

# NAS/NAE/IOM/NRC Study

The Impact of Information Technology on  
the Future of the Research University





# Information Technology and the Future of the Research University

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**Premise:** Rapidly evolving information technology poses great challenges and opportunities to higher education in general and the research university in particular. Yet many of the key issues do not yet seem to be on the radar scope of either university leaders or federal research agencies.

# Phase One

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- Technology scanning (a decade out)
- Implications for the future of the research university
- Possible roles for federal government and other stakeholders

# ITFRU Guidance Committee

- James Duderstadt (Chair), President Emeritus, University of Michigan
- Daniel Atkins, Professor of Information and Computer Science, University of Michigan
- John Seely Brown, Chief Scientist, Xerox PARC
- Marye Anne Fox, Chancellor, North Carolina State University
- Ralph Gomory, President, Alfred P. Sloan Foundation
- Nils Hasselmo, President, Association of American Universities
- Paul Horn, Senior Vice President for Research, IBM
- Shirley Ann Jackson, President, Rensselaer Polytechnic Institute
- Frank Rhodes, President Emeritus, Cornell University
- Marshall Smith, Professor of Education, Stanford; Program Officer, Hewlett Foundation
- Lee Sproull, Professor of Business Administration, NYU
- Doug Van Houweling, President and CEO, UCAIC/Internet2
- Robert Weisbuch, President, Woodrow Wilson National Fellowship Foundation
- William Wulf, President, National Academy of Engineering
- Joe B. Wyatt, Chancellor Emeritus, Vanderbilt University
- Raymond E. Fornes (Study staff), Professor of Physics, North Carolina State University

# ITFRU Activities

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- 2/14/2000: Meeting of ITFRU Steering Committee, NAS, DC
- 5/5/2000: Meeting of ITFRU Steering Committee, Sloan Foundation, NY
- 6/9/2000: ITFRU Members testify before House Science Committee, DC
- 8/24/2000: ITFRU Field Trip, Bell Labs and IBM Labs
- 1/23/2001: Summit Workshop, NAS, DC

## ITFRU Activities (Continued)

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- 3/1/2001: Research Channel begins broadcasts of January 2001 workshop
- 6/19/2001: ITFRU Members facilitate discussion of GUIRR, NAS, DC
- Late 2001-2002: Drafting, revision, and report review of Steering Committee Report, NAS, DC
- 11/7/02: Release of "Preparing for the Revolution", NAS, DC

# Phase 1: Conclusions

- There was a consensus that **the extraordinary evolutionary pace of information technology is likely to continue for the next several decades** and even could accelerate on a superexponential slope.
- The event horizons for disruptive change are moving ever closer. There are **likely to be major technology surprises**, comparable in significance to the appearance of the personal computer in the 1970s and the Internet browser in 1994, but at more frequent intervals. The future is becoming less certain.



## Conclusions (continued)

- The **impact of information technology on the university will likely be profound, rapid, and discontinuous**—just as it has been and will continue to be for the economy, our society, and our social institutions (e.g., corporations, governments, and learning institutions)
- It will affect our **activities** (teaching, research, outreach), our **organization** (academic structure, faculty culture, financing and management), and the broader higher education **enterprise** as it evolves into a global knowledge and learning industry.
- Information technology is a **disruptive technology** in higher education that requires strategic attention.

## Conclusions (continued)

- Yet, **for at least the near term**, meaning a decade or less, **the university will continue to exist in much its present form**, although meeting the challenge of emerging competitors in the marketplace will demand significant changes in how we teach, how we conduct scholarship, and how our institutions are financed.
- Universities must anticipate these forces, develop appropriate strategies, and make adequate investments if they are to prosper during this period.
- **Procrastination and inaction are the most dangerous courses of all during a time of rapid technological change.**

## Conclusions (continued)

- Because of the profound yet unpredictable impact of this technology, it is important that institutional strategies include:
  - ★the opportunity for **experimentation**,
  - ★the formation of **alliances** both with other academic institutions as well as with for-profit and government organizations, and
  - ★the development of sufficient **in-house expertise** among the faculty and staff to track technological trends and assess various courses of action.



**PREPARING FOR THE  
REVOLUTION**

**Information Technology  
and the Future of the  
Research University**

NATIONAL RESEARCH COUNCIL  
OF THE NATIONAL ACADEMIES

# Phase Two: The IT Forum



# IT Forum

- James Duderstadt, President Emeritus, University of Michigan (Forum chair)
- Daniel Atkins, Professor, School of Information, University of Michigan
- John Seely Brown, Chief Scientist, Xerox Corp.
- Jared Cohon, President, Carnegie Mellon University
- Stuart Feldman, Vice President, Internet Technology, IBM
- Nils Hasselmo, President, Association of American Universities
- Brian Hawkins, President, EDUCAUSE
- Shirley Ann Jackson, President, Rensselaer Polytechnic Institute
- Sidney Karin, Professor of Computer Science and Engineering, University of California, San Diego
- Kevin Kelly, Editor-at-Large, *Wired*
- Shirley Strum Kenny, President, Stony Brook University
- Susanne Lohmann, Director, Center for Governance, University of California, Los Angeles
- Anne Margulies, Executive Director, OpenCourseWare, Massachusetts Institute of Technology
- Michael McRobbie, Chief Information Officer, Indiana University
- Diana Oblinger, Vice President, EDUCAUSE
- James O'Donnell, Provost, Georgetown University
- Marshall Smith, Professor, School of Education, Stanford University, and Program Officer for Education, Hewlett Foundation
- Lee Sproull, Professor, Stern School of Management, New York University
- Doug Van Houweling, CEO, University Corporation for Advanced Internet Development
- Robert Weisbuch, President, Woodrow Wilson National Fellowship Foundation
- Wm. A. Wulf, President, National Academy of Engineering (Program chair)

# IT Forum Activities

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- 11/7/2002: IT Forum Meeting, NAS, DC
- 2/25/2003: IT Forum Meeting, NAS, DC
- 4/15/2003: AAU Presidents' Workshop, DC
- 9/3/2003: Carnegie Mellon University, Pittsburgh
- 9/6/2003: AAU Provosts' Workshop, Irvine
- 11/1/2003: NSF Leadership Tutorial, DC
- 3/11/2004: Institute for Creative Technologies, LA
- 9/1/2004: Exec Wkshp, MIT-CMU-Cornell, MIT

## IT Forum Activities (continued)

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- 10/20/04: Keynote, Educause, Denver
- 11/11/04: IT Forum Meeting, Ann Arbor
- 1/24/05: Exec Wkshp: UNC-NCSU-Duke-GT, MU
- 3/21/05: Exec Wkshp: UT, TAMU, UA, ASU, Rice
- 4/24/05: Exec Wkshp: USC, UCLA, UCSD, UCSB, UCI
- 6/1/05: IT Forum Meeting, NAS, DC





## Association of American Universities

1200 New York Avenue, NW, Suite 550 Washington, DC 20005 202.408.7500

*An association of 62 leading research universities in the United States and Canada*

### AAU Issues

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Founded in 1900 to advance the international standing of US research universities, the Association of American Universities (AAU) today focuses on issues that are important to research-intensive universities, such as funding for research, research policy issues, and graduate and undergraduate education.

### *what's new*

May 15, 2004

### NASULGC/AAU Homeland Security Resources

- ▶ CFR Weekly Wrap-up - [pdf](#) - May 14, 2004
- ▶ [Congressional Events Schedule](#) - May 14, 2004
- ▶ Presentation by Neal Sullivan on Defense Basic Research - [pdf](#) - May 6, 2004
- ▶ Press Release on Community Visa Recommendations - [pdf](#) - May 12, 2004
- ▶ Community Recommendations on Visa Policies - [pdf](#) - May 12, 2004
- ▶ AAU Letter Endorsing H.R. 107 on Digital Copyright Law - [pdf](#) - May 10, 2004
- ▶ AAU Summary of H.R. 4283 - [pdf](#) - May 10, 2004
- ▶ Presentation by Claude Canizares on Defense Basic Research - [pdf](#) - May 6, 2004
- ▶ "Visas 101"-Presentation by Peter Briggs - [pdf](#) - May 5, 2004
- ▶ Flowchart on Visa Application Process - [pdf](#) - May 13, 2004
- ▶ Visa Policies - Presentation by Kathie Bailey Mathae and Mary Malaspina - [pdf](#) - May 5, 2004

# AAU Presidents' Summit

- First, the 2x4 (Lou Gerstner)
- Panel 1: Today's Issues
  - \* ("And, oh, by the way, everything is under control ...")
- Discussion 2: Tomorrow's Challenges
  - \* ("But have you thought about ...")
- Discussion 3: Where do you need help?

# Looking at the In-Out Box

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- How do we meet the demand for IT?
- How do we pay for it?
- What about security and privacy issues?
- (We just delegate these issues to our CIOs to handle, and they tell assure us that everything is under control ...)

## But what happens if ...?

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- Someone hands you a device the size of a football containing the entire Library of Congress ...?
- Your faculty members become nomads in cyberspace with the rapid evolution of “cyberinfrastructure” as a functionally complete environment for scholarship and scholarly communities ...?
- What if students use IT to take control of their learning environments?

## And what about ...?

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- The “technological” generation gap among students and faculty?
- The disruptive force of the marketplace brought onto the campus by IT?
- The disaggregation (disintegration) and reaggregation of functions and roles?

## Wait a second ...?

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- How can presidents possibly provide leadership with the future so uncertain?
- We need help!!!
- At last some progress: From denial to acceptance to seeking help ...



## Next, the AAU provosts

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- What bothers you today?
- What do you see coming down the road?
- What are you going to do about it?
- How can we help?



# The Near Term

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- Network and bandwidth management
- How do we pay for this technology?
- How do we protect security and privacy?
- Data management and preservation issues

# The Longer Term

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- The digital generation
- Cyberinfrastructure
- Competition vs. cooperation
- Instability of university paradigm
- Survival of research university
  - \* (At least as we know it today)
  - \* (A subject that NO university president would allow on the table!!!)

# The Longer Term

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Carnegie Mellon  
5000 Forbes Ave.  
Pittsburgh, PA 15213  
(412) 268-2000

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## Keynote Speaker

L'Oréal Executive and Carnegie Mellon alumna and trustee Candace Sheffield Matthews will be the featured speaker at commencement, May 16.

[More...](#)



## Honorary Doctorates

C.D. Mote Jr., William D. Ruckelshaus and Richard A. Tapia (l-r) will receive honorary degrees for their contributions in science, technology and public policy.

[More...](#)

  
**DIVERSITY  
RESOURCE GUIDE**

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Commencement  
**2004**  


# IT Forum - Carnegie Mellon

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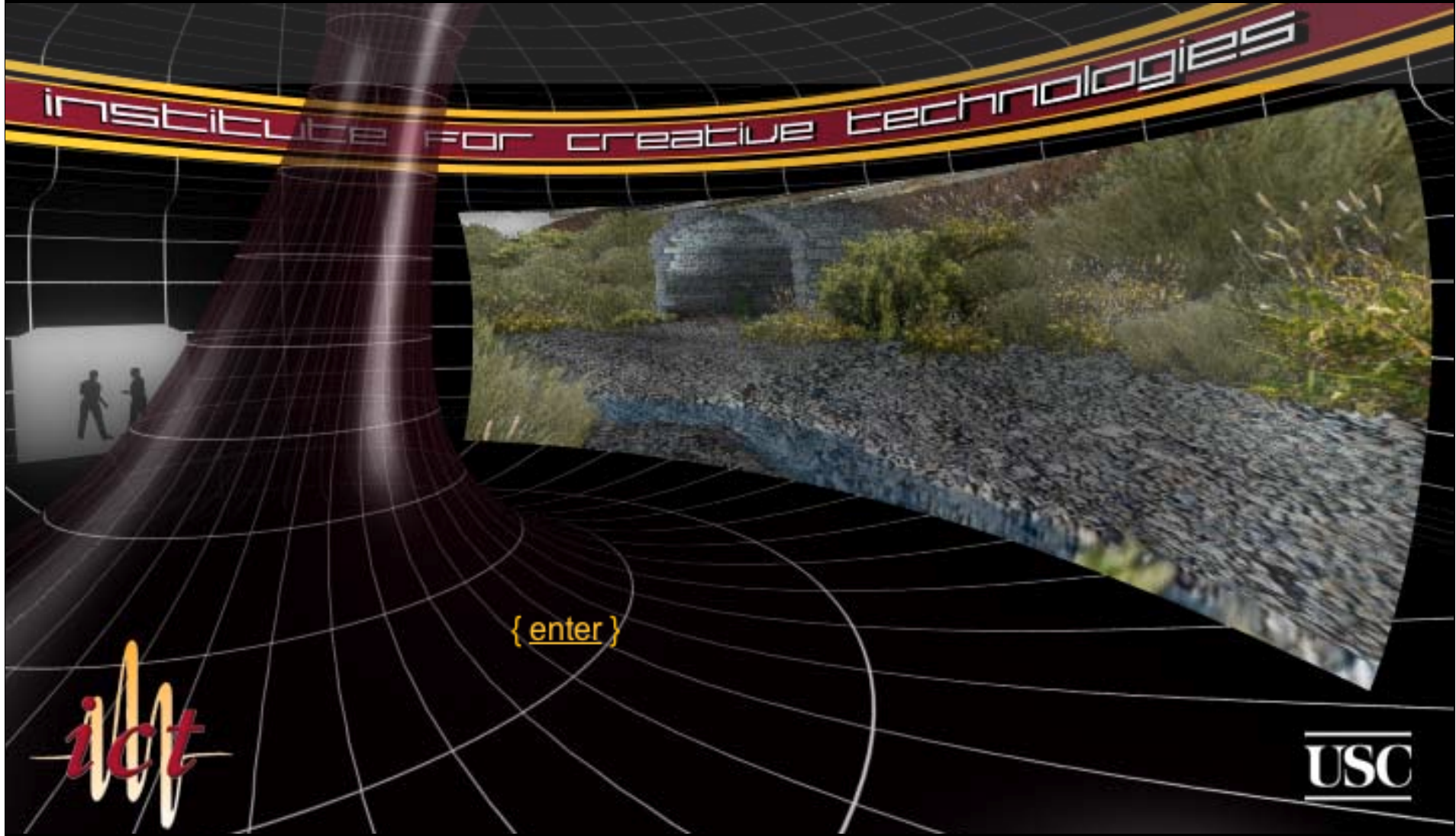
- Today's students are "electrified"; they are a transformative force.
- Example: instant messaging, Wiki's, Blog's, always on-always connected
- Peer-to-peer learning
- Faculty has concluded that best approach is to turn the kids loose, letting them define their own learning environments.

# Some Learning Characteristics of the Digital Generation\*

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- Multiprocessing
- Multimedia literacy
- Knowledge navigators
- Discovery-based learning that merges with play
- Bricolage
- A bias toward action

\*John Seely Brown, Xerox PARC



institute for creative technologies

{ enter }

ict

USC

# Institute for Creative Technologies

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- Goal: Use Hollywood and gaming technologies to build the Army a “holodeck”
- How can technology be used to create an emotional connection between knowledge and learning?
- Can you improve learning and decision making using virtual environments





## Advanced Leadership Training Simulation

[printer friendly version](#)



USC / Paramount Pictures  
soldiers in the field, and text-based intelligence reports, among others.

The Advanced Leadership Training Simulation project explored the role of storytelling for training teams of US Army soldiers for crisis management and leadership skills.

ALTSIM participants assumed various roles in an US Army tactical operations center, working as a team to address situations that were presented to the team through a web-based interface. ALTSIM presented these situations using media of high production value, including graphical maps, video-based news broadcast feeds, audio-based radio communications from soldiers in the field, and text-based intelligence reports, among others.



The ALTSIM project was a partnership between the Institute for Creative Technologies and Paramount Pictures. The research focus of the ALTSIM project was on the creation of highly interactive storylines for use in training applications. A central problem in the field of interactive drama is to enable a high degree of interactivity in virtual environments while preserving a degree level of narrative control necessary to achieve both pedagogical and entertainment goals. The solution explored in the ALTSIM project, called Experience Management, was to formally represent pre-authored storylines as a description of the expected user experience, and then employ storyline adaptation strategies to move the experience back on track in the face of unexpected user behavior.

The ALTSIM project ended in March of 2003, and led to the start of the ongoing

"Leaders" project at ICT.

Research reports:

 Gordon, Andrew S. and Ippa, Nicholas V. (2003) [Experience Management Using Storyline Adaptation Strategies](#), [Proceedings of the First International Conference on Technologies for Digital Storytelling and Entertainment](#), Darmstadt, Germany, March 24-26, 2003.





## FlatWorld: The Mixed Reality Simulation Space

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The FlatWorld project is a mixed reality simulation environment merging cinematic stagecraft techniques with immersive media technology. FlatWorld is a joint effort between the University of Southern California's [Institute for Creative Technologies \(ICT\)](#) and [Integrated Media Systems Center \(IMSC\)](#).

Current virtual environments have severe limitations that have restricted their use. For example, users are often required to wear bulky head mounted displays that restrict a person's freedom to physically move as they would in the real world. Furthermore, a person cannot touch or feel objects in the virtual world.

This project addresses these issues by developing an approach to virtual reality simulation which allows individuals to walk and run freely among simulated rooms, buildings, and streets.



[Click here for the Flatworld Photo Gallery](#)

In film and theatrical productions, sets are constructed as modular components called "flats". Using flats, set designers produce physical, tangible structures that convey a sense of place or activity. FlatWorld utilizes a "digital flat" system. A digital flat is effectively a large screen display. A single digital flat has the ability to appear as an interior room wall or an exterior building face. When physical props are used in conjunction with digital flats, doors and windows can be simulated. Users can touch and open these portals to view an exterior virtual world. Because of their modular characteristics, several digital flats can be rapidly assembled in any open space to simulate multiple situations in a variety of geographic locations. The immersive experience is heightened through the use of immersive audio, tracked stereoscopic graphics, and "4D" sensory effects such as blowing wind and vibrating floors. This approach of using physical props within a virtual environment can create a "mixed reality" world where the physical and the virtual seamlessly coexist.

# The New Literacy

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- Not just from verbal to multimedia, but from “read only, listening, viewing” to composition in all media
- From analysis to synthesis: creativity!!!
- Dewey to Piaget to Papert: constructionist learning
- “I hear and I forget; I see and I remember; I do and I understand; I teach and I master!!!”



# National Science Foundation

WHERE DISCOVERIES BEGIN

nsf.gov

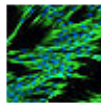
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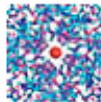
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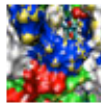
## H I G H L I G H T S



University of Colorado Tissue Engineer to Receive NSF's Coveted Waterman Award



United States Still Leads in Science and Engineering, But Uncertainties Complicate Outlook



Oldest Hemoglobin Ancestors Offer Clues to Earliest Oxygen-Based Life



President Bush Honors Excellence in Science, Mathematics and Engineering Mentoring

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# NSF Leadership Tutorial

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- NSF's role in technology and learning?
- Recognize that NSF is MOST of the action in education research (80% or greater)
- BUT, NSF programs tend to be overly constrained by tradition, by practice, and by Congress.
- Not known for innovative or significant work, at least in this area.

# Premise of Meeting

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- Both the changing needs of our society and the disruptive nature of IT may , may extend beyond the capacity of our existing learning infrastructure of schools, universities, training programs, and cultural institutions.
- Approaching the challenge by reforming existing institutions may not be sufficient. After all, “a butterfly is not simply a better caterpillar”!
- Instead, NSF needs to explore entirely different “learning ecologies”.

# Executive Leadership Core Workshops

- To help university leadership identify the key challenges and opportunities presented by emerging information technologies by comparing perspectives with one another.
- To help the executive leadership team of a university get on the same page as it develops institutional strategies.
- To explore how to build stronger coalitions of universities working together to address some of these challenges.





# MIT-CMU-Cornell Participants

- **Carnegie Mellon University**
- Jared Cohon, President
- Mark Kamlet, Provost
- Joel Smith, Vice Provost/Chief Information Officer
- Randal Bryant, Dean, School of Computer Science
- Jeannette M. Wing, Head, Computer Science Dept
- Pradeep Khosla, Dean, Carnegie Institute of Technology
  
- **Cornell University**
- Jeffrey Lehman, President
- Biddy Martin, Provost
- Polley McClure, Vice President, Information Technologies
- Robert Constable, Dean for Computing and Information Science
- Sarah Thomas, University Librarian
- Robert C. Richardson, Vice Provost for Research
  
- **Massachusetts Institute of Technology**
- Charles M. Vest, President
- Robert A. Brown, Provost
- John Curry, Executive Vice President
- Jerrold Grochow, Vice President for Information Services and Technology
- Jeffrey Schiller, Network Manager
- Lorna Gibson, Professor of Materials Science and Engineering
- M.S. Vijay Kumar, Assistant Provost and Director of Academic Computing
- Pat Dreher, Deputy Chair, IT-SPARCC
  
- **Forum members**
- Jim Duderstadt, President Emeritus, University of Michigan (Forum chair)
- Michael McRobbie, Vice President for Information Technology and CIO, Vice President for Research, Indiana University (Forum member)
- John Seely Brown, Former Chief Scientist, Xerox Corp.



Annette Wing  
Strategic Market Executive

John Curry  
Strategic Market Executive

John Seely Brown  
Strategic Market Executive



# Some Observations

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- What excites you?
  - \* Emerging cyberinfrastructure
- What scares you?
  - \* Dramatic changes in the student culture (IM, peer-to-peer learning, etc.)
  - \* Faculty sometimes wishes they could require students to use of 110 bd modems and ban wireless from the classroom...

# Observation

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- Students are beginning to form communities capable of learning on their own.
- These communities involve teams and challenge the one faculty member-one course paradigm.
- Yet some (e.g., John Seely Brown) believe that this multi-tasking, community building, rapid context switching approach to learning may be the best preparation for leadership roles in the very complex, fast-moving social situations of 21st C society.

# Observation

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- CIOs are reaching a consensus on what the IT infrastructure for the university will be for the next 5 years or so.
- Based on open-source standards (I2, SAKAI, Grid, Cyberinfrastructure)
- Will challenge monopolies (Microsoft, PeopleSoft, Blackboard, ...) or at least encourage them to adapt to open-source strategies...

# Two Approaches

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- The Optimists: Just let it happen. We'll be OK, since we are the leaders
- The Pessimists: We need to “guide” the revolution, getting the faculty engaged in the changing nature of scholarship and learning as an intellectual challenge.
- But just who is driving this revolution? Faculty? Students? The technology itself?
- Question: Is the faculty going to lead, follow, or just get out of the way? Or perhaps learn from their students?

# The Challenge of Complacency

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- Hakuna Matata...We've led in the past, and we will lead in the future, regardless of how disruptive digital technology becomes ...(after all, we don't need to run faster than the tiger...just faster than our competition...)
- NOTE: This is a characteristic of most AAU-class research universities.
- Continuing concern: People are still not thinking deeply about the strategic issues posed by this technology.









# Revolutionizing Science and Engineering through Cyberinfrastructure:



Report of the  
National Science Foundation  
Advisory Panel on  
Cyberinfrastructure

February 3, 2003









# University of North Carolina

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- UNC-Chapel
- North Carolina State University
- Duke
- Georgia Tech
- University of Maryland





## Some Differences

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- MIT-CMU-Cornell were competitors, and eventually began to hold their cards close to the vest...
- UNC-NCSU-Duke were collaborators (Research Triangle)...and rapidly begin to explore alliance issues

## UT-Austin, March 21

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- UT-Austin
- Texas A&M
- Rice
- Arizona
- Arizona State



ARNOLD and MABEL

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OF THE NATIONAL ACADEMIES OF SCIENCES  
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# Newport Beach, California

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- USC
- UCLA
- UCSD
- UCSB
- UCI



# Worries

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- Being too timid...betting on the wrong horse.
- Self-induced complexity because of inadequacy of leadership.
- "I go into my office tomorrow, and nothing works!"
- Still following an incremental strategy, when transformation is increasingly necessary.

## An Example: The Library

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- How many of you are building new libraries? What are you going to put in them? Books? (No... Starbucks!)
- Suppose every student and faculty member can access and search 50 million volumes (a la Google)?
- Suppose every student carries around the 10 TB of the Library of Congress on his or her iPod?



# The Big Question

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- How does one lead a university (or any social institution, for that matter) through order of magnitude changes?
- Perhaps individuals CANNOT lead. Instead perhaps only ecologies such as free markets can adapt!
- No institution is wise enough to chart the course to the future. Need collaboration and an "ecology of experimentation."

# Some Conclusions



## Role of IT Forum

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Perhaps we need to shift our studies from:

“How to save the research university?”

to

“How will scholarship and learning occur in the digital age...and where will they be conducted?”

# An Interesting Comparison

In a single generation following the Civil War, higher education in America changed radically:

- From the colonial colleges to the Humboltian research university
- Land-grant acts creating the great public universities with service missions
- Growing from hundreds to thousands of students
- Empowerment of the faculty

**Everything that could change, in fact, DID CHANGE!**







# An Emerging Consensus

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The consensus in several of our workshops has been that we are well along in a similar period of dramatic change in higher education.

In fact, some of our colleagues were even willing to put on the table the most disturbing question of all: “Will the university, at least as we know it today—even exist—a generation from now?”

Disturbing, to be sure. But worthy of consideration.