OAK RIDGE National Laboratory

2019 TRANSFORM Training Workshop

M. Scott Greenwood, PhD

Oak Ridge, TN

September 11-12, 2019

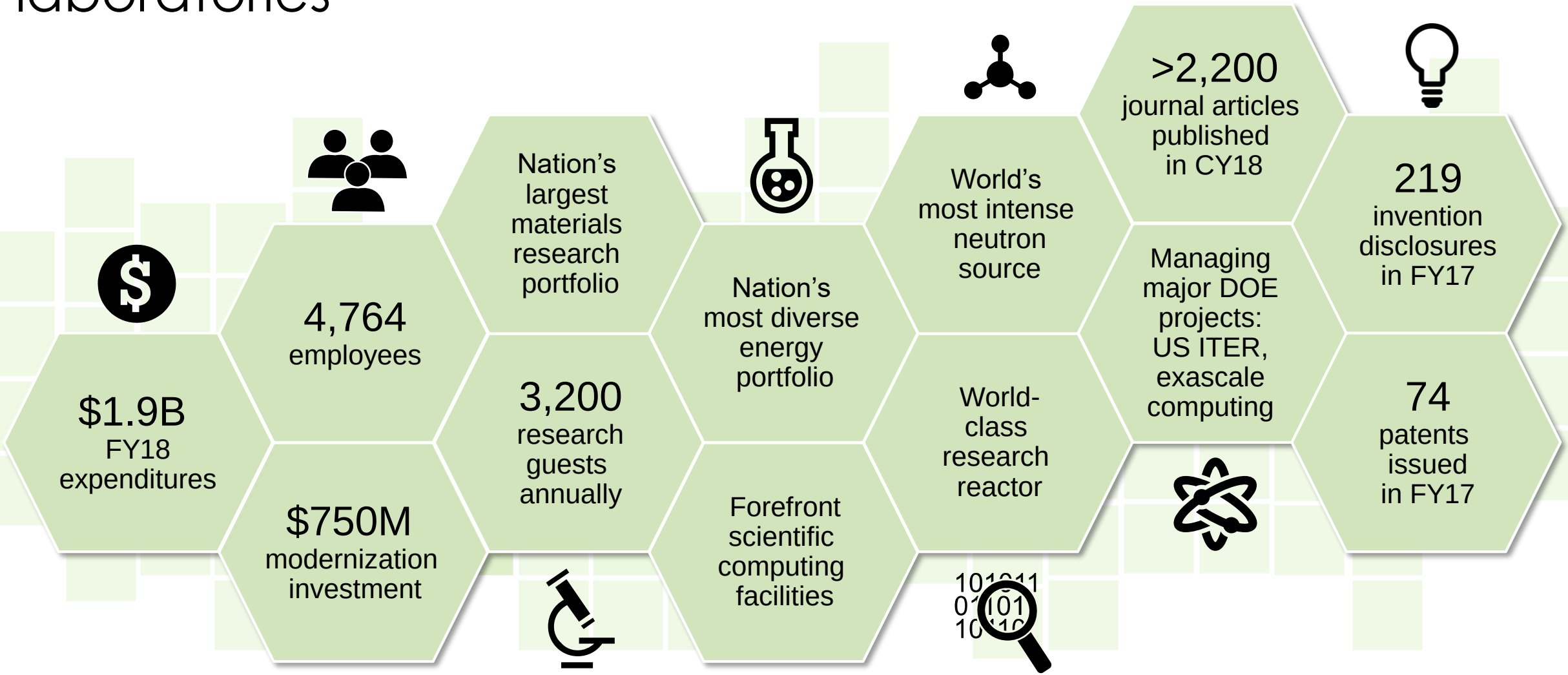
ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

Safety Orientation

- Announcements
- Emergency Exits
- Bathrooms
- Etc.

ORNL is one of the world's leading science and energy laboratories



OAK RIDGE National Laboratory

OAK RIDGE National Laboratory

Welcome to Oak Ridge National Laboratory

https://www.youtube.com/watch?v=OOlg-jC15TI&list=PLD37DC0FD306E52C6&index=2&t=0s

TRANSFORM Training Workshop Agenda Overview

- Will cover a range of topics
  - Modelica introduction to system Modeling with TRANSFORM
  - Hands on example and Q&A opportunities
  - The future of modeling and simulation
  - Tour of ORNL facilities
- Workshop Goals
  1. Understand what TRANSFORM/Modelica is!
  2. Gain confidence in using the tools to get results!
  3. Have a vision for the future of M&S!
  4. Establishing a network of future collaborators!

OAK RIDGE National Laboratory

A Brief Introduction to Modelica

Modelica is …

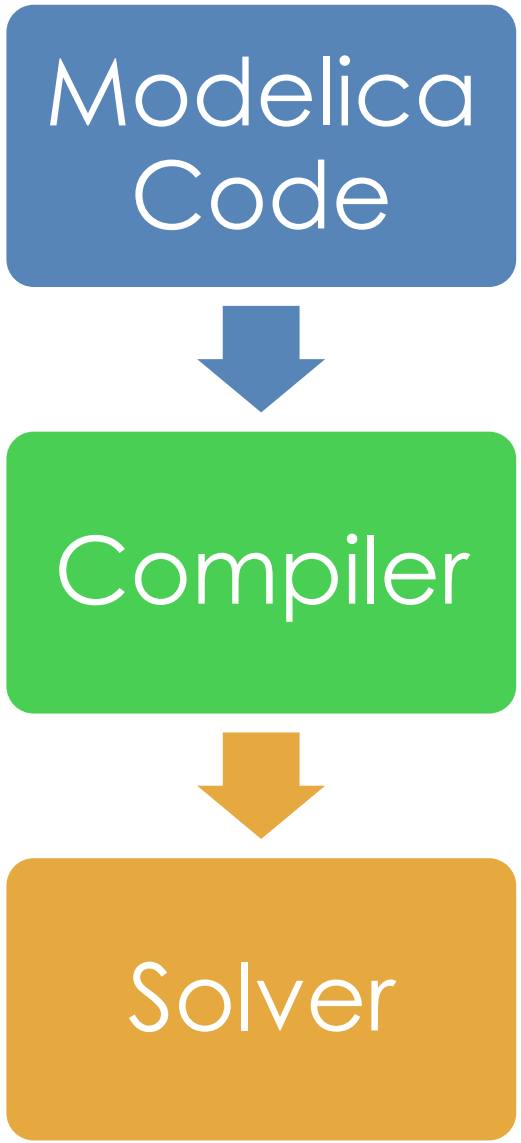
- The underlying technology of TRANSFORM
- **A programming language**
  - https://www.modelica.org/
- Domain neutral
  - Not tied to any particular application (i.e., flexible!)
- Built for hierarchal development
- **Acausal** and ODE (**time-dependent**) solver
  - $\frac{dx}{dt} + y = z^x + yz$

```
partial model Partial_BaseFDCond_Cylinder
  import SI = Modelica.SIunits;

  /* General */
  replaceable package material = NHES.Media.Solids.SS316 constrainedby
    NHES.Media.Interfaces.PartialAlloy "Specify material type"
    a;
  parameter Boolean use_q_ppp = false
    "Toggle volumetric heat generation interface"
   a;

  parameter SI.Length r_inner(min=0) = 0 "Centerline/Inner radius of cylinder"
  a;
  parameter SI.Length r_outer "Outer radius of cylinder"
  a;
  parameter SI.Length[nRadial] r = linspace(r_inner, r_outer, nRadial)
    "Define radial spacing"
  a;
  parameter SI.Length[nAxial] z = linspace(0, length, nAxial)
    "Define axial spacing"
  a;

  parameter SI.Length length "Length of cylinder"
  a;
  parameter Integer nRadial(min=3) = 3 "Nodes in radial direction"
  a;
  parameter Integer nAxial(min=3) = 3 "Nodes in axial direction"
  a;

  /* Assumptions */
  parameter Modelica.Fluid.Types.Dynamics energyDynamics = Modelica.Fluid.Types.Dynamics.DynamicFreeInitial
    "Formulation of energy balances" a;

  /* Initialization */
  parameter SI.Temperature Tref = 273.15 "Center nodes initial temperature"
   a;
  parameter SI.Temperature[nRadial,nAxial] T_start = fill(Tref,nRadial,nAxial)
  a;

equation
  assert(r_outer > r_inner, "r_inner must be greater than r_outer");
  assert(r[1] == r_inner, "r_inner and r[1] must be equal");
  assert(r[end] == r_outer, "r_outer and r[end] must be equal");
  assert(size(r,1) == nRadial, "r and nRadial must have equal sizes");
  assert(size(z,1) == nAxial, "z and nAxial must have equal sizes");
  assert(length > 0, "length of cylinder must be greater than zero");
  assert(z[1] >= 0, "cylinder length z[1] must be >= 0");
  assert(z[end] <= length, "cylinder length z[1] must be >= 0");
  //assert((length-abs(z[end]-z[1]))/length < 1e-3, "length of cylinder must be equal to length of z");

end Partial_BaseFDCond_Cylinder;
```

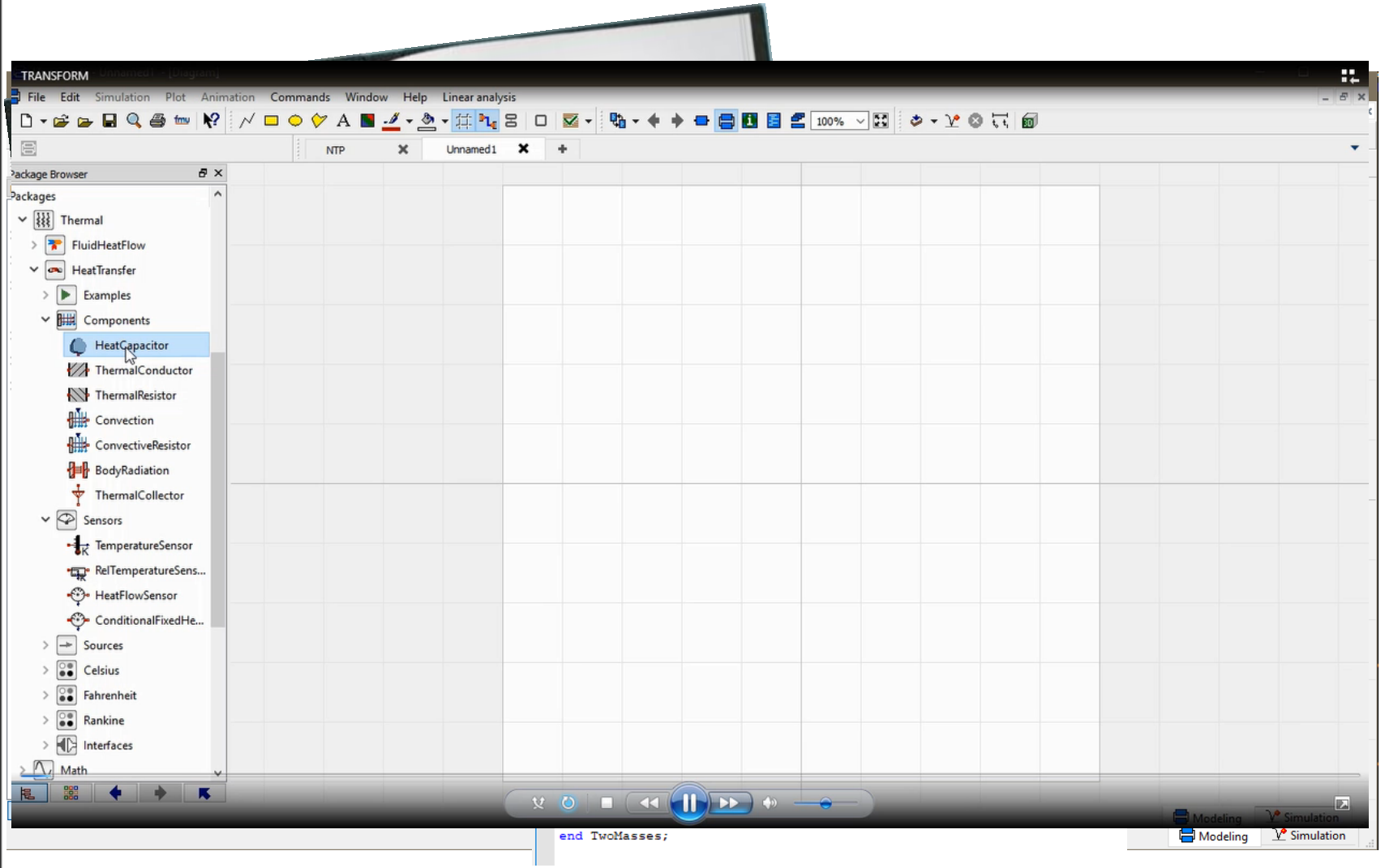
Sample Modelica Code from TRANSFORM-Library

Modelica Compartmentalizes the Solution Process

- Aspects of the solution process are separate
- Solvers are **not** integrated in the model
- Allows you to easily change solvers
- Modelica code is IDE agnostic
- Allows for integration with other models (FMI)
  - model exchange
  - co-simulation



Working with Modelica in the Dymola environment



1) Start with an integrated development environment (IDE)

2) Enter equations and properties using Modelica language syntax

3) Encapsulate code as a new “component”

4) Drag-and-drop component onto the canvas to create a model (i.e.: component-based modeling)

5) All equations are simultaneously solved as a function of time

OAK RIDGE National Laboratory

Prepare for TRANSFORM

Please do the following before the next training!

- Search for "ornl transform github" in your favorite internet browser

- Download
  - https://github.com/ORNL-Modelica/TRANSFORM-Library

  AND
  - https://github.com/ORNL-Modelica/TRANSFORM-Training

- Download and extract into the /Documents/Dymola folder
  - May have to rename the .zip file to something short like "a.zip"

OAK RIDGE National Laboratory

Thank you.

Scott Greenwood

greenwoodms@ornl.gov