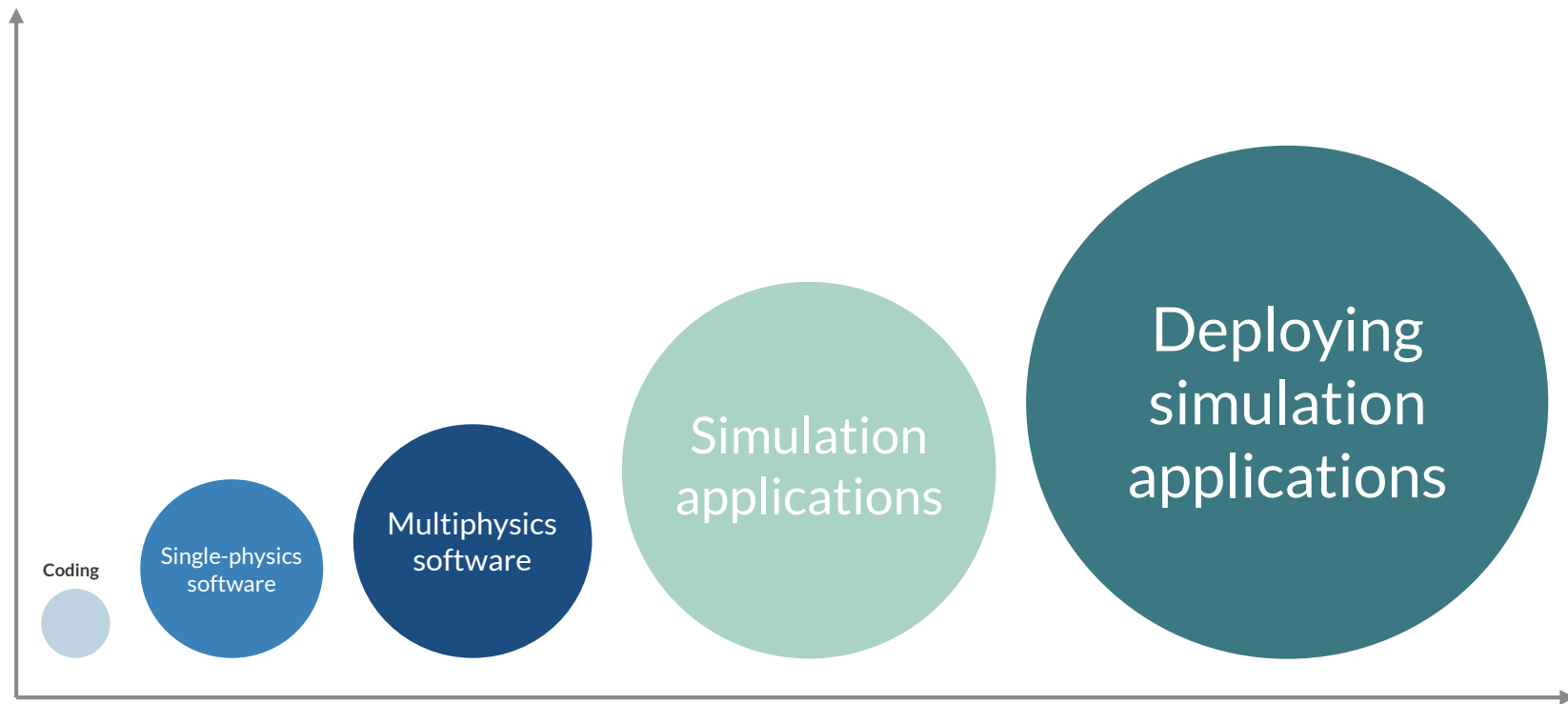


A simulation application for determining the electrolyte potential across the assembly.

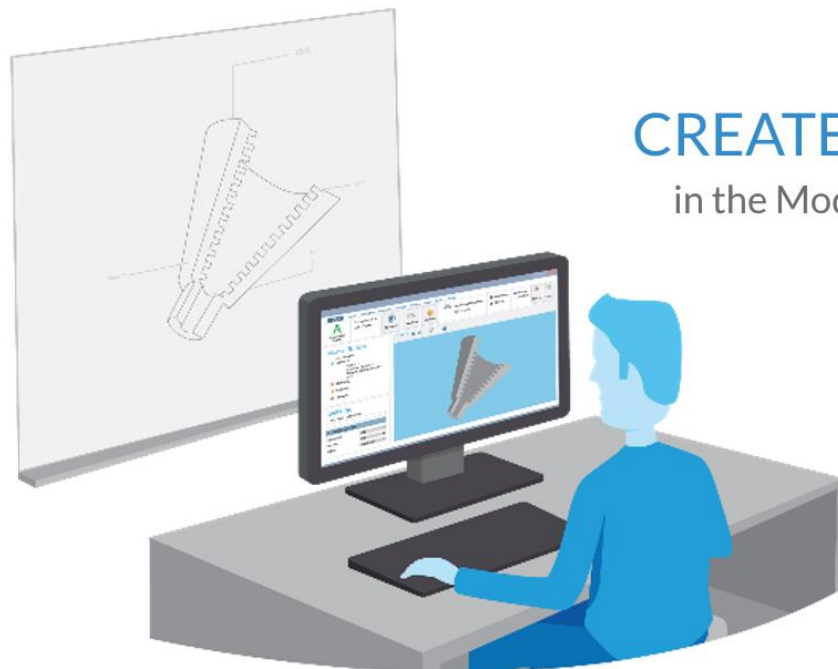
Simulation Applications

- Benefits:
 - Specialized user interfaces applicable to the audience and application
 - No simulation experience required
 - No long-term need for a sophisticated software
 - Build understanding of product, process, or application behavior
 - Feedback from users create more accurate simulations
 - Provide a service to customers, clients, vendors, and colleagues
- Barriers:
 - Deployment?

Democratization: Deployment

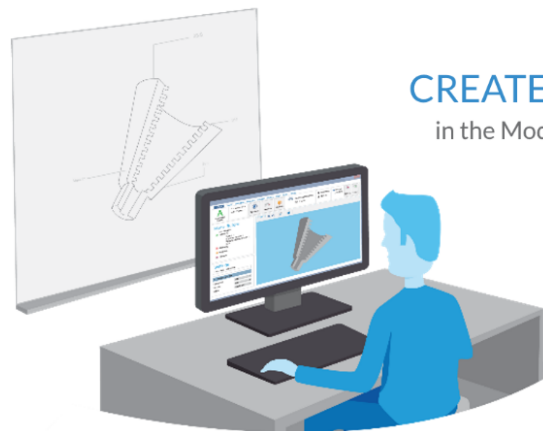


The Model Builder



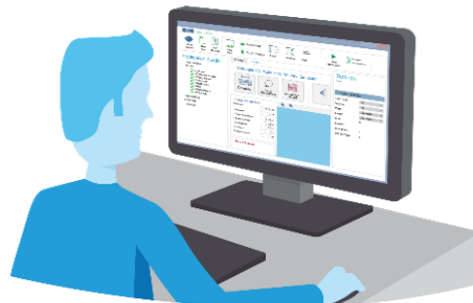
CREATE models
in the Model Builder

The Application Builder

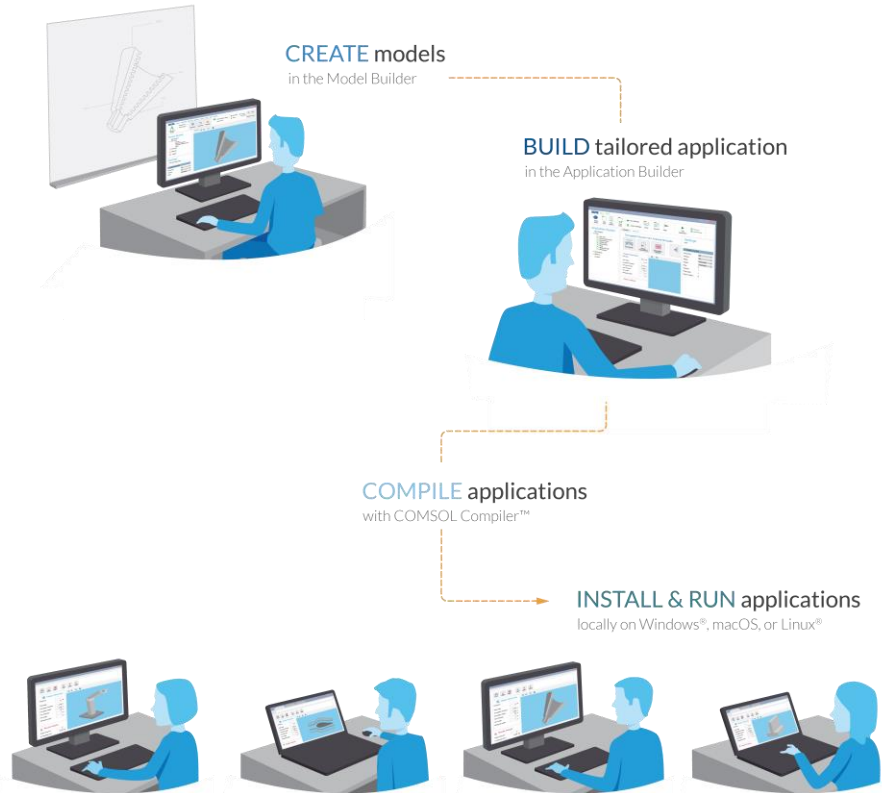


CREATE models
in the Model Builder

BUILD tailored applications
in the Application Builder

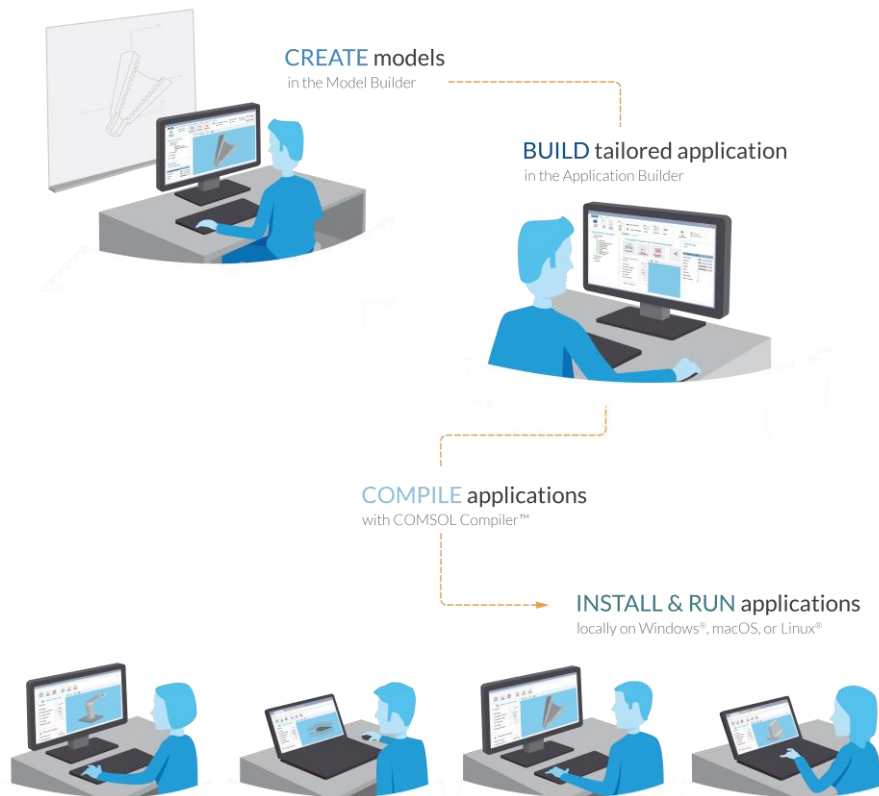


The Deployment of Simulation Applications



Deploying Simulation Applications

- Simulation applications can be run by anyone that is anywhere in the world
 - No restrictions on deployment
 - No license required
 - Use your own branding
 - Sell them or rent them out
- Create your own simulation software!



Model Builder

- busbar.mph
 - Global Definitions
 - Parameters 1
 - Common Model Inputs
 - Materials
 - Component 1
 - Definitions
 - Geometry 1
 - Materials
 - Electric Currents
 - Heat Transfer in Solids
 - Multiphysics
 - Electromagnetic Heating 1
 - Mesh 1
 - Study 1
 - Results
 - Data Sets
 - Derived Values
 - Tables
 - Electric Potential (ec)
 - Temperature (ht)
 - Isothermal Contours (ht)
 - Current Density
 - Export
 - Reports

Settings

3D Plot Group

Plot

Label: Current Density

Data

Data set: Study 1/Solution 1

Title

Plot Settings

View: Automatic

☐ Show hidden entities

☐ Propagate hiding to lower dimensions

☒ Plot data set edges

Color: Black

Frame: Material (X, Y, Z)

Color Legend

☒ Show legends

☐ Show maximum and minimum values

☐ Show units

Position: Right

Text color: Black

Number Format

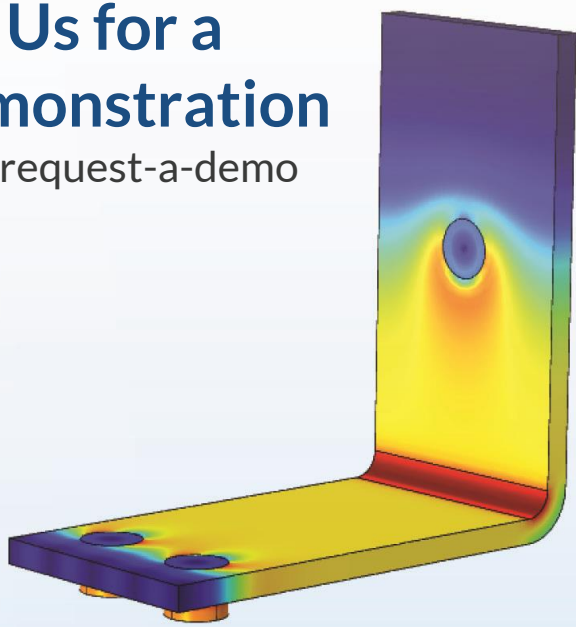
Window Settings

Graphics

Surface: Current density norm (A/m²)

Contact Us for a Live Demonstration

comsol.com/request-a-demo



Messages Progress Log Table

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