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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## Project Display Layout

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1-3. ASRI multi-stage launch vehicle

Students (Trajectory Analysis Group): Kylie Bedwell, Daniel Bettcher & Cameron Sinclair
Students (Mechanical Design Team): David Burnard, Matthew Gregor, Justin Montgomery & Andrew Mudie
Students (Mechatronics Team): Michael Lewis, Matthew Steventon & Jesse Coombs
Supervisors: Dr Laura Brooks, Dr Steven Grainger & Dr Matthew Tetlow
Sponsors: Australian Space Research Institute, Sir Ross and Sir Keith Smith Fund, Dick Smiths & Local Government Risk Services

The Multi-Stage Launch Vehicle (MSLV) is a continuing design and build project that commenced in 2009. The aim of the project is to produce a two-stage sounding rocket that is capable of accelerating payloads to greater velocities (and greater altitudes) than currently achievable by the Australian Space Research Institute (ASRI). Delivery of the MSLV will greatly enhance the research capability of both ASRI and the University of Adelaide, and will allow Australian and international researchers the ability to test high performance payloads, such as Scramjets, at greater velocities than those currently achievable. In 2010, the MSLV project is comprised of three honours project teams: the Trajectory Group, the Mechanical Design Team, and the Mechatronics Team.

The Trajectory Analysis group aims to produce a Range Safety Template (RST) that identifies the probability distribution of all possible ground impact points of the launch vehicle. The RST will be used to approve multi-stage launches at the Woomera Test Facility. The possible ground impact points have been determined through the development of a six degree-of-freedom model of the system's flight dynamics. A sensitivity analysis was conducted to analyse the effect of small variations of key parameters on the trajectory model; failure modes were also considered.

The Mechanical Design Team (MDT) project has focused on designing and testing the mechanical and structural components required for a two-stage rocket and also assessing the rocket's aerodynamics and stability. The MDT have utilised analytical tools, Finite Element Analysis, Computation Fluid Dynamics, Matlab and Pro E to design and theoretically test the stage coupling, fins, parachute, electronics module, camera and payload casing of the two-stage rocket. In addition to this, the designed components were fabricated and flight tested on two single-stage rockets in early October. The experimental data retrieved during these launches will enable verification of theoretical calculations and the approval of all designed components for use on a two-stage rocket in 2011.

The Mechatronics team designed electronics modules for the deployment of recovery systems, as well as to collect and transmit Global Positioning System (GPS) data back to ground, to aid in the recovery of the rocket post flight. The team has designed and manufactured three systems; one for the single-stage Sighter, as well as one each for the two-stage Zuni and Sighter. These systems were deployed for use during the launch campaign held in early October.

The exhibition provides an overview of the 2010 MSLV project in the form of posters presenting the work of each team. In addition to this, a number of the designed rocket components and empty motors and results from the trajectory analysis will be on display, along with a video presentation showing footage of launches, ground tests, and a presentation outlining the structure of the rocket.
4. Assessment of Aerial Firefighting of Bushfires

**Student:** Ruik Ng

**Supervisors:** Dr Paul Medwell, Associate Professor Bassam Dally & Dr Maziar Arjomandi

Bushfires are catastrophic wild fires that severely destroy large areas of bush and forest, which can lead to devastating effects on livestock, homes, buildings and rural communities. Bushfires in Australia are some of the most frequent and hazardous wild fires in the world. It is important that more effective methods of fighting and suppression bushfires are therefore developed to protect the Australian community and environment from the most severe consequences of bushfires. Aerial suppression approaches have become an important strategy when fighting bushfires. This exhibit provides a background review of current aerial firefighting strategies, which includes the use of existing firefighting aircraft, fire control chemicals and associated delivery systems. In addition, this exhibit will also present different alternative approaches, such as the implementation of different civilian and military aircraft for suppressing bushfires, as well as alternative conceptual ideas for chemical delivery systems. The feasibility of these alternative strategies has been studied, and the results will be presented at this exhibit.

5. Hydrodynamic analysis of deep V floats for seaplanes

**Students:** Daniel Burdett, Marion Byrne & Mai-Chi Nguyen

**Supervisors:** Associate Professor Bassam Dally, Dr Matt Tetlow & Mr Richard Jones

**Sponsor:** Tigerfish Aviation

The aim of this project is to analyse the hydrodynamic performance of a seaplane float during takeoff and landing, using computational fluid dynamics (CFD). Industry partner, Tigerfish Aviation, have developed retractable amphibious pontoon technology (RAPT), which reduces the aerodynamic drag penalty imposed by a seaplane’s floats. Three different designs of the RAPT floats have been analysed. For each of these designs, the flow characteristics at the air-water interface during take off have been investigated using the OpenFoam CFD package. The computational model identified as the most appropriate for this analysis uses a two-phase, volume of fluid solver and incorporates the k-omega SST turbulence model. The method was verified against experimental data and then applied to the given RAPT designs at three different operating conditions. The hydrodynamic lift and drag forces were found and the relative performance of the three designs compared. In this exhibition, the chosen CFD method will be explained and the verification and final results presented. Recommendations will be made about the RAPT designs based on their hydrodynamic performance.

6. Design, build and launch of a small satellite, based on CubeSat Designs

**Students:** Callum Chartier, Michael Mackay, Drew Ravalico, Sonja Russell & Andrew Wallis

**Supervisors:** Dr Maziar Arjomandi & Mr Brad Gibson

**Sponsors:** The Sir Ross and Sir Keith Smith Fund, BAE Systems, Engineers Australia National Committee for Space Engineering, Faculty of Engineering, Computer and Mathematical Sciences, Vipac Scientists and Engineers Limited & Nicholas Schulze

The AUSAT satellite project aspires to provide the University of Adelaide with a continuing space program through the construction of a small satellite with imaging capabilities. The project is run in accordance to the CubeSat program developed by California Polytechnic State University. The CubeSat standards were established to integrate a wide range of commercial available electronics in a 10 cm cubic satellite.
The aim of the AUSAT project is to design, test and integrate structural and electronic components to achieve a space ready satellite. A combination of commercial off the shelf and custom built electronic components were selected and designed to ensure the successful operation of the satellite in a low Earth orbit. Testing of various subsystems including thermal vacuum, random vibrations, communications, solar cell and magnetorquer were completed to validate and improve conceptual designs. The exhibition provides an overview of electronic subsystems demonstrating communication, image capture, magnetorquer control as well as showing the mechanical structure and the results of the vibration and thermal testing.

The super quiet unmanned aerial vehicle project aims to develop an aircraft that possesses a low acoustic signature. Aircraft noise that is produced by aircraft in either military or civilian roles may significantly reduce their utility; there is therefore an emerging interest in the application of low noise technologies to aircraft.

The aims of the project are to provide a conceptual design of the aircraft and to research several key areas in association with low noise principles with the potential to be applied to the aircraft. The conceptual design involves a tailless blended wing body configuration, which is not seen in commercial aircraft. The three key areas that were explored are: (1) the effect of the blended wing body at shielding the propulsion noise from the ground, (2) the acoustic properties of a propulsion system and (3) wing trailing edge modifications intended to dampen the generated air flow sound. The results of this research provide a greater understanding of aeroacoustics and can be applied to the detailed design of the super quiet unmanned aerial vehicle.

The exhibition will display a quarter size model of the conceptual design and the experimental apparatus, and will present the results.
8. Design and build a plasma thruster for MAV application

**Student:** Mei Cheong  
**Supervisors:** Dr Maziar Arjomandi & Mr Brad Gibson  
**Sponsors:** Sir Ross and Sir Keith Smith Fund

Micro Air Vehicles (MAVs) are crucial to the advancement of aerospace technologies for the use of military and surveillance operations. However, the major problem preventing MAVs from being fully operational are the limitations encountered by the propulsive systems used. Propulsive systems currently in use for MAVs are incapable of providing a sufficient thrust-to-weight ratio for viable field operations. Plasma actuators, extensively investigated as a means of active air flow control, have been shown to produce a force as a reaction to the airflow induced when activated. This project explores the feasibility of implementing plasma actuators, specifically single Dielectric Barrier Discharge (DBD) plasma actuators, to provide propulsive forces for MAV applications. Experimental work engaged in the project includes the momentum-transfer performance and the influence of geometrical variation of the actuator configuration on the thrust production capabilities of DBD actuators. Results from these works were used to initiate designs for actuators into plasma thrusters for MAV applications. This exhibition will present the actuators investigated, the experimental setups used and details of the results obtained to date.

9. External burning scramjet

**Students:** Scott Beinke, Jia Kok, David Kemp, Phillip Mellen, Thomas Minge & David Wilke  
**Supervisor:** Dr Con Doolan  
**Sponsors:** Australian Space Research Institute, BAE Systems, Sir Ross & Sir Keith Smith Fund & Teakle Composites

This project is concerned with the design and manufacture of an experimental external burning Scramjet engine which has been flight tested on board a Zuni rocket motor in early October. The flight test was facilitated by ASRI as part of their Small Sounding Rocket Program and aspires to further the development of Scramjet technology, in particular the concept of supersonic external burning. Throughout the flight test, experimental data of the external flow field was collected, particularly concerned with the region of external supersonic combustion. External combustion was achieved by injecting hot fuel rich exhaust products from a solid propellant charge. These exhaust products mixed and combusted further within the external supersonic flow, a process enhanced by an expansion ramp combustor. Temperature and pressure measurements were taken and compared with measurements obtained from the control side of the engine where no injection occurs. Additional pressure and acceleration data was recorded to determine the flight state of the vehicle. All flight data has since been compared with numerical simulation results in order to verify the accuracy of the simulation method and support its use as a tool to aid in future Scramjet design.

The exhibit features the Scramjet payload as launched and recovered in addition to the results obtained throughout the flight test. The exhibit will also provide an overview of the Scramjet program including the design process, various sub-system analyses, vehicle manufacture and the pre-flight testing which took place.
10. Predicting bone strength contribution of bone architecture and material properties

Students: Pawel Dyner & Jason Spinozzi
Supervisor: Dr John Codrington
Sponsor: I.M.V.S.

Accurate prediction of bone strength, and thus the prevention of bone fracture in patients, is reliant on an intimate understanding of the bone mechanical behaviour. Factors such as the bone composition, hierarchical macro and microstructure, tissue age and disease, all play fundamental roles in determining the quality and integrity of bone as a material and as a structure.

The overall objective of this work is to study the post-yield mechanical behaviour of trabecular bone subjected to compressive loading. Trabecular bone is a lattice-like porous structure of bony tissue, which fills the inside of most bones, including vertebrae in the spine and the ends of long bones. A specific focus is placed on the influence of non-enzymatic glycation, which occurs naturally with aging and at highly accelerated rates in diabetics. The increased glycation in trabecular bone has been linked to an increased susceptibility to fracture. Knowledge and quantification of this behaviour is therefore vital in controlling the risk of fracture in diabetes patients.

Mechanical testing of machined cubes of bovine trabecular bone was carried out on control and ribose treated (to induce glycation) specimens. From this it is possible to determine the influence of non-enzymatic glycation on the trabecular bone structural properties and behaviour.

11. Smart sensor technology for the detection of structural damage

Students: Kaustav Bandyopadhyay, Manudha T. Herath & Joshua D. Logan
Supervisors: Dr John Codrington, Dr Andrei Kotousov, Associate Professor Ben Cazzolato & Mr Stuart Wildy

Over the past few decades composite structures have gained importance in a vast array of applications due to their favourable mechanical properties compared to traditional metals and metal alloys. Accordingly, this project is focused on developing a new and innovative non-destructive damage detection technique (NDDT) to be used in structural health monitoring for composite structures. Layered composites, or laminates, are the most commonly used type of composite; examples include carbon fibre and fibre glass, and can be found in many modern aircraft, high performance vehicles, and even sporting equipment. However, the presence of multiple layers and reinforcements can make damage detection in these structures significantly challenging.
In this project a cutting edge NDDT has been developed, which utilises a scanning laser Doppler vibrometer (SLDV) system.

Theoretical modelling was first undertaken using fundamental theories in solid-mechanics and finite element analysis to provide an understanding of the mechanical behaviour of delaminated composite beams. The developed NDDT and theoretical models were experimentally verified using a SLDV by taking measurements on artificially damaged composite specimens. The experimental results accurately matched the theoretical predictions and the damages in the specimens were successfully detected.

The exhibition booth will present the cutting edge technology scanning laser vibrometry system, the specimens tested and the summary of experimental results.

12. Identify & resolve the factor(s) leading to inflate pressure losses in Farley riggs’ 5” drill stem testing components

**Student:** Lloyd Moffatt  
**Supervisors:** Dr Antoni Blazewicz, Dr John Codrington & Mr Jonathan Bannister  
**Sponsor:** Farley Riggs Pty Ltd

Drill stem testing is used to determine the likely production capacity of an identified source of hydrocarbons (a hydrocarbon reservoir zone). The equipment used for the testing essentially consists of a hollow drill pipe which allows hydrocarbons to be collected from the prospective reservoir under controlled pressure conditions, for in situ and above ground analysis.

Within the equipment used by Farley Riggs, a problem exists with the maintaining of a steady inflation pressure in the packers during a test procedure. These unwanted and unexpected variations in the packer inflation pressures during various stages of a testing process have led to numerous test failures with consequential significant costs and time losses being incurred. The primary objective of the project was to identify the equipment components causing the unexpected pressure variations and suggest design modifications for improving these components.

Through the analysis of existing pressure charts recorded during drill stem tests operations several components were identified as being the likely cause of the pressure variations. These components were parts of the packer inflation pump, packer assembly and down-hole shut-in tool. The behavior of these components is then analysed under operating conditions using numerical and experimental techniques. The exhibition will showcase the findings of the project thus far and provide insight into the possibility for future project work to be undertaken.

Student: Brandon Geue
Supervisors: Dr Erwin Gamboa & Mr Ian Brown
Sponsor: Babcock INTEC

Corrosion behaviour of materials used for critical system components has a profound effect on reliability and safety. To protect system components from corrosion it is necessary to understand the material’s behaviour under the intended service conditions. Nickel Aluminium Bronze (NAB) is a high grade alloy that is used in many marine applications. Laboratory testing of a recently developed NAB alloy was conducted to provide a better understanding of how the material responds to variations in a submersed seawater environment. Test environments have been selected on the basis of real world applicability and knowledge gaps in current literature. Laboratory tests include monitoring of the corrosion potential during the exposure period, potentiodynamic electrochemical steady state measurements and examination of surface morphology and microstructure. These results of these examinations provide an understanding of the type and severity of corrosion experienced under the given exposure conditions. This information may be used to improve component design and system operation to maximise corrosion resistance resulting in extended component service life, increased safety and appropriate maintenance scheduling where aggressive environments are unavoidable.

14. Design, build and test of a high-efficiency smart Darrieus wind turbine

Students: Thomas Duncker, Craig Hall, Adrian Miles, Matthew Radosevic, Fraser Rigby, Matthew Seccafien & Sam Thoday
Supervisors: Dr Maziar Arjomandi & Mr Brad Gibson
Sponsors: AGL Energy & Parsons Brinckerhoff

Global warming and rising energy costs have dramatically increased the research into renewable energy. Wind Turbines have been seen as a possible solution to the energy crisis but are currently not suitable for small scale use in urban environments. The aim of the project was to design, build and test a Darrieus type wind turbine, capable of developing 1kW of rated power and working efficiently in urban areas. The Darrieus turbine incorporates a smart pitch control system to increase the turbine’s efficiency and lower its required wind speed for start-up to less than 4m/s. The turbine was also fitted with an autonomous over-speed brake to protect the system in extreme conditions.

Current Darrieus wind turbine designs were analysed and simulations performed to design a more efficient and viable wind turbine. A previously built Horizontal Axis Wind Turbine (HAWT) was tested to provide direct comparison for performance parameters such as start up speed, noise, and power output. Component tests were done prior to installation of both turbines to meet strict safety restrictions at the site location. The smart Darrieus wind turbine and modified HAWT will be presented at the exhibition along with all performance results obtained.
15. Assessment of policy, legislative and commercial implications of mixed energy source technologies

**Student:** Alexander Toop  
**Supervisor:** Professor Gus Nathan

With increasing global population, strong growth and development and looming crises of climate change and energy security, the world is looking for new ways to generate electricity and to improve existing ways of producing power. To address the problem of energy security and sustainability, consideration needs to be given to the technical, economic, social and political aspects of technologies and policies. This project investigates these aspects for a promising category of technologies: energy hybrids utilising multiple thermal energy sources.

The project focuses on existing and new technologies that have the potential to be implemented in South Australia – in particular, using solar thermal or geothermal energy to supplement existing and new non-renewable generation. This project investigates the broader context of the legislative and policy frameworks within which the technology will operate and the commercial implications for mixed energy source technologies. It identifies technology specific issues through modelling and analysis, and proposes ways to address these issues, looking to leading overseas jurisdictions to develop new ways to promote investment and development of renewable energy in Australia.

16. Concept design of the blade pitch control for a rooftop wind turbine

**Student:** Jonathon Adams  
**Supervisors:** Dr Peter Lanspeary & Ms Dorothy Missingham AM

The concept design of a rooftop wind turbine project has set the foundation for further investigation into wind turbine design utilising variable pitch technology. Current Darrieus style wind turbines use aerofoils with a fixed mounting angle. Investigating into variable pitch technology may lead to the potential efficiency increase of current wind turbines.

The aim of the project is to investigate the aerodynamic forces acting on the aerofoil of a wind turbine, and investigate the potential benefits of variable pitch technology. Investigating the aerodynamic forces of the aerofoils led to an understanding of the contributing forces to the turbines torque. Software was developed to analysis the lift and drag forces acting on the aerofoil over a 360° rotation cycle, and produce a torque coefficient for the respective turbine. Utilizing the developed software, optimization of the desired torque resulted in the most advantageous angle of attack for the aerofoil at any given rotation angle. The analyse of the aerofoil forces gives a clear idea of the potential efficiency increase of current wind turbines by utilising variable pitch technology. This understanding can aid in the future development at more efficient renewable energy source. The exhibition shows an overview of the turbine analyse, concept of variable pitch technology and the desired outcomes of utilising such technology.

17. Solar Thermal Air Conditioner – Phase II

**Students:** Laurelle Anderson, Tane Bowels, Baines Bruce, Lucy Burke, Todd Hughes, Warren Li Yung Lung, Alexander Sankauskas, Luke Schneemilch & Valentin Zarkhin  
**Supervisors:** Mr Gareth Bridges & Dr Eric Hu

During extreme heat waves in summer, Adelaide’s electricity demand more than doubles in comparison to cooler summer days, to over 3 GW of power. Much of this increase in power usage can be attributed
to the increase in demand for air conditioning and refrigeration. As an alternative to using traditional power intensive cooling methods, this project proposes the solution of using solar thermal air conditioning. The proposed system in this project replaces the work-intensive compressor in a conventional air conditioner with a heat-powered absorption compression system which uses heat obtained from solar collectors. This project aims to design and build a prototype solar thermal air conditioning system suitable for a domestic application.

The air conditioning system has been divided into three sub-systems: a solar collection system, heat exchange and refrigeration system and space cooling system. Each of these subsystems will be on display at the exhibition. The exhibition will also provide an overview of the design of the system, details of the construction phase and results from testing.

18. Air Moisture Condensation System based upon Fluid Dynamics Principles

Students: Jason Gaekwad, Khoa Nguyen & Anton Veigurs
Supervisors: Dr Nicolas Coniglio & Dr Erwin Gamboa

The aim of this project is to conduct a feasibility study into the possibility of using fluid dynamics principles to extract water from the atmosphere, as opposed to conventional refrigeration techniques. The system utilises a vortex tube coupled with condenser and desiccant systems to extract and collect water from the surrounding air. It is aimed for the system to have the ability to produce at least two litres of water per day, which is the recommended amount of water a human must consume on a daily basis. Developed water infrastructure and water treatment processes make this daily intake achievable in first world countries. However, a lack of infrastructure and access to readily available freshwater sources in developing countries often results in contaminated water being used for consumption and cleaning purposes. This can have adverse consequences by aiding in the spread of bacteria and disease. Developing countries, specifically in and around the horn of Africa, have climates with high dew points and high air moisture content levels. As moisture is continually present in the atmosphere, there is potential for it to be condensed out of the air and used as a freshwater source.

The exhibition provides an overview of the developed prototype system and its operation, along with relevant testing results. The manufactured system with all of its components will be on display.

19. Water out of thin air (II)

Students: Hari Prasad Bhowany, Jun David Cao, Khairul Azmi Fahmi Jamil & Muhammad Alif Anwar Mohamad Saa’ri
Supervisors: Dr Eric Hu & Dr Ley Chen

Water Out Of Thin Air (II) project aims to use wind energy as the only source of power to harvest water from thin air. A vapour compressor refrigeration system was developed in 2009 as a method to extract water from thin air. However it was only powered by an electric motor to simulate the windmill rotation due to time constraint.

This year the project is to develop an overall system by using the refrigeration unit and windmill inherited from Water Out Of Thin Air (I) 2009. To achieve this aim, two major modifications have been made to the existing windmill. The modifications include increasing its operating range by attaching a Savonius wind turbine as well as increasing the height of the windmill. A belt transmission system accompanied with a step-up gearbox has also been designed to transfer the windmill rotation to the compressor. The exhibition will display the work done by the Water Out Of Thin Air (II) project throughout the year.
20. Backwash Water Filter Electro-flocculation Cell  

**Student:** Mark Crowhurst  
**Supervisors:** Dr Tien-Fu Lu & David Hart  
**Sponsor:** Dematec Automation, Power, Robotics and Water

With an increasing need for water preservation and a reduction in energy consumption, Dematec Automation has sponsored this project to determine the feasibility of an Electroflocculation based water filter designed specifically for backwash water from swimming pools. Electroflocculation combines the processes of Dissolved Air Flotation and Aluminate Dosing in order to produce superior results to both filtration methods. The process optimises the consumption of electricity in order to effectively remove contaminants from the water. The process introduces an electric charge to the water which creates hydrogen bubbles at one electrode while dissolving Aluminium ions at the other. The Aluminium ions act as a coagulant for suspended solids while the hydrogen bubbles float particles to the surface. The desired result is a thick foam of contaminants on top of relatively clearer water. Optimal results are produced with smaller bubbles. The project aims to determine which variables affect system performance. The electrical signal, electrode design and orientation and flow rate have been tested. It has been found that significant performance gains can be produced. The exhibition provides an overview of technology and the findings of the project. The testing cell and electronics used throughout the project will be on display and operational.

21. Using shallow geo-thermal resources to improve the efficiency of Air conditioning, Heat pump systems  

**Student:** Yuchen Hu  
**Supervisor:** Dr Eric Hu

Nowadays, a kind of common used air conditioning system is called “reverse cycle air conditioning system” which combines a cooling machine with a heat pump to function in summer and winter respectively. However, the efficiency of reverse cycle system depends on outside temperature to a great extent. For the situation of extreme air temperature, far more energy is needed to adjust indoor temperature to the same extent than that of gentle one. Comparatively speaking, the shallow geothermal resource which is also a kind of green power seems to have steadier temperatures than ambient air temperature.

This project is focus on the research of the feasibility of using shallow geothermal heat instead of air to exchange for the air conditioning system. Performances of the shallow geothermal resources' system is measured compared with traditional air cooled ones to show improvement of the modification. Furthermore, the measure of costs of modification and economical saving in energy are also significant factors which need to be considered. The exhibition provides an overview of the shallow geothermal resources system and results analysis. Also, the program which is used to calculate performances for both types of systems will be on display.
Investigation into alternative methods for sourcing fresh water has become essential due to recent droughts and a general scarcity of fresh water. One of these alternative methods is through desalination. However, most desalination processes are highly energy intensive, costly and complicated. Water desalination using direct wind power for energy is a process which uses the renewable mechanical energy from a wind turbine to initiate a thermal distillation process. The thermal distillation process enables pure water to be extracted from a saline water source through evaporation, condensation and subsequent collection. The aim of this project is to build on the 2009 prototype to achieve improved distillate output and system efficiency through the design and build of an integrated system. The final design incorporates the thermal distillation process to heat and evaporate the water, whilst using two heat exchangers, one air-air and one air-water, in series to condense the water vapour into fresh water. Both processes reuse the energy from the heat exchangers creating a sustainable system. The exhibition will show the system produced, results from testing, and the commercial feasibility of the wind powered desalination system.

23. Oscillating water column wave power converter

The Oscillating Water Column (OWC) Wave Power Converter project endeavors to continue ongoing sustainable energy research into wave power conversion technology. The concept of OWC technology has been in existence since the 1970's but has recently seen a recent renewed interest as the drive towards more sustainable energies continues. This unique project investigates methods to achieve resonance with dominant input wave frequencies, in order to increase power output and hence, wave power capture efficiency.

The vessel concept is based on a proposal by SEAVDOV Pty. Ltd. whereby OWC chambers would be implemented into a decommissioned oil tanker, providing power for an off-shore water desalination system with the aid of wind turbines. A two-dimensional analysis has been used to develop a simplified Test Vessel at scale. The Test Vessel is used to test and optimize the parameters that affect the power output and ultimately, efficiency of the OWC system. The results of this project will serve to justify further work at larger scales.

This exhibition will provide an overview of the concepts investigated in this project and discuss the implementation of this technology into shipping tankers. The test vessel will be on display as well as key results such as maximum vessel power output and wave capture efficiency obtained.
**24. MAGIC 2010**

*Students:* Nigel Gaskin, Adam Cundy, Anton Steketee, Benjamin Quast, Sundar Komandurelayavalli, Konrad Pilch, Peter Hardy, Phuong Huynh, Stella Wong & Mark Baulis  
*Supervisors:* Associate Professor Ben Cazzolato, Dr Steven Grainger & Dr Chris Madden  
*Sponsors:* Strategic Engineering, The University of Adelaide, Lex systems & Maxon Motor Australia

The MAGIC 2010 project created a team of Unmanned Ground Vehicles (UGVs) to autonomously search and map an environment, to find threats and other objects of interest. This project was based on the international competition, Multi-Autonomous Ground-robotic International Challenge (MAGIC 2010), for which the University of Adelaide was one of 12 teams to be selected to compete. Students worked with university staff, and the industry partner, Strategic Engineering, to design and manufacture two of these UGVs. Whilst the team has been unsuccessful in reaching the Grand final, the robots provide many fascinating areas for further research. The UGVs incorporate carefully selected hardware components for its mechanical and electrical design, along with extensive software development that display meaningful data with a visually appealing output. Complex algorithms integrate specialised sensors onboard the UGV for accurate positioning. Each UGV is also equipped with an onboard camera which is used to find objects of interest and locate them on the maps. A Ground Control Station (GCS) is used as the main control centre for the UGVs, and all communication is accomplished via a wireless network. A Graphical User Interface (GUI) on the GCS allows human operators to interact with the UGVs and also view the various maps generated. In the exhibition, two UGVs will be on display, along with the GCS. One of the UGVs will be driven around to demonstrate the capabilities of the UGV, whilst the other will be available for inspection. Furthermore, the GCS will also be active to demonstrate the various mapping and camera feed via the GUI. A short movie will be played at regular intervals to explain the motivation, function and accomplishments of the MAGIC 2010 project.

**25. RoboFiddler Mark III**

*Students:* David Carey, Danny Ho & Matthew Yuen  
*Supervisor:* Dr Steven Grainger  
*Sponsor:* NICTA

Encouraging high school students’ interest in the field of Information and Communications Technology is currently a challenging process. RoboFiddler, a robotic violin player sponsored by NICTA, introduces a novel way to aid in this education and increase the appeal of ICT. While other robotic violin players have been designed, this project is unique in that there is no requirement that it be conventionally played to meet competition rules. Unconfined by strict guidelines allows for more exciting and efficient designs.

RoboFiddler has a perpetual method of bowing which involves four motorised drives inducing vibration
in each string. This vibration is regulated by the fingering actuators which are aligned to allow two octaves of notes to be played. The software design can read midi music files and has the ability to implement violin playing techniques including vibrato and legato. The use of midi files increases the adaptability of the design allowing a midi keyboard to directly control the violin. The RoboFiddler with a playable interfaced keyboard are on display, while also having the ability to play uploaded songs.

### 26. PICARSO
**Programmable Interface Controller with Autonomous Robotic Spraying Operation**

**Students:** Ian Hooi, Samuel Oosterholt, Sven Paschburg, Joyce Phan & Neil Yeoh  
**Supervisor:** Associate Professor Ben Cazzolato  
**Sponsors:** Maxon Motors Australia, IWATA Australia, Crowie’s Paints & The University of Adelaide 2010 Open Day Innovation Fund

The PICARSO system is a cable-driven parallel planar manipulator which can process images and reproduce them on a vertical canvas using a spray gun end-effector. The project aims to design and build a robotic painting system for the purpose of exploring a niche area of interactive digital media as a potential promotional or advertising tool, or as an interactive artistic display that can paint murals. The objective is to design and build a system with the ability to paint images in both raster (bitmap) and vector (lines/curves) form within a scalable workspace. The key areas involved in PICARSO’s design are divided into hardware and software. The software design incorporates the development of the code used for trajectory generation of the spray gun, kinematics, driving the motor controllers, as well as image processing. The hardware component involves the design of the spray gun module and the motor mounts to enable the system to hang on any vertical surface. The exhibition will provide an overview of the PICARSO system including both the hardware and software components. Furthermore, the full scaled PICARSO system will be shown in its operational mode. The outcomes and results will be detailed through both videos and images.

### 27. Intelligent AUV Robot Navigation and Positioning using Underwater Inertial Navigation System (INS) {Mark II}

**Students:** Chi Keung Chan, Man Kit Chan, Shane Fitzgerald & Yang Zhao  
**Supervisors:** Associate Professor Amir Anvar & Dr Tien Fu Lu  
**Sponsor:** Defence Science and Technology Organisation (DSTO)

In the modern era of robotics, autonomous vehicles have replaced humans as frontiersmen in the great unknown, exploring unknown locations and operating in hostile environments. Their ability to operate in...
high levels of independence without the intervention of a human operator is the essence of such a vehicle. As such, artificial decision making systems must be implemented to substitute the intelligence of a human. This project aims to provide an autonomous underwater vehicle (AUV) the ability of positioning and navigating itself by applying an intelligent navigation system. To achieve this, a number of inertial and acoustic sensors were integrated and operated through a single board computer. This assembly is responsible for producing continuous sensory information regarding the AUV's static and dynamic parameters. This are then filtered and harvested by a novel software which has the ability to log real time data for post-processing purposes. The functionality of the system has been tested in laboratory for its accuracy. It has also been tested under real-life conditions by a field trip to the ocean. Post processing of the data was performed and results were compared to the predefined mission profiles of the field test. The full system will be on display in its custom-made enclosure, accompanied by the AUV at the exhibition. Some sensors will be operated in real time to showcase the program.

28. Intelligent AUV Robot Navigation and Tracking using Underwater Machine Vision and Sonar Imaging System {Mark II}

Students: Christopher Ballard, Quoc Tran, Jia Yao Cui & Asher Jacobs
Supervisors: Associate Professor Amir Anvar & Dr Tien-fu Lu
Sponsor: Defence Science and Technology Organisation (DSTO)

Autonomous Underwater Vehicles (AUVs) are a part of a larger group of underwater vehicles. Currently AUVs are used for commercial, military and scientific purposes however broader use has been limited by current technology. The AUV's of today use independent machine vision and sonar imaging devices to detect the surrounding underwater environment and look for objects of interest. As each sensor has limitations, a combination of both machine vision and sonar imaging sensors will compensate for the limitations of the individual sensors. This project covers the integration of both sensors and applying them to develop an obstacle avoidance system for AUVs that use both machine vision and sonar imaging. The focus will be placed on obstacle avoidance which will provide a solid basis for future research and development for a range of potential applications.

This project achieves the goal of developing an obstacle avoidance system using both sensors operating in near real-time. The sonar system used is a new addition to the 2010 project while the machine vision system used is a significant evolution of the system developed in 2008. The integration of the subsystems is performed through various forms of logic. The machine vision system has been further developed to include an optical flow based tracking algorithm whereas the sonar imaging system has been built from ground up using the OpenCV and cvblobslib libraries to perform image processing, reflection elimination and tracking. This exhibition provides an overview of how the two sensors have been integrated along with the image processing and logic techniques used. The operational machine vision system will be on display as well as the underwater enclosure that will house the system.
29. Barge Mounted Hydraulically Adjustable Pile Driving Guide

Students: Nicholas Andrew Deussen & Samuel Richard George Mason
Supervisor: Dr Erwin Gamboa
Sponsor: Maritime Constructions

A pile is a column of wood, steel or concrete that is driven into the ground as a type of deep foundation found used in many marine structures such as jetties, wharfs and aids to navigation. During the driving process, a fixed guide mounted on to a barge is employed to ensure the pile is driven correctly. Currently, positioning of the pile uses the barges four point anchoring system, a process that while accurate is extremely time consuming. Maritime Constructions has sponsored this project to develop a hydraulically adjustable pile guide, designed to be mounted to their ‘Tim Tam’ barge, to both reduce the time required for positioning the pile and to improve their capabilities of driving raked piles. This exhibition will detail the solution designed. The guide has been designed to the requirements of all operations of marine-based pile driving, including raising both the pile and hammer, positioning and driving the pile, and removing the barge from the site. The final design utilises low friction sliders translated with hydraulics for the piles horizontal positioning and hydraulic support arms for pitch adjustment.

30. EDWARD 2010

Students: Luke Francou, Jack Parsons, Bo Zhu & Ben Wright
Supervisor: Associate Professor Ben Cazzolato
Sponsors: 4D Systems, Motium & The University of Adelaide

The Edward 2010 project utilises the power of modern control techniques to improve the driveability, safety and comfort of a diwheel. A diwheel is a unique vehicle with two large coaxial wheels that completely encompass an inner frame containing a driver. The inner frame is suspended within the wheels in such a way as to allow the inner frame to rotate freely. An inherent property of this physical arrangement is that the inner frame will slosh (oscillate back and forth) during operation. Although this effect is necessary for acceleration of the vehicle, oscillatory slosh causes difficulties when driving. The unique dynamics of the vehicle can also be exploited to invert the inner frame, so it is possible for the diwheel to be driven while upside down.

Following the successful design and build of the diwheel structure and basic electrical system in 2009, the 2010 team have addressed deficiencies in the existing mechanical structure, upgraded all electrical hardware and redesigned the electronic systems. An entirely new mathematical model of the vehicle has also been developed which incorporates the full range of motion. This model has been used as the basis for the implementation of a control system to control both slosh and invert the inner frame. A
human-machine interface has been developed to allow the driver to control the operation of the vehicle, as well as receive critical feedback about the vehicle.

The 2010 University of Adelaide Mechanical Engineering Exhibition provides the Edward 2010 team with the opportunity to present the finalised diwheel including design, development and testing of all systems. Along with the diwheel display, detailed information and demonstrations of slosh and inversion control will be presented.

31. Bulk solid material stockpile robotic stack/reclaiming prototyping and modelling

Student: Milan Vojin
Supervisor: Dr Tien-fu Lu

One important research area in Robotics focuses on developing models and controllers which can be retrofitted to Bucket Wheel Reclaimers (BWRs). The interest towards such models is two-fold. First, the physical model is needed as input in the bulk material handling system simulation to study and validate various guidance, navigation and control (GNC) strategies. Second, a good physical model may lead to a better understanding of the bulk material handling system itself. This in turn can help designing larger systems for management of industrial stockpiles.

However, due to its linear nature, the BWR simulation model can not possibly capture all the dynamics encountered in a real world system. Consequently, the simulation results are often deceptive and need to be compared against a physical prototype. Thus one of the main goals of this project has been the design, simulation and construction of a BWR prototype platform to be used for Robotic research. In order to ensure that the prototype is not just the combination of electronic, software and mechanical design, the overall design was optimised across the various fields given the current state of technology and budget. The BWR prototype platform and simulation environment will be on display at the exhibition.
32. Development of a Blank-side Lubrication Unit for the Glass Bottle Making Machine

**Student:** Demetrius Kalatzis  
**Supervisors:** Dr Fred Zockel & Ms Dorothy Missingham  
**Sponsor:** AMCOR Glass Australasia

AMCOR Glass is developing an automated lubrication system to replicate the manual lubrication method currently used for the blanks, baffles and neck rings of the bottle moulding machines. This project focuses on the lubrication of the neck rings, whilst Broens Engineering has been contracted to develop a lubrication system for the Blanks and Baffles.

Manual lubrication poses a safety risk to the operators and since the machine has to be taken out of production for two cycles every 15 minutes there is a productivity loss of about 1.5%. As the production rate is approximately 17 000 bottles per hour for one machine, 1.5% represents a significant cost penalty. Additionally, as the amount of lubrication applied depends on the operator's ability and judgement, a human variable is introduced in the production process.

The project is to develop an automated lubrication unit capable of lubricating the neck rings whilst the machine is in operation. A fixed but adjustable quantity of the lubricant is injected pneumatically to the neck rings after the blank moulds are closed. The lubrication unit is to be integrated into the existing production set up once proper function and reliability of the design has been verified. Bottle samples from the tests conducted thus far, mould gear and components from the neck ring lubrication unit will be on display.

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33. Intelligent UAV & AUV Robots’ Swarm Communication Networking with Human Operator in the loop

**Students:** Jake Phoenix, Simon Gallasch, Ling Zhang & Ming Lin  
**Supervisor:** Associate Professor Amir Anvar  
**Sponsor:** Defence Science & Technology Organisation

The aim of this project is to study the design and implementation of an automated & robust multi-robot communication and data transfer system with a human operator in the loop. The purpose of this research and testing is to develop a robotic swarm communication networking system that could eventually be implemented in a robotic community that is currently under development. This community consists of two maritime unmanned aerial vehicles an autonomous underwater vehicle and a micro communication sonobuoy. Applications of this community would include search and rescue missions, damage assessments and environmental study. Our project focuses on the initial stages of development of the communication system in a lab environment. This has been achieved by developing multiple robot scenarios and testing them using both a computer simulation and a group of three mobile robots with wireless capabilities. The focus has been on the development and implementation of a reconnaissance scenario. In this scenario the robots must cooperatively search for
items of interest within an enclosed environment containing obstacles. This requires the development of the following behaviours: obstacle avoidance, object detection and localisation. The exhibition will demonstrate the developed reconnaissance scenario using the simulation and mobile robots.

34. Design, Simulation up to Build & Implementation of a Catapult-Launched Automated Maritime UAV Robot

Students: Andrew Braham, Bryn Crawford, Bao Xing Guan, Hugh Penhall, Jarod Winders & Luke Zadow

Supervisor: Associate Professor Amir Anvar


This proof of concept project focuses on developing a maritime-based unmanned aerial vehicle (MUAV): a multi-purpose aerial robot that is able to deploy sonobuoys, perform surveillance missions, and communicate between the ground control system and other robots via remote links. Currently, the deployment of sonobuoys is not a simple process, and it generally requires several operators to facilitate the process, or the use of disposable or large-scale aircraft. Designing a non-disposable, autonomous MUAV with deployment, surveillance and communications capabilities could provide a very cost-effective alternative to the current methods, and could potentially reduce or eliminate the need for the involvement of human operators in such tasks. To allow this operation to be carried out from within a naval environment (e.g. from the deck of a ship), the MUAV must not rely on the availability of a stretch of flat surface for takeoff and landing; thus, a catapult-type Launch System has been designed, as well as a Recovery System that is able to retrieve the MUAV safely and securely after operation. Both of these full-scale systems are able to operate from within a confined floor space in order to adhere to the naval environment requirements. A Command, Control, Navigation & Avionics (CCNA) System, including an autopilot and a complete tracking system, has been developed, tested, and employed in the MUAV to enable accurate sonobuoy deployment, strong communication links, and consistent and steady autonomous flight. Both computer representations and physical models of each of these systems, along with a running flight simulation and video footage of a number of the test procedures, will be on display at the Exhibition.
35. Cycling Performance

**Students:** Thomas Shelton & Toby Callaghan  
**Supervisors:** Associate Professor Richard Kelso & Dr Paul Grimshaw

The Cycling Performance project aspires to determine how changes to bicycle geometry and set up affect the efficiency of the cyclist. Seat tube angle and crank length are two factors of bicycle geometry which can greatly affect rider efficiency. The seat tube angle is set by the bicycle manufacturer as part of the frame geometry, with minimal adjustability available in the seat position. The length of the cranks has been set seemingly by tradition. While manufactures these days offer a limited range of crank lengths, very little research has been conducted as to how different lengths affect the efficiency of different sized riders.

The aim of the 2010 Cycling Performance project is to determine how changes to the seat tube angle and the crank length affect the overall efficiency of cyclists. A selection of recreational cyclists, all of whom are current or former elite athletes in other sports, have undergone a series of tests on a variable-geometry stationary bicycle. The seat position or crank length has been changed between tests. Their power output has been monitored in each test, while their effort has been measured using respiratory analysis apparatus. The results of these tests will be used to determine how the optimum seat tube angle and crank length change for different riders with different body geometries.

The exhibition display provides an overview of the testing methodology and results. The stationary bike will be available for use, while a video of a test will be shown.

36. Portable Bolt Tester for Rock Climbing

**Students:** Reuben Chambers & Nathan Perkins  
**Supervisor:** Dr Erwin Gamboa

The sport of rock-climbing is popular worldwide despite its inherent danger and lack of recognized safety regulations for outdoor climbing. There exists substantial research behind the equipment that is used in outdoor rock-climbing. However, current research is primarily concerned with the required breaking strength of ropes, harnesses and other hardware and the associated force distributed to the climber in a fall situation. There has not been significant research conducted on the strength or lifespan of the bolts that are used to affix safety gear to the rock face-the anchor bolts. This is of particular concern due to the fact that bolts can be installed by anyone, regardless of experience or knowledge of the installation process and that after a bolt is installed, it is often impossible to visually determine if it has been installed in the correct manner. The aim of this project is to develop a quantitative test procedure for the condition of anchor bolts. In order to achieve this goal, research was undertaken into the nature of rock-climbing falls and testing procedures were developed. Furthermore, a portable device capable of applying a consistent test load to anchor bolts and measuring the resulting displacement was designed and constructed. The portable device will be used in conjunction with the developed testing procedures to determine the service condition of anchor-bolts in the field.
37. Cricket Bowling Machine

**Students:** Richard Gregory, Shevron Lobo, Luke Sheridan & Michael Smith
**Supervisors:** Dr Paul Grimshaw & Associate Professor Richard Kelso
**Sponsors:** Quin Sports Nets, BARVAN PTY LTD & South Australian Cricket Association (SACA)

The value of technology in the modern game of cricket is widely acknowledged and is utilised in a variety of applications to assist players to perform at their best. Bowling machines in particular are used to improve a batsman's performance and to reduce workloads on bowlers. The primary aim of this honours project was to design and build a new bowling machine, dubbed PACE (Performance Applications in Cricket and Engineering). The device both builds upon the capabilities of current bowling machines and also incorporates new and unique features. It has been designed to be entirely mechanical, removing any need for electricity, and to offer full control of the line, length and pace of delivery. Furthermore, the PACE design utilises a unique hand release system which better emulates a bowler's natural delivery and allows for the use of regulation leather cricket balls. The design has been refined with input from SACA, with a view to making it a cheaper alternative to current machines, meaning more clubs can afford the benefits of a bowling machine. On display at the exhibition will be research, the earliest concepts and test results as well as the finished product. Visitors to the exhibition will have the opportunity to get “up close and personal” with PACE with demonstrations and the chance to face a few deliveries in our indoor nets.

38. Protective Sporting Equipment

**Student:** Segaran Odayappan
**Supervisors:** Associate Professor Richard Kelso, Dr Paul Grimshaw & Mr Marc Simpson
**Sponsor:** School of Mechanical Engineering

The safety of the athlete plays an important role in sports science research and the development of protective sporting equipment is an excellent example. The aim of this project is to determine the design features and materials that provide the best impact protection (for lower legs) in sports such as soccer and hockey. Five commercially-available shin pads have been tested in the laboratory using an impact-testing technique based on the controlled drop of an instrumented weight. In order to determine whether current designs could be improved, the shin pad that provided the best shock absorption was then re-tested with the addition of a material known as Sorbothane™, to see if it aided in strengthening the “impact zone” of the pad. The exhibition display will describe all aspects of the testing, from the test rig itself, to the findings from the laboratory tests.

39. Intelligent conveyor belt system

**Students:** Fang Ting Foo, Chee Hong Huang, Hui Ern Song & Amos Sou Xi Wong
**Supervisor:** Dr Ley Chen

Modern industries apply automation in production lines to increase work output and decrease manual labour dependency by allowing better allocation of human resource in other areas. Starr Rubber & Plastics Pty. Ltd, an Adelaide-based manufacturer of shoes, realised the advantages of implementing an automated system on their products and hence sponsored this project to develop a system to aid the manufacture of shoe heels. The aim of this project is to develop an automated system that is capable of
feeding shoe heels into a splitter machine one piece at a time in a required orientation. To achieve automation, a sorting system is used to separate and eject individual shoe heel pieces from a randomly orientated pile. Subsequently, a conveyor system and a flipping mechanism with the assistance of a visual system will be used to correct the orientation of the shoe heels before being fed into the splitter system. Success of the automated system will significantly increase production efficiency of the shoe heels in Starr Rubber & Plastics Pty. Ltd. This means that shoe heels can be produced at a more competitive cost. This exhibition will provide an overview of the working mechanisms of the sorting and flipping systems.

40. Micycle

**Students:** David Caldecott, Andrew Edwards, Matthew Haynes, Miroslav Jerbic, Andrew Kadis & Rhys Madigan

**Supervisors:** Associate Professor Ben Cazzolato

**Sponsor:** Maxonmotor Australia & Knucklehead Engineering

The Micycle is a rideable self-balancing electric unicycle. While a regular unicycle is pedal-powered and is balanced by the skill of the rider, the Micycle is powered by an electric motor and uses a control system to balance in the longitudinal direction. The rider simply leans forward to accelerate, leans back to brake and turns by applying pressure on the foot rests. The Micycle is intended as a fast and portable means of transportation between public transport and home or office. It may also appeal to those seeking the mobility of Segway-like devices but without the size and weight. Furthermore, with an expected thirty minute learning time, the Micycle brings unicycling to the balance-challenged.

At the exhibition, the Micycle will be displayed and demonstrated (ridden). Visitors will be able to experiment with different control parameters and see how this influences the performance (ride stiffness). Video clips showing progress through the design phases will also be on display. Awarded a 2010 Open Day Innovation Fund, the Micycle is to be featured on Network Ten’s ScopeTV, so come and see what the fuss is all about.

41. Wing shape control using truss structures

**Students:** Jing Han Ng, Pee Ter Seet, Teng Chern Ong & Adrian Chiam

**Supervisor:** Dr Ley Chen

The aim of the morphing aircraft wing is to significantly enhance air vehicle performance. This project looks to develop a novel active truss structure mechanism that efficiently changes wing cross sectional profiles to optimise aerodynamic performance across varying flight conditions. Active truss structure mechanism relies on varying the length of trusses to adaptively deform structures to the desired wing rib
shape. The project has assessed a range of truss configurations and various methods of truss actuation. This was accomplished via experimental investigations on a rib model, finite element analysis and computational fluid analysis. Experimental wind tunnel testings has been conducted to verify the theoretical result. Results have shown that the morphing wing demonstrates an improved aerodynamic performance.

42. Micro mover

Students: Peng Lin, Peng Zhou & Sahidam Sulaiman
Supervisor: Dr Tien-fu Lu

The unprecedented number of natural disasters in the past decade has urged many international search and rescue companies to develop various types of rescue robots to search for the trapped victims. The robot that can navigate through narrow spaces to search for the victims has gained much interest among search and rescue companies. In response to this need, a low-cost snake-like robot called flexible cable equipped with scope camera with ultra-bright LED, thermal sensor and sound sensor is developed for the purpose of searching trapped victims under collapsed building. The flexible cable with active mobility can be inserted into narrow and circuitous spaces of rubble piles to search for living body heat and immediately send back video and audio information to the operator outside the collapsed building. System dynamics of flexible cable have been analysed to determine the movement of the flexible cable inside the rubble piles. The design of the flexible cable will consists of a rigid flexible cable covered by cilia made of nylon and vibration motors in each joint which are acting as driving forces. The design and development of the flexible cable is based on the prototypes developed by Tadokoro Laboratory at Tohoku University in 2006.

43. Design and Implementation of an Intelligent Home Security System

Students: Alexander Martin, Anton Ametov, Chun Lung Yeung & David Liew
Supervisor: Dr Tien-Fu Lu

Home security has always been a concern for most people, but despite rapid advances in computer technology, domestic security has remained relatively primitive. Current systems utilise locks and alarms to deter unauthorised entry, but they fail to capture the identity of any intruders that circumvent the measures in place. This project aims to develop an intelligent home security system which utilises face detection and recognition algorithms to achieve automatic access control and surveillance. The security system is composed of cameras that are used to obtain a continuous stream of video data at several selected locations. This video data is then processed using the developed detection and recognition algorithms that determine both the presence and identity of a person. The system monitors selected locations at regular intervals and provides almost instantaneous detection and recognition during runtime. A log is also kept of all visitors, allowing the tenants of the house to review who had visited in their absence. Additionally, in an event of a burglary, the system can provide information to assist police in their investigation, further enhancing the security of a home. The exhibition will showcase the developed home security system, which will not only detect and record details of intruders but also provide a convenient interface for home owners and their friends.
Autonomous Underwater Vehicles (AUVs) are underwater robots useful for many different purposes such as environmental studies, ocean mining, oil and gas piping, search and rescue missions, and military applications.

The current project continues the work from 2008 with the emphasis now on enhancing the previous system.

The use of an AUV is very limited without a reliable communication system present. The aim of this project is to study and design an automated, long-distance, hybrid, secure, real-time communication system. As both local-operators as well as onshore command sites should be able to monitor and control the robot, a method for communicating using internet or satellite technology is designed. The AUV has two modems; one for underwater communication and a RF modem that can be used when the AUV is surfaced. Since the workload of the operator is often very high, controlling the AUV with voice commands is preferred. To do this however, a filter is necessary to distinguish the command keywords from all other chat. Some automation can also be provided for the operator when a GPS and altimeter are added to the system. Encryption is included because the communication is valuable, and there is an obligation to provide security for the system. The complete system is extensively tested in order to improve the understanding and reliability of the results.

Why are houseflies so hard to swat?

Houseflies, in spite of their low-resolution eyes and tiny brain size, are able to robustly encode the apparent motion of objects, surfaces, and edges in a visual scene caused by their relative motion against their changing surroundings. They are able to use this perceived motion of images to regulate their speed and steer themselves away from potential collisions.

This project aims to use a newly developed sensor, based off the predicted neurological response of the housefly, to guide an unmanned ground vehicle (UGV) through a tunnel environment. This new sensor offers many potential advantages over many standard sensor suites commonly found in autonomous vehicles, such as the ability to track multiple objects and to perform robustly under a range of variable conditions. Our project team have developed a platform for which this can be implemented as well as a control system that can use this sensor to successfully navigate the UGV through the tunnel. During the
exhibition we will be running demonstrations of the UGV in operation as well as being on hand to answer questions.

46. Intelligent Condition Monitoring Systems for AUV & UAV Robots’ Operation

**Students:** Amir Parsa Anvar, Ahmad Ammar, Yeow Hun Chan, Jia Qian, Firdhaus Roslan & Jason Hua  
**Supervisors:** Associate Professor Amir Anvar & Dr Steven Grainger  
**Sponsor:** Defence Science and Technology Organisation (DSTO)

Autonomous robots such as Autonomous Underwater Vehicles (AUV) and Maritime Unmanned Aerial Vehicles (UAV) are especially susceptible to faults in their subsystems as the vehicle is typically operating beyond reach of a human operator. The aim of Project 997 is the Design and Build of Intelligent Conditioning Monitoring Systems (ICMS) to ensure that UAVs and AUVs can maintain a healthy state during their operation. A robust condition monitoring system includes intelligent diagnosis, prognosis and remedy. Diagnosis is the method of detecting faults. Prognosis then aims to estimate and predict the consequences if the system were to continue operating with the fault. Remedy is the final stage of the system and it aims to provide the most viable solution to the faults. This idea was invented to provide higher reliability and longer life span to the robots and hence reduce the operating costs. The exhibition provides an overview of the entire ICMS, with the results of an ocean trial and a UAV test-bed displayed.

47. Design, Build and Implementation of small Communication / GPS Navigation Beacon (Micro-Sonobuoy) deployable by UAV Maritime Robot

**Students:** Frederik J. Visser and Nicholas K. Schulze  
**Supervisor:** Associate Professor Amir Anvar  
**Sponsors:** Defence Materiel Organisation, Defence Science & Technology Organisation

The DMO sponsored and DSTO supported Micro Sonobuoy project aims to construct an air deployable beacon capable of underwater and above water communications.

The sonobuoy is to be roughly half the size of the smallest known sonobuoy in use today, making it lighter and more capable of deployment by maritime UAVs. After deployment from an aircraft into a maritime environment the sonobuoy establishes a crucial communications link between aircraft, surface vessels, and underwater vessels. Radio frequency communications will be used above water and acoustic communications below water. A microcontroller acts as a central controller, supplying and receiving signal information to a range of sensors, actuators and modules including.
- Accelerometers
- GPS module
- Piezoelectric transducers
- Solenoids
- RF transceiver module
- Underwater FSK modem

Hundreds of lines of code have been written to determine the state of the sonobuoy and control all mechanical and communication operations. All communications formatting and conversions between RF and underwater are handled by the code to make communication between the M-UAV and the AUV work as a transparent serial link.

The project has thus far achieved modular successes. RF communications have been established, GPS location has been ascertained, command and control has been accomplished and an FSK modem has been designed and tested. The sonobuoy case has been designed and constructed and will be on display at the exhibition along with a demonstration of the working communications and control.

48. Autonomous microdrone

Students: David Chu, Jonathan Dansie, Andrew Ellis & Christopher Penny
Supervisor: Dr Ley Chen

Natural disasters and terrorist attacks often create environments that are unsafe for human exploration. Small autonomous Unmanned Aerial Vehicles (UAVs) provide a platform for exploring these environments remotely and safely. Rotorcraft are particularly useful for these roles due to their vertical takeoff and landing (VTOL) capabilities and high manoeuvrability, and quadrotor UAVs are gaining popularity due to their robustness and simplicity. Quadrotors are UAVs with four rotors which achieve controlled flight by varying the speed of each rotor. This enables full vehicle control with simple fixed pitch rotors, avoiding the complex mechanisms required by traditional two rotor helicopters. Current research often focuses on outdoor quadrotors with GPS capability, or indoor quadrotors using external video systems for feedback for control that could not be practically implemented in real world environments. The Autonomous Microdrone project aims to design and construct an autonomous indoor quadrotor from low cost components and a custom airframe, and investigate the use of onboard visual sensor systems for trajectory control. The microdrone has been designed, built and tested in an indoor environment, and various visual trajectory control systems have been investigated. The exhibition will provide details of the microdrone design process and the results of all component and system testing. The microdrone will also be on display.
49. Design, Build and Implementation of VTOL-UAV Maritime Robot

Students: Tristan Goss, Tuyen Nguyen, Andrew Nobbs, Benjamin Nobbs & Kurt Siu
Supervisors: Associate Professor Amir Anvar & Dr Steven Grainger
Sponsor: Defence Science & Technology Organisation (DSTO)

The Vertical Take-off and Landing Unmanned Aerial Vehicle (VTOL-UAV) Maritime Robot project aspires to provide a means for surveillance and communication in maritime environments. This is facilitated through the design and build of a quad-rotor; a VTOL-UAV utilizing a four rotor propulsion system that can be launched from confined platforms such as ship decks. Most quad-rotors currently rely on differential thrust to provide pitch, roll and yaw capabilities. However, the VTOL-UAV Maritime Robot project aims to deliver what is believed to be the first large-scale quad-rotor in the world to incorporate variable pitch sliding mechanisms similar to those found in helicopters; enhancing manoeuvrability and response of its controls. An iterative design, build and testing approach was taken towards the airframe, propulsion, payload and safety subsystems using a combination of off-the-shelf and custom manufactured components. The payload and safety subsystems allow the deployment of two sonobuoys during flight for communicating with other UAVs and Automated Underwater Vehicles (AUVs) and an emergency-landing parachute. The integration of these subsystems and subsequent performance tests will provide valuable research for future iterations. This year’s finalised build of the quad-rotor will be displayed at this exhibition along with details of the subsystems and performance tests results.

50. Design, Manufacture and Implementation of a Command, Control and Autonomous Navigation System for a VTOL UAV

Students: Garland Hu, Joshua Northeast & Eric Parsonage
Supervisors: Associate Professor Amir Anvar & Dr Steven Grainger
Sponsor: Defence Science & Technology Organisation (DSTO)

A quadrotor is a unique design that encompasses four helicopter style rotors on a cross shaped frame. Control of vehicle motion can be achieved by varying the amount of thrust and torque produced by each rotor. This configuration allows for mechanically simpler designs than the current generation of traditional helicopters, as well as enhanced manoeuvrability, but suffers from poor stability. It has only been in recent years that this design concept has been explored, as improvements in controller and sensor technology, have allowed electronic systems to be developed that balance the vehicle.

The aim of this project was to design and implement a Command, Control and Avionics system for quadrotors which will allow for varying degrees of autonomy, from controller stabilised manual flight to full autonomous navigation through predefined waypoints. The controller is derived from the Paparazzi project, which is an open source community hardware and software package for all forms of Unmanned Aerial Vehicles (UAVs), that has been adopted for our quadrotor design. To test this system, four
quadrotor designs of increasing size, complexity and performance have been designed and built by the team, which demonstrates the full abilities of the designed system.

Our exhibit will showcase each of these aircraft, as well as display results from each of our test flights. The exhibition will also provide an overview of the design methodology and processes used in this project.

51-52. Biodiesel Bike

Students: Alex Arney, Luke Bayly, Kimberly Bennett, Jevon Hughes, Samuel Hurst, Leigh Killmier, Jonathon Lovell & Edward Styles

Supervisors: Dr Colin Kestell & Dr Antoni Blazewicz

Sponsors: Charlie Morgan, Paul Carter, AR Fuels, Move Yourself Trailers, MTQ Engine Systems & Tailem Bend Motorsport Park

The BDM Salt Lake Special (SLS) is a high performance motorcycle fuelled by bio-diesel. The aim of the project is to demonstrate that you do not need to sacrifice performance in order to be environmentally friendly. To achieve this aim, the SLS has been designed to be capable of breaking the current land speed record of 210 km/h. This exhibit outlines the work to date which includes a review of the previous 2 years work and development in the key areas of suspension, aerodynamics and engine development.

53. Investigation of bushfires caused by harvesters and headers

Students: Muhammad Wajahat Zia Subhani & Mohitkumar Keshwani

Supervisor: Dr Ley Chen

Sponsors: South Australian State Emergency Services (SES) & South Australian Country Fire Services (CFS)

The project ‘Investigation of bushfires caused by Harvester/Headers’ aspires to provide South Australian State Emergency Service (SES) and South Australian Country Fire Services (CFS) the causes of fires in
headers/ harvesters. Each year especially during the fire danger season, large number of farm land and farming equipment is destroyed due to fires caused by harvesting machines such as headers. When a fire develops in a header and is not controlled early on, a catastrophic loss may occur, since rural volunteer fire departments may take a considerable amount of time to reach the remote location of the header.

The aim of this project is to determine the sources of fires in headers. The possible sources of fires in headers include static electricity, dust explosions, accumulation of combustible materials on heated components, overheated bearings and faulty electrical cables. Reducing the number of bushfires caused by headers would mean that a large number of farmland, livestock, vegetation and most importantly lives will be saved.

The exhibition will provide an overview of the research, investigation and testing undertaken to determine the possible causes of fires mentioned above. Results of testing and pictures of field trips will also be on display at the exhibition.

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**54-55. Compressed Gas Bike**

**Students:** Sarah Edwards, Daniel Halls, Simon Schulz, Joshua Ellgar, Nicholas Baumgartner & David Whittington

**Supervisors:** Dr Colin Kestell & Dr Antoni Blazewicz

**Sponsors:** Mr Paul Carter, 2H Automotive, Bosch GmbH, Inflex & Bills Motorcycles

The Compressed Gas Bike (CGB) Project is new to 2010 and aims to provide an environmentally friendly solution to two-wheeled transport. Specifically, the main goal was to develop a gas-powered motorcycle suitable for use on Australian roads. The driving force behind the project comes from the increasing interest in alternatively fuelled vehicles, as petroleum independence is being explored. The CGB project was made possible by Mr. Paul Carter, who donated a Cagiva enduro motorcycle (pictured below) to the project team at the end of 2009. The team has also received significant support from the sponsors listed above.

The aims of the CGB project were to gain a benchmark understanding of the petrol-powered Cagiva's performance and successfully integrate a system to suit the chosen alternative fuel: Compressed Natural Gas (CNG). Achieving this, the CNG-fuelled Cagiva was then tested and calibrated to achieve optimal running conditions. The integration of the CNG system required a redesign of the motorcycle's engine control systems, a new intake manifold and throttle body, and an innovative fuel storage and delivery system. This project has aided in driving the engineering and transport industry towards a sustainable future that consists of lower poisonous emissions.

The CGB exhibition will provide a detailed account of the project's progress throughout the year. The CNG-powered Cagiva motorcycle will be on display, as well as details of the CNG system design and the results of the team's experimental studies.
The offset crankshaft engine project seeks to determine the advantages and disadvantages of a reciprocating Internal Combustion (IC) engine design where the crankshaft is offset from the centerline of the bore by a significant amount. The mechanical design of the IC engine has remained essentially unchanged, consisting of a reciprocating piston which is connected to the crankshaft via a connecting rod.

Mr. Bill Arnold, the inventor of this particular offset engine design, has asked us to analyze the engine primarily in terms of torque and manufacturability. Mr. Arnold’s design consists of each piston having two conrods driving two crankshafts which are coupled by gears. The invented design utilizes a four cylinder, horizontally opposed configuration which requires four crankshafts all interconnected with gears. Besides a potential torque advantage this design also eliminated side forces on the pistons. Comparison with a Subaru engine has been selected due to the same horizontally opposed configuration.

The exhibition provides an overview of the offset crankshaft engine configuration, including a theoretical analysis and a comparison of Torque, Power, Inertia, Weight, Manufacturability and Assembly between the offset and the conventional engines. An animated engine will be on display to view the workings of the new concept.

The trend towards smaller house yards has meant that rotary clotheslines are being replaced with space efficient linear clotheslines. Few linear clotheslines retain the function of being height adjustable. This feature is of particular importance if the linear clothesline is to be used by both wheelchair users and able bodied persons, where typically the clothesline would be mounted at a fixed height which may be convenient for use by one but not the other. The project sponsor, the Medical Device Partnering Program, requested that a height adjustable linear clothesline be designed that would be suitable for use by both wheelchair users and able bodied persons. A design has been produced that incorporates height adjustment, making operation easy for all users. This is achieved by using a counterweight and force advantage pulley system in parallel. The counterweight serves to remove the fixed weight of moving parts while the force advantage pulley system makes the variable load of clothes on the clothesline less apparent to the user when adjusting the height. The prototype itself, results of testing and specific details of the final design will be presented at the exhibition.
58-59. Electric Bike

Students: Amy Leow, Andrew Ly, Christopher Drogemuller, Craig Hattersley, Martin Pietsch, Natasha Parker, Quy Nguyen & Zachary Koumi

Supervisors: Dr Colin Kestell & Dr Antoni Blazewicz


The High Performance Electric Motorbike (HiPEM) Project is aimed at producing an electric motorbike with comparable performance characteristics to conventional internal combustion engine designs. The project is motivated by the increasing interest and need for hybrid and electric vehicles. The 2010 HiPEM is to design a high performance and energy efficient motorbike that retains the agility and excitement of conventional motorbike counterparts.

Development of electric drive train technology, vehicle aerodynamics, existing structural component redesign and rider ergonomics have been undertaken to produce an optimal solution. Design of systems in parallel allows systematic integration to produce the best engineering solution. This exhibition provides a visual representation of the Motorbike and further information of how the HiPEM Project developed over the year.

60. Rail Noise Assessment

Students: Karl Baker, Adam Cook, Andrew Cooper & Alexander Morabito

Supervisors: Professor Colin Hansen & Associate Professor Anthony Zander

Sponsors: Environmental Protection Authority

As rail based transportation becomes more important in the context of reducing overall energy use, its impacts on the surrounding environment, in particular environmental noise pollution, need to be considered. This project, sponsored by the South Australian Environmental Protection Authority aims to assess rail noise in SA through measuring, modelling and predicting current and future railway developments. The project has reviewed current Australian and international railway noise criteria with the intention to develop a noise criteria guideline for use in South Australia. Measurements of rail noise have been taken to ensure the developed noise criteria guideline and associated noise descriptors are relevant to local conditions. Rail noise from both passenger and freight trains has been processed to create a relatively simple train noise source model. The model forms the input for SoundPLAN prediction software to produce noise contour maps for a number of locations. The equipment used for the collection and processing of data will be on display.

61. New Ambulance Sirens

Students: Aaron Maddern & Elefterios Privopoulos

Supervisor: Dr Carl Howard

Sponsor: South Australian Ambulance Service

The SA Ambulance Service (SAAS) operate a fleet of approximately 600 emergency ambulance vehicles, and provides South Australians with a high standard of emergency treatment and transportation. There are a number of collisions between ambulance vehicles and public road users and it is believed that a contributing factor to the collisions is that drivers are unaware of an approaching ambulance. Accidents involving ambulance vehicles result in: high annual costs associated with the replacement of vehicles, injury to the specially trained ambulance staff and the general public and service inefficiency. Studies have led to the recent improvement of the visual characteristics of
ambulance vehicles, however, the “wail” and “yelp” sirens currently in use have been utilised for decades.

The aim of this project is to recommend a combination of warning sirens, and where they should be mounted, for installation in the fleet of SAAS ambulances that will provide an effective audible warning signal to motorists and pedestrians. The project has assessed the current sirens used on ambulances, along with a new “Rumbler” siren from the United States, and various European horn type signals. Several laboratory and field tests have been conducted in order to analyse the performance of the signals in terms of vehicle penetration, and psychoacoustic parameters. Factors such as loudspeaker directivity, the effects of wind, and possible degradation of performance due to wear and usage were also explored. The results of the testing and research will be presented in the exhibition.

62. Representation of a wind turbine generator as a noise source

Students: Muhammad Fawwaz Mohd Johari, Kumaraguru Nadaraja, Mohd Munir Omar & Sindhu Shastry

Supervisors: Professor Colin Hansen, Associate Professor Anthony Zander & Dr Valeri Lenchine (SA EPA)

Sponsor: South Australian Environment Protection Authority

Computer models simulating Wind Turbine Generator (WTG) sound emission, based on different computational methods, indicate results with varying levels of discrepancies in comparison to practically measured noise levels. Standards applied in assessing Wind Turbine Generator (WTG) noise emission do not account for the directivity of WTG noise in the vertical or horizontal planes and assume the noise emission is characterised by a uniformly radiating monopole source. It was proposed that by accounting for the directivity and other omitted factors, determined from WTG noise measurements at Starfish Hill Wind Farm, these discrepancies would be minimised. A number of parameters were measured using a system consisting of microphones, temperature & air pressure sensors and GPS which were hoisted to hub height (68m) by a helium inflated weather balloon. Noise levels were measured from ground level up to hub height in 10 metre increments to assess vertical directivity while horizontal directivity was assessed by varying the ground level measurement positions in 24 degree increments, down-wind of the WTG. The WTG directivity factors were incorporated into a SoundPlan model and the results were used to assess if the currently observed discrepancies can be attributed to the noise source characterisation of a WTG.
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