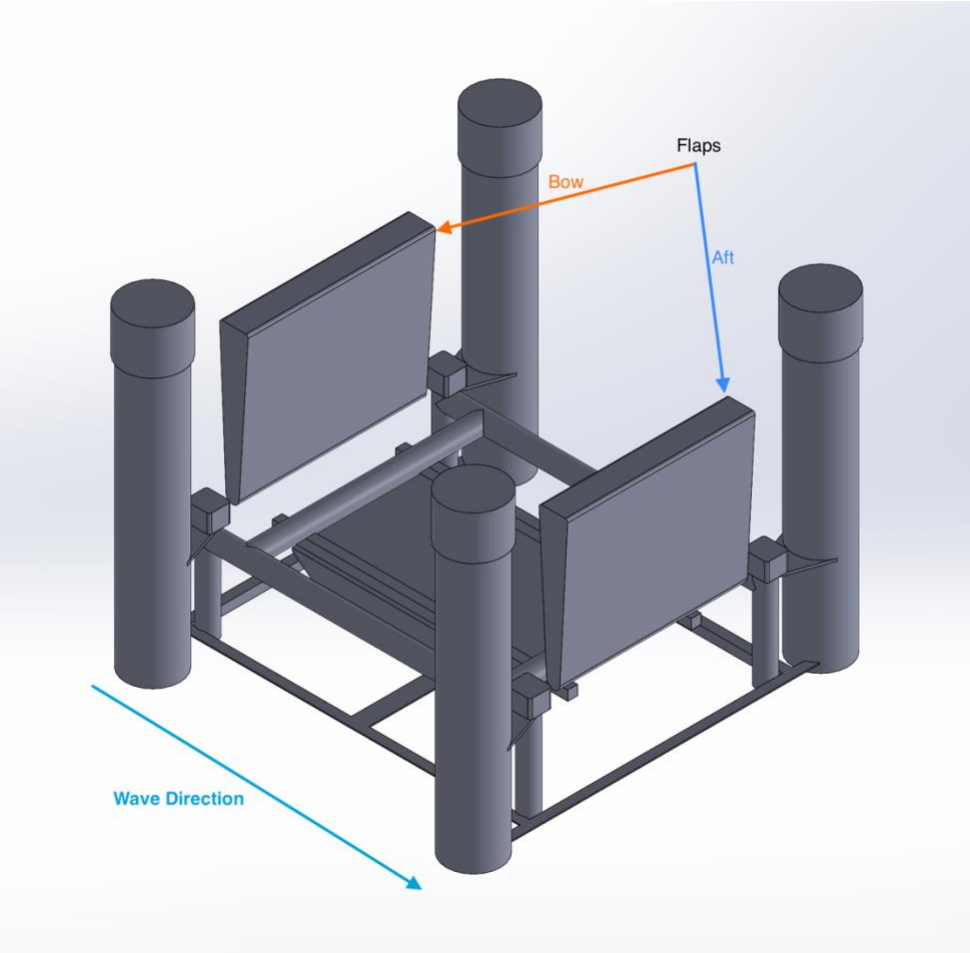
# FOSTWIN Beginners Guide

Document In Drafting Stages Still – Feel free to read!



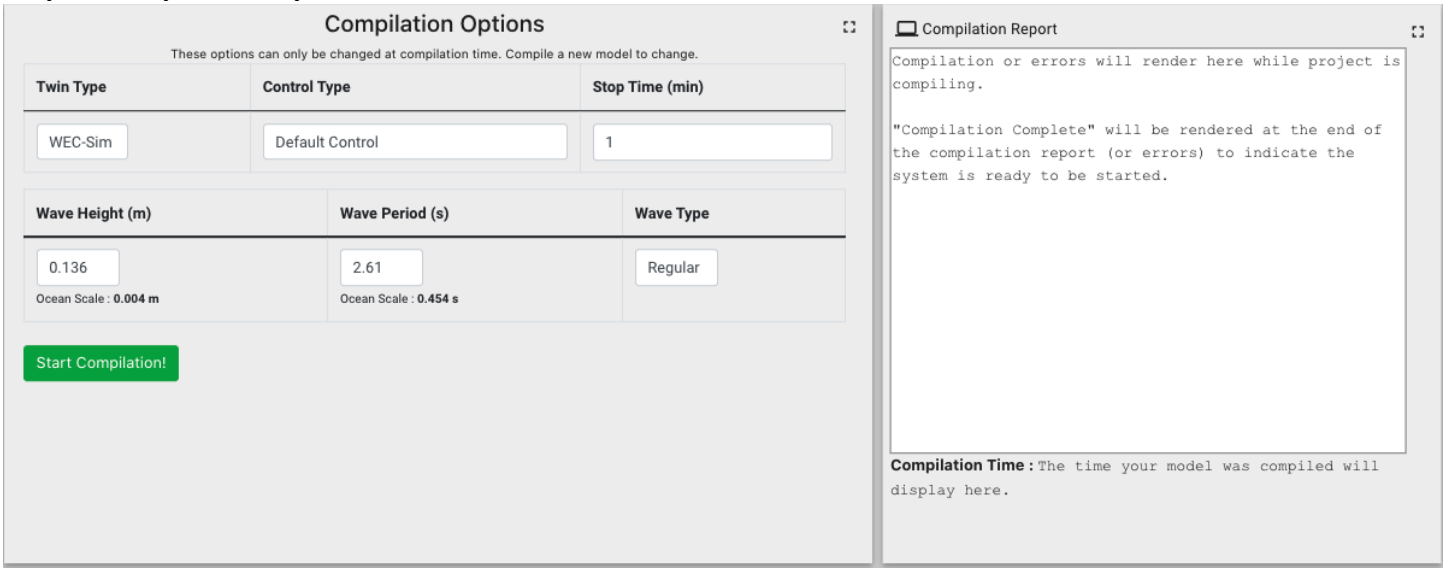

**Purpose:** The purpose of this document is to be a tutorial for first time users in the FOSTWIN Web Platform. This document will guide you through the steps of using the web platform and running your first real time Simulink simulation on Speegoat hardware remotely!

**Background:** It's good to get familiar with the two methods of modeling the FOSWEC device used in the platform. Both methods are simulating the same device (shown above in schematic image), however both achieve a simulation in the different manor.

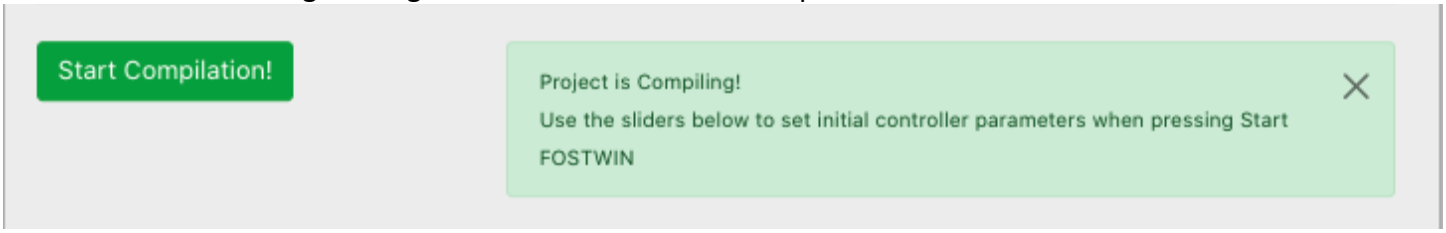
1) **WEC-Sim** – uses simplified geometry and WAMIT (SOTA tool for analyzing wave interactions with offshore structures or vessels) to provide a time domain model of the FOSWEC. Simulation is set up to replicate the test conditions experienced during testing at the O.H. Hinsdale Wave Research Laboratory.
2) **SystemID –** The system identification (ID) model is based off experimental test data collected by the FOSWEC at the O.H. Hinsdale Wave Research Laboratory. System identification techniques from MATLAB were used to establish a multiple input multiple output (MIMO) admittance model of the system.

**NOTE:** For this guide, we're assuming you don't have a model to upload yet and are getting familiar with the web interface. Since we recommend using the default system first before uploading and testing a custom controller, start with this guide then move on to your custom controller if you have one!

**Step 1: Compilation Options**

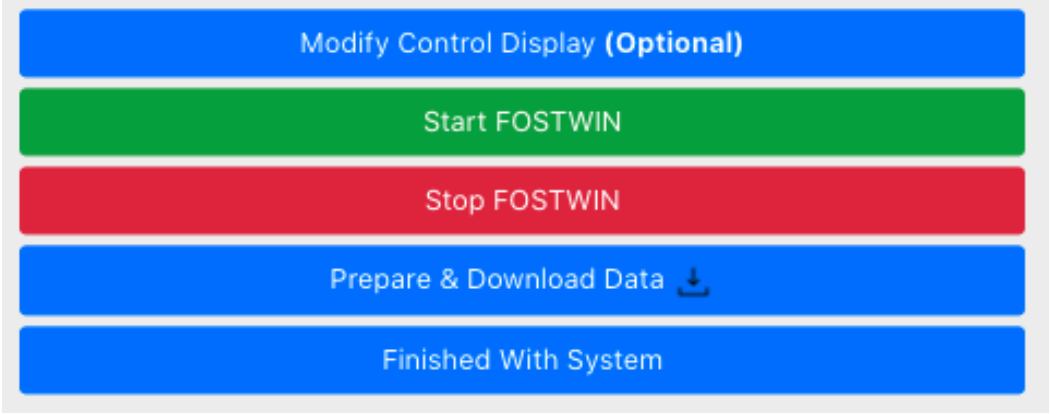



1) **Make your selections in the provided input dropdowns and spinners:**
    a. **Twin Type** (AKA Digital Twin Modeling Method) - use the dropdown to select a twin type. Note that the image to the right of the boxes in image above will switch between showing the WEC-Sim and SystemID digital twin Simulink graphical models when making your selection. **We recommend starting with WEC-Sim as it's a more forgiving model that won't go instable from unrealistic parameters.**
    b. **Control Type** - We've provided a default control model that simulates applying basic velocity proportional damping to the FOSWEC, use this one as a start.
    c. **Stop Time** – the model will automatically stop simulating after this duration of real time simulation. Modify as desired.
    d. **Wave Height** – Select the wave height you'd like to simulate. The selection is in tank scale, so the real-world or ocean scale is shown below if your familiar with realistic wave conditions in the ocean scale. MAXIMUM of 0.5m (tank scale). Wave Height will be set when starting the simulation if "SystemID" is the selected twin. More info in the next main step.
    e. **Wave Period** – Select the time between the crests in each wave. MAXIMUM 10s (tank scale).
    f. **Wave Type** – Regular or Irregular. Regular waves are standard, repeating waves. Irregular waves are calculated using the JONSWAP spectrum and provide more realistic simulation conditions.
2) **Press "Start Compilation"**
    a. Upon successful request to the host machine (remote machine running matlab) you'll be met with the following message in the same box where the previous selections were made.

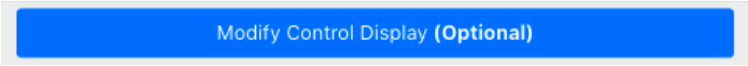


b. After a moment, the right box, “Compilation Report”, will begin to output information about the compilation. The box will automatically scroll to the bottom as new information is added. When the compilation is finished, or if there were errors encountered, “**Compilation Complete**” will be rendered at the end of the report. This will indicate the code has been compiled and shipped to the Speedgoat real-time hardware and the simulation is ready to be started.

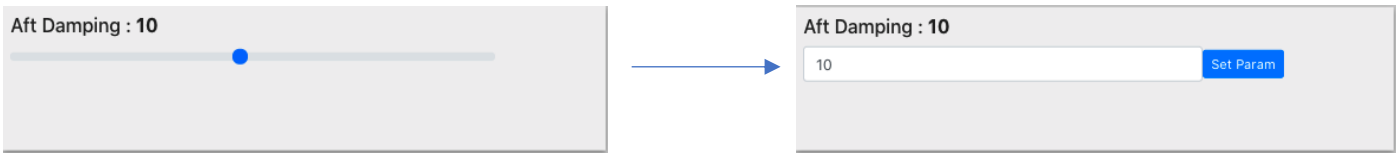

**Model Control Buttons:**




**Optional Step**: **Modify the control display.**




This button opens a dialogue box that allows you to change the names of the lines in the bottom-most chart in the web page to match an uploaded control model, as well as setting the range (max, min, step size) and type (range is a slider, and spinner is numerical input with up and down arrows for fine selection) of the four available control input interfaces. **Since we’re using the default control to get familiar with the system, the two input sliders are already named their appropriate Aft and Bow damping, you may just want to switch them between “range” and “spinner” for the type option depending on your preferences.**

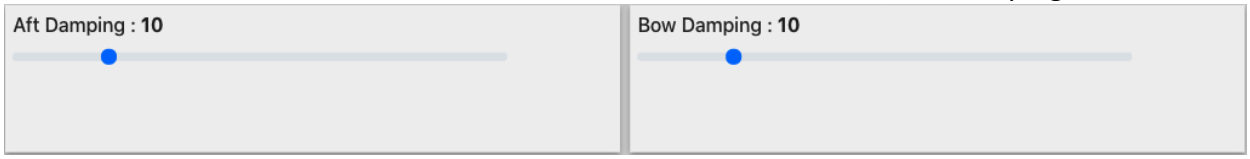




**Step 2: Start the FOSTWIN.**

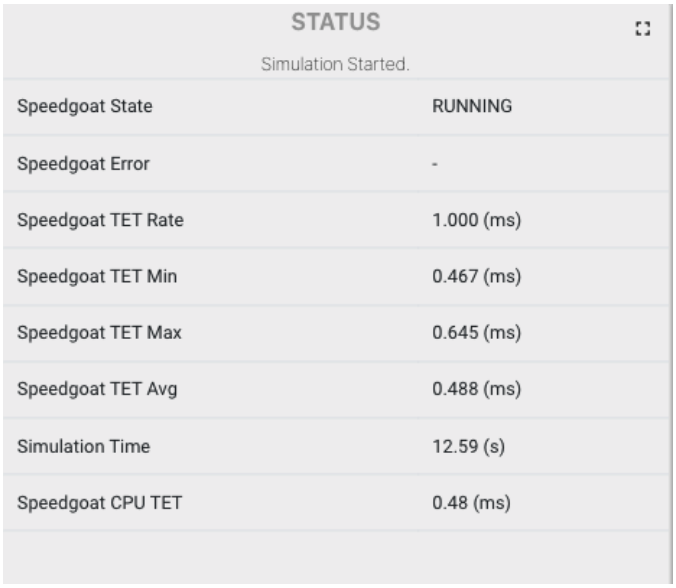
Press the “Start FOSTWIN” button. This will start the simulation. Since the default model implements a simple damping system, there are two control parameters picked up from the webpage when starting the

simulation. These are the Aft and Bow damping sliders (or spinners) pictured below. Every time you start or restart a simulation these sliders will be used to set the initial values used in the damping calculations.



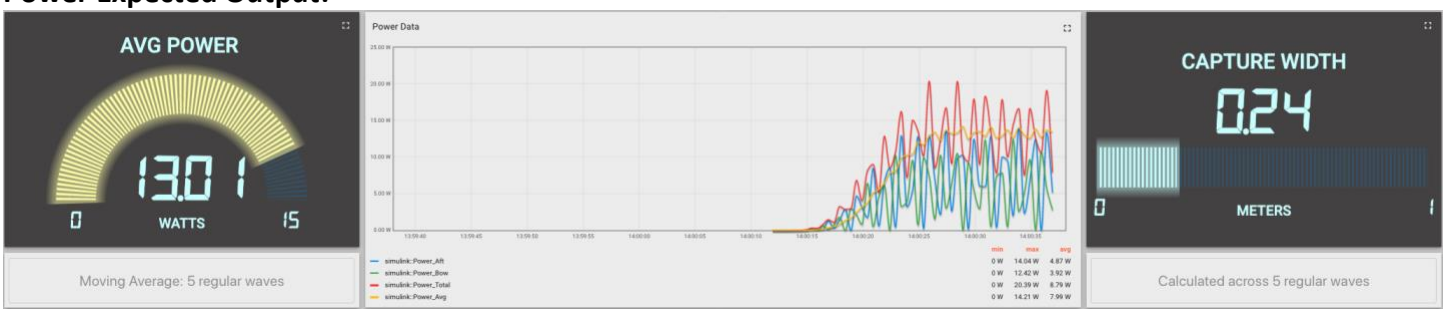

If you've selected "SystemID" as your digital twin, there is now a Wave Height slider that is no longer blurred out. This is because this digital twin model allows for changing the wave height while a simulation is running, rather than only setting it at compilation time. In this case, the Wave Height slider is used just like the control parameters where the initial value is taken from what is set on the slider.


There are a few things you should expect to see when you press the start. First, directly to the right of the button a loading spinner will appear. Once that goes away, you'll see the "STATUS" box to the right of the Model Control Buttons change it's message to "Simulation Started". Then after the model has ran for a couple of seconds, the Speedgoat info will begin to populate. The status box will look like this once the simulation has been started:

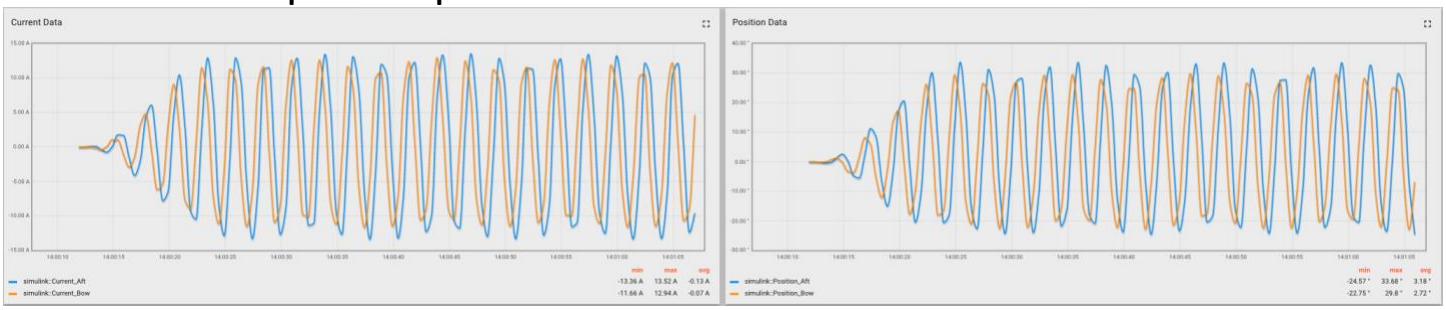



Data will begin to flow into the dashboard. The charts are separated into three rows, with the first being power data coming from the digital twins being simulated, the second containing Current and Position data of the two flaps, and third being the data points exposed from the control model being implemented. With the provided default model these are the simulated torque values on the motor shafts.

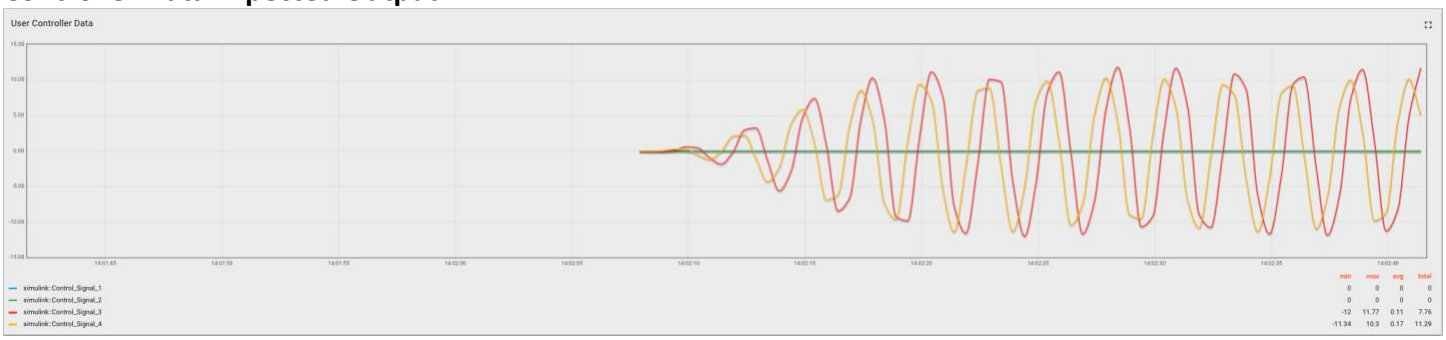
**Power Expected Output:**



**Current & Position Expected Output:**

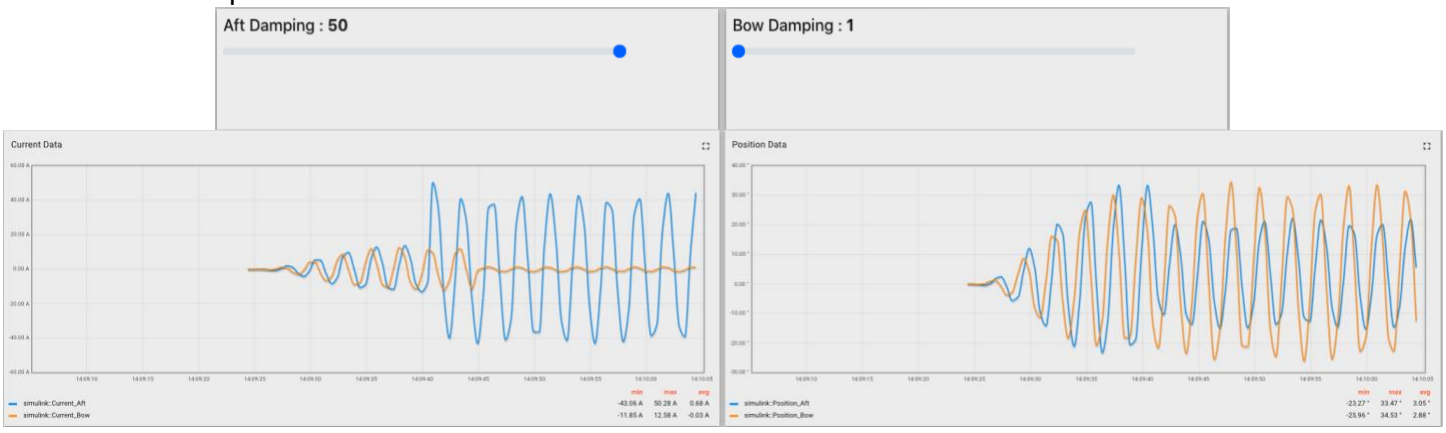


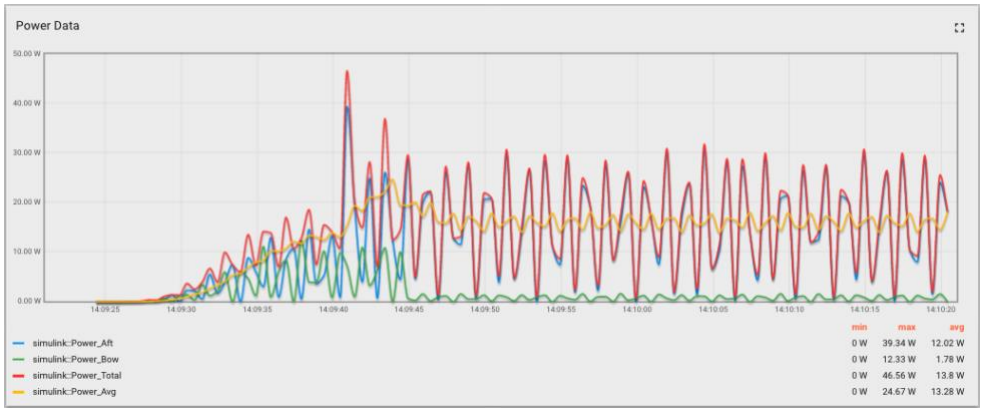

**Controller Data Expected Output:**




**Step 3: Realtime Control**

While the model is running, the same sliders used to set the starting values for Aft and Bow Damping (and Wave Height if SystemID twin) can be used to change those parameters while the model is running. In the images below, you can see what it would look like to set the aft damping unrealistically high and the bow damping to a low value. You can see that the aft flap's change in position over time is reduced and change in current is increased when damping is increased on that flaps torque shaft. The same change in magnitude is displayed on the power chart too. Use these sliders to see if you can find an optimal damping value that creates the most power!

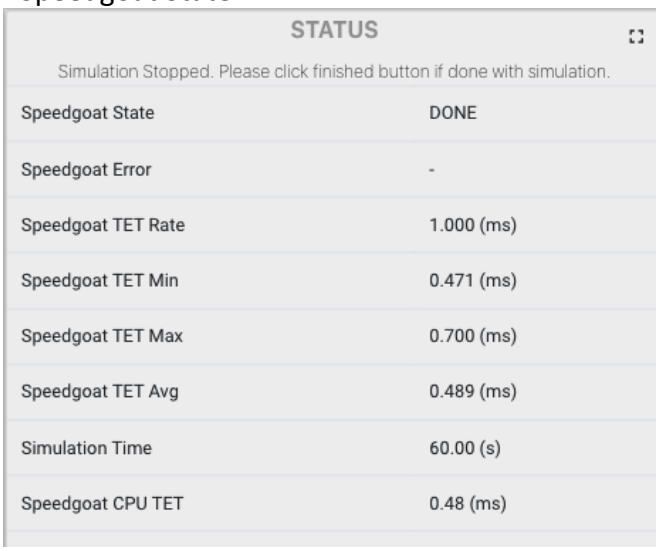






**Step 4: Stop The Simulation**

Since we have a stop time when compiling the model, if you don't intervene the simulation will automatically come to a stop when the duration is complete. However, if you want to stop the model manually before the stop time, just press the "Stop FOSTWIN" button. You can expect to see the following in the "STATUS" box, note the top message and the "Speedgoat State":





**Step 5: Prepare & Download Simulation Data.**

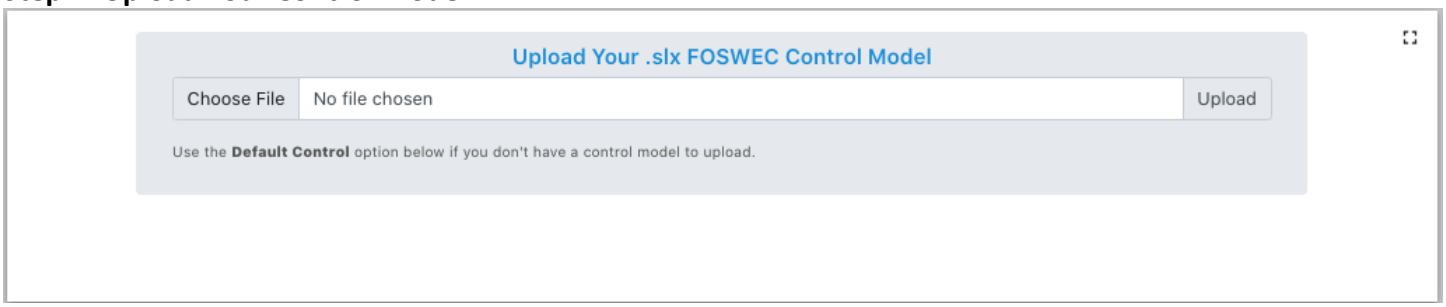
In order for this button to work, a simulation must have been ran and stopped. If one of the requirements isn't met, a small error message will be displayed below the button. **Please note** that if you've stopped a simulation, then restarted another simulation, the previous simulation's data will no longer be recoverable. Data will become recoverable again once the current running simulation is stopped.

Button will trigger a download process (please be patient if running a longer simulation), and you'll have a "simulation-data-CurrentTImeInUTC**.mat**" file downloaded to your browser. This data structure is explained in the README in the open source FOSWIN GitHub repository.


**Step 6: Restart or Finished with System**

After the data you may want for post-analysis has been downloaded, you're ready to either restart another simulation or press the finished button and sign out of the web interface. If you want to just restart the model with the same compilation parameters as before, then the start button works just like before. If you want to change the twin type, stop time, wave parameters (other than Height if systemID) and wave type, then you just need to go back to the compilation box, change the desired parameters, then press compile again!

**Step 7: Upload Your Control Model**




We skipped this portion of the web interface as it's only needed when uploading a custom controller model. Click "Choose File" or in the "No File Chosen" text box to select your file to upload, then press the upload button. You'll be met with a spinner in the grey box pictured above while the file is being uploaded to the host machine, then a "File successfully uploaded to host machine!" message when it goes through. Errors will also be displayed in the chance that something goes wrong when uploading.

Once you've received the success message in the grey box above, select "Uploaded Control" in the Compilation Options box, along with your other desired parameters and go from there. **With uploaded control selected, the control sliders are not pre-populated with their Aft and Bow damping names as we don't know what those parameters may be in an uploaded model. While there is no requirement to change the display names, it may come in handier to use the Modify Control Display (Optional) button now.**

There is a box on the right side of the UI that shows an image of the Simulink model that is currently being ran as the Controller (below the Digital Twin Image). As your uploaded model compiles, the control image will be replaced with an image of the model you've uploaded.