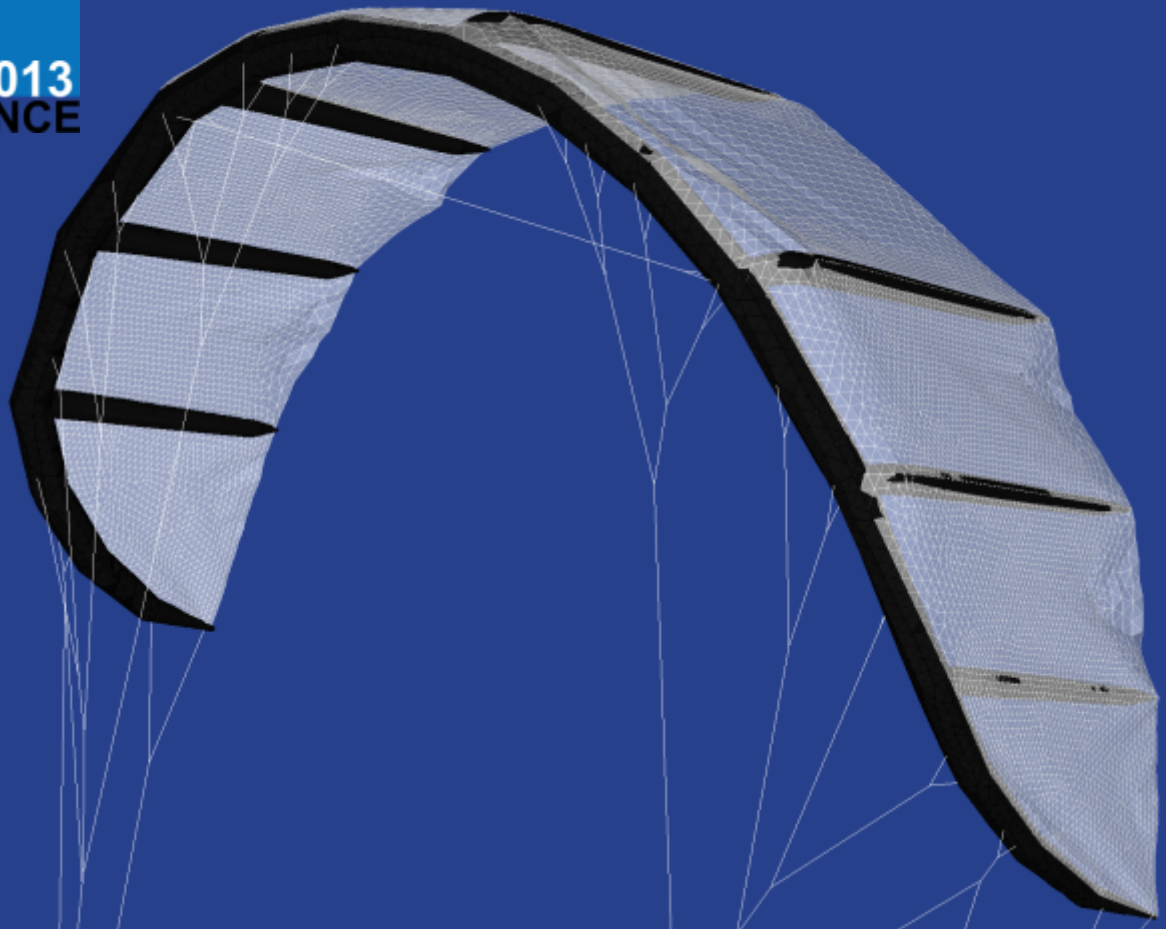
AIRBORNE WIND ENERGY CONFERENCE 2013



Flight dynamic modelling of inflatable membrane kites including aeroelasticity effects

Roland Schmehl, Kite Power Research Group, Aerospace Engineering

TU Delft Delft University of Technology

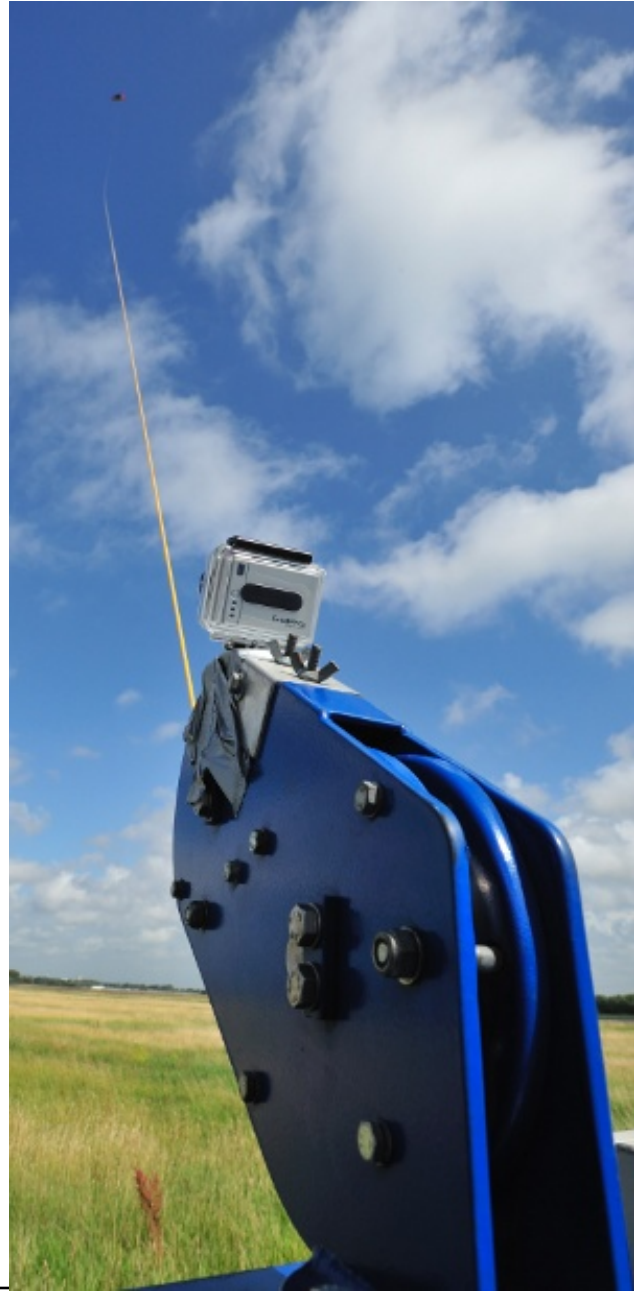
Outline

Part 1: Research focus

- Introduction
- Empirical approach
- FEA & CFD
- Fast FSI
- Experimental research

Part 2: Technology status

- Technology demonstrator
- TechDemo June 2012
- On-campus operation May 2013
- TU Delft Open Days October 2013



Part 1: Research focus

Introduction

Coupling of structural, fluid & flight dynamics

Fluid-Structure Interaction

Flight dynamics

Empirical approach

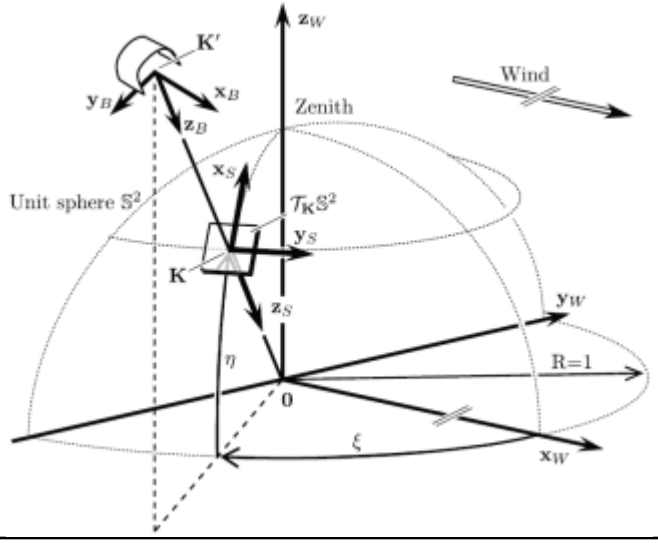
Steering correlation

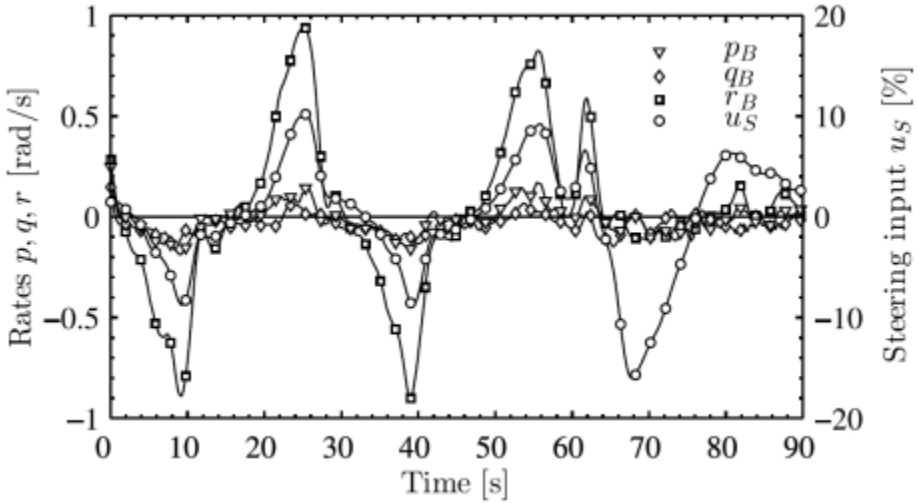
$$r_B = c_1 v_a u_S + c_2 \frac{\mathbf{g}\cdot\mathbf{y}_B}{g}$$

r_B : yaw rate

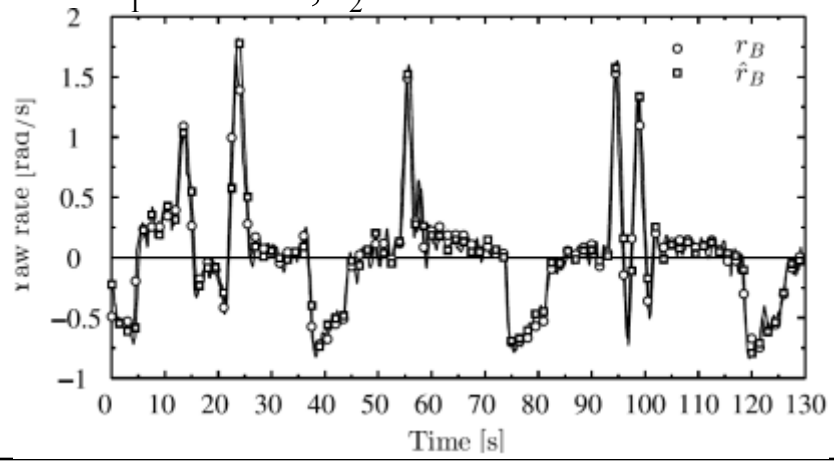
v_a : apparent wind velocity

u_S : relative steering input





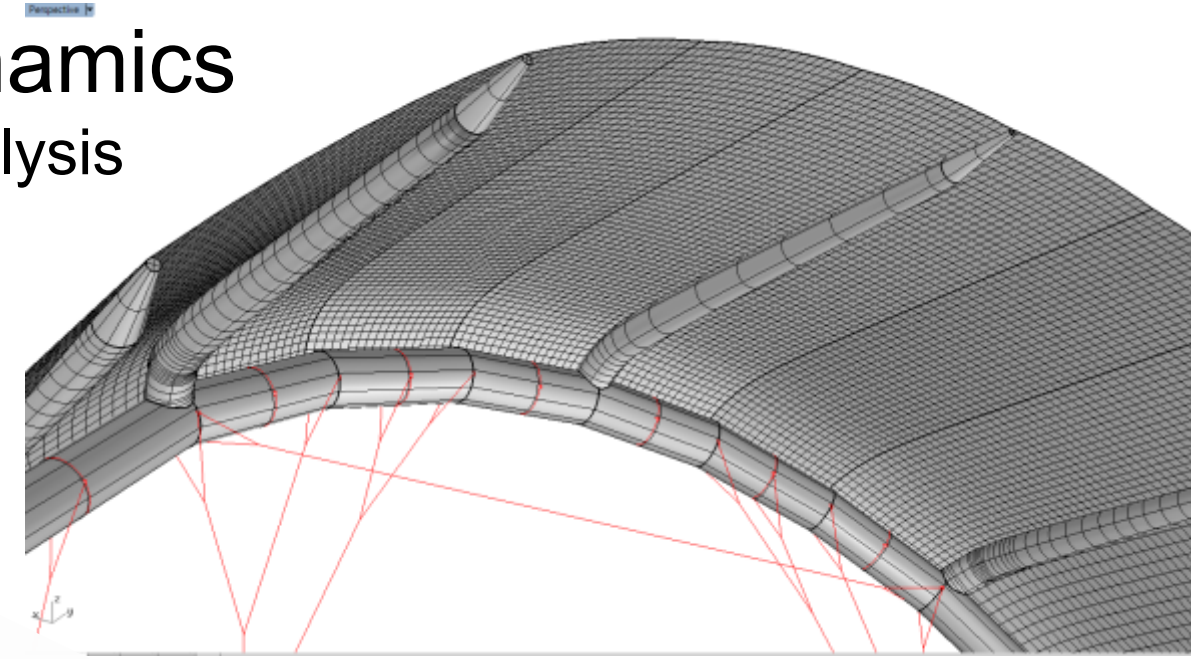
$c_1 = 0.153, c_2 = 0.250$:

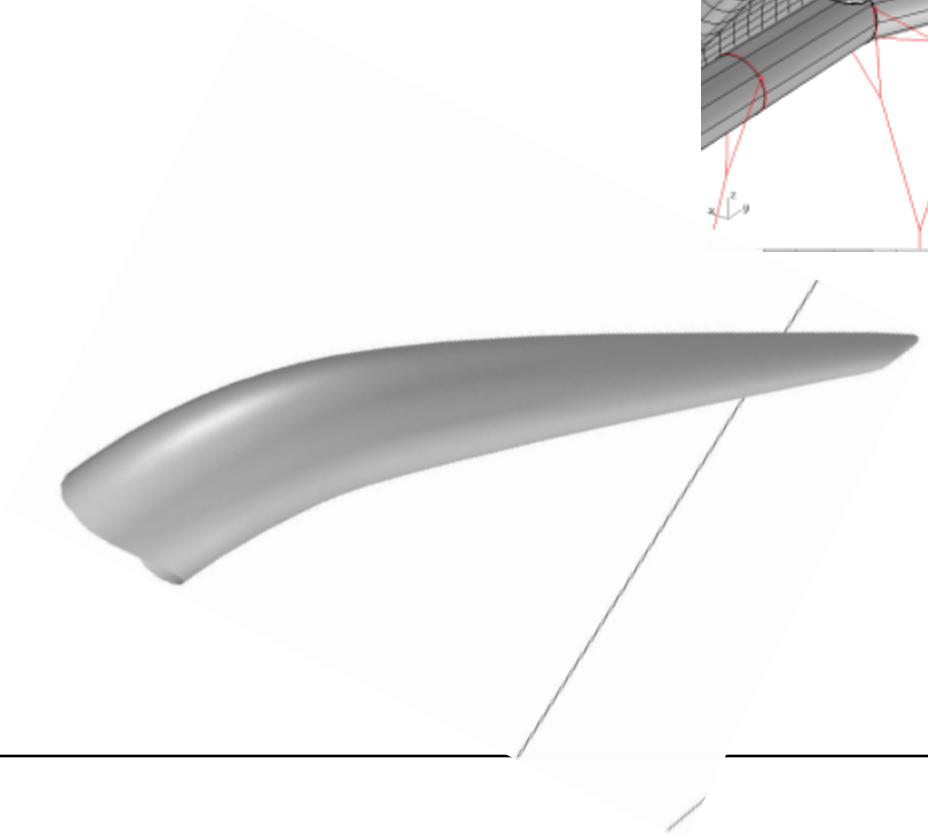


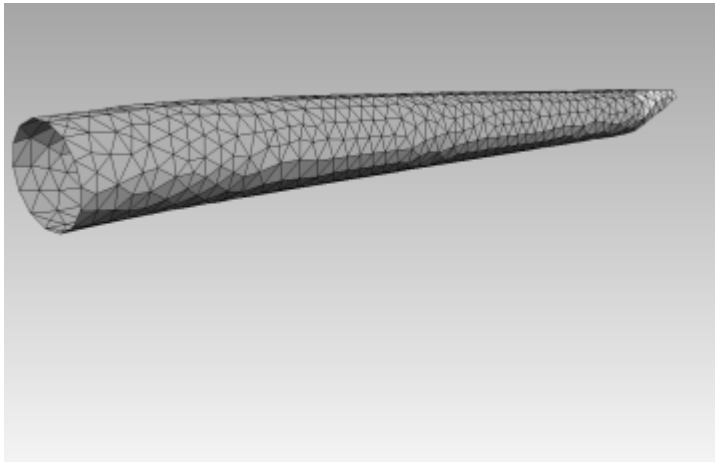
Claudius Jehle & Roland Schmehl: Applied Tracking Control for Kite Power Systems, Accepted for publication in AIAA JGCD

Structural dynamics

Finite Element Analysis

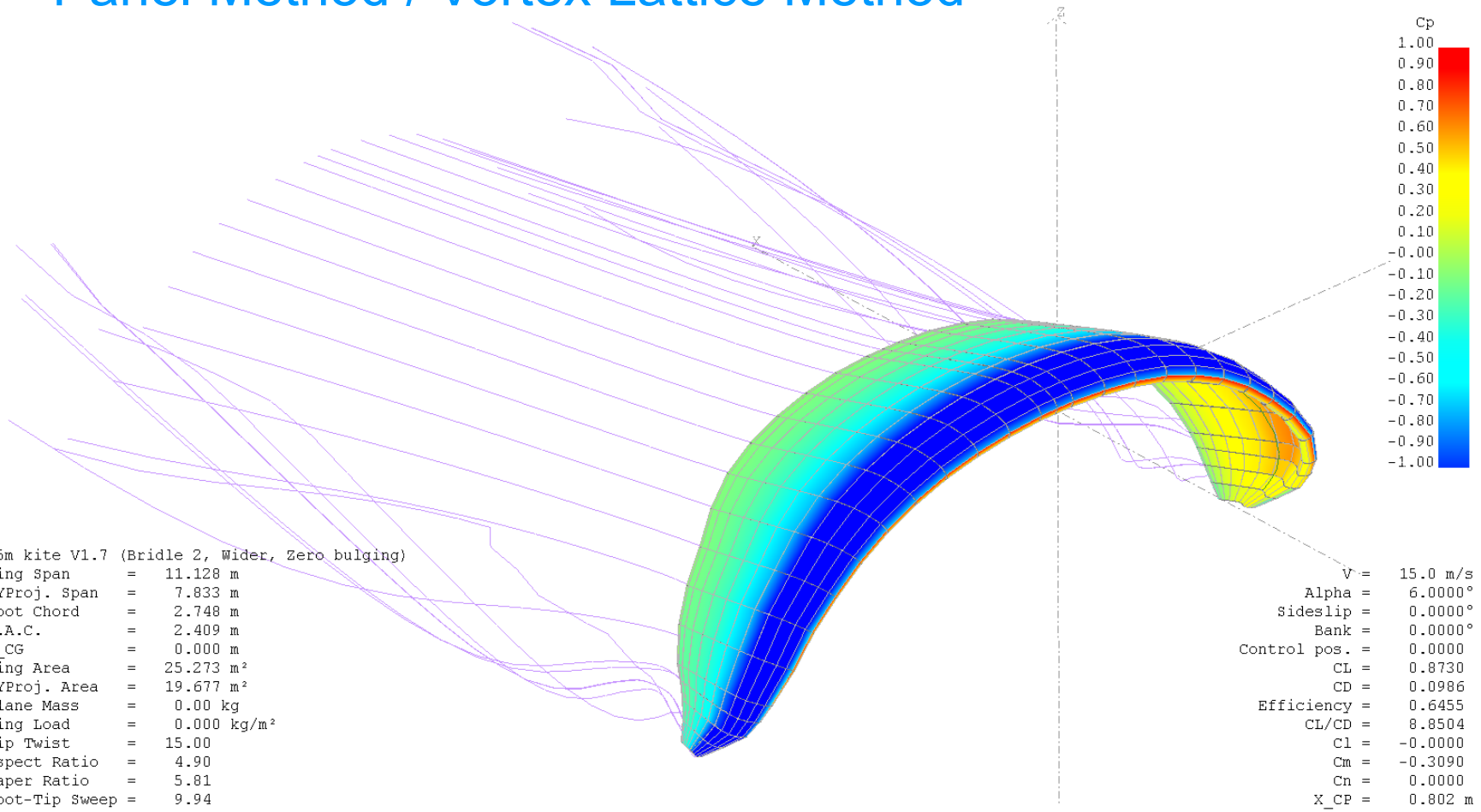


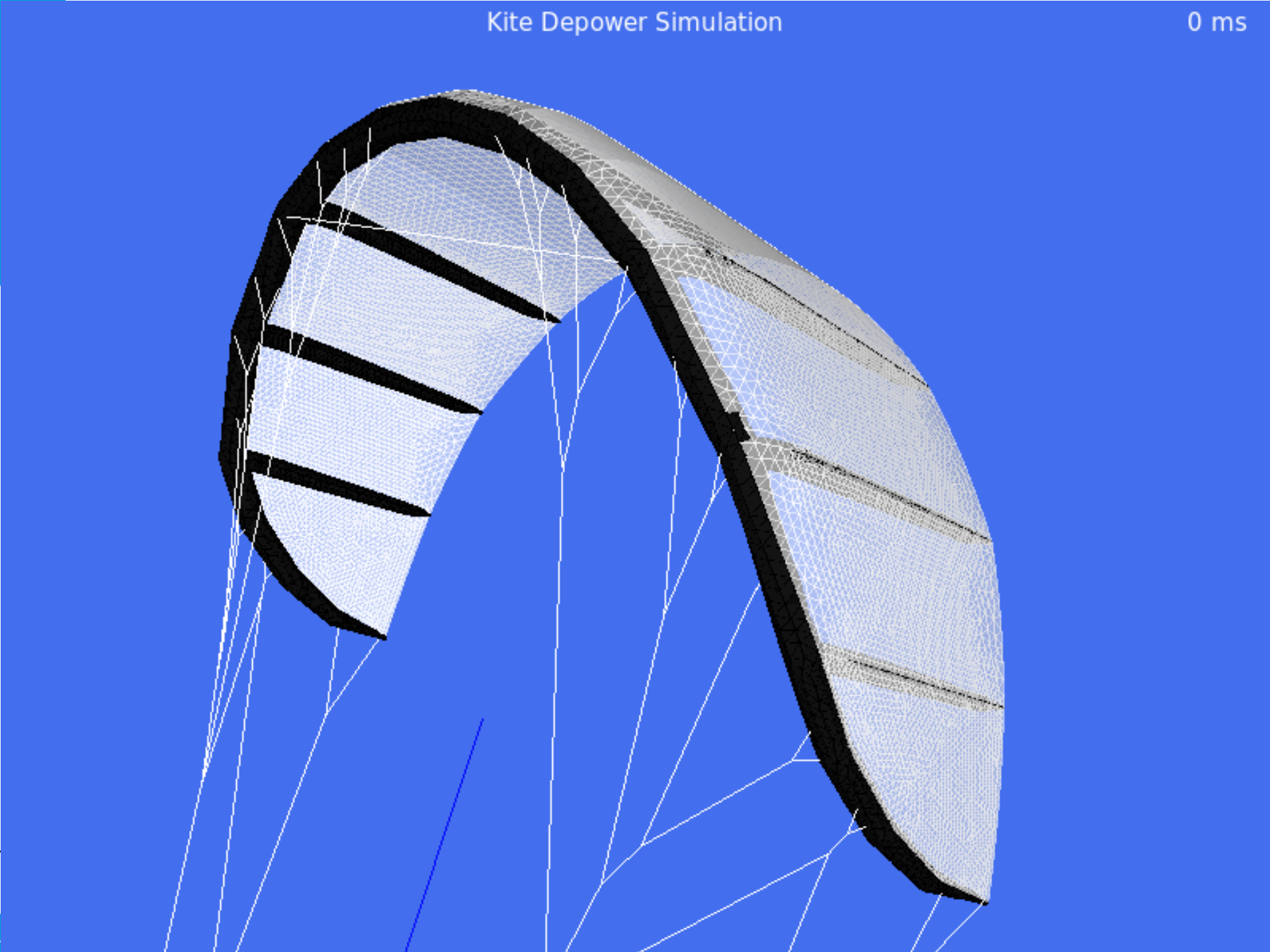


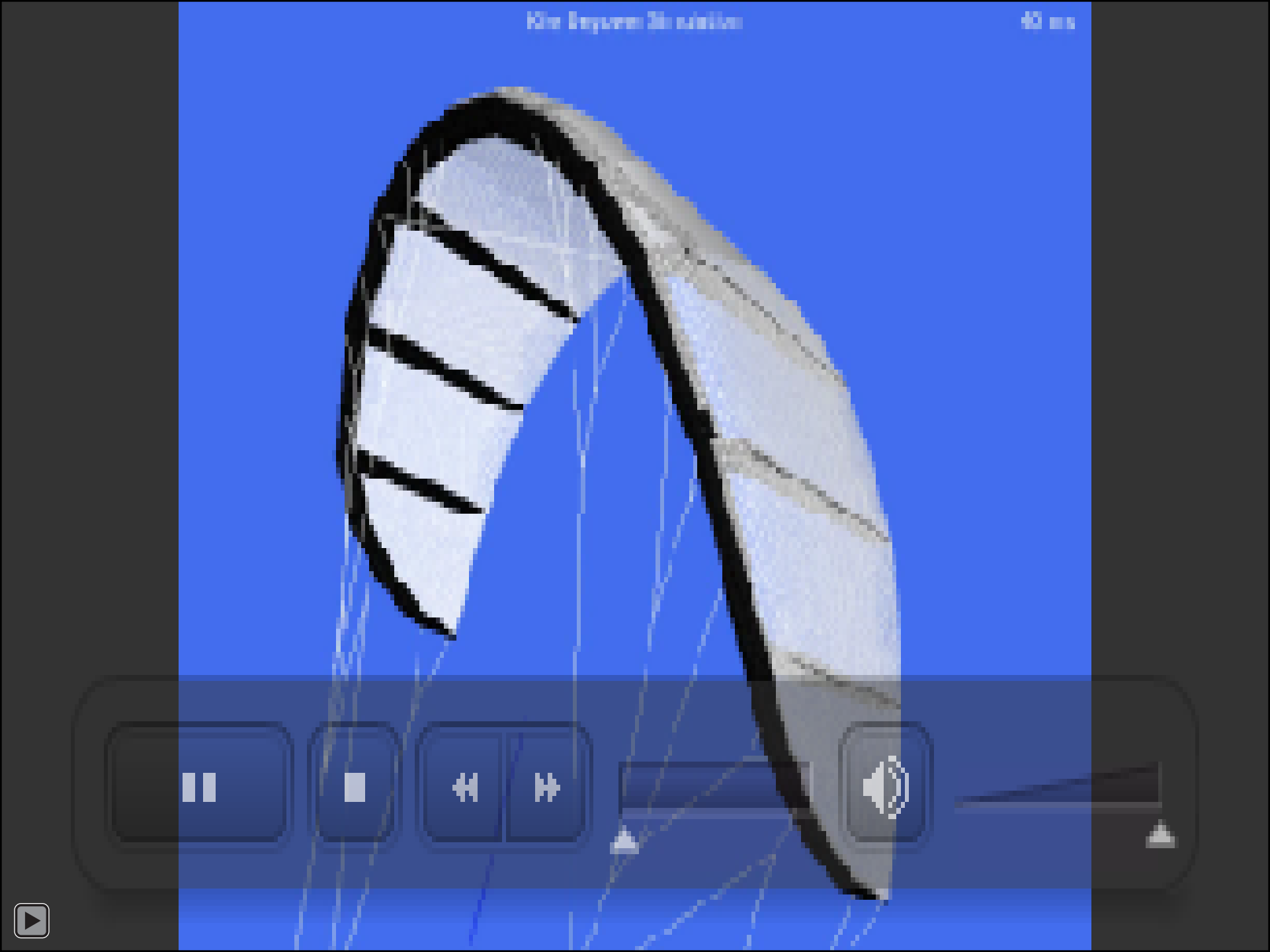


Aerodynamics

Panel Method / Vortex Lattice Method

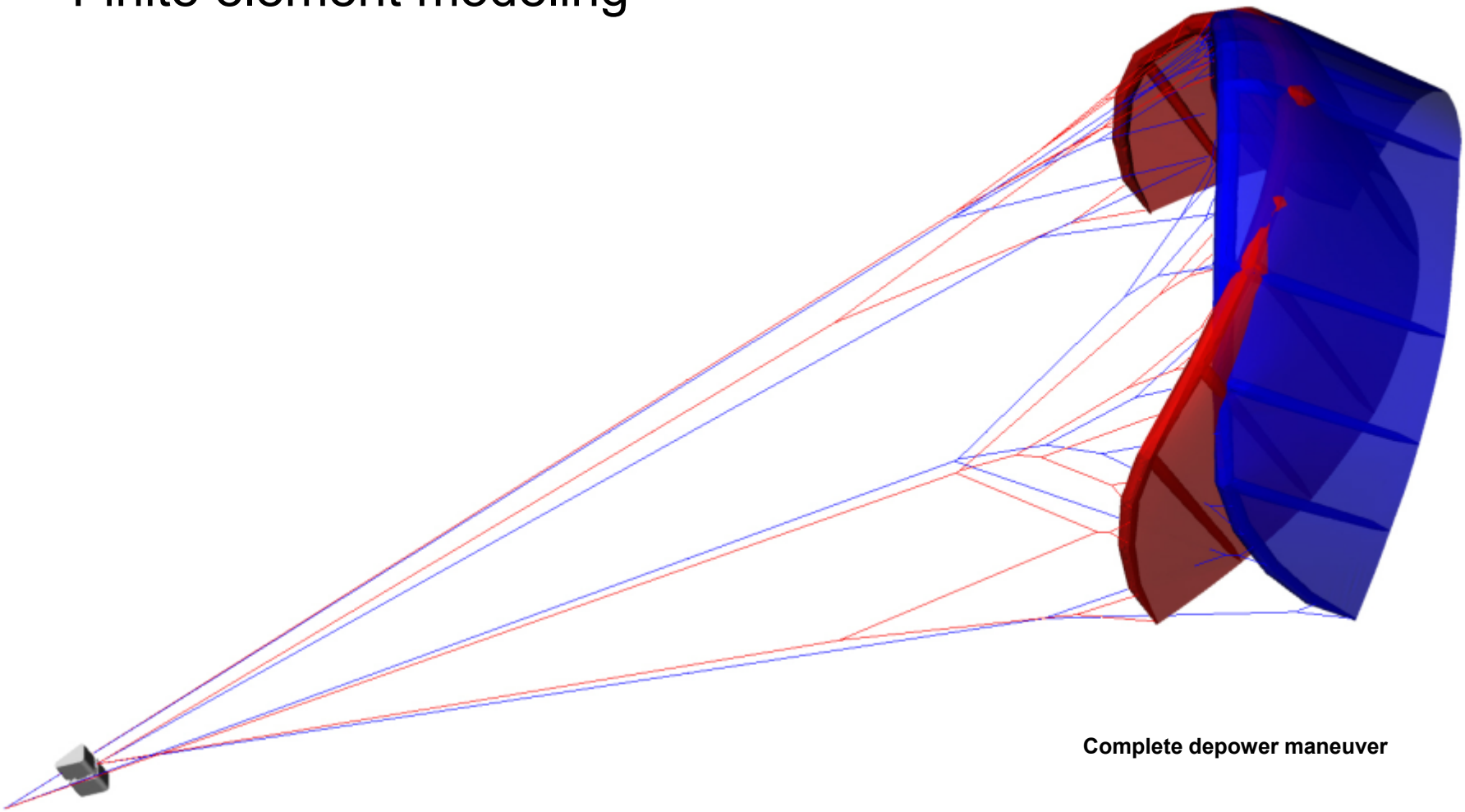



Kite Depower Simulation
0 ms



FEA

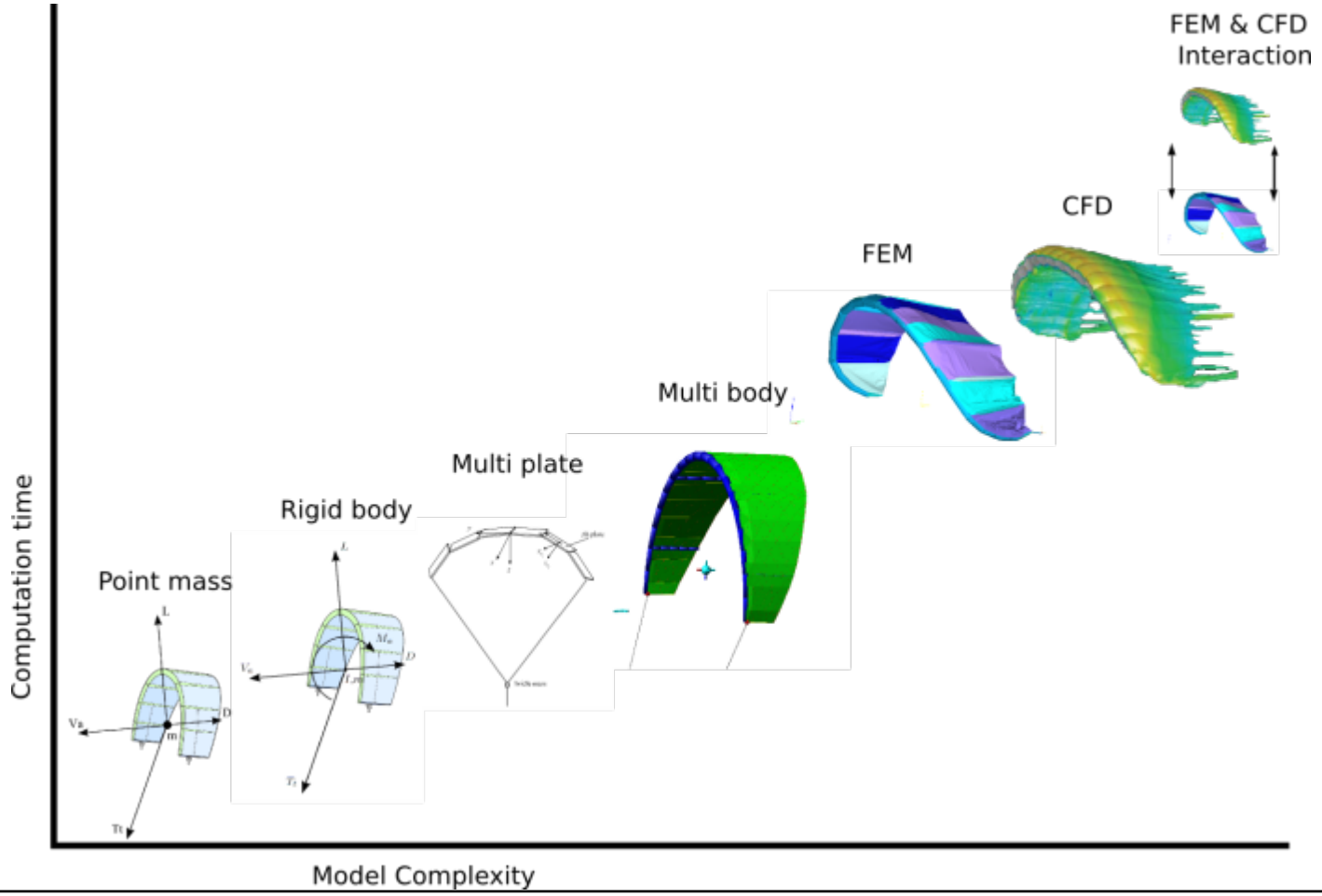
Finite element modeling



Complete depower maneuver

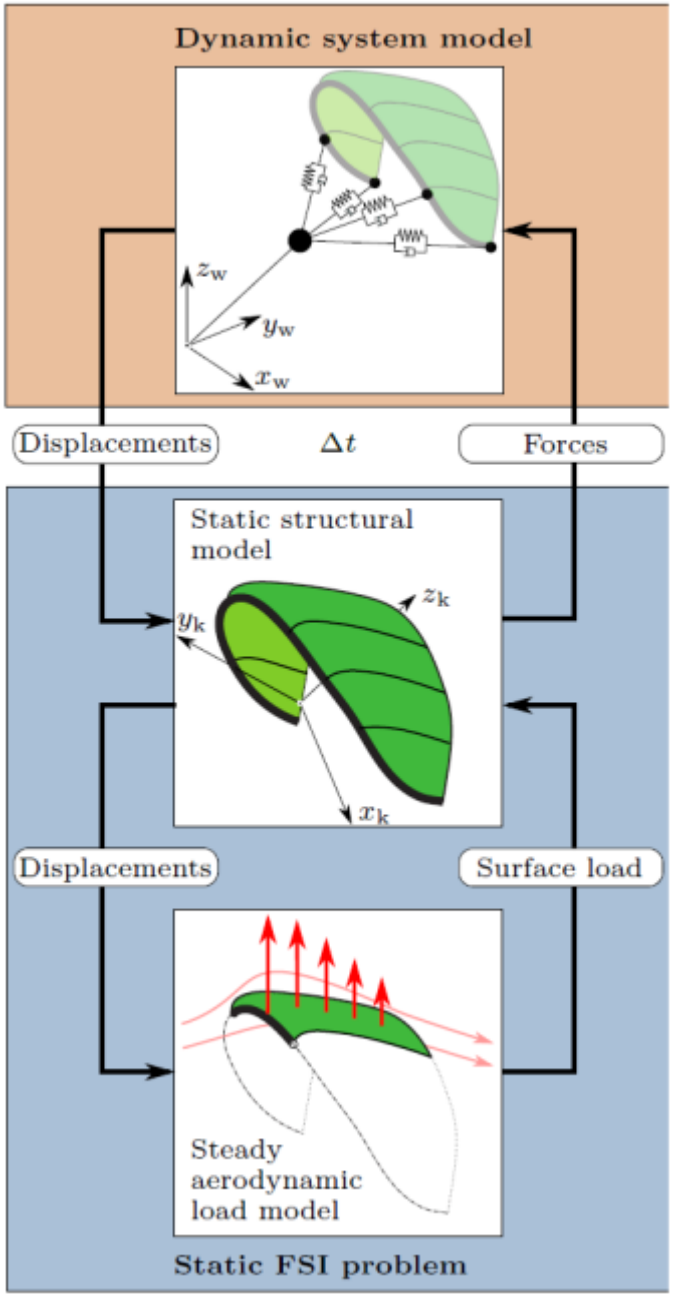
Modeling & Simulation

CPU time vs accuracy



Fast FSI

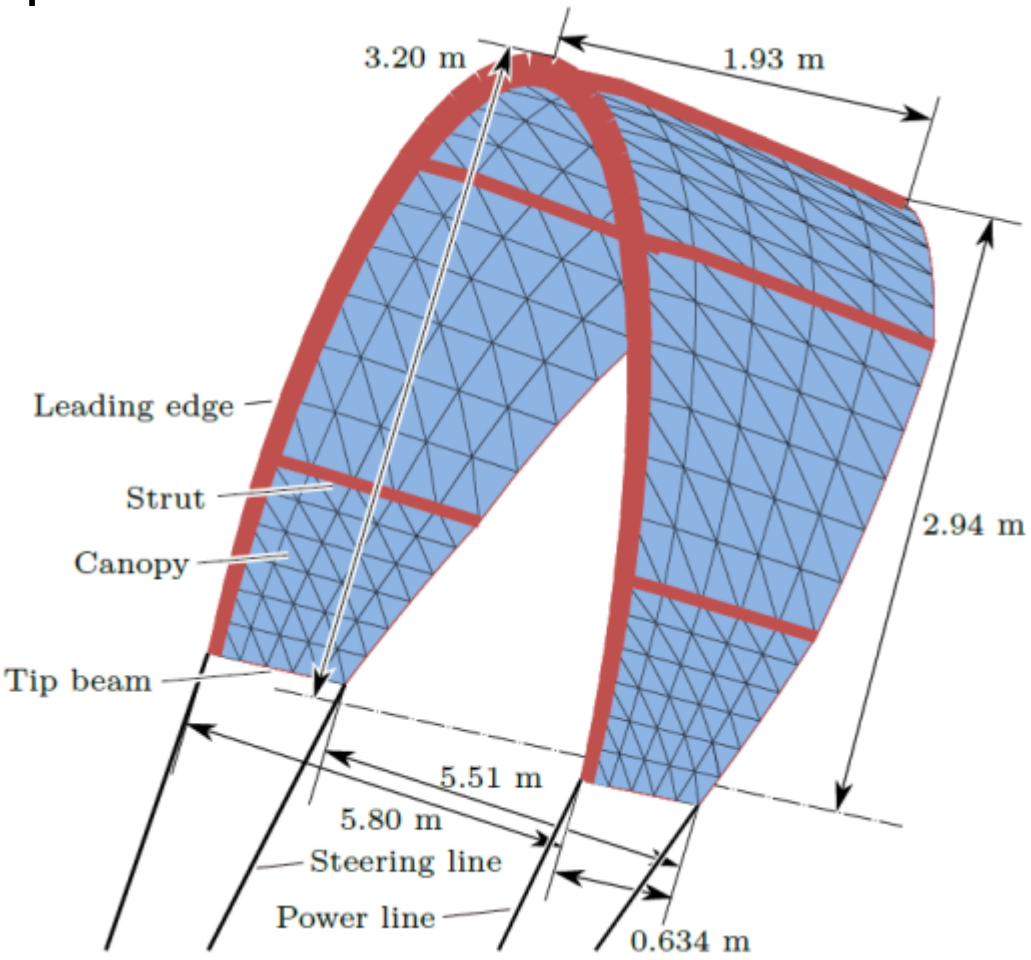
Iterative coupling procedure



Bosch, Schmehl, Tiso, Rixen: Dynamic nonlinear aeroelastic model of a kite for power generation, Accepted for publication in AIAA JGCD

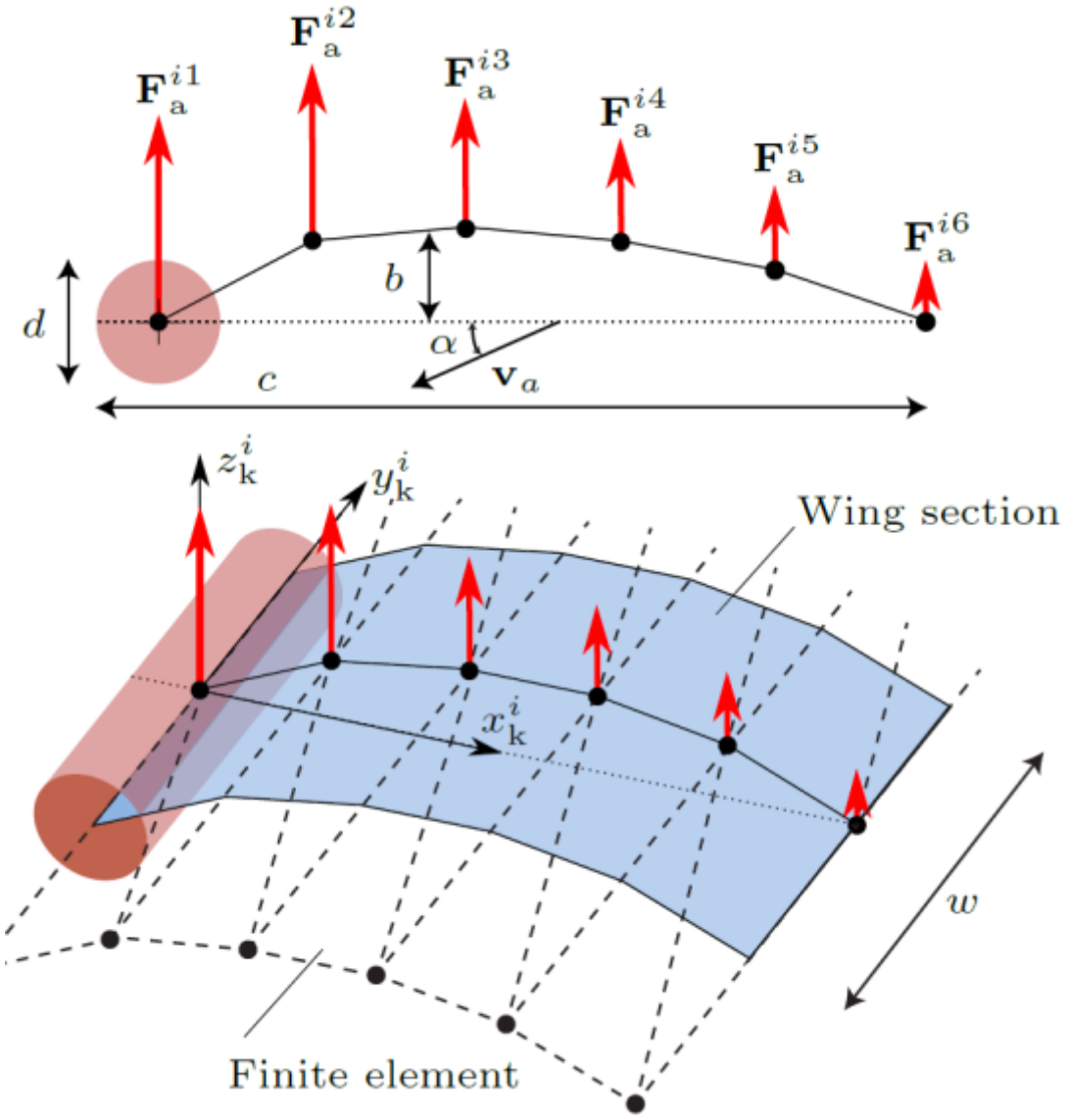
Fast FSI

Model setup



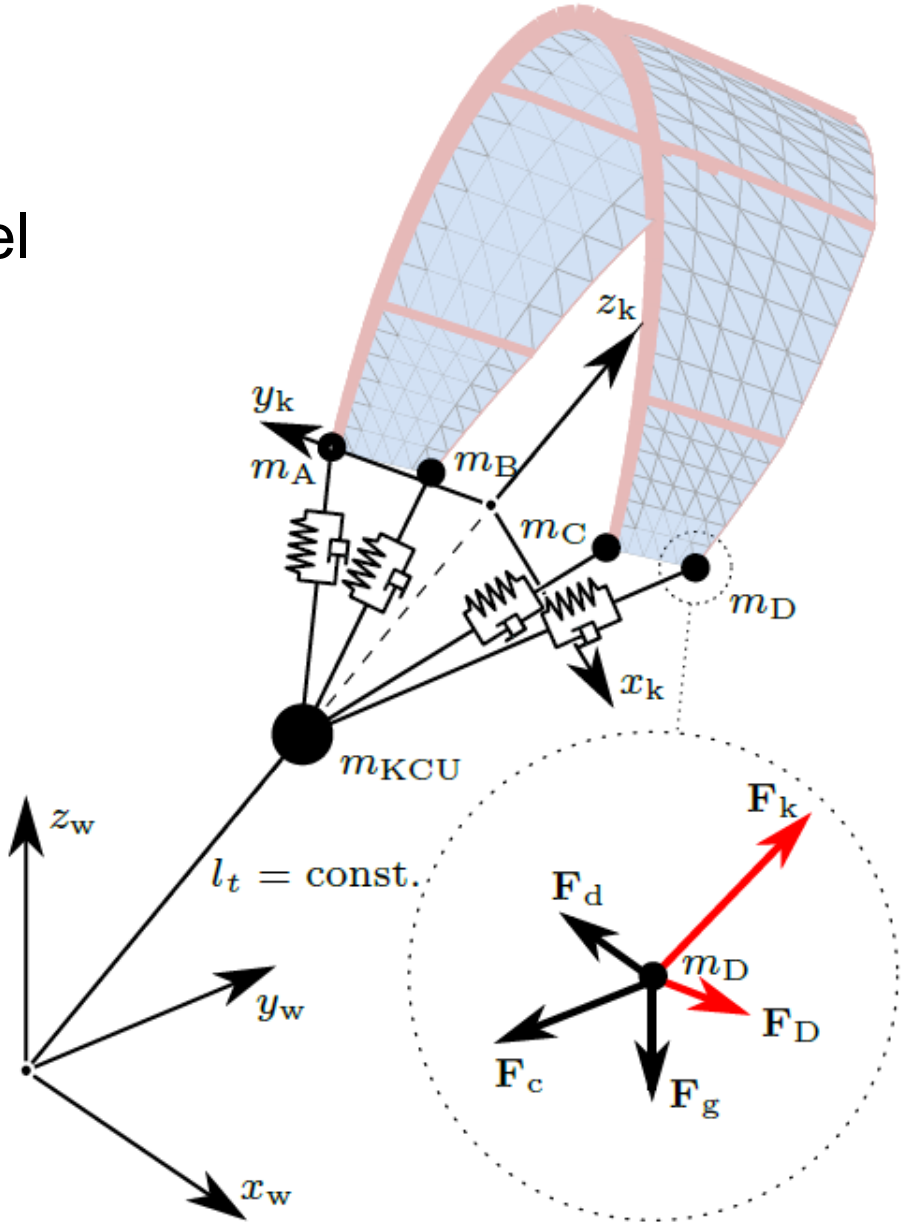
Fast FSI

Aero load model



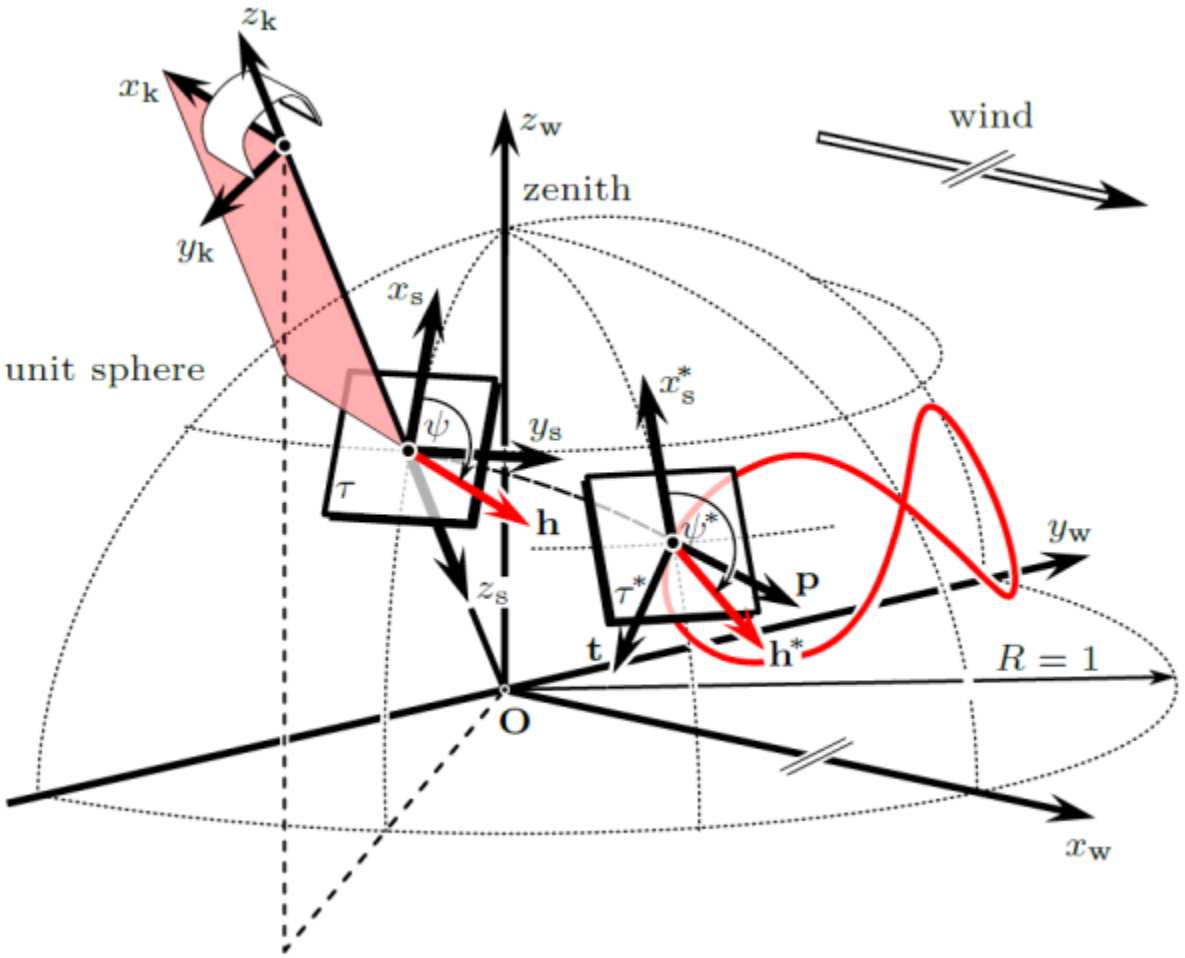
Fast FSI

Dynamic system model



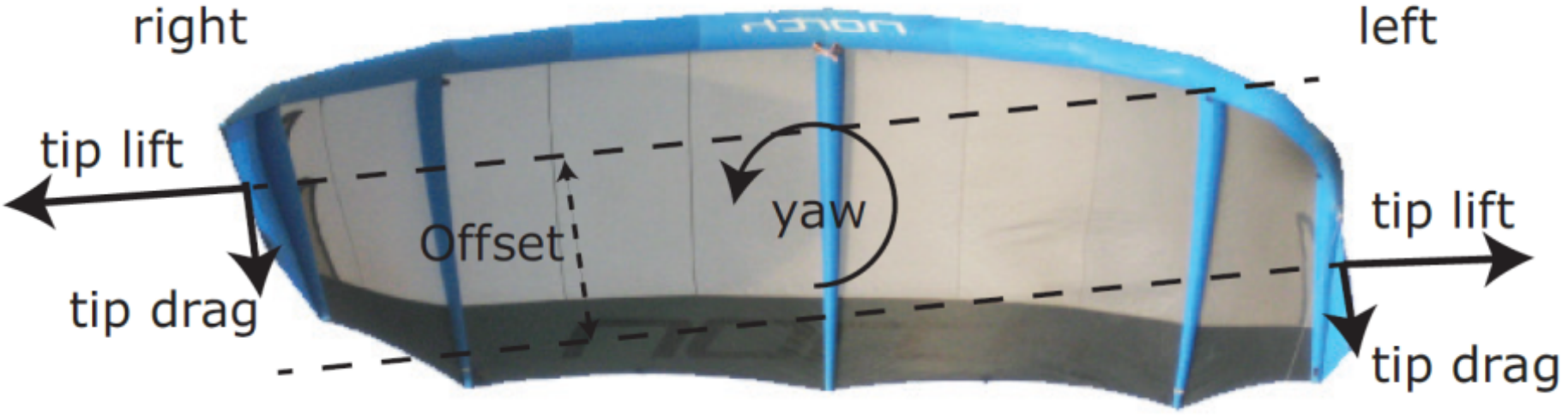
Fast FSI

Tracking controller



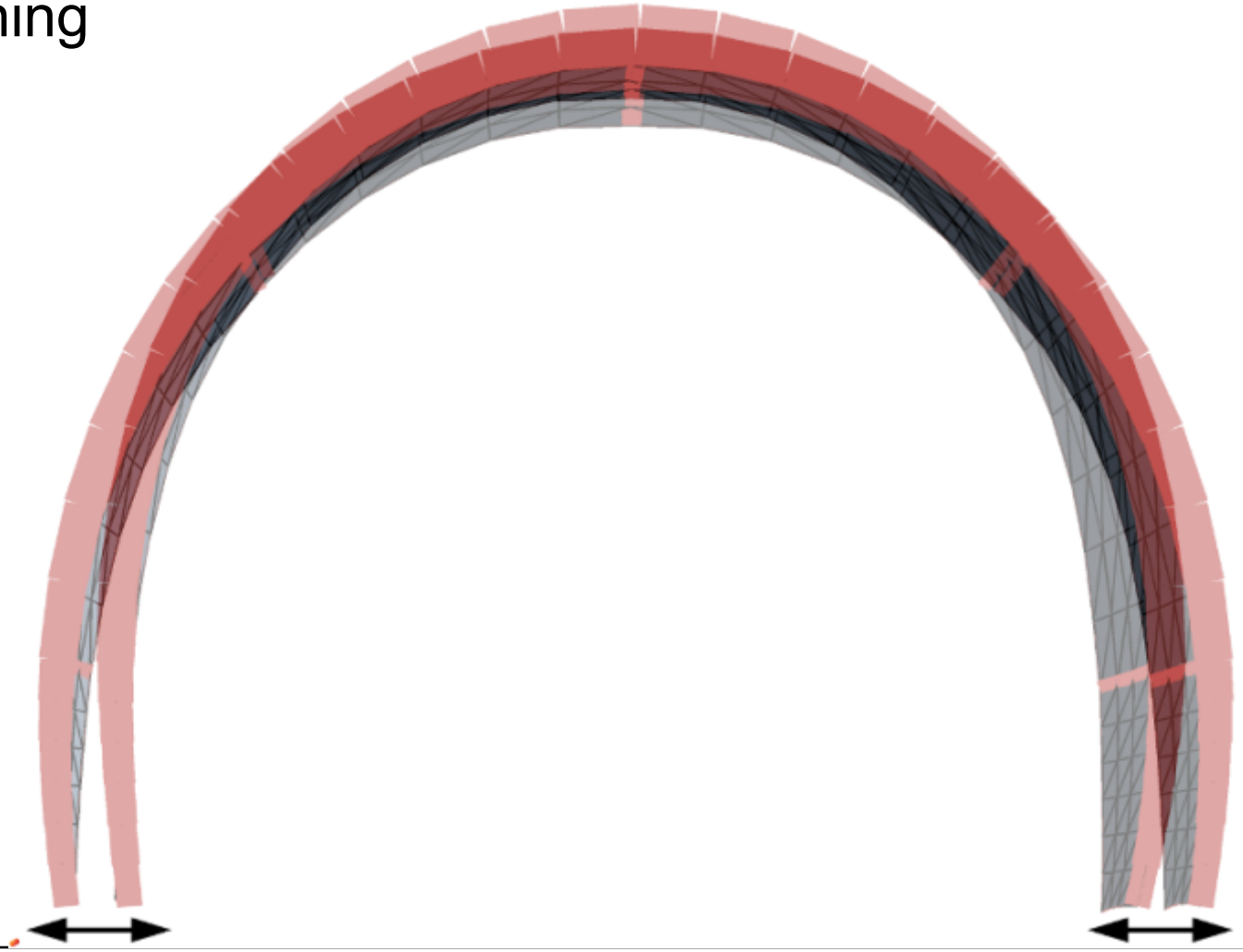
Fast FSI

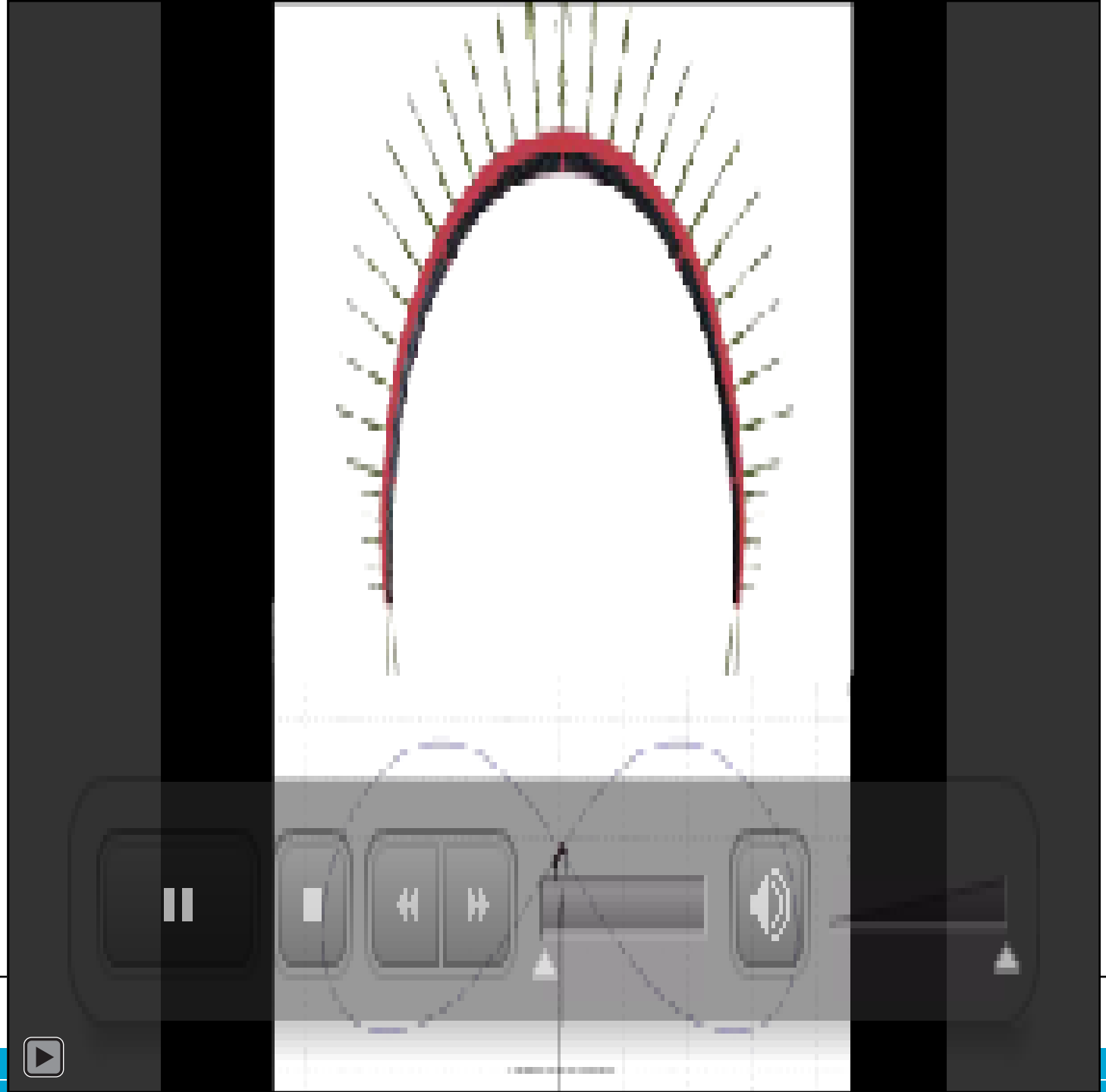
Steering mechanism



Fast FSI

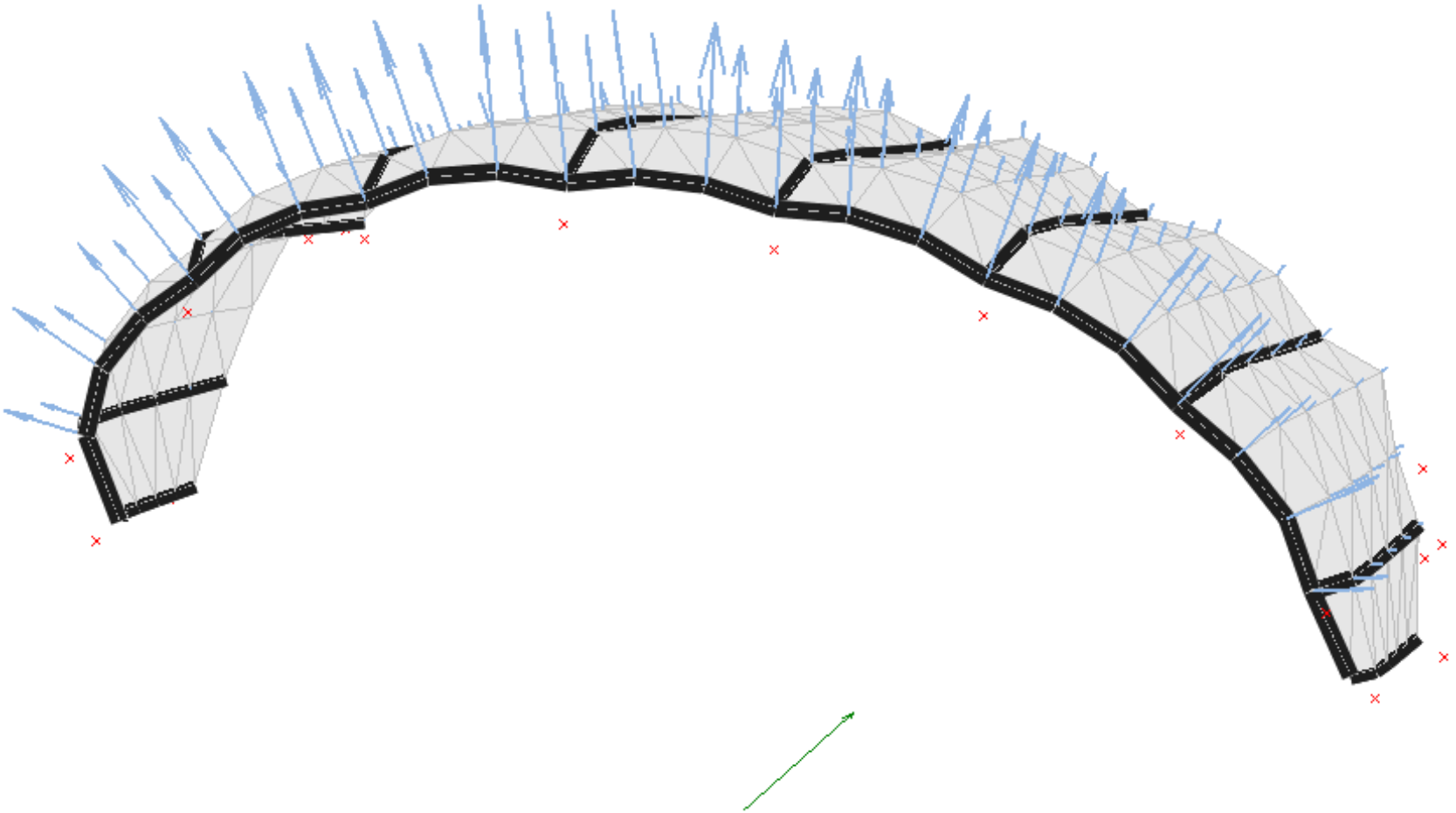
Jellyfishing





Outline

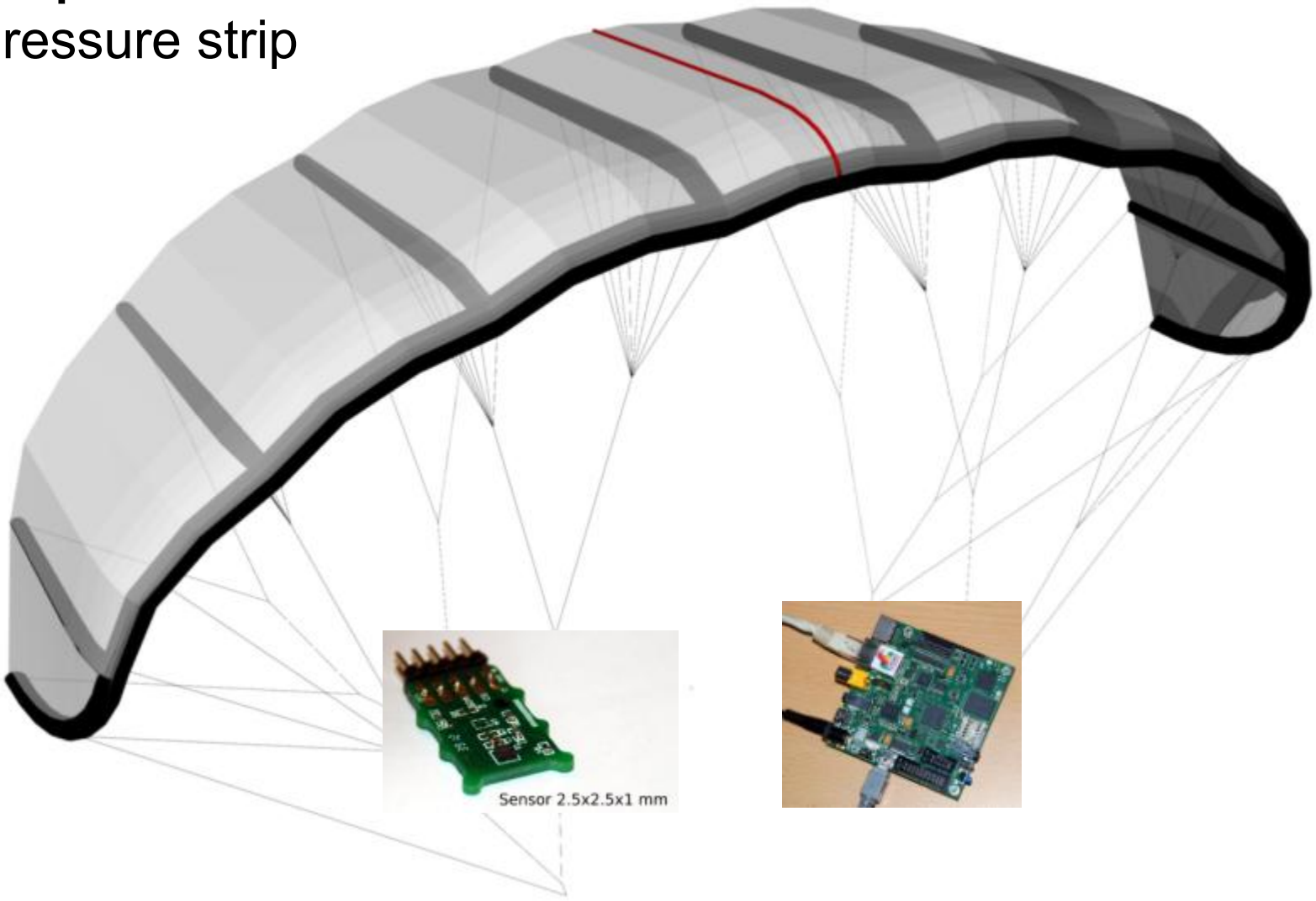
Depower



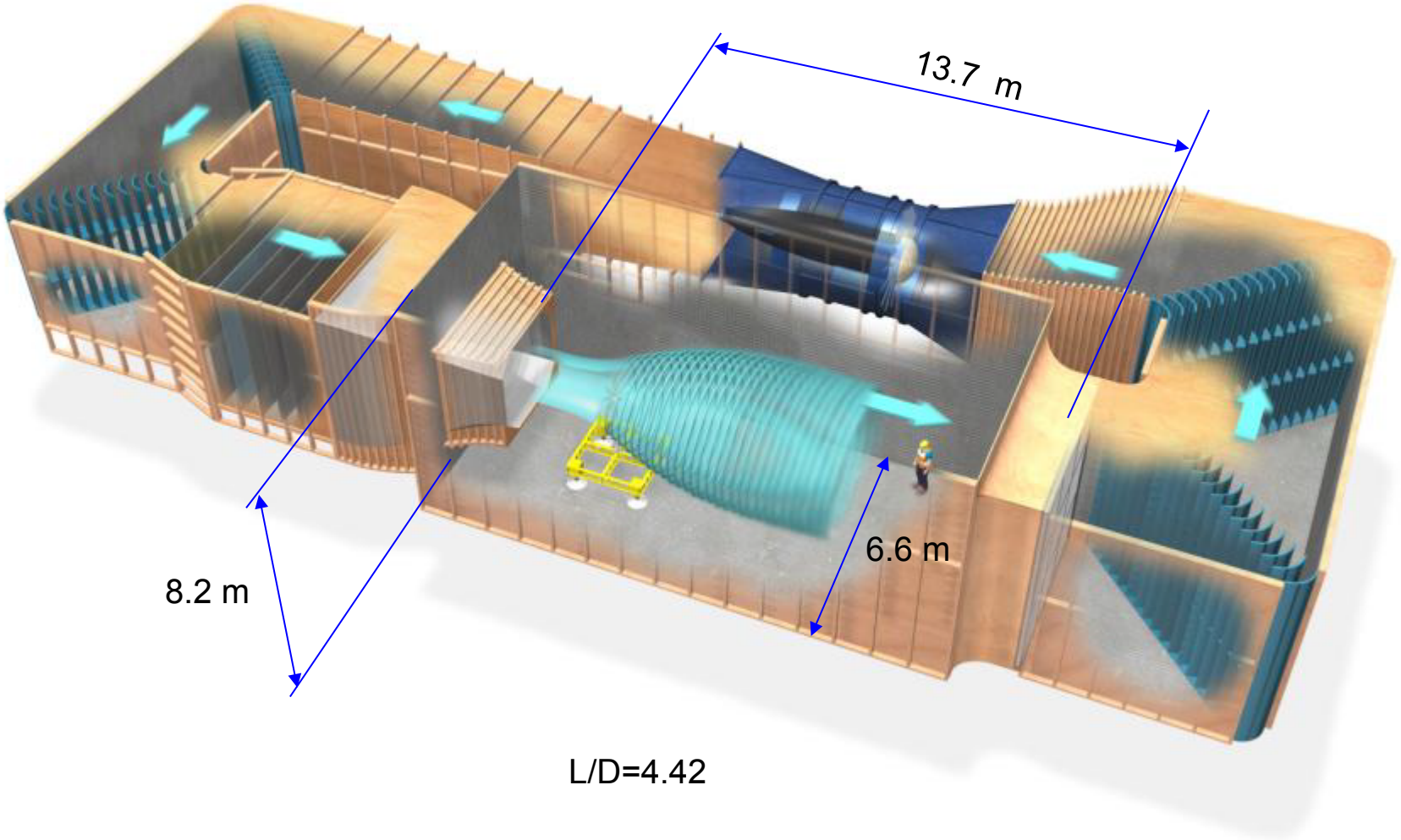
Experimental

Experimental

Pressure strip

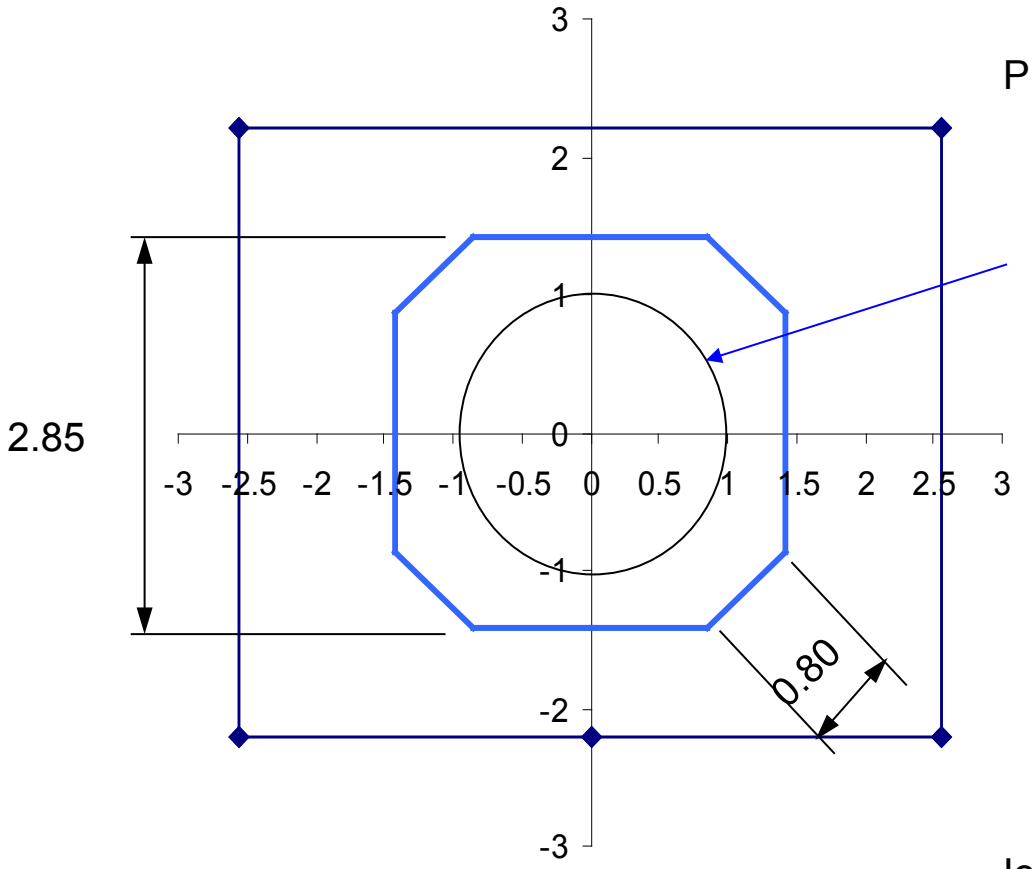


Open Jet Facility



L/D=4.42

Open Jet Facility



Plenum 4.4x5.1

Rotor model 2 m dia.

Jet area 7.483 m^2

Part 2: Technology status

Outline

- Technology demonstration June 2012
- TU Delft on-campus operation May 2013
- University-wide theme for Open Days October 2013

Technology demonstrator

Technical features

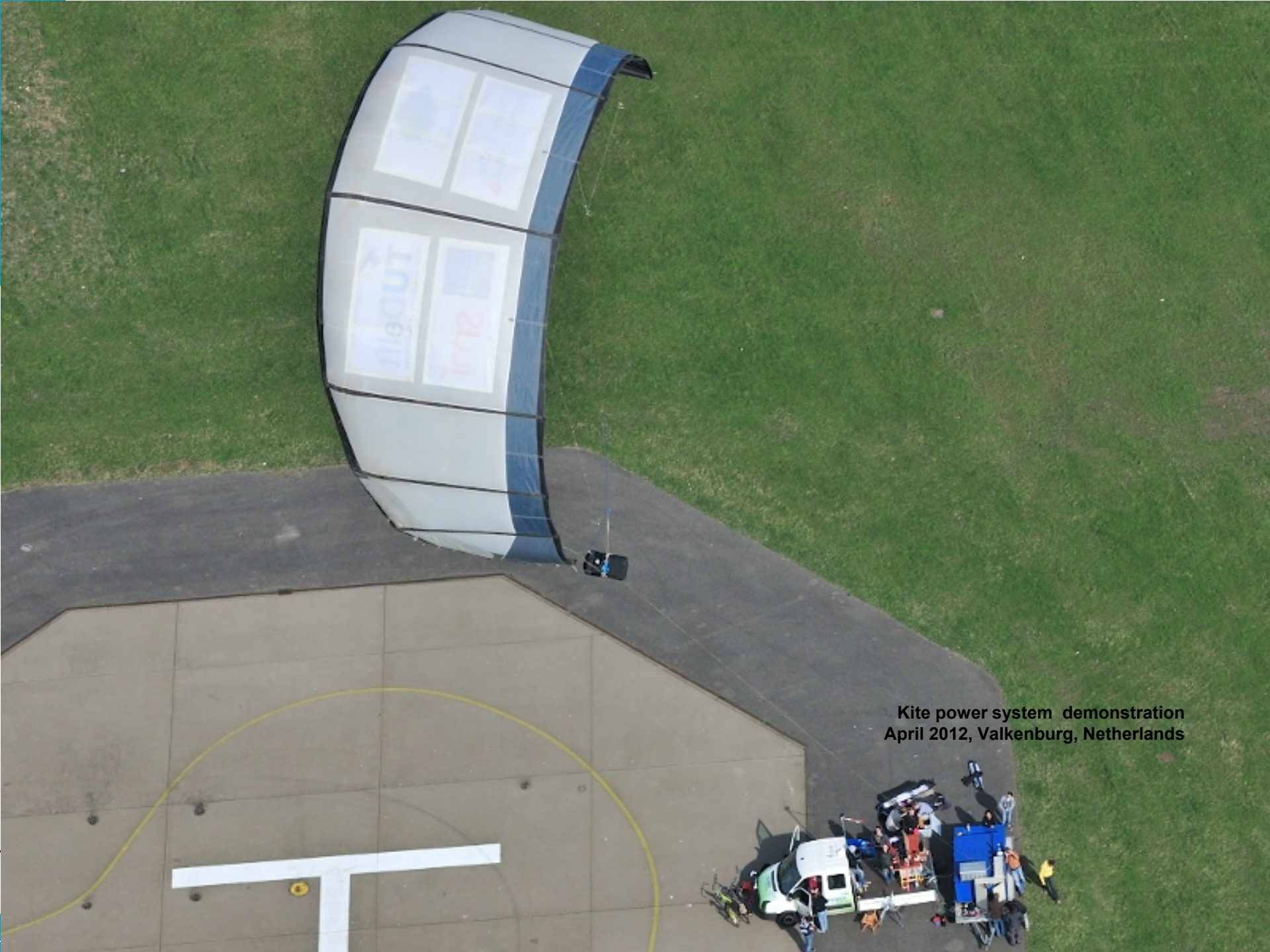
- **20 kW mechanical reel-out power**
- **Mechatronic kite control unit**
- **Single-drum ground station**
- **Fully automatic pumping cycles**
- **Networked control system**
- **Onboard sensor platforms**

Technology demonstrator

Airborne power train: kite > tether > drum

Kite power system demonstration
April 2012, Valkenburg, the Netherlands

Kite power system demonstration
April 2012, Valkenburg, the Netherlands



Kite power system demonstration
April 2012, Valkenburg, Netherlands

Technology demonstrator

Joint test programs

Joint testing TU Delft / EnerKite
May 2012, Valkenburg, Netherlands

http://www.kitepower.eu/newsevents/6-news/95-joint-kite-power-demonstration.html

TechDemo 2012
June 2012 @ Port of Rotterdam

Technology demonstration
June 2012, Maasvlakte 2, Netherlands

TechDemo 2013

TU Delft on-campus operation

TU Delft

Education

TU Delft theme for BSc programme Open Days 2013

Thank you very much!