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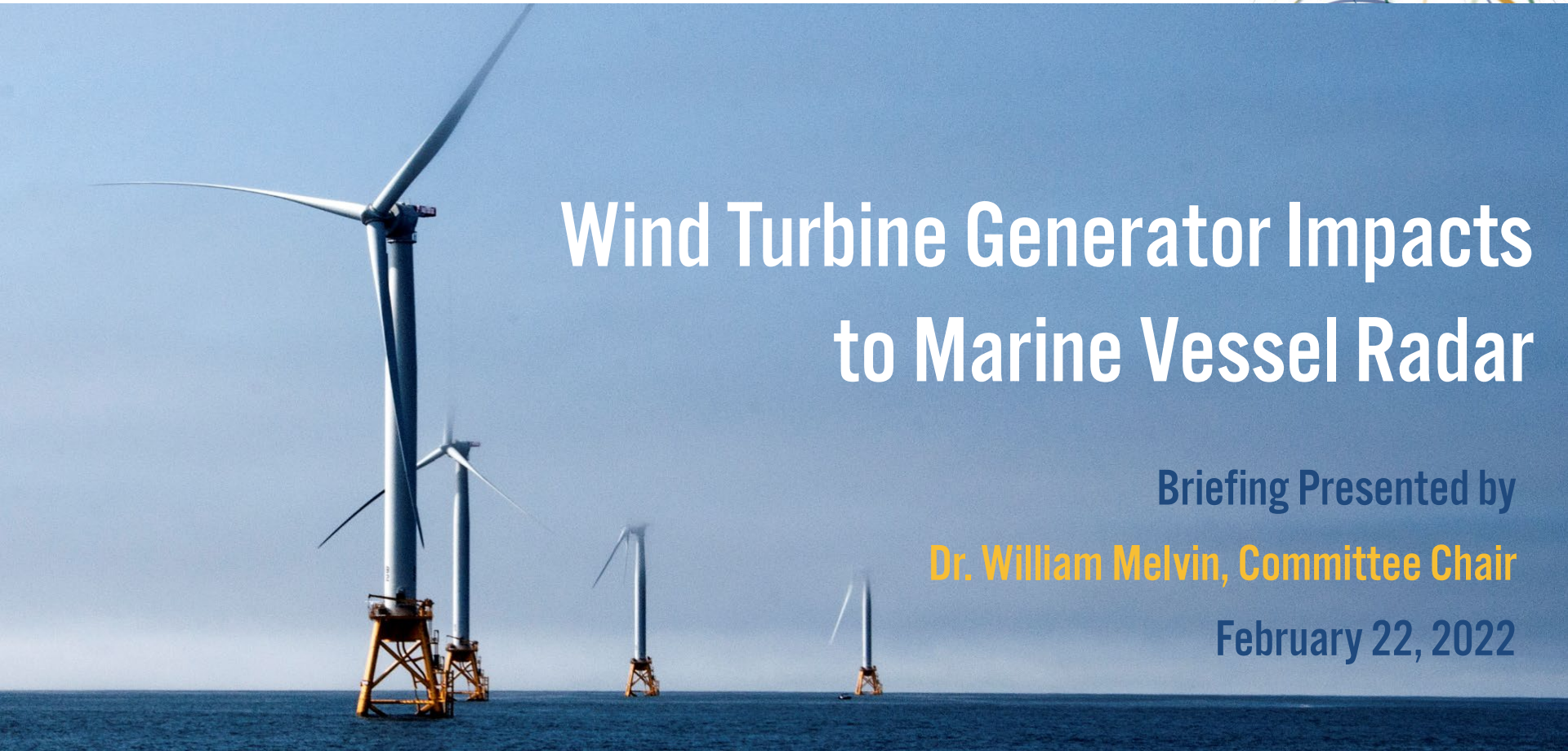


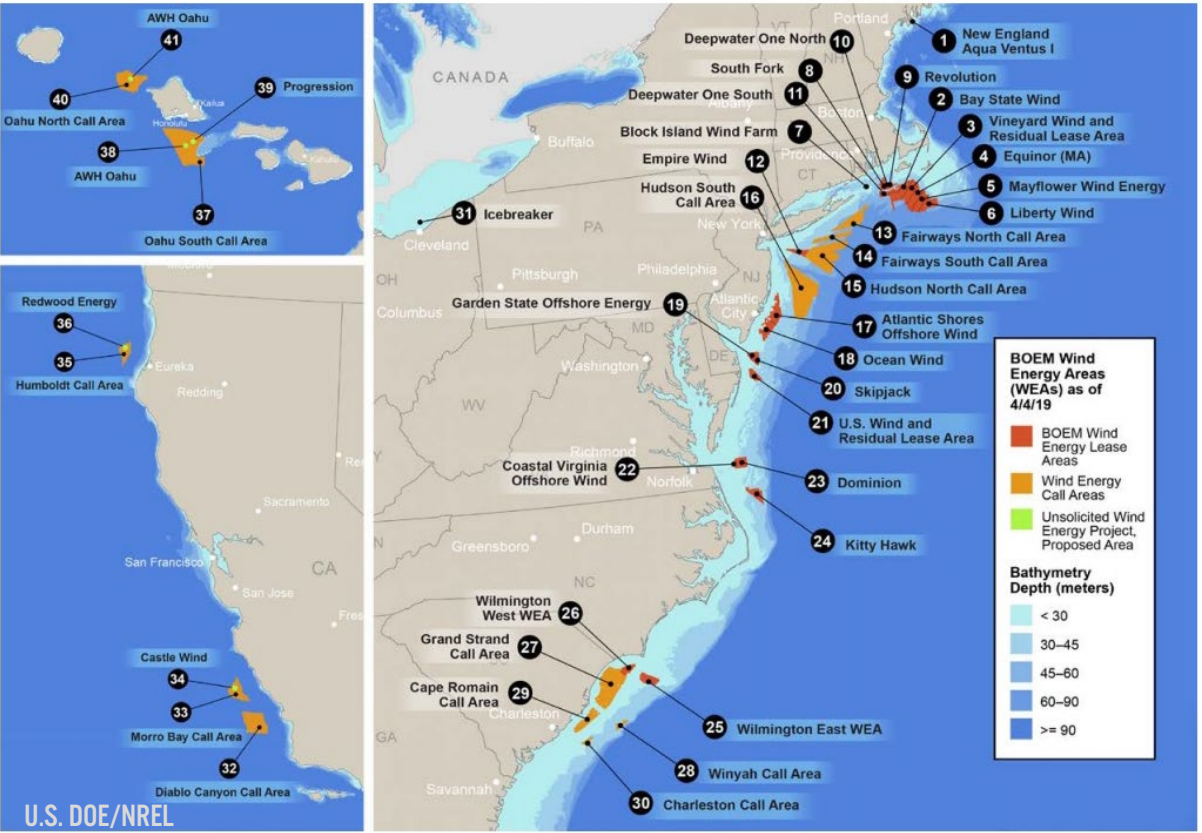
Wind Turbine Generator Impacts to Marine Vessel Radar

Briefing Presented by

Dr. William Melvin, Committee Chair

February 22, 2022

Study Context

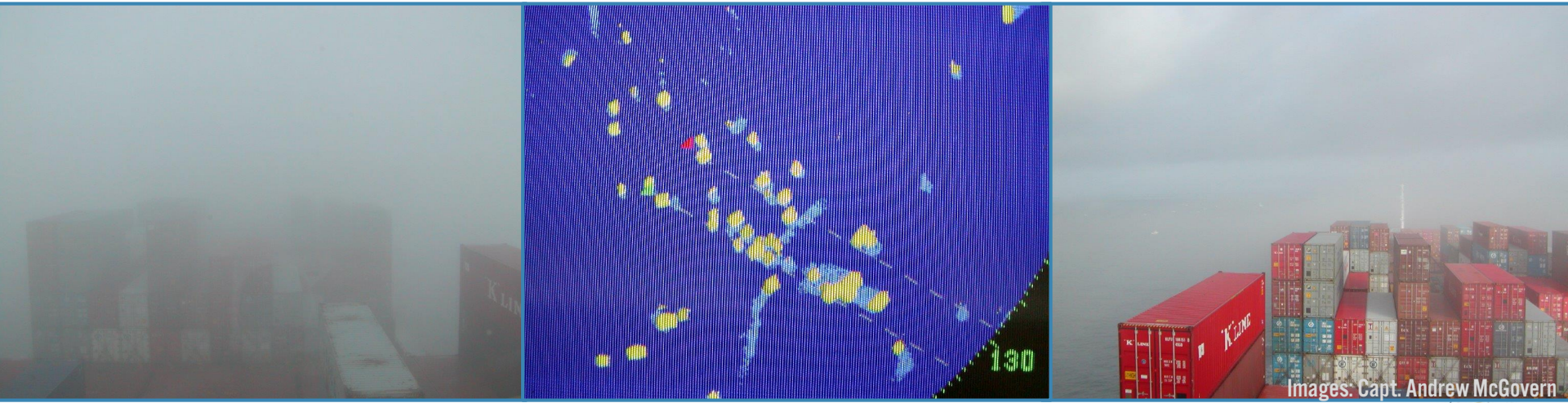


- Offshore wind energy development is expanding across the U.S. Outer Continental Shelf (OCS)

- Executive Order 14008
  - 30 Gigawatts of offshore wind energy by 2030

Study Context

- Marine Vessel Radar (MVR) – a critical tool used by operators to navigate & avoid collision & allision



Images: Capt. Andrew McGovern

Study Context


Norfolk, UK. Image: Ian

Concerns raised during past Bureau of Ocean Energy Management (BOEM) outreach:

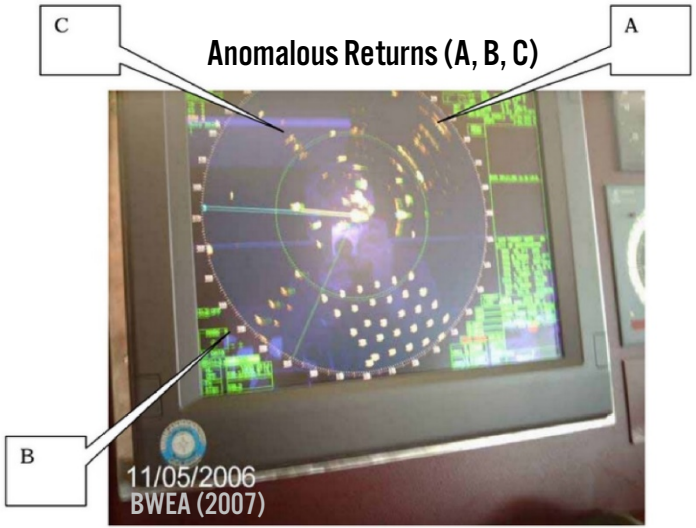
- WTGs may cast radar shadows, obfuscating smaller vessels exiting wind facilities

- Limited amount of research conducted on this topic & other possible forms of radar interference (e.g., radar clutter & false signaling)

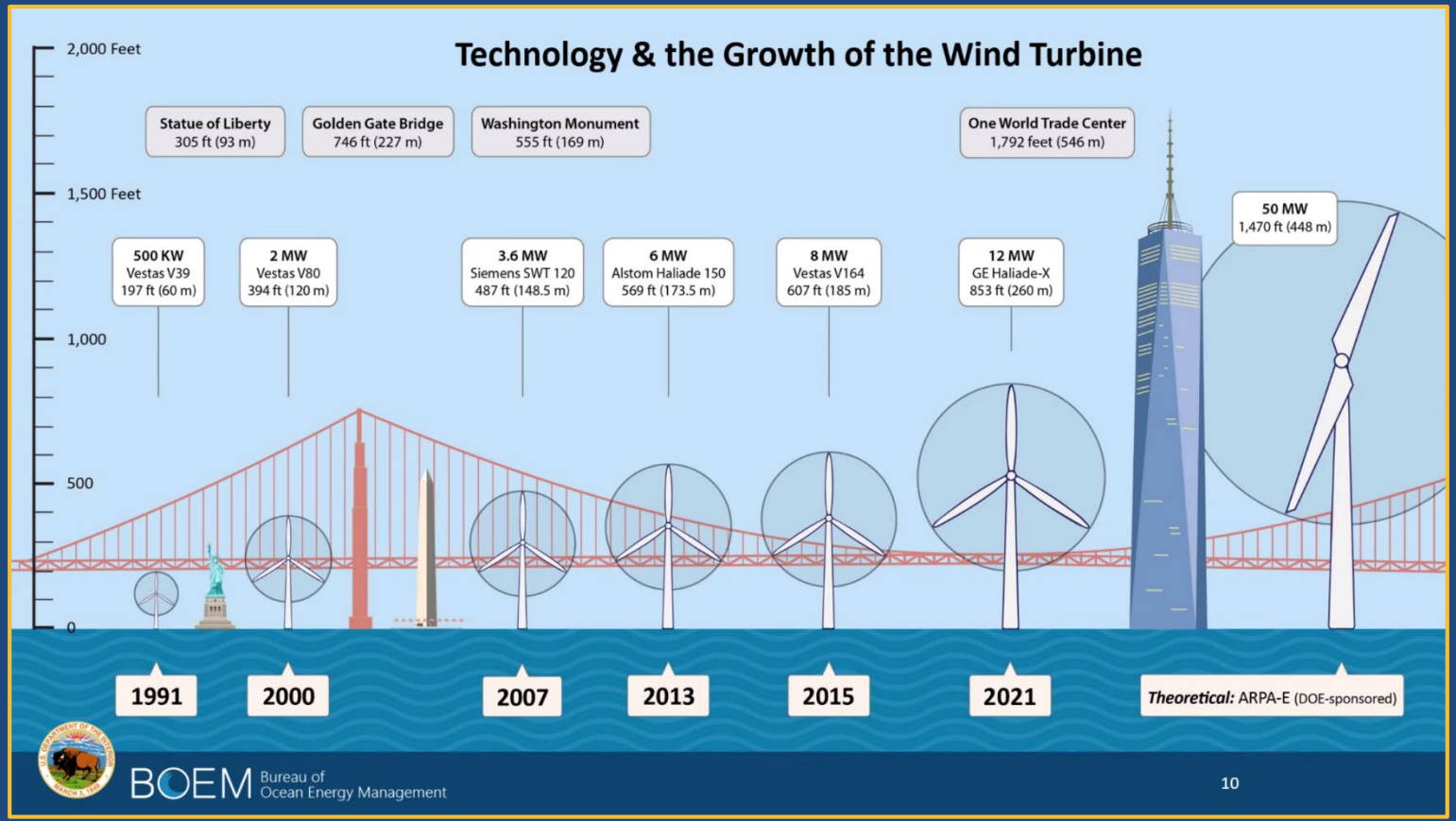
Study Context


Kentish Flats and CWind Tempest. Image: CWind

- Example: 2007 British Wind Energy Association study of the U.K. Kentish Flats Wind Farm



Study Context



Study Context


Block Island Wind Farm Image: U.S. DOE

- WTGs have significant electromagnetic reflectivity
- Rotating blades can return large, numerous Doppler-shifted reflections

- 2014 → Wind Turbine Radar Interference Mitigation (WTRIM) Working Group

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Committee Charge

Assess impacts of offshore wind turbine generators (WTGs) on marine vessel radar

Identify techniques that can be used to mitigate those impacts

Study Committee

William Melvin, Chair

- Georgia Institute of Technology, Georgia Tech Research Institute, Smyrna, GA

Jennifer Bernhard

- University of Illinois at Urbana-Champaign, Champaign, IL

Andrew McGovern

- New Jersey Sandy Hook Pilots Association (Ret.), Great River, NY

Benjamin Karlson

- Sandia National Laboratories, Albuquerque, NM

Hao Ling

- The University of Texas at Austin (Ret.), Austin, TX

John Stone

- United States Coast Guard, Washington, DC

Committee Methods


Image: WindEurope

1. Literature Review & Information-Gathering
2. Radar Analysis

Committee Methods

Information-Gathering Approach:

1. Navigation safety
2. Offshore WTG characteristics & deployment
3. MVR design & operation
4. Electromagnetic characteristics of WTGs
5. The impact of WTGs on MVR performance
6. Strategies to mitigate the impact of WTGs on MVR

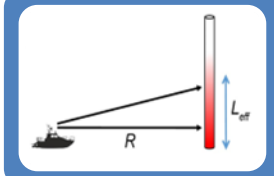
→ Findings
2 Conclusions
2 Recommendations

WTG Impacts to MVR

- WTGs in the maritime environment affect MVR in a situation-dependent manner
- Most common impact:
  - Substantial increase in strong, reflected energy cluttering the operator's display → complications in navigation decision-making

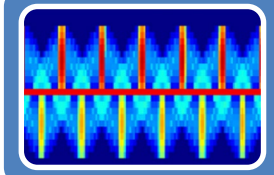
WTG Impacts to MVR

- WTGs cause radar returns that may appear as interference to MVR & could obfuscate radar returns of smaller watercraft or stationary objects



strong stationary returns from the wind turbine tower

the potential for a strong blade flash return for certain geometries and relative radar-vessel positions



Doppler-spread clutter generated along the radial extent of the WTG blade

WTG Impacts to MVR

- Multipath reflection from an observer's shipboard MVR → ambiguous returns
- Other effects: ducting & shadowing

WTG Impacts to MVR

- Magnetron vs Doppler-Based Solid State MVR
  - WTGs reduce effectiveness of both (via different mechanisms)
  - No published studies of WTG interference on Solid-State MVR used for marine navigation

WTG Impacts to MVR

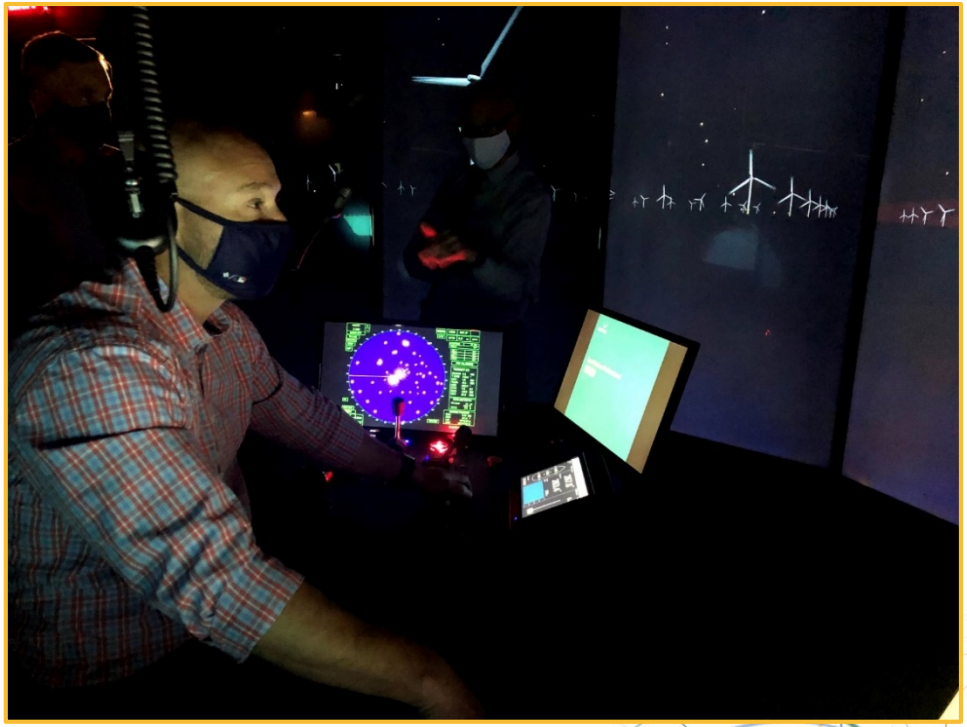
Recommendation (Abrv.): BOEM & other relevant federal agencies (e.g. members of the federal Wind Turbine Radar Interference Mitigation Working Group) should pursue any practicable opportunities to fill gaps in understanding of WTG impacts on MVRs operated in & adjacent to wind farms, giving attention to:

- Comprehensive test planning, data collection, & evaluation over a range of expected, operational conditions
- Innovative & collaborative approaches to facilitate data collection
  - E.g., establishment of a MVR "sensor integration lab" for all classes or types of MVRs & the development of a validated modeling & simulation capability

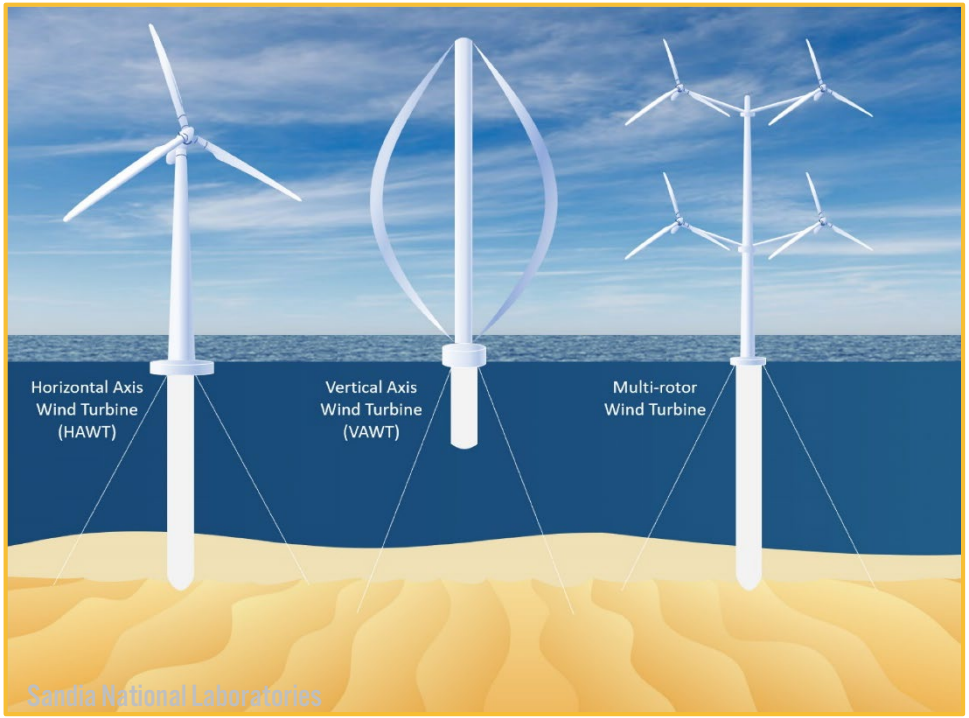

Norfolk, UK. Image: M. Cooper

WTG Impacts to MVR

- Improvements to operator training models based on verification with physics-based models anchored by field collected data



WTG Impacts to MVR



- Research, development, & characterization of reduced radar-cross-section WTGs for MVR
- Data collection & analysis using prototype systems preceding the full deployment of Vertical Axis Wind Turbines
- Data collection & analysis on floating WTGs

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Mitigation

- Opportunities exist to ameliorate WTG-induced interference on MVRs using both active & passive means, such as:
  - Improved radar signal processing
  - Display logic or signature-enhancing reflectors on small vessels to minimize lost contacts

Mitigation

Recommendation (Abrv.): BOEM & other relevant federal agencies (e.g., members of the federal Wind Turbine Radar Interference Mitigation Working Group) should pursue any practicable options to mitigate WTG impacts on MVRs. BOEM & partners should give attention to:

- International Maritime Organization's Standards of Training, Certification and Watchkeeping (STCW) Knowledge, Understanding & Proficiency standards to include operating in or adjacent to multiple structures at sea
  - Similar radar observer training should be considered for U.S. credentialed mariners not subject to STCW code who operate vessels equipped with radar in the vicinity of WTGs

Mitigation

- Updated requirements for vessels <150 gross tonnage to exhibit a radar reflector of suitable size & design while underway in or adjacent to a wind farm to improve their detectability when practicable

- Deployment of reference buoys adjacent to wind farms to provide mariners a reference target to appropriately adjust MVR gain & other control settings to assist in the detection of smaller targets operating in the vicinity of wind farms

Mitigation

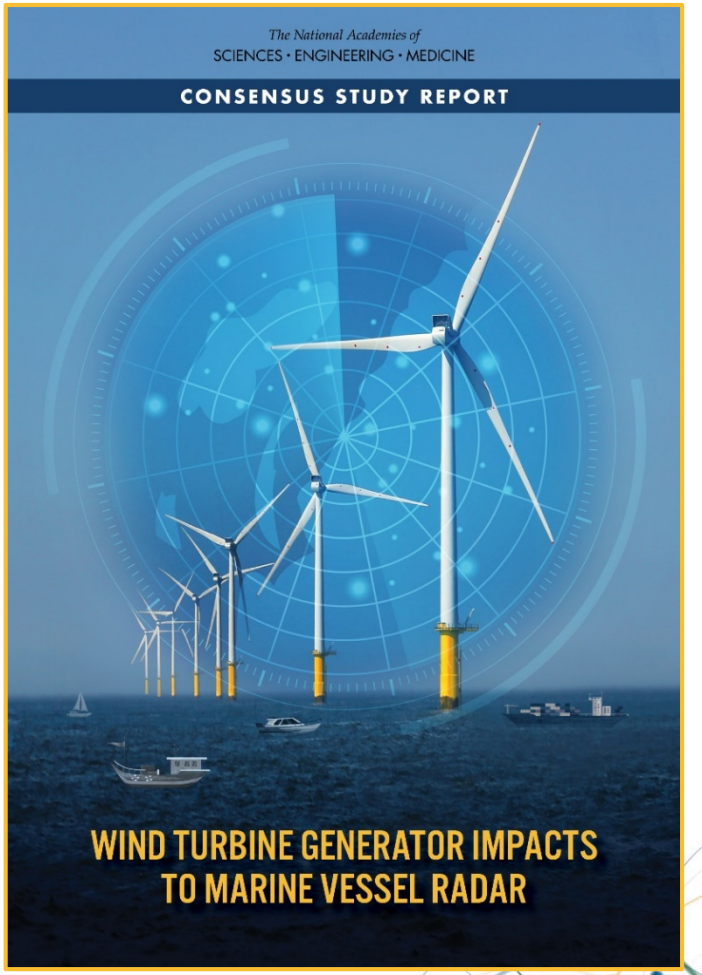
- Evaluation and standardization of radar mounting procedures on marine vessels to mitigate the impact of near-field platform interference on radar performance
- Promotion of radar designs with increased immunity to WTG interference, such as new, Doppler-based, solid-state MVRs with WTG resilience

Mitigation

- Research & development to prove the performance and feasibility of fieldable material & structural WTG design components to reduce the radar cross section of WTGs

Thank you

The report is available for download at nap.edu.



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Backup Slides

Main Takeaways

WTG Impacts

Wind turbines in the maritime environment affect MVR in a situational-dependent manner, with the most common impact being a substantial increase in strong, reflected energy cluttering the operator's display, leading to complications in navigation decision-making

Mitigation

Opportunities exist to ameliorate WTG-induced interference on the MVR using both active and passive means, such as improved radar signal processing and display logic or signature-enhancing reflectors on small vessels to minimize lost contacts

Statement of Task

An ad hoc committee of the National Academies of Sciences, Engineering, and Medicine will undertake a study to assess impacts of offshore wind turbine generators (WTG) on marine vessel radar and identify techniques that can be used to mitigate those impacts. The study will use a combination of literature review and, if informative and practical, apply or adapt existing models to:

- determine and characterize the impacts of WTG on efficacy of marine vessel radar operated on vessels both within and near existing offshore wind facilities, as well as those facilities anticipated to be installed over the next 15 years on the U.S. outer continental shelf; and

- identify actions that could be taken to reduce the impacts on marine vessel radar to preserve its use as a navigational aid for vessels both in and near WTG facilities.

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Statement of Task

- The analysis of impacts to marine vessel radar will include, but not be limited to, parameters such as radar type, radar height, radar range, vessel type and size (vessel carrying radar and vessels to be detected), vessel speeds, turbine height, and turbine spacing.
- The study will analyze potential impacts from the WTG on the ability to navigate in adverse weather conditions and to detect small fixed objects such as buoys.
- The study will estimate the magnitude of clutter, mirroring, shadowing, and any other impacts observed or predicted to be caused by WTGs.
- Finally, the study will consider a variety of mitigation methods including signal filtering, radar antenna relocation, operational training, and replacement of new radar technology, as well as other possible approaches. The study will examine the feasibility of each proposed mitigation method based on vessel type.