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Contributions of the Department of Defense Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs to Training and Education: FY1999–FY2004

J.D. Fletcher

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Preface

This work was performed for Dr. Robert Foster, Director, Biosystems, Office of the Deputy Undersecretary of Defense (Science and Technology) (ODUSD(S&T)) under the "Science and Technology (S&T) Support for Training Transformation and the Human Systems (HS) Technology Area" task. The Institute for Defense Analyses (IDA) task leader for this work was Dr. Dexter Fletcher. Dr. Foster provided technical cognizance.

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A. Overview

This task was assigned to the Institute for Defense Analyses (IDA) by the Director, Biosystems, Office of the Deputy Under Secretary of Defense (Science and Technology) (ODUSD(S&T)). The purpose of this task was to assess contributions made by the Department of Defense (DoD) Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs to science and technology (S&T) in the area of training and education.

This document distinguishes between SBIR/STTR "topics" and "projects." In this context, solicitation *topics* are developed by government scientists and program managers who then act as technical managers for *projects* funded under the topics.

SBIR/STTR project work is divided into three phases:

- Phase 1 supports exploration of the technical merits of an idea or technology.
- Phase 2 supports production of a research and development (R&D) product and evaluation of its commercial potential.
- Phase 3 supports commercialization of the product—its entry into the marketplace.

This review included 80 SBIR/STTR topics. The criteria for selecting topics were that they should focus on training and education, target a credible innovation, begin under FY 1999 through FY 2004 funding, and make at least one Phase 2 award.

FY 1999 was selected as the beginning year for topics to include in this effort because of the review of training and education R&D performed in that year. The 1999 workshop was not limited to SBIR/STTR topics and was organized in a top-down manner that focused on the following R&D topic areas in training and education:

- Intelligent Tutoring Systems (ITSs)
- Authoring Tools

- Distributed Simulation Environments for Instruction

- Dynamic Learning Management.

The FY 1999–FY 2004 SBIR/STTR topics have been categorized in much the same way as the efforts reviewed in 1999. However, the SBIR/STTR topics included in this review generally reflect the applied, entrepreneurial, and commercial aims of the SBIR/STTR program rather than a concentration on S&T progress. They also reflect the specific criteria used to select topics for this SBIR/STTR review.

Four categories of R&D efforts were identified for the FY 1999–FY 2004 review:

1. Intelligent Tutoring Systems (ITSs)
2. Authoring Tools
3. Simulation-Based Training
4. Training System Design and Development.

B. DoD SBIR/STTR for Training and Education

1. Investment

DoD investment in SBIR/STTR training and education during FY 1999–FY 2004 was more than $83 million, which was awarded to 282 projects (184 Phase 1 efforts and 98 Phase 2 efforts). This investment grew substantially over these years, rising from $0.9 million in FY 1999 to $24.6 million in FY 2003. The investment was lower in FY 2004 ($19.4 million), but it is still greater by a factor of about 20 over FY 1999.

More specifically, over the FY 1999–FY 2004 time period:

- The Air Force sponsored 23 topics ($22.8 million awarded for 64 Phase 1 and Phase 2 projects), the Army sponsored 20 topics ($16.8 million awarded for 49 Phase 1 and Phase 2 projects), and the Navy sponsored 5 topics ($3.8 million awarded for 17 Phase 1 and Phase 2 projects).

- ODUSD(S&T), through the Director, Biosystems, sponsored 31 topics and awarded $35.7 million for 140 Phase 1 and Phase 2 projects. Its topics were defined, nominated, and, when selected, managed by the Services and the Defense Advanced Research Projects Agency (DARPA). All three Services (Army, Navy, Air Force) participated about equally in this activity.

- SBIR/STTR investments in intelligent tutoring supported 11 topics, with $15 million awarded for 45 Phase 1 and Phase 2 projects. Authoring Tools (21 topics, $22 million, and 81 projects), Simulation-Based Training (26 topics, $23 million, and 76 projects), and Training System Design and

Development (22 topics, $23 million, and 80 projects) were roughly equivalent in the number of topics, the funds awarded, and the number of projects. About 42 of the 80 SBIR/STTR topics chosen for this review focused on developing training packages for specific subject areas.

- The Army led in proportion of Phase 2 to Phase 1 awards, with 69 percent of Phase 1 awards progressing to Phase 2. The Air Force was fairly close with 60 percent. The Office of the Secretary of Defense (OSD) and the Navy Phase 1 projects were less likely to progress to Phase 2 (46 and 42 percent, respectively).

2. Goals

R&D goals for topics and projects in this review were identified as the following:

- ITSs

  - Natural language tutorial dialogue

  - Automated, continuous, unobtrusive assessment of learner state and progress

  - Representation of knowledge, skill, and ability

  - Dynamic assembly of training from instructional objects [dynamic assembly of instructional interventions that help the learner attain targeted instructional objectives (i.e., help the learner progress from the current state of knowledge, skill, and ability to the objective state].

- Authoring Tools

  - Linking design and development to instructional objectives

  - Authoring by non-Information Technology (IT) specialists

  - Simulation and scenario generation and preparation

  - Rapid (agile) simulation and scenario authoring

  - Creation of computer-generated (automated and semi-automated) participants (allies, enemies, and neutrals).

- Simulation-Based Training

  - Simulation training linked to instructional objectives (for individuals)

  - Simulation training linked to instructional objectives (for teams)

  - Post-simulation performance feedback

  - Synthetic agents and avatars in simulation

  - Haptics in medical training.

- Training System Design and Development
  - Team training
  - Cognitive readiness training for leaders
  - Training in areas of special concern.
- Overall (goals addressed across the four R&D categories)
  - Maintain focus on military relevance
  - Increase accessibility of training, education, and performance aiding
  - Incorporate "intelligent" computational capabilities
  - Increase agility, rapidity, and ease of use in development
  - Provide for reuse and interoperability
  - Develop instructional interventions related to training and education objectives
  - Develop simulation and games for training and education
  - Tailor training and education to learner capabilities and needs.

3. Gaps

Some identified S&T gaps for the four R&D categories appear aligned with the R&D goals just listed.

- **ITSs.** Natural language dialogue; learner and expertise modeling; and generating tailored instructional interactions.

- **Authoring tools.** Object-oriented authoring tools; authoring tools for non-IT personnel; cost-effectiveness tradeoffs; and authoring tools for specific capabilities.

- **Simulation-based training.** Matching simulation-based training to training objectives; automated detection of critical events and decisions; cost-effective application of simulation- and game-based training; and development of specific simulation capabilities.

- **Training systems design and development.** Team training; cognitive readiness training and assessment; and specific training techniques (e.g., language and cultural training).

- **Overall.** Gaps that appeared to be suitable for SBIR/STTR support across all four areas included development of practicable cost-effectiveness models; progress assessment from routine interactions; generation of instructional

materials from reusable objects; and instruction techniques for enhancing cognitive readiness (agility, flexibility, creativity).

4. **Management**

Observations on SBIR/STTR management for training and education include

- **Selecting SBIR/STTR topics for training and education.** Management attention and leadership may be needed to ensure that human systems expertise is included in final selection of SBIR/STTR topics and that well-defined benchmarks are applied in assigning scores during the selection of proposals for funding.

- **Ensuring innovation.** Topics and projects selected for SBIR/STTR funding should be those that pay serious attention to innovation and product production.

- **Infrastructure engineering.** Attention and resources should be allocated for the development of an infrastructure engineering capability and discipline to ensure that returns on SBIR/STTR investments are fully and successfully realized.

- **Oversight for commercialization.** Promising SBIR/STTR innovations and products are too often abandoned in the laboratory. Their implementation and commercialization might be improved if more government oversight were exercised to ensure that R&D firms entering Phase 2 incorporate and embrace the culture of commercialization.

- **Evaluating project results.** More attention should be paid to evaluating the products of SBIR/STTR projects and documenting their S&T value.

- **Submission of project reports.** DoD requires the submission of SBIR/STTR reports to the Defense Technical Information Center (DTIC); however, this requirement is not always met. SBIR/STTR projects develop innovative products, procedures, and technologies that can contribute significantly to training and education S&T. Project results should be reported and made available.

Contributions of the Department of Defense Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs to Training and Education: FY 1999–FY 2004

A. Purpose

The Director, Biosystems, Office of the Deputy Under Secretary of Defense (Science and Technology) (OUSD(S&T)) assigned this task to the Institute for Defense Analyses (IDA). The purpose of this task was to assess contributions made by Department of Defense (DoD) Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs to science and technology (S&T) in the area of training and education. More specifically, IDA was tasked to

- Review topics[1] that concerned training and education and were addressed in the DoD SBIR/STTR program during the FY 1999–FY 2004 time period

- Assess the S&T products and progress of DoD SBIR/STTR investments in training and education during the FY 1999–FY 2004 time period

- Determine how the SBIR/STTR topics might be aggregated and described overall as a research and development (R&D) program

- Identify significant S&T gaps that need to be filled to achieve the objectives of this R&D program.

B. SBIR/STTR Background

The government's SBIR program arose from the recognition in the 1970s that small businesses had become a significant economic factor in creating jobs and pioneering technological innovation (National Research Council, 1999). However, at that time, the share of federal R&D funds being awarded small businesses appeared to be declining.

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[1] This document distinguishes between SBIR/STTR "topics" and "projects." In this context, solicitation *topics* are developed by government scientists and program managers, who then may act as technical managers for *projects* funded under the topics.

In January 1980, the Administration convened a White House Conference on Small Business to determine if support for small business research and innovation should be expanded. The Conference found that small businesses were generating two and a half times as many innovations per employee as large businesses but that large businesses were receiving three times more government assistance. The Conference therefore recommended that legislation be enacted to expand R&D support for small businesses. This recommendation resulted in the Small Business Innovation Development Act of 1982. This Act, whose purpose was to strengthen the role of small businesses in federally funded R&D and help develop a stronger national base for technical innovation, had four specific objectives (National Research Council, 1999):

1. Stimulate technological innovation

2. Increase the use of small businesses to meet federal R&D needs

3. Foster and encourage participation by minority and disadvantaged persons in technological innovation

4. Increase private sector commercialization of innovations derived from federal R&D.

The SBIR program was reauthorized in 1992 and included the addition of the STTR program. The objectives of the STTR program are effectively the same as those of the SBIR program but include the addition of nonprofit research institutions such as universities and Federally Funded Research and Development Centers (FFRDCs). The main practical difference between the SBIR and STTR programs (aside from the much greater size of the SBIR program) is that STTR projects require cooperative and collaborative research between a small business firm (which assumes primary responsibility for the project) and a nonprofit research institution.

In SBIR and STTR programs, a small business is defined as a for-profit firm employing 500 or fewer employees. In practice, over 80 percent of SBIR/STTR funds are awarded to firms that have less than 100 employees. No size limit is specified for non-profit research entities in STTR awards, but the small business firm to which the award is made must manage and control the STTR funding. At least 40 percent of the work must be performed by the business firm, and at least 30 percent of the work must be performed by the research institution. All SBIR/STTR awards must go to firms that are at least 51 percent owned and/or controlled by United States' citizens. The work funded must be performed in the United States.

The 1982 bill was funded by a "tax" of 0.2 percent on the R&D budget of all federal agencies whose R&D budgets exceeded $100 million. Today, the SBIR/STTR legislation requires federal agencies that have extramural[2] research expenditures of more than $100 million to set aside 2.5 percent of their R&D budgets[3] for SBIR and 0.3 percent for STTR (National Research Council, 2004). Awards for all phases of SBIR/STTR work in FY 2004 exceeded $2 billion. Slightly more than 50 percent of the SBIR/STTR funding came from DoD, which supported 1,082 SBIR topics and 118 STTR topics in FY 2004. The SBIR/STTR programs were reauthorized in 2000 (Public Law 106-554) and are now authorized to continue through FY 2008.

SBIR/STTR project work is divided into three phases:

- **Phase 1.** Phase 1 provides awards up to $100,000 of effort for about 6 months to support the exploration of the technical merits of an idea or a technology. Work proceeds to Phase 2 based on Phase 1 performance and results.

- **Phase 2.** Phase 2 provides awards up to $750,000 for about 2 years to produce the actual R&D product and evaluate its commercial potential. No SBIR/STTR funds are provided for Phase 3, which is intended to transition the Phase 2 innovation into the marketplace.

- **Phase 3.** Phase 3 funds must come from the private sector or from another non-SBIR/STTR source. However, some agencies, including DoD, provide "extended funding" for Phase 2. These funds can support further development of innovations as products for the specific use by the agency that provides them.

C. SBIR/STTR Topic Selection

The criteria for including SBIR/STTR topics in this review were that they must

- **Be focused primarily on training and education.** This first criterion was adopted to ensure the inclusion of topics intended to develop new capabilities for the teaching-learning processes. This criterion resulted in the exclusion of topics that primarily emphasized the following:

  – Support issues, such as personnel management or the engineering design of simulators or simulations rather than direct enhancement of learning

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2   Activities not performed by agency employees.

3   For DoD, the Research, Development, Test, & Evaluation "Program 6" budget.

–   Short-term performance aiding (e.g., problem solving, decision aiding, troubleshooting) rather than the longer term development of knowledge, skill, and ability (KSA)[4] targeted by training and education.

- **Target a credible innovation and/or S&T advance.** This second criterion was adopted to ensure that the selected topics focused attention on innovation and advancing S&T rather than on an exclusive concern with producing a training or education program.

- **Have been initiated under FY 1999 through FY 2004 funding.** This third criterion was adopted to determine what S&T progress in training and education had been contributed by the DoD SBIR/STTR program in the 5 years since ODUSD (S&T) had conducted an earlier (1999) comprehensive review of training and education R&D.

- **Have awarded at least one Phase 2 project.** This fourth criterion was adopted to ensure that the topic either had awarded an identifiable product or was about to do so. Most, but not all, SBIR/STTR topics award at least one Phase 2 project.

Many topics included in this review were identified using the DoD SBIR/STTR database provided at http://www.dodsbir.net/. Candidate topics were initially identified by searching for projects that were initiated in the FY 1999–FY 2004 time frame and included the words "training" or "education" in their title, keywords, and/or abstract. Additional candidate topics were identified through personal contacts with government project and program managers. Descriptions and objectives of candidate SBIR/STTR topics, along with reports of the projects they awarded, were then reviewed in accord with the four criteria listed above.

D.   The June 2005 SBIR/STTR Workshop

A large and productive SBIR/STTR workshop was hosted by the Human Systems Reliance Panel, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), and the United States Joint Forces Command (USJFCOM) on 20–24 June 2005. This review includes 67 of the SBIR/STTR topics discussed during the workshop. Based on reports and information acquired through the end of August 2005, 13 topics were added following the workshop, yielding the total of 80 SBIR/STTR topics included in

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[4]   Training objectives are often expressed as knowledge, skills, and abilities (KSAs in training parlance), where "ability" generally refers to the correct application of the knowledge and skills attained. The "A" in KSAs just as often refers to attitude, but that alternative is not addressed in this report.

this review. Appendix A lists these topics and includes a brief description of their objectives.

The purposes of the June 2005 SBIR/STTR Workshop included those listed for this task: assess the contributions of SBIR/STTR activity to training and education S&T; identify clusters of topics that could be aggregated to describe and characterize DoD SBIR/STTR activity in training and education overall; identify S&T products; and identify S&T gaps. The workshop was also intended to improve communication and coordination among government R&D managers, thereby reinforcing and improving the development of the DoD community of interest in training and education.

1.   SBIR/STTR Topic Organization

The June 2005 Workshop brought together a host of government participants, topics, and activities. Its concern with training and education echoed the earlier 1999 workshop that the OUSD(S&T) Director of Biosystems had organized to review training and education R&D in general.

The 1999 workshop was not limited to SBIR/STTR topics and was organized in a top-down manner that focused on the following R&D topic areas in training and education:

- Intelligent Tutoring Systems (ITSs)
- Authoring Tools
- Distributed Simulation Environments for Instruction
- Dynamic Learning Management.

Aggregates of SBIR/STTR topics for the 2005 review and workshop were identified in a bottom-up manner to allow the SBIR/STTR topics themselves determine areas of R&D activity. Even though the topics reflect the applied, entrepreneurial, and commercial mandate of the SBIR/STTR programs, the R&D areas identified in 2005 closely resembled those identified for the 1999 workshop:

- ITSs
- Authoring Tools
    - General authoring tools
    - Authoring tools for simulation
    - Authoring tools for computer-generated participants

- Simulation-Based Training
    - Simulation training for teams
    - Simulation training for individuals
- Training System Design and Development.

These areas are used in this review to describe and characterize DoD SBIR/STTR activity in education and training. SBIR/STTR investment has produced S&T advances in each of them. Other areas might reasonably have been used, but those listed above appeared to provide the best and most comprehensive fit for SBIR/STTR topics created and funded in FY 1999–FY 2004.

Table 1 shows the SBIR/STTR R&D areas and the number of topics presented in each area at the June 2005 Workshop by the Army, the Navy, the Air Force, the Office of the Secretary of Defense (OSD), and the Defense Advanced Research Projects Agency (DARPA).

Table 1. Number of Topics by Service/Organization and by Sub-Areas

R&D Areas	Army	Navy	Air Force	OSD	DARPA	Totals
ITSs	4	–	1	5	1	11
Authoring Tools						
General authoring tools	1	1	1	7	–	10
Authoring tools for simulations	1	1	4	3	–	9
Authoring tools for computer-generated participants	1	–	1	–	–	2
Simulation-Based Training						
Simulation training for teams	3	–	5	1	–	9
Simulation training for individuals	7	–	8	2	–	17
Training System Design and Development	3	3	3	13	–	22
Totals	20	5	23	31	1	80
Proportion of total	0.25	0.06	0.29	0.39	0.01	100.0

All topics chosen for this review are listed in accord with this organization and are briefly described in Appendix A.[5]

a. Intelligent Tutoring Systems (ITSs)

Efforts to imbue computer-mediated environments with intelligence and the capability to participate in instructional interactions (dialogues) generated on-demand and in real time have been viewed for some time as requiring four interdependent capabilities (e.g., Brown, Burton, and DeKleer, 1982; Fletcher, 1975; Foster and Fletcher, 2002):

1. The capability to model the knowledge, skill, and ability possessed by individual learners

2. The capability to model the knowledge, skill, and ability learners need to meet instructional objectives

3. The instructional techniques needed by learners to help them acquire the requisite knowledge, skill, and ability

4. A means to communicate with learners—typically using interactions that can be initiated either by the learner or the computer, preferably undertaken using natural language.

ITSs use computational inference capabilities to build and then use (1) explicit, dynamic models of individual student's needs and abilities, (2) the knowledge, skills, and abilities to be learned by each student, and (3) one-on-one tutorial techniques to help students advance from their current state of learning to the objective state. Computer-mediated learning environments have used similar capabilities since the mid-1950s, but their modeling and inference techniques tended to be more implicit than those found in ITSs (Fletcher and Rockway, 1986). Two features primarily set these systems apart from earlier systems and led DoD to focus R&D on these systems in the early 1970s:

1. Mixed-initiative tutorial dialogues with students—dialogues in which either the student or the computer system could initiate tutorial inquiries and dialogue (Carbonell, 1970)

2. Generation of instructional interactions and interventions as needed on-demand and in real time (Brown, Burton, and DeKleer, 1982).

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[5] Those who attended the June workshop will note that some topics have migrated to different areas. Information presented at this workshop and a more careful review of topic reports suggested these reassignments.

In the 1970s, the capabilities of computer-mediated environments to reduce costs and time-to-learn while ensuring that each student achieved the required level(s) of competency were recognized and accepted. What hindered the adoption and implementation of computer-mediated environments, in addition to the usual problems of administrative and cultural inertia, were the high cost(s) of developing and delivering computer-mediated instruction. It was assumed that the almost irresistible advance of electronics (powered by Moore's Law)[6] would sooner or later solve the delivery problem. What remained were the costs to develop, or "author," these environments. The argument that motivated DoD investment in ITS at the time was that development costs could be reduced substantially by enabling the technology itself to generate instruction content (e.g., instructional items, progress assessment, simulations, and simulation scenarios) and instructional interactions (e.g., tutorial discussion, hints, and critiques) (Fletcher and Rockway, 1986).

The aim of developing computer-mediated environments that can establish and sustain tutorial conversations with individual students or with students acting individually or collaboratively in teams, crews, staffs, and units remains a major scientific and technological objective (Chipman, 2003; Fletcher, 2006; Foster and Fletcher, 2002; Graesser, Gernsbacher, and Goldman 2003). Substantial progress has been made since the 1970s, but more is needed before training, education, and performance aiding (e.g., problem solving, troubleshooting, decision aiding) become true mixed-initiative interactions between students (or groups of students) and computers. This objective, with its ability to deliver tailored instruction and performance aiding, remains as appealing as ever from both cost and effectiveness standpoints. Government R&D managers have continued to pursue it.

Many SBIR/STTR topics mentioned intelligent capabilities in their descriptions, but only those that addressed a generative or inference-making capability were included in this area. Those that did not, but that satisfied the other criteria for selection, were placed in other areas for this review.

As shown in Table 1, 11 SBIR/STTR topics were included in the "ITSs" area (10 of these topics were presented at the June 2005 Workshop, and one was added later).

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[6] The original Moore's Law derives from a speech given by Gordon Moore, later a founder of Intel, in 1965, in which he observed that the number of microcomponents that could be placed in an integrated circuit (microchip) with the lowest manufacturing cost was doubling every year and that this trend would likely continue into the future (Mann, 2000; Service, 1996).

b. Authoring Tools

Authoring tools have been an integral part of computer-mediated instructional environments from the beginning. The Air Force appears to have been the first of the Services to use computer capabilities for instruction. The Air Force provided a system imaginatively named the System Training Program (STP) to support the Semi-Automated Ground Environment (SAGE). SAGE grew out of the 1950s Whirlwind I project to provide a Defense Early Warning system (the "DEW line") to defend against air attacks on the continental United States. SAGE included authoring tools that allowed training specialists to program its training exercises (Fletcher and Rockway, 1986).

Enabling administrators, instructors, and students who are not computer specialists to create and modify computer-mediated instructional environments to meet their specific instructional needs and objectives has also been a goal since the beginning. The first computer system specifically designed and used for instruction (the 1965 IBM 1500 System) included Coursewriter, an authoring language that was intended to be used by classroom teachers to prepare material for their students—even though that was quickly shown to be impracticable. The early Naval Tactical Data System (NTDS) included Lesson Translator (L-TRAN) as an authoring tool. L-TRAN was used by sailors to prepare training materials on the operation of NTDS. There are now numerous additional examples of the successful application of authoring tools. A recent review of commercially available and successfully used authoring tools covered 43 such systems (Nantel, 2004).

Still, the development (authoring) of computer-mediated instructional environments—generative or otherwise—remains an issue in reducing development costs and maintaining, if not increasing, the quality of these environments (Gibbons and Fairweather, 1998; Murray, Blessing, and Ainsworth, 2003). Allowing professional developers, subject matter experts (SMEs), and front-line instructors who are not Information Technology (IT) specialists to create high-quality learning environments in a flexible and cost-effective manner remains a primary concern.

Many SBIR/STTR authoring topics focused on this goal. These topics emphasized the importance of enabling commanders, instructors, and students to tailor instructional environments for their immediate needs and audiences. Imbuing technology with generative capabilities should increase the range, scope, and sheer amount of instruction produced by a single authoring effort, but it will not remove the need for human intervention in the authoring process.

Subtopics for the authoring tools area were identified as those intended for general use in developing computer-mediated instructional environments, those specifically intended for developing instructional simulations, and those intended for developing realistic automated and semi-automated participants (friendly, unfriendly, or neutral) for simulations.

As shown in Table 1, 10 SBIR/STTR topics were included in the "general authoring tools" sub-area. Eight of these topics were presented at the 2005 workshop, and two were added later. Nine SBIR/STTR topics were included in the "authoring tools for simulations" sub-area. Six of these were presented at the 2005 Workshop, and three were added later. Two SBIR/STTR topics were included in the "authoring tools for computer-generated participants" sub-area. Both of these topics were presented at the 2005 workshop.

c. Simulation-Based Training

Since the days of the medieval quintain (a device used to train mounted knights in proper techniques of the lance) and earlier, simulators and simulation have been used widely to provide military training. Today's concern in DoD with networked simulation, interoperability, gaming, realism, immersion, situated learning, and the like may ensure the commercial value of innovative development in this area.

Much DoD training and education is conducted using simulations (e.g., Andrews and Bell, 2000), and there are good reasons for this. Simulations allow "situated" performance-based training to be conducted with reduced costs and increased safety, visibility, replication, and immersion for learners. These features permit practice and feedback on instructional objectives that would otherwise be impracticable to provide. SBIR/STTR topics in training and education are divided into two groups: simulation training for teams and simulation training for individuals. Computer-mediated learning environments appear to be at the core of both groups. As noted, topics included for the 2005 SBIR/STTR review focused on supporting training and education through the use of simulation rather than focusing on the computational techniques used to produce and operate simulations.

As shown in Table 1, nine SBIR/STTR topics were included in the "simulation training for teams" sub-area. Eight of these topics were presented at the 2005 workshop, and one was added later. Seventeen SBIR/STTR topics were included in the "simulation

training for individuals" sub-area. Thirteen of these topics were presented at the 2005 workshop, and four were added later.

d. Training System Design and Development

Intelligent instructional systems, authoring tools, and simulation all come together under the heading of training system design and development. The goal is to create a design capability that reliably ensures the accomplishment of instructional objectives in a cost-effective manner by all members of the training audience. Especially in training systems development, this goal is not one of art or even science but is more akin to engineering (e.g., Woolf and Regian, 2000). Once the specifications for knowledge, skills, and abilities are articulated as instructional objectives—along with their tasks, conditions, and standards—the instructional engineering goal is to apply design principles that reliably achieve these objectives, on time and within budget.

Many SBIR/STTR topics focused on the development of specific training systems. The appeal of using SBIR/STTR resources to develop specific training problems is not difficult to understand and appreciate. Among other things, SBIR/STTR funding can be used to address and solve emerging or recalcitrant training problems, thereby producing products that are likely to find a waiting market—at least within DoD. However, topics included in this review were required to address OUSD(S&T) and SBIR/STTR interests in advancing S&T training and education. Topics that targeted the creation of a specific training capability were included in this review and this area, but they were topics that also seemed likely to advance training and education S&T.

As shown in Table 1, 22 SBIR/STTR topics were included in the training system design and development area. Twenty of these topics were presented at the 2005 workshop, and two were added later.

2. 2005 Workshop Topic Presentations

R&D managers who presented topics at the June 2005 Workshop were asked to follow a fairly tight, common format for their presentations. Appendix B shows this format. It called for brief statements of the general problem or issue to be addressed by the topic, its objective, and the objectives and results of Phase 1 projects completed under the topic. Phase 2 results, final deliverable(s), military payoff, payoff to the company performing the project, and general lessons learned under the topic also had to be reported, along with the topic's successes, payoffs, and remaining R&D gaps.

E. SBIR/STTR Investment in Training and Education

The criteria used in this review for the selection of SBIR/STTR topics are fairly restrictive. More topics could reasonably have been included by relaxing these criteria; however, even under these constraints, the SBIR/STTR program in training and education is a sizable R&D investment. It totals over $83 million across 282 awards (184 for Phase 1 projects and 98 for Phase 2 projects).

Tables 2, 3 and 4 show Phase 1 awards (Table 2), Phase 2 awards (Table 3), and both phases combined (Table 4). These tables show the SBIR/STTR investment made in the 80 education and training topics identified for this review, by organization and by FY (FY 1999–FY 2004). FY 2004 SBIR/STTR topic awards are included in these tables, but funds awarded by these topics in FY 2005 are, of course, not. A search was made for SBIR/STTR topics that were initiated before FY 1999, met all other criteria for inclusion in this review, and made awards in FY 1999 or later; however, none were found.

Table 2. Total Phase 1 Training and Education SBIR/STTR Projects (Number) and Award Amounts ($000) by Service/Organization and by FY

Fiscal Year	Army	Navy	Air Force	OSD	DARPA	Totals
FY 1999	(1) 99.9	–	(6) 597.6	(2) 219.4	–	(9) 916.9
FY 2000	(3) 309.8	–	(4) 396.9	(6) 539.6	–	(13) 1,246.3
FY 2001	(1) 120.0	(7) 580.0	(6) 599.7	(26) 2,593.4	–	(40) 3,893.1
FY 2002	(7) 738.3	(2) 170.0	(11) 1,099.5	(43) 4,276.4	–	(63) 6,284.2
FY 2003	(8) 834.2	(3) 266.6	(9) 899.6	(13) 1,292.4	(7) 690.2	(40) 3,983.0
FY 2004	(9) 829.0	–	(4) 399.6	(6) 599.4	–	(19) 1,828.0
Totals	(29) 2,931.2	(12) 1,016.5	(40) 3,992.8	(96) 9,520.6	(7) 690.2	(184) 18,151.3
Proportion of Phase 1 Total	0.16	0.06	0.22	0.52	0.04	100.0

Note 1 for Table 2: *Sums (totals) may differ slightly because of rounding.*
Note 2 for Table 2: *Number of projects are shown in parentheses.*

Table 3.Total Phase 2 Training and Education SBIR/STTR Projects (Number) and Award Amounts ($000) by Service/Organization and by FY

Fiscal Year	Army	Navy	Air Force	OSD	DARPA	Totals
FY 1999	–	–	–	–	–	–
FY 2000	(1) 500.0	–	(3) 2,794.2	(4) 1,730.3	–	(8) 5,024.5
FY 2001	–	–	(4) 3,092.2	(9) 4,488.7	–	(13) 7,580.9
FY 2002	(4) 3,168.5	(1) 721.0	(3) 2,249.5	(12) 7,993.0	–	(20) 14,132.0
FY 2003	(5) 3,187.8	(4) 2,022.9	(9) 6,959.3	(14) 8,599.2	–	(32) 20,769.2
FY 2004	(10) 7,046.9	(0)	(5) 3,749.8	(5) 3,374.9	(5) 3,373.7	(25) 17,545.3
Totals	(20) 13,903.1	(5) 2,743.9	(24) 18,845.1	(44) 26,186.1	(5) 3,373.7	(98) 65,052.0
Proportion of Phase 2 Total	0.20	0.05	0.24	0.45	0.05)	100.0

Note 1 for Table 3: *Sums (totals) may differ slightly because of rounding.*
Note 2 for Table 3: *Number of projects are shown in parentheses.*

Table 4. Total Training and Education SBIR/STTR Projects (Number) and Award Amounts ($000) by Service/Organization and by FY

Fiscal Year	Army	Navy	Air Force	OSD	DARPA	Totals
FY 1999	(1) 99.9	–	(6) 597.5	(2) 219.4	–	(9) 916.8
FY 2000	(4) 809.7	–	(7) 3,191.1	(10) 2,269.9	–	(21) 6,270.7
FY 2001	(1) 120.0	(7) 579.7	(10) 3,692.0	(35) 7,082.1	–	(53) 11,473.8
FY 2002	(11) 3,906.8	(3) 891.0	(14) 3,349.0	(55) 12,269.4	–	(83) 20,416.2
FY 2003	(13) 4,022.0	(7) 2,289.7	(18) 7,858.9	(27) 9,891.7	(7) 690.2	(72) 24,752.5
FY 2004	(19) 7,875.8	–	(9) 4,149.4	(11) 3,974.2	(5) 3,373.7	(44) 19,373.1
Totals	(49) 16,834.2	(17) 3,760.4	(64) 22,837.9	(140) 35,706.8	(12) 4,063.9	(282) 83,203.2
Proportion of Grand Total	0.17	0.06	0.23	0.50	0.04	100.0

Note 1 for Table 4: *Sums (totals) may differ slightly because of rounding.*
Note 2 for Table 4: *Number of projects are shown in parentheses.*

Based on these data, it appears that DoD SBIR/STTR investment in training and education has grown considerably—from $0.9 million in FY 1999 to $24.8 million in FY 2003 (Table 4). The investment was lower in FY 2004 ($19.4 million), but it is still greater by a factor of about 20 over FY 1999.

For the FY 1999–FY 2004 time period, among the Services (Tables 1 and 4), the Air Force, with 23 topics, 64 awards, and $23 million in awarded funding, appears to have taken the most advantage of the SBIR/STTR program to support S&T in training and education. The Army is not far behind, with 20 topics, 49 awards, and $17 million in awarded funding. Navy participation produced 5 topics, 17 awards, and $4 million in awarded funding.

OSD, specifically OUSD(S&T) BioSystems, is a major player in the SBIR/ STTR training and education arena with 31 topics (Table 1), 140 projects, and $36 million in awarded funding (Table 4), all defined and managed by other DoD R&D organizations. OSD training and education SBIR/STTR activity accounts for about 43 percent of all funding in this area during the FY 1999–FY 2004 time period.

All three Services have participated roughly equally in developing topics and managing training and education projects for the OSD SBIR/STTR program. Ten OSD topics were developed and managed by Army R&D organizations, 10 topics were developed and managed by Navy R&D organizations, and 8 topics were developed and managed by Air Force R&D organizations. Three OSD topics were developed and managed by the Special Operations Command (SOC).

Table 5 shows the SBIR/STTR investment in all 80 education and training topics identified for this review by organization and by (sub)area. SBIR/STTR investments in ITSs supported 11 topics (Table 1) and awarded $15 million to 45 projects (Table 5). Authoring Tools, Simulation-Based Training, and Training System Design and Development were roughly equivalent in number of topics (21, 26, and 22, respectively: see Table 1), number of projects (81, 76, and 80, respectively: see Table 5), and award amount ($23, million, $24 million, and $23 million, respectively: see Table 5). Most (about 42 of 80) SBIR/STTR topics focused on developing training packages for specific subject areas.

Table 6 shows that DARPA and the Army lead in proportion of Phase 2 to Phase 1 awards with 71 and 69 percent, respectively, of their Phase 1 awards progressing

Table 5. Training and Education SBIR/STTR Projects (Number) and
Award Amounts ($000) by Organization and by (Sub-)Areas

R&D Areas	Army	Navy	Air Force	OSD	DARPA	Totals
ITSs	(8) 2,738.7	–	(4) 1,910.0	(21) 5,912.6	(12) 4,063.9	(45) 14,625.2
Authoring Tools						
General authoring tools	(2) 849.0	(5) 1,030.8	(2) 849.9	(37) 8,888.6	–	(46) 11,618.3
Authoring tools for simulations	(4) 986.6	(4) 641.8	(8) 3,399.0	(12) 3,135.1	–	(28) 8,162.5
Authoring tools for computer-generated participants	(2) 849.9	–	(5) 1,896.3	–	–	(7) 2,746.2
Simulation-Based Training						
Simulation training for teams	(10) 3,870.9	–	(13) 5,042.4	(6) 599.4	–	(29) 9,512.7
Simulation training for individuals	(15) 4,473.7	(1) 100.0	(24) 6,993.6	(7) 1,953.0	–	(47) 13,520.3
Training Systems Design and Development	(8) 3,065.3	(7) 1,987.8	(8) 2,746.8	(57) 15,218.1	–	(80) 23,018.0
Totals	(49) 16,834.4	(17) 3,760.4	(64) 22,837.9	(140) 35,706.7	(12) 4,063.9	(282) 83,203.6

Note 1 for Table 5: *Sums (totals) may differ slightly because of rounding.*
Note 2 for Table 5: *Number of projects are shown in parentheses.*

Table 6. Proportion of Phase 2 to Phase 1 Project Awards by Service/Organization

	Army	Navy	Air Force	OSD	DARPA	Totals
Proportions	(20/29) 0.69	(5/12) 0.42	(24/40) 0.60	(44/96) 0.46	(5/7) 0.71	(98/184) 0.53

to Phase 2. The Air Force is fairly close with 60 percent. Both OSD and Navy Phase 1 projects are less likely to progress to Phase 2, with 46 and 42 percent, respectively. Setting aside this variance, it appears overall that about half (53 percent) of Phase 1 projects in SBIR/STTR training and education progress to Phase 2.

Using SBIR/STTR funds, then, to develop specific training packages (both training systems and simulations) appears to be a major factor in SBIR/STTR investment. Many candidate topics were eliminated because they appeared to be more focused on producing a simulator, simulation, or training system to solve a specific training problem than on advancing S&T in training and education. Those topics that remain advance, at least to some extent, the state of the art and practice in training and education. Continued

effort appears to be needed to ensure that SBIR/STTR topics and projects in training and education stimulate technological innovation, in accord with the objectives of SBIR/STTR legislation.

F.   SBIR/STTR Training and Education S&T Products

The products from DoD SBIR/STTR investments in training and education discussed in this section are matched with the topic area into which they seem to fit best. This categorization was based on a reading of product reports and topic descriptions. That said, however, some products can easily be seen to be relevant to more than one topic. The purpose of this section is to suggest how all these products might be aggregated into general areas of S&T activity and to highlight the quality, productivity, and scope of effort evident in the FY 1999–FY 2004 DoD SBIR/STTR investments in training and education.

1.   ITSs

A review of ITS activities in DoD SBIR/STTR training and education topics and projects suggests four general S&T directions and concerns:

1. Natural language tutorial dialogue

2. Automated, continuous, and unobtrusive assessment of learner state and progress

3. Representation of knowledge, skill, and ability

4. Dynamic assembly of training from instructional objects to help learners progress from a current state of knowledge, skill, and ability to the objective state.

Among the capabilities DoD SBIR/STTR training and education topics and projects produced in the area of ITSs in the FY 1999–FY 2004 time period are the following:

- Natural Language Tutorial Dialogue

  – Latent Semantic Analysis (LSA) to match computer-generated interactions with the semantic structure, content, and level of discourse of learners' notes and textual contributions in training for operations planning and leadership

  – Agent system capable of engaging in natural language tutorial dialogue for coaching and training for operations execution

  – Dialogue-based, goal-directed practice to improve command reasoning.

- Automated, Continuous, and Unobtrusive Assessment of Learner State and Progress
  - Overlay techniques for matching learner knowledge state with automatically generated "expert" solutions for training for operations execution
  - Automated observer/controller (O/C) to provide individualized guidance and coaching during computer-based exercise/simulations and diagnostic After-Action Review (AAR)
  - Lightweight, low-cost brainwave detection of attention and focus during training
  - Automated analysis of facial expressions to assess learner levels of attention, mental effort, confusion, and fatigue
  - Low-cost, high-performance, minimally invasive eye tracking to assess learner performance and prescribe optimal training experience
  - Automated recognition and reporting of key situations and actions in simulation-based teamwork training using massively multiplayer (MMP) gaming environments to train small dismounted teams for urban environment operations.
- Representation of Knowledge, Skill, and Ability
  - Intelligent tutoring linked with simulation-based training for training military medical teams to make correct critical decisions under time-limited conditions
  - Recommendations for granularity in expert and student models to support training for anti-submarine warfare tactical air controllers
  - Support for information operations and information warfare training using cognitive modeling, knowledge engineering, and formal representations of knowledge.
- Dynamic Assembly of Training From Instructional Objects
  - LSA techniques for locating in large databases information relevant to learners' needs in training for operations execution and leadership
  - Selection of assets and construction of Web pages based on learner model generated to support training and performance aiding at a distance
  - Novel ways to create face-to-face interaction, coaching, and feedback and provide rapid access to expertise.

2. Authoring Tools

A review of authoring tools produced by the DoD SBIR/STTR training and education topics and projects suggested five general S&T directions and concerns:

1. Linking design and development to instructional objectives

2. Authoring by non-IT specialists

3. Simulation and scenario generation and preparation

4. Rapid (agile) simulation and scenario authoring

5. Creation of computer-generated (automated and semi-automated) participants (allies, enemies, and neutrals).

Among the authoring tools DoD SBIR/STTR training and education topics and projects produced in the FY 1999–FY 2004 time period are the following:

- Linking Design and Development to Instructional Objectives

    – Authoring guidelines for incorporating multisensory (visual, auditory, haptic, tactile, olfactory, and so forth) components in training for information processing and fusion in command and control (C2) environments

    – Authoring tools for combining low-fidelity production with high cognitive fidelity to produce training vignettes that focus attention on specific training objectives and sharing of expertise

    – Authoring tools to embed problem-based training capabilities in emerging Objective Force equipment

    – Authoring tools to ensure motivation and interest in (distributed) Web-based training material through the inclusion of social interaction, dynamic graphics, sound effects, and gaming/simulation.

- Authoring by Non-IT Specialists

    – Fully configurable user interface for instructor-designed simulations and scenarios involving three-dimensional (3-D) displays for satellite operations training

    – Cognitive analysis and framework leading to authoring tools that allow nondesigner SMEs to create Distance Learning materials

    – Diagnostic assessment of Navy watch team readiness linked to recommended training interventions that address performance shortfalls

    – Authoring tools for SMEs to provide and support a continuing cycle of analysis and development

- – Authoring tools to allow SMEs to design and create case-based instruction that help students abstract and apply principles from multiple cases.

- Simulation and Scenario Generation and Preparation

  - – Development and validation of a mission-oriented process to determine the training impacts of simulation federation modifications on proposed system enhancements

  - – Tools for diagnostic assessment of training scenarios in achieving training objectives

  - – Tools to support Distributed Mission Operations (DMO) training by customizing fidelity requirements to mission requirements and assessing the value of these customized levels of fidelity in enabling learners to meet training objectives

  - – Tools to link mission-essential competencies to knowledge and skills that inform the automated and semi-automated selection of training objectives and the design of scenarios

  - – Architecture and authoring tools for integrating 3-D components with Sharable Content Objects (SCOs) to create Advanced Distributed Learning (ADL)-conformant training scenarios.

- Rapid (Agile) Simulation and Scenario Authoring

  - – Authoring tools for materials that allow learners to collect and integrate information from a variety of sources in making tactical decisions rapidly

  - – Authoring tools for creating and customizing scenarios that are directly linked to immediate training objectives and can be modified in near-real time

  - – Authoring tools to enhance the agility of scenario creation and reduce development time to a matter of days or less.

- Creation of Computer-Generated Participants

  - – Authoring tools for representing culture-based behavior—including speech- and gesture-based communications—in joint, multinational operations in asymmetric environments

  - – Authoring tools for incorporating behavior moderators into materials for crowd-control training.

3. Simulation-Based Training

A review of simulation products produced by the DoD SBIR/STTR training and education topics and projects suggested five general S&T directions and concerns:

1. Simulation training linked to instructional objectives (for individuals)
2. Simulation training linked to instructional objectives (for teams)
3. Post-simulation performance feedback
4. Synthetic agents and avatars in simulation
5. Haptics in medical training.

Among the capabilities DoD SBIR/STTR training and education topics and projects produced in the area of Simulation-Based Training in the FY 1999–FY 2004 time period are the following:

- Simulation Training Linked to Instructional Objectives (for Individuals)

  – Web-based training to enhance cultural adaptability in leaders and soldiers, with an administration system for continued maintenance, modification, and development

  – Visual, agent-based representation for training and performance aiding in employing parameterized, hierarchical, and conditional procedures used to communicate with satellites in low earth orbit (LEO)

  – System for training in the use of handheld landmine detection systems to recognize signatures of landmine and clutter types under a variety of soil and environmental conditions

  – Computer-based, Sharable Content Object Reference Model (SCORM)-compliant systems to provide initial, advanced, and refresher training in medical emergency technical skills that integrate first responder higher level cognitive skills with task work skills

  – Personal computer (PC)-based simulation of air campaigns for training Joint Force Air Component Commanders (JFACCs) in mission-essential and supporting competencies.

- Simulation Training Linked to Instructional Objectives (for Teams)

  – Team training for space operations using (1) distributed simulation, (2) collaborative tools to provide workflow modeling, process control, data mediation, and communications infrastructure combined with intelligent agents, and (3) advanced human-machine technologies with automated script creation and approval

- Deployable trainer using simulated team members, team dialogue, and support tools to coach medical professionals in the decision-making and team-coordination capabilities needed to meet major chemical, biological, and radiological (CBR) emergencies.

- Post-Simulation Performance Feedback

  – Automated tools for skills assessment and AAR for detecting significant events and decisions in virtual Distributed Interactive Simulation/High Level Architecture (DIS/HLA) environments that provide small dismounted unit training for military operations in urban terrain

  – Methods for decomposing scenarios into meaningful "chunks" that provide scenario trigger identification and measurement-based evaluation of air combat performance for air combat scenarios

  – Predictive competency-based measurement and performance-aiding system that integrates observer-based and simulator-based measures of complex performance in environments such as DMO training to permit diagnosis and prescription in distributed learning

  – Cognitive models and workload assessment for specifying and assessing performance in a satellite command generation capability

  – Performance support toolkit to assess satellite operation work domains and identify satellite operator work, performance, and context-appropriate feedback and support

  – Tools and techniques for automating the unobtrusive and automated assessment of soldier situational awareness based on movement and behavior in virtual simulations.

- Synthetic Agents and Avatars in Simulation

  – Development of synthetic agents/team members playing different roles to provide distributed, anywhere, anytime, interactive, time-stressed decision-making training and personnel tracking for Air Operations Center (AOC) personnel

  – Development of an ontology for synthetic agents who collaborate with space crew members using speech recognition and simulated equipment to provide distributed training in the use of subscriber terminals

  – Low-cost, commercial off-the-shelf (COTS)-based, PC undergraduate pilot training system with agent-enabled synthetic tower controller and tutor for ground-based training in landing patterns and radio procedures during traffic pattern operations

- Tutoring system with virtual characters to support the acquisition of the social engineering skills needed to obtain intelligence by infiltrating and gaining access to an objective organization.

- Haptics in Medical Training

  - Application of a haptic mouse for training in patient palpitation and recognition of arterial pulses

  - Virtual free-floating needle with multitactile force feedback for needle insertion training in thoracentesis (a procedure to remove fluid from the space between the lining of the outside of the lungs (pleura) and the wall of the chest)

  - Open surgical skills simulator that employs haptic feedback and a curriculum based on task analyses of surgical procedures and performance metrics

  - Hybrid manikin simulator combined with a virtual reality (VR) curriculum adaptable to individual learner needs and performance metrics for training in procedures used to control limb hemorrhage

  - Mock endotracheal tube with haptic feedback coupled to a computer-controlled mannequin head with mechanically controlled airway geometry

  - Optimal approach for assessing simulators for training in combat casualty care procedures that would lead to a standardized assessment methodology

  - Metrics-based training system that combines tissue and blood vessel/flow models, visual and haptics modeling of six primary surgical tools and a graphics system in a simulator incorporating proper physics and stereo visualization

  - Open surgery trainer that allows visual tracking, free-floating Magnetic Levitation (Maglev) haptic feedback with real surgical tools and scenario-based training that can be configured using the eXtensible Markup Language (XML)

  - PC-based endoscopic surgical simulation system that integrates physics processing, device tracking, and graphic rendering with electronic circuitry that identifies and responds to the insertion of tools of different diameters and a gas-pressure approach to simulate syringe haptics.

4.   Training System Design and Development

A review of training system design and development products produced by the DoD SBIR/STTR training and education topics and projects suggested three general S&T directions and concerns:

1. Team training
2. Cognitive readiness training for leaders
3. Training in areas of special concern.

Among the capabilities DoD SBIR/STTR training and education topics and projects produced in the area of Training System Design and Development in the FY 1999–FY 2004 time period are the following:

- Team Training

  – Scenario- and case-based training in an online environment that allows connectivity among trainees, instructor monitoring, practice, and feedback to promote shared goals, beliefs, expectations, and intentions within command group planning teams

  – Web-based, scenario-based distributed training using video clips and automated scoring logic to leverage DMO technology and enhance decision-making by quickly configured, rapidly deployed teams such as the United States Marine Corps (USMC) Combined Arms teams and United States Air Force (USAF) Expeditionary Medical Support (EMEDS) teams.

- Cognitive Readiness Training for Leaders

  – Comprehensive frameworks, including specific critical skills for successful critical thinking and leader dialogue skills needed by battle command (BC) teams (to improve memory for messages and elicit evidence-based inferencing and questioning of information)

  – Web-based assessment and training with automated scenario structuring and selection for enhancing the ability of team leaders to recognize and act on critical points likely to affect the performance of multicultural, multinational teams

  – Customizable training and self-assessment program for leader self-development using self-appraisal, self-regulation, and self-development learning contracts

  – Simulation environment for training JFACCs based on an analyses of the knowledge resources available to support cognitive skills identified in cognitive task analysis of senior leader decision and assessments

- Application and extension of DARPA's Decision Net technology to enhance the situation awareness (SA) (perceive critical elements, assess their relative importance, and project future events) of small-unit leaders in Web-based distributed learning

- Web-based training to enhance junior officer leadership skills in communication, team-building, critical thinking, social appraisal, and emotional management

- Scenario-based practice for intelligence analysts focused on context-specific analytical skills, meta-cognitive skills to probe critical thinking, intelligence research, and automated assessment to improve report generation skills.

- Training in Areas of Special Concern

  - Training system employing closed-loop, adaptive technology as the enabling technology for supporting training in a reduced manning environment

  - Validated naturalistic decision-making scenarios based on cognitive task analyses for training multiple personnel in multiple locations to maintain SA and mission focus and envision exit strategies in Operations Other Than War (OOTW) (e.g., humanitarian relief, noncombat evacuations, peacekeeping)

  - SCORM-conformant, PC-based integrated operator training and rehearsal environment used to provide emergency procedures closed-loop adaptive training for ground satellite operators controlling multiple satellites

  - SCORM-compliant, open system with an underlying process ontology for conducting Web-based training in deficiency reporting and resolution

  - Modular, computer-supported training system based on formal analysis and definition of expert sea-keeping skills to enhance boat handling safety, mitigate shock, and improve high-speed maneuvering in heavy wave conditions

  - Standardized emergency medical protocols for emergency responders and ADL/SCORM-compliant Web-based sustainment training covering knowledge, application, and practice elements and including performance aids that can be downloaded to Palm devices

  - Rapid retraining or refresher training for combat casualty care that can be provided in a variety of computer-based environments: on the Web, in transit, in the field.

5. Across-Topic Areas

The review identified goals that were not limited to a single area and were, in different ways but to an appreciable extent, addressed across the four topic areas. These goals are as follows:

- Maintain focus on military relevance
- Increase accessibility of training, education, and performance aiding
- Incorporate "intelligent" computational capabilities
- Increase agility, rapidity, and ease of use in development
- Provide for reuse and interoperability
- Develop instructional interventions related to training and education objectives
- Develop simulation and games for training and education
- Tailor training and education to learner capabilities and needs.

G. S&T Progress Since FY 1999

FY 1999 was selected as the beginning year for topics to include in this effort because of the review (see Section D) of training and education R&D performed in that year. The FY 1999–FY 2004 SBIR/STTR topics have been categorized in much the same way as the efforts were reviewed in 1999. However, the SBIR/STTR topics included in this review generally reflect the applied and entrepreneurial nature of the SBIR/STTR program rather than a concentration on S&T progress. They also reflect the specific exclusions used to select topics for this SBIR/STTR review.

Tables 7–13 list the 1999 issues and then assesses the attention paid to them by the 80 SBIR/STTR training and education topics included in this review. Issues raised in the 1999 review were rated as Green, Yellow, or Red—roughly signifying the following:

- Green (G): Satisfactory current and/or anticipated research progress
- Yellow (Y): Borderline current and/or anticipated research progress
- Red (R): Insufficient current and/or anticipated research progress.

The headings, R&D objectives, and ratings in Tables 7–13 are taken directly from the 1999 summary of research objectives. Products from the FY 1999–FY 2004 SBIR/STTR training and education topics are reflected onto the 1999 objectives. Ratings of

Table 7. ITSs: Cognitive Theory

1999 R&D Objective	1999 Rating	SBIR/STTR Rating
Understand the evolution of expertise in complex, ill-structured environments	R	M
Investigate domain-specific problem-solving skills and generalizable strategies	Y	M
Determine the role and significance of flexible and adaptive learning in promoting better problem solving and critical thinking	R	M
Capture effective behaviors of outstanding human instructors	G	L
Develop theoretical basis for employing interactive simulations and associated training methodologies to guide use of simulations	Y	L
Develop an understanding of the role of interaction and collaboration in learning	Y	M
Develop techniques for assessing cognitive workload and strategies for mitigating its adverse effects	Y	L

Table 8. ITSs: Assessment

1999 Research Objective	1999 Rating	SBIR/STTR Rating
Develop technologies allowing free-form inputs for assessment	Y	M
Generate valid, unobtrusive, near-real-time assessments from learner interactions with the learning environment	R	H
Develop comprehensive models and measures of individual and team capabilities and performance	R	M
Integrate existing mission and occupational performance requirements	Y	H
Model the relationship between individual training/experience and ease of learning and retention of needed task-specific knowledge and skills	R	L

Table 9. ITSs: Collaborative Group and Team Learning

1999 Research Objective	1999 Rating	SBIR/STTR Rating
Define models for collaboration and interaction considering distance, content, roles, capabilities, and task requirements	Y	H
Create and evaluate collaboration arrangements and interaction strategies	G	M
Develop team-level tutoring concepts	Y	H

Table 10. ITSs: Intelligent Tutoring

1999 Research Objective	1999 Rating	SBIR/STTR Rating
Determine relevant task characteristics for instructional design and selection of instructional strategies	Y	H
Ascertain relevant individual characteristics for instructional design and selection of instructional strategies	G	M
Examine interactions between task and individual characteristics	Y	M
Develop a tutoring capability sensitive to subject matter, level of expected expertise, and learner motivation, ability, and preparation	Y	M
Model effective human tutorial dialogue	G	M
Identify optimal instructional strategies and technical approaches to natural language understanding, generation, and dialogue management	Y	M
Develop tools for authoring and modifying natural language dialogue	Y	L
Develop hardware and associated displays for augmented reality systems	G	L

Table 11. Authoring Tools

1999 Research Objective	1999 Rating	SBIR/STTR Rating
Create authoring tools for curriculum, simulations, assessment, system management, and intelligent tutors	Y	H
Provide automated feedback of individual and system performance data to centralized facilities	G	L
Develop reusable components of intelligent computer-assisted instruction and performance coaches	Y	M
Develop intelligent search engines for quickly selecting, parsing, and reusing archival knowledge	Y	M

Table 12. Distributed Simulation Environments for Instruction

1999 Research Objective	1999 Rating	SBIR/STTR Rating
Develop rapid, efficient processes and procedures for verification and validation of ADL environments	Y	L
Enable synthetic characters to respond to verbal and nonverbal commands and actions	Y	H
Enable the dynamic control of synthetic characters by instructors or intelligent tutors	G	M
Enable the interchange of real and virtual team members to support anywhere/anytime training delivery	G	H
Develop models for immersive training and education	Y	M

Table 13. Dynamic Learning Management

1999 Research Objective	1999 Rating	SBIR/STTR Rating
Develop reliable learner/user identification, authentication, and authorization	G	L
Manage restrictions of access to the network and maintain security between source and destination	G	L
Provide data security protection *transparently* across multiple networks and organizations	G	L
Automated indexing and searching, extraction and recoding of existing, knowledge-bearing digital data	Y	L
Efficient methods for extracting and coding expert human knowledge	Y	M
Learning content aggregation and disaggregation	G	M
Address graceful degradation of learning content	Y	L
High-bandwidth ubiquitous network	G	L

contributions made by the FY 1999–FY 2004 products to these objectives are not intended to be ratings of progress like the Green, Yellow, Red ratings assigned to the 1999 objectives. Rather, they are informal judgments of the concentration and attention that the SBIR/STTR topics and products reviewed in this report paid to the 1999 R&D objectives. These ratings are as follows:

- High (H): significant attention
- Medium (M): occasional attention
- Low (L): little or no attention.

If we equate G (Green – satisfactory progress) with H (High – significant attention), Y (Yellow – borderline progress) with M (Medium – occasional attention), and R (Red – insufficient progress) with L (Low – little or no attention), we find increased attention from the SBIR/STTR topics for about 10 of the 1999 research objectives and decreased attention for about 19 of the 1999 research objectives.

At least two comments apply to these findings. First, these findings are based on informed judgments, but they are still judgments. Second, while there are similarities in the incentives and purposes of the SBIR/STTR programs with those of R&D endeavors in general, there are significant differences, not the least of which stem from the applied, short-term, and commercialization goals of the SBIR/STTR programs. However, even under these constraints, areas can be identified in which more work is needed to carry out goals implicit in the overall SBIR/STTR enterprise in education and training.

H. S&T Gaps

Government R&D managers at the June 2005 Workshop were asked to identify gaps—the remaining capabilities needed to achieve their topic goals. Their views, along with others identified in personal discussions and still others extracted from direct review of SBIR/STTR technical documents, are summarized in the following discussion.

The gaps discussed here are genuine and credible, but the list is undoubtedly incomplete. Moreover, these gaps represent real R&D challenges. Resolving them may require innovation and/or technical breakthroughs, the availability of which may be as much a matter of serendipity as of deliberate design. The highest priority gap to fill, then, may not be determined on an *a priori* basis. It may simply be the one matched with the most promising technical idea. The S&T gaps summarized here are organized around the four major topic areas used elsewhere in this report.

Some of these gaps may—not surprisingly—apply to more than one of the four R&D topic areas. Work to fill some of the gaps has begun. Also, non-SBIR/STTR work to fill them may be ongoing. Nevertheless, some next steps and continued effort appropriate for SBIR/STTR support may be in order. Additional unresolved but significant S&T issues that deserve mention, may well occur to readers. Other issues will arise in the course of S&T progress.

1. **Discussion**

   a. **ITSs**

R&D needs in the ITS area fall under three general topics:

1. Natural language dialogue
2. Learner and expertise modeling
3. Generating tailored instructional interactions.

More specific R&D efforts to advance S&T in each of these three general topics include the following suggestions:

- Natural Language Dialogue

  – Extend LSA capabilities beyond single words to phrases

  – Develop a grammar for tutorial discourse to extend language dialogue understanding beyond single sentences or utterances to full discourse, including anaphoric references

  – Disambiguate semantic classes by creating topic maps and hierarchies

  – Include gestures as well as speech and text in mixed-initiative dialogue.

- Learner and Expertise Modeling

  – Develop nonintrusive, continual assessments to construct robust learner models from tutorial interactions

  – Create robust models of the knowledge, skills, and abilities shared by members of crews, teams, and units

  – Develop techniques for the optimal assembly of available personnel into teams for accomplishing specific missions and tasks

  – Identify and specify the granularity needed in student models to achieve specific training, education, and performance-aiding objectives

  – Enhance modeling capabilities for "higher order" cognitive capabilities such as analysis, critical thinking, adaptability, creativity, and flexibility

  – Develop models of enabling, or "mediating," knowledge, skills, and abilities as well as those for experts

  – Model O/C knowledge, skill, and ability requirements, especially the cognitive processes and critical thinking skills (CTSs) needed for AARs

  – Exploit the display, timing, and data-capture techniques of computer technology to devise more comprehensive models of cognition

– Enhance automated processes for capturing expert knowledge, skills, and abilities.

- Generating Tailored Instructional Interactions

    – Develop capabilities to identify, collect, and assemble sharable objects in real time, on-demand for training interventions tailored to learner needs and objectives

    – Increase the precision with which models of learner and expert knowledge, skills, and abilities are applied to tailor instructional interventions

    – Increase the efficiency and reliability with which instructional techniques lead to the attainment of instructional objectives.

b. Authoring Tools

R&D needs in the authoring tools area fall under four general topics:

1. Object-oriented authoring tools

2. Authoring tools for non-IT personnel

3. Cost-effectiveness tradeoffs

4. Authoring tools for specific capabilities.

More specific R&D efforts to advance S&T in each of these four general topics include the following suggestions:

- Object-Oriented Authoring Tools

    – Extend the SCORM to integrate third-party applications better, especially those concerned with

        – – 3-D displays and the sequencing of 3-D content

        – – Multilearner participation, collaboration, and assessment

        – – Haptics

        – – Psycho-physiological sensors

        – – Global positioning sensors

        – – Speech recognition and natural language understanding

        – – Avatars

    – Design and develop authoring tools for locating and accessing learning objects and their repositories

    – Develop cross-language search capabilities for identifying knowledge objects

- Include assessment in object packages.

- Authoring Tools for Non-IT Personnel

  - Reduce the time and resources needed to capture and represent expertise, especially in complex, ill-structured environments

  - Increase the range of instructional strategies, technologies, and sources of information with which authoring tools deal

  - Apply recent cognitive science achievements to help developers tailor training, education, and diagnostic assessment to individual learner needs

  - Enhance automated capabilities for performing front-end analysis and identifying training objectives, tasks, conditions, and standards

  - Design and develop automated authoring capabilities for rapid generation of simulations, scenarios, and instructional materials

  - Design and develop capabilities for generating instructional materials from case studies, narratives, and technical documentation

  - Design and develop authoring tools for computer-generated (automated and semi-automated) participants (allies, enemies, and neutrals: combatants and noncombatants)

- Cost-Effectiveness Tradeoffs

  - Design and develop authoring tools that treat costs and cost-effectiveness tradeoffs seriously, including tradeoffs for

    - – Tailored, diagnostic feedback vs. simple re-teaching

    - – Learner control vs. system control of training content and sequencing

    - – Direct instruction vs. hints

    - – Training with and without avatars

    - – Training with and without agents

    - – Game-like entertainment vs. simulation vs. direct instruction

    - – Training with and without models of misconceptions

    - – Training vs. performance aiding

    - – Automated vs. human-controlled participants

    - – Development with and without the use of sharable objects

    - – Handoffs between individual and team/collective training

      – –   Levels of physical vs. "psychological" fidelity

      – –   Live vs. constructive vs. virtual simulation

   –   Design and develop cost models with clearly defined cost elements for training and education authoring.

- Authoring Tools for Specific Capabilities

  – Authoring tools and capabilities to integrate training and education with performance aiding, decision-making, and problem solving

  – Authoring tools and capabilities for producing assessments of student progress linked to training objectives

  – Authoring tools and capabilities for developing genuinely entertaining games that produce specifically targeted training objectives

  – Automated aids for designing, developing, and reusing scenarios matched to training objectives

  – Authoring tools and capabilities for case-based instruction

  – Authoring tools and capabilities to reflect emotional states in avatars

  – Authoring tools and capabilities that provide "plug-and-play" cultural modules for training and assessment in multinational environments

  – Authoring tools and capabilities for agile, rapid construction of terrain databases, especially the urban terrain databases

  – Authoring tools and capabilities for performing training needs analyses

  – Authoring tools and capabilities for natural language interactions and mixed-initiative dialogue.

c. Simulation-Based Training

R&D needs in the simulation-based training area fall under four general topics:

1. Matching simulation-based training to training objectives

2. Automated detection of critical events and decisions

3. Cost-effective application of simulation- and game-based training

4. Development of specific simulation capabilities.

More specific R&D efforts to advance S&T in each of these four general topics include the following suggestions:

- Matching Simulation-Based Training to Training Objectives

  – Match scenarios and simulation fidelity to learner needs and training objectives

  – Establish fidelity requirements for training and assessing "higher order" cognitive skills

  – Use diagnostic information from individuals and teams to design, develop, and reuse scenarios.

- Automated Detection of Critical Events and Decisions

  – Automate the assessment of audio communication, communication net traffic, and text message traffic

  – Automate the identification of critical, "trigger" events and decisions for training and post-simulation (after action) feedback.

- Cost-Effective Application of Simulation- and Game-Based Training

  – Imbue nonplayer characters with sufficient knowledge, skills, and abilities to ensure character believability without disrupting scenarios

  – Develop capabilities to assess immersion, its effects on learning, and its cost effectiveness

  – Identify optimally cost-effective combinations of live, virtual, and constructive simulations

  – Determine the cost effectiveness of games and other highly motivating simulation

  – Determine the cost effectiveness of noncognitive effects and models integrated into human behavior representation.

- Development of Specific Simulation Capabilities

  – Simulate urban operations at night among individuals who are using different night vision technologies

  – Incorporate a better understanding of interactions among different behavior moderators operating concurrently

  – Train medical clinical procedures using more realistic, responsive, haptic capabilities with enhanced tool-tissue interactions

  – Enhance integration of noncognitive effects and models into human behavior representation

  – Develop a more precise, metrics-based methodology for determining the transfer of surgical skills from simulation to the real environment

– Enhance simulation-based capabilities for increasing SA of teams and individuals

– Allow free and facile interchange between live and virtual simulation participants

– Enhance haptics and machine-manikin interfaces for training combat casualty care.

d. Training System Design and Development

R&D needs in the training system design and development area fall under three general topics:

1. Team training

2. Cognitive readiness training and assessment

3. Specific training techniques (e.g., language and cultural training).

More specific R&D efforts to advance S&T in each of these four general topics include the following suggestions:

- Team Training

  – Develop capabilities to assess and diagnose shared understanding and team processes from a team's conduct of military operations

  – Develop capabilities for rapid preparation of teams—especially hastily assembled teams—during pre-deployment to accomplish specific missions

  – Extend training to a more comprehensive range of teams—from crews to command staffs—with a focus on communication, coordination, and knowledge representation for rapidly formed "pick-up" teams

  – Develop principles for trading off individual training with training that must be conducted within teams.

- Cognitive Readiness Training and Assessment

  – Account for different types and levels of cognitive abilities when training and assessing leaders

  – Train leaders to recognize and respond to operational patterns in asymmetric environments

  – Represent higher order cognitive skills, such as adaptability, creativity, and critical thinking

  – Develop objective, quantifiable measures for cognitive processes and capabilities

- – Balance discrete-outcome with continuous-immersion training strategies in cognitive skill development

- – Advance the scope of technology-based training and education models and applications beyond declarative knowledge to those involving analytical and evaluative thinking

- – Extend SA to a full range of echelons

- – Develop capabilities for addressing the real-time analysis of tasks and task workloads

- – Develop cognitive training and diagnostic cognitive readiness assessment for a full range of leaders—from strategic corporals to Combatant Commanders

- – Develop effective instruction in time-critical tasks and activities, such as trauma treatment and tactical decision-making.

- Specific Training Techniques (e.g., Language and Cultural Training)

  - – Integrate personnel records management systems seamlessly with training and education interventions to meet individual needs

  - – Determine the military value of training to assess the quantifiable impact of training on military operation success

  - – Develop rapidly modifiable medical training systems for combat casualty care—close to "point of wounding"

  - – Incorporate cultural differences in training for multinational operations, especially for cultural issues relating to information sharing and decision-making

  - – Enhance language and culture preparation for coalition and multinational operations, within military organizations and between military and nonmilitary participants.

2. Prioritization

How should all these gaps be addressed and prioritized by DoD SBIR/STTR training and education activity? One approach might be to concentrate on the unique features of the SBIR/STTR program. Opportunities to create SBIR/STTR topics and seek funding occur at least once a year. These "opportunities" do not have to be planned and budgeted for several years in advance and can respond to promising technical approaches as they arise. These opportunities broaden the base from which technical ideas can be drawn. Individual R&D program mangers have a myriad of small business entrepreneurial ideas and energy from which to draw. Flexibility, rapidity, and product development

seem to be hallmarks of SBIR/STTR topics and projects. R&D activities where these qualities are at less of a premium might be left to other sources of support.

In addition, some other areas are not receiving much R&D attention from other sources and might be particularly appropriate for SBIR/STTR funding. The following (nonexhaustive) list includes some of these topics:

- **Development of practicable cost-effectiveness models.** Improved cost-effectiveness is frequently used as a reason for R&D investment. However, cost models that have well-defined, comprehensive, usable, and widely agreed-upon cost elements are hard to find in training and education. These models are also rarely applied in assessing the military return on investment for training and education R&D products. Development of cost models that could be linked to operational effectiveness would make the resource-allocation discussions of training and education R&D investments more concrete and more competitive.

- **Progress assessment from routine interactions.** Using the communications, click streams, and keyboard inputs recorded from interactive system use to assess learner and user knowledge, skill, and abilities would significantly aid the process of tailoring training, education, performance aiding, decision aiding, information presentations, and so forth to the needs and capabilities of learners, users, and decision-makers. Recording the information can be done easily. Organizing and extracting useful information is much more difficult and needs further investment and effort. Modeling learners and users has received considerable R&D attention for some time (Fletcher, 1975; Morrison, 2003), but the techniques for extracting the needed information from routine interactions (aside from explicit testing) have not. An SBIR/STTR-supported effort to develop techniques for this purpose would improve our ability to create computer-mediated environments for training, education, and performance aiding and, as evidenced by the rudimentary efforts of online shopping sites, might find a commercial market.

- **Generation of instructional materials from reusable objects.** Training and education may be evolving toward the use of personal learning associates that, rather than presenting didactic lessons, would help learners attain instructional objectives by engaging them in open-ended, mixed-dialogue "conversations" (Carbonell, 1970; Chipman, 2003; Fletcher, 2006; Graesser, Gersbacher, and Goldman, 2003). System responses would have to be assembled on-demand, and in real time. These responses would have to be assembled from something, and reusable objects may prove as good or perhaps better for this purpose than anything else. The development of techniques for doing this have not been developed and are receiving limited R&D attention.

A capability for assembling tutorial interactions on-demand, in real time (or near-real time), and tailored to learner needs and abilities would advance the state of the art, reduce authoring costs, and likely succeed in the market place.

- **Instructional techniques for enhancing cognitive readiness (agility, flexibility, creativity).** One aspect of military operations that can most certainly be expected is the unexpected. Mission-essential task lists (METLs), mission-essential competencies, and mission rehearsal are helpful in preparing individuals and units for what can be anticipated in operations and missions. However, some portion(s) of the mission will be unanticipated, unexpected, and often not prepared for. How can individuals and units be better prepared to recognize the unexpected and deal with it in a creative, flexible, and agile manner? Instructional techniques for improving the ability to respond quickly to unexpected exigencies in a creative, unplanned (and successful) manner could be developed. Such techniques would have application beyond military operations. These techniques are receiving only limited R&D attention at present, but they might find SBIR/STTR resources for their development and willing customers in the marketplace.

I. SBIR/STTR Management

Some suggestions for managing the SBIR/STTR programs in training and education arose from this review. They concern (in no particular order) selecting SBIR/STTR topics for training and education, ensuring innovation, infrastructure engineering, oversight for commercialization, evaluating project results, and submission of project reports.

1. Selecting SBIR/STTR Topics for Training and Education

With the notable exceptions of ODUSD(S&T) Biosystems and DARPA, the final decisions about which topics are chosen and funded are usually made with limited or no technically qualified human systems input. The number of proposals an organization is allowed to fund is more likely to be determined on the basis of resources available than on the technical quality of proposals received.

Benchmarking for proposal scores differs between organizations. Its absence is causing scores to be inflated to the point that, in some instances, proposals that fail to score 99 or 100 will not be funded. Management attention may be needed to ensure (1) that human systems expertise is included in final selection of SBIR/STTR topics and (2) that well-defined score benchmarks are established and applied when selecting pro-

posals for funding. The former may not be difficult to provide. The latter will require analysis, decision-making, and exercise of leadership.

2. Ensuring Innovation

The tension between "requirements pull" and "technical opportunity push" is a perennial and well-noted issue for DoD R&D managers. It is as real in DoD SBIR/STTR training and education as it is elsewhere. The task is to seek intersections between the two and create commercially marketable products that are innovative in advancing the state of S&T and of practical military value in advancing the state of operational practice.

The appeal of setting aside some degree of innovation to produce a marketable product for a grateful military customer can be, for many practical reasons, irresistible. Many promising innovations are among the SBIR/STTR products covered by this review, but the innovation and S&T contribution evident in others is marginal. Achieving a proper balance between innovation and short-term "fixes" is always difficult, but the former should not be neglected.

3. Infrastructure Engineering

Most innovations create a "ripple effect" in the technical environment around them. Other activities may need to adjust their products and processes, or entirely new products and processes may have to be created to enable the absorption and institutionalization of the innovation into its environment. The innovation itself may have to be modified or augmented to adjust to its surroundings. Horseless carriages need filling stations, repair shops, and highways. Wireless telegraphs need transmitters, frequencies, and a radio advertising industry. In short, innovations require adaptation to and by the infrastructure into which they are to be introduced.

Timing matters. To be introduced and adopted successfully, an innovation needs sufficient supporting infrastructure for its users to realize its value and potential contributions to achieving their goals. No matter how technically advanced or promising an innovation may be, if it is too difficult, complex, or simply awkward to use (i.e., if it is introduced too soon, without a sufficient supporting infrastructure), it can easily fail in the marketplace.

These considerations suggest a need for conscious and explicit attention to infrastructure development. It does not seem unreasonable to view such development as a form of engineering that requires interdisciplinary effort to ensure that the introduction of

an innovation into its environment includes the technical, social, and economic changes needed for its successful adaptation. Infrastructure engineering is an essential aspect of innovation and deserves specific attention and support in the DoD R&D enterprise.

In the environment affected by DoD SBIR/STTR training and education investments, conscious and goal-directed infrastructure engineering may be needed to allow the successful integration of the innovations they produce. For instance, SCORM may need to be harmonized with the HLA for simulations based on reusable objects to be developed and used; authoring capabilities may need to be modified or developed to permit classroom instructors and students to prepare scenarios developed for haptics-based simulators; and classroom instruction budgeting practices based on instructor contact hours may need to be adjusted to allow the promise of anytime, anywhere training, education, and performance-aiding capabilities to be realized fully.

In brief, conscious attention and resources may need to be allocated to the development of an infrastructure engineering discipline if returns on SBIR/STTR investments of all sorts—including, of course, those made in training and education—are to be obtained fully and successfully.

4.   Oversight for Commercialization

The record for commercializing SBIR/STTR training and education products is spotty. Phase 3 is expected to proceed without further government investment. Once a promising innovation is produced, the responsible firm is expected to find other sources of funding. All SBIR/STTR projects are expected to develop a commercialization plan for a marketable product, and many do so. However, that may not be enough. No guarantees exist to ensure that Phase 3 will be funded or carried out, and significant SBIR/ STTR innovations are often left in the laboratory.

The culture and skills needed for R&D and technological innovation differ from those required for commercialization and marketplace transition. The difference can and evidently does handicap product development. A difficult challenge for many technically inventive R&D firms is recognizing and then effecting the shift of resources (estimated to be about 50 percent) from innovation to commercialization needed to carry out a successful Phase 3 transition. The problem is mitigated somewhat by Phase 2 extended funding, which can help firms develop products for use by a specific agency (e.g., DoD), but, overall, the problem remains. The commercialization track record for SBIR/STTR training and education can be improved with more oversight by government R&D project

managers to ensure that firms entering Phase 2 incorporate and embrace the culture and skills required for marketplace transition.

5. Evaluating Project Results

Few evaluations of the many SBIR/STTR products developed across the FY 1999–FY 2004 time period were documented in project reports. Products that proceed to commercialization will, of course, be subjected to marketplace evaluation and thereby will meet the SBIR/STTR program objective of increasing the commercialization of innovations derived from federal R&D. However, marketplace success depends on many factors other than the contribution that products make to S&T. Valuable, innovative, high-quality products may fail while others of far less worth may end up thriving in the national marketplace. If we are to "leverage" and learn from SBIR/STTR efforts, more attention (at least in addition to marketplace trials) should be given to evaluating the products and documenting their S&T value.

6. Submission of Project Reports

Locating SBIR/STTR project reports—particularly Phase 1 and Phase 2 Final reports—was often difficult and occasionally impossible. Only 57 percent of the Phase 1 final reports that should have been submitted to the Defense Technical Information Center (DTIC) could actually be found there. The Services/organizations differed in their rate of submission: 78 percent for Air Force projects, 67 percent for DARPA projects, 60 percent for Army projects, 52 percent for OSD projects, and 10 percent for Navy projects.

According to Department of Defense Directive (DoDD) 3200.12, *DoD Scientific and Technical Information (STI) Program (STIP)*, research, development, test, and evaluation (RDT&E) managers and performers are required to use and support the STIP. Further, performance of RDT&E studies and efforts are not considered complete until their STI is documented satisfactorily and provided to applicable STI distribution activities. Department of Defense Instruction (DoDI) 3200.14, *Principles and Operational Parameters of the DoD Scientific and Technical Information Program,* identifies DTIC as a central coordinating point for DoD STI databases and systems. It requires the Heads of DoD components to ensure that S&T findings and results derived from DoD contracts and grants are recorded as technical documents. They are further required to make these technical documents available to the DoD community through DTIC and other collection and distribution activities that seem appropriate. Technical documents are defined by

DoDI 3200.14 as "any recorded information that conveys STI or technical data, regardless of media." Notably, STI documentation in the form of journal articles and poster papers at symposia must also be provided to DTIC.

The Defense Federal Acquisition Regulations Supplement (DFARS) 252.235 of November 2004 also states that DTIC is responsible for collecting all scientific and technical reports for DoD (DFARS 235.010) and that R&D contractors shall submit two copies of approved scientific or technical reports to DTIC.

It therefore appears to be a DoD requirement that SBIR/STTR reports be submitted to DTIC. If nothing else, such a requirement would help to ensure that SBIR/ STTR STIP, in the words of DoDD 3200.12, "materially impacts DoD ability to leverage significant investments in defense technology." Requirement or not, many SBIR/STTR projects develop truly innovative products, procedures, and technologies. Their findings can contribute significantly to S&T and should be shared with the DoD R&D community and beyond.

Some SBIR/STTR reports may contain proprietary information needed for their commercial success. DTIC has adequate provisions for protecting these reports. Anecdotal evidence in SBIR/STTR training and education suggests that providing these protections is, at most, a minor problem. In brief, more DoD SBIR/STTR reports from training and education projects should find their way at least to DTIC.

J.   A Final Word

The creativity and energy of participating training and education R&D managers combined with the productivity and inventiveness of the small R&D firms that specialize in human systems attest well to the significant value of the DoD SBIR/STTR program in advancing both S&T and DoD operational capabilities. The program seems to be doing for training and education precisely what its authorizing legislation intended. Management issues concerning reports, commercialization, innovation, evaluation, and topic selection require some attention, but these issues are by no means unresolvable.

In short, much about the DoD SBIR/STTR training and education activity is commendable. R&D managers and several firms have taken advantage of this opportunity and should be commended. Participation in the program should be continued and encouraged—if not expanded.

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Glossary

3-D	three-dimensional
AAR	After-Action Review
ADL	Advanced Distributed Learning
AFB	Air Force Base
AFRL	Air Force Research Laboratory
AI	artificial intelligence
AOC	Aerospace Operations Center Air Operations Center
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
BC	battle command
C2	command and control
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CBR	chemical, biological, and radiological
CBT	computer-based training
CDR	Commander (U.S. Navy)
COTS	commercial off-the-shelf
CTS	critical thinking skill
DARPA	Defense Advanced Research Projects Agency
DFARS	Defense Federal Acquisition Regulations Supplement
DHP	Defense Health Program
DIS	Distributed Interactive Simulation
DMO	Distributed Mission Operations
DMT	Distributed Mission Training
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction

DTIC	Defense Technical Information Center
EBO	Effects Based Operation
EMEDS	Expeditionary Medical Support
FFRDC	Federally Funded Research and Development Center
FY	Fiscal Year
GIS	Geographic Information System
HLA	High Level Architecture
HOSTS	Haptics-Optional Surgical Training System
ICIA	International Communications Industry Association
IDA	Institute for Defense Analyses
IT	Information Technology
ITS	Intelligent Tutoring System
JFACC	Joint Force Air Component Commander
JIT	just-in-time
KSA	knowledge, skill, and ability knowledge, skill, and attitude
LEO	low earth orbit
LSA	Latent Semantic Analysis
L-TRAN	Lesson Translator
Maglev	Magnetic Levitation
METL	mission-essential task list
MMP	massively multiplayer
MRMC	Medical Research and Material Command
NLW	non-lethal weapon
NTDS	Naval Tactical Data System
O/C	observer/controller
ODUSD(S&T)	Office of the Deputy Undersecretary of Defense (Science and Technology)
OFW	Objective Force Warrior
ONR	Office of Naval Research
OOTW	Operations Other Than War
OSD	Office of the Secretary of Defense

PC	personal computer
PETA	Personal Education and Training Assistant
PI	principal investigator
R&D	research and development
RDT&E	research, development, test, and evaluation
S&T	science and technology
SA	situation awareness
SAGE	Semi-Automated Ground Environment
SBIR	Small Business Innovation Research
SCO	Sharable Content Object
SCORM	Sharable Content Object Reference Model
SME	subject matter expert
SOC	Special Operations Command
STI	Scientific and Technical Information
STIP	Scientific and Technical Information Program
STP	System Training Program
STRICOM	Simulation and Training Command
STTR	Small Business Technology Transfer
TATRC	Telemedicine and Advanced Technology Research Center
TCTC	Time Critical Targeting Cell
TPED	Tasking, Processing, Exploitation, and Dissemination
TST	Time Sensitive Targeting
USAF	United States Air Force
USARIEM	United States Army Research Institute of Environmental Medicine
USJFCOM	United States Joint Forces Command
USMC	United States Marine Corps
VR	virtual reality
XML	eXtensible Markup Language

Appendix A.
Small Business Innovation Research/
Small Business Technology Transfer (SBIR/STTR) Topics

Note: *An asterisk (*) (e.g., *OSD) indicates that the topic was added after the June 2005 Workshop.*

Note: A = Army; N = Navy; AF = Air Force; D = Defense Advanced Research Projects Agency (DARPA); OSD = The Office of the Secretary of Defense.

Intelligent Tutoring Systems (ITSs)

AF   2002-085

Adaptive Training for Real-time Intelligence Monitoring and Evaluation

Objective: Develop an innovative capability to support information operations and information warfare training using cognitive modeling, knowledge engineering, and formal representations of knowledge.

A   1999-T006

Creating Knowledge and Improving Training Through Latent Semantic Indexing (STTR)

Objective: Develop and evaluate novel ways for creating face-to-face interaction, coaching, and feedback and for providing rapid access to expertise.

A   2000-010

Automatic Adaptive Support for Selection and Rapid Team Building Leadership Skills Using Latent Semantic Analysis

Objective: Improve the capabilities of Latent Semantic Analysis (LSA) to provide (especially in Distance Learning) instant individualized feedback to instructors and students on written essays and memos.

A   2003-204

Adapting Intelligent Tutoring System for Assessing Collaborative Skills

Objective: Develop an automated event recognition capability to support performance assessment for simulation-based teamwork training in massively multiplayer (MMP) gaming environments for training small dismounted infantry teams in simulated urban environments.

A   2003-T001

The Virtual Observer/Controller (O/C)—Intelligent Coaching in Dismounted Warrior Simulations (STTR)

Objective: Develop an automated observer/controller for training in virtual environments that can assess soldier performance compared with standards.

D   2002-030

Real-time Assessment of Student State

Objective: Develop the capability to build in real time a multidimensional model (including physiological, psychological, and knowledge information) of the student and change teaching behavior based on this model.

OSD   2000-CR01

Automated Dialogue Modeling Using Natural Language Understanding in ADL by the Naval Air Warfare Center Training Systems Division

Objective: Develop a tutoring application that can be used in distributed training to respond with natural language output or topic selection to natural language queries from the student about the subject area.

OSD   2000-CR02

Training Users' Cognitive Readiness for Combat Command Using an Intelligent Tutor To Model Expert Mentor Interactions by the Army Research Institute for the Behavioral and Social Sciences (ARI)

Objective: Develop automated tutoring for an open-ended domain and provide training for more adaptive command leadership.

OSD   2000-CR07

Personal Education and Training Assistant (PETA) for Distance Learning by the Naval Air Warfare Center Training Systems Division

Objective: Develop an embodied, intelligent interface agent that provides the learner with counseling and mentoring; pedagogical support; course selection and scheduling; testing and performance feedback; learning management services; and career management services.

OSD   2001-CR12

The Grain Size of Student Models as a Factor in ICAI Effectiveness by the Office of Naval Research

Objective: Determine whether the grain size of the student model is a significant factor in training effectiveness.

*OSD 2002-DH10

Generative, Knowledge-based Approaches for Rapid Development of Simulation-based Medical Training, Air Force Research Laboratory

Objective: Develop a generative knowledge-based instructional system to rapidly produce simulation-based training for medical procedures.

General Authoring Tools

AF **2000-100**

Force Protection Training Technology

Objective: Design and implement tools for training development modularization and software delivery; distributing just-in-time (JIT) training content during mission preparation; and cross-training deployable environments and civilian domain.

A **2002-024**

Embedded Training for Objective Force Warrior

Objective: develop and evaluate prototype instructional design methodology, authoring tools, and training support for embedded training with projected Objective Force Warrior (OFW) technology and functions.

N **2001-011**

Web-based and Traditional Classroom Lesson Design Guide

Objective: Develop a computer-based instructional design tool that presents heuristics and guidance for designing effective training for traditional (classroom) and Web-based environments.

OSD **2000-CR04**

Digital Resource for Instructional Design in CBT Authoring Environments by the Office of Naval Research (ONR)

Objective: Develop a design tool for courseware development tool to assist non-expert courseware developers, including subject matter experts (SMEs) and others, in using expert instructional design methods.

OSD **2000-CR05**

Dismounted C4ISR Data Presentation and Dissemination by the Army Research Laboratory (ARL)

Objective: Create a toolkit-based development environment for creating military training applications using a multitargeted (game architecture) approach; Exploit Geographic Information System (GIS) collections to create geo-realistic game playing environments using automated feature recognition and extraction.

OSD   2001-CR04

3-D Components for Virtual Environments by the Army Simulation and Training Command (STRICOM)

Objective: Develop a framework and supporting authoring tools for the structured design of 3-D content based on reusable components conformant with the Sharable Content Object Reference Model (SCORM).

OSD   2001-CR11

Authoring Shell for Case-Based Instruction by the Office of Naval Research

Objective: Provide authoring tools for case-based instruction that reflect recent results from ONR-sponsored research on effective case-based instruction.

*OSD 2001-CR13

Toolbox/Intelligent Advisor for Creating Pedagogically Correct, Interesting, and Motivating Instructional Content by the Naval Air Warfare Center

Objective: Enhance Advanced Distributed Learning (ADL) on the Web through intelligent design and authoring software based on pedagogical issues, principles, and standards while focusing on learning object definitions that reap a return on investment.

OSD   2001-CR14

Intelligent Assistant for Web-based Training Vignette Design by the Naval Air Warfare Center

Objective: Develop for short sequences of instruction a content creation tool that focuses on problem solving, decision-making, and high-level cognition, is based upon a single instructional objective, is developed around a training scenario, and supports content management, distribution, and SCORM specification.

*OSD 2002-CR13

Design of Sharable Content Objects With Return on Investment by the Naval Air Warfare Center

Objective: Enhance ADL on the Web through intelligent design and authoring software based on pedagogical issues, principles, and standards while focusing on learning object definitions using SCORM with extended, interoperable, and discoverable meta-data tags.

Simulation Authoring Tools

AF   **2002-068**

DMT Training Requirements and Capability Analysis

Objective: Streamline and optimize the training systems requirements analysis process and associated database to support development of federations for Distributed Mission Operations (DMO) training.

AF   **2002-070**

Time Critical Targeting Cell (TCTC) for Team Training and Evaluation

Objective: Design and develop a synthetic team task environment representing a TCTC for training and evaluation of command and control (C2) strategies and operations.

AF   **2003-052**

Intelligent Scenario Generation Tools for Training and Rehearsal

Objective: Develop software tools to generate training automatically scenarios that meet syllabus requirements and target the development of student skills and competencies identified as weak, deficient, or in need of refresher training.

*AF   **2003-058**

Simulation Models for Satellites

Objective: Develop a specific simulation technology with rotation and zoom capabilities to allow visuals of internal equipment and equipment bays for spacecraft.

A   **2002-027**

Training Rapid Decision-making Processes Required by the Dismounted Objective Force Leader

Objective: Develop interactive computer-based methods to train the rapid decision-making processes needed by dismounted leaders in both conventional and digital battlefield environments.

N   **2002-184**

Training Simulation Intelligent Scenario Generation Tools

Objective: Develop tools with distributed intelligent support that reduce the cognitive workload for instructors, enable efficient scenario planning, improve training effectiveness of limited simulator resources, and enhance training outcomes.

*OSD 2001-CR08

Tactics, Training, and Procedures for the Warfighter Reacting to Crowd Dynamics by the Air Force Research Lab Human Effectiveness Directorate, Brooks AFB

Objective: Develop tactics, training, and procedures for users of lethal and non-lethal weapons (NLWs) that enhance the users' ability to assess the situation rapidly and make better real-time decisions that optimize the force required to meet mission objectives while minimizing conflict escalation.

*OSD 2001-CR09

Cognitive Demands of Warfighter Readiness by the Air Force Research Lab Human Effectiveness Directorate, Williams AFB

Objective: Identify the cognitive skills that contribute most heavily to effective combat mission planning for aviators, develop DMO training interventions designed to develop these cognitive skills, and evaluate the impacts on subsequent mission planning performance.

OSD 2002-CR14

Multimodal Visualization for Virtual Environments Training Systems by the Naval Air Warfare Center

Objective: Develop a design tool that provides guidance to command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) system designers regarding multimodal information presentation and develop a manning assessment tool to identify operators who have a high capacity for monitoring complex, multimodal, information-rich environments.

Computer-Generated Participants' Authoring Tools

AF 2000-098

Enhancing the Usability of Computer-Generated Forces

Objective: Develop and demonstrate computer-generated forces that are easier to build, understand, deploy, and control during exercises.

A 2001-027

Virtual Simulation Tools for Cultural Familiarization

Objective: Develop and deliver experiential training of cross-cultural skills within a mission context and develop new technology to train soldiers to understand cultural differences and to develop appropriate interaction strategies in a mission context using highly experiential, scenario-based training in virtual environments.

AF   1999-096

Distributed Team Knowledge Representation and Scenario-Based Performance Evaluation Methods

Objective: Measure performance by developing efficient, reliable, and valid methods to represent knowledge and to decompose combat training scenarios rapidly to identify critical measurement points and performance criteria.

AF   2000-080

Agent-based Measurement System for Advanced Distributed Learning Technologies

Objective: Develop predictive models of complex performance to permit diagnosis and prescription in distributed (learning) environments such as DMO training.

AF   2002-071

Distributed Interactive Training for the C2 Aerospace Operations Center (AOC)

Objective: Define cognitive models or framework to depict the horizontal and vertical integrated functions within and throughout the AOC, design instructional strategies to teach the integrated functions, and develop preliminary system architectural specifications.

AF   2002-078

Messaging Interaction Simulation

Objective: Enhance space operations training by increasing the fidelity of spacecraft simulation training environments by adding critical Space Operations Center support applications and providing instructors and trainees with training and evaluation support tools.

*AF   2004-070

Distributed Planning, Debriefing, and After-Action Review Capability

Objective: Develop, demonstrate, and evaluate a distributed planning, debriefing, and after-action review (AAR) capability for long-haul, distributed, computer-driven simulations in support of team coordination training.

A   2000-097

Assessing Decision-making Skills in Virtual Environments

Objective: Develop a method for automated assessment of small-unit leader decision-making skills while operating in virtual environments.

A   2003-031

Advancing the Objective Force Through Multinational Coalitions and Inter-agency Task Forces

Objective: Link with emerging technologies designed to improve the Army's collaborative information environment and facilitate execution of Effects Based Operations (EBOs).

A   2003-200

Advanced Virtual Environment Haptic Simulation

Objective: Review potential solutions for stimulating the sense of touch in a virtual environment, developing a prototype using full-body haptic technologies, and integrating it into the Army's virtual simulation environment.

OSD   2003-DH04

Deployable Simulation Training for Operational Medical Personnel & Emergency Responders (OSD/DHP) by the AFRL Wright Patterson Air Force Base

Objective: Accelerate the acquisition of expertise in decision-making and team coordination by developing an intelligent simulation training environment to support operational medical professionals on station and in a deployed status.

Simulation Training for Individuals

AF   1999-082

Training for Space Operators Using a Distributed Mission Training (DMT) Environment

Objective: Develop mission-ready space operators through DMT integration and realistic pre-combat rehearsal exercises for space teams.

*AF   2001-053

A Software Agent Advisor for Satellite Command Composition and Training

Objective: Develop a software agent for satellite ground systems operators to support the training and measurement of satellite command composition and operations.

*AF   2001-054

A Decision Aid for a Surveillance Satellite Crew Shift Supervisor

Objective: Develop a measurably effective decision aid for a surveillance satellite crew shift supervisor.

*AF   2001-055

A Satellite Pre-Pass Contact Support Aid

Objective: Develop a software agent for satellite pre-pass contact operations and support training.

AF   2003-045

Personal Computer (PC)-Based Aircraft Training System and Visualization Tool

Objective: Develop a PC-based system to train landing patterns and radio procedures during traffic pattern operations.

AF   2003-053

Time Critical Targeting Training and Rehearsal Environment

Objective: Design a realistic, fast-paced, interactive, scenario-based system to train personnel on the Time Sensitive Targeting (TST) process and develop and hone the cognitive skills needed to apply the process across a wide spectrum of situations.

AF   2003-064

Simulation and Training Development To Enhance the Tactical Knowledge and Readiness of Information Warfare Teams

Objective: Develop a training capability to facilitate the acquisition of knowledge and skills associated with social engineering (e.g., train students to play the role of a civilian computer technician in order to infiltrate an organization and gain access to an objective computer network).

*AF   2004-069

Enhancing Commanders' Cognitive Readiness at the Operational Level of War

Objective: Develop scenario-based training capability for operational-level leaders using advanced archiving/retrieval of contextualized developmental experiences.

A   2000-098

Training Media to Support Night Operations in Urban Settings

Objective: Develop computer-based technologies to improve soldiers' knowledge of night equipment and transfer of skills to urban settings and provide simulated cross-training experience to improve employment of night equipment in small-unit operations.

A   2002-055

Software-Driven Virtual Minefield

Objective: Develop realistic training with real-time feedback that combines a virtual minefield with computer-modeled sensor signals corresponding to physical target signatures in various soil and environmental conditions.

A   2001-180

Needle Thoracentesis Simulation Workstation for Medical Training

Objective: Create "virtual patients" so physicians can acquire and maintain skills needed to perform needle thoracentesis procedures.

A   2001-T007

Telemedicine and Advanced Medical Technology - Medical/Surgical, Mission Support Modeling, and Simulation (STTR)

Objective: Create "virtual patients" so physicians can acquire and maintain skills needed to perform central venous catheterization.

A   2002-184

Medical Modeling & Simulation—Exsanguinating Hemorrhage From Limbs

Objective: Develop simulation-based training to teach all potential users, combatants, and medical personnel how to apply a tourniquet to stop acute exsanguinating hemorrhage from limbs.

A   2002-T017

Telemedicine and Advanced Medical Technology—Refined Training Tools for Medical Readiness (STTR)

Objective: Develop and apply new tools to evaluate and report the effectiveness of simulators and simulation systems for training medical personnel in key combat casualty care skills by exploiting and/or modifying systems used in military aviation and aerospace industries.

A   2003-162

Haptics-Optional Surgical Training System (HOSTS)

Objective: Develop and demonstrate a computer-based HOSTS for training open surgery procedures.

OSD 2002-CR03

Dismounted Infantry Situational Awareness Assessment in Virtual Simulations by the Army Research Institute

Objective: Develop an unobtrusive system for measuring situation awareness (SA) at squad level, rapidly tailoring content and format for AAR performance feedback, and providing in-depth measures that support research and training management.

OSD 2002-DH03

Medical Modeling & Simulation—Advanced Ureteroscopy Simulation Workstation for Medical Training by the Army Medical Research Acquisition Activity TATRC

Objective: Develop a proof-of-concept and design, develop, build, and demonstrate a PC-based ureteroscopic endoscopic surgical simulation training system for training military and civilian health care professionals.

Training Systems Design and Development

AF 1999-083

Modeling and Simulation of Less-Than-War Scenarios

Objective: Develop innovative training strategies and approaches and evaluate their efficacy for Operations Other Than War (OOTW) training.

AF 2002-072

Integrated Satellite Operations Training and Rehearsal for Multiple Satellite System Ground Control

Objective: Develop a high-fidelity integrated operator training and rehearsal environment for multiple satellite system control.

AF 2002-263

e-Learning and Aptitude Evaluation through a Web-based Training Framework

Objective: Create an advanced SCORM compliant open system for Just-In-Time eTraining, eTesting (JITCube), and Web-based e-Learning.

A 1999-011

Development and Test of a Framework for Critical Thinking Skills in a Military Context

Objective: Develop and evaluate training for critical thinking skills (CTSs) by developing a conceptual model that integrates CTS, knowledge, attitudes, other

relevant cognitive variables, battle command (BC) tasks, and performance within a BC context.

A   2002-026

Planning Exercise System To Promote Shared Mental Models

Objective: Improve the efficiency, effectiveness, and innovativeness of the command group planning process by developing and evaluating a training system that relies on case-based group training for promoting shared understanding.

A   2002-T001

Leader Self-development Support Program (STTR)

Objective: Promote effective self-development for leaders by defining, investigating, and developing capabilities for self-appraisal, self regulation, and self-development.

N   2001-101

Maintenance Skills Training through Distributed Learning Principles

Objective: Design, test, and field a distributed learning system that supports the development of core and advanced technical skills through Web-enabled interactive mentoring and technology-infused curricula that provide the physical stimulation of the senses found in "stand-up" classroom instruction.

N   2001-116

Embedded Training in an Optimized Manning Environment

Objective: Research, design, and develop a prototype training system employing closed-loop adaptive training technology as the enabling technology for supporting training in an optimized manning environment.

N   2002-034

Scalability and Reusability Methods for Intelligent Tutors and Job Performance Aids for the Maintenance of Reduced Manning Ships

Objective: Provide access to real-time, contextual knowledge, either locally or through distance support, for maintaining equipment on reduced manning ships.

OSD   1999-004

Adaptive Instructional Systems by the U.S. Army Research Institute (ARI), Ft. Rucker

Objective: Develop an approach for the design and implementation of CBT systems that dynamically adapt instructional methodology to individual differences

in learning style and rate, capitalize on student strengths, and match content and structure of training events to the student's conceptual structure.

OSD   2000-CR06

Enhancing Situation Awareness in Military Operations by the ARI Benning

Objective: Develop and validate methods for enhancing the individual SA of small-unit leaders in military operations.

*OSD 2000-CR09

Cognitive Learning Strategies for Medical Skills Training and Sustainment via Distance Learning Means by the Special Operations Command

Objective: Identify the cognitive skills that contribute most heavily to effective combat mission planning for aviators, develop training interventions designed to develop these cognitive skills, and evaluate the impacts on subsequent mission planning performance.

OSD   2001-CR06

Scenario-based Decision Skills Training for Geographically Distributed Teams by the Air Force Research Lab Human Effectiveness Directorate

Objective: Develop, implement, and evaluate a scenario-based, distributed training system to enhance team decision-making skills.

OSD   2001-CR07

Professional Leadership Development Skills Training for the 21st Century by the Air Force Research Lab Human Effectiveness Directorate

Objective: Develop a computer-based, Internet-accessible leader training system that targets junior Air Force officers with limited leadership experience in the interpersonal skills needed for unit leadership.

OSD   2001-CR10

Assessment Methods for Tactical Knowledge and Cognitive Readiness of Intelligence Tasking, Processing, Exploitation, and Dissemination (TPED) Teams by the Williams AFB

Objective: Develop automated methods to assess tactical knowledge and cognitive readiness of Intelligence TPED teams.

*OSD 2001-CR15

Instructional System for Enhancing Sea-keeping Cognitive Readiness and Decision-making Skills by the Special Operations Command

Objective: Develop a training system that enhances safety by improving operator sea-keeping readiness and decision-making skills.

OSD 2002-CR01

Warrior Readiness for Coalition and Collaborative Teams

Objective: Design, implement, and evaluate a training and assessment tool for leaders of multinational/multicultural teams.

OSD 2002-CR06

Integration of Behavior Moderators into Cognitive Performance Models for Assessing Cognitive Readiness, Natick Soldier Center, in Collaboration With Army Medical Research and Material Command (MRMC)

Objective: Develop a comprehensive model of behavior moderators present in combat environments and their effects on the individual combatant's ability to accomplish cognitive tasks and develop a full-spectrum model of cognitive functioning applicable to combat environments in which behavioral moderators attenuate or prevent cognitive deficits.

OSD 2002-CR15

Web-based Game Design Advisor, Naval Air Warfare Center in Collaboration With the Army Research Institute

Objective: Develop a set of game design recommendations for Distance Learning courses in the form of a Web-based design aid.

OSD 2002-DH06

Computer Based Simulation Technology for Training Technical Skills in Medicine by the Army Medical Research Acquisition Activity (USARIEM)

Objective: Design and develop unobtrusive techniques and methodologies to predict individual and team readiness to perform critical medical mission objectives.

OSD 2002-DH09

Global Treatment Protocol Course via Advanced Distributive Learning by the Air Force Research Laboratory

Objective: Standardize common patient assessment/treatment protocols, develop ADL/SCORM-compliant, sustainment-level, Internet-accessible training with

downloadable job aids for using these protocols and create an infrastructure for measuring and tracking first-responder readiness.

OSD **2003-DH07**

Distributed Medical Training for Force Mobilization and Disaster Relief by the Office of Naval Research

Objective: Develop and assess computer-based capabilities that can be used in a variety of environments (e.g., on the Web, in transit, in the field) for rapid retraining and/or refresher training in the medical procedures needed for force mobilization and disaster relief.

Appendix B.
2005 Small Business Innovation Research/
Small Business Technology Transfer (SBIR/STTR)
Workshop Slide Templates

- **SBIR/STTR Topic Number and Title.** For example, AF2003-045, *Personal Computer (PC)-Based Aircraft Training System and Visualization Tool.*

- **Distribution Statement.** As shown.

- **Briefer information.** Self-explanatory.

The purpose of this slide is to give the audience a quick understanding of the topic.

- **Heading.** Fill in with correct information (see previous page).

- **Cluster.** Please use the cluster title from the agenda where this SBIR/STTR topic will be briefed, as follows:

  – Monday p.m. – Authoring

  – Tuesday a.m. – Simulation Training for Teams

  – Tuesday p.m. – Instructional System Development

  – Wednesday a.m. – Intelligent Tutoring Systems

  – Thursday a.m. – Simulation Authoring

  – Thursday p.m. – Computer-generated Technologies.

USE SHORT BULLETS TO ANSWER THE FOLLOWING

- **Problem/Issue.** What problem is/was this topic intended to solve or what issue is/was it intended to address?

- **Objective(s).** What were/are the broad goals of this SBIR/STTR research topic? Where possible, quantify.

Phase I	Phase II?
Title Š only if different from header **Performer** **Objective** **Results/Product**	
Title Š only if different from header **Performer** **Objective** **Results/Product**	
Title Š only if different from header **Performer** **Objective** **Results/Product**	

The purpose of this slide is to list and describe, as briefly as possible, the Phase I and Phase II projects that were funded under this SBIR/STTR topic. It is also intended to show which Phase I projects were extended into Phase II.

- **Heading.** As in slide 2.

For each Phase I SBIR/STTR in the topic, please give:

- **Title.** The SBIR/STTR *contract* title (can be shortened to conserve space). For example, *Personal Computer (PC)-Based Aircraft Training System and Visualization Tool* could be rewritten *PC-based Aircraft Training and Visualization*. You do not need to restate the SBIR/STTR contract title if is the same as the topic title.

- **Performer.** The name of the SBIR/STTR contractor company and principal investigator (PI).

- **Objective.** A short objective for the Phase I [e.g., a state-of-the-art analysis of student models in artificial intelligence (AI), conceptual model of language learning].

- **Results/Product.** A short description of what was accomplished/progress toward meeting the objective.

For each Phase II contract,

- If the Phase I did not become a Phase II, provide a short reason why not (e.g., No – lack of funds, No – approach not likely to succeed) in the appropriate cell.

- If the Phase I became a Phase II, indicate in the appropriate cell why it was selected for a Phase II (e.g., Yes – highly creative approach to training language skills).

SBIR/STTR Phase II Contract Title

Place lab or service logo here

Meaningful graphic depicting the Phase II, e.g., model, software flow chart or product design

Meaningful one-liner about what the graphic represents goes here

Company name

4

This is the first of three slides (this slide and the two following) required for *each* Phase II contract funded under the SBIR/STTR topic.

- **Heading:** Indicate the Phase II *contract* title.

- Use the slide to present some graphic or photographic representation of the contract effort or its product.

- Place a caption at the bottom of the slide that highlights the graphic.

- **Company.** Indicate the company performing the SBIR/STTR on the bottom left of the slide.

SBIR/STTR Phase II Contract Title

Place lab or service logo here

Objective

Technology Solution

Results/Findings

Final Deliverable

Company

5

This is the second slide in the series of 3 on each Phase II contract within a topic.

- **Heading:** Use the SBIR/STTR *contract* title.

- **Objective:** A short bullet on the objective of this Phase II. (It may or may not be the same as the Topic objective on the slide one.)

- **Technology Solution:** What technical capability or "idea" [e.g., latent semantic analysis (LSA), machine-learning techniques to extract principles from stories, object-based authoring, SOAR technology (an architecture for intelligent problem solving and learning) to assess cognitive readiness, phrenology] was/will be applied to achieve the objective of this effort?

- **Results/Findings:** In no more than three bullets, describe the results and their contribution to the overall objective of the SBIR/STTR *topic*. Quantify as much as possible. If the Phase II is still in effect, provide expected contributions that Phase II will make in meeting the SBIR/STTR *topic* objective.

- **Final Deliverable:** Is a final report due? If so, when. What form will this final deliverable take?

- **Company.** Indicate the *company* performing the SBIR/STTR on the bottom left of the slide.

This is the last slide in the series of three on each contract within a topic.

- **Heading.** Use the SBIR/STTR *contract* title.

- **Lessons learned.** What went/is going well? What did not/is not?

- **Payoff**

  – A bullet on the return on investment (general knowledge gained, product implementation, problem solved, and/or impact on military operational effectiveness).

  – A bullet on who has or will use its results to do what? (External is better, but internal is all right).

  – For those not yet completed, provide potential payoff.

- **Other.** Anything else you think might be of interest to the audience (e.g., an award-winning SBIR/STTR, significant publication**,** new capability for in-house or contractor use, generation of a program of research or a new SBIR/STTR topic, movement to a Phase III).

- **Company.** Indicate the *company* performing the SBIR/STTR on the bottom left of the slide.

SBIR/STTR Topic Number & Title:

Remaining S&T gaps:

7

The last slide.

- **Heading.** Use the SBIR/STTR *topic*.

- **Remaining science and technology (S&T) gaps.** If topic is completed, use no more than five bullets to answer the most appropriate questions posed below:

    – Does the problem that motivated this project still exist?

    – What S&T gaps remain to be filled in this topic? What remains to be done to solve the problem or resolve the issue addressed by this topic?

    – Have new S&T opportunities emerged or are there additional S&T opportunities yet to be examined?

    – What do we still need to know or be able to do?

    – Has research on this topic identified a new problem/issue that should be addressed by S&T effort(s)? If yes, please suggest some S&T gaps that need to be filled to address this new problem/issue.

If the **Remaining S&T gaps** topic is not completed, provide a bullet or two on what you would do next on this topic.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

This task reviewed contributions made by the Department of Defense (DoD) Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs to science and technology (S&T) in support of training and education. Included were 80 SBIR and STTR topics initiated during the Fiscal Year (FY) 1999–2004 time period—topics that awarded more than $83 million to 282 Phase 1 and Phase 2 projects The review found that these topics could be categorized into four research and development (R&D) areas: Intelligent Tutoring Systems (11 topics and $15 million), Authoring Tools (21 topics and $22 million), Simulation-Based Training (26 topics and $23 million), and Training System Design and Development (22 topics and $23 million). Goals being addressed across all four areas included focusing on military relevance; increasing the accessibility of training and education; incorporating "intelligent" computer capabilities; increasing the agility, rapidity, and ease of materials development; providing reuse and interoperability; linking training and education strategies to instructional objectives; developing games and simulation for training and education, and tailoring training and education to learner capabilities and needs. Gaps that remain to be filled in meeting S&T goals were identified for all four areas. Final discussion identified issues in managing DoD SBIR/STTR programs. These issues included infrastructure engineering, submission of reports, oversight for commercialization, ensuring innovation, evaluating results, and selecting SBIR/STTR topics for training and education.

15. SUBJECT TERMS

Small Business Innovation Research (SBIR), Small Business Technology Transfer (STTR), training, education

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