

# ***ONR Electronic Warfare S&T Industry Day***



*Revolutionary Research . . . Relevant Results*

**10 February 2012**

**Dr. Peter Craig**

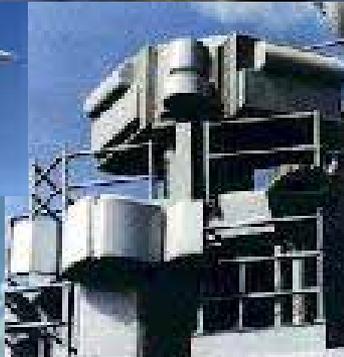
**Electronic Warfare Program Manager**

**C4ISR Department**

**Office of Naval Research**

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# Office of Naval Research Science & Technology



***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; and to manage the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test, and evaluation.

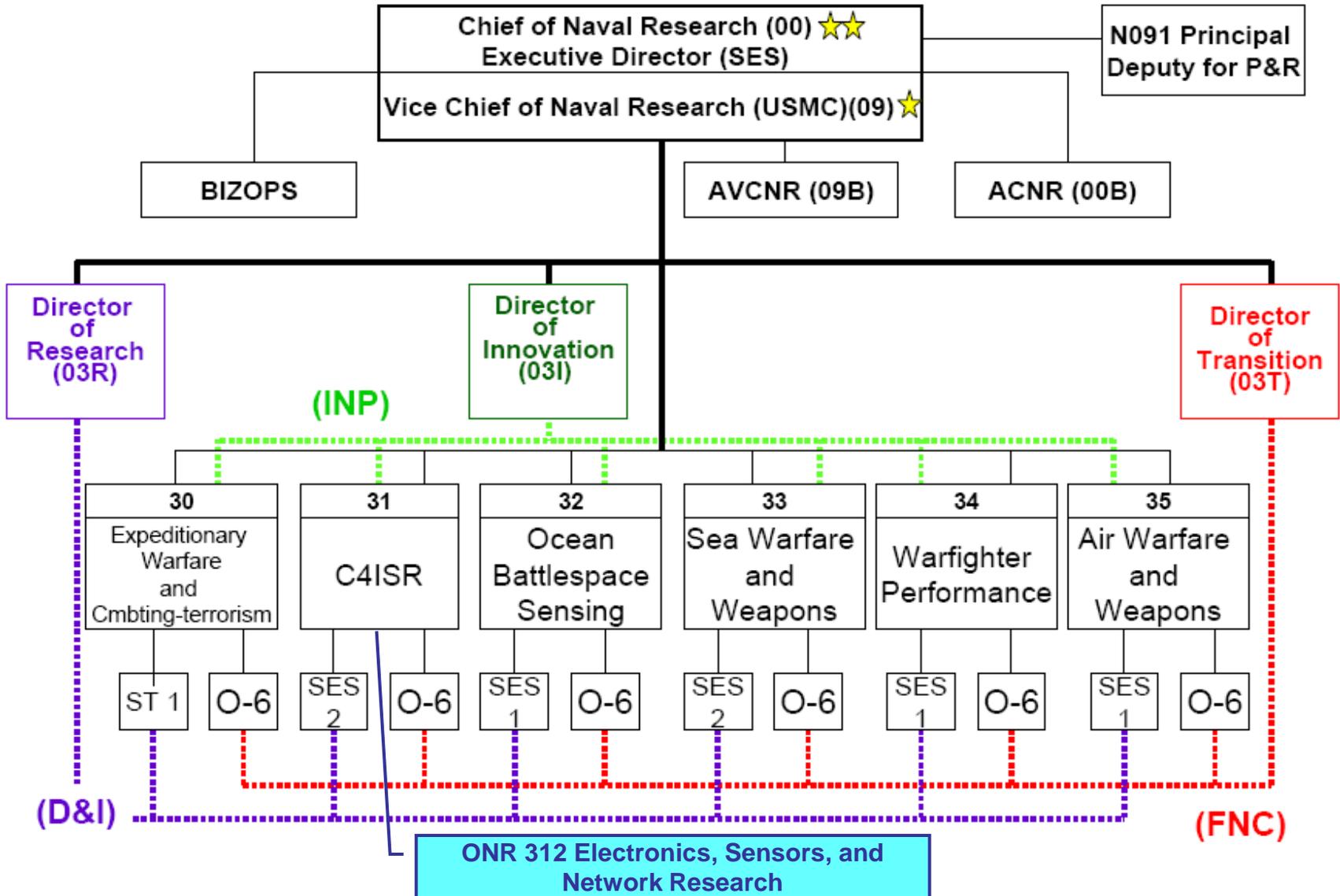
***Naval S&T Vision:*** Sponsor scientific research and technology to:

- ***Pursue revolutionary capabilities for Naval forces of the future,***
- ***Mature and transition S&T advances to improve naval capabilities,***
- ***Respond to current critical needs,***
- ***Maintain broad technology investments to anticipate and counter potential technology surprise.***





# Office of Naval Research Organization (S&T)

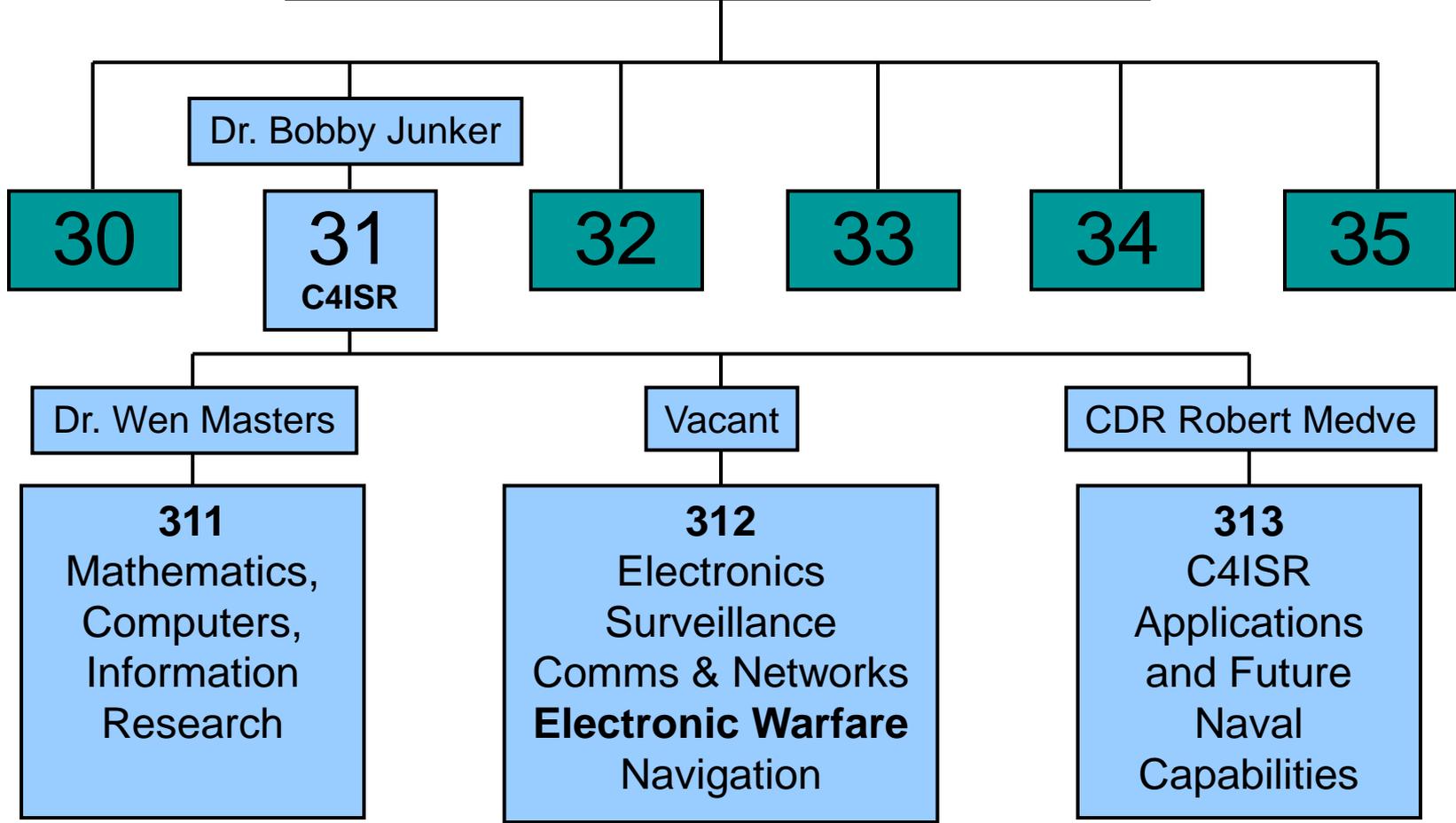




# ONR Organization - S&T



## Chief of Naval Research





# ONR 312 Electronic Warfare



## Electronic Warfare Technology Program

Dr. Peter Craig  
EW Program Manager

Mr. Dave Tremper  
EW Program Officer

Mr. Brad Crane  
EW Program Officer

Mr. Bob Kusuda  
CACI

Mr. Tom Jesswein  
CACI

### 6.2 Discovery & Invention

Distributed EW Assets  
CM for Emerging Threats  
EO/IR Countermeasures  
Wideband ES – Sensing/Processing

Adaptive EW Signal Processing  
Antennas and Components  
Multi-Band Lasers  
Wideband EA – Components/Techniques

EW Modeling & Simulation  
Network Centric EW  
Multi-Mode CM Techniques  
High Power mmW Transmitters

### Future Naval Capabilities (Sea Strike, Sea Shield, ForceNet & Expeditionary Maneuver Warfare)

#### Surface/Subsurface

Enhanced SEWIP  
Enhanced NULKA  
Next Gen CM for SMD  
Submarine Survivability – EW  
EW Battle Management (NEW)

#### Air

Next Generation Airborne EW  
CM for Advanced Imaging IR Seekers  
CM for Millimeter Wave Seekers  
Identification and Defeat of EA Systems

#### Marine Corps

Multifunction Capabilities for MWS  
Future Joint Counter  
Radio-Controlled IED EW  
Hostile Fire (HF) Suppression (NEW)

### SBIR/STTR EW Technologies



# Doing Business with ONR



## Business Opportunities

- Broad Agency Announcements (BAA)
- Small Business Innovative Research / Small Business Technology Transfer (SBIR/STTR)
- Multidisciplinary Research Program of the University Research Initiative (MURI)
- Defense University Research Instrumentation Program (DURIP)
- DoD Experimental Program to Stimulate Competitive Research (DEPSCOR)

Detailed information can be found on the ONR website

<http://www.onr.navy.mil/en/Contracts-Grants.aspx>



# What is Electronic Warfare? Joint Service Definition



**Development of technologies that maximize the operational use of the electromagnetic (EM) spectrum by U.S. forces, ...while denying same from the enemy, ...by using EM means to detect and attack enemy sensor, weapon and command infrastructure systems**

- Immediate battlespace recognition of hostile scenario/intent and optimized, automated response decisions**
- Electronic denial, degradation, disruption or destruction of enemy C4ISR, IADS, acquisition and associated targeting/weapon systems**
- Timely EM control over the entire battlespace: temporal, spectral, spatial**



# Electronic Warfare in Perspective



## The RED Kill Chain...



## ... and the Electronic Warfare Response Chain...



### Situational Awareness/Threat Warning

Requires capability to:

- Continuously monitor all critical portions of the spectrum
- Quickly and accurately classify emitters/emitter function
- Provide specific emitter identification
- Precisely and rapidly locate platforms, events
- Conduct accurate long term monitoring/tracking
- Share key info in near real time

### Counter Targeting/Jamming/ Self-Protection

Requires capability to selectively:

- Limit/deny access (jamming)
- Provide false/misleading information (countertargeting, decoys)
- Counter communications and networks
- Damage/degrade threat sensor capability



*EW Networked Capabilities, Analysis & Assessment, Electronic Protection*

**Battlespace Awareness**

**Spectrum Control**

**Information Dominance**



# Electronic Warfare Terminology

## DoD / JCS Definitions



**Electronic Warfare (EW):** “Any military action involving the use of EM radiation ... to control the EM spectrum or to attack the enemy.”

- **Electronic Warfare Support (ES):** Actions to search for, intercept, ID & locate intentional / unintentional EM sources for the purpose of immediate threat recognition
  - § Provides information/data for immediate decisions regarding operations & tactical actions (avoidance, targeting, cueing)
- **Electronic Attack (EA):** Use of EM ... to attack with the intent of degrading, neutralizing or destroying enemy combat capability
  - § Includes jamming, EM deception, decoys/expendables
- **Electronic Protection (EP):** Actions taken to protect ... from any effects of friendly or enemy employment of EW that degrade, neutralize, or destroy friendly combat capability



# ONR Electronic Warfare S&T Area Objectives



## Own the Spectrum

**Provide Battlespace Awareness - Know who is out there, where they are, and what they are doing...**

Requires capability to:

- Continuously monitor all critical portions of the spectrum (RF/EO/IR)
- Quickly and accurately classify emitters/emitter function
- Provide Specific Emitter Identification (SEI)
- Precisely and rapidly locate platforms, people, things, events
- Conduct accurate long term monitoring/tracking
- Network sensors and share key info in near-real time

ES

**Provide Effective Spectrum Control - Determine who sees what...**

Requires capability to selectively:

- Limit/deny access (jamming) (RF/EO/IR)
- Provide false/misleading information (countertargeting, decoys)
- Damage/degrade threat sensor capability (RF/EO/IR)

EA

**Provide Unrestricted Spectrum Access to Blue Forces – Protect our own ISR capabilities...**

Requires capability to:

- Negate the impact of hostile jamming on U.S. and allied sensors (RF/EO/IR)
- Preserve the integrity of critical networks and data links
- Precisely navigate and target weapons in a GPS-denied environment

EP



# ONR EW S&T Investment Goals

## Alignment to Naval and Joint S&T Needs



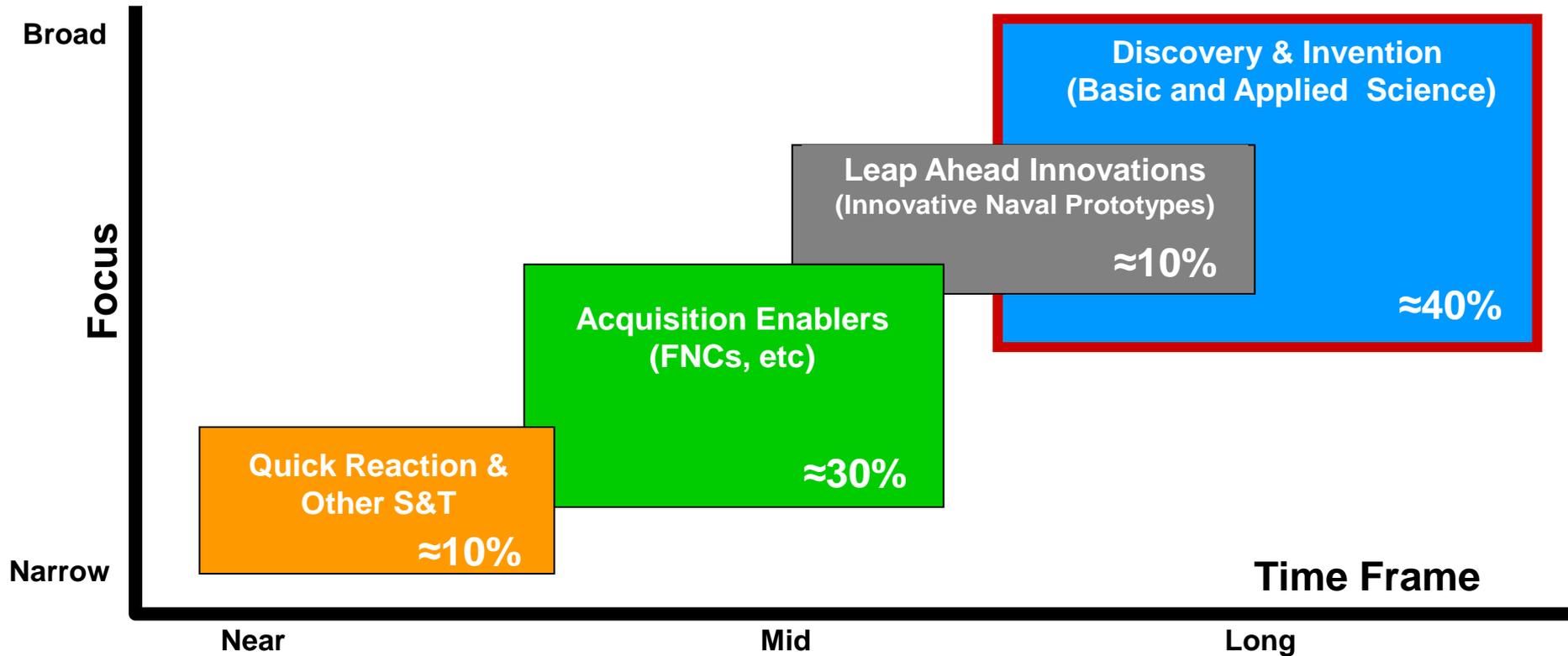
### EW Technology & Techniques for Current and Future Warfighter Needs:

- Extend the EW Spectrum into New Domains (Wavelength/Frequency/Modulation)
- Exploit Non-Traditional and Unintentional Signals
- Detect and Counter Passive Detection Systems
- Explore Network-Enabled Electronic Warfare Cooperative Methods and Solutions
- Develop Tools and Techniques to Provide Real-Time Assessment of EW Effectiveness
- Reduce Size/Weight/Power/Cost of EW Hardware and Systems
- Counter Hostile Use of Advanced EW Technology against US Forces

	SWE	NAE	USE	USMC	Joint
Extend the EW Spectrum into New Domains (Wavelength/Frequency/Modulation)	✓	✓	✓	✓	✓
Exploit Non-Traditional and Unintentional Signals	✓	✓	✓	✓	✓
Detect and Counter Passive Detection Systems	✓	✓		✓	✓
Explore Network-Enabled Electronic Warfare Cooperative Methods and Solutions	✓	✓	✓	✓	✓
Develop Tools and Techniques to Provide Real-Time Assessment of EW Effectiveness		✓			✓
Reduce Size/Weight/Power/Cost of EW Hardware and Systems	✓	✓	✓	✓	✓
Counter Hostile Use of Advanced EW Technology against US Forces		✓		✓	✓



# ONR S&T Portfolio Balance



### Quick Reaction

- Tech Solutions
- Experimentation
- MC S&T (MCWL, JNLW, etc.)

### Acquisition Enablers

- Future Naval Capabilities
- Warfighter Protection
- Capable Manpower
- LO/CLO

### Leap-Ahead Innovations

- Innovative Naval Prototypes
- NSPs
- Swampworks

### Discovery & Invention

- Basic & Early Applied Research
- National Naval Responsibilities
- Education Outreach HBCU/MI



# ONR Portfolio Characteristics



	Direct Fleet Support / Quick Reaction	Future Naval Capability (FNC)	Innovative Naval Prototype	Discovery and Invention (D&I)
<b>% of Portfolio</b>	~10	>30	~10	>40
<b>Focus</b>	Solving emergent fleet / force needs	Transitioning mature S&T to acquisition program of record	Demonstrating Leap-ahead technology	Expanding frontiers of knowledge in areas of naval interest
<b>Motivation</b>	Fleet-identified need	OPNAV-identified capability gap	Significant military advantage	General Naval needs and opportunities
<b>Example</b>	IED Jammer	Enhanced NULKA Payload	Integrated Topside (INTOP)	Real-time EW Effectiveness Monitor
<b>Type of Innovation</b>	Disruptive or sustaining.	Sustaining - makes an existing capability better	Disruptive - makes an existing capability obsolete	Disruptive or sustaining.
<b>Time frame</b>	1-2 years	3-5 years	4-8 years	continuing
<b>Typical TRL entry point</b>	TRL-4 to TRL-5	TRL-3	TRL-2 to TRL-3	TRL-0 to TRL-2
<b>Typical TRL end point</b>	TRL-7	TRL-6	TRL-6	TRL-3 to TRL-4
<b>Technical Difficulty</b>	Medium	Medium	High	High
<b>Operational Integration Complexity</b>	Medium	Usually straightforward	High	N/A
<b>Approval Level to start a program</b>	ONR Corporate	Technology Oversight Group (3-Star)	DON Corporate Board (4-Star)	ONR Department



# Technology Readiness Levels



- 1. Basic principles observed and reported.** Example: Paper studies of a technology's basic properties.
- 2. Technology concept and/or application formulated.** Example: Limited to analytical paper studies.
- 3. Analytical and experimental critical function and/or characteristic proof of concept.** **D&I**  
Example: Components that are not yet integrated or representative.
- 4. Component and/or breadboard validation in laboratory environment.** Example: Integration of "ad hoc" hardware in a laboratory.
- 5. Component and/or breadboard validation in relevant environment.** Example: "High fidelity" laboratory integration of components.
- 6. System/sub-system model or prototype demonstration in a relevant environment.** Example: Testing a prototype in a high fidelity laboratory environment or in a simulated operational environment.
- 7. System prototype demonstration in an operational environment.** Example: Testing the prototype in a test bed aircraft.
- 8. Actual system completed and qualified through test and demonstration.** Example: Developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
- 9. Actual system proven through successful mission operations.** Example: Using the system under operational mission conditions.



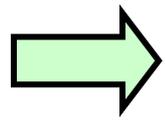
# ONR EW S&T Development Process Annual D&I Refresh



**Oct - Nov**

**ONR EW S&T Future Vision**

- Capability gaps (OPNAV guidance, NARG's)
- Roadmaps (S&T, Acquisition)
- Emerging threats (intell reporting)
- Technology trends (to avoid surprise)



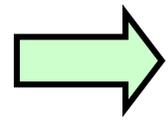
**Dec - Jan**

**D&I BAA**

- Industry
- Academia

**D&I Solicitation**

- NRL
- Warfare Centers
- FFRDC / UARC



**February - March**

**Review White Paper Submissions**

- Evaluate technical merits/innovation, Naval relevance, prior experience, cost realism
- Down-select roughly 2x \$\$ available

**April**

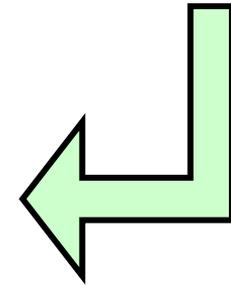
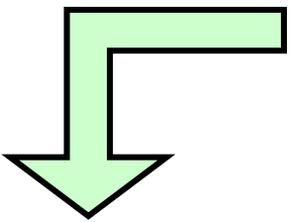
**EW S&T Review (Gathering) – Invitation Only**

**Agenda:**

- EW Requirements view (OPNAV, HQMC)
- EW Acquisition view (NAVSEA, NAVAIR, MCSDC)
- Briefings of current D&I, SBIR, FNC efforts
- Briefings of proposed D&I new starts for following FY

**Actions:**

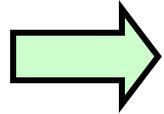
- Invited reviewers advise on D&I new start selection
- Begin dialog regarding new FNC needs
- De-conflict with other service reps (Army, Air Force)



**April - May**

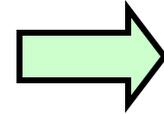
**Select new D&I projects**

- Request full proposals



**Jun - Aug**

- Initiate contract actions
- Prepare FM documentation



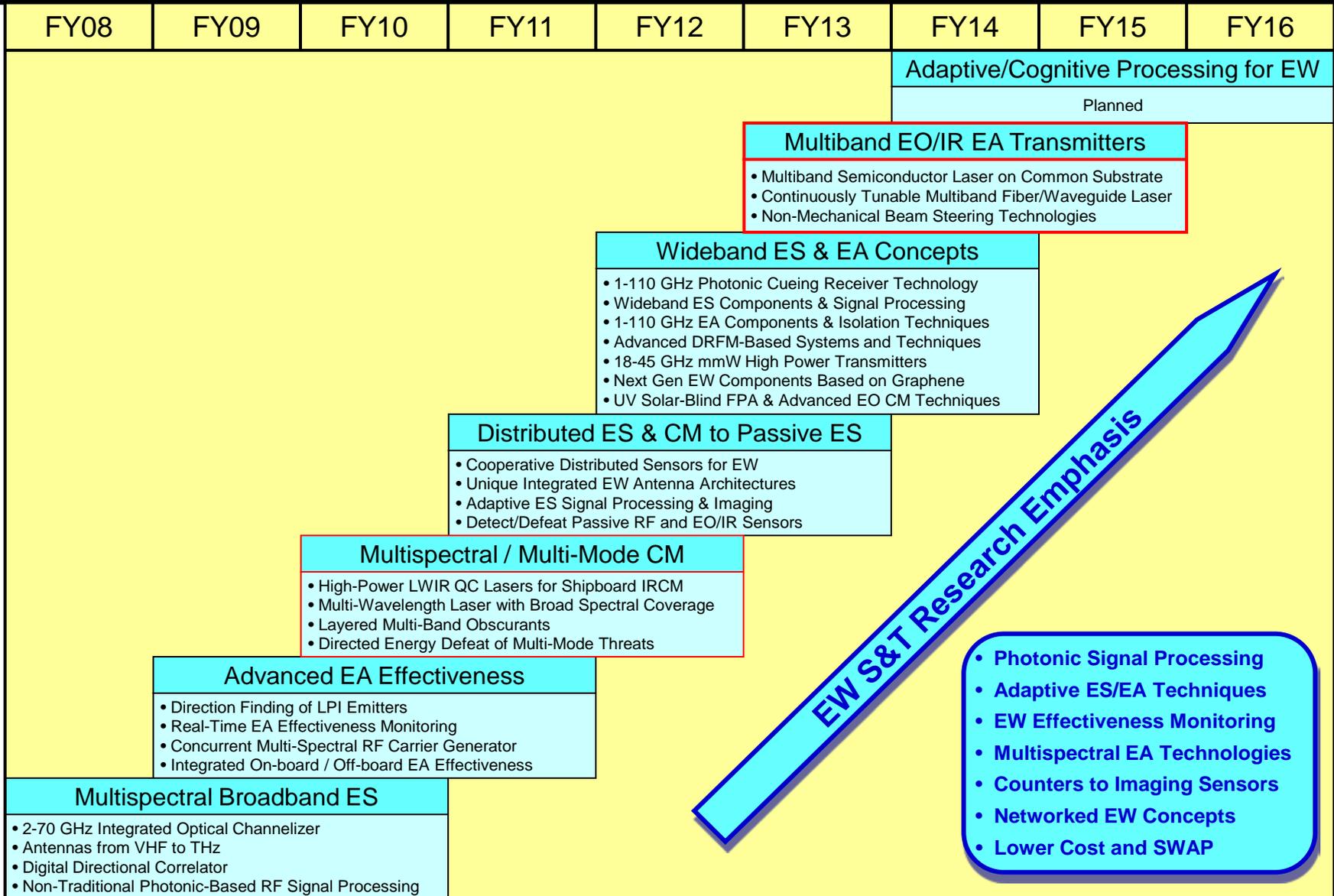
**Oct - Jan**

- Award Contracts
- Send Funding Documents



# ONR 312 EW D&I Products

## Completed, Current, and Planned





# Future EW Vision



Elements of Future EW Systems	Objective Capability (What?)	Enabling Technology (How?)
<b>Distributed</b>	Maximize EW spatial coverage with a minimum of resources without permitting single point failures	Small, lightweight, power efficient ES / EA payloads for manned and unmanned vehicles (UAV, USV, UUV, UGV)
<b>Coordinated</b>	Maximize effectiveness of EW across on/off-board assets, manned / unmanned platforms, kinetic / non-kinetic resources	Multi-asset, coordinated kinetic / non-kinetic M&S; multi-platform ID / targeting / tracking / EA techniques and algorithms
<b>Multispectral</b>	Maximize EW spectral coverage (EO-IR-mmW-RF) and minimize spectral gaps that can be exploited by hostile forces	EO/IR/RF receiver / transmitter sub-systems and components with extended spectral coverage and ultra-wide bandwidth
<b>Adaptive</b>	Maximize flexibility in dynamically responding to time critical, frequency agile emitters	Embedded ES / EA architectures with high-speed reactive ES processing and dynamic EA techniques generation
<b>Robust EP</b>	Maximize operational availability of ISRT sensor assets and preserve situational awareness in the presence of hostile EA	Dynamic / reactive / adaptive signal processing, hardened EO/IR/RF apertures and components
<b>Increased Combat Effectiveness</b>		



# ONR Discovery & Invention

## Last year: ONR BAA 11-006



### Wideband ES - Sensing/Processing

Develop and demonstrate the capability of ES systems to provide wideband (1-110 GHz) spectral coverage:

- Wideband cueing receiver concepts with continuous sensing across the entire spectral range
- Wideband critical receiver components (antennas, low noise amplifiers, tunable filters)
- Wideband adaptive RF signal processing methods and techniques (dynamic, real-time, adaptive, cognitive)

### Wideband EA – Components/Techniques

Develop and demonstrate the capability of EA systems to provide wideband (1-110 GHz) spectral coverage:

- Wideband high power critical EA system components (apertures, power limiters, phase shifters, TTD, driver amplifiers, isolators, circulators, multiplexers, circuits)
- Wideband EA techniques/waveforms and techniques generators (DRFM-based, preserve complex waveforms, multi-aspect false target generation)
- Transmit-to-receive isolation technologies and techniques (close integration of ES & EA systems)

### mmW High Power Transmitters

Improve the capability to deny or deceive sensors or weapons guidance systems operating in the millimeter wave (mmW) bands of the EMS:

- 18-45 GHz frequency range, 4-10 kW ERP for small decoys, capable of being combined to achieve 100 kW or greater ERP for large platforms
- Using vacuum components, solid-state components, or combinations of both
- Include a detailed end-to-end system analysis

### Innovative EW Concepts

Explore truly innovative concepts in the EW areas of ES, EA, or EP which could fundamentally change the way naval forces conduct EW Operations.



# ONR Discovery & Invention

## Last year: ONR BAA 11-006



### Wideband ES - Sensing/Processing

- Wideband Photonic Cueing Receiver for ES (JHU/APL)
- 1-110 GHz Photonic Cueing Receiver (Northrop Grumman)
- Wideband GaN EW Support Receiver Components (HRL)
- Miniature Broadband Tunable Filters for EW Receivers (BAE)
- WB Low Power Cognitive Signal Processing IC (HRL)
- Wideband RF Processing By Net-Positive Parametric Mixers (UCSD/SSC-SD)

### Wideband EA – Components/Techniques

- PolyStrata Time Delay Unit (Nuvotronics)
- 1-110 GHz Two Aperture ESA for EA (Harris)
- Si-based Monolithic DRFM (USC)
- Wideband Intelligent Signal Estimator DRFM (NRL)
- Isolation Improve Between Multiple Aperture EA/ES (MIT/LL)

### mmW High Power Transmitters

- Compact 25-80 kW ERP Decoy Tx w/ Cont 18-45 GHz Coverage (NRL/L3 Corp)
- A Digital Transmitter on Chip (NRL/MIT/LL)
- Enabling Technology for High Power mmW Space Constrained Platforms (University of Colorado – Boulder)

### Innovative EW Concepts

- Next Gen EW Components Based on Graphene (Penn State)
- Phase & Amplitude Modulated Optical Spoofing System (NSWC – Crane)
- High Performance Solar-Blind FPAs for Next Gen MWS (MP Technologies/Northwestern)



# ONR Discovery & Invention

## This year: ONR BAA 12-008



## ONR BAA Announcement # ONR 12-008



- **Posted:** *27 January 2012*
- **Agency Name:** *Office of Naval Research*
- **Research Opportunity Title:** *Electronic Warfare Technology*
- **Program Name:** *Electronic Warfare Discovery & Invention (D&I)*
- **Response Dates:**
  - **White Papers:** *16 March 2012*
  - **Full Proposals:** *8 June 2012*



# ONR Discovery & Invention

## This year: ONR BAA 12-008



**ONR 312 Electronic Warfare (EW) seeks white papers for efforts that shall develop and demonstrate technologies for the next generation components and systems in Electronic Warfare. The primary emphasis of this BAA is on technologies towards**

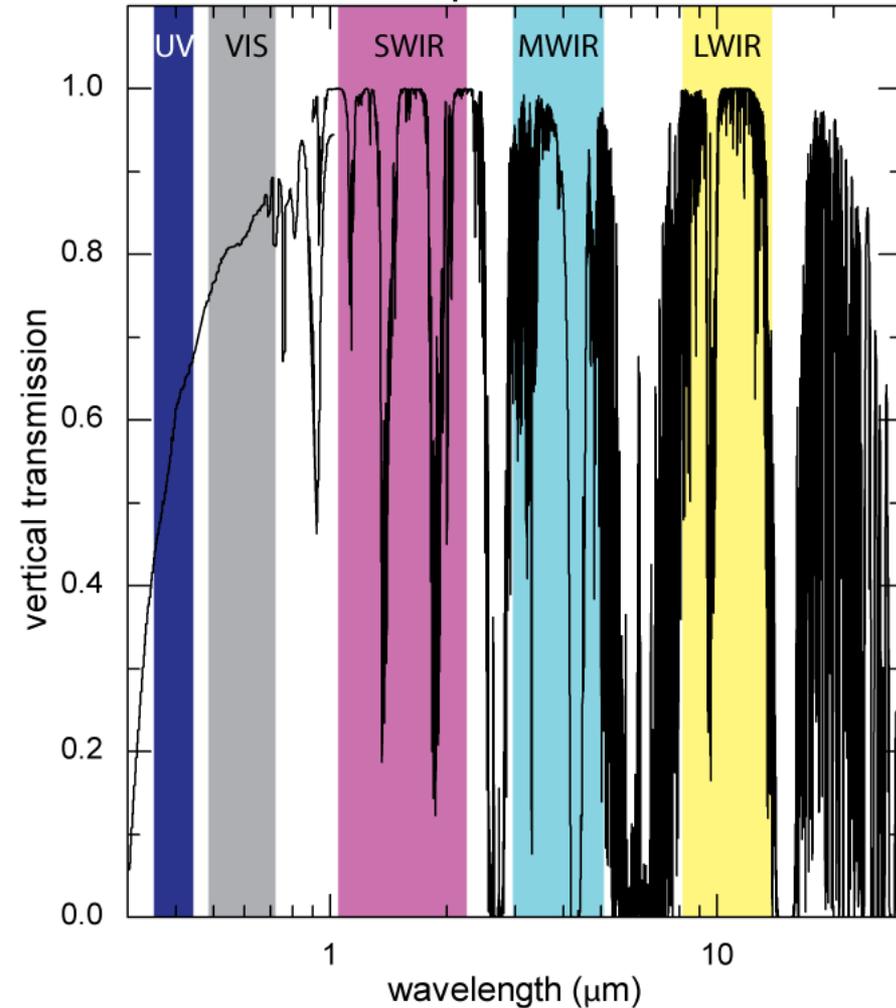
- **Multispectral Semiconductor Lasers**
- **Continuously Tunable Multispectral Fiber/Waveguide Lasers**
- **Non-Mechanical Beam Steering**
- **Innovative EW Concepts**



# Multispectral Integrated Laser Provides Multi-Functionality and Reliability



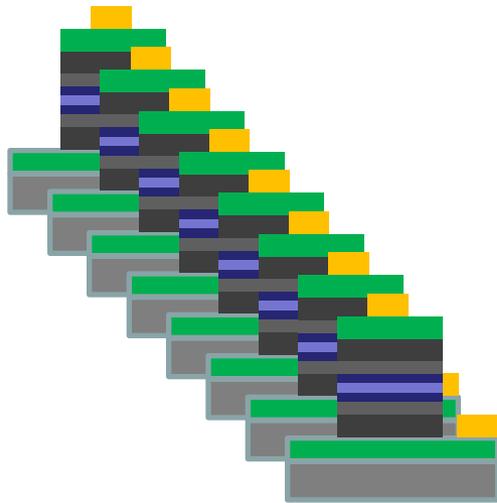
Vertical Atmospheric Transmission



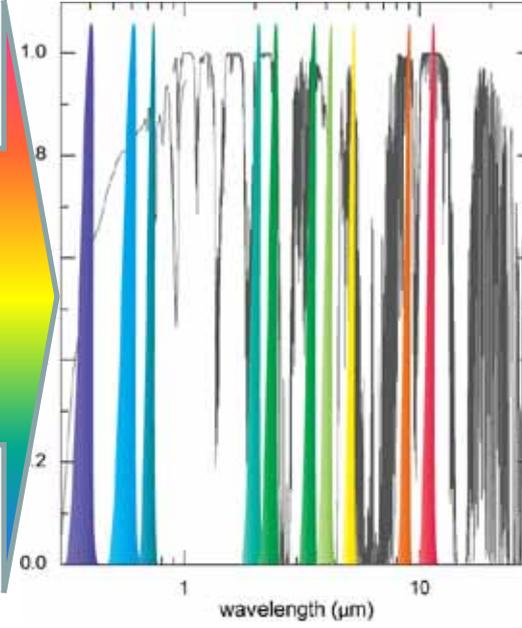
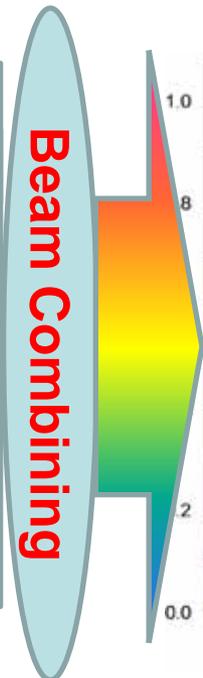
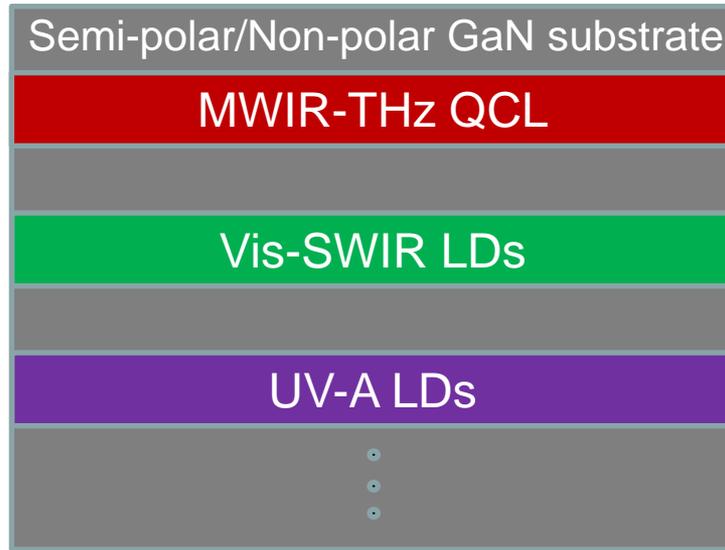
- No free-space optics: removes sensitivity to temperature & vibration, >100x improvement for MTBF
- Fast tuning among multiple wavelengths during engagement
- Search, Spoof and Damage capability in one source
- Waveform agility : modelocked and Q-switched and gain-switched and CW
- Ability to reconfigure on the fly to address unknown threats
- Non-mechanical switchable routing to prosecute multiple threats.



# Multispectral Semiconductor Lasers



Multiple QCL, ICL, Diodes



**Technology Challenges**

- Low defect substrate and epitaxial growth
- Compositional control for ultra-broadband access
- Multi-band monolithic integration (fibers/optics)

**Approaches**

- Multiple discrete diodes, Quantum Cascade Lasers, Interband Cascade Lasers across multiple bands
- Multiple laser on single substrate via bandgap engineering

• Single-package, UV-LWIR spectral lines addressing all known threats

• No platform limitation



# ONR Discovery & Invention

## ONR BAA 12-008 Research Area A

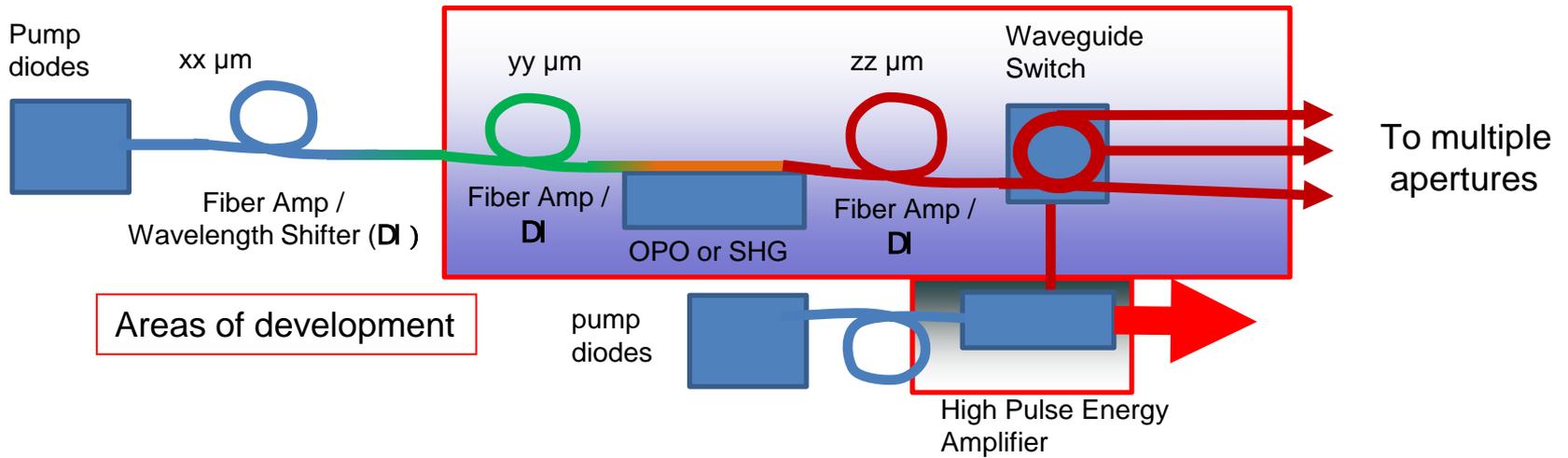


### A. Multispectral Semiconductor Lasers

The objective is to develop and demonstrate a semiconductor-based, multi-wavelength integrated laser source spanning multiple bands of the ultraviolet (UV), visible (VIS), near infrared (NIR), short-wave infrared (SWIR), mid-wave infrared (MWIR), and long-wave infrared (LWIR) spectrum with multiple discrete spectral line emissions. The demonstrated laser system can consist of multiple discrete laser diodes, quantum cascade lasers (QCL), and intraband cascade lasers (ICL) across multiple bands, but the multiple lasers should be combined on a single substrate involving minimal free-space optics (preferably NONE). The demonstrated laser system shall operate at room temperature with at least one spectral line (threshold) or more (objective) in three or more of the UV, VIS, NIR, SWIR, MWIR, and LWIR spectral bands (preferably ALL), with particular emphasis on inclusion of the MWIR band. The multiple discrete laser emissions shall be combined to produce a single continuous wave (CW) multispectral beam with good beam quality ( $M^2 < 3$ ) and output powers of not less than 5 Watts (threshold) to greater than 10 Watts (objective) in EACH spectral band. System architectures consisting of NO free-space optical components are desired in order to minimize the impact of temperature and vibration on the output power and beam quality. Offerors must also directly describe how their approach compares to the current state-of-the-art.



# Continuously Tunable Fiber/Waveguide Lasers



## All Fiber Technology Challenges

- Broad-band transparent, guided fibers
- High-fluence damage-resistant terminators
- Non-mechanical high-speed continuous tuning
- Broad-band fiber dispersion management

## Approaches

- Active/Passive IR transmitting fibers
- Moth-eye facet AR coatings
- Waveguide switching/active routing
- Strong +/- dispersion PC Fiber

- Nonlinear optical tuning: full EO/IR CM coverage from a single package
- Addresses known/unknown threats
- No free-space optics for high reliability



# ONR Discovery & Invention

## ONR BAA 12-008 Research Area B



### **B. Continuously Tunable Multispectral Fiber/Waveguide Lasers**

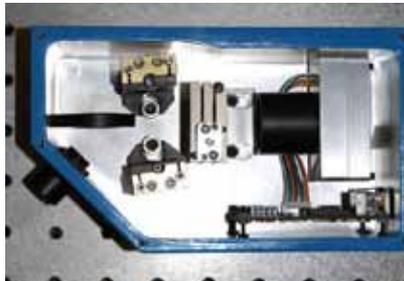
The objective is to develop and demonstrate a multi-wavelength integrated laser source with optical fibers/waveguides as the lasing media, spanning multiple bands of the UV, VIS, NIR, SWIR, MWIR, and LWIR spectrum with continuously tunable output emissions. Proposed laser system concepts are expected to utilize such technologies as broadband transparent guided optical fibers/waveguides, high-fluence damage-resistant inter-connections and terminators, non-mechanical high-speed continuous tuning and switching/routing, and broadband fiber dispersion management. The demonstrated laser system shall produce a single output beam with good beam quality ( $M^2 < 3$ ) and output powers of not less than 10 Watts (threshold) to greater than 20 Watts (objective) across as much of the full spectral tuning range as possible (preferably ALL), with particular emphasis on inclusion of the MWIR band. [Note: while continuous-wave (CW) output is preferred, pulsed emissions with pulse repetition frequency (PRF) greater than 1 kilohertz are permitted - in which case the required output power is measured as an average over 1 second of pulsed emission.] The demonstrated laser system shall operate at room temperature with a system architecture consisting of NO free-space optical components in order to minimize the impact of temperature and vibration on the output power and beam quality. Offerors must also directly describe how their approach compares to the current state-of-the-art.



# Optical Phase Control for Truly Conformal Optical Systems



Classic optics use distance, refractive index, curvature, reflectivity and orientation to control wavefront and steer beams.



Gimbal Turret (Example)  
FOR  $\sim 360^\circ \times 180^\circ$   
Resolution: 0.3 mrad  
Switch time:  $\sim 0.3$  s

Next-Generation phase control will shape and steer beams more quickly and efficiently

## Technology Challenges

- Many element active phase control for  $N^2$  power scaling, precision steering with high efficiency
- Low loss materials and coatings for platform independent approaches to broadband applicability
- Control systems: Active feedback and algorithm optimization for point/track across multiple targets

## Approaches

- Electronically driven coherent control
- Photonic Waveguide Phased Array
- High-Fill Factor MEMS Micro-mirrors (electro-thermal, electro-static)

- Reduced SWAP, increased MTBF (fewer parts), fewer apertures, reduced RCS/drag (conformal)
- Highly adaptable approach – simplifies tech insertion
- Search/Track/Dazzle/Jam from single aperture  $\rightarrow$  engage multiple targets simultaneously



# ONR Discovery & Invention

## ONR BAA 12-008 Research Area C



### **C. Non-mechanical Beam Steering**

The objective is to develop non-mechanical beam steering technologies that will allow coherent energy spanning multiple bands of the UV, VIS, NIR, SWIR, MWIR, and LWIR spectrum to be directed in a low divergence beam with minimal or no side lobes over an angular range covering not less than 120-degrees conical (threshold) up to a complete hemisphere (objective). Beam steering approaches that are fully integrated with the multiband coherent light source or are independent of the source are both acceptable. Technologies that span three or more of the UV, VIS, NIR, SWIR, MWIR, and LWIR spectral bands (preferably ALL) are desired, with particular emphasis on inclusion of the MWIR band. Beam steering technologies proposed should be at least as fast (preferably faster) than current mechanical approaches and should have smaller size, weight, and power (SWaP) characteristics. Proposed concepts should be compatible with installations embedded in the skin of a platform/vehicle (preferably conformal) to minimize aerodynamic drag. Consideration for distortion of the optical beam at extreme steering angles should be discussed and methods of compensation presented. It is also desirable that the technology proposed for the output beam steering function be usable for steering the angle of detection of returning light to an associated receiver/sensor. Architectures consisting of NO free-space optical components are desired in order to minimize the impact of temperature and vibration on the output power and beam quality. Offerors must also directly describe how their approach compares to the current state-of-the-art.



# ONR Discovery & Invention

## ONR BAA 12-008 Research Area C



### **C. Non-mechanical Beam Steering (continued)**

The following additional language will be posted as an Amendment to BAA 12-008 for Area C:

Beam steering technologies proposed should be capable of directing continuous-wave (CW) or pulsed laser beams at power levels of not less than 10 Watts (threshold) to greater than 20 Watts (objective) across as much of the full spectral range of operation as possible. [Note: for pulsed lasers the required output power is measured as an average over 1 second of pulsed emission.]



# ONR Discovery & Invention

## ONR BAA 12-008 Research Area D



### **D. Innovative EW Concepts**

**The objective is to explore truly innovative concepts in the EW areas of ES, EA, or EP which could fundamentally change the way naval (Navy and Marine Corps) forces conduct EW operations.**

This sub-section should only be cited by proposals that do not fall within any of the other sub-sections of this Research Opportunity Description.



# ONR Discovery & Invention

## ONR BAA 12-008 Award Info



- **ONR plans to fund individual awards of \$500,000.00 to \$1,500,000.00 per year, using Discovery and Invention (D&I) (Budget Category 6.2) funds. However, lower and higher cost proposals will be considered.**
- **The period of performance for projects may be from one to three years. Projects will have an estimated start date of 02 January 2013, subject to date of final award and availability of new fiscal year funds.**
- **Some portion of this budget may fund research requests in this program area received from Government entities outside of this BAA.**



# ONR Discovery & Invention

## ONR BAA 12-008 Eligibility



- **All responsible sources from academia and industry may submit proposals under this BAA.**
- **University Affiliated Research Centers (UARC) are eligible to submit proposals under this BAA unless precluded from doing so by their Department of Defense UARC contracts.**
- **There will be no set asides for Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs).**
- **Some topics cover export controlled technologies. Research in these areas is limited to “U.S. persons” as defined in the International Traffic in Arms Regulations (ITAR) - 22 CFR § 1201.1 et seq.**



# ONR Discovery & Invention

## ONR BAA 12-008 Eligibility



- Navy laboratories and warfare centers, as well as other Department of Defense and civilian agency laboratories, and Federally Funded Research & Development Centers (FFRDCs), including Department of Energy National Laboratories, are **not eligible to receive awards under this BAA** and should not directly submit either white papers or full proposals in response to this BAA.
- **NOTE: Responses from these organizations are being solicited separately, though with the same guidance regarding research areas of interest, white paper format and deadlines.**



# ONR Discovery & Invention

## ONR BAA 12-008 Eligibility



- **Bottom line**: All civilian, industry, government, and military organizations are encouraged to submit white paper responses to the four ONR EW research areas as solicited.
- Once a proposed effort has been chosen for funding, ONR will determine the best method to proceed.
- If a contract or grant is required, then the guidance, clauses, and limitations of this BAA are applicable.
- If other means are more appropriate (direct funds transfer to DoD laboratory or warfare center, use of existing contract vehicle, etc.) then separate guidance and limitations may apply.



# ONR Discovery & Invention

## ONR BAA 12-008 White Papers



- The due date for white papers is no later than 3:00 PM (EST) on Friday, 16 March 2012. White papers received after the published due date and time are not eligible to participate in the remaining Full Proposal submission process and are not eligible for Fiscal Year (FY) 2013 funding. Each white paper should state that it is submitted in response to this BAA and cite the particular sub-section of the Research Opportunity Description that the white paper is primarily addressing.
- The only acceptable method for submission of white papers sent in response to the BAA is via electronic mail (email) to [312\\_EC@onr.navy.mil](mailto:312_EC@onr.navy.mil).



# ONR Discovery & Invention

## ONR BAA 12-008 White Papers



### White Paper Format

- **Paper Size – 8.5 x 11 inch paper**
- **Margins – 1” inch**
- **Spacing – single spaced**
- **Font – Times New Roman, 12 point**
- **Number of Pages – No more than four (4) pages (excluding cover page, resumes, bibliographies, and table of contents). White Papers exceeding the page limit may not be evaluated.**
- **Format – one (1) electronic copy in Adobe PDF or Word 2007 DOCX delivered by email.**



# ONR Discovery & Invention

## ONR BAA 12-008 White Papers



### White Paper Content

- **Cover Page**

Including BAA number, proposed title, administrative and technical points of contact (telephone and facsimile number; e-mail address)

- **Technical Concept**

Must address the following without exceeding the four (4) page limit:

1. Project Manager and/or Principal Investigator
2. Relevance to BAA Research Opportunity Description and specific sub-section being addressed ►
3. Technical Objective
4. Technical Approach
5. Deliverables
6. Recent technical breakthroughs that will reduce risk
7. Funding plan (requested funding per fiscal year, as well as total)

- **Operational Naval Concept**

Project objectives, the concept of operation for the new capabilities to be delivered, and the expected operational performance improvements

- **Operational Utility Assessment Plan**

Plan for demonstrating and evaluating the operational effectiveness of the research product in field experiments or tests in a sim environment ►



# ONR Discovery & Invention

## ONR BAA 12-008 Schedule



**The following schedule has been established to facilitate the submission of white papers and their follow-on review and possible selection for FY 2013 funding.**

<b>16 Mar 2012</b>	<b>White paper responses to EW research areas due to ONR</b>
<b>06 Apr 2012</b>	<b>ONR notify selected parties to prepare briefing for EW Review</b>
<b>17 Apr 2012</b>	<b>Quad Chart due to ONR</b>
<b>23 Apr 2012</b>	<b>Briefings due to ONR</b>
<b>26 Apr 2012</b>	<b>Oral presentations at the ONR EW S&amp;T Review</b>
<b>04 May 2012</b>	<b>ONR notify selected parties to prepare/submit full proposal</b>
<b>08 Jun 2012</b>	<b>Full technical/cost proposal due to ONR</b>
<b>02 Jul 2012</b>	<b>ONR notify selected parties of intent to fund efforts</b>
<b>02 Jan 2013</b>	<b>ONR issues awards</b>



# ONR Discovery & Invention

## ONR BAA 12-008 Evaluation Criteria



### **Evaluations will be conducted using the following evaluation criteria**

- **The four technical factors are of equal value**
  - Sub-elements under each factor will be considered but not separately scored
- **The four technical factors (1 – 4 below) are significantly more important than cost**
  - Importance of cost will increase with the degree of equality of the proposals or when the cost is so significantly high as to diminish the value of the proposal's technical superiority

#### **1. Overall scientific and technical merits of the submission**

- a. Degree of innovation,**
- b. Soundness of technical concept,**
- c. Awareness of the state of the art and understanding of the scope of the problem and the technical effort needed to address it, and**
- d. Successful achievement of goals will significantly reduce technical risk to a subsequent development effort.**

#### **2. Naval relevance, transition potential and anticipated contributions of the proposed technology to Electronic Warfare operations.**

- a. Technology addresses a Naval critical need,**
- b. Naval program or initiative depends on the technology,**
- c. Potential transition effort identified, and**
- d. Part of a joint service technology effort.**



# ONR Discovery & Invention

## ONR BAA 12-008 Evaluation Criteria



### Evaluation criteria (continued)

#### 3. Program structure and execution plan

- a. Level of technical risk appropriate for applied research,
- b. Clear statements of objectives, applicability to BAA, anticipated end state, and deliverables,
- c. Concise schedule with clearly identified milestones to objectively measure progress, and
- d. Timing is right (e.g. addresses current or future capability need, leverages recent S&T breakthrough or emerging COTS technology, constructive relationship with other on-going work , etc.).

#### 4. The qualifications, capabilities and experience of the proposed Principal Investigator (PI), team leader and key personnel who are critical in achieving the proposal objectives

- a. Offeror's experience in relevant efforts with similar resources,
- b. Ability to manage the proposed effort, and
- c. Offeror's overall capabilities, facilities, techniques or unique combinations of these which are integral factors for achieving the proposal objectives.

#### 5. The realism of the proposed cost and availability of funds



# ONR Discovery & Invention

## ONR BAA 12-008 Deliverables



The following is a sample of reporting deliverables that could be required under a research effort. The following deliverables, primarily in contractor format, are anticipated as necessary. However, specific deliverables should be proposed by each Offeror and finalized with the contracting agent:

- Detailed Technical Data
- Technical and Financial Progress Reports
- Presentation Material(s)
- Other Documentation or Reports, as required
- Final Report

Research performed under contracts may also include the delivery of software, prototypes, and other hardware deliverables.



# ONR Discovery & Invention

## ONR BAA 12-008 Facilities / GFE



- **Offerors are expected to provide all facilities (equipment and/or real property) necessary for the performance of the proposed effort. Any direct charge of facilities, not including deliverable items, must be specifically identified in the Offeror's proposal and approved by the Government prior to purchase.**
- **Any request to use Government owned facilities or Government Furnished Equipment (GFE) must be included in the Offeror's proposal and approved in advance by the cognizant Government official. After contract award, requests to use Government integration, test, and experiment facilities will be considered on a case by case basis based on availability and justification of need.**



# ONR Discovery & Invention

## ONR BAA 12-008 Classification



- **All white papers and proposals are expected to be unclassified. However, confidential/classified white papers and proposals are permitted.**
- **In order to facilitate intra-program collaboration and technology transfer, the Government will attempt to enable awardees to work at the unclassified level to the maximum extent possible.**
- **If awardees use unclassified data in their deliveries and demonstrations regarding a potentially classified project, they should use methods and conventions consistent with those used in classified environments. Such conventions will permit the various subsystems and the final system to be more adaptable in accommodating classified data in the transition system.**



# ONR Discovery & Invention

## ONR BAA 12-008 Summary



### Things ONR will look for in white paper submissions

- An understanding of Electronic Warfare principles and needs
- Innovative applications of cutting edge science and technology to address Electronic Warfare priorities
- Efforts that focus on multispectral semiconductor lasers, continuously tunable multispectral fiber/waveguide lasers, non-mechanical beam steering, and innovative EW concepts
- Clear statements of the effort's objectives, applicability to Electronic Warfare, anticipated end state, and deliverables.
- Clear and concise schedule including intermediate milestones to objectively measure progress toward goals
- Funding request broken out by performing organization and Government fiscal year.



# ONR Discovery & Invention

## ONR BAA 12-008 Summary



### Things that will cause ONR to reject white papers

- **Proposed effort is not Electronic Warfare related**
  - Communications or navigation systems (counter comms/nav is okay)
  - Intel, reconn, surveillance (ISR) systems (counter ISR is okay)
- **Proposed effort is not Discovery & Invention (6.2)**
  - Off-the-shelf solutions without any clear innovation
  - Demonstrations and field testing of existing systems or components to show military application
- **Reliance on GFE/GFI without prior arrangement/agreement**
- **Poor program planning**
  - No explanation or understanding of underlying S&T
  - Scattershot approaches with little methodology
  - Lack of intermediate milestones to gauge progress
  - No substantiation for requested budget



# ONR Discovery & Invention

## ONR BAA 12-008 Final Comments



- **ONR 312 EW will not entertain requests for individual meetings with industry representatives to discuss potential white paper submissions**
  - **No pre-selection of ideas or concepts**
  - **If in doubt, write the white paper and submit it**
- **This is your opportunity to ask questions**
  - **Written questions are permitted, but all questions and answers will be posted to the ONR BAA website**
- **White paper questions of a business nature can be submitted by e-mail through Friday, 2 March 2012**
  - **All questions and answers will be posted to the ONR BAA website**



# ONR Discovery & Invention Frequently Asked Questions (1)



## GENERAL QUESTIONS

**Question 1:** Will the briefing slides shown at the Industry Day be posted on the ONR website?

**Answer:** Yes.

**Question 2:** Will an attendance list be provided for Industry Day?

**Answer:** Yes, a list will be posted on the BAA website, minus those people who request their names be excluded.

**Question 3:** Who will be the evaluators of the white papers and proposals for this BAA? Will it be just yourself and Mr. Tremper?

**Answer:** The plan is to employ a panel of subject matter experts, consisting of government employees and support contractors who have signed non-disclosure agreements, to review all of the white paper submissions in response to the BAA.

**Question 4:** Does the parallel solicitation that has been distributed to government labs and warfare centers have the same deadline for white papers as the BAA?

**Answer:** Yes, everything is the same: the Research Areas, the deadline for white papers, the deadline for full proposals, and the other significant dates and times.

**Question 5:** Would you have any interest in receiving white papers that are outside the area of Electronic Warfare but still of great interest to the U.S. Navy?

**Answer:** No, the focus of this BAA is on Electronic Warfare so other responses would be inappropriate. For other topics of interest to the U.S. Navy, BAA ONR 12-001 may be more appropriate. However, you are encouraged to seek out the appropriate Program Officer within ONR that handles the technology area of interest and discuss the matter with him or her before submitting any white paper or proposal in response to BAA ONR 12-001. Consult the ONR website to determine the best point of contact.



# ONR Discovery & Invention Frequently Asked Questions (2)



## WHITE PAPERS

**Question 1:** In the white paper, do we need to select one of the suggested research areas in Section 6 that our technology area fits in or can it refer to multiple areas?

**Answer:** Please decide which is the primary research area from Section 6 of the BAA that you wish to address, but you are free to cite other research areas that also apply. We may assign groups of SME's to review the papers by research area so it is important to specify the area that you feel is best aligned to your technology. Research area 4 (other innovative EW concepts) should only be used for white papers that don't fit elsewhere.

**Question 2:** If we intend to write a white paper, are we limited to one white paper of four pages in length for any/all of the subsections listed under section 6 (Research Opportunity Description), or can we write a four page white paper for each subsection (1 through 4) we intend to address?

**Answer:** Any offeror can submit as many white papers as they want to, but each individual proposed effort (with a defined technical objective, approach, and set of deliverables) should be limited to a single 4-page white paper. Each white paper should be able to identify a primary research area (1, 2, 3, or 4) that it is addressing from Section 6 of the BAA (Research Opportunity Description), but can identify multiple additional secondary areas as well.

**Question 3:** Can a single company submit multiple white papers in which each one develops a separate piece of a system?

**Answer:** I would discourage this, since it would require all of the efforts to be funded to get a complete product. In general each white paper should stand on its own merits and not be tied to any other white papers.



# ONR Discovery & Invention Frequently Asked Questions (3)



## WHITE PAPERS (Continued)

**Question 4:** Our company requires proprietary information sent via email to be encrypted. Will this be a problem?

**Answer:** No, it should not be a problem but we will contact you if we are not able to open your encrypted document.

**Question 5:** Regarding encryption of the email for submission of the white paper, do you have a preferred encryption method?

**Answer:** No, but we recommend you investigate encryption features built into Adobe Acrobat Professional.

**Question 6:** We have a concept that may be classified but we do not have a classification guide to get a final determination. How would such a white paper be marked and submitted?

**Answer:** I'm not a security officer so I can't give you specific guidance on marking the paper but I recommend that you contact your company security personnel and mark the paper according to their directions. You should also submit the paper using the instructions in the BAA that refer to classified white paper submission (Section IV Application and Submission Information, Sub-Section 2 Content and Format of White Papers/Full Proposals).

**Question 7:** In the resume section of the white paper submission are we allowed to include information or experience about the company that we feel supports our efforts in these technical areas?

**Answer:** Yes, but I recommend such discussions be kept to a minimum. We do not want 75 page packets submitted that consist of a 4 page white paper and 71 pages of backup material. We will focus on the 4 page technical content and we request that the supplementary material be kept short and to the point.



# ONR Discovery & Invention Frequently Asked Questions (4)



## WHITE PAPERS (Continued)

**Question 8:** Will you provide reasons why a specific paper was not selected for funding?

**Answer:** I have attempted to provide reasons in the past but due to the large number of papers received it is impossible to provide critiques of all of them. Sometimes it is just a matter of the review panel deciding by consensus that certain white papers are better than the others. Sometimes two papers are equally good but the available funding will only support selecting one. In these instances it is almost impossible to define why one paper was accepted and the other was not.

**Question 9:** What happens to white papers that are not selected for further consideration? Is the information destroyed?

**Answer:** Yes

## ORAL PRESENTATIONS

**Question 1:** How long are the oral presentations that are given in April at the EW Program Review?

**Answer:** The presentations are 20 minutes long with a 10 minute question and answer period. Offerors that are selected to give an oral presentation will be provided with a briefing template that ensures the technical, programmatic and required background info is covered.

**Question 2:** You stated that during the oral presentations in April representatives of industry or academia would not be in the audience. Would the audience include proposers from the government?

**Answer:** Possibly, but under the rules for ethical conduct by government employees they are obligated to protect proprietary information and not use it to their own benefit.



# ONR Discovery & Invention Frequently Asked Questions (5)



## FULL PROPOSALS

**Question 1:** Will ONR request more full proposals to be submitted than there are resources to fund?

**Answer:** No, ONR will request full proposals from only those entities whose efforts they intend to fund starting in fiscal year 2013. However, if the final approved DoD budget for fiscal year 2013 includes less funding for ONR EW D&I efforts than is currently anticipated, it may be necessary to limit the awards to match the funding available.

**Question 2:** Is there a limit on the number of awards a single company can receive?

**Answer:** No. It is conceivable that a single company could win all the awards in a single year, though, of course, that's not likely.

**Question 3:** Is it possible to add additional subcontractors over the life of the three year effort?

**Answer:** We would have to see how the contract is set up but I would think it is possible. I know that over a three year period different things may occur but I would encourage you to have identified the people and companies you will be using up front and identify what part each plays in the overall effort. Changes that are necessitated due to unforeseen circumstances in the future would be resolved through modification of the initial contract.



# ONR Discovery & Invention Frequently Asked Questions (6)



## IRAD & DATA RIGHTS

**Question 1:** Is there an option to combine your funding with a company's IRAD?

**Answer:** Possibly. The question would be, "Is the government receiving any benefit in doing this?" It's not the practice of ONR to fund a company to build up their own capability without benefiting the government. There would most likely be intellectual property and data rights issues which would limit the government's ability to use the technology in other efforts they may fund later. ONR prefers to fund efforts that develop innovative ideas and innovative technologies for the benefit of the DoD community over those that solely benefit one company. If your proposed effort does involve IRAD technology or funding or other intellectual property that is protected in other ways (for instance, under a prior SBIR) you can still submit a white paper but the issue of intellectual property and data rights should be specifically pointed out in the white paper. If omitted in the white paper, it must certainly be addressed in the full proposal in Section II (Special Requirements), Sub-section 10 of the Required Technical Proposal Template (2011, Revision 8) that must be completed and submitted with the full proposal.

**Question 2:** Is there room for negotiation on this matter of the government retaining full data rights?

**Answer:** I understand that companies want to develop technology that they can later market to make money but I also have to protect the government's rights to use technology funded by government funds without having to constantly go back to the company to ask permission. Assertion of Data Rights is addressed in Section II (Special Requirements), Sub-section 10 of the Required Technical Proposal Template (2011, Revision 8) that must be completed and submitted with the full proposal. The rules governing data rights are prescribed in Defense Federal Acquisition Regulation Supplement (DFARS) clauses 252.227-7013, -7014 and -7018. All I can recommend is to submit a white paper with your idea and if it is selected then the submitted proposal should contain enough information regarding data rights that something can be worked out during the contracting negotiations that satisfies both parties.



# ONR Discovery & Invention Frequently Asked Questions (7)



## GOVERNMENT/INDUSTRY TEAMING

**Question 1:** Will you fund a company effort if they are also working with the Army or Air Force Research Labs?

**Answer:** Yes, I would be willing to consider it. Just because you are not currently working with a Navy lab should not prevent you from submitting a white paper. However, I would discuss the effort with my colleagues from the other services to determine if there is any background to the effort in their service. Each paper would be handled on a case-by-case basis.

**Question 2:** I'm curious as to the possibilities of combining a proposed effort with other government funded efforts that may happen.

**Answer:** Combining a proposed effort with other government funded efforts is possible, but the relationship and roles would need to be clearly explained and a list of specific deliverables unique to the ONR-funded effort would be needed.

**Question 3:** What is the best way to address this BAA and the separate government “Call for White Papers” for efforts involving combined government/industry efforts? Should the government lab submit a white paper to lead the effort, and in their list show all the participating industry/academic partners? Or should the government lab submit a white paper focusing on leading the transition of the initiative and suggest to the industry/academic partners to pair up and submit a separate white paper geared towards details of technical implementation?

**Answer:** We prefer to see a single proposed effort instead of a group of proposals with aligned efforts. If the government lab is in the position to lead a combined effort then it should be submitted in accordance with the Call for White Papers and not the BAA. The white paper should clearly indicate how the work will be divided among the participants, the roles of each, and recommend a contracting strategy for industry/academic participation (ONR contract (industry) or grant (academia)? Lab contract? Other contract vehicle?). Note that in such a combined effort the government lab participation should have a clear technical value-added and not just act as project manager or as a contracting facilitator.



# ONR Discovery & Invention

## Frequently Asked Questions (8)



### GOVERNMENT/INDUSTRY TEAMING (Continued)

**Question 4:** You've said we can submit papers that partner with a Navy lab. How specific do we have to be in the white paper with respect to how much industry does as compared to how much the Navy does?

**Answer:** You need to clearly delineate what role the Navy lab will play in the effort. You also have to ensure that the Navy is already on board to provide their level of participation. The Navy Principal Investigator should be identified and his resume included. Any partnership with the Navy must have already been established. ONR will not be the go between to set up this partnership. Also, if your effort requires the use or participation of Navy assets or test ranges these have to be arranged by you. ONR will not be a facilitator for your effort.

**Question 5:** Are there guidelines regarding working with Navy labs as opposed to without such partnerships?

**Answer:** No, there are no guidelines. Navy labs may be more cognizant of Navy needs and Navy applications in some cases, so that can be an advantage, but we have funded several efforts over the past few years that were from academia or industry without any participation from Navy labs or warfare centers. Partnering with a Navy lab will not get you any additional consideration during the evaluation process.

**Question 6:** Will representatives from any Naval Warfare Centers (NWCs) be in attendance at the Industry Day?

**Answer:** No NWC participation is planned for Industry Day. As explained in the BAA, it is up to the offeror to make any arrangements for participation with an NWC in advance and that relationship needs to be spelled out in the white paper. ONR will not act as a facilitator for NWC involvement with non-government performers.

**Question 7:** Would a white paper that proposed partnering industry with the Coast Guard Research and Development Center be allowed?

**Answer:** I haven't worked with the Coast Guard before but I think that is something we could work out. I wouldn't let that stop you from submitting a white paper.



# ONR Discovery & Invention Frequently Asked Questions (9)



## **FUNDING**

**Question 1:** Is there a single pot of money to fund industry efforts and a separate pot for government efforts?

**Answer:** No, a single funding source will be used for all the selected efforts whether they are from industry, academia, FFRDC, UARC, government labs, or warfare centers. There are no earmarks for any offeror or group of offerors; the only consideration for funding decisions is the content of the proposal and the available budget.

**Question 2:** Is this funding you have sent aside for 2013 new starts affected by multiyear efforts from previous years and efforts from future years that may be funded?

**Answer:** No, this funding has been identified and set aside for each of the next three years to fund efforts in the Research Areas identified in the BAA.

**Question 3:** How many efforts will be funded in each year?

**Answer:** That depends on how much the selected efforts cost. As stated in the BAA we anticipate most efforts to cost around \$500K - \$1,500K per year for 3 years. It is always possible that higher priced efforts may be selected. However, if you proposed an effort costing \$6 million per year you would need to convince the panel of reviewers that your effort deserves a budget that is 4x above the norm and, quite frankly, that would be very difficult to do. Generally speaking, efforts that request more than \$1.5 million per year need to show a very compelling reason both technically and programmatically to convince the panel of reviewers that they are worthy of being selected.



# ONR Discovery & Invention Frequently Asked Questions (10)



## **FUNDING (Continued)**

**Question 4:** Over how many years will efforts be funded?

**Answer:** Generally, the efforts are three year efforts. One year and two year efforts are fine but if you have a four year effort you need to take a look at the schedule and see if there is any way to compress it down into three years.

**Question 5:** Is there additional funding available in the out-years?

**Answer:** Possibly, but those funds are currently planned to support new start efforts in those years and any funds used to continue current efforts will cut into the amount available for new starts.

**Question 6:** Regarding program funding, is there a profile that is considered more desirable than others?

**Answer:** Not necessarily, but the profile should make sense with respect to the effort being proposed. One would normally not expect the funding to be front-loaded but rather spread out over the life of the program, possibly with a slightly higher profile in the final year as testing and other more costly events occur. But whatever profile is proposed it must be justified by the program plan.



# ONR Discovery & Invention

## ONR BAA 12-008 Points of Contact



### Technical

**Dr. Peter Craig**  
**Electronic Warfare Program Manager**  
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**Arlington, VA 22203-1995**  
**E-mail: [peter.craig@navy.mil](mailto:peter.craig@navy.mil)**

### Business

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**Contract Specialist**  
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# Questions?



# ONR

*Revolutionary Research . . . Relevant Results*



# ONR Discovery & Invention

## This year: ONR BAA 12-008



### Multispectral Semiconductor Lasers

Develop and demonstrate a semiconductor-based, multi-wavelength laser source integrated on a single substrate and spanning multiple bands of the ultraviolet (UV), visible (VIS), near infrared (NIR), short-wave infrared (SWIR), mid-wave infrared (MWIR), and long-wave infrared (LWIR) spectrum with multiple discrete spectral line emissions.

### Continuously Tunable Multispectral Fiber/Waveguide Lasers

Develop and demonstrate an optical fiber/waveguide-based, multi-wavelength integrated laser source spanning multiple bands of the UV, VIS, NIR, SWIR, MWIR, and LWIR spectrum with continuously tunable output emissions.

### Non-Mechanical Beam Steering

Develop non-mechanical beam steering technologies that will allow coherent energy spanning multiple bands of the UV, VIS, NIR, SWIR, MWIR, and LWIR spectrum to be directed in a low divergence beam with minimal or no side lobes over an angular range covering not less than 120-degrees conical (threshold) up to a complete hemisphere (objective).

### Innovative EW Concepts

Explore truly innovative concepts in the EW areas of ES, EA, or EP which could fundamentally change the way naval forces conduct EW Operations.