ITIC: The Integrated Technology Instructional Center
...A Laboratory for the University of the 21st Century...
What is the Integrated Technology Instructional Center?

The core academic facility of the North Campus of the University of Michigan

A campus currently serving the roughly 10,000 students enrolled
in the North Campus schools of Engineering, Music, Art,
Architecture, and Urban Planning

ITIC is the principal library serving these students.

ITIC is also the primary instructional facility,
providing badly needed classrooms
computer workstation areas
design studios

ITIC is also the command center for CAEN,
the Computer Aided Engineering Network
perhaps the most sophisticated computer network on any
college campus in America today, linking UM Engineering,
its faculty and students, to industry and government throughout
the state, the nation, and the world.

But ITIC is far more...indeed

ITIC is, perhaps more than any academic facility on any campus
in our state, the key to the economic future of Michigan

ITIC...a facility that utilizes information technology

...computers, networks, HDTV,...ubiquitious computing,
virtual reality, knowbots, multimedia,...

to integrate together the extraordinary capabilities of
UM Engineering, ranked among the top 5 engineering
schools in the nation, to provide the new forms of
engineering education so critical to Michigan's
established and developing industrial base

to integrate together the creative professions on the
University's North Campus...engineering, architecture,
art, and music to teach and nurture the far-ranging
type of creativity so desperately needed by
Michigan business

to serve, through its location adjacent to
...the Chrysler Center for Continuing Engineering Education
...the headquarters for the statewide Merit Computer Network
...the headquarters and command center for the National
Education and Research Network...
...as a gateway providing access to the great resources
of Michigan's College of Engineering to state industry
...and, indeed, providing Michigan industry literally with
access to the world

ITIC is...
...the electronic library of the future
...the electronic classrooms of the future
...the design and development studios of the future
..a model of the "electronic university" of the 21st Century,
an integrated set of libraries, classrooms,
workstation clusters, design studios..
...llinked together both internally and to the outside world
with robust networks

But ITIC is even more...in fact, ITIC is the future itself!
The Challenge of Change

We are living in the most extraordinary of times...

Who would have predicted even a few years ago
...the collapse of communism
...the end of the cold war
...that the Berlin Wall would crumble,
Germany would be reunified
...that the Soviet Union would fly apart

...that Nelson Mandela would be released
from prision...and that the people of
South Africa would vote to end apartheid.
...a redefinition of the world economic order
...and, of course, mankind pushing against
the very limits of the planet
Yet all of this has happened...
and the pace of change continues to accelerate.
Indeed, many believe that we are going through a
period of change in our civilization just as profound
as that which occurred in earlier times such
as the Rennaissance or the Industrial Revolution
...except that while these earlier transformations
took centuries to occur...
the transformations characterizing our times will
occur in a decade or less!
I used to portray the 1990s as the countdown toward
a new millenium, as we find ourselves swept toward
a new century by these incredible
forces of change.
But the events of the past year suggest that the
21st Century is already upon us...a decade early.
Needless to say, this time of change has
posed great challenges to Michigan.
The America of the 20th Century that we have known...
was a nation characterized by a rather homogeneous,
domestic, industrialized society...
But that is already an America of the past.
Our children will inherit a far different nation...
a highly pluralistic, knowledge-intensive, world nation
that will be the America of the 21th century
The impact of these changes are already painfully apparent
to Michigan's workers and industries.
In fact, it is here in Michigan...in the heart of the "Rust Belt"
that the impact of these extraordinary changes are
most clearly seen...
We all know that past decade was a period of
great difficulty for the people of our state...
Industries of great economic importance to our
nation such as steel and automobiles have
fallen victim to intense competition from abroad...
Plants have closed...we still have many people chronically
unemployed...or under employed...
But are we ready for it?
Indeed, I speak to you today in the wake of the recent news
that General Motors has just announced the elimination
of another 9,000 jobs in our state...including the closing
...right in the backyard of my University...
of perhaps the greatest symbol of American industrial might
the Willow Run assembly plant that a half-century ago
helped win World War II by producing Liberator bombers...
yet today has lost the capacity to compete effectively
in the production of Chevrolets...
While some may still look at the Midwest as a relic
of America's industrial past, let me suggest that in
many ways, it can also be viewed as America's
future.
It is clear that the Rust Belt is in the midst of a profound transition...
...from an industrial economy based upon the abundance
of natural resources, unskilled labor, and, to some degree,
constrained, slowly moving domestic markets...

To a knowlege-based economy, characterized by intensely
    competitive world markets, rapid change, and--most
    important of all--educated people and their ideas.
This last point is very important,
    for today we are seeing a dramatic shift
    in the fundamental structure, nature, and
    perspective of our society.
We are evolving rapidly to a new post-industrial,
    knowledge-based society, just as a century ago our
    agrarian society evolved through the Industrial Revolution.
Key element in transformation, is the emergence of knowledge
    as the new critical commodity, as important as mineral ores,
    timber, and access to low skilled labor were at an earlier time.
This new critical commodity knows no boundaries.
    It is generated and shared wherever educated, innovative,
    and creative people come together with technology
    ...and, as we have learned, it spreads very quickly.
This is a fundamental transformation in our economy that
    is reshaping virtually every product, every service, and every
    job in the United States and the world.

Transportation to Communication
In Michigan, we have a unique vantage point
    from which to view the nature of these changes
    I have been talking about.
 For if there was one sector most strongly influencing
    the progress of the 20th century
    it was transportation ...and its related industries
    ...cars, planes, trains, oil, space...
Transportation determined
    prosperity, national security, even
    our culture...with the growth of the suburbs,
    international commerce, and so on.
In this period, Michigan's
    automobile industry had no equal
    becoming the most prosperous and powerful industrial regions on earth.
Today things are very different for Michigan
    as we enter a new era in which the engine of progress
    will be communication, enabled by the profound advances
    we are now seeing in computer technology, networks,
    satellites, fiber optics, high definition televisions, and so on.
Now we face a world in which hundreds of millions of computers,
     easily plug into a global
    information infrastructure,
Sound improbable? Observation: There are already
    ...30% of homes with personal computers
    ...50% of workers use computers
    ...70% of homes with children 8-12 have Nintendos
        (30 million machines)
Jacques Attali, in his extraordinary essay Millineuem,
    suggest that the impact of information technology
    will be even more radical than that of the harnessing
    of steam and electricity in the 19th century...and
    rather more akin to the discovery of fire by our
    early ancestors, since it will prepare the way for
    a revolutionay leap into a new age that will
    profoundly transform human culture.
The result of this shift leaves Michigan's industries
    less competitive...and at risk of marginalization.
In this brave new world, Michigan's leaders
    quickly recognized that we could not afford to live in the past.
We had to commit to the information age quickly and fully.

The key here was a partnership...
    ...between the public and private sector
    ...between state government and federal agencies
    ...between universities and industry.

NSFNET

An excellent example was the effort to build and manage NSFNET.
The partnership included
    ...Michigan's universities, through the MERIT consortium
    ...IBM and MCI
    ...state government
    ...and the federal government, through NSF
NSFNET has been enormously successful.
    ...7000% growth (11% per month)
        ...Traffic on the backbone has increased
            from 200 million to 15 billion packets a month since 1988.
    ...Over 650 colleges and universities connected
    ...Over 5,000 networks linked
    ...More than 80% of nation's student population
    ...More than 90% of nation's federally-sponsored research
    ...More than 1,000 high schools
    ...Several hundred libraries
    ...Connects some 5, 000 networks worldwide
    ...Scientists connected to NREN can now collaborate
        with their peers in 39 countries on seven continents.
    ...NSFNET standards technology leading the world
    ...US companies now lead in innovation and market share
    ...40 to 1 multiplier for federal investment
The NREN Experience
    The NREN component of the HPCC program is designed
        to dramatically expand and enhance the U.S. portion
        of an existing worldwide infrastructure of interconnected
        computer networks called the Internet.
        (HPCC: High Performance Computing and Communications Program)
    Many educational institutions, government laboratories,
        and industrial research facilities are currently connected
        to the Internet. Yet it still falls short of a widespread,
        uniform, and high performance national infrastructure.
    NREN is designed to not only address broad network
        connectivity, but also provide the basis for necessary
        higher level capabilities and services to scientists
        and educators.
    This requires a program of research into very high speed
        technology, necessary to support access to digital
        laboratories, large scale distributed computing resources,
        visualization of modeling and simulation results,
        rapid interrogation and retrieval of scientific data from
        specialized data bases, remote control of experiments
        and simulations, and teleconferencing.
    In particular, it will require gigabit networks.
    NREN will also provide valuable experience necessary for
        the successful development of a broader, privately-operated
        national information infrastructure.
        Such an infrastructure
        would allow consumers, businesses, schools, and
        government at all levels to share quality information
        when and where they want it at a reasonable cost.
    The vision of the NREN is of an interconnection of the
        nation's educational infrastructure to its knowledge
        and information centers. In this system, elementary
        schools, high schools, two and four year colleges,
        and universities will be linked with research centers and

laboratories so that all may share access to: libraries,
databases, and diverse scientific instruments such
as supercomputers, telescopes, and particle accelerators.
Indeed, we now have what we need to bring
people and knowledge together to address such critical national needs
 as the improvement of both instruction at all levels and research.
There are two components of NREN development:
1)Interagency Interim NREN: Plans call for NSF
to coordinate the Interim NREN
by upgrading its backbone network, by assisting regional networks
to upgrade facilities, capacity, and band width, and by
interconnecting the backbone networks of other agencies.
Coordination among participating agencies and the non-federal
networking community will be expanding through the
creation of a National Networking Council.
2) Gigabit R&D: DARPA will enable the R&D effort that will
support initial deployment of gigabit/s capability.
Coordination of research efforts on very high speed switches,
protocols, and computer interfaces will be necessary.

General Observations
The emphasis is on education and research
and serving research and education communities.
The federal role is to create platforms for exploring
new technologies...to support vision...crazy ideas, dreams.
Might best be viewed as an enabling technology
Commercialization is secondary.
Hope is that the commercial sector will pick this up
and go with it.
Note this is not a case of government developing and
then transferring technology. NREN is
using technology developed by industry...
the federal government is working with
industry and academia as a partner.
The partnership theme is the key:
MERIT + IBM + MCI + Michigan + NSF
...local nets, state nets, agencies, 200 companies
in partnership with users

Some Lingering Issues
Despite its spectacular success, there are lingering issues:
Role of the telecommunications industry
Reluctance to embrace high speed packet data
networking as a product/service
Fear that NREN will become competition
Resistance to diffusion of the application interface standards
preferring standardization on interfaces provided by the
telephone companies instead
Congressional belief in "private enterprise"
The old "industrial policy" arguments
Concern that NSF partnership is not the best way to
advance technology...rather, just let
private industry do it on a more relaxed
time scale
Confusion between NREN and National Information Infrastructure
NREN is believed by some to be responsible for delivery
to everyone for every "good" purpose
Consequently, current Acceptable Use Policy is thought
to be inappropriate
NSF and federal agencies being criticized for failing to
deliver ubiquitous connectivity even though this was never the original charge.
NREN caught between advancing technology (grand
challenges) and delivering low cost service to

broadest possible community
Of course, we must continue to wrestle with these questions and issues
but I hope we will not be bogged down by them.
Given the pace of change today, this isn't good enough.
We simply must strive for a more worthy overarching vision.
In that spirit I'd like to look ahead at how
we might shape the future of information technology
to serve our whole society, to weave it more closely together.
The technology is moving very rapidly...
We are moving in the next few years from M-type
workstation to G-type workstations.
In about the same time frame, 3-5 years, massively
parallel computation servers will offer
tera-ops, while the price to performance ratio
of workstations will continue to improve.
Within 5 years, widely available international networks
capable of point-to-point multimedia (including
video) will be available. Wide area networks in
the gigabit per second range will be in routine
use, but still well short of the 25,000 gigabit
potential of third-generation fiber optic technology.
Wireless communication will support remote
computing and communication allowing workers
to put down roots where they choose
as far from their primary employer as they choose.
A Proposal Concerning the National Information Infrastructure
This brings me to my final comment
...which takes the form of endorsing a proposal
...obvious to many
...but, unfortunately, misunderstood or resisted by many others...
It is my belief that the United States government must commit itself
to a massive effort to build the National Information Infrastructure,
"the interstate highway system for the information age",
that will give all of our citizens access to this incredible future.
We should commit itself to building for 21st century America
a high speed data highway that will
carry the freight of knowledge and information
that will be the foundation for national prosperity.
NREN has given us the knowledge and experience
we need to begin to build NII and it can continue
to lead the way through research and advanced experimentation.
Other countries including not only
advanced nations such as Japan and Germany already are
building such an advanced system.
In today's capital markets,
providing the private telecommunications industry
adequate regulatory incentive to build this network
is likely to compromise the future flexibility
and application of the network itself.
 But like the interstate highway system,
 once this network is completed, the
demand for its use will skyrocket
and its benefits will be felt
across all parts of our economy and society.
I hope that, as a nation, we will have the foresight
to take such a bold and visionary step forward.
Based on what we have learned already from NSFNET experience,
I believe the U.S. should launch
a program to provide the National Information Infrastructure
by the year 2000.
It might be governed by a public corporation

e.g., Corporation for Public Networking
Funds would be dispersed for
....supporting connectivity
....building information resources
Work would be performed by the private sector on RFP basis
NREN itself would continue as a separate program to address
high end needs, to provide the leading edge research
and examples of advanced applications still fully connected to NII.
In making this proposal I am mindful of the lessons from our past.
There are plenty of precedents for a venture such as NII.
When America needed to settle the frontier
we invested in the system of canals to link settlers in the West
to commercial centers in the east.
Later in the 19th century, the government joined
with industry and the states
to develop the national rail system
that launched the industrial age.
Also important to remember that it drew the Union together,
bringing prosperity and progress to once remote regions of the country.
A hundred years later, the US government once again was the catalyst
for infrastructural development when it spearheaded the development
of the interstate highway system.
Perhaps this last is the closest parallel to the proposal for NII
that I make today.
After all in building the interstate,
Government established federal standards for highway construction
Helped finance it
States managed construction which was carried out
by private industry on a competitive basis
Most roads are free, some others charge tolls.
Highways were the circulatory system carrying raw materials
and manufactured goods to create America's
great postwar economic boom.
Later the national and international air transport system,
also a product of federal, local and private industry partnership.
Aren't these the same elements we need to build NII?
My proposal for NII does not look so radical when viewed
from the perspective of our earlier national investments in infrastructure.
Indeed, the relative costs would be much lower for
NII than for the Interstate system.
Perhaps there is another parallel.
The interstates were financed partly though a gasoline tax.
Isn't it reasonable to fund NII with a small tax on users?
Say a half or one percent computer hardware sale?
By my crude calculations this would produce
about $600 million per year or $3 billion over five years.
The parallel to our situation today seems obvious.
Whereas before our need was for a national infrastructure
to transport material goods and
to move people to support our industrial economy.
Today the need is to transport the ideas and information that have become
the lifeblood of our postindustrial (hyperindustrial) economy.
Other industrialized countries have long recognized the need
for government to be a partner in developing national infrastructure.
Fortunately, our own government has taken some initial steps recently
to play a more significant role as catalyst for developing technologies
essential for growth and productivity.
But it would be a mistake to regard investments in NII
as part of a new national technology policy.
Instead it is the infrastructure that will make
important scientific and technological advances possible.

Implications for Higher Education

The Changing Paradigm of the Research University

But there is an even more profound transformation occurring:
that involving the paradigm of the research university itself.
The triad mission of the university as we know it today
--teaching, research, and service--was shaped
by the needs of an America of the past.

Today our nation and our world are changing at an
ever-accelerating pace. Hence, is seems appropriate
to question whether our present concept of
the research university, developed largely
to serve a homogeneous, domestic, industrial society
of the twentieth century, must also evolve rapidly
if we are to serve the highly pluralistic,
knowledge-intensive world nation that will be
the United States of the twenty-first century.

Given the pace and magnitude of change today,
perhaps the decade ahead is
a time for "reinventing" the American university.

But will a gradual evolution of our traditional paradigm be sufficient?
Or will the challenges ahead force a more dramatic,
indeed revolutionary, shift in the paradigm of
the contemporary research university?

I'm not sure how rapid these changes will occur,
but I can tell you that much of the energy on our campuses
today is really part of a process to discover the nature
of the University of the 21st Century...an instititution
that will almost certainly be as different from what we
know today as the modern research university is from
that of the 19th Century...

Is It Time to Break the Mold?

This time of great change, of shifting paradigms,
provide the context in which we must consider
the changing nature of the academic research
enterprise itself.

We must take great care not to simply extrapolate
the past, and instead examine the full range
of possibilities of the future.

But here we face a particular dilemma:

Both the pace and nature of the changes occurring
in our world today have become so rapid and so profound
that our present social structures--in government, education,
the private sector--are having increasing difficulty in even sensing
the changes (although they certainly feel their consequences),
much less understanding them sufficiently to allow institutions
to respond and adapt.

Let me go further. I worry that our present institutions,
such as universities and government agencies, which have
been the traditional structures for intellectual pursuits such
as research, may turn out to be as obsolete and irrelevant
to our future as the American corporation of the 1950s.

I believe we need to explore new social structures capable
of sensing and understanding change, and capable
as well of engaging in the strategic processes necessary
to adapt or control change.

An Example

Let me give you an example of what I mean...

Since the business of the academic research enterprise
is knowledge, let me suggest that the impact of
the extraordinary advances in information technology
could have--likely will have--profound implications.

Technologies such as computers, networks, HDTV,
ubiquitous computing, knowbots, and other
technologies may well invalidate most of the
current assumptions in thinking about the future
nature of the research enterprise.
Will the "university of 21st Century" be localized
in space and time, or will it be a "meta-structure"
involving people throughout their lives, wherever
they may be on this planet--or beyond?
Is the concept of the specialist really necessary
--or even relevant--in a future in which the most interesting
and significant problems will require "big think" rather
than "small think," where intelligent software agents
can roam far and wide through robust networks
containing the knowledge of the world and instantly
and effortlessly extract whatever a person wishes to know.
Will lifestyles in the academy (and elsewhere) become
increasingly nomadic, with people living and traveling
where they wish, taking their work and
their social relationships with them?
In the spirit of these questions, perhaps we should pay far more attention
to evolving new structures such as "collaboratories" rather
than old-fashioned structures such as research universities,
federal research laboratories, research projects, centers, and institutes.
There is a possible implication here. If information technology will indeed
allow--perhaps even require--new paradigms for research organizations,
should we not place a far higher priority on linking together
our scientists and engineers, not to mention linking them
with the rest of the world? This would seem to be
a modest investment compared to other megaprojects
such as the SSC and the Human Genome Project.
Further, without investigating the impact of such
technology-based infrastructure first, we may find ourselves
making massive investments in research structures of the past.

ITIC: The University of the 21st Century?
Concluding Remarks
It is clear that our state is in the midst of a profound transition...
...from an industrial economy based upon the abundance
of natural resources, unskilled labor, and, to some degree,
constrained, slowly moving domestic markets...
To a knowlege-based economy, characterized by intensely
competitive world markets, rapid change, and--most
important of all--educated people and their ideas.
This has not been...and will not be...an easy transition to make.
The truth is that the outcome is still very much in doubt
producing jobs and improving our quality of life.
Whether we will emerge from this transition as a
world economic leader once again...with a
strong, prosperous--albeit new--economy
Or whether we will fail to heed the warnings...
...to make the necessary investments and
sacrifices today necessary for strength and
prosperity tomorrow...
And become an economic backwater in the century ahead.
It is clear that we face a watershed--a fork in the road ahead.
My central theme is that education, broadly defined, will
be the pivotal issue in determining which of these two
alternative futures will be Michigan's...and America's.
Indeed, I am absolutely convinced that the dominant issue of
the 1990s will be the development of our human resources.
Previous economic transformations were closely associated

with major public investment in infrastructure such as
railroads, canals, electric networks, and highways.
In the coming economic transition, an equivalent
infrastructure will be an educated population.
The actions we must take today...
...and the investments we must make...
...will clearly determine our capacity to
respond to this future...