Development and release of WEC-Sim v5.0 open-source software

PRESENTED BY
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   - Continuous integration
   - Modeling cables
   - Capytaine BEM
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   - Wave visualization
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Background
What is WEC-Sim?

**WEC-Sim (Wave Energy Converter Simulator)**

- Simulates wave energy converter dynamics in operational and extreme waves
- Time-domain equation of motion solver based on Cummins’ formulation
- Open source software developed in MATLAB/SIMULINK
  - Available at [https://github.com/WEC-Sim/WEC-Sim](https://github.com/WEC-Sim/WEC-Sim)
- Joint NREL/Sandia project
- Funded by the US Department of Energy
- First Release: v1.0 in June 2014
- Current Release: v5.0 in May 2022
Project Timeline

FY 2019
- WEC-Sim v3.1
- WECCCOMP control competition numerical (Phase 1)
- WECCCOMP special session (OMAE 2019)

FY 2020
- WEC-Sim v4.0
- WEC-Sim Course at Universidad de Costa Rica (PAMEC 2020)
- WEC-Sim v4.1
- Review open source BEM
- WEC-Sim v4.2
- IEA OES phase III OWC V&V complete (KRISO tank test data)

FY 2021
- WEC-Sim v4.3
- WEC-Sim wins R&D 100 Award
- RFTS1 awards for WEC-Sim Support
- RFTS2 awards for WEC-Sim Support
- WECCCOMP control competition experimental (Phase 2)
- WECCCOMP winner announced
- WEC-Sim lectures at OSU for CEE 411/511
- MATLAB Energy Speaker Series
- Oregon State University
- TEAMER
Support the WEC modeling community through WEC-Sim development, maintenance, support and training.

- **Develop and maintain** the WEC-Sim software on GitHub, and **resolve bugs** with the software.
- Provide **WEC-Sim support** via responding to and resolving issues posted by users, and updating the publicly available examples and online documentation.
- **Outreach** via hosting in-person and online training courses (e.g. PAMEC 2022), presenting and **publishing WEC-Sim articles**, and **training the next generation** of WEC numerical modelers.

Assess the current MRE Software landscape, and identify future development needs.

- Solicit public feedback via MRE Software Workshop (e.g. OREC-METS 2022) and online webinar.
- Draft report on current MRE Software landscape, identifying gaps and potential needs for public feedback.
WEC-Sim v5.0
WEC-Sim v5.0

Released May 2022

WEC-Sim

Dec 14, 2014 – Sep 7, 2022

Contributions to master, excluding merge commits and bot accounts

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

WEC-Sim Applications

Mar 27, 2016 – Sep 7, 2022

Contributions to master, excluding merge commits and bot accounts

https://github.com/WEC-Sim/WEC-Sim_Applications
WEC-Sim v5.0

Released May 2022

Source Code Management and UI/UX
- An intuitive and consistent naming convention applied throughout (not reverse compatible)
- Related functions grouped together, redundant functions removed.
- Embedded Simulink functions saved as separate scripts
- Updated and expanded documentation

New Features
- Continuous integration
- Modeling cables
- Capytaine BEM
- Run from Simulink
- Wave visualization
New Features - Continuous Integration
Continuous integration is built on:
- GitHub Actions using
- MATLAB unit testing framework

Why use CI?
- Ensures development does not affect accuracy/functionality
- Prevent bugs and errors
- Ensure documentation builds correctly
WEC-Sim v5.0 – Continuous integration

Tests developed for WEC-Sim source repository and WEC-Sim Applications repository

- Run locally when developing new features (ensures stability of source code)
- Run automatically on both master and dev branches (for WEC-Sim and WEC-Sim Applications)
- Build reports automatically generated
- Run automatically for each commit and pull request

Recent WEC-Sim releases have included developments on:

- Regression tests (accuracy)
- Integration tests (functionality)
- Unit tests (accuracy and functionality)
- Automatic triggering of test suite
- Automatic building of documentation
New Features – Cable Modeling
A number of industry WECs rely on cables/winches/tethers as a means of coupling two or more bodies (frequently requested in user-submitted issues).

These elements are non-linear as they only transmit tensile forces between the connection points (but not compression).

Right: Schematic of the MBARI-WEC*.

Far-right: Mechanics Explorer visualization of the MBARI-WEC. The end-points of the cable connection shown as oversize grey spheres.

Implement as a logic check: cable stiffness + damping force exerted if extended beyond equilibrium length (no force exerted if not).

This does not resolve the motions of the cable, but transmits appropriate forces between the coupled bodies.

Alternative modeling suggestions available for stiff systems.
New Features – Capytaïne BEM
WEC-Sim v5.0 – Capytaine

WEC-Sim relies on Boundary Element Method (BEM) solutions to define hydrodynamic coefficients. Supported codes are NEMOH, WAMIT, AQWA, and now **Capytaine**

- Open-source Python code: [https://github.com/capytaine/capytaine](https://github.com/capytaine/capytaine)
- Capytaine support is current and ongoing.
- Capytaine developer: Matthieu Ancellin
WEC-Sim v5.0 – Capytaine

BEMIO Results: WAMIT, AQWA and Capytaine

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New Features – Run from Simulink
Previously, a simulation was run from the command line, reading information from `wecSimInputFile.m`, and Simulink models would close at run time.

Now, user option to specify parameters directly in Simulink dialog and run from GUI.

A more common workflow, and easier for debugging.

Example:

WEC-Sim/examples/RM3FromSimulink
New Features – Wave Visualization
User-defined wave markers offer a simple way to aid free surface visualization in the native Mechanics Explorer. A useful debugging tool!

Videos files (*.avi of *.gif) can be created using `responseClass.saveViz()` function.

Example:
WEC-Sim_Applications/Wave_Markers

ParaView (VTK) visualization is still supported as a visualization alternative.
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Example:
WEC-Sim_Applications/Wave_Markers

- ParaView (VTK) visualization is still supported as a visualization alternative.
Future Development
Future Work

Advance the state of open source software within the wave energy sector

- Improve WEC-Sim **interoperability with open-source meshing, BEM and optimization** software to facilitate device performance improvements and cost reduction

- **Improve parallelization** to leverage HPC systems for scientific discovery

- **Support the development of the open-source BEM software Capytaine** – improving accuracy, speed and functionality.

- **Outreach and training**, including short courses, webinars, and additional WEC-Sim applications (e.g. offshore wind, flexible bodies)
User feedback guides development! Contributions are always welcomed.

- Report a bug, seek support, request a feature: https://github.com/WEC-Sim/WEC-Sim/issues
- Contribute to the WEC-Sim or WEC-Sim Applications: https://github.com/WEC-Sim/WEC-Sim/pulls
- Additional industry/research support available through the TEAMER program: https://teamer-us.org/
For more information please visit the WEC-Sim website:

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

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Performance: Accomplishments and Progress

WEC-Sim Accomplishments

- New Features: wave gauges, **flexible bodies**, passive yaw, unit tests, drag bodies, parallel computing, continuous integration, Capytaine, run from Simulink, cable blocks, spherical constraints. Two WEC-Sim releases tagged per year.

- Outreach: Wave Energy Control Competition (WECCCOMP), OMAE Special Session, OSU and PAMEC courses, Marine Energy Collegiate Competition (MECC) Support

Industry Support

Established as TEAMER facility in FY21. With 12 TEAMER awards to date, WEC-Sim is one of the most requested facilities. Used to model a broad range of devices, WEC and more...

Progress measured by

Google Analytics (PAMEC 2020 and EWTEC 2021)
Performance: Accomplishments and Progress

WEC-Sim Development and Support

- >600 closed issues & >270 merged pull request since 2014
- >300 closed issues & >140 merged pull requests from 2019-2021
- More than double productivity

WEC-Sim Literature Review

- >125 publications since 2013
- >70 publications from 2019 - 2021, 18 by WEC-Sim authors
- Increase in journal articles (blue) and external author publications (darker)
- Established in FY20 as PRIMRE Signature Project

2021 R&D 100 Award Winner for Software/Services

GitHub

https://wec-sim.github.io/WEC-Sim

https://www.rdworldonline.com/rd-100-2021-winner/wec-sim/

https://tethys-engineering.pnnl.gov/signature-projects/wec-sim
Performance: Accomplishments and Progress

Nov 18, 2016 to Sept 30, 2018

- Users primarily in Europe and North America
- Target underrepresented regions for engagement

Oct 1, 2018 to Sept 30, 2021

- Large domestic and international user-base
- 111% increase in users worldwide (> double)
- Increase in users from South America, Asia and US