

**BALLISTIC MISSILE DEFENSE ORGANIZATION (BMDO)
SMALL BUSINESS INNOVATION RESEARCH PROGRAM
Submitting Proposals**

Send Phase I proposals (six copies of the full proposal, PLUS one copy of Appendices A and B only) by US mail to:

Ballistic Missile Defense Organization
Attn: TRI/SBIR
7100 Defense Pentagon, Room 1E149
Washington, DC 20301-7100

For Administrative Help ONLY: Call 800-937-3150

For Electronic Access: 800-WIN-BMDO (BBS) or www.futron.com/bmdo/sbir.html (A Home Page/World-Wide Web)

Proposals delivered by other means (commercial delivery service or handcarry) must be delivered to Room 1D110, The Pentagon, Washington, D.C. **WARNING: Only persons with access to the interior of the Pentagon building can reach Room 1D110. Delivery to a Pentagon entrance is not sufficient.** (NOTE: Only a few courier services have access to the Pentagon.) BMDO will acknowledge receipt of proposals only if the proposal includes a self-addressed stamped envelope and a form (like Reference B) that needs only a signature by BMDO.

BMDO seeks the most innovative technology that might enable a defense against a missile in flight - lighter, faster, smarter, more reliable components. Proposers need not know details of possible BMDO systems.

BMDO seeks to invest seed-capital, to supplement private capital, in a product with a future market potential (preferably private sector) and a measurable BMDO benefit. BMDO SBIR will not further develop concepts **already mature enough to compete** for private capital or for government development funds. Phase I will show the concept feasibility and the merit of a Phase II for a prototype or at least a proof-of-principle. Phase I proposals will be judged mostly on degree of technology innovation. Phase II competition will also be judged intensely on future market potential. Phase II proposals may be submitted anytime after Phase I starts. Projects showing time sensitivity or submitted under the Fast Track will be considered for Phase II start-up funding and Phase I proposals may include a post-Phase I optional task that will permit rapid start-up if the Phase II or Fast Track application is approved. Principal Investigators who are tenured faculty are not considered primarily employed by a small firm if they receive compensation from the university while performing the SBIR contract; any waiver must be requested explicitly with a justification showing a compelling national need; BMDO expects to grant no waivers.

BMDO intends Phase I to be only an examination of the merit of the concept with an average cost under \$60,000. Although proposed cost will **not** affect selection for negotiation, contracting may be delayed if BMDO reduces the cost ceiling. **Do not** submit the same proposal (or variations) to more than one topic; each idea will be judged once in an open competition among all proposals.

Because BMDO seeks the best nation-wide experts in innovative technology, proposers may suggest technical government reviewers by enclosing a cover letter with the name, organization, address and phone number (if known), and a rationale for each suggestion. BMDO promises only to consider the suggestion.

BALLISTIC MISSILE DEFENSE ORGANIZATION TOPICS

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| BMDO97-001 | Directed Energy Concepts and Components |
| BMDO97-002 | Kinetic Energy Kill Vehicles |
| BMDO97-003 | Sensors |
| BMDO97-004 | Unit Cost Reduction |
| BMDO97-005 | Non-Nuclear Power and Power Conditioning |
| BMDO97-006 | Propulsion and Logistics |
| BMDO97-007 | Thermal Management |
| BMDO97-008 | Survivability |
| BMDO97-009 | Lethality and Vulnerability |
| BMDO97-010 | Computer Architecture, Algorithms, and Models & Simulations |
| BMDO97-011 | Optical Computing and Optical Signal Processing |
| BMDO97-012 | Structural Concepts |
| BMDO97-013 | Structural Materials |
| BMDO97-014 | Electronic Materials |
| BMDO97-015 | Superconductive Materials |
| BMDO97-016 | Surprises and Opportunities |

BMDO TOPIC DESCRIPTIONS

BMDO97-001 TITLE: **Directed Energy Concepts and Components**

DESCRIPTION: Innovative and applied research in the generation, propagation, and detection of directed energy in all forms. Dual-use systems under consideration include, but are not limited to, solid state lasers (i.e., diode lasers), chemical lasers, excimer lasers, IR/Vis/UV lasers, x-ray lasers, gamma-ray lasers, free electron lasers, quantum lasers, particle beams, radio-frequency (RF) and millimeter wave (MMW), and other unique hybrid approaches. As well as, any component or sub-component that is utilized by any of these systems. Included are such topics as beam control, target acquisition, tracking and pointing, mirrors, beam propagation and steering, optics, conversion methods, countermeasures and coatings, and micro-optical devices incorporating these aspects.

BMDO97-002 TITLE: **Kinetic Energy Kill Vehicles**

DESCRIPTION: Kinetic energy (KE) weapons candidates presently include a variety of ground and space based interceptor concepts including their propulsion sub-system components. System elements include ground-based launchers, axial and divert motors/nozzles, smart projectile components, and endo/exoatmospheric guidance and control mechanisms. Technology challenges for KE systems include: finding the booster hardbody within the plume, high performance axial and divert propulsion sub-systems (especially very low mass divert systems), miniature inertial navigation units, array image processing, C.G. Control algorithms, fast frame multicolor and ultra-violet Seekers, acquisition and track; target discrimination, seeker operational environments, lethality/miss distance; aero-optical effects, guidance and fuzing accuracy, shroud separation, window thermal-structural integrity, non-nuclear kill warhead performance, target acquisition in a hostile environment, performance and survivability of electronics in hostile environment; firing rate, projectile guidance and control and projectile launch survivability; and, common among all systems reliability; producibility, safety (non-hazardous operation), maintainability, and low cost/low mass; aeroshell ablation control; electromagnetic launches.

BMDO97-003 TITLE: **Sensors**

DESCRIPTION: Sensors and their associated systems will function as the "eyes and ears" for ballistic missile defense system, providing early warning of attack, target identification, target tracking, and kill determination. New and innovative approaches to these requirements using unconventional techniques are encouraged across a broad band of the electromagnetic spectrum, from radar to gamma-rays. Passive, active, and interactive techniques for discriminating targets from backgrounds, debris, decoys and other penetration aids are sought. Sensor-related device technology is also needed. Examples of some of the specific areas are: cryogenic coolers (open and closed systems), cryogenic heat transfer, superconducting focal plane detector arrays (for both the IR and sub-mm spectral regions), signal and data processing algorithms (for both conventional focal plane and interferometric imaging systems), low-power optical and sub-mm wave beam steering, range-doppler lidar and radar, passive focal plane imaging (long wavelength infrared to ultra-violet; novel information processing to maximize resolution while minimizing detector element densities) interferometry (both passive and with active illumination), gamma-ray detection, neutron detection, intermediate power frequency agile lasers for diffractive beam steering and remote laser induced emission spectroscopy, lightweight compact efficient fixed frequency radiation sources for space-based BMD application (uv through sub-mm wave), new optics and optical materials. Entirely new approaches are also sought. Please indicate the particular subtopic identifying letter your specific proposal/technology addresses:

BMDO97-003A - Acoustic and Seismic

BMDO97-003B - Radar and MMW

BMDO97-003C - UV (<0.3 microns)

BMDO97-003D - Visible (0.3 - 09 microns)

BMDO97-003E - IR (>0.9 microns)

BMDO97-003F - Gamma/X-Ray
BMDO97-003G - Other

BMDO97-004 TITLE: **Unit Cost Reduction**

DESCRIPTION: BMDO seeks drastically lower unit cost of components through manufacturing revolutions that will lead to high volume production from commercial sales. Thus BMDO will consider proposals that offer such a huge unit cost reduction that a heretofore purely anti-missile military technology would become a high volume commercial item. Whereas all other topics seek first and foremost a revolution in the military capability of the technology, this topic seeks only a revolution in the unit cost. BMDO seeks herein only projects that are too risky for ordinary capital investment by the private sector. The proposals must include and will be judged in part on an economic analysis of the expected market impact.

BMDO97-005 TITLE: **Non-Nuclear Power and Power Conditioning**

DESCRIPTION: New technologies for providing power which provide substantial improvements in lower recurring cost, lower mass, and/or smaller size are sought for all applications. New concepts for power sources and power conditioning devices for transportable or mobile systems at 200 kW to 1 MW also need to have high efficiency, low signatures, and high reliability. Power generation and power conditioning devices that operate at cryogenic temperatures for use in a new concept for all cryogenic systems are sought. Power conditioning devices of interest include, but are not limited to, capacitors, inductors, and switches. Space assets' power sources in the 0.5 to 5 kW power range, including solar arrays and their photovoltaic cells, need to tolerate high natural radiation levels. Satellite energy storage systems must provide cycle lifetimes up to 40,000 cycles in low earth orbit sensor satellites. Onboard power sources for interceptor missiles need to be periodically testable and have a quick start-up capability. Power conditioning systems and components for space assets should provide very high efficiency.

BMDO97-006 TITLE: **Propulsion and Logistics**

DESCRIPTION: In general, missile defense places unprecedented demands on all types of propulsion systems; launch to low earth orbit, orbit transfer, orbit maneuvering, and station keeping. Specifically, advancements are needed to achieve major reductions in the costs of placing and maintaining payloads in desired locations. Approaches leading to techniques, methods, processes, and products in support of these propulsion and logistics objectives are sought. Propulsion approaches include liquid, solid, and electric. Advancements are needed in propulsion-related areas, e.g., extending storage time of cryogenic fluids (e.g. H₂ and Xe), reduction of contamination from effluents, and sensors and controls for autonomous operation. Areas of interest include the entire spectrum of space transportation and support: efficient launch systems for small technological payloads as well as full system payloads, assembly, and control systems; expendable and recoverable components; improved structures and materials; and increased propulsion efficiency. In anticipation of solar power demonstration missions incorporating electric thrusters, BMDO seeks high power electric thruster modules (e.g., electrodes, insulators, ignition systems, propellant control, command and control system, thermal management system, and power conditioning unit). With the advent of small surveillance satellites, low power (0.5 to 2 kW) electric propulsion is being considered for station keeping and orbit transfer; for such systems emphasis is being placed on achieving higher power densities for components of the integrated system (thruster, power conditioning unit, fuel control, gimbals, and fuel storage). Low mass interceptors require advances in divert (small thrusters) propulsion systems (either solid or liquid).

BMDO97-007 TITLE: **Thermal Management**

DESCRIPTION: High power levels of various assets must dissipate heat at state-of-the-art capabilities for waste thermal energy acquisition, transport, and dissipation to space. Technology advancements are required in thermal

management for both power generation systems, space platform payloads, and all electronics. Some space platforms will require years of storage of large amounts of cryogenics with minimum cryogen loss and high cryogen delivery rates under condition of zero-g, concept and devices for all types of space-based power cycles, and can satisfy these projected space platform requirements.

BMDO97-008 TITLE: **Survivability**

DESCRIPTION: Missile defense elements must operate and survive against determined attacks. Threat actions can generate a reasonable set of hostile man-made environments before and during operations. Collateral environments and natural space environments (atomic oxygen, space radiation and micrometeorites/debris) provide additional challenges which also affect civilian assets. Survivability engineering technology is needed to achieve a cost-effective, integrated solution to a dynamic and diverse set of hostile environments with a focus toward improving aspects of threat sensing, hardening, passive defense, and camouflage, concealment and deception (CCD).

Sensors enable the defense elements to detect nuclear events, laser and radio frequency weapon attacks, and to respond appropriately. Sensors which can characterize the threat according to direction of attack, and spectral characteristics are under consideration. Technologies to enhance passive defense of missile systems, space assets, and support equipment are needed to operate against the threat support sensors, including radar, passive visible/IR sensors and seekers, and laser radar.

Passive hardening against the nuclear, laser, RF, ballistic and debris environments is needed, in addition to novel hardening technologies and approaches against the natural space environments. Sensor systems, communications antennas (RF and laser), attitude sensors, solar power, propulsion, structure and thermal control are all directly exposed to nuclear, laser, RF and debris in addition to the natural space environments. Materials and component designs which are intrinsically hard to these environments, and/or protective devices are needed, specifically with dual-use commercialization applications. A key BMD area of consideration is seeker/sensor subsystems, the components of which (baffle materials, mirrors, optics, structures, focal plane arrays, read out electronics, and processing) must survive the laser, nuclear, IR, and natural environments. Nuclear and laser hard concepts, materials, and devices for protection against unknown or agile lasers and rejection of RF energy. Structures and coatings providing appropriate thermal characteristics, stability under mechanical impulses and hardness to laser and RF radiation are needed. Processors capable of operating in unique hostile environments presented by the strategic applications while retaining full functionality are desired. Long term space (commercial and government) applications are direct beneficiaries of these advanced technology developments.

Countermeasures and integration of CCD technologies are particular useful to the operational forces and, in general, attempt to incorporate the latest military and commercial technologies to ensure an effective response to any advanced threat. A new class of weapons technologies are evolving incorporating non-lethal methods. These have a broad range of applications as a survivability countermeasure or must themselves be countered to assure full operability. The non-lethal technology efforts in this area have dual-use applications with law enforcement techniques.

BMDO97-009 TITLE: **Lethality and Vulnerability**

DESCRIPTION: A major factor in determining the effectiveness of a ballistic missile defense is the lethality of the directed energy and/or kinetic energy devices used against responsively hardened targets, bulk powder, and submunition targets. Battlefield by-products of post-intercept events are under consideration. New concepts and technologies which produce a much higher probability of hit-to-kill intercepts is required to support applications. Ground and Point-of-Intercept technologies, instrumentations, concepts, and methodologies are under consideration for cost effective incorporation into lethality efforts. Additionally, novel concepts and techniques which reduce the vulnerability of BMD systems will increase the operational confidence level of dedicated assets. Commercial applications may benefit from the incorporation of the techniques utilized in cost-reduction, measurement and diagnostics, and meteorology instrumentation packages.

BMDO97-010

TITLE: **Computer Architecture, Algorithms, and Models & Simulations**

DESCRIPTION: Missile defense systems for battle management demand order-of-magnitude advances. A system must acquire and track thousands of objects with hundreds of networked sensors and data processors, direct weaponry to intercept targets, and determine the degree of kill. Areas of interest are:

- New computer architectures which are robust, compact, and fault-tolerant, but allow for the extremely rapid processing of data. Architectures may be implemented by new designs or innovative applications of existing technologies, such as optical signal processing, systolic arrays, neural networks, etc.
- Very high-level language (VHLL) design for both the development and testing of extremely large software systems.
- Novel numerical algorithms for enhancing the speed of data processing for sensing, discrimination, and systems control. These may be specifically tailored to a particular task (for instance, the execution of a phase retrieval algorithm for interferometric imaging). Includes neural networks.
- Language design to develop code optimized for highly parallel processed architectures.
- Testing techniques that will provide a high level of confidence in the successful operation of concurrent, real-time, distributed large-scale software systems. Examples include sensitivity analysis, data flow testing, mutation testing, static concurrency analysis, and dependency analysis.
- Computer network and communications security. R&D for trusted computer systems in accordance with DoD 5200.28.STD; integration of COMPUSEC with COMSEC (DoD 5200.5).
- Self-adaptive processing and simulation. Algorithms and architectures for advanced decision making.
- Neurocomputing and Man-Machine Interface - rule-based AI and neural networks combined for decision making flexibility and system robustness; development of decision trees and information display for highly automated, short response time, training adaptive high volume scenarios.
- Software architectures for embedded computer networks that especially facilitate incremental system and software integration, hardware and software maintenance, and system evolution, without significant performance degradation.
- Hardware and software self-diagnostic capabilities for monitoring the operational readiness and performance of space and ground systems incorporating embedded computer networks.
- Virtual environments to allow diverse groups to interact in real time in increasingly realistic ways over large distances to include hostile environments definition and ground effects modeling and simulation efforts.

BMDO97-011

TITLE: **Optical Computing and Optical Signal Processing**

DESCRIPTION: Dense computing capability is sought in all architectural variations, from all optic to hybrid computers. Specific examples of areas to be addressed include, but are not limited to, high speed multiplexing, monolithic optoelectronic transmitters, holographic methods, reconfigurable interconnects, optoelectronic circuits, and

any other technology contributing to advances in intra-computer communications, optical logic gates, bistable memories, optical transistors, and power limiters. Non-linear optical materials advancements and new bistable optical device configurations.

BMDO97-012 TITLE: **Structural Concepts**

DESCRIPTION: Minimum weight structures are needed to withstand high-g loading, acoustic and thermal environment of ground based interceptors and to provide solid bases for space systems pointing and tracking. Such structures will benefit from : (1) innovative vibration control techniques, (2) innovative fabrication approaches to cut structure cost, and (3) innovative use of advanced materials and/or design approaches to minimize structure weight. For instance, techniques and experimental verification are needed for active and/or passive methods to measure and control vibrations caused by thermo-mechanical flutter, thruster firing or structure borne noise caused by on-board mechanisms. "Active" structural elements containing materials and electronics to provide predictable mechanical displacement in response to applied electrical signals are of interest. Maximization of displacement, mechanical strength, and reliability; parameter stability over extended temperature ranges; and minimization of driving voltage, power, and weight of these elements are desired. Producibility improvements for curved actuator elements, flexensional, and other integrated motion amplifiers are of interest. Fabrication approaches that provide minimum weight with reduced assembly, inspection, and scrap rates for conventional, advanced composite, and "active" structures are needed to reduce costs. Of course, clever design and material usage to reduce structure weight while maintaining or increasing capability are always desirable goals.

BMDO97-013 TITLE: **Structural Materials**

DESCRIPTION: Many of the anticipated structural advances sought in Topic 97-012 will depend on major improvements in material properties and cost effectiveness. Space structures supporting seekers and antenna must accommodate retargeting maneuvers without detrimental jitter from vibrations and thermo-mechanical flutter. Surface launched interceptors must withstand high g loads, aerothermal heating and structural vibration without compromising tracking accuracy. Lightweight materials are very beneficial for both ground and spaced based systems.

Specific goals require advanced techniques and processes that include imparting oxidation resistance and damage tolerance to composites and creating high elastic modulus composites for use over a broad range of temperatures. The following are sought: (1) innovative manufacturing methods for producing high modulus, fiber-reinforced glass, light metal (i.e., aluminum or magnesium), or resin matrix composites; (2) innovative procedures for the production of instrumentation, sensors and software for on-line process monitoring and evaluation of high modulus, fiber-reinforced composites during fabrication; (3) novel approaches to tailor fiber/matrix interfaces to maximize capability in advanced composites; (4) novel methods to cut fabrication cost of metallic and/or composite spacecraft and interceptor structures; (5) innovative tooling techniques for near-net shape production of advanced composites; (6) novel low-to-no outgassing joining/bonding techniques for advanced composites; (7) innovative surface modifications to promote wear resistance; (8) new methods for integrating instrumentation (e.g., embedded sensors) into advanced composite materials and structures; and (9) novel instrumentation for determination and telemetry of material properties and data from space. Advances are also sought in materials for optical system components, mechanical moving assemblies, and protective coatings.

BMDO97-014 TITLE: **Electronic Materials**

DESCRIPTION: The necessary advances in electronics for the many missile defense applications will require advances in electronics materials. Primary emphasis lies in advancing the capability of integrated circuits, detectors, sensors, large scale integration, radiation hardness, and all electronic components. Novel quantum-well/superlattice structures which allow the realization of unique elective properties through "band gap engineering" are sought as are new organic and polymer materials with interesting electronic characteristics. In addition, exploitation of the unique electronic properties of gallium nitride is of considerable interest. Among the many BMD electronic needs are

advances in high frequency transistor structures, solid state lasers, optical detectors, low dielectric constant packaging materials, tailored thermal conductivity, microstructural waveguides, multilayer capacitors, metallization methods for repair of conducting paths in polyceramic systems, and sol-gel processing for packaging materials.

BMDO97-015 TITLE: **Superconductive Materials**

DESCRIPTION: BMD wants to demonstrate both high temperature superconductor (HTS) and low temperature superconductor (LTS) devices to enable or improve strategic defenses. Emphasis in HTS technology is in components integrated with state-of-the-art cryoelectronics for communications systems at K- and S-bands and radar systems in the X-band power and inductive energy storage. The demonstration of HTS materials to BLIP limited detection of radiation in the optical, IR, MWIR, and LWIR bands as well as for signal processing applications is also of interest. The emphasis in LTS technology is the development and demonstration of high sensitivity detectors, digital electronics and memory enabling on-focal plane array signal processing and operating at temperature greater than 10K. Efforts should address packaging and interface issues and systems integration with cryocoolers and stored cryogenes.

BMDO97-016 TITLE: **Surprises and Opportunities**

DESCRIPTION: Since BMD is an exploration at technology's leading edge, it recognizes that surprises and opportunities may arise from creative minds. BMDO will consider proposals in other technologies where they present an unusual opportunity for BMD. The proposer should take special care to describe the technology in complete detail and why BMD would benefit from exploring its implications. Proposers should note that proposals in this topic will receive preliminary screening that may reject them as too far afield without the benefit of a full technical review received by proposals in the topics already listed. It is recommended that proposers focus their submission toward one of the specific outlined topics unless the technology proposed is truly an unquestionable innovation. This full and open call is for new technology, not for recycling of old ideas.