Decarbonization Research Consortium

WELCOME

12 May 2023

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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

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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***

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Thrust Areas & Cross-Cutting Initiatives

	Approx Impact to Operational Navy Decarbonization (%)	Category	Sub-Category		
			Propulsive efficiency improvements & direct drag reduction		
			Propulsion & power generation improvements		
			Electrification & hybridization		
	5% - 15%	Energy Efficiency Technology	Thermal Mgmt, WHR/EGR & materials		
			Demand Reduction		
eas			Energy Storage		
			Lightweight Materials		
re		Operational Efficiency	Route planning		
A	5% - 15%		Plant & Speed Optimization		
st		improvements	Trim Optimization		
, j			Unmanned systems		
Thr	TBD	Force Structure	"Single Mission Optimized" platforms		
Major			Attritable assets		
			UxV system modeling		
	20% - 70%		Bio-, Renewable-, E-Fuels		
2			Green Ammonia/Green Methanol		
		Fuel Technologies (Production	Hydrogen		
		and/or Lise)	Batteries		
			Nuclear		
			Renewable Energy		
			Fuel Cell Technology		
		Carbon Canturo Lico and Storago	Shipboard		
	שטו	Carbon Capture, Ose and Storage	Terrestrial		
50	N 1/A	Whole ship and system level design	Ship design process		
ing S	N/A	considerations	System level design considerations		
ve	NI / A	Ship integration and technology scaling	Ship integration		
ati 🛛	N/A	for shipboard use	Scaling for shipboard use		
ss- itia		Modeling test sites and demonstration	Modeling & data analytics		
ğ	N/A	canability	Bench scale testing		
С С		capability	Demonstrations & testing		
	TBD	Education and Training	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 Taggi			mate Tagging
	Approx Impact to				Project	Counts	
	Operational Navy			Major	Primary	Secondary	Tertiary
	Decarbonization (%)	Category	Sub-Category	Category	SubCategory	SubCategory	SubCategory
			Propulsive efficiency improvements & direct drag reduction		4	0	0
			Propulsion & power generation improvements		7	3	0
			Electrification & hybridization		2	6	0
	5% - 15%	Energy Efficiency Technology	Thermal Mgmt, WHR/EGR & materials	23	2	0	0
			Demand Reduction		8	0	0
			Energy Storage		0	12	0
			Lightweight Materials		0	0	0
as		Operational Efficiency	Route planning		0	0	0
: Are	5% - 15%		Plant & Speed Optimization	5	5	0	0
		improvements	Trim Optimization		0	0	0
Ist	TBD		Unmanned systems		0	0	1
L I		Force Structure	"Single Mission Optimized" platforms	0	0	0	0
Major Th			Attritable assets	0	0	0	0
			UxV system modeling		0	0	0
	20% - 70%	Fuel Technologies (Production and/or Use)	Bio-, Renewable-, E-Fuels		0	0	0
			Green Ammonia/Green Methanol		0	0	0
			Hydrogen		0	1	0
			Batteries	13	11	0	0
			Nuclear		0	0	0
			Renewable Energy		2	0	0
			Fuel Cell Technology		0	0	0
	TDD		Shipboard	0	0	0	0
	IRD	Carbon Capture, Use and Storage	Terrestrial	0	0	0	0
		Whole ship and system level	Ship design process		0	0	0
50	N/A	design considerations	System level design considerations	0	0	0	0
ss ing		Ship integration and technology	Ship integration		0	0	0
tive	N/A	scaling for shipboard use	Scaling for shipboard use	0	0	0	0
s-C tia			Modeling & data analytics		1	0	5
ros Ini	N/A	Modeling, test sites and	Bench scale testing	1	0	2	2
Ū		demonstration capability	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
					Ŭ	13	J+



Navy Current Activity - Stoplight Chart

	Approx Impact to				Navy Entity		
	Operational Navy				NAV	NAV	
	Decarbonization (%)	Category	Sub-Category	ONR	SEA	AIR	
			Propulsive efficiency improvements & direct drag reduction	0	4	2	
			Propulsion & power generation improvements	9	10	2	
			Electrification & hybridization	4	8	0	
	5% - 15%	Energy Efficiency Technology	Thermal Mgmt, WHR/EGR & materials	7	2	5	
			Demand Reduction	4	8	4	
			Energy Storage	6	12	1	
			Lightweight Materials	0	0	1	
as	5% - 15%	Operational Efficiency	Route planning	1	0	2	
Are			Plant & Speed Optimization	0	5	0	
		Improvements	Trim Optimization	0	0	0	
lst			Unmanned systems	0	1	4	
าาเ	TBD	Farra Chrysterra	"Single Mission Optimized" platforms	0	0	0	
Major Th		Force Structure	Attritable assets	0	0	0	
			UxV system modeling	0	0	0	
	20% - 70%		Bio-, Renewable-, E-Fuels	2	0	2	
			Green Ammonia/Green Methanol	0	0	0	
		Fuel Technologies (Production and/or Use)	Hydrogen	3	1	2	
			Batteries	3	11	2	
			Nuclear	0	0	0	
			Renewable Energy	3	2	0	
			Fuel Cell Technology	0	0	1	
		Carbon Capture, Use and Storage	Shipboard	2	0	0	
	שטו	Carbon Capture, Ose and Storage	Terrestrial	2	0	0	
	N /A	Whole ship and system level	Ship design process	1	0	0	
ы	N/A	design considerations	System level design considerations	0	0	0	
ting	N / A	Ship integration and technology	Ship integration	0	0	0	
Cut	N/A	scaling for shipboard use	Scaling for shipboard use	0	0	0	
ss-(itia		Modeling test sites and	Modeling & data analytics	4	6	1	
р С Г	N/A	domonstration canability	Bench scale testing	0	4	0	
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				Other			
	Decarbonization (%)	Category	Sub-Category	Navy	DoD	DOE	DOT	Other
			Propulsive efficiency improvements & direct drag reduction	6				
			Propulsion & power generation improvements	21				
			Electrification & hybridization	12				
	5% - 15%	Energy Efficiency Technology	Thermal Mgmt, WHR/EGR & materials	14				
			Demand Reduction	16				
			Energy Storage	19				
-			Lightweight Materials	1				
as		Operational Efficiency	Route planning	3				
re	5% - 15%		Plant & Speed Optimization	5				
A		improvements	Trim Optimization	0				
12t	TBD	Force Structure	Unmanned systems	5				
Major Thru			"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 Canture Use and Storage	Shipboard	2				
			Terrestrial	2				
	N/A	Whole ship and system level	Ship design process	1				
50		design considerations	System level design considerations	0				
tin es	N/A	Ship integration and technology	Ship integration	0				
tiv		scaling for shipboard use	Scaling for shipboard use	0				
ss- itia		Modeling test sites and	Modeling & data analytics	11				
L C	N/A	demonstration canability	Bench scale testing	4				
			Demonstrations & testing	0				
	TBD	Education and Training	Education & Training	7				



Category Sub-Category Summary of Major Efforts Propulsive efficiency LCS Stern Flags: Procurement of stern flags to be install on the hull of LCS-1 class ships to reduce resistance. Propulsion & power Finets: Advanced Component Development to identify and evaluate new underwater hull coating systems and underwater hull cleaning and mainternance techniques to reduce hydrodynamic drag on ships. Propulsion & power Propulsion & power generation improvements PAGE Electronic Fuel Injection: Advanced Component Development to identify and evaluate new underwater hull coating systems and underwater hull cleaning and mainternance techniques to reduce hydrodynamic drag on ships. Variable Cycle Advance Technology: Applied research to develop variable geometry and adaptive cycle gas turbine engine technology for next generation air dominance aircraft. T-AO 205 Efficient Replacement Engines: Ship Construction investment to integrate more efficient engines on future T-AO 205 Class ships. Aircraft, Turbine Engine Recuperator: Advanced Component Development to demonstrate an advanced recuperator design on the M250 (helicopter engine). Aircraft, Engine Blade Scanning and Coating: Advanced Component Development of blade scanning technology and turbine engine coatings for compressors blades for naval aircraft. Technology Thermal Mgmt, WHK/EGR & And Development Consortium (ESRDC): Maintains applied research across 8 universities focused on advancing afloat power systems. Power Electronis Building Block: Applied Research in power electronic								
Propulsive efficiency improvements & direct drag reduction LC Stem Flaps: Procurement of stem flaps to be install on the hull of LCS-1 class ships to reduce registance. Improvements & direct drag reduction Finites: Advanced Component Development of alercaft finites to reduce drag on Navy and Maria Corps C-130 alircaft Hull Husbandry: Advance Component Development to upgrade the fuel injection systems and underwater hull cleaning and maintenance techniques to reduce hydrodynamic drag on ships. Propulsion & power generation improvements PAGE Electronic Fuel Injection: Advanced Component Development to upgrade the fuel injection system on the Fairbanks Morse (FM) PAGB Diesel Engines. Variable Cycle Advance Technology: Applied research to develop variable geometry and adaptive cycle gas turbine engine technology for next generation air dominance aircraft. Energy Efficiency Technology Electrification & hybridization Integrated Power Systems, including and Coating: Advanced Component Development to demonstrate an advanced recuperator design on the MZ50 (helicopter engine). Aircraft Integrated Power Systems, including and Coating: Advanced Test Facility, with intent to incorporate an integrated power system on the next targe Surface Combatant. Energy Strificiency Technology Thermal Mgmt, WHR/EGR & Aircraft, Integrated Thermal and Power Madeling: Advanced Component Development to develop, ualify, and integrates SIC devices into prototype power converters. Thermal Mgmt, WHR/EGR & Aircraft, Integrated Thermal and Power Madeling: Advanced Component Development to develop, ualify, and integrates SIC devices into prototype power conver	Category	Sub-Category	Summary of Major Efforts					
Energy Efficiency Technology Fileds: Advanced Component Development to identify and evaluate new underwater hull coating systems and underwater hull coating and maintenance techniques to reduce hydrodynamic drag on ships. Propulsion & power generation improvements PAGE Electronic Fuel Injection: Advanced Component Development to upgrade the fuel injection system on the Fairbanks Morse (FM) PAGE Diesel Engines. Variable Cycle Advance Technology: Applied research to develop variable geometry and adaptive cycle gas turbine engine technology for next generation improvements Propulsion & power generation air dominance aircraft. T-AO 205 Efficient Replacement Engines: Ship Construction investment to integrate more efficient engines on future T-AO 205 Class ships. Aircraft Turbine Engine Recuperator: Advanced Component Development to demonstrate an advanced recuperator design on the M250 (helicopter engine). Aircraft, Engine Blade Scanning and Coating: Advanced Component Development of blade scanning technology and turbine engine coatings for compassors blades for naval aircraft. Electrification & hybridization Integrated Power Systems; The Navy's DDG(X) Program Office continues Advanced Component Development of Next Generation Integrated Power system on the next Large Surface Combatant. Thermal Mgmt, WHR/EGR & materials Thermal Mgmt, WHR/EGR & materials Advanced Technology: Advanced Component Development to develop, qualify, and integrated power and literation seawater pumps. Demand Reduction Electrification & hybridization Silicon Carbide Power Modules: Advanced Component Development to develop, qualify, and inte		Propulsive efficiency	LCS Stern Flaps: Procurement of stern flaps to be install on the hull of LCS-1 class ships to reduce resistance.					
Induction Hull Husbandry: 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. Propulsion & power generation improvements PA6B Electronic Fuel Injection: Advanced Component Development to upgrade the fuel injection system on the Fairbanks Morse (FM) PA6B Diesel Engines. Variable Cycle Advance Technology: Applied research to develop variable geometry and adaptive cycle gas turbine engine technology for next generation air dominance aircraft. T-A0 205 Efficient Replacement Engines: Ship Construction investment to integrate more efficient engines on future T-A0 205 Class ships. Aircraft Turbine Engine Recuperator: Advanced Component Development to demonstrate an advanced recuperator design on the M250 (helicopter engine). Energy Efficiency Technology Electrification & hybridization Integrated Power Systems: The Navy's DDG(X) Program Office continues Advanced Component Development of Next Generation Integrated Power and Energy Systems. Power Electronics Building Block: Applied Research in power electronics building blocks for energy storage and distribution Silicon Carbide Power Modules: Advanced Component Development to walfdate integrated power and thermal management models for legacy and emerging platforms Demand Reduction Electrifice tingerated Test Facility, with intent to incegrate spise ships and Combat Logistics Ships. Trefrent Trasmit/Receive linggrade dimerging platforms Demand Reduction Electric blighting to replace conventional lighting on DDG-51 class ships and Combat Logistics Ships. Efficient Trasmit/Receive linggrade t		improvements & direct drag	Finlets: Advanced Component Development of aircraft finlets to reduce drag on Navy and Marine Corps C-130 aircraft					
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Propulsion & power generation improvements PAGB Electronic Fuel Injection: Advanced Component Development to upgrade the fuel injection system on the Fairbanks Morse (FM) PAGB Diesel Engines. Variable Cycle Advance Technology: Applied research to develop variable geometry and adaptive cycle gas turbine engine technology for next generation air dominance aircraft. T-AO 205 Efficient Replacement Engines: Ship Construction investment to integrate more efficient engines on future T-AO 205 Class ships. Aircraft Turbine Engine Recuperator: Advanced Component Development to demonstrate an advanced recuperator design on the M250 (helicopter engine). Aircraft Leptine Blade Scanning and Coating: Advanced Component Development of blade scanning technology and turbine engine coatings for compressors blades for naval aircraft Electrification & hybridization Integrated Power Systems: 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. Electrification & hybridization Integrated Power Applied Research in power electronics building blocks for energy storage and distribution Silicon Carbide Power Modules: Advanced Component Development to develop, qualify, and integrate of Celevices into prototype power converters. Thermal Mgmt, WHR/EGR & materials Aircraft. Integrated Thermal and Power Management Modelling: Advanced Component Development to validate integrate graver and thermal management models for legacy and emerging platforms Demand Reduction LE D Lighting: Procurement of LED			maintenance techniques to reduce hydrodynamic drag on ships.					
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Energy Efficiency Technology Variable Cycle Advance Technology: Applied research to develop variable geometry and adaptive cycle gas turbine engine technology for next generation air dominance aircraft. Energy Efficiency Technology Integrated Power Systems: Energy Efficiency Technology Integrated Power Systems: Energy String: Energy String: Ene		generation improvements	Engines.					
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Energy Efficiency T-A0 205 Efficient Replacement Engines: Ship Construction investment to integrate more efficient engines on future T-A0 205 (lass ships. Aircraft Turbine Engine Recuperator: Advanced Component Development to demostrate an advanced recuperator design on the M250 (helicopter engine). Aircraft, Engine Blade Scanning and Coating: Advanced Component Development of blade scanning technology and turbine engine coatings for compressors blades for naval aircraft Energy Efficiency Technology Electrification & hybridization Integrated Power Systems: The Navy's DDG(X) Program Office continues Advanced Component Development of Next Generation Integrated Power system on the next Large Surface Combatant. Electrification & hybridization Integrated Power Systems: The Navy's DDG(X) Program Office continues Advanced Component Development on the next Large Surface Combatant. Electrification & integrated Power Systems: Including a full scale Integrated Test Facility, with intent to incorporate an integrated power system on the next Large Surface Combatant. Electrification Electrification Block: Applied Research in power electronics building blocks for energy storage and distribution Silicon Carbide Power Modules: Advanced Component Development to develop, qualify, and integrates SiC devices into prototype power converters. Thermal Mgmt, WHR/EGR & Aircraft, Integrated Thermal and Power Management Modelling: Advanced Component Development to validate integrated power anylifiers with higher efficiency power amplifiers on DDG-51 class ships and Combat Logistics Ships. Efficient Transmit/Receive Integrated Multichip Modules (TRIMMS): System Development and Demonstration to swap high power amplifiers w			generation air dominance aircraft.					
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Energy Efficiency engine). Technology Electrification & hybridization Integrated Power Systems: 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. Electrification & hybridization Integrated Power Systems: 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. Electrification & hybridization Integrated Power Modules: Advanced Component Consortium (ESRDC): Maintains applied research across 8 universities focused on advancing afloat power systems. Power Electronics Building Block: Applied Research in power electronics building blocks for energy storage and distribution Silicon Carbide Power Modules: Advanced Component Development to develop, qualify, and integrate SiC devices into prototype power converters. Aircraft, Integrated Thermal and Power Management Modelling: Advanced Component Development to validate integrated power and thermal management models for legacy and emerging platforms Demand Reduction LED Lighting: Procurement of LED Lighting to replace conventional lighting on DDG-S1 Class ships and Combat Logistics Ships. Efficient Transmit/Receive Integrated Multichip Modules (TRIMMs): System Development and Demonstration to swap high power amplifiers with higher efficiency power applifiers on DDG-S1 Class Rada			Aircraft Turbine Engine Recuperator: Advanced Component Development to demonstrate an advanced recuperator design on the M250 (helicopter					
Energy Efficiency Technology Aircraft, Engine Blade Scanning and Coating: Advanced Component Development of blade scanning technology and turbine engine coatings for compressors blades for naval aircraft Energy Efficiency Technology Electrification & hybridization Integrated Power Systems: 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. Electrification & hybridization Integrated Power Addues: Advanced Component Development consortium (ESRDC): Maintains applied research across 8 universities focused on advancing afloat power systems. Power Electronics Building Block: Applied Research in power electronics building blocks for energy storage and distribution Silicon Carbide Power Modules: Advanced Component Development to develop, qualify, and integrate SiC devices into prototype power converters. Thermal Mgmt, WHR/EGR & materials Aircraft, Integrated Thermal and Power Management Modelling: Advanced Component Development to validate integrated power and thermal management models for legacy and emerging platforms Demand Reduction LED Lighting: Procurement of LED Lighting to replace conventional lighting on DDG-51 class ships and Combat Logistics Ships to reduce load from seawater pumps. Energy Storage Energy Magazine: Advanced Technology Development in Energy Magazine energy storage for future surface combatants. Energy Storage Flywheel: Advance Component Development of a carbon nanotube energy storage flywheel for potential application on Navy sh			engine).					
Energy Efficiency Compressors blades for naval aircraft Energy Efficiency Technology Technology Electrification & hybridization Integrated Power Systems: 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. Electric Ship Research and Development Consortium (ESRDC): Maintains applied research across 8 universities focused on advancing afloat power systems. Power Electronics Building Block: Applied Research in power electronics building blocks for energy storage and distribution Silicon Carbide Power Modules: Advanced Component Development to develop, qualify, and integrate SiC devices into prototype power converters. Thermal Mgmt, WHR/EGR & materials Aircraft, Integrated Thermal and Power Management Modelling: Advanced Component Development to validate integrated power and thermal management models for legacy and emerging platforms Demand Reduction LED Lighting: Procurement of Del Dighting to replace conventional lighting on DDG-51 class ships and Combat Logistics Ships. Efficiency power amplifiers on DDG-51 Class Radar and Electronic Warfare systems. Variable Frequency Drives (VFDs): Operations & Maintenance to integrate Variable Frequency Drives on Combat Logistics Ships to reduce load from seawater pumps. Energy Storage Energy Magazine: Advanced Technology Development in Energy Magazine energy storage for future surface combatants. E			Aircraft, Engine Blade Scanning and Coating: Advanced Component Development of blade scanning technology and turbine engine coatings for					
Energy Efficiency Technology Thermal Mgmt, WHR/EGR Thermal Mgmt, WHR/EGR The			compressors blades for naval aircraft					
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Isubmarines			cubmorings					
Lightweight Materials		lightweight Materials						





Category	Sub-Category	Summary of Major Efforts
	Route planning	Integrated Climate Weather and Ocean Decision Support: 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. Aerial Refueling Drogue Stabilization: Advanced Component Development of Aerial Refueling Drogue Stabilization technology to reduce refueling drogue
		capture time.
Operational Efficiency Improvements	Plant & Speed Optimization	Global Energy Information System (GENISYS): 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 Robust Combat Power Control (RCPC): 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. Condition Assessment System: 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	
	Unmanned systems	MQ-25A Unmanned Aerial Refueler: Advanced Component Development of first CVN-based unmanned aerial refuel (fixed wing UAS). Long Endurance Unmanned Surface Vessel: Applied research to demonstrate commercially available, long endurance USV.
Force Structure	"Single Mission Optimized" platforms	
	Attritable assets	
	UxV system modeling	





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

IN WORK



Category	Sub-Category	Summary of Major Efforts
Whole ship and	Ship design process	
system level design	System level design	
Ship integration and	Ship integration	
technology scaling for	Scaling for shipboard use	
Modeling, test sites and demonstration capability	Modeling & data analytics	Theater Energy Model: 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 Modeling & Simulation: 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	Workforce Development: Investment in workforce talent and technology development supporting Navy power and energy systems





Preliminary Gap Identification

	Approx Impact to					
	Operational Navy	Catagoni	Sub Catagony			
	Decarbonization (%)	Category				
			Propulsive efficiency improvements & direct drag reduction			
			Propulsion & power generation improvements			
	50/ 450/	Francis Ffficiency Taskas land	Electrification & hybridization			
	5% - 15%	Energy Efficiency Technology	I nermal Night, WHR/EGR & materials			
			Energy Storage			
s			Lightweight Materials			
Area:		Operational Efficiency	Route planning			
	5% - 15%	Improvements	Plant & Speed Optimization			
, t			Trim Optimization			
n			Unmanned systems			
hr	TBD	Force Structure	"Single Mission Optimized" platforms			
F			Attritable assets			
jo			UxV system modeling			
laj	20% - 70%		Bio-, Renewable-, E-Fuels			
2			Green Ammonia/Green Methanol			
		Fuel Technologies (Production	Hydrogen			
		and/or Use)	Batteries			
			Nuclear			
			Renewable Energy			
			Fuel Cell Technology			
	TBD	Carbon Canture, Use and Storage	Shipboard			
	TBD		Terrestrial			
	N/A	Whole ship and system level	Ship design process			
ы	N/A	design considerations	System level design considerations			
es es	NI/A	Ship integration and technology	Ship integration			
tix	N/A	scaling for shipboard use	Scaling for shipboard use			
ss-(itia		Modeling test sites and	Modeling & data analytics			
ğ =	N/A	domonstration canability	Bench scale testing			
0			Demonstrations & testing			
	TBD	Education and Training	Education & Training			





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

Legend Nam-centriq. USHC-centric Nany+USMC erJoint.

CUI

Definition: The collection of data from new to more units or sources; the organization of this data into matthe bounds; the visualization of this data in a seen thandly format, and/or the exposure of this data to other user groups "in the cloud"

Green Triangle - Illiestone Green Block - Technology Fielded on Ship

Incjects	22	23	11	35	26	25	25	29	30	31
STEMPARY DATA AGCERSCATION, TSUALIZATION	Data sparsage is most if it with the development of the DoD Advance enception data network constraints, along with the DoV specific Jupiter environment. The LOG IT effort investiges these capabilities to constraint when understands in the data can reade, and be accessed by various user common iter. Work needs to constrain to how best to "operationalize the data" and to identify the appropriate use constraint when understand the laptice plottles is intereded to be used for "one wait interacts be accessed for C2 uses, user to Robert C2, or not Check-domin included that with the appropriate use constraints. The I DoE IT effort effort effort that is register to investige the laptice environment (Line in Case). A FMD that (Line (Insteady on the laptice) with the OFREP-4 servit message (Line iffed) particle of the C2 particle of the appropriate use capability (developing to add to rights) to develop a more like it also a service nation in the interaction of the DOE appropriate use cannot be accessed by variable data with the development of the laptice environment (Line if C2, or not Check-domin include) data with the development of the DoE appropriate use can be accessed by the appropriate use can be interacted and the data of the appropriate use can be accessed by the appropriate use (Line if the Q) is DEND Advance environment. The DOE accessed and the cost is interacted on the interaction of the IDOE accessed in the outprint acceleration of the appropriate data water and the activity operation data water and the cost of the DOE accessed in the Name and the cost of the outprint acceleration and the to be accessed and the outprint acceleration to the implement of the IDOE accession and processes to accelerate an approximate acceleration of the IDOE accession and processes to accelerate and approximate acceleration and the activity operation and the activity and the cost is integrated acceleration and because and the activity and the cost is integrated acceleration and the actinity approximation acceleration and the a									
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OPREP-6 Parsing	PC2 development	Capability transitioning to the further development an	NAMWAR-2 PED MUB	OPEEP-9 Neuri Men Lubs: Operational syn feel inventory (ship-2)	age Berning: project, started real currently being Service curgo fae() data to intended	to FY20 by NS ² adity NEVC PA to be pened and	WC-Candenock in 2, worklagewich housed in hopite	i pertnerikip with SAUWAR and P r system, Prototy	i Idaho National BO MLE; ubjato pa in work PY12	
CLF/CMA Data	CLF-CNA Data - Detailed UNREF sciences its data cotiles at by MSC form all CLF vessels. CNA combines this data with NANSUF DSEP data to produce quartery and ansual reports of recepting project to demonstrate an improved visual latitor tool that combines mobile energy field management with predictive quartery and ansual reports of recepting project to demonstrate an improved visual latitor tool that combines mobile energy field management with predictive quartery and ansual reports of recepting quarters capabilities for each comparison project to demonstrate an improved visual latitor tool that combines mobile energy field management with predictive quartery and ansual report of the demonstrate and ansual report of the data with STAMP, an OLD-spontoved, ICTD, that is designed to provide coble, Spirowigh the branks,									
Projecti	22	23	24	15	26	17	11	39	ю	21

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CUL

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

