Celebrating 50 Years of Analytic Excellence

1956 - 2006

2006 Annual Report

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Message from the President

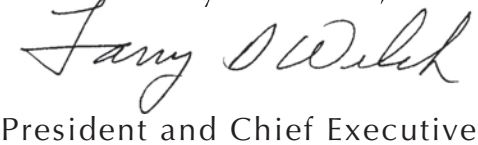
Since the end of the cold war, now more than a decade and half ago, national security leaders have been dealing with an increasingly complex world environment, characterized by global interdependence and a widening range of the causes and nature of conflict. Further, the technologies available to potential enemies have expanded in scope and in their consequences overseas and at home. These trends and others have increased the challenges facing the national security leadership.

To help meet the needs of this more complex environment, we have steadily expanded IDA's structure and research capabilities to provide broader scope where appropriate, more depth where called for, and faster response when needed as the nation moves increasingly from a national security environment that changed only incrementally year to year to one that can change drastically overnight. We are meeting those needs while maintaining the high standards of quality that makes our work so valuable to national security decision makers. The most convincing evidence that we are on the right track in meeting these needs is the increasing demand for our work from a wide range of sponsors. We welcome the increased opportunity to contribute to national security.

With that growing demand comes increasing challenges, responsibilities, and accountability – to recruit and mentor the right additions to our research staff and management, to provide the environment and support for our researchers to do their best work, to accord needed attention to information security, and to honor increasing sensitivity about conflicts of interest. We welcome the increased challenges.

These challenges, and others, influence the trust on the part of our sponsors that is so essential to fulfilling our mission – trust in the quality of our work, trust in our objectivity and credibility, and trust in the value returned from investment in our research. In our fiftieth year, we have earned the trust and confidence of the national security community. Throughout this special 50th Anniversary issue of our Annual Report we have highlighted our continuing evolution as we grow and broaden the depth and breadth of our research capabilities to meet the evolving needs of our sponsors. Today, as we look forward to the next 50 years, IDA remains committed to continuous improvement in our ability to serve the national interest.

General Larry D. Welch, USAF (Ret.)



President and Chief Executive Officer

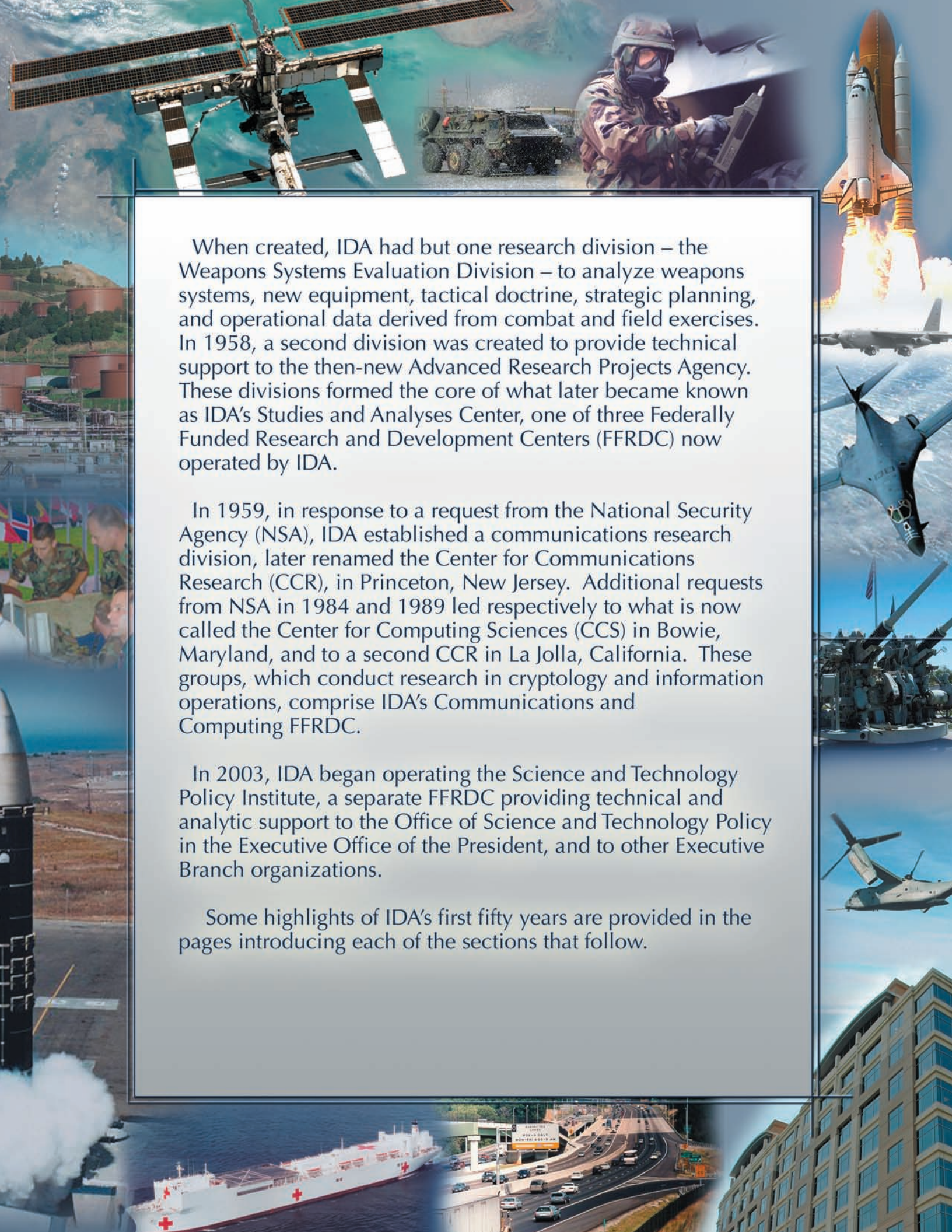
Prologue

Two ideas critical to IDA's birth emerged from World War II. The first was the necessity for unifying the several Services into a single, coordinated department. The second was the realization of the strength of the relationship between science – and scientists – and national security.

The first reached fruition when President Truman signed the National Security Acts of 1947 and 1949, creating the Department of Defense. To give the nascent Office of the Secretary of Defense (OSD) the technical expertise and analytic resources to hold its own and to help make unification a reality, James Forrestal, the Department's first Secretary, established the Weapons Systems Evaluation Group (WSEG) in 1948 to assist OSD and the Organization of the Joint Chiefs of Staff by:

- bringing scientific and technical as well as operational military expertise to bear in evaluating weapons systems;
- employing advanced techniques of scientific analysis and operations research in the process; and
- approaching its tasks from an impartial, supra-Service perspective.

The demands on WSEG were more than its small staff of military and civilian analysts could satisfy, and by the early years of the Eisenhower Administration, there were calls for change. The several options gradually coalesced into one and, in 1955, the Secretary of Defense and the Chairman of the Joint Chiefs of Staff asked James R. Killian, Jr., then President of MIT, to help establish a consortium of major research universities to sponsor a civilian, nonprofit research institute. And so, in April 1956, IDA was incorporated as a non-profit organization.



When created, IDA had but one research division – the Weapons Systems Evaluation Division – to analyze weapons systems, new equipment, tactical doctrine, strategic planning, and operational data derived from combat and field exercises. In 1958, a second division was created to provide technical support to the then-new Advanced Research Projects Agency. These divisions formed the core of what later became known as IDA's Studies and Analyses Center, one of three Federally Funded Research and Development Centers (FFRDC) now operated by IDA.

In 1959, in response to a request from the National Security Agency (NSA), IDA established a communications research division, later renamed the Center for Communications Research (CCR), in Princeton, New Jersey. Additional requests from NSA in 1984 and 1989 led respectively to what is now called the Center for Computing Sciences (CCS) in Bowie, Maryland, and to a second CCR in La Jolla, California. These groups, which conduct research in cryptology and information operations, comprise IDA's Communications and Computing FFRDC.

In 2003, IDA began operating the Science and Technology Policy Institute, a separate FFRDC providing technical and analytic support to the Office of Science and Technology Policy in the Executive Office of the President, and to other Executive Branch organizations.

Some highlights of IDA's first fifty years are provided in the pages introducing each of the sections that follow.

Systems Evaluations

IDA's evaluations of defense systems support decisions on acquisition and program planning 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.

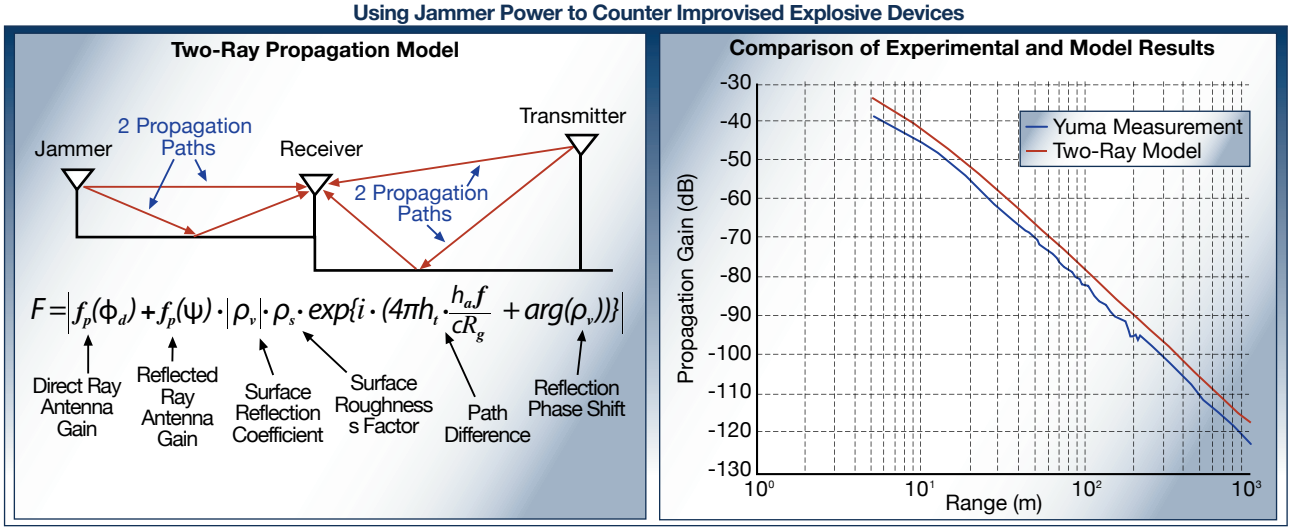
Tactical Systems and Missile Defense

Countering Radio-Controlled Improvised Explosive Devices

Countering improvised explosive devices (IEDs) is a key challenge in Iraq today, and IEDs could threaten U.S. forces in future operations elsewhere. Major concerns are the ease with which such systems can be constructed and employed, the relatively low risks to enemy users in some situations, and the potential for significant lethality. DoD requested that IDA conduct an analysis of alternatives for countermeasures against future radio-controlled IEDs. This assessment identified:

- IED threat characteristics.
- Countermeasure mission needs, system requirements, and critical operations.
- Top-level countermeasure evaluation factors and system functional objectives.
- Key measures of effectiveness and system technical performance and supportability parameters.

Using Jammer Power to Counter Improvised Explosive Devices



IDA applied a two-ray propagation model (left) to analyze the jammer power at a receiver (representing an IED) in the presence of a transmitter (intended to blow up the IED). IDA applied the model to various test configurations at the U.S. Army Yuma Proving Ground in Arizona and found it to satisfactorily follow the experimental results (chart on the right). The curve obtained with the model did not require any adjustable parameters; the small constant offset from the measured curve is a result of the uncertainty in the actual gain of the antenna. With a demonstrated good approximation to experimental data, the model was then used to help assess the effectiveness of notional alternative jammers.

- Alternatives for the Joint Service Counter Radio-Controlled Improvised Explosive Device Electronic Warfare (JCREW) program.

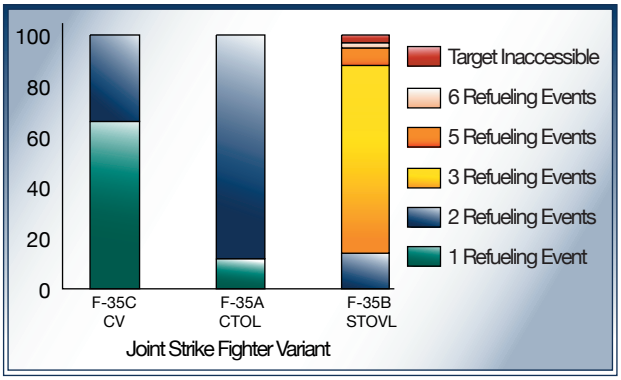
IDA researchers identified performance needs and assessed the capabilities and costs of alternative systems. The analysis established realistic expectations for JCREW solutions to existing and expected future radio-controlled IED threats. This work also highlighted the need for flexibility to deal with evolving threats, compatibility, and interoperability. Our study is serving as the basis for ongoing DoD architectural design efforts to develop a family of systems to counter future radio-controlled IEDs.

Alternative Tactical Aircraft Forces

DoD asked IDA to examine the capabilities of future U.S. tactical air forces to deal effectively with advanced systems being developed by potential adversaries. We worked with the intelligence community and the Joint Staff to identify the projected characteristics of future threats and likely operational concepts for U.S. forces. Then, in support of DoD's Joint Air Dominance Working Group, we examined the effectiveness in major combat operations of several alternative mixes of U.S. tactical air forces. These analyses were briefed to DoD leadership during the Quadrennial Defense Review.

Our analyses took account of many detailed tactical considerations, including the effects of terrain masking on strike missions and of the capabilities of electronic warfare aircraft to protect U.S. strike forces. In addition, we assessed the relative dependence of the alternative force mixes on aerial refueling under a variety of assumptions regarding the availability of foreign airfields. In the process of conducting these analyses, IDA refined and updated its state-of-the-art suite of analytic tools for examining air warfare capabilities.

Airborne Refueling Events Required to Reach Targets



One of the tactical aviation issues analyzed by IDA is the dependence of aircraft on airborne refueling to reach strike targets in a hypothetical combat scenario. In one case, our results showed that the F-35B STOVL (short takeoff, vertical landing) variant required more refueling from airborne tankers to reach the scenario targets than the F-35A CTOL (conventional takeoff and landing) or F-35C CV (carrier) variants, and that the F-35B could not reach some scenario targets due to operational range constraints. For this scenario, strike sorties originated from the same basing location for all Joint Strike Fighter variants. However, we found that the F-35B could potentially use austere airfields inaccessible to either the F-35A or F-35C to reduce its distance to targets and thus reduce the number of refueling events.

Air Dominance Weapons Roadmap

IDA assisted DoD in developing a joint roadmap to meet future air-delivered, air dominance weapons needs. Current weapons include the AIM-120 Advanced Medium Range air-to-air missile, the AIM-9 Sidewinder air-to-air missile, and the AGM-88 High Speed Anti-Radiation missile. The new roadmap defines a cost-effective evolution of U.S. capabilities through 2024.

Working closely with the Services, we selected appropriate warfighting scenarios, identified and characterized future threats to air forces, and identified promising air dominance weapon alternatives. Then, using a variety of computer models and other analytic tools, IDA and

Service analysts examined the military effectiveness of the alternatives and estimated both procurement and life-cycle costs. The study results are expected to inform and guide DoD decisions on future air-launched weapons developments.

Unmanned Combat Air System

DoD is developing the Unmanned Combat Air System (UCAS), which will leverage state-of-the-art stealth and survivability technologies to perform strike; intelligence, surveillance, and reconnaissance; and electronic attack missions.

To inform development choices, IDA evaluated the effectiveness and cost of UCAS concepts, assessed their feasibility, and quantified their warfighting utility. We found that a tactical aircraft-sized UCAS capable of loitering in defended airspace would improve U.S. warfighting capabilities, at costs ranging from $100 million-$200 million per vehicle. Among the concepts considered, a derivative of the X-47B proved most cost-effective.

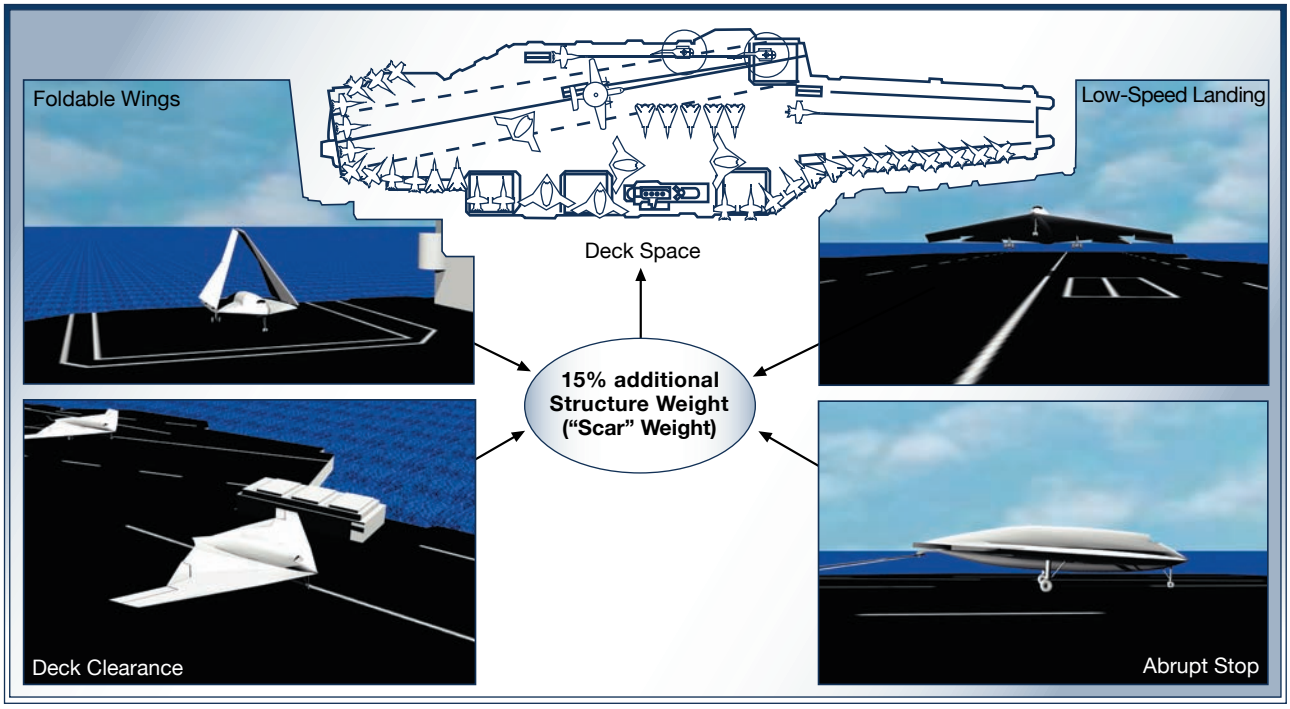
The study also assessed the maturity of key UCAS-related technologies, concerns about carrier-based employment, and the advisability of developing a single UCAS design for both land-based and carrier-based roles.

In a related effort, IDA examined whether evolving UCAS requirements were better suited to a single, joint program or separate Navy and Air Force programs. After examining the likely effectiveness and costs of jointly developed versus separate UCAS programs, our study recommended separate programs due primarily to the divergent operational requirements of the two Services.

Naval Joint Strike Fighter Variants

DoD is developing and procuring three variants of the Joint Strike Fighter (JSF), two

Carrier-based UCAS Design Requirements Effect on Structure Weight



Carrier basing places unique requirements on unmanned combat aerial system (UCAS) designs. The air vehicle design is constrained to fit within the deck space available, the limited space of the aircraft elevators, and the hanger deck, and to clear various obstacles such as raised areas of the flight deck. These constraints drive features, such as foldable wings that add weight to a design. In addition, the design must accommodate carrier-unique landing rigors such as low-speed flight and abrupt stops. This also drives air vehicle designs to larger wings and more robust structures that increase weight. IDA estimated a carrier-based UCAS would require 15% additional structure weight (i.e., "scar" weight) than an equivalent land-based UCAS to accommodate these requirements.

of which are for the Department of the Navy. The Navy is acquiring the larger and longer-range F-35C for aircraft carrier (CV) operations, and the Marines are buying the F-35B because of the basing flexibility enabled by its short-takeoff and vertical landing (STOVL) capabilities.

Given planned force structures, Marine JSF aircraft will occasionally fly from aircraft carriers, and Navy JSFs will fly from land bases in support of Marine missions. In light of these basing realities, IDA was asked to compare the effectiveness and costs of various mixes of F-35C and F-35B aircraft.

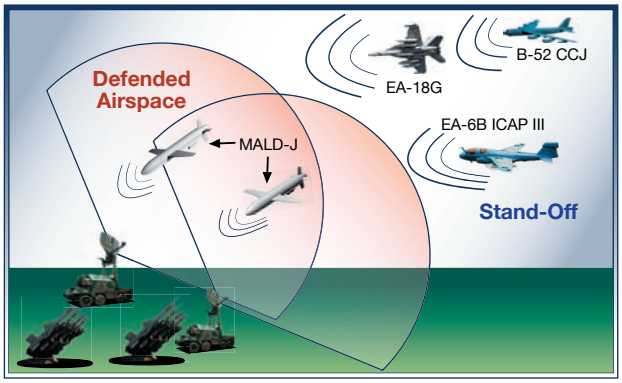
We have completed Phase 1 of the study. In scenarios where persistence and range were important, mixed fleets containing more CV variants outperformed alternatives that had more STOVL variants. The reverse was true in scenarios involving remote or numerous austere basing locations, where fleets containing more STOVL aircraft proved advantageous. Phase 1 results are being used to inform more detailed analyses in Phase 2, which will account for multiple missions and logistics in the context of different types of future combat operations.

Joint Airborne Electronic Attack

In 2001, DoD completed an Analysis of Alternatives for Airborne Electronic Attack (AEA) that identified three classes of AEA capabilities needed to deal with future threats. The Services, in turn, identified the systems and programs to provide those capabilities. Subsequent funding reductions in some programs led DoD to re-examine the adequacy of the planned AEA program to address future threats.

As part of the new study, IDA quantified the benefits of several AEA capabilities, including a redefined B-52 stand-off jamming package and a jamming variant of the Miniature Air Launched Decoy. Using an enhanced version of our air warfare toolset, IDA researchers estimated the increased warfighting effectiveness that would be provided by selected AEA options in a key planning scenario. These results helped inform DoD decisions regarding the future AEA program.

Joint Airborne Electronic Attack



IDA assessed the utility of key U.S. Joint Airborne Electronic Attack (JAEA) systems in a 2012 Major Combat Operation. The Navy EA-18G Growler, the Marine Corps EA-6B Prowler Improved Capability (ICAP) III, and the proposed Air Force B-52 Core Component Jammer (CCJ) are not designed to survive within defended airspace, but use their large payload and power capabilities to transmit with high power and thus conduct attacks from stand-off locations. Conversely, the expendable Air Force Miniaturized Air Launched Decoy Jammer (MALD-J) transmits its attacks with relatively low power, facilitating a compact design that can operate within defended airspace. IDA used a campaign analysis to measure the marginal utility of each of these electronic attack capabilities to determine the best use of DoD investments.

Integrated Air and Missile Defense

DoD is pursuing integrated air and missile defenses in which relevant systems developed by the Services are combined into a family of systems that share data and employ joint kill chains, architectures, and concepts of operations. In support of this initiative, IDA is developing methodologies and tools to quantitatively evaluate the joint capabilities of the family of systems against likely threats. The assessments will help determine where to focus development efforts and identify promising operational concepts.

Our researchers have developed an aggregated, mission-level, force-on-force simulation, called DIAMDS. This tool is fast running, allowing IDA to explore many sensitivities, tradeoffs, and different scenario conditions. Employing DIAMDS, IDA researchers examined the military utility of alternative integrated fire control options.

Currently, we are conducting follow-on analyses supporting the new evaluation of alternatives process.

Battle Management for Missile Defense

IDA provides analytic and technical support to the Missile Defense Agency's Joint National Integration Center in Colorado Springs, supporting the integration and testing of the Command and Control, Battle Management, Communications (C2BMC) system, which is the integrating element of the Ballistic Missile Defense System.

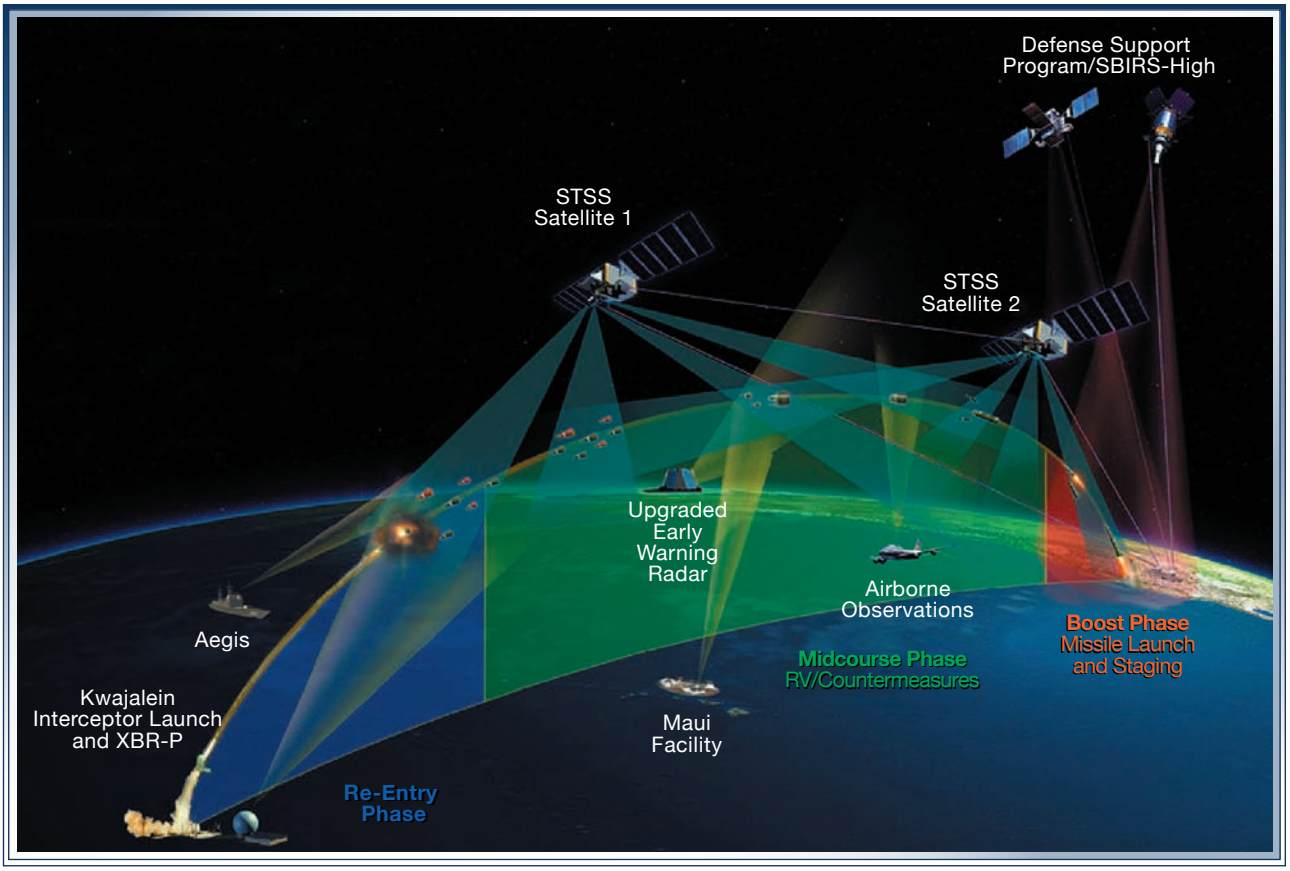
The IDA team reviewed proposals for upgrading the technical capabilities of the C2BMC test facility. We also helped develop and assess architectures and plans for ground-based, hardware-in-the-loop and flight testing, and our researchers assisted in selecting, defining, and planning C2BMC experiments aimed at improving future missile defense capabilities.

C3, Surveillance, and Space Systems

Signals Intelligence Tradeoffs

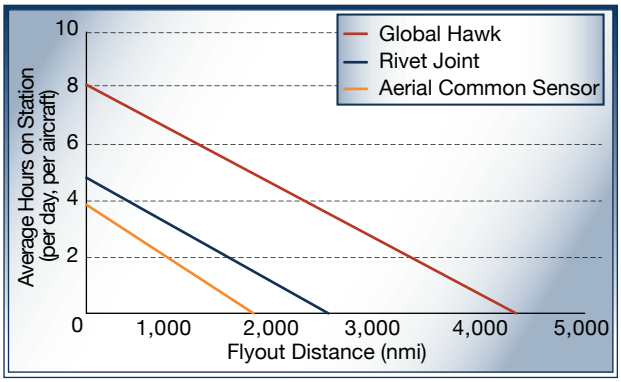
Signals intelligence (SIGINT) is one of the primary technical intelligence disciplines. DoD asked IDA to evaluate tradeoffs among the large number of airborne SIGINT systems currently planned or proposed, with particular

Global Missile Tracking Using STSS Satellites



The Missile Defense Agency is planning to field initially a constellation of research and development Space Tracking and Surveillance System (STSS) satellites (pictured) and beginning after 2016 an operational constellation of STSS satellites. These satellites will employ sensors capable of detecting visible and infrared light. IDA supported early integration activities for the STSS; the Terminal High Altitude Area Defense system; the Kinetic Energy Interceptor; and the Command, Control, Battle Management, and Communications System. Specific activities included message-level integration, integration during a live or replayed flight event, and the development of an Operation Concept document for STSS.

Tradeoff between Time on Station and Distance Covered for Aerial Reconnaissance and Surveillance Platforms



The tradeoff between the time a platform is on station performing its mission and the distance the platform needs to cover to reach that station is one of the many factors that IDA takes into account when assessing the effectiveness of different reconnaissance and surveillance platforms. One advantage of larger unmanned aerial vehicles such as Global Hawk is their long flight endurance, which can result in greater platform reach or longer time on station than manned alternatives.

focus on the relative merits of the manned Aerial Common Sensor aircraft and various unmanned aerial vehicles (UAVs).

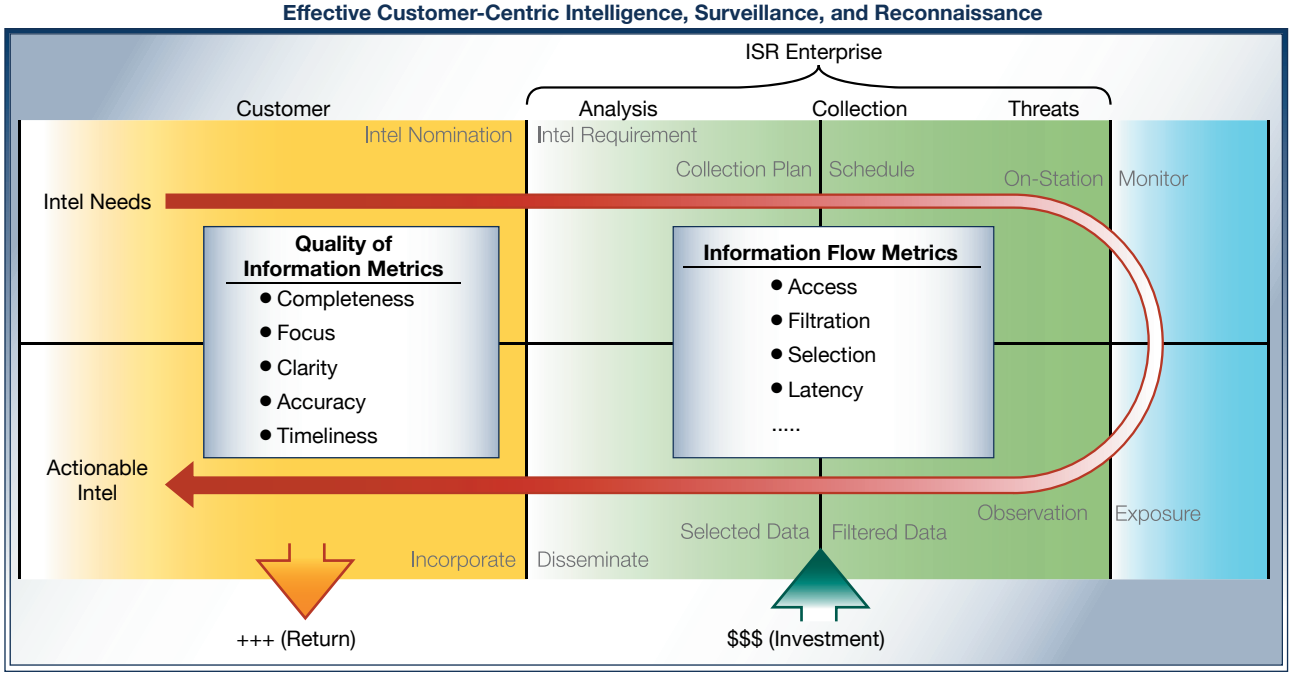
We are investigating tradeoffs in the context of information needed by national agencies as well as commanders in the field. These tradeoffs are being conducted for two scenario types: a large-scale major combat operation and routine peacetime global intelligence collection. Initial results helped inform decisions on the fiscal year 2008 defense program. Later results will influence the ongoing defense programming process and the long-term intelligence, surveillance, and reconnaissance architecture roadmap.

Customer-Centric Intelligence, Surveillance, and Reconnaissance

Most past studies of intelligence, surveillance, and reconnaissance (ISR) capabilities have focused on the technical performance of collection systems. However, the ISR enterprise consists of more than collectors and should be evaluated as an integrated system. DoD asked IDA to assess the performance of the integrated ISR enterprise in selected contingency operations and to highlight the capabilities provided by individual elements.

With the goal of estimating the value of disseminated intelligence to the end user, the study team assessed the ability of the ISR enterprise to collect, process, and move information. This approach provided insights

Effective Customer-Centric Intelligence, Surveillance, and Reconnaissance



The Intelligence, Surveillance, and Reconnaissance (ISR) Enterprise does not collect or analyze information in isolation; rather, it provides the customer with information relevant to intelligence needs. This drawing illustrates how investments in the ISR Enterprise improve information flow and benefit the end user, and lists some of the metrics IDA employs to evaluate the flow and quality of information. Our goal is to understand the functional relationship by which information flow affects quality of information. This relationship will allow decision-makers to understand what characteristics and elements of the ISR Enterprise enable or inhibit its success.

on which system elements and performance characteristics of the ISR enterprise enabled or inhibited its success in the operational environments examined.

Space Radar System Capabilities

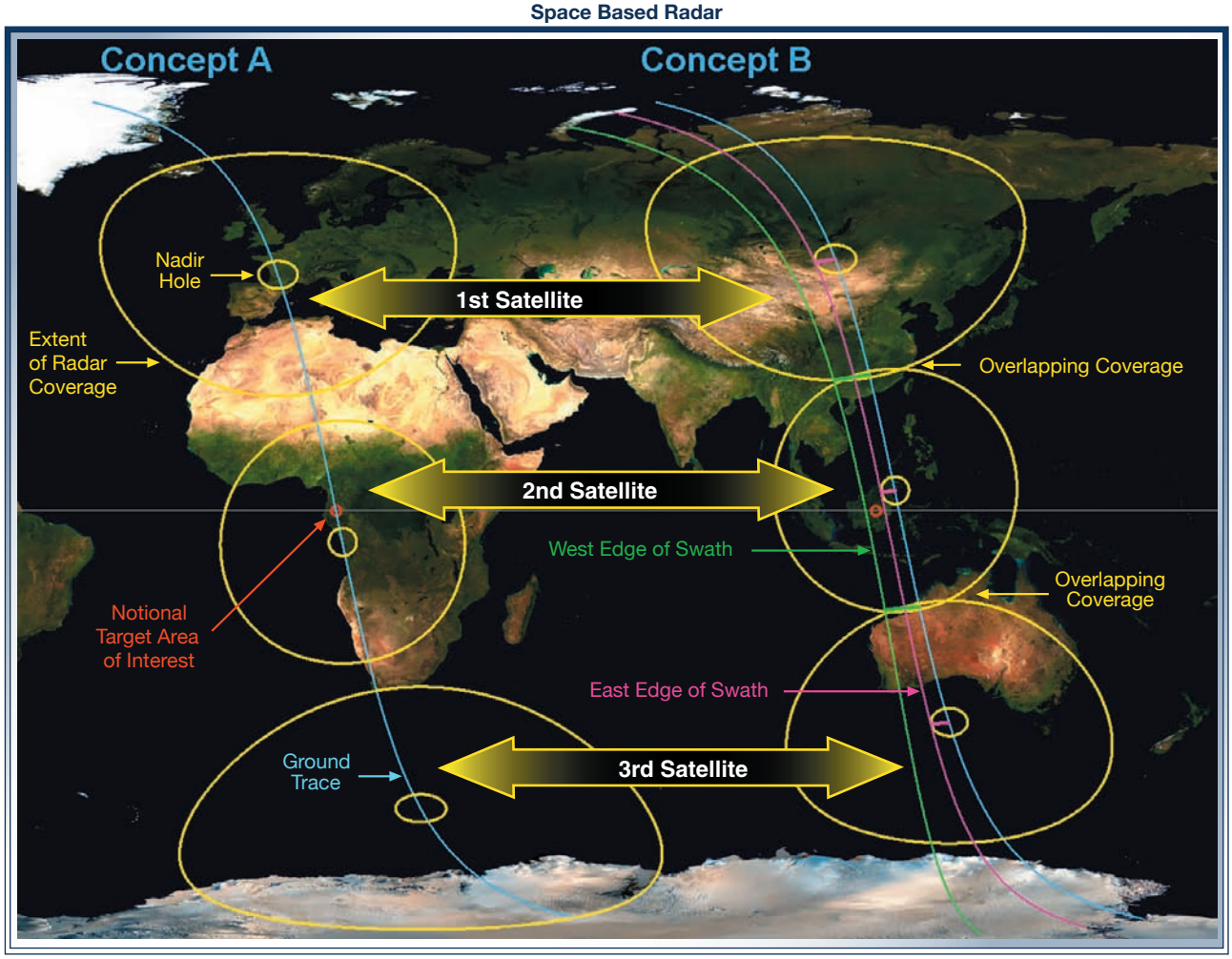
DoD and the intelligence community are developing a space radar to collect imagery and to detect moving vehicles so that they can provide persistent intelligence, surveillance, and reconnaissance worldwide. Previously, IDA assessed the contributions of the space radar and other sensors to theater-level combat operations. This year, DoD asked us to examine the capabilities of the space radar to meet peacetime intelligence needs.

The missions we are examining are imagery collection, area surveillance, vehicle tracking, and cueing of other sensor systems. Key performance measures include the degree of global coverage, responsiveness, persistence, resolution, and collection capacity of the space radar system, with particular emphasis on quantifying the value of persistence in the moving target indicator modes of the space radar.

Navigation Systems

In support of the Department of Transportation, IDA established an independent review board to examine navigation systems. The board's

Space Based Radar



IDA examined satellite constellation design concepts to maximize the period of surveillance of an illustrative target area of interest provided by a limited number of satellites. In Concept A, Gap Tolerant Surveillance, the satellite ground track passes through the target area. Satellite passes are spaced out in time so that gaps between satellites are no longer than the gap in coverage due to the nadir hole. Concept B, One-Sided Chain of Coverage, achieves continuous coverage of a swath over the target area by displacing the satellites' ground track and spacing the satellites so that their areas of coverage overlap. The edge of the swath to the west is defined by the extent of the overlapping coverage of adjacent satellites, while that to the east is defined by the edge of the nadir hole. Although Concept B achieves continuous coverage, it is for a shorter duration than Concept A for a given number of satellites.

initial analysis focused on whether the long-range aid to navigation (LORAN) system should be modernized to provide a backup to the global positioning system (GPS) or phased out.

More recently, the board examined the requirements and program definition for the GPS IIIA system, finding that the modernized GPS will require continued improvements in the operating control segment. The board is now assessing ways to implement the new GPS system, consistent with planned costs and schedules.

Information and Computing Systems

Information Technology for National Intelligence

To improve information sharing, provide focus, and encourage innovation, the Director of National Intelligence (DNI) Chief Information Officer established the Information Sharing and Customer Outreach Directorate (ISCO). IDA is providing ISCO continuing strategic planning and technical expertise to help conceptualize the future state of information sharing in the intelligence community.

We helped develop strategies and plans; assessed technological capabilities; examined privacy and civil liberty issues; summarized interagency organizational functions and relationships; provided Red-Team reviews of programs and initiatives; and participated in integrated tiger teams.

Architecture of Internet-Scale Distributed Systems

DoD is transforming the way it employs information technology, moving toward a multi-enterprise system with associated capabilities modeled as services. In this paradigm, everything is modeled as a requestor or a service provider. To deal with the new Internet-scale distributed environment, DoD has developed new ways of handling service naming, discovery, and negotiated usage, and has defined a set of core services that must be made available across different platforms and enterprises.

IDA has been helping by defining various classes of services that are equivalent to desired capabilities and organizing them in a layered fashion to address complexity. We also have been assisting in the areas of information assurance, cascading authentication, dynamic cross-enterprise trust, and authorization.

Cyber Intrusion

IDA researchers assessed the damage to national security arising from an intrusion into an engineering computer network at a large defense contractor. The network was unclassified, as were all of the documents that were exfiltrated, but some sensitive information was compromised. We assessed how a receiving country might benefit from the compromised information – accelerating system developments, facilitating information warfare, and enhancing intelligence collection against U.S. interests.

We identified gaps in current DoD policy regarding the reporting of such incidents and preservation of intrusion artifacts, and we suggested improvements in four network protection policy areas. Also, based on lessons from the case study, we recommended better methodologies for use in future damage assessments.

Tracking War Material Moving to and from Ports

IDA designed and demonstrated a pilot version of an Internet-based system to support the Regional Agile Port Intermodal Distribution (RAPID) Center, a facility developed by the Delaware River Maritime Enterprise Council to help the U.S.

Transportation Command improve security and the logistical visibility of war material moving among ports and Army forts and depots. The resulting pilot system supports the automated tracking of cargo and provides a common operating picture for stakeholders. It also enables the RAPID Center to send security alerts via mobile phones or email.

To date, the pilot system has successfully supported the movement of Army material to and from 21 different ships at three ports: Philadelphia, PA, Charleston, SC, and Savannah, GA. Also, to improve flexibility and in response to concerns about the potential vulnerability of centralized operations, the RAPID Center demonstrated the capability to sustain operations when some of the operators were at remote or mobile locations.

Test and Evaluation

IDA has supported the office of the Director, Operational Test and Evaluation (DOT&E) since soon after Congress established the office in 1983. Our researchers have played an important role in helping DOT&E define and implement policies and practices for both live fire and operational test and evaluation.

We also have helped DOT&E ensure that the nation's test infrastructure meets the testing needs of advanced weapons. In the years since 1983, we have assisted in forming an investment program to develop new multi-Service test capabilities; investigated alternatives for the size, location, and capabilities of new and existing large test facilities; and analyzed the current and future adequacy of the test and evaluation work force.

In recent years, IDA has assisted DOT&E in adapting test and evaluation as the Department learns from recent conflicts. For example, IDA studied the 1999 Serbian air war and Operation Iraqi Freedom to determine whether weapons used in those conflicts had been adequately tested and to develop insights on how future testing could be improved. Similarly, lessons from ongoing operations in Iraq and Afghanistan have enabled testing with the most recent tactics and against current threats. With IDA's help, DOT&E is working with the Services to speed up testing of urgently needed weapons, while still ensuring that weapons are adequately tested and evaluated.

Land Warfare

The Stryker family of vehicles consists of two basic variants: the Infantry Carrier Vehicle and the Mobile Gun System. While the

IDA analytically combines the results of technical tests with those of operational tests (which are more representative of combat) in order to estimate a weapon's effectiveness, suitability, and survivability in combat. This series of photographs, taken from an early technical test of the Guided Multiple Launch Rocket System (GMLRS), shows a rocket exploding near its aimpoint (orange box; later tests used actual targets). For these tests, IDA suggested using witness plates (the large metal plates surrounding the impact area) to gather collateral damage information. As predicted, the warhead results obtained during these technical tests employing an actual rocket flight differed significantly from those obtained from the traditional method of testing a stationary warhead in controlled conditions. The results of this analysis were used to refine computer predictions as well as to develop GMLRS rules of engagement in Iraq.

Infantry Carrier Vehicle has been used in Iraq, the Mobile Gun System required more developmental effort. This past year, IDA monitored Mobile Gun System technical testing and assessed the results, which showed that although the Mobile Gun System's reliability has improved, it was still well short of program requirements.

In parallel, IDA supported DOT&E and the Army in developing a test strategy in which the operational test for the Mobile Gun System would take place in conjunction with a unit's training Mission Rehearsal Exercise and separate event at Fort Hood, TX. With this approach, testing and evaluation needs were met while supporting the Army's planned deployments of the Mobile Gun System to Iraq. IDA also helped develop the live fire test and evaluation of the system's vulnerability to threat attack, highlighting the need for testing against a specific threat that has emerged from combat experience in Iraq.

The Guided Multiple Launch Rocket System (GMLRS) is the Army's precision indirect fire guided rocket. An early version of the unitary warhead variant of the GMLRS has been deployed to Iraq. Although the testing prior to the deployment was mostly technical, IDA worked with the Army to add important live fire and operational conditions to the test events. At the suggestion of IDA researchers, large wooden and metal plates were placed at various distances around the impact area to unobtrusively gather realistic fragment data. This allowed testers to determine the shape and extent of the fragment pattern. Also, these data allowed the Army to verify computer models used to estimate GMLRS lethality.

Air Warfare

To reduce losses of helicopters to man-portable air defense systems, the Army's Special Operations Command intends to upgrade the missile warning systems on its helicopters. Because IDA had participated in many previous tests of missile warning systems, the Command asked us to compare the performance of existing missile warning systems and new systems likely to be available in the near future. We examined relevant tests for six systems, assessing results in terms of probability of detection, time to intercept, and false alarm rate.

The EA-18G Growler will replace the EA-6B Prowler Electronic Attack radar and communications jamming aircraft as the Prowlers are retired in 2012. Significant tests and an acquisition decision on the Growler are anticipated in 2007. In preparation for these events, IDA outlined concepts for testing and evaluating the system. The concepts linked mission areas, critical operational issues, measures of effectiveness, suitability, survivability, and, ultimately, testing requirements. Our study concepts influenced the Growler's test master plan approved by DOT&E.

Strategic Warfare and Net-Centric Systems

DoD weapons, command and control, and surveillance systems are being networked to operate together and share information in real-time. While increasing U.S. net-centric capabilities, networks are subject to attack or exploitation from a variety of sources ranging from casual hackers to state-sponsored organizations. For the past several years, IDA has supported DOT&E's assessment of the Combatant Commands' ability to protect and defend operational networks and maintain the availability, confidentiality, and integrity of the information.

Depending on the theater of operations, a particular Service operational test agency leads the assessment effort for DOT&E during an exercise, with support from Service and National Security Agency Red Teams as well as Joint Task Force - Global Network Operations, as needed. The Red Teams try to penetrate the DoD networks using tools available in open sources. IDA provides DOT&E with an independent, high-level assessment that focuses on consistency in processes, methodologies, metrics, and overarching trends. IDA also is exploring measures to

characterize a command's ability to protect its networks. Results of the overarching assessment are reported annually to Congress.

Our researchers also participated in the planning, observation, and analysis of the operational testing of the Deployable Joint Command and Control (DJC2) system that integrates shelters, communications systems, and information technology into a deployable operations center to support joint task forces. We observed Combatant Command exercises and participated in the Multi-Service Operational Test and Evaluation. In this test, the U.S. Southern Command's Standing Joint Force Headquarters completed scenario tasks as a forward deployed element of a joint task force conducting disaster relief and counter-terrorist operations. IDA integrated data from developmental tests, operational assessments, and operational tests. Our analysis confirmed that the support crew could marshal, deploy, assemble, and support the DJC2 and that the staff could successfully conduct operations within the DJC2.

In 2006, IDA worked with DOT&E to establish criteria for characterizing the operational capability of the Ballistic Missile Defense System (BMDS). Because this system and its constituent elements are developmental programs, many of the tests conducted to date have demonstrated capabilities that satisfied developmental, not operational, objectives. In support of future testing, IDA helped DOT&E develop a test and evaluation concept that identifies operational issues and performance measures for the BMDS. Our researchers used criteria from this test and evaluation concept to assess the operational realism of flight tests conducted in 2006. These ongoing assessments highlight test aspects where operational realism is lacking and provide specific ways to improve the operational realism of future flight tests of BMDS.

Naval Warfare

For the last eight years, DoD has been replacing sonar system processing software and computers in nuclear submarines with the Acoustic Rapid Commercial-Off-the-Shelf Insertion (ARCI) system. In 2006, the Navy conducted an operational test pitting an ARCI-equipped U.S. submarine against the Swedish diesel-electric submarine, HSWMS *Gotland*. IDA participated in planning the exercise and analyzed the results. This operational test also provided DOT&E with an initial evaluation of U.S. submarine capability against the diesel-electric submarine threat. IDA remains heavily involved in the test planning of each upgrade of ARCI, the most significant of which will be aboard USS *Ohio*, the lead ship in the newly converted and modernized SSGN class of submarines.

Over the next decade, the Navy plans to spend approximately $1.1 billion testing ship

A Small Diameter Bomb attacks an actual threat air defense vehicle using the bomb's airburst function. IDA is evaluating many of the nation's most important munitions, and assessing the effectiveness of weapons against realistic targets is an important part of our munition evaluations. Traditionally, munition live-fire tests were conducted using a static warhead. While this procedure provided some detailed information, it did not replicate the dynamics of an actual flight test. IDA has encouraged the Services to move away from static tests as much as possible and include realistic targets in planned flight tests. This can reduce the program's overall test cost while providing more realistic assessments.

self-defense systems against anti-ship missiles. IDA worked with DOT&E and the Navy to develop the Capstone Enterprise Air Warfare Ship Self Defense Test and Evaluation Master Plan, which consolidates previously separate test events into fewer, multi-purpose events. In addition to saving about $240 million, this approach provides more robust testing by examining end-to-end performance of the combat system rather than focusing on a slice of combat capability – e.g., the radar or the air-defense missile by themselves.

Live Fire Test and Evaluation

The Small Diameter Bomb (SDB) is an all-weather precision attack glide bomb that relies on the Global Positioning System for guidance. In 2006, SDB completed operational testing, went into full-rate production, and has been used successfully in combat. The SDB program was noteworthy for the degree to which the activities supporting both operational and live fire testing and evaluation were integrated.

During all phases of the SDB testing, IDA advised DOT&E on test planning and conduct. First, IDA proposed a more robust flight test program using live weapons to attack a variety of realistic targets. A total of 17 weapons were delivered against seven types of targets. Also, our researchers questioned the premature removal of a particular fuzing option without more test-based justification. Added test events showed that the observed fuzing problems were unique to the testing environment and would not be duplicated in operational use.

Resource Analyses for Test and Evaluation

IDA helps ensure DoD has the capability to test weapon systems by assessing various aspects of the test and evaluation (T&E) infrastructure, resources, and policy. This year IDA continued its support of the Test Resource Management Center (TRMC), helping it develop the Strategic Plan for Defense T&E Resources to guide the Services and defense agencies in their investments in T&E capabilities.

In a separate project for TRMC, IDA examined NASA's aeronautical research facilities to determine which ones were important to DoD missions and suggested policy options for a new interagency agreement with NASA. The agreement, which established the National Partnership for Aeronautical Testing, provides the underpinning for a continuing partnership between the two agencies for managing their respective components of the federal aeronautics test infrastructure.

For DOT&E, IDA assessed the test resources available to support operational testing, and we studied organizational and policy alternatives for creating a combined test force for testing the Ballistic Missile Defense System. Our study identified ways to maintain the operational test representatives' independent perspectives and analytical credibility while economizing resources, eliminating duplication of effort, and supporting the Missile Defense Agency's mission and objectives. MDA is now implementing most of this plan.

Additionally, IDA examined the demographics of the T&E workforce, and the findings are expected to support DoD decisions on workforce sizing and shaping initiatives.

Acoustic Rapid Commercial-Off-the-Shelf Insertion Sonar System

The Navy is upgrading all sonar system processing software and computers in nuclear submarines with the Acoustic Rapid Commercial-Off-the-Shelf (COTS) Insertion (ARCI) sonar system. The ARCI sonar system, shown here on a *Los Angeles*-class submarine, underwent operational testing in 2006. The Swedish diesel-electric submarine, HSWMS *Gotland*, on loan to the U.S. Navy, played the role of the adversary in these tests. IDA evaluated this test for DOT&E and is involved in the test planning and assessment of future ARCI upgrades.

1956 - 1966

Institute Highlights

- Weapons Systems Evaluation Division, now the System Evaluation Division, was established to support DoD's Weapons Systems Evaluation Group, providing operational analyses and systems assessments.
- Advanced Research Projects Division, now the Science and Technology Division, was initially established to provide assessments of science and technology issues for DoD's new Advanced Research Projects Agency, and later for the DDR&E and other sponsors.
- Communications Research Division, later renamed the Center for Communications Research, was established in Princeton, New Jersey, to conduct basic research in communications, emphasizing mathematical approaches.
- Economic and Political Studies Division was established to examine economic, political, and operations research aspects of national security issues.
- Jason Division was established to attract new academic scientists to work on national security problems, emphasizing imaginative applications of the physical sciences.
- Universities overseeing IDA expanded from the five initial members in 1956 – CalTech, Case, MIT, Stanford and Tulane – to twelve by 1964 with addition of California, Chicago, Columbia, Illinois, Michigan, Pennsylvania, and Princeton.

Research Highlights

- Anti-ballistic missile defense research focused on reentry physics and discrimination techniques and assessments of overall ABM system performance.
- Space technology studies examined rocket propulsion, launch vehicles, manned space flight, manned orbital space station concepts, and communications satellites.
- Civil defense effectiveness assessed under various nuclear attack scenarios.
- Gaither Panel, formed at the request of the National Security Council – and supported by IDA – took a fresh look at defense needs and resource priorities under conditions of an all-out attack by the Soviet Union on the United States.
- Committee on Military Assistance to Allies, set up by President Eisenhower – and supported by IDA – reviewed results to date of the post-WWII Mutual Security Program.
- Commercial aviation study for the Federal Aviation Administration examined cost-effectiveness of an air traffic control system to serve civil and military jet traffic between the United States and Europe.
- Journal of Missile Defense Research, later renamed the Journal of Defense Research, established with IDA editorial direction for the Journal's first ten years.

Technology Assessments

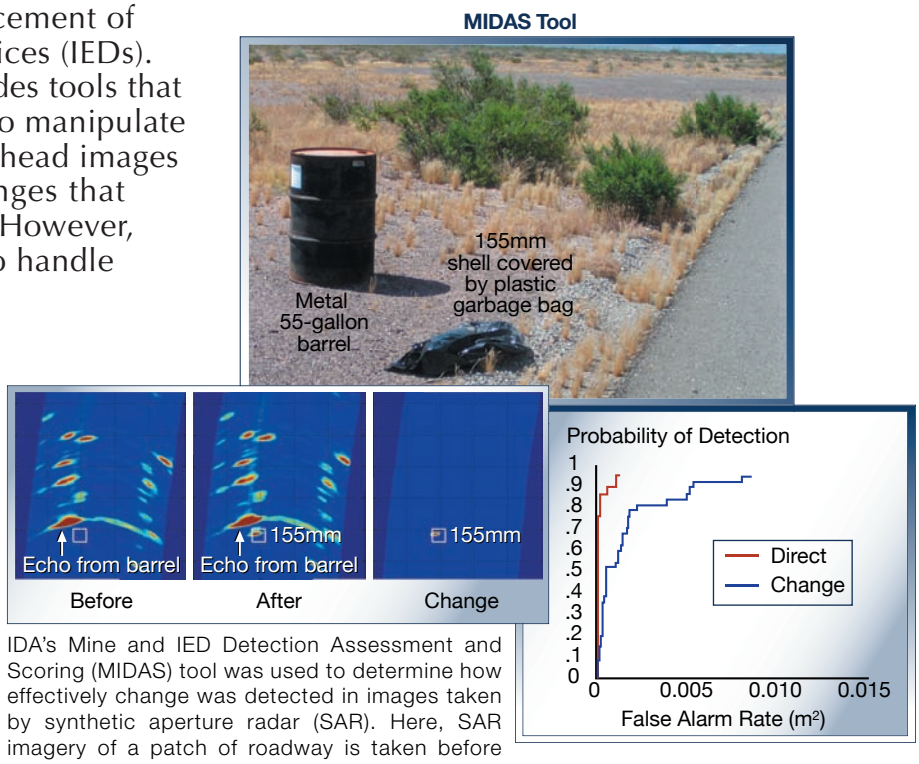
IDA provides multidisciplinary scientific, technical, and analytical support related to identification, evaluation, development, and use of advanced technologies in defense systems. This work involves assessments of technology feasibility, performance, producibility, demonstrations, and development risks. IDA further assists DoD in developing technology strategies, plans, and standards; identifying investment priorities; and assessing implications of domestic and international trade and technology cooperation, plans, and controls.

Countering Improvised Explosive Devices

Imagery to Detect Changes in Terrain Features

The Army is developing a new Change Detection Workstation (CDWS) for identifying changes in terrain features resulting from the emplacement of improvised explosive devices (IEDs). The existing CDWS provides tools that enable an image analyst to manipulate current and archived overhead images to detect and locate changes that have occurred over time. However, these tools are too slow to handle tactically meaningful volumes of imagery. DoD asked IDA to evaluate the potential to increase the throughput of image analysts by automating the registration of imagery, which involves precisely aligning terrain features in one image to the same features in other images of the same area taken previously.

The study team examined the relationships between technical performance and operational concepts. For example, when flying at low altitudes, imagery from a wide-angle imager would be more difficult to register than that from a narrow-angle imager, due to large nonlinear distortions in the former. We showed how registration performance would vary based on differences in the altitudes of the air vehicles, sensor resolutions, and terrain relief height scales.



IDA's Mine and IED Detection Assessment and Scoring (MIDAS) tool was used to determine how effectively change was detected in images taken by synthetic aperture radar (SAR). Here, SAR imagery of a patch of roadway is taken before and after a 155mm shell wrapped in a garbage bag (the test improvised explosive device) was placed next to a metal 55-gallon barrel. The IED is detected as a change in the scene – even in close proximity to metal clutter (the barrel). The two receiver operating characteristic curves in the graph – created by IDA using MIDAS to score and analyze the imagery data provided by PSI – are for direct detection (red curve) in which all anomalies in the Day 2 data are potential targets and for change in detection (blue curve) in which only changes from Day 1 and Day 2 are counted as potential targets. Results show that change detection greatly reduces the false alarm rate and may make the approach viable for route maintenance concepts of operation.

The results highlighted the benefits of using high-altitude systems in comparison with low-altitude, helicopter-borne pod systems.

Nuclear Quadrupole Resonance Sensors

IDA is assessing the technical performance of an advanced mine detector (AMD) that incorporates nuclear quadrupole resonance (NQR) sensors for confirmation. Operationally, the AMD would be employed in combination with the hand-held AN/PRS-14 detector, which would do the initial searching for suspected IEDs and buried mines. When objects are detected, the NQR sensor would be used to verify the presence or absence of explosives.

We calculated the effectiveness of the overall system in terms of the probability of detection, area swept per minute, and the number of false alarms, which typically limits the rate of advance for mine detection systems. Analyzing field tests conducted in 2006, we found the number of false alarms was reduced by a factor of 20 when the AMD system was employed, in comparison with tests using the AN/PRS-14 alone.

Advanced Mine Detector Field Test Data
Number of False Alarms per m²

	Low-Clutter Environment	High-Clutter Environment
AMD with inactive NQR search head retracted	0.041	0.22
AMD with active NQR search head extended	0.006	0.004

A hand-held advanced mine detector (AMD) – the AN-PSS-14 with nuclear quadrupole resonance (NQR) – was tested with and without the NQR activated both in a low-clutter environment (Yuma Proving Ground, AZ) and in a high-clutter environment (Aberdeen Proving Ground, MD). The AMD maintained the high probability of detection of the AN-PSS-14 alone while reducing the number of false alarms by large factors, even in the high-clutter environment. Reducing the false alarm rate greatly improves the rate of advance that can be achieved with hand-held detectors.

Vehicle-Based Detection Systems

DoD is developing vehicle-mounted systems to detect IEDs and landmines at standoff ranges. One such system uses forward-looking, ground-penetrating radar and infrared sensors to detect changes in terrain features over time. The vehicles would be used for route maintenance, which would involve scanning key road segments periodically to determine if insurgents had placed IEDs under or around the roadway.

IDA is helping design, monitor, analyze, and report on system testing. Our researchers developed analytic tools used to evaluate and provide insight into system performance. The tools compute detection probabilities, false alarm rates, position accuracy, and system bias.

Testing Counter-IED Technologies

Counter-IED systems must be able to operate effectively in the presence of high densities of man-made background electromagnetic signals unrelated to IEDs. Some of the highest levels of radio-frequency background are encountered in nations that do not have well-developed infrastructures of land-line communications.

IDA is providing technical and analytic support for DoD's efforts to develop a test environment in which new counter-IED technologies could be evaluated in the presence of background electromagnetic signals matched to those of potential combat areas. We helped develop the plan for collecting electromagnetic data from current and prospective areas of interest, analyze the resulting measurements to extract key

features likely to affect counter-IED systems, and implement a realistic testing environment that recreates these features.

Sensors, Surveillance, and Target Acquisition

Vertically Interconnected Sensor Array

The Vertically Interconnected Sensor Array (VISA) program is developing new focal plane array readout technology with expanded spectral range, faster frame rates, and improved resolution. Layers of detectors, analog circuits, and digital circuits are stacked, enabling electronic signals in one layer to be routed to other layers using vertical pathways, thereby allowing a near 100% detector fill factor. Also, detector signals in each pixel are read in parallel without using row-column multiplexers, thus achieving fast frame rates with high image resolution.

In support of the VISA program, IDA is generating and evaluating technical approaches and identifying potential military applications enabled by the new technology. One possible application involved real-time signal processing at the focal plane. We found that the higher power requirements and the resulting heat dissipation needed at the focal plane would be particularly challenging for this application.

Sensor Integrated Fusion Technology

DoD's Sensor Integrated Fusion Technology (SIFT) program is developing autonomous sensor management techniques to improve the timeliness and tactical relevance of threat information provided by intelligence collection systems. SIFT includes automated data correlation and payload management, enabled by advanced on-board processing.

Table A: Typical UAV Mission without Onboard Processing

Step	Task	Duration (minutes)
1	GMTI sweep #1	10.0
2	Transfer to communication	0.0
3	Send GMTI#1 to GCS	0.5
4	Breakout GMTI#1	1.0
5	Relay to DCGS-A	0.5
6	Direct GMTI#1 to analyst	0.0
7	Analyze GMTI#1	30.0
8	Review, prioritize target list	5.0
9	Send TL #1 to GCS	0.5
10	Update flight plan	2.0
11	Send flight plan to UAV	0.5
12	Return to location #1	25.0
13	EO/IR snapshot #1	2.0
14	Transfer to communication	0.0
15	Send EO/IR #1 to GCS	0.0
16	Breakout EO/IR #1	1.0
17	Relay to DCGS-A	0.5
18	Direct EO/IR #1 to analyst	0.0
19	Analyze EO/IR #1	3.0
20	Prepare and issue report	0.0
	Total	81.5

Table B: Typical SIFT UAV Mission with Onboard Processing

Step	Task	Duration (minutes)
1	GMTI sweep #1	10.0
2	Transfer to EIS	0.0
3	Generate target list	2.0
4	Task EO/IR	0.0
5	EO/IR snapshot #1	2.0
6	Transfer to communication	0.0
7	Send EO/IR #1 to GCS	0.0
8	Breakout EO/IR #1	1.0
9	Relay to DCGS-A	0.5
10	Direct EO/IR #1 to analyst	0.0
11	Analyze EO/IR #1	3.0
12	Prepare and issue report	0.0
	Total	**18.5**

Table A displays a sequence of events for a typical unmanned aerial vehicle mission with no onboard tasking capability. Table B depicts that same mission performed with SIFT onboard sensor tasking. On-board processing potentially offers significant improvements in timelines and workload. In the tables, the steps in black indicate those that take the same amount of time for the two missions; the red steps in Table A, which require 65.0 minutes, are equivalent to the blue steps in Table B, which require only 2 minutes. (GMTI, Ground Moving Target Indicator; GCS, Ground Control Station; DCGS-A, Distributed Common Ground Station-Army)

Our research showed that most of the operational advantages sought by the SIFT program could be achieved by having one sensor automatically cue another, thus eliminating an operator step and speeding the flow of information. With the accelerated data rates, intelligence collectors might be able to carry out missions such as "track and hold" of high-value targets. For this mission, we found that sensor algorithms that prioritize candidate targets by likelihood of interest would be sufficient to achieve useful operational performance and would be easier to implement than a fully automatic target recognition capability.

An additional IDA paper outlined considerations for a SIFT flight demonstration, including space, weight, and power characteristics of candidate unmanned aerial vehicles and performance specifications for sensor packages.

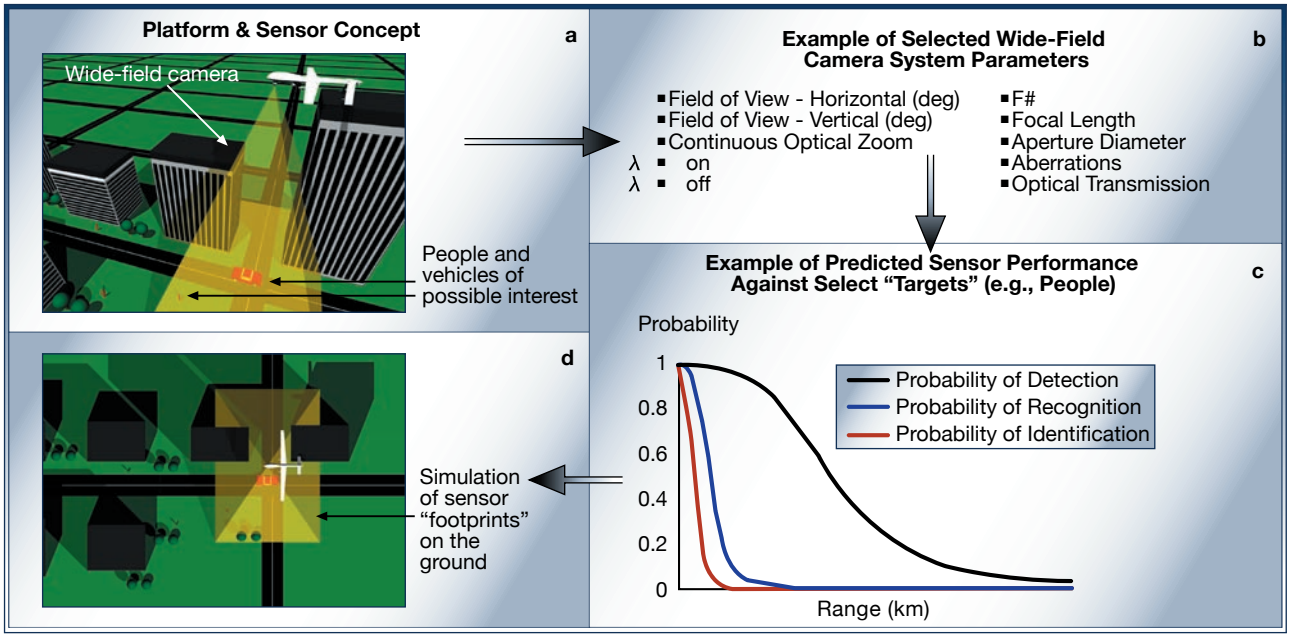
Urban Resolve 2015 Experiments

IDA researchers developed a concept for a new intelligence, surveillance, and reconnaissance system using sensor payloads on unmanned aerial vehicles and tagging technologies to provide persistent surveillance and tracking in urban areas. The concept was simulated as part of the U.S. Joint Forces Command's (JFCOM) Urban Resolve 2015 (UR2015) experiment.

We refined the concept by developing specific UAV and sensor designs and estimated the operational performance of individual sensors. Through testing and monitoring of the experiment, our researchers ensured the system simulation was consistent with the design.

As a result of the UR2015 experiment, JFCOM partnered with other DoD organizations to field the Angel Fire persistent surveillance system, which provides real-time, wide field-of-view imagery to units on the ground.

Support for Urban Resolve 2015 Experiments



This figure provides an overview of the process IDA researchers used in support of simulation of ISR system sensors during Urban Resolve 2015 experiments. The process begins with a concept identifying platforms and sensors. Here, a wide-field-of-view camera is highlighted as an example sensor (box a). Next, IDA developed detailed system design parameter specifications for components of the sensor system to achieve desired performance, such as resolution at range (box b). The third step was to use existing or newly developed sensor system performance models against relevant "targets" (box c). The final step was to work with the Modeling and Simulation developers to ensure their simulation of the sensor systems gave the expected performance based on the concept, the sensor system parameters, and the performance modeling (box d).

Biological Science and Technology

Human-Assisted Neural Devices

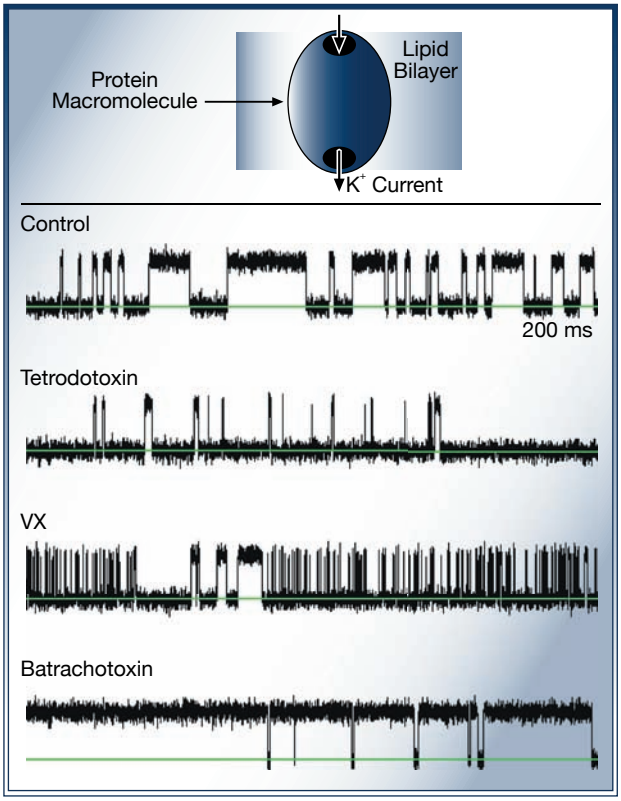
The brain accepts inputs and generates outputs through the electrical activity of neurons. To help people injured in combat, the Defense Advanced Research Projects Agency (DARPA) is exploring new technologies for restoring neural function by accessing and decoding the patterns of neuronal activity in the brain and then integrating these patterns into peripheral devices or system operations.

IDA has been providing technical assessments and evaluating the feasibility of new technologies since the program's inception. One such technology involves an advanced prosthetic arm that would be controlled directly by brain activity (i.e., thought) while at the same time providing sensation into the brain. Another effort is currently testing implantable chips that might someday restore lost function to the brain itself.

Engineered Biomolecular Nano-Devices

DARPA is developing a new type of sensor for chemical or biological agents. The heart of the sensor is a biological protein (ion channel) engineered to interact with chemical or biological agents of interest. In the presence of threat agents, the electrical current through the ion channel would be transiently blocked with a unique temporal signature that would permit the threat to be identified with high sensitivity and low false alarm rates. Since the beginning of the program, our researchers have been assessing the feasibility of component technologies and evaluating potential obstacles to development.

Engineered Biomolecular Nano-Devices/Systems (MOLDICE)



In biological systems, specialized proteins called ion channels conduct ionic currents through cell membranes. These proteins can be isolated from bacteria and placed into a platform that allows the ionic current to be measured. These proteins can be used as sensors because chemical or biological threat agents will interact with certain ion channels, causing characteristic blockages of the ionic current. In principle, the magnitude and temporal characteristics of the blockage will allow the chemical or biological agent to be identified. To test this hypothesis, IDA first simulated the ionic currents for a control case in which no threat agents or other molecules known to interact with ion channels were present. IDA then simulated ionic currents that might be observed in the presence of several toxins and chemical warfare agents. The simulated currents were then distributed to several DARPA MOLDICE performers to determine which of the competing signal processing algorithms were best able to identify the simulated chemical-biological threat agent. The results of this challenge allowed DARPA to proceed with a single signal processing group.

Space, Air, and Missile Technologies

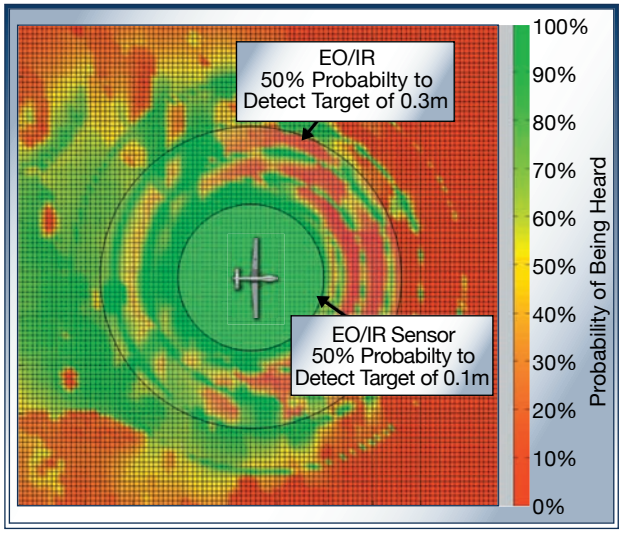
UAV Sensors and Signatures

To be effective in surveillance missions against dismounted combatants, unmanned aerial vehicles should

remain undetected both visually and acoustically while onboard sensors track the targets. DoD asked IDA to examine sensor capabilities and UAV signatures for selected systems currently being used for this mission.

The analysis combined two separate graphical, computer-based simulation tools to determine if the electro-optical/infrared sensors on low- to mid-altitude UAVs could detect individuals on the ground before the aircraft were heard or seen by the targets. Resulting recommendations for UAV concepts of operations are now being implemented by Army units.

Relationship between a UAV's Sensor Capabilities and Its Acoustic Signature



Sensor performance tools and aircraft acoustic analysis tools have been used extensively and separately over the years to analyze specific system performance levels. Until now, there had been no effort to use these tools in combination to study the relationship between an aircraft's sensors and its acoustic signature. IDA combined outputs from two existing tools to provide useful information and new understanding regarding the use and application of UAVs in a combat environment. The two tools were the Toyon-developed Geospatial Analysis and Planning Support Toolbox software and the U.S. Army Engineer Research and Development Center-developed Sensor Performance Evaluator for Battlefield Environments. The figure shows a representative plot of electro-optic/infrared sensor performance superimposed over aircraft acoustic analysis. The two circular rings show the maximum radius for detecting an object with characteristic length of 0.3 m and 0.1 m with 50% probability. The contour plot shows the probability of being heard, with green being 100% sure of being heard and red indicating 0% chance of being heard, for an aircraft flying left to right in the figure.

Aircraft Prognostics

Historically, aircraft either have been retired or refurbished in life-extension programs based on estimates of fatigue damage to key components accumulated over the life of the aircraft. DoD is seeking improved ways to assess risks of aircraft fatigue failures to enable more efficient maintenance and retirement planning and better management of fleet safety and readiness. The DARPA Prognosis program is focused on this issue.

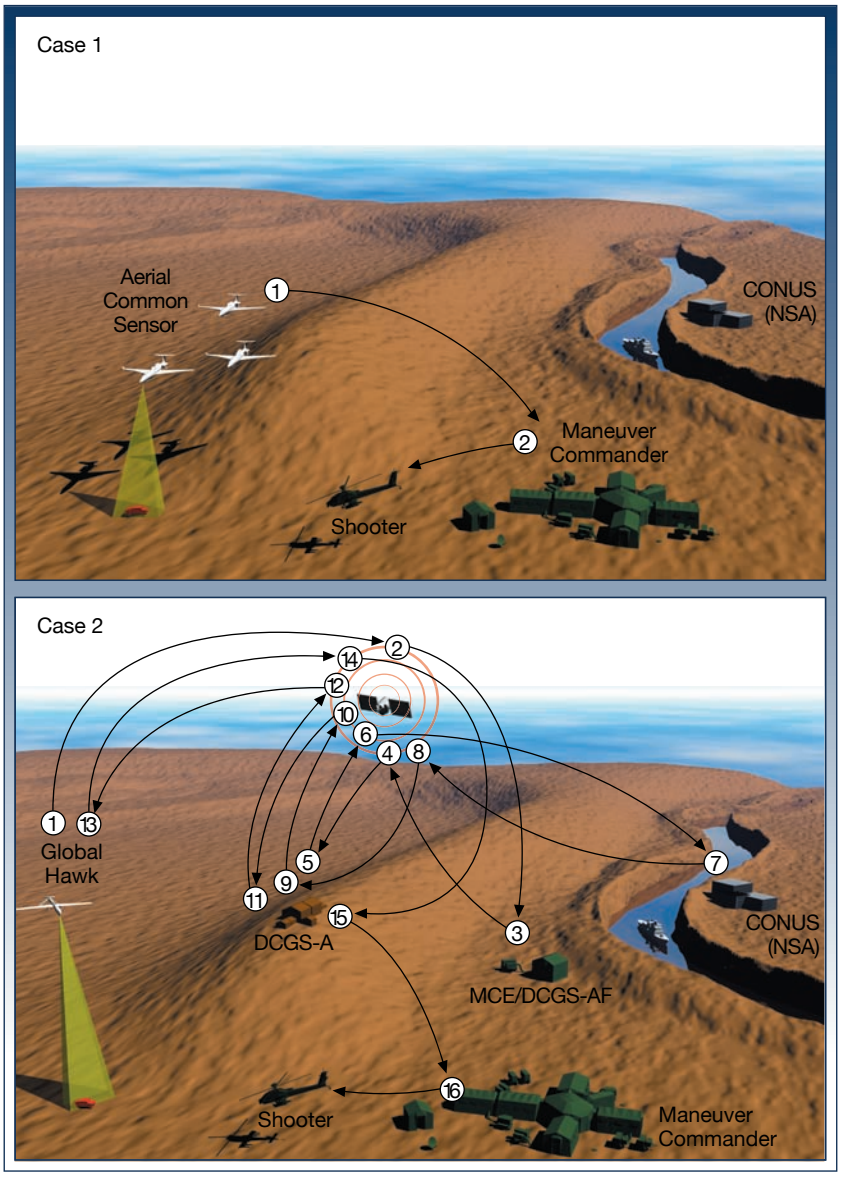
In support of this effort, IDA researchers have investigated the effects of flight load uncertainties on the risks of aircraft structural failure, using F-18 wing attachment bulkheads as an example. IDA used test data on fatigue crack growth to describe initial defect distributions, which we then extrapolated forward based on expected applied loads in future flights. Risk was calculated as a probability of failure (POF) during a single flight.

Results showed that a 5% to 10% uncertainty in the knowledge of applied flight loads reduced confidence in estimated POF risk, which in turn could lead to replacing components with usable life remaining. The load uncertainty could be reduced by placing additional sensors on the aircraft, but at increased costs for the sensors and monitoring systems. IDA proposed an approach for evaluating tradeoffs between cost of sensors and component maintenance and replacement suggested an economically viable strategy for selecting an appropriate sensor system.

Aerial Common Sensor

The Army is pursuing the Aerial Common Sensor (ACS) program, which comprises a fleet of new aircraft

Aerial Common Sensor Warfighting Assessment



This figure illustrates how two different ISR architectures might be used to detect a communication emission from a time-sensitive, high-value target and cue the Ground Moving Target Indicator (GMTI) radar, which can track the target and make a handoff to a shooter. In Case 1, the Aerial Common Sensor is the detection platform. In Case 2, the Global Hawk Block 30 is the detection platform. The numbered arrows represent the flow of target information from detection, to the handoff, to the shooter who completes the engagement.

equipped with advanced sensors for intelligence, surveillance, and reconnaissance (ISR) missions. In the past year, DoD re-examined the need for ACS-like capabilities in the context of other ISR systems that would be available at the same time as the proposed ACS aircraft. In support of this effort, DoD asked IDA to examine the information flow – detection, processing, exploitation, and dissemination – in tactical ISR missions. The purpose was to identify capability gaps that might exist if an ACS-like system were not deployed as some versions of current assets are retired.

In addition to the ACS system, a variety of alternative sensor and communications architectures were examined in selected tactical scenarios, including situations involving time-sensitive, high-value targeting. The architectures varied widely, embodying differing mixes of satellites, unmanned aerial vehicles, manned aircraft, and ground-based elements. Our researchers quantified the timelines associated with the alternative paths for the signals intelligence data and judged the effects on mission success.

Materials

Material Options for UAVs

For the last several years, IDA has been examining ways to increase the performance of unmanned aerial vehicles by using advanced lighter weight materials in the airframe,

more aggressive and riskier designs, and advanced engine materials and technologies. This year, we analyzed design tradeoffs related to maneuverability. To withstand the higher g-loads associated with more maneuverable aircraft, the UAV airframe would have to be strengthened, increasing its structural weight and thereby, for any given design, reducing the UAV's range and/or payload.

We investigated UAVs ranging in size from 10,000 to 35,000 pounds gross takeoff weight (GTOW). Using parametric models derived from actual aircraft data, we found that a UAV's empty weight (no fuel or payload) would go up by 5% to 10% of total GTOW as a result of increasing maneuverability-driven g-loads from 9g to 16g. For the 35,000-pound GTOW aircraft, the increased empty weight would reduce range by about 200 nautical miles or payload by about 2,000 pounds. These analyses are helping inform design tradeoffs for future UAVs.

Computer and Information Technologies

Information Technology for Geospatial Intelligence Support

The National Geospatial Intelligence Agency (NGA) will be moving its headquarters to Fort Belvoir, VA, in 2011. NGA asked IDA to assist in planning an information technology (IT) infrastructure at the new site that would enable the agency to meet mission needs of all geospatial intelligence users.

NGA supports national users, tactical military users, and a still-emerging, non-traditional customer base (e.g., (FEMA) during Hurricane Katrina). Our researchers structured an approach to collecting and quantifying enterprise-wide information loading with the new IT infrastructure. The approach included a disciplined way to identify and assess management and investment options and suggested a means to monitor implementing actions via process models and simulations. Linking specific demand and performance to the value delivered to users by the new IT infrastructure was perhaps the most critical feature of the IDA approach.

Trusted Path and Virtual Machines

Virtual machine architectures (VMAs) offer the potential to significantly improve security. In a VMA, multiple virtual machines are created on a single real machine, and each virtual machine may be isolated or interconnected as necessary. Recent improvements in computer hardware have made VMAs more practical to deploy, yet little effort has been directed at determining if and how a trusted path (TP) – a secure communication path between a human and the computer service – could be established in a VMA.

IDA is examining challenges and identifying possible solutions in implementing a trusted path in a VMA using commercially available components. We identified a new TP triad that categorizes trusted path mechanisms into three classes: initiate, perceive, and architect. Our researchers are currently developing a prototype TP on a VMA, which will be used to test IDA-developed TP concepts.

Trusted Integrated Circuit Strategy

Advanced integrated circuits (ICs) are increasingly manufactured overseas. A 2005 Defense Science Board study highlighted the potential risks associated with depending on foreign suppliers for critical defense elements. IDA is assisting in developing technologies, policies, and industrial strategies to manage this situation.

One IDA effort focused on analyzing vulnerabilities in the IC supply chain, particularly for field programmable gate arrays. A second effort assisted DoD in establishing a research program to develop new technologies to protect against threats to the IC supply chain. A third effort assisted DoD in developing policies and strategies for helping trusted suppliers – such as the Trusted Foundry – manage IC supply risks in developing, acquiring, and sustaining defense systems.

The State of Computer Science Research

Computers and information technologies are critical for attaining information dominance on the battlefield and for increasing productivity and competitiveness in the marketplace. The innovations that created computers and the new information technology economy are partly a result of several decades of DoD investment in fundamental computer science (CS) research. DoD asked IDA to analyze the state of CS research, including a careful review of DoD's historical involvement in the field.

Noting the overlap between CS and IT research, we found that overall federal funding in the last decade has doubled for CS and tripled for IT. Additionally, we highlighted issues with the e-gov database, which contains research and engineering data for CS, IT, and other technical areas. Based on our analysis, DoD has taken steps to improve the database.

Technology Planning and Strategy

Quantum Leap Technologies for Irregular Warfare

IDA helped review DoD's current technology base program and its alignment with the Department's changing priorities. Focusing on the desired capabilities, our researchers worked with DoD resource sponsors to identify existing research programs and to suggest areas that required additional focus regarding irregular warfare.

In particular, we identified and prioritized technical thrusts related to human and information systems. As a result of this work and in response to Strategic Planning Guidance, DoD is developing a new program area in human behavior and socio-cultural modeling.

C4ISR for Homeland Defense

Defense Science Board and National Research Council studies recommended that DoD provide relevant command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) technology for use by first responders in a major disaster. DoD asked IDA to examine available C4ISR capabilities and determine their capacity to support DoD's homeland defense mission.

Initial Operational Capability of the Joint C4 Coordination Center

SGM Robert Miller of the Delaware National Guard (standing center) provides an update on incident status at the National Guard Bureau's Joint C4 Coordination Center (JCCC). The JCCC, one of the major elements of the IDA-supported Joint CONUS Communications Support Environment development, maintains National Guard C4 communication status for all states, monitors incident situations across the country, and coordinates mutual C4 support between Guard units.

Our researchers helped develop a concept for a Joint Continental U.S. Communications Support Environment (JCCSE), which supports net-centric information technology capabilities and provides a trusted information exchange environment for homeland defense missions. The basic premise was validated during Hurricane Katrina recovery efforts, where elements of JCCSE helped restore initial communications.

IDA also analyzed a concept for continuous communication between civilian and military responders, which led to the development of the Joint Incident Site Communications Capability.

Wind Farms

Congress asked DoD to report on the effects of windmill farms on military readiness, with a focus on air defense radars. In support of this effort, IDA evaluated data available from allies – predominantly the United Kingdom. After determining that measured data on wind turbine-induced scattering was inadequate, our researchers characterized the technical needs for a U.S. data collection site, set parameters for a collection system, and helped select a test organization.

Subsequently, the Air Force Research Laboratory collected radar cross-section data at a wind farm in New York. Results showed that the high Doppler return in the turbine blade flashes can generate false target tracks or hide real targets from air defense radars.

Science Study Groups

IDA runs two programs for DARPA – the Defense Science Study Group (DSSG) and the newer Computer Science Study Panel (CS Study Panel) – that introduce outstanding young science and engineering professors to national security challenges and encourage them to apply their talents to these issues.

DSSG members cover a broad range of disciplines, while those in the CS Study Panel focus on computer science and related disciplines. Both groups learn about DoD operational and technical procedures and relevant challenges through briefings by senior military and industrial leaders, visits to military and industrial facilities, interactions with troops, and discussions with technical and research specialists.

Computer Science professors in the Computer Science Study Panel were briefed on A-10 operations at Nellis Air Force Base as part of their first-year introduction to the military operational environment. (L to R facing the camera, Michael Ernst of the Massachusetts Institute of Technology, Charles Izbell of the Georgia Institute of Technology, and Geoffrey Gordon of Carnegie-Mellon University.)

IDA selected 15 exceptional academics to participate in the 2006-2007 DSSG class. Distinguished mentors and advisors worked with the members to provide perspectives on defense issues and helped members with their research papers. IDA and DARPA work to ensure that DSSG alumni are offered opportunities for continued involvement in national security, such as serving as members of boards and study groups for organizations addressing significant technological issues.

Each year DARPA selects 12 promising tenure-track assistant professors to participate in the CS Study Panel. During the first year's orientation, IDA introduced members to the range and nature of DoD operations and technical challenges via site visits and interactive discussions with military personnel. Concurrently, members prepared research proposals related to national defense needs. In the second year, DARPA selected 10 Panel members to receive research grants up to $500,000. If the member obtains matching funding, an additional $250,000 is granted for the third year. IDA facilitates research and networking for members throughout the program.

International Technology Planning and Controls

Critical Technologies Program

IDA provides technical and analytic support for U.S. and foreign proposals at the multilateral Wassenaar Arrangement (WA) negotiations on export controls for conventional arms and dual-use goods and technologies. Our researchers initiated or supported a number of U.S. proposals and played a key role in modifying controls on non-destructive inspection equipment, solar arrays, turning machines, equipment used to manufacture advanced optical equipment, and accelerometers and gyros.

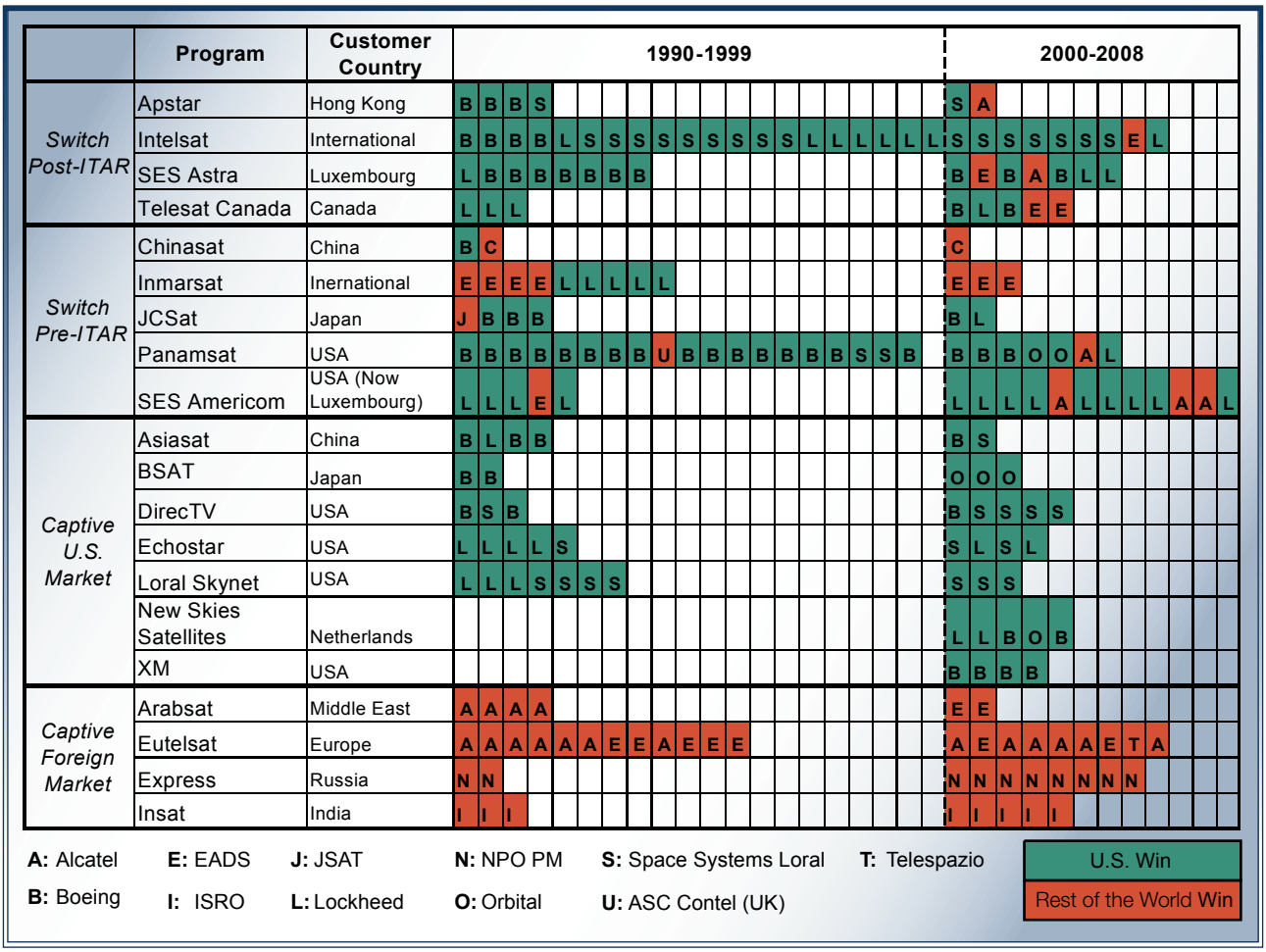
We also helped establish new controls on microwave power modules, solid-state power switching devices, imprint lithography, silicon carbide substrates, passive coherent location systems, and underwater sonar navigation systems. IDA technical support was instrumental in WA Participating States reaching agreement – after several years of negotiations – for a major modification to the technical underpinnings of laser controls.

Export Controls and the U.S. Defense Industrial Base

IDA examined the impact of current and proposed U.S. export controls on four industries: satellite manufacturing, semiconductors, machine tools, and advanced materials. We found that U.S.-based industry has not suffered significant economic impacts to date as a result of export control regulations. For instance, in the satellite industry, statistical tests and region-by-region analysis showed that export controls did not explain the drop in U.S. revenues between 1995 and 2005 – revenues that rebounded dramatically in 2006.

On the other hand, U.S. export controls cause unreliability in supply relationships, diversion of business investment funds, restricted access to foreign talent, and barriers to selected overseas markets, the combined effects of which could damage U.S. competitiveness in the future.

Major Commercial GEO Satellite Programs: 1990-2008



There are several specific examples of traditionally exclusive U.S. customers changing their behavior after the switch to ITAR. In most cases, however, the customer will purchase from both U.S. and European providers. Only one specific example exists where a customer appears to have moved away from U.S. providers. Canadian Telesat bought from only U.S. vendors prior to 1999 but acquired all recent satellites from EADS. Each cell above represents a major satellite sale and is color coded as to if a U.S. or foreign company won the contract.

Note: This analysis includes all customers that have ordered four or more satellites since 1990. Launches plotted by launch year, not necessarily by launch date (exact launch date was not always available).

1967 – 1976

Institute Highlights

- Program Analysis Division and International and Social Studies Division replaced the Economic and Political Studies Division.
- Cost Analysis Group was formed to provide costing support to IDA divisions.
- Jason Division was disestablished and the Jason group of university scientists affiliated with another organization.
- University oversight of IDA ended in 1968 in the aftermath of Vietnam-related demonstrations at Princeton and other member universities.

Research Highlights

- Vietnam War operations were analyzed, including aircraft and ground force performance.
- Subversion warfare studies examined enemy operations in South Vietnam, South Vietnam's economic problems, and the Hamlet Evaluation System.
- Command, control, and operational support studies conducted to assess equipment, systems, logistics, and processes needed to respond to national and international crises.
- STRAT-X study examined future ballistic missile options and basing concepts.

- Bomber survivability studies focused on the ability of strategic bombers to survive surprise attacks and to carry out their missions.
- Strategic force levels and mixes were assessed within limits set in Vladivostok Accords.
- ELECTRONICS-X study examined acquisition and support of electronic systems and subsystems, with focus on cost and reliability.
- Computer export controls were assessed for likely impacts on national security, given rapidly expanding worldwide trade in advanced computers.
- 1973 Arab-Israeli War lessons assessed for U.S. and Soviet equipment.
- China and Eastern Europe regional studies examined key military, political, and economic trends and developed broad U.S. policy alternatives.
- Night vision studies focused on equipment, systems, and fundamental physical factors.
- Presidential commission on law enforcement included an IDA-led task force on science and technolgoy, which examined technologies related to crime prevention and criminal apprehension.
- Measures to mitigate another Arab oil embargo studied for the Federal Energy Administration, with emphasis on the cost-effectiveness of oil stockpiling options.

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; environmental technologies and plans; 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.

Cost Analyses

Independent Cost Analysis for the AESA Radar

The AN/APG-79 radar for the Navy's F/A-18E/F tactical aircraft incorporates an active electronically scanned array (AESA) to increase detection range and to improve capabilities for electronic warfare and suppression of enemy air defenses. In 2003, when the program was in development, IDA provided a baseline cost estimate for the program and identified hardware development risks that could increase production and development costs.

This past year, we conducted a second analysis of the radar before its transition to full-rate production. We re-examined the hardware development risks identified in the previous study and found that most potential problems had been resolved. A number of software issues remain, however, and we are now creating a new baseline cost estimate for the radar.

Operating and Support Costs of the Future Combat Systems Program

DoD asked IDA to review the technologies and operating concepts for the Army's Future Combat Systems (FCS) program to identify potential sources of operating and support (O&S) cost risk. We highlighted two areas for attention during program development.

FCS vehicles are being designed to be much more reliable than typical current combat vehicles. Achieving this higher reliability will increase production costs; however, we showed that less reliable vehicles would raise FCS life-cycle costs due to increased field maintenance and spare parts, combined with the need to buy more spare vehicles to maintain the readiness of operational FCS units.

A second area of cost risk relates to networking. The FCS concept calls for using high-speed, mobile, peer-to-peer networks for command, control, and communications, as well as intelligence, surveillance, and reconnaissance functions. While individual enabling technologies have been demonstrated under non-combat conditions for a small number of network nodes, achieving

satisfactory networking under combat conditions – for the hundreds of vehicles in a brigade – poses a development challenge. The operational complexity of the network and the sheer volume of needed software lead to O&S cost risks.

Costs of Maintenance Manpower

Because traditional cost estimating relationships have proven inadequate for estimating maintenance manpower for advanced combat aircraft, our researchers developed a discrete-event simulation model – the IDA Maintenance Estimation and Sortie Utilization Rate Evaluation (IMEASURE). The model projects staffing needs within an aircraft squadron for propulsion, airframe, and avionics maintenance technicians.

IMEASURE has become an important tool in providing DoD sponsors with timely, high-quality estimates of life-cycle costs early in an aircraft's development phase. We have successfully applied this model in studies of advanced tactical aircraft, such as the Joint Strike Fighter and the F-22A, and in analyses of the upgraded UH-1 helicopter, the proposed unmanned combat air vehicle, and alternative designs for a new bomber.

Recent improvements to IMEASURE include the addition of modules related to repairs of low-observable features, engine depot maintenance, and phased maintenance. The model also is being used to estimate the life-cycle cost implications of alternative levels of operational suitability.

Contingency Operations Support Tool

IDA's Contingency Operations Support Tool (COST) provides an automated, common basis for DoD's financial and resource management community to estimate the costs of military operations, including ongoing counterterrorism efforts. DoD's Financial Management Regulations mandate the use of COST as the common estimating tool for reimbursement of war-related expenses, and COST is one of the two automated systems used by DoD to plan and execute joint contingency operations.

In 2006, IDA's COST development team refined the tool to enable better estimates of the costs of ongoing operations in Iraq, Afghanistan, and elsewhere. We also developed a new application, the Budget Integration Framework, which has revolutionized the way DoD manages and assesses supplemental budget requests.

Acquisition Planning and Resource Management

Business Case for Improving DoD Fuel Efficiency

Fuel efficiency has not been addressed explicitly during the acquisition process for most weapons and support systems. In part, this is because more fuel-efficient systems generally cost more to buy than other technological approaches that meet the same mission performance goals. However, in light of the recent steep rise in fuel costs, savings in operating expenses may now offset procurement cost penalties.

DoD asked IDA to see if a business case could be made for acquiring fuel-efficient ground vehicles, such as Army trucks. Our researchers developed a methodology that takes account of the logistics systems needed to deliver fuel to operating forces. DoD is considering making this analytic approach a required element in analysis of alternative studies conducted for major acquisition programs.

Rapid Development Process

IDA was asked to help define a "rapid development" track within the DoD acquisition process. The track would be used for comparatively small programs that require some development yet could be fielded within three to four years. Key findings include the following:

- The Services can and do buy new systems requiring only limited development in a three- to four-year period.
- Some opportunities for Joint and Combatant Command (COCOM)-unique programs requiring only limited development are not being developed.
- The DoD processes for identifying and acquiring joint and COCOM-unique smaller systems are often ineffective.

We found that some comparatively easy steps could be taken to mitigate the problems. One promising approach would build on existing joint experimentation programs, strengthening the linkages to COCOM priorities during the selection of experimentation topics and expanding the experimentation process itself to include mature prototypes.

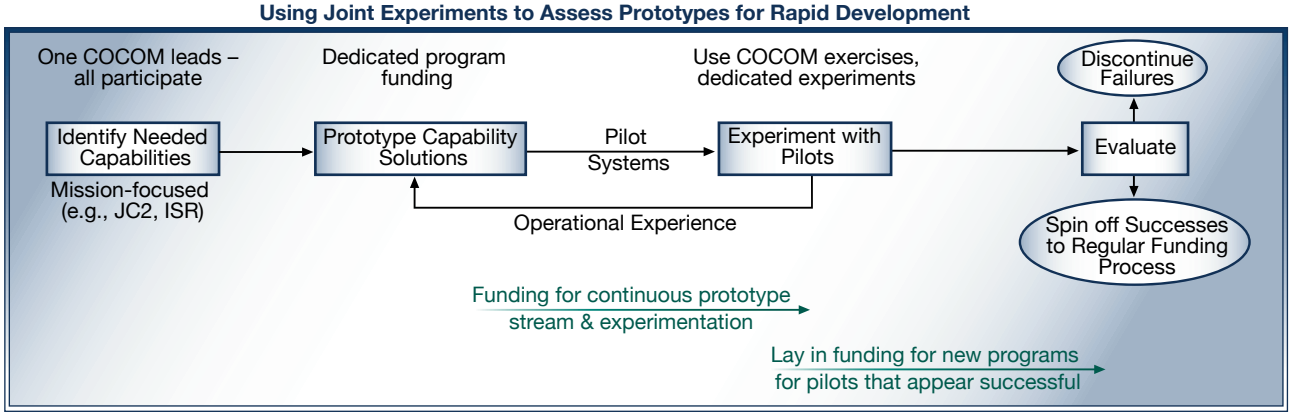
Resource Analyst Training

IDA's Resource Analyst Orientation course helps provide analysts newly assigned to the Office of the Secretary of Defense and headquarters-level offices in the Services and military departments with a practical overview of DoD's resource management and acquisition processes and analytical techniques used in them.

The course was originally developed to help the OSD Office of Program Analysis and Evaluation. However, attendance recently has expanded to include students from other OSD offices, the Services, the Joint Staff, other federal agencies, foreign nationals, and representatives from professional schools such as the Naval Postgraduate School and Defense Acquisition University.

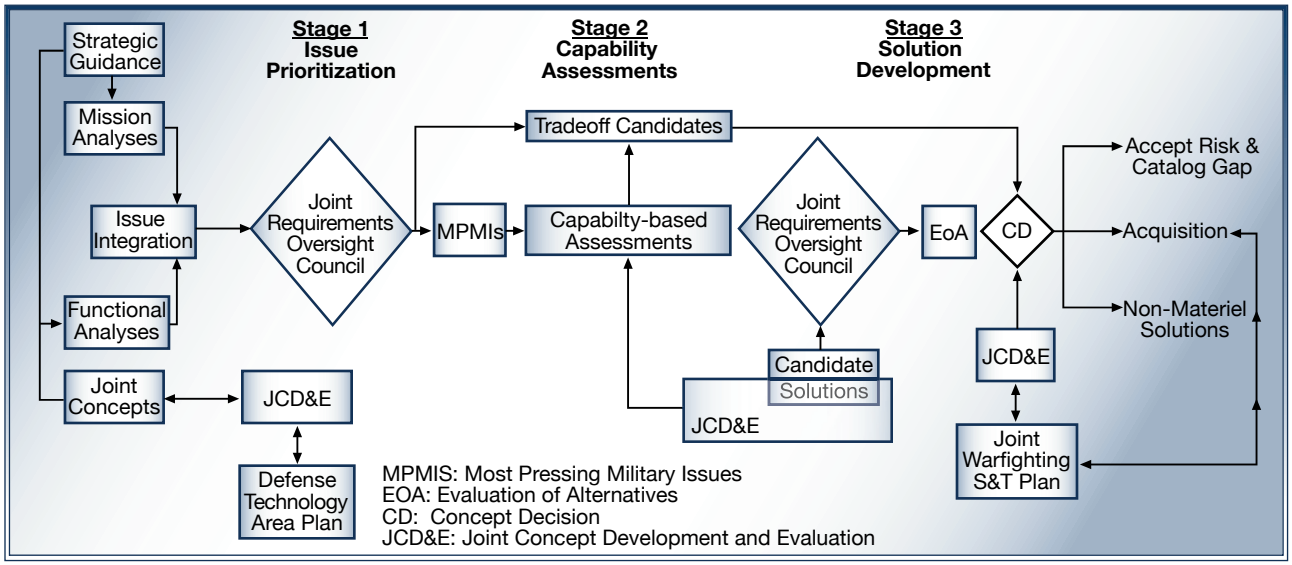
The process portion of the orientation course covers the capabilities identification process, the acquisition process, and all phases of the Planning, Programming, Budgeting and Execution system. We recently expanded the curriculum to include discussions about the difficulties in integrating DoD's decision processes across numerous organizations and disciplines. Specific functional topics introduced include cost-effectiveness analyses, inflation and discounting, contracting, operational test and evaluation, the DoD Future Years

Using Joint Experiments to Assess Prototypes for Rapid Development



Joint experiments can be used to rapidly assess and mature prototype developments. IDA suggested a process in which pilot systems directly related to Combatant Command needs would be drawn from a variety of sources and explored in experiments. The pilot systems showing most utility would be spun off for procurement through the regular funding process.

Proposed Integrated Processes for Capabilities Development Planning



This figure depicts a three-stage process for capabilities development planning. In Stage 1, strategic guidance is created, mission analyses for the present are conducted by various DoD components, and functional area and functional needs are analyzed for future concepts. These concepts are informed by broad-level joint concept development and experimentation (JCD&E), which in turn is informed by the Defense Technology Area Plan. The Joint Requirements Oversight Council (JROC) conducts a high-level risk analysis before creating a statement of Most Pressing Military Issues. In Stage 2, the JROC reviews capabilities-based assessments against the issues statement to identify candidate approaches for resolving the priority capability gaps. In Stage 3, solutions for resolving the capability gaps are developed using an evaluation of alternatives and concept decisions, which identify resources and direct the acquisition process to proceed with solution approaches, or accept the risk. The resources for new starts are identified by a tradeoff process informed by Stage 1 and Stage 2 analyses. Concepts are refined and technology development efforts begin by taking into account JCD&E with candidate solutions and the Joint Warfighting science and technology plan.

Defense Program, and weapon system costing, which is taken up in more detail.

The cost-estimating portion of the course begins with "Weapon Costing 101," which introduces basic costing concepts such as life-cycle costs, direct/indirect costs, fixed/variable costs, and work breakdown structure. Additional lectures address topics such as cost estimating relationships, learning curves, software cost estimating, contractor overhead allocation and pricing, and cost risk modeling. The cost estimation segment concludes with a discussion of cost estimating lessons learned from past major DoD weapon systems.

Implementing Capability-Based Planning

Capability-based planning is intended to improve DoD processes for identifying, developing, and rapidly fielding needed military capabilities. To assist in implementation, IDA provided an analytic framework for understanding what capability-based planning could do, how the major processes involved in capability development relate to each other, and how the outputs of the processes should be timed to support a "battle rhythm" for Pentagon planning activities. Our findings are being incorporated into a new DoD instruction on Capability-Based Planning Implementation.

SAFETY Act

The 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 the liability risks to the developing corporations. In response, Congress passed the Support Anti-terrorism by Fostering Effective Technologies Act of 2002 (the SAFETY Act), which limits legal liabilities of the developers of anti-terrorist products and services. The Department of Homeland Security (DHS) asked IDA to

Where are SAFETY Act products used?

Alltel Stadium
Jacksonville, FL

(Verified ID, Verified Identity Pass, Inc.)

Kansas City International Airport
Kansas City, MO

(Reveal CT-80 Explosive Detection Systems, Reveal Imaging Technologies)

Port of Long Beach
Long Beach, CA

(Container Inspection Services, Washington Group International, Inc.)

Cal Expo
Sacramento, CA

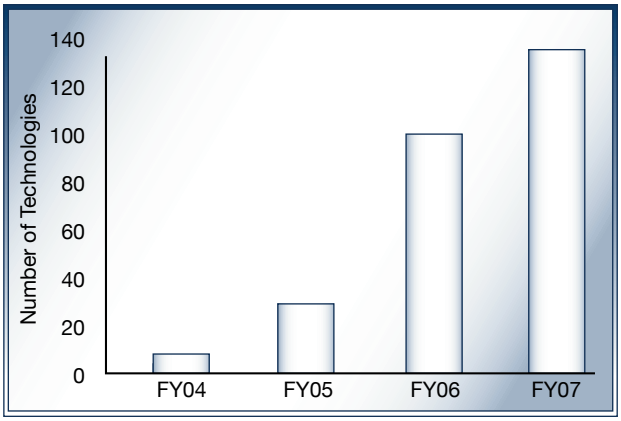
(Rapid Responder Crisis Management Software, Prepared Response, Inc.)

Many of the 130 plus technologies that have been awarded SAFETY Act protection are deployed to protect airports, ports, and sporting and entertainment venues.

assist in implementing the provisions of the SAFETY Act.

Those seeking the protections of the SAFETY Act submit Internet-based applications, which contain information needed to determine whether the statutory criteria for protection have been met. The information includes descriptions of the technology, the intended use of the technology, the liability environment, and selected financial data related to the applicant company.

Cumulative SAFETY Act Awards by Fiscal Year



More than 130 technologies have been awarded protection under the SAFETY Act since its inception in 2002.

IDA researchers developed and implemented a peer-review process to evaluate each application against the economic and technical criteria specified in the law. A pool of experts drawn from IDA, other federally funded research and development centers, the federal government, and academia serve as reviewers.

As of January 2007, DHS had granted the highest level of SAFETY Act protection – called Designation and Certification – to 82 anti-terrorist products or services, and had granted Designation status to another 39 products or services.

Joint DLA-Services Engineering Support System

As manager of DoD's wholesale supply system, the Defense Logistics Agency (DLA) is responsible for supplying 95% of the repair parts used on over 1,400 weapon systems maintained by the military Services. This results in about $6.6 billion in DLA sales to the Services annually.

To provide needed technical support to DLA in this mission, a joint DLA-Services engineering support system was established in the 1990s. Under this system, the Services provide technical guidance and assistance to DLA in buying repair parts for which they are reimbursed. These reimbursement costs have grown to more than $100 million annually, which, in turn, DLA recoups by charging higher prices for repair parts bought by operating forces.

DLA asked IDA to examine ways to improve the efficiency and effectiveness of the engineering support system. Our researchers are focusing on the scope of the overall system, the quality of the support provided, the responsiveness of the system, and the cost-effectiveness of alternative ways to carry out this mission.

Enterprise Telecommunications for Net-Centric Operations

The Defense Information Systems Agency is continuing its planned transition to the Defense Information Systems Network (DISN) Subscription Services (DSS), the net-centric information technology approach introduced in 2005. DSS simplifies the fee-for-service approach and encourages high bandwidth usage of the DISN for data sharing.

IDA assisted in transitioning existing processes and systems to the new paradigm, facilitating the move to full DSS implementation in fiscal year 2008 or 2009. Our researchers enhanced and expanded the DISN Subscription Analyzer, a database tool used to validate billing information and support the design and forecast of alternate DSS scenarios. In addition, we evaluated the DSS billing methodology and identified alternatives to the current distribution of shares, share price, and subscription packages.

Training, Readiness, and Personnel

10th Quadrennial Review of Military Compensation

The 10th Quadrennial Review of Military Compensation is chartered to seek ways to improve the efficiency of the compensation system. In support of the Review, IDA researchers are:

- Identifying occupations in which the compensation system has not been sufficiently flexible to allow the Services to meet their staffing requirements.
- Discussing ways in which DoD can improve the system for managing the Basic Allowance for Housing (BAH). BAH budgets are determined two years before payments are made, and both rates and the eligible population may rise in the interim. BAH was underfunded by almost $3 billion in 2005.
- Determining ways to make the DoD health benefit more efficient. This work builds on previous IDA studies on the determinants of medical benefit use by DoD dependents and retirees.
- Investigating use of vouchers instead of, or in addition to, providing services directly. This approach could broaden the choices available to Service members and their families.
- Examining the extent to which a cafeteria benefit plan would help distribute benefits more equitably.
- Assessing the pros and cons of a pay-for-performance system.

Enlistment Early Warning System

Thirty years of experience with the all-volunteer force suggests that DoD increases recruiting resources too slowly during economic expansions and over budgets during recessions, leading to enlistment shortages or waste. To help mitigate this problem, DoD is using new methods to forecast enlistments and allocate recruiting resources over business cycles.

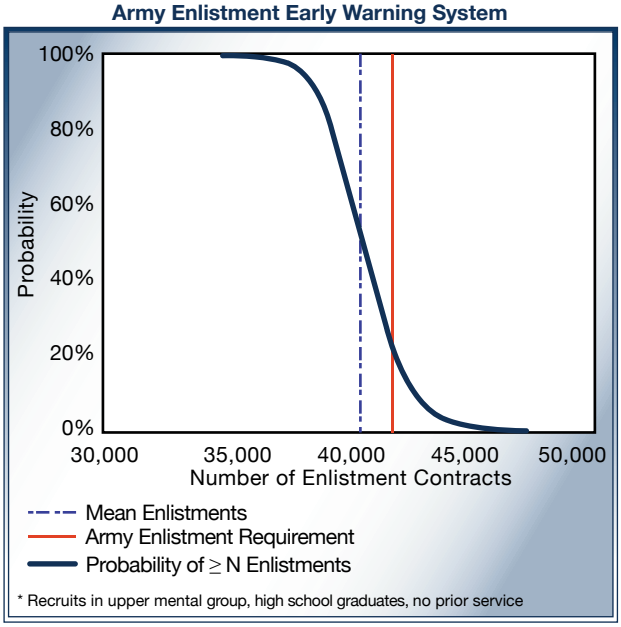
To provide the needed forecasts, IDA developed an Enlistment Early Warning System (EEWS) for each Service. Quarterly, the EEWS forecasts enlistments for the next year and uses computer simulations to estimate the probability of recruiting success. Forecasts are developed using econometric models based on national monthly economic data. Validation tests have shown the forecasts to be accurate. DoD is now using the EEWS to forecast recruiting and reduce budgeting lags.

Example of Enlistment Early Warning System Forecast Accuracy

Month	Forecast	Actual	Percent Error
2006:01	171	187	-8.5%
2006:02	145	148	-2.0%
2006:03	178	174	2.3%
2006:04	160	134	19.4%
2006:05	148	169	-12.4%
2006:06	176	201	-12.4%
2006:07	181	212	-14.6%
2006:08	191	185	3.2%
2006:09	176	182	-3.3%
2006:10	173	167	3.5%
2006:11	155	154	0.6%
2006:12	170	164	3.6%
CY2006	2024	2077	-2.5%

The Enlistment Early Warning System (EEWS) allows the Services to predict enlistments with considerable accuracy. This example shows the actual number of female Marine recruits (upper mental group, high school graduates, no prior service) compared with the number predicted by the EEWS the year before. While some individual months show larger errors, the total predicted for the year was only 2.5% from the actual number.

Army Enlistment Early Warning System

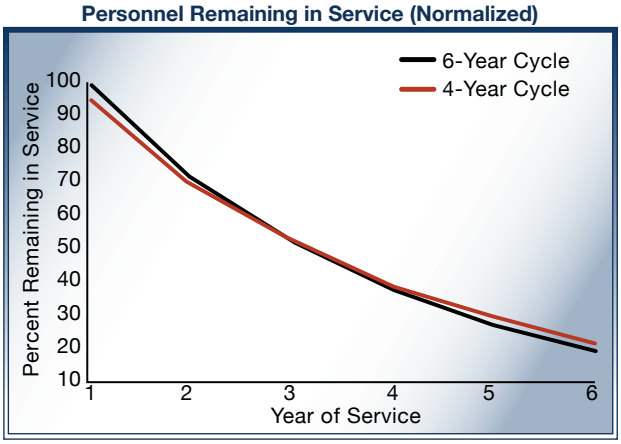


In the example above, the expected number of high-quality enlistment contracts is 40,551, and the recruiting goal is 41,851. The probability of achieving the recruiting goal is 19%.

Reserve Recruiting and Retention

IDA researchers have developed a dynamic, discrete-choice model to project from recent experience how different activation policy options might affect accessions and retention in the Reserve Components (RC). RC members' decisions on whether to join and stay in the Reserves are determined in part by expectations of future activations, preferences for active duty, and projected incomes.

To date, model parameters have been estimated for enlisted Army Reserve (USAR) and Army National Guard (ARNG) members with no prior active service. These parameters can be used to estimate the effects of policy changes. For example, the Army's current force generation plans call for USAR units to mobilize on a five-year cycle and ARNG units to mobilize on a six-year cycle. Our model predicts that, with all else equal (notably pay and bonuses), switching to a four-year



This chart shows how Army Reserves and Army National Guard retention varies depending on whether activations occur every 4 years or every 6 years. At the beginning of the first year of service, 100% of those recruited under a 6-year cycle are serving. Under a 4-year cycle, the number recruited is slightly lower; thus, the number serving is lower. By the beginning of Year 6, IDA observed that increased retention under a 4-year cycle results in a net increase of personnel serving relative to the 6-year cycle.

cycle would lower accessions but raise retention, as the resulting force would include – because of so-called selection effects – proportionately more reservists who prefer active duty.

Advanced Distributed Learning

The Advanced Distributed Learning (ADL) initiative was undertaken to make education, training, and performance aids available anytime, anywhere. This year, IDA coordinated the work of software engineers and instructional designers in industry, government, and academia. The effort resulted in agreed upon specifications for developing and packaging sharable objects so that they could be available across the Internet (or the Global Information Grid). These specifications are being widely adopted nationally and internationally.

The Content Object Repository, Discovery, and Registration/Resolution Architecture (CORDRA) being developed in part by IDA focuses on precise identification and rapid location of computer-based objects needed for a particular instructor application. ADL-Registry, the first implementation of CORDRA, relies on a system of registries to provide global visibility for objects, but ensures local control over access to them.

Disparities among States in Veterans Disability Payments

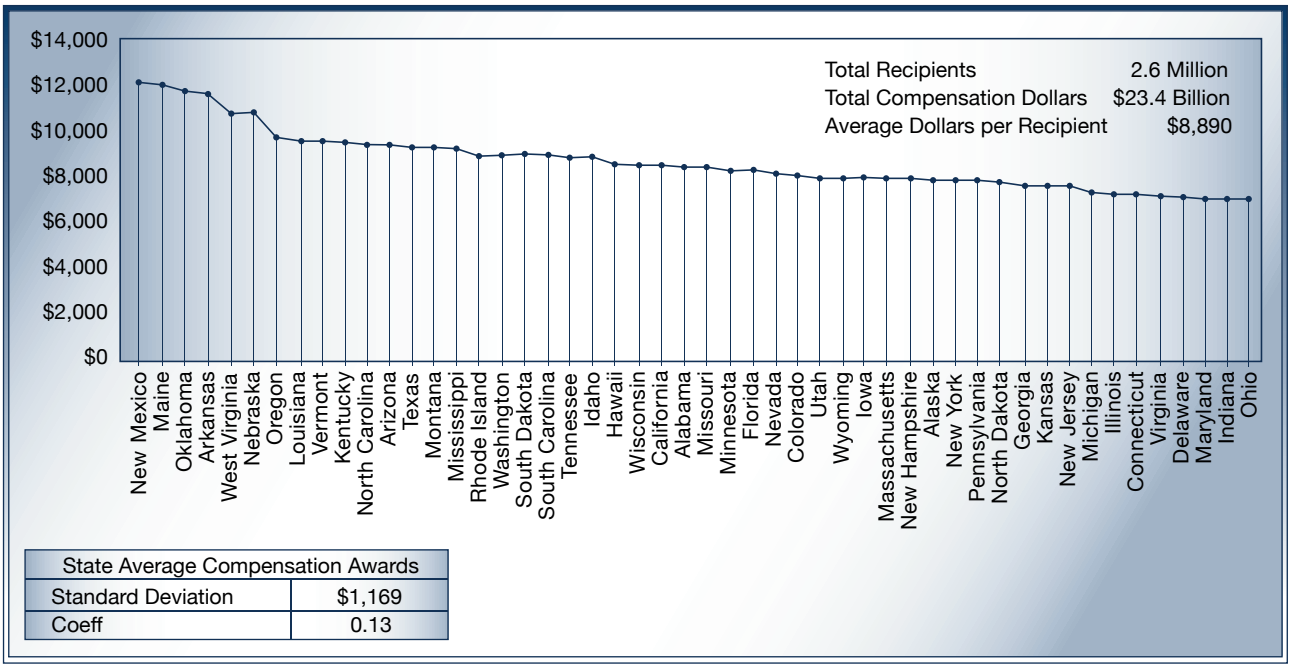
The Department of Veteran Affairs (VA) asked IDA to examine the underlying causes of disparities among the 50 states in average compensation payments to veterans. Our researchers identified the most important factors and then conducted appropriate statistical tests to quantify their influence on the observed variation in disability compensation awards.

We found that the sizes of the state-wide average awards are driven largely by the proportion of recipients who receive the maximum benefit. We also found that claims for Post Traumatic Stress Disorder contributed significantly to the variation across states. Based on these findings, we identified several actions that could be taken to address issues related to the consistency of awards.

Modeling and Simulation Planning

Six functional communities within DoD are developing modeling and simulation (M&S) business plans to focus and integrate M&S investment and to identify opportunities for collaboration across the Department. IDA is providing analytic support to four communities – analysis, training, test and experimentation, and concept development – while maintaining close

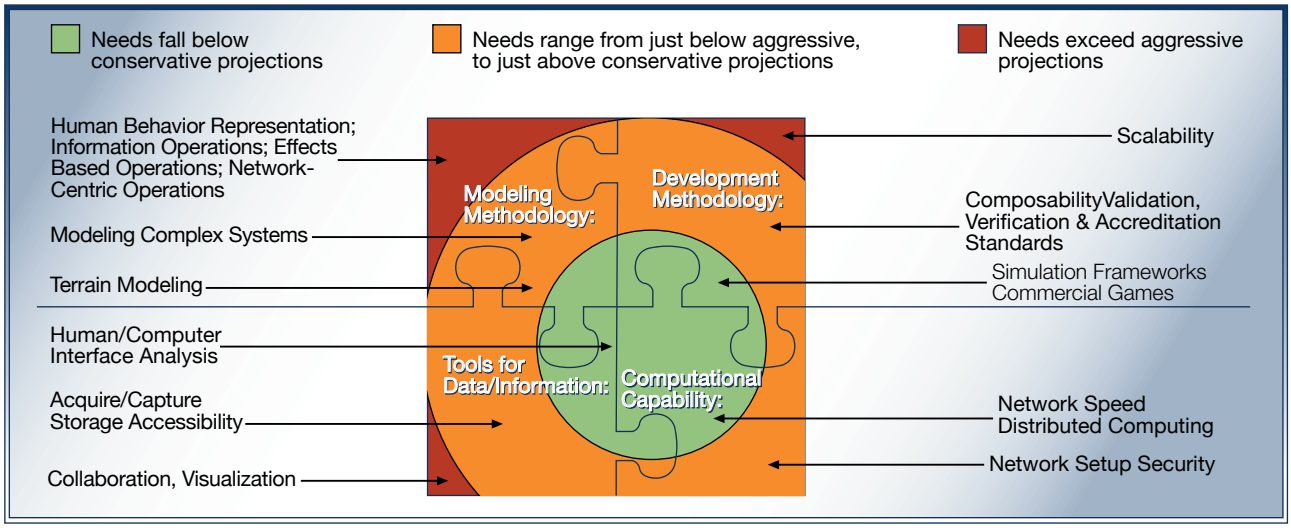
Average Disability Compensation Dollars by State (Fiscal Year 2005)



State Average Compensation Awards	
Standard Deviation	$1,169
Coeff	0.13

In 2005, the Department of Veteran Affairs provided a total of $23.4 billion in disability compensation to 2.6 million veterans. This figure shows that the average disability compensation award was $8,890. However, there is almost a $5,000 difference between the state with the highest average (New Mexico) and the state with the lowest average (Ohio).

Current Modeling and Simulation Research and Development Capability



While research to improve computational capabilities has resulted in significant improvements in the past several years, this chart suggests that research methodologies – particularly for human behavior representation, information operations, and other important areas – needs significant attention. Here, the burgundy areas are those where even with the most aggressive investment program, the needs significantly exceed what can be delivered. Conversely, those areas in orange – such as terrain modeling and network speed distributed computing – are given no real priority, and progress in developing and fielding solutions to modeling and simulation issues will move along more slowly, but there should still be some progress.

contact with the other two – acquisition and operational planning.

Our researchers helped each community identify current management processes and develop an M&S vision. By comparing current capability to the vision, M&S gaps were identified – i.e., tools, methodologies, data, intellectual capital, and research.

We emphasized the need for existing M&S tools to incorporate more useful representations of human behavior, command and control, information operations, network centric operations, and effects-based operations. We also helped the communities reach consensus on developing new M&S capabilities for analyzing irregular warfare and counterterrorism operations.

Additionally, IDA researchers helped develop a concept for a capability-based test and evaluation process aimed at making testing in joint environments more efficient and enabling test results to be more immediately useful across the Department.

1977 - 1986

Institute Highlights

- Computer and Software Engineering Division, since renamed the Information Technology and Systems Division, was established to examine applications of complex computer systems to DoD missions and related software and security issues.

- Cost Analysis and Research Division was established by expanding the mission of the existing Cost Analysis Group to include improving cost-estimating methods and enhancing understanding of cost-technology trends and defense industry cost drivers.

- Operational Evaluation Division was spun-off from the renamed System Evaluation Division to focus on operational test and evaluation and to support Unified Commands.

- Strategy, Forces and Resources Division was formed by combining two earlier IDA divisions to work on issues related to strategy, the capabilities of forces, the support infrastructure, and improving organizations and management processes.

- Supercomputing Research Center, later renamed the Center for Computing Sciences, was established to help NSA exploit new computer technologies.

Research Highlights

- Strategic Defense Initiative assessments helped lay the groundwork for continuing research on ballistic missile defenses and potential threat countermeasures.
- Falklands War reviewed for lessons related to equipment, operations, and training.
- SALT studies considered the implications for the Strategic Arms Limitation Talks of so-called "gray area" systems and of limits on ICBM testing.
- Overhead costs in defense industries were examined, using proprietary industry data, to improve DoD's understanding of their effects on overall defense system costs.
- Militarily Critical Technologies List was assembled by IDA, with inputs from industry and government experts, in response to the Export Administration Act of 1979.
- Defense Science Study Group was established to introduce leading scientists and engineers from academia to defense matters, with emphasis on technology developments and needs.
- Infrared devices and forward-looking infrared systems were assessed to help DoD structure programs for new focal plane array technologies.
- Air defense of the Central Region study examined technical aspects of DoD's initiative to modernize NATO air defenses to counter projected Soviet force developments.
- Training technologies determined cost-effectiveness of simulators and other training devices.

Force and Strategy Assessments

The United States faces an evolving security environment, featuring new and unpredictable threats. At the same time, existing challenges may increase in scale and complexity, such as international terrorism, proliferation of weapons of mass destruction, and information warfare. IDA is helping DoD assess the implications of these evolving threats for force structure and readiness, and develop new organizational and managerial frameworks, procedures, programs, and strategies. Our researchers also help evaluate and implement new 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 sustaining overseas operations.

Non-Traditional Security Challenges

Improving Capabilities for Irregular Warfare

DoD asked IDA to develop a process for identifying program initiatives to improve irregular warfare capabilities. Our study describes the set of missions associated with current operations in Iraq, identifies the capabilities needed to carry out the missions, and assesses current U.S. effectiveness. The results provide a foundation for characterizing the principal differences between irregular warfare and major combat operations in terms of five themes:

- Human "terrain" (versus physical terrain).
- Mix of diverse civilian and military organizations (versus dominance of military).
- Irregular combat operations (versus major combat operations).
- Consolidation of security and stability (versus defeat the enemy and move on).
- Transition to the host nation government (versus decisive victory).

Preliminary applications of the process focused on influencing the population, unity of effort among military and civilian organizations, military use of law enforcement techniques, transition to the host nation, and implications for technology development.

Range of Mission Types Involved in Irregular Warfare

Combat and Support
- Neutralize Red Forces
- Protect Blue Forces
- Protect the Population
- Work with Indigenous Security Organizations
- Protect Physical Sites
- Stand-up New Indigenous Military Units

Supporting Civil Systems
- Fire Protection and Workplace Safety
- Electoral Process
- Historical, Cultural, Recreation
- Health Care
- Disaster Preparedness and Response
- Education
- Public Welfare, Relief
- Finance
- Media
- Public Administration
- Public Works/Utilities, Telecom, Transport
- Trade and Commerce
- Labor
- Food Distribution, Agriculture, Fisheries
- Police
- Courts, Civil Detention Facilities
- Disarm, Demobilize, Reintegrate

Iraqi Perspectives

IDA continued its research into the captured archives of the former regime of Saddam Hussein. Our analysis of the captured materials and interviews with former Iraqi officials has been adopted as a text in the Joint Military Professional Education system. The published report, *The Iraqi Perspectives Project: A View of Operation Iraqi Freedom from Saddam's Senior Leadership*, was

recently declassified and made more widely available, which stimulated greater interest in, and use of, the research tools developed by IDA to exploit captured enemy documents.

The growing interest in learning from the perspective of an adversary spurred an ongoing series of lectures by members of the research team to senior U.S. government and military staffs, allied government personnel, and academic audiences.

The study team is examining additional topics, including the former regime's perspectives on terrorism, the Iran-Iraq War, Operation Desert Storm, the 1991 uprisings, post-1991 sanctions, and other issues drawn from the captured archives.

Former Iraqi Prime Minister, Dr. Iyad Allawi, during an IDA interview conducted as part of an extensive analysis following *Operation Iraqi Freedom*. IDA's investigation included more than 100 interviews that included General George W. Casey, Commander of the Multi-National Force-Iraq; the former Iraqi Prime Minister, Dr. Iyad Allawi; members of the 1st Marine Expeditionary Force and attached units; Iraqi Security Forces; and Fallujah residents.

Defeating Improvised Explosive Devices

IDA has been helping the Joint Improvised Explosive Device (IED) Defeat Organization (JIEDDO) create a comprehensive IED event database for use by all analytic organizations supporting JIEDDO. To date, 13 IDA staff members have deployed to Iraq and Afghanistan on three-month assignments to assist in data collection and to support counter-IED analysis in theater.

Our researchers also studied pre-deployment training, strategic IED challenges, and U.S. Marine Corps IED casualties. Using tools and methods developed for exploiting captured documents, we provided insights on the relationships and capabilities of networks that existed in Iraq in the past to improve understanding of how those networks are functioning today. Throughout the year, we supported a number of quick-turn analyses to address issues related to threat behavior or to the effects of coalition systems and initiatives.

Thirteen IDA analysts were deployed to Iraq as part of an effort by multiple federally funded research and development centers to provide analytic support to DoD's overarching effort to counter improvised explosive devices. Drew Miller, pictured here in protective gear in Iraq, was one of the IDA researchers deployed.

Terrorist Perspectives

The Terrorist Perspectives Project has sought to build a strategic understanding of al Qaeda and associated movements (AQAM) based primarily on their own words, available through captured documents and open-source information.

Our researchers have found that while the members of AQAM remain optimistic about the ultimate outcome of the long war, many of its leaders are discouraged at their lack of progress. They are particularly concerned

about their inability to spread their ideas among the worldwide community of Muslims.

We identified the reasons that movement leaders offer for this failure, and based on these enemy self-assessments, we are now developing a strategic framework for combating terrorism and tools for assessing America's progress.

The members of this study team regularly engage with military educational institutions to promulgate understanding of the enemy.

Asian Counterterrorism Research

The Council for Asian Terrorism Research (CATR) includes government, academic, and research institutions from South East and South Asia that are promoting and sharing research on terrorism and counterterrorism. IDA coordinates CATR meetings and efforts and provides subject matter experts who contribute to seminars and papers.

Council for Asian Terrorism Research (CATR) conferences promote the development of integrated and cooperative approaches to counterterrorism in the Asia-Pacific region. Pictured is IDA Research Analyst Katy Oh Hassig and Major General A.N.M. Muniruzzaman, the Director General of the Bangladesh Institute of International & Strategic Studies, at the CATR conference held in Goa, India, in October 2006.

CATR uses the unique strengths and perspectives of its member institutions and countries to enhance both understanding of and responses to the rise of terrorism and politically motivated violence. By promoting and sharing research, CATR members draw upon the diverse expertise and perspectives that exist across the region to develop new approaches, enhance existing capabilities, and build integrated and cooperative efforts to counter terrorism in the Asia-Pacific region and in other areas that directly affect regional security.

Lessons in Combating Terrorism in Africa

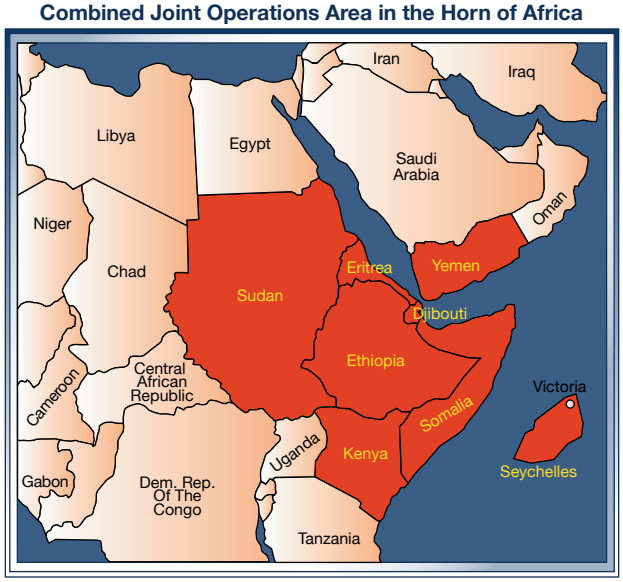
In 2005, IDA examined the interagency aspects of combating terrorism. A follow-on study of interagency counterterrorism activities focused on the Horn of Africa. This region has an al Qaeda presence, fragile local governments, the failed state of Somalia, tension caused by the encroachment of extremist Islam into African culture, the presence of international organizations including the United Nations and the African Union, and a Chinese presence.

The Horn of Africa was selected for study both because of the complexity of the environment and because of the presence there of the Combined Joint Task Force - Horn of Africa, which is envisioned to become an interagency organization. Also, several regionally focused efforts coordinated through the U.S. embassy in Nairobi, Kenya, involve many U.S. government agencies. This wide array of U.S. government activities provides an ongoing laboratory in which to observe operations in the field and extract lessons for improving future interagency operations.

IDA researchers interviewed numerous U.S. government personnel departments

and agencies that are working on policies and programs related to the Horn of Africa, both in the field and in Washington. Interviews in the Washington area gave insight into U.S. policy for the region, and from those with long experience in the Horn, a perspective on the history of U.S. involvement. Interviews and field trips in the Horn of Africa and Yemen provided insight into day-to-day activities in the region.

Combined Joint Operations Area in the Horn of Africa



Strengthening Interagency Operations

As part of the recent Quadrennial Defense Review, DoD examined options for strengthening interagency operations. IDA was asked to establish a baseline of assigned roles and responsibilities against which current missions and organizations could be assessed.

We also developed two illustrative scenarios as a basis for assessing interagency responsibilities and for identifying major gaps, overlaps, and misalignments. One scenario focused on stability operations overseas and the other involved a no-warning 10-kiloton, nuclear ground burst within the United States.

Civil Reconstruction and Stabilization Response Capability

Post-conflict situations demand U.S. capabilities that span military and civilian agencies and often require cooperation with partner nations. Deploying and employing robust non-military capabilities in a timely fashion has proven challenging.

IDA examined 16 personnel and manning models used by various organizations that participate in stability and reconstruction missions and identified best practices. Based on this work, we recommended methods to staff the proposed Civil Response Corps for the Department of State Coordinator for Reconstruction and Stabilization.

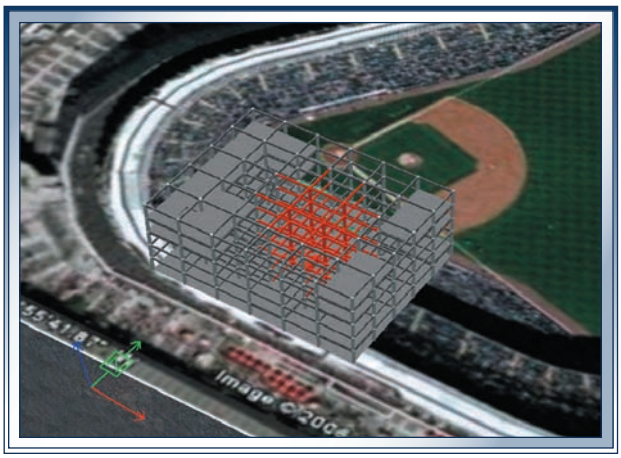
Our researchers found that authorities, organizations, and processes exist, but their scope, scale, and application are not adequate to meet mission needs. Those systems offering the most capability in the least amount of time require predeployment organization and training that increase costs. We proposed an interim system that relies on commercial contracts and a long-term solution that involves recruiting, organizing, training, and deploying personnel much like the military reserves.

DoD and the Department of State used this study to develop options for implementing the Civil Response Corps; to seek congressional support for needed authorities, reorganization and resources; and to streamline efforts to coordinate military and civilian activities in conflict prevention and reconstruction and stabilization operations.

Risk Management Methods for Infrastructure Protection

The Department of Homeland Security is developing a risk management framework to guide its efforts to protect the nation's critical infrastructure. To inform resource allocation

Risk Management Methodologies to Guide Infrastructure Protection



IDA is using simulations to estimate the consequences of terrorist attacks. Above is a computer simulation of the effect of a truck bomb set off in a tunnel beneath a stadium. The stadium is a hybrid structure that includes open areas over steel and concrete construction. Fatalities are estimated to be 100% within cells outlined in red; they are due both to shock-wave effects and structural failure.

decisions, DHS asked IDA to develop a Common Risk Model (CRM) to compare risks to assets or systems (e.g., dams, chemical facilities, nuclear plants) across different sectors of the national infrastructure.

The IDA-developed CRM is transparent, defensible, and easily applied by DHS or other responsible agencies within the federal government. It uses a straightforward mathematical definition of terrorist risk, as the product of likelihood of attack, likelihood of attack success, and consequences of attack in dollars, lives, or both.

This year, IDA focused on the likelihood of success and the consequences, whose product is a conditional risk. Our researchers conducted a pilot test, calculating conditional risks for more than 60 assets from different infrastructure sectors.

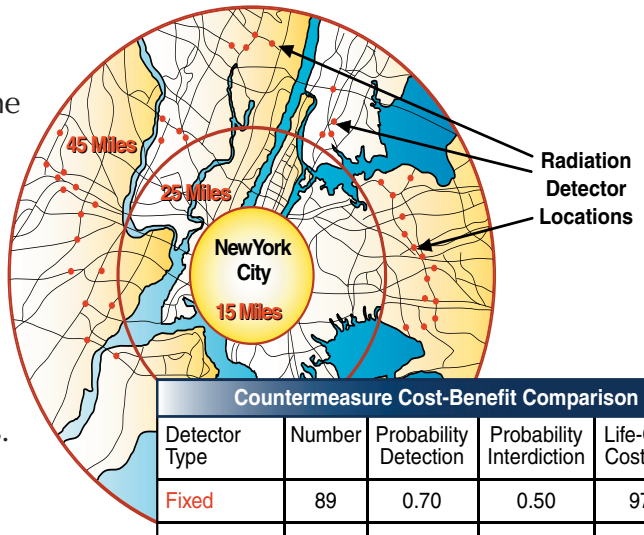
Support for Securing the Cities Program

DHS asked IDA to help develop countermeasures against the smuggling of radiological or nuclear weapons into U.S. urban regions.

Because state and local emergency responders will likely be the primary operators of countermeasures deployed within the United States, the study team first developed an approach for DHS to engage state and local governments in discussions of countermeasure options. We also assessed the mechanisms available to channel federal assistance to those governments.

Then, our researchers developed a suite of models to estimate the cost-effectiveness of potential urban region countermeasures systems. The first model examines the road network to find the chokepoints where radiation detectors could be deployed most effectively. The second calculates the probability that a system of radiation detectors and law enforcement assets would interdict the smuggling of a radiological or nuclear weapon. The third model estimates the life-cycle costs of the countermeasures system.

Planning for the Deployment of Radiological Countermeasures around U.S. Urban Regions



Countermeasure Cost-Benefit Comparison

Detector Type	Number	Probability Detection	Probability Interdiction	Life-Cycle Cost ($M)
Fixed	89	0.70	0.50	97.9
Relocatable	45	0.35	0.28	223.2
Law Enforcement	1500	0.10	0.10	4.5

The IDA radiological countermeasures model suite enables analysts to evaluate the cost-effectiveness of alternative countermeasures options for U.S. urban regions. Here, we evaluated fixed roadside radiation detectors and mobile relocatable detectors deployed at the radiation detector locations requiring the smallest number of detectors on the road network surrounding New York City at a distance of 15 to 45 miles. We also evaluated detectors deployed in police cars that patrol the region. (Results are notional.)

Modeling of Medical Consequences

The Department of Health and Human Services asked for IDA's assistance in developing medical consequence models that can be used to help estimate future needs for medical countermeasures for chemical, biological, radiological, and nuclear events.

Our researchers used exposure scenarios developed by the Department of Homeland Security to quantify the number and severity of casualties, which then provided a basis for estimating medical needs. This year, we focused on scenarios involving the release of nerve agents and the detonation of a nuclear device. The analysis of the nuclear weapon scenario included estimates of the casualties resulting from prompt and delayed effects of the event.

Joint Force Planning, Operations, and Assessments

Support for Combatant Commands – Linking Plans to Resources

There are increasing demands on unified Combatant Commands (COCOMs) to participate in Washington-based processes, particularly capabilities-based planning and various acquisition initiatives. Capitalizing on IDA's traditional role in helping Pentagon offices develop and implement new management approaches, we are now assisting the COCOMs to adapt to evolving planning processes. Currently, IDA

Informing the Apportionment of Risk and Resources within a Plan

X Capability Shortfall X Capability Excess/Redundancy X Capability Sufficiency

TIER 1 JCA / TIER 2 JCA	Critical Effects: Adversary unable to conduct a surprise attack (H)	Adversary WMD capabilities are destroyed or secured (H)	Adversary leadership is isolated and neutralized (I)	Adversary refrains from threatening freedom of navigation (I)
Joint Access and Access Denial				
Contingency Basing (H)				
Counter-Operational Mobility (L)				X
Forcible Entry (L)				
Freedom of Navigation (H)				
LOC Protection (H)		X		X
Seabasing (L)		X		X
Joint Air Operations				
Air Interdiction (L)				
Offensive Counterair Ops (H)		X		
Strategic Attack (L)				
Tactical Air Support (H)				X
Joint Battlespace Awareness				
Analysis and Production (H)	X	X		
Dissemination and Integration (H)	X	X	X	
Evaluation and Feedback (H)	X	X	X	
Observation and Collection (H)	X	X	X	
Planning and Direction (H)	X	X		
Processing and Exploitation (H)	X	X		
Joint Maritime Littoral Operations				
Maritime Interdiction (H)		X		X
Maritime/Littoral Expeditionary Operations (L)				X
Maritime/Littoral Fires				

H - Highly Important
I - Important
L - Less Important

Commander can reduce risk ***here***, by accepting increased risk in ***this*** "excess" capability area, in ***this*** "sufficient" capability area (where importance was assessed as less (L), or in ***this*** capability area, which was assessed as (L) because it has no role in mission execution

researchers are involved at six COCOM headquarters, working full-time on-site or from IDA's Virginia offices.

One IDA-developed approach involves a prototype methodology with supporting tools for resource allocation and risk management. This methodology, known as Linking Plans to Resources (LPTR), has been a central element of recent IDA support to the COCOMs.

The major stages of this methodology are:

- Identifying the desired operational effects for each mission, by phase or line of operation, as best suits the planners, and mapping capabilities to achieve those effects using the Joint Capability Areas.
- Conducting capability gap and sufficiency analyses to assess risk.
- Identifying mitigation strategies where capability gaps have been identified.

Information developed in the LPTR process could help COCOMs align many of the major headquarters processes. For example, the LPTR data could be used to inform a command's participation in the Programming, Planning, Budgeting, and Execution System, to assist in developing a command's Joint Mission Essential Task List, to help in defining technology priorities to feed the design of experiments, and to set the analytic agenda. Over the past two years, we have helped implement the LPTR methodology at most COCOMs.

We are also helping the commands implement adaptive planning, perform their roles in the analytic agenda, and prepare capability development strategies to remedy identified gaps through rapid capability insertion.

Strategic Assessment Groups

In 1998, IDA was asked to form an Independent Strategic Assessment Group (ISAG) in support of the commanders of the North American Aerospace Defense Command (NORAD)/U.S. Space Command and Air Force Space Command. The Group provided assessments of long-term strategic issues and helped in formulating and standing up the new Strategic Command and Northern Command. Subsequently, the single ISAG was divided into two groups – the NORAD/Northern Command ISAG and the Space Command ISAG.

In 2006, the IDA-led ISAG for the NORAD/Northern Command focused on the following areas:

- Organizational and policy issues, including those related to the composition of new joint functional component commands.
- Reserve forces and civil agencies, including lessons learned from operations associated with the Katrina and Rita hurricanes.
- Reconnaissance and surveillance technologies, including those needed to support maritime domain awareness.
- Integrated missile defenses, including the monitoring of activities related to the spiral fielding of missile defense capabilities.

IDA's Space Command ISAG continued its analyses of organizational, provisioning, and space acquisition issues, including identifying steps that could be taken to improve the Space and Missile Center's ability to support acquisition of advanced capabilities. This ISAG also examined ways to improve space situational awareness.

Defense Joint Intelligence Operations Center

In 2006, the Combatant Commands and the Defense Intelligence Agency established the Defense Joint Intelligence Operations Center (DJIOC) to improve national intelligence support of the Combatant Commands. IDA was asked to assist in integrating and synchronizing planning for the Center.

More specifically, we assessed mechanisms for implementing the horizontal integration of information; helped develop the Intelligence Campaign Planning (ICP) process for sequencing and synchronizing interagency, national, and allied intelligence assets; and assisted with the development of a force management capability – the Global Force Management (GFM) process – to align Blue Force intelligence capabilities with assigned ICP tasks. The GFM process provides for flexible force apportionment and allocation, improving visibility and understanding of the worldwide Blue Force intelligence picture.

Battle of Fallujah

An IDA team explored the operational and strategic lessons gleaned from the Battle of Fallujah – known as Al Fajr (New Dawn) – with emphasis on U.S. efforts to teach Iraqis to plan and execute a major military operation, to coach them on information operations, and to build their self-confidence and external respect.

We analyzed and documented the evolution of the so-called Teach, Coach, and Build approach in the context of 2004 events, highlighting lessons from the strategic level to the tactical level. At the operational and strategic levels, for example, we examined how the Multi-National Force-Iraq and U.S. Mission partnered with members of the newly formed Iraqi interim government to set the conditions for Al Fajr, and we looked at U.S. Advisory Support Teams that trained and mentored Iraqi Security Forces.

Our researchers conducted more than 100 interviews, including sessions with the commander of the Multi-National Force-Iraq, the former Iraqi Prime Minister, members of the 1st Marine Expeditionary Force, Iraqi Security Forces, and Fallujah residents.

At the tactical level, the Teach, Coach, and Build construct was reflected by the Marines' Regimental Combat Team 1, which led the Al Fajr operation, in training participating Iraqi Security Forces and subsequently assigning them important, relevant missions within the capabilities of the Iraqi forces at that time.

IDA analyst Bill Knarr (left) discusses the role Iraqi Special Forces Commander General Fahdil (center) played in Operation Al Fajr (Fallujah).

Personnel Accounting Mission

DoD asked IDA to examine ways to improve the effectiveness and efficiency of the processes used to account for missing personnel from World War II, the Korean War, the Vietnam War, and the Cold War.

The study examined four aspects of the personnel accounting mission:

organizational issues, policies, recovery operations, and procedures for identifying remains. Some organizational issues appear to be caused by a lack of clear policies, a lack of a long-term strategy for the mission, stove-piped funding sources, and non-shared databases. We provided recommendations for improving these and other aspects of the personnel accounting mission.

Chemical Challenge Study

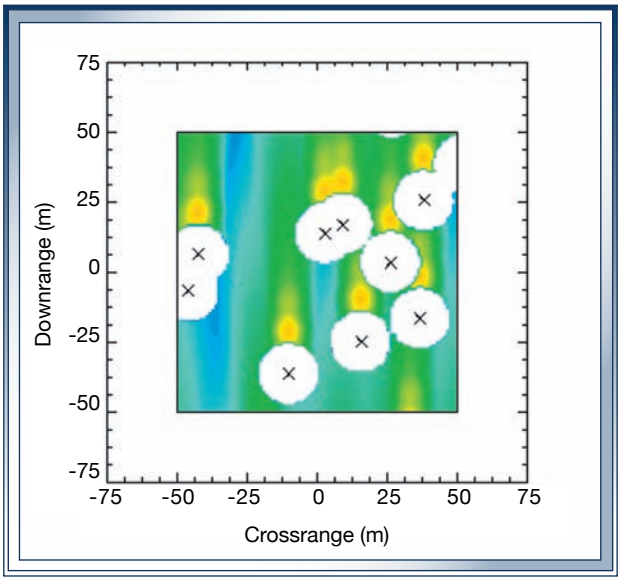
DoD's chemical defense needs have been determined largely based on planning scenarios that date from the Cold War. To improve the requirements generation process, IDA conducted a Chemical Challenge Study. Challenge is the amount and distribution of chemical liquid and vapor presented to personnel, sensors, or other equipment on the battlefield.

We derived challenge levels for a broad range of attacks by enemy forces using artillery, missiles, and bombs to deliver traditional chemical warfare (CW) agents. The study team examined attacks of varying intensity and developed comparative measures to relate attack intensity to the challenge outcome. We modeled fragmentation from point detonating munitions to account for their combined ballistic and chemical challenge, and conducted sensitivity analyses related to munitions burst heights, ballistic protection, and meteorological conditions.

The study results provide a technical foundation for developing scenario-dependent needs for CW defenses. The results also have been used in other IDA studies of chemical sensors and are the basis for DoD's decontamination test requirements.

Additionally, we contributed to the International Task Force 46 effort, a multinational study conducted under the US/UK/CA Memorandum of Understanding on Chemical, Biological, and Radiological Defense. Applying historical research, intelligence estimates, modeling and simulation, and other analytic methods, the IDA team characterized the technical aspects of future CW battlefield challenges. Participating countries will use this information to help design future individual protective equipment and to determine decontamination and medical needs.

Distribution of Persistent Chemical Agent



This figure depicts the distribution of a persistent chemical agent deposited per unit area (mg/m^2) of a one-hectare target. The range from blue to yellow indicates varying amounts of deposition. In this figure, deposition is ignored in those portions of the target within range of shell fragments likely to cause serious injury to personnel (areas within the white circles).

Installation Protection Program

DoD's Installation Protection Program (IPP) provides U.S. military installations with improved capabilities for mitigating or minimizing effects of chemical, biological, and radiological (CBR) attacks. CBR defense improvements at each installation encompass non-materiel items, such as augmentations of incident response plans, as well as a tailored family of systems (FoS) that enhances CBR agent detection and identification,

warning and notification, physical protection, consequence management, and restoration capabilities.

IDA is assessing the IPP FoS design and fielding process (with an emphasis on operational effectiveness) and the systems' in-field use (with an emphasis on readiness and sustainability). Among the issues being examined are the number and priority of the installations being considered in the program, the baseline capabilities planned for each installation, the off-the-shelf nature of the FoS options, the approach to test and evaluation, and the effects of cost and schedule constraints on planned FoS capabilities. Our initial recommendations, many of which are now being implemented, encompass CBR threats, roles and methodologies for operational effectiveness analyses, and operational suitability considerations in FoS specifications.

Infrastructure Sensitivity to Chemical Hazards

DHS asked IDA to examine investment strategies to counter potential threats to U.S. ports from the release of hazardous industrial chemicals, conventional chemical warfare agents, and new technology CW agents.

We postulated the release of chemicals at selected U.S. ports under various weather conditions, estimated the resulting exposure levels at different distances from the release point, and projected the numbers of people who would be exposed to harmful chemical dosages. For some industrial chemicals, we found the effects would be relatively limited and would not result in closure of the port. In other cases examined, releases of CW agents could close a major port for many months due to decontamination challenges.

Improving DoD Processes and Organizations

Special Operations Forces Roles and Missions

The 2005 Unified Command Plan designated the U.S. Special Operations Command (USSOCOM) as the lead for planning, synchronizing, and as directed, executing global operations against terrorist networks. USSOCOM asked IDA to review the Command's initiatives to execute these responsibilities, to examine the fit between the Command's new missions and its long-standing stewardship responsibilities for special operations forces, and to recommend ways to increase the effectiveness of the Command.

The IDA team identified several actions to improve USSOCOM's ability to:

- Provide conceptual leadership within DoD for planning operations against terrorist networks.
- Participate in and influence Pentagon management processes for deliberate planning, force management, and resource allocation.
- Engage effectively in interagency planning.
- Shape requirements for needed intelligence collection.
- Influence DoD's resource allocation priorities.

Our findings contributed to the latest Quadrennial Defense Review, and DoD adopted practices for deliberate planning, interagency participation, and resource allocation that are consistent with the study's recommendations.

Force and Strategy Assessments

Need for a DoD Chief Management Official

Seeking to improve its business support areas, DoD asked IDA to assess the possible roles for, and the added value of, a DoD Chief Management Official (CMO). Our researchers reviewed long-standing concerns with DoD's management of business support processes, ongoing management practices, and recent initiatives.

We found that although DoD has improved business management in recent years, there is a need to define duties for a CMO that broaden and formalize current efforts, and that address deeper organizational challenges limiting the effectiveness of management initiatives.

The proposed duties for a CMO are:

- Providing strategic leadership.
- Leading a planning and execution framework that engages both the customer and supplier communities.
- Recruiting and developing business personnel.
- Leading the development of business management tools.

Our study concluded that formalizing these duties in the context of an effective management framework would help accelerate ongoing DoD initiatives and pave the way for continued improvements in subsequent administrations.

Defense Planning Scenarios

Defense Planning Scenarios (DPSs) identify critical mid- and longer-term challenges that DoD, with interagency and foreign partners, must be prepared to handle.

To enhance the rigor and utility of the scenarios, our researchers developed a four-step process. It begins with a high-level, independent panel that develops "challenge" options, including problems and objectives. The Deputy Secretary, with his own advisory group, next selects one option for further development. IDA researchers then organize a senior interagency group to craft a strategic concept – combining relevant elements of national power – for the selected challenge. We then integrate the component parts into a full scenario.

We are currently developing new scenarios covering Africa, South West Asia, South America, and South East Asia. Completed scenarios are used as a basis for planning within DoD and by interagency partners.

Strategic Risk Assessment Framework

IDA developed a new approach for evaluating the ability of overall defense programs to mitigate strategic risks to the nation. The approach involves structured risk assessment interviews with senior decision-makers to determine how well they believe a particular Future Years Defense Program – and associated defense capabilities – could deal with a variety of potential future national security challenges.

More than two dozen senior DoD decision-makers – from the Chairman of the Joint Chiefs of Staff to Combatant Commanders to the Secretary's top civilian aides – have participated in the interview process. Our approach identified areas of higher and lower risk, and provided a basis for senior leaders to explore differences in fundamental assumptions about future threats, capabilities, and alternative program options.

National Security Strategy Issues

Improving Defense Resource Management in Other Countries

For more than a decade, IDA has supported DoD in assisting U.S. security partners improve their management of defense resources. In the 1990s, this effort focused on Eastern European militaries preparing for NATO membership. Since 9/11, the emphasis has shifted to defense establishments in the Middle East and Asia-Pacific regions.

Our researchers are introducing modern management concepts and analytic techniques to partner nations – most recently Indonesia, Kuwait, Mongolia, and the Philippines – to improve defense planning within the context of limited budgets and to strengthen democratic civilian direction of the military. The concepts and tools are helping these nations plan for improving their capabilities in areas such as counterterrorism and international peace support operations.

Understanding Conflicts in a More Proliferated World

As part of a broader study of the strategic implications of continued nuclear proliferation, our researchers are exploring strategies for the United States and South Korea in the event of a nuclear war started by North Korea. To gain insights on the dynamics of war termination, we examined plausible bargaining processes in which each side tests the other's willingness to bear pain – and demonstrates its own willingness to suffer – by making and receiving reciprocated nuclear strikes.

Done carefully, this kind of "auction in pain" can drive the two sides to discover mutually tolerable agreements for ending the war that may be less satisfactory than total defeat of the opponent, but correspondingly less destructive. Done poorly, such auctions may cost both sides far more destruction than necessary.

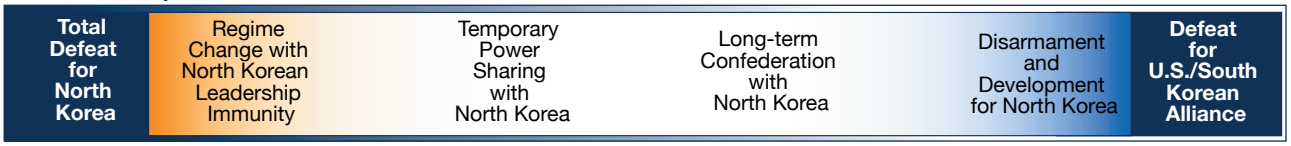
These analyses illustrate that outcomes of such wars could depend less on the maximum damage that the sides are capable of imposing, and more on the relative capabilities of alliances and single states to continue as effectively functioning political entities while suffering the damage that may be involved in attaining an acceptable outcome.

Strategic Planning for Securing Cyberspace

DoD asked IDA to help develop a strategy for securing cyberspace, critical information infrastructures, and the physical and cyber assets that support them. We provided background research and analyses, critical review, and assistance in writing the strategy document.

The effort examined relevant doctrine, strategy, the cyberspace infrastructure and industrial base, emerging threats to cyberspace, evolving defensive capabilities, and technology trends. International cooperation and legal issues also were reviewed. The resulting strategy, which initially focused on securing cyberspace, has broadened to become the National Military Strategy to Operate in Cyberspace.

Spectum of Outcomes for Nuclear War between North Korea and the U.S.-South Korean Alliance



IDA analyses illustrate that the theoretical outcomes of a nuclear war between North Korea and a United States-South Korea Alliance can depend less on the maximum damage that the sides are technically capable of imposing, and more on the relative capabilities of alliances and single states to continue as effectively functioning political entities while suffering the damage that may be involved in winning a tolerable outcome.

1987 - 1996

Institute Highlights

- Center for Communications Research – La Jolla, California, a second Center for Communications Research, was established at the request of NSA to conduct fundamental research in cryptology and related disciplines.
- Simulation Center was established to serve as a forum for demonstrating new simulation technologies and to apply advanced distributed simulation in defense analyses.
- Support for Director, Operational Test & Evaluation was broadened in response to a call by Congress for analytic support of operational testing to be provided by an impartial source, free from Service-related and commercial conflicts of interest.
- Phase One Engineering Team (POET), consisting of multiple FFRDCs, was established to provide analyses and technical evaluations of ballistic missile defense systems.

Research Highlights

- Live fire testing of Bradley Fighting Vehicles, monitored and reported on by IDA, resulted in design changes to improve crew protection and vehicle survivability.
- Operations Desert Shield and Desert Storm support included pre-war simulations of combat outcomes assuming Iraqi use of chemical munitions and post-war lessons.
- "73 Easting" tank battle in Operation Desert Storm reconstructed.

- V-22 tilt-rotor aircraft study was conducted in response to a Congressional request for an independent assessment of alternatives to the then-canceled V-22 program.
- B-1B and B-2 bomber studies examined the ability of strategic bombers to penetrate enemy air defenses and to carry out their missions.
- Bosnia assessments included analyses of air operations and a survey of Bosnian Federation military needs in the context of the U.S.-supported equip and train program.
- Counter-drug work focused on interdiction options and impacts of interdiction policies.
- Support for DoD Bottom-Up Review included analyses of tactical aircraft forces, Army aviation and space launch options.
- Cost of military medical care study led to improved understanding of rapidly growing DoD medical costs, including costs of peacetime care and wartime preparedness.
- Computer and information security assessments of architectures, programs, and policies helped DoD manage an increasingly complex and important issue.
- Independent analyses of space systems concepts and costs conducted for NASA.
- Expert systems developed to support FBI criminal investigations.

High Performance Communications and Computing

For nearly 50 years IDA has played a key role in the research endeavors of the National Security Agency, 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. Still, we remain engaged with industry and academia – including the two examples we present – and some of our work is unclassified and can be shared with this larger community.

Communications Research

The IDA Centers for Communications Research (CCR) in Princeton, NJ, and La Jolla, CA, perform mathematical research that supports the NSA's two missions: protecting the information and communications of the U.S. government, and deriving foreign signals intelligence.

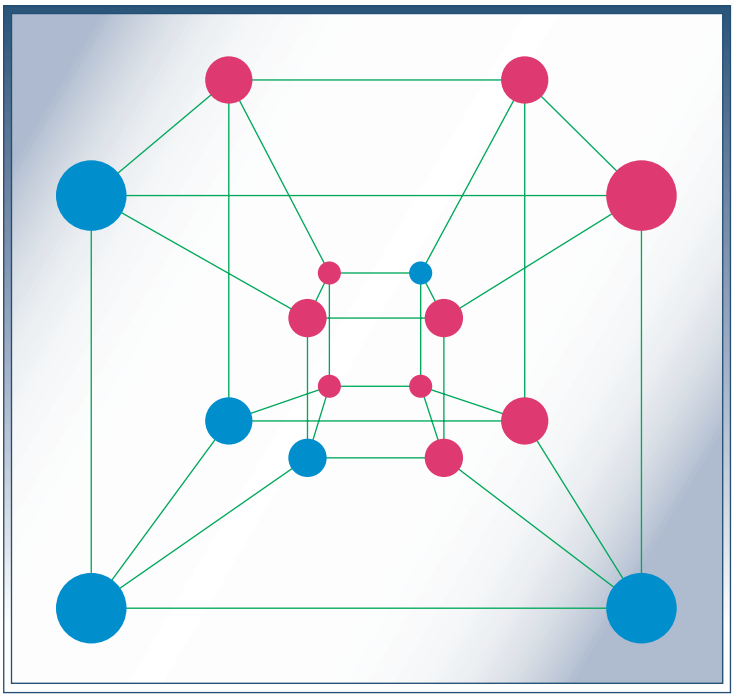
Mathematics remains the fundamental science employed to create and analyze the complex algorithms used to encipher vulnerable communications. Virtually every branch of pure and applied mathematics has proved to be useful in these efforts. For example, techniques from the geometry of algebraic curves provide novel and unexpectedly effective methods for detecting and correcting errors in data transmission. 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.

Systems that transmit or store data must provide confidentiality and reliability in the presence of natural or adversarial interference. Mathematical methods such as signal coding and cryptography are used to accomplish these goals. Many areas of mathematics are important to these endeavors, and the constantly changing intellectual terrain has introduced new mathematical problems that must be solved so that NSA can perform its mission. Even where no explicit mathematical ideas are involved, mathematical modes of thinking seem to be ideally suited to cryptologic problems.

The researchers at CCR, most of whom have a Ph.D. in mathematics, have a broad range of backgrounds and interests, because highly specialized knowledge is needed to solve some of NSA's most difficult problems. When a problem cannot be solved by known methods, insights often come from those who can see how different areas of mathematics can be used in non-obvious ways. As a result, much of CCR's success comes from collaboration in teams, rather than isolated research.

It is critical to our work that we recruit the very best new mathematical talent. 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. For eight to ten weeks, visiting mathematicians work

Orthogonal Design



0	0	0	0	0	0	0	0	0	0	0	0	0
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0	4	2	2	4	2	5	2	0	1	4	0	4
0	4	2	5	0	3	3	5	3	0	1	1	3

A square array of numbers in which any two rows are orthogonal (i.e., represent perpendicular vectors) is sometimes called an orthogonal design. These designs were first introduced in 1867 by J.J. Sylvester and have long played roles in areas ranging from pure mathematics to the design of experiments, signal processing, error-correcting codes, and algorithm design. In recent years, many novel applications have emerged, including cell phone design and quantum error correction. Researchers at the Centers for Communications Research have occasionally studied these objects, and the figures give a tiny glimpse of some results obtained in 2006.

A “Hadamard matrix” of order n is a two-dimensional n by n array of 1's and -1's in which any two rows are perpendicular.

A d-dimensional matrix is Hadamard if each two-dimensional subarray is a Hadamard matrix. Although this is almost impossible to visualize in any generality, the figure on the left represents a 4-dimensional Hadamard matrix (with $n = 2$, and the two colors encoding 1 and -1); the orthogonality property is equivalent to saying that every circuit with 4 vertices contains an odd number of vertices of each color.

Mathematicians have learned that “symmetry” is a harbinger of applicability and power, and pursue it whenever possible. The design in the figure on the left has 384 symmetries. The study of symmetries of higher-dimensional designs has been elusive, but results from 2006 show, for instance, that a 10-dimensional generalization of the array in the left figure has over 3.7 billion symmetries.

Another paper from 2006 uses a mixture of theory and computation to produce many heretofore unknown “generalized Hadamard matrices” whose entries are complex numbers. In the figure on the right, an integer k is shorthand notation for $\exp(2\pi ik/6) = \cos(2\pi k/6) + i \sin(2\pi k/6)$, a complex number representing a rotation through a multiple of 60 degrees. Any two rows of this 13 by 13 array are orthogonal, and these examples provide support for an interesting conjecture on the possible orders of such matrices.

side by side with CCR's full-time staff and visitors from NSA, focusing on a few specific problems each year. Most of the visitors are full-time faculty or graduate students. The influx of new people and ideas throughout the history of this program has led to numerous solutions to important NSA problems.

Computing Research

While high-end computing is an important part of the research program at the Center for Computing Sciences (CCS), its mission 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.

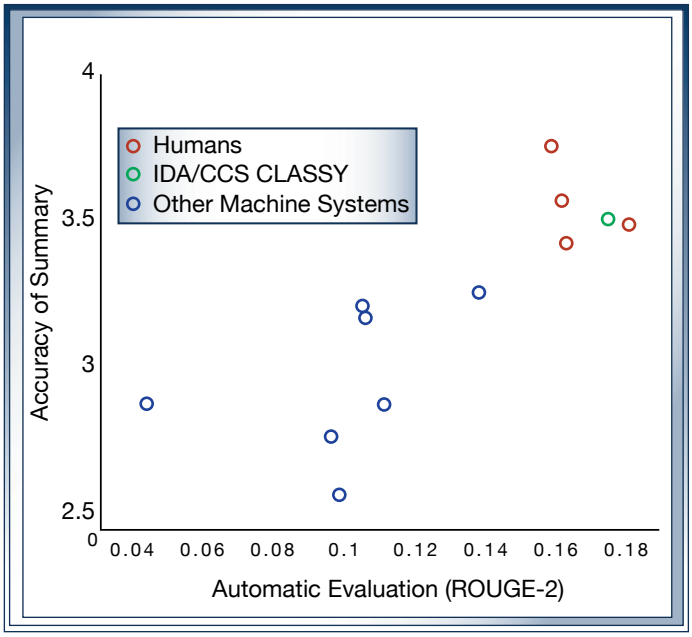
To achieve its mission, CCS focuses the skills of some of the country's best computer scientists, engineers, and mathematicians on using all aspects of computational science to solve intelligence-related problems of importance to national security. Parts of the problem set we confront are clearly not unique to the defense and intelligence communities; 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 policymakers have concluded that continued development of high-performance computing platforms will require government research and development support. The amount of computing 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's Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratory. CCS also maintains a vigorous dialog with many of the leading U.S. makers of high-end computers.

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.

An additional complexity for this topic results from 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 – protect data and collect data – is far from clear; indeed, a new, blended mission is developing. All three IDA Centers are working closely with NSA to bring the best talent to bear on the scientific problems generated by this blending.

Multilingual Summarization Evaluation 2006



Environmental, economic, and other global issues make it imperative for English speakers to understand how other countries and cultures perceive and react to important events. Thus, it is vital that English speakers be able to access documents efficiently in a variety of languages.

The quantity of non-English documents makes it impossible to expect quality human translation. Therefore, we have come to rely on machine translation (MT) systems for translation to English. While MT systems continue to improve, generated translations remain difficult to read and understand, with critical words often omitted, and inconsistent translations for the same word in a document. Translation of Arabic documents is particularly challenging due to errors introduced by incorrect sentence-splitting, tokenization, and lemmatization.

One approach to handling the volume of documents is to use summarization systems to automatically generate single or multi-document (cluster) summaries of MT-translated documents. Based on the generated summaries, small sets of documents can be identified for translation using the limited human resources.

CLASSY (Clustering, Linguistics, and Statistics for Summarization Yield) is an automatic summarization system, developed by the Center for Computing Sciences (CCS) for summarizing English documents. CLASSY uses trimming rules to shorten sentences in the document, identifies sentences as being more or less likely to be included in a summary, generates a summary for each document, selects sentences for a multi-document summary for a cluster of related documents, and finally organizes the selected sentences for the final summary.

In 2006, CCS participated in the Multilingual Summarization Evaluation, which evaluated summaries of document sets containing a mix of both English and Arabic documents. Both the Arabic source and the MT output were available, and either or both could be used. The evaluation compared the accuracy of the CCS CLASSY against summaries created by eight other machine systems and four human-generated summaries.

In the figure above, 24 document sets of approximately 12 documents each were evaluated and scored on a scale of 1 to 5, with 1 being a low level of accuracy and 5 being the highest level of accuracy. Each point plotted is an ordered pair – the ROUGE-2 evaluation (an automatic system that measures the fraction of the number of word pairs that a summary has in common with the model human summaries) and human evaluation – representing the average performance of a software summarization system or a human summarizer. The analyses revealed that the CLASSY system significantly out-performed the other machine systems and scored within the range of human performance.

1997 - 2006

Institute Highlights

- Joint Advanced Warfighting Program, consisting of a mix of civilian and military personnel, was formed to help transform military capabilities and stimulate innovation, with emphasis on joint concept development and experimentation.

- Science and Technology Policy Institute, with offices in Washington, DC, supporting the Office of Science and Technology Policy and other federal departments and agencies, became IDA's third FFRDC.

Research Highlights

- Independent assessment panels convened to provide rapid reviews of major defense issues, including the role of Special Operations Command in war on terrorism, Strategic Command merger and missions, roles of new Under Secretary for Intelligence, ballistic missile defense challenges, and Joint Tactical Radio System program restructuring.

- Overseas seminars conducted first in former Soviet Bloc countries and then other nations, focusing on defense planning, resource management, and crisis management, with the goal of helping nations develop Western-style defense establishments.

- Deep attack weapons mix study examined the cost-effectiveness of alternative mixes of air-to-surface and surface-to-surface munitions, and B-2 bomber force levels.

- Independent cost estimates developed for the F-22 Raptor and the Joint Strike Fighter alternative engine program in response to Congressional requests to DoD.
- Purchase price of KC-767 tankers was estimated for use in proposed leasing agreement.
- Future Combat Systems program was examined in terms of technology readiness, management structure, acquisition program challenges and costs.
- Operations Iraqi Freedom and Enduring Freedom was examined for lessons for future joint military operations and for operational test and evaluation programs.
- Iraqi Perspectives Project involved interviews with former members of Saddam's regime and reviews of captured documents to better understand Iraqi behavior.
- Contingency Operations Support Tool was developed to improve DoD's ability to estimate contingency costs and used in creating supplemental budget requests for Iraq war.
- Quadrennial Defense Reviews supported with rapid response analyses of major acquisition issues and of ways to improve DoD organizations and management processes.
- Biological science and technology capabilities were expanded to support both DoD and NIH, including helping the National Cancer Institute streamline clinical trials.
- Anti-terrorism technologies were evaluated for SAFETY Act protection granted by the Department of Homeland Security.

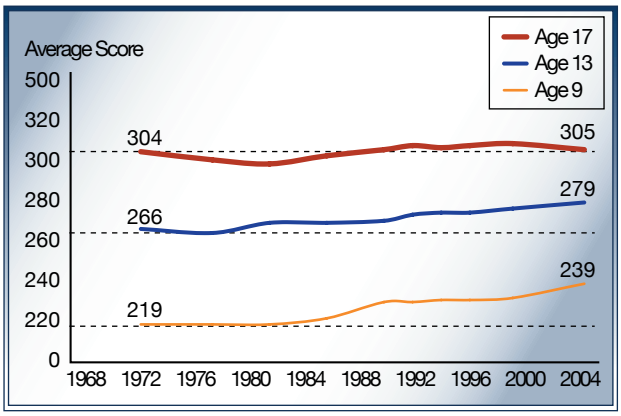
Science and Technology Policy Institute

The Science and Technology Policy Institute (STPI) is IDA's newest federally funded research and development center, which provides technical and analytic support to the Office of Science and Technology Policy (OSTP) in the Executive Office of the President and to a growing number of other government organizations. The National Science Foundation administers STPI for OSTP.

Improving Elementary and Secondary Mathematics Education

There are concerns that U.S. children are not receiving the high-quality instruction needed to provide the sound grounding in mathematics that has become important for success in contemporary society. While the No Child Left Behind Act calls for teachers and school administrators to use research-based methods and materials in their classrooms, few such materials exist in mathematics, leaving teachers with little guidance on how to improve student achievement in this area.

Trends in Average Long-term Math Test Scores: 1973-2004



Long-term math test scores are from NAEP Mathematics Scale Scores; 2004 scores are denoted using a modified assessment. Due to differences in scoring procedures, scores should not be compared across age groups.

Source: Perie, M., Moran, R., and Lutkus, A.D. (2005). NAEP 2004 Trends in Academic Progress: Three Decades of Student Performance in Reading and Mathematics (NCES 2005-464). U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. Washington, DC: Government Printing Office.

To address this problem, the President established the National Mathematics Advisory Panel, under the leadership of the Department of Education, to examine research on mathematics instruction in algebra. In support of the Panel's efforts, STPI analyzed the following:

- The content of algebra education in the United States in 2006.
- Reported differences between traditional course-based algebra curricula and the integrated mathematics programs adopted by some school systems.
- Characteristics of K-8 mathematics education across a sample of 21 states.
- Uses of the National Assessment of Education Progress to interpret the results of national versus state-based math testing.
- The use of American College Test scores as predictors of college and workforce readiness.

U.S. Competitiveness in Global Information Technology

The federal Networking and Information Technology Research and Development (NITRD) program was established to drive innovation in U.S. scientific research and related developments in national security, communications, and commerce. Although the United States has been a global leader in information technology (IT), concerns

are growing that the U.S. leadership role is diminishing.

The President's Council of Advisors on Science and Technology (PCAST) is reviewing progress in achieving NITRD program objectives. In support of this review, the PCAST requested that STPI develop a snapshot of the United States' global IT competitiveness.

STPI developed metrics to help understand the current and likely future IT capabilities of selected industrialized and future competitor nations. Our analysis focused on research and development, educational achievement, workforce composition, infrastructure, legal and regulatory frameworks, and strength of technology users and producers. We provided a data-driven view of the global IT "ecosystem" and identified areas of concern for future NITRD investment.

Envisioning Future Engineering Research and Education Centers

There are growing concerns that the United States is losing its competitive edge in science and engineering. Partly in response to similar concerns in the early 1980s, the National Science Foundation (NSF) established the Engineering Research Centers (ERC) program. The program facilitates interdisciplinary science within a collaborative environment between academic and industrial scientists so that innovations can be rapidly transitioned to the marketplace and students are better positioned to enter the workforce.

NSF asked STPI to evaluate how the ERC program could better support U.S. competitiveness in a global economy and further catalyze innovation and creativity in academia and industry. To understand related research practices in other countries, STPI researchers examined and visited science and engineering "centers of excellence" in Germany, China, Korea, Japan, and the United Kingdom.

We found that foreign engineering research programs are driven mostly from the top down and are focused more on technology transfer and industry support than on fundamental research. This contrasts with the typical U.S. approach, where researchers are encouraged to find a balance between making fundamental breakthroughs and more incremental development and refinement of ideas and technologies. The NSF is using STPI's findings to rethink the structure of the ERC program.

Improving National Cancer Institute Translational Cancer Research Operations

Translational cancer research is aimed at transitioning scientific discoveries arising from labs, clinics, or health analyses of the general population into new clinical tools and applications that reduce cancer incidence, morbidity, and mortality. The Director of the National Cancer Institute (NCI) established the Translational Research Working Group – composed of academic researchers, representatives from industry and foundations, government officials, and patient advocates – to advise the National Cancer Advisory Board on future translational research activities.

NCI asked STPI to provide strategic and analytic support to the Working Group in several areas: identifying impediments to translational research as well as conditions that have fostered NCI-supported successes; conceptualizing the structured developmental pathways by which translational research proceeds; soliciting and analyzing inputs from

the broad cancer research community; and developing and refining initiatives and implementation plans to improve the effectiveness of NCI translational research. The STPI-prepared final report of the Working Group, which contains 15 proposed initiatives with associated implementation plans and timelines, was delivered to the Advisory Board in June 2007.

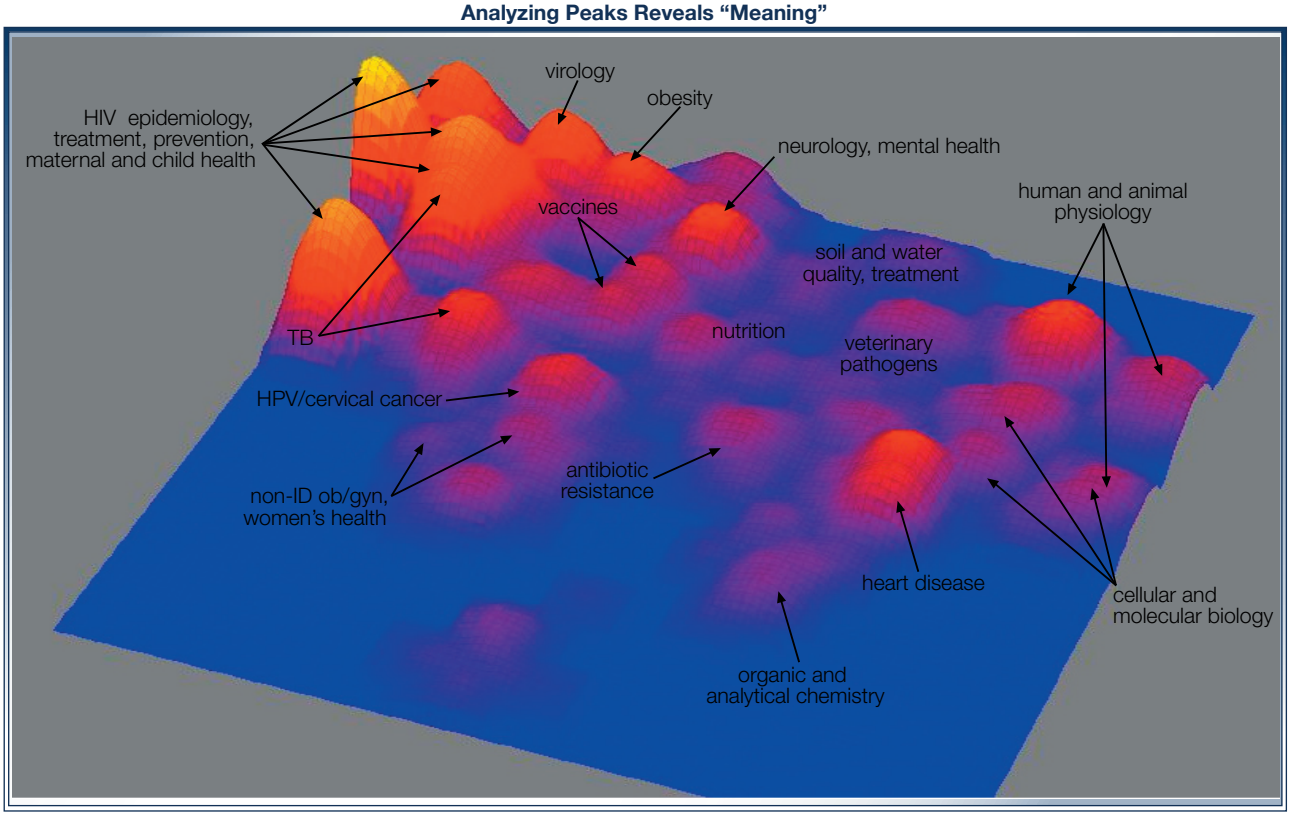
Needs Assessment for Global International Health Research

The National Institutes of Health (NIH) Fogarty International Center (FIC) promotes scientific research and training internationally to reduce disparities in global health. As part of its strategic investment planning process, FIC asked STPI to help identify future program directions that would maximize FIC's impact on global health research and on the development of health research capacity in developing countries.

STPI researchers examined NIH award information, MEDLINE publication data, clinical trials data, and organizational websites to provide strategic insights into:

- FIC investments with the biomedical research capacity-building efforts of the U.S. government and other biomedical funders.
- NIH investments in developing-country researchers with global health priorities and FIC's training efforts.

Analyzing Peaks Reveals "Meaning"



STPI employed text clustering and visualization techniques to better understand the research topics in which countries and institutions concentrate. "Mountains" and "valleys" are generated based on the number of publications in given topics. Using this technique we can quickly identify both highly active and underrepresented research topic areas. For example, above we find South African biomedical publications are largely focused on HIV and AIDs related topics.

- Country-level biomedical research and clinical trials portfolios with FIC's training efforts.

Our assessment identified countries where FIC has had substantial capacity-building influence and signature programs that occupy unique niches internationally.

How High-Risk Science Is Selected for Funding

There have been concerns that the traditional peer review process used to allocate federal research funding in the United States is overly conservative, sometimes rejecting risky but potentially high-payoff research. The NIH Director's experimental Pioneer Award Program was established to identify and fund such high-risk research.

NIH asked STPI to review the selection process over a five-year period to determine the extent to which it has supported the goals of the Pioneer Award Program; has been fair and robust; and has attracted and identified new researchers, ideas, and approaches. During 2006, our researchers continued the planned multi-year evaluation process.

Assessing the Condition of Scientific Collections

An important component of the research infrastructure in the United States is the wide variety of object-based collections supported and maintained across various federal departments and agencies. These collections have been used to identify potentially invasive species found on ships prior to being given approval by the United States to dock.

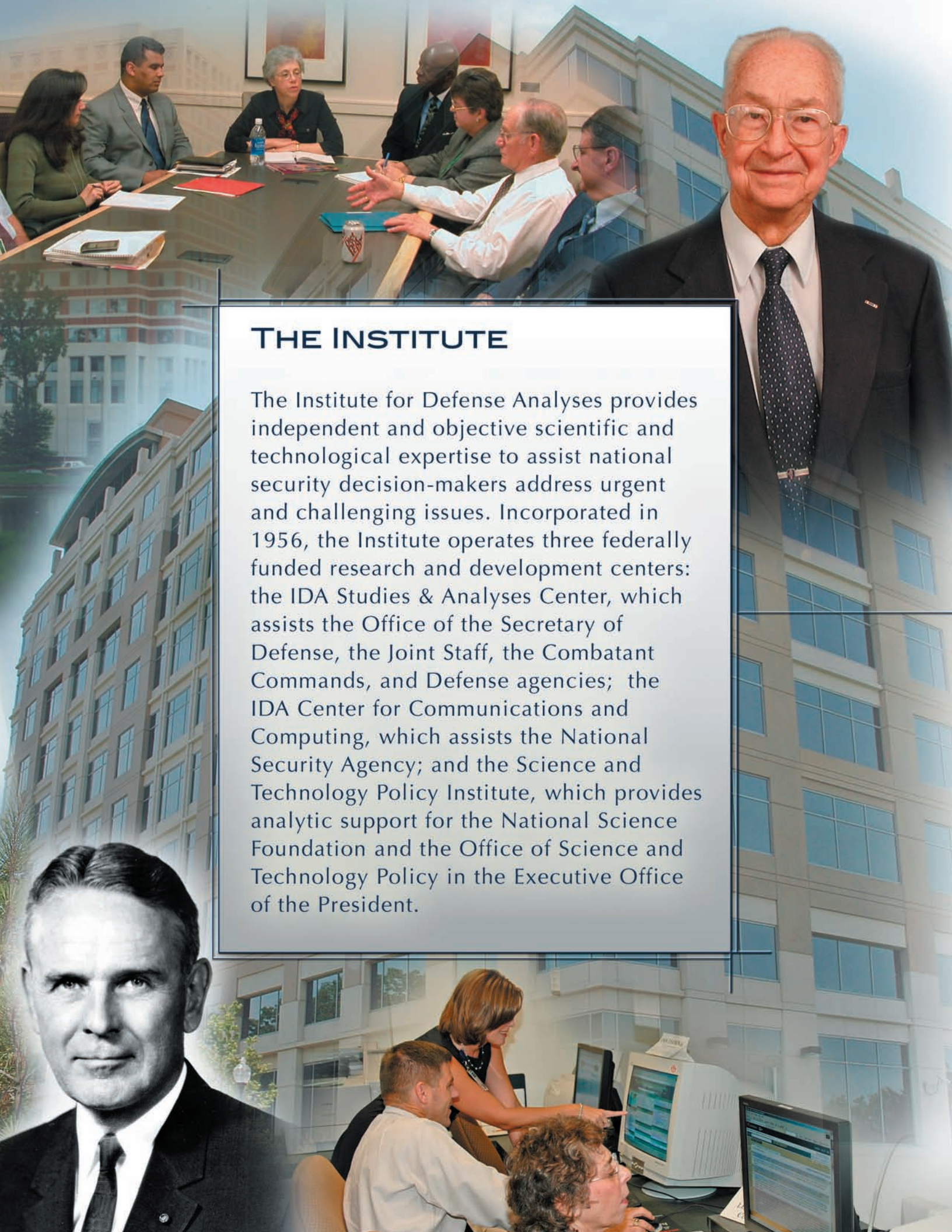
In 2005, the directors of OSTP and the Office of Management and Budget identified the "stewardship of federal scientific collections" as one of two areas for special attention by the National Science and Technology Council (NSTC). In response, NSTC established an Interagency Working Group on Scientific Collections to examine the size, scope, and condition of object-based collections. Primary goals include:

- Evaluating the state of object-based scientific collections at, supported by, or used by U.S. federal agencies or in federally supported activities.
- Fostering coordination of collections across federal agencies.
- Increasing government and public awareness of the importance and uses of collections.

OSTP asked STPI to provide technical support for designing and analyzing data collected via an online survey hosted by OSTP. We are currently reviewing preliminary findings and working with the agencies to assure comparable and complete responses related to collections managed or sponsored across the federal government.

Agencies included in this project include the National Aeronautics and Space Administration (with collections of moon rocks, space dust, and space hardware), the Department of Agriculture (with collections of seeds, among many others), and the Geological Survey (with collections of rocks, fossils, etc.). Our assessment will help inform decisions on resources needed to maintain object-based collections.

IDA Community



The Institute

The Institute for Defense Analyses provides independent and objective scientific and technological expertise to assist national security decision-makers address urgent and challenging issues. Incorporated in 1956, the Institute operates three federally funded research and development centers: the IDA Studies & Analyses Center, which assists the Office of the Secretary of Defense, the Joint Staff, the Combatant Commands, and Defense agencies; the IDA Center for Communications and Computing, which assists the National Security Agency; and the Science and Technology Policy Institute, which provides analytic support for the National Science Foundation and the Office of Science and Technology Policy in the Executive Office of the President.

In 1955, Secretary of Defense Wilson and the Joint Chiefs of Staff asked MIT to create a new, civilian corporation to provide the Department with comprehensive and objective analyses. Responding to the call, MIT – in collaboration with Cal Tech, Stanford, Tulane, and Case – created IDA in 1956. To lead it, they recruited General James McCormack, a respected military scientist and Rhodes Scholar with degrees from West Point and MIT; to direct IDA's research, they brought in Dr. Albert G. Hill, an MIT physics professor and former Director of Lincoln Laboratories. This mix of people with practical experience in national security and cutting-edge technical skills set a pattern that continues today at IDA.

The world – and IDA – has changed considerably since 1956. Instead of the dominant threat posed by the Soviet Union, the United States faces a somewhat amorphous and disparate group of state and non-state challenges. Instead of a research agenda dominated by the use and consequences of nuclear weapons, IDA's research today reflects the breadth of the nation's scientific and technical challenges, the emergence of new technologies, and the need to address these challenges and exploit these technologies in an environment of public scrutiny and budgetary constraint. Instead of a single division working with DoD's Weapons Systems Evaluation Group, IDA today administers three Federally Funded Research Centers to meet the multiple needs of today's sponsors.

Research Centers

IDA Studies and Analyses Center – Alexandria, Virginia

IDA's Studies and Analyses Center, the largest of our three FFRDCs, is sponsored by the Office of the Secretary of Defense and consists of seven research divisions. Most of the staff work out of IDA's primary facility in Alexandria, VA.

Cost Analysis and Research Division

Dr. David L. McNicol, Director

CARD estimates the full life-cycle costs of acquiring defense systems and undertakes tasks that advance the state of the art of weapons system cost estimation. The division also undertakes a wide variety of projects that involve costing issues, acquisition policy issues, and concerns with resource allocation mechanisms in federal agencies.

Information Technology and Systems Division

Ms. Priscilla E. Guthrie, Director

ITSD analyzes multi-dimensional information and intelligence issues for DoD and intelligence community sponsors. The work leverages staff expertise and experience in tackling key national security community challenges in data and information sharing; information assurance; enterprise policy, governance, architecture, and integration; communications; systems engineering; intelligence systems; information science and emerging technology. ITSD products help sponsors plan research and development programs, make informed acquisition decisions on highly technical subjects, formulate strategies and policies, and develop organizational practices that better leverage information and advanced information technology.

IDA then...

Joint Advanced Warfighting Division

Mr. Karl H. Lowe, Director

JAWD was established at IDA in 1998 at the request of the Vice Chairman of the Joint Chiefs of Staff and the Under Secretary of Defense for Acquisition, Technology, and Logistics to serve as a catalyst for stimulating innovation and breakthrough improvements in joint military capabilities. The team's core work includes advanced concept development, operations analysis, and joint experimentation in support of the Joint Staff, Joint Forces Command, and the Office of the Secretary of Defense. JAWD is composed of both military personnel on joint assignment (three from each Service) and civilian analysts from IDA. Located mainly at IDA's Alexandria, VA, campus, JAWD also maintains an office in Norfolk, Virginia, to facilitate interaction with U.S. Joint Forces Command.

Operational Evaluation Division

Mr. Robert D. Soule, Director

OED supports the Office of the Secretary of Defense in the planning, observation, and evaluation of Service and defense agency 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 interagency mission planning process. In addition, OED teams with the Studies and Analyses Center's Cost Analysis and Research Division to support the Department of Homeland Security in evaluating new counterterrorism technologies as part of the review process under the Support Anti-terrorism by Fostering Effective Technologies (SAFETY) Act.

...and now.

Science and Technology Division

Dr. Michael A. Rigdon, Director

STD researchers investigate and model scientific phenomena and conduct technical characterizations and evaluations of devices and systems to assess the limits of performance available in their operational environments and the mission capability they provide. 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

SFRD performs integrated, interdisciplinary studies of plans and policies related to national security strategy, the structure and capabilities of U.S. and foreign forces, and the infrastructure supporting U.S. forces. This work includes development of associated methodologies, models, and simulations. The division also assists in streamlining government organizations, management systems, and processes.

System Evaluation Division

Dr. George E. Koleszar, Director

SED assesses military force effectiveness, system performance, and joint and allied interoperability. It also examines mission needs, develops system architectures, performs system-of-systems analyses, investigates new operational concepts, and assesses the risks and costs that accompany technological integration. These studies help sponsors choose among competing systems, set force or inventory levels, and identify suitable concepts for employing systems.

Science and Technology Policy Institute, Washington, DC

Dr. Robert E. Roberts, Director

The Science and Technology Policy Institute provides the same rigorous analytic approach of our Studies and Analyses Center as it supports the White House Office of Science and Technology Policy. STPI assembles timely and authoritative information regarding significant science and technology developments and trends in the United States and abroad, and analyzes this information, with particular attention to how it affects the federal science and technology research and development portfolio and interagency and national issues.

Center for Communications and Computing

IDA's Center for Communications and Computing plays a key role in the research endeavors of the National Security Agency, 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.

Centers for Communications Research, Princeton, New Jersey, and La Jolla, California

Dr. David M. Goldschmidt, Director, CCR–Princeton (through May 2007)

Dr. David J. Saltman, Director, CCR-P (beginning June 2007)

Dr. Joe P. Buhler, Director, CCR–La Jolla

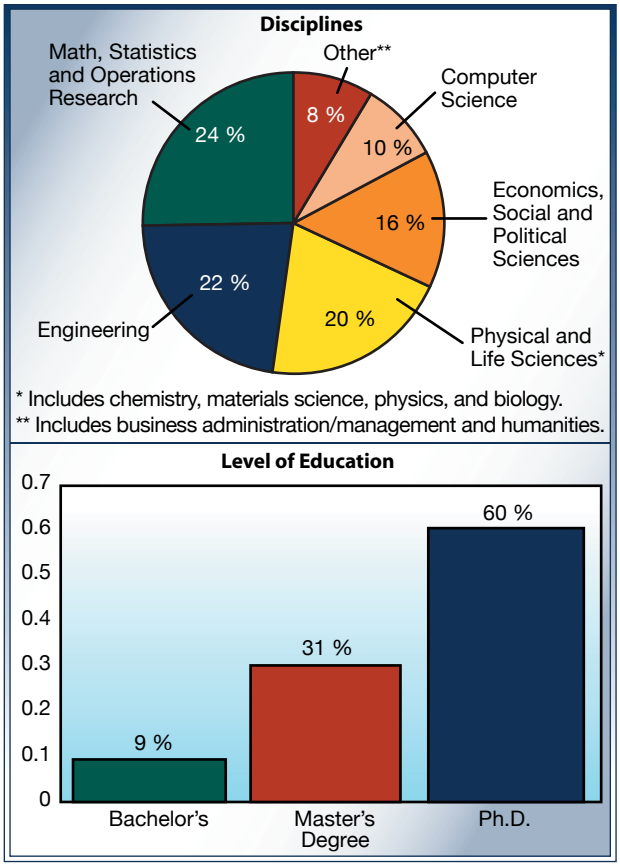
The two CCRs conduct fundamental research supporting the National Security Agency in cryptology and related disciplines. Their work includes creating and analyzing complex encipherment algorithms, conducting speech and signal analyses, and developing information processing algorithms.

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 technologies in support of communications security applications; and information processing technologies, focusing on applications for large data sets.

People



Fifty years ago, IDA was created, at least in part, because of the government's difficulty in recruiting and retaining scientific talent and in maintaining the needed research environment. Recruiting and nurturing exceptional people remain an IDA priority.

Leadership

Following in the footsteps of distinguished former trustees – such as scientists Dr. James R. Killian, Jr., Dr. Jack Ruina, and Dr. Herbert York as well as outstanding military figures such as General Maxwell Taylor, Major General James McCormack, Jr., and General Andrew J. Goodpaster, today's officers and trustees represent the breadth of IDA's research.

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Rewarding Excellence

To underscore our commitment to excellence, IDA maintains several award programs to acknowledge employees whose performance has been exceptional. Primary among these is the Andrew J. Goodpaster Award for Excellence in Research, which was established in 1984 and renamed in General Goodpaster's honor two years later.

(L to R) Chairman of the IDA Board of Trustees, Dr. John Palms; Board Member Mr. Robert Prestel, and Board Member Dr. Martha Krebs.

Mr. Kevin Woods, winner of the 2006 Andrew J. Goodpaster Award, presents his findings to the IDA staff.

The 2006 Goodpaster Award was presented to Mr. Kevin Woods of the Joint Advanced Warfighting Program for his groundbreaking work on the Iraqi Perspectives Project, which has stimulated a different way to think about present and future adversaries. Beginning in 2003, when Mr. Woods was an Army officer assigned to JAWP, he was deployed to Iraq by the U.S. Joint Forces Command to gather data and analyze lessons learned during Operation Iraqi Freedom. Initially, Mr. Woods and his team examined the major combat operations phase in a traditional manner; that is, they looked at it from the U.S. and Coalition forces' perspectives.

(Left to right.) Ms. Jennifer Padgett, Senior Administrative Specialist for the Science and Technology Division; Mr. Bruce Angier, Administrative Officer for the Cost Analysis and Research Division; and Mrs. Lynda J. Lacey, Executive Assistant for the System Evaluation Division. Ms. Padgett and Mrs. Lacey won the 2006 IDA President's Award for Excellence, which recognizes sustained superior performance over a significant period of time that contributes significantly to IDA's success. Mr. Angier was the 2006 winner of the W.Y. Smith Award for Excellence, which recognizes the outstanding contributions by a non-research professional staff member.

Later, after Mr. Woods joined IDA as a Research Staff Member, the team was asked to view the campaign from an Iraqi perspective. Mr. Woods then conceived and orchestrated a series of interviews with senior military and civilian officials of Saddam Hussein's regime to capture their perspectives of the war. Combining these interviews with information gleaned from thousands of captured documents, tapes, and maps, Mr. Woods wove a compelling story of Saddam's era in power and opened new windows into the inner workings of his regime. Expanded into a book, Iraqi Perspectives Project has been published by the Government Printing Office and has been circulated widely by the U.S. Naval Institute.

IDA also recognizes the integral work our non-research staff perform, awarding the W.Y. Smith Award for Excellence for outstanding

contributions by a non-research professional staff member, and the IDA President's Award for Excellence to recognize sustained superior performance over a significant period of time that contributes significantly to IDA's success.

Seminars

The IDA seminars are an irregularly scheduled series of mid-day talks on topics, given at both the Studies and Analyses Center and the Center for Communications and Computing, of interest to the staff. Topics include specific defense issues as well as other aspects of national security. They may also address issues of foreign policy, international relations, economic policy, and technology. Speakers this past year (shown with their then-current affiliation) included:

- Dr. Jonathan Berry and Dr. Bruce Hendrickson, Sandia National Laboratories
  "Experience with a Graph Software Infrastructure on Massively Multithreaded Supercomputers"

- Dr. Claire M. Fraser-Ligett, President and Director, Institute for Genomic Research (TIGR)
  "The Implications of Emerging Infectious Disease on Biodefense Preparedness"

- Dr. Michael Green, Senior Advisor and Japan Chair, Center for Strategic & International Studies
  "The Future of U.S. Security Strategy in Asia"

- Dr. Hendrik Lenstra, Jr., Mathematical Institute, University of Leiden, The Netherlands
  "Searching for Good ABC-Triples"

- General Peter Pace, USMC, Chairman of the Joint Chiefs of Staff
  "The Global War on Terrorism: The Way Ahead"

- Dr. Susan Rice, Senior Fellow, Brookings; Former Assistant Secretary of State for African Affairs
  "The National Security Implications of Global Poverty"

Dr. Susan Rice

- Professor Edwin L. Thomas, Morris Cohen Professor of Materials Science and Engineering; Director of the Institute for Soldier Nanotechnologies; Massachusetts Institute of Technology

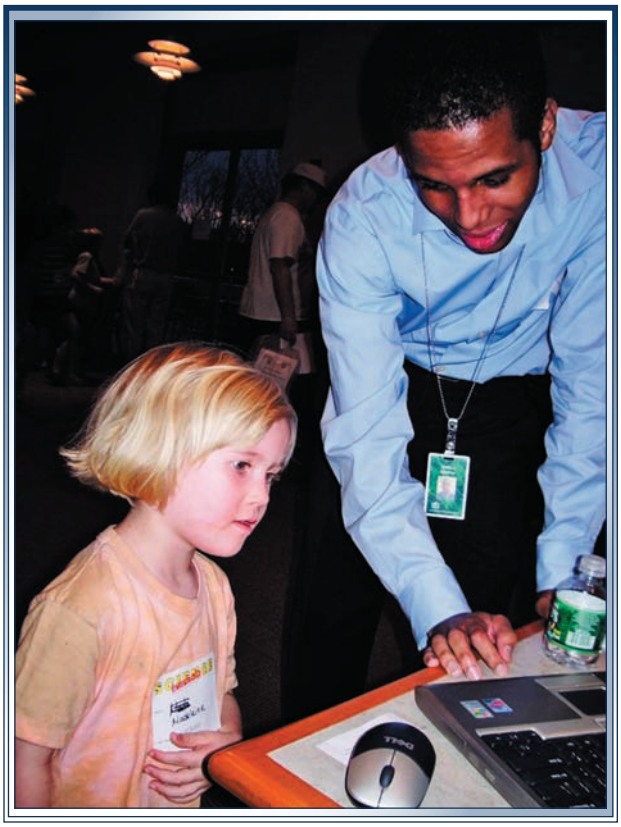
  "Science for the Soldier: From the Lab to Baghdad"

- Dr. Patrick J. Wolfe, Electrical Engineering & Computer Science, Harvard University

  "Time-Frequency Representations and Statistical Models for Speech: Exploring the Space of Acoustic Waveform Variation"

Community Involvement

For many years, IDA has been reaching out to our surrounding communities, taking part in activities such as tutoring and mentoring in collaboration with local schools and Eagle Scout Troops. And while IDA's Educational Outreach Program has changed over the years, our focus on giving back to the community has not. In 2006, IDA employees volunteered many hours of their time tutoring in local elementary, middle, and high schools. IDA also held its first annual essay contest, which was open to high school students in Alexandria, VA, and coordinated a Science Night at our headquarters facility that was open to local school children as well as the children of IDA employees. IDA employees created interactive displays that provided a hands-on learning experience as the children explored various scientific principles and phenomena.



Nafis Upshur of the Strategy, Forces, and Resources Division helps a youngster from the Alexandria City Public Schools at the IDA-sponsored Science Night.

Sponsors

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.

Office of the Secretary of Defense

- Under Secretary of Defense, Acquisition, Technology and Logistics
  - Director, Defense Research and Engineering
  - Assistant to the Secretary of Defense, Nuclear, Chemical, and Biological Defense Programs
  - Deputy Under Secretary of Defense, Acquisition and Technology
  - Deputy Under Secretary of Defense, Advanced Systems and Concepts
  - Deputy Under Secretary of Defense, Industrial Policy
  - Deputy Under Secretary of Defense, Installations and Environment
  - Deputy Under Secretary of Defense, International Technology Security
  - Deputy Under Secretary of Defense, Science and Technology
  - Director, Acquisition Resources and Analysis
  - Director, International Cooperation
  - Director, Test Resource Management Center
  - Executive Director, Defense Science Board
- Under Secretary of Defense, Policy
- Under Secretary of Defense, Comptroller
- Under Secretary of Defense, Personnel and Readiness
- Under Secretary of Defense, Intelligence
- Assistant Secretary of Defense, Networks and Information Integration
- Director, Operational Test and Evaluation
- Director, Program Analysis and Evaluation

Joint Staff and Combatant Commands

Defense Agencies

- Defense Advanced Research Projects Agency
- Defense Information Systems Agency
- Defense Intelligence Agency
- Defense Logistics Agency
- Defense Security Cooperation Agency
- Defense Threat Reduction Agency
- Missile Defense Agency
- National Geospatial-Intelligence Agency
- National Security Agency

Joint Program Offices

- Joint Improvised Explosive Device Defeat Organization
- Joint Land Elevated Netted Sensor Program Office
- Joint Program Office for Chemical and Biological Defense
- Joint Strike Fighter Program Office
- Joint Tactical Radio System Joint Program Office
- Navy Explosive Ordnance Disposal Technology Division

Non-DoD

- Central Intelligence Agency
- Delaware River Maritime Enterprise Council
- Department of Health and Human Services
- Department of Homeland Security
- Department of State
- Department of Transportation
- Department of Veterans Affairs
- Director of National Intelligence
- Federal Bureau of Investigation
- National Aeronautics and Space Administration
- National Institutes of Health
  - Fogarty International Center
  - National Cancer Institute
  - National Institute of Allergy and Infectious Diseases
- National Science Board
- National Science Foundation
- Office of Science and Technology Policy
- Office of National Drug Control Policy
- United States Coast Guard