AIR FORCE STUDIES BOARD

ABOUT THE BOARD

The Air Force Studies Board (AFSB) serves as a convening authority for independent discussion of strategic issues and challenges to the U.S. Air Force. In collaboration with Air Force leadership, the Board develops topics for studies, workshops, and roundtables related to the development and application of science and technology that are then subsequently executed by established policies within the Academies. Recently, these in-depth studies have addressed critical issues such as, acquisition processes, strategic deterrence, hypersonics and assuring the future scientific and technical qualifications of Air Force personnel.

CURRENT PROJECTS

Air Force Development Planning Roundtable
Future Air Force Needs for Defense Against High-Speed Weapon Systems
Owning the Technical Baseline for Acquisition Programs in the U.S. Air Force: A Study
The Role of Experimentation Campaigns in the Air Force Innovation Life Cycle
Optimizing the Acquisition Strategy of Secure and Reliable Electronic Components: A Workshop

SELECTED RECENT REPORTS


Operations within the U.S. Airforce are dynamic, take place over large distances, occur over different operational timelines, and cannot be routinely seen or recorded, making it difficult for Airmen, national decision makers, and citizens to visualize and comprehend the full scope of Air Force operations. As a result, the Air Force faces increasing difficulty in succinctly and effectively communicating the complexity, dynamic range, and strategic importance of its mission. To address this concern, the National Academies of Sciences, Engineering, and Medicine convened a workshop to explore options on how the Air Force can effectively communicate the strategic importance of the Service, its mission, and the role it plays in the defense of the United States.


This congressionally-mandated, classified report reviews current, projected, and planned U.S. national security space systems and architecture and assesses known and projected threats to space systems vital to U.S. national security. The report recommends strategies and architectures for addressing these potential threats while taking into account affordability, technological risk, and other factors that might limit implementation.


The AFSB held a workshop series to identify the essential elements of the technical baseline that would benefit from realignment under Air Force or government ownership, and the value to the Air Force of regaining ownership under its design capture process of the future. Over the course of three workshops from November 2014 through January 2015, presenters and participants identified the barriers that must be addressed for the Air Force to regain technical baseline control to include workforce, policy and process, funding, culture, contracts, and other factors and provided a terms of reference for a possible follow-on study to explore the issues and make recommendations required to implement and institutionalize the technical baseline concept.

For the U.S. Air Force, simulation for training offers a cost-effective and in many instances a safer way to replicate real-world missions. Current technical issues related to simulation for training include simulation fidelity and multi-level security, among others, which will need to be addressed in order for the Air Force to take full advantage of this technology. This workshop, held in November 2014, examined the current status of simulation training, alternative uses, current and future technologies, and how the combination of simulation and live training can improve aircrew training.


This report identifies the broad analytic issues and factors that must be considered in seeking nuclear deterrence of adversaries and assurance of allies in the 21st century. The report describes and assesses tools, methods, and approaches for improving the understanding of how nuclear deterrence and assurance work or may fail in the 21st century and the extent to which such failures might be averted or mitigated by the proper choice of nuclear systems, technological capabilities, postures, and concepts of operation of American nuclear forces.


This report provides recommendations to improve development planning for near-term acquisition projects, concepts not quite ready for acquisition, corporate strategic plans, and training of acquisition personnel. The report reviews past uses of development planning by the Air Force, and offers an organizational construct that will help the Air Force across its core functions. Developmental planning can provide the Air Force leadership with a tool to answer the critical question, Over the next 20 years in 5-year increments, what capability gaps will the Air Force have that must be filled? Development planning will also provide for development of the workforce skills needed to think strategically and to define and close the capability gap. This report describes what development planning could be and should be for the Air Force.

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The Aeronautics and Space Engineering Board (ASEB) was established in 1967 to focus talents and energies of the engineering community on significant aerospace policies and programs. In undertaking its responsibilities, the ASEB oversees ad hoc committees that recommend priorities and procedures for achieving aerospace engineering objectives and offers a way to bring engineering and other related expertise to bear on aerospace issues of national importance. Among these issues are the research and development (R&D) aspects of the Next Generation Air Transportation System (NextGen); the National Aeronautics and Space Administration’s (NASA’s) aeronautics research program; national aeronautics R&D policy and its implementation; space policy and programs, with a focus on human spaceflight and space operations; commercial space activities; and other aerospace engineering topics.

SELECTED RECENT REPORTS

3D Printing in Space (2014)
This report evaluates the prospects of in-space additive manufacturing. This report examines the various technologies available and currently in development, and considers the possible impacts for crewed space operations and robotic spacecraft operations. Ground-based additive manufacturing is being rapidly developed by industry, and 3D Printing in Space discusses government-industry investments in technology development. According to this report, the International Space Station provides an excellent opportunity for both civilian and military research on additive manufacturing technology. Additive manufacturing presents potential opportunities, both as a tool in a broad toolkit of options for space-based activities and as a potential paradigm-changing approach to designing hardware for in-space activities. This report makes recommendations for future research, suggests objectives for an additive manufacturing roadmap, and envisions opportunities for cooperation and joint development.

Autonomy Research for Civil Aviation: Toward a New Era of Flight (2014)
The development and application of increasingly autonomous (IA) systems for civil aviation is proceeding at an accelerating pace, driven by the expectation that such systems will return significant benefits in terms of safety, reliability, efficiency, affordability, and/or previously unattainable mission capabilities. These systems, however, face substantial barriers to integration into the national airspace system without degrading its safety or efficiency. This report identifies key barriers and suggests major elements of a national research agenda to address those barriers and help realize the benefits that IA systems can make to crewed aircraft, unmanned aircraft systems, and ground-based elements of the national airspace system. It also develops a set of integrated and comprehensive technical goals and objectives of importance to the civil aeronautics community and the nation.

Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration (2014)
The United States has publicly funded its human spaceflight program on a continuous basis for more than a half-century. And yet, the long-term future of human spaceflight beyond this project is unclear. This report explores the case for advancing this endeavor, drawing on the history of rationales for human spaceflight, examining the attitudes of stakeholders and the public, and carefully assessing the technical and fiscal realities. This report recommends maintaining the long-term focus on Mars as the horizon goal for human space exploration. With this goal in mind, the report considers funding levels necessary to maintain a robust tempo of execution, current research and exploration projects and the time/resources needed to continue them, and international cooperation that could contribute to the achievement of spaceflight to Mars. According to Pathways to Exploration, a successful U.S. program would require sustained national commitment and a budget that increases by more than the rate of inflation.
NASA’s Strategic Direction and the Need for a National Consensus (2014)

NASA is widely admired for astonishing accomplishments since its formation in 1958. Looking ahead over a comparable period of time, what can the nation and the world expect of NASA? What will be the Agency’s goals and objectives, and what will be the strategy for achieving them? More fundamentally, how will the goals, objectives, and strategy be established and by whom? How will they be modified to reflect changes in science, technology, national priorities, and available resources? In late 2011, the U.S. Congress directed the NASA Office of Inspector General to commission a “comprehensive independent assessment of NASA’s strategic direction and agency management.” This report finds that only with a national consensus on the Agency’s future strategic direction can NASA continue to deliver the knowledge, the national security, economic benefits, and the technology that have been typified by its earlier history. This was a joint study with the Space Studies Board.


NASA’s Office of the Chief Technologist (OCT) has begun to rebuild the advanced space technology program in the agency with plans laid out in 14 draft technology roadmaps. It has been years since NASA has had a vigorous, broad-based program in advanced space technology development and its technology base has been largely depleted. However, success in executing future NASA space missions will depend on advanced technology developments that should already be underway. Reaching out to involve the external technical community, the Academies considered the 14 draft technology roadmaps prepared by OCT and ranked the top technical challenges and highest priority technologies that NASA should emphasize in the next 5 years. This report provides specific guidance and recommendations on how the effectiveness of the technology development program managed by OCT can be enhanced in the face of scarce resources.

STANDING ACTIVITIES

Aeronautics Research and Technology Roundtable
Space Technology Industry-Government-University Roundtable
Committee on Biological and Physical Sciences in Space

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The Board on Army Science and Technology (BAST) conducts studies and facilitates interactive discussions that address scientific and technical issues of importance to the U.S. Army. The BAST identifies study topics, proposes statements of task, and encourages its members to serve on study committees.

SELECTED RECENT REPORTS


One of the remaining sites with chemical weapons stockpiles is the Blue Grass Army Depot near Richmond, Kentucky. In this case, caustic hydrolysis will be used to destroy the agents and energetics, resulting in a secondary waste stream known as hydrolysate. This report develops criteria for successfully treating the hydrolysate, identifies systemization data that should factor into the criteria/decision process, suggests potential modifications to suggested treatment that would allow continued onsite processing, and assesses waste disposal procedures. This study further examines the possibility of delay or failure of the existing technology and examines possible alternatives to onsite treatment.


At the request of the U.S. Army, this report reviews the criteria for successfully treating the hydrolysate. This report provides information on the composition of the hydrolysate and describes the PCAPP processes for treating it; discusses stakeholder concerns; reviews regulatory considerations at the federal, state, and local levels; discusses Department of Transportation regulations and identifies risks associated with the offsite shipment of hydrolysate; establishes criteria for successfully treating the hydrolysate and identifies systemization data that should factor into the criteria and decision process for offsite transport and disposal of the hydrolysate; and discusses failure risks and contingency options as well as the downstream impacts of a decision to ship hydrolysate offsite.


The Department of Defense is continuing to invest in research to improve helmet performance, through better design and materials as well as better manufacturing processes. At the request of the DOD Director of Operational Test and Evaluation, the report evaluates the adequacy of the Advanced Combat Helmet test protocol for both first article testing and lot acceptance testing, including its use of the metrics of probability of no penetration and the upper tolerance limit (used to evaluate backface deformation). The report also evaluates appropriate use of statistical techniques in gathering data; adequacy of current helmet testing procedures; procedures for the conduct of additional analysis of penetration and backface deformation data; and scope of characterization testing relative to the benefit of the information obtained.

**Assessment of Supercritical Water Oxidation System Testing for the Blue Grass Chemical Agent Destruction Pilot Plant (2013)**

This report reviews and evaluates the results of the tests conducted on one of the SCWO units to be provided to Blue Grass Chemical Agent Destruction Pilot Plant (BGCAPP). The BGCAPP will destroy chemical agent and some associated energetic materials by a process of chemical neutralization known as hydrolysis. The resulting chemical waste stream is known as hydrolysate. Among the first-of-a-kind equipment to be installed at the plant are three supercritical water oxidation (SCWO) reactor systems. This report provides recommendations on SCWO systemization testing inclusive of durability testing and discusses systemization testing objectives and concepts.

The Pueblo Chemical Depot (PCD) in Colorado is one of two sites that features U.S. stockpile of chemical weapons that need to be destroyed. The PCD features about 2,600 tons of mustard-including agent. The PCD also features a pilot plant, the Pueblo Chemical Agent Destruction Pilot Plant (PCAPP), which has been set up to destroy the agent and munition bodies stored at the site using novel processes. The PCAPP uses a combined water recovery system (WRS) and brine reduction system (BRS) to destroy TDG and make the water used in the chemical neutralization well water again. This report presents the results of a National Research Council investigation of this process done for the Assembled Chemical Weapons Alternatives program. The report includes diagrams of the Biotreatment area, the BRS, and WRS; a table of materials of construction, the various recommendations made by the committee; and more.

Making the Soldier Decisive on Future Battlefields (2013)

The U.S. military does not believe its soldiers, sailors, airmen, and marines should be engaged in combat with adversaries on a “level playing field.” To that end, the United States has used its technical prowess and industrial capability to develop decisive weapons that overmatch those of potential enemies. This report establishes the technical requirements for overmatch capability for dismounted soldiers operating individually or in small units. It prescribes technological and organizational capabilities needed to make the dismounted soldier a decisive weapon in a changing, uncertain, and complex future environment and provides the Army with fifteen recommendations on how to focus its efforts to enable the soldier and tactical small unit (TSU) to achieve overmatch.
The Board on Energy and Environmental Systems (BEES) conducts program-specific studies and provides authoritative and independent advice to the executive and legislative branches of government and the private sector on energy and environmental technology issues and related public policy. The Board directs expert attention to energy supply, distribution, and demand technologies and systems. It also addresses related issues in national security, defense, and homeland security, such as protection of critical energy infrastructure against potential terrorist attacks.

SELECTED RECENT REPORTS


The 21st Century Truck Partnership (21CTP) brings together federal agencies and industry partners to coordinate research aimed at reducing fuel consumption and emissions in Medium and Heavy Duty Vehicles (MHDVs) while ensuring the next generation of these vehicles will be both safe and cost effective. This report is the third in a series of three that have reviewed the research and development initiatives carried out by the 21CTP. Since the second report in 2012, the Partnership has made impressive technical progress in some areas and has produced several noteworthy fuel-saving advancements through the process of fully integrating multiple technologies in SuperTruck demonstration vehicles.

**Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles (2015)**

The light-duty vehicle fleet is expected to undergo substantial technological changes over the next several decades. New powertrain designs, alternative fuels, advanced materials and significant changes to the vehicle body are being driven by increasingly stringent fuel economy and greenhouse gas emission standards. Written to inform The United States Department of Transportation’s National Highway Traffic Safety Administration (NHTSA) and Environmental Protection Agency (EPA) Corporate Average Fuel Economy (CAFE) and greenhouse gas (GHG) emission standards, this report is a technical evaluation of costs, benefits, and implementation issues of fuel reduction technologies for next-generation light-duty vehicles.

**Overcoming Barriers to Deployment of Plug-in Electric Vehicles (2015)**

At the request of Congress, this report identifies barriers to the introduction of electric vehicles and recommends ways to mitigate these barriers. The report examines the characteristics and capabilities of electric vehicle technologies, such as cost, performance, range, safety, and durability, and assesses how these factors might create barriers to widespread deployment. The report provides an overview of the current status of PEVs and makes recommendations to spur the industry and increase the attractiveness of this promising technology for consumers.


Medium- and heavy-duty vehicles (MHDVs) such as tractor-trailers, coaches, transit buses and vocational vehicles are used in every sector of the economy. The fuel consumption and greenhouse gas (GHG) emissions of MHDVs have become a focus of legislative and regulatory action in the past few years. This report provides guidance to the National Highway Traffic Safety Administration (NHTSA) as it develops a second round (Phase II) of fuel consumption and GHG emission standards for MHDVs. The report’s recommendations address the regulation of natural gas vehicles, trailers, and tires, and vehicle certification using modeling and simulation, among other topics.
Transitions to Alternative Vehicles and Fuels (2013)
For a century, almost all light-duty vehicles (LDVs) have been powered by internal combustion engines (ICEs) operating on petroleum fuels. Energy security concerns over petroleum imports and the effect of greenhouse-gas (GHG) emissions on global climate are driving interest in alternatives. This report assesses the potential for reducing petroleum consumption and GHG emissions by 80% across the U.S. LDV fleet by 2050, relative to 2005. It examines the current capability and estimated future performance and costs for each vehicle type and non-petroleum-based fuel technology as options that could significantly contribute to these goals. By analyzing scenarios that combine various fuel and vehicle pathways, the report also identifies barriers to implementation of these technologies and suggests policies to achieve the desired reductions.

An Assessment of the Prospects for Inertial Fusion Energy (2013)
This report describes and assesses the current status of Inertial Fusion Energy (IFE) research in the United States, compares the various technical approaches to IFE, and identifies the scientific and engineering challenges associated with developing inertial confinement fusion (ICF) in particular as an energy source. It also provides guidance on an R&D roadmap at the conceptual level for a national program focusing on the design and construction of an inertial fusion energy demonstration plant.

Assessment of Advanced Solid State Lighting (2013)
The standard incandescent light bulb, which still works mainly as Thomas Edison invented it, converts more than 90% of the consumed electricity into heat. Given the availability of newer lighting technologies that convert a greater percentage of electricity into useful light, there is potential to decrease the amount of energy used for lighting in both commercial and residential applications. Although technologies such as compact fluorescent lamps have emerged in the past few decades and will help achieve the goal of increased energy efficiency, solid-state lighting (SSL) stands to play a large role in dramatically decreasing U.S. energy consumption for lighting. This report summarizes the current status of SSL technologies and products—light-emitting diodes (LEDs) and organic LEDs (OLEDs)—and evaluates barriers to their improved cost and performance.

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The Board on Infrastructure and the Constructed Environment (BICE) addresses questions of technology, science, and public policy applied to the relationship between the constructed and natural environments and their interaction with human activities. Focus areas include infrastructure investment and community building, facilities asset management, physical security and multi-hazard vulnerabilities, and building design and construction. The BICE brings together expertise from a wide range of scientific, engineering, and social science disciplines to address problems and issues in these areas.

SELECTED RECENT REPORTS


The U.S. Congress has an ongoing interest in ensuring that the 500,000 buildings and other structures owned and operated by the U.S. Department of Defense (DOD) are operated effectively in terms of cost and resource use. Section 2830 of the National Defense Authorization Act for fiscal year requires the Secretary of Defense to submit a report to the congressional defense committees on the energy-efficiency and sustainability standards used by DOD for military construction and major renovations of buildings. DOD’s report must include a cost-benefit analysis, return on investment, and long-term payback for the building standards and green building certification systems. This report summarizes the recommendations for energy efficiency.

**Predicting Outcomes of Investments in Maintenance and Repair of Federal Facilities (2012)**

This report identifies processes and practices for transforming the current portfolio of federal facilities into one that is more economically, physically, and environmentally sustainable. This report addresses ways to predict or quantify the outcomes that can be expected from a given level of maintenance and repair investments in federal facilities or facilities’ systems, and what strategies, measures, and data should be in place to determine the actual outcomes of facilities maintenance and repair investments.

**Achieving High-Performance Federal Facilities: Strategies and Approaches for Transformational Change (2011)**

In 2010, General Services Administration's Office of Federal High-Performance Green Buildings asked the Academies to appoint an ad hoc committee of experts to conduct a public workshop and prepare a report that identified strategies and approaches for achieving a range of objectives associated with high-performance green federal buildings. This report identifies examples of important initiatives taking place and available resources. The report explores how these examples could be used to help make sustainability the preferred choice at all levels of decision making.


Many of the services Americans take for granted such as water, wastewater, power, transportation, and telecommunications, rely on aging infrastructure systems that are now in need of renovation after 50 to 100 years of use. Using the same processes, practices, technologies, and materials to meet developing needs will likely yield increasing instances of service disruptions, higher operating and repair costs, and the possibility of catastrophic, cascading failures. This report outlines a framework to ensure that ongoing activities, knowledge, and technologies can be aligned and leveraged to help meet multiple national objectives.
RECENT WORKSHOPS AND EVENTS

*Conducted under the auspices of the Federal Facilities Council

Federal Leadership in Asset Management Policy Forum
October 20-21, 2015
This forum brought together national and international leaders to discuss a vision for new policies and strategies designed to generate dramatic, positive changes for Federal asset management and performance.

Strategically Incorporating Sustainability, Resilience, and Footprint Consolidation in Portfolio Planning
September 14, 2015 & October 27, 2015
This workshop encouraged participants to identify practical strategies, tools, and resources for incorporating sustainability, resilience, and footprint consolidation into the portfolio prioritization process.

November 4, 2015

Building Control Systems Cyber Resilience Workshop
November 17-18, 2015
This workshop addressed current and future cyber threats as well as ways to manage cybersecurity risks for different facility and building types.

The Potential Role of Private Finance in Federal Building Construction
December 14, 2015
This event explored the opportunities that exist for private financial participation in Federal building construction and barriers (perceived and real) to such private involvement. It helped identify what needs to occur at the legislative and regulatory level to increase opportunities for the beneficial involvement of the private sector.

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ABOUT THE BOARD

The mission of the Board on Mathematical Sciences and their Applications (BMSA) is to support and promote the quality and health of the mathematical sciences and their benefits to the nation. The BMSA addresses four key areas at the interface of mathematical sciences and public policy: responsible and effective use of computational models; creation of knowledge from large amounts of data; mathematical and statistical underpinnings of risk analysis; and leadership for the mathematical science. The Board’s Committee on Applied and Theoretical Statistics (CATS) addresses the same goals with a specific focus on data analytics and statistics.

SELECTED RECENT REPORTS


If the United States is to sustain its economic prosperity, quality of life, and global competitiveness, it must continue to have an abundance of secure, reliable, and affordable energy resources. There have been many improvements in the technology and capability of the electric grid over the past several decades. Many of these advances to the grid depend on complex mathematical algorithms and techniques, and as the complexity of the grid has increased, the analytical demands have also increased. The workshop summarized in this report was developed as part of an ongoing study of the Committee on Analytical Research Foundations for the Next-Generation Electric Grid. Mathematical Sciences Research Challenges for the Next-Generation Electric Grid summarizes the presentations and discussions from this workshop. This report identifies critical areas of mathematical and computational research that must be addressed for the next-generation electric transmission and distribution system and to identify future needs and ways that current research efforts in these areas could be adjusted or augmented.


The National Marine Fisheries Service (NMFS) is responsible for the stewardship of the nation’s living marine resources and their habitat. As part of this charge, NMFS conducts stock assessments of the abundance and composition of fish stocks in several bodies of water. At present, stock assessments rely heavily on human data-gathering and analysis. Automatic means of fish stock assessments are appealing because they offer the potential to improve efficiency and reduce human workload and perhaps develop higher-fidelity measurements. The use of images and video, when accompanied by appropriate statistical analyses of the inferred data, is of increasing importance for estimating the abundance of species and their age distributions. This report is the summary of a workshop that discusses analysis techniques for images and videos for fisheries stock assessment. Experts from diverse communities shared perspective about the most efficient path toward improved automation of visual information and discussed both near-term and long-term goals that can be achieved through research and development efforts. This report is a record of the presentations and discussions of this event.

Training Students to Extract Value from Big Data: Summary of a Workshop (2014)

Training Students to Extract Value from Big Data summarizes a workshop convened in April 2014 by the National Research Council’s Committee on Applied and Theoretical Statistics to explore how best to train students to use big data. The workshop explored the need for training and curricula that should be included. One impetus for the workshop was the current fragmented view of what is meant by analysis of big data, data analytics, or data science. New graduate programs are introduced regularly, and they have their own notions of what is meant by those terms and, most important, of what students need to know to be proficient in data-intensive work. This report provides a variety of perspectives about those elements and about their integration into courses and curricula.

Mathematics is a cumulative discipline: new research is reliant on well-organized and well-curated literature. Yet, while much information is contained in the individual items that comprise the mathematical literature, a greater amount of information is represented by the links between items. This is not just via references but in the interrelation of concepts, insights, and techniques as they are developed and spread between mathematical disciplines. This report details how information contained in individual items within the literature could be readily extracted and linked to create a comprehensive Digital Mathematics Library that is more than the sum of its contributing publications. Specifically, the report proposes the establishment of an organization; the development of a set of platforms, tools, and services; the deployment of an ongoing applied research program to complement the development work; and the mobilization and coordination of the mathematical community to take the first steps toward these capabilities.

The Mathematical Sciences in 2025 (2013)

The mathematical sciences are part of nearly all aspects of everyday life--the discipline has underpinned such beneficial modern capabilities as Internet search, medical imaging, computer animation, numerical weather predictions, and all types of digital communications. This report examines the current state of the mathematical sciences and explores the changes needed for the discipline to be in a strong position and able to maximize its contribution to the nation in 2025. It finds the vitality of the discipline excellent and that it contributes in expanding ways to most areas of science and engineering, as well as to the nation as a whole, and recommends that training for future generations of mathematical scientists should be re-assessed in light of the increasingly cross-disciplinary nature of the mathematical sciences. In addition, because of the valuable interplay between ideas and people from all parts of the mathematical sciences, the report emphasizes that universities and the government need to continue to invest in the full spectrum of the mathematical sciences in order for the whole enterprise to continue to flourish long-term.

Frontiers in Massive Data Analysis (2013)

While systems have been developed to store and manage such massive amounts of data, some of which streams by and is only examined “on the fly,” our ability to infer knowledge from data at this scale is limited. A major challenge is developing statistically well-founded procedures that allow us to control the inevitable errors; many traditional tools of data analysis are not feasible at this scale. This report describes the cross-disciplinary skill set that data analysts need to address the challenges of exploiting big data. It identifies gaps in current capabilities and recommends promising research directions in multiple component areas, ranging from data representation to methods for including humans in the data-analysis loop. The report also proposes a list of key computational problems, the “seven computational giants” of massive data analysis.

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Board on Mathematical Sciences and their Applications: nationalacademies.org/bmsa
Division on Engineering and Physical Sciences: nationalacademies.org/deps
ABOUT THE BOARD

The important questions in physics and astronomy change as we learn more about nature, and the rate of change has been increasing. The Board on Physics and Astronomy (BPA) informs the government and the public about trends in and developments at the forefronts of physics and astronomy, fosters interactions with other fields, strengthens connections between basic research and technology development, and seeks to provide guidance on what is needed to continue expanding our understanding in these fields and why doing so is important.

SELECTED RECENT REPORTS


The electromagnetic spectrum is a vital part of our environment. Measures of radio frequency emissions from natural phenomena enable both practical applications, such as weather predictions and studies of the changing of Earth’s climate here at home, and reveal the physical properties of cosmic sources. The spectrum is therefore a resource to be used wisely now and to be protected for future generations. This handbook sets forth the principles for the allocation and protection of spectral bands for services using the radio spectrum for scientific research. It describes the radio frequency bands used by scientific services and includes relevant regulatory information and discussion of scientific use of frequency bands. This reference will guide spectrum managers and spectrum regulatory bodies on science issues and serve as a resource to scientists and other spectrum users.


Active remote sensing is the principal tool used to study and to predict short- and long-term changes in the environment of Earth - the atmosphere, the oceans and the land surfaces - as well as the near space environment of Earth. All of these measurements are essential to understanding terrestrial weather, climate change, space weather hazards, and threats from asteroids. Active remote sensing measurements are of inestimable benefit to society, as we pursue the development of a technological civilization that is economically viable, and seek to maintain the quality of our life. This report describes the threats, both current and future, to the effective use of the electromagnetic spectrum required for active remote sensing. The report offers specific recommendations for protecting and making effective use of the spectrum required for active remote sensing.

**Optimizing the U.S. Ground-Based Optical and Infrared Astronomy System (2015)**

New astronomical facilities, such as the under-construction Large Synoptic Survey Telescope and planned 30-meter-class telescopes, and new instrumentation on existing optical and infrared (OIR) telescopes, hold the promise of groundbreaking research and discovery. How can we extract the best science from these and other astronomical facilities in an era of potentially flat federal budgets for both the facilities and the research grants? Optimizing the U.S. Ground-Based Optical and Infrared Astronomy System provides guidance for these new programs that align with the scientific priorities and the conclusions and recommendations of two decadal surveys, *New Worlds, New Horizons for Astronomy and Astrophysics* and *Vision and Voyages for Planetary Sciences in the Decade 2013-2022*, as well as other reports. This report describes a vision for a U.S. OIR System that includes a telescope time exchange designed to enhance science return by broadening access to capabilities for a diverse community, an ongoing planning process to identify and construct next generation capabilities to realize decadal science priorities, and near-term critical coordination, planning, and instrumentation needed to usher in the era of LSST and giant telescopes.

This report assesses whether the proposed Astrophysics Focused Telescope Assets (AFTA) design reference mission described in the April 30, 2013 report of the AFTA Science Definition Team (SDT), WFIRST-2.4, is responsive to the overall strategy to pursue the science objectives of New Worlds, New Horizons in Astronomy and Astrophysics, and in particular, the survey’s top ranked, large-scale, space-based priority: the Wide Field Infrared Survey Telescope (WFIRST). This report considers the versions of WFIRST-2.4 with and without the coronagraph, as described in the AFTA SDT report. The report compares the WFIRST mission described in New Worlds, New Horizons to the AFTA SDT WFIRST-2.4 design reference mission, with and without the coronagraph, on the basis of their science objectives, technical complexity, and programmatic rationale, including projected cost. This report gives an overview of relevant scientific, technical, and programmatic changes that have occurred since the release of New Worlds, New Horizons, and assesses the responsiveness of the WFIRST mission to the science and technology objectives of the New Worlds report.


The field of condensed matter and materials research has played a key role in meeting our nation’s needs in a number of areas, including energy, health, and climate change. Harvesting the Fruits of Inquiry highlights a few of the societal benefits that have flowed from research in this field. This report communicates the role that condensed matter and materials research plays in addressing societal needs. The report uses examples to illustrate how research in this area has contributed directly to efforts to address the nation’s needs in providing sustainable energy, meeting health needs, and addressing climate change issues. Written in an accessible style, this report will be of interest to academia, government agencies, and Congress.


This report answers three questions: (1) What is the current state of high-field magnet science, engineering, and technology in the United States, and are there any conspicuous needs to be addressed? (2) What are the current science drivers and which scientific opportunities and challenges can be anticipated over the next ten years? (3) What are the principal existing and planned high magnetic field facilities outside of the United States, what roles have U.S. high field magnet development efforts played in developing those facilities, and what potentials exist for further international collaboration in this area? This report contains a recommendation for the funding and siting of several new high field nuclear magnetic resonance magnets at user facilities in different regions of the United States. Continued advancement in high-magnetic field science requires substantial investments in magnets with enhanced capabilities. This report also contains recommendations for the further development of all-superconducting, hybrid, and higher field pulsed magnets that meet ambitious but achievable goals.

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The purpose of the Computer Science and Telecommunications Board (CSTB) is to provide a base of expertise in the fields of computer science, information technology, and telecommunications; monitor and promote the health of these fields; initiate studies involving these fields as critical resources and sources of national economic strength; respond to requests for advice from government agencies, nonprofit organizations, and private industry; and foster interaction among computer science, telecommunications, and other fields of science and technology.

**SELECTED RECENT REPORTS**

**Telecommunications Research and Engineering at the Communications Technology Laboratory of the Department of Commerce: Meeting the Nation’s Telecommunications Needs (2015)**

The Department of Commerce operates two telecommunications research laboratories located at the Department of Commerce’s Boulder, Colorado, campus: the National Telecommunications and Information Administration’s (NTIA’s) Institute for Telecommunications Sciences (ITS) and the National Institute of Standards and Technology’s (NIST’s) Communications Technology Laboratory (CTL). CTL develops appropriate measurements and standards to enable interoperable public safety communications, effective and efficient spectrum use and sharing, and advanced communication technologies. CTL is a newly organized laboratory within NIST, formed mid-2014. As it is new and its planned work represents a departure from that carried out by the elements of which it was composed, this study focuses on its available resources and future plans rather than past work. The Boulder telecommunications laboratories currently play an important role in the economic vitality of the country and can play an even greater role given the importance of access to spectrum and spectrum sharing to the wireless networking and mobile cellular industries. Research advances are needed to ensure the continued evolution and enhancement of the connected world the public has come to expect.

**Bulk Collection of Signals Intelligence: Technical Options (2015)**

The Bulk Collection of Signals Intelligence: Technical Options is a result of an activity called for in Presidential Policy Directive 28 (PPD-28), issued by President Obama in January 2014, to evaluate U.S. signals intelligence practices. The directive instructed the Office of the Director of National Intelligence (ODNI) to produce a report within one year “assessing the feasibility of creating software that would allow the intelligence community more easily to conduct targeted information acquisition rather than bulk collection.” ODNI asked the National Academies of Sciences, Engineering, and Medicine to conduct a study, which began in June 2014, to assist in preparing a response to the President. Over the ensuing months, a committee of experts produced this report.

**At the Nexus of Cybersecurity and Public Policy: Some Basic Concepts and Issues (2014)**

Our nation is increasingly dependent on computers and information technology. Systems as diverse as our power grid, health care system, armed forces, and financial services, rely on computers and networks at every stage. Malevolent actors can exploit vulnerabilities in these systems to steal money, intellectual property, or classified information; snoop on private conversations; impersonate others; harass or bully innocent people anonymously; damage important data; disrupt the operation of physical machinery controlled by computers; or deny the availability of normally accessible services. In light of growing concerns for our nation’s cybersecurity and numerous policy proposals, this report was assembled to help decision makers and the interested public make informed choices.
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LABORATORY ASSESSMENTS BOARD (LAB)

ABOUT THE BOARD

The Laboratory Assessments Board (LAB) oversees activities involving the review of the technical quality of internal research conducted at laboratories. This includes laboratories established by federal agencies at national laboratories and government-owned, contractor-operated facilities but may include others as well. Assessments are performed by committees appointed under the auspices of the Board and established separately for each institution or laboratory. The LAB also oversees the activities of the Army Research Laboratory Technical Assessment Board (ARLTAB) and the Committee on National Institute of Standards and Technology Technical Programs (CNISTTP).

SELECTED RECENT REPORTS

Peer Review and Design Competition in the NNSA National Security Laboratories (2015)

Since 1992 it has been U.S. policy not to conduct explosion tests of nuclear weapons. The resulting technical challenges have been substantial. Whereas a nuclear test was in some sense the ultimate “peer review” of the performance of a particular NEP design, the cessation of nuclear testing necessitated a much greater reliance on both intralab and interlab expert peer review to identify potential problems with weapon designs and define the solution space. This report assesses the quality and effectiveness of peer review of designs, development plans, engineering and scientific activities, and priorities related to both nuclear and non-nuclear aspects of nuclear weapons, as well as incentives for effective peer review.


This report is an independent assessment regarding the transition of the National Nuclear Security Administration (NNSA) laboratories - Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories - to multiagency, federally funded research and development centers with direct sustainment and sponsorship by multiple national security agencies. The report makes recommendations for the governance of NNSA laboratories to better align with the evolving national security landscape and the laboratories’ increasing engagement with the other national security agencies, while simultaneously encouraging the best technical solutions to national problems from the entire range of national security establishments.

An Assessment of the National Institute of Standards and Technology Engineering Laboratory: Fiscal Year 2014 (2015)

The mission of the Engineering Laboratory of the National Institute of Standards and Technology (NIST) is to promote U.S. innovation and industrial competitiveness through measurement science and standards for technology-intensive manufacturing, construction, and cyberphysical systems in ways that enhance economic prosperity and improve the quality of life. This report evaluates the organization’s technical programs, portfolio of scientific expertise within the organization, adequacy of the organization’s facilities, equipment, and human resources, and the effectiveness by which the organization disseminates its program outputs.

An Assessment of the National Institute of Standards and Technology Material Measurement Laboratory: Fiscal Year 2014 (2015)

The National Institute of Standards and Technology’s (NIST’S) Material Measurement Laboratory (MML) is our nation’s reference laboratory for measurements in the chemical, biological, and materials sciences and engineering. This report assesses the scientific and technical work performed by NIST’S Material Measurement Laboratory. In particular, the report assesses the organization’s technical programs, the portfolio of scientific expertise within the organization, the adequacy of the organization’s facilities, equipment, and human resources, and the effectiveness by which the organization disseminates its program outputs.
The Army Research Laboratory Technical Assessment Board (ARLTAB) provides biennial assessments of the scientific and technical quality of the research, development, and analysis programs at the Army Research Laboratory, focusing on ballistics sciences, human sciences, information sciences, materials sciences, and mechanical sciences. This report discusses the biennial assessment process; provides detailed assessments of each of the ARL core technical competency areas reviewed during the 2013-2014 period; and presents findings and recommendations common across multiple competency areas.

The Quality of Science and Engineering at the NNSA National Security Laboratories (2013)
The three National Nuclear Security Administration (NNSA) national security laboratories are a major component of the U.S. government’s laboratory complex and of the national science and technology base. This report assesses the quality of science and engineering in terms of the capability of the laboratories to perform the necessary tasks to execute the laboratories’ missions, both at present and in the future. The report identifies four basic pillars of stockpile stewardship and non-proliferation analysis: (1) the weapons design; (2) systems engineering and understanding of the effects of aging on system performance; (3) weapons science base; and (4) modeling and simulation.

Managing for High-Quality Science and Engineering at the NNSA National Security Laboratories (2012)
This report presents assessments of the evolution of the mission of the NNSA Labs and the management and performance of research in support of the missions, and the relationship between the Laboratory Directed Research and Development (LDRD) program and the ability of the Labs to fulfill their mission. The report examines the framework for managing science and engineering research at the Labs and provides an analysis of the relationships among the several players in the management of the Labs—the NNSA, the site offices, the contractors, and the Lab managers—and the effect of that relationship on the Laboratories’ ability to carry out science and engineering research.

Research and development (R&D) organizations are operated by government, business, academe, and independent institutes. The success of their parent organizations is closely tied to the success of these R&D organizations. This report covers three key factors that underpin the success of an R&D organization: (1) the mission of the organization and its alignment with that of the parents; (2) the relevance and impact of the organization’s work; and (3) the resources provided to the organization, beginning with a high-quality staff and management.

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In recognition of the increasing importance of materials science to innovations in engineering and manufacturing, the National Materials and Manufacturing Board (NMMB) combines the charges of two preexisting boards: the National Materials Advisory Board and the Board on Manufacturing and Engineering Design. The NMMB builds on the achievements of its parent boards by providing objective, independent assessments of the current state of materials and manufacturing research—including at the atomic, molecular, and nano-scales—and the applications of new and existing materials in innovative ways, including pilot-scale and large-scale manufacturing, the design of new devices, and disposal.

**SELECTED RECENT REPORTS**

**Airport Passenger Screening Using Backscatter X-Ray Machines: Compliance with Standards (2015)**

This report reviews previous studies as well as current processes used by the Department of Homeland Security and equipment manufacturers to estimate radiation exposures resulting from backscatter X-ray advanced imaging technology system use in screening air travelers. It examines whether exposures comply with applicable health and safety standards for public and occupational exposures to ionizing radiation and whether system design, operating procedures, and maintenance procedures are appropriate to prevent over exposures of travelers and operators to ionizing radiation. This study aims to address concerns about exposure to radiation from X-ray backscatter AITs raised by Congress, individuals within the scientific community, and others.

**Applying Materials State Awareness to Condition-Based Maintenance and System Life Cycle Management: Summary of a Workshop (2015)**

In August 2014, the committee on Defense Materials Manufacturing and Infrastructure convened a workshop to discuss issues related to applying materials state awareness to condition-based maintenance and system life cycle management. The workshop was structured around three focal topics: (1) advances in metrology and experimental methods, (2) advances in physics-based models for assessment, and (3) advances in databases and diagnostic technologies. This report summarizes the discussions and presentations from this workshop.

**Big Data in Materials Research and Development: Summary of a Workshop (2014)**

This report is the summary of a workshop convened by the Standing Committee on Defense Materials Manufacturing and Infrastructure in February 2014 to discuss the impact of big data on materials and manufacturing. The materials science community would benefit from appropriate access to data and metadata for materials development, processing, application, development, and application life cycles. Currently, that access does not appear to be sufficiently widespread, and many workshop participants captured the constraints and identified potential improvements to enable broader access to materials and manufacturing data and metadata. This report discusses issues in defense materials, manufacturing and infrastructure, including data ownership and access; collaboration and exploitation of big data’s capabilities; and maintenance of data.

**Limited Affordable Low-Volume Manufacturing: Summary of a Workshop (2014)**

This report is the summary of a workshop convened by the National Materials and Manufacturing Board in August 2013 to discuss affordable, low-volume manufacturing. The workshop focused on four critical issues relevant to manufacturing: low-volume manufacturing; use of commercial off-the-shelf equipment; short production runs; and commercial manufacturing services. The workshop discussion also considered variable-rate manufacturing and high-mix manufacturing, both aspects of low-volume manufacturing. This report examines the characteristics of low-volume manufacturing and considers future advances in limited affordable low-volume manufacturing in the United States.
**Triennial Review of the National Nanotechnology Initiative (2013)**

The National Nanotechnology Initiative (NNI) is a multiagency, multidisciplinary federal initiative comprising a collection of research programs and other activities funded by the participating agencies and linked by the vision of “a future in which the ability to understand and control matter at the nanoscale leads to a revolution in technology and industry that benefits society.” This report is the latest review of the NNI, an assessment called for by the 21st Century Nanotechnology Research and Development Act of 2003. The overall objective of the review is to make recommendations that will improve the NNI’s value for basic and applied research and for development of applications in nanotechnology that will provide economic, societal, and national security benefits to the United States. In its assessment, the committee found it important to understand in some detail—and to describe in its report—the NNI’s structure and organization; how the NNI fits within the larger federal research enterprise, as well as how it can and should be organized for management purposes; and the initiative’s various stakeholders and their roles with respect to research.

**Novel Processes for Advanced Manufacturing: Summary of a Workshop (2013)**

Additive manufacturing is the process of making three-dimensional objects from a digital description or file. The workshop addresses different aspects of additive manufacturing including surface finish and access to manufacturing capabilities and resources. Electromagnetic field manipulation of materials is the use of electric and/or magnetic fields to change the mechanical or functional properties of a material or for the purposes of sintering. The workshop examined research prioritization in this area as well as other objectives. This report presents a summary of the key points of this workshop and includes outlines of the open discussions on each area.

**Optics and Photonics: Essential Technologies for Our Nation (2012)**

It is critical for the United States to take advantage of emerging optical technologies for creating new industries and generating job growth. This report assesses the current state of optical science and engineering in the United States and abroad—including market trends, workforce needs, and the impact of photonics on the national economy. It identifies the technological opportunities that have arisen from recent advances in, and applications of, optical science and engineering. The report also calls for improved management of U.S. public and private research and development resources, emphasizing the need for public policy that encourages adoption of a portfolio approach to investing in the wide and diverse opportunities now available within photonics. This report is a useful overview not only for policymakers, such as decision-makers at relevant Federal agencies on the current state of optics and photonics research and applications but also for individuals seeking a broad understanding of the fields of optics and photonics in many arenas.

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The mission of the Naval Studies Board (NSB), created in 1974 at the request of the Chief of Naval Operations (CNO), is to be a source of independent, long-range, scientific and technical planning advice for the naval forces. As mutually agreed upon between the CNO and the President of the National Academy of Sciences (NAS) and with the appropriate attention to the influence of the domestic economy, national objectives, social imperatives, and anticipated military requirements, the NSB will conduct and report upon surveys and studies in the field of scientific research and development applicable to the operation and function of the Navy.

SELECTED RECENT REPORTS

This classified report, conducted at the request of the CNO, reviews U.S. Navy cyber defense capabilities. In addition to reviewing cyber defense-related studies conducted within and outside the U.S. government, the terms of reference of the study are to (1) Review U.S. Navy information technology modernization plans and processes with respect to the evolving threat and robustness to cyber attack, and identify any shortcomings; (2) Recommend any immediate operational and technical mitigation strategies needed to address any shortcomings identified above, as well as recommend any future mitigation strategies, including any architectural and procedural changes that would lead to more resilient naval systems and more robust network and communications capabilities given the evolving threat; (3) Review and assess the adequacy of current Department of the Navy policies, strategies, approaches, and investments in comparison to the findings and recommendations to both (1) and (2) above; and (4) Identify any other critical issue—not addressed in this study—that the U.S. Navy should consider in subsequent studies.

This report, conducted at the request of the CNO, examines the issues surrounding capability surprise, both operational and technical, facing the U.S. Navy, Marine Corps, and Coast Guard. The report selects a few surprises from across a continuum of surprises, from disruptive technologies, to intelligence-inferred capability developments, to operational deployments, and assess what the Naval Forces are doing (and could do) about them while being mindful of future budgetary declines. The report then examines which processes are in place or could be in place in the Navy, the Marine Corps, and the Coast Guard to address such surprises.

U.S. Naval Forces’ Capabilities for Responding to Small Vessel Threats (2013)
This classified report, conducted at the request of the CNO, examines U.S. Naval Forces’ capabilities for responding to the potential exploitation of small vessels by adversaries. The terms of reference of the study are to: (1) Characterize known and potential small vessel types that could be potentially exploited by terrorists or small groups acting as agents of hostile governments, including the types of threats therein; (2) Identify U.S. regions of interest, both within and outside the continental United States, that could be potentially threatened by the use of small vessels; (3) Review and assess the adequacy of current and planned U.S. Naval Forces’ policies, strategies, approaches, and capabilities, including the adequacy of interagency and intergovernmental cooperation in these areas, for responding to these potential small vessel threats in U.S. regions of interest; (4) Identify promising science and technology areas for U.S. Naval Forces’ capabilities for responding to these potential small vessel threats in U.S. regions of interest, including detection, tracking, and identification research areas and their interface with current and planned intelligence and other national means; and (5) Recommend any other initiatives, excluding budgetary and organizational, that should be undertaken by U.S. Naval Forces in an effort towards improving their overall capabilities for responding to the potential exploitation of small vessels by adversaries.
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ABOUT THE BOARD

The Space Studies Board (SSB) was established in 1958 to serve as the focus of the interests and responsibilities in space research for the Academies. It provides an independent, authoritative forum for information and advice on all aspects of space science and its applications. It oversees advisory studies and program assessments, facilitates international research coordination, and promotes communications on space science and science policy between the research community, the federal government, and the interested public. The SSB also serves as the U.S. National Committee for the International Council for Science (ICSU) Committee on Space Research (COSPAR).

SELECTED RECENT REPORTS


As the complexity of societal infrastructure and its vulnerability to environmental disruption increases, the demands for deeper scientific insights and more actionable information continue to rise. To serve these demands, NASA’s ESD is challenged with optimizing the partitioning of its finite resources among measurements intended for exploring new science frontiers, carefully characterizing long-term changes in the Earth system, and supporting ongoing societal applications. This challenge is most acute in the decisions the Division makes between supporting measurement continuity of data streams that are critical components of Earth science research programs and the development of new measurement capabilities. This report seeks to establish a more quantitative understanding of the need for measurement continuity and the consequences of measurement gaps. It presents a framework to assist NASA’s ESD in their determinations of when a measurement or dataset should be collected for durations longer than the typical lifetimes of single satellite missions.

**The Space Science Decadal Surveys: Lessons Learned and Best Practices (2015)**

The Academies have conducted 11 decadal surveys in the Earth and space sciences since 1964. The decadal surveys are notable in their ability to thoroughly sample the research interest, aspirations, and needs of a scientific community. Through a rigorous process, a primary survey committee and thematic panels of community members construct a prioritized program of science goals and objectives and define an executable strategy for achieving them. These reports play a critical role in defining the nation’s agenda in that science area for the following 10 years, and often beyond. This report considers the lessons learned from previous surveys and presents options for possible changes and improvements to the process, including the statement of task, advanced preparation, organization, and execution. This report discusses valuable aspects of decadal surveys that could be taken further, as well as some challenges future surveys are likely to face in searching for the richest areas of scientific endeavor, seeking community consensus of where to go next, and planning how to get there.

**Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration (2014)**

The United States has publicly funded its human spaceflight program on a continuous basis for more than a half-century. And yet, the long-term future of human spaceflight beyond this project is unclear. This report explores the case for advancing this endeavor, drawing on the history of rationales for human spaceflight, examining the attitudes of stakeholders and the public, and carefully assessing the technical and fiscal realities. This report recommends maintaining the long-term focus on Mars as the horizon goal for human space exploration. With this goal in mind, the report considers funding levels necessary to maintain a robust tempo of execution, current research and exploration projects and the time/resources needed to continue them, and international cooperation that could contribute to the achievement of spaceflight to Mars. According to Pathways to Exploration, a successful U.S. program would require sustained national commitment and a budget that increases by more than the rate of inflation.

This report surveys the current state of knowledge of the solar system and recommends a suite of planetary science flagship missions for the decade 2013-2022 that could provide a steady stream of important new discoveries about the solar system. It is a vital resource for government agencies supporting space science, the planetary science community, and the public. According to this report, NASA’s highest priority large mission should be the Mars Astrobiology Explorer Cacher (MAX-C), a mission to Mars that could help determine whether the planet ever supported life and could also help answer questions about its geologic and climatic history. Other projects should include a mission to Jupiter’s icy moon Europa and its subsurface ocean, and the Uranus Orbiter and Probe mission to investigate that planet’s interior structure, atmosphere, and composition.

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