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The Institute

The mission of IDA is to assist the Office of the Secretary of Defense, the Joint Staff, the Unified Commands, and Defense Agencies in addressing important national security issues, particularly those requiring scientific and technical expertise. IDA also conducts related research for other government agencies on national problems for which the Institute's skills and expertise are especially suited. Incorporated in 1956, the Institute operates two Federally Funded Research and Development Centers for the Department of Defense - one focusing on studies and analyses, the other on communications and computing - and one for the National Science Foundation and the Office of Science and Technology Policy in the Executive Office of the President.

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Message from the President

Admiral Dennis C. Blair, USN (Ret)

Last year's message discussed many of the important changes underway in the national security arena. The pace of these changes shows no sign of slackening. Here in Washington, the growth in the defense budget is slowing, forcing tough choices on priorities; the nation's intelligence organization has been restructured as the result of two major commission reports; and key leadership positions in national security organizations have turned over as the Administration prepares for the next four years. Abroad, world events continue to involve the United States and its armed forces in a diverse range of operations, from sustained deterrence of a major regional conflict in Korea, to post-conflict operations in Iraq, and to tsunami relief on the shores of the Indian Ocean.

It is clear from the task summaries in this report that IDA is heavily involved in helping the Department of Defense and our other sponsors, such as the Department of Homeland Security, the Veterans Administration, and intelligence agencies, improve efficiency and effectiveness across the full range of their activities. Our researchers are helping devise approaches to fundamental issues related to military force levels and structures; helping improve communications systems and networks; examining the acquisition and testing of complex systems; developing models and simulations to improve tactical, small-unit counterinsurgency operations in cities; estimating the costs and performance of advanced technologies; and analyzing hundreds of issues in between.

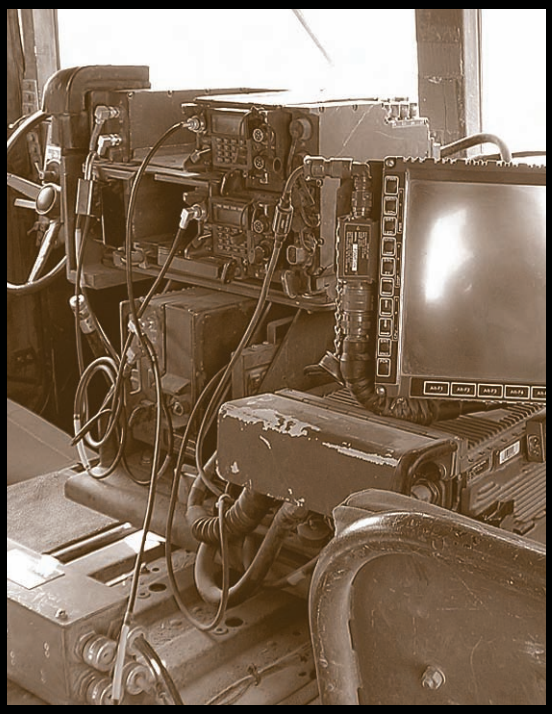
With so many challenging projects underway at IDA, it is no wonder that in the year and a half I have been President of the Institute, I have often been asked about the organization's relative anonymity, especially in light of the importance and often controversial nature of our research. Why isn't IDA better known and more in the news? Our low profile is the direct and conscious result of our commitment to impartiality, high-quality work, and candor. Our assessments and recommendations flow from the facts of our research. When sponsors engage IDA to conduct a study, they count on us to dig deeply into the questions they ask, then to provide hard-edged, technically accurate and well-supported analyses and recommendations. If they are looking for supplementary support for a preconceived idea, they go elsewhere.

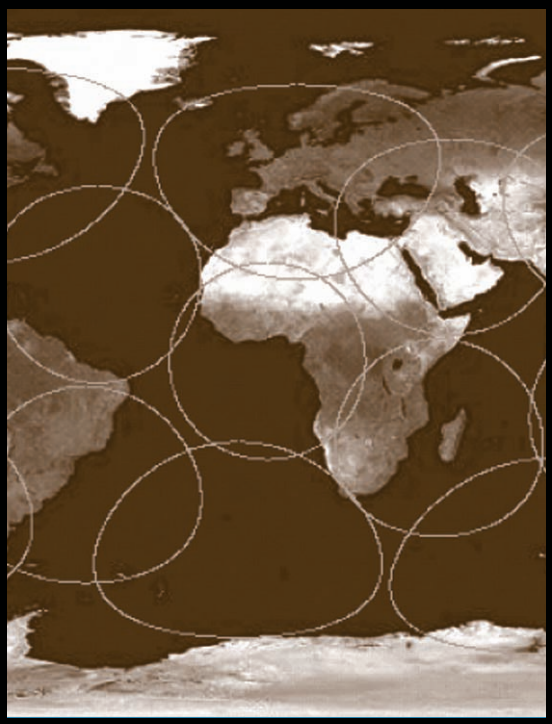
By the same token, we assure our sponsors that the research, assessments, and recommendations in our reports belong to them; we do not distribute or publish our findings without sponsors' consent. This combination of quality, objectivity, and discretion is what distinguishes IDA. While our sponsors do not always enjoy receiving IDA assessments and recommendations that challenge favored programs or policies, they always know how we reached our conclusions, they take them seriously, and they generally come back to us when faced with tough problems in

the future. We could not perform this valuable service if we also sought wider public recognition for our work.

More important, we could not perform this valuable service without the talent and dedication of our 900-person staff. Their educational qualifications – roughly three out of five of our researchers have PhDs – and their deep understanding of sponsor problems are only the foundation of their excellence. What has most impressed me is their dedication to bringing sound research and analysis to bear to improve the decisions and operations of the Department of Defense and our other sponsors. They really care about getting their analysis right, and their greatest satisfaction comes when their work makes a difference in a government policy or decision. The problems we are grappling with are incredibly complex – highly technical, highly important to the country, and often highly contentious within the government. IDA's researchers approach these problems with an inspiring blend of intellectual curiosity, exuberance, and sense of dedication.

Admiral Dennis C. Blair, USN (Ret)





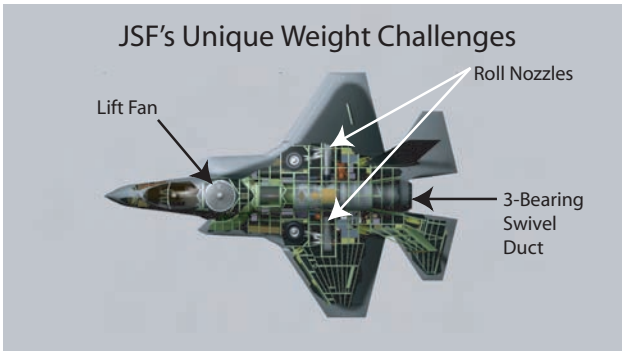
Systems Evaluations

IDA's evaluations of defense systems support decisions on acquisition and program planning, and involve assessments of military utility, system performance, and the risks and costs of technological integration. These efforts cover systems at all stages of development and deployment, including test and evaluation. IDA also conducts broad assessments of new operational concepts, current and future mission needs, system architectures, and system interoperability. To accomplish this, we maintain expertise with the systems of all Services, including tactical systems for land, naval, and air warfare; strategic systems and missile defense; mobility systems; command, control, communications, computers, intelligence, surveillance, and reconnaissance systems; space systems; and information and computing systems. Our research helps DoD set force and inventory levels, identify suitable concepts for system employment in wartime, and choose among alternative weapon systems.

Tactical Systems

Joint Strike Fighter Review Panel

In late 2003, the Joint Strike Fighter (JSF) program reported that the aircraft's structural weight was projected to significantly exceed previous estimates. DoD asked IDA to assess the program and provide recommendations on weight management initiatives and on a number of other important elements of the program.



The lift fan, roll nozzles, 3-bearing swivel duct, munitions bays, and gear requirements create a unique weight challenge for the Joint Strike Fighter Short Take Off Vertical Landing variant. In examining weight issues that have arisen, the Independent Review Team started with engineering-level weight estimates, added historical growth factors, evaluated potential weight saving options, and adjusted for potential thrust improvements to provide insight and identify specific weight-related recommendations.

IDA's assessment noted that the JSF will provide a significant step forward in survivability, reliability, and maintainability, while providing a common platform for a new generation of mission systems. However, we determined that higher-than-estimated system weight, particularly for the short take-off and vertical landing variant, seriously could affect aircraft performance and, thus, efforts should be made to lower weight during the ongoing design phase before the aircraft enters production.

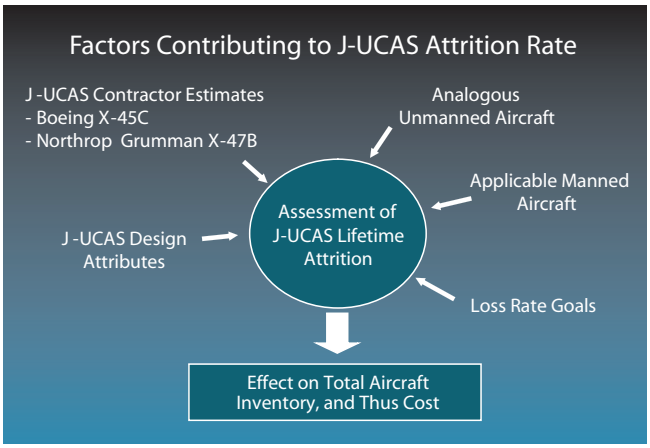
IDA provided an independent weight estimate for each JSF variant, estimated how this weight would impact performance, evaluated several options for addressing the problem, and then recommended ways to improve the situation. The team further recommended that the program office work with the operational community to reevaluate JSF requirements to ensure that the final design incorporates the right balance of capability and cost. These recommendations were adopted by the program and approved by the Defense Acquisition Board.

Joint Unmanned Combat Air Vehicles

IDA worked with DoD to assess technology opportunities for unmanned combat air vehicles (UCAVs) and to quantify operational benefits, costs, and risks. The resulting UCAV Options Study found that UCAVs could provide a range of useful mission capabilities that could considerably improve the overall effectiveness of future tactical aircraft forces. Given these findings, DoD established the Joint Unmanned Combat Air Systems (J-UCAS) Program at DARPA and merged into that program the ongoing DARPA-Air Force X-45 and DARPA-Navy X-47 developments.

OSD asked IDA to continue studying UCAVs, with particular focus on airborne electronic attack, air defense suppression, penetrating surveillance, and strike capabilities. Key issues include survivability versus surface-to-air and air-to-air

threats, communications requirements, noncombat loss rates, the impacts of multi-vehicle employment, and life-cycle costs. The results of this ongoing assessment will be used to help estimate the combat effectiveness, costs, and needed force size for a range of UCAV variants, including DARPA's J-UCAS concepts.

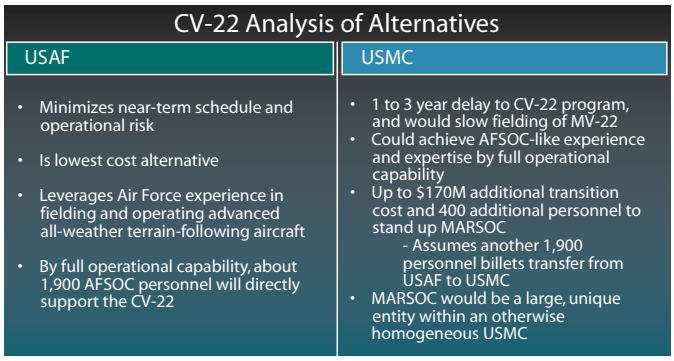


IDA took into account many factors in assessing the lifetime attrition rate of the Joint Unmanned Combat Air Vehicle. Using these inputs, estimates of noncombat losses per 100,000 flight hours were developed by analogy where possible; otherwise, they were based on scientific or engineering expertise. The implications of a range of estimates were also considered.

CV-22 Organizational Analysis

The CV-22 is a special operations variant of the V-22 Osprey tilt-rotor aircraft being developed by the Marine Corps. CV-22s are intended to penetrate denied airspace at night and in adverse weather to conduct infiltration, exfiltration, and resupply missions. The U.S. Special Operations Command was asked to study the merits of alternative organizational assignments for the CV-22 aircraft. The Command, in turn, asked IDA to assess the relative capabilities, costs, and other implications of operating CV-22s in the Air Force as currently planned, or alternatively in the Marine Corps, Army, or new joint units.

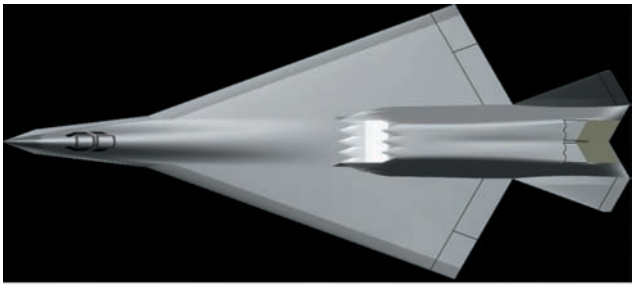
IDA concluded that keeping the CV-22 special operations program entirely within the Air Force Special Operations Command (AFSOC) minimizes near-term schedule and operational risks by leveraging more than 10 years of AFSOC effort devoted to developing and fielding the CV-22. It also maintains program stability, retains the experienced personnel already in the program, has the lowest cost, and requires fewer personnel because it can draw the existing capabilities within AFSOC Headquarters. DoD concurred with these findings.



The CV-22 analysis of organizational alternatives shows the pros and cons associated with assigning the indicated Service with responsibility for the CV-22 and its employment in special operations missions. Although other alternatives were also considered, the two primary organizations were the USAF and the USMC. The program currently resides with the Air Force Special Operations Command; moving it would require the formation of a Marine Corps Special Operations Command.

Long-Range Global Strike

DoD anticipates that long-range strike aircraft (LRSA) will continue to be essential for many operational missions for the foreseeable future. The Department asked IDA to investigate the broad capabilities and specific characteristics that would be most important



The Long Range Global Strike study considered many conceptual designs for long-range strike aircraft. The results of the study showed that the preferred concepts for starting development in 2012-2015 were those for manned and unmanned stealthy subsonic penetrating aircraft, which could resemble the current B-2 bomber (shown above, dropping a JDAM). Stealthy supersonic designs, like the conceptual Mach 2 Long-Range Strike Aircraft (bottom image), which would have an aerodynamic shape conducive for this speed regime, had the highest life-cycle cost, greatest technical risk, and lowest overall effectiveness.

for future LRSA that would first complement and then eventually replace existing bombers.

IDA assessed the technical performance, mission effectiveness, and costs of four LRSA concepts that appeared most promising in an earlier phase of the study. One concept involves a standoff "arsenal aircraft," which essentially is an armed derivative of a large commercial freighter aircraft. We estimated that the arsenal aircraft would have the lowest platform cost and technical risk, but would lack the strike effectiveness of the other alternatives. The effectiveness of the arsenal aircraft would improve significantly, however, if equipped with advanced long-range and loitering weapons.

A second concept involves a stealthy, supersonic aircraft. This option would have the highest life-cycle cost, greatest technical risk, and lowest overall effectiveness of the candidates considered.

We concluded that the two remaining concepts – involving manned and unmanned versions of stealthy, subsonic penetrating aircraft – would be the preferred LRSA solutions for starting system design and development in 2012-2015. IDA's results are being used by OSD and the Air Force to help define the capabilities and design characteristics of the next generation LRSA system.

Assessment of Aviation Forces

DoD is pursuing a number of major programs to modernize and improve air superiority and strike capabilities. These programs include the F/A-22 Raptor, F-35 Joint Strike Fighter, and Joint Unmanned Combat Air Systems, as well as many smaller programs, such as mission planning systems and munitions that provide important associated capabilities.

OSD asked IDA to assess the planned aviation force's ability to provide capabilities for a range of prospective future needs. The study's initial investigations have focused on understanding DoD's new planning scenarios and the roles that planned U.S. air superiority and strike forces will play. The study also is examining how U.S. capabilities would be affected by base capacity, the ability of U.S. forces to overfly or operate from foreign nations, and threat capabilities. In 2005, IDA will develop a range of alternative air superiority and strike forces, assess their capabilities in these scenarios, and estimate the cost to procure and operate them.

Unmanned Ground Vehicles and the Future Combat Systems

The Army's Future Combat Systems (FCS) program is intended to provide future ground combat units that are lighter and more rapidly deployable, while being more lethal, sustainable, and survivable than current forces. Current FCS concepts include a variety of air and ground unmanned systems, including tactical unmanned ground vehicles (UGVs). Unlike unmanned aerial vehicles, the use of UGVs on the battlefield is unprecedented, and thus their employment and associated tactics are still being developed.

Because of its decade-long experience in UGV studies, IDA was asked to identify potential operational issues associated with integrating UGVs into an FCS unit. We identified operational issues and possible approaches for resolving them in the following areas:

- UGV mobility
- Employment and operational concepts, tactics, techniques, and procedures
- Command and control
- Fire control and target engagement
- Operational tempo
- Computer security and information assurance
- Survivability
- Safety
- Training

Unmanned Ground Vehicle Variants

IDA's assessment of unmanned ground vehicles included three variants of a conceptual Armed Robotic Vehicle (ARV). The ARV-Assault (ARV-A) and ARV-Reconnaissance, Surveillance, and Target Acquisition (ARV-RSTA) are expected to be approximately 8.5 ton vehicles with a common chassis (about 14 feet long) and two mission module variants: The ARV-A will be equipped with advanced sensors and offensive weapons, and the ARV-RSTA will have an advanced sensor suite and a weapon for self-defense. The ARV-Assault (Light) ARV-A(L)) would be an approximately 2.5 ton, 13 foot long vehicle, which would be used in place of the heavier version for airmobile operations.

Future Fleet Architecture

Current naval combatants were designed for missions dominated by consideration of conflicts with the former Soviet Union. While naval challenges are shifting to more confined areas, such as littorals or straits, U.S. naval forces also must be prepared to deal with any reemergence of serious open-ocean threats. In FY 2004, Congress asked for two independent studies on future fleet architectures, and DoD asked IDA to help with one of them.

Our role was to identify alternative future fleet architectures that would be comparable in cost over the long term, and to estimate the capabilities of the alternatives with respect to the programmed fleet. In examining possible future conflicts, we concluded that pervasiveness and agility are key capabilities for the fleet in nontraditional situations that do not involve confrontations with major naval powers over sea control. In this context, IDA identified several alternative future fleets consisting of smaller and faster craft, placing greater emphasis on unmanned vehicles. To operate effectively, such naval forces would require

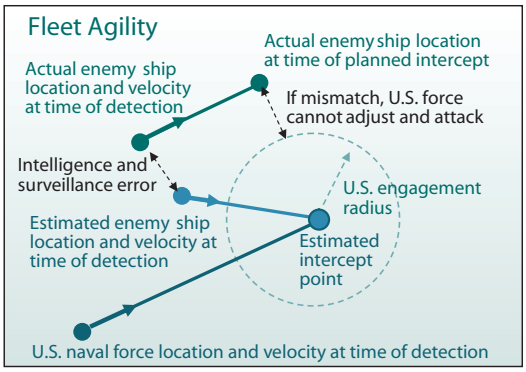
Ship Designs

A. Large ship for aviation, weapons, and support. Displacement: 57,000 tons Length: 250 m

B. Small VSTOL carrier. Displacement: 13,500 tons Length: 180 m

C. Surface combatant ship. Displacement: 1,000 tons Length: 70 m

D. Surface combatant craft. Displacement: 100 tons Length: 40 m



The Future Fleet Architecture study used naval forces that incorporated novel ship designs: a large (A) and a small (B) aviation ship, both smaller than current U.S. Navy aircraft carriers (about 330 m); and small, fast surface combatant craft (C,D), smaller than current U.S. Navy surface combatants (about 150 m). One of the analyses performed on these conceptual forces assessed the concept of fleet agility by examining the fleet's capability to anticipate and move swiftly enough to attack an adversary that is maneuvering deceptively. Errors in the initial estimate of the enemy's position and direction of motion can cause U.S. forces to arrive at a location some distance from the enemy's actual location. For the alternative fleets studied, the miss distance – which should be small enough to carry out the intended attack – differed due to differences in average speed and in capability for reducing intelligence errors by networking through a number of vessels. Using illustrative settings, the analysis compared the agility of the alternatives in bringing force to bear on an enemy with that of the programmed fleet, capturing the number and quality of surveillance platforms, speed of deployment, and enemy speed and deception capability.

extensive networking among the distributed combatants. IDA's work will contribute significantly to the OSD response to Congress in 2005.

Integrated Air and Missile Defense

DoD is pursuing integrated air and missile defenses in which relevant Service systems would be combined into a family of systems by 2010. To achieve this goal, the Department needs joint architectures, joint concepts of operations, a single integrated air picture, combat identification, integrated fire control, and automated battle management aids. As part of this effort, DoD asked IDA to assess the expected capabilities of the family of systems.

IDA developed a methodology for examining these capabilities and has started a broad analysis of needed force levels that examines the expected capabilities of alternative groupings of U.S. air and missile defense systems pitted against various air and missile threats.

Intelligence, Surveillance, and Reconnaissance Systems

Sensors for Detecting and Tracking Ground Moving Targets and Cruise Missiles

DoD is developing a variety of systems to improve detection and tracking of moving targets on the ground and in the air, including space-based radar and Global Hawk – which have ground moving target indicator (GMTI) capability – and the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor and the Medium Extended Air Defense System – which are designed to aid in cruise missile defense (CMD). The proposed E-10A Multi-Sensor Command-and-Control Aircraft will have both GMTI and CMD capability, and the developmental Joint Unmanned Combat Air System may include GMTI capability. Also, when these new systems enter service between now and 2020, several current systems will remain in the force.

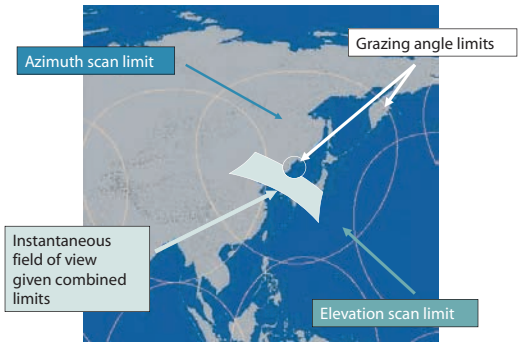
DoD asked IDA to examine tradeoffs among the full array of existing and planned sensors to ensure that the planned GMTI and CMD systems provide desired capabilities without unnecessary duplication. Our researchers subsequently compared the capabilities of a broad range of alternative mixes of GMTI and CMD sensor systems to support warfighting needs. DoD is using the results to help set program and budget priorities among these systems.

Intelligence, Surveillance, and Reconnaissance Options to Support Global Strike

Global strike operations typically begin by attacking an adversary's early warning and air defense capabilities so that follow-on forces can more effectively accomplish their missions. This requires intelligence, surveillance, and reconnaissance (ISR) operations to maintain battlespace awareness, which is essential for rapidly detecting, targeting, and attacking threatening forces. ISR systems must provide timely search, tracking, and identification of targets; assess battle damage after hostilities begin; and allow for rapid data transfer with other weapons systems.

Potential Coverage

Actual Field of View



IDA's analysis of space-based radar capability (illustrated here with 21 satellites orbiting at 1000 km) showed that although the potential coverage is very good (top, notional), each radar's field of view at any specific time (and thus tracking performance) is reduced by radar scan limits in azimuth and elevation (bottom, notional).

IDA identified alternative concepts for enhancing battlespace awareness to support future global strike missions. We then refined these concepts and analyzed the comparative cost and effectiveness of selected platforms and sensors that could be integrated into a single system of systems. We concluded that an integrated space, airborne, and ground-based family of sensors would provide capabilities that could deal with the most diverse set of future security situations. Our results will assist DoD in defining the required attributes and in selecting development options for a future ISR system of systems.

MASINT Planning

Measurement and signature intelligence (MASINT) systems measure physical characteristics of targets or events and provide information on their location, composition, and performance. IDA assists the Director of Central Intelligence MASINT Committee in identifying technical enhancements and process changes to improve overall MASINT effectiveness.

In 2004, IDA's work focused on two technical studies and one overall process examination. First, our researchers analyzed the collection, transportation, processing, and analysis of samples of chemical and biological material from Iraq. Our results contributed to improving the coordination of sample analyses among the intelligence

community agencies and the flow of resulting data to intelligence analysts. In addition, IDA investigated the ability of a class of geophysical data collection systems to satisfy intelligence needs. The results of this analysis contributed to the MASINT Committee's annual Technology Status Review of Capabilities.

IDA also examined research and development options for review by the MASINT Committee. We recommended a multiyear process that would focus the resources of the Committee on the areas of highest operational potential. The Committee accepted that recommendation, and IDA will be assisting in the first phase of the process in 2005.

Command, Control, and Communications Systems

Joint Command and Control Capability

Future warfighting capabilities will require enhanced battlespace awareness, timely information exchange, and net-centric forces to support joint and multinational operations. To support such command and control (C2) capabilities, DoD has developed a strategy to evolve the Global Command and Control Family of Systems, consisting of joint and Service C2 capabilities, from its current state to a single joint C2 architecture to be called the Joint Command and Control (JC2) capability. The Department plans to begin implementing JC2 in 2006 by initially providing C2 capability to Combatant, Joint Task Force (JTF), and JTF Component Commanders.

DoD asked IDA to conduct an analysis of alternatives (AoA) of the JC2 program. The work will involve (1) analyzing current C2 capabilities; (2) assessing capabilities-based needs and gaps; (3) developing system demonstration and development alternatives, evaluation methodologies, and measures of effectiveness; and (4) evaluating JC2 system demonstration and development alternatives.

Joint Battle Management Command and Control

DoD is developing and fielding integrated joint battle management command and control (JBMC2) capabilities. To assist in this endeavor, U.S. Joint Forces Command and OSD are developing a JBMC2 Roadmap, which will establish processes to integrate the Services' BMC2 capabilities and define the steps needed to meet DoD's goal of either making interoperable or phasing out legacy C2 systems by 2008.

DoD asked IDA to develop a methodology for assessing the interoperability of legacy systems and to apply that methodology to a limited number of systems in FY 2004. Our methodology involves first establishing the current interoperability status and identifying existing shortfalls. Next, we will project the status of the system forward to 2008 and identify future shortfalls and alternative solutions. Last, we will analyze the alternative solutions and make recommendations to integrate legacy systems into JBMC2, to phase them out, or to retain them temporarily as stand-alone capabilities. The Situational Awareness Data Link and the Advanced Field Artillery Tactical Data System are the first two systems to be assessed. Additional legacy systems will be addressed in FY 2005, and the results incorporated into subsequent versions of the JBMC2 Roadmap.

Joint Blue Force Situational Awareness

DoD's Joint Blue Force Situational Awareness (JBFSA) effort includes the capabilities and processes employed to collect, evaluate, and disseminate Blue Force situational awareness information – U.S. joint and coalition force identification, location, status, and intent from multiple sources. These processes are supported by the evolving Global Information Grid communications and enterprise services.

IDA was asked to assist Joint Forces Command and the Army (the lead Service for JBFSA) in developing an integrated architecture and associated investment strategy for JBFSA capabilities. This is part of a larger body of work being conducted under DoD's Family of Interoperable Operating Pictures initiative and, as such, involves a large degree of Service interaction and coordination. IDA completed an initial set of far-term JBFSA architecture products in 2004 and will continue this work through 2005.

Information and Computing Systems

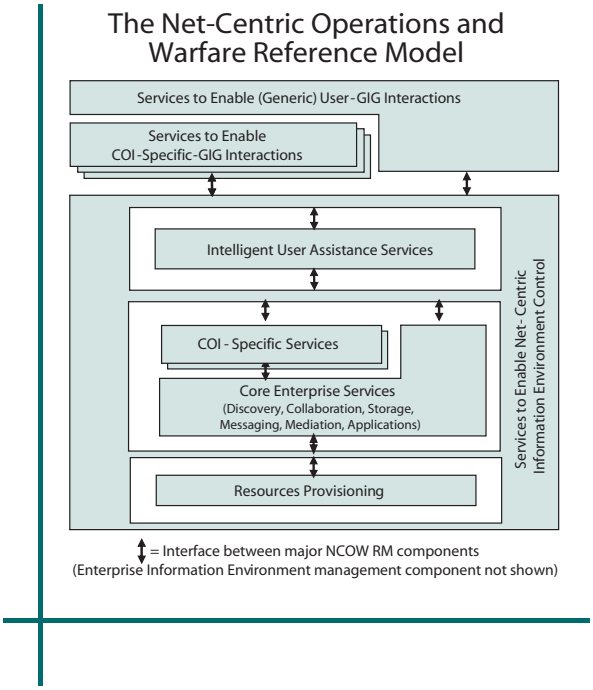
Core Architecture Data Model

IDA was asked to develop a comprehensive data interoperability approach that would enable the various DoD organizations preparing systems architectures to compare the information technology being used and the reuse solutions being pursued in order to better coordinate development efforts.

IDA found that architecture data interoperability requirements can be satisfied by:

- Specifying an information exchange standard to capture the DoD architecture data semantics and syntax.
- Developing a key management strategy based on enterprise-wide unique record identifiers.
- Using authoritative data sources.
- Specifying XML resources for Net-Centric Enterprise Services.

IDA's Core Architecture Data Model XML specifications can act as an application programming interface to move data from any commercial architecting tool into an architecture data repository and vice versa. This approach was successfully demonstrated in 2003, and in 2004, we began a second phase of the study which focused on extending this capability to cover DoD Architecture Framework products.



Information Assurance

IDA continues to provide technical, operational, and policy analyses in support of several key DoD information assurance initiatives, including the Defense-wide Information Assurance Program and the National Information Assurance Partnership (NIAP), as well as the National Security Agency's Advanced Research and Development Agency (ARDA).

In 2004, IDA identified specific areas of emerging scientific and technology advances that are important to DoD needs and that are receiving venture capital investment. Our findings were then used to engage the venture capital community to transition selected opportunities to DoD developers and users, and to provide test and evaluation feedback to the venture-capital-funded companies on their products and services. In other efforts, IDA enhanced DoD's understanding of the information assurance workforce, improved the Department's architecture for computer network defense, and helped assess hardware assurance.

The NIAP is a joint effort between the National Institute of Standards and Technology and the National Security Agency to promote technically sound security practices, metrics, and evaluations of commercial IT products. To meet the requirements of The National Strategy to Secure Cyberspace, DoD and the Department of Homeland Security asked IDA to conduct a government-wide examination of policy, support infrastructure, and IT system development and acquisition processes. The review is expected to have far-reaching effects on the way security evaluations are done.

Lastly, IDA's work with ARDA focuses on the problems of extracting intelligence from, and providing security for, electronically transmitted or manipulated information. Our researchers have explored issues and potential solutions related to information exploitation, access to global information systems, quantum information science, advanced integrated circuits, gaining novel intelligence from massive data, and insider threats.

Business Management Modernization Program

The Business Management Modernization Program (BMMP) was established in 2001 to provide DoD with relevant, reliable, and timely business information by modernizing business practices and by integrating systems and processes in logistics, acquisition, installations and environments, strategic planning and budgeting, personnel and health care, accounting, and finance.

Since its inception, BMMP has been developing a Business Enterprise Architecture (BEA) for the Department-wide global information grid. The BEA, and an associated transition plan, guide DoD in transitioning the thousands of information systems currently supporting business activities into more modern, typically commercial-off-the-shelf systems. IDA assists the BMMP management office by participating in critical reviews and assessments of architectural products as they are produced. We also are assessing the strategic approaches to achieving BMMP goals and the development, sustainment, and evolution of the BEA.

Test and Evaluation

IDA continues to play a key role in a wide variety of test and evaluation activities. Most of this effort supports the Director, Operational Test and Evaluation (DOT&E), the principal advisor to the Secretary of Defense on operational test matters. With IDA's continuing support, DOT&E ensures that major weapons systems undergo operational and live fire tests and evaluations that are sufficiently realistic to determine their operational effectiveness, suitability, lethality, and survivability. In addition, DOT&E, with IDA's continuing support, ensures that the nation's test infrastructure is capable of supporting future weapon development. This year, IDA also initiated work for the newly formed Defense Test Resource Management Center, which is responsible for strategic and budgetary planning of the DoD test infrastructure.

Operation Iraqi Freedom

Shortly after the capture of Baghdad in 2003, DOT&E requested that IDA assess the performance of specific weapon systems or programs used during the conflict. The objective was to compare actual performance with those systems' experiences in operational test and evaluation to determine the extent to which operational test and evaluation predicted the systems' performance in combat, and then to seek ways DOT&E could improve test processes. IDA worked closely with the Services and the system program offices to gather as complete a set of performance data as possible.

Some assessments produced surprising results. For example, Javelin, a hand-held antitank weapon, was used extensively in Iraq. In northern Iraq, an Army Special Forces reconnaissance team equipped with Javelins encountered an Iraqi Army armored unit. The team engaged the enemy with the Javelin, and, with support from Air Force and Navy aircraft, defeated the Iraqis, suffering no losses of friendly forces. The soldiers used the Javelin at or beyond its intended maximum range and were able to win the battle based only on their self-taught understanding of the weapon. Firing 19 Javelins, they scored 17 hits. Although not envisioned at the time of the operational test, results of using the Javelin in this manner were consistent with the test findings.

Land Warfare

Over the past several years, IDA has helped develop the test strategies for the Guided Multiple Launch Rocket System (GMLRS), which dramatically improves the range and accuracy of currently fielded rockets, and the High Mobility Artillery Rocket System (HIMARS) – a wheeled rocket and missile launcher that can be loaded onto a C-130 transport aircraft, thus increasing the mobility of the Army's rocket and missile systems. In addition to developing individual test strategies, IDA also helped the Army develop a single operational test for the systems, which allowed the Army to conserve test resources, while providing a more thorough test of both systems. The testing included GMLRS missions fired from HIMARS against actual targets and two 96-hour operational field exercises of a HIMARS-equipped unit that included live and simulated firings. We analyzed the data from these events to assess GMLRS' performance against a variety of targets and HIMARS' ability to process and fire munitions in a timely, accurate, and reliable manner. Our analysis will be used by DOT&E for its report to Congress.

Top Left. Firing of Guided Multiple Launcher Rocket Launcher System (GMLRS) off a High Mobility Artillery System (HIMARS).

During the HIMARS and GMLRS combined operational test, one mission consisted of two launchers firing 12 rockets against a simulated target. The pictures show two HIMARS launchers firing GMLRS rockets (A), the rockets dispensing bomblets (B), and the bomblets hitting around and on the simulated target (C). IDA worked for over two years in helping to design and evaluate this test. This and other missions will be combined in our analysis of both HIMARS and GMLRS, which will support the DOT&E's report to Congress.

Joint Biological Point Detection System Trailer Variant at Multi-Service Operational Test and Evaluation.

IDA also assisted DOT&E in analyzing the Joint Biological Point Detection System (JBPDS), which is designed to detect the presence of biological warfare agents, provide agent identification in near-real time, and collect samples for further laboratory analyses. JBPDS will be integrated into the Stryker Nuclear, Chemical, and Biological Reconnaissance Vehicle. A six-phase multi-Service operational test and evaluation, which supported the Services' urgent-need fielding requests, was conducted on the shelter, man-portable, trailer, and shipboard JBPDS variants. Systems were challenged with biological warfare simulant aerosols generated from ground-based and aerial disseminators. Our analysis confirmed that, despite system performance limitations, JBPDS can detect and identify some biological warfare agents in time to take preventive measures, provide treatment, and reduce casualties through early warning to unit commanders.

Also, IDA analysis for DOT&E indicated that component-level laboratory testing is not sufficient to confidently predict JBPDS performance in the field. Thus, whole system live-agent chamber testing is now planned to characterize live-agent and simulant detection performance to provide a sound correlation basis for predicting the system's ability to detect biological warfare agents in the field.

Air Warfare

IDA researchers supporting DOT&E observed the operational test of the Joint Air-to-Surface Standoff Missile (JASSM) and found poor reliability in both the initial and follow-on operational tests conducted this year. As a result, the Air Force halted JASSM testing and constituted a team of high-level government and outside experts, including an IDA researcher, to monitor missile improvements. IDA analysts also helped define an adequate test program for the Electronic Safe and Arm Fuze should the Air Force decide to put this new fuze in JASSM to replace the somewhat unreliable mechanical fuze currently employed.

The F/A-22 Raptor completed initial operational testing this year. IDA's evaluation team – the largest we have ever put together for a single program – supported DOT&E in monitoring all aspects of the F/A-22 testing, including the flight line at Edwards Air Force Base, the Aggressor Squadron at Nellis Air Force Base, the mission control center in Nevada, and trials using the air combat simulator. At IDA headquarters, we installed the capability to receive and analyze large amounts of classified data from these trials, which we used to recreate and assess the many simulated missile firings during the air-to-air combat trials. We also evaluated the F/A-22's performance against a wide variety of air and ground threats, taking account of aircraft flight envelope, weapons integration, radar signature, and maintainability. The report we helped DOT&E write will include recommendations for follow-on testing of deficiencies discovered during this test and planned upgrades to the system. This assessment will support DOT&E's report to Congress prior to initiating full-rate production of the F/A-22.

This year, IDA evaluated testing issues related to more than a dozen electronic warfare acquisition programs at various levels of maturity. The urgent threat posed by infrared-guided Man Portable Air Defense Systems (MANPADS) resulted in the accelerated testing and initial fielding of a simplified version of the Large Aircraft Infrared

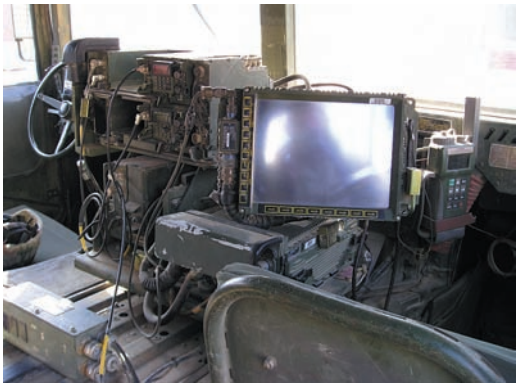
Countermeasure system, the Advanced Tactical Infrared Countermeasures/Common Missile Warning system programs, and the upgraded AAR-47V(2) missile warning system. IDA participated in test design, on-site monitoring, and rapid analysis of test results to assist with identifying performance issues prior to fielding these systems. We were essential in assuring that accurate simulations of threat missiles were used and assisted in determining the optimal test conditions for the few live missile launches. The expertise developed during these tests also enabled us to provide advice to the Department of Homeland Security Counter-MANPAD program that is intended to develop a system for protecting commercial aircraft from MANPAD threats.

Strategic Warfare and C4I Systems

From November 2003 to January 2004, an IDA analyst traveled to Iraq and Afghanistan to gain first-hand evidence from users in the field about the performance of the Army Battle Command Systems, including a specific brigade-level command and control system that was facing a full-rate production decision. The IDA staff member interviewed commanders and staffs in more than 20 Army units at the battalion, brigade, and division level in Baghdad, Mosul, Tikrit, and Balad in Iraq, and Bagram and Kandahar in Afghanistan. The information gathered was presented to support a full-rate production decision of the command and control system in the DOT&E report to Congress.

The Missile Defense Agency (MDA) is developing the Ballistic Missile Defense System (BMDS) to defend against ballistic missiles in all phases of flight. DoD is now fielding a limited defensive operations (LDO) capability to defend the United States against long-range ballistic missiles from rogue nations such as North Korea. This initial limited capability will include space-based sensors for early detection; Aegis ships for early tracking; the Cobra Dane radar on Shemya, Alaska, for fire control tracking; interceptors launched from Fort Greely, Alaska; and battle management and communications elements.

IDA was asked to estimate the probability of engagement success (P_{ES}) for the initial BMDS LDO capability. We reviewed flight testing, ground and field testing, and hardware-in-the-loop testing performed over the past few years. Our study showed there were insufficient data to accurately determine P_{ES}, primarily because of the lack of system-level testing of the BMDS LDO capability. Our assessment also raised other



(Top). An IDA analyst on the roof of Task Force 1-18IN in Balad, Iraq. IDA participated in an Army assessment of command, control, and communication systems in Iraq and Afghanistan.

(Bottom). Force XXI Battle Command, Brigade, and Below equipment in a HMMWV in Kandahar, Afghanistan. This combat identification system enables troops to view the positions of friendly forces overlayed on a map of the area, and includes a radio for broadcasting the vehicle's position to others.

issues related to the operational performance of the BMDS LDO that are now being addressed by MDA.

Live Fire Test and Evaluation

Live fire test and evaluation (LFT&E) involves assessing the lethality of developmental and fielded munitions and missiles and the survivability of manned combat systems. The *Seawolf* (SSN 21) is the first submarine to undergo survivability testing under the LFT&E program. This year, IDA helped DOT&E document *Seawolf* vulnerabilities identified in testing and described possible improvements to the LFT&E process for other ships or submarines. The testing revealed that submarine fires can spread catastrophically. As a result of fire testing, improved insulation materials were provided in several areas, improved hose reel systems were installed, bilge sprinkling systems were added, thermal imagers were confirmed effective, and fire ventilation doctrine was developed. Full-ship shock testing of USS *Jacksonville* (SSN 699) provided numerous lessons that improved *Seawolf* design, and shock testing of major hull penetrations revealed significant weaknesses that were corrected.

Resource Analysis for Test and Evaluation

IDA examines DoD's test resources and technical test capabilities to ensure that they can support DoD testing requirements for current, emerging, and future weapons systems. These activities include identifying promising science and technology efforts for use in future testing; assessing investment options to meet joint test and evaluation needs; and examining test facility costs and user charge polices.

This year, IDA began work for the recently established Defense Test Resource Management Center, which is responsible for strategic planning for DoD's test and evaluation infrastructure and resources and for certifying that Service budgets include adequate resources for necessary test and evaluation and infrastructure modernization. Our researchers provided analyses of test and evaluation infrastructure capabilities and developed analytic methodologies to support the budget certification process.

IDA also continued working on test and evaluation infrastructure issues for DOT&E. We participated in several studies of new test capabilities and analyses of the resources needed to support testing of advanced weapon systems in a joint forces environment. Also, our researchers helped develop a DoD roadmap that identifies revised policies, new methodologies, and upgraded test infrastructure to support testing in a joint forces environment.

Technology Assessments

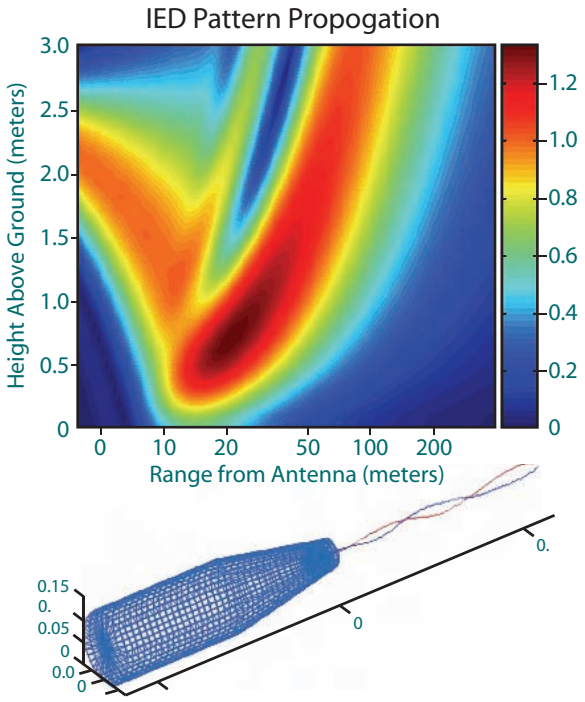
IDA provides scientific, technical, and analytical support related to identifying, evaluating, developing, and using advanced technologies for defense systems. This work involves assessments of technology feasibility, performance, producibility, demonstrations, and development risks. IDA also assists DoD in developing technology strategies, plans, standards, and investment priorities, as well as assessing the domestic and international implications of trade and technology cooperation, plans, and controls.

Sensors, Surveillance, and Target Acquisition

Detection of Improvised Explosive Devices

Insurgents in Iraq are using improvised explosive devices (IEDs) to attack military and civilian personnel. In 2004, several IDA projects focused on developing and exploiting technologies for countering IEDs.

IDA hosted 140 representatives of government research and development organizations at a two-day workshop focused on the IED challenge. The workshop stressed the need for a "systems approach" aimed not only at finding and neutralizing emplaced IEDs, but also on attacking enemy activities that support the production and deployment of these devices.



Because the majority of IEDs encountered are simply lying on the surface, with varying degrees of concealment, it is important to understand the effect of surface proximity on electromagnetic fields used to detect or defeat these devices. This effect is studied through the pattern propagation factor, which is the ratio of electric field strength in the presence of the surface to the corresponding field in free space. The graphic above uses colors as shown on the colorbar key to indicate this ratio. Near the surface, we expect field strength to be very much reduced from its free space value. This effect must be taken into account when designing and testing IED detection systems. The graphic in blue shows a numerical model of a similar 152-mm artillery shell. The blue and red wires leading from the fuse well represent one possible configuration of the electrical connections to a blasting cap detonator. Models such as this help us understand how such IEDs can be detected or otherwise defeated with electromagnetic systems.

IDA also hosted two technology workshops that focused on specific methods of detecting hidden IEDs. Taking the view that IEDs are a form of command-detonated land mine, the first of these workshops concentrated on determining how well IEDs could be detected using the systems and sensors that have been developed by the Army for countering landmines. The second workshop gathered researchers from universities, government laboratories, and the private sector to discuss U.S. technological capabilities to detect IEDs by directly sensing their explosive content.

In addition to the traditional detection technologies, IDA researchers also have studied other defeat mechanisms that could apply to IEDs. These include detection of radio-controlled fusing devices and of other signatures common to many IEDs.

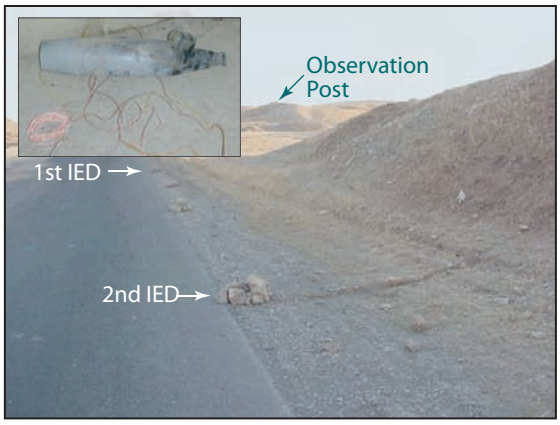
Operational Effectiveness and Neutralization of Improvised Explosive Devices

A typical roadside IED is built using a stolen artillery shell and is detonated with a blasting cap. The device may

be triggered either directly or by using a radio-controlled command link assembled from consumer-grade components.

IDA has been assisting DoD in identifying and evaluating technical countermeasures for detecting and neutralizing this threat. We found that the enormous variety of commercial devices available to terrorists makes it difficult to identify a "one size fits all" solution to defeating IEDs. We recommended a systematic means of rapidly and comprehensively evaluating each new type of threat, determining its susceptibility to a range of neutralization strategies, and rapidly disseminating this information to deployed forces.

Also, we have been helping identify common characteristics of IEDs that might be exploited by U.S. countermeasures. IDA continues to support DoD in developing plans for the testing and operational employment of advanced systems to provide more robust countermeasures to IEDs.



A great many of the IEDs encountered in Iraq are based on standard artillery projectiles equipped with improvised fuses, such as blasting caps. The upper photograph shows one such device, discovered before detonation and the lower one shows an implementation of a similar one with its buried detonation wire, as is typical in Iraq. IDA is investigating the electromagnetic characteristics of such devices using detailed E-M field models as described in the caption on page 18.

Ground Standoff Mine Detection System

Landmine detection remains a challenge for U.S. troops deployed abroad. The State Department estimates that roughly 60 to 70 million landmines are emplaced worldwide, with Iraq and Afghanistan being among the most heavily mined countries.

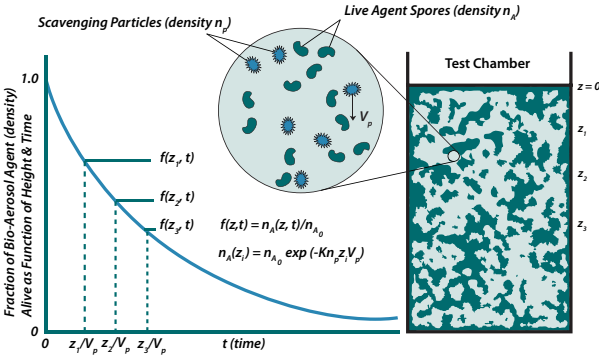
IDA continues to assess the performance of vehicle-based mine detection systems that incorporate ground-penetrating radars and metal detectors to detect surface-laid and buried antitank landmines. The goal is to be able to reliably detect mines from standoff distances, at a high rate of advance, with few false alarms. Recent testing has been structured to set benchmarks for development of advanced mine detection sensors that could be integrated into the Army's Future Combat Systems program. IDA researchers have been monitoring tests and analyzing data to assess progress in meeting technical objectives. The next phase of the program will focus on advanced ground-penetrating radar, an area of particular IDA expertise.

The GSTAMIDS mine detection system consists of a ground-penetrating radar, a metal detector, and an infrared sensor mounted on a Meerkat blast-protected vehicle.

Biological Sciences and Technology

Particulate Agent Defeat

DARPA has initiated a project to mitigate the threat of chemical or biological agent clouds. Performance requirements are demanding: to recognize a threat cloud within one minute of its appearance and to neutralize the cloud within five minutes. Four primary investigators have been funded to demonstrate different technical approaches to recognition, and four additional performers have been funded to demonstrate neutralization.



How much neutralizing (scavenger) aerosol mass is required to neutralize a representative biological agent cloud: thickness 10^4 cm, area spread 10^7 cm2, volume 10^{11} cm^3? The model used here assumes that the neutralizing scavenging aerosol is spatially mixed with the bio-agent aerosol. The terminal velocity of scavenging particles in free fall in air is assumed large compared to spores, typically about a micron in diameter. Particles of this size have a typical terminal velocity of ~0.3 cm/s. The scavenging particles could have a velocity an order of magnitude greater. As the particles fall, they collide with and collect spores, so that the rate of spore depletion is proportional to the capture efficiency, collision velocity, the current density of spores, and the density of scavenging particles, leading to the curve and the equations in the figure.

On the right side of the figure we show a representation of the test chamber with a mixture of particles that are homogenous at time zero. As the scavenging particles fall through the cloud, they decrease the concentration of live agent at lower levels in the chamber.

Because of IDA's expertise in the theoretical basis for describing and predicting particle behaviors, DARPA asked us to provide technical and analytic support to the project management team. Our researchers will help set experimental parameters, monitor testing activities, and verify that the phenomena observed are appropriate and relevant to the battlefield challenges. IDA researchers also will assist the primary investigators as they develop and test their technologies to help ensure that each of the technical approaches performs to its maximum potential.

Prompt Agent Defeat

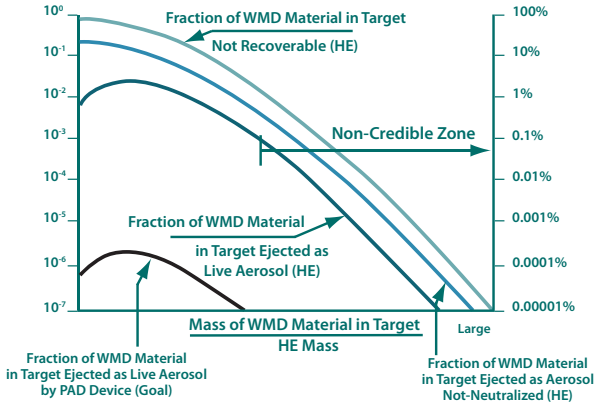
The objectives of the warfighter confronted with biological weapons of mass destruction (WMD) facilities include the physical destruction of the targets, denial of use by the enemy of these targets and their contents, and the avoidance of collateral effects by the release of WMD materials resulting from weapons attacks of the targets. Conventional weapons employ high explosives to disassemble target structures by producing strong shock waves and high-pressure gasses capable of fragmenting metal and other structural components, but these physical effects are known to produce aerosols from stored biological materials that can have catastrophic effects on civilian and military personnel in the vicinity and downwind of the attacked targets. The Prompt Agent Defeat Program (PAD) is exploring ways to allocate payload mass to components that can suppress these aerosols while maintaining acceptable levels of physical damage in the targets.

The PAD program is investigating technologies for destroying biological facilities while suppressing the release of live biological materials that typically would occur with a conventional weapons attack.

We are examining the technical challenges, testing strategies, results to date, and future directions for the program. In particular, we are helping to improve understanding of the biological underpinnings for determining how well weapons perform in neutralizing aerosols resulting from attacks on biological manufacturing or storage facilities.

Recently, we conducted a rapid assessment of white phosophorus/high explosive weapon concepts and operational tests in the so-called CrashPAD effort. This work identified shortcomings in quantitative assessment methods and recommended how the relatively sparse data collected from full-scale tests could be used to generate neutralization estimates and associated confidence bounds.

Prompt Agent Defeat Program



The representative curves shown here characterize the compromises to damage that result by using smaller high-explosive components and potential live aerosol reduction. For example, the upper curve shows the amount of bio-material left over for potential release as an aerosol after the attack/explosion. The next curve below it is for a 10% bio-release, shown to be typical through testing. The curve in the lower left shows the goal of the program - to achieve a six-order of magnitude limitation of the WMD material release while maintaining physical target damage.

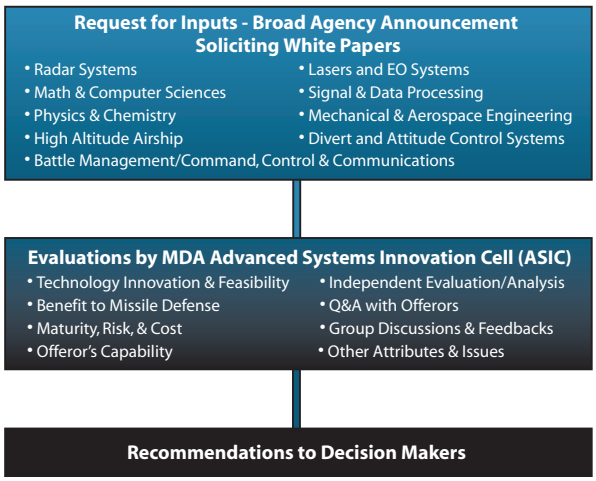
Space, Air, Missile, and Weapons Technologies

MDA Advanced Systems Integration Cell

The Missile Defense Agency has established the Advanced Systems Innovation Cell (ASIC) to assess innovative concepts and to develop algorithms to improve ballistic missile defense system (BMDS) capabilities. IDA is assisting ASIC in evaluating advanced missile defense concepts and in setting priorities for technology investments. In 2004, we helped assess proposed development efforts in the following technology areas:

- Radar systems, including integrated system concepts, radar waveforms, transmit/receive modules, signal processing, and seekers.
- Lasers and electro-optical systems, including high-energy lasers, ladar systems, optical signal processing, and passive electro-optical/infrared systems, including ideas and concepts for advanced IR materials and focal plane arrays.
- Signal and data processing.

Broad Agency Announcement Evaluation Process

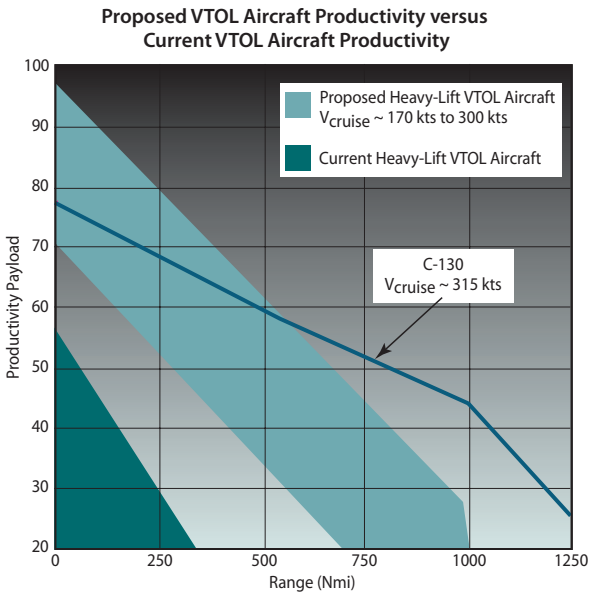


- High-altitude airship technologies, including platform designs, subsystems, components and payloads, fuel cells, solar arrays, and alternative energy sources.

Heavy-Lift Technical Assessment

DoD is examining concepts for a new heavy-lift, vertical take-off and landing (VTOL) aircraft to transport personnel and materiel directly from offshore bases or ships to forward areas without having to transit through beaches or ports. The aircraft also would be designed to move armored vehicles being developed in the Army's Future Combat Systems (FCS) program anywhere in the battlefield, thus increasing the agility and tactical mobility of FCS units. Current heavy-lift VTOL aircraft have neither the payload nor the range to meet these emerging needs.

DoD asked IDA to assist the Joint Vertical Aircraft Task Force in assessing heavy-lift VTOL technology. Our researchers helped identify potential aircraft concepts that could satisfy notional mission profiles, including conventional helicopters, tilt-rotor aircraft, and other advanced concepts. We estimated the range and payload capabilities of each concept, and assessed aircraft empty and gross weights, productivity, and costs. Finally, IDA reviewed the current state of science and technology for heavy-lift VTOL aircraft and helped identify critical technology developments needed to achieve significant improvements in operational capabilities.



Proposed next-generation heavy-lift VTOL aircraft would provide a significant increase in productivity through increased payload fraction (ratio of payload to maximum gross weight) and increased cruise speed over current heavy-lift VTOL aircraft (shown in green). These increases in productivity would be enabled by technology advances in structures, aero-mechanics, engines, drive systems, and advanced aircraft concepts.

Materials

Accelerated Insertion of Materials

DARPA's Accelerated Insertion of Materials (AIM) program is attempting to significantly shorten the time between development and production of new materials. Currently, designer knowledge bases – incorporating design parameters, reliability, manufacturing, reproducibility, and other essential information about new materials – are time consuming and costly to develop, thus delaying the production of new materials. The process typically takes 15-20 years, if it is successful at all. The AIM program is trying to revolutionize the way designers and materials engineers interact by establishing a new process for integrating design and materials engineering and by accelerating the acquisition of selected materials data. IDA researchers have helped develop AIM's technical objectives, evaluate proposals, review early test results, and recommend appropriate courses of action to resolve the many technical issues that have arisen. We are now

evaluating potential applications of the methodologies developed under the AIM program in various areas of materials development and certification to specific materials development initiatives.

Computer and Information Technologies

OIF Bandwidth, a Critical Resource for Combat and Support Operations

The U.S. Joint Forces Command asked IDA to examine the Operation Iraqi Freedom (OIF) communications architecture, to analyze what happened from a communications perspective during major combat operations, and to identify both internal DoD and external bandwidth usage.

This past year, IDA's work focused on the joint integrated networks and theater connections to Service components. We made an initial assessment of the "last tactical mile" (LTM), the network connection between headquarters and tactical units in the field. The study results will be used to examine the differences among Service components in capacity, performance, and bandwidth usage during OIF. Improved understanding of the communications architecture from the joint integrated network through the LTM should provide insights that will enable better planning and utilization of bandwidth in future contingencies.

Geospatial Analysis/Integrity Tool

Following the September 11 attacks, the National Geospatial-Intelligence Agency (NGA) was asked to provide more data for large and previously low-priority geographic areas. For some regions of interest in the war on terrrorism, NGA digital mapping data – used for planning, command, and control of military operations – had been limited in quantity and quality and, in some cases, out of date and fragmented. NGA aggressively began shifting production resources from established military products toward the development of an integrated geographic information system more relevant to the war on terrorism. The agency has continued to expand this concept as the Geospatial Intelligence Feature Data (GIFD) program. Teams of NGA staff, contractors, and international partners are now populating a worldwide GIFD database.

To support the GIFD program, IDA has developed the Geospatial Analysis/Integrity Tool (GAIT) to automate analysis of feature coding, attribution, geometry, topology, and metadata content. We have delivered prototype software to NGA, and our researchers are now performing independent analyses of selected GIFD data sets. NGA user experience has shown that GAIT detects errors that existing production validation tools miss, often decreasing processing time from hours to minutes.

Information Technology for Geospatial Intelligence

NGA's primary mission is to provide timely, relevant, and accurate geospatial intelligence to support national security operations. NGA's Enterprise Operations Directorate maintains the information technology (IT) systems that comprise the geospatial intelligence infrastructure, supports operational production of geospatial intelligence products, and manages NGA's data environment. The Directorate plays a critical role in creating customized geospatial intelligence products, migrating the National System for Geospatial Intelligence to an all-digital environment, and leveraging technology to ensure seamless access to geospatial intelligence

applications. IDA provides independent analyses of alternatives to help the Directorate meet its operational goals. Also, our analysts have provided technical expertise and analytic capabilities in support of the Directorate's IT procurement activities.

Technology Policy and Strategy

Antiterrorist Technologies

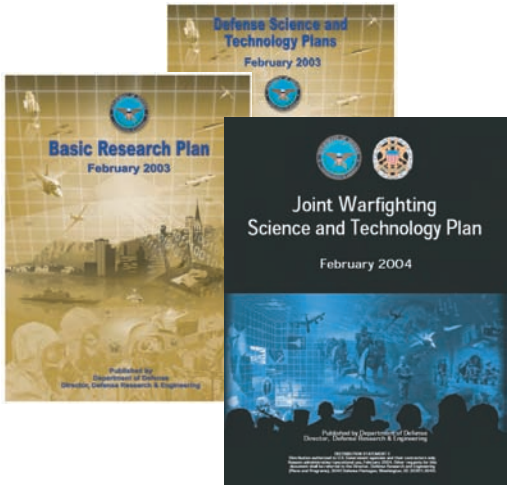
Concerned that development and deployment of technologies needed for homeland security could be inhibited by the threat of unreasonable exposure to lawsuits, Congress passed the Support Anti-Terrorism by Fostering Effective Technologies (SAFETY) Act of 2002. The Act provides various litigation management and risk management protections for sellers of qualified anti-terrorism technologies.

The Department of Homeland Security (DHS) asked for IDA's assistance in implementing the legislation. IDA researchers have worked closely with DHS staff in:

- Designing an application kit used in submitting technologies for consideration as certified/designated anti-terrorism technologies.
- Developing a method for reviewing and evaluating applications.
- Creating a web site for distributing and receiving applications.
- Participating in evaluations of the likely performance of anti-terrorist technologies, products, and services.
- Participating in evaluations of economic considerations, including product liability insurance.

More than 300 people from IDA, the federal government, and academia serve as technical reviewers on one of the following seven panels to evaluate applications: biological, chemical, explosive, nuclear/radiation, cyber, human, and economic/insurance.

By the end of 2004, IDA had evaluated 58 full applications and 150 pre-applications, which are designed to give potential applicants feedback on the suitability of their technology applications before committing time and effort to completing a full application. As of December 2004, seven anti-terrorism technologies have been awarded certification.



IDA contributes to several of the DoD Defense Science and Technology Plans, including the Basic Research Plan, issued biennially, and the Joint Warfighting Science and Technology Plan, issued annually. These are the DoD's strategic planning documents and receive wide readership within the defense community, other government agencies, Congress, and the public.

Joint Warfighting Science and Technology Plan

DoD develops the Joint Warfighting Science & Technology Plan (JWSTP) to help ensure that applied and advanced science and technology investments support future joint warfighting needs. This past year, IDA assisted in developing a revised approach for the JWSTP that aligns science and technology plans with the new Joint Capabilities Integration and Development

System capabilities-based planning and requirements determination processes. We also authored drafts of the new JWSTP sections dealing with science and technology initiatives to support battlespace awareness, command and control, and force application.

Defense Science Study Group

The Defense Science Study Group (DSSG) was established to foster among young, emerging leaders of science and technology a long-term understanding of the technical dimensions of national security issues and an appreciation for the people and operations involved. The program, supported by DARPA, provides members with an overview of the systems, missions, and operations of the armed forces and the intelligence community. Each DSSG member writes a research paper applying his or her technical skills to a challenge DoD is facing.

This year, IDA selected 14 exceptional academic scientists and engineers from among 137 nominees to participate in the ninth two-year DSSG class (2004-2005). The members visited military installations, intelligence agencies, laboratories, and industrial facilities and met with key national security officials. Mentors and advisors – all with distinguished careers in government and/or academia – work with the members on their research papers, help provide access to places and organizations involved with national security, and suggest ways for alumni to become more involved with national security matters.

DSSG members are given the opportunity to interact with Service personnel at bases across the country, including airmen who work on the B2 Stealth bomber at Whiteman AFB in Missouri (top) and soldiers who work with the Stryker Brigade at Fort Wainwright, Alaska.

International Technology Planning and Controls

Critical Technologies Support

Since 1979, IDA has provided technical and analytic support for U.S. programs to keep advanced technologies and products out of the hands of potential enemies. This year, our researchers supported the U.S. delegation to the multilateral Wassenaar Arrangement on export controls for conventional arms and dual-use goods and technologies. Established to address post-Cold War security concerns, the Wassenaar Arrangement promotes transparency and responsibility in transfers of conventional arms and sensitive dual-use materiel and technologies. The goal is to prevent

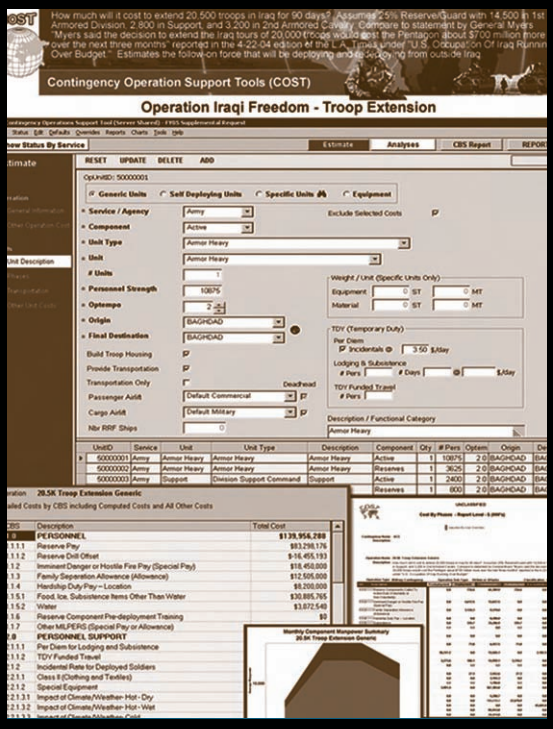
destabilizing accumulations of weapons and technologies in unsettled regions and to apply pressure to states whose behavior is a cause for serious concern. The Wassenaar Arrangement Expert Group meets twice a year to consider technical changes – modifications, additions, and deletions – to the control lists.

IDA has become increasingly involved in Wassenaar Arrangement activities through participation in the Technical Working Group, interagency and bilateral meetings to prepare U.S. proposals and to review foreign proposals. Also, our researchers have provided on-site technical support at the Expert Group meetings in Austria. IDA's role is to help shape the technical aspects of U.S. positions prior to the various working group meetings. For the 2004 Expert Group meeting, the United States submitted 17 proposals, of which 13 were accepted. IDA assisted in the preparation and justification of 15 of these 17 proposals and assisted in the evaluation of 16 of the 32 foreign proposals.

Global Technology Knowledge Base

DoD tracks foreign scientific and technological developments to maintain awareness of opportunities for cooperation and to prevent technological surprise. In support of this effort, IDA was asked to expand the worldwide technology capability assessments in the Militarily Critical Technologies Program (MCTP) documents and to make the information more readily available to the government in a searchable, electronic information system.

To date, we have developed a prototype portal, the Global Technology Knowledge Base (GTKB), to provide electronic access to worldwide science and technology assessments. The GTKB has been populated initially with MCTP assessments and with separate Service-developed assessments of selected technologies. The portal, which provides a variety of search methods by technology and/or by country, will be used for developing the Global Research Watch directed by the National Defense Authorization Act of 2004.



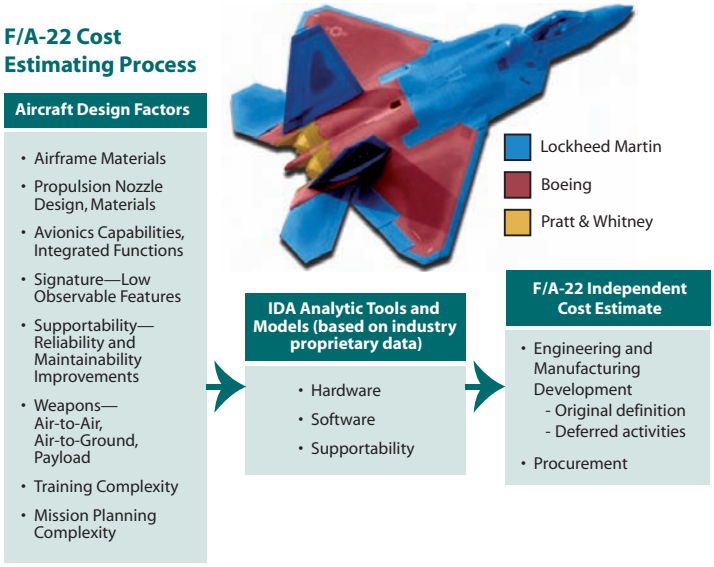
Resource and Support Analyses

IDA develops methods and models for estimating the costs to develop, test, procure, operate, and support defense forces and systems. We apply these techniques when evaluating the resource consequences of defense policy, planning, programming, and acquisition decisions. Our work improves the understanding of the cost implications of pending decisions and leads to better tools and methods for addressing resource issues. IDA also examines infrastructure and support activities, including the military health care system, the military and commercial suppliers and technology base, the training establishment, and environmental technologies and plans.

Cost Analyses

F/A-22 Independent Cost Estimate

The F/A-22 Raptor, now approaching full-rate production, is projected to be the most capable and costly tactical aircraft in the U.S. force. It will replace existing F-15 Eagles in the air superiority role and complement other aircraft in the strike role. In response to a series of past F/A-22 cost increases, Congress directed DoD to provide an independent cost estimate of the program. DoD in turn asked IDA to conduct this work because of our long-standing costing expertise, our objectivity, and our track record of working with and safeguarding proprietary data from industry.



IDA cost analysts consider the distinctive design factors of the F/A-22 Raptor as it develops its independent cost estimate.

Using updated cost databases and analytic methods, IDA's estimate will cover completion of engineering and manufacturing development (EMD), deferred EMD activities, and production aircraft procurement. We were also asked to relate F/A-22 program costs to the congressional and DoD procurement budget caps of $37.3 billion and $42.2 billion, respectively. In December 2004, DoD issued Program Budget Decision 753, which cut 96 aircraft and $10.5 billion from the Air Force's planned program. IDA will now examine that budget cap as well as continue the above analyses. Our analysis will determine the number of aircraft that can be bought under the caps and assess alternative production schedules.

Space-Based Radar Costs

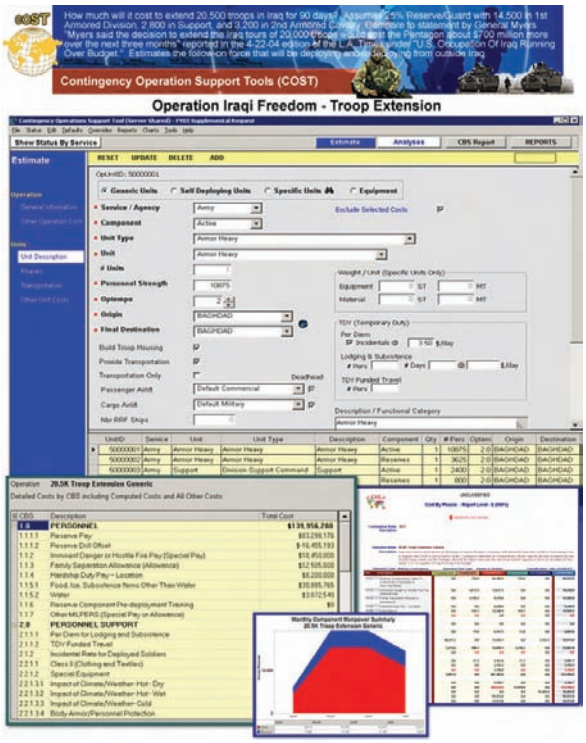
The OSD/Cost Analysis Improvement Group asked IDA to assist with its independent cost assessments of major space programs and to develop metrics for tracking program cost performance between acquisition milestones.

The space-based radar (SBR) program, a constellation of satellites intended to detect and track military targets during day and night, is one of several new space programs examined by IDA this past year. Our SBR analyses pointed to the likelihood of higher costs and longer schedules relative to the program office's original estimates. These cost and schedule changes were driven primarily by recently identified increases in payload weight. Our researchers also developed a methodology for quantifying and documenting changes that occur throughout the development process, thus enabling DoD analysts to rapidly assess the implications for overall cost and schedule performance.

Contingency Operations Support Tool

Developing accurate cost projections for U.S. contingency operations is difficult due to the complexity and varying nature of U.S. overseas operations, the rapid planning and execution that typifies many operations, and the fluid decisionmaking environment during their early stages.

IDA's Contingency Operations Support Tool (COST) provides an automated, common basis for the Defense Department's financial and resource management community to estimate the costs of contingency operations worldwide. Using the COST model, DoD analysts can create a rough initial cost estimate in the early stages of planning when relatively little is known about an operation, followed later by more detailed estimates as additional information becomes available.



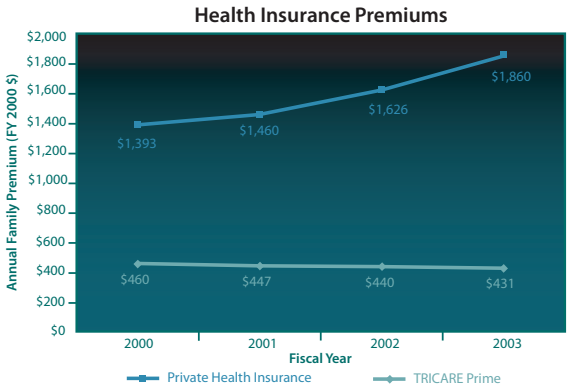
How much will it cost to extend 20,500 troops in Iraq for 90 days? Using IDA's Contingency Operations Support Tool, DoD analysts can create a rough initial cost estimate. Here, IDA's COST program assumes 25% Reserve/Guard with 14,500 in 1st Armored Division, 2,800 in Support, and 3,200 in 2nd Armored Cavalry.

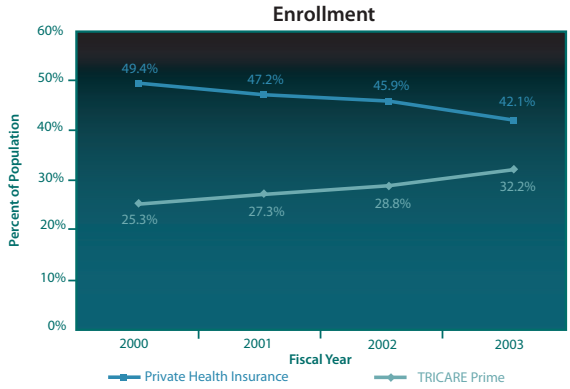
In FY 2004, IDA's COST development team refined the model to enable better estimates of the costs of ongoing operations in Iraq, Afghanistan, and elsewhere. COST provided estimates that served as the basis of more than $115 billion of supplemental funding requests through the summer of 2004. DoD has mandated that COST be used as a common estimating platform for reimbursing all Service and agency war-related costs. IDA continues to host various COST servers used by DoD's Primary COST Team in Washington, by the Special Operations Command in Tampa, by the Northern Command in Colorado Springs, and by major Marine commands worldwide.

Forecasting TRICARE Utilization and Costs

Retired beneficiaries under age 65 years have traditionally been infrequent users of the military health system, primarily because many have other sources of private health insurance. However, there has been an increase in the use of the military health system by these previously nonreliant beneficiaries. If this trend continues, it will have a significant impact on the cost of the military health care benefit, TRICARE. DoD asked IDA to analyze both the cost of returning beneficiaries and potential future beneficiaries.

Our researchers estimated the impact of rising health insurance premiums and out-of-pocket expenses on the propensity of retirees and family members under age 65 to return to the military health system. We found that the majority of beneficiaries dropping their private insurance opted for the TRICARE Prime option, which entails a $460 enrollment fee per family but no deductibles and very low co-payments. Using historical insurance choices, enrollment histories, and utilization trends, IDA





Private health insurance premiums continue to rise while the TRICARE Prime enrollment fee declines (both in FY 2000 dollars). The increasing disparity in premiums between private and military health care coverage is inducing beneficiaries to drop their private health insurance and enroll in TRICARE Prime.

estimated the impact of beneficiary demographics, private insurance coverage, retiree family incomes, and beneficiaries' satisfaction with plan access and quality on the utilization of inpatient, outpatient, and prescription services. Combining the utilization models with models of insurance choice and unit costs, we were able to forecast the effects of returning formerly reliant beneficiaries on military health system costs from FY 2006 to FY 2011.

Acquisition Planning and Resource Management

Rolling Capture of Acquisition Lessons Learned

This year, IDA began a multiyear program to examine and systematically document major acquisition programs to identify important lessons learned. While IDA and others have conducted such studies periodically in the past, this new effort is intended to fill gaps in these studies and to collect data on a more continuous basis – enabling responsive feedback to DoD's acquisition managers on what is working and what is not.

In addition to focusing on major programs whose acquisition strategy, management structure, or contractual arrangements embody particularly innovative features, we also will monitor selected programs to assess accomplishments and to identify the reasons for any shortfalls relative to original plans. The overall goal is to extract acquisition lessons from experience on a rolling basis, so that the Department's management of major acquisition programs can be improved continuously, rather than after the lapse of a substantial number of years.

Operations and Maintenance Program Balance

DoD's budget includes more than $100 billion to operate and maintain combat forces and their supporting infrastructure. Despite the size of the operations and maintenance (O&M) budget, no fully sufficient tools are available to assess the adequacy of O&M budget levels across the disparate types of forces and support activities.

IDA was asked to develop benchmarks for O&M spending, focusing on the aggregate size and broad content of the total O&M budget. Initially, we reconstructed historical O&M budget databases, identified cost drivers, and developed rough cost-estimating relationships. Such historical analyses are needed to place into context proposed new O&M expenditures. We are also establishing benchmarks for current data to serve as bases for projecting future needs. During the upcoming FY 2006 program review, our

analysts will be examining two key O&M areas: activities related to force operating tempo (such as the flying hour program) and depot maintenance.

Trusted Integrated Circuit Supply Chain

Advanced integrated circuits (ICs), the critical components in numerous defense systems, face increasing threats and vulnerabilities. A host of technical and economic factors has led to the relocation to other countries of many fabrication sources for advanced semiconductors, which potentially increases chances that an adversary could obtain intellectual property or add malicious circuitry that could affect the performance of defense systems.

DoD has contracted with a major domestic semiconductor company to provide controlled access to a trusted state-of-the-art semiconductor manufacturing facility located in the United States. This led to the formation of the Trusted Foundry Program Office, which is seeking to better understand the threats, vulnerabilities, and consequences of a trusted foundry, and is defining the desired characteristics of trusted integrated circuits.

In 2004, DoD asked IDA to analyze specific customer needs and to assess the demand for trusted ICs. In addition, IDA is assisting the Trusted Foundry Program Office in developing criteria for certifying trusted suppliers, in assessing the capabilities of proposed suppliers, and in establishing the needed customer relationships.

Defense Resource Management Studies

For the last 10 years, IDA has helped DoD assist Eastern European countries seeking NATO membership to improve their abilities to manage defense resources. In 2004, we expanded that work to include other security partners in the war on terrorism. Our researchers began multiyear projects in the Philippines and Kuwait, and led an in-depth joint resource management assessment in Mongolia. At the same time, we continued to provide advice to a small number of Eastern European countries as they implemented and refined their new resource management processes.

IDA's effort in the Philippines supports defense reforms endorsed by President Bush and Philippine President Arroya. To date, IDA has assisted the Philippine Department of National Defense match its resource allocations to its defense strategy to produce a realistic, balanced, multiyear defense program. IDA also was asked to help the Philippine Department of National Defense restructure its acquisition decisionmaking to better integrate it with other resource decisions and streamline an overly complex and inefficient process. Our efforts are helping the ministry focus its resources in areas required to confront the challenges posed by global terrorism and threats to its democratic government.

In Kuwait, we assembled and managed a team to help Kuwait create new national security and defense strategies and a new national military strategy that will ultimately be compatible with U.S. plans for future operations in that region. This work will strengthen the foundations for the concurrent resource management improvement study that will run over the next two to three years.

Support to the Department of Veterans Affairs

To better estimate long- and short-term trends in the veteran population and associated workload for government employees, the Department of Veterans Affairs (VA) developed the Veterans Actuarial Model. The VA asked IDA to validate and verify the model, and to propose ways to improve it.

After examining the model's methodologies, assumptions, organization, modeling techniques, and requirements, IDA will develop a roadmap for improving the model's fidelity and utility. In addition, IDA will help the VA develop a strategy for future research and assessments. With IDA's help, the VA ultimately aims to create a family of sophisticated models and simulations that will provide accurate information for use internally and for interactions with other federal agencies and Congress.

DoD Organizations and Processes

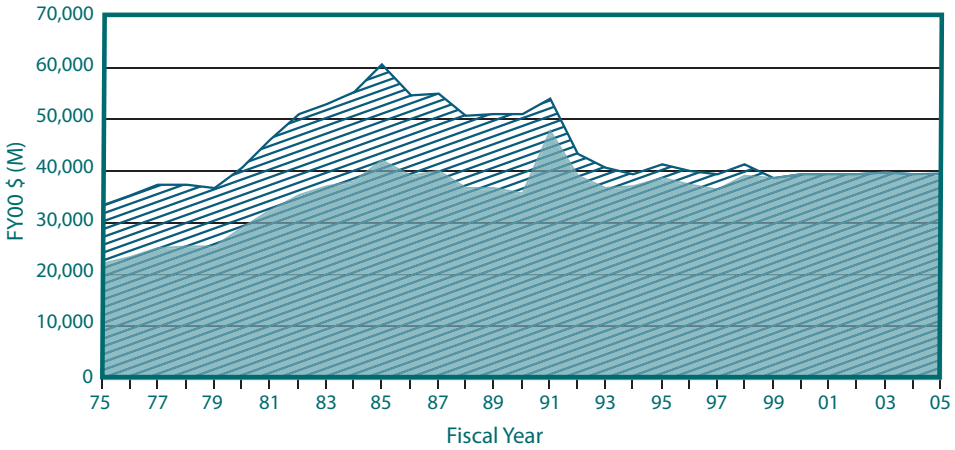
USMC Headquarters Alignment

The Marine Corps asked IDA to review its headquarters organization and processes to assess whether the Corps' small headquarters staff might be more effectively structured and employed to meet the challenges of the new global security environment, of sustaining the high pace of current operations, and of responding to evolving Pentagon management systems. IDA analysts documented current practices used by existing USMC headquarters organizations, and is developing and refining initiatives for improving USMC headquarters operations. One potential concern is that responsibility has not been assigned to a single headquarters staff official for creating an integrated, resource-informed plan for future USMC capabilities development. We are proposing initiatives that would establish an Expeditionary Maneuver Warfare Integrator on the USMC headquarters staff, integrate the responsibilities of this official within the existing headquarters management system, and balance these responsibilities with those of the other senior officers on the headquarters staff.

Improving Planning, Programming, and Budgeting in DoD

IDA has a long history of providing independent analyses of DoD's Planning, Programming, and Budgeting (PPB) system. Currently, our researchers are supporting

Force Mission Operating and Maintenance with and without Funding Policy Changes



By normalizing FYDP data for funding policy changes, analysts can examine DoD program trends on a consistent basis. For example, in the above case concerning the net shift of operating and maintenance funding from infrastructure to forces, including or excluding the normalization data (represented by the crosshatched area) reverses apparent cost trends. Excluding information in the crosshatched area makes it appear that cost is increasing over time. Alternatively, including information from the crosshatched area would lead one to conclude that costs are decreasing over time.

DoD's move to a capabilities-based planning structure by helping develop concepts for integrating processes and data to support top-level, strategic decisionmaking. Part of this work focuses on improving the link between current PPB data and the capabilities categories to be used for decisionmaking – a complex undertaking due to the breadth of potential military challenges facing U.S. forces and the multiple capabilities that many individual combat units possess.

Also, IDA researchers are helping integrate the currently separate data systems used in DoD's programming and budgeting processes. This OSD-led effort is implementing a program-budget framework recommended in earlier IDA work.

In addition, we are supporting DoD's efforts to increase the usefulness of the Future Years Defense Program (FYDP) databases by developing tools to analyze program, budget, and appropriation data, and by reviewing changes to FYDP data elements proposed by government users. IDA also continues to examine the more than 40 years of FYDP historical data, correcting disconnects and anomalies that result from changes in DoD funding policies. By normalizing the FYDP data for policy changes, DoD and IDA analysts can examine program and budget trends on a consistent basis.

Management of the Army's Future Combat Systems Program

The U.S. Army's Future Combat Systems (FCS) program is attempting to develop and field a brigade-sized unit of action equipped with the following:

- A sophisticated, mobile, ad hoc network.
- A family of light, highly mobile manned vehicles.
- Several varieties of unmanned aerial and ground vehicles.
- Advanced munitions.
- Highly capable sensors.

FCS units of action are intended to operate interdependently within a joint system of systems, including capabilities developed by joint and other Service programs.

FCS poses unprecedented management challenges. To meet these challenges, the Army is relying heavily on its industry partners for engineering, integration, and management support. The Army asked IDA to review the distinctive elements of its FCS management approach and to apprise them of any "weaknesses in procedures, policies, or practices that could impact FCS program development efforts."

IDA analysts observed FCS management activities, reviewed program documentation, and interacted extensively with program management officials. Our study documents the major Army actions that have shaped the program, the selection of the industry participants, the terms and conditions of the agreement between the Army and Boeing Company to develop a unit of action, and the ethical environment established in both the government and industry.

We found that the Army had adopted many traditional management approaches for FCS intended to mitigate risks associated with the development process. At the same time, because FCS is a highly ambitious program, our researchers emphasized that new program management approaches will be needed.

IDA proposed initiatives that would strengthen FCS management in the following five main areas:

- Building FCS as a joint system of systems.
- Managing the early fielding of FCS concepts and capabilities for use in existing systems.

- Strengthening corporate Army decisionmaking and oversight for FCS.
- Managing the strategic risks of FCS.
- Setting goalposts to focus FCS reviews on substantive program issues.

The results of this study have been widely briefed to the Department's senior leadership, and the Army is taking steps to implement many of the recommendations.

Training, Readiness, and Personnel Issues

Training Capabilities Analysis of Alternatives

IDA assisted OSD and the U.S. Joint Forces Command in conducting a Training Capabilities Analysis of Alternatives (AoA) to:

- Compare current training capabilities with training requirements in order to identify gaps in the current joint training capability.
- Identify alternatives for removing those gaps.
- Assess the cost and effectiveness of the alternatives.

IDA was asked to structure and integrate the cost and effectiveness parts of the analysis. We considered three alternatives: using current training tools and programmed enhancements; implementing improvements in the kind of joint collective training provided today, which is oriented around large exercises; and emphasizing the introduction of innovative approaches to training.

Since representatives of the combatant commanders identified better support for training combatant commander and joint task force staffs as the most important joint training deficiency, the AoA found that the nontraditional initiatives had the highest potential payoff from additional funding. Implementation actions are now being considered as part of DoD's budget preparation process.

Employer Support of Reserve Components

Mobilizing large numbers of National Guard and Reserve personnel has imposed costs on employers – in the form of lost revenues, lost production, and replacement

Support for the Training Capabilities Analysis of Alternatives

Alternative	Effectiveness		Cost
	Filling gaps in traditional exercises	Supporting frequent, flexible COCOM and JTF staff training	
Base Case	Fully addresses 25 gaps with at least one federate	Not oriented toward this kind of exercise	Costs already programmed (zero)
Better Exercise Support Tools	Fully addresses 33 gaps with at least one federate	Not oriented toward this kind of exercise	$348 million
Nontraditional Initiatives	Not oriented toward this kind of exercise	Have considerable potential	$42 million for study and prototypes

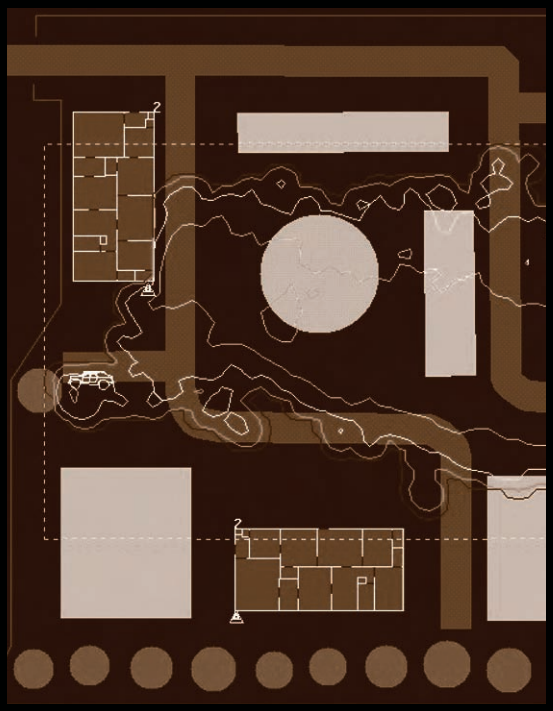
costs – and on those reservists whose military earnings are less than their civilian earnings. However, DoD does not know precisely which employers and reservists suffer the greatest losses. In addition, many employers do not know their legal responsibilities to reservists returning from active duty, and the Defense Department has had no way to directly contact employers to help them understand these responsibilities. At the conclusion of a series of studies, IDA recommended that reservists be required to identify their civilian employers, that these employers be surveyed about how their costs were affected by the activation of reservist employees, and that a system for early warning of adverse trends in employer-reservist problems be established.

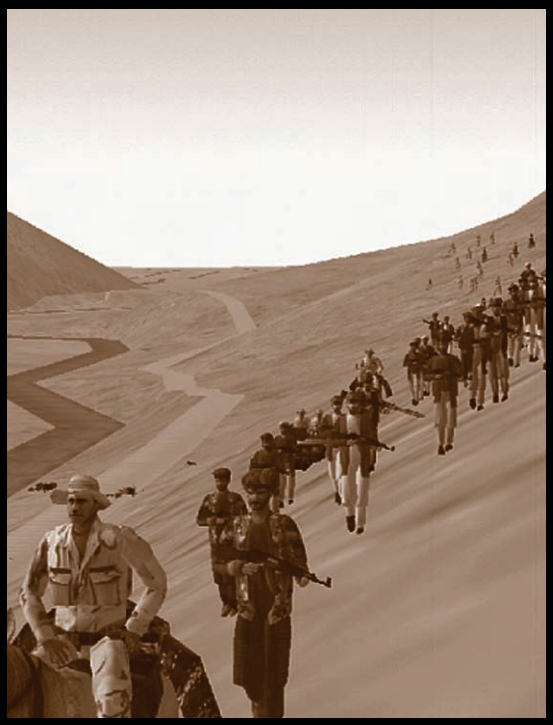
New Resource Analyst Training

Analysts newly assigned to the Pentagon often find themselves involved in tasks that require a sophisticated understanding of how DoD's major management systems work on a day-to-day basis and how analyses contribute to decisionmaking. They often have only a limited background in DoD business practices and have not previously supported decisionmaking at senior levels in government.

IDA was asked to develop a course to provide newly arriving analysts with a theoretical and practical overview of DoD's resource management processes with the aim of reducing the time it takes these analysts to become productive.

The resulting four-day course is conducted five times per year at IDA using many IDA subject-matter experts to deliver lectures and lead discussions. Students learn about the history, the intent, and the action officer's roles in the Planning, Programming, Budgeting, and Execution System; the requirements review and approval process; and the acquisition process. Students also review major analytic methods used in cost and program analysis to broaden their analytic foundations and understanding. IDA provides this instruction to more than 100 new analysts each year from the OSD staff, the Joint Staff, Service programming staffs, and the DoD cost analysis community. Exchange officers from Australia and Great Britain also have attended, and a derivative of the course was given to defense cost analysts in Australia.





Force and Strategy Assessments

The security environment of the United States continues to evolve with the appearance of new and unpredictable threats. Weapons of mass destruction, information warfare, and terrorism are among the increased challenges that the United States expects to face in the 21st century. To address these threats, the Department of Defense has given higher priority to areas such as air and missile defense, chemical and biological defense, and information assurance. IDA is helping DoD analyze the implications of these changing priorities for force structure and readiness, and to develop new plans, programs, and strategies. Our researchers have developed unique expertise to help evaluate and implement new technologies, operational concepts, and force and support capabilities. IDA's work is a key input to the Department's efforts to transform its forces for the future, while modernizing existing systems and preserving near-term readiness.

Joint and Combined Force Planning, Operations, and Assessments

Iraqi Perspectives Project

In support of U.S. Central Command and U.S. Joint Forces Command, a team from IDA's Joint Advanced Warfighting Program interviewed 23 top members of Saddam Hussein's government and military and reviewed hundreds of documents captured during Operation Iraqi Freedom. The project's purpose, similar to the post-World War II debrief of senior German officers, is to understand the war from the enemy's point of view and to assess our understanding of the enemy during the conflict.

To date, the effort has highlighted Iraqi assessments of likely courses of action, lessons learned from the first Gulf War, and what Iraqi intelligence reported to Saddam Hussein. More important, it has provided insight into gaps and inaccuracies in U.S. thinking and planning. Results have been briefed to U.S. and coalition civilian and military leadership.

JAWP researcher (right) collects the perspective of a former Iraqi Republican Guard Commander – whose face is distorted to protect his identity – with the assistance of an interpreter and tactical maps in Baghdad (December 2003).

Lessons Learned in Global War on Terrorism

In support of U.S. Joint Forces Command, IDA's Joint Advanced Warfighting Program led an IDA/JFCOM team of military officers and civilians in identifying lessons in the global war on terrorism. The team embedded officers at the headquarters of regional combatant commands for 60 days, studying day-to-day operations and associated interagency coordination.

Another team interviewed senior officials at the National Security Council, Defense Department, State Department, CIA, DHS, and the FBI to understand coordination activities at the national level. Follow-on efforts include on-site case studies of major national events that explore the coordination processes used in each.

Support to Joint Requirements Office for Chemical, Biological, Radiological, and Nuclear Defense

IDA has supported the Joint Staff's requirements office for chemical, biological, radiological, and nuclear defense since its inception several years ago. This year, our work focused on three areas:

- Determining chemical and biological (CB) weapon-related "combat consumables." We estimated the possible exposure of U.S. forces to CB agents in combat operations in selected scenarios. Extending these results to a theater-wide campaign, we calculated the overall usage of CB defense equipment and the resulting peacetime inventories needed to ensure adequate wartime supplies.

- Developing equipment to counter battlefield CB agents. The amount of agent that an enemy might bring to bear on U.S. combatants depends in part on the nature and extent of the enemy's CB stockpile and the delivery mechanisms employed. IDA is examining plausible operational attacks under varying threat assumptions to determine the sensitivity of CB defensive equipment needs to a wide range of threat conditions.
- Examining chemical, biological, and radiological detector requirements. IDA is conducting three studies to identify effective combinations of point and standoff detectors for ports, air bases, maneuver units, and naval task forces. Results show how many detectors would be needed to provide confidence that CB agents would be promptly detected. Also, this work is being used to help set performance objectives for advanced detector systems.

National Personnel Recovery Architecture

DoD policy calls for U.S. military personnel to be recovered if they are isolated behind enemy lines or captured. Congress asked DoD to develop a National Personnel Recovery Architecture that takes account of U.S. government civilians and contractors in addition to military personnel. IDA was asked to assess existing capabilities, identify shortfalls, and propose corrective steps to achieve a national architecture, including the required funding. We made the following recommendations:

- Promulgate a National Security Presidential Directive on personnel recovery to establish basic principles of a coherent and cohesive architecture.
- Initiate a program within the Department of State to enhance U.S. embassies' readiness for personnel recovery incidents.
- Standardize the government contracting process for personnel recovery coverage for contractors.
- Improve personnel recovery training of DoD and non-DoD individuals.

Force Development and Experimentation

Improving Organizations and Processes for Stability Operations

IDA researchers identified specific tasks needed for stability operations and investigated models for organizing, accessing, and/or building the capabilities to carry out those tasks effectively. For example, our researchers examined the interagency organizational model used by the Federal Emergency Management Agency, a DoD-developed concept for reorganizing ground troops to focus on reconstruction and stabilization operations, and several foreign models for bringing selected capabilities to bear.

We identified the most promising concepts for organization and process at the strategic, operational, and tactical level, and recommended improvements to both DoD and broader U.S. government organizations and processes.

Measuring Progress in Iraq

IDA assisted the Office of the Secretary of Defense and the Coalition Provisional Authority (CPA) in Iraq in developing metrics for the reconstruction effort. The team found that existing strategic plans outlined reconstruction tasks but did not specify data, reporting, and analysis needed to measure progress. We determined that while Military Civil Affairs units were in the best position to oversee such assessments, they lacked an integrated, standard reporting system and communications channels to civilian leadership.

IDA assisted in developing metrics, including proposals for combining polling data with observed participation in local organizations (public and private) to assess the legitimacy and performance of emerging political and economic institutions, and connecting strategic goals to resources and standard measures for the provision of services. Our results were used directly by CPA, and they provided the basis for continued work by the U.S. Embassy in Iraq and the newly established Office of the Coordinator for Reconstruction and Stabilization in the Department of State.

Improving DoD Plans, Processes, and Organizations

Support for Defense Planning Scenario Development

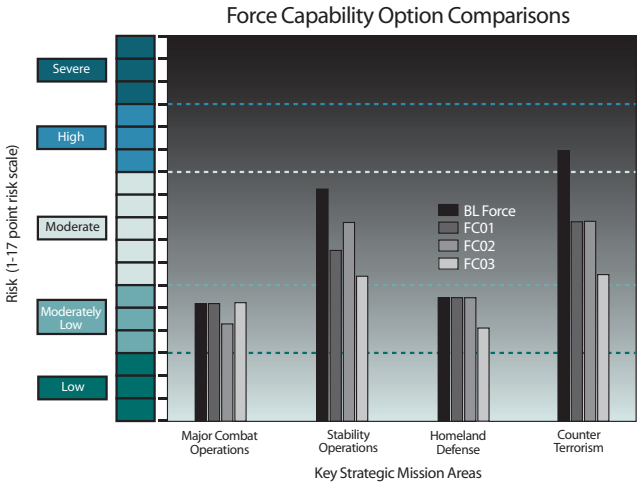
IDA is assisting DoD in developing new Defense Planning Scenarios to support department-wide capabilities-based planning. Our researchers prepare scenario details, review and integrate inputs from DoD components, and support the coordination process.

To date, new scenarios have been developed covering homeland defense and major combat operations. The scenarios will be used in DoD program/budget analyses; in major studies, including studies on stability operations and force rotation; in force planning and concept development activities, such as the Joint Integrating Concepts; in war games; and in the Quadrennial Defense Review.

Integrated Cross-Capability Assessment and Risk Management Study

IDA is assisting DoD to build concepts, processes, and analytical approaches for implementing capabilities-based planning at the highest levels of decision making, involving Department-wide strategy and capability tradeoffs. The Integrated Cross-Capability Assessment and Risk Management (ICCARM) Study includes four related efforts:

- Creation and testing of the Risk Assessment Model, a tool for evaluating the performance of alternative force capabilities and for assessing strategic risk in and across broad DoD mission areas, based on structured interviews with subject-matter experts.
- Development of several illustrative "force capability options" within currently



The graph depicts four key mission areas and the risk scores of a baseline force (BL Force - the U.S. force currently programmed for 2012) and three equal-cost alternative "force capability options" (FC01-3), which represent revisions to 10% of the Army force structure, 10% of the Navy/Marine Force structure, or across all Services, respectively. The risk scores were constructed from three parameters - force inadequacy, expected consequences, and the likelihood of a particular mission - based on a series of structured interviews with subject-matter experts. The graph highlights that there are equal-cost alternatives to the currently planned 2012 force structure capabilities that can reduce strategic risk.

planned total defense spending levels, based on insights from recent analyses and interviews with two dozen senior defense professionals.
- Support for DoD efforts to create a Department-wide framework and lexicon for institutionalizing capabilities-based planning.
- Review of existing studies and analytical tools that address broad cross-capability tradeoffs.

Insights and methods developed in ICCARM are being considered for use in the next Quadrennial Defense Review.

IDA Combatant Command Program

IDA launched a pilot program in support of Combatant Commanders consisting of two IDA research staff members stationed at U.S. Pacific Command (PACOM) headquarters in Hawaii. The IDA team is assisting with communications among PACOM and OSD, Joint Staff, JFCOM, and Defense Agencies; facilitating collaboration among the various Combatant Commands on similar issues and processes; improving IDA research staff's awareness of current operational issues; and leveraging IDA's ongoing efforts to assist PACOM. The overall goal is to help speed the introduction of new capabilities into operational units.

National Security Strategy Issues

Agents of Radicalization

Key to the long-term success of al Qaida's strategy is its ability to radicalize Muslims outside of its Arab and South Asian core and mobilize Muslims across the globe to support the al Qaida agenda. IDA has developed tools for identifying the differences in ideological and social, as well as the operational ties between al Qaida and Muslims in various regions. These tools are intended to help identify trends and develop countervailing U.S. strategies.

Our work pointed to the importance of breaking the link between Western European and American Muslims and extreme Islamist ideology. A second priority is to assist non-Arab Muslims in achieving their local aspirations through peaceful means. In the long term, pursuit of these priorities can isolate al Qaida's ideology.

Building U.S. Strategic Influence

Success in combating terrorism will depend in part on the ability of the United States to defuse anti-Americanism and reduce support for the jihadist agenda. The United States and the West have long been scapegoats for domestic frustrations and insecurities in the Muslim world, but in the current environment, this is further fueled by opportunistic individuals and groups promoting radical agendas.

IDA has been developing metrics for measuring progress in the ideological war on terror. Unlike metrics for tactical operations, those for the ideological war must measure gradual, subtle, and often fleeting shifts in attitudes that are difficult to discern. Our researchers have developed a set of ideological indexes that measure the economic, political, psychological, and cultural factors that shape the public space within which terrorist organizations operate: a "fear index," which measures physical and psychological security; a "humiliation index," which measures the gap between a groups' self-worth and its external status; and a "hope index," which measures economic and political progress and empowerment.

Homeland Security Information Sharing

The Department of Homeland Security (DHS) combines 22 disparate domestic agencies into one department to protect the nation against threats to the homeland. DHS missions of deterrence, mitigation, and response all depend on timely and effective information sharing.

IDA is helping DHS assess the Homeland Security Information Technology Plan and develop and implement the Information Systems Strategic Plan. We also are supporting the interagency team developing the plan to implement Presidential Executive Order 13356, Strengthening Terrorist Information Sharing. Finally, a senior IDA researcher is participating as a member of the Homeland Security Information Policy Board.

NORTHCOM Independent Strategic Assessment Group

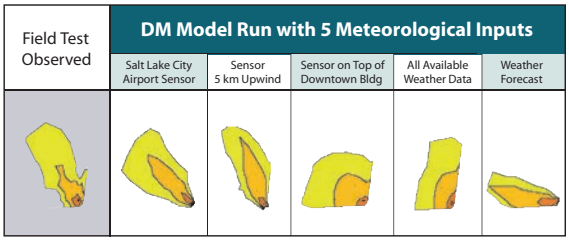
IDA was asked to form an Independent Strategic Assessment Group (ISAG) to support the U.S. Northern Command (NORTHCOM), which was established by DoD in 2002 to oversee and control operations of U.S. forces in the United States, Canada, and Mexico.

The ISAG has several panels – with membership comprising former government officials, along with representatives of academia and industry – covering topics such as reserve forces and civil affairs, organization and policy, reconnaissance and surveillance, and integrated missile defense. To address questions posed by the Commander, IDA researchers conduct detailed analyses and develop recommendations, which are vetted by the ISAG plenary group. Results are then presented to the NORTHCOM Commander for consideration.

Hazardous Material Transport and Dispersion in Cities

The Defense Threat Reduction Agency (DTRA) and the Department of Homeland Security have conducted field studies in which environmentally safe, inert tracer gases are released to study gas flow and dispersion in cities. These experiments are aimed at improving understanding of the potential effects of the release of chemical or biological agents by terrorists.

IDA is examining the sampling methods and meteorological data collected during the experiments, estimating the extent of gas dispersion using DTRA's enhanced modeling tools, and comparing predicted dispersion with the field experiment observations. Through collaborations with other organizations, IDA analyzed the predictions of other dispersion models and created protocols for objectively comparing observations and predictions of differing models to assist operational users of the predictive tools.



The figure shows a comparison of plumes (one observed and five predicted) for the release of a tracer gas in downtown Salt Lake City, Utah. The single observed plume represents the results of one 2-hour release out of 18 releases of an actual field study, while the five predicted plumes reflect an example of model-run results based upon varyng the weather inputs to the model. The plume contours range from red to orange to dark yellow to light yellow, which correspond to 2-hour dosage levels of 3,600,000, 360,000, 36,000, and 3,600 parts per trillion, per minute, respectively. While general comparisons may be made between the observed and predicted plumes with regard to the direction and speed of dispersion, the IDA study used 13 standard statistics to compare concentrations paired in space and time, as well as a measure of effectiveness to compare observed and predicted areas of coverage of the tracer gas. These comparisons highlight the importance of the underlying choice of input meteorology for assessing any prediction.

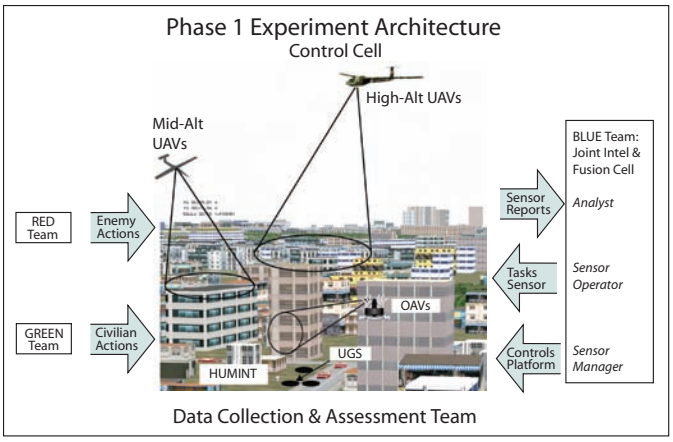
The New Triad

DoD plans to create a New Triad that combines strategic nuclear and conventional forces with defenses against ballistic missiles. IDA has been examining how this New Triad could change the nature of U.S. strategy for maintaining nuclear deterrence. Our researchers concluded that, first, the best strategies and the degree to which the adversary can be deterred are dependent upon the capabilities provided by the New Triad, of which both sides would be substantially uncertain before engaging one another. Second, while any sensible opponent would want to resolve such uncertainties before attempting to test U.S. will with WMD, this probably cannot be done. We concluded that, as a result of the uncertainties created, credible New Triad capabilities might provide an extra measure of deterrence.

Modeling and Simulation

Learning from the First Victories of the 21st Century: Mazar-e Sharif

In October 2001, U.S. Special Operations Forces (SOF) in Afghanistan linked with the Northern Alliance, an indigenous force on horseback, and directed precision weapons from the air to defeat the Taliban in the area around the city of Mazar-e Sharif. At the request of U.S. Central Command, an IDA/DARPA team collected data from the battlefields and, using state-of-the-art simulation tools, reconstructed selected events from that campaign to create an instructional tool for future leader development; to support historical analyses; and to facilitate research and development for irregular warfare. The project emphasized the interdependencies among indigenous forces, SOF, air operations and other government agencies; and the power of small, adaptable units integrating joint/coalition capabilities.



The above graphic illustrates the Human-in-the-Loop Experiment Architecture for Phase 1 (Developing Situational Understanding) of URBAN RESOLVE. As a human-in-the-loop experiment, individuals in concert with a computer simulation role played the Blue, Red, and Green Teams of the experiment. Within this architecture, the Joint Intelligence and Fusion Cell (Blue Team) receives sensor reports from a suite of intelligence-gathering assets (high- and mid-altitude unmanned aerial vehicles [UAVs], organic aerial vehicles [OAVs], unattended ground sensors [UGS], and human intelligence [HUMINT]), which it controls, based on the interaction of those assets with enemy forces (Red Team) and civilians (Green Team) in an urban environment. The Data Collection and Assessment Team collects and assesses data from a variety of sources in the simulation and in the experiment, while the Control Cell exerts overall oversight and control over the experiment.

URBAN RESOLVE: A Human-in-the-Loop Experiment

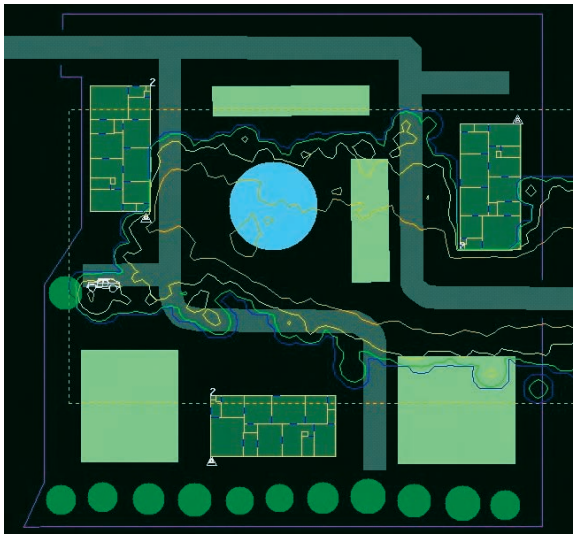
Fighting in an urban environment without sustaining unacceptable friendly or civilian casualties or damage to civilian infrastructure represents a continuing challenge. The U.S. Joint Forces Command, the DoD Executive Agent for Joint Urban Operations, asked IDA to design and conduct an experiment to explore ways to improve urban combat operations.

Completed in October 2004, Phase I of the experiment, code-named Urban Resolve, examined combinations of future high-, medium-, and low-altitude sensors on unmanned platforms, unattended ground sensors, and human intelligence to find and monitor an adaptive Red force attempting to hide, deceive Blue forces, and prepare defenses against an impending Blue attack. Low-altitude unmanned sensors and the ability to "tag" Red personnel and vehicles proved especially instrumental to Blue's success. Phases II and III will explore combat force applications.

Modeling and Simulation of Chemical, Biological, and Radiological Effects

IDA plays a major role in the DARPA-sponsored Advanced Conflict and Tactical Simulation (ACATS) program, which is developing an improved modeling and simulation tool to represent chemical, biological, and radiological (CBR) effects in an urban environment. ACATS is based on an existing military combat simulation – the Joint Conflict and Tactical Simulation – that is being upgraded to include representations and capabilities relevant to the civilian first responder and emergency response communities.

IDA is structuring the overall ACATS development program; assessing and testing existing capabilities; specifying improvements; examining and selecting appropriate CBR-related algorithms and data; developing scenarios and test plans; and reviewing model documentation. Our researchers also are helping with efforts to integrate ACATS with other modeling efforts to form a comprehensive "building protection tool kit."



Screen capture from ACATS illustrating the release of a chemical agent in a built-up area with various terrain features, including buildings, grassy areas, trees, fencing, paved roads, and a pond. IDA recommended and provided a new algorithm for the model's chemical sensor, represented by the small white triangle at the corner of each building, based on the review and analysis of existing algorithms. Particularly important to note is that the chemical cloud, generated by a second model, known as MESO/RUSTIC, realistically flows around the buildings. Previously, chemical plumes in models like ACATS were generated via models that ignored buildings and other closed terrain.

Human Behavior Representation

To properly characterize the use of military systems and other instruments of national power – including diplomatic, economic, and informational systems – analytic tools must include valid representations of human behavior. The Defense Modeling and Simulation Office asked IDA to review the state-of-the-art in human behavior representation (HBR) modeling. The review identified and described 19 comprehensive models that explicitly emulate human cognition and performance. The models were evaluated with respect to 12 cognitive functions. We found that:

- All models can represent decisionmaking and either short- or long-term memory.
- Peripheral functions – such as perception and attention, and psychomotor control – are well represented in most models.

- Central cognitive functions – such as learning and problem solving – are represented in relatively few models.

- Very few models have the capability to simulate emotional or social behaviors.

Overall, although HBR modeling continues to improve, no existing model offers true "plug and play" interoperability with military simulations. To date, the human representations that have been incorporated into military simulations have required the sustained commitment of individuals with specialized skills in both the computer and cognitive sciences.

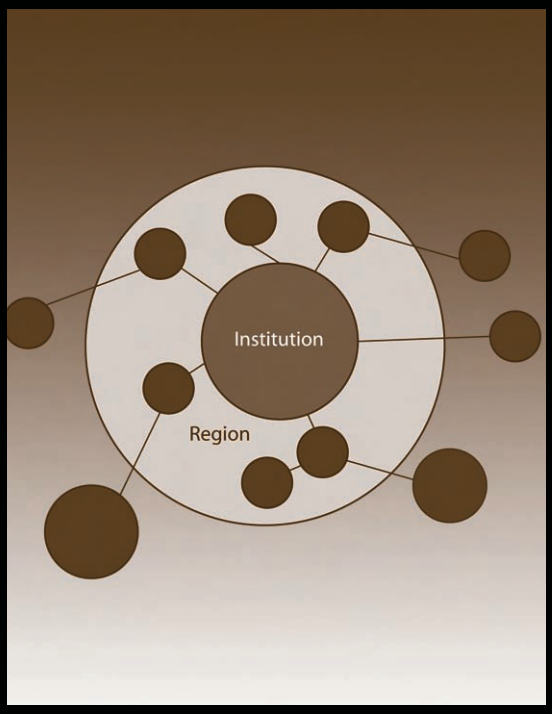
Cognitive/Behavior Function Represented	Number of HBR Models in which Cognitive/Behavior Function is Represented (out of 19 HBR Models reviewed)
Attention	13
Decisionmaking	19
Long-term Memory	17
Perception	16
Short-term Memory	14
Psychomotor Performance	11
Cognitive Workload	3
Emotional Behavior	3
Learning	5
Problem Solving	5
Situation Awareness	4
Social Behavior	5

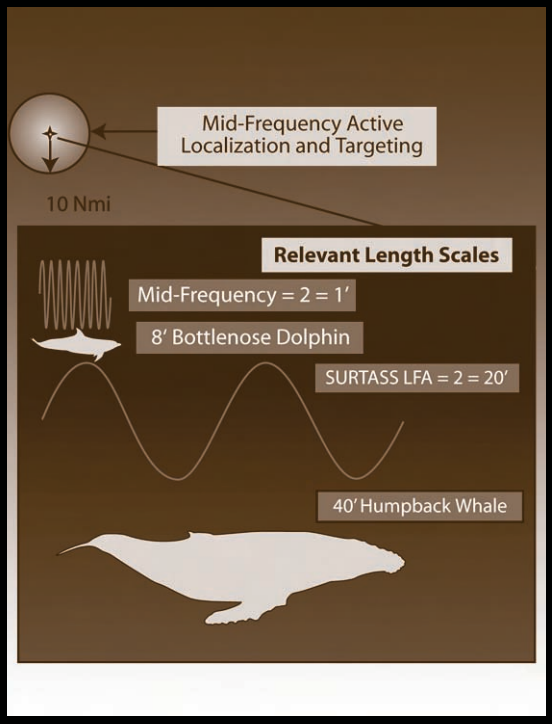
Cognitive/Behavior Function not well represented in Models (represented in 0-5 of the Models)

Cognitive/Behavior Function moderately represented in Models (represented in 6-11 of the Models)

Cognitive/Behavior Function well represented in Models (represented in 12-19 of the Models)

IDA compiled a list of 14 cognitive and behavioral functions based on a review of the cognitive psychology, cognitive engineering, and cognitive modeling literature. IDA then conducted a review of 19 Human Behavior Representation models to determine whether the identified list of cognitive and behavior functions is represented. Six of the 14 cognitive and behavioral functions are not well represented.

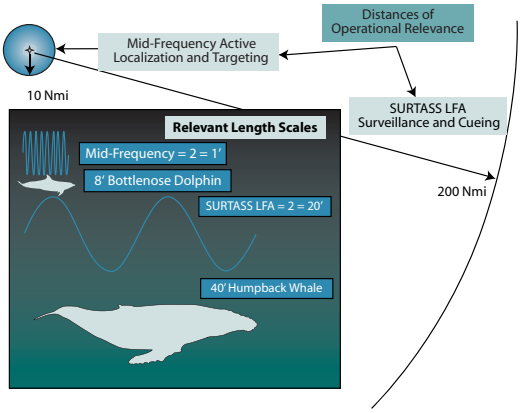




Science and Technology Policy Institute

The Science and Technology Policy Institute assists the Executive Branch of the U.S. government as it formulates federal science and technology policy by providing objective, high-quality analytic support to inform policymakers. Chartered by an act of Congress in 1991, STPI provides the highest quality and rigorously objective technical analytical support for the Office of Science and Technology Policy and other government users, under the sponsorship of the National Science Foundation.

Active Sonar Impact on Marine Mammals



The use of active sonar and its impact on marine mammals is an emotionally and politically charged issue. The U.S. Navy operates many types of active sonar with frequencies ranging from about 250 Hz (long-range surveillance) to 100 kHz (mine hunting and bottom imaging). These active sonar include a range of source levels, different areas of operation, and varying tactical procedures for operation and are associated with a spectrum of Naval platforms and missions. Given the contentious nature of this issue and the apparently conflicting statements from the scientific community, OSTP asked STPI to review the use of active sonar and its impact on marine mammals. The figure above compares nominal ranges of potential operational significance for mid-frequency and surveillance toward array sonar system-low frequency active (SURTASS LFA) sonars, and illustrates the relevant length scales for whales and dolphins, and the wavelengths (l) of radiation associated with mid- and low-frequency sonars.

The Office of Science and Technology Policy (OSTP) was established to serve as a source of scientific and technological analysis for the President of the United States, as well as to lead interagency efforts to develop and implement sound science and technology budgets. Subsequently, Congress in 1991 chartered the Critical Technologies Institute to provide rigorously objective technical and policy analyses to OSTP and other Executive Branch agencies, through financial sponsorship of the National Science Foundation. The institute was renamed the Science and Technology Policy Institute (STPI) in 1998 to reflect the broader mandate of serving the entire federal science and technology (S&T) establishment. And, in December 2003, STPI became the third federally funded research and development center administered by IDA.

This year, STPI conducted nearly 30 research activities for OSTP that ranged from informal technical briefings for senior planners and policymakers to more formal assessments. The work dealt with subjects as diverse as space launch policy – in which we analyzed the domestic space launch market and U.S. launch capabilities – and marine mammals – in which we identified research opportunities that could resolve ambiguities regarding the impact of selected sonar frequencies on marine mammals.

Also, STPI helped OSTP establish improved practices for emergency preparedness telecommunication; assisted in forming a comprehensive national strategy for dealing with biological and chemical threats; and clarified the regulatory purview of the federal government, states, and localities relative to the protection of people, property, and the environment following a disaster.

Three STPI projects are described in more detail in the paragraphs that follow.

Nanotechnology Programs and Policies

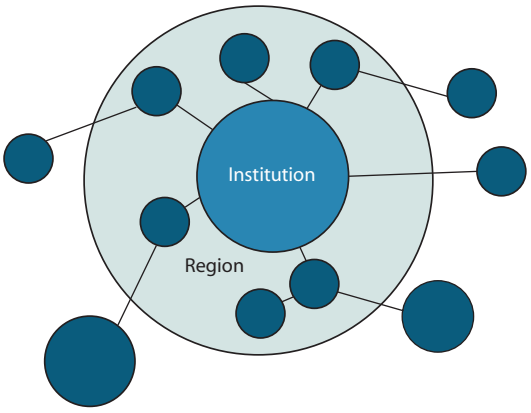
The National Nanotechnology Initiative (NNI) is a federal R&D program that encompasses the efforts of more than 20 agencies with programs and/or interests related to nanotechnology. This multiagency effort is coordinated by the Nanoscale Science, Engineering, and Technology (NSET) Subcommittee, which reports to the National Science and Technology Council's (NSTC) Committee on Technology. OSTP plays a central role in coordinating these efforts. STPI has provided technical support to OSTP, including analyzing international R&D investments and surveying the toxicology of nanotechnology. Because of the interdisciplinary nature of nanotechnology R&D, STPI also examined actual and/or potential involvement of the social and behavioral sciences in nanoscale S&T. We provided evidence for limited involvement of social and behavioral scientists in interdisciplinary nanotechnology settings and suggested mechanisms to expand their participation in selected areas.

Federal, State, and International S&T Collaboration

Many states provide a favorable R&D environment for local industry by providing research support to university systems, focusing on the education of a technically proficient workforce, providing tax incentives to attract industry, and minimizing regulatory red tape for plant development. While federal S&T programs usually focus on research and early-stage development of technologies, states often speed programs from the laboratory to market. The President's Council of Advisors on Science and Technology (PCAST) asked STPI to help structure a workshop to examine how state and federal cooperation might improve the return on these S&T investments, and to document key findings.

The United States also has many formal and informal mechanisms to facilitate the advancement of science through joint research with other countries. In October 2004, STPI organized a conference for PCAST to explore trans-Atlantic cooperation at the individual, academic, corporate, and national levels. One topic addressed at the conference involved ways to expand the scientific benefits from facilities developed for so-called "big science" – including particle physics, nanotechnology, and molecular biology – which have consumed an increasing share of global R&D expenditures in recent years. Through international cooperation, it might be possible to increase the scientific value of facilities such as CERN's Large Hadron Collider, Japan's Super Kamiokande neutrino detector, NASA's space-based telescopes such as Hubble, and NSF's polar research facility in Antarctica. STPI is helping PCAST develop a list of such high-cost facilities to use as examples, and will suggest a plan for maximizing the sharing of these and future facilities to increase their global scientific productivity.

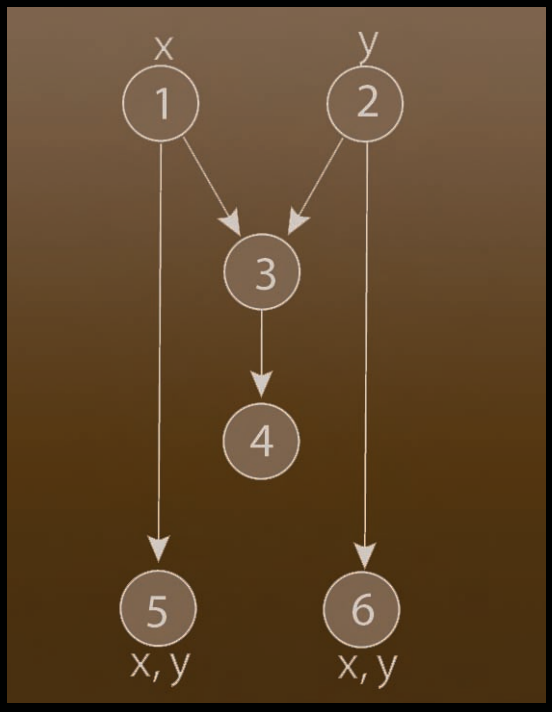
State-Anchored Institutional Clusters

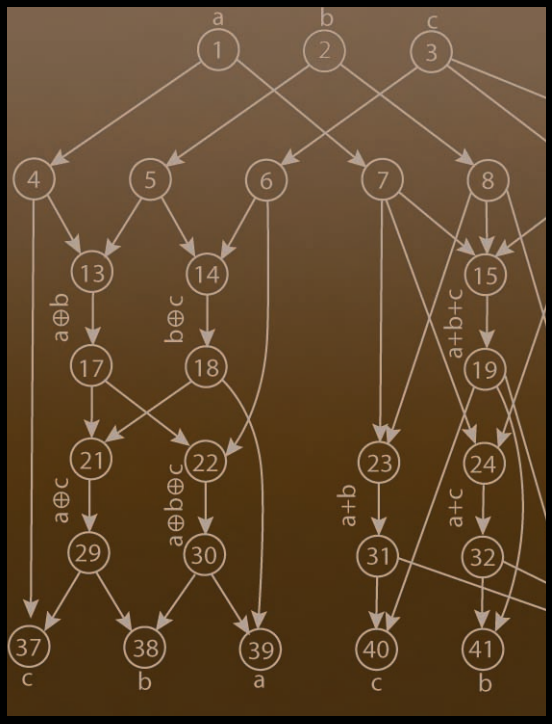


Institutional clusters, also known as state-anchored districts, are dominated by public or nonprofit entities (the center circle in the image above) such as R&D labs, universities, defense installations, or government offices, which play the role of a key anchor tenant in the district. Smaller entitites (the darker blue circles), such as supplier firms, are attracted to or dependent on the larger public institution. The growth of some U.S. cities, such as Santa Fe, New Mexico, and Colorado Springs, Colorado, often is tied to such entities.

Federal Cross-Agency Funding Policies

The strength of U.S. science and technology derives in part from the fair and open competition for federal research grants and contracts. Federal "intramural" scientists – i.e., those who work directly for the federal government – play key roles in supporting specific agency missions. The financial relationships between federal intramural scientists of one agency and the extramural competitive grants programs of another agency vary widely. OSTP asked STPI to examine agency-specific regulations and practices to determine whether intramural scientists and engineers can compete for federal extramural research support, and to review agency restrictions, if any, on reimbursed and unreimbursed costs for research conducted by federal scientists employed by other agencies. STPI interviewed senior federal officials and examined spending reports at 10 key federal agencies, and we continue to assist OSTP in its efforts to promote greater clarity regarding support for federal scientists and engineers across agencies.





High Performance Communications and Computing

IDA is a key component in the research endeavors of the National Security Agency. For over 45 years, we have provided cutting-edge research in those areas of mathematics and computer science that are fundamental to the NSA mission of protecting our national security information systems against foreign exploitation, and providing the United States with effective signals intelligence. Reflecting changes in NSA needs, the structure of the program has evolved into two separate but interrelated sets of activities: communications research and computing research. The sensitivity of communications scurity and communications intelligence forces most of this work to remain highly classified; accordingly, we can provide only a very general description of the NSA support program here.

Communications Research

The Centers for Communications Research (CCR) in Princeton, New Jersey, and La Jolla, California, conduct mathematical research supporting the twin tasks facing cryptologists: cryptography and cryptanalysis. Mathematics remains the fundamental science employed to create and analyze the complex algorithms used to encipher vulnerable communications. Virtually every branch of pure and applied mathematics has proved to be useful in these efforts. For example, techniques from the geometry of algebraic curves provide better methods for detecting and correcting errors in data transmission. Even where no explicit mathematics is involved, the mathematical mode of thinking seems to be ideally suited to cryptologic problems. As the modes and means of modern communications become more complex, the National Security Agency (NSA) has asked that the Centers expand their research into other areas including speech, the processing of signals to remove noise and distortion, and network security.

With the complexity of the global security environment and the explosion in the modes and means of communications, NSA, like the rest of DoD, must deal not only with collecting massive amounts of data, but also with transforming that raw data into useful information. Because mathematics can contribute to this transformation, IDA has been increasing its capabilities in this area. To ensure that we take advantage of work already done, we held an unclassified conference with the Center for Discrete Mathematics and Computer Science at Rutgers University entitled "Mining Massive Data Sets and Streams: Mathematical Methods and Algorithms for Homeland Defense," which attracted participants from academia, industry, and government.

It is critical in our work that we recruit the very best new mathematical talent. This requires that the community foster and maintain close ties with the academic mathematical world. For decades, IDA has hosted SCAMPs, special study programs that last eight to ten weeks in the summer. About 40 academic mathematicians, ranging from graduate students to renowned professors, are brought in to work closely with the regular IDA staff and visiting NSA mathematicians on difficult and important problems. This past summer, the two CCRs collaborated with the Center for Computing Sciences (CCS) on a broad slate of information processing problems in addition to more traditional cryptologic topics.

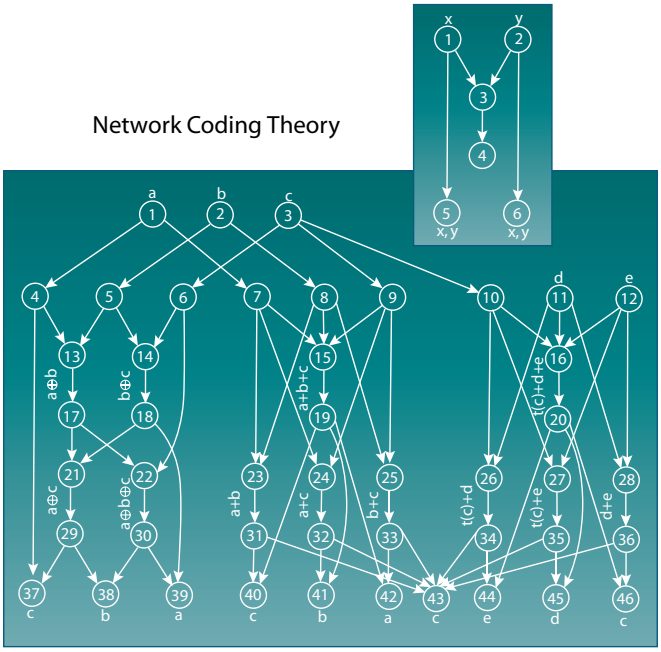
Computing Research

High-end computing is an important part of the research program at the Center for Computing Sciences. However, to reflect global political and technological changes, the CCS's mission has broadened to include not only high-performance computing for cryptography, but also cryptography itself, network security, signal processing, and computational/mathematical techniques for mining and "understanding" very large data sets. To achieve its mission, CCS focuses the skills of some of the country's best computer scientists, engineers, and mathematicians on using all aspects of computational science to solve intelligence-related problems of importance to national security. Parts of the problem set we confront are clearly not unique to the defense and intelligence community; these areas are of concern to the entire computing science community and are addressed in many different settings. Indeed, initiating discussions with academia and industry is an important component of the CCS mission.

Senior technology policy makers have concluded that continued development of high-performance computing platforms will require government research and development support. This point of view is based on the realization that the amount of computing

An important new class of ideas in network communications has emerged recently, called "network coding theory." While traditional network routing tries to avoid data collisions, network coding intermixes data at nodes to improve transmission rates.

Network Coding Theory



In the diagram, nodes 1 and 2 are source nodes that emit messages x *and* y *(respectively) at each time step, where* x *and* y *are chosen from some fixed set of possible symbols. Nodes 5 and 6 are sink nodes that need (both) messages* x *and* y*. Is there any way to pass the messages through the network?*

The bottleneck on the edge from 3 to 4 makes it impossible to solve this information transmission problem (in one step) purely by routing. However, if node 3 is allowed to add its inputs, it is easy for node 5 to get the messages it needs. It receives x and x+y*, and recovers* y *by subtracting x from* x+y*. Thus, under the (realistic) assumption that the nodes have at least a little computational ability, it is possible to transmit information more efficiently than is possible by routing.*

More generally, we can imagine an arbitrary network with nodes connected by arrows in which some nodes are source nodes that produce messages chosen from some alphabet, and others are sink nodes that have a list of messages that they need. We assume that the messages come from a finite set of symbols on which arithmetic is possible, and allow nodes to perform computations.

Many existing networks have this form; this allows for theoretically superior alternatives to traditional network routing used for moving data through packet networks, and may have numerous other applications to secure and reliable communication.

CCR's Dr. Randall Dougherty, together with IDA consultants Prof. Chris Freiling of California State University, San Bernardino, and Prof. Ken Zeger of the University of California, San Diego, have written several papers in this field. In one, they provide a counterexample to a previously published conjecture that any solvable network (allowing arbitrary computations at the nodes) actually admits a solution in which all the computations at the nodes are linear.

The counterexample network is shown in the lower image. Source nodes 1, 2, 3, 11, and 12 emit messages a, b, c, d, *and* e*, respectively, chosen from the set {00, 01, 10, 11}. Nodes 37 through 46 are sink nodes, each demanding the message indicated. The network is solvable, as the reader can confirm using the computations given in the figure. The symbol* $\oplus$ *denotes addition (exclusive or) of binary vectors of length 2, and* + *indicates the addition of 0, 1, 2, and 3 modulo 4; moreover,* t(x) *denotes the bit-reversal of* x*.*

Dougherty, Freiling, and Zeger show that the network does not admit a solution using linear computations, and that in a certain sense the network does not even have an approximate linear solution. The key idea is that the left third of the network is not compatible with fields with an odd number of elements, and the right two-thirds is incompatible with fields with an even number of elements, so that no linear solution is possible

power available from architecture intended primarily for the consumer market is not, and probably never will be, sufficient to meet the specialized requirements of the most demanding national security-related computations. CCS is active in this discussion because of its depth of experience in NSA's most advanced computing problems and its active collaborations with the Department of Energy national security laboratories in New Mexico and California (Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratory).

As every personal computer user knows, various software components interact with each other in complex, sometimes unintended, and possibly unpleasant ways. Protecting computer networks and other U.S. communications is now as important as designing and using these computers and networks. For several years, the CCS SCAMP summer program has concentrated on understanding the origin and consequences of these remarkable side effects. The effort has gradually broadened to include interactions among programs communicating over very large networks such as the World Wide Web. The studies at the SCAMPs highlighted the need for a great improvement in tools and techniques for understanding structure and for predicting consequences of execution of large programs.

For the past decade, CCS has provided NSA with research tools for massively parallel processors. In addition to continuing this fundamental effort, CCS and the CCRs have focused on research problems associated with the processing, searching, and "understanding" of massive amounts of data. The main emphasis has been on building software research tools that use the most current web-based technology to increase capabilities to absorb and explore giant data sets.

The Crypto Mathematics Institute in July 2004 honored Al Hales for the 11½ years he served as Director of CCR-La Jolla. He was presented with a plaque which read, "Alfred W. Hales, Builder of CCR-La Jolla, Champion of Young Mathematicians. In appreciation of the mathematical talent, boundless energy, and generosity of spirit that you have given to our community."

The IDA Community

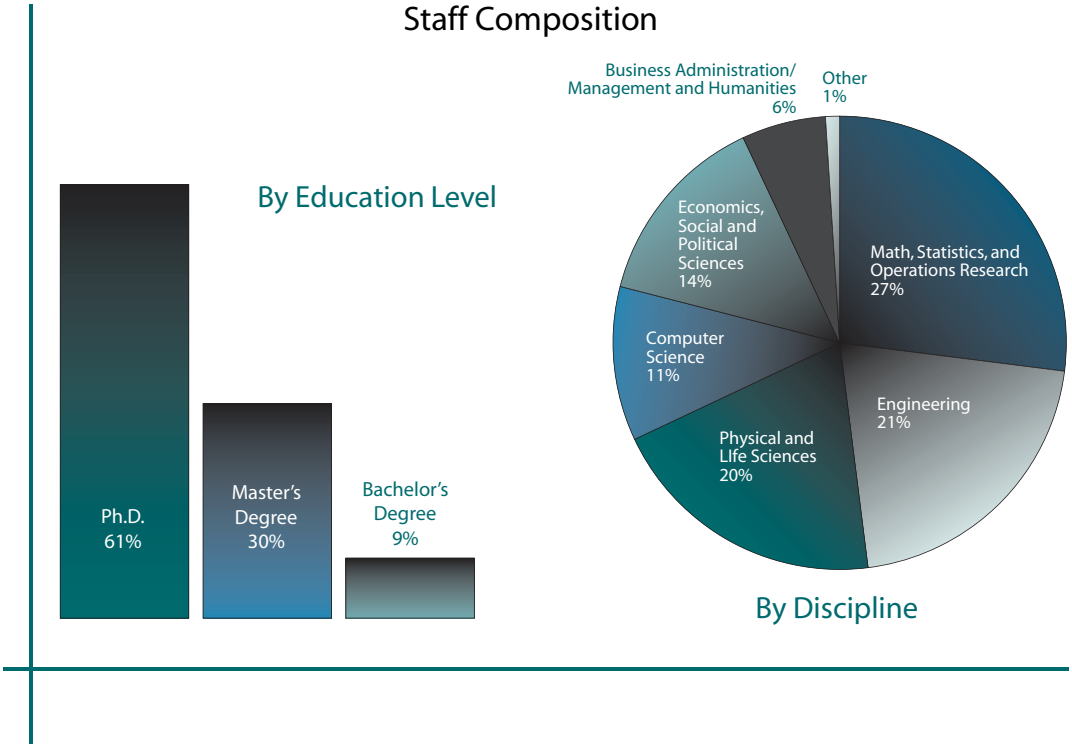
Since its formation in 1956, IDA has provided its sponsors with timely, authoritative, objective analyses on important national issues that have significant scientific and technical content. We bring an experienced staff, a dedication to quality, and a commitment to sponsor satisfaction.

Fundamentals for Success

IDA's mission is to bring the best scientific and analytic minds to bear on the most important issues of national security. To do this, we constantly renew and evolve our analytic resources to ensure that IDA meets its sponsors' needs. This means reaching into the community to find and cultivate first-rate people and providing them with the tools necessary, and setting challenges high enough, to maintain IDA's standard of excellence.

IDA's ability to provide the high-quality analyses for which we are known is due to the dedication and hard work of our skilled and diverse staff. We employ more than 800 research, professional, and support staff in offices in California, the District of Columbia, Maryland, New Jersey, and Virginia. Our research staff includes a rich mix of scientists, engineers, mathematicians, and economists who apply state-of-the-art systems engineering and research and development techniques to tackle critical issues of national importance. Educated at the nation's leading universities, more than 90% of IDA's research staff have an advanced degree, three out of five a doctorate.

The research staff is backed by an equally accomplished and dedicated professional staff of editors, programmers and computer information specialists, security personnel, human resource specialists, accountants, graphic artists, administrative assistants, and others. Their talents ensure that our sponsors consistently receive accurate and timely products.



Awarding Excellence

Each year, IDA recognizes those employees who surpass the normal level of excellence. IDA presents annually the Andrew J. Goodpaster Award for Excellence in Research to an individual who has demonstrated intellectual leadership within the IDA community, and the W.Y. Smith Award for Excellence for outstanding contributions by a non-research professional staff member. The IDA President's Award for Excellence is presented each year to two IDA employees to recognize sustained superior

performance over a significant period of time that contributes significantly to IDA's success. And three times per year, IDA presents the IDA Achievement Award to recognize staff whose outstanding achievements or accomplishments are above and beyond the normal scope of an employee's job and are not usually visible to sponsors.

This last year, the following individuals were singled out for their exceptional contributions to IDA's mission:

*IDA President **Adm. Dennis Blair** presents **Dr. Steve Warner** with the Goodpaster Award.*

The analytic career of **Dr. Steve Warner** of the Operational Evaluation Division comprises a sustained period of excellence in research, highlighted by numerous outstanding publications and constructive impacts for our sponsors. It is for his distinguished record that he was awarded the **2004 Andrew J. Goodpaster Award for Excellence in Research**.

Dr. Warner has contributed outstanding analytic performance in a wide range of research areas, and has brought great intellectual rigor, energy, and practical skill to the task of applying analytic methods to solving real-world defense problems. His work over his career at IDA has spanned a remarkable diversity of topics, ranging from counter-drug strategies for key inter-agency working groups, maritime and fisheries enforcement for the Coast Guard, and transport and dispersion models for the Defense Threat Reduction Agency. Dr. Warner's more recent research has been devoted to evaluating submarine and anti-submarine warfare systems for DOT&E. This work included the significant development of a new concept of sequential test designs for "free play" operational testing of new submarines and their combat systems in which the submarines would be confined to a given test area on realistic missions until detection occurred and simulated weapons were fired.

This year, the **W.Y. Smith Award for Excellence** was presented to **Mr. Allan Lonergan** from IDA's Finance Office. For the last nine years, Mr. Lonergan has served as IDA's Purchasing Supervisor, deftly managing all purchasing and property management activities at IDA's Alexandria and Washington, DC, locations and providing oversight of the other off-site locations. He routinely balances the needs of the IDA staff for the timely procurement of quality goods and services with the stringent government audit requirements for purchasing and tracking those products.

*Left to Right. **Mr. Aundra M. Campbell, Ms. Erika Tildon,** and **Mr. Allan Lonergan**.*

This year's **President's Award for Excellence** was awarded to **Ms. Erika Tildon**, the Science and Technology Division (STD) Senior

Publications Coordinator, and to **Mr. Aundra M. Campbell**, Executive Assistant for the Joint Advanced Warfighting Program (JAWP).

Ms. Tildon joined STD in October 2003 after a five-year hiatus from IDA. She immediately became an integral member of the division's Publications team, demonstrating a consistently high quality and quantity of work, attention to detail, superb organizational skills, excellent problem-solving skills, ability to learn quickly, and willingness to be of help to others. She has brought to the job a fresh, invigorating work ethic, enthusiasm, and a willingness to go the extra mile to support STD's publications. Mr. Campbell's tireless efforts helped to seamlessly blend the administrative arrangements of the JAWP and Simulation Center when those divisions were combined. He quickly and ably took the lead in creating joint rosters, shared communications arrangements, and streamlined support. There is not an administrative job that Mr. Campbell does not perform competently and professionally. His competence, friendly disposition in the face of adversity, and steadfast reliability have combined to make him an enormously important player in the accomplishment of the JAWP's mission.

IDA Achievement Award Winners

Left to Right. ***Mr. Domingo Limo, Ms. Jamie Ratner,*** *and* ***Ms. Lori A. Patterson****.*

Strong Leadership

The dedication of IDA's talented staff is coupled with the knowledge and commitment of IDA's Board of Trustees and corporate officers. Board members, with experience in industry, government, academia, or the military, provide policy guidance to the Institute and its officers.

Admiral Dennis C. Blair*, USN (Ret.)*
President, Institute for Defense Analyses

Dr. John M. Palms*, Chairman*
Distinguished President Emeritus,
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President and Director, The Institute for Genomic Research

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Chairman, Projects International, Inc.

(from left)
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USMC (Ret.) Director, Africa Center for Strategic Studies (NDU)

Dr. Edward R. Jayne, II
Partner, Heidrick & Struggles and Managing Partner, Global Semiconductor, Hardware, & Systems Practice, Heidrick & Struggles

(from left)
Dr. Martha A. Krebs
Science Strategies

Dr. Jill P. Mesirov
Associate Institute Director, Chief Informatics Officer, and Director, Bioinformatics and Computational Biology Programs, The Eli and Edythe L. Broad Institute, MIT & Harvard University

(from left)
Dr. William H. Press
Research Scientist, Los Alamos National Laboratory

Mr. Robert L. Prestel
Former Deputy Director, National Security Agency

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USA (Ret.) President, Association of the U.S. Army

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USAF (Ret.) Senior Fellow, Institute for Defense Analyses

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Effective Organizational Structure

The depth and breadth of IDA's research and analytic capabilities are mirrored in its three Federally Funded Research and Development Centers.

Studies and Analyses Center, Alexandria, Virginia

Cost Analysis and Research Division
Dr. Stephen J. Balut, Director
CARD collects, analyzes, and estimates the full life-cycle costs of acquiring and operating forces, systems, and components. The division also creates new or improved methodologies and computer-based models for cost estimation.

Information Technology and Systems Division
Dr. L. Roger Mason, Jr., Director
ITSD analyzes the development, application, and management of computer and information technologies. This work assesses the technologies by themselves and in relation to the development and use of weapon, support, and command and control systems. The results of this work help DoD plan its research and development program, make acquisition decisions, and formulate technology policy.

Joint Advanced Warfighting Program
Mr. Karl H. Lowe, Director
JAWP was established at IDA at the request of senior DoD officials to serve as a catalyst for stimulating innovation and breakthrough improvements in joint military capabilities. This includes the development, demonstration, and application of advanced simulation (constructive, live, and virtual) capabilities and the use of modeling and simulation to examine advanced warfighting concepts. The JAWP team is composed of both military personnel on joint assignments (three from each Service) and civilian analysts from IDA, including a strong cadre focusing on modeling and simulation. JAWP is located primarily in Alexandria, Virginia, but also maintains an office in Norfolk, Virginia, to facilitate interaction with the U.S. Joint Forces Command.

Operational Evaluation Division
Mr. Robert R. Soule, Director
OED supports the Office of the Secretary of Defense in the planning, observation, and evaluation of Service operational tests of major new weapon systems and the Live Fire Tests of the lethality and vulnerability of weapons and platforms. The division also supports the Office of the Secretary of Defense, the Joint Staff, and the Combatant Commands in evaluating military deployments and operations, and in developing, integrating, and improving the mission planning process.

Science and Technology Division
Dr. Michael A. Rigdon, Director
STD investigates and models scientific phenomena and conducts technical characterizations and evaluations of devices and systems, the environments in which they operate, the targets they engage, and the missions they perform. The division also conducts technology assessments critical to research and development programs, acquisition decisions, technology planning, and technology proliferation.

Strategy, Forces, and Resources Division
Mr. Michael Leonard, Director
SF&RD performs integrated, interdisciplinary studies of defense planning and policy related to national security strategy, the structure and capabilities of U.S. and foreign forces, and the infrastructure supporting U.S. forces.

System Evaluation Division
Dr. George E. Koleszar, Acting Director
SED assesses military effectiveness, system performance, and joint and allied interoperability. It also examines mission needs, develops system architectures, investigates new operational concepts, and assesses the risks and costs that accompany technological integration. These studies help DoD choose among competing systems, set force or inventory levels, and identify suitable concepts for employing systems in wartime.

Centers for Communications and Computing

Centers for Communications Research, Princeton, New Jersey, and La Jolla, California
Dr. David M. Goldschmidt, Director, CCR–Princeton
Dr. Joe P. Buhler, Director, CCR–La Jolla
The two CCRs conduct fundamental research supporting the National Security Agency in cryptology and related disciplines. Their work includes creating and analyzing complex encipherment algorithms, conducting speech and signal analyses, and developing information processing algorithms.

Center for Computing Sciences, Bowie, Maryland
Dr. Francis Sullivan, Director
CCS conducts fundamental research for the National Security Agency in support of signals intelligence and information assurance missions in supercomputing and parallel processing technologies, including the development of parallel processing algorithms and applications; computer network techologies in support of communications security applications; and information processing technologies, focusing on applications for large data sets.

Science and Technology Policy Institute, Washington, DC
Dr. Robert E. Roberts, Director
STPI provides objective technical analytical support for the Office of Science and Technology Policy, assembling timely and authoritative information regarding

significant science and technology developments and trends in the United States and abroad, and analyzing this information, with particular attention to how it affects the federal science and technology research and development portfolio and interagency and national issues.

An Enriching Work Environment

IDA has created an atmosphere conducive to the careful study of public issues, but also one in which analysts are motivated by a sense of the urgency and the importance of their work. Through a variety of collaborative programs, IDA seeks to expand and strengthen its own research capability, develop new initiatives involving national security, and promote its intellectual diversity.

IDA provides summer employment opportunities to talented undergraduate and graduate students. In 2004, IDA welcomed 28 talented and diverse Summer Interns who hailed from universities across the country and had backgrounds ranging from aeronautical and astronautical engineering, computer science, and physics, to economics and political science.

Speaker Program

Each year, IDA invites members of the national defense research and analytic communities to share their knowledge and experiences with IDA staff. The speaker program includes the President's Colloquia Series, which features distinguished military and civilian leaders who talk on a range of technical and policy issues related to national security. IDA also conducts seminars on specialized topics capitalizing on the knowledge of experts in the fields relevant to IDA's research programs. This year, these included Counter-Terrorism and Homeland Security Seminars, Information Technology Seminars, and our recurring IDA Seminars. Seminars are conducted at all four of IDA's facilities and include presenters both from within and outside the classified and Defense communities. Speakers from diverse backgrounds and covered topics ranging from the "Challenges of Information Integration in Homeland Security" to "Reconstructing Iraq: The Way Forward," and from "Net-Centric Enterprise Services" to the "New Challenges Facing the Marine Corps."

Dr. Stephen A. Cambone
Under Secretary of Defense for Intelligence
"The Intelligence Challenge to DoD"

Ambassador Robin Raphel
Coordinator for Iraq Reconstruction
U.S. Department of State
"Reconstructing Iraq: The Way Forward"

General Michael W. Hagee,
USMC, Commandant, United States Marine Corps
"New Challenges Facing the Marine Corps"

Dr. Michael C. Hudson
Director, Center for Contemporary Arab STudies
Georgetown University
"America Adrift in the Middle East"

Ms. Dawn C. Meyerriecks
Chief Technology Officer
Defense Information Systems Agency (DISA)
"Net-Centric Enterprise Services"

Master Chief Petty Officer Terry D. Scott, *USN*
Master Chief Petty Officer of the Navy
"Views from the Fleet"

The Honorable William J. Perry
Former Secretary of Defense
"New Challenges Facing the DoD"

Mr. Edwin Dorn
Member of the IDA Board of Trustees, Dean, LBJ School of Public Affairs, The University of Texas at Austin
"The Challenges of Teaching Leadership"

Mr. Steven I. Cooper
Chief Information Officer
Department of Homeland Security
"Challenges of Information Integration in Homeland Security"

In Memorium

General Andrew J. Goodpaster

In May 2005, the country and the Institute for Defense Analyses lost a hero. General Andrew J. Goodpaster, U.S. Army (retired), died at the age of 90 after a battle with a recurring illness.

General Goodpaster served his country in the U.S. Army for 43 years, providing combat leadership from battalion commander in World War II to senior command in Vietnam. He was the epitome of a courageous soldier – always physically and mentally prepared and committed to the most demanding duties. Just prior to his retirement from the military in 1974, General Goodpaster served as Supreme Allied Commander in Europe, only to be summoned back to active duty in 1977 to become the 51st Superintendent of West Point. In addition to serving on the battlefield, General Goodpaster also served as a trusted and valued advisor to four presidents, from Eisenhower to Carter, counseling national leaders during times of crisis between nuclear superpowers over events in Berlin, Hungary, and Cuba.

But General Goodpaster's greatest contributions were to peace, not war. He focused a brilliant mind and a commanding presence on building, sustaining, and expanding peace. He was an exceptional scholar and a tireless and inspiring educator. He held leadership positions at the Eisenhower Institute, the George C. Marshall Foundation, the Woodrow Wilson International Center for Scholars, and the Smithsonian Institution.

Two years after retiring from the Army in 1981, General Goodpaster became President of IDA. In the two years he led IDA, he set it on the path it has followed to this day in providing impartial, accurate, and practical advice to the Department of Defense and other sponsors. He served on the Board of Trustees for the past 20 years, providing invariably useful advice to IDA's board and officers. He enthralled IDA researchers with his sincere interest in them and their work and with his relevant stories of past events he had observed or led.

Although we benefit from his legacy, we now will have to manage without one of the nation's finest and wisest patriots.

IDA works primarily for the Office of the Secretary of Defense, Joint Staff, Combatant Commands, and Defense agencies. We also conduct research for other government agencies. IDA does no work for industry.

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  - Deputy Under Secretary of Defense, Logistics & Materiel Readiness
  - Deputy Under Secretary of Defense, Science and Technology
  - Director, Acquisition Resources and Analysis
  - Director, Defense Procurement and Acquisition Policy
  - Director, Defense Systems
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- Under Secretary of Defense, Personnel and Readiness
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Joint Staff and Commands

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- Defense Intelligence Agency
- Defense Logistics Agency
- Defense Security Cooperation Agency
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- Defense Threat Reduction Agency
- Missile Defense Agency
- National Geospatial-Intelligence Agency
- National Security Agency
- Pentagon Force Protection Agency

Joint Program Offices

- Interagency Global Positioning System Executive Board
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- Joint Land Elevated Netted Sensor Program Office
- Joint Program Office for Biological Defense

Non-DoD

- Central Intelligence Agency
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- Office of National Drug Control Policy
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