Fact Sheet

Defense Advanced Research Projects Agency

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DARPA DISRUPTIVE MANUFACTURING TECHNOLOGIES PROGRAM FACT SHEET

The Defense Advanced Research Projects Agency (DARPA) Disruptive Manufacturing Technologies program is developing technologies that will have a pervasive impact on Department of Defense (DoD) systems and platforms, both current and future. Metrics for the DARPA Disruptive Manufacturing Technologies program are significant and pervasive cost savings for multiple platforms or systems and/or decreases in cycle time for manufacturing of components for existing Defense systems and future military procurements.

Background

The rate at which asymmetric threats evolve has increased the speed with which new systems and platforms must be produced and increased the need to distribute new technologies (e.g., upgraded body armor) to a larger number of troops. At the same time, increased lethality of our modern weapon systems has resulted in a reduction of the number of large systems required to accomplish missions. This new environment places a premium on fast and affordable manufacturing processes. Furthermore, when the cost of manufacturing spare parts is taken into consideration, it becomes clear that new approaches to defense manufacturing are critically needed to guarantee the future success of the military. To address this shortfall, DARPA is sponsoring the Disruptive Manufacturing Technologies program. To ensure that the focus of these projects is on manufacturing and not on the product of manufacture, each project has one or more "challenge parts" – components currently manufactured for a defense system that provide the benchmarks for cost and cycle-time improvements.

Disruptive Manufacturing Technology for Integrated Circuits

A related program, DARPA's Three-Dimension Micro Electromagnetic Radio Frequency (3-D MERFS) program, was launched in 2004 to dramatically increase the performance and decrease the size, weight, and cost of millimeter wave systems. Under the 3-D MERFS program, subcontractor Rohm & Haas developed and demonstrated a new lithographically printed rectangular coaxial transmission line structure. This Polystrata™ technology for the first time enables monolithic integration of complex, compact, and high-performance millimeter wave systems.

Under the Disruptive Manufacturing Technologies program, BAE Systems is leveraging the Polystrata™ technology to dramatically decrease the cost of traveling wave tube amplifiers commonly used in electronic warfare, information warfare, radar, and communication systems. BAE, with partners Rohm & Haas and the University of Colorado at Boulder, will be

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demonstrating the ability to integrate existing active components, such as millimeter wave amplifiers, directly within the Polystrata™ transmission lines. This integration requires the team to overcome significant impedance matching and thermal management challenges.

If successful, however, the BAE Systems team will have demonstrated not only a 10 times decrease in traveling wave tube amplifiers cost, but also a new paradigm for millimeter wave circuits. The current monolithic microwave integrated circuit (MMIC) paradigm, developed in DARPA's Monolithic Microwave Integrated Circuit program, integrates transmission lines, amplifiers, and impedance-matching features on various III-V semiconductor materials. The revolutionary capability enabled by these circuits has driven the cell phone revolution, and the development of countless military systems. However, MMICs utilize the semiconductor area very inefficiently, resulting in large and expensive III-V chips. The Hybrid Microwave Integrated Circuits (HyMICs) paradigm promises to remove the large impedance matching and transmission line structures from the semiconductor chip, housing them in the inexpensive Polystrata™ material. If successful, this approach will dramatically decrease the requirements on the semi conductor chip in terms of both area and yield, revolutionizing the cost of millimeter wave systems.

Phase I of this project, scheduled to end in 2008, will result in a proof-of-concept, 20-watt amplifier module implemented with Polystrata™ technology. Phase II, scheduled to end in 2010, will culminate in the demonstration of a form-fit-function, 160-watt amplifier ready for military insertion. The contractor for this effort is BAE Systems. Their phase I contract amount is $4.85 million.

Disruptive Manufacturing Technology for Software Producibility

Adaptation is an increasingly important property of modern weapon systems. Due to rapidly evolving asymmetric warfare, existing systems must be adapted quickly to meet emerging threats. Current software engineering tools do not adequately support the rapid addition of new capabilities to existing models and code. The reality that perfect software and hardware are unlikely to be delivered causes concern that operational degradation can result from accidental system faults.

Critical functionality and long-life for complex manufacturing systems cannot be ensured without software-enabled products that can adapt to new environments. The goal of this effort is to develop new technology for the design, production, and deployment of software-intensive systems based on adaptive, model-based software technology. Tools developed in this program directly address this missing capability and will provide a strategic advantage to the United States.

The central innovation is the development of an integrated, model-based software technology tool suite that will be uniformly applied to software adaptation across multiple timescales. BAE Systems, Massachusetts Institute of Technology, and Vanderbilt University Institute for Software-Integrated Systems are teamed in the Producible Adaptive Model-based Software (PAMS) project. PAMS is new technology founded upon proven methods in Model-Based Software Engineering developed in previous DARPA programs such as Model-Based

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Integration of Embedded Software and Software Enabled Control and now being applied to programs such as Future Combat Systems; DD(X) Multi-Mission Future Surface Combatant; Joint Air/Ground Operations Unified, Adaptive Replanning; and Single Integrated Air Picture. PAMS represents a major departure from current model-based software technology by shifting the emphasis from design tool and component reusability to model-based system adaptation at all levels of abstraction and throughout a system's life cycle.

The effectiveness of program results will be demonstrated and measured in two key DoD application areas: flight control/vehicle management systems and software-defined radios. The flight control/vehicle management systems experiments will demonstrate design and run-time adaptation; the software-defined radios experiments will demonstrate design, load, and run-time adaptation. These substantially different domains will provide compelling evidence that this technology is broadly applicable and can have a significant impact on a large cross section of critical DoD systems. A 90 percent cost reduction over the use of current, best-of-breed software engineering tools is expected through the adoption of this technology. In addition, a significant improvement in software robustness measured in terms of test coverage over the entire system and rework costs associated with software defects is expected.

This program consists of two 18-month phases. At the end of phase I, in the first quarter of FY 2009, the program will assess developed technologies for their contribution to system goals. Phase II, scheduled to end the third quarter of FY 2010, will be a series of experiments to evaluate the project through testing for progress and to formulate next steps. BAE Systems received $3.4 million for phase I.

Disruptive Manufacturing Technology for Advanced Materials

Advanced materials are critical to the performance of defense systems and platforms. Everything the warfighter uses is composed of materials, and innovative processing technologies can enable new capabilities as well as improved performance. Better, stronger, smarter, and longer-lasting materials can make a substantive difference on today's battlefield. Three advanced materials projects are underway as part of the DARPA initiative in Disruptive Manufacturing.

The first advanced materials project is focused on polymer composites. It will develop and demonstrate non-autoclave manufacturing technology for polymer matrix prepreg composite structures, including aspects of a compatible material family, processes, tooling, equipment, and design guidelines. The technology development will focus on establishing robust materials and out-of-autoclave processes for fabrication of full-size aerospace structural components with the same performance as autoclave-processed materials. The developments in this program will enable the use of the same materials and processes for both development and production, mitigating risks frequently realized in program life cycles at maturation to production. Polymer composite parts can be manufactured in low volume production at 75 percent of the cost of autoclaved components. This project is being led by Boeing, which received $2.64 million in phase I funding from DARPA.

The second advanced materials project focuses on superalloys. Direct Digital Manufacturing (DDM) of airfoils is a concept that disrupts the state-of-the-art investment casting

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process for manufacturing superalloy airfoils, the high strength blades that power aircraft turbine engines. DDM of airfoils will eliminate nearly all the tooling, handling, and associated causes for scrap in airfoil investment casting. It will enable production of new designs that are impossible using current processing and more efficient on-demand manufacturing. DDM's underlying technology involves layer-by-layer patterning of photocurable ceramic resins through large area maskless lithography. The phase I program is led by the University of Michigan and is funded at $3.33 million.

The third advanced materials project has a ceramic focus. Pressureless sintering of plasma-synthesized boron carbide nano-size powder will disrupt the current methods for manufacturing body armor. Boron carbide armor is lightweight and has excellent ballistic properties, but current batch processes for its manufacture are slow and costly. The challenge component is the Enhanced Small Arms Protection Inserts (ESAPI) plate for use in body armor. The underlying technology is two-pronged: reduce the cost of armor-grade powder through novel plasma synthesis in a continuous process, and use pressureless sintering to densify the powder into ceramic armor without the need for high-cost hot pressing. Together, these developments will reduce the cost of armor inserts by two-thirds. Phase I, scheduled to end in 2008, is aimed at the manufacture of test plates that will achieve a National Institute of Justice Level IV ballistics rating. PPG Industries Inc. is leading this effort with phase I funding of $986,000.

Additional Resources

- Point of contact for media inquiries: Jan Walker, (703) 696-2404, jan.walker@darpa.mil
- Disruptive Manufacturing Technology program websites:
    - Integrated Circuits - http://www.darpa.mil/MTO/Programs/dmt/index.html
    - Software Producibility - http://www.darpa.mil/ipto/programs/dmt/dmt.asp
    - Advanced Materials - http://www.darpa.mil/dso/thrusts/materials/novelmat/disman/index.htm
- Disruptive Manufacturing Technology solicitation: http://www.fbo.gov/servlet/Solicitation/R/ODA/DARPA/CMO/BAA06-34

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