AF ManTech

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Highlights

Spring 2003

Air Force Research Laboratory • Materials & Manufacturing Directorate

CAI Team Earns Defense ManTech Achievement Award

Drs. John Russell (upper right) and Frances Abrams (lower right), along with Mr. Dennis Hager (lower left), deputy chief of the ManTech Division, and Paul Hauwiller of the Anteon Corp. (top left), were part of the Composites Affordability Initiative (CAI) team presented the prestigious *Defense Manufacturing Technology Achievement Award for 2002.* The award ceremonies took place during the 2002 Defense Manufacturing Conference (DMC) held in Dallas recently. The CAI team is comprised of dedicated engineers representing the best and brightest from the AFRL/MLM and VA Directorates, the Office of Naval Research, Boeing, Lockheed Martin and Northrop Grumman.

Through AFRL/MLM's leadership, commitment and funding over the past seven years, the CAI has helped revolutionize composite material affordability. This success has led to the transition of large integrated structures into the baseline of the F-35 (JSF) aircraft.

The Defense Manufacturing Technology Achievement Award is presented annually for outstanding technical accomplishments in achieving the vision of the DoD ManTech Program. That vision is to "Realize a responsive world-class manufacturing capability to affordably meet the warfighter's needs throughout the defense system life cycle."

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ManTech Highlights is an unofficial publication (cleared for public release) for the promotion of information relevant to, and about, the people and programs of the Manufacturing Technology Division of the Air Force Research Laboratory (AFRL) Materials and Manufacturing Directorate at Wright-Patterson AFB, Ohio.
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CAI Team Unveils Cost Analysis Tool

WRIGHT-PATTERSON AFB, Ohio – The Composites Affordability Initiative (CAI) Team, established in 1998 by the Air Force Manufacturing Technology (ManTech) Division of the Air Force Research Laboratory, has successfully developed and demonstrated a cost analysis tool (CAT) that's saving money in the design of composite airframe structural concepts.

CAICAT, as the tool is called, enables increased cost reductions by identifying the most affordable composite airframe structural concepts earlier in the design phase with greater dependability than previously possible. In validations by the primary aerospace contractors, such as Lockheed Martin, Boeing and General Electric, nearly 75 percent of the structures and assemblies evaluated fell within 10 percent of actual costs, and more than a third were within two percent!

When ManTech began CAI, its charter was to bring down the costs associated with the manufacture of composite structures, considered essential to high-performance aircraft advancement. Currently, the CAI team makeup includes representatives from the Air Force Research Laboratory's Materials and Manufacturing Directorate, the Air Vehicles Directorate and the Office of Naval Research, along with prime aerospace contractors Boeing, Lockheed-Martin, Northrop Grumman and General Electric Aircraft Engines.

That charter is upheld by CAICAT's ability to capture costs related to the development and fabrication of composite aircraft structures, including their direct and indirect costs. Direct costs include fabrication/assembly labor and materials, while indirect costs include floor space and cycle time. CAICAT also pulls in costs related to research, development, test and engineering (RDT&E), as well as operational and support costs (O&S).

Prior to CAICAT, cost estimates were accomplished using weight-based parametric models, which was just a cost estimate using the weight of the proposed structure.

One of the early findings of the CAI team was that weight-based models did not have the ability to accurately, and credibly estimate the cost of composite structures manufactured with today's emerging technologies. Therefore, any cost savings derived from technology advancements were difficult to estimate accurately. To fill this void the CAI team collaborated to create a cost model that would be accepted across the aerospace industry as well as the Department of Defense.

The CAI team developed CAICAT by leveraging commercial software developments. A direct cost model software developed by a company called Galorath was modified to include existing and emerging composite fabrication/assembly processes including: hand lay-up; vacuum assisted resin transfer molding; fiber placement; co-resin transfer molding, Z-pinning, etc., as well as some state-of-the-art metal processes such as high speed machining.

Galorath also developed specific modules that described the process steps, their variables and related costs. Aerospace industry leaders supplied cost data required for the modules, while processing data and costs from the major aerospace contractors were merged to develop industry accepted cost standards.

Indirect cost and factory simulation models were customized for the CAI team from commercial products by vendors MCR and AutoSim, respectively. The Navy developed the O&S module, while the CAI cost team developed the RDT&E module.

CAICAT offers the aerospace industry the opportunity to improve the decisions made during the preliminary design phase by enabling them to review 10 times as many options as before. If the preliminary design phase needs to be compressed, CAICAT allows them to conduct a set number of projections in one-tenth the time compared to traditional methods.

The real success of CAICAT, following the Air Force's validation, is demonstrated by the fact that industry is using it extensively. CAICAT has already been used on a growing list of systems, such as the Joint Strike Fighter, F/A-22 Raptor, F-16 and the Navy's F-18, and more.

For more information contact the Technology Information Center (TIC) by calling (937) 255-4689. Refer to TIC Item #01-393.

F-35 in flight. (USAF Photo)

Lean Aerospace Initiative Saves Budget Dollars, Improves Quality, Productivity

By Gary Cunningham

WRIGHT-PATTERSON AFB, Ohio – Becoming *Lean* is a statement common to program managers and researchers within the Air Force Research Laboratory's Materials and Manufacturing Directorate (AFRL/ML). Especially those in the Manufacturing Technology (ManTech) Division where *Lean* is synonymous in Air Force ManTech program circles with best principles and practices, affordability, improved quality and productivity.

What is Lean? *"Lean is not just a matter of eliminating waste, rather becoming Lean is a process of eliminating waste with the goal of creating value for enterprise stakeholders."* — from the book, *Lean Enterprise Value.* Becoming Lean also represents a fundamentally different approach for managing and organizing enterprises.

The aerospace enterprise journey to becoming Lean began approximately 10 years ago.

Through the 1980s, Department of Defense (DoD) budgets went up and down, with the tendency in the manufacturing industry being to simply shrink in place until the next surge in spending began. As the 20th century's final decade began, three key drivers quickly made it apparent that a new approach to the production process was going to be needed in order to survive. First, were the severe reductions in DoD budgets following the end of the cold war, followed closely by international and domestic competitive pressures and meeting the needs of the Air Force warfighter.

In 1993, a consortium of U.S. defense aerospace firms, the Air Force Aeronautical Systems Center and ManTech began the *Lean Aircraft Initiative* (LAI) at the Massachusetts Institute of Technology (MIT). Defense manufacturing programs haven't been the same since.

The origins of Lean can actually be traced to the International Motor Vehicle Program (IMVP), conducted by MIT, and described in the book, *"The Machine that Changed the World,"* published in 1990. In the book, the IMVP focused on a single manufacturer, Toyota, as a benchmark for lean implementation within the auto industry. With IMVP research acting as a catalyst, the U.S. auto industry responded by re-engineering management, design and manufacturing processes to become more competitive in the global market.

So too, the LAI was developed out of necessity as declining defense procurement budgets collided with military industrial over-capacity, resulting in a demand for less expensive, more quickly producible and higher quality products.

Within AFRL/ML, the main objective of LAI is looked upon as the development of a framework for implementation of enterprise-wide Lean principles and practices that better support the nation's military aircraft needs.

Lean practices trimmed $15 billion off the F/A-22 budget. (USAF Photo)

Lean manufacturing practices are generally aimed at transforming the aerospace enterprise, including smaller companies within the ManTech supply chain, that are increasingly responsible for as much

as 80 percent of the production work on some Air Force programs, into Lean Supplier Networks for prime aerospace contractors, like Boeing and Lockheed Martin. The primary contractors employ a manufacturing production flow system that necessitates consistent, reliable delivery of quality components from all suppliers. Failure to meet any quality or delivery goal, by any supplier, can drastically slow production and limit the warfighter's access to the finished system.

Becoming Lean better aligns these small suppliers with their primary contractor to ensure all

The C-17 purchase price fell thanks to Lean. (USAF Photo)

manufacturing goals are met. This is something they would not be able to do on their own because most don't possess the necessary financial and/or technical resources.

A variety of Lean practices have been incorporated into many prime aerospace manufacturing facilities, in some cases creating drastic changes in how the company operates. Some of the practices involve cross training of workers on multiple tasks and placing them into U-shaped production cells, standardizing their work procedures and shortening the production line to decrease the time spent for the part getting to the worker, and/or the worker acquiring the part.

At some facilities the Lean practices used involve eliminating ergonomic problems by designing new tools, or altering work-station configurations that improve the physical nature of the production process. A production floor process known as Kanban was also installed where needed. Kanban is the use of cards, carts or crates as signals to trigger production in feeder operations.

A Kaizen event or workshop is a Lean tool that is often considered the "bread and butter" of the Lean manufacturing world. An Integrated Product and Process Development (IPPD) team is put together representative of every key position in the production process. Depending upon the size of the operation, the team numbers eight to 20 employees. The Kaizen team meets for four or five days, and focus in some particular area or operation of the plant to be improved.

A Kaizen's popularity comes from the fact that every team member is encouraged to participate in the improvement process. After sharing their knowledge, experience and ideas, creative solutions are derived, and a timetable for implementation is established. Kaizen events have been proven to increase productivity by as much as 120 to 800 times.

An expansion of Lean usage in 1998 to include space programs caused LAI to be renamed the Lean Aerospace Initiative. LAI's vision then became to "*Significantly reduce the cost and cycle time for military aerospace products throughout the entire value chain while continuing to improve product performance*."

By late 2000, the Lean consortium consisted of 25 industry and 13 government organizations, along with MIT. The consortium's efforts are a cooperative agreement with approximate funding obligations on an annual basis being 50 percent from the government, 33 percent from industry and 17 percent from MIT.

The application of Lean principles and practices by members of the LAI Consortium have substantially lowered costs and achieved shorter cycle times and significant quality improvements by re-engineering organizations and key processes. This includes all aspects of the product realization process, starting with Integrated Product and Process Development; focusing on improvements in product quality, waste minimization and response time; building

strong supplier relationships through partnering and teaming; and using less of everything including design time, inventory, buffers, management layers, capital and cycle time.

Recent examples of Lean's successful impact on Air Force programs include:

· The purchase price of a C-17 decreased from $260 million to $178 million for the remaining 80 aircraft out of the original 120 purchased.
· Cost reduction of $15 billion for the F/A-22 Raptor has been attributed to the use of lean-enabled practices as of December 2000.
· Unit price of a Joint Direct Attack Munition kit down to $15,000 per, instead of the initial estimate of $68 thousand apiece.
· The Rocketdyne RS-68 low cost engine design already has 95 percent fewer parts than the current Space Shuttle main engine, yet following the infusion of Lean principles and practices have now reduced the touch labor needed per engine from $171,000 to $8,000.
· After Lean was applied to the Atlas V supply chain there was a 35 percent reduction in the parts count, and a 30 percent reduction in the supplier base.

By the end of 2001, Air Force ManTech programs to infuse Lean practices and principles into Air Force Depots and the Air Logistics Centers have been successfully implemented on the F-15 depot maintenance at Warner Robins Air Logistics Center in Georgia.

Lean's future with the Air Force was confirmed during an Air Force Materiel Command (AFMC) keynote address at the LAI Executive Board Roundtable in December 2000, when Gen. Lester Lyles, AFMC commander, was quoted as encouraging the LAI Consortium by saying, "Get the word out; create and teach Lean curriculum across the country. Kick it up a notch!"

For more information on Lean, contact the AFRL/ML Technology Information Center at (937) 255-4689. Refer to TIC Item #02-212.

Mark your calendar to attend the ML Roadmap Review 22-24 July 2003 at the Dayton Convention Center Dayton, OH

Check www.utcdayton.com for info updates

Warfighter Support

ManTech Succeeds With Demand Pull Supplier Pilot Program For JDAM

By Gary Cunningham

WRIGHT-PATTERSON AFB, Ohio – "Precision-guided weapons have played an important role in the war in Afghanistan," James G. Roche, Secretary of the Air Force, said while attending the fourth annual Air Armament Summit in Sandestin, Florida, last April.

"The Air Force has dropped more than 8,500 tons of weapons in the conflict and nearly 75 percent of those weapons were precision-guided, or Joint Direct Attack Munitions (JDAM)," the secretary added.

JDAMs success in Operation Enduring Freedom is well documented. Not so well documented, however, is the role the Manufacturing Technology (ManTech) Division here has played in improving the production process of the JDAM kits needed to replenish the warfighter's stockpile of this valuable weapon for use in the war against terrorism.

To accomplish this, the ManTech Division of the Air Force Research Laboratory's Materials and Manufacturing Directorate, under contract with the Boeing Corporation, is successfully completing the Demand Pull Supplier Pilot (DPSP) program.

A JDAM is a guidance tail kit comprised of an inertial navigational system and a global positioning system guidance control unit. JDAM converts existing, unguided, 1,000 and 2,000-pound bombs into accurate, adverse weather "smart" bombs. A joint U.S. Air Force and Navy program, in addition to Operation Enduring Freedom, the JDAM has demonstrated dramatic precision bombing capability during Operations Allied Force (Kosovo), and Desert Fox (Iraq).

By infusing Lean principles into the component manufacturing process for the JDAM kits, DPSP has so far provided dramatic results with an average productivity increase of 25 percent, reduced supplier cycle time 60 percent, yet maintained per unit cost, quality and on-time delivery levels. This success means that JDAM kit production has met initial planned increases, and has proven component suppliers can also meet surge requirements for operations such as Enduring Freedom.

Many JDAM components are manufactured by a group of small (less than 200 employees) manufacturing

enterprises. As the final assembler and warrantor for the tail kits, Boeing employs a Just in Time (JIT) production flow system that necessitates consistent, reliable delivery of quality components from all suppliers. Failure to meet any quality or delivery goal can drastically slow production and limit the warfighters access to low cost precision guided munitions.

The DPSP infusion of Lean manufacturing practices was aimed at transforming the small companies within the JDAM supply chain into JIT suppliers, and better align them with the DPSP system in place at Boeing to insure all manufacturing goals were met.

A variety of Lean practices were incorporated into the supplier's manufacturing process, in some cases creating drastic changes in how the company operated. Some of the practices involved cross training of workers into U-shaped cells, standardizing work procedures, shortening the production line to decrease the time spent for the part getting to the worker, and/or the worker acquiring the part.

At some facilities the Lean practices used involved eliminating ergonomic problems by designing new tools, or altering work-station configurations that improved the physical nature of the production process. A production floor process known as Kanban (Japanese) was also installed where needed. Kanban is the use of cards, carts or crates as signals to trigger production in feeder operations.

Lean steps taken for the JDAM may seem common sense solutions to some, but these issues are pervasive across the Department of Defense contractor community. As high as 70 percent of the value of defense systems and major subsystems is borne in the supply chain, and the percentage continues to grow with increased outsourcing of both fabrication and subassembly.

Industrial base assessment data clearly show that smaller suppliers tend to lack the capabilities needed to respond to demands for affordability and quality improvements or to properly discharge the increased responsibilities being delegated by their customers. Small businesses may be unable to cope with the need to change due to a lack of capital or a lack of technical resources, or both.

Results show that each of the JDAM component suppliers dramatically improved productivity by an average increase of 25 percent, reduced cycle times by 60 percent, yet maintained cost, quality and on-time delivery levels. Each supplier more than met current surge request capability created by the Air Force's use of precision bombing missions in support of Operation Enduring Freedom.

"The Air Force has dropped more than 8,500 tons of weapons in the (Afghanistan) conflict and nearly 75 percent of those weapons were precision-guided, or Joint Direct Attack Munitions (JDAM)."

Air Force ManTech also benefits by having a proven business case relating supplier development activities directly to measurable improvements in cost, quality and schedule for the JDAM program. Boeing benefits through risk reduction in support of meeting their pre-negotiated cost and schedule milestones for JDAM, both for their scheduled production increases and for their surge demands.

Participating small enterprises benefit by implementing improved capabilities, processes & performance leading to better stability, and profitability, as well as future additional business opportunities.

Finally, the warfighter benefits because JDAM's will be procurable in quantity and at government established pricing when they're needed. Refer to TIC Item #02-086.

Images – Opposite page, JDAM dropped by F-16; at left, Weapons Loader preps JDAM prior to loading it on the aircraft. (All images are: USAF Photos).

Interactive Missile Design Program Accelerates Spiral Development

By 2nd Lt. Corey Bliss

WRIGHT-PATTERSON AFB, Ohio — Under a contract with the Manufacturing Technology (ManTech) Division of the Air Force Research Laboratory's Materials and Manufacturing Directorate, and Lockheed Martin Missiles and Fire Control (LMMFC), an interactive design-manufacturing network for missiles, referred to by Lockheed Martin as the Interactive Missile Design (IMD) system is blazing a path in missile design up to four times faster than ever before. IMD is also often referred to as "spiral development."

LMMFC, in Orlando, Florida, is using the IMD software to integrate multiple design disciplines with both residual and supplier manufacturing knowledge. This means that IMD has taken on an integral role in the preliminary and conceptual missile design process for them. Recent LMMFC projects in which IMD has significantly reduced design time include the Extended Range Javelin, Common Modular Missile, Advanced Fire Support System, Precision Attack Munitions, and Multi-Role Armament and Ammunition Systems, for the Air Force and Army.

The IMD System is an application based upon the commercially available Adaptive Modeling Language (AML), created by TechnoSoft Inc. of Cincinnati. Using AML as the underlying architecture, IMD is a cross-platform, multi-disciplinary design system that integrates system-level missile design and analyses with cost estimation. The IMD System has the ability to analyze cost and performance tradeoffs that are necessary for cost-as-an-independent-variable (CAIV) studies. This analysis significantly reduces conceptual and preliminary design time, which in turn reduces overall program cycle time. This reduction in program cycle time leads to reductions in overall cost and time to market.

Missile design is a multi-disciplinary process that involves design and analyses in the areas of propulsion, structural, aero-thermal, aerodynamics, high fidelity multiple degree-of-freedom simulations, controls, lethality, internal component packaging, and cost modeling. IMD allows missile designers to quickly move through a classical missile design process interacting with these various disciplines.

The addition of optimization software, which can be integrated into IMD through AML, allows the designer/analyst to make design changes, perform sensitivities of those changes in affecting performance and cost, and consequently optimize the weapon system more efficiently.

Missile range, accuracy, and lethality performance can be maximized using comprehensive modeling, simulation, and optimization analyses. IMD additionally supports users in determining which design constraints should be eased when proposed designs cannot meet performance requirements. Criteria and tolerances can also be captured to determine whether design parameters, such as miss-distance, burnout velocity, autopilot gain and phase margins, thermal protection material recession, and seeker acquisition range, etc., can successfully achieve desired performance levels within a specified tolerance.

IMD is an even more powerful design tool when enhanced with TechnoSoft's real time internet-based collaborative design extension, known as the Web-Based Design Environment, or WDE. The WDE software was originally developed under a Dual-Use Science and Technology contract by ManTech, the Air Vehicles Directorate and Lockheed Martin.

The IMD/WDE integration allows for the interaction of many geographically dispersed designers and analysts working on the same WDE server-based model. The collaboration of these dispersed engineers and designers to work together, from the initial design concept to a virtual prototype, significantly saves valuable design time. Additionally, subcontractors, teammates, suppliers, manufacturers, and customers can be incorporated into the design process to offer design input.

When applied to Lockheed Martin's missile design effort, the IMD/WDE system allows for a distributed server, multiple-user environment to be offered over the Web. This Web-enabled Missile Design Environ-

ment, IMD/WDE, will allow the integration of COTS (Component Off The Shelf) databases into IMD. For example, cost impact analysis of inertial measurement unit (IMU) alternatives, data available on the Web, can be traded using IMD.

These alternatives may be implemented as micro-electro-mechanical (MEM), optical, or mechanical. The performance of these IMU alternatives can be evaluated, thus propagating the impacts in missile configuration. In addition, the missile manufacturing supply chain can become involved in the conceptual design and analysis process, increasing manufacturing efficiency and enabling optimized application of the manufacturing processes.

The IMD/WDE System offers significant and invaluable savings in design time and cost. This dynamic real-time design environment optimizes the process by collaborating users such as military customers, industry designers, and manufacturers. Future conceptual missile designs will drive the entire design team to develop new technologies for use in enabling the design and manufacture of missiles that are more efficient to the warfighter and the taxpayer.

Specifically, just in the conceptual missile design process alone, the IMD/WDE system has saved LMMFC more than $3 million to date.

In addition, future payoffs include the Supersonic/Hypersonic Vehicle Design Simulation System (SHV-DSS), which is a similar web-based, conceptual design environment for extremely high-speed vehicles. Much like the missile design environment, these vehicles will be designed four times quicker than in previous design processes and will be analyzed for quick turn-around in “what if” scenarios.

For more information on IMD, contact the Technology Information Center (TIC) at (937) 255-4689, and refer to TIC #02-023.

Below: An F-16 drops a JASSM during a test. (USAF Photo)

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