Python Lesson 5
OpenMDAO

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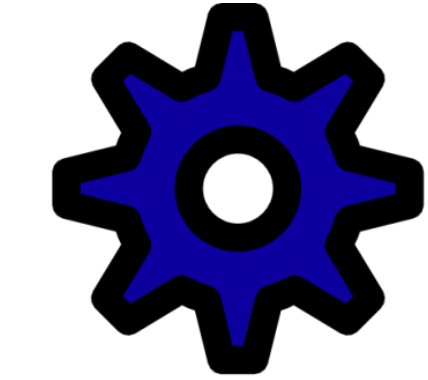
Aero-Elastic Design Section - Risø

Outline

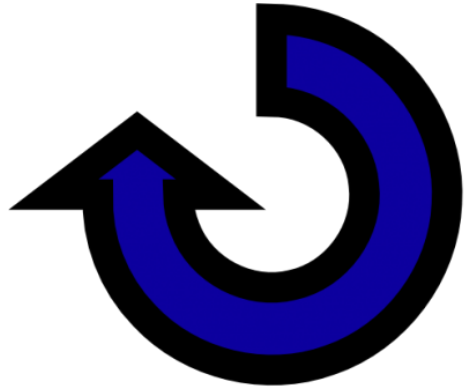
1. OpenMDAO concepts
2. Work on OpenMDAO at DTU
3. Work on OpenMDAO at NREL
4. FUSED-Wind
5. OpenMDAO guided tutorial
6. OpenMDAO exercise

Table of Contents

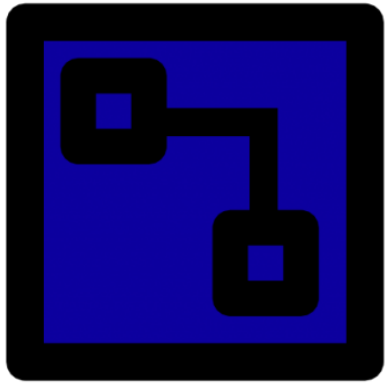
OpenMDAO concepts



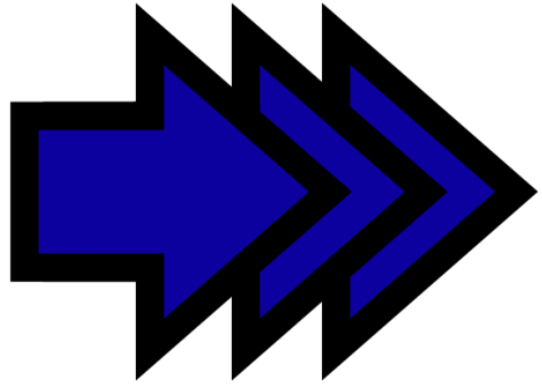
Component



Driver



Assembly



Workflow

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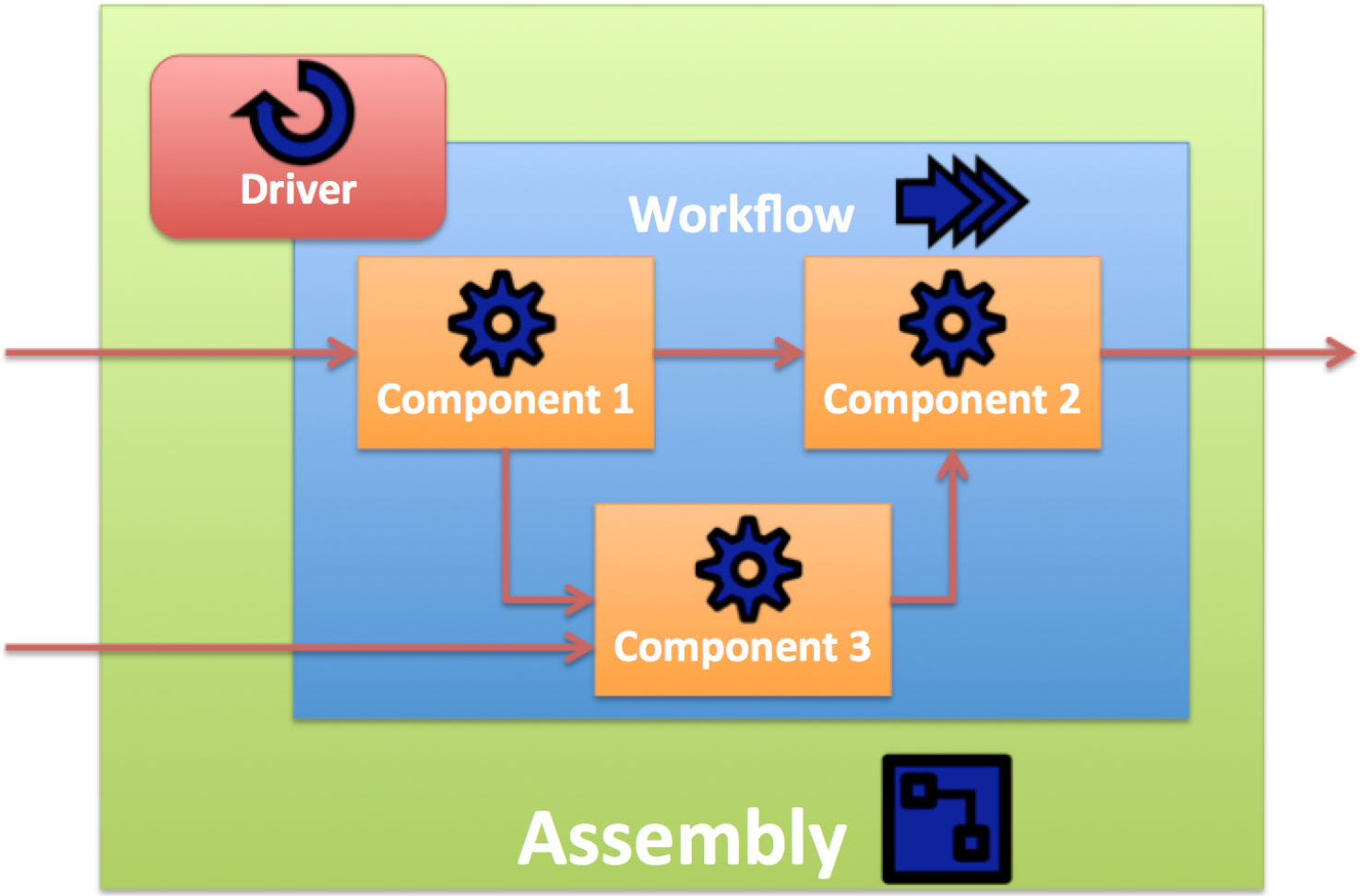
In practice



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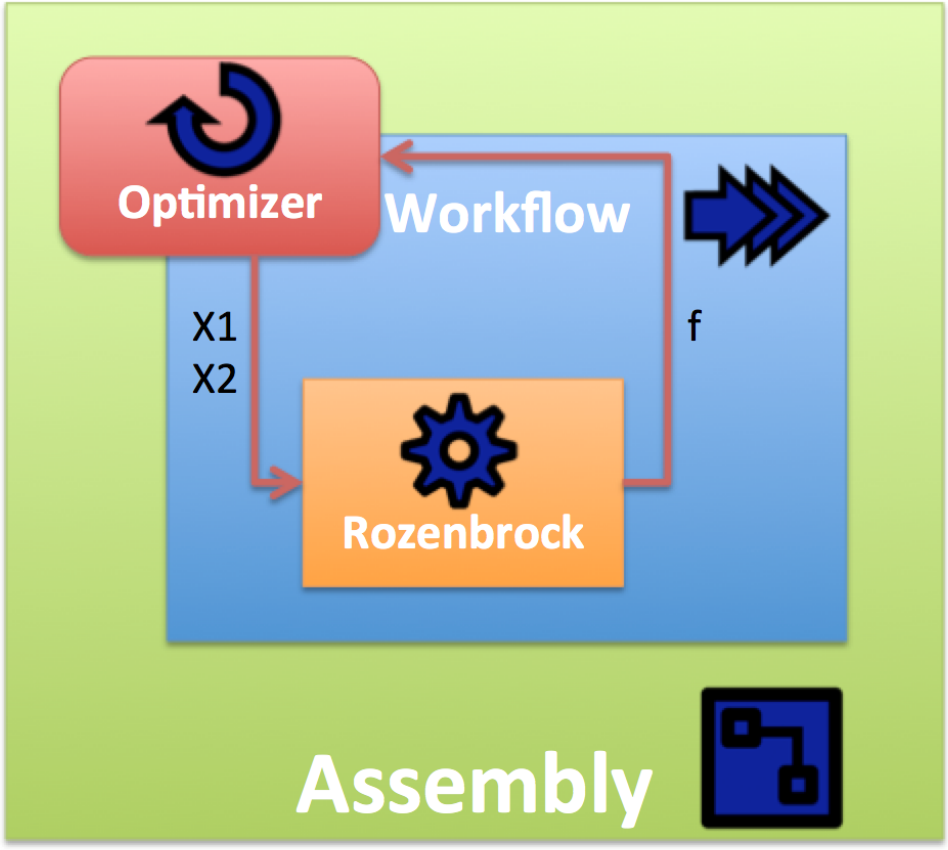
Example: The Rozenbrock optimization

The Rozenbrock function: $f = 100(x2 - x1^2)^2 + (1 - x1)^2$



Component definition

```
class Rosenbrock(Component):
    """ Standard two-dimensional Rosenbrock function. """

    x1 = Float(iotype='in')
    x2 = Float(iotype='in')
    f  = Float(iotype='out')

    def execute(self):
        """ Just evaluate the function. """
        x1 = self.x1
        x2 = self.x2
        self.f = 100 * (x2 - x1**2)**2 + (1 - x1)**2
```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Assembly definition

```
class Optimization(Assembly):
    def configure(self):
        """ Configure driver and its workflow. """
        super(Assembly, self).configure()
        self.add('rosenbrock', Rosenbrock())
        self.add('driver', CONMINdriver())
        self.driver.workflow.add('rosenbrock')
        self.driver.add_parameter('rosenbrock.x1',
                                  low=-2, high=2, start=-1.0)
        self.driver.add_parameter('rosenbrock.x2',
                                  low=-2, high=2, start=-2.0)
        self.driver.add_objective('rosenbrock.f')

        # Some additional optimizer options
        #...

opti = Optimization()
opti.run()
```


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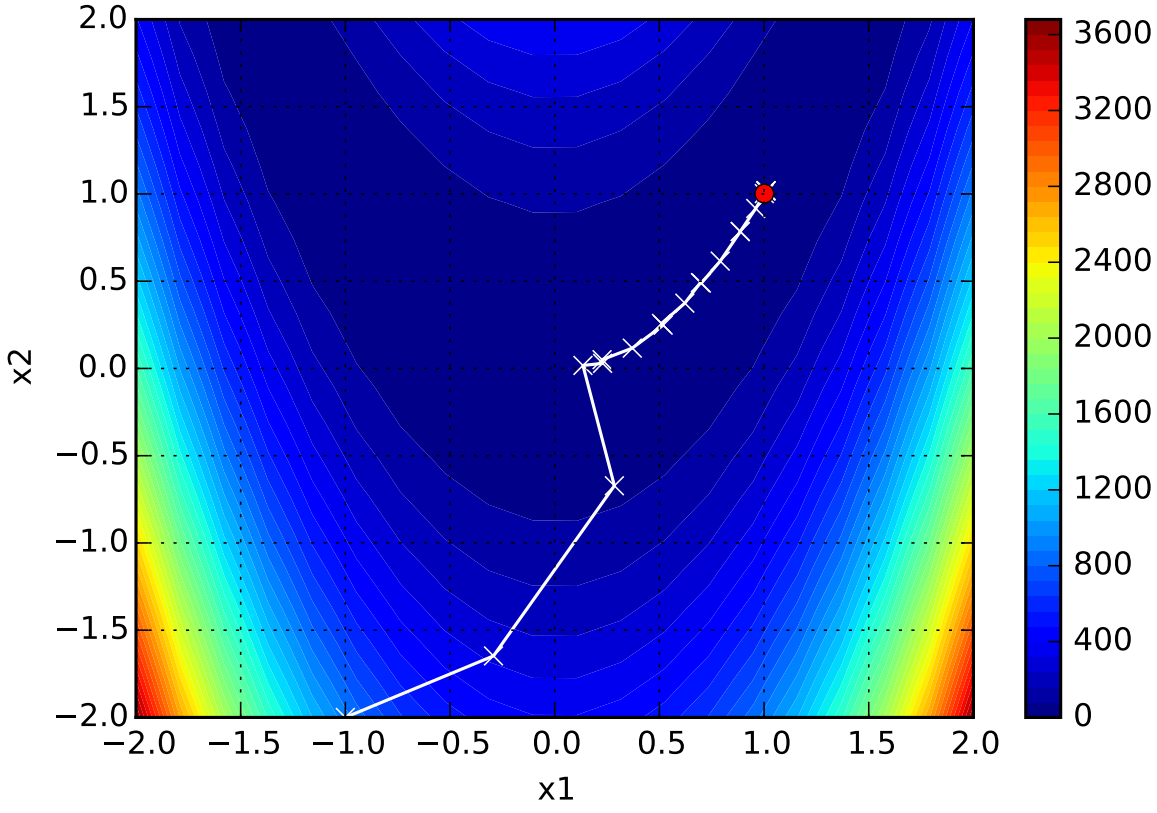
Rosenbrock optimization

After a few iterations. . .



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Different types of Drivers:

- Optimizers (support for gradients)
  - Natives (COBYLA, CONMIN, Genetic, NEWSUMT, SLSQP)
  - DAKOTA plugin (20+)
  - pyOpt plugin (10+)
  - more..
- CaseIteratorDriver: loop through a list of cases, possibly in parallel
- Design of Experiment: do parameter studies
- Sampling. . .

Different types of variables

- Array
- Bool
- Complex
- Enum
- File
- Float
- Int
- Slot
- Str

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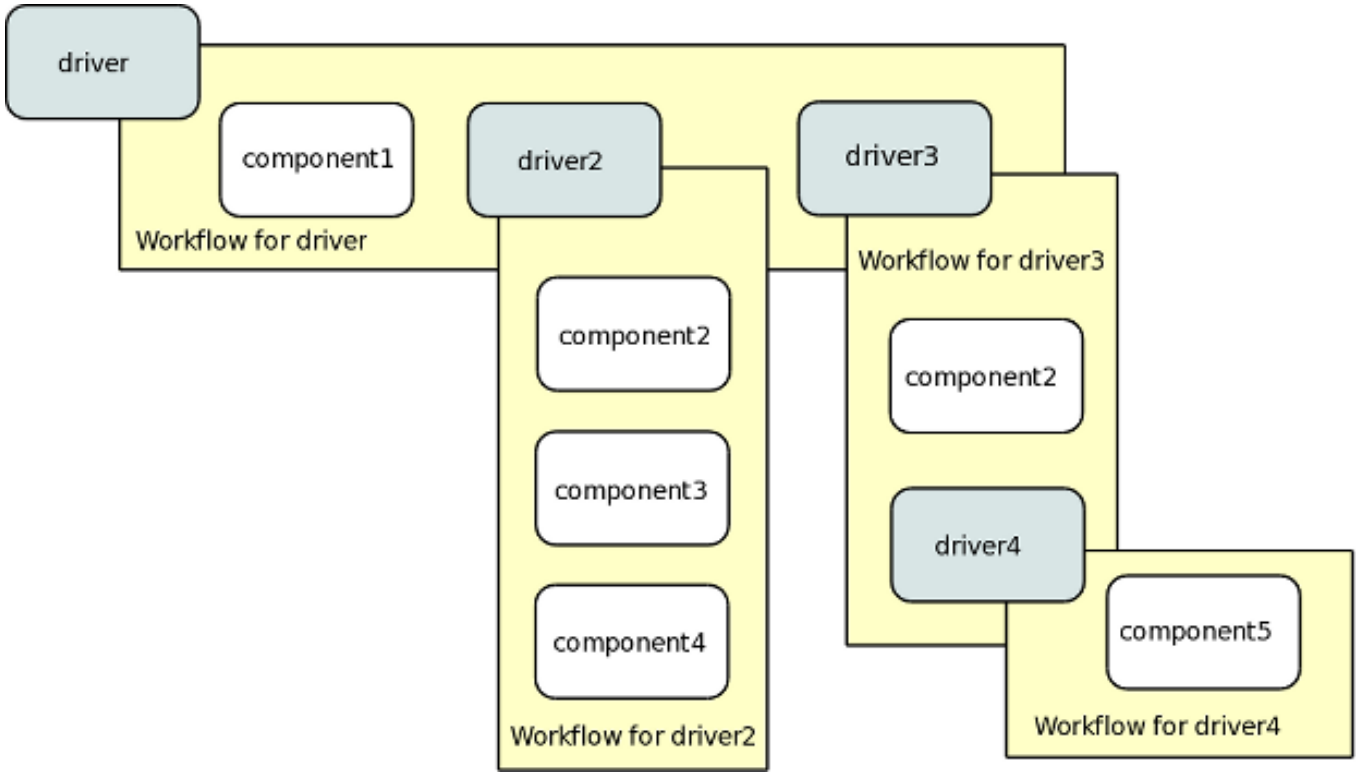
Different types of Assembly usage (1/2)

Several nested drivers within one assembly



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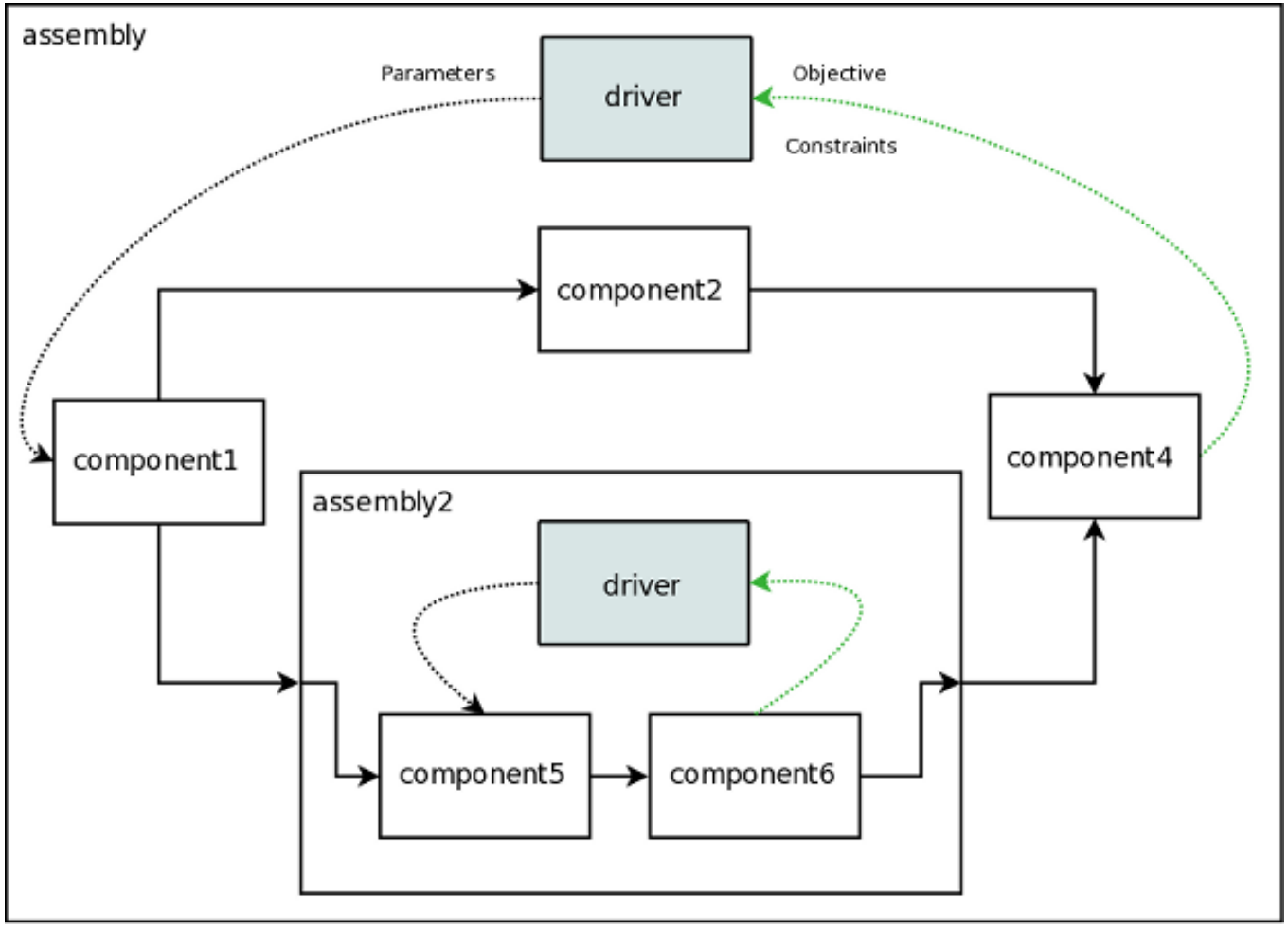
Different types of Assembly usage (1/2)

Nested assemblies



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GUI

There is web-based GUI, that you can use to explore your assemblies:

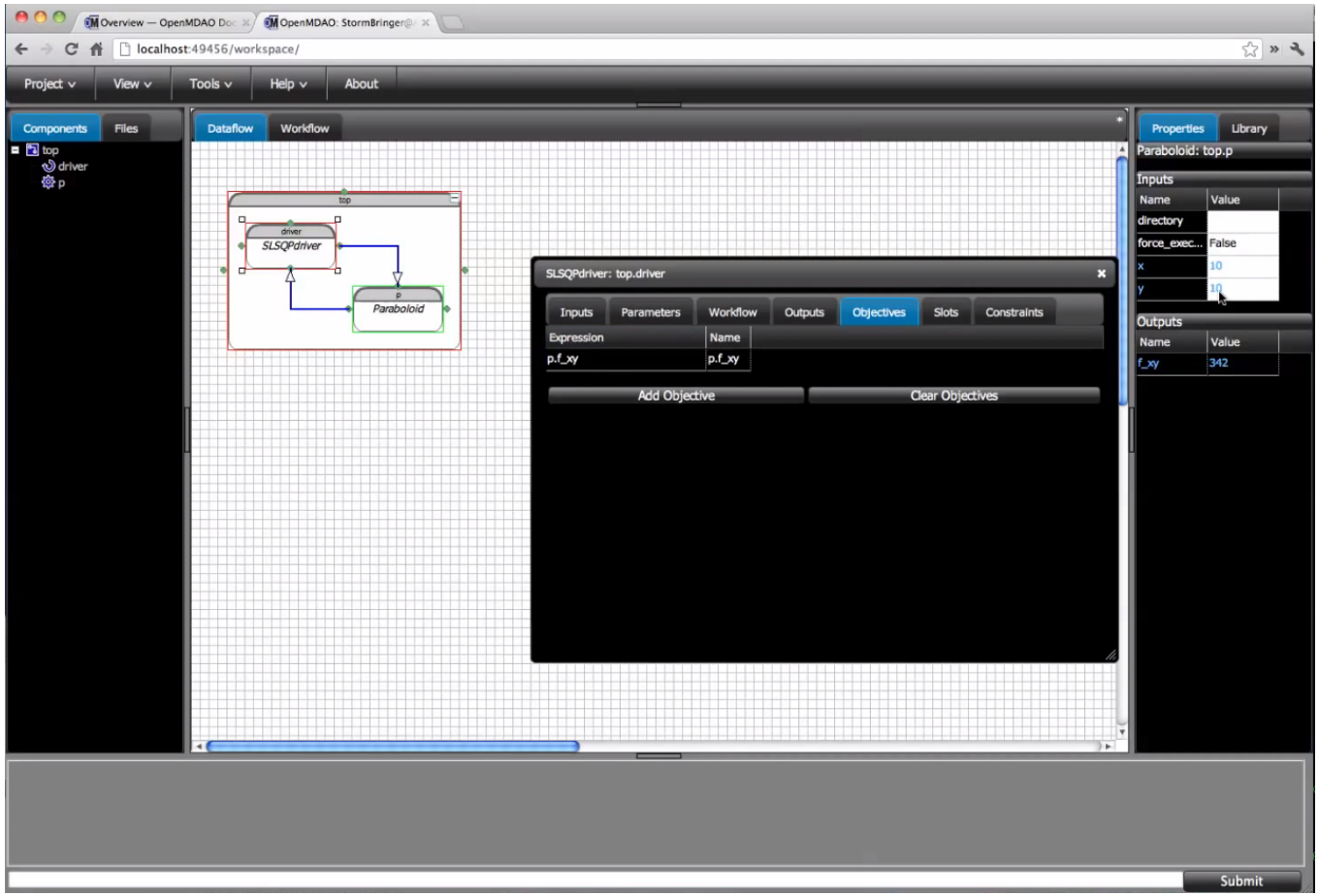

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Table of Contents

Projects (1/3)

Topfarm (Pierre-Elouan)

Wind Farm Layout optimization

- Wake models (FUSED-Wake)
- Foundation cost
- Electrical grid cabling cost model
- Wind Farm Financial Balance
- DWM HAWC2 Fatigue database
- WAsP-CFD

Projects (1/3)

Topfarm (Pierre-Elouan)

Wind Farm Layout optimization

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FUSED-Wake (Pierre-Elouan)

Framework for analysis of wind farm wake models: `NOJensen`, `GCL`, `Ainslie`, `FUGA`, DWM, EllipSys3D AD/AL

- Uncertainty Quantification
- Model Averaging
- Multi-fidelity modelling

Projects (2/3)

Light Rotor

- Wind turbine optimization
  - aerodynamic (`HAWC2` & `HAWCStab2`) (Frederik, Carlo)
  - structural (`Becas`, `CSProps`) (David, Witold)
- Airfoil optimization
  - Aerodynamic (`XFoil`, `EllipSys2D`) (Frederik, Franck)
  - Noise model (`TNO`, `XFoil`) (Franck)

Projects (2/3)

Light Rotor

- Wind turbine optimization
  - aerodynamic (`HAWC2` & `HAWCStab2`) (Frederik, Carlo)
  - structural (`Becas`, `CSProps`) (David, Witold)
- Airfoil optimization
  - Aerodynamic (`XFoil`, `EllipSys2D`) (Frederik, Franck)
  - Noise model (`TNO`, `XFoil`) (Franck)

Aero-servo-elastic optimization (Carlo's PhD)

`HAWCStab2` & `HAWC2`

Projects (3/3)

Ellipsys-HAWC2 coupling

- Coupling between EllipSys3D fully resolved and HAWC2 (Joachim)
- Coupling between EllipSys3D Actuator Disc/Line and HAWC2(aero) (Niels T)

Topology optimization (Alexander)

Wrapped Codes

- Operational
  - EllipSys3D
  - Becas
  - HAWC2
  - HAWCStab2
  - XFoil
  - CSProps
- Under development / Planned
  - FUGA
  - DWM-HAWC2
  - WAsP
  - WAsP-CFD
  - WRF
  - CORWIND

Table of Contents

Table of Contents

Table of Contents

Table of Contents