

# Decarbonization Research Consortium

**WELCOME**

*12 May 2023*

[nps.edu/decarb](https://nps.edu/decarb)

**Decarbonization Research Consortium Meeting**  
**12 May 2023 / 1 – 3 pm ET / 10 am – Noon PT**  
**VIRTUAL**

**Agenda**

- 1:00 – 1:10      Welcome/Introductions  
Follow-up from 13 April Meeting
- 1:10 – 1:25      Presentation: Siemens Energy
- 1:25 – 2:45      Decarb Research Roadmap Discussion
- 2:45 – 3:00      Admin/Homework/Conclusion

# ONR Decarbonization Research Consortium

## Research Agenda and Roadmap Discussion

*12 May 2023*

*Bill Muras*

[nps.edu/decarb](https://nps.edu/decarb)

# Agenda/Outline

- BLUF/Exec Summary
- Consortium Mission Statement and Purpose
- Guidance Documents, Alignment and Timelines
- Navy Specific Considerations and Constraints
- **Thrust Areas and Cross Cutting Initiatives**
- **Summary of Current Activities**
- **Identified Gaps**
- Year 1 Research Agenda
- DRAFT Summary Integrated Roadmap
- Next Steps

\*\*\* Need Consortium Member feedback on categories\*\*\*

# Thrust Areas & Cross-Cutting Initiatives

	Approx Impact to Operational Navy Decarbonization (%)	Category	Sub-Category
Major Thrust Areas	5% - 15%	Energy Efficiency Technology	Propulsive efficiency improvements & direct drag reduction
			Propulsion & power generation improvements
			Electrification & hybridization
			Thermal Mgmt, WHR/EGR & materials
			Demand Reduction
			Energy Storage
			Lightweight Materials
	5% - 15%	Operational Efficiency Improvements	Route planning
			Plant & Speed Optimization
			Trim Optimization
	TBD	Force Structure	Unmanned systems
			"Single Mission Optimized" platforms
			Attritable assets
			UxV system modeling
	20% - 70%	Fuel Technologies (Production and/or Use)	Bio-, Renewable-, E-Fuels
			Green Ammonia/Green Methanol
			Hydrogen
			Batteries
			Nuclear
			Renewable Energy
			Fuel Cell Technology
	TBD	Carbon Capture, Use and Storage	Shipboard
			Terrestrial
Cross-Cutting Initiatives	N/A	Whole ship and system level design considerations	Ship design process
			System level design considerations
	N/A	Ship integration and technology scaling for shipboard use	Ship integration
			Scaling for shipboard use
	N/A	Modeling, test sites and demonstration capability	Modeling & data analytics
			Bench scale testing
	TBD	Education and Training	Demonstrations & testing
			Education & Training

# Summary of Current (Navy) Activities

- **Work so far**
  - **Using Navy Operational Energy and Climate “tagged” investment**
  - **Eliminate duplicates and bucket into major category and up to 3 sub-categories**
  - **Summarized and presented on following pages**
- **More to do ... still need to consider ...**
  - **SME and PI/PO discussions/outreach**
    - **Deeper dive into various R&D programs**
  - **2021 DoD Energy & Power COI Roadmap**
  - **ONR Power & Energy Focus Area**
  - **Consortium member feedback**
  - **DOE, DOT and other DoD activities**

# Example – NAVSEA Detail

				NAVSEA CURRENT EFFORTS - OE and PBIS Climate Tagging			
	Approx Impact to Operational Navy Decarbonization (%)	Category	Sub-Category	Project Counts			
				Major Category	Primary SubCategory	Secondary SubCategory	Tertiary SubCategory
Major Thrust Areas	5% - 15%	Energy Efficiency Technology	Propulsive efficiency improvements & direct drag reduction	23	4	0	0
			Propulsion & power generation improvements		7	3	0
			Electrification & hybridization		2	6	0
			Thermal Mgmt, WHR/EGR & materials		2	0	0
			Demand Reduction		8	0	0
			Energy Storage		0	12	0
			Lightweight Materials		0	0	0
	5% - 15%	Operational Efficiency Improvements	Route planning	5	0	0	0
			Plant & Speed Optimization		5	0	0
			Trim Optimization		0	0	0
	TBD	Force Structure	Unmanned systems	0	0	0	1
			"Single Mission Optimized" platforms		0	0	0
			Attritable assets		0	0	0
			UxV system modeling		0	0	0
	20% - 70%	Fuel Technologies (Production and/or Use)	Bio-, Renewable-, E-Fuels	13	0	0	0
			Green Ammonia/Green Methanol		0	0	0
			Hydrogen		0	1	0
			Batteries		11	0	0
			Nuclear		0	0	0
			Renewable Energy		2	0	0
			Fuel Cell Technology		0	0	0
	TBD	Carbon Capture, Use and Storage	Shipboard	0	0	0	0
			Terrestrial		0	0	0
Cross-Cutting Initiatives	N/A	Whole ship and system level design considerations	Ship design process	0	0	0	0
			System level design considerations		0	0	0
	N/A	Ship integration and technology scaling for shipboard use	Ship integration	0	0	0	0
			Scaling for shipboard use		0	0	0
	N/A	Modeling, test sites and demonstration capability	Modeling & data analytics	1	1	0	5
			Bench scale testing		0	2	2
			Demonstrations & testing		0	0	0
	TBD	Education and Training	Education & Training	0	0	5	0
		Other	Other	2	2	2	2
		Unknown	Unknown	1	1	1	1
			N/A		0	13	34

# Navy Current Activity - Stoplight Chart

	Approx Impact to Operational Navy Decarbonization (%)	Category	Sub-Category	Navy Entity		
				ONR	NAV SEA	NAV AIR
Major Thrust Areas	5% - 15%	Energy Efficiency Technology	Propulsive efficiency improvements & direct drag reduction	0	4	2
			Propulsion & power generation improvements	9	10	2
			Electrification & hybridization	4	8	0
			Thermal Mgmt, WHR/EGR & materials	7	2	5
			Demand Reduction	4	8	4
			Energy Storage	6	12	1
			Lightweight Materials	0	0	1
	5% - 15%	Operational Efficiency Improvements	Route planning	1	0	2
			Plant & Speed Optimization	0	5	0
			Trim Optimization	0	0	0
	TBD	Force Structure	Unmanned systems	0	1	4
			"Single Mission Optimized" platforms	0	0	0
			Attritable assets	0	0	0
			UxV system modeling	0	0	0
	20% - 70%	Fuel Technologies (Production and/or Use)	Bio-, Renewable-, E-Fuels	2	0	2
			Green Ammonia/Green Methanol	0	0	0
			Hydrogen	3	1	2
			Batteries	3	11	2
			Nuclear	0	0	0
			Renewable Energy	3	2	0
			Fuel Cell Technology	0	0	1
	TBD	Carbon Capture, Use and Storage	Shipboard	2	0	0
			Terrestrial	2	0	0
Cross-Cutting Initiatives	N/A	Whole ship and system level design considerations	Ship design process	1	0	0
			System level design considerations	0	0	0
	N/A	Ship integration and technology scaling for shipboard use	Ship integration	0	0	0
			Scaling for shipboard use	0	0	0
	N/A	Modeling, test sites and demonstration capability	Modeling & data analytics	4	6	1
			Bench scale testing	0	4	0
			Demonstrations & testing	0	0	0
	TBD	Education and Training	Education & Training	2	5	0



# Navy Current Activity - Stoplight Summary

	Approx Impact to Operational Navy Decarbonization (%)	Category	Sub-Category					
				Navy	Other DoD	DOE	DOT	Other
Major Thrust Areas	5% - 15%	Energy Efficiency Technology	Propulsive efficiency improvements & direct drag reduction	6				
			Propulsion & power generation improvements	21				
			Electrification & hybridization	12				
			Thermal Mgmt, WHR/EGR & materials	14				
			Demand Reduction	16				
			Energy Storage	19				
			Lightweight Materials	1				
	5% - 15%	Operational Efficiency Improvements	Route planning	3				
			Plant & Speed Optimization	5				
			Trim Optimization	0				
	TBD	Force Structure	Unmanned systems	5				
			"Single Mission Optimized" platforms	0				
			Attritable assets	0				
			UxV system modeling	0				
	20% - 70%	Fuel Technologies (Production and/or Use)	Bio-, Renewable-, E-Fuels	4				
			Green Ammonia/Green Methanol	0				
			Hydrogen	6				
			Batteries	16				
			Nuclear	0				
			Renewable Energy	5				
			Fuel Cell Technology	1				
	TBD	Carbon Capture, Use and Storage	Shipboard	2				
			Terrestrial	2				
Cross-Cutting Initiatives	N/A	Whole ship and system level design considerations	Ship design process	1				
			System level design considerations	0				
	N/A	Ship integration and technology scaling for shipboard use	Ship integration	0				
			Scaling for shipboard use	0				
	N/A	Modeling, test sites and demonstration capability	Modeling & data analytics	11				
			Bench scale testing	4				
			Demonstrations & testing	0				
	TBD	Education and Training	Education & Training	7				

# Summary of Major Efforts - Preliminary

Category	Sub-Category	Summary of Major Efforts
Energy Efficiency Technology	Propulsive efficiency improvements & direct drag reduction	<p><b>LCS Stern Flaps:</b> Procurement of stern flaps to be install on the hull of LCS-1 class ships to reduce resistance.</p> <p><b>Finlets:</b> Advanced Component Development of aircraft finlets to reduce drag on Navy and Marine Corps C-130 aircraft</p> <p><b>Hull Husbandry:</b> Advance Component Development to identify and evaluate new underwater hull coating systems and underwater hull cleaning and maintenance techniques to reduce hydrodynamic drag on ships.</p>
	Propulsion & power generation improvements	<p><b>PA6B Electronic Fuel Injection:</b> Advanced Component Development to upgrade the fuel injection system on the Fairbanks Morse (FM) PA6B Diesel Engines.</p> <p><b>Variable Cycle Advance Technology:</b> Applied research to develop variable geometry and adaptive cycle gas turbine engine technology for next generation air dominance aircraft.</p> <p><b>T-AO 205 Efficient Replacement Engines:</b> Ship Construction investment to integrate more efficient engines on future T-AO 205 Class ships.</p> <p><b>Aircraft Turbine Engine Recuperator:</b> Advanced Component Development to demonstrate an advanced recuperator design on the M250 (helicopter engine).</p> <p><b>Aircraft, Engine Blade Scanning and Coating:</b> Advanced Component Development of blade scanning technology and turbine engine coatings for compressors blades for naval aircraft</p>
	Electrification & hybridization	<p><b>Integrated Power Systems:</b> The Navy's DDG(X) Program Office continues Advanced Component Development of Next Generation Integrated Power and Energy Systems, including a full scale Integrated Test Facility, with intent to incorporate an integrated power system on the next Large Surface Combatant.</p> <p><b>Electric Ship Research and Development Consortium (ESRDC):</b> Maintains applied research across 8 universities focused on advancing afloat power systems.</p> <p><b>Power Electronics Building Block:</b> Applied Research in power electronics building blocks for energy storage and distribution</p> <p><b>Silicon Carbide Power Modules:</b> Advanced Component Development to develop, qualify, and integrate SiC devices into prototype power converters.</p>
	Thermal Mgmt, WHR/EGR & materials	<p><b>Aircraft, Integrated Thermal and Power Management Modelling:</b> Advanced Component Development to validate integrated power and thermal management models for legacy and emerging platforms</p>
	Demand Reduction	<p><b>LED Lighting:</b> Procurement of LED Lighting to replace conventional lighting on DDG-51 class ships and Combat Logistics Ships.</p> <p><b>Efficient Transmit/Receive Integrated Multichip Modules (TRIMMs):</b> System Development and Demonstration to swap high power amplifiers with higher efficiency power amplifiers on DDG-51 Class Radar and Electronic Warfare systems.</p> <p><b>Variable Frequency Drives (VFDs):</b> Operations &amp; Maintenance to integrate Variable Frequency Drives on Combat Logistics Ships to reduce load from seawater pumps.</p>
	Energy Storage	<p><b>Energy Magazine:</b> Advanced Technology Development in Energy Magazine energy storage for future surface combatants.</p> <p><b>Energy Storage Flywheel:</b> Advance Component Development of a carbon nanotube energy storage flywheel for potential application on Navy ships and submarines.</p>
	Lightweight Materials	

*IN WORK*

# Summary of Major Efforts - Preliminary

Category	Sub-Category	Summary of Major Efforts
Operational Efficiency Improvements	Route planning	<b>Integrated Climate Weather and Ocean Decision Support:</b> Applied Research on improved integration of weather and ocean forecasts into ship routing, ship response and propulsion efficiency planning, and Refueling at Sea logistics planning, as well as prediction of hazardous and extreme weather events and trends for climate adaptation, resiliency, and mitigation. <b>Aerial Refueling Drogue Stabilization:</b> Advanced Component Development of Aerial Refueling Drogue Stabilization technology to reduce refueling drogue capture time.
	Plant & Speed Optimization	<b>Global Energy Information System (GENISYS):</b> Advanced Component Development and Operations & Maintenance to develop and field a software suite to increase operational reach and endurance through the capture and utilization of shipboard power and energy data on DDG-51 and LPD-17 Class ships <b>Robust Combat Power Control (RCPC):</b> Advanced Technology Development of a Combat Power and Energy Control System to anticipate, align and configure shipboard resources based on system state and mission context. <b>Condition Assessment System:</b> Procurement and integration of Integrated Condition Assessment System(ICAS) and Enterprise Remote Monitoring (eRM) to enable remote monitoring and real time health assessments of shipboard equipment.
	Trim Optimization	
Force Structure	Unmanned systems	<b>MQ-25A Unmanned Aerial Refueler:</b> Advanced Component Development of first CVN-based unmanned aerial refuel (fixed wing UAS). <b>Long Endurance Unmanned Surface Vessel:</b> Applied research to demonstrate commercially available, long endurance USV.
	"Single Mission Optimized" platforms	
	Attritable assets	
	UxV system modeling	

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# Summary of Major Efforts - Preliminary

Category	Sub-Category	Summary of Major Efforts
Fuel Technologies (Production and/or Use)	Bio-, Renewable-, E-Fuels	<p><b>Mobility Fuels Program:</b> Advance Component Development R&amp;D to test all new sources of MIL-STD qualified F76 marine diesel and JP5 aircraft fuel for use in Navy and Marine Corps ships and aircraft.</p> <p><b>Service Review of Commercially Approved SAF:</b> R&amp;D to coordinate a review with other services to consider applications of non-MIL-STD qualified SAF for use in DoD aircraft.</p> <p><b>Direct Air Capture and Blue Carbon Removal Technology:</b> Applied research to development technologies that capture carbon dioxide from seawater and the air to turn such carbon dioxide into clean fuels.</p>
	Green Ammonia/Green Methanol	
	Hydrogen	<p><b>Shipboard Hydrogen R&amp;D:</b></p> <p><b>Refueling &amp; Support Package (RASP):</b> Applied Research to development a hydrogen production system to support unmanned systems fueled on and off ships.</p>
	Batteries	<p><b>Common Affordable Safe Energy Storage (CASES):</b> Advanced Component Development to develop and qualify advanced batteries for integration on Navy and Marine Corps airframes.</p> <p><b>Battery Development and Safety:</b> Advanced Component Development to identify, qualify, and field advanced batteries on naval tactical systems.</p> <p><b>Commercial Advanced Batteries:</b> Coordination of advance batteries R&amp;D with commercial industry, including the automotive industry, to expedite safe fielding of advanced batteries on defense systems.</p> <p><b>Battery Commonality</b></p> <p><b>Battery Certification</b></p> <p><b>Large Format Lithium Ion Batteries</b></p>
	Nuclear	
	Renewable Energy	<p><b>Alternative Energy S&amp;T:</b> ONR maintains Applied Research in advanced energy systems having potential to reduce the cost of energy and increase energy security, reliability, and resiliency.</p> <p><b>Subsea &amp; Seabed Warfare (SSW) Energy Harvesting:</b> Applied Research in renewable energy technologies that would enable recharging of undersea systems.</p> <p><b>Biocentric Technology:</b> Applied Research focusing on microbes that produce electricity from organic matter found in sediment or wastewater.</p> <p><b>Ocean Renewable Energy:</b> Advanced Component Development to field ocean renewable energy, including marine and hydrokinetic energy systems.</p>
	Fuel Cell Technology	<p><b>H2 Stalker:</b> Advanced Component Development of a hydrogen fuel cell power system integrated on the Stalker Group 2 unmanned aerial system.</p> <p><b>Microbial Fuel Cells:</b> Basic Research in electricity harvested from specialized natural bacteria that use non-hazardous organic compounds as fuel, and then provide electrical current to an electrode</p>
Carbon Capture, Use and Storage	Shipboard	<b>Direct Air Capture and Blue Carbon Removal Technology:</b> Applied research to development technologies that capture carbon dioxide from seawater and the air to turn such carbon dioxide into clean fuels.
	Terrestrial	

*IN WORK*

# Summary of Major Efforts - Preliminary

Category	Sub-Category	Summary of Major Efforts
Whole ship and system level design	Ship design process	
	System level design	
Ship integration and technology scaling for	Ship integration	
	Scaling for shipboard use	
Modeling, test sites and demonstration capability	Modeling & data analytics	<b>Theater Energy Model:</b> Integration of energy data, refuel command & control, optimization systems, and force modeling capabilities to establish a theater energy model and perform energy supportability assessments to support real-time energy command & control, and acquisition decision making <b>Modeling &amp; Simulation:</b> Leverage modeling, simulation and data sources to develop assessments and tools to support operational capability assessments
	Bench scale testing	
	Demonstrations & testing	
Education and Training	Education & Training	<b>Workforce Development:</b> Investment in workforce talent and technology development supporting Navy power and energy systems

*IN WORK*

# Preliminary Gap Identification

	Approx Impact to Operational Navy Decarbonization (%)	Category	Sub-Category	Navy
Major Thrust Areas	5% - 15%	Energy Efficiency Technology	Propulsive efficiency improvements & direct drag reduction	6
			Propulsion & power generation improvements	21
			Electrification & hybridization	12
			Thermal Mgmt, WHR/EGR & materials	14
			Demand Reduction	16
			Energy Storage	19
			Lightweight Materials	1
	5% - 15%	Operational Efficiency Improvements	Route planning	3
			Plant & Speed Optimization	5
			Trim Optimization	0
	TBD	Force Structure	Unmanned systems	5
			"Single Mission Optimized" platforms	0
			Attributable assets	0
			UxV system modeling	0
	20% - 70%	Fuel Technologies (Production and/or Use)	Bio-, Renewable-, E-Fuels	4
			Green Ammonia/Green Methanol	0
			Hydrogen	6
			Batteries	16
			Nuclear	0
			Renewable Energy	5
			Fuel Cell Technology	1
	TBD	Carbon Capture, Use and Storage	Shipboard	2
			Terrestrial	2
Cross-Cutting Initiatives	N/A	Whole ship and system level design considerations	Ship design process	1
			System level design considerations	0
	N/A	Ship integration and technology scaling for shipboard use	Ship integration	0
			Scaling for shipboard use	0
	N/A	Modeling, test sites and demonstration capability	Modeling & data analytics	11
			Bench scale testing	4
			Demonstrations & testing	0
	TBD	Education and Training	Education & Training	7

# Agenda/Outline – NEXT STEPS

- BLUF/Exec Summary
- Consortium Mission Statement and Purpose
- Guidance Documents, Alignment and Timelines
- Navy Specific Considerations and Constraints
- Thrust Areas and Cross Cutting Initiatives
- Summary of Current Activities
- Identified Gaps
- **Year 1 Research Agenda**
- **DRAFT Summary Integrated Roadmap**
- Consortium Evolution

# Next Steps

- **Year 1 Research Agenda**
  - Will be asking funded projects:
    - 1) How do your projects align with the Thrust Areas and Gaps as depicted in prior slides?
    - 2) How do you see the project developing over time (roadmap) to fit into the larger Navy decarbonization goals?
- **Research Roadmap**
  - Will be asking all Consortium Participants for assistance with:
    - Develop “CEP-like” summary for each major thrust area, incorporating Year 1 funded projects and other relevant efforts, to align with and support longer-term Navy decarbonization goals.



# Sample Capability Evolution Plan (CEP)



RC2 CEP --

## Data Aggregation, Exposure & Visualization

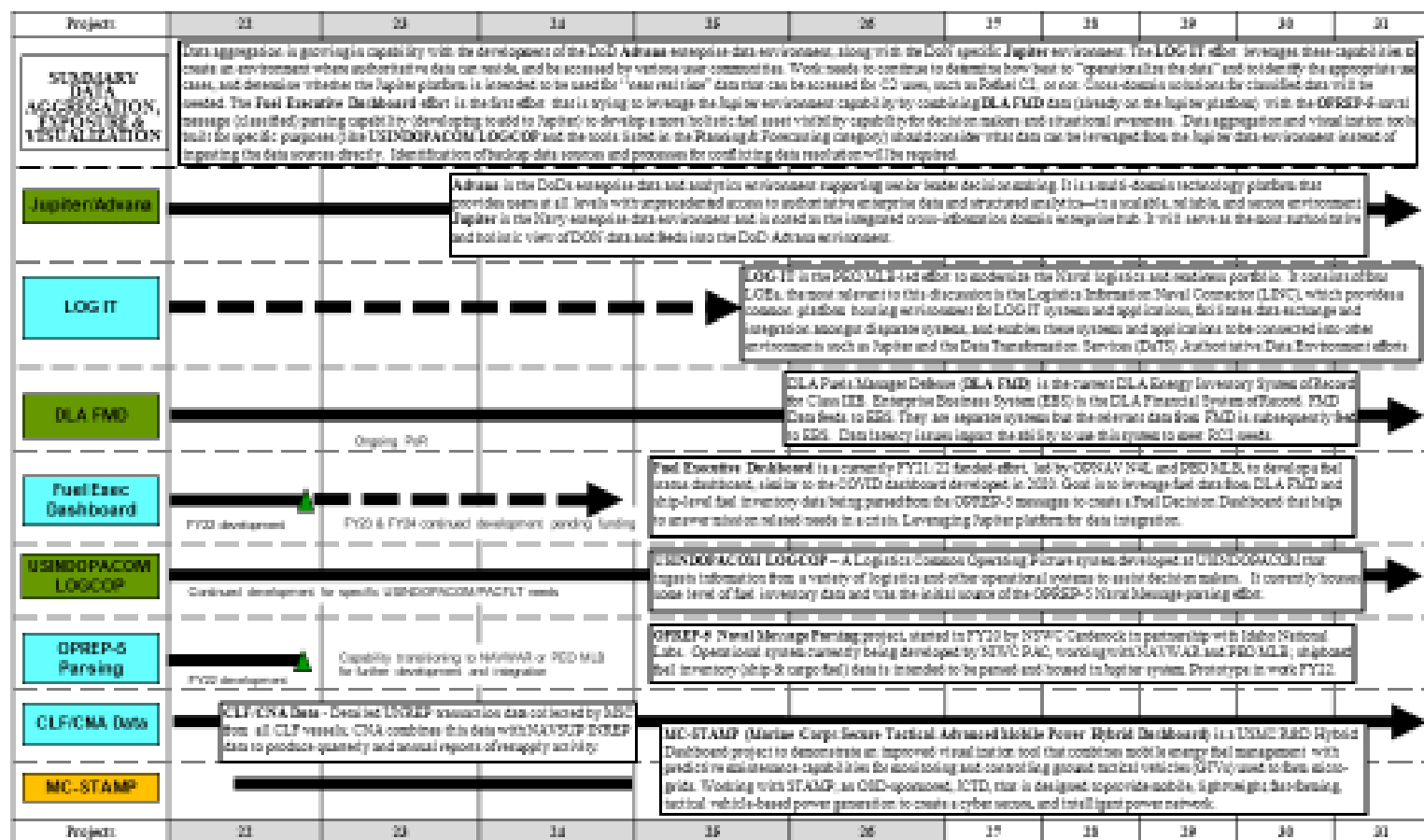
Definition: The collection of data from one or more units or sources; the organization of this data into usable formats; the visualization of this data in a user friendly format; and/or the exposure of this data to other user groups "in the cloud"

**Legend**

Navy-centric  
USMC-centric  
Navy=USMC or Joint

Green Triangle – Milestone  
Green Black – Technology Fielded on Ship

CUI



CUI

Dated: July 2022

6

Pre-Decisional, OPNAV N4L Working Deliverable



# Decarbonization Research Consortium

## Path Forward

**June Meeting: Research Roadmap + Federal Landscape**

**23 June 2023, Hybrid**

**In-person, Washington, DC & Online**

**By 23 June, share draft Roadmap with ONR**

**July/Aug**

**1-2 Meetings per month**

**Address Comments/Gaps in Roadmap**

**Identify tentative Next Steps for Consortium**

**Aug 31 Final Research Roadmap to ONR**

**Finalize Next Steps for Consortium**