Special Notice 14-SN-0016
Special Program Announcement for 2014 Office of Naval Research
Research Opportunity:
"Reactive Composite Material (RCM) Optimization and Lethality"

I. INTRODUCTION

This announcement describes an Applied Research Challenge (ARC) topic entitled "Reactive Composite Material (RCM) Optimization and Lethality," to be launched under the ONRBAA14-001, Long Range Broad Agency Announcement for Navy and Marine Corps Science and Technology which can be found at http://www.onr.navy.mil/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements.aspx. The research opportunity described in this announcement specifically falls under numbered paragraph 2 of the "Naval Air Warfare and Weapons (Code 35)" sub-section. The submission of proposals, their evaluation and the placement of contracts will be carried out as described in that Broad Agency Announcement.

This announcement is being initially released under the current Long Range BAA numbered ONRBAA14-001 in order to allow sufficient time for all interested parties to submit white papers prior to full proposals. It is expected that proposals will be received under the anticipated new Long Range BAA numbered ONRBAA15-001, which is expected to be released in late September 2014 since the requested submission date for proposals is after the expiration of the current Long Range BAA numbered ONRBAA14-001. The requirements of proposal submission, evaluation and award of any resulting contracts will ultimately be subject to ONRBAA15-001. Potential Offerors may review the current Long Range BAA numbered ONR BAA14-001 to get a general understanding of what the proposal requirements may be in the anticipated follow-on Long Range BAA numbered ONRBAA15-001.

The purpose of this announcement is to focus attention of the scientific community on (1) the area to be studied, (2) industry day, for dialogue amongst those interested in this area, and (3) the planned timetable for the submission of white papers and proposals.

II. TOPIC DESCRIPTION

The proposed ARC topic will explore and exploit Reactive Composite Materials (RCM) which offers a game-changing opportunity for weapon designers. The potential to create a reactive composite with material properties that allow it to be a true "drop-in" replacement for inert warhead components will afford weapon designers unique opportunities to engage and defeat current and future targets. Current generation reactive composites provide catastrophic kills against light air, ground, and surface targets and the damage done to targets is readily apparent improving the ability to detect battle damage and reducing or eliminating the need for additional sorties to restrike a "kill". At the weapon system level, reactive composites will offer weapon designers the potential to undertake trade studies that could ease weapon targeting and guidance requirements reducing the overall system cost. Metal composite fragments will ignite fuels, oils, and propellants allowing for the deployment of reactive composite weapons against fuel depots

and supply points with catastrophic effects. This capability can be exploited against fuel laden vehicles, small boats and aircraft with similar devastating effects.

Incorporating improved RCM material properties and energy coupling mechanisms into our lethality models will allow our exploitation of this technology against appropriate targets. The enhanced energy output affords weapon designers the ability to create new classes of smaller, lighter weapons while maintaining or improving lethality. These weapons are uniquely suited for smaller platforms such as UAVs and increasing weapon load outs. Warheads utilizing reactive composites will by design have reduced collateral damage as reactive fragments do not pass through targets, but break-up and deliver their energy within the target.

The ability to increase the RCM energy density while maintaining or increasing energy release effectiveness will allow the engagement of more advanced targets (complex hardened constructions, light armor). An improved understanding of how to manipulate the material properties and energy release characteristics of reactive composites could allow for the insertion of this technology in other classes of weapons – ballistic projectiles, shaped charge warheads with as yet unknown effects. Linking these insights to an improved lethality model will maximize future transition investment opportunities and weapon selection.

Background:

This Applied Research Challenge is built on previous ONR investments, which investigated the dynamic response, initiation, combustion efficiency, and material properties of reactive composite material (RCM) systems. These initial investments demonstrated that without a better understanding of the structure/properties relationships between ingredients, composition properties (particle sizes, purity, formulation, etc.), and effects of processing techniques, this Edisonian approach would fail to provide an optimum solution to this multifaceted technology problem. Recent work has shown that apparent increases in target damage do not necessarily translate into increased predicted lethality. Improved understanding of the RCM/target relationships will result in reduced development times and provide the material science needed to design composites with either specific or generic ordnance application potential.

RCM has demonstrated increased levels of damage to a variety of tactical targets. However, the ability to translate increased damage into enhanced lethality – a higher probability of kill (P_K) is hindered by inadequacies with the model and a lack of insight into which target classes are most impacted by RCM technology application. Initial technology transition efforts unfortunately have focused on engagements where significant improvements are not possible over the existing weapon system design.

Current inert metal fragments derive their effectiveness from kinetic energy (KE) that causes damage to targets by penetration, perforation, and direct impact. RCMs are blends of metals, metal oxides, intermetallics, and/or polymers, which are consolidated and formed into a composite warhead case or discrete composite fragments. RCM fragments penetrate the target, pulverize, and rapidly release chemical energy through oxidative combustion. The use of RCM is predicated on increasing the lethality over inert materials by the release of chemical energy in

addition to kinetic energy. Chemical energy released by a reactive composite produces high-temperature products that can ignite combustible material and produce overpressure effects that promote area damage within targets. The rapid metal oxidation from a self-contained prompt reaction within the target produces a regional shock wave similar to an explosive event. Figure 1 shows an example of a typical fragment projectile impacting an anvil in an instrumented pressure chamber. It indicates a "prompt" energy release followed by a longer lasting "quasi-static" (Q-S) or afterburn pressure increase.

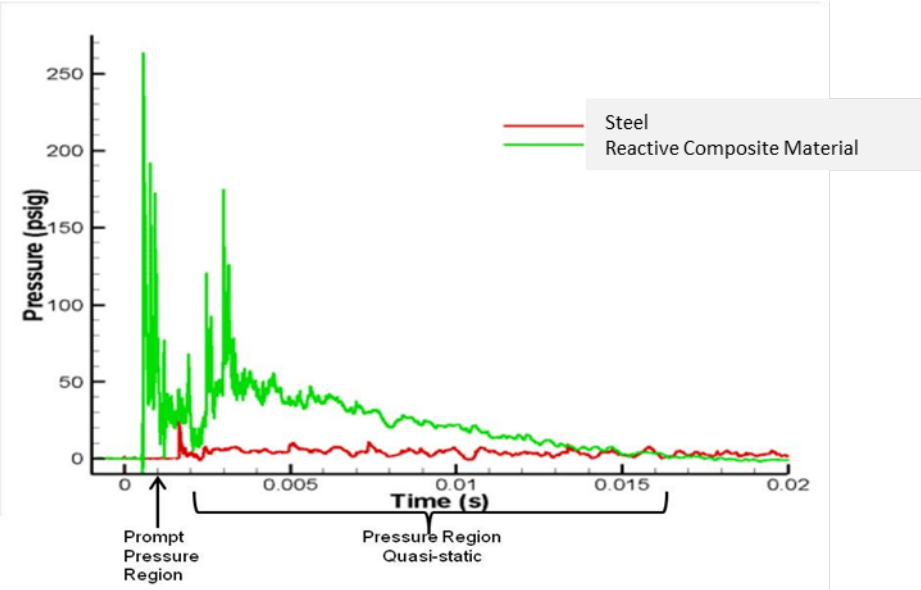

FIGURE 1. TYPICAL PLOT OF THE ENERGY RELEASE IN A COMBUSTION CHAMBER COMPARED TO THE ENERGY RELEASE OF A STEEL FRAGMENT OF THE SAME MASS

First generation reactive composites were composed of low density metal powders and polymers which were blended, pressed, sintered and machined to generate individual fragments. Their effectiveness was limited due to their low density and poor material properties which resulted in volumetrically large fragments that were only marginally capable of being explosively launched and were ineffective against light skinned targets due to their low probability of target hit. Additionally, they required relatively high impact velocities to obtain efficient combustion.

The current generation of RCM is produced from blended metal powders to produce dense metal components capable of being formed into cylindrical cases, and other generic case designs. The metal/metal RCM are non-explosive compositions. Once consolidated, they are insensitive to normal stimuli and can be classified for shipping and storage as flammable solids rather than explosives. The current class of metal/metal composites exhibit near-steel density, material properties sufficient to survive explosive launch, fragment creation, and steel plate penetration up to the thickness of the fragment. These metal/metal reactives combust and deliver energy at lower impact velocities than the earlier generation of reactive materials.

Our lethality modeling capability for RCM–based fragments and weapon systems is based on work done over a decade ago under the Reactive Material Enhanced Warhead ATD and has not kept pace with our ability to manipulate RCM properties to effect changes in how they respond and release energy when launched and engaging a target. The modeling tools reflect the first generation of RCM and do not allow for easy or accurate manipulation of RCM mechanical or energy release properties. While these models can efficiently discriminate between inert materials such as steel and tungsten at differing fragment sizes, they are inadequate for looking at RCM variations; such as compositions, material properties, and energy release characteristics.

The major obstacle to achieving total theoretical energy output is directly related to the numerous factors that must be optimized to provide predictable, reproducible, maximum combustion efficiencies as a function of impact velocity. Figure 2 shows representative factors that influence oxidative combustion efficiencies of metal/metal composite materials.

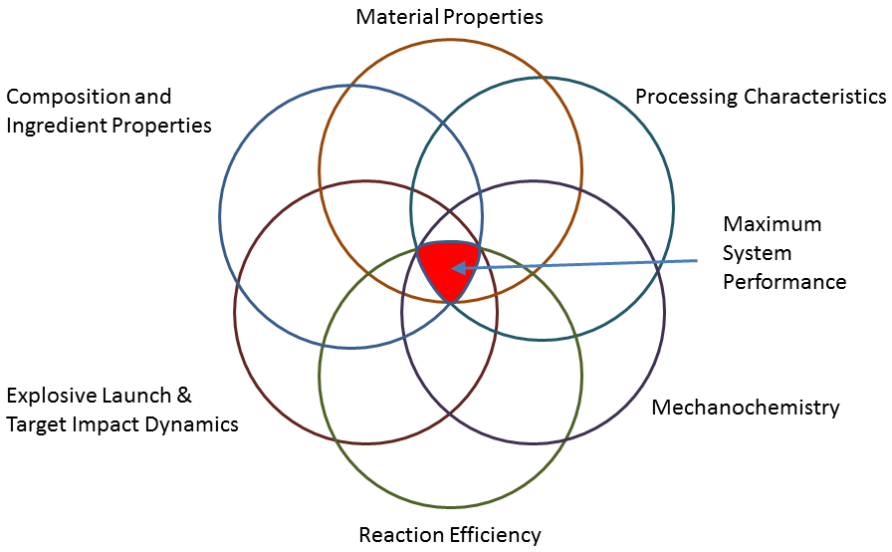

FIGURE 2. TYPICAL FACTORS WHICH INFLUENCE COMBUSITION EFFICIENCY IN METAL/METAL COMPOSITE MATERIALS

Material properties as well as their history and processing characteristics play a significant role in the final oxidative combustion behavior. A central technology challenge is that micron-sized metal powders typically exhibit reduced oxidation energy content and reactivity as their density increases. This program will exploit recent gains in our understanding of how ingredient pre-processing and formulation design can affect the metal/metal composite's energy release characteristics. Investigations will focus on developing structure property relationships between fracture characteristics of metal/metal composites and their combustion efficiencies under dynamic shock loading. A goal is to be able to predict how material property variations affect the energy release response of metal/metal composites. The ultimate goal of the applied research challenge is to extend ONR's RCM foundational work, enhancing measured energy density outputs at lower velocities and linking RCM structure property relationships to Lethality Modeling.

Objective:

The Office of Naval Research (ONR) is interested in receiving proposals, which define applied research programs focused on coupling tailored launch, penetration, and break-up characteristics of current and future Reactive Composite Materials (RCM) with existing and future predictive lethality models. This effort will provide and validate maximum RCM energy generation within a target's structure and provide much needed improvements in how RCM damage mechanisms will be incorporated and assessed within current lethality tools. Improving our modeling tools to more accurately predict RCM lethality (P_K) for specific applications and specific reactive composite material compositions against targets of interest will be one of the major outputs of this ARC.

Program success will hinge on exploring the material property relationships, which control energy release efficiency with improvements in lethality modeling under dynamic shock conditions. The ability to predict composite material launch survivability, penetration efficiency and combustion energy outputs, from known or measured physical properties will be defined and validated. Improved understanding of how RCM interact with and couple energy into a target will be used to improve Fast Air Target Encounter Penetration Model (FATEPEN) which is used to predict weapon system lethality. This initiative will require a multi-disciplinary applied research initiative focusing on physics, chemistry, materials science and statistics.

The metrics against which the success of this ARC will be measured are shown below.

METRIC	BASE	OPTION
1) Lethality Models	Ability to input unique RCM Properties and Energy Release Data	Ability to Predict Weapon/Target Sets for Notional RCM
2a) Measured Energy Density	1.5 kcal/g	2.0 kcal/g
2b) Energy Release	80 % Combustion Efficiency Within 10 msec	90% Combustion Efficiency Within 500 µsec
3a) Explosive Launch Survivability	6,000 ft/sec	8,000 ft/sec
3b) Mechanical Property/ Target Penetration	Determine Energy Release for Baseline RCM as a function of material strength, target impact velocity and target impact surface to include single/multi-layer targets of various thicknesses and materials to include residual fragment velocity and break-up characteristics	Determine Energy Release for Higher Density RCM (up to 15 g/cc) as a function of material strength, target impact velocity and target impact surface to include single/multi-layer targets of various thicknesses and materials to include residual fragment velocity and break-up characteristics

Understanding the relationship between RCM material properties and how they penetrate into a target is not well understood. The responses of various metals used in warhead construction launched against targets of different thicknesses/materials/complexity have been incorporated into FATEPEN over the decades. However, our knowledge of how RCM responds when explosively launched at a target is very limited. To better understand the dynamic response of RCM to explosive launch and target impact requires a series of tests to capture data similar to that available for inert materials. Initial samples of higher strength and density RCM has resulted in fragments that easily penetrate the target, do not easily fracture, and result in reduced energy release efficiencies. Understanding how RCM respond under dynamic loading will guide appropriate material composition design and selection. These properties must be linked to lethality model calculations which accurately reflect measured experimental inputs.

Using ingredient pre-processing and formulation consolidation techniques to alter material properties, will provide inputs on how tensile strength and fracture toughness can be manipulated to produce a reactive composite of superior strength that will reliably and repeatedly launch and penetrate targets of interest. The metrics for the base program will provide materials that, based on lethality model calculation, will provide increase P_K for specific weapon system/target set combinations. These RCMs will afford weapon designers a range of materials and tools to assess their potential as replacements for inert construction materials. The option goals will result in weapons capable of engaging and defeating advanced hardened and complex targets that typically evade easy attack by conventional fragmenting warheads. Again, coupled with the increased energy density above, these materials will allow weapon designers to exploit their unique capabilities to engage and defeat numerous existing and future targets.

III. INDUSTRY DAY

ONR will hold a classified industry day on Tuesday, 19 August 2014 at 9:00 AM at QINETIQ North America, 4100 N. Fairfax Street, Suite 800, Arlington, VA 22203. There is no registration fee for participation. The purpose of the meeting will be to provide potential offerors with a better understanding of the scope and objectives for the ONR Reactive Composite Material (RCM) Optimization and Lethality Applied Research Challenge. The briefing will be held at 9:00 AM Eastern Standard Time (EST) with check-in beginning at 8:30 AM (EST). All attendees are required to pre-register at the ONR online registrations site https://www.onlineregistrationcenter.com/ARCIndustryDay by 5:00 PM (EST) on Tuesday, 12 August 2014. Please follow the directions on the registration web page for passing your security clearance information; **WALK-IN REGISTRATION WILL NOT BE PERMITTED.** If requested attendance exceeds capacity, it may be necessary to limit the number of attendees from each contractor, and organizations will be so notified. ONR will reply via email on or before Wednesday, 13 August 2014 to those parties who plan on attending the briefing with the specific directions, schedule, and any other appropriate information. Briefing slides can be provided by secure means to potential offerors not able to attend.

IV. WHITE PAPER SUBMISSION

Although not required, white papers are strongly encouraged for all offerors seeking funding. Each white paper will be evaluated by the Government to determine whether the technology advancement proposed appears to be of particular value to the Department of the Navy. Initial Government evaluations and feedback will be issued via e-mail notification from the Technical Point of Contact. The initial white paper appraisal is intended to give entities a sense of whether their concepts are likely to be funded.

Detailed Full Proposal (Technical and Cost volumes) will be subsequently encouraged from those Offerors whose proposed technologies have been identified through the above referenced e-mail as being of "particular value" to the Government. However, any such encouragement does not assure a subsequent award. Full Proposals may also be submitted by any offeror whose white paper was not identified as being of particular value to the Government or any offeror who did not submit a white paper.

For white papers that propose efforts that are considered of particular value to the Navy but either exceed available budgets or contain certain tasks or applications that are not desired by the Navy, ONR may suggest a full proposal with reduced effort to fit within expected available budgets or an effort that refocuses the tasks or application of the technology to maximize the benefit to the Navy.

White papers should not exceed four (4) single-sided pages, exclusive of cover page and resume of principal investigator, and should be in 12-point Times New Roman font with margins not less than one (1) inch. White papers shall be in Adobe PDF format (preferred) or in Microsoft Word format compatible with MS Office 2010.

The cover page should be labeled "White Paper for ONR 2014 Research Opportunity: Reactive Composite Material (RCM) Optimization and Lethality" and include the following information: title of the proposed effort, technical point of contact, telephone number, fax numbers, and e-mail address.

The 4-page body of the white paper should include the following information:

(1) Principal Investigator;
(2) Relevance of the proposed effort to the research areas described in Section II;
(3) Technical objective of the proposed effort;
(4) Technical approach that will be pursued to meet the objective;
(5) A summary of recent relevant technical breakthroughs; and
(6) A funding plan showing requested funding per fiscal year.

A resume of the principal investigator, not to exceed 1 page, should also be included after the 4-page body of the white paper.

To ensure full, timely consideration for funding, white papers should be submitted no later than Tuesday, 09 September 2014. White papers received after that date will be considered as time and availability of funding permit.

The planned date for completing the review and notification of valuation is Friday, 03 October 2014.

V. FULL PROPOSAL SUBMISSION AND AWARD INFORMATION

Full proposals should be submitted under ONRBAA15-001 if issued by Friday, 31 October 2014. Full Proposals received after that date will be considered as time and availability of funding permit.

ONR anticipates that only contracts will be issued for this effort.

Full proposals for contracts should be submitted in accordance with the anticipated Long Range BAA numbered ONRBAA15-001 instructions at Section IV, Application and Submission Information, item 2.b, Full Proposals and item 6, Submission of Full Proposals for Contracts, Cooperative Agreements, and Other Transactions. Until the anticipated ONRBAA15-001 is released, Offerors may refer to the same sections under current Long Range BAA numbered ONRBAA14-001 for an example of the submission instructions likely to be included in the anticipated ONR BAA 15-001. The Technical Proposal/Content shall be single spaced and not exceed fifteen (15) pages. The cover page, resumes, bibliographies, and table of contents are excluded in the page count. For contract proposal submission, one (1) electronic submission on CD-ROM is requested.

ONR plans to fund one (1) to two (2) individual awards with a value of $250,000 to $1,250,000 per year, using applied research funds. However, lower and higher cost proposals will be considered.

The period of performance for projects may be up to two (2) years with two additional one year options.

Although ONR expects the above described program plan to be executed, ONR reserves the right to make changes including making no awards or more than two awards.

Funding decisions should be made by Friday, 14 November 2014 and notification of selection of full proposals is Friday, 28 November 2014. Selected projects will have an estimated award date of on or about Tuesday, 30 June 2015.

VI. SIGNIFICANT DATES AND TIMES

Event	Date	Time
Industry Day	Tuesday, 19 August 2014	9:00 AM
Registration for Industry Day	Tuesday, 12 August 2014	5:00 PM
Recommended White Paper Submission Date*	Tuesday, 09 September 2014	5:00 PM
Notification of White Paper Valuation*	Friday, 03 October 2014	
Recommended Full Proposal Submission	Friday, 31 October 2014	5:00 PM
Notification of Selection: Full Proposals *	Friday, 28 November 2014	
Awards *	Tuesday, 30 June 2015	

Note: * These are approximate dates**.**

VII. POINTS OF CONTACT

In addition to the points of contact listed in anticipated ONRBAA15-001, the specific points of contact for this announcement are listed below:

Technical Points of Contact:

Primary:
Dr. Clifford Bedford
Program Officer
clifford.bedford@navy.mil

Secondary:
Mr. Matthew Beyard
Program Officer
matthew.beyard@navy.mil

Business Point of Contact:

Ms. Jennifer Brown
Senior Contracting Officer
jennifer.brown4@navy.mil

VIII. ADDRESS FOR THE SUBMISSION OF WHITE PAPERS AND FULL PROPOSALS FOR CONTRACTS

Unclassified White Papers should be submitted by email to the Technical Points of Contact listed above. Files exceeding 10MB in size should not be emailed, but instead transmitted via a file transfer service, for example AMRDEC SAFE Site, https://safe.amrdec.army.mil, or mailed on CD-ROM or DVD to the address for the Primary Point of Contact noted in the box below.

Unclassified full proposals and all supporting documentation should be submitted on DVD or CD-ROM, and should be sent to the Primary Point of Contact at Office of Naval Research using the following address:

Primary Point of Contact	Secondary Point of Contact
Office of Naval Research Attn: Clifford Bedford ONR Department Code 351 875 North Randolph Street – Suite 1133 Arlington, VA 22203-1995	Office of Naval Research Attn: Matthew Beyard ONR Department Code 351 875 North Randolph Street – Suite 1143B Arlington, VA 22203-1995

Classified White Papers and Full Proposals shall be submitted directly to the attention of ONR's Document Control Unit at the following address:

OUTSIDE ENVELOPE (no classification marking):

Office of Naval Research
Document Control Unit
ONR Code 43
875 North Randolph Street
Arlington, VA 22203-1995

The inner wrapper of the classified proposal should be addressed to the attention of Dr. Clifford Bedford, ONR Code 351 and marked in the following manner:

INNER ENVELOPE (stamped with the overall classification of the material)

Program: Reactive Composite Material Applied Research Challenge
Office of Naval Research
Attn: Dr. Clifford Bedford
ONR Code: 351
875 North Randolph Street
Arlington, VA 22203-1995

An 'unclassified' Statement of Work (SOW) must accompany any classified proposal. For both classified and unclassified Full Proposals, a non-proprietary version of the SOW must also be submitted.

IX. SUBMISSION OF QUESTIONS

Any questions regarding this announcement must be provided to the Technical Points of Contact and/or the Business Point of Contact listed above. All questions shall be submitted in writing by electronic mail.

Answers to questions submitted in response to this Special Notice will be addressed in the form of an Amendment and will be posted to the following web pages:

- Federal Business Opportunities (FEDBIZOPPS) Webpage – https://www.fbo.gov/
- ONR Special Notice Webpage - http://www.onr.navy.mil/Contracts-Grants/Funding-Opportunities/Special-Notices.aspx

Questions regarding **White Papers or Full Proposals** should be submitted no later than (NLT) two (2) weeks before the dates recommended for receipt of White Papers and/or Full Proposals. Questions after this date may not be answered.

Questions of a security nature should be submitted to:
Diana Pacheco
Industrial Security Specialist
Office of Naval Research
Security Department, Code 43 One Liberty Center 875 N. Randolph Street Arlington, VA 22203-1995 Email Address: diana.pacheco@navy.mil
Note: All UNCLASSIFIED communications shall be submitted via email to the (TPOC) with a copy to the designated Business POC.

CLASSIFIED questions shall be handled through the ONR Security POC. Specifically, any entity wanting to ask a CLASSIFIED question shall send an email to the ONR Security POC with copy to both the TPOC and the Business POC stating that the entity would like to ask a CLASSIFIED question. DO NOT EMAIL ANY CLASSIFIED QUESTIONS. The Security POC will contact the entity and arrange for the CLASSIFED question to be asked through a secure method of communication.