

Abstract Modeling Streamlines CFD Processes Improving Productivity and Engineering Collaboration

Amol Patil

Davis Evans

Karlheinz Peters

Santosh T. Patil

Novus Nexus, Inc.

Agenda

- Introduction
- Why Abstract Modeling
- A Closer Look at Abstract Modeling
- Abstract Modeling Automated Process
- Abstract Modeling for Simulation Applications
- Conclusion

Agenda

- Introduction
- Why Abstract Modeling
- A Closer Look at Abstract Modeling
- Abstract Modeling Automated Process
- Abstract Modeling for Simulation Applications
- Conclusion

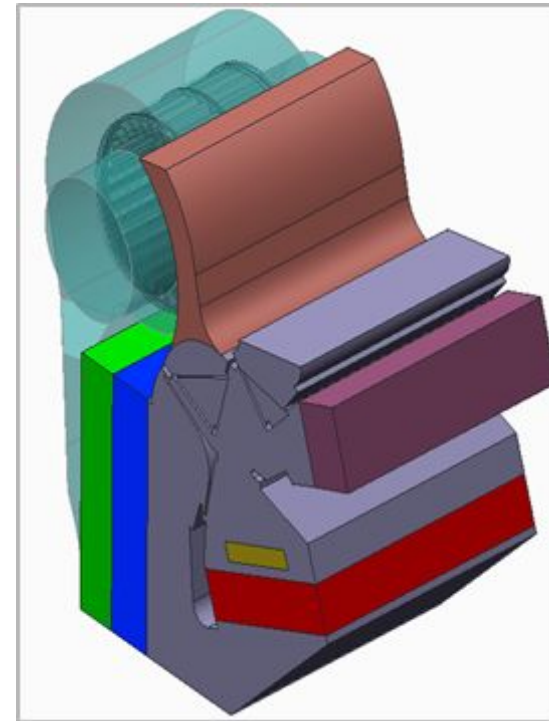
Traditional Art and Simulation

Common objective: Accurate representation of real objects in their environment

- Paintings, sculptures, etc.
- Virtual models



Source: Image by Hans Benn from Pixabay



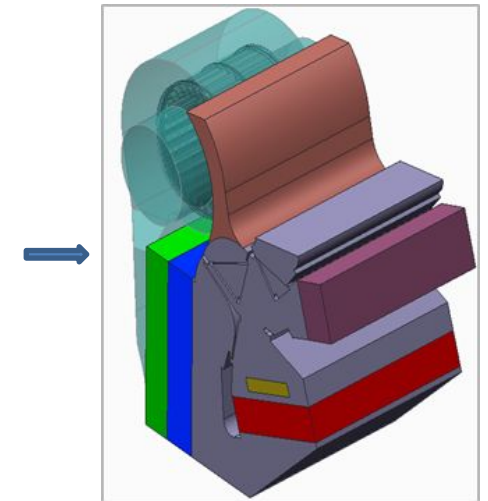
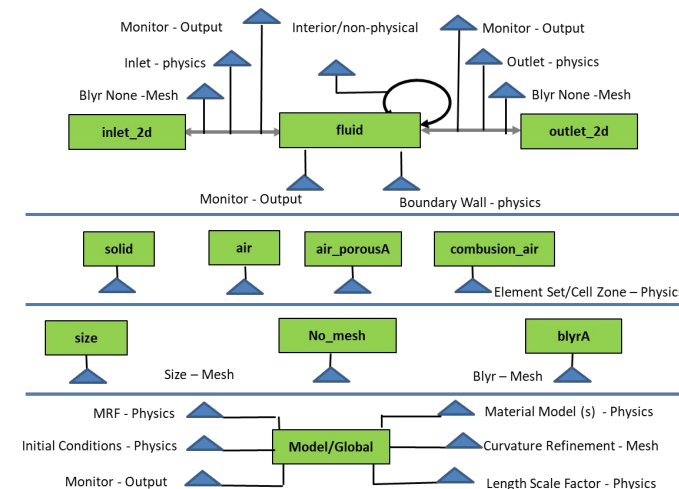
Abstract Art and Modelling

Different objectives

- Abstract art
 - Abstraction has freed artists from objective reality
 - New, independent art discipline
- Abstract Modelling
 - Needs to refer to real objects
 - Abstraction is a transitional step to enable re-usability



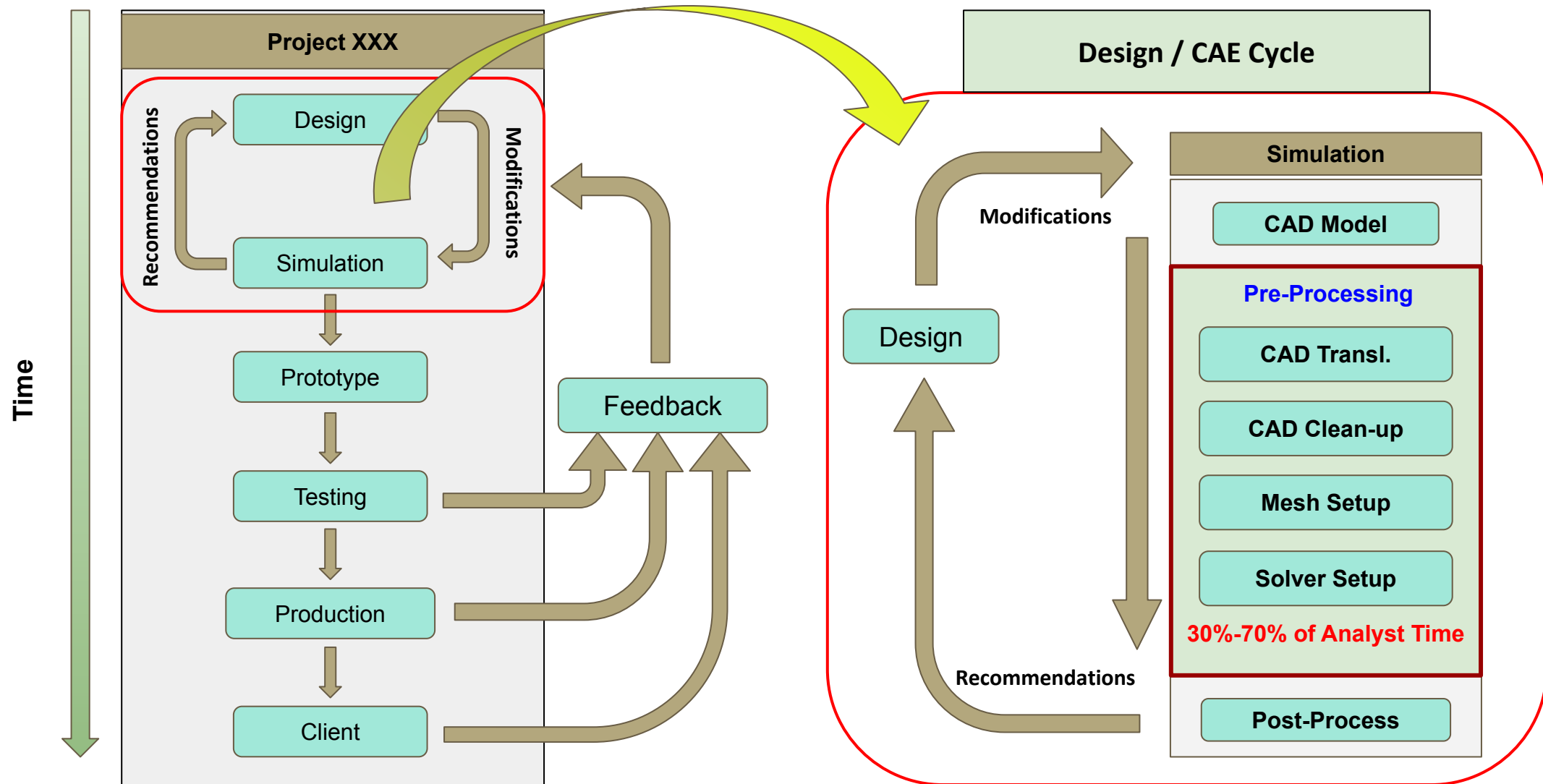
Source: Photo by [Meagan Carsience](#) on [Unsplash](#)



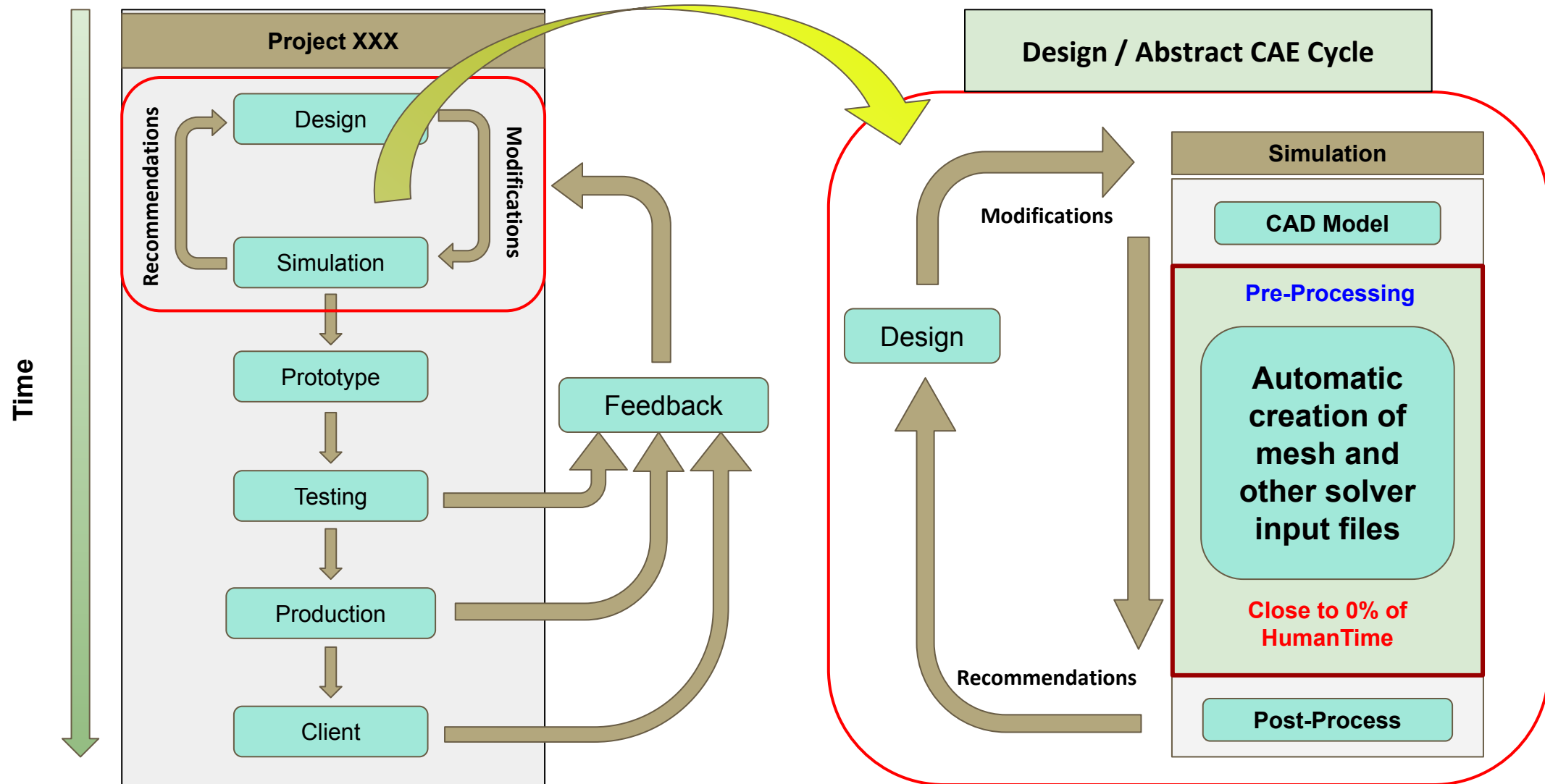
Agenda

- Introduction
- **Why Abstract Modeling**
- A Closer Look at Abstract Modeling
- Abstract Modeling Automated Process
- Abstract Modeling for Simulation Applications
- Conclusion

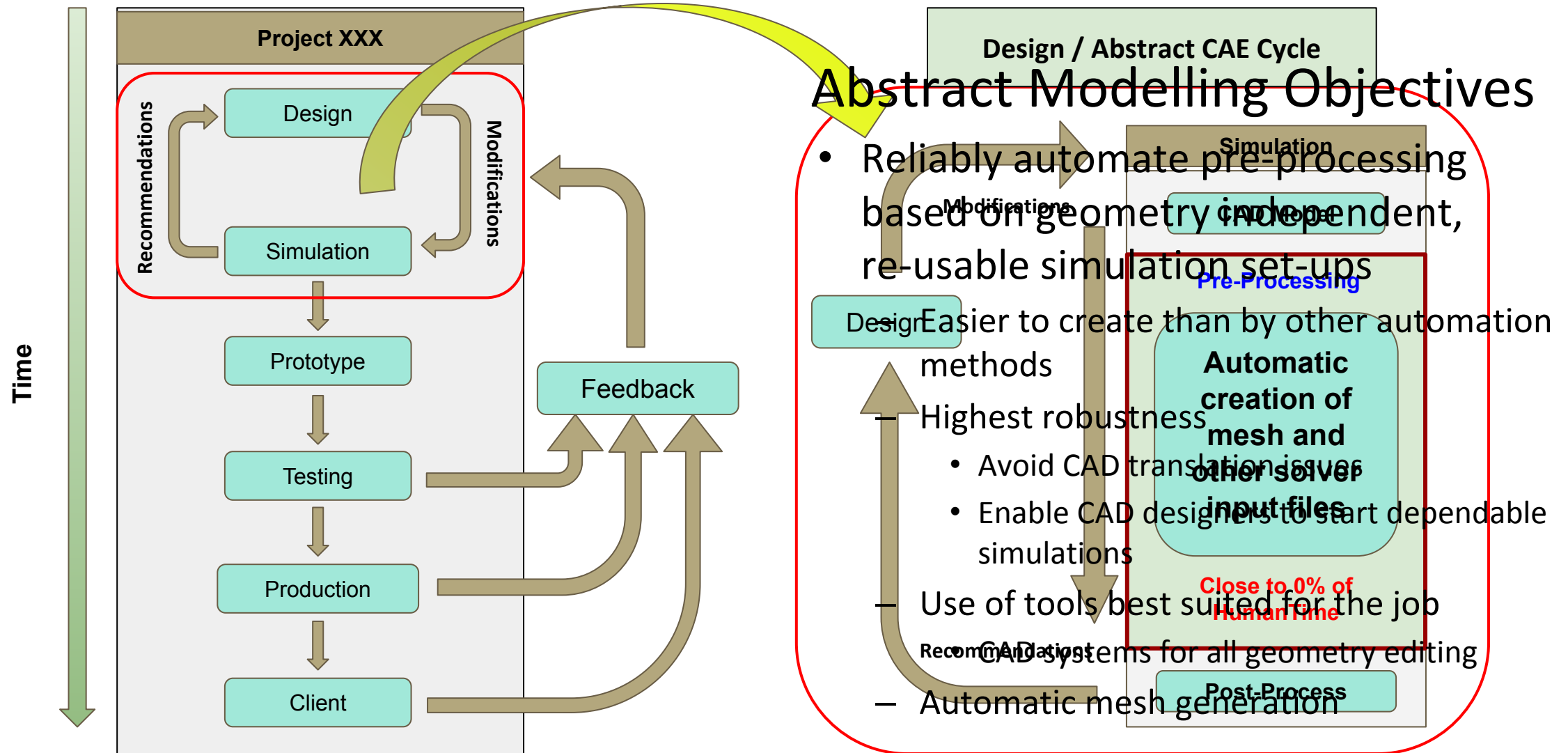
Standard CFD/CAE Processes



Abstract Pre-Processing



Abstract Pre-Processing

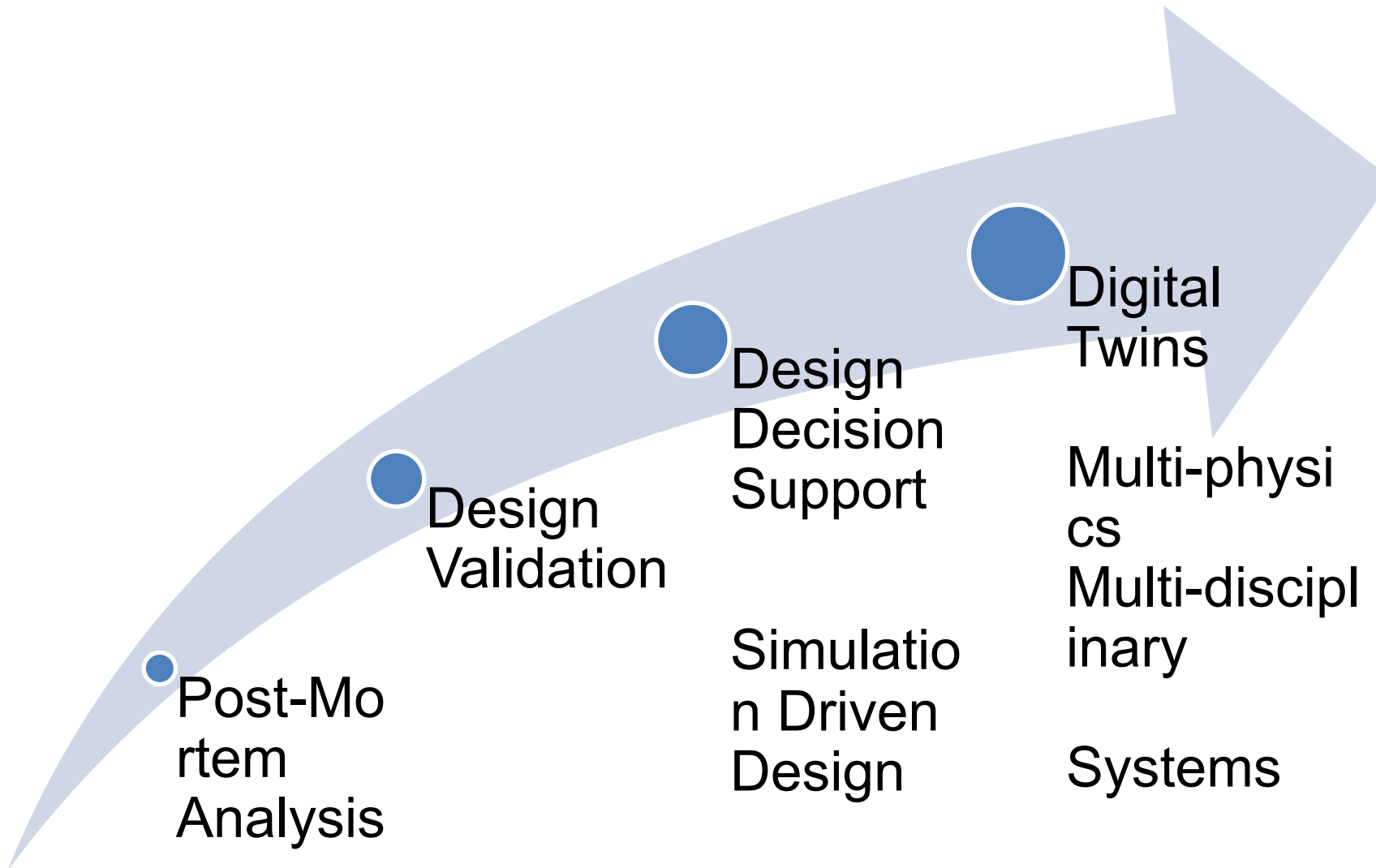


**Automatic
creation of
mesh and
other solver
input files**

Abstract Modelling Objectives

- Reliably automate pre-processing based on geometry independent, re-usable simulation set-ups
 - Easier to create than by other automation methods
 - Highest robustness
 - Democratization of simulation
Enable CAD designers to start dependable simulations
 - Avoid CAD translation issues
 - Use of tools best suited for the job
 - CAD systems for all geometry editing
 - Automatic mesh generation

Evolution of Simulation



Simulation
has become
business
relevant



Demand will
go up
significantly

Evolution of Simulation

Simulation importance for business

- Ever growing competitive pressure
 - Product development as quickly and economically as possible
 - Product quality & reliability key for competitiveness and profitability
 - Products growing in complexity
- Increased use of virtual tests key factor to remain competitive
 - More and earlier in the design cycle
 - Higher fidelity and system level
 - Result: better, more innovative products
- Challenge: Limited resources

How to meet the challenge

- More simulation and democratization through automation
 - Empower designers to initiate dependable, accurate simulations
 - More efficient CAD -> solver process for increased simulation capacity
- “Smart” use of open source tools
 - Economic extension of simulation SW capacity
 - E.g. for early stage, non mission critical use cases
 - Should be a plug and play option (no considerably different processes)

Democratization of Simulation

Survey by Tech-Clarity regarding designers having direct access to simulation tools – respondents' feedback:

96% recognize benefits if designers use simulations

- Earlier detection of problems
- Possibility to reduce the number of prototypes
- Less rework
- More innovative designs

65% state designers do not perform enough simulations

- Lack of simulation expertise
- Complexity of simulation tools
 - too hard to use
- Simulation turn-around time considered too long

Agenda

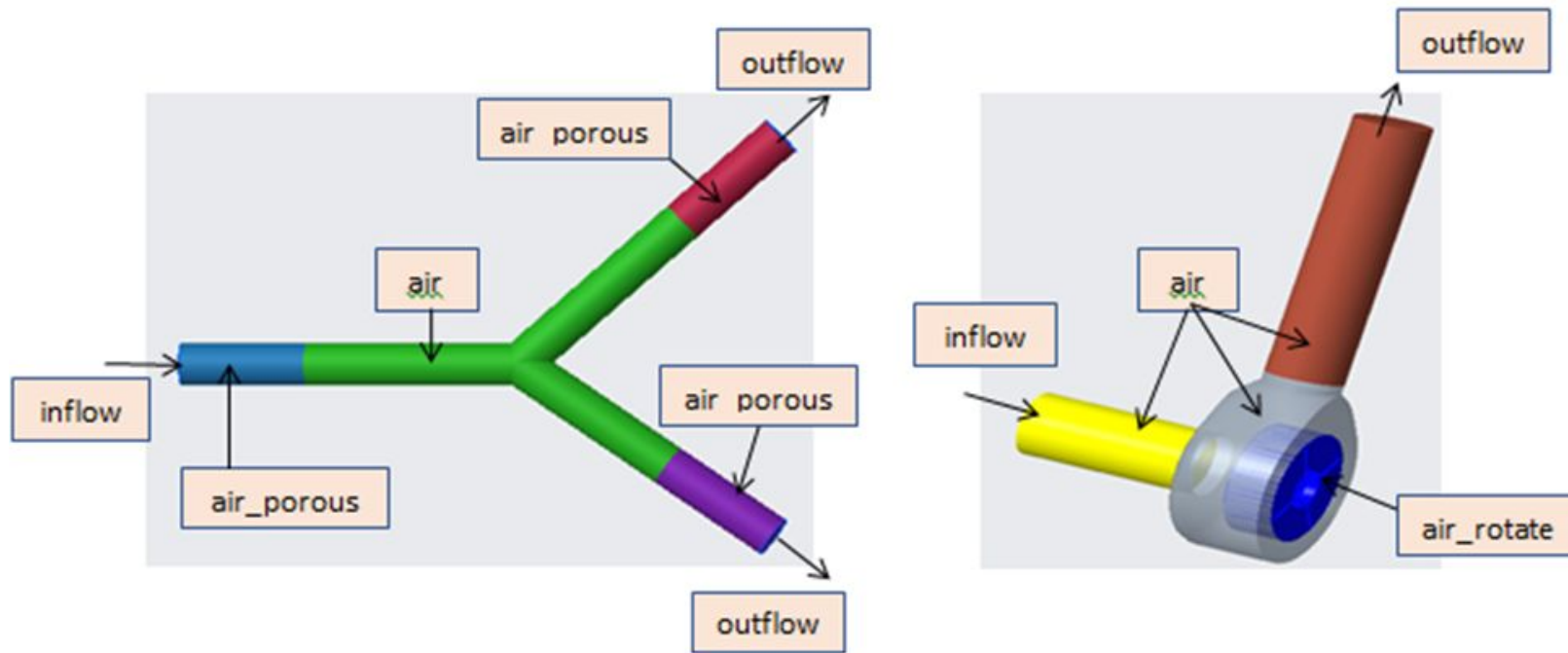
- Introduction
- Why Abstract Modeling
- **A Closer Look at Abstract Modeling**
- Abstract Modeling Automated Process
- Abstract Modeling for Simulation Applications
- Conclusion

A Closer Look at Abstract Modeling

- Abstract simulation set-up requires considering potential geometries by using placeholders instead
 - 3D CAE/CFD simulations always done for specific geometries
 - “Classes” used as placeholders
 - Classes have dimensions
 - CAD parts or their faces refer to classes via text attributes
- Abstract models can be broader than the requirements for a specific simulation
- Abstract models able to work with multiple CAD systems and solvers

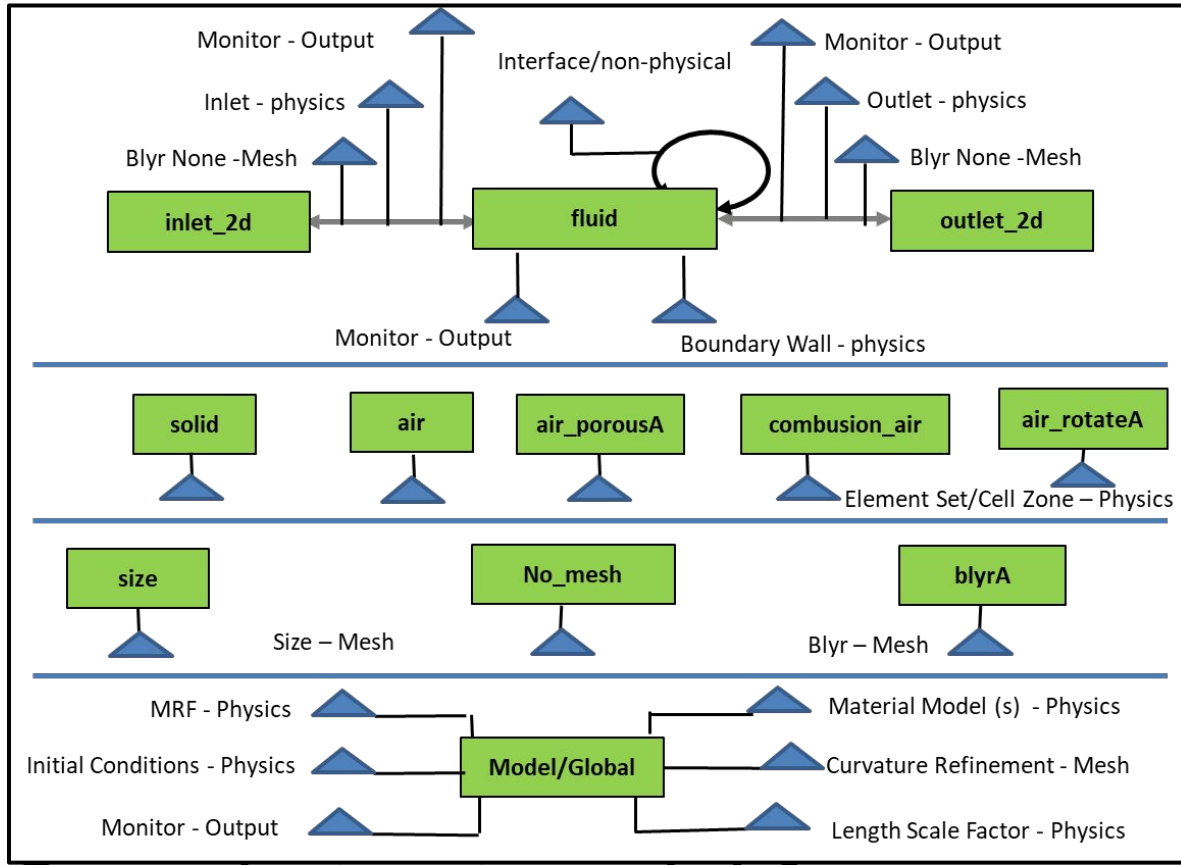
A Closer Look at Abstract Modeling

Simulation set-up done for specific geometries

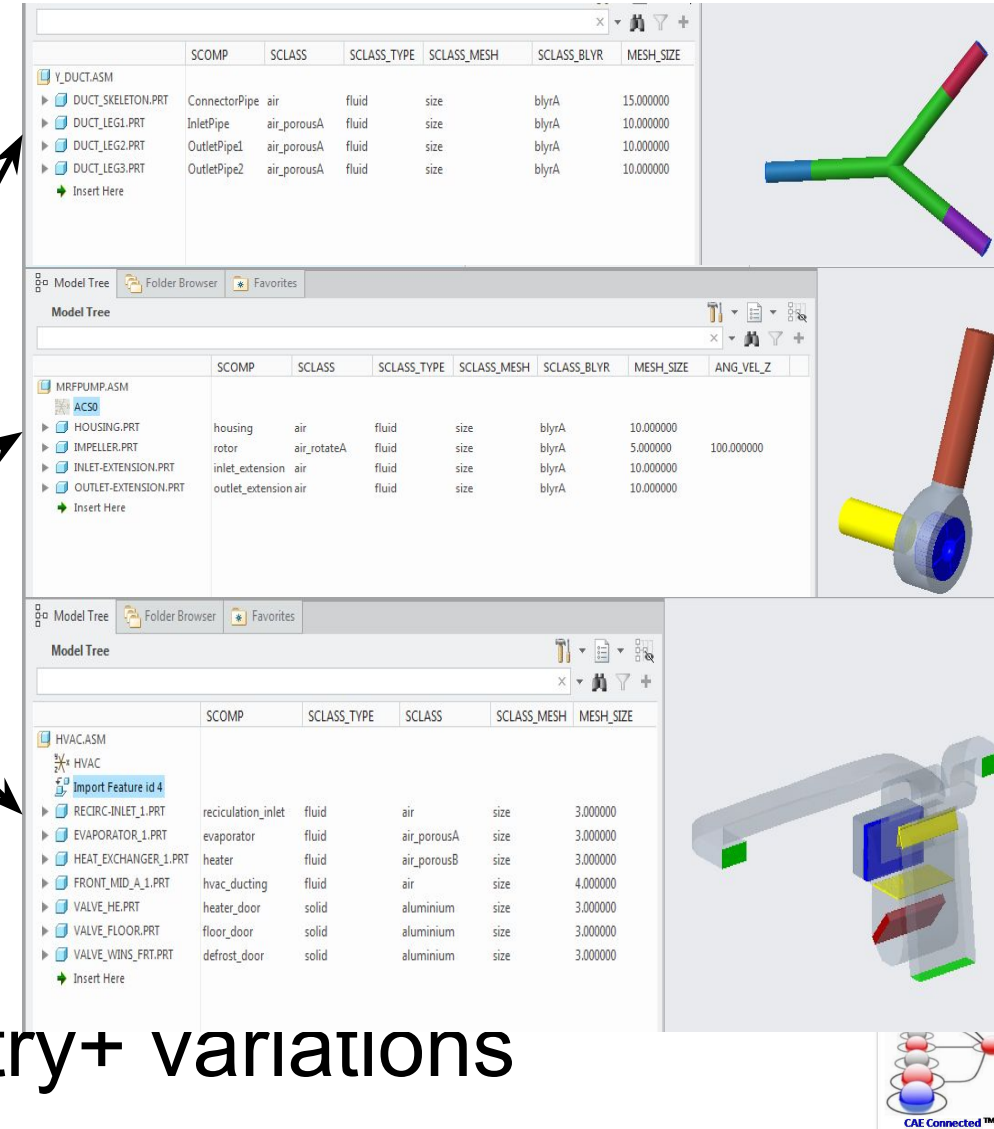


Necessary to repeat when geometry changes

Abstract modeling concept



One abstract model for many geometry+ variations



A Closer Look at Abstract Modeling

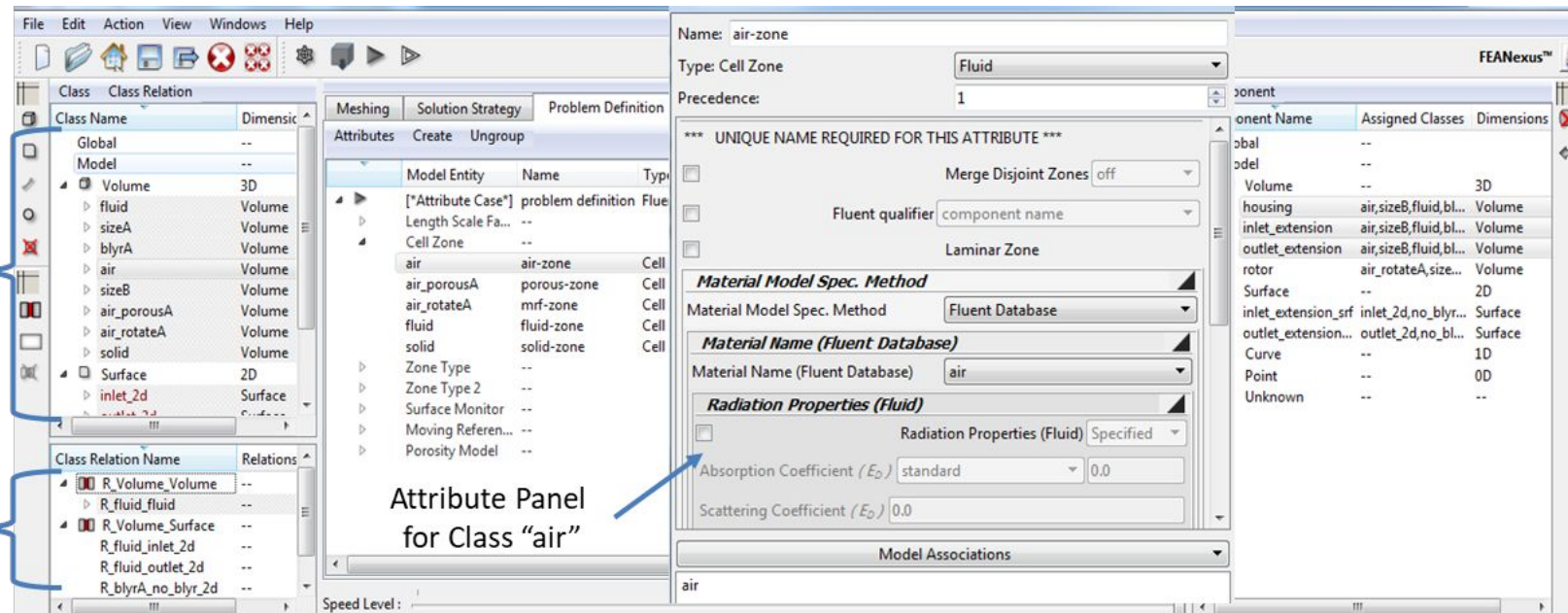
Abstract modeling concept advantages

- A simpler, faster way to reliably automate the process from CAD to solver input
- Increasing analyst capacity for value adding tasks
- Enabling CAD designers to initiate dependable simulations with always comparable results
- Best-Practice/Knowledge capturing and management tool

A Closer Look at Abstract Modeling

Abstract modeling ingredient #1: Abstract Model

- Created by simulation specialist
- Used by designers and/or simulation specialist



The screenshot displays the NAFEMS software interface with the following components:

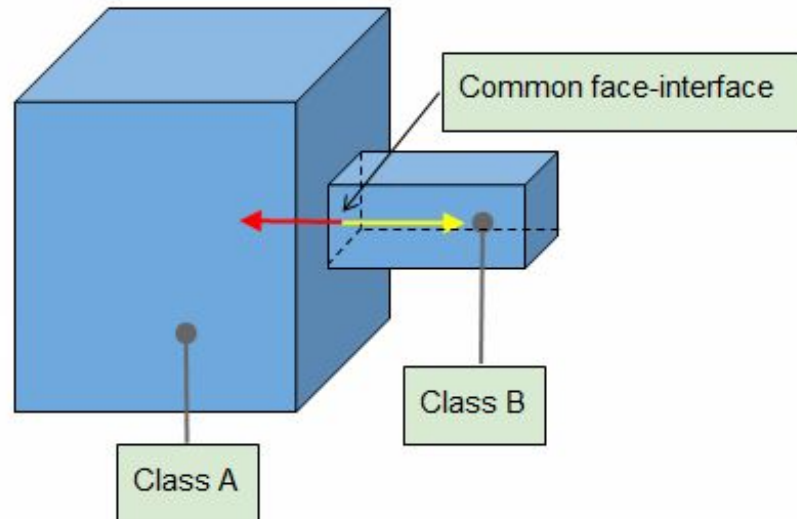
- Class Relation Panel (Left):** Shows a hierarchy of classes. The 'air' class is selected under the 'Volume' category. A blue bracket labeled "Abstract Classes" points to this panel. Below it, the 'Class Relation Name' panel shows relationships like 'R_Volume_Volume' and 'R_fluid_fluid', with a blue bracket labeled "Abstract Relations" pointing to it.
- Modeling Panel (Center):** Contains tabs for 'Meshing', 'Solution Strategy', and 'Problem Definition'. The 'Problem Definition' tab is active, showing a table of model entities. A blue arrow points to the 'air' entity, with a label "Attribute Panel for Class 'air'".
- Attribute Panel (Right):** Displays the configuration for the 'air' class. It includes fields for 'Name' (air-zone), 'Type' (Cell Zone), 'Precedence' (1), and 'Material Model Spec. Method' (Fluent Database). It also shows 'Radiation Properties (Fluid)' with 'Absorption Coefficient (E_D)' set to 'standard' and 'Scattering Coefficient (E_D)' set to '0.0'.
- FEANexus Panel (Far Right):** A table listing components and their assigned classes and dimensions.

A Closer Look at Abstract Modeling

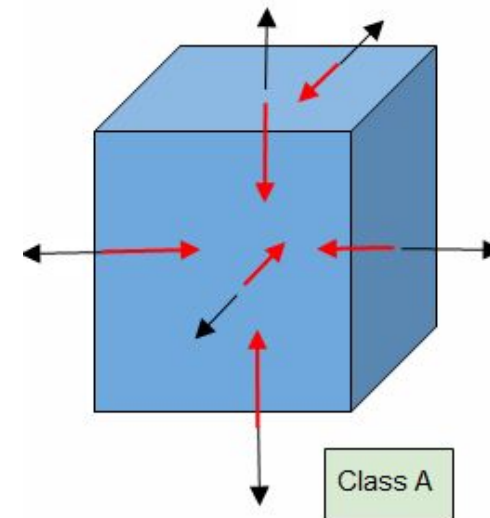
Abstract modeling ingredient #1: Abstract Model

- Classes and relations have child entities
- Allows identification of e.g. specific face sides

Class Child Entity Interface



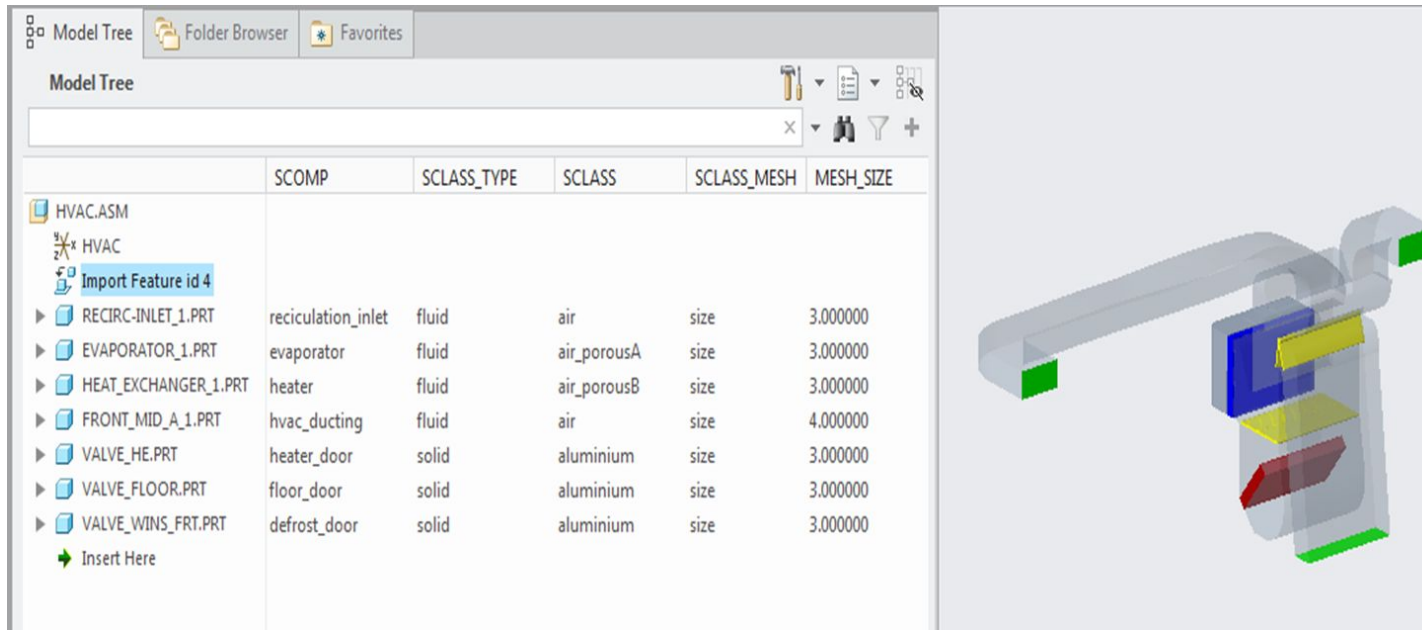
Class Child Entity Boundary



A Closer Look at Abstract Modeling

Abstract modeling ingredient #2: CAE CAD Model

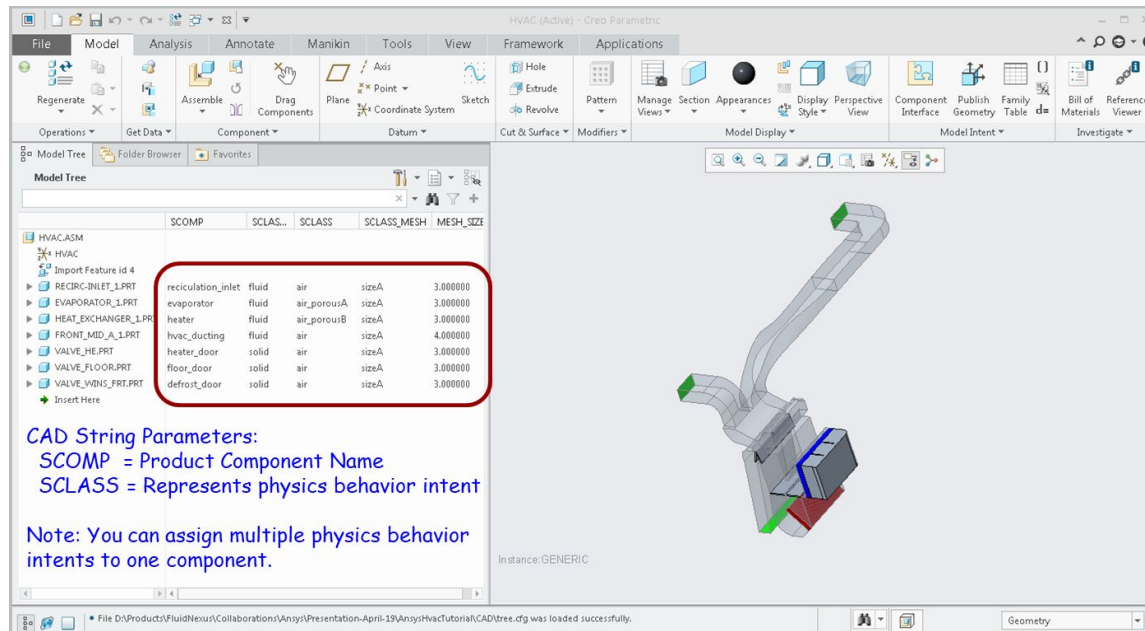
- CAE/CFD view created by designer or simulation specialist
- Used by its creator



A Closer Look at Abstract Modeling

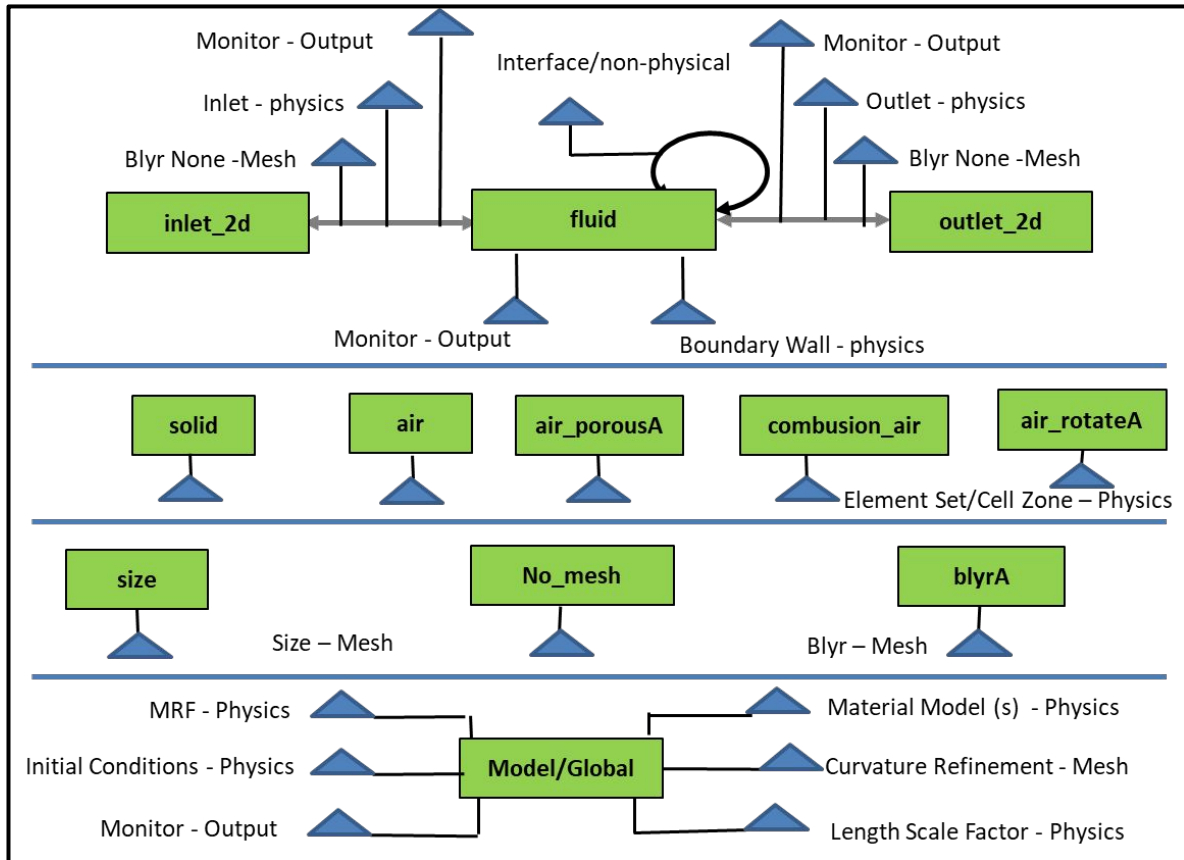
Abstract modeling ingredient #2: CAE CAD Model

- Created by designer or simulation specialist
- Used by its creator



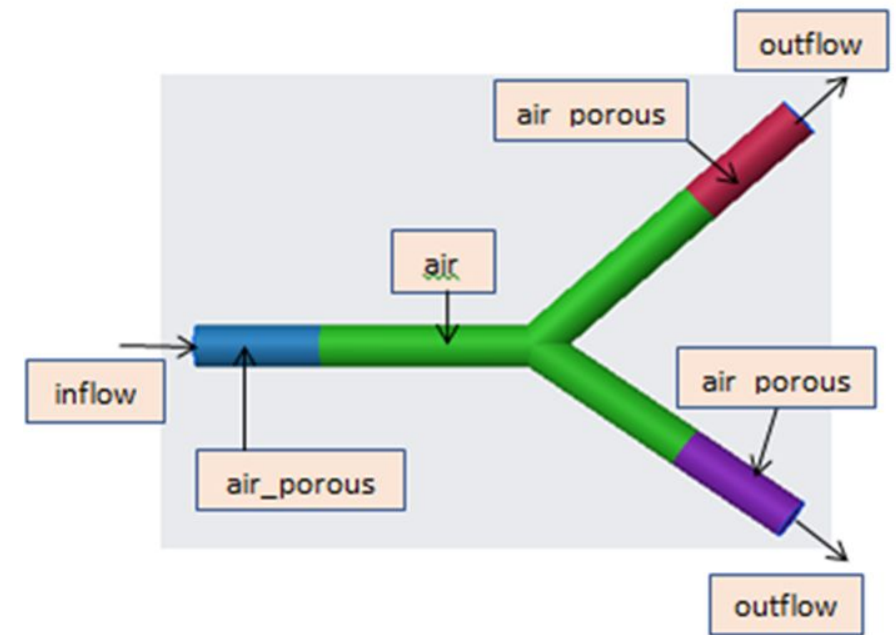
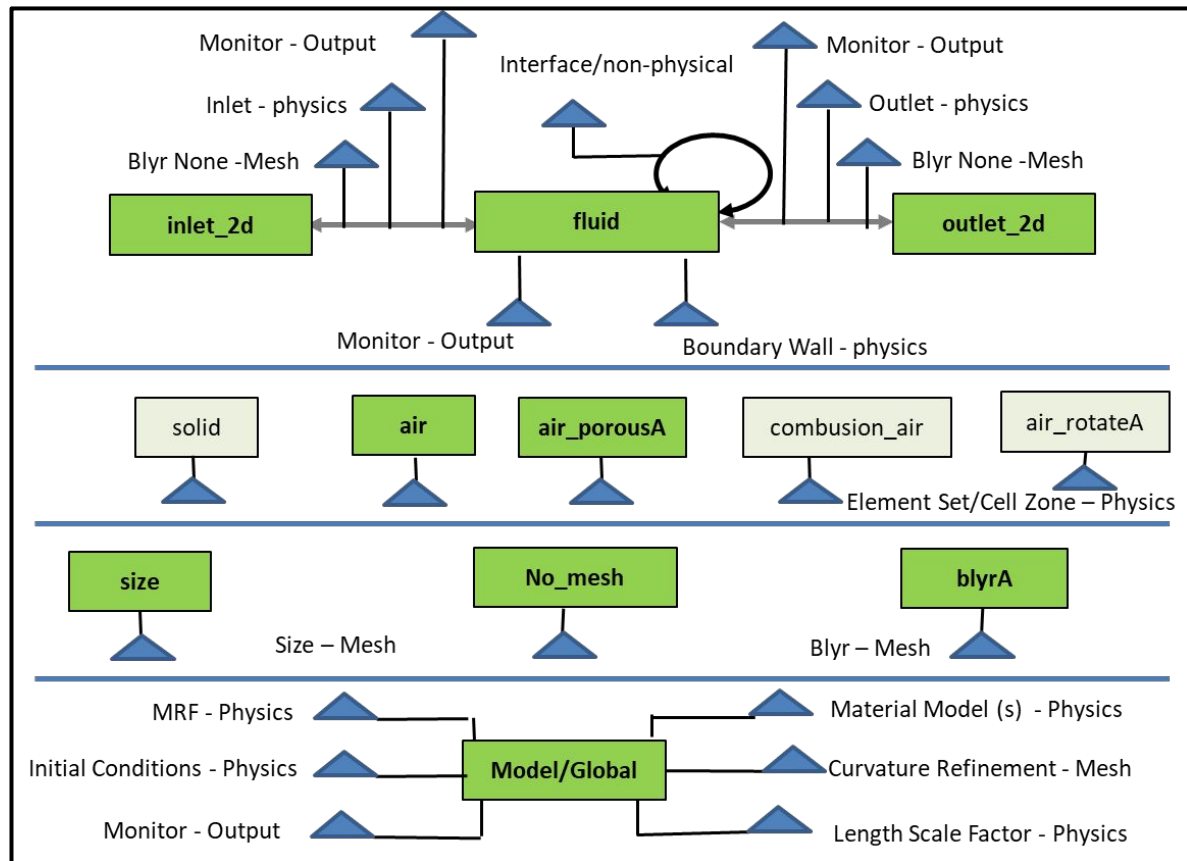
Abstract model versatility

- More comprehensive than a specific application



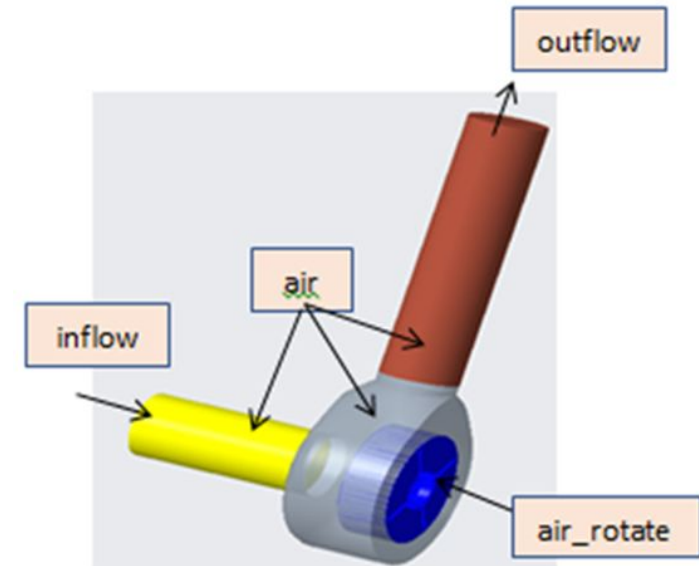
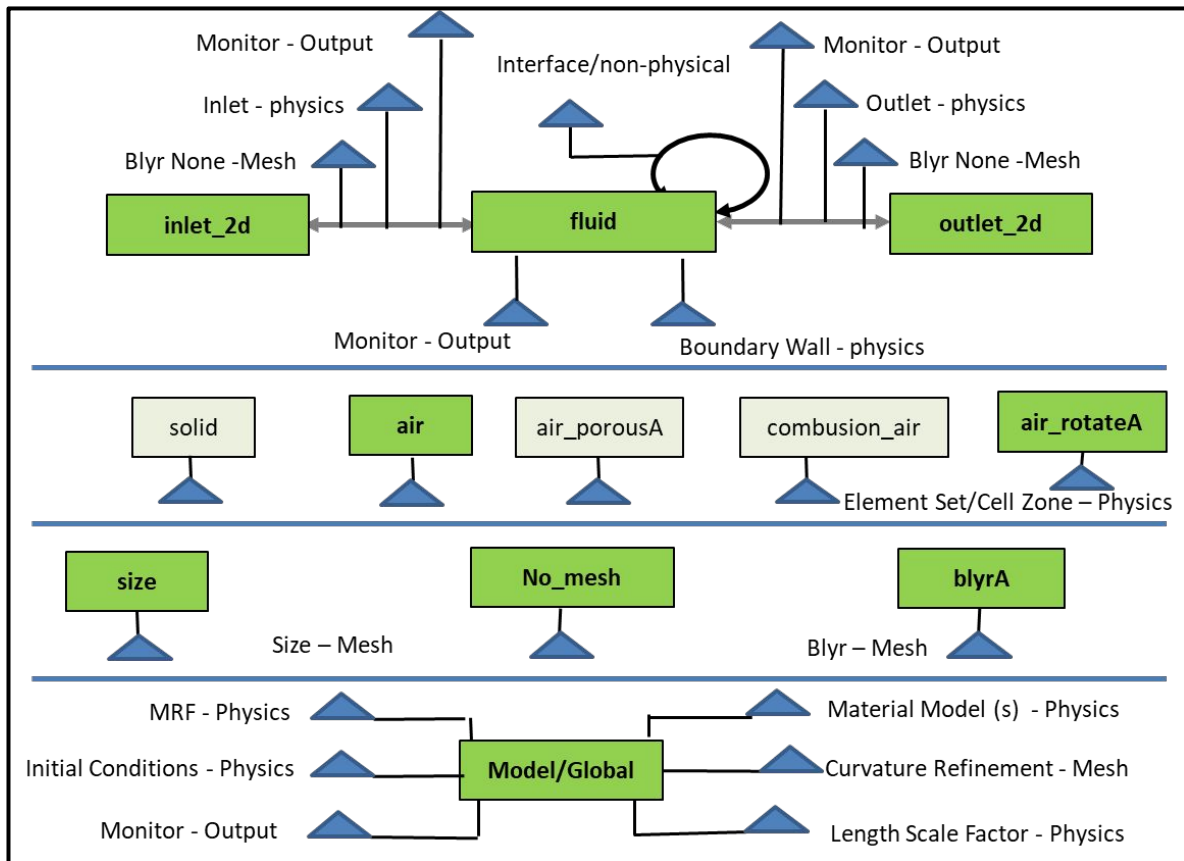
Abstract model versatility

- More comprehensive than a specific application



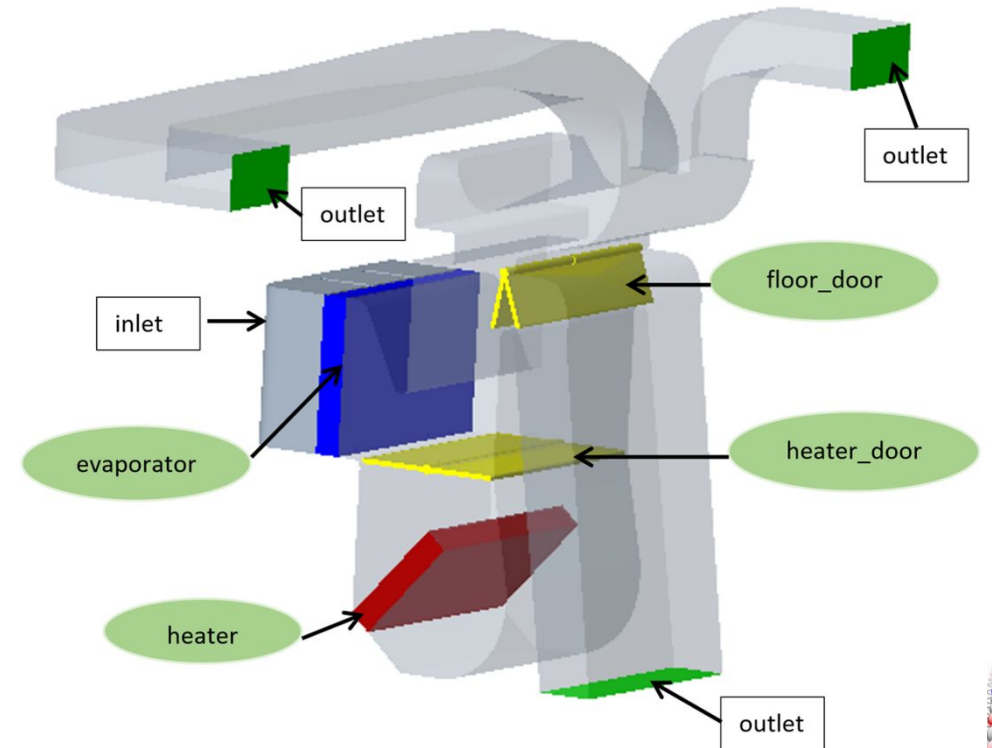
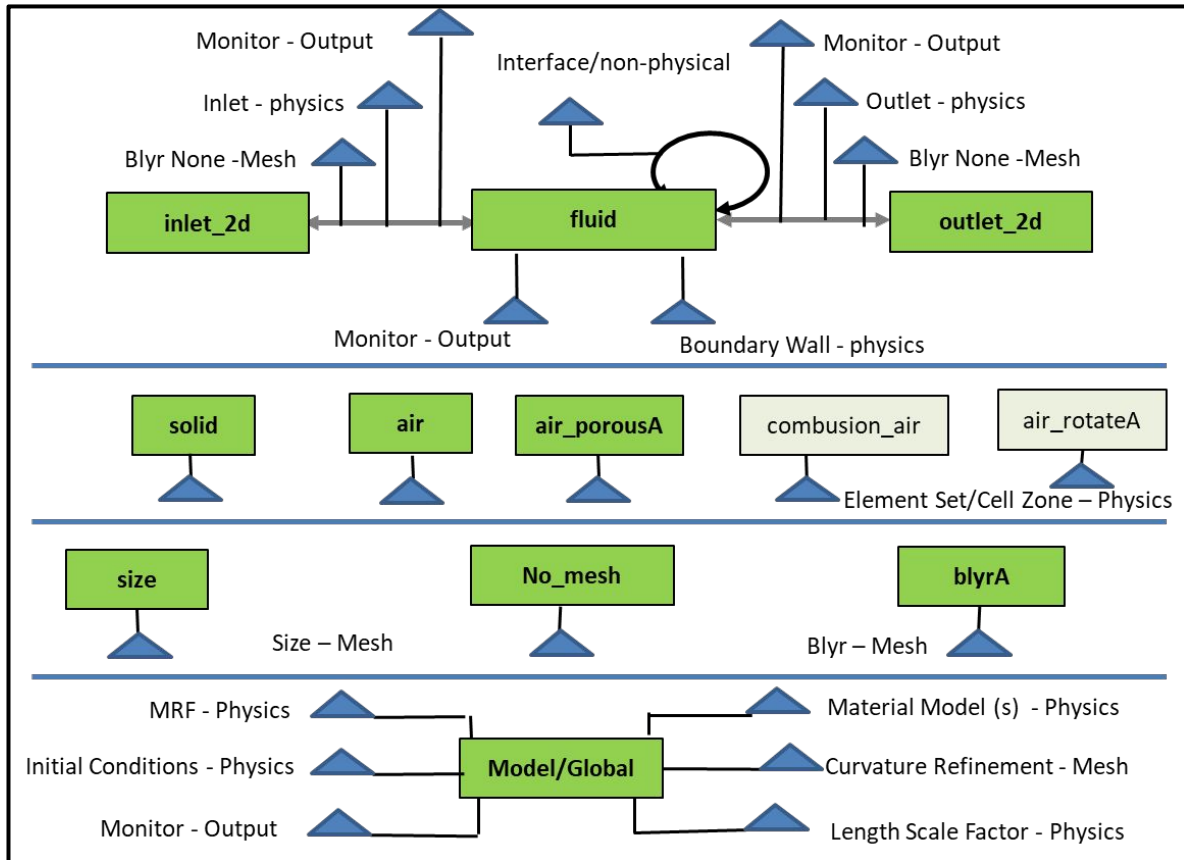
Abstract model versatility

- More comprehensive than a specific application



Abstract model versatility

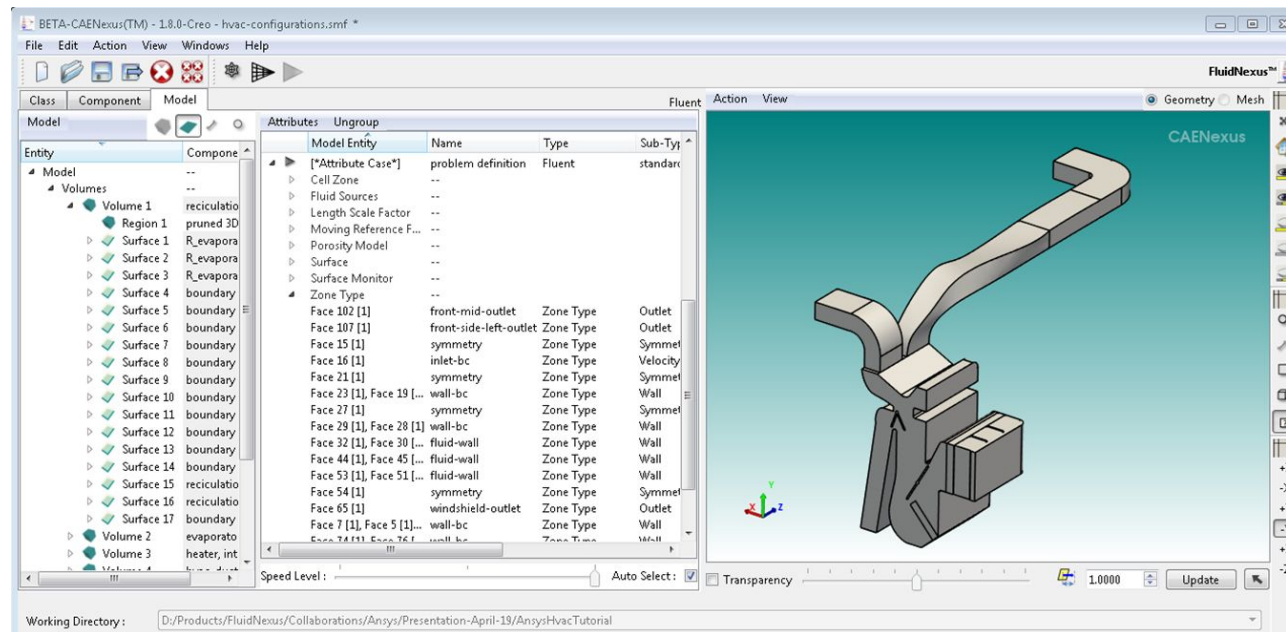
- More comprehensive than a specific application



A Closer Look at Abstract Modeling

Combining ingredient #1 and #2: Simulation Model

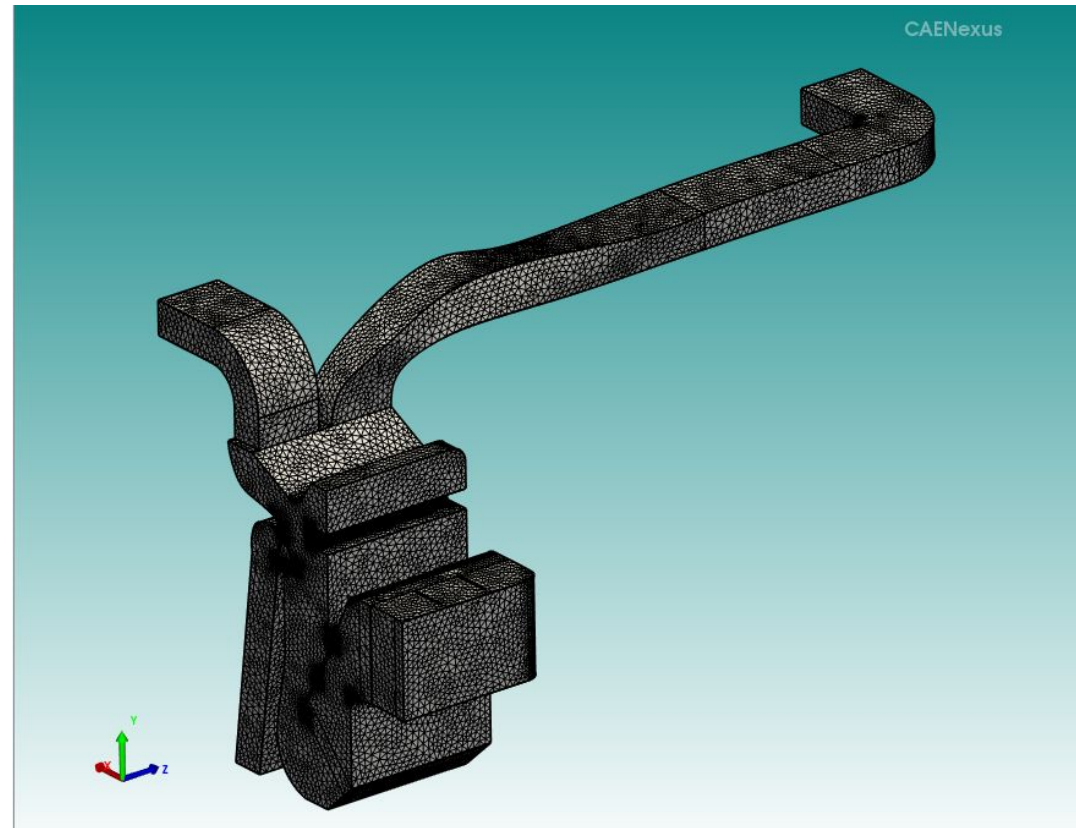
- Automatically generated
 - Parameters from classes transferred to real geometry
- Base for automatic creation of mesh and solver input files



A Closer Look at Abstract Modeling

Combining ingredient #1 and #2: Simulation Model

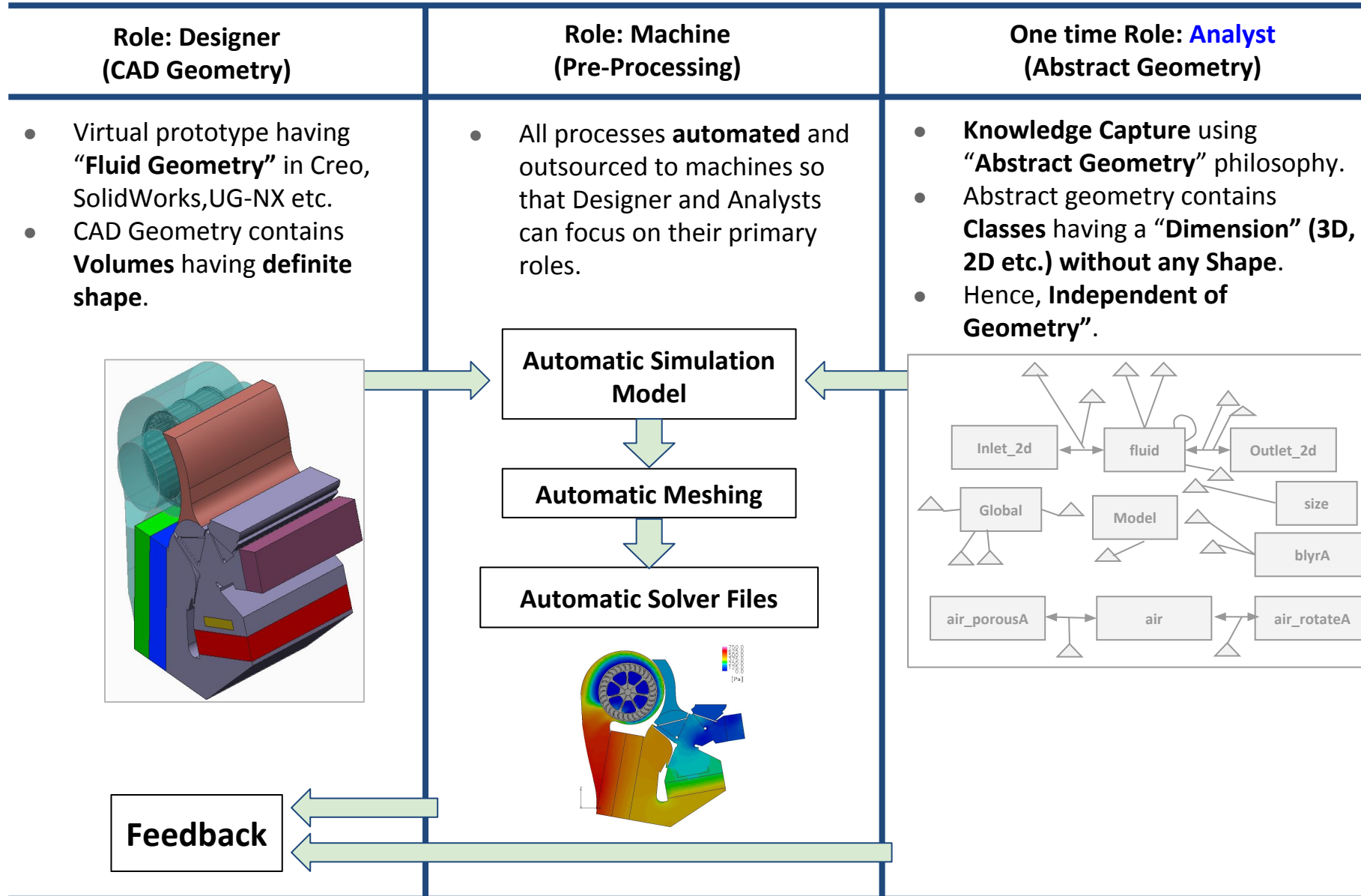
- Mesh created directly from CAD files – no translation



Agenda

- Introduction
- Why Abstract Modeling
- A Closer Look at Abstract Modeling
- **Abstract Modeling Automated Process**
- Abstract Modeling for Simulation Applications
- Conclusion

Abstract Modeling Automated Process

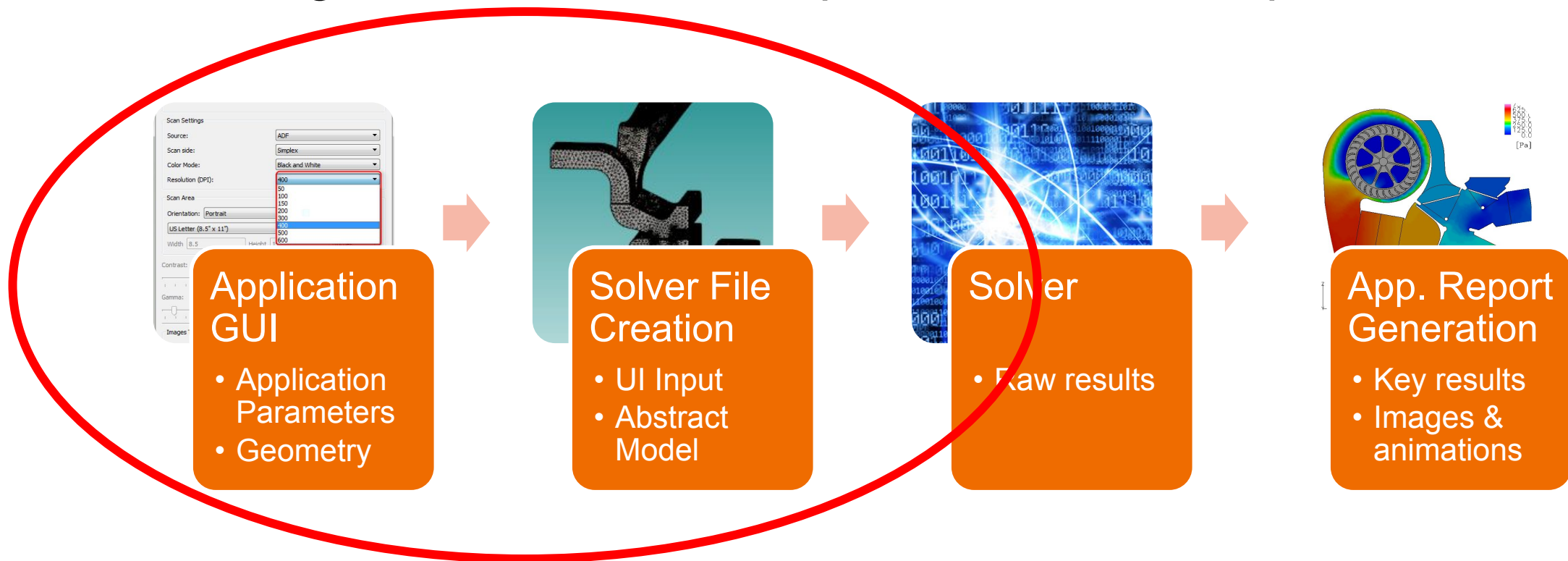


Agenda

- Introduction
- Why Abstract Modeling
- A Closer Look at Abstract Modeling
- Abstract Modeling Automated Process
- **Abstract Modeling for Simulation Applications**
- Conclusion

AM for Simulation Applications

- Abstract modeling “natural” core of simulation application front-end
 - Managed from simulation specific GUI via scripts



Agenda

- Introduction
- Why Abstract Modeling
- A Closer Look at Abstract Modeling
- Abstract Modeling Automated Process
- Abstract Modeling for Simulation Applications
- **Conclusion**

Conclusion

Abstract modelling's unique combination of benefits

- ✓ Democratization of simulation
 - Extending use of simulation
 - Enabling CAD designers to run dependable simulations supporting design decisions
- ✓ Systematic capturing and re-use of simulation know-how and best practices
- ✓ Consistent, comparable simulation results independent of where, when or by whom simulations are performed
- ✓ Vastly improved efficiency of CAD to CAE solver input process through robust automation, easy to set-up

Abstract modeling - making the art of simulation
a reliable service



Questions?
THANK YOU!