DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Submission of Proposals

The responsibility for carrying out the DARPA's SBIR Program rests with the Program Management Office. The DARPA Coordinator for SBIR is Bud Durand.

DARPA invites the small business community to send proposals directly to DARPA under the following address:

DARPA/PMO
Attention: Bud Durand
1400 Wilson Blvd.
Arlington, VA 22209-2308

The proposals will be processed in the Program Management Office and distributed to the appropriate technical office for evaluation and action.

DARPA has identified 38 technical topics to which small businesses may respond. A brief description of each topic is included below. The topics originated from DARPA technical offices.

INDEX

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

FY 1988 Small Business Innovation Research Topics

SB88-001 TITLE: Expendable Air Vehicles/High Altitude Balloon Technology

DESCRIPTION: DARPA is interested in exploiting balloon borne communications and surveillance capabilities. Balloons offer several unique capabilities when combined with powerful and lightweight electronics, available today. Two basic kinds of balloons are being considered. One is twenty four hour life, zero pressure balloon intended for 70,000 feet and a nominal 25 pound payload. The other is a super pressure balloon intended for one year endurance at 120,000 feet with a 50 pound payload. Any novel concept related to high altitudes balloons for military applications will be considered but several enabling techniques are specifically needed in this program.

1. Robust launching and gas handling techniques for the smaller balloon. The launch must be made by a ship at sea with minimum ship board equipment and personnel. A separate ground launch version will also be considered.
2. Novel, unique, expendable and lightweight payloads which have military applications.
3. Power generation and storage systems providing high power density.
4. Long endurance balloon vehicle concepts for balloons having a one year life at 120,000 feet.
5. Propulsors capable of operations at 120,000 feet to provide low velocity (less than 25kt) repositioning capability. Low cost and weight are critical.
6. Simulations of upper atmosphere balloon drift patterns for 24 hours at 70,000 feet and one year at 120,000 feet.

SB88-002 TITLE: Advanced Computer Architecture for Acoustic Data Procession

DESCRIPTION: The U.S. Navy utilizes both fixed and mobile arrays of hydrophones to perform passive and active acoustic detection of Soviet submarines. The processing required to detect, classify, locate, and track targets within the whole ocean area increases with the number of phones and their sensitivity. Algorithms are required to eliminate noise, to perform adaptive beamforming, and perform cross-correlation between fixed-fixed, fixed-mobile systems. In addition, new algorithms are required to integrate information received from both air assets (such as helicopters dipping sonobuoy), surface ships, and underwater vessels as well as fixed arrays. New approaches are sought to determine how to meet the real-time processing requirements for detection, classification, location, and tracking of enemy submarines using acoustic signals. It is anticipated that the investigation of potential solutions will be divided into two phases:

1. Development of new algorithms for parallel processors coupled with a theoretical assessment of the types of architectures on which the algorithm would perform best.
2. Based on the theoretical results, development and evaluation of selected algorithms on parallel processors with the most potential for performance movement in order to experimentally verify the utility of the new algorithms.

SB88-003 TITLE: Lightweight Synthetic Aperture Radar (SAR) Concepts

DESCRIPTION: SAR concepts appropriate for use in all satellites and aircraft are of interest for navel applications. These systems must be relatively inexpensive and capable of detecting all modulations of the ocean surface. Research should address the following areas.

1. SAR hardware technology for all lightweight systems.
2. SAR signal processing technologies where size and cost are critical.
3. Determination of the optimum SAR wave length for detecting modulations of the ocean surface.

SB88-004 TITLE: Mapping Expert Systems to VLSI/Wafer Scale Technology

DESCRIPTION: Considerable effort has been devoted by DARPA and the services to the development of various expert system shells and AI technologies over the past decade. Many of these technologies are well enough understood that the basic “shell” technology or underlying algorithm can be implemented as an application specific integrated circuit (ASIC). In order to achieve performance gains as well as reduce the size of the supporting hardware so that it may be embedded in operational military systems, these algorithms can be mapped onto VLSI or after-scale chips. Because much of the technology for supporting expert systems or AI algorithms is very dynamic, this will require new design features and characteristics and the trade-off of performance, number of rules, flexibility of the algorithm, etc. New approaches are sought to developing ASICs using AI technology for embedding in operational military systems. It is anticipated that the investigation of candidate systems would be divided into two phases:

1. A conceptual design for mapping specific AI algorithms or expert system technology onto ASICs, including a theoretical assessment of performance gains, analysis of design tradeoffs, and technical feasibility.
2. Based on the successful theoretical results and potential benefit, fabricate prototype chips, and demonstrate and evaluate these chips on a military problem, in an experimental system.

SB88-005 TITLE: Expendable Ocean Optical Measurement Devices

DESCRIPTION: The optical properties of the ocean are of interest to the Navy. These properties must be measured over large ocean areas to support several programs. One approach is to deploy large numbers of expendable optical sensors from aircraft. Cost, therefore, is a major consideration which will require innovative techniques in order to be mass produced inexpensively. Measurements of absorption backscatter and temperature to a depth of 400 feet are of principle interest. Ideas for accomplishing the data collection are also of interest.

SB88-006 TITLE: Acoustic Propagation Models and VLSI

DESCRIPTION: As acoustic signals propagate through water, they encounter conditions which lead to multiple reflections, interference, noise, and attenuation of the original signal. Some of these effects can be eliminated or reduced using propagation models. However, the granularity required to make these models useful requires large data sets and very intensive numeric computations. Current algorithms exceed the capabilities of most commercial processors for 2-D; very few 3-D algorithms can be run. New parallel processing architectures offer potential promise for developing new versions of these algorithms which will be provide significant performance gains. Several factors may be traded off including the data set size, dimensionality and granularity of the algorithm, and speed of execution. New VLSI technology offers potential promise for improving performance of current algorithms by mapping them onto VLSI chips. Several factors may be traded off including chip size, data manipulation requirements, data flow to/from the chip.

New approaches are sought to develop acoustic propagation model algorithms which can yield performance gains of the order of 100-1000 times by mapping them onto parallel processors or VLSI chips. It is anticipated that investigations of candidate algorithms will be divided into two phases:

1. Conceptual design (including simulation) of the algorithm for a parallel processor (or for mapping onto a VLSI chip) with a theoretical and analytical assessment of the performance gains and feasibility based on existing environmental and experimental data.
2. Based on successful theoretical results, implement and demonstrate the algorithm on a parallel processor or fabricate a prototype chip, and demonstrate and evaluate the chip in an experimental setting.

SB88-007 TITLE: Innovative Concepts for Oxygen Extraction

DESCRIPTION: DARPA is pursuing a program to extract dissolved oxygen from seawater for a number of naval and other potential applications. We solicit innovative technology that can either assist the biologically-based approach we are currently pursuing, or offer alternatives to it. Concepts proposed must show potential for efficient and compact systems or show potential ways to improve the present program.

SB88-008 TITLE: Optical Scattering Layers in the Oceans

DESCRIPTION: The DARPA is interested in a survey of available oceanographic data which can be used to characterize optical scattering layers in the ocean. The data must determine the likelihood of encountering a well defined, stratified optical scattering layer across the world's oceans within 300 feet of the surface. If existing data can be processed to acquire this information, a detailed follow on study effort will be considered.

SB88-009 TITLE: Innovative Micro-Computer Based Graphical Displays for Seismic Array Processing

DESCRIPTION: New approaches are sought for displaying data from seismic arrays and/or milti-sensor stations that are able to provide a comprehensible estimate of the Azimuth and velocities of the individual phases which are contained in a seismic event. These approaches are expected to be implemented using modern, graphics-assisted computational techniques and are expected to lead to significant advances in analyst productivity in terms of the seismic monitoring of nuclear explosions. Effort should address both the implementation aspects of the approach and how the approach satisfies the need for increased analyst productivity in detecting and locating seismic events. Technologies and areas of high quality waveform graphics and workstations should be exploited in these efforts.

SB88-010 TITLE: Statistical Procedures for Determining Compliance with Yield Threshold Nuclear Test Limitations

DESCRIPTION: The Threshold Test Ban Treaty (TTBT) is an agreement between the US and the USSR to not detonate a nuclear explosion over 150 kilotons. The principal evidence for compliance consists of yield estimates determined by seismic means. There is a systematic unknown bias in these yield estimates, as well as an element of independent uncertainty from event to event. Although the bias is unknown it is thought to lie within specified bounds.

The problem is to develop statistical techniques which will lead to sound and powerful judgments as to compliance. It is desired to make judgments not only on individual events but also on the complete set of observed yield estimates at any time.

SB88-011 TITLE: Innovative Deposition Techniques for Durable Optical Coatings

DESCRIPTION: Optical coatings are applied to most high-quality optical components in order to eliminate front-surface reflection, boost the reflection, or otherwise modify the spectral reflectance/transmission characteristics of the component. Typically the coating is applied using the technique of evaporative vacuum deposition. In the design of thin flames, individual layers are assumed to be continuous and homogenous. However, resulting film layers are assumed to be porous and nonuniform. Advances in electron microscopy have revealed that optical thin films produced by evaporation are strongly columnar in nature with voids between the columns. This microstructure determines the optical and physical properties of the film. Interference filters often "drift" in time due to the absorption of water vapor into the voids of the microstructure, resulting in a shift of the apparent index of refraction of the structure. Coating hardness and durability are also degraded due to the microstructure.

Current research has investigated modification to traditional deposition techniques in order to decrease the void volume with a corresponding increase in packing density. One technique that has achieved considerable improvement in film performance is ion bombardment of the coating during deposition. However, this techniques would be difficult to implement for coating target optical structures. New approaches for coating deposition are sought to solve the problems discussed above.

Research proposed should be limited to a basic analysis of innovative deposition techniques. The theory of the technique should be well developed with an emphasis on describing basic experimental research which would demonstrate the applicability of the technique to various coating requirements.

SB88-012 TITLE: Integrated Optical Polishing/Coating Techniques

DESCRIPTION: Current commercial optical coating techniques rely on the vacuum deposition of film materials onto optical substrates (e.g. glass plates, mirrors, polished lenses). The coatings are required to modify the spectral reflectance/transmittance properties of the finished optical component. For most quality components, these optical coatings are critical to the final optical performance. However, the polishing process necessary to obtain the required optical figure and the optical coating process are usually accomplished in separate facilities and are often in conflict.

The optical polishing process is macroscopic in nature; that is, the final figure specification is given in terms of macroscopic surface smoothness. The microscopic process of the interaction of the polishing compound and the surface material is not an issue. On the other hand, vacuum deposition techniques require a uniform substrate surface free of surface defects. The presence of even a few defect sites profoundly effects the microstructure of the resulting film.

Innovative techniques are sought which would integrate the polishing and coating processes. The proposed effort should begin with the definition of an integrated polishing/coating technique. An initial experimental effort would be used to demonstrate the validity of the proposed technique.

SB88-013 TITLE: Processing Algorithms for Sensor Fusion in Visible/IR/Radar

DESCRIPTION: A great deal of research has been conducted in the area of fusion of data from sensors operating in different spectral regions (e.g. infrared and radar imagery). The goal is to demonstrate the synergism that would result from the combination of information from dissimilar spectral regions. Recent improvements in imaging radars together with shape and Doppler information provided by laser radars have increased interest in sensor fusion work. However, reality has not lived up to expectations. It is difficult to register scenes from separate sensors, which further might be mounted on separate platforms. The sensors often have different fields-of-view and different resolutions; the platforms often operate at different altitudes and velocities. Existing processing algorithms are unable to compensate for these difficulties.

Innovative techniques are sought to overcome the problems described above. Proposals should focus on the description of new processing techniques. The initial investigation will include an analytical assessment of the technique based on existing experimental data. The proposal should include possible demonstrations of the technique in a laboratory environment.

SB88-014 TITLE: Innovative Sensors for Detection of Relocatable Targets

DESCRIPTION: The Strategic Technology Office of the Defense Advanced Research Projects Agency (DARPA/STO) is investigating the technology for detecting and identifying strategic targets which are capable of relocating on a frequent basis. Examples of this category of targets are rail-mobile and road-mobile intercontinental ballistic missiles. Current target acquisition systems are often based on target emission/reflections using visible, infrared or radar portions of the spectrum. The ability of the target to move stresses the capability of existing sensors and associated processor technologies. In addition, detection capability is further degraded if the target is located in a cluttered environment and employs active deception and denial techniques (e.g. camouflage).

DARPA/STO is interested in innovative techniques for detecting and identifying relocatable targets. Possible approaches may take advantage of other regions in the electromagnetic spectrum, of unique signature phenomenology of man-made versus natural objects, of innovative sensor designs, or of innovative sensor processing technology. It is anticipated that the investigation of innovative concepts would be divided into two phases:

1. Concept definition and analysis. The analysis will include theoretical development based on physical principals as well as an analytical assessment of available experimental data.

2. Based upon successful conceptual analysis, a laboratory demonstration will be developed to verify the technical approach.

SB88-015 TITLE: Low Observable Technology for Infrared Suppression

DESCRIPTION: A technology base is required that will allow the suppression of infrared signatures that contribute to aircraft detection or missile guidance against aircraft. Techniques to cool propulsion systems or airframe parts, inherently cool propulsion systems, materials and coatings with reduced propulsion systems, materials and coatings with reduced emissivity or which can deflect aircraft radiance, or techniques to modify plume signatures are all of interest. Also, infrared control techniques and materials which can synergistically support radar and/or optical control signature control requirements are of interest.

SB88-016 TITLE: Advanced Short Take-off/Vertical Landing Aircraft (ASTOVL) Technology

DESCRIPTION: Recent technological advances in high thrust to weight engines, composites aircraft structures, computer integration of flight/propulsion controls, and computation fluid dynamics have indicated that various concepts for ASTOVL aircraft may be feasible in the next decade. Several common technologies to all ASTOVL concepts need further investigation e.g., hot gas reingestion (computer modeling scaling laws, nozzle geometry); Fan Air Collection, valves, ducting (design code development, turning and mixing losses, low loss duct flow, etc.); Thrust Augmentation by burning (low loss, compact burner technology), Jet Plume/Aircraft Structure Interaction (analytical prediction of jet plume trajectories, definition of thermal environment, Thermal/Acoustic fatigue testing of lightweight materials); Ground Erosion (code development on jet impingement and surface erosion mechanics, surface material treatments); and Integration of Flight/Propulsion controls (determine impacts on system design, innovative architecture/redundancy).

SB88-017 TITLE: Advanced Radar Cross Section Measurement Analysis

DESCRIPTION: The development of new and innovative techniques to deal with electromagnetic scattering problems are necessary in order to advance the state-of-the-art in radar cross-section control, antenna design, etc. The scope of this problem area includes:

1. Development of new algorithms for the solution of Maxwell's equations, particularly for low frequency scattering, and for 3-dimensional complex composite structures.
2. Evaluation and application of non-Von Neuman computer architectures specifically to solve electromagnetic scattering problems.
3. Interactive systems which assist the designer in evaluating different design options.
4. The application of innovative theoretical or data representations which might offer some advantage in the solution of Maxwell's equations, or might assist in the analysis and understanding of radar data.
5. Rapid software prototyping systems which could allow analysts or radar facilities to rapidly reconfigure to meet new or unanticipated requirements.
6. Innovative radar measurement and analysis techniques.

SB88-018 TITLE: Remotely Piloted Vehicle Technology

DESCRIPTION: Desires to field Remotely Piloted Vehicles (RPVs) to the Services which are highly reliable, provide increased utility and are cost effective have increased over the past few years. This situation has placed greater emphasis on achieving combinations of higher altitude, longer endurance, greater payload capacity, higher reliability and increased survivability. To achieve these more efficient cost effective systems it is necessary to exploit various technology areas and extend the state-of-the-art. New and innovative approaches are sought to enhance the capability of the RPV system. It is anticipated that investigation into candidate components, subsystems or systems would be divided into two phases. First, conceptual designs would be generated and validated through theory and analytical assessment and/or testing. Second, based on successful results of the first phase, fabrication of proof of concept designs and experimental verification of the approach would be made. Areas of intent are as follows:

1. Methods and test techniques to design and test low Reynolds number airfoils with mild stall characteristics,
2. Techniques to reduce turbulent boundary layer and separation drag,
3. Measurement of atmospheric characteristics at high altitudes (greater than 60,000 ft) and developing techniques and methods to enhance the response of air vehicles to this environment,
4. Core avionics equipment which allow better positive description, control, and relieve air traffic control problems,
5. Advanced propulsion techniques which emphasize low fuel consumption and diesel fuels.

SB88-019 TITLE: National Aero-Space Plane Technology Innovations

DESCRIPTION: The National Aero-Space Plane (NASP) program incorporates major technological advances in: high temperature, high strength, oxidation, resistant reusable materials; cryogenic fluid management; advanced turbulence and boundary layer transition modeling; ramjet/scramjet propulsion; active leading edge, nose and structural cooling and advanced high temperature instrumentation. This research task will address any of the areas with innovative new design ideas suitable for eventual incorporation in a flight research vehicle. A first phase program of design, analysis and proof of concept experimentation should be described with sufficient concept descriptions to enable comparison with other approaches. The second phase would involve large scale test and analysis.

SB88-020 TITLE: Real-Time Mission Planning System

DESCRIPTION: The planning of combat air missions for both single and multiple aircraft must consider a dynamic mission environment and a variable series of goals and threats. Missions which are planned for hours before the first flight may be altered enroute, and also new plans must be quickly adapted while refueling and rearming for the next mission. Goal selection and trajectory and waypoint determination must trade3 off the accomplishment of goals against threats, usage of expendables, winds, etc. Current concepts for mission planning have considered many algorithmic approaches, including many versions of dynamic programming, simulated annealing, and other techniques. New methods are sought for new high-speed planning systems with applications for both manned and autonomous aircraft that exploit modern computing techniques such as parallel processing, neural network processing, etc. Such approaches must consider transition to future airborne military computing systems.

SB88-021 TITLE: Material Structures for Three Dimensional Nonvolatile Mass Storage

DESCRIPTION: Parallel processors for data intensive applications, such as those involving artificial intelligence, will soon become memory limited unless major advancements can be made in the mass storage area; i.e., a replacement for magnetic/optical disks. DARPA is interested in exploring the applications of optics to the realization of a high density, nonvolatile, mass storage system capable of reading and writing data in two dimensional formats. Desirable characteristics are: density greater than 100 gigabits/cubic inch, a read speed less than 10 microseconds, a write speed less than 100 microseconds, and non-destruction of stored data upon read-out. One envisioned application would be to provide two-dimensional data fields to two-dimensional spatial light modulators for optical computing. Current research needs are in the areas of materials for three-dimensional optical storage and holographics for beam shaping. The storage media need not be homogeneous, but rather may consist of a layered structure; i.e., a buffered stack of two-dimensional storage planes.

SB88-022 TITLE: Non-Destructive Chemical/Structure Analytical Techniques for Semiconductor Surfaces and Interfaces

DESCRIPTION: Solid State devices are affected by the surface and interface properties of semiconductors at least as much as by bulk properties. However, the techniques for evaluating the physical, chemical, or electrical condition of the surface or the interface region non-destructively are generally not sensitive enough to predict possible device problems.

Techniques that advance the state-of-the-art in surface and interface evaluation of technologically significant semiconductors are being sought. Efforts should concentrate on advancing one or all of the following areas:

1) The identification of surface preparation problems that may result in residual damage.
2) The identification of impurities that may be incorporated at or near surfaces or interfaces.
3) The development of techniques that can be used as quality inspection for incoming wafers and/or as process control monitors.

In all cases the proposal should be clear on how the correlation to actual device results will be obtained.

SB88-023 TITLE: Real Time In-Situ Process Sensors for Advanced Materials and Microelectronics Manufacturing

DESCRIPTION: Emerging methodologies for control of manufacturing of complex structural and electronic materials (e.g., composites, layered electronic structures) involve the applications of Intelligent Processing strategies based upon artificial intelligence (AI) techniques which integrate sophisticated process models, laboratory scientist and factory process operator knowledge including heuristics, and key in-process sensors to determine local conditions and materials response as the microstructure and chemistry evolves to final product during processing.

As related to both analytical and empirical models, such in-process sensors should enable real time determination of the state of the evolving material and allow the process control system to modify the process trajectory to achieve the desired microstructure, chemistry and final properties in the processed material. Such sensors are sought for process such as:

- MOCVD (Metal-Organic Chemical Vapor Deposition)
- Plasma Deposition Processing of Advanced Composites – Bulk Crystal Growth
- Carbonization and Graphitization of Carbon-Carbon
- Chemical Vapor Infiltration of Ceramic Composites
- Hot Isostatic Pressing of Metallic and Ceramic Powders.

SB88-024 TITLE: Coatings for Fibers in High Temperature Composite Materials

DESCRIPTION: Fiber reinforced composites are required for use in extreme environments of stress, high temperature, corrosion and impact loading. It is crucial in many cases that fibers be coated to inhibit high temperature chemical reaction with the matrix, provide the proper interfacial bond (strong/weak) with the matrix, tailor electrical properties of the composites, etc. There are a variety of techniques for coating monofilaments, or fibers in a tow. Often the coatings are not uniform in thickness, do not completely cover the fibers, and do not adhere to the fibers.

New and improved techniques for coating fibers in a tow (specifically graphite and ceramic fibers) are sought with the view of incorporating them into metallic, carbon, ceramic, and hybrid matrices. Fiber sources can be commercial or experimental. Respondents should indicate which fibers they wish to study and in which composites they could be incorporated. The characterization methods for determining coating uniformity, adherence and effects of coating on fibers mechanical properties should be discussed.

SB88-025 TITLE: High Temperature Structural Composite Material

DESCRIPTION: Composite materials, both fiber reinforces and particulate reinforced, are increased use in DOD weapons systems as the stringent requirements for stronger, stiffer structures mandate the utilization of these engineered materials. Applications include airframes, propulsion systems, missiles, rockets and components in a variety of advanced vehicles.

New approaches are sought to process and fabricate composites with anticipated use temperature of 800 C (1500 F) and above. Composites of interest include, but are not limited to:

- Ti and Nb-intermetallic matrix composites, especially aluminides of Ti and Nb.
- Oxidation inhibited carbon-carbon composites.
- Ceramic matrix composites with substantial toughness.
- Hybrid composites for special application such as low observables.

The research approach should indicate the strategy for choice of reinforcing species, and understanding of the importance of the fiber or particulate/matrix interface, particularly how this is affected by processing conditions, and how the interface will influence mechanical behavior. In addition to mechanical property evaluation, offerors are encouraged to utilize appropriate advance techniques for characterization of microstructures.

SB88-026 TITLE: Application of Distributed Systems

DESCRIPTION: Research on distributed systems has produced many interesting distributed software and hardware systems and concepts over the past few years. These include distributed data bases, distributed signal processing, distributed AI techniques, and distributed debugging. Applications of these and other similar concepts to selected military areas has already included areas such as distributed sensor nets and distributed communication networks. Other new applications of distributed systems are requested that have direct strategic or tactical defense applications. Proposals in this area should show clearly how distributed systems or components of distributed systems can improve military capabilities in the field. In each case, the essential computation as well as computational resources should be fully distributed and shown a significant advantage over a centralized approach. Proposals involving components of distributed systems should show how they contribute to the development of a distributed system. Applications may cover existing capabilities which can be carried out much more efficiently using distributed computation or, preferably, entirely new capabilities not previously possible or practical. Examples that involve only trivial cases of distributed computing or a single central nodal point are not desired.

SB88-027 TITLE: Automated Planning Systems for Battle Management or Robotics Emphasizing Adversarial Reasoning

DESCRIPTION: Most automated planners, with few exceptions, have not attempted to deal with the problem of adversaries. Exceptions include work by Lehner and Wilkins'. The classical framework for thinking about adversaries is game trees, in which my moves and my opponent's alternate. One could import this idea into planning by generating a few plans, making a copy of the temporal database for each one, then generating the opponent's counterparts as similar temporal database copies, and so forth. Unfortunately, the resulting tree would be artificial. There is no natural "move" structure to impose on real-life planning, so the time after which the enemy will react is somewhat arbitrary. Furthermore, much of what agents do is hidden from adversaries, so their reactions will be uninteresting. And, of course, it is not obvious how to find quintescent positions where a "broad evaluation function" can be applied. Still, we must find some way of thinking about how the enemy reacts to what we do. We begin by having some notion of what the enemy's plan is. To infer it, we must use plan recognition techniques. Some aspects of the enemy's plan may suggest goals (e.g., "stop this advance") to be incorporated into our plan. Other aspects (e.g., our belief that the enemy plans to shoot anything that enters a certain field of fire) get added to the "world physics."

Our plan, including our countergoals, is now formulated. It is then projected as usual, and potential problems are noted. At this phase, the enemy's actions appear as problems in the same sense that nature presents problems. An enemy field of fire is dangerous in much the same way that a forest fire is dangerous. Planning must come to a halt when it is detected that our actions will not have the desired effect, and enemy action is one way that can happen. Crudely put, the protected fact "Our troops are alive and well" can be violated. We can now apply standard planning techniques to the problem. If an enemy machine-gun installation is causing the problem, we can add steps to the plan to get rid of it. In addition, there is a special class of techniques for the enemy-action situation, revolving around the idea of deception. A full-scale solution to the problem of what other agents believe would be quite complex, but that's probably unnecessary. In most cases, all we want to do is alter our plans so that the enemy cannot tell what we are doing. All behavior is, so it is a useful tack to try to conceal it. A step up on complexity arises when we allow misleading actions, such as diversionary attacks. There may be standard methods of creating useful diversions, or it may be that this problem is too hard to tackle now.

To sum it up, the planner is looking for a "fixed point," in mathematical jargon, a stable set of beliefs about its own intentions and the enemy's, such that what it believes the enemy will do makes sense given the enemy's likely knowledge of the planner's intended actions; and the planner's intended actions make sense given the enemy's plan. There are many planning problems involving the enemy where such fixed points can be found without too much trouble. In particular, if the forces controlled by the planner are quite small compared to enemy forces, then it is unlikely that the planner's activities can affect what the enemy does, e.g., a single autonomous vehicle operating near enemy lines. It will probably treat enemy activity as a violent form of weather; get too near a storm and you are destroyed. The vehicle's actions do not themselves cause enemy activity, but are only affected by it. Of course, there are cases where the presence of the robot will give away the proximity of the entire friendly army, and change the enemy's plans drastically, but in those cases we should just treat "Avoid detection by the enemy" as a top-priority constraint on all plans, and not attempt to think about what happens if the constraint is violated. Note that another form of planning closely related to the adversarial situation is worst-case planning. Here we want to think about how well we can cope with various possible disasters. Even if there is no opponent, we can treat Nature as an opponent by assuming that just by chance she acts as if she were out to get us. This kind of planning is harder than normal adversarial planning because there is no notion of the "opponent's" plan; in principle we have to think about virtually everything that could happen in order to anticipate all disasters. Reasoning about deception is of no use in worst-case planning, because the opponent is assumed to be clairvoyant, and to always do what will damage us the most. It is difficult to see how to automate this kind of planning using current approaches. It is quite possible that in most circumstances there is no systematic way to think about the worst case; you make a few guesses about what might happen, but if the worst case actually comes to pass it will probably involve events you didn't anticipate.

SB88-028 TITLE: Algorithms for Parallel Computers

DESCRIPTION: Research in parallel computers has reached the point where the first generation of parallel systems is commercially available and the second generation is being developed. While there are many theoretical and practical results for conventional sequential computers, parallel computers present both new opportunities and challenges. Proposals are requested for the development of parallel algorithms for parallel computers, prototype implementations on a variety of systems, and the measurement and analysis of the system performance. Problems selected should be representative of the most computationally demanding in various scientific and engineering domains. The results of these projects will be used as a basis for developing better ways to develop insight in how the emerging generation of parallel computers applies to the most challenging scientific and engineering problems.

SB88-029 TITLE: High Level GaAs Design Tools

DESCRIPTION: Advances in material technology and crystal growth have made it possible to fabricate high quality, low defect Gallium Arsenide (GaAs) substrates. The resulting improvement in yield has made it possible to produce complex GaAs integrated circuits. The superior speed/power performance and the excellent radiation hardness capabilities of the GaAs technology will make VLSI possible with switching speeds many times greater than presently obtained with silicon.

To date, the design of GaAs circuits has required expert knowledge of the process and design rules. There is a need for a design methodology and technique that will allow system designers to do rapid, successful VLSI designs in GaAs for application specific integrated circuits (ASIC) rather than the few experts that are currently using GaAs. A high level design tool which is cell based using structured logic which can be integrated into existing silicon CAD systems would be valuable. The methodology would allow a designer to control short interconnect paths for high speed operation. The system should be easily adapted to any existing or readily available GaAs foundry. Results of this study must be complete enough to verify the design methodology with a specific foundry.

SB88-030 TITLE: Automated Planning Systems for Battle Management or Robotics Emphasizing Reasoning about the Future

DESCRIPTION: Strategic planning is concerned with the future. As an automated planner makes decisions, it must record them in some temporal database. Information about the actions of allies, adversaries, and nature must also be stored there. The temporal database must be an active memory, which notices "interesting" conjunctions of facts and draws "interesting" inferences. A classical database stores facts. A temporal databse stores occasions on which facts are true. A classical database draws inferences from conjunctions of facts. A temporal database must draw inferences from the overlap of occasions. This kind of inference is a type of forward chaining, drawing conclusions as soon as their premises are known. Some preliminary work on projection, defined as forward chaining through time, has been done. The work of deKleer and Brown, Forbus, and Kuipers on qualitative physics concerns itself with predicting the operation of devices with weak knowledge of their parameters. Dean has included some simple forward chaining machinery in his temporal database. However, much remains to be done. For one thing, qualitative-physics research is "too qualitative." In this paradigm, the reaction to the uncertainty caused by incomplete knowledge is to generate several different scenarios, each consistent with what is known. In some cases, a better reaction would be to use more quantitative knowledge and avoid the uncertainty.

Projection must also deal with the problem of loops. If a device oscillates, we want to notice that rather than blindly simulate it. The usual approach is to characterize the system at a course enough level that loops are easy to detect. In realistic planning, oscillations are lest likely, but loop detection is harder. Another problem that arises is that as the projection goes further into the future, there are likely to be bigger and bigger uncertainties about overlaps. We need to be able to halt the projection and resume it as further constraints make the overlap definitely present or absent. It is probably infeasible to monitor possible overlaps in arbitrary cases.

The purpose of all this machinery is for detecting bugs in plans. As the projector paints its picture, "demons" must note the existence of problems. Such demons amount to a generalized form of protection. Adding risk and uncertainty to the picture may complicate it surprisingly little. Handling them requires solving three problems: 1) Assigning probabilities to future events, or in some other way weighing risks, 2) Generating alternative scenarios given different alternative futures of varying probability, and 3) Patching plans to cope with possible events.

The first problem has remained naggingly difficulty for some time. There is much discussion in AI about the need for new models of reasoning about uncertainty, but the only really well worked-out model is Bayesian inference. Fortunately, ad hoc schemes for assigning numbers to possibilities have worked pretty well. The second problem is mostly a matter of temporal database technology. We need to be able to copy the current database and make changes to the copy corresponding to a scenario of some degree of likelihood. There needs to be several copies in existence at one time. The programming technology for managing multiple copies of this kind already exists (e.g., Dean's thesis). The only danger is that too many copies will be attempted, clogging the system.

The third problem, patching the plan, has not been addressed at all, but that's mainly because it has been neglected in the non-probabilistic case as well. Risk and uncertainty behave the same up to a point, but they diverge when the possibility of learning new information exists. For a risky situation, there is no way by definition to drive probabilities to 1 by learning more. In an uncertain one, there well may be. It is not hard to find ways of distinguishing between risk and ignorance – there is a consensus to use probability ranges instead of point estimates – but it is somewhat harder to plan to narrow the range. Many of these issues are dealt with in classical decision theory. Our collection of temporal databases may be considered equivalent to a decision tree, but there is more to it than that. The classical theory assumes that estimates of utility were to be obtained from a human decision maker. We need to reinvent utility theory for a truly autonomous agent, who must be able to compare a given risk of loss of itself against another risk of losing some other resources that it might be able to save. Such comparisons are nontrivial. Coming up with theories of utility for robots is likely to be an uncomfortable job, as well as technically tricky.

SB88-031 TITLE: New Industrial Uses for Solid State Laser Technology (One Micron, 100-1000 Watts)

DESCRIPTION: The near term goal of an active DARPA laser technology program is to develop a 1—watt average power, solid-state laser system having a total mass of less than one cubic meter. Laser pulses would be generated at one pulse per second at a wavelength of about one micron. A far term goal of this same program is to increase the average power to 1000 watts within the same size and weight. New industrial and commercial applications are sought for this technology. Typical examples include material processing and treatment, medical applications, and laser chemistry.

SB88-032 TITLE: Advanced Electro-Optic/Infrared Sensor Concepts for Increased Performance and Survivability

DESCRIPTION: New and unique ways are sought to design and fabricate electro-optic and infrared sensor components and systems for ruggedness and protection against high intensity laser and microwave radiation. Proposals should describe novel methods of engineering and fabrication, shielding, filtering, isolation, or gating which do not degrade overall sensor performance. Ideas are particularly solicited which are innovative and outside traditional hardening technology.

SB88-033 TITLE: Medium Power Microwave Radiation for "Out-of-Band" Disruption of Electronic Equipment

DESCRIPTION: Proposals are sought which offer new method of enhancing the damaging and disruptive efforts of microwaves on electronic circuitry and systems. Such schemes might depend on pulse shaping, repetition, modulation, use of multiple frequencies, spread spectrum, etc., but should not require a frequency of operation "in-band" to a particular target (such as conventional jamming or deception). Of specific interest are schemes which do not depend on high power or a detailed knowledge of the target for their effectiveness. Successful proposals will give physical or theoretical evidence of feasibility and utility.

SB88-034 TITLE: Novel Techniques to Detect and/or Neutralize Mines and Explosives

DESCRIPTION: The use of mines and hidden explosive devices has been demonstrated historically to be of major significance in both high and low intensity conflicts. Approximately twenty-five percent of all vehicles destroyed in World War II were due to mines; in Viet Nam the figure was nearly seventy percent. Current detection methods involve either manual probing or use of metal detectors. Both methods are manpower intensive and slow, and both leave human operators exposed to covering fire. Current neutralization techniques include plows, rollers, or flails attached to the front of a vehicle, and projected explosive charges. These methods are slow and vulnerable to covering projected explosive charges. These methods are slow and vulnerable to covering fire, and are rarely used until the presence of a minefield is established. A minefield protected with covering fire can be extremely difficult to breach, similarly, the use of infrequent individual mines is very difficult to counter.
The problem of detection and/or neutralization is complicated by a wide variety of mines (buried/surface-laid and metallic/non-metallic), fuzing techniques (e.g., pressure, magnetic, trip-line), and environmental conditions. It is most desirable that detection systems should be capable of operating in real time, at normal vehicular advance rates, with high detection/false target ratios, and with sufficient standoff to allow the carrying vehicle to avoid engaging a detected mine. Neutralization systems should be robust, easy to use, capable of clearing large areas at high rates, and should impose minimal logistic and manpower requirements.

Proposals in this topic area should address both analytic and experimental efforts. The analytic portion of the proposed effort should address the fundamental physics or mechanics of the proposed solution in quantitative terms, and explore variations of key parameters or assumptions. The experimental portion should perform or describe key experiments to validate and optimize the system. The proposal should describe the plan for these efforts and show how they will lead to development of a system with the desired capabilities.

SB88-035 TITLE: Novel Land Mine and Barrier Concepts and Technologies

DESCRIPTION: Mines and barriers have historically demonstrated a substantial capability to delay and disrupt maneuvering units, and to provide an important element of successful defensive tactics. Modern technology developments have the potential to improve the flexibility, ease of use, and effectiveness of mine/barrier systems, and to allow for novel uses and for engagement of new types of targets.

The purpose of this task is to explore new land mine/barrier system concepts or relevant technology development efforts which can demonstrate significant new capabilities or improvements to existing capabilities. It is expected that these efforts will be primarily analytical, however, experimental validation of key principle is strongly encouraged. Analytical efforts should include a clear statement of the intended use or application of the system, analysis of relevant threat characteristics, quantitative analysis of the system operation, effectiveness, parametric tradeoffs, comparison with existing or competing capabilities, and analysis of expected development and production costs.

SB88-036 TITLE: Neural Network Technology for Coupling Sensor System Outputs to Electrical/Mechanical Effectors

DESCRIPTION: The Defense Advanced Research Projects Agency (DARPA) has been heavily engaged in recent years in the development of technologies for various autonomous weapon systems. These technologies include sensors for day/night and all-weather conditions and Automatic Target Recognizers. Automatic Target Recognition (ATR) is a key element in a variety of autonomous weapon systems including smart munitions, target cuers for aircraft, and fire and forget missiles. More recently, ATR has emerged as an important element in advanced systems such as the Smart Weapons Program (SWP) and the Electromagnetic Gun Weapons System (EMGWS), both of which seek to apply advanced multiple sensor, ATR and Strategic Computer Technologies. In each of these systems the outputs of the sensors are directed to a high speed image processor for extraction of targets from the scene and classification. Without ATR algorithms which can function under a variety of input scene conditions, the utility of these systems is at risk. Even though considerable funds have been expended by DOD to solve this problem over the past ten years, robust and reliable ATR algorithms are still not available. Attempts have been made to combine conventional bottom-up processing with a top-down, rule-based artificial intelligence system in order to take advantage of a priori and contextual information. However, imposing top-down information at processing levels below the feature space conversion has limited its effectiveness. As a result, the top-down information is only used for consistency checks of the bottom-up conclusions. What is needed is a processing technique which permits the utilization of top-down information at all levels of processing, without a severe processing time penalty.

New approaches, involving neural networks technology, are sought to solve the ATR problem posed above and to achieve robust and reliable ATR algorithms. It is anticipated that the effort would be divided into two phases:

1. An investigation of alternative approaches to neural network technology for suitability to the ATR problem.
2. Perform evaluation of selected neural network approach(s) via computer simulation.

SB88-037 TITLE: New Superconductor Technology Applied to Advanced Infrared Sensor Arrays Development

DESCRIPTION: It was recognized at DARPA soon after its formation that infrared (IR) sensor systems exhibit a number of advantages compared to other sensor systems such as radar. With Soviet advances in methods and techniques for reducing the effectiveness of radar, the nation will have to rely increasingly on the use of IR sensor systems. Among the applications, in which IR sensor systems have been developed with varying degrees of success, are tank-mounted thermal imaging systems for navigational aids and weapon sights, helicopter-mounted thermal imaging systems for battlefield surveillance and target acquisition, fire control, man-portable thermal weapon sights, smart sensors for munitions missile seekers, threat warning for air defense, and both airborne and shipborne IR Search and Track systems for fleet defense and point defense, respectively. New applications, emphasizing the development of autonomous weapon systems will stress the performance of IR sensor systems. In practice it would be desirable to have IR sensor arrays with high responsivity and sensitivity at room temperature and enough detector elements to completely fill the field stop of the IR sensor system. However, state-of-the-art IR sensor systems employ either photon detection arrays requiring low operating temperature (liquid nitrogen and lower as the IR cutoff wavelength increases from about 10 micrometers) for high responsivity and sensitivity or thermal detection arrays operating at room temperature but at low responsivity and sensitivity. In addition, the number of detector elements in an IR sensor array is limited by the hybridization process used to couple the detector elements to the silicon multiplexer. The results of basic research reported on new high temperature superconductors indicate the potential for developing IR sensor arrays with greatly improved operating characteristics.

New approaches, involving the application of the new high temperature superconductor technology, are sought to develop IR sensor arrays with high responsivity and sensitivity at an operating temperature close to the superconducting transition temperature. It is anticipated that the effort will include:

1. Characterization of candidate superconducting material properties relevant to IR detection.
2. Fabrication of candidate IR detector test structures.
3. Measurement of candidate IR detector device properties.

SB88-038 TITLE: Advanced Superconductor Materials and Structures

DESCRIPTION: The recent discovery of high temperature metal oxide superconductors offers many new revolutionary avenues to producing advanced DOD systems components. Novel materials processing and fabrication approaches are sought to produce high temperature ceramic superconductors that can operate at or above 90 K with appropriate current carrying capabilities in forms useful for large scale and small scale applications such as computers, motors, magnets, sensors, electronic devices, etc. Materials should be characterized as to structure (x-ray diffraction, TEM, etc.), appropriate superconducting properties, composition and compositional uniformity on both the macro- and microscopic scales; these observations are to be correlated with processing conditions. Specific processing procedures leading to the formation of high temperature superconductors should include development and demonstration of a capability to fabricate such materials in at least one of the following forms: thin films; filaments or fibers; tapes; single crystal; dense monoliths; composites. Indications of how each developed form would actually be implemented in one or more of the above applications are to be included as well.

Offerors are required to indicate what materials and applications research they have already accomplished in this area. Although this announcement pertains to metal oxide superconductors, proposals will be considered on other materials systems which offer a possibility of a superconducting transition temperature at or above 90 K.