School of
Civil Engineering

Icarus Program

Projects, S2 2015

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

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Turbulent Mixing, Dispersion & Water Quality in Estuaries

Mentor: Hubert Chanson | Discipline: Civil / Hydraulics

Researchers at UQ-CE and QUT organised a major research field trip on 29-30-31 July 2015 to Eprapah Creek, for which a number of Icarus student volunteers participated.

During the semester 2, 2015, a group of Icarus students will participate to the data processing and analyses, under the expert supervision of Prof. Hubert Chanson and Dr Hang Wang.

Activity

The focus of the analyses will be on the water quality sampling, instantaneous velocity data and velocity profile, as well as possibly the bathymetry. Each student will be expected to volunteer at least one day per week (preferably 1.5 days per week), and maximum 2 days per week, for the whole semester. Maximum 6-7 group size.

Pre-requisite:

- Participation in the Icarus program in semester 1, 2015.
- Participation in the research field trip at Eprapah Creek on 29-30-31 July 2015.

Contact details

- Professor Hubert CHANSON (49-553) – h.chanson@uq.edu.au
- Dr Hang WANG - hang.wang@uqconnect.edu.au

Figure 1. Field equipment installation in Eprapah Creek's upper estuary in 2006.

Figure 2. Site 2A mid-estuary, looking downstream.

Strike a Match, Light a Candle

Mentor: Kevin Sevilla & Surya Singh | Discipline: Civil & Mechatronics

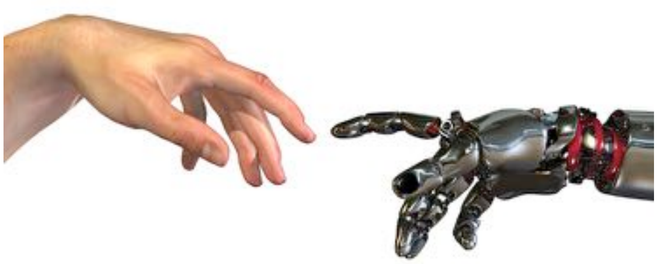
Robots and other autonomous systems have become an increasingly common fixture in modern society. Despite the fact that using robots in place of humans in situations that are particularly dull, dirty, or dangerous raises several ethical questions, the fact remains that in certain contexts, robots offer the best option.

In this project, students will be introduced to control systems and robotics content that parallels the mechatronics 4202 course. In session students will be introduced to the ethical considerations in modern robotics, control systems with Matlab programming, and computer vision technology with C.

Students will meet up to three hours per week to progress their knowledge of robotics. Expectations will be that students will have commitments outside of the regularly scheduled sessions, with the complexity, and ultimate success or failure of the project dependent on the goals set forth by the students themselves.

For those interested, the following video illustrates the outcomes of a previous student design team connected with the 4202 course.

https://www.youtube.com/watch?v=z4qVI7Ybxac



Estimating surface wind speeds during tropical cyclones

Mentor: Matthew Mason | Discipline: Civil / Wind

Tropical cyclones cause damage to buildings and infrastructure each year. This is not only a problem in Queensland, but across Australia and around the world. One way engineers can reduce the impact of these events is to design and build structures to a level that resists the hazard these storms pose. In order to do this, though, we need to understand how our current buildings perform when exposed to such extreme events. An integral part of this is determining what wind speeds impacted structures during storms so that accurate forensic engineering is possible. Unfortunately this information is seldom available and new techniques need to be developed to infer it.

During early 2015 Tropical Cyclone Marcia made landfall on the Queensland coast. Wide spread damage occurred to Byfield, Yeppoon and Rockhampton. Following the storm, high resolution aerial imagery (photographic and Lidar) was acquired of damaged structures and forests (Figure 1 & 2). The aim of this project will be to see how images such as these can be used to determine the intensity of surface wind speeds over an impacted area. Students will be required to explore image processing techniques and may look at coupling this analysis with analytical wind field models. Wind speed and direction should be inferred, with a secondary aim of quantifying damage to individual structures.

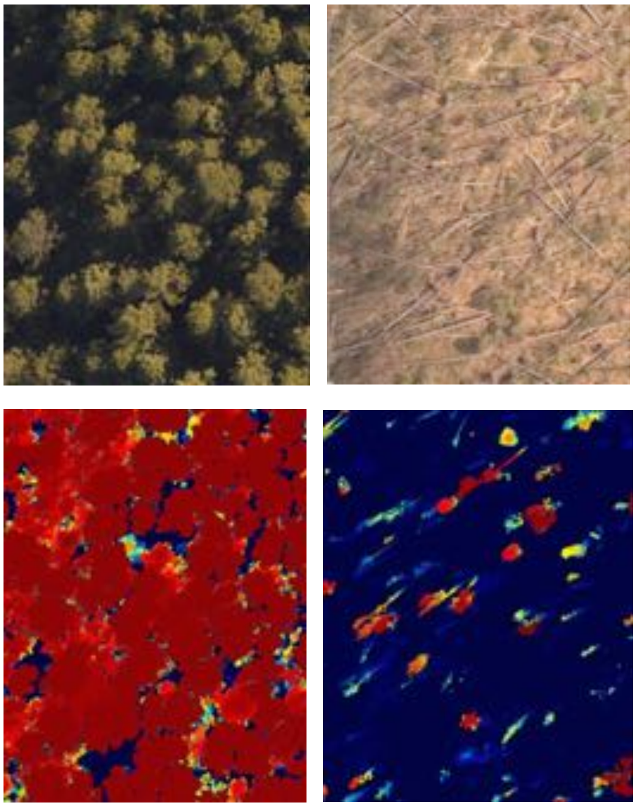


Figure 1. Damage to pine trees. Left images are before, right are after storm. Lower images are Lidar. All images show the same area.

Figure 2. Damage to building in Yeppoon.

Burning stuff with the sun

Mentor: Ilje Pikaar | Discipline: Civil / Environmental

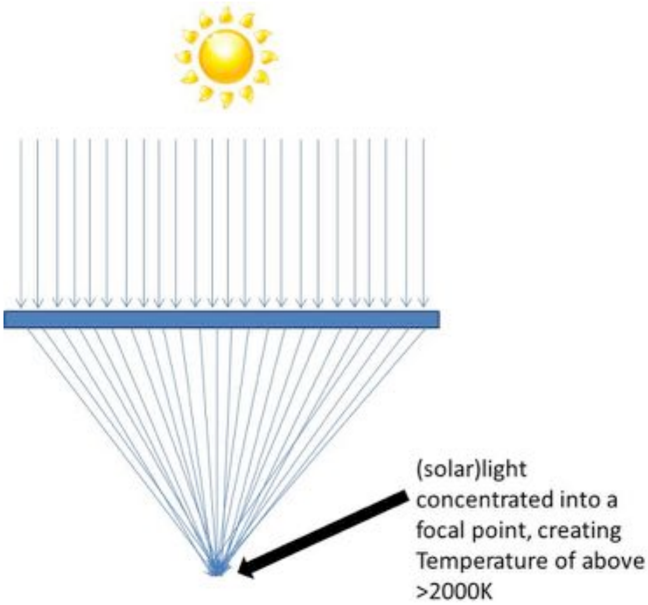
To achieve a more sustainable future, attempts are made to develop a circular economy where resources are recovered rather than wasted. Important resources are ammonium and phosphate, both of which are used in megaton quantities as fertilizer or as building-blocks in the chemical industry.

Research has been focusing on the decentralized recovery of ammonium from urine. While proposed technologies are interesting from an academic perspective; their economic potential and practical feasibility are not promising. The development of cheap, robust systems at a house-hold scale would be a major step forward.

In this context, Fresnel lenses offer great potential: https://www.youtube.com/watch?v=jrje73EyKag . By concentrating solar radiation, one could achieve temperatures of above 2000K, basically 'burning' urine away, leaving ammonium (as well as salt, phosphate) as a recovered product.

In addition to urine, the concept can also be used to dewater waste streams having high moisture content (i.e. 70-80%) such as sludge or agro-residues. A Fresnel based reactor can be used to incinerate the organics, while the generated heat will reduce the moisture content by generating steam.

This project aims to develop a first prototype Fresnel lens based reactor for either ammonium recovery from synthetic urine or dewatering/incineration of sludge.



The Virtual Reality Rose Theatre Model and Fire Safety

Mentor: Jose Torero | Discipline: Civil / Interdisciplinary

The building foundations for the Rose Theatre, a very important London theatre from the time of William Shakespeare, were discovered in 1989 during the renovation of an office tower. While the foundations remain, the office tower does as well, which means that the theatre will not be able to be reconstructed in situ, if anywhere.

Ortelia Virtual Spaces has reconstructed the theatre in virtual format to investigate what the building looked like and how theatre itself took place there: what effects were possible to create and what weren't. The importance in such an investigation for theatre is that theatre researchers tend to make assumptions and guesses about the theatre of the early modern era, based on 2D sketches, when being able to enter into a venue a 3D model produces very different results.

This theatre model has already provided important information on how theatre worked at the time, but there is much more that can be learned. One important aspect is the limitations that would be discovered if one could actually recreate (in bricks and mortar) such a building today, given contemporary fire regulations. This project reflects the work that would have been done for the neighbouring Shakespeare's Globe Theatre, reconstructed near the site of the Rose Theatre in London. While Shakespeare's Globe purports to be an accurate reconstruction, numerous modifications were essential to make it safe for today's audiences to visit. The model has been built using Autodesk Maya and will be displayed using the Unity engine.

The project will be supervised by Prof. Jose L. Torero (School of Civil Engineering), Prof. Joanne Tompkins (School of communication and Arts) and Mr. Lazaros Kastanis (Ortelia Virtual Spaces).

Maximum Number of Students: 6

This project has a number of outcomes. Students will required to explore the 3D model of the reconstructed in detail in order to:

- Identify and mark issues in the building relating to modern day fire standards
- Propose changes to the structure to accommodate fire regulations while maintaining the utility of the space.
- Identify a procedural methodology for using VR tools to modify theatre spaces in order to accommodate fire regulations while maintaining the utility of the space.
- Propose a list of standard 3D objects to be stored in a 3D database (stairs, doors, walls etc) that can be used to show necessary changes required to meet fire regulations.
- Students would work with the modeller and the theatre researcher to investigate which aspects of the VR model would need modification to accommodate contemporary fire regulations and safety. Students will provided with guidance in issues of 3D modelling and real-time applications.

DIY Structures Demonstration Kits

Mentor: Vinh Dao & Joe Gattas | Discipline: Civil / Structures

A popular theory of education is that there are three styles of learning: visual, auditory, and kinesthesic. While evidence to support the efficacy of this model is disputed, there is little doubt that students who can access a variety of teaching materials and methods are better able to progress their education.

Typical university instruction is geared towards visual and auditory teaching aids. Several UQ SoCE courses also have practical laboratory sessions, but at best these occur once once per semester for any given course. Various in-class physical demonstration models exist, but they are not widely used due to the difficult logistics of offering such models to large groups of students. For example, the Mola Structural Kit (https://www.catarse.me/pt/mola) costs $250. Having one kit for every five students would therefore cost close to $10,000 and is thus beyond the capacity of the School to offer.

The present project is to develop low cost physical teaching aids for first and second year Structures courses (ENGG1400, CIVL2330). Using the School's 3D printer and laser cutter, students will have to prototype and validate aids suitable for distribution to the whole student cohort.

The project will involve the following activities:

- Research existing best practice in Structures teaching aids.
- Develop CAD and Rapid Prototyping capabilities.
- Iteratively design and prototype a range of teaching aids.
- Present final teaching aids designs to Structures and Teaching Committee academics for approval and mass-production.

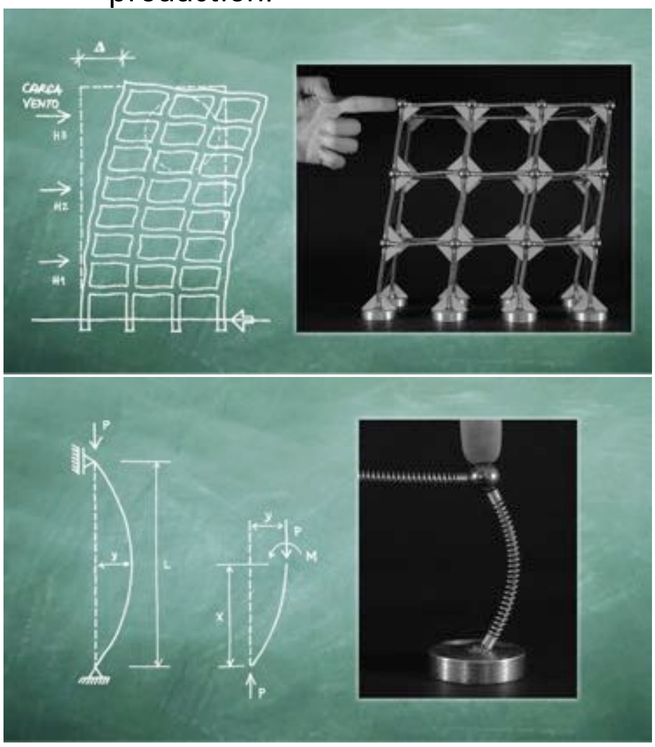


Figure 1: Demonstration models for learning structural concepts https://www.catarse.me/pt/mola

Computer Programming for Transport Data Analysis

Mentor: SangHyung Ahn & Jiwon Kim | Discipline: Civil / Transport

Session Schedule: 1pm – 3pm, Friday
Requirement: Students are required to have laptop computers.

Our world is becoming increasingly interconnected and intelligent. At the heart of this trend is the availability of ubiquitous sensors and the massive amount of data collected from them. With the rise of big data, the demand for data processing, mining and analysis is experiencing an exponential growth in a wide range of application domains ranging from science and engineering to business and government.

The transport sector is also undergoing a major change in data collection and usage. Traffic and trip data collected from various sources (e.g., roadside sensors, mobile devices, and smart tags/smart cards) open up new opportunities to improve transport planning and operations and provide better services to transport system users.

The first step toward using such data is to process data to transform raw datasets into accessible and usable formats. In many real-world applications, data processing tasks are very complex and time consuming and, therefore, basic computer programming skills are essential in automating the process and improving the accuracy.

This project aims to provide students with advanced knowledge and skills to effectively program and use computers to perform various data analysis tasks. The topics covered by the project sessions will include an overview of C++ programming language, object oriented programming, data structures, algorithms, graphical user interfaces (GUIs), and plotting library.

After learning the basic concepts of C++ programming language, students will exercise their skills through the following activities.

- To implement some of the famous algorithms to solve real world transport problems such as shortest path finding (e.g., find the shortest route between two intersections on a road map).
- To develop a simple software application tool that can import and process data and plot graphs on a GUI control (Fig. 01b)

01a: Data to Information & Data Processing Keywords

01b: A GUI of Go Card Data Loader

Fire tornados, oil spills and pelagic fish farming

Mentor: Peter Nielsen | Discipline: Civil / Interdisciplinary

A modest amount of angular momentum in the incoming fluid has a dramatic effect on buoyant plumes as demonstrated most spectacularly by fire tornados: Centrifugal forces keep the light, rising fluid together and hinders entrainment, like a chimney without walls, Figure 1. In cyclones the angular momentum is generated by the Coriolis effect and hence tropical cyclones do not occur closer than about 6o° latitude from the equator.

In this project we investigate the possibility of using an artificial supply of angular momentum to stabilise other buoyant plumes e.g. oil spills from “blowout preventer valves” at the ocean floor, Figure 2, and hot-water sea-floor vents, Figure 3.

The key question about tornados is: why don’t they diffuse, but rather manage to keep the angular momentum together within a fairly narrow radius? This relates to the fact that Turner (1966) found that the descending outer flow is not concentrated at the container walls but at a smaller radius, see Figure 4. It is still unknown what determines this preferred downflow radius.

The School of Civil Engineering is looking for enthusiastic students to investigate these systems in the field, in the laboratory, and on computers to answer discover how much torque is required to make a plume with a given buoyancy flux become a tornado. The project will be mentored by Prof. Peter Nielsen <p.nielsen @uq.edu.au>. If enough students are interested, additional mentors will be engaged assist students in developing methods to generate and measure vortices in fire, water, and air.

Figure 1:Fire tornado photographed by Chris Tangey near Alice Springs, September 17 2012.

Figure 2: The Deep Sea Horizon (BP) oil spill disaster in the Gulf of Mexico happened when a so-called "blowout preventer valve", pictured here, failed and large amounts of buoyant crude oil (with dissolved gas) started leaking out and rose towards the surface, entraining some of the surrounding sea water as it rose. Introduction of angular momentum to the entrained seawater might have diminished entrainment and kept the spill within a smallish surface area, easy to collect. Photo source Wikipedia.

Figure 3: Hot, bubbly, mineral rich water issuing from a vent in the sea-floor. The rate of entrainment may be reduced if angular momentum is introduced to the laterally entrained water. The mineral rich water may then reach the surface and provide nutrients for a rich ecosystem like in areas with natural upwelling. Each vent may then feed the equivalent of 300t of tuna per year. Photo from Wikipedia.

Figure 4: Turner, J S (1966): The constraints imposed on tornado-like vortices by the top and bottom boundary conditions. J Fluid Mech, Vol 25, pp 377-400.

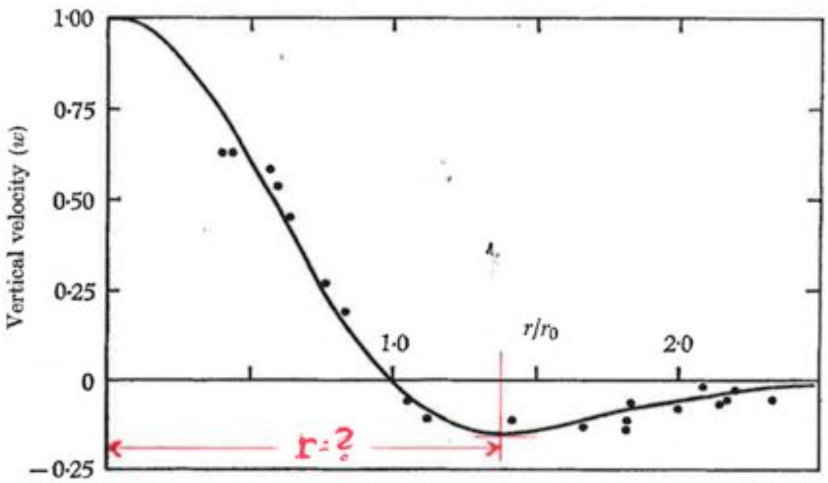


FIGURE 14. Relative measurements of vertical velocity compared with the form (10) (adjusted in both directions to give the best fit). The form of vertical velocity near the axis has not yet been measured.

Using the Earth to Cool or Heat Buildings

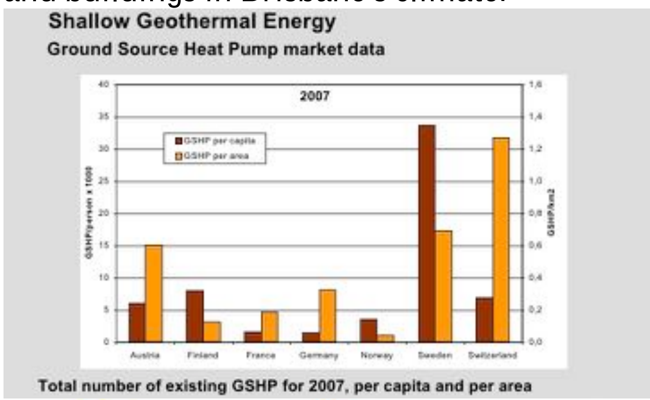
Mentor: David Williams | Discipline: Civil / Geotechnical

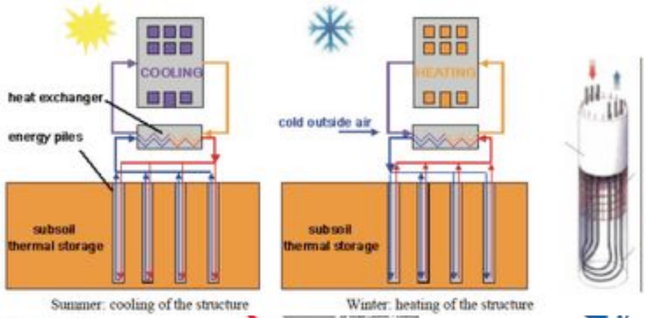
The earth maintains a much more stable temperature than the air. For example, in Brisbane, the air temperature in July can vary from a minimum of about 5^{o}C to a maximum of about 25^{o}C, while the ground temperature varies from 15^{o}C just below the surface to 17^{o}C below 1 m depth. The air temperature in Brisbane in January can vary from a minimum of about 15^{o}C to a maximum of about 35^{o}C, while the ground temperature varies from 25^{o}C just below the surface to 22^{o}C below 1 m depth.

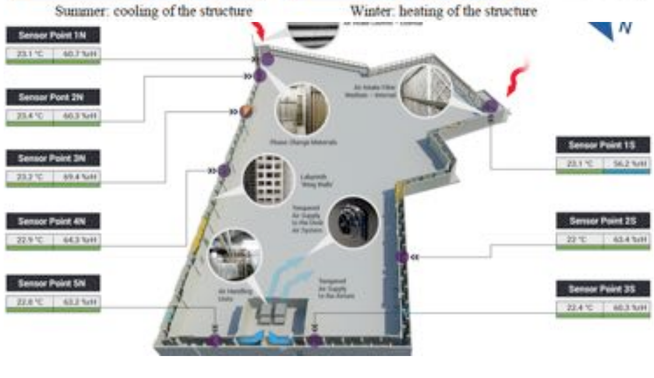
We can make use of the differences between the air and ground temperatures to cool buildings in the summer or heat them in the winter. In northern Europe and northern USA and Canada, the ground/air differential temperature has been used particularly to heat houses or buildings during their cold winters. This can simply be achieved by circulating air through a buried trench, but is more efficiently achieved via shallow (25 to 100 m deep) geothermal energy piles. The piles contain pipes that circulate a fluid (typically water), being warmed (or cooled) by contact with the earth, with the heat (or cold) extracted by surface heat pumps to heat (or cool) the house or building.

In Brisbane, although the temperature differentials are not as high as they are in colder climates, they are still significant and the energy is essentially free. A local example of the use of the earth to cool a building is in the Advanced Engineering Building. Air is cooled by being circulated around a buried Labyrinth (a tunnel surrounding most of the buried Level 1 of the building), and the cooled air is pumped into the Atrium. This is the only source of cooling of the Atrium. In the summer months, the circulation of air around the labyrinth cools it to about 23^{o}C. In the Atrium, the air warms to about 26 to 27^{o}C by the time it reaches the roof, accompanied by a decrease in the relative humidity.

This project aims to explore the potential for the use of shallow geothermal energy piles to augment the cooling and heating of houses and buildings in Brisbane's climate.





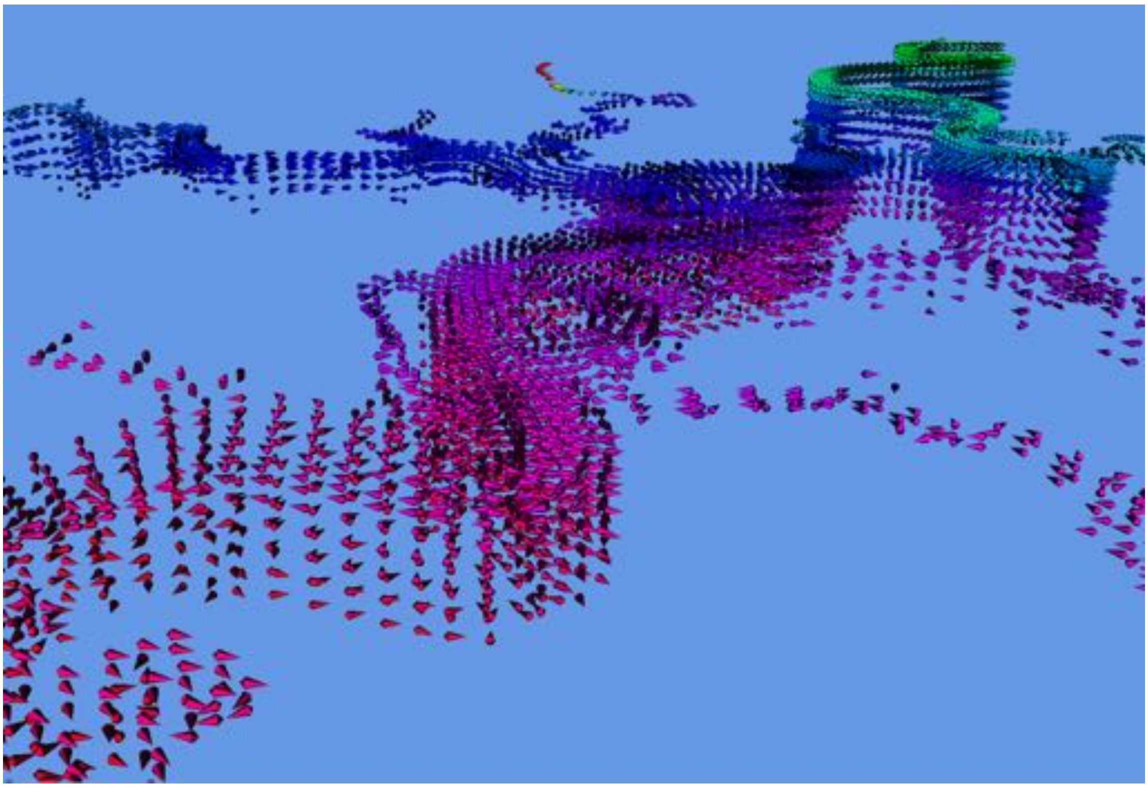


What do the water quality models tell us?

Mentor: David Callaghan & Badin Gibbes | Discipline: Civil / Interdisciplinary

With recent increases in computational power, engineers are now able to readily simulate complex three-dimensional flows and water quality in environmental systems such as lakes, rivers and oceans. These models can produce a large amount of data that covers large spatial distances and extends over long timeframes. A key challenge faced by the engineering profession is the development of new techniques for visualising and analysing the data developed by these models so that the results can be effectively used to inform engineering design and management decisions.

This project seeks to use undergraduate students to test a newly developed model visualisation platform. Students will interact with water quality model data in a range of different formats and provide guidance on the most effective methods for presenting and understanding a complex environmental data set.



Swash & Surf Sediment Transport

Mentor: Tom Baldock | Discipline: Civil / Coastal

Two projects will be available to Icarus students to support fourth-year and post-graduate research activities.

Project One will investigate large scale experimental modeling of sediment pickup by surf zone bores. This project will use a dam-break flume in the hydraulics lab to generate breaking wave bores that propagate over a sloping sediment bed, simulating the inner surf zone of a beach. The sediment transport will be measured by trapping sediment overwashing the end of the flume, which provides the data for testing sediment transport models. Computer modelling of the hydrodynamics can be performed if students wish to do that. See Othman et al, 2014, Coastal Engineering, for a paper describing the setup. Postdoctoral researcher Florent Birrien can also assist with mentorship.

Project two will use dam-break flows to mimic the wave uprush on beaches and to measure sediment transport pick-up by bores or surge waves the hydraulic laboratory. A special dam-break flume will be fitted with a mobile bed and sediment trap, with sediment caught during overwash of the flow at the end of the flume. The experiments will build on previous work and focus on pick-up of sediment just below the still-water line, representing the inner surf zone on real beaches. Ultrasonic sensors will be used to measure flow depths and derive flow velocity.

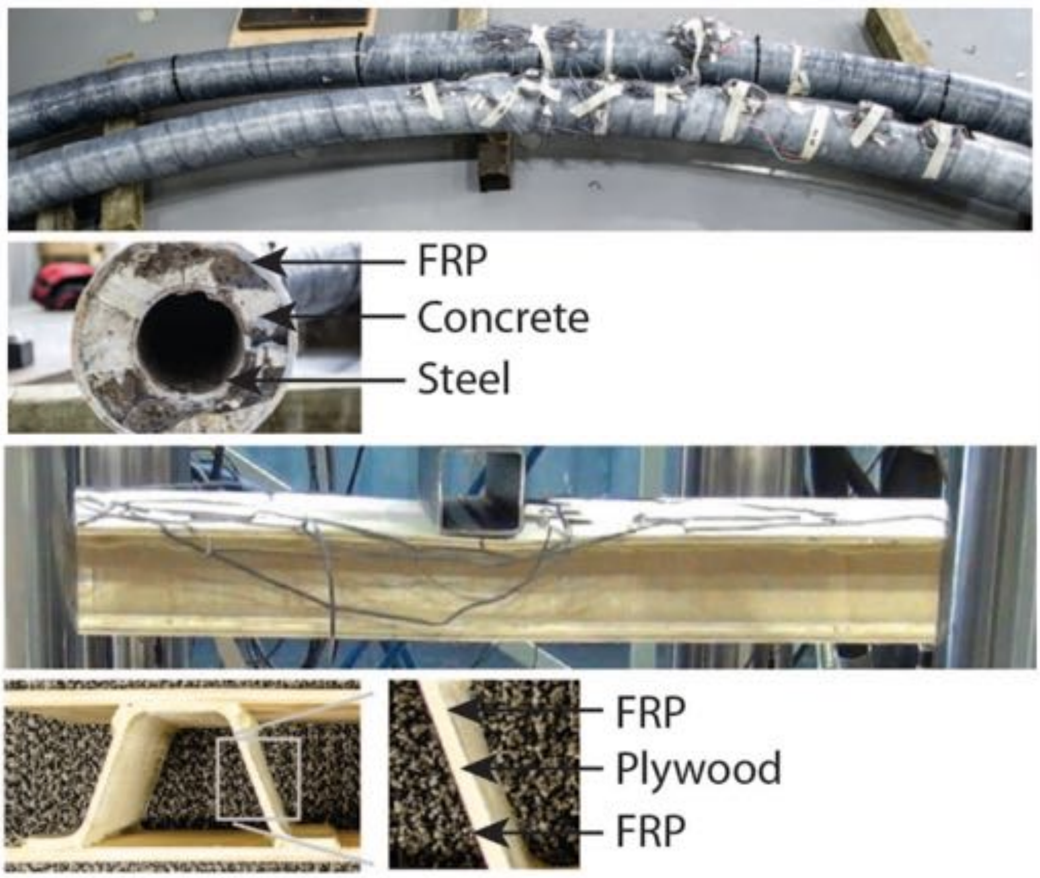
Composite Structures

Mentor: Dilum Fernando | Discipline: Civil / Structures

The UQ Advanced Composite research group investigates of ultra-high performance hybrid structural systems. These systems combine complementary material properties for optimum structural performance. For example, FRP-concrete hybrid systems use the high tensile strength FRP as a natural complement to high compressive strength concrete. Similarly, FRP-steel hybrid systems use FRP orthotropic material properties for confinement and strengthening of steel structures against local buckling.

Students are invited to join the activities of the Advanced Composite research group to discover more about the above hybrid systems. Activities include prototype manufacture, experimental testing, and numerical and theoretical analysis. There are also weekly group meetings and intermittent site visits to partnered timber manufacturing centres.

UQ have recently also developed highly innovative hybrid FRP-timber structures. Previously expensive manufacturing methods have limited the application of such structures, however a new folded fabrication process is now enabling UQ researchers to manufacture low-cost, high-strength, sustainable building elements.

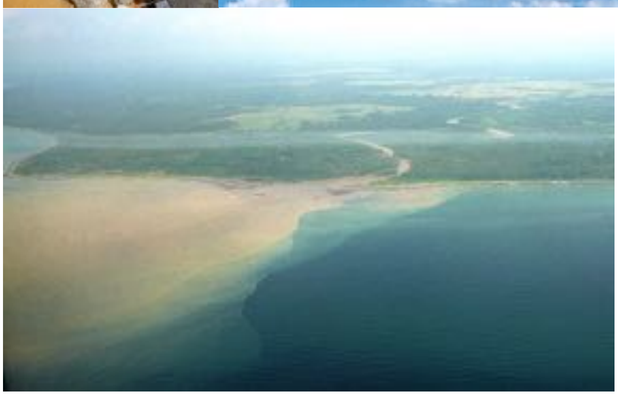


Turbidity Challenge 2

Mentor: Alistair Grinham, Simon Albert, Paul Fisher, Badin Gibbes | Discipline: Civil / Environmental

Sediment plumes have the potential to disrupt the biogeochemical and ecosystem processes occurring in natural water systems. Scientists and engineers and increasingly being tasked with providing estimates of the potential impacts of such plumes particularly those associated with engineering works such as dredging operations. Monitoring of sediment plumes generally relies on single point measurements using expensive instrumentation. This project seeks to address this knowledge gap by testing the application of newly available image analysis methods (see: http://misclab.umeoce.maine.edu/research/HydroColor.php) along with the use of low cost industrial turbidity sensors across a range of environmental settings (rivers, lakes, estuaries and coastal waters) in South East Queensland.

The project will focus on exploring the relationship between standard water quality probe turbidity measurements and these new sensors (photographic images and low cost industrial sensors) across differing suspended sediment concentrations and particle size ranges. The long term challenge is to successfully apply a combination of low-cost water sensors and airborne imaging sensors to characterise water quality in environmental systems. The project will expose students to a combination of field and laboratory testing of environmental samples.



Erosion Control Challenge

Mentor: Alistair Grinham, Simon Albert, Paul Fisher, Badin Gibbes |
Discipline: Civil / Environmental

Erosion and sediment control on civil engineering project sites is a key component of modern civil and environmental engineering practice. A particular focus of most erosion and sediment control programs is on water-driven erosion and sediment processes, with little attention given to aeolian (wind-driven) processes. This project seeks to test the effectiveness of a range of low cost aeolian erosion control systems at a major civil engineering infrastructure site. The project will expose students to a combination of field and laboratory testing as well as the broader design of field-scale engineering experiments.

Station Simulation

Mentor: SangHyung Ahn | Discipline: Civil / Transport

Session Schedule: 3pm – 5pm, Tuesday
Requirement: Students are required to have laptop computers.

Modeling is one of the ways to solve real-world problems. In many cases, we can't afford to find the right solutions by experimenting with real objects: building, destroying, making changes may be too expensive, dangerous, or just impossible. If this is so, we leave the real world and go to the world of models as shown in Fig. 01a and Fig. 01b (video available). We build a model of a real system: its representation in a modeling language. This process assumes abstraction: we omit the details we think are irrelevant and we keep those we think are important. The model is always less complex than the original system.

The whole modeling process is to find a way from a problem to its solution through a risk-free world where we are allowed to make mistakes, undo things, go back in time, and start over again.

In simulation modeling, a method is a general framework we use to map a real world system to its model. A method suggests a type of language, a sort of "terms and conditions" for model building. To date, there are three methods: System Dynamics (SD), Discrete-Event Modeling (DEM) and Agent-Based Modeling (ABM).

Since this project aims to model a Bus Rapid Transit (BRT) system at operational level (i.e., medium-low abstraction level to low abstraction level), students will learn both DEM and ABM by using a general purpose simulation system, AnyLogic.

As a simulation introductory course, students will learn basic statistics and probability such as distribution fitting (i.e., Maximum Likelihood estimation and Goodness-of-Fit testing) and Random Number Generator (RNG).

The project also entails data collection via field measurements and video recording (i.e., field surveys), input parameter modelling (e.g., probability distributions for arrival times and dwell times), analysis of the current system, and testing and suggestion of alternative operation scenarios.

01a: A Highway Junction Simulation Model (AnyLogic)
http://bit.ly/Icarus2015StationSimulation

01b: A 3D Animation of a Bus Station Simulation (AnyLogic)

RapidBridgeBuilder

Mentor: SangHyung Ahn | Discipline: Civil / Construction

Session Schedule: 3pm – 5pm, Thursday
Requirement: Students are required to have laptop computers.

RapidBridgeBuilder is a discrete-event special-purpose simulation modelling tool for Accelerated Bridge Construction (ABC) geared towards practitioners. The idea of ABC is to construct a railway overpass bridge in an accelerated manner in order to minimize disruption to both road and rail traffic. The purpose of this tool is to identify the best design and construction process in applying ABC using simulation technique. This tool allows a person to choose the location of a potential bridge and design 3D bridge members, simulate and visualize the construction process as 3D animations as shown in Fig. 01a and Fig 01b (video available).

Students participating in this project will learn modelling skills for Discrete-Event Simulation (DES) by using general purpose simulation and 3D visualization systems such as Stroboscope and Vitascope++. Students will also have an opportunity to participate in the development of RapidBridgeBuilder software tool.

As a simulation introductory course, students will learn basic statistics and probability such as distribution fitting (i.e., Maximum Likelihood estimation and Goodness-of-Fit testing) and Random Number Generator (RNG) by exploring example models focusing on construction operations.

01b: A Simulation Network Fragment of RapidBridgeBuilder (Stroboscope)
http://bit.ly/RapidBridgeBuilder

01a: 3D Animations of Manipulating Trusses of RapidBridgeBuilder (Vitascope++)

Folded Structures Lab: Introductory Topics

Mentor: Joe Gattas | Discipline: Civil / Structures

Origami engineering is a rapidly growing research field that involves the adaption of geometric sheet patterns to invent and improve folded structures and devices. By utilising folded patterns, origami engineers can transform many sheet materials into efficient and easily-manufactured applications, with current applications already seen in deployable and modular housing; energy-absorbing packaging and barriers; and lightweight automobile and aircraft components.

The UQ Folded Structures Lab (UQ_FSL) has numerous research projects investigating structural and architectural applications of folded geometries. Undergraduate students are invited to join UQ_FSL to develop the following:

- FRP-timber hollow sections
- Steel and FRP Pliable Portal Frames
- Digitally-Fabricated Timber Columns
- Folded Self-Braced Steel Sections and Frames
- Diamond & Distributed Folded Frame Structures

Activities include prototype manufacture, experimental testing, weekly group meetings, and geometric, numerical, and theoretical analyses.

Figure 1: Folded circular hollow sections

Figure 2: Top and front views of pliable portal

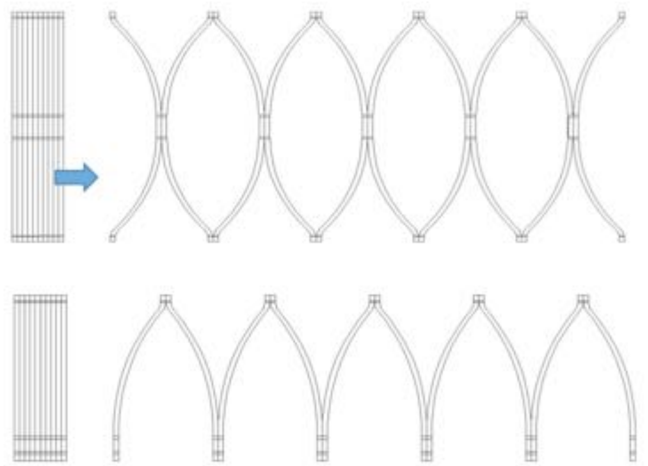
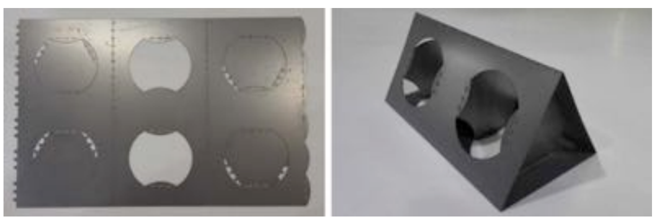


Figure 3: Folded self-braced section



Folded Structures Lab: Advanced Topics

Mentor: Joe Gattas | Discipline: Civil / Structures

Requirement: Previously completion of an Icarus Project in folded structures.

Students who have previous experience in folded structures are invited to work on advanced parametric and digital fabrication topics.

Project 1: Alternate methods for curved-crease geometries.

Curved-crease origami generates striking geometries that are often employed for architectural applications. Manufacture of these panels is challenging, however specialist robotic companies can cut and fold aluminium panels easily, if expensively. This project looks at alternative methods to manufacture curved-crease geometries. Options include cutting of cylindrical structural elements, use of bar-linkage manufacturing devices, folded timber fabrication, or robotic fabrication

Figure 1: Robofold curved-crease fabrication
http://www.curvedfolding.com/page/kingkong-by-robofold

Students will develop extended geometric parametric design, digital fabrication, MATLAB, CAD, and numerical analysis capabilities.

Project 2: Investigation of robotic control processes for civil engineering applications.

The increase in capabilities of engineering digital modelling and simulation software mean that designers can control more processes than ever before. In building design, this heralded the return of the master builder: a designer who is able to integrate the activities of architect, structural engineering, fabricator, and builder into a single parametric workflow. Students in this project will investigate how robotic arms, common in manufacturing, can be controlled and applied to civil engineering purposes.

Figure 2: Robotic Arm 3D Printed Bridge
http://mx3d.com/projects/bridge/

TeeZee Spin-Off Company

Mentor: Joe Gattas | Discipline: Civil / Stategy

Requirement: Admission by invitation only.

The TeeZee was developed as part of the Festi Flat semester 1 Icarus Program. It has many beneficial features, however continued development of these features requires knowledge of suitable avenues for TeeZee commercialisation. This project is therefore targeted at progression of the TeeZee to commercial application, including formation of a start-up company via UQ UniQuest.

Students will need to:

- Use lean start-up entrepreneurial strategies find suitable markets;
- Develop a business case to present to UniQuest; and
- Engage a network of interested parties (customers, investors, business professionals).

Figure 1: The TeeZee Pyramid Accordion Shelter https://www.youtube.com/watch?v=Re-XBICmXTo

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