IDA

Annual Report 2007

IDA

The IDA Mission

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

When the Cold War ended, many expected a period of adapting to new national and international circumstances. Most expected that, after a few years, stable and predictable geopolitical conditions would emerge, allowing the international community to focus on better meeting the needs of people around the globe. Few expected two decades of increasingly complex national and international security challenges, with the prospect of more decades of the same.

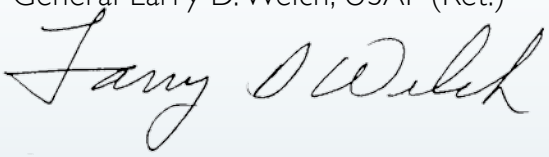
Our research portfolio at IDA reflects that expanding set of challenges – expanding in scope and depth, and serving traditional as well as new government sponsors. While the portfolio is too broad for a comprehensive coverage in this brief message, there are at least ten sets of challenges that have been evident for the past few years and that are likely to be driving U.S. security needs for the foreseeable future:

- Understanding and adapting to the evolving world order and building and sustaining coalitions of nations focused on common objectives.
- Developing, maturing, and integrating interagency capabilities to better meet crises at home and abroad.
- Managing resources to meet priority needs.
- Sustaining needed capabilities and acquiring new capabilities effectively and efficiently.
- Structuring military forces to meet 21st century challenges, while continuing to support ongoing global operations.
- Sustaining an effective all-volunteer force.
- Providing the space-based capabilities that are increasingly critical to a wide range of operational and technological challenges.
- Countering weapons of mass destruction.
- Ensuring security and freedom of action in cyberspace.
- Leveraging advanced technologies to sustain our current military advantages; to protect our forces, citizens, and allies from asymmetric attacks; and to improve the nation's economy and the well-being of its people.

This year's Annual Report describes how researchers at IDA's three Federally Funded Research and Development Centers approach these complex challenges facing our sponsors. To meet that need, we are constantly improving existing research capabilities and growing new capabilities. Each IDA research division and center strives to provide the best possible objective and timely help to national security decision makers. Collectively, our researchers address a broad spectrum of issues related to systems, technologies, resources, strategy, planning, and support needs.

Our success in meeting these needs has and will continue to depend on recruiting and sustaining the highest quality people; providing the most supportive and productive environment for our research; creating project teams with the right leadership and needed technical and analytic expertise drawn from across our research divisions; and insisting on objective, high-quality, timely products that help support the hard decisions that characterize the national security environment – today and tomorrow.

General Larry D. Welch, USAF (Ret.)



President and Chief Executive Officer

Studies and Analyses Center

The Studies and Analyses Center, the largest and oldest of IDA's three federally funded research and development centers, consists of eight research divisions:

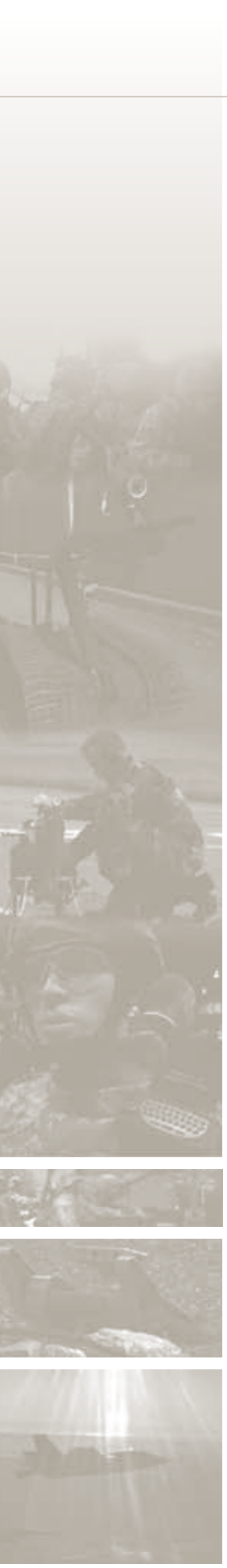
- Cost Analysis and Research Division
- Information Technology and Systems Division
- Intelligence Analyses Division
- Joint Advanced Warfighting Division
- Operational Evaluation Division
- Science and Technology Division
- Strategy, Forces and Resources Division
- System Evaluation Division

In any year, our research effort is spread across more than 300 projects, sponsored by a variety of offices within OSD, the Joint Staff, Combatant Commands, and Defense agencies. In addition to providing analyses for the Department of Defense, the Center also conducts analyses for other government agencies, including the Department of Homeland Security, the Director of National Intelligence, the National Aeronautics and Space Administration, the Federal Bureau of Investigation, and the Department of Veterans Affairs.

Our contributions reflect the diverse responsibilities of these offices as well as the breadth and depth of the Center's technical and scientific expertise and its analytic and real-world experience. The level of effort per project varies from quick-reaction work completed over a handful of weeks, to multi-year projects that engage more than 20 researchers.

Major research program areas include:

- Providing independent reviews of test and evaluation programs.
- Assessing joint force strategy, capabilities, operations, and plans.
- Improving DoD's capabilities to estimate costs.
- Evaluating technologies for advanced applications.
- Assessing technology issues in support of the acquisition process.
- Developing better analytic tools for examining defense issues.
- Streamlining DoD organizations, management systems, processes, and support.



Cost Analysis and Research Division

The Cost Analysis and Research Division (CARD) grew out of a group established to provide weapon systems costing support to other IDA divisions. Over the years, as CARD's efforts have diversified, the work has retained a direct connection to resource issues. Now, in addition to developing cost estimates of major acquisition programs and other government activities, IDA develops new costing tools, helps improve government budgeting and acquisition data, examines the defense industrial base, and analyzes resource issues related to the test and evaluation infrastructure.

Some cost analyses are motivated by concerns about the funding needed for major acquisition programs. For example, CARD this year conducted an independent assessment of the Future Combat Systems program, highlighting key differences between two earlier cost estimates that had been provided to Congress. (This effort is described in more detail in the Study Highlight on page 7.)

Often cost estimates are undertaken to support decisions about what is included in a program or how the program is structured, as was the case with IDA's work this year on the Joint Strike Fighter (JSF) Alternate Engine program. Here, our researchers examined the four basic elements of cost (development, procurement, operations, and support), technological risks, and defense industrial base issues to inform the government's decision on whether to proceed with an alternative engine program for the JSF.

We also are continuing efforts to improve cost estimating of real-world operations. An IDA-developed model is used across DoD to estimate contingency costs, and in recent years, we have both upgraded the model and helped our sponsors use it to project operating and support costs in Iraq, Afghanistan, and elsewhere.

IDA efforts related to DoD budgeting and acquisition data have included a study to help improve the Earned Value Management System, used to help oversee contracts on major defense acquisition programs and major automation information systems. We have developed techniques, algorithms, and tools to automate the analysis of earned value data. One new tool will improve the analysis of likely contract outcomes by rolling up data from individual contracts to the program level. We are assessing the costs and benefits of such data integration and helping prepare an implementation strategy.

During the past year, our researchers helped examine a variety of issues related to the test and evaluation (T&E) infrastructure, including assessing

the implications of the increasing T&E workload, examining alternatives for the realignment of Air Force test facilities, and developing ways to integrate independent testing into the missile defense program.

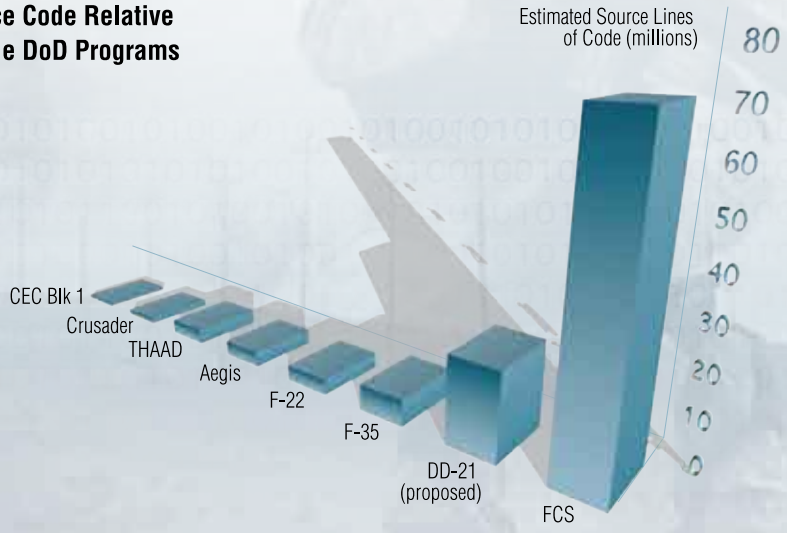
Major resource analysis issues tend to cut across process and organizational boundaries. Therefore, dealing with them requires broad knowledge of DoD. Similarly, the subject-matter knowledge and analytic techniques are cultivated in several different academic disciplines. IDA provides the diverse expertise required to provide our sponsors with effective solutions to a wide variety of resource analysis problems.

Study Highlight

Future Combat Systems Cost Review

The Future Combat Systems (FCS) program – the centerpiece of the Army's force transformation efforts – is developing a new kind of mobile force. Using networked situational awareness and cooperative fires, FCS units equipped with lighter, less heavily armored vehicles will be able to outperform traditional forces on future battlefields.

FCS Program Source Code Relative to Other Large-Scale DoD Programs



The FCS software development program is one of the largest and most complex software development tasks DoD has ever undertaken. The program's success will depend on FCS being able to integrate and operate with several million lines of new code delivered by the Joint Tactical Radio System, the Warfighter Information Network-Tactical, One Semi-Automated Forces, and other programs. The image above illustrates the estimated number of source lines of code the FCS program will need to integrate, relative to other large-scale DoD development programs. Although the FCS program office has developed novel software management processes, IDA is concerned that existing software costing methods may understate the total costs for a software development of this magnitude.

The FCS program is developing a variety of systems, sensors, networks, software, and hardware. The software development for FCS is one of the largest software efforts ever undertaken by the Department of Defense and is currently projected to deploy more than 70 million source lines of code. Also, the effectiveness of FCS-equipped units will depend to varying degrees on 52 complementary systems being developed outside the FCS program, including communications and networking capabilities being developed within the Warfighter Information Network-Tactical program and the Joint Tactical Radio System programs.

DoD asked IDA to conduct a congressionally mandated independent estimate of FCS development costs and an assessment of FCS reliance on complementary systems.

Our work focused on the following areas where the Army's official cost position disagreed most with the DoD's 2005 independent cost estimate:

- *Lead systems integrator (LSI) effort after Critical Design Review.*
- *Software development.*
- *Risk associated with network transport capabilities from complementary systems.*

Our researchers compared the planned developmental activities for FCS networked system of systems with analogous efforts for selected past system-of-systems programs. Using such analogies, we estimated the likely LSI effort that will be required in the later stages of FCS development. We found that activities associated with system-of-systems integration, validation, and testing are likely to dominate remaining tasks, and that these areas have significant cost risks at currently planned funding levels. We recommended that DoD pay close attention to these areas in overseeing contractor plans and progress.

In addition, we estimated costs due to potential growth in lines of software source code, system integration software needs, and large-scale re-use of existing modeling and simulation software. We found potential for cost growth in all three software areas. Again, we recommended that DoD pay close attention to contractor plans and progress in these software areas.

Our team also reviewed the 52 designated complementary systems to assess their levels of technological maturity, program status, and importance to the realization of FCS capabilities. Twelve of these systems were judged to be critical to FCS brigade combat team performance, and we estimated the cost and schedule risks associated with four to six of these systems that were not technologically mature at the time of our assessment.

Information Technology and Systems Division

Increasingly, the information environment enables, and is intrinsically embedded in, the fabric of our government and society. While this environment must be viewed holistically, the Information Technology and Systems Division (ITSD) focuses on the organizational, operational, policy, and technical facets of essential cyberspace operations.

To do so, ITSD conducts technology assessments, systems evaluations, and strategic planning relative to the application of information technology for complex defense and national security problems, focusing on information integration, information assurance, and intelligent systems. ITSD staff are engaged in the transition from isolated, stand-alone systems and platforms, built with a high percentage of custom hardware, to a secure, robust information environment that extensively leverages commercial products.

This evolving information environment requires the flexibility and agility of the public Internet coupled with a robustness and the security necessary to safeguard citizens and assets. ITSD's experience and knowledge of this environment, in addition to its technical expertise, enables IDA to maintain the necessary situational awareness and to identify and lead the collaborative engagement opportunities required to counter adversaries in a world where attacks can literally travel at the speed of light.

Our work encompasses a variety of tasks that include enterprise architectures, IT system strategy, computer network defense, information security management, advanced cybersecurity concepts, microsystems technology, cognitive systems, and trusted integrated circuits. Results from these tasks are directly used in a variety of defense functions such as command and control; logistics; network operations; intelligence, surveillance, and reconaissance; missile defense; and DoD business processes.

This past year, ITSD supported a number of projects to assist the Department of Defense, the Director of National Intelligence, and others. Our work included:

- Supporting the government's progress in restoring domestic capabilities to build trusted circuits and in getting programs to address concerns about offshore supplies of critical components.

- Developing the National Strategy to Secure Cyberspace.
- Creating an approach to reduce the test-to-implementation time in a net-centric enterprise.
- Recommending methods for extending the NATO data model.
- Supporting maturation of a model for enterprise architecture data sharing among allies.
- Providing engineering expertise to drive the creation of net-centric services.
- Creating a model to support the Office of Management and Budget's review of the governmentwide information sharing portfolio.
- Providing significant input on the Information Assurance Model and Common IT Security Framework.

As we move forward, ITSD will continue to support sponsors who face policy and technological challenges and those who are driving the creation of the secure information environment.

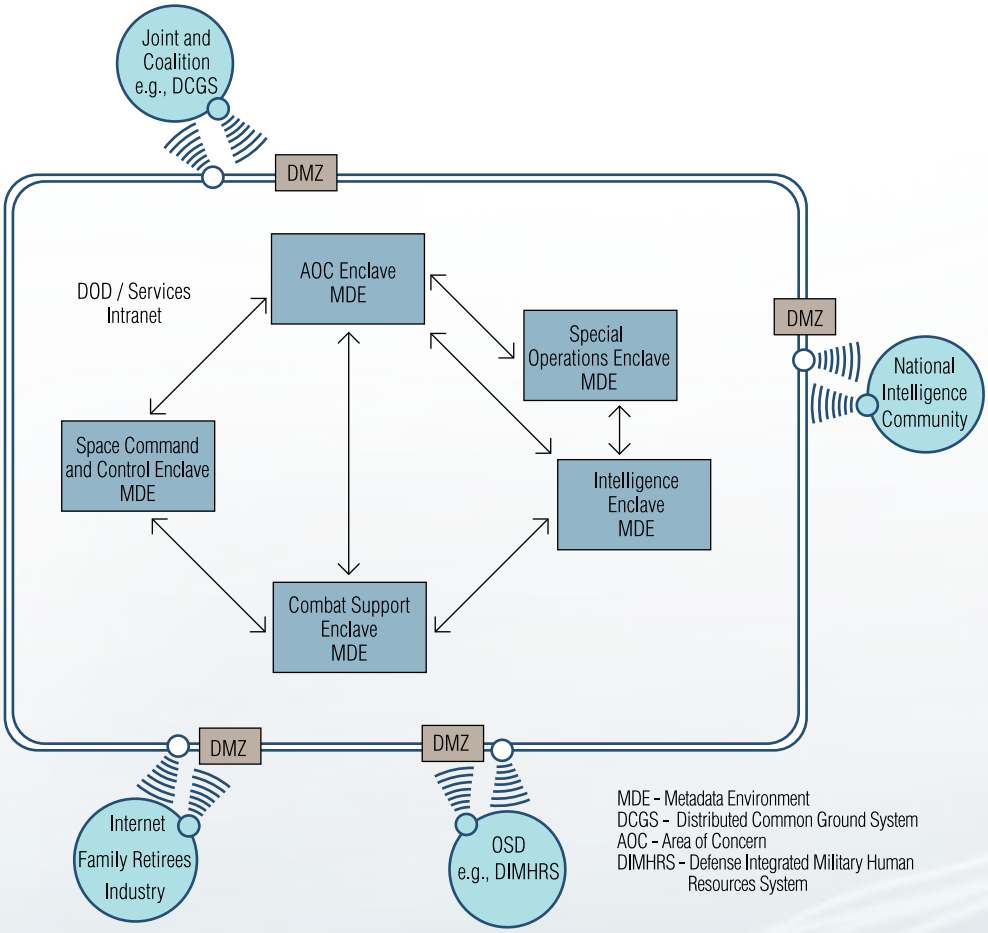
Study Highlight

Internet-Scale Distributed Environment

DoD net-centric operations must have enterprise-wide information-sharing capabilities in an environment that is highly resistant to cyberattacks, either internal or external. To achieve this, DoD must transition rapidly both its legacy systems and its operations to this envisaged environment.

IDA is supporting DoD in designing an architecture for an Internet-scale (i.e., global) distributed information environment, initially for the Air Force. The architecture comprises multiple "enclaves," with cross-enclave interactions enabled by defined trust relationships and well-defined rules for information and service exchange. Using enclaves as the basic component of the architecture provides two important advantages: it enables the enterprise to be organized into more manageable chunks (the enclaves), and it enables an operationally acceptable and rapid transition path.

Enterprise and Cross Enterprise Model



An enterprise (large square) is a collection of integrated enclaves. Enclaves (shaded squares) are logical collections of capabilities, each set configurable to satisfy unique enclave requirements and responsibilities. Trust relationships (double-headed arrows) enable federated cooperation and data sharing between enclaves and broker differences in security permissions. Similar trust relationships operate within the "demilitarized zones" (DMZs) that federate each enterprise (e.g., the Air Force) to other enterprises that, collectively, comprise DoD.

Our researchers have developed specifications of the architecture and its metadata naming services, and we have detailed approaches to address key technical challenges, including credentialing, authentication, and authorization. IDA also has identified the tools that will provide for assured information sharing. These efforts will result in an operational Air Force distributed data environment that is representative of DoD's envisaged net-centric enterprise.

Intelligence Analyses Division

The newly established Intelligence Analyses Division (IAD) serves as the face of the IDA Studies and Analyses Center to the intelligence community, focusing on critical intelligence issues affecting national security. IAD coordinates intelligence tasks with other IDA divisions, emphasizing systems, technology, organizational, and management process challenges. Our researchers have extensive experience in and knowledge of areas important to intelligence analyses, including geopolitical events and trends; terrorism groups; technical capabilities of foreign weapons systems; force employment concepts of potential regional, national, and transnational threats; and threat financing.

Among the work IAD conducted this past year is an ongoing project to help DoD improve the management of selected intelligence-related capabilities through the use of portfolio management techniques. In this effort, we are assisting in developing a framework from which to make sound decisions involving future intelligence, surveillance, and reconnaissance system acquisitions in support of Combatant Commands.

IDA also contributes to a number of key intelligence initiatives, including activities related to DoD's efforts to counter improvised explosive devices in Iraq and Afghanistan, in support of which IDA has maintained 4 to 7 analysts in theater and other researchers in the Washington, DC area; intelligence transformation efforts carried out by the Joint Forces Command's J2 organization; cyber operations; and surprise technology and vulnerability analyses that include studies to determine the security of critical national infrastructures and systems.

Timely, accurate intelligence information is essential to commanders in the field and to decisionmakers at all levels in the national security community. IDA has a long history of conducting intelligence analyses in support of military and national intelligence sponsors, and our new intelligence division is helping us focus the cross-disciplinary expertise resident at IDA on the many challenges facing the intelligence community in an increasingly complex world.

Study Highlight

Sharing Counterterrorism Information

The Director of the National Counterterrorism Center (NCTC) asked IDA to conduct an independent review of the overall relationship between NCTC and the Department of Defense. The goal was to address concerns expressed by the Combatant Commands regarding NCTC's sharing of terrorism intelligence information and to recommend options for improving information sharing while still protecting sensitive sources and methods.

During the 60-day study, the IDA research team visited key DoD and intelligence community commands and agencies that are primary producers or consumers of counterterrorism intelligence and interviewed senior leadership in defense and national intelligence organizations.

Our investigation found major fault lines between operations and intelligence information, and between finished intelligence products and non-disseminated information with intelligence value. The IDA team also examined the Intelligence Reform and Terrorism Prevention Act and extant Director, National Intelligence (DNI) Directives concerning roles and responsibilities of the nation's counterterrorism enterprise. We also found a wide variance in both the DoD and intelligence communities on how this law and DNI Directives were to be implemented.

Our researchers concluded the following:

- *The intelligence community and DoD commands and agencies do not share all counterterrorism information with NCTC or among individual entities involved in countering terrorism.*
- *Cultural hurdles and a keen interest in protecting sensitive sources cause some collection agencies to consider themselves owners of the data.*
- *The intelligence community and DoD should adhere to roles and responsibilities already established in law and in directives.*
- *Information technology systems must be modernized and integrated to create a working information-sharing environment.*
- *The DNI must create incentives to share information; today it uses only sanctions against improper sharing.*

Based on these conclusions, IDA developed a number of recommendations that NCTC and DoD have implemented.

Joint Advanced Warfighting Division

The Joint Advanced Warfighting Division (JAWD) was formed by merging three IDA programs: the DoD-chartered Joint Advanced Warfighting Program (JAWP), established to serve as a catalyst for transforming U.S. military capabilities to meet 21st century challenges; IDA's Simulation Center, created to demonstrate potential applications of future technologies through simulation; and IDA's Combatant Command Program, a cross-division effort that involves IDA researchers on site at selected combatant command headquarters to improve links between the commands and Pentagon planning activities and to facilitate the networking of shared interests and perspectives among the commands.

The division's staff includes experts with advanced degrees in physics, engineering, mathematics, cultural anthropology, business, education, economics, political science, and history, along with individuals with combat experience in the armed forces (active and retired) and service in the Departments of Defense and State, the Central Intelligence Agency, law enforcement agencies, and academia.

The division's research centers on five areas:

- Developing joint operational concepts.
- Designing and executing joint experimentation.
- Collecting and analyzing lessons from ongoing operations, training, and experimentation.
- Developing new training and education approaches that emphasize adaptability and the lessons of contemporary and historical experience.
- Examining processes for faster delivery of new military capabilities to warfighters.

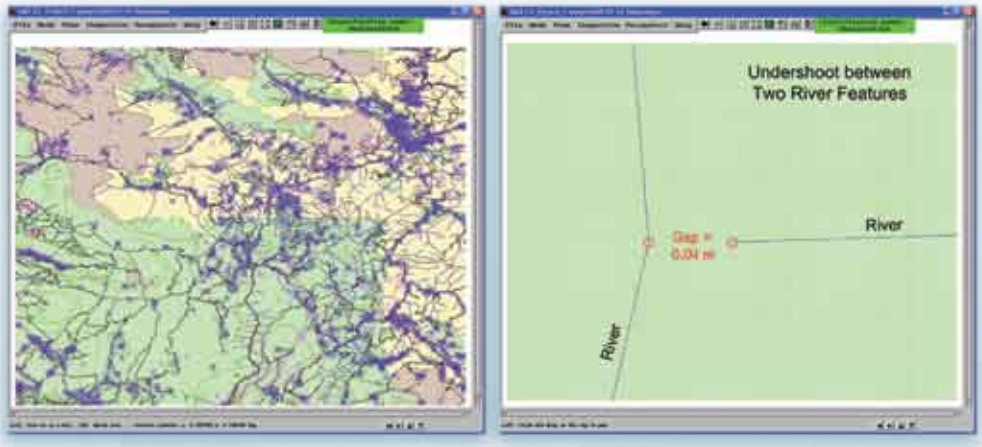
This past year, military and civilian members of JAWD served tours of varying length in Iraq and Afghanistan to improve understanding of lessons from current operations that might have implications for future DoD choices on force balance, training and education, concepts, and experimentation.

JAWD also published a series of papers providing insights on what the United States can learn from a deeper understanding of enemy perspectives. The papers addressing Iraqi perspectives paint a picture of Saddam's regime drawn from interviews with former senior Iraqi officers and government officials, Saddam's personal tapes, and documents captured from the regime. The papers addressing the perspectives of al Qaeda and associated movements are based on the writings of the movement's chief theorists and the ongoing discourse of adherents via various forms of correspondence. Together, this body of work constitutes an important way of looking at the strategic

challenges and opportunities posed by the thinking of adversaries. The effort focused on terrorists is described in more detail on the next page.

Other researchers continuously update software designed to identify errors in digital mapping, improving the quality and reliability of mapping products produced by DoD contractors worldwide.

Geospatial Analysis Integrity Tool



The National Geospatial-Intelligence Agency uses digital processes to produce traditional paper maps and charts as well as new digital products from geospatial databases. Digital data representations, however, present numerous opportunities for introduction of errors – often quite small – that adversely impact use of the data in increasingly sophisticated analytical applications.

JAWD analysts created the Geospatial Analysis Integrity Tool (GAIT), which automatically inspects geospatial feature and elevation data for attribution, geometric and topologic errors in far greater detail, efficacy, and efficiency than was ever previously possible.

The left image shows the GAIT project feature data for part of Montenegro (shown in color) with elevation data from the Shuttle Radar Topographic Mission (shown in shaded relief). GAIT analyzed 1 GB of source data in less than 4 minutes on a desktop personal computer and identified errors in the data, such as the gap between two river features (right image).

We now have researchers at five geographic Combatant Commands, helping to adapt and implement the IDA-developed Linking Plans to Resources (LPTR) concept. LPTR is an automated methodology that links combatant command resource needs to operational plans. It is changing how the commands identify, prioritize, and articulate operational needs, creating a common framework and lexicon for comparatively weighing requirements and resources in disparate mission areas.

Looking ahead, we will continue to support important aspects of DoD's transformation agenda, helping illuminate choices for the next Quadrennial Defense Review. At the same time, we will continue to provide direct support – both on site and through reach-back – to U.S. forces in Iraq and Afghanistan, helping to develop strategy options.

Study Highlight

Terrorist Perspectives Project

Following the opening phase of Operation Iraqi Freedom, one of our JAWD analysts interviewed senior military and civilian officials of Saddam Hussein's regime to capture their perspectives of the war. We combined these interviews with information gleaned from thousands of captured documents, tapes, and maps to develop a picture of Saddam's era in power. This work opened new windows into the inner workings of his regime.

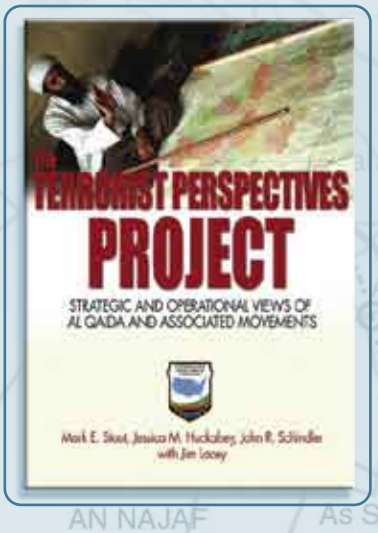
The success of our work in Iraq inspired a counterpart effort, the Terrorist Perspectives Project, to see what could be learned by applying a similar approach to collecting and analyzing the discourses, writings, and pronouncements of al Qaeda and associated movements (AQAM) regarding their transnational struggle.

This project has built a strategic understanding of AQAM. According to our analysis, AQAM views itself as a movement, rather than a loose grouping of tactical networks. The movement's intellectual leaders believe they must spread their interpretation of Islam to all Muslims, measuring progress by the percentage of those who rally to their banner.

We also found that AQAM's intellectual leaders are concerned about the uncoordinated, counterproductive actions of members who engage in violence for expressive purposes and who often seek only martyrdom. AQAM leaders realize the collateral damage such undirected violence inflicts is counterproductive, driving people away from the movement.

To help U.S. leaders better understand AQAM, our researchers have conducted outreach efforts to promulgate the study's findings. The study team, a mix of active-duty military officers and IDA civilian analysts, has conducted more than 100 briefings of the project results and is regularly included as part of the curriculum at Joint and Service military educational institutions. An unclassified version of the study report was prepared for publication by the U.S. Naval Institute Press in March 2008.

IDA has applied its understanding of AQAM to develop ways to combat the movement. For example, one of our findings – that AQAM's leadership is concerned that they are losing the war of ideas to the United States and its partners and is failing to attract enough Muslims to their banner – has caught attention of the policy community, and the study team has offered ideas for building on these concerns.



Operational Evaluation Division

The Operational Evaluation Division (OED) was formed in 1984 with the primary mission of supporting DoD's office of the Director, Operational Test and Evaluation (DOT&E), which was established by Congress in response to concerns about the independence of testing for new weapon systems. DOT&E turned to IDA for analytic support because of our impartiality and freedom from affiliations with industry, and because of the continued high quality, objectivity, and rigor of our analyses.

We have comprehensive knowledge of military systems and of the issues underpinning successful test and evaluation programs. These capabilities enable IDA to provide analytic support across the full range of DOT&E's oversight responsibilities for operational and live fire testing. The work spans a range of activities from evaluation planning and test design to data analysis and reporting of test results. Our researchers observe field testing, where they gain valuable perspective on how tests are conducted and how to understand and interpret results.

Over the past year, our researchers developed a test and evaluation concept paper for the EA-18G Airborne Electronic Attack (AEA) system, which provided an analytical basis for evaluating operational effectiveness, suitability, lethality, and survivability. The concept outlined an end-to-end mission focus that helped shape resource and scenario development for operational testing. IDA analysts and DOT&E officials will use the concept as a basis for reviewing EA-18G test plans, assessing test results, and supporting acquisition decisions throughout the development and production phases.

Based on its observations of tests and on broad access to data collected during the testing process, IDA supports DOT&E's assessments of the performance of new weapons systems, examining the factors critical to demonstrating that desired mission capabilities – effectiveness, suitability, and survivability – are actually achieved. During the past year, we observed tests

OED Research Staff Member Dr. Robert Atkins (third from left) aboard the *San Antonio* (LPD 17) class of amphibious transport dock ships. OED researchers, in support of DOT&E, often travel to the test sites and observe the testing in the field. From these first-hand observations, they gain valuable perspective on how tests are conducted and how to understand and interpret their results.

and prepared analytical reports on new systems across the spectrum of warfare areas. In land warfare, examples included the Army's new generation of helicopters – the latest model of the UH-60 Blackhawk assault helicopter, the CH-47F cargo helicopter, and a new commercial-derivative light utility helicopter. For these programs, we developed metrics for mission success that enhanced operational test realism and became the centerpiece of DOT&E's report to Congress.

This past year we also contributed to assessments of various Navy systems, including a new radar for the F/A-18E/F, upgrades to *Ohio*-class submarines, the *Virginia*-class attack submarine, and upgrades to the MK-48 torpedo. The division also assessed Air Force systems, including models for evaluating AMRAAM air-to-air missile upgrades, and joint programs, including ballistic missile defenses, and sensors for chemical and biological defenses. IDA analyses continued to stress the importance of assessing systems in the context of the full end-to-end sequence of mission events in realistic operational environments.

Recently, both in Afghanistan and Iraq, DoD has sought to deploy new weapon systems into combat as rapidly as possible, and the testing community is working to ensure that these new capabilities are effective, with any limitations clearly understood and, where possible, corrected. To aid in this effort, IDA researchers have observed expedited testing and assessed a number of systems, including new precision GPS-guided multiple launch rocket system rockets and Excalibur artillery rounds, Stryker armored vehicles, warning and jamming systems for U.S. helicopters to defend against man-portable infrared guided missiles, and the Mine Resistant Ambush Protected (MRAP) transport vehicles. For MRAP, we provided the concept around which the testing for jammers designed to counter improvised explosive devices was constructed. The IDA team also helped identify data shortfalls for urban operations and design test events to overcome them.

Study Highlight

SAFETY Act

The number and financial magnitude of legal actions following the terrorist attacks on September 11, 2001, led to concerns that deployment of future technologies for homeland security could be impeded by liability risks. In response, Congress passed the Support Anti-terrorism by Fostering Effective Technologies Act of 2002 (the SAFETY Act), which limits legal liabilities to the developers of anti-terrorist products and

services. IDA supports implementation of the SAFETY Act by independently assessing technical capability and efficacy, the need for liability protections, and insurance and financial information.

IDA's technical and economic expertise is uniquely suited to conducting the in-depth analyses of anti-terrorism technologies for which industry is seeking SAFETY Act protections. The technologies have included explosive detection systems; chemical, biological, and radiological sensors; blast resistant materials; vulnerability assessments; and security services, including event security for the Super Bowl. To augment in-house capabilities, we reach out, as needed, to other federally funded research and development centers, other non-profit organizations, the federal government, and academia to ensure that each technology is reviewed by subject-matter experts. IDA also has developed a secure method of obtaining and archiving information via a Department of Homeland Security (DHS)-accredited Web site and information technology system.

The comprehensive, IDA-developed review procedures evaluate each application against the technical and economic criteria specified in the Act. The results of the review are provided to DHS, which determines the level of protection, if any, granted to the applicant.

Through a disciplined process of technical reviews, refined over several years, the IDA team was able to assist DHS in lowering the average processing time of a SAFETY Act application from 163 days in 2006 to 113 days in 2007, while continuing to produce high-quality independent evaluations.

In 2007, IDA played a critical role in the first SAFETY Act Workshop, providing detailed information about technical and economic requirements of the SAFETY Act.

Due to these and other achievements, in 2007 IDA received the DHS Under Secretary, Science and Technology's Award for Outstanding Contractor, and the DHS-IDA SAFETY Act team received the DHS Secretary's Award for Team Excellence.

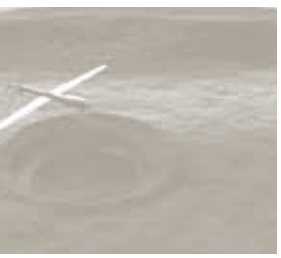
The combined IDA and Department of Homeland Security SAFETY Act team received the 2007 Under Secretary's Award for Program and Contractor Support.

Science and Technology Division

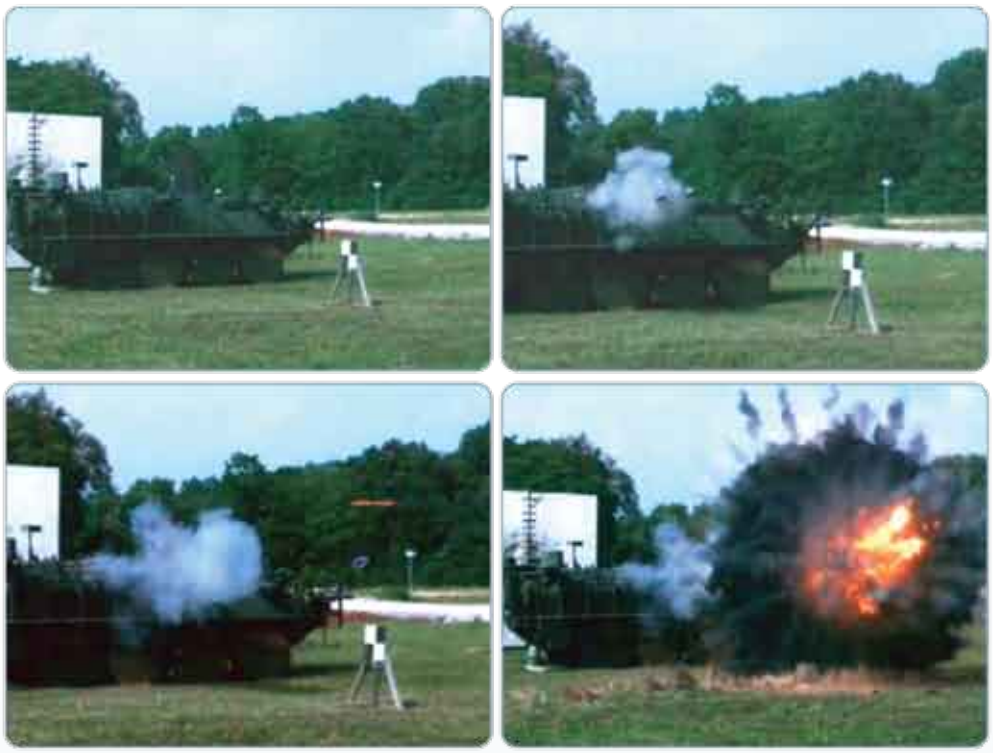
Bringing nationally recognized, interdisciplinary scientific and technical expertise to support our warfighters is the core Science and Technology Division (STD) activity. Since its creation in 1960, when Dr. Herbert York, the first Director, Defense Research and Engineering (DDR&E), requested that IDA assemble a group of outstanding scientists and engineers to advise him on critical national security issues, STD has been providing the national security enterprise with high-quality and objective analyses.

Today, after almost half a century, the need for such objective technical advice is even more acute. Virtually every weapon system, sensor, secure communication network, platform – land, sea, air, or space – and intelligence system being considered or under development incorporates state-of-the-art technology. And current limitations in U.S. operations are being remedied through applications of new technologies that enable new concepts of operations. To enhance our support to national security, STD has focused on honing three key capabilities:

- *Evaluating Program Technology Risks and Options*. Free from commercial and Service advocacy, STD assesses DoD programs' technical risks and recommends risk-mitigation strategies. Understanding the technical readiness of the program is crucial to adequately budgeting resources to ensure mission success. STD also works with sponsors to develop, execute, and analyze a comprehensive technology test plan to provide an unbiased examination of program performance.
- *Developing and Evaluating Innovative Concepts*. Working with experts across IDA, STD assists the Department of Defense in developing and evaluating innovative concepts that promise a tremendous improvement in either mission effectiveness or cost. These concepts generally exploit new discoveries in science or technology and require a rigorous technical analysis to assess potential efficacy. If these concepts are shown to be technically feasible, our cross-divisional efforts can assess the full programmatic details, from developing a detailed technology roadmap, to identifying impact on training or operations, to deriving a cost estimate. Often, the analyses identify alternative concepts that might achieve the mission objectives more efficiently.



Active Protection Systems



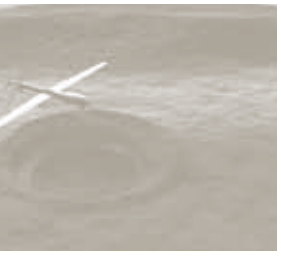
Active protection systems (APS) are under development and testing to provide a means for military vehicles to counteract enemy weapons such as rocket-propelled grenades. This sequence shows how a vehicle-mounted APS might detect and track such a threat and fire a directed munitions blast to destroy it. In 2007, IDA studied the utility of the APS concept for combat vehicles in response to congressional legislation. This study is being followed by a second in 2008 that includes lighter-weight tactical vehicles.

- *Assessing Disruptive Technologies and Technological Opportunities.* Crucial to ensuring the success of our national security enterprise is avoiding technological surprise. Equally important is avoiding overly optimistic assessments of new technologies, thereby diverting precious resources to develop innovative, yet physically impractical, technologies. By remaining grounded in analyses, STD provides national security professionals with an understanding of global technology trends and the impact of emerging advances on their missions.

Over the past year, STD supported its sponsors through technical analyses that affected several critical national security challenges. For example, STD identified vulnerabilities in technologies being deployed in theater to defeat improvised explosive devices and recommended a means to reduce these vulnerabilities. Our staff has been analyzing innovative

concepts proposed to detect weapons-grade nuclear material in shipping containers. Working with others across IDA, STD is helping to protect U.S. troops by assessing active protection systems used in combat land vehicles and proposing specific ways of making the systems more robust. In addition, we have been working with multiple sponsors across the Department to integrate and synthesize data collected from intelligence, surveillance, and reconnaissance assets to better identify threats to our forces.

The DDR&E in its recent Strategic Plan states, "While transformation can occur from changes in doctrine and force employment concepts, technology has been, and remains, a key driver to capabilities-based transformation." As partners with the Department of Defense for half a century, IDA and STD are poised to meet the evolving threats and to provide the Department the scientific tools, expertise, and knowledge required to defeat those who seek to harm our nation.



Study Highlight

Defending the United States against Nuclear Weapons

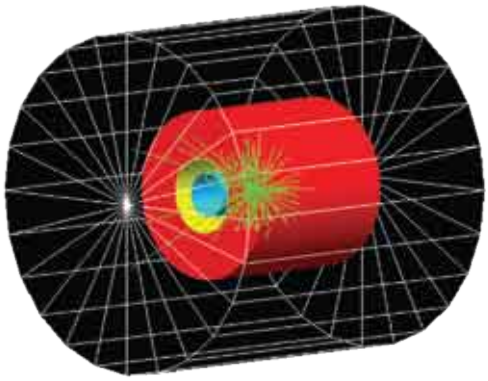
In a changing world, where a bipolar strategic power structure, stabilized by mutually assured destruction, is no longer operative, a new paradigm of detection and interdiction is arising. IDA's Science and Technology Division, together with the Strategy, Forces and Resources Division, has built analytic capability in nuclear science and technology that meets the technical challenges posed by this new paradigm.

Ballistic missile defense assumed that the most likely mode of nuclear attack on the United States was through space. Now, however, the United States assumes that clandestine delivery by private or commercial traffic over land, sea, or air is also plausible. Because manual search of all traffic entering and leaving the United States is not an economically viable defense option, IDA has helped develop concepts of operation for automated detection of fissile materials and is evaluating detection systems designed for this purpose.

Technical means to enable standoff detection of small numbers of hidden, shielded weapons will require novel approaches, such as active interrogation. In this concept, a beam of particles or radiation induces a strong signature in the target of interest. IDA is analyzing the possible beam/signature options to

determine whether the induced signatures might exceed both natural backgrounds and the other beam-induced signatures from structural and naturally occurring materials. In addition, we are assessing the possibility of alternative paths to nuclear weapon development that may not require a large industrial infrastructure.

Ge Well Detector



Part of IDA's assessment of detector concepts for fissile material detection, the image above shows intermediate results of simulated gamma ray interactions with detector components.

Unlike a nuclear attack by an intercontinental ballistic missile, a clandestine terrorist attack will not have a clear signature of the identity and location of the perpetrator. Identifying the originator of the attack will depend on post-detonation forensic analysis of weapon residue. IDA is completing a Forensics Collection Technology Study to identify viable systems concepts for collecting samples in the post-attack environment. This includes scrutinizing the potential of robotic collection systems, since the most valuable samples will also be the most radioactive and least accessible.

In the Cold War scenario, a high-altitude electromagnetic pulse (HEMP) attack was regarded as a prelude to a large-scale exchange, designed to reduce effectiveness of strategic military systems. Current scenarios must include the possibility that a standalone HEMP attack would target civil infrastructure. IDA reviewed the phenomenology of EMP from high-altitude bursts and analyzed the possible effects of EMP on the U.S. power grid.

Finally, the Cold War threat to the physical security of U.S. nuclear weapons in DoD custody was presumed to be an agent of a foreign government whose objective would be to steal a weapon to glean intelligence or for blackmail. Now, the threat must encompass those who would want to detonate the weapon in place. In a recent assessment of DoD nuclear weapons physical security, IDA analyzed the dozen or so nuclear weapon configurations in terms of threat, vulnerability, and remediation cost metrics and made recommendations that will help prioritize security enhancements.

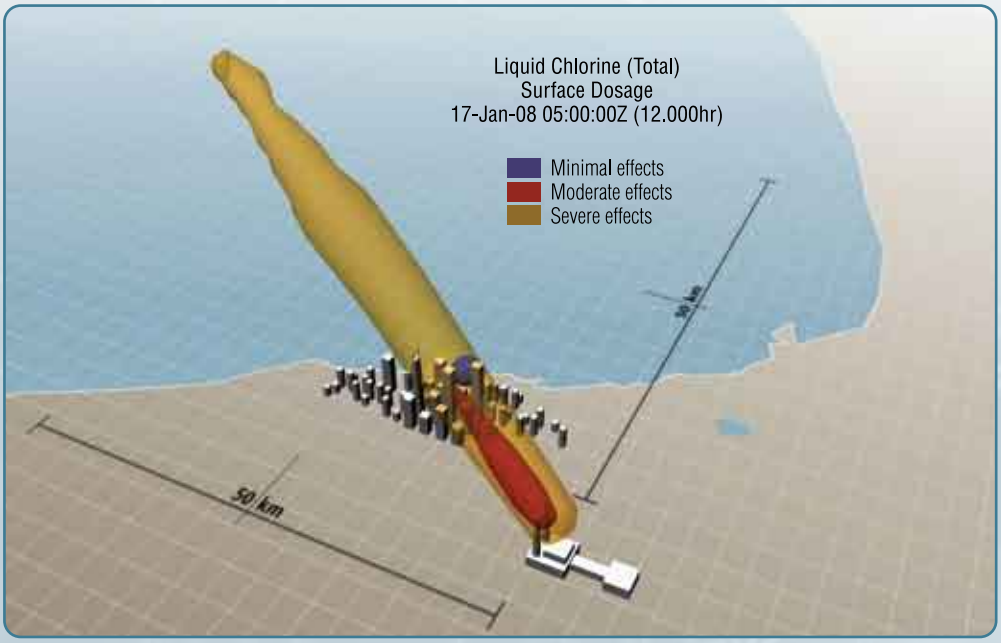
Strategy, Forces and Resources Division

When IDA was established, the research focused initially on systems and technologies. To help provide context for this work, and to meet a wide range of other sponsor needs, IDA formed the Strategy, Forces and Resources Division (SFRD), which conducts interdisciplinary studies of broad policy, strategy, and long-range planning issues; the capabilities of military forces and homeland defenses; defense support and infrastructure; and organizational and management studies.

For several years, we have been developing new defense planning scenarios for use in force capabilities assessments, program development, and long-range planning activities.

In support of DoD planning processes, we have developed improved analytic tools for assessing and managing overall force and program risk. These tools are intended to inform decisionmaking during Quadrennial Defense Reviews, as well as in the annual planning, programming, and budgeting processes.

Effects of a Chemical Release Caused by Industrial Sabotage



Modeling suggests that a release of chlorine resulting from industrial sabotage in an industrial area outside Chicago could potentially affect thousands of people if winds were to blow the chlorine toward the downtown area.

The demand for Asia-Pacific studies has increased significantly in recent years. Our researchers have analyzed the political and economic dynamics of North Korea; applied game theory to gain insights concerning nuclear strategy for East Asia; and analyzed terrorist organizations, their motivations, and support networks in Asia. We also have established small teams of force planning and programming experts to assist U.S. security partners – mostly Asian countries in recent years – in planning and managing their military establishments.

IDA has conducted numerous studies of the capabilities of U.S. forces to defend against chemical and biological weapons, examining everything from initial agent detection through medical treatment of casualties. While we continue to analyze the defense of U.S. military forces, other recent efforts have focused on the protection of civilian populations against terrorist attacks. During the past year, we examined the relative likelihood of chemical and biological attacks of various sizes in different operational scenarios and completed the first comprehensive assessment of chemical and biological warfare training across the Services.

For many years, IDA has been analyzing U.S. counterdrug operations. This work has now been extended and broadened to include interdiction of various contraband materials in the context of potential terrorist threats to the homeland. For example, our researchers have studied the direct and indirect (deterrence) effects of maritime cordons and of nuclear sensor networks deployed around urban areas. Some of this research involved interactions with state and local officials. We also developed and tested risk assessment/management techniques for prioritizing the defense of U.S. critical infrastructure against terrorist attacks.

A recent organizational and management study examined the need for a "Chief Management Official" in DoD and alternative organizational levels and authorities for such a new position. This study, requested by Congress, provided the analytic underpinnings for recent legislation on this topic. Another study focused on the Special Operations Command's new responsibilities as the proponent for Special Operations Forces manpower across the Services.

IDA work on manpower supply – recruitment, compensation, and retention – included key studies addressing Reserve Component mobilization, compensation, and employer-support issues.

We anticipate a continued increase in sponsors' needs for the kinds of broad policy, strategy, force capabilities, and organizational studies conducted in this division, as DoD and other sponsors strive to deal with the complexities of the international environment, day-to-day operational demands on military forces and other U.S. capabilities, and growing budget pressures.

Study Highlight

Defense Planning Scenarios

Defense Planning Scenarios (DPSs) lay out critical mid- and longer-range challenges that DoD, with U.S. interagency and foreign partners, must be prepared to handle. Scenarios, which can range from preventing electromagnetic pulse attacks to counterinsurgency operations against Islamic extremists trying to depose friendly regimes, describe basic planning assumptions for these hypothetical contingencies. The assumptions include the plausible timing and magnitude of challenges, likely allied help, and major limits on U.S. access to foreign bases and territory.

For several years, IDA has helped design a "living library" of scenarios that provides DoD's leadership with a menu from which to choose and then promulgate the top-priority challenges. The scenario library also establishes a broad test-bed of plausible cases – across all types of military operations – for DoD to assess its capabilities and, potentially, the risks of relying on the planned future force to meet those crises. In addition, the scenario development process itself effectively links DoD organizations with interagency partners and close allies in vital strategic planning efforts.

IDA developed a four-step process for building scenarios.

1. *For each scenario, IDA sets up a high-level, independent panel – which consists of senior professionals such as former secretaries of defense, combatant commanders, and U.S. ambassadors – that works with an experienced, interdivisional team of IDA analysts to craft several "challenge" options.*
2. *The Deputy Secretary of Defense selects one or more of these options for further development.*
3. *IDA assembles a senior interagency group, including representatives from the National Security Council and the Departments of Defense, State, Treasury, and others (including close allies whenever feasible) to devise a strategic concept to address the selected challenges.*
4. *IDA integrates all parts into a full scenario for final coordination and approval by the Deputy Secretary.*

We are currently developing several new scenarios, including "meta-scenarios," which combine numerous individual DPSs into an illustrative, year-by-year security future spanning the next decade. A meta-scenario features a time-line of ongoing U.S. operations and major crisis scenarios with associated time-phased demands for capabilities and forces. While nobody expects the future to unfold exactly as postulated in this work, it is intended to improve DoD's abilities to prepare for and respond rapidly to whatever challenges do occur.




System Evaluation Division

The System Evaluation Division (SED) is IDA's oldest research division, tracing its origins to the formation of IDA in 1956. SED's mission – to provide high-quality analyses of the performance of air, land, sea, and space-based systems – has changed little over the years. The subjects of our analyses and the operational context for the work have changed significantly, however, as the result of revolutionary advances in technologies, new threats, and the continuously evolving international political environment.

SED also examines the overall capabilities of military forces that use these systems, analyzes mission needs, develops system architectures, investigates new operational concepts, estimates the risks that accompany technological integration, and, with help from IDA's Cost Analysis and Resaerch Division, assesses the cost-effectiveness of alternative approaches for meeting mission needs. These analyses help sponsors choose among competing programs, set force or inventory levels, and identify suitable concepts for employing systems in realistic operational environments.

This year, we analyzed alternative mixes of Short Take-Off Vertical Landing (STOVL) and carrier-launched (CV) variants of the Joint Strike Fighter (JSF) aircraft now in development. The study was conducted to help the Department of the Navy decide how many of each variant to buy to best meet Navy and Marine Corps needs.

Responding to congressional direction for an independent study of the bomber force structure, DoD asked IDA to examine the effectiveness of alternative future bomber forces in a wide variety of possible conventional and nuclear contingencies. The study focused particularly on the numbers of B-52 bombers that should be retained in the active inventory.

Our efforts in the area of system trade studies and technology integration included support for U.S. efforts to counter improvised explosive devices (IEDs), where we have been assessing alternative technologies for countering the next generation of radio-frequency controlled IEDs. (This effort is described in more detail on page 28.)

In recent years, IDA has conducted several studies on integrated air and missile defenses. One effort examined tradeoffs among alternative architectures of sensors and command and control systems for integrating cruise missile defenses into the U.S. air and ballistic missile defense forces. We are also analyzing the potential contributions of automated battle management aids.

We also continued assessing hostile cyber intrusions, which included an analysis of the effects of intrusions into a U.S. defense contractor's unclassified computers. One of the results of our research is an ongoing examination of the

need to change the policy for reporting incidents of cyber intrusions of defense industry IT systems.

Other recent systems studies included:

- An analysis of alternative designs for the Next Generation Bomber.
- An assessment of the planned Space Radar program.
- A tradeoff study of airborne and space-based signals intelligence systems.
- The development of a methodology for determining the fully burdened cost of providing fuel to military systems.
- Continued analyses of the capabilities of unmanned aerial vehicles.

For the future, we anticipate a continuing need to address counterterrorism and irregular warfare, integrated ballistic and cruise missile defenses, and tactical communications systems. We also expect to be examining alternatives for upgrading the U.S. airlift fleet, providing ballistic missile defense in Europe, and developing space tracking and surveillance systems.

Study Highlight

Countering Future IED Threats

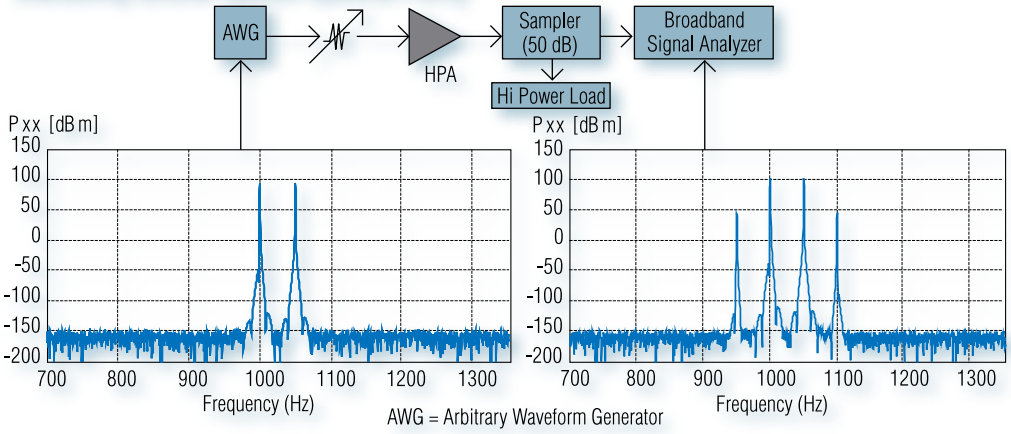
Countering IEDs continues to be an important challenge for the United States. For radio-controlled IEDs (RCIEDs), which can be assembled in secret and quickly emplaced, there is relatively little risk for the user. U.S. forces, interagency personnel, allied military forces, and civilian populations are all potential targets of RCIEDs that could be employed by enemies with relatively limited resources.

IDA led a multi-FFRDC team to assess the technologies needed to develop and field a future system, called the Joint Service Counter RCIED Electronic Warfare (JCREW) system, to counter this threat.

The team raised the following key technological issues:

- *Power amplifier designs for JCREW must meet simultaneous and mutually uncongenial requirements. The designs must have high power for good standoff range, be highly efficient to function within available prime vehicle (and man-portable) power sources, and have high spectral purity to be compatible with communication services.*

Evaluating JCREW System Spectral Purity



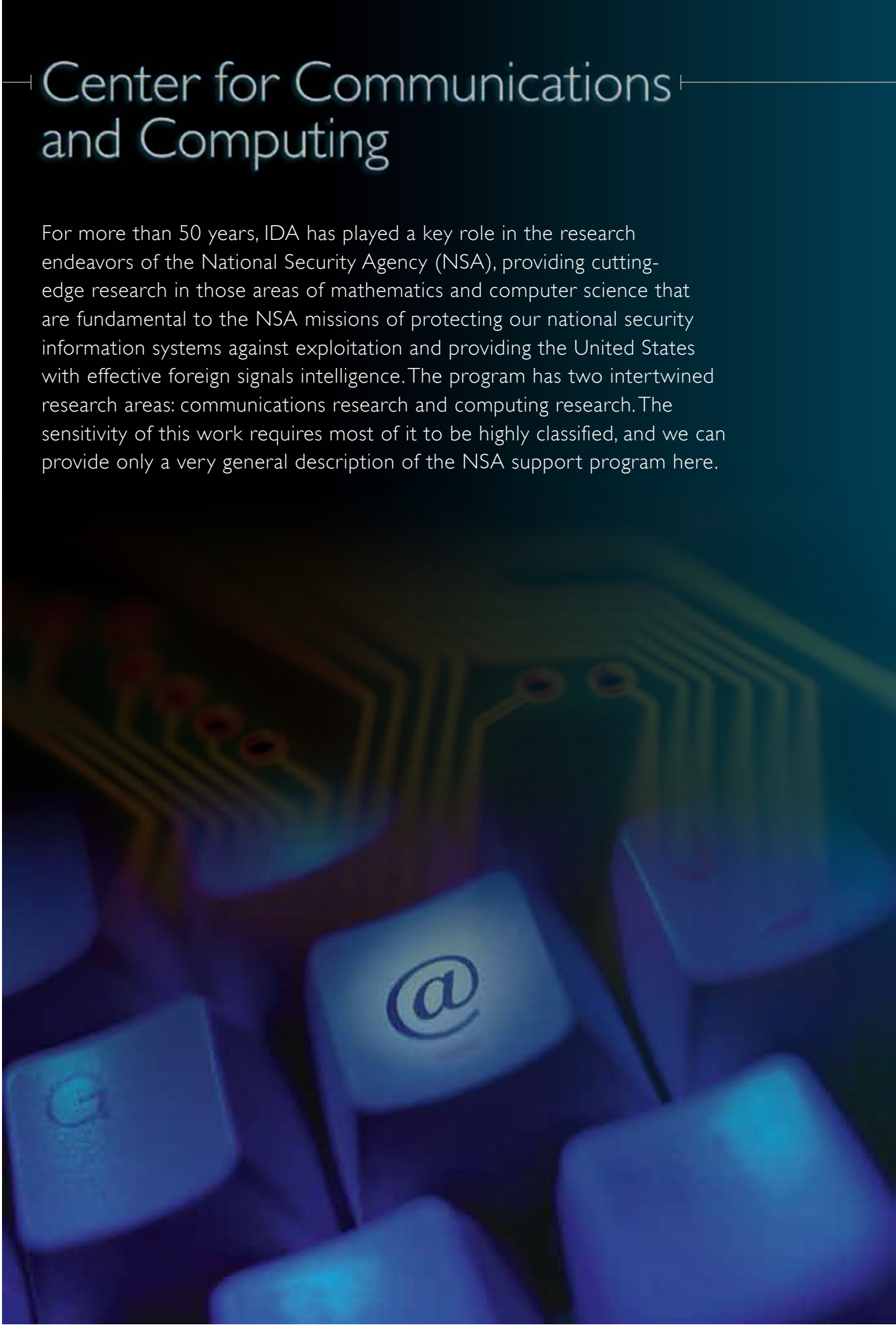
IDA investigated several causes of degradation to JCREW systems spectral purity and identified one important contributor: intermodulation (IM) products, which are created when multiple tones are generated by a single high power amplifier. IDA and the Naval Explosive Ordnance Disposal Technology Division validated a straightforward model to describe this phenomenon and used this model to explore spectral purity issues in the context of a CREW system compatibility. Amplification of two input carrier frequencies (on the left) leads to additional undesired IM products at the output (right), and their characterization is captured by these two-tone measurements. Here, the two input tones generate two in-band IM products.

- *The system architecture must be flexible to support rapid counters to as-yet undetermined threats. The commercial communications technology base is multifaceted, and specific directions cannot be predicted. There are a host of potential devices (e.g., Bluetooth, Zigbee, WiMax, and "cognitive radio") that could be used to trigger IEDs but not all will emerge as threats.*
- *As advanced commercial technologies are incorporated into future IED threats, challenges will multiply: The electromagnetic background environment may no longer be segregated in distinct bands by service (e.g., cell phone frequencies); threats may cohabit the same spectral space as friendly systems; U.S. countermeasures must develop more efficient means for classifying signals as hostile, suspect, or friendly; and instead of reacting to each new signal detected, future JCREW systems will have to develop and maintain electromagnetic environment situational awareness in order to determine responses.*
- *Antenna-vehicle integration and electromagnetic performance must be considered simultaneously to maintain adequate performance and avoid dead zones in the vicinity of a JCREW-protected vehicle.*

Currently, the IDA team's efforts are focusing on analyzing electromagnetic environment background data, studying vulnerabilities of modern communications systems, assessing transmitter chain architectures, validating modeling and simulation tools, and developing protocols for JCREW system component test and evaluation.

Center for Communications and Computing

For more than 50 years, IDA has played a key role in the research endeavors of the National Security Agency (NSA), providing cutting-edge research in those areas of mathematics and computer science that are fundamental to the NSA missions of protecting our national security information systems against exploitation and providing the United States with effective foreign signals intelligence. The program has two intertwined research areas: communications research and computing research. The sensitivity of this work requires most of it to be highly classified, and we can provide only a very general description of the NSA support program here.



Communications Research

The IDA Centers for Communications Research (CCR) in Princeton, New Jersey, and La Jolla, California, employ mathematics to create and analyze the complex algorithms used to encipher vulnerable communications. As the modes and means of modern communications become more complex, the Centers have expanded their research into other areas including speech, the processing of signals to remove noise and distortion, and network security.

The constantly changing intellectual terrain has introduced new mathematical problems that must be solved so that NSA can perform its mission. While our researchers were trained primarily in mathematics or related areas, they are knowledgeable about a variety of areas in the mathematical sciences and stay abreast of this ever-widening field through education and collaboration. Thus, when a problem cannot be solved by known methods, serendipitous insights often come from different areas of mathematics that are used in novel ways. Indeed, much of CCR's success comes from collaboration in teams, rather than research by a single investigator.

Academic mathematicians and computer scientists contribute to CCR's work by attending workshops and conferences, which are held at each CCR site. By far the most important of these is the summer study program known as SCAMP where, for 8 to 10 weeks, visiting mathematicians – typically full-time faculty or graduate students – work side by side with CCR's full-time staff and visitors from NSA, focusing on a few specific problems each year. The influx of new people and ideas throughout the history of this program has led to numerous solutions to important NSA problems.

Computing Research

Developing and using the best in high-end computing has always been an important part of the research program at the Center for Computing Sciences (CCS). This mission, however, has broadened over the years to reflect global political and technological changes 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 carry out its mission, CCS focuses the skills of some of the country's best computer scientists, engineers, and mathematicians, using all aspects of computational science to solve intelligence-related problems of importance to national security and beyond. In fact, parts of the problem set we confront extend beyond the defense and intelligence communities to the entire computing science world and are addressed in many different settings. An important component of the CCS mission, therefore, includes initiating such discussions with academia and industry.

Among the problem sets CCS is working on is the development of high-performance computing platforms. Senior technology policymakers have concluded that continued development of these platforms will require government research and development support. The amount of computing power needed to meet the specialized requirements of the most demanding national security-related computations will far exceed the capabilities of even the most advanced designs of the next-generation laptop machines with parallel computers. For use in our problem set, these devices need architectural modifications and use of even more advanced technologies. CCS's depth of experience in NSA's most advanced computing problems; our active collaborations with Defense Advanced Research Projects Agency and the Department of Energy's Lawrence Livermore National, Los Alamos, Sandia, and Oak Ridge National Laboratories; and our sustained and vigorous dialog with many of the leading U.S. makers of high-end computers enable us to provide significant insights into this challenge.

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.

Adding complexity to this topic is the fact that adversaries of the United States "live" on the same World Wide Web and use the same technology as U.S. entities. Hence, the traditional distinction made between two NSA missions – protecting data and collecting data – is far from clear;

indeed, a new, blended mission is developing. Both CCS and CCR are working closely with NSA to bring the best talent to bear on the scientific problems generated by this blending.

Study Highlight

Counting Lattice Paths

Because the path from basic math to direct application and exploitation is not always clear, IDA researchers continue to attack challenging mathematical problems at both ends of the basic/applied continuum. One result of such basic research is a recent discovery made by researchers at the Center for Communications Research in Princeton, working jointly with visiting professors at the Heilbronn Institute for Mathematical Research in Bristol.

A particle that moves in a plane by always taking discrete jumps either rightwards or upwards traces out a zigzag trajectory called a lattice path. *The problem of enumerating lattice paths is a fundamental mathematical problem that has numerous applications, including statistical mechanics and random walk theory, as well as the statistical analysis of election races.*

Suppose we impose the constraint that our moving particle must stay between two boundary lines, namely the vertical y *axis, and the sloping line with equation* y = mx. *Then it has been known since 1887 that, provided the slope* m *is a whole number, there is a surprisingly simple formula for the number of lattice paths from the origin to the point* (x, y)*:*

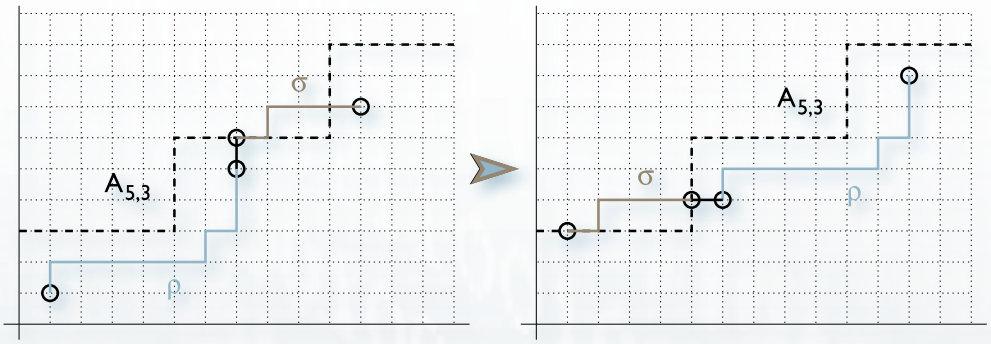
$$\binom{x+y}{x} - m\binom{x+y}{x-1}$$

where the expressions $\binom{x+y}{x}$ *and* $\binom{x+y}{x-1}$ *are* binomial coefficients *from the famous binomial theorem. This formula is derived by first counting* all *lattice paths, and then subtracting the lattice paths that illegally cross one of the boundary lines. That is why the formula has two terms, one subtracted from the other.*

Surprisingly, if the slope m *is a fraction, then the formula no longer holds,*

and, in fact, no simple formula is known. However, in 2006, our researchers made the remarkable discovery that a simple formula can be obtained if the straight line of fractional slope is replaced by a zigzag line. By cleverly cutting and reassembling a lattice path (shown by the colored line in the figure below), one can again derive the formula by counting all paths and subtracting the paths that illegally cross the zigzag boundary (shown as a dashed line).

Lattice path transformation

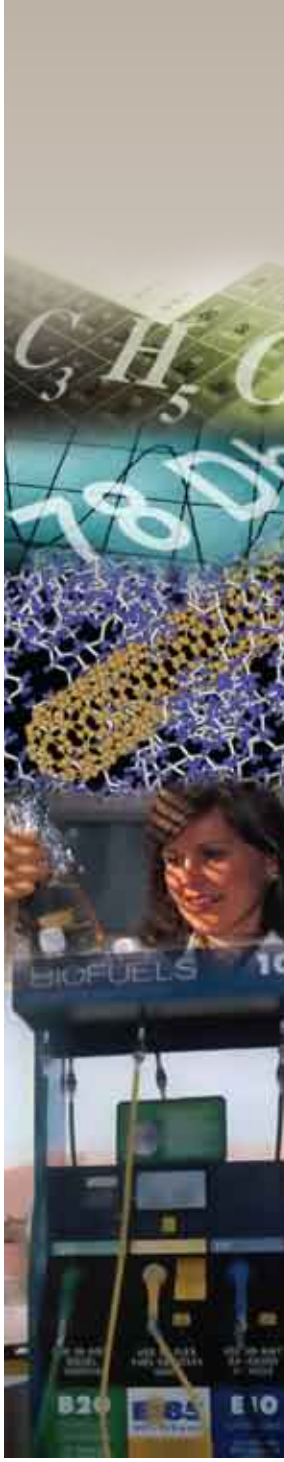


Despite the simplicity of the formula, it had remained overlooked for more than a hundred years. It is not yet clear what the ultimate implications of this breakthrough are, but exact enumeration formulas in statistical mechanics have a history of yielding important physical insights. This new formula, therefore, remains an intriguing object for further research.

Science and Technology Policy Institute

Chartered by an act of Congress in 1991, the Science and Technology Policy Institute (STPI) provides timely and authoritative analysis of significant science and technology developments in the United States and abroad for the White House Office of Science and Technology Policy (OSTP) as well as a growing number of other agencies within the Executive Branch of the U.S. government, including the National Institutes of Health and the Federal Bureau of Investigation.

Since its inception in December 2003 as an IDA-operated FFRDC, STPI has provided rigorous and high-quality support for OSTP on topics spanning the spectrum from the ethical, legal, and societal implications of nanotechnology research to aeronautics research and development; and from U.S. visa policies to efforts that facilitate international research collaboration. In carrying out its work, STPI consults widely with representatives from private industry, institutions of higher education, and nonprofit organizations and incorporates into its work the information and perspectives derived from these consultations.



The Science and Technology Policy Institute's (STPI) key functions are to:

- Assemble and analyze timely and authoritative information regarding significant S&T developments and trends in the United States and abroad, focusing on how these developments affect the federal research and development portfolio and interagency and national issues.
- Analyze alternatives available for ensuring the long-term strength of the United States in the development and application of S&T, including identifying the appropriate roles for the federal government and other sectors.
- Provide technical support for the President's Council of Advisors on Science and Technology and for committees and panels of the National Science and Technology Council.

This past year, STPI launched a new broad area that encompassed many fields associated with the competitiveness of the United States. Tasks included assessing the U.S. innovation ecosystem surrounding competitiveness in information technology, comparing the primary indices of competitiveness to identify measures that OSTP should track to understand the overall competitiveness of the U.S. economy, assessing offshoring, and completing a comparative study of international practices for engineering research and education.

Other STPI analyses included supporting the National Mathematics Advisory Panel and identified barriers to training biomedical researchers. We also examined the economic impact of export controls on the viability of the commercial satellite industry.

STPI's work for the National Cancer Institute this year helped the Institute understand how to make translational research, which takes research from the laboratory to the patient, more productive and efficient. In the area of scientific support infrastructure, STPI examined options for federal infectious disease information collection, analysis, and sharing. We also reviewed the scientific collections, such as geological samples and seed depositories.

STPI also provided support for OSTP in the area of aerospace policy. Here, we helped develop the National Aeronautics S&T Strategy and Plan, as well as assessed the implementation of the Operationally Responsive Space concept.

In the area of energy and the environment, STPI analyzed the lifecycle benefits and externalities associated with biofuels production, analyzed the federal portfolio of renewable energy research and development in support of a National Science Board panel, and reviewed the current state of weather modification research.

In the coming year, STPI will continue supporting OSTP, providing objective analyses for the America COMPETES Act, assisting the FBI in its violent crime studies, and helping craft OSTP's Science and Engineering Indicators.

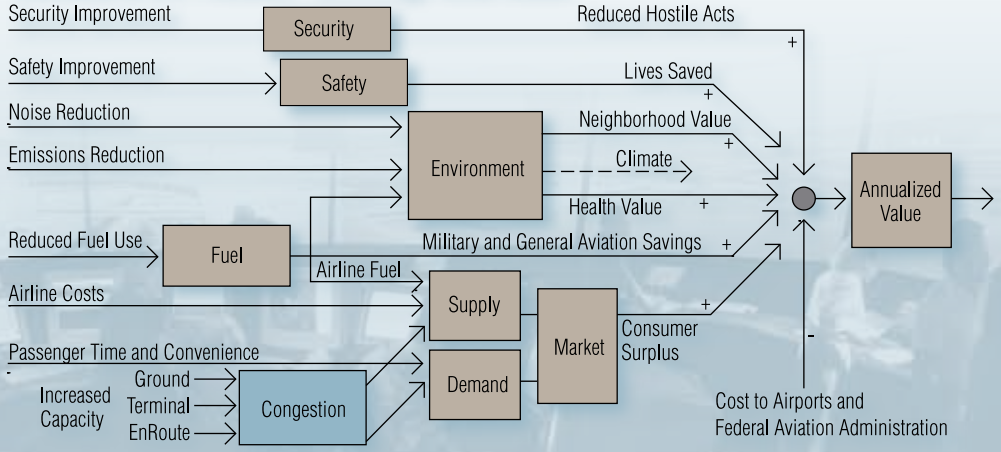
Study Highlight

The Next Generation Air Traffic Control System

In recent years, there has been explosive growth in air travel. One factor in addressing the increasing congestion in American skies is the Federal Aviation Administration's Next Generation Air Transportation System (NextGen) upgrade to the country's air transport system. NextGen is expected to double the current system's capacity. The President's Science Advisor, as a member of the committee overseeing NextGen's Joint Program Development Office, asked STPI to assess NextGen technology development options and their economic implications.

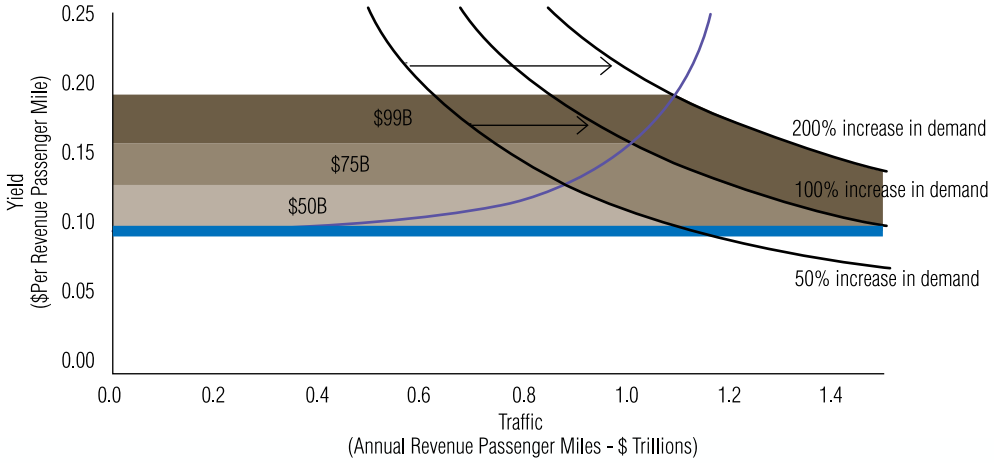
To do so, STPI developed the NextGen Value model, which assesses multiple technology options in terms of their quantitative impacts on outcome measures such as aviation capacity, safety, fuel consumption, and delay times. Together, these metrics were used to assess the economic value measured as consumer surplus in order to identify research priorities for the NextGen program. Our analysis determined that capacity-enhancing technologies could save the airline industry between $75 billion and $100 billion annually by enabling closer spacing of aircraft.

Elements of STPI NextGen Technology Value Model



The NextGen Value model enables the government to assess multiple technology options in terms of their quantitative impacts on outcome measures, such as aviation capacity, safety, fuel consumption, and delay times. These metrics were combined into an overall assessment of the economic value measured as consumer surplus and then used to identify research priorities for the NextGen program.

Economic Impact of Air Transportation Congestion



This graphic depicts the impact congestion has on decreasing the economic benefits of air transportation. The analysis uses as a baseline FAA's forecast of 2009 travel demand and air carrier costs. The blue line represents carrier costs per revenue passenger mile if there were no delays caused by congestion. The black curves are zero congestion demand curves for various levels of demand growth, which results from population growth and growing per capita income. The purple curve combines the effect of congestion delays on the supply and demand curves, so that, with congestion, market equilibrium is at the intersection of the purple and black curves.

If congestion were eliminated, market equilibrium would be where the black curve intersects the blue line. Therefore, the beige trapezoids represent the loss of consumer surplus (consumer benefit) as measured in dollars when the market equilibrium moves from the noncongestion point to that due to congestion. NextGen will reduce congestion delay, shrinking the purple curve and the beige trapezoids. (Dollar values are 2006 constant year dollars.)

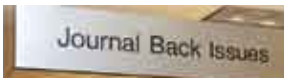
In terms of economics, our analysis found that airlines would be more willing to invest in advanced air traffic technologies if the airlines were provided economic incentives to do so. STPI determined that airlines would make NextGen investment decisions primarily based on the benefits of avoiding delays and cancellations in adverse weather conditions. However, these benefits vary greatly depending on the specific airline operations

By calculating the economic impact NextGen would have on airline operations due to reduced delays and flight redirection to avoid bad weather, STPI was able to evaluate profit opportunities based on the timing and capturing of benefits, and costs for the major airlines. This analysis clearly showed that the rate of return would be too low for most airlines to make the required investments.

Thus, STPI concluded that if NextGen is to succeed, the government needs to consider providing airlines with economic incentives for equipping with the emerging capacity-improving technologies. The study also concluded that while there is little benefit to airlines for reducing delays in good flying conditions, airlines would benefit from new policy measures such as introducing fees for services used or congestion prices, and by restricting congested air space to those airlines equipped for NextGen.

IDA Community

IDA's mission is to bring the best scientific and analytic minds to bear on the most important issues of national security. Our reputation for excellence has been earned by our people – individuals of exceptional creativity, expertise, and determination who work closely with our sponsors and each other. Our staff are a mix of professionals whose diversity of talent and expertise provide IDA with the platform for a truly multidisciplinary approach to our sponsors' challenges.

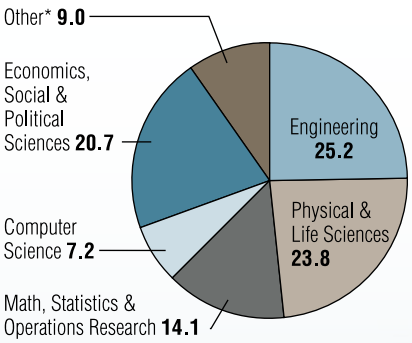


Service – Quality – Independence – Respect

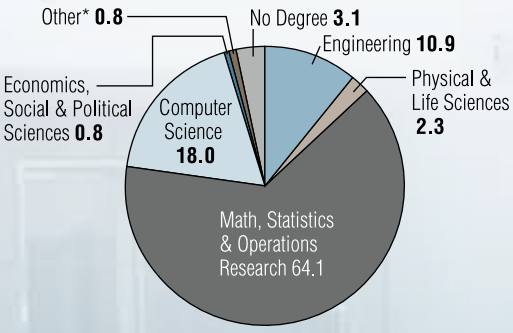
IDA's core values – providing service to our nation, conducting quality research, maintaining our independence and integrity, and respecting one another – are the cornerstones of our organization. The strength behind these words, and our ability to provide the caliber of research for which we are known, is driven by the men and women who work at all of our FFRDCs.

IDA Staff at a Glance

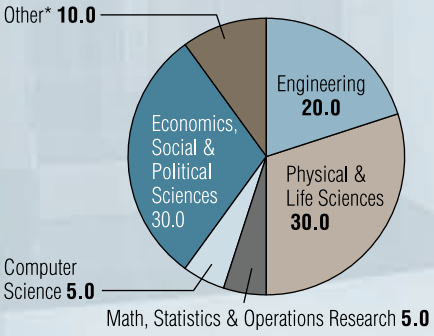
Studies and Analyses Center



Center for Communications and Computing

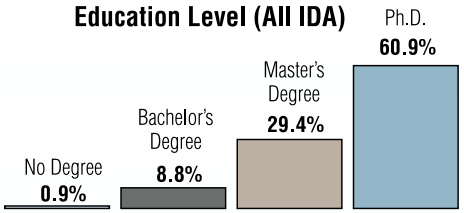


Science and Technology Policy Institute



* Includes Business Administration/Management, Humanities

Education Level (All IDA)



IDA employs more than 1,100 research, professional, and support staff in offices in California, Virginia, Maryland, Washington, DC, and New Jersey. Over 90 percent of IDA's research staff has an advanced degree, three out of five a doctorate.

In addition to working on some of the most challenging projects in national security, researchers at IDA collaborate with a diverse and talented set of colleagues, many of whom are at the top of their fields. The breakdown of disciplines among our three FFRDCs reflects each center's analytic focus. The Studies and Analyses Center, which works in the areas of operational and systems evaluations and science and technology analyses, has a particularly strong cadre of analysts with degrees in the physical sciences and engineering. The Center for Communications and Computing, with its strong capabilities in cryptology, cryptanalysis, and the many disciplines of computational science and engineering, is heavily weighted toward mathematics, statistics, and operations research. Finally, STPI, with its broader S&T charter, has a staff whose backgrounds are more evenly distributed across the disciplinary spectrum.

Recognizing Excellence

Mr. Robert C. Holcomb, winner of the 2007 Andrew J. Goodpaster Award.

Each year, IDA recognizes those among our staff who exemplify our values and dedication to excellence. For our research staff, these attributes are recognized by awarding the Andrew J. Goodpaster Award for Excellence in Research, which this past year was given to Mr. Robert C. Holcomb of the Operational Evaluation Division. Over the 14 years Mr. Holcomb has been with IDA, he has served as the project leader for two of the Army's most important and highest visibility programs – the Force XXI Battle Command Brigade and Below (FBCB2) system, and the Future Combat Systems (FCS) program. In both tasks, Mr. Holcomb showed great analytical creativity in proposing better ways to test the systems to thoroughly understand their capabilities and limitations.

In 2005, Mr. Holcomb participated in a joint system evaluation project, traveling to Jordan for an operational assessment of the Seeker light observation aircraft. Later in 2005, he joined a cross-division team supporting the counter-IED assessment task, for which he spent five weeks in Iraq as part of a "quick-look" evaluation of the effectiveness of several counter-IED systems in use in the theater.

Mr. Holcomb returned to Iraq for an extended period as a key member of IDA's deployed team of analysts supporting Multinational Corps Iraq (MNC-I) in connection with the counter-IED task. There, he produced balanced and carefully shaped assessments of specific high-interest initiatives, and, as part of the IDA analytical in-theater team, provided weekly briefings to the Corps commander, component commands, and staff, alerting them to new trends and helping them to evaluate initiatives in the field.

IDA also presents the William Y. Smith Award for Excellence and the President's Award for Excellence to recognize the accomplishments

of our nonresearch staff. This year, IDA presented the Smith Award to Brad Gernand of the IDA Library. The 2007 President's Award for Excellence was presented to Janet Park of the Cost Analysis and Research Division and Zelma Cameron of the System Evaluation Division.

(left to right) Mr. Brad Gernand, winner of the William Y. Smith Award, and Ms. Zelma Cameron and Ms. Janet Park, winners of the President's Award for Excellence.

Creating an Environment That Fosters Excellence

At IDA, we understand that it is not enough to hire individuals who are top in their field. We must also create an environment that nurtures and encourages continued professional growth. This means providing researchers and support staff alike with opportunities to keep abreast of the latest developments in their areas of expertise, whether by attending or presenting at conferences and symposia, pursuing additional formal educational opportunities, or publishing in key professional journals and other publications.

Ken Krieg, Under Secretary of Defense for Acquisition, Technology and Logistics, speaking before IDA employees. His presentation, "Institutional Reform and Governance," was one of dozens given throughout the year by key decision-makers and leaders as part of the IDA Seminar Series.

Part of creating a stimulating and challenging work environment involves bringing to IDA key decision-makers and leaders in a variety of relevant fields as part of the IDA Seminar Series. These series of mid-day talks, given at both the Studies and Analyses Center and the Center for Communications and Computing, are on topics that include specific defense issues as well as other aspects of national security, and touch on related subjects such as international relations, economic policy, and technology. The speakers this past year included:

Admiral Edmund P. Giambastiani, Vice Chairman of the
Joint Chiefs of Staff
"The Future of the U.S. Military Forces"

Kenneth J. Krieg, Under Secretary of Defense for Acquisition,
Technology and Logistics
"Institutional Reform and Governance"

Jay M. Cohen, Under Secretary of Homeland Security for
Science and Technology
"Enabling Scientific and Technical Solutions for Protecting the Nation"

Dr. Eric Evans, Director, MIT Lincoln Labs
"Technology for National Security"

Lieutenant General Sir John Kiszely,
Director of the UK Defence Academy
"Post-modern Challenges for Modern Warriors"

Ambassador Peter Chaveas, Director,
Africa Center for Strategic Studies
"Africa & U.S. Strategic Interests"

Major General (Ret) Gong Xianfu, Vice Chairman of the
China Institute for International Strategic Studies (CIISS)
"The Role of the PLA in China's Future Security Policy"

Dr. Tia Newhall, Professor, Swarthmore College
"Nswap: A Reliable, Adaptable, Scalable Network RAM System"

Prof. Raman Parimala, Visiting Professor, Emory University
"The u-Variant of Function Fields of p-adic Curves"

Noam Elkies, Professor, Harvard University
"Genus 2 Jacobians with Real Multiplication"

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

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