



DTOcean (Optimal Design Tools for Ocean Energy)

WBS 2.1.3.703

Marine and Hydrokinetics Program

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Jesse Roberts

Sandia National Laboratories

Project Overview

Project Summary

- The DTOcean project pioneered a new, open-source collaborative development model for wave and tidal array design tools that considers the entire ocean energy farm throughout its lifecycle.
- The software helps to find optimal array designs that minimize the levelized cost of energy (LCOE) and identify cost drivers, allowing the industry to capably progress towards economic viability.
- DTOcean was an international collaboration between 18 European institutions and Sandia National Labs (SNL) in the United States.
- DTOcean was funded under the Seventh Framework Programme (FP7) which bundles all research-related European Union (EU) initiatives together under a common umbrella. Sandia funding provided by the US DOE.

Project Objective & Impact

Objective: Automate the design of an MHK array

Major outcomes:

- 1) The development of state-of-the-art design tools for arrays of ocean energy devices.
- 2) A thorough qualitative assessment of EU MHK research and research organizations.
- 3) An improved path forward for MHK array design tools and European collaboration
- 4) Direct transfer of the DTOcean software tool to the US MHK industry

Project Information

Project Principal Investigator(s)

Jesse Roberts

WPTO Lead

Bill McShane

Project Partners/Subs

Data Only Greater – Mat Topper

Project Duration

- FY14
- FY19

Marine and Hydrokinetics (MHK) Program Strategic Approaches

Data Sharing and Analysis

Foundational
and
Crosscutting
R&D

Technology-
Specific
Design and
Validation

Reducing
Barriers to
Testing

Foundational and Crosscutting R&D

- Improve MHK resource assessments and characterizations needed to optimize devices and arrays, and understand extreme conditions

DTOcean is a first of a kind whole plant MHK array optimization code that incorporates device positions, device installation, cable routing, mooring type, and maintenance schedule with communication between each stage.

Data Sharing and Analysis

- Leverage expertise, technology, data, methods, and lessons from the international MHK community and other offshore scientific and industrial sectors
- Expertise from the diverse set of fields associated with the 18 partners institutions have been captured and integrated into the DTOcean code.
- Additionally, reasonable benchmarks for many project costs have been stored in the default DTOcean database allowing users to quickly get started with reasonable assumptions for an ocean energy array simulation.

Technology-Specific Design and Validation

- Improve methods for safe and cost efficient installation, grid integration, operations, monitoring, maintenance, and decommissioning of MHK technologies
 - Evaluate current and potential future needs for MHK-specific IO&M infrastructure (vessels, port facilities, etc.) and possible approaches to bridge gaps
- The DTOcean design process ensures that necessary and important design stages are considered by the developer.
 - Previous ocean energy array design tools only considered small portions of the overall array design with no direct and simple method to communicate with other tools or analytic methods that consider other portions of the design process.
 - The revolutionary design of DTOcean remedies this issue with a formal design process which communicates between the many diverse stages of ocean energy array design.
 - The DTOcean database allows for the specification of multiple ports and device types for installation and will automatically choose the most cost-effective option considering static and variable costs due to weather, labor, fuel, and vessel charges.

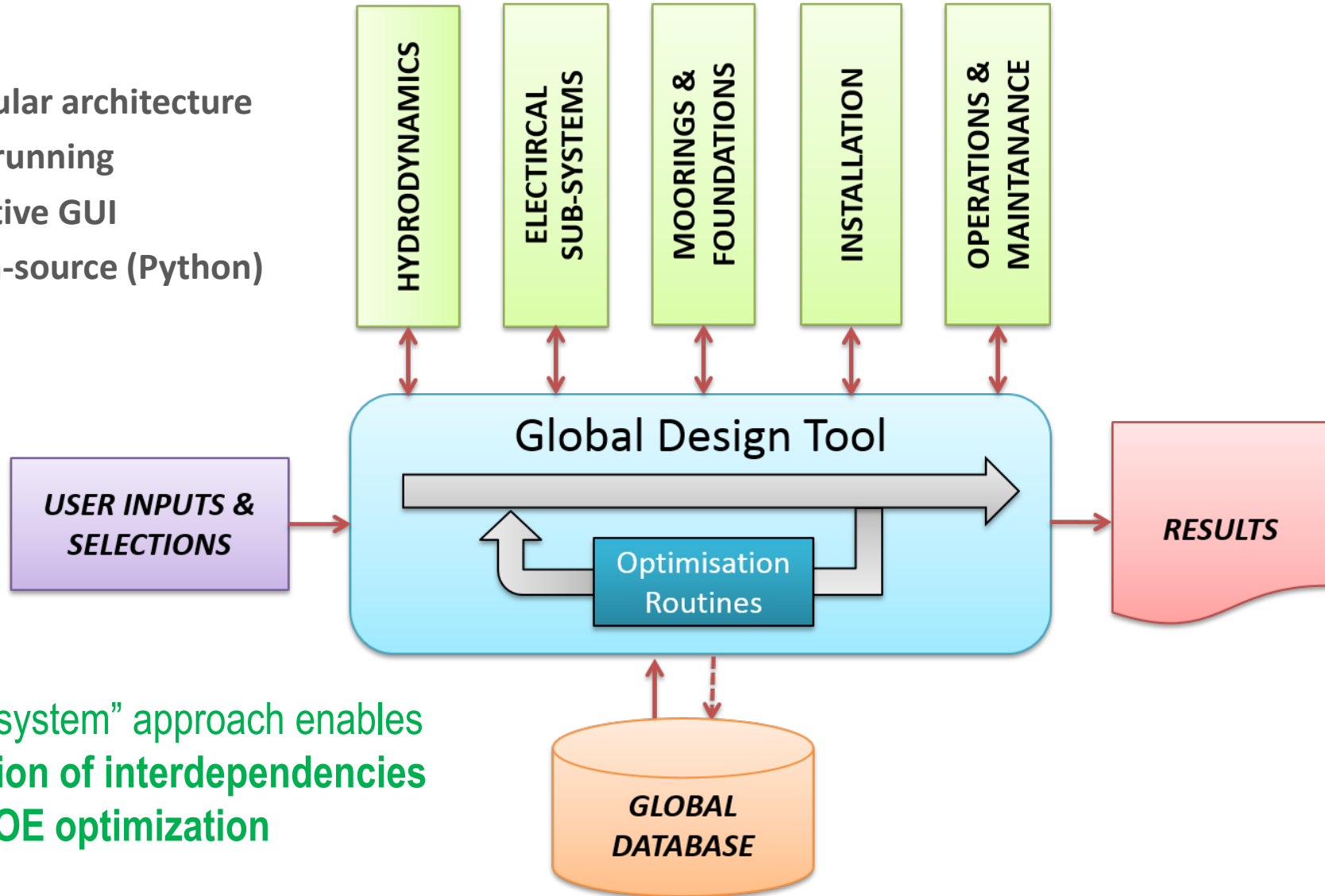
FY17	FY18	FY19	Total Project Budget	
		(Q1 & Q2 Only)	FY17–FY19 Q1 & Q2 (October 2016 – March 2019)	
Costed	Costed	Costed	Total Costed	Total Authorized
\$55K	\$44K	\$23K	\$122K	\$148K *

*All funds within this peer review time frame were carryover from FY16.

- There was no new BA in FY17, FY18, or FY19.

Management and Technical Approach

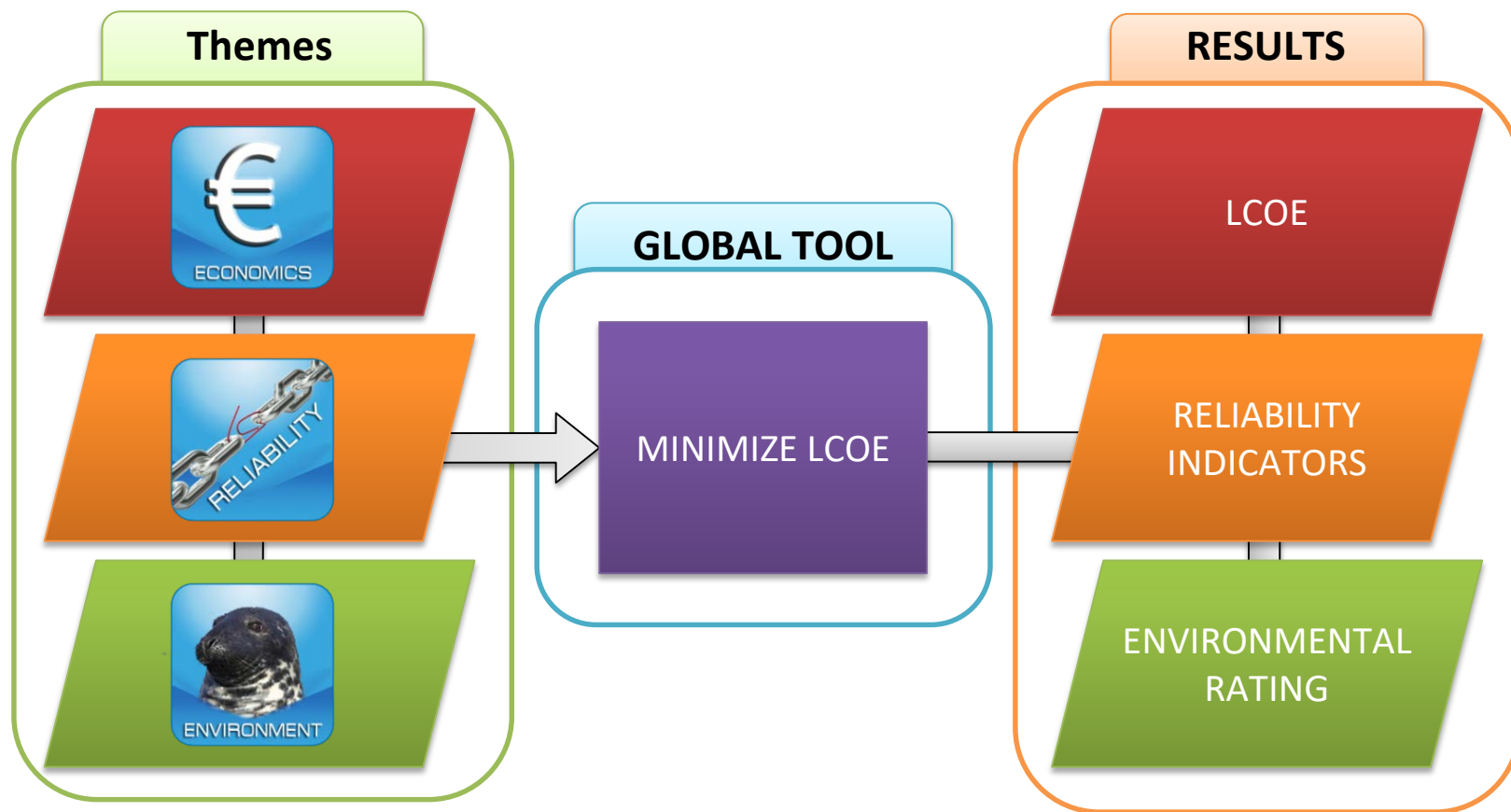
- Modular architecture
- Fast-running
- Intuitive GUI
- Open-source (Python)



“Whole system” approach enables evaluation of interdependencies and LCOE optimization

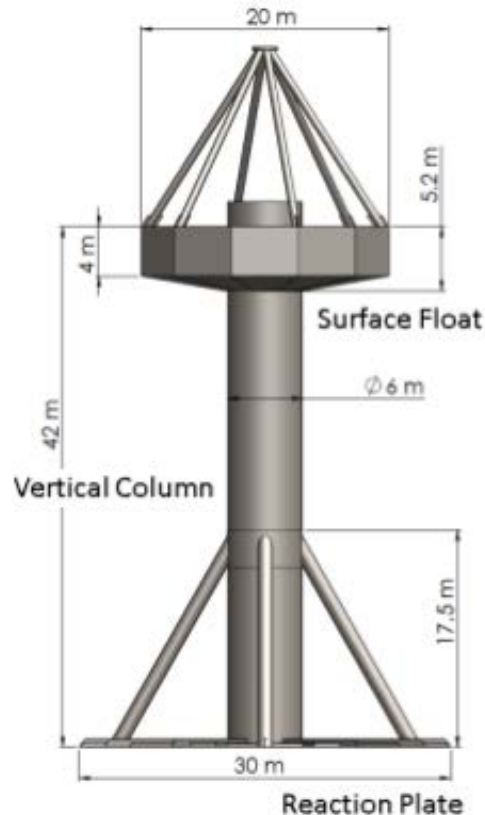
Management and Technical Approach

The software uses 3 thematic assessments:

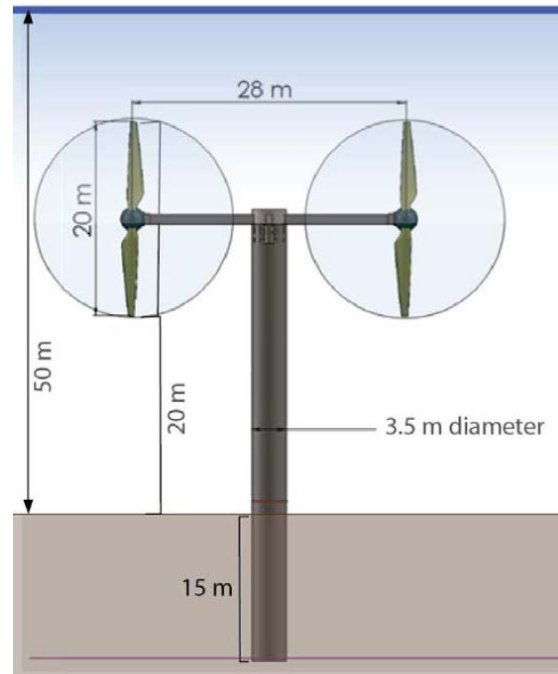


Minimizes LCOE and provides insight into **environmental acceptability** and identifies/ranks **reliability concerns** for array components

Evaluate wave and tidal scenarios and improve software:



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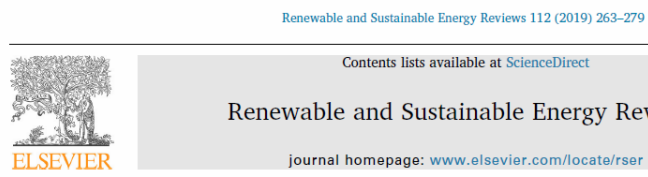
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**IMPROVED
SOFTWARE**

End-User Engagement and Dissemination Strategy

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



Reducing variability in the cost of energy of ocean energy arrays

Mathew B.R. Topper^{a,*}, Vincenzo Nava^{b,c}, Adam J. Collin^d, David Boulde^e, Francesco Ferri^f, Sterling S. Olson^g, Ann R. Dallman^g, Jesse D. Roberts^g, Pablo Ruiz-Minguela^b, Henry F. Jeffrey^g

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^f Department of Civil Engineering, Aalborg University, Aalborg, Denmark
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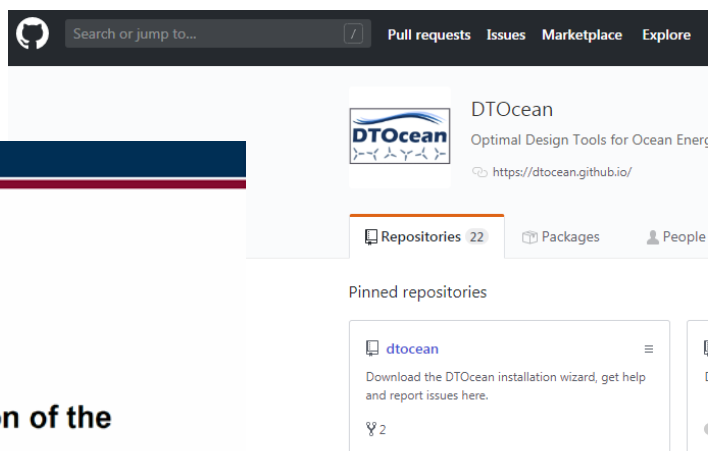
Data Only Greater Releases New Version of DTOcean

SANDIA REPORT

SAND2018-11136
Unlimited Release
Printed October 2018

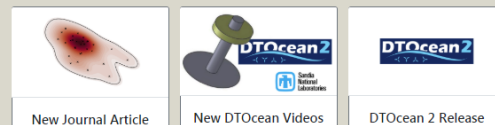
Comprehensive Evaluation of the DTOcean Toolset

Mathew B.R. Topper¹, Sterling S. Olson², Ann R. Dallman², Jesse D. Roberts²

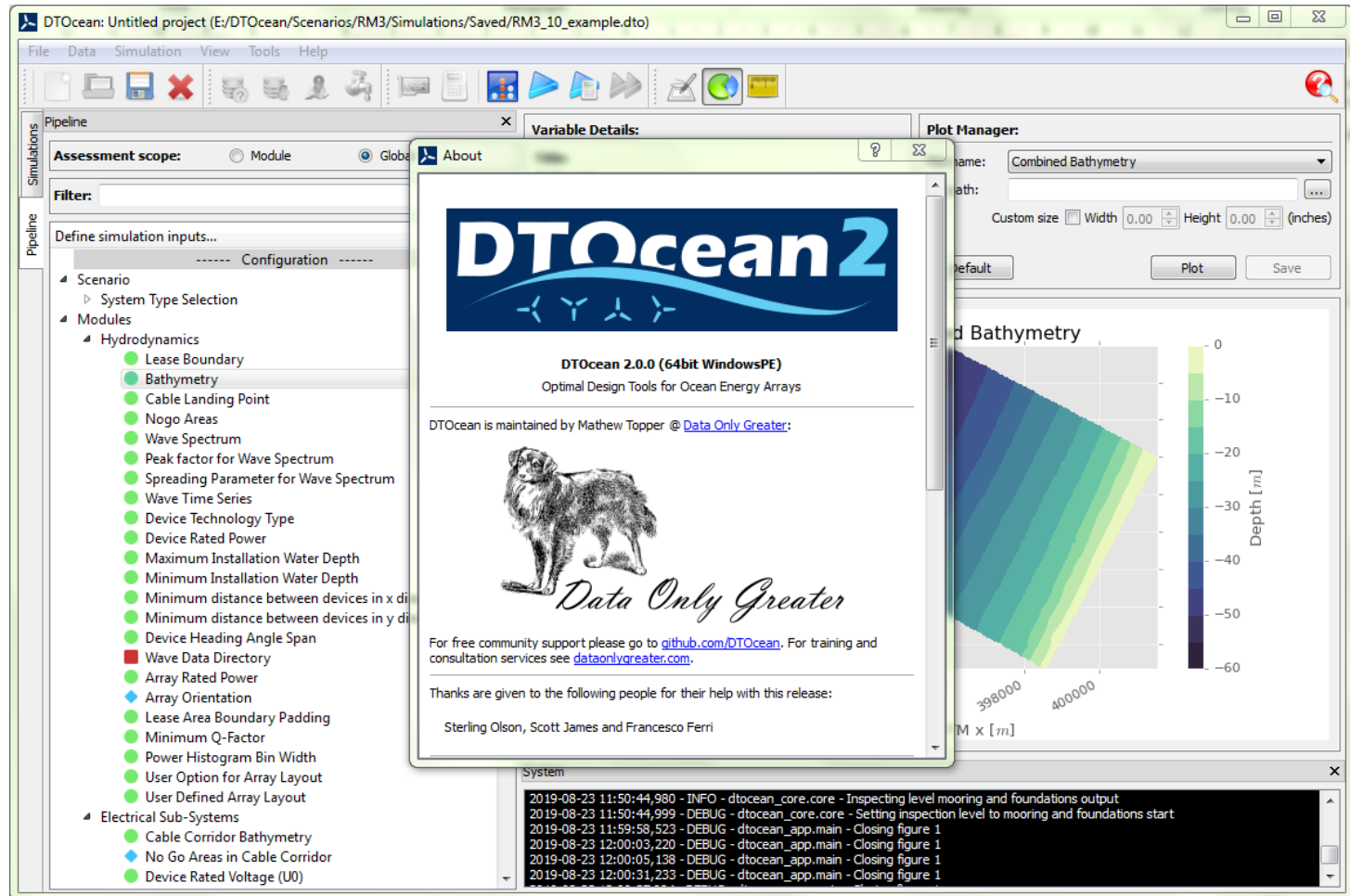


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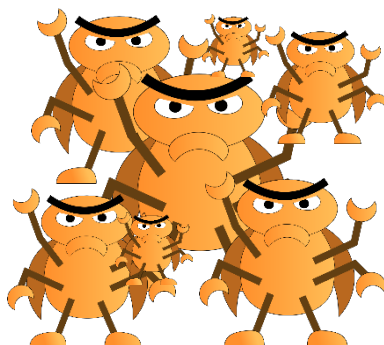
Latest News



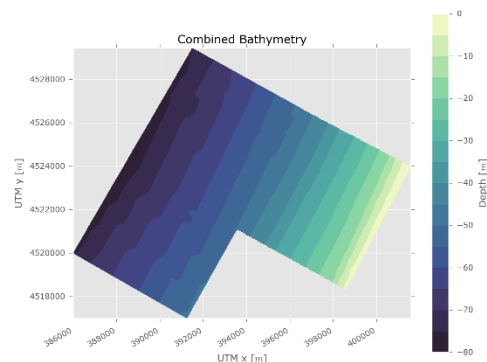
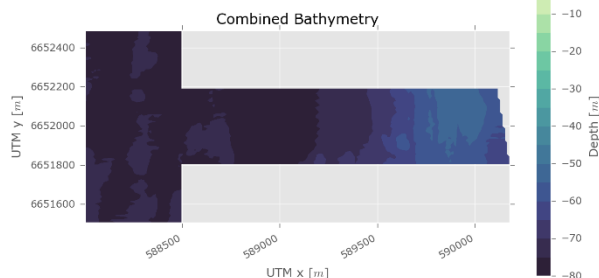
DTOcean Version 2.0 Released in March 2019



**FEWER
BUGS**

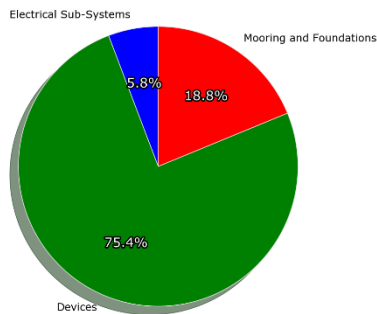


**MORE
FLEXIBILITY**

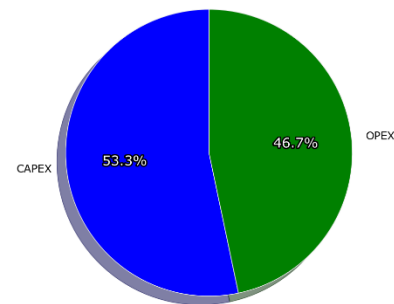


**DRY CAPEX
TO FULL LCOE**

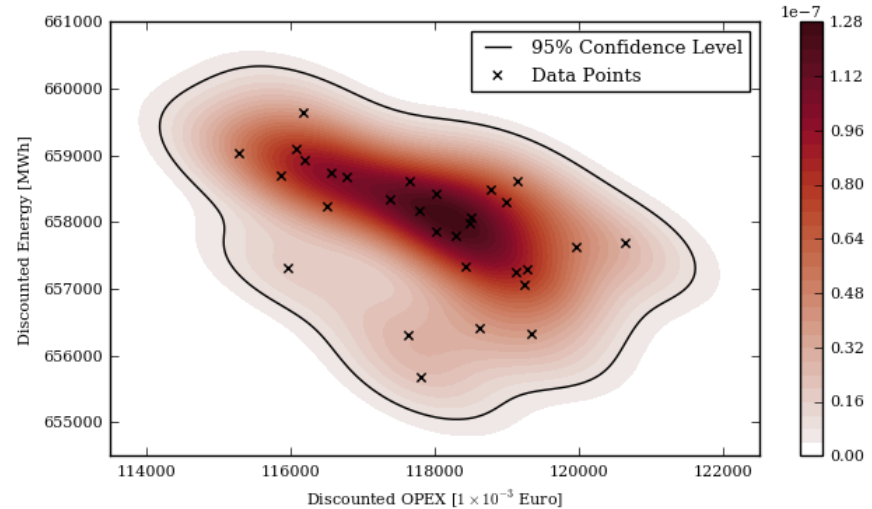
CAPEX Cost Breakdown



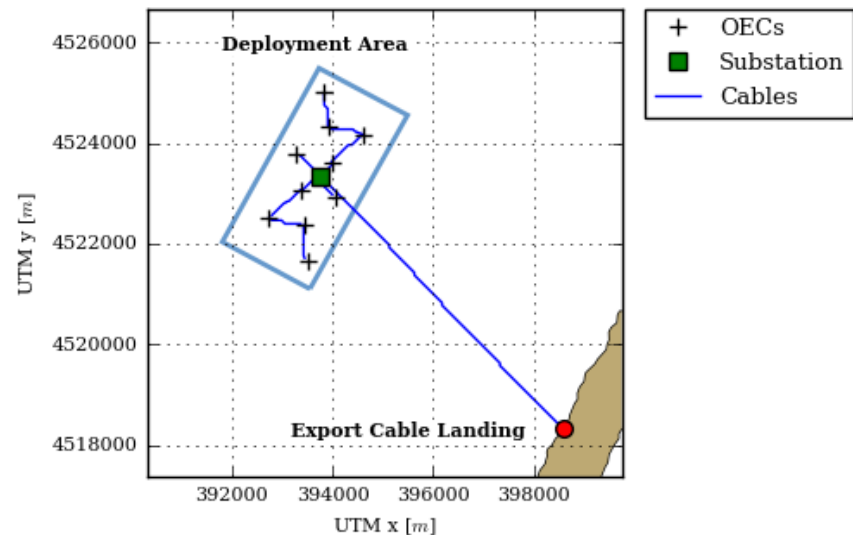
Most Likely LCOE Breakdown



LCOE AS A PROBABILITY DISTRIBUTION



RM3 MODEL RELEASED AS WAVE EXAMPLE



INVESTIGATION INTO THE RELATIONSHIP OF LCOE TO POWER PRODUCTION IN TIDAL ARRAYS (USING RM1)

LCOE BASED DEVICE POSITION OPTIMIZATION STRATEGY ADDED TO TOOL

