Tutorial 1 — First Co-simulation

Overview

This tutorial will show you how to:

1. Open a project in the INTO-CPS App
2. Run a co-simulation
3. View a 3D plot (Windows only)

Requirements

This tutorial requires the following:

- INTO-CPS Application
- COE (Co-simulation Orchestration Engine) accessible to the Application
- Tutorial materials

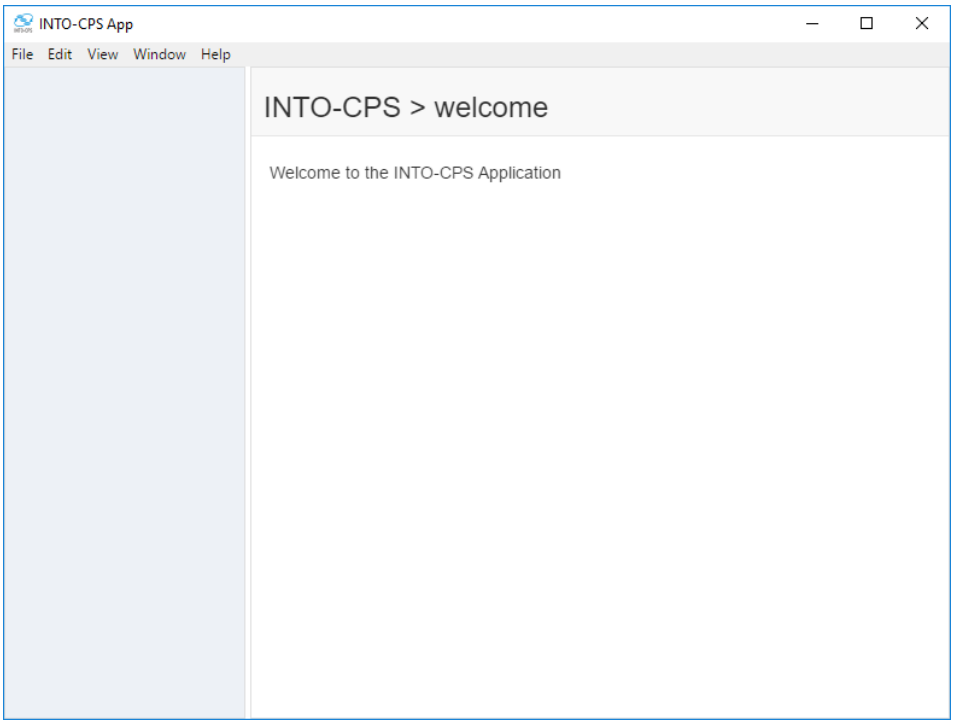
You may have been provided with tools and tutorials on a USB drive at your training session. Otherwise:

- Follow Tutorial 0 with the guidelines to install the INTO-CPS Application and COE.
- Ask your instruction for the tutorial materials. These are available for students and members of the INTO-CPS Association[1].

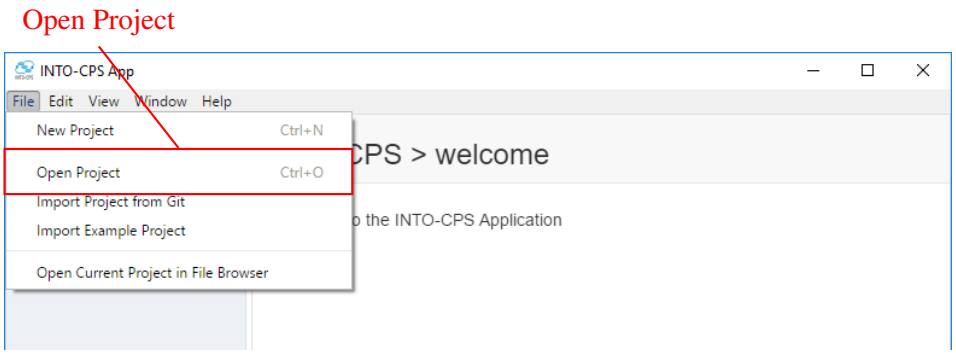
1 Opening a Project

Step 1. Launch the *INTO-CPS Application*. On first loading, it will look like the screenshot below. If you have opened a project previously, that project will be opened automatically.

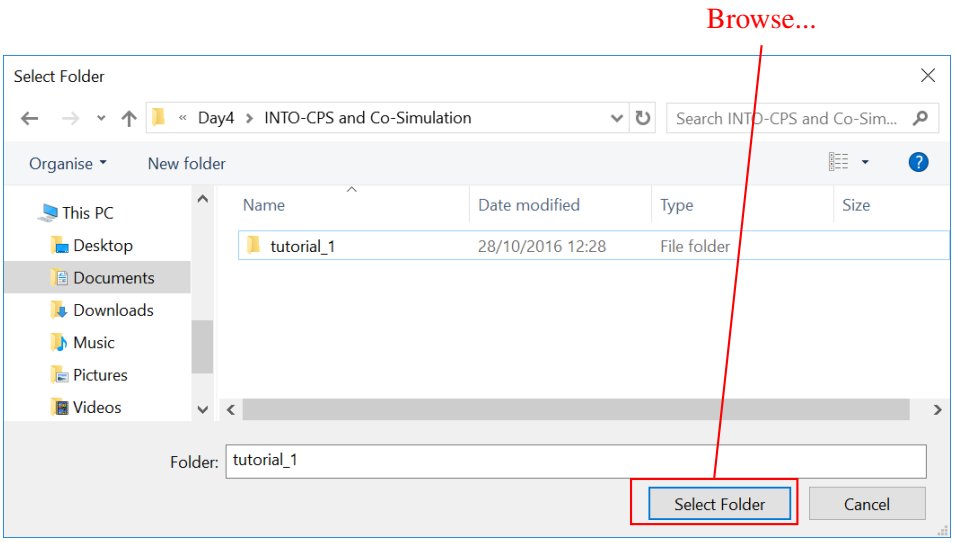
[1] `https://into-cps.org/`



Step 2. To open a project, select *File* > *Open Project*.



Step 3. Find *Tutorials/tutorials_1*, select it and press *Select Folder*.



Step 4. Once the project is opened, you will see that project browser on the left of the INTO-CPS Application window is now populated. The entries in the project browser correspond to folders and files in the *Tutorials/tutorials_1* folder. You can read the project description in the *README.md* file.

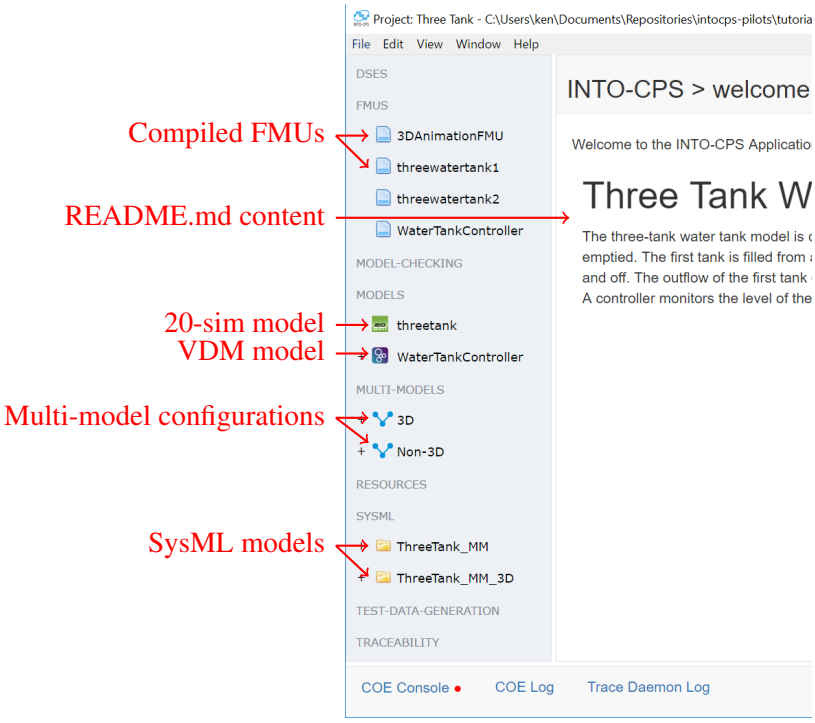
The elements in the *tutorial_1* project are:

FMUs Compiled FMUs (with file extension .fmu) that are used in co-simulation.

Models Source models used to generate the FMUs. The icon of each entry shows which tool created the model. In this case Overture and 20-sim.

Multi-models Used to configure co-simulations, including which FMUs are used and other co-simulation settings.

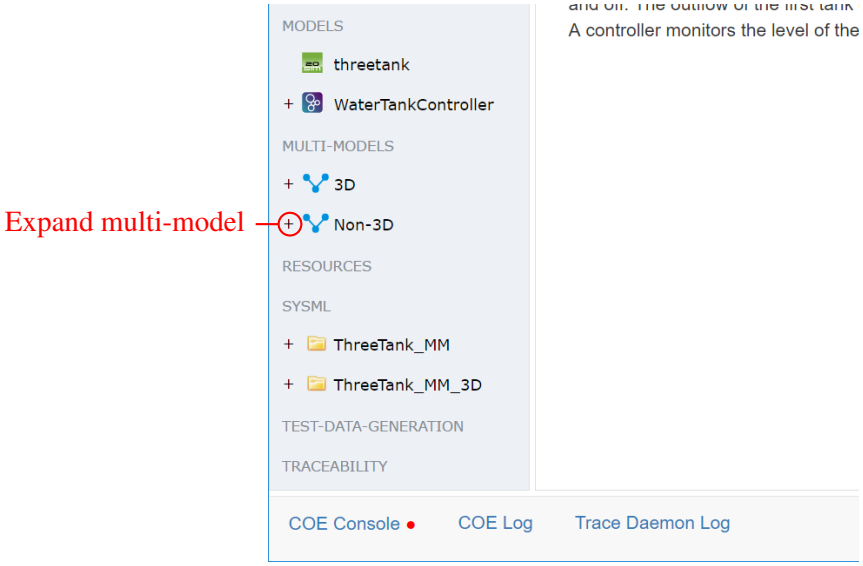
SysML Architectural models that are used to create model and multi-model descriptions.



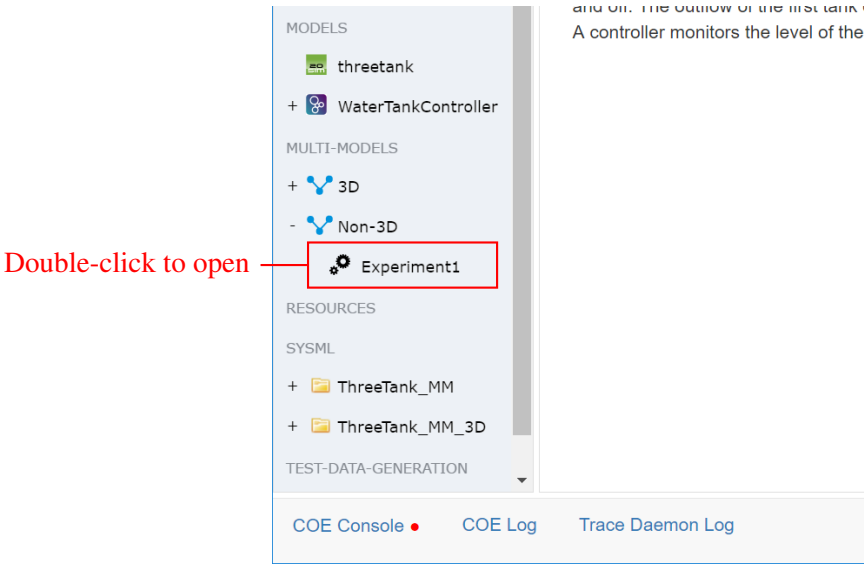
2 Running a Co-simulation

To run a co-simulation we must use one of the multi-model configurations. We'll start with the *Non-3D* multi-model (since it works on all platforms).

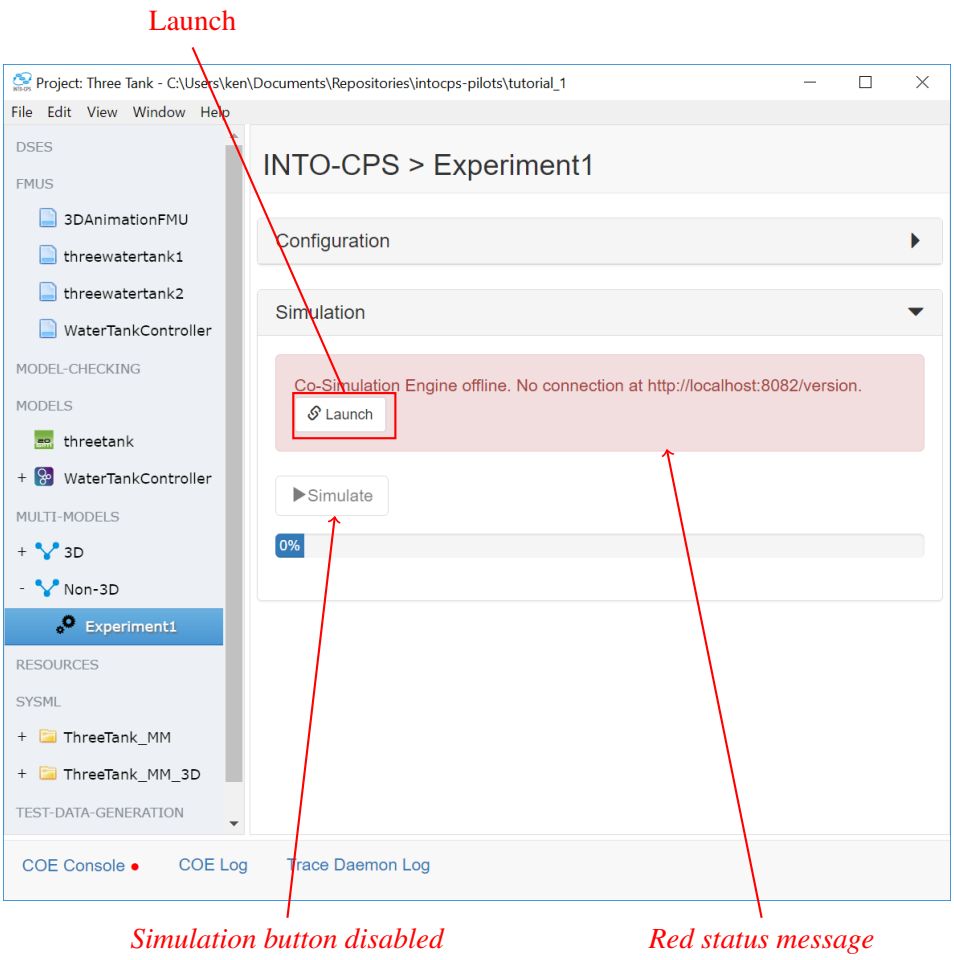
Step 5. Click the + symbol next to *Non-3D* multi-model to expand it.



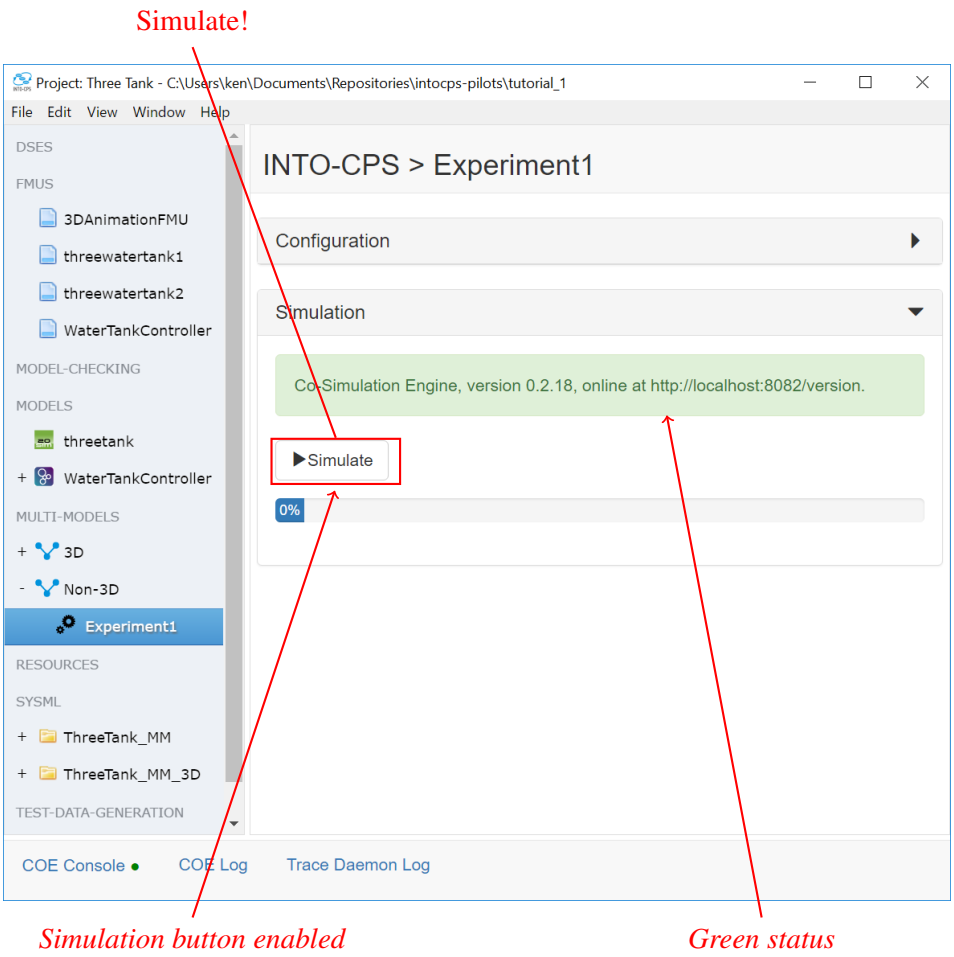
Step 6. There is one co-simulation configuration in this multi-model called *Experiment1*. Double-click this to open this configuration.



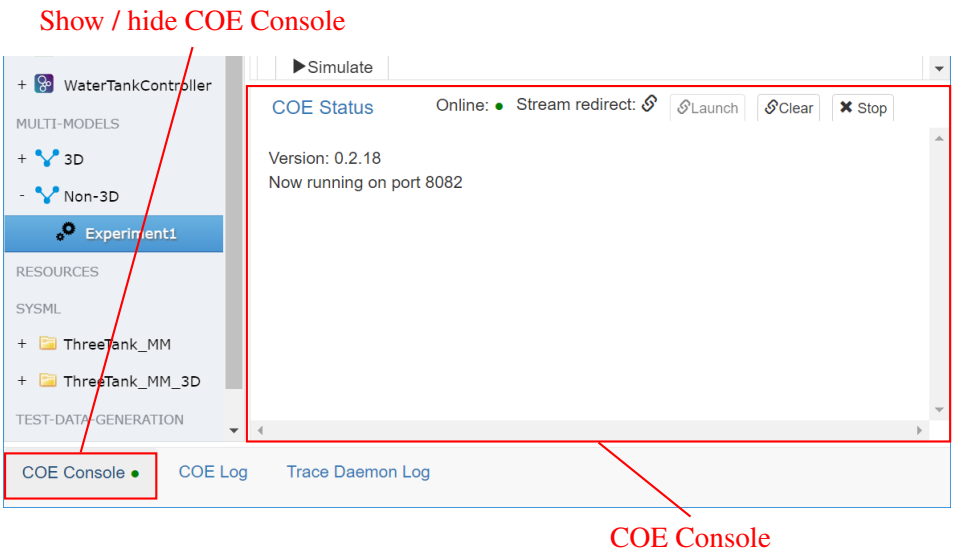
Step 7. Once the *Experiment1* co-simulation configuration is open, you will see the following screen. The COE (Co-simulation Orchestration Engine) is a separate tool from the INTO-CPS Application. This screen gives the status, which is offline. To launch it, press *Launch*.



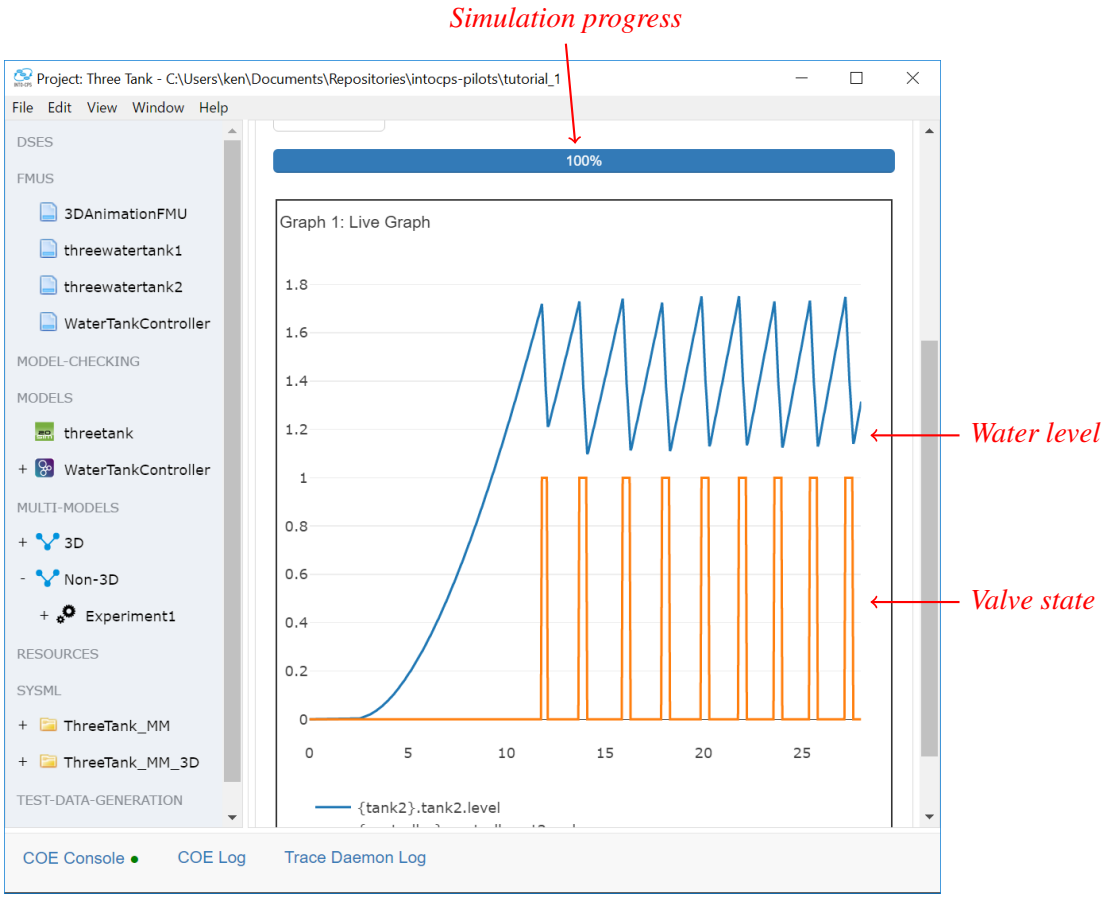
Step 8. Once the COE is online, the status message will become green and the *Simulate* button will be enabled. Press *Simulate* to run a co-simulation.



You can also see the status of the COE in the bottom left corner. Pressing here brings up the COE Console, which shows output from the COE and allows you to stop and launch the COE. Pressing the button again will hide the console.



Step 9. When simulating, you may see a Java console windows appearing, status information will appear in the *COE Console*, and a *live plot* will show variables in the model across time.



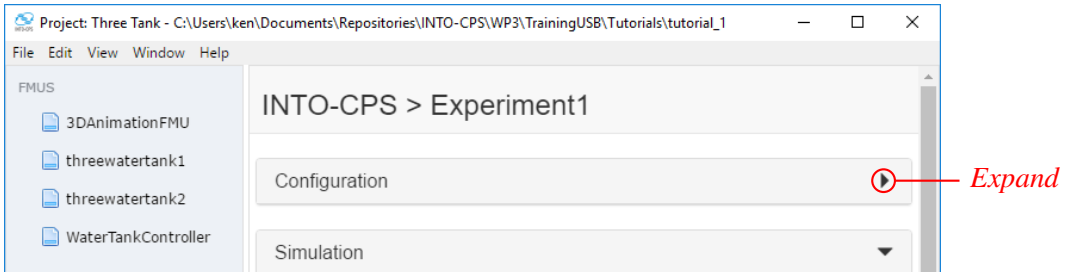
This multi-model is of a water tank system. The live plot shows the water level in one of the tanks that is constantly being filled, and the state of the valve (1 = open, 0 = closed) that allows water to flow out of the tank. You can see the water level rise and fall as the controller opens and closes the valve. The water tank was modelled in 20-sim and the controller modelled in VDM.

Congratulations!

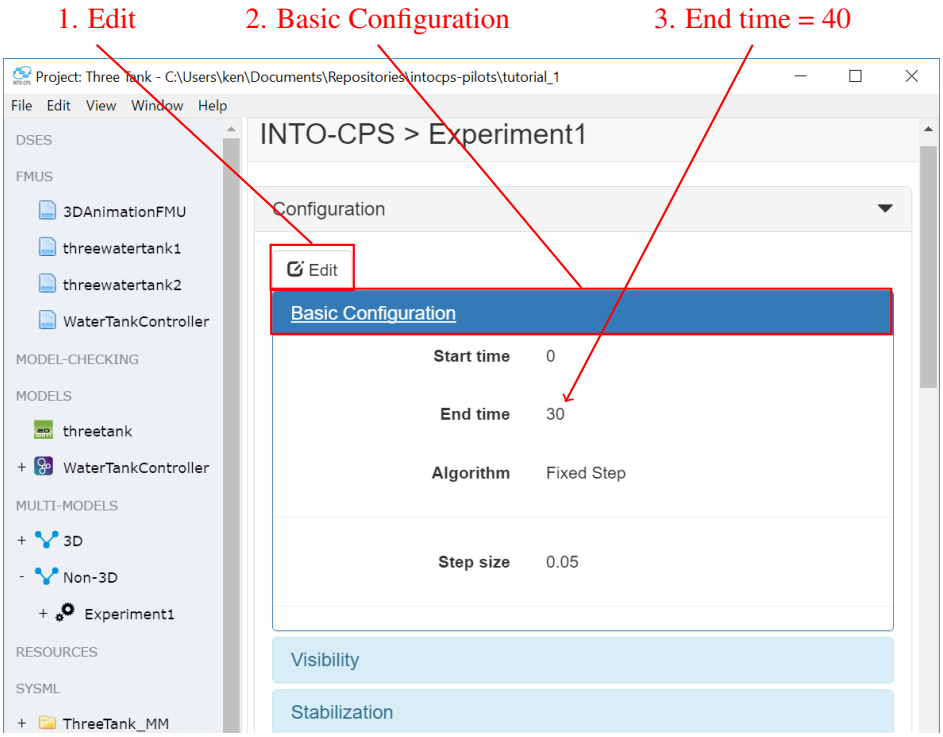
You have completed your first co-simulation with the INTO-CPS Application.

3 Changing Co-simulation Parameters

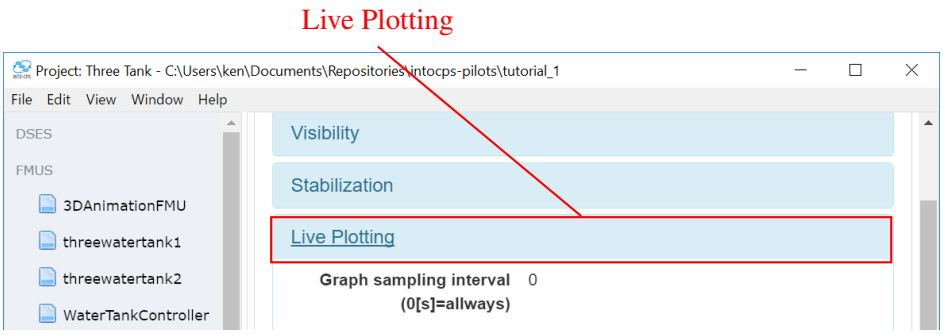
Step 10. We can change the length of the co-simulation, the parameters of the master algorithm, and the variables that are plotted using the *Configuration* pane of the co-simulation configuration. Expand the pane by pressing the triangle.



Step 11. Press the *Edit* button, which allows you to make changes, then press *Basic Configuration*. Set the *End time* to 40 (seconds).

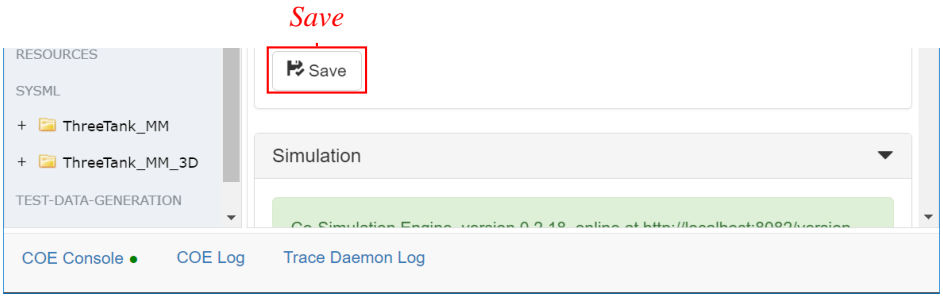


Step 12. Press *Live Plotting*.

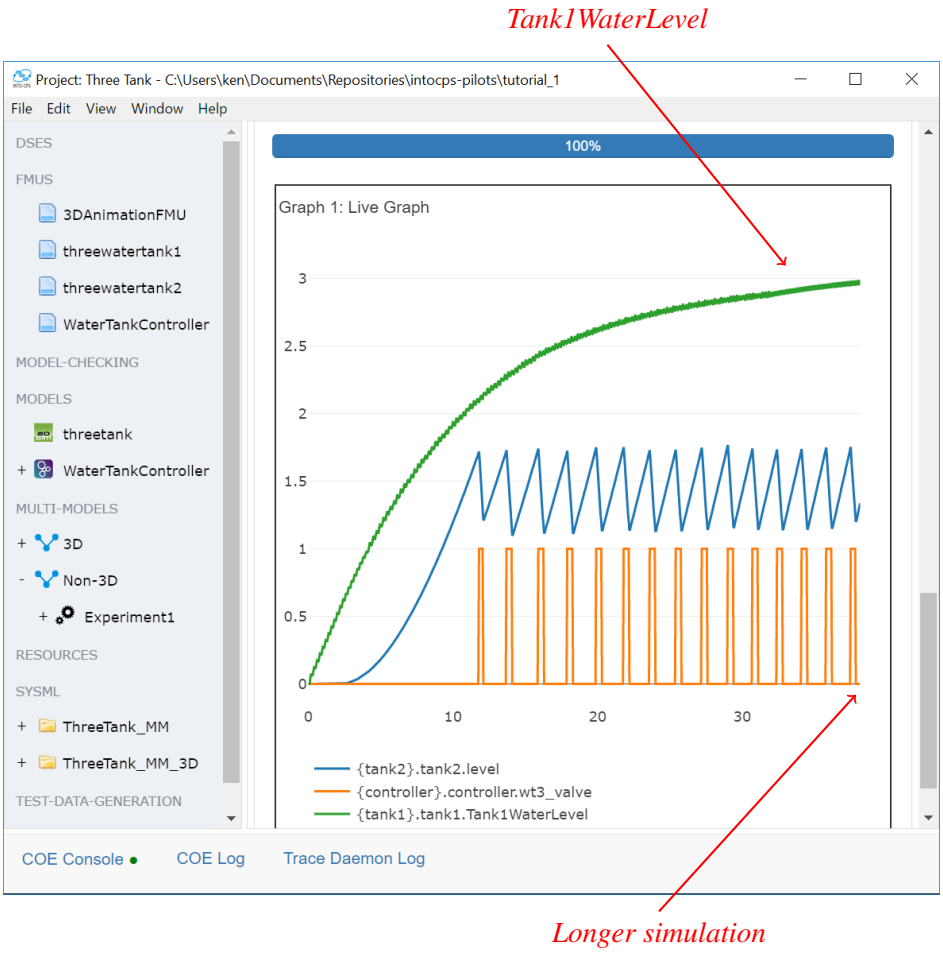


Scroll down to find **tank1.tank1** and check *Tank1WaterLevel*.

Step 13. Press the *Save* button.



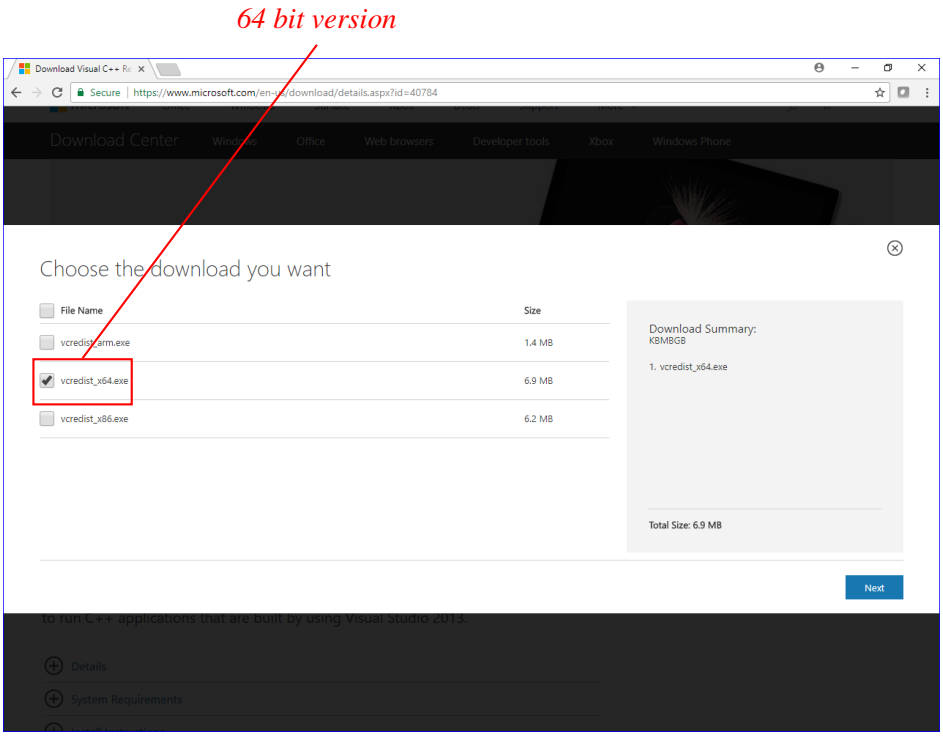
Step 14. Run the co-simulation again with the *Simulate* button. You will see a new variable on the graph, and that the co-simulation runs for a further 10 (simulated) seconds than before.



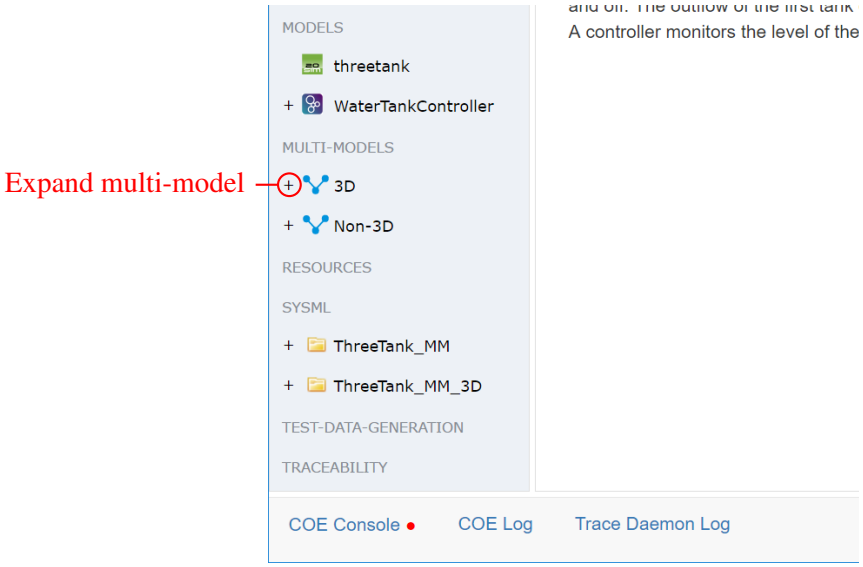
4 Viewing a 3D Plot (Windows Only)

The 20-sim tool is able to create 3D visualisations of simulations, which are linked to variables in a model. These can be included within an FMU generated by 20-sim, however *this feature is currently only available on the Windows platform*.

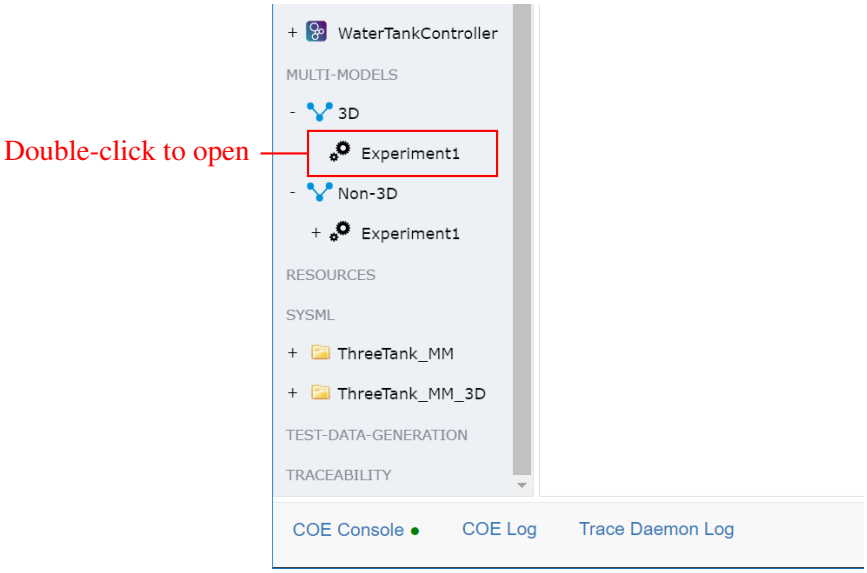
Step 15. Install the "Visual C++ Redistributable Packages install run-time components that are required to run C++ applications that are built by using Visual Studio 2013". You can find the file here: `https://www.microsoft.com/en-us/download/details.aspx?id=40784`. Click **Download**, choose the 64 bit version, click next, and run installer.



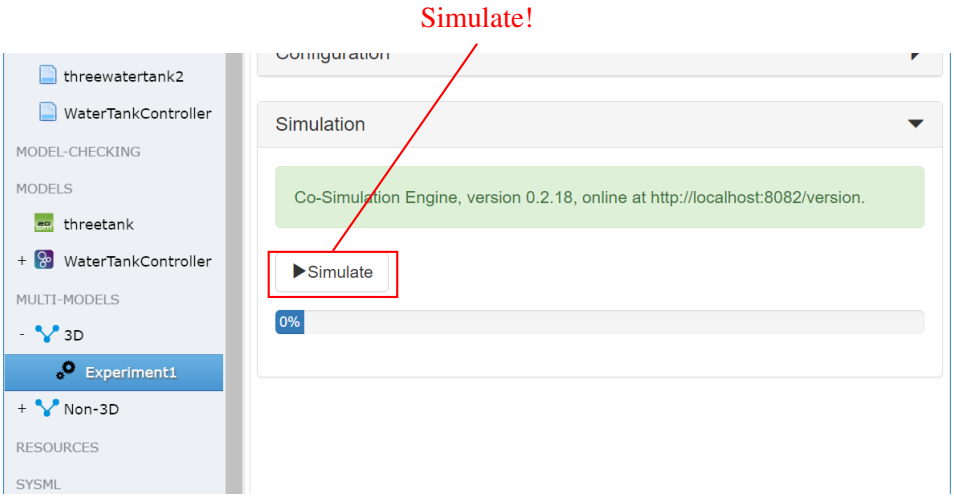
Step 16. The *3DAnimationFMU* is included in the multi-model configuration called *3D*. Click the + symbol next to the *3D* multi-model to expand it.



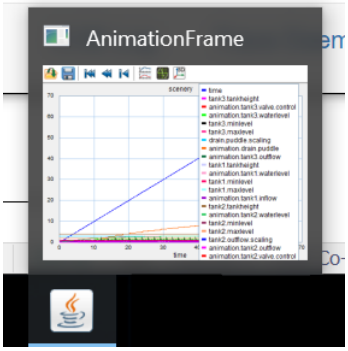
Step 17. There is one co-simulation configuration in this multi-model, also called *Experiment1*. Double-click this to open this configuration.



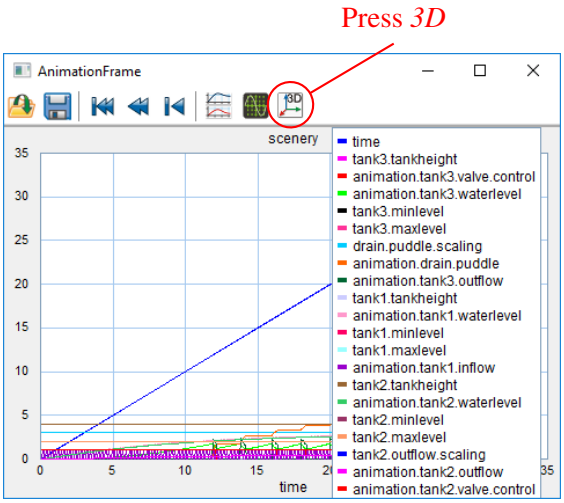
Step 18. Click *Simulate*. See Step Step 7. if the *Simulate* button is disabled or the COE is offline.



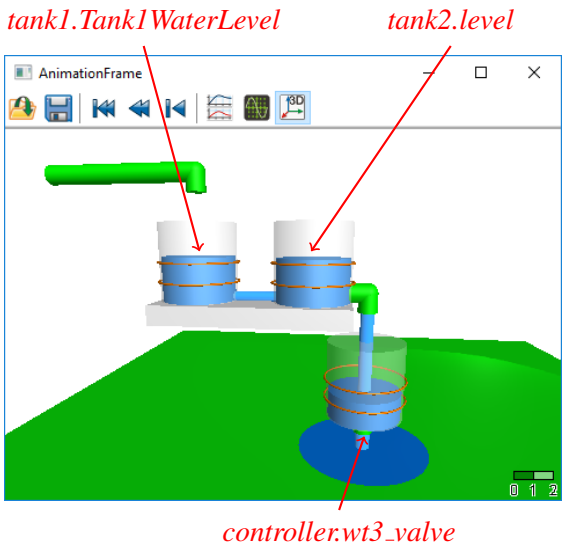
Step 19. The *3DAnimationFMU* launches as a Window called *AnimationFrame*.



To see the 3D visualisation, you must press the button called *3D*.



Step 20. The *AnimationFrame* window should now show you a 3D scene with water levels changing as seen on the live plot. The valve empties water on to a puddle on the floor.



Warning: The *3DAnimationFMU* will crash the COE if the *AnimationFrame* does not have focus when the simulation ends. If this happens, simply relaunch the COE as covered in Step 7.

5 Additional Exercises

When this tutorial is complete, either move onto Tutorial 2, or try the following additional exercises:

1. What will happen on the long term? Will tanks 1 and 2 overflow? (Hint: experiment with different co-simulation parameters to find out; and configure the ”Graph sampling interval” to 0.1 in order to observe the complete simulation plot).