



WEC-Sim Training Course



Online Training Materials

PRESENTED BY

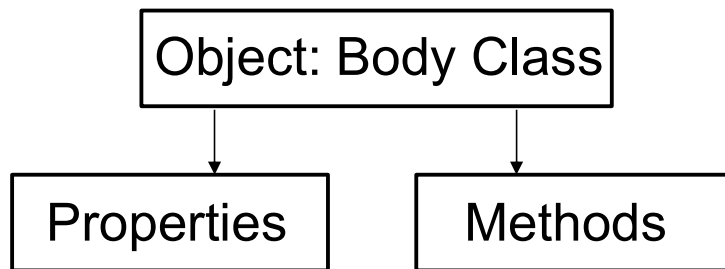
Sal Husain, NREL





Body Class

Body Class: Overview



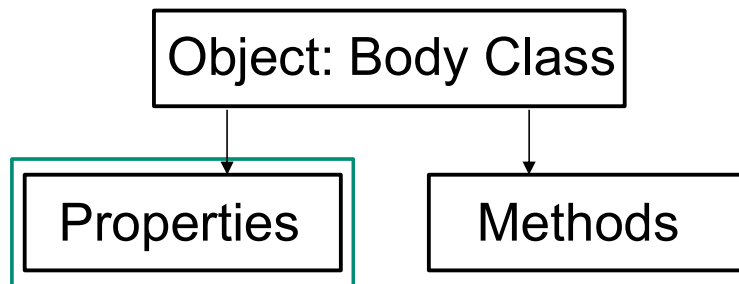
OSWEC Example

```
%% Body Data
% Flap
1 body(1) = bodyClass('hydroData/oswec.h5'); % Initialize bodyClass for Flap
2 body(1).geometryFile = 'geometry/flap.stl'; % Geometry File
3 body(1).mass = 127000; % User-Defined mass [kg]
4 body(1).inertia = [1.85e6 1.85e6 1.85e6]; % Moment of Inertia [kg-m^2]
body(1).initial.displacement= [0, 0, 0.1]; % Initial displacement [x, y, z] m
body(1).initial.axis = [0, 1, 0]; % Axis of initial angle disp.
body(1).initial.angle = 1; % Initial ang. disp. in rad.
% Base
body(2) = bodyClass('hydroData/oswec.h5'); % Initialize bodyClass for Base
body(2).geometryFile = 'geometry/base.stl'; % Geometry File
body(2).mass = 999; % Placeholder mass for a fixed body
body(2).inertia = [999 999 999]; % Placeholder inertia for a fixed body
```

1. Generate Body Object
2. Identify geometry file in .stl format
3. Specify mass and moment of inertia properties,
4. Specify initial position initial cartesian position of the center of the center of gravity and initial angular orientation if different from the geometry file.

The definition of linear and quadratic damping parameters for the heave mode in the *wecSimInputFile.m* for the OSWEC example.

Body Class: Properties



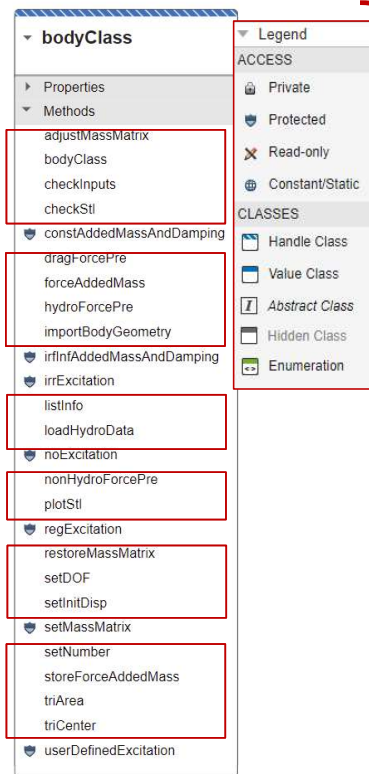
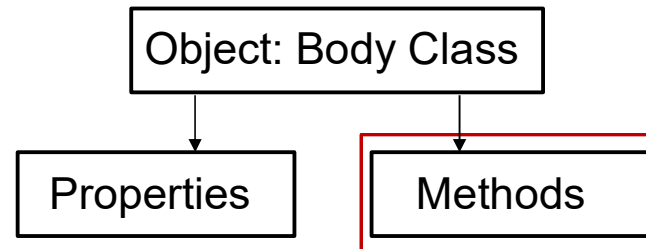
The properties inside green rectangles can be accessed by the user

bodyClass	Legend
Properties	ACCESS
✗ b2bDOF	Private
centerBuoyancy	Protected
centerGravity	Read-only
dof	Constant/Static
✗ dofEnd	CLASSES
✗ dofStart	Handle Class
excitationIRF	Value Class
flex	Abstract Class
gbmDOF	Hidden Class
✗ geometry	Enumeration
geometryFile	
h5File	
✗ hydroData	
✗ hydroForce	
hydroStiffness	
inertia	
initial	
linearDamping	
mass	
✗ massCalcMethod	
meanDrift	
morisonElement	
name	
nonHydro	
nonlinearHydro	
✗ number	
paraview	
quadDrag	
✗ total	
viz	
volume	
yaw	
Methods	

```
>> body
body =
    1x2 bodyClass array with properties:

    centerBuoyancy
    centerGravity
    dof
    excitationIRF
    flex
    gbmDOF
    geometryFile
    h5File
    hydroStiffness
    inertia
    initial
    largeXYDisplacement
    linearDamping
    mass
    meanDrift
    morisonElement
    name
    nonHydro
    nonlinearHydro
    quadDrag
    paraview
    viz
    volume
    yaw
    dofEnd
    dofStart
    hydroData
    b2bDOF
    hydroForce
    massCalcMethod
    number
    total
    geometry
```

Body Class: Methods



The methods inside red rectangles can be accessed by the user

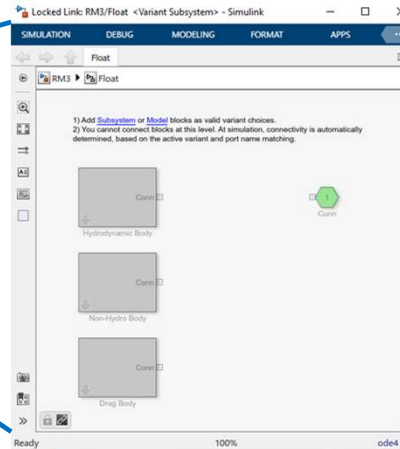
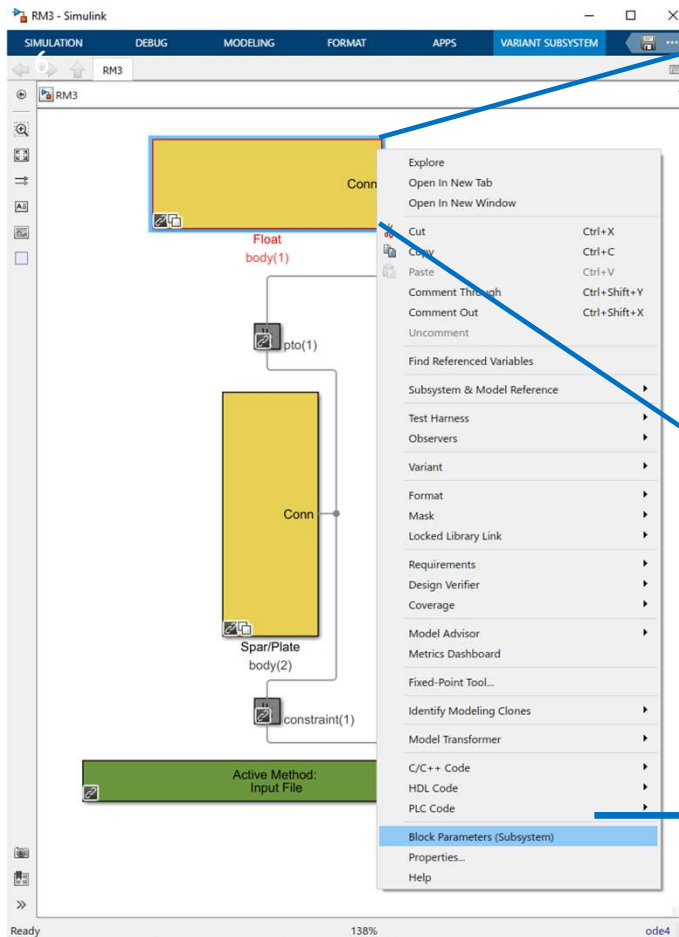
```
>> methods(body)

Methods for class bodyClass:

adjustMassMatrix    checkStl            hydroForcePre       loadHydroData       restoreMassMatrix    setNumber            triCenter
bodyClass           dragForcePre        importBodyGeometry  nonHydroForcePre    setDOF               storeForceAddedMass
checkInputs         forceAddedMass      listInfo            plotStl              setInitDisp          triArea

Methods of bodyClass inherited from handle.
```

Variant Subsystems



```
378 sv_udfWaves=Simulink.Variant('typeNum>=30');
379 % Body2Body
380 B2B = simu.b2b;
381 sv_noB2B=Simulink.Variant('B2B==0');
382 sv_B2B=Simulink.Variant('B2B==1');
383 numBody=simu.numHydroBodies;
384 % nonHydro
385 for ii=1:length(body(1,:))
386     eval(['_nhbody_' num2str(ii) ' = body(ii).nonHydro;'])
387     eval(['_sv_b_' num2str(ii) '_hydroBody = Simulink.Variant(''_nhbody_' num2str(ii) '==0'');'])
388     eval(['_sv_b_' num2str(ii) '_nonHydroBody = Simulink.Variant(''_nhbody_' num2str(ii) '==1'');'])
389     eval(['_sv_b_' num2str(ii) '_dragBody = Simulink.Variant(''_nhbody_' num2str(ii) '==2'');'])
390 end; clear ii
391
```

Block Parameters: Float

Variant Subsystem

The Variant Subsystem contains one or more choices where each choice is a Subsystem or Model block. At most one choice can be active in simulation.

Variant control mode: The active choice is determined by the variant control expression that evaluates to true. For example, V==EngineType.Small or V==1. The active choice is chosen before propagation of signal attributes. No attributes are propagated to the inactive choices and the inactive choices are removed prior to propagation of signal attributes.

Variant activation time:

Variant choices (table of variant systems)

Name (read-only)	Variant control expression	Condition (read-only)
Drag Body	sv_b1_dragBody	(N/A)
Hydrodynamic Body	sv_b1_hydroBody	(N/A)
Non-Hydro Body	sv_b1_nonHydroBody	(N/A)

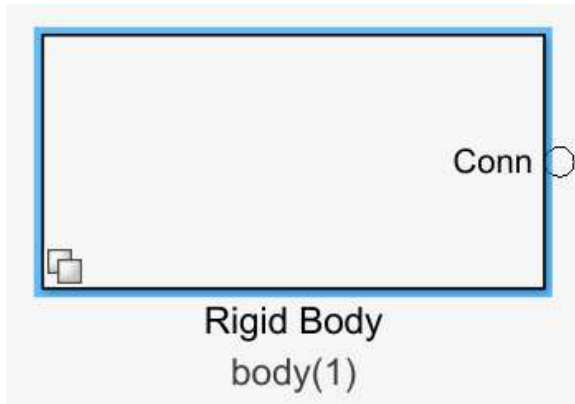
☒ Allow zero active variant controls
☐ Propagate conditions outside of variant subsystem

[Open block in Variant Manager](#)

OK Cancel Help Apply

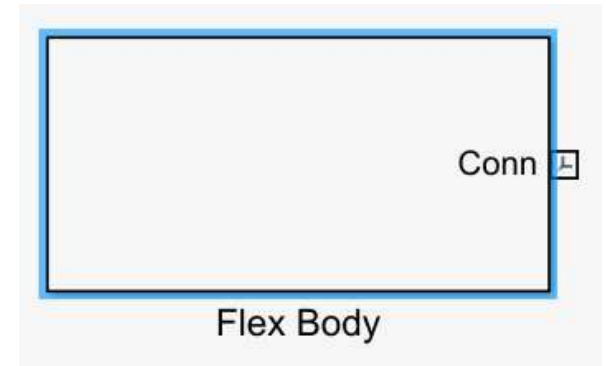
Body Blocks

Rigid body block



Rigid bodies that move in 6 DOF (surge, sway, heave, roll, pitch, yaw)

Flexible body block

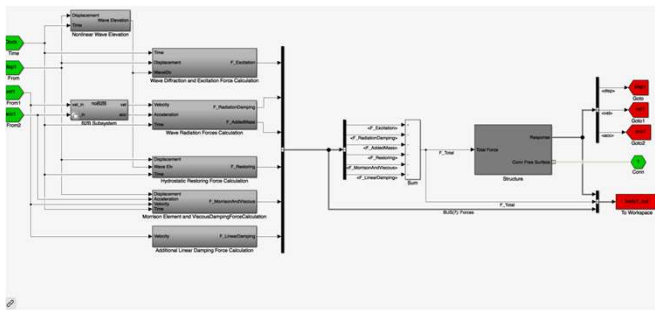


Flexible bodies with additional movement modes defined in BEM

*** See Advanced Features → Generalized Body Modes for more information on the flexible body block.**

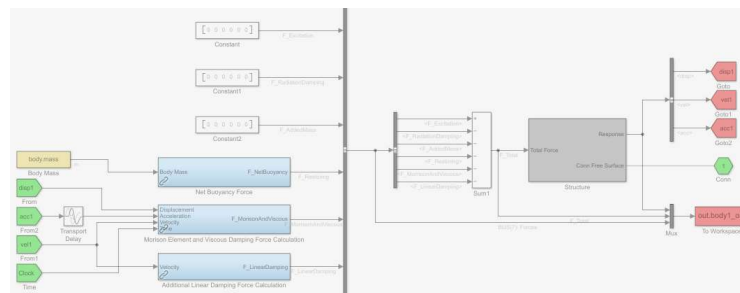
Rigid Body Block

Hydrodynamic body block



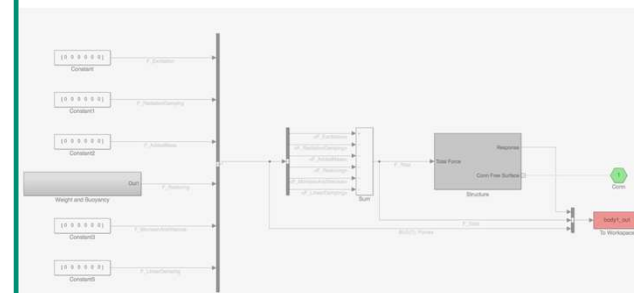
Includes blocks for calculating all the different forcing terms

Drag body block



Wave exerted forces are zero, but weight, buoyancy, and drag forces calculated

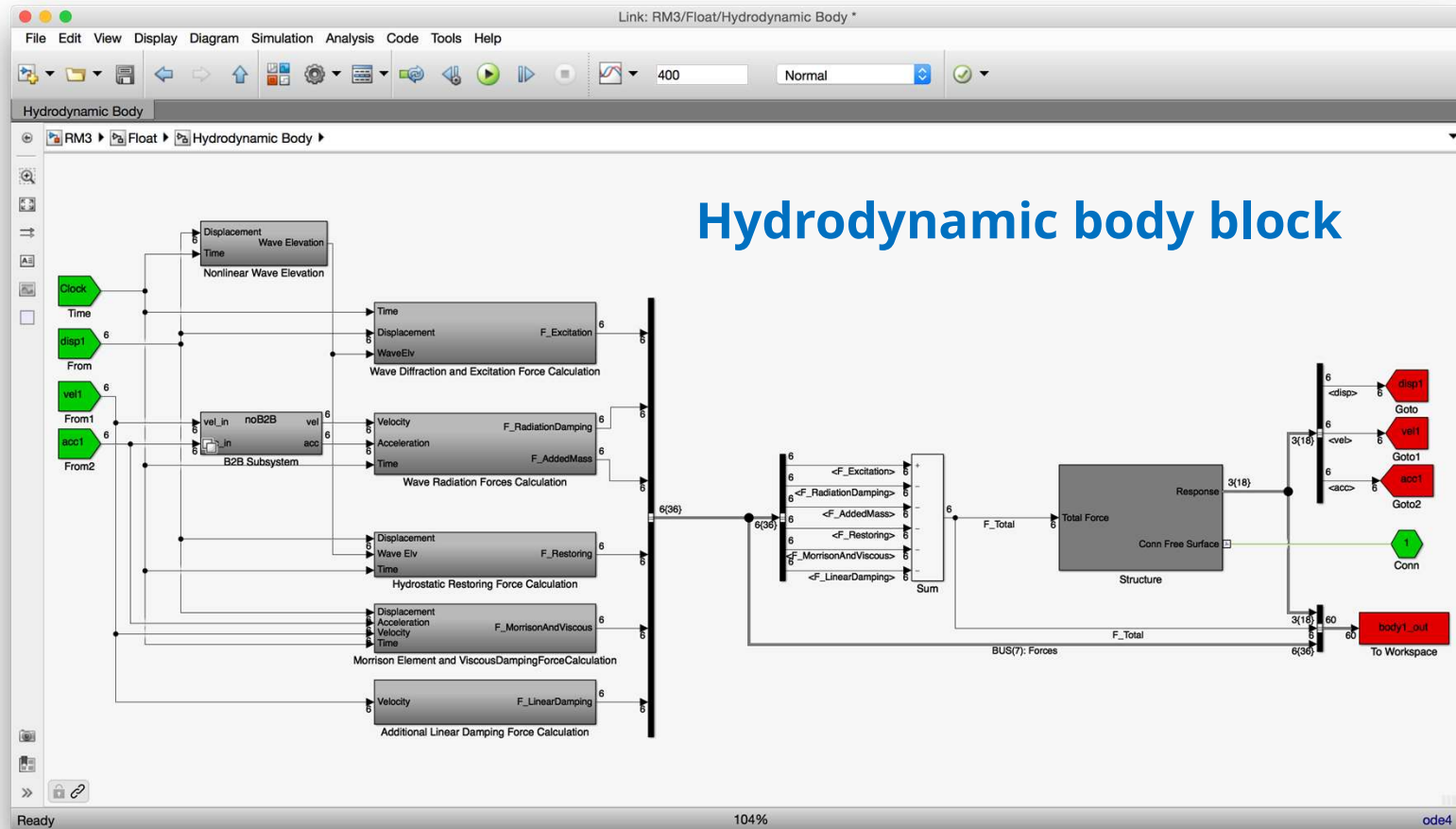
Non-hydrodynamic body block



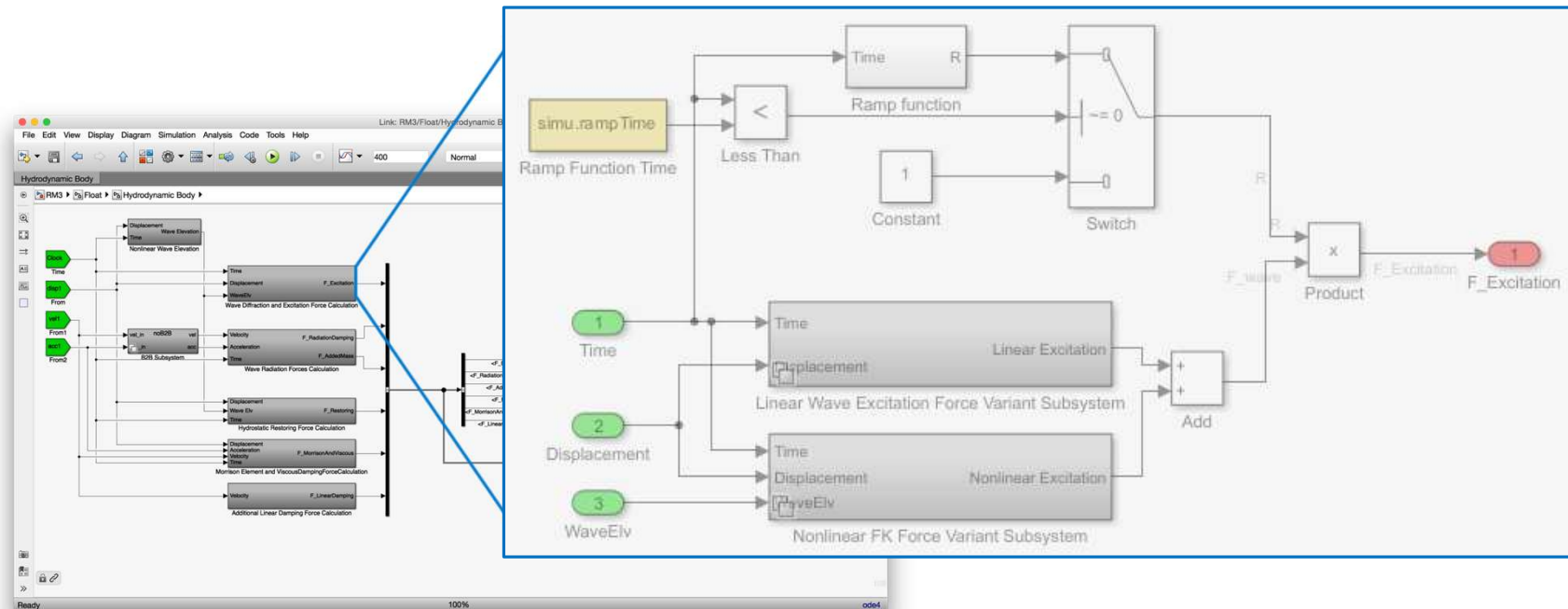
Everything is zero except for weight and buoyancy

Note: Connection forces between multiple bodies from the joint/PTO are handled by **Simscape Multibody**

Body Force Dimension Display



Body Class: Excitation Force

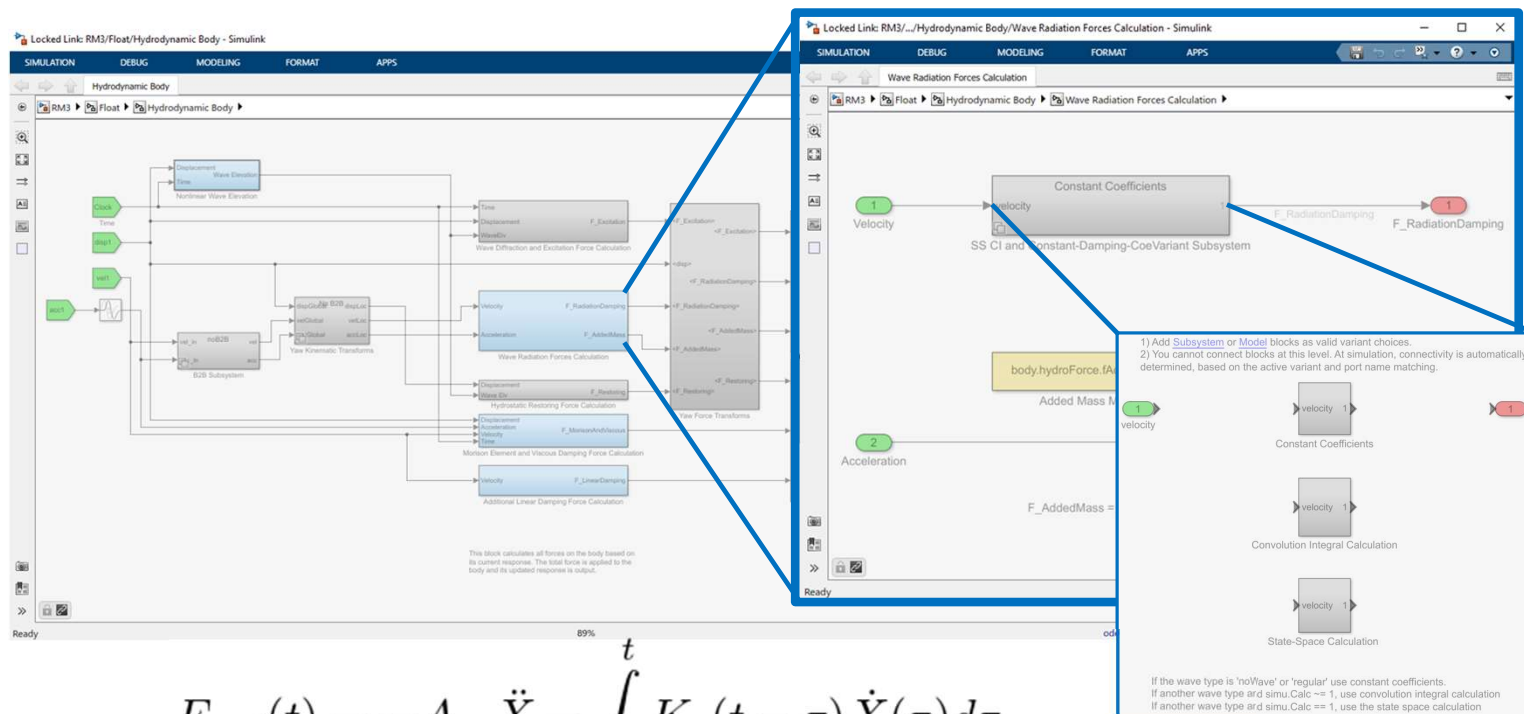


$$f_{ex}(t) = Re \left[R_f F_x(\omega_r) e^{i(\omega_r t + \phi)} \int_0^{\infty} \sqrt{2S(\omega_r)} d\omega_r \right]$$

$$f_{ex}(t) = \int_0^{t-\tau} \eta(\tau) h_f(t - \tau) d\tau$$

Hydrodynamic Body Block:

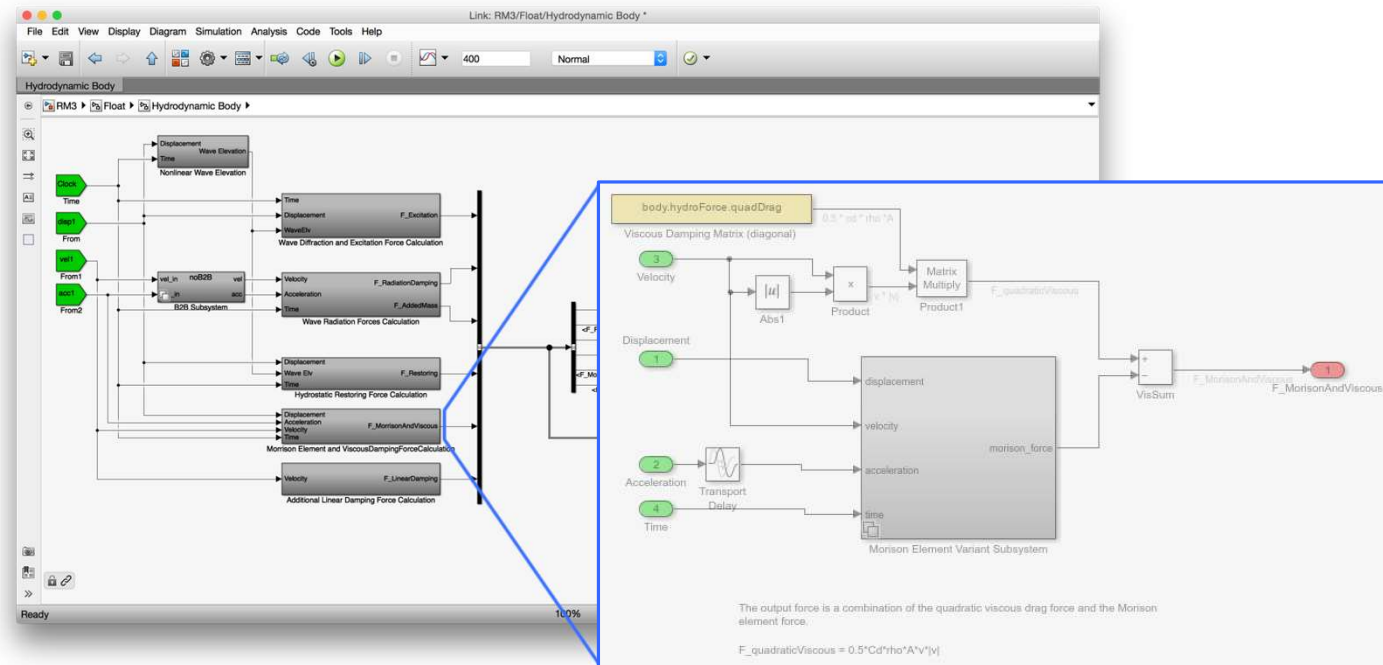
Wave Radiation Force Calculation Block



$$F_{rad}(t) = -A_{\infty} \ddot{X} - \int_0^t K_r(t - \tau) \dot{X}(\tau) d\tau$$

$$K_r(t) = \frac{2}{\pi} \int_0^{\infty} B(\omega) \cos(\omega t) d\omega$$

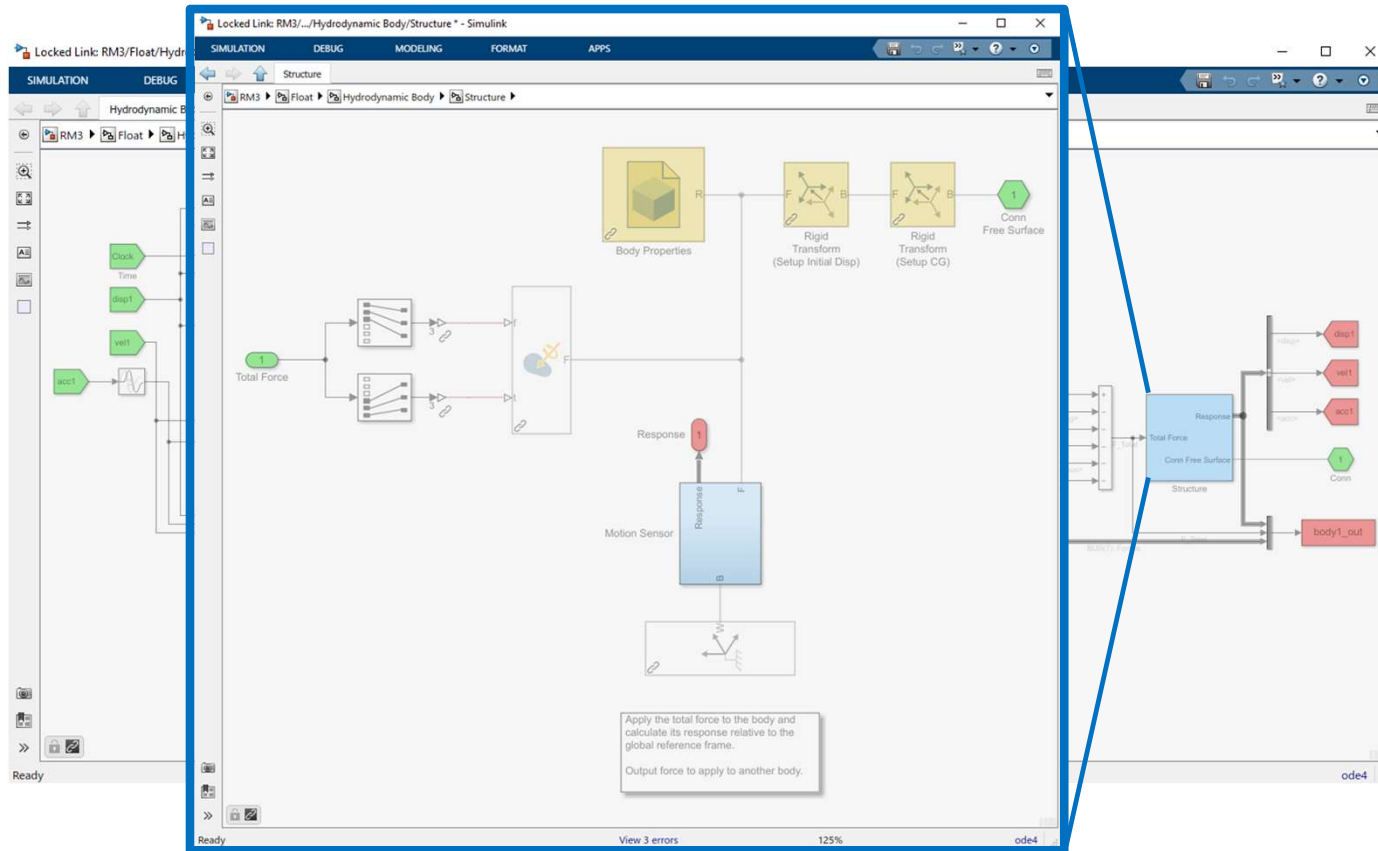
Body Class: Morrison and Viscous Damping Force



$$F_v = -C_v \dot{X} - \frac{C_d \rho A_d}{2} \dot{X} |\dot{X}| = -C_v \dot{X} - C_D \dot{X} |\dot{X}|$$

$$F_{me} = \rho \forall \dot{v} + \rho \forall C_a (\dot{v} - \ddot{X}) + \frac{C_d \rho A_d}{2} (v - \dot{X}) |v - \dot{X}|$$

Simscape Multibody



Thank you

For more information please visit the WEC-Sim website:

<http://wec-sim.github.io/WEC-Sim>

If you have questions on this presentation please reach out to any of the WEC-Sim Developers on GitHub:

<https://github.com/WEC-Sim/WEC-Sim>



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