

Engineering and the  
Environment

UNIVERSITY OF  
Southampton

NB

Engineering and the  
Environment New Boundaries

2012

# Clearing space junk

Working towards a sustainable  
environment in space

## Performance sports excellence

Our expertise helps British athletes achieve success

## Combating hand-arm vibration syndrome

Providing diagnostic tools to help reduce injury risk

## Back on track: optimising railway design

Reducing costs and increasing safety on our railway systems

# In this issue

Welcome to *Engineering and the Environment New Boundaries*.

In this issue, you will discover how our research is addressing some of the most challenging issues facing society, from energy and climate change to transport efficiency and medical conditions.

Engineering and the Environment at Southampton brings together a wide range of engineering disciplines, as well as environmental science and audiology. With over 40 years of cutting-edge research, we have had (and continue to have) a significant impact on society.

We are ranked number one in the UK for mechanical engineering according to *The Guardian University Guide 2013*, because our world-class research directly informs the education we offer. We transform research into real-world solutions that produce business opportunities, enhance quality of life and boost the economy.

On page four, find out how engineers at Southampton are helping British athletes to improve their race times using cutting-edge aerodynamics technology. On page 10, you can read how researchers at the Institute of Sound and Vibration Research are helping to combat hand-arm vibration syndrome, a condition that affects about one million people in the UK alone.

As modern living becomes ever more reliant on satellites, our researchers are looking at ways to clear space of redundant spacecraft to prevent collisions that threaten our technology-based lifestyles. Find out more on page 12.

And from travelling in orbit to travelling on trains, our geomechanics research is helping to drive the intelligent design of railway systems to reduce costs and increase safety. Read more on page 16.

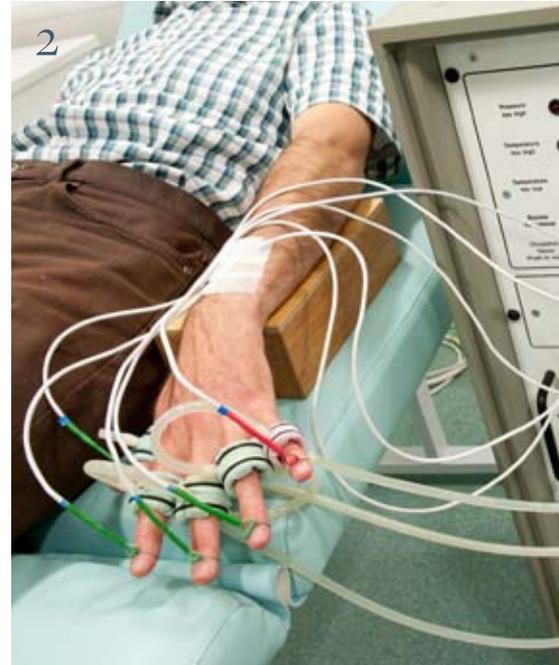
For more information, visit [www.southampton.ac.uk/engineering](http://www.southampton.ac.uk/engineering)

Cover image: NASA/courtesy of nasaimages.org

## Please send us your feedback

We are keen to receive any feedback you have about *Engineering and the Environment New Boundaries*.

If you have any comments or suggestions, please do send them to [engenv@southampton.ac.uk](mailto:engenv@southampton.ac.uk)





**1 Performance sports excellence**

Our expertise helps British athletes achieve success.

Page 4

**2 Combating hand-arm vibration**

Providing diagnostic tools to help reduce injury risk.

Page 10

**3 Clearing space junk**

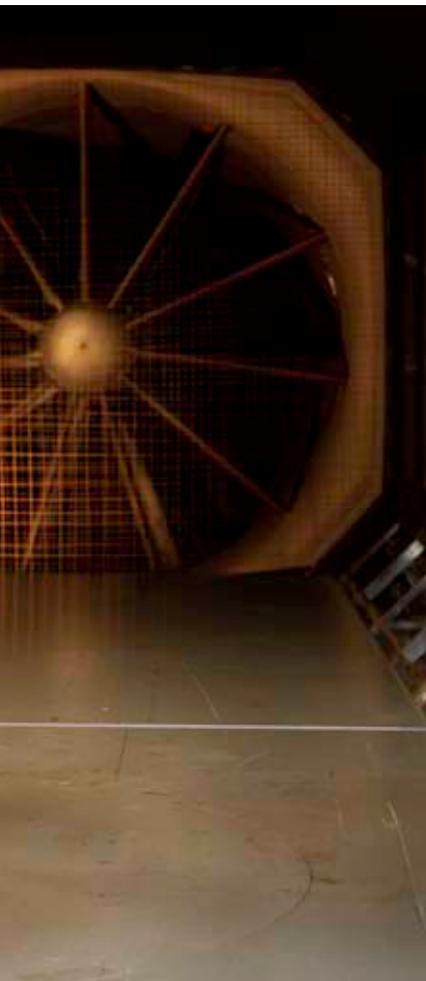
Working towards a sustainable environment in space.

Page 12

**4 Back on track:  
optimising railway design**

Reducing costs and increasing safety on our railway systems.

Page 16



## More highlights

**Preventing wear and tear**

Surface engineering inspired by nature.

Page 20

**Intelligent traffic systems**

Working with government to maximise traffic efficiency.

Page 21

**Recent publications**

Journal papers highlighting engineering impact.

Page 22



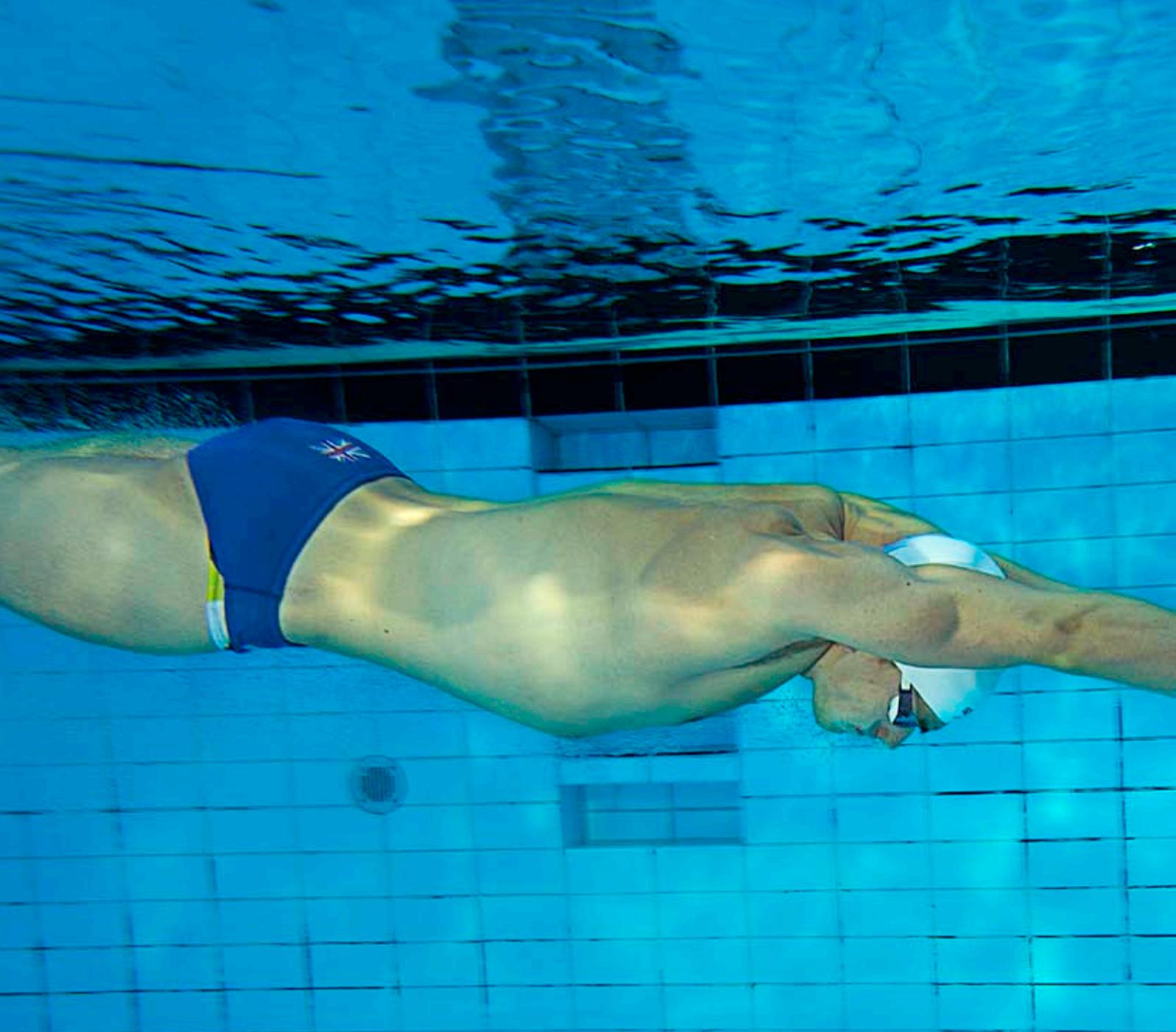
The University of Southampton has been awarded a prestigious Queen's Anniversary Prize for higher and further education for its innovation and world-leading expertise in performance sports engineering. Find out more on page four.





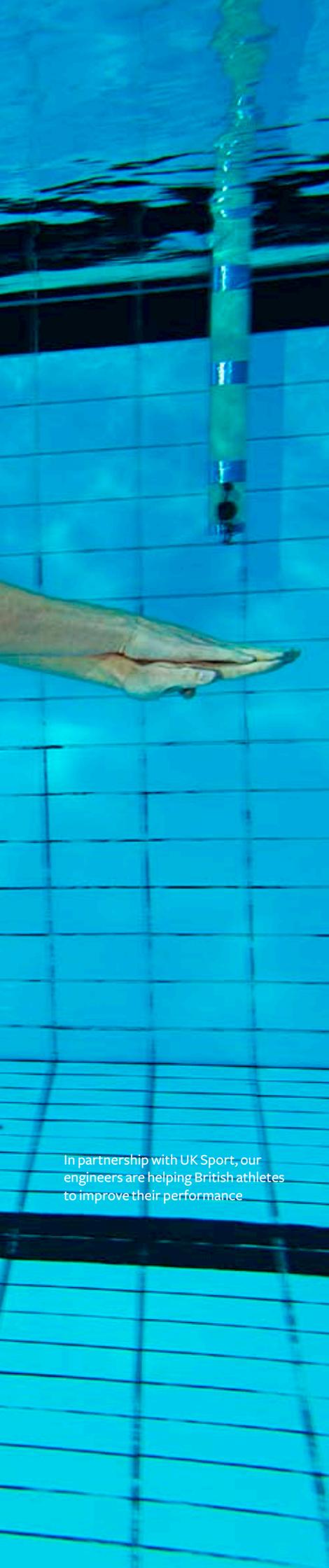
# Performance sports excellence

When the difference between winning and losing is down to fractions of a second, anything that gives you the edge is an advantage. At the University of Southampton, our engineers are bringing together science and sport to optimise the performance of British athletes.



“Gold medals can be won or lost within fractions of seconds and our job is to ensure that the athletes are in the best possible position to take advantage of those tiny margins. The knowledge and expertise that the University of Southampton contributes is critical to our work.”

Dr Scott Drawer,  
Head of Research and Innovation at UK Sport



In partnership with UK Sport, our engineers are helping British athletes to improve their performance

The University has been engaged in performance sports engineering for over 40 years, achieving an unrivalled international reputation for innovative engineering design and aerodynamics for performance sports. From Formula 1 (F1) cars and America's Cup yachts, through to technical support for elite athletes in cycling, kayaking, rowing, downhill racing and now swimming, the Performance Sports Engineering Laboratory (PSEL) at the University has made a unique and exceptional contribution to the success of sport in the UK.

#### Innovation and expertise

The PSEL groups together academics and research engineers across Aerodynamics, Computational Engineering and Ship Science. The internationally renowned Wolfson Unit for Marine Technology and Industrial Aerodynamics (WUMTIA), is working closely with the yachting industry, developing longstanding associations with numerous America's Cup teams and contributing significant improvements to the design and safety of racing yachts.

Our advanced rolling road wind tunnel technology developed here provided facilities and expertise for several UK F1 teams and the almost unbeatable Penske Indy Car teams in the 1980s and 1990s.

The University's contribution has been recently recognised when it received the prestigious Queen's Anniversary Prize for higher and further education in February 2012, for innovation and world-leading expertise in performance sports engineering.

"I am delighted the long-standing achievements of the University have been

recognised in this way. We have seen our research impact at the highest level in competitive sport, but are equally proud of our graduates who excel in the ultra-competitive technology driven world of motorsport and performance sailing," says Professor Stephen Turnock, Director of the PSEL. "It is rare to find a team without one of our ship science, aeronautical or mechanical engineering graduates playing a leading role."

#### Supporting UK athletes

Stephen explains that the University's international reputation resulted in UK Sport approaching the team in 2005 to access its resources. Since then our engineers have had a close working relationship with UK Sport and in 2007 the WUMTIA was awarded the status of Innovation Partner, a relationship that continues today. This partnership has been focused on sports involving high speed where there are potential gains in the aerodynamic and hydrodynamic characteristics of the athletes and their equipment. Complementing this has been the support by UK Sport of a steady stream of PhD students looking at longer term research and development.

By employing our wind tunnel facilities, engineers from the WUMTIA have used their expertise to help the British cycling team to focus on improving the understanding of the complex aerodynamic interactions involved. Stephen explains that the research is all about the athlete's positioning on the bike. "It is about finding what is best for each athlete and how this can reduce drag." The team measures the small changes in drag and searches for the optimum body ▶

## “It is about finding what is best for each athlete and how this can reduce drag.”

Professor Stephen Turnock,  
Director of the Performance Sports  
Engineering Laboratory

position. “We assess the fluid dynamic flow to understand how subtle changes in body position can better control the flow.”

### Winning combination

The results for the British cycling team have been dramatic. From coming third in the medals table at the Athens Olympic cycling events in 2004, Great Britain progressed over the next five years to come top of the medals tally for three out of six UCI Track Cycling World Championships and in 2008 to lead the Beijing Olympic cycling medals table by an impressive margin. British cycling has greatly improved its world standing in track cycling and is now considered a dominant force in the sport.

At London 2012 Olympic Games, the British Cycling team were really successful. In track events, they won gold in the Men’s Sprint, Men’s Team Sprint, Men’s Team Pursuit, Men’s Keirin, Women’s Keirin, Women’s Team Pursuit and Women’s Omnium. They also won silver in the Women’s Sprint and bronze in the Men’s Omnium. In road events, the team won gold in the Men’s Individual Time Trial and silver in the Women’s Road Race.

Along with research in collaboration with British cycling, other research has focused on the winter sport of Skeleton. Amy Williams was helped to her Skeleton Gold Medal in Vancouver 2010 by the University. Her sled was designed by two of our graduate students and over 200 hours of wind tunnel testing helped Amy find her optimum sliding position. The four-year project combined experimental work, the latest computational analysis techniques, and testing in wind tunnels, to improve the understanding of Skeleton performance. Competition within this sport is fierce and the margin of victory can be as little as 0.01 of a second.

Head of Research and Innovation at UK Sport, Dr Scott Drawer, explains: “Gold medals can be won or lost within fractions of seconds and our job is to ensure the athletes are in the best possible position to take advantage of those tiny margins.

The knowledge and expertise that the University of Southampton contributes is critical to our work.”

### Improving technique

More recent research at the PSEL, in partnership with UK Sport, involves helping British swimmers to improve their performance. Using a controlled overspeed tow winch, four or five wireless sensors on the swimmers’ body and a camera attached to a device that follows the swimmer along from the side of the pool, the team can measure the forces and drag acting on the swimmer.

The team uses commercial sensors, similar to the ones that are in smart phones, to capture the large amounts of data needed to analyse the forces and drag that effect the athletes’ bodies. “You can also use optical motion capture devices with point light sources on different parts of the body to see what the trajectory of the body is in time and space,” says Stephen.

“We can put up on the screen straight after they have finished their swim, information on the details of their stroke and the efficiency with which they are propelling themselves. And this provides them with data that many of them have never seen before, but that they can use with their coaches to try and work on improving their technique,” says Dr Dominic Hudson from the Fluid Structure Interactions group.

“The winning margins are so much smaller than they used to be; we need to find new areas to make advances. These days, improvement comes through the accumulated effect of many smaller gains, rather than through achievement of one large step change. And research like this allows us to pinpoint these small gains and identify areas where improvements can still be made,” explains Angus Webb a PhD student involved in the project.

At London 2012 Olympic Games, the British Swimming team won silver in the Men’s 200m Breaststroke and bronze in the Women’s 800m Freestyle and the Women’s 400m Freestyle.



Our researchers provide British swimmers with data to help them improve their technique

### Influencing efficiency

UK Sport and our British athletes are interested in knocking fractions of a second off times in order to be successful. But the same challenges are tackled in Ship Science at the University, where all the small details that can make a difference on the energy efficiency of ships are investigated, explains Stephen.

“Currently, three or four per cent of the world’s carbon dioxide emissions come from shipping. Over the next 30 years that could go up to 20 per cent, so the challenge is to reduce this,” he says. “The big wins have already been found, so it is all about small details again and actually the performance sport work is a precursor to what has to be done in the shipping world.”

Similar sensors to the ones that measure the forces and drag of British swimmers in the water are being used to analyse how ships respond to large rogue waves. “We put a string of sensors down the hull of a ship

model in order to understand how the ship flexes under the wave loads,” says Stephen. “It is much simpler than previous ways of measuring these forces and it appears to be as accurate, if not better than previous methods.”

**Funders:** UK Sport and British Swimming

For more information on performance sports engineering at the University, visit [www.southampton.ac.uk/performancesports](http://www.southampton.ac.uk/performancesports)

# Combating hand-arm vibration syndrome

Southampton's research into hand-arm vibration syndrome has influenced company practice and international policy around the world, provided health services with more effective diagnostic tools and helped control the risk for millions of workers. Professor of Human Factors Michael Griffin from the Institute of Sound and Vibration Research (ISVR) talks about this multidisciplinary project.

**Q** *Why is it important to tackle hand-arm vibration syndrome?*

In the UK, there are about one million people at risk of developing hand-arm vibration syndrome, which is a combination of a vascular disorder known as vibration-induced white finger and what I call deafness in the fingers – the lack of the sense of touch – which can result from prolonged exposure to vibration at work.

**Q** *What does your research involve?*

At the Human Factors Research Unit, we have a broad approach to hand-arm vibration syndrome. Our studies include trying to find out what kind of vibration causes the disorder as well as measuring vibrations in work environments.

These investigations then help us to give guidance to companies and individuals to help minimise the risks.

Our laboratory research includes studies with patients to analyse how the disease affects them. From that knowledge and experience we have developed new diagnostic methods that are being used in medical clinics in this country and abroad. We also test protective equipment that is available to minimise vibration, such as gloves. In our laboratory, we test gloves from various companies around the world to see if they meet the international standard for anti-vibration.

**Q** *What impact does your research have on society?*

The diagnostic tools we develop help doctors to assess the extent to which a patient is affected by hand-arm vibration syndrome. For example, we have developed a unique machine that is used internationally to measure the blood pressures in all five fingers simultaneously at different temperatures in order to assess the damage to the hands. We also carry out laboratory work to try to understand how vibration travels through the fingers and how we can minimise vibration with gloves and other protective equipment.

**Q** *Does your research inform policy on hand vibration standards?*

I am the Chair of the British Standards Institute (BSI) committee on human vibration so our research informs British vibration standards. More importantly, we are involved in improving international standards for hand vibration. We provide information and give guidance to policy makers on the development of new and improved vibration standards for gloves. We also advise on the measurement and evaluation of hand-transmitted vibration and the testing of tools, and the diagnosis of hand-arm vibration syndrome.

**Q** *How important is multidisciplinary collaboration in your research?*

Our research into hand-arm vibration syndrome is completely multidisciplinary. We have a long standing collaboration with the Medical Research Council Lifecourse Epidemiology Unit (MRC LEU) here at the University who work in partnership with us on aspects of the research. We have a 20-year partnership with the University of Trieste in Italy, which focuses on epidemiological research on hand-transmitted vibration, and enables us to share ideas and move the research forward.

**Q** *Why is Southampton a good place to do this kind of research?*

From when it was founded in 1963, the ISVR became world-famous because it developed a unique approach to looking at all aspects of sound and vibration, from the engineering and the mathematical through to the psychological and the medical. The ISVR developed a critical mass of research, knowledge, and contacts in sound and vibration and continues to be world leading. Nowhere else in the world has been able to build a viable unit researching human responses to vibration and maintain continuity of research; not just research in hand-transmitted vibration, but also research in whole-body vibration and motion sickness – there is a lot of synergy between the various multidisciplinary studies in the Human Factors Research Unit.

**Q** *How would you rate Southampton for early career research opportunities?*

Many people have come through the ISVR to develop their careers and of course, over the 40 years I have been here, many have gone on to set up their own facilities and expertise elsewhere. In some cases they have become competitors of the ISVR, but more often they have become funders of research here. Either way, we are pleased if we have nurtured their careers, it indicates the status and standing of the community they contributed to during their time here.

**Q** *What would you say is your biggest achievement here at Southampton?*

To me I hope my biggest achievement is what I will be doing today. I see the research carried out through my career as developing the tools and experience enabling us to tackle the challenges we are faced with now. We are addressing real problems all the time – they move the research on and so we are always looking forward. The critical mass of research resources here has enabled us to advance understanding in our field, and the world-class reputation of the ISVR has enabled us to attract the best talent to help us with the challenges we come across – having a friendly, capable and viable team is the greatest asset.

**Funders:** Over the years, funders have included the HSE and the EU. All recent funding has come from services rendered to industry, either by selling the HVLab Diagnostic Instruments to customers or assessing patients referred for diagnosis of the hand-arm vibration syndrome.

For more information about engineering research at Southampton, visit [www.southampton.ac.uk/hfru/research/hand\\_transmitted.html](http://www.southampton.ac.uk/hfru/research/hand_transmitted.html)



# Clearing space junk

As modern living becomes ever more reliant on satellites for communication, navigation, weather forecasts and more, orbiting junk is becoming a pressing global issue. Southampton researchers are tackling this space junk problem.

NASA/courtesy of nasaimages.org



A team of engineers, led by Dr Hugh Lewis in the Astronautics Research Group at the University, is using computer models to simulate the space debris environment. Using these models the team can then predict how many functioning satellites as well as defunct equipment – space junk – there will be orbiting the earth in the future.

Hugh explains that space is an integral part of our technologically dependent world. “In order to protect our lifestyle, we have to be able to protect the spacecraft that provide important services and that means making sure that the environment they are operating in is as safe as we can make it,” he says.

#### Collision risk

In the past, the thinking was that ‘space is big’; however, the region of space populated by our satellites is constrained to particular orbits around the Earth. At present, there are between 60 and 80 launches a year and

in some cases, several satellites can be put into orbit at each launch. “Typically, we are launching 150 to 200 spacecraft into space each year and they subsequently occupy key orbits. Some could be up there for centuries,” says Hugh. “As we continually add spacecraft, the collision risk will consequently increase and in a non-linear way – doubling the number of spacecraft could quadruple the collision risk,” he adds.

Most of our space activity takes place in low-Earth orbit. “Within that region there are orbits that are considered to be prime real-estate and this is where many high-value Earth observation satellites are positioned,” Hugh says. “These are typically expensive satellites, all on similar orbits and space debris in these regimes could ultimately have a great impact on our everyday lives.”

#### Unique achievement

Hugh and colleagues have developed the

Debris Analysis and Monitoring Architecture to the Geosynchronous Environment (DAMAGE). This is a three-dimensional simulation model of the debris environment in space. It runs on a typical office computer and allows the team to try out different strategies for mitigating the space debris problem. “The simulations enable us to develop rules and guidelines that are subsequently adopted by the international space-faring community,” Hugh says.

DAMAGE can simulate the historical and future debris populations. During the early 2000s, in collaboration with the Space Debris Group at QinetiQ, Dr Graham Swinerd (now retired), Hugh and the team extended the applicability of DAMAGE to cover space regions from low-Earth orbit to medium-Earth orbit and up to geostationary-Earth orbit. “There are only a handful of models worldwide with similar capability,” explains Hugh. “DAMAGE is unique in the UK ▶

and is only one of two models developed in academia with research grant funding.”

Several decades ago the space agencies of the USA and Russia realised that we could not carry on polluting space and so established the Inter-Agency Space Debris Coordination Committee (IADC). Since then, the IADC has grown to include the UK Space Agency and 11 others. The aim of the committee is to discuss the technical challenges that exist in terms of space debris and to identify ways in which these challenges and the growth of space junk, can be prevented. “More recently, the United Nations (UN) has recognised the need for a sustainable approach to the use of outer space and space debris has been identified as a particular threat to this. At the same time, there has been an increase in the number of space-faring nations coming forward and it is important to encourage their use of space rather than to stifle it with too much regulation,” says Hugh.

#### International guidelines

Ideally, the UN wants to allow these emerging space-faring member states to exploit space in the way pioneering nations have done for many years, but also make sure that future generations will be able to do the same. “We don’t really want to limit space launches or impose tough restrictions; we need to find ways to tackle the space debris problem to ensure the long-term sustainability of our space activities,” says Hugh.

The IADC have produced a set of guidelines that identifies good practice in space, some of which are enforced at a national level. “The guidelines contain measures such as preventing the release of debris during normal spacecraft operations, performing collision avoidance manoeuvres and disposing of a spacecraft once it has completed its mission,” says Hugh.

The research conducted by Hugh and his team has shown that this ‘post-mission disposal’ guideline can have a significant, beneficial effect on the space debris population.

“This is a really important guideline as it reduces the chances that defunct spacecraft will be involved in a collision – they are essentially just big targets and any collision could result in huge numbers of new debris.”

#### Removing rubbish

In 2007, China conducted an anti-satellite test that saw a missile targeted at a defunct weather satellite. “This single event created 3,000 fragments the size of a tennis ball or larger and provided a clear demonstration of the consequences of a collision,” says Hugh. This and an accidental collision involving an Iridium satellite in 2009 were important wake-up calls to spacecraft operators. “Our simulations and the guidelines that we help to define are designed to help reduce the number and consequences of these collisions,” he adds.

The space community is now looking at active debris removal, which involves identifying particular objects in orbit that pose a collision risk and removing them. “This is a really difficult challenge, because firstly you have to rendezvous with the debris and capture it safely – it could be tumbling – and secondly remove it from orbit without causing any other collisions,” says Hugh. Some of these objects are large and can weigh up to nine metric tonnes.

Hugh and his team are working with the UK Space Agency and other space agencies in the IADC to define the requirements of active debris removal and to establish appropriate guidelines. In particular, it is important to identify which objects should be removed. Using DAMAGE the team makes a forecast to see which objects pose the biggest collision

risk and these are then targeted for removal in the simulation so that the benefits can be understood. The team can also advise on the technology that might be required to reach and remove particular objects, so that the industry can move forward with the technological designs that are needed.

There is also a political dimension to Hugh’s work. “If you can remove a non-functioning satellite from orbit, there is nothing to stop a nation from removing another country’s functioning spacecraft,” says Hugh. “There is also a liability issue to consider as well – if a redundant Russian satellite is removed by the USA, who is liable if another spacecraft is damaged in the process?”

#### Sustainable future

With international partners and the IADC, Hugh and his team have been working towards guidelines that are effective within the context of these political and legal issues. Work is also being carried out with a number of European partners to reduce the vulnerability of spacecraft to debris impact. “We are also working to inform the wider space industry across Europe about the importance of complying with the space debris mitigation guidelines,” Hugh explains. “The goal is to increase the compliance with the guidelines and build towards a sustainable future. This needs international collaboration. That’s the only way to achieve this kind of desired future.”

**Funders:** UK Space Agency and EU Framework 7 (ACCORD and ReVuS projects)

For more information on this research, visit [www.southampton.ac.uk/~hglewis/spacedebris/index.html](http://www.southampton.ac.uk/~hglewis/spacedebris/index.html)



“In order to protect our lifestyle, we have to be able to protect the spacecraft that provide those services and that means making sure that the environment that they are operating in is as safe as we can make it.”

Dr Hugh Lewis,  
Astronautics Research Group

NASA/courtesy of nasaimages.org



Engineers at Southampton are looking to reduce the cost and increase the safety of railway designs

# Back on track: optimising railway design

Geomechanics research at the University of Southampton is helping to drive the intelligent design of railway systems globally, providing the industry with the tools to reduce costs and increase safety.

William Powrie, Professor of Geotechnical Engineering and Dean of Engineering and the Environment, explains more.

**Q** *How does engineering at Southampton impact on railway design?*

We have two major projects that are looking at how we can improve railway design. Our Rail Damper project has led to the development of a device that can be attached to rails to minimise railway noise.

Our Geotechnical Railway project is associated with understanding the way in which vegetation and climate affect railway embankments and cuttings, primarily through the removal of moisture from the soil which results in uncontrolled and potentially problematic movements of the ground and hence the track it supports.

This can result in the imposition of temporary speed restrictions. At the other extreme, a period of very wet weather can result in increased moisture content within the slope, potentially causing unsafe ground. Another strand of this project looks to understand the ground, ballast, sleepers and rails, as a system so that performance can be optimised and maintenance reduced.

**Q** *What is the impact on society of these two research projects?*

The rail damper we have developed in the Institute of Sound and Vibration Research, in collaboration with Tata Steel are now being used commercially in 13 countries and

are reducing the noise associated with key railway lines and the associated nuisance to those who live nearby. In conjunction with Mott MacDonald, we have already helped both Network Rail and London Underground to develop guidance for the management of vegetation on embankment and cutting slopes so as to minimise both dry-weather settlements and the risk of slip failures in wet weather.

**Q** *What do you see as the biggest challenge with these projects?*

Our biggest challenge with these projects is in predicting the true nature of the interactions between the components of the



railway. When optimising the performance of the whole system, we can't just address the components individually. Arguably, this is where things have taken a wrong turn in the past – when changes to traditional practice have been made, the full implications have not been thought through.

**Q** *Is multidisciplinary collaboration important in your research?*

Yes, multidisciplinary collaboration is very important, both within engineering – for example, between disciplines of civil engineering for the ground and the track, mechanical engineering for the behaviour of vehicles, data acquisition and management, and sound and vibration research. We also need to be able to quantify the economic and societal benefits of the changes and interventions we propose, so collaborations with experts in these fields are vital as well.

**Q** *What are the benefits of doing this research at Southampton?*

Southampton has one of the biggest critical masses of high-quality engineering expertise in the UK and in Europe. We have a 60-year history of excellence in key disciplines such as civil engineering and sound and vibration research. We have excellent experimental facilities and the ability to carry out difficult field investigations – frequently developing the instrumentation needed to do the research as we go. This is backed up by all round excellence in numerical modelling

using high-performance computers. I think also that Southampton offers a rare blend of having the knowledge needed to identify and understand the underlying science, coupled with the pragmatic ability to put together a workable engineering solution.

**Q** *What have been your biggest achievements since joining the University?*

I'm a geotechnical engineer, which means that I'm interested in the behaviour of the ground and things that look like the ground – materials that appear to be solid, but are made up of particles with pores in between, which can be filled with water, air or a mixture of the two. I'm now working on railway geotechnics, but I have also worked on understanding gas and liquid flow in landfills and the construction of underground structures like the Jubilee Line extension stations at Canary Wharf and Canada Water, in London. The advances in understanding in both these areas, which have come through into current design guidance and enabled things to be built or done in a way that would not have been possible before, are things that I am proud to have led.

**Q** *What support is available for early career researchers here?*

Mentoring and internal peer review is always available to researchers at all stages of their careers and we can always learn from new

perspectives provided by others. We give preference to early career researchers in the allocation of PhD studentships and we encourage people to work in teams which can help introduce a new researcher to the research councils and to industry. We are also moving towards common ownership of facilities and laboratories, which gives new career researchers unparalleled access to cutting-edge research kit. Our goal is to give all our staff the support to bring in the research grants and contract funding so they can do work of the highest international quality.

**Funders:** Principal funders are the EPSRC and Network Rail.

For more information about research at Southampton, visit [www.sr2.soton.ac.uk/](http://www.sr2.soton.ac.uk/)

# In brief



## Predicting wind flows in cities

Key safety considerations in cities include the effect of local winds on the loading on man-made structures and on the dispersion of pollutants. Engineers at Southampton are researching these issues with high-powered computer simulations that lead to greater understanding of the nature of wind flow and turbulence and their effects in the urban environment.

Professor of Fluid Dynamics, Ian Castro, and the Aerodynamics and Flight Mechanics (AFM) research group, which is a national centre for research in turbulent flow, are using both the University's supercomputer, *Iridis 3*, and national facilities to carry out large-scale simulations of turbulent flows in urban environments. These large-scale simulations have resolutions fine enough to capture obstacles representing buildings and thus generate fine-scale details of the flow as well as heat transfer and pollutant dispersion phenomena. This allows engineers to make more informed decisions on building designs and safety and it also informs meteorologists who need better near-surface information for improved weather forecasting.

Such calculations can be made using commercial Computational Fluid Dynamics (CFD) codes. Some features of the AFM team's methodologies are now included in a major software release by CD-adapco – the world's largest independent CFD-focused provider of engineering simulation software. "We are pleased to be using large-scale computing facilities to generate better understanding of wind flows in urban environments in order to help both meteorologists and city planners," says Ian.

**Funders:** NERC via the Universities Weather Research Network



## Unique hip-replacement

All metal resurfacing hip replacement surgery can result in the patient reacting to the metal ions from the implant which can lead to further medical problems. To solve this problem, engineers at Southampton have helped develop longer-lasting, biocompatible, ceramic hip resurfacing.

Compared to a total hip replacement, a resurfacing hip replacement requires the removal of considerably less bone and presents a lower risk of dislocation. The procedure involves a large metallic shell replacing the surface of the femur, articulating against a thin metal socket in the pelvis.

A team of engineers at the University, led by Professor Martin Browne, Head of the Bioengineering Sciences research group and Dr Alex Dickinson, have been working as part of a Technology Strategy Board Knowledge Transfer Partnership with the development team at Finsbury Orthopaedics Ltd and Aurora Medical Ltd, to develop a ceramic alternative that circumvents the possibility of metal sensitivity reactions.

State-of-the-art technologies in materials testing and implant design were reviewed and rigorous pre-clinical tests and computer simulations were developed to verify the design prior to commencing clinical trials.

The research has produced a unique hip resurfacing system that has since been bought by DePuy International Ltd, which is suitable to treat a patient group currently without a successful solution: the young female osteoarthritis sufferer.

**Funders:** Technology Strategy Board



## World's first printed plane

Engineers at Southampton have designed and flown the world's first 'printed' aircraft, which could revolutionise the economics of aircraft design.

The Southampton University laser sintered aircraft (SULSA) is an unmanned air vehicle. Its entire structure has been printed, including wings, integral control surfaces and access hatches. It was printed on a laser sintering machine, which can fabricate plastic or metal objects, building up the item layer by layer. No fasteners were used and all equipment was attached using 'snap fit' techniques so that the entire aircraft can be put together without tools in minutes.

Using laser sintering the project led by professors Andy Keane and Jim Scanlan from the University's Computational Engineering and Design research group, allows the designer to create shapes and structures that would normally involve costly traditional manufacturing techniques. This technology allows a highly-tailored aircraft to be developed from concept to first flight in days. Using conventional materials and manufacturing techniques, such as composites, this would normally take months. Furthermore, because no tooling is required for manufacture, radical changes to the shape and scale of the aircraft can be made with no extra cost.

"The flexibility of the laser sintering process allows the design team to re-visit historical techniques and ideas that would have been prohibitively expensive using conventional manufacturing," says Jim.

**Funders:** EPSRC



## Ecological engineering

Several fish populations have declined or become extinct due to poor river development practices, but engineers at Southampton are looking at environmentally sustainable solutions to help prevent this happening in the future.

Dams and barrages have affected over 60 per cent of the world's largest rivers. While these are essential to provide adequate water for human life, they can have a negative impact on freshwater ecosystem services such as fisheries that are worth up to US\$70bn a year.

Traditional fish passes, designed to allow species to pass by hydroelectric dams and other structures, suffer from bias towards a few species of fish and their swimming capability, while ignoring the importance of behaviour. At the University, environmental engineer Dr Paul Kemp and his team have been working on innovative fisheries engineering that incorporates fish pass designs based on the understanding of behaviour and performance of endangered and economically viable species.

“For too long the mitigation of environmental impacts of river infrastructure, such as dams, has been focused on developing fish passes for salmon. Today the drive is to develop multi-species fish passes taking into consideration other endangered species such as the European eel, populations of which have declined by over 90 per cent and are now protected by EU legislation”, says Paul.

**Funders:** UK Environment Agency, European Commission FP7 and Swedish hydropower companies

# In brief

## Preventing wear and tear

All instrumentation, machinery and equipment with moving parts are susceptible to wear and tear arising from surface interactions such as friction. Tribology – the science of friction, lubrication and wear – encompasses materials science, lubrication, corrosion, coatings, nanotechnology and bioengineering. Engineers and scientists at Southampton are pioneering green tribology that aims to research aspects of tribology systems which are important for energy conservation and conversion, quality of life and environmental sustainability.

Director of the national Centre for Advanced Tribology at Southampton (nCATS),

Professor Robert Wood and his team, are investigating the tribological aspects of multifunctional and resource-responsible surfaces (ie reducing the need for rare earth metal additions in tribological coatings), green lubricants, carbon footprint, emissions, total loss systems and biomimetics.

Wear and erosion adversely affects biomedical implants, engines, aircraft skins, ship hulls and conventional and nuclear power plants to name a few, but the techniques used to protect equipment can be harmful to the environment. Therefore the team at nCATS is looking at green alternatives.

“Our research seeks innovative multidisciplinary approaches to reduce wear and friction using surface engineering inspired by nature, green chemistry for manufacturing and new lubricants for wind turbines,” says Robert.

nCATS performs around £125,000 of consultancy work per year delivering real solutions to industrial problems and has won over £6m in research contracts linked to UK and overseas companies.

**Funders:** EPSRC, University of Southampton and industry sponsors



## Intelligent traffic systems

Research staff in the Transportation Research Group (TRG) at Southampton, are working with the UK government to improve traffic efficiency.

With growing congestion on UK roads the government is under pressure to tackle the problem in the most cost-effective way and Head of the TRG at the University, Prof. Nick Hounsell and his team, have been looking at various ways to tackle this problem.

One way is to encourage more use of buses. Funded by Transport for London, the team has undertaken research to design, specify and evaluate bus priority systems in London.

TRG's research has enabled priority to be given to 8,000 buses at 2,000 traffic signals, generating passenger savings of up to £29m a year through reducing journey times.

The team has also worked in partnership with SERCO and the Highways Agency to propose optimal methods to forecast traffic conditions on Britain's motorway network, enabling control centre staff to provide improved real-time information to drivers and improve traffic management.

"This research has improved transport systems as well as generating economic benefits to society and financial benefits to British industry," says Nick.

TRG research has also benefited British industry. For example, working with Jaguar, the team has been improving in-vehicle information systems. Using data from an in-vehicle device designed by TRG, the team has advised Jaguar on the design of future systems that includes more emphasis on driver experience and usability.

**Funders:** Transport for London, SERCO Group plc and Jaguar



## Micro-wind turbines

Engineers at Southampton are influencing UK policy on micro-wind turbine installation and use.

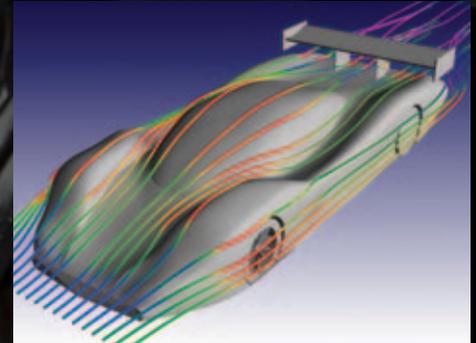
Recently, micro-wind turbines have increased in popularity, especially in urban areas, as a way to potentially generate electricity through natural resources and contribute towards a more sustainable future. However, work carried out by the Energy and Climate Change Division (EECD, [www.energy.soton.ac.uk](http://www.energy.soton.ac.uk)), on the UK national micro-wind turbine trial, has shown that in most instances such turbines on buildings have very poor performances.

Professor AbuBakr Bahaj, Head of EECD at the University says: "The team has provided the necessary robust and rigorous analysis of the performance of a variety of turbines through these trials and it is imperative that a thorough site investigation of the wind resource is carried out prior to any installation."

Dr Patrick James, who led the Energy Savings Trust funded project, says: "We have monitored around 80 turbines at various sites in the UK. The analysis of the performance of these turbines has resulted in a halt to a significant number of installations in the built environment and an extension of this study has been incorporated into the UK Department of Energy and Climate Change's 2050 Energy Pathways report."

Following the research, manufacturers have released revised performance data or reclassified their devices and the UK market has fundamentally shifted to pole mounted turbines on rural farms.

**Funders:** UK Energy Savings Trust (EST)



## Knowledge and innovation

Sophisticated computer simulations are used in many sectors of industry to reduce the high cost of prototyping, experiments and to provide better answers to complex problems in less time. Dezinforce, a spin-out company from the University of Southampton, developed a specialised platform for technical professionals in high-tech market sectors to run complex third party simulation programs and make the designs that they produce faster and cheaper.

Dezinforce was set up in 2007 by professors Simon Cox, Andy Keane and Nigel Shadbolt from the University and its intellectual property was sold to Microsoft in 2011, with many of the staff joining international positions in Microsoft. The company's programs run in a low-cost, commodity processor-based high-performance computing system configured by the Dezinforce software, enabling flexibility and ease for clients.

Leading built environment specialist, Arup, adopted Dezinforce's high-performance computing based on-demand engineering optimisation and saved its client valuable time and cost. "Dezinforce's optimisation technology enabled us to evolve an optimum design faster than other algorithms out there," says Dr Darren Woolf, Associate Director of Arup's Environmental Physics team.

"Dezinforce and its underpinning research pioneered the use of Cloud computing from the early 2000s and it is exciting to see how this has now become a widespread platform in the consumer and business sectors," says Simon.

**Funders:** EPSRC and Microsoft

For more information visit [www.southampton.ac.uk/engineering/inbrief](http://www.southampton.ac.uk/engineering/inbrief)

# Journal papers published in 2011 and 2012

Southampton's Engineering and the Environment academics have contributed to over 390 papers in leading scientific journals in 2011 and 2012; here are just a few. For more research papers, please view individual staff profiles online.



**P. J. Nowatzki, R. R. Koepsel, P. Stoodley, K. Min, A. Harper, H. Murata, J. Donfack, E. R. Hortelano, G. D. Ehrlich, A. J. Russell**  
*Salicylic acid-releasing polyurethane acrylate polymers as anti-biofilm urological catheter coatings*  
Acta Biomaterialia 2012 Vol. 8 pp. 1869-1880

**M. C. Draper, X. C. Niu, X. Soongwon, J. B. James, J. B. Edel**  
*Compartmentalization of electrophoretically separated analytes in a multiphase microfluidic platform*  
Analytical Chemistry 2012 Articles ASAP DOI: 10.1021/ac301141x

**O. Thuong, M. J. Griffin**  
*The vibration discomfort of standing people: Relative importance of fore-and-aft, lateral, and vertical vibration*  
Applied Ergonomics 2012 Vol. 43 pp. 902-908

**E. Wilson, E. Rustighi, B. R. Mace, P. L. Newland**  
*A comparison of models of the isometric force of locust skeletal muscle in response to pulse train inputs*  
Biomechanics and Modelling in Mechanobiology 2012 Vol. 11 pp. 519-532

**J. Claus, O. Coceal, T. G. Thomas, S. Branford, S. E. Blecher, I. P. Castro**  
*Wind direction effects on urban flow*  
Boundary Layer Meteorology 2012 Vol. 142 pp. 265-287

**J. Lambert, A. R. Chambers, I. Sinclair, S. M. Spearing**  
*3D damage characterisation and the role of voids in the fatigue of wind turbine blade materials*  
Composites Science and Technology 2012 Vol. 72 pp. 337-343

**J. J. Valletta, A. J. Chipperfield, G. F. Clough, C. D. Byrnes**  
*Metabolic regulation during constant moderate physical exertion in extreme conditions in Type 1 diabetes*  
Diabetic Medicine 2012 Vol. 29 pp. 822-826

**S. Box, B. Waterson**  
*An automated signalised junction controller that learns strategies from a human expert*  
Engineering Applications of Artificial Intelligence 2012 Vol. 25 pp. 107-118

**E. K. Dedes, D. A. Hudson, S. R. Turnock**  
*Assessing the potential of hybrid energy technology to reduce exhaust emissions from global shipping*  
Fluid Structure Interactions Energy Policy 2012 Vol. 40 pp. 204-218

**S. J. Elliott, J. Cheer, J-W. Choi, Member, IEEE, Y. Kim**  
*Robustness and regularization of personal audio systems*  
IEEE Transactions on Audio, Speech and Language Processing 2012 Vol. 20 pp. 2123-2133

**M. Sun, J. Lamb, S. Xu, Z. Shu**  
*Optimal time-weighted H2 model reduction for Markovian jump systems*  
International Journal of Control 2012 Vol. 85 pp. 613-628

**S. A. Papanicolopoulos, A. Zervos**  
*A method for creating a class of triangular C1 finite elements*  
International Journal for Numerical Methods in Engineering 2012 Vol. 89 pp. 1437-1450

**Y. Huang, M. J. Griffin**  
*The effects of sound level and vibration magnitude on the relative discomfort of noise and vibration*  
Journal of the Acoustical Society of America 2012 Vol. 131 pp. 4558-4569

**O. P. Dewhurst, N. Angarita-Jaimes, D. M. Simpson, R. Allen, P. L. Newland**  
*A system identification analysis of neural adaptation dynamics and nonlinear responses in the local reflex control of locust hind limbs*  
Journal of Computational Neuroscience 2012  
DOI 10.1007/s10827-012-0405-9

**C. L. Morfey, S. V. Sorokin, G. Gabard**  
*The effects of viscosity on sound radiation near solid surfaces*  
Journal of Fluid Mechanics 2012 Vol. 690 pp. 441-460

**A. Kourmatzis, J. S. Shrimpton**  
*Turbulent three-dimensional dielectric electrohydrodynamic convection between two plates*  
Journal of Fluid Mechanics 2012 Vol. 696 pp. 228-262



**H. G. Lewis, A. Saunders, G. Swinerd, R. J. Newland**

*Effect of thermospheric contraction on remediation of the near Earth space debris environment*

Journal of Geophysical Research 2011 Vol. 116 pp. A00H08

**A. S. Bahaj, L. E. Myers, R. I. Rawlinson-Smith, M. Thomson**

*The effect of boundary proximity upon the wake structure of horizontal axis marine current turbines*

Journal of Offshore Mechanics and Arctic Engineering 2012 Vol. 134 pp. 021104

**M. Albert, M. Franchin, T. Fischbacher, G. Meier, H. Fangohr**

*Domain wall motion in perpendicular anisotropy nanowires with edge roughness*

Journal of Physics: Condensed Matter 2012 Vol. 24 pp. 024219

**J. M. Renno, B. R. Mace**

*Vibration modelling of helical springs with non-uniform ends*

Journal of Sound and Vibration 2012 Vol. 331 pp. 2809-2823

**S. S. Bennett, D. A. Hudson, P. Temarel**

*A comparison of abnormal wave generation techniques for experimental modelling of abnormal wave-vessel interactions*

Ocean Engineering 2012 Vol. 51 pp. 34-48

**J. R. Chaplin, V. Heller, F. J. M. Farley, G. E. Hearn, R. C. T. Rainey**

*Laboratory testing the Anaconda*

Philosophical Transactions of the Royal Society A 2012 Vol. 370 pp. 403-424

**X. G. Qiao, N. Gao, M. J. Starink**

*A model of grain refinement and strengthening of Al alloys due to cold severe plastic deformation*

Philosophical Magazine 2012 Vol. 92 pp. 446-470

**H. Fangohr, D. Chernyshenko, M. Franchin, T. Fischbacher, G. Meier**

*Joule heating in nanowires*

Physical Review B 2011 Vol. 84 pp. 054437

**Q. Li, K. H. Luo, Y. L. He, Y. J. Gao, W. Q. Tao**

*Coupling lattice Boltzmann model for simulation of thermal flows on standard lattices*

Physical Review E 2012 Vol. 85 pp. 016710

**T. G. Leighton, P. R. White**

*Quantification of undersea gas leaks from carbon capture and storage facilities, from pipelines and from methane seeps, by their acoustic emissions*

Proceedings of the Royal Society A 2012 Vol. 468 pp. 485-510

**A. J. Redford, N. D. Sandham, T. G. Roberts**

*Numerical simulations of turbulent spots in supersonic boundary layers: Effects of Mach number and wall temperature*

Progress in Aerospace Sciences 2012 Vol. 52 pp. 67-79

**C. E. J. Dancer, M. Achintha, C. J. Salter, J. A. Fernie, R. I. Todd**

*Residual stress in a functionally graded silicon carbide material*

Scripta Materialia 2012 Vol. 67 pp. 281-284

**K. C. Zygalakis, T. Roose**

*A mathematical model for investigating the effect of cluster roots on plant nutrient uptake*

The European Physical Journal 2012 Vol. 204 pp. 103-118

**N. B. Hounsell, B. P. Shrestha, A. Wong**

*Data management and applications in a world-leading bus fleet*

Transportation Research Part C 2012 Vol. 22 pp. 76-87

**S. S. Rajahram, T. J. Harvey, J. C. Walker, S. C. Wang, R. J. K. Wood**

*Investigation of erosion-corrosion mechanisms of UNS S31603 using FIB and TEM*

Tribology International 2012 Vol. 46 pp. 161-173

[www.southampton.ac.uk/engineering](http://www.southampton.ac.uk/engineering)  
[engenv@southampton.ac.uk](mailto:engenv@southampton.ac.uk)  
+44 (0)23 8059 0000

