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Next Generation Undersea capabilities

Projection of Underwater Dominance

NG Visit
Breakout Session, NOC. 13:00-15:30 12th May 2016
Prof S.R.Turnock

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- Long history in marine and maritime research
- A wide-ranging collaborative community of scholars focussed on all aspects of the marine and maritime domain
- Academically strong students both at undergraduates, masters and doctoral level
- Engagement and impact with wide ranging external organisations from policy making through to leading scientific and industrial organisations
- In recent years has strengthened its ability to work collaboratively across disciplines

Southampton Marine and Maritime Institute

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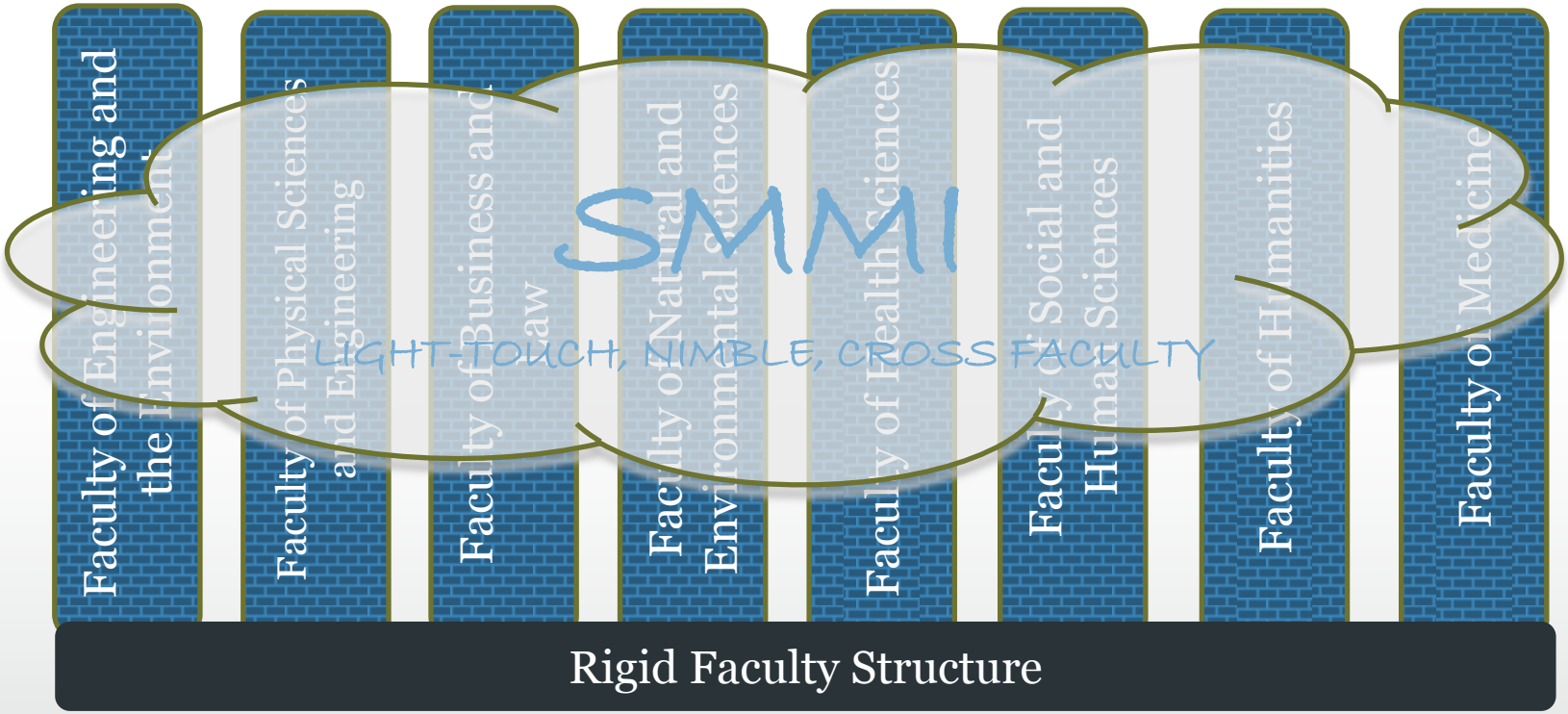
Evolved from bottom up through on-going collaborations between groups such as ship science, maritime law, oceanography, marine archaeology.
Strongly supported from its formation in 2012, with arrival of Lloyd's Register in Boldrewood Innovation Campus



350 academics and researchers
15-25% of research turnover from marine and maritime projects
≈20% REF Impact Case Studies

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Autonomous Systems USRG

Existing Southampton Platform Research

Project: ASTRA (EPSRC)
Application: Stratospheric science

Project: Triangle (INDSRY)
Application: Ship safety

Project: Earth Science Dynamics
Application: Glaciology

Project: BERISUAS (EU)
Application: Maritime safety

Project: AETHER (INDSRY)
Application: Security

Project: Autosub (NERC)
Application: Maritime exploration

Project: SUAVE (INDSRY)
Application: Safety of UAVs

Project: Aladdin (INDSRY)
Application: Emergency Response

Project: HIATUS
Application: Green Transportation

Project: AGRIUAV (EPSRC)
Application: Agriculture

Project: Delphin
Application: Maritime Search

Project: Orchid (EPSRC)
Application: Emergency Response

Project: HALO (INDSRY)
Application: Security

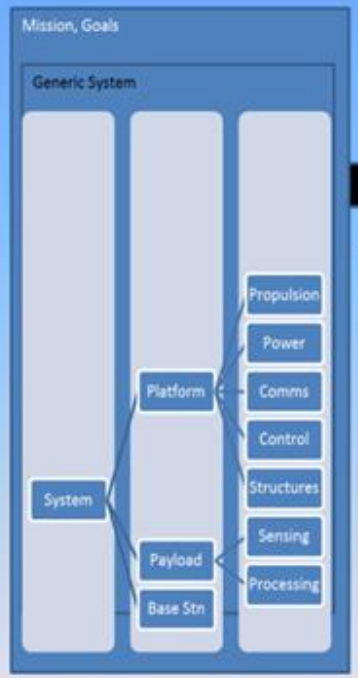
Project: 2Seas (EU)
Application: Maritime protection

Project: MARS Glider(NERC)
Application: Maritime

Project: MAVIS (EPSRC)
Application: Atmospheric science

Project: Autonomous ship
Application: Transportation

Fundamental Science/ Technology



Miniaturisation of electronics
Miniature Sensors
Efficient Structures
Embedded Systems
Design Optimisation
Flow Control
Tribology
Image Processing
Aeroelastic Tailoring
Efficient Propulsion
Data Modelling
Energy Storage
Composite Structures
Agent Based Control
Fuel Cells
Biogeochemical Sensors
Systems Reliability
Failure Prediction
Integrated 3D Printing
High b/width Comms
Smart Sensors
Advanced Propulsion
Turbulence Modelling
Energy Harvesting

Key
FEE
FPSE
FNES

GSNOCS-led NERC Doctoral Training Partnership

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Policy and Researcher Development

- **Lloyd's Register**
- Health and Safety Executive Labs
- Brattle
- DECC
- **DEFRA**
- Science Media Centre
- Business Innovation and Skills
- **NERC**
- **House of Commons, Scrutiny Unit**

Industrial and Case Partners

- **Aker Solutions**
- **ABP mer**
- **Anglo-American**
- **AWE**
- BG
- **BGS**
- BP
- **Cambridge C C**
- DSTL
- **Environ. Agency**
- Eon
- **Forest Research**
- **Fugro EMU Ltd**
- **GNS Science, NZ**
- **Kongsberg**
- **Lloyd's Register**
- **MESL**
- National Grid
- **National Inst'ments**
- **Natural England**
- Neftex
- **Ordnance S'vey**
- Sainsbury
- Shell
- **Stratex**
- **The Crown Est.**
- **Thermo Fisher**
- Tullow
- **Vitacress**

Internationalisation

AWI ANU Bergen BIOS Brown Montpellier Geomar GFZ-Potsdam Ifremer IPGP IMAS JASMTEC LDEO MARUM MIT MPIM Miami Michigan NIWA Oslo Otago Princeton Scripps SOEST Stockholm UCLA VUW WHOI Yale

SPITFIRE

Southampton Partnership for Innovative Training of Future Investigators Researching the Environment

University of Southampton

- S'pton Marine and Maritime Institute
- Institute for Life Sciences
- Electronic Engineering
- Electronics and Computer Science
- Engineering and the Environment
- Mathematics and Statistics
- Centre for Biological Sciences
- Medicine
- Geography and Environment

Hosting and Training Partners

Graduate School of the National Oceanography Centre Southampton

Ocean and Earth Science, University of Southampton

National Oceanography Centre

BAS CEH MBA PML
Cefas HR Wallingford NHM SAHFOS

Doctoral Training Centres

Active DTCs

- Transport & Environ EPSRC
- Web Science EPSRC
- Energy Env. Resil. ESRC
- Complex Systems EPSRC
- Food Security BBSRC

Proposed EPSRC CDTs

- Autonomous Vehicle Systems
- Energy Storage & Utilisation
- HP Comp Simulation
- Sustain Infrastruct Systems
- Maritime Fluid Struct Interactions

University Institutes and Multidisciplinary Strategic Research Groups

Southampton Marine and Maritime Institute, Institute for Life Sciences, Southampton Statistical Sciences Research Institute (S3RI), Ageing & Lifelong Health, Complexity, Computationally Intensive Imaging, Digital Economy, Energy, Nanoscience, Population Health , Sustainability Science.

Understanding Maritime Futures

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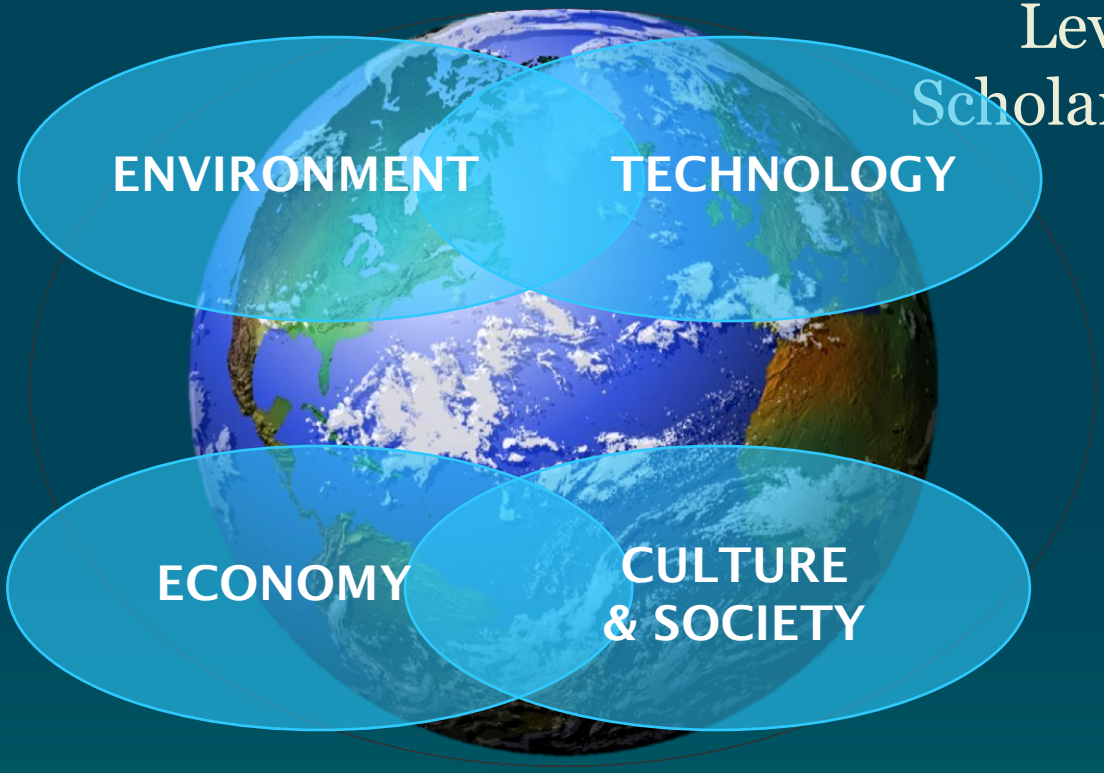
Leverhulme Trust Doctoral Scholarship Programme – 2015-18



The Leverhulme Trust

Prof. Damon Teagle – SMMI, Director of LTDS
Dr. Stephanie Jones – English, Hums
Dr. Fraser Sturt – Archaeology, Hums
Prof. Penny Temarel – FSI, FEE
Prof. Mikis Tsimplis – Inst. Maritime Law
Prof. Philip Wilson – FSI, FEE

NEXUSS

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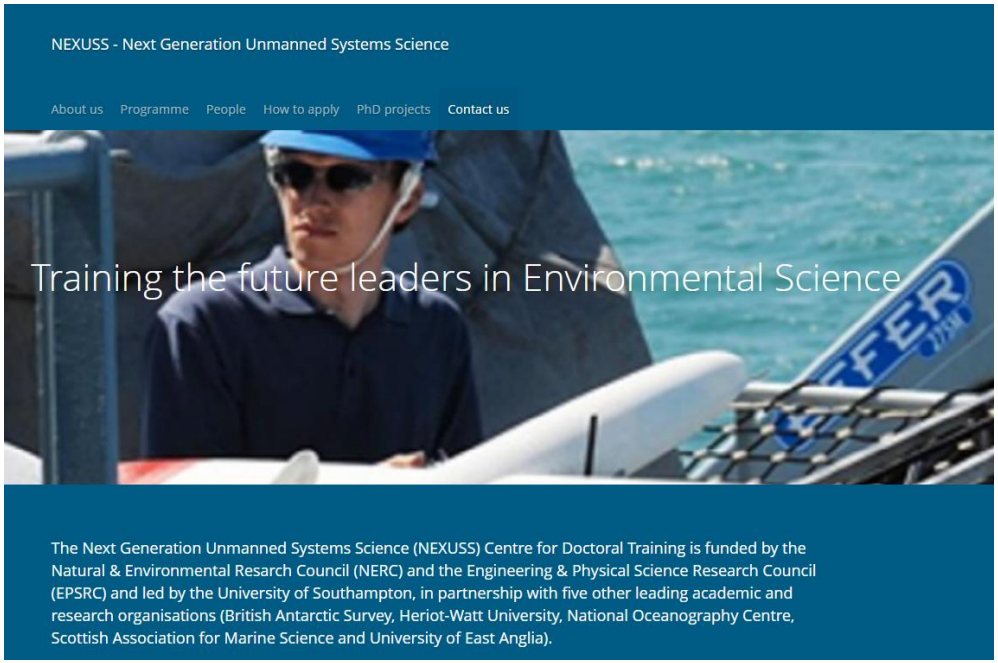

- Annual multi-platform “Grand-challenge”

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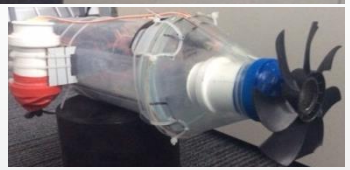
SESS6072 Maritime Robotics

- One of only a very few Masters level modules world wide dedicated to equipping the next generation of engineers with the skills to design, build and operate underwater autonomous systems







£100
8 weeks

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Marine Autonomy: Low cost(disposable?) AUVs NG study

- Professor's Stephen Turnock, Damon Teagle, Philip Wilson, Jim Scanlan, Hywel Morgan, Mikis Tsimplis, Victor Humphrey, Neil White, Nick Jennings, Kirk Martinez
- Drs Nick Townsend, Richard Wills, Andras Sobester, Mario Brito, Shoufeng Yang. + others

Electronics and Computer Science, Maritime Law, Management, Maritime Robotics, Ocean and Earth Science, Computational Engineering and Design, IT Innovation, …

Consider the technology readiness of low cost, disruptive technology maritime robotic systems

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Disruptive Technologies…

- Availability of consumer electronics and sensors
- 3D printing and related technologies
- Open source software
- Energy storage and environmental harvesting
- Cyber systems and Big Data

Structronics

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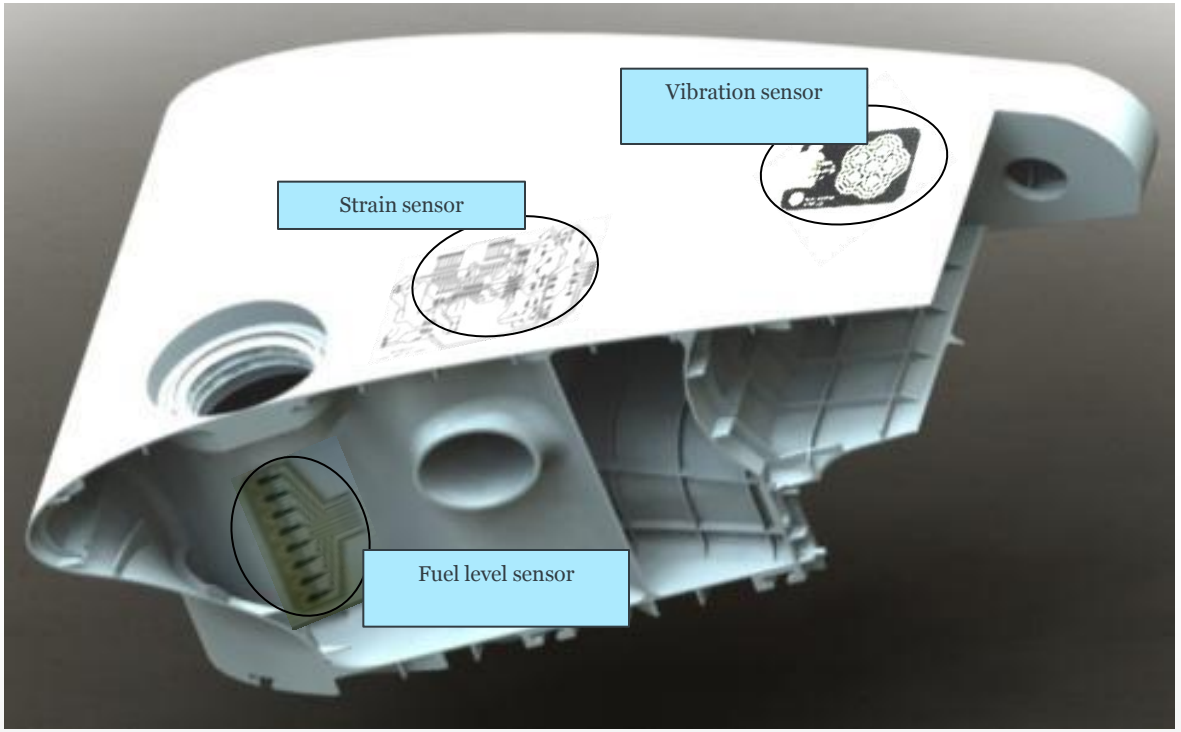
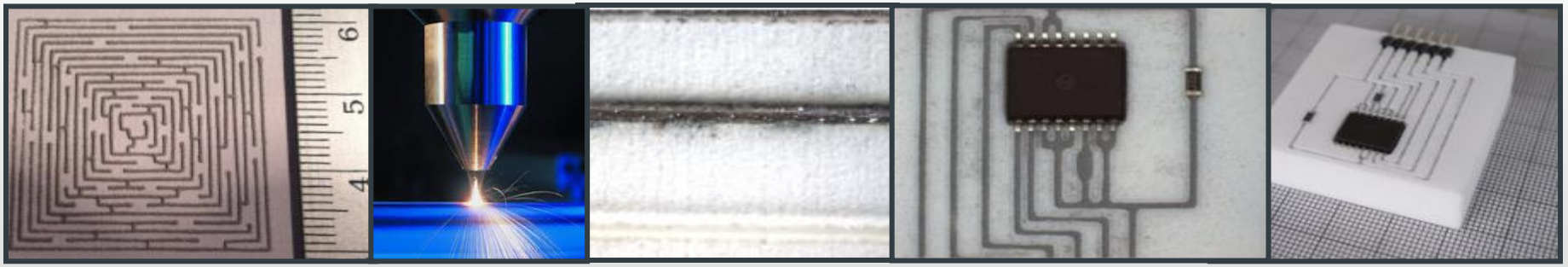
- Print “systems” not just parts
- Multi-material printing
- Structures that contain wiring





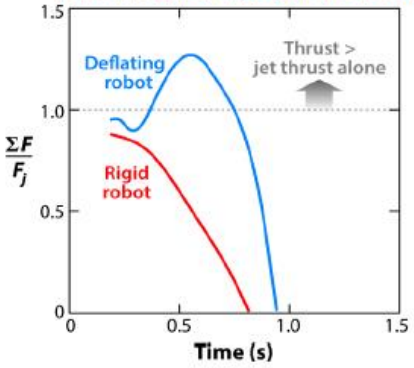
Soft Robotics design concept

SOFT AQUATIC ROBOTS

New disruptive design concepts are needed for the automation of tasks currently precluded to commercial underwater robots. Soft robotics enables innovative vehicles which exploit unsteady hydrodynamic forces to increase their maneuverability and efficiency. Structural compliance inherently provides these robots with the capability to operate in close proximity with submerged structures and perform agile navigation in highly cluttered environments.

Soft-bodied, pulsed-jet propelled vehicles for enhanced underwater **maneuverability** and **efficiency**

Non-dimensional propulsive force



SHAPE-CHANGE THRUST ENHANCEMENT

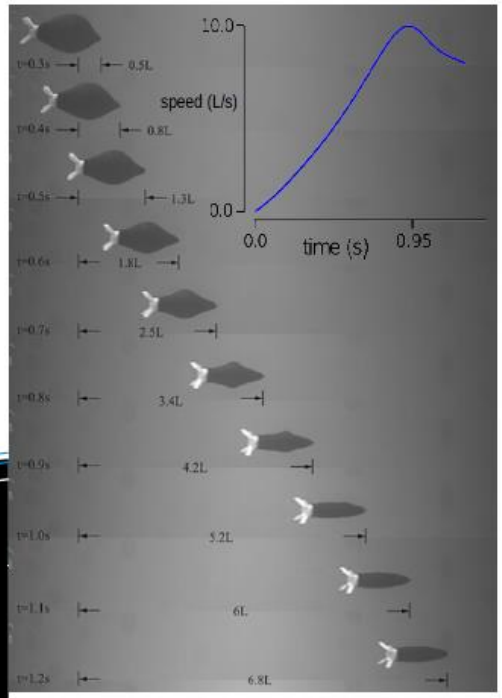
This kind of vehicles propel themselves by performing a routine of inflation and deflation during which they ingest and expel water. This produces a sequence of jets which thrust the vehicles forward.

Shape-variation effects can increase thrust as much as 30%, providing up to 130% acceleration and 200% speed compared to an equivalent fixed-shape vehicle (left hand side and bottom figure).

Optimal modulation of the flow features of the issuing jet provides an increase in average impulse as high as 42% compared to a continuous jet (see *Krueger and Gahrib, Physics of Fluid, 2003)*.

FIELDS OF APPLICATION

As opposed to standard ROVs and AUVs, the soft bodied robot we are developing can exploit its structural compliance and enhanced maneuverability to deal with otherwise unfeasible tasks such as performing inspection and sampling missions in cluttered and highly unstructured submerged environments. This will make this kind of vehicles suitable for marine operations such as those entailed with offshore engineering, mantainance of marine renewables energy harvesting plants, rescue operations, underwater mines countermeasures, port security and environmental monitoring.



This project is sponsored by the Lloyd's Register Foundation and the University of Southampton

for furhter information visit: http://www.southampton.ac.uk/engineering/about/staff/gdw1d12.page

Energy Scavenging…

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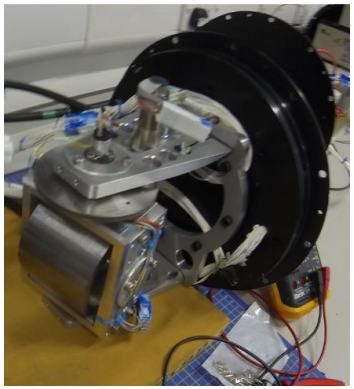
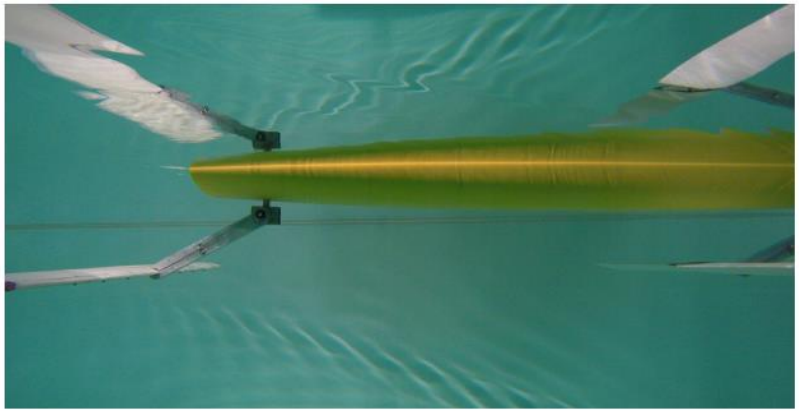
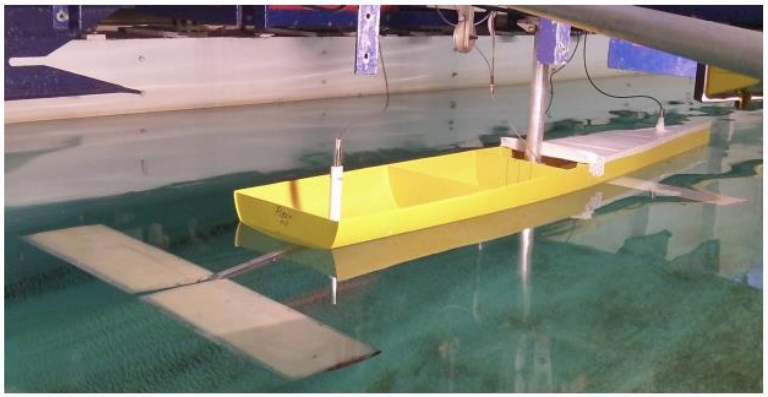
- Gyroscopic systems for actuator less orientation, energy storage and capture from wave motions







From transport, energy and fishing to high growth marine sectors of seabed mining, aquaculture and offshore energy, emerging information ecosystems will transform utilisation and sustainability of ocean resources.

In EXPOSURES, we demonstrate how on-demand autonomous underwater vehicles (AUVs) can drive intelligent data analytics to rapidly assess environmental processes and impacts in marine waterways. The result will be create new marine information ecosystem that exploits underwater IoT infrastructures such as those offered by the European SUNRISE facility.

Low cost AUVs, information sharing and fusion the key to rapid insight

Oceans are challenging environments to construct and operate industrial assets. Foundations of offshore structures are vulnerable to localised scour whilst busy navigation channels are subject to ongoing sediment transport. Natural hazards are amplified by extreme weather events and the impact of climate change. Maintaining knowledge about the complex interplay between human activity and micro/macro ecological processes is essential for optimisation of periodic maintenance, response to crisis or extreme weather events, assessment of environment impact and license compliance.

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Discussion - introductions

Challenges

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- How to create a recognised underwater picture?
- Sensors, fusion, communication (below and above the water)
- Fusion, Visualisation Vehicles (Stealth / persistence)
- Platforms (from small to extra-large) / Multirole
- Processing / Navigation
- Power / energy / Propulsion
- Swarming / Artificial Intelligence
- Ease of deployment and recovery if required

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Challenge – map, find, act

- Oceans – vast, complex, ever changing
- Physical challenges – pressure, salt, temperature
- Map changing space – how quickly, how accurately,
- Finding static or dynamic objects or features
- Actions, once found, what happens next and how quickly?

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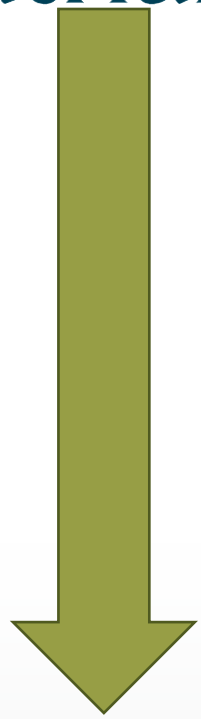
Scale of Vehicle

Mini <10kg

Small 10kg-100kg

Medium 100-1000kg

Large 1000kg+



Mass, Cost, Range, Function, Development Time

- What is good enough for a particular task?
- Non-heterogeneous fleet of vehicles and systems that collaborate on adaptable tasks – how to communicate given limited data rate and range?

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Groups activity

Maritime Robotics Laboratory

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- 20+ years of activity
- Developed its own range of underwater and surface autonomous vessels
- 20 staff and phd students involved including close collaboration with Electronic & Computer Science, Ocean & Earth Sciences and National Oceanography Ce

Technology expertise

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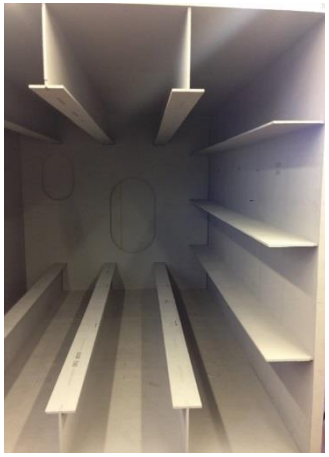
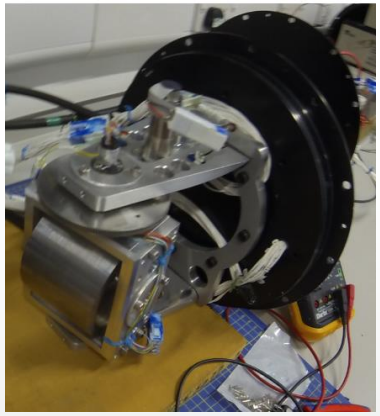
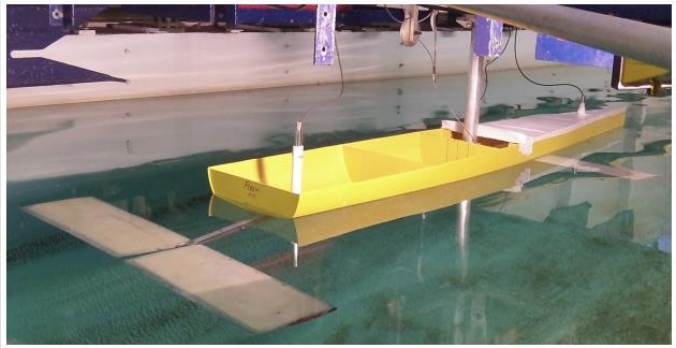
- Vehicle and systems design
- Energy management and harvesting
- Software design
- Hardware integration
- Control engineering
- Decision making
- Inspection tasks







EUH2020 Bridges project

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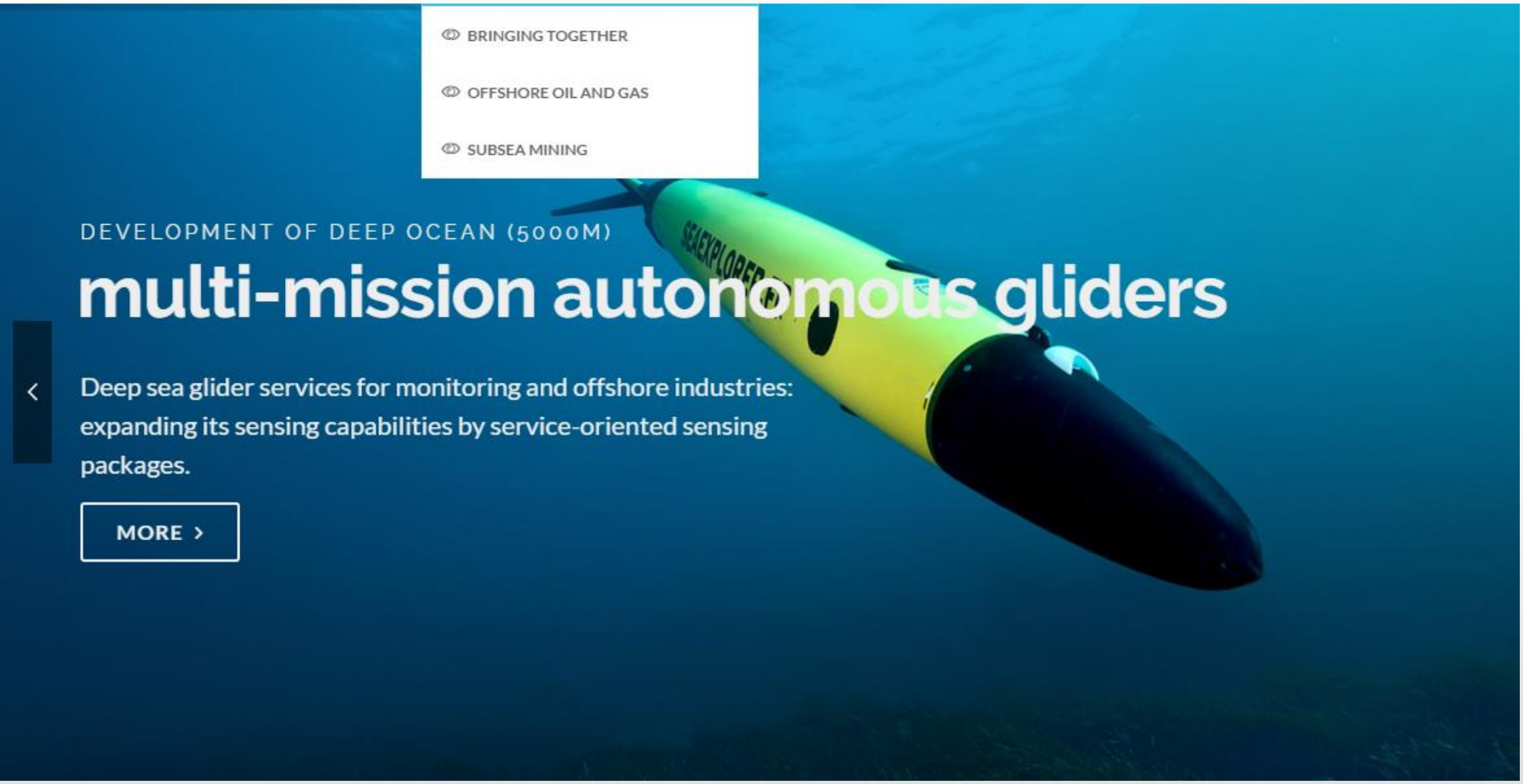
HOME PROJECT RESEARCH AND INDUSTRY GLIDER DEVELOPMENT ENVIRONMENTAL SERVICES IN PROGRESS CONTACT

BRINGING TOGETHER

OFFSHORE OIL AND GAS

SUBSEA MINING



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Transatlantic Autonomous Surface Vessel

FORTITUDE

Aim to design an Autonomous Surface Vessel capable of crossing the Atlantic Ocean.

Group Design Project 2014/15 and 2015/2016

Final Hull Design

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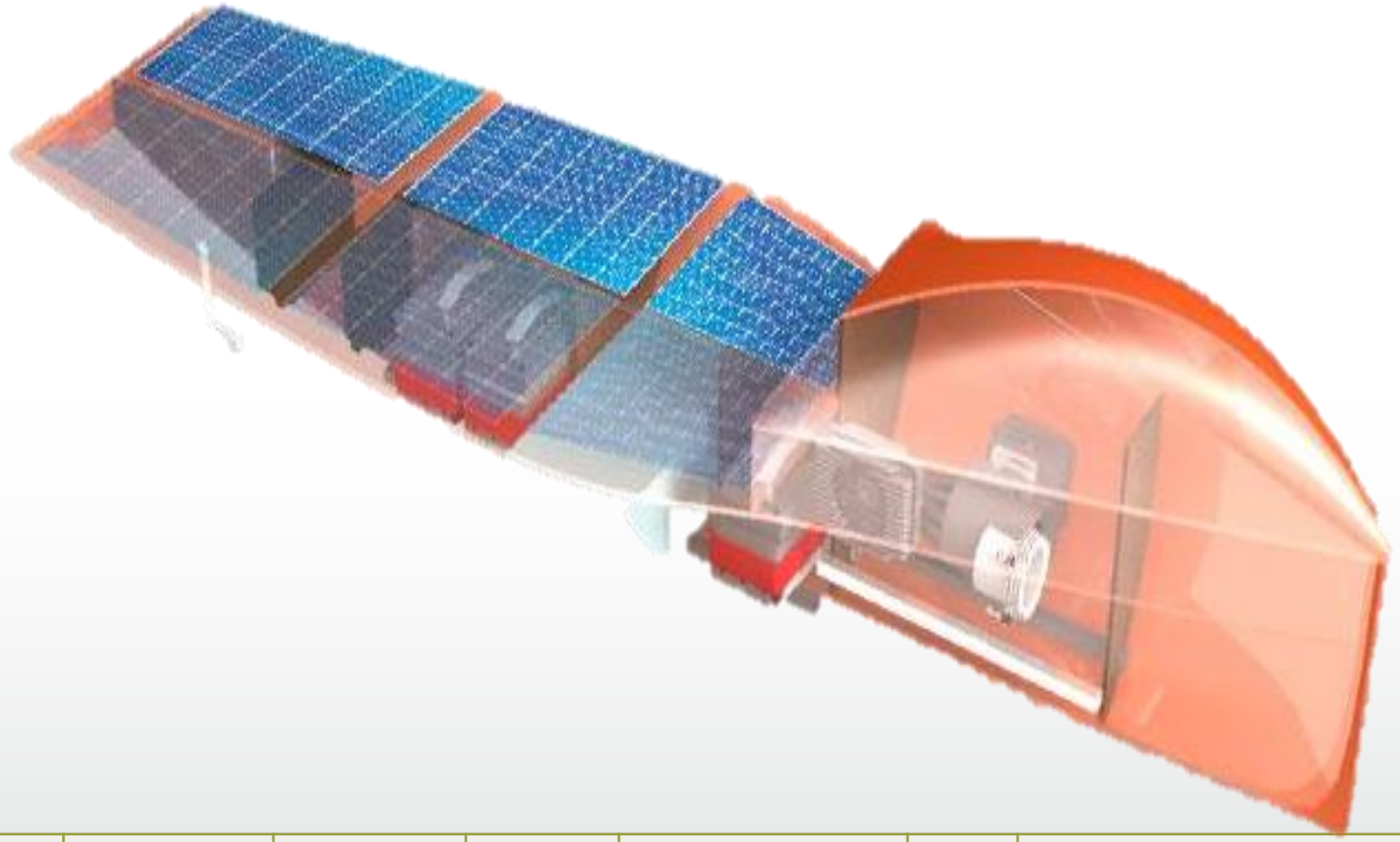

Length, m	Max Beam, m	Draught, m	Fn	Displacement, kg	Cb	Total Surface Area, m^2	Solar panel area, m^2
3m	0.95m	0.21m	0.28	155	0.4	5.54	1.5

Phase 1 complete May 2015

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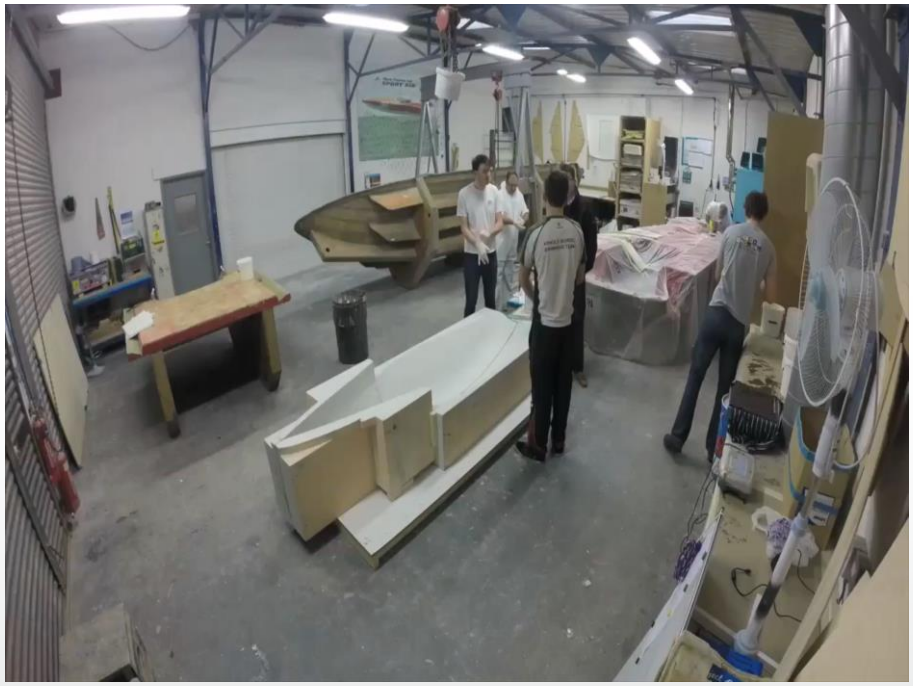

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Systems and Control Research

From Algorithms to Experimental Benchmarking to Applications

27 October 2015

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Our Academic Staff

- Bing Chu
- Chris Freeman (EEE research group)
- Mark French
- Paul Lewin (EEE research group)
- Paolo Rapisarda
- Eric Rogers

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Our Research Interests: Theory

- Nonlinear adaptive and robust control
- Iterative learning control/Repetitive control
- Multidimensional systems
- Switched systems
- Model predictive control
- Behavioural systems theory
- Networked systems
- Data-driven control

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Our Research Interests: Applications

- Experimental benchmarking on in house testbeds
- Next generation healthcare
- Autonomous Underwater Vehicles (AUVs)
- Unmanned Aerial Vehicles (UAVs)
- Atomic force microscopes
- Electrical machines and drives
- Energy and sustainability

Iterative Learning Control

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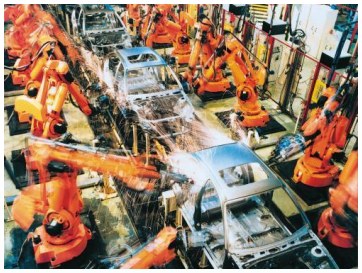
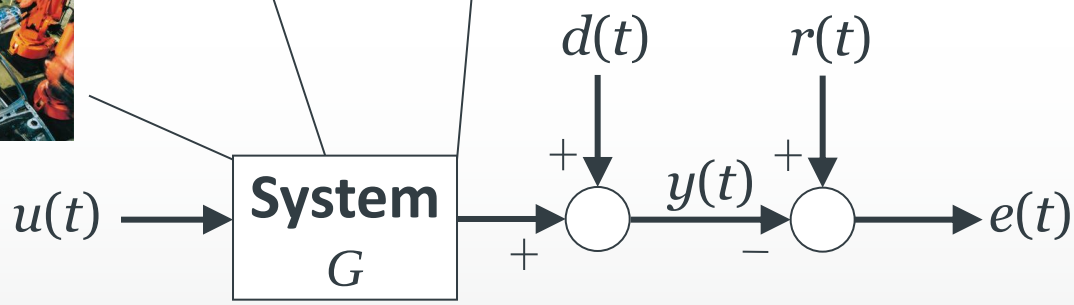


Systems: working **repetitively**

Aim: **high tracking performance**



Main Idea of ILC: learn from the past, proceed, get better

Theoretical development and practical applications of ILC

AUVs and UAVs

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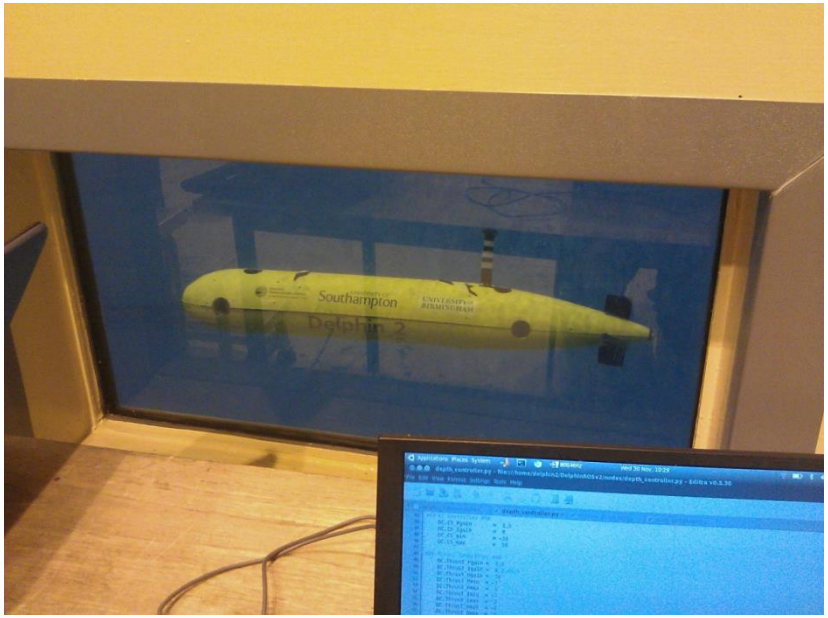

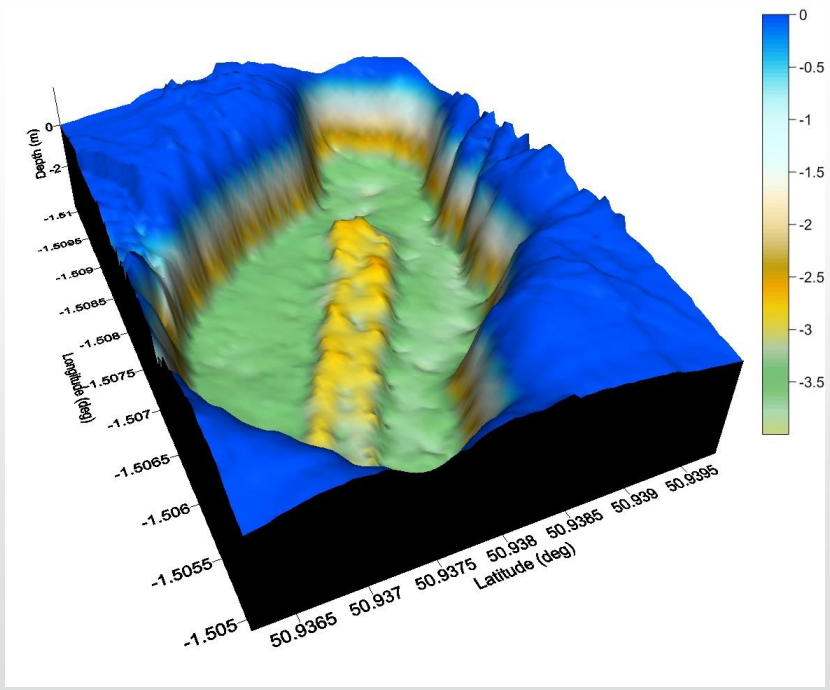

Robotics

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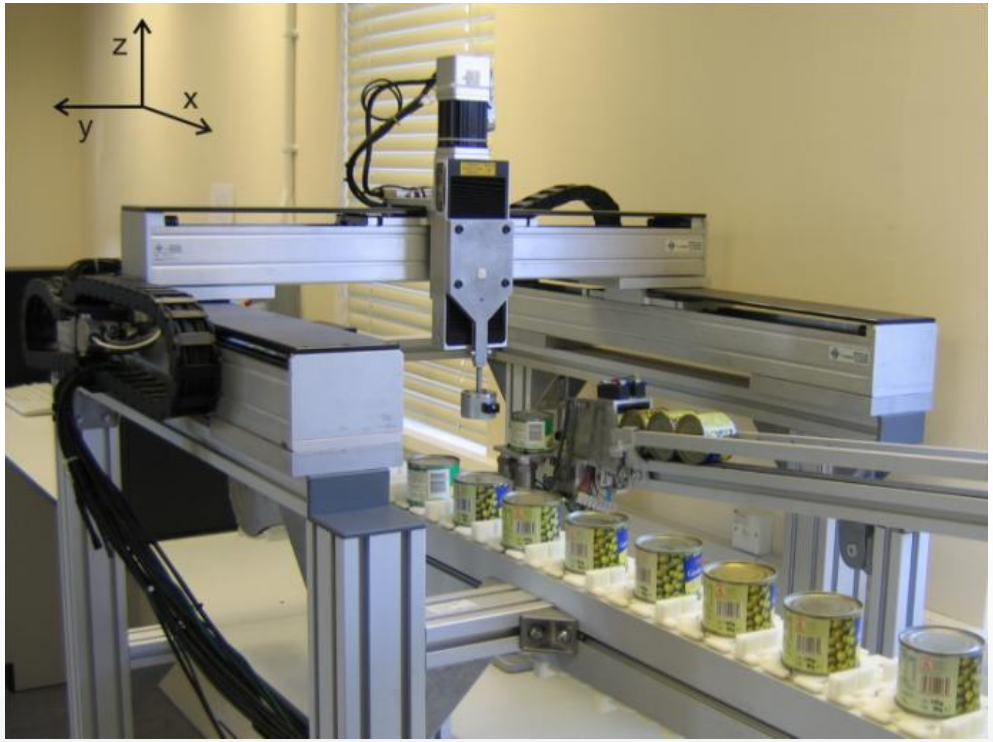

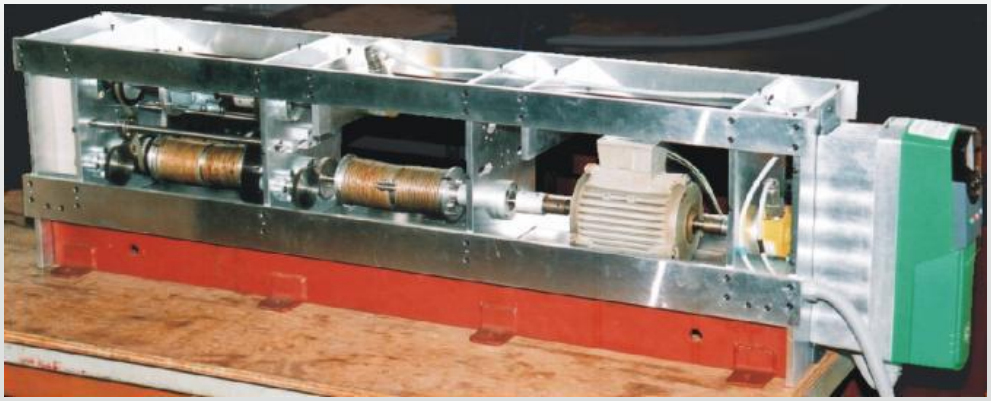

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Big Data Research for Critical Decision-Support

Dr Z. A. Sabeur *et al*

University of Southampton IT Innovation Centre, ECS

zas@it-innovation.soton.ac.uk

BIG Data Research(1)

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le facto Big Data Processing Technologies (unstructured, semi-structured and structured data, NoSQL, Hadoop, Storm …)

✓Heterogeneous Data Sources low level aggregation

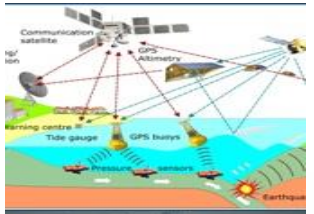
- ✓ open/ proprietary data, harmonisation/alignments, semantic conflicts removal, a-synchronicities, multi-modalities, enrichment
- ✓ OGC Sensor Web Enablement standards 2.0

✓Observation Data Mining and distributed Machine learning

✓Strategic Data Fusion Framework (JDL level 0, 1, 2, 3 with context ontology modelling and easoning)

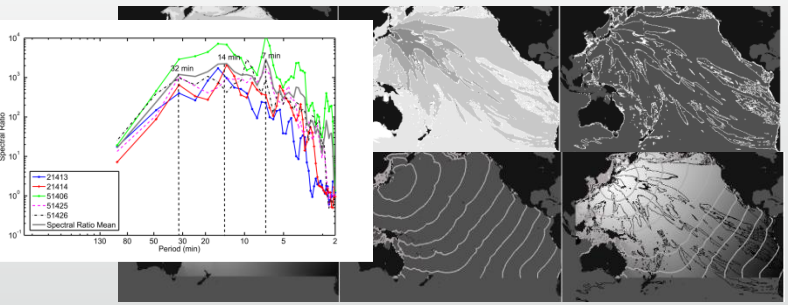
TRIDEC

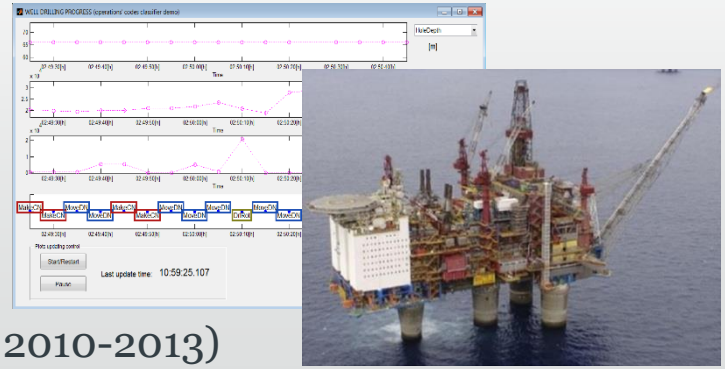
Critical Operations: *1) Tsunami Warning systems, intelligent detection of tsunamigenic ignals; 2) Offshore industrial operations with advanced situation awareness, reporting and arly detection of critical events*



. A.Sabeur et al (2013). Modeling and detection of hydrodynamic trends for advancing early-tsunami warnings. ISOPE2013, 23rd nternational Ocean and Polar Engineering Conference, Anchorage, Alaska June 30th- July 5th 2013.

. Zlatev, G. Veres and Z. A. Sabeur (2013). Agile Data Fusion and Knowledge Base Architecture for Critical Decision Support. International ournal of Decision Support Systems Technology. (IJDSST), 5, (2), 1-20.



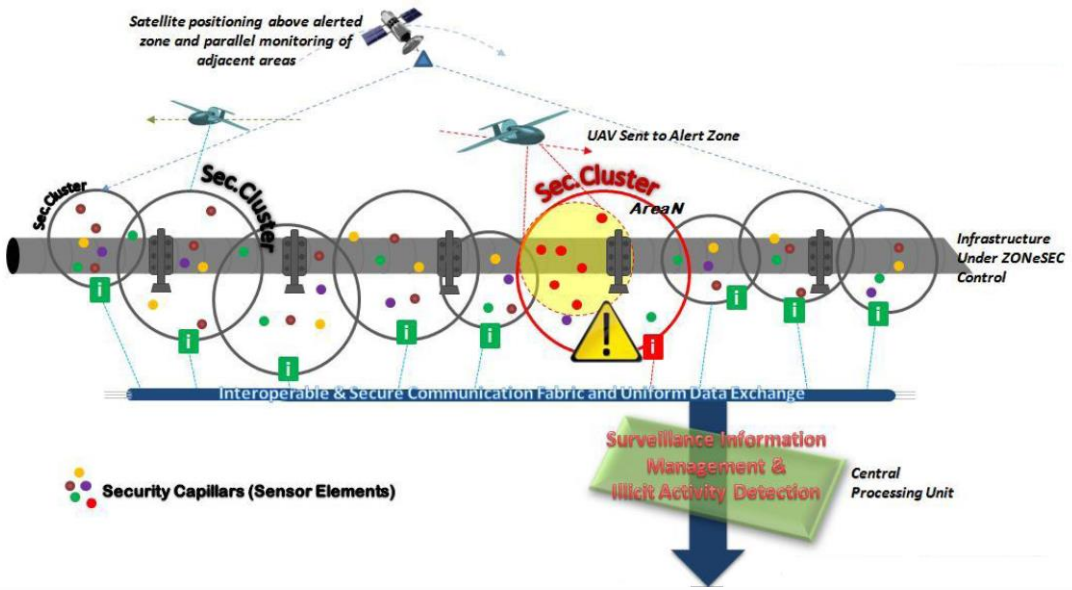


(For more details see www.tridec-eu.com; 2010-2013)

BIG Data Research(2)

24/7 surveillance system for the security of Wide Zones of high economic importance

- ✓ Intelligent fusion of in situ and remote sensing data for the critical surveillance of large spatial areas of transnational gas pipelines in European waters (and inland zones)
- ✓ Deployment of secure and interoperable observation data and information management services using standards
- ✓ Deployment of deep learning classifiers for the detection of unusual operation events which may occur at the Wide Zone
- ✓ Semantically enriched domain knowledge representations are stored in a KB for supporting high level data fusion and reasoning with reduced uncertainties and false alerts



The deployed services for BIG Data intelligent processing are part of our so-called SDAIM Knowledge Base (KB) in our ZoneSEC project: **Surveillance, Detection and Alerts Information Management (SDAIM) Knowledge Base.**

(For more details see www.zonesec.eu ; 2014-2018)

Thank you.

For further details, please contact:

University of Southampton IT Innovation Centre

Dr Z A Sabeur, Science Director

zas@it-innovation.soton.ac.uk