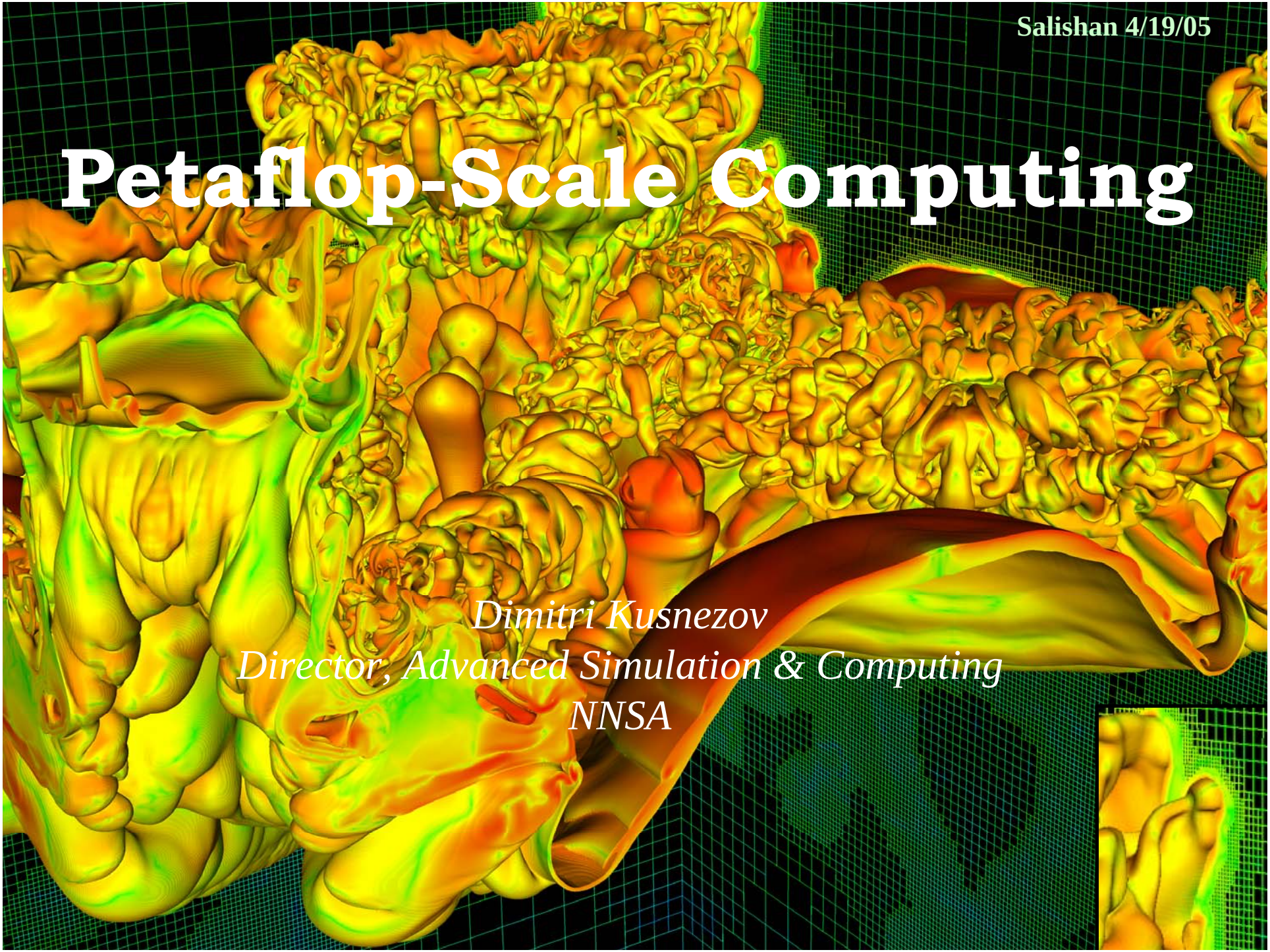
Salishan 4/19/05

Petaflop-Scale Computing

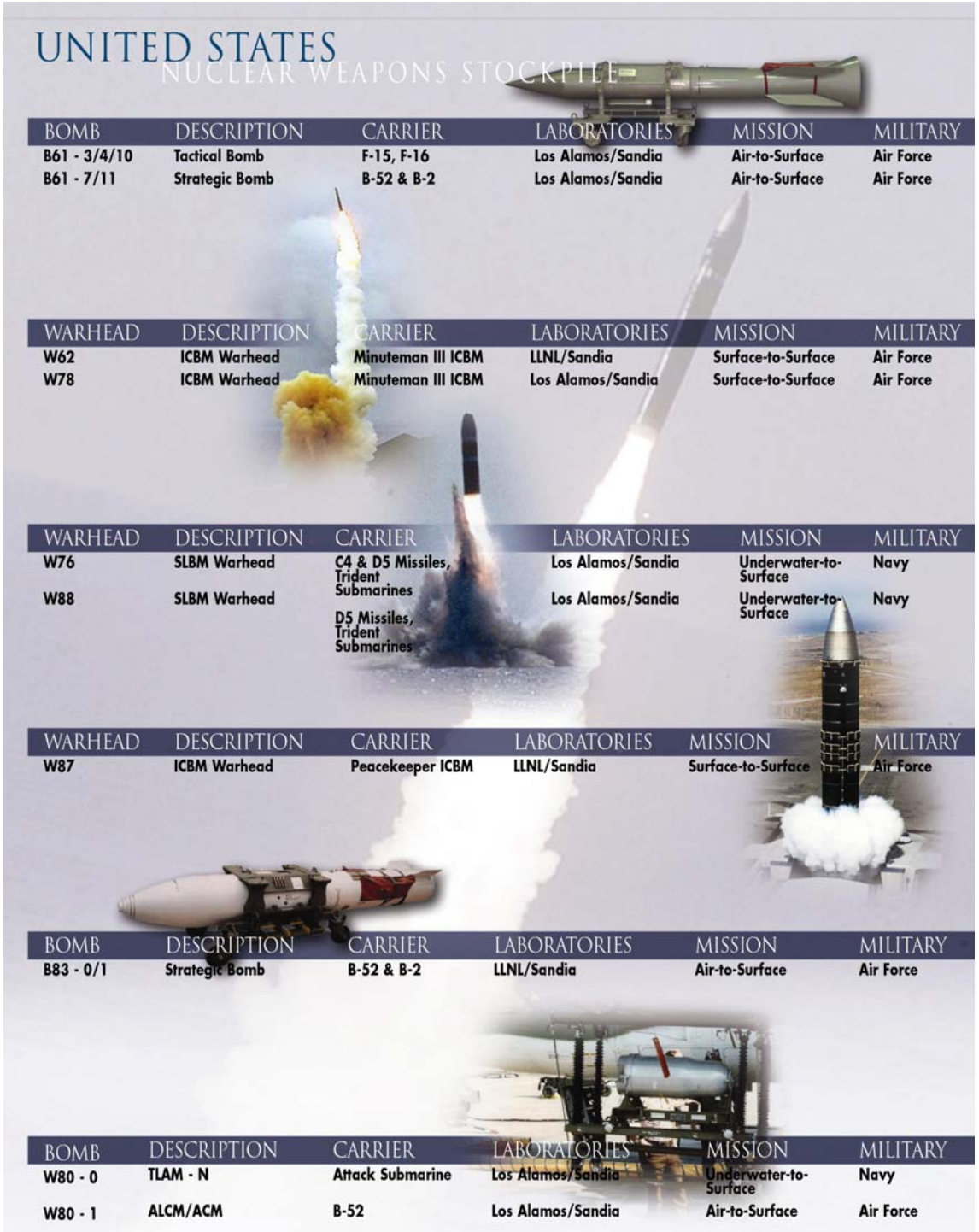


Dimitri Kusnezov
Director, Advanced Simulation & Computing
NNSA

Central Problem: *Replacement of underground testing with a rigorous scientific methodology with which to assess and maintain our confidence in our nuclear stockpile.*

Time Urgencies: *Supporting national policy with respect to the maintenance of our nuclear stockpile requires that we be able to certify annually to the Secretaries of the Departments of Energy and Defense that the stockpile is safe, reliable and secure.*

National Program: *Planned and coordinated across the three Defense Program Laboratories with partnerships with academic centers and industry.*



Our Motivation & Mission:

Provide the science-based capability to assess and certify the safety, performance and reliability of nuclear weapons and their components without nuclear testing

- Tools for annual certification & assessment
- Maintain a credible deterrent with a "zero-yield" nuclear test ban
- Support the President's Comprehensive Test Ban policy
- Ensure the effectiveness of science-based stockpile stewardship

Types of Issues:

- *As-built issues*
- *Aging issues*
- *Replacement of materials with those that are available or environmentally friendly*

Fiscal Restraint Setting In…

OCALLY OWNED SINCE 1896 | seattletimes.com

Bush's budget may be tough sell at Capitol

DEFICIT-REDUCTION PLAN GOES TO CONGRESS TODAY

Program cuts could be politically difficult

Seattle Times news services

WASHINGTON — When President Bush sends an austere budget to Capitol Hill today, it will be received by lawmakers worried about the record deficit and eager to rein in spending, but nervous about how they can eliminate federal programs without suffering serious political consequences.

And those are just the Republicans.

"I think members, especially Republican members, went home for the election and heard that people are quite upset that we are running up these deficits," said Sen. Judd Gregg, R-N.H., chairman of the Senate Budget Committee.

Nevertheless, few GOP lawmakers are optimistic about their ability to eliminate or substantially cut 150 domestic discretionary programs, a budget goal that Bush cited in his State of the Union address last week.

Bush's $2.5 trillion budget proposal would eliminate some funding for education, environmental protection and business development, while significantly increasing military and international spending, according to administration documents.

Overall, discretionary spending other than defense and homeland security would fall by nearly 1 percent, the first time in many years that funding for the major part of the budget

Please see > BUDGET, A8

MORNING FOG, then sunny. High 47, low 32. > LOCAL B8

The Seattle Times

25¢ King, Pierce and Snohomish counties and Bainbridge Island | 50¢ Island, Kitsap and Thurston counties 75¢ Elsewhere

INDEPENDENT AND LOCALLY OWNED SINCE 1896 | seatt

Bush: Freeze domestic spendin

The Washington Examiner

Capsule

$2.5 trillion budget leaves $390 billion gap

Agence France-Presse

WASHINGTON – President George W. Bush sent Congress a "lean" $2.5 trillion 2006 budget plan that would cut scores of domestic programs while boosting defense, with a projected deficit of $390 billion. The proposal, which ignited protests from opposition Democrats:

- would raise military spending 4.8 percent to $419.3 billion and add eight percent to the budget for Homeland Security, including fee-funded services.
- At the same time, non-defense spending not mandated by law, so-called discretionary spending, would be cut one percent. About 150 domestic programs deemed inefficient or unnecessary would be eliminated.
- The deficit for the fiscal year starting October 1 would be reduced to 390 billion, or three percent of gross domestic product from a projected $427 billion in the current year.
- The deficit would decline to $233 billion, or 1.5 percent of GDP, by fiscal 2009 under the outline, which aims to fulfill Bush's pledge to cut the deficit in half as a percentage of GDP.
- The plan assumes economic growth of 3.6 percent in 2005 and 3.5 percent in 2006, in line with

Doug Mills/NYT

President Bush conducts a Cabinet meeting on the federal budget Monday at the White House.

Budget proposal

What each agency would spend next year under President

Bush cuts budget to rein in deficit

Far-reaching fiscal fix would cut domestic programs, fund terror fight

BY DAVID STOUT
The New York Times

WASHINGTON – President Bush sent Congress a 2006 budget of just under $2.6 trillion Monday, laying out a politically ambitious blueprint for slashing many domestic programs while raising spending on the military and homeland security.

The president said his budget would further his goal of cutting the federal deficit in half, as a percentage of the gross domestic product, by 2009, while promoting prosperity and entrepreneurial principles. He said that it would do that while continuing to strengthen the military so that it could win "the global war on terror" and spread freedom around the world.

"In every program, and in every agency, we are measuring success not by good intentions, or by dollars spent, but rather by results achieved," Bush said in his budget

BUSH BUDGET SUMMARY

Associated Press

BUSH'S BUDGET: President Bush sent Congress a $2.57 trillion budget Monday that would boost spending on the military and homeland security but cut or restrain money across a wide swath of other programs.

DETAILS: The budget would reduce subsidies paid to farmers, cut health programs for poor people and veterans and trim spending on the environment and education. It leaves out future costs for the wars in Iraq and Afghanistan and does not include the billions of dollars that would be needed to overhaul Social Security.

OPPOSING SIDE: Democrats say Bush is resorting to draconian cuts that would hurt the needy in order to protect first-term tax cuts that primarily benefited the wealthy.

BUDGET TOTALS

- Receipts: $2.178 trillion.
- Outlays: $2.568 trillion.
- Deficit: $390 billion.

Plan could fuel rise in NW electricity ra

BY CHRISTOPHER SCHWARZEN
Seattle Times staff reporter

A federal budget plan to cut the na-

from the Bonneville Pow
tion that would go toward
The administration's

Bush budget calls for big cuts

Dems, some in GOP balk at $2.57T plan

By Judy Keen
USA TODAY

WASHINGTON – President Bush sent Congress on Monday what he called a "lean budget" for next year that in-

… and we will feel the consequences into the future

which aims to fulfill Bush's pledge to cut the deficit in half as a percentage of GDP.

■ The plan assumes economic growth of 3.6 percent in 2005 and 3.5 percent in 2006, in line with most private economists' forecasts.

■ Economists said the plan lacked key details about curbing the federal deficit. "Some efforts are made to restraint spending but it is clearly not enough to allow a significant improvement in fiscal deficit as tax cuts enacted in 2001 and 2003 will be extended," said Marie Pierre Ripert at Ixis Corporate and Investment Bank.

■ The plan sent to Congress is merely a blueprint of White House spending plans. A budget must be approved by Congress, which also would decide on specific funding plans each year.

■ Among the biggest cuts come in programs for housing (down 11.5 percent), agriculture (down 9.6 percent), transportation (down 6.7 percent) and justice (down 5.5 percent).

Democrats came out swinging immediately in response.

House Democratic leader Nancy Pelosi said the plan excludes many programs that will be sought by the administration – including an estimated $80 billion for Iraq and $4.5 trillion in coming years for reorganizing the Social Security retirement program.

"The president's budget is a hoax on the American people," Pelosi said.

Budget proposal

What each agency would spend next year under President Bush's budget proposal, compared with the current year. Figures are in billions of dollars.

Department	Current yr.	2006
Agriculture	94.6	94.9
Commerce	6.5	6.3
Defense-military	426.3	444.1
Defense-civil pros	44.5	43.5
Education	64.3	71.0
Energy	22.0	22.2
EPA	8.2	7.9
Health-Human Services	643.9	585.8
Homeland Security	33.3	33.3
Housing-Urban Dev.	40.2	42.6
Interior	9.8	9.4
International Asst	17.0	14.8
Judiciary	6.1	5.7
Justice	23.4	21.2
Labor	51.7	50.0
Legislative Branch	4.4	4.1
NASA	15.7	15.7
National Science Found.	5.7	5.6
Ofc. Personnel Mgmt.	64.3	61.0
Small Bus. Admin.	0.8	3.0
Social Security	583.5	559.0
State	14.1	11.9
Transportation	60.6	58.2
Treasury	52.9	56.5
Veterans Affairs	68.3	68.0
Other indep. agencies	22.6	19.7

Source: AP

Nick Shwaery/Examiner

…and spread freedom around the world.

In every program, and in every agency, we are measuring success not by good intentions, or by dollars spent, but rather by results achieved," Bush said in his budget message.

The president has already vowed to cut or eliminate entirely about 150 nonmilitary programs, including 48 in the Department of Education, that he says have become ineffective. The White House has estimated that this trimming and consolidation can save $20 billion a year.

But some politically popular programs are intact. For example, Head Start, the program for poor children that was begun under President Lyndon B. Johnson's "Great Society" vision, is to receive $6.9 billion, about the same as in the current budget.

Taken as a whole, the budget tome seems intended to slow the seemingly inexorable growth in government spending — something that President Ronald Reagan did not manage to do, his vows to the contrary.

Bush's spending plan, which has already sparked opposition on Capitol Hill as details have leaked out, is certain to be furiously debat-

cuts that primarily benefited the wealthy.

BUDGET TOTALS

■ Receipts: $2.178 trillion.

■ Outlays

■ Deficit

■ Discr…

$946 billion

■ Mand…

$1.41 trillion

■ Intere…

ed in the month… on strict party… nority leader, … Nevada, quickl… calling Bush's p… responsible an… in our nation's…

The budget… money to fina…

"In every program, and in every agency, we are measuring success not by good intentions, or by dollars spent, but rather by results achieved." –
President Bush

…er, sum will be… 2006 fiscal yea…

If the past is… budget for the… gins on Oct. 1 w… ent from the… sketched Mond…

Pentagon Scales Back Arms Plans

Current Needs Outweigh Advances in Technology

By Jonathan Weisman *and* Renae Merle
Washington Post Staff Writers

Rising war costs and a stubborn budget deficit have forced the Pentagon to propose billions of dollars in cuts to advanced weapons systems, as the military refocuses spending from its vision of a transformed fighting force to the more down-to-earth needs of its ground troops.

An internal defense budget document for fiscal 2006 shows a vivid shift of emphasis from procuring the weapons of the future to fighting the wars of the present, numerous defense analysts said yesterday. The Air Force and the Navy—once favored by Defense Secretary Donald H. Rumsfeld—would have to sacrifice some of their high-tech weapons development for the humble needs of the Army, such as tank treads and armor.

"The Air Force and the Navy are paying the bills to fix the Army's shortfall in resources," said Loren B. Thompson, defense industry analyst with the Lexington Institute.

The internal budget document, approved by Deputy Defense Secretary Paul D. Wolfowitz and leaked to reporters over the weekend,

See WEAPONS, *A4, Col. 1*

We expect an exciting spring and summer.

ASC

Today's Washington Landscape is Quite Contentious…

- Legislators are starting to see the national importance of high-end computing, but…
  - I believe that support is not universal because the rewards are not apparent
  - Investment is not appropriate: lifecycle costs typically are equivalent to cost of system – 150M system requires 150M support over its few years of life
- Lack of clear national commitments dilute message – it is not enough to promise great things…
- Many agencies have needs and desires, but there is no unified position that all agencies support. Everyone wants to lead

Some more reflections

- ASC has enjoyed sustained support for about 10 years. I believe that the acclaim we have generated is not unique to us – any agency with similar investment could likely field similar systems
- The unique strengths the national labs bring is their ability to push the science, by bringing diverse expertise together to focus long-term on a single common problem. *It is the scientific accomplishment that will define the success, not the size of the platforms.*
- We will have to ask the difficult questions on whether the investments have reaped the appropriate rewards – I don't believe in a "built it and they will come" approach. Science must be carefully coordinated with the lifecycle of the platforms
- Unlike Experimental and Theoretical sciences, Computational science starts out as a field which needs extensive coordination and long-term financial support and broad scientific cooperation.

Complex science has popular appeal, but maintaining a healthy industry seems problematic.

THE NEW YORK TIMES, TUESDAY, NOVEMBER 9, 2004

UBPOENAED ON NIGERIAN PAYMENTS

Company, the oil services company, has disclosed in a one of its joint ventures may have improperly paid win a multibillion-dollar contract. The company also es officials had issued subpoenas to current and for- llogg Brown & Root, its engineering and construction l in September that an internal investigation had of the TSKJ consortium, which it helps lead, may have igerian officials a decade ago. Nigeria is also investi- at the consortium paid as much as $180 million to se- ie TSKJ liquefied natural gas project. *(Reuters)*

. IS ASKED FOR DATA ON SALES INCENTIVES

Management Holding, the asset manager, said it had connection with undisclosed sales-incentive agree- e firms that sell its mutual funds. The Securities and on and the NASD have asked Alliance to provide infor- a company document filed with the commission. The gating programs in which mutual fund companies yments to brokers in exchange for preferential treat- d in December to settle federal and state complaints tain investors to make improper trades in its funds. *(Bloomberg News)*

LUDE CHUBB IN THEIR INSURANCE INQUIRIES

oration, a property and casualty insurer, said North

SAN FRANCISCO, Nov. 8 — A panel of leading computer scientists warned in a report issued on Monday that unless the federal government significantly increased support for advanced research on supercomputing, the United States would be unable to retain its lead on that technological front.

TECHNOLOGY

Panel Urges Washington To Finance Fast Computer

By JOHN MARKOFF

SAN FRANCISCO, Nov. 8 — A panel of leading computer scientists warned in a report issued on Monday that unless the federal government significantly increased support for advanced research on supercomputing, the United States would be unable to retain its lead on that technological front.

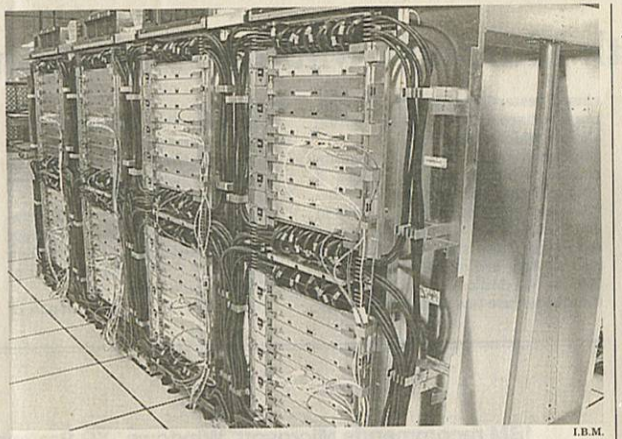
The panel of scientists, which was convened by the National Research Council, warned of a looming imbalance between hardware and software technology in high-performance computing.

"We are calling for a sustained and long-term investment to help develop advanced software and algorithms," said Steven Wallach, a computer designer at Chiaro Networks, a maker of an optical router for high-speed computing and a member of the panel.

The report, "Getting Up to Speed: The Future of Supercomputing," was based on an effort begun in 2002.

"Our situation has deteriorated during the past 10 years," said Susan L. Graham, a computer scientist at the University of California, Berkeley, who was co-chairwoman of the panel.

The authors of the report, which was prepared for the Energy Department, said they were recommending that the federal government spend $140 million annually on new super-



I.B.M.

The BlueGene/L supercomputer from I.B.M. is now ranked as the most powerful supercomputer in the world, passing Japan's Earth Simulator.

Scientists warn that the U.S. must triple spending to keep its supercomputing lead.

"If we don't start doing something about this now there will be nothing available in 10 years when we really need these systems, " Ms. Graham said.

Also on Monday, the BlueGene/L supercomputer from **I.B.M.** was placed first on a list of the world's 500 fastest computers in a ranking announced at a high-performance-computing conference in Pittsburgh. The ranking is issued twice each year. The I.B.M. machine, which is being installed at Lawrence Liver-

fices and the computer industry, has now fallen to third place in the current top 500 list. It is behind the I.B.M. system, which reported a computing speed of 70.72 trillion calculations per second, and a supercomputer designed by **Silicon Graphics** Inc. for the National Aeronautics and Space Administration, which last month reported that it had reached 51.87 trillion calculations per second. The Japanese system is rated at 35.8 trillion calculations a second.

The top 10 this year included the fourth-ranked I.B.M. cluster-style supercomputer that was recently installed at the Barcelona Supercomputer Center in Spain. A system designed from **Apple Computer** components that is installed at Virginia Tech in Blacksburg, Va., ranked eighth on the list.

Over all, the **Intel** Corporation con-

AOL's Chief Revamps It, With an Eye On Yahoo

By SAUL HANSELL

Jonathan F. Miller, the chief exec utive of America Online, unveiled broad reorganization that cement his power over the company and em phasizes his new strategy of takin on Yahoo as a free Web portal.

The reorganization creates thre new business units: content and ac vertising, Internet access and fe based services.

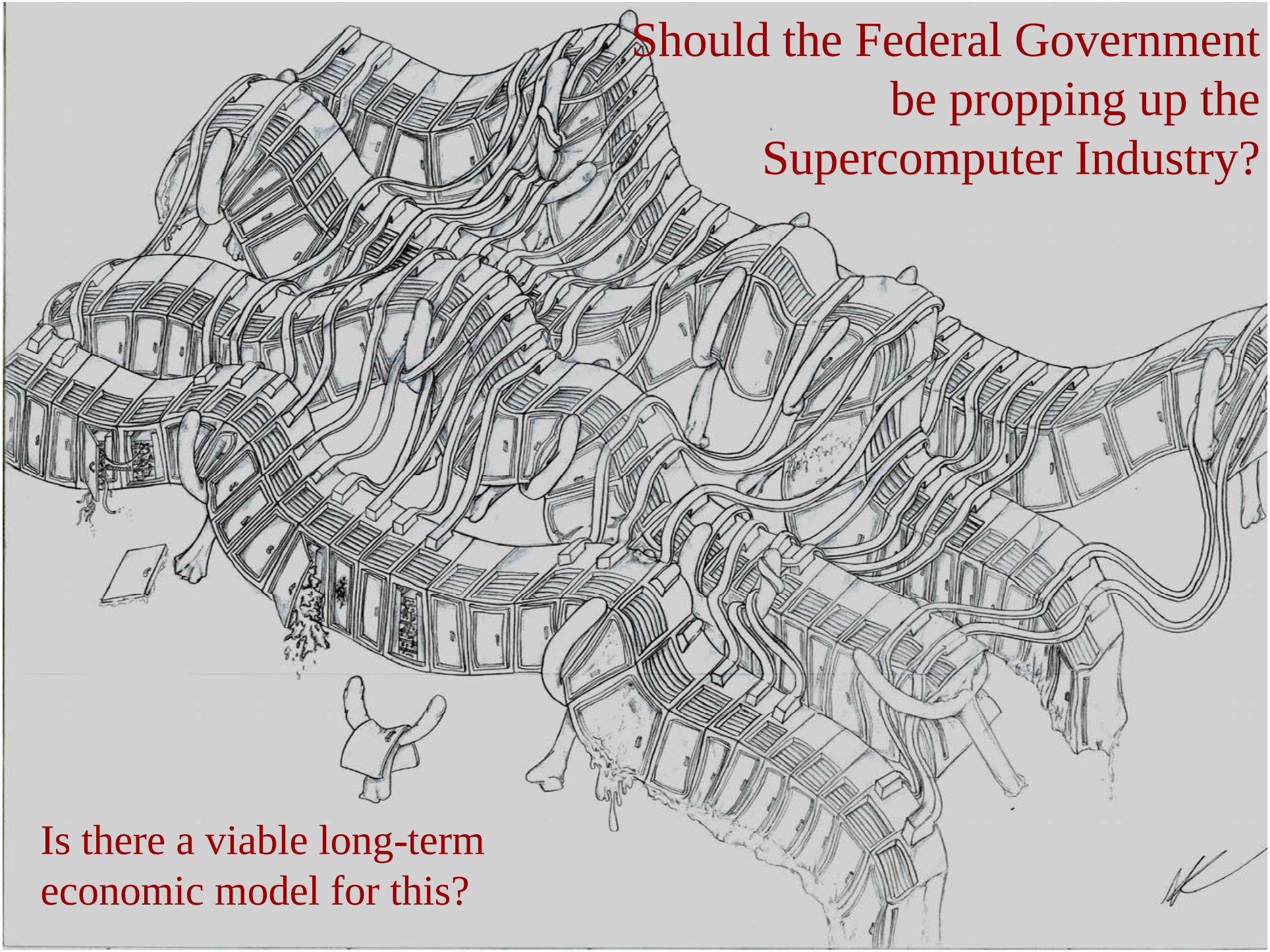
The Internet access group will b run by Neil Smit, who had been th head of the company's custome service unit. It will incorporat AOL's broadband unit, which ha been separate from its tradition dial-up business. The broadband un was run by Lisa Hook, who is leavin the company. She said in an inte view that she wanted a new cha lenge.

Mr. Miller said in an interview th it was no longer necessary to sep rate broadband service in marketin or in the structure of the company.

"We want to be a broadband con pany all the way through," he said.

The content and advertising un will be run by Theodore J. Leonsi who is also a vice chairman of AO It will handle the service offered AOL's paying members and M Miller's major new thrust: buildi AOL.com into a free Web site su ported by advertising. Mr. Leons will take on many of the responsib ities of J. Michael Kelly, who r

Problem: There is not a study that I am aware of that did not in the end recommend more Federal funding.


Should the Federal Government be propping up the Supercomputer Industry?
Is there a viable long-term economic model for this?

Why do we talk about 'Peak'?

Currently (from my point of view) it is somewhat of a 'catch-22' – recognized benchmarks are not reflective of our workload needs, yet they help support vendor needs for their product lines and will be made public

INDEX TO BUSINESSES

TECHNOLOGY

IBM Claims Fastest-Computer Tit

THE NEW YORK TIMES, WEDNESDAY, SEPTEMBER 29, 2004

I.B.M. Supercomputer Sets World Record for Speed

By JOHN MARKOFF

An I.B.M. machine has reclaimed the title of world's fastest supercomputer, overtaking a Japanese computer that had caused shock waves at United States government agencies when it set a computing speed record in 2002.

Supercomputing technologies were widely viewed as indicators of national industrial prowess in the 1980's and 1990's. They are used extensively in weapons design.

More recently, federal officials have become concerned that lagging investment in high-performance computing could leave the United States vulnerable to competition in industries ranging from biotechnology to materials science.

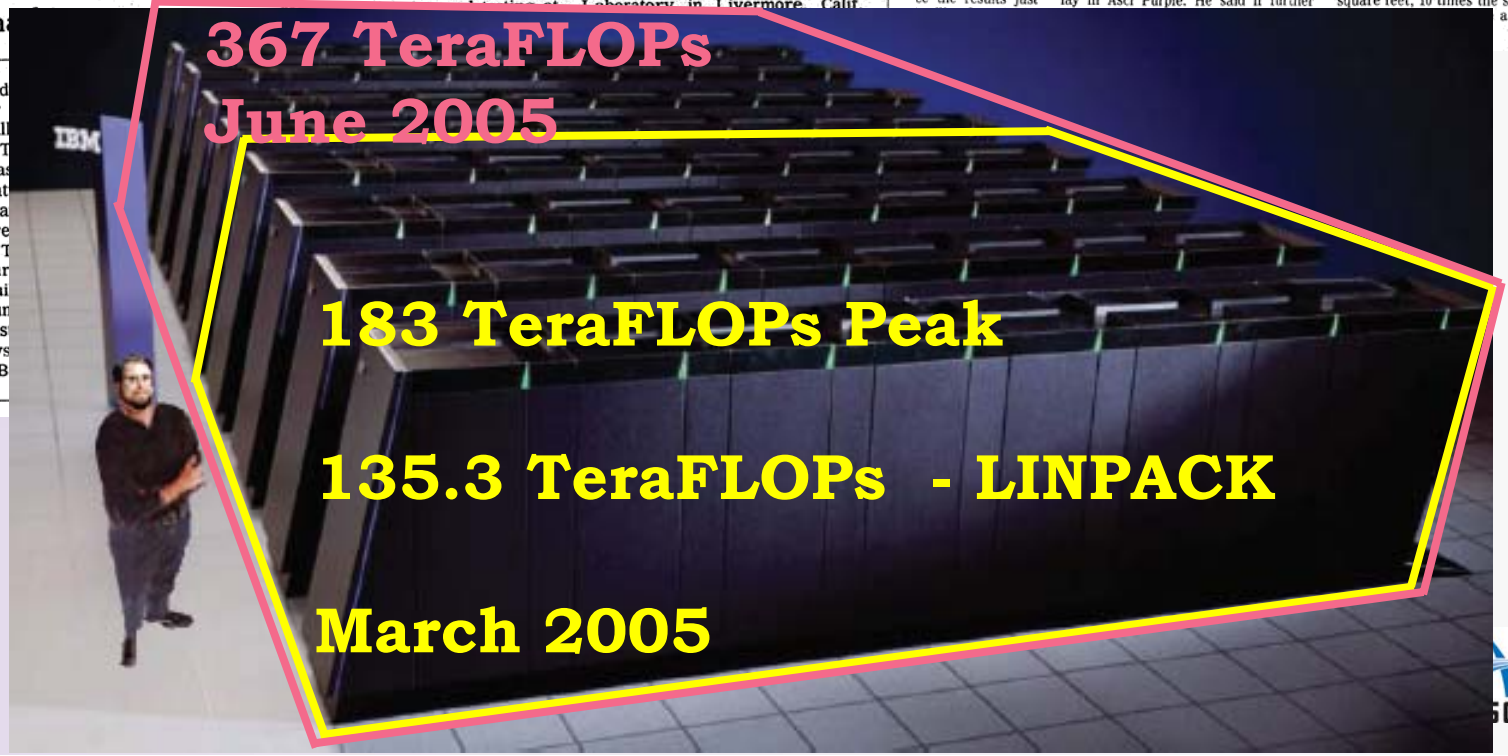
The International Business Machines computer is based on a computing technology, called BlueGene/L, that takes an approach

The fastest computer is only a prototype for a much larger

the Blue Gene/L system had attained a sustained performance of 36.01 trillion calculations per second, or teraflops, eclipsing the top mark of 35.86 teraflops reached in 2002 by the Earth Simulator in Yokohama. The new speed was

commercial applications, first in the petroleum and biotechnology industries, Mr. Turek said.

A large-capacity version of the BlueGene/L system is scheduled to be installed early next year at the Lawrence Livermore National



Shift in Programmatic Emphasis

ASCI Initiative

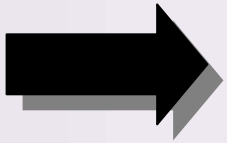
3D Scaling

Proof of Concept

Dependence on Legacy Codes

Test-experienced Designer
Decisions informed by legacy simulations

Rapidly changing development environments that push technology



ASC Program

Enhanced predictability through improved physics and numerics

Exploration of ever more demanding problem spaces

Greater trust and use of modern ASC codes

Expert judgment informed by simulations and 'QMU' methodologies

Robust, stable production environments with common interfaces

Future stockpile deliverables demand ASC capabilities

Informing Change:
Recent Program Review Findings

"The increasing size and complexity of new applications will require the continued evolution of supercomputing for the foreseeable future."

- NRC, The Future of Supercomputing, 2005

"Some excellent new science is beginning to emerge in association with ASC. Encourage the advance of Nuclear Weapons science at every opportunity in the Stockpile Stewardship Program and ASC programs."

- JASON, Requirements for ASCI, Oct 2003

Informing Change:
Recent Program Review Findings

A PetaFLOP will be needed before 2014, and physics will demand more in future years.

- JASON & Independent Review

Effective use of Capability computing depends on a fix for the Capacity computing over-subscription.

- JASON & Independent Review

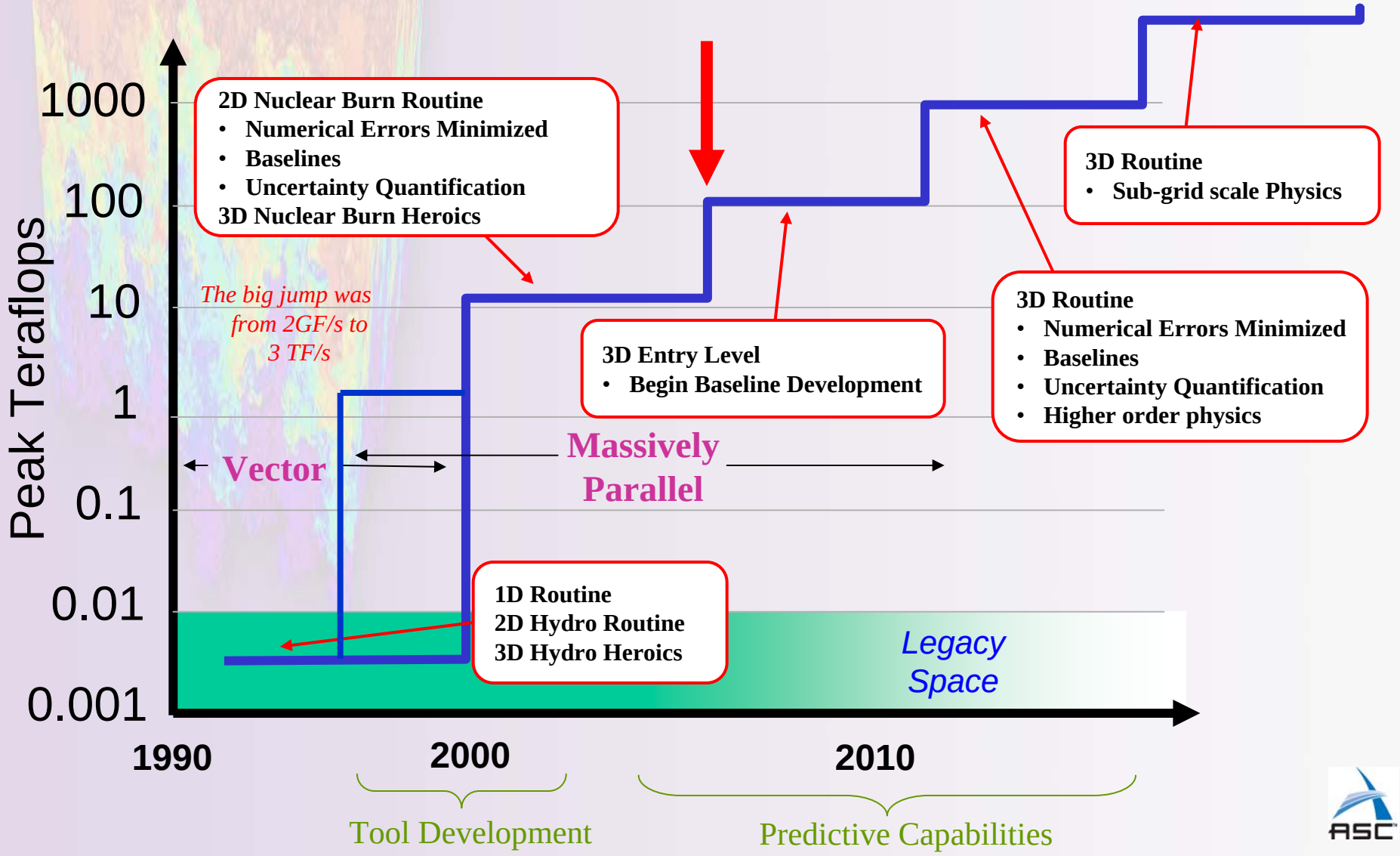
A single supercomputer architecture does not solve all problems equally well. New architectures should be explored to optimize computations.

- NRC & JASON

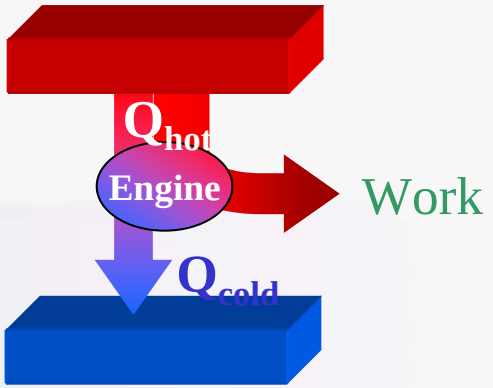
Mission requirements tempered by lessons learned are shaping our platform approach

Weapon Physics Simulations

Evolution of Dimensionality and Computational Science



Is there value is discussing *Efficiency*?



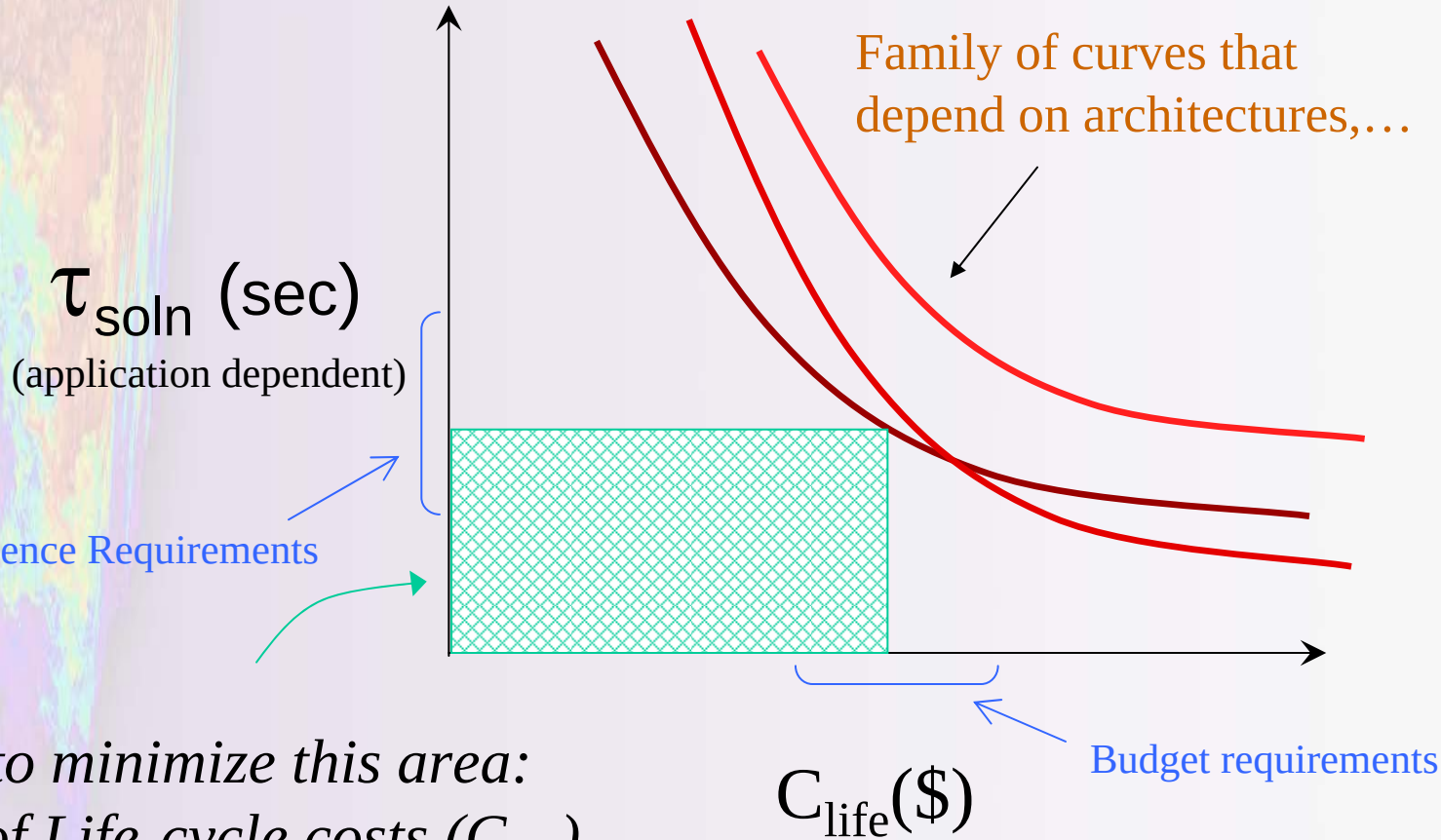
From thermodynamics: work delivered by an engine
energy supplied for its operation.

- Applications to engines is well defined and characterizes the maximum Work you obtain from a heat engine (steam, diesel, gas…)
- The value is that it is the best you can achieve under the constraints of physics: *the most efficient heat engine allowed by physical laws.*
- Real heat engines have lower efficiency than the ideal Carnot limit
- It is 'Universal' – nothing can do better – *not design dependent.*

It would be nice if a simple measure could guide our decisions and investments – but I am not aware of any. I do not believe this can readily translate to Supercomputers.

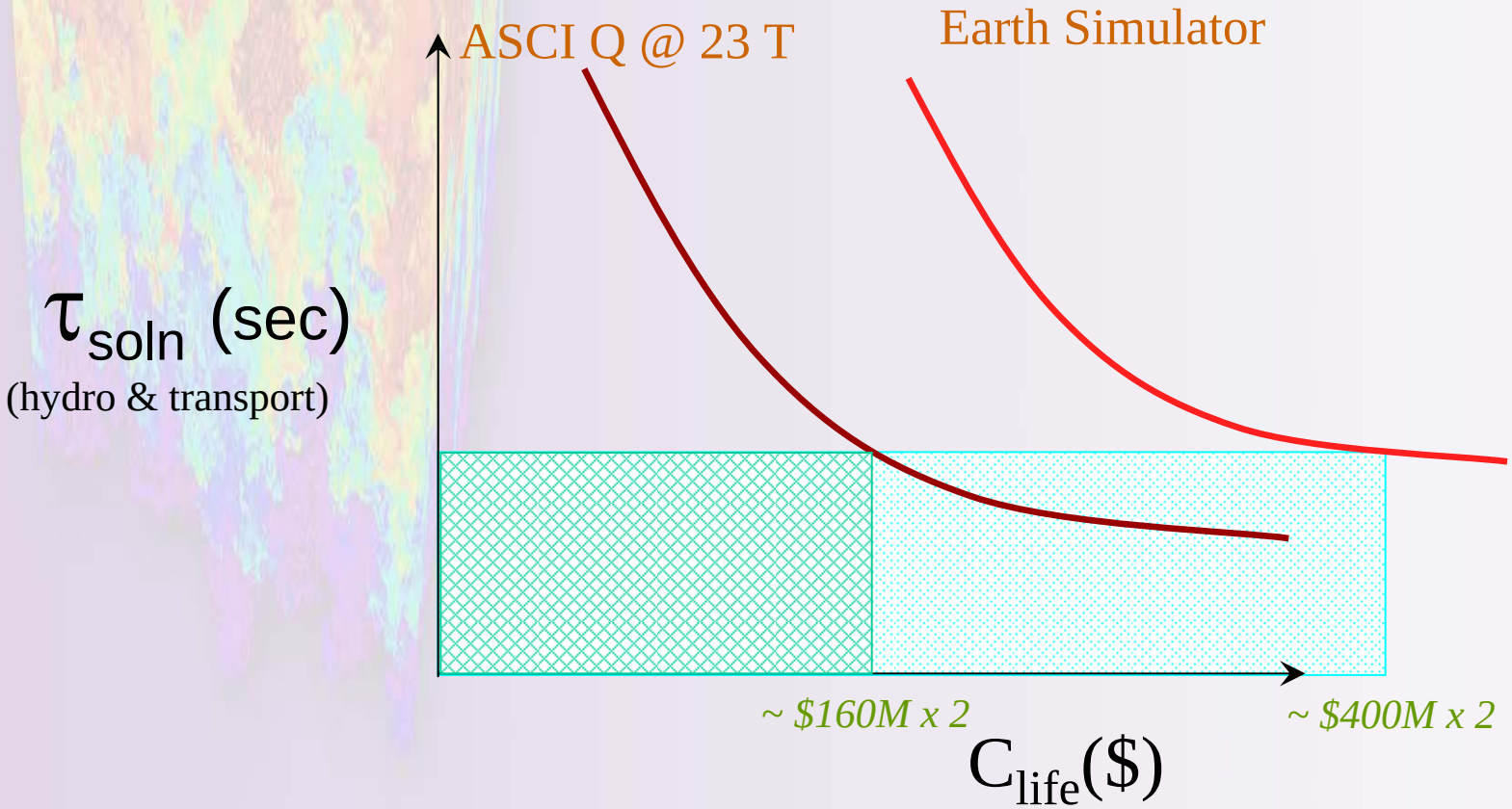
I believe one can construct counterexamples on how % Peak can be fooled – by adding superfluous code that increases % Peak while reducing the spirit of efficiency by increasing time-to-solution and 'work' done.

What would help us would be a relation of this type:



I would like to minimize this area: the product of Life-cycle costs (C_{life}) and Time-to-solution (τ_{soln})

Performance Modeling [PAL group at LANL] has suggested that for Hydro & Transport:



For readily vectorized and optimized problems on the ES (climate problems they study), the curves would be interchanged since a very large α-cluster would be needed to match time-to-solution.

Some Issues & Observations

- **Keep a focus on *Lifecycle Costs* – including footprint, power, software, maintenance, ...**
- **Productivity, including *time-to-solution* and ease of use**
- **Capability for code users rather than architectural capability**
- **Sufficient capacity to allow use as a capability tool**
- **Stable user environments (platforms, O/S, tools) for physicists and engineers**
- **Infrastructure (networks, storage systems, parallel file systems, viz) must scale with growing computing capability**
- **Focused investments in the 1 to 5 year timeframe can affect computer system design, but not the underlying semiconductor technology**

Power Estimates for PetaFLOP systems

2008:

- Intel processor based: 18-27 MW
- AMD processor based: 24-36 MW

2011:

- Intel processor based: 6-9 MW
- AMD processor based: 9-13 MW

(Estimates based on vendor roadmaps, caps on power/socket; including processors, disks and interconnect.)

Welcome comments on other possible solutions here.

Approximate sizes of some current obligations:

Purple – 4.8 MW
BG/L – 1.7 MW
Q – 3 MW
Red Storm – 2MW

With cooling, multiply by 1.5-2 !

A Possible Future for ASC…

A computational environment better balanced to our current programmatic needs:

- Growing user base is driving the need for Capacity clusters

- Long-term needs to maintain the nuclear testing moratorium drive us to improve the physics base of our understanding. This will drive Capability computing for pushing the envelope on integral, large-scale code calculations

- Emerging needs to address and understand focused scientific issues will require cost effective solutions on special architectures.

Most notable changes:

- capacity computing requirements will increase the time-interval between capability procurements
- capability systems will no longer be the largest possible to construct but will be based on productivity
- Special architectures will likely be optimized to attack specific physics issues

Capacity Systems

Cost-effective computers capable of running the majority of stockpile calculations not requiring the extreme performance characteristics of the Capability and specialized systems.

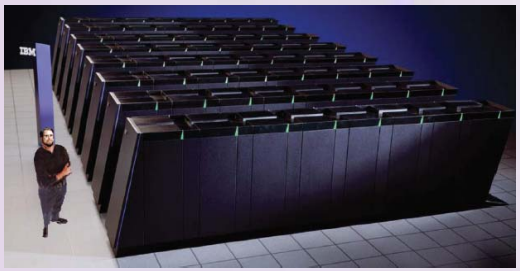
Capability Systems

Computers uniquely equipped to run integrated weapons performance codes at the higher end of memory and processor capabilities

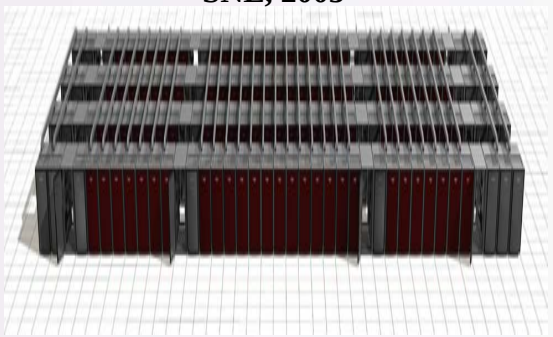
specialized systems

Cost-effective computers designed to achieve extreme speeds in addressing specific, stockpile-relevant issues

Blue Gene/L - IBM (180/360TF)
LLNL, 2005



Red Storm – Cray (40TF)
SNL, 2005



Attributes

Capacity Systems:

- Available for large volume, smaller size simulations
- Potential for common Tri-Lab procurement contracts
- A goal is to provide a common software environment for Tri-Lab applications
- Support Capability system runs

Capability Systems:

- Available for smaller numbers of large size simulations
- One major Capability system available at a time

specialized systems:

- Optimized to run specific applications at extreme scales highly effectively
- Could feed technology for future Capability and Capacity systems
- Support Capability system runs

The Need for Capacity Systems

- Results of a 2004 study of capacity computing requirements showed strong demands in the following areas:
  - Meeting Directed Stockpile Work commitments
  - Code development for modern codes
  - Baselining of modern codes against Underground Test data
  - Inertial Confinement Fusion experimental design and analysis
  - Nuclear Effects and survivability of devices in hostile environments and fratricide
  - Understanding the properties of materials

- 2004 Study did not account for Quantification of Margins & Uncertainty (QMU) workload
  - *Quantification of Margins and Uncertainty as a methodology is being developed and the attendant sensitivity studies are just now beginning*
  - *These sensitivity studies will stress current Workhorse systems and push demand up in the out years*

The Need for Capability Systems

- Physics “holy grails”
  - *High Explosives characteristics (>10x)*
  - *Boost (unknown)*
  - *Pu Equation of State (unknown)*
  - *Detailed case modeling (~ 6x)*
- Methods enhancements to codes increase run times
  - *Radiation transport (4x-7x)*
  - *Neutronics (strongly resolution dependent)*
  - *Hydrodynamic algorithms (computation time is strongly algorithm dependent)*
- Current Challenge systems are used to perform few simulations
  - *Calculations use significant processors*
  - *Required to be able to determine effects and importance of 3D effects*
    - Earlier efforts assumed 3D effects were minimal
    - As the stockpile continues to age, increasing number of 3D calculations become necessary

The Need for specialized systems

- Explore solution spaces for specific stockpile problems that prove intractable in current simulation environments
  - Physics “holy grails” and code methods provide potential candidates
- Disruptive Technologies with potential to
  - Greatly increase performance of simulation applications
  - Significantly reduce ownership costs
- Systems to sustain long-term capability vitality in science and engineering to support national security
- Higher risk than Capacity and Capability systems with higher potential productivity benefits

The Future

- *Predict with confidence* is our vision
- *Productivity* of our physics and engineering users is vital
  - *It's the science, not the computers*
- Our strategy is needs-based and depends on increasing high-end computing capabilities
  - *ASC has succeeded dramatically in growing the use and reliance on computational method in both science and engineering in the weapons program*
- No successful program is an island — success depends on success of the community
- Remain agile and ready to capitalize on scientific breakthroughs
  - *Rely on production computing, but, understand that disruptive technologies can lead to increased productivity*
- *So when petaflops?*