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Offshore Wind Energy Projects

Summary of a Workshop

Peter Johnson, *Rapporteur*

March 25–26, 2010
Keck Center of the National Academies
Washington, D.C.

Sponsored by
Minerals Management Service,
U.S. Department of the Interior

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Transportation Research Board
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Conference Proceedings on the Web 4

NOTICE: The workshop that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competencies and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The workshop was sponsored by the Minerals Management Service, U.S. Department of the Interior.

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Cover photo: The cover photo is taken from Offshore Wind Energy Workshop: Background Info & Workshop Goals*, PowerPoint presentation by John Cushing, Senior Technical Advisor, Minerals Management Service, Offshore Wind Energy Workshop, March 25, 2010.*

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Contents

Preface

This summary of the Offshore Wind Energy Projects Workshop held on March 25–26, 2010, was prepared by Peter Johnson, rapporteur, as a factual summary of what occurred at the workshop. The planning committee's role was limited to planning and convening the workshop. The views contained in this report are those of individual workshop participants and do not necessarily represent the views of all workshop participants, the planning committee, the Transportation Research Board (TRB), the National Research Council (NRC) of the National Academies, or the sponsors of the workshop.

This workshop summary has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published summary as sound as possible and to ensure that the report meets institutional standards for clarity, objectivity, and responsiveness to the charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

On behalf of NRC, TRB and the Marine Board thank the following individuals for their review of this report: Elmer P. Danenberger III, Reston, Virginia; Judith Hill Harris, City of Portland, Maine; and Malcolm L. Spaulding, University of Rhode Island, Narragansett. Although these reviewers provided many constructive comments and suggestions, they did not see the final draft of the workshop summary before its release.

The review of this summary was overseen by C. Michael Walton, University of Texas at Austin. Appointed by NRC, he was responsible for making certain that an independent examination of this summary was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this summary rests entirely with the author and the institution.

Offshore Wind Energy Projects
A Workshop

Peter Johnson, *Rapporteur*

There is a growing interest in offshore wind energy production in the United States. Several projects have been proposed or are in development, particularly along the Eastern Seaboard. The Energy Policy Act of 2005 vested responsibility for the safe and environmentally responsible development of offshore renewable energy production on the outer continental shelf with the Minerals Management Service (MMS) of the U.S. Department of the Interior.[1]

In mid-2009, MMS, in collaboration with the Federal Energy Regulatory Commission, issued a regulatory framework and interim guidelines for the orderly, safe, and environmentally responsible development of offshore renewable energy projects on the outer continental shelf. Under the current agreement, MMS is responsible for overseeing nonhydrokinetic renewable energy projects (such as wind).[2] The regulations published in mid-2009 put forth a general framework for leases and project review but do not specify standards or prescriptive requirements for facility design, fabrication, and installation or for environmental and safety management, inspection, and facility assessment.

Therefore, MMS asked the National Academies for assistance in these areas, beginning with a workshop to bring together interested parties and stakeholders for exchange of technical information, discussion of key issues, identification of problems or concerns, and review of possible approaches that MMS might consider. The following is the statement of task for this workshop:

> **Statement of Task:** An ad hoc committee will organize a workshop on offshore wind energy projects. The workshop will include presentations and discussion on design and operational options for turbines, blades, towers, substructures, foundations, and electrical connections to the grid. The workshop will highlight processes and procedures that can be used within the Minerals Management Service's regulatory regime to minimize risk to safety and the environment and minimize disruptions to the supply of electricity. In particular, the workshop will examine the MMS process for selecting and managing certified verification agents (CVAs) and for identifying appropriate standards for assuring good engineering judgment and practice; for reviewing and approving designs, fabrications, and installations; and for determining acceptable qualifications and role for a CVA.[3]

[1] MMS is now the Bureau of Ocean Energy Management, Regulation, and Enforcement within the U.S. Department of the Interior.

[2] This agreement also gave joint responsibility to the Federal Energy Regulatory Commission and MMS for marine hydrokinetics projects.

[3] A CVA is an independent third-party organization that reviews the design and construction of a project and certifies that it meets certain standards.

To conduct this project, the Transportation Research Board's Marine Board convened a planning committee of six members, appointed by the National Research Council, to organize a one-and-a-half-day workshop to provide MMS with input from public and private institutions involved in offshore wind energy developments. The workshop was held on March 25 and 26, 2010, at the Keck Center in Washington, D.C. About 95 participants attended the workshop. The workshop agenda (see page 9) has links to each presentation in PowerPoint format. The planning committee members (see page 17) chaired the workshop, led various discussions, and moderated the sessions. The remainder of this section summarizes the presentations, discussions, comments from the participants (who are listed on page 13), and key results of the workshop.

WORKSHOP TOPICAL OVERVIEW PLENARY SESSIONS (DAY 1)

The workshop began with introductions of moderators and participants and several presentations to define the subject, the goals, and the background of relevant work to date conducted both in the United States and abroad. The first presentation by MMS Senior Technical Advisor John Cushing described the status of MMS programs and its expectations for the workshop. MMS goals for this workshop were stated as the following questions:

- What constitutes good engineering judgment and practices for the design, fabrication, and installation of offshore wind energy structures?
- How can or should existing standards and practices be used for the above?
- What is the CVA role in determining appropriate standards and practices?
- What is the CVA role in determining appropriate environmental and functional loads?
- What is the CVA role in conducting monitoring programs and on-site inspections to verify compliance?
- What constitutes acceptable qualifications for a CVA?

The next (stage-setting) presentation by Malcolm Sharples, an MMS consultant, described studies and investigations recently conducted to understand the offshore wind systems that have been developed, experience to date in other settings, and analyses of safety and environmental issues that have been conducted to date.

The workshop continued with three panel sessions:

Panel A: Safety Principles for Construction and Operations
Panel B: The CVA Process: How Can It Be Adapted for Offshore Wind Projects?
Panel C: What Existing Standards Are Available and Could Be Applied or Adapted?

For each session, a moderator presided over several speakers who presented their views of the topic and how to consider the issue. The presentations were followed by questions from the audience and general discussions. The workshop agenda (see page 9) has links to these presentations.

Panel A

Panel A included two presentations concerning general safety principles and their application to offshore wind energy systems. The presentations used examples from recent work in other regions and related industries such as offshore oil and gas development. Panelists noted the importance of addressing safety throughout the development process, to include design, fabrication, installation, operations and maintenance, and decommissioning and removal.

Panel B

Panel B consisted of three presentations by practitioners involved in some aspect of the CVA process and its potential application to future offshore wind projects. The presentations covered some history of how and why MMS incorporated the CVA process for offshore oil and gas and how it could be adapted for wind energy. They described how it has worked, what systems and functions it applies to, and what steps in the development process are incorporated. They also provided reasons why a similar process might be selected, adapted, and applied to the case of offshore wind energy development and how it might be modified to suit the special needs of this industry.

Panel C

Panel C consisted of three presentations on the subject of adapting existing standards from other industries and countries for U.S. offshore wind energy applications. One of them compared the standards for offshore structures issued by the International Electrotechnical Commission and the American Petroleum Institute and concluded that the differences between the two were minor. Another presented the Germanischer Lloyd guidelines and standards that cover certification of wind turbines and total wind farm systems in Europe. It referenced publications, the detailed requirements for certification, and the history of applications. A final presentation covered the current American Petroleum Institute structural standards in place for offshore platforms and the possible application of these to wind farms.

Workshop Breakout Group Sessions

The workshop continued with four breakout group sessions that met concurrently during the afternoon of the first day. Participants in each of the four breakout groups were asked to review existing data and information on the given subject presented in the plenary session and offer comments on how critical the issue was and what could be done to develop an effective and efficient process (using the CVA approach) for ensuring safe operating environments for U.S. offshore wind energy projects in the future. Comments offered by individual participants during the breakout group discussions included the following:

- Group 1: CVA role and qualifications:
  – The CVA role is viewed as advisory for verifying conformance with appropriate standards and as an active validation role regarding appropriate environmental loads. The monitoring and inspection role would be defined on a case-by-case basis.
  – CVA qualifications could follow existing systems established by MMS for other applications, with appropriate expansion if needed for other than structural systems requiring a professional engineer certificate in civil engineering.

– Missing information could be obtained by working cooperatively with industry associations to create road maps and define codes. One option noted would be to create a volunteer advisory group to help MMS through the process, especially if the CVA role is expanded beyond structures.

– There is a need to better define various agency regulator responsibilities and pursue active memoranda of understanding with other federal agencies.

- Group 2: Standards and practices:

– Industry could provide appropriate consensus standards that could be adopted by MMS, and MMS could then accept a design basis approach as an interim solution. MMS could also encourage interagency cooperation to develop common requirements.

– MMS could determine what type classification and project certification may be used by the CVA.

– Standards could incorporate current industry practices, with additional emphasis on health, safety, environment, and structural integrity. Certain standards would need to be site specific.

- Group 3: Metocean[4] data:

– It would be helpful to have a definition of critical data needs in terms of design and use, as well as information on best practices for data collection, best sources of existing data, and effective dissemination strategies.

– Early action to define a matrix of relevant variables for candidate standards, identify historical data and gaps, quantify the significance of the gaps, and fill gaps with a cooperative data collection effort would be helpful. One possibility would be to use a public–private cooperative covering a wide coastal area (within target regions) to meet multiple needs (variety of stakeholders).

– It would be helpful to continue this forum for future discussions of data needs and developments and to disseminate information on data needs and gaps. Consideration of establishing an interagency task force with private-sector advisors to work on data tasks, especially identification of acceptable tools for data analyses and application to design loading, was suggested.

- Group 4: Other system design issues:

– It was pointed out that the safety of personnel is an important issue that needs careful consideration with regard to construction and installation, but especially with regard to maintenance operations. Participants observed that it is not clear who is responsible for setting standards for personnel safety, for training, and for oversight.

– It may be necessary to consider the question of ship–structure allisions, especially if wind farms are installed in regions with high ship traffic.

– It also may be useful to give attention to special aspects of offshore wind energy installations, such as seabed subsoil analysis, foundation design for towers, and total design for transmission cable systems.

– A CVA program using much the same approach as that in place for offshore oil and gas might be considered, but with the option to modify and improve it as more experience with offshore wind energy is obtained.

[4] Meteorological and oceanographic.

– Public education is important, especially in preparation for adverse conditions, possible outages caused by severe weather, and other hazards resulting in loss of power.

FINAL WORKSHOP PLENARY SESSION: GROUP REPORT AND WRAP-UP

In the final workshop plenary session, each of the four breakout groups reported on its discussions and observations to the full assembly of participants. This also allowed an opportunity for questions and comments from all. The workshop agenda (see page 9) has links to the four reports in PowerPoint format.

Breakout Group 1

Breakout Group 1 focused on the role and qualifications to be expected of a CVA in a typical offshore wind energy project. Comments offered by participants included the following:

- What constitutes good practice is a key question.
- A CVA should incorporate good existing practices by cataloging what exists, preparing a road map, and defining the regulator's responsibility.
- It is important to develop agreement documents between state governments and the federal government to streamline the process.
- A typical CVA role might focus on structures, because structural rules are already in place.
- Perhaps the CVA should only advise on other items, because developers have a lot of existing private oversight.
- The CVA role may need to be evaluated on a case-by-case basis.
- Regarding CVA qualifications, perhaps a special advisory committee could be considered to perform an accreditation process.

Several group members commented that the discussion was missing many of the lessons learned from European experience, which would be very instructive. Some also thought it would be useful to review road maps for codes and standards, especially those that are the responsibility of all regulators. One suggestion for an early next step was to establish a voluntary advisory group to coordinate with states and look beyond structures to turbines and other components of the wind energy system.

Breakout Group 2

Breakout Group 2 focused on standards, specifically, what existing standards could be applied or adapted and what standards need to be developed separately because the wind energy system presents unique challenges not covered by previous regulations. Comments offered by individual participants included the following (not in order of importance):

- Industry could develop consensus standards first, and then MMS could select a design basis and get interagency agreement on it. It will be important to determine what to accept as industry standards and how.

- Because MMS is mostly involved in structural safety standards, the role of a CVA could be established based on the needs of each project. It was noted that the American Wind Energy Association has a working group to design a road map and identify gaps.
- Industry could specify safety management systems and develop and implement best practices with CVA oversight.
- CVA organizational qualifications could include multidisciplinary expertise in engineering and a network of experienced inspectors.

Breakout Group 3

Breakout Group 3 focused on questions regarding the adequacy of metocean data and issues related to using historical data to determine maximum design storm conditions for structural loading and other system requirements. This subject is more limited than others, but data needs are broader than just determining design standards for wind energy systems. Comments offered by individual participants included the following:

- This issue should also include what data should be collected and measured in general by all agencies.
- There is already a large amount of publicly available data, but these data need to be investigated for adequacy of measurement and analysis and adapted to unique conditions of wind energy systems (e.g., extrapolating wind data from surface buoy observations to the hub height of a wind turbine).

The group also discussed other data needs, such as measurements of seabed geotechnic conditions in regions under consideration for wind farms. It was mentioned that European projects have collected such data and would offer a model for best approaches in the United States.

It was also mentioned that public–private partnerships may be appropriate to use for future data collection, processing, and dissemination. An atlas for large regions might be helpful and could be produced with available data, with analyses focused on wind farm needs. One question raised was how to define best practices for applying data to set design standards so that a common product could be widely used. It was mentioned that the National Oceanic and Atmospheric Administration could possibly develop and package existing data sets in a form specifically tailored for use by wind projects if industry needs could be clearly defined.

Breakout Group 4

Breakout Group 4 covered several topics that were not part of the other categories. Participants discussed what else creates risks to human health and the environment and considered how a CVA could address the dynamics of the system and what the drivers are. Comments offered by individual participants included the following:

- Beyond design and construction, issues could include shutdown procedures, training of personnel, and how to accommodate marine transportation safety. For example, in Europe, platforms are designed to fail should a certain size ship collide with them, because losing the platform is considered preferable to sinking the ship.
- Regarding the use of failure analyses, lessons could be learned from the offshore oil and gas industry.
- The potential effect on utility customers of multiple power failures caused by a catastrophic event at a wind farm should be considered.

- Prescriptive standards could be valuable because many operators might not be original developers with extensive experience.[5]
- One issue that needs attention is public education, which should include explanations of past achievements as well as of the challenges ahead.
- Adopting a total system perspective (e.g., towers, electrical, generators, operations) for safe operations was discussed.[6]
- Regulators need to be involved in hazard analysis for the total system.

MMS RESPONSE TO THE COMMENTS

After the breakout group reports and discussion, MMS responded with initial reactions. MMS Senior Technical Advisor John Cushing defined the process and path forward to address these issues as arduous and time consuming but necessary, because MMS wants to get it right from the start. MMS believes that, to the extent possible, it will be most effective to use industry-derived consensus standards as a basis for regulations and to develop a full regulatory process from this base. MMS has asked the National Academies to conduct a follow-on study after this workshop and will urge all workshop participants to remain engaged and offer advice as this work continues. MMS also understands that future work on this subject will require even more engagement among U.S. offshore wind energy developers, the offshore oil and gas industry, and regulators. It will also benefit from the more extensive experience of wind energy developers in Europe.

Further discussion highlighted the following issues:

- It would be useful to consider technical and environmental issues in more depth in future forums of this type and, possibly, to engage offshore oil and gas experts as well (some favored using Houston as a location for such a forum).
- It would also be useful to continue this type of workshop with a specific focus on learning from the European experience and capturing European best practices in offshore developments for implementation here.
- In Europe, much attention has been given to the design and installation of subsea cables, which are a factor affecting overall system reliability and safety. These issues may also affect U.S. offshore projects.
- Further discussion and clarification are needed to specifically define the role of the CVA. Would the CVA evaluate the system design basis and determine whether it is valid, or would doing so be the sole responsibility of MMS?
- Questions were posed regarding how MMS is engaging the U.S. Army Corps of Engineers (USACE) in the whole process. For example, USACE is involved in state waters and issues its own permits.

WORKSHOP WRAP-UP

At the conclusion of the workshop, participants made a number of observations based on the presentations, discussions, and comments:

[5] This comment should not imply that operators should not also be required to employ competent personnel who establish a comprehensive safety management regime.

[6] A systems perspective encourages designers and operators to evaluate the interactions of various components and subsystems that affect overall performance, failure modes, and level of risk.

- Although a lot of useful information is available to draw on to develop an adequate safety oversight and review program, this information has not been put into a decision matrix. Many participants felt that doing so would facilitate the process and improve the outcome. The major challenges are defining the scope, selecting the key issues, and deciding how to move forward.
- It would be useful and productive to continue the dialog begun in this workshop and to continue to engage the organizations and stakeholders represented here.
- The workshop served a useful purpose, included interactive discussions, and brought together a good cross-section of affected parties. It was noted that a few perspectives—venture capitalists, certain other agencies (e.g., the Bureau of Land Management), and local communities and mariners in affected regions—were missing and could be consulted in the future. Public communication about how wind farms relate to critical infrastructure questions is important to consider in the future. Expanding interaction with developments in Europe, from which many lessons can be learned, could also be useful.
- Many participants noted the importance of continuing a total systems approach and seeking to learn as much as possible from other industries. Also noted was that it would be helpful to use a risk-based perspective and identify performance requirements as the process moves forward.
- Developing a more common understanding of terms used in the industry as well as in the promulgation of regulations and standards would be helpful.
- Whatever government process is implemented, participants emphasized that it should facilitate rather than hinder private development and that it therefore should be a simple and productive process.

TRB TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Offshore Wind Energy Workshop

Schedule and Agenda

Thursday, March 25

7:30–8:00 a.m.
Registration and Continental Breakfast — **Keck Lobby**

MORNING PLENARY SESSION — **Keck 100**

8:00–8:10 a.m.
Welcome and Workshop Schedule
Vice Admiral James Card (U.S. Coast Guard, Ret.), Presiding

8:15–9:00 a.m.
Overview: What MMS Wants from the Workshop
John Cushing, MMS Senior Technical Advisor

9:00–9:45 a.m.
The Role of CVAs in Offshore Wind Projects: Charting a Course
Dr. Malcolm Sharples, Offshore Risk and Technology Consulting, Inc.

9:45–10:00 a.m.
Break

10:00–10:45 a.m.
Panel A: Safety Principles for Construction and Operations
Moderator: Ali Mosleh, University of Maryland
Speakers: Alberto Morandi, American Global Maritime, Inc.
Stephen Devoy, MatthewsDaniel Company
Discussants: Jim Magill, U.S. Coast Guard
David J. Wisch, Chevron

10:50–11:50 a.m.
Panel B: The CVA Process: How Can It Be Adapted for Offshore Wind Projects?
Moderator: Jeremy Firestone, University of Delaware
Speakers: Peter Casbarian, Casbarian Engineering Associates, LLC
Kent Dangtran, Dangtran OTC, LLC
Kenneth Richardson, American Bureau of Shipping

Noon–1:00 p.m.
Panel C: What Existing Standards Are Available and Could Be Applied or Adapted?
Moderator: David J. Wisch, Chevron
Speakers: Dan Dolan, MMI Engineering
Matthias Laatsch, Germanischer Lloyd
- *Guideline for the Certification of Offshore Wind Turbines*
- *Standard Design of Offshore Wind Turbines*

Sean Verret, Energo Engineering

1:15–2:00 p.m.
Lunch in Breakout Rooms **As Assigned**

AFTERNOON BREAKOUT SESSIONS

Participants in each of the four breakout groups are asked to review existing data and information on the given subject presented in the plenary session and offer comments on how critical the issue is and what could be done to develop an effective and efficient process (using the CVA approach) for ensuring safe operating environments for U.S. offshore wind energy projects in the future. Specific questions include:

- What did participants learn from the presentations at this workshop?
- What other substantive studies have been done on the subject, and what information is available from other sources?
- How critical is this issue to designing an effective CVA process?
- What information is missing and how can it be obtained?
- What important tasks could be undertaken in the near term?

2:15–5:15 p.m.
Breakout Discussion Groups

Group 1: CVA Role and Qualifications **Keck 100**
Leader: Jeremy Firestone, University of Delaware
Rapporteur: Joedy Cambridge, TRB, Marine Board
Description: This group will continue and expand discussion of the topic introduced by Panel B regarding how the CVA process can be adapted for offshore wind projects.

Group 2: Standards and Practices **Keck 101**

Leader: Judith Hill Harris, City of Portland, Maine
Rapporteur: Jill Wilson, TRB
Description: This group will continue and expand discussion of the topic introduced by Panel C regarding what existing design, construction, and operation standards are available from various sources within and outside the United States and could be applied or adopted for use in offshore wind energy development projects. Participants will discuss appropriate standards in use in other regions of the world for similar projects as well as those in use in other industries that have similar requirements and functions. Participants will comment on where additional or new standards for wind energy projects need to be developed, tested, or proven effective and useful.

Group 3: Metocean Data to Define Maximum Design Conditions **Keck 109**

Leader: Steven R. Barnum, Hydrographic Consultation Services
Rapporteur: Peter Johnson, TRB
Description: This group will explore questions related to the availability and applicability of the metocean data (e.g., winds, waves, currents, storms) needed for setting design conditions for offshore wind energy systems. Participants will comment on whether sufficient data are available and whether new data collection and analyses would be needed for the specific regions where projects might be proposed. They will consider the question of maximum storm conditions that could be used for system requirements.

Group 4: Other System Design and Performance Concerns **Keck 110**

Leader: David J. Wisch, Chevron
Rapporteur: Beverly Huey, TRB
Description: This group will discuss certain remaining system design and performance factors unique to offshore wind energy developments that might raise safety concerns or create risks to human health or the environment—factors that should be subject to setting minimum standards and safe practices. Among those factors that may be included are turbine certification practices and their applicability to U.S. offshore projects, safety practices for operation and maintenance of wind generator systems, storm shutdown practices, and topside structural designs.

5:30–7:00 p.m.
Reception and Buffet **3rd Floor Atrium**

Friday, March 26

7:30–8:15 a.m.
Continental Breakfast — **Keck Lobby**

MORNING PLENARY SESSION — **Keck 100**

8:15–8:30 a.m.
Review of the Schedule
Vice Admiral James C. Card (U.S. Coast Guard, Ret.), Presiding

8:30–10:00 a.m.
Report-Outs from Breakout Groups

Group 1: CVA Role and Qualifications
Group 2: Standards and Practices
Group 3: Metocean Data to Define Maximum Design Conditions
- Report
- Existing Metocean Models

Group 4: Other System Design and Performance Concerns

10:00–10:15 a.m.
Break

10:15–11:15 a.m.
MMS Response and Reaction
Comments and Questions and Answers with Audience

11:15–Noon
Wrap-Up and Next Steps

Noon
Adjourn

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March 25–26, 2010
Washington, D.C.

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SAFETY AND REGULATION

James C. Card, *Chair*, (U.S. Coast Guard, Ret.) offers professional services to the maritime community based on 42 years of maritime safety, security, and environmental protection experience in the U.S. Coast Guard and the American Bureau of Shipping (ABS). As senior vice president and chief technology officer at ABS, he was responsible for overall management of ABS global technology, research, and rule development for ships and offshore facilities. He enjoyed a 36-year career with the U.S. Coast Guard that included positions as vice commandant, commander of the Pacific area, and assistant commandant for marine safety, security, and environmental protection. As leader of the nation's marine safety, maritime security, and environmental protection programs, he carefully balanced national needs and priorities with those of maritime commerce. He has authored many papers on marine safety, environmental protection, and concepts for tankers and human factors in marine operations. During his Coast Guard career, he led many U.S. delegations to the International Maritime Organization. Admiral Card is a graduate of the U.S. Coast Guard Academy, the Massachusetts Institute of Technology (MS degrees in naval architecture and marine engineering and mechanical engineering), and the Industrial College of the Armed Forces.

RISK ASSESSMENT

Ali Mosleh, Professor of Mechanical Engineering at the University of Maryland, conducts research in various risk assessment fields such as expert quantitative opinion, reliability growth modeling, probabilistic reliability physics, common cause failure analysis, dynamic accident simulation, and dynamic probabilistic risk assessment. He also conducts human reliability analyses and develops methodologies for security risk management and space systems risk analysis. He has performed risk and safety assessment, reliability analysis, and decision analysis for the nuclear, chemical, and aerospace industries. Dr. Mosleh is the editor of four books and the author or coauthor of four source books and guidebooks and more than 140 papers in technical journals and for conferences. He was the organizer or chairman of numerous international conferences and technical sessions. He chairs the Engineering Division of the International Society for Risk Analysis and is a board member of the International Association of Probabilistic Safety Assessment and Management. He is a member of the board of editors of the *Journal of Reliability Engineering and System Safety*. He is a member and program chairman of the Executive Committee of the Human Factors Division, American Nuclear

Society, as well as a member of the Risk Analysis Methodology Committee, International Society for Risk Analysis. He also serves as codirector of the Center for Technology Risk Studies at the Clark School of Engineering, University of Maryland. Dr. Mosleh is an expert consultant to national and international organizations on risk and reliability issues. He has a PhD in nuclear science and engineering from the University of California, Los Angeles.

OFFSHORE SYSTEMS ENGINEERING

David J. Wisch is a ChevronTexaco Fellow with Upstream Technology–Engineering and Construction Management, responsible for core technology, R&D coordination, codes and standards, industry committee activities, structural engineering, computer operations, and administrative support. He is a member of the American Petroleum Institute (API) task groups on installation, fatigue, desk leg design, and assessment of existing facilities and chairs the API Committee for Standardization of Offshore and Arctic Structures and Standardization of Offshore and Subsea Structures. He holds BS and MS degrees in civil engineering from the University of Missouri and has done postgraduate studies in the doctoral program at Tulane University.

LAW AND POLICY

Jeremy M. Firestone is an Associate Professor of Marine Policy in the College of Earth, Ocean, and Environment at the University of Delaware. His research interests include U.S. ocean and environmental law and policy; governance, regulation, and intergovernmental relations; and renewable energy policy. He is currently involved in an offshore wind energy project focused on understanding the values associated with and the development of a policy framework for offshore wind power development. The goals of the project are to anticipate public positions on offshore wind (both pro and con) to provide a basis for incorporating public views into the design of both communications and policy and to identify problem areas in current law and policy. Dr. Firestone holds a BS in molecular biology from the University of Michigan, a JD from the University of Michigan Law School, and a PhD in public policy from the University of North Carolina at Chapel Hill.

NAVIGATION AND HYDROGRAPHICS

Steven R. Barnum, President of Hydrographic Consultation Services, recently retired from the National Oceanic and Atmospheric Administration (NOAA) after serving 3 years as director of the agency's Office of Coast Survey, where he was the nation's chief hydrographer, responsible for overseeing NOAA's hydrographic services, including the mapping and charting of all U.S. navigational waters. While at NOAA, Captain Barnum also served as head of its commerce and transportation goal team, which is one of the

four major strategic planning units within the agency, where he coordinated activities supporting safe, efficient, and environmentally sound transportation. Immediately before assuming his goal team position, he served as chief of the Office of Coast Survey's Navigational Services Division. Captain Barnum began his career with NOAA in 1980, when he was commissioned as an ensign in the NOAA Corps. He has specialized in Coast Survey mission objectives for the most part and has more than 8 years of hydrographic field operations aboard five NOAA ships. His ship assignments include serving as commanding officer of the NOAA ships *Thomas Jefferson* and *Whiting*. He holds a BS in electrical engineering from Louisiana Tech University, a BS in computer science from the University of Maryland, and an MS in software engineering from the Johns Hopkins University.

MARINE ENVIRONMENT AND POLICY

Judith Hill Harris serves as Director, Department of Transportation, for the City of Portland, Maine. Her areas of responsibility include operations, planning and regulatory compliance for transportation policy, port security, marine environmental issues, and commercial fisheries. She is also responsible for port security grant funding. She has served on the State of Maine's Homeland Security Planning Team and on the Maine Emergency Management Weapons of Mass Destruction Response Team and is the former chair of the Port of Portland's Maritime Disaster Task Force. She also serves as a technical advisor to the Muskie School of Public Service, University of Maine, for the State of Maine's National Pharmaceutical Stockpile plan and to the Greater Portland Council of Governments Hazardous Waste Commodity Flow Study and Disaster Planning Team. Ms. Harris is a former member of the Federal Commercial Fishing Industry Safety Advisory Committee and is a current member of the Traffic Board of the North Atlantic Ports Association; the American Association of Port Authorities' Harbors, Navigation, and Environment Committee; and the Area Maritime Security Committee. Before joining the Department of Ports and Transportation, Ms. Harris was executive vice president and chief financial officer of Seafood Management Corporation for 15 years, where she advised large corporate clients on mergers and acquisitions, strategic planning, resource plans, security and intelligence, and technology transfer.