

WEC-Sim Training Course

for users and developers

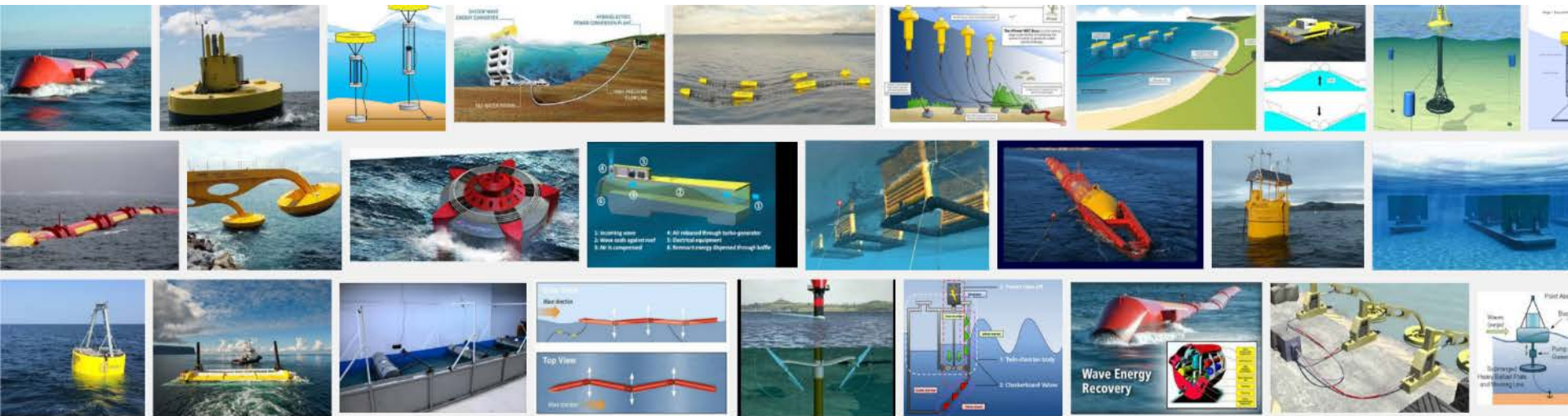
August 17, 2017

Yi-Hsiang Yu (NREL)

Kelley Ruehl (Sandia)

Course Agenda

Time	Topic	Description
9:00 am	WEC-Sim Overview ~20min	Overview of course topics and WEC-Sim code
9:30 am	Theory & Workflow ~20min	Cummins' equation and WEC-Sim workflow (BEM->BEMIO->WEC-Sim)
10:00 am	Running WEC-Sim ~30min	Description of what happens when you execute WEC-Sim (<i>wecSim.m</i>)
11:00 am	Code Structure Overview ~1hr total	Overview of WEC-Sim's input file (<i>wecSimInputFile.m</i>), classes (<i>*.m</i>) and library blocks (<i>*.slx</i>)
1:00 pm	Wave Implementation ~30min	Description wave modeling implementation in WEC-Sim, in the classes (<i>*.m</i>) and blocks (<i>*.slx</i>)
1:30 pm	Body Implementation ~30min	Description body implementation in WEC-Sim, in the classes (<i>*.m</i>) and blocks (<i>*.slx</i>)
2:00pm	Q&A ~1hr	Open Q&A for attendees to WEC-Sim Lab team



WEC-Sim Overview

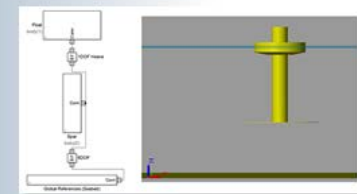
Yi-Hsiang (NREL)

What is WEC-Sim?

- WEC-Sim (Wave Energy Converter Simulator)
 - Simulates wave energy converter dynamics in operational waves
 - Time-domain rigid body equation of motion solver based on Cummins' formulation
 - Open source code developed in MATLAB/SIMULINK
 - Joint NREL/Sandia project funded by the US Department of Energy
 - First Release: v 1.0 in June 2014
 - Current Release: v 2.2 in June 2017



WEC-Sim
Wave Energy Converter
SIMulator



License:

Copyright 2014 the National Renewable Energy Laboratory and Sandia Corporation

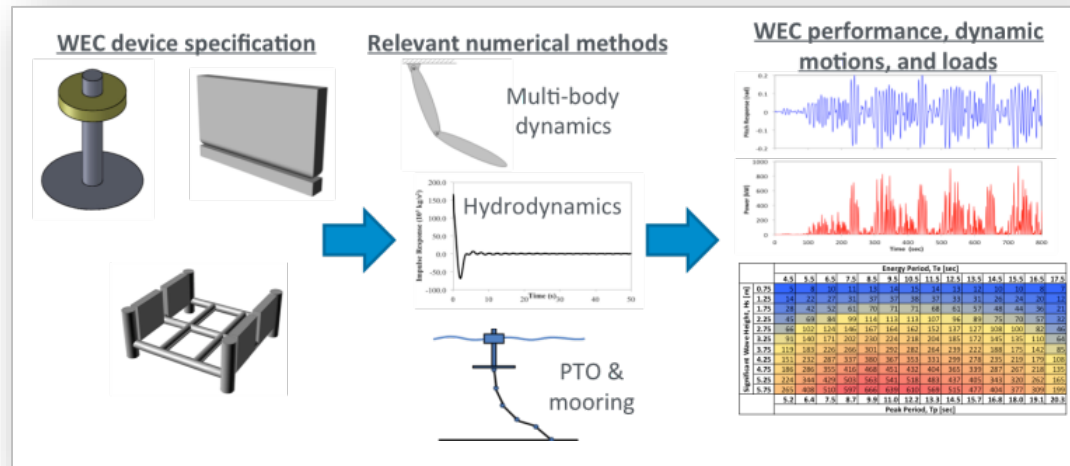
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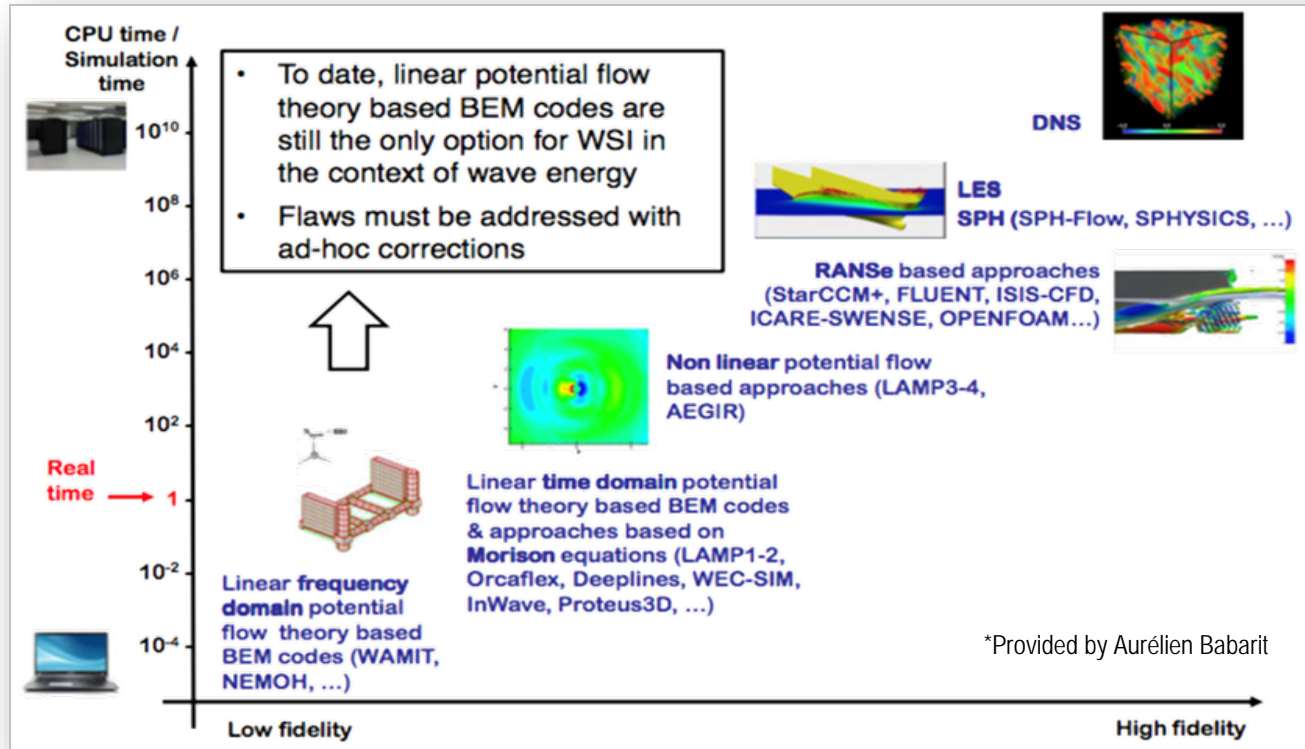
Why use WEC-Sim?

- WEC-Sim has the ability to model the dynamics of devices that are comprised of rigid bodies, power-take-off (PTO) systems, and mooring systems.
- WEC-Sim uses hydrodynamic coefficients derived from frequency-domain boundary element (BEM) simulations to model the relevant hydrodynamics.
- Time-domain simulations are performed by solving the governing WEC equations of motion in 6 degrees-of-freedom.



Why use WEC-Sim?

- Linear/weakly nonlinear time domain model: CPU time \ll Real Time



- Dynamics simulated by solving time-domain equation of motion (Cummins, 1962)

$$m\ddot{x}(t) = \boxed{f_{hs}(t)} + \boxed{f_{ex}(t)} + \boxed{f_{rad}(t)} + \boxed{f_v(t)} + \boxed{f_{pto}(t)} + \boxed{f_m(t)}$$

Hydrostatic restoring force
 Wave excitation & diffraction force (from BEM simulations)
 Radiation force: added mass and radiation damping (from BEM simulations)
 Viscous force
 Power take-off force
 Mooring force

- Use radiation and diffraction method and calculate the hydrodynamic forces from frequency-domain Boundary Element Method (BEM)

$$f_{rad}(t) = \underbrace{-A_\infty}_{\text{BEM}} \ddot{x} - \int_0^t \underbrace{K(t-\tau)}_{\text{BEM}} \dot{x}(\tau) d\tau$$

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

$$= \int_{-\infty}^\infty \eta(\tau) \underbrace{f_e(t-\tau)}_{\text{BEM}} d\tau$$

- CAD (Computer-aided design), e.g. Rhinoceros, SolidWorks, ANSYS, etc.
- BEM (Boundary Element Method), e.g. WAMIT, NEMOH, AQWA
- BEMIO (Boundary Element Method Input/Output)
 - <http://wec-sim.github.io/WEC-Sim/>
 - Requires MATLAB (R2015b)
- WEC-Sim (Wave Energy Converter Simulator)
 - <http://wec-sim.github.io/WEC-Sim/>
 - Requires MATLAB (R2015b), Simulink, Simscape and SimMechanics (Simscape Multibody in 2016a)
- ParaView
 - <http://www.paraview.org/>
 - Optional, for additional visualization and analysis capabilities



WEC-Sim (GitHub) Repositories

The screenshot shows the GitHub profile for WEC-Sim. The profile header includes the repository icon, the name 'WEC-Sim', and the URL <https://github.com/WEC-Sim>. Below the header, there are tabs for 'Repositories' and 'People'. A search bar and filters for 'Type' and 'Language' are visible. The repository list on the left includes:

- WEC-Sim**: Wave Energy Converter Simulator (WEC-Sim). Language: Matlab. 18 stars, 32 forks, updated 5 days ago.
- WEC-Sim_Applications**: Applications of the WEC-Sim code. Language: Matlab. 1 star, updated 5 days ago.
- WDRT**: WEC Design Response Toolbox (WDRT). Language: Python. 1 star, 2 forks, updated 20 days ago.
- moorDyn**: Language: C. Updated on Jun 8.
- bemio**: Boundary Element Method I/O (bemio). Language: Python. 4 stars, 11 forks, updated on Jun 7.

Annotations with blue dashed boxes and arrows point from specific repositories to descriptive text on the right:

- A blue dashed box around the 'WEC-Sim' repository points to the text 'WEC-Sim Source Code'.
- A blue dashed box around the 'WEC-Sim_Applications' repository points to the text 'Additional Applications'.
- A blue dashed box around the 'moorDyn' repository points to the text 'Compiled MoorDyn Library'.

On the right side of the repository list, there are sections for 'Top languages' (Python, Matlab, C) and 'People' (Carlos Michelen, kmruehl, lawsonro3).

WEC-Sim Source Code

Additional Applications

Compiled MoorDyn Library

To use MoorDyn in WEC-Sim,

1. Please Download MoorDyn from the repo <https://github.com/WEC-Sim/moorDyn>
2. Place all the files and folders under WEC-Sim/source/functions/moorDyn folder

WEC-Sim (GitHub) Repositories

WEC-Sim

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

Repositories People 3

Search repositories...

Type: All Language: All

WEC-Sim
Wave Energy Converter Simulator (WEC-Sim)
Matlab ★ 18 🍴 32 Updated 5 days ago

WEC-Sim Applications
Applications of the WEC-Sim code
Matlab ★ 1 Updated 5 days ago

WDR
WEC Design Response Toolbox (WDR)
Python ★ 1 🍴 2 Updated 20 days ago

moorDyn
C Updated on Jun 8

bemio
Boundary Element Method I/O (bemio)
Python ★ 4 🍴 11 Updated on Jun 7

Top languages
Python Matlab C

People 3 >
cmichelen Carlos Michelen
kmruehl Kelley Ruehl
Michael Lawson

<http://wec-sim.github.io/WDR/>

WDR was developed by Sandia National Laboratories and the National Renewable Energy Laboratory (NREL) to provide extreme response and fatigue analysis tools, specifically for design analysis of ocean structures such as WECs.

WEC Design Response Toolbox

Old Python based BEMIO

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

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WEC-Sim




Wave Energy Converter SIMulator





WEC-Sim (Wave Energy Converter SIMulator)

WEC-Sim (Wave Energy Converter SIMulator) is an open-source wave energy converter simulation tool. The code is developed in MATLAB/SIMULINK using the multi-body dynamics solver Simscape Multibody. WEC-Sim has the ability to model devices that are comprised of rigid bodies, power-take-off systems, and mooring systems. Simulations are performed in the time-domain by solving the governing WEC equations of motion in 6 degrees-of-freedom. The WEC-Sim project is funded by the U.S. Department of Energy's Water Power Technologies Office and the code development effort is a collaboration between the [National Renewable Energy Laboratory \(NREL\)](#) and [Sandia National Laboratories \(Sandia\)](#).


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

 **WEC-Sim / WEC-Sim**


 Watch 19  Star 18  Fork 33


 Code  Issues 2  Pull requests 2  Projects 7 Insights ▾


Labels **Milestones** [New issue](#)


 2 Open ✓ 144 Closed


Author ▾ Labels ▾ Projects ▾ Milestones ▾ Assignee ▾ Sort ▾

 **ode14x compatability?** **question**

#191 opened 25 days ago by bradling  5

 **AQWA excitation phase** **BEM/bemio** **bug**

#186 opened on Jun 22 by kmruehl  4

 **ProTip!** Bookmark issues and pull requests to revisit later.

Thank you!

All the webinar materials and recordings are available online:

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



The screenshot shows the WEC-Sim webinars page. On the left is a navigation menu with links: Getting Started, Examples, Theory, Code Structure, Advanced Features, Webinars (selected), License, Publications, Release Notes, and Contact Us. The main content area is titled "Webinars" and includes a search bar. Below the title, a paragraph states: "The WEC-Sim team is hosting a series of advanced features webinars. Dates and topics are listed below. Once completed, the recordings and presentations will be posted to this page." A table follows with two columns: Date and Topic. The table lists five webinars from April 18, 2017, to August 17, 2017. Below the table, the section "WEC-Sim Webinar #1 - BEMIO & MCR" is highlighted, with a paragraph stating: "The presentation and recordings of WEC-Sim Webinar #1 on BEMIO & MCR hosted on April 18, 2017 are available below. Download the presentation by clicking the image below." A large image of the webinar presentation is shown, featuring a collage of images related to offshore wind energy, including a wind turbine, a ship, and a diagram of a wind turbine. The title "WEC-Sim Webinar #1" is at the bottom of the image.

Date	Topic
April 18, 2017	BEMIO and MCR
May 24, 2017	Nonlinear Hydro, Non-Hydro, and B2B
June 13, 2017	PTO and Control
July 18, 2017	Moorings and Visualization
August 17, 2017	WEC-Sim Training Course

WEC-Sim Webinar #1 - BEMIO & MCR

The presentation and recordings of WEC-Sim Webinar #1 on BEMIO & MCR hosted on April 18, 2017 are available below. Download the presentation by clicking the image below.

WEC-Sim Webinar #1