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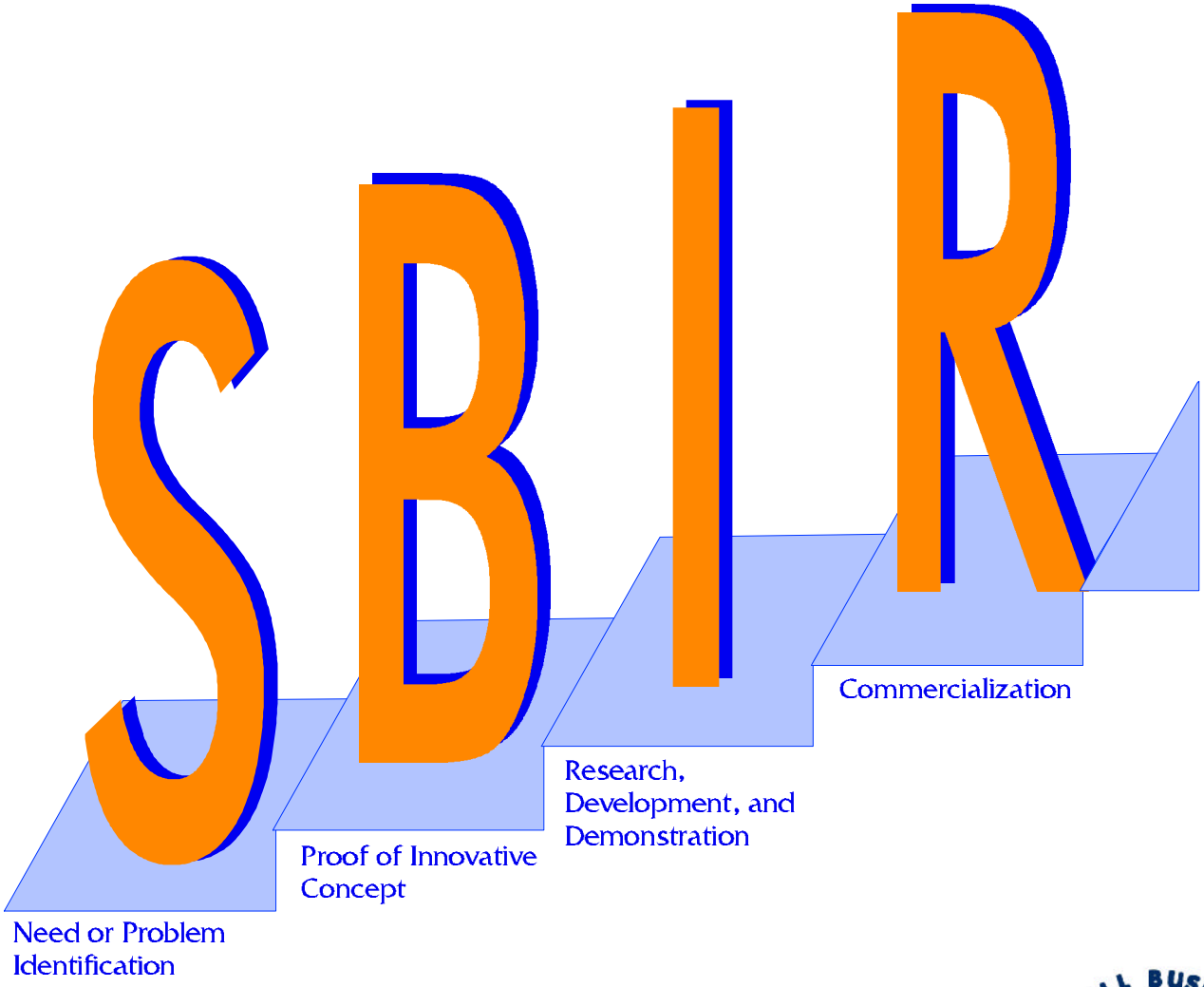
EPA's Small Business Innovation Research (SBIR) Program:

Innovative Solutions for Environmental Problems



National Center for Environmental Research and Quality Assurance

EPA's Small Business Innovation Research (SBIR) Program:

Innovative Solutions for Environmental Problems

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EPA's SBIR Program

In the Report

The SBIR Program was created by the Small Business Innovation Development Act, which was signed by the President on July 22, 1982, to strengthen the role of small enterprises in federally funded R&D and thus help the nation develop a stronger base for technical innovation.

INTRODUCTION

The Small Business Innovation Research (SBIR) Program is an important part of the Environmental Protection Agency's (EPA) research and development efforts and helps the Agency to achieve its overall mission to protect human health and the environment. Through the SBIR Program, EPA makes awards to small, high-tech firms for research and development of cutting-edge technologies. The Program is intended to spawn commercial ventures that improve our environment and quality of life, create jobs, increase productivity and economic growth, and improve the international competitiveness of the U.S. technology industry.

Over the past decade, dozens of innovative technologies and processes have emerged from this Program. A number of these have moved quickly from "proof of concept" to commercialization. In other cases, companies are still seeking the start-up capital or other support needed to achieve commercialization of their technologies.

This report describes some of the innovative technologies developed under EPA's SBIR Program. In addition, the report emphasizes:

- The accomplishments of the EPA SBIR Program over the past several years.
- The relation of the SBIR Program to the Office of Research and Development Strategic Research Plan and priorities.
- How the SBIR Program is being targeted to meet EPA's innovative technology development needs.
- How the SBIR Program is managed, including the external peer review that EPA uses to identify proposals involving high quality technical expertise and concepts with high potential for technological and commercial success.
- Descriptions of successful technologies developed under EPA's SBIR Program, and the resulting creation of U.S. and foreign sales and new jobs for skilled workers.

EPA SBIR PROGRAM ACCOMPLISHMENTS

From FY1990 to FY1995, EPA awarded 318 SBIR contracts to fund R&D at small businesses across the country. During this period, the following notable accomplishments have been achieved:

- EPA awarded 220 Phase I SBIR contracts totaling $11.8 million.
- EPA awarded 98 Phase II SBIR contracts totaling $17.6 million.
- Five companies received Phase III funding from EPA totaling $1.5 million. These contracts were funded by the Environmental Technology Initiative—a Presidential program headed by EPA to expand the development and use of innovative technologies to address environmental problems.
- An ever-increasing number of SBIR participants are succeeding in commercializing their new products and technologies. According to a recent survey conducted by ORD's National Center for Environmental Research and Quality Assurance (NCERQA), of the 98 SBIR Phase II contracts awarded by EPA from FY1990 to FY1995, 11 new innovative technologies have already been commercialized and 15 more are likely to be commercialized in the near future. This is consistent with the results of surveys conducted by the Small Business Administration and the General Accounting Office, which indi-

Three Phases of the SBIR Program

PHASE I: 6-month feasibility study

PHASE II: development of technology proven feasible in Phase I (1-2 years)

PHASE III: commercialization of the technology developed in Phase II (cannot be funded under the SBIR Program)

cated that one in four SBIR participants commercialize their technologies within 6 years of receiving their Phase II SBIR awards.

- Eleven innovative technologies funded by EPA's SBIR Program have been successfully commercialized during this 6 year period (some of which are described in Appendix A). These technologies have yielded millions of dollars in revenue for small developers, with the added benefits of creating jobs, stimulating economic growth, and enhancing U.S. competitiveness in the environmental technology industry.

- The innovative technologies and products developed under the SBIR Program are: (1) helping companies comply with increasingly stringent emissions standards, (2) allowing firms to avoid the use of toxic and hazardous materials in production processes, (3) enabling companies to recover and recycle materials for reuse, and (4) providing companies the option of selecting environmentally friendly products.

- EPA's SBIR awardees have received a number of prestigious awards in recognition of their innovation, accomplishments, and contribution to society. These awards include the R&D 100 Award, the Tibbitts Award, the Discovery Award, Popular Science's Best of What's New Award, the Lead Tech Product of the Year Award, the Governor's Award for Energy Efficiency, EPA's Outstanding Small Business Enterprise Award, the Massachusetts Small Business Innovation Research Award, and the New Englander Award.

- EPA's SBIR Program is highly competitive; therefore, only 10 percent of the small companies submitting Phase I proposals to the Agency are awardedan SBIR contract. Over the past 6 years, an average of 87 percent of the small companies receiving a Phase I award from EPA submitted a Phase II proposal. Of these companies submitting Phase II proposals, an average of 58 percent received Phase II awards (see Appendix B for information about the solicitation process and EPA's SBIR awards).

- Despite rigorous competition, hundreds of small companies from across the country have successfully won SBIR contracts. Companies in 32 different states have received SBIR awards from EPA within this 6 year period, with Colorado, Massachusetts, and California receiving the largest number of Phase I and Phase II awards. (The geographic distribution by state of the SBIR contracts awarded from FY1990 to FY1995 is provided in Appendix C.)

- To assist small companies interested in submitting an SBIR proposal to EPA in the future, NCERQA is updating a booklet that describes the entire solicitation and proposal process. In addition, NCERQA is preparing a guide to help SBIR awardees identify sources of capital and other commercialization assistance.

RELATION OF THE SBIR PROGRAM TO THE ORD STRATEGIC PLAN

During the past 2 years, ORD has transformed itself to provide better science and engineering support specifically targeted to meet the needs of EPA decisionmakers. ORD has taken a number of steps to construct a new foundation for science and research in EPA that is based on: (1) risk and ORD's ability to improve risk assessments by reducing uncertainty, and (2) ORD's ability to contribute to better and more cost-effective risk reduction.

As part of its new strategic directions, ORD has consolidated and realigned its research laboratories around the risk assessment paradigm. ORD has also made a major commit-

ment to include our nation's best scientists in EPA's research program to ensure that the science and engineering underlying the research is of the highest quality possible. Through the SBIR Program, NCERQA is tapping the talent and innovation of America's small businesses to find new, improved solutions to priority environmental problems.

Beginning in FY1997 through FY2000, EPA will set aside 2.5% of the Agency's extramural budget to fund small business R&D under the SBIR Program.

The SBIR Program is an important component of the new directions described in the ORD Strategic Plan. It is one of the many mechanisms used by ORD for accomplishing the research objectives in the plan. The research topics described in future SBIR solicitations will be derived from the topic-specific research plans that have been or are currently being developed from the ORD Strategic Plan. These plans describe the specific research that must be done to provide the information that EPA policy makers need in order to make decisions. These research plans are written by Agency-wide work groups and undergo independent peer review. By focusing the SBIR solicitation research topics on the priority areas defined in the specific research plans, the work accomplished under the SBIR Program will complement ORD's extensive intramural research program.

The six high priority areas for research listed in the ORD Strategic Plan, which will be emphasized in SBIR solicitations issued by EPA over the next few years, include:

- Drinking water disinfection
- Particulate matter
- Human health protection
- Ecosystem protection
- Endocrine disruptors
- Pollution prevention and new technologies.

Within each priority research area, the ORD Strategic Plan defines risk-based criteria that can be used to select the most important research that is needed by EPA. The criteria include the extent to which risk management options currently exist, whether new technical solutions can be efficient and cost effective, and whether other organizations are already developing needed solutions. These criteria also will guide the selection of research proposals solicited under the SBIR Program.

Other areas of high importance to ORD's research program that will continue to be part of the Agency's SBIR Program solicitation include:

- Air pollutants
- Indoor air
- Global change
- Drinking water (other than disinfection)
- Waste site risk characterization
- Waste management and site remediation.

The relationship between the research topics included in the SBIR solicitation and the ORD Strategic Plan priorities is depicted in the table on the following page.

RELATION OF THE SBIR PROGRAM TO EPA SCIENCE AND TECHNOLOGY NEEDS

The small business research community represents an excellent resource to meet EPA's priority science and technology needs. In the past, SBIR solicitations have identified general areas of research needs for various media and pollutant categories. For example, recent solicitations included the following research topics:

Relationship of SBIR Research Topics to ORD Strategic Plan Priorities	ORD STRATEGIC PLAN HIGHEST PRIORITIES						OTHER IMPORTANT RESEARCH AREAS					
	Drinking Water Disinfection	Particulate Matter	Human Health Protection	Ecosystem Protection	Endocrine Disruptors	Pollution Prevention and New Technologies	Air Pollutants	Indoor Air	Global Change	Drinking Water (other than disinfection)	Waste Site Risk Characterization	Waste Management and Site Remediation
Technologies for Prevention and Control of Air Emissions		◆	◆	◆		◆	◆		◆			
Waste Reduction/Pollution Prevention			◆	◆		◆						
Drinking Water Treatment	◆		◆							◆		
Municipal and Industrial Wastewater Treatment and Pollution Control				◆								◆
Treatment, Recycling, and Disposal of Solid Wastes, Hazardous Wastes, and Sediments				◆		◆						◆
Technologies for *In-Situ* Site Remediation of Organically Contaminated Soil, Sediments, and Groundwater				◆		◆						◆
Technologies for Treatment or Removal of Heavy Metals at Contaminated Sites				◆		◆						◆
Technologies for Prevention and Control of Indoor Air Pollution			◆			◆		◆				
Biosensors and Immunoassay for Pesticide Residue Identification and Monitoring			◆									
Wet Weather Flow Treatment and Pollution Control			◆									
Innovative Monitoring Technologies			◆	◆							◆	

- ❖ Technologies for prevention and control of air emissions
- ❖ Waste reduction/pollution prevention tech-niques
- ❖ Drinking water treatment technologies
- ❖ Technologies for municipal and industrial wastewater treatment and pollution control
- ❖ Treatment, recycling, and disposal of solid wastes, hazardous wastes, and sediments
- ❖ Technologies for *in-situ* site remediation of organically contaminated soil, sediments, and groundwater
- ❖ Technologies for treatment or removal of heavy metals at contaminated sites
- ❖ Technologies for prevention and control of indoor air pollution
- ❖ Biosensors and immunoassay for pesticide residue identification and monitoring
- ❖ Technologies for wet weather flow treatment and pollution control
- ❖ Innovative Monitoring Technologies.

The SBIR projects funded in these various categories have frequently addressed important Agency priorities. Some of these projects and the environmental significance of the resulting technologies or products are discussed in Appendix A. Information on other SBIR projects funded by EPA over the past 5 years is available on the Internet (see Appendix D for how to access this and other sources of information).

Information on EPA's SBIR Program and projects is available on the Internet at:

http://www.epa.gov/ncerqa

EPA's current science and technology needs are defined in the topic-specific research plans developed from the ORD Strategic Plan. For future SBIR solici-tations, ORD plans to focus the research topics on the priority science and technology needs identified in the research plans. In addition, ORD will seek increased involvement from the Agency's Regional and Program Offices and ORD Laboratories in identifying specific research topics to be included in upcoming SBIR solicitations.

As in previous years, all SBIR proposals will undergo external peer review and final selection will be based on the technical quality of the proposal with regard to the selection criteria defined in the solicitation. Through this review process, ORD will ensure that those projects that best fulfill the Agency's science needs and that also complement the intramural research being conducted by EPA are selected for funding under the SBIR Program.

MANAGEMENT OF THE EPA SBIR PROGRAM

The SBIR Program is authorized under the Small Business Innovation Development Act of 1982, which was intended to strengthen the role of small businesses in federally funded R&D and help develop a stronger national base for technical innovation. The Program is funded by setting aside a specific percentage of each participating agency's extramural research budget every fiscal year (FY). From FY1997 to FY2000 the set-aside percentage is 2.5 percent.

EPA's SBIR Program has three phases. Phase I investigates the scientific merit and technical feasibility of the concept; Phase II is the principal R&D effort to develop the technology proven feasible in Phase I; and Phase III is the commercialization of the technology.

EPA publishes annual solicitations for Phase I and Phase II proposals, which describe the research topics to be addressed. EPA issues its Phase I solicitation in October/November,

with proposals due into the Agency by mid-January. The Phase II solicitation is issued in the spring, with proposals due approximately 45 days after the issue date. All of the SBIR Phase I and Phase II proposals received by EPA are subjected to a rigorous external peer review process, which is coordinated by NCERQA, and awards are made by the Agency on the basis of the scientific and technical merit of the proposal.

Additional information on the management and administration of EPA's SBIR Program is provided in Appendix B.

Appendix A: SBIR Success Stories

In Appendix A

SBIR PROGRAM COMMERCIALIZATION SUCCESS STORIES

The companies featured in this section have successfully transitioned their ideas into revenue-generating products. Their success stories represent just a small part of the return on EPA's SBIR investment. The Agency applauds the success of these firms, as well as the other participants in EPA's SBIR Program.

ENOX Technologies, Inc.

ENOX Technologies, Inc., in Natick, MA, has developed a plasma combustion ignition system that assures ignition stability and complete combustion in lean-burn engines. The patented INO_x system significantly lowers combustion temperature, improves engine efficiency, reduces nitrogen oxide (NO_x) emissions, extends engine life, and reduces required engine maintenance. The INO_x system is able to ignite very lean air/fuel ratios in an open chamber cylinder design, with no engine modification or tear down. The technology produces a continuous electrical discharge at the gap of a conventional spark plug for any desired number of degrees of engine rotation. The energy delivered ensures that combustion will occur even at the leanest conditions.

Environmental Significance. The INO_x system enhances engine performance, extends engine life, reduces maintenance and energy costs, and brings the engines into compliance with requirements of the Clean Air Act Amendments (CAAA) of 1990 at a fraction of the cost of competing technologies. Under the CAAA, NO_x emissions from stationary natural gas engines were to be reduced to about 3.0 g/hp hr from 15 g/hp hr by May 31, 1995. The INO_x technology routinely reduces NO_x emissions to under 3.0 g/hp hr at rated engine load with little or no sacrifice in fuel efficiency. (Installation of the INO_x ignition system results in a 40 to 90 percent drop in NOx emissions.) This brings NOx emissions within virtually all state and federal CAAA emission limits.

Conventional technology needed to meet CAAA requirements was costing as much as $750,000. The INO_x system costs only $40,000 to $102,000 and can be installed quickly because it requires no modification of the engine's head.

Impact of Commercialization. ENOX has successfully retrofitted over 100 engines with its patented INO_x technology. In 1995, the INOx ignition system was placed among "the most technologically significant new products" in the world when ENOX received the presitgious R&D 100 Award. The company's success with INO_x was again recognized in

Installation of the INOx ignition system on a typical gas engine compressor. The INOx system causes NO_x emissions to drop by consistently and completely firing very lean air/fuel mixtures from increased turbocharger boost pressures and thus reducing combustion temperatures. This leads to lower NOx formation rates and reduced NO_x concentrations in the exhaust. In addition, it produces more stable engine performance from extended duration discharge.

1996 when ENOX received one of the first Tibbetts Awards. This award recognizes "Models of Excellence" for SBIR projects at the state and local level that are encouraging economic development. ENOX also received the 1995 Massachusetts Small Business Innovative Research Award and the New Englander Award.

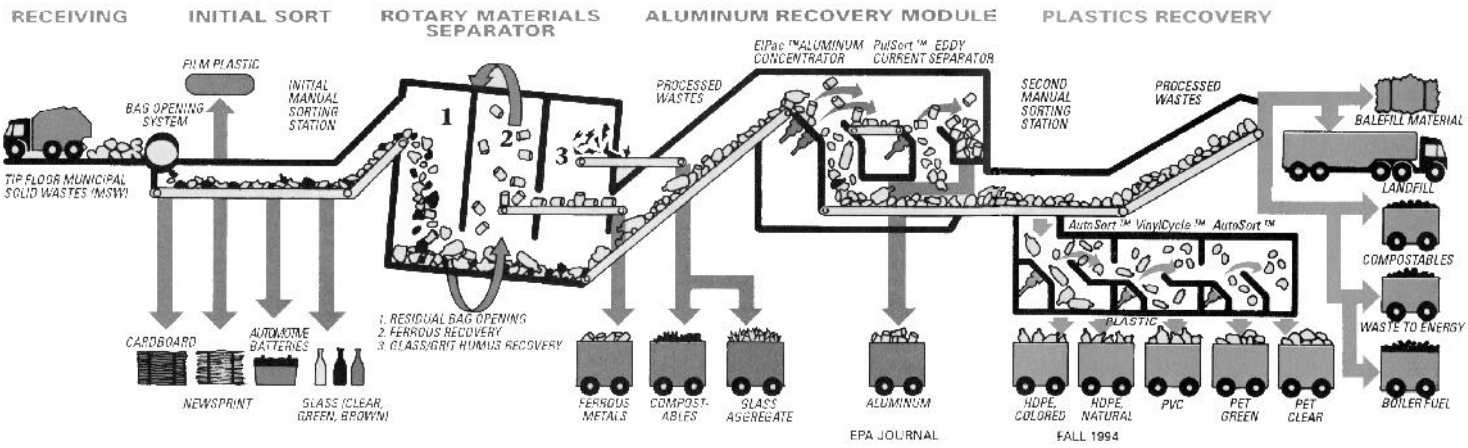
Development and commercialization of the INOx system has resulted in substantial growth of both staff and sales. Since 1990, ENOX has grown from a staff of 3 to a company of 25 employees, with product sales currently estimated at $10 million.

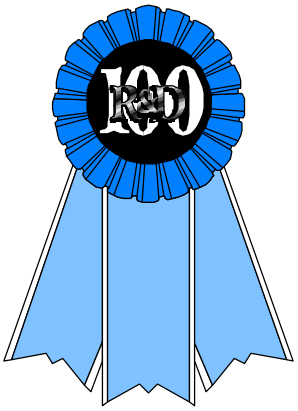
National Recovery Technologies, Inc.

In 1988, EPA awarded National Recovery Technologies, Inc. (NRT), located in Nashville, TN, an SBIR contract to develop a technology that uses an electromagnetic sensor to separate polyvinyl chloride (PVC) plastics from a mixed waste stream of HDPE (high-density polyethylene), PET (polyethylene terephthalate), and PVC plastic bottles. The resulting technology, the VinylCycle® line of plastics separators, assists in recycling plastic bottles by minimizing the mixing of different types of plastic resins so that they can be more effectively processed into recycled products. The patented NRT VinylCycle® system accepts whole or crushed plastic bottles as they are fed by a vibrating conveyor. Once inside the machine, the bottles pass over a detector array that can sense the presence of the chlorine atoms in PVC bottles. Air jets are triggered to separate and kick the PVC bottles away from the remaining PET and HDPE containers. The system can process up to 10 bottles per second. Recycled PET that has been processed by NRT VinylCycle® units is being used in the production of many products—from carpet to clothing.

Environmental Significance. The presence of PVC plastics in the waste stream creates high toxic chlorine emissions when the waste is incinerated. These emissions are eliminated by the VinylCycle® system, which can be used to separate PVC plastics from the waste stream before incineration. In addition, VinylCycle® promotes the recycling of plastics in the waste stream by: (1) separating PVC plastics from PET and HDPE plastics,

AutoSort® and VinylCycle® Systems Automate the Plastics Recovery Process





and (2) reducing the labor cost required for manual separation of the various types of plastics. Separation and purity are critical for plastics recycling because PVC and PET plastics have incompatible chemistries, and it takes only one PVC bottle among 20,000 PET bottles to contaminate an entire batch.

NRT has also been awarded other SBIR contracts to develop additional innovative technologies to improve recycling and reduce worker exposure to the municipal waste stream.

Impact of Commercial Success. By 1996, over 40 VinylCycle® systems were in operation in the U.S., Europe, Japan, and Australia. NRT reports over $6 million in sales to date, with gross sales expected to reach $280 million to $1.4 billion over the next 10 years.

The success of VinylCycle® has fostered development of a color/polymer sorter for plastics. Separate funding from another EPA SBIR contract has resulted in the successful development and subsequent commercialization of MultiSort®, which allows automated sorting of 5,000 pounds per hour of plastic bottles by color and type to facilitate recycling. NRT reports over $1 million in sales of MultiSort® in the U.S., Europe, and Japan.

Since winning its first SBIR contract, NRT has grown from 3 employees to a staff of 30 in 1994. In recognition of its admirable accomplishments, NRT received EPA's 1991 "Outstanding Small Business Enterprise Award" and became one of the first companies to receive the Tibbetts Award in 1996.

Membrane Technology and Research, Inc.

Membrane Technology and Research, Inc. (MTR), in Menlo Park, CA, received an SBIR contract from EPA to develop a membrane separation process capable of recovering volatile organic compounds (VOCs) from contaminated air streams. The VaporSep® recovery system developed by MTR combines proven condensation techniques with a unique pressure-driven membrane vapor separation process. This combination produces far better recovery performance than condensation alone, achieving much higher recovery rates or maintaining existing recovery rates under less extreme temperature and pressure conditions.

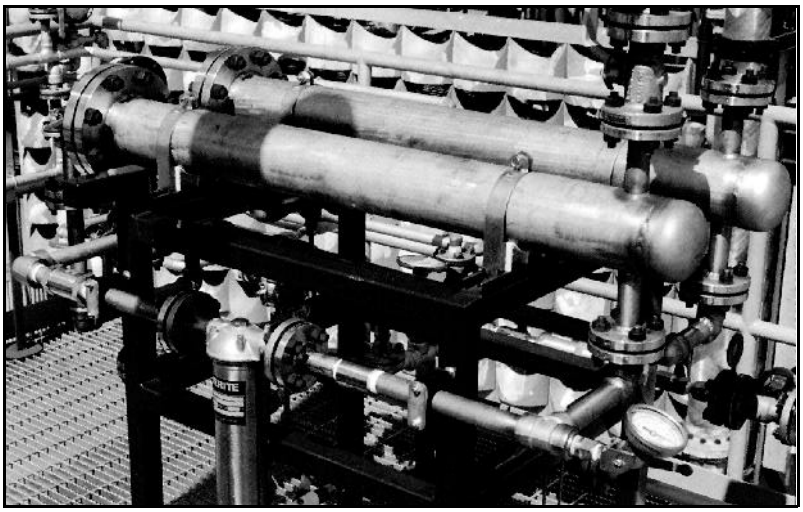
The key to the VaporSep® recovery process is an organic-selective composite membrane that is 10 to 100 times more permeable to organic compounds than to air. This rugged, high-flux polymeric membrane consists of a very thin, highly selective, rubbery top layer and a tough, relatively open microporous support layer. The top layer performs the separation; the porous support layer provides mechanical strength. The backing material for the structure is a nonwoven fabric.

Environmental Significance. VOCs and other organic compounds are the most common pollutants emitted from chemical processes. Titles I and III of the CAAA of 1990 require elimination or control of a large percentage of these emissions. Each year, chemical manufacturers alone must remove some 500 million pounds of organic pollutants from 50 million cubic feet of air.

Air and organic vapor permeate the membrane at rates determined by their relative permeabilities and the pressure difference across the membrane. Depending on the system design, MTR's VaporSep® system removes and recovers between 90 and 99.99 percent of the VOCs from the feed air stream and reduces the VOC content of the vented gas to 100 ppm or less. In addition, the recovered VOCs can be reused at a fraction of the cost of virgin compounds.

Impact of Commercial Success. MTR has installed more than 30 VaporSep® systems at various chemical and pharmaceutical plants, and has reported sales of the system at $4.4 million. MTR's achievement was recognized in 1990 when the company received theR&D

100 Award for the Vapor-Sep® technology. A subsequent SBIR award from EPA allowed MTR to complete design of an innovative membrane module that will allow expansion of the VaporSep® product line to low-flow-rate conditions. This membrane module is designed specifically for application to extremely low gas flow conditions in small vent streams, such as gasoline station tank vents or purge streams from chillers in commercial air conditioning units. Although this module has not yet been commercialized, MTR is actively pursuing a licensing agreement and expects the technology to be commercially available in the near future.



Condensation/membrane separation usually achieves 90% to 99% recovery of VOCs and creates no secondary wastes. The MTR system at left was installed at Vista Chemical for recovery and direct recycle of vinyl chloride from a polyvinyl chloride (PVC) process. The benefits include recovered monomer values, lower acid neutralization costs, and reduced incinerator maintenance.

Aster, Inc.

Aster, Inc., located in Fairborn, OH, was awarded an SBIR contract by EPA to develop a process for recycling solid automotive paint wastes into automotive sealants. Aster proposed to develop a process for recycling the paint sludge into compounding ingredients for automotive sealants that meet current auto makers specifications for paintable sealants.

NOMINEE Governor's Award for Excellence in Energy Efficiency

Prior to the SBIR award, Aster had developed the recycling technology and a sealant formulation prototype containing 50 percent of recycled paint waste solids. The SBIR contract provided funding to conduct the research needed to develop a sealant that met the specification standards of the automotive industry and to bring the recycling technology into commercial application for the auto manufacturing and sealant industries.

Environmental Significance. About 75 million pounds of paint sludge are generated by the U.S. automotive industry each year, making a significant contribution to landfills. By recycling the paint sludge into compounding ingredients for automotive sealants, Aster's process significantly reduces the amount of paint sludge requiring disposal in our nation's rapidly filling landfills.

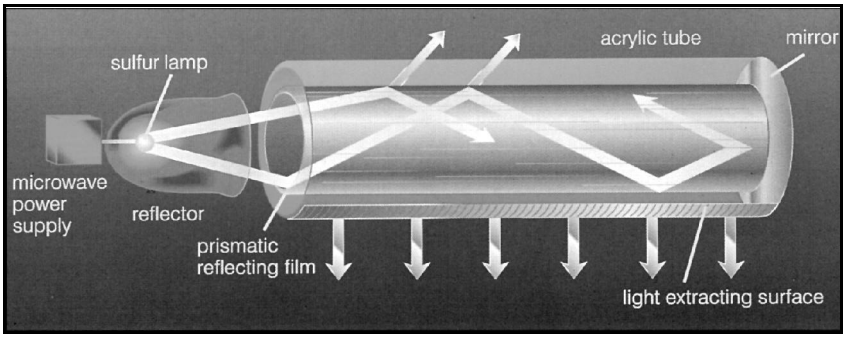
Impact of Commercial Success. Aster has licensed their paint waste recycling technology to a company that has shared a portion of the commercialization cost. Since commercializing the technology, Aster's sales have doubled and new business opportunities have developed. In recognition of the company's achievement, Aster has been nominated for the Governor's Award for Excellence in Energy Efficiency.

Fusion Systems Corporation

Fusion Systems Corporation, in Rockville, MD, developed a high-efficiency, mercury-

free lamp using recently discovered sulfur lamp technology. Each Fusion Systems bulb contains a small amount of sulfur and inert argon gas. When the sulfur is bombarded by focused microwave energy it forms a plasma that glows very brightly producing light very similar to sunlight. Because there are no filaments or other metal components, the bulb may never need to be replaced. The sulfur lamp can be used in a variety of configurations. For example, it can be used with reflectors for lighting arenas and other large areas or with a light pipe to light buildings, parking garages, and tunnels.

Fusion Systems' Sulfur Lamp



Under Phase I, Fusion Systems investigated variations of the lamp system parameters with the primary goal of achieving a 150 percent increase in efficiency (from 68 to 95 lumens per watt) while maintaining good bulb color and brightness. Another goal of the research was to improve lamp starting down to -40°C. Both of these factors were considered critical for realizing commercial success.

During Phase II, Fusion Systems Corporation focused on improving bulb efficacy and starting, using the energy-saving ideas developed during Phase I. At the conclusion of Phase II, Fusion Systems had improved various component efficiencies resulting in a mercury-free lamp with a system efficiency of greater than 100 lumens per watt that is capable of driving distributed lighting systems.

Fusion Systems' lamp offers a number of potential environmental and other benefits including: (1) removal of toxic mercury from light sources, which reduces environmental exposure to toxins in the event of bulb failure; (2) low infrared output, which minimizes heat in the light beam and allows a wider choice of materials for use in optics; (3) very low ultraviolet (UV) output, which minimizes degradation of materials exposed to the light and eliminates the need for UV filters; (4) increased efficiency and lower operating costs; (5) a full-color spectrum that improves visual performance; and (6) color stability and reproducibility for long-term color consistency.

Environmental Significance. It is estimated that 450 to 500 million fluorescent lamps are discarded in the United States each year, resulting in the disposal of more than 30,000 metric tons of mercury-contaminated waste in landfills. Mercury can leach from the soil to water and then be available to animals and humans. Humans are typically exposed to mercury through the consumption of fish and fish products. Although mercury has not been shown to cause cancer in humans, long-term exposure to organic or inorganic mercury compounds can cause permanent brain and kidney damage or damage to developing fetuses. Mercury is classified as a hazardous waste by EPA. Under the Resource Conservation and Recovery Act (RCRA), wastes exhibiting >0.2 mg/L TCLP of mercury, must be disposed of as a code D009 hazardous waste. There are currently no definitive regulations for disposal of mercury lamps under RCRA; however, proposed rulings are being considered.

The Fusion Systems' lamp contains no mercury. Therefore, there is no risk of exposure to mercury in the event of bulb failure and no mercury-contaminated waste to be landfilled. An added environmental benefit of Fusion Systems' sulfur lamp is that it has the potential to reduce the total energy requirements associated with heating, cooling, and illuminating commercial and industrial buildings

and the pollutants associated with generating that energy.

Impact of Commercial Success. Since completing Phase II, Fusion Systems has commercialized their sulfur lamp and is marketing Solar 1000™—the company's first series of sulfur lamp products. Commercialization of this product line has substantially increased sales and resulted in a 225 percent increase in staffing.

In recognition of Fusion Systems Corporation's innovation in developing their sulfur lamp, the company received the 1995 Discovery Award and the 1995 Grand Award in Popular Science's "Best of What's New" feature.

SBIR PHASE III SUCCESS STORIES

In FY95, EPA awarded five SBIR Phase III contracts to companies that had demonstrated the technical feasibility and commercialization potential of technologies that could benefit the public and further the Agency's mission. These Phase III projects were funded as part of the President's Environmental Technology Initiative (non-SBIR funding). These technologies, briefly described in this section, are on the brink of commercialization and hold great promise for future environmental benefits.

Precision Combustion, Inc.

Precision Combustion, Inc. (PCI), of New Haven, CT, has developed a very fast light-off, high efficiency Microlith™ catalytic converter capable of reducing automotive emissions. During Phases I and II, PCI demonstrated initial product performance and durability through testing at U.S. auto manufacturers. PCI also demonstrated effective application of the catalytic converter to a variety of industrial air toxic environments. The Phase III funding has been directed toward further development and optimization of this technology for application in several specific automotive platforms and for targeted industrial air toxic solutions. Phase III funding will also be used for development of a process for volume production of successful prototypes. Phase III will conclude with the design and testing of several optimized Microlith™ converters for U.S. auto company specifications and for VOC emissions reduction.

Environmental Significance. The Microlith™ catalytic converter is capable of inexpensively achieving the Ultra-Low Emissions Vehicle (ULEV) standards mandated by California and the Northeast States for Co-ordinated Air Use Management. The California Air Resources Board (CARB) has established the following ULEV standards for a 50,000 mile certification:

- CO = 1.7 g/mile
- NMOG (non-methane organic gases) = 0.04 g/mile
- NO_x = 0.2 g/mile
- Formaldehyde = 0.0008 g/mile

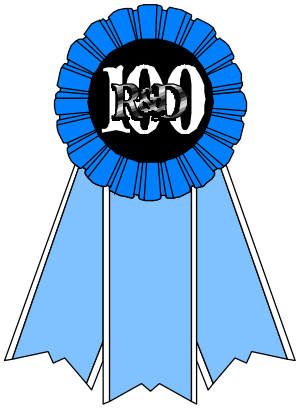
Under the CAAA of 1990, the EPA adopted the existing California ULEV standards for its Clean Fuel Fleet Program. EPA has not developed ULEVs for general use vehicles.

There is substantial likelihood that most future automobiles will use Microlith™ converters for emissions control. Testing by an auto manufacturer has shown a substantial reduction in hydrocarbon and NO_x emissions—at approximately half of the ULEV levels, even after 50,000 mile rapid engine aging, and carbon monoxide emissions at 20 percent of the ULEV standard.

Impact of Commercial Success. Since award of the Phase I contract, PCI has grown from 4 to over 20 employees. PCI is currently developing detailed manufacturing and marketing plans for the Microlith™ converter. They predict that Microlith™ catalytic

converters will achieve greater than 50 percent market share of the new converter technology being used to meet imminent and future automotive emissions standards. PCI is expanding applications for the Microlith™ technology to include air cleaning, diesel converter operation, and catalytic combustion for gas turbine engines (notably for hybrid electric vehicles). By the year 2003, PCI projects sales for the Microlith™ to be in the $500 million range.

Niton Corporation



Niton Corporation, located in Bedford, MA, has developed the XL Spectrum Analyzer Lead Detector—an innovative technology for measuring lead in lead-based paint. Niton's XL uses a patented L x-ray fluorescence method for measuring lead. The silicon PIN diode in the XL is a superb detector for L x-rays and the technology works very well for surface and buried lead. At the completion of Phase II, Niton concluded that the current instrument should be complemented by a K x-ray detector for deeply buried and layered lead, and for two independent measures of lead concentration. During Phase II, Niton prototyped electronics and software algorithms. In Phase III, Niton will focus on completing the hardware and electronics, testing software algorithms, and commercializing a dual detector instrument, the cost of which will be comparable to the current XL.

Environmental Significance. EPA has established air exposure limits for lead of $\leq$1.5 µg/m^3 over a 3-month period. Exposure to lead by pregnant women can be transferred to the unborn child and may cause premature birth, low birth weight, or abortion. Lead exposure in infants and young children may lead to decreased intelligence scores, decelerated growth, and hearing problems. Brain and kidney damage to adults and children may result from exposure to high levels of lead.

The Phase III effort will yield a uniquely powerful, affordable XRF Spectrum Analyzer lead detector, without substrate bias. The instrument can detect surface, buried, deeply buried, and layered lead in lead-based paint, without disturbing the paint surface and risking exposure to the lead. In addition, the analyzer is capable of measuring the low action levels set by EPA, HUD, and OSHA.

Impact of Commercial Success. Niton's accomplishment in developing the XL Spectrum Analyzer Lead Detector was recognized by numerous awards, including the prestigious 1995 R&D 100 Award, the 1995 Lead Tech Product of the Year Award, and a finalist for the 1994 Discovery Award. Commercialization of the XL has substantially increased Niton's annual revenues—from $600,000 to $3,000,000. Niton's staff has also grown to 27 as a result of the company's success.

IonEdge Corporation

IonEdge Corporation, located in Ft. Collins, CO, has developed and patented a dry plating method that eliminates the use of liquid chemicals and offers substantial advantages over conventional electroplating techniques. Through the SBIR Program, IonEdge demonstrated their dry plating process using a batch plating prototype developed in Phase II. Using this prototype, zinc and cadmium coatings of acceptable quality and uniformity have been plated on batches of steel fasteners.

The focus of Phase III is to test market the dry plating process to a select group of customers in the fastener plating industry. Using the Phase II prototype, customer parts will be plated in quantities and the cost of running the operation will be determined. Phase III will conclude with examination of future scale-up needs to expand throughput and an estimation of pricing.

Environmental Significance. Conventional liquid electroplating processes result in wastewater from rinsing, scrubber blowdown, spent electroplating solutions or residuals from bath

purification, and floor washdown; solid wastes from spent acid, residuals from bath maintenance and purification and wastewater treatment sludge; and air emissions occur as mists. IonEdge's zero-waste dry plating method eliminates these wastes and offers the added benefit of recycle and reuse of the metals (such as zinc and cadmium) used in the plating process.

Impact of Commercial Success. Since receipt of the SBIR contract, the number of IonEdge employees and the company's sales have quadrupled. In addition, EPA's interest in this process has helped Ion Edge obtain additional funding from NSF, ARPA, the Navy, and a private company to further develop and commercialize this process.

Oxley Research, Inc.

Oxley Research Inc. (ORI), located in New Haven, CT, has developed a new, environmentally beneficial, cost-saving process for the online electrolytic regeneration of acid cupric chloride—an etchant used widely in the fabrication of multilayer printed circuit boards. ORI's innovative process maintains solution etching power and recovers a high grade of easily sold copper metal, similar to "cathode copper."

Under Phase II, ORI successfully demonstrated a pre-prototype version of the process. Phase III is focused on the design, construction, and testing of a 2.5 kg/hr engineering prototype that will be operated in conjunction with a commercial spray etcher.

Environmental Significance. ORI's technology replaces widespread chemical regeneration, which typically involves the use of chlorine gas or hydrogen peroxide/hydrochloric acid. By eliminating use of those chemicals and the generation and disposal of about 4 to 5 gallons per day of excess etchant per gallon of etchant inventory, ORI's process offers substantial environmental incentives and potential cost reductions for the printed circuit board fabricator. Chlorine and hydrochloric acis are regulated as hazardous air pollutants (HAPs) under Section 112 of the CAAA of 1990. Exposure to chlorine, hydrogen peroxide, and hydrochloric acid may cause damage to the eyes, skin, and respiratory system.

The ORI process also offers significant improvements over previous attempts to electrolytically regenerate acid cupric chloride. Its advantages include avoidance of chlorine evolution, production of monolithic copper deposits, and low power operation.

Impact of Commercial Success. EPA's support of this technology through the SBIR Program has enabled ORI to obtain additional funding for its commercialization from the NIST/DOE Energy Related Inventions Program (ERIP) and the State of Connecticut. Also, through other SBIR awards, ORI plans to expand this etchant regeneration technology beyond printed circuit boards to include leadframe etching.

KSE, Inc.

KSE, Inc., in Amherst, MA, has developed a cost-effective technology for benzene-free polymerization of methyl vinyl ether (MVE) with maleicanhydride (MAN). MVE/MAN copolymers are widely used in high visibility consumer products, such as denture adhesives, and are made commercially using a benzene solvent. In Phases I and II, KSE completed the laboratory research and development for producing MVE/MAN copolymers without the use of benzene or any extraneous solvent. The KSE process offers several advantages over conventional technology, including an order of magnitude enhancement in reactor productivity (generating over 200 percent return on investment), elimination of hazardous emissions, and more economical production of MVE/MAN copolymers.

Environmental Significance. The KSE process eliminates: (1) the use of hazardous solvents (e.g., benzene), in the production of MVE/MAN copyolymers, and (2) the presence of solvent residual in the copolymers, which are used in products such as denture adhesives.

Benzene is regulated as a HAP under Section 112 of the CAAA of 1990. Under RCRA, benzene is designated as a hazardous waste that is subject to reporting requirements. Under the Clean Water Act, the reportable quantity of benzene is 1,000 pounds. EPA's maximum permissible level of benzene in drinking water is 5 ppb. Brief exposure to benzene at high levels usually results in drowsiness, dizziness, and headaches that disappear after the exposure stops. Long-term exposure to benzene at various levels has been determined to be carcinogenic by the U.S. Department of Health and Human Services and it may also be harmful to the immune system.

Impact of Commercial Success. KSE has entered into an exclusive manufacturing and distribution agreement with a major chemical manufacturer. Phase III will focus on production of solvent-free copolymers and derivative products in commercial equipment to meet customer specifications. Further process optimization studies are being undertaken in Phase III to facilitate the commercialization of the KSE process.

KSE anticipates that their technology will be commercialized by the end of 1996 and reports that sales have already increased 40 percent since they received their SBIR award.

APPENDIX B: Administration of the SBIR Program

In Appendix B

MANAGEMENT OF THE EPA SBIR PROGRAM

The Small Business Innovation Development Act, which was signed by the President on July 22, 1982, emphasized the benefits of technological innovation and the ability of small businesses to transform research and development results into new products. The Act noted that, while small business is the principal source of significant innovation in the nation, the vast majority of federally funded R&D is conducted by large business, universities, and government laboratories. According to a Bureau of the Census survey, small firms receive only 11 percent of their R&D funds from the federal government, as compared to the 26 percent received by large companies. The SBIR Program is designed to redirect some of this federal funding to the small business community.

The basic purpose of the Act was to strengthen the role of small enterprises in federally funded R&D and thus help the nation develop a stronger base for technical innovation and wider commercialization of the ideas generated in the laboratories, research facilities, and factory floors of small hi-tech companies.

In 1992 Congress enacted the Small Business Research and Development Enhancement Act (Public Law 102-564), which extended the SBIR Program through October 1, 2000.

HOW THE SBIR PROGRAM IS FUNDED

Under the SBIR Program, each federal agency with an annual extramural budget in excess of $100 million must establish an SBIR Program. The Program is funded by setting aside a specific percentage of each participating agency's extramural research budget every fiscal year (FY). In FY1982, this set-aside was 1.25 percent. The Small Business Research and Development Enhancement Act of 1992 incrementally increased this percentage from 1.25 percent to 1.5 percent in FY1993, increasing to 2 percent in FY1995, and then rising to 2.5 percent in FY1997 and continuing at that percentage until FY2000. The Act also raised the maximum funding for Phase I SBIR awards from $50,000 to $100,000 and the limit for Phase II awards from $500,000 to $750,000.

THE SBIR SOLICITATION PROCESS

The SBA publishes a Pre-Solicitation Announcement (PSA) each quarter, which provides interested small businesses information about the timing and topics of upcoming solicitations. Each federal agency with an SBIR Program is unilaterally responsible for targeting research areas and administering its own SBIR funding agreements. These agreements include any contract, grant, or cooperative agreement entered into between a federal agency and any small business for the performance of experimental, developmental, or research work funded in whole or in part by the federal government.

The Small Business Innovation Development Act requires participating agencies to issue a solicitation that sets the SBIR process in motion. The solicitation lists and describes the research topics to be addressed in the proposals and invites companies to submit their proposals for consideration. Each of the 11 federal agencies participating in the SBIR Program publishes annual solicitations for Phase I and Phase II. EPA issues its Phase I solicitation in October/November, with proposals due into the Agency by mid-January. This solicitation, which is available electronically on the Internet and in hardcopy by mail, identifies the relevant research topics that should be addressed by companies responding to the request for proposals. The proposed research must address a single research topic, or an important segment of the topic, described in the EPA SBIR solicitation.

SBIR awards are limited to small businesses. To be eligible for an SBIR award, a small business must meet each of the following criteria:

- Is independently owned and operated and has its principal place of business located in the United States;
- Has no more than 500 employees, including its affiliates;
- Is not the dominant firm in the field in which they are proposing to carry out SBIR projects;
- Is organized for profit; and
- Is at least 51 percent owned by U.S. citizens or lawfully admitted permanent resident aliens.

SBIR PROGRAM PHASES

All federal SBIR Programs have three phases, ranging from "proof of concept" to commercialization. Each phase is described below.

Phase I—The objective of this phase is to determine the scientific merit and technical feasibility of the proposed effort and the quality of performance of the small concern. Under Phase I, EPA awards firm-fixed-price contracts of approximately $65,000. The period of performance of Phase I contracts is typically 6 months.

Phase II—Phase II is the principal research or R&D effort. Only firms successfully completing Phase I are eligible for Phase II awards. Competitive awards are based on the results of Phase I and the scientific and technical merit and commercial potential of the Phase II proposal. Under Phase II, EPA awards firm-fixed-price contracts of approximately $220,000. The period of performance of Phase II projects is typically 1 to 2 years.

Phase III—This phase focuses on commercial development and application of the results of Phase II. Funds from the mandated SBIR set-aside cannot be used for Phase III awards. Agencies may fund Phase III from other sources of funds, but developers normally must find non-federal sources of capital for commercial applications of SBIR-funded research or R&D.

For the first time in the history of its SBIR Program, EPA provided Phase III funding for five highly promising projects in FY1995. Funding for this Phase III pilot was provided through the Environmental Technology Initiative (ETI). ETI is a Presidential program headed by EPA to expand the development and use of innovative environmental technologies.

The number of Phase I, Phase II, and Phase III SBIR contracts awarded by EPA from FY1990 through FY1995 is provided in the table on the following page.

THE SBIR PROPOSAL PEER REVIEW PROCESS

All SBIR Phase I and Phase II proposals received by EPA are subjected to a rigorous external peer review process. EPA selects awardees based on the scientific and technical merit of the proposal with respect to the selection criteria published in the SBIR solicitation.

EPA SBIR Program Proposal and Award Data

SBIR Award Profile (Dollars in Thousands)

	1990	*1991*	*1992*	*1993*	*1994*	*1995*	*Total*
Total Amount of Phase I Awards	$1,586	$1,522	$2,041	$1,699	$1,905	$3,027	$11,780
Total Amount of Phase II Awards	$1,649	$2,099	$2,250	$3,418	$2,950	$4,195	$16,561
Total Amount of Phase III Awards *	$0	$0	$0	$0	$0	$1,480	$1,480

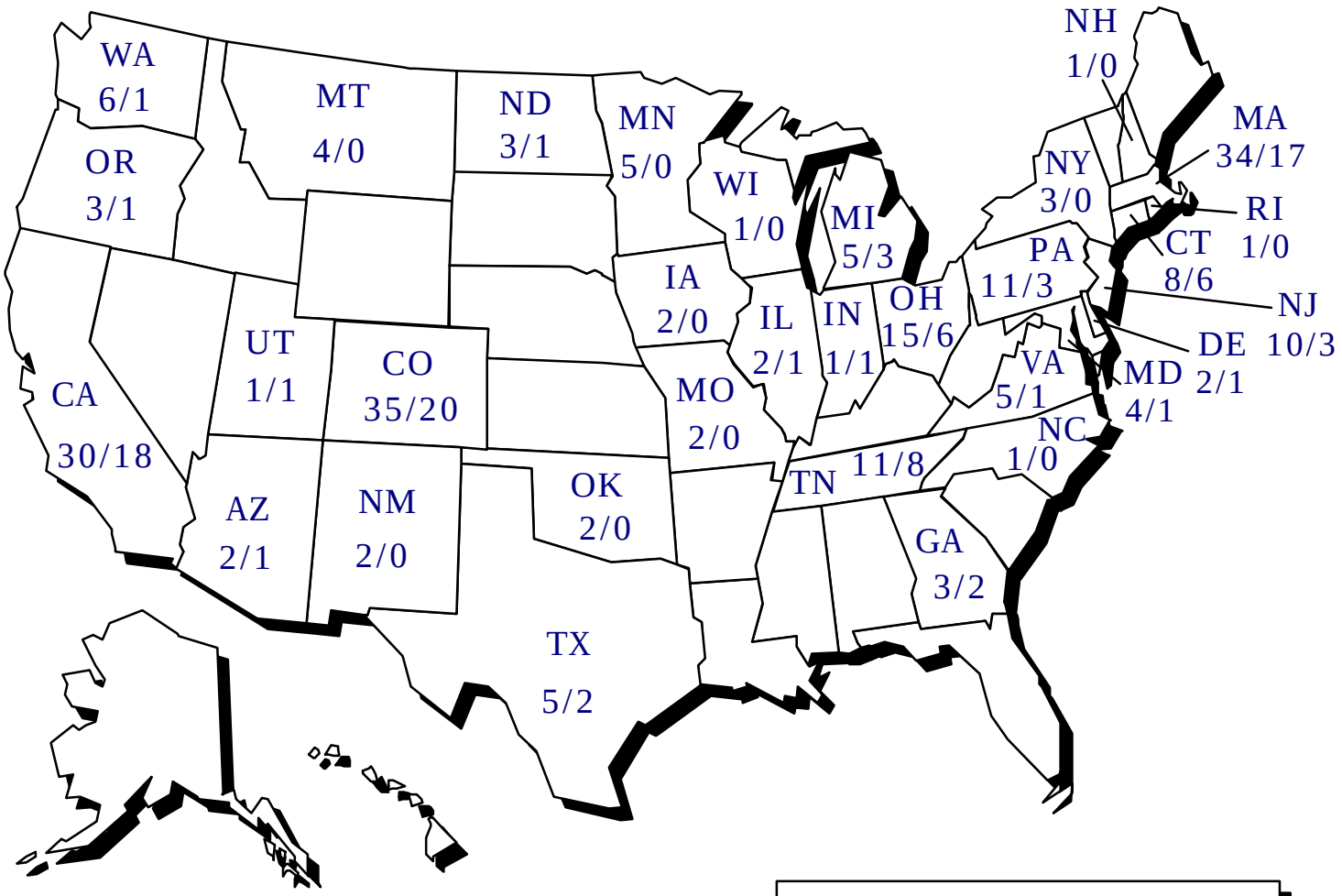
Agency Solicitation Profile

	1990	*1991*	*1992*	*1993*	*1994*	*1995*	*Total*
Number of Phase I Proposals Received	434	367	427	442	382	476	2,528
Number of Phase I Awards	32(7%)	31(8%)	41(10%)	34(8%)	35(9%)	47(10%)	220
Number of Phase II Proposals Received	24	28	27	41	29	27	176
Number of Phase II Awards	11(46%)	14(50%)	15(56%)	21(51%)	18(62%)	19(70%)	98
Number of Phase III Proposals Received	0	0	0	0	0	21	21
Number of Phase III Awards	0	0	0	0	0	5(24%)	5
Number of Phase I Awardees Competing for Phase II	28(88%)	27(87%)	41(100%)	29(85%)	27(77%)	TBD	152+
Number of Phase I Awardees Recieving Phase II Awards***	14(50%)	15(56%)	21(51%)	18(62%)	19(70%)	TBD	87+

* Phase III contracts were funded by the Environmental Technology Initiative (ETI).
** TBD= to be determined
***Only Phase I awardees from the previous year are eligible for Phase II awards.

APPENDIX C: Geographic Disbribution of EPA SBIR Awards

Geographic Distribution of EPA SBIR Awards (FY1990 - FY1995) by State



SBIR Phase I Awards for FY1990-FY1995	220	$11,780,000
SBIR Phase II Awards for FY1990-FY1995	98	$17,561,000

APPENDIX D: SBIR Program Information and Contacts

In Appendix D

SOURCES OF INFORMATION ON THE SBIR PROGRAM

EPA's SBIR Program solicitations can be downloaded from the NCERQA Home Page at the following address: http://www.epa.gov/ncerqa. Abstracts of EPA SBIR Phase I, Phase II, and Phase III projects funded over the past 5 years are also available on the NCERQA Home Page. Information on the government-wide SBIR Program is available through SBA Online, which can be accessed through the Internet at http://www.sbaonline.sba.gov or via SBA's electronic bulletin board at 1-800-697-4636. SBA Online provides quick access to an overview of the SBIR Program, pre-solicitation announcement information, the titles of all SBIR awards issued during the last two fiscal years, and the SBIR proposal preparation handbook.

CONTACTS FOR EPA'S SBIR PROGRAM

The EPA SBIR Program is managed by the Environmental Engineering Research Division (EERD) of the National Center for Environmental Research and Quality Assurance (NCERQA) within EPA's Office of Research and Development. For information on the Program, contact:

Program Representatives

Mr. Stephen A. Lingle
Director, Environmental Engineering Research Division
Tel: (202) 260-2619
Fax: (202) 260-4524

Mr. Donald F. Carey
SBIR Program Manager
Tel: (202) 260-7899
Fax: (202) 401-1014

Mr. Marshall Dick
Tel: (202) 260-2605
Fax: (202) 401-1014

Ms. Marian Huber
Tel: (202) 260-6817
Fax: (202) 401-1014

EPA SBIR Solicitations:

Contracts Management Division (MD-33)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711
or
NCERQA Home Page:
http://www.epa.gov/ncerqa

EPA SBIR Project Abstracts:

NCERQA Home Page (abstracts for past 5 years):
http://www.epa.gov/ncerqa
or
FEDRIP (abstracts from 1982 to present):
Tel: (703) 487-4929

SBA CONTACT FOR THE GOVERNMENT-WIDE SBIR PROGRAM

For SBIR Program Information:

U.S. Small Business Administration
Office of Technology
409 Third Street, SW
Washington, DC 20416
Tel: (202) 205-6450

SBA Online:

Internet—http://www.sbaonline.sba.gov
or
Bulletin Board—1-800-697-4636

To be Added to Mailing List for Pre-Solicitation Announcements Call (202) 205-7777

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