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 downwind sails for a Stewart 34 yacht
Duration: 4-6 months
Project 1
Supervisor: Prof. Richard Flay
This project would test the relative performances of symmetric and asymmetric spinnakers on a model of a Stewart 34 yacht in the wind tunnel. Downwind aero models using depowering surfaces would be developed for use in a VPP.

Full scale downwind sail flow visualisation and mapping
Duration: 4-6 months
Project 2
Supervisor: Prof Richard Flay
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.

Measurement of sail forces using directional load cells in the wind tunnel
Duration: 4-6 months
Project 3
Supervisor: Prof. Richard Flay
Directional load cells have been used at full scale to measure the corner loads on an asymmetric spinnaker. This project would aim to replicate the tests in the wind tunnel, and compare the results both with the overall forces as measured by the wind tunnel force balance, and with those results already measured at full scale.

Towing tests on a Laser sailing dinghy
Duration: 4-6 months
Project 4
Supervisor: Prof. Richard Flay
This builds on previous work to measure the hydrodynamic forces on a full scale Laser sailing dinghy by using a directional load cell attached to the rope towing the dinghy. A range of righting moments will be investigated and measured using an instrumented platform on the boat. The data will be compared with published data and CFD results where possible.

Research projects currently available at the Yacht Research Unit

Measurement of wind speed on a moving yacht
Duration: 4-6 months
Project 5
Supervisor: Prof. Richard Flay
This project builds on previous work. A sonic anemometer has been mounted on the top of a yacht mast, with Inertial Measurement Units (IMUs) present both at the sonic location and inside the yacht hull. The project will involve calculation of the motion centre from the IMU data, such that the translational velocities at the masthead can be calculated and removed from the sonic anemometer data. The system will be tested both in the wind tunnel and in the field.

Directional load measurements on kites
Duration: 4-6 months
Project 6
Supervisor: Prof Richard Flay
Traction kites are now used in a number of ways, including for kite surfers, yacht propulsion and cargo ship propulsion assistance. They are very difficult to model experimentally in the wind tunnel because of scale effects and control issues. This project aims to measure a kite's performance at full scale through use of a directional load cell. Tests will be carried out on dry land and potentially on water using a self-contained waterproof data acquisition unit. Results will be compared with published literature and theory.

Investigation of Polynesian canoe sail aerodynamics.
Duration: 4-6 months
Project 7
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.

Yacht CFD Projects

Stewart 34 hydrodynamic simulation using free-surface panel method
Duration: 4-6 months
Project 8
Supervisor: Dr Stuart Norris
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 the free-surface potential flow code FS Flow. The data will then be entered into a VPP (FS Equilibrium or similar) 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.

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.

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.

Research projects currently available at the Yacht Research Unit

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.

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.

Comparison of cyclist riding positions using a mannequin.

Duration: 4-6 months
Project 19
Supervisor: Prof. Richard Flay

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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.