The School of Mechanical Engineering welcomes you to the annual student Project Exhibition. On display are Level IV student projects dealing with both research and design.

The projects are initiated either by one of our industry partners or by our staff and deal with topics ranging from system analysis and design to experimental investigations of fundamental research problems. On a number of occasions in the past student solutions have led to patentable systems.

Although some projects are undertaken by individual students, most are group projects involving up to ten students, and represent in excess 300 hours of work per student.

The School of Mechanical Engineering would like to thank all contributing organisations for their support and we look forward to further strengthening industry involvement in our final year projects in the future.

We hope you will enjoy the exhibition and take the opportunity to discuss with students and staff any aspect of the projects that you find of interest.

ASSOCIATE PROFESSOR BASSAM DALLY
Head, Mechanical Engineering
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1. Automated Watering System

**Students:** Minjie Hu, Wentao Tang (withdrawn) & Jing Yu  
**Supervisor:** Dr Tien-Fu Lu  
**Sponsor:** Australian Plant Phenomics Facility (The Plant Accelerator)

The aim of our project is to manufacture an automated watering system to survey the drought resistance of various plants. The requirements of the system are convenient to operation, move and in low cost. Following the requirements, the system is designed to be component by a scanner, a weighing scale and a water pump. Furthermore the system would be installed in a trolley to achieve moveable of the system. The main ideal of the project is to compare the weighing results of the scale with the target weights in the database, and then the water pump could water the various plans by the compared results. The whole process is controlled by the computer, the only things that the operator needs to do are put the plan on the scale and move the mouse. In order to make the survey more accurate, a leveling mechanism is considered in the project. This leveling mechanism would keep the weighing scale level each time after the trolley is stopped.

2. Design, Build and Implementation of Intelligent Submersible Robot Systems

**Students:** Duy Anh Bui, Chen Chen, James Rutter & Qian Wang  
**Supervisors:** Associate Professor Amir Anvar & Dr Tien-Fu Lu  
**Sponsor:** Defence Science and Technology Organisation (DSTO)

The 2011 Autonomous Underwater Vehicle (AUV) Robot project exhibition demonstrates the systems and experimental data produced by the team this year.

The project’s main goal is to integrate the three sub-systems of the AUV and incorporate them into the intelligent Command and Control systems of the submersible Robot. These three sub-systems are Communications, Navigation, and Vision. There were several goals achieved relating to each sub-systems this year. Firstly, the Communications security has been vastly improved with an integrated cryptography system, error-control codes, and a signature scheme that can be applied to underwater-
images taken by the machine vision camera. The Navigation system sees improvement through reprogramming of the Inertial Measurement Unit (IMU), with strings of data being translated to output acceleration in three axes, and importantly, the AUV’s heading in degrees. The submersible Robot also uses a Doppler Velocity Log (DVL) multi-sensor, which is used to track the AUV’s underwater positions with respect to its pre-assigned initial-position in real time. The AUV’s underwater vision sensors were integrated onto the vehicle, requiring significant troubleshooting and development of software and hardware. Machine vision and Sonar outputs are able to develop an accurate analysis of the AUV’s surrounds and possible obstacles.

The exhibition will provide an overview of the subsystem and structural design, the results of the air and underwater testing. The implemented AUV will be on the display as well as the testing results.

3. Design, Build and Implementation of Intelligent Troubleshooting Systems for Maritime Air Robots’ Operations

Students: Thomas Dowling & Thomas Putland
Supervisors: Associate Professor Amir Anvar & Dr Steven Grainger
Sponsor: Defence Science and Technology Organisation (DSTO)

The aim of this project is to develop Intelligent Troubleshooting Systems (ITSs) by considering Diagnostic, Prognostic and Remedy system algorithms to provide real time health monitoring of two Maritime Unmanned Aerial Vehicle (UAV) Robots. The two UAVs are a Vertical Take-Off and Land (VTOL) UAV and a Catapult Launched (CL) UAV which are being developed by two independent Honours Project groups. Sub-systems of UAV-Robots to be monitored include the aircrafts Energy Supply, Propulsion and Navigation processes.

The ITSs will be utilising the intelligent systems Neural Networks (NN) and Fuzzy Logic (FL). NN can recognise complex relationships between multiple inputs and is capable of learning new relationships from data. Fuzzy Logic (FL) is applied to investigate and monitor real-time events and identify the degrees of truth to which an event occurs. In conjunction with expert knowledge of a UAV subsystem, NN and FL are then used to determine the state of health of the UAV subsystem.

Real time application of ITSs for UAVs is expected to increase the safety, operational capability and reliability of maritime air robots, while also decreasing repair and replacement costs.
4. Design, Build and Implementation of a new version of VTOL Maritime UAV Robot Systems

**Student:** XuNing Zhao

**Supervisors:** Associate Professor Amir Anvar & Dr Steven Grainger

**Sponsor:** Defence Science and Technology Organisation (DSTO)

The Vertical Takeoff and Landing (VTOL) Unmanned Aerial Vehicle (UAV) is capable of performing an extensive range of maritime applications. The versatility of UAVs has seen them in high demand for various applications, and has caused a sharp increase in the UAVs' market around the world. This project aims to improve, investigate, design and develop a new prototype version of a VTOL UAV Robot for Maritime Air operations that is deployable on confined platforms such as ship decks.

The project is a continuation of the previous year’s quadrocopter UAV. The UAV was redesigned and will feature four pair of rotors arranged in coaxial configuration, instead of the previous year’s variable pitch design, for added stability. The frame was specially designed to fit the eight rotors to facilitate operations in a maritime environment. The UAV was designed for the payload deployment of micro sonobuoys, allowing for communication between UAVs and AUVs within the area of deployment. An off-the-shelf dynamic control system was adapted to allow for improved manoeuvrability and control.

The project will detail the UAV’s design, concept, the specific payload carried, UAV operations in Maritime environment, and lastly various testing and improvements made.
5. Design, Build and Implementation of a new version of Micro-Sonobuoy deployable by M-UAV (Mark II)

Students: Desmond Lim & Braydon Munro
Supervisor: Associate Professor Amir Anvar
Sponsors: Defence Science and Technology Organisation (DSTO) & Boeing Defence Australia

This project aims to build on the previous sonobuoy Mark I via analysing faults and limitations in the previous design and implementing design changes in an attempt to bring the Micro-sonobouy to a fully functional prototype stage.

The communication Micro-sonobuoy is much lighter and smaller than sonobuoys which are used currently used for oceanic mining, maritime environmental study and naval defence applications. The only one of its kinds as a designated communication relay, having major advantages in weight, physical-size and also the capability of deployment by Maritime Unmanned Air Vehicles (M-UAVs). The Micro-sonobuoy is deployed into a maritime environment where it establishes crucial communication links between the M-UAV, Autonomous Underwater Vehicle(s) within human operator in the loop via radio frequency and underwater acoustic communications.

The Micro-sonobouy (Mark II) has thus far achieved modular successes. RF communications have been established, GPS location has been ascertained, command and control has also been accomplished and an FSK modem has been designed and tested. In this exhibition, the Micro-sonobouy will be displayed along with a demonstration on the working communications and control.

6. Design, Build and Implementation of Intelligent Swarm Networking System
Operations of Maritime UAVs and Submersible Robots

Students: Christine Head & Matthew Allwright
Supervisor: Associate Professor Amir Anvar
Sponsor: Defence Science and Technology Organisation (DSTO)

Intelligent swarm networking began with the study of natural systems such as the flocking of birds. Principles of swarm networking have been implemented in robotic systems, allowing autonomous robotic behaviours that can be utilised in real-life scenarios such as search and rescue, reconnaissance and exploration. A ‘system of systems’ approach to these applications presents opportunity to increase efficiency of an operation, while reducing the risk of mission failure. Considerable research has gone in to swarm optimisation techniques and, since the introduction of autonomous vehicles, study and experimentation has been performed on 2D systems. There is less documentation on scenarios in three dimensions. The aim of this project is to investigate and implement swarm networking techniques in a
3D environment using simulation software. Sensor function, swarm techniques and scenario development are integral components of the project and physical trials are required in order to validate results. Validation is constrained by the mode of testing – a swarm of ‘Open Robots’ operating in a 2D scenario are utilised for validation. Despite this constraint, the real-time trials are a useful test of models and outputs of the simulated vehicles. The presentation will discuss the achievements to date of this research and design project.


Students: Dongyang Li, Lu Wang & Xiongwei Zhu
Supervisor: Associate Professor Amir Anvar
Sponsors: Defence Science and Technology Organisation (DSTO), Acacia Research and Development, GHD Australia & Orange Outdoors

With the increasing demands for maritime air operational development and surveillance, the Unmanned Aerial Vehicle (UAV) has become an important asset. The project was to design a multi-functional maritime UAV Catapult-launched Robot, that can satisfy both deployment and communication requirements. The project involved both the design of the hardware, such as the structure efficiency of the UAV, and the software which was built and tested to control the motion of the UAV. It includes Command, Control, Navigation, and Avionics systems, a Communication system, and Micro-Sonobuoy deployment capabilities. The main focus of this project was to design a lightweight maritime UAV and also modify a catapult launcher system through the use of conceptual designs before the final configuration was chosen. In the exhibition, a semi-finished product aircraft (T-10) with testing and modification will be shown for the project requirements. Next, the improved catapult launcher as an important component of the project also will be shown with the UAV. Finally, two recovery systems will be shown in the figure1 below which is parachute recovery and net recovery systems.
8. Design, Build and Implementation of Intelligent Troubleshooting Systems for Maritime Underwater Robots’ Operations

**Students:** Manjit Garcha, Ritchie Saliba & Taranjit Singh  
**Supervisors:** Associate Professor Amir Anvar & Dr Steven Grainger  
**Sponsors:** Defence Science and Technology Organisation (DSTO) & Rockwell Automation

The Autonomous Underwater Vehicle (AUV) troubleshooting project aspires to provide the University of Adelaide with a continuing robotic program that will develop key intelligent models, thus strengthening the submersible robotic community. This is facilitated through sponsorship from the Defence Science and Technology Organisation (DSTO). The program provides practical, reliable and cost-effective AUV missions through the use of an effective Intelligent Troubleshooting System (ITS). The aim of the 2011 AUV troubleshooting project is to implement an effective troubleshooting system in order to perform a diagnosis, prognosis and remedy of possible faults that may be encountered during missions in an oceanic environment. Diagnosis, prognosis and remedy of the battery, thrusters and water leakage systems will be executed through mathematical models and thorough testing which will be monitored on the Graphical User Interface (GUI). As the thrusters will experience high buoyant forces during underwater operations they have been analysed and tested underwater that simulate this operating environment. The battery, thrusters and water leakage sensor results will provide a greater understanding of the AUV’s intelligent systems behaviour and will be used to further develop the software and hardware such that it will be able to withstand the extreme underwater environments. The exhibition will provide an overview of the AUV subsystem and ITS design, as well as the results of battery, thrusters and water leakage monitoring (which will be displayed on the GUI). The structure of the test bed and the GUI will be on display as well as the model of the AUV.

9. Design, Build and Implementation of Oceanic Robot-Glider

**Students:** Martin Hasenohr & Simon Clements  
**Supervisor:** Associate Professor Amir Anvar  
**Sponsor:** Defence Science and Technology Organisation (DSTO)

The Design, Build and Implementation of Oceanic Robot-Glider is a project aimed at the manufacture and implementation of an unmanned, autonomous underwater vehicle that is propelled using unconventional methods. This Robot-glider has been designed to independently sample ocean data, such as temperature and pressure from shallow marine environments and output this data to an external source. Oceanic gliders are innovative and groundbreaking vehicles, ideally suited to missions
in which endurance is of paramount importance, such as oceanic research. There is a market for such a craft because much of the oceans ecosystem and conditions remain unmapped. The most prominent means of researching the ocean to date has been using manned research vessels, which require fuel, supplies and additional research craft to survey the aquatic environment. This Glider does not share these limits, being autonomous and battery powered, with an equivalent manufacturing cost of less than a day aboard a manned research vessel. Furthermore, this Glider was designed for extended autonomous operation and continuous data sampling at a range of differing depths, which is a unique characteristic made possible by the saw tooth profile of its motion.

10. Levitating magnet vibration isolation device

Students: Yann Frizenschaf, Siobhan Giles, Jack Miller, Christopher Stapleton & Thomas Pitman

Supervisors: Associate Professor Ben Cazzolato & Mr Will Robertson

The MagLev 2011 project consisted of the design, build and testing of a vibration isolation table which utilises magnetic levitation to overcome performance issues associated with traditional linear-spring-type isolators. The main purpose of a vibration isolation system is to reduce the transmission of vibration from the environment to the isolated payload, which may consist of precise, vibration-sensitive measuring equipment. Existing vibration isolation systems incorporating linear mechanical springs exhibit the undesirable characteristic of changing performance with changing payload mass. In contrast, the nonlinear force-displacement relationship of magnetic fields theoretically allows a constant resonance frequency across a range of payload masses via the use of a magnetic spring. The focus of the project was to design a stably levitating prototype capable of reducing the vibration transmitted to the isolated table. Active vibration isolation through the use of electromagnets as actuators was also implemented in order to improve performance. The exhibition will demonstrate vibration isolation using inclined permanent magnets as isolation elements, and details of the prototype’s performance results compared to existing systems. The prototype itself will be on display, as well as early conceptual design work.
11. Biologically inspired image processing and gaze control strategies for target pursuit

Student: Kerry Halupka
Supervisors: Associate Professor Ben Cazzolato, David O’Carroll & Steven Wiederman

A flying insect, whilst pursuing prey or mates, is engaged in a computationally challenging task. The small insect brain must visually detect and discriminate moving targets, which are embedded within a complex optical flow pattern (induced by ego-motion). Size-selective neurons within higher-order regions of the brain likely serve a role underlying this pursuit behaviour. Emulating these neural mechanisms would allow for the development of target detection and tracking algorithms. The aim of this project was to incorporate current bio-mimetic models for target detection in applications for target pursuit. A major goal of the project was to implement the key elements of the model using industry-standard discrete-time simulation tools, thus opening up practical applications of the model for real-time, closed loop simulations or robotics. Other additions to the model include a velocity sensor and a more physiologically accurate filter. The resultant model was tested for efficiency and accuracy to biological pursuit tactics within a virtual world specifically designed to emulate an insect's natural environment. This exhibit will showcase the design and development of the algorithms, including testing within the virtual world. The model, and movies of simulated pursuits, will be on display.

12. EDWARD 2011 – ‘cause it rocks

Students: Jonathon Atterton, Benjamin Davis, Samuel Hart & Erin Pearce
Supervisor: Associate Professor Ben Cazzolato
Sponsor: The University of Adelaide

In 2009 students at the University of Adelaide designed and built an electric diwheel known as EDWARD (Electric Diwheel With Active Rotation Dampening). The group was successful in producing an electric diwheel, a vehicle with two large coaxially aligned wheels with a frame suspended between them to seat a single driver. The project was continued by a new group of students in 2010, with the aim to improve both the mechanical and electrical systems, focusing on implementing software based control systems. The group made a number of changes to the diwheel, including upgrading to appropriately powered motors, implementing active slosh control and an inversion control system to allow the vehicle to be driven upside down.

Continuing on the hugely successful 2009 and 2010 projects, EDWARD 2011 has improved the electrical and electronic components of the diwheel with a focus on improving the control systems, ease of use, safety and reliability. Major goals have included rectifying existing flaws in the mechanical structure, upgrade or replacement of some of the electrical hardware and implementation of changes to the control system, including remote control capabilities. This exhibit will showcase the design process that went in to building the diwheel as well as demonstrate its capabilities, including slosh, swing-up, inversion and remote control.
13. Point of sale computer vision system

Students: Mark Warburton & Nicholas White
Supervisors: Associate Professor Anthony Zander & Professor Anton van den Hengel

The Point of Sale Vision System project involves the development of a prototype system to demonstrate the potential use of computer vision for the identification of the number and type of small articles present within a defined area. The project aims to reduce the time and labour associated with the identification of these small items by eliminating the tedious task of manual pattern matching by the checkout operator. The development of this vision system will include the construction of a rig that will house a camera in conjunction with a lighting system and an appropriate capture surface. A software system will also be developed for the image processing and identification of objects. The intent is for the customer to be able to place the small items for purchase on the capture surface in a defined area and the vision system will then identify the parts, the number of each and any associated information such as price. This information will then be displayed visually to the checkout operator through a Graphical User Interface.

14. Autonomous Sailing Vessel

Students: David Seidl, Adam DiFiore, Sam Harris, Donal Gallagher, Rob Morris, Tom Murphy, Matt Paes, Nathan Costi, Benjamin Bowmer, Christopher Ferdinands & Christopher Lee
Supervisors: Associate Professor Bassam Dally, Associate Professor Richard Kelso & Dr Steven Grainger
Sponsor: Exide Technologies

SCIPPAR – Sailboat with Controlled Intelligent Path Planning for Autonomous Racing

The Autonomous Sailing Vessel project aims to achieve two primary goals. These goals are to modify a pre-existing vessel to complete an autonomous voyage and to develop a new vessel concept for future autonomous sailing.

The vessel to make the journey was built using an existing Heron dinghy. Off-the-shelf components were employed to provide physical control over the sails and the rudder. Control of these actuators are achieved through use of the real time operating system, QNX, and an Arduino microcontroller.

The concept vessel will be purpose-built for autonomous use, with no compromises being made for human integration into the design. This fully autonomous vessel has been designed to be inherently stable and operate for extended periods of time.

Although the Autonomous Sailing Vessel is primarily designed for autonomous racing, its concepts can be applied to a wide variety of applications. These may include autonomous long term marine research,
marine patrols and border protection or reacting to marine environment emergencies such as oil spills.

The exhibition will showcase the vessels adapted for autonomous sailing, and present the methods used to develop them. The concept vessel will be presented, and the work behind its development will be explained.

15. Automatic wine bottle alignment system for labelling

Students: Mustafa Amiruddeen, Theodore Foster & Jiaping Pu
Supervisors: Dr Ley Chen & Dr Eric Hu
Sponsor: David Franz Wines

The aim of this project is to create an automatic alignment system for labelling wine bottles, for our sponsor David Franz Wines. David Franz Wines currently utilises a painting system, which with additional colours requires alignment, in order to create label designs that are unique to the winery. If the alignment of the label painting system is offset slightly when applying a new colour of paint, major defects can be seen within the bottle label and they are no longer eligible for sale. It is also imperative that the new automated alignment system does not interfere with the currently used labelling system. The project’s success is solely dependent on its image processing system, which will be used to automate the current manual alignment system. The image processing is carried out using a digital camera and simple programming, and this methodology can be applied to many different designs which give our sponsor flexibility when designing their labels. In order for the image processing to be carried out efficiently, drive systems are required to rotate the bottle to the position required by the image processing system and actuate different parts of the existing system. A system such as this which is completely automated would reduce the risk of human errors which was the major concern in the manual system. The exhibition displays the prototype of the subsystems, video results of the testing, the structural design, and it also provides an overview of image processing and the understanding behind the programming used.

16. Building Energy Simulation Models for Jacob’s Creek Visitor Centre

Students: Andrew Crocker, Shouyang Lai & Terence Taye
Supervisors: Dr Ley Chen, Dr Zhao Feng Tian & Dr Eric Hu
Sponsors: Jacob’s Creek & Orlando Wines

This is a research project in the field of sustainable energy. By increasing the overall energy efficiency, the electricity usage and carbon footprint can be reduced in large commercial buildings. For average commercial buildings a large portion of the energy usage is in the Heating, Ventilation and Air Conditioning (HVAC) Systems.
Attempting to increase the energy efficiency of such a building can be difficult and costly due to the lack of knowledge about the energy inefficiencies occurring. This project involves thermodynamic modelling of the Jacob's Creek Visitor Centre (JCVC) located in South Australia as an example of how inefficiencies can be found and reduced. The energy consumption of the HVAC systems of the whole building has been modelled using EnergyPlus. The indoor air flow, temperature distribution and air conditioning duct system have been modelled using Computational Flow Dynamic (CFD) modelling methods. From these simulations, thermodynamic models obtained from the models can be compared with the results from experimental tests. The findings of this comparison can then be used to create simulations of the JCVC building with changes implemented in an attempt to reduce the energy usage. The results of these simulations indicate that the energy usage of the JCVC's HVAC system may be reduced by up to 30% if the modelled changes are implemented to the real system.

The exhibition provides an overview of the simulation results to improve the energy efficiency of JCVC. The method outlined in this project could also be applied to other commercial buildings.

![Simulation results](image)

17. Research and development of an autonomous, solar powered unmanned aerial vehicle

**Students:** Michael Giuliani, Bradley Hocking, William Ling & Michael Psalios

**Supervisor:** Dr Ley Chen

**Sponsors:** Saint Spyridon Greek Orthodox Parish and Community & Gochermann Solar Technology

Although still in its infancy on the world stage, a solar powered unmanned aerial vehicle (UAV) will open the market to a green option for military and civilian applications. The objective of this project is to present the design methodologies and test results of a solar powered UAV which can achieve 24 hour endurance. The robust conceptual design methodology employed a systems engineering approach resulting in a highly optimised solution. The development of the wing design was an iterative process, where the main driving factor was to provide sufficient surface area such that the solar cells could deliver the required cruise power whilst charging the batteries. Additionally, an aerofoil with high lift was necessary in order to achieve low power consumption. However, limitations were imposed on the wing’s upper camber to avoid reductions in solar efficiency, limiting its aerodynamic performance. Testing was carried out on many of the UAV components to compare with the initial parameter estimates and manufacturers specifications and to prepare the UAV for flight testing. On display at this exhibition will be a variety of exciting items including; a model UAV that was used during the testing phase; the centre wing section of Solar Eclipse complete with structure and solar array; videos of the component and flight tests; and many interesting and informative posters describing aspects of the design.
This project received very positive feedback at an international conference and has potential to fuel further research at the University of Adelaide.

**18. Retrofit an Old Van for Electric Drive**

**Students:** Dale Todd, Scott Retalick, Tim Hilton & Stephan Bouwer  
**Supervisor:** Dr Ley Chen  
**Sponsor:** Molnar Engineering

The increasing interest in society to reduce carbon emissions and explore alternative energy sources for the automotive industry, has lead Molnar Engineering to form a partnership with an engineering team from the University of Adelaide. The aim of the project was to retrofit an internal combustion-powered van to all-electric drive. On display will be an all-electric, retrofitted 2002 Mitsubishi Express van. This vehicle was selected with the intent of being used for light courier work whilst providing the potential for garage hoist developments. The all-electric drive system was designed to deliver a calculated driving range of at least 50km on a single battery pack charge, when driving at metropolitan speeds. To achieve this goal, leading technology batteries were used to power a high efficiency 3-phase AC electric motor and controller. The vehicle also features onboard mobile charge capabilities, power assisted brakes, electric demister and a 12 volt power supply for auxiliary components and accessories. The major design challenges included the integration of off-the-shelf purchased electric vehicle components with original factory components of the vehicle such as the manual gearbox and drive train. Two primary design requirements were to maintain the vehicle’s original load space and to construct a vehicle which was user-friendly and similar in operation to conventional road vehicles. The vehicle was designed in accordance with local road transport authority regulations. Visual multimedia will illustrate and describe the processes involved during the engineering selection, design, manufacture, implementation and testing phases of the project, along with potential future developments and optimisation. The team’s research into the environmental impacts and viability of retrofitting vehicles for all-electric drive will also be displayed.

**19. Innovative Scissor Lift Design for Automotive Industry**

**Students:** Yuanyuan Bian, Tao Liu, Lu You & Long Zhang  
**Supervisor:** Dr Ley Chen  
**Sponsor:** Molnar Hoists

Innovative Scissor Lift Design for Automotive Industry is a cooperating project between The University of Adelaide and Molnar Engineering. This project aims to reduce shipping cost of Molnar Scissor Lift, SL02, by cutting off the shaft between scissors. However, the remove of shaft leads to the unbalance between the two sides. To fix this problem, some mechanical modifications and one mechatronics control system are going to be invited into the design. The control system is composed by sensors, valves for hydraulic system and programmable logic controller (PLC). Some brackets are designed and added to the hoist for the sensors. The project team is required to combine these new stuffs with hoist and make the scissors synchronised. The new design does not only aim to reduce the shipping cost but also make the whole system perform well without mechanical linkage between both sides. The whole system should be different after the team’s work. The exhibition will provide an overview of the new hoist system and the team’s achievement. This innovative design will be commercialised by Molnar Engineering later this year.
Due to the continual increase in human life expectancy the frequency of bone fractures associated with poor mechanical quality has also increased. Understanding the mechanical properties of bone can aid in better identification of patients at risk of fracture and in the development of targeted treatments to improve bone strength. Bone is a complex multi-phase composite having mechanical properties that are strongly dependent on its constituent parts. Bone also has in-built toughening mechanisms that help to resist fracture. The key components of bone material are the organic phase (primarily Collagen I) and the inorganic phase (Hydroxyapatite crystals).

This research aims to investigate the contribution of the organic and inorganic constituents to the fracture resistance of cortical bone. This involves a selection of in vitro treatments that will alter the quality of the constituent phases in order to evaluate their individual contribution to the fracture properties of bone. Miniature fracture specimens were machined from a bovine humerus and radius and were subsequently mechanically tested. The fracture resistance curve (a representation of the resistance of the material to fracture) was obtained as a function of crack growth using the unloading compliance method. To supplement this technique, stages of the crack growth were sequentially labelled using fluorochrome stains to observe the crack path and natural toughening mechanisms. The exhibition will present an overview of the study including the results from the fracture testing and microscopy analysis. This work has shown that each phase of cortical bone contributes in a unique manner to the fracture resistance and toughening mechanisms present in cortical bone.

The quality of bone in any person is dependent on a myriad of variables, including age, physical activity and disease; and over a lifetime typically degrades, especially trabecular bone consisting of both organic and inorganic constituents. Trabecular bone is found at the end of long bones and transmits a large percentage of loading from the joint surface to the mid-shaft of the bone, while also filling the inner space of vertebrae in the spinal column. The structure of trabecular bone is a sponge-like lattice, which has a micro-architecture specifically adapted for the loads it experiences. Biological processes, such as non-enzymatic glycation, which alters the covalent bonding between proteins in trabecular bone, can dramatically affect the mechanical behaviour of the bone material. Non-enzymatic glycation naturally occurs with age and is accelerated in diabetes mellitus patients, and has been reported to lead to increased risk and frequency of fracture.
The prime focus of this study is to analyse the effects of non-enzymatic glycation via mechanical compressive reloading of bovine bone samples. Secondary to this, the effect of demineralization and denaturing of proteins was also investigated. The exhibition will present the background theory behind this investigation, as well as the development of the methodology, results and future work.

22. Design and build of Mini Shear Test Rig for composite materials  

**Student:** Ashley Skewes  
**Supervisors:** Dr Antoni Blazewicz, Dr John Codrington & Associate Professor Andrei Kotousov

Biomedical Researchers from the School of Mechanical Engineering at the University of Adelaide intend to study the shear testing of bone samples using microscopic analysis to find the effects of disease in humans and animals. This will be achieved by comparing the fracture of healthy and diseased bone during sinusoidal fatigue tests. Unlike industrial materials that can be produced in large sizes, bone samples are limited by the size of the bone. This project produced a mini test rig that facilitates effective application and measurement of shear loads applied to a bone test piece. The project was separated into three components that were designed separately including the test rig structure, the drive system and the test-sample holding mechanism. The complete unit fits under a microscope so weight and size were important attributes to minimize during design. Financial constraints have restricted the hardware options available which have in turn dictated the design of the unit. The mini shear test rig will be on display at the exhibition together with a brief overview of the design and implementation process.

B) Measurement of hydrogen content in low alloy steel weldments (sub-project)

**Students:** Robert Duffield & Tiong Sern Ng  
**Supervisors:** Associate Professor Reza Ghomashchi & Dr Nicolas Coniglio

Hydrogen assisted cold cracking (HACC) is a serious issue that affects the pipeline industry worldwide. Hydrogen introduced to the weld metal during the welding process can result in crack formation within a few days after the weld completion. Many weldability tests have been developed to determine the HACC susceptibility of weld metals. However these tests provide qualitative rankings rather than a quantitative characteristic value of the thermo-metallurgical factors promoting HACC. The two factors promoting HACC that Project 1103 concentrates on are the critical stress limit and the diffusible hydrogen content.

Among the numerous tests to characterize pipeline girth welds, the WIC test has been extensively used because of its suitability in reproducing conditions close to the ones encountered during pipeline girth welding. However this test has several drawbacks such as the cost of manufacturing, the inability to be reused and difficulties applying instrumentation. A re-usable test to determine the critical stress for HACC to occur is greatly desired.

This project aimed to determine the feasibility of, and to design, a test rig that is able to perform weldability tests on weld metal alloy steels. An investigation into the requirements of such a rig was performed to determine the specifications that needed to be matched. The rig specification requires a controlled loading, instrumentation for determining local conditions for cracking, a crack detection device and ability to be implemented on the universities automatic welding machine, the AUTORON, which limits the rig size and weight. After having laid down the different possibilities a hydraulic system has been selected for load application. Specific instrumentation has been proposed to allow the acquisition of the necessary data for analysis.
The subproject aimed to design suitable apparatus and the correct method to be used to prepare and test specimens to determine the diffusible hydrogen content of the weld metal. Although mass spectroscopy and gas chromatography were initially considered, a silicon Oil immersion technique was chosen. This method has the benefits of being cheap and fast, and does not place reliance on the use of external equipment or resources.

25. Tomography of Stress Corrosion Cracks

Students: Simon Craig, Eleanor King & Glenn Sneddon
Supervisors: Dr Erwin Gamboa & Dr Nicolas Coniglio

Stress corrosion cracking (SCC) is a highly localised form of corrosion, which can pose a significant threat to the integrity of gas transmission pipelines. Previous failures have cost millions of dollars and have resulted in loss of life. The goal of this project is to improve the understanding of high pH SCC in pipeline steels by producing a time-stepped movie of three dimensional SCC growth and investigating the effect of the microstructure, metallurgy and existing crack morphology on crack growth rates. The three-dimensional nature of the crack is an important factor for crack interaction and, there is no existing research that has investigated the three-dimensional macroscopic growth of high pH SCC as the crack grows. In this study, SCC has been induced in an API 5L X65 pipeline steel using a linearly increasing stress test machine. X-ray computerised tomography to generate cross-sections and three-dimensional models of the sample at different stages of testing. These cross-sections were examined to estimate crack growth rates and stress intensity factors along the crack front. Both optical and electron microscopy was used to analyse the microstructure and metallurgy along the crack path. This seminar will report on the results to date, including the cross-sections and three-dimensional models of cracked samples. The exhibition will present the results of this research, including the 3D models of the samples, images of selected fracture surfaces and cracks and an analysis of crack characteristics. Some cracked samples will also be on display under a microscope.

26. Development of new oil, gas and environmental technologies utilizing natural fracture network

Students: Barnam Bora, Michael Davis, Jessica Goodchild, Aditya Khanna, Kate McKenzie, James Sobey & Paul Weller
Supervisors: Associate Professor Andrei Kotousov & Pavel Bedrikoetsky

Conventional hydrocarbon reserves are becoming less viable as an energy resource. This has led to global interest in unconventional resources, such as Coal Seam Gas (CSG). Within Australia, CSG is an unconventional resource which has emerged as a fast growing industry. CSG has the potential to deliver cleaner power when compared to coal fired electricity plants and presents itself as a lucrative export commodity. However, large scale CSG production has not been possible due abundance of cheap mined coal coupled with the low permeability of Australian coal seams. In order to make CSG production economically efficient, new production enhancing technologies need to be investigated.

The objective of this project is to investigate a novel reservoir stimulation technology utilising graded proppant (sand-like particle) injection. Implementation of this technology will allow for sequential filling of the natural fracture network, leading to significant increase in permeability and well productivity.

A mathematical modelling approach is adopted to investigate the fluid and mechanical phenomena involved. These models have been incorporated into a industry ready computer software application. It is expected that the implementation of this technology would enhance CSG production under Australian conditions.
27. Design and build of a plasma thruster for MAV application

Student: Amelia Greig
Supervisors: Dr Maziar Arjomandi & Dr Cristian Birzer

Micro Aerial Vehicles (MAVs) exhibit great potential for reconnaissance and surveillance uses, both military and civilian. Currently, one of the biggest challenges in MAV operation is developing a propulsion system capable of providing a sufficient thrust to weight ratio. Dielectric Barrier Discharge (DBD) plasma actuators produce an ionic wind that transfers momentum to the surrounding air. While DBD plasma actuators have mostly been investigated as active flow control devices, the momentum transfer to the air produces a net thrust that could potentially be used to power a small aircraft.

This project investigates the use of DBD plasma actuators as a propulsion system for MAVs. The configuration of the actuator and the resulting effect on the thrust produced were investigated through direct force measurements, Particle Image Velocimetry and Computational Fluid Dynamics. Theoretical relationships between various actuator parameters and response force generated were developed to compare with the experimental data. From this, a prototype plasma thruster for MAV application was designed, built and tested. The exhibition will provide an overview of the experimental results, thruster design and thruster testing with the prototype plasma thruster on display.

28. Design and build of an aileronless UAV

Students: Brooke Balogh, James Connell, Samuel Dudley, Mark Fosdike, Craig Lucas, Stephen Robb, Tyler Schembri & Peter Tsimopoulos
Supervisor: Dr Maziar Arjomandi
Sponsors: Aztronics Pty Ltd, R & M Balogh, Clark Surfboards, Carbon Fiber Australia, Codan, GIGAVAC, Noarlunga Model Aerosports, GTP Financial Services Pty Ltd & QPE Pty Ltd

Actively controlling the flow of fluid over an aircraft wing has been an area of increasing interest and investigation in recent years. This technique, known as circulation control, enables an enhancement of lift and a change in the drag produced by a conventional wing, which in turn can have beneficial effects on fuel consumption and operating costs. This project aims to serve as a proof of concept for applying dielectric barrier discharge (DBD) plasma actuators to control wing circulation in order to achieve rolling manoeuvres of an Unmanned Aerial Vehicle (UAV). This modern plasma technology is remarkably simple and highly robust. When a high voltage is applied to the electrodes, a strong electric field is produced and triggers an avalanche of electrons, converting the local atmosphere into ionic plasma. When properly applied, this phenomenon can be used to control the aerodynamic vortex produced by every aircraft, potentially replacing conventional ailerons. Plasma actuators are a lightweight, easily controllable electronic alternative to mechanical ailerons and are easily implemented onto the surface of a wing without the need for structural alteration.

The changes in wing lift produced by plasma actuators were investigated through both stationary thrust testing and active wind tunnel testing. Constructed as a test platform for the plasma actuator technology, a UAV dubbed ‘SPARC’ was designed and manufactured to be equipped with DBD plasma actuators in place of mechanical control surfaces. The exhibition displays the results of these efforts, providing a detailed insight into the workings and benefits of this new aviation technology and how it can be applied for practical benefit. On display will be the UAV SPARC along with demonstrations of the onboard electronics systems that were used to monitor and implement plasma-actuated roll control.
29. Modelling and optimisation of air distribution systems for commercial aircraft cabins using CFD techniques

**Students:** Gary Cai, Jason Ting & Samuel Woo  
**Supervisors:** Dr Zhao Feng Tian & Associate Professor Bassam Dally

This project investigates the use of personalised ventilation systems in aircraft cabins to better understand and improve the microclimate around the breathing zone of each passenger. The high density and close proximity of passengers in the enclosed aircraft cabin environment exposes them to the risk of contracting airborne diseases such as the common flu, SARS, chickenpox and tuberculosis. This risk is further aggravated by the increased geographical coverage, frequency and duration of modern air travel. Current aircraft personalised ventilation systems still cannot ensure a constant circulation of fresh humidified air around each passenger’s breathing zone to shield them from airborne contaminants. Hence novel designs, that could be easily manufactured and integrated with current aircraft cabin seating designs, have been proposed and evaluated using computational fluid dynamics (CFD) techniques. The optimal personalised ventilation system design will create a constant supply of fresh air to each passenger’s breathing zone. It will also shield them from harmful contaminants throughout the flight. Due to the limited availability of CFD functions, various CFD models were developed using CFX Expression Language (CEL) to properly investigate such cases. A further validation of different turbulence models were done, by verifying with respective experimental cases, to ensure reliable results were obtained by the selected turbulence model used. The exhibition provides an overview of the various CFD models developed, PV designs and how the performance of individual PV designs differs from each other. Animations of each design will be shown to display their effectiveness.

30. FSAE Aerodynamics Package

**Students:** Llewellyn Thomas, Dylan Stevens & Andrew Karas  
**Supervisors:** Dr Antoni Blazewicz & Dr Zhao Feng Tian  
**Sponsors:** FGI & Centreline Patterns

Formula SAE is an open-wheeled motorsport competition with vehicles designed by engineering students from different Universities across the globe. New rules in the 2011 competition allow drastically more freedom in the design of the vehicle aerodynamics. This project investigates the feasibility of fitting an aerodynamics package to The University of Adelaide’s 2011 entry into the competition. The aerodynamics package is comprised of devices which change the way the airflow passes over the car, altering the aerodynamic forces acting on the car. The goal of the package is to improve lap times of the vehicle and ultimately its final score obtained at the competition.

Reducing the drag force created by the car bodywork as well as any additional aerodynamics package devices will enable the car to achieve a higher top speed. However, much more significant to increasing overall performance is the maximising of downforce imparted on the car, ultimately allowing it to corner faster and brake harder. To achieve this, the project has extensively utilised computational fluid dynamics (CFD) as a low-cost design tool, while wind tunnel testing has also been carried out in order to assess the accuracy of the computer simulations. The exhibition presents an overview on the design, costing, manufacture and testing of the aerodynamics package, while the final front and rear wing assemblies shall be on display.
What is the best way to manage a volunteer organisation? More specifically, a volunteer group of University students from different year levels and different academic backgrounds, charged with the engineering challenge of building a Formula SAE racing car? This was the problem when student interest sparked the reformation of the Formula SAE team at The University of Adelaide in 2010. Unlike previous University of Adelaide teams, students would be undertaking the project as an extracurricular activity and not part of any formal studies.

Faced with this problem, where do you start? What motivates volunteer participation in the Formula SAE team? What expectations do these volunteer team members hold? What is the motivation for sponsors to provide financial and in-kind support? What are the benefits to students and the University? These questions and many more required understanding before any effective management plan could be developed.

The 2011 Formula SAE Management project has sought the answers to these questions to establish a suitable long term team strategy and develop and implement an appropriate management structure encompassing Engineering, Finance & Human Resource Management. These outcomes will be used as the basis for a sustainable Formula SAE team at the University of Adelaide.

The results of some of the questions posed as part of this project are quite surprising, these together with the proposed strategy and management structure are presented as part of the display.

32. Design and Fabrication of submarine model

This project was initiated by a group of students who are aspiring to learn more about submarine design and modern submarine technologies. The ultimate goal of the project is to design and construct a fully functional autonomous submarine, which is capable of performing a range of practical missions such as underwater pipeline inspections, exploration, and surveillance tasks. Specific objectives for this year included development of the concept, and the design and fabrication of the major components and systems of the submarine. The design process and decisions are supported by computational analysis of the main structural components, hydrodynamic performance, and motion control. Trials of the submarine have confirmed its expected capabilities and characteristics. At the exhibition the structural components and control systems will be on display together with the recorded videos of the trials.
33. Experimental and CFD analysis of jet flow for noise research

Student: Anthony Muggridge & Delong Qu
Supervisor: Dr Con Doolan

With approximately 11.6 million passengers flying into or out of Australian airports each year (Australian Bureau of Statistics 2011), sound created by aircraft is an important problem that needs urgent solutions. The University of Adelaide aims to build a test facility within the University's anechoic chamber to study the noise produced by jet turbulence. This project aims to provide design recommendations for such a facility to ensure it is both safe and useable. CFD (Computational Fluid Dynamic) models and experiments are what are being used by the project to make the recommendations. The CFD models have been verified and validated to ensure an accurate final model. The experimental setup is a scaled and simplified model of the proposed design to be built within the University’s anechoic chamber. This design involves a jet nozzle in one wall of the chamber and a collection cone in the opposite wall to allow air to exit the chamber. The exhibition provides an overview of the methodology used in verifying and validating the model as well as the requirements needed for the facility to be both safe and useable.

34. Simulation of a Thermally Soaring Unmanned Aerial Vehicle (UAV)

Student: Elise Fahy
Supervisor: Dr Maziar Arjomandi

Thermals are convective updrafts that occur naturally in the atmospheric boundary layer and can be exploited for energy gain by sailplanes, birds, and more recently, unmanned aerial vehicles (UAVs). Over the last decade, research into thermal soaring UAVs has involved theoretical models and numerical simulations of varying complexity, flight testing, and atmospheric data analysis. In this project a specific scenario of operation has been developed to test the feasibility of thermal soaring by evaluating performance. A thermal model has been developed in MATLAB using theoretical equations, weather data from the Bureau of Meteorology and aerial images of the operational area. This model generates a map over the operational area of average expected updraft speeds coupled with probabilities of finding a thermal with a particular updraft speed. The performance has been evaluated by using energy analysis and a Simulink model incorporating the equations of motion to find range and endurance. Combined with the thermal model, a simplified flight simulation has demonstrated a flight through the operational area using thermal soaring, and has determined the feasibility of thermal soaring for this scenario of operation. This exhibition outlines the outcomes of the project in two main areas: thermal modelling and performance evaluation.

35.-37. ASRI Multi-Stage Launch Vehicle


Students (Mechanical design team): Michael Bowen, Benjamin Gibbs, Dahe Gu & Ryan Hardman

Student (Avionics team): David Pohlenz

Supervisors: Dr Laura Brooks, Dr Steven Grainger, Dr Matthew Tetlow & Mr Matthew Steventon

Sponsors: Australian Space Research Institute, Sir Ross and Sir Keith Smith Fund, BAE Systems & Defence Science and Technology Organisation

The 2011 Australian Space Research Institute (ASRI) Multi-Stage Launch Vehicle (MSLV) is a continuing project which aims to increase the performance capabilities of current ASRI rockets. The MSLV will be a two stage rocket consisting of a Zuni rocket first stage and a Sighter rocket second
stage. The two stage configuration allows for higher velocities and altitudes to be reached compared to each individual rocket flown as a single stage. Completion of the MSLV will enhance the research capabilities of Australian universities and organisations. In 2011 the ASRI MSLV project consists of three teams: The Trajectory and Stability Analysis Team, The Mechanical Design Team and The Avionics Team.

The 2011 Trajectory and Stability Analysis Team (TSAT) developed a Range Safety Template (RST), which is a major requirement for the two-stage launch approval. Two RSTs were developed, one from the In-house software and the other from the Range Safety Template Toolkit (RSTT) provided by the Defence Science and Technology Organisation (DSTO).

The major design objectives of the 2011 Mechanical Design Team (MDT) were related to the Sighter second stage rocket and were to; investigate the potential design of a fibreglass body tube, the design of a new recovery system, the design of a supersonic flow test section and the design of a dual camera system. A vibration analysis of the single stage Sighter rocket as well as the two-stage rocket was performed as well as the optimisation of the stage coupling spigot designed by the 2010 MDT.

The Avionics Team has designed a new avionics system for the Sighter second stage rocket. The system must trigger the recovery system which deploys the parachutes at the appropriate points of the rocket’s trajectory and record data from a number of sensors including accelerometers, gyroscopes, pressure sensors and a Global Positioning System (GPS) module. GPS data must be transmitted to ground stations for easy location of the rocket after landing. A modular design has been used to facilitate easy reuse, modification or expansion in future years of the project.

The exhibition provides an overview of the objectives completed by each of the three teams and includes the Sighter payload with all mechanical and avionic components as well as the interactive In-house RST software.

38. Construction of a test rig and scaled aircraft wing for validation and comparison of a beam theory based wing model

Student: Samuel Polglase
Supervisor: Dr Maziar Arjomandi
Sponsors: School of Mechanical Engineering & DLR (German Aerospace Centre)

In preliminary aircraft design the initial estimation of the wing structures mass is an important component in any new aircraft concept. Classical mass estimation methods which employ the use of statistical data are not sufficiently accurate for new aircraft concepts which move away from conventional design and for designs which employ significant composite material structure. Thus it becomes necessary to create new methods which are capable of estimating this mass to a suitable degree of accuracy. This leads to less iterations further into the design process resulting in time and cost savings. A theoretical beam wing model, which was developed in 2010 through collaboration with the DLR (German Aerospace Centre), is the beginning of such a new mass estimation model.
The project compares the results of the mass estimation model against a physical wing through the use of a purpose-built wing structure and experimental test rig. The test rig subjects the wing structure to a static bending load which will simulate a span-wise lift distribution on the wing. This load and the resulting strain in the wing structure have been measured providing the experimental data needed for the successful validation of the wing mass estimation tool. The test rig and wing structure have been designed such that they will be suitable for future stress analysis related teaching in undergraduate course work.

![Test Rig and Wing Assembly](image)

### 39. Design and Build of a Prosthetic Attachment

**Students:** Allan Liu, Yi Lu, Hoang Sang Vu & Sarah Bruno  
**Supervisors:** Associate Professor Ben Cazzolato & Mr William Robertson  
**Sponsors:** Australian Institute of Sport & University of the Sunshine Coast

Each year over 100,000 trans-femoral amputations are conducted worldwide. Such lower-limb amputees often experience medical complications with the use of conventional socket-type prostheses such as tissue damage and infection. This further reduces their already compromised ability to perform the activities of daily living, or to participate in sporting activities. These restrictions subsequently predispose them to other health and well-being problems such as depression, obesity and low self-esteem.

To address this multi-factorial health issue, this preventative health research investigates an alternative method of prosthetic anchoring and attachment which mitigates contact forces through the flesh at the end of the residual limb, and without resorting to a pin which extends beyond the skin such as occurs with trans-cutaneous osseointegrated prostheses.

Finite element analysis was used to investigate alternative geometries and optimise the design. Two prototypes of the prosthetic attachment technology were developed and tested experimentally. The outcome is a technology that can support at least half the weight of the 80th percentile white male (100kg). This exhibit will highlight the results and future direction of this technology. Furthermore, both prototypes will also be on display for the public to interact with.

### 40. Replicating the 3D kinematics of the ovine stifle joint using a hexapod robot

**Students:** Simon Gilbie & James Tudor Tsourtos  
**Supervisors:** Associate Professor Ben Cazzolato, Dr John Costi, Dr Dominic Thewlis & Dr Paul Grimshaw

This research project forms a pilot study undertaken to investigate the feasibility of using a 6 degree of freedom robot in future biomechanical research. Physiological motion is very complex and current testing methods on biological specimens do not accurately recreate live conditions. If these methods
are proved to be successful, then it will allow for more physiologically accurate testing of medical devices, such as artificial joints and prostheses. The 3D motion of an ovine stifle joint (sheep knee joint) was measured in vivo and subsequently replicated in vitro in a hexapod robot co-developed by University of Adelaide and Flinders University.

The project consisted of two key stages. The first stage was the in vivo measurement of the 3D motion of the knee joint in a live sheep. Ethical clearance was granted for the required training and testing. Reflective markers were surgically attached to the hind limb to allow optoelectronic capture of the motion of the knee as the sheep walked down a specially constructed walkway. Ground reaction forces and bone strains were also measured to assist with validation.

The second stage of the project was to replicate the in vivo measurements using the hexapod robot. The joint motion recorded in vivo was processed and transformed ready for use as an input into the hexapod robot. The knee joint of the sheep was harvested and mounted in the hexapod robot for in vitro testing. The motion and biomechanical data of the knee joint when undergoing deflections in the hexapod robot was measured. This project has developed methods which will form the basis for further testing of in vitro specimens in a 6 degree of freedom environment.

The exhibition will present the results, equipment used, and images and video footage from testing.

41. Performance and damage assessment of composite archery arrows

**Student:** Marianne Rieckmann

**Supervisors:** Dr John Codrington, Associate Professor Ben Cazzolato & Mr Stuart Wildy

**Sponsor:** Easton Technical Products

This research project investigates the vibrational behaviour of arrows to determine significant changes that may occur due to structural damage. The performance of an arrow has been shown to be dependent on the vibrational behaviour, which is affected by physical attributes such as weight, bending stiffness, and the presence of damage. Modern archery arrows are constructed from composite materials that are strong and lightweight, however this composite structure is prone to damage from impacts during normal use.

In this project, the vibrational behaviour of arrows was investigated using analytical methods, finite element analysis and experimental work. Analytical methods for predicting the vibrational modes of cylindrical structures provide an understanding of the dominant modes of vibration of arrows. Finite element models present a detailed picture of the vibrational behaviour for both damaged and undamaged arrows. Analytical and finite element models were experimentally verified using a scanning laser Doppler vibrometer. Evaluation of the modal behaviour of arrows has shown a good match between the theoretical modelling and the experimental results. Comparison of the vibrational behaviour of damaged and undamaged arrows formed the basis of a feasibility study on the viability of a practical damage detection device.
This exhibit will present an overview of the theoretical and experimental results along with details of a practical damage detection device for composite archery arrows.

(Figure courtesy of J L Park)

42. Improved oxygen analysis for the use in a closed circuit rebreather

**Student:** Jonathon Adams  
**Supervisors:** Dr John Codrington & Ms Dorothy Missingham

With SCUBA diving becoming increasingly more popular, the environmental demands and performance requirements of life support equipment is continually pushed to its safe operating limits. Recreational, commercial, and military divers often require, or simply desire, equipment which allows for increased exposure of depth and or time. This need has led to the use of Closed Circuit Rebreathers (CCR). CCR’s operate by recycling the exhaled breathing gas, purifying the carbon dioxide and then replenishing the metabolised oxygen before being “re-breathed”. Current technology for rebreathers utilises electrochemical cells for oxygen analysis, however, the operating conditions the cells are subject to effect the output response when varied. Erroneous measurement may result in too little or too much oxygen being respired, potentially resulting in symptoms such as unconsciousness to full body convulsions.

This project focused on investigating the accuracy of electrochemical cells under variable operating conditions of a CCR, with an additional aim to assess the viability of alternative oxygen analysis techniques. A test rig was designed and built for controlling the environmental parameters of the gas flow (including humidity and temperature) and for determining the effect said conditions have on the accuracy on the oxygen cells. The monitoring of operating conditions improves the accuracy, and hence safety, of oxygen analysis in CCRs through real time calibration techniques.

43. Portable Bolt Tester for Rock Climbing Mk II

**Students:** Xiaolong Liu, Teng Sun, Qi Xu & Ji Yang  
**Supervisor:** Dr Erwin Gamboa

Sport rock climbing is one type of popular sport that is inherently dangerous and requires the utmost attention to safety. Safety equipment, including the bolts fixed in the rock, is used for reducing the risk of potential falls. The portable bolt tester MK II project aims to design a portable bolt tester for testing the integrity of bolts in the rock without any damage to both the bolts and rock. The climbing bolts may be installed by people with little or no experience and also the anchors may be degraded from exposure to the environment. Visual judgement of the safety of bolts is not reliable for all bolts. So a device is necessary to be designed to test the safety of the bolts, such as U bolt and ring bolt. In 2010, Portable bolt tester MK I was designed to be a portable device capable of applying 5KN test load to the bolts and measuring the resulting displacement. The device made in 2010 was not fully developed. The project
this year focuses on improving the loading system, designing a more accurate measurement system and reducing the total weight of the device. Compared with the 2010 design, the new device designed this year is expected to have an easier crank handle operation device, a more reliable measurement system with Monster Pod and 15%-20% weight reduction. The exhibition provides an overview of the bolt tester and the measurement system with the testing results of them.

44. One-handed walker

**Students:** Tung Yat Michael Cha & Hasith Cyril Pathirana Arachchige  
**Supervisor:** Associate Professor Anthony Zander  
**Sponsor:** Medical Device Partnering Program

Stroke victims and older people often have difficulties with their mobility during daily activities. This project involves the design, build and testing of prototype walker that permits either one hand or two handed operation. The design specifically addresses the needs of stroke victims or older people with limited strength in one or both of their hands and hence cannot easily apply the brakes in conventional walker designs. The design assists the users to apply the braking force and also applies brakes to both wheels at the same time avoiding the danger of skidding the device to one side. In addition, this project will investigate the potential for the device to be used as a dining chair by the user to overcome problems encountered with accessing and moving into position a conventional dining chair.

45. Make a splash

**Student:** Nick Kastelein

**Supervisors:** Associate Professor Ben Cazzolato, Associate Professor Richard Kelso & Mr Richard Jones

Water is used for recreational activities all over the world. One of the most common water activities is doing "bombs"; leaping into the water and trying to make as big a splash as possible. It has been observed, however, that the ability to make a large splash is not necessarily just dependent on the size of the person jumping in. The purpose of this project was to analyse how the shape of a projectile influences the magnitude of the splash it will make upon entering the water, to better understand this phenomenon.

This project builds on previous research into splashes which was motivated by military demands, the shipping industry, and professional diving, where minimising splash is desirable. The study of splash mechanics can be traced back to 1908 when A. M. Worthington published photographic results of a variety of splash scenarios. Later research focused on entrance velocity, object size, and interface properties and most research has involved spherical projectiles, though some experimentation has included other discrete shapes.

In contrast to all previous splash research, the goal of this project was to maximise the splash from a projectile. The scenario was controlled by only considering water entries of axi-symmetric, 725 gram, aluminium projectiles with the same entrance velocity. Numerical optimisation of splashes simulated using a transient, two-phase CFD model was undertaken to maximise the splash for these constraints. Lastly, the results of the CFD model and optimisation were validated experimentally using manufactured projectiles and high frame rate video recording. At this exhibit, slow-motion video flow visualisation and
numerical simulations of splashes will be on display, and information will be available about how CFD has created opportunities for modelling and understanding many different real-world fluids problems.

46. Cheating Road Bike

**Students:** Chen Huang Lu, Jonathon Schubert & Oakkar Zaw  
**Supervisors:** Mr Gareth Bridges & Dr Paul Medwell  
**Sponsor:** BikeSA

Cheating undermines the integrity of sports throughout the world. In the last few decades professional road cycling has been riddled with confirmed instances of drug cheating, and further allegations that have clouded every great performance. However performance enhanced bicycles are the causes for new recent allegations whereby bicycles are now including hidden propulsion devices, otherwise known as ‘mechanical doping’. The cheating road bike project aims to demonstrate that this form of cheating is possible via the use of an undetectable artificial propulsion device that is able to provide a significant performance advantage over competitors.

The project aims to design, build and test a hidden device comprised of an electric motor, battery power source and drive transmission system that allows the ride to gain an advantage 5% power increase for a 10-minute period of the race – without detection. This device will be concealed within the frame of the bicycle, provided by BikeSA, and aim to bypass current detection methods implemented by the International Cycling Union (UCI), including the recently introduced X-ray detection method imposed onto the professional cycling teams. The exhibition will display the project to date; and methods of testing and validation that have been employed.

47. Cricket Bowling Machine 2011

**Students:** Richard Borrelli, Cameron Chitty, Mitchell Parker & Maxwell Schlicker  
**Supervisors:** Dr Paul Grimshaw & Associate Professor Richard Kelso  
**Sponsors:** Quin Sports and Nets & A1Anco Engineering

Cricket is a physically demanding sport with an increasing rate of overuse injuries to fast bowlers. In an attempt to minimise these injuries, the workload of a bowler can be reduced with training aids such as cricket bowling machines. Cricket bowling machines have been used for over 20 years but have limitations such as being too predictable, electricity dependent and unable to bowl real cricket balls.

Cricket Bowling Machine 2011 followed on from the 2010 Cricket Bowling Machine project which developed a new mechanical cricket bowling machine. Project 1201 has improved the 2010 Cricket Bowling Machine into a feasible training aid that has a quicker reload time, is safer, more reliable and easier to use. The 2011 Cricket Bowling Machine has been designed to repeatedly and reliably bowl deliveries at approximately 120 km/hr. With further development, the machine could potentially become
a commercially viable product that could benefit a variety of users from schools and local cricket clubs to professional teams.

Innovations from the 2011 project include a new energy generation system with a more efficient energy release mechanism, tensioning mechanism and length adjustment. The exhibition will provide an overview of the design and manufacture of the new bowling machine and the results from field testing. The Cricket Bowling Machine will also be on display with demonstrations throughout the exhibition. Come and see the new Cricket Bowling Machine in action.

### 48. Modeling of spinal loads during office work tasks

**Student:** Samuel Dyson  
**Supervisors:** Dr Paul Grimshaw & Dr Michael Cole (Australian Catholic University, Brisbane)

Low back pain (LBP) is a musculoskeletal condition that affects millions of Australians each year. It has been reported that between 15 and 40% of the general population of developed countries are affected by low back pain annually and it is estimated that between 60 and 90% of people will experience LBP in their lifetime. For decades, scientists have been conducting research aimed at determining the causes and risk factors for LBP, but there is still considerable debate in the literature. Much of the research surrounding low back pain has focused of Manual Materials Handling (MMH) in industry which involves lifting, lowering, pushing, pulling, bending and twisting. Less attention has been given to how LBP may be caused or aggravated among common office workers, people who do not regularly lift heavy objects while at work, yet still report experiencing LBP. Despite the prevalence of this condition, 70 to 80% of all reported cases are idiopathic. The lumbar spine, also known as the lower back, experiences significant loads during lifting and body movement and is a common site of injury.

The aim of this project is to collect three-dimensional (3D) kinematic and kinetic data for tasks common to office workers, such as rising from a chair with and without armrests and use these data to model the loads on the lumbar region of the spine. Experimental results will be presented along with experimental equipment and software.

### 49. Cycling Performance

**Students:** Stephen Jeffs, Marek Carls & Arjun Palaniappan  
**Supervisors:** Associate Professor Richard Kelso & Dr Paul Grimshaw  
**Sponsor:** Dr David Bentley

Optimisation of efficiency and power is imperative in the world of elite cycling and can be achieved by changing the bicycle geometry, most commonly the crank length. This project aims to build on a previous study on cycling performance by Callaghan and Shelton (2010). The project involves testing fit male subjects at a range of cadences at various crank lengths to determine which crank length and cadence yield the highest efficiency. Furthermore, a group of subjects will be tested at five crank lengths for maximum power output over six second intervals.

The testing is conducted using the Wattbike, a stationary bicycle designed in collaboration with British Cycling. It has been modified with the inclusion of variable length crank plates (in 2010) and a handlebar clamp to change the horizontal and vertical positions of drop handlebars. A breath gas analyser, the Cosmed k4b2 is used to obtain respiration data from subjects for the calculation of efficiency. Optimal crank length and cadence data will be analysed in relation to subjects’ leg dimensions and height to provide recommended crank lengths for maximum power and efficiency.
50. Bicycle Aerodynamic Test System

Students: Aaron Miller, Peter Damin & Joshua Halman
Supervisor: Associate Professor Richard Kelso

Cycling is renowned for being a competitive sport throughout the western world and has recently seen an increase in popularity. Research has shown that at high speeds, aerodynamic drag can account for up to ninety percent of the overall resistance on a standard bicycle. Wind tunnel tests allow for a bicycle to remain stationary whilst air flows over it, allowing aerodynamic forces to be measured. This testing method can allow subsequent adjustments, resulting in a quantified reduction of drag. The aim of this project is to design and build a Bicycle Aerodynamic Test System that can accurately and precisely measure the aerodynamic forces on the bicycle and rider in various configurations whilst the bicycle is being actively ridden. This system is designed to be used in the University of Adelaide’s newly constructed wind tunnel at their Thebarton campus and will be the only such system in South Australia. After extensive benchmarking and research, the system incorporates useful and innovative features of previous designs into a simple, user-friendly package, resulting in a competitive world class design. The completed rig will be on display.

51. Solar chimney for desalination

Students: Adrian Khor, Hyun-woo Lee & Ivan Khoo
Supervisors: Dr Maziar Arjomandi & Associate Professor Bassam Dally
Sponsors: Intercast & Forge and Panurgem Consulting Engineering

A solar chimney is a sustainable thermal technology which harnesses solar energy using a solar collector during the day to create an updraft of hot air through the chimney. There are several practical applications to this technology, such as room cooling and food drying. However, the use of a solar chimney to provide a passive alternative to water desalination has been largely unexplored. The aim of this project is to determine the feasibility of a solar chimney for desalination, followed by the design and build of a physical proof-of-concept (POF) of a solar chimney system capable of desalinating at least 1 litre of saline water a day. The system will comprise of 4 subsystems: a solar chimney, solar collector, water mistifier evaporation system and a condenser. To aid the design process, the behaviour and performance of the solar chimney has been simulated using Matlab and CFD. These results were then validated using published research works and preliminary experiments before manufacturing of the final design is undertaken. This exhibition will showcase the proof-of-concept (POF) model of the solar chimney developed and project outcomes. Upon successful completion of the project, this concept could be implemented in dry rural areas around Australia as a cheaper and cleaner alternative to the current commercial desalination plant.
52. Design, build and test of a high-efficiency smart Darrieus wind turbine (phase 2)

**Students:** Mark Bourne, Ricky Tso, Peng Cheng, Alex Merenda & Scott Schulz  
**Supervisor:** Dr Maziar Arjomandi  
**Sponsors:** AGL Torrens Island, Maxon Motor, Bolly Aviation & Basetec Services

Increased demand for sustainable, distributed energy production systems has led to a market opening for small scale wind turbine technology that is efficient and low impact. With sponsorship and support from AGL Torrens Island, Maxon Motor, Bolly Aviation and Basetec Services a small Vertical Axis Wind Turbine (VAWT) of the gyromil type with active pitch control has been designed, built and tested to fill these technological requirements.

Multiple Streamtube modelling, efficient turbine blades, control systems design, manufacture and testing have been the main focus of the project. The resultant Smart VAWT system is capable of self starting and behaving in both drag and lift configurations, making it efficient in low and high wind speeds. The turbine will be at the exhibition with composite blades installed. Test results, prototype blades and a demonstration of the control system will also be presented.

53. Coarse Tailings De-Watering Project

**Student:** Nathan Scott  
**Supervisor:** Dr Erwin Gamboa  
**Sponsor:** OneSteel

Due to the diversity and rapid growth within the Australian mining industry operating methods and equipment are constantly changing and improving. Through awareness of this rapid, diversified growth and with the goal of addressing and improving operating issues, the company OneSteel has sponsored this project to investigate the options available for tailings dewatering. Currently at their short-term coarse tailings storage facility, OneSteel are experiencing unsatisfactory dewatering as the process in place does not remove enough water from the tailings slurry.

This project explores the options available for eliminating this excess water through an effective dewatering process that would reduce current cleanup needs, sustain the operating life of the storage facility and increase the percentage of water reclaimed from the process. Research findings from this project have identified, defined and quantified the main causes of inadequacy of the current system. An extensive literature review then enabled an early selection of a conceptual solution to the dewatering problem to be proposed. From these research findings and in conjunction with OneSteel, testing of the proposed solution was undertaken and has yielding promising results. This exhibition will present the research findings that led to the proposed concept selection along with testing results obtained to date.
54. Ultrasound for the Control of Cyanobacteria

**Students:** Xiaochao Ji, Xingyou Zhang & Jilei Miao  
**Supervisors:** Professor Colin Hansen & Associate Professor Anthony Zander  
**Sponsors:** Australian Research Council, Water Quality Research Australia Limited, SA Water, Melbourne Water Corporation, Water Corporation (WA) & United Water International

This project is directed at the development and testing of a concept design for mechanical mixer that will ensure uniform ultrasound exposure to cyanobacteria infested water passing through it. The aim is to have an adjustable, continuous, high-rate flow that will ensure that the cyanobacteria are exposed sufficiently to cause their flotation vesicles to collapse but not enough to kill the cyanobacteria cells and cause them to release toxins into the water. The project described here is a contribution to a much larger project involving the development of a comprehensive ultrasonic treatment system to control blue green algae in water supply reservoirs. This larger project is funded by The Australian Research Council, Water Quality Research Australia Limited, SA Water, Melbourne Water Corporation, Water Corporation (WA) and United Water International. The current project will focus on the simulation of the fluid flow around the water mixer. Analysis of the ultrasonic field and its impact on the algae will not be included. The fluid flow will be modelled using computational fluid dynamics and tested using a small scale experimental model. The main purpose of the testing and modelling is to ensure that there is no recirculation of processed water. The investigation of the flow around the water mixer will also provide a better understanding of the working environment of the treatment device. The exhibition will provide the structure and working principles of the design, acoustical and CFD analysis and the results of scale model testing.

55. Solar Thermal Air-Conditioner Phase III, Solar Heat Collection

**Students:** Michael Campbell, Adam Greco & Henry Spry  
**Supervisors:** Mr Gareth Bridges, Andrew Allison & Dr Eric Hu  
**Sponsors:** Adelaide Moulding & Casting Supplies

The project is aimed at producing a Solar Heat Collection system (SHCS) that can provide enough process heat energy to power a domestic Solar Thermal Air Conditioner (STAC) at a reduced cost in comparison to existing SHCS designs. In Adelaide, the peak electrical loads placed on the national grid force periods of ‘brown outs’ for certain suburbs. Government data relating to air-conditioner operation on hot summer days indicates that air-conditioner operation is directly responsible for these grid overloads. Solar Thermal Air-Conditioning is one method of reducing a household’s dependence on volatile grid delivered electricity, and alleviating the stress placed on the local electricity grid.

The SHC design from the 2010 phase of the STAC project delivered this process heat input, but was determined as being too expensive for domestic applications. To rectify this weakness a redesign of the parabolic collector support structure (PCSS) has been undertaken with the aim of identifying alternative materials or manufacturing processes that can reduce cost without impacting system effectiveness. Additionally, both the tracking and thermal modelling components of the 2010 design are inadequate for their respective tasks. These sub-systems have been redesigned to operate effectively. Successful testing of this low-cost SHCS design alternative will improve the economical feasibility of SHC for process heat applications. The exhibition will include an overview of the PCSS, tracking and thermal model designs in addition to the theoretical and physical testing results. The SHCS will also be displayed.
56. Solar Thermal Air-Conditioner Phase III, Refrigeration Unit  
Students: Nicholas Rubbo, Lucas Horvath, Robert Caporella & Rami Rasheed  
Supervisors: Mr Gareth Bridges & Dr Eric Hu

Imagine an air-conditioner that uses solar energy to cool your home in summer!

Every year, during the summer months, the increased usage of refrigeration air-conditioning systems results in significant straining of the state’s electrical power infrastructure; sometimes leading to us sweltering in summer black outs. The intention of the solar thermal air-conditioner project is to reduce this reliance on base load power through the domestic application of such a system. This reduction in power consumption is achieved through the use of a heat driven absorption refrigeration system, which uses thermal energy provided by a solar collection system. The aim of phase III of the “Solar thermal air-conditioner – refrigeration unit” project is to design and build a prototype absorption refrigeration unit for the solar thermal air-conditioner system. The specifications of system components will be calculated using a combination of thermodynamic and heat transfer approaches. This prototype absorption refrigerator will provide a base from which testing and optimisation can be undertaken in future years.

The exhibition provides an overview of the solar thermal air conditioner focusing on the design of the absorption refrigeration system including details on the system components. The progress achieved in the construction of the prototype system will be on display including a virtual model.

57. Potential for novel energy storage systems in SA involving wind power and hydrogen  
Students: Andrew George & Jessica Tai  
Supervisors: Professor Gus Nathan & Rob Dickinson

Wind power is expected to play an integral role in the transition away from traditional fossil fuel power generation in a carbon-priced economy. However the intermittent nature of wind power is a limiting factor in its widespread implementation. But what if you could incorporate a storage system into a wind farm and store excess wind power for use at a later date when the wind stops blowing?

Kangaroo Island’s electricity demand is currently being met by a 33 kV underwater cable connecting the Island to the mainland power grid and a back-up diesel generation plant consisting of three 2 MW generators. The ageing cable is nearing the end of its operating life and the back-up plant is incapable of supplying power to the entire population, therefore providing niche conditions for the implementation of wind power with hydrogen storage.

Research into hydrogen production, storage and power generation, and an analysis of the wind resource on Kangaroo Island was conducted. A MATLAB model was developed to assess the techno-economic viability of different wind-hydrogen systems for varying scenarios of current and predicted power demand of KI. Fifteen years of BOM wind data measured on KI was used as the driver for the model, while hydrogen generation and storage, mainland grid supply and diesel generation were also incorporated into the model.

Results of the techno-economic assessment will be presented at the exhibition, including details on how such a system could provide enough power to a growing population and whether the system is a viable option for Kangaroo Island.
Kangaroo Island is one of the prime tourist destinations of the state. Every year it sees over 185,000 tourists to the island, while 4,500 people live permanently on the island. With the Premier’s plan to double tourists to the island over the next few years, ensuring the island’s energy security is of the utmost priority. Unfortunately, with the current 33kV submarine transmission line connecting the island, there are problems in supplying power during peak load.

Previously, three 2MW Diesel Gen-sets were commissioned to help alleviate any load issues. These can be dispatched almost instantaneously, however, they have limited operating life spans. Requests to upgrade the submarine transmission line have been rejected and any further requests can only begin in 2015. Therefore, a solution must be found to eliminate this supply problem and to prepare the island for increases in demand in the foreseeable future.

To coincide with the green image of the Island’s governing body, a solution incorporating Biomass, Photo-Voltaics and Batteries was designed and analysed to determine viability. HOMER: Hybrid Optimization Modelling Software was used to evaluate the technical and economic feasibility of the systems proposed. The ultimate goal was to determine how large a viable system must be, as well as how long the system is able to defer any upgrades to the current 33kV submarine transmission line.

Critically, any system designed will need to participate as a member of the National Energy Market (NEM) and therefore, the power price must be set competitively in order to be dispatched by the Australian Energy Market Operator (AEMO).

Results of the financial and technical viability of the project will be available at the exhibition for public scrutiny.

**59. Oscillating water column wave power converter**

**Students:** Adrian Dobrzycki, James Hallion & Mohd Mohd

**Supervisors:** Professor Graham Nathan & Brian Kirke

**Sponsor:** Seadov Pty Ltd

Demand for the development of sustainable energy technologies has led SEADOV P/L to sponsor this project to develop a low-cost wave energy converter system using Oscillating Water Column (OWC) technology. OWC technology is used to convert wave energy into electrical energy through the rise and fall of waves inside a column that develops an alternating positive to negative air pressure distribution to drive a turbine. The project uses a floating platform that allows independent variation of the heave and roll natural period to approximately match them to the local average wave period. The benefits of the floating system are that it can be moved to sheltered waters in the event of extreme weather conditions and has the potential for increased output efficiency through resonance of its heave and roll motions.

The design consists of four 200L drums acting as OWC chambers that are held together by a steel frame. The system's natural frequencies are controlled by changing the total mass and position of the mass whilst maintaining neutral buoyancy with added foam. Power output was calculated using measured air pressure readings in the OWC chambers and estimations of known turbine and generator efficiencies. This allowed the determination of the oceanic conditions that the system can achieve.
economic viability. In addition, the effects of systematically varying design parameters such as aperture size, OWC wavefront length, and the difference between system natural period and the wave period were investigated. The project aimed to minimise cost to better increase the competitiveness of wave energy against generators and off-grid power sources, particularly at remote coastal communities.

60. Sustainable Marine Current Energy

Students: William Tregenza, Joshua Talbot & Alex Marschall
Supervisors: Dr Antoni Blazewicz, Associate Professor Richard Kelso & Associate Professor Andrei Kotousov
Sponsors: Santos, GPA Engineering & Angas Park

In recent times the world’s dependence on fossil fuels has become a political, economic and environmental issue. This issue has sparked a multitude of research into the development of sustainable, renewable, zero emission sources of energy. Of the current renewable energy sources, the use of marine currents is a promising yet underdeveloped resource.

The 2011 Sustainable Marine Current Energy (SMCE) team aims to produce a prototype marine current turbine with emphasis on optimisation of the turbine blades. Biomimicry of a humpback whale pectoral flipper has inspired the incorporation of leading edge tubercles into blade design. It has been proven that leading edge tubercles increase lift at high angles of attack. Preliminary CFD analysis has been used to verify this concept. A prototype marine turbine and four sets of blades have been manufactured based on multiple design stages. This design will be tested within a water flume to determine the optimum turbine blade configuration. During the 2011 MechExpo the SMCE project will showcase the complete design, with all alternative sets of blades, as well as present all results and conclusions.

61. Optimisation of cooking stoves for humanitarian purposes

Students: Matthew Higgins, Gregory MacFarlane, Matthew Read, Josh Wilkey & Tomas West
Supervisors: Dr Paul Medwell & Dr Cristian Birzer
Sponsors: Solver Paints, Engineers Australia & Engineers Without Borders

Open fires and traditional cook stoves are used by an estimated 2.2 billion people around the world, but are inefficient and cause the deaths of approximately 1.6 million woman and children annually as a result of indoor air pollution they produce. Development of improved stoves has benefited many families, but new developments are required to utilise alternative biomass fuels such as animal dung. The problems are unique to each global location, and there is no single solution to satisfy the needs of all cook stove users. This project, in partnership with Engineers Without Borders - Australia, focuses on the needs of communities in the Terai region of Nepal, where extensive deforestation has left oxen dung as the primary fuel used for cooking.
This project has identified and experimentally evaluated improved cook stove concepts. An improved combustion stove and biochar producing gasifier stove were developed, and the incorporation of a fan to increase the stoves’ performance was investigated. The improved combustion stove employs the preheating of primary combustion air to increase stove efficiency. The biochar producing gasifier stove separates the pyrolysis process from combustion to burn solid biomass more cleanly and efficiently, and produces biochar as a by-product, which can be used as a soil enhancer. The team intends to work with in-field volunteers to integrate these designs into the Terai region of Nepal.

62. Development of an enhanced solar ventilation system using phase change materials

Students: Peter Hardy, Cheng Peng, Haikun Shi & Kan Ye
Supervisors: Dr Eric Hu & Dr Zhao Feng Tian

With the cost of electricity rising and the federal government committed to reducing Australia’s carbon dioxide emissions, the use of mechanical air conditioning systems is becoming less viable. Solar ventilation systems are becoming popular as an alternative to mechanical ventilation as they do not require electricity and can provide an indoor environment that is healthier and more comfortable.

A significant limitation of solar ventilation systems is that they cannot work at night, which is desirable for building heat removal to reduce daily cooling loads and to provide ventilation for businesses that operate outside of standard working hours. The project has attempted to close this technology gap by enhancing a solar ventilation system with latent heat storage, provided by the addition of phase change materials (PCM), to increase the daily operational time. The project focus was to design and build a PCM enhanced solar ventilation system and quantify the effects of PCM addition using both computer modelling and experimental data. A mathematical model of a PCM enhanced solar ventilation system has been written in Matlab to estimate system performance over time and computational fluid dynamics (CFD) modelling has been employed to give an accurate assessment of instantaneous system performance. Both models have been validated using published numerical data. A prototype of the PCM enhanced solar ventilation system has been constructed and tested. The results? Well we could tell you now, but we’d rather you came and found out for yourself.

63. 3D CFD model of Adelaide CBD and surrounding parklands

Student: Mengjiao Xu
Supervisors: Dr Paul Medwell, Dr Cristian Birzer & Dr Zhao Feng Tian

Rapid development of urban centres has led to many environmental problems and climate quality issues as seen in many cities across the world. Understanding the urban thermal environment has therefore become important for a city’s urban planning. This project focuses on the urban climate study of the Adelaide CBD. The Adelaide CBD is predominantly surrounded by parklands, and this unique layout makes it an ideal location for urban climate studies. However, there are few urban climate studies on Adelaide city, particularly using computational fluid dynamics (CFD). This project aims to develop a simplified computational (CFD) model of the Adelaide CBD and surrounds, as a tool for understanding Adelaide’s urban thermal environment and predicting changes on the climate during urban planning processes. The computational model was developed using commercial CFD software, ANSYS CFX. Boundary conditions were set using data measured by Australian Bureau of Meteorology. The mathematical method was validated against existing numerical and experimental data. The computational model of the Adelaide CBD will be displayed in this exhibition.
64. Energy Mapping of T1 at Adelaide Airport

Students: James Martin, Chi Lai, Xuyang Huang & Hongfei Tang  
Supervisor: Dr Eric Hu  
Sponsor: Adelaide Airport Limited

Energy usage in the Adelaide Airport terminal building, Terminal One, represents 90% of the carbon footprint of Adelaide Airport Limited. The aim of the project is to understand the energy usage situation in T1 and recommend the ways to improve its energy efficiency. This project consists of 2 stages. The first involves an energy audit of the Terminal One building, using all available information, such as measured data from the Building Management System (BMS), recorded historical data and local knowledge. The second stage involves an analysis of all collected information. This analysis will show current energy flows and patterns, as well as various comparisons of collected information. From this, improvements to technologies, systems and practices can be recommended, in order to reduce future energy consumption. The outcomes of the project will also be used as a tool to promote AAL and its green image.

This exhibition will showcase the analysis of energy data of T1 and relevant findings of the project, along with the recommendations.

65. Increasing solar panels' efficiency through green roof technology

Students: Sze Liang Tan, Chenhua Fan, Wang Yao & Yangkun Zhang  
Supervisors: Dr Ley Chen & Dr Eric Hu  
Sponsor: Zoos South Australia, AGL, Hassell & Government of South Australia (Department of the Premier and Cabinet)

Green roof technology is known for reducing urban heat island (UHI) effect and is therefore a potential solution for naturally increasing solar panel efficiency. This project aims to increase the efficiency of solar panels by implementing green roof technology. It has been known that efficiency of solar panels drops when the operating temperature rises above 25ºC. The increase of solar panel efficiency will help to encourage the public to pursue clean energy. In this project, two supporting structures for the solar panel were designed to fit into the green roof. These solar panels are designed to be set up in two different locations with similar conditions. The first location of one solar panel is on a green roof while the other location is on a normal roof. Power output data are recorded from both solar panels. Comparisons are made on both results and these results will provide a better understanding of the integration of both solar panel and green roof technology and can be used to improve these systems further. The final integrated system which includes the structure design, efficiency analysis and output results will be displayed in the exhibition.

66. Heat Balance Based Energy Analysis for Adelaide Airport Terminal One

Students: Mohammad Fikri Abd Rahim, Umair Haggan Aminurrahman, Nik Muhammad Mohamed Nazri & Nik Nadzran Nik Kamaruzamil  
Supervisor: Dr Ley Chen  
Sponsor: Adelaide Airport Limited

Due to growing awareness on the increasing power consumption in Adelaide Airport Terminal 1 (T1), Adelaide Airport Limited (AAL) has sponsored this project to analyse the energy efficiency of the heat based energy system in the T1. Heat based energy system is correlated with the T1’s Heating Ventilation and Air-Conditioning system (HVAC) system and also the Building Management System
(BMS) that control and monitor the air-conditioning system. The energy efficiency of all the systems can be increased by utilizes heat balance based energy analysis.

The aim of this project is to increase the energy efficiency in the T1 by analysing the energy efficiency of the heat based energy system and recommend the ways to improve its energy efficiency. This project consists of three stages of investigating, identifying the problems and coming out with the possible solutions. The first stage involves reviewing a preliminary audit of T1’s current energy analysis. The second stage involves performing a heat balance on the specified thermal zones to the selected area to find issue and problems with the system. Then the results of the heat balance will be analysed to determine the best possible solutions to overcome the issue, which is the final stage. This exhibition will show the current problems identified such as large temperature differences in different areas and both chillers and boilers are running at the same time. This exhibition also will show that there is a good scope for increasing energy efficiency through fine tuning and optimising the operation of the HVAC system.

67. Energy Auditing for Peter Lehmann Wines Ltd
Students: Damien Lynch, Cong Ji, Chao Yang & Junbo Wang
Supervisor: Dr Eric Hu
Sponsor: Peter Lehmann Wines Ltd

The aim of the energy auditing project is to complete an energy audit of the cellar door and the waste water treatment plant of the Peter Lehmann winery and supply energy-saving recommendations based on the results and research.

Energy auditing is a process of analysing data within a defined area to identify specific energy use and costs of electrical devices. With this knowledge some control measures can then be undertaken for review and possible implementation. As the cellar door has been noted to be consuming energy at higher levels than expected, a detailed analysis of were the power is being distributed has been completed.

The recommendations provided by the project will allow Peter Lehmann Wines Ltd. to consider options for future investment and possible financial gain, as well as a better understanding of the power distribution within the cellar door and across the waste water treatment plant.

The exhibition supplies figures of power consumption of electrical devices within the cellar door and waste water plant of the winery. Along with the power distribution, further research into newer technologies will be presented and explained with comparisons and to what is currently being used at the winery followed by recommendations for future energy-saving techniques.

68. Auditing of water usage and winery wastewater characteristics in wineries at process level
Students: Yuchuan Cao, Yu Chen, Ning Chen, Bingjiang Fu, Dongjiao Lu, Di Lu & Fan Wu
Supervisor: Dr Eric Hu
Sponsors: Yalumba, The Australian Wine Research Institute & CSIRO

The team of energy and water audits in Yalumba Oxford Landing winery (YOLW) focus on the data collection and analysis based on current energy and water usage in Oxford Landing site so that the recommendations of improving the winery industry to a more sustainable and efficient stage can be raised. During the last few years, the word “sustainability” has become one of the key words that people cares seriously. Yalumba, as one of main manufacturers supplying wine to Australian market, with
Australian winery research institute and CSIRO (Commonwealth Scientific and Industrial Research Organization) Land and Water sponsored this team to audit the energy and water usage for the Yalumba Oxford landing site in order to lead the industry of Oxford Landing site to a sustainable way.

The team of energy and water audits in YOLW aims to collect the detail statistics of energy and water usage in YOLW. Based on the collected data, a detail and complete analysis will be provided to show the advantages and disadvantages exist in the current operating system. According to the analysis results, recommendations will be listed to improve the sustainable design in industry. The energy audit, guided from AS/NZS 3598:2000 (Australian/New Zealand Standard for Energy Audits), focuses on the electricity consuming details for the 9 specific systems which make up the whole production line. Data resulting from the investigation will be systematically presented and a following analysis and discussion will be taken on. Hopefully, the previous work can reveal the current energy-consuming condition for the site. In terms of audit, both water quality and water quantity will be investigated. Three main sections related to water usage will be researched on, which are tank cleaning, winery transfer and other water usage. For each section, a detail data collection and analysis will be provided separately. The recommendations in terms of saving and reusing energy and water will be provided to enhance the sustainability of the industry. Improving the sustainability of the industry can not only help company to save a considerable amount of bills but also save more resource. It will also be helpful to reduce the green gas emission. The exhibition provides the detail statistics and data analysis of the project. The samples of waste water will be shown with the report of waste water analysis.
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