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. The closing date is 1 November 2011.

Full-scale pressure measurements on sails.

Duration: 4-6 months
Project 1 [started]
A pressure measurement system for full-scale yacht sails has been developed. This project will aim to carry out full scale measurement of pressures on spinnakers for comparison with wind tunnel and CFD data This project involves understanding/learning the basics of sail aerodynamics, experimental techniques, and instrumentation.

Design and optimisation of multi-element wing sails for multi-hull yachts.

Duration: PhD
Project 2 [started]
This PhD research project will bring together the aerodynamics of multi-element aerofoils which operate in a turbulent flow, with the optimisation required to achieve maximum speed made good under various constraints of overturning moment, range of wind speeds, and limits on area, height etc. The research will be carried out using a combination of CFD, wind tunnel experiments, and possibly some model scale testing if resources permit. Applicants should have a strong background in aerodynamic theory, as well as being accomplished sailors. Knowledge of wind engineering would also be an advantage.

Measurement of full scale wind turbulence on a moving yacht.

Duration: 4-6 months
Project 3 [started]
Correct simulation of apparent wind turbulence is one of the next stages in the advance of wind tunnel and CFD modelling. This project will build on previous work in developing a system for measuring wind speed and turbulence on a moving yacht, by subtracting the yacht's motion from the signal by using a low-cost inertial measurement system. Basic programming and instrumentation skills will be useful for this project.

VPP simulation of a Stewart 34 yacht and comparison with experimental data.

Duration: 4-6 months
Project 4
The YRU has recently been using a Stewart 34 yacht for much of its full scale testing. This project would develop hydrodynamic data for this yacht using standard series and CFD data, and compare the resulting performance predictions using empirical, wind tunnel experimental and full scale measured aerodynamic data.

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Downwind sail corner load estimation.

Duration: 4-6 months
Project 5
There is a need to develop a tool to provide sail designers with a quick estimation of corner loads (ie. tack, head, clew) for a range of offwind sails. This project would involve measuring the corner loads independently in the wind tunnel for several types of offwind sails over a range of conditions. A regression analysis would then produce a simple spreadsheet tool to predict loads for a given sail type, wind speed and wind angle. Measurement of full scale loads on a typical downwind sail could then also be carried out if time allows.

Design and build of a mannequin for wind tunnel experiments.

Duration: 4-6 months
Project 6
Several areas of aerodynamic testing involve humans and their associated drag (eg. cycling, skiing, dinghy sailing, etc). One of the hardest aspects is to get repeatable body shapes across a range of tests. This project would involve the design and build of a full scale human mannequin with flexible joints, suitable for use in a range of test types. Cycle testing would then be carried out using the mannequin and a human subject for a range of conditions to examine the improvements in consistency.

Development of directional load cell for sail corner load measurement.

Duration: 4-6 months
Project 7
Conventional load cells are capable of measuring tension only. This project would involve combining a load cell with an Inertial Measurement Unit (IMU) which reports orientation under any conditions. The load and positional data would then be transmitted wirelessly to a base station. This would allow the load to be decomposed into directional loads, allowing the forces and moments produced by the sail to be calculated in real time. Full scale testing would be carried out to test and validate the system.

Wind tunnel modelling of aerodynamic interference in a fleet race.

Duration: 4-6 months
Project 8
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.

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

Duration: 4-6 months
Project 9
Nothing to do with yachts. 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.

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Investigation of foot-round effects on asymmetric sails.

Duration: 4-6 months
Project 10
The size and shape of the foot round on asymmetric spinnakers has been found to have a considerable effect on the driving force produced by the sail. This project will use wind tunnel testing and possibly CFD simulation to look at these effects and provide a better understanding of the flow phenomena at the foot of the sail and the interaction with the deck and water surface.

Investigation of masthead rig aerodynamics using VSPARS at full scale.

Duration: 4-6 months
Project 11
This project will use the VSPARS sail scanning system (www.vspars.com) to determine the rig deflection and sail shapes resulting from different rigging tension on a Stewart 34 masthead yacht. This yacht is known to favour slack rigging, resulting in a large masthead fall-off and hence separation between the genoa and mainsail.

Influence of staysails on spinnaker shape and performance.

Duration: 4-6 months
Project 12
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 13
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.

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

Duration: 1 year ME
Project 14
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.

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To provide software for routing with varying tidal currents.

Duration: 1 year ME
Project 15
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 16
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.