Department of Energy Laboratory Plan
For the Office of Science's
Argonne National Laboratory

Mission and Overview

Argonne National Laboratory (ANL) was founded in 1946 and traces its scientific legacy directly to nuclear physics research teams led by Nobel Laureate Enrico Fermi. ANL was largely responsible for the science behind the emergence of the U.S. nuclear power industry and today has transformed itself into a multipurpose laboratory with a mission focus and deep capabilities in basic and applied materials science, chemistry and chemical engineering, energy technologies and analysis, high-performance computing, physics, and biosciences. ANL also leads research in other scientific areas of importance to the Department of Energy (DOE) such as environmental science and national security.

ANL has retained strong capabilities in the design, construction and management of major scientific user facilities. As a DOE steward of critical national research infrastructure, the laboratory provides university, industry and government researchers with access on a competitive basis. These research facilities include the Advanced Photon Source (APS), which provides x-ray beams for research ranging from materials to structural biology; the Intense Pulsed Neutron Source (IPNS), which has achieved many "firsts" in the field of neutron scattering; the new Center for Nanoscale Materials (CNM), which focuses on exploring the nanoscale physics and chemistry of nontraditional electronic and magnetic materials; the Argonne Tandem-Linac Accelerator System (ATLAS), a superconducting linear accelerator for heavy ions; and the Electron Microscopy Center (EMC), which allows the exploration of inorganic and organic materials on the atomic scale. The ANL user community now includes over 3900 scientists and engineers.

Laboratory Focus and Vision

Six core competencies underpin activities at ANL:

1. Materials science, nanoscience, chemistry, and

Lab-at-a-Glance

Location: Argonne, IL

Type: Multi-program lab

Contract Operator: UChicago Argonne, LLC

Responsible Site Office: Argonne Site Office

Website: http://www.anl.gov/

Physical Assets:

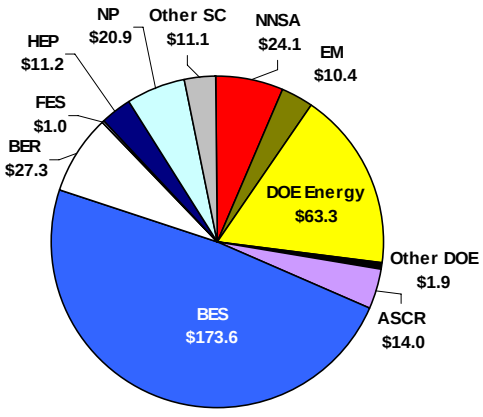
- 1,500 acres and 99 buildings
- 4.4M GSF in Active Operational buildings
- 82K GSF in Non-Operational buildings
- Replacement Plant Value: $1.534B
- Deferred Maintenance: $62.5M
- Asset Condition Index:
  - Mission Critical 0.96 (Good)
  - Mission Dependent 0.96 (Good)
- Asset Utilization Index: 0.96 (Good)

Human Capital:

- 2552 employees
- 565 students (undergrad and grad)
- 3921 Facility Users and Visiting Scientists

FY 2006 Total DOE Funding: $358.9M

FY 2006 DOE Funding by Source
Argonne data (BA in Millions):



FY 2006 Non-DOE Funding: $86.8M
FY 2006 Dept. of Homeland Security: $25.6M

biology.

2. Synchrotron radiation science and technology for the study of materials of all kinds.
3. Energy related research, including transportation science and engineering, and nuclear fuel cycle and reactor design.
4. Integration of modeling, fundamental science, engineering and economic expertise for energy and environmental issues.
5. Advanced software tools, massively parallel computer architectures and large-scale computational sciences.
6. Fundamental physics tied to cosmology and the origins of the elements.

The Office of Science believes that these six competencies will enable ANL to deliver its mission and customer focus, to perform a complementary role in the DOE laboratory system, and to pursue its vision for scientific excellence and pre-eminence in the following areas:

- Pursuing the limits of high spatial and temporal resolution for materials research.
- Exploring the frontiers of low- and medium-energy nuclear physics, including the study of rare and unstable isotopes, which are key to understanding element nucleosynthesis and the origin and evolution of the universe.
- Integrating physics, materials science, biology, chemistry, and computational science to create a sustainable and secure energy future.
- Creating the world's leading core accelerator technology development capability.
- Advancing computational science (architectures and applications) to tackle national R&D challenges requiring petascale capabilities and beyond.
- Realizing the vision of creating materials and catalysts (including enzyme systems) by design.

Business Lines

The following capabilities, aligned by business lines, distinguish ANL and provide a basis for effective teaming and partnering with other DOE laboratories, universities, and private sector partners in pursuit of the laboratory mission. These business lines and the distinguishing capabilities outlined in the table below provide an additional window into the mission focus and unique contributions and strengths of ANL and its role within the Office of Science laboratory complex. Items in italics within the Distinguishing Capabilities column identify research facilities that give ANL particular strategic strengths and capabilities. Descriptions of these facilities can be found at the website noted in the Lab-at-a-Glance section of this Plan.

Business Lines	Distinguishing Capabilities	Distinguishing Performance	Mission Relevance
Materials Science	• Materials Synthesis, Characterization, and Modeling; • Hard X-ray Nanoscale Research; • *Advanced Photon Source;* • *Center for Nanoscale Materials;* • *Electron Microscopy Center;*	International leader; most highly cited papers in materials science per http://isihighlycited.com Only site with co-located photon, neutron, electron, and ion based materials analysis facilities; High caliber staff as indicated by award	Understand materials structure and properties for energy, health and national security applications; Lead portions of the nanoscale revolution.

Business Lines	Distinguishing Capabilities	Distinguishing Performance	Mission Relevance
	• *Intense Pulsed Neutron Source.*	of 2003 Nobel Prize in Physics to Alexei Abrikosov.	
Mathematics & Computer Sciences	• Advanced Architecture Research • Applied Modeling & Simulation • Computational Mathematics	Leader in fundamental architecture for massively parallel computer systems: MPICH - for message passing – see http://www-unix.mcs.anl.gov/mpi/mpich/ PVFS - for parallel file systems – see http://www.pufs.org NEOS - for on-line optimization - see http://www-neos.mcs.anl.gov/ PETSc - for partial differential equations –see http://www-unix.mcs.anl.gov/petsc/petsc-as/ "DOE Top 10" scientific achievement for large-scale massively parallel optimization; Designated partner, with the Oak Ridge National Laboratory (ORNL), to establish leadership class computing for open scientific research.	Providing computational tools to advance the forefront of science and engineering.
Advanced Biosciences	• Structural Biology/Genomics: Biomolecular Structure Determination • Bioinformatics • Environmental Molecular Science • Terrestrial Carbon Research • HT Molecular Biology and Biochemistry • *Structural Biology Center*	Top 3 world-wide in production & characterization of protein structures; data summarized at http://www.mcsg.anl.gov (click on "SG Progress") Co-location of the APS, IPNS, and protein crystallization center provides unique capabilities	Increase bio-defense capabilities; develop new energy sources and environmental technologies; and advance systems biology as supported through the Genomics:GTL Program.
Fundamental Physics	• Nuclear Structure and Astrophysics with Stable and Unstable Ion Beams; • Laser Trapping of Individual Atoms; • High Energy Physics Experiments and Theory; • *Argonne Tandem-Linac Accelerator System (ATLAS)*	World leader in experimental & theoretical nuclear physics Most highly cited nuclear theory paper of past decade: Phys Rev c51, p. 38 (l995) see http://isihighlycited.com Lead roles in international collider experiments	Understand fundamental matter and forces and master connections between high energy & nuclear physics, astrophysics & cosmology.
Energy & Environmental S&T	• Nuclear Fuel Cycle & Reactor Design; • Transportation Science and Technology; • Integration of Economics, Computing, Engineering and Sciences; • *Cloud and Radiation Testbed;* • *Engine Research Facility for Diesels;* • *Advanced Powertrain Test*	International leadership in closed fuel cycle (UREX+1a) & reactor technologies World leader in vehicle testing (confirmed by Toyota, Hyundai, GM, Ford, others). Shared leadership of Atmospheric Radiation Measurement (ARM) program; Nationally recognized expertise in environmental assessment as evidenced by being chosen to do the Trans-Alaska Pipeline EIS.	R&D on next-generation nuclear reactors and advanced nuclear fuel cycles. Advance integrated science and technology approaches to energy & environmental challenges. Advance the frontiers of large-scale, systems-level modeling and simulations as applied to energy and environmental technologies.

Business Lines	Distinguishing Capabilities	Distinguishing Performance	Mission Relevance
	Facility for Hybrid Vehicles.		
Accelerator Design	• Synchrotron Radiation Sources • Accelerator R&D for Heavy-Ion Beams • Superconducting RF Design	World's first superconducting heavy ion accelerator. New classes and performance standards for RF cavities World-leading development of synchrotron operations Advanced acceleration concepts	Maintain DOE lead in accelerator design, construction and operations.

Major Activities

Following is a set of major activities that ANL is currently pursuing to support elements of the DOE mission and build on core strengths and capabilities of the laboratory. These activities are either currently supported or appear in the FY 2008 budget submission to Congress. The companion documents, the DOE's Five Year Plans, provide greater insights into these activities in terms of various five-year budget scenarios.

The major activities are:

1. Synthesis, Characterization, and Modeling of Novel Structural, Electronic, Magnetic, and Superconducting Materials
2. Petascale Computing
3. Genomics, Systems Biology, and Structural Biology
4. Integrated Energy, Environment & Economic Research

1. Synthesis, Characterization, and Modeling of Novel Structural, Electronic, Magnetic, and Superconducting Materials

- **Summary**: We aim to create novel inorganic and biological materials with pre-determined properties that are tailored for specific functions or applications.
- **Expectations**: International leadership in materials science including the synthesis, characterization, and modeling of novel structural, electronic, magnetic, or superconducting materials that underpin DOE missions in fundamental and applied materials science and energy security.
- **Benefit Perspective**: Potentially *Transformational* Benefits.
- **Risk Perspectives**:
  - Technical: *Moderate risk* -- owing to exploratory nature of research. This risk is mitigated by the very high quality of the scientific and support staff.
  - Market:/Competition: *Moderate risk* -- because of the intense global competition in materials research.
  - Management/Financial: *Low risk* -- because of expected stability of programmatic funding and facility operations funding from DOE.

In addition to traditional strengths in materials research resident within the basic and applied technical divisions at ANL, the new Center for Nanoscale Materials (CNM), a state-of-the-art facility for the design, synthesis, fabrication, and characterization of materials at the nanoscale, will begin full

operations in the fall of 2007. The CNM is one of five national DOE Nanoscale Science Research Centers (NSRCs). The NSRCs are based on a new model for scientific user facilities and will provide the nation with specialized tools and expert staff which, when taken together, are not readily available at universities and industrial labs. The CNM will focus on the design and synthesis of nanomaterials and nano-assemblies for coherent control of spin, charge, and photons at the nanoscale and the study of bio/organic/inorganic interfaces for energy conversion.

The CNM's six primary themes are nanofabrication, electronic and magnetic materials and devices, nanophotonics, nano-bio interfaces, x-ray imaging, and theory and simulation. The facility will employ 60 permanent staff and postdocs and will accommodate up to 80 users at one time. Keys to the success of the CNM are (a) its close partnership with the other DOE user facilities at Argonne - i.e., materials synthesized at the CNM can be characterized with the forefront tools available at the Advanced Photon Source, the Intense Pulsed Neutron Source, and the Electron Microscopy Center - and (b) collaborations with staff in technical divisions throughout the Physical Sciences, Computing & Life Sciences, Applied Science & Technology, and Scientific User Facilities Directorates.

2. Petascale Computing

- **Summary:** ANL will focus on advanced architecture deployment and integration at the petascale to support DOE's missions and INCITE investigators.
- **Expectations:** Development of petascale computing capabilities for: creation of "designer" nanomaterials for industrial, medical, and other applications; modeling of whole microbial cells for bioengineering and synthetic biology applications in support of energy and environmental research.
- **Benefit Perspective:** Potentially *Transformational* Benefits
- **Risk Perspectives:**
  - Technical: *Moderate risk* -- because of commercial risk as well as semiconductor design and software risk. This risk is mitigated by the particular choice of application.
  - Market/Competition: *Moderate risk* -- because the transformation requires adoption by industry.
  - Management/Financial: *High risk* -- because of close coupling with business plans of computer vendors who may or may not stay in the market.

ANL is a partner with ORNL to develop leadership-class computing capabilities to support forefront science, and while supporting broad classes of advanced architectures, ANL aims to focus especially on architectures with promise for reaching petascale levels of computing capability. This activity builds on ANL's strengths in High Performance Computing (HPC) software, advanced hardware architectures, and application expertise; and enables forefront research, engineering, and facilities**.**

Major technical hurdles must be overcome to develop a computer architecture that achieves high application performance with reasonable cost and power consumption. ANL is working with IBM and other vendors to achieve this goal, in collaboration with researchers at other DOE laboratories and at universities. ANL also must ensure that applications software with appropriate scientific content, efficiency and reliability is available to meet the community's needs. In addition to hiring new staff, ANL will collaborate with other DOE laboratories (especially ORNL and LBNL), the University of Chicago, Northwestern, and the University of Illinois and other universities to build strong software development teams.

3. Genomics, Systems Biology, and Structural Biology

- **Summary:** Argonne will combine its world-class expertise in structural biology and bioinformatics with growing investment in systems biology to develop a comprehensive approach to the study of complex biomolecular systems. The goal is to use biological systems as a basis for solving fundamental problems in biofuel production, environmental remediation and carbon cycling.
- **Expectations:** A comprehensive approach to the design and management of microbial systems that can be used in a wide variety of industrial and environmental contexts in which they will provide cost-effective alternatives to physical processing strategies.
- **Benefit Perspective:** Potentially *Substantial* benefits.
- **Risk Perspectives:**
    - Technical: *Moderate risk* -- because engineering of complex systems is a developing capability.
    - Market/competition: *High risk* -- for the bioenergy part of the program because many groups are investing heavily in this area; moderate risk for other parts. These risks are mitigated by the broad range of potential applications of the developing technology.
    - Management/Financial: *Moderate risk*-- because although funding may become available from diverse sources, the needed technical advances may require prolonged investment.

Research at the interface of structural and systems biology is poised to lead to significant advances in our understanding of the function of molecular complexes that are key to the functioning of the cell. These breakthroughs will have immediate and substantial impact on applications to DOE mission needs. Existing Argonne programs will position the laboratory for significantly increased programmatic support of fundamental research through the DOE Genomics: GTL Program as well as through NIH and other agencies. Currently, Argonne is partnering with regional institutions to apply for a DOE GTL Bioenergy Research Center.

With the University of Chicago, Argonne has formed the joint Institute for Genomics and Systems Biology (IGSB) to drive forward capabilities in this field. The State of Illinois has funded the construction of the Advanced Biosciences Facility, a $33M building that will house programs in structural and systems biology including the IGSB. Initial planning for this facility is underway, with construction scheduled to begin in FY 2008 and be completed in FY 2010.

4. Integrated Energy, Environment & Economic Research

- **Summary:** Combine ANL's expertise in decision science, computational, fundamental, and applied research with social/economic science capabilities to develop a suite of products and tools that advance DOE's mission to provide a more diverse, sustainable and secure energy future for the Nation while mitigating environmental impacts.
- **Expectations:** An integrated analytical science and engineering-based energy/environment/economic and social modeling framework to provide the DOE with a new capability for (1) informing policy and investment decisions leading to a more diverse, sustainable and secure energy future; (2) developing new technology options, primarily in the transportation, transmission and nuclear generation sectors; and (3) integrating R&D programs from basic to applied to deployment.
- **Benefit Perspective:** Potentially *Transformational* Benefits
- **Risk Perspectives:**
    - Technical: *Moderate risk* -- in terms of developing a decision-support framework; *High*

risk in terms of developing specific technologies due to uncertainties in basic research.

- Market/Competition: *High risk* because many different organizations (public and private) are competing for market share in this area.
- Management/Financial: *Low risk* because the programs will be implemented incrementally.

The DOE currently lacks an integrated approach to the analysis of the impacts that technology options have on energy utilization and production, the economy, and the environment. ANL's ability to draw upon the systems and decision modeling expertise, as well as the basic and applied scientific talent, contained within the lab and the social/economic sciences capabilities of the University of Chicago (together with its partner universities Northwestern University and the University of Illinois) presents an opportunity to provide analytical capabilities that DOE has never before had available.

This investment exploits ANL's considerable technical expertise in advanced materials synthesis and characterization, nuclear fuel cycle and reactor design, transportation science and engineering, molecular photochemistry, computational sciences, and large-project delivery. It is anticipated to have broad economic impact, e.g., reduced dependence on foreign petroleum, more efficient energy production, and a significant reduction in greenhouse gas emissions.

Financial Outlook

Detailed information regarding the financial outlook for the Argonne National Laboratory is subject to 1) competition and merit review, 2) the availability of appropriated funds, and 3) programmatic decisions. The first two factors cannot be predicted or estimated in advance. The third, programmatic decisions are developed in accordance with the planning targets reflected in the Department of Energy programmatic Five Year Plans, a companion document to these strategic laboratory business plans. In addition, because of the Office of Science commitment to competition and merit review, there is often a time lag between programmatic decisions and the determination of which research provider can best deliver the greatest value in conducting the research. Thus, it is not always apparent how programmatic decisions unfold for particular laboratories. Nevertheless, some decisions, such as the plans for large scientific user facilities, show clear paths to individual labs and therefore inform their business plans.

Performance of non-DOE funded work is a vital role of our national laboratories, contributing to national security, energy security, environment stewardship, scientific discovery, and more fundamentally, the competitiveness of the U.S. economy. For the Argonne National Laboratory, this is no exception. The Office of Science is supportive of this work and although it is not addressed in any detail within the accompanying Five Year Plans, the Office of Science believes it is sufficiently important and appropriate to address within this strategic laboratory business plan. A brief perspective and financial outlook is therefore provided.

Argonne's non-DOE funded work engages both the Federal and private sectors and represents approximately 25% of the laboratory's total budget. The major ANL non-DOE federally funded activities are primarily supported by the Department of Homeland Security, focused on infrastructure assurance; the National Institutes of Health, emphasizing but not limited to protein characterization; the Department of Defense, covering a broad range of specialized technical (and often classified) assistance, infrastructure assurance, environmental assessments and nuclear-related issues; the Department of Agriculture, for hazardous waste assessments; the Department of State, in support of the International Atomic Energy Agency; and the Nuclear Regulatory Commission, providing a technical basis for regulatory decisions. It is anticipated that each of these areas will continue to grow. Also anticipated is that the Intelligence Community will become a key sponsor over the next

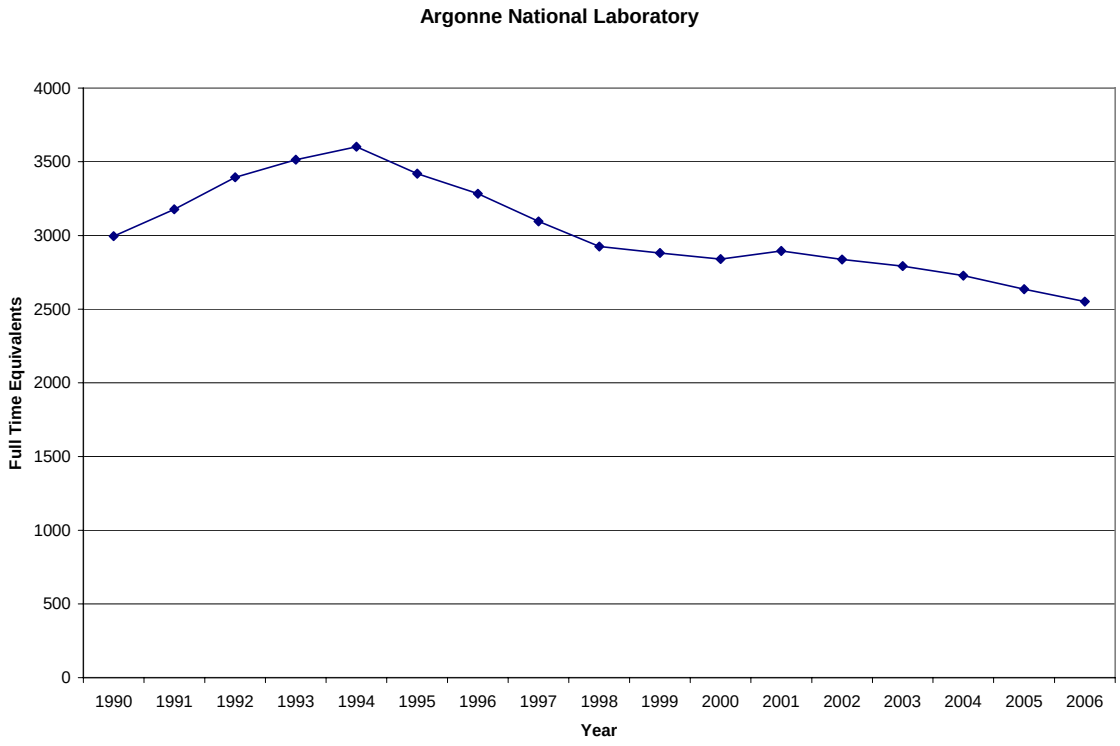
five years. Argonne's work for the private sector is varied and is typically a much smaller effort per project and of shorter duration than that for the Federal sector. Typical current work examples include locomotive engine combustion studies for GM Electromotive and EUV lithography support for Intel.

Uncertainties and Risk Management

External Factors: Over the next five years, ANL will have a number of concerns driven by external forces. ANL's future is directly coupled with Federal support for a broad science and technology program.

S&T Workforce: ANL's ability to recruit and retain scientific staff and maintain relationships with external partners (universities, other labs, private industry) is vital to its ability to maintain core science and technology programs. At the postdoctoral level, ANL has revamped its core program by making it more competitive and providing more fellowship positions. The Office of Science has requested that ANL, along with other laboratories, explore and/or expand such incentives as onsite daycare and flexiplace working arrangements to attract the best and brightest to replace its aging workforce and Argonne has accepted these specific recommendations and has undertaken additional activities mentioned in the following discussion of diversity.

Workforce Trends



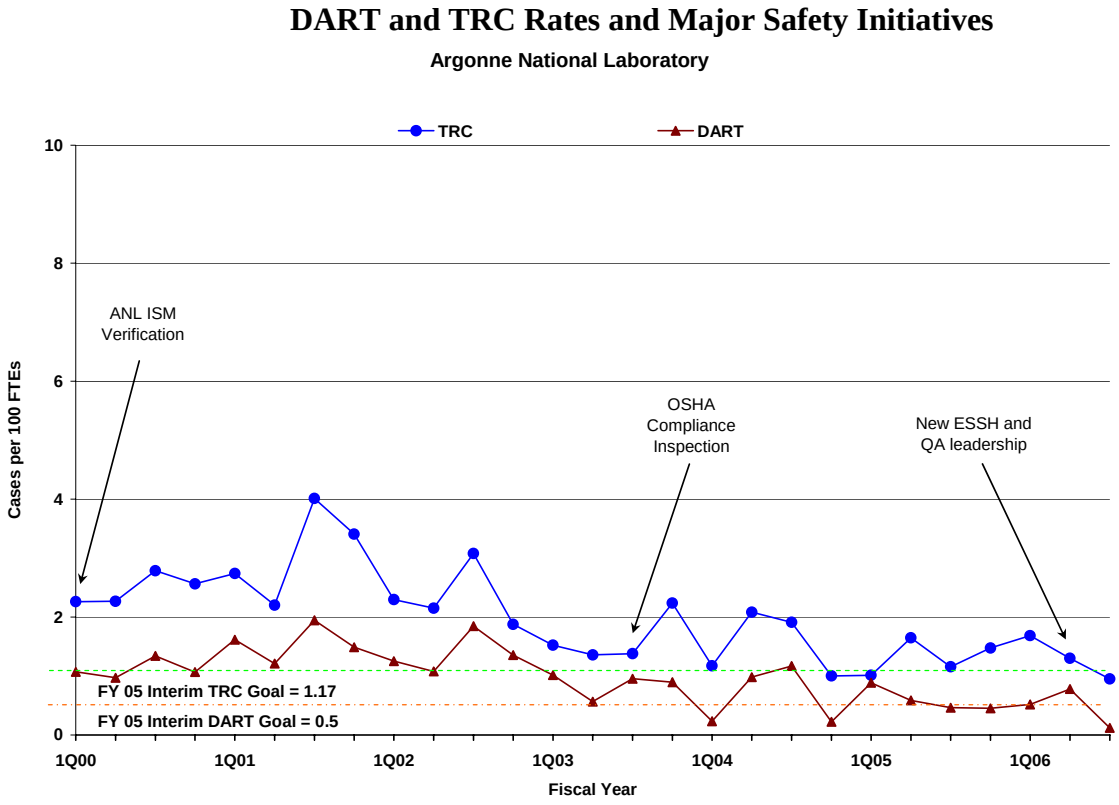
Workforce Diversity: As with most DOE labs, ANL must make significant progress in the recruitment and retention of under-represented populations. Developing a new strategy for attracting, developing and retaining world-class talent is a priority during FY 2007 as the laboratory tries new approaches to workforce planning. Particular attention is focused on improving and retaining

workforce diversity and strength by leveraging partnerships with regional universities and targeted professional societies to develop longer-term relationships; insisting on wide searches and qualified diverse candidates for each job posting; encouraging an inclusive culture through training and development opportunities; maximizing the value of employee affinity groups as laboratory resources; addressing exit issues critical to retaining a diverse workforce; and continuing effective educational outreach programs to maintain a diverse workforce development pipeline.

Safety: Argonne is continuing to improve its safety culture and performance. The laboratory is bolstering its environment, safety, and health efforts and its quality assurance efforts under newly placed leadership and through management-supported rigorous self-assessment activities. Under the new contract with UChicago Argonne LLC, Jacobs Engineering and BWXT will bring their "best practices" in safety to the lab. One of these best practices is the Jacobs behavior-based safety program. BWXT will bring its expertise to bear on improving the nuclear safety compliance program and will play a significant role in refining continuous-improvement processes that are now under way.

Immediate challenges facing Argonne include improved nuclear safety compliance; the advent of 10CFR851, Worker Safety and Health; and the revamping of the lab's quality assurance program. As part of its program to improve nuclear safety compliance, the lab has created a stand-alone nuclear operations division.

Argonne is committed to several short- and long-term goals intended to achieve and institutionalize safety and quality improvements, including ISO 14001 certification of the environmental management program and ISO 9001 certification of the laboratory's business systems. On a longer timeline is the lab's commitment to strive for DOE Voluntary Protection Program "Star" status for its safety and health programs.



Physical Infrastructure: ANL is located on a 1,500 acre federal reservation near Chicago, Illinois. Established in the late 1940s, it has 4.5M square feet of space in 99 buildings. Sixty percent of its space, as well as most of its utility systems and roads, are over 40 years old. ANL's Asset Utilization Index (AUI) is 0.96 for offices, 0.95 for laboratories and 0.98 for warehouses. The replacement plant value of ANL's general purpose facilities is $1.534B.

Maintenance, recapitalization, and modernization are supported both with overhead (for maintenance and Institutional General Plant Projects [IGPP]), operating, and GPP funds, and with line-item funding (for projects that cost $5M or more). ANL attained a maintenance investment index of 2.1% of replacement plant value (excellent) in FY 2006, which will be continued in FY 2007 and the out-years. ANL's deferred-maintenance (DM) backlog is $62.5M. The Asset Condition Index (ACI) is 0.96 for mission critical facilities (the DOE goal is 0.964 or above) and 0.96 for mission dependent facilities (the DOE goal is 0.948 or above). ACI is computed as 1 minus the result of deferred maintenance divided by replacement plant value. To reduce the DM backlog, thereby improving the ACI, ANL has initiated a deferred maintenance reduction effort with $1.982M of funding in FY 2008. The laboratory will begin funding $2M of IGPP in FY 2008 to address roofing needs.

The proposed FY 2008 funding for the cleanup and demolition of excess facilities is $469,000 to complete demolition of Building 40, Calibration Laboratory. While the Office of Environmental Management is currently funding the demolition of some excess facilities (e.g., Building 301 Hot Cells), ANL has a backlog of excess facilities with an estimated disposition cost of approximately $185 million, including many that were not built and operated by the Office of Science such as the Alpha Gamma Hot Cell Facility and Building 200 Hot Cells.

The FY 2008 GPP funding request is for $5.7M. Funding has been approved for one new $17M line-item project, Building Electrical Services Upgrade, Phase II, started in FY 2007. This project will upgrade critical portions of the electrical power distribution system in 18 multiprogram buildings and five support facilities, including the cooling towers that supply cooling water for site experiments. ANL's future recapitalization and modernization challenges include laboratory roofs, space modernization, roads/parking/lighting upgrades, fire safety improvements, and central heating plant upgrades, as well as the cleanup and demolition of numerous contaminated facilities. The laboratory is working to achieve the goals for energy reduction and use of renewable energy established in the Energy Policy Act of 2005.