Capabilities and Uses of Sensor and Video-Equipped Waterborne Surveillance-ROVs for Subsea Detection and Tracking of Oil Spills

IOGP-IPIECA Oil Spill Response Joint Industry Project Surveillance, Modelling & Visualization.

Work Package 1: In Water Surveillance

Table of Contents

1 Executive Summary

This report is one of a series of reports in the IOGP-IPIECA Oil Spill JIP, which examines the latest tools and techniques under the headings of “Surveillance, modeling and visualisation.” Under the surveillance heading, two reports focus on systems and sensors working at the surface or in the water column. This report provides a summarization and analysis of the current ROV fleet assets currently available to the market and provides a follow-up evaluation of the current sensors available for monitoring hydrocarbons, including video cameras. This document builds upon the Battelle report “Capabilities and Uses of Sensor-Equipped Autonomous Oceanographic Vehicles for Subsea Detection & Tracking of Oil Spills” (published November 2014) which focused on the overall compatibility of candidate oil detection sensors and autonomous ocean vehicle (AOV) platforms. The scope is extended to cover additional items including ROVs and Video Based Surveillance Systems.

The report also provides a summary review of sensors capable of detecting and monitoring hydrocarbons. This also builds upon the Feb 2012 report from TOTAL titled, “Observations of Marine Pollution by Hydrocarbons”. This section also includes follow-up information from the 2013 Report from API titled “Monitoring Hydrocarbon releases in Deep Water Environments” Additional comment and findings are provided related to the monitoring recommendations made in the US National Response Teams Guidance (May, 2013) Environmental Monitoring of Atypical Dispersant Operations”

Additional summary recommendations are provided that include certain oil spill scenarios based upon the the types of scenario identified in the IOGP-IPIECA Good Practice Guidance (GPG) Series. The summary recommendations include the utility and prioritization of combinations of platforms and sensors in order to achieve the best probability of success of the detection and monitoring of hydrocarbons in a given response scenario. These are based upon the operational limitations of conducting emergency response operations and the availability of the proposed platforms within relevant timeframes (i.e. some equipment may need to be available 24/7 with duty personnel to operate).

2 Unmanned Underwater Vehicles (ROV Focus)

Waterborne surveillance is a critical area for incident response and operational use. The various marine platforms available to the industry continues to grow in count and complexity as more deepwater exploration continues due to increased energy demands. The platforms themselves (the ROVs, AUVs, etc.) provide the basis for utilizing the various sensor packs and tools listed in this report and extends the capabilities of the operators to ensure that safe and effective operations are carried completed to plan. This report provides an overview of the available equipment as of 2014 and a summary of recommendations is provided based on various scenarios that can occur where the equipment would be utilized. Recommendations are provided based on the platforms used and the tools utilized based on various environmental and operational factors.

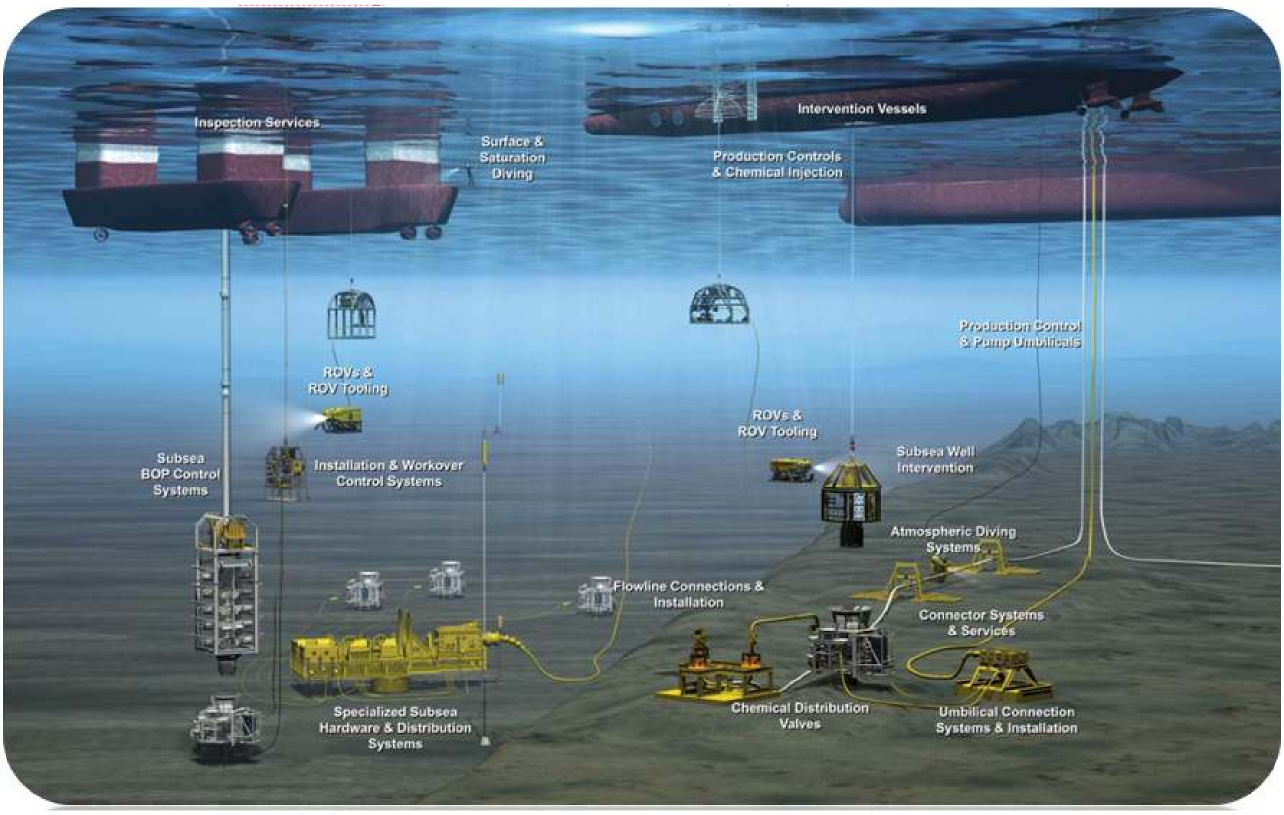


Figure 1-Subsea Environment

Currently for In-Water surveillance there exists multiple platforms to effect a survey & intelligence mission. The ROVs are a primary focus of this report and they fall under a high level grouping called Unmanned Underwater Vehicles (UUVs). The AUV's are commonly referred to as UUVs in military parlance and also classified within the Autonomous Oceanographic Vehicles (AOV) segment. Figure 1 displays a typical subsea infrastructure view that replicates a common field arrangement of equipment. The ROV is the primary construction and support platform for the subsea equipment in water depths in excess of 300 feet.

2.1 Remotely Operated Vehicles (ROV)

ROV Components

A Remotely Operated Vehicle (ROV) is a tethered underwater vehicle that includes various components to operate while deployed. The Class III Working Class ROVs typically require the most components to operate in the deepest operational areas and a summary description and examples of each are provided for context.

ROV-This consists of the actual ROV (Fig. 2) which is comprised of a high strength frame, buoyancy material, the propulsion systems, a power and telemetry system, and a sensor interface design which includes, electrical, hydraulic and mechanical interfaces to support the specific mission parameters.

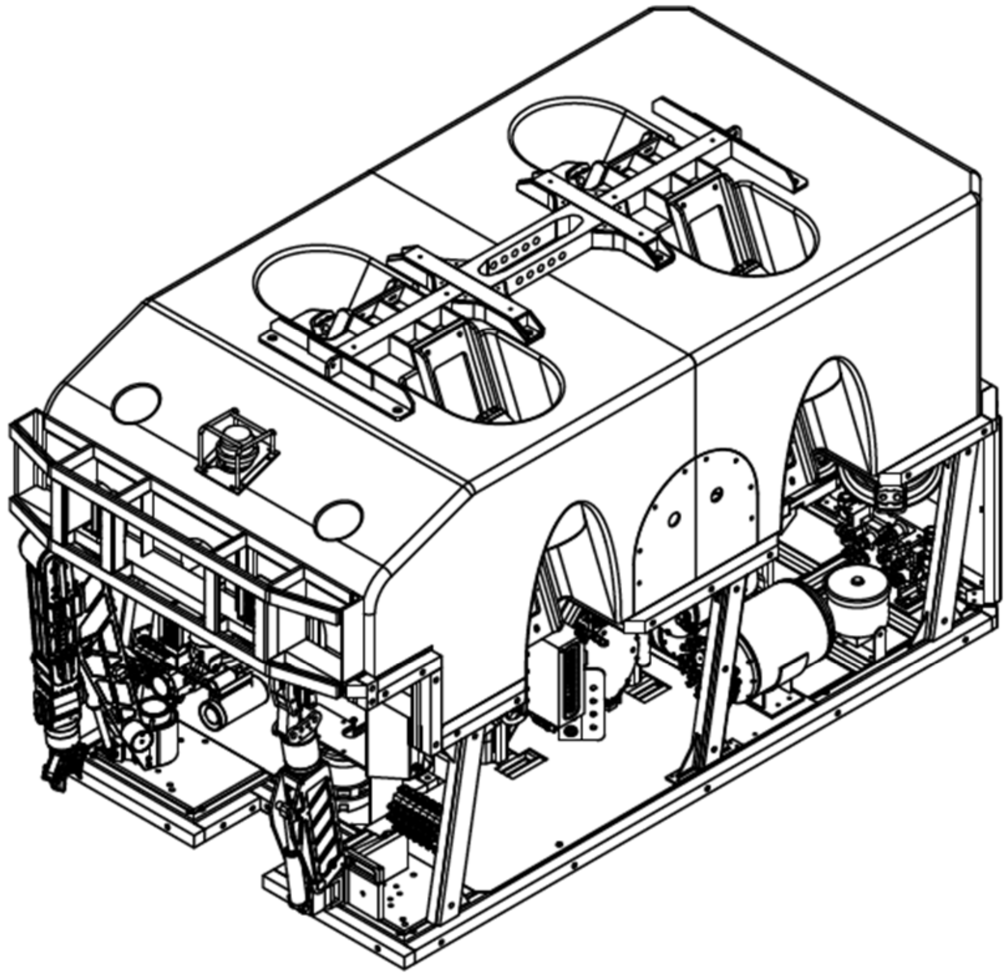


Figure 2-A Typical Working Class ROV

LARS (Launch and Recovery System)-The LARS system is the term used to describe all of the components involved in moving the vehicle to its operational depth in a controlled fashion. The LARS typically consists of the TMS (Tether Management System), an umbilical winch, a slip ring, an A-frame (Fig. 3) or crane, a sheave, an HPU, and a mounting skid.

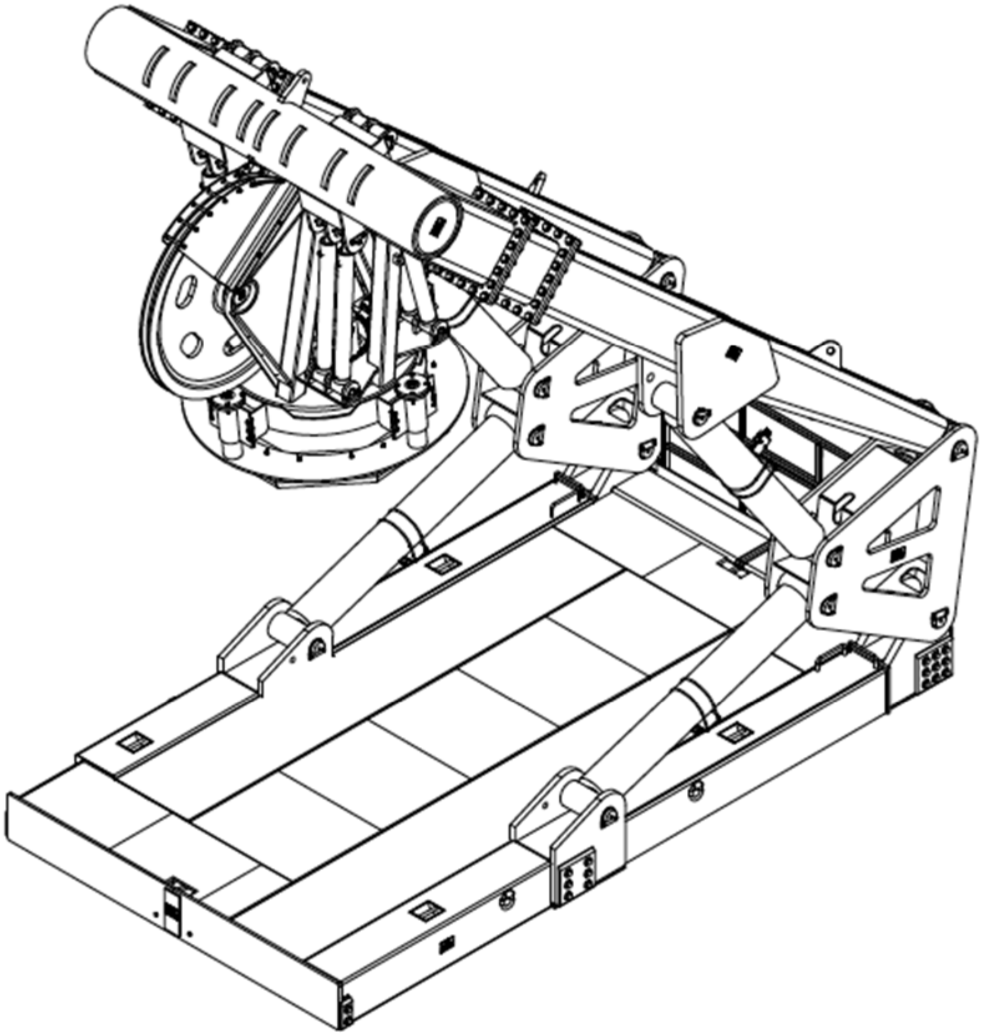


Figure 3-A Typical A-Frame Member of the LARS

For installations designed around operate in heavy weather environments, the LARS are typically designed based upon the following configurations:

Guide Wire Cursor Deployment

The guide wire system is typically used on semi-submersible drilling rigs, tension leg platforms, and other similar installations. This method is useful when some horizontal movement is acceptable and there is no structure present to attach the rails. Cursor guide wire lengths are typically 150 feet. A pair of 2 inch parallel wire ropes are strung from the top of the fixed A-frame on the vessel deck to a subsea mounted lower cursor frame assembly, which is either bolted or welded to the pontoon. A specially designed and tested breakaway joint connects the wires to the lower cursor frame. This breakaway joint prevents damage to the a-frame, vessel, and most importantly personnel if a wire becomes overloaded.

Rail Cursor Deployment

Commonly utilized on deepwater drillships as well as construction / intervention vessels, a removable guide rail assembly is used to constrain the cursor's path. Typical rail lengths are 70 feet - 80 feet in length. The cursor rail assembly interfaces with the vessel hull via hull mounted guide rails, a subsea rail pin assembly (which supports the weight of the cursor rail assembly once deployed), and by topside cursor rail pad eyes which secure the top end of the rail assembly to the vessels hull. Rail systems can be used in an over-the-side launch and recovery system via an A-frame or through a moon pool opening with a fixed a-frame.

Moonpool System

A moonpool (Fig. 4) is used to protect the ROV during launch and recovery and is built within the hull of the supporting vessel. A centrally located design also reduces the amount of pitch and roll the LARS system has to counter when deploying the ROV.

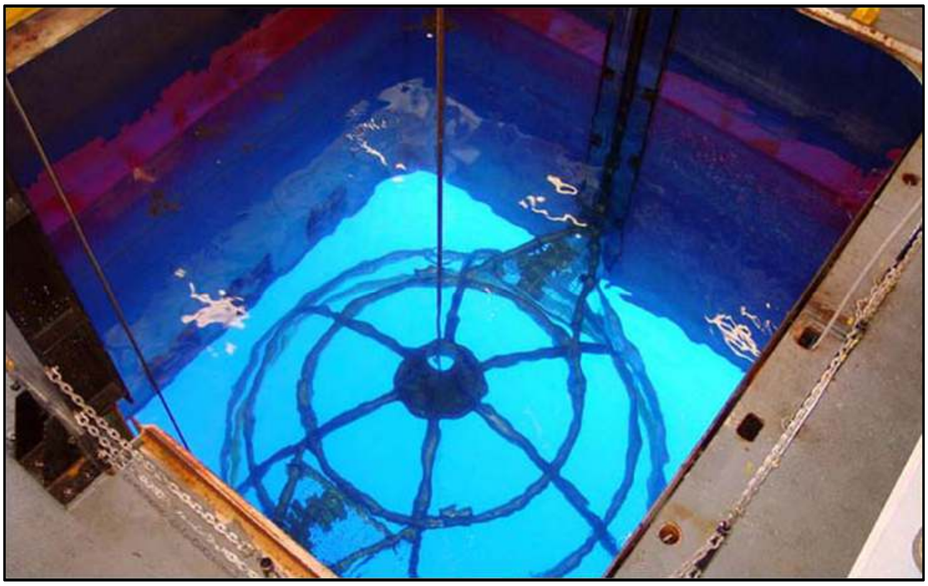


Figure 4-Vessel MoonPool with Cage

The moonpool can be sealed from below while the vessel is operating under normal conditions and this helps reduce drag on the ship while operating underway.

TMS (Tether Management System)-The ROV TMS provides the means to deploy the ROV from the surface to the working depth. When the ROV arrives at the working depth, the TMS can pay-in or pay-out the umbilical. The TMS has Lighting, an electronic control system, cameras and an electro-hydraulic system to power the tether drum and latch the ROV during deployment. The TMS system for larger ROVs typically consists of a cage assembly (Fig. 5) or a tophat unit (Fig. 6). The cage provides a protective shell for deploying the ROV for day-to-day operations and rough seas. A Side Entry Cage can best be described as a box that the ROV is parked inside of while it is raised and lowered in the water column. A Tophat sits on top of the ROV and does not encase the ROV compared to the Side Entry Cage.

Figure 5-Tophat Deployment

Figure 6-Cage Deployment

Winch Drum-The winch drum provides the means to store the length of umbilical to lower the ROV to operational depth and also to control the lowering and lifting speed of the ROV through its mechanical and hydraulic controls. Winch drums typically come configured as a traditional, traction, or heave compensated configuration. The heave compensated designs incorporate motions sensors to provide feedback to the motors to reduce the load on the ROV or cage.

HPU (Hydraulic Power Unit)-The HPU are critical units in the ROV ecosystem because they help provide hydraulic power to the ROV manipulator and tooling systems. The HPU allows the ROV to operate with heavy equipment and tooling with the equivalent strength of a land-based backhoe

Crew Training and Competency

Personnel operating and maintaining ROV systems are typically required to possess suitable qualification and experience related to the safe and efficient operations of the vehicle and supporting equipment. IMCA (International Marine Contractors Association) provides guidelines to the industry in regards to the minimum requirements and qualifications required to operate an ROV. The entry level guide for ROV personnel is supported by IMCA R 002 Rev. 2, May 2009 and is titled *Entry level requirements and basic introductory course outline for new remotely operated vehicle personnel*. The *Code for Practice for The Safe & Efficient Operation of Remotely Operated Vehicles* (IMCA R 004 Rev. 3, July 2009) provides the industry-accepted standard for new ROV personnel. ROV operators and contractors typically base their training programs off of the IMCA recommendations and typically provide more advanced internal training specific to each organizations training requirements.

The ROVs can be organized within 5 classifications. The classifications include:

2.1.1 Class I Observation Vehicles

Smaller form-factor ROVs typically fitted with camera, lights, and a sensor tool to enable observations. They are typically functionally designed around the sensor pack and aren't typically retrofitted in the field. The observation class includes specialty vehicles that are primarily used to augment the operations of larger vehicles. Providing visual or sonar/lidar support allows a more complete picture of the subsea operations. The observation class ROVs also allow for better inspections within confined and difficult to reach spaces that a larger work class ROV cannot access.

Section	Manufacturer/Platform	Class	L (m)	W (m)	H (m)	Weight Dry (kg)	Depth Rating (m)	Speed (Fwd knots)	Thrust (Fwd kg)	Payload Weight (kg)
6.1.1	Oceaneering SeaMaxx	I	0.8128	0.6096	0.4572	104	3050	2.5	N/A	N/A
6.1.2	Oceaneering Hyrda Minimum	I	1.651	0.9906	0.508	249	3050	3	N/A	N/A
6.1.3	Ageotec Sirio	I	1.651	0.9906	0.508	40	300		16	10
6.1.4	Aquabotix HydroView Pro	I	0.48	0.37	0.3	6.8	152	4	N/A	0.9
6.1.5	Deep Ocean Needlefish P150	I	0.64	0.35	0.29	18	175	2	5	3.6
6.1.6	Seabotix LBV300-5	I	0.52	0.44	0.26	13	300	2.8	N/A	N/A
6.1.7	VideoRay Pro4	I	0.37	0.29	0.22	38.5	305	3.9	N/A	N/A

Table 1-Class I ROV Summaries

2.1.2 Class II Observation Vehicles with Payload Option

An Observation Class II ROV is typically outfitted with two simultaneously viewable cameras/sensor packages with the capability of additional sensor add-ons. Class II vehicles should be capable of operating without loss of original function while carrying at least two additional sensors.

Section	Manufacturer/Platform	Class	L (m)	W (m)	H (m)	Weight Dry (kg)	Depth Rating (m)	Speed (Fwd knots)	Thrust (Fwd kg)	Payload Weight (kg)
6.2.1	Ageotec Perseo GTV	II	1.45	0.95	0.735	160	1,500		70	40
6.2.2	Ageotec Perseo	II	0.98	0.71	0.51	80	600		35	40
6.2.3	Deep Ocean Eng L4N	II	1.054	0.72	0.66	113	500	N/A	41	40
6.2.4	Deep Ocean Eng S5N	II	1.27	0.8	0.76	158	1500	N/A	77	40
6.2.5	Depp Ocean Eng T4N	II	0.927	0.502	0.356	45	305	N/A	23	N/A
6.2.6	FET Mojave	II	1	0.6	0.5	85	300	3.5	53	12
6.2.7	FET Mohawk	II	0.93	0.77	0.62	165	2000	3	N/A	42
6.2.8	FET Mohican	II	1.15	0.77	0.8	340	2000	3.5	N/A	35
6.2.9	Submersible Systems TRV-005	II	1.524	1.219	0.457	250	1000	6	104	15

Table 2-Class II ROV Summaries

2.1.3 Class III Work Class Vehicles

The Work Class vehicles have an increased payload capability compared to the Class I and II and can handle multiple sensor packages with plug-in type operational enhancements. Class III vehicles commonly have a multiplexing capability that allows additional sensors and tools to operate without being "hardwired" through the umbilical system.

Class III A – Work class vehicles < 100 Hp

Class III B – Work class vehicles 100 Hp to 150 Hp

Class III C – Work class vehicles >150 Hp

Section	Manufacturer/Platform	Class	L (m)	W (m)	H (m)	Weight Dry (kg)	Depth Rating (m)	Speed (Fwd knots)	Thrust (Fwd kg)	Payload Weight (kg)
6.3.1	Oceaneering Millennium Plus	III	3301	1676	1929	3991	4000	N/A	907	181
6.3.2	Oceaneering Magnum Plus ROV	III	8.53	5.1	6.07	6750	3048	N/A	725	158
6.3.3	Oceaneering Maxximum	III	3.048	1.83	2.13	4853	3050	N/A	997	200
6.3.4	Oceaneering Spectrum	III	1.4	0.9	0.85	290	610	N/A	117	227
6.3.5	Ageotec Pegaso	III	1500	1000	800	350	1500	N/A	N/A	N/A
6.3.6	DSSI Global Explorer	III	2.8	1.22	1.6	200	3048	N/A	N/A	N/A
6.3.7	DOER Marine H6500	III	2.032	1.4	1.47	110	6500	N/A	N/A	50
6.3.8	DOER Marine H2000	III	1.524	1	0.97	120	2000	N/A	327	54
6.3.9	DOER Marine H3000	III	1.524	1	1.5	405	3000	N/A	327	54
6.3.10	SMD Atom	III	2.52	1.5	1.5	2000	4000	N/A	550	150
6.3.11	SMD Quasar	III	3.2	1.8	1.8	3500	4000	3.5	550	250
6.3.12	SMD Quantum	III	3.63	2	2	5000	4000	3.5	N/A	350
6.3.13	FET Super Mohawk	III	1.4	0.9	0.85	395	3000	3	110	65
6.3.14	FET Tomahawk	III	1.86	1.21	1.2	1000	3000	3.5	N/A	160
6.3.15	FET Comanche	III	2.1	1.3	1.25	1130	6000	3	240	215
6.3.16	Submersible Systems TRV-M	III	1.524	1.219	0.61	295	1000	4	N/A	27
6.3.17	Submersible Systems TRV-HD	III	1.7	1.384	0.914	795	1000	3	N/A	136
6.3.18	Schilling HD	III	2.9	1.7	1.9	3700	4000	3	900	250
6.3.19	Schilling UHD-III	III	3.5	1.9	2.1	5500	4000	3	1200	450
6.3.20	Saipem Innovator Leviathan	III	3.45	1.63	2.13	795	3500	3	N/A	113

Table 3-Class III ROV Summaries

2.1.4 Class IV Towed and Bottom Crawling Vehicles

Towed vehicles are attached to a vessel and pulled along with either onboard propulsion or an onboard winch system. Class IV vehicles are typically much larger and heavier than Class III work class vehicles, and are configured for special purpose tasks. Typical applications of a Class IV vehicle include trenching, excavation, and cable/pipeline installations.

2.1.5 Class V Prototype & Development Vehicles

Class V vehicles include those being developed and those regarded as prototypes. Special-purpose vehicles that do not fit into one of the other classes are also assigned to Class V. The AUV type is currently assigned to Class V (Source: NORSOK Standard U102; IMCA R 004 Rev. 3).

2.2 Cameras/Sensors

The use of topside and underwater sensors does not mitigate a hydrocarbon release but the data they provide can help inform decision making for the subsequent mitigation effort. As demonstrated in the Macondo incident, there exists a need to detect, measure, and provide direct product capture for analysis to verify the hydrocarbon makeup. The Special Monitoring

of Applied Response Technologies (SMART) program provides guidance on performance criteria for particulate monitoring for spills both inland and in coastal zones, which applies to several of the scenarios listed in this paper (Scenario 2 and 3 specifically). A discussion around the SMART classifications as relates to sensor usage is provided for reference. The use of the tools within specific time frames (i.e. large scale detection and near field detection) is factored into the deployment recommendations
(Source: Special Monitoring of Applied Response Technologies, August 2006, http://response.restoration.noaa.gov/SMART).

The various sensors used for spill analysis are broken into the following categories:

Optical (example: high definition video)

Stereoscopic (example: 3D)

Multispectral (example: Landsat Thematic Mapper)-Multi-spectral concentrates on a few targeted frequencies.

Hyperspectral (example: imaging spectroscopy)-Typically refers to a sensor which utilizes a full range of the solar illumination range as opposed to specific frequency ranges such as multi-spectral. The collection of data typically involves the spectral and spatial data together to provide a more complete monitoring capability.

The sensor sets are evaluated against in situ observation (direct) and remote sensing (indirect). Utilizing both methods with the various toolsets listed should provide the response community with enough information to effect a corrective action on an incident such as a spill or a leak. The aspect of passive and active is discussed for the sensor evaluations as this affects the overall recommendations based upon the various data injects into the incident. A passive sensor typically is receiving naturally transmitted radiation whereas an active sensor typically is transmitting and receiving radiation. Examples of passive sensors include thermal infrared and passive microwave radiometers. High-resolution multispectral sensors and lasers are two types of active sensors.

2.2.1 Image/Still Cameras

Figure 7-Class I HD Still Camera
(Source: DSSI)

The use of high-resolution still cameras has become prevalent to provide high fidelity inspection imagery. The capture of imagery is traditionally provided via direct capture on the camera and the imagery is transferred over the network or via software capture. This method allows the ROV/AUV operator to capture video directly off the video source and attach any additional metadata required for operations.

High definition digital imagery now provides resolutions capable of detailed surveys. A typical high-resolution imagery camera uses an 18-megapixel image sensor for capture and includes a video output that serves as a viewfinder for capturing the correct imagery. The high end cameras used for measuring spill and flow throughput utilize a built-in long range laser scaler for linear measurements and a precision ground optical dome to ensure that no optical distortion occurs in the imagery. An example camera is the DSSI DPC-8800 which utilizes four lasers, one located at each corner of a 10-cm square, that project four thin beams of light directly in view of the camera. The light beams are used to illuminate a spill or equipment within the field of view with four bright green dots that are always the same distance apart regardless of the distance from the camera. Green lasers are used for long range penetration underwater. Once the imagery is captured, the points referenced on the object or spill can be used to provide mm-level measurement accuracy.

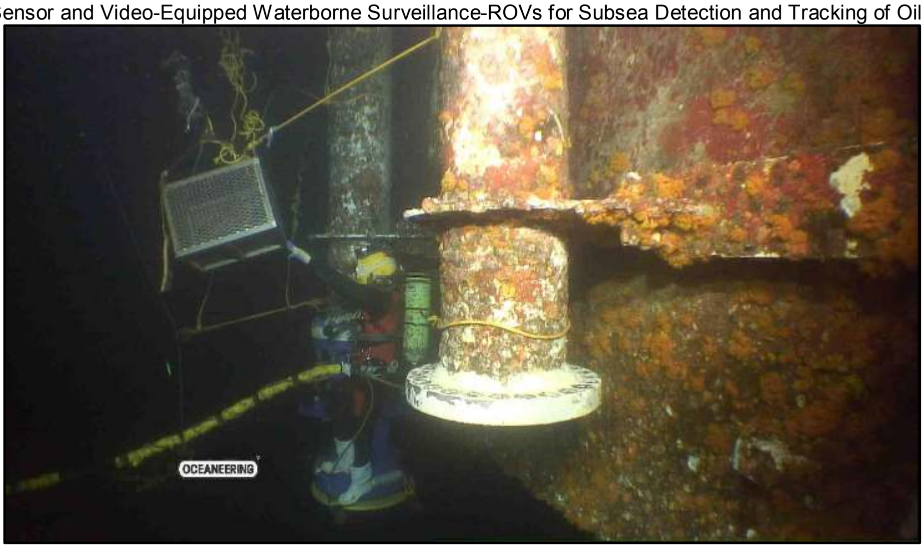


Figure 8-HD Subsea Still Imagery
(Source: Oceaneering)

2.2.2 Video Cameras

For daily operations and emergency response (ER) incidents, video and telemetry data capture is a key aspect in assessing the operation or event. The operational and ER teams are responsible to select and distribute selected video to other parties through a controlled release. During a spill, various parties must be able to view the video based on operational, legal, and analytical requirements. The sites may include offshore platforms, drill ships, remotely underwater vehicles (ROV), docks, support vessels, and onshore locations. Cameras provided for offshore and subsea uses are typically categorized by direct optical connection via fiber or copper or via an encoded stream that is transmitted over a TCP/IP network.

Standard Definition Video

Standard definition cameras are still utilized for the majority of ROV installations. The migration over to high definition has been more pronounced due to the increased resolution available with the newer digital cameras which allows for the video to be transmitted back over the ROV umbilical without requiring additional direct fiber/copper connections.

High Definition Video

Figure 9-3D and HD Camera Unit Mounted on ROV
(Source: Oceaneering)

High Definition video systems now provide resolutions at 1920x1080 at 60 fps which provides a high grade view of operations. An RS-232 serial interface with the ROV control computer enables the remote control of all the camera functions. Due to the higher bandwidth requirements of the HD video, fiber optics are typically used for the transport of the video signal to the ROV control van. The HD-SDI (high definition-serial digital interface) SMPTE-292M video output is transmitted over the fiber-optics communications link to a fiber-optic to HD-SDI converter at the surface. The SDI is a higher capacity connector used for HD video connections.

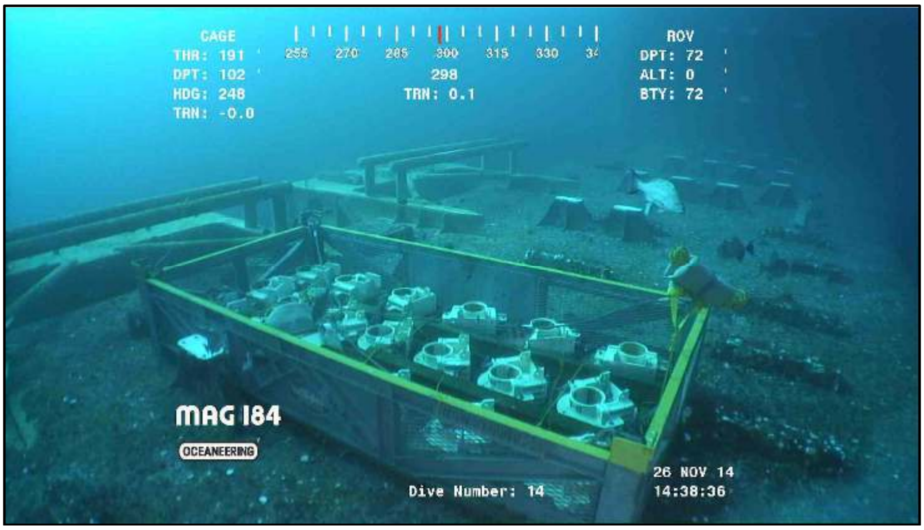


Figure 10-Subsea HD Camera View with Overlay
(Source: Oceaneering)

3D

3D Imagery now provides for advanced views of oil spills with the added capability of providing photogrammetry capabilities. The key benefit of using 3D for spill observations is the use of stereo photogrammetry. Stereo photogrammetry is a method by which the 3-dimensional size and range of objects in view of the 3D camera pair can be measured. Linear measurements are made using images simultaneously obtained from two different camera positions. The range from the camera pair to a point in space and its 3-dimensional relative coordinates are calculated using a triangulation technique where the focal length of each of the two camera lenses, the camera separation, or “baseline,” and the stereo disparity are known. Stereo disparity is the horizontal difference in the location of the point as observed from the same pixel positions in each camera. Using this method for any two points in space determines the distance between them, and a third point enables a 3-dimensional measurement.

RF Video Transmission

RF Video transmission systems are used for operational and incident response situations to provide a real-time view of the video and sensor data across the vessels in the field. This is preferred over satellite due to the lower cost and low latency involved with the direct transmittal over RF. 900 MHz is the most common frequency utilized due to the quality of transmission over water. 2.4 GHz and 5.8 GHz are used for shorter-range operations such as transmitting crane video onboard a vessel between rooms onboard the vessel.

Video Output Formats

The two most common methods for viewing video for ROV operations are the direct optical/analog camera monitors and encoded video (analog video converted to digital format). The determination of which to use is typically tied to the operational requirements for the mission. The use of direct optical/analog video feeds is useful for SIMOPS (Simultaneous Operations) where low latency in the range of <250ms is required. An example scenario where this is used is ROV and diver operations working in coordination with each other and rig support video. The rig support video scenario as relates to the oil and gas industry is typically composed of an ROV host ship transmitting video to a drillship or platform so that the crew can view and direct the activities of the ROVs subsurface.

The encoder video option is useful for transmitting video in a mesh configuration (transmitting to more than one vessel at the same time) and for remote operations (transmitting video onshore). The encoding of video typically requires a video encoder that receives the direct optical/analog camera feed from the ROV and the encoder converts the video and rebroadcasts it over the network. This is valuable for transmitting video over satellite so that operations can be monitored from a remote command center or control room. An optional capability called transcoding allows additional data to be converted to different formats with additional data added to the video. An example of this is the injection of GPS coordinate data into the video and rebroadcasting the video over H.265 instead of H.264. Transcoders can be used onshore to create a compatible mobile video output in 3GP.

The use of video integrated into a COP (Common Operating Picture) and GIS (Geographic Information Systems) allows for better operational oversight of the subsea operations and all of the related oil spill cleanup activities. Most modern GIS systems allow the direct input of the encoded video for analysis and playback. A common scenario is to take 3 different camera views and play them in-sync with each view to analyze problems such as pipeline leaks and subsea equipment damage (Fig. 11).

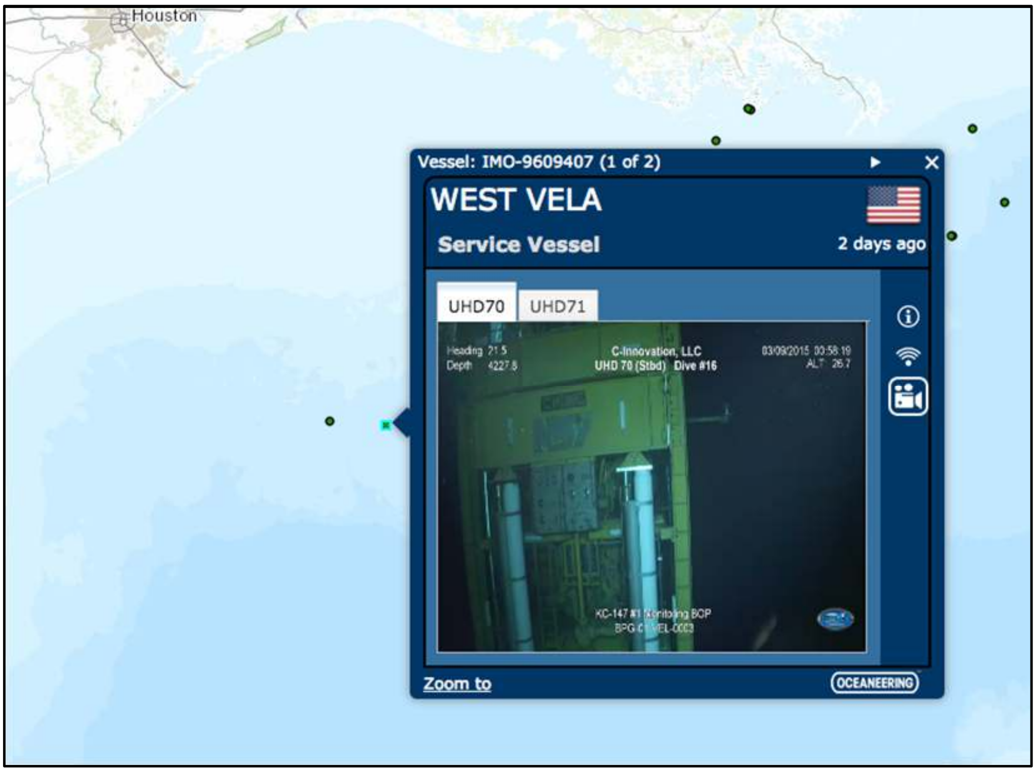


Figure 11-Live Video Incorporated into a COP GIS Platform (Courtesy of Oceaneering International, Inc.)

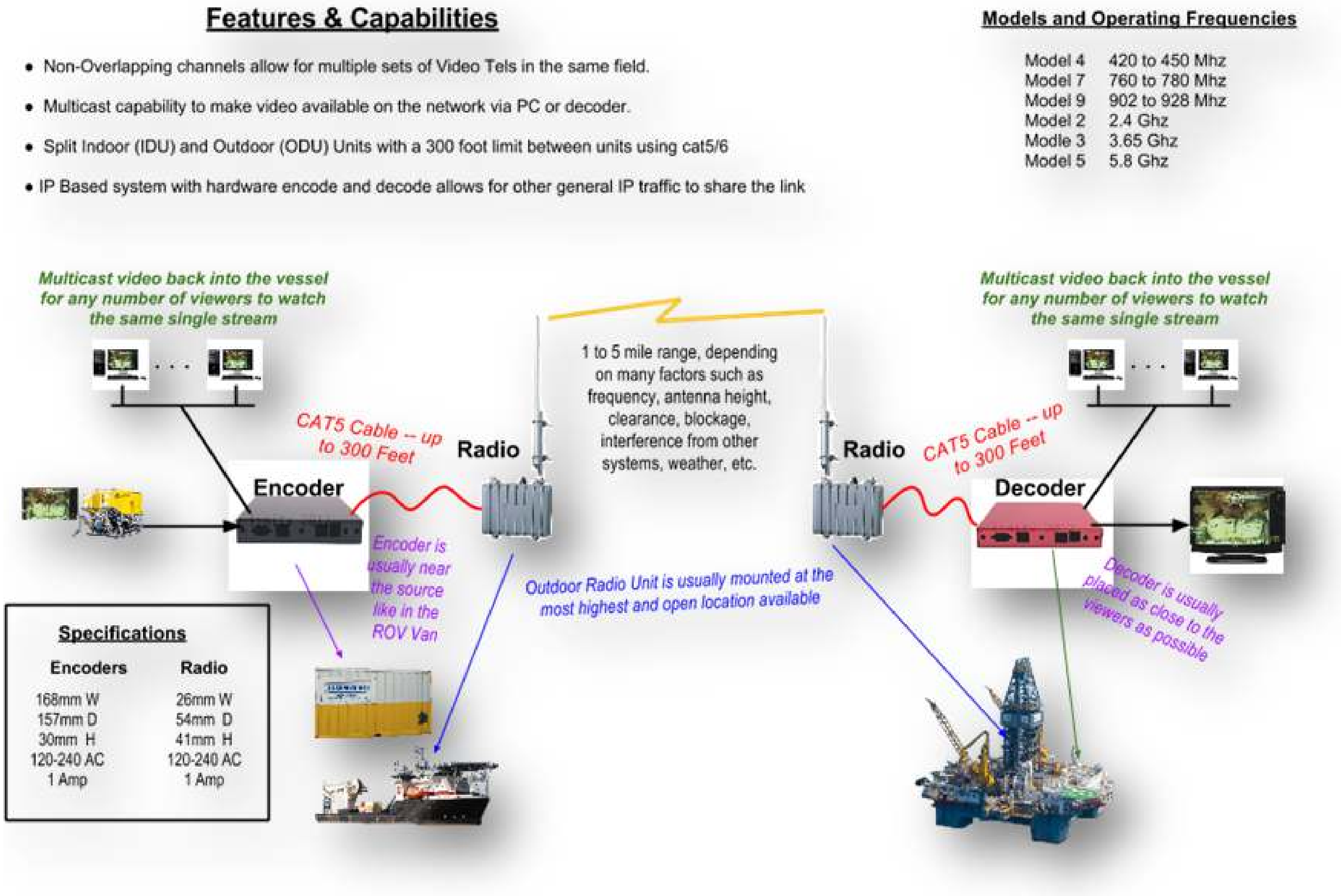


Figure 12-Vessel to Vessel Video Wireless Network

3 Oil Spill Scenarios

The scenarios listed below are categorized based upon the IOGP-IPIECA Good Practice Guidance (GPG) Series. A summary recommendation is provided concerning the utility and prioritization of combinations of platforms and sensors in order to achieve the best probability of success for the detection and monitoring of hydrocarbons. On land release isn't covered in this study.

On Land Release	Coastal Terminal Release	Tanker in Transit	Offshore Platform	Offshore pipeline	Deepwater Well Blowout
Rupture during excavation work by local construction company at site close to a village	Storage tank rupture due to structural failure	Tanker suffers shell plate damage to one of the cargo tanks releasing oil before entry to port	Accidental discharge of crude oil during daylight hours	Rupture during dredging activity work by local company	Blowout through the riser, drill pipe/tubing, choke/kill lines at the rig

(Source: IOGP-IPIECA)

The utilization of a tiered preparedness and response method provides clear guidance upon which to measure the response requirements. A scale of 1 to 3 is utilized starting with a localized response as Tier 1, a regional response for Tier 2, and a larger tactical preparedness and response for Tier 3 spills. Tier 3 incidents require a coordinated response by all parties involved to ensure the containment and management of a large spill. The scenarios discussed below are not necessarily tied specifically to a Tier 1,2, or 3 response since a simple coastal terminal release could escalate into a full Tier 3 response if the containment is not managed properly.

Incident response in regards to responding to incidents offshore or remote locations demands a tactical view of the operation. The tools and sensors to provide real-time data feedback have been maturing over the years. For daily operations and emergency response (ER) incidents, video and telemetry data capture is a key aspect in assessing the operation or event. The operational and ER teams are responsible to select and distribute selected information to other parties through a controlled release. The sites may include offshore platforms, drill ships, remotely underwater vehicles (ROV), docks, support vessels, and onshore field sites. Current information/data/video is gathered and transmitted via satellite systems or provided land-based Internet circuits.

Operational focus on "how" the data integrations should be accomplished and ensuring that companies are staying away from 'closed' systems is critical to a successful Common Operating Picture (COP). A large number of the platforms available recently (i.e. weather, asset tracking, telemetry, spill extent) have all predicated that the user utilize their specific interface or middle tier UI. This can cause compatibility issues with an incident host company's systems and can preclude third-party providers access or compatible access to share data.

The recommended approach is making sure that all of the providers of any particular data set make their information available via an open-standard model, albeit one that can support security requirements and compatibility. This isn't a requirement to provide free data but it is a requirement to ensure that as data is generated, ingested, and processed, etc., it should meet a common language requirement. A similar example lies within the aviation industry with English as the common language to communicate between aircraft. XML at a technical minimum is a good starting point so that the differences in each company's datasets can be 'transformed' to make each data set match up at some point.

Key highlights to ensure the sensor data can be successfully utilized effectively include:

Data Federation (share the best bits w/ each other)

Open Standard format (use common language)

Knowledge of Data (app store model)

Browser UI (adds instant cross platform compatibility)

3.0.1 Release at Coastal Terminal (Scenario 2)

Figure 13-Oil Boom Deployment
(Source: http://www.greatlakes.org/tarsands)

A release of hydrocarbons from a coastal terminal presents a scenario that can be as difficult as a deepwater well blowout due to the shortened time-frame to react to prevent direct environmental impacts. The geophysical limitations presented by this type of release preclude the use of the majority of the ROV systems due to depth and host vessel limitations and this impacts directly the sensor and tool combinations that can be used to mitigate the effects of the release.

Operational Response

	IOGP-IPIECA Preparedness Levels	IOGP-IPIECA Response Levels
T1	Ensure that the local facility operator's incident response teams are properly trained to respond and recovery from a release.	Tier 1 response should include the deployment of containment booms to ensure the spill is contained. The recovery teams would be utilized to ensure the recovery operation starts immediately due to close proximity to resources.
T2	Small vessels and recovery equipment should be contracted and tested on an annual basis to validate the response plan.	The Tier 2 response should include small vessels supporting the containment plan.
T3	The operator has an option to utilize the Tier 3 response center to maintain an operational focus on the response initiative.	The Tier 3 response would be enacted if the release could not be contained with local resources. Rapid mobilization of equipment and resources should occur to support the recovery operations and cleanup.

The response to this type of spill would require a limited mobilization of personnel and equipment.

1) Specified operator/contractor vessels would be dispatched to support the incident with the most experienced personnel in regards to spill mitigation and analysis.
2) The support contractors would support staging material coordinators at the heliport and a dock location to track receiving items and make sure the material arrives on scene for deployment. The dispersant materials and the oil containment material would be key parts of this staging process.
3) The support contractors would staff up for 24-hour support in inventory and shipping.
4) The ROV contractor would mobilize the ROV support team to include class-I and II observation ROVs and any applicable class V vehicle (AUV for area survey).
5) The contractors would provide at least (1) Operations Project Manager to "live" in the client's facility for instant support
6) The engineering support division (the engineers responsible for the rapid design and integration of custom tooling and equipment) would staff up to 24-hour engineering support.
7) Video & data streaming solutions (topside and underwater) are deployed to support telemetry back to the command center.
8) The HSE equipment companies mobilize to provide gas detection equipment and fit clean air respirators.
9) Have an installation crew on standby to support if an ROV installation is required. Installations should follow the guidelines set forth in Guidelines for Installing ROV Systems on Vessels or Platforms (IMCA R 018, May 2013).

Precautions/Considerations

Due to the limited depth related to the near-shore release, immediate emphasis should be placed on containment via boom deployment and small vessel deployments to support the cleanup. Care must be taken in the use of a fluorescent dye for fluorometer detections in that dyes such as Fluorescein are being phased out in the latest environmental legislation in regards to discharges at sea. It is important to ensure with the environmental legislation for the spill area that approved dyes can be used.

UUV Requirements/Recommendations

Class I Observation ROVs can be used to inspect areas where oil can become trapped dockside. The smaller Class I ROVS are readily transportable to the spill area by personnel and can be manually lowered along the spill areas dockside. External examination of the bunded area is useful to ensure no leaks are occurring with the containment system.

Class II ROVs are used to clear up debris and fouling subsurface in areas of pipelines and dense machinery

Class V systems (AUVs) would only be used on a larger scale coastal terminal release where the boom extents are quite extensive and long range surveillance along the spill area is required. The system would be used to provide survey data (bathymetry) and oil detection for submerged flows.

Sensor Requirements/Recommendations

Scenario 2: Release at Coastal Terminal						
		ROV Classes				
Sensor Group	Sensor	Class I	Class II	Class III	Class IV	Class V
Subsea Direct Sensors	Fluorometer	1	3	3	1	3
	NDIR (CH4)	1	3	3	1	1
Subsea Indirect Sensors	CTD	1	3	3	1	3
	DO (electrochemical)	1	3	3	1	1
	DO (optical)	1	3	3	1	3
	NDIR (CO2)	1	3	3	1	1
	Turbidity Meter	1	3	3	1	3

Hydrophone devices are useful for deployments for this type of release in case the spill around the terminal area involves a flowline or any pressure vessel in contact with the main water body. Fluorometer devices can be utilized by the ROV up to a maximum range the 20m. They are capable of detecting most hydrocarbon-based fluids in concentrations as low as 0.002μg. Optical cameras using small observation ROVs (Class I) are utilized for inspecting pier-side infrastructure to ensure pockets of oil do not stay undetected and could be released during inclement weather conditions

ROV Operations

Normal operational procedures are utilized for operating the ROVs in contaminated areas such as fresh water rinses before dives and pre-dive equipment checks. It is recommended to utilize The Code of Practice for the Safe & Efficient Operation of Remotely Operated Vehicles (IMCA R 004 Rev. 3) as a minimum guideline for the ROV operation. The ROV crew traditionally wears gloves for normal operations with the addition of nitrile gloves over the PPE gloves when recovering the ROV from the contaminated area. Nitrile gloves provide better chemical resistance than latex gloves.

3.0.2 Oil Tanker in Transit Offshore (Scenario 3)

Figure 14-Tanker Leak with Containment Booms
(Source: John Gaps III, AP)

The oil tanker scenario assumes the vessel has no major oil handling facilities nearby and the vessel must take refuge at a nearby port close to an international boundary.

Operational Response

	IOGP-IPIECA Preparedness Levels	IOGP-IPIECA Response Levels
T1	The SOPEP (shipboard oil pollution emergency plan) is utilized and provides the procedures to contact the appropriate personnel and authorities.	Tier 1 response should include the deployment of containment booms to ensure the spill is contained.
T2	The Tier 2 provides for regional authorities to utilize local and national resources to be on contract or standby to provide shoreline cleanup and support for the incident activities.	The Tier 2 response should include small vessels supporting the containment plan
T3	The operator has an option to utilize the Tier 3 response center to maintain an operational focus on the response initiative	The Tier 3 response should include large-scale response from government entities to ensure the proper resources and logistics are activated to protect the shoreline if the oil spill is not contained quickly.

The response to this type of spill would require a tiered mobilization of personnel and equipment and a coordinated response from regional personnel (Tier II) to ensure the response plan provides for adequate resources offshore.

1) Specified operator/contractor vessels would be dispatched to support the incident with the most experienced personnel in regards to spill mitigation and analysis.

2) The support contractors would support staging material coordinators at the heliport and a dock location to track receiving items and make sure the material arrives on scene for deployment. The dispersant materials and the oil containment material would be key parts of this staging process.
3) The support contractors would staff up for 24-hour support in inventory and shipping.
4) The ROV contractor would mobilize the ROV support team to include the available Class I, II, III, ROVs
5) The contractors would provide at least (1) Operations Project Manager to "live" in the client's facility for instant support
6) The engineering support division (the engineers responsible for the rapid design and integration of custom tooling and equipment) would staff up to 24-hour engineering support.
7) Video & data streaming solutions (topside and underwater) are deployed to support telemetry back to the command center.
8) The HSE equipment companies mobilize to provide gas detection equipment and fit clean air respirators.
9) Have an installation crew on standby to support if an ROV installation is required. Installations should follow the guidelines set forth in Guidelines for Installing ROV Systems on Vessels or Platforms (IMCA R 018, May 2013).

Precautions/Considerations

Due to the proximity to port area, immediate emphasis should be placed on containment via boom deployment and small vessel deployments to support the cleanup.

UUV Requirements/Recommendations

Class I Observation ROVs can be used to inspect areas where oil can become trapped dockside. The smaller Class I ROVS are readily transportable to the spill area by personnel and can be manually lowered along the spill areas dockside. External examination of the bunded area is useful to ensure no leaks are occurring with the containment system.

Class II Observation ROVs can be used to inspect areas where oil can become trapped dockside and alongside the tanker hull. The smaller Class II ROVs are readily transportable to the spill area by personnel and can be manually lowered along the tanker sides. External examination of the boom deployment is useful to ensure no leaks are occurring with the containment system.

Class III work class ROVs can be use to assist in the repair of the tanker hull and the deployment of sensors to measure the effectiveness of dispersants.

Sensor Requirements/Recommendations

Scenario 3: Oil Tanker in Transit Offshore						
		ROV Classes				
Sensor Group	Sensor	Class I	Class II	Class III	Class IV	Class V
Subsea Direct Sensors	Fluorometer	1	3	3	1	1
	NDIR (CH4)	1	3	3	1	1
Subsea Indirect Sensors	CTD	1	3	3	1	1
	DO (electrochemical)	1	3	3	1	1
	DO (optical)	1	3	3	1	1
	NDIR (CO2)	1	3	3	1	1
	Turbidity Meter	1	3	3	1	1

Hydrophone devices are useful for deployments for this type of release in case the spill around the terminal area involves a flowline or any pressure vessel in contact with the main water body. Fluorometer devices can be utilized by the ROV up to a maximum range the 20m.

ROV Operations

Normal operational procedures are utilized for operating the ROVs in contaminated areas such as fresh water rinses before dives and pre-dive equipment checks. It is recommended to utilize The Code of Practice for the Safe & Efficient Operation of Remotely Operated Vehicles (IMCA R 004 Rev. 3) as a minimum guideline for the ROV operation. The ROV crew traditionally wears gloves for normal operations with the addition of nitrile gloves over the PPE gloves when recovering the ROV from the contaminated area. Nitrile gloves provide better chemical resistance than latex gloves. Observations ROVs can be used for near-shore spills to provide surveillance around

3.0.3 Offshore Platform (Both Surface & Subsurface Accidental Releases of Finite Amount) (Scenario 4)

Figure 15-Offshore Platform Oil Spill Incident
(Source: Australian Maritime Safety Authority)

The offshore platform release scenario assumes a production platform in place and a new exploration well being drilled and project being sampled for analysis. The platform will be assumed to be near productive fishing grounds and also near the feeding grounds for seabirds.

Operational Response

	IOGP-IPIECA Preparedness Levels	IOGP-IPIECA Response Levels
T1	The operator ensures that the onboard crew is trained on the response plan and vessels that operate nearby are stocked with appropriate dispersant and boom levels.	Tier 1 response should include the deployment of containment booms to ensure the spill is contained. The SOPEP (shipboard oil pollution emergency plan) is utilized and provides the procedures to contact the appropriate personnel and authorities.
T2	The Tier 2 preparedness initiatives provide for the contracted resources in the plan to provide aerial reconnaissance and dispersant deployment.	The Tier 2 response should include small vessels supporting the containment plan
T3	The operator has an option to utilize the Tier 3 response center to maintain an operational focus on the response initiative and this should be tested annually to ensure the response facility will support the required information flows from the incident area.	If the spill is contained using Tier 1 and 2 Resources then no escalation is required for this scenario.

The response to this type of spill would require a tiered mobilization of personnel and equipment.

1) Specified operator/contractor vessels would be dispatched to support the incident with the most experienced personnel in regards to spill mitigation and analysis.
2) The support contractors would support staging material coordinators at the heliport and a dock location to track receiving items and make sure the material arrives on scene for deployment. The dispersant materials and the oil containment material would be key parts of this staging process.
3) The support contractors would staff up for 24-hour support in inventory and shipping.
4) The ROV contractor would mobilize the ROV support team to include the available Class I, II, III, and IV ROVs and any applicable class V vehicle (AUV for area survey)
5) The contractors would provide at least (1) Operations Project Manager to "live" in the client's facility for instant support
6) The engineering support division (the engineers responsible for the rapid design and integration of custom tooling and equipment) would staff up to 24-hour engineering support.
7) Video & data streaming solutions (topside and underwater) are deployed to support telemetry back to the command center.
8) The HSE equipment companies mobilize to provide gas detection equipment and fit clean air respirators.
9) Have an installation crew on standby to support if an ROV installation is required. Installations should follow the guidelines set forth in Guidelines for Installing ROV Systems on Vessels or Platforms (IMCA R 018, May 2013).

Precautions/Considerations

Due to the limited depth related to the near-shore release, immediate emphasis should be placed on containment via boom deployment and small vessel deployments to support the cleanup. Care must be taken in the use of a fluorescent dye for fluorometer detections in that dyes such as Fluorescein are being phased out in the latest environmental legislation in regards to discharges at sea. It is important to ensure with the environmental legislation for the spill area which approved dyes can be used.

UUV Requirements/Recommendations

Class I Observation ROVs can be used to inspect areas where oil can become trapped dockside. The smaller Class I ROVs are readily transportable to the spill area by personnel and can be manually lowered along the spill areas dockside. External examination of the bunded area is useful to ensure no leaks are occurring with the containment system.

Class II ROVs can be utilized during a deepwater well blowout to support the Class III ROV operations. The observation capabilities and additional sensor capabilities allows the Class III ROV to be free to complete more heavy lift and operational tasks requiring higher HP and hydraulic power.

Class III ROVs are utilized to carry out the well intervention duties and to help facilitate the repair and recovery of well components. The onboard cameras onboard also provide the direct view of the spill from subsurface which aids the responders in preparing the proper engineering plan.

Class IV ROVs may be utilized during a large spill incident in deepwater to provide trenching and excavation capabilities to clear debris fields and also provides the capability of deploying backup or standby pipelines to divert the oil.

Class V vehicles are utilized to carry out the detection and survey of the spill area and provides valuable water column samples utilizing the oil detection and flow measuring sensor packs.

Sensor Requirements/Recommendations

Scenario 4: Offshore Platform (Finite Amount)		ROV Classes				
Sensor Group	Sensor	Class I	Class II	Class III	Class IV	Class V
Subsea Direct Sensors	Fluorometer	1	3	3	1	3
	NDIR (CH4)	1	3	3	1	1
Subsea Indirect Sensors	CTD	1	3	3	1	3
	DO (electrochemical)	1	3	3	1	1
	DO (optical)	1	3	3	1	3
	NDIR (CO2)	1	3	3	1	1
	Turbidity Meter	1	3	3	1	3

Hydrophone devices are useful for deployments for this type of release in case the spill around the terminal area involves a flowline or any pressure vessel in contact with the main water body. Fluorometer devices can be utilized by the ROV up to a maximum range the 20m.

ROV Operations

Normal operational procedures are utilized for operating the ROVs in contaminated areas such as fresh water rinses before dives and pre-dive equipment checks. It is recommended to utilize The Code of Practice for the Safe & Efficient Operation of Remotely Operated Vehicles (IMCA R 004 Rev. 3) as a minimum guideline for the ROV operation. The ROV crew traditionally wears gloves for normal operations with the addition of nitrile gloves over the PPE gloves when recovering the ROV from the contaminated area. Nitrile gloves provide better chemical resistance than latex gloves. Observations ROVs can be used for near-shore spills to provide surveillance around the platform area and also subsurface by providing visual support for the Class III ROVs.

3.0.4 Offshore Pipeline Rupture (Scenario 5)

Figure 16-Offshore Leak with Containment Teams
(Source: Gerald Hubard, AP)

The offshore pipeline rupture assumes a scenario where a dredging project caused damage to the pipeline and caused a release of hydrocarbons at a significant rate. The response scenario will vary based upon nearshore and deepwater and the appropriate response plans should reflect the appropriate response to protect the shoreline and environmentally sensitive areas (ESAs).

Operational Response

	IOGP-IPIECA Preparedness Levels	**IOGP-IPIECA Response Levels**
T1	The Tier 1 preparedness should include active verifications of response vessel availability and boom/dispersant inventories appropriate to support any pipeline incidents.	Tier 1 response should include the deployment of containment booms through support vessels to ensure the spill is contained.
T2	The Tier 2 preparedness initiatives provide for the contracted resources in the plan to provide aerial reconnaissance and dispersant deployment.	The Tier 2 response should include small vessels supporting the containment plan
T3	The operator has an option to utilize the Tier 3 response center to maintain an operational focus on the response initiative	The Tier 3 response center should be activated to ensure coordination efforts are focuses on containing the subsurface spill. This includes deploying available IMR vessels and support ROVS capable of providing real-time video and data from subsea to inspect the damage and coordinate an engineering plan.

The response to this type of spill would require a tiered mobilization of personnel and equipment.

1) Specified operator/contractor vessels would be dispatched to support the incident with the most experienced personnel in regards to spill mitigation and analysis.
2) The support contractors would support staging material coordinators at the heliport and a dock location to track receiving items and make sure the material arrives on scene for deployment. The dispersant materials and the oil containment material would be key parts of this staging process.
3) The support contractors would staff up for 24-hour support in inventory and shipping.
4) The ROV contractor would mobilize the ROV support team to include the available Class I, II, III, and IV ROVs and any applicable class V vehicle (AUV for area survey)
5) The contractors would provide at least (1) Operations Project Manager to "live" in the client's facility for instant support
6) The engineering support division (the engineers responsible for the rapid design and integration of custom tooling and equipment) would staff up to 24-hour engineering support.
7) Video & data streaming solutions (topside and underwater) are deployed to support telemetry back to the command center.
8) The HSE equipment companies mobilize to provide gas detection equipment and fit clean air respirators.
9) Have an installation crew on standby to support if an ROV installation is required. Installations should follow the guidelines set forth in Guidelines for Installing ROV Systems on Vessels or Platforms (IMCA R 018, May 2013).

Precautions/Considerations

Due to the limited depth related to the near-shore release, immediate emphasis should be placed on containment via boom deployment and small vessel deployments to support the cleanup. Care must be taken in the use of a fluorescent dye for fluorometer detections in that dyes such as Fluorescein are being phased out in the latest environmental legislation in regards to discharges at sea. It is important to ensure with the environmental legislation for the spill area which approved dyes can be used.

UUV Requirements/Recommendations

I

Class I Observation ROVs can be used to inspect areas where oil can become trapped dockside. The smaller Class I ROVS are readily transportable to the spill area by personnel and can be manually lowered along the spill areas dockside. External examination of the bunded area is useful to ensure no leaks are occurring with the containment system.

II

Class II ROVs can be utilized during a deepwater well blowout to support the Class III ROV operations. The observation capabilities and additional sensor capabilities allows the Class III ROV to be free to complete more heavy lift and operational tasks requiring higher HP and hydraulic power, such as activating pipeline repair tools.

Class III ROVs are utilized to carry out the well intervention duties and to help facilitate the repair and recovery of well components. The onboard cameras onboard also provide the direct view of the spill from subsurface which aids the responders in preparing the proper engineering plan.

Class IV ROVs may be utilized during a large spill incident in deepwater to provide trenching and excavation capabilities to clear debris fields and also provides the capability of deploying backup or standby pipelines to divert the oil.

Class V vehicles are utilized to carry out the detection and survey of the spill area and provides valuable water column samples utilizing the oil detection and flow measuring sensor packs.

Sensor Requirements/Recommendations

Scenario 5: Offshore Pipeline Rupture		ROV Classes				
Sensor Group	Sensor	Class I	Class II	Class III	Class IV	Class V
Subsea Direct Sensors	Fluorometer	1	3	3	1	3
	NDIR (CH4)	1	3	3	1	1
Subsea Indirect Sensors	CTD	1	3	3	1	3
	DO (electrochemical)	1	3	3	1	1
	DO (optical)	1	3	3	1	3
	NDIR (CO2)	1	3	3	1	1
	Turbidity Meter	1	3	3	1	3

Hydrophone devices are useful for deployments for this type of release in case the spill around the terminal area involves a flowline or any pressure vessel in contact with the main water body. Fluorometer devices can be utilized by the ROV up to a maximum range the 20m.

ROV Operations

Normal operational procedures are utilized for operating the ROVs in contaminated areas such as fresh water rinses before dives and pre-dive equipment checks. It is recommended to utilize The Code of Practice for the Safe & Efficient Operation of Remotely Operated Vehicles (IMCA R 004 Rev. 3) as a minimum guideline for the ROV operation. The ROV crew traditionally wears gloves for normal operations with the addition of nitrile gloves over the PPE gloves when recovering the ROV from the contaminated area. Nitrile gloves provide better chemical resistance than latex gloves.

3.0.5 Deepwater Well Blowout (Macondo Type; Continuous Release) (Scenario 6)

Figure 17-MC252 Fire Offshore
(Source: US Chemical Safety Board)

The deepwater well blowout scenario covers the various methods used to respond in addition recommendations made on the equipment preparation and staging to mitigate the incident. This type of scenario requires a large amount of coordination to ensure the proper sensors are utilized correctly.

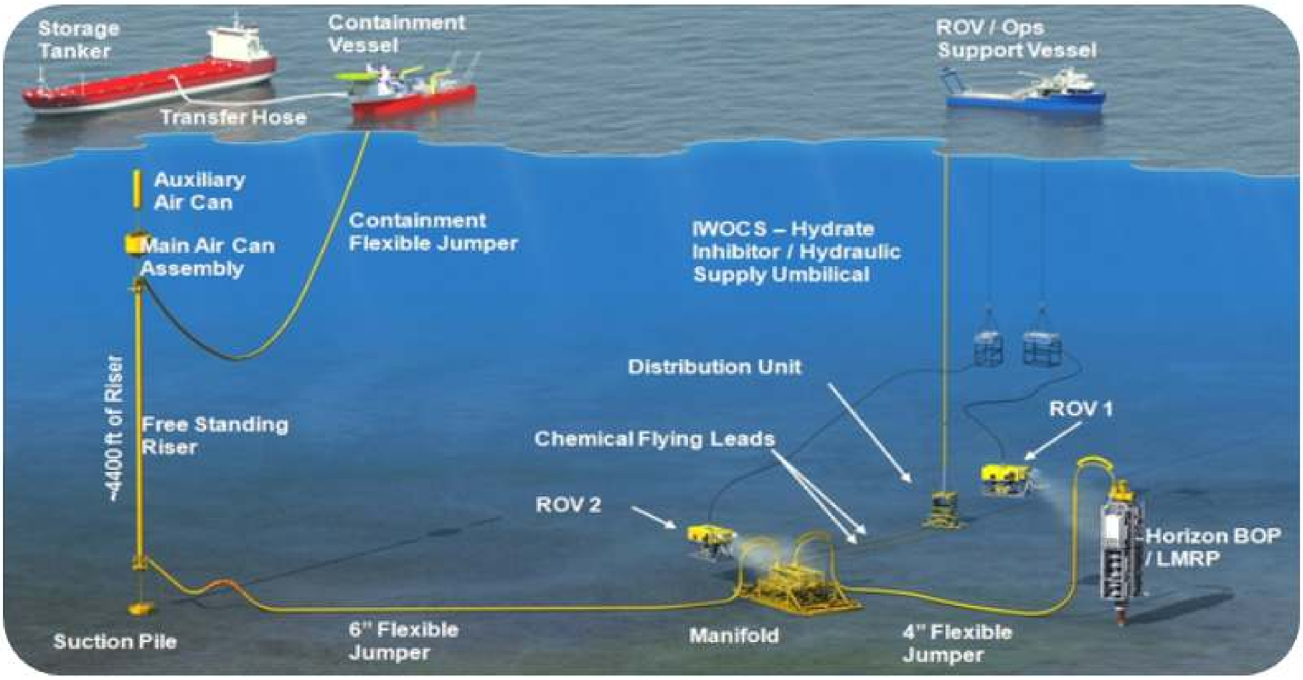


Figure 18-Oil Containment Equipment

Operational Response

	IOGP-IPIECA Preparedness Levels	IOGP-IPIECA Response Levels
T1	The platform teams should continue to train for recovery operations. Supply vessels in support of the platform should maintain appropriate dispersant inventories.	Tier 1 response should include the deployment of containment booms to ensure the spill is contained. The SOPEP (shipboard oil pollution emergency plan) is utilized and provides the procedures to contact the appropriate personnel and authorities.
T2	The Tier 2 preparedness initiatives provide for the contracted resources in the plan to provide aerial reconnaissance and dispersant deployment.	The Tier 2 should be activated to ensure the aerial and dispersant resources are available and inventory levels are coordinated to ensure the supply levels are appropriate to the spill amount.
T3	The partner support agreements provide access to a Tier 3 response center and associated drills via partner agreements should provide up to date incident response plans.	The operator will utilize the Tier 3 response center and will mobilize all available resources and partner agreements available. The Tier 3 response typically would require government support to mobilize the required resources and equipment to contain the spill

The response to this type of spill would require a tier III mobilization of personnel and equipment.

1) Specified operator/contractor vessels would be dispatched to support the incident with the most experienced personnel in regards to spill mitigation and analysis.
2) The support contractors would support staging material coordinators at the heliport and a dock location to track receiving items and make sure the material arrives on scene for deployment. The dispersant materials and the oil containment material would be key parts of this staging process.
3) The support contractors would staff up for 24-hour support in inventory and shipping.
4) The ROV contractor would mobilize the ROV support team to include the available Class I, II, III, and IV ROVs and any applicable class V vehicle (AUV for area survey)
5) The contractors would provide at least (1) Operations Project Manager to "live" in the client's facility for instant support

6) The engineering support division (the engineers responsible for the rapid design and integration of custom tooling and equipment) would staff up to 24-hour engineering support.
7) Video & data streaming solutions (topside and underwater) are deployed to support telemetry back to the command center.
8) The HSE equipment companies mobilize to provide gas detection equipment and fit clean air respirators.
9) Have an installation crew on standby to support if an ROV installation is required. Installations should follow the guidelines set forth in Guidelines for Installing ROV Systems on Vessels or Platforms (IMCA R 018, May 2013).

Precautions/Considerations

Due to the limited depth related to the near-shore release, immediate emphasis should be placed on containment via boom deployment and small vessel deployments to support the cleanup. Care must be taken in the use of a fluorescent dye for fluorometer detections in that dyes such as Fluorescein are being phased out in the latest environmental legislation in regards to discharges at sea. It is important to ensure with the environmental legislation for the spill area which approved dyes can be used.

UUV/Tooling/Sensor Requirements/Recommendations

Class I ROVs can be utilized during a deepwater well blowout to support nearshore efforts by providing high-resolution imagery to look for oil spill debris in shallow water areas. The Class I ROVs are utilized at the BOP subsurface level to support the SIMOPS view of the ongoing subsea operations. The Class I ROVs can be transported subsurface in a cradle by the Class III ROVs.

Class II ROVs can be utilized during a deepwater well blowout to support the Class III ROV operations. The observation capabilities and additional sensor capabilities allows the Class III ROV to be free to complete more heavy lift and operational tasks requiring higher HP and hydraulic power.

Class III ROVs are utilized to carry out the well intervention duties and to help facilitate the repair and recovery of well components. The onboard cameras onboard also provide the direct view of the spill from subsurface which aids the responders in preparing the proper engineering plan.

Class IV ROVs may be utilized during a large spill incident in deepwater to provide trenching and excavation capabilities to clear debris fields and also provides the capability of deploying backup or standby pipelines to divert the oil.

Class V vehicles are utilized to carry out the detection and survey of the spill area and provides valuable water column samples utilizing the oil detection and flow measuring sensor packs.

Sensor Requirements/Recommendations

Scenario 6: Deepwater Well Blowout		ROV Classes				
Sensor Group	Sensor	Class I	Class II	Class III	Class IV	Class V
Subsea Direct Sensors	Fluorometer	1	3	3	1	3
	NDIR (CH4)	1	3	3	1	1
Subsea Indirect Sensors	CTD	1	3	3	1	3
	DO (electrochemical)	1	3	3	1	1
	DO (optical)	1	3	3	1	3
	NDIR (CO2)	1	3	3	1	1
	Turbidity Meter	1	3	3	1	3

Hydrophone devices are useful for deployments for this type of release for detecting flows from riser pipes and drill pipe under high pressure. Fluorometer devices can be utilized by the ROV up to a maximum range the 20m. Still imagery and live video will be highly utilized during this type of incident. The use of vessel-to-vessel video (RF) will also be utilized to ensure the SIMOPS view of is shared across vessels in the field without consuming satellite bandwidth.

ROV Operations

For events of this scale, the ROV crew rotations will typically involve a 24-hour rotating schedule. The ROVs typical work day is 12 hours. The daily operations include dive plan meetings, a pre-dive check, the vehicle launching, the dive, the vehicle recovery, and a post-dive check. The first one or two operating days at the spill site are typically used for system testing and operational verification which will as a minimum include the first dive and may include the second dive if problems are encountered on the first. Any repairs or modifications, downloading of data, reporting, logging and any other operational tasks are also included in this period. Normal operational procedures are utilized for operating the ROVs in contaminated areas such as fresh water rinses before dives and pre-dive equipment checks. It is recommended to utilize The Code of Practice for the Safe & Efficient Operation of Remotely Operated Vehicles (IMCA R 004 Rev. 3) as a minimum guideline for the ROV operation or NORSOK U-102 Remotely Operated Vehicle (ROV) Services (Edition 2, September 2012). The ROV crew traditionally wears gloves for normal operations with the addition of nitrile gloves over the PPE gloves when recovering the ROV from the contaminated area. Nitrile gloves provide better chemical resistance than latex gloves.

A proper command center onshore should be enable full-time communications and coordination with the ROVs and vessels responding to the event. For SIMOPS (Simultaneous Operations), a command and control plan should be put in place to ensure effective management of the spill response. An ICS (Incident Command System) provides for a standardized incident management system to coordinate all of the activities at a large scale.

The ICS allows for the coordinated effort be centralized for large-scale events such as a deepwater well blowout. The ROV activities typically falls under the Operations section and this provides the Incident Commander the capability to interact and view the activities occurring subsea and around the incident site. The ROV video and telemetry fits into the larger Common Operating Picture. The COP map interface allows for a simple method to continue gathering the information and transmitting it through a controlled release mechanism. The increased use of video and telemetry storage allows for replay capabilities, which allows for detailed analysis and continuous improvement processes. The data layers that are commonly added to the COP interface include weather, bathymetry, ocean eddy currents, live video, and asset tracking.

Figure 19-ROV SIMOPS Room

4 Summary Recommendations

The use of ROVs as provided by the information above demonstrates that the use of all assets available (i.e. ROV, AUV, etc.) is important to effectively respond to an incident. The near shore spill provides a tighter constraint due to the depths involved subsurface. This predicates the use of smaller, more agile sensor platforms. The deepwater well blowout provides for the utilization of all available assets due to the surface leaks and the subsurface contamination from the blowout.

Utilizing the below instrumentation charting that are based upon the summarizations provided by the November 2014 Battelle report, ”Capabilities and Uses of Sensor-Equipped Ocean Vehicles for Subsea and Surface Detection and Tracking of Oil Spills”. The recommendations are written to provide similar guidance in format and ratings for the ROV and sensor integration to provide a consistent reporting structure. The ratings of 1, 2, and 3 are broken down into the following:

1. The sensor is not expected to be compatible with the ROV listed
2. The sensor is compatible but will require an external mounting configuration and the sensor may preclude other integrated sensors from outfitting onboard the ROV.
3. The sensor rated at a level 3 should easily fit within the vessel and does not preclude additional sensor integrations onboard the ROV.

(Source: November 2014 Battelle report, ”Capabilities and Uses of Sensor-Equipped Ocean Vehicles for Subsea and Surface Detection and Tracking of Oil Spills”)

Direct Sensor Integration

			Direct Sensor Detection																						
Vehicle		ROV Class	ASD Sensortechnik BackScat1	Bowtech Leak Detection System	Chelsea Technologies Subsea Pipeline Leak	Chelsea Technologies UniLux Fluorometer	Chelsea Technologies UV AquaTrack Fluorometer	CONTROS HydroC CH4 Hydrocarbon	CONTROS HydroC PAH Fluorometer Sensor	CONTROLS Mobile Leak Detection System	Hack FP 360 SC Oil-in-Water Sensor	Neptune Oceanographic SNIFFIT	OceanTools OceanSENSE Leak Detection	Phaze Hydrocarbon Leak Detector	Sea & Sun Technology UV Fluorometer	Seapoint UV Fluorometer	Smart Light Devices LDS3 Laser Leak Detection	Sonardyne Automatic Leak Detection Sonar	Teledyne TSS MELDS System	TriOS enviroFlu-DS	TriOS enviroFlu-HC	Turner Designs C3 Submersible Fluorometer	Turner Designs Cyclops 6K customizable	Turnder Designs Cyclops 7K customizable	Weatheford BigEars Passive Acoustic Leak
6.1.1	Oceaneering SeaMaxx	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.2	Oceaneering Hyrda Minimum	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.3	Ageotec Sirio	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.4	Aquabotix HydroView Pro	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.5	Deep Ocean Needlefish P150	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.6	Seabotix LBV300-5	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.7	VideoRay Pro4	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.2.1	Ageotec Perseo GTV	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.2	Ageotec Perseo	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.3	Deep Ocean Eng L4N	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.4	Deep Ocean Eng S5N	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.5	Depp Ocean Eng T4N	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.6	FET Mojave	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.7	FET Mohawk	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.8	FET Mohican	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.9	Submersible Systems TRV-005	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.3.1	Oceaneering Millennium Plus	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.2	Oceaneering Magnum Plus ROV	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.3	Oceaneering Maxximum	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.4	Oceaneering Spectrum	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.5	Ageotec Pegaso	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.6	DSSI Global Explorer	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.7	DOER Marine H6500	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.8	DOER Marine H2000	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.9	DOER Marine H3000	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.10	SMD Atom	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.11	SMD Quasar	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.12	SMD Quantum	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.13	FET Super Mohawk	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.14	FET Tomahawk	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.15	FET Comanche	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.16	Submersible Systems TRV-M	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.17	Submersible Systems TRV-HD	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.18	Schilling HD	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.19	Schilling UHD-III	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.20	Saipem Innovator Leviathan	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Table 4-Direct Sensor Integration

Indirect Sensor Integration

			Indirect Sensor Detection																
Vehicle		ROV Class	AADI Conductivity Sensor 4319	AADI Oxygen Sensor 3830	AADI Seaguard O2	AADI Turbidity Sensor 4112	AML Oceanographic Smart CTD	CONTROLS HydroC CO2 Carbon Dioxide Sensor	Sea & Sun Technology Conductivity Sensor	Sea Bird SBE 19plus V2 SeaCAT	Sea Bird SBE 25 plus Sealogger	Sea Bird SBE 49 FastCAT CTD Sensor	SeaBird SBE 911 plus;917 plus	SeaPoint Sensors Turbidity Meter	Teledyne RD Instruments Citadel CTD CT-EK	Wetlabs WQM	YSI EXO Series	Sequoia LISST-DEEP	4DEEP Inwater Imaging Submersible Microscope
6.1.1	Oceaneering SeaMaxx	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.2	Oceaneering Hyrda Minimum	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.3	Ageotec Sirio	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.4	Aquabotix HydroView Pro	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.5	Deep Ocean Needlefish P150	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.6	Seabotix LBV300-5	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.1.7	VideoRay Pro4	I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6.2.1	Ageotec Perseo GTV	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.2	Ageotec Perseo	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.3	Deep Ocean Eng L4N	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.4	Deep Ocean Eng S5N	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.5	Depp Ocean Eng T4N	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.6	FET Mojave	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.7	FET Mohawk	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.8	FET Mohican	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.2.9	Submersible Systems TRV-005	II	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6.3.1	Oceaneering Millennium Plus	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.2	Oceaneering Magnum Plus ROV	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.3	Oceaneering Maxximum	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.4	Oceaneering Spectrum	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.5	Ageotec Pegaso	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.6	DSSI Global Explorer	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.7	DOER Marine H6500	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.8	DOER Marine H2000	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.9	DOER Marine H3000	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.10	SMD Atom	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.11	SMD Quasar	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.12	SMD Quantum	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.13	FET Super Mohawk	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.14	FET Tomahawk	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.15	FET Comanche	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.16	Submersible Systems TRV-M	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.17	Submersible Systems TRV-HD	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.18	Schilling HD	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.19	Schilling UHD-III	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6.3.20	Saipem Innovator Leviathan	III	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Table 5-Indirect Sensor Integration

5 References

The following references were utilized in the completion of this paper.

ACSA	http://acsa-alcen.com
AADI	http://www.aadi.no
Ageotec	http://www.ageotec.com
AML Oceanographic	http://www.amloceanographic.com/
Aquabotix	http://www.aquabotix.com
ASCO	http://www.ascoworld.com
ASV	http://www.asvglobal.com
Atlas Elektronik	http://www.atlas-elektronik.com/en/
Atlas Maridan	http://www.maridan.atlas-elektronik.com/
Autonomous Underwater Vehicle Applications Center	http://auvac.org
Bluefin Robotics	http://www.bluefinrobotics.com/
C&C Technologies	http://www.cctechnol.com
Chelsea Technologies Group	http://www.chelsea.co.uk
CleanupOil	http://www.cleanupoil.com
CONTROS	http://www.contros.eu/
ECA Robotics	http://www.eca-robotics.com
Deep Ocean	http://www.deepocean.com
DOER Marine	http://www.doermarine.com
DSSI	http://www.deepseasystems.com
Exocetus	http://exocetus.com
Falmouth Scientific, Inc.	http://www.falmouth.com
FET	http://www.f-e-t.com

FLIR Systems, Inc.	http://www.flir.com
Hamamatsu Photonics K.K.	http://hamamatsu.com
INFRATEC GmbH	http://infratec.com
International Submarine Engineering	http://www.ise.bc.ca
JAI	http://jai.com
Jenoptik	http://jenoptik.com
Kongsberg Maritime AG	http://www.km.kongsberg.com
Laser Diagnostic Instruments	http://www.ldi.ee
Miros	http://miros.no
Oceaneering	http://www.oceaneering.com
OceanServer Iver2	http://iver-auv.com/
Optimare Systems GmbH	http://optimare.de
RD Instruments	http://www.rdinstruments.com
Rutter	http://rutter.ca
Saipem	http://www.saipem.com
Schilling Robotics	http://www.fmctechnologies.com
Sea & Sun Technology	http://www.sea-sun-tech.com
Sea Robotics	http://searobotics.com
SIEL Advanced Sea Systems	http://www.sielnet.com
SMD	http://www.smd.co.uk
Submersible Systems, Inc.	http://www.submersiblesystems.com
Teledyne Gavia	http://www.gavia.is
Teledyne Webb Research	http://www.webbresearch.com
TriOS Optical Sensors	http://www.trios.de/
Videoray	http://www.videoray.com

6 Appendix A-ROV Systems Summary

The following is a list of the ROVs used for reference for this report. This isn't meant to be the definitive list but should provide a good summary reference for the various types of systems available.

6.1 Class I Observation Vehicles

The observation class includes specialty vehicles that are primarily used to augment the operations of larger vehicles. Providing visual or sonar/lidar support allows a more complete picture of the subsea operations. The observation class ROVs also allow for better inspections within confined and difficult to reach spaces that a larger work class ROV cannot access.

6.1.1 Sea Maxx


Manufacturer
Oceaneering International, Inc.
Depth Rating
10,000 ft / 3,050 m
Optional Depths
13,000 ft / 4,000 m
Payload
10 lb/3.6kg in seawater
User Adjustable with Lead
Power
1,500 V AC 50/60 Hz 2.2 kW Peak
Speed
Forward: 2.5 knots
Lateral: 1.0 knots
Vertical: 1.25 knots
Dimensions
Length: 32 in /.8128 m
Width: 24 in /.6096 m
Height: 18 in /.4572 m
Vehicle Weight
In Air: 244 lb/104 kg
In Water: positive 2.5 lbs

Optical
HD Camera 1920 x 1080i Superwide
3.8x zoom
110° FOV @ Full Wide
0.1 lux Light Sensitivity
Optical Glass Dome Port
HD-SDI Fiber Optic Video Link
Heading
Micro Strain Mini Gyro
± 1° Resolution
Auto Heading Feedback Only
Optional - Fiber Optic Gyro (FOG)
Superwide
3.8x zoom

Summary: Oceaneering subsidiary Deep Sea Systems (DSSI) has designed and built the Sea Maxx Satellite Remotely Operated Vehicle (SAT-ROV) to work in tandem with work class ROVs at depths up to 4,000 meters. This SAT-ROV is deployed from a separate housing mounted beneath the work class ROV cage.

The SAT-ROV is powered by four thrusters including two horizontal, one lateral and one vertical. It is equipped with a wide angle HDTV camera module, two variable intensity 40 watt LED lights and a 450′ length tether.
The small size of the Sea Maxx allows it to inspect difficult to reach and confined areas that a larger Work Class ROV cannot access.space and any additional mobilization time for as secondary ROV unit.

6.1.2 Hydra Minimum

Manufacturer
Oceaneering International, Inc.
Depth Rating
10,000 ft / 3,050 m
Payload
100 lb/45.36kg in seawater
PROPULSION
6 1hp DC brushless electric motors consisting of:
4x Vectored Horizontal
2x Vertical
Speed
Forward: 3 knts
THRUST
Axial 170 lbs
Lateral 80 lbs
Vertical 85 lbs
Dimensions
Length: 65 in / 1.651 m
Width: 39 in / .9906 m
Height: 20 in / .508 m
Vehicle Weight
In Air: 550 lb/249 kg

Optical
1 x high-resolution CCD color camera w/ Pan & Tilt unit
1 x additional CCD camera (optional)
Sonar
1 x Obstacle Avoidance Sonar (optional)
Optional - Fiber Optic Gyro (FOG)
Superwide
3.8x zoom

Summary: Oceaneering developed the Hydra® Minimum ROV for tandem operations with the company’s work class ROV, the Hydra® Magnum. The Minimum is deployed through a 1,000 ft. capacity Tether Management System (TMS) and separate cage attached to the bottom of a standard Hydra Magnum cage.

The Minimum adds redundancy to increase uptime for uptime operations. With six one horsepower, DC powered, brushless electric motors, the Minimum has the ability to operate in currents of up to 3 knots fore, aft and laterally. Should backup operations be required, the Minimum interfaces through the Magnum's umbilical by utilizing dedicated fiber optic telemetry and video transmission between surface and subsea units.

The Minimum's video suite includes a high-resolution CCD camera with Pan and Tilt unit. Capabilities for an additional video camera or for optional Obstacle Avoidance Sonar are installed in the system.

6.1.3 Sirio

Manufacturer
Ageotec
Depth Rating
984 ft / 300 m
Payload
10 kg
Power Requirements
220-240 VAC, 380-410 VAC single phase 50/60 Hz 3 kW
PROPULSION
2 vertical oblique at 40° vectored and 2 horizontal vectored DC brushless thrusters
Thrust
Forward: 16 kg
Lateral: 7 kg
Vertical: 15 kg
Dimensions
Length: 65 in / 1.651 m
Width: 39 in / .9906 m
Height: 20 in / .508 m
Vehicle Weight
In Air: 88.18 lb/ 40 kg

Optical
The Colour camera (540 lines, low light auto-switch mode to BW) is fitted inside the electronic POD protected by an hemispherical PMMA high transparency dome.
Control Unit
Pilot monitor and video recorder are fitted in 12 U flight- case with the surface electronic control and power supply for vehicle.
Optional
2nd external camera
Sonar
2F electric manipulator Transponder installation kit Contact CP Probe installation kit

Summary: The chassis is built of polyethylene H.D. and has a stainless steel load frame and lift points. They system comes with a video overlay capability provided by Nautec which provides: heading, date and time, tilt position, depth, cp probe data, and navigation input string. For the control unit and SCU/CPU, the pilot monitor and video recorder are fitted in a a 12u flight case with the surface electronic control and power supply interface for the ROV.

The Colour camera (540 lines, low light auto-switch mode to BW) is fitted inside the electronic POD protected by an hemispherical PMMA high transparency dome.

6.1.4 HydroView Pro


Manufacturer
Aquabotix
Depth Rating
500 ft / 152 m
Power Requirements
Lithium Battery - Run Time 3 hours
PROPULSION
Motors
Model 5M 2 Thrusters, 3 Hovering/Pitch
Model 7M 4 Thrusters, 3 Hovering/Pitch
Model 8M 4 Thrusters, 1 Lateral, 3 Hovering/Pitch
Speed
Forward: 4 Knots
Reverse: 2 Knots
Dimensions
Length: 19 in / .48 m
Width: 14.6 in / .37 m
Height: 12 in / .3 m
Vehicle Weight
In Air: 15 lb/6.8 kg

Optical
Resolution: 1MP
Auto Focus: 6" to infinity
Field of View: 66 degrees diagonal
Image Sizes: WXGA(1280 x 800), True HD 720p (1280x720), VGA (640x480)
Control Unit
Pilot monitor and video recorder are fitted in 12 U flight- case with the surface electronic control and power supply for vehicle.
Optional
2nd external camera
Sonar
2F electric manipulator Transponder installation kit Contact CP Probe installation kit

Summary: The HydroView Pro is an observation class ROV used for visual inspections. It includes the following standard features:
LED lights, HD camera, Depth Sensor, Temperature Sensor, Orientation Sensor, Standard 250 foot cable, Waterproof carrying case, Topside box which generates its own Wi-Fi, Propeller Guards, Free Download of the Application to use on your iPad, or PC computer.

The system comes with various optional accessories including: 12V power supply,Grabbing Arm,Environmental Sensors, User Control Workstation, Scanning Search Sonar, High Intensity Lighting, Wide Angle 1080p HD Camera, and a Very High Definition HD Camera. The system is capable of forward speeds of 4kts and reverse speeds of 2 knots.

6.1.5 Needlefish P150

Manufacturer
Deep Ocean
Depth Rating
53 ft / 175m
PROPULSION
4 Shaft driven 48VDC brushed motors
Speed
Forward: 2 knots / 1m/sec
Thrust
Forward: 11 lb/5 kg
Dimensions
Length: 25.30 in/.64 m
Width: 13.88 In/.35 m
Height: 11.5 in/.29 m
Payload: 8 lb/3.6 kg
Vehicle Weight
In Air: 40 lb/18 kg

Optical
DOE Smart / Zoom Camera
● 1/4 type super HAD CCD imaging
● 380K pixels with 18:1 optical zoom Auto / Manual focusing ● Depth Rating: 122m (400 ft)
● Tilting + / - 90 degrees
● 1.0 lux typical at f1.4
● NTSC / PAL versions available
Optional plug and play secondary continuous camera
Control Unit
Utilizes 2 Joysticks
Auto depth, camera focus / zoom
Secondary joystick only hand controller with deck cable
Optional
Radiation tolerant video cameras
Rear facing camera (low light optional) and light
Depth pressure transducer
S-Video functionality on DOE Smart / Zoom camera
tooling UT thickness gauge
2 function manipulator
Spot Cleaning Brush

Summary: The Needlefish P150 is a portable system designed for inspections, NDTS and small object retrieval. It is equipped with two horizontal and two "vertrans" thrusters. It has no electronics in the sub-unit which ensures high reliability in areas of high radiation. It is designed for the nuclear industry with stable materials and provides good visibility with its DOE camera. It has an optional rear facing camera for operating in tight spaces and also a video overlay system to overlay customer tooling data. The system can also be outfitted with a 2-function manipulator for object retrieval or manipulation and a spot cleaning brush can be mounted onto ROV for clearing fouling.

6.1.6 Seabotix LBV300-5

Manufacturer
Seabotix
Depth Rating
984 ft / 300 m
PROPULSION
Five (5) Brushless DC thrusters - Two (2) forward, two (2) vertical and one (1) lateral. Each thruster is identical and isolated
Speed
2.8 knots
Dimensions
Length: 20.5 in/.52 m
Width: 17.5 in/.44 m
Height: 10.2 in/.26 m
Vehicle Weight
In Air: 28.7 lb/13 kg

Optical
Camera Tilt
180 degrees - internal chassis rotates
Range of View
270 degrees - 180 degrees from tilt, 90 degrees from camera lens
Camera - Primary
680 line High-resolution color - 0.1 Lux @ f2.0
Focus
Manual focus control via operator control unit. 90mm to infinity
Video Format
NTSC or PAL
Lighting
700 Lumen LED array. Variable intensity via operator control unit.
Control Unit
Operator control unit, monitor and surface power supply built into protective case
Optional
Longer tether lengths
SIngle Function three jaw grabber
Additional external LED Lighting
HD1080i Camera
Zoom Camera-10x optical zoom.

Summary: The Seabotix is an observation ROV that comes with five brushless DC thrusters - Two (2) forward, two (2) vertical and one (1) lateral. Each thruster is identical and isolated and provides a high level of maneuverability. The system comes with an integrated navigation and control console

6.1.7 VideoRay Pro4

Manufacturer
Seabotix
Depth Rating
1000 ft / 305 m
PROPULSION
48 VDC power to Ultra submersible
Horizontal/Vertical 2 Brushless/1 Brushless
Direct Drive/Geared
100 mm Propellers/65 mm Propeller
Speed
3.9 knots
Dimensions
Length: 14.75 in/.37 m
Width: 11.4 in/.29 m
Height: 8.75 in/.22 m
Vehicle Weight
In Air: 85 lb/38.5 kg

Optical
Camera Tilt
180 degrees - internal chassis rotates
Range of View
90deg Hori/140deg Diag-wide angle
Camera - Primary
HD - 0.004 Lux
Video Format
NTSC or PAL
Lighting
3600 Lumen LED array. Variable intensity via operator control unit.
Control Unit
Operator control unit, monitor and surface power supply built into protective case

Summary: THE PRO 4Ultra BASE Remotely Operated Vehicle (ROV) System has been specifically configured for operations requiring Pro 4 performance in an ultra portable package. The Ultra BASE features a drastic reduction in control panel weight - about 40% lighter than the standard Pro 4 Control Panel. The Pro 4 Ultra BASE system includes a standard Pro 4 submersible, an ultra thin, sleek convertible touchscreen tablet / keyboard PC loaded with VideoRay Cockpit control software, and a wired USB Logitech hand controller. The Ultra BASE configuration is limited to small VideoRay accessories such as the manipulator (not included). It will not run sonar or any complex accessory components. The Auto Heading software feature is also disabled in the Ultra BASE ROV system. The user must also select a tether configuration for this system.

6.2 Class II Observation Vehicles with Payload Option

An Observation Class II ROV is typically outfitted with two simultaneously viewable cameras/sensor packages with the capability of additional sensor add-ons. Class II vehicles should be capable of operating without loss of original function while carrying at least two additional sensors.

6.2.1 Perseo GTV

Manufacturer
Ageotec
Depth Rating
4921 ft / 1,500 m
Payload
40 kg
Power
1,500 V AC 50/60 Hz 2.2 kW Peak
Thrust
Forward: 70 kg
Lateral: 50 kg
Vertical: 48 kg
Dimensions
Length: 57 in/1.45 m
Width: 37.4 in/.95 m
Height: 28.94 in/ .735 m
Vehicle Weight
In Air: 375 lb/170 kg

Optical
3x HD video channels, main cameras. 1x switched video channel, manipulator or rear camera. Basic configuration: 1x High-resolution Monochrome Camera, 570 TVL, 0,001 LUX, 1/3ccd and 1x High-resolution Color Camera, 480 LTV, 0.1 lux, 1/3 CCD.
Navigation
Flux-gate compass unit with solid state rate gyro sensor with high azimuth stability; electronic depth sensor; Standard functions: Auto-heading and Auto-depth. Auto-altitude function available on request, if altimeter sensor is fitted.

Summary: The Perseo GTV comes built with a modular chassis built with high impact polypropylene. The load frame and lift points are manufactured in stainless steel and the pressure housings are in anticorodal aluminum 6060. IT comes with 2 vertical and 4 vectored thrust propulsion units which provides the unit with 48kg of downward thrust, 70kg of forward thrust, and 50kg of lateral thrust.

The system comes equipped with a high-resolution color camera system and supports 3x HD camera systems simultaneously. The system comes standard with 2x150W halogen lamps for lighting and includes an intensity control regulator.

6.2.2 Perseo


Manufacturer
Ageotec
Depth Rating
1969 ft / 600 m
Payload
18 kg and 40 kg
Power Requirements
400 VAC 3-phase 50÷60 Hz 8 kW
Thrust
Forward: 35 kg
Lateral: 25 kg
Vertical: 22 kg
Dimensions
Length: 38.58 in/.98 m
Width: 27.95 in /.71 m
Height: 20.08 in/ .51 m
Vehicle Weight
In Air: 176.37 lb/80 kg

Optical
2 video-channels. High-resolution cameras Colour 86 is standard as well black&white camera BW42.
2x150 W halogen lamps with control intensify regulator. Tilt with feedback position displayed on pilot monitor is standard a joystick potentiometer provides an accurate tilt angle.
Control Unit and SCU-CPU
Pilot monitor and video-recorder are fitted in 15U Flight- case with the surface electronic control and power supply. NauTec video overlay as standard provides digital compass data, date time, tilt icon position depth, CP Probe or Metal detector value. Vehicle equipment data may be exported to the clients's survey and navigation computer.

Summary: The Perseo is built for visual and instrument inspections and comes built with a modular chassis built with polyethylene H.D.. The load frame and lift points are manufactured in stainless steel and the pressure housings are in anticorodal aluminum 6060. IT comes with 2 vertical and 4 vectored thrust propulsion units which provides the unit with 22kg of downward thrust, 35kg of forward thrust, and 25kg of lateral thrust.

The system comes equipped with a high-resolution color camera system and a black & white BW42 camera. Tilt with feedback position displayed on pilot monitor is standard a joystick potentiometer provides an accurate tilt angle.

6.2.3 L4N

Manufacturer
Deep Ocean
Depth Rating
1640 ft / 500 m
Payload
40 kg
Power Availability
24VAC@6.6kw
Thrust
Forward: 41 kg
Lateral: 21 kg
Vertical: 21 kg
Dimensions
Length:41.5 in/1.054 m
Width: 28.5 in/.72 m
Height: 26 in/ .66 m
Vehicle Weight
In Air: 250 lb/113 kg

Optical
2 video-channels. High-resolution cameras Colour 86 is standard as well black&white camera BW42.
2x150 W halogen lamps with control intensify regulator. Tilt with feedback position displayed on pilot monitor is standard a joystick potentiometer provides an accurate tilt angle.
Control Unit and SCU-CPU
Pilot monitor and video-recorder are fitted in 15U Flight- case with the surface electronic control and power supply. NauTec video overlay as standard provides digital compass data, date time, tilt icon position depth, CP Probe or Metal detector value. Vehicle equipment data may be exported to clients's survey and navigation computer.

Summary: The L4N is an inspection class ROV platform that comes standard with four brushless thrusters-two horizontal, one lateral, and one vertical.

The system supports optional analog or digital cameras capable of resolution of 1280x960. The chassis is manufactured with Polypropylene and a skid chassis is available for fitting off additional tooling. The system has two primary lights at 4,800 lumens each and provides a color range of 6,000k.

6.2.4 S5N

Manufacturer
Deep Ocean
Depth Rating
4,921 ft / 1500 m
Payload
40 Kg
Power
190 VDC - Thrusters / Lighting
24 VDC - Telemetry / Video / Sonar etc.
220 VAC - Manipulator or Additional Tooling
Thrust
Forward: 73 kg
Lateral: 30 kg
Vertical: 16 kg
Dimensions
Length: 50 in/ 1.27 m
Width: 31.5 in/.80 m
Height: 30 in/.76 m
Vehicle Weight
In Air: 350 lb/158 kg

Optical
Resolution: >380K pixels Illumination: < 1 lux SNR: 50 db
Lens: 37mm
Pan/Tilt: Tilt assembly with Lighting and Camera Control: RS232
Vehicle Control/Navigation
Heading Sensor: FP2000 Accuracy: +/- 0.10 FSS Pressure Range: 0-1500 psi Total Error Band: +/- 2% FSS Maximum Depth: 1000 Meters

Summary: S5N is a portable high performance ROV system, combining power, telemetry and payload with ease of use, ruggedness and reliability providing a powerful overall performance envelope and versatility. It has five high performance thrusters four vectored and a single vertical.

The power and control system is network architecture for simplicity and ease of use, with multiple micro-processors providing redundancy and expanded capabilities. Specially designed high performance brushless thrusters provide the highest power to weight ratio and reliability vs. other vehicles in this class. The graphical user interface (GUI), with multiple menu screens, provides intuitive feedback and active user control for ease of vehicle handling, navigation, collection and display of sensor data, as well as setting and storing custom system configurations.

6.2.5 T4N

Manufacturer
Deep Ocean
Depth Rating
1000 ft / 305 m
Thrust
Forward: 23kg
Lateral: 10kg
Vertical: 10kg
Dimensions
Length:36.5 in/.927 m
Width: 19.75 in/.502 m
Height: 14 in /.356 m
Vehicle Weight
In Air: 99 lb/45 kg

Optical
Pan/Tilt: Tilt assembly with LED Lighting and Camera Control: Pilot box or GUI
HD camera option available
Resolution: 1280x960
Illumination: 0.05 SNR: 50 db Lens: 20x
Vehicle Control/Navigation
MLH Pressure Sensor Accuracy: +/-0.25
FSS Pressure Range: 50-500 psi
Maximum Depth: 380 Meters

Summary: The T4N is a rapid deployment ROV that comes with an updated portable topside control system with a GUI interface and a video overlay to provide metadata within the video. The system has a standard thruster configuration of 2 forward, 1 vertical and 1 lateral. The system comes with 2 LED lights rated at 1500 lumens and are capable of dimming by the operator.

The camera comes with a pan/tilt system controlled via the pilot box or the GUI. It is capable of 1280x960 resolution and provides a 20x zoom capability.

6.2.6 FET Mojave

Manufacturer
Forum Subsea Technologies
Depth Rating
984 ft / 305 m
Thrust
Forward: 53kg
Lateral: 53kg
Vertical: 26kg
Dimensions
Length:39.4 in/1 m
Width: 23.6 in/.6 m
Height: 19.7 in /.5 m
Vehicle Weight
In Air: 187 lb/85 kg

Optical
Camera tilt unit with Basic Camera
LED Lighting
Second Support Camera
Acoustic Camera
Vehicle Control/Navigation
Controlled by subCAN in conjunction with DVL and gyrocompass
Hands off Auto-Position
Waypoint Following for Set Courses
Return to Location Memory Function
Station Keeping in Currents

Summary: Compact, ergonomic design and lightweight construction allow for rapid setup and deployment using any domestic power supply. The FET Mojave comes with an advanced subCAN control & diagnostics system

300m Depth Rating
LED lighting as standard
5 x SPE-75 DC Thrusters
80 - 260V Single Phase Domestic Input
Auto Position / INS Options
Excellent payload options available
Graphic User Interface (GUI) Control
53 Kg Horizontal 26 Kg Vertical Thrust
Choice of Manipulators / Tooling
Auto Heading and Depth
Simple maintenance and operation

Mojave can be supplied with a complete range of specialist tooling / sensor skids for use Offshore or Inshore Oil & Gas, Scientific, Port Security, Military, Civil Engineering and numerous other applications.

6.2.7 FET Mohawk

Manufacturer
Forum Subsea Technologies
Depth Rating
6561 ft / 2000 m
Thrust
Forward: 80kg
Lateral: 60kg
Reverse: 70kg
Dimensions
Length:36.6 in/.93 m
Width: 30.3 in/.77 m
Height: 24.4 in /.62 m
Vehicle Weight
In Air: 364 lb/85 kg

Optical
Multiple video / telemetry channels
HD / stereo / PATZ / multi-beam / digital stills camera interfaces
4 x video channels , 2 x RS 485 channels, 4 x RS 232 channels
(1 dedicated to subCAN)
Vehicle Control/Navigation
Hands free navigation / station keeping
Power management and system protection
Live monitoring and diagnostics

Summary: Sub-Atlantic's fully electric MOHAWK remotely operated vehicle is a small compact, high performance professional ROV system which can be used for a variety of underwater tasks including observation, survey, NDT inspections and tooling.

This small, professional inspection ROV delivers exceptionally high thrust in all directions from Sub-Atlantic's reliable AC power thruster system. Mohawk provides high quality video for inspection work but also has the capabilities for running underslung tool packages such as tree valve torque tools, high pressure water jetting pumps and small hydraulic or electric manipulators.

Mohawk is rated at 1000 msw / 3280 fsw standard but can be easily upgraded to 2000 msw / 6560 fsw. Mohawk uses a small diameter main lift cable which reduces the Launch and Recovery System requirements and vessel deck space.

6.2.8 FET Mohican

Manufacturer
Forum Subsea Technologies
Depth Rating
6561 ft / 2000 m
Thrust
Forward: 110kg
Lateral: 110kg
Reverse: 110kg
Dimensions
Length:45.2 in/1.15 m
Width: 30.3 in/.77 m
Height: 31.5 in /.8 m
Vehicle Weight
In Air: 750 lb/340 kg

Optical
HD / Stereo / PATZ / Digital / Acoustic camera interfaces
Camera Tilt Unit
4 x video channels , 2 x RS 485 channels, 4 x RS 232 channels
(1 dedicated to subCAN)
Vehicle Control/Navigation
Hands free navigation / station keeping
Power management and system protection
Live monitoring and diagnostics

Summary: The Mohican ROV features a small diameter tether and high output brushless DC thrusters operating on Sub- Atlantic's 'Dynamic VectoringTM system. The Mohican comes with three or six simultaneous video channels transmitted through a fibre-optic telemetry system for sharp, high quality video inspections.

The ROV is also equipped with additional power sources for attachment of manipulator and tools such as our high pressure jetting and cleaning skid used in platform inspections.

Mohican uses a 3000 Volt, 400 Hz power transmission system from surface to ROV resulting in a small tether, main lift cable and launch & recovery system. This transmission system makes Mohican particularly suited for long tunnel inspections and deep live-boating operations.

6.2.9 TRV-005

Manufacturer
Submersible Systems
Depth Rating
3280 ft / 1000 m
Thrust
Forward: 104 kg
Lateral: 50 kg
Reverse: 68 kg
Dimensions
Length:60 in/1.524 m
Width: 48 in/1.219 m
Height: 18 in /.457 m
Vehicle Weight
In Air: 550 lb/250 kg

Optical
Sony Color Zoom, Focus, Pan & Tilt
Low Light Colour, Pan & Tilt
Rotary Color 360º Viewing
Colour Manip Camera
Cameras on two Video CCT's (any combination of two cameras can be viewed at any time)
Vehicle Control/Navigation
Gyro/Fluxgate Combination w/pitch & roll.
Auto Depth, Heading & Altitude

Summary: The TRV 005 Series has an open, angular frame made of T6061 marine grade aluminum which is designed to allow superior through flow for better hydrodynamics. The rugged frame is built to take abuse and allows secure mounting of any auxiliary equipment. Finally, the aluminum frame contributes significantly to the mass required for stability.

In an attempt to minimize downtime, the TRV has a totally modular design. This allows minimum expertise to maintain the TRV, keeping the vehicle in a fully operational condition. Telemetry, Power and Capacitor bottles, HPU and Valve Pack are separate for easy change out. From convenient, easy to remove connectors, oil filled cables and simplicity in removing the foam block for complete access, the TRV was designed for the true offshore environment.

6.3 Class III Work Class Vehicles

The Work Class vehicles have an increased payload capability compared to the Class I and II and can handle multiple sensor packages with plug-in type operational enhancements. Class III vehicles commonly have a multiplexing capability that allows additional sensors and tools to operate without being “hardwired” through the umbilical system.

6.3.1 Millenium Plus


Manufacturer
Oceaneering International, Inc.
Depth Rating
10,000 ft / 3,050 m
Optional Depths
13,000 ft / 4,000 m
Payload
400 lb/181 kg
Power
220HP
110HP (Cage & TMS)
Thrust
Forward: 907 kg
Lateral: 907 kg
Vertical: 943 kg
Dimensions
Length: 10.83Ft/X m
Width: 5.5FT/X m
Height: 6.33FT/X m
Vehicle Weight
In Air: 8800 lb/3991 kg

Optical
2x HD Camera 1920 x 1080i Superwide
3.8x zoom
110° FOV @ Full Wide
0.1 lux Light Sensitivity
Optical Glass Dome Port
HD-SDI Fiber Optic Video Link

Vehicle Control/Navigation
Fly-By-Wire Station Keeping
Auto Heading, Depth, Altitude, Pitch
Survey-Grade Gyro
Backup Flux Gate Compass
High-resolution Digiquartz
Kongsberg 1071 Obstacle Avoidance Sonar

Summary: The MILLENNIUM® Plus ROV (Remotely Operated Vehicle) is a side entry cage deployed, dual manipulator 220hp heavy work class ROV. The cage and Tether Management System (TMS) supplies an additional 110hp, is capable of powering skids and also has thruster control and auto heading features.

The Millennium Plus is easily serviceable, accepts many tooling packages and has simple survey integration capabilities. The Millennium Plus system employs microprocessor based telemetry to minimize maintenance, decrease set up time, simplify troubleshooting and to provide automatic control functions.

6.3.2 Magnum Plus

Manufacturer
Oceaneering International, Inc.
Depth Rating
10,000 ft / 3,050 m
Optional Depths
13,000 ft / 4,000 m
Payload
350 lb/158 kg
Power
170 HP
85HP (Cage & TMS)
Thrust
Forward: 725 kg
Lateral: 794 kg
Vertical: 544 kg
Dimensions
Length: 8.53ft/X m
Width: 5.1ft/X m
Height: 6.07FT/.X m
Vehicle Weight
In Air: 6750 lb/3061kg

Optical
2x HD Camera 1920 x 1080i Superwide
3.8x zoom
110° FOV @ Full Wide
0.1 lux Light Sensitivity
Optical Glass Dome Port
HD-SDI Fiber Optic Video Link

Vehicle Control/Navigation
Fly-By-Wire Station Keeping
Auto Heading, Depth, Altitude, Pitch
Survey-Grade Gyro
Backup Flux Gate Compass
High-resolution Digiquartz
Kongsberg 1071 Obstacle Avoidance Sonar

Summary: The MAGNUM® ROV (Remotely Operated Vehicle) is a side entry cage deployed, dual manipulator 170hp heavy work class ROV. The cage or Tether Management System (TMS) supplies an additional 85hp, is capable of powering skids and also has thruster control and auto heading. The ROV delivers performance in water depths to 10,000 fsw and also in severe weather conditions.

Fiber optics are used as the primary transmission link for all video and data signals between the vehicle and the surface control console. This allows extremely high quality video transmission as well as plug and play installation of sensors and equipment. provide automatic control functions.

6.3.3 Maxximum

Manufacturer
Oceaneering International, Inc.
Depth Rating
10,000 ft / 3,050 m
Optional Depths
13,000 ft / 4,000 m
Payload
441 lb/200 kg
Power
170 HP
85HP (Cage & TMS)
Thrust
Forward: 997 kg
Lateral: 952 kg
Vertical: 1315 kg
Dimensions
Length: 120 in/3.048 m
Width: 72 in/1.83 m
Height: 83.86 in/2.13 m
Vehicle Weight
In Air: 10700 lb/4853kg

Optical
2x HD Camera 1920 x 1080i Superwide
3.8x zoom
110° FOV @ Full Wide
0.1 lux Light Sensitivity
Optical Glass Dome Port
HD-SDI Fiber Optic Video Link

Vehicle Control/Navigation
Fly-By-Wire Station Keeping
Auto Heading, Depth, Altitude, Pitch
Survey-Grade Gyro
Backup Flux Gate Compass
High-resolution Digiquartz
Kongsberg 1071 Obstacle Avoidance Sonar

Summary: The MAXXIMUM® Remotely Operated Vehicle (ROV) is a Side Entry Cage deployed, dual manipulator 270hp Heavy Work Class ROV. The Cage or Tether Management System (TMS) supplies an additional 110hp and is capable of powering skids and also has Thruster control and Auto Heading. The system employs a microprocessor-based telemetry system to minimize maintenance, decrease set up time, simplify troubleshooting, and provide more automated control functions. Tooling control is accomplished external to main telemetry in order to maintain both flight control and tooling control at maximum flexibility and efficiency.

6.3.4 Spectrum

Manufacturer
Oceaneering International, Inc.
Depth Rating
2,000 ft / 610 m
Optional Depths
3,000 ft / 914 m
Payload
500 lb/227 kg
Thrust
Forward: 117 Kgf
Lateral: 88 Kgf
Vertical: 78 Kgf
Dimensions
Length: 55 in/1.4 m
Width: 35.4 in/.9 m
Height: 33.5 in/.850
Vehicle Weight
In Air: 639 lb/290 kg

Optical
1x Wide Angle Low Light
1x Color CCD
1x Color Zoom CCD
2x B&W CCD Aft
Vehicle Control/Navigation
Can be fitted with a skid deployed 5F manipulator
Capable of operating light tools such as AX/VX Ring tool,Trash Pump, CP Probe, and Light Survey Sensors
Tritech Sea King Obstacle Avoidance Sonar

Summary: The Spectrum represents a new generation of Oceaneering's fleet of light electric work class Remotely Operated Vehicle (ROV) with deepwater capabilities up to 3,000 MSW.

The Spectrum is based on the highly successful Super Mohawk light work class ROV, and is combined with Oceaneering's latest purpose built ROV control system, OPAC (Oceaneering Power and Control) which includes the latest technology and onboard diagnostics. The OPAC system is also directly interchangeable with the same system controlling other OII ROVs such as Magnum®, Millennium® and Maxximum® thus providing added redundancy.

6.3.5 Pegaso

Manufacturer
Ageotec
Depth Rating
4,921 ft / 1500 m
Payload
132 lb/60 kg
Thrust
Forward: 140 kg
Lateral: 90 kg
Vertical: 100 kg
Dimensions
Length: 59 in/1.500 m
Width: 39.37 in/1.000 m
Height: 31.5 in/.800 m
Vehicle Weight
In Air: 882 lb/400 kg

Optical
3x video channels. Zoom, focus and still camera controls provided as standard. High-resolution Monochrome Camera, 570 TVL, 0,001 LUX, 1/3 CCD H High-resolution Color Camera, 480 LTV, 0.1 Lux, 1/3CCD.
Vehicle Control/Navigation
Fluxgate compass unit with solid state rate gyro sensor featuring high azimuth stability;electronic depth sensor; Standard functions: Auto-heading and Auto-depth. 2 vertical and 4 horizontal vectored Tecnadyne 1060 DC brushless thrusters.

Summary: The Pegaso is a light work class vehicle for visual and instrument inspection, observation, search and survey.

The Modular chassis is manufactured in high impact resistant Polypropylene. This material is totally maintenance free and non-corroding. Any chassis member can be easily replaced and all the additional equipment may be bolted directly onto it. Hard Anodized Aluminium loading frame and lift points. All pressure housing are manufactured in Aluminium Anticorodal 6060.

6.3.6 Global Explorer


Manufacturer
DSSI
Depth Rating
10,000 ft / 3,050 m
Payload
200 lbs/90 kg
Power
170 HP
85 HP (Cage & TMS)
Dimensions
Length: 8.53ft/X m
Width: 5.1ft/X m
Height: 6.07FT/.X m
Vehicle Weight
In Air: 6750 lb/3061 kg

Optical
10X Zoom HDTV
Stereo 3D HDTV 3.8X
18 megapixel digital stills w/built in laser scaler
Multiple low light, wide angle utility TVs
Pan 140 degrees, tilt 90 degrees
Sensor Suite
Multibeam Imaging
Scanning Sonar
Sonar Altimeter
CTD
Depth
Gyro
Transmission

Summary: The Global Explorer ROV has 4 horizontal and 2 vertical thrusters and is electrically powered. IT is equipped with a high definition camera suite including a 10x zoom HDTV camera, a stereo 3d HDTV camera with 38x zoom, and a still camera capable of 18 Megapixel stills with a built-in laser scaler. The HD camera can pan 140 degrees and tilt 90 degrees for an enhanced field of view.

Fiber optics are used as the primary transmission link for all video and data signals between the vehicle and the surface control console. This allows extremely high quality video transmission as well as plug and play installation of sensors and equipment. provide automatic control functions.

6.3.7 H6500


Manufacturer
DOER Marine
Depth Rating
22,000 ft /6500 m
Payload
110 Lbs/50 kg
Power
100 HP
Hydraulics
3000 psi@10gpm
Power
25 HP
Dimensions
Length: 80”/2.032 m
Width: 55”/1.4 m
Height: 58”/1.47 m
Vehicle Weight
In Air: 2700 lb/1224 kg

Optical
10X Zoom HDTV
Stereo 3D HDTV 3.8X
18 megapixel digital stills w/built in laser scaler
Multiple low light, wide angle utility TVs
Pan 140 degrees, tilt 90 degrees
Sensor Suite
Multibeam Imaging
Scanning Sonar
Sonar Altimeter
CTD
Depth
Gyro
Transmission

Summary: The H6500 provides deep diving capabilities with a custom designed manifold to allow for quick access to the data, video and instrument power connections without entering the main cans. The system has an onboard HPU unit to provide power to the hydraulic thrusters, platform actuators and the manipulator.

The system has two manipulator options: (1) comes with 1 7-function arm and one 5-function arm. (2) comes with two 5-function arms. This allows a flexible configuration to outfit various tool packs.

6.3.8 H2000

Manufacturer
DOER Marine
Depth Rating
6600 ft /2000 m
Payload
120 Lbs/ 54kg
Power
100 HP
Hydraulics
3500 psi@3 gpm
Thrust
Forward: 327 lbs
Lateral: 137 lbs
Vertical: 187 lbs
Dimensions
Length: 60"/1.524 m
Width:39"/1 m
Height:38"/.97 m
Vehicle Weight
In Air: 895 lb/405 kg

Optical
Three simultaneous video signals (NTSC/PAL)
Six data channels, 2xrs486 and 4xrs232
1x Ethernet
HD Fiber Ready
On-Screen Overlay
Sensor Suite
Various Camera and Light packages
Digital Stills Cameras
Lasers
Sonar
CTD
Altimeter
Sampling Devices

Summary: The H2000 is a ultra compact work class ROV. Designed for multi-mission use from a variety of platforms, the H2000 can be used for underwater tasks including survey, sampling, search/recovery, NDT and inspection.

6.3.9 H3000

Manufacturer
DOER Marine
Depth Rating
9842 ft /3000 m
Payload
120 lbs/ 54 kg
Power
100HP
Hydraulics
3500 psi@3 gpm
Thrust
Forward: 327 lbs
Lateral: 137 lbs
Vertical: 187 lbs
Dimensions
Length: 60 in/1.524 m
Width: 39 in/1 m
Height: 59 in/1.5 m
Vehicle Weight
In Air: 895 lb/405 kg

Optical
Three simultaneous video signals (NTSC/PAL)
Six data channels, 2xrs486 and 4xrs232
1x Ethernet
HD Fiber Ready
On-Screen Overlay
Sensor Suite
Various Camera and Light packages
Digital Stills Cameras
Lasers
Sonar
CTD
Altimeter
Sampling Devices

Summary: DOER's H3000 is a midsize work class ROV. Designed for multi-mission use from a variety of platforms, the H3000 is well suited to underwater tasks where station keeping, maneuverability and power are key.

Typical applications include deep water survey, sampling, documentary filming, search/recovery/salvage, submersible support/rescue, ocean observatory support, oil/gas/alternative energy support, tunnel and aqueduct inspection.
The system supports auto heading and depth and comes standard with a five function Sea Mantis manipulator.

6.3.10 Atom

Manufacturer
SDM
Depth Rating
13123 ft /4000 m
Payload
330 lbs/150 kg
Hydraulics
3500 psi@3 gpm
Speed
Forward: 2.9 knots
Lateral: 2.3 knots
Vertical: 2.0 knots
Dimensions
Length: 99.2 in/2.52 m
Width: 59 in/1.5 m
Height: 59 in/1.5 m
Vehicle Weight
In Air: 4409 lb/2000 kg

Optical
Standard 6 x channels composite
Optional 2 x HDTV channels
Hydraulic channels
Standard 10ch iHCU (15 LPm), 1ch (high flow)
Optional Torque tool controller
2ch iHCU (95 LPm)
Upgrade Options
survey kit
1 2 x cameras/4 x Rs**232 channels**
Ethernet (10/100T)
survey kit 2
Interface for 2 x seabat 7125 units or high bandwidth instruments
survey kit 3
Interface for 2 x seabat 7125/8125 units or high bandwidth instruments

Summary: SMD's Atom is an ultra-compact work class ROV comparable in size to an electric ROV system. The vehicle is suitable for drill support, survey and light construction duties and can be mobilised on vessels and rigs with limited deck space.

Designed with ease of operation and maintenance in mind, the Atom boasts the latest DVECSII distributed control, graphical displays and pilot aids coupled with proven powerful Curvetech™ components. The Atom can be supplied as a complete package with SMD's ultra compact TMS and LARS.

6.3.11 Quasar


Manufacturer
SDM
Depth Rating
13123 ft /4000 m
Payload
551 lbs/250 kg
Speed
Forward: 3.5 knots
Lateral: 2.8 knots
Vertical: 2.2 knots
Dimensions
Length: 126 in/3.2 m
Width: 71 in/1.8 m
Height: 71 in/1.8 m
Vehicle Weight
In Air: 7716 lb/3500 kg

Optical
Standard 6 x channels composite
2x composite/2x HDTV Channels
Hydraulic channels
12ch iHCU (15 LPM), 1ch (high flow)
Upgrade Options
survey kit 1
2 x cameras
4 x Rs232 channels
Ethernet (10/100T)
survey kit 2
Interface for 2 x seabat 7125 units or high bandwidth instruments
survey kit 3
Interface for 2 x seabat 7125/8125 units or high bandwidth instruments

Summary: The Quasar is the medium size vehicle in SMD's Q Series work class ROV range. Utilising the latest multi-platform Curvetech™ components, the vehicle offers class-leading in-current performance, tooling and instrument space and access for maintenance. Quasar is an excellent all round performer capable of survey, construction and drill support operations.

6.3.12 Quantum


Manufacturer
SDM
Depth Rating
13123 ft /4000 m
Payload
772 lbs/350 kg
Speed
Forward: 3.5 knots
Lateral: 2.8 knots
Vertical: 2.2 knots
Dimensions
Length: 145 in/3.63 m
Width: 78.7 in/2 m
Height: 78.7 in/2 m
Vehicle Weight
In Air: 11023 lb/5000 kg

Optical
Standard 8 x channels composite
2x HDTV Channels
Hydraulic channels
2x12ch iHCU (15 LPM), 4ch (high flow)
Upgrade Options
survey kit 1
2 x cameras
4 x Rs232 channels
Ethernet (10/100T)
survey kit 2
Interface for 2 x seabat 7125 units or high bandwidth instruments
survey kit 3
Interface for 2 x seabat 7125/8125 units or high bandwidth instruments

Summary: Quantum is SMD’s largest work class ROV suitable for heavy construction duties. Utilizing the latest multiplatform Curvetech™ components, the vehicle offers class-leading in-current performance and extensive free tool and instrument space. Designed to cope with power intensive deepwater tasks, the Quantum is the ultimate subsea construction and survey tool.

6.3.13 FET Super Mohawk

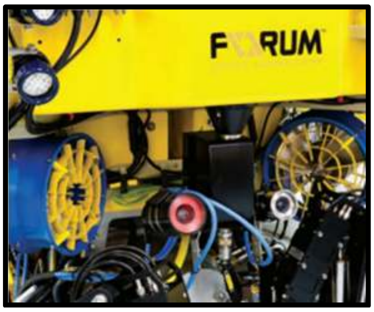
Manufacturer
FET
Depth Rating
9843 ft /3000 m
Payload
143 lbs/65 kg
Speed
Forward: 3 knots
Thrust
Forward: 110 kgf
Dimensions
Length: 55 in/1.4 m
Width: 35.4 in/.900 m
Height: 33.5 in/.850 m
Vehicle Weight
In Air: 871 lb/395 kg

Optical
Camera Pan & Tilt Unit
HD / stereo / PATZ / multi-beam / digital stills camera interfaces
Optional
3000m Buoyancy set (60Kg payload)
Additional payload buoyancy set (25kg)
Digital Video and Survey Database options

Summary: Super Mohawk II Is a robust, durable and long proven ROV system designed for high payload, with plenty open deck space and skid mounted options. The subCAN control system provides advanced diagnostics, precise vehicle control and reduced reactive maintenance. Thus, the benefit of increased dive time, reduced vessel standby and operating costs. The system can be supplied as free flying or with Tether Management System.

- subCAN control system, management & advanced diagnostics
- Auto Heading Depth & Altitude
- Large area open deck space for location of sensors/equipment
- Up to 90Kg of payload (with additional payload kit)
- IMR, navigation, survey, scientific and threat detection skids
- Dual manipulator and cleaning /cutting options
- Multiple video / telemetry channels as standard
- Deep water cage TMS option
- Full Dynamic Positioning / Inertial Navigation options
- GigaByte Ethernet / CWDM options
- Operated globally as ‘Spectrum’ by Oceaneering International

6.3.14 FET Tomahawk



Manufacturer
FET
Depth Rating
9843 ft /3000 m
Payload
353 lbs/160 kg
Speed
Forward: 3.5 knots
Dimensions
Length: 73.23 in/1.86 m
Width: 47.64 in/1.210 m
Height: 47.24 in/1.20 m
Vehicle Weight
In Air: 2204 lb/1000 kg

Optical
SD and HD Camera
Stills Camera
Telemetry
Fibre integration of all standard and optional data
4 x video channels , 2 x RS 485 channels, 4 x RS 232 channels (1 dedicated to subCAN)
Options
3000m Rated Buoyancy with various high payload options
3000m rated cage Tether Mang System
Digital Video & Survey Data Rec. system
Seebyte CoPilot Dynamic Pos. software

Summary: Tomahawk has been developed for the following missions:
High speed survey & geophysics, Inspection Repair & Maintenance (IRM), Drill and completion support / well intervention including fluid injection, AX / VX and torque tool capability. Light Intervention & construction, pre / post pipe & cable lay survey, touch- down monitoring and diver support tasks plus many other oil & gas, renewable Energy, civil engineering, military or scientific missions.

6.3.15 FET Comanche

Manufacturer
FET
Depth Rating
9843 ft /6000 m
Payload
474 lbs/215 kg
Speed
Forward: 3 knots
Thrust
Forward: 240 kgf
Dimensions
Length: 82.7 in/2.1 m
Width: 51.2 in/1.3 m
Height: 49.2 in/1.250 m
Vehicle Weight
In Air: 2491 lb/1130 kg

Optical
SD and HD Camera
Stills Camera
Telemetry
Fibre integration of all standard and optional data
4 x video channels , 2 x RS 485 channels, 4 x RS 232 channels (1 dedicated to subCAN)
Options
3000m Rated Buoyancy with various high payload options
3000m rated cage Tether Mang System
Digital Video & Survey Data Rec. system
Seebyte CoPilot Dynamic Pos. software

Summary: Comanche has been developed for the following missions and tasks: Construction IRM – cleaning, cutting, NDT. Drill / rig / completion support & well intervention, e.g. AX/VX gasket change out, BOP shutdown, fluid injection, hot stabbing, drilling and tapping. Additionally, survey including pre / post pipe / cable lay and touch-down monitoring, diver support, renewable energy, submarine / maritime rescue, munitions search and recovery, scientific research and data / sample collection plus numerous other missions.

6.3.16 TRV-M

Manufacturer
Submersible Systems, Inc.
Depth Rating
3300 ft /1000 m
Payload
60 lbs/27 kg
Speed
Forward: 4 knots
Lateral: 2 knots
Vertical: 3 m/s
Dimensions
Length: 60 in/1.524 m
Width: 48 in/1.219 m
Height: 24 in/.610 m
Vehicle Weight
In Air: 650 lb/295 kg

Optical
Sony Color Zoom, Focus, Pan & Tilt
Low Light Colour, Pan & Tilt
Rotary Color 360º Viewing
Colour Manip Camera
Cameras on two Video CCT's (any combination of two cameras can be viewed at any time)
Modular Components:
Telemetry Can, Power Can, Capacitor Bottle, HPU, 2 x 4-Function Valve Pack
Navigation:
Gyro/Fluxgate Combination w/pitch & roll.

Summary: The TRV-M Series has an open, angular frame made of T6061 marine grade aluminum which is designed to allow superior through flow for better hydrodynamics. The rugged frame is built to take abuse and allows secure mounting of any auxiliary equipment. Finally, the aluminum frame contributes significantly to the mass required for stability.

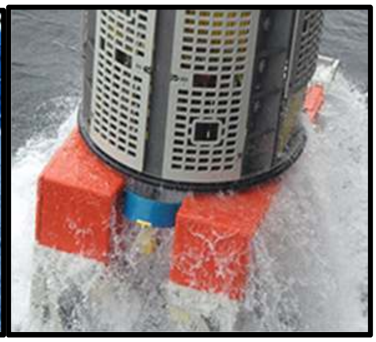
6.3.17 TRV-HD

Manufacturer
Submersible Systems, Inc.
Depth Rating
3300 ft /1000 m
Payload
300 lbs/136 kg
Speed
Forward: 3 knots
Lateral: 1.5 knots
Vertical: 2 m/s
Dimensions
Length: 67 in/1.700 m
Width: 54.5 in/1.384 m
Height: 36 in/.914 m
Vehicle Weight
In Air: 1750 lb/795 kg

Optical
Sony Color Zoom, Focus, Pan & Tilt
Low Light Colour, Pan & Tilt
Rotary Color 360º Viewing
Colour Manip Camera
Cameras on two Video CCT's (any combination of two cameras can be viewed at any time)
Modular Components:
Telemetry Can, Power Can, Capacitor Bottle, 2 x HPU's,
2 x 7 Function Valve Packs
Navigation:
Gyro/Fluxgate Combination w/pitch & roll.

Summary: The TRV-HD Series provides for more payload capacity and has an open, angular frame made of T6061 marine grade aluminum which is designed to allow superior through flow for better hydrodynamics. The rugged frame is built to take abuse and allows secure mounting of any auxiliary equipment. Finally, the aluminum frame contributes significantly to the mass required for stability.

6.3.18 Schilling HD

Manufacturer
Schilling
Depth Rating
13123 ft /4000 m
Payload
551 lbs/250 kg
Thrust
Forward: 900 kgf
Lateral: 900 kgf
Vertical: 850 kgf
Dimensions
Length: 114 in/2.9 m
Width: 67 in/1.7 m
Height: 74.8 in/1.9 m
Vehicle Weight
In Air: 8157 lb/3700 kg

Optical
Pan and Tilt Cameras
HD & SD
Hydraulic channels
High Capacity ISOL-89 Pump
5000psi@50gpm
Options
Dedicated Propulsion and Tooling Hydraulic Circuits
Can be Used with Either a Highly-efficient, All-electric Tether Management System (TMS) or in a Free-Fly Configuration.

Summary: Schilling Robotics' HD ROV is a 150hp, compact remotely operated vehicle is designed for accommodating the specific needs of the IMR and drill support markets. The HD™ system is optimized for installation onboard drilling rigs and ROV support vessels, where available deck space is limited. It includes dedicated interfaces for integrating intervention or survey tooling. Ergonomic design provides users with spacious access to the system for maintenance and onboard capacity for installing additional intervention tools and work packages within the vehicle's footprint. Combined with Schilling's electric TMS system, the standard model is capable of excursions up to 425 meters. This compact system is configured for ease of road transportation and rapid mobilization, while providing the flexibility to perform a wide variety of deepwater operations.

6.3.19 Schilling UHD-III

Manufacturer
Schilling
Depth Rating
13123 ft /4000 m
Payload
992 lbs/450 kg
Thrust
Forward: 1200 kgf
Lateral: 1200 kgf
Vertical: 1000 kgf
Dimensions
Length: 137.8 in/3.5 m
Width: 74.8 in/1.9 m
Height: 82.7 in/2.1 m
Vehicle Weight
In Air: 12125 lb/5500 kg

Optical
Pan and Tilt Cameras
HD & SD
Hydraulic channels
High Capacity ISOL-89 Pump
5000psi@50gpm
Options
Dedicated Propulsion and Tooling Hydraulic Circuits
Can be Used with Either a Highly-efficient, All-electric Tether Management System (TMS) or in a Free-Fly Configuration.

Summary: The UHD-III meets API 53 standards for BOP intervention with RAM closure in less than 45-seconds

- Hydraulic power to 250-hp; Auxiliary power to 150-hp
- Optimizes work performance with automatic power efficiency management
- More space for tools and instruments than comparable ROVs
- Increases ROV pilot efficiency through intuitive ROV control interface, automated navigation, and positioning systems
- Customer configurable, modular control system simplifies tooling integration
- Dedicated propulsion and tooling hydraulic circuits that optimize ROV and tooling performance
- 60-minute or less rapid maintenance design

6.3.20 Saipem Innovator 250

Manufacturer
Saipem
Depth Rating
11482 ft /3500 m
Payload
250 lbs/113 kg
Speed
Forward: 3 knots
Lateral: 2 knots
Vertical: 2 knots
Dimensions
Length: 136 in/3.45 m
Width: 64 in/1.63 m
Height: 83.9 in/2.13 m
Vehicle Weight
In Air: 1750 lb/795 kg

Optical
HD & SD Camera
Tilt and Zoom Mount
Options
Dedicated Propulsion and Tooling
Hydraulic Circuits

Summary: The Innovator is a full heavy work class ROV with dual 250 hp dual-shaft electric motors. They provide thrust to four horizontal and 3 vertical thrusters. It comes with a heavy weather Launch and Recovery System (LARS) to enhance operational capability in harsher conditions, plus fully electric umbilical winches feature active heave compensation. Thruster control is provided by way of a mechanical thruster repositioning to give 30, 45, and 60 degrees. The vertical thrusters also will have pitch and roll control.

6.4 Class IV Towed and Bottom Crawling Vehicles

Towed vehicles are attached to a vessel and pulled along with either onboard propulsion or an onboard winch system. Class IV vehicles are typically much larger and heavier than Class III work class vehicles, and are configured for special purpose tasks. Typical applications of a Class IV vehicle include trenching, excavation, and cable/pipeline installations. Further analyses of these vehicles were not provided for the bases of this study.

6.5 Class V Prototype & Development Vehicles

Class V vehicles include those being developed and those regarded as prototypes. Special-purpose vehicles that do not fit into one of the other classes are also assigned to Class V. The AUV type is currently assigned to Class V. This class was covered by Battelle's November 2014 report labeled "Capabilities and Uses of Sensor-Equipped Ocean Vehicles for Subsea and Surface Detection and Tracking of Oil Spills".

7 Appendix B-List of Acronyms

The following list of acronyms are provided for reference

AOV	Autonomous Oceanographic Vehicle
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
HPU	Hydraulic Power Unit
IC	Incident Commander
ISB	In-Situ Burning
LARS	Launch and Recovery System
MOU	Memorandum of Understanding
IOGP	International Association of Oil & Gas Producers
OSPR	Oil Spill Preparedness and Response
OSPR JIP	Oil Spill Response Joint Industry Project
OSRO	Oil Spill Removal Program
OSRP	Oil Spill Response Plan
PPE	Personal Protective Equipment
RRT	Regional Response Team
SMART	Special Monitoring of Applied Response Technologies
TAD	Technical Assistance Document
TCP/IP	Transmission Control Protocol/Internet Protocol
TMS	Tether Management System

8 Appendix C-References

Alaska. Industry Preparedness and Pipeline Program. (1999). *Technical review of leak detection technologies*. Anchorage, AK: The Program.

Alyeska Pipeline Service Company. (1991). *Implementation plan for enhancements to trans-alaska pipeline system oil spill contingency plan-pipeline*. Anchorage, Alaska 1835 S. Bragaw St., Anchorage 99512: Alyeska Pipeline Service Co.

Arthur, M., Coelho, G., & Twomey, P. (2013). *Monitoring hydrocarbon releases in deep water environments: A review of new and emerging technologies.* (No. 13-01). Lusby, MD: HDR Ecosystem Management & Associates, Inc.

Battelle. (2014). *Capabilities and uses of sensor-equipped autonomous oceanographic vehicles for subsea detection & tracking of oil spills.* November.

Cheremisinoff, N. P., & Davletshin, A. R. (2011). *Emergency response management of offshore oil spills: Guidelines for emergency responders*. Salem, MA; Hoboken, NJ: Scrivener; Wiley.

Christ, R. D., & Wernli, R. L. (2014; 2014). *The ROV manual: A user guide for remotely operated vehicles* (Seco ed.). Amsterdam: Butterworth-Heinemann is an imprint of Elsevier.

Deal, T. (2006). *Beyond initial response: Using the national incident management system's incident command system*. Bloomington, IN: AuthorHouse.

Huang, L., Marini, L., Cazalas, R., & Guillou, A. (2012). *Observation of marine pollution by hydrocarbons.* (No. EP1-11-90). France: Euro Engineering.

IMCA. (2009). Code of practice for the safe & efficient operation of remotely operated vehicles. (IMCA R 004 Rev. 3, July, 2009)

IMCA. (2009). Digital video offshore: A review of current and future technologies. (IMCA R 012 Rev. 1, June, 2009)

IMCA. (2009). Entry level requirements and basic introductory course outline for new remotely operated vehicle personnel. (IMCA R 002 Rev. 2, May, 2009)

IMCA. (2013). Remotely operated vehicle intervention during diving operations. (IMCA R 020, Oct, 2014)

IMCA. (2013). ROV mobilisation. (IMCA R 009 Rev. 1, Sep, 2013)

Jackson, N. A., & Congressional Cartography Program. (2010). *Deepwater horizon incident, gulf of mexico*. Washington, DC: Congressional Cartography Program. Retrieved from http://hdl.loc.gov/loc.gmd/g3862c.cp000011

Lewis, A., & Daling, P. (2007). *Oil in ice-JIP: A review of studies of oil SPill dispersant effectiveness in arctic conditions. (JIP project 4, act. 4.11).* (No. 11).Marine Environmental Technology.

Marine Technology Society. San Diego Section, University of California . Institute of Marine Resources, & MTS Undersea Vehicle Committee. (1984). *Remotely operated vehicles: ROV '84 technology update--an international perspective*. San Diego, CA: The Section.

National Oceanic and Atmospheric Administration. (2006). *Special monitoring of applied response technologies.* (). Seattle, WA: NOAA Office of Response and Restoration.

NORSOK. (2012). U-102 Remotely operated vehicle (ROV) services (Edition 2, September 2012)

Uluocha, N. O., Obafemi, A. A., & Nigerian Cartographic Association. (2003). *Cartography, GIS and sustainable environmental management* (1st ed.). Lagos: Nigerian Cartographic Association.

United States. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. (2011). *Macondo: The gulf oil disaster : Chief counsel's report*. Washington, D.C.: National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling.

Walsh, D. W. (2012). *National incident management system: Principles and practice* (2nd ed.). Sudbury, MA: Jones & Bartlett Learning.