Energy in Motion – A cost effective , re-useable solution for power & communications delivery offshore

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OPT introduction

Introduction video

PB3 - History of Development

Challenge: To improve range and resolution of offshore maritime surveillance

Customer: US Navy, US Department of Homeland Security

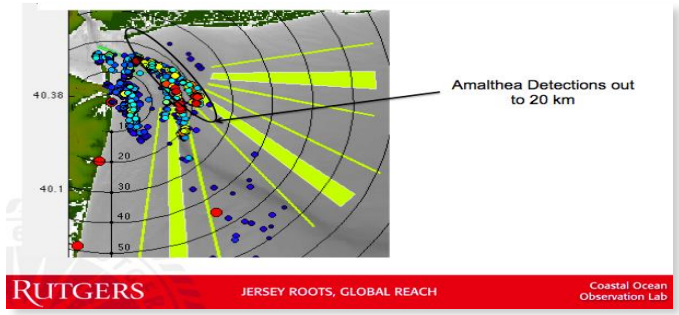
Location: East Coast USA (Atlantic)

Result of project:

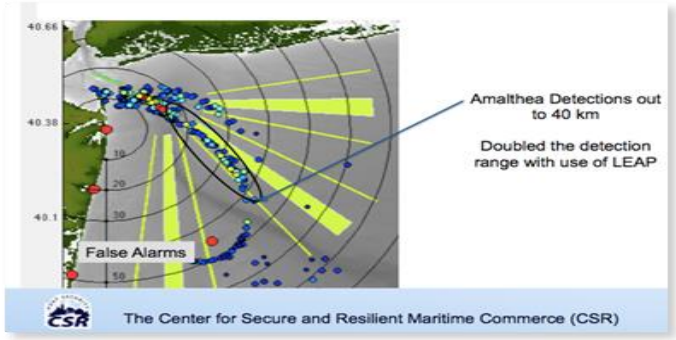
- **Increased performance**
  - Increased range and resolution
  - No false targets so quicker resolution of problem
  - Provided operational capability in rough weather

  (Operated through Hurricane Irene)

- **Reduced cost**
  - Reduction in ship time (no false target investigations)
  - Better allocation of resources



Better, more accurate data enables more efficient use of assets and improved performance



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PB3 -History of Development : Technical Advisor Panel (TAP)

- Seven members :
  - Gardline Marine Sciences,
  - DNV GL,
  - University of Western Australia (UWA) Centre for Offshore Foundation Systems (COFS),
  - Two major Oil And Gas Operators
  - International O&G equipment manufacturer
  - Leading meteorological and oceanographic sensor manufacturer.
- Formed to intensify efforts to accelerate PowerBuoy™ commercialisation and market adoption
- Purpose: To review and provide valuable expert industry feedback on market and application requirements and test protocols in order to increase speed to market.

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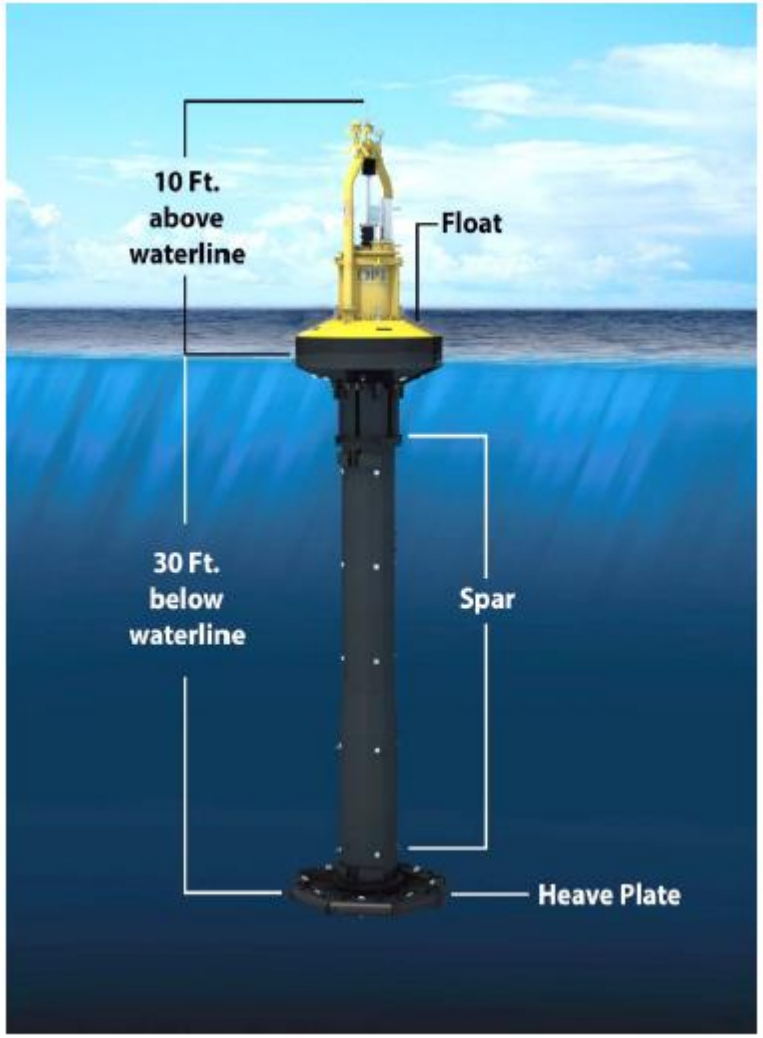
How does it work?



The PowerBuoy consists of a float, spar, and heave plate

The float moves up and down the spar in response to the motion of the waves.

The heave plate maintains the spar in a relatively stationary position.

The relative motion of the float with respect to the spar drives an internal mechanical system in the spar that converts the linear motion of the float into a rotary one.

The rotary motion drives electrical generators that produce electricity

Electricity is provided to the payload or is exported to nearby marine applications using a submarine electrical cable.

Excess electricity not needed for the payload is stored.

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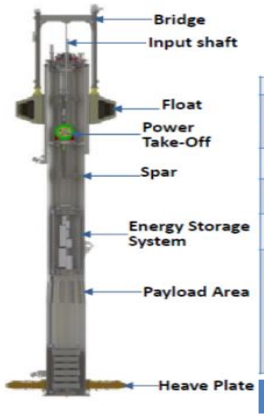
The Commercial PB3

Two PB3 PowerBuoys that were deployed off of the coast of New Jersey, USA 2016



Dimensions	Electrical
Total Height: 14.3 m	Guaranteed continuous power 350W 24/7 for 7 days or 100W for 14 days (programmable)
Draft: 10.8 m	Average Power Capacity: 8,400 Wh/Day (Annual Average: Site Dependent)
Spar Diameter: 1.0 m Float Diameter: 2.7 m	Payload Peak Power: up to 3 kW peak power to load; 7,500 W (custom)
Weight: 10,000 kg	Battery Capacity (ESS): 44 kWh modular and scalable up to 150 kWh
Mooring : Single or three point Minimum Depth 20m Max Depth w/standard design: 1,000 m *Other mooring designs available for deeper deployments	DC Output: 24 Vdc and 300 Vdc (standard) 5 Vdc to 600 Vdc (custom) AC Output: 100 V to 480 Vac, 50/60 Hz Power Generation Sea States: 1-6

Communications	
Wi-Fi	802.11, 54mbs@200m
Cellular	GSM, GPRS, 3&4G, CDMA
Satellite	Iridium, Inmarsat

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Atlantic Ocean Deployment Data July 2016– 10th December 2016

Measurement	Highest Single Hourly Total (kW)	Highest Day Total (kWh)	Deployment Avg. (W/hr)	Deployment Total (kWh)
Generator Power	**1.450**	**34.742**	**357**	**1,242**

4+ years of equivalent continuous operation validated

Metric	Ocean Test	ALT	Total (Ocean + ALT)
PTO strokes (zero crossings)	2,528534	~60,000,000	62,528,534

PB3 in Action

PB3 deployment video

PB3 using camera video

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PB3 Applications – FEED, E&P, IM&R

Ship transit and rig communications/telemetry

Remote metocean system

Reservoir pressure monitoring

Security and Navaids for exclusion zone /Incursion evidence gathering

Near Term Applications

Well head & down hole gauge monitoring

Pipeline leak & motion monitoring

Powering an AUV docking station for residential IM&R and E&P

Power for NUI's

Powering & control of subsea trees

Medium Term Applications

Powering & control of local chemical injection & HPU's
(umbilical replacement & intervention)

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PB3 Applications - Decommissioning

Saving of 62 - 85% compared to current guard vessel costs over 6 months (operator verified figures)

Activity	Project Phase	Application	Description
		Well head leak monitoring	WP&A is a critical procedure and operators and the regulator need to ensure that there is no leakage. The PB-3 offers a long term monitoring solution
		Reservoir pressure monitoring	Prior to decommissioning operators often leave the well dormant. During this period, the reservoir will often "re-pressurise" allowing the operator to return and open operations. The PB-3 offers a long term monitoring solution
		Hotel Power	The topside removal is a long and complex process during which the main power generator has been removed. The PB-15 (or multiple PB-3's) could offer hotel power to keep alive priority systems
	Cold Suspension onwards	Drill cuttings monitoring & disturbance deterrent	The most important environmental concern is the pile of drill cuttings left from operations on the sea bed that contain contaminants. These are often left in situ rather than disturb them by removal. Disturbance is a concern during the removal of the structure and also post removal
Jacket removal & long term monitoring	Cold suspension onwards	Guard Vessel replacement – (Navaids for exclusion zone /Incursion evidence gathering)	Once the topside has been removed, the jacket is a navigation hazard that needs a 500m exclusion zone. As there is no power at this stage, the PB-3 offers a great multi functional system. The jacket can be left in situ for up to 2 years before removal
Topside removal	Cold Suspension & Removal	Bird scaring	When there is no activity on the platform/FPSO birds often use the structure. Their fouling often causes a H&S risk for workers.
All	Cold Suspension onwards	Met ocean	One of the biggest costs in the programme is lost hours due to weather conditions. Thus, on site knowledge of real-time met ocean conditions can improve efficiency greatly.

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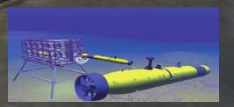
Future - Residential AUV Networks (Conceptual)



Why Residential AUV's?

Business Advantages

Current Practice	Residential AUV	Benefit
Operation from onsite vessel @ $50-100K/day	No onsite Vessel - system designed for 3 years of maintenance free continuous operati	Reduce O&M costs
> 1 week emergency response	Immediate	Mitigate Production losses
Inspection interval 2-4 years	Daily inspections	Increase Integrity Assurance
60 people working offshore	1 remote operator on land	Mitigates H&S
On site weather conditions hamper operations	No interruption – (PB-3 is particularly suited to remote and harsh environments)	Increased operational efficiency

Must be connected to existing infrastructure (rigs or at wellhead) for power & comms

PB3 enabled Operational Advantages over current residential AUV's

Current Practice	Issue	PB3 Benefit
Limited deployment locations : AUV garage must be either connected to a rig or tied into existing subsea electrical & comms infrastructure	• Limited distance of operations • Costly to install • Upgrade of existing infrastructure	• Can deploy anywhere quickly to enable AUV operations along complete pipeline. • Totally autonomous from infrastructure. • Low cost & minimal site impact. • No re-design needed
Suitable for larger fields only: Needs to be in place for long periods due to cost of install (no short term deployments)	• Only suitable for some sites. Smaller sites may not be cost effective. • Not cost effective for short term deployments	• Dynamic infrastructure. • Can be deployed & moved later with minimum cost. • Short & long term deployments are easy to do

Development

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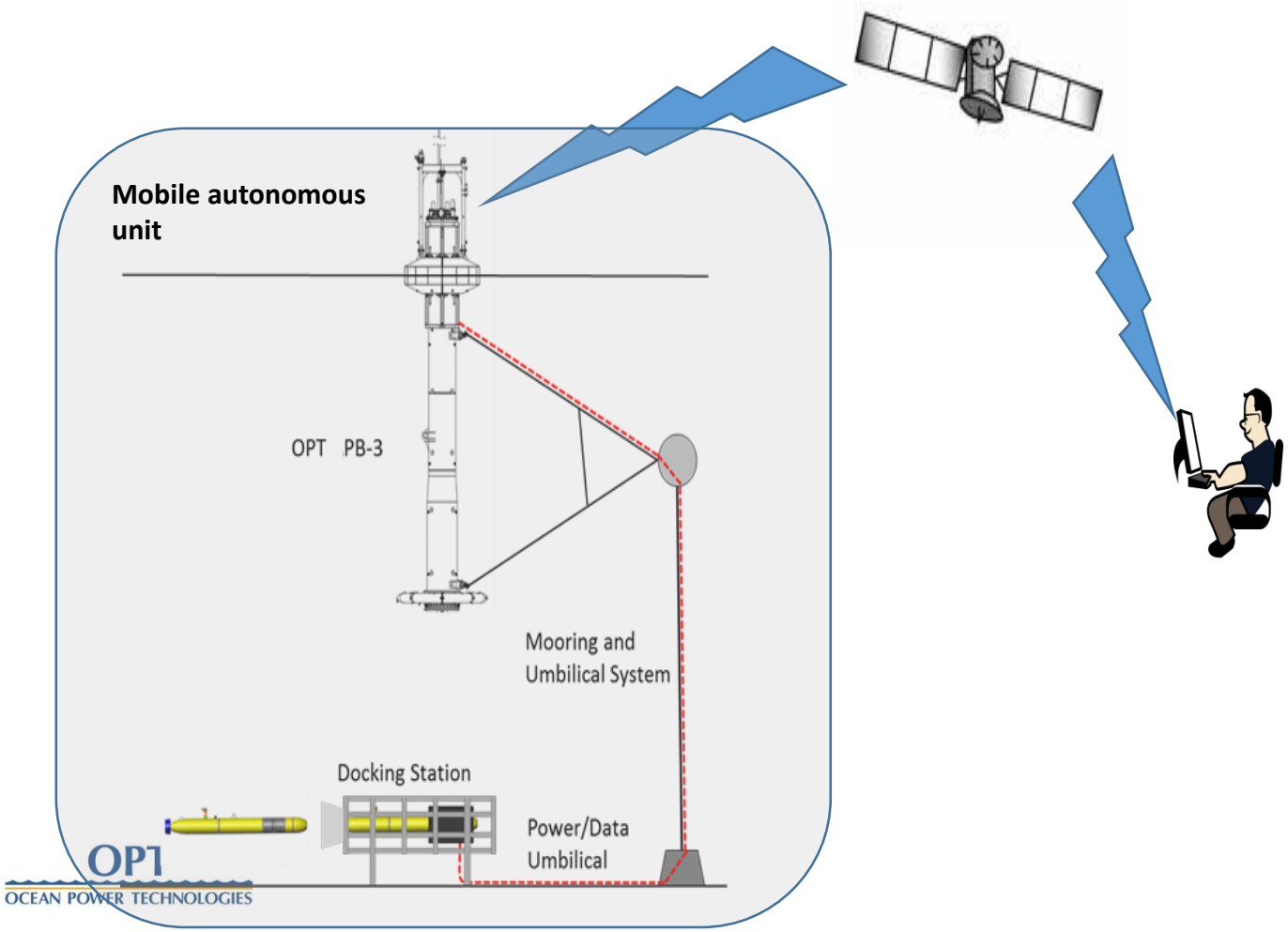
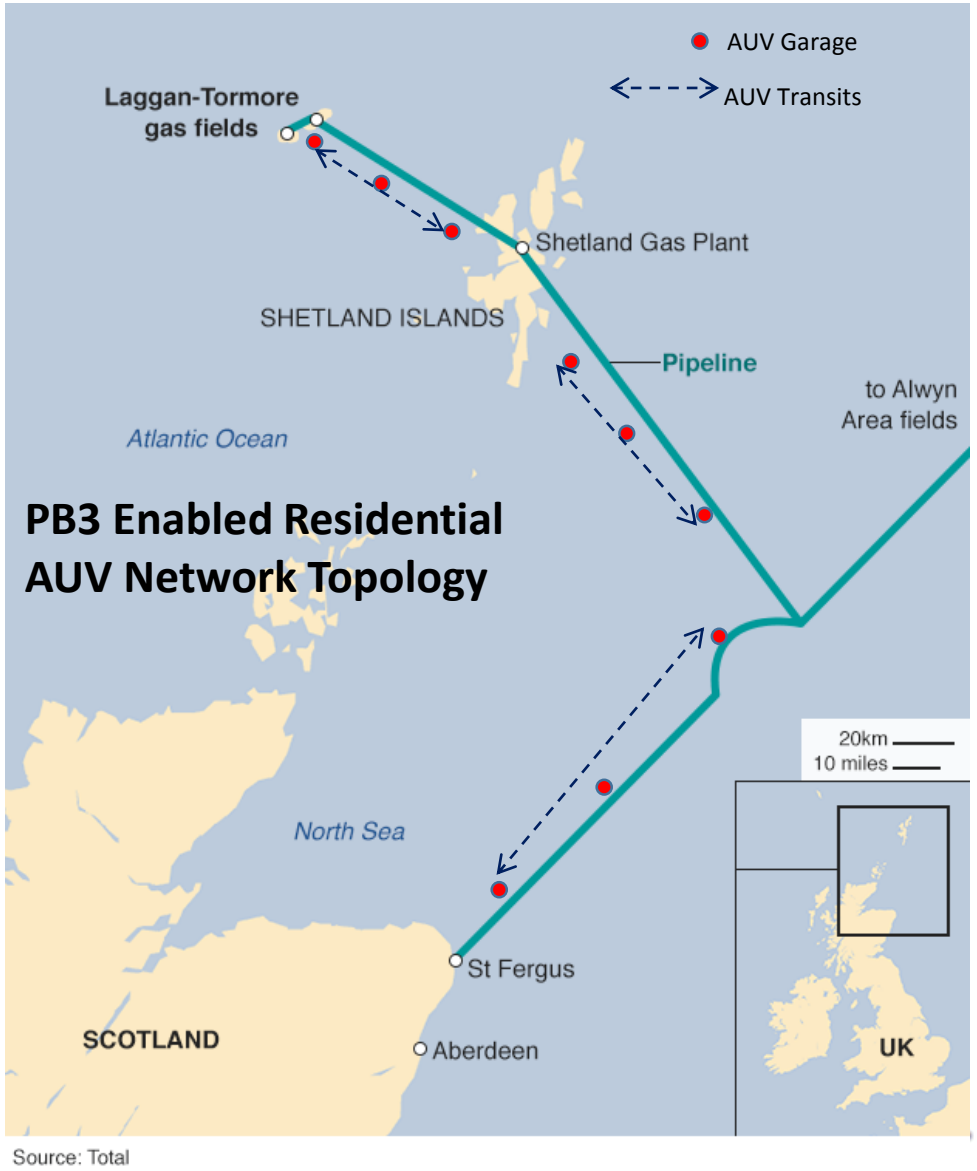
PB3 – Residential AUV configuration

Typical time to deploy on site 1-2 days





Source: Total

Conclusion – What doe s the PB3 deliver?

A substantial reduction in the cost of delivering power & communications for a variety of offshore operations

- A re-usable platform tested to North Sea conditions
- Real-time operational control
- Increased safety of personnel
- New cost effective operations across the whole offshore field life cycle

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