THE UNIVERSITY OF AUCKLAND
FACULTY OF ENGINEERING

# Research projects currently available at the Yacht Research Unit

**The following list is provided for those looking at studying in the Yacht Research Unit at The University of Auckland. If you are interested in a particular project, it is often possible to extend the project duration from the minimum indicated. Please contact us to discuss further.**

**Email** yru@auckland.ac.nz

**Web** www.engineering.auckland.ac.nz/uoa/yachtresearchunit

**PhD study scholarships** www.auckland.ac.nz/uoa/cs-scholarships-for-doctoral-students

**Note:** Applications to The University of Auckland Doctoral Scholarships are now open for domestic and international students.

Jump to: Yacht Experimental Yacht CFD Optimisation and Routing Bike Testing

## Yacht Experimental Projects

### Wind tunnel testing of a Stewart 34 yacht

**Duration:** 4-6 months
**Project 1**
**Supervisor:** Assoc. Prof. Peter Richards
Much of the full scale testing is carried out on a Stewart 34 yacht. This purpose of the this project would be to develop a set of realistic aerodynamic coefficients for the Stewart 34 and compare the results of several past full-scale tests. This would be achieved by building a model and carrying out a range of force measurements, flow measurements and flow visualisation in the wind tunnel.

### Full scale downwind flow visualisation and mapping at full scale

**Duration:** 4-6 months
**Project 2**
**Supervisor:** Assoc. Prof. Peter Richards
Improvements in CFD have now led to more detailed simulations of downwind sail performance. Whilst it is straightforward to compare these to wind tunnel tests, there is not much literature available on measured full-scale flow behaviour. This project will aim to carry out flow visualisation, possibly using smoke or surface tufting, and flow mapping using 3D velocity probes. The testing will use asymmetric and symmetric spinnakers at full scale.

### Wind tunnel modelling of aerodynamic interference in a fleet race.

**Duration:** 4-6 months
**Project 3**
**Supervisor:** Assoc. Prof. Peter Richards
Using several yacht models of the same size, a number of fleet racing scenarios will be examined in the wind tunnel. In particular, starting scenarios will be investigated with the target boat (on which forces will be measured) at various stages of advancement on the rest of the fleet. Tactical considerations can then also be investigated. Good sailing knowledge is required for this project.

## Research projects currently available at the Yacht Research Unit

### Influence of staysails on spinnaker shape and performance.

**Duration:** 4-6 months
**Project 4**
**Supervisor:** Prof. Richard Flay
This project will build on previous work on staysails and will use the VSPARS system in the wind tunnel to investigate the shape change in asymmetric spinnakers and associated performance change when a staysail is used.

### Blockage testing using geosimilarity models in the wind tunnel.

**Duration:** 4-6 months
**Project 5**
**Supervisor:** Prof. Richard Flay
This will build on previous work to determine the maximum size of model which can be tested in a particular size of open jet wind tunnel, and the blockage corrections which need to be made. This will involve design and construction of identical models at different scales and measuring their performance for a range of conditions.

### Experimental investigation of hull-sail interference effects.

**Duration:** 4-6 months
**Project 6**
**Supervisor:** Assoc. Prof. Peter Richards
The performance and efficiency of sails depend significantly on how close the hull/sail junction comes to approximating an image plane. The size and shape of the foot round on asymmetric spinnakers has also been found to have a considerable effect on the driving force produced by the sail. An experimental investigation of the interference effects between the foot of the sail and the heeled deck edge will be carried out, both for upwind and downwind sails. This may consist of force and pressure measurement and also flow visualisation techniques to gain a better understanding of the flow phenomena at the foot of the sail and the interaction with the deck and water surface.

### Stewart 34 VPP setup and performance investigation

**Duration:** 4-6 months
**Project 7**
**Supervisor:** Assoc. Prof. Peter Richards
This project will complete initial work undertaken to determine the hydrodynamic performance of the Stewart 34, using a combination of the Delft series and results obtained from FS Flow. The data will then be entered into FS Equilibrium and the performance evaluated and compared with measured data from full scale tests. Eventually, this VPP setup will be used in real-time at full scale to evaluate performance effects of measured aerodynamic changes.

### Investigation of Polynesian canoe sail aerodynamics.

**Duration:** 4-6 months
**Project 8**
**Supervisor:** Prof. Richard Flay
New Zealand was first settled by Polynesian explorers who travelled vast distances using simple sailing canoes. Building on past work, this project will involve experimental work to look at the performance of woven reed sails in a cats-paw configuration, and also the effect of sail porosity on sail performance.

# Research projects currently available at the Yacht Research Unit

## Yacht CFD Projects

### Simulation of asymmetric spinnaker aerodynamics using OpenFoam.

**Duration:** 4-6 months
**Project 9**
**Supervisor:** Assoc. Prof. Peter Richards
The YRU has a number of ongoing projects aimed at improving the understanding of flow around downwind sail through numerical, experimental and full-scale studies. This project would involve modelling an existing experimental benchmark case in OpenFoam (a free, open-source CFD package) and investigating the potential uses of the system. In particular, a simulation of flow features around the foot of the sail are of interest.

### Aerodynamic modelling of upwind sails using panel methods.

**Duration:** 4-6 months
**Project 10**
**Supervisor:** Dr Stuart Norris
Applying the open source APAME panel code to modelling sail aerodynamics. This will involve meshing the surface, development of wake models, and post-processing tools.

### Aerodynamic modelling of sails using RANSE codes.

**Duration:** 4-6 months
**Project 11**
**Supervisor:** Dr Stuart Norris
Applying the open source RANSE code OpenFOAM to modelling sail aerodynamics. This will involve development of meshing tools and evaluation of coupling methodologies.

### Hydrodynamic modelling of hulls using RANSE codes.

**Duration:** 4-6 months
**Project 12**
**Supervisor:** Dr Stuart Norris
Applying CFX to the modelling of a yacht hull with leeway, where the yacht is free to sink and trim. This entails problems in meshing, mesh deformation, and corrections for artificial air-entrainment at the hull surface.

### Modelling sail aerodynamics using LES.

**Duration:** 4-6 months
**Project 13**
**Supervisor:** Dr Stuart Norris
Development of an in-house Large Eddy Simulation code to modelling the aerodynamics of downwind sails.

### Modelling the aeroelasticity of sails using a coupled RANSE/FEM code.

**Duration:** 4-6 months
**Project 14**
**Supervisor:** Dr Stuart Norris
Development of a 3D coupled RANSE/membrane model for the modelling of yacht sails.

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## Optimisation and Routing Projects

### Development of an optimisation package for upwind sails that combines nonlinear programming and CFD

**Duration:** 1 year ME
**Project 15**
**Supervisor:** Prof. Andy Philpott

There has been a large amount of success in the development of gradient-based methods for optimizing aeroplane wings using CFD. The best methods use solutions to adjoint PDEs to obtain gradients for the objective function in terms of the shape variables. This project will attempt to extend these methods to appendage shape optimisation. The first step in this process will be to look at the 2D problem, and to formulate an appropriate adjoint system of PDEs for this problem. It is hoped that a full 3D implementation could be integrated with the equations of a simple VPP.

### To provide software for routing with varying tidal currents.

**Duration:** 1 year ME
**Project 16**
**Supervisor:** Prof. Andy Philpott

In 1999 Kalman Bekesi carried out a project that used stochastic dynamic programming to compute optimal routing strategies for America's Cup yachts. These strategies were aimed at minimizing the expected arrival time at a destination (the next mark) with a stochastically varying wind direction, and constant wind speed. This project will extend the code developed by Kalman Bekesi to deal with a changing wind speed and a varying tidal current.

The wind speed will be approximated by a Markov process. We shall use the tidal current model developed by Mike O'Sullivan and Adrian Croucher to compute deterministic tidal currents at any point in time and space. It is hoped that the strategies that are computed by the new code will be simulated on various legs of Auckland Harbour courses using the ACROBAT race modelling program, and compared with simple decision rules.

### Develop tools for computing probabilistic optimal routing strategies given ensemble weather forecasts.

**Duration:** 1 year ME
**Project 17**
**Supervisor:** Prof. Andy Philpott

It is now commonplace in North America for weather forecasters to issue a collection of weather forecasts, computed using weather models starting from perturbed initial conditions. These weather forecasts are called ensemble forecasts. Each member of the ensemble (called a scenario) is assumed to occur with some probability (based on the likelihood of observing the perturbation generating the scenario).

Constructing optimal routes for sailing vessels in an ensemble weather forecast is a challenging problem. An optimal route for each scenario may differ considerably from others so it is difficult to decide on the course to be implemented. A plan that can be implemented that does not adapt to new information on the weather as it evolves can be computed using stochastic dynamic programming. This will form part of the project. A second aim is to develop a model that can be used to construct branching scenarios from the ensemble forecasts. We propose to do this using a scenario bundling technique commonly used in stochastic programming.

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## Bike Projects

### Aerodynamic drag of cyclists – development of a time trial simulator.

**Duration**: 4-6 months
**Project 18**
**Supervisor:** Prof. Richard Flay
This project will make use of the University's custom designed bike testing rig to measure aerodynamic drag of cyclists. The rig can set the pedalling torque via computer and deduce the power output whilst measuring the cadence and drag. The time trial simulator would record the distance travelled and adjust the torque to match pre-programmed hills on a course, in accordance with the cyclist's speed. The ultimate goal is improvement in lap times around a specific course. A keen interest in cycling would be an advantage.

### Aerodynamics of multiple bikes riding in a pack

**Duration**: 4-6 months
**Project 19**
**Supervisor:** Prof. Richard Flay
This project will aim to quantify the drag reduction available to a cyclist by riding in proximity to other riders in a range of configurations. This will be carried out using multiple bikes set up in the wind tunnel, with one bike being placed on the drag balance cycle rig. Flow visualisation will also be carried out.

### Comparison of cyclist riding positions using a mannequin.

**Duration**: 4-6 months
**Project 20**
**Supervisor:** Prof. Richard Flay
A dynamic mannequin has been developed for use in the wind tunnel, capable of being mounted on a pedalling bike. The advantage of this is that exactly the same riding position can be maintained for long periods. The aim of this project will be to explore in a repeatable way the aerodynamics of a range of riding positions and bike setups.