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This month's issue of *The CIP Report* features the Oil and Natural Gas Sector, an integral component and subsector of the Energy Sector. Specifically, in the wake of the BP *Deepwater Horizon* oil spill last year and the recent earthquake and tsunami in Japan, this issue examines the innovation and protection of oil and natural gas critical infrastructure.

First, representatives from the Lawrence Livermore National Laboratory (LLNL) reveal its efforts to assess the vulnerabilities, risks, and consequences of damage to critical infrastructure in the Oil and Natural Gas Sector. The President of Business Development and Innovation at Rutter Technologies details the capabilities of Rutter Technologies' Sigma S6 Radar Technology to detect offshore oil spills. Then, the Director for Maritime Security Issues at the U.S. Government Accountability Office (GAO) analyzes the maritime dimension of oil and gas critical infrastructure. Next, the Chief of Naval Operations Energy and Environmental Readiness Division highlights its alternative fuel-powered riverine boat, the Riverine Command Boat — Experimental (RCB-X). Finally, a Petroleum Geologist discusses the potential reservoirs for significant gas reserves in the Marcellus Shale in West Virginia.

This month's *Legal Insights* examines the laws and organizations pertinent to the oil and natural gas industry, including the Jones Act, the Oil Pollution Act of 1990, and the Minerals Management Service (MMS).

We would like to take this opportunity to thank the contributors of this month's issue. We truly appreciate your valuable insight.

We hope you enjoy this issue of *The CIP Report* and find it useful and informative. Thank you for your support and feedback.

Mick Kicklighter
Director, CIP/HS
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Assessing the Vulnerabilities, Risks, and Consequences of Damage to Critical Infrastructure

by Nancy Suski, Lawrence Livermore National Laboratory, and
Craig Wuest, Lawrence Livermore National Laboratory

Since the publication of *Critical Foundations: Protecting America's Infrastructure*, there has been a keen understanding of the complexity, interdependencies, and shared responsibility required to protect the Nation's most critical assets essential to our way of life. The original five Sectors defined in 1997 have grown to 18 Critical Infrastructure and Key Resources (CIKR), which are discussed in the 2009 *National Infrastructure Protection Plan* (NIPP) and its supporting Sector-Specific Plans. The NIPP provides the structure for a national program dedicated to enhanced protection and resilience of the Nation's infrastructure.

Lawrence Livermore National Laboratory (LLNL) provides in-depth, multi-disciplinary assessments of threat, vulnerability, and consequence across all 18 Sectors at scales ranging from specific facilities to infrastructures spanning multi-State regions, such as the Oil and Natural Gas (ONG) Sector. Like many of the CIKR Sectors, the ONG Sector is comprised of production, processing, distribution, and storage of highly valuable and potentially dangerous commodities. Furthermore, there are significant interdependencies with other Sectors, including Transportation, Communications, Banking and Finance, and Government Facilities. Understanding the potentially devastating consequences and collateral damage resulting from a terrorist attack or natural event is an important element of LLNL's infrastructure security programs.

Our work began in the Energy Sector in the late 1990s and quickly expanded to other CIKR Sectors. We have performed over 600 physical assessments with a particular emphasis on those Sectors that utilize, store, or ship potentially hazardous materials and for whom cybersecurity is important. The success of our approach is based on building awareness of vulnerabilities and risks and working directly with industry partners to collectively advance infrastructure protection.

This approach consists of three phases:

The *Pre-Assessment Phase* brings together infrastructure owners and operators to identify critical assets and help the team create a structured information request. During this phase, we gain information about the critical assets from those who are most familiar with operations and interdependencies, making the time we spend on the ground conducting the assessment much more productive and enabling the team to make actionable recommendations.

The *Assessment Phase* analyzes ten areas: threat environment, cyber architecture, cyber penetration, physical security, physical penetration, operations security, policies and procedures, interdependencies, consequence analysis, and risk characterization. Each of these individual tasks uses direct and indirect data collection, site inspections, and structured and facilitated workshops to gather data. Due to the importance of understanding the cyber threat, LLNL has built both fixed and mobile cyber penetration, wireless penetration, and supporting tools that can be tailored to fit customer needs.

The *Post-Assessment Phase* brings vulnerability and risk assessments to the customer in a format that facilitates implementation of mitigation options. Often the assessment findings and recommendations are briefed and discussed with several levels of management and, if appropriate, across jurisdictional boundaries. The end result is enhanced awareness and informed protective measures.

(Continued on Page 3)

Vulnerabilities *(Cont. from 2)*

Over the last 15 years, we have continued to refine our methodology and capture lessons learned and best practices. The resulting risk and decision framework thus takes into consideration real-world constraints, including regulatory, operational, and economic realities.

In addition to "on the ground" assessments focused on mitigating vulnerabilities, we have integrated our computational and atmospheric dispersion capability with easy-to-use geo-referenced visualization tools to support emergency planning and response operations. LLNL is home to the National Atmospheric Release Advisory Center (NARAC), which serves as the operations hub for the Interagency Modeling and Atmospheric Assessment Center (IMAAC). NARAC/IMAAC has capabilities to respond to toxic industrial chemical spills, nuclear-power plant accidents, fires, chemical/biological agents, radiological/nuclear devices (RDDs, INDs), and other airborne hazards.

Our web-based capabilities provide hazards assessments of critical infrastructure for defensive planning and can provide infrastructure operators and emergency responders with a baseline for planning and exercises. LLNL's infrastructure security web mapping services facilitate dissemination of technical information for all phases of disaster management. Examples of some of these products available through the NARAC/IMAAC are shown in Figure 1.

Examples of assessments performed, under the auspices of the California National Guard, include several petroleum refineries, a strategic assessment of the California petroleum pipeline system, the West Coast Maritime System, and the California Electricity Grid. Strategic assessments typically involve a larger region of critical infrastructure and are focused on interconnectivities and nodal analysis, rather than individual facilities. Other facility-specific assessments include detailed information on hazardous materials and the potential impacts of atmospheric releases on surrounding populations. These assessments can be integrated into larger maps (as shown in Figure 2 on page 15) along with other critical infrastructure information to better

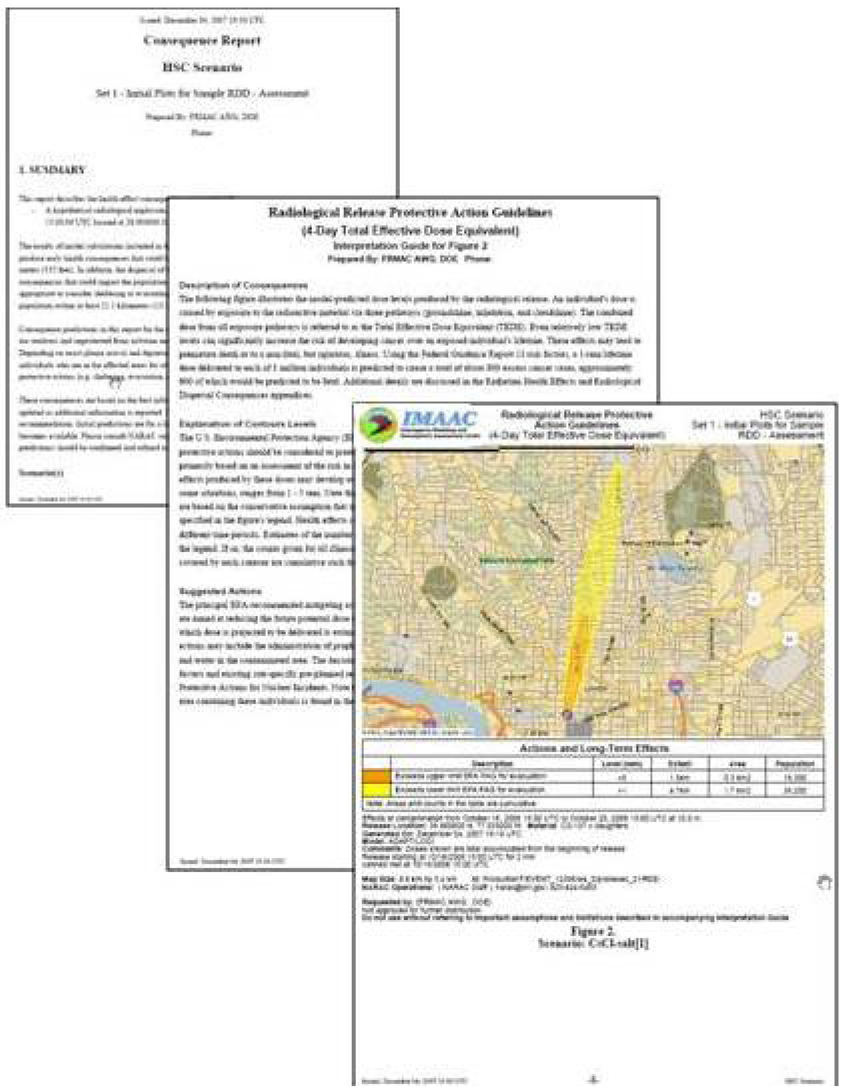

Figure 1: Consequence assessment products guide response decisions on evacuation, sheltering, relocation and worker protection.

(Continued on Page 15)

Detecting Offshore Oil Spills with Rutter Technologies' Sigma S6 Radar Technology

by Byron Dawe, Rutter Technologies
President, Business Development and Innovation

The tremendous growth in offshore oil and gas exploration, which has saturated almost every corner of the globe and seen upwards of 20 nations drilling into offshore oil reserves, has reached epidemic proportions as industry strives to lay claim to their own piece of deepwater geography. The rapid acceleration of exploration has brought with it an increased concern for the surrounding offshore marine environment. Since the late 1960s, offshore exploration water depth records have been broken every decade, beginning with deepwater drilling at 1200 meters 40 years ago, to 1800 meters in the late 1980s and advancing to 2400 meters in the last decade. In Canada, the deepest well ever drilled was completed in September 2010, 260 miles off the coast of Newfoundland, at a record 2600 meters. As industry strives to meet increasing production demands, the ecological risks associated with this activity have also increased. This article will look at how technology has evolved to accommodate and provide solutions for the growing concerns surrounding offshore oil spills.

Over the past several decades, there have been a number of major oil spill events in the world's oceans. One of the earliest commercial oil spills occurred on March 18, 1967, when the tanker, *Torrey Canyon*, ran aground off the coast of Cornwall, England, spilling 830,000 barrels of crude oil.[1] One of the most well-known oil spills occurred in Prince William Sound, Alaska on March 24, 1989, when the tanker, *Exxon Valdez*, struck Prince William Sound's Bligh Reef and spilled 260,000 to 750,000 barrels of crude oil.[2] Another oil spill of significance occurred on December 12, 1999, and involved the Maltese-registered tanker, *Erika*, that dumped 134,000 barrels of oil off France's Atlantic coastline.[3] Most recently, the *Deepwater Horizon* oil spill in the Gulf of Mexico flowed for three months in 2010 and is the largest accidental marine oil spill in the history of the offshore petroleum industry.

The *Erika* spill was extremely difficult to contain due to strong currents and high winds from a winter storm, making the clean-up challenging. The spill threatened beaches, fisheries, and wildlife along hundreds of miles of coast-line. In the wake of the *Erika*, the European Maritime Safety Agency (EMSA) was established on June 27, 2002 to provide technical and scientific assistance to the European Commission and Member States in the proper development and implementation of European Union (EU) legislation on maritime safety, pollution by ships, and security on board ships.[4] EMSA was the first organization to establish a set of basic standards for oil spill detection equipment. These include

(Continued on Page 5)

1 "Torrey Canyon 'Lessons Learned,'" BBC News, (Mach 19, 2007), http://news.bbc.co.uk/go/pr/fr/-/2/hi/uk_news/england/devon/6469059.stm.

2 Elizabeth Bluemink, "Size of Exxon Spill Remains Disputed," *Anchorage Daily News*, (Thursday, June 10, 2010), http://www.adn.com/2010/06/05/1309722/size-of-exxon-spill-remains-disputed.html.

3 "Total Loses Erika Oil Spill Appeal, Radio France Internationale – English Service, (March 30, 2010), http://www.english.rfi.fr/environment/20100330-total-loses-erika-oil-spill-appeal.

4 European Maritime Safety Agency (EMSA) http://www.emsa.europa.eu/.

Oil Spill Detection *(Cont. from 4)*

area determination, trajectory prediction, and detection to at least two nautical miles. The capability to measure oil thickness was noted as a preferred attribute. To meet the mandate for assisting EU/ European Economic Area (EEA) Member States in their response to ship-sourced pollution, EMSA has contracted a network of stand-by Oil Spill Response Vessels (OSRVs) that are deployed throughout the European Union. The OSRVs are equipped with advanced equipment to provide optimal detection and containment of oil, and used to support the existing pollution oil spill response capacity of respective EU/EEA countries.

The Brazilian national oil company, Petrobras, has also established standards for radar based oil spill detection systems. This requirement also includes the ability to determine spill thickness.

Another jurisdiction which has been extremely proactive in its investment and evaluation of oil spill technologies has been Norway. In 2010, Rutter teamed with Aptomar AS, a Norwegian company that supplies infrared camera technology and software which measures relative thickness of an oil slick. The combined system also incorporates tools which assist in the management of oil spill recovery. By integrating both systems, Rutter and Aptomar have created an Oil Spill Response and Management system that is unique in the industry, providing an optimal solution for oil spill detection, confirmation, and management during clean-up operations. It is this system which has met the rigorous standards for compliance by the Norwegian Clean Seas Association for Operating Companies (NOFO). NOFO was created on behalf of 25 operating oil companies early in Norwegian offshore oil development. Its mandate is to develop and maintain oil spill preparedness technologies and activities to combat oil pollution on the Norwegian Continental Shelf.[5] As of January 1, 2011, only two companies in the world have met the NOFO compliance standard for oil spill radar detection requirements, with one of those being Rutter. According to NOFO, "…these two systems have demonstrated long-term and consistent performance during several oil-on-water exercises and/or during real oil spill response operations."

Much work has been done over the past several decades to demonstrate that microwave radar is effective in the detection of oil on water. Detection is accomplished by observing the absence of sea clutter return in the radar image where oil is present. The sea clutter return is suppressed by the dampening of the wind driven capillary waves by the oil. The capillary waves that have a wavelength of about half the radar wavelength are the primary source of sea clutter returns. At microwave frequencies, the radar wavelength for X band is 3.2 cm and ocean waves having wavelengths in this range (wind waves) are significantly attenuated by the presence of oil. While this mechanism has been understood for some time and used in airborne Side-Looking Radar, its use with shipboard radar has not been widespread due mainly to two reasons: very low grazing angles from shipboard radar result in relatively low sea clutter response; and most shipboard radars use horizontal polarization which provides a less favorable sea clutter return when compared to vertical polarization. The processing in these systems was also not designed to detect the subtle signal changes required to detect oil slicks. These limitations have restricted the usefulness of shipboard marine radar for oil slick detection and monitoring.

The Rutter Oil Spill Response Radar (OSSR) is based upon its core Sigma S6 enhanced radar processing technology. The Sigma S6 system maintains the complete dynamic range and resolution of the raw radar signal through all processing and recording. This ensures maximum fidelity for all subsequent processing through to imaging and tracking. The data depth resolution delivers the capability to discriminate very small signal differences and can detect target oil slicks of small size and at long ranges.

The Sigma S6 enhances signal to to noise, signal to clutter ratio, and clutter to noise ratio. This is

(Continued on Page 6)

5 The Norwegian Clean Seas Association for Operating Companies (NOFO), Our Operations, http://www.nofo.no/modules/module_123/proxy.asp?D=2&C=107&I=349.

Oil Spill Detection *(Cont. from 5)*

accomplished using both pulse to pulse and scan to scan processing. The system is capable of performing a real-time moving window process over a large number of consecutive radar scans with full vessel motion compensation. At this level of processing, sea clutter becomes very smooth and receiver noise will be suppressed to very low levels. For surface oil spill detection, this results in a well-defined area outline of the oil slick where there is minimal or no sea clutter return. During vessel clean-up operations requiring slick delineation, the ability to detect oil slicks while moving provides considerable operational benefits.

A significant component of the NOFO process is the implementation of oil-on-water exercises. Norway is one of a few select countries which allow the discharge of oil at sea for the purposes of equipment and procedure testing. It was in 2008 that Rutter was invited by NOFO to participate in two oil-on-water trials to evaluate the Sigma S6's capability to detect and monitor surface oil. It was the success of these trials which led to significant research and development by Rutter to eventually develop a refined Oil Spill Detection (OSD) system, culminating in a third trial in June 2010 and NOFO approval as an OSD system.

The Rutter OSD radar automatically detects oil over a large radar coverage area. Once detected, the Sigma S6 OSD is capable of auto-outlining the suspected oil spill and alerting the operator with visual and audible alarms. It provides continuous real-time local surveillance and can be installed either onboard a vessel or at a fixed site. Incorporating the Sigma target tracking module, the system is able to deliver accurate real-time vector information of the oil spill movement to other sensors or systems such as cameras, Geographical Information Systems, or an oil spill drift prediction system. It is this unique capability that has led to Rutter and Aptomar achieving significant sales in Norway, Brazil, and the United States.

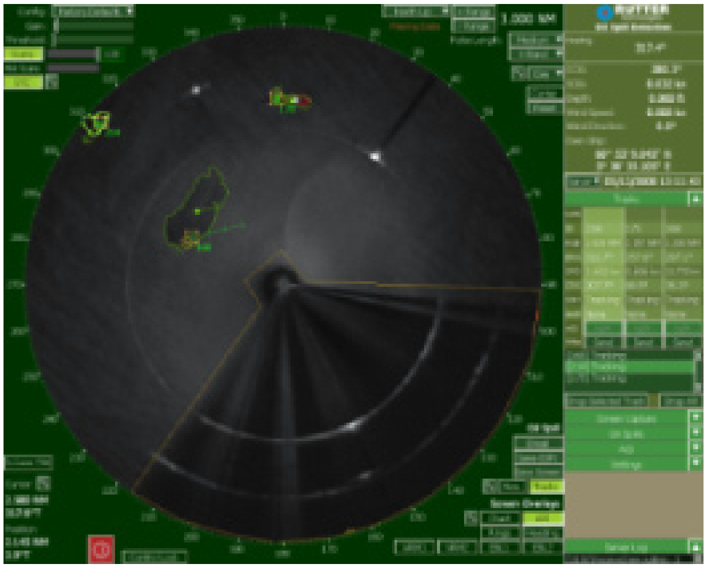

Figure 1: A screen shot from the Rutter OSSR showing the system generated oil spill outlines as well as the predictive future path of the oil.

As a direct result of the *Deepwater Horizon* event, the United States has been actively investigating and acquiring the latest technologies for marine oil spill remediation. Recently the Bureau of Ocean Energy Management, Regulation and Enforcement, in its post analysis of the BP Deepwater Horizon, Macondo Well Blowout and oil spill of April 2010, has dictated that the use of X-Band radar and infrared cameras for use in night clean-up operations is a requirement. The directive goes on to state that "…in the interim before new regulations are developed we are requiring compliance with the Norwegian Clean Seas Association for Operating Companies (NOFO) standard - Requirements for oil recovery vessels on the Norwegian Continental Shelf, Rev. 10, September 2010, regarding x-band radar and infrared capability."[6]

The potential for expanded oil exploration in even more remote offshore areas, including the Arctic shelf, signals the likelihood of an oil spill in a geographic region with its own unique challenges. With continued oil exploration and

(Continued on Page 15)

6 NTL 2010-N10: Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources, Bureau of Ocean Energy Management Regulation and Enforcement, http://www.doi.gov/news/pressreleases/loader.cfm?csModule=security/getfile&PageID=70560.

Oil and Gas Infrastructure: The Maritime Dimension

by Stephen L. Caldwell,*
U.S. Government Accountability Office (GAO)

Introduction

Every government and private activity across the economy is dependent to some degree on oil and gas. This subsector of the Energy Sector (one of 18 categories of critical infrastructure) is used to generate electricity, heat buildings, cook, and fuel all modes of transportation. Yet the Sector itself is dependent on transportation to move it from its sources to refineries or processing plants and finally to distribution networks and to the end-users. The maritime environment plays a key role in both the production of oil and gas (from offshore wells and pipelines) and their transportation (by tankers that cross the oceans). This article describes the maritime dimension of the Oil and Gas subsector, to include some of the related threats, vulnerabilities, consequences, mitigating measures, and remaining challenges.

Facilities and Tankers

Several types of maritime facilities are used to produce and transport oil and gas. Hundreds of offshore oil platforms are used to produce domestic oil and gas, mainly in the Gulf of Mexico. The oil and gas from these platforms are usually transported to refineries via submarine pipelines. Tanker vessels are used to import oil and gas from overseas and the United States' extensive reliance on imported energy is expected to increase. Transporting oil and gas by sea involves a global maritime supply chain with tankers owned by many different companies, as well as routes across international waters that no government controls. There are more than 3,000 registered crude oil tankers and more than 200 liquefied natural gas (LNG) tankers. Very large tankers are too large for many U.S. ports, so tankers are sometimes unloaded at deepwater facilities such as the Louisiana Offshore Oil Port (LOOP). The LOOP is a terminal in the Gulf of Mexico and is the only facility that can receive very large and ultra-large tankers. The LOOP accounts for more than ten percent of crude oil imports and the facility and its storage terminals are connected to more than 50 percent of the refining capacity in the United States.

Threats

Threats against maritime oil and gas infrastructure are well documented. Despite an often heavy security presence, terrorists have attempted — and in some cases succeeded — to attack oil and gas tankers and terminals. Successful examples include the 2002 attack on the tanker *Limburg* near Yemen, the 2003 hijacking of the tanker *Penrider* near the Straits of Malacca, the 2004 attack on offshore terminals near Iraq, and the 2006 (and more recent) assaults on gas terminals in Nigeria. In addition to terrorist attacks, pirates have recently and successfully targeted oil and gas tankers to include the high visibility hijackings of the *Sirius Star* and *Longchamp* near Somalia. According to a recent article in *Foreign Policy*, from 2005 to 2009, pirates attacked 31 oil and gas tankers.

Figure 1: GAO photo of an offshore oil and gas platform in the Gulf of Mexico.

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Maritime *(Cont. from 7)*

Vulnerabilities

These attacks demonstrate factors that make the oil and gas maritime supply chain vulnerable. Port terminals (at both origin and destination nations) are inherently vulnerable because they must provide access by land and sea and because they are sprawling installations, often close to busy population centers. Likewise, the tankers that transport oil and gas are vulnerable because they travel on direct routes that are known in advance and, for part of their journey, they may have to travel through chokepoints that do not allow them to maneuver away from possible attacks. Since so many different players are involved, terrorists have room to probe the supply system for the weakest link.

Consequences

While attacks on energy tankers and terminals have been relatively rare, successful attacks could have substantial consequences from a public safety, economic, and environmental perspective. These consequences would vary by the type or oil or gas commodity. For instance, gas (e.g., LNG) has the potential to catch fire, or possibly explode and thus endanger lives. The economic consequences of a major terrorist attack on a tanker or related facility could include a temporary price spike reflecting fears of further attacks and supply disruptions. While the loss of one tanker or facility might not have a significant impact, if an attack results in port closures for multiple days or weeks, price responses and higher costs could mean billions of dollars of losses in economic welfare to consumers, businesses, and governments. Last year's *Deepwater Horizon* incident in the Gulf of Mexico brings new attention to the potential environmental consequences of a major oil spill caused by a terrorist attack on facility or tanker, or even caused accidentally by pirates seizing an oil or gas tanker. Environmental cleanup of crude oil can take several years and cost billions of dollars. According to Exxon Mobil, the company spent $2.2. billion on the *Exxon Valdez* cleanup. The total cost of cleaning up the *Deepwater Horizon* spill, with damage to the environment, as well as the impact to the livelihood and economic status of the region, will not be determined for some time. However, current estimates suggest that the cleanup and related damages could easily eclipse the *Exxon Valdez* as the most costly offshore spill in U.S. history.

Protective Measures

Many protective security measures are in place at both the international and national level to protect oil and gas facilities and tankers from attack. The International Maritime Organization and its International Ship and Port Facility Security (ISPS) code set baseline requirements for maritime security. National governments and terminal operators are taking such actions as improving physical security at port facilities and conducting waterside patrols. For example, port facilities report compliance with the ISPS code requirements, and tanker operators report strengthening their security posture while loading and at sea. Many navies are patrolling threatened waters, such as the Persian Gulf and Gulf of Aden. In the United States, additional actions are being taken beyond those required in the ISPS code to protect the energy supply chain. These actions include monitoring the arrival of tankers and crews, boarding selected vessels before they reach port, escorting selected tankers into port, and providing waterside security patrols at energy terminals. In addition, officials responsible for port security have developed response plans to address a successful attack and mitigate the consequences. Finally, officials have conducted exercises to test their operational capabilities and their response plans. Such exercises help determine the strengths and weaknesses of various plans and the ability of multiple agencies or communities to respond to an emergency incident related to energy-related maritime infrastructure.

Challenges

Despite the protective measures in place, maritime security officials in both government and industry face continued challenges in protecting energy tankers and related port infrastructure. For tankers transiting international waters, the primary challenge involves patrolling the lengthy travel routes and frequent danger spots with only a limited number of naval vessels. For port infrastructure, some

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Navy Fuels `Great Green Fleet' Vision: Latest Milestone on the Road to Energy Security

On 22 October 2010, in the waters off Naval Station Norfolk, the Navy reached another milestone on the road toward energy security. Conducting a full power demonstration of an alternative fuel-powered riverine boat, the Riverine Command Boat - Experimental (RCB-X) ran on a 50/50 blend of algae biofuel and petroleum, achieving a top speed of 44.5 knots (about 52 miles per hour).

Figure 1: On 22 October 2010, the Navy conducted a full power demonstration of this alternative fuel-powered RCB-X running on a blend of 50 percent algae-based and 50 percent petroleum-based fuel, achieving a speed topping 44 knots *(about 52 miles per hour).*

The demonstration marked an important step toward meeting Secretary of the Navy Ray Mabus' goal of fueling half the Navy's energy consumption through alternative fuels by 2020.

"Running the RCB-X at its maximum power throughout this test of a 2nd generation marine biofuel was a Wright Brothers moment for the Navy," stated Rear Admiral Philip Cullom, director of the Energy and Environmental Readiness Division on the Chief of Naval Operations staff, which leads the Navy's Task Force Energy.[1] It was the first time a naval surface vessel from any nation has ever been driven at full power on biofuel, let alone one derived from algae.

The successful RCB-X demonstration came almost one year to the day after Mabus laid out his energy goals for the Navy and Marine Corps. Naval Sea Systems Command's advanced fuels program office is leading the testing and demonstration program in coordination with the Task Force Energy Maritime Working Group. The riverine demonstration is just one of a series of progressively larger scale tests and evaluations scheduled through 2012. These exhibitions will culminate in 2012 with a Green Strike Group of U.S. Navy ships and aircraft operating locally and in 2016, with deployment of a Great Green Fleet of ships and tactical aircraft, all powered by alternative fuels.

The Great Green Fleet

The Great Green Fleet is of course a takeoff from the Great White Fleet, a group of naval vessels that sailed around the world between 1907 and 1909. The purpose of the Great White Fleet's "world tour" was principally to showcase the Navy's capabilities and U.S. seapower, though coincidentally, like the Great Green Fleet, it was meant to provide an operational evaluation of innovative energy efficiencies. The Great Green Fleet will experiment with hybrid electric drive and other energy saving technologies, but the main purpose behind this journey will be to demonstrate the Navy's commitment to achieving energy security, enhancing combat capability, and reducing greenhouse gases. "Going green is about combat capability and assuring Navy's mobility," said Cullom. "By

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1 Navy on Course to Meeting Energy Conservation on Ships - Interview by Max Cacas (October 28 2010).

Riverine *(Cont. from 9)*

having reliable and abundant alternate sources of energy, we will no longer be held hostage by any one source of energy, such as petroleum."[2]

Tom Hicks, Deputy Assistant Secretary to the Navy (Energy), agrees. "Alternative fuels really give the Navy a chance to divest a bit from petroleum to provide some increased insulation from a pretty volatile petroleum market."[3]

Why Algae?

Algae are attracting attention as a fuel source because the strains can potentially produce at least ten times more fuel per acre than the corn used to make ethanol or the soybeans used to make biodiesel. Moreover, algae can be grown on virtually any type of land, using brackish water, meaning that fuel production would not compete with food production.[4] Another advantage of biofuels is that fuels made from biomass burn cleaner than fossil fuels and require no drilling to acquire, which means fewer greenhouse gas emissions throughout the fuel's lifecycle. According to Solazyme, the company from which the Navy acquired its algae-based oil, this type of fuel results in up to 85 percent less greenhouse gas emissions than fossil fuels.

Figure 2: Rear Admiral Philip Cullom shows off a container of the algae-petroleum fuel blend.

Solazyme is one of several companies working to engineer the "perfect" strain of algae for biofuel production. Jonathan Wolfson, the company's Chief Executive Officer and co-founder says, "[o]ur unique microbial conversion technology process allows algae to produce oil in standard industrial fermentation facilities quickly, efficiently and at commercial scale."[5]

Presently, the company grows algae in tanks inside a Pennsylvania warehouse. Fed by sugar beets, switch grass, or a host of other plants, the algae is cut and dried into pebbles that resemble couscous. It is then shipped to Iowa, where the oil is extracted. After the oil is extracted it is sent to refineries in Texas, where it is blended with traditional diesel.

In September 2010, the U.S. Navy ordered more than 150,000 gallons of ship and jet fuel from Solazyme. The company received a $21.8 million grant from the U.S. Department of Energy in 2009 to build a new refinery in Riverside, Pennsylvania, to help push production to commercial levels.

Don't Call it Biodiesel

The algae-based fuel used by the Navy is known as hydro-processed renewable diesel (HR-D). Unlike biodiesel, HR-D does not include water; which is incompatible with shipboard fuel systems. HR-D is a drop-in replacement for traditional fuel, meaning that the fuel system's integrity is not compromised, and there are no performance or maintenance issues. The RCB-X demonstration provided further evidence of this. "The boat's performance was indistinguishable from what it would have been using standard diesel fuel," said Cullom.[6]

The RCB-X is a 49-foot boat (see Figure 1 on page 9) which the Navy one day hopes to use for patrols in rivers and bays. Cullom said it was an ideal place for the team to begin alternative fuels testing. "It's always best, of course, when you're doing testing like this to start small. We'll be able to extrapolate the performance that we see on one into the next ones," he said.[7]

(Continued on Page 17)

2 Great Green Fleet - Navy New Service.
3 The U.S. Navy and Biofuels - by Robert Rapier, Consumer Energy Report.
4 New York Times, 26 July 2010.
5 Navy Taps Solazyme for Bioengineered Algae Fuel by Jason Dearen, Associated Press and Navy Unveils Its 'Mean, Green Riverine Machine' In Norfolk by Bill Sizemore, Norfolk Virginian-Pilot.
6 New York Times, 26 July 2010.
7 Navy on Course to Meeting Energy Conservation on Ships - Interview by Max Cacas Reporter, Federal News Radio.

The Marcellus Shale Play in West Virginia

by Katharine Lee Avary,
Consulting Petroleum Geologist

The Marcellus Shale (Middle Devonian) is found throughout much of West Virginia, both in outcrops and in the subsurface. It is not present in extreme eastern West Virginia, where older rocks crop out and it is not preserved in westernmost West Virginia where rocks younger than Marcellus unconformably overlie rocks older than the Marcellus. The Marcellus varies in thickness across the State, with a maximum thickness of more than 100 feet in the north, gradually thinning to the south and west.

Long before the current interest in producing gas from shales (fine-grained sedimentary rocks), these shales were recognized as the sources of much of the gas trapped in other conventional reservoirs. The advent of new drilling technology (the ability to drill several thousand feet horizontally) coupled with new completion technology (massive hydraulic fracturing) has caused geologists and engineers to revise their thinking and recognize that the shales are also reservoirs for significant gas reserves.

West Virginia is no stranger to gas produced from Devonian-age shales; thousands of wells were drilled in southwestern West Virginia beginning in the 1930s, which targeted the younger Lower Huron Member of the Ohio Shale. These wells were drilled vertically and generally completed by a technique known as "shooting." Shooting involved using liquid nitroglycerin as a means to enhance the natural fracture systems present in the shale so gas could move more freely into the well bore. In the late 1970s and early 1980s, spurred in part by the Natural Gas Policy Act of 1978, the U.S. Department of Energy's Eastern Gas Shales Project and the Gas Research Institute's programs, drilling began east of the "historic" productive area, where the Lower Huron consists of black, organic rich shales interbedded with gray shales and siltstones.

The Marcellus has been penetrated by thousands of wells which were drilled to deeper targets, but had been largely ignored as a reservoir until the first modern hydraulic fracture of the Marcellus took place in 2004 in Washington County, PA. Operators began permitting wells, both horizontal and vertical, targeting the Marcellus in West Virginia. More than 3100 wells have been permitted; records for about half of those have been received by the Geological Survey and production has been increasing each year. In 2010, more than 31 billion cubic feet (Bcf) of gas was reported as produced from Marcellus wells, nearly doubling the previous cumulative production (2005-2009) for Marcellus wells. The vertical wells are primarily in southern West Virginia, where the Marcellus is thinner, and has a lower reservoir pressure. Many of the southern West Virginia wells are also completed in shallower shales, such as the Rhinestreet and Lower Huron.

In north central West Virginia and the northern panhandle, the Marcellus is thicker and higher reservoir pressures have been reported. Many horizontal wells have been drilled in Upshur, Doddridge, Harrison, Taylor, Preston, Wetzel, and Marshall counties. The Marcellus is less thermally mature to the north and west, (Marshall and Wetzel counties) and hydrocarbon liquids such as propane, ethane, and butane are often produced along with methane gas.

While the Marcellus is present in the Valley and Ridge Province in West Virginia's eastern panhandle, its depth can vary quite dramatically in a short distance due to the geologic structures present in that

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Legal Insights

The Gulf Oil Spill: Legal Responses to Maritime Oil and Gas Disasters

The United States has experienced a rich history of maritime calamites affecting the Oil and Gas Sector. The two most recent examples, Hurricane Katrina in August and September of 2005 and the BP Gulf Oil Spill in the spring and summer of 2010, are still fresh in living memory. Similarly, there is a rich history of devising legal approaches and tactics to prevent, mitigate, and respond to these adverse events. The Oil and Gas Sector has been identified by the U.S. Departmnet of Homeland Security (DHS) as a critical infrastructure; oil and gas provide most of the energy relied on by the American economy. It is indeed a critical infrastructure, and has been legally treated as such. The body of legal mechanisms with an impact on the continuation of this Sector in the face of catastrophe was and is being put to the test by the BP oil spill and its fallout. Some legal mechanisms performed as designed and intended while others were revealed to require updates or reviews. While not a policy prescription, this article will outline three legal devices implicated by the recent spill, and describe the criticisms and support each has received when brought to bear on this unprecedented event as well as their implication on the legal regimes governing other critical infrastructure sectors.

The Jones Act

The Jones Act, the name given to Section 27 of the Merchant Marine Act of 1920,[1] requires that goods transported in coastal shipping between U.S. ports (cabotage) must be carried by U.S. flagged and owned ships crewed by U.S. citizens that were constructed in the United States. All such ships must therefore operate under all applicable U.S. laws, including workplace and labor restrictions. Detractors note that the cost of building and staffing ships in the United States and complying with U.S. law is much higher than in the rest of the world. Consequently, this creates a disadvantage to American cabotage. Proponents note the importance to national security of the ability to locally build and equip a maritime industry. However, waivers of the provisions of the Jones Act are available and the reported refusal of the Obama administration to waive the provisions during the BP spill created a media controversy. Waivers are available on a case-by-case basis. Most recently, they were granted in September 2005, in the wake of the Hurricane Katrina disaster,[2] for the explicit purpose of maintaining economic and national security in face of diminished oil and gas extraction, refinement, and distribution.

In the aftermath of Hurricane Katrina, the waiver was issued in response to a distinctly different reality on the ground and in the gulf during the BP oil spill. Hurricane Katrina caused severe production delays that necessitated foreign vessels move commercial cargo related to the oil and gas industry from one U.S. port to another, necessitating the waiver. In the case of the BP oil spill, the vast majority of foreign maritime aid consisted of cleanup and mitigation, not commerce, removing the need for a waiver as the Jones Act itself did not apply. The Jones Act actually contains a provision allowing oil spill response vessels to operate in U.S. waters without a waiver.[3] Several offers of foreign help were refused due to cost, redundancy, or incompatibility, and not due to Jones Act concerns; several other foreign flagged ships actually did

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1 P.L. 66-261.
2 http://npga.org/files/public/Jones_Act_Waver_9-05.pdf.
3 Title 46 United States Code 55113.

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contribute to the cleanup without waivers. In fact, Admiral Thad Allen, National Incident Commander of the Unified Command for the *Deepwater Horizon* oil spill, ensured that expedited Jones Act waivers would be available should the Jones Act be implicated.[4]

The Jones Act implications of the BP oil spill perhaps clarify the relevance of this law to critical infrastructure protection only when paired with the implications at work in the Hurricane Katrina response. Critical oil and gas infrastructures were damaged during Katrina, threatening national and economic security, which successfully triggered a Jones Act waiver. In the BP case, though the scale of disaster was unprecedented, international maritime aid was not an infrastructure "gap filler" but rather disaster recovery. When and if those two factors should combine, damage to critical infrastructure and unforeseen scale of damage, the Jones Act and necessity for waivers will become necessary on a massive scale. The element of the BP spill that caught most response mechanisms by surprise was the sheer scale and intractability of the problem, a factor that must be considered in planning for future disasters and the implications of the Jones Act going forward.

The Oil Pollution Act of 1990

The Oil Pollution Act of 1990[5] was passed in response to the 1989 *Exxon Valdez* oil spill and, among several other provisions, imposed liability on responsible parties for damages from discharged oil and cleanup costs; capped that liability (not including removal costs) at $75 million per spill for offshore facilities; and created the Oil Spill Liability Tryst Fund. The Oil Spill Liability Tryst Fund can provide up to $1 billion per spill after that liability cap has been reached. The damages expected and forecast from the BP spill exceed that liability limitation by orders of magnitude. BP has pledged not to invoke the cap but estimated in September 2010 that the claims against them due to the spill amounted to just under $20 billion.[6] BP appointed Kenneth Feinberg (former administrator of the September 11th Victim Compensation Fund) to manage claims on a corresponding $20 billion fund they have established.

The primary issue this law presents is the potential that BP, or the responsible party for the next oil and gas disaster, would insist on the liability limitation or, as is the case with BP, not make all genuine victims whole because they are not bound to outside of common law tort remedies. While BP is one of the few actors in the Oil and Gas Sector with resources and capital and credit reserves to pay all legitimate claims, they also have the resources to fight those claims. They have been chastised for their slow processing and underpayment of claims. Several gulf coast attorney generals have asked a U.S. district judge to supervise Kenneth Feinberg's administration of BP claims.[7] BP has decided not to invoke the liability limitations. However, faced with both the tremendous amount of claims and legal and public scrutiny, they, or the next party responsible for a massive oil and gas calamity, may insulate themselves from at least the legal and financial obligations by invoking the liability limit.

The unprecedented scale of the damage accruing to residents and businesses on the Gulf Coast, and the fact that the chain of responsibility so clearly ended with a handful of entities protected by a virtual immunity from liability, spurred public and legislative efforts to increase the liability cap. Critics have also noted that investment in safety is negatively skewed toward underinvestment if the drilling entity will only be liable for the first $75 million of damage. An aggressive legislative proposition[8] supported by the president suggested increasing the limit to $10 billion retroactively, in effect ignoring the constitutional ban on ex post facto laws. This legislation

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4 http://www.whitehouse.gov/blog/2010/06/15/ongoing-administration-wide-response-deepwater-bp-oil-spill-june-15-2010.
5 http://thomas.loc.gov/cgi-bin/query/z?c101:H.R.1465.
6 http://money.cnn.com/2010/09/14/news/companies/bp_citigroup_claims/index.htm.
7 http://www.bloomberg.com/news/2011-02-01/bp-deliberately-underpaying-claims-mississippi-says.html.
8 http://menendez.senate.gov/newsroom/press/release/?id=c9ca441f-ddac-4ebb-ad3a-b044cb3c79f8.

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is stalled, in part because of concerns raised regarding the survival of smaller, independent firms in the face of the insurance premiums that would accompany removal of the liability limit. Insurers would raise their rates in response to their policy holders' increased exposure to potential liability. In combination with the fact oil and gas companies have no capital reserve requirement in the event of a disaster, this could subsequently force entities smaller than the major conglomerates to shut down. This fact dictates that whatever reforms are made to laws affecting liability for oil spills must be made gradually and with the continuity of this Sector in mind. Removal or increase of the liability cap could solve the many issues associated with the claims against BP but could cripple a critical infrastructure by forcing the majority of otherwise competitive and valuable firms out of business.

The Minerals Management Service

The Minerals Management Service (MMS) came into being in 1982, ceased to exist in 2010, and reorganized into three separate entities in the wake of the BP spill.[9] As originally constituted, the MMS' mandate was both the environmental and safety regulation of and revenue collection and distribution of royalties from offshore drilling. Its foundation coincided with a political drive to reduce regulation of business and a reaction to the oil crisis of the 1970s that triggered increased interest in the domestic energy production. Naturally, over the years the revenue collection imperative overwhelmed the regulatory function, slowing or completely stalling any regulatory reform efforts. This includes efforts begun to incorporate a risk management system or a requirement that all operators have safety and environmental management plans.[10] This apparently contradictory pair of mandates eventually led to an entity rife with corruption and incompetence that was universally blamed both on public opinion and official investigations for the conditions that allowed the spill to occur.

General criticisms of the MMS abound, criticisms that predate the BP oil spill. In recent years, several GAO reports criticized their revenue collecting systems as inefficient, improperly organized, and ineffective.[11] An investigation by the Inspector General of the U.S. Department of the Interior in 2008 found that MMS staff was engaged in improper relations with individuals from the industry they were regulating,[12] including accepting bribes. As for MMS blame in the spill itself, detractors first point to the fact that MMS did not perform an environmental impact assessment as required by the National Environmental Policy Act on any of the plans and permitting for the Macondo well, the well that eventually caught the Nation's attention on a constant video feed. MMS was also criticized for its hasty and uncritical approval of BP's Oil Spill Response Plan, also implicated as a causal factor in both the explosion and subsequent spill.

MMS was eventually broken up into three entities within the U.S. Department of the Interior: the Bureau of Ocean Energy Management, the Bureau of Safety and Environmental Enforcement, and the Office of Natural Resources Revenue. The underlying cause of the dysfunction and ineffectiveness of MMS, insofar as it contributed to the BP spill, had been properly identified as the melding of leasing, safety, and revenue collection responsibilities into the same entity without enough institutional separation. The solution was to endow each new entity with its own, non-conflicting responsibilities. This reorganization should serve as a lesson for regulators of all critical infrastructure sectors: de-conflict before, rather than after, a calamity. Most critical infrastructure sectors exhibit at least some of the complex characteristics as the oil industry in that several overlapping regulators have sometimes conflicting mandates and interactions with the private sector owners and operators

(Continued on Page 18)

9 http://www.doi.gov/deepwaterhorizon/loader.cfm?csModule=security/getfile&PageID=32475.
10 Deepwater Presidential Report, https://s3.amazonaws.com/pdf_final/DEEPWATER_ReporttothePresident_FINAL.pdf p. 71.
11 GAO-07-682, March 28, 2007, http://www.gao.gov/new.items/d07682t.pdf. GAO-03-29, January 2003, http://www.gao.gov/new.items/d03296.pdf. GAO-04-448, April 2004, http://www.gao.gov/new.items/d04448.pdf.
12 http://www.eenews.net/public/25/15844/features/documents/2010/05/25/document_gw_02.pdf.

Vulnerabilities *(Cont. from 3)*

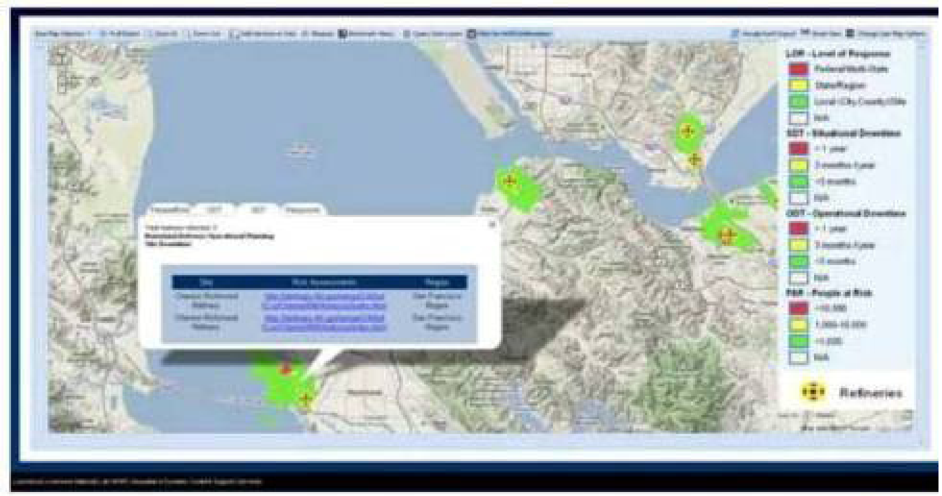

Figure 2: This map illustrates the locations of refineries in the San Francisco Bay area. The colors indicate potential site downtime, as noted in the legend. The Information Window provides descriptions of the site and a link to detailed analysis. The site can be investigated further by selecting additional tabs within the Information Window.

understand the system-wide impacts of an event and plan emergency response operations.

Our experience has shown that this kind of systems approach to infrastructure security and response planning provides a mechanism for Federal, State, and local governments to work with private infrastructure owners and operators to meet the over-arching goal of the NIPP "…to build a safer, more secure, and more resilient America by preventing, deterring, neutralizing, or mitigating the the effects of deliberate efforts by terrorists to destroy, incapacitate, or exploit elements of our Nation's CIKR and to strengthen national preparedness, timely response, and rapid recovery of CIKR in the event of an attack, natural disaster, or other emergency." ❖

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Oil Spill Detection *(Cont. from 6)*

and production in such remote and ecologically sensitive areas, such as the Arctic, and deep water exploration further offshore, the more important it will be to have the best and most advanced technologies available for both prevention and remediation of oil spills. ❖

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facilities are having challenges complying with the ISPS Code. GAO visits to energy facilities abroad showed that some port facilities had put extensive security measures in place, while other facilities had such problems as unattended gates and downed fences. Other protective measures, such as boarding and escorting tankers, require expensive resources such as boats and appropriately trained law enforcement personnel. Ports also face challenges in planning, exercising, and executing responses to an attack on energy tankers or terminals. Part of the problem is that there can be multiple stakeholders responsible for planning and executing different parts of the response — for example law enforcement, environmental protection, and firefighting. Again, resources are an issue with many of these stakeholders. In some ports, for instance, local firefighters do not have enough fire boats or are not sufficiently trained for maritime firefighting.

Conclusion

Maritime oil and gas tankers and related port facilities are critical to the economies of the United States and other developed nations. Yet these tankers and terminals remain vulnerable to threats from terrorists and pirates. The recent *Deepwater Horizon* incident helps to highlight one of the potential consequences of a successful attack on such vessels and facilities — severe environmental damage and economic costs. This is a good time for government and industry maritime officials

Figure 2: GAO photo of Coast Guard enforcing a security zone around a moored LNG tanker.

involved in oil and gas production and transportation to review their security measures for compliance with international and national standards and to redouble their vigilance. ❖

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Riverine *(Cont. from 10)*

What About Cost?

Because the market is still in its infancy, the fuel is not yet cost-competitive with petroleum. Initial supplies of the experimental renewable diesel fuel cost around $400 per gallon, but with time, that price has dropped to around $60 per barrel, according to Cullom.[8]

Tom Hicks explains some of the reasons for the high cost. "The quantities we are buying today, there's research and development that is factored into that — there's a lot of testing and certification that we are buying, and these are very small batches. As the Navy, we purchase roughly 32 million barrels of fuel per year, so that's 1.2 or 1.3 billion gallons of fuel. The quantities you are talking about here are pretty small — 20,000, 50,000, 100,000 gallons of experimental biodiesel fuel, which is pretty small relative to that. To an extent, you pay for that lack of economy of scale at this point."[9]

Cullom feels that the Navy initiative, by increasing demand for such products, will help drive prices down over time.

What's Next?

The Navy is not the only branch of the military testing alternative fuels. The Air Force has tested a biofuel blend in its C-17 Globemaster III cargo plane.

Cullom said that with the successful test of the RCB-X on biodiesel under their wing, the Navy will expand the test to larger ships of the fleet. But first, the Navy's Task Force Energy is turning its attention to testing the use of biofuels in one of its workhorse aircraft — the Sikorsky H-60 Seahawk helicopter.

"Our goal, as a Navy, is to be an early adopter of new technologies that enhance national security in an environmentally sustainable way," said Cullom.[10] ❖

For more insights into the Navy's demonstration of alternative fuels, see our cover story entitled "From Seed to Supersonic: How Camelina Powered the Navy's Premier Fighter Jet" in this issue of *Currents*.

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8 Ibid.
9 The U.S. Navy and Biofuels - by Robert Rapier, Consumer Energy Report.
10 Navy to Fuel Half Its Vessels Alternatively By 2020 by Natalia Real, Fish Information and Services, 26 October 2010.

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of the infrastructure within their purview. MMS did not establish institutional boundaries between their different mandates; the incentives to maximize oil production and revenue eventually overwhelmed the incentives to ensure adequate safety and environmental planning and response.

Stakeholders from nearly every critical infrastructure sector, whether government regulators or private sector owner and operators, engage in some form of planning for or modeling of worst case scenarios, such as chemical releases, oil spills, fires, earthquakes, or blackouts. These efforts should encompass not just cleanup and mitigation, but any legal issues that may take months or years to play out; we should test these legal responses without a corresponding real calamity. The Jones Act was not directly implicated in the BP oil spill disaster, but the lesson that future disasters could be of an unforeseeable scale must be incorporated into planning to incorporate foreign entities into our disaster response. The Oil Pollution Act of 1990, as applied to this disaster, revealed both that the liability cap was too low for potential disasters and safety incentives and that any subsequent reforms must consider the second-order effect on insurance premiums and operating costs. Any changes in legal regimes to critical infrastructure sectors will also have these second-order effects and externalities that could seriously impede the very critical infrastructures they attempt to improve. Finally, the saga of MMS should serve as a warning to any regulator of a critical infrastructure that incentives matter and "mission creep" may create contradictory incentives and subsequent overemphasis of one priority over another at the expense of the survival and safety of that critical infrastructure. ❖

Marcellus Shale *(Cont. from 11)*

part of the State. Horizontal drilling is probably less likely to take place in the eastern panhandle due to the nature of the folding and faulting there. Also, the Marcellus is more thermally mature further to the east. The search for reservoirs of significant gas reserves in the Marcellus Shale Play in West Virginia continues to this day. ❖

For more information, as well as illustrations which accompany this summary, please visit us at: http://www.wvwaterconference.org/docs/Combined%20Presentations/New%20Gas%20Well%20Extraction%20Methods%20Does%20Marcellus%20Opportunity%20Mean%20Water.pdf.

The Center for Infrastructure Protection works in conjunction with James Madison Univerity and seeks to fully integrate the disciplines of law, policy, and technology for enhancing the security of cyber-networks, physical systems, and economic processes supporting the Nation's critical infrastructure. The Center is funded by a grant from the National Institute of Standards and Technology (NIST).

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