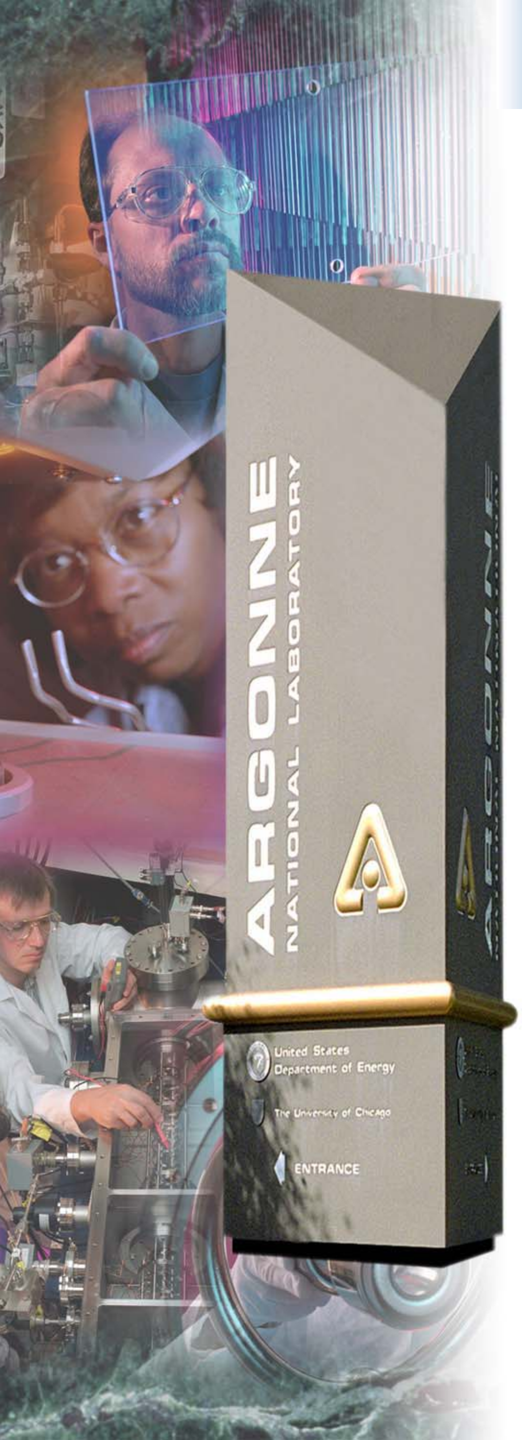
ARGONNE NATIONAL LABORATORY



The Role of the National Lab Today

Robert Rosner

Director, Argonne National Laboratory

and Professor of Physics and Astrophysics,

The University of Chicago

(Slightly modified version of a presentation to the Washington Science Policy Alliance Science and Technology Policy Seminar Series, January 10, 2006)

THE UNIVERSITY OF CHICAGO

Office of Science
U.S. DEPARTMENT OF ENERGY

Argonne National Laboratory is managed by
The University of Chicago for the U.S. Department of Energy

What I will discuss …

- The underlying "big question": How does the U.S. remain economically competitive in the global economy?
- The origins of National Labs
  - The "big questions" motivating the creation of the Labs
    - *Argonne as a case study*
    - *2006 marks Argonne's 60th year*
- Why National Labs in today's world?
    - *Are they the proverbial "hammer for which everything looks like a nail," or would they now have to be invented, had they not existed?*
      - Who needs the National Labs, and why?
      - What is/are their unique contribution(s)?

The 'Big Question': Retaining U.S. economic leadership in a highly competitive world

- The world is "flat": The "First World" has lost many of its competitive advantages
  - Agriculture: the 2nd and 3rd Worlds have caught up!
  - Raw material extraction: colonial extraction system is long gone
  - Industry has become globalized
- GDP growth is known to depend heavily on R&D
  - ~50% of last century's GDP growth is due to R&D
  - Present economy is "coasting on the results of the basic research completed 20+ years ago" (J. Friedman/MIT)

What does it take to compete?

- The "low road": push areas that cannot be outsourced. For example:
  - Services: hospitality industry (hotels, restaurants …), shops, construction, professions (law, medicine, …), safety …
  - Uniqueness of U.S.: tourism
- The "high road": push into areas of forefront technology where small timing advantages can translate into eventual large competitive advantages. For example:
  - Communications: Internet (software and hardware)
  - Non-commodity software: simulations
  - New industrial technologies: "green" technologies, new paradigms for energy production and transportation …

What are the obstacles?

- General U.S. scientific illiteracy and, at times, active antipathy to science
  – The classic image: Scientists as "geeks" or "Frankensteins," but fundamentally naïve innocents
  – Post-WWII to the moon landings: scientists as "heroes"
  – Vietnam war to present: scientists as Dr. Strangelove, originators of "Frankenfood," malevolent purveyors of dangerous technologies
  – Industry push for short-term results
  – Demise of the great industrial labs
  – Basic research as an activity done by others …
  – Increasing gap between research and development: "Valley of Death"
- Underinvestment in human capital
  – Insufficient investment in science education, esp. in physical sciences, and when compared to China, India, Korea …
  – Perceived antagonistic visa policies towards foreign science students and workers

The "Valley of Death"

Step 1: Basic Research

Stuff that no one who's serious would think has applications	Stuff that only visionaries would think has applications	Stuff that smart people think has applications	Stuff that everybody thinks has applications
? ↔	? ? ↔	? ? ↔	?

#1

Step 2: Pre-competitive Research & Development →

#2

Step 3: (Product) Development →

Step 4: Make and sell products

- **The reward system:**
  1. Publications/Presentations
  2. High risk, low profit
  3. Moderate risk, but profit
- **Choke point 1:** high risk/small rewards lead to very small exploit-exploitation rate of basic research ideas
- **Choke point 2:** lowered risk leads to higher rate of exploitation of new ideas

Note: Boundaries shown between the "Basic Research" categories are not hard and fast!

But first, some words about the origins of the National Lab system …

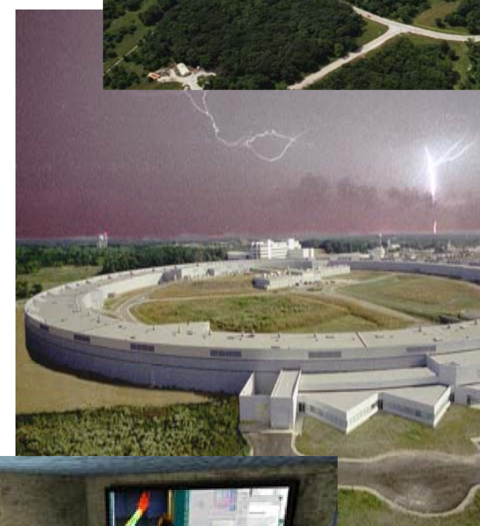
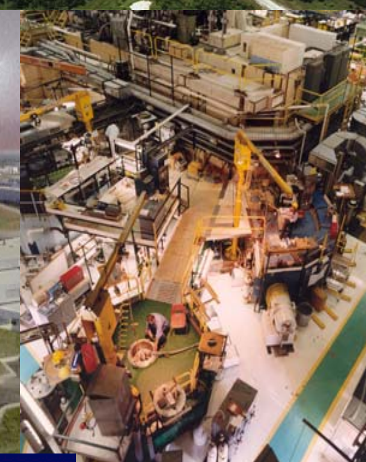
- National Labs emerged out of WWII weapons projects, viz.,
  - Manhattan Project: Ames, Argonne, Los Alamos, Oak Ridge
  - Radar: MIT Radiation Lab
- The impetus was the need for flexible, rapid-response research that

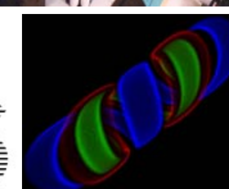
	Argonne Score Card
– Was directed	Fermi
– Was interdisciplinary	Yes!
– (Often) needed large research teams	Yes!
– Had access to first-rate academic scientists	Yes! (U of C)
– (Often) needed large, expensive (1-of-a-kind) facilities	Reactors

- These labs
  - Were a great success!
  - Ultimately justified their existence on the basis of national security

Consider Argonne today: What is it?

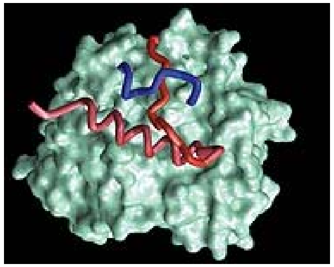
- Founded in 1943, designated a national laboratory in 1946 – our 60th!!
- Managed by The University of Chicago for the Department of Energy (DOE)
  - ~ 3,000 employees, 4,000 facility users
  - ~ $500M budget
  - 1,500-acre site in Illinois
- “Multi-purpose” Lab: Broad R&D portfolio
- Additional sponsors: NIH, DHS, …
- Not a weapons laboratory
  - Homeland security an important component, but NOT the dominant component of the Lab

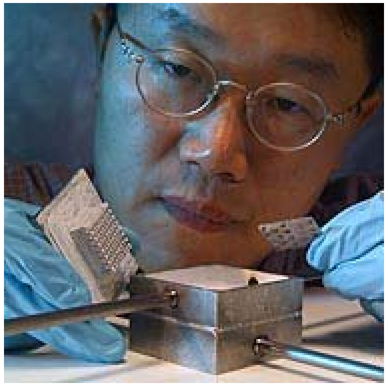






About Argonne: What is being done there?

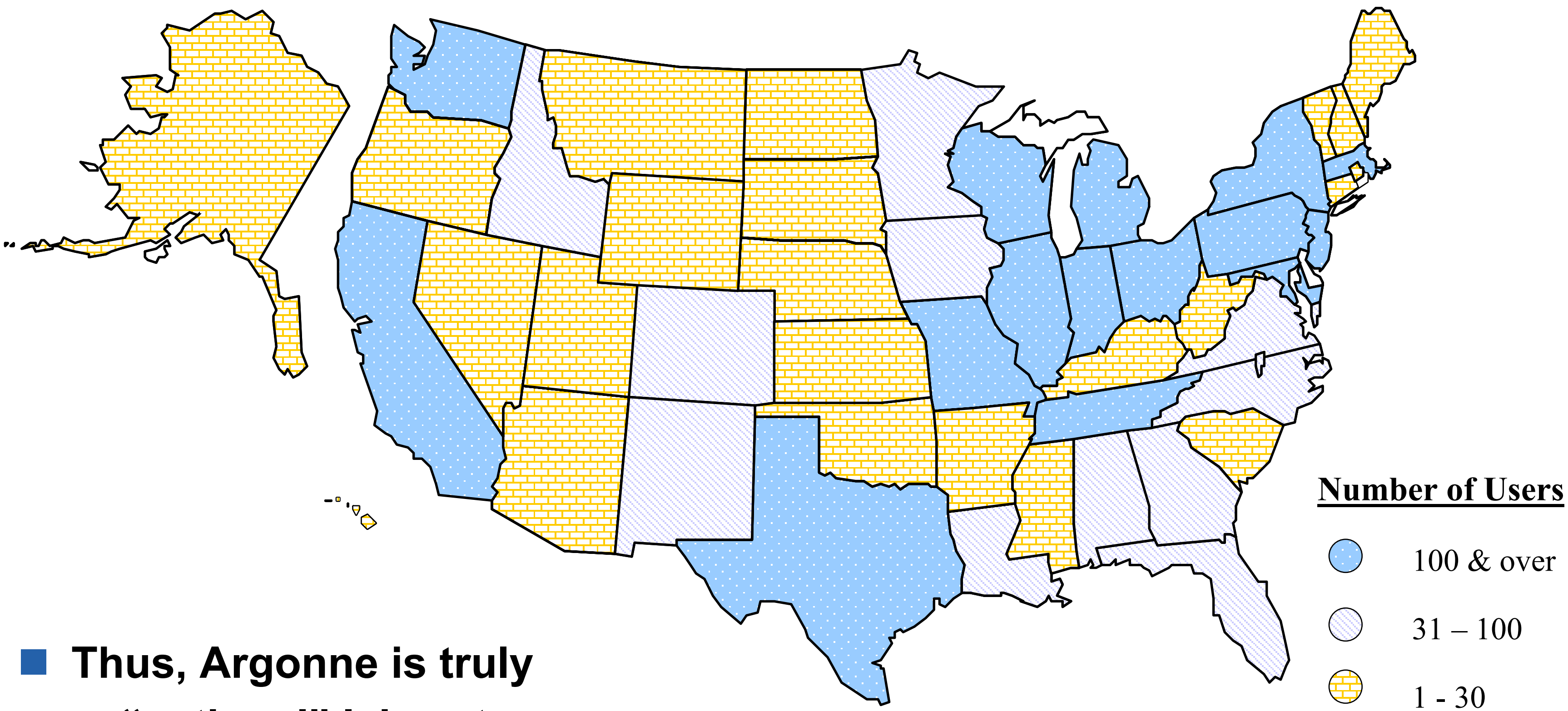
- Basic and applied research
  - Computer science, applied math, and computational science
  - Materials and chemical sciences and engineering
    - *Multidisciplinary nanoscience and nanotechnology*
  - Nuclear, high energy, and atomic physics
  - Structural biology, functional genomics, and bioinformatics
  - Environmental science, technology, and assessment
  - Transportation technology
  - Advanced energy science research
    - *Nuclear: Design, development, and evaluation of advanced nuclear energy systems; proliferation-resistant nuclear fuel-cycle technologies*
    - *Non-nuclear: Fuel cells; hydrogen generation …*
  - Homeland security: infrastructure risk assessment, sensors …
- Design, construction, and operation of accelerator-based user facilities
  - Advanced Photon Source (APS)
  - Intense Pulsed Neutron Source (IPNS)
  - Argonne Tandem-Linac Accelerator System (ATLAS)





Our theme: Basic sciences coupled with applied science & technology, with facilities as enabling cornerstones, all within the context of DOE's mission

About Argonne: where are the collaborators and users?



- **Thus, Argonne is truly a “national” laboratory**

… returning to the "Valley of Death" and our industrial competitiveness in the 21st Century ...

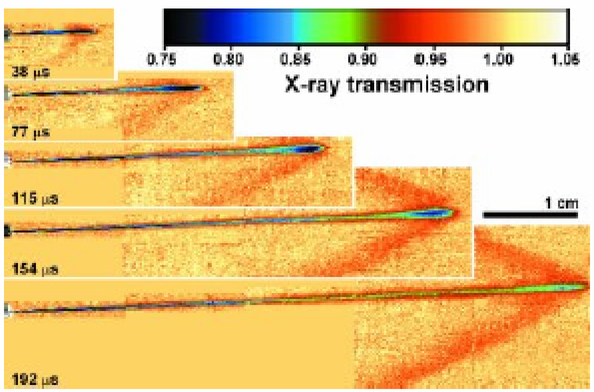
- The key question: As the industrial sector abandons basic research and focuses R&D (especially the "D") primarily on near-term objectives, who will carry out the "missing" basic research, and who will cross the "valley of death"?
- We can define what is needed: "Jeffersonian science" (G. Holton & G. Sonnert 1999)
  - "Use-inspired basic research" (D.E. Stokes)
  - A long-range vision for R&D
  - The capabilities for sustaining focused long-term research
  - Consistent funding
- We can see where National Labs can fit into this scheme
  - They can (and do) provide the rapid-response interdisciplinary research teams
  - They can (and do) capably manage large common research facilities for the scientific and technical communities
  - They have the 'ethos' to carry out research outside the 'publish or perish' paradigm
    - *For example: taking on projects that might be viewed as too risky for academia-driven 3-year grant renewal cycles*

What is it about National Labs that suit them so well for Jeffersonian Science?

- As a "line organization," a national lab is able to reconfigure its "departments" in response to particular research needs far more readily than typical research universities
- Unlike universities, the "reward system" is not necessarily all about publications
  - Labs have alternatives to "publish or perish"
- The ethos of completely free and open inquiry within academia is moderated within Labs by far more readily accepting proprietary research responsibilities from industry
- Relative consistency of federal funding for large facilities permits far more effective research infrastructure management
  - Large facilities can plan on 5- to 10-year basis
  - Researchers (=users) are liberated from the tyranny of constant scrambling after infrastructure support
- These considerations are all within DOE's charter, i.e., the Labs are then truly implementing DOE's broad mission

An example: Argonne's Transportation R&D Center

- **What are the main research targets?** (http://www.transportation.anl.gov)
  - Automobiles: advancing toward an environmentally benign passenger car, from fuel production through recycling of obsolete vehicles
  - Heavy Vehicles: safer, cleaner trucks, buses, and locomotives
  - Transportation Systems: improving traffic flow, safety, and security
- **What are some of the specific research areas?**
  - Batteries and fuel cells — Basic & applied science & chemistry
  - Engines, emissions control/combustion — Engineering, chemistry, **APS**
  - Materials & Manufacturing — Material sci., engineering, chemistry, **APS**
    - *Light-weight structural materials*
    - *Lightweight structural ceramics & composites*
    - *Low-friction, high-temperature tolerance*
  - Modeling & Computing
    - *Powertrain Systems Analysis Toolkit (w/ Ford, GM, and Daimler-Chrysler) for simulation of drive trains, from conventional to hybrid to fully electric*
    - *Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model*
    - *Systems-level assessments of transportation sector*



Shocks generated by diesel injector, using the 'x-ray transparent engine'

What is needed for success?

- National Labs cannot do it on their own
  - The academic and industrial communities are directly essential to the Labs' success
    - *Academia provides the feedstock of scientists and engineers*
    - *Academia is a great incubator of ideas: world's leading graduate education*
    - *Industry can provide the "pull": where do we want to go?*
  - The primary and secondary education communities must revitalize science education in the U.S.
    - *The U.S. needs a scientifically literate populace*
  - There needs to be a clear articulation of — and agreement on — what Labs can do that others can't do, or can't do as well
    - *The Labs' mission is to complement research activities in academia and in the private sector, and not to compete*
- The Federal agency sponsors can (and do, and should) foster collaborations between the Labs and other stakeholders
  - Primarily DOE, but also NIH, DHS, DOD, DOT, NSF, NASA, Commerce, Agriculture, EPA …

Summary …

- We are in a global battle to remain "healthy, wealthy, and wise"
- The National Laboratory system — which developed to serve national (military) defense needs — has evolved to serve national (economic) defense needs in a way that complements the academic and industrial research sectors
  – Capable of responsive interdisciplinary efforts unfettered by "publish-or-perish" constraints
  – Able to take the long view on technical issues of key economic importance to the nation
  – Capable of effectively sustaining large complex research facilities and operating them as national user facilities
- The key necessary ingredient is collaboration between the Labs, academia, and industry

Which brings us to ... Discussion