Deepwater Horizon Containment and Response: Harnessing Capabilities and Lessons Learned

The Deepwater Horizon incident, with the loss of eleven lives, was a terrible tragedy for the victims and their families, and for the people of the Gulf Coast.

At the same time, there is inspiration in the way thousands of selfless and dedicated women and men have devoted themselves to addressing the challenges from the Deepwater Horizon incident. The entire spill response has been and will continue to be conducted under the Unified Command structure, in which ultimate authority resides in the United States Coast Guard. Within that structure, the efforts of individual responders and the teams in which they have worked have been critical to the clean-up of the Gulf Coast.

BP shares with everyone else a determination that an oil spill of this magnitude will never again occur in this country, or anywhere else. This document is a follow up to discussions between BP and the Bureau of Ocean Energy Management, Regulation and Enforcement relating to steps that can be taken to ensure that the oil exploration industry, operating under the Coast Guard's direction, can respond to an oil spill of any size from a marine facility quickly and effectively. We appreciate your comments and feedback.

As we at BP look back over events since April 20, our sense of concern over the Deepwater Horizon incident, and our determination to make things right for the people, environment and communities of the Gulf Coast region have never been stronger.

One way we can help make things right is to share - with the industry, government at all levels, and a wide range of stakeholders - the lessons learned and the capabilities developed. We believe this will enhance response to future incidents of any size.

The nature of the Deepwater Horizon incident – including the scope, scale, and complexity of the response – has driven large capability advances for the oil exploration industry as a whole. These new capabilities should be an integral part of an improved planning and response regime for industry, government and other responders. We believe it is valuable to document them even as our response efforts continue. These advances can serve as part of an initial discussion on how to institutionalize the increased capabilities and ensure that they can be readily mobilized in addressing a marine oil spill of any size.

We believe the experiences and new capabilities gained can be grouped into four broad areas:

Lesson 1: Collaboration

A broad range of stakeholders has come together in the wake of the Deepwater Horizon incident to provide effective solutions and build new capabilities.

It would have been extremely difficult for any one company to address the challenges resulting from Deepwater Horizon alone. The response has benefited from close collaboration with and the capabilities of the U.S. Coast Guard, Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) and dozens of other partners and stakeholders from government, industry, academia and the affected communities, as well as around the globe.

Lesson 2: Systemization

The response has required the development of extensive systems, procedures and organizational capabilities to adapt to changing and unique conditions.

As the Deepwater Horizon spill continued despite efforts at the wellhead, the response effort progressed, expanded, and took on not just new tasks and directions but new personnel and resources. As a result, from source to shore, existing systems were evolved and expanded and new ones developed to advance work flow, improve coordination, focus efforts and manage risks. The adoption of these systems will ensure the ability to respond more rapidly at scale with a clear direction as to personnel, resource and organizational needs.

Lesson 3: Information

Timely and reliable information has been essential across both the containment and response operations to achieve better decision-making, ensure safe operations and inform stakeholders and the public.

Reliable information is indispensable in managing any crisis but especially amid the far-reaching challenges, relentless pressures and often hazardous conditions confronting spill response. The Deepwater Horizon responders have been able to take advantage of cutting-edge tools to manage information-sharing inside the Unified Command and externally, to improve decision-making and coordinate complex activities across response and containment, such as simultaneous operations.

At the same time, the response has needed not only transparency in providing information but also full explanation of the available facts to the public. Communications must address understandable concerns about the spill effects, clarify misperceptions, and provide policymakers with the facts, data and rationales they need to serve their constituencies in a 24/7 news cycle.

Lesson 4: Innovation

The urgency in containing the spill and dealing with its effects has driven innovation in technology, tools, equipment, processes and know-how.

The result has been a series of developments, ranging from incremental enhancements to step changes in technologies and techniques, that have advanced the state of the art and laid the foundation for future refinements as part of an enhanced regime for any type of source-to-shore response.

Highlights of these key capability advancements include:

Containment (the effort to disperse, cap, close and ultimately stop the release of hydrocarbons at the source):

- A variety of new open containment systems proven in deepwater conditions with demonstrated techniques to mitigate hydrate formation. (page 9)
- The proven capacity to engineer and construct closed systems allowing not only for the collection of hydrocarbons but also the control of flow and the introduction of well-control fluids. (page 12)
- Safe simultaneous operation of a large number (16 or more) Remotely Operated Vehicles (ROVs) in close proximity to perform a wide range of novel interventions on open and closed containment systems. (page 14)
- Development of advanced visualization techniques enabling the simultaneous operation for extended periods of a large number (19 or more) major vessels in a narrow radius and hazardous conditions without incident. (page 16)
- Rapid retrofit of multipurpose vessels for subsea installation, high-volume containment, flaring, Dynamic Positioning (DP) vessel to DP vessel offloading, and top kill and hydrostatic kill operations. (page 20)
- Initial development of more robust non-wireline ranging technologies for faster well intercept in the context of the deepsea drilling of a relief well. (page 22)
- Development in a compressed time period of a robust system for long-term containment featuring the first installation of free-standing riser, hydrate inhibition and emergency hurricane disconnection capability. (page 24)
- Novel subsea systems to inject dispersant efficiently at source, with demonstrated effectiveness in substantially reducing surface oil and Volatile Organic Compounds (VOCs). (page 26)
- Experience in coordinating industry, agency and academic expertise to efficiently produce reliable, high-quality data on subsurface, seabed and water column conditions. (page 28)

Response (the work done in surveillance, on the open water, near shore and onshore to remediate the spill, protect the shore, repair damage and respond to local community needs.

- Specific booming plans and placement detail across the four-state response area, grounded by Area Contingency Plans (ACPs) and informed by actual performance and effectiveness. (page 34)
- An expanded pool of trained responders along with protocols and procedures to integrate and support accelerated response to impact on wildlife. (page 36)
- In the Vessels of Opportunity (VOO) program, the foundations for a vetted, trained, and knowledgeable fleet of committed shoreline and community responders fully integrated into the overall effort through a replicable command structure. (page 38)
- A single, comprehensive and integrated view of the entire response effort from sky to sea to shore to enable rapid, coordinated decision-making. (page 40)
- An in-place repeater radio system stretching from the Florida Panhandle to Louisiana and a robust software information backbone supporting communications across response activities. (page 42)

BP has prepared this report as a follow up to discussions with the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) in order to provide a preliminary outline of some of the important lessons learned in the course of responding to the explosion on the Deepwater Horizon drilling rig, focusing in particular upon the key equipment, facilities and planning tools that were successfully deployed in responding to this event. The purpose of this report is to assist BOEMRE in assessing the capabilities that are now available to respond to oil spills in the Gulf of Mexico region. The response to the Deepwater Horizon incident has involved many participants and, accordingly, no report of this nature and prepared at this time can be comprehensive.

The report makes no attempt to cover all aspects of the Deepwater Horizon response to date, and our understanding of how best to learn from the response will evolve as the response continues to develop. This report is not an evaluation of any aspect of the oil spill response capabilities existing prior to the incident, nor does it provide a plan or proposal for how industry and government might respond to any future oil spill event. Separately, BP is conducting its own investigation of what caused the Deepwater Horizon incident, and is fully participating in government investigations as well. Information from those efforts will be shared with the government and public through the appropriate channels.

September 1, 2010

Contents

Please see supplementary media materials on the DVD in the back inside cover

- Modular scale-up of Shoreline Clean-up Assessment Teams (SCATs), a critical asset in shoreline assessment, remediation and mapping, with protocols ensuring consistency of process and data collection. (page 44)

- The use of strategic and tactical aerial surveillance, including up to 100 sorties on peak days, to serve not only as eyes of the response, but as directors for open-water and on-shore activities. (page 46)

- A system of branch offices, reflecting the insight that "all oil spill response is local," with the clear mission, authority and dedicated resources to protect local coastlines. (page 48)

- New, highly scalable skimming technology, maintenance and deployment systems that enabled the largest skimming response in history. (page 50)

- Demonstration of controlled in-situ burning as a fully proven technique for oil recovery, featuring advanced methodology, equipment and a standing expert base. (page 52)

- Precise and effective application of dispersants driven by advanced surveillance technology and operational streamlining supported by a network of global experts. (page 54)

- The largest mobilization of boom in any oil spill response – a total of more than 14 million feet – and significant expansion of the supply chain and of the number of experts. (page 56)

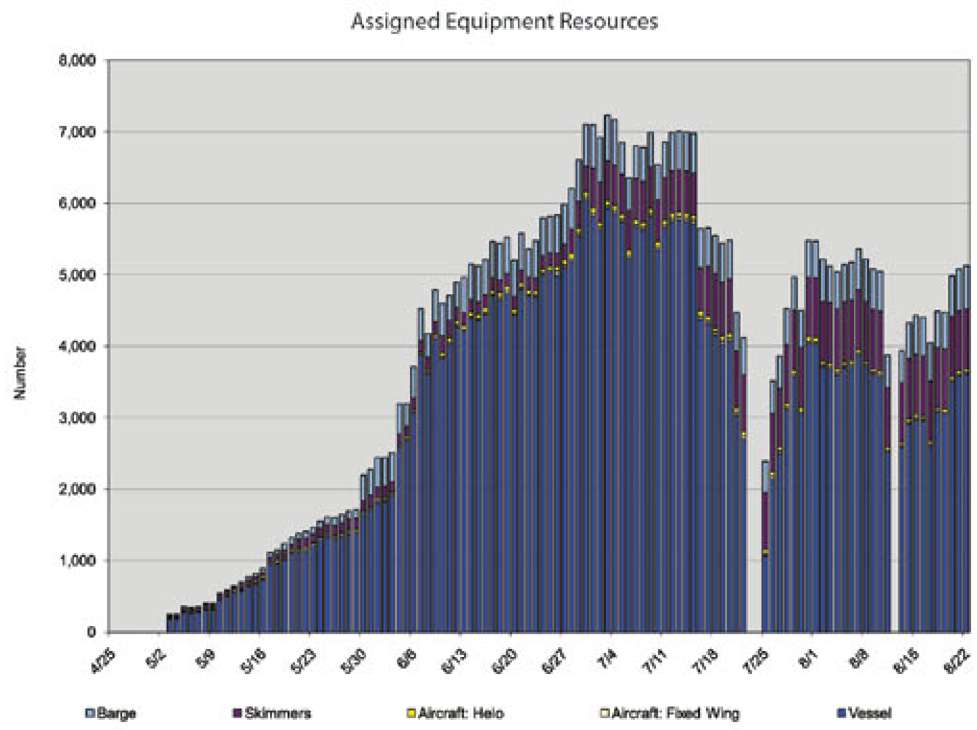
- Successful, modular expansion of "small-scale," minimally invasive clean-up techniques harnessing the natural remediation of marsh with the capability to deploy responders to remote locations with limited infrastructure. (page 58)

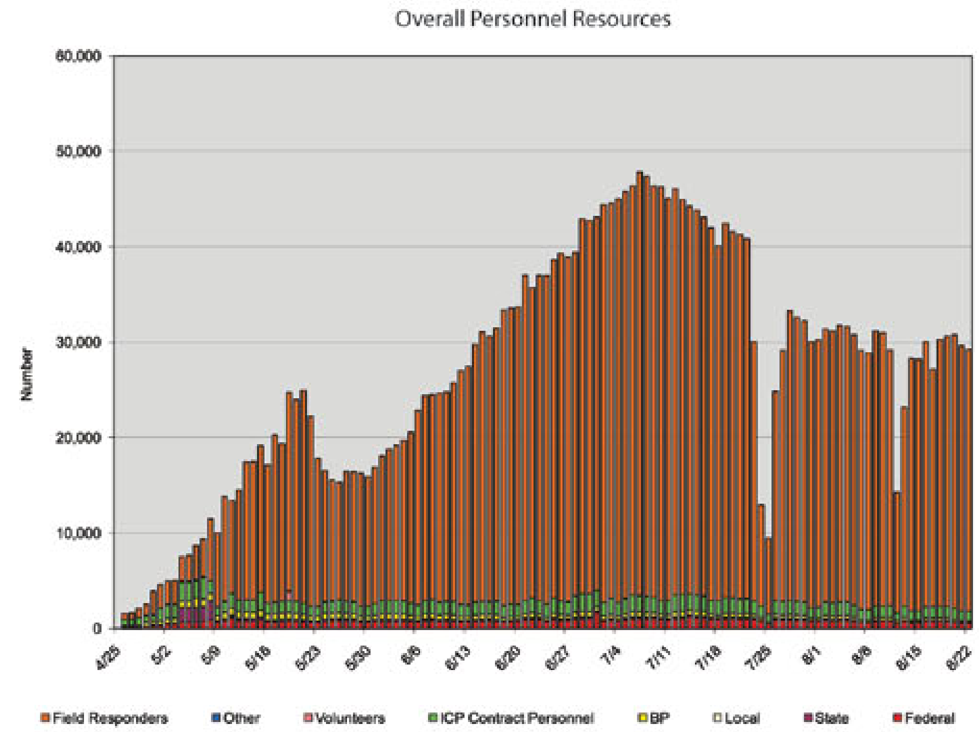
- New turnkey approaches to beach cleaning employing advanced technology, sensitivity to the public, close cooperation with communities and a pool of trained community responders. (page 60)

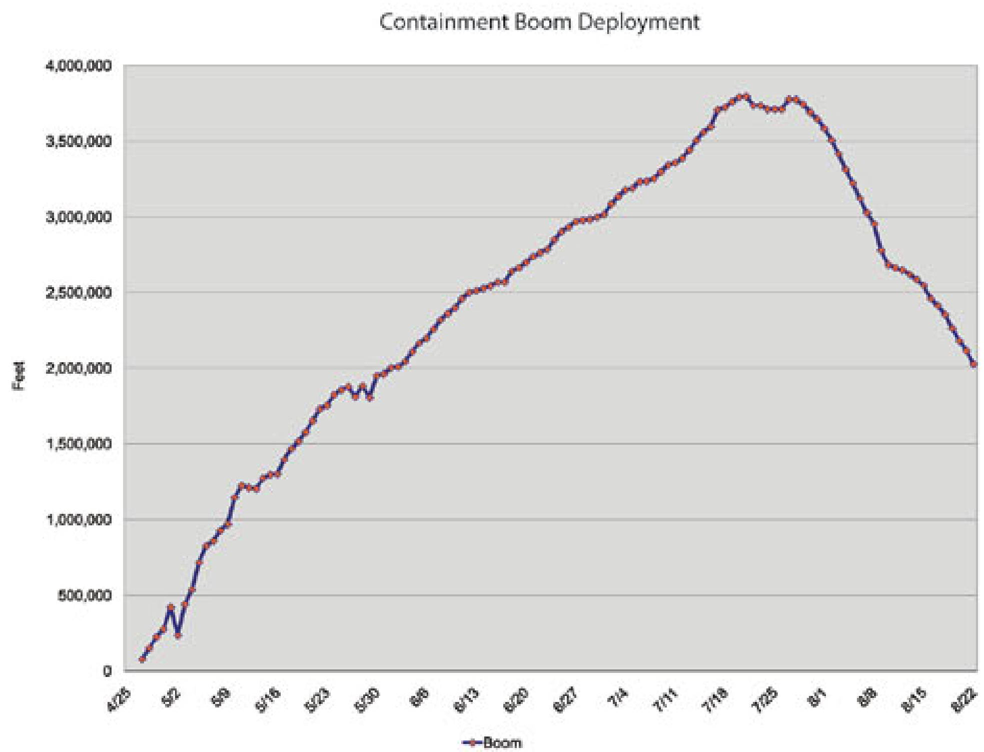
Response Metrics

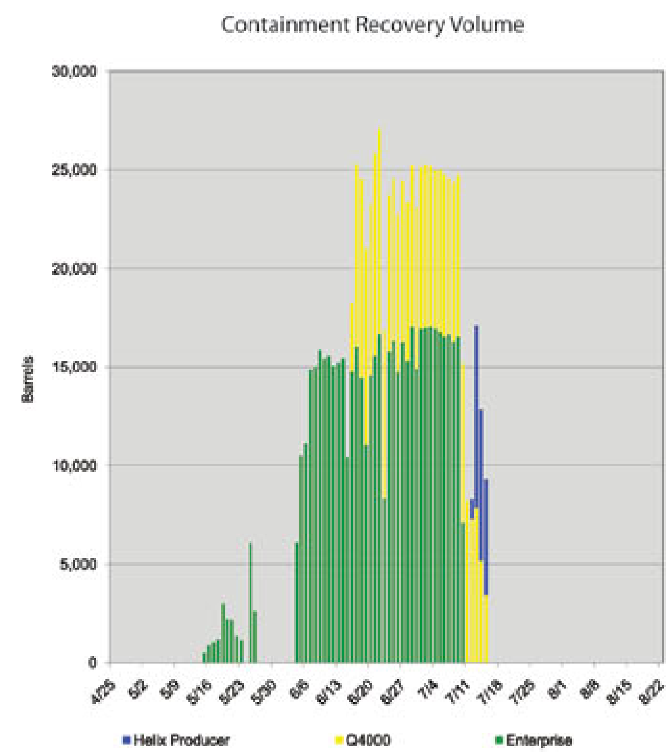
A daily briefing at an Incident Command Post (ICP). The response was coordinated from five ICPs in Houma, LA, Houston, TX, Mobile, AL, Miami, FL and Galveston, TX.

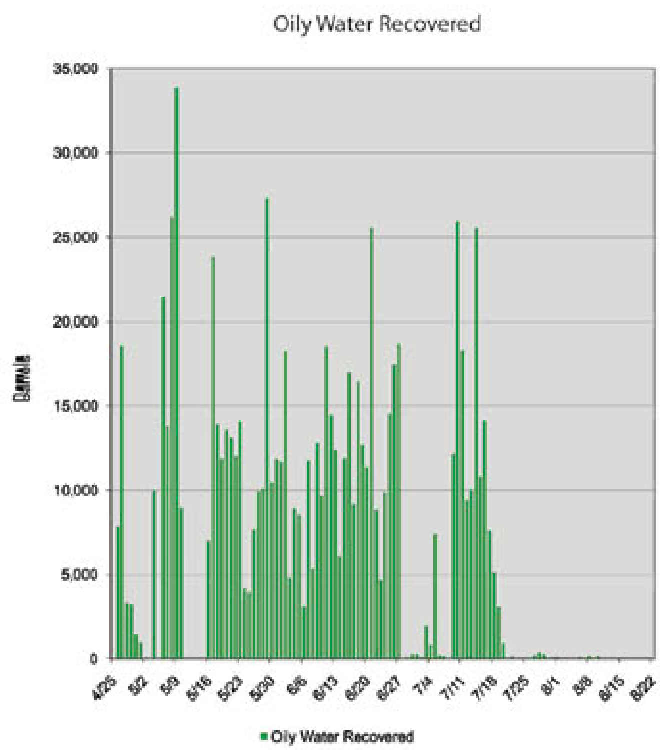
Updated August 22; 2200 Hours











A review of some key metrics – Assigned Equipment Resources, Overall Personnel Resources, Containment Boom Deployment and Containment Recovery Volume, and Oily Water Recovered – gives a sense of the scale, scope and duration of the response and containment efforts.

1

The Nature of the Challenge

The Deepwater Horizon incident has presented far-reaching challenges on a number of levels to BP and to those who collaborated with the company on the response.

The first challenge has been the unprecedented scale, intensity and duration of the incident and the corresponding response. The company had a plan in place that conformed to regulatory requirements, but no plan can foresee every development and contingency. As the spill continued and touched a wider area and range of stakeholders, response teams learned and adjusted. For example:

- Shortly after establishing the first Incident Command Post (ICP) in Houma, Louisiana, additional ICPs were required to manage the scale and uncertainty of the approaching spill. Over time, the response teams saw opportunities for altering the response structure to ensure support and authority flowed rapidly to local leadership and communities;

- ICP leaders and responders understood that a comprehensive view of the specific location of surface oil, along with robust communication among leadership, airborne units and responders on the water, would allow efficient allocation of resources; and

- As it became clear that the spill could last for a considerable time and hurricane season approached, the response team stepped up its long-term planning for issues such as boom and skimmer supply and placement and inclement-weather operations.

A second challenge involved the complex conditions in which the spill response was taking place. At the source, containment teams were operating amid extreme conditions in terms of pressure, temperature and flow.
For example, the spill location and depth involved high pressure (approximately 2240 psi) and low temperatures (approximately 39 degrees F). This was conducive to the formation of methane hydrates, which hindered initial efforts at open-system containment.

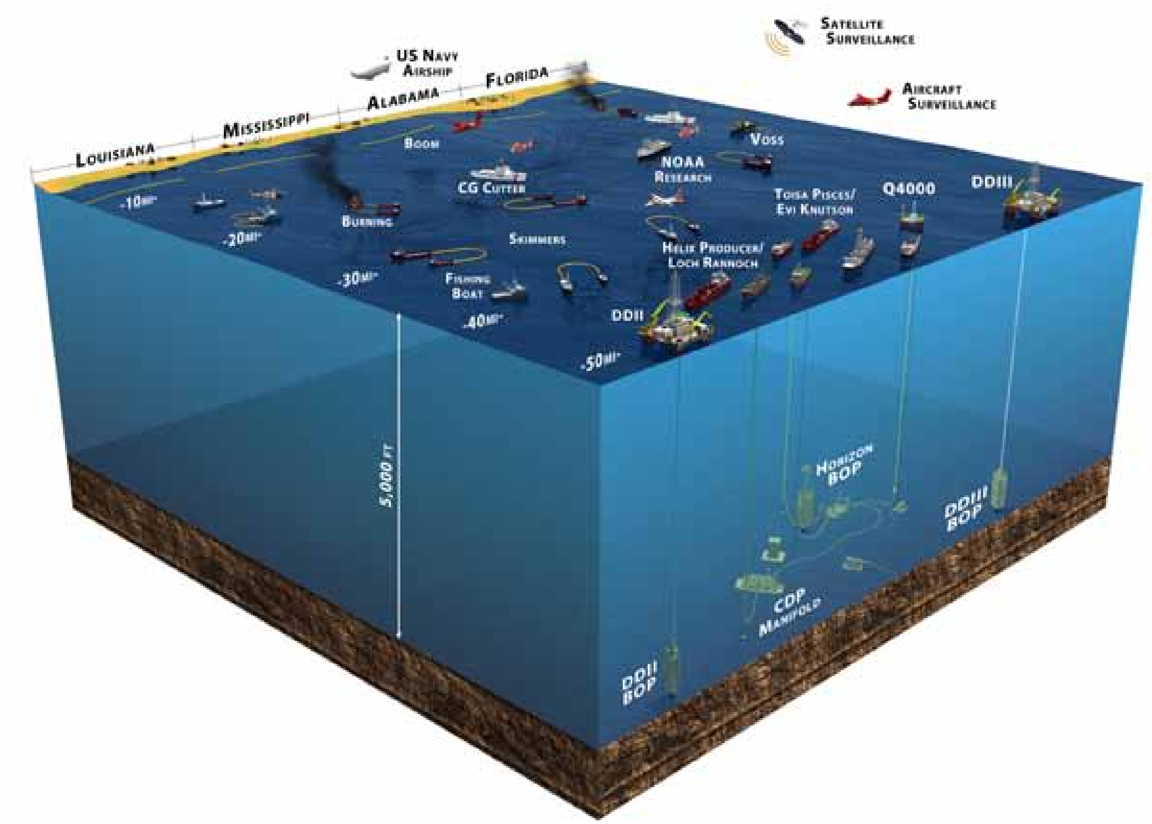
Over time, these experiences led to enhanced capabilities that can benefit the industry and the public in the future:

- By thinking ahead and planning strategically, the response addressed a dynamic operating environment;

- Identifying, sequencing, and building a suite of parallel technical options enabled rapid solutions; and

- Responding through local integration enabled operational solutions leveraging community experience and addressing local needs (Branch Office construct).

The following sections lay out the lessons learned and applied not just to overcome major challenges that accompanied the Deepwater Horizon incident, but also to create new capabilities to advance the state of the art in responding to spills of any size, and, in several instances, to offer broader applications.



The response effort from the seabed to the shoreline and across four states. The response dealt with challenges of unprecedented scale under complex conditions.

2

Building New Containment Capabilities

Since the early days of the Deepwater Horizon incident, a team of hundreds of professionals has participated on-site and from the Houston operations headquarters in designing and implementing containment approaches.

Teams were already in action on April 21 attempting to close the well via remotely operated vehicles (ROVs) working on the blowout preventer (BOP). Within a few days, project teams were identifying, methodically ordering and designing a suite of options in the areas of open and closed containment.

The implementation efforts extended across industry, government and the scientific community, design departments and manufacturing facilities, and throughout the supply chain, all with a single goal: to contain, disperse and ultimately stop the flow of hydrocarbons into the Gulf of Mexico.

Working within the Unified Command structure led by the U.S. Coast Guard, the Deepwater Horizon response team has accepted a range of important challenges. Those challenges have required the leveraging and modification of capabilities of vessels, equipment and devices. Due to the nature of tools required, multiple efforts were simultaneously launched to build ever-increasing containment capability. New procedures and protocols have been established for containment operations, and new organizations, systems and supply chains have been created.

The first-of-a-kind situations confronted, along with the highly compressed timeframes and the challenge of stemming the flow of hydrocarbons, drove the participants in the containment effort to expand existing equipment and processes and to develop innovative solutions, while maintaining high standards of safety and assurance and building in multiple options and redundant systems.

Ultimately, the response yielded incremental, and in many cases step change improvements, beyond the existing state of the art across the range of disciplines involved.

Near-Source Open Containment

Supplemental multimedia available for this subject: **Top Hat Installation**

The open-containment operation was engaged in some of the highest profile and most closely scrutinized efforts in the overall response. Many of their activities were broadcast live to a worldwide audience, as they pursued a range of initiatives to capture the flow of hydrocarbons from the wellhead and thereby limit the environmental impact until a closed containment system and hydrostatic kill operations could be implemented.

Prior Industry Practice in Open Containment: Prior to the incident, industry experience with open-containment measures – involving the capture of hydrocarbon flow in open water without latching or sealing – had occurred in shallow water and involved lower volumes.

Past experience had presented no occasion for industry to attempt subsea open containment at the depths and conditions involved in Deepwater Horizon. In particular, prior open-containment efforts had not needed to address the fluid properties produced by the combination of the hydrocarbons, deep-ocean pressures and cold seawater that contributed to the formation of hydrates.

Innovations Undertaken in Open Containment: The containment team, under the supervision of Unified Command, painstakingly prepared and developed multiple systems in undertaking a range of first-of-a-kind deepwater open-containment efforts.

The open containment team's rapid engineering of a hydrate-inhibition system allowed successful installation of a top hat.

CAPABILITY HIGHLIGHT

A variety of new open-containment systems proven in deepwater conditions with demonstrated techniques to mitigate hydrate formation

These innovations included:

- The development of three variations of Riser Insertion Tube Tools (RITT), one of which was successfully deployed on May 16 as an interim solution. The RITT demonstrated the team's ability to lift more than 6,000 barrels of oil a day, and more than 22,000 barrels total, from the broken well riser to a surface vessel. A total of three RITTs were constructed, although only the first was put into operation;

- Ten "top hat" open-containment devices designed for a variety of connection scenarios. Eight top hats in total were constructed, and one top hat was deployed. The top hat design involved the construction of a device smaller than the previously used cofferdam. The base design also inhibited hydrate formation through venting of hydrocarbons, injection of methanol, a passive water seal and a column of nitrogen inside the connected pipe and top hat to initiate containment;

- The successful installation of a top hat over the Deepwater Horizon BOP to recover more than 17,000 barrels of oil per day, and 500,000 barrels total, to a surface vessel;

- Recovery of gas critical in maintaining low VOCs at the working surface; and

- The use of standardized, interchangeable connections (J-latches) on the top hats and RITTs, which allowed for various tools to be stored on the seafloor for contingent use if or when required.

Resulting Capabilities Available for Deployment: These innovations have resulted in a series of new open containment capabilities that can be adapted and refined for deployment including:

- Specifications for and an existing inventory of immediately deployable top hat and RITT open-containment devices that are proven at depth, standardized for attachments and further evolved from the initial design;

- The creation of demonstrated techniques to minimize hydrate formation on open-collection devices;

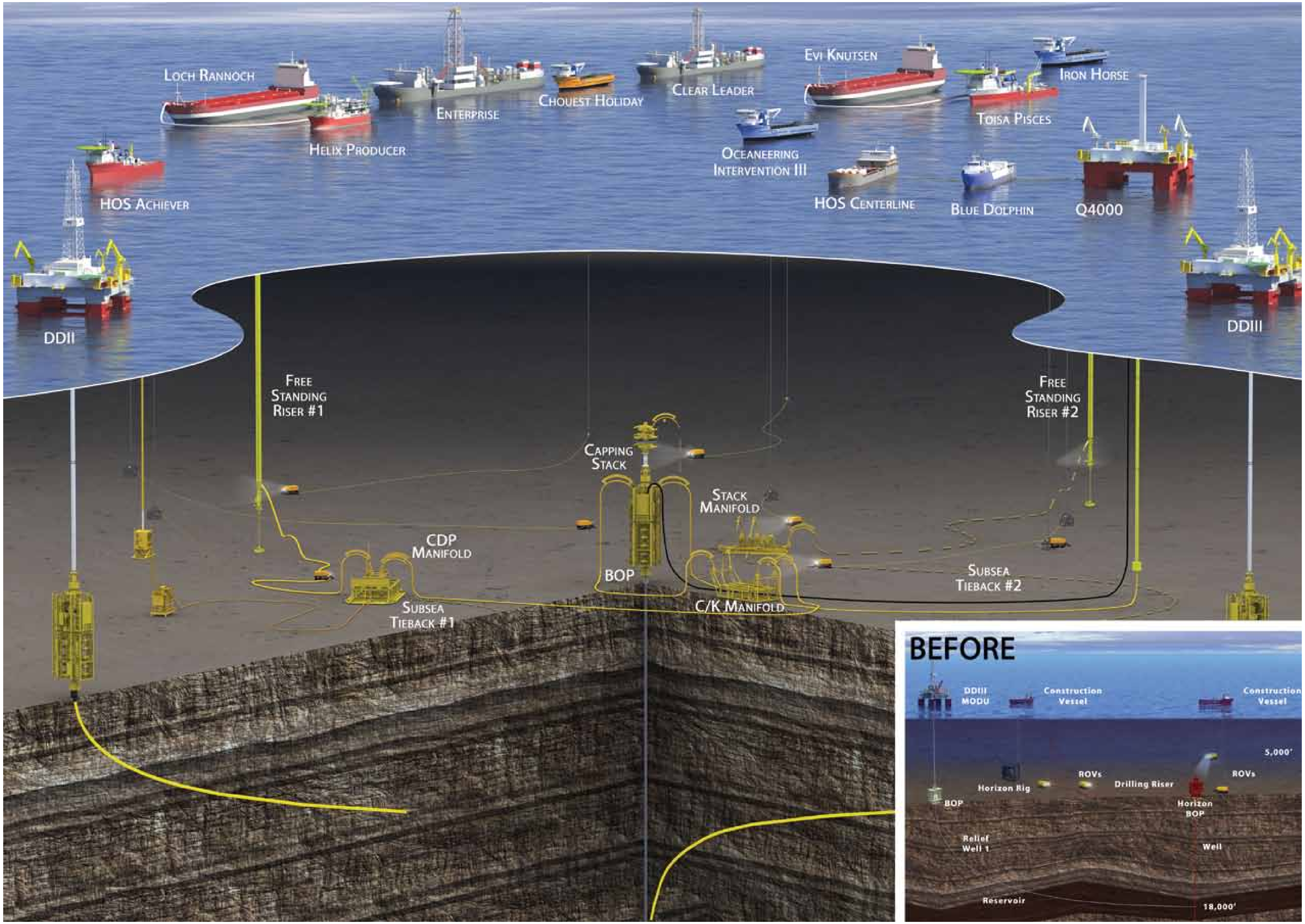
- The conversion to standardized components for tool interchangeability;

- Protocols for system integration tests and diagnostic pressure measurements; and

- Plans and organizational schemes for immediate stand-up of a dedicated near-source containment team.

Subsea Containment Scheme

The Q4000, a multipurpose vessel used both for a range of subsea containment activities and for collection and disposal of oil.



Subsea Containment Scheme: The Final State.

Near-Source Closed Containment

The objective of the closed-containment team was to provide the capacity to move from an open system of collection to a closed system – with a latched, sealed and pressure-containing device – allowing not only for the collection of hydrocarbons but also the control of flow, as well as the introduction of well-control fluids used in top kill and hydrostatic kill operations.

Supplemental multimedia available for this subject: **ROV Videos 1-8**

Prior Industry Practice in Near Source Closed Containment: As with open containment, offshore operators had made repairs to closed systems, such as pipelines that seal off surrounding water from contact with hydrocarbons. However, activities of this nature had not been undertaken at such depths.

In particular, no operator had:

- Engaged at depths of 5,000 feet in shearing and removal of damaged risers with one-inch thick walls;
- Dismantled and reconstructed closed systems to cap a wellhead in deepwater; or
- Attempted these containment procedures on a live well.

The Capping Stack, connected to the well via the transition spool to the Lower Marine Riser Package and blowout preventer. Successful installation of the Capping Stack represented the completion of the closed system that allowed for initial shut-in of the well flow.

Innovations Undertaken in Near-Source Closed Containment: The containment team meticulously planned and successfully completed a range of first time engineering and operational tasks. These efforts enabled larger-scale collection of hydrocarbons through closed systems, the closing off of the well, and the later hydrostatic kill and cementing of the well. Advances included:

- The construction and installation of a subsea manifold connected to the BOP for the purpose of implementing a top kill and its successful conversion to a flow manifold as a further means to remove hydrocarbons from the wellhead to a collection vessel. The construction and installation of the manifold was completed in just two weeks. Under normal circumstances, a comparable design-build-deploy cycle would have been 18 to 24 months;

CAPABILITY HIGHLIGHT

The proven capacity to engineer and construct closed systems allowing not only for the collection of hydrocarbons but also the control of flow and the introduction of well-control fluids

- The first-ever use of digital radiography at depth to evaluate drill pipe within the damaged riser;
- The first-ever use of shears and other tools at depth to cut and then remove a damaged riser;
- The creation of a wet mateable control connection system for hurricane recovery;
- The development and installation of a closed system atop the Lower Marine Riser Package (LMRP) above the BOP including the removal of a flange and the installation of a transition spool and capping stack;
- The use of the closed system to control the source and later to close off the well and stop the flow of hydrocarbons; and
- The utilization of the manifold as an integral part of the successful hydrostatic kill to seal off and stop the flow from the well.

Resulting Capabilities Available for Deployment: Through these activities, BP and its collaborators can offer a range of new capabilities:

- The capability to perform digital radiography at depth;
- The capability to cut and remove damaged risers and debris;
- Specialized tools designed to work at depth to remove and install this equipment;
- The ability to construct a closed system, using flange tools, latch caps and stacks, to enable control of flow;
- Specifications and constructed devices for redundant systems in case of failure of initial containment efforts; and
- Plans and organizational schemes to support standup of a dedicated near-source containment team.

Subsea Operations: Remotely Operated Vehicles

A critical tool used in the containment effort was a fleet of expertly maneuvered Remotely Operated Vehicles (ROVs). Without these versatile machines, and the collaboration of the companies that own them, most if not all of the tasks the containment team was called upon to complete would have been virtually impossible.

Prior Industry Practice in Subsea Operations: Offshore operations industry-wide benefit from the wide availability of advanced, highly capable ROVs that have long operated at depths of up to 9,000 feet. BP, as a leading subsea operator, and key contractors have made extensive use of the vehicles to carry out a broad variety of maneuvers, many similar in nature to those required for containment efforts in Deepwater Horizon.

The standard deployment of ROVs at a very active deepwater site would normally involve approximately six vehicles managed by three vessels. The ROVs, which are operated via tethers that could be subject to tangling, would not normally be called upon to work in the same numbers and in such close proximity as required for Deepwater Horizon response.

Moreover, a number of usual procedures for operating ROVs would have been inefficient or time-consuming to maintain at the containment site, including bringing the vessels back to the surface to switch out tools – a step that would require trips of up to four hours in each direction.

Innovations Undertaken in the Operations of ROVs: The containment team, through extensive storyboarding to plan operations and manage risk, advanced the state of the art in the simultaneous operation of multiple ROVs in a number of areas:

- The deployment, at peak, of 27 ROVs at depth overcoming harsh pressure and temperature conditions, low visibility, and distance from the surface;
- The simultaneous operation of up to 16 ROVs – nearly three times the number generally deployed at a very active single site – managed by eight surface boats;
- The extension of operational durations beyond the previous industry norm of a 10-day maximum with one ROV deployment lasting 33 days. Work was transferred between ROVs as needed to maintain continuity and advance time-critical operations;

CAPABILITY HIGHLIGHT

Safe simultaneous operation of 16 ROVs in close proximity to perform a wide range of novel interventions on open- and closed-containment systems

- Centralized management of these simultaneous subsea operations from the integrated Highly Immersive Visualization Environment (HIVE) command center in Houston. This consolidated management approach reduced the complexity of direction to offshore, created efficiencies and time savings, reduced the potential for conflict or accidents, ensured the ability to interact and share knowledge when designing procedures or tasks and streamlined the development of contingencies and changes;
- Advanced engineering of tasks to be "ROV-friendly" – for example, the use of specially designed grips on components to be installed to make handling and maneuvering easier;
- The implementation of standardized "plug-and-play" interfaces allowing use of the same tools by different types of ROVs, as well as deploying subsea "toolboxes" to minimize the need to resurface the vessels for change-outs;
- The deployment of a large-scale subsea hydraulic accumulator, based on the sea floor near the work area for ROVs and powered by a nitrogen charge, that provided and maintained for a longer period the hydraulic pressure and flow needed to operate some of the subsea devices via an ROV. The accumulator was also used as a redundant system for many other hydraulically actuated devices, such as the capping stack;
- The first-time use of ROVs on a number of complex construction, intervention and maintenance tasks such as the establishment of connections in closed systems, including a "pit stop" maneuver in which multiple vehicles were deployed simultaneously on task to minimize hydrocarbon release; and
- Well-integrity and seafloor monitoring through ROV-mounted hydro-acoustic devices mapped into onshore telemetry systems while ROVs continued with other tasks.

Controllers in the Highly Immersive Visualization Environment (HIVE) coordinated the operation of up to 16 remotely operated vehicles simultaneously. The centralized management approach created efficiency and enabled novel interventions 5,000 feet below the surface.

Resulting Capabilities Available for Deployment: The activities of the containment team have advanced the demonstrated capabilities of ROVs for spill containment in the following areas:

- Redefining the baseline for efficient and safe simultaneous operation of ROVs;
- Reliable operation at depth with demonstration of novel subsea interventions;
- New models and communications tools for highly integrated central control and onsite staffing;
- Advancements in subsea hydraulic distribution allowing for more efficient operation of ROVs;
- Plug-and-play retooling, advancements in subsea tool storage and ROV-friendly engineering and fabrication; and
- A well-integrity and seafloor monitoring plan facilitated by ROV acoustic telemetry system.

Simultaneous Operations (SIMOPS)

The wide variety of tasks conducted by the containment team required the support of a fleet ranging from large drilling ships to drilling rigs, multipurpose support vessels to fireboats to tugs, all operating in a highly confined area in hazardous conditions due to the presence of hydrocarbons in the water and the frequent operation of flares on recovery vessels.

SIMOPS management was needed to mitigate the risks and enable these vessels – including some that could not vary their positions beyond a few feet without endangering the mission – to maneuver as needed to complete their tasks.

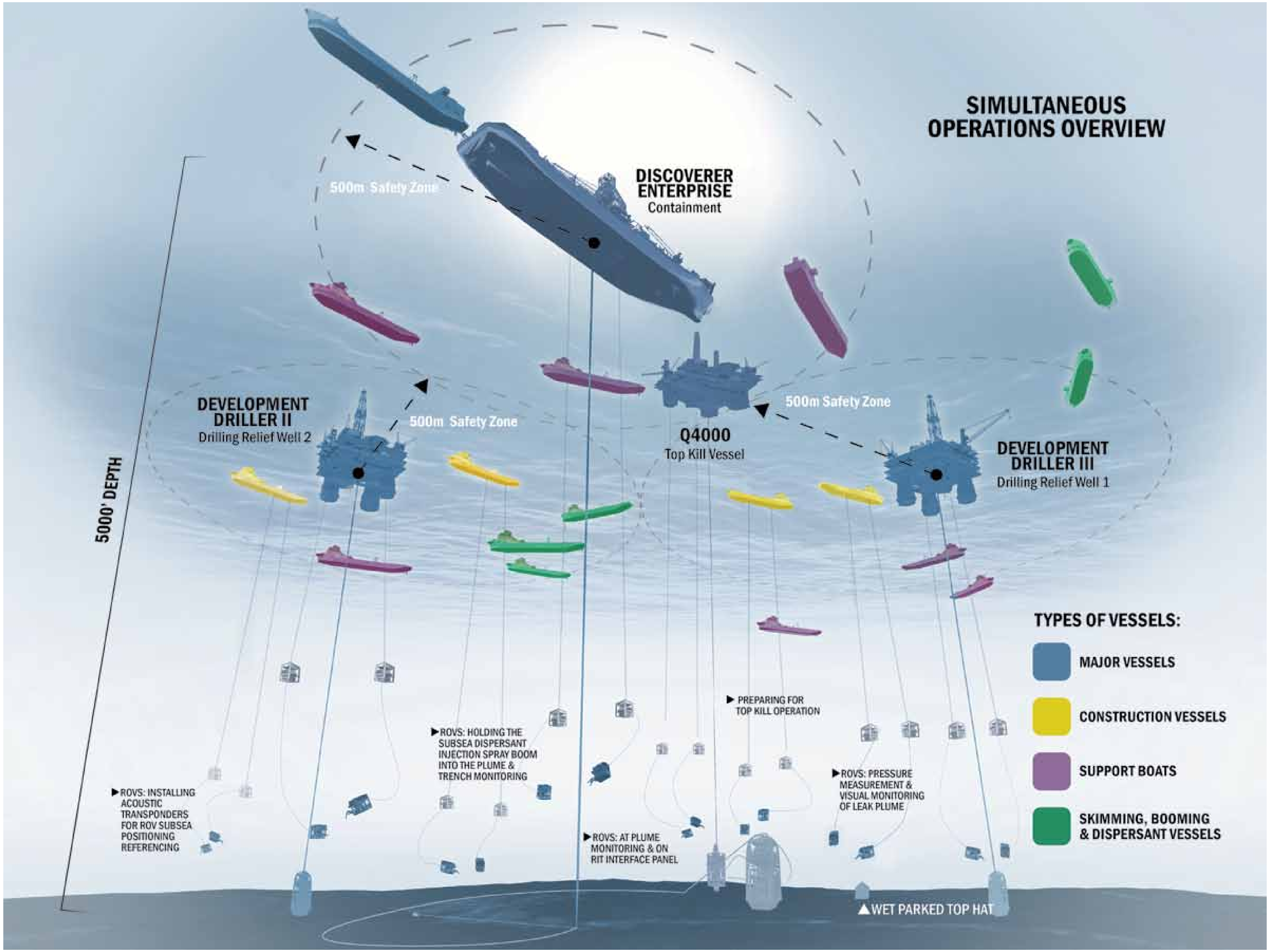
Prior Industry Practice in Simultaneous Operations: BP SIMOPS experience with Atlantis and Thunderhorse has involved the deployment of three to four major ships in close proximity of a platform. These operations have been some of the most complex in industry to date. Separations of several hundred meters have been common, with distance closing to as little as 40 to 50 feet, but only involving two vessels at a time. Even in cases where these best practices were observed, SIMOPS teams have had months to plan the positioning and movement of vessels.

CAPABILITY HIGHLIGHT

Development of advanced visualization techniques enabling the simultaneous operation for extended periods of 19 major vessels in a narrow radius and hazardous conditions without incident

SIMOPS

The operation of containment and support vessels in a highly confined area above the source was enabled by the establishment of a rotating on-site branch director, working in coordination with the Houston-based team and in close collaboration with dozens of vessel captains.



Up to 19 major vessels, some tethered to ROVs 5,000 feet below, operated in close quarters simultaneously within a 500-meter range of the source. The use of advanced visualization techniques and storyboarding made it possible to plan simultaneous operations in a matter of days rather than months, in a manner that mitigated risk.

Innovations Undertaken in Simultaneous Operations: The SIMOPS team, with the cooperation of the owners and captains of responding vessels, implemented precision planning and risk management including:

- The simultaneous operation, without incident, of up to 19 principal vessels up to 250 meters in length within a 500-meter radius of the wellhead, and 40 to 50 within a one-mile radius, operating at times with separations of 25 feet or less;

- The establishment of a rotating on-site branch director, working in coordination with the Houston-based team, with 24/7 command of vessel operations;

- The continuous use of storyboarding as part of the SIMOPS planning process to allow team members to visualize the precise positioning and maneuvering of vessels;

- Novel applications of the relatively new Automatic Identification Software (AIS) – previously used primarily near-shore but enabled by an on-site transponder and the placement of receivers on ships – to provide SIMOPS and captains real-time visualization, identification, tracking and positioning of vessels on graphic displays;

Remotely Operated Vehicles (ROVs) closing the valve on the end of the damaged riser pipe. Advancements in ROV tooling and subsea hydraulic distribution permitted highly efficient ROV operations.

- The conduct of these operations, and the first-ever SIMOPS involving management of flares of hydrocarbons from vessels, without compromising BP standards for marine safety even in the presence of high levels of Volatile Organic Compounds (VOCs);

- The use of sprays from fireboats to create airflows to reduce the VOC levels and to reduce radiant heat from the Q4000 flare while in close working proximity to other vessels;

- The innovative utilization of dynamic positioning technology not normally used in the Gulf of Mexico, including Differential Absolute and Relative Positioning Sensor (DARPS), Artemis, Sidescan, and prisms, as well as the use of inertial navigation as a contingency when operators ran out of available communication frequencies; and

- The first-ever deployment in U.S. waters of offtake operations from one dynamically positioned vessel to another.

Resulting Capabilities: The work of the SIMOPS team in management of the large fleet of vessels included in the Deepwater Horizon response under challenging conditions has demonstrated the following capabilities for future deployment:

- Robust, proven systems and tools for planning and implementing the management of large numbers of vessels at extremely close quarters, including storyboarding and a centralized, onsite control regime;

- The deployment of AIS as an enabling technology for real-time visualization and management of offshore marine operations;

- Demonstrated protocols for directing vessel traffic in the presence of flaring, even with the continuous incidence of VOCs and the need to ensure that levels were below the lower explosive limits (LELs), as well as new techniques for managing the presence of these hazards; and

- Unique experience in handling a range of offtake operations at scale, including dynamically positioned (DP) vessel-to-DP vessel, DP vessel-to-Mooring vessel, and DP vessel-to-Thruster Assist vessel..

Multipurpose Containment/Production Vessels

The containment team was called upon to engage in a diverse range of tasks including open and closed containment, subsea operations, top and hydrostatic kill and hydrocarbon collection, containment, processing, offloading and/or flaring. To accommodate these tasks in the limited space available on the surface, the team needed vessels with a high degree of capability and flexibility, including the ability to support these tasks while remaining essentially stationary in the water.

The team managed this situation by gaining access to several multipurpose vessels – including the Discoverer Enterprise, the Discoverer Clear Leader, the Q4000, Discoverer Inspiration and the West Sirius – but still found the need to extend their capabilities and missions to support additional tasks. The Discoverer Enterprise and Q4000 were deployed, the Discoverer Clear Leader was fully modified, Discoverer Inspiration was prepared for modification and the West Sirius was used to deploy free-standing risers.

Prior Capability of the Discoverer Enterprise and Q4000: Discoverer Enterprise is the only dynamically positioned drill ship in the world that has production test facilities permanently mounted, as well as internal storage capability of more than 100,000 barrels. However, the vessel was only designed for short duration well testing at rates of less than 17,000 barrels/day and in the past had processed a maximum of 35,000 barrels during a test. Originally slated for relief-well drilling activities, the Discoverer Enterprise was instead soon pressed into support of subsea containment and installation activities along with its collection and storage capabilities. This deployment required multiphase separation, gas throughput and flaring.

Supplemental multimedia available for this subject: **Hydro-Static Kill**

The Q4000, in contrast, is a subsea light well intervention vessel that was fitted with equipment to accommodate 8,000 barrels a day of collection but had no storage. It was used to support the full range of closed containment activities, including containment, processing, flaring, and top kill operation.

CAPABILITY HIGHLIGHT

Rapid retrofit of multipurpose vessels for subsea installation, high-volume containment, flaring, DP vessel-to-DP vessel offloading, and top kill and hydrostatic kill operations

Innovations Undertaken with the Discoverer Enterprise and Q4000: The existing capabilities of the Enterprise and the Q4000 were expanded in unprecedented ways without compromising safety:

- Containment at a scale well beyond that anticipated: The Enterprise accommodated more than 522,000 barrels of total containment, and the Q4000 expanded its containment levels to 8,000 barrels of oil per day, and 200,000 barrels total;
- The use of flaring to keep oil out of the water in a manner designed to minimize risk. Flaring was used as an emergency measure and exhibited efficient destruction capability and relatively low emissions through the use of Schlumberger's Evergreen Burner System. The Q4000, with no storage capacity, flared oil as well as natural gas;
- Use of the dynamic-positioning capabilities of the Discoverer Enterprise to support the installation of and collection of hydrocarbons from the RITT and the top hat. Keeping the open containment devices in place required Discoverer Enterprise to maintain its positioning within a tolerance of just five feet, even as it was offloading to a vessel required to maintain tension on the connecting hose and to avoid the flare from the Q4000;
- Deployment of the Q4000 to support closed containment, top kill and hydrostatic kill activities, including the installation of the BOP manifold, the top kill and junk shot efforts, the reversal of the manifold to accommodate collection, and the successful hydrostatic kill operation; and
- Installation of a light-duty intervention riser, previously used on Thunderhorse, which allowed for a quick connect and emergency disconnect for the Q4000.

Resulting Capabilities Available for Deployment: The learnings of the containment team in refitting and expanding the capabilities of the Enterprise, the Q4000 and later, the Clear Leader and the West Sirius, offer a number of potential benefits for the design and deployment of multipurpose vessels for spill response:

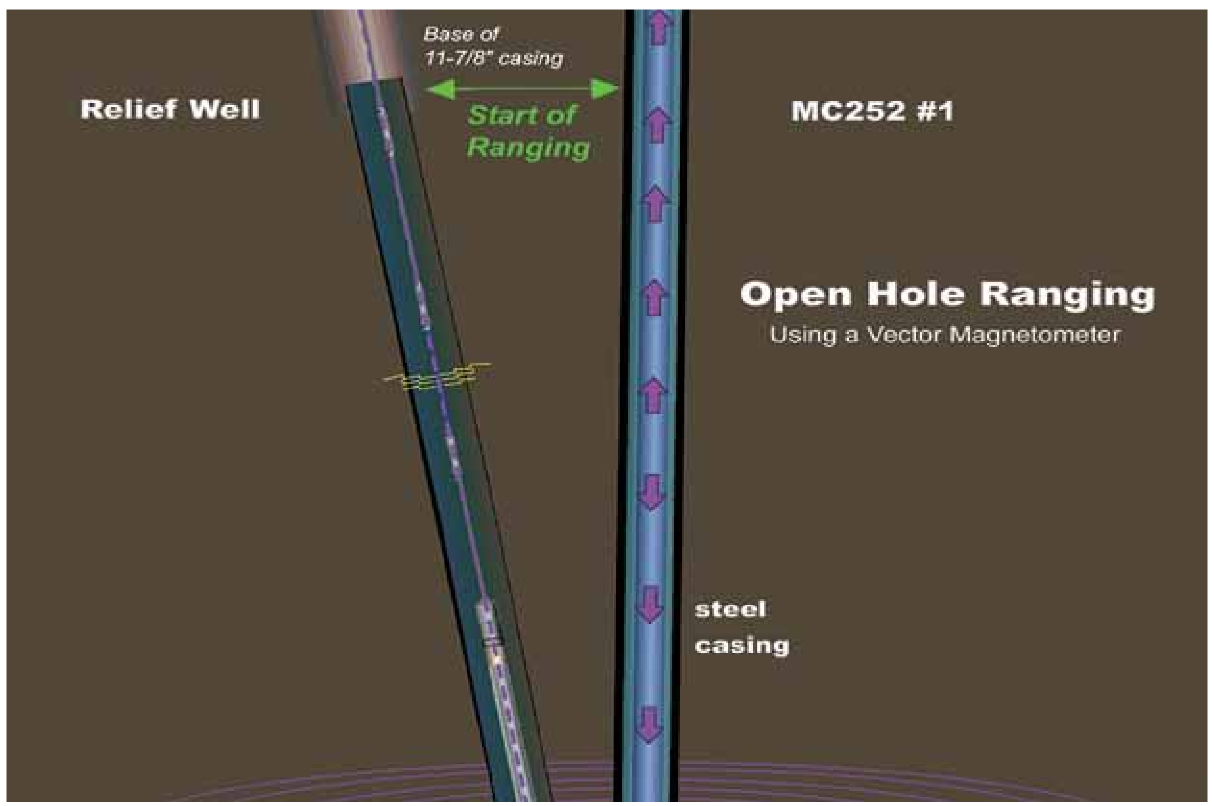
- A step change in the use of flexible multipurpose vessels fitted both to support the construction and operation of open and closed capture devices and to accommodate significant containment and flaring and/or offloading; and
- Improved understanding of the tolerances and use of the vessels in accommodating well-control fluids, as well as the appropriate mixes and management of those fluids in kill situations

Relief Wells

From the beginning, the drilling of a relief well has been planned as a strategy for sealing the Deepwater Horizon well. Under the direction of Unified Command, BP teams and contractors have progressed with the drilling of two relief wells using two deepwater semi-submersible rigs under contract, the Development Driller II (DDII) and the Development Driller III (DDIII).

Existing Industry Practice in Relief Wells: While the drilling of relief wells to kill a well is an established industry practice, many of the techniques and equipment required had previously been deployed in land- or shallow water- environments, and needed to be adapted in significant respects for deepwater.

While "ranging" – the process of locating the existing well casing for intercept – had been in use for more than 15 years, the technology was mature, and required multiple open hole ranging runs. Differences existed among experts on appropriate ranging techniques for use in deepwater. Little experience existed in drilling relief wells on floating platforms. Moreover, many months are generally spent in planning and preparation before wells are "spudded."



Ranging is the process of locating the existing well casing for intercept. The relief well team initiated the development of two innovative non-wireline technologies that will enable ranging while drilling relief wells.

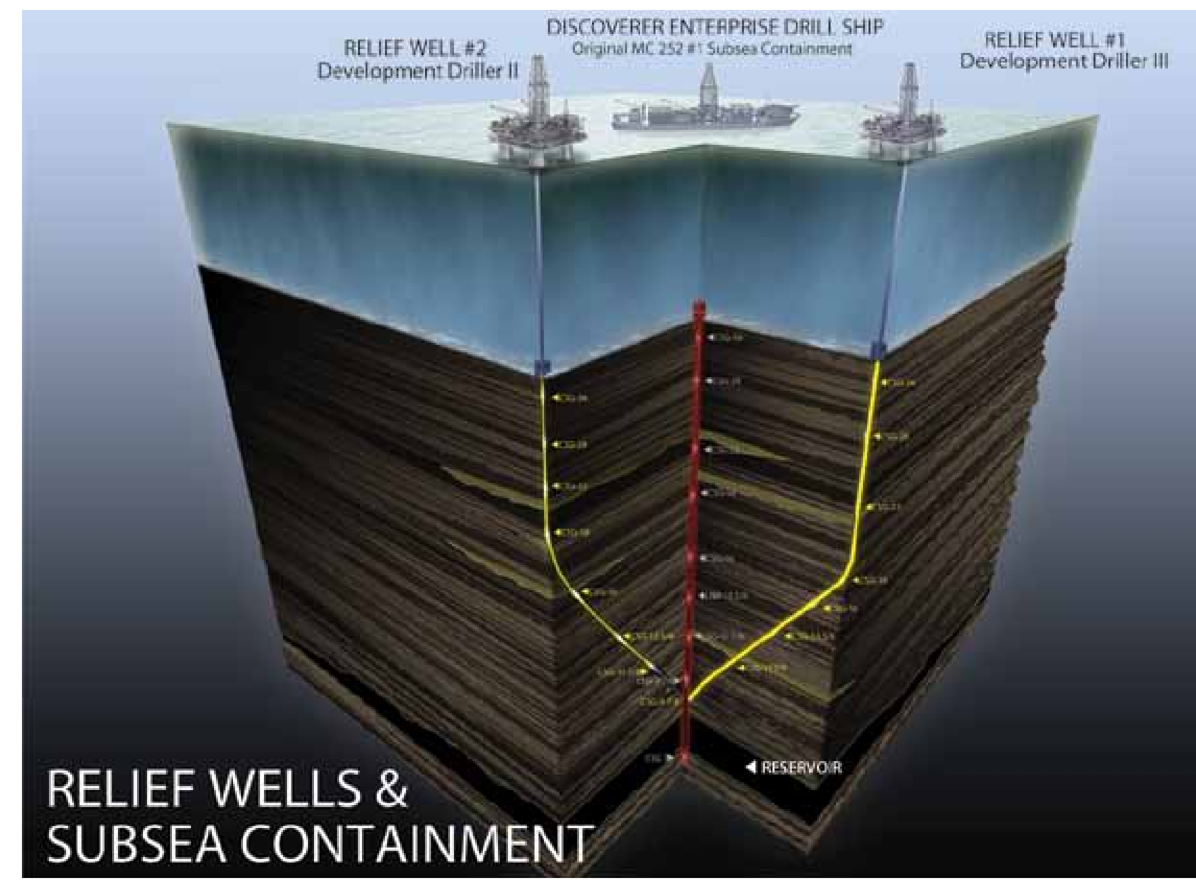
Supplemental multimedia available for this subject: **Relief Well and Ranging**

CAPABILITY HIGHLIGHT

Initial development of more robust non-wireline ranging technologies for faster well intercept in the context of the deepsea drilling of a relief well

Innovations Undertaken in Relief Wells: A dedicated relief-well operation in deepwater was implemented and rapidly took innovative steps including:

- Planning, risk management, acquisition of a drilling vessel and spudding of the initial relief well within 12 days of the Deepwater Horizon incident;
- The identification of optimal kill strategies for deepwater, and the selection of "pass-by" ranging as the appropriate strategy for subsea;
- The initial development of two non-wireline ranging tools that will enable ranging while drilling;
- The equipping and positioning of vessels to provide mud- and cement- pumping capabilities offshore, as well as the construction of an offshore cement mixing and pumping plant;
- The development of procedures to drill in the presence of VOCs while maintaining strict standards for safety; and
- Drilling to within 30 to 50 feet of intercept in approximately 100 days.



The drilling of two relief wells was part of the containment plan for ensuring final "kill" of the Deepwater Horizon well. A dedicated relief well operation was stood up and rapidly took innovative steps allowing the drilling of a relief well to within 30 to 50 feet of intercept in approximately 100 days.

Resulting Capabilities Available for Deployment: The efforts of the relief-well organization to date have produced a range of expanded capabilities that can be refined if needed in future efforts:

- A breakthrough in the development of two non-wireline ranging technologies and the verification of pass-by as the appropriate technique;
- The development of diagnostics and a decision tree to select optimal kill strategies in deepwater conditions;
- Procedures for safe drilling with hydrocarbons in the water;
- Technologies and blueprints for equipping and positioning boats to provide mud- and cement- pumping capabilities offshore, as well as to mix cement; and
- Plans and organizational schemes for immediate standup of a dedicated relief-well team.

Long-Term Containment Disposal Project

The mission of the Long-Term Containment Disposal Project (CDP) team was to design a six-month containment solution while other teams continued to focus on near term containment, the day-to-day response and the relief wells.

Prior Industry Practice: Many aspects of the solution selected for containment disposal have not previously been deployed, either in the Gulf of Mexico or globally. The CDP plan was built around the adaptation of floating production, storage and offloading (FPSO) units, which had not previously been used in the Gulf of Mexico.

Other elements of the solution were also not yet standard industry practice in the Gulf of Mexico, including free-standing risers, dynamically positioned offtake shuttle tankers, flexible pipelines and the use of a dedicated methanol-deployment-purposed vehicle and seabed distribution system for hydrate mitigation.

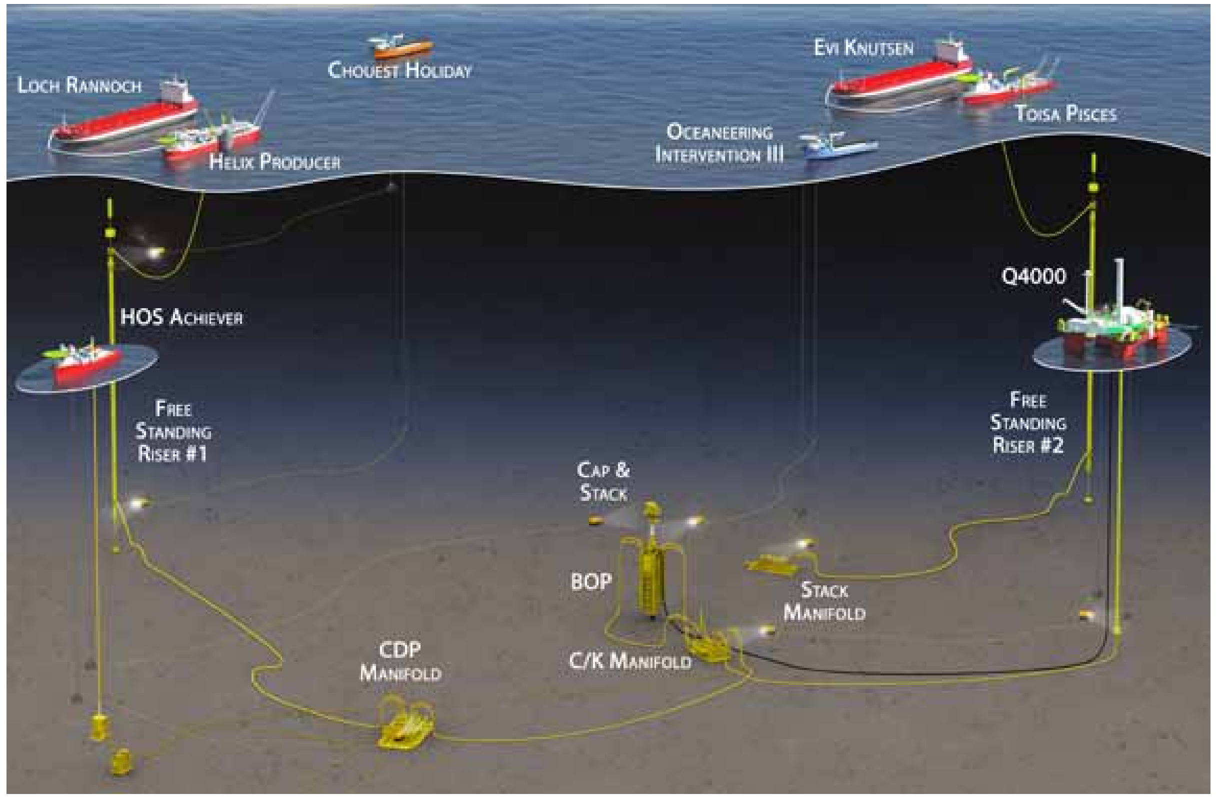
Innovations Undertaken in CDP: The CDP team pursued a range of innovations in planning, mitigating the risks of and implementing a project that, from inception to deployment, took about eight weeks compared to the normal three or more years for a similar project:

- The identification, modification and deployment within seven weeks of two FPSOs, the Toisa Pisces and the Helix Producer 1, the first in the Gulf of Mexico planned for long-term containment. The Helix Producer 1 ramped up to more than 20,000 barrels of collection on July 13, prior to well shut in;

CAPABILITY HIGHLIGHT

Development in a compressed time period of a robust system for long-term containment featuring the first installation of free-standing riser, hydrate inhibition and emergency hurricane disconnection capability

- The design, construction and installation of the first two containment purposed free-standing risers in the Gulf of Mexico;
- The development of a hurricane-impact mitigation system including a quick-connect/disconnect release mechanism for a rapid evacuation;
- The deployment of three DP2-class shuttle tankers, each with capacity of 750,000 barrels, allowing FPSOs to offload while attached to a free-standing riser;
- The design and implementation of a hydrate-inhibition system featuring the engineering of a subsea methanol delivery system from a dedicated vessel;
- The use of coiled tubing for supplying subsea dispersant to the source at the seafloor;
- The use of standardized connectors allowing a range of tankers to connect to the FPSOs for offloading; and
- The option for tie-back into nearby production facilities to provide a "hurricane proof" route for disposal, if necessary. This option was created by re-scoping other developments on BP-operated infrastructure. Major plant vessels were on standby until the need ceased.



The Containment and Disposal Project team quickly developed a six-month solution for containing hydrocarbon flow with innovations including the first Gulf deployment of free-standing risers and a novel hydrate-inhibition system.

Resulting Capabilities Available for Deployment: The CDP solution offers numerous opportunities for long-term operation as well as containment disposal in the event of a spill:

- A full blueprint and proof of principle for a novel solution for the Gulf of Mexico adapting existing technologies – including FPSOs, the first producing free-standing risers, flexible pipe, and DP2-class shuttle tankers. This solution combines the potential for rapid deployment with flexibility and robustness for long-term operation;

- Demonstrated hydrate-mitigation systems; and

- Hurricane-impact avoidance and rapid emergency responsiveness.

Subsea Dispersants

BP, working closely with the U.S. Coast Guard and the U.S. Environmental Protection Agency (EPA), reviewed and undertook a subsea deployment of dispersants with the objective of reducing the environmental and safety impact of the release of oil from the Deepwater Horizon well.

Industry Practice on Dispersants: The EPA has permitted use of dispersants subsea to remediate oil spills since the 1990s.

Although there have been limited trials and some discussion in technical papers of applying dispersant to the source, industry practice in general has been to deal with subsea oil spills by first allowing the hydrocarbons to rise to the surface and then dispersing the oil through aerial application of dispersant. However, most oils evaporate quickly, leaving a waxy residue which is unresponsive to chemicals and limits the times at which dispersants can be successfully applied at the surface. In addition, there is an indication that injecting dispersants into colder oil on the surface or into a mixture of oil and seawater requires more chemical to achieve the desired effect.

Innovations Undertaken in Dispersants: Under the supervision of Unified Command, BP undertook a novel approach to dispersant use:

- Following multiple tests and computer modeling soon after the incident, the first subsea injection of dispersant directly into oil at the source, using newly engineered tools at the site of the RITT and later, at the open top hat containment device;

- Reduction of dispersant use at the surface by almost 70 percent with good results, as measured by observation of lower amounts of oil and lower measurements of VOCs at the surface, enhancing safety of containment operations at the site;

CAPABILITY HIGHLIGHT

Novel subsea systems to inject dispersant efficiently at source, with demonstrated effectiveness in substantially reducing surface oil and VOCs

- The testing of alternative subsea dispersant mechanisms, such as the use of subsea bladders in the Subsea Autonomous Dispersant Injection (SADI) and automatic injection of dispersant in the event of hurricane evacuation; and

- The development of surface observational tests of subsea dispersant effect.

Resulting Capabilities Available for Deployment: The use of dispersants subsea has resulted in the potential for further advancements in their use, along with areas for additional investigation and action:

- A process that is more efficient in dispersing oil, allowed surface use of dispersants to decrease by nearly 70 percent, reduced VOC emissions at the containment site and reduced shoreline impacts;

- New and potential tools and processes for subsea application of dispersants.

- The proven capability to ramp-up supply of dispersant; and

- The potential to improve on the current swirl test for dispersant effectiveness.

Surface oil above the source before and after subsea dispersant injection. Testing found that dispersant use reduced the level of oil and volatile organic compounds (VOCs) at the surface, enhancing safety and making subsea containment efforts possible.

Subsurface, Seabed and Water-Column Monitoring

Subsurface, seabed and water-column monitoring were essential to the well-integrity test, the hydrostatic diagnostic test and subsea dispersant application and required sophisticated research tools and data-sharing systems. Monitoring activities were conducted in coordination with federal and state government agencies, academic and independent research institutions, individual scientists and researchers and vessel operators.

Prior Industry Practice in Subsurface, Seabed and Water-Column Monitoring: Standard geophysical practices used in regular industry operation, as well as proven techniques employed in previous well-control incidents, were available for subsurface and seabed monitoring operations.

Innovations Undertaken in Subsurface, Seabed and Water Column-Monitoring: In coordination with multiple stakeholders, responders used innovative strategies and protocols to rapidly, efficiently and accurately monitor the integrity of the subsurface, seabed and water column, including:

- Formation of the Deepwater Horizon Joint Analysis Group (JAG), a team of academics and experts from agencies including National Oceanographic and Atmospheric Administration (NOAA), EPA, United States Geological Survey (USGS), and the White House Office of Science and Technology Policy, to analyze subsurface monitoring data;

- Systems to rapidly deliver monitoring data, such as seismic monitoring to identify subsurface changes at six-to-24 hour intervals -- an industry first (compared to most industry experience of time-lapse changes at the "monthly" or "yearly" interval);

- Seismic lines were safely shot through an extremely narrow corridor between other vessels with clearances of approximately 200 meters or less, to either side of planned seismic lines (compared to industry norm rarely within a 500 meter zone or marine obstructions);

- Multiple active and passive acoustic-monitoring devices at the seabed and in the water column;

- Wellhead-mounted geophone for integrity monitoring;

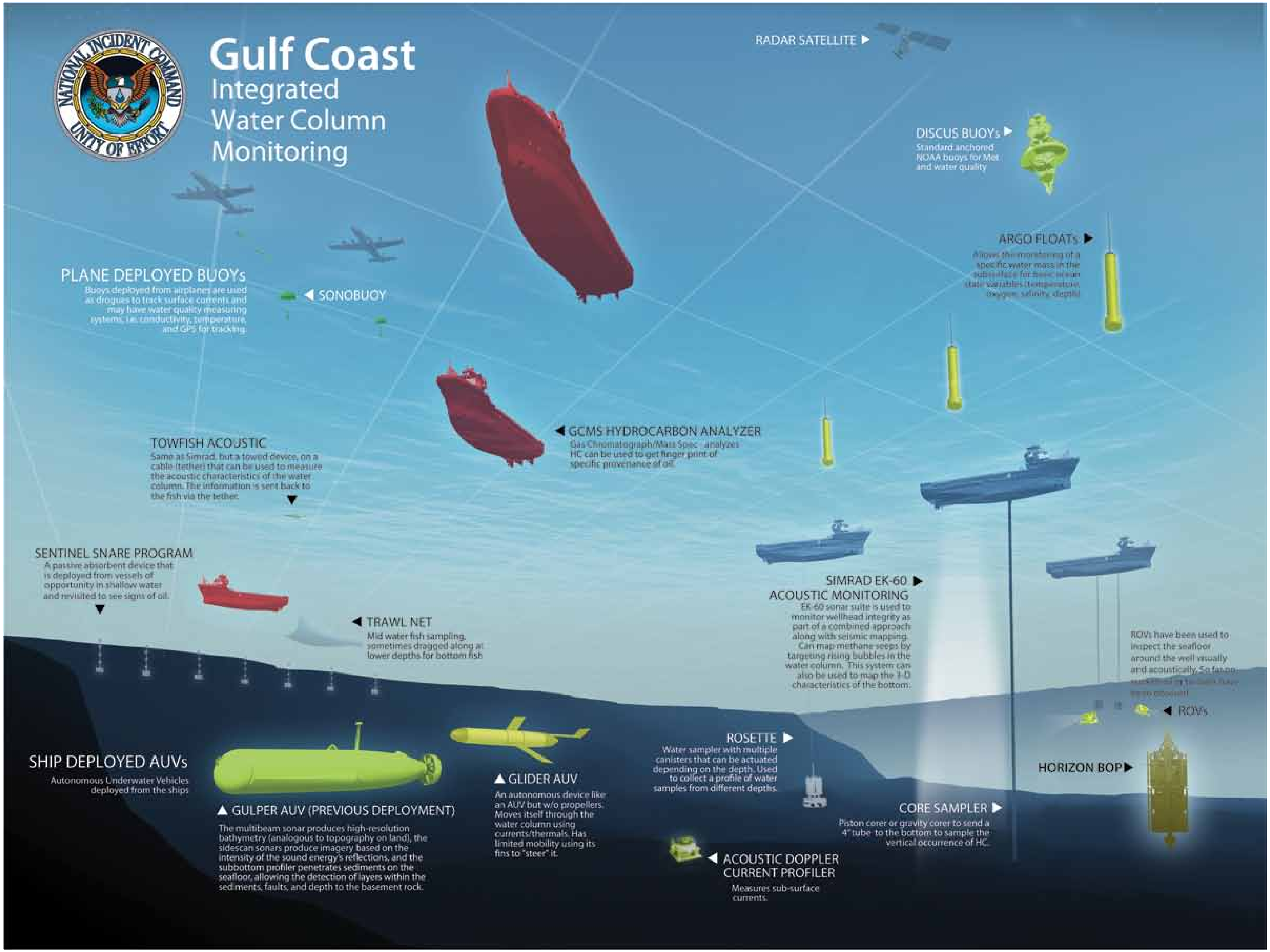
- Continuous monitoring of the wellhead, seabed and water column visually and through ROV sonar coverage and subsea-mounted acoustic-monitoring devices;

CAPABILITY HIGHLIGHT

Experience in coordinating industry, agency and academic expertise to efficiently produce reliable, high-quality data on subsurface, seabed and water column conditions

Water-Column Monitoring

A response worker takes samples. In coordination with multiple stakeholders, responders used innovative strategies and protocols to rapidly, efficiently and accurately monitor the integrity of the subsurface, seabed and water column.



Water column and subsea monitoring operations. Data and water samples collected helped inform a range of response activities, including subsea dispersant injection techniques.

- The use of Autonomous Underwater Vehicles (AUVs) seabed clearance and high-resolution 2D seismic surveys to inform relief-well drilling;

- Complex seismic-monitoring operations conducted before well integrity testing and hydrostatic diagnostic testing;

- A continuously updated simulated forecast of subsurface oil distribution, conducted in conjunction with the Foundation for Scientific and Industrial Research (SINTEF) at the Norwegian Institute of Technology;

- The development of Dispersed Plume Characterization – a sample and analysis of the entire water column from surface to seabed;

- The design of a rigorous aerial, surface and subsea program to monitor the effect of subsea dispersant application on the oil and the water column; and

- The deployment and coordination of multiple vessels, platforms, and new technologies such as AUVs, high-endurance wave gliders, and passive sampling devices, as well as two retrofitted deepsea research vessels with marine laboratories, specialized monitoring equipment and teams of marine scientists.

Resulting Capabilities Available for Deployment: These innovations have resulted in a series of new capabilities that can be adapted and refined for deployment including:

- An established regime for water-column monitoring that is continuing to operate;

- A large and nearly continuous set of high-quality data, as well as thousands of water samples that will continue to inform new scientific learnings and future response strategies;

- Robust dispersant monitoring and evaluation systems to help inform dispersant injection rates subsea;

- Streamlined system to acquire, process and interpret geophysical data in less than 24 hours and standardized protocols for sampling, data collection, and information-sharing;

- An improved understanding of the effect of subsea dispersant application; and

- New techniques for detecting geophysical differences in the subsurface and the water column.

3

From Offshore to Shoreline: “All Oil Spill Response is Local”

The response to environmental incidents of large scale requires a mindset that transcends traditional approaches. Oil spills have a wide range of impacts on water and shoreline as well as local communities.

The team quickly recognized that, due to the scale and extent of the incident, it needed a comprehensive strategy, captured in a catchphrase used by the spill response team: “all oil spill response is local.”

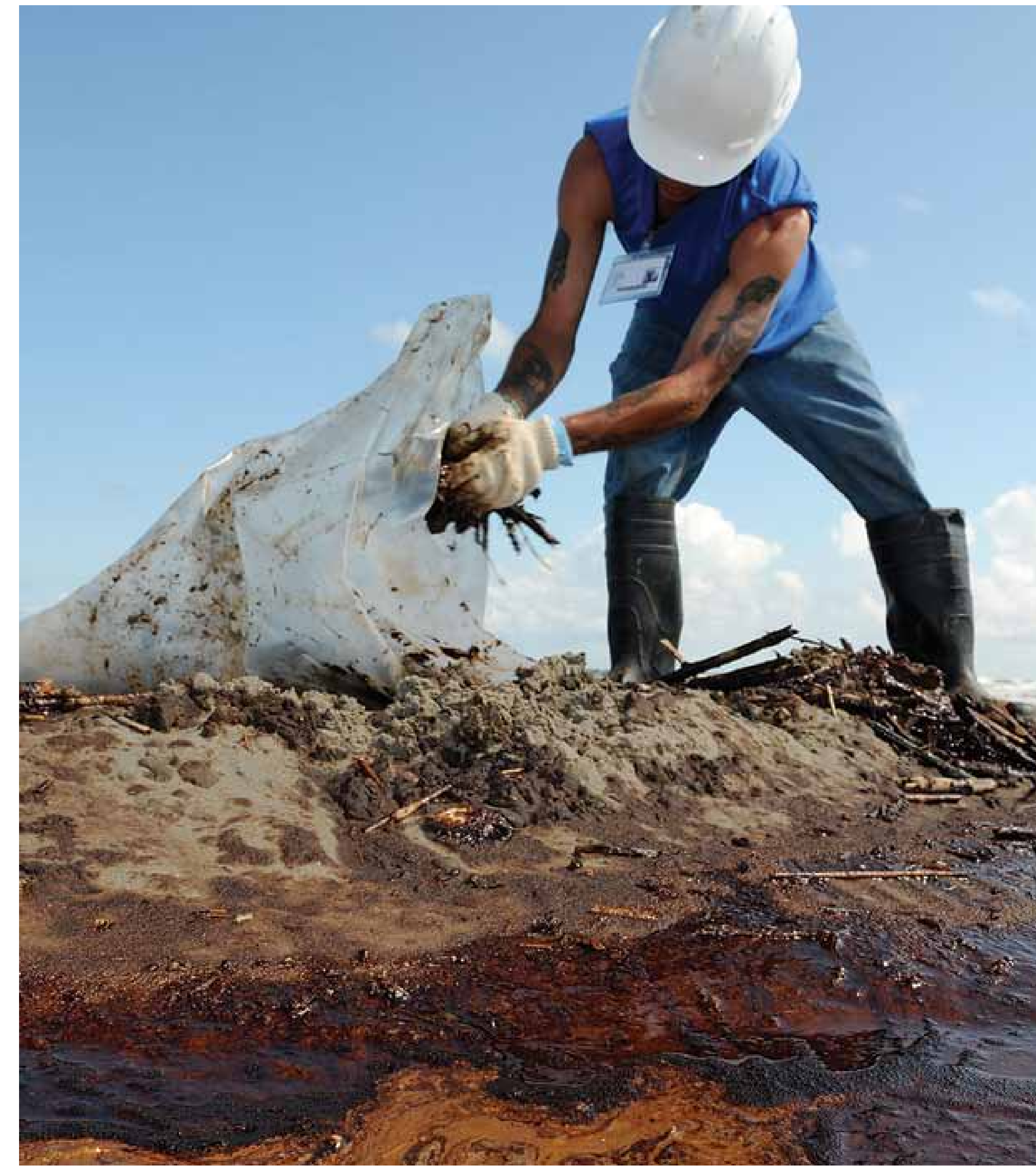
Based on this perspective, the team’s actions across the response theater can be broken down into five primary activities:

- **Preparedness** drives more effective resource deployment and utilization in the first days of the response.
- **First response** comprises the tactics developed to ensure rapid deployment to address the most likely scenarios. Critical elements include the engagement of community resources through programs such as Vessels of Opportunity (VOO).
- **Assessment and surveillance** reflect the priority of understanding the situation at hand, and assembling information in a manner that supports the development of clear objectives. Shoreline Clean-up Assessment Teams (SCAT) provide an assessment process that engages stakeholders at every phase of the response, and multiple surveillance tools are integrated into a COP supporting the broader response.
- **Prevention** systems and capabilities require strong coordination and controls given their interdependence and the need to minimize the footprint of restoration. Decisions as to when and where skimming, controlled in-situ burning and dispersant are deployed require understanding of their capabilities, and boom represents the final barrier in shoreline protection beyond these tools. A Branch Office Structure further improves the effectiveness of these decisions.
- **Restoration** of the shoreline usually takes up the majority of the time in a response due to the delicate nature of the coastal environment. Marsh-cleaning and beach-cleaning, while sharing the goal of returning the impacted area to its original condition, are significantly different activities requiring different tools, logistical support and skill sets.

Supplemental multimedia available for this subject:
Response Video 1: Response Overview

Strategic planning was key to staying ahead of events in the response effort as it unfolded. For example, a severe weather planning function was stood up on May 21, well before the first tropical storm, Bonnie, which occurred in late July.

Ultimately, as was the case with containment, the intensity and sense of urgency behind the response in each of these five activities has generated new or modified systems and capabilities that, if maintained, shared and institutionalized, can increase the effectiveness of future efforts.



A response worker removes debris. The insight that the response operated under the catchphrase “All oil spill response is local.”

Preparedness

Area Contingency Planning

Area Contingency Plans (ACPs), created by local government officials in each state, represent an important planning and preparedness tool in oil spill response. A robust ACP is built with strong collaboration between all stakeholders and industry, identifies the sensitive environmental areas to be protected, defines the proven protection strategies, and identifies the resource needs for implementing those strategies. Effective ACPs, when properly constructed and implemented, are key not only to coordinated responses but also to local understanding of, and pre-agreement to, strategies and allocation of resources that are critical to rapid deployment.

Supplemental multimedia available for this subject: **Response Video 2: ICPs at Work**

Prior ACP Practice: Current ACPs, intended to provide some of the priorities and plans for immediate shoreline protection, are constructed largely on a state-by-state basis with "macro-level" response protocols.

A complete ACP enables response teams to apply best practices for allocation of response resources.

Response Team Efforts to Enhance ACPs: The response team worked to assist states in refining or developing ACPs and geographical response plans to enable the most effective possible response to spills and their aftermath, including:

- Advocacy for full local participation and industry involvement in developing parish-by-parish, town-by-town trigger-point geographic response plans which clearly specify when and where to deploy resources based on local conditions and oil movement; and
- Specific support and facilitation of Florida workshops that produced a draft ACP that may provide a model for other states to follow, with clear goals and metrics, detailed specifications in its environmental plan, spelled-out resource requirements and specific reference to the involvement of responders, vendors and stakeholders.

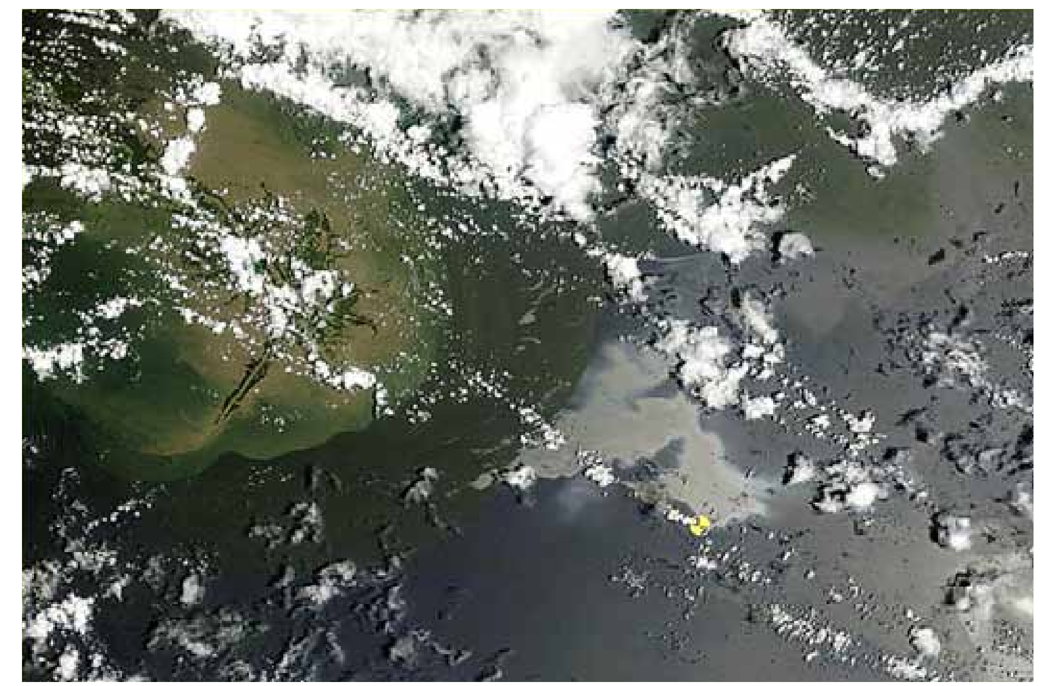
Resulting Capabilities: Continuation of industry, state and local efforts to enhance ACPs could provide valuable benefits for future responses including:

- Specific booming strategies, grounded in ACPs, and informed by actual performance and effectiveness across a four-state area;
- The opportunity to follow the process built by the response team in facilitating the draft Florida ACP and to suggest it as a model for other states; and
- Efforts to achieve state and local advance agreement to overall strategies and priorities in allocation of resources, including informed support for best practices in areas such as booming, spill remediation and protection of sensitive habitats and areas.

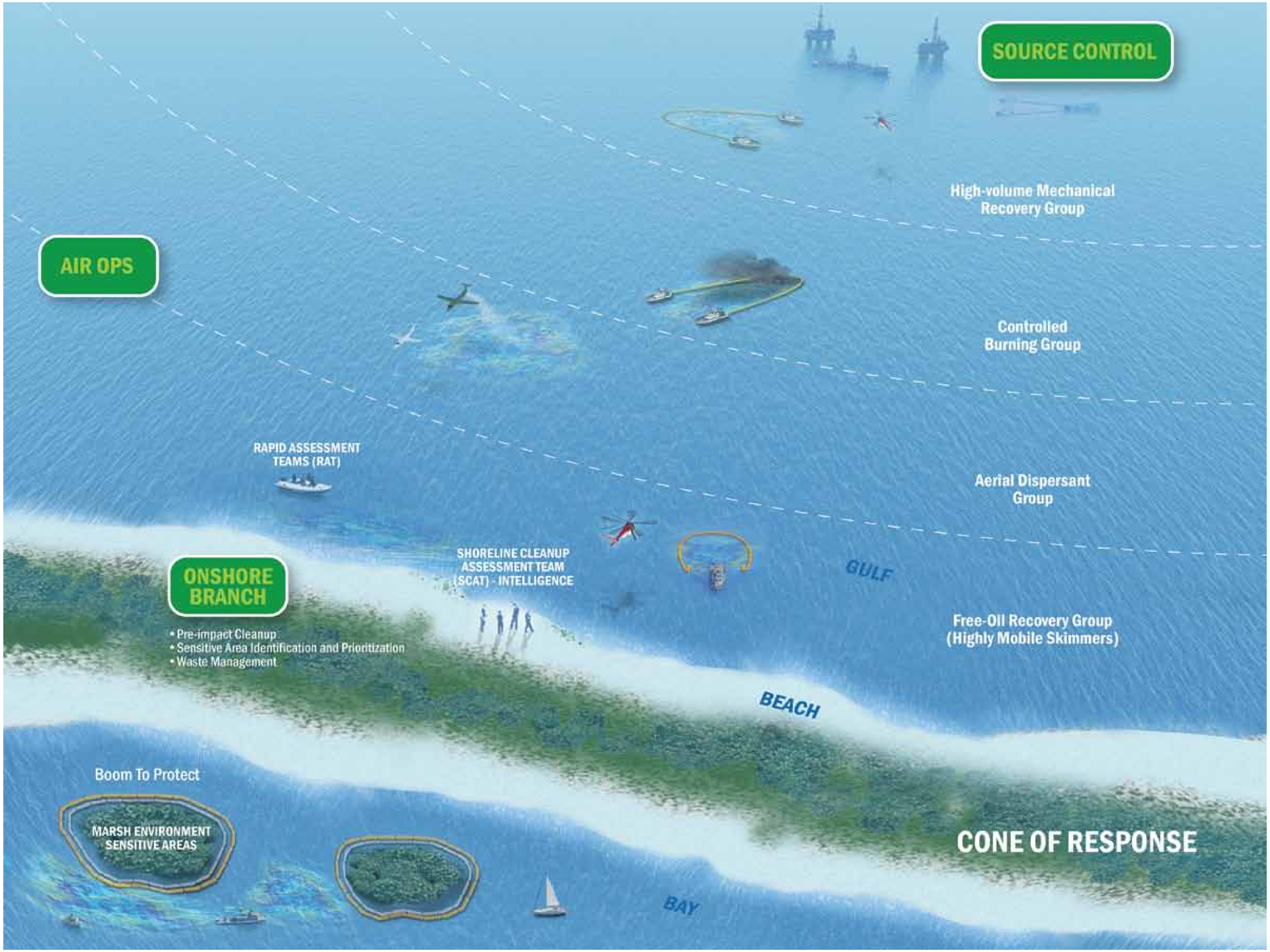
CAPABILITY HIGHLIGHT

Specific booming plans and placement detail across the four-state response area, grounded in Area Contingency Plans (ACPs) and informed by actual performance and effectiveness

Cone of Response



A satellite image of the response area. Satellite imagery was used to locate oil and direct response efforts in a timely manner.



This diagram highlights the array of forces deployed from the source to the shore to locate, assess, remediate and remove oil.

Wildlife

The response team worked hard in cooperation with wildlife experts, both inside and outside the government, in order to try to protect wildlife and sensitive habitats by accelerating response, and to rescue and rehabilitate wildlife affected by the spill.

Prior Practice in Wildlife Response: In the event of a spill, best practice is to call in professionals with an intimate knowledge of the most sensitive species and their habitats and trained to observe, protect and rescue wildlife.

Supplemental multimedia available for this subject: **Response Video 3: Wildlife**

Response Team Efforts to Protect and Rescue Wildlife: The response team stepped up to the challenge of providing the full resources needed to protect and rescue affected wildlife, including:

- The fourfold expansion of experts engaged for community response;
- New systems to more closely integrate wildlife teams into the overall response effort to expedite resources and support;
- The setup of wildlife response call centers with a public hotline publicized in advertising and on the BP.com website, with progress toward rapid response times of under an hour;
- The establishment of animal treatment facilities, for example the capacity to treat up to 10,000 birds; and
- A dedicated plan to protect sensitive rookeries.

Resulting Capabilities: The wildlife protection and rescue effort has created the following capabilities:

- A substantially expanded and rapidly deployable pool of trained response workers across the Gulf region;
- Protocols and procedures to better integrate and support wildlife protection and rescue teams and for the standup of call centers, a public hotline and rapid response capacity; and
- Procedures for the protection of sensitive nesting areas.

CAPABILITY HIGHLIGHT

An expanded pool of trained responders along with protocols and procedures to integrate and support accelerated response to impacts on wildlife

The capture, treatment and release of birds. The team of experts engaged and trained for community response was expanded fourfold.

Vessels of Opportunity

Vessels of Opportunity (VOO) embodied the concept of collaboration as an instrumental part of spill response. The impact of the spill on communities, including many fishermen and other vessel owners, from Louisiana to Florida led to an unprecedented number of applicants and participants for the VOO program. In responding to this demand, the team learned that, when properly integrated into the command structure, VOO can serve not only as a community-engagement tool but also fulfill an impressive range of response operations.

Prior Practice on VOO: The VOO program has existed in concept for more than two decades. However, while a VOO equivalent was established in Alaska in the wake of the Exxon Valdez spill and continues in operation today as a preparedness measure, the Deepwater Horizon response drew on the unparalleled resources of Gulf Coast shipmasters and crew.

Several of the 5,800 vessels employed in the Vessels of Opportunity (VOO) program. The VOO program capitalized on local mariners' knowledge of area shorelines and waters.

Supplemental multimedia available for this subject:
Response Video 4: Vessels of Opportunity

CAPABILITY HIGHLIGHT

In the VOO program, the foundations for a vetted, trained, and knowledgeable fleet of committed shoreline and community responders fully integrated into the overall effort through a replicable command structure

Response Team Actions on VOO: The response effort has fully embedded and greatly benefited from the implementation of the VOO program:

- The establishment of a 5,800-vessel VOO fleet, providing employment to local mariners and empowering them to participate in the protection of their coastlines;
- The full integration of VOO into response teams, and the expansion of its scope beyond transport and logistics to booming, skimming, and even participation in controlled in-situ burning. The response team has frequently capitalized on vessel owners' knowledge of local shorelines and waters and their insight on the effect of currents on oil flow in sensitive coastal areas;
- Development of a systematic approach to selection, inspection, training, badging and equipping to meet Occupational Safety and Health Administration (OSHA) and other regulatory requirements; and
- The organization of fleets into task forces with specific accountabilities within a command and control structure. A VOO fleet requires rigorous tasking within the incident command structure.

Resulting Capabilities: The VOO program offers strong potential as a part of a future response system:

- A proven capability to rapidly deploy a vetted and trained fleet of near-shore responders with a deep knowledge base and passion for protecting their shorelines and communities;
- A structured program and protocols for on-boarding and tasking, including recruitment, vetting, sorting by use, badging, training and observation of regulatory requirements;
- A model for integration and a replicable command structure; and
- The opportunity to "do the right thing" by involving a vital element of shoreline communities and providing employment for individuals and families in the affected areas.

Vessel of Opportunity (VOO) operators. The VOO program demonstrates the capability to rapidly deploy a vetted and trained fleet of near-shore responders.

Assessment and Surveillance

Common Operating Picture

The Common Operating Picture (COP) created an integrated view across more than 200 previously disparate data types, employing newly developed equipment and technology to provide a seamless and rapid assessment of the entire response effort. The COP has ensured that responders and leaders in command posts and the field have accurate, reliable information indispensable to good decision-making, effective communications with local officials and the public, and a systematic and coordinated spill response.

Prior Practice on Information-Sharing: Responding to oil spills at scale involves a multitude of data sources and requires agreement on the right data to use to guide deployment of resources. In particular, responders need to "know their oil" – where it is and what state it is in – to direct the correct response.

Infrastructure must be in place to ensure that information is collected and shared in a way that ensures a common perspective on response strategies, coordination and optimal allocation of resources.

The Evolution of the Common Operating Picture: The team developed the COP to provide an instant, interactive and accurate visual of the spill status and response activities for all responders.

The COP:

- Builds on the key concept of "knowing your oil," providing comprehensive, continuous data on the location and nature of oil on the water and onshore;
- Creates a central nervous system spanning "space to sky to sea to shore," linking the full range of responders and providing capability to input as well as receive data;
- Is accessible via a flexible internet platform over personal computers and hand-held devices;
- Collects multiple inputs from the full range of responders in the air, on the water and onshore, along with geographic information system (GIS) data, NOAA and EPA databases and other sources for the most up-to-date mapping of the spill;
- Offers ongoing updates on response efforts including boom and buoy placement and the location of nearshore/open-water skimming vessels and burning activities; and
- Offers a powerful tool for communications with local officials, coordinating activities and directing resources.

CAPABILITY HIGHLIGHT

Single, comprehensive and integrated view of the entire response effort from sky to sea to shore to enable rapid, coordinated decision-making

Common Operating Picture (COP)

The Common Operating Picture (COP) builds on the concept of "knowing your oil," providing the entire response team comprehensive, continuous data on the location and nature of oil on the water and onshore.

The Common Operating Picture (COP) provides a virtually real-time assessment of the entire response effort, providing responders and leaders in command posts and the field access to the same information.

Resulting Capabilities: The COP offers numerous potential benefits for future response efforts:

- A fully developed, instantly deployable system for reliable, up-to-date and comprehensive common communications and information;
- Rapid decision-making, prioritization, and effective resource deployment, and
- State-of-the-art and readily available information tools.

Tactical Communications

Coordinating activities of the response team required extensive communications capability, which in turn required the installation of robust information platforms – including much of the physical infrastructure – covering five states across the Gulf Coast.

Prior Tactical Communications Infrastructure: No spill response effort had ever had to coordinate activities across five states spanning the Gulf Coast. The scale of the response, the number of agencies responding and varied nature of operational activities – from ICPs and branch offices to the air to near-shore and open-water vessels to onshore SCATs and marsh- and beach-cleaning units – required a number of communications platforms, as no one platform could provide response wide capability and capacity.

Moreover, the development of a COP required a robust information backbone accessible to the response units as well as government agencies.

Response Team Efforts to Build a Tactical Communications Infrastructure: Supported by BP information technology unit, the response team moved rapidly to put in place the communications hardware and software needed to coordinate its efforts, including:

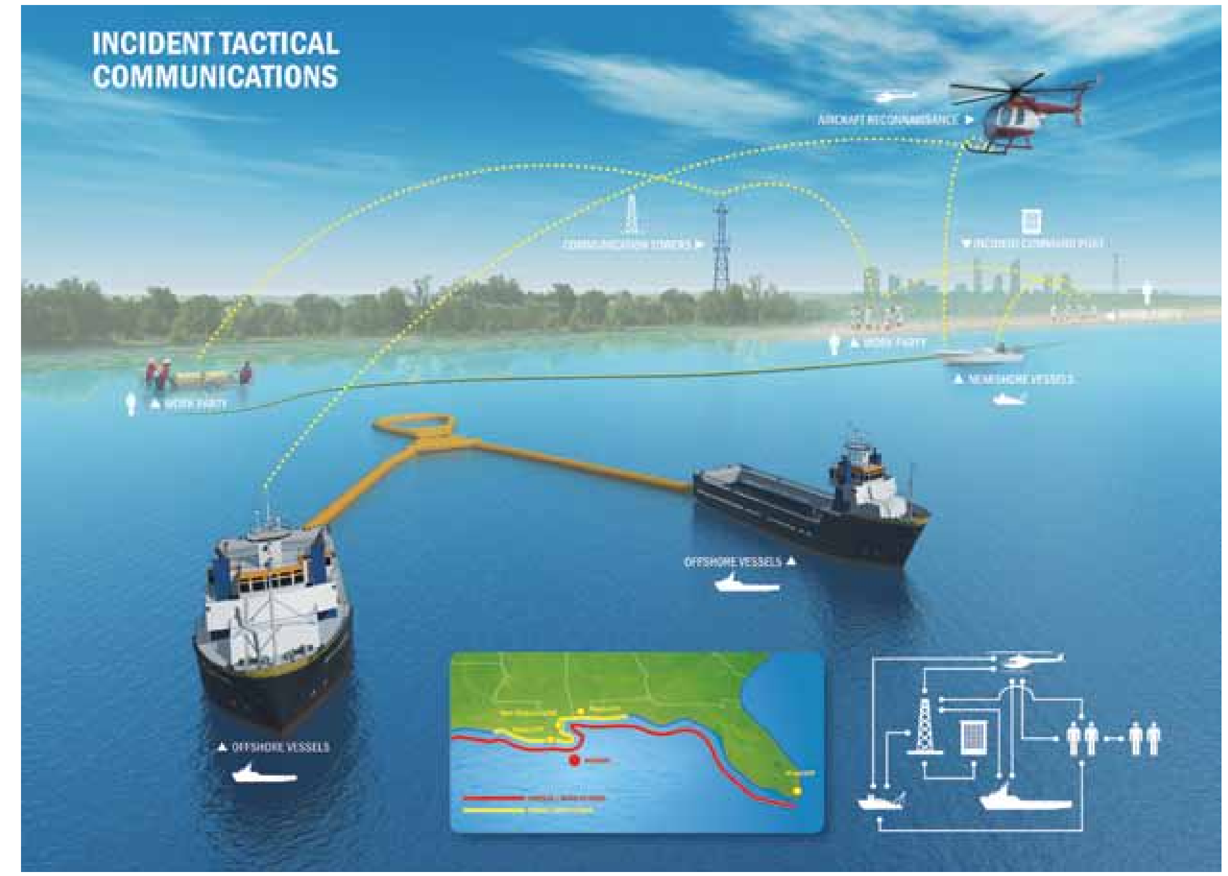
- Construction of a repeater radio system spanning 26 leased towers from the Florida Panhandle to near the Louisiana/Texas border and providing communications links among the ICPs branch offices, vessels near-shore and in the open water, pilots/spotters and shore units (marshes, beaches). The repeater system included marine VHF, aviation band and BP "business band" connections;
- Streaming of the radio system over an Internet connection available to responders;
- The development of the software "data warehouse," linked to NOAA Environmental Response Management Application® (ERMA), that provided the backbone for the COP; and
- The use of secure of "cloud computing" operations allowing the team to rapidly scale collaboration tools.

CAPABILITY HIGHLIGHT

An in-place repeater radio system stretching from the Florida Panhandle to Louisiana and a robust software information backbone supporting communications across response activities

Resulting Capabilities: The tactical communications effort left behind a range of capabilities deployable by any future response operations:

- An existing repeater radio system of 26 towers across the Gulf outfitted with aviation band and VHF marine band connections;
- A robust information backbone to power the COP; and
- Protocols for the development of secure cloud computing support for collaboration tools.



The tactical communications effort involved construction of a repeater radio system spanning four states, providing communications links among the ICPs, branch offices, vessels, aircraft and shore units.

Shoreline Clean-up Assessment Teams (SCATs)

The Shoreline Clean-Up Assessment Teams (SCATs), made up of scientists from BP, the NOAA, state Departments of Environmental Quality and state universities, play a critical role in the preparation, planning and validation of shoreline protection and treatment.

Prior SCAT Practice: Standard procedure in the wake of a spill has been to convene a SCAT to engage in important activities, including:

- Pre-assessment before probable oil contact, key in determining the extent of damage;
- Initial assessment after the spill reaches the shore, reporting back to the response team with findings and shoreline treatment recommendations (STRs). SCAT experts are equipped to verify the presence of oil, identify the nature and source of potential contamination, and make treatment recommendations; and
- Post-assessment to validate the success of shoreline treatment efforts.

A member of a Shoreline Clean-up Assessment Team (SCAT) completes an assessment. Standardized data collection protocols and centralized analysis systems helped ensured response resources were allocated effectively.

Supplemental multimedia available for this subject: **Response Video 5: SCAT in Action**

CAPABILITY HIGHLIGHT

Modular scale-up of SCATs, a critical asset in shoreline assessment, remediation and mapping, with protocols ensuring consistency of process and data collection

Expansion of the SCAT Program: The response team capitalized on the capabilities of the SCAT program through:

- The development of a new model of centralized organization, with linkages at the top to drive standardized protocols and ensure quality control in the collection of data across a massive theater of operation including four ICPs;
- The modular expansion to 16 SCATs, which assessed approximately 8,000 miles of shoreline, of which approximately 1,700 miles was marsh area. The SCATs, composed of scientists from government agencies and BP, are each led by a qualified academic from a state university;
- The establishment of liaisons and division of labor between SCATs and Rapid Assessment Team (RATs), who are tasked with providing an early warning system for the approach of oil in the near-shore environment, as well as Forensic Rapid Assessment Teams (FRATs) who determine whether potential contamination is actually oil or substances such as sargassum or algae bloom;
- The systematic and detailed management of SCAT survey data in a common NOAA database across the theater of operations; and
- The generation of a cultural/archaeological catalog in coordination with experts including State Historic Preservation Offices (SHPOs) and the National Park Service.

Resulting Capabilities: The response team advanced the work of the SCATs, providing a series of potential benefits that goes beyond future remediation efforts:

- A deep bench of trained experts that can be rapidly re-established and redeployed, if needed to respond to a future spill of any size;
- New protocols ensuring consistency of process and data collection;
- New systems including the FRAT/RAT liaisons and database improvements; and
- Updated mapping of the shape and characteristics of thousands of miles of ever-changing coastline.

Air Surveillance

Tactical surveillance operations to direct water-based responders on a real-time basis from the air.

In this response, aerial surveillance served an expanded role as the critical coordination mechanism for more than 6,000 response vessels, alerting controlled in-situ burn teams to fresh oil and directing skimmers to the right locations. The recognition that "eyes on oil means boats on oil" drove the response team to continuous improvements of its efforts in open-water surveillance – tracking, spotting, recognizing and reporting to water-based teams the presence and location of oil on the water, as well as its nature. In addition, air surveillance served as one of the first responders feeding real-time photos and location data to the COP.

Supplemental multimedia available for this subject: **Response Video 6: Air Surveillance**

Best Practices in Air Surveillance: Surveillance efforts required experienced spotters with the ability to distinguish actual oil on the water from seaweed, shadows or other "spots," to avoid misdirection of resources.

Tracking oil required a large number of sorties night and day to keep up with the rapidly changing location and condition of surface oil. Intercepting the oil required communications equipment that was interoperable between air- and water-based responders.

Response Team Strategy for Air Surveillance: Working with the Coast Guard, NOAA, State Fisheries, the National Geospatial Intelligence Agency (NGIA), the U.S. Air Force, as well as other government resources, and several international and commercial providers of advanced sensing equipment, the response team undertook the following steps:

- Use of a "tactical surveillance" strategy in which surveillance teams directed water-based responders on a real-time basis from the air;
- Nearly 100 sorties on peak days, including night flights using a virtual air-traffic control system, offshore platforms to refuel and rigorous tasking of aircraft;
- The deployment of state-of-the-art imaging and location tools, including the integration and calibration of satellite imagery with multi-spectral and thermal photography, side-looking aerial radar (SLAR), infrared sensing and field observations, to improve the ability to distinguish sheen from skimmable/burnable oil and generate an up-to-date and significantly more accurate operating picture;
- The establishment of common communications linkages between airborne units and vessels and the connection of both to the COP;
- Air de-confliction, scheduling and optimization of daily overflights at Tyndall Air Base;
- The development of detailed taxonomy and training materials on characteristics of oil in open-water in different environments; and
- A team of around 100 experienced and newly trained oil spotters paired with fixed-wing and helicopter pilots.

CAPABILITY HIGHLIGHT

The use of strategic and tactical aerial surveillance, including up to 100 sorties on peak days, to serve not only as eyes of the response, but as directors for open-water and on-shore activities

Resulting Capabilities: Replicable capabilities include:

- A proven method of tactical surveillance to drive speed, accuracy and efficiency in response in
- dispatching vessels;
- The integration of satellite imagery and other technologies with field observations to locate and track oil and distinguish its characteristics;
- A cadre of more than 100 spotters with basic and advanced training on the ability to "know their oil" to assure the right tool is chosen; and
- Advanced flight scheduling, service and prioritization to get and keep more flights in the air.

Prevention

Branch Office Structure

The evolution of the Branch Office Structure exemplifies the concept that "oil spill response is local." Across the Gulf Coast, 19 branch offices were created to greatly expand coordination and planning capability, increase responsiveness, engage local knowledge, increase deployment accuracy, and serve as hub for community outreach. Once established, the branch offices across the Gulf Coast drove all of the near-shore and on-shore response activities and often effectively engaged local stakeholders in the response.

Supplemental multimedia available for this subject:
Response Video 7: Branch Offices in Action

Prior Practice on Branch Office Structure: To grow scale in the first month of the incident, the entire Gulf response was divided into four ICPs in addition to the Houston ICP for source control, with largely centrally allocated resources. During this growth phase, assets including vessels, planes and personnel were controlled and allocated at the ICP level.

The Evolution of the Branch Office Structure: The response team made the activation and empowerment of a strong Branch Office Structure a top priority through:

- The establishment of 19 branch offices with staff sizes varying from 35 to around 2,300, as well as access to experts, equipment and supplies;
- The clear mission and authority to oversee activities relating to a specific stretch of local coastline in accordance with the overall ICP strategic direction. Branch office directors implemented decisions regarding assets under their control; and
- The mandate to engage with state and local agencies and officials, responding to their concerns and giving them a voice in the process.

Resulting Capabilities: The establishment, empowerment and resourcing of branch offices will help ensure the effectiveness of response in a number of ways:

- Rapid and effective near-shore response capability through strong operating leadership at the local level;
- Direct involvement in response, better access and greater understanding of strategies and priorities on the part of state and local officials;
- The tapping of local knowledge and the delegation of necessary authority to the community level where it is often most effective in solving and providing early warning of problems; and
- Greater accountability for execution in solving problems, addressing local concerns and protecting coastlines.

A briefing in a branch office. Nineteen branch offices established across the Gulf Coast drove all of the near-shore and on-shore response activities and often effectively engaged local stakeholders.

CAPABILITY HIGHLIGHT

A system of branch offices, reflecting the insight that "all oil spill response is local," with the clear mission, authority and dedicated resources to protect local coastlines

The establishment of branch offices provided rapid and effective near-shore response capability through strong operating leadership at the local level.

Open-Water Skimming

While skimming oil from water had been tried and tested through other responses, the scale and duration of this response, along with the frequently dynamic and variable nature of oil characteristics, proved a new challenge for skimming. This challenge drove significant improvements to skimming equipment, along with new approaches to organization, maintenance, and deployment of skimmers.

Supplemental multimedia available for this subject: **Response Video 8: Open Water Skimming**

Existing Practice in Open-Water Skimming: Skimming fleets are staged along coastline across the United States. For this spill, all Gulf Coast skimming assets were immediately deployed to skim oil. Due to the need for change-out of crews, repair, refueling and resupply, the longest continuous runtime in previous spills had lasted 14 days. One long-standing challenge to skimming is that hydrocarbons are encountered in various states: oil can be significantly weathered or emulsified, degraded and found in dense or grease-like mats.

Improvements in Open-Water Skimming to Respond to the Deepwater Horizon Incident: The response team took actions including:

- A skimming capacity of more than 1.2 million barrels per day* – the largest such capacity in history;
- Deployment of more than 60 open-water skimmers at the peak of the response through retrofit of existing vessels and international cooperation. This deployment included twelve responder class vessels on-site by day five, as well as a number of vessels provided by the Coast Guard;
- An innovative "command and control" system that combined air intel with an on-water director coordinating all skimming traffic centrally for optimal placement of vessels;
- The deployment of four "Big Gulp" skimmers, based on an innovation by a barge owner who retrofitted his own vessel to handle emulsified oil and sea grass;
- The development of an innovative 72-hour "pit stop" for skimmers extending runtime to more than 100 days; and
- New techniques to improve the efficiency of skimming operations in deepwater, including enhanced booming, centrifuge separation of fluid on skimming vessels and barges, and the deployment of the TransRec 150 on a 280 foot Platform Support Vessel (PSV), a new generation skimmer from Norway.

* Capacity computed as "estimated daily response capacity" according to Coast Guard and BOEMRE regulations.

CAPABILITY HIGHLIGHT

New, highly scalable skimming technology, maintenance and deployment systems that enabled the largest skimming response in history

Response Capabilities: Response operations for spills of any size in the future can be based on:

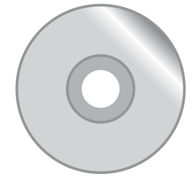
- New capability to convert offshore and platform supply vessels to skimmers; and
- An expanded network of skimming experts and experienced crews.

Supplemental multimedia available for this subject: **Skimming Overview**

At the peak of the response more than 60 open-water skimmers were deployed within an innovative "command and control" system which combined air intel with on-water, central coordination of skimming traffic for optimal vessel placement.

Controlled In-Situ Burning

Through this response, controlled in-situ burning has undergone a step change from a conceptually tested approach to a proven and mission-critical method for removing oil from open-water. Techniques, understanding of burn criteria, preservation of specialized fireboom, and the base of experts have all been significantly augmented through the experiences gained in this response.



Supplemental multimedia available for this subject:
Response Video 9: Controlled In-Situ Burning

Existing Practice in Controlled In-Situ Burning: Prior to the Deepwater Horizon incident, controlled in-situ burning of spilled oil had occurred only once in open U.S. waters – one burn conducted in Prince William Sound during the Exxon Valdez incident.

A controlled in-situ burn in open water. Controlled in-situ burning of spilled oil, which had occurred only once in U.S. waters, was elevated to one of the most effective means of removing oil during the response.

Advances by the Response Team in the Use of Controlled In-Situ Burning: With the assistance of the foremost experts on controlled in-situ burning and the full cooperation of government authorities, the response team established a new standard for the use of the practice:

- Performed 411 controlled burns, the longest lasting nearly 12 hours, remediating an estimated 265,000 barrels of oil;
- Trained and deployed 10 teams and increased the number of qualified experts from fewer than ten to more than 50;
- Drove improvements in fireboom technology, including water-cooled and reusable booms;
- Designed new techniques to contain, control, and direct burns and a "dynamic burn" process that allows continuous feeding of the ongoing burn with new oil to increase controlled in-situ burn length;
- Developed and deployed a new manual ignition technique;
- Created new safety techniques, including the use of colored tarps for aerial identification of controlled burn-capable vessels; and
- Identified factors for determining the appropriateness of controlled in-situ burning.

CAPABILITY HIGHLIGHT

Demonstration of controlled in-situ burning as a fully proven technique for oil recovery, featuring advanced methodology, equipment and a standing expert base

Resulting Capabilities: As a result of the response team's efforts, controlled in-situ burning is now an established methodology in the response toolkit with:

- New techniques, technology, protocols and procedures increasing the availability, effectiveness and safety of controlled in-situ burning as a means of dealing with spills in the open-water;
- A corps of trained and catalogued operators and experts; and
- A remaining inventory of existing and field-tested fireboom, as well as a significantly enhanced supply chain capable of expanding production to deliver the 23,000 feet of total fireboom deployed.

A number of techniques developed during the response, including dynamic burning and vectoring, allowed teams to control the direction of burns, extend the length of burns, and conduct multiple burns at the same time.

Aerial Dispersants

The application of dispersants under the direction of Unified Command at the subsea source and in the open water may have been the most effective and fastest-mobilized tool for minimizing shoreline impact. Multidisciplinary global expertise was mobilized to drive success in a very complex operation.

Existing Practice with Dispersants: The use of dispersants in open water has been conducted since the 1990s under strict protocols and is backed by solid science. In the initial stages of the Deepwater Horizon spill response, dispersants were a primary response method and were sprayed on the surface waters from aircraft.

A plane targets dispersant to break up oil before it reaches shore. The response team increased the effectiveness of dispersant application through process and supply chain improvements, the use of imaging and other technologies, and the establishment of sampling and monitoring programs.

Supplemental multimedia available for this subject: **Response Video 10: Dispersants**

CAPABILITY HIGHLIGHT

Precise and effective application of dispersants driven by advanced surveillance technology and operational streamlining supported by a network of global experts

The Response Team's Efforts with Dispersants: Working under the guidance of the EPA and with the direct approval of the Coast Guard Federal On-Scene Coordinator, the response team increased the effectiveness of dispersant application through:

- The aerial application of dispersant in approximately 400 sorties, initiating use within two days of the spill;
- Process improvements to optimize the number and targeting of sorties;
- The use of imaging and other technologies involving trained spotters to increase the precision of and to minimize the volume of dispersant applications;
- Improvements in the supply chain to increase the availability of Corexit dispersant to ensure that operations were never constrained by supply; and
- The establishment of detailed sampling and monitoring programs by the responsible government agencies and BP.

EPA has to date performed two rounds of important studies of the dispersants used in the Deepwater Horizon response. Those studies have demonstrated that overall, dispersants have greater benefits for the environment in responding to a spill than potential risks. BP is supporting additional studies of this issue.

Resulting Capabilities: The improved targeting and evidence-based use of dispersants offer strong benefits to future response efforts:

- Success in minimizing the amount of oil on the surface;
- Optimal processes for aerial application of dispersants;
- The opportunity for ongoing improvement in tests to demonstrate safety and effectiveness, as well as for public education about the benefits of dispersant use;
- Supply chain capacity to ensure adequate supply of the most effective dispersant; and
- Close collaboration with a network of experts on dispersant use and assessment.

Booming

The Deepwater Horizon response has included the largest deployment of boom in the history of spill response – to date, the response has mobilized more than 14 million feet and deployed approximately 4.2 million feet of containment boom and approximately 9.1 million feet of sorbent boom. While booming is one of the most high-profile methods for protecting shorelines, its application is often misunderstood.

Booming can be effective when applied through well-established and tested strategies that:

- Account for current, wind, sea state and shoreline type;
- Acknowledge that natural forces will significantly detract from the effectiveness of boom; and
- Reflect the fact that in many situations, other tactics can provide better protection of the shoreline.

Prior Booming Practice: Boom comes in different types and widely varying commercial quality. Containment boom is used to block or contain oil slicks, while sorbent boom is selectively permeable so that it absorbs oil and not water. These types of booms are often used in combination, especially to protect critical ecosystems such as rookeries.

As part of the 24/7 response operation, workers load boom onto a vessel for deployment.

Supplemental multimedia available for this subject: **Response Video 11: Booming**

CAPABILITY HIGHLIGHT

The largest mobilization of boom in any oil spill response – a total of more than 14 million feet – and significant expansion of the supply chain and of the number of experts

The Response Team's Activities in Boom Deployment: The Deepwater Horizon spill response team, cooperating with government officials at all levels as well as environmental experts, worked to maximize the use of boom to keep oil out of sensitive ecosystems while ensuring that the nature and location of application was appropriate.
Its actions included:

- Deployment of approximately 4.2 million feet of containment boom and 9.1 million feet of sorbent boom;
- Cooperation with environmental and wildlife experts to optimize the use of boom to protect sensitive areas such as rookeries;
- Efforts to inform officials, agencies and stakeholders on the optimal application of boom in specific circumstances;
- Utilization of VOO resources to deploy, tend, and maintain boom; and
- In-field repair facilities to allow re-use of damaged boom.

Resulting Capabilities: The team's efforts in boom deployment offer the following opportunities for the future:

- Advanced procedures and protocols for boom deployment;
- Working relationships with wildlife and environmental experts focused around optimizing the use of boom to protect sensitive areas and species;
- Advance discussion with officials and the general public on boom-deployment strategies; and
- VOO engagement in deployment and maintenance.

A vessel deploys boom. The response team cooperated with government officials and environmental experts to maximize the use of boom while ensuring appropriate placement and application.

Clean-Up

Marsh Cleaning

The marsh cleaning operation is systematically deploying trained teams across the Gulf Coast employing a best-practice, "small-scale" approach on a larger scale. The response to marsh cleaning has been carefully managed by Unified Command (including NOAA) and will continue.

Best Practice for Marsh Cleaning: Marsh cleaning is normally deployed on a small scale, using techniques established that complement the natural remediation process while protecting fragile marsh ecosystems. These best-practice response strategies had not been adapted previously for marsh cleaning of this magnitude.

Supplemental multimedia available for this subject: **Response Video 12: Marsh Cleaning**

Layers of boom protect a marsh. Teams of 16 to 20 responders made up the more than 2,500 person marsh cleaning operation, which used proven techniques for effective and non-invasive remediation.

CAPABILITY HIGHLIGHT

Successful, modular expansion of "small-scale," minimally invasive clean-up techniques harnessing the natural remediation of marsh with the capability to deploy responders to remote locations with limited infrastructure

Advances by the Response Team on Marsh Cleaning: Marsh-cleaning teams employed an array of proven techniques enhanced by new equipment, tools and logistical processes, including:

- The recognition that a "small-spill" approach applied at scale while complementing and accelerating the natural remediation properties of marshes can lead to an effective outcome;
- The rapid and efficient ramp-up of a marsh-cleaning operation of more than 2,500 workers through the development of modular task forces made up of 16 to 20 responders;
- The deployment of new tools such as concrete-pumping arms, used to inject water deep into marshes to accelerate natural flushing of oil;
- The development of tactics to address the logistical challenges of deploying clean-up workers to isolated sites across a large area, for example the use of shallow water barge "floatels" to house responders close to the clean-up site; and
- The engagement of local knowledge through the VOO program which improved maneuverability in the shallow marsh waters and reduced unintended damage.

Resulting Capabilities: Capabilities developed through marsh-cleaning operations available for future response include:

- Structures and protocols to scale marsh-response teams efficiently and effectively on a modular basis;
- Systems to simultaneously deploy responders to facilitate clean-up work in remote, disparate locations in difficult conditions with limited existing infrastructure;
- New tools and techniques adapted for effective and non-invasive clean-up that harness the natural remediation capabilities of the marsh; and
- Boom deployment and removal strategies for marsh areas that maximize clean-up and minimize risk of damage.

Beach Cleaning

The response team has directed extensive resources toward keeping oil off the beaches, and, where oil has appeared, toward rapidly and effectively cleaning them. To minimize intrusion, the response has emphasized close cooperation with the most affected communities.

Supplemental multimedia available for this subject: **Response Video 13: Beach Cleaning**

Prior Practice in Beach Cleaning: Because of the continual effect of tides on the sand, failure to reach oil on the beach before the next tide cycle can lead to deposits becoming buried below the surface. Rapid beach cleaning has therefore always been a top priority. On the other hand, large-scale beach-cleaning operations can also have an intrusive, disconcerting effect on beachgoers and the general public.

Response Team Advancements in Beach Cleaning: The response team has taken steps that have advanced the methodology of beach cleaning while reducing intrusion:

- The introduction of nighttime shifts to reduce intrusion for beachgoers, reduce heat stress on workers and increase effectiveness;
- The training of more than 11,000 qualified community responders;
- Organization and equipping of beach-cleaning crews to minimize the footprint on the beach and focus on removing oil before the next tide cycle;
- Assessment and adaption of mechanical equipment previously used to condition and clean beaches of rocks, sea grass and other debris, applying new attachments and procedures to allow deeper and faster cleaning of oiled shoreline;
- Evolution of these transitional techniques, using continuous-improvement methodology, into the "Sand Shark" fit-for-purpose mechanical beach-cleaning vehicle, which digs deeper and "lifts and sifts" sand to remove oil while minimizing sand removal; and
- Protocols to determine when and how to remove oil from beaches and to manage resulting waste.

CAPABILITY HIGHLIGHT

New turnkey approaches to beach cleaning employing advanced technology, sensitivity to the public, close cooperation with communities and a pool of trained community responders

Resulting Capabilities: The beach-cleaning aspect of the spill response has created new turnkey capabilities that can be deployed in response to a spill of any size:

- Increased strategic focus on removing oil with a single tide cycle, providing the right tool for the right problem and coordinating with local officials;
- Five "Sand Shark" machines;
- Oil-removal and waste-management protocols for a range of operating conditions;
- Organizational structure and control-of-work methods to maximize impact of beach cleaning teams; and
- A pool of trained community responders.

A Sand Shark developed specifically for the beach clean-up effort, using continuous improvement methodology, allowed deeper digging to capture oil below the surface.

4

Key Lessons From the Deepwater Horizon Response

The Deepwater Horizon spill response has driven large capability improvements for our industry as a whole. These new capabilities can be an integral part of an improved planning and response regime for industry, government and responders.

We believe the new capabilities built over the course of these last four months, and laid out in the two previous sections, reflect five broader lessons from the Deepwater Horizon response:

Lesson 1: Collaboration

A broad range of stakeholders has come together in the wake of Deepwater Horizon to provide effective solutions and build new capabilities.

It would have been difficult for any one company to address the challenges resulting from Deepwater Horizon alone. The response has benefited from close collaboration with -- and the capabilities of -- the U.S. Coast Guard, BOEMRE, and dozens of other partners and stakeholders from government, industry, academia and the affected communities, as well as around the globe.

At its peak, this collaboration brought together:

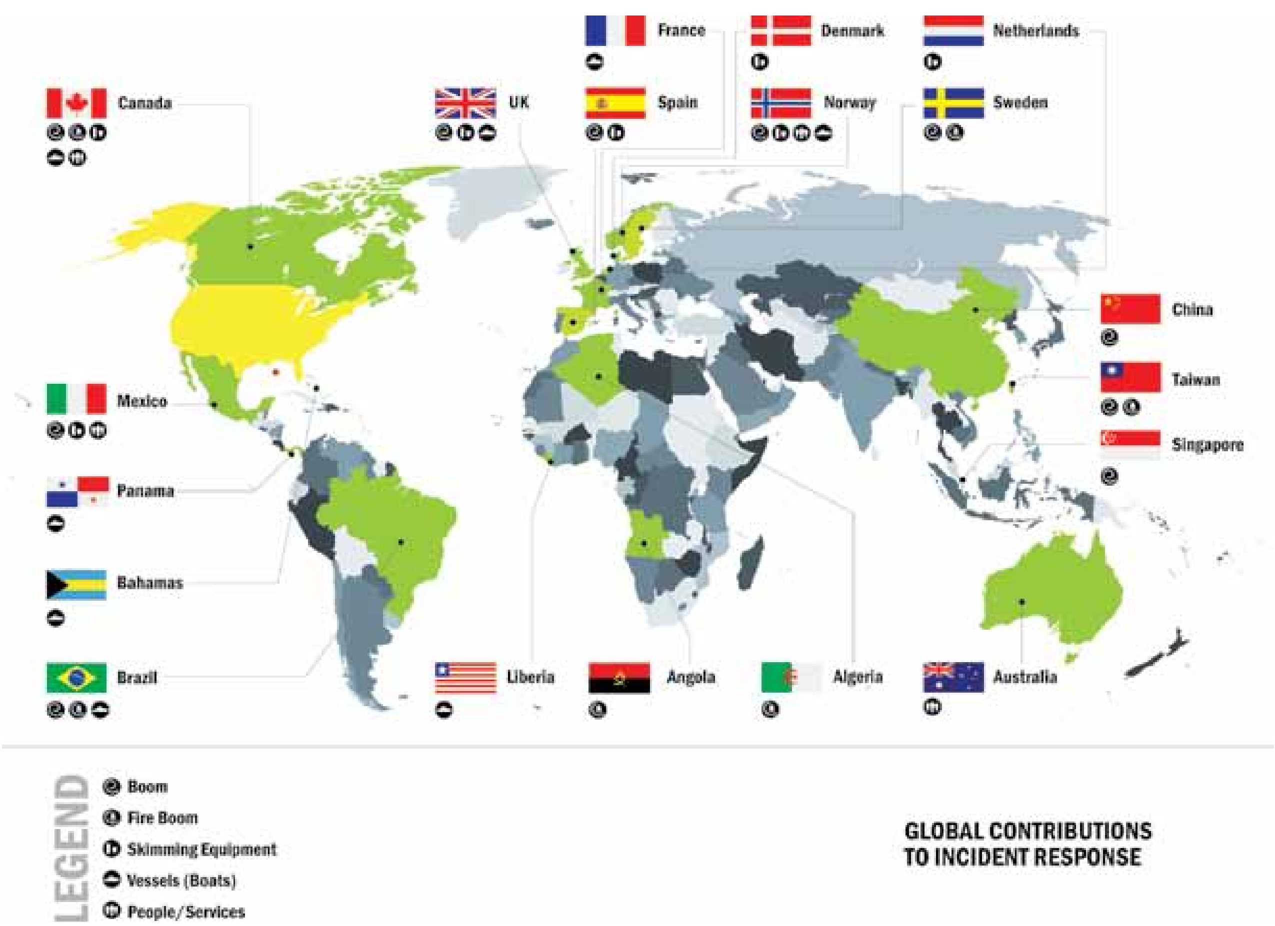
- More than 47,800 responders;
- Dozens of federal, state and local agencies;
- Eight exploration and production operators;
- Hundreds of industry suppliers;
- More than 6,000 marine vessels, including approximately 5,800 VOOs;
- Six deepwater drilling vessels;
- Two FPSOs;
- 150 aircraft; and
- Partners and governments from no fewer than 19 countries…

…all working through five ICPs and 19 Branch Offices

Many of the participants in this response diverted efforts from other tasks to join or direct resources to the subsea and surface response efforts. Moreover, the collaboration was illustrated by the willingness of industry peers not only to supply equipment but also to release suppliers and vendors to participate fully in the effort by accommodating BP requests for equipment, support and materials above their own.

As a result of this extensive collaboration, the industry and the nation as a whole now have these capabilities available:

- Greater familiarity and strengthened relationships among industry, government and responders;
- A network of seasoned experts and support personnel drawn from around the world; as well as
- An expanded and proven roster of suppliers and vendors with specific capabilities.



The response benefited from close collaboration among the Coast Guard, BOEMRE, and dozens of other partners and stakeholders from government, industry and the affected communities, and at least 19 countries around the world.

Lesson 2: Systemization

The response has required the development of extensive systems, procedures and organizational capabilities to adapt to changing and unique conditions.

As the Deepwater Horizon spill continued despite efforts at the wellhead, the response effort also progressed, expanded, and took on not just new tasks and directions but new personnel and resources.

As a result, from source to shore, existing systems were evolved and expanded and new ones developed to advance work flow, improve coordination, focus efforts and manage risks.

The value of these systems was underscored by the ability of a large containment team to operate efficiently in close quarters, to coordinate on an ongoing basis from an offshore base, and ultimately to succeed in containing and capping the well.

Some of these new, modified or expanded systems have included:

- The expanded use of visual 4D planning for complex surface and subsea operations. Storyboarding of each aspect of positioning, construction and interventions allowed the maximum number of potential tasks to be completed in extremely close proximity, greatly mitigated risks, and increased the likelihood of success in interventions;
- The adaptation of the HIVE into a single point of management for all ROVs deployed at the containment site;
- The standing up or expansion of purpose-built organizations in disciplines such as near-source containment, relief wells, long-term containment and disposal and SIMOPS, with streamlined processes for decision-making and action;
- An offshore SIMOPS director position, staffed 24/7 to oversee and safely coordinate the movements of highly complex operations; and
- The rigorous and detailed integrated planning across multiple parallel activities and sites, which has been practiced continuously for every day of the response, engaging all levels within the response hierarchy.

The response effort in open water, near shore and onshore also evolved new systems, protocols and organizational capabilities. The length of the spill required a continuous scaling of the effort and the development of systems and protocols for qualifying and training responders, optimally organizing work flow and increasing the efficiency and effectiveness of operations. Systems introduced, adapted or built out in the course of the response included:

- The Branch Office Structure within the ICPs, designed to delegate appropriate authority to the local level for greater effectiveness;
- The use of modular structures deploying small, well-organized units to a range of locations instead of simply expanding existing teams, allowing efficient scaling of operations;

- The VOO program, qualifying a trained force with structure and protocols for integration, command and deployment;
- Enhanced work flows, systems and protocols for air surveillance; and
- Improved supply-chain management to anticipate needs, step up production and ensure timely delivery of high-quality and fit-for-purpose materials and equipment such as dispersant; fire, containment and ocean boom; and skimmers that are not conventionally produced in the large quantities required for a spill response of this nature.

As the spill extended in length, another system vitally needed in both containment and response was a strategic-planning function within the ICS Planning Section with dedicated resources connected to the ongoing operations but focused on addressing a range of developing scenarios over the longer term. Critical issues addressed by the strategic planning team included:

- The building-in of multiple levels of contingency for containment operations by dedicated teams;
- "Trigger-point" geographic response plans to coordinate and prioritize resources as operational conditions require (e.g., oil reaching a certain distance from shore);
- Severe weather plans to protect people, equipment, shorelines and sensitive areas while minimizing disruption to operations, including demobilization and re-mobilization priorities and procedures (*e.g.,* essential/nonessential staff, VOOs, staging, surveillance and boom removal and redeployment); and
- Critical resourcing to keep necessary functions fully staffed on an ongoing basis while arranging appropriate relief.

The adoption of these systems will ensure the ability to respond more rapidly at scale with a clear direction as to personnel, resource and organizational needs. The new capabilities upon which future containment efforts may be able to call include:

- Next generations of existing crisis and contingency plans building on the know-how, equipment and systems developed in the Deepwater Horizon response;
- Organizational charts and procedures accelerating the stand up of dedicated teams in key disciplines;
- The development of enhanced decision trees and protocols for future spill responses;
- Streamlined processes for completing hundreds of tasks; and
- New lessons in the risk management of complex interventions and responses.

Lesson 3: Information

Timely, reliable information has been essential across both the containment and response operations to achieve better decision-making, ensure safe operations and inform stakeholders and the public.

Reliable information is indispensable in managing any crisis but especially amid the far-reaching challenges, relentless pressures and often hazardous conditions confronting spill response. The Deepwater Horizon responders were able to take advantage of cutting-edge tools to manage information-sharing inside Unified Command and externally, to improve decision-making and to coordinate complex activities across response and containment, such as simultaneous operations.

State-of-the-Art Information Tools: The countless uses of state-of-the-art information capabilities to make smarter decisions and enable safe, effective response include the following:

- Among the most important information in addressing the spill was to "know your oil." Teams both at the source and in the field were trained to understand the characteristics of surface oil – which could range from thick sludge to thin sheens – and its rapid movement in ocean current and flows so that they could distinguish the type of oil and direct appropriate responses;

- The HIVE was retrofitted with 12 monitors connected to high definition cameras, with real-time video logging allowing instantaneous comparisons of current to previous footage. ROV operators were connected to the HIVE by a open communications system;

- The deployment of a range of information tools in SIMOPS included novel applications of the relatively new AIS, providing a shared, ongoing visualization of vessel positioning and headings;

- Multiple tiers of redundancy for communications via satellite connections, maintained regardless of weather conditions and proximity, as well as shortwave communications for vessel-to-vessel and field-to-shore connections, depending on the need, proved necessary across a range of containment efforts;

- The COP deployed state-of-the-art information technology to deliver instant visualization of oil movement and characterization, as well as response activities from the open-water to the shoreline, to all leaders and responders via their PCs or PDAs;

- The development of common communications tools was also vital to allow air surveillance teams to remain in contact with on-water skimmers, boom teams and controlled in-situ burning operations and put "boats on oil;" and

- The Alternative Response Technology (ART) team screened more than 120,000 ideas for new containment and response technologies, techniques and approaches from individuals and experts around the world.

Scale-up of Scientific Capability: Another valuable information component of the overall response was the rapid scale-up in scientific capability. For the Deepwater Horizon spill, the response team pulled together experts from disciplines such as geochemistry, industrial hygiene, water sampling, air sampling, reservoir monitoring, ecology, environmental science, hydrogeology, flow assurance, process safety, toxicology, zoology, ornithology and geophysics. This wide net provided the intellectual edge needed for an effective response.

A Focus on Dialogue: Finally, participants across both theaters have recognized the importance of keeping our partners in government at all levels informed along with, our many stakeholders, and the general public, on our strategies and on the progress of our efforts.

The Deepwater Horizon response was the first to encounter the combination of multiple, highly competitive cable news outlets with the broadband Internet and a web of specialized websites, blogs and other social media. The resulting 24/7 coverage of a spill of this magnitude and duration has naturally engendered an unprecedented level of concern.

To address this challenge, the response team has employed a range of communications efforts. Unified Command has encouraged many initiatives, including the following:

- Media access to ongoing response efforts, at the source and on the shore, and daily briefings to keep the public informed on progress;

- The extensive use of graphics and animations to illustrate the complex actions needed to respond to the Deepwater Horizon incident;

- Ongoing postings of statistics on matters relating to all aspects of the spill response -- from wildlife to water column sampling to air quality – on the BP website, which has experienced millions of visits;

- The development of structures for information, such as the requirement that branch directors do their best to provide information to local communities; and

- Support for the ART program to obtain public feedback on way to try to improve the spill response.

Going forward, responders will be able to benefit from all these efforts to address the concerns of the public and the need to communicate the facts as quickly as possible.

Lesson 4: Innovation

The urgency in containing the spill and dealing with its effects has driven innovation in technology, tools, equipment, processes and know-how.

The concentration of talent, compressed timeframes for effective solutions, and the need to achieve results quickly at scale without compromising standards for safety and risk management made the Deepwater Horizon response a natural laboratory for innovation both in technology and systems.

The result has been a series of developments, ranging from incremental enhancements to step changes in technologies and techniques, that have advanced the state of the art and laid the foundation for future refinements as part of an enhanced regime for any type of source-to-shore response.

As laid out in more detail in the previous two sections, these innovations cover areas including:

Innovations in Equipment:

- Open and closed containment
- Subsea hydraulic distribution and Tools for ROVs
- Hydrate mitigation
- Acoustic telemetry
- Information technology
- Multipurpose vessels
- Ranging technologies
- FPSOs and riser systems
- Subsea dispersant injection
- Surveillance communications and data management
- Skimmer technology
- Boom technology
- Controlled in-situ burning technology
- Beach-cleaning technology
- Marsh-cleaning technology

Innovations in systems, process and procedure:

- System integration tests
- Diagnostic pressure measurements
- Removal of damaged risers
- Closed system construction
- Redundant systems
- 4D planning
- Storyboarding
- Marine SIMOPS
- Visualization tools for marine ops
- Flaring
- Diagnostics and measurement
- Dynamic positioning
- Containment disposition
- Emergency disconnect/hurricane evacuation
- Dispersant management and testing
- Supply chain management
- Controlled in-situ burning
- Skimming
- Booming
- Branch Structure
- VOC risk management
- Offtake operations
- Relief well operations
- Kill strategy
- Ranging
- ROV SIMOPS (HIVE)
- Beach cleanup
- Wildlife protection/rescue
- Marsh management
- VOO command structure
- Offshore construction
- Shore cleanup

Organizational Schemes

- Near source containment
- Relief wells
- Containment disposal
- SIMOPS
- Branch office organization
- Strategic planning

These innovations are available for further refinement, advancement and institutionalization to save time and effort in standup and advance rapid resolution of any future incidents that should occur.

Mobilizing for the Future

5

As this document has presented in words and pictures, the largest spill response in history has resulted in extensive new capabilities that could represent an important mobilization platform. These new capabilities track the learnings laid out in the previous section:

- ***New and strengthened <u>collaborative</u> relationships*** spanning government, industry and a range of stakeholders, from around the globe, as well as a ***greatly expanded cadre of trained and highly motivated experts and responders;***

- ***Advanced <u>systems</u>, processes, protocols, procedures and organizational capabilities*** that can significantly reduce the time and accelerate the effectiveness of any response;

- ***Novel applications of state-of-the-art <u>information</u> tools and techniques*** that can improve decision-making, increase safety and reduce risk, enhance the speed and effectiveness of response and advance understanding of spills and appropriate countermeasures on the part of leaders, stakeholders, communities and the public; and

- ***<u>Innovations</u> in the form of both incremental advances and step changes in technology and techniques,*** spanning containment and response.

Moreover, seen from a broader perspective, the containment and response teams also demonstrated three fundamental capabilities on behalf of the industry:

- To contain oil flow in deep water, using technologies and skills acquired during the intense period of the containment effort from the time of the incident on the rig until the flow was stopped;

- To track and address oil in several locations on the open water of the Gulf and near shore; and

- To respond onshore to the equivalent of simultaneous local spills.

BP is determined to maintain and strengthen these new capabilities – and supports BOEMRE actions in that direction.

Accordingly, we are already taking a number of steps to help advance the process of sustaining and expanding the capabilities from the spill response.

We are sharing our lessons, experiences and advancements through various industry mechanisms, and we are looking forward to making response leaders and experts available for additional activities in this regard.

More important, we are working through efforts such as this report to build collaboration within Unified Command led by the U.S. Coast Guard, with full participation, by BOEMRE, and other members of the government response team.

The work of Unified Command has expanded industry capabilities and know-how to bring the current crisis closer to resolution and lay the groundwork for new approaches.

All of us at BP are deeply grateful for BOEMRE support in the Deepwater Horizon response and the opportunity to present this report. We would like to expand upon this dialogue and fully capitalize on the unique opportunity to build on the lessons from Deepwater Horizon and together, lead further advances in the state of the art of spill response.

Appendix

ACP	Area Contingency Plan
AIS	Automatic Identification Software
ART	Alternative Response Technology
AUV	Autonomous Underwater Vehicle
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BOP	Blowout Preventer
CDP	Long Term Containment Disposal Project
COP	Common Operating Picture
DARPS	Differential Absolute and Relative Positioning Sensor
DDII	Development Driller II
DDIII	Development Driller III
DP	Dynamically Positioned
EPA	United States Environmental Protection Agency
ERMA	Environmental Response Management Application®
FPSO	Floating Production, Storage and Offloading Unit
FRAT	Forensic Rapid Assessment Team
GIS	Geographic Information System
HIVE	Highly Immersive Visual Environment
ICP	Incident Command Post
JAG	Deepwater Horizon Joint Analysis Group
LEL	Lower Explosive Limit
LMRP	Lower Marine Riser Package
NGIA	National Geospatial Intelligence Agency
NOAA	National Oceanographic and Atmospheric Administration
OSHA	Occupational Safety and Health Administration
PSV	Platform Support Vessel
RAT	Rapid Assessment Team
RITT	Riser Insertion Tube Tool
ROV	Remotely Operated Vehicle
SADI	Subsea Autonomous Dispersant Injection
SCAT	Shoreline Clean-up Assessment Teams
SHPO	State Historic Preservation Office
SIMOPS	Simultaneous Operations
SINTEF	Foundation for Scientific and Industrial Research, Norwegian Institute of Technology
SLAR	Side-Looking Airborne Radar
STR	Shoreline Treatment Recommendations
USGS	United States Geological Survey
VOC	Volatile Organic Compound
VOO	Vessel of Opportunity

Supplemental Multimedia DVD Contents

Hydro-Static Kill

Skimming Overview

Top Hat Installation

Relief Well and Ranging

ROV Video 1: Subsea Staging Area

ROV Video 2: Successful 1st cut of Riser

ROV Video 3: Riser Cutting above BOP - Diamond Blade Cutter

ROV Video 4: LMRP Cap Removal

ROV Video 5: BOP to Choke Manifold Connections

ROV Video 6: Bolt and Flange Removal

ROV Video 7: Transition Spool Installation

ROV Video 8: Capping Stack Installation

Response Video 1: Response Overview

Response Video 2: ICPs at Work

Response Video 3: Wildlife

Response Video 4: Vessels of Opportunity

Response Video 5: SCAT in Action

Response Video 6: Air Surveillance

Response Video 7: Branch Offices in Action

Response Video 8: Open-Water Skimming

Response Video 9: Controlled In-Situ Burning

Response Video 10: Dispersants

Response Video 11: Booming

Response Video 12: Marsh Cleaning

Response Video 13: Beach Cleaning

Credits

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