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Solent LEP

Marine and Maritime Autonomy Test Bed Proposal – PUBLISHABLE VERSION

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Glossary

Abbreviations

Acronym	Description
ACER	Autonomous Control Exploitation and Realisation
ADS	Aerospace, Defence, Security & Space
COFDM	Coded Orthogonal Frequency Division Multiplexing
CSRs	Contract Status Reviews
DSTL	Defence Science & Technology Laboratory
EU	European Union
GBER	General Block Exception Regulation
GVA	Gross Value Added
JOSCAR	Joint Supply Chain Accreditation Register
L-band	0.5 - 1.5GHz
LCM	Life Cycle Management
LEP	Local Enterprise Partnership
MCA	Maritime & Coastguard Agency
MCC	Mobile Control Centre
MISC	Marine Integration & Support Centre
NOC	National Oceanographic Centre
OFCOM	Office of Communications
RIB	Rigid Inflatable Boat
SME	Small & Medium Enterprise
SMMN	Solent Maritime Mesh Network
UK	United Kingdom
USV	Unmanned Surface Vessel
VHF	Very High Frequency
VIP	Very Important Person

1 Executive Summary

As the Maritime World moves towards autonomy, the Solent will see the wide-scale adoption of autonomous operation. From Academia, to specialist SMEs, to Port Authorities, companies across the Solent will need to test, teach and develop specialist autonomous systems.

To meet this growing opportunity and to develop *Brand Solent* as the international centre for Autonomy, BAE Systems, in partnership with ASV Global, Unmanned Air specialists Bluebear Systems Research and SeeByte are pleased to submit our proposal for £464K of funding from the *Solent Local Enterprise Partnership* for the development of the Marine and Maritime Autonomy Test Bed.

The Autonomy Test Bed will consist of:

- **Air and Surface test vehicles:** An unmanned surface vehicle and optional unmanned air vehicle available for experimentation, mounting of sensors, communications and support equipment for experimentation and demonstration. An additional option is provided within this proposal to plan and simulate underwater vehicles.
- **Secure Maritime Communications Network:** a high-bandwidth radio network to support safe and reliable testing of USVs and UAVs across the Solent.
- **Mobile Control Centre:** a versatile mobile control centre to support sea trials, training, customer demonstrations of UAV and USV operation across the Solent. This to include the capability to simulate underwater and air vehicles in support of real trials where the use of physical vehicles may be inappropriate.
- **Solent Test Sites:** operational areas across the region for ready access to the Test Bed.

Impact of the *Solent Local Enterprise Partnership* funding:

- **New High Value Jobs:** The Test Bed will create new jobs to promote, manage and control operations. It is anticipated that further new employment opportunities in naval architecture, port authorities, communications, electronics and academia will be created as the Solent becomes the centre for maritime autonomy.
- **Attract International Investment:** By allowing enterprises to share a common infrastructure, the Solent will grow its critical mass of expertise and reputation as the Centre for Autonomy Testing & Training encouraging further inward investment.
- **Builds Innovation, Skills and Education:** In collaboration with the Solent's premier Universities, the Test Bed will develop world class autonomous research, training and certification programmes.
- **Greater Efficiency:** The Test Bed will significantly reduce the cost of practical research, product development, testing and training for SME's, Industry and academia.
- **Collaboration across the Solent:** Many Government departments, Academia and Research Institutes, SME's, and Global Industry have pledged their support for the Test Bed.

A Quick Start: BAE Systems and its partners are committed to a start by 1st of January 2017 and I am pleased to recommend this proposal to you

[Signed on original]

Richard Williams, Com bat Systems Director, BAE Systems Naval Ships

2 Strategic Case

2.1 Project Overview

The marine and maritime surface vessel autonomy sector is a high technology market currently worth approximately £100m p.a. globally and growing in excess of 10% per year. Numerous marketing studies including the UK Marine Industries Technology Roadmap, the Global Marine Trends 2030, the UKTI RAS Working Group and Global Strategic Trends Reports have all recognised autonomy and an autonomous test bed as a key enabler within the maritime market.

Currently autonomous trials with real equipment are usually undertaken on the ranges in West Wales and Northern Scotland. These ranges are geographically remote and require booking a long time in advance. Although they have advantages they are difficult for stakeholder attendance and lack the flexibility for short notice, short term or longer term use available with our proposal.

The Solent area has a growing number of world class businesses operating in the autonomy sector. This proposal aims to strengthen the Solent's position as both a national and future international hub for the development and testing of unmanned systems and the future delivery of training and certification of operators.

Vehicle and autonomous systems providers can reserve the test bed at a daily rate and request the use of the USV, UAV, mobile control centre and communications system in the combination as required for their trial, demonstration or experimentation.

Specifically, the project aims to provide an infrastructure to support autonomous development as follows:

- **Air and Surface test vehicles**
  Provision of a high performance, general purpose unmanned surface vessel (USV) demonstrator, providing businesses and academia in the Solent area with affordable access to an advanced unmanned platform for training, testing of new unmanned

technologies, and promotional demonstrations otherwise prevented by the inherently high capital cost of market entry in this sector.
Our offer includes the provision of an Unmanned Air Vehicle (UAV) test bed (Blackstart) from Bluebear Systems, this air vehicle is less than 20kg which allows straightforward experimentation within CAA regulations. It has two test bays to allow testing of new communications and sensor equipment.
Finally, we are able to offer, as an option within this funding proposal, a simulator solution for underwater vehicles which will allow trialling of systems which operate within the three domains of above water, air and below water.

- **Secure Maritime Communications Network**
  A high-bandwidth radio network will be developed to support safe and reliable testing of unmanned surface vessels with coverage stretching across a range of test regions in the Solent area (the Solent Maritime Mesh Network).
- **Mobile Control Centre**
  A versatile mobile control centre will be provided to support sea trials, training, customer demonstrations and USV operations at a variety of Solent locations.
- **Safe Operations**
  The facility will provide a common approach to safety and regulatory compliance during unmanned operations.
- **Sector Growth**
  The outcome being to boost the growth and productivity of organisations operating in this sector in the Solent area and provide a catalyst for future autonomous systems and shipping.

Currently, individual enterprises are duplicating effort establishing the necessary infrastructure to grow this sector. Through the provision of an accessible, standardised autonomous test facility, linked with academia, industry experts and end-users, the Solent can become the natural focal point for world class collaboration between industry, academia, and public service bodies.

This proposal leverages the outcome of previous R&D programmes by BAE Systems to develop unmanned technology to support the Royal Navy at Exercise Unmanned Warrior 2016.

Figure 1 provides an overview of the Autonomy Test Bed. The main elements of the solution are a Mobile Control Centre, unmanned air and surface vehicles and a radio network. The Mobile Control Centre will contain a number of operator positions and a range of sensors (ADS-B is a potential future enhancement), it will also be capable of being integrated with the MISC at Portsdown which will give access to additional sensors and the ability to hold larger scale tests that can be conducted using just the mobile centre.

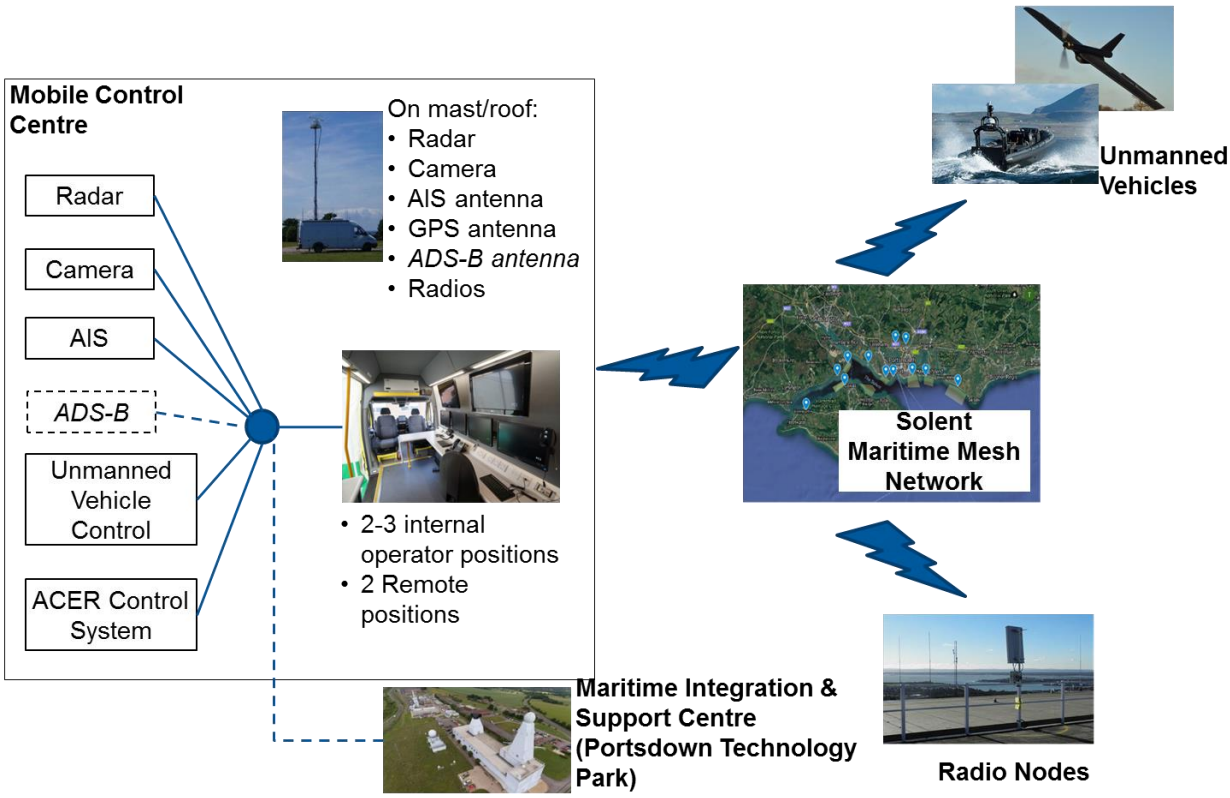

Figure 1: Overview of Autonomy Test Bed

An illustration of the type of demonstration we are able to support was our Unmanned Capability demonstration at the Maritime Integration facility in Portsmouth in June 2016, a summary presentation is available on YouTube:

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

2.1.1 Unmanned Surface Vehicle (USV)

Figure 2 shows the proposed unmanned surface vessel which is based on the 9m catamaran from Cheetah Marine based in Ventnor on the Isle of Wight. ASV will procure this vehicle and add the autonomous control software and hardware required to operate as an unmanned vessel. An example of this vehicle is shown – the actual vehicle may be differently painted and equipped. Note the space available for installation of test equipment as required and the protected wheelhouse for when manned operation is undertaken.

Figure 2: Proposed Cheetah Marine USV Hull

2.1.2 Unmanned Air Vehicle (UAV)

Figure 3 shows the Bluebear Blackstart unmanned air vehicle which will be procured under this proposal. This vehicle is less than 20kg and includes two payload bays for experimental loads which may include sensors, additional processing, and communications equipment. The Blackstart ground control station will be included in the ACER equipment in the Mobile Control Centre. The UAV has already been flown in trials from Langstone Harbour and Hayling beach and could be operated from a number of locations across the Solent including the BAE Systems site at Cowes.

The ACER equipment will include the capability to simulate one or more air vehicles and so development of autonomous control software for swarms of air vehicles, or trials with unmanned surface vehicles and simulated aircraft may be supported.

Although we strongly recommend this capability, if unaffordable it is possible to remove this element and we have shown the cost benefit of so doing.

Figure 3: Blackstart UAV

2.1.3 Unmanned Underwater Vehicles (UUV) - Option

Our offer includes an option for the provision of a simulator for underwater operations from SeeByte Limited who will deliver the project from their base in the National Oceanographic Centre in Southampton. This includes their SeaTrack and Nepture planning tools and a

simulator which will allow a combination of real trials using the USV and UAV plus any 3rd party vehicles provided, and simulated UUV's. A more complx example of such a trial would be where a USV rendezvous with a UUV to upload data from the UUV via the rebroadcast station on a UAV back to shore. All this can be planned using the tools on the MMC.

Figure 4: Neptune planning software

2.1.4 Mobile Control Centre

This proposal includes the development of a flexible, safe, and cost effective mobile control centre to support autonomous testing and training.

- Currently, unmanned vehicles can be expensive, time-consuming and hazardous. Today, testing is generally conducted from a manned support boat. This allows control at sea in close proximity to the test vessel and mitigates issues with unreliable, short range communication links and provides quick response in the event of technical problems or potentially hazardous incidents.

- Approximately 10% of the population suffer from severe motion (sea) sickness and 85% suffer symptoms to some degree. Companies operating in the maritime autonomy sector report difficulty in recruiting suitably qualified engineers who are resilient to motion sickness – particularly those required to undertake activities at sea such as software integration which require high levels of prolonged concentration and focus.

- Similarly, working at sea presents certain risks, and specialist training is required including sea survival training, and the use of personal protective equipment including life jackets and foul weather clothing.

- Live VIP demonstrations of unmanned systems can be inflexible, costly and difficult to coordinate. Typically visitors and prospective customers wish to see both the control system and the unmanned system and to achieve this normally involves the use of support boats. However, a surprising number are reluctant to embark. The additional time taken for safety briefings and transit to/from the operating area is considerable, and it is often difficult to accommodate more than a handful of visitors.

Moving to a land based mobile control centre removes almost all of these disadvantages.

The development of autonomous systems has highlighted the need for planning, control, monitoring and post analysis equipment. BAE Systems has been developing the operational control software for Naval ships to include these functions and will provide a complete set of this software for the Mobile Control Centre which can be used for Naval applications as well as to support civil or research goals.

The Mobile Control Centre vehicle will be fitted out by Marine Electronic Systems (MES) Ltd based at Totton near Southampton. MES will modify a vehicle already owned by BAE Systems and will fit electronics provided by BAE Systems along with a radar supplied by Furuno (who have an office at Havant) and other sensors and radio equipment.

Figure 5 and *Figure 6* illustrate the proposed concept for a mobile control centre. This customised vehicle will have the following key features:

- Radar and long-range camera systems mounted on telescopic mast
- Data radios to connect to the Solent Maritime Mesh Network (SMMN)
- Marine band VHF radios for voice communication with marine traffic
- ASView – an unmanned vehicle base station operator's console
- ACER – the BAE Systems control software developed for DSTL providing an open architecture control system for unmanned systems
- Space to host temporary 3rd party/client equipment
- A telescopic mast to extend operating horizon
- Room for seated operators
- Air conditioning and towed power generator where local mains power is not available.

Figure 5: Ground Vehicle based Control Station (previous supplier contract)

Figure 6: Example Control Station (previous BAE Systems project)

In the future, it is essential that the technology makes the break to land based control. This proposal is a key stepping stone to provide a flexible, safe and cost effective transition.

Our proposal will reuse a van which has already been procured and fitted with a mast. The vehicle will be stripped, refurbished and delivered in line with the proposals above.

2.1.5 Solent Maritime Mesh Network

To facilitate the use of the Solent as an autonomous testing and training hub, this proposal includes the provision of a secure L-band radio mesh network using a series of radios mounted on the roofline of selected buildings in 6 separate sites.

The intention at present is to provide a mix of radios at those sites. We will provide a mix of 5 Watt COFDM radios, UHF radios using TV White Space technology (which has straightforward OFCOM requirements), and WiFi/WiMax radios for maximum flexibility. The exact balance and positioning of radios being dependent on modelled propagation at each site to provide the right radio mix at each location – decided in the first 4 weeks of the programme. Also taken into account will be coverage of large swathes of the Solent seascape and specifically an agreement with the MCA (Maritime & Coastguard Agency) shown in *Figure 8.*

The sites are intended to include, but not be limited to, the MISC building at Portsdown Technology Park, the National Oceanographic Centre (NOC) Innovation Centre in Southampton and BAE Systems premises at Cowes on the Isle of Wight, in addition to the radios on the unmanned vessel and mobile control centre.

Figure 7: Example Radio Node at Portsdown Technology Park

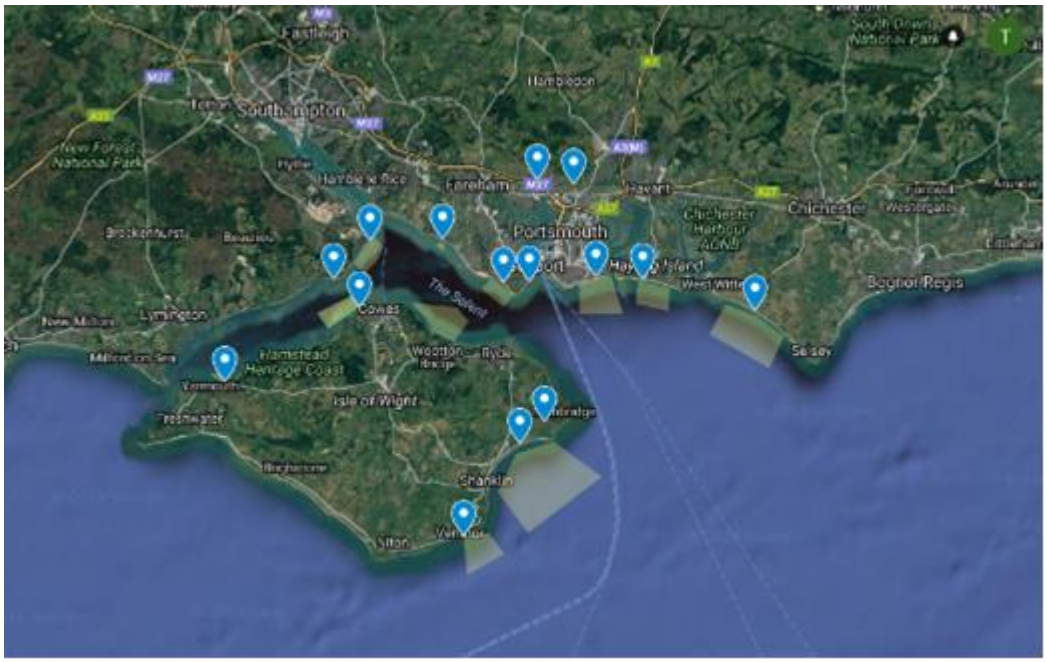

Figure 8: Example Solent Area Operating Areas, radios will not be provided at all of these bases (coverage of COFDM radios shown, UHF has better operating ranges)

The details of the current OFCOM radio license is listed below, but a new license will be required to overcome some of the specified limitations.

Class	Science & Technology
Frequency	1310 MHz
Max Effective Radiated Power	9.35 dbW
Channel Width	Not defined
Antenna Type	Omnidirectional
Antenna Gain	4.5dB
Antenna Height Above Ground	10m (3m above sea level in vessels)
Area Covered	Within 50km of ASV office

BAE Systems also have operating licence for the UHF radios using TV White Space in the Solent area. The Wifi radios need a special, but easily obtained OFCOM licence to transmit at slightly higher powers (when taking into account the transmitter and antenna gains) than normally permissible in these bands.

2.2 Project Rationale

Now is the time to develop the Solent as an autonomous testing and training hub. The opportunity exists to provide a coordinated approach to the exploitation of the UK and international Marine and Maritime Surface Autonomy sector, developing essential enabling infrastructure, common operational processes, promoting collaborative enterprise behaviours and removing barriers to market entry.

The Solent is ideally suited as a hub for Marine and Maritime Autonomy due to the number of existing academic and commercial enterprises in the area and the proximity to Portsmouth Naval Base and the commercial ports at Portsmouth and Southampton. The sector is growing rapidly and now is an ideal opportunity to kick-start a locally collaborative approach that does not exists elsewhere.

2.2.1 Alignment to Solent LEP Strategic Priorities

The Solent LEP vision is to create an environment which will better facilitate growth and private sector investment in the Solent area, allowing business to grow, become more profitable and enable new businesses to form and prosper.

It identifies marine and maritime as the largest sector in the Solent region and establishes the route to reinvigorate its 'Global reputation for marine and maritime excellence through integrated leadership and planning, new technologies and promoting *Brand Solent*'.

This proposal aligns perfectly with Proposal LGD28 "Marine Autonomous Systems Test-Bed" identified in "TRANSFORMING SOLENT – Marine and Maritime Supplement" by Rear Admiral Rob Stevens in March 2014 and the Solent sponsored recommendations from the UK Marine Industries Technology Roadmap.

2.2.2 Supporting Solent LEP Strategic Sectors

Clear support is evident for the Solent key areas of air, marine and maritime autonomy, defence, and advanced technologies and is likely to provide opportunities in the long term transformation of the ports of Southampton and Portsmouth - when unmanned technologies eventually become mainstream business. This technology will have a major impact on commercial shipping and this project will help position the Solent region at the forefront of this future transformation.

2.2.3 Brand Solent

We intend to brand the test bed including the name "Solent" to identify the capability and establish it within the autonomy domain. Within this document we have referred to this as "*Brand Solent*".

This proposal supports *Brand Solent* directly by providing a "shop window" to the Marine and Maritime Autonomy sector which does not currently exist. The very nature of the industry has, to date, been largely conducted out at sea, where the public, prospective customers and investors have no direct access.

It will complement the synthetic testing environment provided by the Centre for Maritime Intelligence Systems (CMIS). This partnership at Portsdown Technology Park has already been the subject of investment by the Solent LEP, and offers demonstration facilities and a synthetic environment. It would be our intention to negotiate a link into the CMIS to allow the test bed to provide a physical demonstration capability.

By bringing the control of unmanned vessels on-shore, we will massively increase the visibility of autonomous testing and training capabilities. A mobile control centre provides the opportunity to promote the capability at key International Maritime events such as the Southampton Boat Show, Cowes Week and Seawork exhibition. The opportunity provided by a custom sign-written vehicle to advertise the Solent's activity in this sector while parked up or moving should not be underestimated.

2.2.4 Innovation

The Marine and Maritime Autonomy Hub proposal provides a unique, innovative test and training capability for the Solent. BAE Systems, Bluebear, Seebyte and ASV have significant Intellectual Property, patents and innovative technologies which can be brought to this programme.

By providing a standardised, open architecture test and development environment with standard operating procedures, a community of practise will form which will stimulate innovation, new business partnerships and the creation of novel intellectual property in all areas of the emerging unmanned systems sector. This will include, but not be limited to, safe unmanned navigation, route planning and obstacle avoidance, advanced autonomous and agent based behaviours, launch and recovery and the development of machine deployed payloads.

2.2.5 New High Value Jobs

Growth in the Marine, Air and Maritime Autonomy sector will generate new high value job opportunities in project management, naval architecture, communication systems engineering, electronics, software, control systems and data and image processing. While

the jobs created directly by this proposal are modest, it is anticipated that the indirect growth could be considerable. ASV Ltd has grown from two employees to more than 60 in just six years, representing a significant success story, and the aim is to repeat this success across the sector particularly for SMEs. Seebyte have established a facility within the National Oceanographic Centre. Bluebear will support UAV operations from within the Solent area and although based in Bedford are looking to establish a facility in the Solent area within the next 18 months.

2.2.6 Productivity

This project would aid Solent productivity by providing the essential sector-specific capital assets required to enable small businesses, academia and larger companies alike to focus on the innovative, new technology ideas that really create value and drive future sector growth.

By removing the need for enterprises to invest in the costly up-front capital required for this sector, and by rolling-out proven and cost effective risk, safety and regulatory compliant working practises, resources can be focussed on the generation of new and better value-adding technologies.

The technologies developed with this project will be high value, high margin items with export potential - the type of work which will significantly enhance Solent productivity measures.

By allowing enterprises to share a common infrastructure, the Solent will grow its critical mass of expertise and attract new investment. Leveraged through a strong existing marine sector, and the proximity of commercial shipping ports and Naval Base, the Solent is ideally located to attract further levels of private sector investment.

2.2.7 SME Support

By its very nature, this proposal will benefit SMEs hugely by providing access to assets and facilities they could not normally get access to or afford. It is to the benefit of BAE Systems and other major prime contractors to develop SMEs. More than 70% of BAE Systems' approved suppliers are classified as SMEs and they provide innovative and agile solutions which complement the capabilities of large businesses.

2.2.8 Skills and Education

Training and certification for future unmanned systems operators is an issue only just emerging within the sector, and a recent meeting of the Maritime Autonomous Regulatory Working Group identified that only BAE Systems has current plans to address this need. There is opportunity, through our subcontractors, and in collaboration with local higher education establishments including the premier Solent universities and Warsash Maritime Academy to incrementally develop a world class training and certification programme recognised by the Maritime & Coastguard Authority (MCA).

We are currently in discussion with Southampton University, DSTL and NOC regarding opportunities to make use of these facilities to underpin Undergraduate and Master's course modules with practical experience.

2.2.9 Wider Economic Impacts

The provision of unmanned systems infrastructure in the Solent area will:

- Facilitate applied research at facilities such as DSTL and NOC
- Attract graduate applicants to courses at universities able to make use of these facilities
- Attract new businesses otherwise unable to bear the high start-up costs in this sector
- Consolidate the Solent's position as the leading UK hub for marine and maritime industries
- Attract inward investment from international companies wanting to develop technologies in this space.

2.2.10 Social and Environmental

The Solent has a proud heritage of air, marine and maritime industries, and unmanned/autonomous vehicles have the opportunity to start a new and exciting chapter in this story.

Work undertaken on the proposed infrastructure will help reassure regulatory bodies and the wider public that unmanned marine systems offer safe and predictable behaviour in the vicinity of other sea users, and help the long term transition to wide scale adoption.

The project will help enhance the region's 'technology' reputation; the like of which has been so successful in places like Singapore, San Francisco and Boston. The project will build upon the Solent's growing capability in autonomy.

These positive social impacts on the younger generation will be to encourage them to be proud of the Solent as a growing and vibrant area for innovation and development which will not only encourage home-grown talent but will also act as a talent magnet for innovation in the autonomy sector.