Air Force SBIR STTR

Advantage

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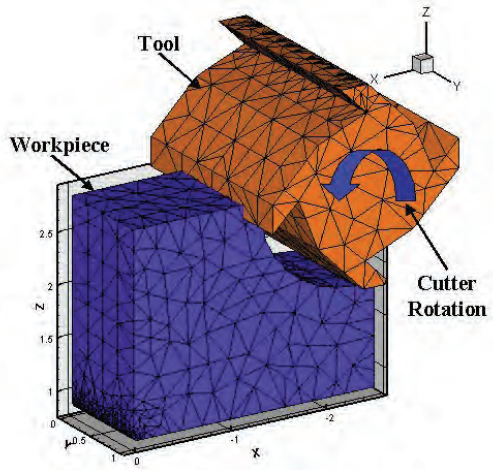
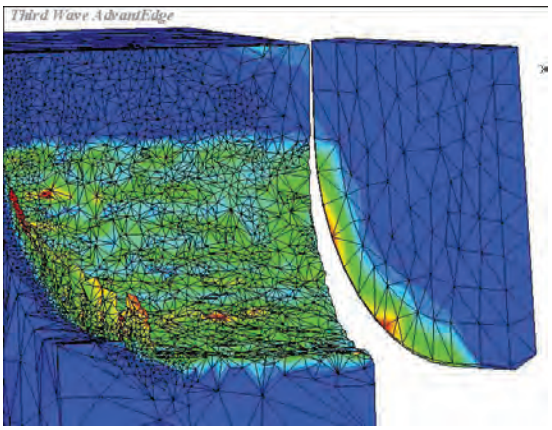
Offering a brief look at the vital research and development contributions made by the Small Business Innovation Research (SBIR) Program in direct support of the Air Force mission.





Left: Depiction of multiple tooth cutting with variable chip load. Cutter rotates and feeds forward relative to the workpiece, providing enhanced capability for HSM modeling of titanium. Right: Tracking heat transfer into the workpiece and chip. Tool is progressing into second pass and utilizing heat generated from the first pass.

PROJECT SUMMARY:

- *The Air Force needs improved high speed machining (HSM) techniques that can significantly increase metal removal rates and promote cost efficiencies*
- *Third Wave Systems (TWS) enhanced a non-commercial version of its Computer Aided Engineering (CAE) software, AdvantEdge FEM, to simulate various cutter geometries and process conditions, ultimately identifying high-opportunity operating envelopes for titanium machining*
- *AdvantEdge FEM allows users to increase material removal rates, improve tool life, predict chip shape, shorten product design cycles, reduce trial and error testing, and improve part quality through residual stress prediction*
- *TWS's customers include Department of Defense prime contractors such as airframe builders and jet engine manufacturers, as well as automotive companies, major cutting tool suppliers, and metals suppliers*

Improved Titanium Machining Process

Air Force Requirement

Recent advances in the high speed machining of aluminum-based materials have significantly reduced the cost of aluminum aerospace structures. In order to improve machining productivity and reduce finished product cost, new and innovative concepts are being sought which have the potential to substantially improve metal removal rates and machining efficiencies. In particular, specific opportunities are being sought in development of improved cutting tool and machining technologies that could significantly increase metal removal rates.

SBIR Technology

High speed machining (HSM) techniques save industry millions of dollars each year. In addition, research utilizing physics-based modeling into the thermal and mechanical roles of the cutting tool and workpiece has led to the ability to thermally tune the machining process, resulting in lower cutting forces and higher material removal rates while maintaining tool life.

Third Wave Systems (TWS) enhanced a non-commercial version of its Computer Aided Engineering (CAE) software, AdvantEdge Finite Element Model (FEM), to simulate various cutter geometries and process conditions, ultimately identifying high-opportunity operating envelopes for titanium machining. A variety of component technologies were advanced from AdvantEdge FEM's two-dimensional setting to a new three-dimensional environment, building upon successive modeling component technologies to provide deeper insight into the machining process. Using AdvantEdge FEM, TWS demonstrated the feasibility of doubling metal removal rates while maintaining tool life through the correct combination of tooling geometry and process parameter selection.

Transition Impact

Today, the commercially-available AdvantEdge FEM 3D software is the first modeling package dedicated to the three-dimensional modeling of material behavior during cutting conditions and the cutting process. AdvantEdge FEM allows users to increase material removal rates, improve tool life, predict chip shape, shorten

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SBIR Perspectives

AFRL Sensors Directorate

Sensors Directorate scientists and engineers (S&E) respond to questions from the SBIR/STTR Advantage editorial staff.

How does the Sensors Directorate interface with the system program offices (SPOs) in identifying and managing SPO-sponsored SBIR projects?

Our primary interface is through the SBIR Topic Suggestion Module (TSM). Each Product Center (e.g., Aeronautical Systems Center) has its own topic selection process and schedule, so we want to enter our ideas in the TSM and make contact with Center points of contact well in advance of the solicitation.

Technical advisors working within the core technical competencies (CTC) and Focused Long Term Challenge (FLTC) portfolio encourage discussions regarding topics as well as encouraging Sensors branch personnel to brainstorm and submit their own topics into the TSM. Additionally, contact is maintained with SPO personnel who act as focal points within their organizations for the topic areas worked within the CTC. These points of contact provide feedback regarding timelines and focus areas. We jointly develop SBIR topics with the SPOs, and the topics are entered directly by the SPOs into their system for the Product Center "rack-and-stack," as well as in the SBIR Topic Module.

Over time, our understanding of long-term planning objectives and the SPOs' understanding of viable SBIR research areas collectively lead to successful topic development. Recent examples include SBIR topic submissions related to Intelligence, Surveillance, and Reconnaissance (ISR) technologies which must evolve quickly to transition to the current fight in places like Afghanistan. Teamwork is key – the AFRL and SPO team refines the topic to get it formally accepted.

Managing SPO-sponsored topics differs depending on the SPO personnel. We prefer stakeholder involvement from proposal technical evaluation to program progress and presentations during the Phase I and Phase II contract execution.

When you think of successful SBIR project transitions and payoffs, what examples come to mind?

One of the directorate's more successful SBIR topics which originated several years ago was related to Low Cost Reconnaissance Sensing and ultimately resulted in a Space Computer Corporation contract on hyperspectral reconnaissance. This topic resulted in a Phase II project that was expanded for multiple users along with a current Phase III contract. It was a key component to producing hyperspectral processing capabilities successfully demonstrated under the Spectral Infrared Remote Imaging Transition Testbed (SPIRITT) Advanced Technology Demonstration (ATD), Civil Air Patrol (CAP) Airborne Real-time Cueing Hyperspectral Enhanced Reconnaissance (ARCHER) production system, Hyperspectral Collection and Analysis System (HyCAS) Advanced Concept Technology Demonstration (ACTD), Airborne Cueing and Exploitation System Hyperspectral (ACES Hy) low rate production program, and Tactical Satellite-3 (TacSat-3) Advanced Responsive Tactically Effective Military Imaging Spectrometer (ARTEMIS) satellite demonstration.

In another SBIR project, CAP Wireless, Inc., developed a solid state amplifier that transitioned directly to Warner Robins Air Logistics Center, and replaced an aging tube amplifier in the ALQ-161 self-defense system of the B-1B bomber.

"We are making a change in the way we utilize the Small Business Innovation Research (SBIR) program. Historically, we've done a good job of developing internal topics and responding to Product Center needs. However, we should be making every effort to help Product Center personnel develop topics throughout the year, rather than simply reacting to a solicitation data call. We need to take a look at the Product Center needs and consider how we can leverage our SBIR program to more effectively meet those needs. By utilizing the SBIR program as an extension of our own expertise and capability, we can increase the value of the program for everyone."

Brian M. Kent, Ph.D., ST
Chief Scientist
Sensors Directorate

Successful transitions have also occurred through efforts of the Anti-Tamper/Software Protection Initiative (AT SPI) SBIR workshop, in which invited Phase II performers interact with larger, more established contractors in the hopes that mutually beneficial partnerships are created. The Sensors Directorate hosts this annual workshop sponsored by the Director of Defense Research and Engineering (DDR&E). In 2009, the Sensors Directorate hosted 37 small businesses and 18 additional large businesses attended. Pikewerks and Luna Innovations are just two examples of companies with successful transitions. Pikewerks developed a Kernel-mode software protection system to prevent piracy, reverse engineering, and tampering of critical applications and data. Luna Innovations designed and developed stand-alone secure processor cards for processing critical program information.

It is rewarding to see R&D occur in areas in which we have written SBIR topics and solid developments have resulted.

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SBIR Spotlight

Brief profiles of companies that currently participate in the SBIR/STTR contract process

Acree Technologies Incorporated, Concord, CA
Acree Technologies explored methods to benefit from the resiliency and ease of fabrication of plastic insulators which still have the toughness and resistance to surface flashover damage of a ceramic by coating the plastic insulator with a ceramic surface treatment. The advantage of plastic over ceramic insulators is that they are easier and less expensive to construct, particularly for large complex shapes, and they are resilient and more durable. The resiliency of plastic insulators is particularly important in vacuum applications where the insulator may form an integral part of the vacuum seal and may be subjected to compressive stresses as the chamber is pumped down.

Acree Technologies delivered a coated plastic insulator to the Air Force for use in a high-power pulse power device. The coated insulator should increase the life of the pulse power component while allowing the performance of the pulse powered device to increase.

This SBIR project (topic number AF05-005) is managed by the Air Force Research Laboratory (AFRL) Directed Energy Directorate. Visit Acree Technologies at www.acreetech.com.

Aerodyne Research, Inc., Billerica, MA
A gas sampling probe that quenches chemical reactions by using supersonic expansion and helium dilution was developed by Aerodyne Research for the Arnold Engineering Development Center under SBIR topic number AF05-301. The probe was designed through rounds of computational modeling and laboratory testing, and was subsequently manufactured and then tested at the University of Tennessee Space Institute behind a J85-GE turbojet engine.

The experimental test results demonstrated that the Chemical Quick-Quench (CQQ) probe suppressed the oxidation of carbon monoxide (CO) inside the probe system and preserved more CO at afterburning conditions. In addition, the CQQ probe prevented hydrocarbons from being partially-oxidized to form CO at idle powers, thus measuring more hydrocarbons and less CO at that low power condition.

The CQQ probe has the potential to be employed as a standard method to measure the performance of afterburning military engines. In particular, measuring the combustion efficiency of afterburning engines has been difficult due to the challenge of measuring CO in the reacting plume. By quenching chemistry in the sampling process, the CQQ probe allows the accurate measurement of CO and more reliable determination of the afterburning engine performance. Visit Aerodyne Research at www.aerodyne.com.

Aptima, Inc., Woburn, MA
Aptima developed the Simulation of Cultural Identities for Prediction of Reactions (SCIPR) to allow planners to predict how attitudes may change in response to certain events. SCIPR is an agent-based computer simulation that forecasts the effects of actions on peoples' opinions and cultural identities. This SBIR project is managed by the AFRL Human Effectiveness Directorate under topic number AF05-069.

The reactions of various individuals to events are a result of multiple feedback loops that interact with one another. SCIPR models these complex feedback loops using both multi-agent and systems dynamics modeling. While it does not predict the actual attitude, it does allow the user to identify the relative direction and change in attitude over a period of time in response to different sequences of events.

SCIPR is a fully functioning prototype that accounts for the ways in which people interpret and react to events. It enables users to ask what-if questions in order to gauge the effects of alternative courses of action on the identities and belief systems of friends, foes, those in between, and those who are ambivalent. Visit Aptima at www.aptima.com.

Boston Applied Technologies, Inc., Woburn, MA
Under a SBIR project managed by the AFRL Space Vehicles Directorate (topic number AF06-267), Boston Applied Technologies, Inc. (BATi) developed, built, and tested a composite focal plane array (FPA) device with an arbitrary tunable spectral response, which is capable of covering the whole midwave infrared (MWIR) range. The key component is a large aperture electro-optical tunable filter that is made from a transparent OptoCeramic® material. The tunable filters can perform very fast (sub-millisecond) reconfiguration on spectral response.

Filters with aperture from millimeters to inches are available for U.S. customers. These filters can work with many FPA devices for rapid reconfiguration of spectral response. The working range covers from visible to MWIR (up to 7-microns).

The developed device, with its capability of arbitrary tunable spectral response, can be used for target detection and reduced false alarm rate. In particular, spectral regions where the background scene is bright (relative to the target) could be excluded.

The tunable optical filters developed in this SBIR program extended the application of BATi's electro-optic ceramic materials technology to MWIR. Visit BATi at www.bostonati.com.

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product design cycles, reduce trial and error testing, and improve part quality through residual stress prediction. Additionally, the modeling technology provides a baseline platform for derivative software products that can be used by commercial airframe designers for distortion prediction, and CNC programmers for tool path optimization.

AdvantEdge FEM commercial users are located across the United States, primarily representing the aerospace, automotive, academic, and cutting tool industries. TWS's current customers include Department of Defense prime contractors such as airframe builders and jet engine manufacturers, as well as automotive companies, major cutting tool suppliers, and metals suppliers.

Company Impact

"This SBIR project provided TWS with valuable opportunities for enhancing the AdvantEdge FEM software and securing its spot as the world's leading CAE machining modeling software. Since the completion of the SBIR project in 2005, the company has experienced consistent growth in software sales, engineering services and staffing, and remains one of the top SBIR award recipients in Minnesota.

In 2008, TWS was awarded an Air Force contract for close to $3 million to ensure the successful transition of modeling and high performance machining technologies into commercial applications for the efficient and affordable fabrication of titanium integrally bladed rotors used in F135 and F136 engines.

SBIR Topic Number:
AF01-134

Title:
Improved Titanium Machining Process

Contract Number:
F33615-02-C-5320

Company Name:
Third Wave Systems, Inc., Minneapolis, MN

Technical Project Office:
AFRL Materials & Manufacturing Directorate, Wright-Patterson AFB, OH

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In some cases, small businesses have stood up a division based on topics we have sponsored. We have a win-win situation: the small businesses develop successful products and we gain access to new technology.

"In a general sense, I think of the projects that fund the lower tier companies that are successful in developing a project or knowledge that has broad impact to our prime contractors," observes a Sensors Directorate engineer. "An example would include a new material system or electronic device technology that can be used by any Department of Defense customer or an integrated subsystem demonstration or systems engineering analysis." (Editor's note: See this and other transition success stories posted to the Electronic Library of the Air Force SBIR/STTR Website, www.sbirsttrmall.com).

How can system program offices and AFRL technology directorates get more "bang for the buck" from the SBIR program?

All parties need to stay engaged. We must sustain one-on-one relationships between our directorate and SPO personnel to form the core activity of identifying SPO-sponsored SBIR projects. Proactive and continuing interface is needed to nurture a project from initiation to Phase II/III completion.

Other improvements would come from better time synchronization of the elements of the SBIR process so that topic selection and funding decisions are made with full knowledge of the year's activity.

For more information concerning this article, please contact Claudia Duncan or Julie Harris, (937) 904-9764/9155, afrl.sn.sbir.office@wpafb.af.mil.

U.S. AIR FORCE

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The goal of the Air Force SBIR Program is to serve the technology needs of Air Force warfighters. It accomplishes its mission as part of the Air Force Research Laboratory's (AFRL) integrated research and development (R&D) team. AFRL's mission is leading the discovery, development, and integration of affordable warfighting technologies for our air, space, and cyberspace forces.

SBIR Advantage is published quarterly by the Air Force SBIR Program office. This publication offers an overview of AF SBIR issues and information.

The purpose of SBIR Advantage is to provide Air Force, DoD, and other government leadership with additional insight into the vital contributions made by the SBIR program to Air Force R&D.

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