Floating Wind Array Ontology and Modeling Framework

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WESE Workshop

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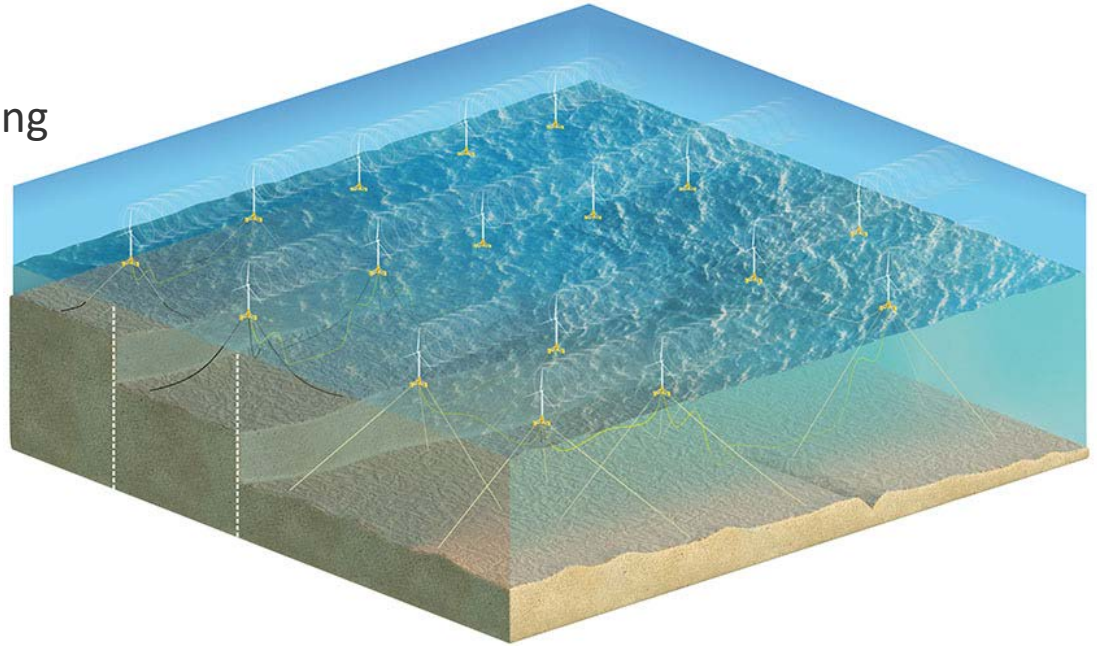
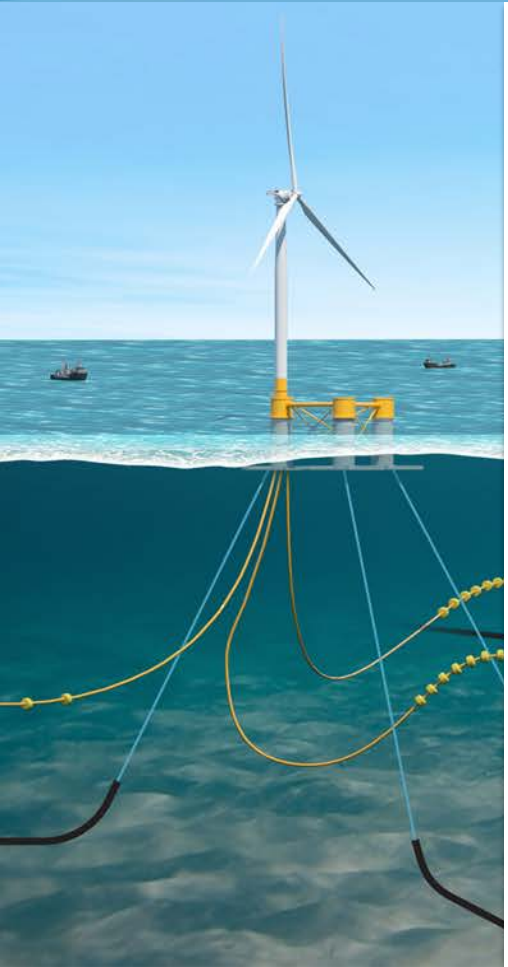
Presentation Outline

- Floating array design and modeling challenges
- Floating Array Model
- Design Tool Compatibility

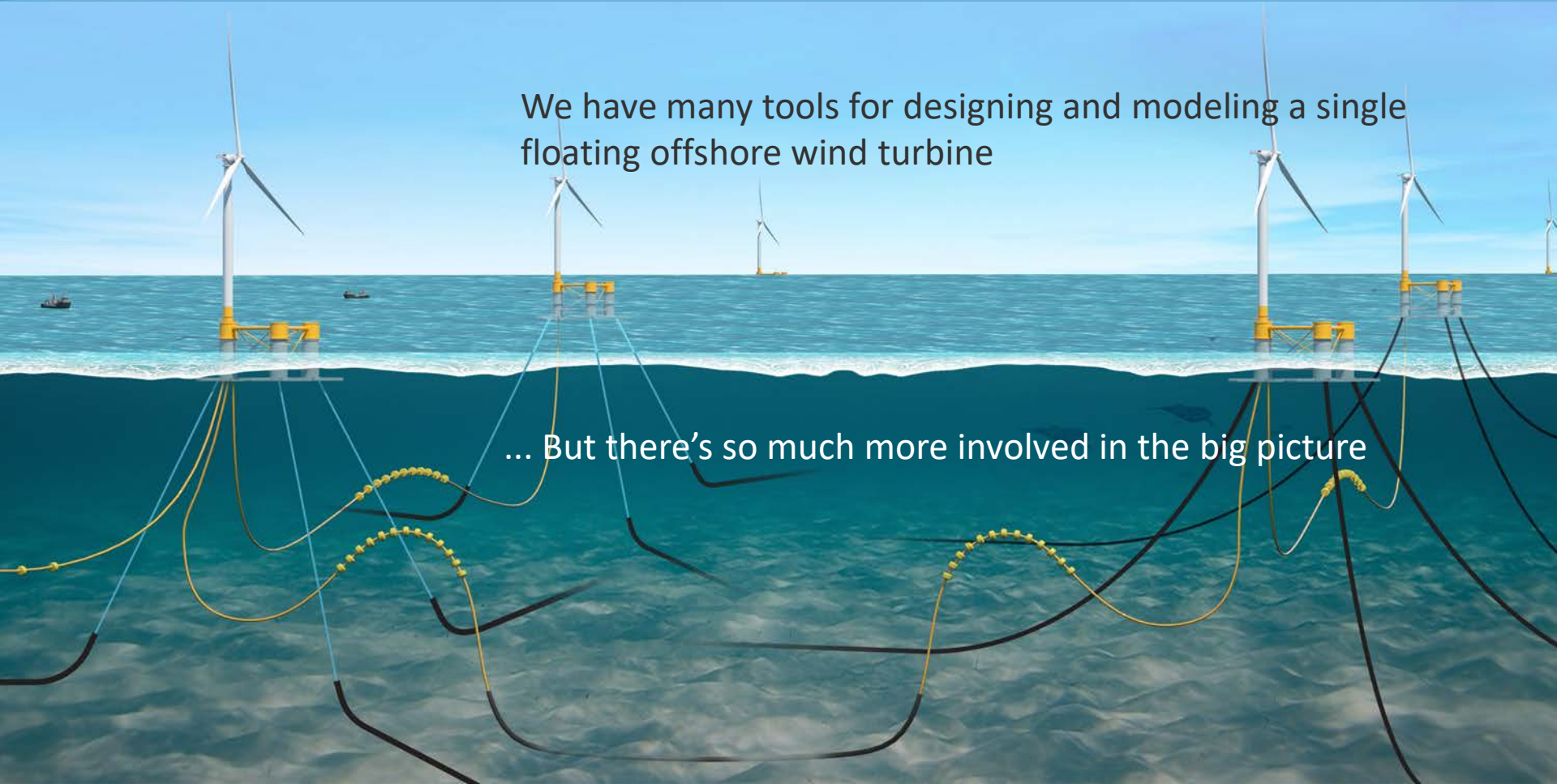


Floating Array Design



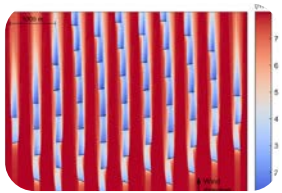
We have many tools for designing and modeling a single floating offshore wind turbine

Floating Array Design

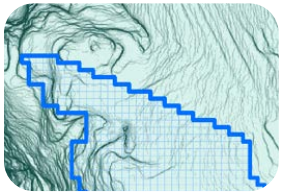


Floating Array Design

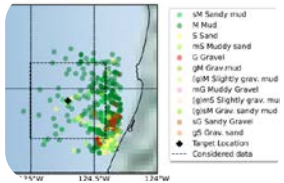
Array design and optimization requires a *coupled* design approach considering many variables



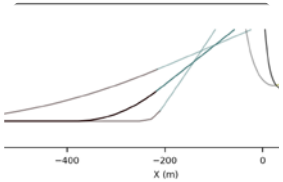
AEP



Bathymetry



Soil Conditions



Component Design

Mooring and Cabling Layout

Co-Use

Failure & Risk Analysis

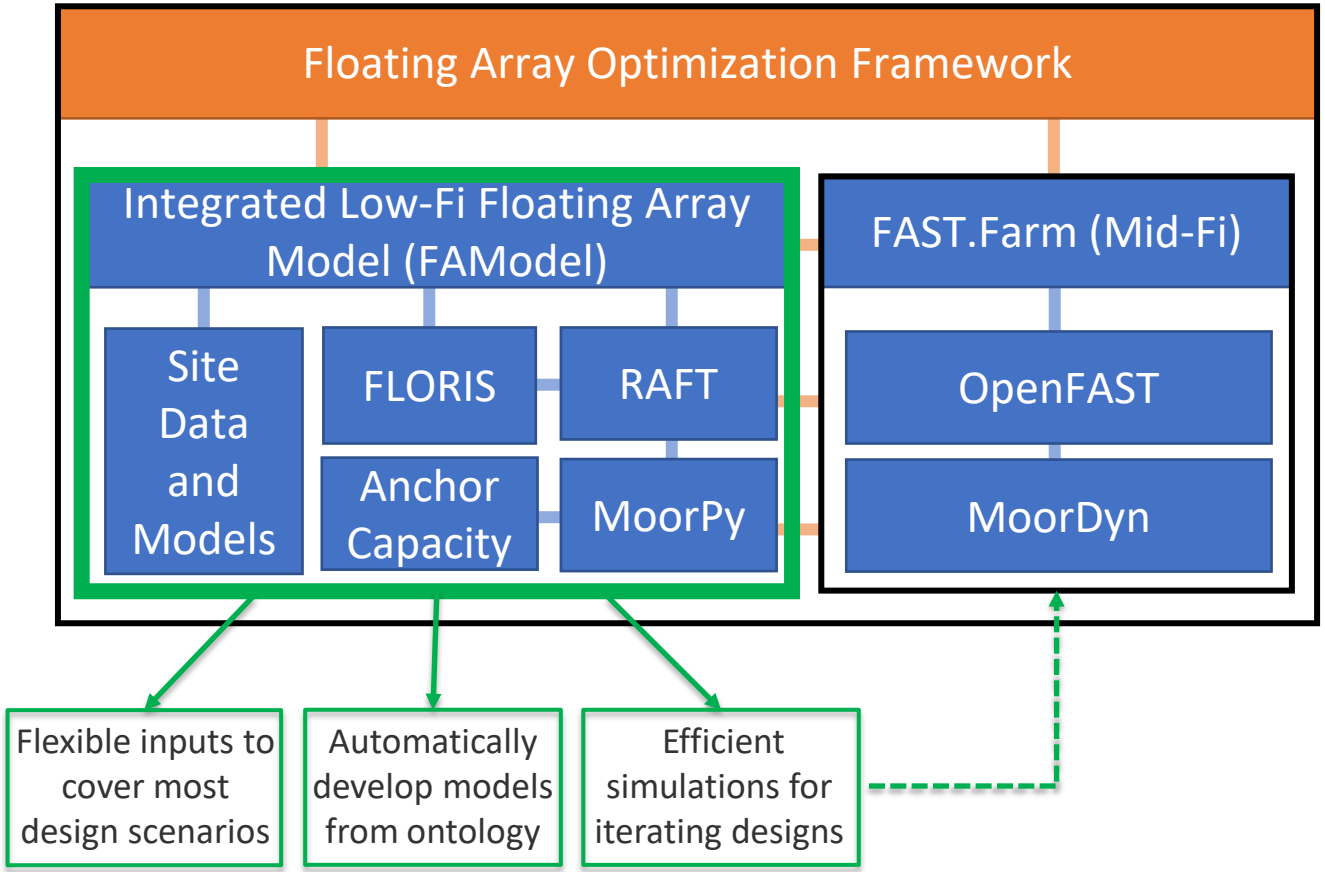
Installation & Maintenance

Environmental & Social Risk

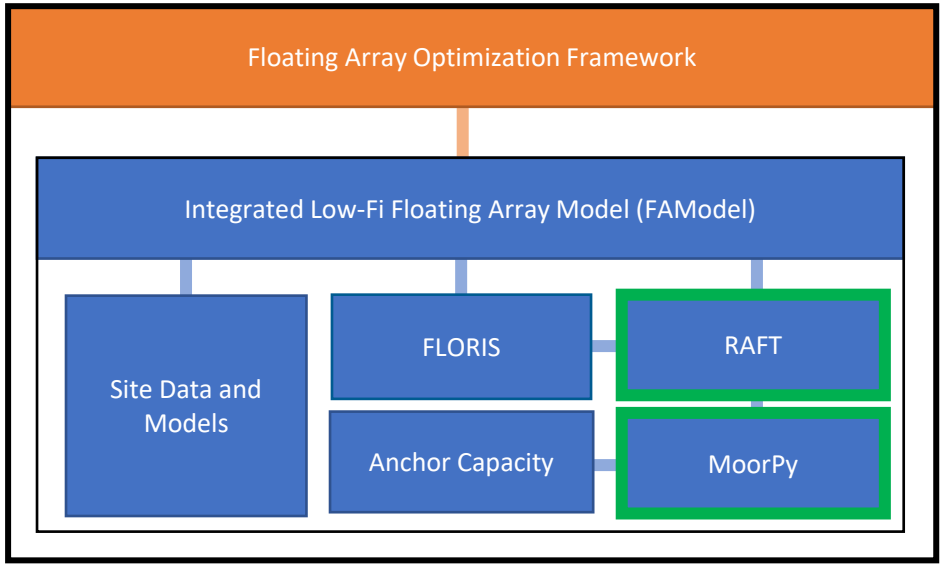
Floating Array Model (FAModel) Objective:

Python framework to streamline holistic low-fidelity FOWT modeling for array-level analysis

FAModel: an accessible floating array modeling framework

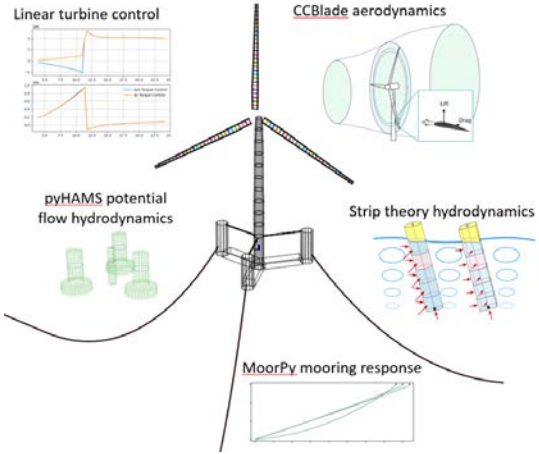


RAFT and MoorPy Overview

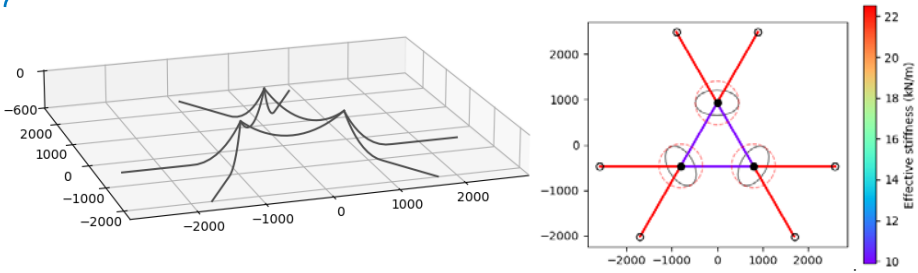


RAFT

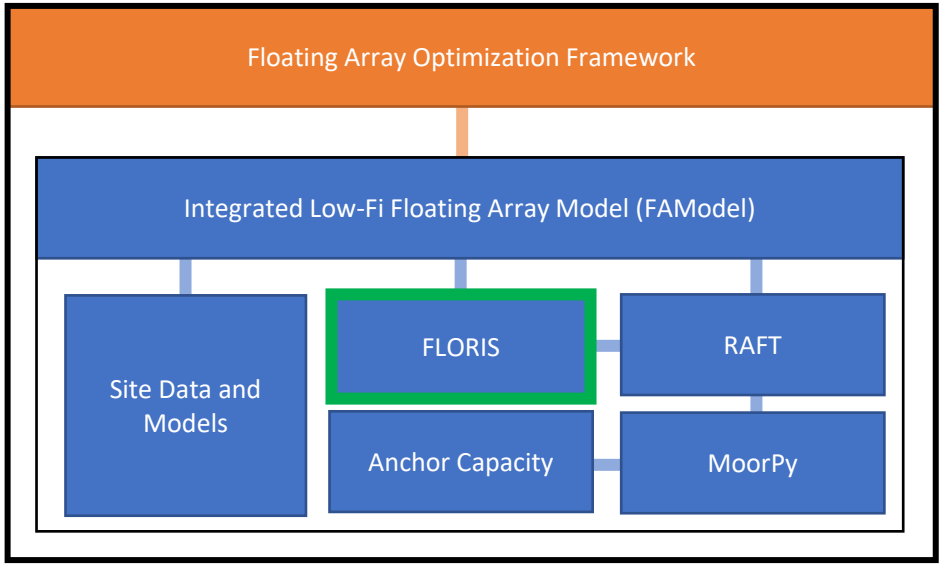
Frequency-domain (low fidelity)



MoorPy : Quasi-static mooring line model

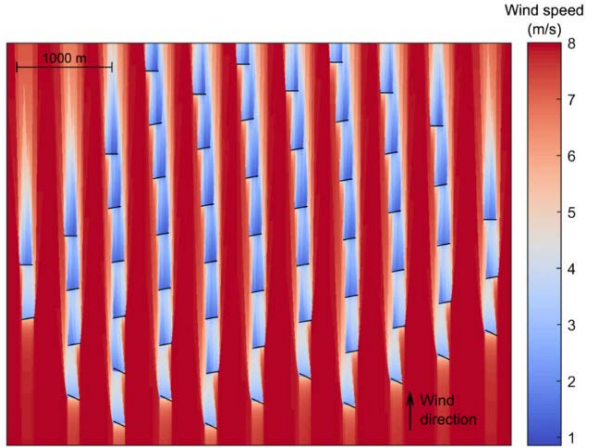


FLORIS Overview



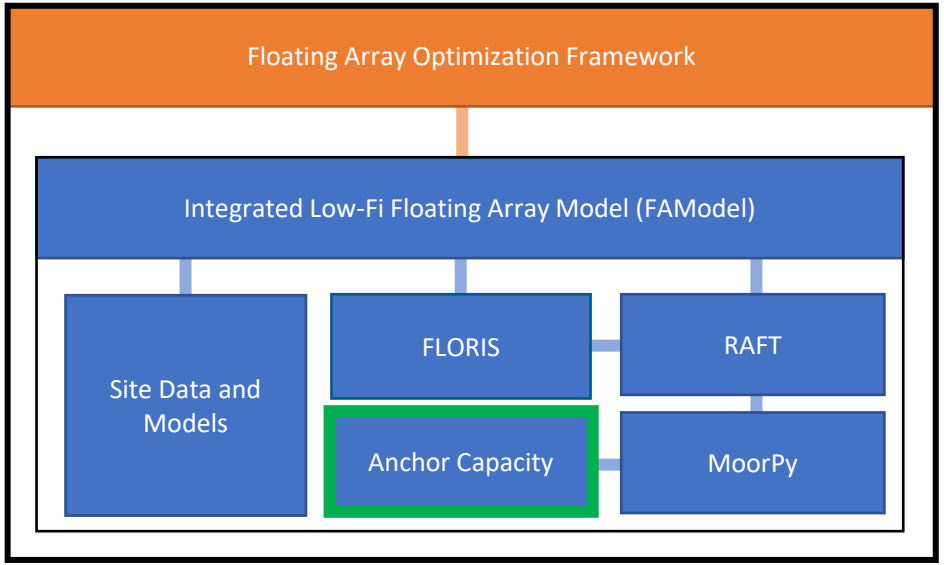
FLORIS

Steady-state wake modeling and wind farm controls (low fidelity)



- Various wake models (Gaussian, Curl, etc.)
- Wake steering
- Turbulence models

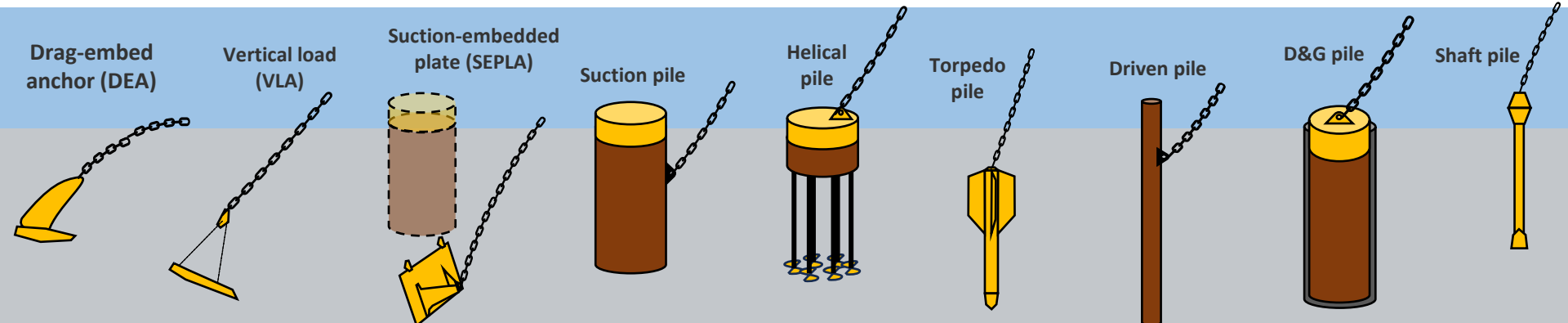
FLORIS Overview



Anchor Capacity Models

Intermediate model with specialized approaches for different anchor types

- Integrated with MoorPy to determine loading
- Uses soil properties and profile
- Uses anchor-specific geometric properties



```yaml
type: draft/example of floating array ontology under construction
name:
comments:
# Site condition information
site:
    general:
        water_depth : 200        # [m]      uniform water depth
        rho_water   : 1025.0     # [kg/m^3] water density
        rho_air     : 1.225      # [kg/m^3] air density
        mu_air      : 1.81e-05   #          air dynamic viscosity
        #...

    boundaries:  # project or lease area boundary, via file or vertex list
        file:   # filename of x-y vertex coordinates [m]
        x_y:    # list of polygon vertices in order [m]
          - [-3000, -3000]
          - [-3000, 3000]
          - [3000, 3000]
          - [3000, -3000]

    bathymetry:
        file:   './bathymetry200m_sample.txt'

    seabed:
      x : [-10901,    0,    10000]
      y : [-10900,     0,  10000 ]

      type_array:
        - [mud_soft ,  mud_firm ,   mud_soft]
        - [mud_soft ,  mud_firm ,   mud_soft]
        - [mud_soft ,  mud_firm ,   mud_soft]

      soil_types:
        mud_soft:
          Su0 : [2.39]  # [kPa]
          k : [1.41]    # [kPa/m]
          depth: [0]    # [m]
        mud_firm:
          Su0 : [23.94] # [kPa]
          k : [2.67]    # [kPa/m]
          depth: [0]    # [m]
```

FAModel Input: IEA Wind Task 49 Ontology

- Interoperable ontology that standardizes communication of designs
- Ontology file is input to FAModel

https://github.com/IEAWindTask49/Ontology

FAModel Inputs: Ontology

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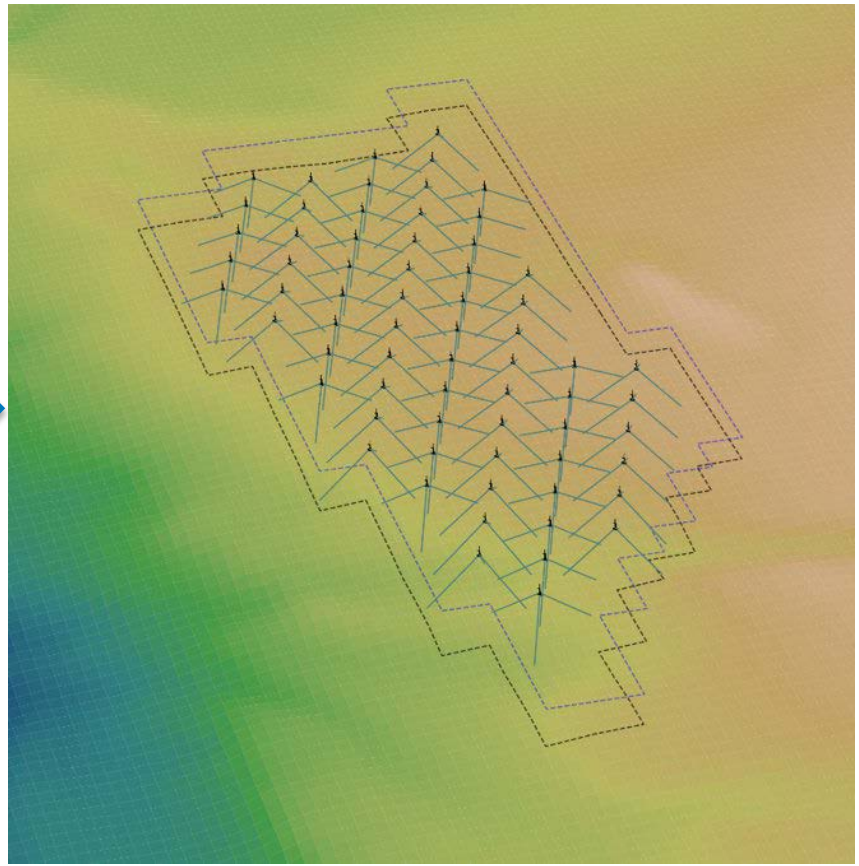
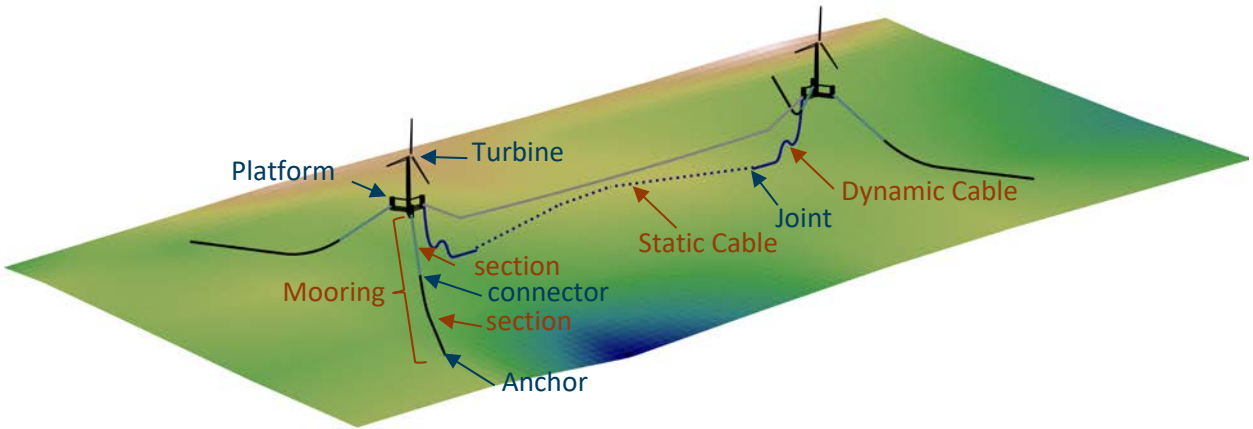


FAModel Framework

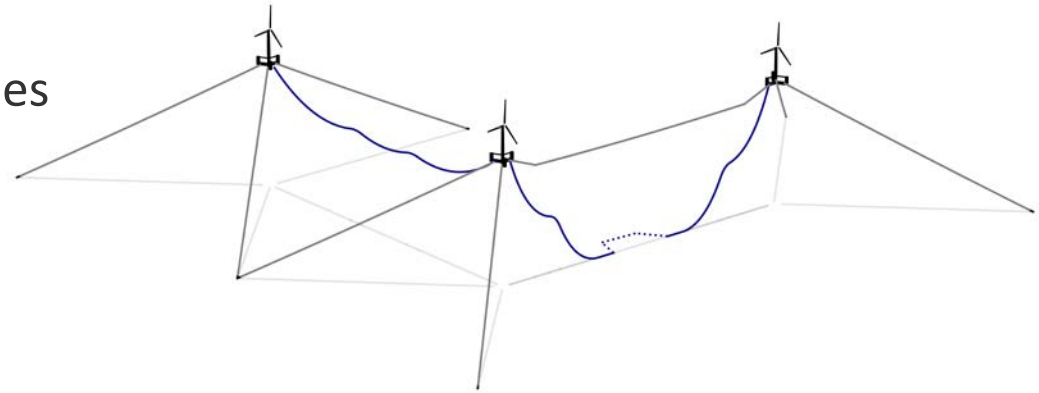
- Ontology information is parsed and stored in project class and its component classes
- Each component type has a class
- Every component stores its location, design information, and objects connected to it



FAModel Capabilities

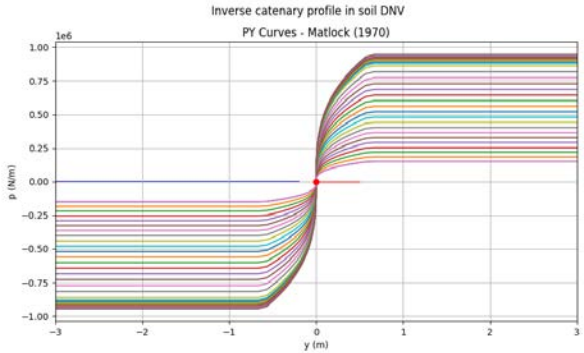
Flexible model set up to handle a variety of configurations

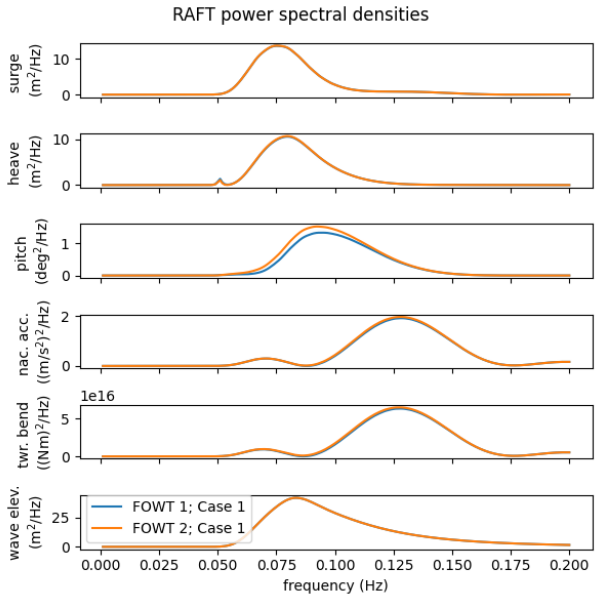
- Shared moorings
- Shared anchors
- Static, dynamic, suspended cables
- Most anchor types
- Flexible layout structure

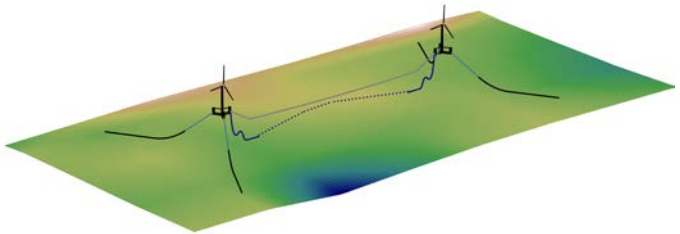


FAModel Capabilities

- **Forces & Motions**
  - Mooring
  - Anchor
  - Cable
  - Marine growth
  - Platform
- Area analysis
- Visualization
- AEP and wake modeling
- Failure modeling
- Component Costs

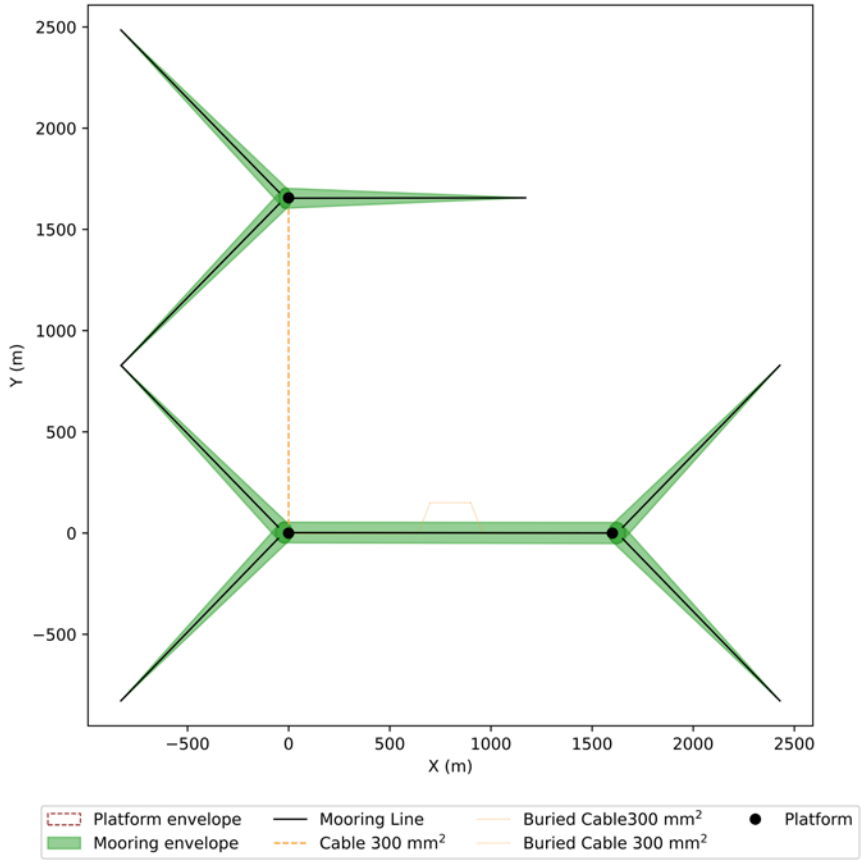






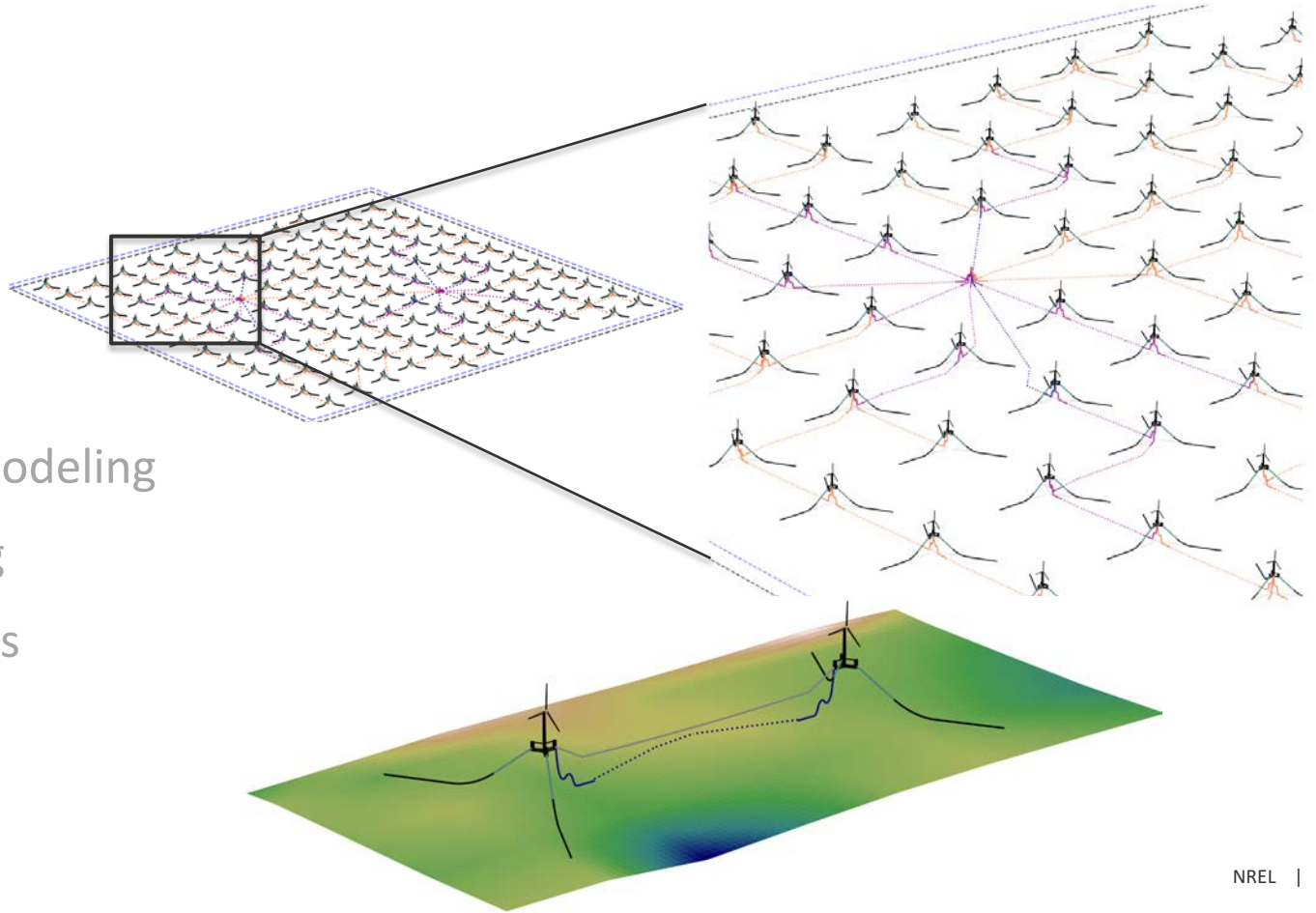
FAModel Capabilities

- Forces
- **Area analysis**
  - Fishing considerations
  - Search and rescue
- Visualization
- AEP and wake modeling
- Failure modeling
- Component costs



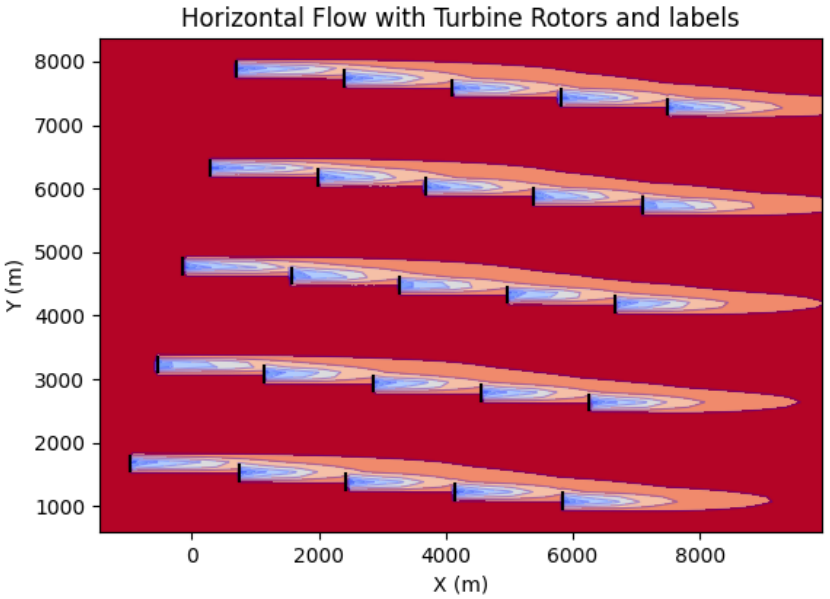
FAModel Capabilities

- Forces
- Area analysis
- **Visualization**
  - Array layout
  - Cable routing
- AEP and wake modeling
- Failure modeling
- Component costs



FAModel Capabilities

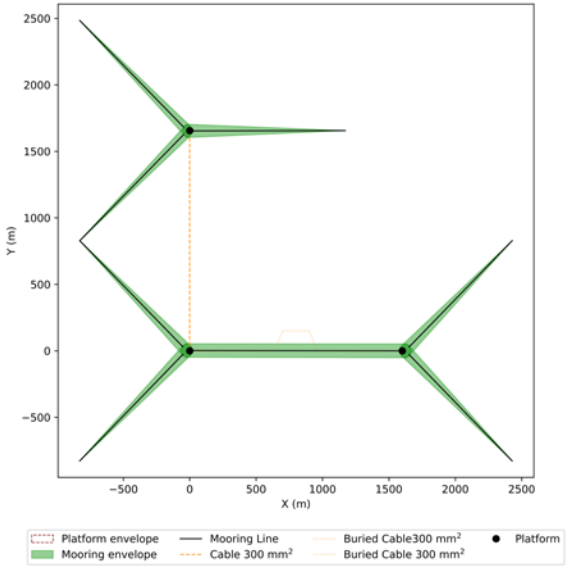
- Forces
- Area analysis
- Visualization
- **AEP and wake modeling**
  - Includes turbine offsets
- Failure modeling
- Component costs



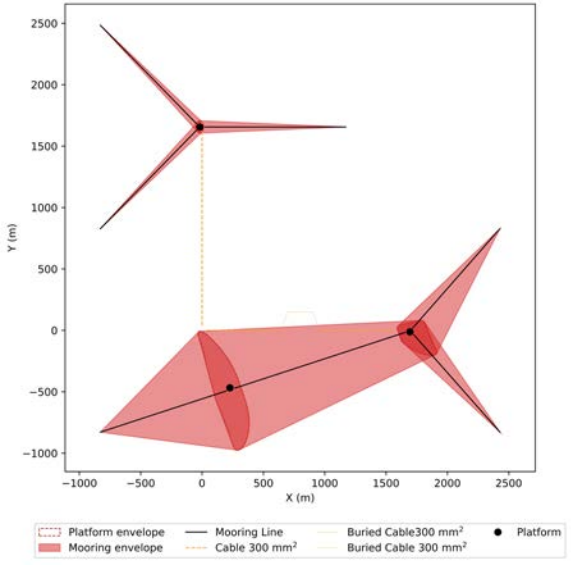
FAModel Capabilities

- Forces
- Area analysis
- Visualization
- AEP and wake modeling
- **Failure modeling**
- Component Costs

Regular Motion Envelopes



Line Failure Motion Envelopes



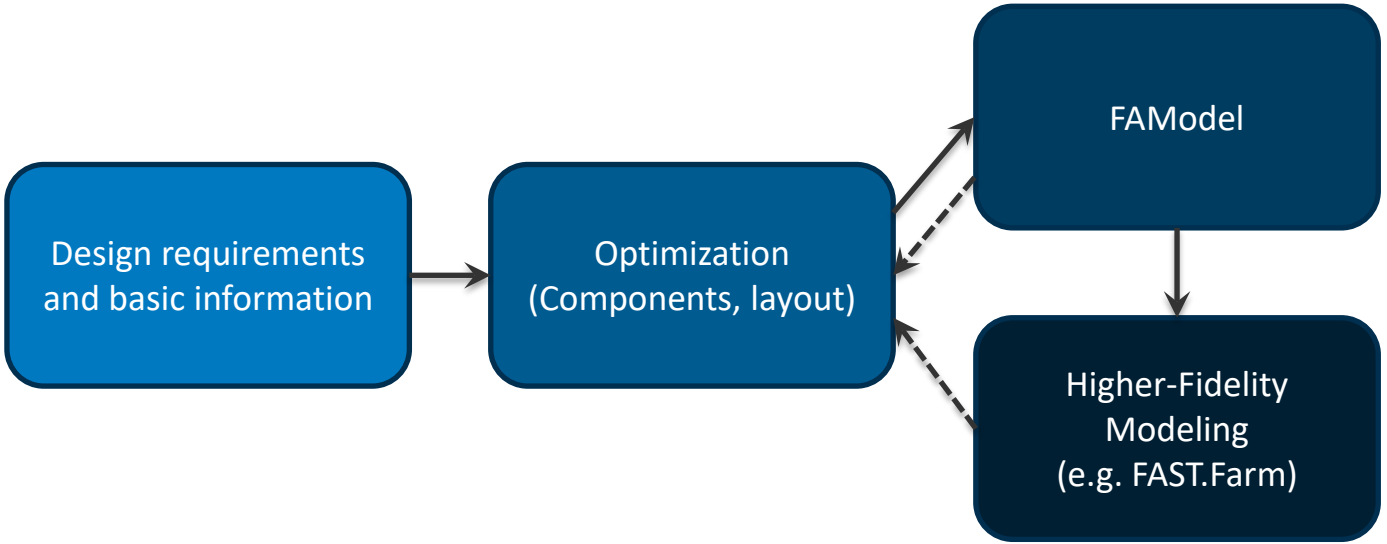
FAModel Capabilities

- Forces
- Area analysis
- Visualization
- AEP and wake modeling
- Failure modeling
- **Component Costs**

- Cost calculations available for:
  - Cables
  - Moorings
  - Anchors
- Dictionaries of cost information can be provided by user for any component
- Total cost of all components available

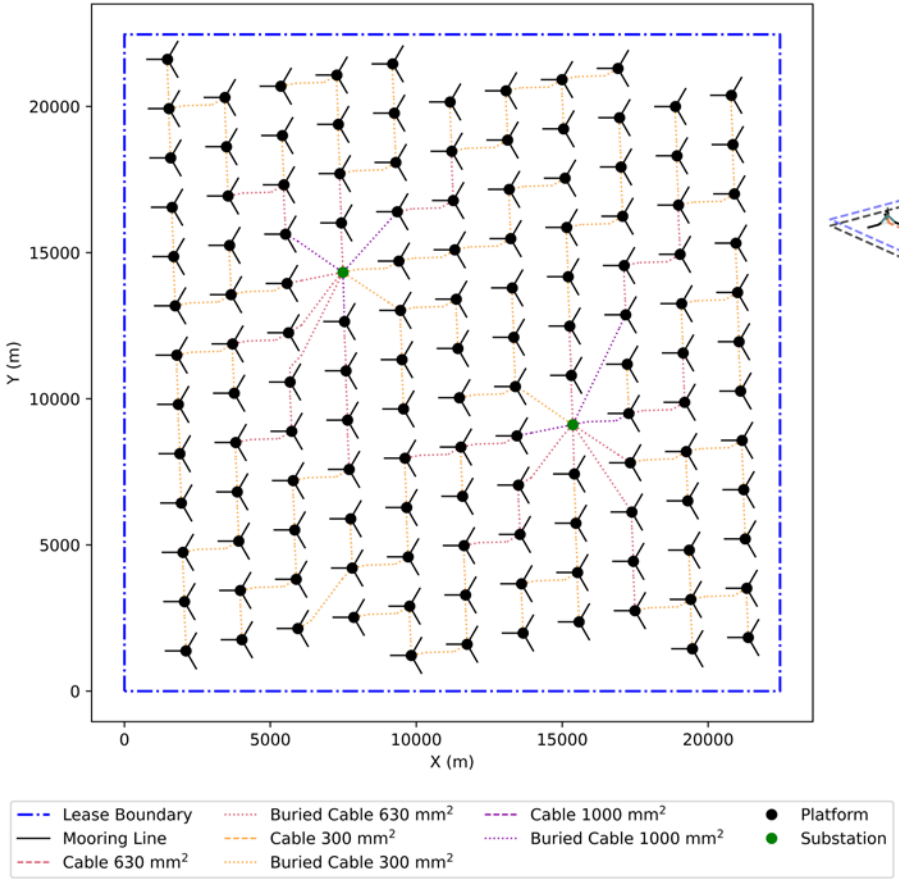
Compatibility with Design Tools

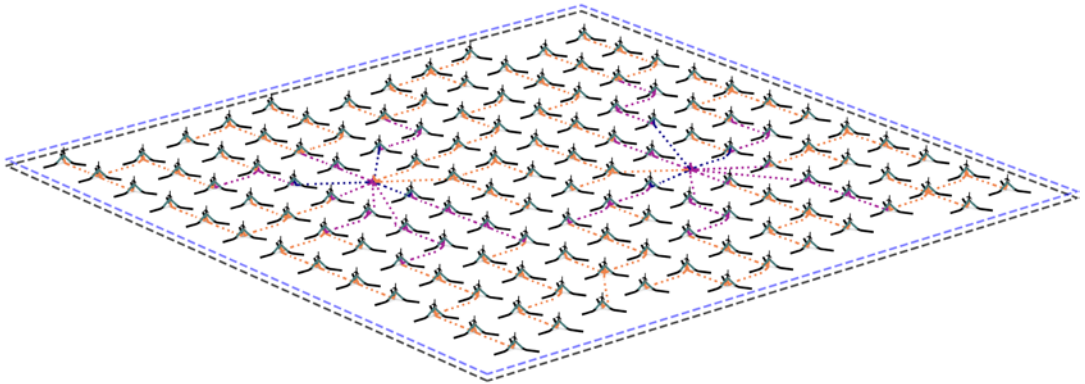
- NREL optimization tools easily integrate with FAModel
- Simplifies design process



Test Cases

Floating Array Design Gulf of Maine Reference Array





Also Currently Being Used In:

- Standardized Mooring Project
- CEC Comprehensive Shared Moorings Project
- Floating Array Design Project
- IEA Wind Task 49

Conclusion

- Integrates various low-fidelity array modeling to enable a fast yet holistic approach to array design
- Ontology input file provides concise, logical, and flexible description of array design
- Compatible with various open-source design tools

Future Work

- FAModel currently focused on underwater components
- With open-source approach, we hope to expand our vision and capabilities while maintaining ease of use
- Useability vs universality

Questions?

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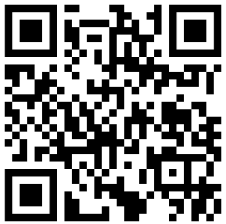
www.github.com/FloatingArrayDesign/FAModel



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Thank you!

FAModel can be found online at:

www.github.com/FloatingArrayDesign/FAModel