Automation of Non-Destructive Testing

Professor Tariq Sattar
TWI Chair and Director of LSBIC
Granta Park, Great Abington, Cambridge CB21 6AL
School of Engineering, LSBU

The London South Bank Innovation Centre for Automation of NDT

Based in Granta Park, Great Abington, Cambridge CB2 6AL

London South Bank Innovation Centre

- TWI joined forces with London South Bank university to create LSBIC
- Start 1st July 2015

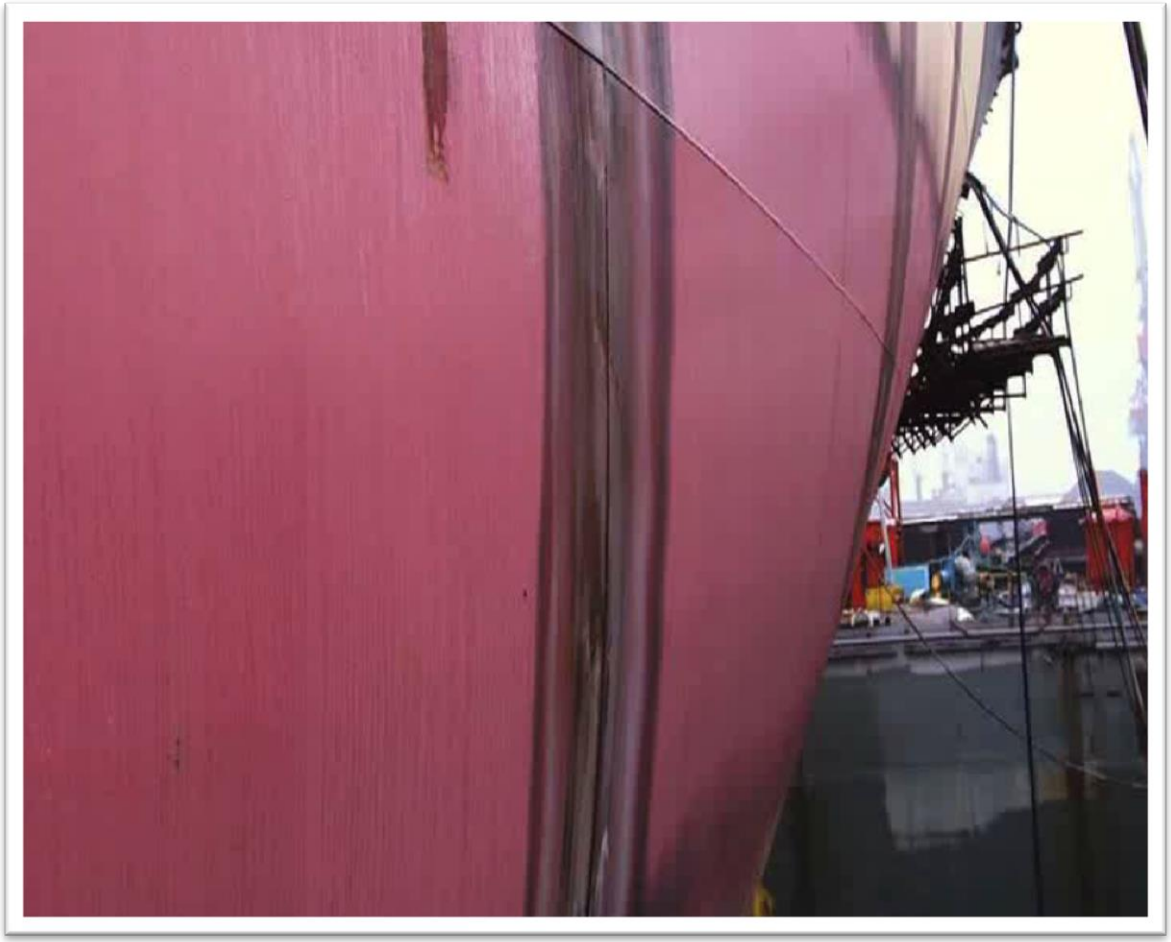
Example where Robotic NDT would save time and cost and improve Health & Safety

Internal inspection of Gas Boiler in Power Plant

90m tall boiler, tapered at the bottom

Robust wall climbing robots with large payload capability use permanent magnet adhesion and fast wheeled motion.

Wireless robot shown here performs phased array ultrasound NDT of vertical & horizontal welds on ship hulls.



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Robotic Non Destructive Testing (NDT)

R&D of Mobile robots to provide access and perform NDT of

- very large structures
- test sites located in dangerous and hazardous environments

The aim is to

- reduce inspection costs, outage times during planned outages
- Provide in-service inspection where possible to eliminate outages

Background IP: Wall Climbing and underwater robots for NDT

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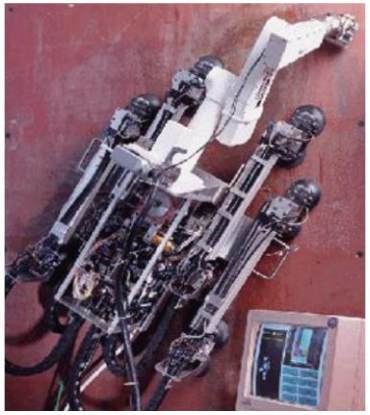
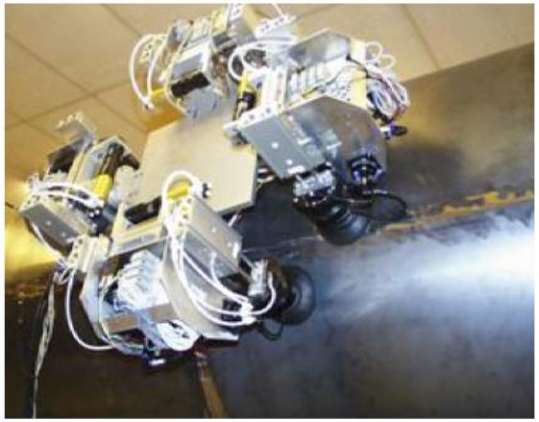
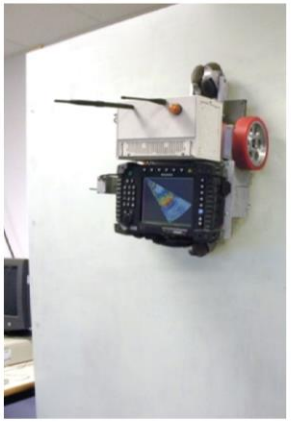



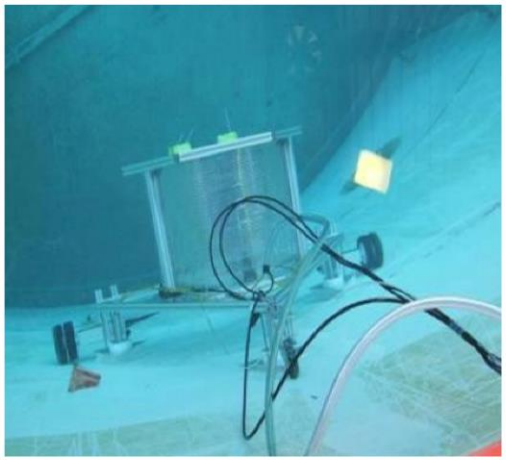

Some wall climbing robots for NDT developed by LSBIC that use pneumatic vacuum adhesion

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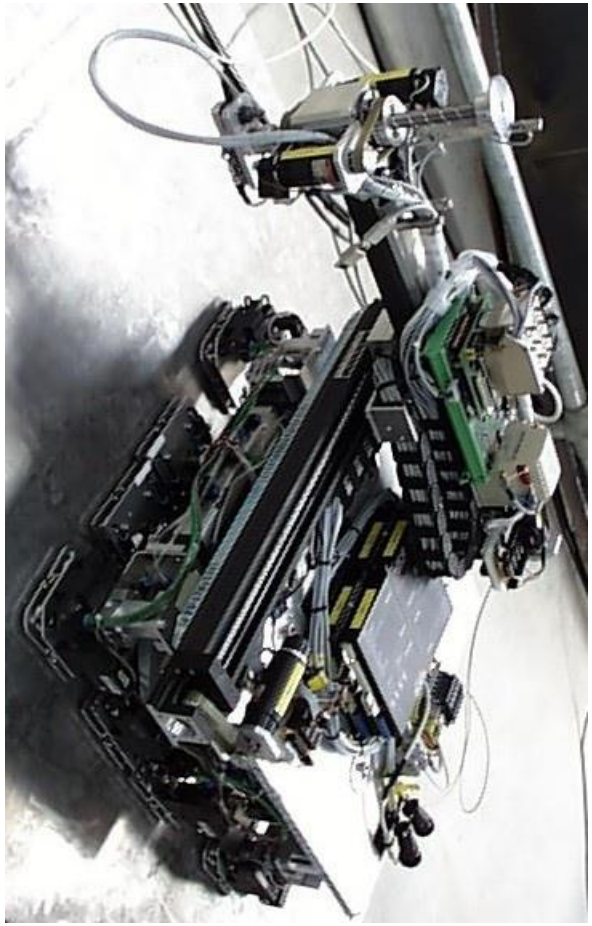

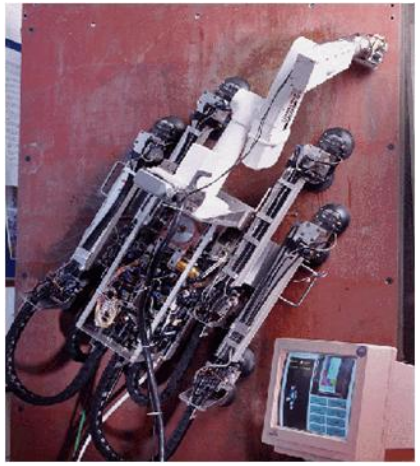

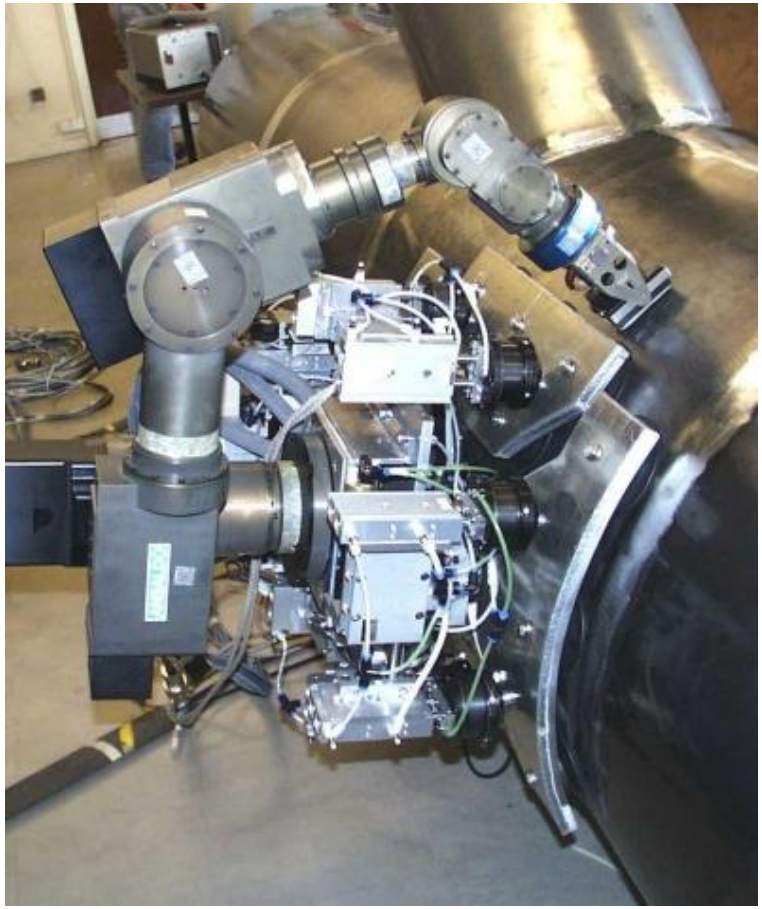

Some previous wall climbing robots for NDT developed by LSBIC

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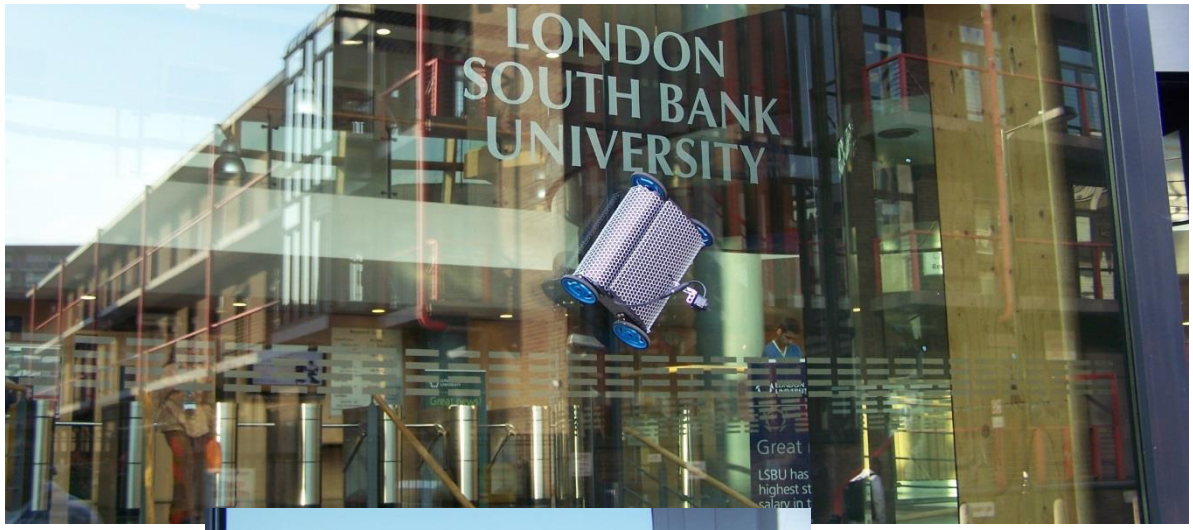
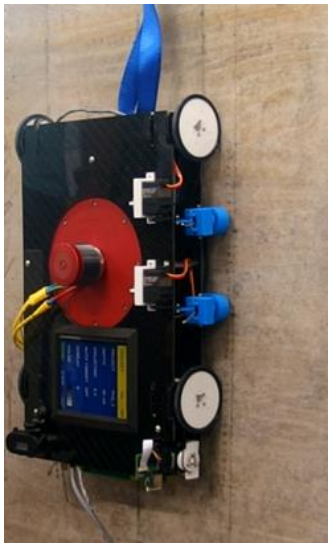
Adhesion using Vortex (partial vacuum) to climb on all types of surfaces e.g. glass, brick, concrete, steel, composites





Some previous underwater robots for NDT developed by LSBIC

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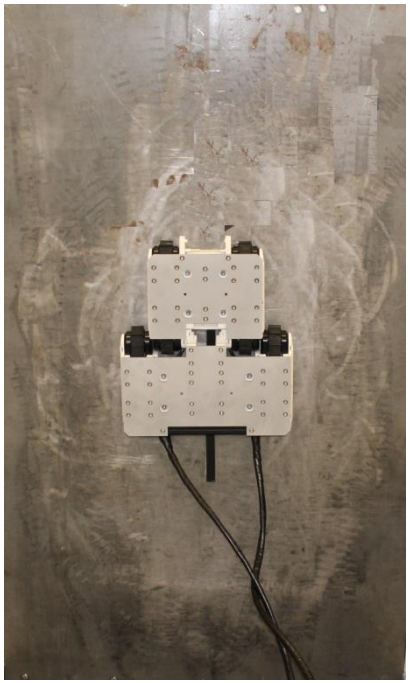

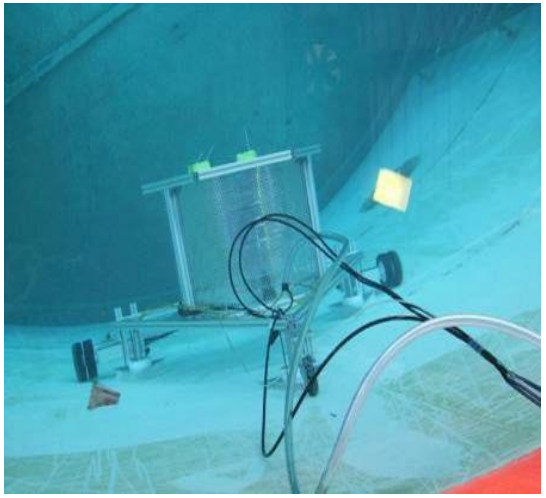

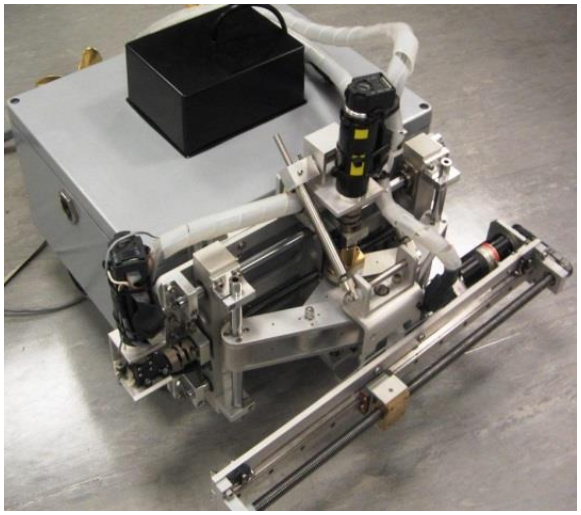

Wall climbing robots for NDT developed by LSBIC that use permanent magnets for adhesion

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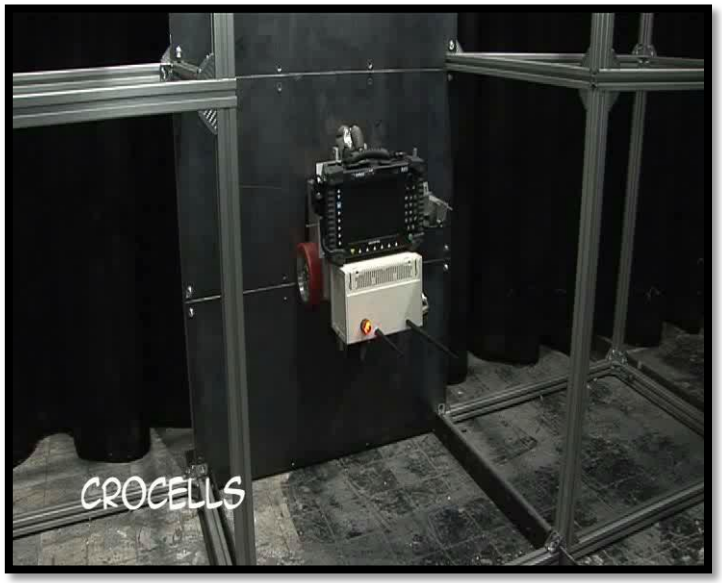
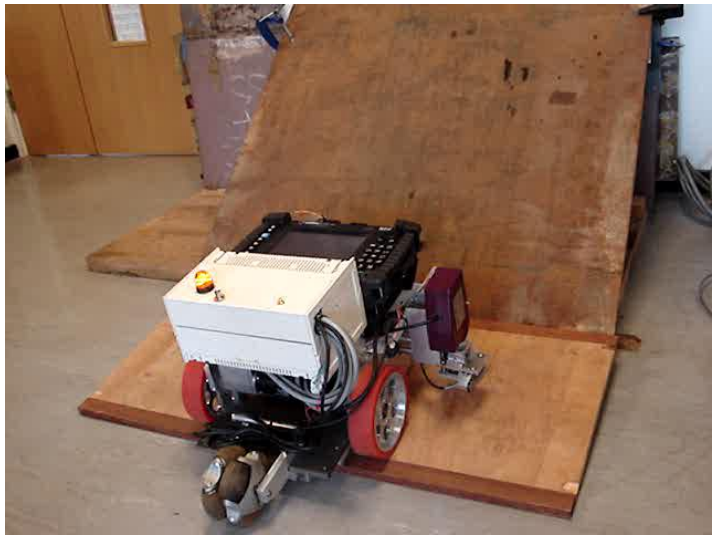
LHS: Advanced wireless wall climbing robot for the inspection of welds on ship hulls. RHS: Magnetic Adhesion Concrete Climber





FPSO swimming and floor inspection wheeled robot to inspect tank floors and welds on strengthening plates

Successful Proposals. 24 Month Projects

Winspector H2020 FTI 1/09/2015	Grant 608,522 EUR	Kick-off 1 March 2013
TankRob H2020 FTI 1/09/2015	Grant 668,218 EUR	Kick-off 1 May 2016
	Grant 670,291 EUR	Kick-off 1 Dec 2016

Project Status

TankRob, H2020 FTI Pilot-2015

In-service intrusive Non-Destructive Testing of above ground and underground petrochemical storage tank floors and walls to detect corrosion

Project value: EUR 2,409,117, LSBIC: EUR 608,522

Project start: 01 May 2016

Pre-kick off meeting In TWI on 26 April 2016

Kick-off meetings in TWI between 17-23 May 2016.

ROBTANK: Mobile in-service robot enters through manholes on the floating or fixed roof of a storage tank to inspect its floor and walls

WInspector, Horizon 2020 FTI Pilot-2015

Advanced shearography kit and robotic deployment platform for on-site inspection of blades

Project value: EUR 2,317,939, LSBIC: EUR 608,522

1. Grant and Consortium Agreements signed

2. Project Kick-off meeting on 1-2 March 2016, WRS Marine Group, Strijen, Netherlands. Project Officer present at the meeting.

3. Requirements being prepared by GameSa Ltd.

4. Two major risks identified

- Platform access performance not as advertised
- 3D vibrations in both blade and platform render shearography useless where relative images should not vary by more than ±1mm
- LSBIC is proposing a solution to stabilize the shearography platform

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Vestas

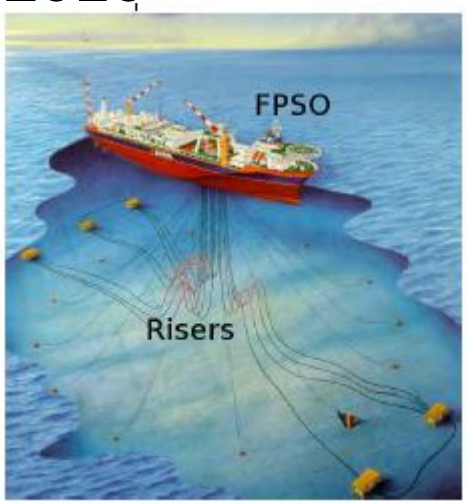
Project Status

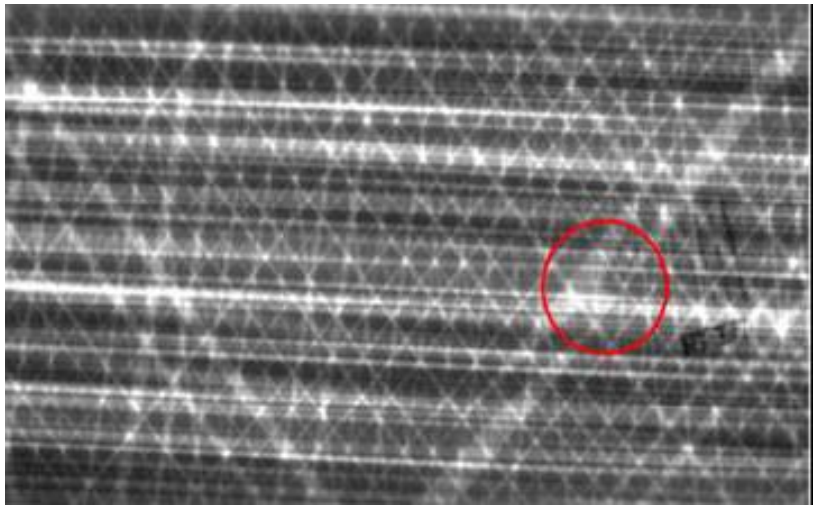
RiserSure, H2020 FTI Pilot-2016

Rapid Integrity Assessment of Flexible Risers for Offshore Oil and Gas Installations

Project value: EUR 2565674,00 , LSBIC: EUR 670291,25

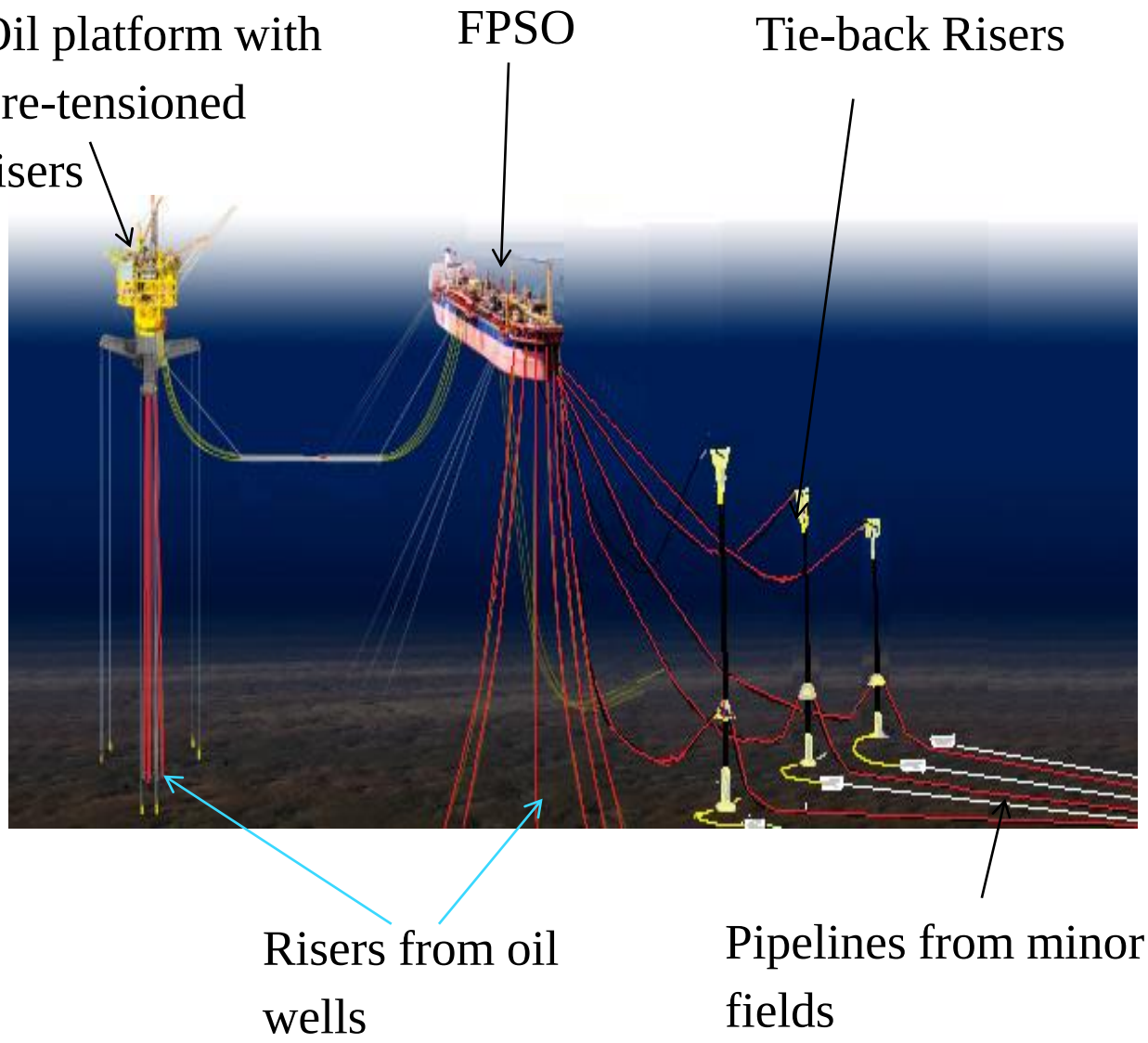
Expected Project start: 01 September 2016





TankRob, H2020 FTI Pilot-2015

In-service intrusive Non-Destructive Testing of above ground and underground petrochemical storage tank floors and walls to detect corrosion



The floating platform, riser, flow-line and tie-back environment

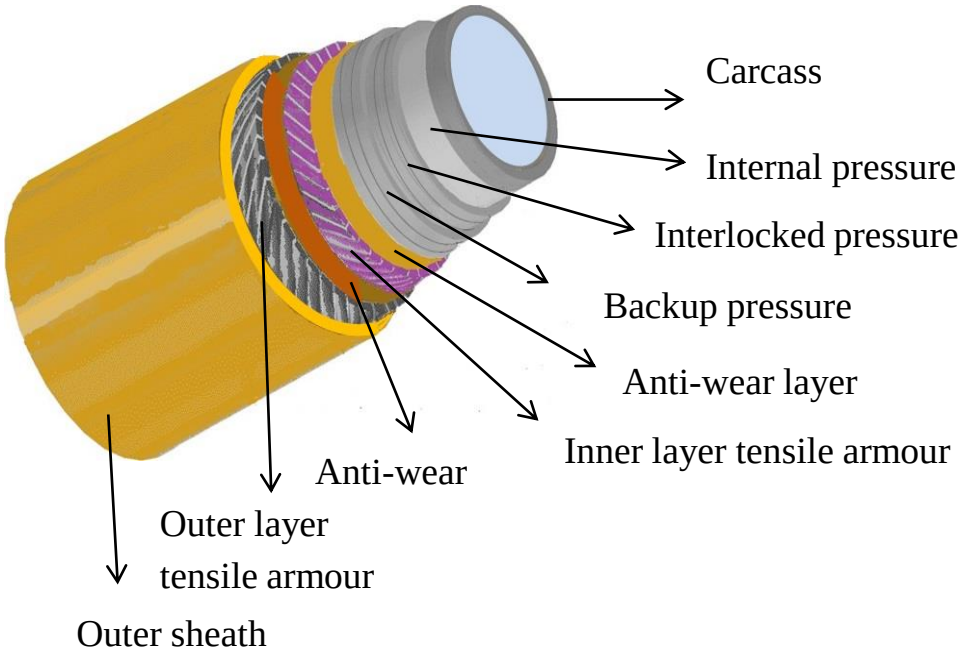
Horizon 2020-FTI Pilot-2015

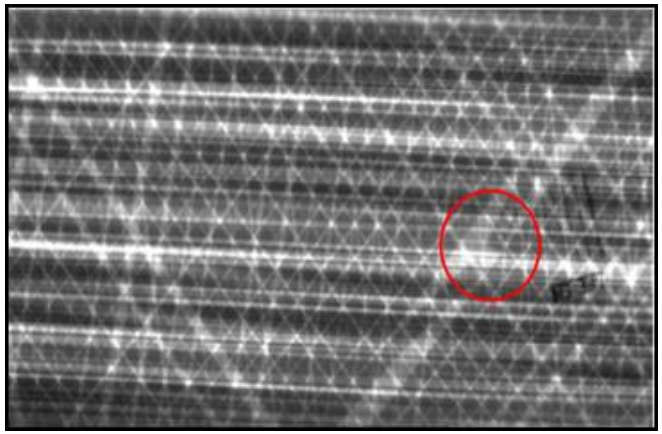
RiserSure

Rapid Integrity Assessment of Flexible Risers for Offshore Oil and Gas Installations

Project value: EUR 2,957,699

LSBIC: EUR 896,672

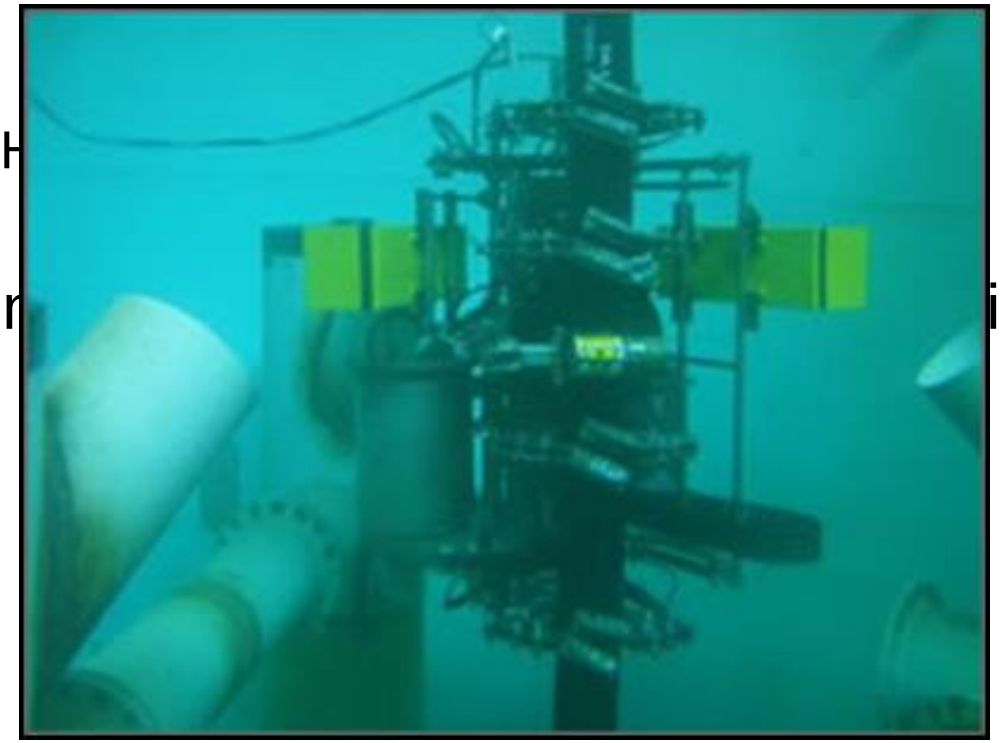


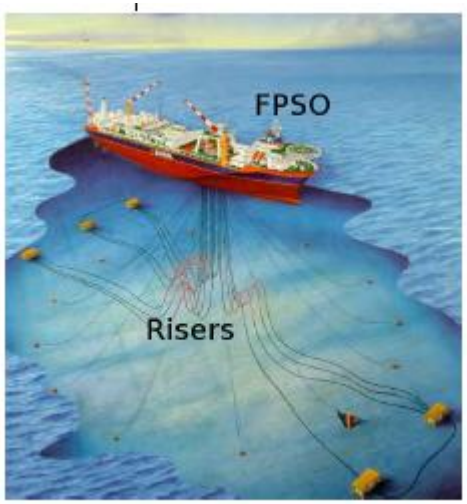


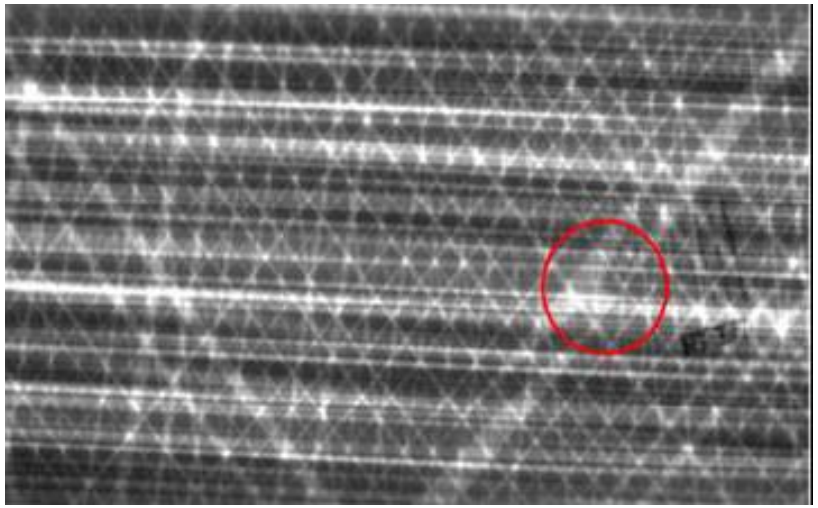
Project Status

RiserSure, H

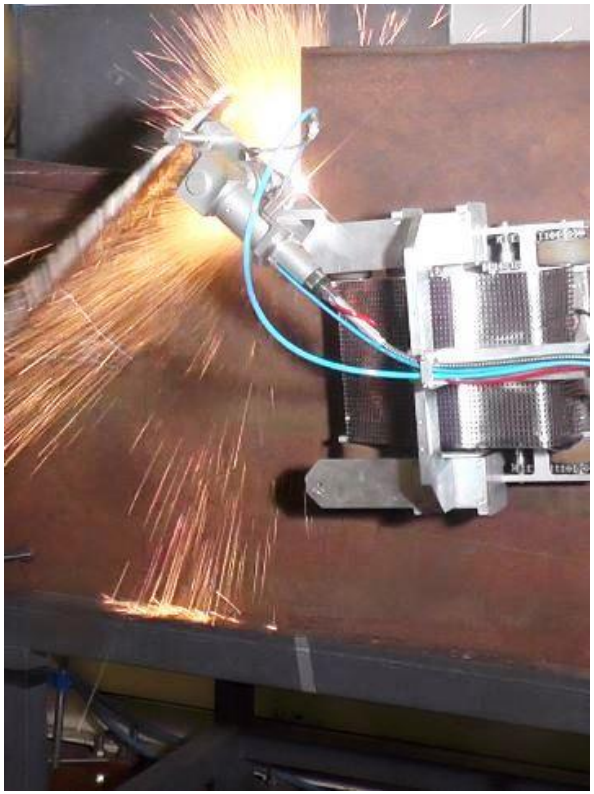
Rapid Integrity Assessmer il
and Gas Installations







Demonstration of STRONGMAN carrying TWI laser cutting tool for nuclear decommissioning – 21 S



T.P. Sattar, P. Hilton, Md Omar Faruq Howlader, Deployment Of Laser Cutting Head With Wall Climbing Robot For Nuclear Decommissioning, Proceedings of CLAWAR2016, QMC, London, Sept 2016

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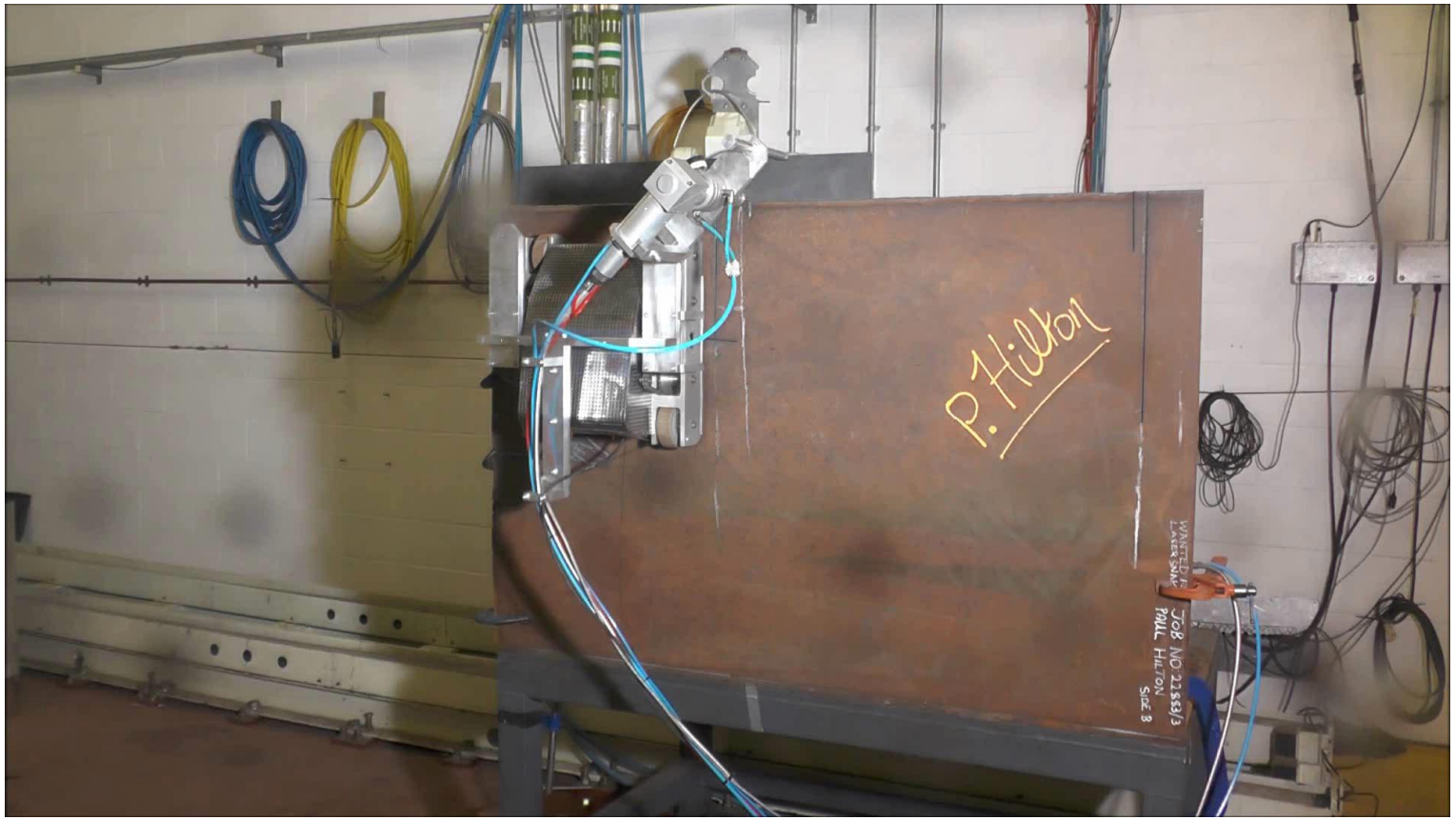

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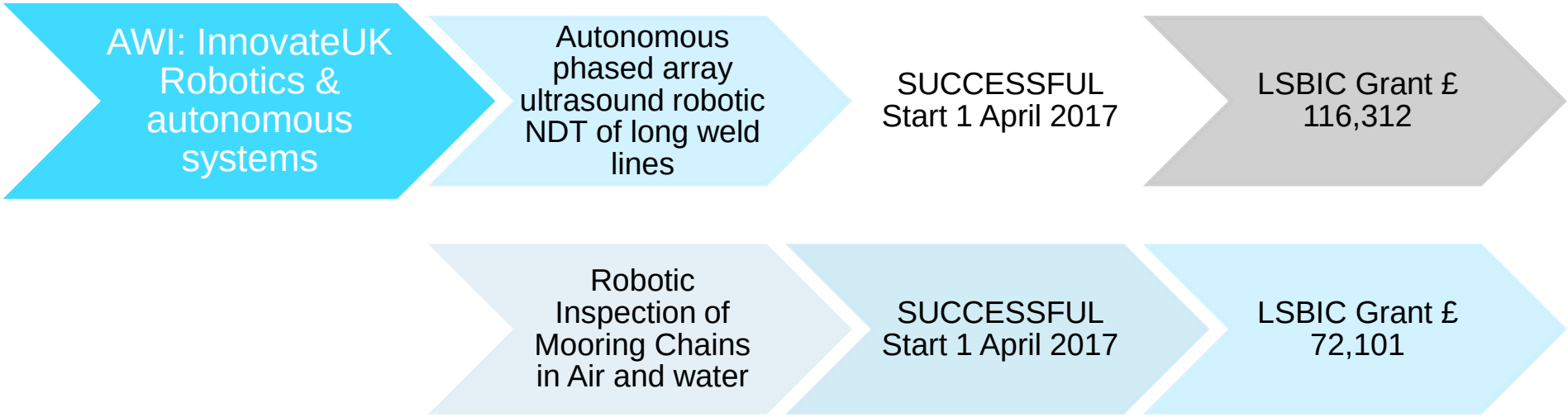
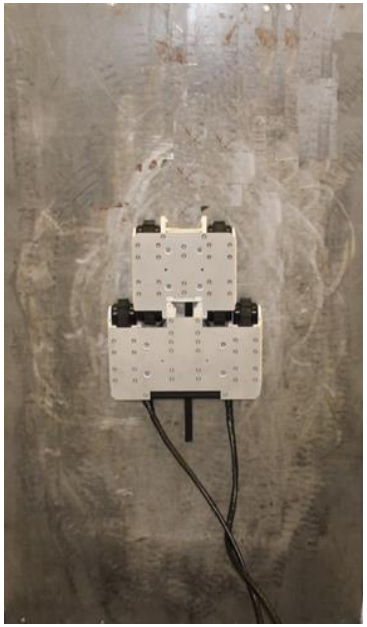
Two new InnovateUK Robotics and Autonomous Systems, start April 2017



Developing story boards

FTI for September 2016 – based on TRL6 developments by LSBU and partners e.g.

1. SIRCS -Structural Integrity of Reinforced Concrete Structures



Mobile robots to access large vertical structures and perform NDT

Hulls of ships, bridges, dams, tank walls, buildings, etc.

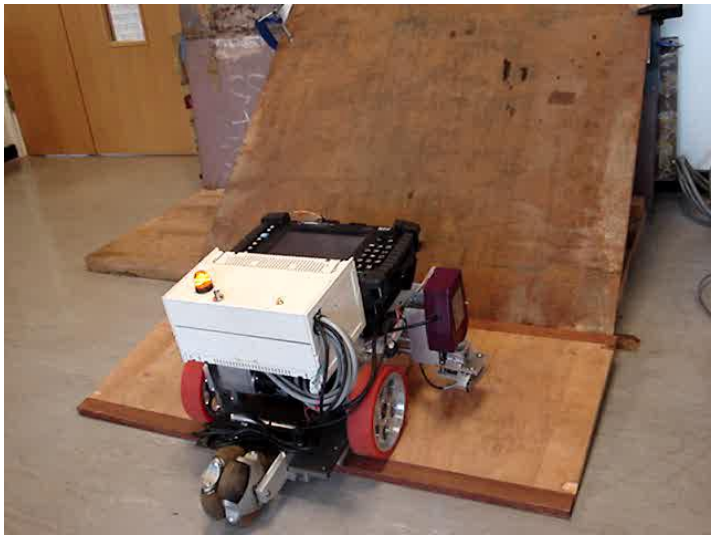
Advanced Wall climbing robot for the inspection of welds on cargo containers ships

Permanent magnets

Wireless control and data acquisition

Ultrasonic phased array NDT

Mass 35Kg



Climbing Robot Cell for welding and NDT - CROCELLS

- Team of climbing robots
- One performs Electric arc welding by profiling seam with a laser system
- A utility robot follows the welder and carries the wire drum and feeder
- A tug robot aides the welding robot
- An NDT robot tracks the welding hot spot and performs weld inspection with phased array ultrasonics

Magnetic adhesion climbing robots

Adapt to surface curvatures (concave or convex) or change surfaces

NDT robot adapts to Convex/Concave structures

WALL CLIMBING COMPETITION

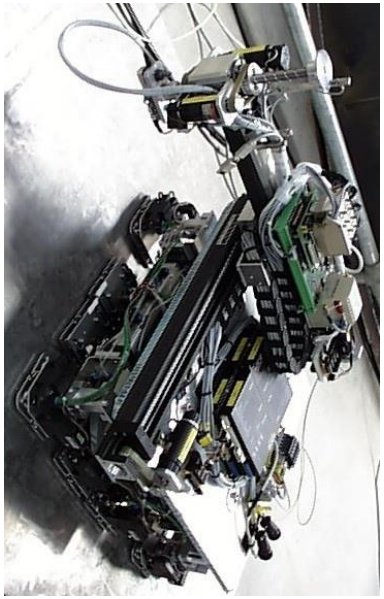
QMC LONDON Sept 2016 CLAWAR2016 conference

STRONGMAN

Permanent magnet adhesion wall climber carries additional payloads of up to 20 kg

Climbing NDT robots that use different adhesion techniques: permanent magnets, pneumatic suction cups and Vortex machines

CROCELLS



ROBAIR

VORTEX

Underwater Weld & Corrosion Inspector for offshore floating structures

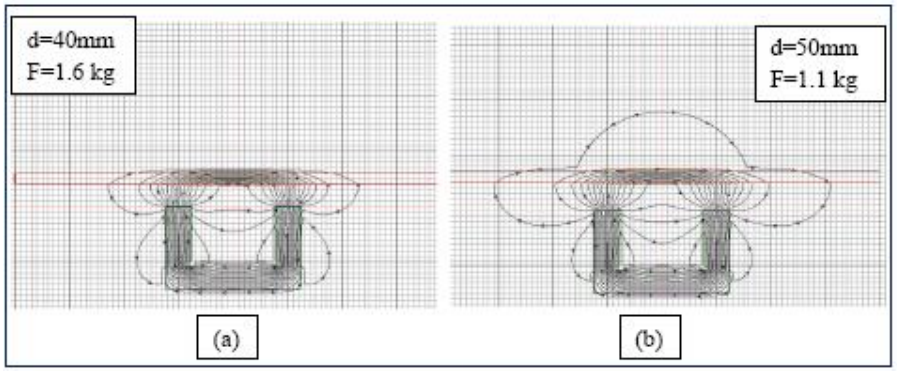


Figure 7-9 Magnetic field lines inside steel reinforced concrete when concrete cover (d) is (a) 40mm (b) 50mm

CONCRETE CLIMBER
Uses permanent magnet adhesion

Dr Salman Hussain, PhD study to investigate flux focussing techniques

Salman Aseer, BEng(Hons) Mech Eng (First) IMechE Prize Best final year project

Wall climbing robots for NDT, inspection and surveillance on non-ferrous surfaces

ANSYS analysis of streamlines and pressures created by VORTEX machines
Aim: Increase Payload capability of climbing robot

Achieved: 4 kg with an A4 sized robot.

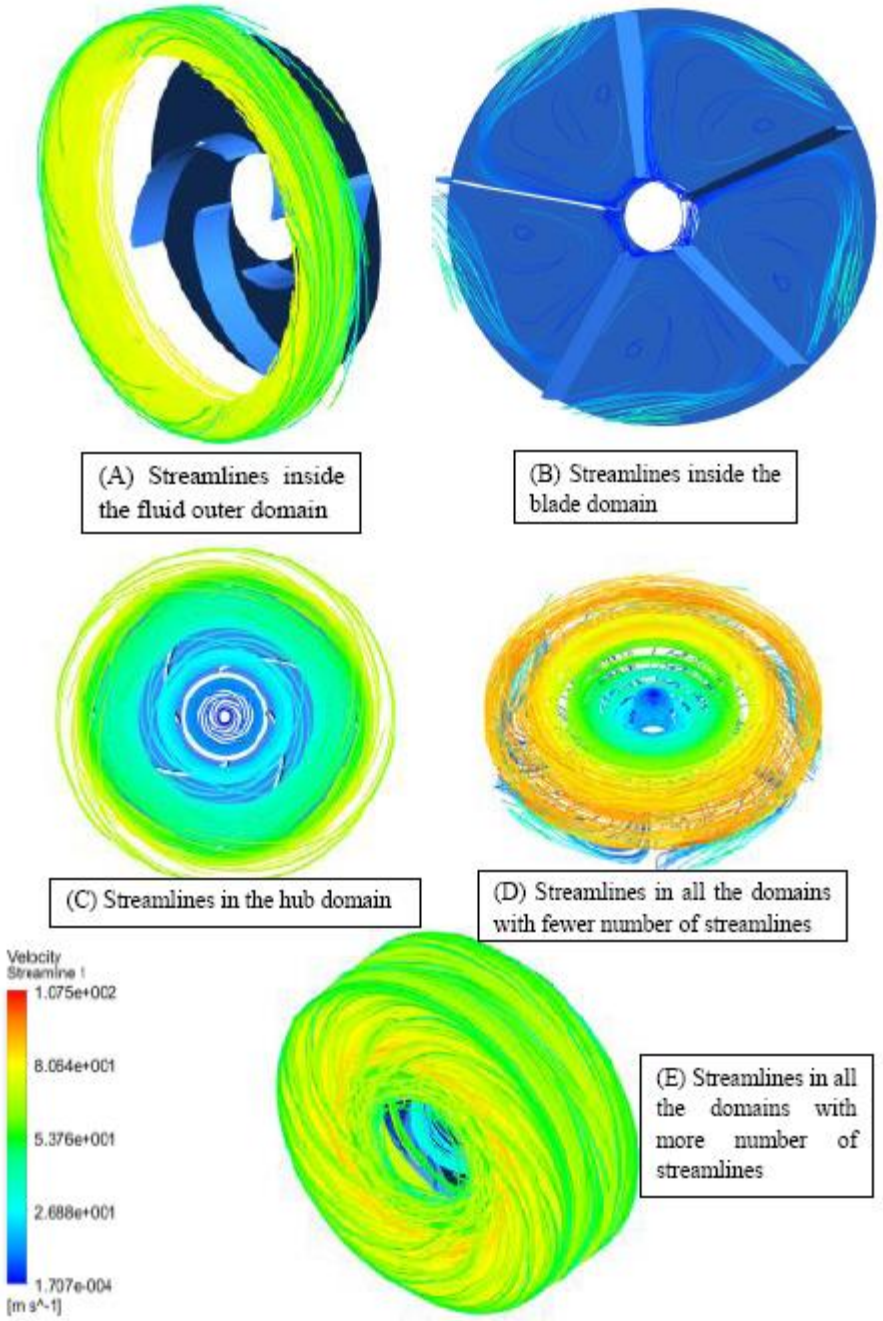
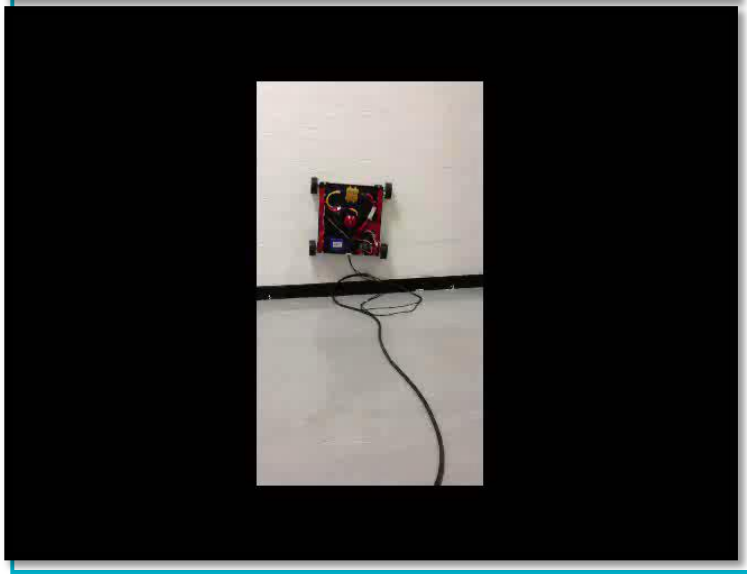
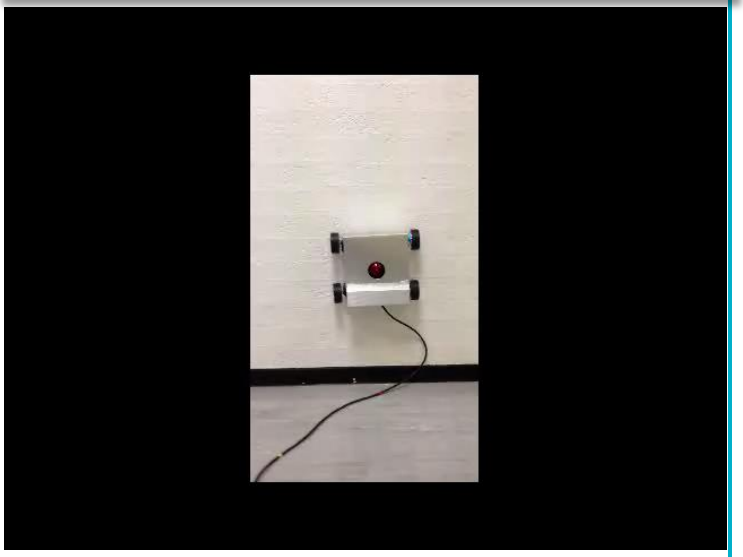


Figure 3-10 isometric view to show the streamlines inside the vortex chamber in the blades

VORTEX MACHINES: Wall climbing robots for NDT, inspection and surveillance on non-ferrous surfaces



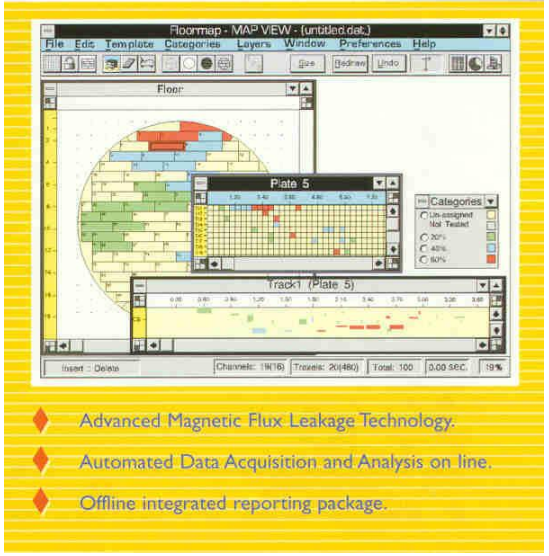


STORAGE TANK INSPECTION

CLEAN TANKS
Diameter 2 to 20 metres, fixed roof. Visual inspection, a few ultrasonic thickness measurements.

Crude oil tanks floating roofs, dia 20 - 100 metres, carbon steel. Floor thickness of 6-12.5mm, Preparation: 6-9 months .Another 3-6 months to clean .

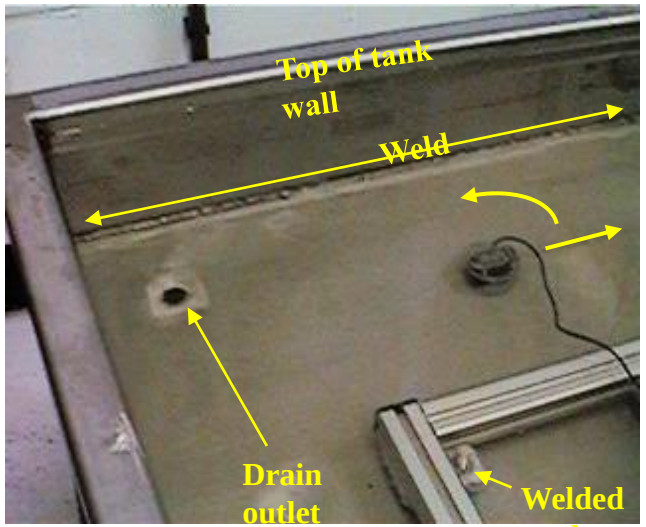
Visual inspection followed by MFL. UT final method to validate the problem areas.

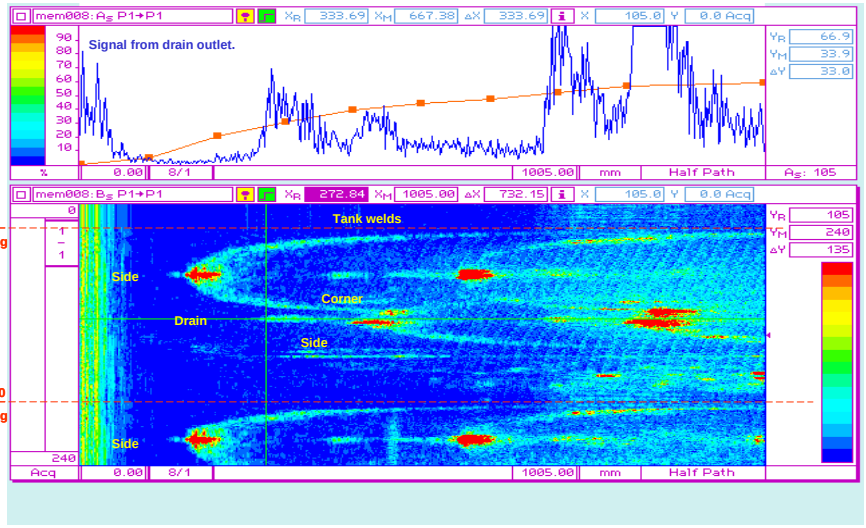


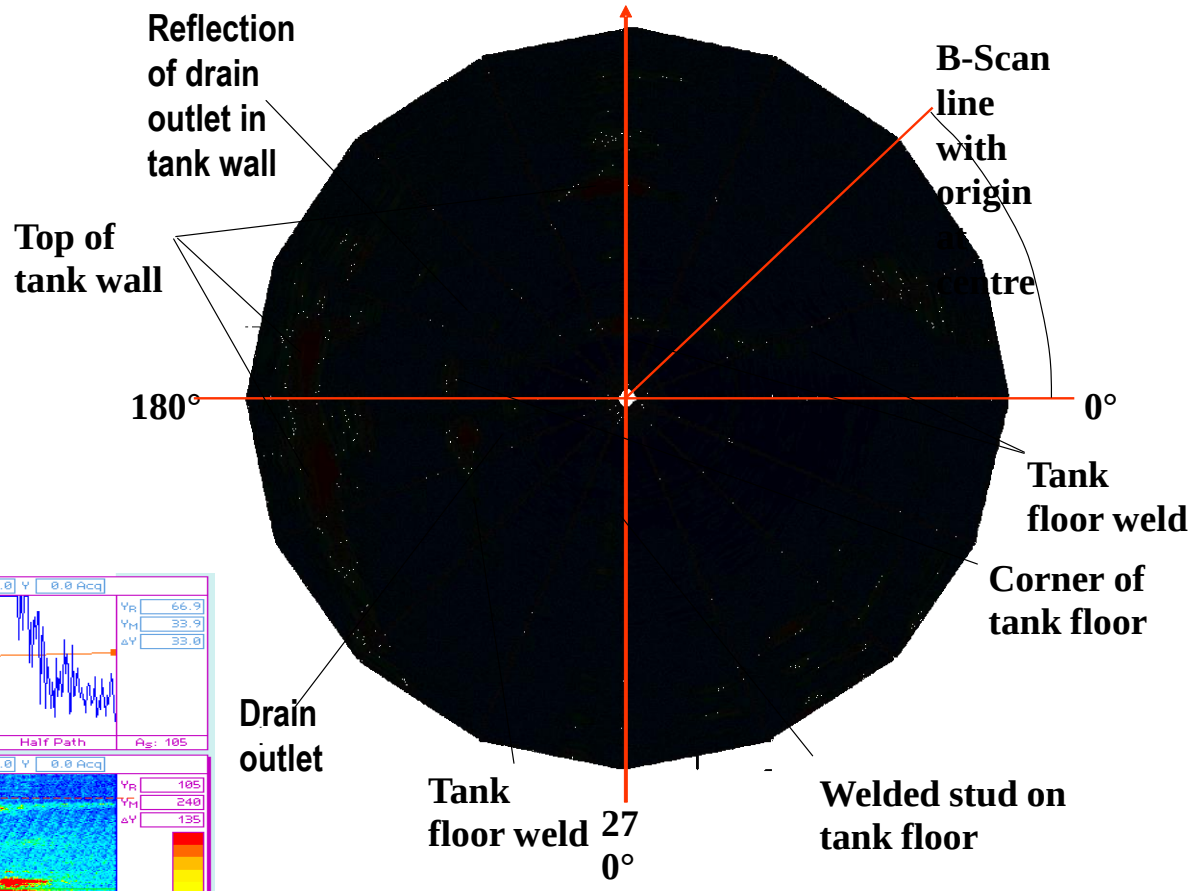
Manual tank floor inspection, underside corrosion defects

ROBTANK: Mobile wall climbing robot enters through manholes on the floating or fixed roof of a tank to inspect tank floor and internal walls

Mapping of floor defects using rotating bulk wave ultrasonic technique





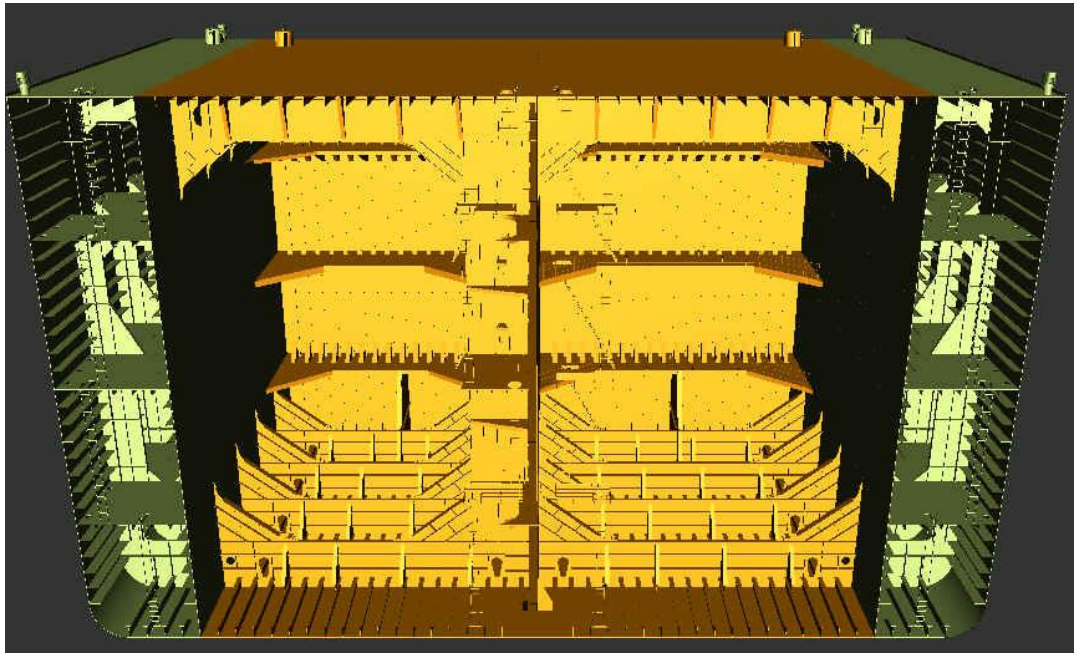


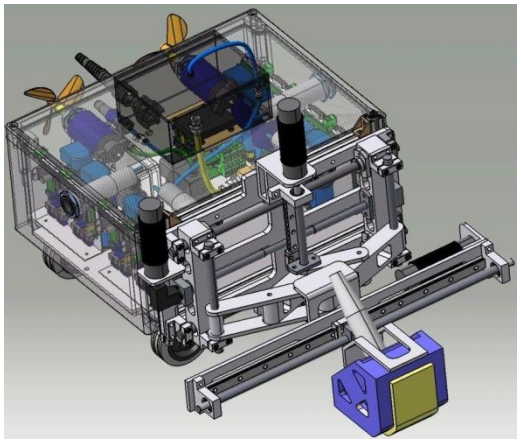
Floating Production Storage of Oil (FPSO)

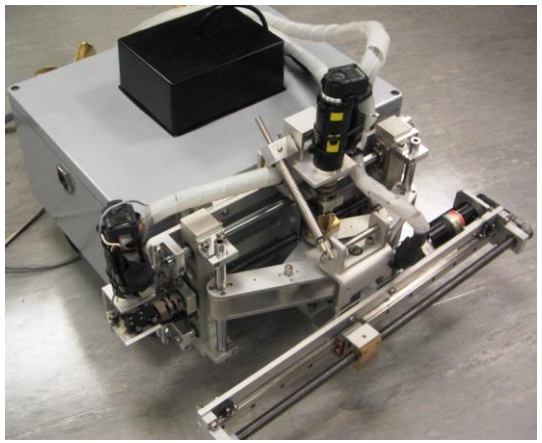
Task: Inspect welds between strengthening plates and tank floor

- Outage required with cleaning of tank before inspectors can enter tank – problem of disposal of cleaning medium
- Eliminate outage by performing in-service inspection with mobile swimming robots or empty without cleaning and use amphibious robot

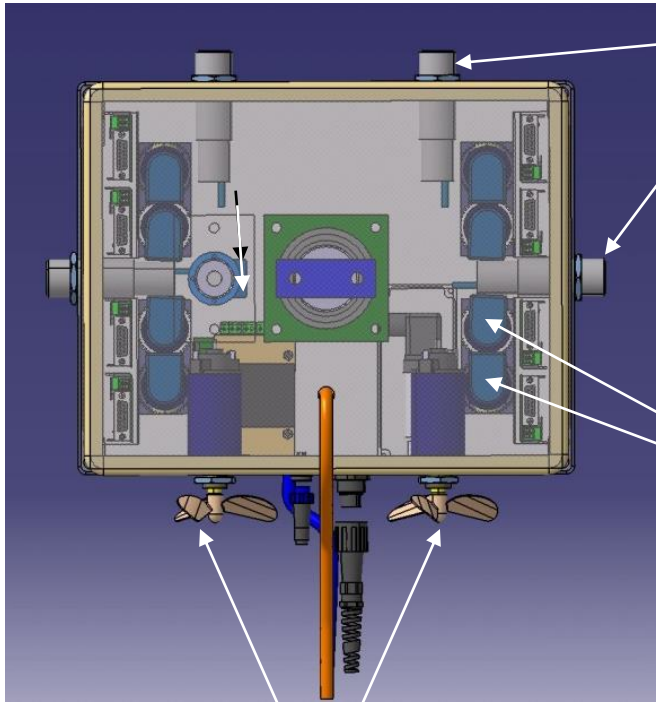
Two tanks are emptied, cleaned and inspected in 3-4 weeks with 60-70 man-days work and costs between £30-40k.







Scanning Arm mounted on this face



Ultrasonic range finders for detecting walls and strengthening plates

Two motors, one for wheel motion, the other to change direction of wheel

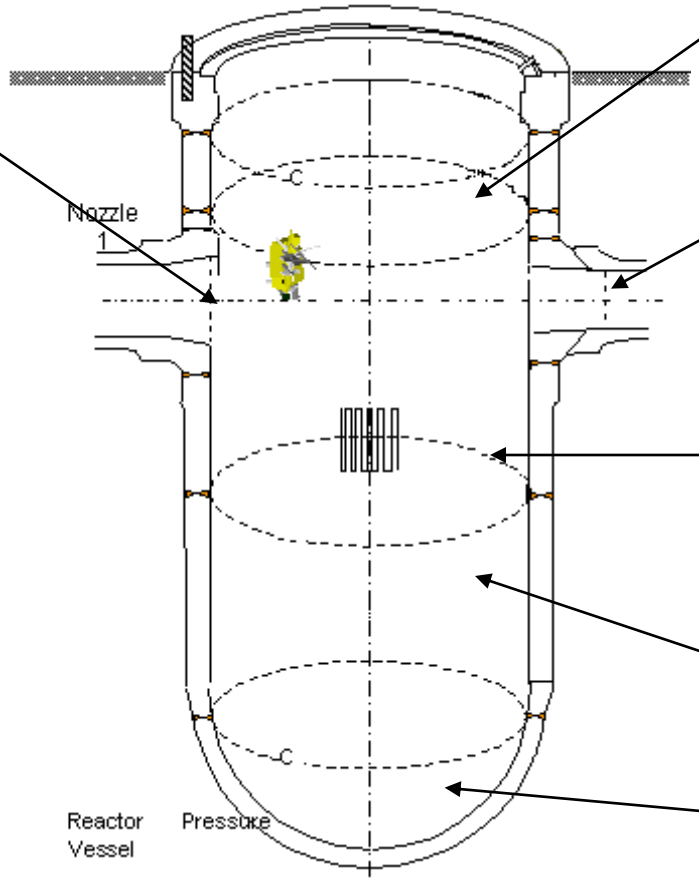
Thrusters

FPSO swimming and floor inspection robot to inspect tank floors and welds on strengthening plates

Mobile Robot Inspection of Reactor Pressure Vessels

RIMINI project

Inspection of RPV Circumferential and Nozzle welds



Upper shell

Nozzle weld to shell

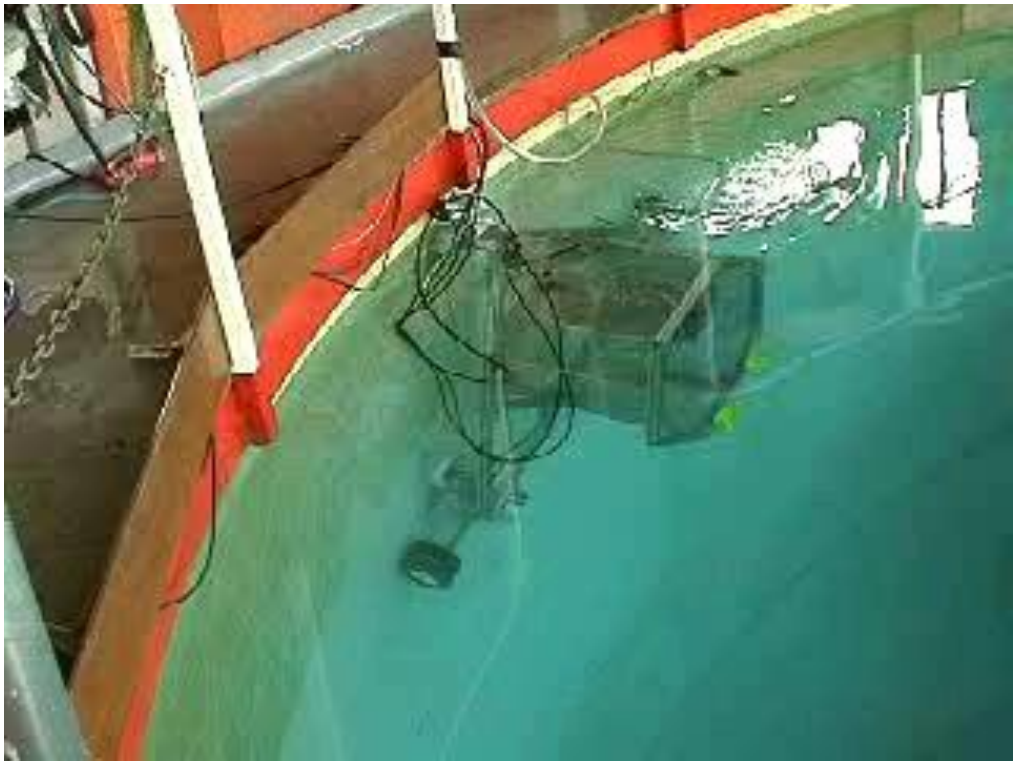
Nozzle weld to safe end

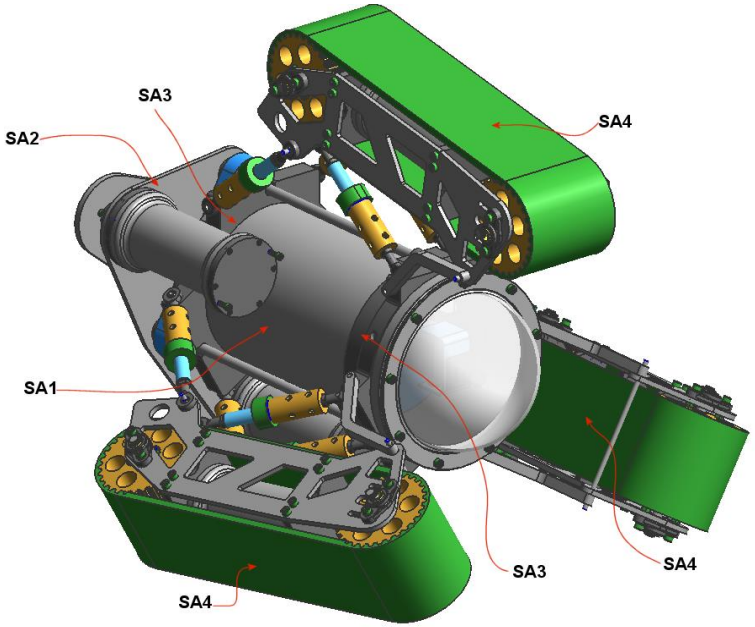
Circumferential weld

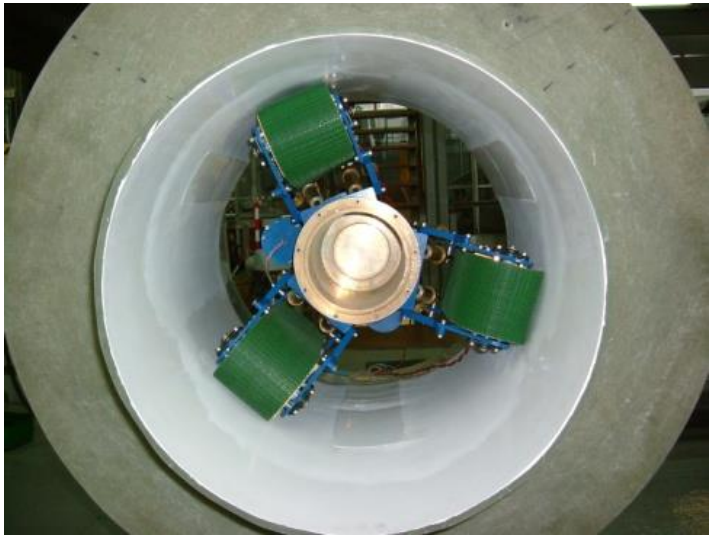
Lower shell

Bottom head

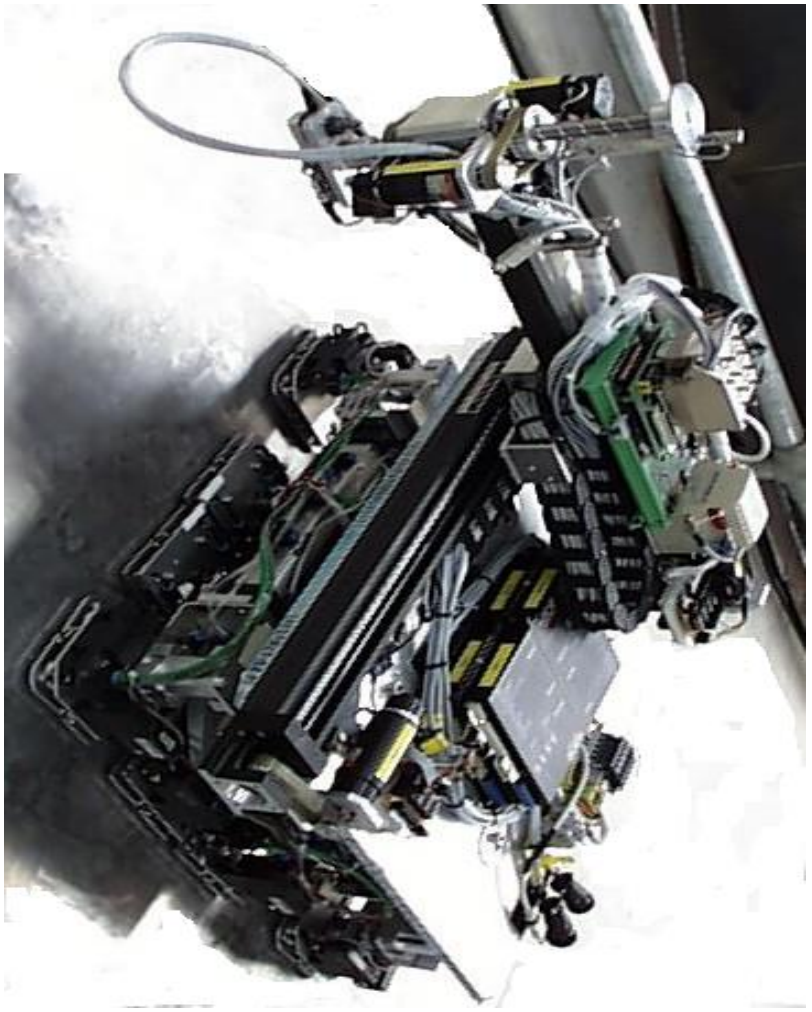
Nozzle inspection robot

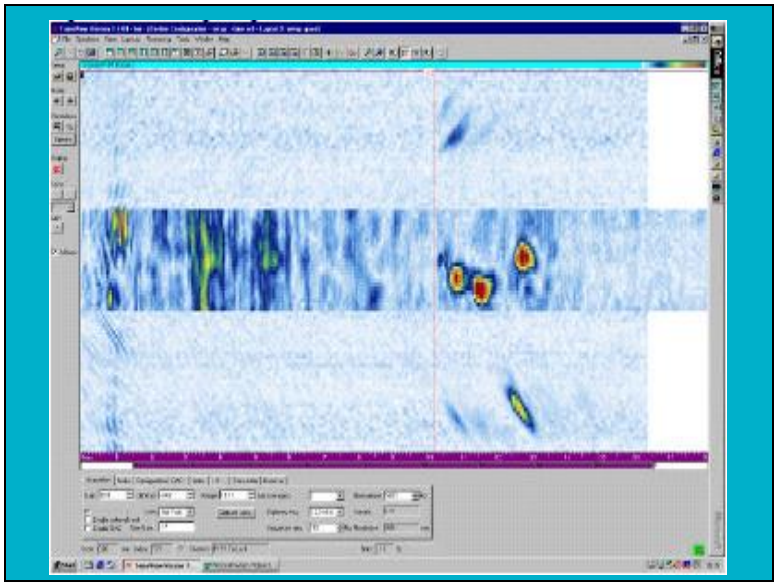




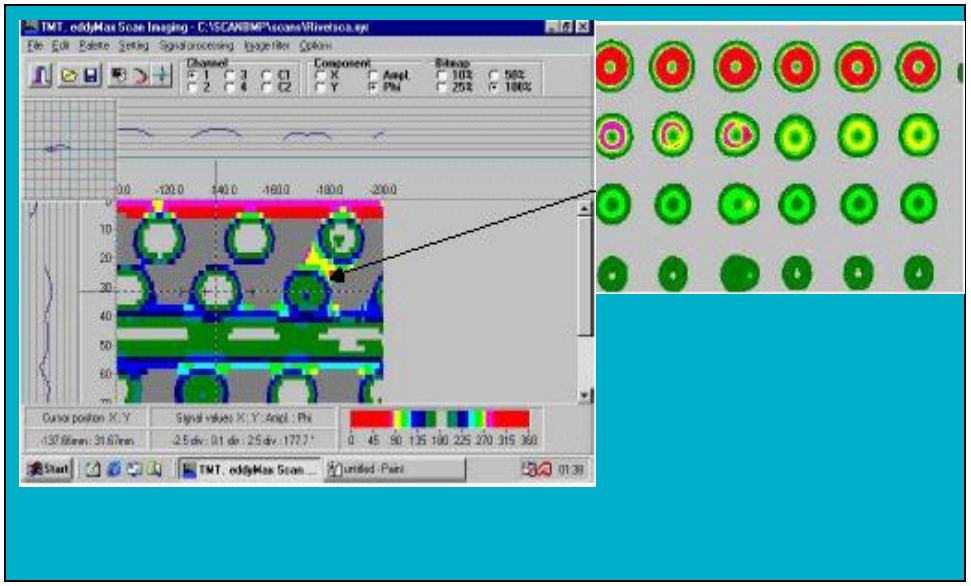


Inspection of rows of rivets on aircraft wings and fuselage with a climbing robot

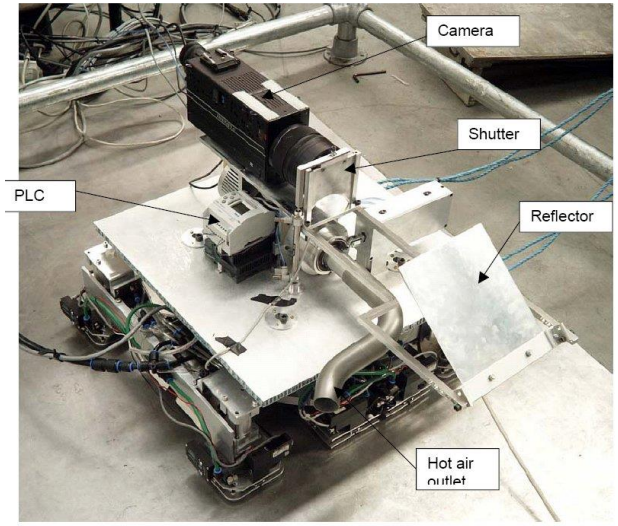


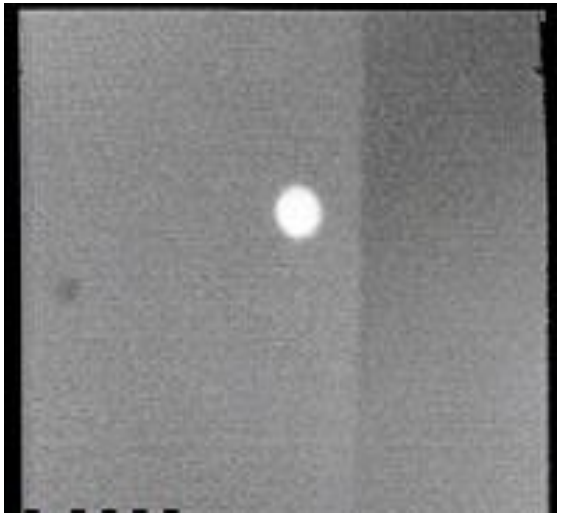


ULTRASONIC PHASED ARRAYS to inspect rivets on aircraft, ROBAIR project



EDDY CURRENTS inspection of rows of rivets on the wings and fuselage of aircraft, ROBAIR project





Thermographic detection of loose rivets

Eddy Current Inspection of turbine blade with 7 axis, force controlled portable arm

Mass of arm: 22 kg

Reach: 600 mm

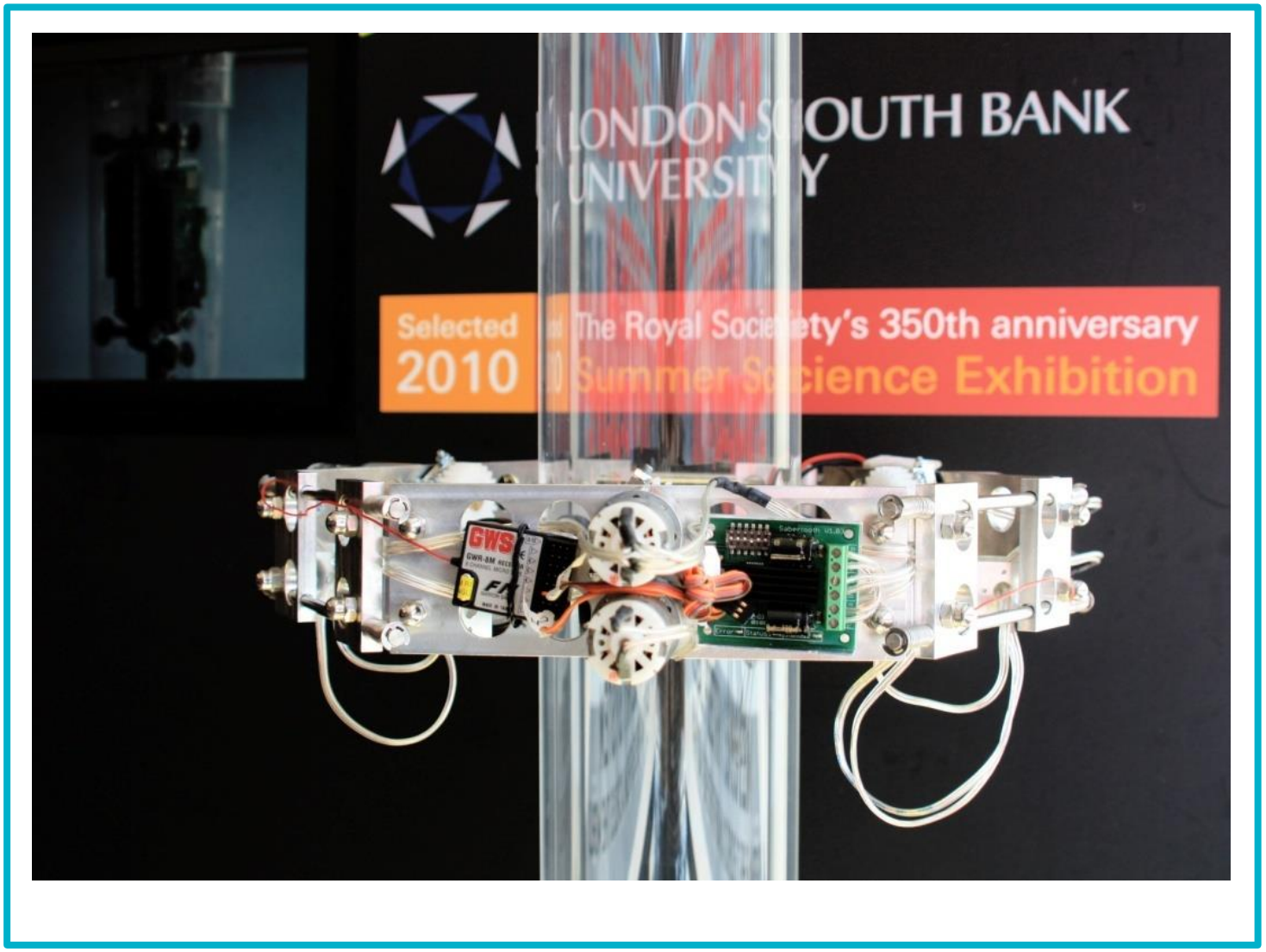
Repeatability: 1 mm

Adept Controller with force sensor module

Contact force adaptation to uncertain complex surfaces

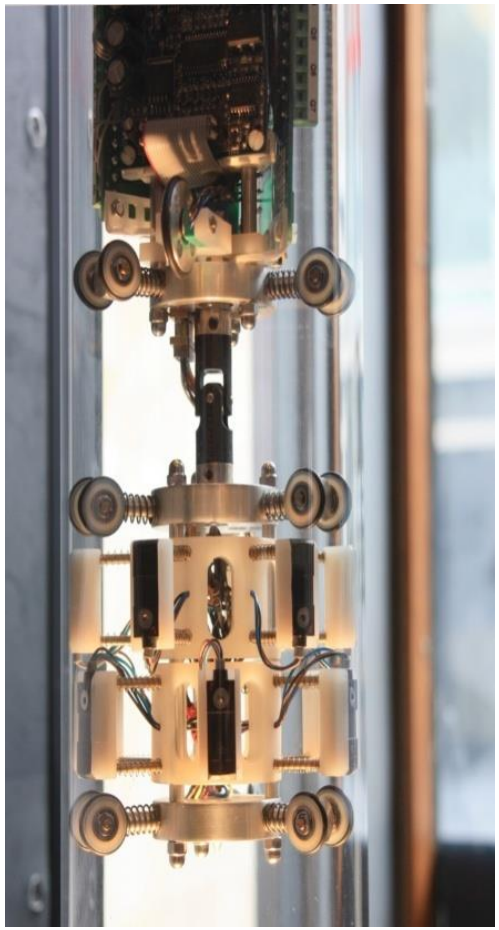
2008 Highly Commended innovation award – the Industrial Robot International Journal

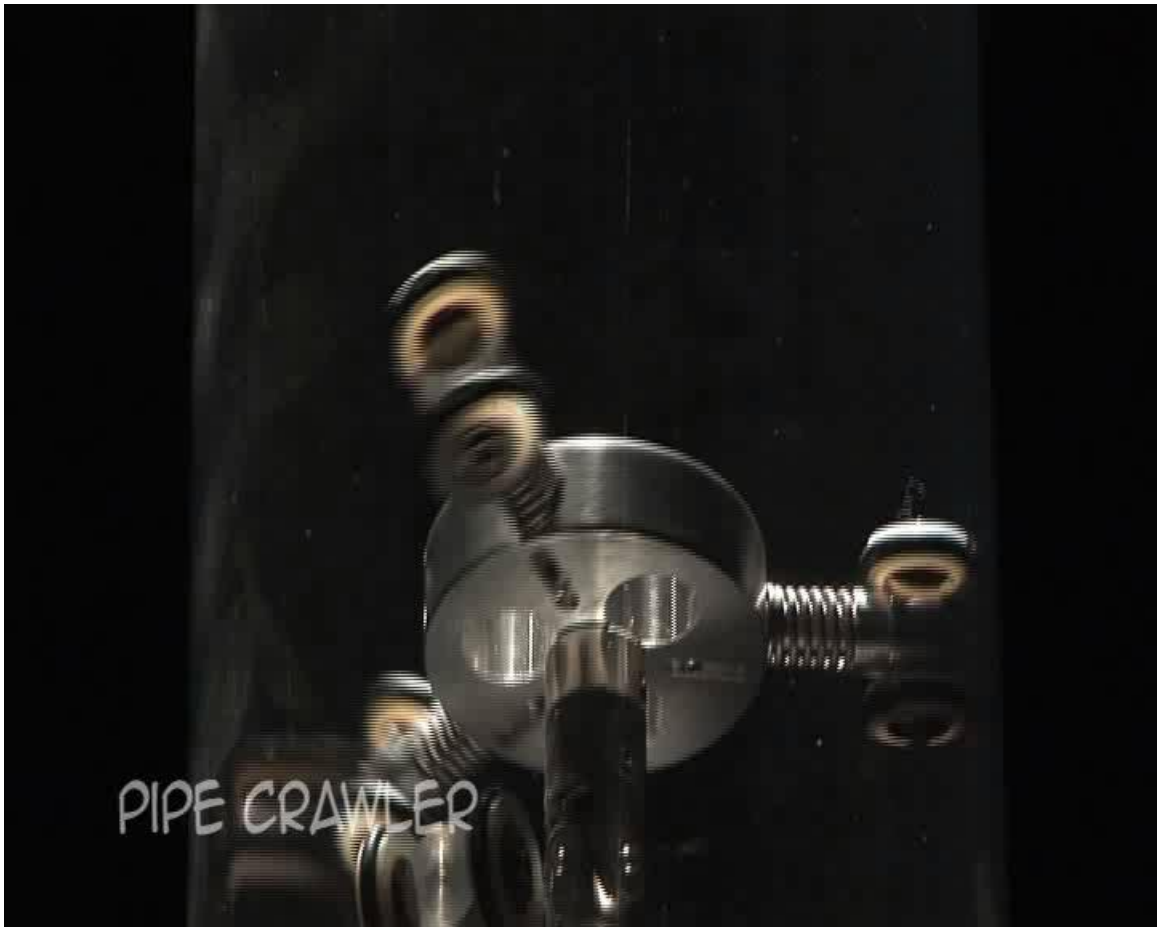
Climbing ring robot for wind turbine tower and pipe inspection



The Ring Pipe Climbing Robot

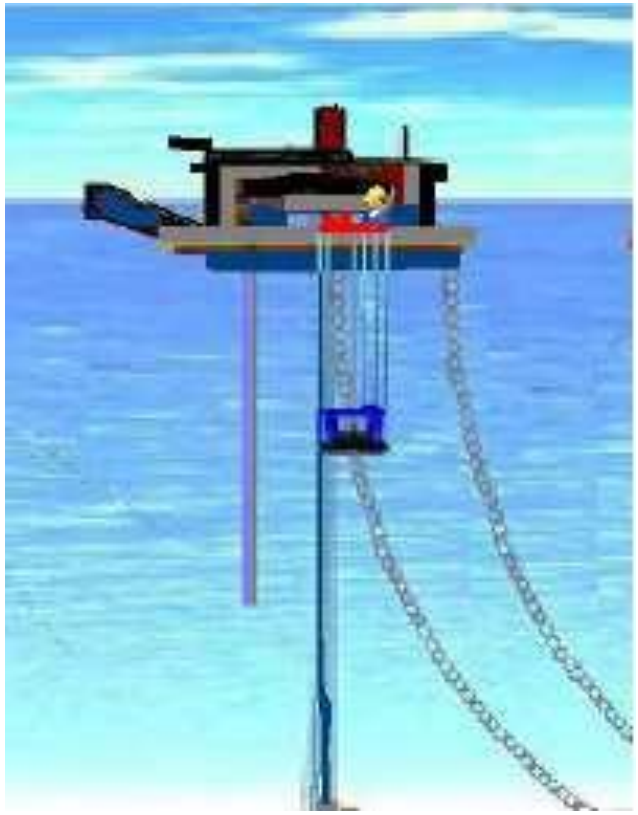
Internal pipe climbing robot

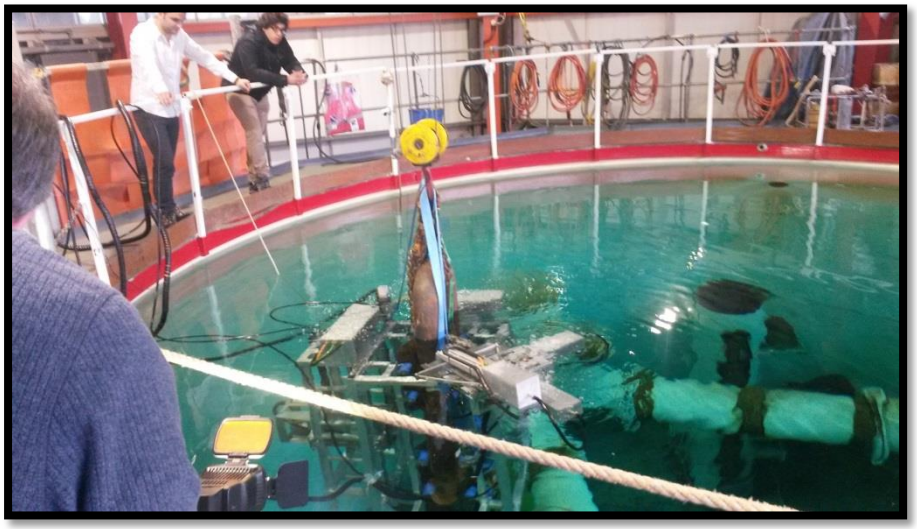


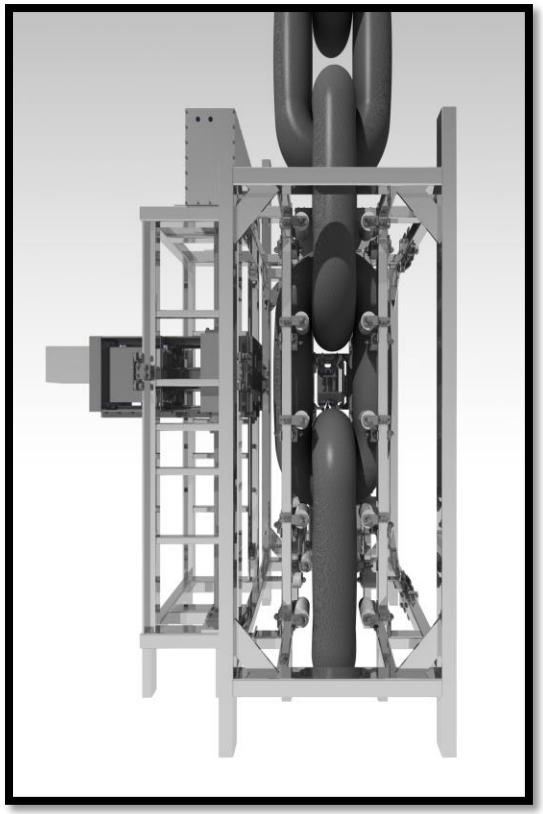


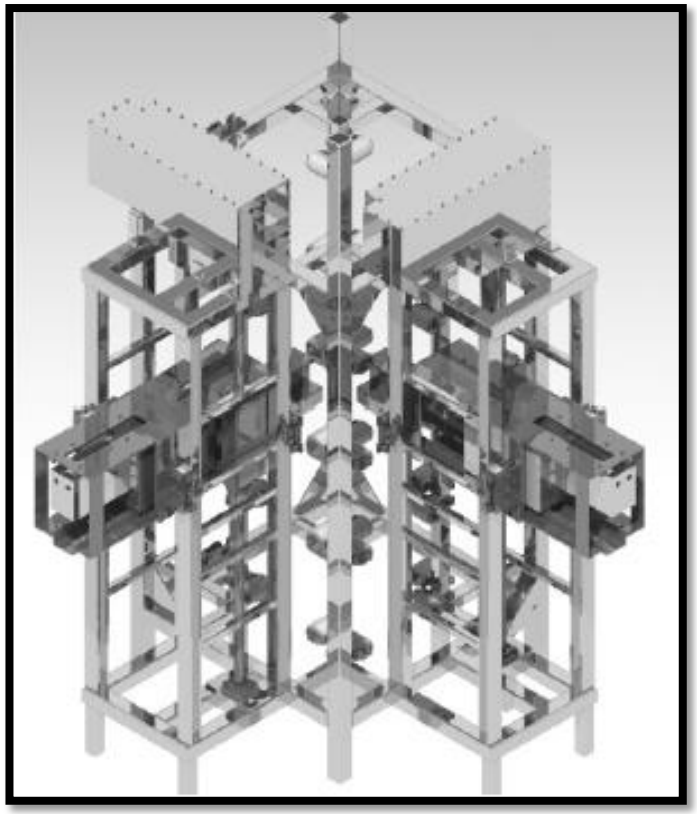
Mooring chain climbing robot

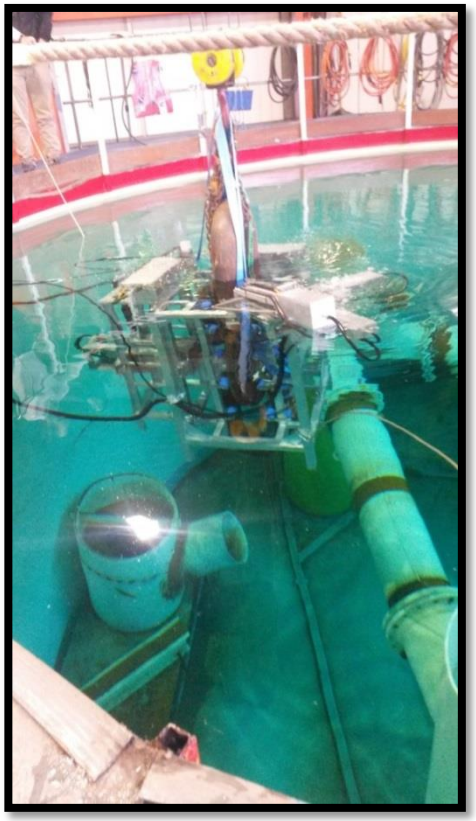
Moorinspect





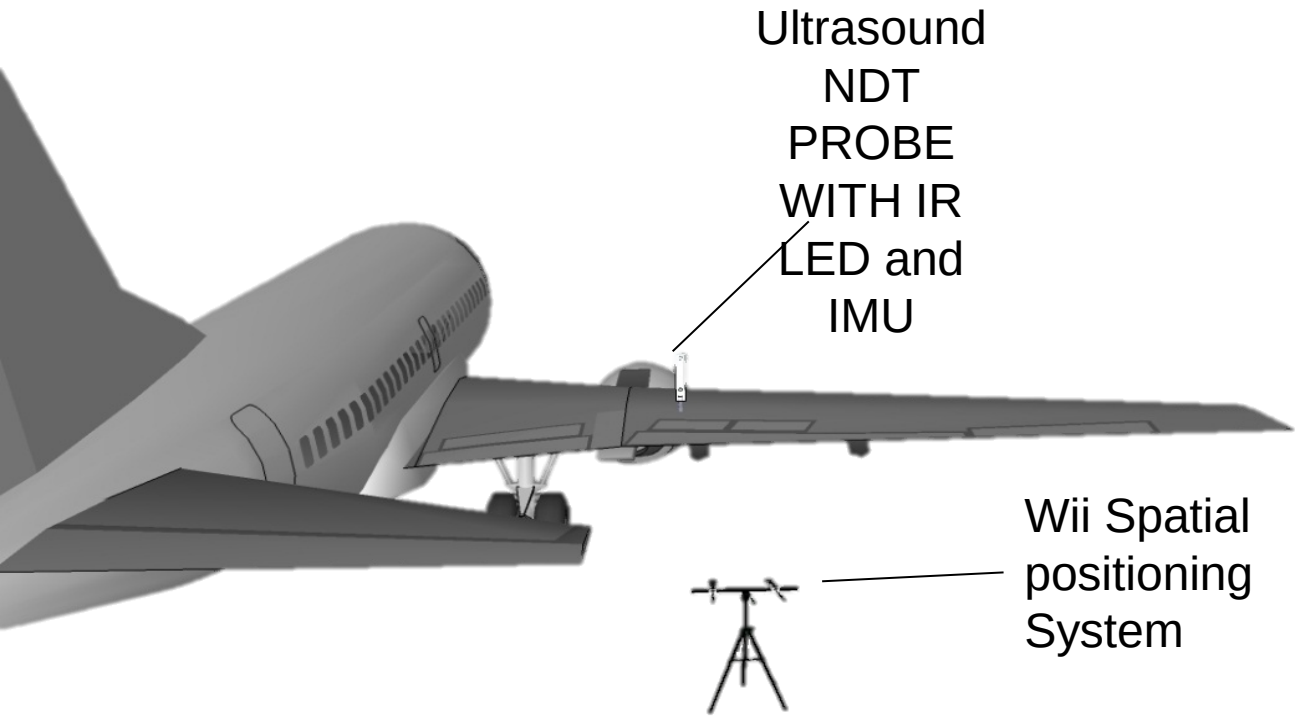






INEXPENSIVE SPATIAL POSITION SYSTEM FOR THE IMPROVEMENT OF MANUAL ULTRASOUND NDT

Dr Mohammad Al-Rashed, IEE best student, BEng (Hons) EEE (First)



Emerald Group Publishing Limited

Industrial Robot

Innovation Award 2014 – For practical innovation in the field of robotics

Highly Commended

is awarded to: Tariq Pervez Sattar

Department of Engineering and Design, London South Bank University, 103 Borough Road, London SE1 0AA, UK

for the paper: Inexpensive spatial position system for the automation of ultrasound roll with mobile robots

presented at the: 17th International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines (CLAWAR 2014)

Dr Clive Loughlin, Editor, Industrial Robot

Dan Jegging, Publisher, Industrial Robot

Emerald

The *Industrial Robot*
Innovation Award 2008
Highly Commended

Presented to

Hernando Leon Rodriguez, Bryan Bridge and Tariq P. Sattar

London South Bank University

For the paper

Climbing ring robot for inspection of offshore wind turbines

Presented at the

11th International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines (CLAWAR 2008), Coimbra, Portugal, 8-10 September 2008.

Dr Clive Loughlin, Editor, Industrial Robot

Harry Colson, Publisher, Emerald

London South Bank
Innovation Centre

CLAWAR Association Best Technical Paper Award

Second Prize to the value of €50 awarded to

Paper ID# 37

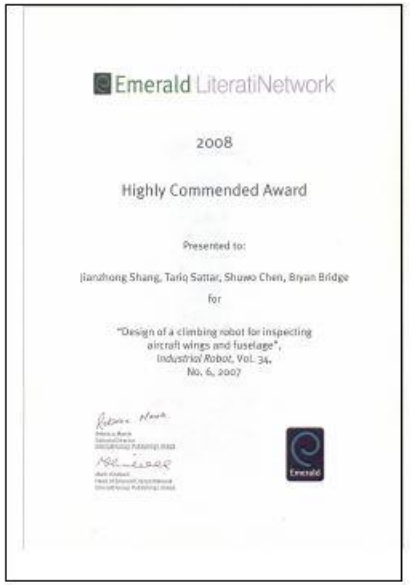
Title: Inspection of floating platform mooring chains with a climbing robot

Authors: Alvaro Garcia Ruiz[1], Tariq Pervez Sattar[2], Marcos Correa Sanz[1] and Borja Salanova Rodriguez-Filloy[1]

Affiliations: [1] Innovative Technology and Science Ltd (InnotecUK), UK, [2] Centre for Automated and Robotic NDT, London South Bank University, UK

Presented at CLAWAR 2014: 17th International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines, Poznan University of Technology, Poland, 21-23 July, 2014.

Chair
CLAWAR Association



Emerald LiteratiNetwork

2008

Highly Commended Award

Presented to:

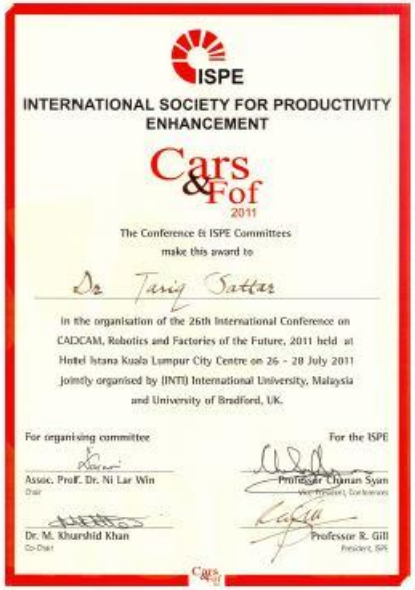
Jianzhong Shang, Tariq Sattar, Shuwo Chen, Bryan Bridge

for

"Design of a climbing robot for inspecting aircraft wings and fuselage", *Industrial Robot*, Vol. 34, No. 6, 2007

Emerald

London South Bank
Innovation Centre



ISPE

INTERNATIONAL SOCIETY FOR PRODUCTIVITY ENHANCEMENT

Cars&Fof 2011

The Conference & ISPE Committees make this award to

Dr Tariq Sattar

in the organisation of the 26th International Conference on CADCAM, Robotics and Factories of the Future, 2011 held at Hotel Istana Kuala Lumpur City Centre on 26 - 28 July 2011 jointly organised by (INTI) International University, Malaysia and University of Bradford, UK.

For organising committee

Assoc. Prof. Dr. Ni Lar Win, Chair

Dr. M. Khurshid Khan, Co-Chair

For the ISPE

Professor Charan Syan, Vice President, Conferences

Professor R. Gill, President, ISPE

Cars&Fof

Emerald Group Publishing Limited

Industrial Robot

Innovation Award 2010 – For practical innovation in the field of robotics

Highly commended

is awarded to: T. P. Sattar

for the paper: "Remote mobile vehicle and its suitable non-destructive testing inspection methods for the melt weld inspection"

presented at: 13th International Conference on Climbing and Walking Robots CLAWAR 2010 Nagoya Institute of Technology, Japan 31 August-3 September 2010

Dr Clive Loughlin, Editor, Industrial Robot

Harry Colson, Publisher, Industrial Robot

Emerald

Research you can use

The *Industrial Robot*
Innovation Award

Presented to

Jianzhong Shang, Bryan Bridge, Tariq P. Sattar, Shyamal Mondal and Alina Brenner

For the paper

Development of a climbing robot for inspection of long weld lines

Presented at the

10th International Conference on Climbing and Walking Robots (CLAWAR 2007), 16-18 July 2007, Singapore.

Dr Clive Loughlin, Editor, Industrial Robot

Harry Colson, Publisher, Emerald

The *Industrial Robot*
Highly Commended Award

Presented to

Jianzhong Shang, Tariq P. Sattar, Shuwo Chen and Bryan Bridge

For the paper

Design of a climbing robot for inspecting aircraft wings and fuselage

Presented at the

9th International Conference on Climbing and Walking Robots (CLAWAR 2006), 12-14 September 2006, Brussels, Belgium.

Dr Clive Loughlin, Editor, Industrial Robot

Harry Colson, Publisher, Emerald

Emerald LiteratiNetwork

Industrial Robot: An International Journal

2015 Highly Commended Paper Award

Is awarded to Tariq Sattar

for the paper Inexpensive spatial position system for the automation of inspection with mobile robots

Tony Rocha
Publishing Director
Emerald Group Publishing Limited

Jon Bowden
Head of the Emerald Literati Network
Emerald Group Publishing Limited

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The TIMES Science Section

Robots usher in Royal Society's 350th anniversary

By Clive Cookson, Science Editor
Published: June 25 2010 03:00

Wall-climbing robots and flying robotic penguins are to inhabit London's South Bank as part of the capital's biggest science fair since the 1951 Festival of Britain.

One of the most striking exhibits comes from the London South Bank University, whose scientists are demonstrating their latest wall-climbing robots. These machines scale vertical surfaces

London South Bank

Innovation Centre

Emerald

CLAWAR 2005 Climbing Robot Competition
The *Industrial Robot* Innovative Climbing Award

Presented to

London South Bank University

Presented at the

8th International Conference on Climbing and Walking Robots
(CLAWAR 2005),
12-15 September 2005, London, UK.

Dr Clive Loughlin
Editor
Industrial Robot

Sharon Parkinson
Managing Editor
Emerald

Emerald

The *Industrial Robot*
Innovation Award 2008
Highly Commended

Presented to

Alina-Alexandra Brenner and Tariq P. Sattar

London South Bank University

For the paper

Robotic system for inspection of test objects with unknown geometry using NDT methods

Presented at the

11th International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines
(CLAWAR 2008),
Coimbra, Portugal, 8-10 September 2008.

Dr Clive Loughlin
Editor
Industrial Robot

Harry Coleon
Publisher
Emerald

Robot Detectives: Sherlock Holmes meets Spiderman exhibit for the Royal Society of Science (2011) and the Royal Academy of Engineering (2012)


The Royal Institution
of Great Britain
L'Oréal Young Sci
at the Royal Institu

London
South Bank
Innovation Centre

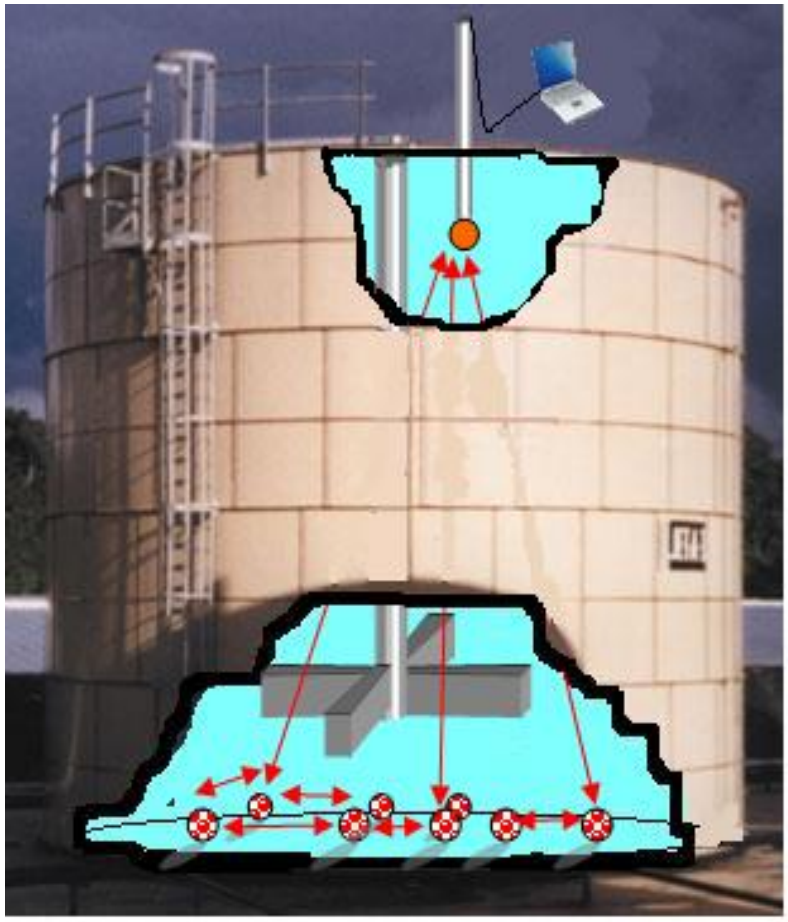
End

Sensor Bots for petrochemical tank floor assessment –Richard Anvo N'zebo, 1st Class BEng(Hons) EEE
Funding by TWI/NSIRC and LSBU

1. Active buoyancy control - Progress

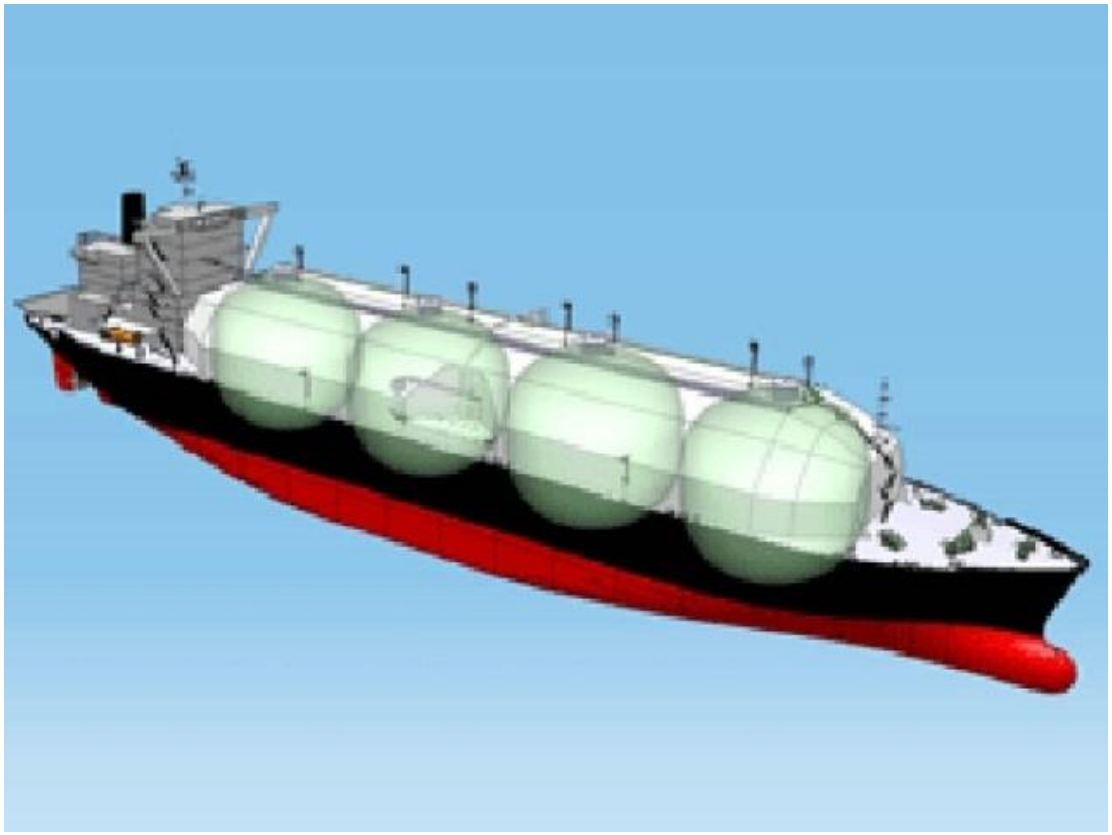
2. Ultrasound NDT

3. Under liquid data communications



PhD student: Farhan Tanvir Santo BEng(Hons) Mechanical Engineering (First)

Vessel energy efficiency enhancement using sensing for LNG Storage Containers



Fast Inspection Of Mooring Chains In Air And Water (FIMCAW) –Mahesh Dissanayake, 1st Class BEng(Hons) EEE