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Insights

First Quarter 2008
Volume 5 • Number 1
www.lockheedmartin.com

Strategies and Advancements in Net-Centric Operations

Insights

Inside

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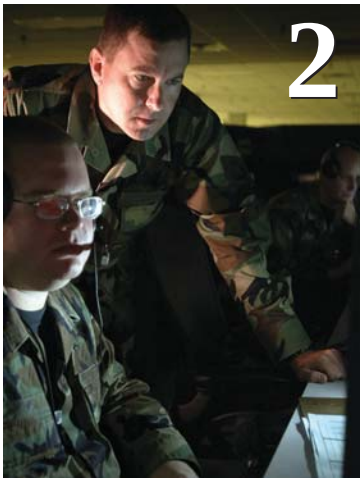

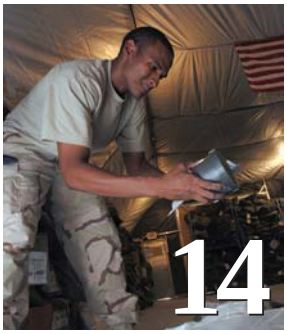

Insights is a customer publication of the Lockheed Martin Corporation.

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Insights is published quarterly. We welcome your comments; you may email the editor with ideas for future articles or suggestions.

Photos throughout this publication have been provided courtesy of the Department of Defense, including the U.S. Air Force, U.S. Army, U.S. Marines, U.S. Navy and the National Aeronautics and Space Administration (NASA).

A Conversation
with Maj. Gen. William T. Lord

Q: What do you see as major challenges in standing up the Air Force's Cyberspace Command?

Maj. Gen. Lord: Among the many challenges that face this new organization, I would say that socializing the Air Force's concept of operating in cyberspace is near the top.

Many people think that cyberspace is just the Internet but the Air Force definition is much broader and connects to most, if not all, electromagnetic devices. With that in mind, Air Force Cyberspace Command will need to take a very holistic approach to operating in the domain. This is a cultural change which both the Secretary of the Air Force and the Chief of Staff of the Air Force are attacking.

BIOGRAPHY

Maj. Gen. William T. Lord, Commander, U.S. Air Force Cyberspace Command

Maj. Gen. Bill Lord is Commander, U.S. Air Force Cyberspace Command, Barksdale Air Force Base, Louisiana. He has responsibility for establishing cyberspace as a domain in and through which the Air Force flies and fights, to deliver sovereign options for defense of the United States.

In this current duty, he is creating the Air Force Major Air Command for organization, training, and to equip combat forces to operate in cyberspace.

Maj. Gen. Lord has held various duties with tours in Europe, the U.S. Central Command and the White House. He has commanded at the detachment, squadron, group, wing, joint and major air command levels.

Before assuming his current position, Maj. Gen. Lord was Commander, 81st Training Wing, Keesler Air Force Base, Miss., leading his wing prior to, during and following the Hurricane Katrina national disaster.

Maj. Gen. Lord is a graduate of the U.S. Air Force Academy and holds a bachelor's degree in biological and life sciences. He has two master's degrees — in business administration and national resource strategy.

"...Cyberspace is *increasingly* CRITICAL and *inseparable* from our national POWER and interests."

Q: The Command is developing a Cyberspace Warfare Doctrine — what will this provide?

Maj. Gen. Lord: In order to create effects in and through cyberspace, the Air Force must first provide combatant commanders with forces to efficiently conduct operations. We are developing those forces with a view toward the doctrine so we are in line with the national and military objectives. The Air Force has identified the following desired end states:

- Deter and prevent cyberspace attacks against vital U.S. interests;
- Rapidly respond to attacks and reconstitute networks;
- Integrate cyber power into the full range of global and theater effects;
- Defeat adversaries operating through cyberspace;
- Freedom of action in cyberspace for U.S. and allied commanders;
- Persistent cyberspace situational awareness.

Adversaries and the Cyberspace Threat

Q: How sophisticated are the cyberwarfare capabilities of potential adversaries?

Maj. Gen. Lord: Since cyberspace can be accessed by just about anyone at any time and at low cost, threats can come from nation-states to individuals. Creativity is the biggest threat to the domain. Since the way you operate inside the domain evolves on a daily basis we must strive to be a step ahead of our adversaries.

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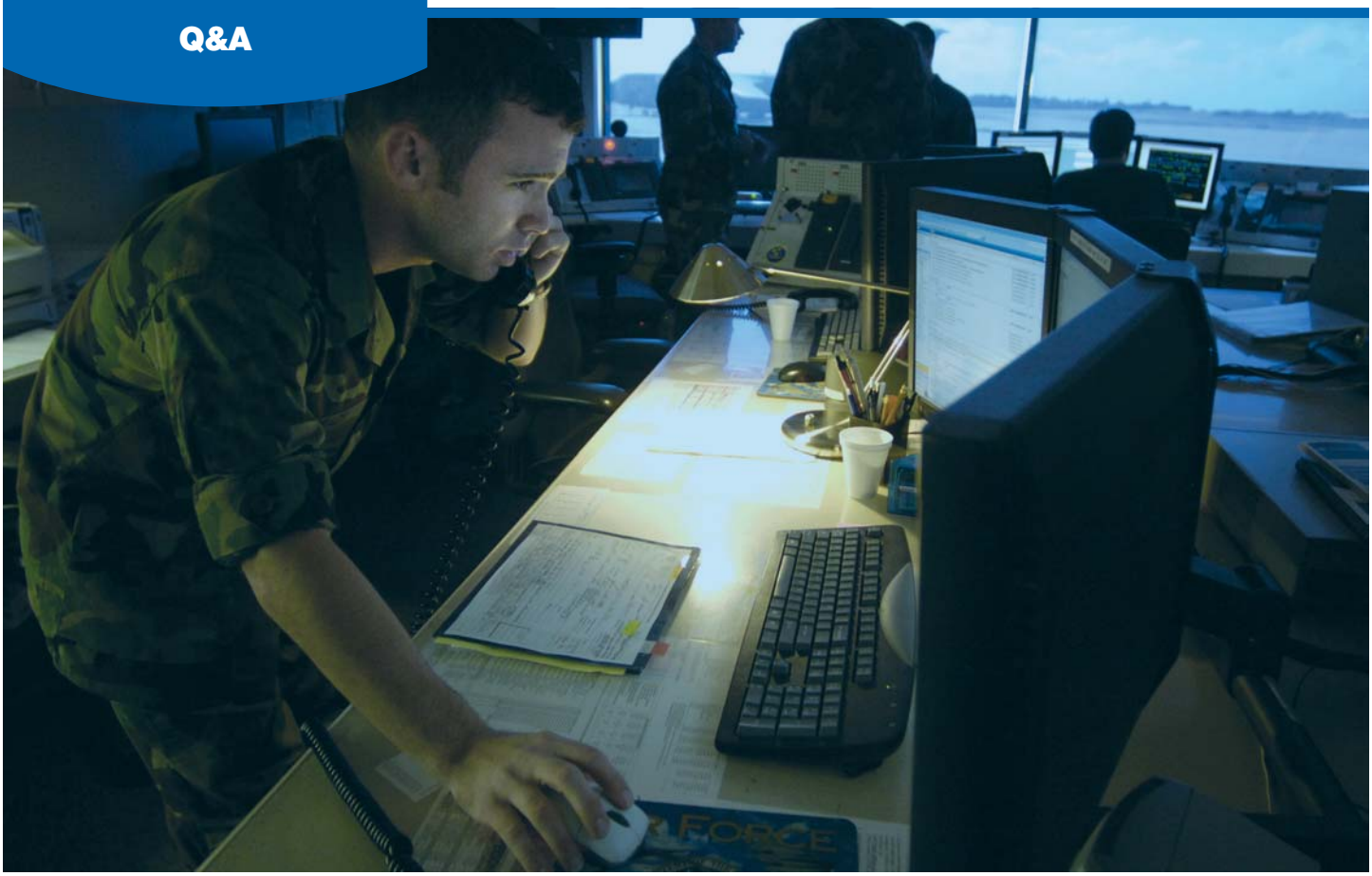

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Q: How vulnerable is the U.S. infrastructure today to a major cyber attack? Is a cyber version of Pearl Harbor possible?

Maj. Gen. Lord: An event of that magnitude is definitely not beyond the realm of possibility. The country of Estonia recently experienced a cyber 'Pearl Harbor' of its own. The unprecedented cyber attack crippled Web sites operated by Estonian government ministries, banks, media outlets and other companies. It effectively paralyzed the country's entire cyber infrastructure.

President Bush has acknowledged the vulnerability of a number of our systems to cyber attack. Because of the increasing sophistication of computer attack tools, an increasing number of actors are capable of launching significant assaults against our infrastructures and cyberspace.

Cyber attacks on U.S. information networks can have serious consequences such as disrupting critical operations, causing loss of revenue and intellectual property, or loss of life. Countering such attacks requires the development of robust capabilities where they do not exist today if we are to reduce vulnerabilities and deter those with the capabilities and intent to harm our critical infrastructures.

Cyber Threat Impacts Warfighting Strategy

Q: How is warfighting strategy now affected by the threat of an adversary's cyberspace capabilities?

Maj. Gen. Lord: From the *2006 Quadrennial Defense Review*: "...Cyberspace is increasingly critical and inseparable from our national power and interests. Adversaries' denial of the domain to U.S. military operations could take away battlespace awareness, command and control, precision strike, and leave our exquisite, 21st Century capabilities paralyzed."

"...cyberspace can be ACCESSED by just about anyone at *anytime* and at *low cost*, THREATS can come from *nation-states* to INDIVIDUALS."

The cyber threat is a current reality. It is a threat that must be addressed. The Air Force will be prepared to provide combat-ready forces trained and equipped to conduct sustained global operations in and through cyberspace, fully integrated with air and space operations.

Air Force Cyberspace Command will provide robust, survivable access to cyberspace with offensive and defensive capabilities that ensure cross-domain freedom of action for our friends and allies, and deny the same to our adversaries.

Q: You have mentioned a need to integrate kinetic and non-kinetic effects as part of cyberspace defense — would you elaborate?

Maj. Gen. Lord: Synergizing and integrating air, space, and cyberspace capabilities allows us to create effects across the range of military operations. The marriage of kinetic and non-kinetic capability can produce an effect which is greater than the sum of the parts. The bottom line is that we want to change a specific behavior of an enemy and use the least amount of force to do that.

Q: How will you coordinate planning and other actions with branches of other services or component commands, such as the Joint Task Force — Global Network Operations and Joint Forces Component Command — Network Warfare?

Maj. Gen. Lord: To be successful we will need to partner with experts in and outside of the Department of Defense. The primary goal of AF-CYBER is to give the warfighter a full range of cyber capabilities in a very short period of time. Two unique aspects of fighting in cyberspace are the variety and limitless scalability of our weapons and the ability to conduct global operations before and during an actual conflict or military operation...at the speed of light.

Specialized 'Cyber Training' Needed to Fight Cyber Threat

Q: What types of skill sets will the Air Force need to recruit for Cyberspace Command?

Maj. Gen. Lord: We are currently investing millions of dollars to attract the most highly-trained cyber force possible. We are in direct competition with industry for currently trained cyberspace experts. This being the case, we will have to "grow" some of our own experts.

For many years, the Air Force has provided highly technical training to individuals with appropriate backgrounds. Similar to our pilot training, we are starting to send qualified individuals to an initial cyber training course followed by on-the-job training at specific units to let them perfect their skills. The Air Force produces the best trained aircrew in the world from the ground up. Our goal is to take a similar approach in developing our future cyberspace operators.

Q: One initiative the Command is involved in is "Cyber Training." What will this consist of and why will it be important in combating cyber threats?

Maj. Gen. Lord: Developing the cyberspace career force will require establishing the right combination of pre- and post-accession learning experiences to deliberately develop a professional force of cyber warriors capable of planning and executing cyber operations at the tactical, operational, and strategic levels.

Once specific career fields are established for cyber operations — establish the domain, operate the domain, and use the domain — the development process will build the foundations for a sustainable cyber career field, relying on revised or newly developed accession processes, pre-commissioning programs and educational tools. The development of a cyber weapons school with aggressor squadrons will also be required to test Air Force capabilities.

We seek to create a professionally trained and credentialed cyberspace career force that has a fully developed theory of cyber power, and benefits also from a practical association with industry and academia. This should provide a solid, overall focus that the career professional needs to be effective.

'Cyber Synergies' Will Develop From Industry-Government Partnership

Q: What do you foresee as industry's role in working with the government, as a partner, to combat cyber threats? Do you foresee the Command establishing cyber synergies with private industries, such as banking and finance, communications, energy and transportation?

Maj. Gen. Lord: The DoD and civilian business have many of the same enemies in cyberspace. Partnership with industry is a key theme in the development of the Air Force Cyberspace Command.

Our goal is to foster a cross-flow of information and technology with anyone who uses cyberspace to conduct business. The synergy you get with this type of partnership only serves to protect our networks better and speed the development and delivery of technology for America's warfighting capability.

A Service-Oriented Architecture *Approach Helps Speed Threat Detection*

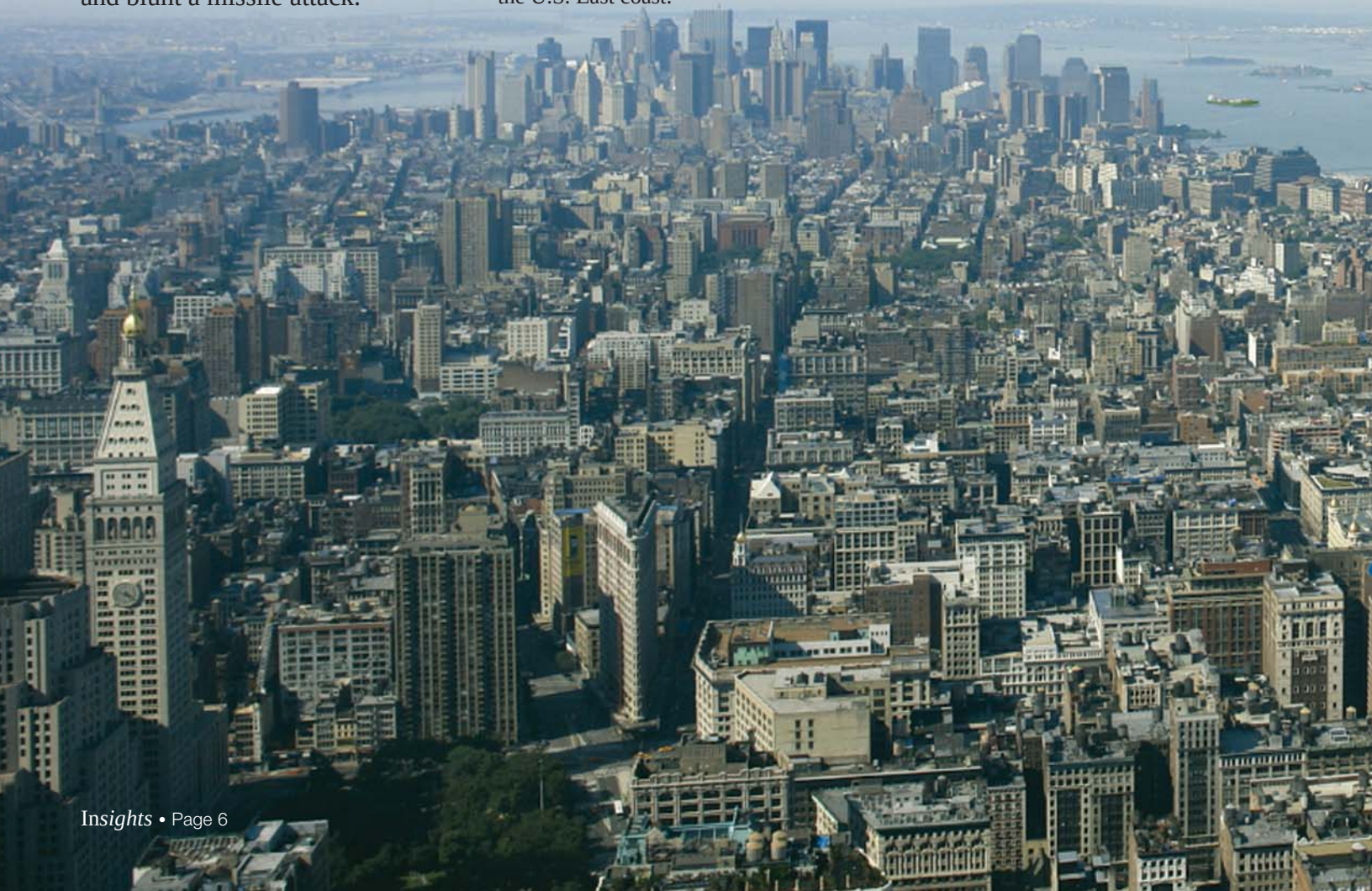
Experiment highlights how government agencies can collaborate, share data across a networked environment to track down a rogue ship and blunt a missile attack.

Put yourself into the role of analysts tracking hundreds of vessels in search of one — a ship suspected of smuggling a cruise missile on board and within reach of American shores.

Using information gleaned from commercial data, intelligence reports and data collected from many types of surveillance and tracking sensors, the analysts work against a time crunch. They must succeed in identifying the rogue ship as it wends its way largely undistinguished from scores of ships in the busy North Atlantic waters. A terrorist onboard is in command with the objective of launching a surprise attack when the ship reaches a point closer to the U.S. East coast.

It's an undertaking that might be called "find the haystack... and then the needle." If the analysts work quickly enough and can identify the ship — and also confirm that it carries a missile, an attempted strike can be thwarted.

While analysts typically focus on designated areas such as a specific maritime sector or a surveillance mode, this time the search requires they work cooperatively to assess intelligence that has been collected from multiple modes of surveillance stretching from the Middle East to the U.S. Atlantic coastline over a span of weeks.



Experiment Demonstrates 'How' Networked, Data-Sharing Capabilities Can Be Realized

Fortunately, the incident was not real — but a scenario created as part of a net-centric experiment focused on wide area persistent surveillance operational concepts and technologies conducted at Lockheed Martin's *Center for Innovation* laboratory. The asymmetric missile threat that was the focus of the experiment, however, is very real, drawing upon a tactic of using a commercial vessel to disguise an attack and potentially slip through national defenses.

The simulation demonstrated a new approach to the task of assessing threats, using a service-oriented architecture approach, or SOA. The architecture's technical advantages made it possible to combine and integrate a diverse spectrum of surveillance and tracking data. It also allowed Lockheed Martin personnel representing government operators responsible for homeland security to work cooperatively and share data to counter the threat.

The SOA approach enabled operators to have an enhanced situational awareness of trans-oceanic vessel traffic numbering in the hundreds and gave them greater ability to respond to the threat posed by the terrorist-controlled ship in the scenario.

Greg Maultsby, Lockheed Martin's deputy program manager for the project, explains that the demonstration scenario was created using DoD experimentation guidelines and was developed in partnership with U.S. Northern Command and government agencies involved in homeland security to establish authenticity.

"We simulated activities of two agencies that would be most directly responsible for wide area surveillance: NORAD-NORTHCOM and the newly formed Office of Global Maritime Situational Awareness," says Maultsby. The Corporation's engineers performed the roles of watch officers and operators responsible for intelligence, maritime surveillance and air surveillance in the experiment.

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The Challenge of Multiple Input Sources

The experiment included many input sources simulating tracking and surveillance platforms, representing the increasing number and variety of powerful resources available to analysts. Multiple sources such as satellites, air surveillance, unmanned surveillance and high-performance radar technology provide views of targets across a diverse spectrum and from different physical vantage points.

Other tracking data, such as that provided through the Global Positioning System, as well as shipboard automated identification signals, mark various locations and add to the task of pulling all the information together. The challenge is correctly fusing multiple data points into a common operating picture and a single source of trusted information for analysts.

Data fusion was among several tasks accomplished through a Multi-Sensor Service-Oriented Architecture test bed — MSSOA — developed by Lockheed Martin for the experiment and with inputs from government defense and homeland security organizations.

Building the MSSOA Test Bed

Lockheed Martin developers chose to tailor an existing SOA solution, provided by BEA Systems, Inc., a commercial software developer specializing in enterprise solutions, including service oriented architectures. "A substantial amount of the solution we needed was already available as a commercial product and we could use that as a foundation for our architecture," says Robert Hodges, the Corporation's chief architect for MSSOA.

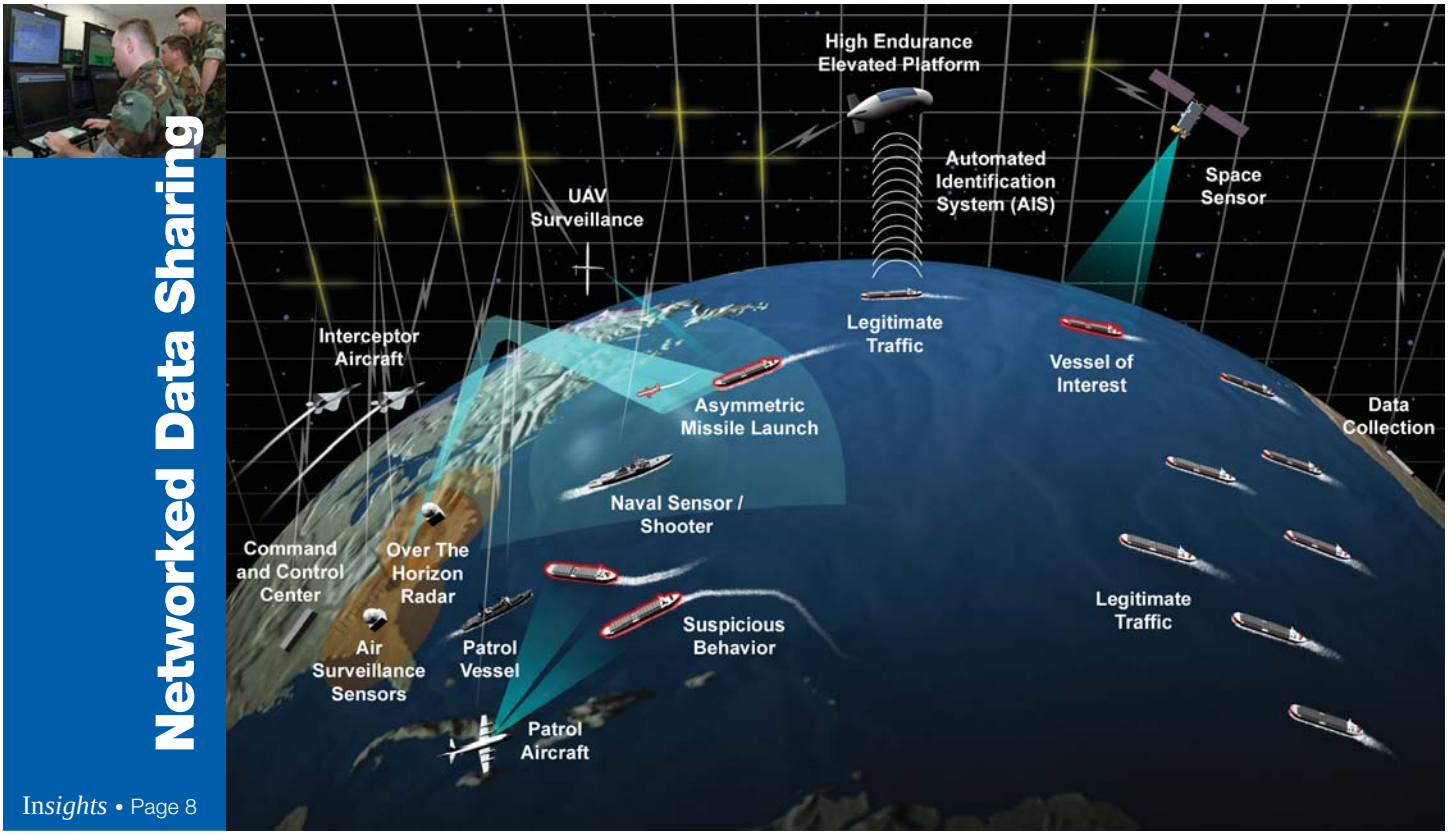
"With the SOA foundation in place, we built on that. Many different Lockheed Martin organizations contributed simulation software which became service applications within the SOA structure. We added data fusion and threat assessment capabilities and collaboration knowledge services which, with the enterprise service bus, enabled all services and systems to communicate with each other and share data."

System Promotes Data Sharing

The SOA approach made possible what would have otherwise been an exceedingly costly and time-consuming integration task. Says Hodges: "With the capabilities that a service-oriented architecture provides, often referred to as 'loosely coupled services,' different agencies can perform their assigned tasks, yet the data created can be readily shared with others as needed, and with appropriate security safeguards provided."

Analysts can also tap into the Web for specialized applications. This ability is a significant feature as the number of analysis tools available through Web services as well as other information, such as weather data and other tools grows daily. The system's open architecture leverages the plug-and-play capabilities of these services and information sources.

"We have created a system that users can shape or morph to fit both their immediate and long term needs and preferences," says Hodges. "For the first time we also put in place a true 'event-driven' system. Every time a sensor detects activity, it becomes an event and those events can flow through the entire system where they are available to all analysts, or initiate pre-defined routines." Operators call upon the different services available through



the architecture to analyze the data, and in the process, create a repository of threat assessments, he explains.

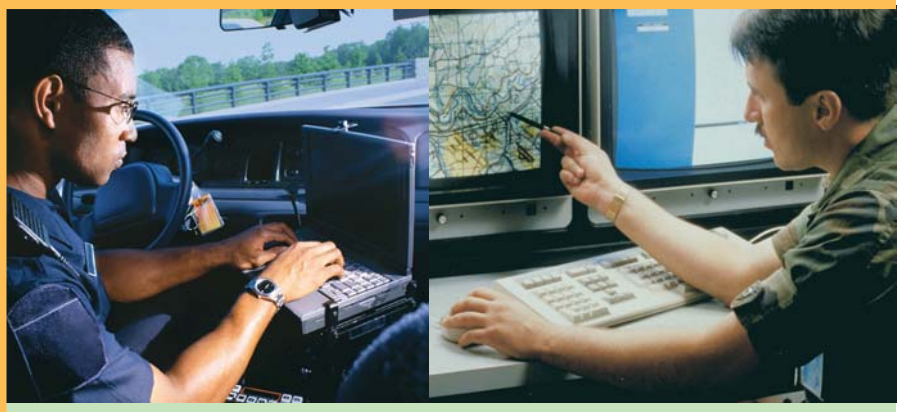
Simulation Provides Way To See Results in Action

The experiment at the *Center for Innovation* in November provided a dramatic first-hand view for members of the customer community. They saw how a SOA-based, net-centric system could be employed to connect scores of analysts and operators, across different government agencies in a secure networked environment to assess data, share information and collaborate on a critical issue in real time. It also used the *Center's* integrated missile defense test bed modeling and simulation programs, which complemented other simulations that are a part of the MSSOA.

As activities unfolded, the surveillance teams scrutinized sensor and surveillance inputs looking for data anomalies, clues that could point to an intended threat. Soon, as clues began to materialize, the two agency teams began to work more closely together, realizing they had information about the threat to share and that the MSSOA system would allow them to do so easily.

"We used two months of fictional case files and simulated intelligence reports" to build the scenario, says Maultsby. "With this data, analysts could track one suspect vessel along its ocean path, including a port stop where the smuggled missile appeared to have been loaded and terrorists boarded." In all, the operators flagged 29 ships as "vessels of interest" because of intelligence data or the ship's erratic behavior, such as reversing direction or not sending identifying signals.

In the MSSOA experiment, the agency teams succeeded in correctly identifying the rogue ship. Their identification was confirmed by air surveillance video that showed a launcher beginning to rise from the cargo hold. The team's success in tracking the vessel allowed more than adequate time for a NORAD-NORTHCOM response to defeat the missile threat.



It's About Sharing The Data

A Service-Oriented Architecture Approach Can Pave the Way For Cooperation Among Agencies that Need to Work Together.

Using a service-oriented architecture to enable networked data sharing and analysis could lead to greater levels of cooperation among defense and civilian government organizations where information sharing has been singled out as a critical-need capability.

Lockheed Martin's experiment used a service-oriented architecture approach to analyze intelligence and surveillance data, and make it available to multiple users in real time. The experiment demonstrated how two distinctly different government organizations involved with homeland security, U.S. Northern Command and the new Office of Global Maritime Situational Awareness, could work together to respond to a possible maritime asymmetric missile threat.

The focus on partnership may well be one of the more significant outcomes of the project, notes Lockheed Martin's Larry Easton, one of the experiment's proponents.

Leveraging the technical capabilities of the architecture in this net-centric experiment, Easton believes, showed how two agencies with different roles can work together and use the same data to carry out different responsibilities. "The system allows them to share data — even though how they interact with and use their systems are different," he says.

Making Information Easy to Access and Share

For the experiment, data sharing was made possible in a number of ways through the technical capabilities of the service-oriented architecture test bed. Its enterprise service bus allows operators to access and extract needed information from many sources. Operators can obtain data from several simulated sensors and threat assessment services, such as the Maritime Integrated Domain Awareness Solution, from the test bed network. They can build personalized operational pictures to make it easier to work with the data and share their views of it with others.

While the benefits of using the SOA technology may be apparent to government customers, an appeal made even stronger by use of affordable commercial software, much work on re-thinking and testing government information sharing policies is being addressed.

Information Sharing Policies Under Review

"Government policies on information sharing are maturing and evolving in parallel with newer technologies," says Easton. "Customers tell us they continue to work on policies that will set rules and guidelines for determining 'what' information can be shared, and 'how' that should be done."

The non-classified service-oriented architecture test bed that Lockheed Martin created at its *Center for Innovation* laboratory could readily support follow-on experiments aimed at facilitating different ways agencies can work together and help answer some of the policy questions, says Easton.

F-22 Raptor

Neil Kacena
Vice President and Deputy,
Advanced Development Programs
Lockheed Martin Aeronautics

Fresh from the hands of the testers to those of the operators, the F-22 Raptor has wasted no time in demonstrating its effectiveness, unique flexibility and synergy with other assets in operationally-realistic scenarios.

With more than 100 Raptors delivered, the fighter is operational and has been put through its paces in demanding joint exercises. It is clear that the introduction of the F-22 is ushering in a shift in both the scope of the contribution that the aircraft can make to an increasingly net-enabled fight, and in the evolving role played by Raptor pilots in facilitating these contributions.

Last year, in the spring, a dozen F-22s and more than 250 personnel from the U.S. Air Force's 1st Fighter Wing's 27th Fighter Squadron from Langley Air Force Base, Va., took part in a 90-day deployment to Kadena Air Base, Japan. More than 670 sorties were flown during the deployment, which proved the Raptor's worldwide reach.

Pilots and maintainers from the 1st Fighter wing's 94th Fighter Squadron participated in the Raptor's first trip to Red Flag earlier in 2007. This large-scale exercise, conducted over the vast range complex near Nellis Air Force Base, Nev., involved realistic air-to-air and air-to-ground engagements, including ground-based defenses. The F-22 showcased its advantages of stealth, supercruise, maneuverability and sensor fusion during the exercise and confirmed its sustainability with a 100 percent sortie generation rate for the 94th Fighter Squadron pilots.

5th Generation Fighter *is the* Ultimate Force Multiplier

Additionally, the National Aeronautic Association awarded the Raptor team the 2006 Collier Trophy, the most prestigious award in American aviation.

New Roles for Aircraft and Range of Tactical Options Envisioned

The Raptor was cited for its overwhelming performance in the Northern Edge joint military exercise. During the large-scale, force-on-force exercise, Raptor pilots flew 97 percent of their scheduled missions, achieved an 80-to-1 kill ratio against their Red Air opponents and scored direct hits with 100 percent of their 1,000-pound, satellite-guided GBU-32 Joint Direct Attack Munition air-to-ground weapons.

In addition, Raptor pilots increased overall situational awareness for the entire Blue Force team through the F-22's integrated avionics package.

The result is that the F-22 is performing roles not envisioned during two decades of system development. These new capabilities are pointing the way toward an unanticipated range of employment options and tactical connectivity enhancements that promise even greater force-multiplication effects from the Raptor.

The Raptor's speed, stealth, and situational awareness allow it to engage and destroy its targets beyond visual range and to employ uniquely flexible formations not constrained by 4th generation fighter limitations. The ability to develop and communicate real time situation awareness is the key to the rapid decision making required in the 21st Century combat environment.

F-22's Advanced Datalink Capability Helps with Bandwidth Concerns

Specifically, Lockheed Martin, working with its industry partners, has demonstrated the aircraft's ability to transfer vast amounts of sensor data and imagery to other network nodes, at rates — hundreds of megabytes per second — that are orders of magnitude faster than current systems.

This Radar Command Data Link capacity, or RCDL, demonstrated two years ago in ground testing and more recently aboard a surrogate aircraft, offers the promise of dramatically increasing the value of

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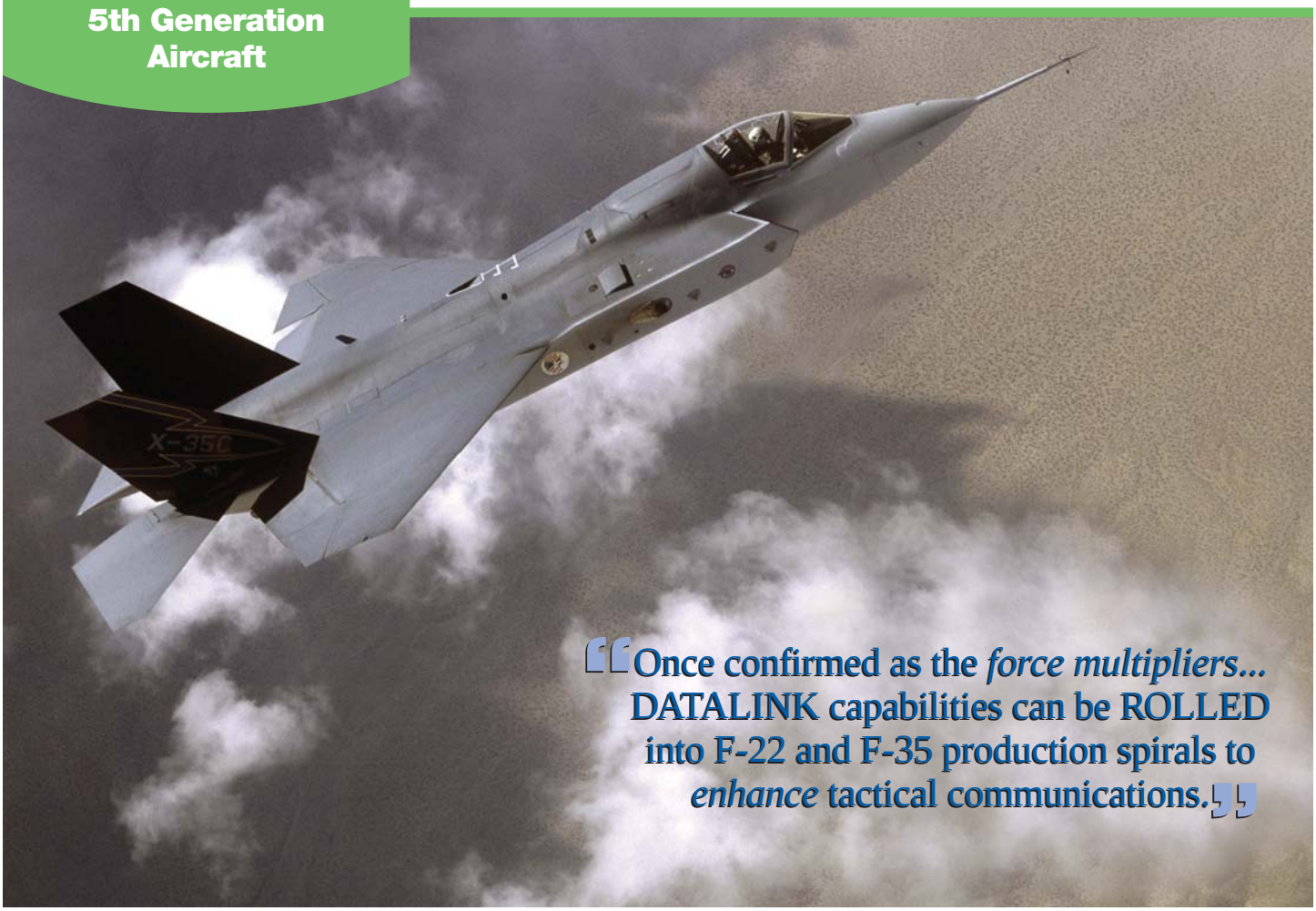

> "Once confirmed as the *force multipliers*... DATALINK capabilities can be ROLLED into F-22 and F-35 production spirals to *enhance* tactical communications."

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5th generation aircraft to perform ISR, electronic warfare, and command and control tasks either sequentially or simultaneously. What one pilot knows, all can know; information details are not limited due to throughput limitations. Related, but perhaps even more profound, the RCDL offers the potential to make a strong contribution to the bandwidth bottleneck problem confronting the DoD.

An equally compelling development is the Tactical Targeting Networking Technology initiative — TTNT — an airborne datalink developed through the Defense Advanced Research Projects Agency that essentially brings secure Wi-Fi to front-line air and ground combat platforms. Here again, what one pilot knows, many can know.

The essential elements of TTNT, alternately referred to as the Airborne Networking Waveform and the Joint Airborne Network Tactical Edge, were demonstrated at the 2006 Joint Expeditionary Force Experiment, the JEFX '06. Lockheed Martin has proposed to the Air Force that new concepts of employment be validated on two Raptors in the context of a future JEFX event.

Once confirmed as the force multipliers that initial industry and DoD experimentation suggests, these datalink capabilities can be rolled into F-22 and F-35 production spirals to enhance tactical communications.

'Command Post' Role In Leading the Fight

These advanced communications capabilities will also facilitate and enable the role of 5th generation fighters as key linchpins in a network-enabled warfare environment involving air, ground, and sea-based forces of both the U.S. and our coalition partners.

Likewise, once the Raptor's robust ISR collection, aggregation, and real-time secure dissemination capabilities are validated and assessed, force planners will be able to refine, and optimize requirements for future manned, unmanned, and space ISR platforms.

Very much related to such economy of force considerations, the Raptor's ability to act as a "command post" within a mission force, directing other less sophisticated aircraft to the fight could expand the lethality, enhance the survivability, and extend the longevity of

legacy tactical aircraft in inventory such as the F-15, F-16, F/A-18, and other coalition aircraft.

F-22 Pilots Will Have Unmatched Battlespace Awareness

While advanced technology is certainly the F-22 capability enabler, it is the pilot that remains paramount to realizing the Raptor's net-enabled potential. Indeed, the F-22 has allowed (and the F-35 will, as well) the role of the 5th generation fighter pilot to transition from performing repetitive tasks associated with flying the aircraft and employing its weapons to that of managing a host of onboard capabilities, wingmen and support assets to accomplish the mission.

Simply put, the F-22's technology places the pilot in the optimal position to execute what visionary Air Force Col. John R. Boyd two decades ago termed the Observe-Orient-Decide-Act loop. The aircraft will enable the pilot to do this more rapidly and with far more reach than any projected future adversary.

The bottom line is that the Raptor's unique combination of stealth, speed, agility, precision and situational awareness combined with air-to-ground and air-to-air combat capabilities make it simply the best fighter in the world.

It's expanding information capabilities will increase the pilot's ability to engage targets and to coordinate attacks with unmatched battlespace awareness.

The F-35 will leverage the investment made and lessons learned in the F-22 program to provide a similarly capable platform.

Autonomic Logistics

With logistics support costs comprising roughly two-thirds of an aircraft's life cycle cost, Lockheed Martin's 5th generation fighters — the F-22 and the F-35 — incorporate at their cores what is known today as Autonomic Logistics — the automated heart of the aircrafts' sustainment systems. Simply said, Autonomic Logistics provides the same efficiencies and improvement to force sustainment as the aircraft's net-enablement does to the operational mission.

Autonomic Logistics is designed to reduce operational and support costs by increasing reliability and reducing required maintenance. Essentially, the system performs constant behind-the-scenes in-flight monitoring, maintenance and prognostics to support the aircraft and ensure its continued good health. It is a seamless, embedded solution that integrates current performance, operational parameters, current configuration, scheduled upgrades and maintenance, component history, predictive diagnostics (prognostics) and health management, and service support for the aircraft.

Through Autonomic Logistics, aircraft know what they need for optimal performance and call ahead for it. Information is sent to the ground in real-time and triggers requisite personnel, equipment, and parts to be pre-positioned for quick turnaround of the aircraft. Where warranted, an aircraft may even be diverted to an alternate landing site to facilitate the repair.

The upshot is increased operational availability of the aircraft at lower costs resulting from shorter downtimes and through elimination of unneeded periodic maintenance.

Actionable Logistics:

The DoD Logistics Modernization Imperative

Louis A. Kratz
Vice President,
Focused Logistics
Corporate Engineering
& Technology

Success in Upgrading Defense Logistics Will Depend, In Part, on the Value of Government-Industry Partnerships

The Department of Defense is today spending heavily — some $2 billion annually — to improve and overhaul its venerable logistics enterprise resource planning system. This has been the workhorse defense logistics system for more than 40 years and continues to serve the military's operational needs today.

Badly needed improvements will continue in incremental fashion until 2015, when the upgrade is scheduled for completion. The Defense Department is making this investment to achieve a future capability that industry can help provide today.

The U.S. clearly possesses the leading military logistics capability in the world. Yet, U.S. logistics operations that have nobly supported the campaigns in Afghanistan and Iraq, as well as recent humanitarian operations in Indonesia and the U.S. Gulf Coast during the Hurricane Katrina disaster, have taxed the system and

highlighted shortfalls of the architecture. These events underscore the need to upgrade and modernize DoD logistics to improve speed and reliability of delivery and to reduce costs.

Financial Challenges Will Pressure Plans for Change

Today, the Defense Department has more than 1.1 million military and civilian personnel, at a cost exceeding $130 billion annually, carrying out logistics operations across the four military services and three organizations responsible for logistics — the Defense Logistics Agency, U.S. Transportation Command and Defense Information Services Agency. These government operations, which include transportation, supply, maintenance, engineering, and data management functions, are supported by a DoD-unique infrastructure that includes maintenance and distribution depots and approximately $65 billion in inventory.

There is growing recognition among some that this defense-unique logistics workforce, infrastructure and inventory will be hard to sustain. As costs mount, and pressure grows to "reset the force," the government will likely find it difficult to recruit and retain the type of increasingly

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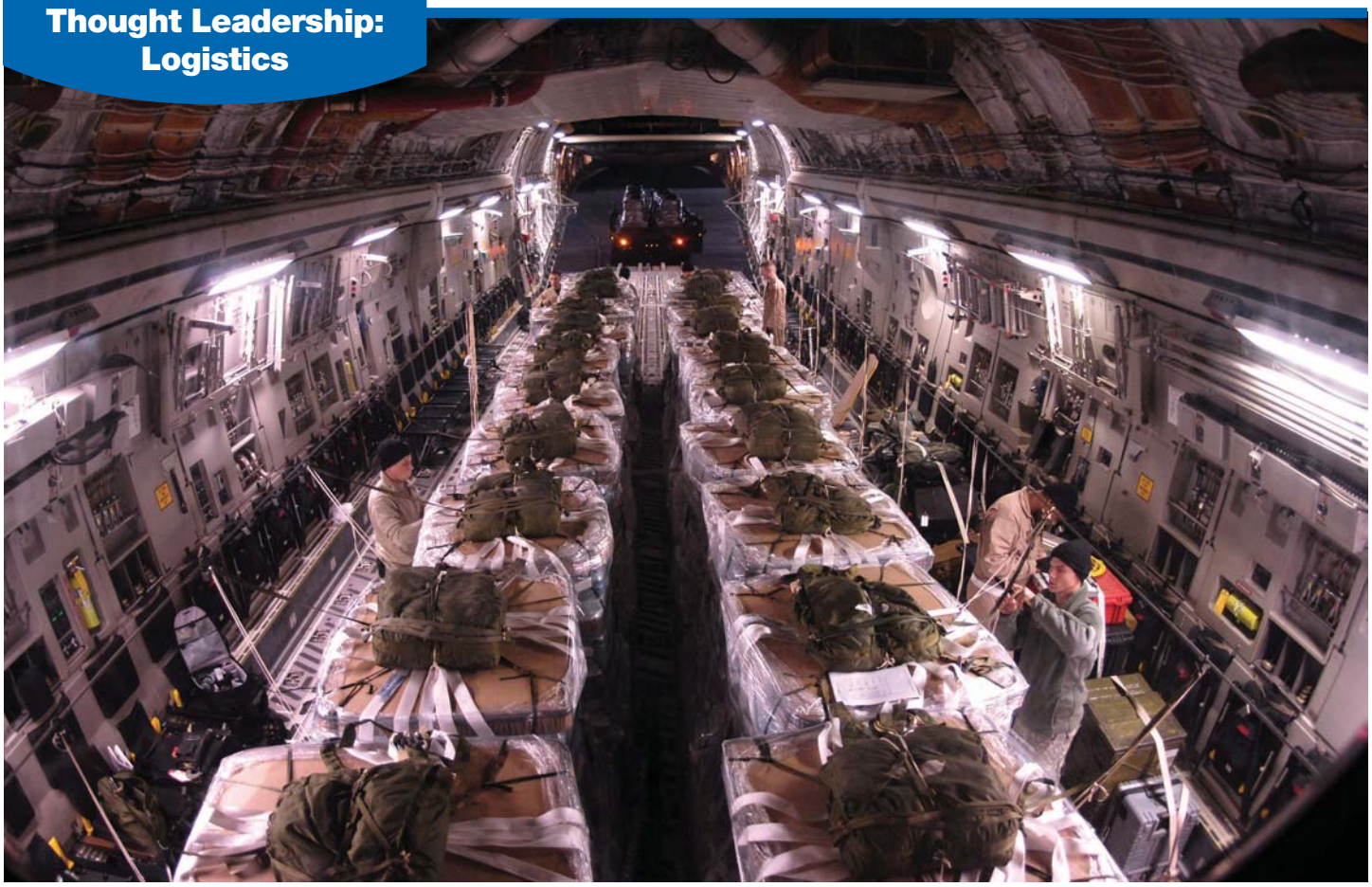

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technical personnel required; and, more importantly, the government might not be able to afford them in the face of other difficult resource choices.

A logistics modernization — now made possible and practical by the growing sophistication of commercially-available technology and infrastructure — is increasingly a fiscal imperative for the Pentagon. The transformation at hand for logistics is two-fold — developing and fielding defense systems that require less logistical support; and, secondly, leveraging commercial services, infrastructure, and best practices, utilizing outcome- or performance-based metrics.

Leverage Industry's Strengths, Build Partnerships

In its efforts to modernize business processes, the DoD has over the past decade adopted some commercial practices and increased its reliance on industry as

service providers and partners. A few broad and noteworthy developments bear particular mention:

- Outsourcing of commercially-available consumable items and a reliance on existing commercial supply chains for items such as food, fuel, shop materials and medical supplies. This move has improved material availability to almost 100 percent and has reduced lead times to 24-48 hours.
- Use of corporate contracts for weapon system-unique consumable items, a development that has dramatically improved availability.
- Application of active and passive Radio Frequency Identification — RFID — and Unique Item Identification, a move that has reduced average customer wait times. This has led to better integration of end-to-end distribution processes and improved asset visibility.
- Use of commercial partnering and continuous process improvement techniques that enhance logistics operations and reduce costs at maintenance facilities.

The Change-Agent Effects of Performance Contracting

Of perhaps greater significance is the DoD's growing use of innovative contracting to drive performance from its industry partners. This use of outcome-based contracting, through which the Pentagon buys *performance* from equipment manufacturers rather than products or services, is an alternative to buying spare parts on an "as-need" basis. The approach encourages improved weapon systems

readiness and equipment availability. Lockheed Martin has been at the fore of delivering such successful performance driven outcomes to the government.

The company's work on the U.S. Army's High Mobility Artillery Rocket System program — where payment is outcome-based — has resulted in a HIMARS operational availability of 99 percent. A similar outcome-based contract for the Javelin missile has dramatically raised the missile's system availability; it now exceeds 95 percent.

Additionally, work under a Performance Based Logistics contract, or PBL, with the U.S. Navy has led to an increase in Aegis cruiser availability from 62 percent to 94 percent. The success of these contracting vehicles points the way forward for logistics modernization.

While PBL programs for a wide range of military aircraft, weapon systems and platforms have validated the efficacy of the approach, there has been far less government-industry partnering and risk-sharing in the logistics realm.

Indeed, 2007 marked an important milestone for the Pentagon's use of commercial infrastructure. Unable to obtain country clearance to install defense fixed RFID infrastructure in Pakistan, the Defense Logistics Agency awarded a contract to Savi Networks, a joint venture between Lockheed Martin's Savi Technology and Hutchinson Port Holdings, to provide asset visibility for all items moving through Pakistani ports and over land to Afghanistan. In so doing, the DoD gained the visibility it needed and paid for it on a "transaction basis" — without having to make a capital investment cost to leverage the existing infrastructure.

"DoD has over the *past* decade ADOPTED some commercial *practices* and INCREASED its *reliance* on industry as service *providers* and partners."

The Way Ahead

The bottom line is that we just can't get there from here unless, and until, we fundamentally transform how logistics services are delivered to the warfighter. Industry capability certainly exists to help enable this logistics overhaul.

Take for example, Exostar, the secure, collaborative business network that Lockheed Martin and other major DoD suppliers started in 2000 as a shared, neutral industry platform to modernize electronic data interchange capabilities.

Today, Exostar involves 30,000 companies in the aerospace defense value chain and provides a highly secure environment for information flow and supply chain execution. It enables trading partners, regardless of size or technical sophistication, to access and act upon real-time planning, logistics and transactions.

Industry has an inherent incentive to gain real-time or time-demand information to deliver mission availability through its PBL contracts. With that recognition in mind, the way ahead seems to involve a few straightforward steps:

- Fully fund logistics communications and command and control programs that will provide battlefield logisticians with bandwidth and C2 tools they need for direct access to the supply chain.
- Accelerate implementation of the PBL philosophy across defense logistics operations, including shifting the responsibility for inventory management and supply chain execution to industry.
- Drive industry to higher levels of performance by benchmarking aerospace industry performance against best-in-class commercial industry performance. Use innovative contracting to spur continuously improving performance and outcomes.

The budget imperative for logistics transformation certainly exists. Contractual mechanisms are in place. What remains is for the Defense Department to take the same steps in the logistics realm that it has in achieving success with PBL contracting. Lockheed Martin stands ready, as a partner, to respond.

Command and Control *On the Move*

Designed to Meet Both Military and Domestic Needs, Newly Developed Equipment Can Give Commanders A Front Seat View Of the Battlefield And Help Coordinate Emergency Response At Home.

Command and control systems that provide a richly detailed picture of battlefield activity and allow commanders to coordinate military efforts may also find a place in different kinds of battlefronts — at natural disasters and other domestic crises that demand well-coordinated emergency response.

Soldiers engaged with enemy forces in a remote mountain canyon have similar situational awareness and communications needs as firefighters who may find themselves face-to-face with flames on a mountain slope.

In fact, for anyone who must contend with emergency situations, real-time information about what's taking place and unfaltering communications is critical.

Graphic Displays Right in the Vehicle

On the warfighting front, new, more mobile systems that are connected to defense networks through satellite links will allow commanders to move around on the battlefield while maintaining an ability to proactively command and control actions within their battlespace.

This "C2 On-the-Move" capability is achieved through an array of mobile electronics gear, improved power sources and vehicle-mounted satellite communications antennas that enable uninterrupted contact with networked data. (See story, page 21.)

These emerging new systems can give users access to command and control information from the front seat of almost any wheeled platform, such as Humvees, the heavily fortified Mine Resistant Ambush Protected vehicle and others like Bradley and Stryker vehicles. Details about unit locations, enemy movement and weapon and aviation support — displayed on large screens in field command posts or tactical operations centers — can now be seen from the vehicle.

The vehicles will deliver a timely and complete view of the battlefront to field commanders, or emergency response command leaders.

Commanders Get Mobile And Get Closer to the Battle

"With these systems, commanders will now be able to command and control the battle from a vantage point on the battlefield where they are best able to influence operations and proactively participant in it," notes Donald Howard, Lockheed Martin's director of Mobile C4ISR Systems. They will be more responsive to events viewed first hand through these mobile battle command systems and less dependent on waiting for information to flow to them through voice communications, he says.

The U.S. Army and U.S. Marines hope to achieve this new mobility through a combined effort known as the Common Army-Marine Command and Control pro-

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"...the ability for first responders to BEAM live video communications *directly* from the disaster scene... could be of significant VALUE in coordinating emergency response."

Continued from Page 19.

gram, or CAMC2. The U.S. Air Force is mounting the Tactical Air Control Party-Modernization, or TACP-M program, a mobile C2 effort which includes a vehicular communications system that would help plan and direct close air support operations.

Howard says the enhanced situational awareness that mobile systems provide also could prove enormously valuable to first responders, firefighters and disaster relief workers, those in government agencies such as the Federal Emergency Management Agency and Department of Homeland Security, and groups such as the Red Cross. In fact, the list would include anyone involved in directing and assisting with emergency, support and security operations.

Designed for Mobility And Dual Purposes

As Lockheed Martin has prepared systems for CAMC2 it has done so with a dual role in mind.

"For both defense users and emergency responders we've had to take into account how to incorporate sophisticated capabilities into vehicles that are typically weight restricted, either because they are armored or because they carry other heavy gear," says Howard.

Other needs have also been addressed. "We have factored in the impact of vibration and shock and developed ergonomic designs so that the equipment is a good fit," he says. It can be easily moved away from occupants in emergencies or situations calling for quick exit. "And we have made them intuitively easy to use as well."

For first responders, the vehicles and mobile C2 technology can be easily tailored. "The technology has a broad range of function — but it can be easily scaled down to meet specific requirements or budget constraints," notes Howard. Another aspect of the dual military and domestic role: a choice of communications routers and radios that are configurable, based on a user's available bandwidth and the requirements for secure communications.

Domestic and Emergency Response Uses

Howard provides examples of how a border patrol guarding against illegal immigration might use a mobile C2 system. "Outfitted with routers, laptops and secure communications in a small patrol vehicle — a crossover SUV for example—border agents could not only talk to other vehicles similarly equipped in the immediate area, but transfer information — perhaps images or a situational awareness picture, beyond line of sight."

"A surveillance aircraft assisting on patrol might detect what appear to be illegal aliens. The pilot could relay images of the suspects to the lead patrol vehicle. The agents could transmit the aerial images to the other patrol vehicles and they all work as a team, with the pilot, to track down and detain the suspects for questioning."

The range of communications and visualization capabilities that have been developed for defense purposes — whether

directly fed from aircraft or satellite — should prove as useful for emergency responders and civil agency users as it will be for military commanders.

In fighting forest fires, for example, aerial images provide information on the path of a fire. Having live satellite information at

> "...LIVE satellite *information* at the scene of the fire... could HELP plan the *response* to FAST moving events..."

the scene of the fire, at the fingertips of those directing battle efforts, could both help plan the response to fast moving events, as well as keep firefighters out of harm's way, if there is an abrupt shift in the fire's direction.

In responding to a hurricane or other similar disaster the same communications and visualization capabilities would be just as valuable. In addition, the ability for first responders to beam live video communications directly from the disaster scene, such as the aftermath of Hurricane Katrina or a city hit by a terrorist attack, could be of significant value in coordinating emergency response.

These systems would improve communications among first responders and fill important capability gaps that exist today among emergency response elements.

What Puts the *Mobility* into Mobile C2?

Technology Enablers with Improved Satellite Communications, New Power Sources and Smaller, Full-Range Computers Take Command and Control 'On-the-Move.'

Several factors have contributed to the development of new mobile C2 systems which can deliver timely on-the-scene overviews of activities to military commanders as well as those managing civil emergency response operations.

One of the most important factors, says Jim Quinn, Lockheed Martin's director for Land Force Operations, is the emergence of enabling technology that makes it possible for satellite communications on the move.

The U.S. Army's Warfighter Information Network-Tactical program, for example, will use pivoting gimballed dish antennas on vehicles, permitting contact with satellites to be maintained even when moving through obscured areas or mountainous terrain.

Says Quinn: "There's no doubt that line-of-sight radios will still be around. But when you get into disadvantaged areas — an urban canyon, for example — then the user can turn to non-line-of-sight communications via satellite to avoid losing contact with the command post. Having satellite communications and the bandwidths that come with them is key to running battle command applications and for providing the same common picture that those in the command post see."

More Technology Enablers

Very sophisticated systems that use a vehicle's internal power or connect to an external source also have paved the way for mobile C2.

Another technology enabler is the reduction in size for information processing power. Servers are small enough to fit in the back of a vehicle yet powerful enough to handle routing, in-line encryption for mobile security, and a full range of network communications.

These new mobile C2 systems also come with an open systems architecture which makes it easy to add new programs or access web applications through satellite downlinks to the vehicle's location. "Firefighters, for example, might want to subscribe to a weather link and pair that with satellite imagery of the fire," says Quinn. "A look at the front line of the fire and the winds aloft could help them create fire breaks or air drop flame retardants."

The systems that Lockheed Martin plans to offer were successfully put to the test in two recent Army experiments, C4ISR On-The-Move and Air Assault Expeditionary Force at Fort Dix, New Jersey and Fort Benning, Georgia.

Changing Capabilities... Changing CONOPS

Joint Maneuver and Engagement: Exploring the *'what ifs'* of Net-Centric Effects

This past fall Lockheed Martin combined the simulation and analysis capabilities of its *Center for Innovation* laboratory with extensive collaboration from the military user community in the Tidewater, Virginia area — to carry out the third in a series of "campaigns" to demonstrate the value of enhanced network connectivity to the joint warfighter.

Targeting Capability Gaps

Lockheed Martin's Joint Maneuver and Engagement experiment was a continuation of the company's Joint Fires Urban Operations/Close Air Support campaign — UO/CAS — which took place earlier in the year.

The successful UO/CAS campaign validated several concepts for joint operations — the impact of using non-traditional intelligence, surveillance, and reconnaissance with the combined force, the dynamic re-tasking of air missions, and the use of advanced command, control, and communications systems to share information among combat forces and speed combat decision-making.

There was also a major by-product, namely, the emergence of strong user interest in exploring how these capabilities enhance U.S. forces' effectiveness and change the way they fight the battle.

As Erich Sanchack, campaign director for Force Application in the Corporation's Advanced Concepts organization notes, one of the most significant outcomes of the UO/CAS campaign — and for the capabilities that were demonstrated — was the promise it held for helping DoD users re-cast their concepts of operations, not only for air assets, but for joint maneuver forces operating in concert with them.

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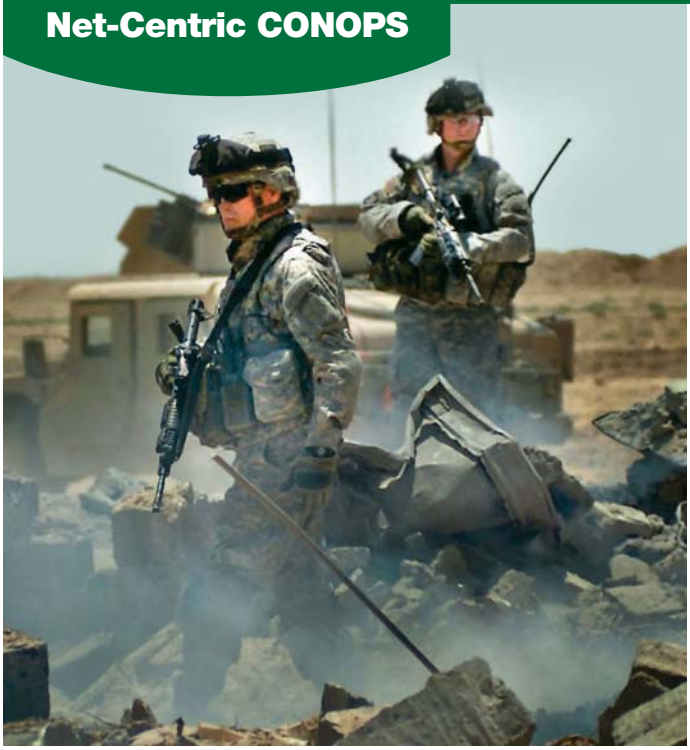

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As Sanchack notes: "Through the (UO/CAS) campaign, we worked collaboratively with customers to find potential paths that would improve how they operate. The campaign raised the prospect of changing the way they do business and was an impetus behind the JME (Joint Maneuver and Engagement) experiment. The JME campaign provided a 'deeper dive' into the potential of net-centric connectivity to impact customer CONOPS across the joint maneuver force."

The Enduring Objective: Shortening the Kill Chain

The JME campaign was tailored to explore and quantify networked tactical intelligence, particularly non-traditional ISR data, such as imagery that might be gathered from Sniper targeting pods. The campaign investigated how this networked intelligence data can immediately be exploited to enhance situational awareness and the overall effectiveness of ground forces dispersed over wide areas of operations.

The previous campaign's area of emphasis, namely pushing actionable information to the tactical edge to support rapid mission planning, execution and assessment, remained the overarching objective. However, a specific focus of the Joint Maneuver and Engagement campaign was on modeling the effectiveness of current and emerging ground vehicles and of ground forces who have been given increased situational awareness.

Fashioning an experiment to explore the "what if we could..." questions most relevant to today's highly distributed, mobile, and joint military forces demanded that the team collaborate with military users to target priority capability gaps.

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Tikrit Scenario

The value of the Joint Maneuver and Engagement campaign, as well as other experiments, is based upon the extent to which the parameters of the campaign conform to the scenarios that forces expect to confront during real military operations.

With this imperative in mind, one of the JME mission threads was based on a multi-objective, multi-platform, joint force engagement in the Tikrit, Iraq area. As with other experiments in the campaign, information about threat types and employment of forces are drawn from operational experience and associated threat data bases.

MISSION:

Capture of High Value Targets — Overview

For this scenario, set in 2015, three "high value targets" — in this case, senior terrorist leaders — were discovered near the center of Tikrit. Their location had been obtained just recently through human intelligence sources and they were expected to relocate within 24 hours. The mission was to capture and extract them to a U.S.-controlled facility.

Although the population generally supported U.S. involvement, fear induced by terrorists prevented residents from taking an active role in supporting U.S. operations. Furthermore, the city had a significant number of indigenous and foreign terrorists embedded in the general population. These elements were well-armed with machine guns, mortars, and portable air defense systems. They were extremely difficult to distinguish from the peaceful population unless they initiated hostile action.

MISSION:

Capture of High Value Targets — The Plan

The U.S. plan was to employ three convoys of ground forces to infiltrate the city and secure the area around the targets' hideaway. Once captured, they would be taken to an extraction point. A combat search and rescue helicopter, the CSAR-X, would transport the terrorists from Tikrit.

In addition to the significant number of ground forces in the scenario, several support platforms and systems were available to the joint force. The Tactical Operations Center operator, assisted by several advanced command and control capabilities, served as the overall mission coordinator and ensured that all units were synchronized.

National and tactical ISR services, including the use of a shared tactical UAV, were employed throughout the operation to monitor operations, search and identify threats, assist with bomb damage assessment, and perform other ISR tasks as requested by command elements.

An A-10 aircraft flew combat air patrol and was available to provide close air support if required. It was equipped with a Sniper Advanced Targeting Pod and advanced, low-collateral damage weapons.

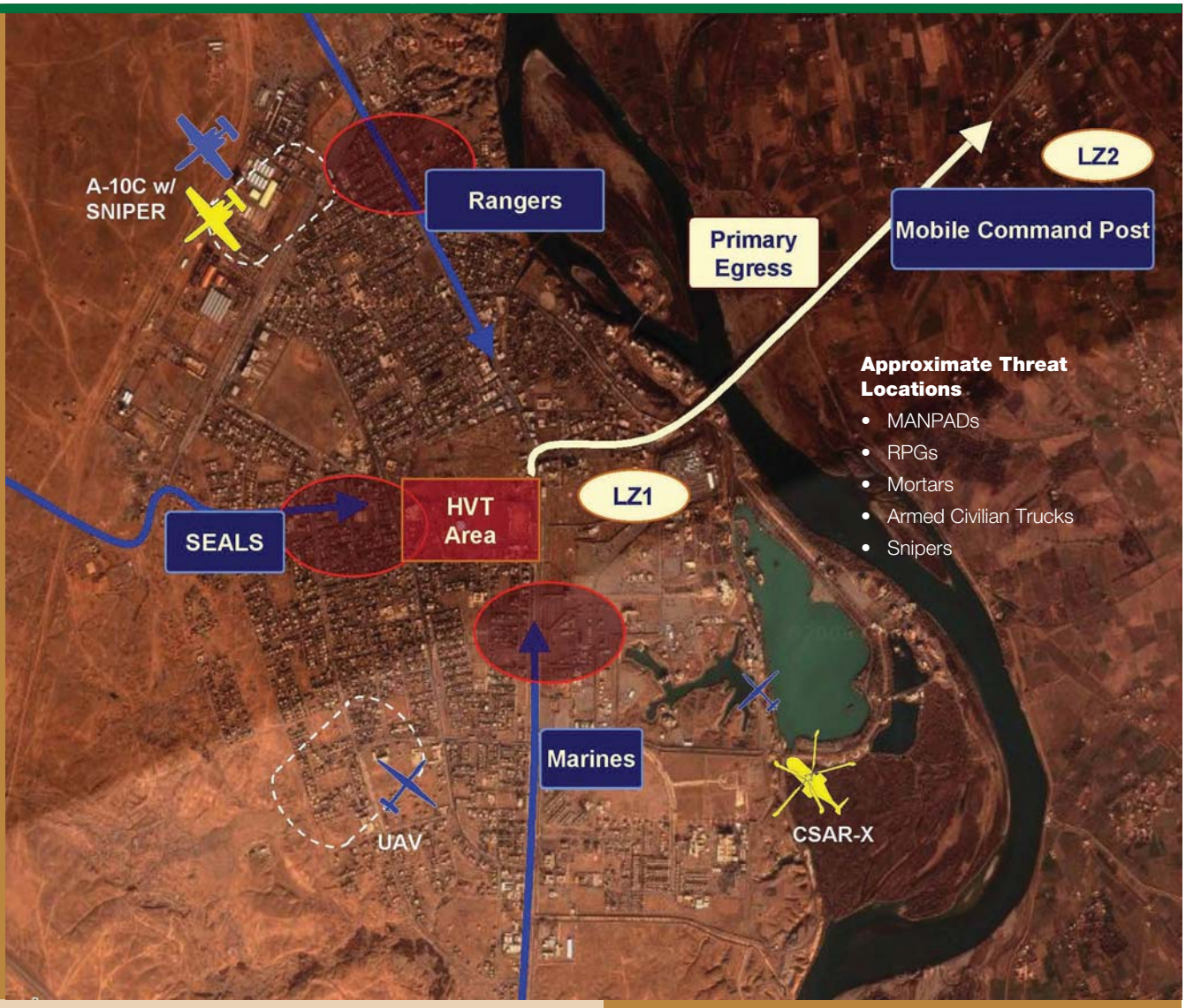
Owing to the 2015 context, the recently-fielded Joint Light Tactical Vehicle, the JLTV, provided a net-centric platform for both convoys and special forces. The joint force was outfitted with ground-launched Hellfire missile capability to provide indirect fires support.

MISSION:

Capture of High Value Targets — Execution

As the scenario begins, the troop convoys converge on the terrorists' original location, leveraging their close air support, fires and ISR capabilities as needed. During the course of this, the UAV overhead detects a roadblock on one of the routes and relays this to ground forces which re-route on the fly.

Tikrit Thread — Major Event Sequence



As the U.S. forces advance, the targets learn of the operation and relocate. Operators from the Joint Intelligence Center are notified of this development through National ISR sources and alert the tactical teams. By having advanced C2 capabilities and shared situational awareness, the joint forces are able to rapidly replan the mission and continue to the new terrorist location in a coordinated operation.

The CSAR-X, accompanied by a UAV in a "scout" role, rapidly updates its mission in flight, based on the evolving situation on the ground, and switches to a newly designated landing zone. While in-flight, its UAV scout detects an enemy ground missile threat and the A-10 is dispatched to attack it, as the CSAR-X continues the mission.

Ground forces converge on the new location of the targets. Once the terrorist perimeter is secured, they are captured and transported to the new landing zone where they are taken from Tikrit by the CSAR-X.

Net-Centric Systems Pay Dividends in Battle

As the experiment was underway, participants were able to trade and assess the utility of specific future "technology insertions," such as the JLTV for the Humvee, which provide substantially greater tactical connectivity and ability to dynamically re-task missions.

They also tested the use of new air- and ground-launched munitions, which could lead to significantly lower collateral damage with no loss in mission effectiveness, and the pairing of manned and unmanned air assets. In the scenario this greatly enhanced the survivability of the manned CSAR-X helicopter.

Major Events in Tikrit Thread

- Experiment begins with A-10 aircraft on combat air patrol and UAV airborne for ISR support of all units
- U.S. Army Rangers use ground-launched Hellfire missile capability for indirect fire support as they advance
- UAV detects a roadblock on the U.S. Marines' ingress route and the Marines are re-routed
- As U.S. forces advance, the terrorists are alerted to the operation and relocate
- CSAR-X combat search and rescue helicopter in flight, with organic UAV scout, to extract targets at pre-designated landing zone
  - The CSAR-X reroutes to avoid threat detected by UAV scout
- Intelligence alert via a RSS feed that the "high value targets" have relocated
  - All forces are rerouted to the new target location
- U.S. Army Rangers and Marines secure the targets' area perimeter; U.S. Navy SEALS arrive at the new terrorist location
- National/Tactical ISR integration identifies a portable air defense system along the CSAR-X advancing route
  - The aircraft changes to landing zone 2
  - An air strike by the A-10 flying overhead is requested
- The terrorists are captured and taken to landing zone 1 where the CSAR-X transports them to another location

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Those discussions led the team to focus on multiple capability areas: providing a rapid response to newly generated time-sensitive targets; the effective exchange of information with joint and combined forces' C2 systems; and, improving the joint commander's ability to apply precision effects in the urban environment. Within these capability areas, the team also addressed: leveraging ISR assets, cross-cueing sensors and employing precision kinetic and non-kinetic capabilities; and, exploring solutions to difficulties of delivering precision effects, without causing unacceptable levels of collateral damage.

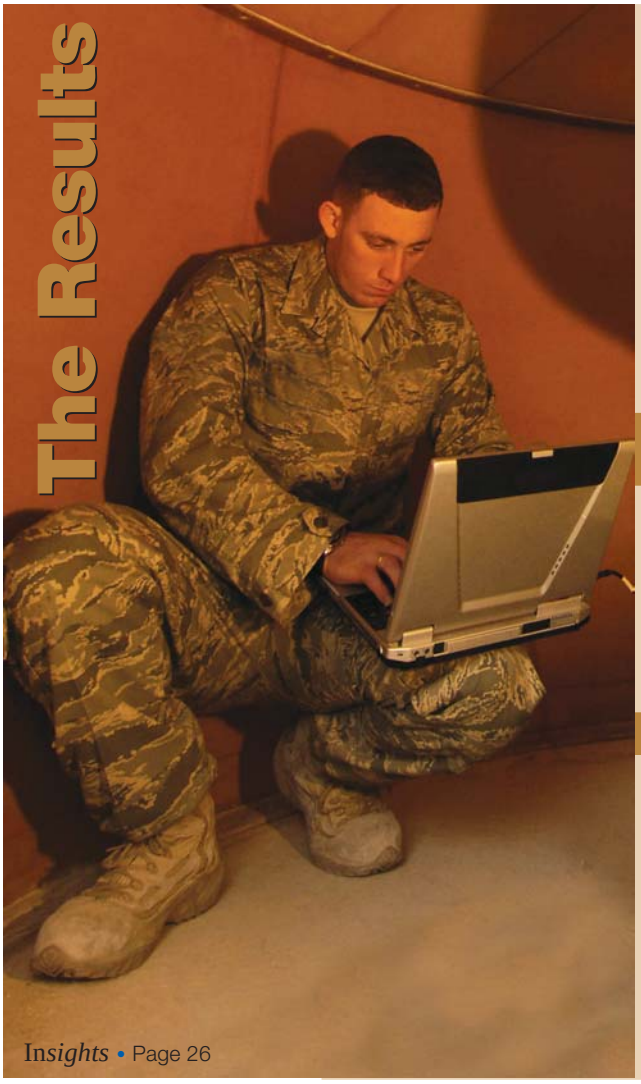
The Joint Maneuver and Engagement Campaigns

The Joint Maneuver experiment was set in a 2015 environment and divided into two mission "threads" or scenarios, one set in Tikrit, Iraq, (see story, page 24) and the other at the military's Western Test Ranges in the southwestern United States. (The western ranges offered the attributes of hostile territory and also allowed for rapid participation in live-fly exercises against challenging terrain at U.S. military facilities in the area.)

In the western experiment thread, the primary blue force objective was to neutralize enemy command and control and the associated air defense infrastructure, including major surface-to-air missile threats, with a secondary mission of surveillance and reconnaissance.

Major events within the experiment included immediate ISR taskings in a non-traditional sense, using a variety of air assets that were available, and also included air-to-air engagements, combat search and rescue and infiltration by special forces. A variety of communications links were employed during the experiment to test the effects of bandwidth capabilities on outcomes.

A manned F-16 simulator was employed to perform close air support missions in a simulated urban environment. This was coordinated with a manned joint terminal attack controller directing combat aircraft in the attack. While engaged in the area for close air support, the F-16s conducted immediate non-traditional ISR with a Sniper pod on locations assigned by the attack controller on the ground. The sequence involved coordinated and multiple attacks in the close quarters of an urban environment using real-time, annotated imagery transfers between the F-16 and the ground controller.



The Results

The campaign's top-level hypothesis, confirmed through the experiment's results, is that both close air support and search and rescue missions can be more effective when non-traditional ISR and net-centric C3 concepts are widely employed to improve situational awareness.

The Joint Maneuver Engagement Campaign's specific, CONOPS-impacting findings — confirmed through the running of multiple scenarios and technology threads to explore customer-identified capability gaps — addressed these areas:

4TH AND 5TH GENERATION TACTICAL AIRCRAFT INTEROPERABILITY

Employing the F-22 and F-35 and their accompanying sensors, C3 systems and ability to exploit non-traditional ISR data enables significant improvements in suppressing enemy air defenses. In the western range scenario, use of 5th generation fighters decreased the time needed to attack "pop-up" targets and increased the lethality against time-sensitive targets.

C3I AND SITUATIONAL AWARENESS

The Tikrit mission scenario demonstrated that forces using net-enabled Joint Light Tactical Vehicles were successfully able to identify potential threats before they were encountered through video inputs from ISR sources. In conducting the experiment, the team used a Humvee acting as a surrogate JLTV, and equipped with advanced C3I capabilities and satellite communications data links, to support many of the systems under development.

> "THROUGH this *collaborative* process, we AVOID giving them 'what they *don't* need'."

In both mission threads, the combination of virtual and constructive simulations made it possible to investigate trade-offs in mission performance and capabilities that could be achieved by swapping out legacy equipment with modernized weapons and technology and by their associated net-centric connectivity.

Industry-Government Collaboration at the Core

Experiments such as Joint Maneuver and Engagement can provide the Corporation with insights in developing systems for customers and making other research and development investments. Additionally, for Sanchack and others involved with the campaign, success is realized in the extent to which it receives DoD "community of interest" buy-in.

At the core of the experiment's success has been the Corporation's ability to closely collaborate with its customer community. This has involved the Joint Forces Command, the U.S. Army's Training and Doctrine Command, and U.S. Air Force components including intelligence, plans and programs, to craft an experiment that closely replicates the complexity and diversity of major customer challenges.

Direct customer involvement allows Lockheed Martin to better align its internal resources to customer needs and priorities. Says Sanchack: "Through this collaborative process, we avoid giving them 'what they don't need.'" Where relevant, this cooperation also speeds up the prototyping process.

"We have been able to work creatively and iteratively with an expanding customer community of interest and this has helped give a broader fidelity and deeper relevance to our live-virtual constructs," says Sanchack. "As we have been able to share and interpret the outcomes of the campaigns with a growing segment of customers, there's no doubt that both we and the military have benefited from the collaboration."

As more DoD users — from the combatant commands, the defense agencies, the Office of the Secretary of Defense and the military services — have been exposed to the experiment, interest has emerged in having the *Center for Innovation* and other mission-specific Lockheed Martin entities explore derivative threads, says Sanchack.

"For us, the real measure of success is whether these campaigns are accepted as valid and meaningful by the warfighter," says Sanchack. "Customer involvement is important, in fact, it's essential, because it signals an acceptance of the experiment rationale and the relevance of the issues being addressed. It's the only real stamp of approval."

NATIONAL/TACTICAL ISR INTEGRATION

On request, tactical forces could receive streaming full-motion video of ISR while a mission was in progress. This, in turn, allowed JLTV operators to identify threats earlier and counter them by calling for close air support or engaging with organic capability.

ADVANCED STRIKE WEAPONS

The Tikrit mission thread showed that when employed, advanced highly precise strike weapons could result in greater enemy attrition with a negligible increase in collateral damage. For this scenario, the ground-launched Hellfire missile proved to be a viable alternative to traditional indirect fires for destroying both stationary and moving targets with accuracy.

COGNITIVE HUMAN PERFORMANCE MEASUREMENT

The experiment developed and implemented a foundational capability for measuring various aspects of operator cognitive loading and performance. In the Tikrit scenario, the experiment demonstrated the value of this ground-breaking methodology for measuring operator risk assessment and mitigation behavior.

Connections

Lunar Mission to Analyze Earth's Moon

Lockheed Martin will design, build and operate a new NASA mission to analyze the internal structure and gravitational forces of the Earth's moon.

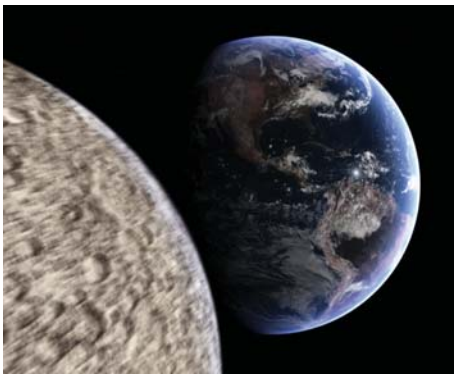
The lunar mission is called Gravity Recovery And Interior Laboratory, or GRAIL, and is the latest under NASA's Discovery program.

Two identical spacecraft will orbit the moon in a low, polar orbit. They will use Ka-band ranging instruments to send signals between one another, and then relay the data back to Earth to be analyzed.

Scientists will examine the minute differences in distance the signals traveled between spacecraft. This will give unprecedented insight into the gravitational changes over the entire moon.

During the three-month science phase of the mission, GRAIL will create a global, high-accuracy, high-resolution lunar gravity map providing new understanding to the history and internal structure of the moon - from crust to core. The mission is expected to launch in 2011.

GRAIL is the fifth NASA Discovery mission Lockheed Martin has worked on. Previously, Lockheed Martin designed and built the Lunar Prospector spacecraft; developed the aero shell entry system for the Mars Pathfinder mission; designed, built and operated the spacecraft for the Stardust mission; and designed, built and operated the Genesis spacecraft.



"Two *identical* spacecraft will ORBIT the moon in a *low*, polar orbit."

U.S. Navy Test Confirms Missile Firing Capability of Aegis Open Architecture

Aegis Fire Control and Mk 41 Launching System Upgrades Perform Successfully At White Sands Missile Range

The next-generation Aegis weapon system, called the Aegis Open Architecture Weapon System, has performed a successful missile firing, marking the first test of upgrades to both the Aegis fire control system and the Mk 41 vertical launch system.

The test was done recently at White Sands Missile Range aboard the "USS Desert Ship," the U.S. Navy's land-based, live-fire test bed for surface-to-air weapons.

The fire control system that was tested is a tailored commercial product equipment suite Lockheed Martin built to incorporate the Aegis Open Architecture computer program products. The missile launch system is the version of the below-deck system employed on Navy destroyers beginning with the USS Pinkney.

Open Architecture System

The Aegis Open Architecture system will allow the Navy to stay on technology's leading edge by using commercial computing hardware and open system software. The Navy can more easily refresh technology and implement capability upgrades to the weapon system as they are developed in the future.

The systems engineering and methodical testing at White Sands provides greater assurance to the Navy that the next generation Aegis Open Architecture system will perform. The USS Bunker Hill will be the first of 22 cruisers to be modernized with the new system when it begins its depot modernization this year.

Aegis Ballistic Missile Defense

The Aegis Weapon System is the premier naval surface defense system and the foundation for the Aegis Ballistic Missile Defense Weapon System, which recorded several important missile intercepts in 2007.

- Late last year, the Aegis BMD weapon system onboard the USS Lake Erie detected, tracked and targeted two ballistic missiles simultaneously. The weapon system then guided two missiles to intercept both targets, making it the first time two ballistic missile targets were simultaneously engaged in the exo-atmosphere.

- Also last year, in the first test for Japan's Aegis BMD capability, the Japanese Ship Kongo was successful in shooting down a missile target. The test also included a successful exchange of tracking data between the Lake Erie's Aegis BMD system and the Theater High Altitude Area Defense Weapon System.

Net-Centric Connections

Continued on Page 30.

FastC2AP

Improving Situation Awareness In Maritime Domains

Lockheed Martin has worked with the U.S. Navy to build a Web-accessible suite of software tools that can be used to configure and manage "intelligent agents" to improve situational awareness in maritime domains.

The technology has been tested with the Navy's Sixth Fleet in the Mediterranean maritime domain where users were able to transform huge amounts of data into meaningful information and actionable knowledge.

The tools are called the Fast Connectivity for Coalitions and Agents Program — FastC2AP — and were developed by Lockheed Martin's Advanced Technology Laboratories through funding from the Defense Advanced Research Projects Agency.

For two weeks during a NATO exercise, the Maritime Operations Center used FastC2AP to monitor merchant ships, fishing boats, cruise ships and warships as they traveled along the Mediterranean Sea. The results showed that the FastC2AP tools and other associated software provided two orders of magnitude improvement in the tracks processed by the Center, and that the intelligent software agents helped operators manage overwhelming amounts of actionable data for naval intelligence centers.

Navy Admiral Henry Ulrich III, commander of U.S. Naval Forces Europe, has recommended that FastC2AP be transitioned to "program of record" status to ensure continued engineering and programmatic support.

Brain-Inspired Technology to Analyze Urban Environments

Lockheed Martin is applying brain-inspired technologies to develop a prototype system that will use sensor data to recognize and identify objects in urban environments.

The intent is to reduce the time an image analyst spends manually identifying objects, cutting from 1,300 hours to 10 hours, the time spent analyzing typical surveillance imagery. Faster turnaround with images will give analysts more time to assess risks and plan strategies.

The system is called Object Recognition via Brain-Inspired Technology — or ORBIT, for short. It uses three technology components: electro-optical; light detection and ranging; and, brain-inspired technologies to automatically recognize objects from ground and air surveillance.

The brain-inspired object-recognition technology will automatically generate lists of recognizable imagery, like mailboxes and dumpsters, and help analysts determine if concealed explosive devices are nearby. The system will recognize images as humans do, based on low-level and complex patterns, the object's shape and texture, and features that are common to a class of objects.

The ORBIT system will be able to determine if an area is of interest and propose potential recognitions of the area.

Lockheed Martin's Advanced Technology Laboratories leads a team developing the system for the Defense Advanced Research Projects Agency and the National Geospatial-Intelligence Agency, which is funding the work.

New Space Lab for NASA's Orion and Constellation

Lockheed Martin has opened a new space Exploration Development Laboratory in Houston, dedicated to support NASA's Project Orion and Constellation program.

Orion is the next-generation human spaceflight vehicle. It will transport up to six astronauts to and from the International Space Station and up to four to the moon and destinations beyond, beginning in 2015 after the space shuttle is retired.

The Exploration Development Laboratory is a 10,000 sq. ft. test facility and part of an integrated lab network that includes facilities in Denver, Col., Glendale, Ariz., and Arlington, Va. The network will reduce cost and schedule risk by providing an early opportunity to perform systems level avionics and software testing for Orion in a realistic environment in the development phase of the program.

Initial testing of critical systems will be done in the Exploration Development Laboratory, including the guidance, navigation and control, automated rendezvous and docking, crew interfaces, and software development processes. These will also include system integration tests and mission tests that employ the team's "test like you fly" philosophy.

Close proximity to NASA's Johnson Space Center will enable the Lockheed Martin team to work closely with the Orion and Constellation program early in the development and testing phase to gain clarity on requirements.

Fusion Technologies, Intelligent Agents Deliver New Capabilities

Special fusion technologies and other intelligent technologies developed by Lockheed Martin form the basis for systems that are benefiting U.S. Army helicopter pilots and maneuver commanders.

They were developed and integrated to form "associate technologies" that allow pilots and commanders to manage teams of unmanned vehicles, while freeing them to fly and focus on more cognitively demanding tasks, like avoiding threats and battlespace management.

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Fusion Technologies, Intelligent Agents Deliver New Capabilities

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The technologies were integrated into a Mobile Commanders Associate and Warfighter's Associate systems. Fusion and agent-based discovery capabilities for improved situational awareness, avoiding fratricide and battlefield monitoring were integrated into the Mobile Commanders Associate. It improved the fidelity and speed of data required by commanders aboard Blackhawk helicopters.

With the Link 16 data link also integrated into the Blackhawk MCA, the helicopter was, for the first time, able to send and receive tactical information with attack aircraft, like the F/A-18, and ISR aircraft.

Lockheed Martin also defined the Warfighter's Associate technology, which introduces scan-to-scan tracking capability to the Apache helicopter. This increases the fidelity of the tactical picture while helping improve pilot safety. The program was sponsored by the Army's Aviation Applied Technology Directorate.

> "...*associate technologies* allow pilots and commanders to MANAGE teams of unmanned vehicles, *while* freeing them to FLY and FOCUS on more *cognitively* demanding tasks..."

Lockheed Martin is working on automating the process of military airspace control, developing a system that will help the U.S. Air Force leverage the skills of their planning experts to better control airspace over a battle zone, and to transfer that knowledge to less experienced operators.

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GILA System Deconflicts Airspace

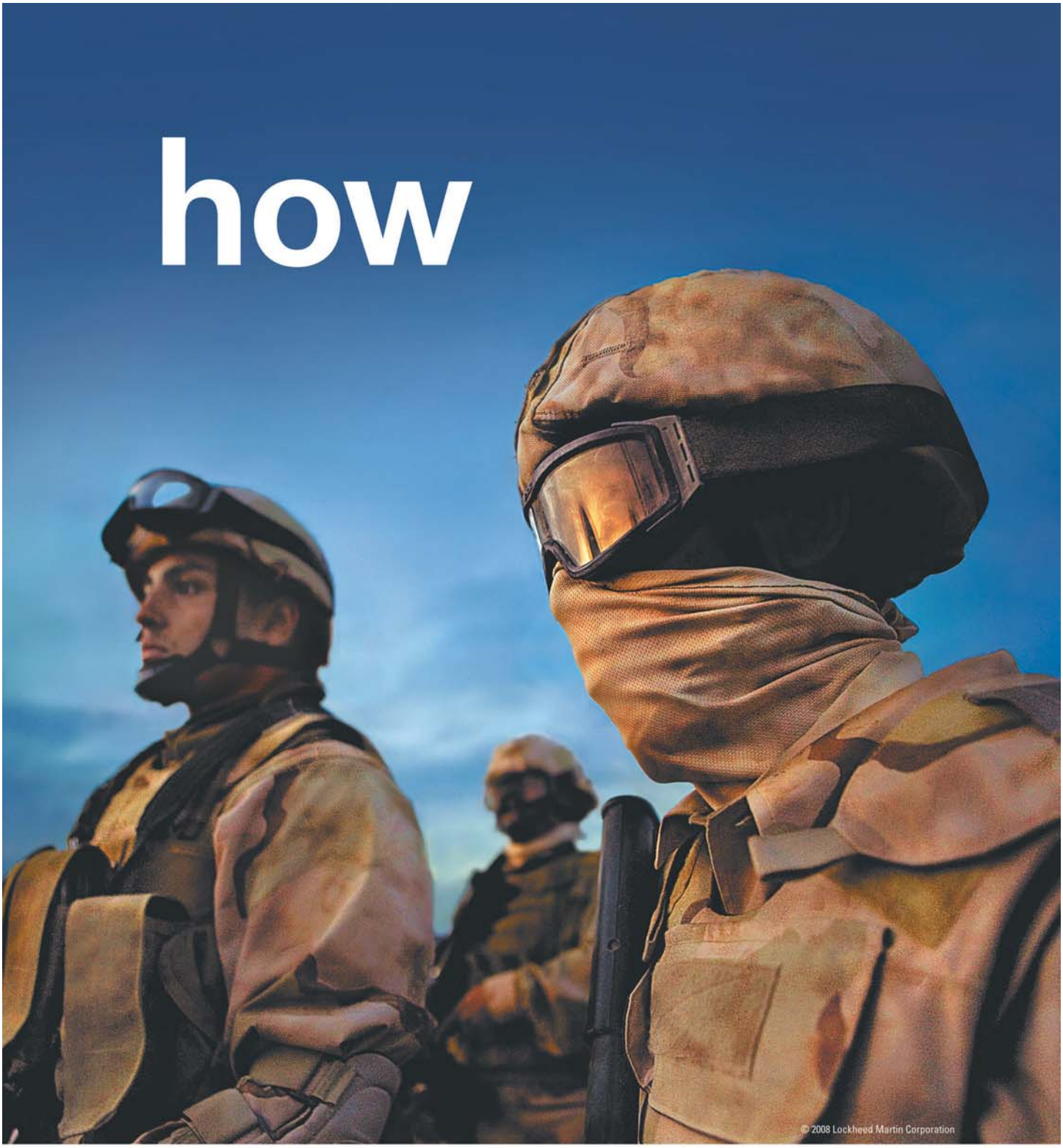
Airspace Control System Mimics Human Tasks

Air operations centers use airspace control orders to deconflict the airspace in which manned and unmanned air vehicles and weapons all operate. Improper deconfliction of the airspace can endanger pilots and make air assets less effective.

The Lockheed Martin system, called Generalized Integrated Learning Architecture, or GILA, will help planners create airspace control orders by automatically learning planning tasks from air space experts. The technology could be extended to other operations, improving the Air Force's capability to rapidly and safely use large numbers of manned and unmanned aircraft and weapons in airspace.

Lockheed Martin leads a team of university partners in developing the GILA system, using advanced machine learning and planning research from the partners. The results will be integrated into tools for military planners, starting with a Web-based tool for airspace deconfliction.

Over the next 12 months, the team will add robustness to the system and expand the scope of the domain problem to include more aspects of military air operations. The research will also extend the GILA system's learning and reasoning capability to perform on par with a human novice, with the goal of exceeding human performance.



BETWEEN MISSION DEFINED AND MISSION ACCOMPLISHED,
THERE IS ONE IMPORTANT WORD: HOW.

AND IT IS THE HOW THAT MAKES ALL THE DIFFERENCE.

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