# OPTIMISING A NOVEL WINGLET FOR USE ON A WIND TURBINE BLADE

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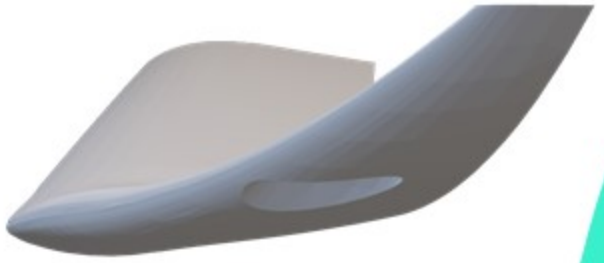

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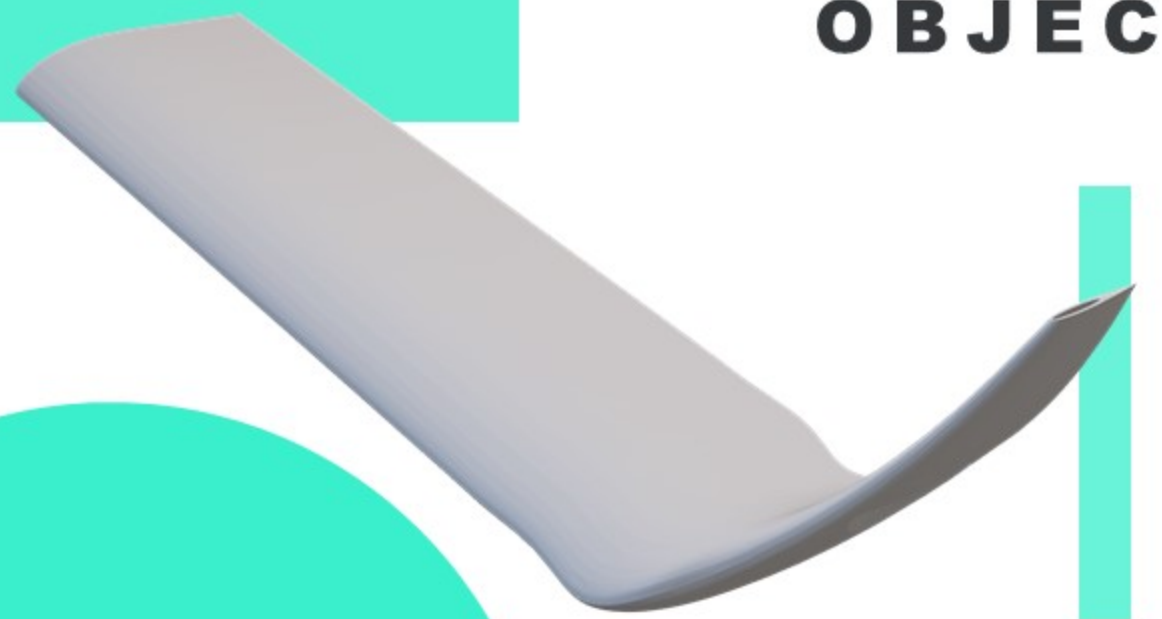


## OBJECTIVES

Reduce wake for optimal turbine performance globally

Minimise drag for local turbine efficiency

Maintain lift for necessary power generation

## AGENDA

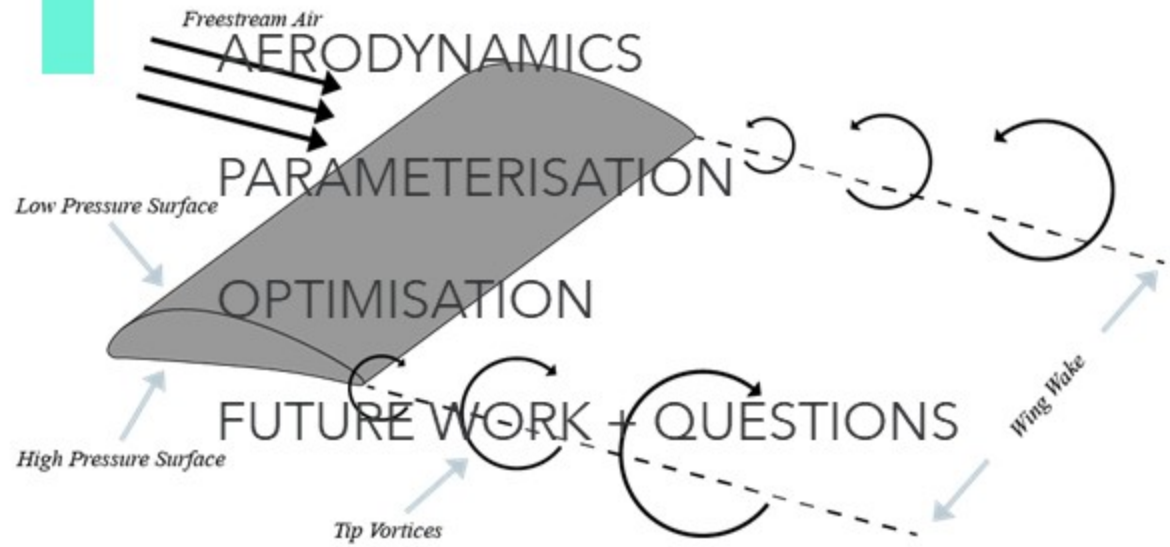
OBJECTIVES

AERODYNAMICS

PARAMETERISATION

OPTIMISATION

FUTURE WORK + QUESTIONS



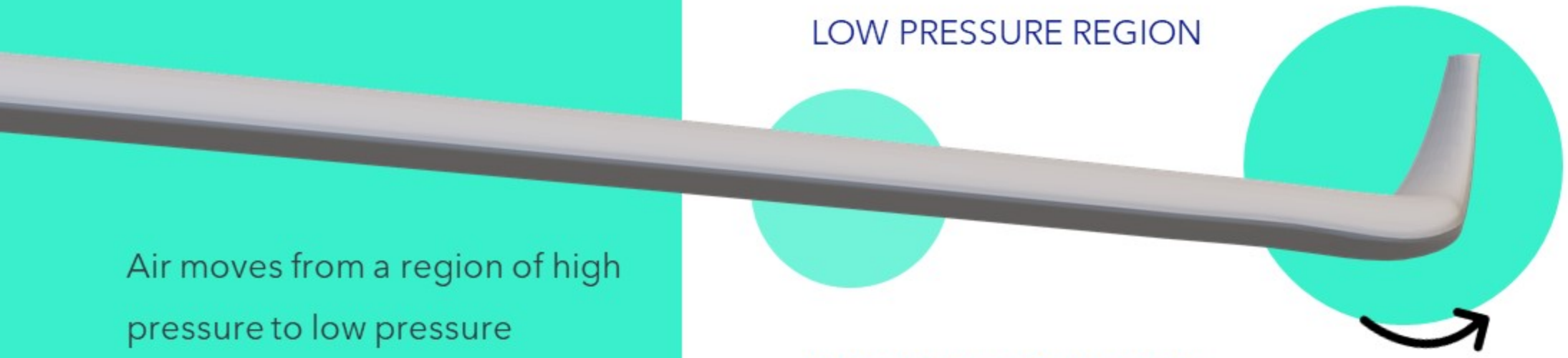
# AERODYNAMICS

Blade creates lift through a pressure difference

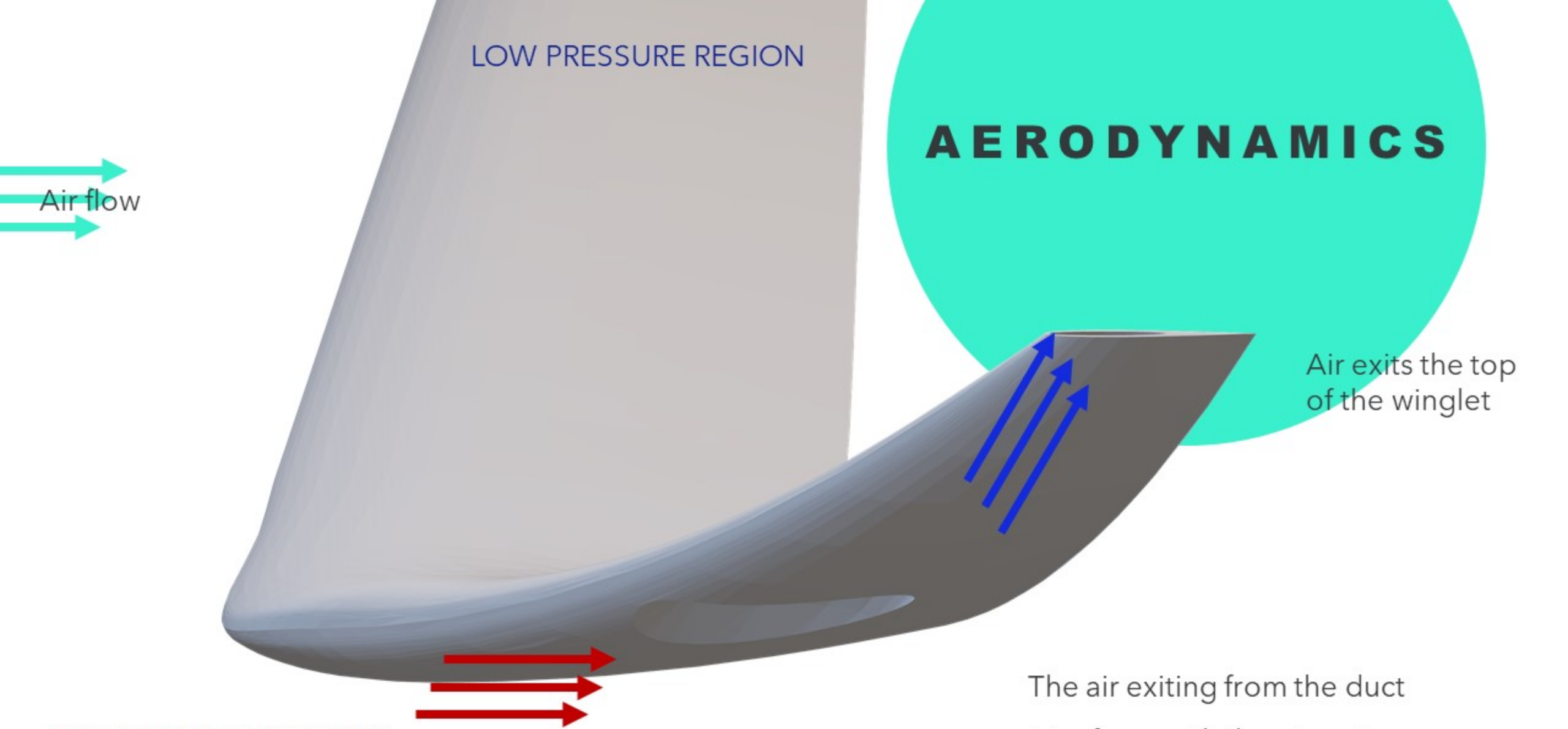
Air moves from a region of high pressure to low pressure

Calculations of aerodynamic properties is “slow” using CFD

The winglet creates a barrier between the upper and lower surface



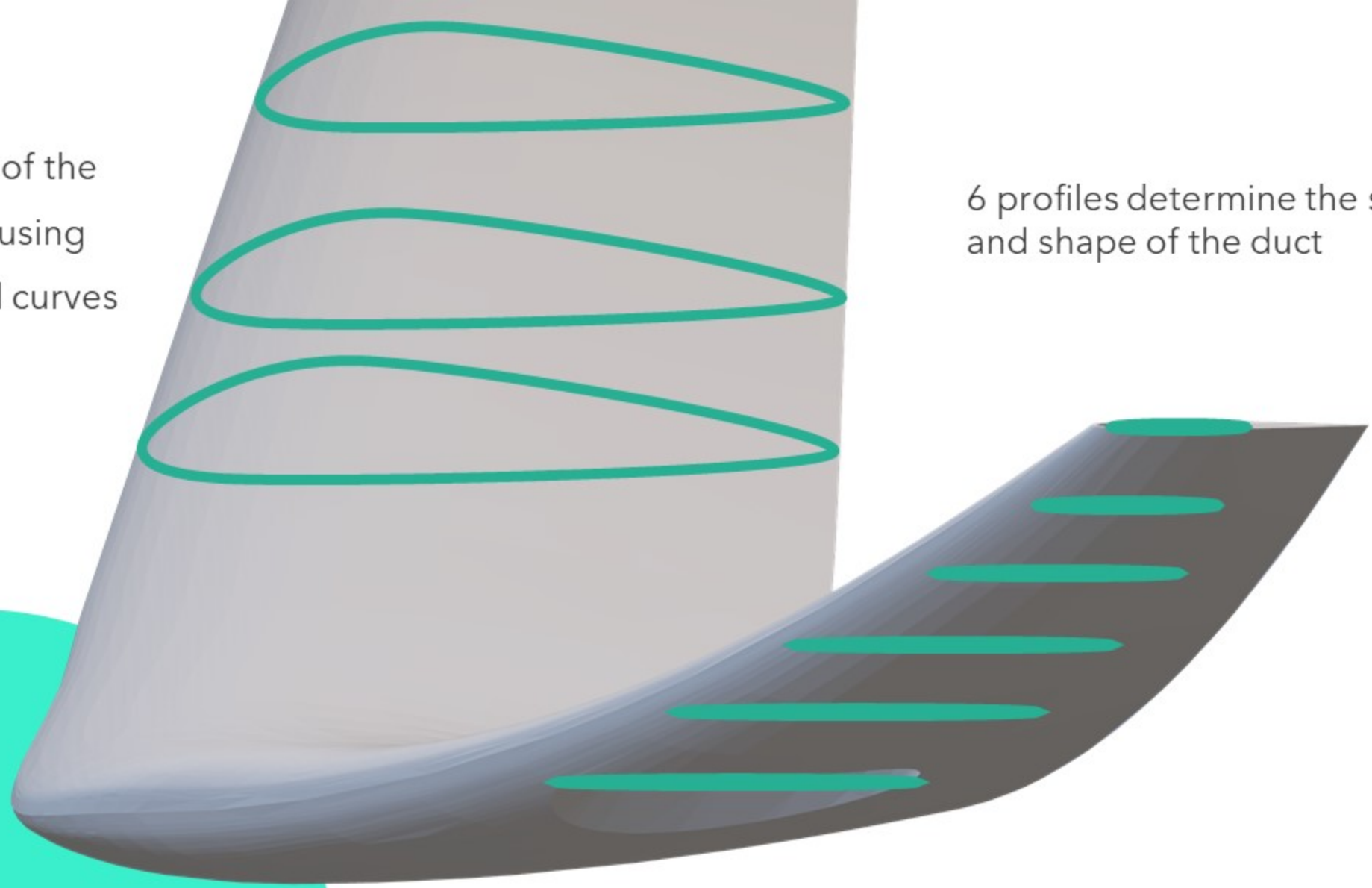
# AERODYNAMICS



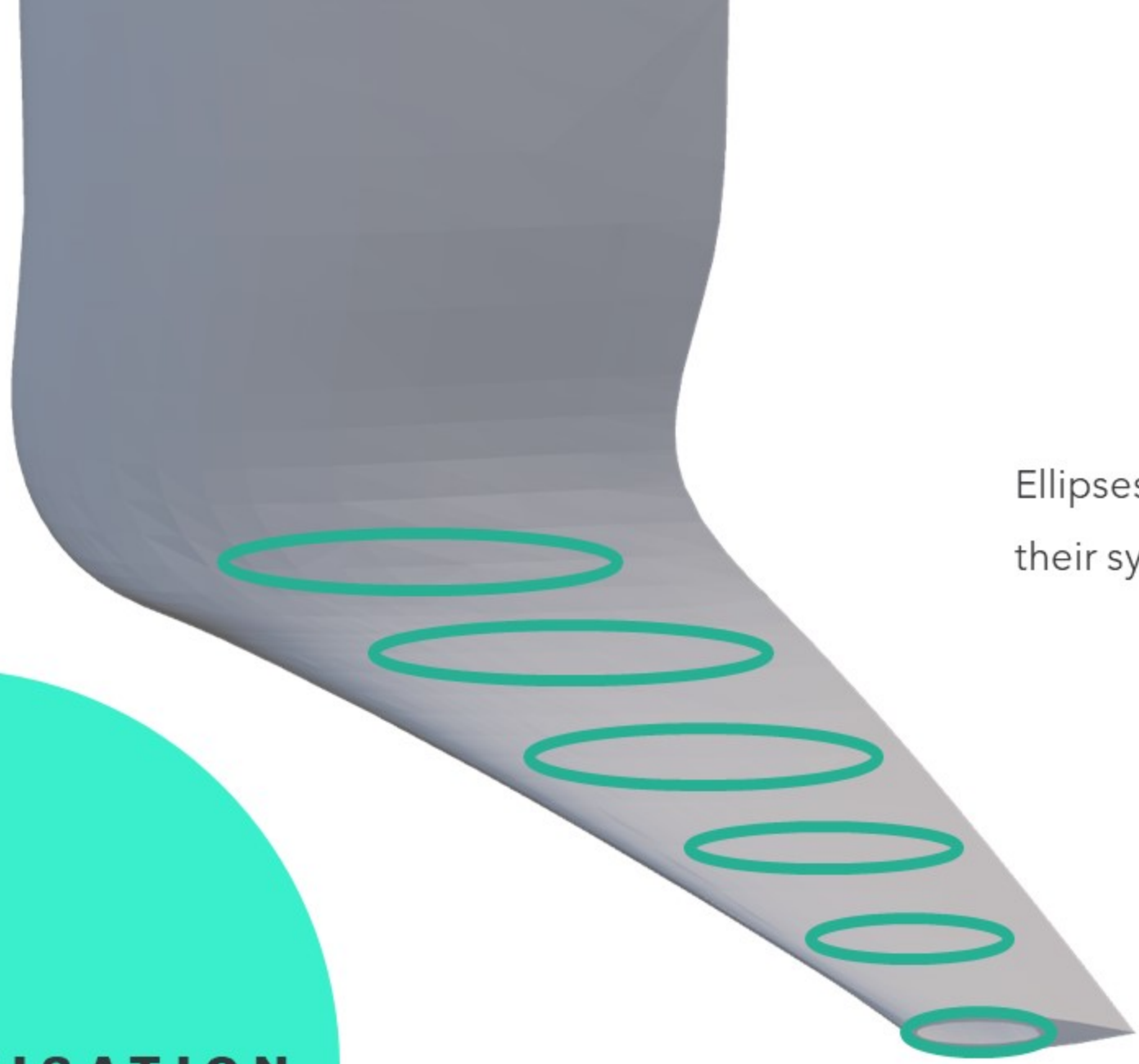
# PARAMETERISATION

The outer profile of the blade was made using predefined airfoil curves

6 profiles determine the size and shape of the duct



The blade profiles are **cambered** while the outer winglet profiles are **symmetric**



Ellipses were used because of their symmetry and easy formula

# PARAMETERISATION

SIZE

ECCENTRICITY

Y-AXIS SHIFT

Each profile has 3 associated parameters that can be changed

A total of 18 parameters define the shape of the duct

# PARAMETERISATION

# OPTIMISATION

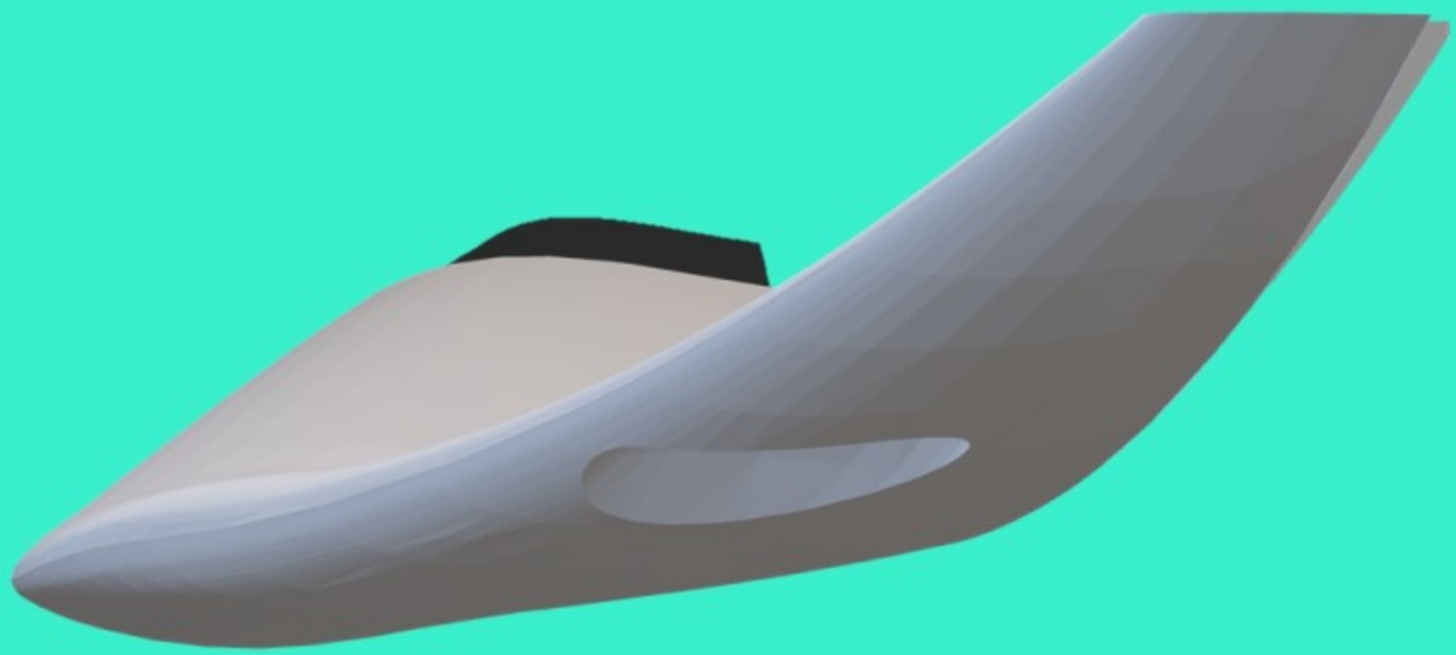
**Initial Design**
- Use design from patent and conduct Trefftz plane analysis to measure wake

**Design of Experiments**
- Create additional designs based on results from initial design

**Genetic Algorithm**
- Breed designs from DoE together to automatically create new designs

**Bayesian Optimisation**
- Create surrogate function to identify areas of interest

# OPTIMISATION

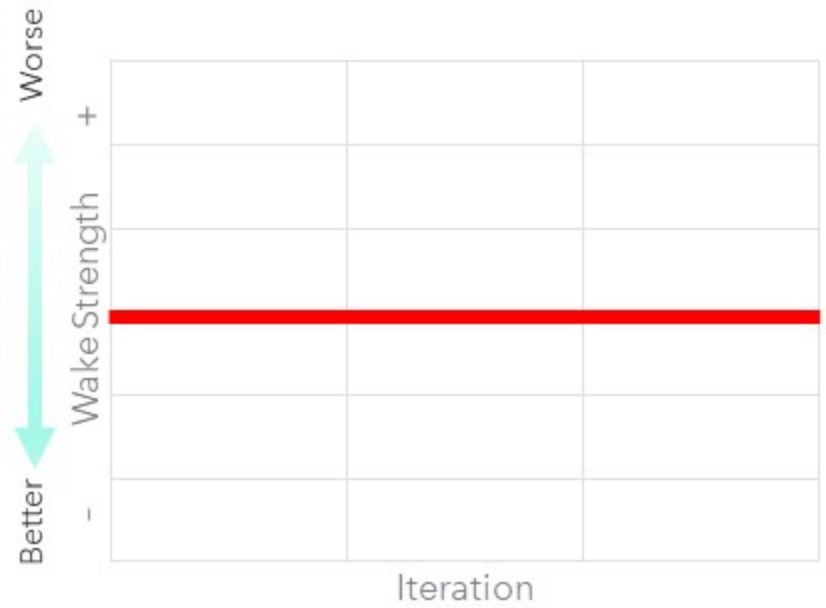


Duct measurements taken from patent

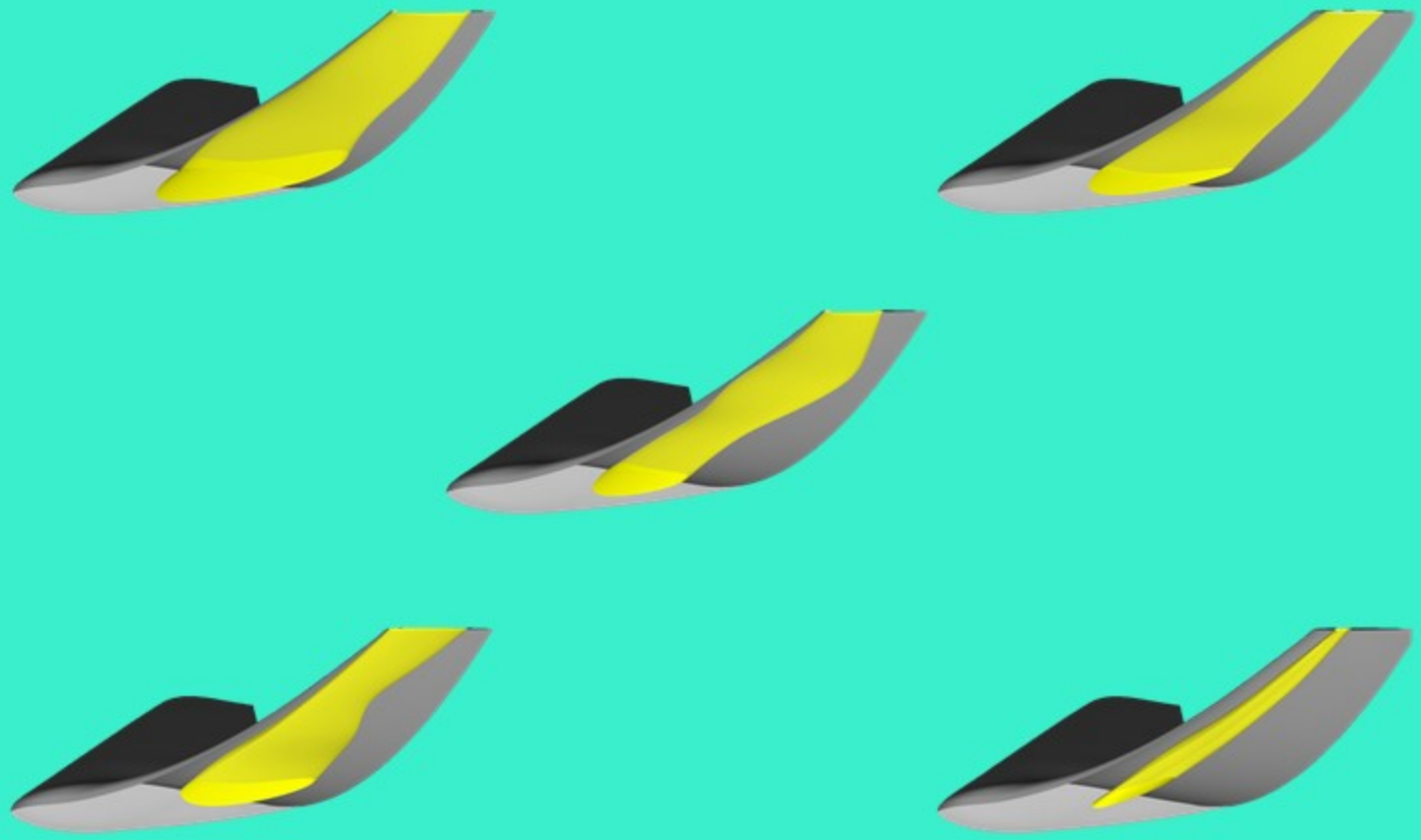
Modified slightly to conform to ellipses


Initial Design → Design of Experiments → Genetic Algorithm → Bayesian Optimisation

# OPTIMISATION

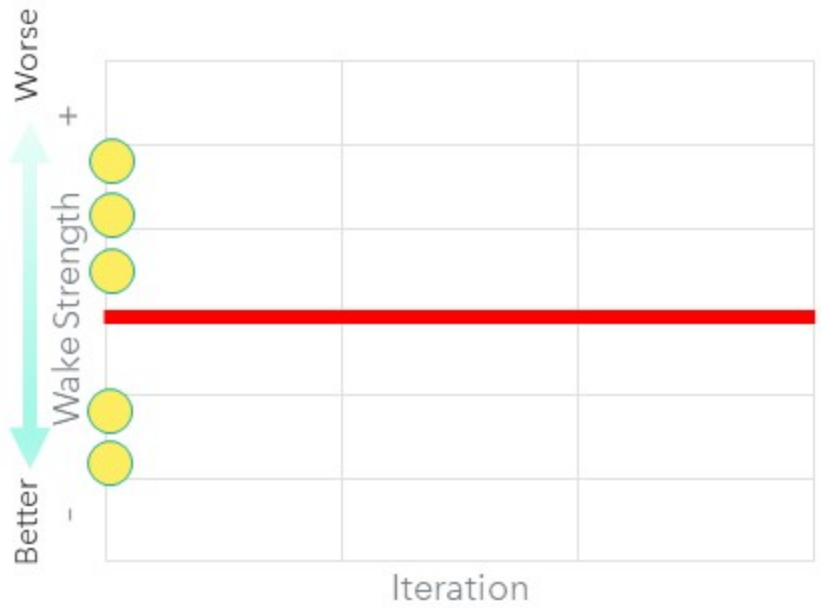



Initial Design → Design of Experiments → Genetic Algorithm → Bayesian Optimisation



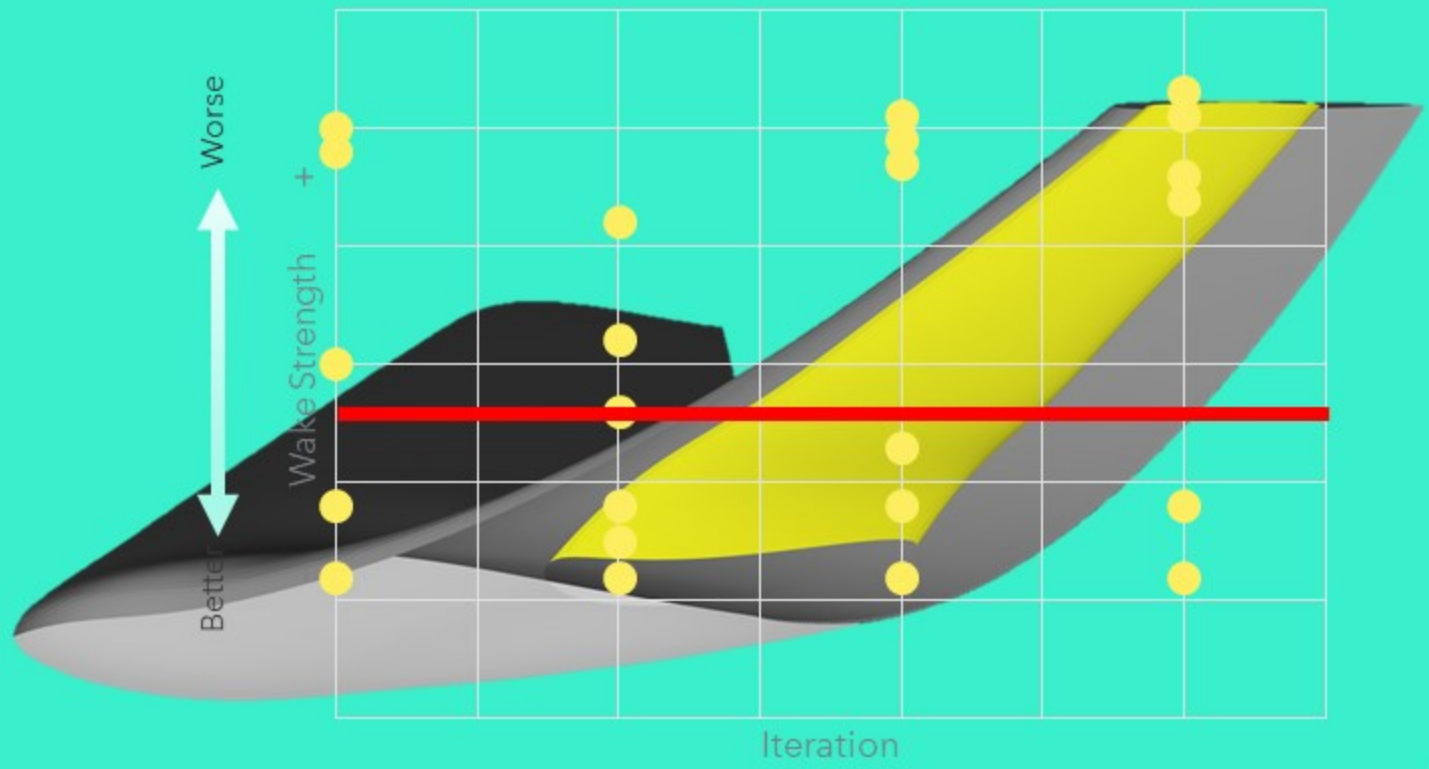
# OPTIMISATION

5 different geometries created based on results from initial design




Initial Design → Design of Experiments → Genetic Algorithm → Bayesian Optimisation

# OPTIMISATION




4 new designs created every generation from a population of 6 (two elites)

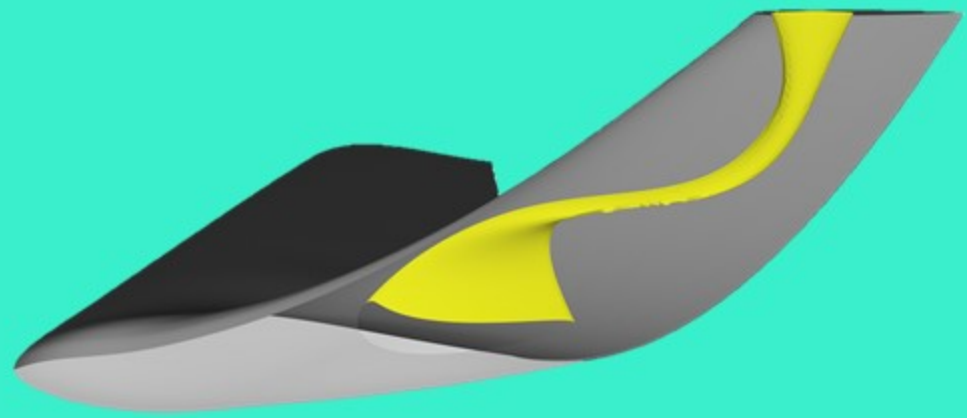
Tournament selection
Single point crossover

3 generations run

+ Could be run in parallel

– Small population size

Initial Design → Design of Experiments → Genetic Algorithm → Bayesian Optimisation



# OPTIMISATION

1 new designs created every generation

EGO algorithm

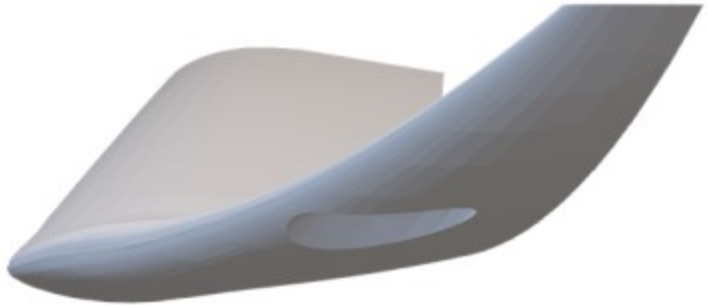
3 generations run

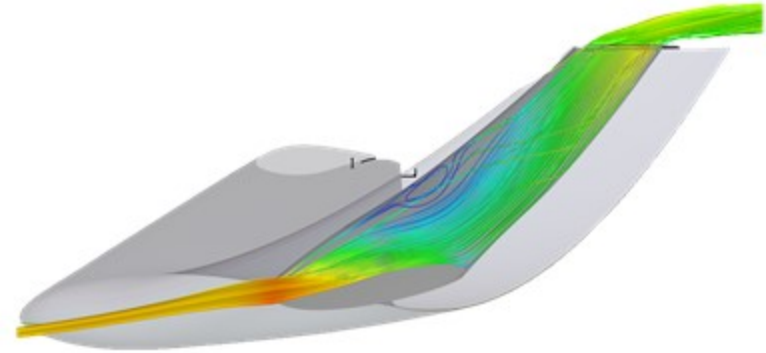
+ Surrogate model which uses previously run data to generate new suggestions

- Serial computation
- Difficult to constrain duct profiles
- Meshing issues

Initial Design → Design of Experiments → Genetic Algorithm → Bayesian Optimisation

# FUTURE WORK





## FUTURE WORK

Reducing the number of parameters to make optimisation easier

Running simulations across a range of angles of attack to improve design robustness

Introducing visualisations during the optimisation process to further engage engineers in the design process

# THANK YOU

Faculty of Science and Engineering, Swansea University

EPSRC Centre For Doctoral Training in Enhancing Human Interactions
and Collaborations with Data and Intelligence Driven Systems

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