A Novel Way to Acquire Data in a Safe, Reliable and Cost-Effective Manner by the Use of Autonomous Marine Vehicles*

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Abstract

This presentation covers advances made with the use of autonomous marine vehicles (AMVs) to acquire data in a safe and reliable manner managing risk:

- Collect and validate Metocean data,
- Monitor loop and eddy currents,
- Surface oil slick detection and in-situ measurements,
- Early tests in seismic acquisition and processing.

Hence derive and implement solution driven conclusions from lessons learned for future offshore missions. To achieve these objectives, AMV's equipped with sensors to conduct the above services were deployed.

The METOC vehicles equipped with Teledyne RDI Workhorse acoustic Doppler current profilers (ADCPs) were launched to patrol an area where they monitored and delineated eddy current features at near-surface depths. The Hydrocarbon vehicles monitored areas identified by the client with natural seep-related hydrocarbon surface expressions. Both vehicles were used for detection, in-situ measurement of, and delineation of plumes, they were also equipped with optical sensors which provided real-time imaging for the duration of the mission. The above mission demonstrated a new and novel way of using technology that is safe, environmentally friendly and cost-effective.

Traditional data acquisition methods are expensive, limited in range and mission duration, and must be regularly maintained. Implementing remote monitoring and survey technologies at lower data acquisition costs and with greater operational efficiencies, the AMV provides a significant competitive advantage to acquire data in a safe and reliable manner. This presentation will develop into discussing these case studies in detail with references to projects conducted word-wide but primary focus on this particular region. Value proposition and lessons learned will be discussed. To date, 25 missions have been conducted for 12 different clients, half of them repeat clients.

GEO 2016

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Sudhir Pai, Managing Director

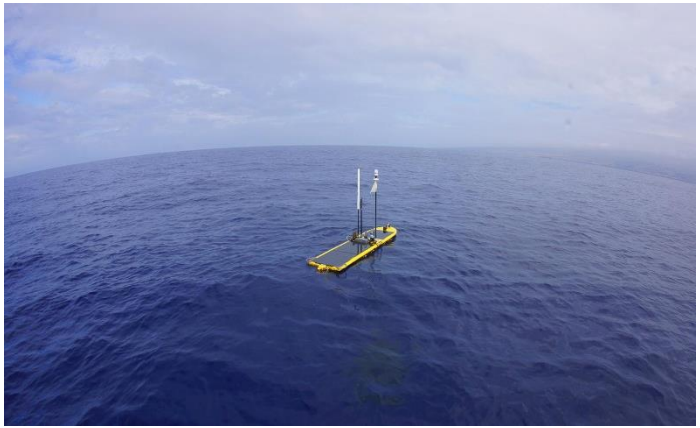
Liquid Robotics Oil and Gas,
A joint venture with Schlumberger

Tim Perrin, Chief Geophysicist

Schlumberger WesternGeco

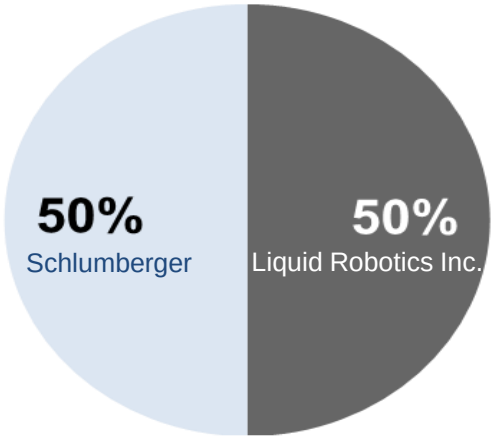
liquid robotics OIL+GAS

- Who we are and what we do
- Technology
  - The Wave Glider®
  - Sensors
- Business applications
- Case Studies
- Benefits to Drilling Industry

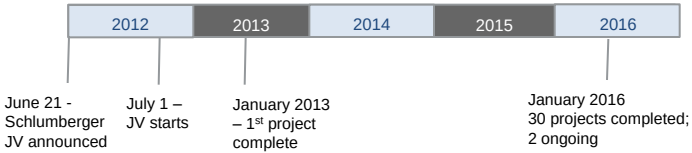


Liquid Robotics Oil and Gas Overview

- A joint venture with Schlumberger
  - Oil and Gas business managed by the joint venture
  - Liquid Robotics, Inc. (LRI) continues to run non-Oil and Gas business
- Oil and Gas Based in Houston, TX, USA
  - Technology: Wave Glider the flagship product, operates in marine environment
  - Engineering customization
  - Data acquisition and data management for exploration and production customers

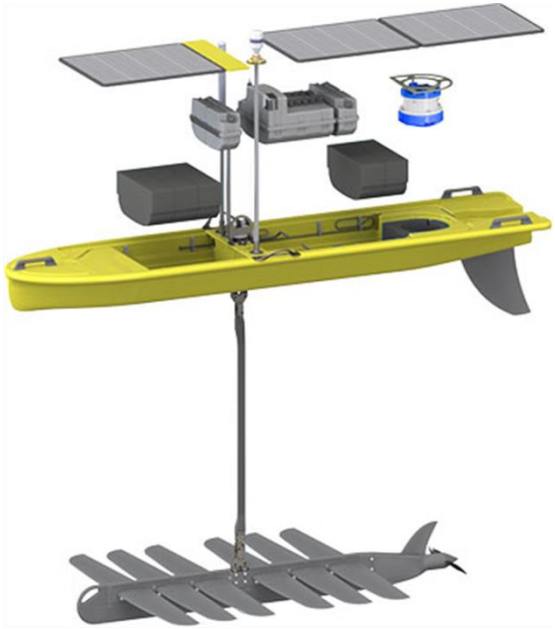


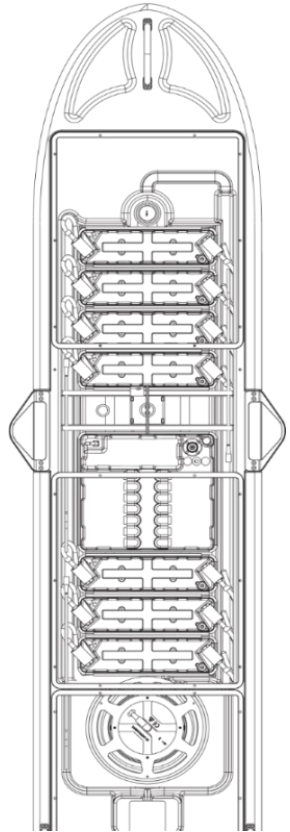
Milestones



The Wave Glider Technology

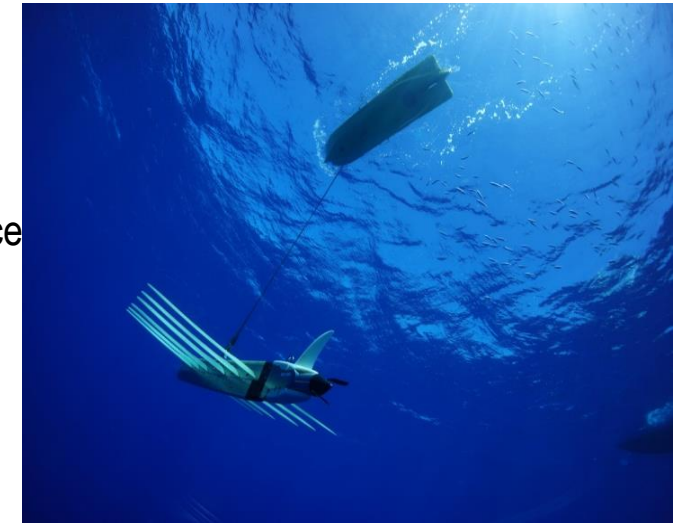
- **Wave and solar energy harvesting system**
  - Dual wave and solar propulsion
  - **Solar power** for computing, communications and sensor payloads
- **Wave Powered Sub**
  - Wing system converts **wave energy** into forward thrust
- **Hydrodynamic Float**
  - Modular design for maximum payload and solar collection capacity
  - Designed for speed and endurance **with optimal water depth**
- **High speed Umbilical**
  - Connection between the Float and Sub
  - High power, high data rates
- **Adaptable Modular Power system (AMPS)**
  - Advanced power system with large rechargeable battery capacity
  - Flexible, modular design
- **Solar Powered Auxiliary Thruster**
  - For thrust and burst speed





Business Lines

- **METOC**: Meteorology and Oceanography
  - Exploring the physical parameters of the ocean-currents, temperature, etc.
  - METOC-ADCP (Acoustic Doppler Current Profiler);
  - METOC-WDR (WatchDog Rig)
- **SEEP**: Hydrocarbon detection
  - Pre-site and oil spill surveys
- **GATEWAY**: Communication between subsea wellheads and surface
  - Acoustic data harvesting
- **MAG**: Magnetometer measurements
  - Assisting the drilling industry better plan wells
  - Specifically near arctic and equator
- **SEISMIC**: Complimenting streamer technology
  - 100% with WesternGeco
- **PAM**: Passive Acoustic Monitoring
  - Marine mammal monitoring (GOM, Australia, Arctic)
- **OTHERS**: Security, TURBIDITY, long distance communication



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Proven Operational Capability

Wave Glider Operations

- Mediterranean
- Gulf of Mexico
- Australia
- North Sea
- Great Lakes
- Coral Sea
- Pacific
- Atlantic
- Indian
- Arctic
- St. Lawrence River
- Middle East
- Brazil

Case Study – Gulf of Mexico METOC and SEEP for pre-site surveys

Project Description

Test and validate the utilization of autonomous marine vehicles (AMVs) for pre-exploration mission to collect and deliver metocean data and monitor loop and eddy currents. The vehicles were also used to detect surface oil slicks and provide in-situ measurements.

Location: Gulf of Mexico

Solution

Four AMVs were deployed, two Metocean vehicles equipped with Acoustic Doppler Current Profilers (ADCPs) sensors and two with hydrocarbon detection sensors. The metocean vehicles provided an comprehensive knowledge of meteorological and oceanographic events in the region. The hydrocarbon vehicles assisted in getting a background pre-site survey done to establish and benchmark the area.

Results

These missions demonstrated a new and novel way of using technology that is safe, environmentally friendly and cost-effective. Traditional data acquisition methods are expensive, limited in range, mission duration and must be regularly maintained.

Case Study – Gulf Of Mexico METOC for Close Pass Seismic

Project Description

In the process of seismic exploration, commercial vessels tow multiple acoustic streamers listening for the reflection of acoustic energy from the sub-surface. Close passes near oil platforms optimize data acquisition but are of significant risk without real-time measurement of currents and weather information.

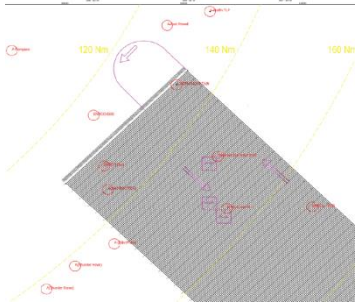
Location: Gulf of Mexico

Solution

Perform a METOC survey with three Wave Gliders placed outside the extrusion zone but “facing” the operation to give early warnings should expected current profiles due to various meteorological and oceanographic phenomena change.

Results

The information helped the seismic survey party chief determine how closely the vessel could pass obstructions while avoiding streamer entanglement. Using the AMV improved the efficiency of the streamer survey because it safely ensured that an optimal amount of the survey area was covered in a safe and efficient manner.




Horn Mountain Platform


Ensco 8506 Platform


Noble Jim Day Platform

Case Study - SEEP Hydrocarbon – Surface Oil Monitoring

Project Description

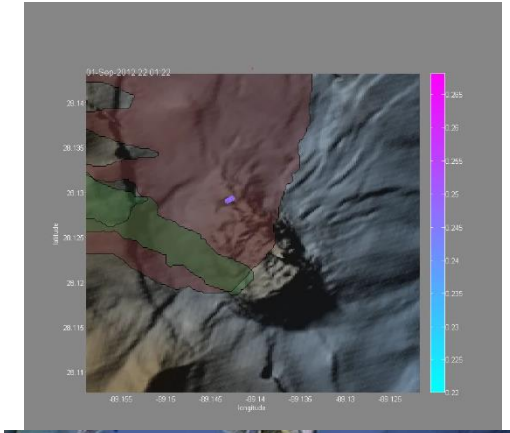
In 2010 Liquid Robotics began work to deploy Wave Gliders to help monitor surface slicks.

Location: Gulf of Mexico

Data Snapshot

6 Month deployment
8,669 Nautical miles traveled
2,109,649 Fluorometer points measured, transmitted, and recorded
132.930 Weather points measured, transmitted, and recorded
78,759 Ocean current points measured, transmitted, and recorded
2,570GB of Acoustic data measured and recorded
9,576 Wave Glider hours at sea requiring only 62 hours of boat operations at sea

Work culminated in a presentation of results at the Offshore Technology Conference (OTC) in 2013.



Seismic Acquisition with Wave Gliders v/s OBN

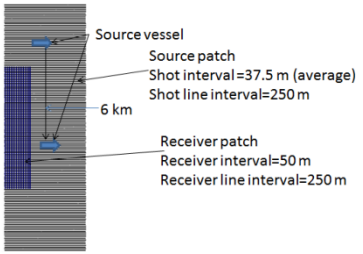
Marine acquisition using Wave Gliders: A field feasibility test
Nick Moldoveanu, Antoun Salama, Olav Lien, Everhard Muyzert,
Sudhir Pai, Schlumberger Dave Monk, Apache Corporation

Summary

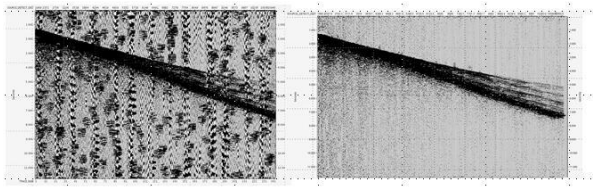
In the summer of 2013 Apache conducted a field test in the Gulf of Mexico to acquire seismic data during an ocean bottom node (OBN) survey using unmanned water vehicles, towing a miniature streamer…We present the results of this test and compare the seismic data acquired with the Wave Gliders and OBN.

Results

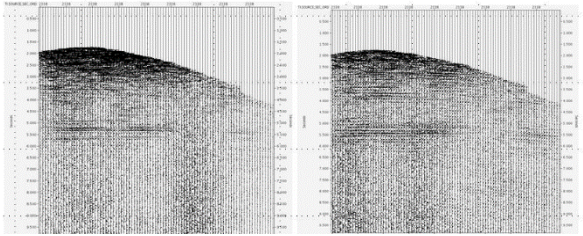
The field test proved that wave gliders equipped with streamers could be used to acquire seismic data that is usable and comparable with the node data. This field test conducted during a node survey gave us the possibility to evaluate the operational and data processing aspects of the wave glider platform marine acquisition and to do a very useful comparison between OBN and miniature streamer Wave Glider data.



Source and receiver patches of the OBN surveys



Wave Glider shot gather after a 2 Hz low cut filter was applied (left) and after deblending (right)



Comparison between wave glider data (left) and node data (right), at the same location

Seismic Acquisition with Wave Gliders v/s OBC

- Deployment
  - 3 wave gliders equipped with 3D sensor arrays (3DSA) during a Q-Seabed OBC survey and acquire seismic data during shooting of two source patches
- Evaluation
  - evaluate the performance of the 3D seismic array
    - holding station capability
    - maintaining the desired depth
    - accurate measurements of the pitch and the orientation (azimuth)
- Comparison
  - Compare quality of seismic data acquired with the wave glider vs. OBC Q-Seabed data

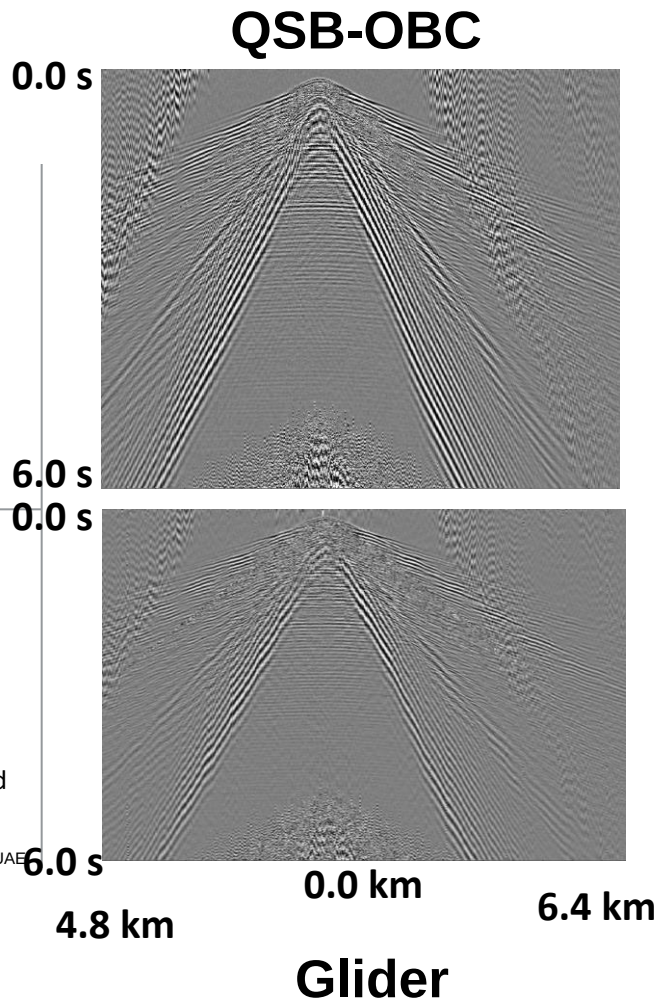
Results

3D SA evaluation criteria indicate consistent performance

Field test results show data quality of 3DSA single hydrophone CRG and Q-Seabed hydrophone CRG is comparable in terms of signal-to-noise and frequency bandwidth

With the exception of the non-repeatable swell noise, the same type of noise that is recorded and visible on OBC hydrophone data is recorded and visible on 3DSA data

Sholte waves are slightly weaker on the 3DSA data due to the propagation through the water



Courtesy ADMA UAE

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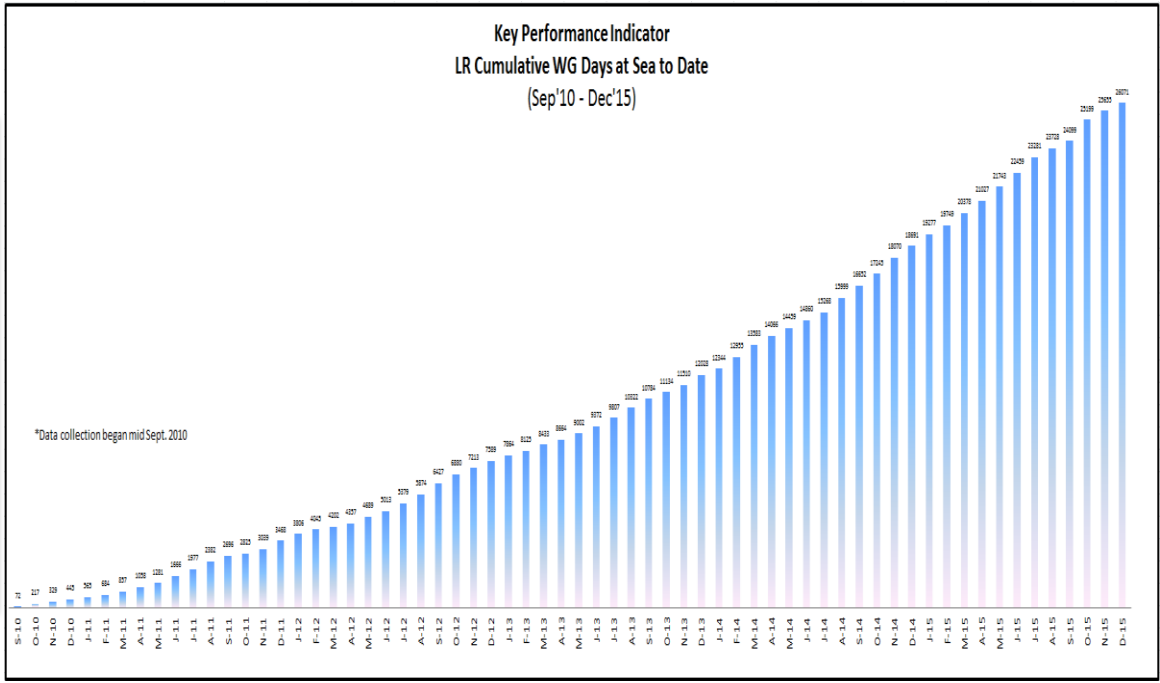
Statistics

15	Hurricanes navigated
51	Unique sensors integrated
282	Vehicles manufactured
9,380	Longest single mission (NM)
22,000+	Total days at sea
400,000+	Miles traveled to date
24,000,000	Data packets delivered



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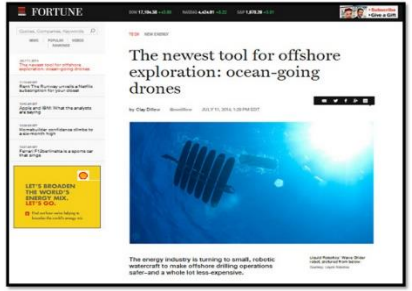
"These vehicles will provide us a steady stream of data about water quality and should significantly increase the available data for ongoing research activity."
Chief Operating Officer - BP Gulf Coast Restoration Organization

"Using a Wave Glider to harvest data acoustically from seabed instruments is a highly economical, and sustainable way to monitor our production"
Geophysicist - Shell's Aerial Monitoring research team.

"Innovation and technology play a huge role in environmental monitoring could we continue to collect data in the same way we always have collected it, absolutely we could. Is that really what we should be doing with Chevron or should we be pushing the envelope, how can we do things safer, smarter, better? We just started thinking about what else could we do, have we challenged ourselves to think of some new innovative ways to collect data and the Wave Glider came up."
Wheatstone Environmental Manager - Chevron Australia"

Each craft collects a wide range of information that is valuable for an offshore exploration and production environment,"
Manager, New Exploration Ventures - ConocoPhillips



2014 Harts E &P Meritorious Award
for engineering outstanding innovation in systems integration

2010 Technology Innovation Award
Wall Street Journal

WORLD ECONOMIC FORUM
Technology Pioneer 2013

theguardian cleantech Global Cleantech 100 we're on the list.

Chevron

WINNER

2014 World Oil Awards
New Horizons Idea

The Economist Names
Liquid Robotics as Top Innovator for the
2015 Ocean Innovation Challenge

GOINGGREEN

Going Green Global 200
AlwaysOn
2012

Global Cleantech 100
Cleantech
2012

2012

GoingGreen Global 200 -WINNER-

RBR 50

Fast Company
2012

M T R

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Pete Spain - Teledyne
Iain Walsh - Wet Labs Inc

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