PhD Opportunities

Potential funding available

UNIVERSITY OF Southampton

Civil, Maritime and Environmental Engineering

Towards Enhancing the Design Life of Concrete Structures with Stainless Steel Reinforcement

Sheida Afshan (Infrastructure)

Description: The aim of the project is to solve the problem of deterioration of concrete structures currently facing the Civil and Structural Engineering community with introduction of the use of stainless steel reinforcement. You will investigate the nonlinear response of stainless steel reinforced concrete structural components through a combined experimental, analytical and numerical modelling approaches. You will use the obtained results to develop validated structural design rules making a major impact in the development of the future structural design standards.

References: Melo J, Afshan S, Rosetto T, Varum H. Experimental investigation of cyclic response of stainless steel reinforced concrete columns. Society for Earthquake and Civil Engineering Dynamics 2019 conference, London, United Kingdom, 9-10 September 2019.

Key-skills: Finite Element Analysis, computer programming, structural analysis, civil engineering materials, and experimental methods.

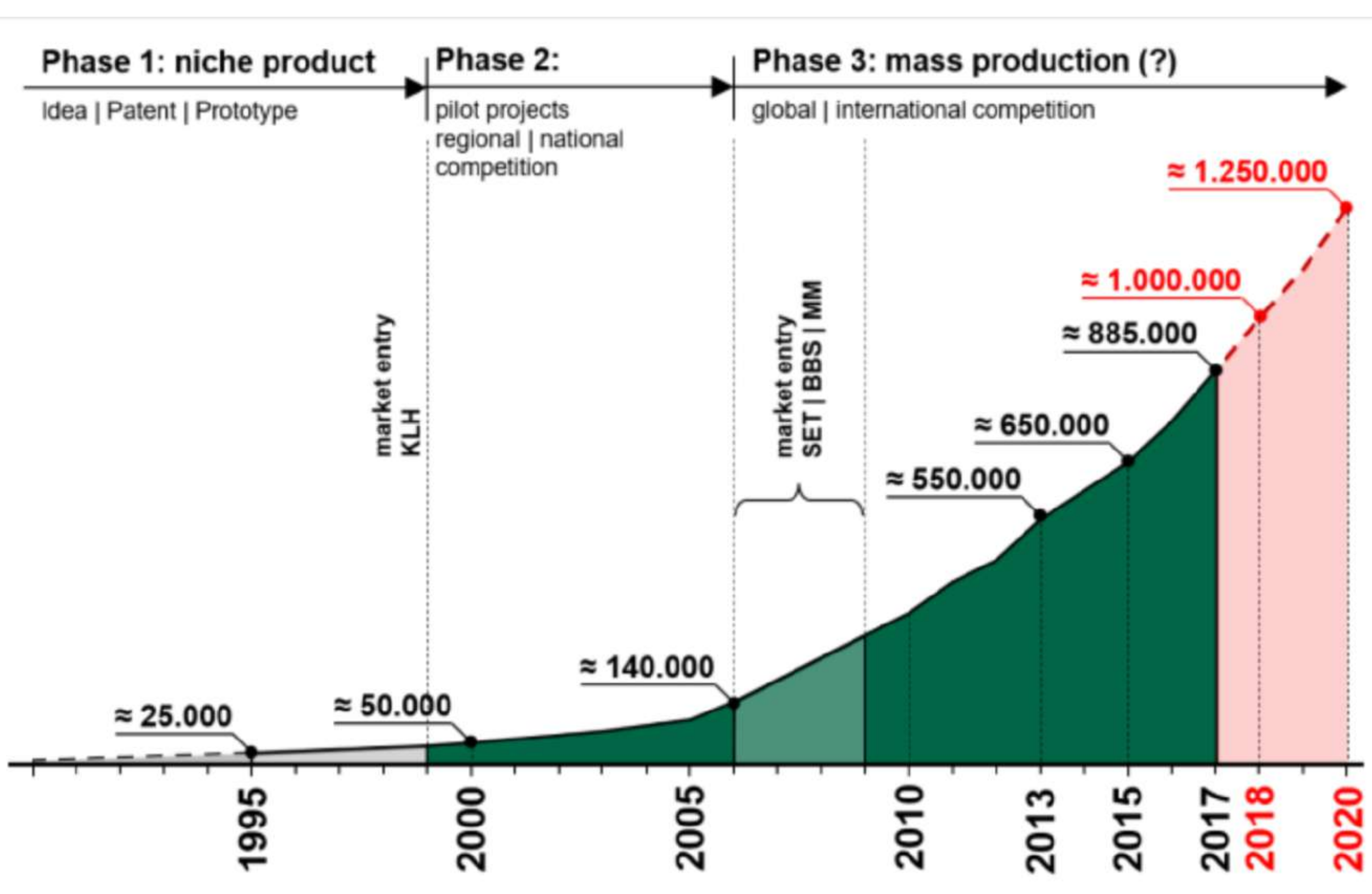
Rebar corrosion – A4 elevated section, London, UK.

Industry partners: Acerinox

Effect of Climate Conditions on Performance of Timber Structures

Sheida Afshan (Infrastructure) & Adrian Campbell (industry supervisor)

Description: As a natural and renewable building material, timber is being increasingly used in different structural forms. One of the key issues in wood construction however is durability and performance in varying climate conditions. This project will investigate the effect of climate conditions on the structural performance of timber products such as cross-laminated timber panels. The durability and residual capacity of timber structural components exposed to varying climate conditions (e.g. moisture content and temperature) will be examined at material level and component level. Reliable performance data will be generated through a programme of experimental testing and numerical modelling methods for service life prediction of timber components.



Increasing trend in CLT production

References: Campbell A. Mass timber in the circular economy: paradigm in practice? Proceedings of the Institution of Civil Engineers – Engineering Sustainability; 172(3): 141–152.

Key-skills: Finite Element Analysis, structural analysis, civil engineering materials, and experimental methods.

Industry partners: KLH UK

If Interested in any of the above please email S.Afshan@soton.ac.uk

Originally Presented at the CMEE Showcase, 24th January 2020

PhD Opportunities

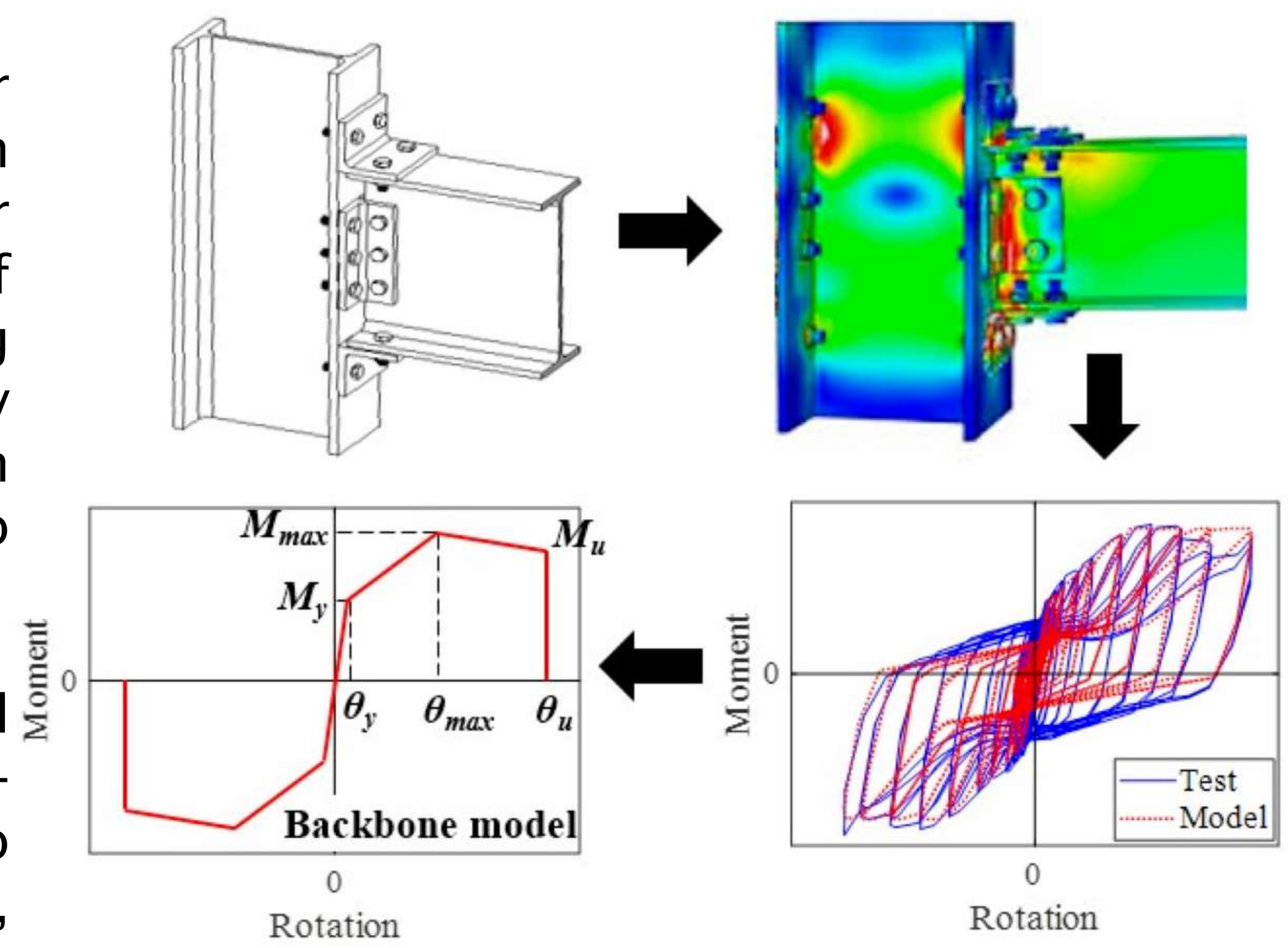
Potential funding available

UNIVERSITY OF Southampton

Civil, Maritime and Environmental Engineering

Standardized Numerical Models and Damage Fragilities for Semi-Rigid Steel Connections

Ahmed Elkady (Infrastructure)



Framework for developing numerical modelling recommendations

With the advent of performance-based design and the advances in our computational capabilities, considerable attention has been directed in recent years towards the robust modelling of structural elements behaviour to facilitate nonlinear static/dynamic analyses procedures. The objective of this research is to develop accurate standardized numerical modelling guidelines for Semi-rigid (SR) connections. These connections are abundantly used in construction steel practice worldwide for their ease of fabrication and erection. Their usage spans conventional and light weight structures to capacity-designed ductile buildings in highly seismic regions.

The research methodology will utilize the available wealth of experimental data on SR connections while complementing the gaps with validated high-fidelity finite-element simulations. The generated data pool will be used to assess the robustness of existing numerical modelling approaches. Second, using rigorous statistical analyses guided by an understanding of mechanics-based phenomena, key material and geometric parameters influencing the behaviour will be identified and standardized numerical models will be developed. The test/simulation data pool will also be used to develop damage fragility functions. With collaborative feedback from the industry, these functions can then be linked to consequences functions for the repair cost and time associated with the different damage states, thus enabling the quantification of monetary losses and repair downtime in steel structures in support of performance-based engineering. The final step of the research will be the quantification reliability of steel buildings with SR connection under strong wind and column removal scenarios.

Key-skills: Steel Design; Structural Analysis; Solid Mechanics; MATLAB; ABAQUS FEA/CAE (recommended)

GFRPs in Concrete: Innovations Beyond FRP Bar Reinforcement

Mithila Achintha Paththini Marakkala (Infrastructure)

Owing to the high strength properties and the excellent in-service and physical characteristics of Fibre Reinforced Polymer (FRP) materials have potential application as reinforcement in concrete structures. When FRPs used as internal reinforcement in concrete, mostly the Carbon Fibre Reinforced Polymer (CFRP) are used since the long-term performance of Glass Fibre Reinforced Polymer (GRFP) under some environment conditions, such as exposure to high alkalinity, seawater, or deicing salts, remains unknown. Since CFRPs are more expensive than GFRP, the currently used reinforcement systems in the form of FRP bars are not structurally and economically feasible. This project proposes to make use of strength/strain capacities, and the geometric flexibilities of FRP before curing with resin to develop innovative, structurally efficient combined flexural and shear reinforcement systems in structurally optimal, concrete structures. Unlike the existing FRP internal reinforcement systems in concrete, which are largely made from unidirectional FRPs and are prone to brittle FRP/bond failures, we will use multi-directional FRP to form 3D geometries of reinforcement. The proposed research will encompass a combined experimental, analytical and numerical investigation in order to provide the knowledge required to design efficient GFRP reinforcements in structurally efficient, low embodied energy concrete structures.

Key-skills: Computational modelling, laboratory experiments, Finite Element Method

If Interested in any of the above please email a.elkady@soton.ac.uk or Mithila.Achintha@soton.ac.uk

Originally Presented at the CMEE Showcase, 24th January 2020

PhD Opportunities

Potential funding available

UNIVERSITY OF Southampton

Civil, Maritime and Environmental Engineering

Wave Augmented Propulsion

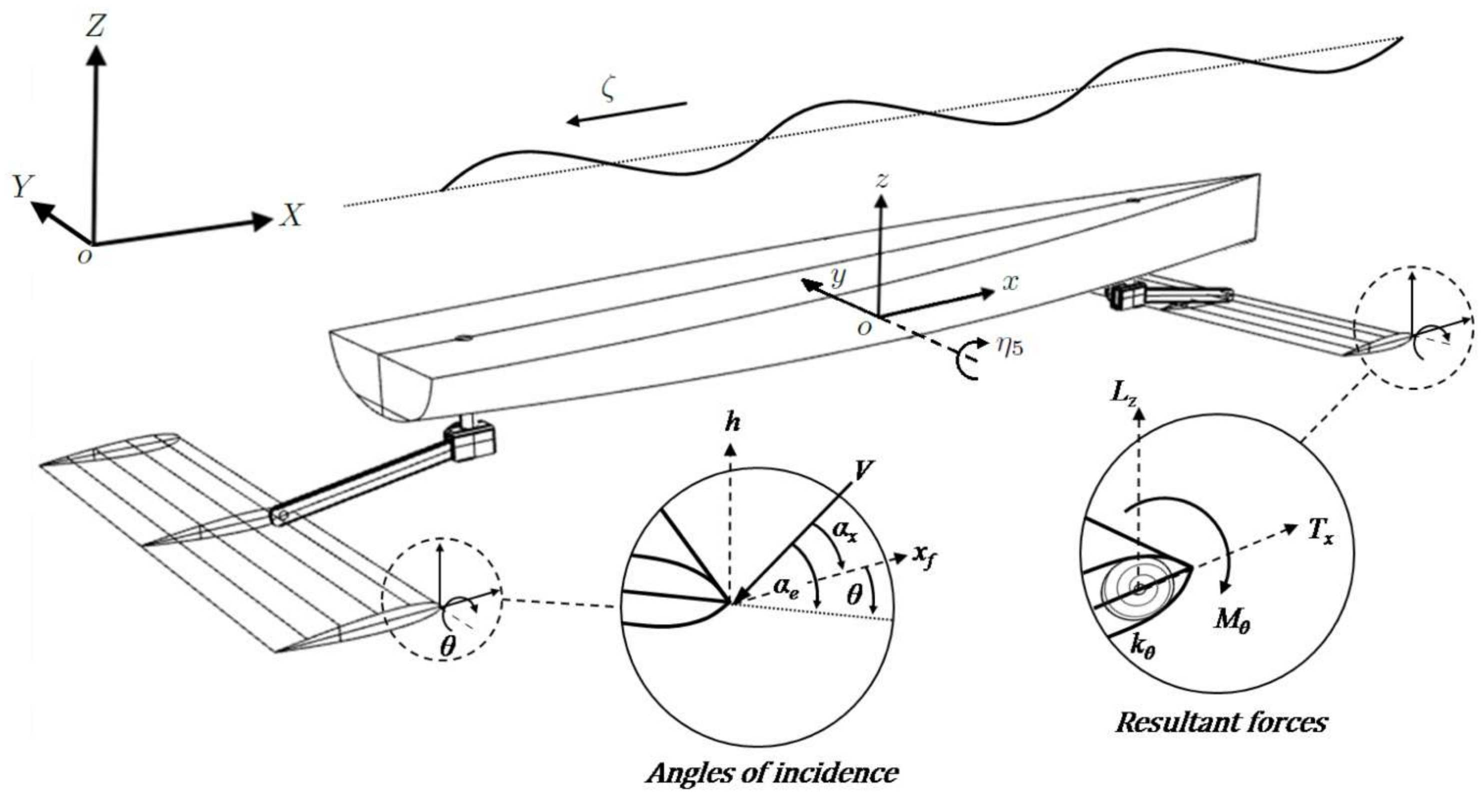
Nicholas Townsend (Maritime Engineering)

Wave propelled boats utilise submerged flapping foils to convert wave energy directly into propulsion. **Predicting the benefit** (additional thrust, resistance/fuel saving and comfort) is challenging as it is time varying and dependent on the coupled responses of the wave induced hull motions (surge, heave, pitch) and the foil flapping motion (driven by the wave-induced hull motions and incident wavy flow).

References: Bowker, J. A., et al. "Experimental analysis of submerged flapping foils; implications for autonomous surface vehicles (ASVs)." OCEANS 2016 MTS/IEEE Monterey. IEEE, 2016**.**

Key Skills: Numerical Modelling, Experimental Hydrodynamics

Potential Partners: Wartsila, Autonaut



Exemplary research studies

Offhore Ocean Farming

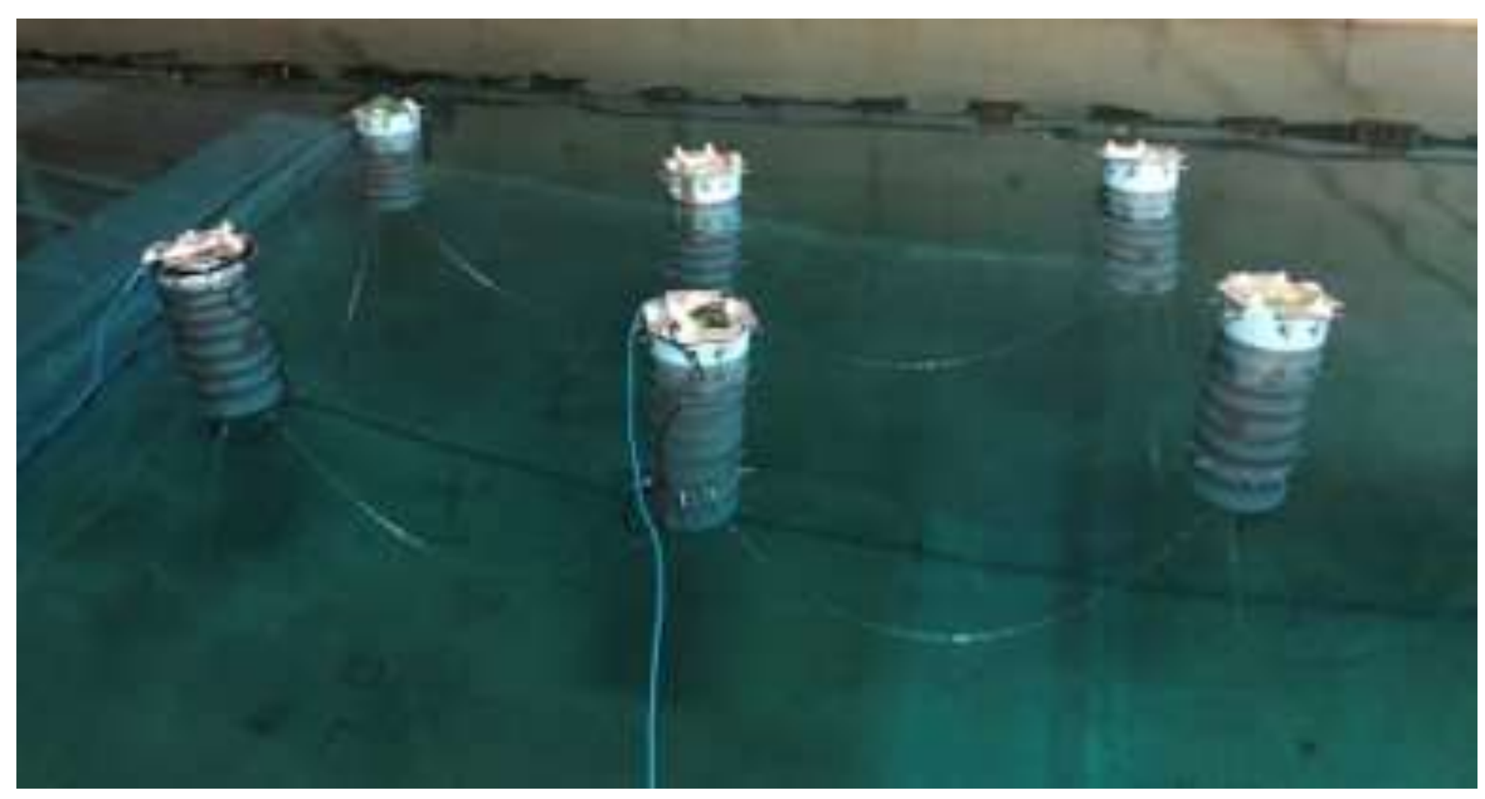
Nicholas Townsend (Maritime Engineering)

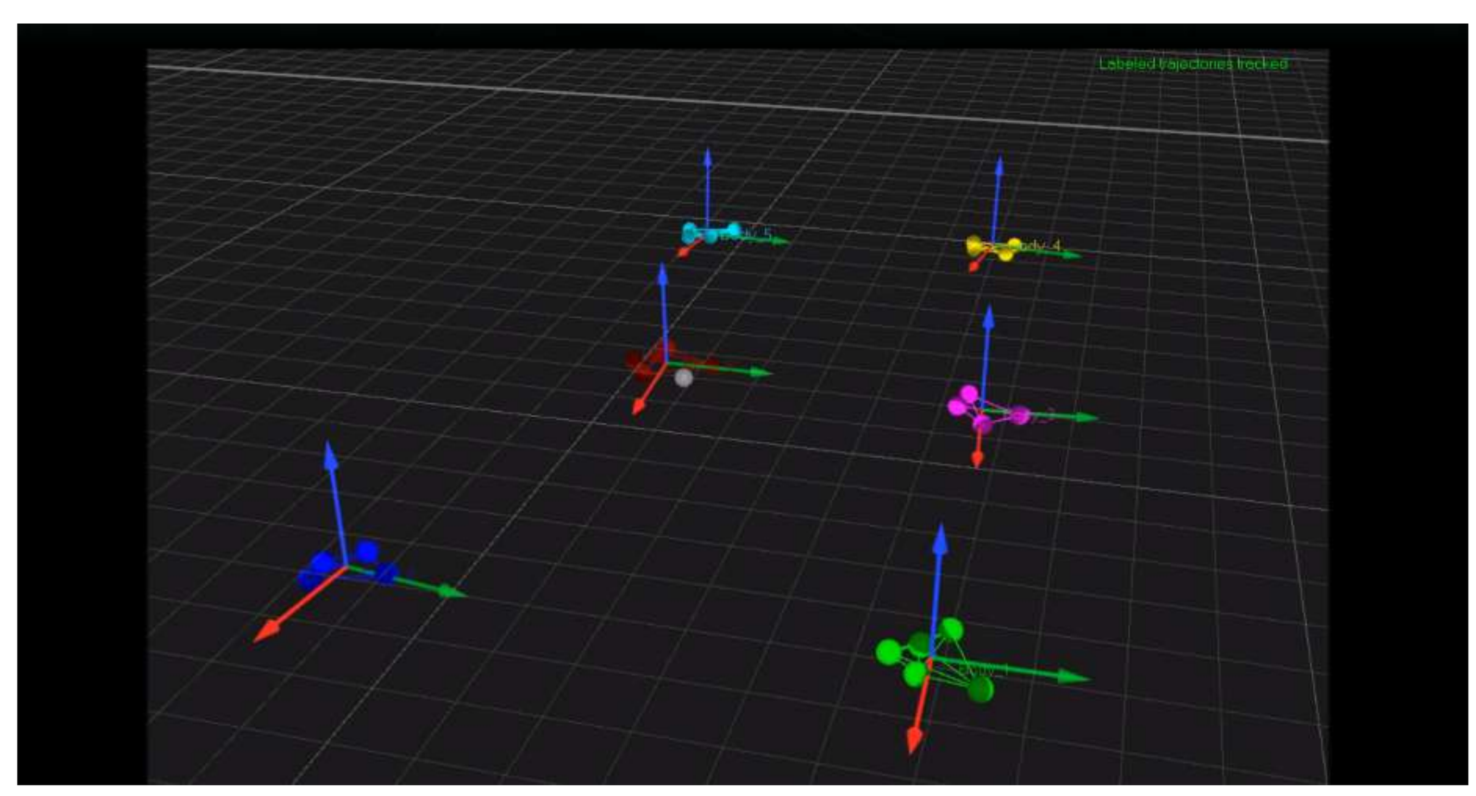
Offshore ocean farms have huge potential however, all previous attempts at offshore ocean farming have been unsuccessful. **A major challenge and vision is the ability to capture ambient energy and realise self-sufficient remote operation**.

This is a major challenge because the recoverable power is highly dependent on the farm configuration and conditions (array layout, separation, number, wave direction) and the time varying hydrodynamic properties (with significant changes in wetted surface, porosity, permeability, mass, volume etc. over a growth cycle).

References: Austin, Alexandria, et al. "Novel concepts for offshore ocean farming." (2019).

Key Skills: Numerical Modelling, Experimental Hydrodynamics





Example wave response study on moored ocean farm arrays

Potential Partners: Stevens Institute of Technology (USA)

If Interested in any of the above please email N.C.Townsend@soton.ac.uk

Originally Presented at the CMEE Showcase, 24th January 2020

PhD Opportunities

Potential funding available

UNIVERSITY OF Southampton

Civil, Maritime and Environmental Engineering

Sustainable future yacht and small craft structures

James Blake & Jeanne Blanchard (Maritime Engineering)

Most small sailing and motor craft are constructed from glass reinforced polymers (GRP) and the industry represents, by volume, one of the most prolific constructors of worldwide glass composites. GRP has proven through life operational efficiency, facilitating low craft displacements and therefore lower installed power requirements and are cheap to build, maintain and repair. However, GRP has significant environmental impact at the beginning and end of life. To improve and reduce carbon emissions, this PhD research will investigate the utility of natural fibres and resins, and recyclable or biodegradable polymers to create future marine small craft. The challenge is to understand the effect of the marine environment on the structural reliability of these new materials, generating the data set for future design guidance and test the limits of current construction processes. The research will be supported by state of the art experimental facilities and techniques to detail multiscale material behaviour and understand fluid structure interactions. Two key supporters of this initiative are the World Sailing Sustainability Commission and the Royal National Lifeboat Institution (RNLI).

Example of structural & environmental challenges for sustainable composites (RNLI Atlantic 85)

Key Skills: composite engineering, computer programming, experimental testing, structural engineering

Design of propeller and propeller-energy efficiency devices for realistic ship operations

Dominic Hudson, Joe Banks, Dominic Taunton (Maritime Engineering)

International shipping contributes ~ 3.1% of global GHG emissions, which without change may increase to 18% by 2050. Emissions from international shipping are not formally included in Carbon budgets, but they are included in the UK's 2050 target to reduce emissions by at least 80% relative to 1990. This places an urgent requirement on shipping to reduce its CO2 emissions. Around two-thirds of global shipping emissions derive from three vessel types, wet- and dry-bulk carriers and container vessels. Any effective approach to reduce emissions must therefore apply to these vessels.

Ships are normally designed for a single condition, representing one loading condition and a 'design' speed in calm water. Ships very rarely operate at this single condition. Designing a ship for real operational conditions (wind, waves, speeds, loading conditions) will lead to reduced CO2 emissions. This requires knowledge of a ship's fuel consumption in waves.

There are currently no accepted means to predict, measure or analyse ship performance for actual operational profiles; an essential pre-requisite for designing for real conditions. The most reliable means to establish both power in calm water and power increases in waves is through scale-model testing. Almost all model-testing focuses only on ship added resistance in waves (drag) and neglects the effects of propeller efficiency, propeller-hull and propeller-machinery interactions in waves. There are also uncertainties associated with scaling of results and limitation to the sea-states tested. Recent advances in computational fluid dynamics analysis (CFD) are starting to make this a viable alternative, but also typically do not include propeller efficiency and machinery interactions and are generally restricted to head waves. Prpic-Orsic and Faltinsen (2012), in a rare investigation into overall propulsive power in waves, concluded that in high sea-states the effects of propeller efficiency on fuel consumption were in fact larger than the 'added resistance'. However, this study relied on quasi-steady modelling of the dynamic problem, based on propeller efficiencies measured at varied immersion depths. It also neglected the effects of immersion on torque.

Objectives

This research project aims to quantify accurately ship added power in waves through (i) analysis of data measured onboard vessels, (ii) measurement and prediction of propeller open-water efficiency in unsteady flow conditions induced by ship motions in waves using the Boldrewood towing tank with detailed flow measurement (PIV) and motion capture capability, (iii) investigation of propeller-machinery interactions in unsteady operation, (iv) performance of realistic energy-efficiency devices (such as propeller-boss-cap-fins, or upstream ducts or fins) in actual conditions.

References

Prpic-Orsic, J. and Faltinsen, O.M., 2012, Estimation of ship speed loss and associated CO2 emissions in a seaway, Ocean Engineering, 44, 1-10.

Industry Partners: Shell Shipping and Maritime

If Interested in any of the above please email jirb@soton.ac.uk or dominic@soton.ac.uk

PhD Opportunities

Potential funding available

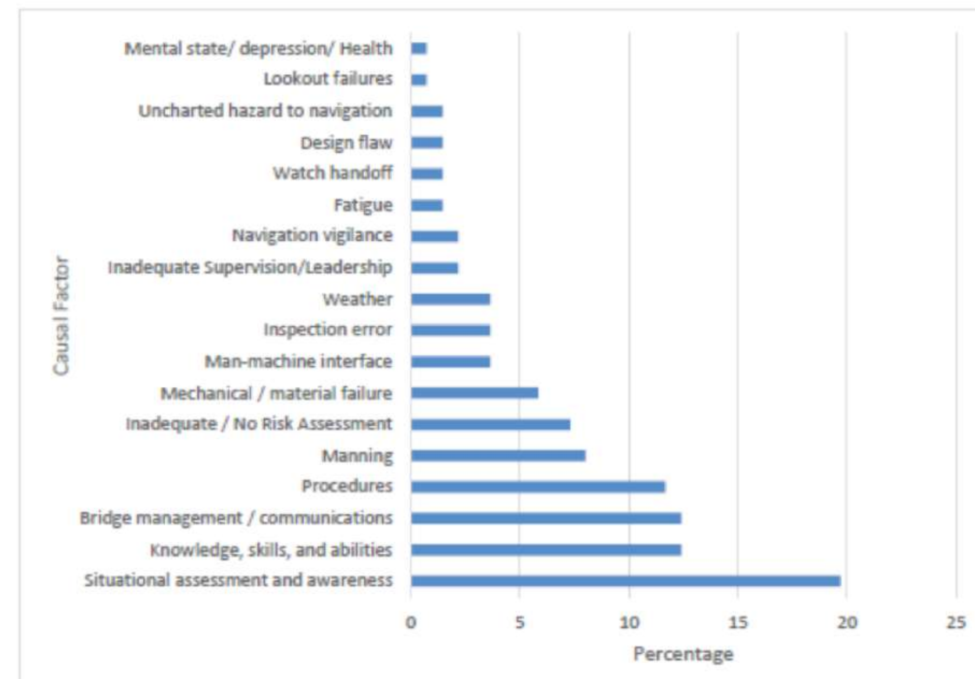
UNIVERSITY OF Southampton

Civil, Maritime and Environmental Engineering

Improving Ship Safety through closing the design loop

Dominic Hudson, Dominic Taunton (Maritime Engineering)

Despite increased training of ship's crew there are still a significant number of accidents and incidents. Is this because despite the training, the equipment has poor usability? This poor usability results in the crew having to adapt their use from the intended use in order to perform their tasks. Any resulting incidents or accidents will often identify the improper use of the equipment as a training issue. This project will analyse accident reports and near miss reports to identify the most common tasks and work areas for more detailed investigation. Through either observation by trained occupational therapists or monitoring via commercially available wearable technologies and cameras, this project will determine how the crew are using the equipment on board the ship in order to perform their tasks. Determine if the equipment is being used as designed or if the equipment does not meet accepted standards. Equipment could include access ways, hatches, stairs and ladders in addition to navigation and control equipment. The approach can be applied to any vessel type, but those ships or ship types which have more incident data available will be more suitable.



Cause of serious vessel incidents from analysis of reports

A review of 128 RAM 3, 4 & 5 incidents for STASCO [1] showed that knowledge, skills and abilities was the second largest cause of these incidents, whereas design flaws was ranked 7th, see figure 1. However, it is possible that many of the incidents attributed to knowledge, skills and abilities are in fact poor design and usability and peoples attempts to adapt the use of the equipment (correct design flaws) is incorrectly classified under knowledge, skills and abilities.

Deliverables

1) A review of the equipment, tasks and work areas most likely to have poor usability. (Y1)
2) An improved reporting process which will capture the usability issues. (Y1)
3) Recommendations for replacement or changes to training for those high risk items of equipment, tasks and work areas. (Y2
4) Training package for Ships Bosuns (as the person usually responsible for equipment and training on board) in usability feedback, so toolbox talks could include discussing concerns over usability and the associated risks. (Y3)

Key-skills: ship design, human factors

Industry Partners: Shell Shipping and Maritime

Design, build and test of a fully-composite tank for cryogenic fluids

Dominic Hudson, Yikun Wang (Maritime Engineering) & Wendell Bailey (Energy)

Based on the recent advances made by NASA (2014) in the development of new designs and manufacturing techniques for constructing fully composite tanks for the storage of cryogenic fluids. Demonstration of the technology has been achieved on a large scale; (5 metre diameter, liquid volume 136 000 L, operating at -250 oC [containing liquid hydrogen] and pressure tested to 3.6 bar [1]). The current work is focal on the development of composite propellant tanks for space rockets; however research is needed to explore how this new technology can be deployed by the marine industry. The most immediate application may include the storage and transportation of Liquid Natural Gas (LNG), progressing towards future fuels like liquid Hydrogen.

The installation of fully composite cryogenic tanks in a marine application has the advantage of potentially reducing the weight of existing storage vessels by 30 % and reducing their manufacturing costs by 25 % [1]. Composite tanks can also offer superior insulating properties, which could minimise the volume of existing system used for insulating the storage tank. Composites used for this application would eliminate problems with corrosion and its associated maintenance required in harsh working environments, however, there remain other question and concerns about the following: i) gas permeability, ii) impact resistance, iii) fire resistance, iv) micro cracking primarily from in-service fatigue.

One of the key outcomes from the proposed research, aside from collating relevant information/existing work upon the subject and identifying potential solutions for the issues outlined above; should be the creation of a "work plan" to collaborate with composite manufacturers to attempt to demonstrate the technology by way of design and construction of a prototype for experimental testing.

The University have past experience with the development of semi-composite cryogenic storage tanks for the Deep Sea Recovery (DSR) project [2]. The cryogenic tank developed for this marine application used a metallic liner stiffened by a wound composite outer layer for the purpose of reducing weight. The University is also conducting new experimental work (impact testing) in the development of carbon-fibre wound high-pressure gas cylinders for a commercial client.

The new concepts behind the manufacture of a fully composite tank include making a hybrid structure that combine at least two reinforced composite materials. The inner composite may utilise a braided composite to form a "sleeving" that enhances its resistance to crack propagation and also preserves its ability to retain fluid over a wide temperature and pressure range. The outer lining may consist of a wound fibre-resin composite to add stiffness and strength. The assembly, integration and compatibility of dual composite structures are novel and need further investigation, in addition to the assessing the practicalities required to manufacturing such structures with existing or emerging techniques and assessment of their scalability.

The technical expertise within the dynamic structures group, the connections with the composite industry, the wide range of facilities, including world leading capabilities in Non Destructive Evaluation (NDE) of composite structures and materials using CT/DIC/thermography, coupled with the experimental and cryogenic expertise within Cryogenics form a very powerful team, well equipped to explore this field of interest.

References:

[1] http://gcd.larc.nasa.gov/projects/archived-projects-2/composite-cryogenic-propellant-tank/#.VgzgMk3lt3w
[2] http://www.deepsearecovery.co.uk

Key Skills: Composites and materials engineering

Industry Partners: Shell Shipping and Maritime

If Interested in any of the above please email dominic@soton.ac.uk

Originally Presented at the CMEE Showcase, 24th January 2020

PhD Opportunities

Potential funding available

UNIVERSITY OF Southampton

Civil, Maritime and Environmental Engineering

Machine Learning for Stress and Fatigue Detection in Ship Crews

Dominic Hudson, Dominic Taunton (Maritime Engineering) & Sarvapali Ramchurn (ECS)

It is often reported that 80% of maritime accidents are due to human error, with a large proportion of these attributed to a failure to follow procedures. The usual response to this is to increase training. A recent research project (MARTHA) which looked into fatigue and sleepiness onboard ships, concluded that although all crew showed increased levels of fatigue by the end of a voyage, certain crew member (particularly 2nd Officers) were more susceptible to tiredness and that fatigue and stress were inter-related.

The aim of this project will be to measure and predict the levels of fatigue and stress in targeted Deck Officers from modern LNG ships. This will be carried out using a range of both intrusive and non-intrusive methods. Intrusive methods will include modern fitness trackers which can record activity, heart rate and track sleep in an unobtrusive manner. Non-intrusive methods will include environmental sensors built into the ship that allow the monitoring of physical activities and environmental parameters (temperature, humidity etc…). This will be combined with vessel tracking data from AIS and ship motions data and environmental data from wave buoys. Machine learning techniques (e.g., deep learning and Bayesian classifiers) can then be used to determine periods of acute stress and poor sleep leading to fatigue. Based on these outputs, optimisation algorithms will be developed to reduce tiredness and stress levels. Moreover, this information can then be used to develop more realistic training programmes which incorporate appropriate stressors, which could potentially reduce the negative effects of stress/ fatigue as the trainees become habituated to the stressors. The project will also investigate the levels of activity and stress when off watch and when not at sea, in particular the periods before and after a long sea voyage.

The ideal candidate will have strong interests in Machine learning, Ubiquitous Computing, Artificial Intelligence, and Human Factors or Human-Computer Interaction. Depending on the background of the successful PhD student, suitable training will be provided from specialist modules across Engineering and Health Sciences. In particular Ship Design and Economics and Research Methods for Evidence Based Practice. The student will also be given the opportunity to learn about ship operation and crew training from Shell Shipping. Training in relevant analysis software will also be provided.

The recent Global Marine Technology Trends 2030 document highlighted the increasing technology onboard ships and the need for highly skilled crew to operate them. Skilled crew requires good training programmes, which need to reinforce the correct human behaviours in stressful situations, especially as humans have finite resources in terms of memory and attention. The design of shipboard systems is usually the responsibility of engineers, but the evaluation of these systems needs to be carried out from the human perspective. This needs a multi-disciplinary approach building on the work already carried out between engineering and psychology in the laboratory and incorporating real in-situ measurement based on occupational health practice. The research has the potential to reduce major shipping accidents, saving lives and reducing environmental impact. Currently, a career at sea is not viewed in the same aspirational way as, say, becoming a commercial airline pilot. Yet the physical, mental and emotional requirements are very similar. The need to recruit highly skilled crew for ship operations will require significant development of training that more adequately prepares people for the ships of the future.

Key Skills: computing

Industry Partners: Shell Shipping and Maritime

Reducing shipping emissions through accurate assessment of energy efficient technologies using statistical analysis of operational data

Dominic Hudson, Adam Sobey (Maritime Engineering) & Sujit Sahu (Mathematics)

Global shipping is responsible for 3.1% of anthropogenic CO_2 emissions (IMO, 3rd Greenhouse Gas report, 2014), yet is outside of UNFCCC commitments to reduce emissions. The International Maritime Organisation has introduced requirements for ships to be certified with an Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP). In 2018 IMO for the first time set out its ambitions for reducing CO_2 emissions from shipping – by 40% in terms of Carbon intensity by 2030 and by 50% in terms of absolute emissions reductions by 2050. To achieve the first goal, by 2030, will rely on efficient use of existing knowledge in ship design, operation and energy efficient technologies.

Central to efforts to reduce shipping's global CO_2 emissions is an ability to measure accurately the fuel consumption of a ship during its operation. This enables:

- Benchmarking of operational performance against intended EEDI limits and timescales
- Accurate assessment of technology aimed at reducing emissions (propeller modifications, ducts, anti-fouling coatings, air lubrication, wind-assist devices, etc.)
- Tackling of identified 'split incentives' in owner-charterer agreements for ship operation – who pays for emissions reduction techniques? who benefits from reduced fuel use?
- Charterers to assess (and choose) energy efficient vessels in a transparent manner

These rely on accurate fuel consumption measurement, which is in practice hard to achieve due to the lack of measurements made during ship operation and typically, at best, propeller shaft power is measured and used as a 'proxy' for fuel consumption. Interpreting such data is difficult due to uncertainties arising from:

- Imprecise measurement of vessel operational speed through the water
- Reliance on poorly resolved (spatially and temporally) measurements, or models, of ocean current, wind strength and direction and wave height and direction
- Continuous changes in vessel operating parameters such as engine revolutions, heading, draught and trim
- Uncertainties in the condition and performance of shipboard machinery

This project aims to address these uncertainties through combining naval architecture understanding with statistical techniques to derive reliable estimates of fuel consumption with environmental and operational parameters, together with quantification of uncertainties and statistical reliability.

Typical analysis of a vessel's powering performance is based on the relationship between shaft power (derived from torque measurements) and vessel speed. For a given ship's operating condition (draught, trim, engine speed) in calm water, this relationship would be unique and vary smoothly with speed. Variations in operating conditions and environmental parameters (waves and wind) together with uncertainties in the measurement of vessel speed through the water result in considerable scatter in such data. It is thus extremely challenging to measure ship power in practice, particularly when small changes, arising from, say, fitting energy efficiency devices, are required to be determined.

In order to improve accuracy and to integrate uncertainty arising this project will develop rigorous hierarchical statistical models (HSMs) for measurements that ultimately calculate ship power and fuel efficiency. HSMs, postulated in a Bayesian framework, are ideally suited for this problem since they allow synthesis of information from different disparate sources, such as environmental, mechanical, meteorological, operational, into a unified model that allows the propagation and presentation of integrated uncertainty.

HSMs provide a means to incorporate detailed component-wise spatial, and temporal information and capture the nature of the dependence between observations and processes.

Key Skills: Statistics

Industry Partners: Shell Shipping and Maritime

If Interested in any of the above please email dominic@soton.ac.uk

Originally Presented at the CMEE Showcase, 24th January 2020

PhD Opportunities

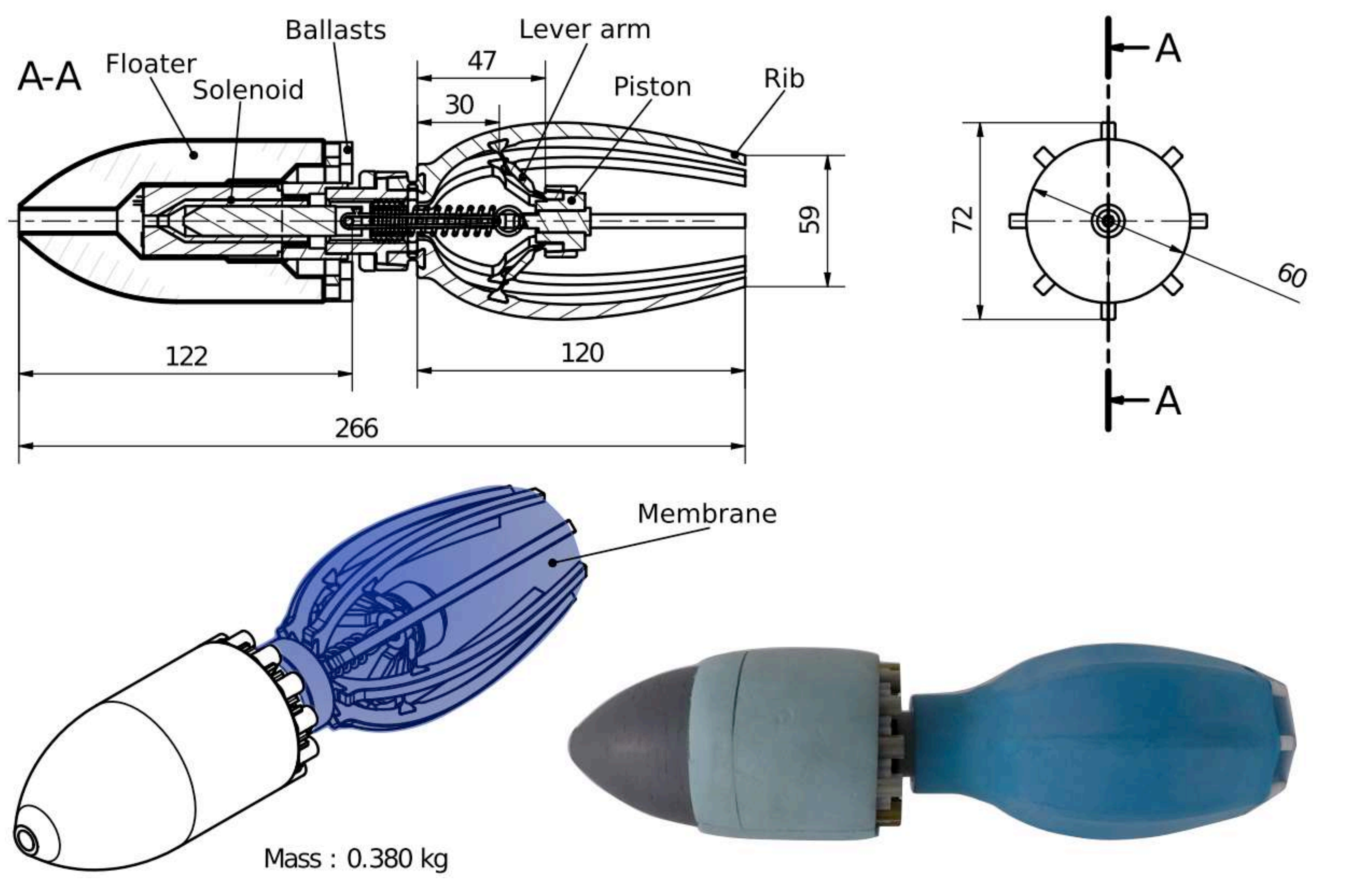
Potential funding available

UNIVERSITY OF Southampton
Civil, Maritime and Environmental Engineering

Biologically inspired underwater soft robotics

Gabriel Weymouth & Blair Thornton (Maritime Engineering)

Animals glide effortlessly through amazing underwater acrobatics, while our best underwater vehicles fight against the water during the simplest accelerations and manoeuvres. Using soft robotics, the student working on this project will develop high-performance underwater vehicles capable of biological levels of performance and efficiency. Southampton leads the UK in underwater robotics and biological fluid mechanics, and previous work in this direction has led to world record vehicles (Guinness Book 2019, fastest underwater acceleration) and high profile publications.

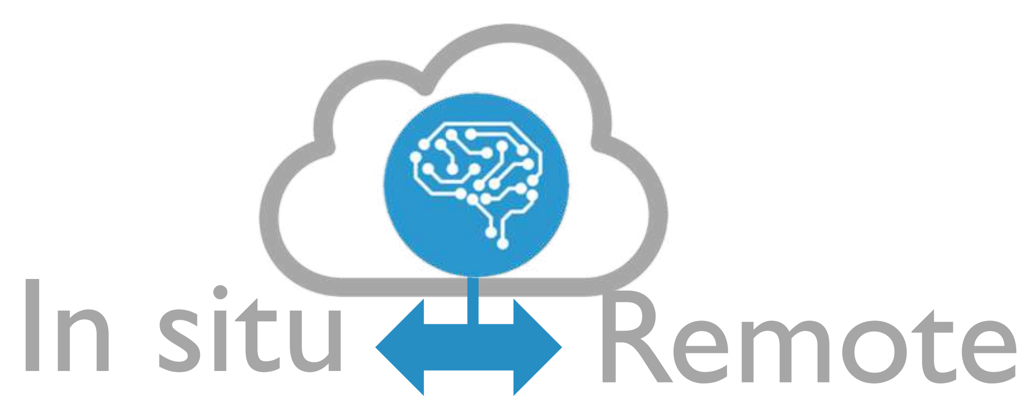


Flexible biological inspired robot capable of swimming as efficiently as any animal in the ocean

Key skills: Fluid mechanics, and depending on the student - interest in either computation/simulation or hands on robotics

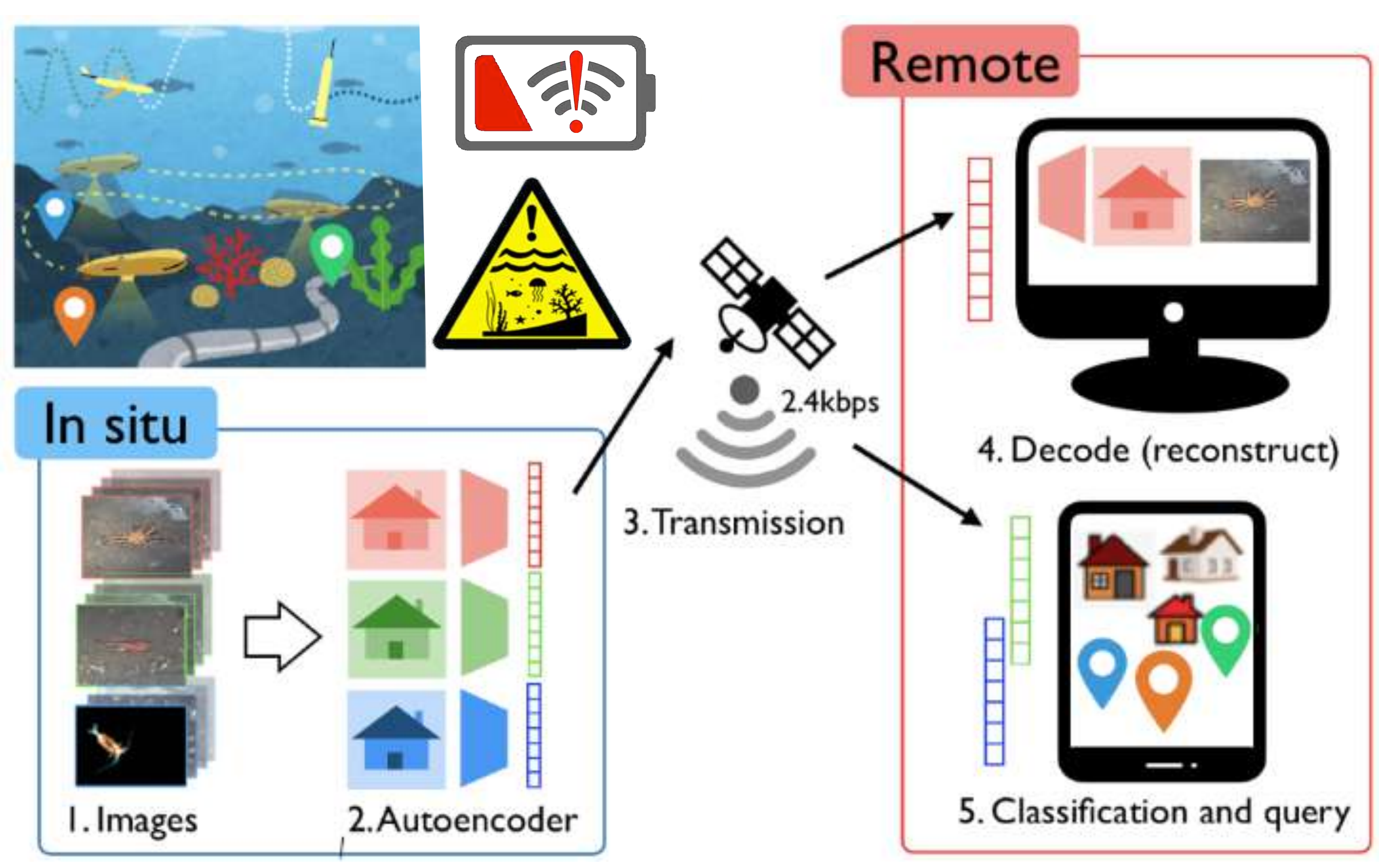
Shared in situ and remote intelligence for machines in extreme environments

Blair Thornton (Maritime Engineering) & Jon Hare (ECS)



What? Investigate how to make machines smarter and more flexible when surveying extreme environments such as the ocean.

Why? 90% of all data that exists has been generated in the last 2 years. In built environments like homes and offices, most of the data processing needed to generate knowledge from this data takes place on remote servers, and the machine that sits in your living room or pocket doesn't need to be smart to be useful. Extreme environments lack the energy and communication infrastructure to transfer data in this way, and so machines need to be smarter to allow sensible decisions to be made when they are needed.



How? This PhD will develop the concept of intelligence that is shared between different physical locations, where machines in extreme environments are able to prioritise, encode and communicate the most important information over the limited bandwidths available for communication, so that complex decisions can be made remotely, using more powerful computational resources or be augmented by human judgement. You will investigate how intelligence can shared between different locations, to maximise productivity and real-time awareness during deep-sea surveys.

Key skills: Engineering background, a passion for field robotics, machine learning and computer vision

If Interested in any of the above please email G.D.Weymouth@soton.ac.uk or B.Thornton@soton.ac.uk

Originally Presented at the CMEE Showcase, 24th January 2020

PhD Opportunities

Potential funding available

UNIVERSITY OF Southampton

Civil, Maritime and Environmental Engineering

Biochemical and microbial interactions with advanced coatings and sealants in industrial biotechology applications

Prof Sonia Heaven & Dr Yue Zhang (WEEG)

Industrial and environmental biotechnology is a rapidly developing field that covers both well-established sectors such as anaerobic digestion and wastewater treatment, and innovative processes needed to underpin an emerging circular bioeconomy. Advances in materials science are delivering new materials, coatings and sealants for the containment solutions required for these processes. The research challenge is to understand how these may interact with the physical and biochemical conditions encountered in new applications and markets.

The first stage will look at a defined range of products and materials, testing them to see their performance and endeavouring to determine key factors affecting durability and life expectancy. The work builds on Southampton's extensive expertise in both anaerobic digestion and materials testing, and conditions found in anaerobic digestion plants will be taken as a model system in the first instance. One aim will be to develop a suite of testing approaches that could in future become the basis for industry-wide standards.

The research will then move on to look at novel materials and testing methodologies under a range of conditions relevant to future applications in industrial biotechology. This will involve different disciplines, bringing together knowledge of the chemical and microbiological characteristics of these systems with advanced materials properties and testing methods.

The project offers the chance to work closely with an industrial partner who has a world-leading reputation for quality and innovation in its products, and a strong track record of environmentally-responsible manufacturing.

Key Skills: Engineering, chemistry, biology, materials

If Interested in any of the above please email S.Heaven@soton.ac.uk

PhD Opportunities

Potential funding available

UNIVERSITY OF Southampton

Civil, Maritime and Environmental Engineering

Exploring highly aerated flows in civil engineering hydraulics

Gerald Muller & Sergio Maldonado (WEEG)

Gilgel Gibi Dam and Spilway, Ethiopia

Hydropower is a major contributor to the world wide resource of renewable energy. Highly aerated flows occur in reservoir spillways and plunge pools and in many hydraulic structures such as ski jumps, stilling basins and hydraulic jumps. These flows are characterised by their fast flow velocities up to 40 m/s, and by the fact that there are significant differences in energy dissipation between model and full scale flows which were attributed to the higher air content at full scale. Recently, the compression and expansion of air bubbles was shown to play a crucial role in the energy dissipation in plunge pools, explaining these scale differences, Müller (2019). The water-air mixtures behave like a compressible medium with some very interesting characteristics- the speed of sound for water with 10% air content e.g. is 33 m/s, much less than the speed of sound in water (1450 m/s) or in air (300 m/s). The exploration of highly aerated water as compressible flow is however only at its very beginning. The questions of the effect of negative (sub-atmospheric) pressures, potential dynamic effects such as pressure oscillations, the transition form supersonic to subsonic flows etc. have not even been touched. In this project, the effects of air content on the performance of hydraulic structures will be explored using theoretical analysis, numerical modelling and data from published experiments.

Key Skills: Hydraulics / Fluid Mechanics, Matlab

Resource recovery from municipal wastewater with forward osmosis membrane based process

Yongqiang Liu (WEEG)

In modern society, municipal wastewater needs to be purified to remove organic carbon pollutants and nutrients such as nitrogen and phosphorus before discharge into natural water bodies to protect environment and human health. As one of the most important and essential infrastructures, municipal wastewater treatment plants are well known for their large footprint, intensive energy and chemical consumption. Although various technologies have been studied to harness resources in wastewater such as anaerobic digestion for energy recovery, struvite crystallisation for nutrient recovery and reverse membrane for water recovery to reduce environment impact of wastewater treatment, to make useful products and to drive treatment towards sustainability, the highly diluted nature of municipal wastewater make these technologies unfeasible or too costly. Forward osmosis (FO) membrane filtration driven by osmotic pressure attracts intense attention recently for wastewater preconcentration to allow a direct use of the above-mentioned technologies for resource recovery. Thus, a promising prospect of forward osmosis filtration as a key unit to design next-generation wastewater treatment plants can be expected due to its smaller footprint, more flexible operation, lower membrane fouling propensity and lower energy consumption if draw solution is well selected and the process is well designed. However, most studies focus on single or a few of model chemicals to investigate FO membrane filtration. The study on chemistry of wastewater, and interactive relationship between chemistry of wastewater and draw solution, and their effects on flux, membrane fouling and cleaning, pollutant rejection, is lacking, which makes the real-world application of FO membrane for wastewater treatment challenging. This PhD project will dedicate to this with the ultimate goal to allow energy, nutrient and water recovery cost effective and sustainable. We have been carrying out relevant research in this area, and hope you could join to further this research.

Key Skills: Background of chemical engineering or environmental engineering or chemistry is preferred.

If Interested in any of the above please email g.muller@soton.ac.uk or Y.Liu@soton.ac.uk

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PhD Opportunities

Potential funding available

UNIVERSITY OF Southampton

Civil, Maritime and Environmental Engineering

Transport and fate of microplastics from rivers to the ocean

Gustavo de Almeida & Sergio Maldonado (WEEG)

Since the 1950's the world has witnessed the dramatic increase in production and widespread consumption of plastics. Over the last decades, the multiple benefits of this cheap, lightweight, strong and —most relevant to this proposal, durable— material are undeniable. Long regarded as advantageous, plastic durability has turned into the cause of one of the main environmental concerns of the 21st century. Once in the environment, plastic accumulates and undergo slow degradation, persisting in the environment for hundreds, if not thousands of years. Plastics account for more than 60% of all floating debris in the oceans and their fragmentation into smaller sizes produces particles that are difficult to trace or remove from the environment, and can be ingested by fish and even small invertebrates. Despite the multiple environmental and health issues associated with plastics in the environment, the transport, transformation and accumulation of plastics in rivers and the ocean remain poorly understood. This project is aimed at developing a detailed understanding of these processes, which is fundamental to address this critical environmental risk. To this end, the successful candidate will work on a pioneering research that will combine state-of-the-art laboratory experimentation and computational modelling. The outcomes of this project are expected to underpin future technologies to predict, monitor and mitigate the accumulation of plastics in the environment.

The successful candidate will have a 1st or very strong 2:1 degree in Engineering, Physics or closely related disciplines and a strong interest in fluid mechanics and environmental engineering. The project will offer an unique opportunity to learn advanced laboratory, analytical and computational methods in fluid dynamics. If you wish to discuss any details of the project informally, please contact Dr Gustavo de Almeida (g.dealmeida@soton.ac.uk). Please notice that funding (fees and stipend) are fully covered for UK applicants only.

Key Skills: Hydraulics, Fluid mechanics, experimentation, computational modelling

Understanding bedforms and their effect on the flow

Sergio Maldonado (WEEG)

Experiment showing the formation of bedforms (sand dunes) in a flume

Sand ripples and dunes are ubiquitous features found in the beds of rivers and coastal waters. These bedforms are not only scientifically fascinating, but their presence is also important from an engineering perspective because they enhance the resistance experienced by the flow (or effective bed friction), which is important to e.g. design flood mitigation measures and assess shoreline stability; topics which are gaining relevance in the context of sea level rise and other climate change effects. Although the mechanics describing how these features form are relatively well understood, why they tend to the shapes they attain has been much less explored, leaving our understanding incomplete. This project tries to deepen our understanding of these bedforms by exploring possibilities based on certain principles which are often overlooked in this field, such as the second law of thermodynamics. At the end, a better understanding of these ubiquitous features and their interaction with the flow will lead to better tools employed in Civil and Environmental Engineering, particularly for the creation of long-term predictions of the evolution of rivers and coasts, which are currently highly uncertain. The successful candidate will make use of world-class resources at the university, such as powerful supercomputing facilities and state-of-the-art laboratories.

The successful candidate will have a 1st or very strong 2:1 degree in Engineering, Physics, Mathematics or closely related disciplines and a strong interest in fluid mechanics, geophysics and environmental engineering. If you wish to discuss any details of the project informally, please contact Dr Sergio Maldonado (s.maldonado@soton.ac.uk). Please notice that only UK applicants will be fully funded.

Key Skills: Fluid mechanics, numerical modelling

If Interested in any of the above please email g.dealmeida@soton.ac.uk or s.maldonado@soton.ac.uk

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