Code 35
Naval Air Warfare & Weapons Department
Focus Area Forum Overview

Dr. Knox Millsaps, SES
Department Head

CDR Kyle McDaniel
Military Deputy/Directed Energy Weapons Division Director, Code 353 (Acting)

Dr. David González
Naval Air Platforms Division Director, Code 351 (Acting)

Dr. Chad Stoltz
Kinetic Weapons Division Director, Code 352 (Acting)

LtCol Hugo Gonzalez
US Marine Corps Liaison

Code 35 Focus Area Forum (FAF) Agenda

Time	Event	Briefer	Room
0730-0900	Check-In		Ball Room Lobby
0900-0915	Introduction	Mr. Trip Barber	Ball Room
0915-0945	ONR Overview	CAPT Pete Ladowicz	Ball Room
0945-1015	Doing Business with ONR	Mr. Jamie Thompson	Ball Room
1015-1030	Code 35 Overview	Dr. Knox Millsaps	Ball Room
1030-1045	Break		Ball Room
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1145-1200	Expeditionary Weapons	Col Howard Marotto	Ball Room
1200-1300	Lunch		
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1300-1400	Code 35 Hard Problem Break Out Discussions • Air Vehicle Technology • Aerospace Structures & Materials • Science of Autonomy and Controls • Energetic Materials • Kinetic Weapons • Terminal Defense • Directed Energy – Laser • Directed Energy – High Power Microwave	 Dr. David Gonzalez, Dr. Dave Findlay, & Dr. Leighton Myers Mr. Bill Nickerson Mr. Marc Steinberg & Dr. Brian Holm-Hansen, Dr. Chad Stoltz, Dr. Tim Ransom, & Mr. Chris Milby Mr. Ken Heeke, Dr. Roger Sullivan, Mr. Dan Simons & Mr. Taylor Young Mr. Tom Boucher, Ms. Teresa Berra, & Ms. Chloe Lee Mr. Peter Morrison, Mr. Quentin Saulter, and Mr. Matt Ketner Mr. Matt McQuage	 Tidewater III, 2nd Floor Tidewater II, 2nd Floor Ballroom Arlington, 3rd Floor Potomac VI, Ballroom Level Potomac IV, Ballroom Level Potomac V, Ballroom Level Potomac III, Ballroom Level
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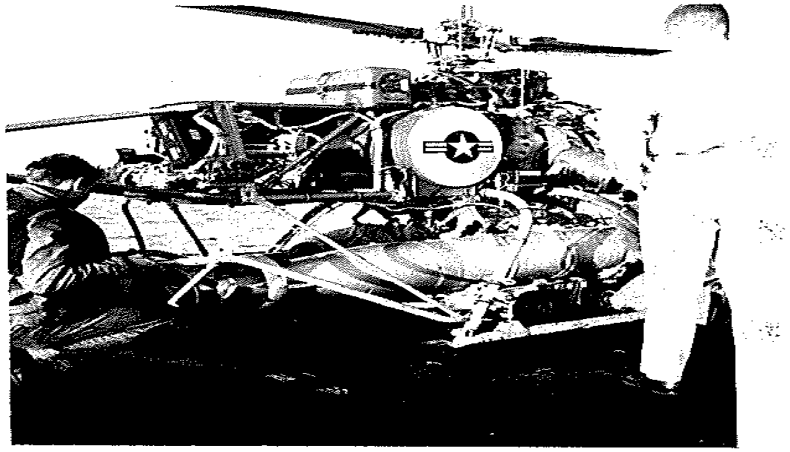
Office of Naval Research Overview

CAPT Pete Ladowicz

Assistant Chief of Naval Research (ACNR)

ONR … Innovating since 1946

Mr. Bishop Checks His Drone



Sauro, TM3, Loads A Torpedo

Third Division

Who ever heard of a 3,500 ton Aircraft Carrier? But it's true. RICH, along with every other FRAM 1 Destroyer, does carry aircraft in the form of two Drone Helicopters, one of which has flown "all the way" to the Southern Hemisphere, quite an accomplishment for the often temperamental drones. Our congratulations to the 3rd Division for a job which is being done well.

And It Flys, Too!!!

Courtesy of USS RICH (DD 820) Med Cruise Book 1965-1966

ONR Organization

*ONR - To plan, foster and **encourage scientific research** in recognition of its paramount importance as related to the maintenance of **future naval power**."*

– Public Law 588, 1 Aug 1946

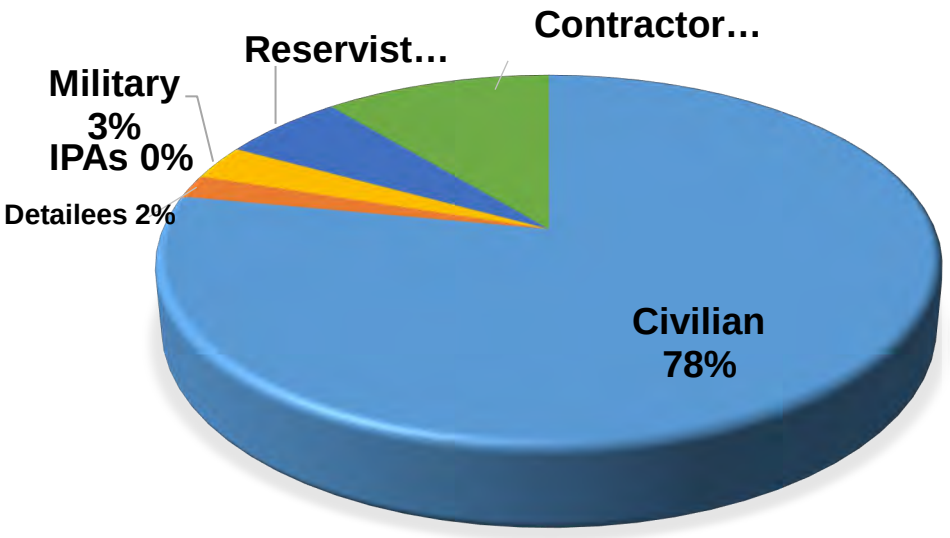
NAVAL STEM

DEPARTMENT OF THE NAVY HBCU/MI

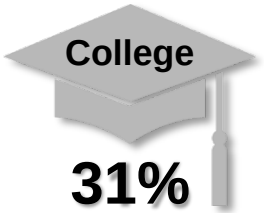
COMMUNICATE. COORDINATE. CULTIVATE.

Who We Are

Workforce Demographics

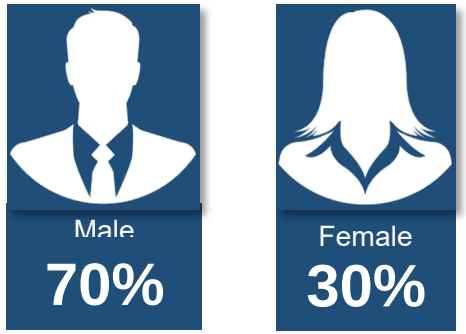


Degrees



Average Length of Service

12

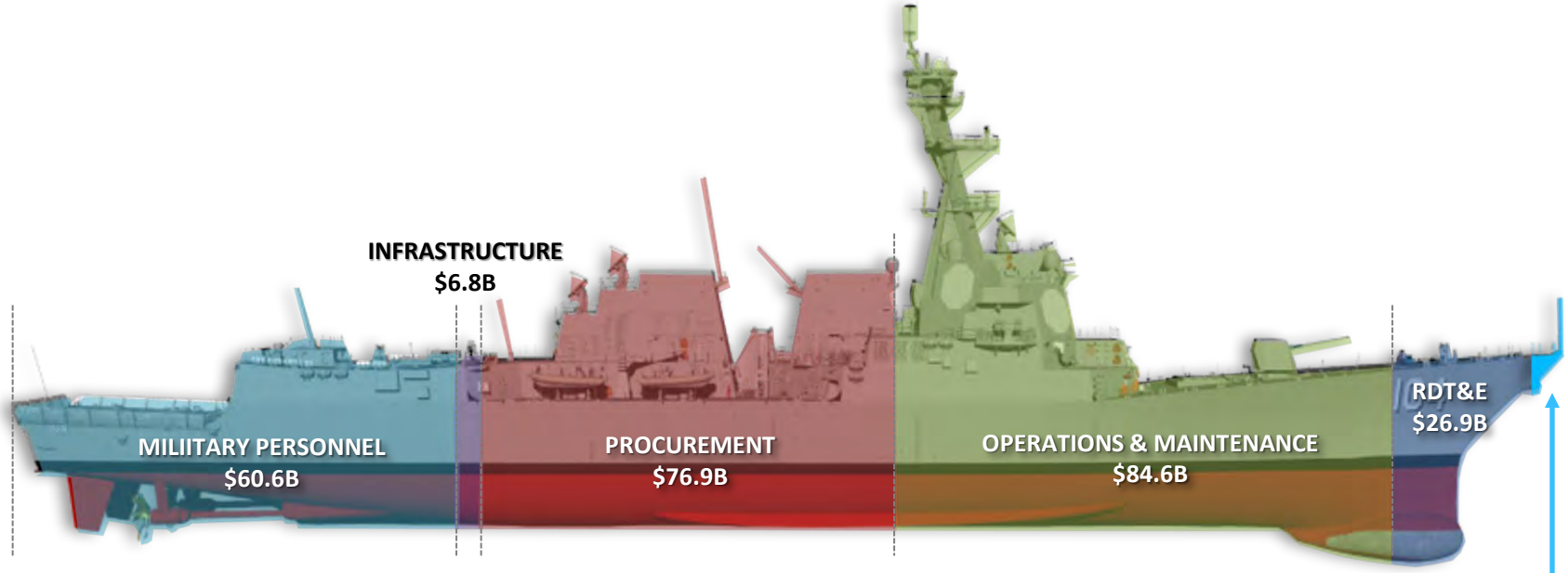


Average Age

46

Budget

FY24 DoN Budget Request $255.8B

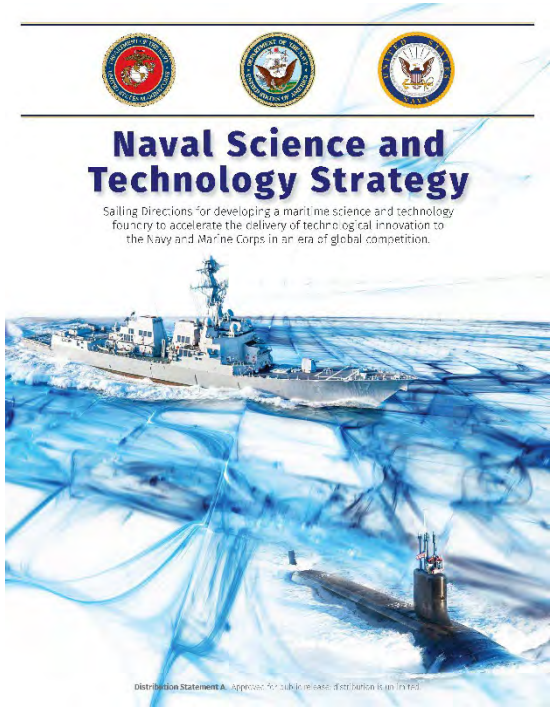


Naval Research Enterprise => $2.74B *(10.2% of FY24 $26.9B RDT&E Budget)*

Basic Research	Applied Research	Advanced Technology Development	6.4, 6.6, 6.7
$637.2M	**$1,026.3M**	**$904.2M**	**$173.8M**

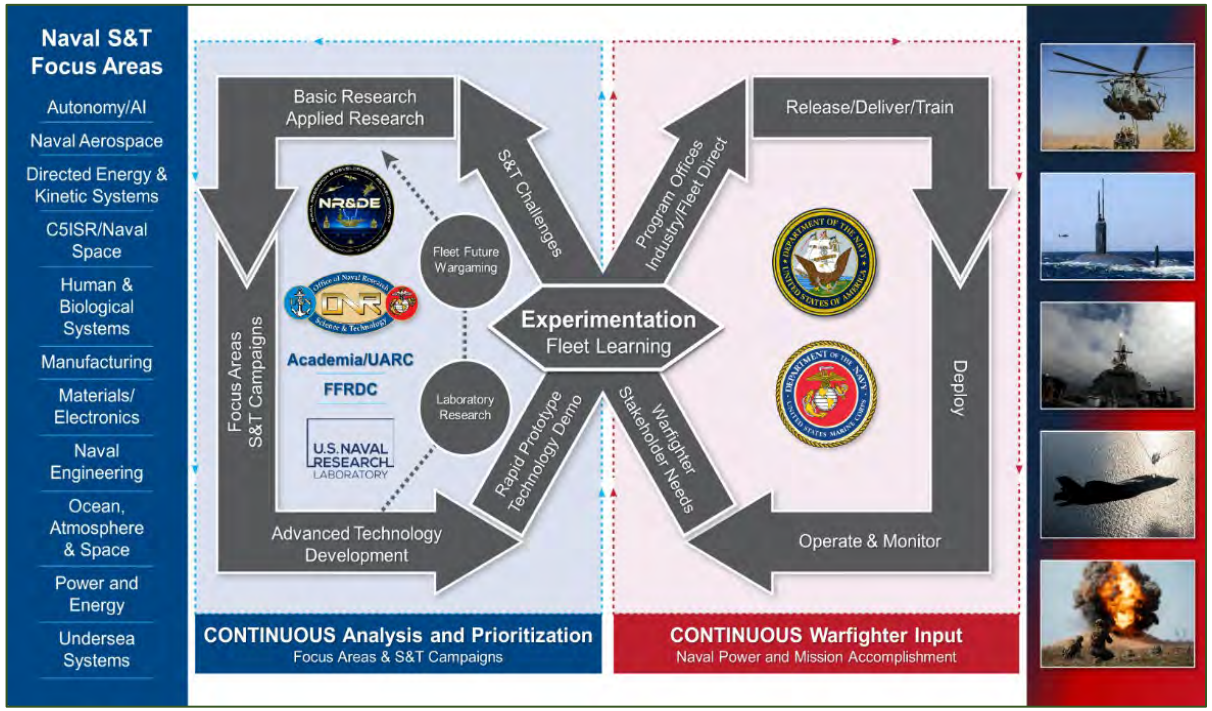
Naval S&T Strategy

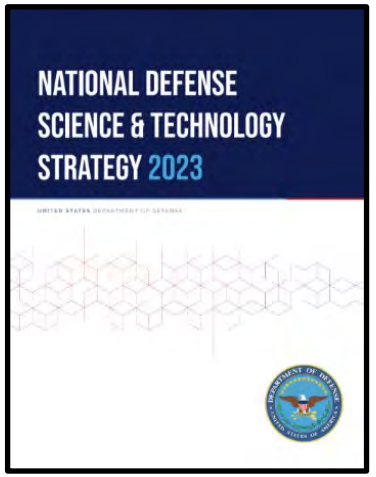
- **In line with SecNav Priorities for the Navy, the Naval S&T Strategy focuses on:**
- ***Strengthening Maritime Dominance***
  - Realize Technology Gains Faster
  - Find Disruptors –updated *Decision Engine*
  - Play to Our Strengths
  - Experimentation and War Gaming
- ***Building a Culture of S&T Excellence***
  - Sailor, Marine, Scientist, and Engineer Teaming
  - S&T Tradecraft - *Partnering and Building Capacity*
  - NPS, USNA, NWC & STEM/HBCU-MI
- ***Enhancing Naval Scientific Diplomacy***
  - Partnerships at Home & Abroad
- ***Naval Warfare Alignment***
  - CNO NAVPLAN & Get Real Get Better Framework
  - Navy and USMC Force Design

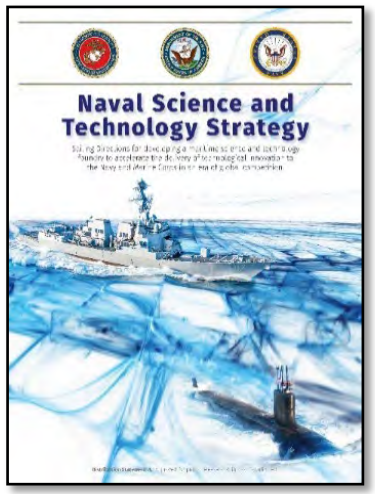


2024 NAVAL ST STRATEGY_FINAL.PDF (defense.gov)

Delivering Maritime Combat Power







"I encourage all of you — our nation's scientists, engineers, researchers, inventors, entrepreneurs, and problem solvers — to join us. — We are indeed in an innovation race — and it is one we must win."

– Honorable Carlos Del Toro
Secretary of the Navy

Sense of Urgency & Strategic Patience

BA1 & BA2
Basic and Applied Research

- Improve and accelerate basic and applied research ***to meet the challenge of strategic competition***.
- Improve ***S&T Tradecraft*** – Prevent technical surprise: prioritize and invest in high payoff efforts.

BA2 & BA3
Rapid Capability & ADV Development Transition

- Drive advanced technology development and experimentation to ***address most pressing Fleet and Force challenges***.
- Better leverage ***war gaming***, experimentation, red teaming, and Fleet and Force exercises.

Naval S&T Outreach and Partnerships

- Strengthen maritime ***national and international partnerships*** in Science and Technology.
- Support ***rapid innovation*** with new and existing partners.
- Develop the ***next generation of scientists, engineers, and technicians*** in support of maritime technical superiority.

ONR Portfolio Perspective

Naval Research Laboratory

Directly Sponsored Work

U.S. NAVAL RESEARCH LABORATORY

- Basic and Applied Research and Advanced Technology Development for Anticipated Navy and Marine Corps Needs
- The Navy's Corporate Laboratory
- World-Class Research Team

Delivering Warfighter Advantage

Integrated Research Portfolio → **NRL Basic & Applied Research**

NRL Research Focus Areas


Acoustics


Remote Sensing


Oceanography


Marine Geosciences


Marine Meteorology


Space Science

Office of Naval Research Global

MISSION
Obtain, coordinate & make available worldwide scientific information

VISION
Be the partner of choice for S&T leaders

Connecting 4000+ People

> 1000 Partners

Engagement in 58 Countries

Departments

- INTERNATIONAL SCIENCE
- INTERNATIONAL ENGAGEMENT
- SCIENCE ADVISOR PROGRAM
- EXPERIMENTATION AND ANALYSIS
- FOREIGN COMPARATIVE TEST
- TECH SOLUTIONS

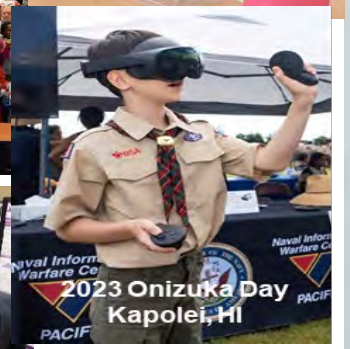
NavalX

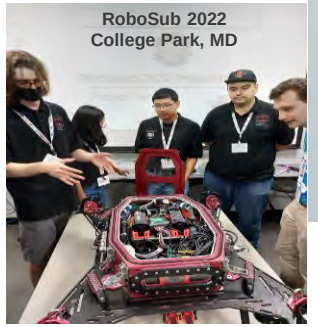
Connecting Experts & Solutions with Workforce Needs

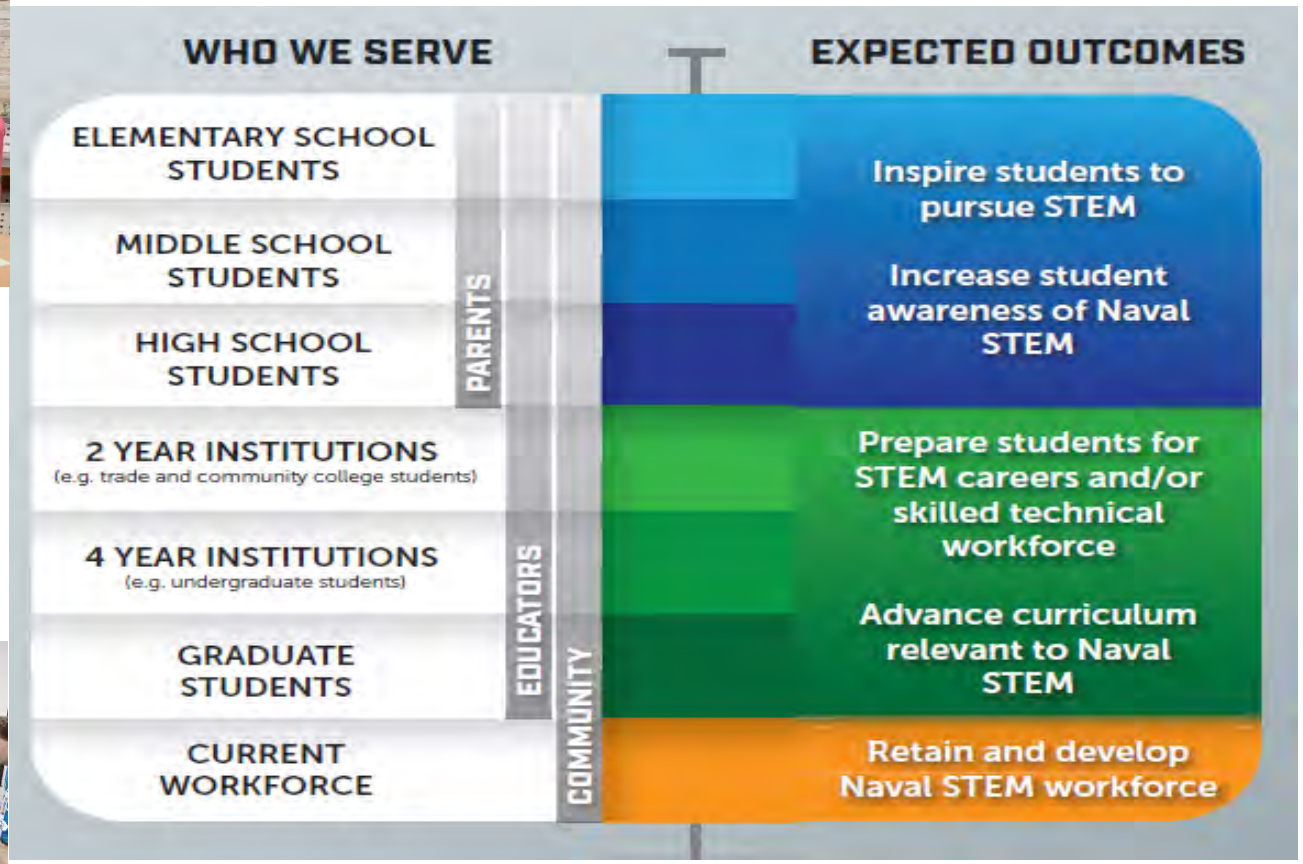
Enabling a Responsive Collaborative Naval Network

CAW = Centers for Adaptive Warfighting

Naval STEM Outreach to over 300,000 Students Annually







Reference: Naval STEM Strategic Plan of December 2022


NRE
NAVAL RESEARCH ENTERPRISE
U.S. NAVAL RESEARCH LABORATORY
GLOBAL
NAVAL X
NAVAL POWER STARTS HERE
UNCLASSIFIED
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Doing Business with the Office of Naval Research

Mr. E. Jamie Thompson SES
ONR Director for Contracts, Grants and Acquisitions

Agenda

- Overview of ONR Procurement
- How Do I Find Grant, Contract & OT Opportunities
- How Do I Submit a Proposal
- Now that I have an Award, What's Next?
- SAVED ROUNDS

Overview of ONR Procurement

ONR Mission

ONR Mission:

- To plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security. ONR is tasked with discovering, developing and delivering new technology and capability for the Navy and Marine Corps. Our Sailors and Marines must have the decisive technological edge to ensure they have the advantage in every engagement

ONR Procurement Mission:

- Award and administer grants, contracts and other transaction instruments for assigned DON Science and Technology (S&T) research ad activities supporting that research.

Overview of ONR Procurement

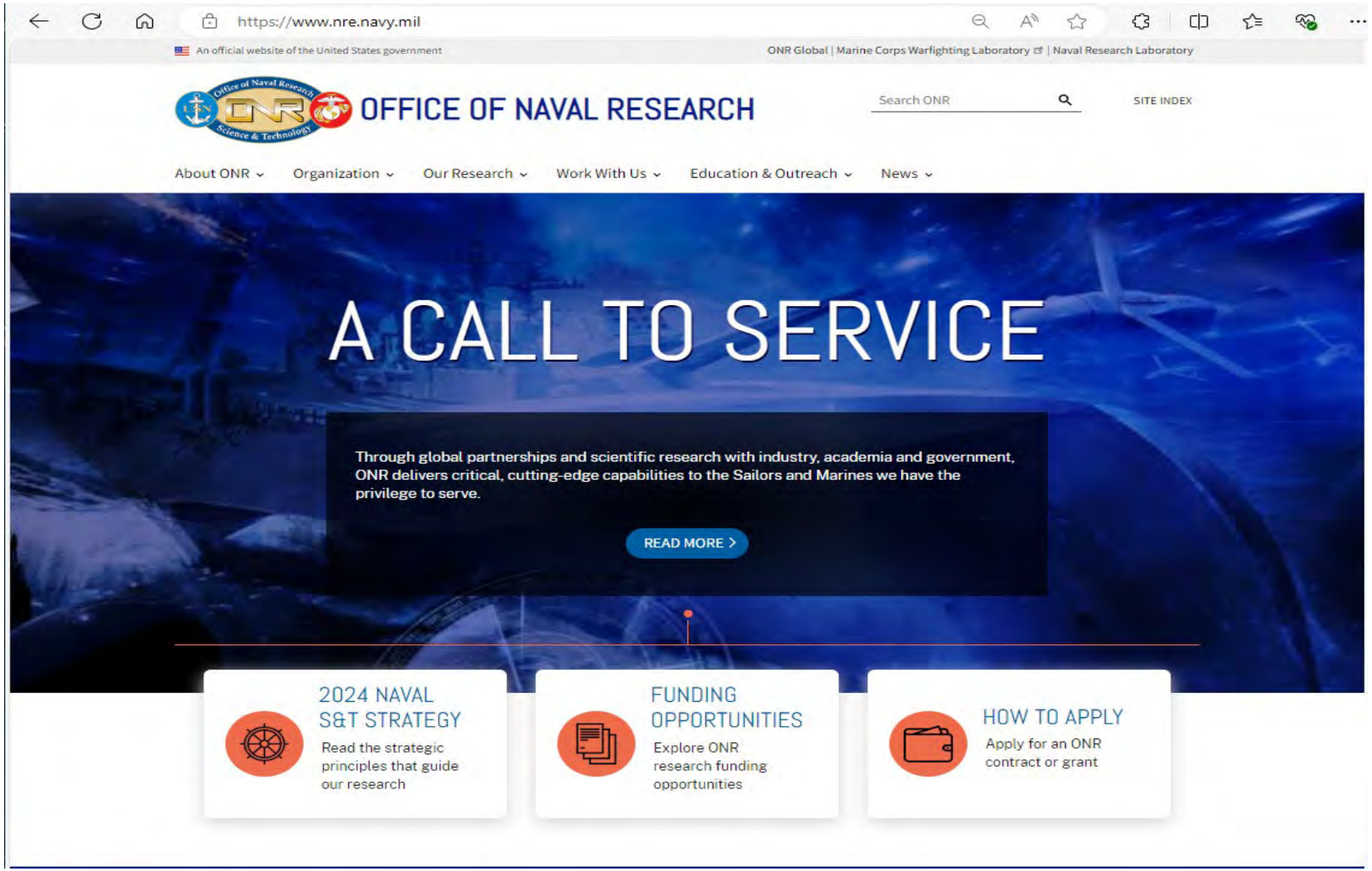
- ONR typically invests $1.8B into naval research & research support per annum
- Grants – typically publish 5 grant-focused Funding Opportunities Announcements (FOAs) per annum
  - Young Investigator Program (YIP) FOA
  - Multidisciplinary Research Program of the University Research Initiative (MURI) FOA
  - Science, Technology, Engineering and Mathematics (STEM) FOA
  - Historically Black Colleges and Universities (HBCU) FOA
  - Defense University Research Instrumentation Program (DURIP) FOA
- Grants, Contracts and OTAs --
  - Long Range BAA and Science and Technology for Advanced Manufacturing Projects (STAMP) BAA.
  - ONR issued 11 BAA calls in FY 23 (specific interest areas under the Long Range BAA).

Overview of FY23 ONR Research Funnel		
Opportunities for Performers	Performer Responses	Research Awards
• 5 Grant focused FOAs • 2 BAAs • 11 BAA Calls	1,634 submissions By 638 performers Avg # of submissions 1	876 New Grants 234 New Contracts 15 New OTs 1,110 New Awards

How Do I FIND Grant, Contract or OT Opportunities?

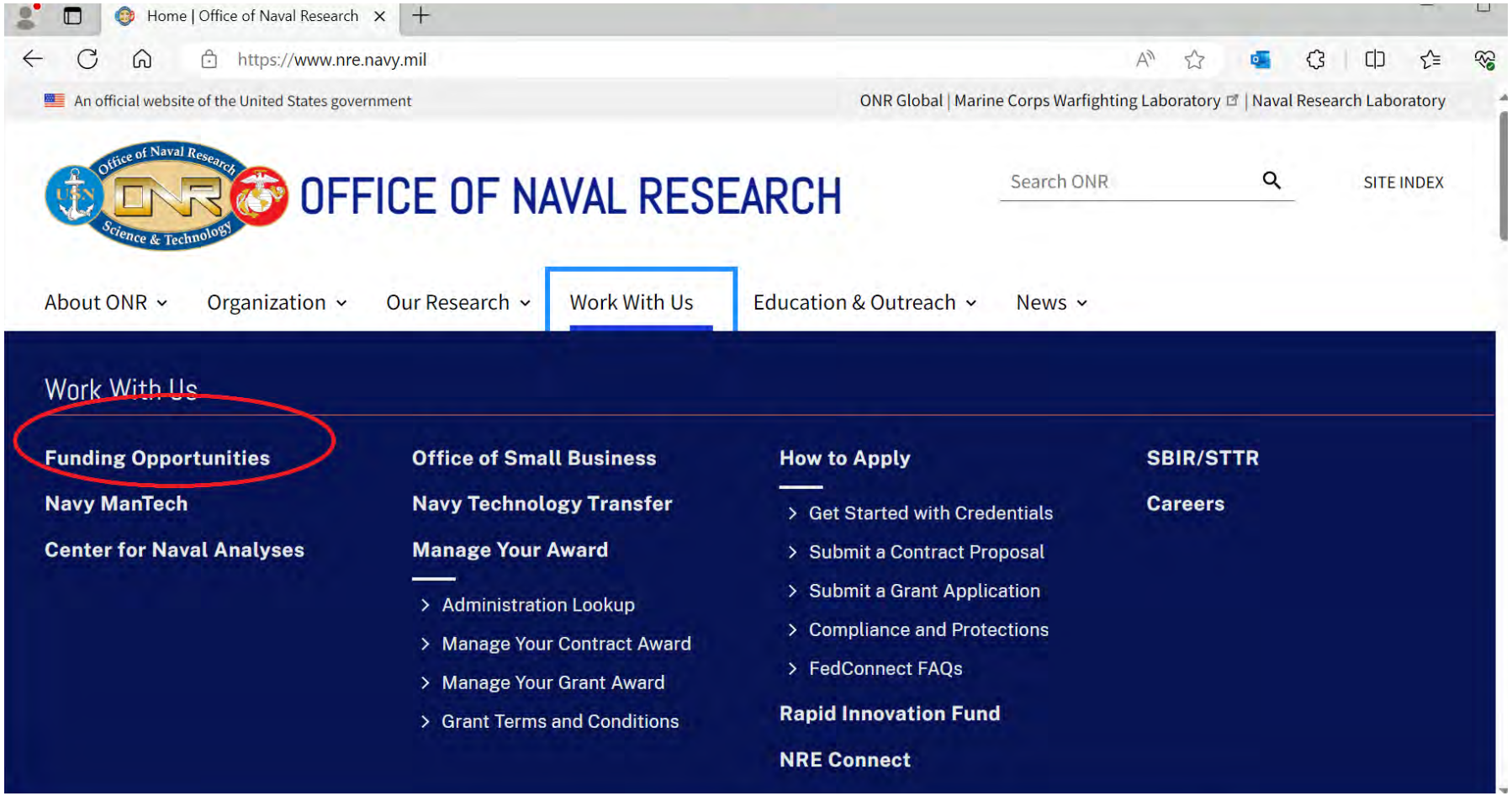
Broad Agency Announcement (BAA)

BLUF: www.nre.navy.mil



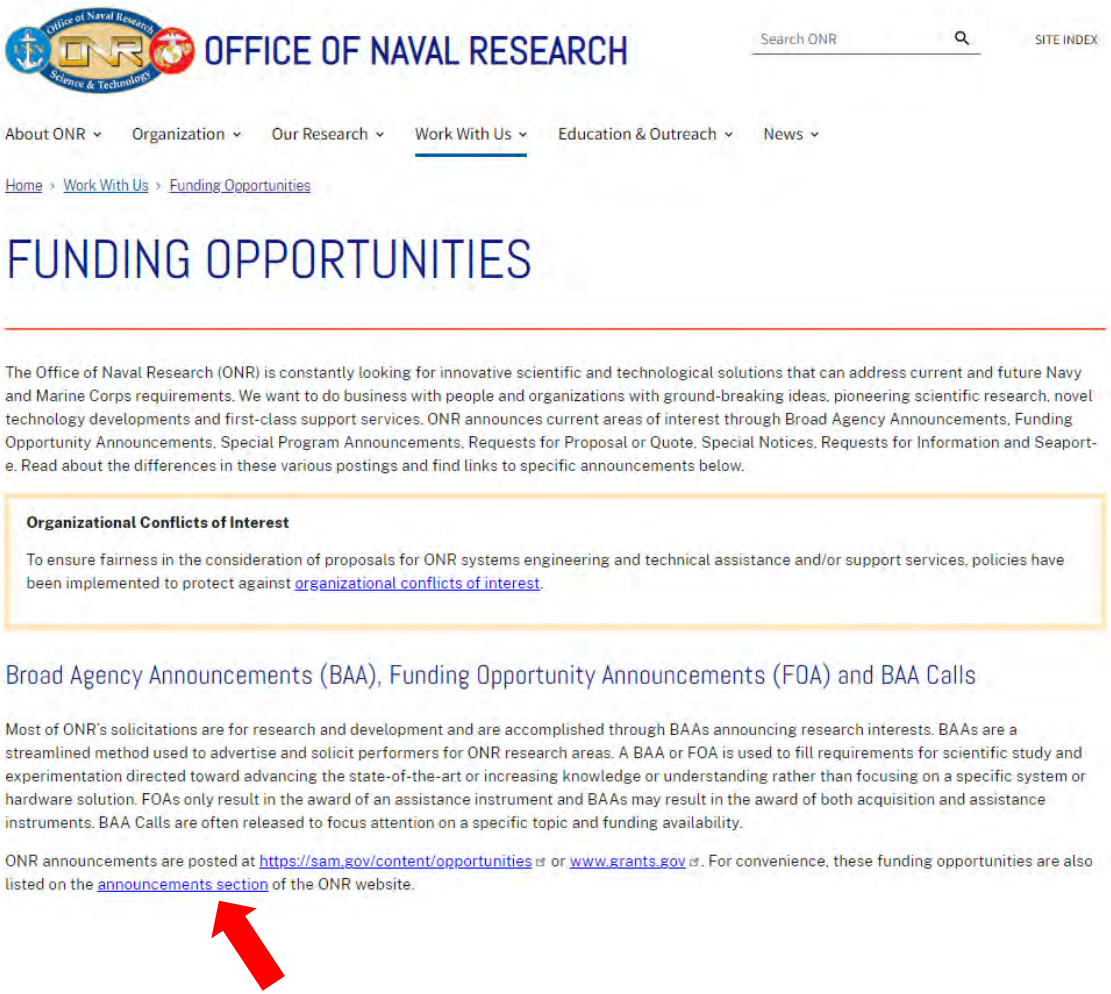
Broad Agency Announcement (BAA)

BLUF: Select the "Working With Us" tab and then click "Funding Opportunities"



Broad Agency Announcement (BAA)

BLUF: Review how we engage S&T performers & CLICK "announcements section"



OFFICE OF NAVAL RESEARCH

Search ONR | SITE INDEX

About ONR | Organization | Our Research | Work With Us | Education & Outreach | News

Home › Work With Us › Funding Opportunities

FUNDING OPPORTUNITIES

The Office of Naval Research (ONR) is constantly looking for innovative scientific and technological solutions that can address current and future Navy and Marine Corps requirements. We want to do business with people and organizations with ground-breaking ideas, pioneering scientific research, novel technology developments and first-class support services. ONR announces current areas of interest through Broad Agency Announcements, Funding Opportunity Announcements, Special Program Announcements, Requests for Proposal or Quote, Special Notices, Requests for Information and Seaport-e. Read about the differences in these various postings and find links to specific announcements below.

Organizational Conflicts of Interest

To ensure fairness in the consideration of proposals for ONR systems engineering and technical assistance and/or support services, policies have been implemented to protect against organizational conflicts of interest.

Broad Agency Announcements (BAA), Funding Opportunity Announcements (FOA) and BAA Calls

Most of ONR's solicitations are for research and development and are accomplished through BAAs announcing research interests. BAAs are a streamlined method used to advertise and solicit performers for ONR research areas. A BAA or FOA is used to fill requirements for scientific study and experimentation directed toward advancing the state-of-the-art or increasing knowledge or understanding rather than focusing on a specific system or hardware solution. FOAs only result in the award of an assistance instrument and BAAs may result in the award of both acquisition and assistance instruments. BAA Calls are often released to focus attention on a specific topic and funding availability.

ONR announcements are posted at https://sam.gov/content/opportunities or www.grants.gov. For convenience, these funding opportunities are also listed on the announcements section of the ONR website.

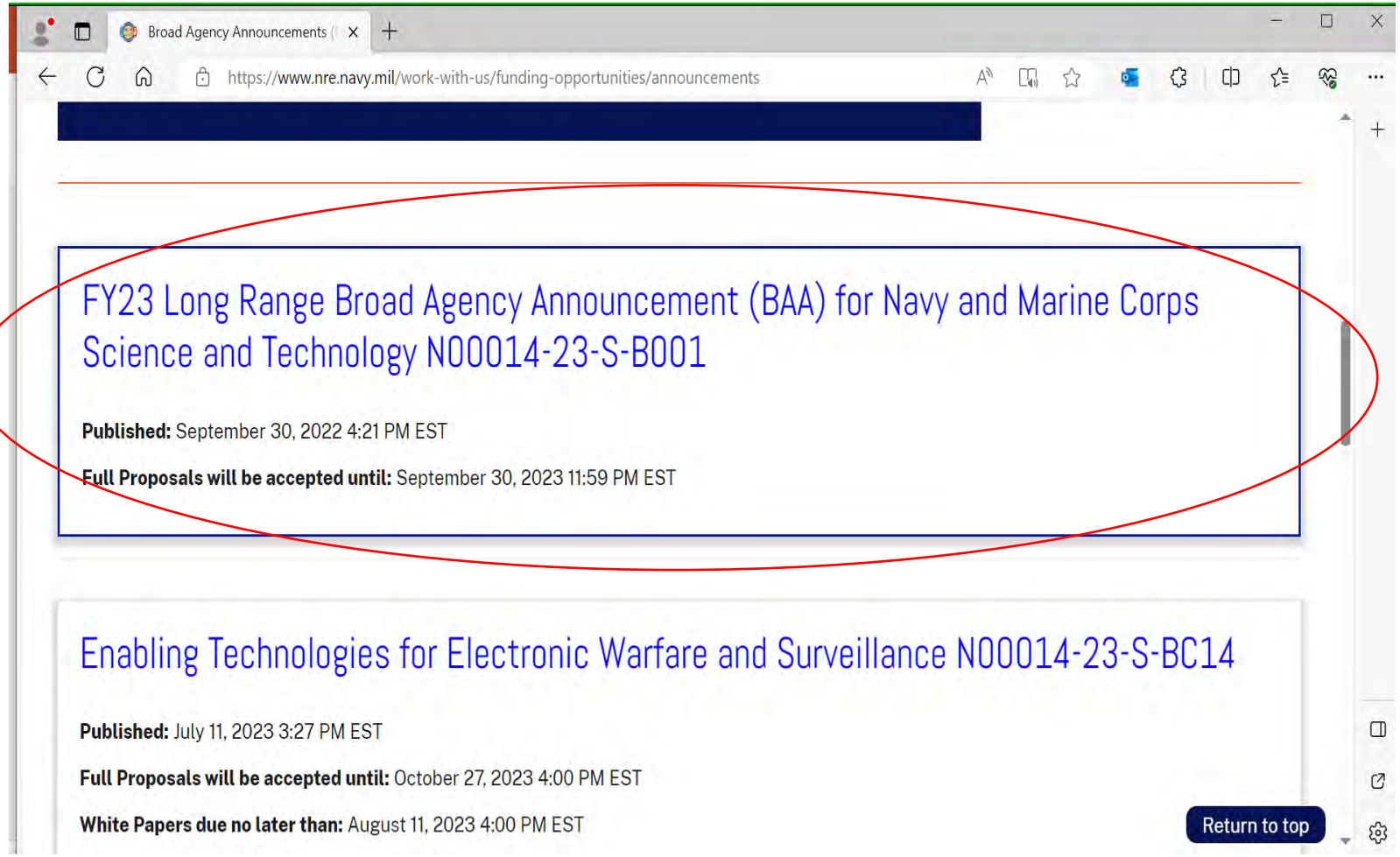
Performer interest items:

- BAA, FOA, & BAA Calls
- Commercial Solution Opportunities
- Request for Proposals
- Request for Quotes
- Request for Information
- Special Notices

- ***Non S&T interest items***:
- Commercial Solution Opportunities
- Request for Proposals
- Request for Quotes
- Request for Information
- Special Notices
- Seaport (service support)

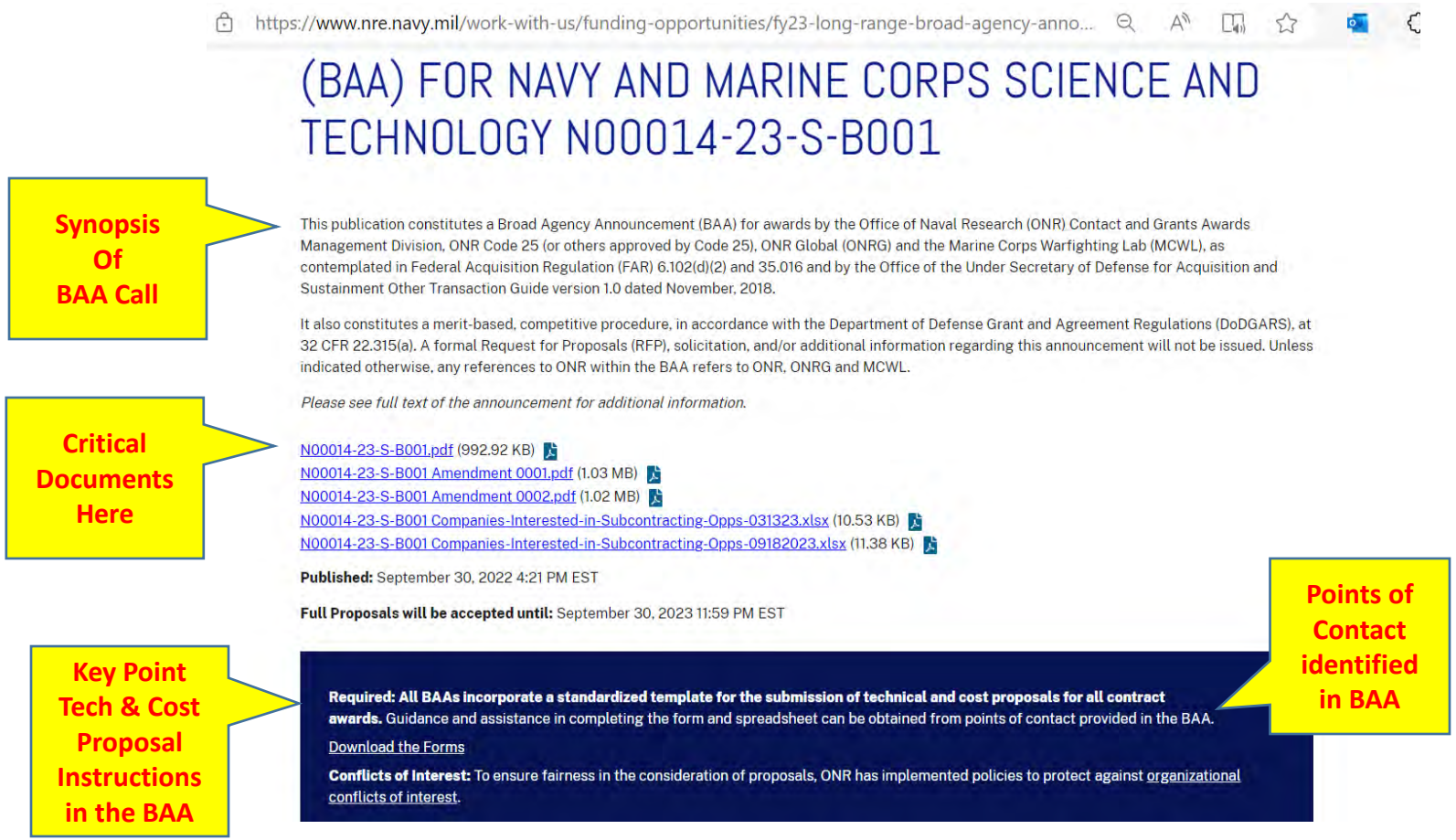
Broad Agency Announcement (BAA)

BLUF: Select the Opportunity you are interested and note the submission deadline



Broad Agency Announcement (BAA)

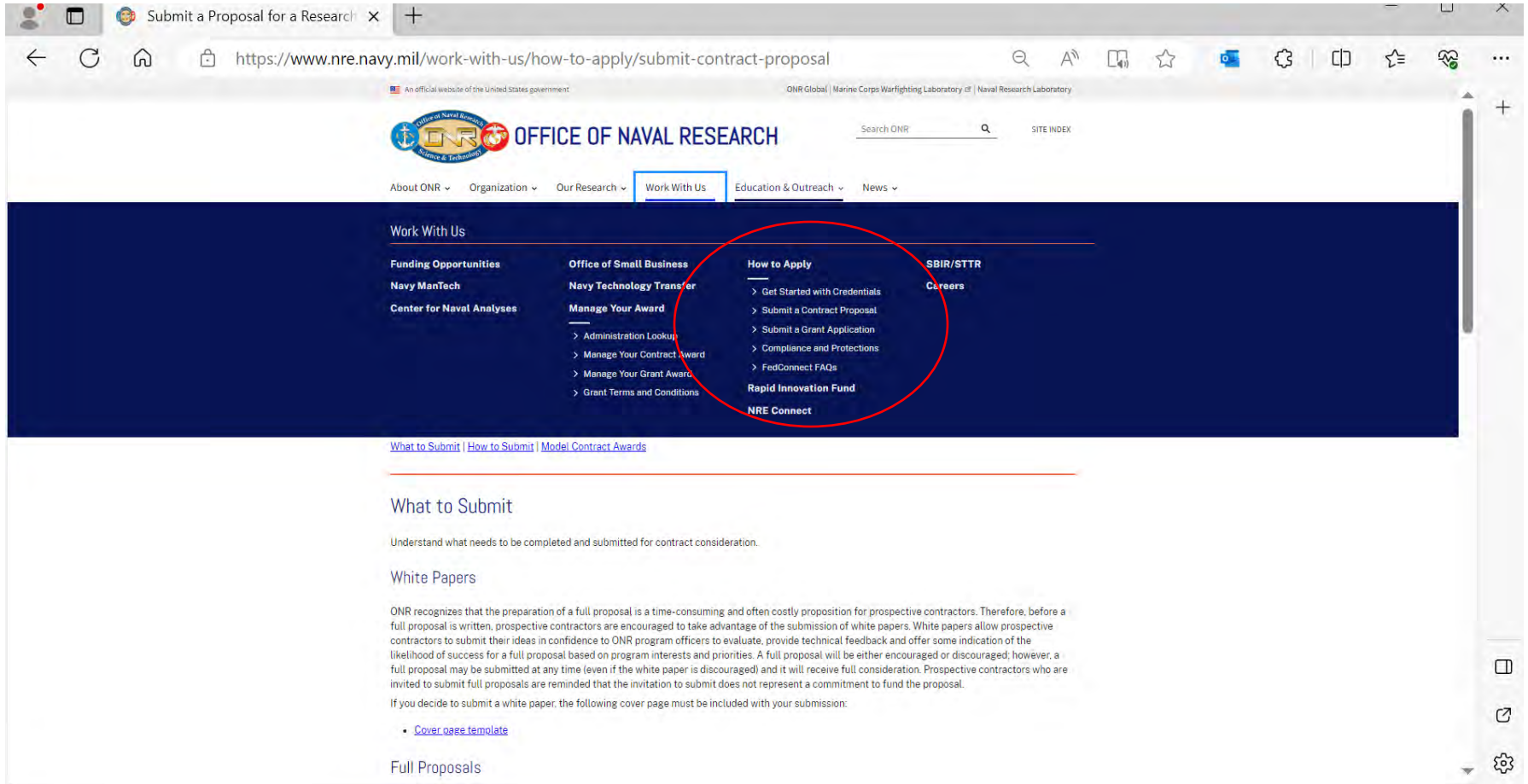
BLUF: Synopsis, Key Documents, Proposal Instructions & POCs are provided.



How Do I Submit a Proposal?

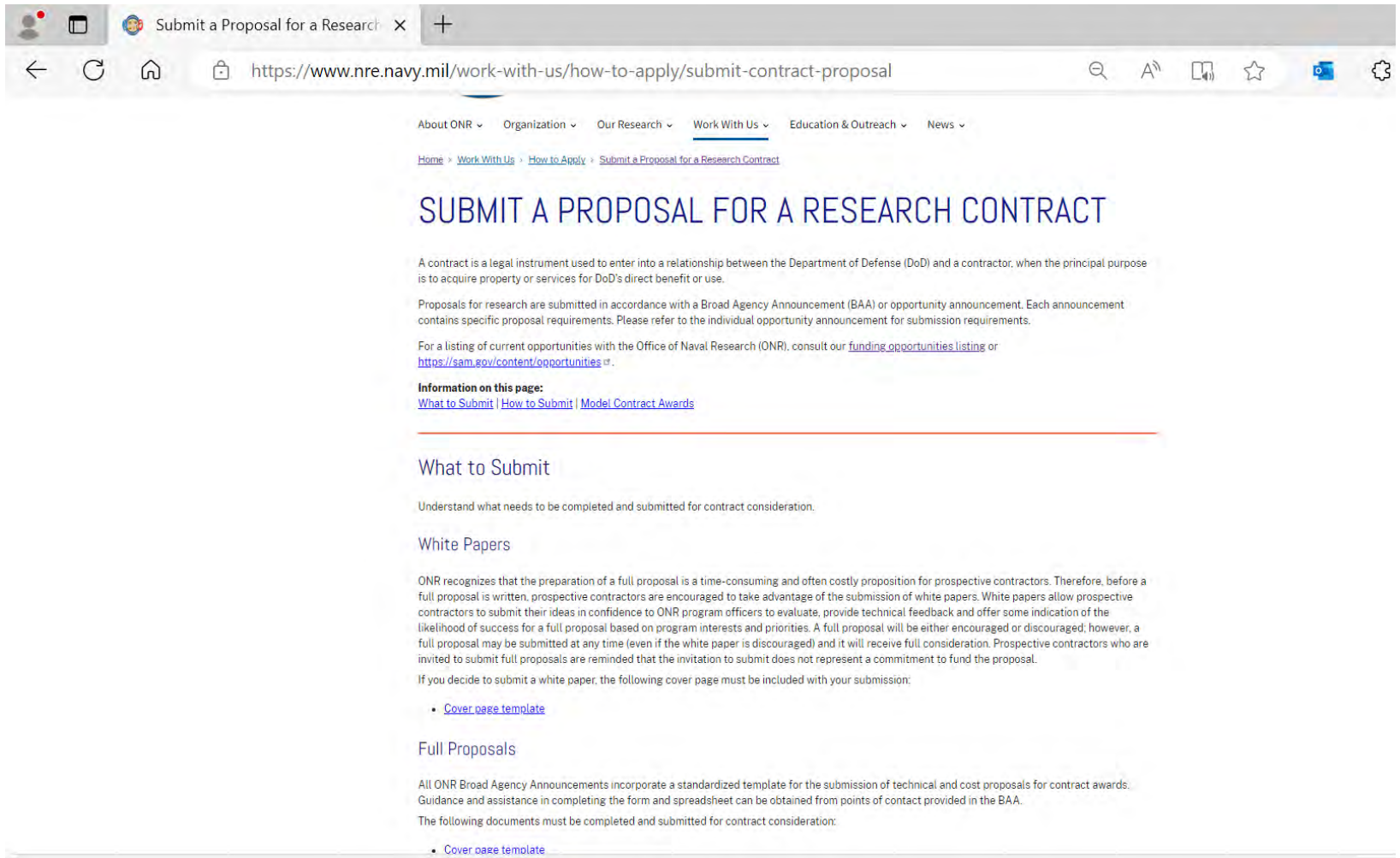
The Instruments

BLUF: Type www.nre.navy.mil; Click "Work with Us"; Select "How to Apply"



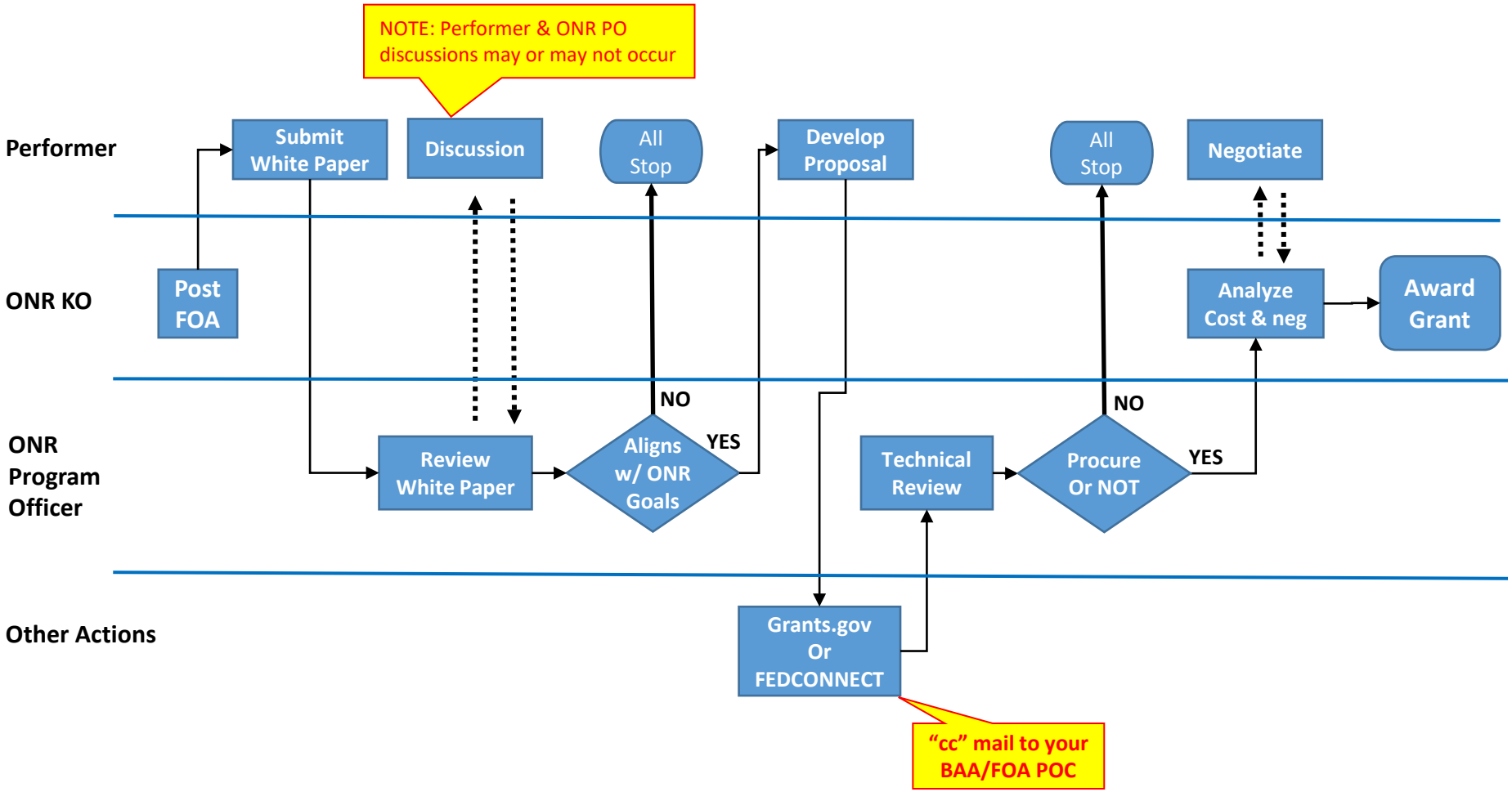
Broad Agency Announcement (BAA)

BLUF: Simple as follow the directions…White Papers first; proposals when asked



Overview of ONR Submission Process

BLUF: Numerous moving parts; responsiveness is key to fast awards



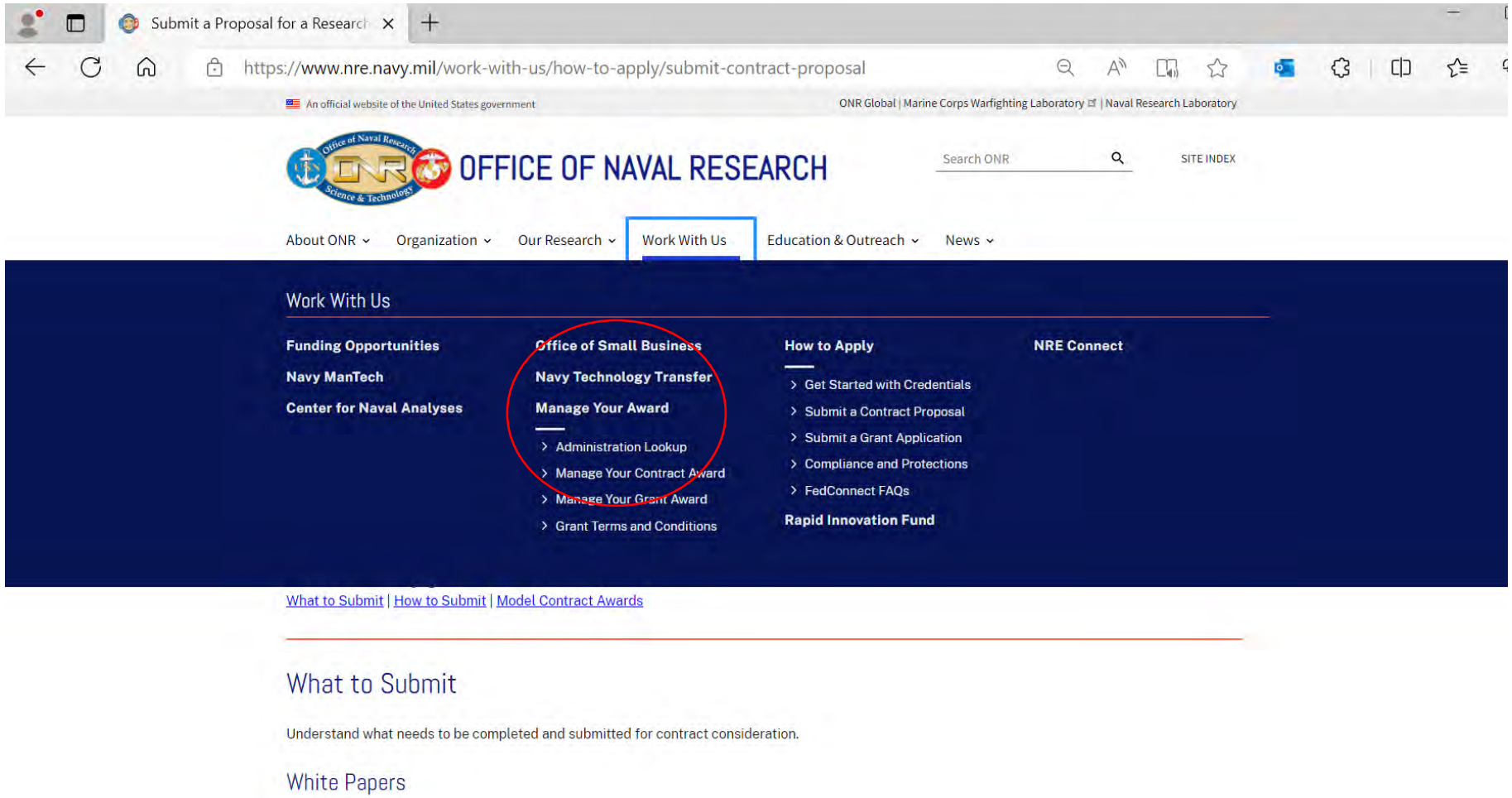
Overview of ONR Research Instruments

	Grants	Contracts	Other Transactions
Purpose	Support & Simulation of Public Purpose	Procuring DON Research Needs	Access to non-traditional firms
Applicable Regulation	DOD Grants and Agreement Regulations	FAR, DFARS & NCMARS	None. However, DoD awarding agencies use DoD Other Transactions Guide
Data Rights/ Release	Public Release of Reports is assumed	Information can be restricted	Negotiable
Fee	None	Profit & Fee	Profit
Vehicle Type	Cost Reimbursement (CR) with Not to Exceed (NTE)	CR with NTE or Fixed Price	Primarily Fixed Price
Is a Cost Proposal Required?	YES	YES	YES
Typical Technical Readiness Levels (TRL)	TRLs 1 & 2	TRLs 3, 4 & 5	TRLs 3, 4, 5, 6, & 7

Now That I Have an Award, What's Next?

Managing Your Award

BLUF: Go to ONR "Working with Us", then click on "Manage Your Award" and follow the guidance.



Accounts for Invoices, Mods, & Report

You need accounts with:

- PIEE* and Electronic Data Access (EDA) Module – notifies performers of, and provides access to new award and modification documents.
- PIEE and Wide Area Workflow (WAWF) Access – Portal for performer invoice submission
- Reporting
  - Research Performance Progress Reports – Grant Performers required to submit annual performance reports (and, later this year, final reports) to Army Research Office (ARO) Extranet website**
  - PIEE and Delivery Schedule Manager (DSM) Access – Forthcoming terms and conditions will require grant performers to submit reports to Administrative Office through this PIEE module in lieu of using email. Plans to expand use to other award types.

Good News: Everything you need is addressed on ONR's website under the "Work with Us" tab and "Manage Your Award" tab

*DoD's Procurement Integrated Enterprise Environment (PIEE) at https://piee.eb.mil/.

** ARO extranet site at https://extranet.aro.army.mil/.

Communications

- Communications are not restricted at any point in our Broad Agency Announcement Process
  - Technical POC – Check you BAA/FOA for your technical POC
  - Business POC – Ms. Lisa Rosenbaum
    - Lisa.L.Rosenbaum.civ@us.navy.mil
    - Office: 703-254-3117
  - Small Business Liaison – Ms. Ellen Simonoff
    - ellen.simonoff.civ@us.navy.mil
    - Office: 703-696-2607

How do Performers get awards faster

- Incomplete Proposal drive long reviews and may result in no award
- Common Performer errors that slow/prevent ONR awards
  - **not registered in SAM.gov;** therefore ONR cannot make an award
  - **SAM.gov account is inactive**…which means ONR cannot award a procurement
  - Required data –identified in the BAA/FOA – is not provided
    - Subcontractor data
    - Travel spreadsheet not submitted
    - Subcontractor/vendor quotes missing
    - Missing consultant information
    - Proposing unallowable costs
  - Check your email address
    - navy.mil ≠ us.navy.mil;
    - Performer email autofill sometimes assigns a performer exchange suffix to the Navy Program Officer…another communication roadblock
  - BOTTOM LINE: **Working together we can improve the speed of research!**

Wrap up/Conclusion

Thank you for your time this morning, we appreciate what you do and look forward to working with you!

Code 35 Focus Area Forum (FAF) Agenda

Time	Event	Briefer	Room
0730-0900	Check-In		Ball Room Lobby
0900-0915	Introduction	Mr. Trip Barber	Ball Room
0915-0945	ONR Overview	CAPT Pete Ladowicz	Ball Room
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1300-1400	Code 35 Hard Problem Break Out Discussions • Air Vehicle Technology • Aerospace Structures & Materials • Science of Autonomy and Controls • Energetic Materials • Kinetic Weapons • Terminal Defense • Directed Energy – Laser • Directed Energy – High Power Microwave	 Dr. David Gonzalez, Dr. Dave Findlay, & Dr. Leighton Myers Mr. Bill Nickerson Mr. Marc Steinberg & Dr. Brian Holm-Hansen, Dr. Chad Stoltz, Dr. Tim Ransom, & Mr. Chris Milby Mr. Ken Heeke, Dr. Roger Sullivan, Mr. Dan Simons & Mr. Taylor Young Mr. Tom Boucher, Ms. Teresa Berra, & Ms. Chloe Lee Mr. Peter Morrison, Mr. Quentin Saulter, and Mr. Matt Ketner Mr. Matt McQuage	 Tidewater III, 2nd Floor Tidewater II, 2nd Floor Ballroom Arlington, 3rd Floor Potomac VI, Ballroom Level Potomac IV, Ballroom Level Potomac V, Ballroom Level Potomac III, Ballroom Level
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Scheduled 1on1s throughout the day (20 minute targets) on site starting at 1400		*Classified 1on1's at ONR Available on 10 or 12 July	

ONR Code 35 – Naval Air Warfare & Weapons

Overview

Dr. Knox Millsaps

ONR Code 35 Department Head

Code 35 Military Missions

Strike

- Long-range, time-critical, resilient kinetic weapons
- Volume fires
- Low-cost swarming technology

Defense

- Defensive Counter Air
- Ship terminal defense
- Escort / Area defense – Surface Action Group (SAG) and Carrier Strike Group (CSG) - Expeditionary Strike Group (ESG) - Expeditionary Forward Area Basing (FAB)

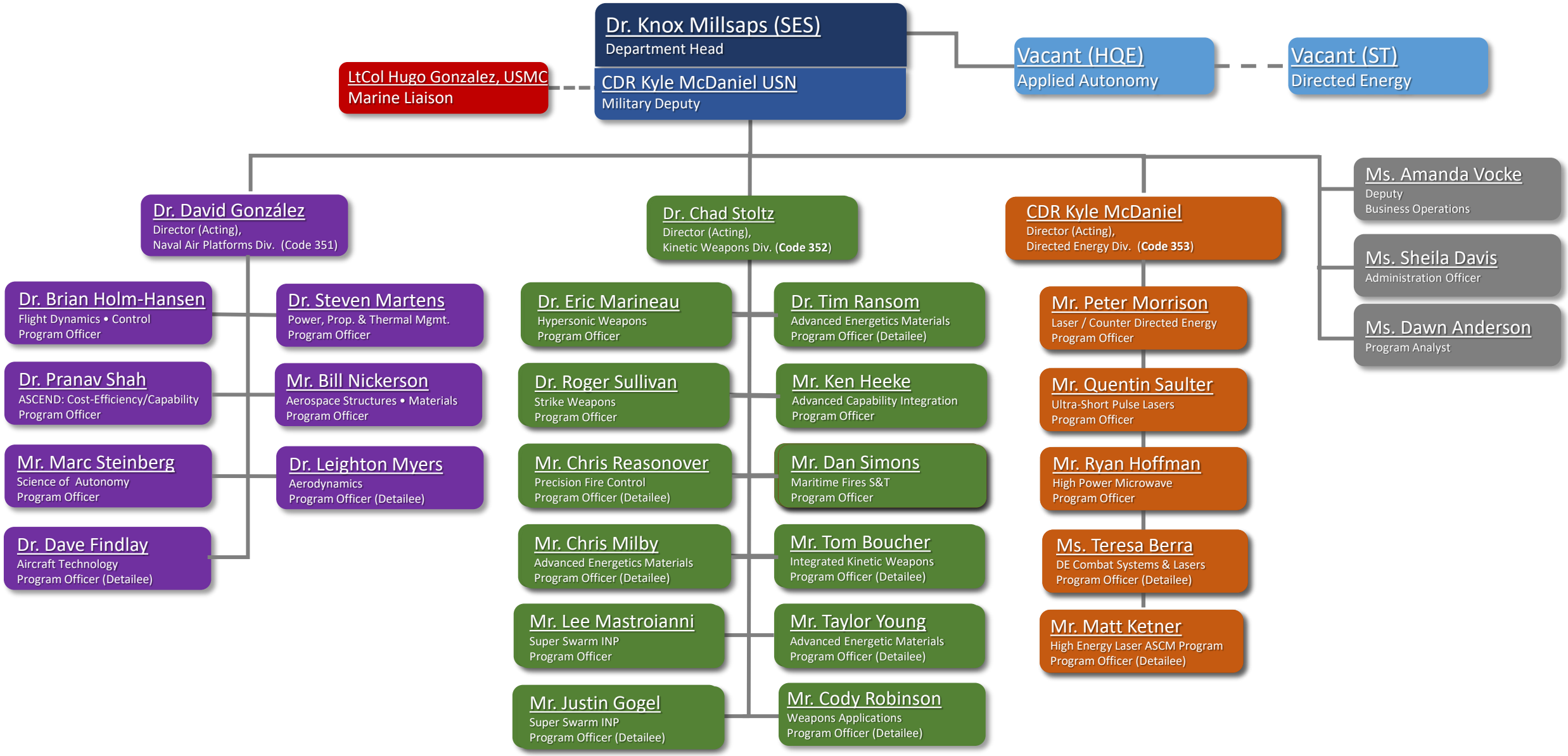
Naval Air Warfare & Weapons

Code 35 Research Objectives, Core Competencies & Objectives

S&T Objectives

- Longer Range, Faster, More Lethal Weapons
- More Effective Defensive Protection for Ships, Aircraft, Expeditionary Advanced Bases & Logistics
- Sustainment Science & Technology
- Twenty First Century Air Operations & Autonomy

Code 35 - Organizational Chart



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Doing Business with ONR Code 35

Dr. David González

Naval Air Platforms Division Director, Code 351 (Acting)

Dr. Chad Stoltz

Kinetic Weapons Division Director, Code 352 (Acting)

ONR Long Range Broad Agency Announcement

- New Long Range BAA is issued every October 1 online
  - https://www.nre.navy.mil/work-with-us/funding-opportunities
  - Topics on ONR Website: https://www.nre.navy.mil/
- Organized by ONR Research Codes
  - Code 31: C5ISRT
  - Code 32: Ocean Battlespace Sensing
  - Code 33: Sea Warfare & Weapons
  - Code 34: Warfighter Performance
  - Code 35: Naval Air Warfare & Weapons

Office of Naval Research Code 35 Air Warfare & Weapons Focus Area Forum Research for the Naval Domain N0001424SBC09
Published: June 10, 2024 5:32 PM EST
Full Proposals will be accepted until: January 31, 2025 11:59 PM EST
White Papers due no later than: June 21, 2024 11:59 PM EST

Demand Signals

S&T	Air	Surface	C5I	Under Water	Expeditionary
N94	**N98**	**N96**	**N2/N6**	**N97**	**N95**
Naval Research Enterprise	Commander, Naval Air Forces	Commander, Surface Forces	NIWC	Commander, Submarine Forces	HQMC
Office of Naval Research	NAVAIR/NAWCs	NAVSEA/NSWCs	Executive Offices	NAVSEA/NUWCs	MARCORSYSCOM
Chief of Naval Research	Program Executive Offices	Program Executive Offices	Program Offices	Program Executive Offices	Program Executive Offices
Naval Research Laboratory	Program Offices	Program Offices		Program Offices	Program Offices
ONR Global	PMA 201	PEO IWS 2.0			
PMR 51	PMA 281	PEO IWS 3.0			
NAVALX	PMA 268	PEO IWS 1.0/10.0/X			
	PMA 265				
	PMA 263				

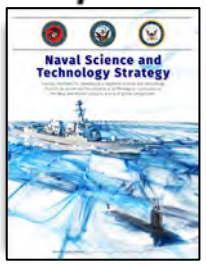
Fleet

Marine Forces

COCOMs

ONR Research & Development Ecosystems

Inputs



Strategic Guidance

Conferences
Meetings
Public Information

Industry / Academia

Gaps / IPL
Meetings
TDA Process

Fleet / Acquisition

6.1 & 6.2 (5-10 years out)

BAR Portfolio

- Identify New Technology
- Discover scientific principles
- Quantify Physical Limits

6.2 (3-5 years out)

Tech Candidate

- Propose FNCs
- Direct Transition
- Identify limiting factors

6.3 (2-3 years out)

Future Naval Capability (FNC)

- TRL 6 technology transition
- Direct Transition
- Termination

6.4+

Transition to Fleet & Force

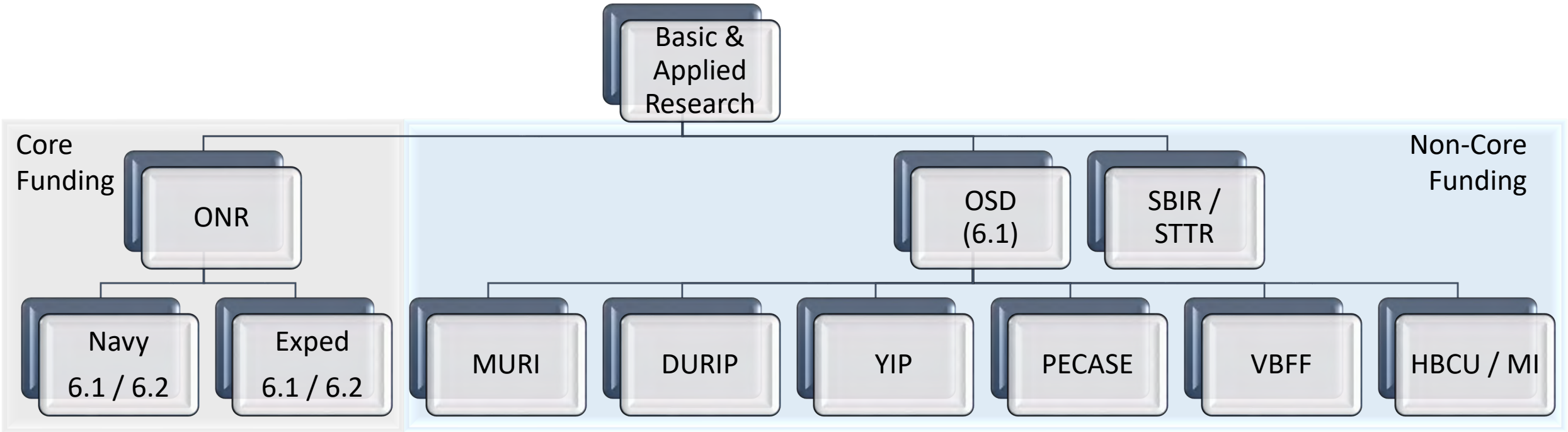
- Capability Gap

Innovative Naval Prototypes (INP) → **Transition Leap Ahead Capability**

Basic Research	Applied Research	Advanced Development	Procurement
Phenomenology, Algorithms, Modelling, Simulation, New Concepts	Real Data, Functional Algorithms, Expected Performance	Functional Hardware, Real Time Algorithms, Real Environment and Operations	Ruggedized Hardware, Maintenance and Sustainment, Operations and Training

Basic & Applied Research (BAR)

- Undiscovered and emerging technologies investigated through basic and applied research
  - Goal: Increase fundamental knowledge, foster opportunities for breakthroughs
  - Provide the basis for future Naval systems
  - Maintain the health of the defense science and engineering workforce
  - BAR Peer Reviews: Assess portfolio in terms of S&T quality, scientific breakthroughs & contributions, and program risk to determine strengths/weaknesses of the current portfolio



Basic & Applied Research (BAR) – Non-Core

- University Research Initiatives (URI) fund promising new research
  - Stimulate innovation, and attract outstanding researchers to naval-relevant research projects:
    - Wide-ranging university research efforts (MURI)
    - University research equipment support (DURIP)
    - National recognition of exceptionally talented young scientists and engineers (PECASE)
    - Department of Defense's most prestigious single-investigator basic research award (Vannevar Bush Faculty Fellowship)

- HBCU/MI and HBCU/MI Equipment and Instrumentation
  - Strengthen the capabilities of the institutions to conduct basic and applied research
  - Increases the quality and quantity of science, technology, engineering and mathematics (STEM) programs
  - Focus on minority researchers and graduates.

- Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR)
  - Strengthen the role of innovative small business concerns (SBCs) in Federally-funded research or research and development

Technology Candidates ("TechCan")

Background

- TechCan Objective: Increase agility and reduce transition risk when responding to Fleet needs by exploring lower TRL solutions that could be matured to higher TRLs prior to the FNC process.
- TechCans crucial element of the broader FNC portfolio
- Each Department Head & Expeditionary Portfolio Director (EPD) selects TechCans from their allocated funding

Goal: Reduce transition risk for lower TRL efforts that may later be successfully proposed as FNC Advanced Development projects

Future Naval Capabilities (FNC) Overview

- A collaborative Naval process involving ONR, Acquisition, *Resource Sponsor* (RS), and the Fleet/Force
- Develop new technologies from fundamental research with quantifiable exit criteria to address validated warfighter requirements
- Matures from Technology Readiness Level (TRL) 4/5 to TRL 6/7 with a 3-year delivery window
- Delivers software, hardware, knowledge products to acquisition Programs of Record (PORs)
- Collaborative development managed by all stakeholders and is codified in a signed *Technology Deployment Agreement* (TDA)

Goal: Effectively Develop and Deploy New Capabilities for the Warfighter

Innovative Naval Prototype (INP) Overview

- A collaborative Naval process involving ONR, Acquisition community, Resource Sponsor (RS), and the S&T Resource Sponsors (N94)
- Develop revolutionary and disruptive technologies from fundamental research which addresses current or anticipated warfighter requirements
- Mature projects from Technology Readiness Level (TRL) 2/3 to TRL 6 within a specified timeframe

- Deliver software, hardware and prototype demonstrations for consideration by prospective acquisition and resource sponsor plank owners
- Collaborative development process where prospective plank owners are invited to sign a Memorandum of Understanding (MOU)

Goal: Develop Game-Changing Operational Capabilities for the Warfighter

Funding Opportunities

- Basic (6.1) Research

Funding Opportunity	FOA Release	Due Date	Award Duration	Avg. Award Funding	Acad	Indus	Gov't
6.1 BAR Portfolio	Oct	Mar (WP) / Sep (Prop)	1 – 4 years	$100 - 300 K / yr	✓	✓	✓
ONR 6.1 Special Notice	Varies	Varies	Varies	Varies	✓	✓	✓
Expeditionary Portfolio 6.1	TBD	TBD	Varies	Varies	✓	✓	✓
ONR Young Investigator	March	July	3 years	$250 K / yr	✓	✗	✗
DURIP	February	May	1 year	$150 – 1,000 K	✓	✗	✗
MURI	February	May	3 – 5 years	$1,500 K / yr	✓	✗	✗
Vannevar Bush FF	August	Oct (WP) / Apr (Prop)	3 years	$1,000 K / yr	✓	✗	✗
HBCU/MI 6.1	July	Sep (WP) / Dec (Prop)	3 years	$150 K / yr	✓	✗	✗
HBCU/MI Equip. & Instr.	May	August	1 year	$100 – 600 K	✓	✗	✗
PECASE	Varies	Varies	5 years	$250 K / yr	✓	✗	✗

Funding Opportunities

- Applied (6.2) Research

Funding Opportunity	FOA Release	Due Date	Award Duration	Avg. Award Funding	Acad	Indus	Gov't
6.2 BAR Portfolio	Oct	Mar (WP) / Sep (Prop)	1 – 4 years	$100 - 300 K / yr	✓	✓	✓
ONR 6.2 Special Notice	Varies	Varies	Varies	Varies	✓	✓	✓
FNC Tech Candidate	December	Feb (WP) / May (Prop)	1 – 3 years	$1 – 4 M over life cycle	✗	✓	✓
INP SEEDLING	December	Feb (WP) / Mar (Prop)	1 – 2 years	$1 – 4 M over life cycle	✗	✓	✓
Expeditionary Portfolio 6.2	December	March	Varies	Varies	✗	✓	✓
Expeditionary Portfolio Tech Candidate	December	March	Varies	Varies	✗	✓	✓
SBIR / STTR	Dec (xx.1) / Apr (xx.2)	Feb (xx.1) / June (xx.2)	1 – 4 years	$150 – 2,250 K over life cycle	✓	✓	✗

Funding Opportunities

- Advanced Technology Demonstrations (6.3)

Funding Opportunity	FOA Release	Due Date	Award Duration	Avg. Award Funding	Acad	Indus	Gov't
Future Naval Capabilities (FNC)	December	Feb (WP) / May (Prop)	3 – 5 years	$2 – 59 M over life cycle	✗	✓	✓
Innovative Naval Prototype (INP)	December	Feb (WP) / Mar (Prop)	3 – 8 years	$10 – 100 M over life cycle	✗	✓	✓
Expeditionary Portfolio 6.3	December	March	Varies	Varies	✗	✓	✓
ONR-G Experimentation & Analysis (E&A)	Varies	Varies	Varies	Varies	✗	✓	✓

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Code 351
Naval Air Platforms Overview

Dr. David González
Naval Air Platforms Division Director, Code 351 (Acting)

Naval Air Platforms

Objective: Investigate and mature technologies in support of delivering capabilities or improvements to aviation platforms (manned/unmanned) and air-ship operations; and developing other technologies specific to the air domain or aviation regime.

Operational Challenges: Increased complexity and cost of air vehicles; increased operational dependence upon unmanned systems and/or capabilities; extremely capable and advanced threats in the air domain.

Research Areas:

- Aerodynamics
- Flight Dynamics and Control
- Materials & Structures
- Power, Propulsion & Thermal Management
- Autonomous Vehicles
- Artificial Intelligence
- Science of Autonomy

Research Applications:

- Next-Gen Tactical Aircraft & Vertical Lift
- Autonomous Air, Sea Surface, Undersea, Ground, and Amphibious Systems
- Revolutionary Launch & Recovery Approaches
- Infinitely Repairable Airframes
- Live Virtual Constructive simulation-based certification processes

Warfighting Payoff:

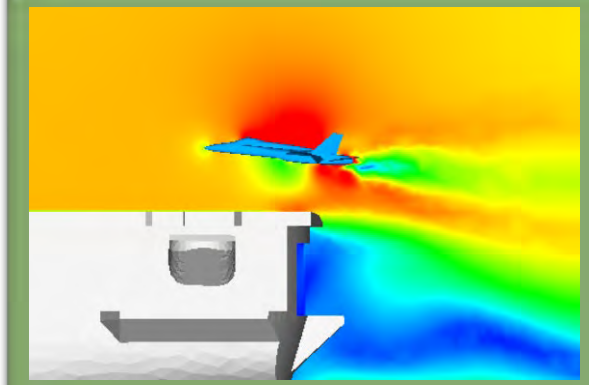
- Reduced TOC, increased Lifecycle Cost Savings
- Increased operational availability, tempo, envelop
- Multi-platform, multi-use, scalable technologies
- Low-Cost Risk-Worthy Air Assets (Weapon-Platform Gap)

National Defense Strategy Key Capabilities Addressed:

- Missile Defense, Joint lethality in contested environments, Forward maneuver and posture resilience

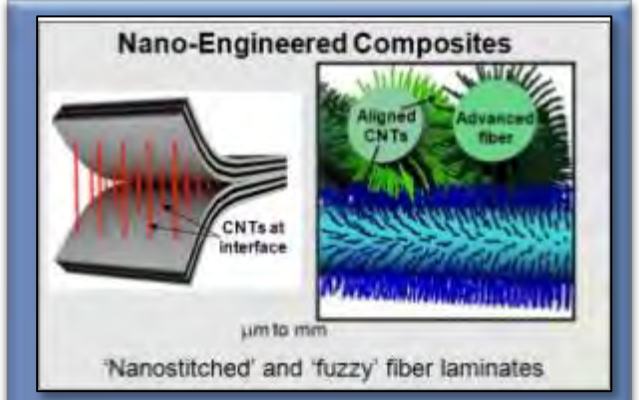
Sea-Based Aviation (SBA) National Naval Responsibilities (NNR)

Focus Areas



- Launch and Recovery
- Unsteady Aerodynamics
- Flow Control
- Advanced Handling Qualities
- Improved Fixed-Wing High-Lift
- Enhanced V/STOL Ops
- Autonomous Deck Operation
- Advanced Concepts

Aircraft



- Mode Characterization
- Lightweight Materials
- Advanced Composites
- Advanced Structural Concepts
- Degradation/Corrosion
- Protection/Maintenance
- Additive Repair
- Engineered Interfaces

Structures

- Advanced Cycles
- Engine-Airframe Integration
- Power-Dense Turbomachinery
- Jet Noise Reduction
- Thermal Management
- Hot-Section Materials/Coatings
- Small UAV Propulsion

Propulsion

The Office of Naval Research (ONR)

National Naval Responsibility Purpose

- To maintain the health/currency/technical superiority of identified Navy-unique Science & Technology in order to provide:
  - Robust U.S. research capability to address long-term S&T problems of interest to the Dept. of the Navy
  - Adequate pipeline of new scientist and engineers in disciplines of Navy importance
  - S&T products necessary to ensure future superiority in integrated naval warfare

Five NNRs include:

- Ocean Acoustics
- Undersea Weapons
- Naval Engineering
- Undersea Medicine
- **Sea-Based Aviation**

ONR must ensure U.S. world leadership in these targeted unique areas through research, recruitment and education, to maintain an adequate base of talent and sustain critical infrastructure for research and experimentation.

Aerodynamics

Advancing Aerodynamics S&T & Future Workforce Development to Enable Enhanced Mission Capabilities for Naval & Expeditionary Air Vehicles & Weapons by Focused Investments in Four (4) Areas of Interest (AOI)

Dr. David Gonzalez
Aerodynamics Program Officer
351 Naval Air Platforms Division Director (Acting)

Dr. Leighton Myers
Deputy Aerodynamics Program Officer

Research Areas:

- Flow & Boundary Layer Control
  - Fundamental understanding of flow controllability enabling novel effectors for enhanced performance of air vehicles & weapons
- Unsteady & Separated Flow Dynamics
  - Critical understanding of salient & non-stationary fluid flow phenomena
- Aero-Coupled Phenomena
  - Research into critical couplings between fluid flows & other relevant phenomena inducing non-linear air vehicle/weapon response
- Novel Experimental Techniques & Diagnostics
  - Innovative techniques, diagnostics, & multi-sensor data fusion for real-time characterization & prediction of complex fluid dynamic environments

Research Applications:

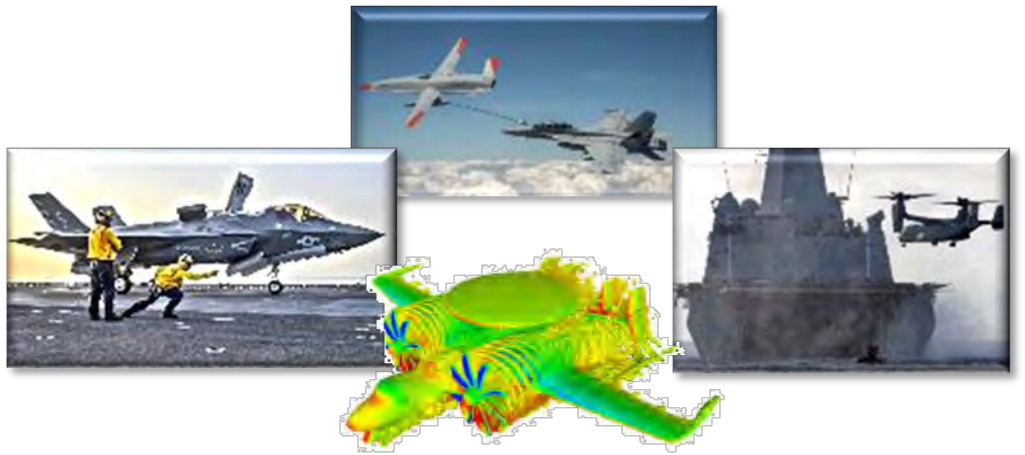
- Next-Gen Tactical Aircraft & Vertical Lift
- Collaborative Combat Aircraft
- Revolutionary Launch & Recovery Approaches
- High-Speed Tactical Weapon Aerodynamics & Maneuverability
- Maritime Aero-Optical Environment

Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
ONR - Work With Us | Office of Naval Research (navy.mil)

Aircraft Technology Applications

Maturation of Applied Research Through Design, Fabrication and Testing for Application to Existing and Future Naval Air Platforms and Improving Ability to Accurately and Efficiently Model & Simulate Flight Systems

Dr. David Findlay
Aircraft Technology Applications
Program Officer



Development Areas

- Forward-thinking Concepts Toward Shore- & Sea-based Air Vehicles
- Multi-disciplinary Consolidation of Advances in Aeromechanics Sciences
- Improved Performance, Safety & Affordability of Operational Systems
- Automated / Pilot-Augmented Guidance, Navigation & Control
- Enhanced Simulation-Based Acquisition - Realization of full System Capability
- Innovative Sea-based Launch and Recovery Technologies

Applications

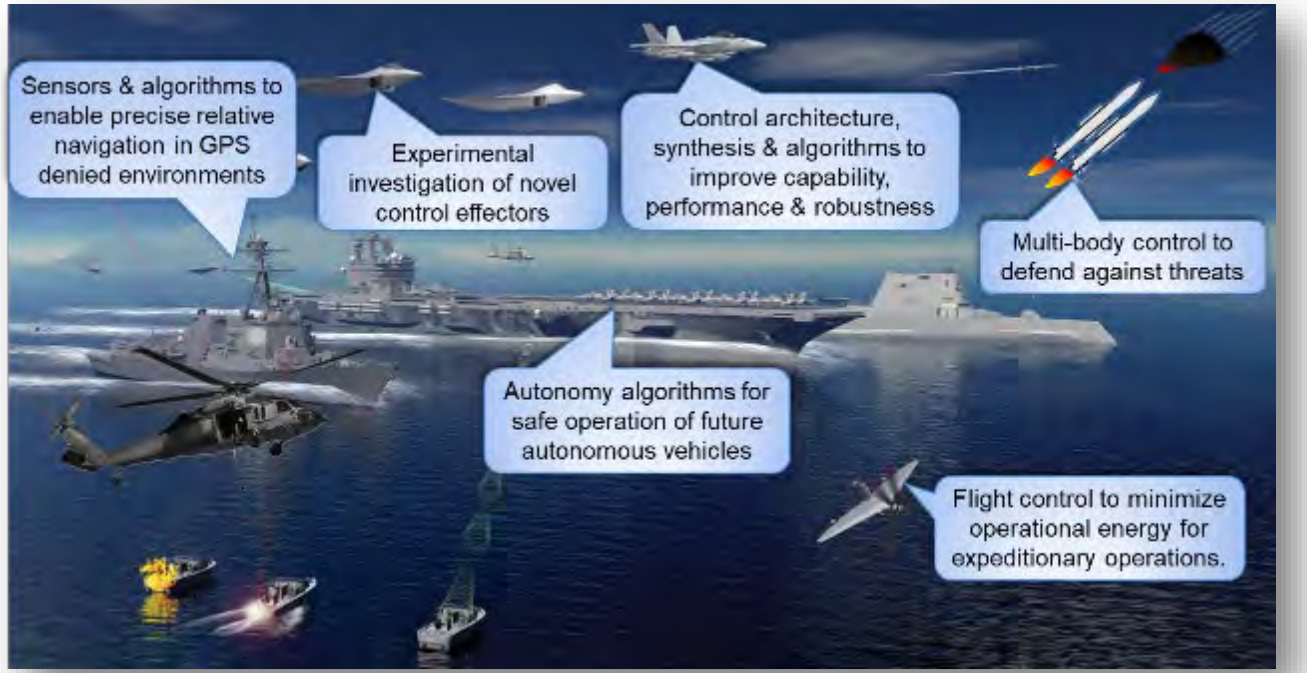
- Live Virtual Constructive simulation-based certification processes
- CVN-based Air Operations
- VTOL Sea-based Capabilities
- Ship-based Unmanned Air Vehicles
- Ship-launched Electronic Warfare Air Vehicles

Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
ONR - Work With Us | Office of Naval Research (navy.mil)

Flight Dynamics & Control

Advanced displays, inceptors, algorithms, effectors, and sensors for Naval Aviation

Dr. Brian Holm-Hansen
Flight Dynamics & Control
Program Officer



Research Areas:

- Control law synthesis methods for performance and robustness
- Real-time optimal collaborative control
- Guaranteed performance for multi-body control systems
- Advanced dynamics of coupled human/machine control systems

Research Applications:

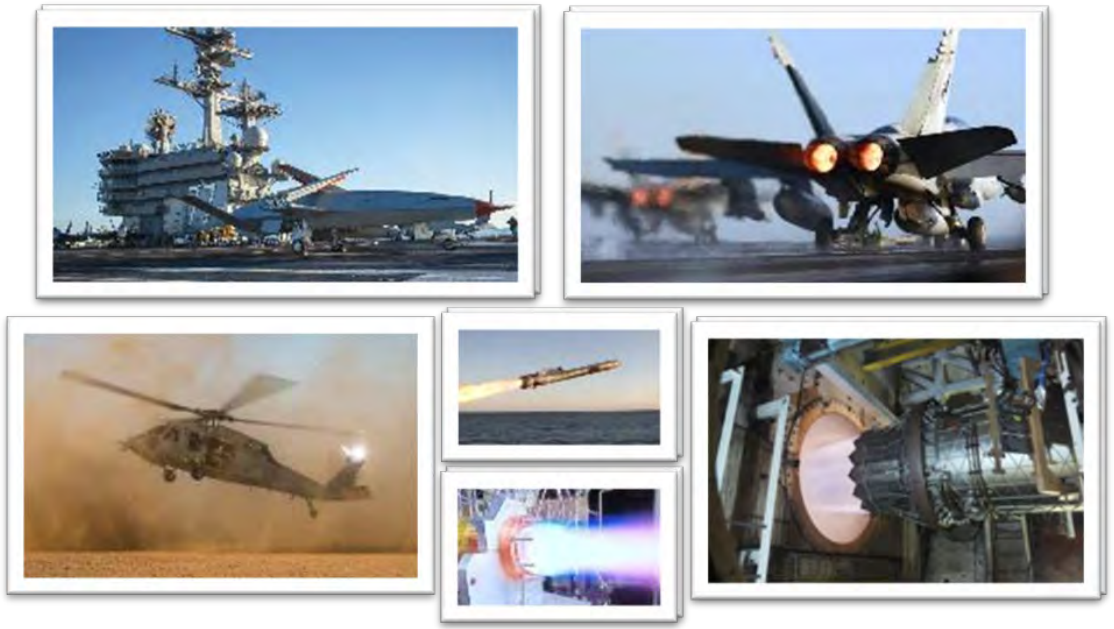
- Distributed, resilient, long-endurance monitoring and control of the maritime environment.
- Improved recovery for piloted aircraft

[Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)]
[ONR - Work With Us | Office of Naval Research (navy.mil)]

Naval Aviation Propulsion, Power, Thermal Management and Jet Noise Reduction

Delivering cutting edge Propulsion, Power, and Thermal Management (PPTM) and Jet Noise Reduction (JNR) Science & Technology (S&T) to the Naval Aviation Enterprise in a Cost Efficient Manner While Preparing the Next Generation of DoD Engineers and Scientists

Dr. Steve Martens
Power, Thermal Management and Jet Noise Reduction Program Officer



Research Areas

- Advanced PPTM Concepts up to Mach 3
- Rotating Detonation Combustion
- High Temperature Fuels and Coke Mitigation
- Highly Integrated Inlets and Exhausts
- Heat Collection, Distribution, and Rejection
- High Temperature Materials and Coatings
- Sand and Dust Mitigation
- Jet Noise Reduction
- Power Generation/Turbo Alternators
- Air Bearings/Alternate Lubrication Approaches
- Sustainment S&T (Materials, Additive, Repairs)

(Some) Relevant Applications

- 5th and 6th Generation Tactical Aircraft
- Future Vertical Lift (FVL) Family of Aircraft
- Autonomous & Collaborative Combat Aircraft (ACAs)
- Small UAS & Decoys
- Cruise Missiles
- Legacy Navy Aircraft

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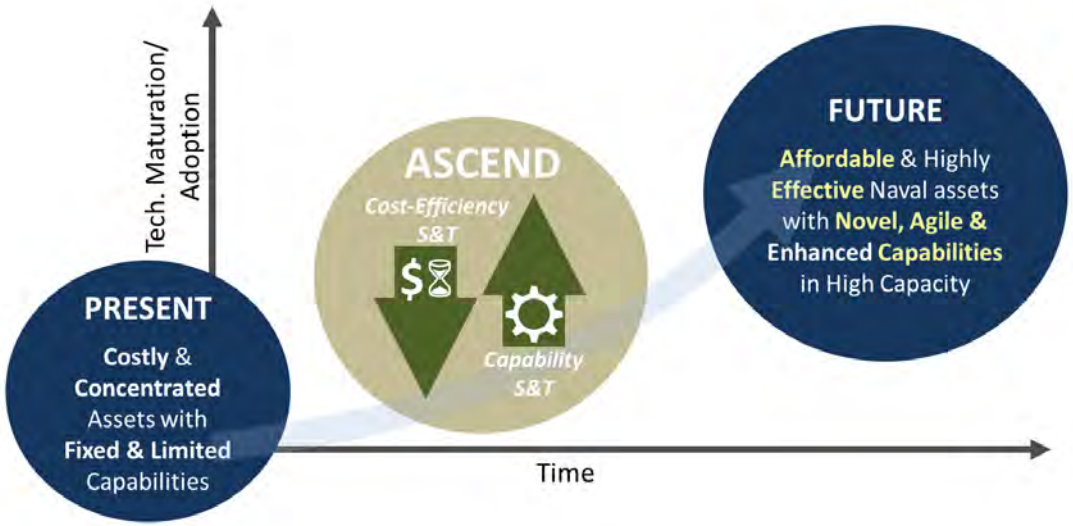
Aero S&T of Cost-Efficiency & Capabilities in Naval Domain (ASCEND)

Dr. Pranav D Shah
Program Officer



Research Areas

A list of research opportunities relevant to ASCEND portfolio includes (not limited to):

- High Number/Rate Storage & Deployment: *Rapidly packaging/deploying aerial assets from minimal space in high number*
- Rapid, Low-Cost & Limited-Life Concepts for Design, Manufacturing & Assembly
- Persistent Technologies for aerial assets
- Multi-functional Materials/Structures for aerial assets (including aircraft and weapons)
- Self-Similar Concepts: *Scalable (by number) and swappable (by similarity) components*
- Modular Components with Hybrid Life and Swappable Capabilities
- Rapid Multi-discipline Analysis and Optimization

Research Concentration Areas

Cost-Efficiency: Basic and applied research in Cost-Efficiency area strides in developing novel rapid, limited-life low cost (L3C) concepts for design, manufacturing and assembly of Naval aerial assets (including unmanned, attritable and expendable assets).

Capabilities: Basic and applied research in Capabilities area strides in improving existing or introducing novel capabilities enabling highly effective Naval aerial assets with novel, agile & enhanced capabilities in high capacity.

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Science of Autonomy

Science of Autonomy Lead (ONR-wide focus)
Participant in Science of Artificial Intelligence, Expeditionary Fundamental Research

MARC STEINBERG
Science of Autonomy
Program Officer

Research Areas

- Human/Autonomy Collaboration
- Perception & Intelligent Decision-Making
- Scalable, Robust Collaboration
- Situated & Embodied Intelligence
- V&V, Safety, Proficiency/Performance Assessment, Trust, Reliability, Robustness

Applications

- Autonomous Air, Sea Surface, Undersea, Ground, and Amphibious Systems
- Human/Autonomy Teams/Hybrid Force
- Multi-UxV Systems, Swarms, Coalitions
- Large Spatiotemporal Scale Operations

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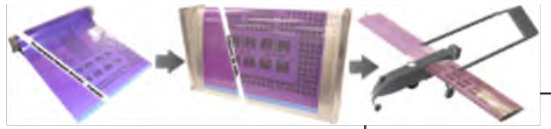
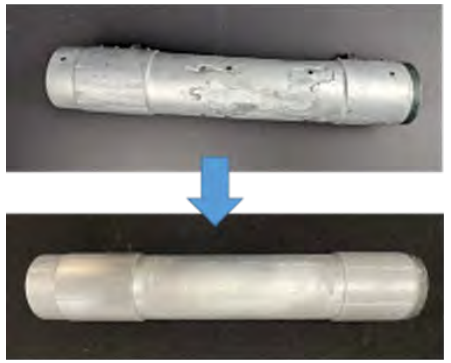
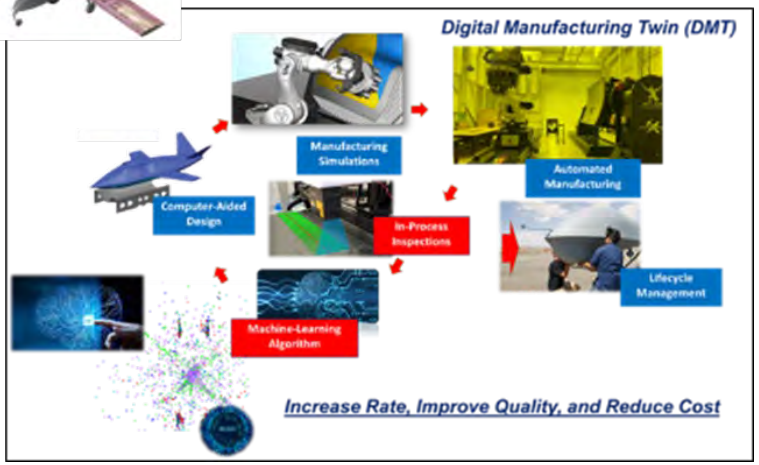
Aero Structures & Materials

Future Structures, Materials & Processes S&T – via Lightweight & Survivable Structures; Affordable & Sustainable M&P; Advanced Materials & Manufacturing; Design & Maintenance Tools.

Mr. Bill Nickerson
Aero Structures and Materials
Program Officer







Research Areas

Multifunctional Structures
- Integrated EMI / Com / Energy Harvesting / Storage

Digital Engineering / Manufacturing
- Automated Manufacturing – Robotics / ML Enabled
- Integrated Manufacturing / Maintenance Data Capture / Analysis

Next Gen Materials
- Metallic alloys, Spray/Additive Deposition Methods
- Composites and Tailored Materials – New Polymer M&P, Flow-Surface Interactions

Reliability & Sustainment S&T
- Multi-Cycle Repair Methods, Portable NDI – Rapid Cert, Remote Expert
- Automated Repairs – Multi-substrate, Portable, On-demand

Applications

Infinitely Repairable Airframes
- Solid State Structural Repair

Deployable Depot
- Portable, point-of-use Sustainment

Enhanced M&P Transition
- Advanced Coatings, NDI, and Manufacturing Processes

Advanced Structural Design
- Digital Engineering / Manufacturing / Knowledge Tools

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Summary

Operational Challenges: Increased complexity and cost of air vehicles; increased operational dependence upon unmanned systems and/or capabilities; extremely capable and advanced threats in the air domain

Research Areas:

- Aerodynamics
- Flight Dynamics and Control
- Materials & Structures
- Power, Propulsion & Thermal Management
- Autonomous Vehicles
- Artificial Intelligence
- Science of Autonomy

Research Applications:

- Next-Gen Tactical Aircraft & Vertical Lift
- Autonomous Air, Sea Surface, Undersea, Ground, and Amphibious Systems
- Revolutionary Launch & Recovery Approaches
- Infinitely Repairable Airframes
- Live Virtual Constructive simulation-based certification processes

Code 35 Focus Area Forum (FAF) Agenda

Time	Event	Briefer	Room
0730-0900	Check-In		Ball Room Lobby
0900-0915	Introduction	Mr. Trip Barber	Ball Room
0915-0945	ONR Overview	CAPT Pete Ladowicz	Ball Room
0945-1015	Doing Business with ONR	Mr. Jamie Thompson	Ball Room
1015-1030	Code 35 Overview	Dr. Knox Millsaps	Ball Room
1030-1045	Break		Ball Room
1045-1100	Doing Business with Code 35 (BAR, FNC, INP, & BAAs)	Dr. David González and Dr. Chad Stoltz	Ball Room
1100-1115	Naval Air Platforms	Dr. David González	Ball Room
1115-1130	Kinetic Weapons	Dr. Chad Stoltz	Ball Room
1130-1145	Directed Energy	Mr. Matthew Ketner	Ball Room
1145-1200	Expeditionary Weapons	Col Howard Marotto	Ball Room
1200-1300	Lunch		
1230-1330*	Code 35 Hard Problem Break Out Discussions • Power, Propulsion, & Thermal Management • Hypersonics	 Dr. Steven Martens Dr. Eric Marineau	 Fairfax Room, 3rd Floor Prince William Room, 3rd Floor
1300-1400	Code 35 Hard Problem Break Out Discussions • Air Vehicle Technology • Aerospace Structures & Materials • Science of Autonomy and Controls • Energetic Materials • Kinetic Weapons • Terminal Defense • Directed Energy – Laser • Directed Energy – High Power Microwave	 Dr. David Gonzalez, Dr. Dave Findlay, & Dr. Leighton Myers Mr. Bill Nickerson Mr. Marc Steinberg & Dr. Brian Holm-Hansen, Dr. Chad Stoltz, Dr. Tim Ransom, & Mr. Chris Milby Mr. Ken Heeke, Dr. Roger Sullivan, Mr. Dan Simons & Mr. Taylor Young Mr. Tom Boucher, Ms. Teresa Berra, & Ms. Chloe Lee Mr. Peter Morrison, Mr. Quentin Saulter, and Mr. Matt Ketner Mr. Matt McQuage	 Tidewater III, 2nd Floor Tidewater II, 2nd Floor Ballroom Arlington, 3rd Floor Potomac VI, Ballroom Level Potomac IV, Ballroom Level Potomac V, Ballroom Level Potomac III, Ballroom Level
1330-1400	Code 35 Hard Problem Break Out Discussions Aero S&T of Cost-Efficiency and Capabilities in Naval Domain (ASCEND)	 Dr. Pranav Shah	 Prince William Room, 3rd Floor
1400-1600	ONR Department Introductions & Overviews (31, 32, 33, 34, 35, NRL & NavalX)	DH/Directors/MILDEPS	Ball Room
1630-1800	No Host Social		Hyatt - Lobbibar
Scheduled 1on1s throughout the day (20 minute targets) on site starting at 1400		*Classified 1on1's at ONR Available on 10 or 12 July	

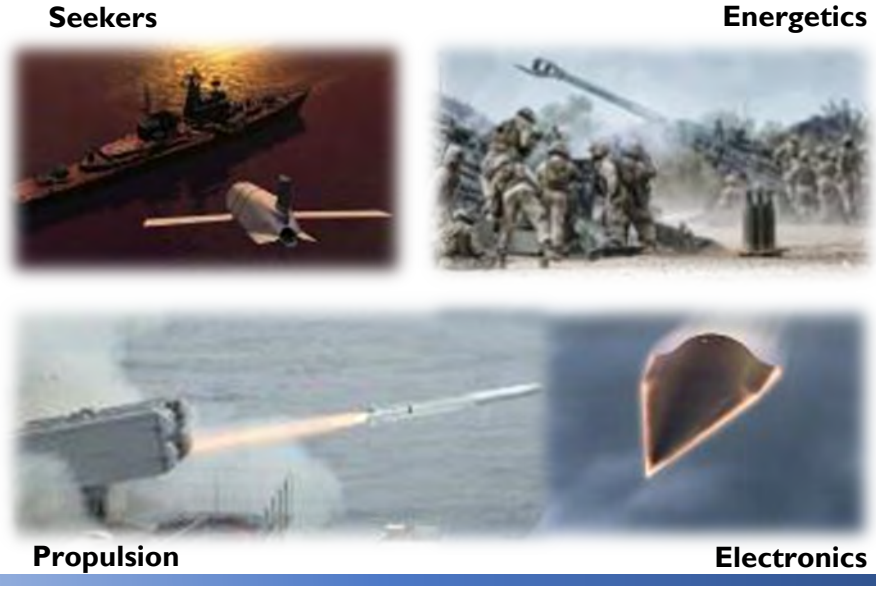
Code 352
Kinetic Weapons Division

Dr. Chad Stoltz
Director, Kinetic Weapons Division (Acting)

Kinetic Weapons

Objective: Investigate and mature technologies in support of sub-systems applicable to current and/or future kinetic weapons systems, i.e., missiles, rockets, projectiles, bombs and mortars. Developmental areas include but not limited to: propulsion; seekers; guidance, navigation and control; warheads; and related targeting, networking, and command and control systems.

Operational Challenges: Long range, denied navigation, non-fixed targets, jamming, robust defenses, maritime environment.



Research Areas:

- Energetic Materials and Weapon Lethality
- Hypersonic Aerothermodynamics
- High Speed Propulsion and Materials
- Missile Applications
- Maritime Fires
- Guidance and Fire Control
- Advanced Capability Applications
- Advanced Autonomous Systems
- Lethal UxS and Counter UxS
- Weapon Autonomy
- Weapon integration (FNC/INP)

Warfighting Payoff:

- Improved weapon performance in order to pace peer competitors.
- Introduction of new technologies in order to leverage advances in computing power and methods, electronics packaging, materials and fabrication methods, artificial intelligence and machine learning, and achieve cost savings.

National Defense Strategy Key Capabilities Addressed:

- Missile Defense, Joint Lethality in Contested Environments

ONR Program Portfolios

- **Basic & Applied Research (BAR)**
  - Managed by Program Officers
- **Technology Candidates (Tech Can)**
  - Increase agility and reduce transition risk when responding to Fleet needs by exploring lower TRL solutions that could be matured to higher TRLs prior to the FNC process
  - Managed at Department level
- **Future Naval Capabilities (FNCs)**
  - Develop new technologies from fundamental research with quantifiable exit criteria to address validated warfighter requirements in program of record
  - Selected by OPNAV (N2/N6, N95, N96, & N98) Resource Sponsor
  - Transition funding by OPNAV Resource Sponsor through signed transition agreement
- **Innovative Naval Prototypes (INPs)**
  - Develop revolutionary and disruptive technologies from fundamental research which addresses current or anticipated warfighter requirements
  - Selected by Chief of Naval Research in coordination with OPNAV Resource Sponsors & Acquisition Leadership
- **Expeditionary Warfare Portfolio**
  - Includes BAR, Tech Can, FNCs, and INPs focused on Marine Corps technology gaps – Cross Cutting all ONR Departments
  - Developed with Commandant Marine Corps (CMC), Deputy CMC for Combat Development & Integration, Marine Corps Warfighting Laboratory, and Office of Naval Research

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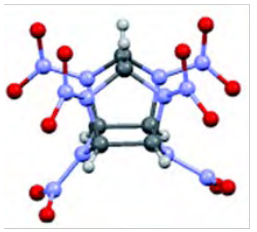
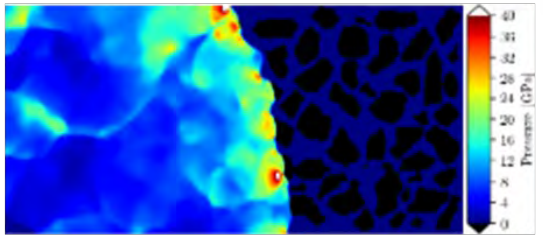
Advanced Energetic Materials

Advancing Energetic Materials S&T & Future Workforce Development with the Objective of Enhanced Performance and Safety for Kinetic Weapon Systems

Dr. Chad Stoltz
Energetic Materials Program Officer
352 Kinetic Weapons Division Director (Acting)

Dr. Tim Ransom
Deputy Energetic Materials Program Officer




Research Areas

- Energetic Materials/Concepts to enhance warhead/propellant performance
- Novel dynamic diagnostics development and implementation for understanding complex energy release phenomena
- Atomistic through continuum level modeling solutions for properties, performance, and lethality predictions, composite design, and understanding safety and vulnerability

Applications

- Enhanced Lethality Warhead Concepts with Reduced Form Factors
- Tactical Propulsion with Improved Range, Speed, and Maneuverability
- Increased Reliability and Safety, Reduced Vulnerability and Cost

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Weapon Autonomy and Applications

Providing Autonomy and AI solutions that improve existing shipboard kill chains and other relevant weapon applications

Mr. Tom Boucher
Weapons Autonomy & Applications
Program Officer

Research Areas

- Autonomy and AI in Shipboard Self Defense Kill Chains
- Lethality and Weaponization of UxS
- Autonomous Weapon Control
- Air Delivered ASW Sensors and Weapons

Applications

- Autonomy and AI for Shipboard Medium Caliber Gun Systems
- Autonomous Weapon Payloads for USVs
- Weaponization of Drone Swarms for USMC

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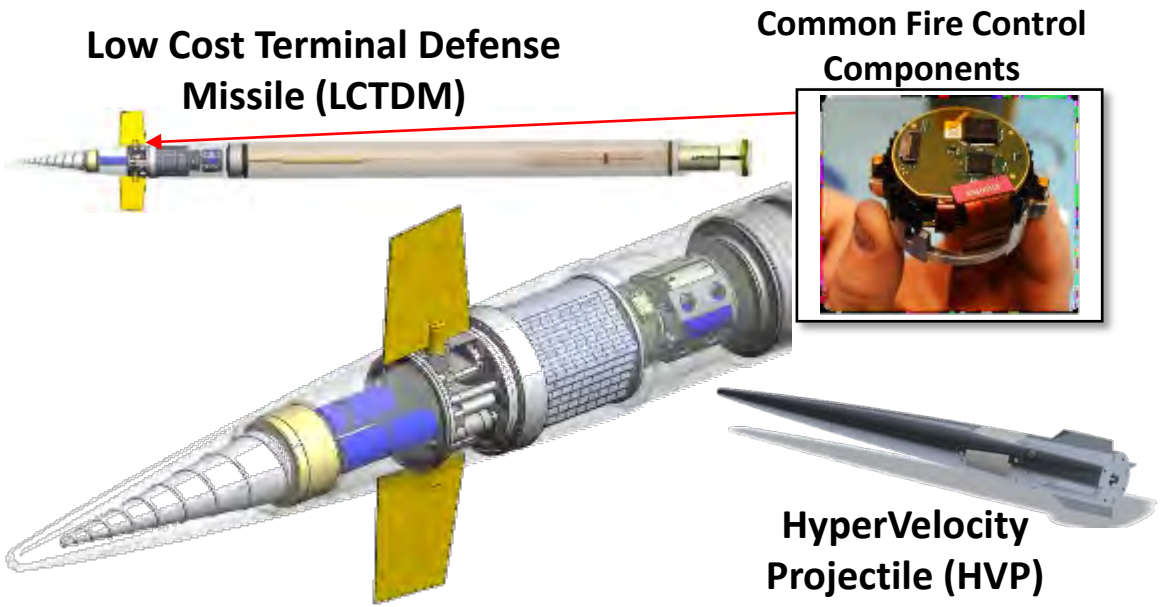
Precision Fire Control & Low-Cost Interceptors

Advancing fire control technologies to enable cruise missile defense using small, low-cost interceptors that contribute to the layered defense of surface combatants and expeditionary forces both in capability and capacity to defeat complex raids of hypersonic missiles and cruise missiles

Mr. Chris Reasonover
Precision Fire Control Program Officer
Ms. Chloe Lee
Precision Fire Control Deputy Program Officer



Objectives

- Develop precision guidance and fire control technologies
- Demonstrate engagement of surrogate air threats with HyperVelocity Projectiles (HVPs) and modified MK 66 2.75-inch rockets

Research Areas

- Novel fire control and communication waveforms
- Precision aero-control devices
- Adaptive and collaborative guidance laws
- High acceleration-tolerant electronic components

Applications

- Advanced RF seekers
- Advanced radar track filters
- Gun-launched guided projectiles
- Small guided missile interceptors

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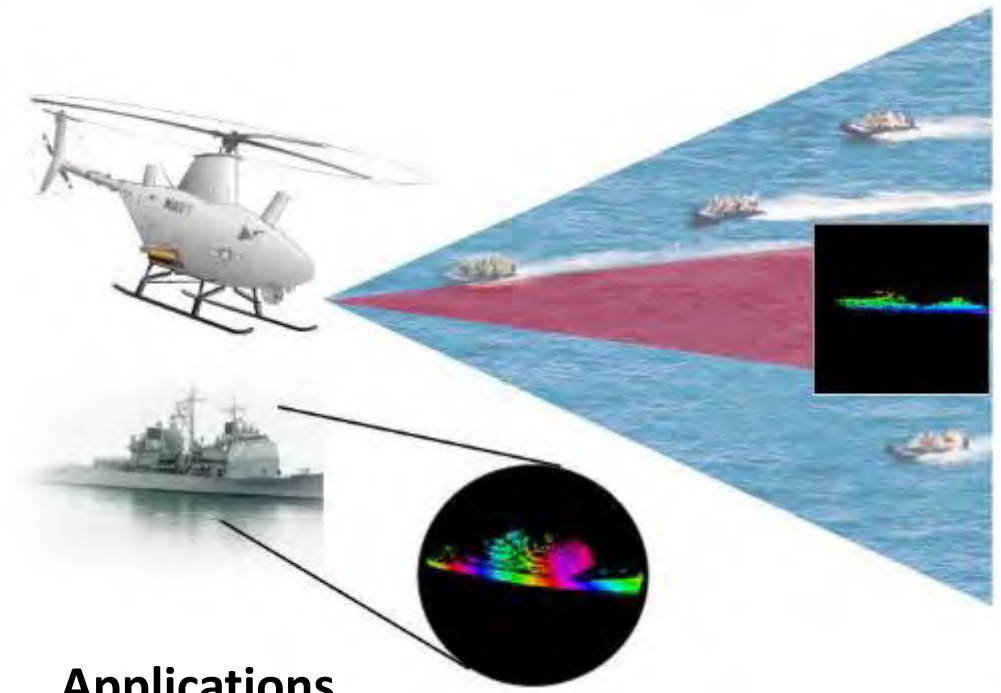
Advanced Capability Integration

Guiding Applied Research Through Advanced Technology Development to Acquisition Programs of Record in the Areas of Kinetic Weapons, Directed Energy Systems & Weapons, and Naval Aircraft Systems

Mr. Ken Heeke
Advanced Capability Integration
Program Officer



Development Areas

- LIDAR & EO/IR for Weapons Development
- Advanced Weapons Propulsion
- Advanced Seeker & Warhead Technologies
- Airborne precision targeting systems, to include Target Identification, Recognition & Designation Technologies

Applications

- Kinetic Weapons
- Directed Energy Technologies & Weapons
- Naval Aircraft Systems

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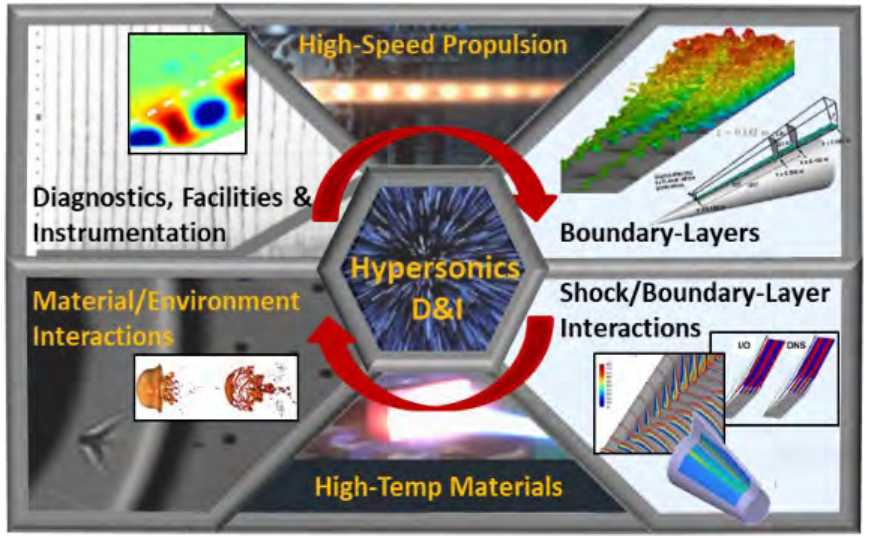
Hypersonic Aerothermodynamics, High-Speed Propulsion and Materials

Create new fundamental knowledge and develop computational, experimental and flight testing capabilities along with the workforce needed to support the RDT&E of high-speed and hypersonic weapons

Dr. Eric Marineau
Hypersonics Program Officer



Research Areas

- Hypersonic boundary-layers
- Shock-wave / boundary-layer interactions
- High-speed air-breathing propulsion
- Ultra-high temperature materials
- Environment-material interactions
- Test facilities, instrumentation and diagnostics

Applications

- Develop enabling technologies to increase range, lethality and survivability of weapons meeting Naval SWaP-C constraints to prosecute highly-defended, time-sensitive targets from survivable standoff ranges
- Develop, validate and transition predictive multiphysics modeling and simulation tools for hypersonics

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Advanced Autonomous Systems

Multi-domain, heterogeneous swarms of unmanned systems capable of rendering the adversaries ability counter either inadequate or irrelevant

Mr. Lee Mastroianni
Program Officer in area of Advanced Autonomous Systems conducting broad research and capabilities development from Applied Research through Advanced Technology Development (Prototype Systems)

Research Areas

- Extended range/performance platforms
- Multi-domain capable platforms
- Austere environment employment / low footprint
- Manufacturing for scale-up of volume and greatly reduced cost
- Modular Open systems Architecture (MOSA) and Commercial Off-the-Shelf and Government Off-the-Shelf leverage
- Modular payload capabilities
- Precision navigation and timing and communications denied autonomy
- Perception and sensor advances

Applications

- Long-Range Precision Strike
- Wide area intelligence, surveillance, and reconnaissance

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Weapons Lethality

Development of Analytical Tools to Support Weapon Design and to Assess the Performance and Effectiveness of Novel Kinetic Weapon Concepts

Mr. Chris Milby
Energetics Program Officer

Research Areas

- Reactive material warhead technologies
- Advanced Diagnostic and Experimental Techniques to assess Lethality Metrics
- Integration of non-traditional lethal mechanisms into lethality and effectiveness (L&E) codes
- Effects of less than lethal damage on threat missile performance
- Novel energetic integration technologies

Applications

- Advanced projectile warhead
- Integration of advanced L&E and damaged states into advanced threat models
- Technologies for maintaining warhead performance in reduced weight/volume

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Maritime Fires

Researching, Developing, and Demonstrating Threat-informed, Future-focused Fires Capabilities for the Naval Services

Mr. Dan Simons
Maritime Fires Program Officer

Research Areas

- Fire-and-forget, all-weather engagements of stationary, relocatable, and moving land and sea targets
- Very low size, weight, power, and cost of weapons components and weapons systems, having low manpower and training needs, low cognitive burdens to operate, and low logistics burdens
- Accelerating the kill chain (find, fix, track, target, engage, assess (F2T2EA))
- Increasing the ranges of munitions
- Increasing lethality of munitions for land and sea targets
- Survivability of launch platforms and munitions throughout the mission
- Friendly force deception from fires engagements

Applications

- Small arms
- All stages of the F2T2EA kill web model
- Precision guided munitions
- Long range precision fires
- Small armed unmanned systems of all platform types (UxS)

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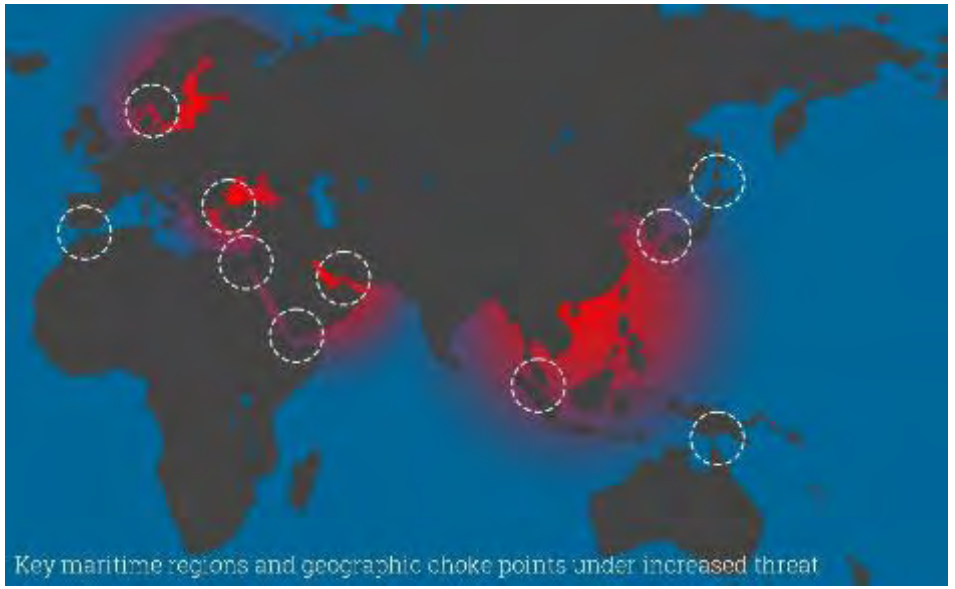
Advanced Capability Applications

Threat driven technology development of Air Warfare and Naval Weapons technologies for deployment to the Fleet/Forces in a three to seven year window, as aligned with new and existing Naval Programs of Record.

Dr. Roger M. Sullivan
Advanced Capability Applications
Program Officer



Public Release Image from "Chief of Naval Operations Navigation Plan 2022", page 5 (https://media.defense.gov/2022/Jul/26/2003042389/-1/-1/1/NAVIGATION%20PLAN%202022_SIGNED.PDFdefense.gov last accessed 04/17/2023)

Research Areas

- Manned-Unmanned Teaming with Applied Artificial Intelligence
- Autonomous Air-to-Air Refueling
- Hard-kill Self Defense for Aircraft
- Dynamic Maritime Targeting
- Advanced Tactical Communications
- Advanced Seeker Design & Target Recognition
- Advanced Dome and Window Materials

Applications

- Network Enabled Weapons
- Naval Unmanned Air Systems
- High Value Air Asset Mission Resilience

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Advanced Energetic Applications

Developing novel kinetic solutions to adversarial problems utilizing advanced energetic materials and innovative lethality mechanisms

Mr. Taylor Young
Advanced Energetic Applications
Program Officer

Research Areas

- Enhanced Lethality Warhead and Fuzing Technologies
- High Performance Explosives and Energetic Materials
- Advanced Air Breathing Propulsion Technologies
- Autonomous Target Identification and Prosecution
- Modular and Tailorable Payload Technologies

Application Areas

- Air Delivered Anti-Surface Warfare (ASuW) Munitions
- Long Range, Intelligent, Wide Area-of-Effect Munitions
- Attritable Armed Unmanned Systems (UxS)

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Summary

Operational Challenges: Long range, denied navigation, non-fixed targets, jamming, robust defenses, maritime environment

Research Areas:

- Energetic Materials and Weapon Lethality
- Hypersonics Aerothermal dynamics
- High Speed Propulsion and Materials
- Missile Applications
- Maritime Fires
- Guidance and Fire Control
- Advanced Capability Applications
- Advanced Autonomous Systems
- Lethal UxS and Counter UxS
- Weapon Autonomy
- Weapon integration (FNC/INP)

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1145-1200	Expeditionary Weapons	Col Howard Marotto	Ball Room
1200-1300	Lunch		
1230-1330*	Code 35 Hard Problem Break Out Discussions • Power, Propulsion, & Thermal Management • Hypersonics	 Dr. Steven Martens Dr. Eric Marineau	 Fairfax Room, 3rd Floor Prince William Room, 3rd Floor
1300-1400	Code 35 Hard Problem Break Out Discussions • Air Vehicle Technology • Aerospace Structures & Materials • Science of Autonomy and Controls • Energetic Materials • Kinetic Weapons • Terminal Defense • Directed Energy – Laser • Directed Energy – High Power Microwave	 Dr. David Gonzalez, Dr. Dave Findlay, & Dr. Leighton Myers Mr. Bill Nickerson Mr. Marc Steinberg & Dr. Brian Holm-Hansen, Dr. Chad Stoltz, Dr. Tim Ransom, & Mr. Chris Milby Mr. Ken Heeke, Dr. Roger Sullivan, Mr. Dan Simons & Mr. Taylor Young Mr. Tom Boucher, Ms. Teresa Berra, & Ms. Chloe Lee Mr. Peter Morrison, Mr. Quentin Saulter, and Mr. Matt Ketner Mr. Matt McQuage	 Tidewater III, 2nd Floor Tidewater II, 2nd Floor Ballroom Arlington, 3rd Floor Potomac VI, Ballroom Level Potomac IV, Ballroom Level Potomac V, Ballroom Level Potomac III, Ballroom Level
1330-1400	Code 35 Hard Problem Break Out Discussions Aero S&T of Cost-Efficiency and Capabilities in Naval Domain (ASCEND)	 Dr. Pranav Shah	 Prince William Room, 3rd Floor
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1630-1800	No Host Social		Hyatt - Lobbibar
Scheduled 1on1s throughout the day (20 minute targets) on site starting at 1400		*Classified 1on1's at ONR Available on 10 or 12 July	

Code 353
Directed Energy Weapons Division

Mr. Matthew Ketner
Program Officer, Directed Energy Weapons Division

Directed Energy Weapons

Objective: Investigate and mature technologies related to High Power Microwave (HPM) and lasers for use in defensive applications against a wide variety of threats in multiple domains.

Operational Challenges: High speed maneuvering threats; low, slow and small (LSS) targets (difficult to detect and target); battle damage assessment (BDA) / measurement of effects; size, weight & power (SWaP) requirements vs. availability; (E3) Electromagnetic Compatibility/Vulnerability/Susceptibility

Vulnerable High-Value Units

Hard to Detect / Low Slow & Small

Deep Magazines / Low-Cost Defense

Research Areas:

- Counter Directed Energy Weapons
- High Power Microwaves
- Pulsed Lasers
- Continuous Wave Lasers
- Lethality
- Operations & Analysis
- Mission Design

Warfighting Payoff:

- Low cost per shot to counter low cost UAS threats
- Low collateral damage in cluttered, congested environments
- Deep magazine
- Counter Swarm

National Defense Strategy Key Capabilities Addressed:

- Missile Defense, Joint Lethality in Contested Environments, Space and Cyberspace as Warfighting Domains

Directed Energy Weapons Division

Provide the Navy and Marine Corps advanced Directed Energy technologies, systems, and techniques to gain and sustain tactical, operational, and strategic advantage in the arena of across the full range of military operations.

CAPT(s) Kyle McDaniel, USN
Military Deputy /
Directed Energy Weapons Division Director (Acting)

Research Areas

- High Energy Laser and Microwave sources, subsystems, atmospheric propagation, & lethality modeling
- DE propagation atmospheric modeling Application of Artificial Intelligence and other approaches to enhance DE weapons effectiveness, cost, and sustainability
- Modeling & Simulation, Military Utility Assessment, Operations Analysis to support development of INP & FNC Concepts
- Modeling & Simulations to support analysis and development of advanced prototypes and subsystems

Applications

- Research to support development of DE FNCs and INPs to support Navy and Marine Corps warfighting applications
- High Energy Laser (CW & Pulsed) and High-Power Microwave weapons system prototypes and subsystem to counter advanced high-end threats at all aspect angels

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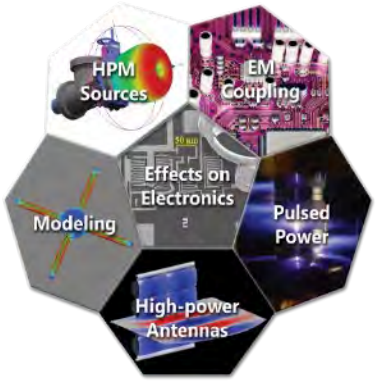
Directed Energy - High Power Microwaves (HPM)

Provide the Navy and Marine Corps advanced HPM technologies, systems, and techniques enabling a new class of HPM payloads that will be highly effective in the future defensive and offensive battlespace. Use HPM to gain and sustain tactical, operational, and strategic advantage in the arena of EM Maneuver/Spectrum Warfare and Integrated Defense for U.S. forces across the full range of military operations.

Mr. Ryan Hoffman
Program Officer ONR 353

Counter Surface Threats



Counter Air Threats

Research Areas

- Novel, compact solid-state and vacuum electronics based HPM sources at X-band and higher
- Wide-bandwidth, high power, frequency agile amplifiers
- Novel antenna array concepts and distributed arrays for agile beamforming
- Improved prediction capability and assessment of target effects with advanced computer simulation and modeling
- Novel HPM sensors and instrumentation
- Power and Energy for high voltage storage and transfer
- Computer simulation and modeling codes to enable the next generation of HPM sources and amplifiers, both beam driven and solid state

Applications

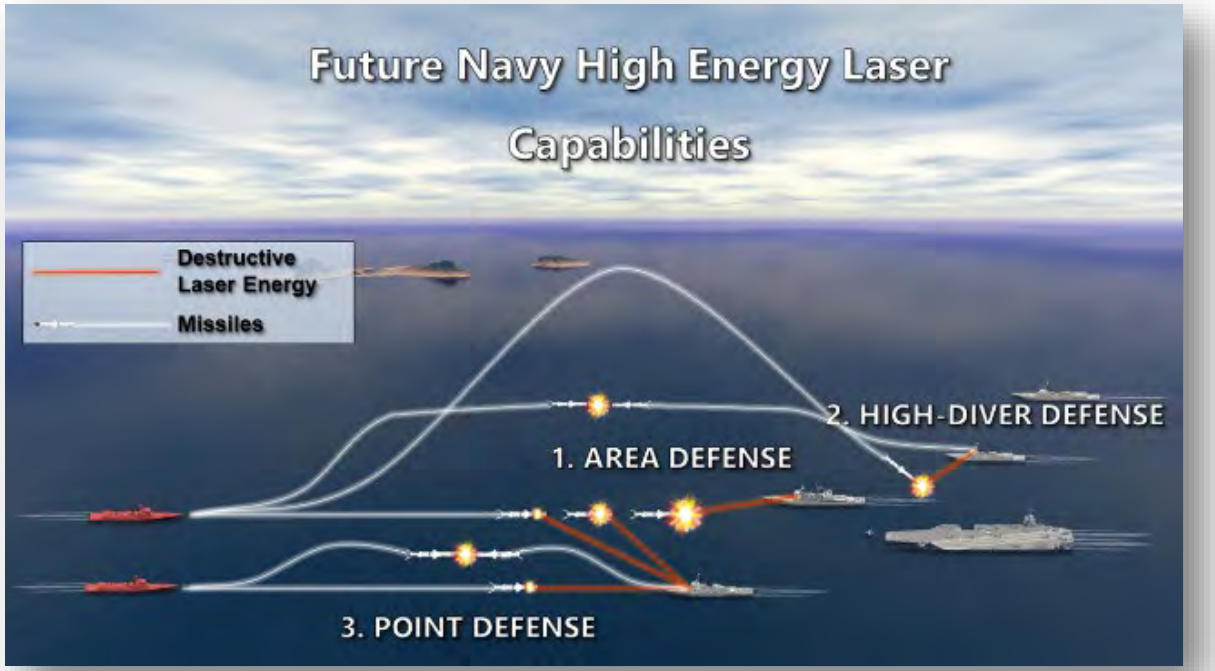
- Counter surface vessel and vehicle
- Counter air small-UAS and other threat
- Electronic strike on infrastructure and facilities
- Flexible RF waveforms for emerging threats and multi-mission capabilities (Cyber and EW)
- Modular, scalable solid state RF source technology with distributed arrays for agile beam forming
- Improved and predictive lethality
- Compact, lightweight airborne HPM payloads

Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
ONR - Work With Us | Office of Naval Research (navy.mil)

High Energy Lasers

Laser Weapon Testbed Development for the Facilitation of Counter Anti-Ship Cruise Missile Capabilities for Navy Ships

Matthew Ketner
High Energy Laser Program Officer



Research Areas

- Directed Energy Science and Technology (S&T)
- High Energy Lasers
- Beam Control Systems
- HEL Diagnostics

Applications

- Counter Anti-Ship Cruise Missile
  - Area Defense
  - Point Defense
  - Advanced Threats

Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
ONR - Work With Us | Office of Naval Research (navy.mil)

Laser Weapons & Combat System Integration

Researching, Developing, and Demonstrating High Energy Laser Weapons & Integration With Combat Systems

Ms. Teresa Berra
Laser Weapons &
Combat System Integration
Program Officer

Research Areas

- Integration of Directed Energy Weapons with Ship Combat Systems
- Target detection, track & Aim Point Selection utilizing high resolution sensors (EO/IR/MW)
- Automation of the Detect-Track-Aimpoint Selection For Laser Weapons
- Real Time Target Battle Damage Assessment During Engagement Kill Chain

Applications

- High Energy Laser Weapons Integration, Test, Deployment, & Sustainment
- Combat System Integrations
- Application of Directed Energy Weapons to all stages of F2T2EA* kill web model

* Find-Fix-Track-Target-Engage-Assess

Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
ONR - Work With Us | Office of Naval Research (navy.mil)

Laser / Counter Directed Energy Program

Advancing Continuous Wave (CW) Laser and Counter Directed Energy S&T & Future Workforce Development to Enable Enhanced Mission Capabilities for Directed Energy Weapons through Focused Investments

Mr. Peter A. Morrison
Laser & Counter Directed Energy
Program Officer

Research Areas

- Lasers
  - Novel, Robust, More Efficient Solid State Laser Sources
  - Novel Beam Directors, Optics & Laser Targeting Systems
- Counter DE
  - Counter High Energy Laser Materials
  - Counter High Power Microwave

Applications

- Surface Navy HELs *(NAVY ODIN & HELIOS, ONR HELCAP)*
  - Counter Unmanned Air Vehicles
  - Counter Small Boat
  - Counter Anti-Ship Cruise Missile
- USMC HEL for Expeditionary
  - Counter Unmanned Air Vehicles
- Counter DE for protecting Navy systems
  - Communications, C4ISR, UAS, Air assets, Personnel (Navy & USMC)

Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
ONR - Work With Us | Office of Naval Research (navy.mil)

Ultra Short Pulse Laser

Advancing Ultra Short Pulse Laser S&T & Future Workforce Development to Enable Enhanced Mission Capabilities for Naval & Expeditionary Air & Vehicle Weapons by Focused Investments in Four (4) Areas of Interest (AOI)

Quentin Saulter
Ultrashort Pulse Laser Program Officer

Operational view of layered counter-threat systems using Ultrashort Pulsed Laser Systems to neutralize or destroy multiple threat systems/vehicles.

Research Areas

- USPL laser sources
- Laser matter interactions
- Long range atmospheric propagation physics
- Adaptive optics compensation techniques

Applications

- Laser Weapon Development
- Material Defense Development
- Subsystem Development

Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
ONR - Work With Us | Office of Naval Research (navy.mil)

Summary

Operational Challenges: High speed maneuvering threats; low, slow and small (LSS) targets (difficult to detect and target); battle damage assessment (BDA) / measurement of effects; size, weight & power (SWaP) requirements vs. availability; (E3) Electromagnetic Compatibility/Vulnerability/Susceptibility

Key Research Areas:

- Counter Directed Energy Weapons
- High Power Microwaves
- Pulsed Lasers
- Continuous Wave Lasers
- Lethality
- Operations & Analysis
- Mission Design

Code 35 Focus Area Forum (FAF) Agenda

Time	Event	Briefer	Room
0730-0900	Check-In		Ball Room Lobby
0900-0915	Introduction	Mr. Trip Barber	Ball Room
0915-0945	ONR Overview	CAPT Pete Ladowicz	Ball Room
0945-1015	Doing Business with ONR	Mr. Jamie Thompson	Ball Room
1015-1030	Code 35 Overview	Dr. Knox Millsaps	Ball Room
1030-1045	Break		Ball Room
1045-1100	Doing Business with Code 35 (BAR, FNC, INP, & BAAs)	Dr. David González and Dr. Chad Stoltz	Ball Room
1100-1115	Naval Air Platforms	Dr. David González	Ball Room
1115-1130	Kinetic Weapons	Dr. Chad Stoltz	Ball Room
1130-1145	Directed Energy	Mr. Matthew Ketner	Ball Room
1145-1200	Expeditionary Weapons	Col Howard Marotto	Ball Room
1200-1300	Lunch		
1230-1330*	Code 35 Hard Problem Break Out Discussions • Power, Propulsion, & Thermal Management • Hypersonics	 Dr. Steven Martens Dr. Eric Marineau	 Fairfax Room, 3rd Floor Prince William Room, 3rd Floor
1300-1400	Code 35 Hard Problem Break Out Discussions • Air Vehicle Technology • Aerospace Structures & Materials • Science of Autonomy and Controls • Energetic Materials • Kinetic Weapons • Terminal Defense • Directed Energy – Laser • Directed Energy – High Power Microwave	 Dr. David Gonzalez, Dr. Dave Findlay, & Dr. Leighton Myers Mr. Bill Nickerson Mr. Marc Steinberg & Dr. Brian Holm-Hansen, Dr. Chad Stoltz, Dr. Tim Ransom, & Mr. Chris Milby Mr. Ken Heeke, Dr. Roger Sullivan, Mr. Dan Simons & Mr. Taylor Young Mr. Tom Boucher, Ms. Teresa Berra, & Ms. Chloe Lee Mr. Peter Morrison, Mr. Quentin Saulter, and Mr. Matt Ketner Mr. Matt McQuage	 Tidewater III, 2nd Floor Tidewater II, 2nd Floor Ballroom Arlington, 3rd Floor Potomac VI, Ballroom Level Potomac IV, Ballroom Level Potomac V, Ballroom Level Potomac III, Ballroom Level
1330-1400	Code 35 Hard Problem Break Out Discussions Aero S&T of Cost-Efficiency and Capabilities in Naval Domain (ASCEND)	 Dr. Pranav Shah	 Prince William Room, 3rd Floor
1400-1600	ONR Department Introductions & Overviews (31, 32, 33, 34, 35, NRL & NavalX)	DH/Directors/MILDEPS	Ball Room
1630-1800	No Host Social		Hyatt - Lobbibar
Scheduled 1on1s throughout the day (20 minute targets) on site starting at 1400		*Classified 1on1's at ONR Available on 10 or 12 July	

Expeditionary Science & Technology

Naval Air Warfare & Weapons

Col Howard "Howie" Marotto

Expeditionary Portfolio, USMCR

Conclusions

ONR/NRL Department Overviews
(31, 32, 33, 34, & NRL)

Panelists

LCDR Andres Xenachris

Military Deputy Code 31 - C5ISRT Department/Naval STEM

Dr. Tom Drake SES

Department Head Code 32 - Ocean Battlespace Sensing Department

CAPT Steven Tarr III

Military Deputy Code 33 - Sea Warfare and Weapons Department

Dr. Patrick Mason SES

Department Head Code 34 - Warfighter Performance Department

CAPT Jesse Black

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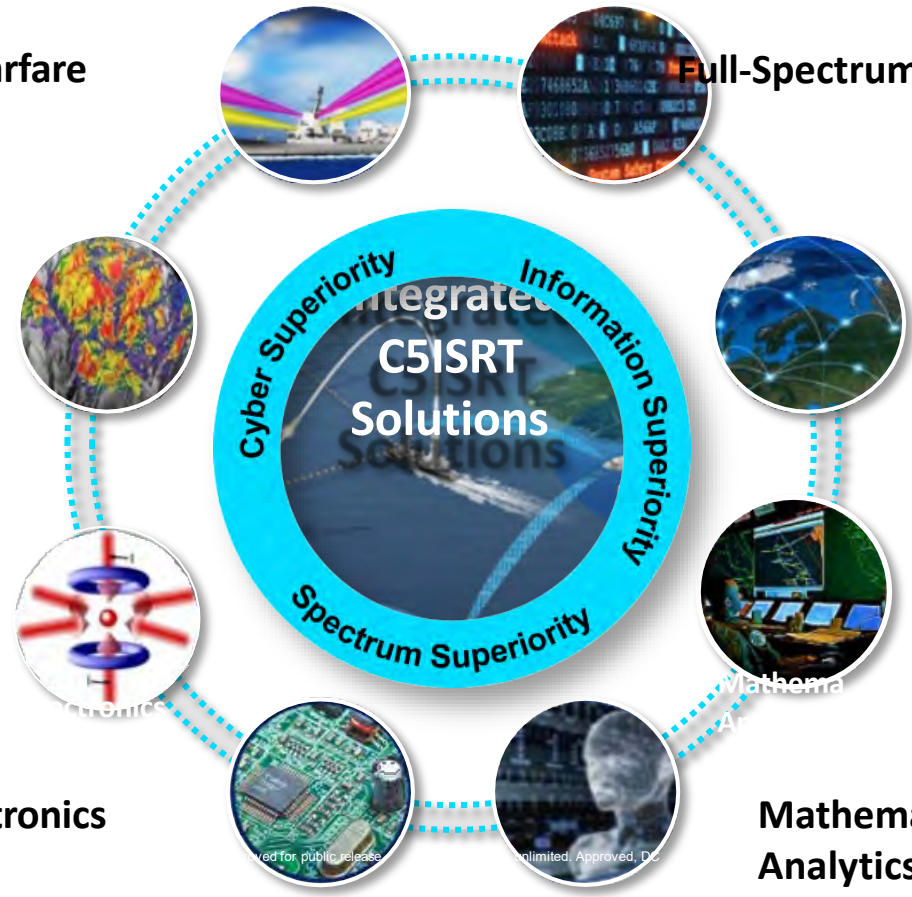
Department Head Code 34 - Warfighter Performance Department

CAPT Jesse Black

Commanding Officer - Naval Research Laboratory

Code 31: Command, Control, Computing, Communications, Cyber, Intelligence, Surveillance, Reconnaissance and Targeting Department



Electromagnetic Warfare

Full-Spectrum Cyber

Surveillance, Sensors and Phenomenology

Communications and Networking

Quantum, Positioning Navigation and Timing

Intelligence, Decision-Making Superiority, C2 and Combat Systems

Microelectronics

Mathematical Foundations for Analytics and Predictive Science

Naval STEM Education and Outreach

Naval_STEM@navy.mil

February 26, 2024

Naval STEM Education and Outreach

Vision: Foster and cultivate a diverse, world-class STEM workforce in order to maintain the U.S. Navy and Marine Corps' technological superiority.

Naval STEM Executive Board

- Assistant Secretary of the Navy Manpower and Reserve Affairs
- Chief of Naval Personnel
- Commander, Marine Corps Combat Development Command
- Superintendent, United States Naval Academy

Chief of Naval Research
Naval STEM Executive, Chair

Naval STEM Coordination Office

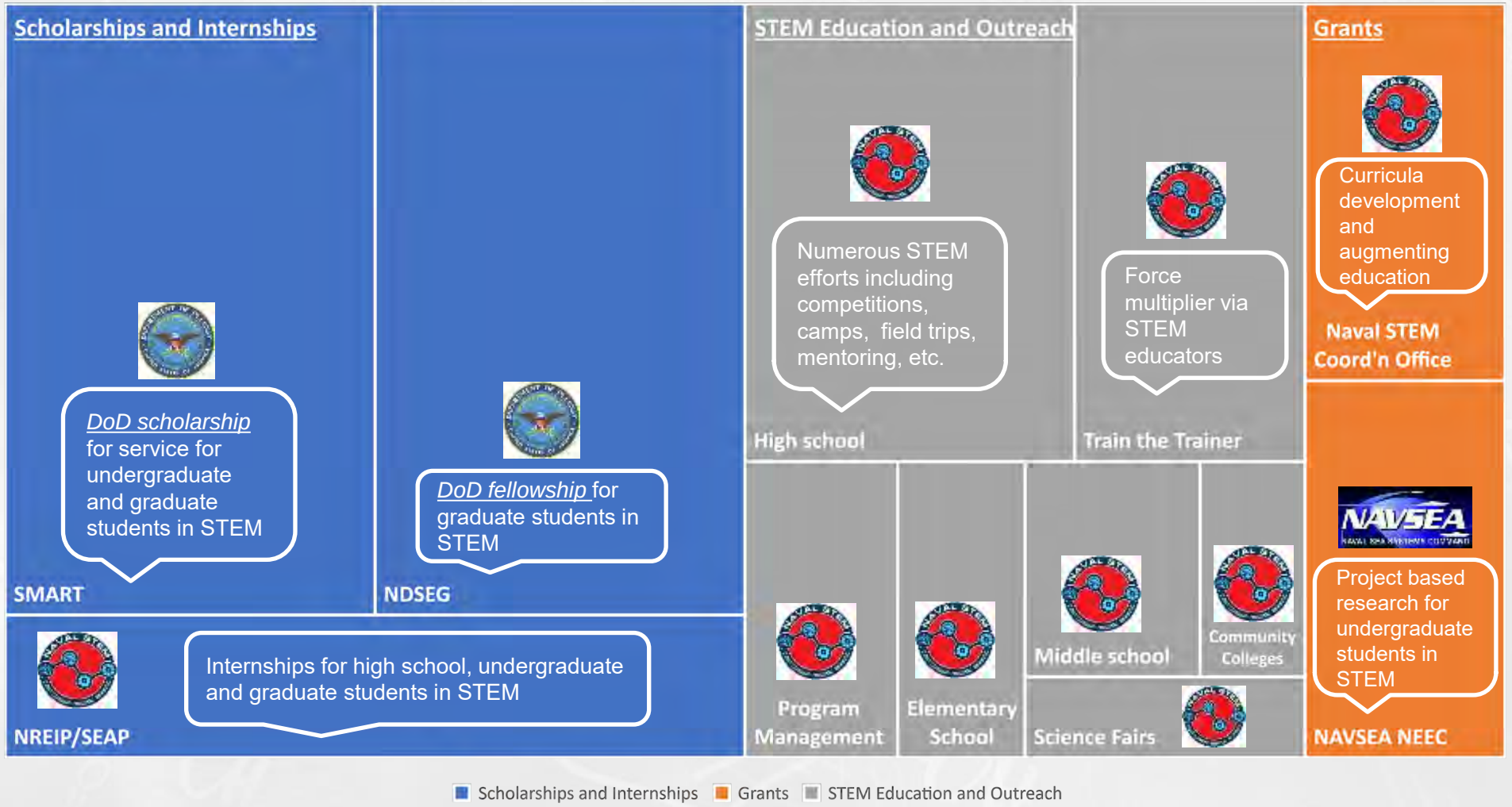
Naval STEM includes both Navy and Marine Corps education and outreach programs from K-PhD to STEM Workforce Initiatives

Naval STEM Stakeholder Organizations

- Assistant Secretary of the Navy Manpower and Reserve Affairs
- Assistant Secretary of the Navy Research Development and Acquisition
- Deputy Chief of Naval Operations Manpower, Personnel, Training and Education
- Deputy Commandant for Manpower and Reserve Affairs
- DON Chief Information Officer
- Bureau of Medicine and Surgery
- Marine Corps Systems Command
- Naval Air Systems Command
- Naval Facilities Systems Engineering Command
- Naval Information Warfare Systems Command
- Naval Sea Systems Command
- Naval Supply Systems Command
- Commander, Navy Installations Command
- Office of Naval Research
- Naval Research Laboratory
- Director, Innovation, Technology Requirements and Test Evaluation
- Marine Corps University
- Naval Postgraduate School
- United States Naval Academy
- Naval Operational Type Commands, as appropriate
- United States Naval War College
- Strategic System Programs

NOTE: SECNAVINST 3900.45A outlines the governance structure for Naval STEM

Naval STEM Education and Outreach Equities Reach Over 300,000 Students Annually

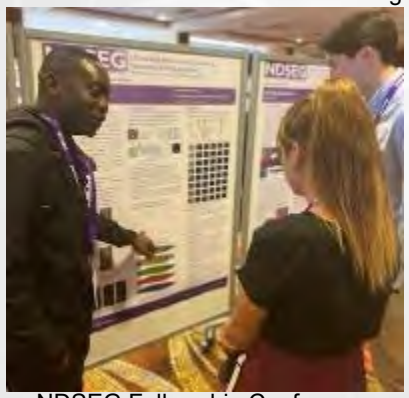


Naval STEM Target Audience

Navy League's STEM Expo
National Harbor, MD

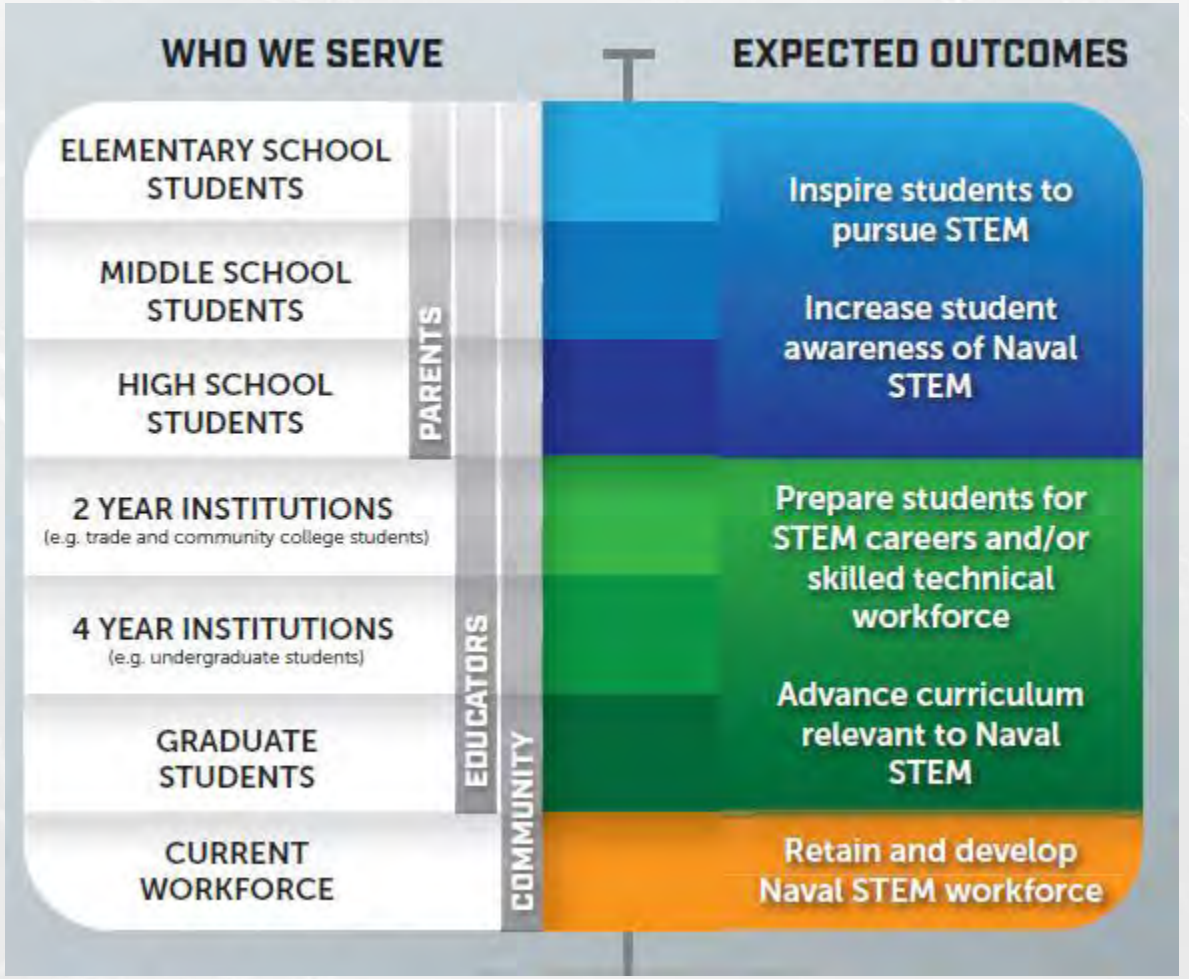
SeaPerch: Remotely Operated Vehicle (ROV) competition
College Park, MD

National Naval Officers Association (NNOA) STEM Event
San Diego, CA



NDSEG Fellowship Conference
San Antonio, TX

RoboSub: Autonomous Underwater Vehicle (AUV) competition
San Diego, CA



Select Naval STEM Highlights

- **Naval Horizons**
  - Annual STEM essay contest designed to increase student awareness of cutting edge STEM topics that impact the Navy and Marine Corps
  - *Since inception in 2020, the online contest features a total of 59 videos and has resulted in 42,000+ views and 2,500+ contest winners*
  - Contest open March – June annually
  - Learn more: http://navalhorizons.us/

- **Navy & Marine Corps Junior Reserve Officer Training Corps (JROTC) Flight Academy**
  - 8 week STEM academy designed to introduce high school students to aviation studies
  - In 2024, 28 high school students currently participating; in 2023, 28 high school students participated and 22 obtained their private pilot license
  - Since inception in 2021, 19 alumni have either earned a ROTC scholarship or are attending a service academy and 7 alumni are attending Historically Black Colleges and Universities (HBCUs)

Naval Horizons

Navy & Marine Corps Junior Reserve Officer Training Corps (JROTC) Flight Academy

STEM Opportunities for Students

- **Science and Engineering Apprenticeship Program (SEAP):**
  - An 8-week summer internship for high school students at a naval laboratory.
  - See more: https://navalsteminterns.us/seap/
  - Opens: August 1, 2024
- **Naval Research Enterprise Internship Program (NREIP):**
  - A 10-week summer research internship for college students at a naval laboratory.
  - See more: https://navalsteminterns.us/nreip/
  - Opens: August 1, 2024

- **Science, Mathematics and Research for Transformation (SMART) scholarship:**
  - This scholarship for service program gives undergraduate and graduate students a full scholarship and guarantee of employment upon degree completion.
  - See more: https://www.smartscholarship.org/smart
  - Opens: August 1, 2024
- **National Defense Science and Engineering Graduate (NDSEG) fellowship:**
  - This fellowship for graduate students is designed to increase the number of United States citizens trained in science and engineering disciplines of military importance leading to doctoral degrees.
  - See more: https://ndseg.sysplus.com/NDSEG/About

STEM Funding Opportunity for Academia, Industry & Non-Profits

- **Department of the Navy (DON) STEM Funding Opportunity Announcement (FOA)**
  - Annual FOA to fund educational initiatives that Maintain, and/or cultivate a diverse, world-class STEM workforce directly relevant to the needs of Department of Navy's current and future workforce
  - $200K/year, up to 3 years
  - Published on grants.gov and ONR website
- **Eligibility**
  - Academia
  - Non-profit organizations
  - Industry
- **Naval Partnerships**
  - Partnerships with naval organizations are highly encouraged
- **White papers required**
- **Evaluation Criteria (equally weighted)**
  - Alignment with the DON mission
  - Scientific and technical merit
  - Program viability during and after the period of performance
  - Diversity-equity-inclusion

https://navalstem.us/our-partners/

Panelists

LCDR Andres Xenachris

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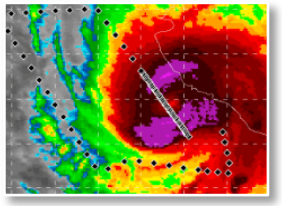
CAPT Jesse Black

Commanding Officer - Naval Research Laboratory

Code 32: Ocean Battlespace Sensing Department



Marine Meteorology

Remote Sensing

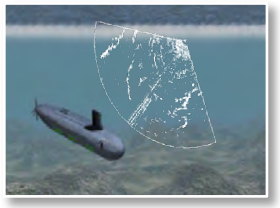
Anti-Submarine Warfare

Littoral Geosciences

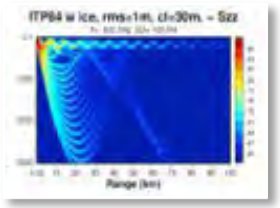
Mine Warfare &
Ocean Engineering

Undersea Systems
Technology & Autonomy

Marine Mammals &
Biology

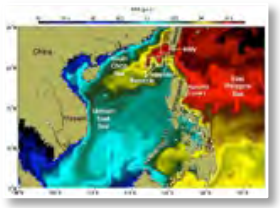


Undersea Signal
Processing



Ocean Acoustics (NNR)

Research Facilities



Physical Oceanography

Panelists

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CAPT Jesse Black

Commanding Officer - Naval Research Laboratory

Code 33: Sea Warfare and Weapons Department

Undersea Weapons & Payloads

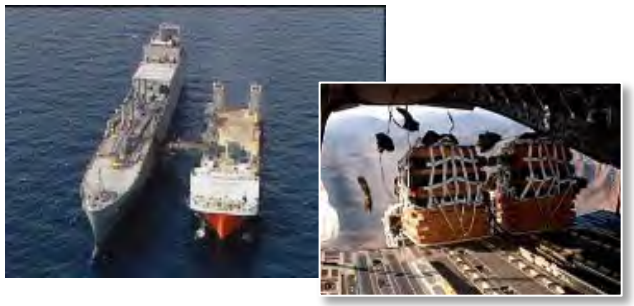
Naval Power Systems

Undersea Weapons

Advanced Naval Platforms

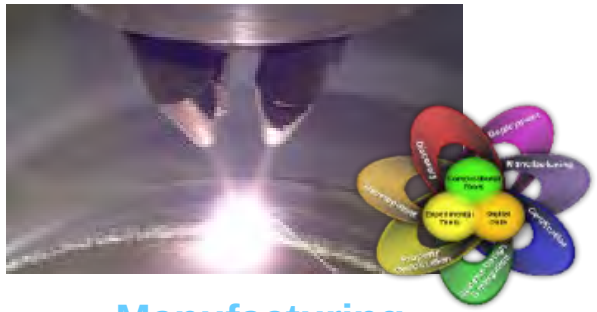
Platform Design and Engineering

Sustainment

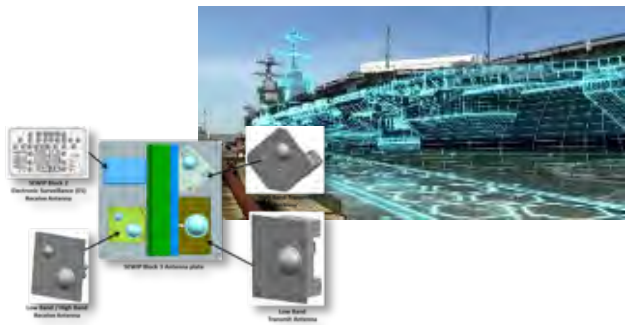


Advanced Naval Materials & Manufacturing

Materials



Manufacturing



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Commanding Officer - Naval Research Laboratory

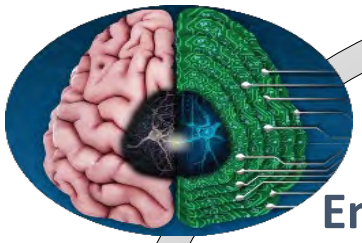
Code 34: Warfighter Performance Department

Human Research Protection Program

Preserve the rights and welfare of human subjects in Naval- supported research

Decision Sciences

Vision: Better Decisions, Faster



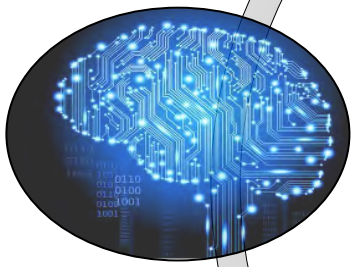
Enhancing warfighter effectiveness and efficiency through bioengineered / biorobotic systems, medical technologies, improved manpower, personnel, training & system design

Human Performance

Vision: Win in Extreme Environments

Information Warfare & Future Conflict

Vision: Shaping & Understanding Attitudes & Behaviors



Medical

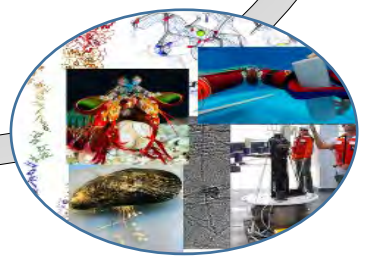
Vision: Assured Warfighter Health, Survivability, & Recovery

Manpower Personnel Training & Education

Vision: Outthink, Outfight Any Adversary

Biocentric Technologies

Vision: Naval Innovation Driven By Biological Principles



Intelligent & Autonomous Systems

Vision: Intelligent Autonomy To Enable Human-Machine Team As a Force Multiplier

Panelists

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Department Head Code 32 - Ocean Battlespace Sensing Department

CAPT Steven Tarr III

Military Deputy Code 33 - Sea Warfare and Weapons Department

Dr. Patrick Mason SES

Department Head Code 34 - Warfighter Performance Department

CAPT Jesse Black

Commanding Officer - Naval Research Laboratory

U.S. NAVAL RESEARCH LABORATORY

Naval Research Laboratory Overview

Dr. Bruce Danly, Director of Research

CAPT Jesse Black, Commanding Officer

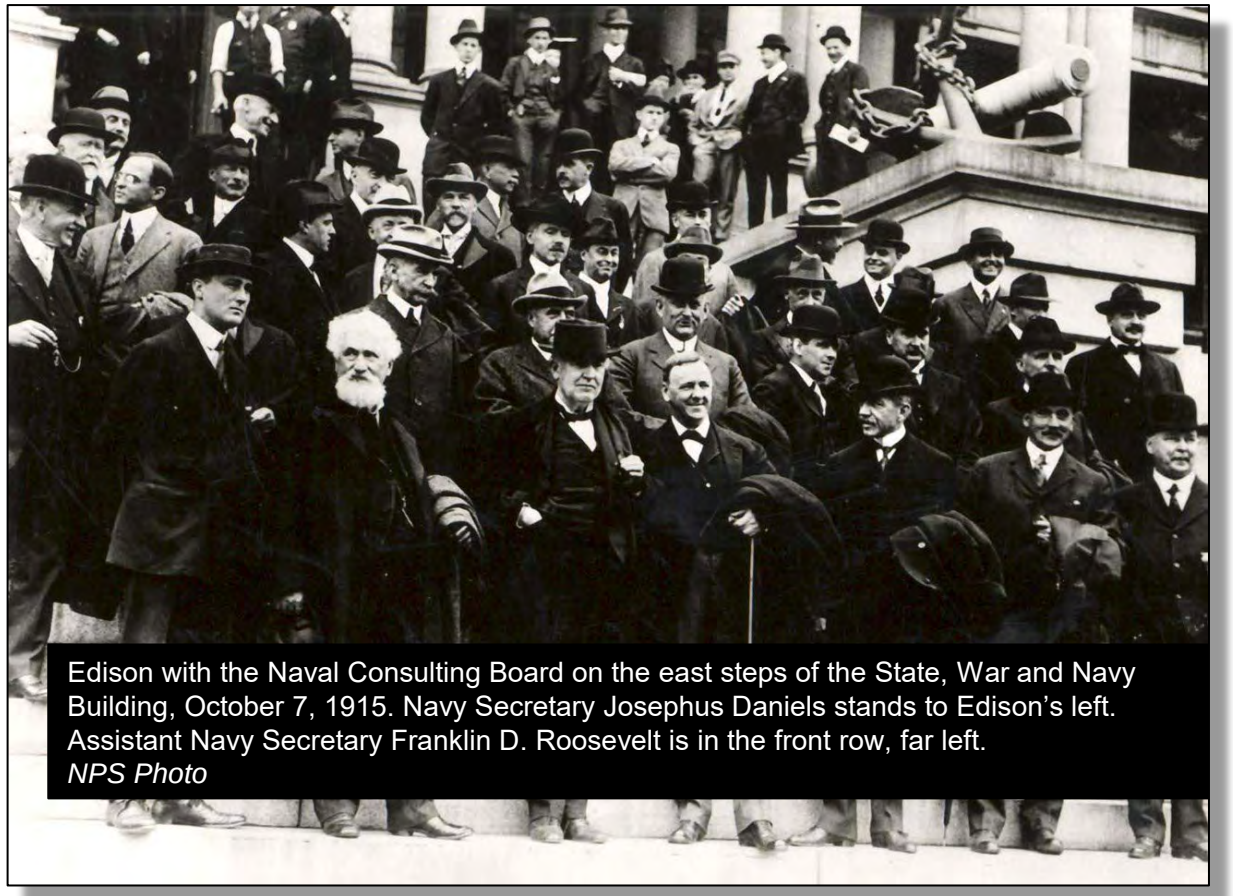
CAPT Randy Cruz, Executive Officer

11 Jul 2024

U.S. NAVAL RESEARCH LABORATORY

The Origin of the Laboratory

On May 30, 1915 the *New York Times* ran a two-page spread entitled, "Edison's Plan for Preparedness,"



Edison with the Naval Consulting Board on the east steps of the State, War and Navy Building, October 7, 1915. Navy Secretary Josephus Daniels stands to Edison's left. Assistant Navy Secretary Franklin D. Roosevelt is in the front row, far left.
NPS Photo

"The Government should maintain a great research Laboratory, jointly under military and civilian control. In this could be developed the continually increasing possibilities of great guns, the minutiae of new explosives, all the technique of military and naval progression, without any vast expense.

When the time came, if it ever did, we could take advantage of the knowledge gained through this research work and quickly manufacture in large quantities the very latest and most efficient instruments of warfare."

NRL Celebrated its Centennial in 2023!

NRL's Mission Statement

Department of the Navy's full-spectrum corporate laboratory

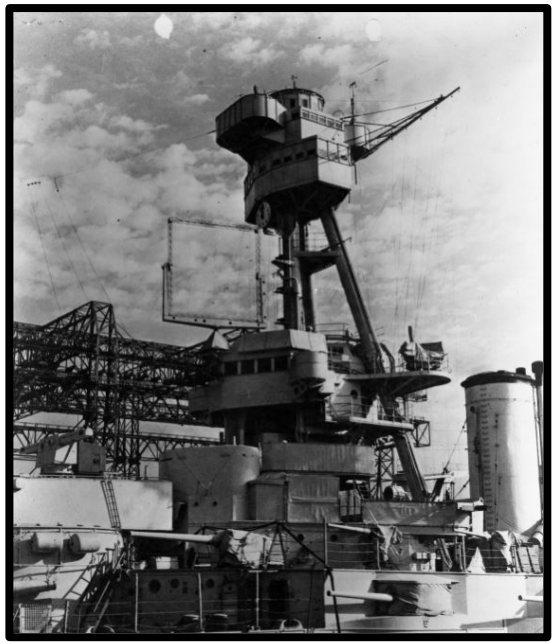
Conduct a broadly based multidisciplinary program of ***scientific research*** and ***advanced technological development*** directed toward ***maritime applications*** of new and improved materials, techniques, equipment, systems and ocean, atmospheric, and space sciences and related technologies.

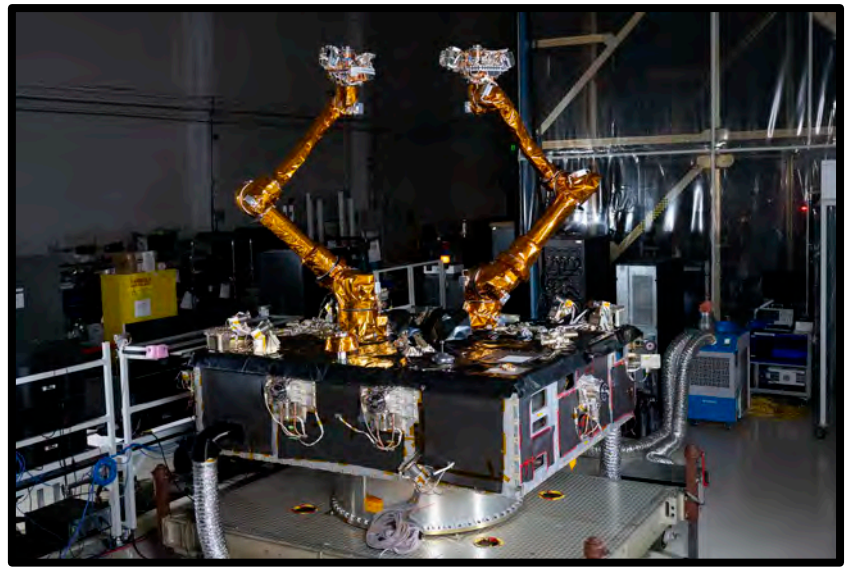
- **A relentless search for fundamental, high pay-off scientific understanding**
- **Advanced technological development**
- **Transition scientific advancements to the Naval Force**
- **Transfer technology and information to the economy**

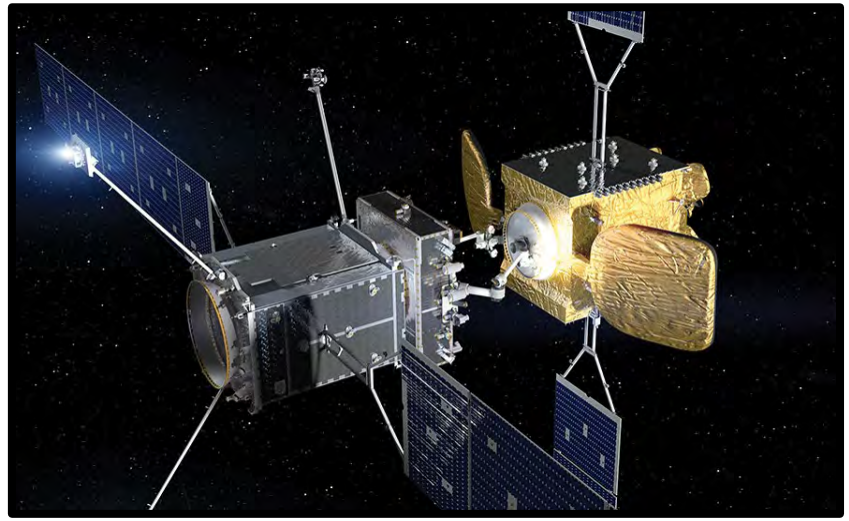
NRL's job is to uncover the hidden and give our Sailors and Marines the warfighting advantage!

U.S. NAVAL RESEARCH LABORATORY

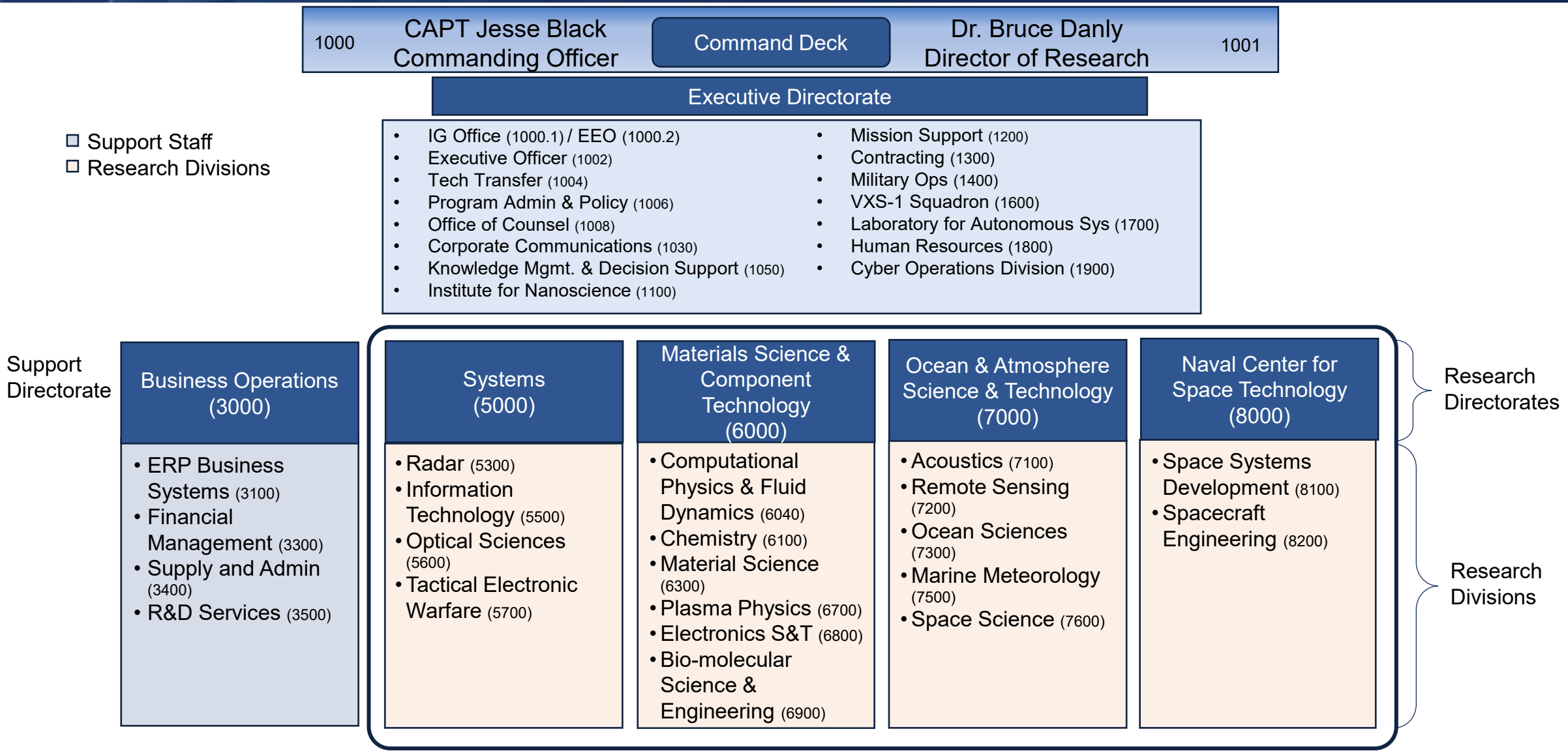
The Past, The Present, and the Future







Organization – NRL Directorates and Divisions



NRL Looks at problems Differently (*Our Secret Sauce*)

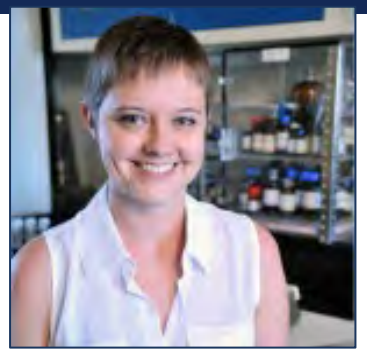
1,790 Science and Engineering (S&E) Professionals

- 418 electrical engineers
- 334 physicists
- 152 engineers (other)
- 160 computer scientists
- 109 mechanical engineers
- 89 chemists
- 81 aerospace engineers
- 57 oceanographers
- 53 meteorologists
- 46 physical scientists
- 34 mathematicians
- 30 biology/microbiology
- 29 astronomers
- 4 metallurgists
- 39 others (geology, psychology, health physics, etc.)

Approximately 900 PHDS

Strong Ties to:

- Academia
- Industry
- Allies



"If I had asked people what they wanted, they would have said faster horses" - Henry Ford

Major Locations and Facilities

Marine Meteorology Division

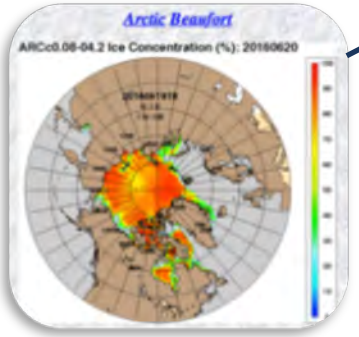
Washington, DC and surrounding

Patuxent River, MD

Monterey, CA

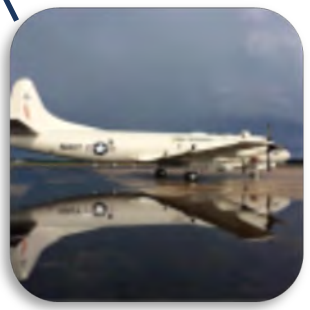
Stennis Space Center, MS

Key West, FL



Ocean Sciences Division

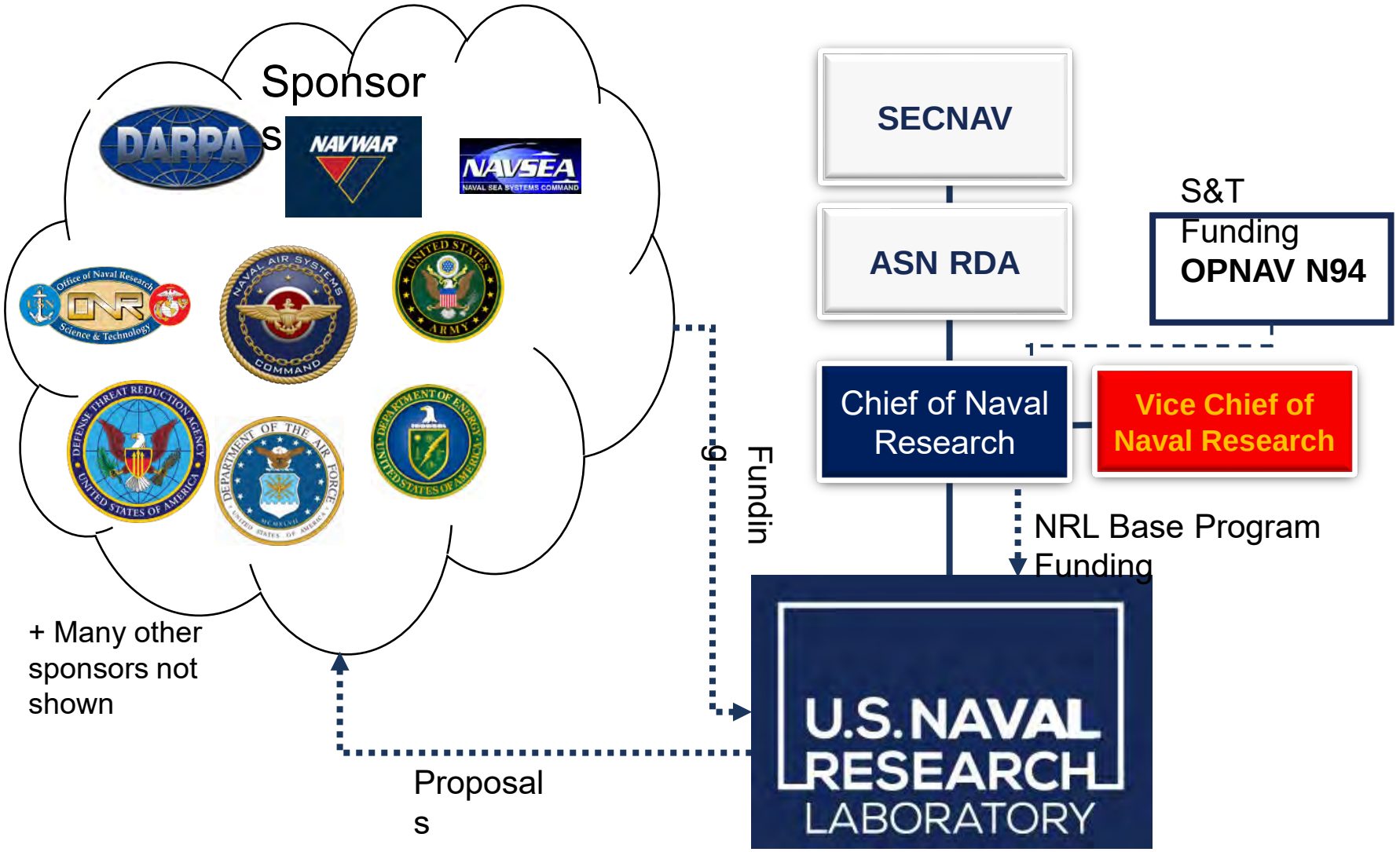
Chemistry Division (Corrosion Branch)



Flight Support

- NRL Physical Plant
  - 880 Acres
  - 222 buildings
- World-class research lab equipment
- Institute for Nanoscience
  - 5000 ft^2 Class 100 clean room
- Laboratory for Autonomous Systems Research (LASR)
  - Multiple ecological environments
  - Configurable high-bays
- Scientific Research Library
- VXS-1 (scientific research squadron)
  - P-3C,RC-12M, UV-18
- Multiple smaller sites
  - CBD @ Chesapeake Beach, MD
  - Worldwide space systems infrastructure (Quantico, Blossom Point, Pomonkey, etc.)

NRL – A Working Capital Fund Laboratory

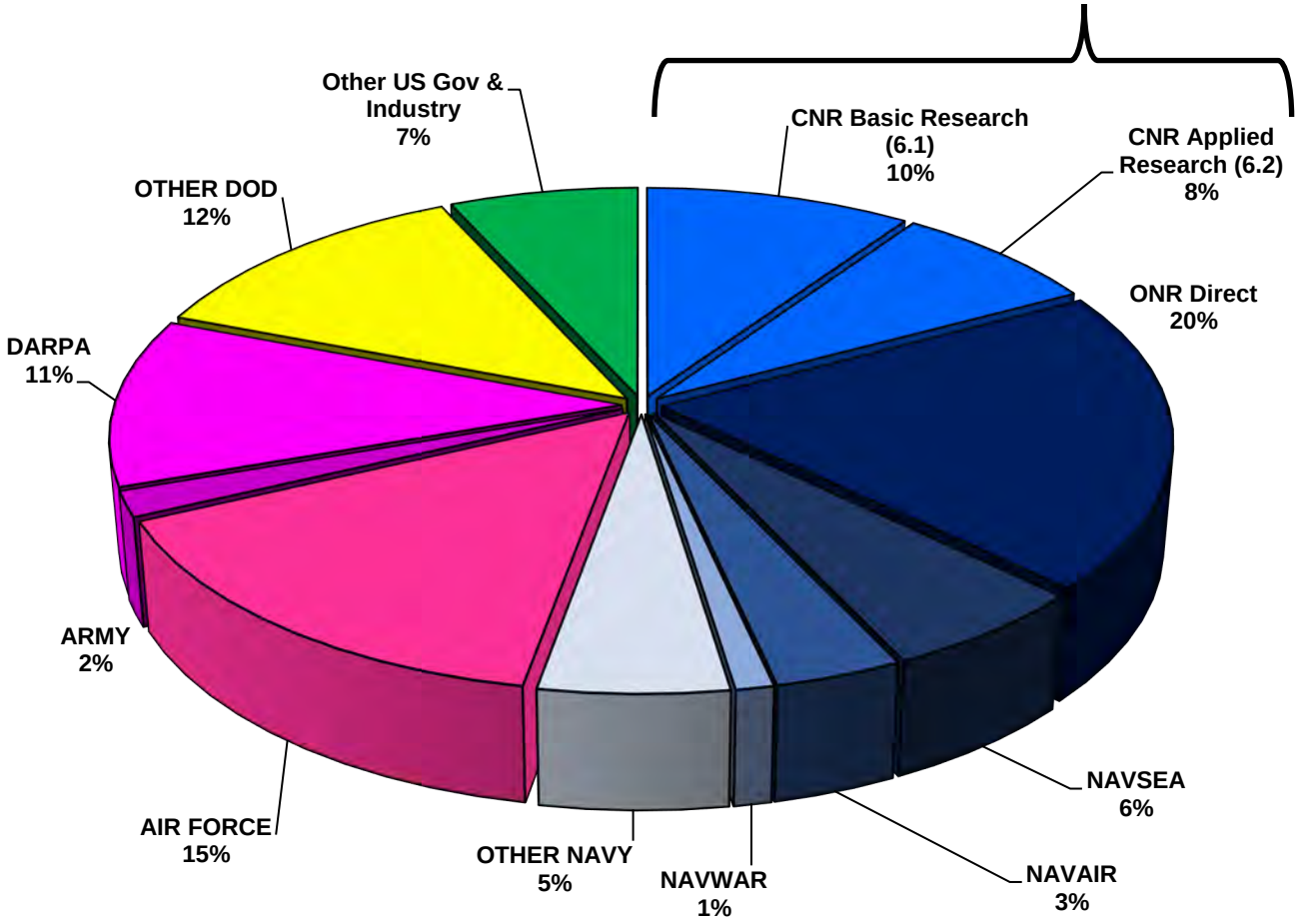


- NRL Reporting is through Chief of Naval Research (CNR) to ASN(RDA) and SECNAV
- Funding resourced through CNR/ONR from OPNAV N94 for NRL Base Program
- Financial operations according to Working Capital Fund model
  - All expenses covered through sponsored programs
  - NRL Scientists & Engineers propose S&T projects to DON, DOD, and Other USG prospective sponsors, and when funded, carry out this work

Navy Working Capital Organization

Customer Funds

NRL Base Program

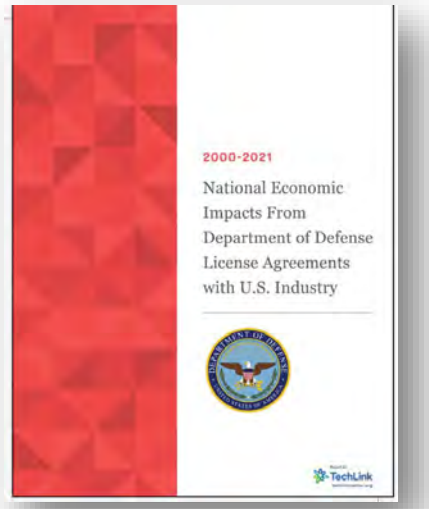


~$1.2B a Year in business

Note: This is NRL's typical funding profile with slight changes from year to year

U.S. NAVAL RESEARCH LABORATORY

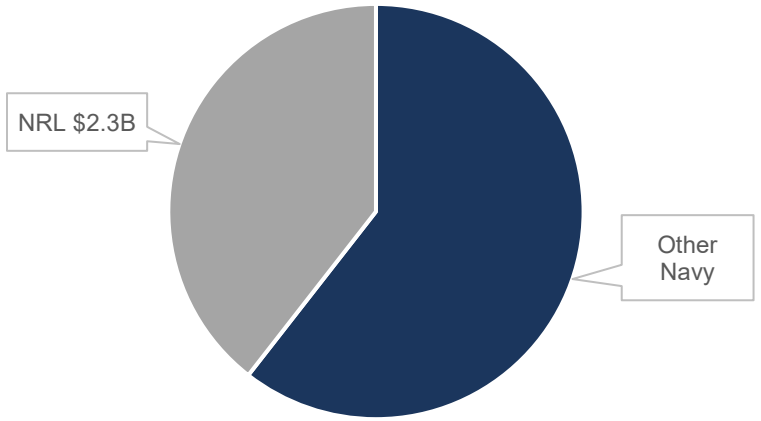
Economic Impact



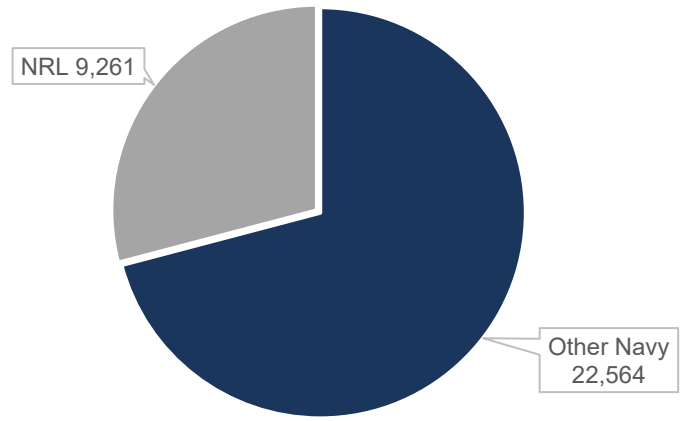
FY 2021-23

- **1,364 Active Patents**
- **266 Invention disclosures**
- **$1.5M in IP Royalties**
- **54 New CRADAs**
  - **$10.8M in committed funding**
- **18 Educational Partnerships**

NRL Economic Contribution (Output)
2000-2021 via License agreements



NRL Economic Contribution (Employment)
2000-2021 via License agreements



NRL Research Focus Areas (NRL Base Program) Basic and Applied Research (6.1 and 6.2)

Battlespace Environments

Understand environmental processes & predict environmental variability from the ocean bottom through the middle atmosphere

Electronics

New electronic and electro-optic phenomena, materials, theory and techniques for future forces and technological surprise avoidance

Electromagnetic Warfare

Technologies for total awareness and dominance of electromagnetic battlespace

Space Research & Space Technologies

Understand the space environment and its effects on systems

Conduct unique experiments in space, specific to future DON needs

Undersea Warfare

Research and advanced technologies for undersea sensors for anti-submarine and counter-mine warfare

Information Technology

Networks and Communications, Information Assurance and Cyber Warfare, Decision Support, and Autonomous Systems

Materials & Chemistry

Development of advanced functional, structural and biologically derived materials driven by advances in physics and chemistry

In-house basic and applied research … physical, space, environmental science and engineering

Break Out Sessions

Time	Floor	Room	Break Out Session	Program Officer
1230-1330	3rd Floor	Fairfax	Power, Propulsion & Thermal Management	Steve Martens
1230-1330	3rd Floor	Prince William	Hypersonics	Eric Marineau
1330-1400		Prince William	Aero S&T Cost-Efficiency and Capabilities (ASCEND)	Dr. Pranav Shah
1300-1350	3rd Floor	Arlington	Energetic Materials	Dr. Chad Stoltz, Dr. Tim Ransom, Mr. Chris Milby
1300-1350	2nd Floor	Tidewater II	Aerospace Structures & Materials	Bill Nickerson
1300-1350	2nd Floor	Tidewater III	Air Vehicle Technology	Dr. David Gonzalez, Dr. Dave Findlay, Dr. Leighton Myers
1300-1350	BR Floor	Potomac III	Directed Energy - HPM	Matt McQuage
1300-1350	BR Floor	Potomac IV	Terminal Defense	Ms. Teresa Berra, Mr. Tom Boucher, Chloe?
1300-1350	BR Floor	Potomac V	Directed Energy - Laser	Mr. Peter Morrison, Mr. Quentin Saulter, Mr. Matt Ketner
1300-1350	BR Floor	Potomac VI	Kinetic Weapons	Mr. Ken Heeke, Dr. Roger Sullivan, Mr. Taylor Young, Mr. Cody Robinson
1300-1350	BR Floor	Ballroom	Science of Autonomy and Controls	Mr. Marc Steinberg, Dr. Brian Holm-Hansen

ONR Code 35 Focus Area Forum

Naval Aviation Propulsion, Power, Thermal Management and Jet Noise Reduction Portfolio Interest

July 11, 2024

Dr. Steve Martens, Ph.D.
steven.martens3.civ@us.navy.mil
Air Warfare and Weapons | Air Platforms

Propulsion, Power, Thermal Management, and Jet Noise Reduction Portfolio Vision

- Support Department of the Navy (DoN) and Office of Naval Research (ONR) national security enhancement strategies through the establishment of long-term basic and applied research initiatives with the objective of advancing the technical superiority of Sea-Based Aviation (SBA) Propulsion, Power, Thermal Management and Jet Noise Reduction Science and Technology (S&T).
- Develop the next generation of engineers/scientists to work in industry and government labs
- Provide the Naval Aviation Enterprise with advanced technology in power, propulsion, thermal management and jet noise reduction in a cost-effective manner.

Propulsion, Power, Thermal Management, and Jet Noise Reduction Focus Areas

- Advanced Propulsion and Power Concepts for High Speed (up to Mach 3), Long Endurance and Responsiveness
- Advanced High Stage-Loading and Efficient Turbomachinery, including Distortion Tolerant Fans, Casing Treatments, and advanced methods in blade-disk aeromechanics
- Advanced Cooling and Thermal Management for Engines and Auxiliary Systems, including new Concepts of heat collection, distribution, and rejection
- Advanced Materials, Coatings, and manufacturing Science for Naval Propulsion System Components
- Jet Noise Reduction, including High Fidelity Modeling, Advanced Diagnostics, and NEW JET NOISE REDUCTION CONCEPTS!!!
- Advanced Diagnostics and Control for Integrated Power, Propulsion and Thermal Management, Including Supervisory Control
- Advanced Highly Integrated Propulsion, Including Inlets and Exhausts
- Dust Ingestion: Including Modeling, Separating, Deposition, Coatings, Sensing, etc…
- Sustainment, including materials, coatings, repair
- Small Turbine Engines; technologies to enable inexpensive engines, removal of oil system, rotating detonation augmentor to drastically reduce length, integrated with generators for high power/weight
- Small Heavy Fuel Engines; technologies to enable advanced sealing, fuel flexibility and reliability

How to become a Principal Investigator

- Attend the appropriate program review to learn what is already being funded
- Ensure that you are working on a research area that aligns with focus areas. Code 35 interest areas can be found here: https://www.nre.navy.mil/organization/departments/code-35
- Start with a couple slides and a half hour phone call
- If we can find an appropriate area, develop a white paper and we will help put you in contact with academia, industry, or government partners
- Based on white paper feedback, a proposal may be requested. You'll need to follow BAA instructions: https://www.nre.navy.mil/work-with-us/funding-opportunities/announcements
- I may steer you towards other government entities that are better suited for proposed work
- Include background discussions in your proposal, including letters of support. Peer reviewers won't know what we have discussed or who you have talked to
- Proposals will be peer reviewed, and with my endorsement, reviewed by ONR leadership for final approval

Overview ONR Hypersonics Research

Hypersonic Weapons Systems
Focus Area Forum, 2024

Dr. Eric Marineau
Program Officer, Hypersonics
Code 35, Naval Air Warfare and Weapons
eric.c.marineau.civ@us.navy.mil

ACCELERATING TO THE NAVY & MARINE CORPS AFTER NEXT

Introduction

- ONR Mission and Overview of NRE and NRDE
- Naval Air Warfare & Weapons (Code 35)
- Hypersonics Program Vision
- University, Lab and Industry Collaborations
- Hypersonic Workforce Development
- Young Investigators
- Hypersonic Research Infrastructure
- Multidisciplinary University Research Initiative (MURI)
- Material-Environment Interactions
- Solid-Fuel Air-Breathing Combustion Research
- Hypersonic Research Challenges and Opportunities

Lessons from History

Established by Congress in 1946, The Office of Naval Research's mission is to:

"…plan, foster and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security…"

The Naval Research & Development Establishment (NRDE)

The Naval Research Enterprise

ONR Research Portfolios

C5ISRT

COMMAND, CONTROL, COMPUTING, COMMUNICATIONS, CYBER, INTELLIGENCE, SURVEILLANCE, RECONNAISSANCE AND TARGETING

SEA WARFARE AND WEAPONS

NAVAL AIR WARFARE AND WEAPONS

OCEAN BATTLESPACE SENSING

WARFIGHTER PERFORMANCE

NAVAL X

Naval Air Warfare & Weapons Department (Code 35)

Hypersonic Aerothermodynamics, High-Speed Propulsion and Materials

Create new fundamental knowledge and develop computational, experimental and flight-testing capabilities along with the workforce needed to support the RDT&E of high-speed and hypersonic weapons

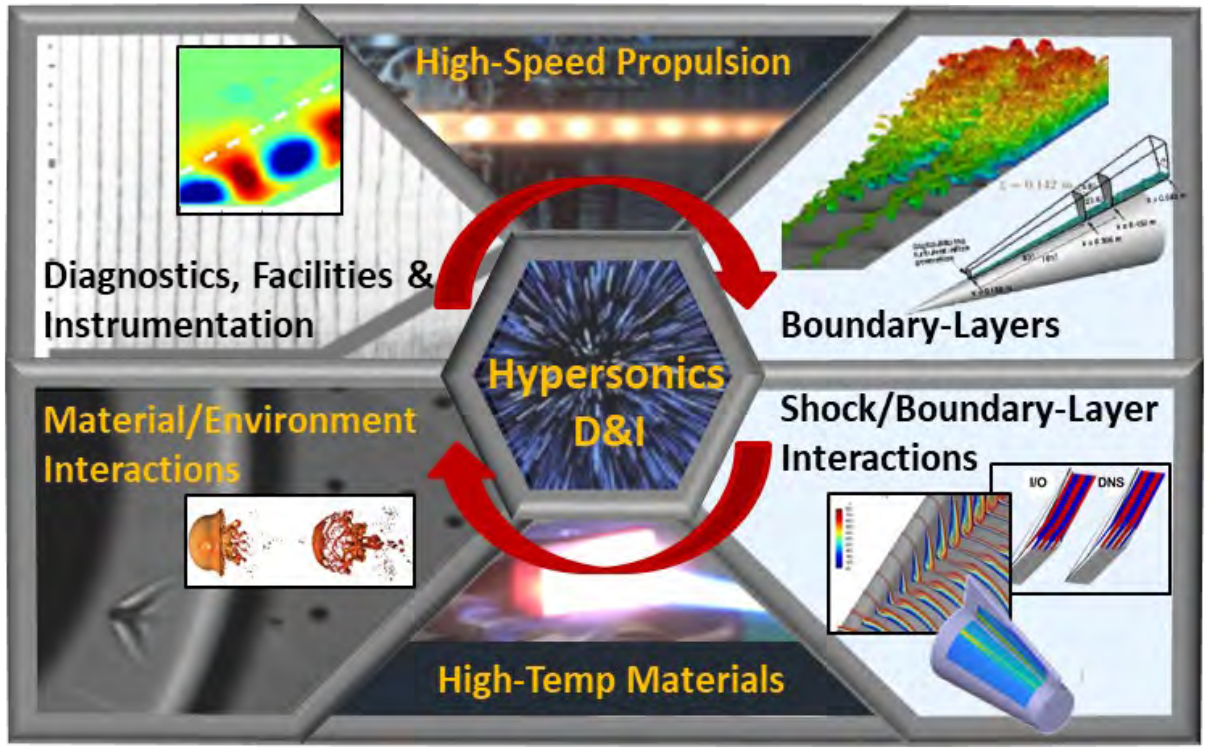
Dr. Eric Marineau
Program Officer, Hypersonics

Research Areas

- Hypersonic boundary-layers
- Shock-wave / boundary-layer interactions
- High-speed air-breathing propulsion
- Ultra-high temperature materials
- Environment-material interactions
- Test facilities, instrumentation and diagnostics

Applications

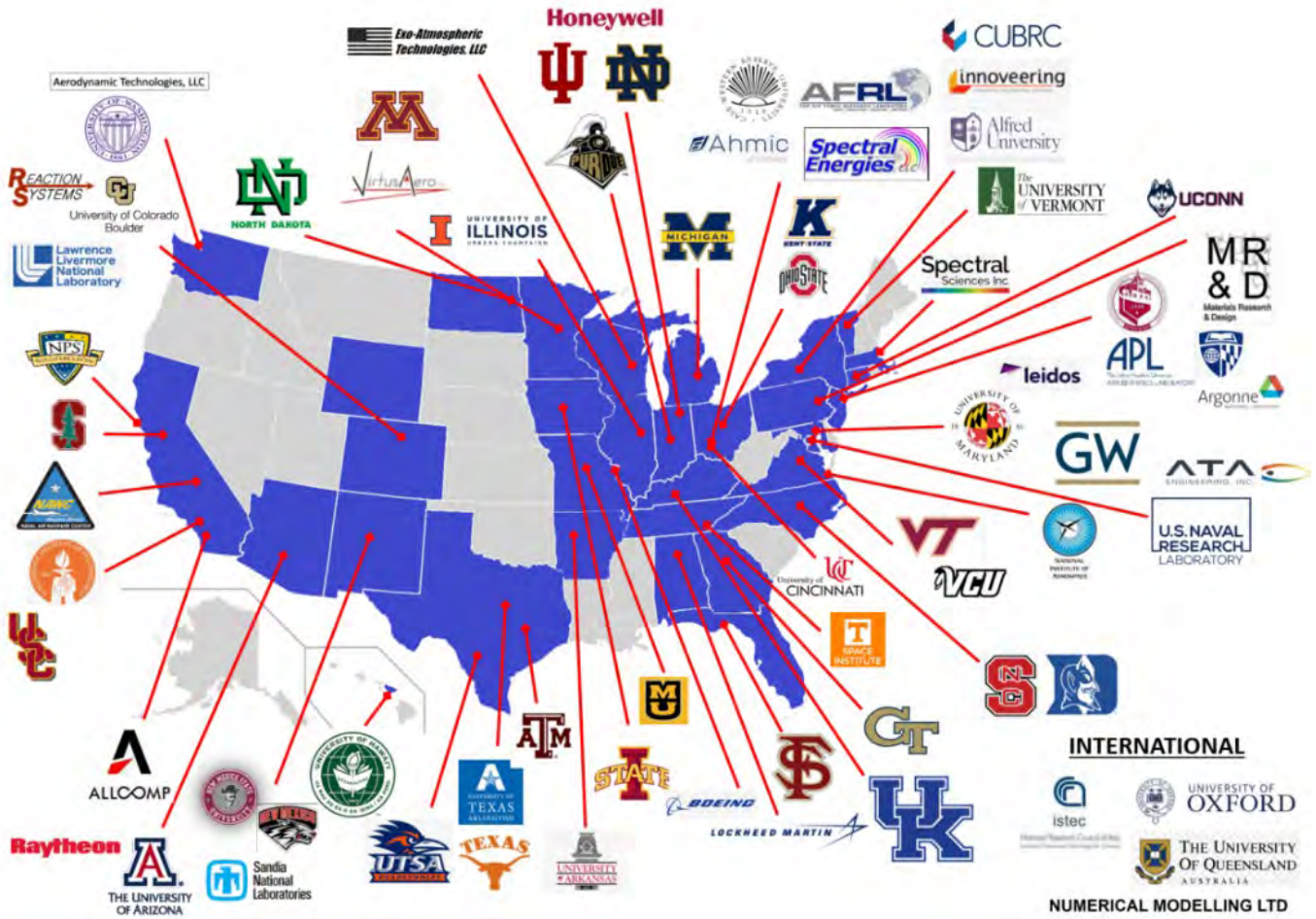
- Develop enabling technologies to increase range, lethality and survivability of weapons meeting Naval SWaP-C constraints to prosecute highly-defended, time-sensitive targets from survivable standoff ranges
- Develop, validate and transition predictive multiphysics modeling and simulation tools for hypersonics

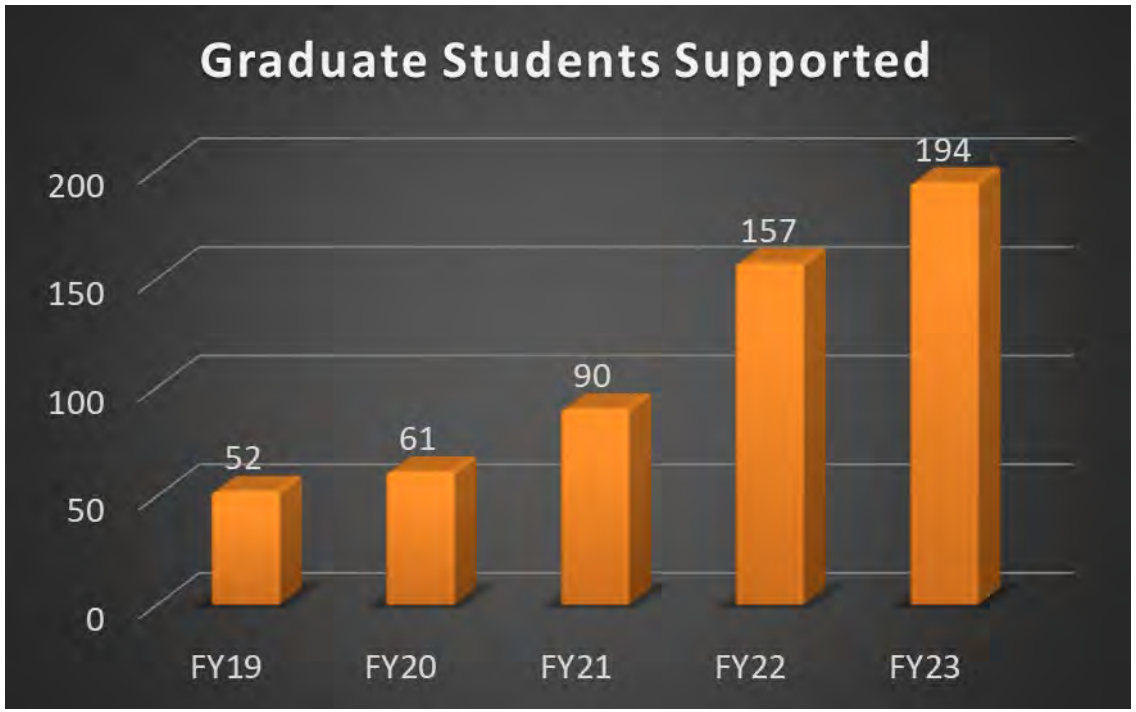


Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
ONR - Work With Us | Office of Naval Research (navy.mil)

University, Lab and Industry Collaborations

95 University performers at 54 Universities, 16 Lab performers at 10 labs, 15 Industry performers at 15 companies





194 Graduate Students Supported in FY23

12 Young Investigators Currently Supported

Aaron Towne

PhD, Caltech, 2016
FY24 ONR YIP: *A probabilistic transition model for hypersonic boundary layers*

Bryan Schmidt

PhD, Caltech, 2016
FY23 ONR YIP: *Water Entry of Hypervelocity Projectiles*

Matthew Zahr

PhD, Stanford, 2016
FY22 ONR YIP: *Improved Simulation of Internal and External Hypersonic Flows using High-Order Implicit Shock Tracking*

Joe Jewell

PhD, Caltech, 2014
FY21 ONR YIP: *Detailed Investigation of Hypersonic Instability, Breakdown, and Natural Transition under Quiet Flow with Simulated Ablation-Gas Injection*

Brian Bojko

PhD, SUNY at Buffalo, 2016
FY23 ONR Core: *Improved Flamelet Progress Variable Approach for Compressible High-Speed Flows*

Hallie Chelmo

PhD, University of Minnesota, 2017
FY23 ONR Core: *Investigating the Formation of Ice Crystal Aggregates and Their Impacts on Hypersonic Vehicles*

Dorrin Jarrahbashi

PhD, UC Irvine, 2014
FY22 ONR Core: *Resolving Shock-Driven Droplet Breakup and Evaporation at Hypersonic Conditions*

Ryan Johnson

PhD, University of Virginia, 2014
FY22 ONR Core: *High Fidelity Simulations of Combustion in High-Speed Propulsion Engines*

Babak Anasori

PhD, Drexel University, 2014
FY21 ONR Core: *2D MXenes Ultra-high Temperature Materials for Hypersonic Systems*

Daniel Araya

PhD, Caltech, 2015
FY21 ONR Core: Assessment of *Hypersonic Boundary Layer Transition and Turbulent Heating Prediction Methods for Complex Geometries*

Saniya LeBlanc

PhD, Stanford, 2012
FY20 ONR Core: *Energy Carrier Transport in Advanced Structural Materials for Thermal Management*

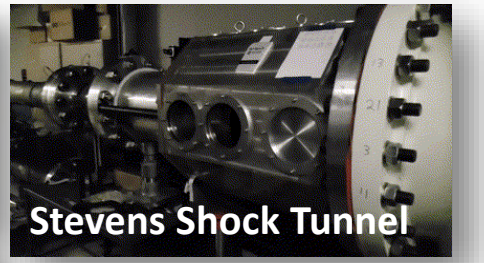
Neal Bitter

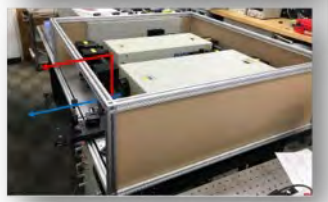
PhD, Caltech, 2015
FY20 DoD HPCMP Frontier: *Direct Numerical Simulations of Turbulence at Hypervelocity Flight Conditions*

New Hypersonic Research Infrastructure

Investments in test facilities, instrumentation and diagnostics at 13 universities since 2015 →

Strengthening university research infrastructure





Laser Diagnostics

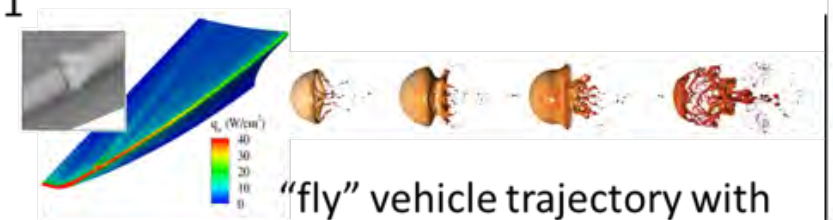
ONR MURI Topics in FY20, 21, 22, 23 and 24

Up to $45M in basic research investments in Multidisciplinary University Research Initiative (MURI) in hypersonics

MURI: Research efforts intersect more than one traditional science and engineering discipline. A multidisciplinary team effort can **accelerate research progress in areas particularly suited to this approach by cross- fertilization of ideas**, can **hasten the transition of basic research findings to practical applications**, and can help to **train students**

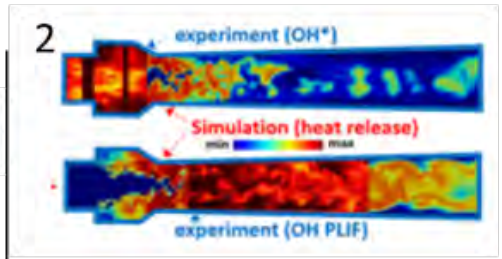
FY20	**Particulate and Precipitation Effects on High-speed Flight Vehicles** [1]	**Tom Schwartzentruber**	**U of Minnesota**
FY21	**Discovering and Modeling Turbulence and Chemistry Interactions in High-speed Reactive Flows** [2]	**Venkat Raman**	**U of Michigan**
FY22	**Development of Validated Hypersonic Plasma Kinetics Models Including Atomic Excitation** [3]	**Iain Boyd**	**CU Boulder**
FY23	**Combustion of Solid Fuels in High Enthalpy Flows**	**Greg Young**	**Virginia Tech**
FY24	**Phononic Subsurfaces & Porous Metasurfaces for the Control of Hypersonic Boundary-Layer flows**	**Mahmoud Hussein**	**CU Boulder**
FY24	**DETER: Disrupting Electron Transport to Minimize Thermal Conductivity**	**William Fahrenholtz**	**Missouri S&T**

1

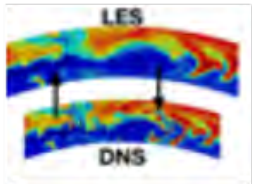


"fly" vehicle trajectory with damage evolution in CFD

2

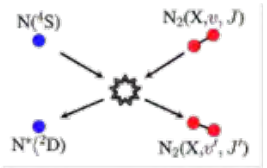


Data assimilation



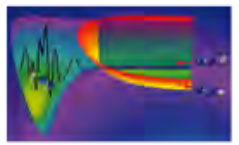
Adaptive model refinement

3



Molecular beam experiments

Must resolve atom electronic states!

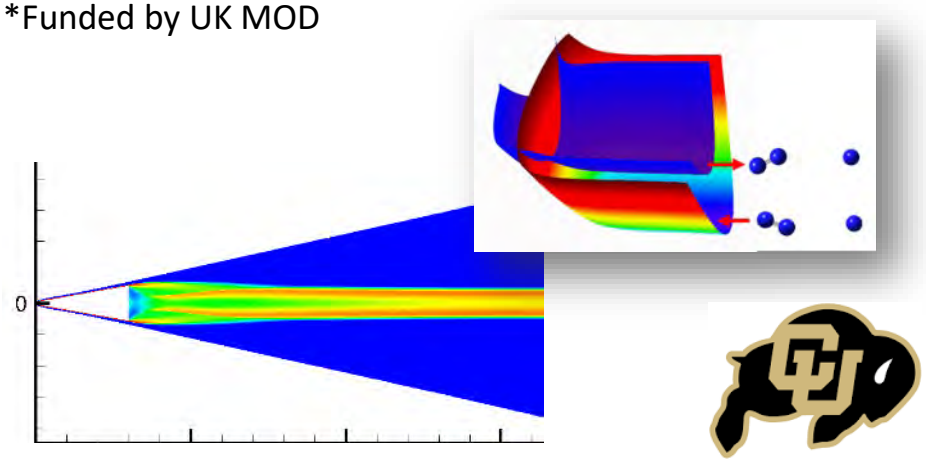


FY22 MURI: Development of Validated Hypersonic Plasma Kinetics Models Including Atomic Excitation (CU Boulder)

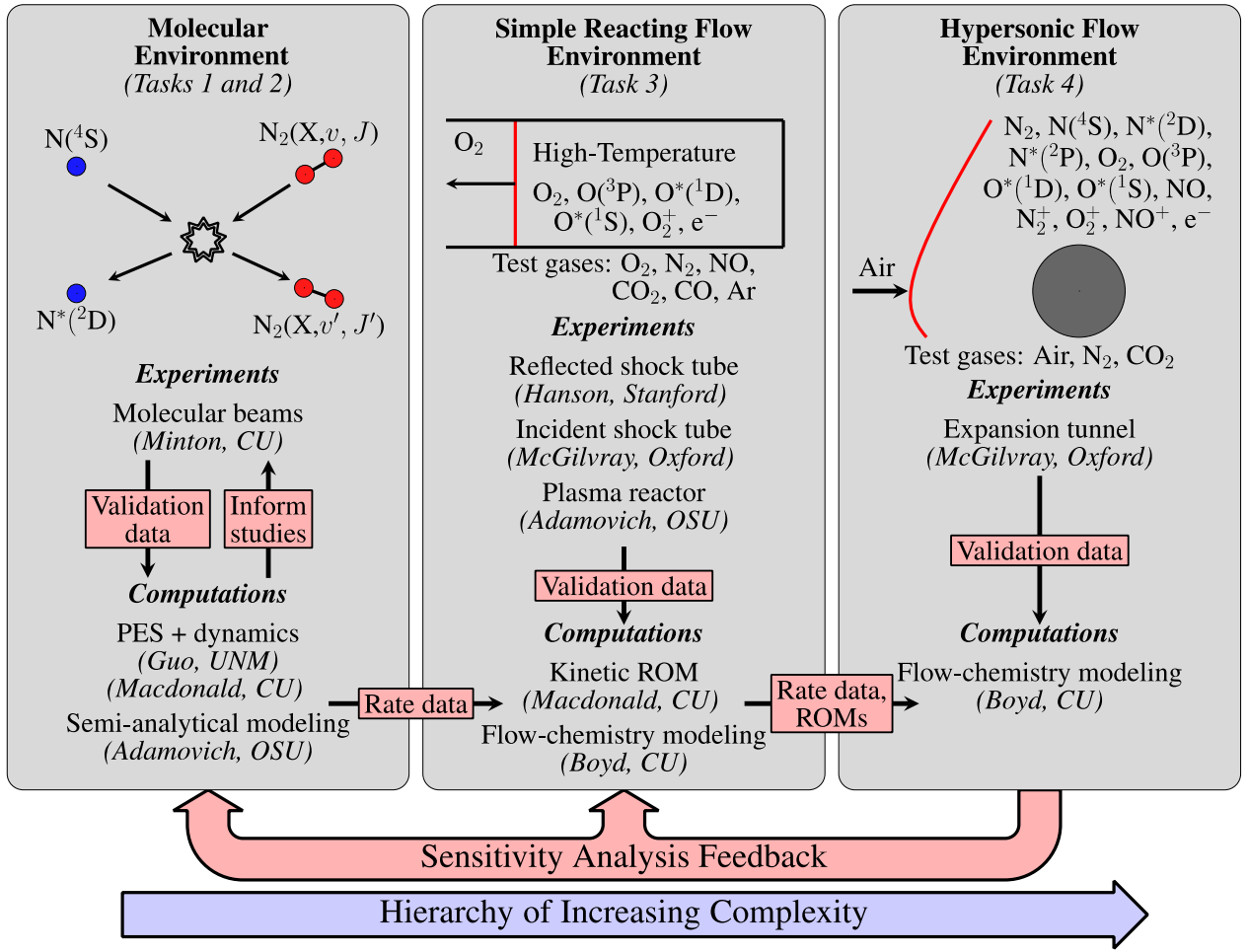
MURI Objective: Understand the fundamental processes driving the spatiotemporal evolution of weakly ionized hypersonic flows.

Project Team:
Iain Boyd (University of Colorado, PI)
Tim Minton (University of Colorado)
Robyn Macdonald (University of Colorado)
Ron Hanson (Stanford University)
Igor Adamovich (Ohio State University)
George Schatz (Northwestern University)
Matt McGilvray* (University of Oxford)

*Funded by UK MOD



Collision Induced Excitation (CIE) - Heavy particles $\mathbf{A + M \Leftrightarrow A^* + M}$
Associative ionization (AI) $\boldsymbol{A^* + B^* \Leftrightarrow AB^+ + e^-}$



FY22 MURI: Development of Validated Hypersonic Plasma Kinetics Models Including Atomic Excitation (CU Boulder)

Summary of Project Elements

1. Pathway to plasma generation
    i. Collision Induced Excitation (CIE) - Heavy particles $\mathrm{A} + \mathrm{M} \Leftrightarrow A^* + \mathrm{M}$
    ii. Associative ionization (AI) $A^* + B^* \Leftrightarrow AB^+ + e^-$
2. Advanced experiments
    a) Cross-sections: Molecular beam studies for reactions (i) + (ii) [Minton]
    b) Rates: Reactor [Adamovich], Shock-tube [Hanson, McGilvray] and Expansion-tube [McGilvray] studies on (i)-(ii)
    c) New diagnostic development as needed [Hanson, Adamovich]
3. Advanced modeling
    a) Cross-sections: Computational chemistry [Shatz, Macdonald] and Semi-analytical [Adamovich] for (i) + (ii)
    b) Rates: Modeling of shock tube experiments and reduced order modeling [Boyd, Macdonald]
    c) Validation in hypersonic flow modeling of expansion tube experiments [Boyd]

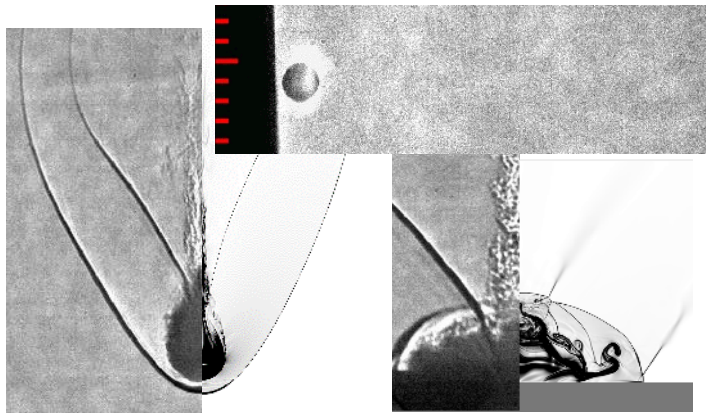
Material-Environment Interactions

Big Problems

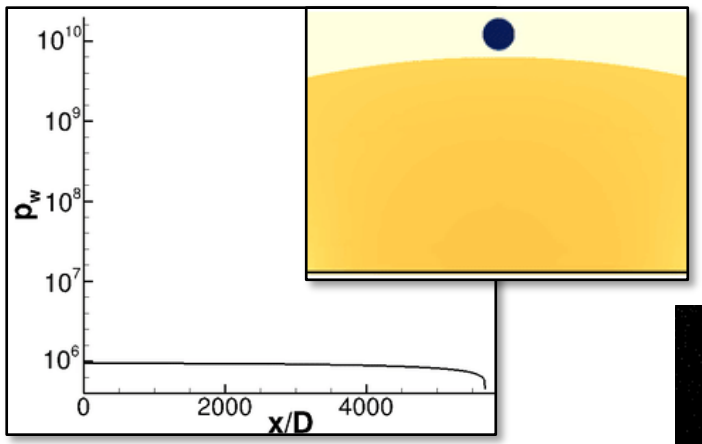
- **Understand & model the complex physical phenomena in high-speed multiphase flow / material interactions**
- **Understand & predict the effect of weather on flight performance**

Scientific or Warfighting Impact

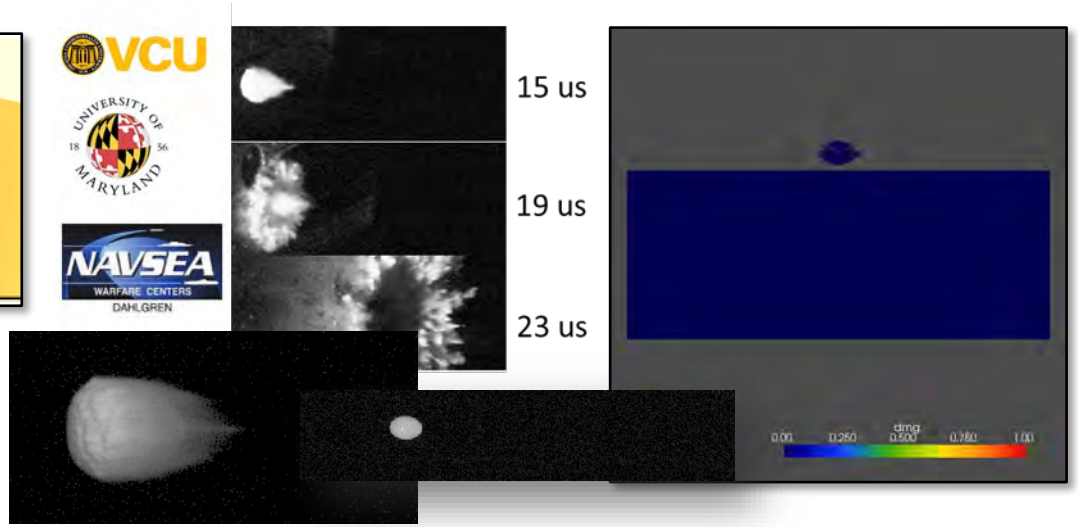
- **Predictive modeling to provide go / no-go criteria for employment of hypersonic weapons**
- **Scientific foundation for developing materials and structures with improved performance under weather / particles → Improved kinematic performance, survivability and lethality**



Droplet Aero-breakup (Stevens/NSWCDD experiments & UMD simulations)



Droplet Impingement (UMD & Stevens/NSWCDD)

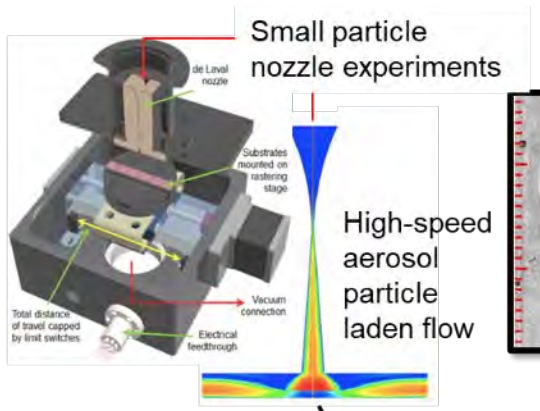


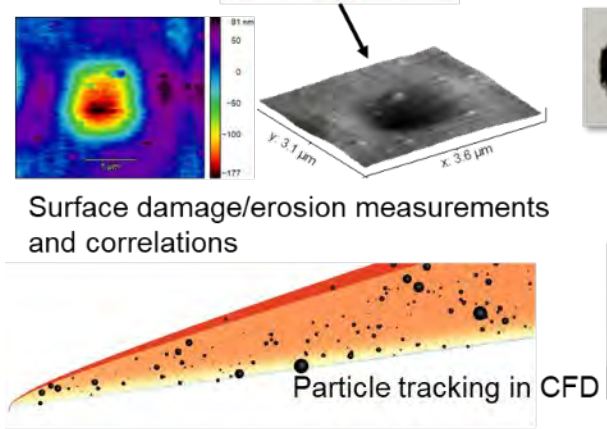
Material Response (VCU/UMD)

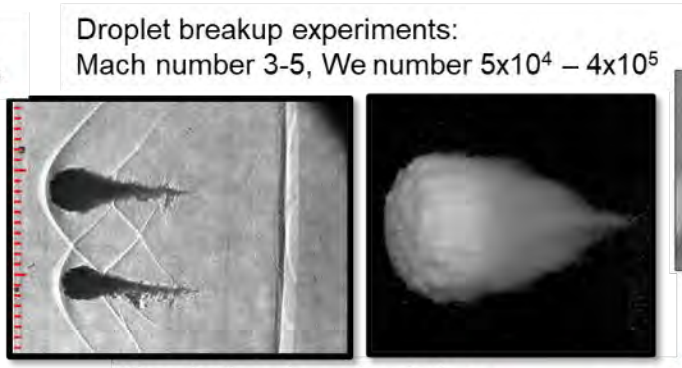
FY20 ONR MURI: Particulate and Precipitation Effects on High-speed Flight (University of Minnesota)

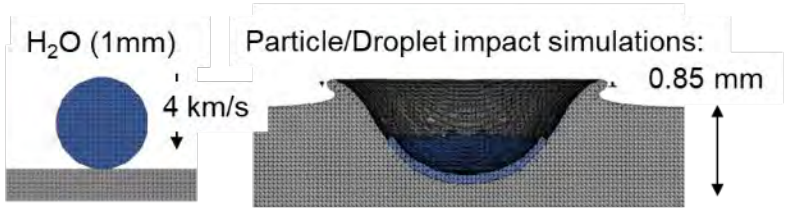
MURI Objective:
Understand/predict the coupled physics arising when solid particles or liquid droplets interact with M>3 flow and impact solid surfaces

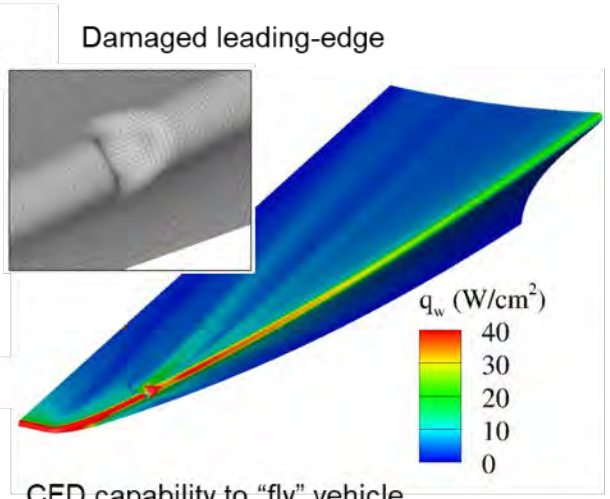
Project Team:
Tom Schwartzentruber (Minnesota, PI)
Graham Candler (Minnesota)
Chris Hogan (Minnesota)
Sean Garrick (UIUC)
Alice Koniges (Hawaii)
Nick Parziale (Stevens)
Stuart Laurence (Maryland)











Thermodynamic Comparative Analysis of Hypersonic Materials Using Oxy-torch & Plasmatron Screening, & Arc Jet Testing

- Define direct and comparative materials response trends using oxy-torch, plasmatron, and arc-jet
- Develop an understanding for the thermochemical response and behavior of hypersonic materials after exposure to extreme ground-based screening and testing.
- Materials: Non-porous ablators (Graphite) and Dense Non-Ablators (UHTCs)

ERICA CORRAL (PI) – THE UNIVERSITY OF ARIZONA

LUCA MADDALENA & VIJAY GOPAL (CO-PIs) – UT ARLINGTON

MARCO PANESI & FRANCESO PANERAI (CO-PIs) - UIUC

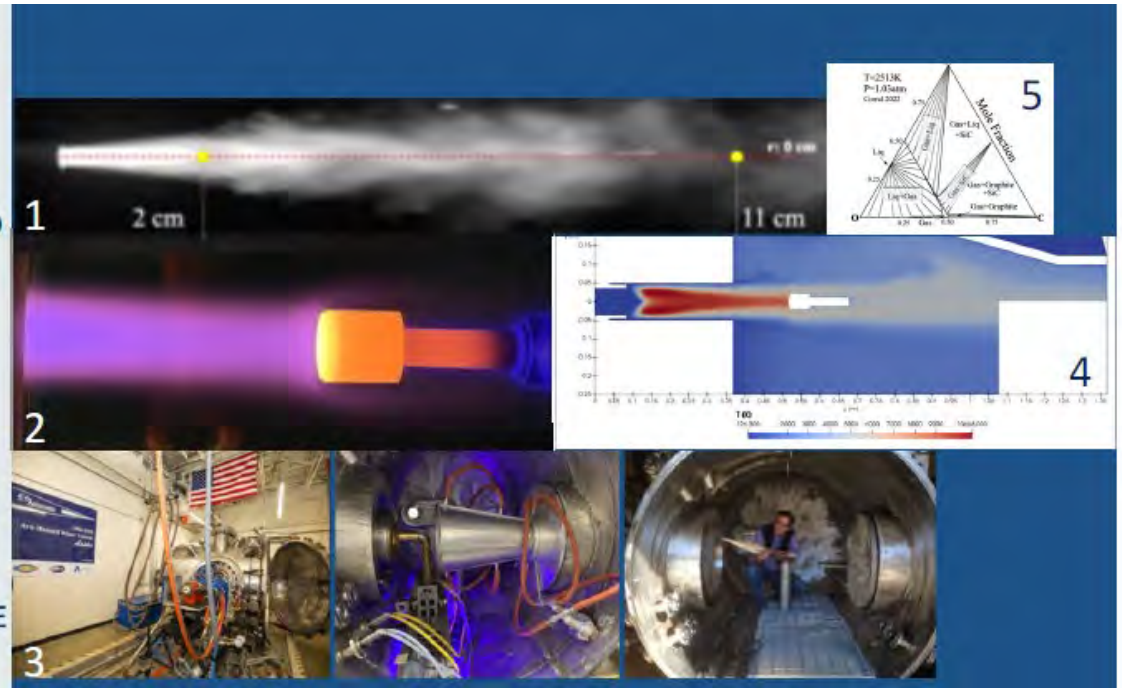
ONR Grant N00014-23-1-2623

Tasks

1. Identify test conditions for each facility and materials
2. Validate and characterize key test matrix conditions
3. Fabricate and test materials
4. Conduct thermochemical assessment, analysis, and characterization of materials before after testing

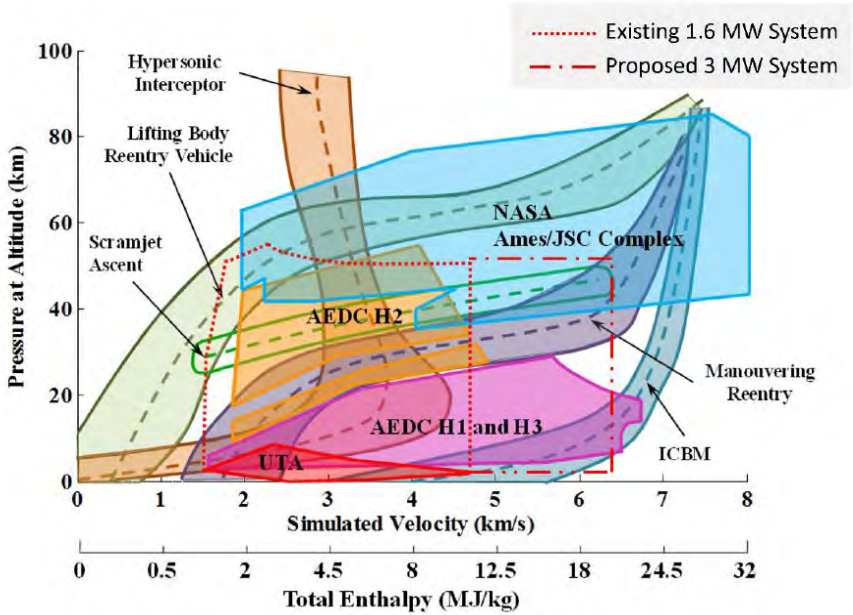
UNIVERSITY FACILITIES & CAPABILITIES:

1. SCREENING W/ OXY-TORCH (UARIZONA)
2. SCREENING W/ PLASMATRON WIND TUNNEL (UIUC)
3. TESTING W/ ARC HEATED WIND TUNNEL (UTA)
4. MODELING OF GAS FLOWS FOR EACH FACILITY (UIUC)
5. MODELING OF THERMODYNAMIC EQUILIBRIUM MATERIALS RESPONSE (UARIZONA)

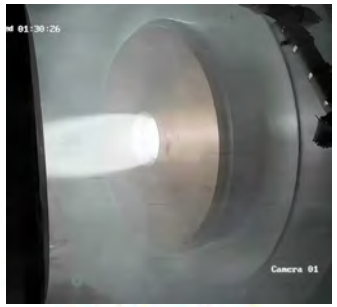


ONR-UTA Arc-Heated Plasma Wind Tunnel

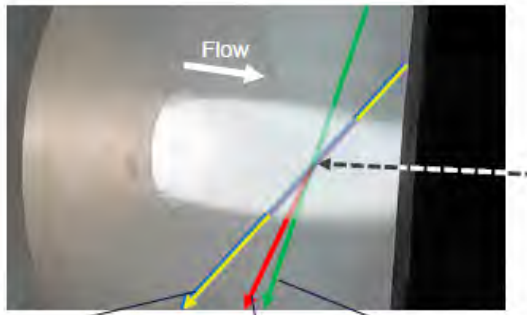
- **Non-Intrusive Diagnostics**
  - **Velocity** at 1 kHz with FLEET (RMS turbulent fluctuations + length scales)
  - **Atomic Oxygen concentration** with fs-TALIF
  - **Vibrational and Rotational temperature** with fs-ps hybrid CARS
  - **Freestream density fluctuations** with FLDI
- **FY23 DURIPS**
  - **3MW Power Supply → 20 MJ/Kg enthalpy + simulated flight trajectory**
  - **Vacuum System for Envelope Expansion of the ONR-UTA Arc-Heated Plasma Wind Tunnel → Mach 6 Nozzle**
- **Arc-Jet Freestream Turbulence Characterization and it's Influence on Laminar Heating Augmentation in the Stagnation Region (ONR Grant N00014-22-1-2460, Luca Maddalena PI)**

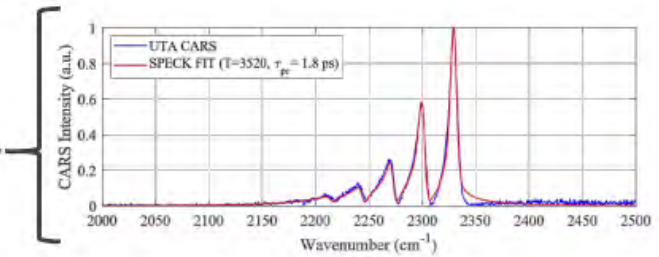


Envelope Expansion (FY23 DURIPS)



UTA

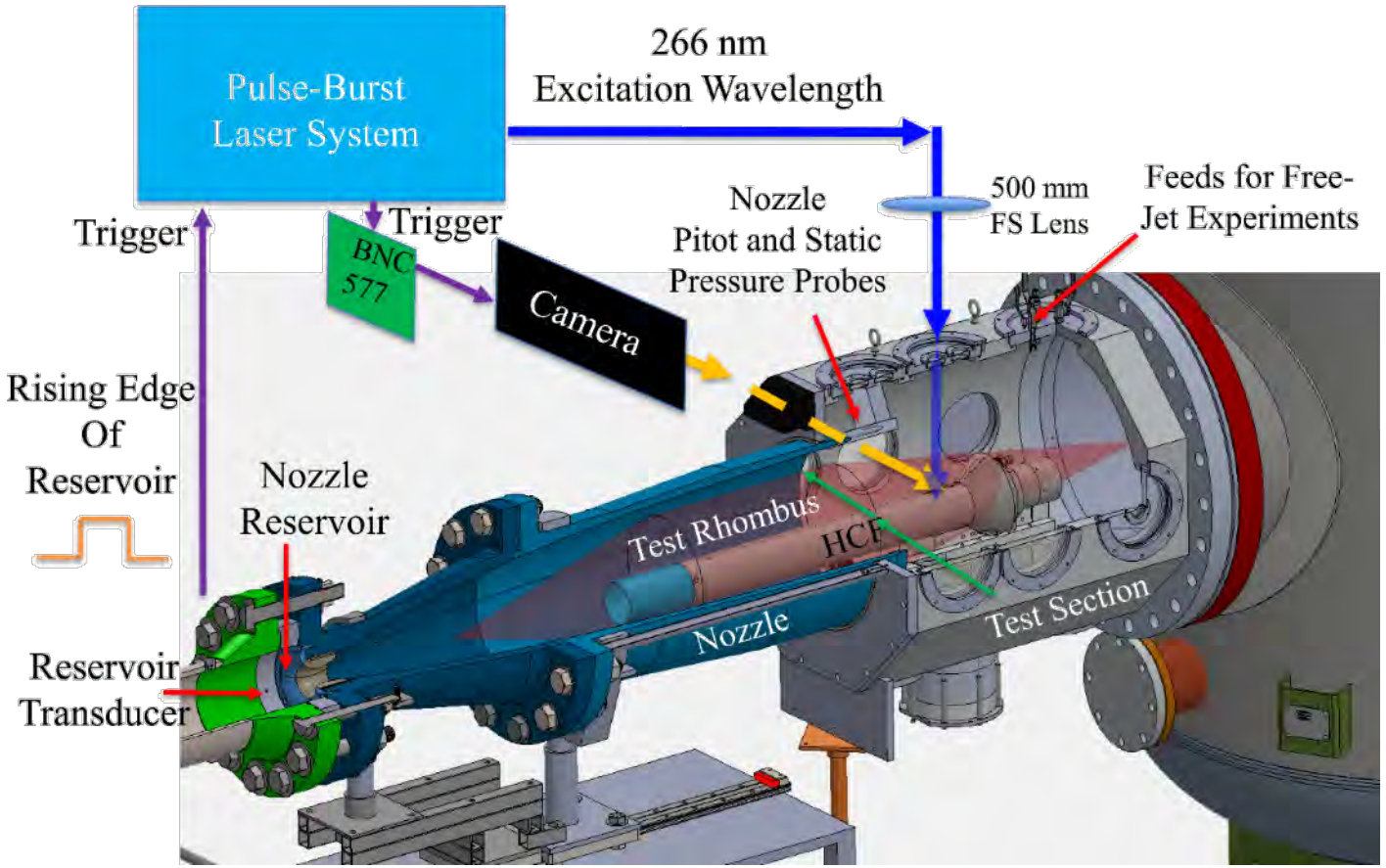




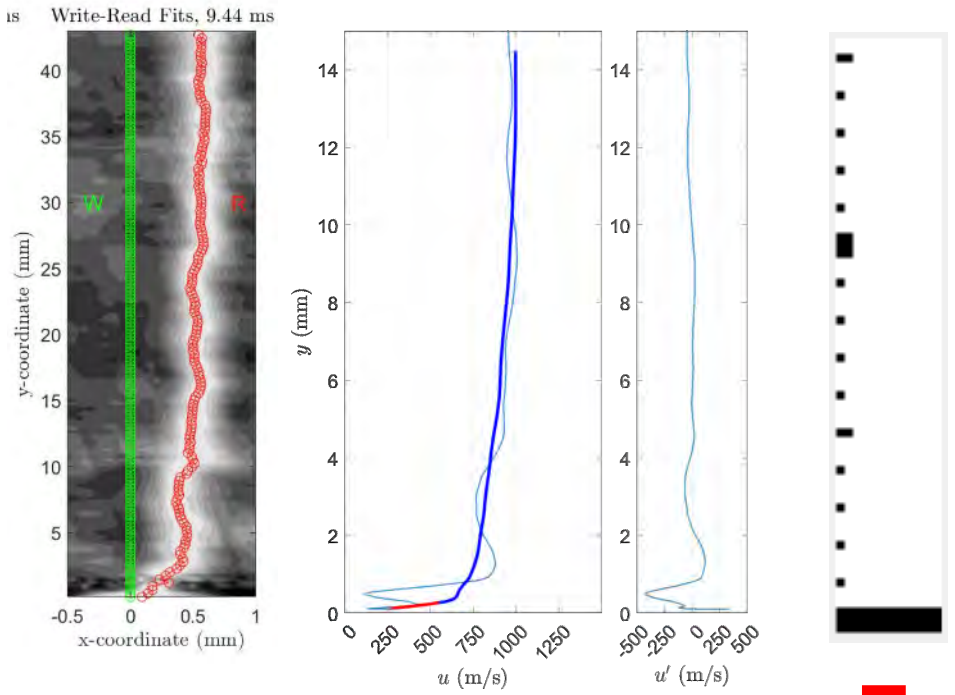
Vibrational Temperature Measurement of Diatomic Nitrogen

Laser Diagnostics for *Turbulent Boundary Layers (1/2)*

Non-intrusive velocity measurements with tagging velocimetry



50 kHz Acetone Tagging Velocimetry (ATV)

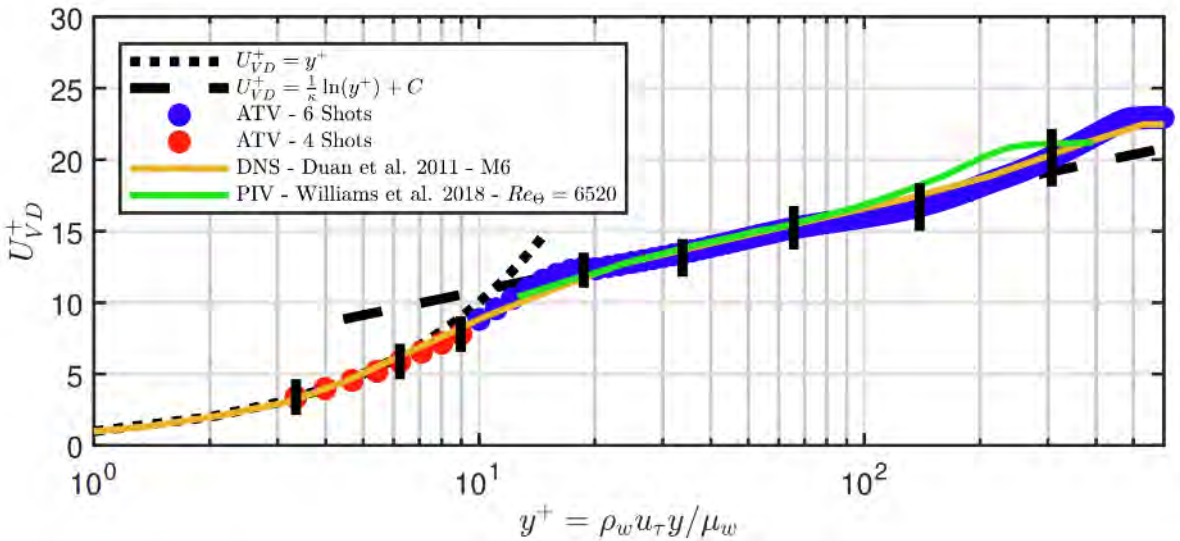


100 kHz Krypton Tagging Velocimetry (KVT)

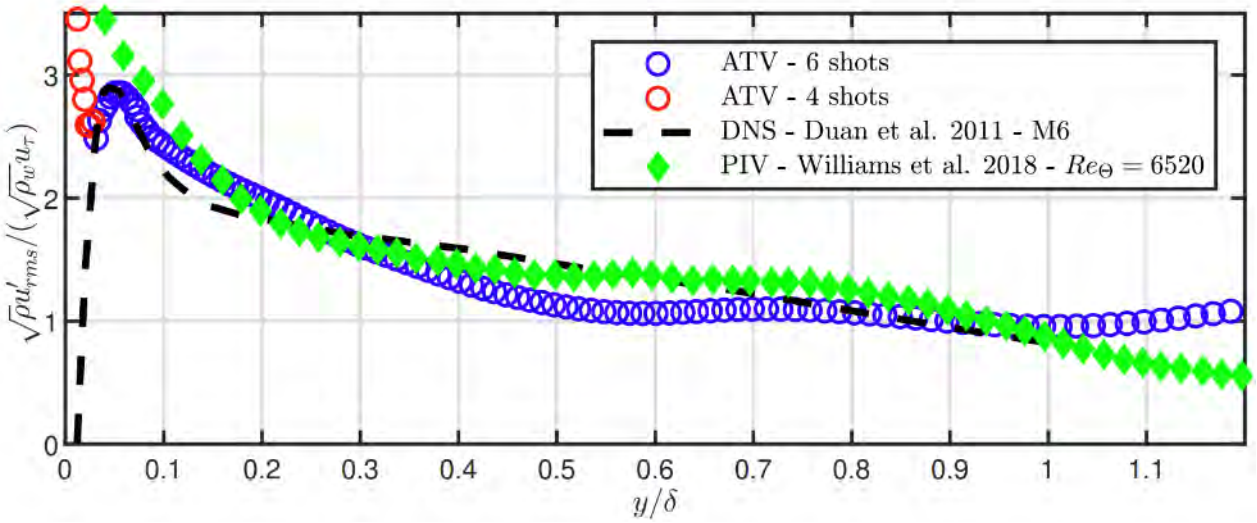
FY20 ONR YIP N00014-20-1-2549 and N00014-23-1-2474 (PI – N. Parziale)

Laser Diagnostics for *Turbulent Boundary Layers (2/2)*

- **Profiles of mean velocity and velocity fluctuations at Mach 6**
- **Very near-wall measurement, y^+=3**
- **Good comparison with other experiments and DNS**
- **Next target: wall-normal fluctuations and high Reynolds number experiments (*Re_τ > 2400*) → N00014-23-1-2474**



Mean velocity (Van Driest Transformed) of ATV vs. DNS in Duan et al (2011) and PIV in Williams et al (2018)

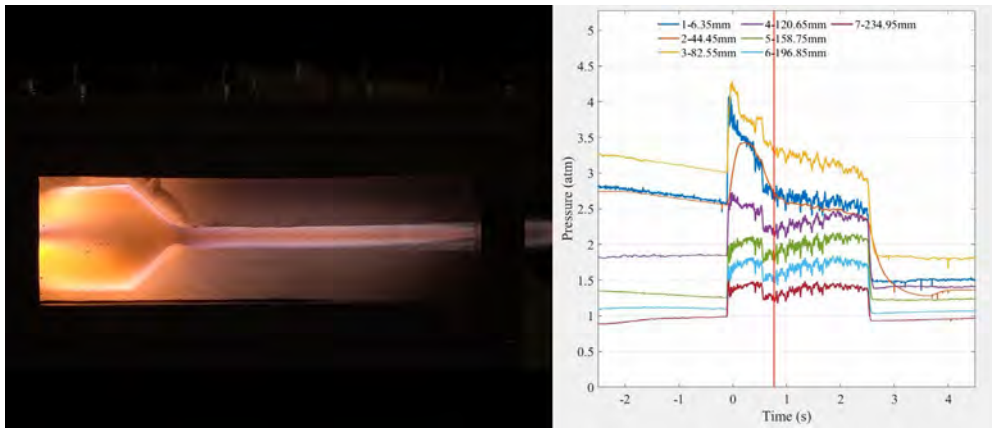


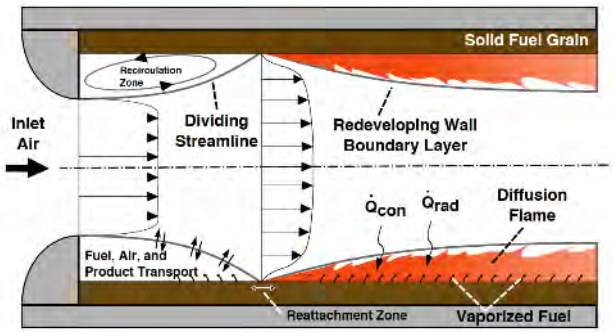
Velocity Fluctuations (u' rms) vs. DNS data in Duan et al (2011) and PIV data in Williams et al (2018).

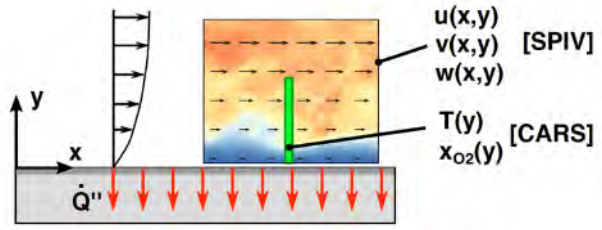
FY20 ONR YIP N00014-20-1-2549 and N00014-23-1-2474 (PI – N. Parziale)

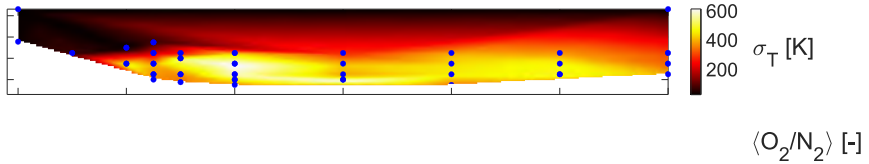
Solid-Fuel Air-Breathing Combustion Research

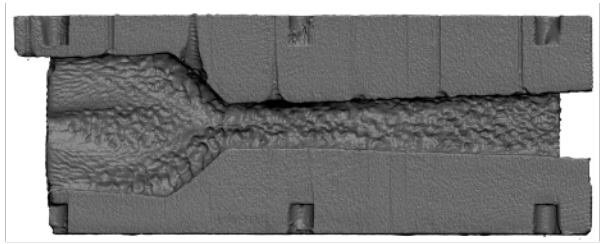
- **Complex** solid fuel **combustion physics** → pyrolysis, flame holding, coupled turbulence / finite-rate chemistry, radiative heat transfer
- **Combustion in Solid Fuel Ramjets – PI Carson Slabaugh, Purdue**
  - Quantify the rate-controlling physics of turbulent combustion in a solid fuel ramjet
- **Experimental and Numerical Investigation on the Combustion Characteristics of Solid Fuels in Supersonic Combustors – PI Greg Young, Virginia Tech**
  - Explore and demonstrate key fundamental characteristics of solid fuel scramjet operation











Thermally Choked Condition

Non-Choked Condition

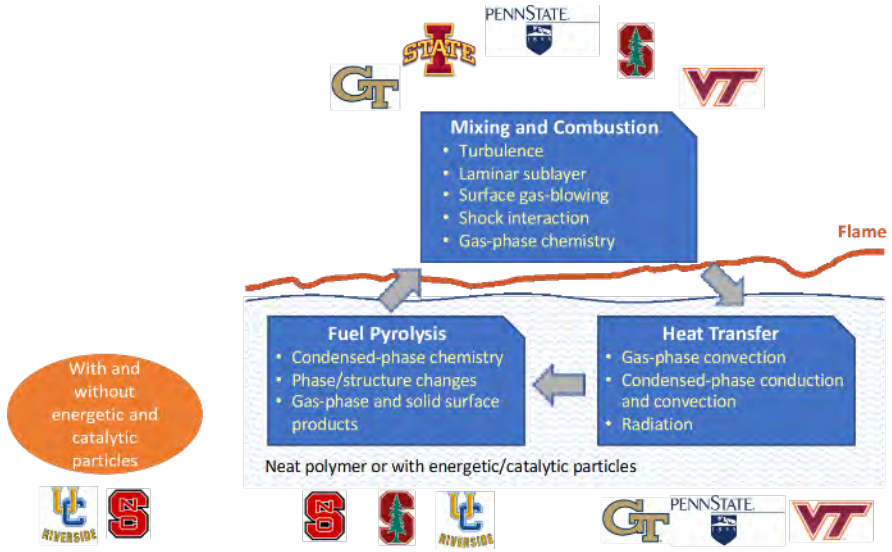
ONR Grant N00014-20-1-2374 & N00014-23-1-2301

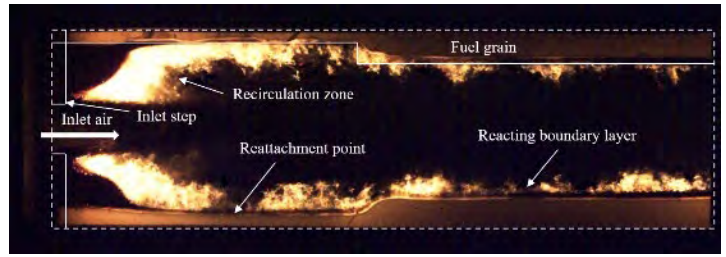
ONR Grant N00014-21-1-2299

FY23 ONR: MURI Combustion of Solid Fuels in High Enthalpy Flows (Virginia Tech)

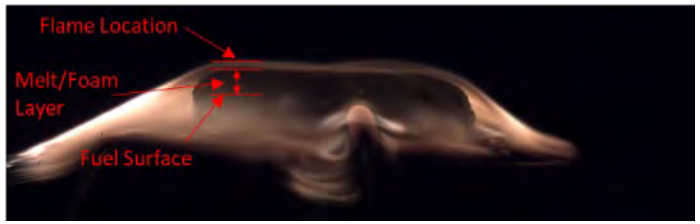
Understand, describe and model the critical, rate-controlling physicochemical processes in solid-fuel combustion among the coupled physical phenomena over different spatial and temporal time scales

- **Suresh Menon** – Continuum modeling, machine learning, uncertainty quantification
- **James Michael** – Advanced diagnostics
- **Hai Wang** – Hydrocarbon gas phase kinetics and oxidation
- **Phil Westmoreland** – Polymer decomposition chemistry
- **Rich Yetter** – Heterogeneous combustion and heat transfer
- **Greg Young** – Heterogeneous combustion and turbulent mixing
- **Michael Zachariah** – Particle dynamics and polymer composite combustion





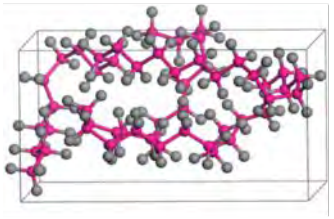
Subsonic Flow



Counterflow

Supersonic Flow

Outcome → Integrated, unified, multiscale model for solid fuel combustion for fuels of varying properties and under a wide range of operating conditions



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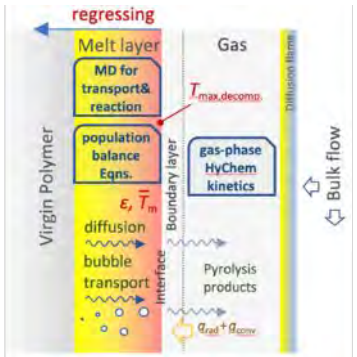

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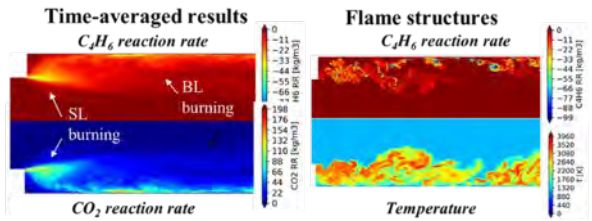


Research Challenges and Opportunities (1/2)

- **Detailed information on ONR Website** https://www.nre.navy.mil/organization/departments/aviation-force-projection-and-integrated-defense/aerospace-science-research-351/hypersonic-aerodynamics
- **Boundary layer transition prediction methods applicable to complex geometries** that incorporate (1) receptivity to free-stream disturbances, particulates and roughness, (2) linear growth, and (3) non-linear breakdown for multiple competing mechanisms. This also includes the **validation against high quality experimental data.**
- **Reduced order models to predict surface heat transfer rates and fluctuating pressure distributions in hypersonic turbulent and transitional boundary layers and shock-wave/boundary-layer interactions**. The models need to incorporate residual effects from specific laminar-turbulent breakdown mechanisms.
- **Novel methodologies to develop improved RANS and LES wall models from high fidelity computations (DNS) and/or detailed measurement**
- **Novel flow diagnostics for non-intrusive, time-resolved measurements of velocity and thermodynamic state-variables** that can be successfully transitioned from small-scale hypersonic facilities to large-scale test and evaluation (T&E) facilities such as shock tunnels, expansion tunnels, blowdown tunnels, Ludwieg tubes, and arcjets.

Research Challenges and Opportunities (2/2)

- **Physics-based, fully-coupled computational tools to predict environment-material interactions** such as **surface-chemistry, in-depth material response, and weather and atmospheric particles effects** on hypersonic weapons. The tools should be validated through novel diagnostics, facilities, and experimental data.
- **High-fidelity computational tools to predict surface pyrolysis, flame-holding limits, coupled turbulence / finite-rate chemical kinetics and radiative heat transfer effects for SFRJs** operating over a wide range of conditions.
- **Experimental studies** with advanced diagnostics under relevant conditions **to improve the understanding of critical phenomena for SFRJ combustion** such as solid fuel pyrolysis and recession, fuel mixing and flame-holding limits.
- **Advanced ultra-high temperature materials, cooling strategies, and thermal protection systems.**
- **Don’t hesitate to reach out to ONR program officers with ideas for new research topics not included on the ONR website!**

Conclusions

- **ONR is vested in**
  - **Developing new fundamental knowledge, experimental and computational capabilities in hypersonic aerothermodynamics, high-speed propulsion and ultra-high temperature materials**
  - **Developing the future workforce → 194 full-time graduate students supported in FY23**
  - **Investments in hypersonic research infrastructure**
- **Integrated basic and applied research program facilitates and accelerates knowledge transfer from academia to government and industry**
- **Close coordination with AFOSR, ARO, HVSI, OUSD R&E (JHTO / UCAH and TRMC), and NASA**

Kinetic Weapons Division

Naval Air Warfare & Weapons Department

11 July 2024

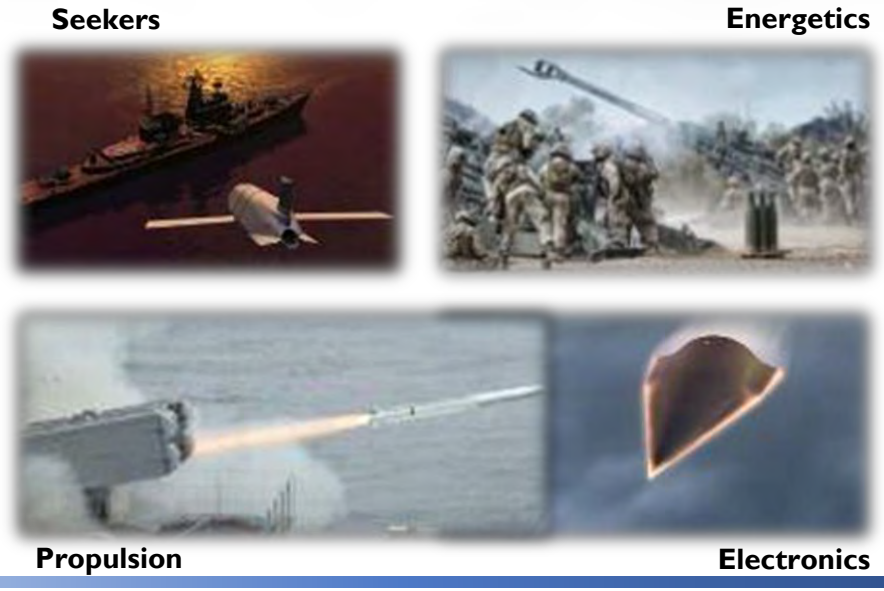
Dr. Chad Stoltz

Director, Kinetic Weapons Division (Acting)

Kinetic Weapons

Objective: Investigate and mature technologies in support of sub-systems applicable to current and/or future kinetic weapons systems, i.e., missiles, rockets, projectiles, bombs and mortars. Developmental areas include but not limited to: propulsion; seekers; guidance, navigation and control; warheads; and related targeting, networking, and command and control systems.

Operational Challenges: Long range, denied navigation, non-fixed targets, jamming, robust defenses, maritime environment.



Research Areas:

- Energetic Materials and Weapon Lethality
- Hypersonic Aerothermodynamics
- High Speed Propulsion and Materials
- Missile Applications
- Maritime Fires
- Guidance and Fire Control
- Advanced Capability Applications
- Advanced Autonomous Systems
- Lethal UxS and Counter UxS
- Weapon Autonomy
- Weapon integration (FNC/INP)

Warfighting Payoff:

- Improved weapon performance in order to pace peer competitors.
- Introduction of new technologies in order to leverage advances in computing power and methods, electronics packaging, materials and fabrication methods, artificial intelligence and machine learning, and achieve cost savings.

National Defense Strategy Key Capabilities Addressed:

- Missile Defense, Joint Lethality in Contested Environments

ONR Program Portfolios

- **Basic & Applied Research (BAR)**
  - Managed by Program Officers
- **Technology Candidates (Tech Can)**
  - Increase agility and reduce transition risk when responding to Fleet needs by exploring lower TRL solutions that could be matured to higher TRLs prior to the FNC process
  - Managed at Department level
- **Future Naval Capabilities (FNCs)**
  - Develop new technologies from fundamental research with quantifiable exit criteria to address validated warfighter requirements in program of record
  - Selected by OPNAV (N2/N6, N95, N96, & N98) Resource Sponsor
  - Transition funding by OPNAV Resource Sponsor through signed transition agreement
- **Innovative Naval Prototypes (INPs)**
  - Develop revolutionary and disruptive technologies from fundamental research which addresses current or anticipated warfighter requirements
  - Selected by Chief of Naval Research in coordination with OPNAV Resource Sponsors & Acquisition Leadership
- **Expeditionary Warfare Portfolio**
  - Includes BAR, Tech Can, FNCs, and INPs focused on Marine Corps technology gaps – Cross Cutting all ONR Departments
  - Developed with Commandant Marine Corps (CMC), Deputy CMC for Combat Development & Integration, Marine Corps Warfighting Laboratory, and Office of Naval Research

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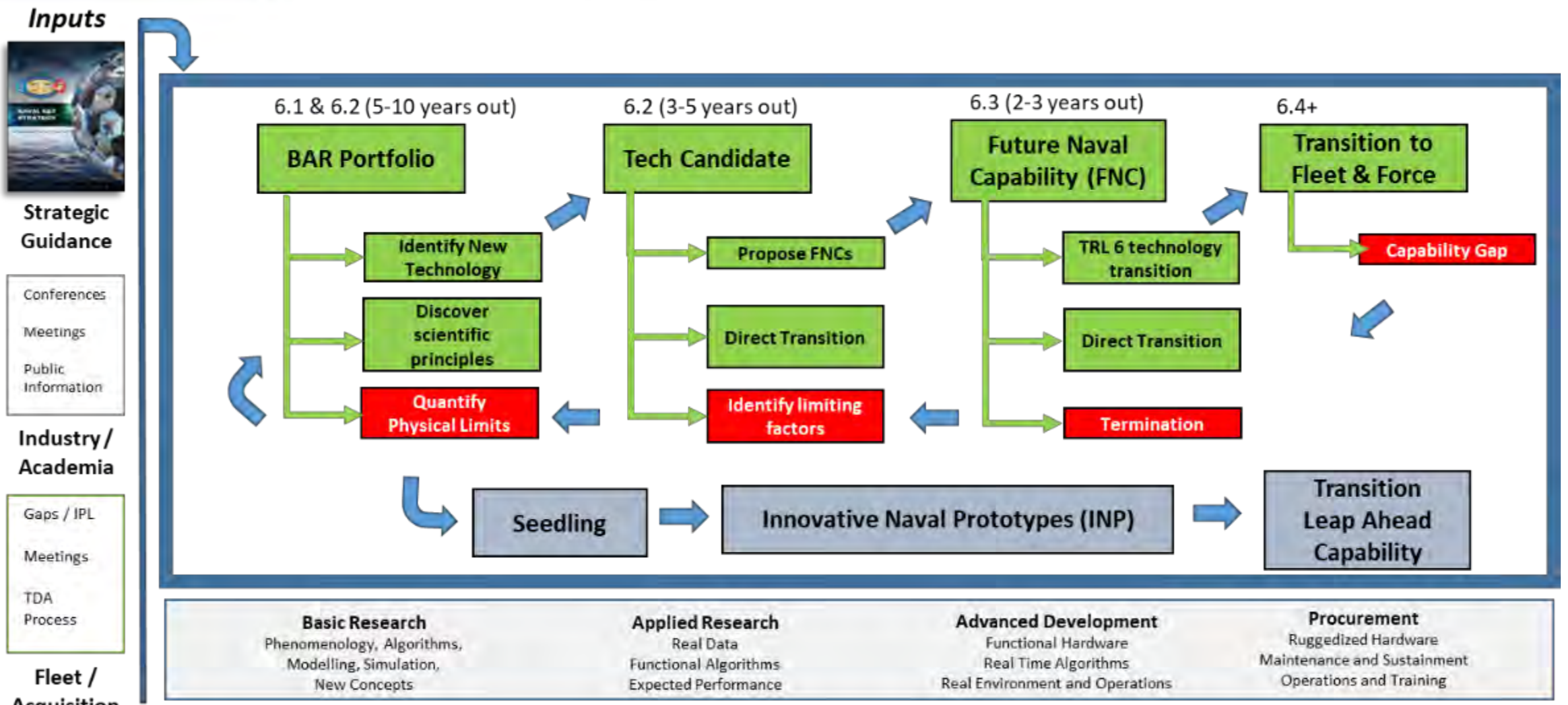
ONR Research & Development Ecosystems



Advanced Energetic Materials

Advancing Energetic Materials S&T & Future Workforce Development with the Objective of Enhanced Performance and Safety for Kinetic Weapon Systems

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Dr. Tim Ransom
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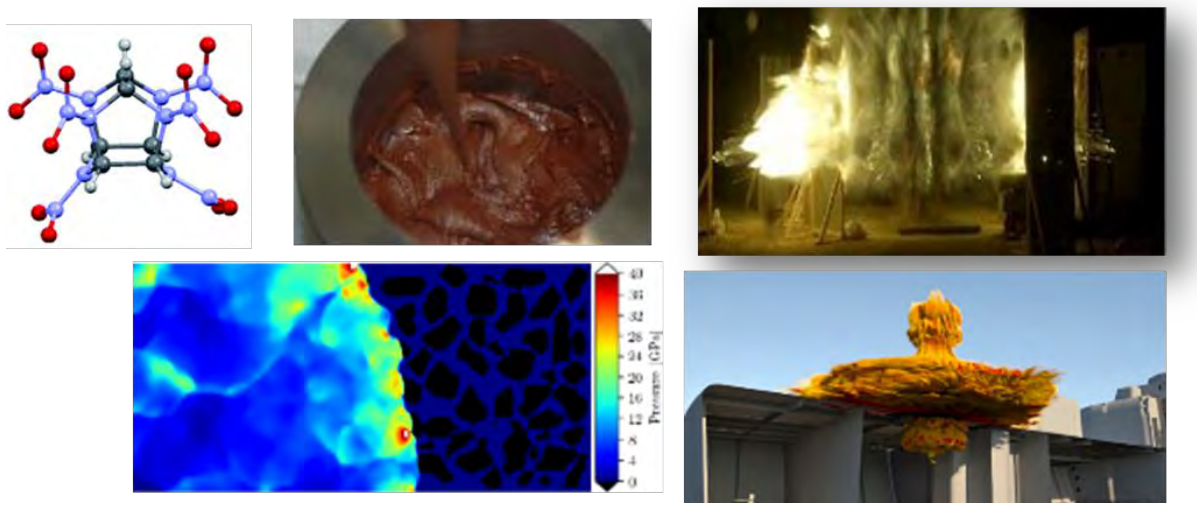

Research Areas

- Energetic Materials/Concepts to enhance warhead/propellant performance
- Novel dynamic diagnostics development and implementation for understanding complex energy release phenomena
- Atomistic through continuum level modeling solutions for properties, performance, and lethality predictions, composite design, and understanding safety and vulnerability

Applications

- Enhanced Lethality Warhead Concepts with Reduced Form Factors
- Tactical Propulsion with Improved Range, Speed, and Maneuverability
- Increased Reliability and Safety, Reduced Vulnerability and Cost

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Weapons Lethality

Development of Analytical Tools to Support Weapon Design and to Assess the Performance and Effectiveness of Novel Kinetic Weapon Concepts

Mr. Chris Milby
Energetics Program Officer
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Research Areas

- Reactive material warhead technologies
- Advanced Diagnostic and Experimental Techniques to assess Lethality Metrics
- Integration of non-traditional lethal mechanisms into lethality and effectiveness (L&E) codes
- Effects of less than lethal damage on threat missile performance
- Novel energetic integration technologies

Applications

- Advanced projectile warhead
- Integration of advanced L&E and damaged states into advanced threat models
- Technologies for maintaining warhead performance in reduced weight/volume

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Weapon Autonomy and Applications

Providing Autonomy and AI solutions that improve existing shipboard kill chains and other relevant weapon applications

Mr. Tom Boucher
Weapons Autonomy & Applications
Program Officer
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Research Areas

- Autonomy and AI in Shipboard Self Defense Kill Chains
- Lethality and Weaponization of UxS
- Autonomous Weapon Control
- Air Delivered ASW Sensors and Weapons

Applications

- Autonomy and AI for Shipboard Medium Caliber Gun Systems
- Autonomous Weapon Payloads for USVs
- Weaponization of Drone Swarms for USMC

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Advanced Energetic Applications

Developing novel kinetic solutions to adversarial problems utilizing advanced energetic materials and innovative lethality mechanisms

Mr. Taylor Young
Advanced Energetic Applications
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Research Areas

- Enhanced Lethality Warhead and Fuzing Technologies
- High Performance Explosives and Energetic Materials
- Advanced Air Breathing Propulsion Technologies
- Autonomous Target Identification and Prosecution
- Modular and Tailorable Payload Technologies

Application Areas

- Air Delivered Anti-Surface Warfare (ASuW) Munitions
- Long Range, Intelligent, Wide Area-of-Effect Munitions
- Attritable Armed Unmanned Systems (UxS)

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Hypersonic Aerothermodynamics, High-Speed Propulsion and Materials

Create new fundamental knowledge and develop computational, experimental and flight testing capabilities along with the workforce needed to support the RDT&E of high-speed and hypersonic weapons

Dr. Eric Marineau
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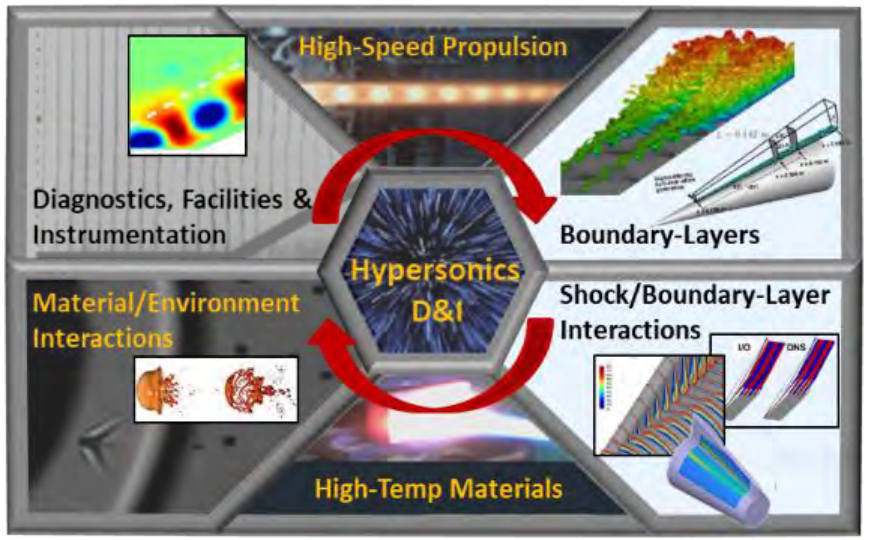

Research Areas

- Hypersonic boundary-layers
- Shock-wave / boundary-layer interactions
- High-speed air-breathing propulsion
- Ultra-high temperature materials
- Environment-material interactions
- Test facilities, instrumentation and diagnostics

Applications

- Develop enabling technologies to increase range, lethality and survivability of weapons meeting Naval SWaP-C constraints to prosecute highly-defended, time-sensitive targets from survivable standoff ranges
- Develop, validate and transition predictive multiphysics modeling and simulation tools for hypersonics

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Advanced Capability Integration

Guiding Applied Research Through Advanced Technology Development to Acquisition Programs of Record in the Areas of Kinetic Weapons, Directed Energy Systems & Weapons, and Naval Aircraft Systems

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Advanced Capability Integration
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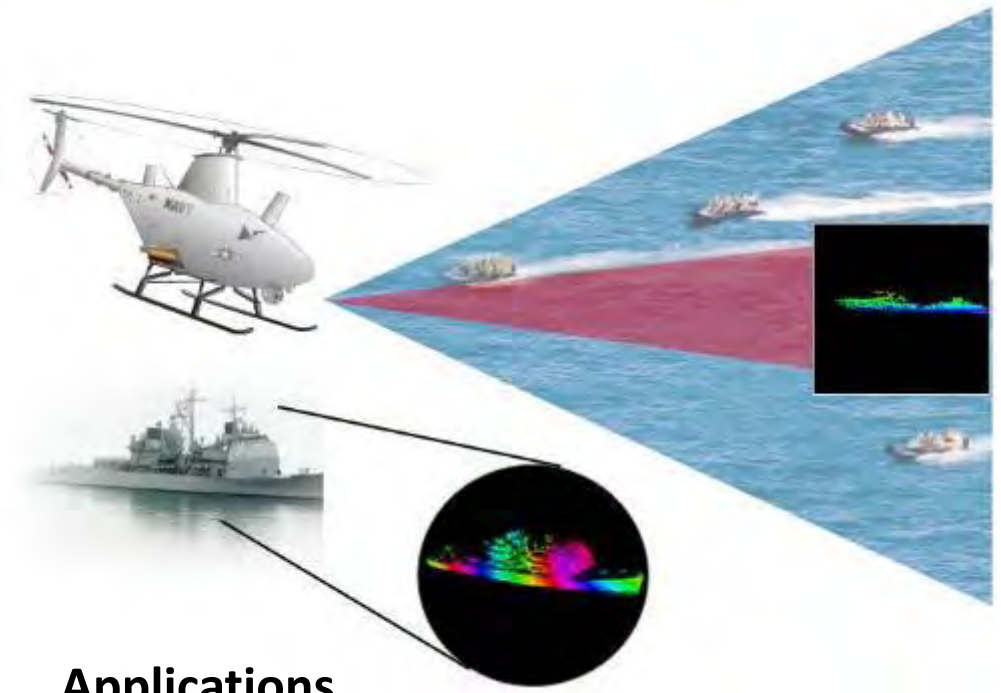

Development Areas

- LIDAR & EO/IR for Weapons Development
- Advanced Weapons Propulsion
- Advanced Seeker & Warhead Technologies
- Airborne precision targeting systems, to include Target Identification, Recognition & Designation Technologies

Applications

- Kinetic Weapons
- Directed Energy Technologies & Weapons
- Naval Aircraft Systems

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Precision Fire Control & Low-Cost Interceptors

Advancing fire control technologies to enable cruise missile defense using small, low-cost interceptors that contribute to the layered defense of surface combatants and expeditionary forces both in capability and capacity to defeat complex raids of hypersonic missiles and cruise missiles

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Ms. Chloe Lee
Precision Fire Control Deputy Program Officer
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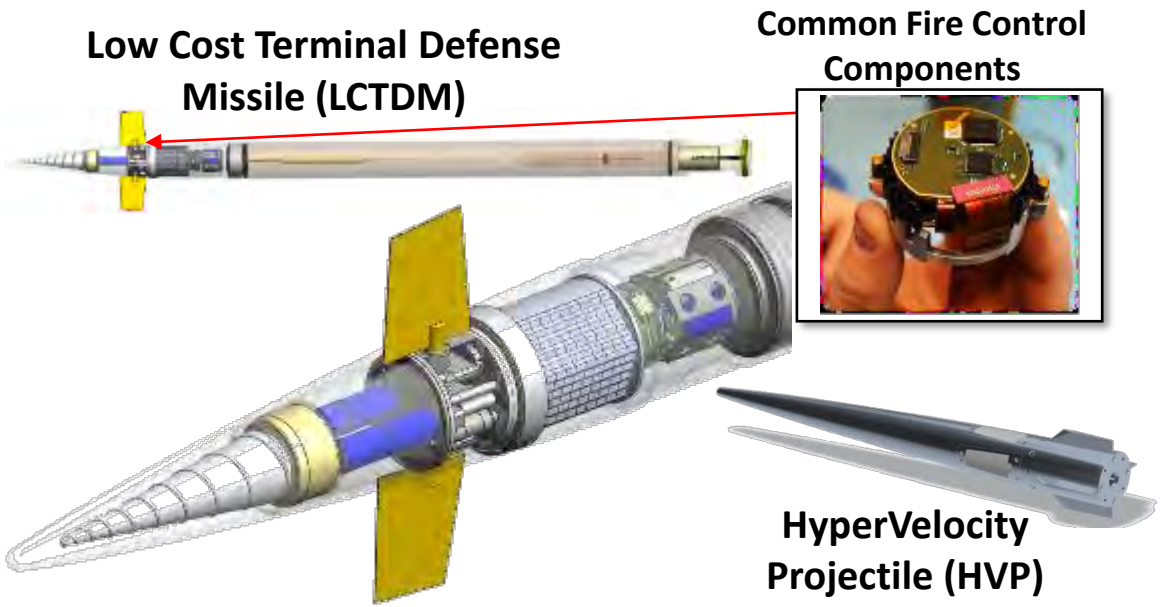
Objectives

- Develop precision guidance and fire control technologies
- Demonstrate engagement of surrogate air threats with HyperVelocity Projectiles (HVPs) and modified MK 66 2.75-inch rockets

Research Areas

- Novel fire control and communication waveforms
- Precision aero-control devices
- Adaptive and collaborative guidance laws
- High acceleration-tolerant electronic components



Applications

- Advanced RF seekers
- Advanced radar track filters
- Gun-launched guided projectiles
- Small guided missile interceptors

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Advanced Autonomous Systems

Multi-domain, heterogeneous swarms of unmanned systems capable of rendering the adversaries ability counter either inadequate or irrelevant

Mr. Lee Mastroianni
Program Officer in area of Advanced Autonomous Systems conducting broad research and capabilities development from Applied Research through Advanced Technology Development (Prototype Systems)
lee.s.mastroianni.civ@us.navy.mil

Research Areas

- Extended range/performance platforms
- Multi-domain capable platforms
- Austere environment employment / low footprint
- Manufacturing for scale-up of volume and greatly reduced cost
- Modular Open systems Architecture (MOSA) and Commercial Off-the-Shelf and Government Off-the-Shelf leverage
- Modular payload capabilities
- Precision navigation and timing and communications denied autonomy
- Perception and sensor advances

Applications

- Long-Range Precision Strike
- Wide area intelligence, surveillance, and reconnaissance

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Advanced Capability Applications

Threat driven technology development of Air Warfare and Naval Weapons technologies for deployment to the Fleet/Forces in a three to seven year window, as aligned with new and existing Naval Programs of Record.

Dr. Roger M. Sullivan
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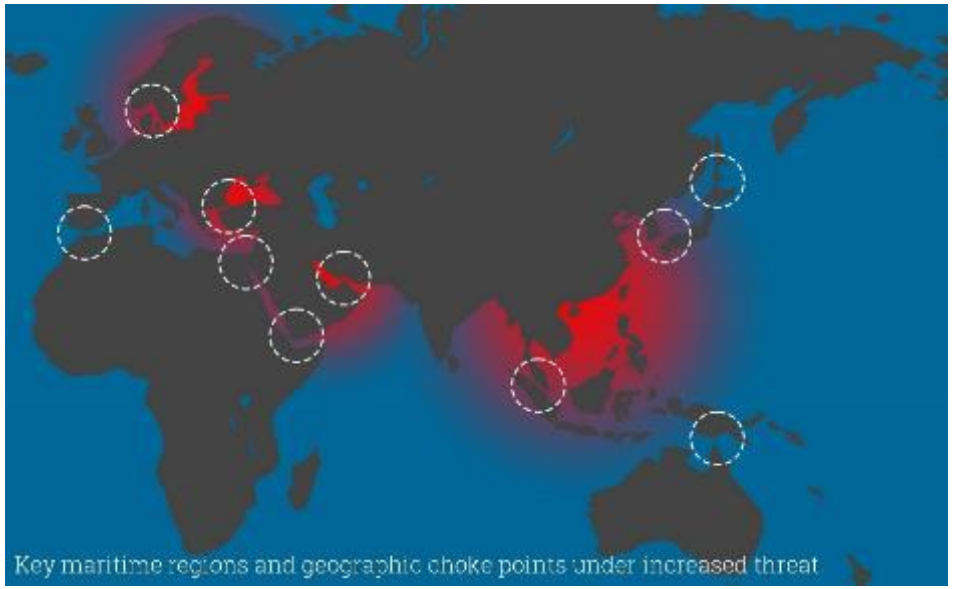

Public Release Image from "Chief of Naval Operations Navigation Plan 2022", page 5 (https://media.defense.gov/2022/Jul/26/2003042389/-1/-1/1/NAVIGATION%20PLAN%202022_SIGNED.PDFdefense.gov last accessed 04/17/2023)

Research Areas

- Manned-Unmanned Teaming with Applied Artificial Intelligence
- Autonomous Air-to-Air Refueling
- Hard-kill Self Defense for Aircraft
- Dynamic Maritime Targeting
- Advanced Tactical Communications
- Advanced Seeker Design & Target Recognition
- Advanced Dome and Window Materials

Applications

- Network Enabled Weapons
- Naval Unmanned Air Systems
- High Value Air Asset Mission Resilience

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Maritime Fires

Researching, Developing, and Demonstrating Threat-informed, Future-focused Fires Capabilities for the Naval Services

Mr. Dan Simons
Maritime Fires Program Officer
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Research Areas

- Fire-and-forget, all-weather engagements of stationary, relocatable, and moving land and sea targets
- Very low size, weight, power, and cost of weapons components and weapons systems, having low manpower and training needs, low cognitive burdens to operate, and low logistics burdens
- Accelerating the kill chain (find, fix, track, target, engage, assess (F2T2EA))
- Increasing the ranges of munitions
- Increasing lethality of munitions for land and sea targets
- Survivability of launch platforms and munitions throughout the mission
- Friendly force deception from fires engagements

Applications

- Small arms
- All stages of the F2T2EA kill web model
- Precision guided munitions
- Long range precision fires
- Small armed unmanned systems of all platform types (UxS)

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ASCEND

Aero S&T of Cost-Efficiency & Capabilities in Naval Domain

Dr. Pranav D. Shah

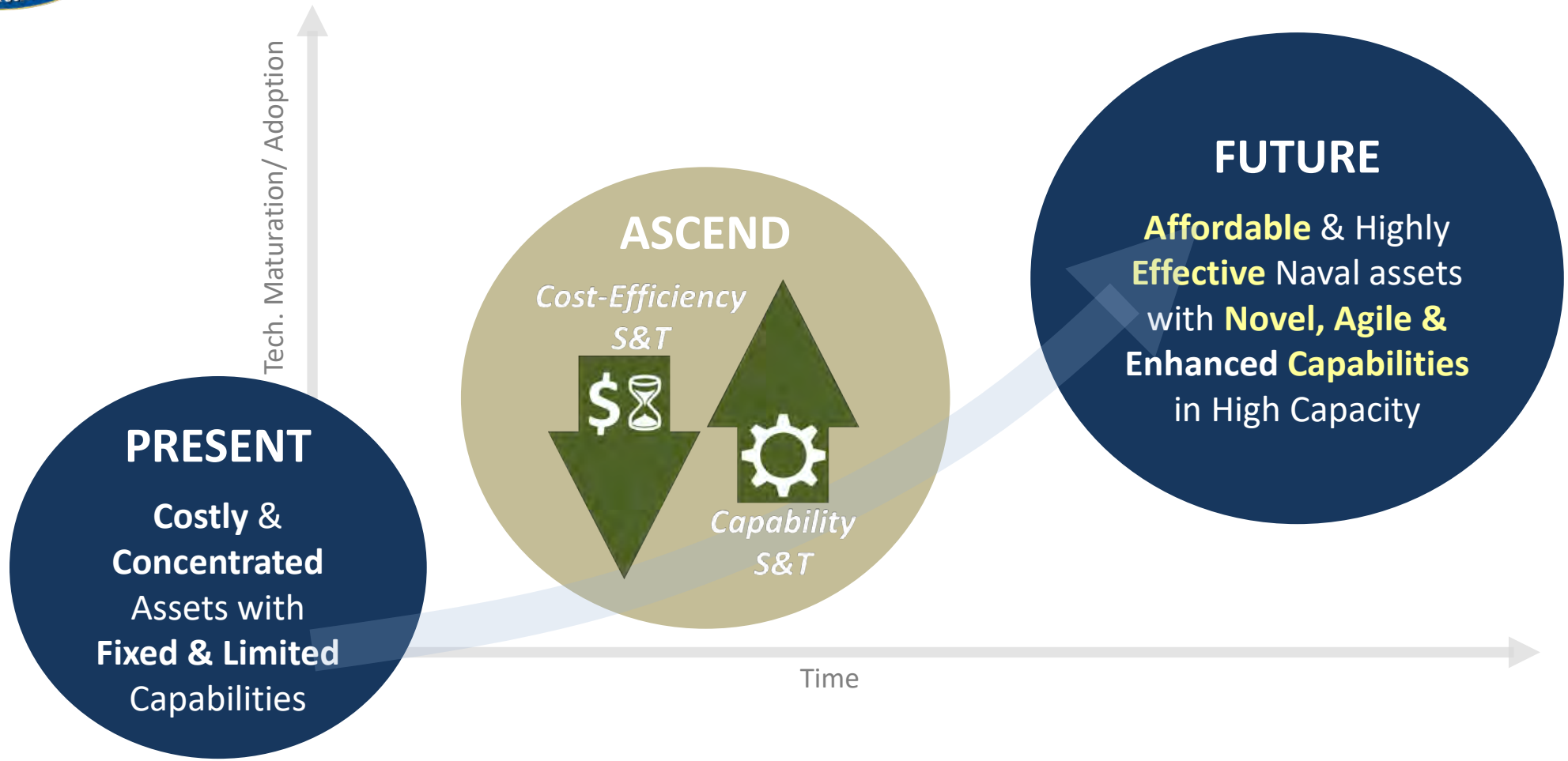
pranav.d.shah.civ@us.navy.mil

Code 35 Focus Area Forum
July 11, 2024

Approved, DCN# 543-1691-24 April 4 2024

ASCEND

Aero S&T of Cost-Efficiency & Capabilities in Naval Domain



Develop & Deliver effective, cost-efficient, & resilient Naval capabilities via S&T development traversing multiple disciplines driven by Capability and Cost-efficiency S&T.

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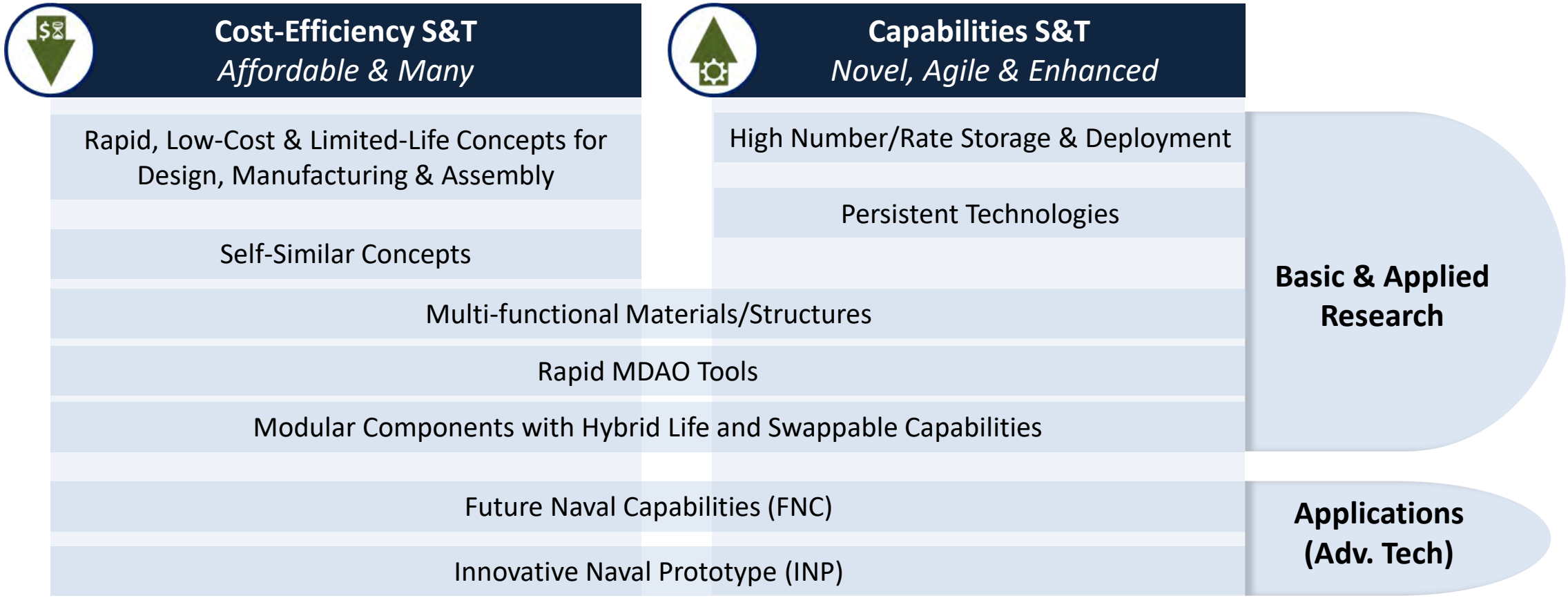
Aero S&T of Cost-Efficiency & Capabilities in Naval Domain



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Aero S&T of Cost-Efficiency & Capabilities in Naval Domain

High Number/Rate Storage & Deployment:
Rapidly packaging/deploying aerial assets from minimal space in high numbers.

Rapid, Low-Cost & Limited-Life Concepts for Design, Manufacturing & Assembly

Persistent Technologies:
Persistent aerial assets continuing a mission even after sustaining some level of damage.

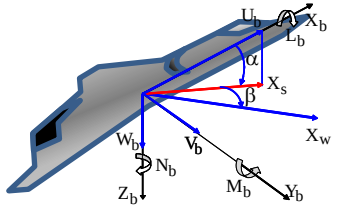
Multi-functional Materials/Structures

Modular Components with Hybrid Life and Swappable Capabilities:
Aerial assets with components with "Hybrid Life" and "Swappable Capabilities".

Rapid Multi-discipline Analysis and Optimization

Self-Similar Concepts: *Scalable (by number) and swappable (by similarity) components.*

Cost-Efficiency S&T Capabilities S&T

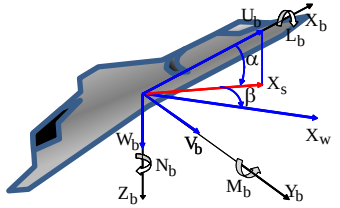


Flight Dynamics & Control

Dr. Brian Holm-Hansen

Office of Naval Research
Code 351

Program Vision



Sensors & algorithms to enable precise relative navigation in GPS denied environments

Experimental investigation of novel control effectors

Control architecture, synthesis & algorithms to improve capability, performance & robustness

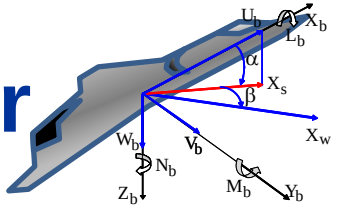
Multi-body control to defend against threats

Autonomy algorithms for safe operation of future autonomous vehicles

Flight control to minimize operational energy for expeditionary operations.

Improve mission capability by advancing the science and technology to navigate, guide & control air vehicles.

A few words from our sponsor



- **OPNAV N94 grades ONR with the following metric:**
  - **Actual Expenditures = Planned Expenditures, per the submitted budget**

Expenditure Shortfall: ONR failed to meet its execution metric. Its budget is too big and needs to be reduced.

Reduction in expenditure plan, i.e., obligations, to prevent a shortfall in FY2.

$

Cumulative Planned Expenditures

Total Budget = Budget Passed by Congress

FY2 Planned Expenditures

FY1 Actual Expenditures

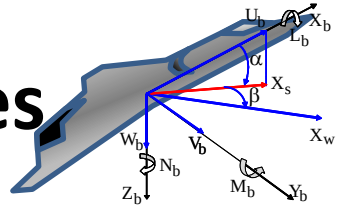
Start

Fiscal year

End

Please provide an accurate budget plan!

Alignment with Corporate Priorities



- **How does your portfolio support the Chief of Naval Operations Guidance (CNOG)?**

WHERE WE ARE GOING

- **Terminal Defense:** Pursue a fully-integrated combat capability that employs lethal and sustainable effects to defend naval forces against complex raid scenarios.

  Supported Commander: Deputy CNO for Warfighting Requirements and Capabilities (OPNAV N9)

- **Naval Operational Architecture:** Remain on schedule to operationally test the NOA Increment 1 in 2023 within a Carrier Strike Group, working closely with international partners and Joint Force companion efforts to build cyber-secure information technology.

  Supported Commander: Commander, Naval Information Systems Warfare Command (NAVWAR)

- **Contested Logistics:** Recapitalize our logistics fleet through used sealift buys in 2022, achieving T-AO 205 Initial Operational Capability by 2023, delivering Next-Generation Logistics Ship by 2030, and recapitalizing C-130s by 2030. Continue war-gaming and experimentation to inform how a survivable Navy logistics construct supports the sustainment of military operations in a contested environment.

  Supported Commander: Deputy CNO for Fleet Readiness and Logistics (OPNAV N4)

- **Counter-CSISRT:** Continue to develop capabilities that support naval units operating inside adversary weapons engagement zones, focusing on full-spectrum sensing and signature management.

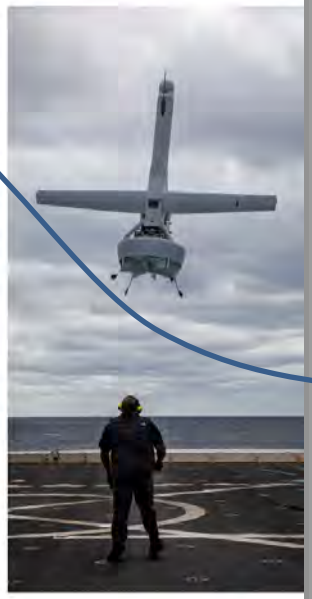
  Supported Commander: Deputy CNO for Information Warfare/Director of Naval Intelligence (OPNAV N2/N6)

- **Long Range Fires:** Develop and integrate joint, all-domain capabilities to project power at increasing ranges through contested maritime environments. Pursue a mix of weapons with required enablers, including CPS development and all-up-round testing.

  Supported Commander: Deputy CNO for Warfighting Requirements and Capabilities (OPNAV N9)

- **Artificial Intelligence (AI):** Leverage AI to support other elements of the Capability NIF, including both warfighting and corporate applications. By 2023, launch a framework to identify gaps and accelerate delivery of AI-enabled capabilities to the Fleet and Navy enterprises.

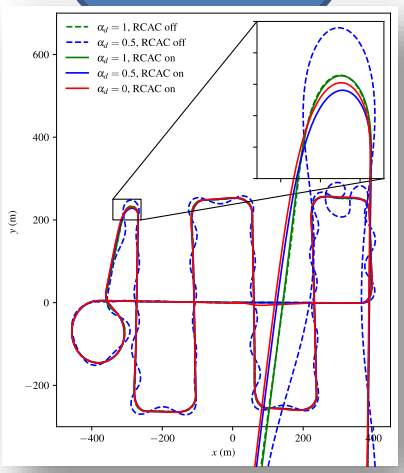
WE WILL MODERNIZE CAPABILITIES TO CREDIBLY DETER WAR AND, IF NECESSARY, WIN IN CONFLICT



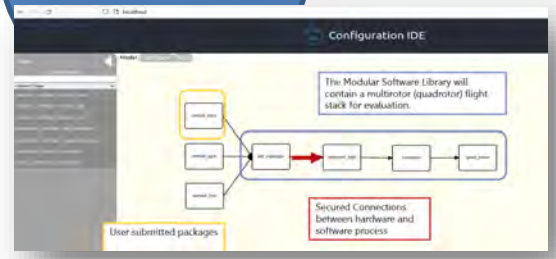
BRC: Guaranteed Performance of Multibody Control Systems

Claire Tomlin, UC Berkeley
Murat Arcak, UC Berkeley
Alexandre Megretski, MIT
Frank Lewis, TX Arlington
Dennis Bernstein, Michigan
Kamesh Subbarao, TX Arlington

Rapid Autopilot Prototyping
Dennis Bernstein, Michigan

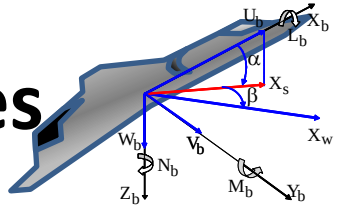


Cyber Secure Avionics
Dr. Hal Aldridge, Secmation



NAVIGATION PLAN 2022_SIGNED.PDF (defense.gov)

Alignment with Corporate Priorities



- **How does your portfolio support USMC Commandant's Priorities?**

Marine Corps Force Design 2030

"In addition to tactical resupply unmanned aerial systems (UAS), we are currently fielding thousands of small UAS in the GCE to provide small unit leaders with an **organic intelligence, surveillance, and reconnaissance (ISR)** capability."

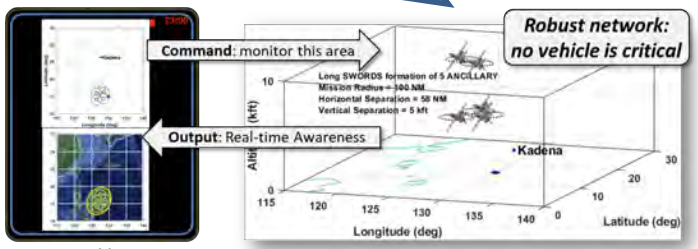
Multi-Domain Reconnaissance

"Our wargames, modeling and simulation, experiments, and exercises, along with evidence from the Western Pacific to Ukraine confirm the requirement for littoral, multi-domain reconnaissance capabilities"

Marine Corps Force Design 2030, June 2023 Update
David H. Berger
General, U.S. Marine Corps
Commandant of the Marine Corps
2019 - 2023

Multi-Agent Planning & Re-planning
Katia Estabridis, NAWC-WD

A Novel Computational Framework for Real-Time Optimal Control
Anil Rao, U Florida



Tablet

Controls, Autonomy, Sensing

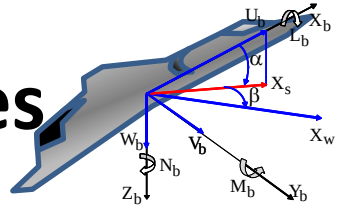
Obstacle Avoidance and Navigation using Unmanned Air Vehicle Passive Acoustics
Jason Geder, NRL

Navigation Systems for Littoral Autonomous Proximity Operations
John Junkins, TAMU

Unsteady Maneuvering Of Carrier-based Aircraft using Aerodynamic Flow Control
Ari Glezer, GA Tech

Force Design 2030 (marines.mil)

Alignment with Corporate Priorities



- **How does your portfolio support published warfare community S&T objectives?**

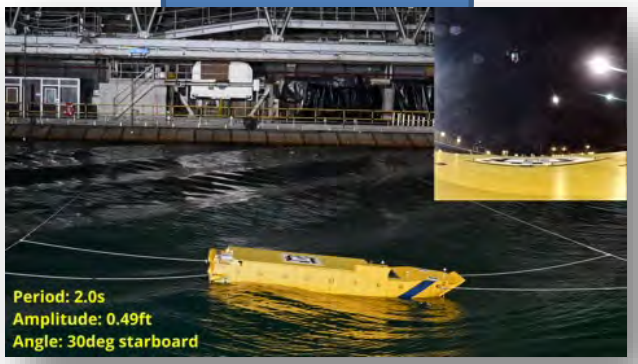
"Accelerate the adoption of new technologies into our fleet through a continuum of **operational experimentation and prototyping: Overcome 'Valley Of Death'**"

Moat of Death

2022 Operational Mission Focus Areas

Assistant Secretary of the Navy for Research, Development And Acquisition

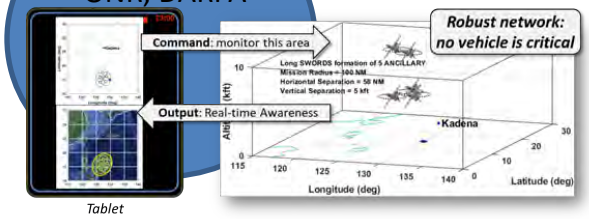
Autonomous Shipboard Landing
Joe Horn, Penn State



"**Freedom of action** in the electromagnetic spectrum, **at the time, place, and parameters of our choosing**, is a required precursor to the successful conduct of operations in all domains.

Department of Defense Electromagnetic Spectrum Superiority Strategy

TALISMAN
ONR, DARPA

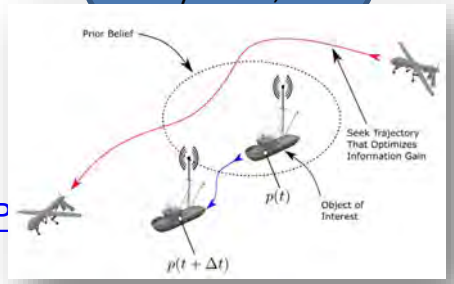


Defense Priorities:

1. Defend **the homeland**
2. Deter **strategic attacks**
3. Deter **aggression**, be **prepared to prevail**
4. Build a **resilient** Joint Force and defense **ecosystem**

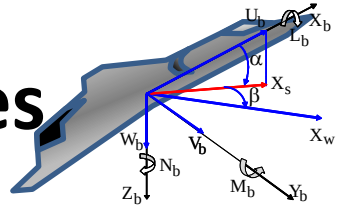
Fact Sheet: 2022 National Defense Strategy

Efficient Solutions for High-Dim Diff Game Problems
Stanley Osher, UCLA



2017-NAVAL-STRATEGY.PDF (defense.gov)
DoD Electromagnetic Spectrum Superiority Strategy 2020 (defense.gov)
media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NP

Alignment with Corporate Priorities



- **How does your Portfolio address a known warfare gap**

"sacrificing operational readiness and **accepting exceptional near-term risk for future longer-term modernization development** is unfortunately no longer a luxury that the United States possesses"

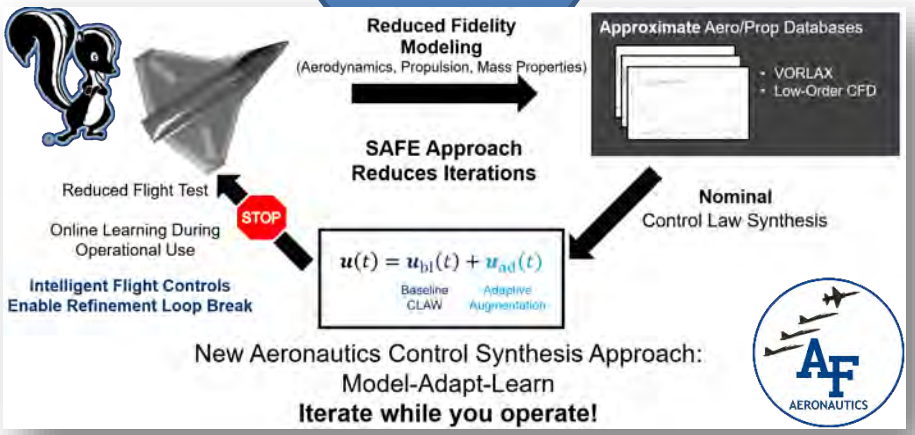
Representative Vicky Hartzler, April 27, 2022
House Armed Services Tactical Air and Land Forces Subcommittee
*Navy Will Endure Strike Fighter **Gaps** Until 2031 Lawmakers Say*

"**We can't afford the ultimate numbers that we have at this price** that we're paying today. **We have to squeeze efficiencies out**. And that is the 2022 focus for naval aviation, is the cost transformation,"

Vice Adm. Kenneth Whitesell, Commander, U.S. Naval Air Forces

U.S. Naval Institute News

Smart Adaptive Flight Control Environment
Greg Tallant, LM Skunk Works



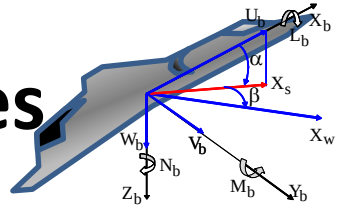
Advanced Helo Display for Zero-Zero Shipboard Landings
Amanda Lampton, STI

Linearized High-Fidelity Aeromechanics for Extended Reality Simulation and Control of Shipboard Interactions
Umberto Saetti, U MD

Safe Flight Envelope Characterization And Emergency Landing With Reachability
Matthew Kirchner, NSWC-WD

Navy Will Endure Strike Fighter Gaps Until 2031, Lawmakers Say - USNI News

Alignment with Corporate Priorities

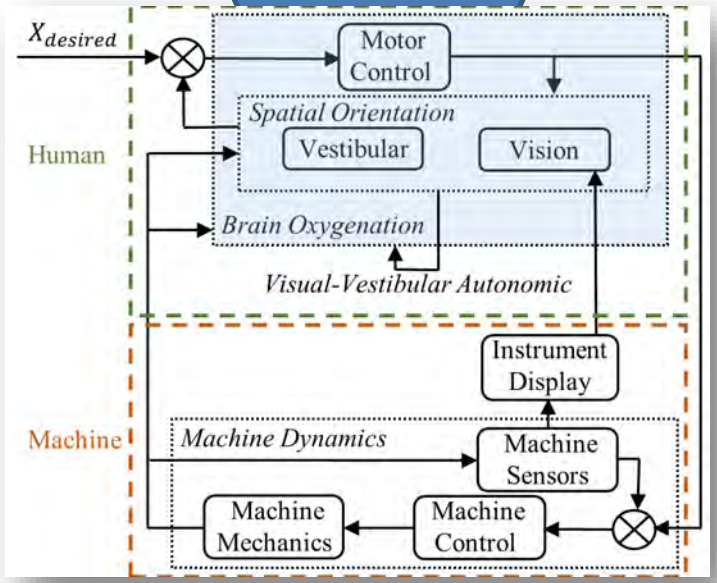


- **How does your Portfolio address Technology Strategy Pillars**

Human-Machine Interfaces

"this technology will have a multitude of benefits for our service members. Highly immersive realistic training environments provide real-time feedback to enhance **warfighter performance**"

Human-Machine Cybernetic Modeling
Dan Merfeld, Ohio State



Multi-loop cybernetic model

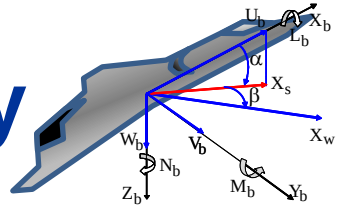
Non-Intrusive Air Data for Hypersonic Flight Control
FY23 STTR

Hypersonics

"While strategic competitors are pursuing and rapidly fielding advanced hypersonic missiles, the DoD will develop leap-ahead and cost-effective technologies for our air, land, and sea operational forces."

USD(R&E) Technology Vision for an Era of Competition, February 1, 2022

Trust in Science & Technology



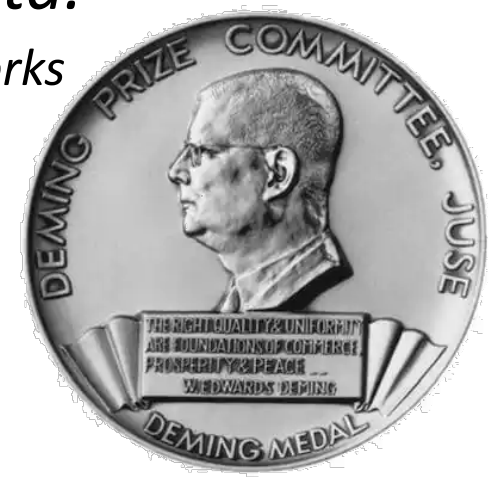
- *"In God we trust. All others must bring data."*

  W. Edwards Deming, Statistician

  - ✓ Lectured on "Statistical Product Quality Administration" in 1950's Japan and contributed to Japan's post-war economic growth to be the world's second-largest economy
  - ✓ Awarded the National Medal of Technology in 1987 by President Ronald Reagan.
  - ✓ Japanese Union of Scientists and Engineers created the Deming Prize for contributions to Total Quality Management

- *"In God we trust. All others must bring data."*

  - *Also, a common phrase at Lockheed Martin Skunk Works*
  - *Does the theory produce something useful?*
    - ✓ Model & Simulation
  - *Are the models and simulation useful*?*
    - ✓ Experiment



*All models are wrong, but some are useful.

2024 ONR Code 35 Focus Area Forum
Aerodynamics Program Review

July 11, 2024

Hyatt Regency Crystal City, Arlington, VA

Leighton Myers, Ph.D.
Deputy Program Officer, Code 351
Aerodynamics

ONR S&T Strategy

Broad

Narrow

Focus

5-20 years

Discovery & Invention (Basic and Applied Science)

≈45%

4-8 years

Leap Ahead Innovations (Innovative Naval Prototypes)

≈12%

2-4 years

Acquisition Enablers (FNCs, etc)

≈30%

1-2 years

Quick Reaction & Other S&T

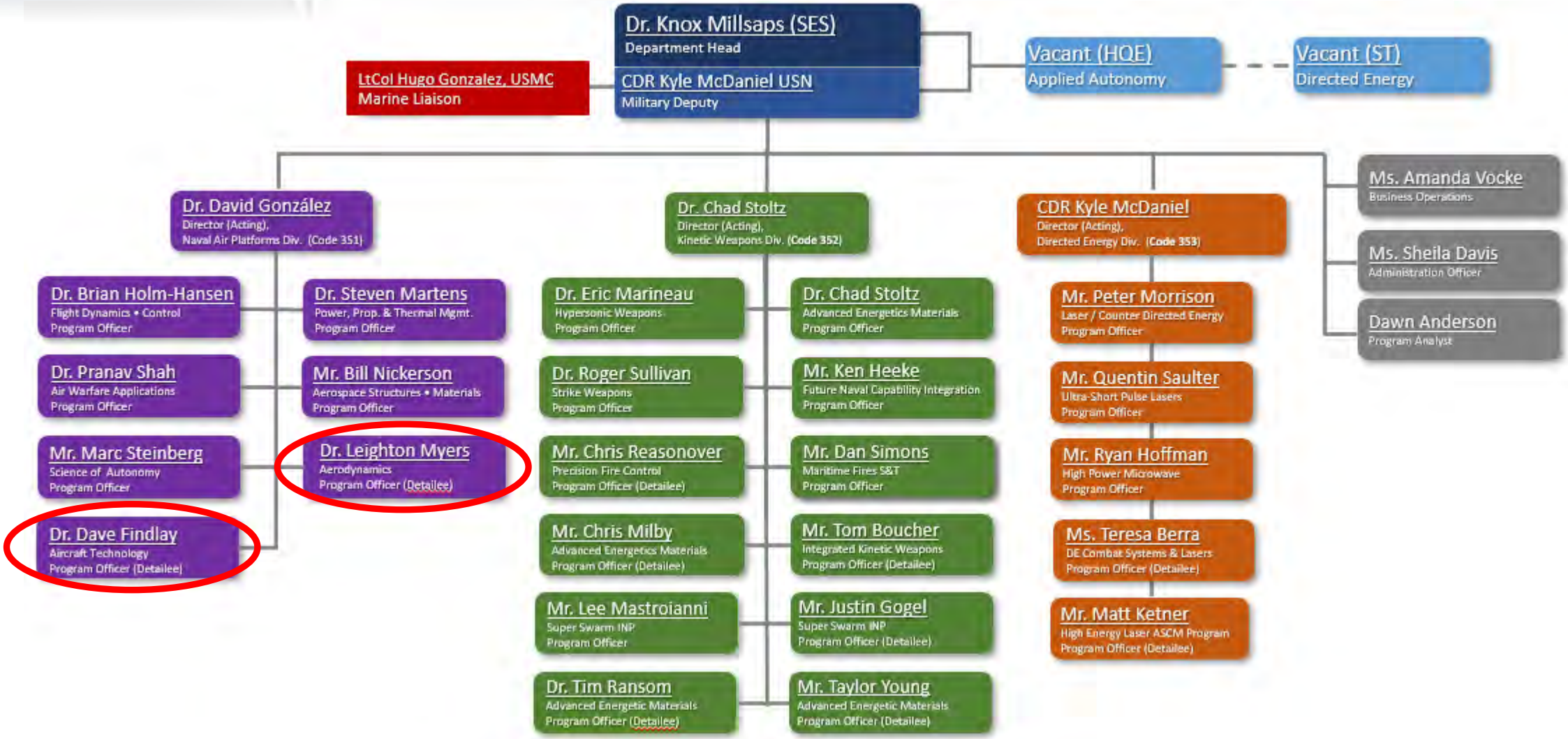
≈8%

Near

Far

Time Frame

Code 35 – Organizational Chart



Alignment with Corporate Priorities

CNO Priorities

Relevance:

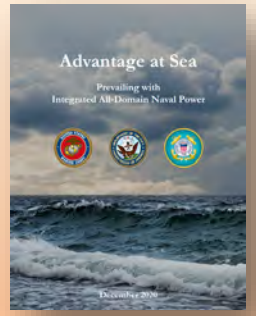
- Deliver combat credible maritime force
- Persistently operate forward with agility & flexibility
- Modernize **weapons**, sensors, & **platforms**
- Ensure wholeness of combat capable and lethal forces maximizing benefits of DMO, EABO, LOCE
- Develop and field affordable, lethal, numerous, and connected capabilities – **integrated unmanned platforms**
- Develop & field distributed weapons of increasing range and speed, volume and tempo of fires, magazine depth
- Development of technologies to advance autonomous and MUM-T systems employment in air warfare
- Integrate more closely with USMC & USCG

USMC Priorities

Relevance:

- **Long-range UAS platforms** operating from Naval platforms with ISR, Strike, & Logistics capabilities
- **Future uncrewed aviation** capabilities must expand & increase dramatically – speed, range, versatility
- **Emerging VTOL concepts** such as Electric, Hybrid, High-Speed
- Short-, medium-, and long-range air defense systems
- Shortfalls in expeditionary long-range precision fires

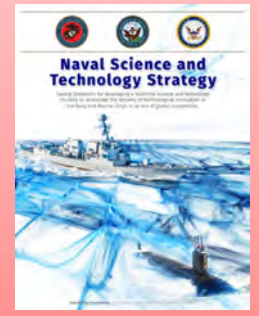
All-Domain Naval Power



Warfare S&T Objectives:

- Surface & Air Warfare – Adv., precise, long-range, and lethal fires with a sufficient inventory
- Power Projection & Strike – Improved weapons ranges, modernized aircraft
- Air & Missile Defense – Next-gen aircraft, defensive missile systems
- Sustainment – Resilient and adaptable logistics to sustain forces

Naval S&T Strategy



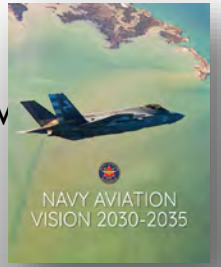
Relevance:

- Strengthening Maritime Dominance
  - "Rapidly harvest the benefits of basic research"
- Building a Culture of Warfighting Excellence
  - "help [our scientists and engineers] better understand naval problems, provide resources, clear the obstacles…"
  - "solve naval problems and enable capabilities for our naval warfighters"
- Enhancing Strategic Partnerships
  - "maximize collaboration in DoD COI's to use each other's best practices and eliminate costly duplication"

NAE Navy Aviation Vision 2035

Relevance:

- Longer-range, greater speed for F/A-XX
- Increased speed, range, and capacity for future kinetic weapons
- MUM-T to extend strike range and enhance maneuverability
- NGAD FoS with manned and unmanned **A/C with attritable assets**
- Rotary-wing tech enabling long-range, persistent ISR-T, IAMD, long-range offensive ASuW and ASW, comms data relay, fleet logistics, and PR
- Collaborative weapon salvos
- Enhanced passive & active kill chains



Portfolio Vision

- **Vision**
  - Be the foremost authority in advancing basic & fundamental understandings of aerodynamic principles to spearhead game-changing Naval aviation capabilities.

- **Mission**
  - Enable efficient, ground-breaking scientific research in fundamental aerodynamics via multiple coordinated funding opportunities across **academia**, **industry** and **government labs** and train future S&T workforce in support of advancing Naval Aviation to enable strategic superiority and assured success for the warfighter across all operational battlespaces.



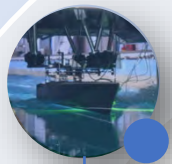


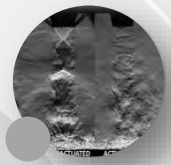

Aerodynamics Portfolio Summary

Advancing Aerodynamics S&T & Future Workforce Development to Enable Enhanced Mission Capabilities for Naval & Expeditionary Air Vehicles & Weapons by Focused Investments in Four (4) Areas of Interest (AOI)

Innovative techniques, diagnostics, & multi-sensor data fusion for real-time characterization & prediction of complex fluid dynamic environments.

AOI IV - Novel Exp. Techniques & Diagnostics





AOI I - Flow & Boundary Layer Control

Fundamental understanding of flow physics & controllability enabling development of novel effectors for enhanced performance of air vehicles & weapons.

Dr. DAVID GONZALEZ
Program Officer

RICHARD LAVALLAIS
SETA

DALI BHULLAR
ANALYST

Dr. LEIGHTON MYERS
Deputy Program Officer

Research into critical couplings between fluid flows & other relevant phenomena inducing non-linear air vehicle/weapon response.

AOI III - Aero-Coupled Phenomena

AOI II - Unsteady & Separated Flow Dynamics

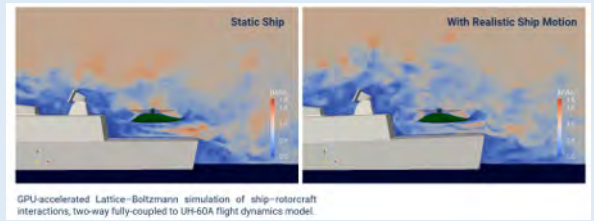
Critical understanding of salient & non-stationary fluid flow phenomena.

https://www.nre.navy.mil/organization/departments/code-35/division-351/aerodynamics

Aerodynamics Portfolio
Key Payoffs in Basic and Applied Research

Modelling, Simulation and Tools

Adaptive WMLES, Integrated Flight Dynamics & Aerodynamics Simulation, Real-Time, Two-Way Coupled Flight Simulation, Two-Way Coupling ROM, Establishing Scales Critical to DI



GPU-accelerated Lattice–Boltzmann simulation of ship–rotorcraft interactions, two-way fully-coupled to UH-60A flight dynamics model.

FSI for Flexible Wings, Rotary Wing Icing Analysis System, Rotor BL Transition, V/STOL Transition Modeling

System Integration & Design

Compact Air Compressor for Aircraft AFC

Test Infrastructure

Advanced Flow Diagnostics & Data Fusion, Novel Surface Pressure & Skin Friction Meas.

Wind Tunnel Facility Modernization

Efficient Cruise/ Improved Range & Endurance

Turbulent Drag Reduction, Modern Integration of Resilient Riblets

Realistic Inflow on Supersonic Inlets, Shockwave BL Interaction

Wing IGE in High Sea States, Turbulence Effect on Tip Vortex

30 Projects focused on:

- *Flow & BL Control*
- *Unsteady & Separated Flow*
- *Aero-Coupled Phenomena*
- *Novel Exp. Techniques & Diagnostics*

High-Speed Maneuvering/ Agile & Dynamic Flight

Finless UCAS Control, Fluidic Fences, AFC for Unsteady Maneuvering, Unsteady Load Mitigation

Integrated Swirling Jets, LE Vortex Manipulation Chemical Impulse, Jet Manipulation, AFC Flight Demonstration

Low-Speed Maneuvering/ Improved Launch & Recovery

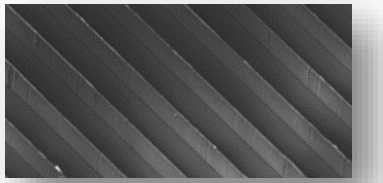
3D Effects on Turbulent Shear Layers

IGE Hover Over Inclined Surfaces, VTOL Landing Effects, Navigating Unsteady Airwakes

Enabling Maritime Superiority and Developing S&T Workforce that can Solve Future Naval Problems

Hard Problems & Desired Portfolio Outcomes

- **Transformative Improvements in Tactical Aircraft Performance**
  - Problem: Launch & recovery (L&R) from ships significantly penalizes aircraft designs – require innovative concepts to maximize range, endurance &/or payload.
  - Outcome(s): Development of aerodynamic technologies enabling:
    - Precision control and increased maneuverability of air vehicles
    - Drag reduction technologies for range extension
    - Reduction of landing speeds; Increased onboarding rates
    - High-speed vertical flight vehicles without degraded payload capability
    - Expansion of vehicle operational limits to more complex sea states



AOI I – Fluid & BL Control	•Active flow control (AFC) technologies – *e.g.* directional control, drag reduction, etc.
AOI II – Uns. & Sep Flow	•Methods for high-fidelity flight control loads assessment •Vortex wake dynamics
AOI III – Aero-Coupled	•Coupling between fluid phenomena induced by static & dynamic features •Impulsive response & resilience to gusting environments •Understanding aero-elastic stability & its control
AOI IV - Diagnostics	•Real-time in-situ diagnostics •Data processing & fusion from disparate sensors

- Technology Outlook:
  - Near-Term: AFC technologies for TACAIR; Novel CFD methods for high-fidelity environmental characterization; Data mining algorithms; Physics-based reduced-order models; Drag reduction technologies

Hard Problems & Desired Portfolio Outcomes

- **High-Speed Tactical Weapon Systems & Integration**
  - Problem: Affordable tactical short- and long-range weapons with increased speed, lethality, volume of fire, and magazine depth.
  - Outcome(s): Aerodynamics research to:
    - Develop active flow control schemes to maximize air-breathing propulsion performance – *e.g.* through inlets, isolators, combustion chamber, and/or nozzle
    - Understand physical phenomena to minimize engine size & maximize payload
    - Enable hyper-maneuverability and/or range extension
    - Internal & External separation at high-speed

AOI I – Fluid & BL Control	•Active flow control technologies – *e.g.* directional control, drag reduction, etc.
AOI II – Uns. & Sep Flow	•Understanding massive flow separation effects on control authority •Shock/turbulent boundary layer interactions •Methods for high-fidelity flight control loads assessments
AOI III – Aero-Coupled	•Aero-elastic stability for airframe stability •Aero-optical phenomena
AOI IV - Diagnostics	•Real-time in-situ diagnostics •Data processing & fusion from disparate sensors

- Technology Outlook:
  - Near-Term: AFC technologies for munition & separation aerodynamics control, inlet performance; Drag reduction technologies

Hard Problems & Desired Portfolio Outcomes

- **Long-Range and/or Long-Endurance Multi-Mission UAS**
  - Problem: Medium & large long-range UAS operating from Naval platforms with surveillance, strike, and/or logistics capabilities. Operational capabilities via conventional & non-conventional L&R infrastructure at high-op tempo from non-aviation-capable ships.
  - Outcome(s): Fundamental & applied research into:
    - Aerodynamics of novel VTOL airframe configurations enabling runway independence, long range, and/or high-speed
    - Active flow control effectors enabling precise control during L&R
    - Drag reduction technologies for range extension
    - Aero-elastic & aero-acoustic implications of distributed propulsion configurations

AOI I – Fluid & BL Control	•Active flow control technologies – *e.g.* directional control, drag reduction, etc.
AOI II – Uns. & Sep Flow	•Methods for high-fidelity flight control loads assessment •Self-induced aero-induced coupling effects, off-axis response, etc.
AOI III – Aero-Coupled	•Coupling between fluid phenomena induced by static & dynamic features •Impulsive response & resilience to gusting environments •Understanding aero-elastic stability & its control
AOI IV - Diagnostics	•Real-time in-situ diagnostics •Data processing & fusion from disparate sensors

- Technology Outlook:
  - Near-Term: AFC effectors for UAS precision control during L&R; Drag reduction technologies; Integrated environmental sensors onboard ships relaying real-time data to landing aircraft

Aerospace Structures & Materials

Basic and Applied Research / Concept Development

Bill Nickerson – Air Platforms, Code 351
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Air Vehicle & Hypersonic Air Systems Objectives & Priorities for S&T Investments

From Strategic Guidance to Outcomes

Navy Unique Air Vehicle System Goals

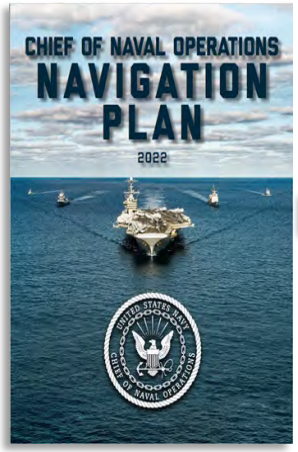
- Reach Beyond Technology (reduce weight & drag, increase lift)
- Reusable Hypersonic Aircraft
- Next Gen Aerial Refueling
- Carefree Naval Aviation (ship operations, agility)
- Automated, Autonomous and Attritable Air Vehicles
- Survivable Aircraft
- Efficient & Scalable Cargo Lift
- Infinitely Repairable Airframe
- Forward Deployed Sustainment
- Future Depot
- Qualification by Simulation
- Life Cycle Reform (manufacture and disposal)

Military-Focused/Navy-Relevant Air Vehicle System Challenges

Crewed and Uncrewed Shipboard landings in Challenging Conditions
Autonomy and Manned/Unmanned Teaming
Readiness and Sustainment, including Corrosion Prevention and Control
Thermal Management, including at High Mach
Survivability and Low Observable
Limited Range of Shipboard Aircraft
Battle Damage Repair Capability
Performance & Life Forecasting
Faster delivery of capability

Tri-Service Investment Assessment, Leveraging & Partnering

Pervasive Enablers: Digital Engineering, Advanced Manufacturing, Test & Validation



2022 Force Design Imperatives: Get Real, Get Better

Distance, Deception, Defense, Distribution, Delivery, and Decision Advantage

NAVIGATION PLAN PRIORITIES AND OBJECTIVES

READINESS | CAPABILITIES | CAPACITY | SAILORS

Investments In: Re-usable Hypersonics, Unmanned Tanking, Next-Generation Aircraft, Smaller Lethal Platforms, Counter-Surveillance

Emerging / Future Platform Architectures:

- High-Speed/Long-Range VTOL
- Hybrid-Electric Systems
- Attritable UAS
- Hypersonic Reusable Systems
- Wing-in-Ground-Effect & Seaplane Vehicles

Air Systems Group Concept Areas

Air Vehicle & Hypersonic Air Systems S&T Vision

Capability → Availability

Outdistance:

Go *Further* / Go *Faster*

aero & next gen materials

Range and Performance

- Reduce drag / increase lift
- **Advanced & multi-functional structures**
- **Materials for high loading/lightweight structures**
- **Thermally resistant materials**
- **Topology optimization**
- Efficient store separation

Reusable Hypersonic Aircraft

- Thermal management
- **High temp materials**
- Propulsion integration
- Ablation trajectories

Next Gen Aerial Refueling

- A4RS
- High fidelity M&S for evaluation of new tech
- ARS lab upgrade

Long Range Fires

Outperform:

Fight *Better*

survivability & functionality

Carefree Naval Aviation

- Advanced guidance and control
- High lift for carrier approach
- ILM, SIMPLER, LSPC
- **SHM/CBM+**
- **Multifunctional Structures**

Automated, Autonomous and **Attritable**

- Automated operations & tasking
- RETERNS
- ASW modernization
- **Novel launch and recovery**

Survivable Aircraft

- LO materials and repair
- **Battle damage repair**
- RATMAD
- Efficient fire & **ice protection**

Efficient & Scalable Cargo Lift

- Advanced cargo systems

Contested Logistics / ASW / C5-ITRT

Outlast:

Last *Longer*

readiness and sustainment

Infinitely Repairable Airframe

- **Corrosion prevention & control**
- Durable mechanisms & **transparencies**

Forward Deployed Sustainment

- **Efficient shipboard/field maintenance**
- **AM repair**
- LoSToC

Future Depot

- **Additive repair/ manufacture**
- **Advanced & portable NDI**
- **Automated repair**
- **Advanced data analytics**

Durable subsystems

- LIFE
- **Reliable fuel containment**
- **MRF Dampers**
- High speed bearings testing

Readiness & Sustainment

Outproduce:

Deliver *Quicker*

design, manufacture, qualify

Digital Warfare – Qualification by Simulation

- **High fidelity M&S for testing and training**
- DIVE
- Virtual/Mixed reality for cost-effective simulation
- Virtual Hypersonics

Design and Manufacture

- **Digital Engineering & Manufacturing**
- **Automated manufacturing/ML-enabled**
- **New manufacturing methods (e.g. solid state processing, etc.)**
- **Material reclamation**

Affordability & Safety

Near, mid and long term, interdisciplinary technology development to ensure continued superiority of US Naval Aviation

AVE S&T Area Alignment →

A novel approach to structural life management – **assure the aircraft will last as long as we want it to**

Next generation tools, NDI and repair processes to **halve the time required for aircraft overhaul**

ONR Future Structures, Materials & Processes →

Revolutionize deployed maintenance / repair to **maintain op tempo at the tactical edge**

Assured maritime aviation regardless of environment while maximizing mission effectiveness

Warfighter Needs →

AVE Development Needs →

- Reduced Drag and Improve Lift
- Automated Operations and Mission Tasks
- Advanced Control and Aero Concepts
- **Improved Methods and Tools, and Efficient Application of Tools**

- **Fleet-Focused Readiness and Sustainment Technologies**
- **Improved Corrosion Protection**
- **Efficient Shipboard/FRC Maintenance**

- **Advanced Structures for Air Platforms and Systems**
- **Materials for High Loading/ Lightweight Structures**

- Advanced Cargo Systems
- Efficient Fire and **Ice Protection**
- Reliable Fuel Containment and Aerial Refueling Systems
- **Durable Mechanisms and Transparencies**

ONR Aero Structures & Materials Portfolio →

Portfolio Vision

- Increase Operational Performance
  - Lethality / Range via
  - **Advanced, Lightweight and Survivable Structures**
    - Air Vehicle and Weapons

Transparent Armor – V22 Down look Window

Weapons – Loaded F/A 18 F

- Improve Operational Endurance
  - **Affordable and Sustainable M&P**
  - **Next Gen Materials & Manufacturing**

Extreme Environment CVN 76

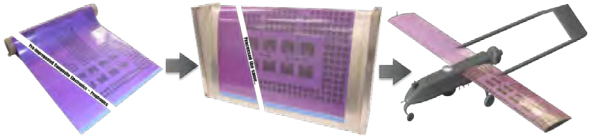
- Deliver Engineering Knowledge
  - **Design / Maintenance Tools**
    - Operator Capabilities
    - Future Workforce

NextGen Materials MQ 4C

Future Structures, Materials & Processes

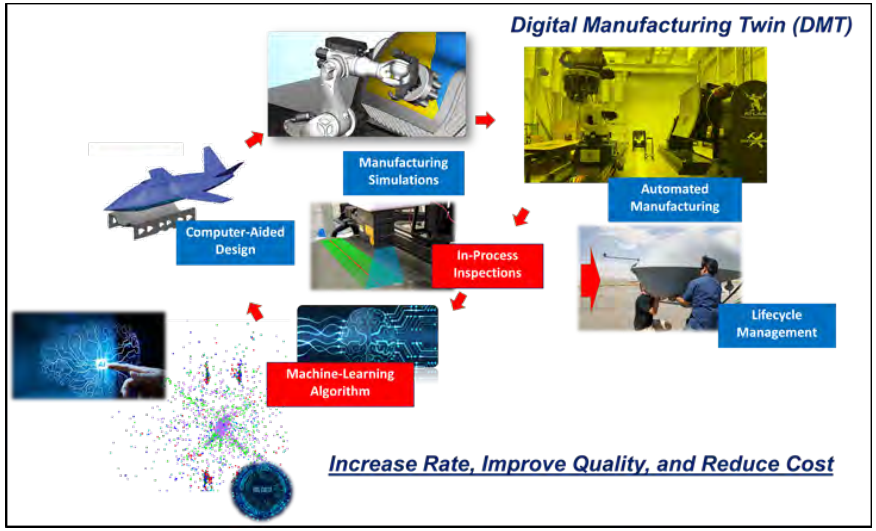
Multifunctional Structures

- Integrated EMI/Com Functionality
- Integrated P&E / Harvesting / Storage



Digital Engineering / Manufacturing

- Automated Manufacturing – Robotics/ML Enabled
- Non-traditional Layups and Curing Methods
- Integrated Manufacturing Data Capture / Analysis

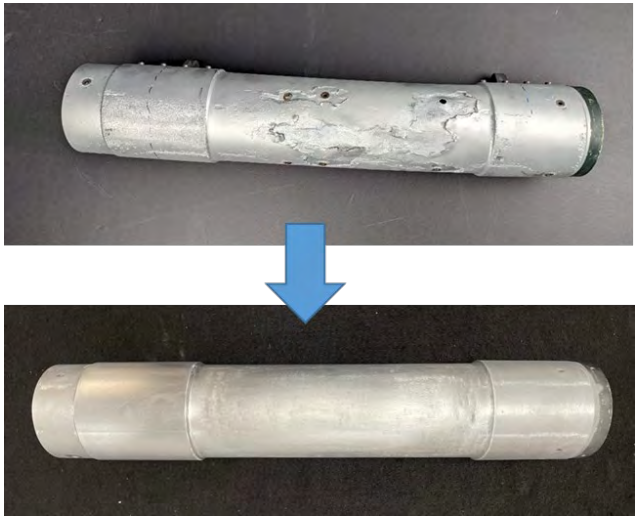


Next Gen Materials

- Metallic alloys – MPEA, AM/AFS Optimized
- Spray/Additive Deposition Methods for Metal/Ceramic
- Composites – Affordable Thermoplastics, New Polymeric M&P
- Tailored materials for Armor, Flow-Surface Interactions

Reliability & Sustainment S&T

- In-situ / Multi-Cycle Repair Methods
- Portable NDI – Rapid Cert, Remote Expert
- Enhanced M&P for Durability
- Automated Repairs – Scarf Sand/Bond, Spray Deposition
- Maintenance Data – Point of Use Capture for Advanced Accuracy, Trustworthiness and Curation



Program Success Stories - Future

- Multifunctional Structures
  - Structurally Integrated Electrodes (5 years)
  - Structurally Integrated Com (5 years)
  - Tunable EO/IR Apertures (7 years)
  - Advanced Lightweight Armor (5-10 years)
  - Vibrational Dampening

- Digital Engineering / Manufacturing
  - Digital Maintenance Tools for Data Fidelity (5 years)
  - Large Scale Bulkhead Prototype (5 years)
  - OOA Composites (5 years)
  - Advanced Feedstock for Tailored, Bespoke PMC Layups (5 years)

- Next Gen Materials
  - MPEA Alloy Compositions (3 years)
  - Enhanced M&P Guidance (3 years)
  - Thermoplastic Composites – Materials and Forming (5 years)
  - Ti Processing – Blisk, Airframe, In-situ DED

- Sustainment
  - S3R FNC – In-situ Load Bearing Material Deposition for Metallic Structure Repair (2 years)
  - Next Generation Self-Sealing Fuel Bladder (5 years)
  - Portable, Remote NDI (7 years)
  - Infinitely Repairable Airframe (10 years)

New Ideas / Opportunities

- New Ideas
  - Infinite Life / Infinitely Repairable Airframe
    - Advanced Design Methods
    - Digital Maintenance
    - Zero-baseline Repairs
    - Enhanced M&P
  - Future Depot – Forward/Expeditionary Sustainment
    - Data-drive Repair Cycles
    - Portable and/or Remote NDI
    - In-situ Robotics/ML Enabled Repair
  - Digital Engineering for Manufacturing
    - Real-time automated fabrication
    - Optimized Process Sensing and Control
    - AI/ML for Ultra-Low Defect Composites
  - Advanced Structural Design
    - Post buckled Design – Lightweight (Honeycomb Free) Naval Airframes/Weapons
    - Tailored Materials for Armor and Apertures
    - Multifunctional Structures (Antenna/Energy Storage)

New Ideas / Opportunities

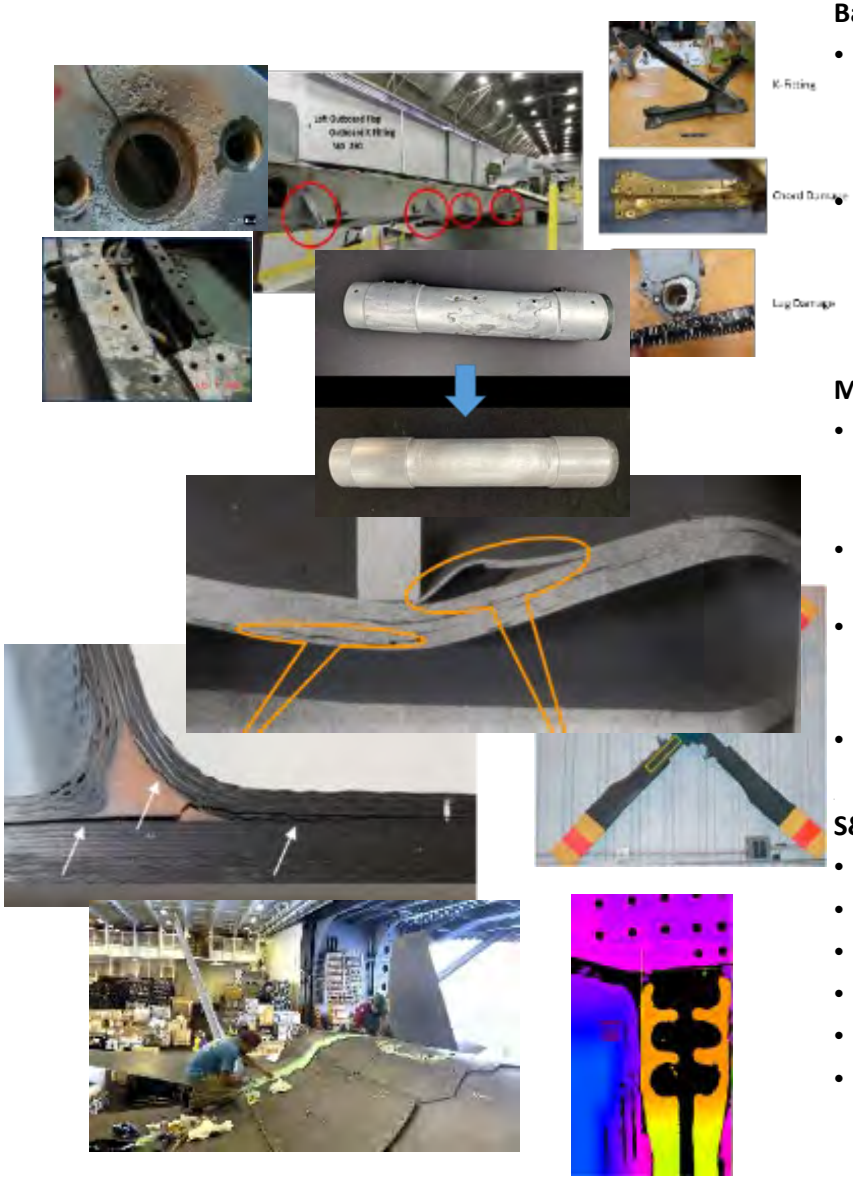
- New Ideas
  - Subsystems
    - MR Fluids, Piston Seals
    - Dampers – Design / Durability
    - Ballistic Cargo Floor Panels
    - Anti-icing/De-icing
  - Drive Systems
    - Integrated Sensors – Vibrational / Strain
    - CBM+ / Carrier Suitability
    - Inlet / Nozzle – Distortion, Stability
  - Prototype / Certification
    - Attritable, Short / Cyclical Life, Repeatable
    - Actuators, Rotor Mast, Drive Systems, Wings/Flaps
  - HT Materials
    - Engines, LO, Airframes
    - PMC, CMC, Ceramics, Metallics

Naval Aircraft Sustainment S&T

METALS

COMPOSITES

NDI / M&P



Background

- Sustainment S&T is needed to identify and develop advanced materials and manufacturing technologies targeted at repair and remanufacturing / refurbishment of airframes and associated structural or functional components
- Extremely high return on investment, with resulting increase in operational availability
  - Opportunity to decrease MMH/FH escalation – improving readiness
  - Opportunity to decrease FRC maintenance turnaround time (TAT) and unexpected over/above damage – resulting in decreased cost and improved A_o.

Major Challenges

- Majority of system costs are realized during sustainment
  - Primarily material degradation from the harsh operational environment
  - Inspection and Mx actions driven by service life time / usage data
- Corrosion, wear and fatigue of metal structures – galvanic coupling, airframe, drive system, landing gear, lugs, fasteners
- Impact, delamination, thermal/moisture degradation and lighting strike damage of composite structures – ply-drops, skins, control surfaces, OML components
- Protective / functional coatings degradation from reversion, weathering and electrochemical damage

S&T Topic Areas

- Portable and in-situ additive repair – metal and composite targets
- Advanced NDI and near-real time analytics – remote SME
- Improved fidelity data – capture, metrics and analytics
- Condition-based maintenance methodologies – sensors and tracking
- Battle Damage – repair and recover to the fight
- Advanced M&P – surface prep and finishing, coatings and sealants, metrology, localized post-processing of microstructure such as heat treatment and/or curing, field repair of LO
- Transparencies and EO aperture durability – coatings and remediation

DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.

Focus Area Forum Break Out Discussion

USPL & CDEW

Ultrashort Pulse Lasers *Counter Directed Energy Weapons*

ONR's Session Moderators:

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CDEW

Counter Directed Energy Weapons
Research & Technology

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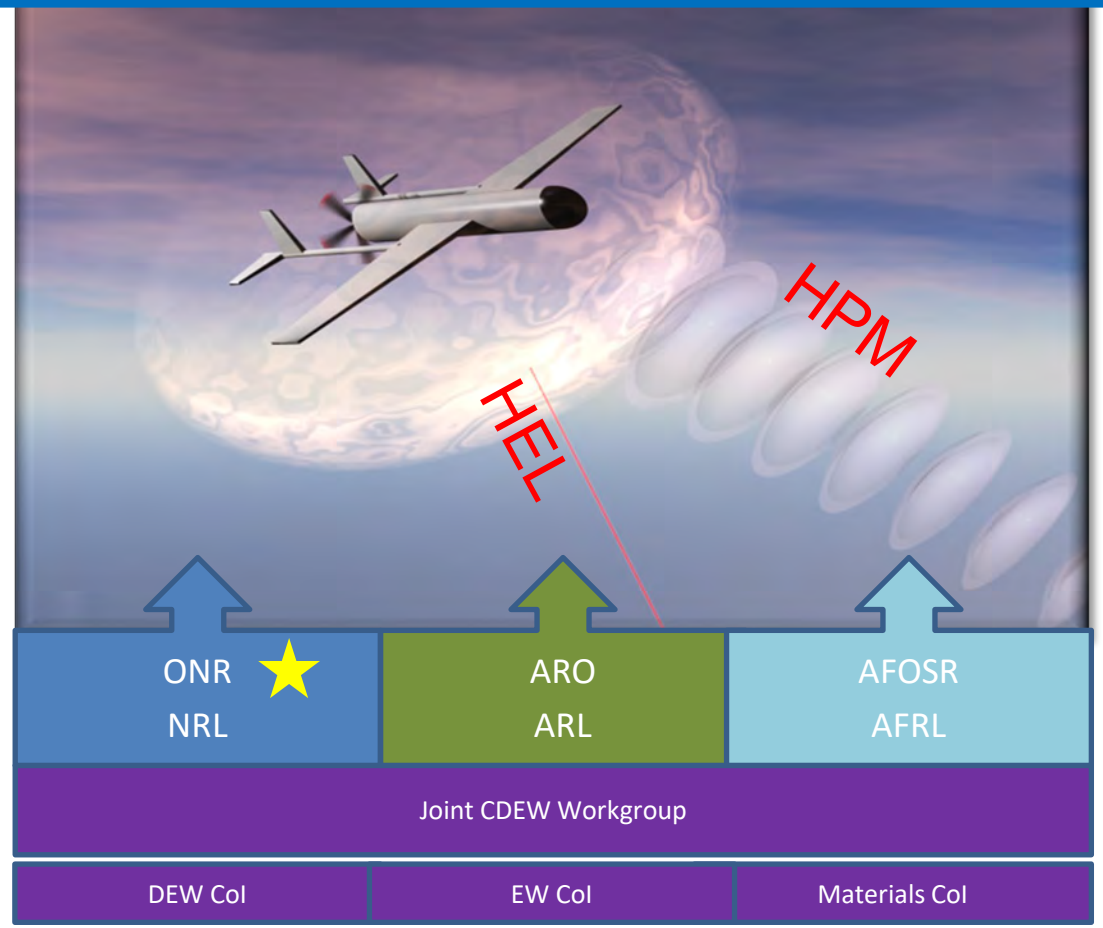
Navy's S&T Counter DEW Focus:
PROTECTION FROM ADVERSARIAL HEL & HPM THREATS

BOTTOM LINE: DEW THREATS ARE INCREASING IN INTENSITY & COMPLEXITY!



CoI - Community of Interest

UNCLASSIFIED Source: FAA Report (2016-2023)
https://www.faa.gov/aircraft/safety/report/laserinfo

Whitepapers encouraged for any of the following:

AIR – Rugged Designs for Increased Protection of Airmen (Pilots, Observers, Targeteers), Sensors & Airframe Structures

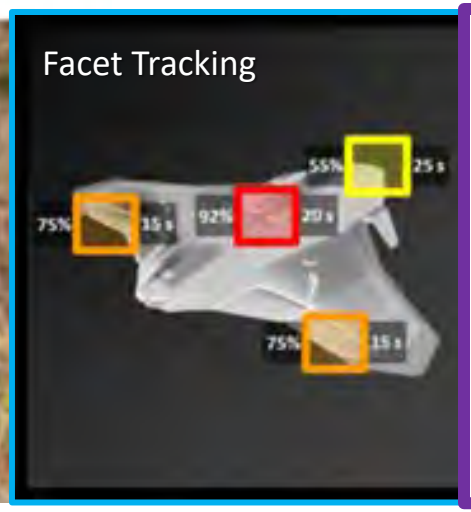
SEA - Protection of sailors & observers, sensors & exposed ordnance

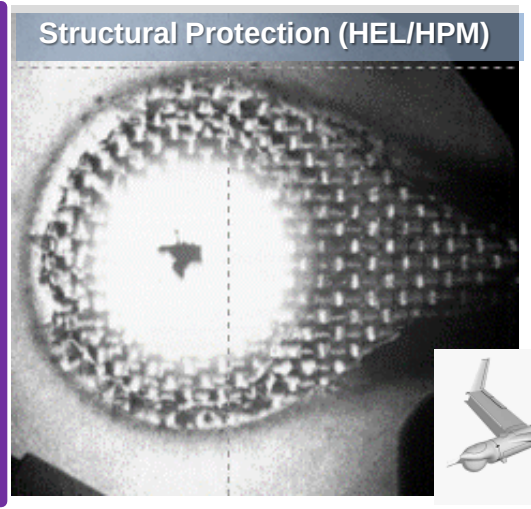
LAND - Protection of soldiers, sensors & exposed ordnance

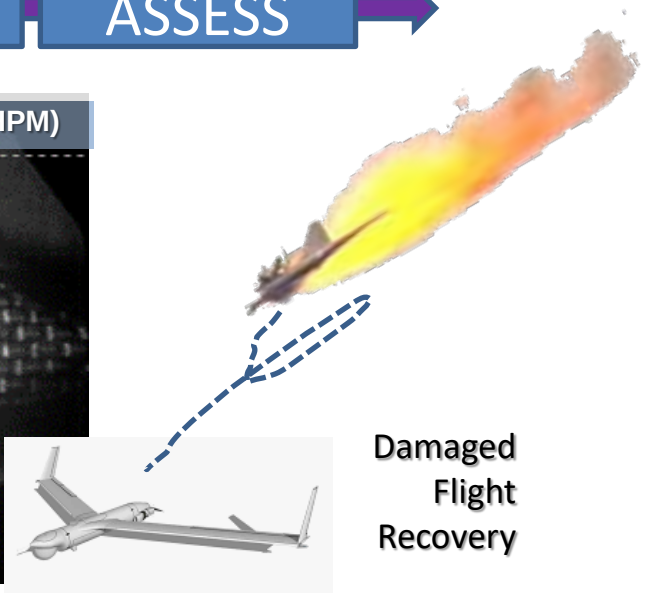
F2T2EA Context for CDEW Solutions Sought

Research & Development Conceptualization // Opportunities

FIND | FIX | TRACK | TARGET | ENGAGE | ASSESS







Damaged Flight Recovery

Find & Fix

("Left of Launch") Standoff outside adversarial "Find & Fix" ranges and detect/sense emissions for "reverse targeting" of Adversarial DEW Threats

Question: How can you find, identify & geo-location of HEL and HPM sources?

Track & Target

Obscure, change flight profiles, or create signals or geometries that decrease closing of track loops (Nano-obscurants, Chaff, EW*)

Question: How can sensor breaks/tracking loss be achieved or negated by HEL/HPM?

outside adversarial DEW capabilities to complete mission objectives?

Engage

Material improvements to selected "soft" locations for increasing the damage thresholds (Improved Structural Sacrificial Ablatives)

Eliminate effects through selective Structural, Optical** or EMI** shielding/hardening (Metamaterials, Additive Manufacture EMI Shielding)

Question: Can DEW threat engages, can effects be minimized/negated? -> DEW Robust Platforms

Question: Can Rugged (USMC), Low Cost (<$50/unit) Laser Eye Protection** reach OD-8 in LRIP?***

Assess

Platform's potential to Deceive & Report Threats

Question: Can platforms sense & deceive threats to "act defeated" (like a wounded duck,) but recover?

Notes:

**Electronic Warfare Functions are coordinated/managed by ONR Code 31*

***Optical & EMI effects on Human Systems are coordinated/managed by ONR 34 & AFRL (LEP/LasPro)*

**** OD – Optical Density, LRIP - Low Rate Initial Production (1,000 units)*

USPL

Ultra Short Pulse Laser
Research & Technology

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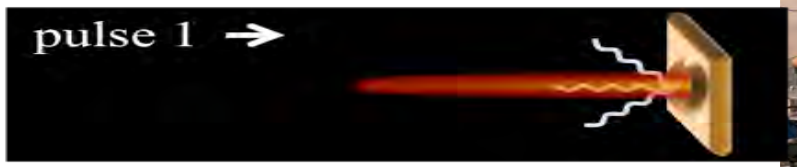
NAVAL S&T STRATAGY

Ultra Short Pulse Laser (USPL)



Operational deficiencies:

- Commercial and Laboratory USPL sources not physically suitable for military use
- USPL Source operations not designed for military use
- Compact Longwave (LWIR) Source does not exist
- Propagation of USPL LWIR not understood
- Material Interaction of USPL LWIR not understood

Projected Need:

- Develop compact military usable LWIR USPL system for field testing
- Define operational capabilities
- Create USPL Weapon System
- Test effectiveness
- Transition to Warfighter

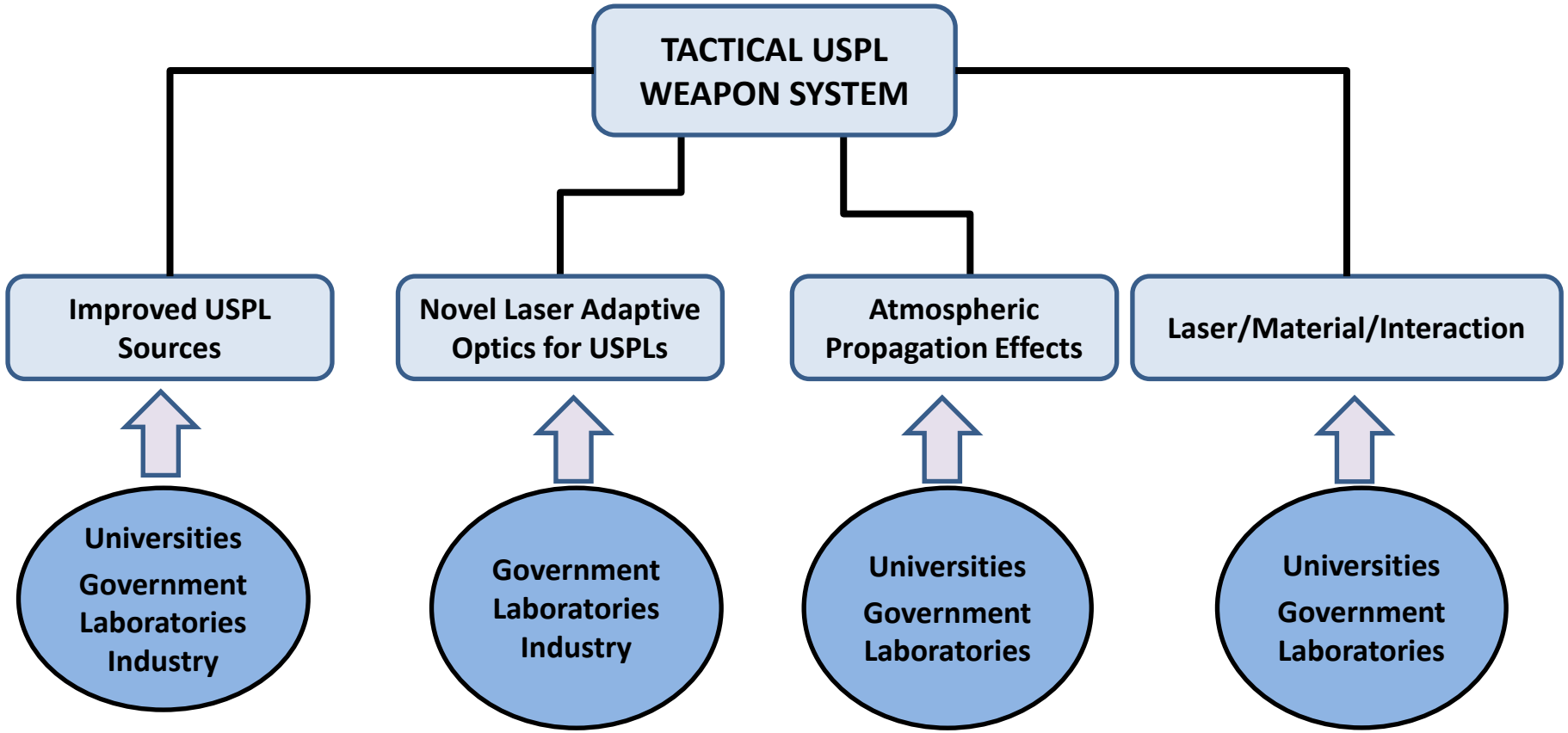
Technology opportunities:

- New commercial high rep rate USPL source
- High Energy MWIR/LWIR sources for experimentation
- New USPL fiber optic technologies
- New USPL Beam Control technology
- Artificial Intelligence Control Technology
- Complex Dynamic Systems Modeling and Simulation

Operational approach:

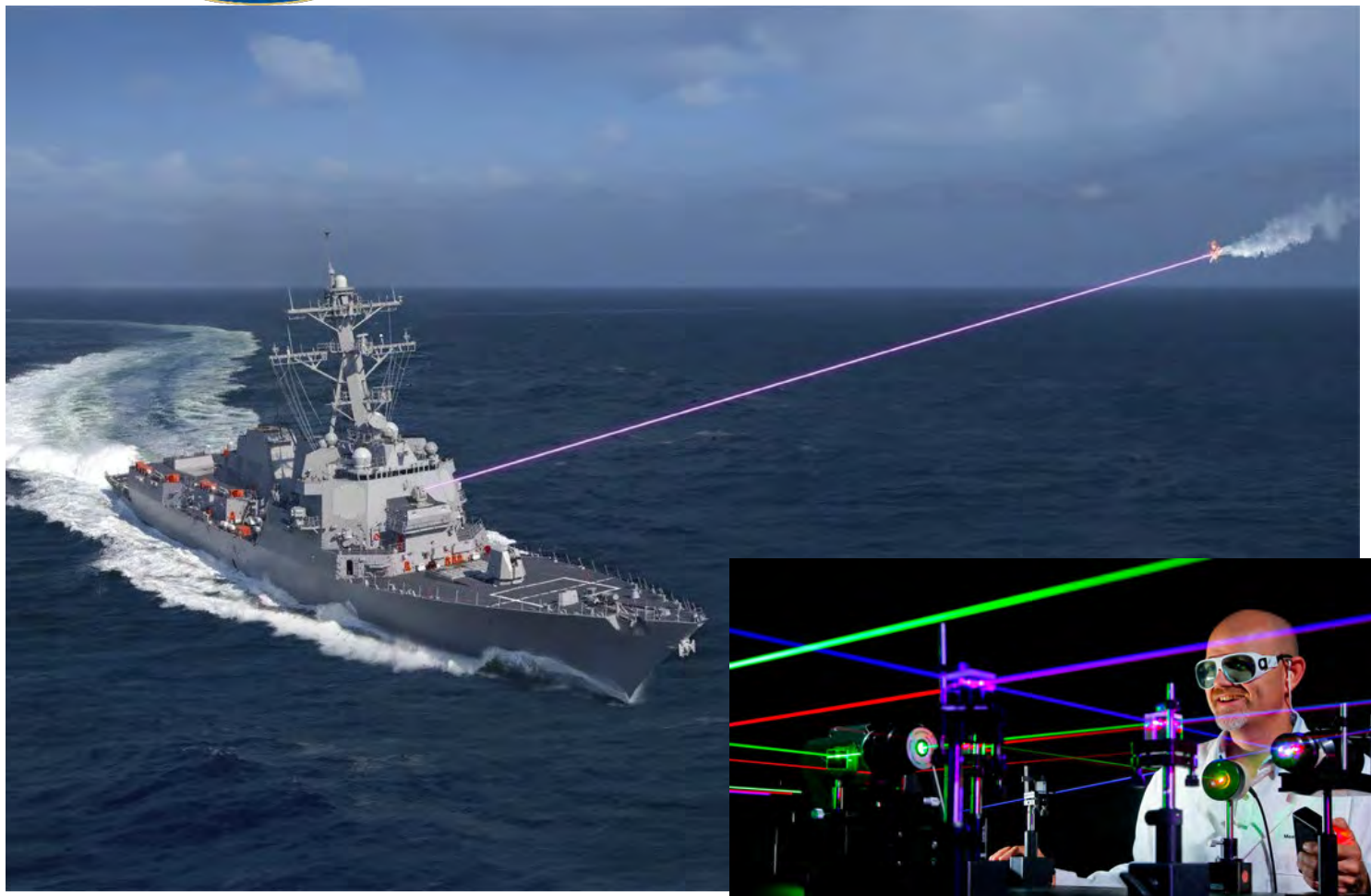
- Perform concept exploration/ Test concepts/Evaluate Concepts for USPL program
- Raise TRL and reduce risk of Systems/ components and subcomponents
- Field test new system concepts
- Deliver New Operationally Effective USPL Weapon System

TOP LEVEL USPL S&T PROGRAM REQUIRMENTS



Focus Area Forum Opportunities

ULTRA SHORT PULSE LASER
Desired Portfolio Outcomes



Needs Analysis

- System Development of More compact, high power directed energy systems
  - *High Effectiveness*
- More Power Efficiency
  - *Reductions to (average) cooling & electrical power loads*
- Short Engagement Times
  - *Long range (10's of kilometers)*

Concept Exploration

- Ultrashort Pulse Laser Sources & Rugged Subsystems Development - Five (5) Years
- Investigation of Atmospheric Propagation Five (5) Years in parallel
- Investigation of Ultrashort pulse laser lethality Five (5) Years in parallel

Key Knowledge, Scientific Metrics & Fleet Impact(s)

- Develop long wave infrared (LWIR) Ultrashort pulse sources
- Develop Ultrashort Pulse Laser adaptive optics
- Enhance & Improved Maritime Propagation and Optimize Lethal Effects
- Integration of Ultrashort pulse technologies, robust systems onto Platforms

  e.g. Aircraft/Rotorcraft, Sea Based Ships (DDG, LCS), Ground Based (USMC)
- Reductions in time and costs during subsequent engineering phases

Terminal Defense Kill Chain

Focus Area Forum, 2024

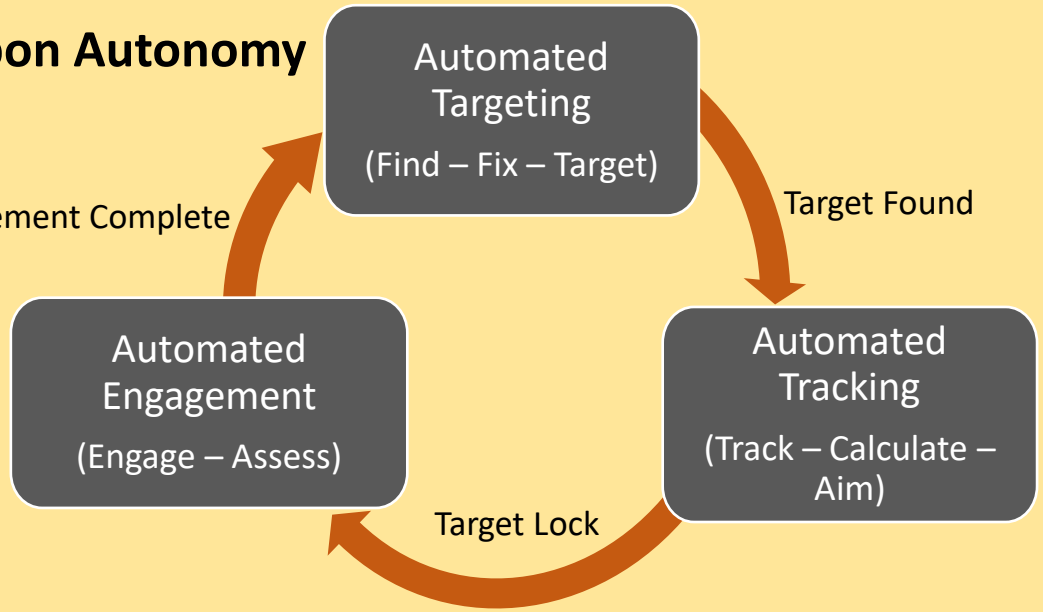
Mr. Tom Boucher
Mr. Chris Reasonover
Ms. Teresa Berra

Terminal Defense Kill Chain
Research Focus

Code 31 | Code 35

DETECT		CONTROL			ENGAGE			ASSESS
Find	Fix	Track	Classify	Target	Launch	Guide	Lethality	Assess

Weapon Autonomy



Launch	Guidance	
	Midcourse	Terminal
• Initialize • Calibrate	• Illuminate • Self-locate • IFTUs	• Detect • Track • Guide

Precision Fire Control & Low-Cost Interceptors

Laser Weapons

- Target Detection, Track & Aim Point Selection utilizing high resolution sensors (EO/IR/MW)
- Automation of the Detect-Track-Aimpoint Selection For Laser Weapons
- Real Time Target Battle Damage Assessment During Engagement Kill Chain

Weapon Autonomy and Applications

Providing Autonomy and AI solutions that improve existing shipboard kill chains and other relevant weapon applications

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Weapons Autonomy & Applications
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Research Areas

- Autonomy and AI in Shipboard Self Defense Kill Chains
- Lethality and Weaponization of UxS
- Autonomous Weapon Control
- Air Delivered ASW Sensors and Weapons

Applications

- Autonomy and AI for Shipboard Medium Caliber Gun Systems
- Autonomous Weapon Payloads for USVs
- Weaponization of Drone Swarms for USMC

Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
ONR - Work With Us | Office of Naval Research (navy.mil)

Precision Fire Control & Low-Cost Interceptors

Advancing fire control technologies to enable cruise missile defense using small, low-cost interceptors that contribute to the layered defense of surface combatants and expeditionary forces both in capability and capacity to defeat complex raids of hypersonic missiles and cruise missiles

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Ms. Chloe Lee
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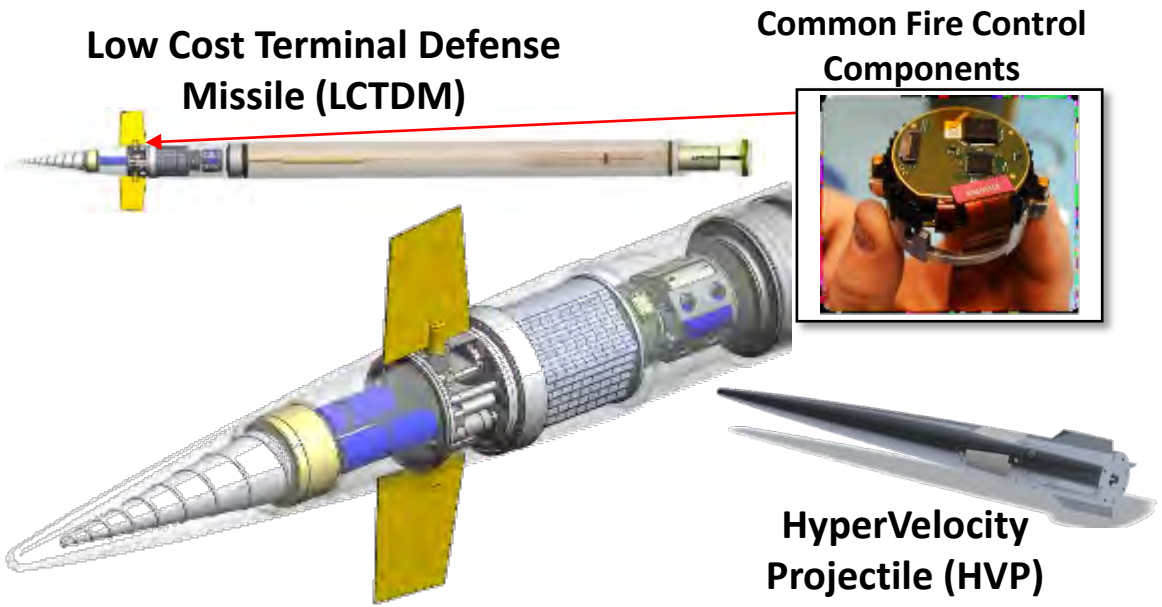
Objectives

- Develop precision guidance and fire control technologies
- Demonstrate engagement of surrogate air threats with HyperVelocity Projectiles (HVPs) and modified MK 66 2.75-inch rockets

Research Areas

- Novel fire control and communication waveforms
- Precision aero-control devices
- Adaptive and collaborative guidance laws
- High acceleration-tolerant electronic components



Applications

- Advanced RF seekers
- Advanced radar track filters
- Gun-launched guided projectiles
- Small guided missile interceptors

Code 35 - Naval Air Warfare and Weapons | Office of Naval Research (navy.mil)
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Laser Weapons & Combat System Integration

Researching, Developing, and Demonstrating High Energy Laser Weapons & Integration With Combat Systems

Ms. Teresa Berra
Laser Weapons &
Combat System Integration
Program Officer
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Research Areas

- Integration of Directed Energy Weapons with Ship Combat Systems
- Target detection, track & Aim Point Selection utilizing high resolution sensors (EO/IR/MW)
- Automation of the Detect-Track-Aimpoint Selection For Laser Weapons
- Real Time Target Battle Damage Assessment During Engagement Kill Chain

Applications

- High Energy Laser Weapons Integration, Test, Deployment, & Sustainment
- Combat System Integrations
- Application of Directed Energy Weapons to all stages of F2T2EA* kill web model

* Find-Fix-Track-Target-Engage-Assess

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