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National Institute of Standards and Technology

NIST Special Publication 886

Proceedings of the Second Annual Manufacturing Technology Conference: Toward a Common Agenda
April 18-20, 1995
Gaithersburg, MD

Cheryl Albus, Editor

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- Advanced Systems

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- Applied and Computational Mathematics[2]
- Statistical Engineering[2]
- Scientific Computing Environments[2]
- Computer Services
- Computer Systems and Communications[2]
- Information Systems

[1] At Boulder, CO 80303.
[2] Some elements at Boulder, CO 80303.

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Cheryl F. Albus, Editor

Manufacturing Engineering Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899-0001

Sponsored by

U.S. Department of Defense and
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August 1995

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National Institute of Standards and Technology
Special Publication 886
Natl. Inst. Stand. Technol.
Spec. Publ. 886
918 pages (August 1995)
CODEN: NSPUE2

U.S. Government Printing Office
Washington: 1995

For sale by the Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

Introduction

The Second Annual Manufacturing Technology Conference: Toward a Common Agenda helped to define the major elements of a common manufacturing agenda that involves the efforts of government, industry, and academia. The framework in which the conference was built upon is based primarily on the Manufacturing Infrastructure Subcommittee of the Committee on Civilian Industrial Technology, which is part of the President's National Science and Technology Council. The subcommittee identified five areas of emphasis and prepared white papers for each area. The areas of emphasis are:

Advanced Manufacturing Systems
Engineering Tools for Design and Manufacturing
Manufacturing Processes and Equipment
Manufacturing Training and Education
Manufacturing Deployment

A sixth area was identified, Business Practices, after discussions held at two previous workshops (10/94 and 3/95).

The conference opened with an overview of the National Science and Technology Council Committee on Civilian Industrial Technology and overviews of the subcommittees on Manufacturing Infrastructure and Advanced Materials Processing. Following the overviews, executives from major industry sectors provided a perspective of their industry's view on federal activities relating to manufacturing. The industry sector presentations set the stage for the second day, where parallel working groups evaluated the white papers developed by the Manufacturing Infrastructure Subcommittee. Feedback sessions provided a base for the subcommittee to begin developing a manufacturing road map effort.

The conference provided a forum for government, industry and academia to identify specific strengths and weaknesses of the white papers and to lay the framework toward building a common manufacturing agenda that will strengthen U.S. industry's competitiveness.

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Industry Keynote Speaker

J. Tracy O'Rourke
Chairman & CEO Varian Assoc.,Inc.
Chairman, National Association of Manufacturers

Remarks by:
J. Tracy O'Rourke
Chairman & CEO Varian Associates, Inc.
Chairman, National Association of Manufacturers
2nd Annual Manufacturing Technology Conference
National Institute of Standards and Technology
Gaithersburg, Maryland - April 18. 1995

"Driving the Manufacturing Rebound Ahead: An Agenda for Action"

As you know from the introduction -- in coming here this morning to deliver the industrial keynote remarks for this conference, I wear two hats. I have the privilege of serving as the 1995 Chairman of the National Association of Manufacturers. However, my full-time job involves heading a pioneer electronics manufacturer in California's Silicon Valley, where I am Chairman and CEO of Varian Associates.

My vantage point -- in these positions on opposite coasts -- gives me a good, clear view of how important manufacturing is to the competitiveness and long-term future of both America and my company. More significantly, I can see a recognition of manufacturing's importance spreading beyond the industry itself to the public and to our nation's policy makers. The N - A - M is pleased to have had a part in this renewed recognition of manufacturing's prominence through the ongoing activities of what we call the Manufacturing Campaign, which we created precisely for that purpose.

We in industry are clearly paying more attention to manufacturing as the economic data and productivity numbers show. For example, the World Economic Forum recently rated United States manufacturers number one in world competitiveness -- a position we have not held in a very long time. Studies by both the Brookings Institute and McKinsey & Company now rank the productivity of U.S. workers well above that of their traditional rivals in Germany and Japan.

So I think it's safe to say that -- for now -- American manufacturers are back on top. I say "for now" because we dare not sit back and enjoy the view. What we've regained over the past decade we can easily lose again -- which is what brings me here today. Simply put, I've come here to help define a framework of actions to ensure that the United States maintains a strong, internationally competitive manufacturing sector.

A bit later on, I intend to share with you some of our experiences at Varian, and point out how some of the work here at the N-I-S-T has helped us accomplish some fairly good results. My purpose is not to regale you with tales of how good we are, but rather to illustrate for you the kinds of things I think industry as a whole must do to get -- and stay -- competitive on a world basis. I'll focus on both manufacturing and business practices, which are key aspects of the CCIT Manufacturing Infrastructure Subcommittee's thrust areas. Before doing so, however, let me comment briefly on the larger technology policy issues swirling about us today, and tell you a bit about how the N - A - M views them.

Technology policy was not specifically included in the Contract With America that dominates today's headlines. But -- because a number of specific technology programs were caught up in the budget battle -- technology and research & development issues have received a great deal of attention during the famous "First 100 Days" that concluded less than two weeks ago. As the budget process grinds on, technology policy will continue to attract attention. At the N - A - M, we have weighed into this debate by laying down some principles to help guide both the Administration and the Congress, and both Republicans and Democrats.

Boiled down to their essence, these principles convey a simple and straightforward message: "Cut, but cut carefully." Let me explain briefly the reasoning behind both the need for cuts and the need for care.

The N - A - M has long argued that the federal government has grown too large, has become too intrusive, and has weighed too heavily on economic growth in this country. I would wager that no one in this room would dispute this, whatever their political stripe. We have now begun to take significant -- indeed historic -- steps to reverse this. The need to downsize government extends to every sphere and activity, including R&D. We can't fund everything we want anymore, and the approximately 75- billion-dollar federal R&D enterprise is no exception. For example, we should look for savings by restructuring our federal laboratory system, which now consumes nearly one of every three federal R&D dollars. In short, we can no longer avoid the cold, hard fact that we have to cut back.

Before we cut, however, we must prioritize. America's manufacturers face this problem in their own companies every day as they make hard choices about where to allocate R&D and other investment dollars. But -- because R&D is such an important driver of economic momentum -- accounting for anywhere from one-third to one-half of all U.S. economic growth since World War II -- the need for care in making cuts is essential. To serve the best interests of the country, as well as those of manufacturers, decisions on federal technology policy and R&D spending cuts should be based on three things:

1 - a clear understanding of how the 80-billion-dollar-per-year corporate R&D structure has evolved over the years to meet new challenges;

2 - a grasp of what today's R&D practices and trends are, in both the private and public sectors; and

3 - an understanding of how federal R&D efforts can benefit from the lessons learned in the private sector.

One of the most important of those lessons learned is the value of technology partnerships -- partnerships between companies, in consortia, with universities . . . and even with government. In fact, technology partnerships are rapidly becoming an industry "best practice".

As someone with a long history of doing business with the government, I must tell you that my experiences add up to something less than a positive. So, when someone mentions the idea of industry-government partnerships, I'm skeptical with good reason. But, I've also learned that no one, including Varian, has all the resources needed to go it alone. We *need* partnerships, and we need to make them work. The role and rules of partnering will be major elements in the upcoming debate over federal R&D policies.

Industry and policy makers -- each and every one of us -- must become engaged in this debate. The N - A - M's position is to favor a range of technology partnerships and programs as part of an overall federal R&D portfolio. This does not mean that we are prepared, at this time, to support any particular program, or agency, or funding level. Rather, we support a *process* that can yield the best mix of policies and programs that will be needed to keep the United States out in front in the race for global competitiveness.

Our gathering here today of industry, government, and academia is an indispensable component of this process. The National Science and Technology Council structure represents the best mechanism we've ever had to bring together the various technology stakeholders. And, I think the Manufacturing Infrastructure Subcommittee and its constituent Working Groups have done an excellent job of laying the groundwork for building a common manufacturing agenda.

I say this, of course, as a not entirely disinterested party. In fact, we at the N - A - M like to claim paternity for this undertaking. As many of you know, industry quickly responded to the "Advanced Manufacturing Initiative" proposed by the Bush Administration in early 1992. And the N - A - M took the lead in creating the Manufacturing R&D Coalition. This Coalition -- in which many of you in this room such as Dick Engwall of Westinghouse, played leading roles -- worked intensely on their objective for a considerable time. The result was a rather remarkable document called "Crafting a Common Manufacturing R&D Agenda."

The impact of this work is clearly evident in all six thrust areas identified by the Manufacturing Infrastructure Subcommittee. Speaking as a results-oriented manufacturer, however, we need to move beyond the definition phase and into a hands-on phase. With that in mind, I'm serving up a challenge. That challenge is that you produce in this conference -- not only a national manufacturing R&D agenda -- but also an action plan to implement that agenda. I know that's not an easy task . . . but it's what we need to move this crucial effort ahead.

In doing so, I hope we'll see the same spirit of teamwork that's been so important to the progress we're celebrating in N - A - M's centennial year. Teaming is the heart of America's newly revitalized manufacturing economy. Researchers tell us that today some two-thirds of all big U.S. companies assign workers to self-managed teams. It is this renewed emphasis on empowering people and investing in team relationships that makes modern manufacturing tick. And I know of no better way to overcome resistance to change and new ways and ideas than the solid blocking and tackling that comes through good teamwork.

Let me give you just one example. Only a few years ago you would never have heard the term "agile manufacturing" being used in polite business conversation. Just a few weeks ago in Atlanta, I spoke to hundreds of people at an entire conference organized around that practice. In the late 1980s, there weren't many of us discussing such ideas as virtual companies, empowerment, or continuous improvement. Not so today. New ideas like this are taking hold across the country and around the world. And that creates a very good environment for the kind of change that goes with my challenge to you.

It may be that we are entering a phase in our economic development that naturally fosters the formation of more consortiums. Some challenges may be so daunting that we have no other choice than to band together to deal with them. But bringing people together in new ways also presents its own set of challenges. The innovative ideas needed to move us ahead often demand that people completely change how they think about the world of work. I know that first-hand, because of what my company is going through.

Back at the beginning of my remarks, I said I would share some of the Varian experience with you. I think it offers a good case in point for what we're talking about here, and I'd like to turn to that now. May we have the first slide up, please . . .

Presentation by J. Tracy O'Rourke

National Institute of Standards and Technology, Advanced Manufacturing Technology Conference
April 18, 1995 – Gaithersburg, Maryland

"Journey Toward Excellence; The Varian Experience"

JTO April 18 1995 | 1 | varian®

Four Core Businesses

- Health Care Systems
- Instruments
- Semiconductor Equipment
- Electron Devices

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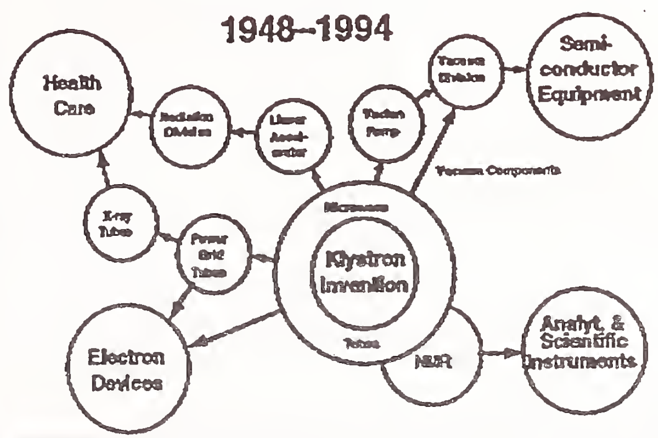
Product Evolution 1948–1994



JTO April 18 1995 | 3 | varian®

Product History 1948-1986

Over its first four decades Varian introduced some 75 products.

In 1986:

- 50% were still active
- 25% had been sold
- 25% had been dropped

JTO April 18 1995 | 4 | varian®

Presentation by J. Tracy O'Rourke

National Institute of Standards and Technology, Advanced Manufacturing Technology Conference
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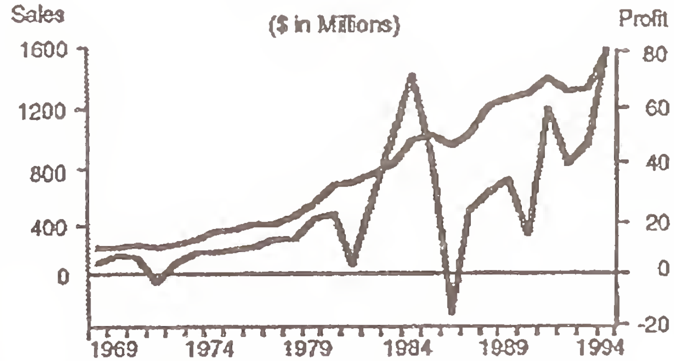
27-Year Financial History
1968 – 1994



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The Challenge Circa 1990

Mature Industries + Rich Competitors

= Price Inelasticity

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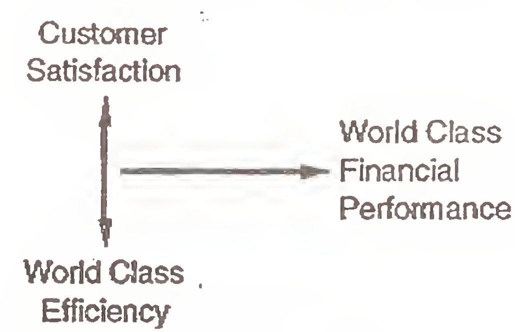
The Varian Vision

- Maximize value as we pursue worldwide growth
- Gain competitive advantage
- Focus on opportunities with significant market potential in our core businesses
- Seek breakthrough technologies

JTO March 1995 7 varian

Varian's Key Goal



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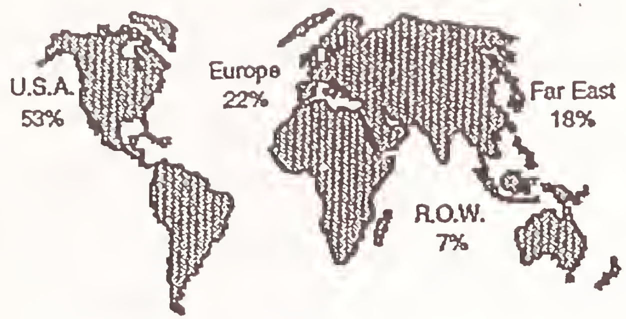
Presentation by J. Tracy O'Rourke

National Institute of Standards and Technology, Advanced Manufacturing Technology Conference
April 18, 1995 – Gaithersburg, Maryland

1994 Sales by Region



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The Master Plan

Phase I
Exit.....
– Underperforming Products
– Doubtful Strategic Fits

Phase II Operational Excellence

Phase III Accelerate Profitable Growth

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Operational Excellence

- Customer Focus
- Unbending Dedication to Quality
- Fast Response, Flexible Manufacturing
- Fast Time to Market
- Organizational Excellence

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Organizational Excellence

Eliminate All Senseless Efforts
(EAS–E)

- Number of policies cut by 80%
- 70,000 hours saved each year

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Presentation by J. Tracy O'Rourke

National Institute of Standards and Technology, Advanced Manufacturing Technology Conference
April 18, 1995 – Gaithersburg, Maryland

Correlation Between Operational Excellence and Baldrige Award Criteria

	Customer Focus	Commitment to Quality	Flexible, Responsive Factories	Fast Product Development Time	Excellent Organization & Teamwork
1.0 Leadership	●	●			●
2.0 Information & Analysis	●		●		
3.0 Strategic Quality Planning	●	●			
4.0 HR Development & Management				●	●
5.0 Management of Process Quality		●	●	●	
6.0 Operational & Quality Results		●	●		
7.0 Customer Focus & Satisfaction	●				●

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Malcolm Baldrige National Quality Award Applications

1992 Application (555*)
- Limited deployment of quality approaches
- 2 years of data in many cases

1993 Application (645*)
- Rapid increases in quality deployment
- Reached second round

1994 Application (709*)
- Consistent, integrated application
- Selected for site visit

(* internal score)

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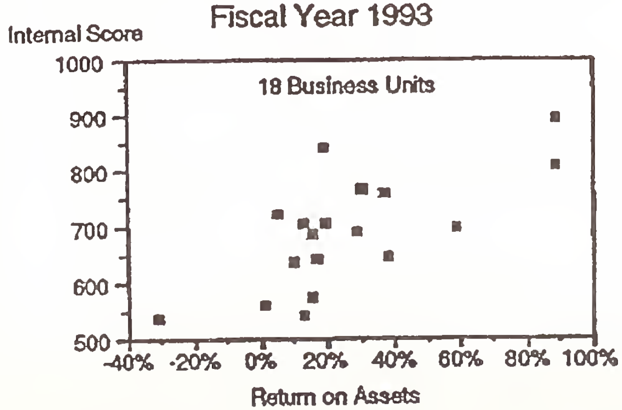
Internal Indicator Scores and ROA

Fiscal Year 1993



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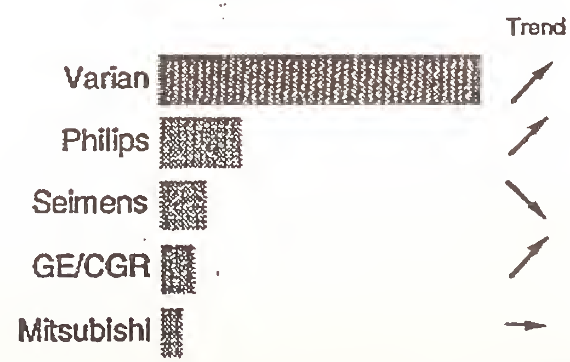
Health Care Systems Competitive Position

Oncology Systems



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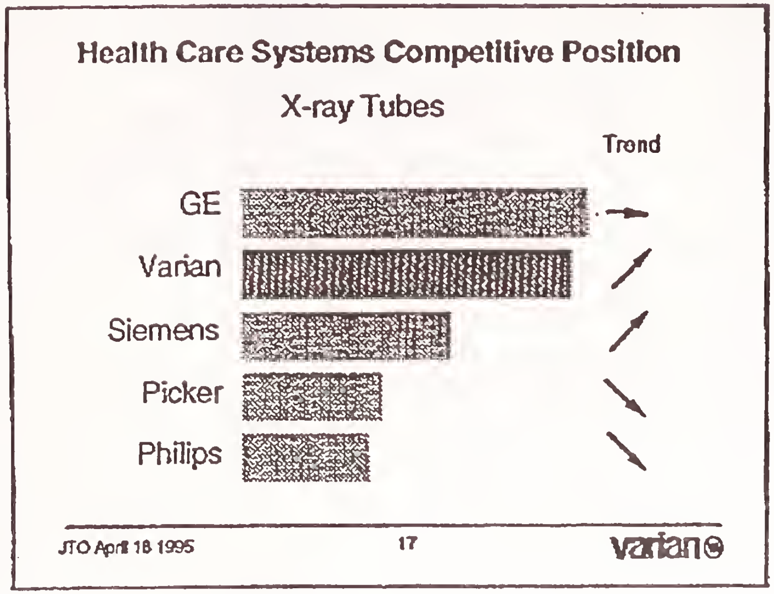

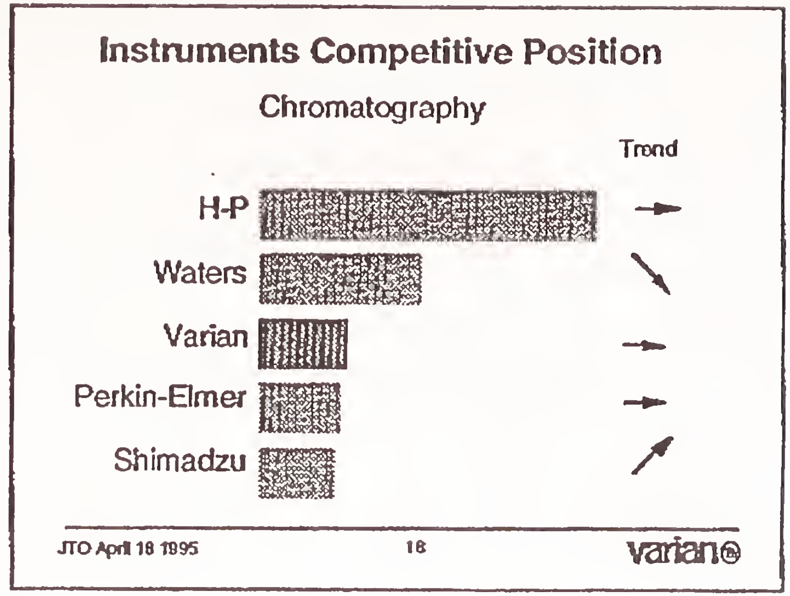

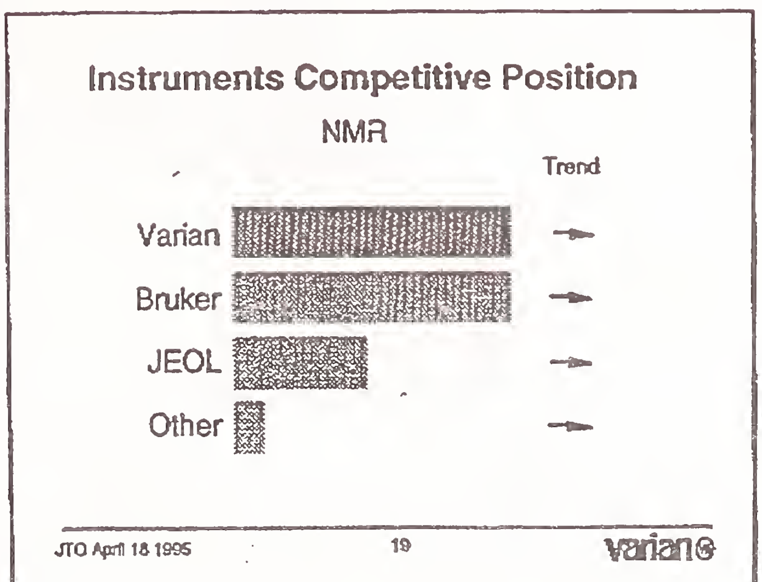

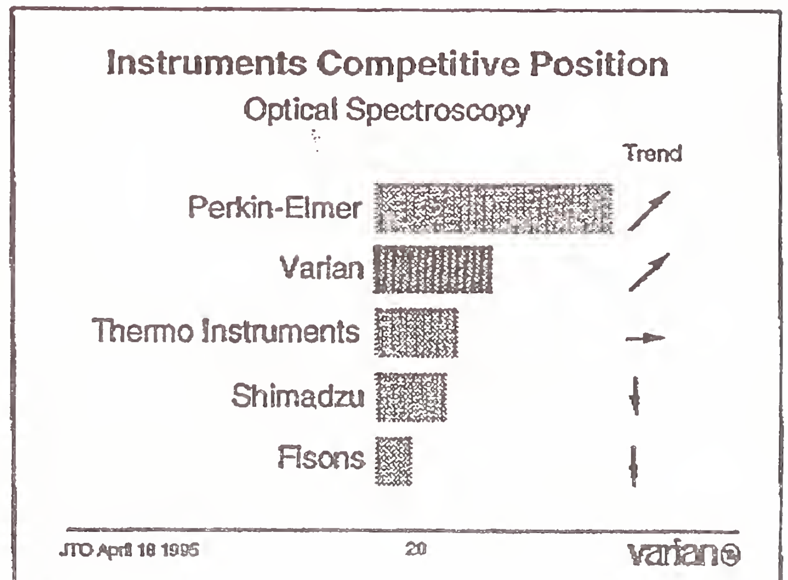

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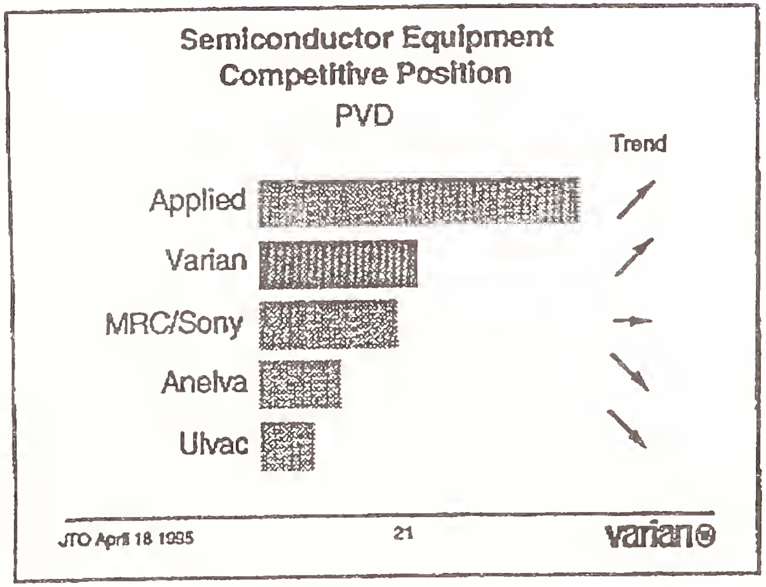
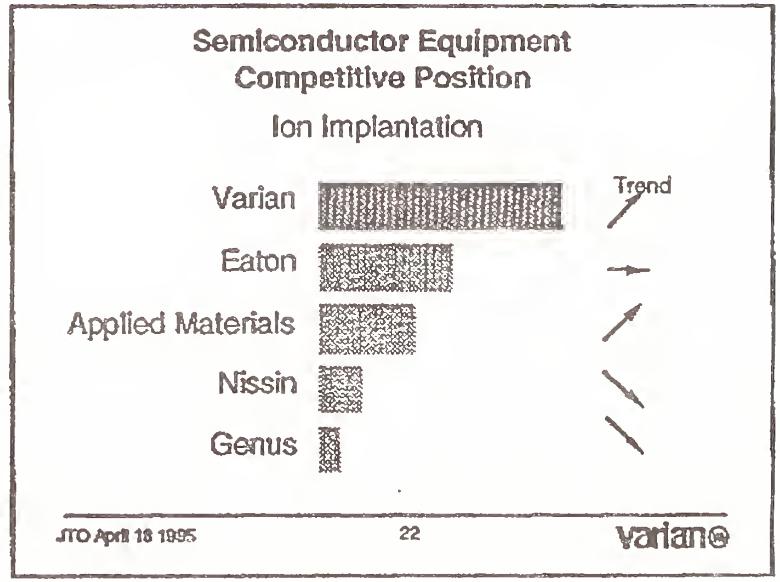
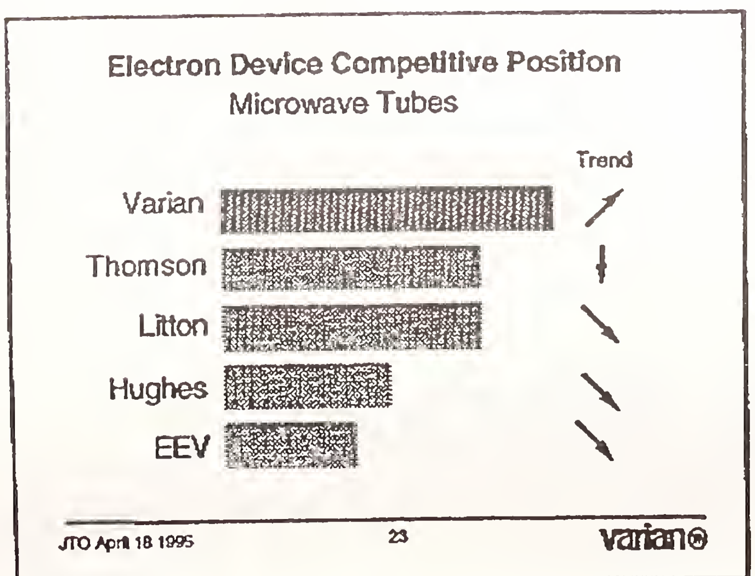
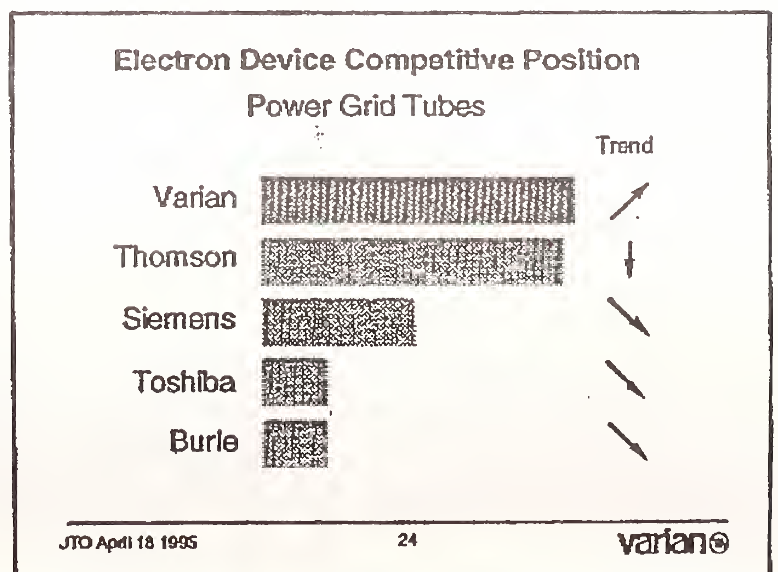








Fortunately, the Varian experience is no isolated example. America can be proud of what its manufacturers have achieved. If we were passing out grades for economic performance in 1994, the U.S. would have to get a top score. Simply put, it was the best combination of growth, employment, and price stability in 30 years.

But, while a lot of people appreciate that the economy is better, they aren't as aware that the real story behind that rebound is the country's extraordinary competitive comeback. That rebound reflects some fundamental structural changes, powered largely by a much less understood revolution in manufacturing. I use the term "revolution" advisedly, because that's just what it is. Over the past decade, manufacturing companies across America have been undergoing a transformation on a scale not seen since the Industrial Revolution of the 1800s.

I'll be the first to admit that a lot of manufacturing's problems of a decade ago were self-induced and the result of considerable arrogance and complacency. Fixing many of those problems didn't exactly call for rocket science, just hard work and common sense. But, we did it. And, despite all we've accomplished, there is still no *guarantee* that tomorrow will bring a new, golden age of manufacturing progress.

As I suggested earlier, this is no time to let up. If we expect to continue enjoying the fruits of an innovative manufacturing industry, then the going may very well get tougher from here. That's why the challenge I've given you this morning is so important. Global competitiveness is what it's all about. If we're going to survive, much less prosper, we're going to have to do it in a highly competitive environment of constant change. And, in many respects, that environment will be dictated, at least in part, from offshore.

If we go forward from here, then we'd better be committed to a steady diet of revolutionary rather than evolutionary changes. We'd better be willing to shake up our organizations every now and then to reinvigorate how the work gets done. And we'd better be committed to pressing ahead with new concepts and approaches like those spelled out in the six-part framework developed by the Manufacturing Infrastructure Subcommittee. Those are the kinds of initiatives that will create the momentum needed to drive us ahead toward the promise of a new and even better industrial age.

Toward a Common Framework for Manufacturing Programs & Policies

An overview of the National Science and Technology Council (NSTC) Committee on Civilian Technology (CCIT) and overviews of the Subcommittees on Manufacturing Infrastructure and Advanced Materials Processing.

Joan Kelly Horn
Executive Secretary
Committee on Civilian Industrial Technology

Joan Kelly Horn
Executive Secretary
CCIT

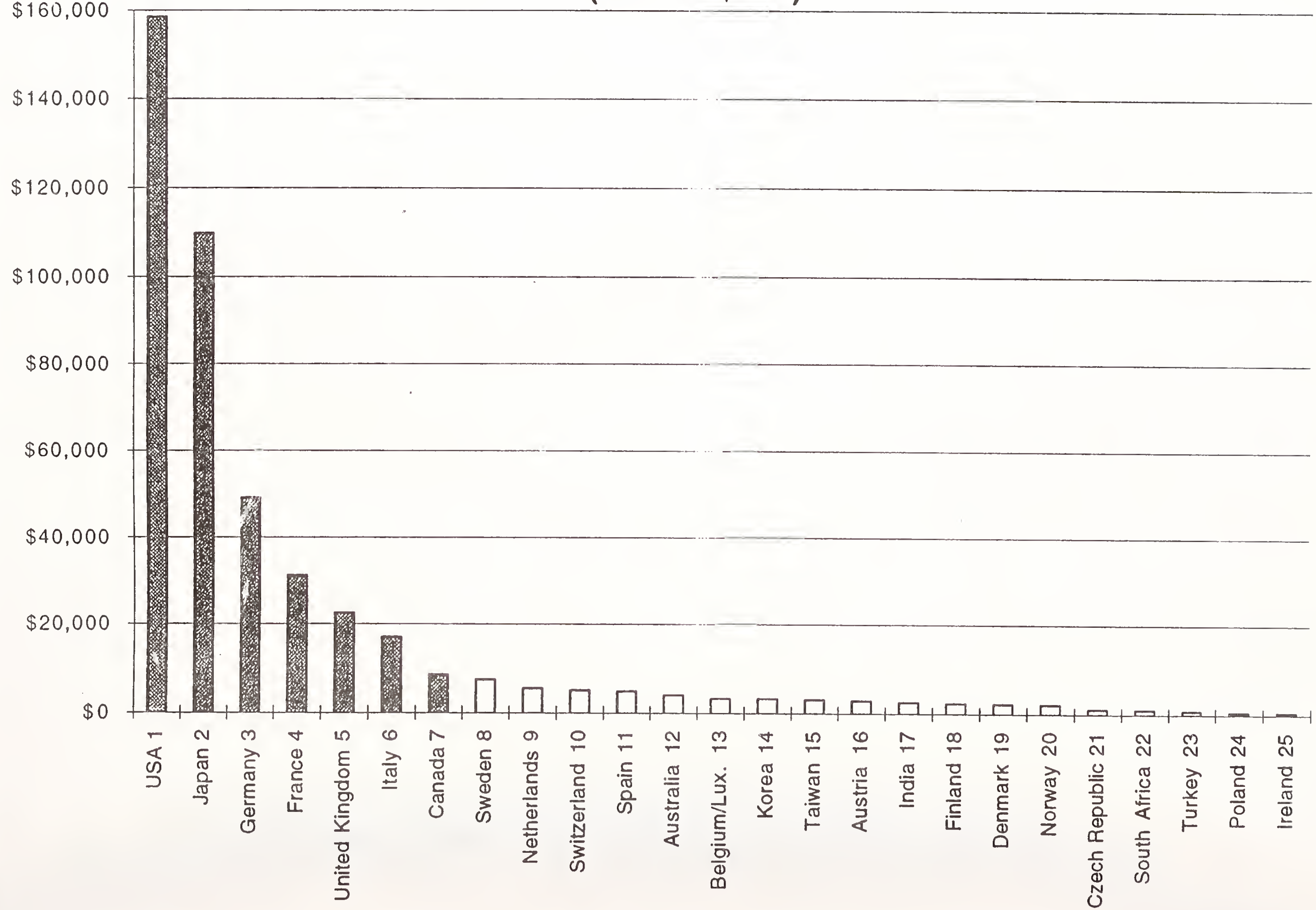
CIT

"With the end of the cold war, the globalization of the world economy, and the explosion of new information and manufacturing technologies, technology is more dominant than ever in raising productivity and achieving world-class industrial performance."

CIT

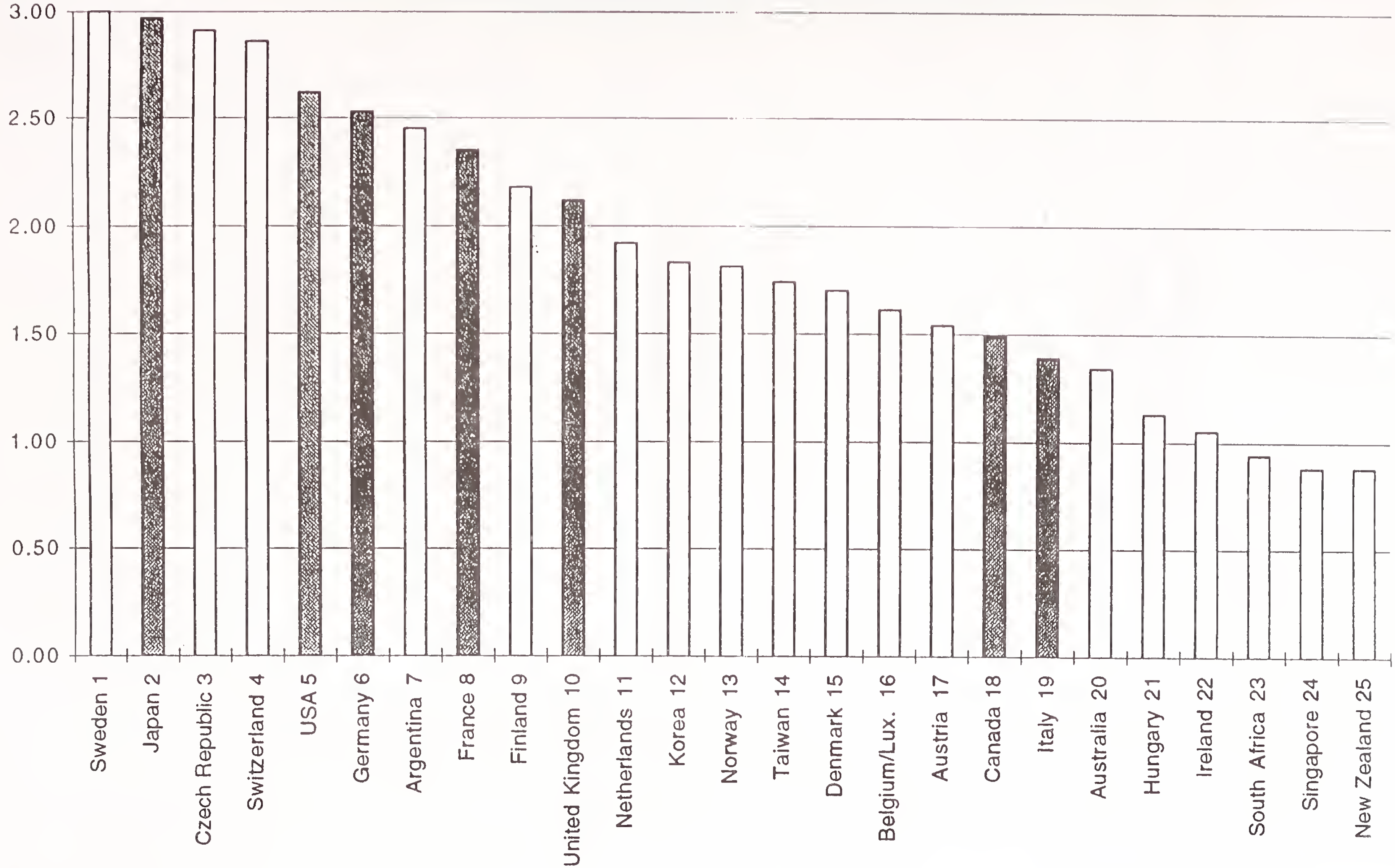
"Technological innovation drives economic growth. It is a powerful force for the creation of good jobs and steady rise in living standards."

TOTAL R&D 1992
(Millions $U.S.)



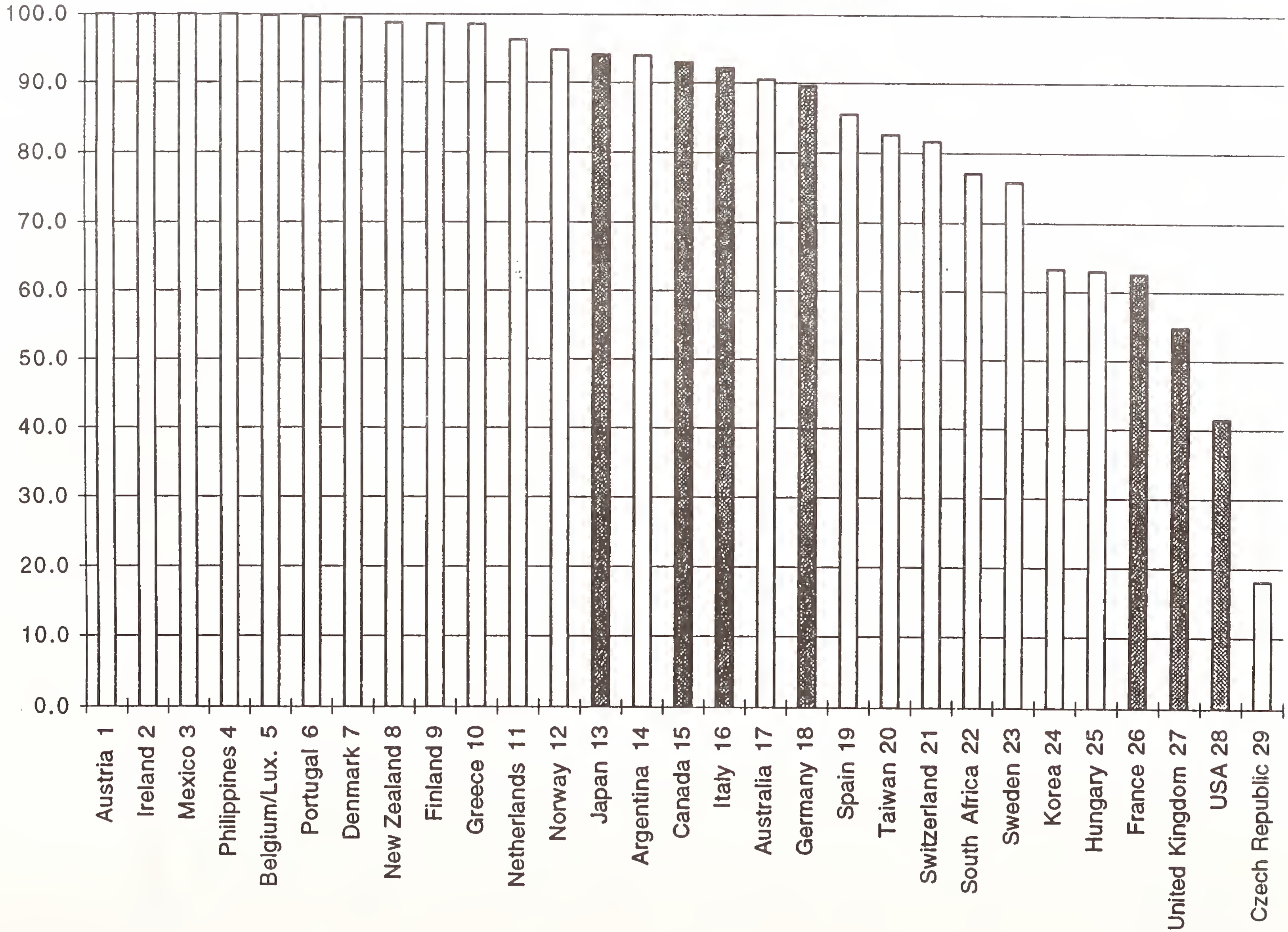
Source: World Competitiveness Report 1994, World Economic Forum
Geneva, Switzerland

TOTAL R&D AS PERCENT OF GNP 1992



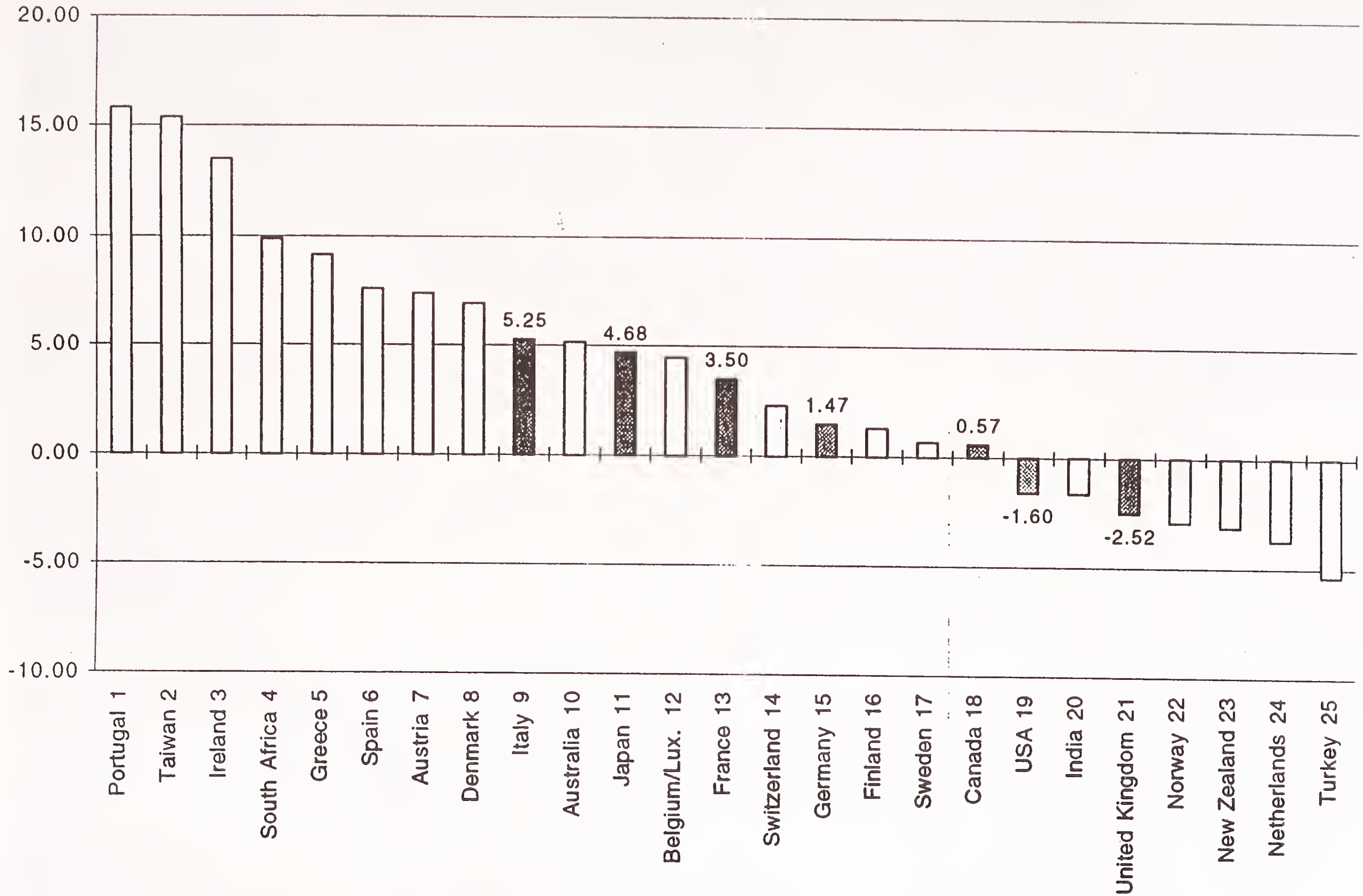
Source: World Competitiveness Report 1994, World Economic Forum
Geneva, Switzerland

NON-DEFENSE PERCENTAGE OF GOVERNMENT R&D



Source: World Competitiveness Report1994, World Economic Forum
Geneva, Switzerland

PERCENT REAL GROWTH IN BUSINESS R&D



Source: World Competitiveness Report 1994, World Economic Forum
Geneva, Switzerland

NSTC

National Science & Technology Council (NSTC)

Fundamental Science	Civilian Industrial Technology	National Security
Education & Training	International Science & Engineering	Information & Communication
Health Safety & Food	Environment & Natural Resources	Transportation

The Committee on Civilian Industrial Technology

Functions of the NSTC

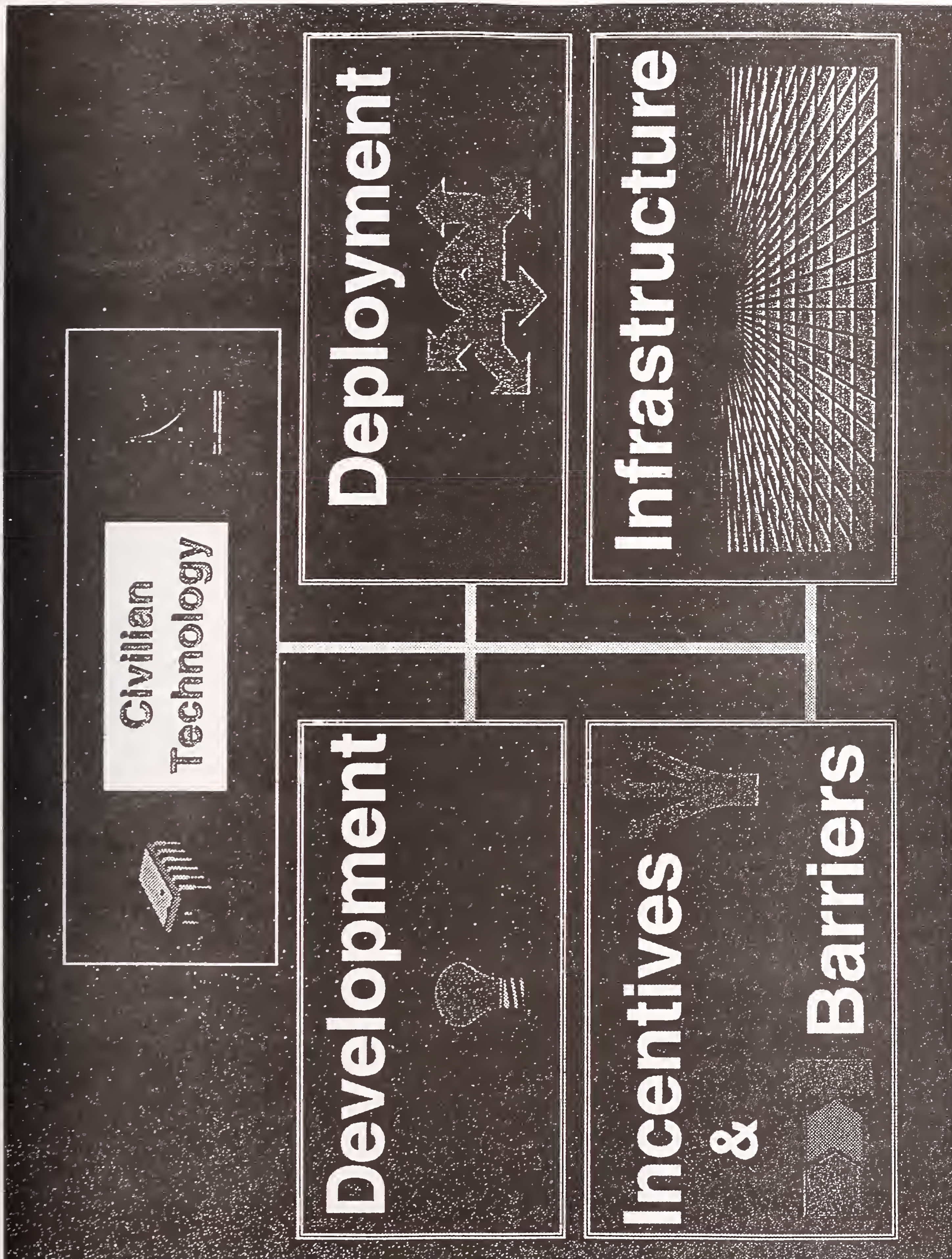
- Coordinate the S&T policy making process
- Ensure S&T policy decisions and Programs are consistent with the President's stated goals
- Help integrate the President's S&T policy agenda across the Federal Government
- Ensure S&T are considered in development and implementation of Federal policies and programs
- Further international cooperation in S&T

Technology Administration
Department of Commerce

1-9/BJN

CIT

“ The Committee on Civilian Industrial Technology (CCIT) of the National Science and Technology Council (NSTC) is responsible for oversight and coordination of government-wide R&D and allied technology programs that promote industrial competitiveness and economic growth.”


Civilian
Technology
Development
Deployment
Incentives
&
Barriers
Infrastructure

CIT

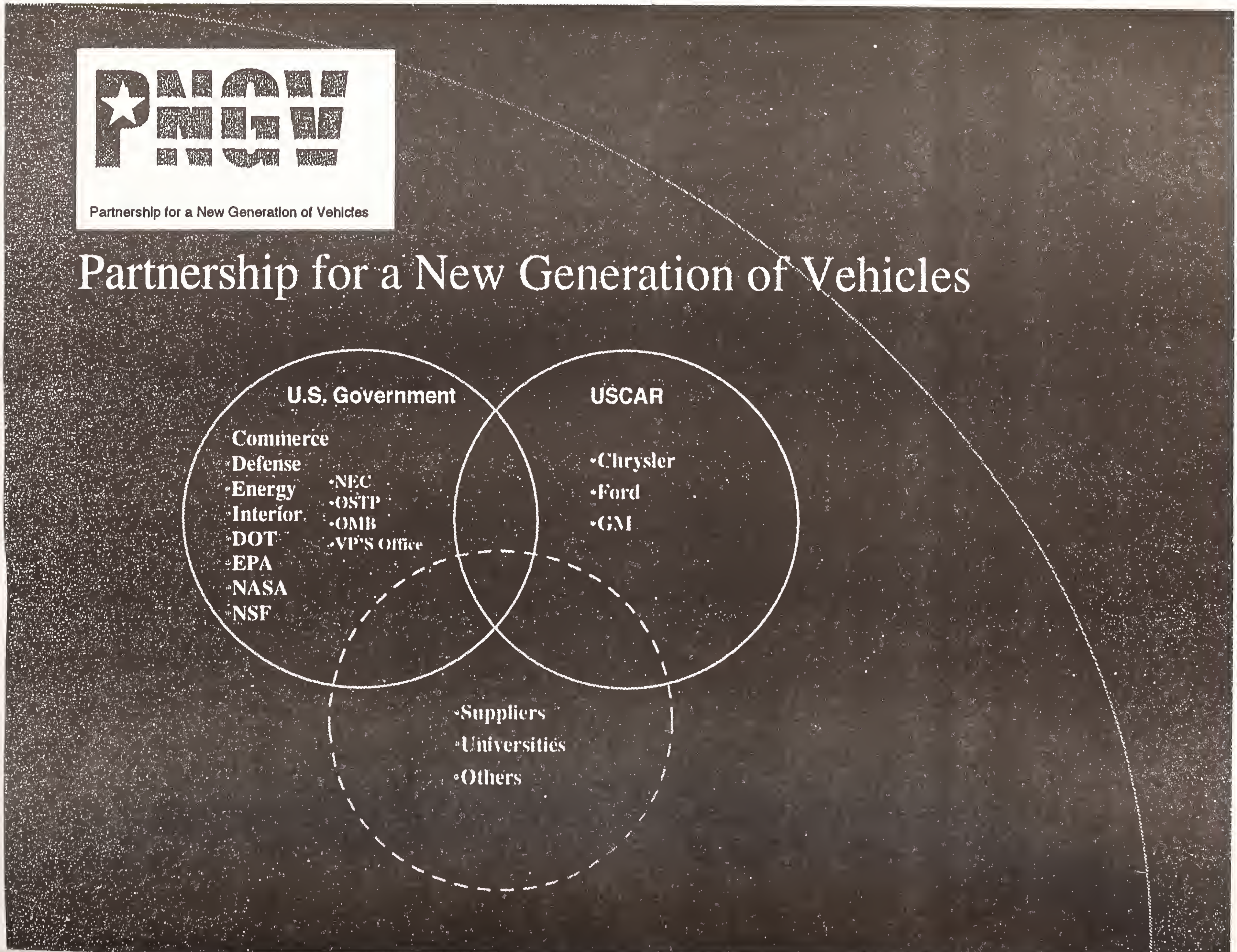
Principles governing Industry-Government civilian technology partnership include:

- industry leadership
- cost-sharing
- competitive, merit-based selection
- evaluation of partnership success
- mechanisms for ending programs

CIT

Civilian Industrial Technology Committee (CIT)

Materials	Electronics (NEMI)	Environmental Technologies
Manufacturing	Automotive (PNGV)	Construction & Building


PNGV
Partnership for a New Generation of Vehicles
Partnership for a New Generation of Vehicles
U.S. Government
Commerce
•Defense
•Energy
•Interior
•DOT
•EPA
•NASA
•NSF
•NEC
•OSTP
•OMB
•VP'S Office
USCAR
•Chrysler
•Ford
•GM
•Suppliers
•Universities
•Others

NEMI

National Electronics Manufacturing Initiative

The purpose of the NEMI, as articulated by the industry working group, is to secure a sustainable world-class advantage for the U.S. electronics manufacturing industry.

NEMI

Working group representatives:

- 18 electronics equipment manufacturing companies
- 20 suppliers of electronics manufacturing components, material, equipment & systems
- 8 universities
- 10 government agencies, 6 national laboratories
- 2 state governments

Task: Set Priorities coupled to Government R&D plans and actions

Building & Construction Initiative

The Industry:

- Employment for 6 million
- New construction = $470B, renovation = $300 B(1993)
- Highly fragmented industry segments
- U.S. leadership in only 4 of 19 construction technologies
- Modest R&D investment ($2.1B overall 1992), mostly in public works (private sources were about $900M)
- Safety issues; incidence of injury among highest of all industries

Building & Construction Initiative

Industry - Government Planning

- NIST
- CERF

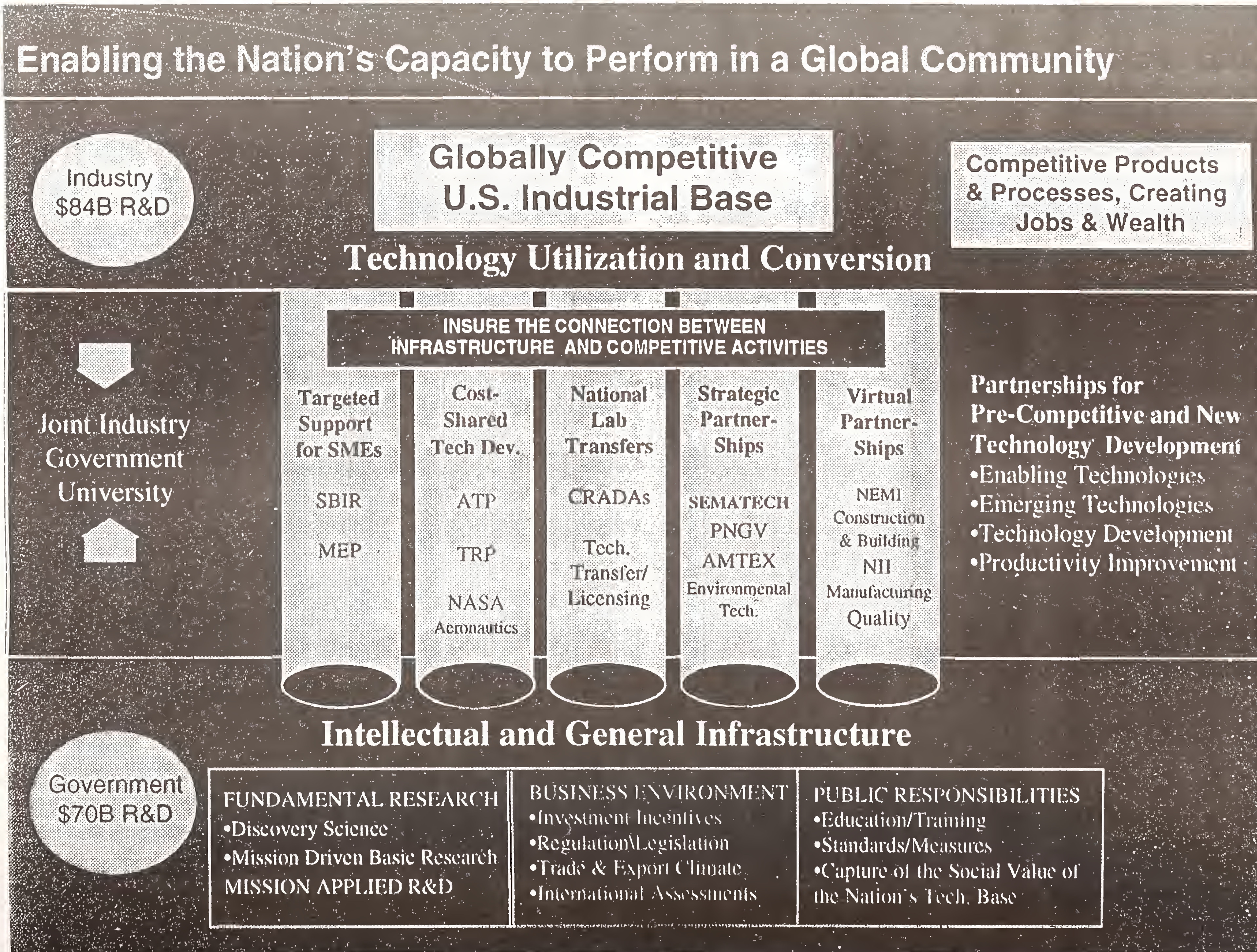
Infrastructure

- Need for leadership in industry and government
- regulatory barriers
- liability laws
- adversarial relations — builders, owners and regulators
- financial disincentives for innovation

Building & Construction Initiative

Technology Foci Identified

- Information and decision
- automation in design, construction and operation
- high performance materials, components and systems
- environmental quality
- risk reduction technologies
- performance standards system
- human factors


Enabling the Nation's Capacity to Perform in a Global Community
Industry $84B R&D
Globally Competitive U.S. Industrial Base
Competitive Products & Processes, Creating Jobs & Wealth
Technology Utilization and Conversion
Joint Industry Government University
INSURE THE CONNECTION BETWEEN INFRASTRUCTURE AND COMPETITIVE ACTIVITIES
Targeted Support for SMEs
SBIR
MEP
Cost-Shared Tech Dev.
ATP
TRP
NASA Aeronautics
National Lab Transfers
CRADAs
Tech. Transfer/ Licensing
Strategic Partner-Ships
SEMATECH
PNGV
AMTEX
Environmental Tech.
Virtual Partner-Ships
NEMI
Construction & Building
NII
Manufacturing Quality
Partnerships for Pre-Competitive and New Technology Development
•Enabling Technologies
•Emerging Technologies
•Technology Development
•Productivity Improvement
Intellectual and General Infrastructure
Government $70B R&D
FUNDAMENTAL RESEARCH
•Discovery Science
•Mission Driven Basic Research
MISSION APPLIED R&D
BUSINESS ENVIRONMENT
•Investment Incentives
•Regulation\Legislation
•Trade & Export Climate
•International Assessments
PUBLIC RESPONSIBILITIES
•Education/Training
•Standards/Measures
•Capture of the Social Value of the Nation's Tech. Base

Joseph Bordogna
Asst. Director for Engineering
National Science Foundation

NSTC CCIT Manufacturing Infrastructure Subcommittee

Joseph Bordogna
Chairperson

April 18, 1995

Manufacturing Matters

- A strong manufacturing base is vital to the economic and military strength of the nation:
  - » 1/5 of GDP (over $1 trillion)
  - » 21 million employed (17% of total workforce)
  - » 20 to 30% higher paying jobs
  - » Employs 75% of scientists and engineers
  - » Conducts 90% of nondefense private R&D
  - » Each 100 jobs supports 60 non-manufacturing positions
  - » Provides essential products for other sectors of economy
  - » $500 billion trade deficit in manufacturing from 1985 to 1990

"To live well, a nation must produce well"

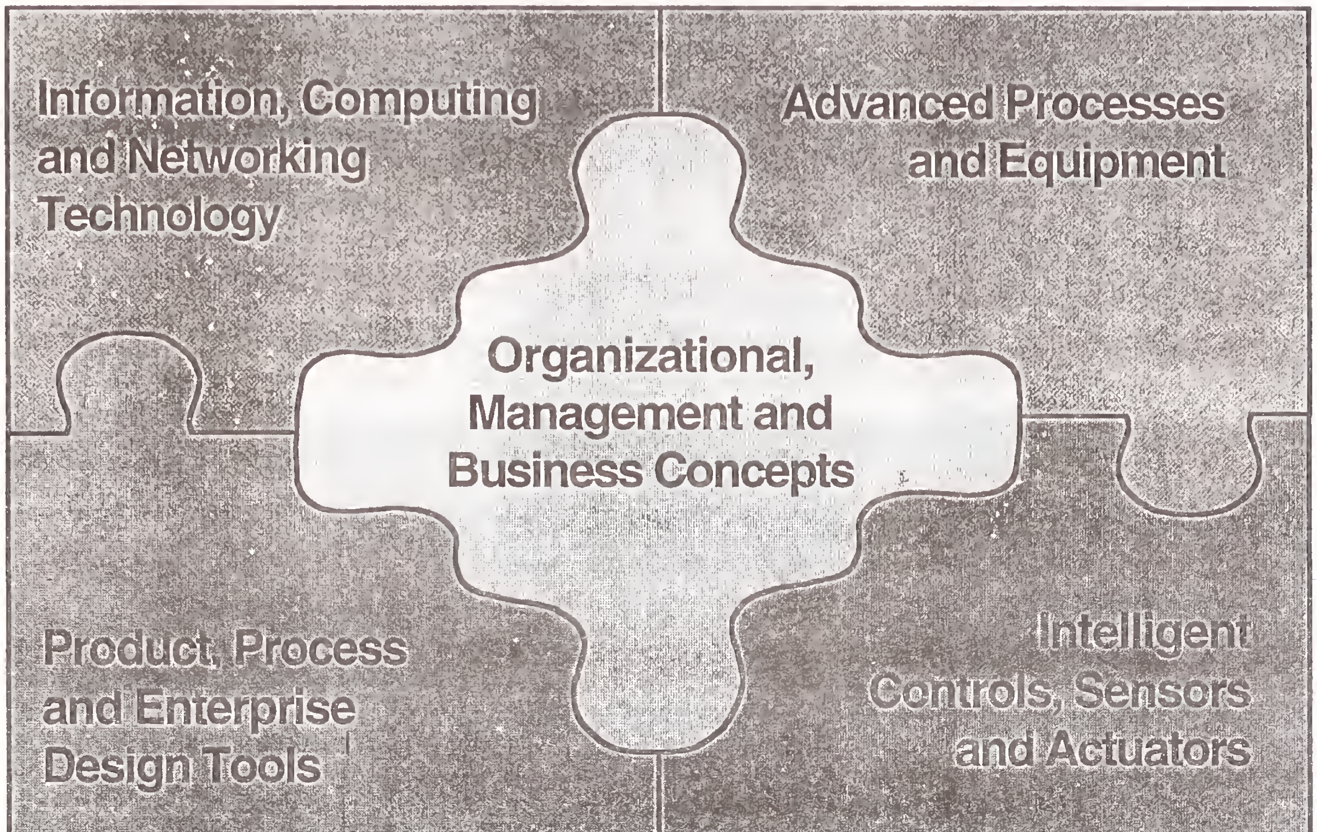
Paradigm Shift

From		To
Inefficient operations with large overhead	→	Highly resource efficient companies
Rigid organizations that are slow to change	→	Rapidly configurable, flexible responsive, agile enterprises
Disconnected "islands of automation"	→	Computer integrated operations
Status Quo mentality and reliance on standard products	→	New focus on quality, safety and customer satisfaction
Technology followers	→	Technology innovators
Specialized functions and workers	→	Diverse, highly skilled, motivated, technologically literate workforce
Adversarial relationships with other stakeholders	→	Partnerships between industry, the workforce, educational institutions and government

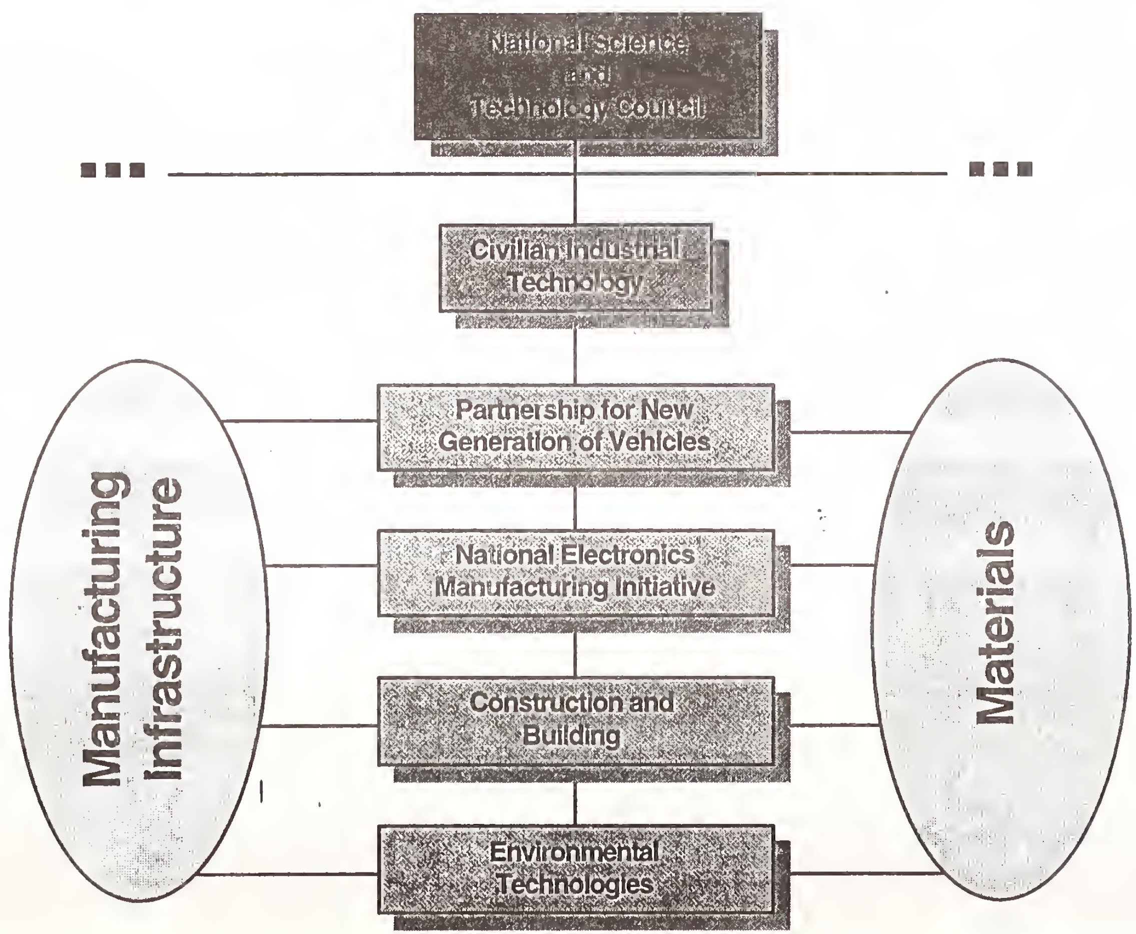
Manufacturing Paradigms

	Craftsmen and Custom	Mass Production	Automated Production	"Next Generation" Systems
Timeframe	Up to Present	1800s to Present	1950s to Present	1990s and Beyond
Lot Sizes	Small	Very Large	Moderate	Small
Unit Costs	High	Low	Moderate	Low
Quality	Variable	Good	Good	Excellent
Delivery Times	Long	Long	Moderate	Short
Flexibility	High	Low	Moderate	High
Environmental Consciousness	Low	Low	Moderate	High

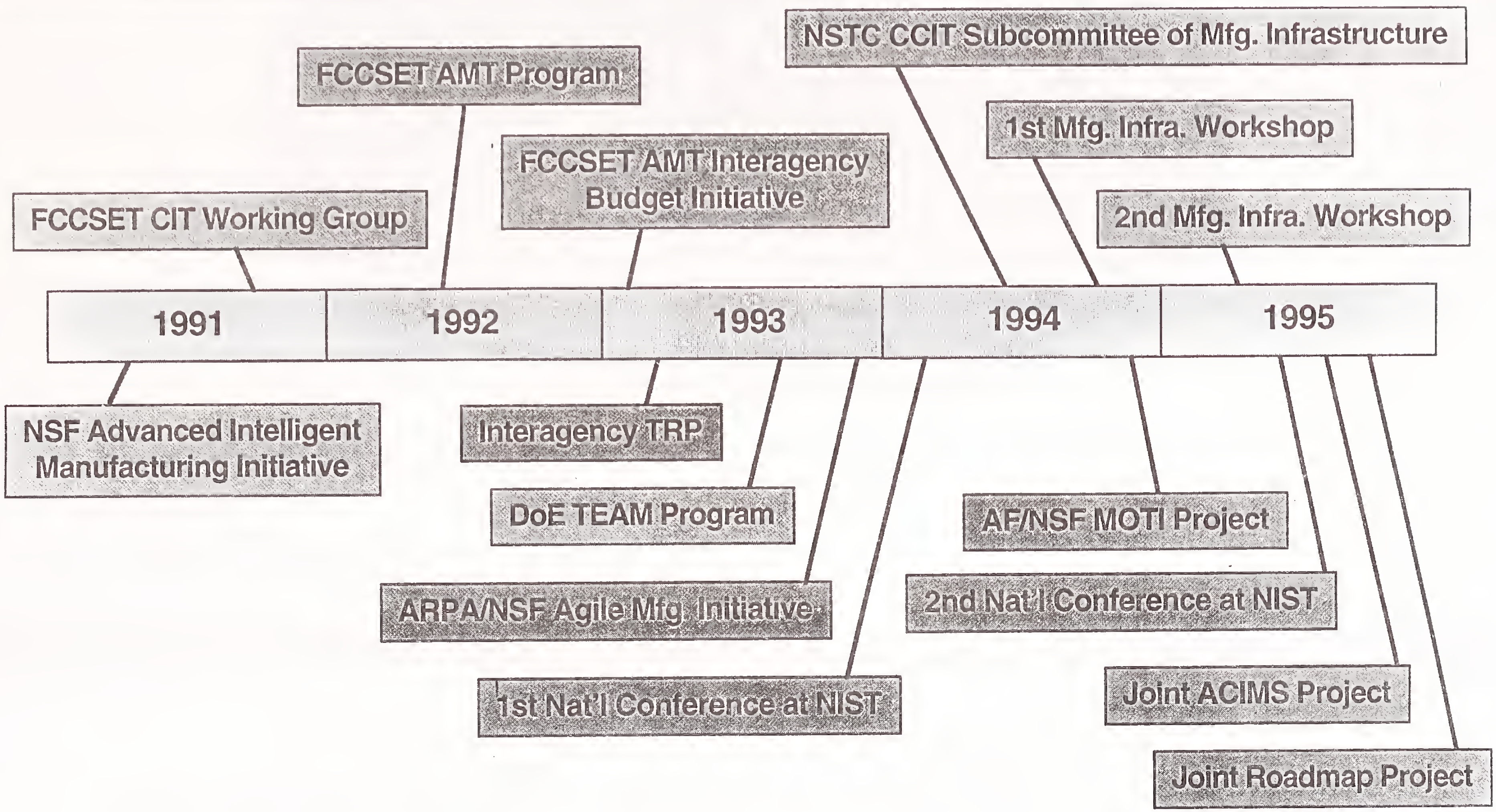
Enabling Technologies



NSTC Organization

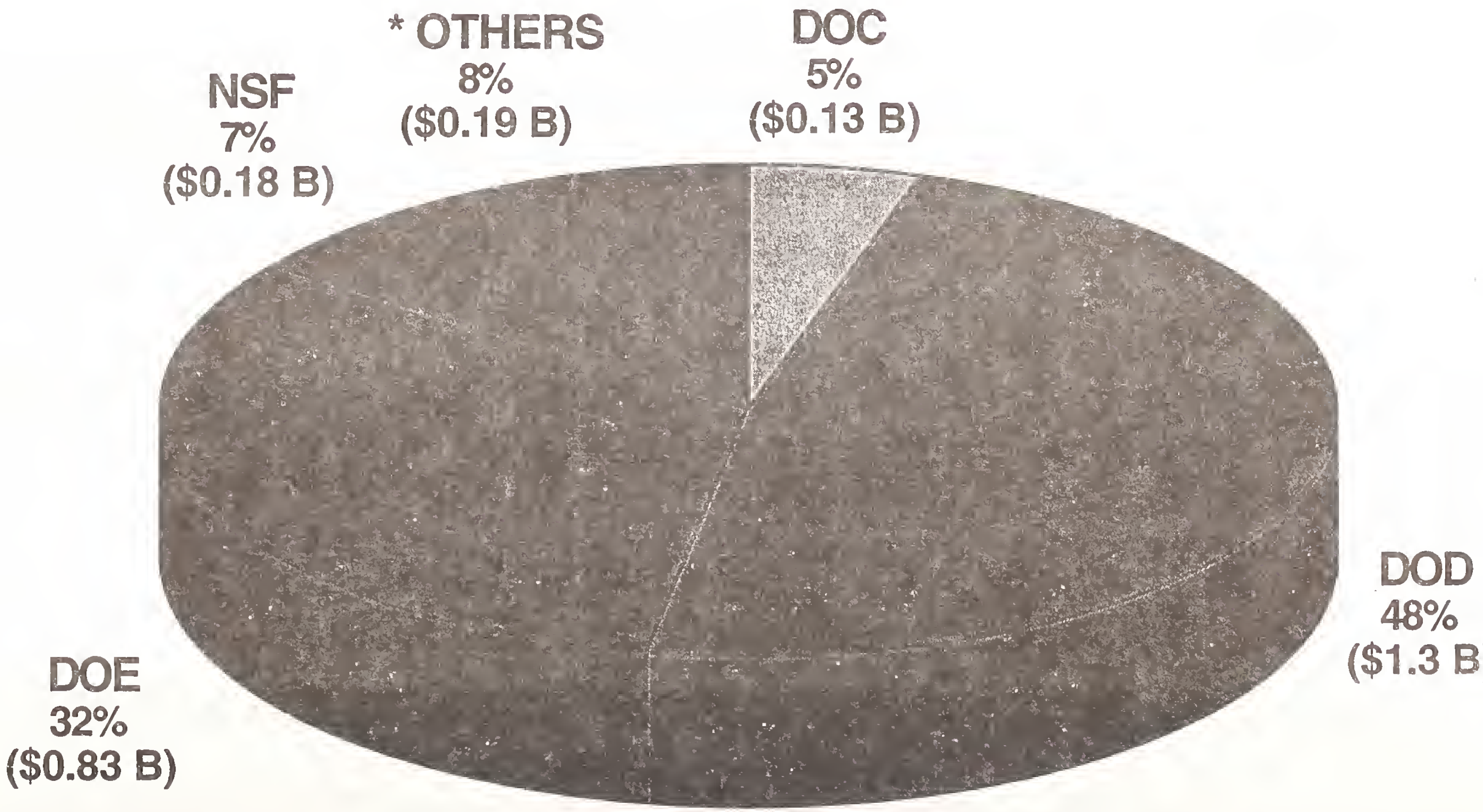


History of Interagency Efforts



FY1994 Mfg. Technology Funding

(Total = $ 2.6 Billion) (Includes Materials Processing)

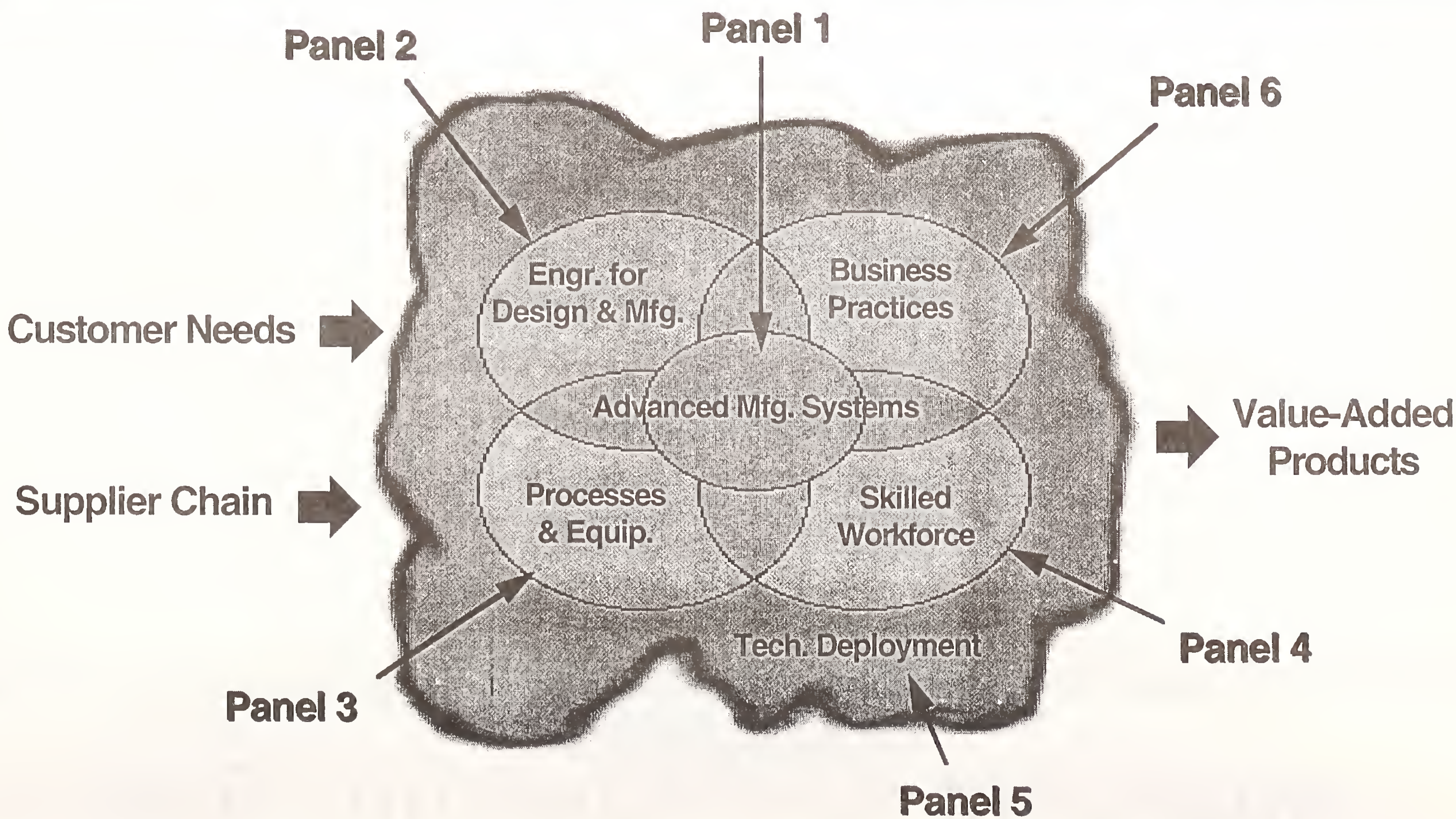


* Others = DOI, HHS, NASA, USDA

Mfg. Infrastructure Elements

- Advanced Manufacturing Systems
- Engineering for Design and Manufacturing
- Advanced Processes and Equipment
- Manufacturing Training and Education
- Technology Deployment
- Business Practices

Mfg. Infrastructure Elements



Advanced Manufacturing Systems

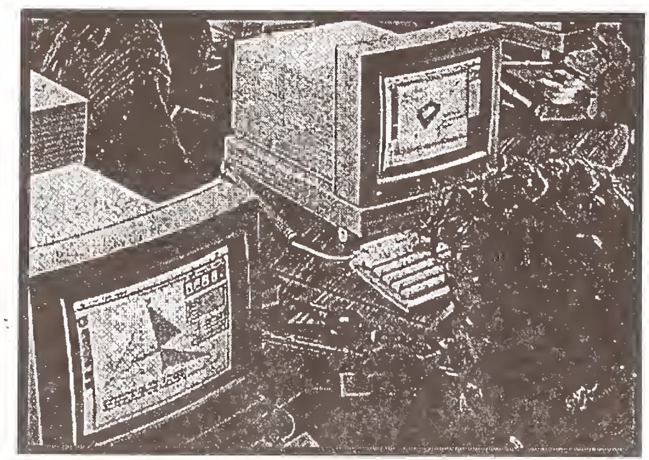
Priorities

- Innovative systems concepts
- Enabling science and technology
- Technology demonstrations
- International cooperation
- Common vision

Engineering for Design and Mfg.

Priorities

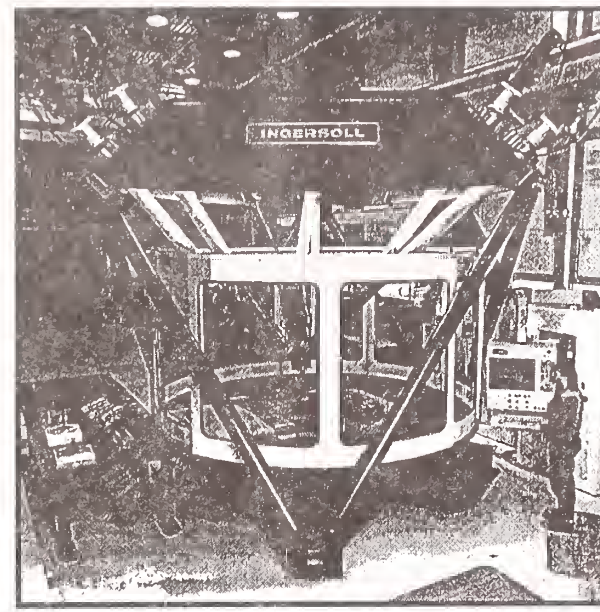
- Collaborative methodologies
- Interoperable tools
- Hybrid prototyping
- Conceptual phase tools
- Design for manufacturability
- Business practice integration
- Modeling and simulation



Processes and Equipment

Priorities

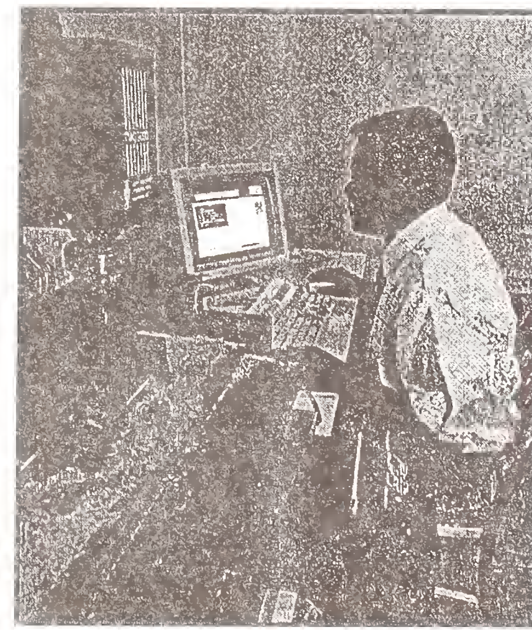
- Intelligent control systems
- Rapid prototyping
- New methods and equipment
- Environmental consciousness



Training and Education

Priorities

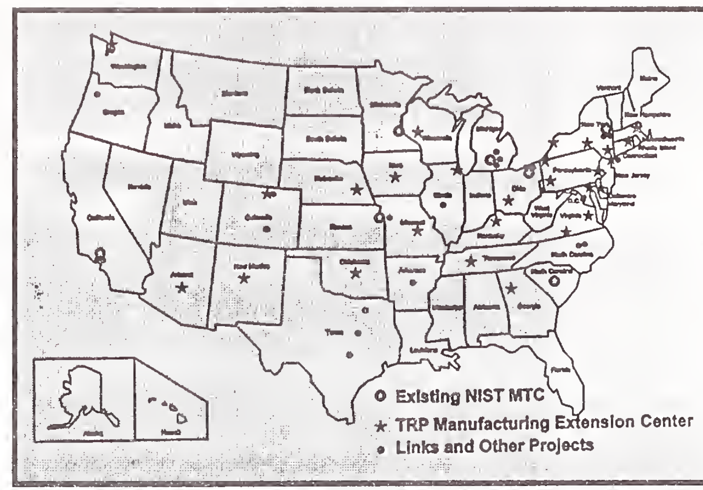
- Coherent framework
- Improve quality for worker training and education
- Consumer information system
- Access for at-risk population
- Leverage funding
- Financial support mechanisms
- Measure results



Deployment

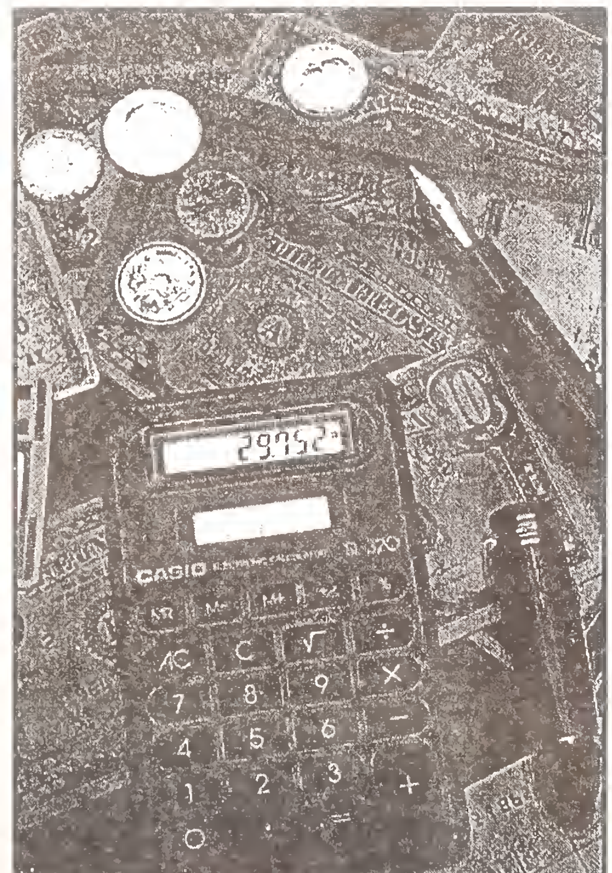
Priorities

- All tiers of industrial base
- Leverage existing public and private resources
- Government role should focus on areas of strength
- Provide mechanisms for deployment to small and medium enterprises



Business Practices

Priorities



Relationship with Other NSTC Activities

NSTC Subcommittees and Groups

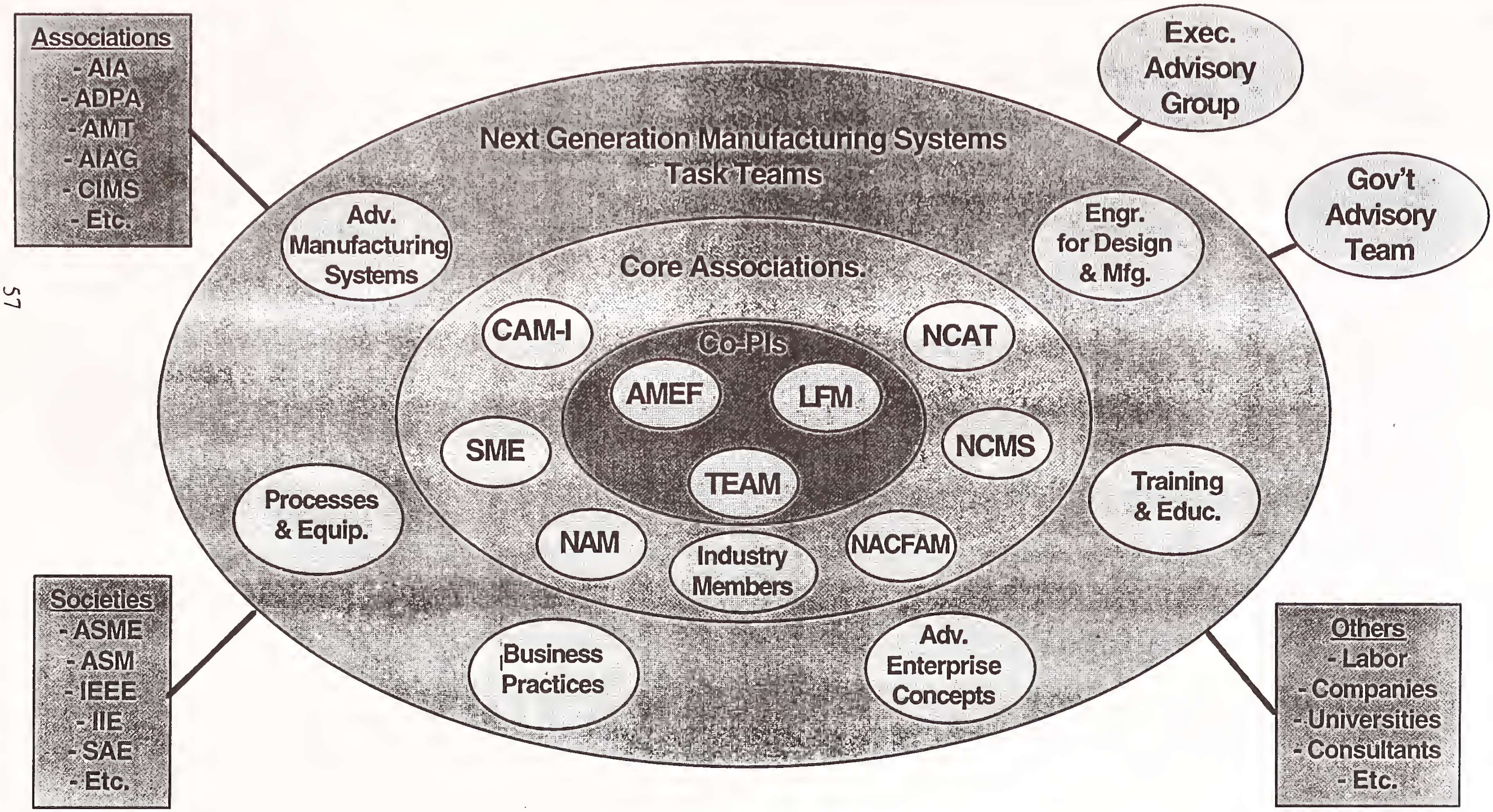
Manufacturing Infrastructure Elements	Partnership for a New Generation of Vehicles	National Electronics Manufacturing Initiative	Advanced Materials	Building and Construction	Environmental Technologies	High Perfromance Computing and Communications	Aeronautics Materials and Manufacturing
Manufacturing Systems	High	High	Moderate	Moderate	Moderate	High	High
Engineering Tools	High	Moderate	Moderate	High	High	High	High
Processes and Equipment	High	Moderate	High	Moderate	High	Moderate	High
Education and Training	High	Moderate	Moderate	High	High	High	Moderate
Technology Deployment	Moderate	Moderate	Moderate	Moderate	High	High	Moderate

● = High Interaction   ◐ = Moderate Interaction   ○ = Low Interaction

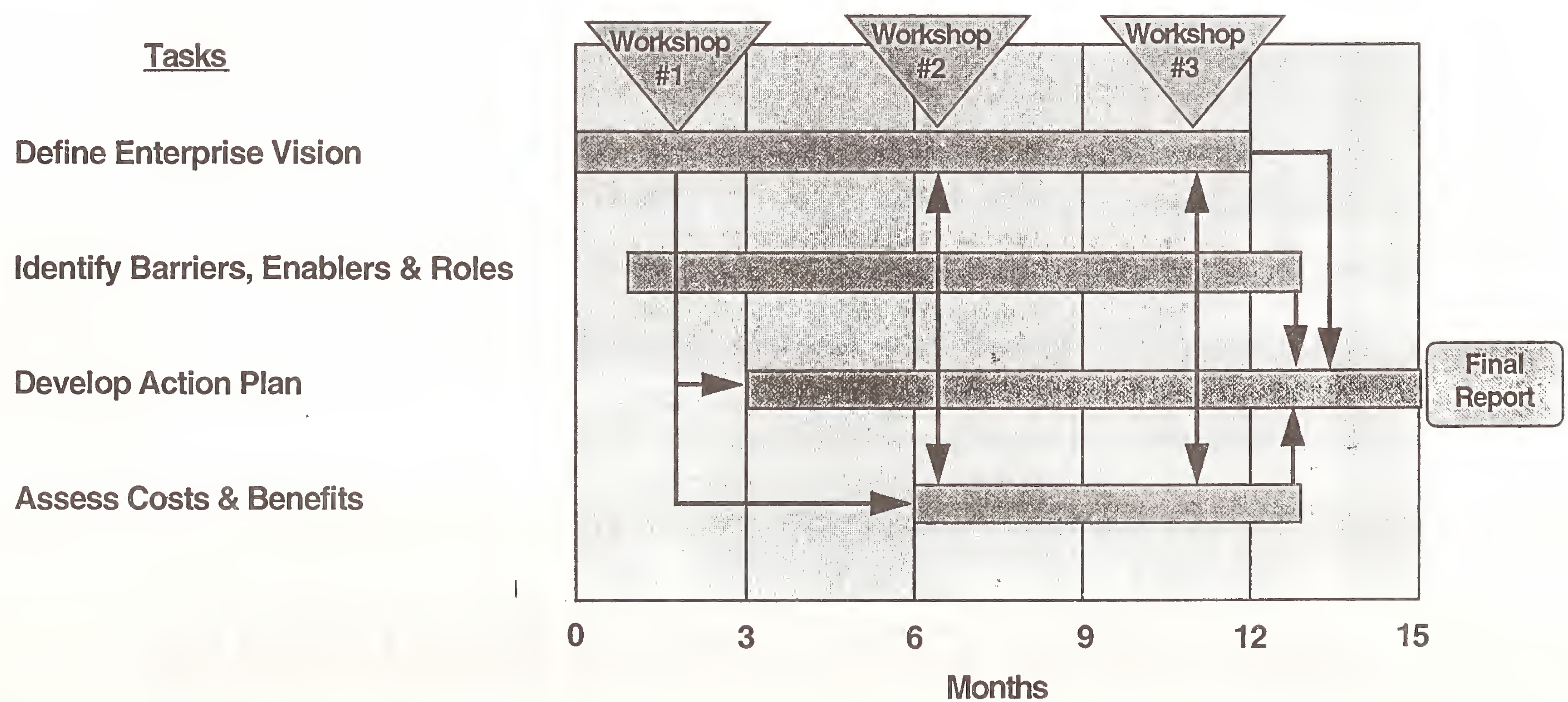
Next Steps

- Results from this meeting will be key input to Subcommittee report
- Draft interagency investment priorities for wide review in 60 days
- Quarterly meetings of Subcommittee panels (including non-government participants)
- Launch collaborative industry/government/ academe roadmapping for Next Generation Manufacturing Systems

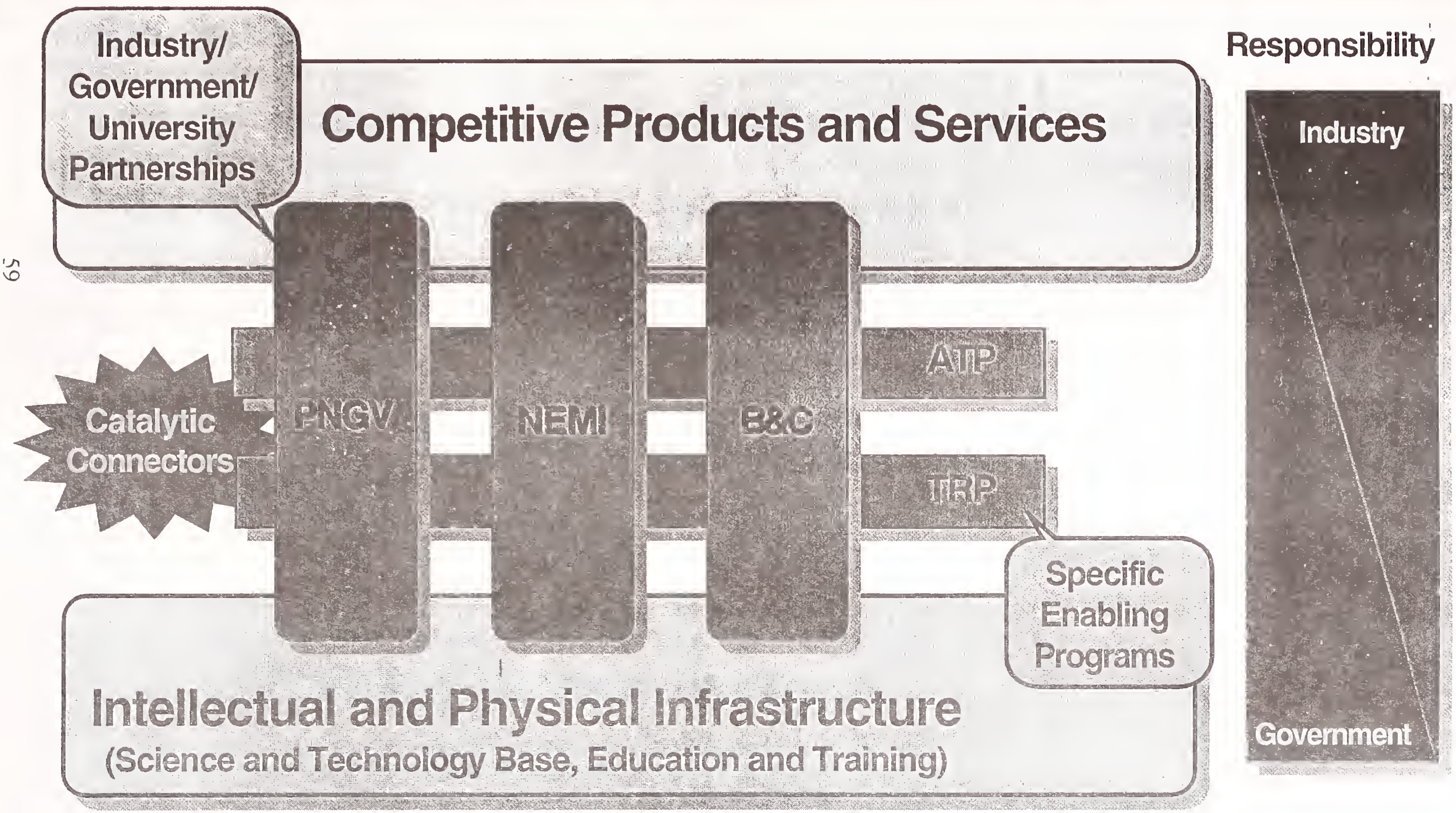
Creating a Unified Agenda



"Roadmapping" Schedule



Enabling the Nation's Capacity to Perform in a Global Economy



Lyle Schwartz
Director
Materials Science and Engineering Laboratory
NIST

CCIT / ADVANCED MATERIALS PROCESSING

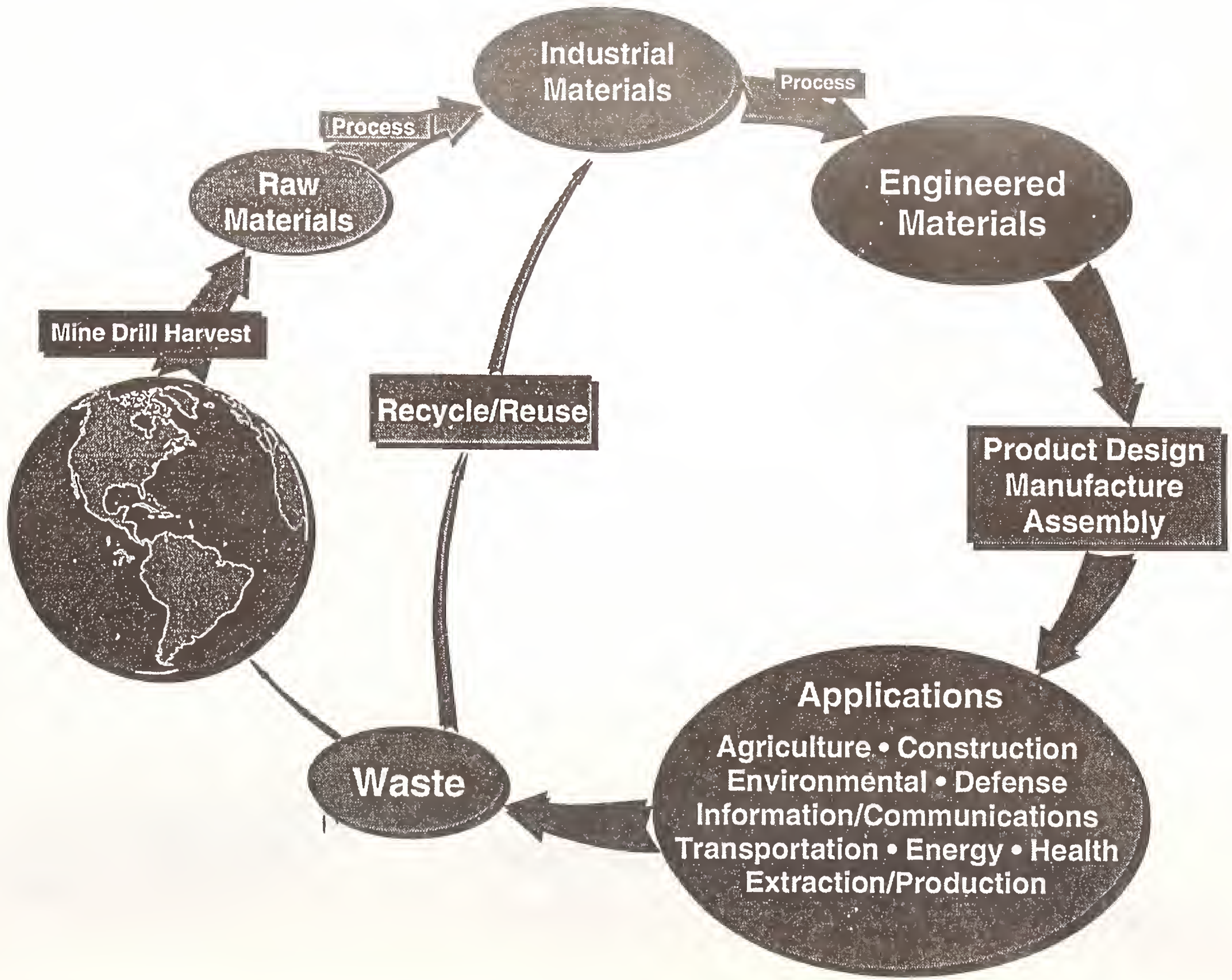
Role of Materials Technology in Meeting Industrial Needs

Lyle H. Schwartz
Director, Materials Science and Engineering Laboratory
National Institute of Standards and Technology

NIST
Gaithersburg, MD
April 18, 1995

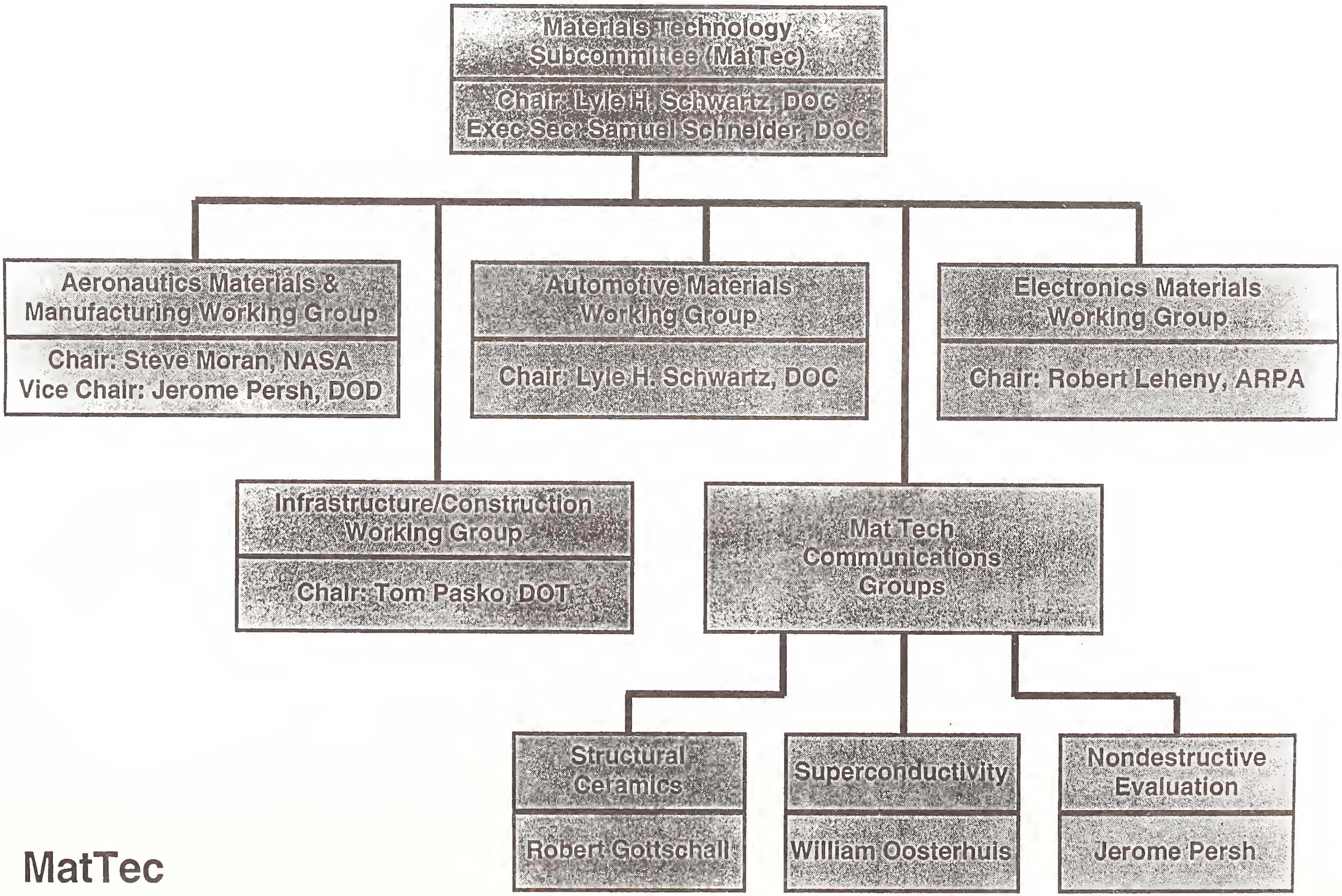

The World Appears
Different ...
... Depending on Your
Point of View

THE TOTAL MATERIALS CYCLE



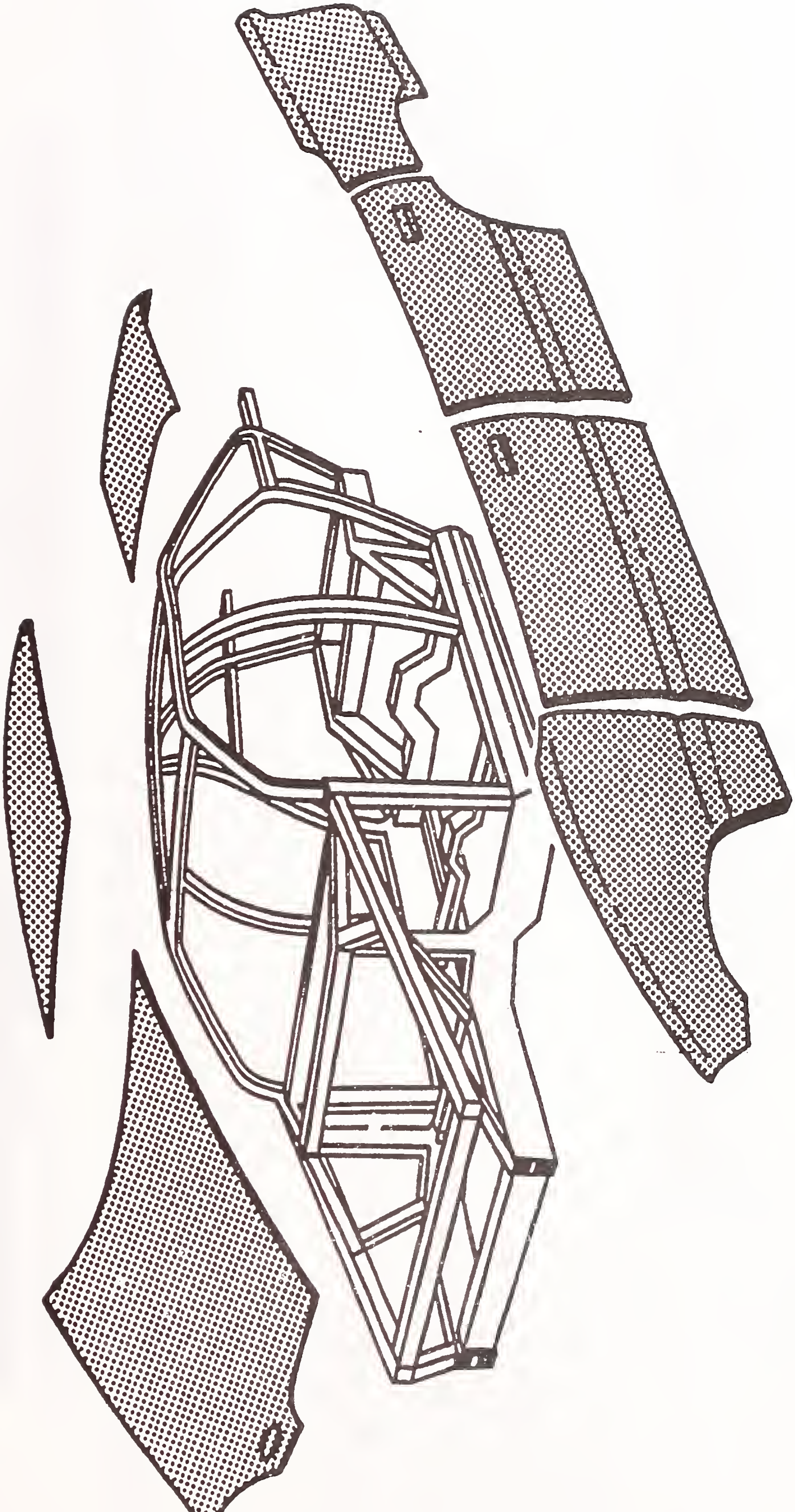
THE MATERIALS TECHNOLOGY SUBCOMMITTEE (MatTec)

- A Subcommittee of the NSTC Committee on Civilian Industrial Technology
- Supports NSTC Goals Through Focused Working Groups
- Fosters Communication and Coordination Amongst Materials Programs of the Federal Government
- Focus on Affordability—Key Processing/Manufacturing


Materials Technology Subcommittee (MatTec)
Chair: Lyle H. Schwartz, DOC
Exec Sec: Samuel Schneider, DOC
Aeronautics Materials & Manufacturing Working Group
Chair: Steve Moran, NASA
Vice Chair: Jerome Persh, DOD
Automotive Materials Working Group
Chair: Lyle H. Schwartz, DOC
Electronics Materials Working Group
Chair: Robert Leheny, ARPA
Infrastructure/Construction Working Group
Chair: Tom Pasko, DOT
Mat Tech Communications Groups
Structural Ceramics
Robert Gottschall
Superconductivity
William Oosterhuis
Nondestructive Evaluation
Jerome Persh

MatTec

AUTOMOTIVE



MatTec - AUTOMOTIVE

- NSTC Oversight Committee(s): Civilian Industrial Technology
- Core Organizations:
  - Private Sector - USCAR/USAMP
  - Government Agencies - DOE, DOD, NSF, EPA, DOC/NIST, DOT, NASA
  - Partnership - Partnership for a New Generation of Vehicles (PNGV)

MatTec - AUTOMOTIVE (Cont.)
PARTNERSHIP FOR A NEW GENERATION OF VEHICLES (PNGV)

Goal 1: Significantly Improve National Competitiveness in Manufacturing

- Advanced Manufacturing Techniques to Make It Easier to Get New Products into the Marketplace Quickly

Goal 2: Implement Commercially Viable Innovation From Ongoing Research on Conventional Vehicles

- Technologies That Can Lead to Near-Term Improvements in Automobile Efficiency, Safety, and Emissions

Goal 3: Develop a Vehicle Up to Three Times Fuel Efficiency of Today's Comparable Vehicle

- Achieve [redacted] the Average of Concorde/Taurus/Lumina, at Comparable Purchase Price

MatTec - AUTOMOTIVE (Cont.)

Technical Focus:

- Lightweight, Recyclable Materials for Structural Applications
- High-Strength, Longer-Life, High Temperature Materials for Engine Components
- Cost Effective Process Technologies and Component Fabrication
- Advanced Materials for Alternative Propulsion Systems

MatTec - AUTOMOTIVE (Cont.) COMMON REQUIREMENTS FOR ALL AUTOMOTIVE MATERIALS

- Plentiful, Readily Available Supply of Raw Materials
- Low-Cost Fabrication at Mass Production Volumes
- Capability to Produce Reliable Parts at Mass Production Rates
- Capability to Meet Quality, Durability, Reliability, and Recyclability Needs
- Broad Supplier Capability in Both Materials and Components

MatTec - AUTOMOTIVE (Cont.)

Program Readiness:

- Technical Roadmap Defined
- Management Structure Planned
- Vice-Presidential Workshop Held
- Materials Suppliers Engaged
- Implementation Process Underway


AERONAUTICS

MatTec - AERONAUTICS

NSTC Oversight Committee(s): Civilian Industrial Technology; Transportation

Core Organizations:

- Private Sector - AIA, Airframe and Propulsion OEMs, Materials Suppliers
- Government Agencies - NASA & DOD lead; DOE, EPA, FAA, DOC/NIST, NSF

MatTec - AERONAUTICS (Cont.)

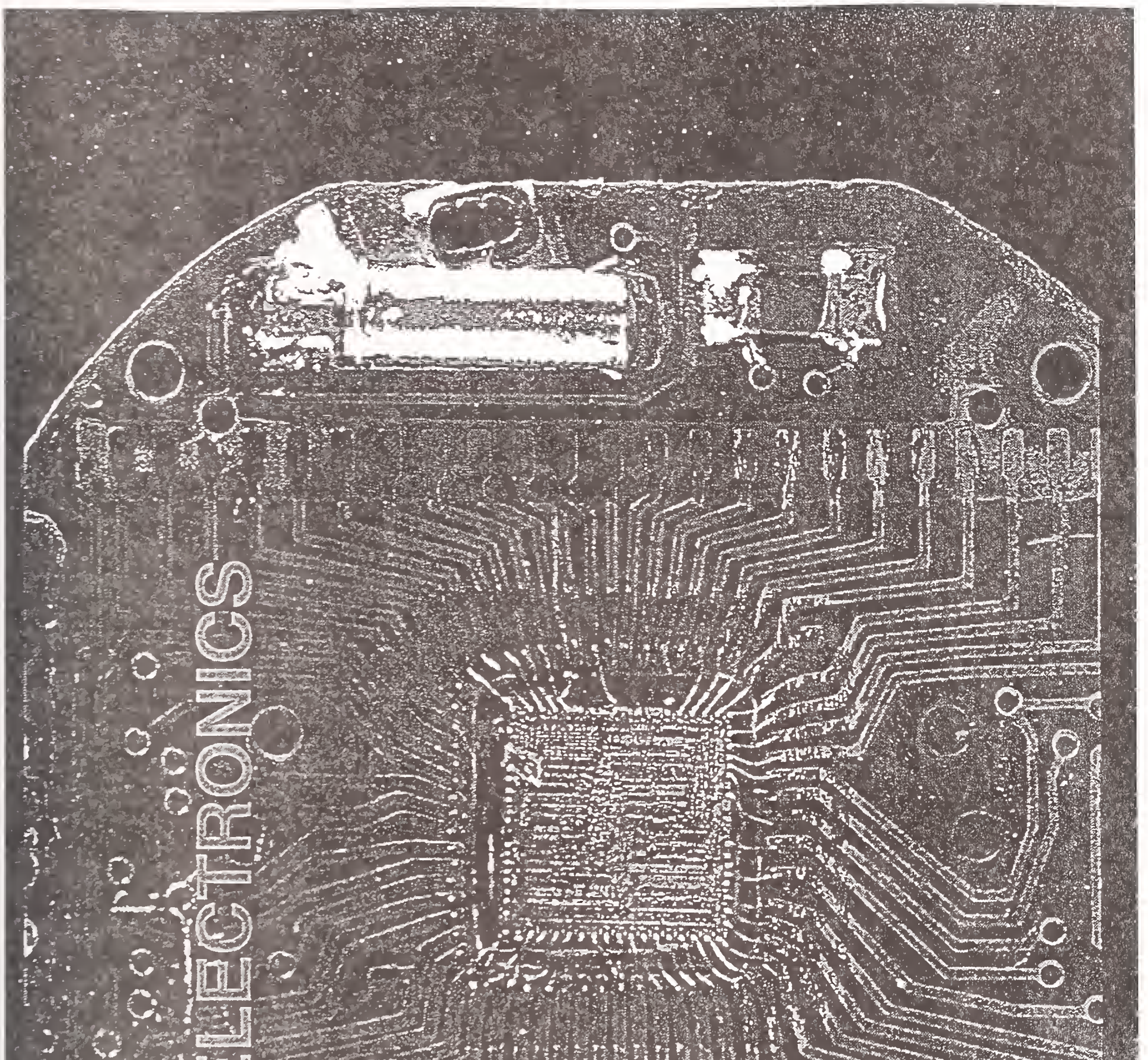
Technical Focus:

- Low Cost, Lightweight Materials for Subsonic Airframes
- Lightweight, High Temperature Materials for Turbine Engines and Supersonic Airframes
- Low Cost, Environmentally Friendly Materials Processes
- Materials and Process Standards

MatTec - AERONAUTICS (Cont.)

Program Readiness:

- R&D Roadmap Prepared for Review by NSTC Agencies
- Some Relevant Government Programs Underway
- NASA's High Speed Civil Transport Program
- DoD and NASA – Composites Manufacturing Programs


ELECTRONICS

MatTec - ELECTRONICS

NSTC Oversight Committee(s): Civilian Industrial Technology

Core Organizations:

- Private Sector - Industry Associations (e.g., SIA, SEMI, EIA)
- Government Agencies - ARPA, DOE, DOC/NIST, NSF

MatTec - ELECTRONICS (Cont.)
NATIONAL ELECTRONICS MANUFACTURING INITIATIVE (NEMI)

- Focus - Information Hardware
- Scope - Product, Process and Infrastructure Technologies
  - Electronic Components and Component Processes
  - Module Interconnect Systems and Processes
  - Electromechanical Assembly, Including Packaging
  - Electronic Parts Manufacturing Infrastructure

MatTec - ELECTRONICS (Cont.)

Technical Focus:

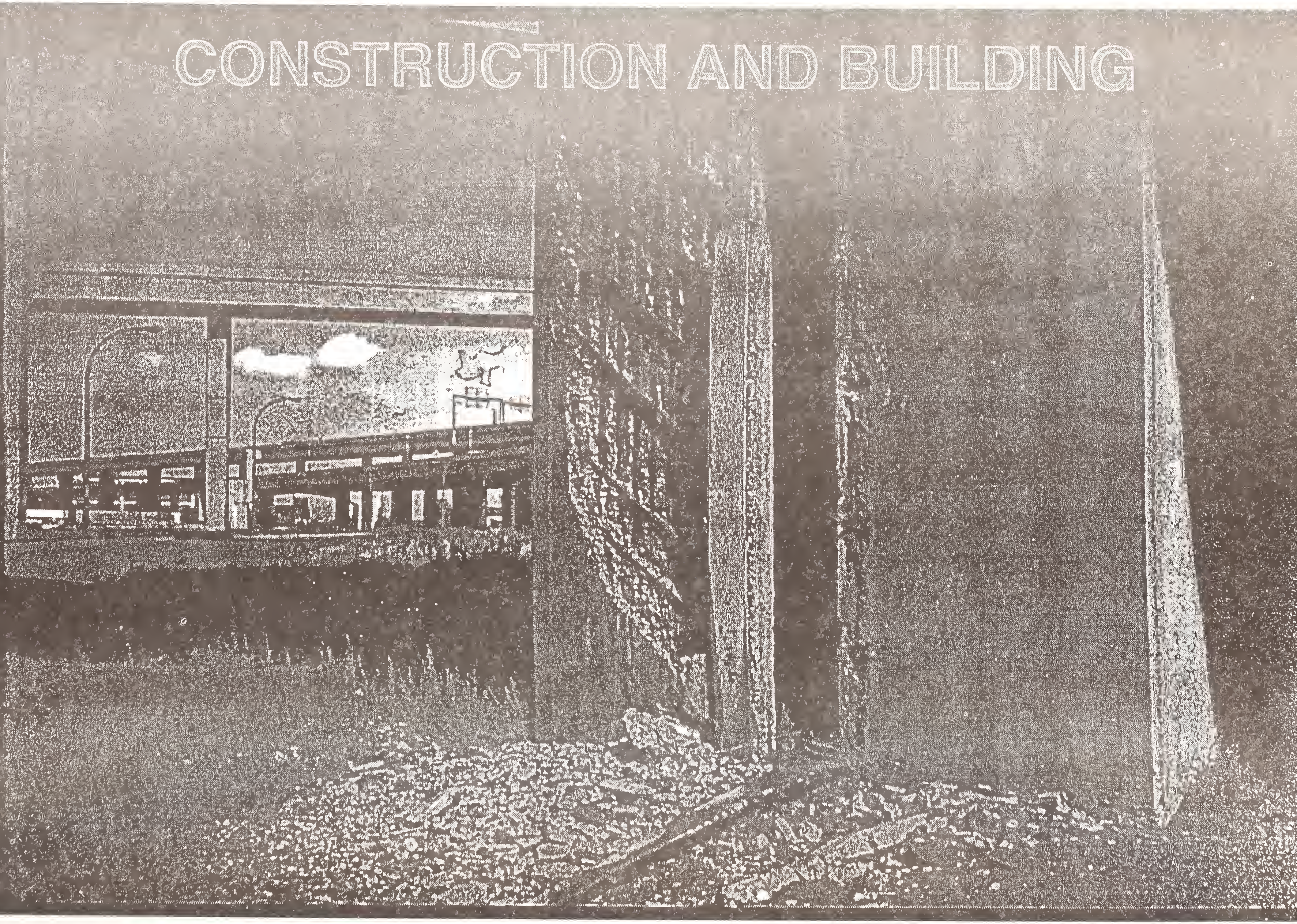
- Track NEMI Roadmap for Materials Technologies Barriers
- Continuing Focus on Silicon Technology and Higher Scale Integration
- Packaging and Interconnection, Materials Issues

MatTec - ELECTRONICS (Cont.)

Program Readiness:

- Technical Assessment for Materials Technologies Completed in Draft Form
- NEMI being "Internalized" by Private Sector
- Government Roles Need Further Clarification

CONSTRUCTION AND BUILDING



MatTec - CONSTRUCTION AND BUILDING

NSTC Oversight Committee(s): Civilian Industrial Technology; Transportation

Core Organizations:

- Private Sector - Civil Engineering Research Foundation and Construction Related Groups
- Government Agencies - DOT Lead, DOC/NIST, DOD, DOE, EPA

MatTec - CONSTRUCTION AND BUILDING (Cont.)

Technical Focus:

- Longer Life Constructed Facilities AND Buildings
- Reduced Repair Costs, Easier Construction Through New Materials
- Lower Materials Production Costs
- New Design and Construction Technologies Development
- New Codes and Practices Acceptable to the Trades/Local Governments

MatTec - CONSTRUCTION AND BUILDING (Cont.)

Program Readiness:

- Technical Roadmap for Materials Technologies has been Developed:

  "Materials for Tomorrow's Infrastructure"

  Available from:
  Civil Engineering Research Foundation
  (202) 842-0555
  CERF Report # 94-5011

- Government Programs are Expanding in DoT and DoC

SUMMARY

- Materials Availability at Affordable Cost is Central to the Pursuit of Most Industrial Manufacturing Goals
- Federal Government Scientists and Programs have become an Integral Part of the Web of Technology Development Required to Achieve These Goals
- MatTec is Organized to Coordinate and Facilitate the Public/Private Interface in this Process

Manufacturing Sector Needs and Issues

Representatives of six major industries summarized key issues within the framework developed by the CCIT Subcommittee on Manufacturing Infrastructure.

James M. Sinnet
V.P. and General Manager
McDonnell Douglas Corp.
New Airfcraft and Missile Products

AEROSPACE SECTOR NEEDS AND ISSUES

by

J. M. Sinnett
Senior Vice President
New Aircraft and Missile Products
McDonnell Douglas Aerospace

Good afternoon, Ladies and Gentlemen. It is a pleasure for me to be here today to share some of our thoughts regarding the needs and issues surrounding manufacturing technology for the aerospace business.

First, it is important for me to express the context of these thoughts. While we come to you from primarily the defense side of the business, we believe the principles universally apply to the commercial side of the business. Most examples and background originate from the tactical aircraft end of our business.

Overall, Aerospace industry sales grew for a dozen or so years, prior to peaking in 1991-1992, as illustrated in Figure 1. Since then, for the most part, we have been living off business backlog, or prior years' orders. The balance of trade, for U. S. Aerospace, compared to total U. S. Merchandise, illustrates the economic importance of the Aerospace manufacturing sector. Again, I remind you that we are primarily working off our backlog, with new orders at an all-time low.

As we go forward, perhaps we should reflect, quickly, upon the state of the Aerospace industry, Figure 2.

We believe the overwhelming issue of the day to be a matched set: affordability and profitability. Both are closely linked to acquiring new business. "Affordability", beyond being the buzz-word of the day, means that we must stem the rising tide of unit costs to compete in the world market place. The dynamic here is that as the number of units being built decline, certain fixed costs (for example, those linked with under-utilization of plant capacity) also must be controlled. In addition, it is even more necessary to reduce our direct costs...those associated with the design, development, and production of our product. While we cut costs to enhance the marketability of our product, it is equally as important to ensure profitability of the enterprise, for that is what allows us to stay in business...providing value to our shareholders in return for their investment in us AND providing us necessary working capital for plant and equipment improvement, as well as the means to invest in technology for increased operating efficiencies.

Our vision is to be world leaders in Aerospace. While sometimes this vision is not so apparent on the National Level, it certainly provides a stimulus for us at the corporate level. But, it is becoming more and more difficult to succeed on an international basis. Elements include: the desire of other nations to build an indigenous capability; cooperative arrangements between foreign countries, economic and military; and the rising costs of U. S. products. The reality of life is that we, in our business, often compete as companies against nationalized industries. Having said that, let me be perfectly clear that I am NOT advocating that we nationalize the U. S. Aerospace Industry. However, it is clear that we must consider the changing world environment proactively in order to maintain world leadership.

Another approach, gaining much favor and attention in business circles these days is establishing strategic alliances. These are primarily between prime manufacturers, prime manufacturers and their suppliers, and among the lower tier suppliers, each playing to their specific level of strength as a team. Certain hidden advantages may occur from such alliances, particularly in the product definition stage, as integrated product development is facilitated, and interface requirements better understood between product levels.

Much has been written and said about Dual-use from both perspectives; commercialization of the defense industry and using commercially-based manufacturing techniques to improve defense manufacturing efficiencies. From our perspective as a prime aircraft manufacturer and weapon system integrator, our ability to employ such techniques is, at best, marginal. We must capitalize on two elements: supplier support and dual-use technologies.

Finally, with regard to market risk, one of the unique aspects of the defense business is its lack of stability in procurement quantities, subject to significant change on an annual basis. Often, given the defense acquisition and development process, the idea of cycle time reduction is a non sequitur. Agility is often at odds with unpredictable change. Agile manufacturing can have some significance in a plant where multiple products are produced, particularly as cellular manufacturing processes are introduced. However, one of the characteristics of our business is uniqueness of product. This is true whether talking of a defense product or a commercial product. But, the risk of change is borne in a different manner. For a defense product, the customer bears the risk. This is not so for commercial aircraft. While airliners of a given model may all look the same from the outside, they are built to specific interior and equipment specifications of a given airline. If an order is reduced or cancelled, the manufacturer can be stuck with "white tails" that may be particularly difficult to sell to other customers. The manufacturer often bears the burden of risk; in this case, cost of inventory.

I will not bore you with any more details of the changing environment for Aerospace, except to make two illustrative points. I believe these are necessary to have us all on the same wave length for an understanding of relevant magnitude of quantities produced and rates of production. Recall my earlier comment about reduced rates, plant capacity, and fixed costs.

In 1985, the Department of Defense procured about 500 fixed wing and 350 rotary wing aircraft, see Figure 3. The FY 1995 procurement is for about one-tenth the fixed wing and one-fifth the rotary wing aircraft produced ten years ago. This year, the government of Switzerland is procuring more fighter aircraft than the United States. Naturally, we have been witnessing an accompanying consolidation in the Defense Aerospace business. The same trend appears for commercial aircraft in the past five years.

For a specific comparison of combat aircraft "rate production", consider the F-4 "Phantom", Figure 4. In the late 1960's we delivered up to 72 aircraft per month from our plant in St. Louis. The total production quantity was 5057 aircraft, operated by three U.S. Services and more than 30, worldwide.

Today, McDonnell Douglas is blessed with a number of production programs, Figure 5. There are four tactical aircraft lines (fighter/attack and trainer aircraft) in St. Louis. Last year we delivered, from those four production programs a total of 115 aircraft; including "kits" and Foreign Military Sales.

Historically, one of the traits of the aircraft business was the anti-cyclic nature of defense and commercial business downturns. Figure 6 shows that since 1990, they are in cycle. Namely, both are currently at low stages of any procure/delivery cycle. The commercial business has been said to be on the verge of an upturn...in about a year...for the past three years or so.

Now that we are on the same wave-length, let's turn to one other paradigm. For the past 90 years, particularly for military aircraft, we have emphasized the application of technology to improve the performance, capability, and effectiveness of our products; with costs a secondary, at best, consideration. I believe we may have now turned the corner to emphasize technology to reduce the cost of our product...and, by the way, still meet the "requirement". In addition, we have evolved an increasing focus on process technology; which, in conjunction with good business practices, shows the promise of providing breakthroughs in affordability. It remains for us to motivate and capture an equivalent groundswell from our respective work forces.

If we examine the economics associated with so-called high rate versus low rate production, different cost drivers emerge for the production process. This is characterized in Figure 7. With high rate, emphasis is on recurring costs, as a relatively bigger piece of the pie. For low rate, non-recurring costs (such as for engineering, tooling, and manufacturing set-up) dominate the picture. Our focus should be on both. There is real leverage to be gained through IPPD- Integrated Product and Process Definition, DFMA- Design For Manufacture and Assembly, and a plethora of emerging information technology tools. The latter can be exploited to facilitate process simulation and establishment of a virtual factory, to work out process kinks prior to making physical commitments in plant, equipment and process. The benefits will be reduced costs, via reductions in cycle time, inventory, and non-value added work, and improvements in product quality.

Now, I would like to share with you just a few examples of the work going on in my division in order to illustrate the kind of technology elements we believe can have an impact. I believe these will characterize the "needs" of our industry in a broader sense.

We are developing a number of processes for insertion to our factory floor and application to our existing programs. Some of these are highlighted by Figure 8:

- o Automated Fiber Placement (Composites)
- o High Speed Machining (Metals)
- o Tool-by-Light (Assembly)
- o Low Cost Tooling (Composites)

First, let's address composite materials initiatives.

One could argue that most composites technology, while providing a lighter weight product, is too expensive (in some cases, considered too risky) for commercial application and for the new defense paradigm..."It's the cost, dummy!!" In many cases material fabrication is expensive and the use of robotics has only emulated a labor intensive process, rather than spurring totally new processes. One exception is "fiber placement" of composites; where strips of material are laid in complex curvatures or shapes, and the material is consolidated "on the fly". The process variables are temperature, pressure, and rate. All are machine control parameters. Therefore, once process variables are established for a specific product, say an inlet duct, operator certification is all that is required to provide a quality product...each and every time.

Another characteristic of the most often selected composite materials is that they require a cure cycle; often in an autoclave at elevated temperature and pressure. This leads to massive, expensive tools, and often difficult process control for uniformity of temperature, surface characteristics, and relative thermal expansion between the part and the tool. We have developed a technique by which we fabricate the base tool from room temperature cure composites (no autoclave). An example, showing some of the manufacturing steps, is illustrated in Figure 9. To the surface of the tool, we apply an arc-spray metallic coating, which serves as both a vapor barrier between the tool and the part to be made, and as a hard surface for part definition. The final tool is produced at a fraction of the cost, weight, and volume of traditional steel tools. Thermal expansion of both the part and the tool is identical (both are composite) and temperature control at the tooling interface is facilitated by doing away with the massive heat sink of the traditional tool.

Often composite parts are designed like metal parts, without taking advantage of the unique mechanical properties and design allowables associated with the material. In the extreme, consider the simple substitution of materials; composites rather than metals in the same basic design. This is indeed a more costly prospect. We have a technology program, sponsored by the U. S. Navy, to develop an advanced structural concept utilizing the full material characteristics and advanced manufacturing processes. It is called "Advanced Lightweight Aircraft Fuselage Structure", or ALAFS, illustrated in Figure 10. Inherent in the design is the use of large unitized structures to reduce the number of parts, number of fasteners, number of assembly steps, and opportunities for error. The program goal is to provide a 30% reduction in cost and a 20% reduction in weight, compared to a like conventional structure.

As an example of metal fabrication, let's consider "High Speed Machining". The fundamental is a tool bit that rotates at speeds up to 40,000 RPM, removing material at hundreds of inches per minute, Figure 8. Under these conditions, the traditional heat build-up that occurs in the part during the machining process simply does not occur. Chips are flying so quickly that there is literally no time for heat transfer to the part. The heat goes with the chips. This provides unprecedented thermal stability-no warpage or distortion-of the part. When combined with machine control technology, parts can be machined to unprecedented tolerances and tolerances maintained over a large area. Application of the process will allow us to machine parts which replace previously built-up sheet metal and machine part subassemblies as illustrated in Figure 11. The result is a higher quality product at less cost...fewer parts, fewer tools, fewer fasteners, fewer opportunities for error...and often at less weight than the assembly replaced.

Further, this opens entire new possibilities for the reduction in numbers of assembly tools, since they are eliminated in some cases, and in other cases, the billet can serve as the tool. Figures 12 through 15, in turn, show the main door structure still attached to the parent billet, the opposing side skin, and the billet being used as a tool to mate skin and structure. The contrast between this and traditional tooling concepts for multiple part build-up is best illustrated by comparing Figures 14 and 15. This comparison is indicative of the reduction of tools and several associated "care and feeding" steps (design, fabrication, inspection, maintenance, set-up, and accounting); which can all be eliminated.

Now, take this one more step by integrating the design data base (a digital solid geometry model) and a design process called feature based design, Figure 16. This will allow us to define a structure with integral features, such as back-up structural support ribs, to further reduce the number of parts in perhaps a more complicated assembly. In principle, feature based design can apply at the air vehicle level or all the way down to the individual piece part level. It is all resident in the digital design data base.

If we then use high speed machining for the process, it is called an HSM Isogrid part, Figure 17. Not being satisfied with merely machining the part from a secondary NC machine program, we found a vendor who could machine the part directly from our solid geometry digital design data base...from definition to fabrication, "untouched by human hands". The results are impressive to us. We believe them indicative of the benefits to be derived from the combination of technology application and process change.

Earlier, I alluded to product and process simulation as a means to gain real manufacturing cost leverage. Let's move away now from the parts discussion to the holistic view. My vision is that we employ information and computational technologies to achieve a distributed interactive simulation of the entire definition, development, production, delivery, and support process: Distributed between customer and supplier...at all levels; Interactive with design constraints, requirements, technical trade studies, and cost as an independent parameter. Such a simulation would be slaved from the digital product definition in solid geometry...a single digital data base. Integral elements would be fabrication, assembly, tooling, parts flow, and factory arrangement.

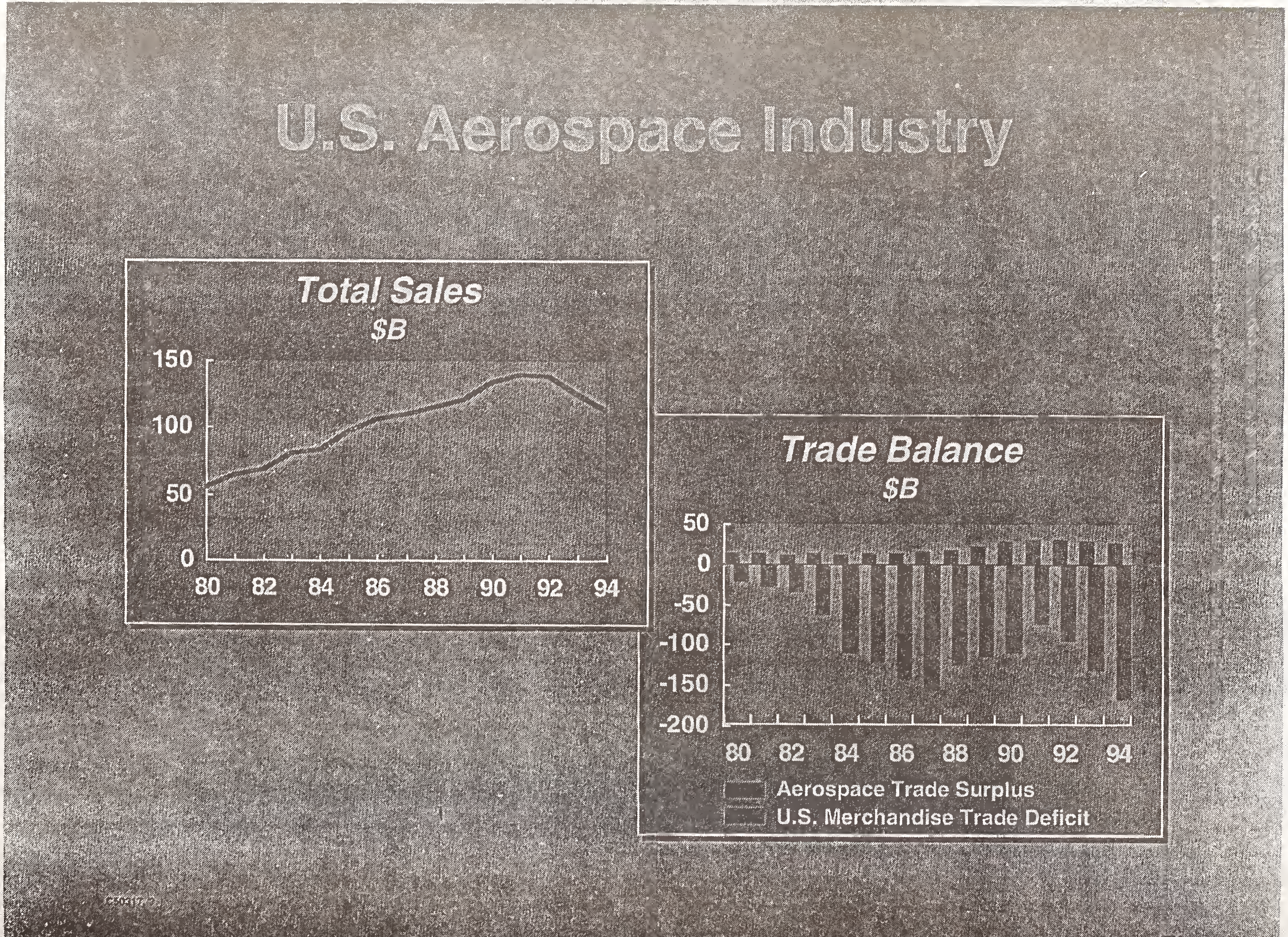
We have begun the journey via a process we call DMAPS, or Design, Manufacturing, and Producibility Simulation, Figure 18. In its entirety, it includes not only product and process definition, but, also, business practices, and cost sensitivities.

Product definition is built from a single data base, as shown in Figure 19. This geometric definition encompasses the product from the external mold line to the build up of structural elements and installation of subsystems and components. Aero, propulsion, thermal, structural, electromagnetic, geometric, and mass properties analyses may be conducted; linked to the single data base. Electronic mock-ups continue to replace physical ones.

The process allows us to construct a "virtual prototype", Figure 20, as a focus for both product definition and development of the supporting analytical tool sets themselves. Such a virtual prototype provides a focus for further integration of the tool sets and definition of the supporting manufacturing, assembly, and sustainability processes for the product. Probably the most significant tangible example is the F/A-18 E/F Forward fuselage and its Assembly Tool, Figure 21. The first F/A-18 E/F Engineering and Manufacturing Development aircraft is currently being fabricated and assembled, with a targeted first flight date late this year. Similarly, we have employed virtual prototyping to verify engine installation procedures for both product assembly and product support.

Well, there is a quick walk-through of many issues and several answers suggested from one segment of the aerospace business. I am confident that you can find the parallels in different sectors of aerospace in particular, and manufacturing in general. Specific applications of the technologies highlighted will, of course, need to address specific product, process, and factory elements or characteristics unique to those business sectors.

In parting, allow me to summarize a few of the strategies which we think are particularly relevant to Aerospace Manufacturing, Figure 22. We must determine a new way of doing business. In order to succeed in global competition, we need to find a way to accommodate low rate production...affordably. We need to be flexible so that we can build the latest technology and developments into our processes and into our factory to reduce costs. We cannot wait for the "next" new start. We need to shorten the product development cycle, reduce risks through application of all elements of virtual prototyping, modeling and simulation with integral cost analyses, and, finally, provide world class quality...at the lowest unit cost.



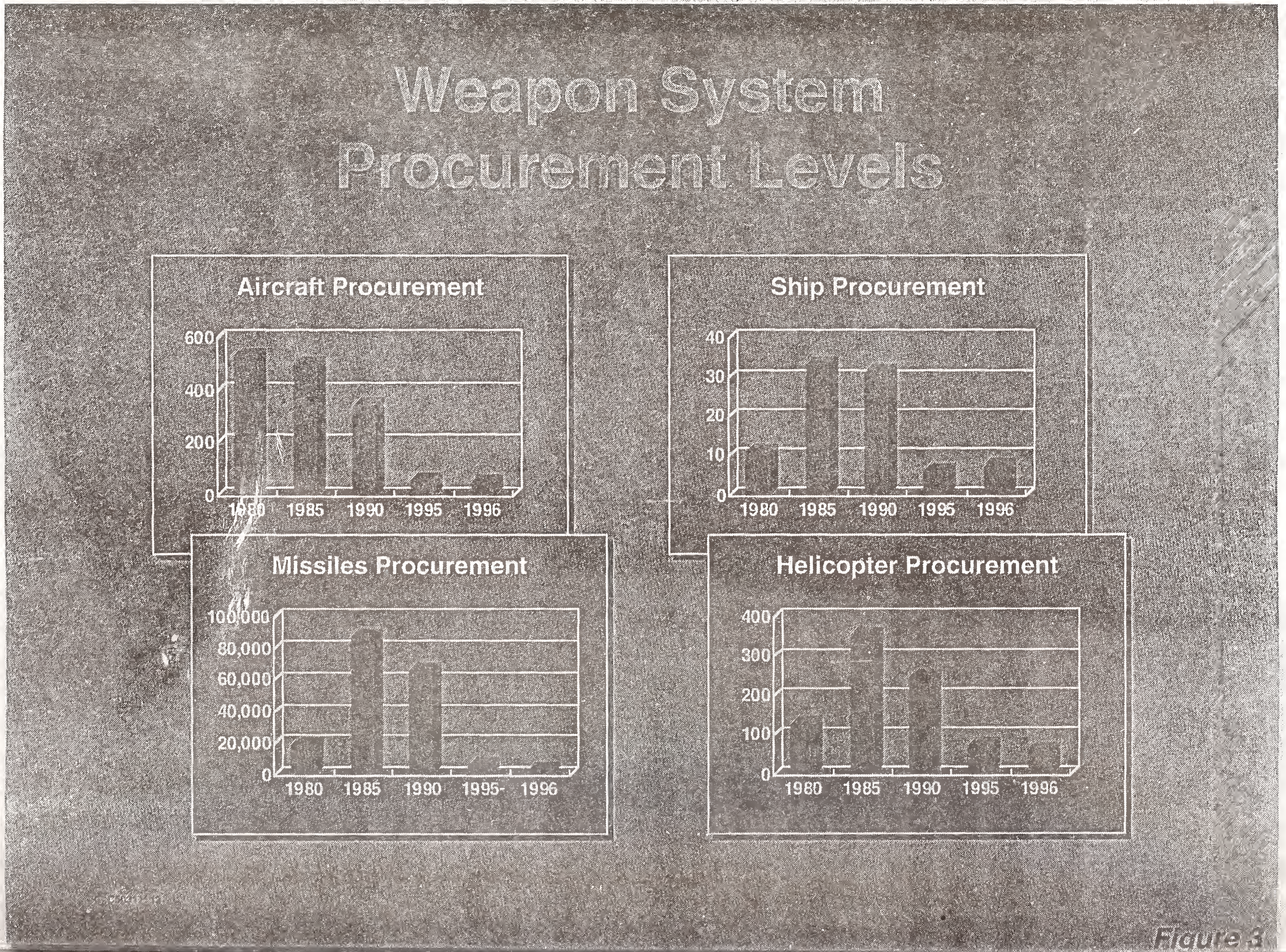
U.S. Aerospace Industry
Total Sales
$B
150
100
50
0
80
82
84
86
88
90
92
94
Trade Balance
$B
50
0
-50
-100
-150
-200
80
82
84
86
88
90
92
94
Aerospace Trade Surplus
U.S. Merchandise Trade Deficit

Figure 1

State of the Aerospace Industry

- Affordability and Profitability
- Global Leadership
- Industry Teams and Alliances
- Market Risk Today

Figure 2


Weapon System
Procurement Levels
Aircraft Procurement
600
400
200
0
1980 1985 1990 1995 1996
Ship Procurement
40
30
20
10
0
1980 1985 1990 1995 1996
Missiles Procurement
100,000
80,000
60,000
40,000
20,000
0
1980 1985 1990 1995- 1996
Helicopter Procurement
400
300
200
100
0
1980 1985 1990 1995 1996
Figure 3

F-4 Phantom

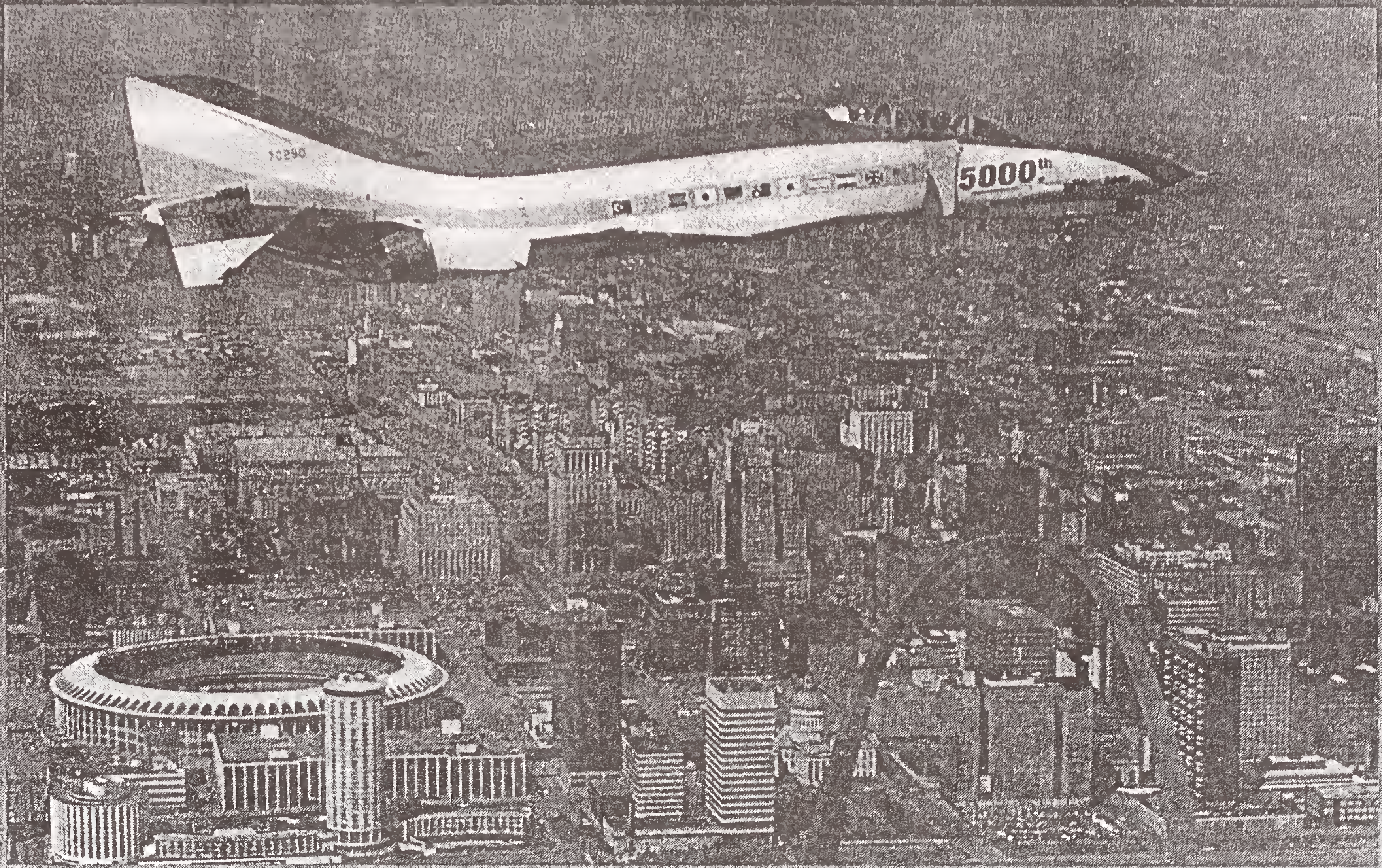


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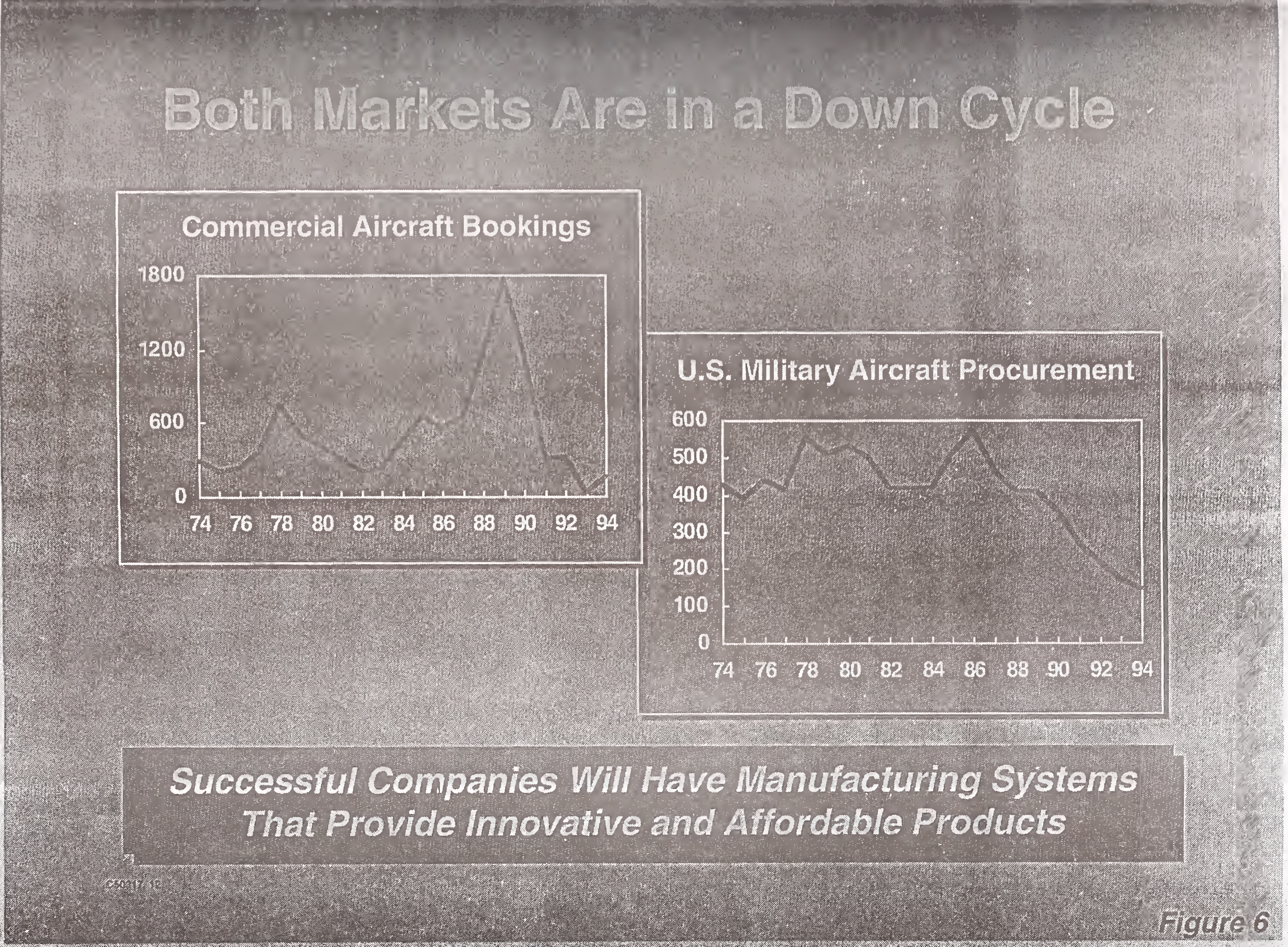
Figure 4

McDonnell Douglas Production Aircraft

C503177-4

Figure 5


Both Markets Are in a Down Cycle
Commercial Aircraft Bookings
1800
1200
600
0
74 76 78 80 82 84 86 88 90 92 94
U.S. Military Aircraft Procurement
600
500
400
300
200
100
0
74 76 78 80 82 84 86 88 90 92 94
Successful Companies Will Have Manufacturing Systems
That Provide Innovative and Affordable Products
Figure 6

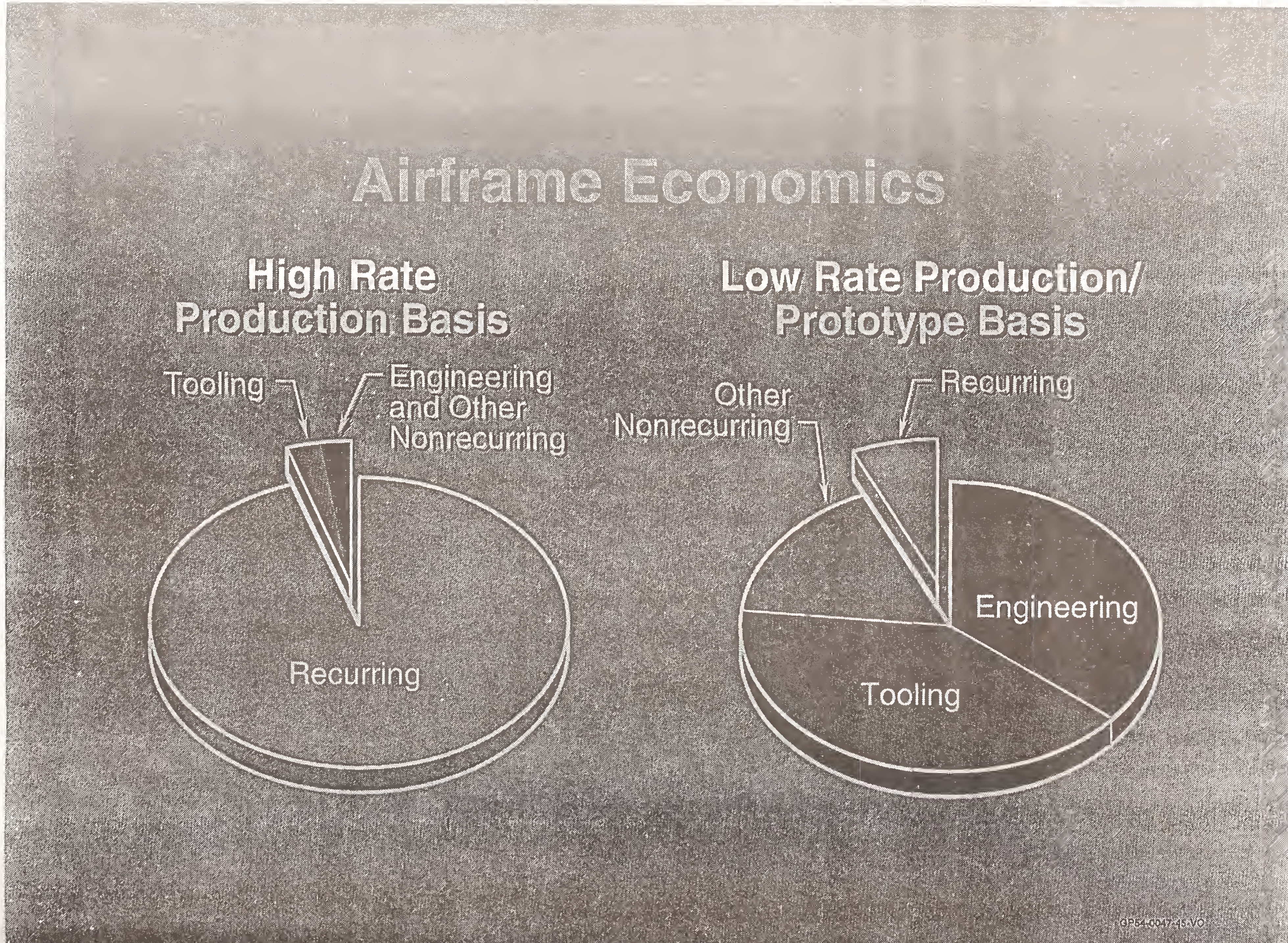

Airframe Economics
High Rate Production Basis
Tooling
Engineering and Other Nonrecurring
Recurring
Low Rate Production/ Prototype Basis
Other Nonrecurring
Recurring
Engineering
Tooling
GP54-0047-45-VO

Figure 7

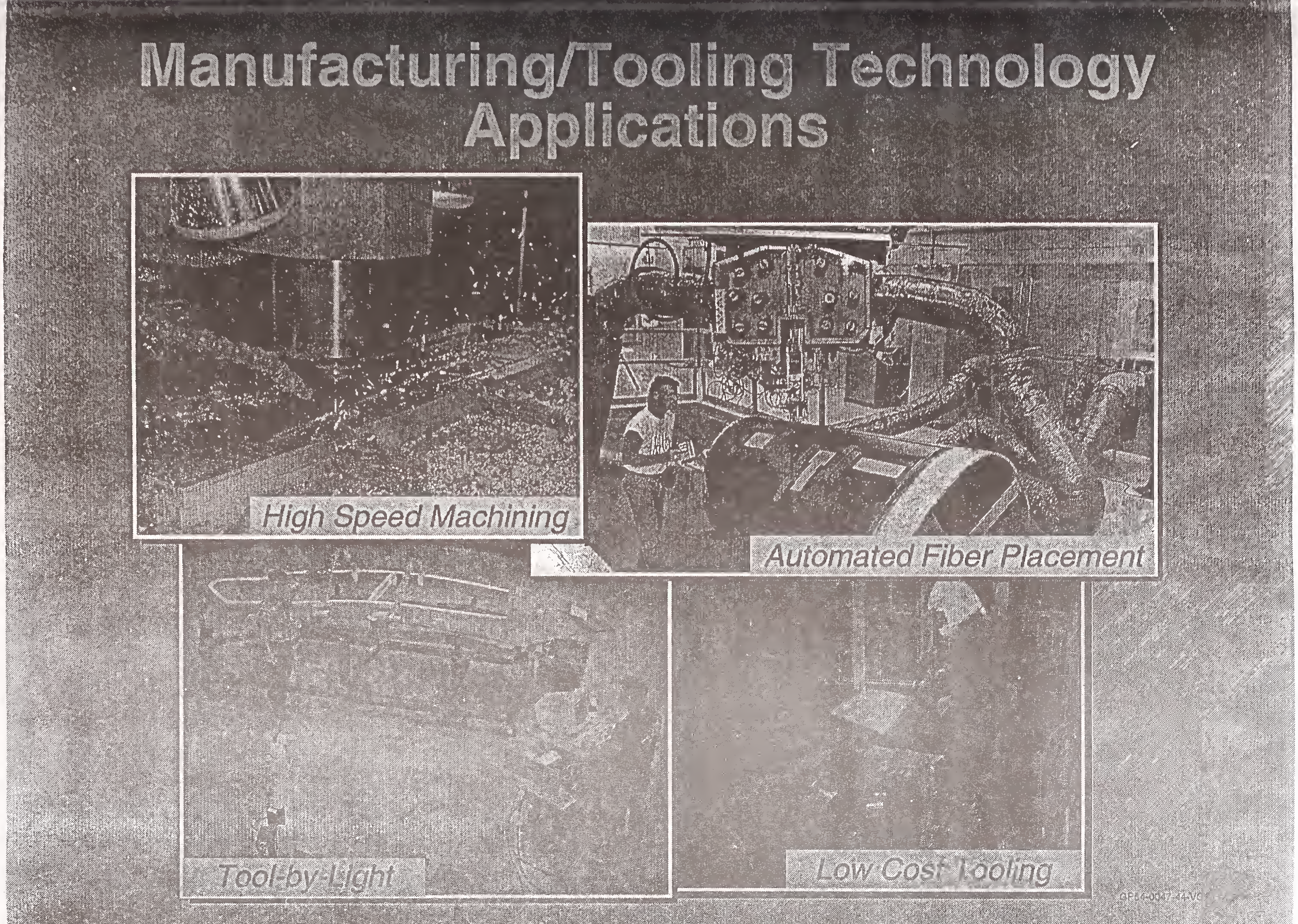
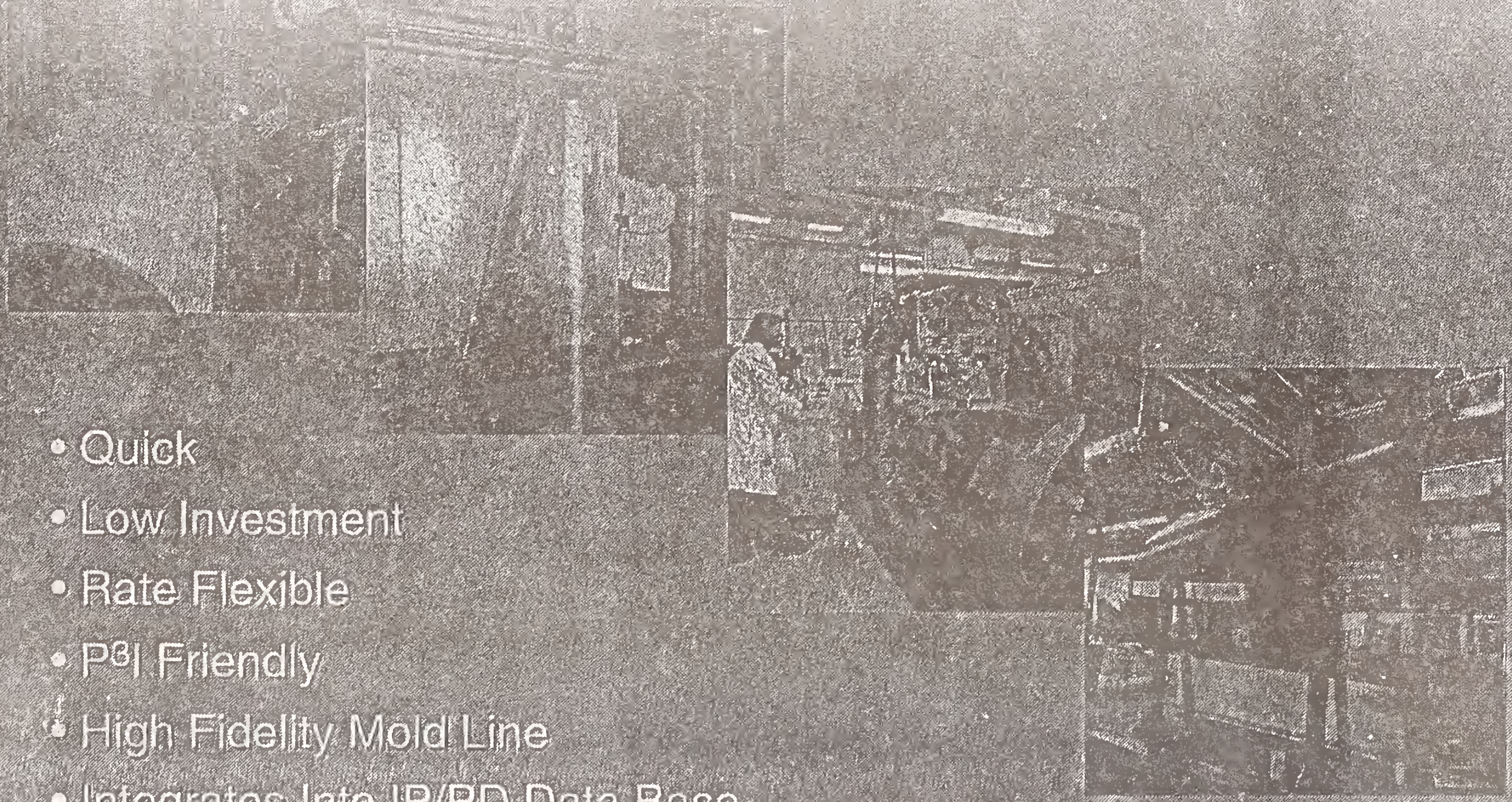

Manufacturing/Tooling Technology Applications
High Speed Machining
Automated Fiber Placement
Tool-by-Light
Low Cost Tooling

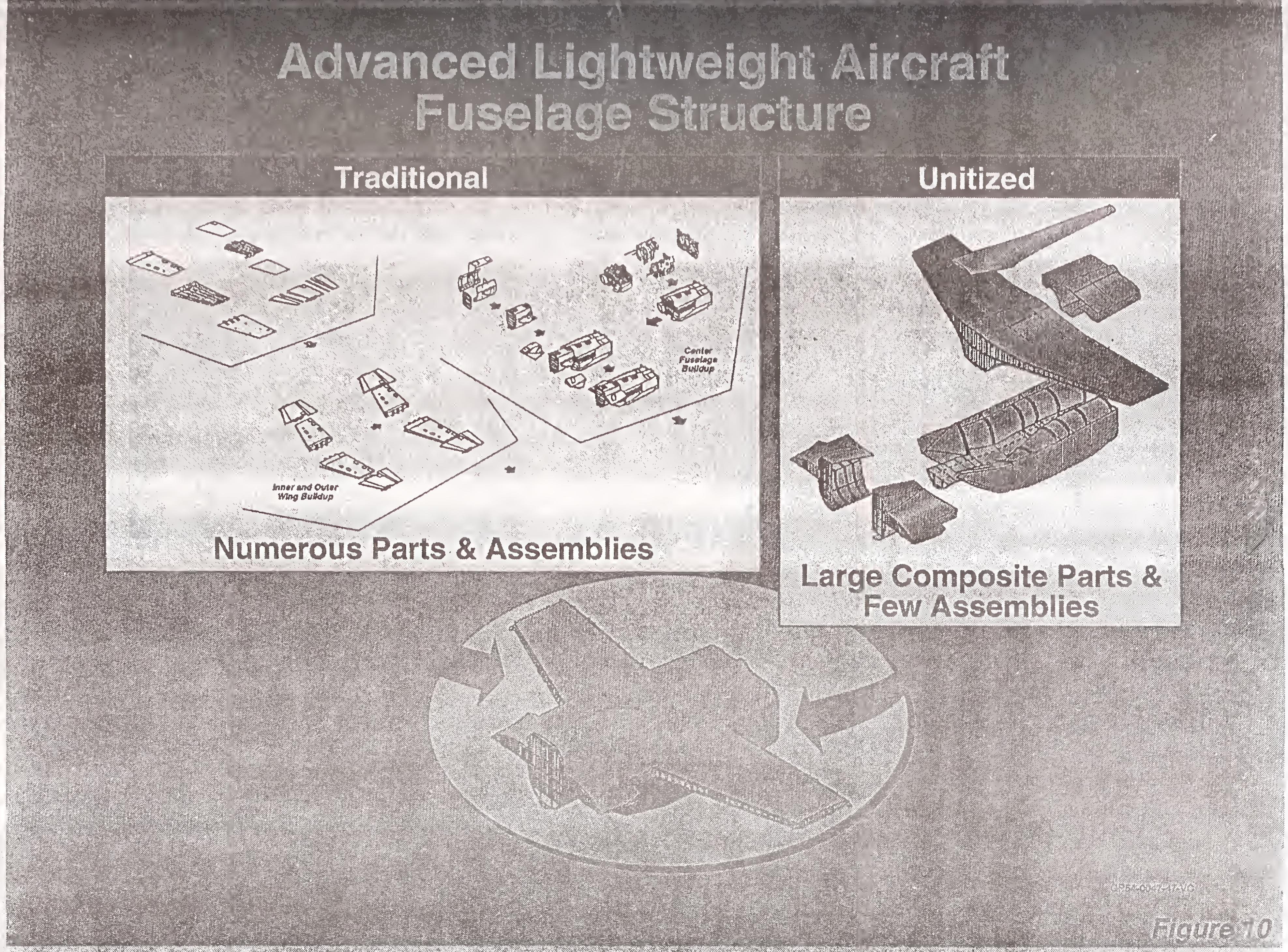
Figure 8

Low Cost Composite Autoclave Tooling



- Quick
- Low Investment
- Rate Flexible
- P^{3}I Friendly
- High Fidelity Mold Line
- Integrates Into IP/PD Data Base

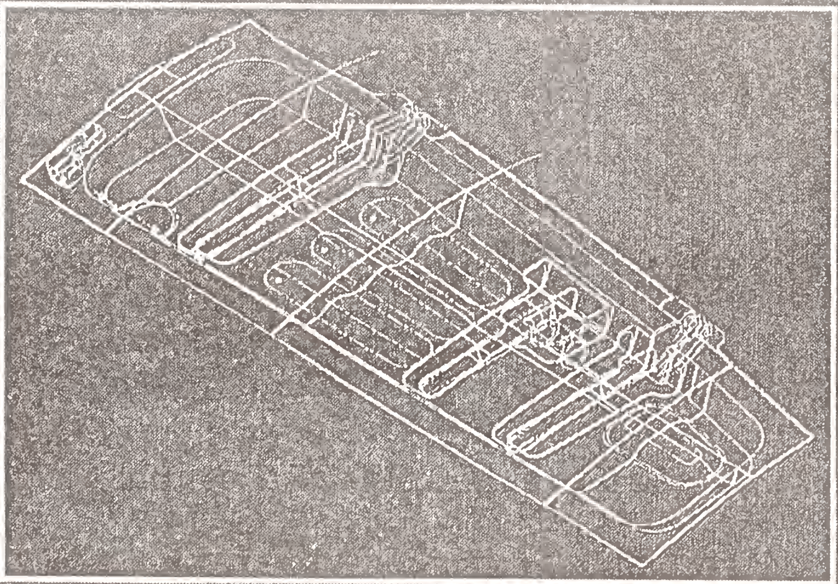
Figure 9

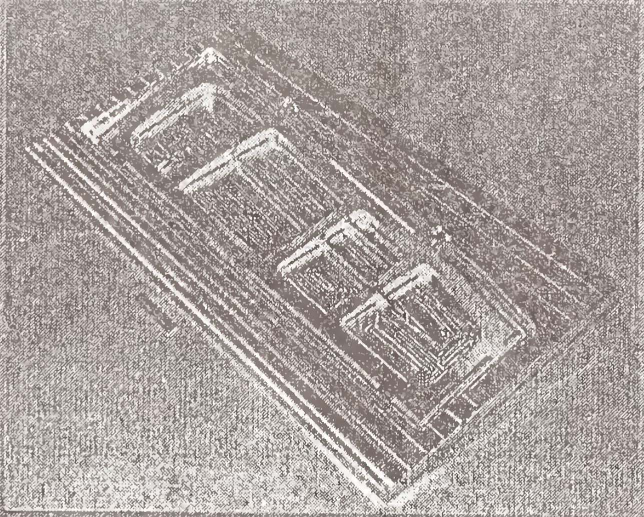


Advanced Lightweight Aircraft
Fuselage Structure
Traditional
Unitized
Center Fuselage Buildup
Inner and Outer Wing Buildup
Numerous Parts & Assemblies
Large Composite Parts & Few Assemblies
Figure 10

Nose Gear Door

Unitized Structure Uses Self Tooling Approach





	Current Design	High Speed Machining Design
Parts	7	4
Fasteners	190	87
Tooling	22	5
Fabrication Labor (hrs)	78	16
Weight (lbs)	3.47	3.39
Cost	$6,000	$1,500

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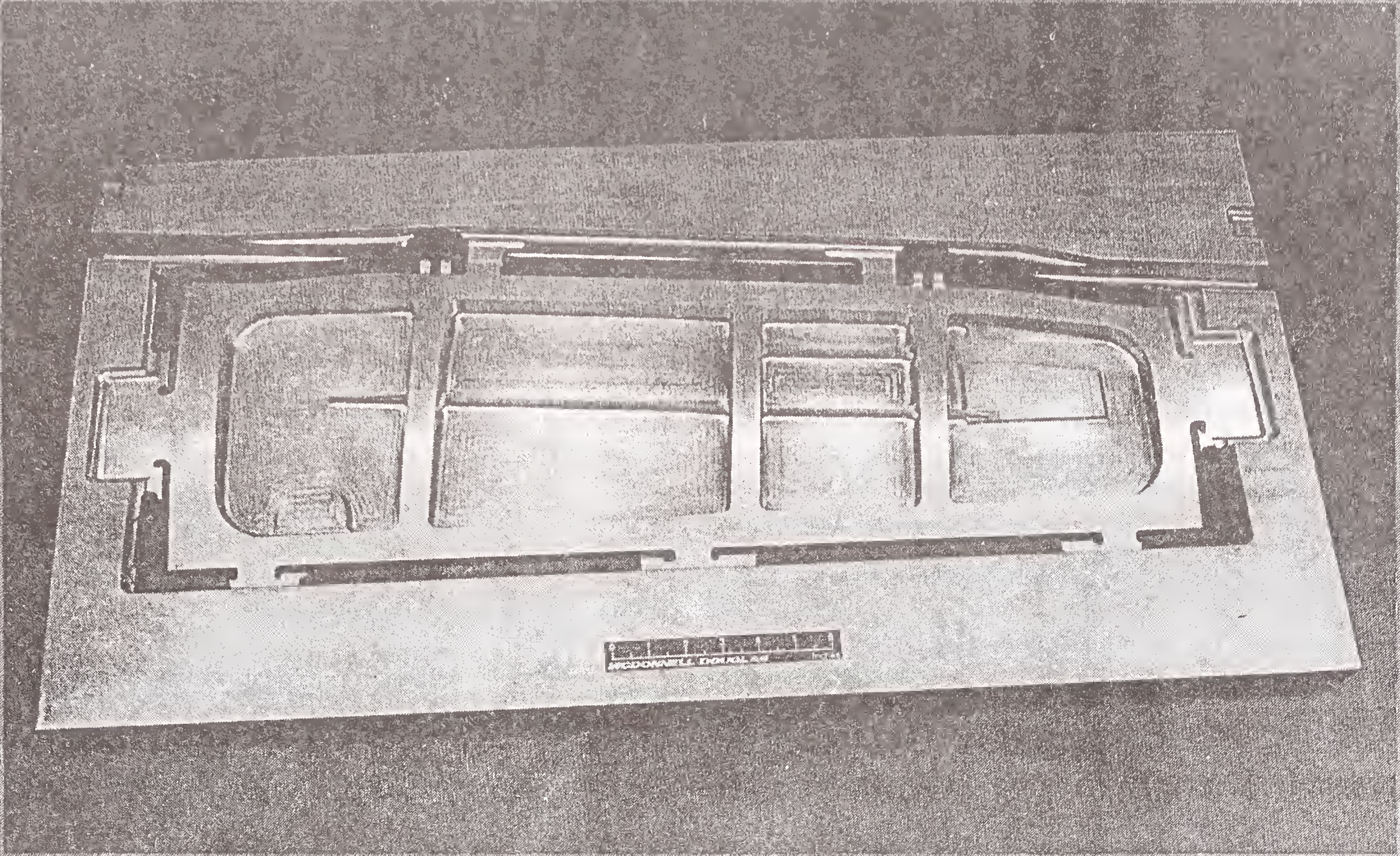
Figure 11

Nose Gear Door Panel in Billet



GP54-0047-56-C

Figure 12

Nose Gear Door Skin

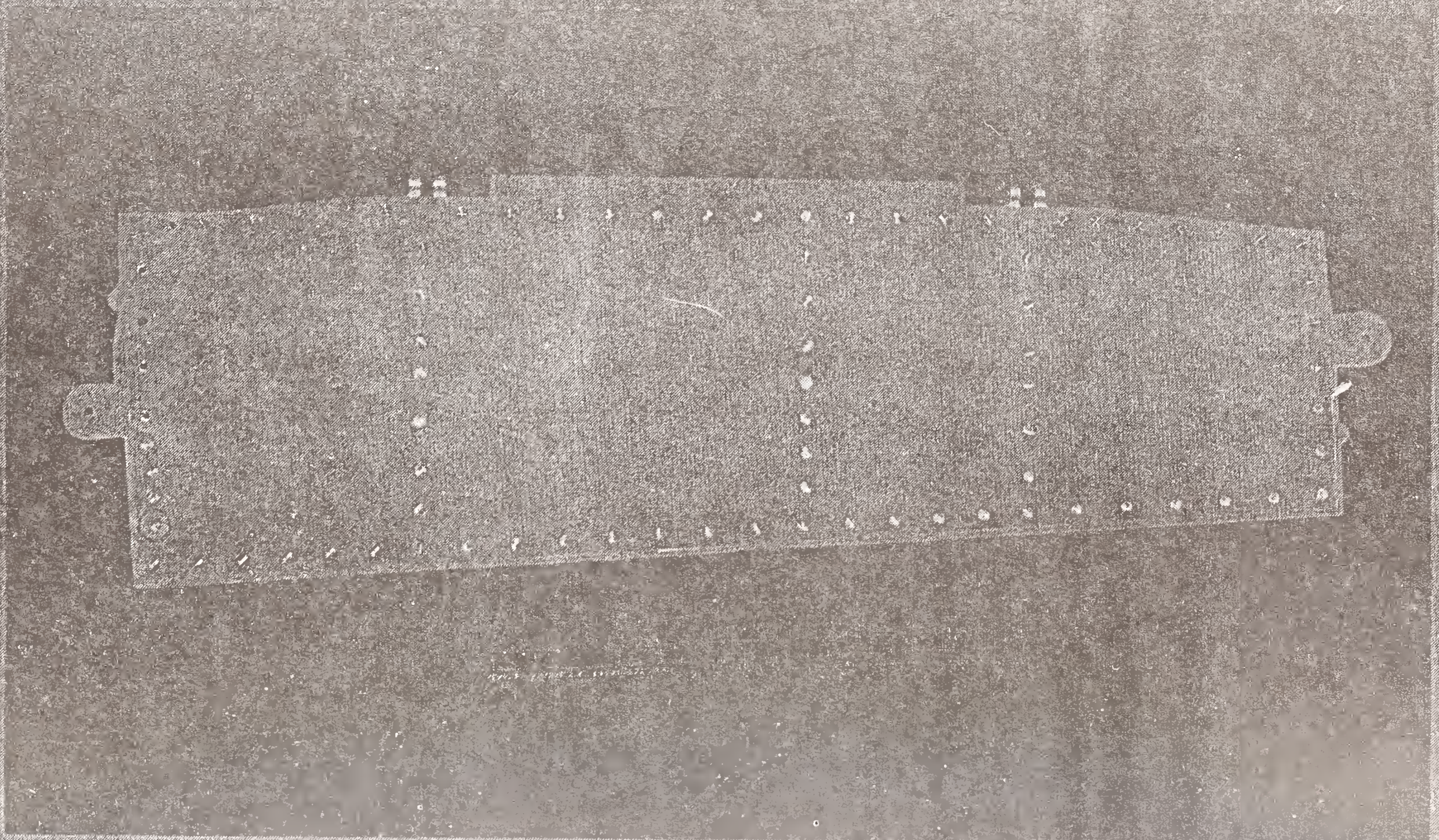
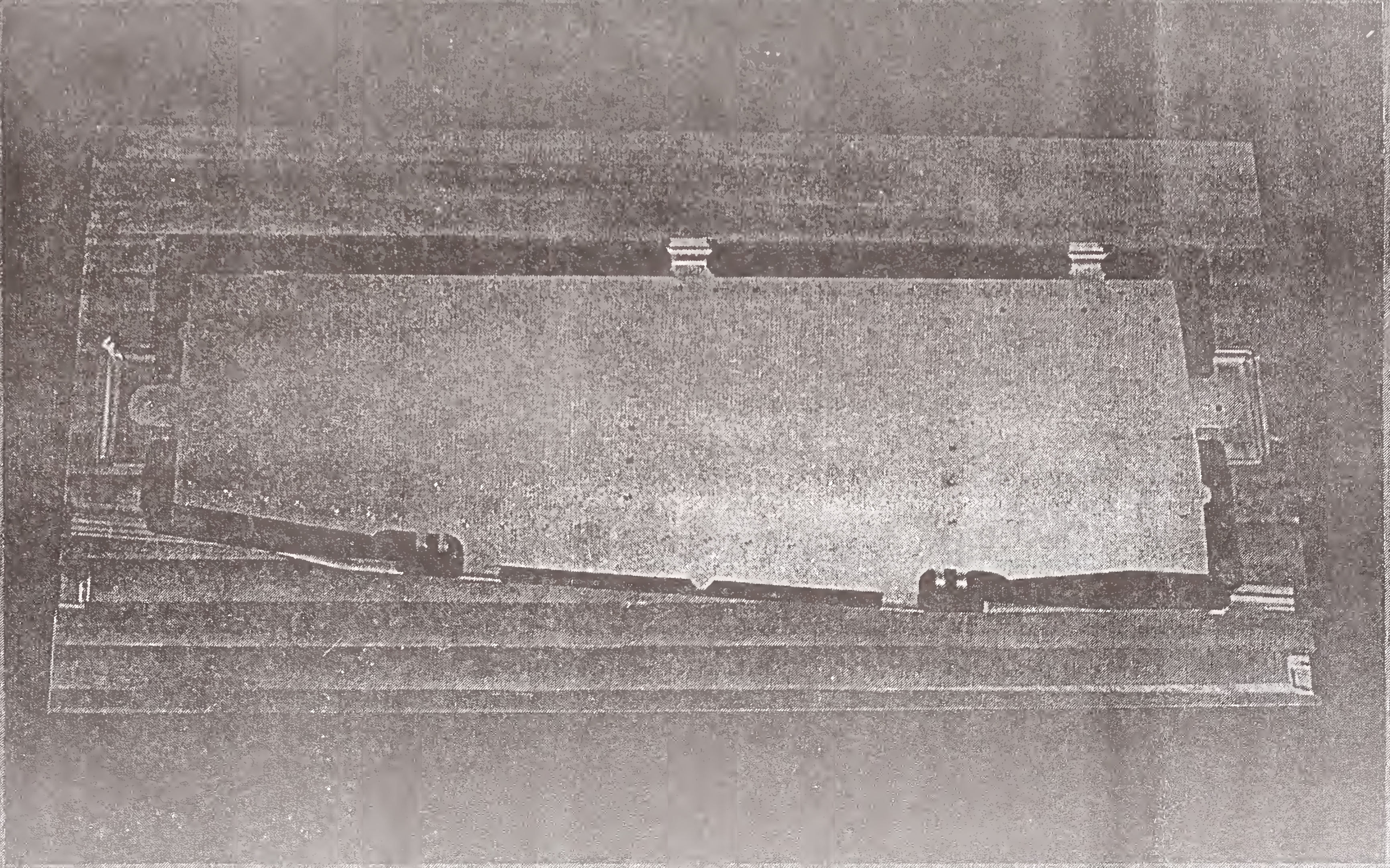


Figure 13

Skin Attached Using Billet as Tool



GP54-0047-57-D

Figure 14

Standard Nose Gear Door Assembly Tools

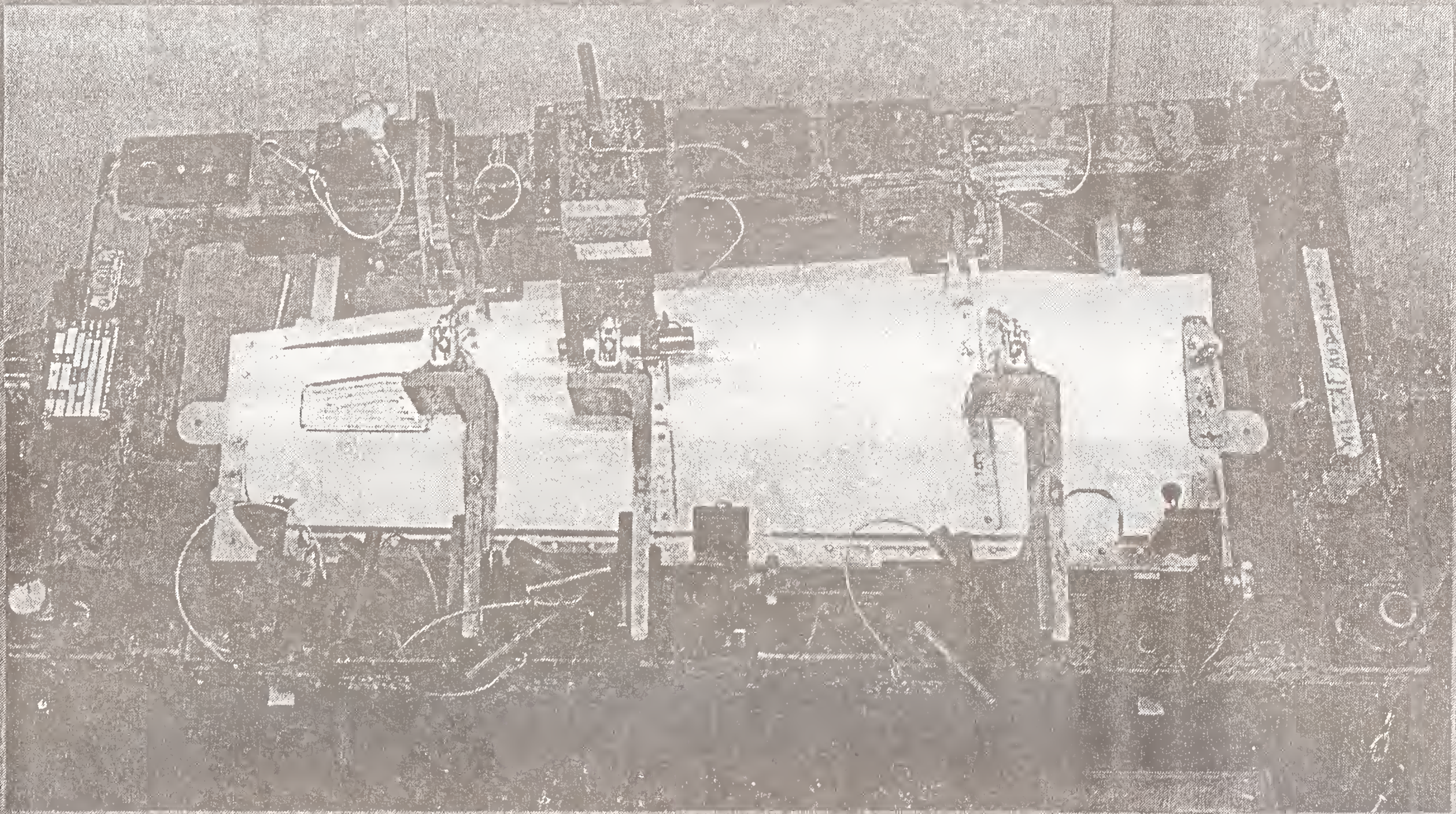


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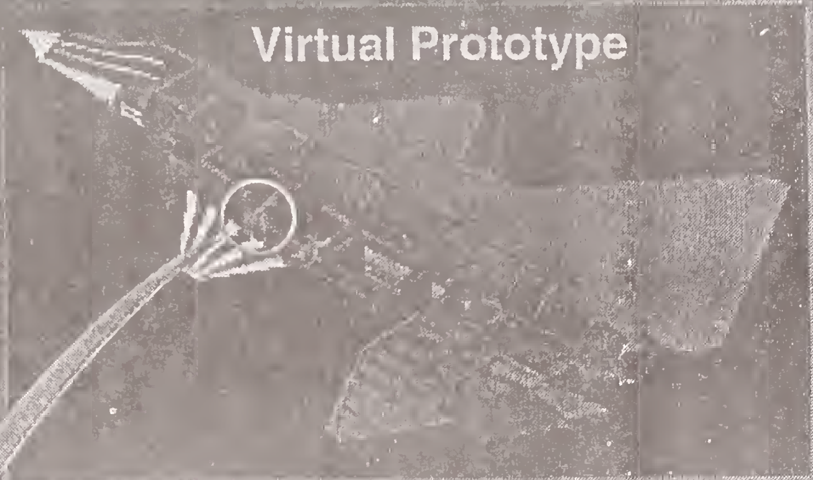
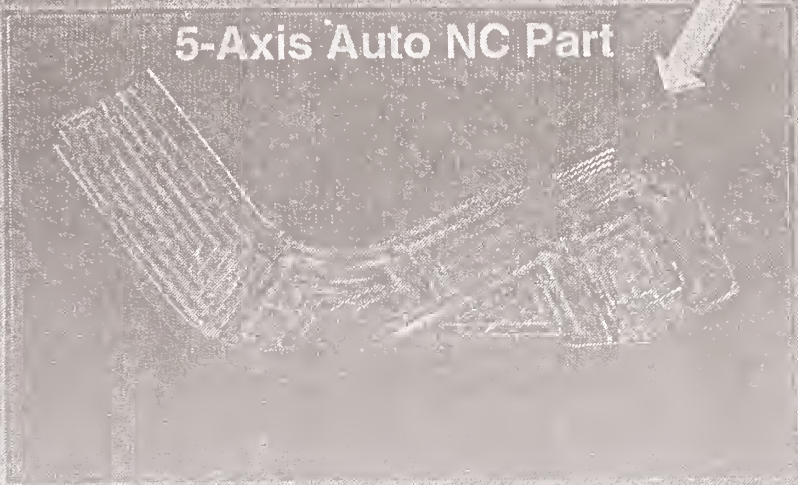
Figure 15

Feature Based Design

Toolset
- Common Geometry
- Solid Models
- Parametric Design and Associativity
- Direct Design Links to Analysis and Manufacturing
- Automated NC Programming
- Feature Based Cost Models

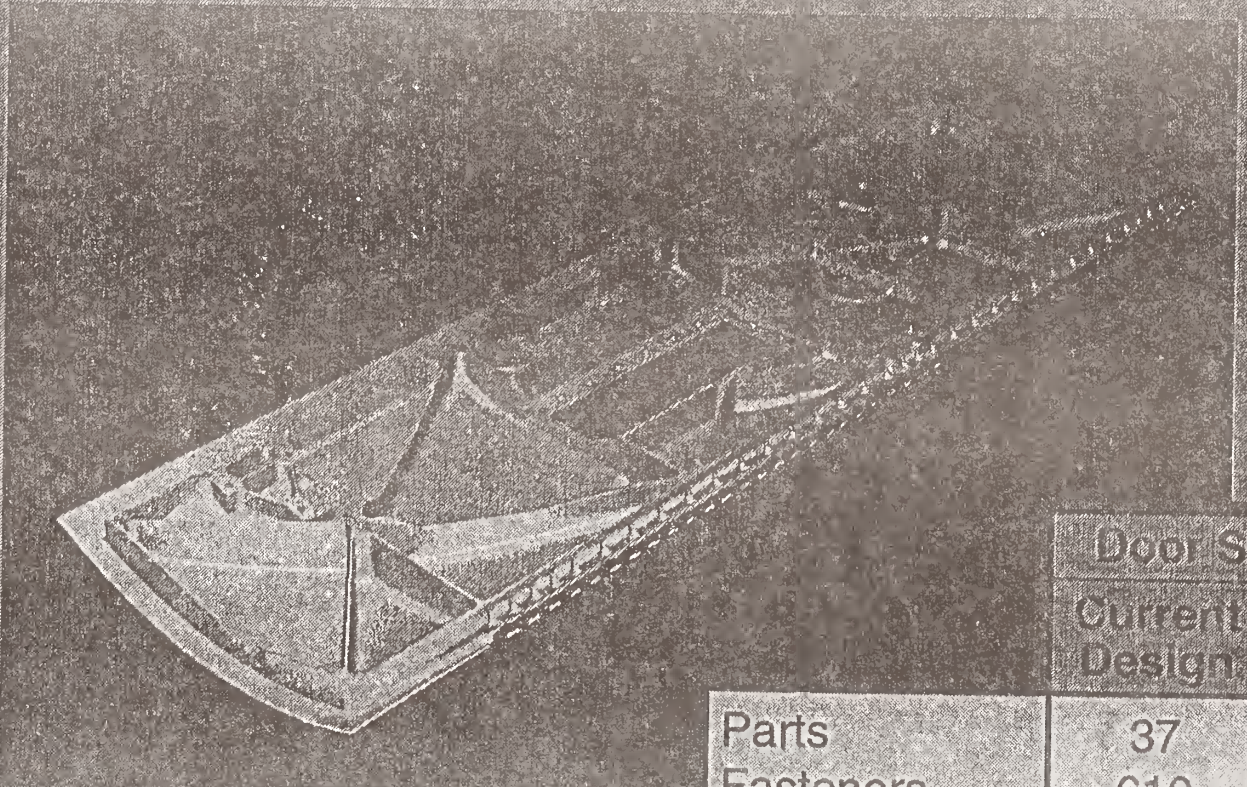




Benefits
- Reduced Lead Time
- Reduced Design Cycle Time
- Reduced Design Staff
- Digital Interface with Manufacturing and Quality
- Electronic Build-to-Packages

Figure 16

Alternate Door Design Enabled Simpler Fabrication



	Door Structure	
	Current Design	HSM Isogrid
Parts	37	2
Fasteners	610	99
Parts Welds	60	0
Tools	72	0
N/C Programs	4	1
Mfg Hours	207	34

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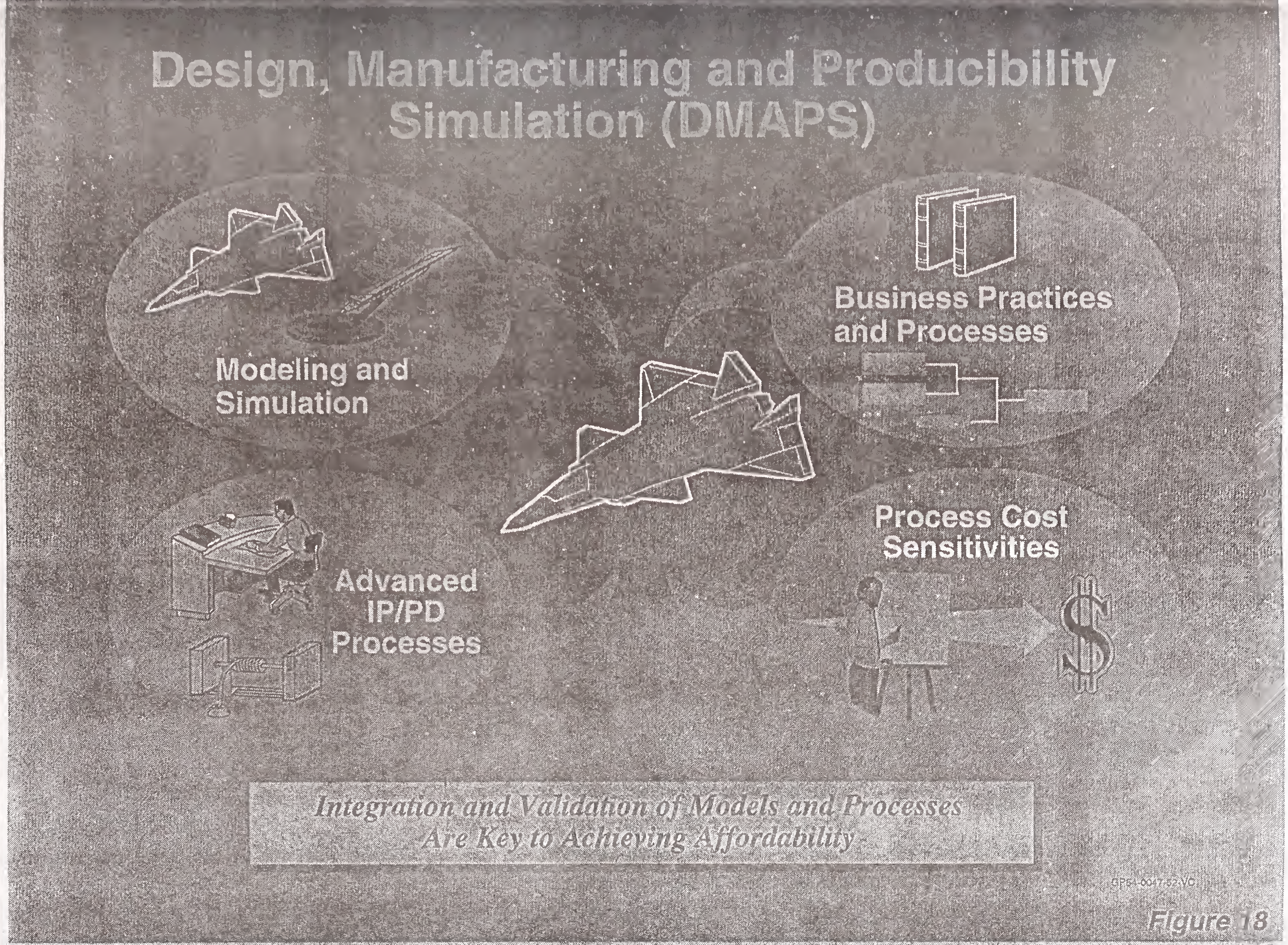
Figure 17


Design, Manufacturing and Producibility Simulation (DMAPS)
Modeling and Simulation
Business Practices and Processes
Advanced IP/PD Processes
Process Cost Sensitivities
Integration and Validation of Models and Processes Are Key to Achieving Affordability
Figure 18

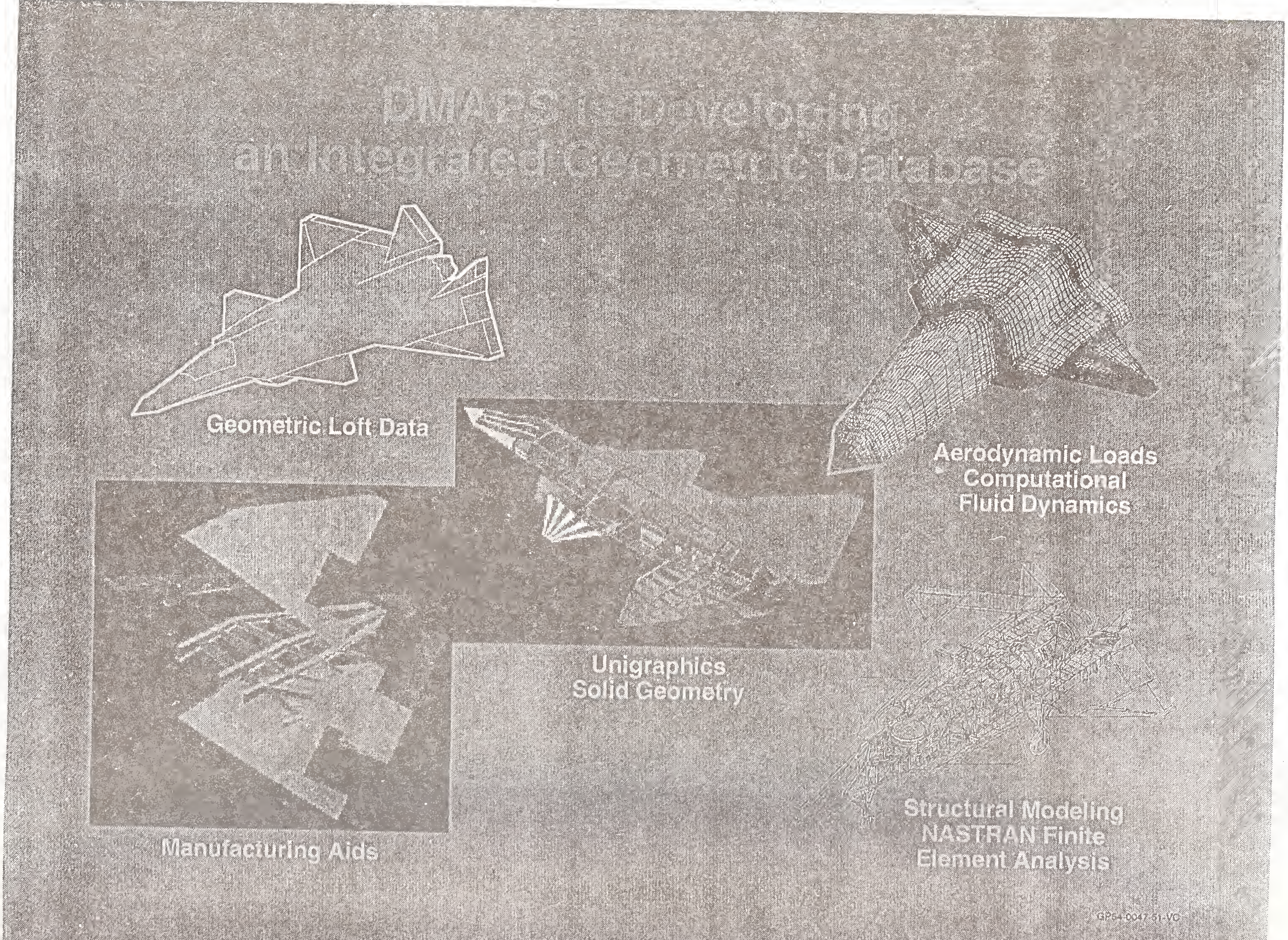
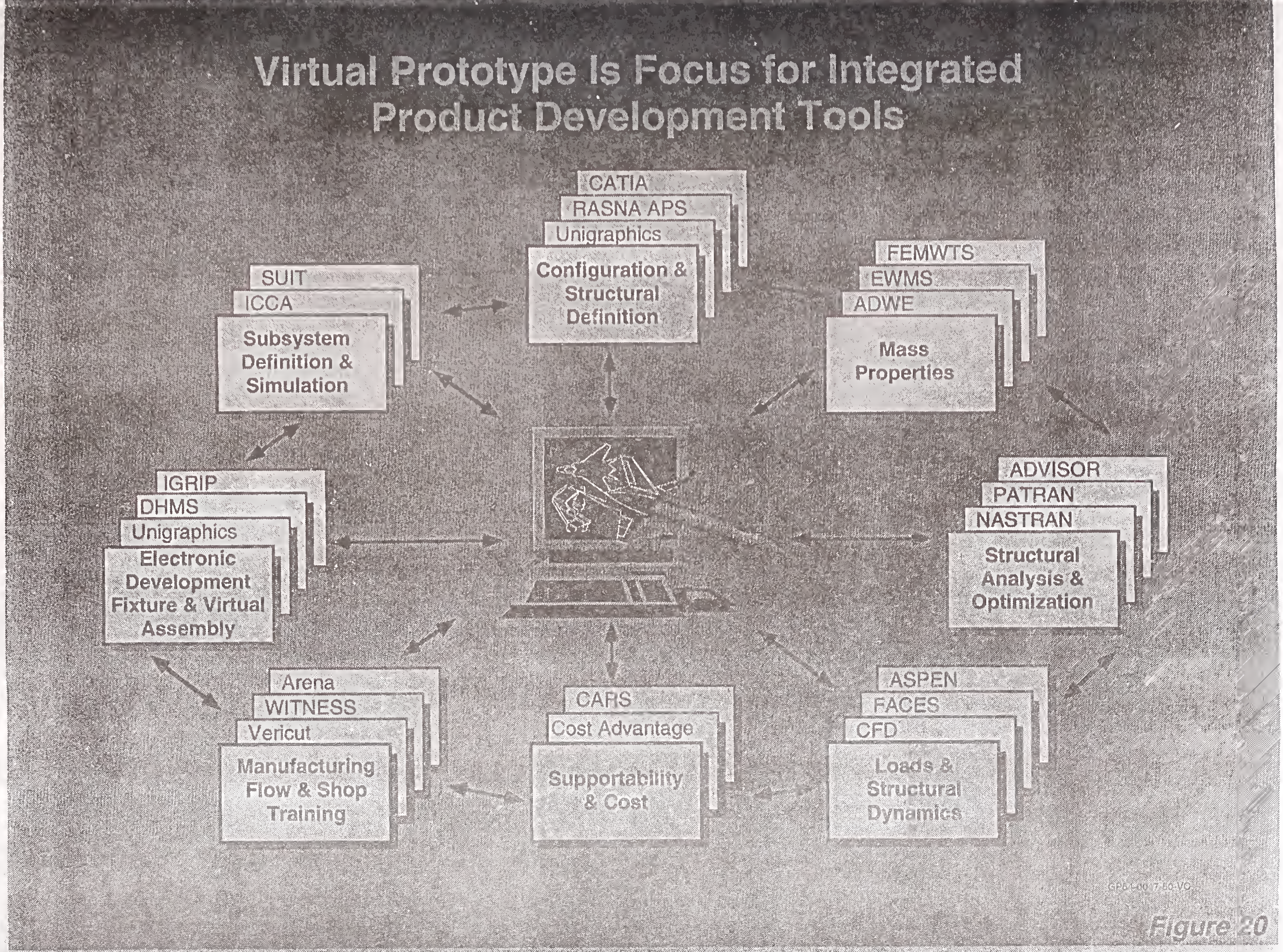

DMAPS Developing
an Integrated Geometric Database
Geometric Loft Data
Aerodynamic Loads
Computational
Fluid Dynamics
Unigraphics
Solid Geometry
Structural Modeling
NASTRAN Finite
Element Analysis
Manufacturing Aids
GP54-0047-51-VG

Figure 19

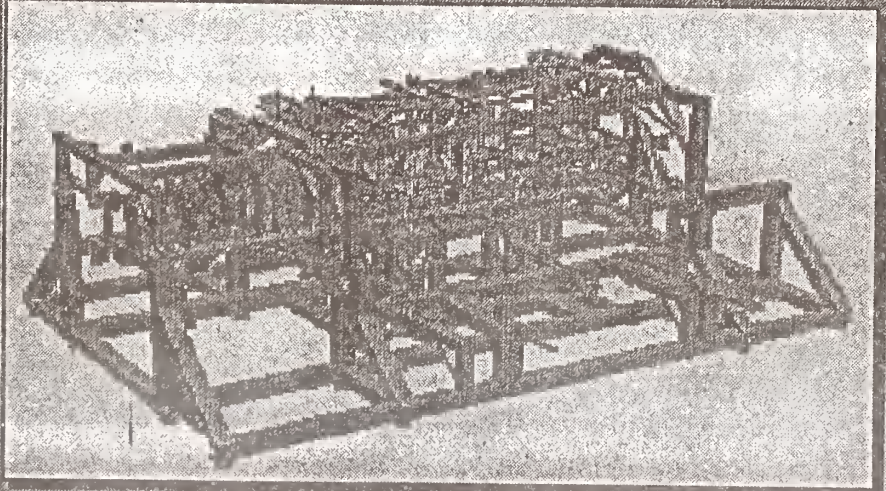


Virtual Prototype Is Focus for Integrated Product Development Tools
CATIA
RASNA APS
Unigraphics
Configuration & Structural Definition
SUIT
ICCA
Subsystem Definition & Simulation
FEMWTS
EWMS
ADWE
Mass Properties
IGRIP
DHMS
Unigraphics
Electronic Development Fixture & Virtual Assembly
ADVISOR
PATRAN
NASTRAN
Structural Analysis & Optimization
Arena
WITNESS
Vericut
Manufacturing Flow & Shop Training
CARS
Cost Advantage
Supportability & Cost
ASPEN
FACES
CFD
Loads & Structural Dynamics
Figure 20

Virtual Manufacturing

Toolset
- Graphic Simulation of Part to Part and Part to Tool Fit
- Manufacturing / Process Flow Simulation for Optimization of Resources and Schedules
- Virtual Reality to Facilitate Communication
- Variability Reduction for Improved Quality
- Process Based Costing

Benefits
- Validated Design / Tooling Prior to Fab / Assembly
- Reduced Lead Time and Inventory
- Factory Requirements
- Automated Work Instruction
- Reduced Learning Curves
- Cost Visibility to Process Change



F/A-18E/F Forward Fuselage and Assembly Tool

GP54-0047-55-VG

Figure 21

Future Aerospace Manufacturing Strategies

Low Rate Production
...Separate Cost From Rate

Flexibility
...Ability to Take Advantage of Latest Development

Short Product Development Cycle
...Quick to First Flight

Rapid Technology Insertion
...Prototyping Products and Processes

Affordability
...Ability to Compete

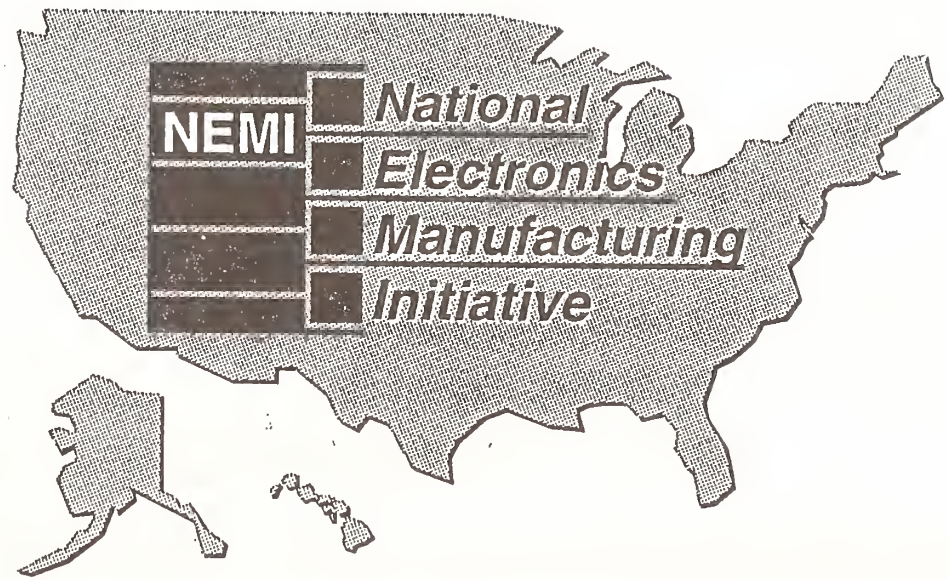
World Class Quality
...Global Competition

New Way of Doing Business

GP54-0017-46-VC

Figure 22

Mauro Walker
Senior Vice President
Director of Manufacturing
Motorola, Inc.



The National Electronics Manufacturing Initiative

Mauro Walker

Draft Mission Statement

The National Electronics Manufacturing Initiative (NEMI) meets industry goals of improved competitiveness and greater profitability while also meeting government goals of national security, sustained economic growth, and creation of quality jobs. NEMI develops and implements a coordinated private sector program to improve U.S. competitiveness in electronics and the industries that depend on electronics.

The right people; the right time; the right focus

NEMI National Electronics Manufacturing Initiative

United States Differentiating Strengths

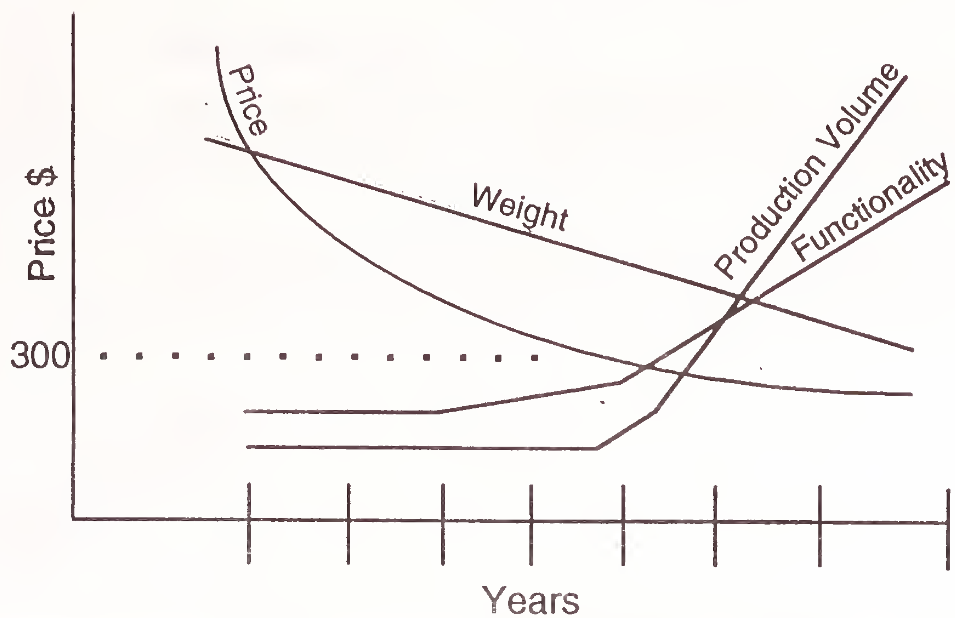
Best in Class basic sciences and information technology

World's largest and most advanced market for electronics

Major supplier of semiconductors and semiconductor technology

The right people; the right time; the right focus

Portable Electronics



Market Projections
Next Consumer Electronics Product: Hand-held Terminal

Key Market "Laws" Utilized

- **KEI, HAKU, TAN, SHO (Shorter, Thinner, Smaller, Lighter)**
- **Doubling of volume decreases cost by 20 percent**
- **Moore's Law**

The right people; the right time; the right focus

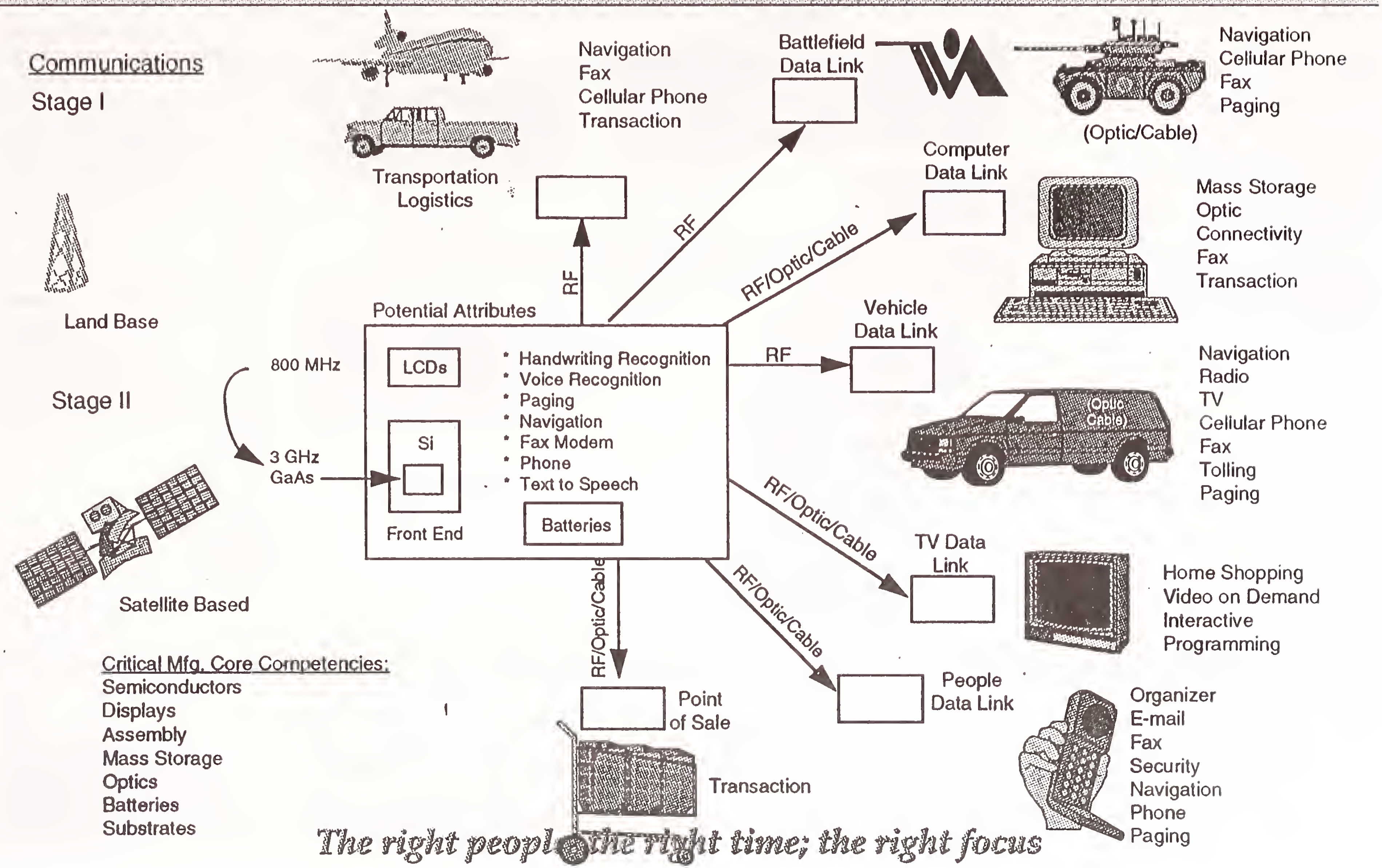
Future Electronic Manufacturing in U.S.

1. Current U.S. high end products evolving to consumer products -- cellular phones, pagers, personal computers.

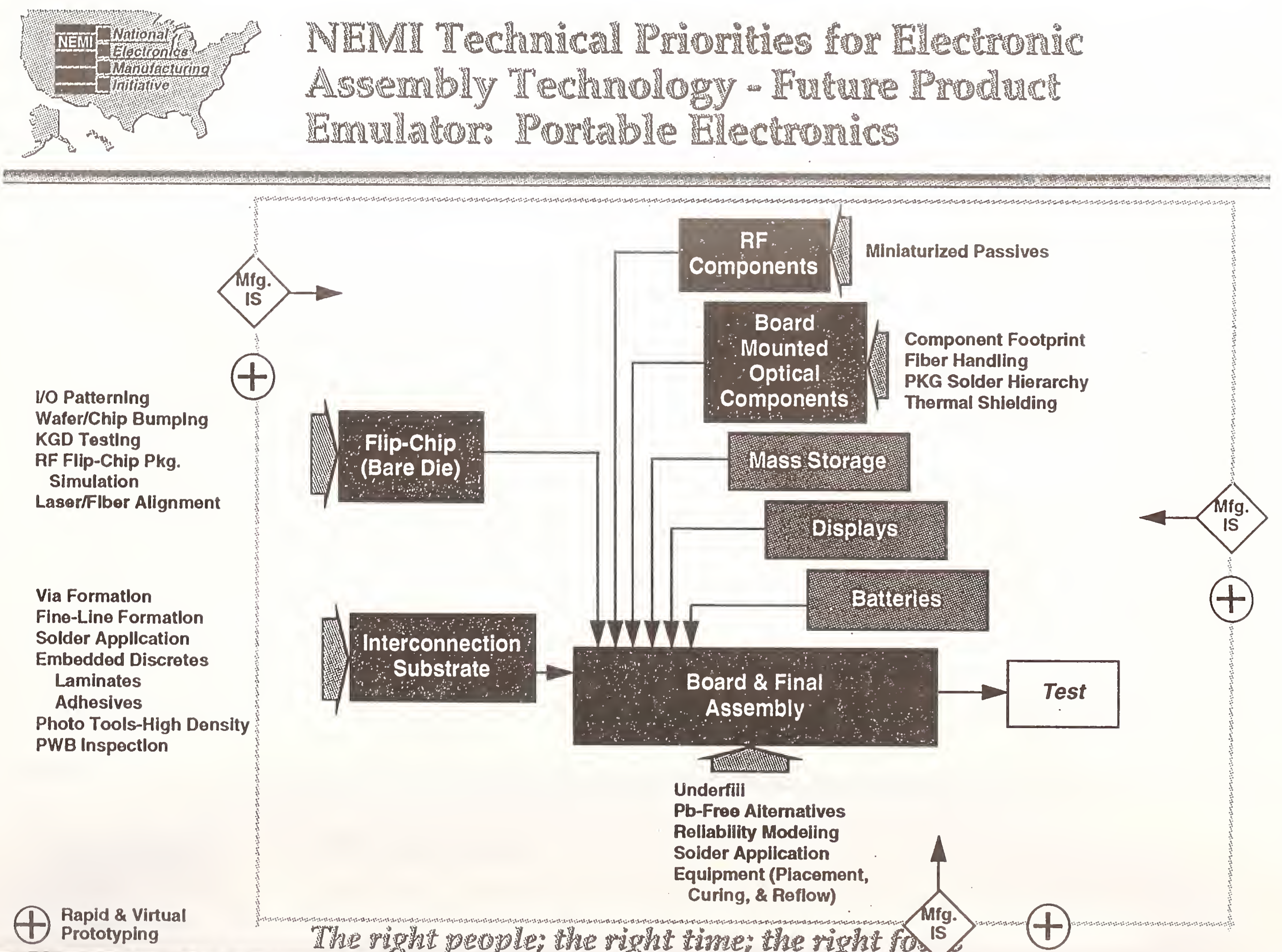
2. Replaced with other high end products (high capacity voice/data, multi-functional products) so mass electronic business could be incremental.

3. Mass electronic manufacturing will require a re-building of the high volume electronic food chain -- strategic components, and support infrastructure of equipment, materials and system tools.

NEMI Future Product Emulator–Portable Electronics



NEMI Technical Priorities for Electronic Assembly Technology - Future Product Emulator: Portable Electronics



The right people; the right time; the right fo...

NEMI National Electronics Manufacturing Initiative

NEMI Technical Plan Work Program Priorities

Work Program

Interconnection Substrates
- **Via Formation**
- **Fine-Line Formation**
- **Solder Application**
- **Embedded Discretes**
- **Laminates**
- **Adhesives**
- **Equipment (high density photo tools, PWB inspection)**

Board Assembly
- **Underfill Materials & Processes**
- **Pb-Free Alternatives**
- **Reliability Modeling**
- **Solder Application**
- **Equipment (Placement, Curing, Reflow)**

Flip Chip Technology
- **I/O Patterning**
- **Wafer/Chip Bumping**
- **KGD Testing**
- **RF Flip-Chip Pkg Simulation**
- **0.5 µm Laser/Fiber Alignment**

Manufacturing Information Systems

Rapid & Virtual Prototyping

RF Components
- Miniaturized Passives

Board Mounted Optical Components

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NEMI National Electronics Manufacturing Initiative

Issues Concerning Related Critical Core Manufacturing Competencies

DISPLAYS

- 5" color video displays are projected to cost \$100-\$150 in year 2000
- Price breakpoints of \$50-\$80 are needed
- Broadband infrastructure will be the driver
-

MASS STORAGE

- A multimedia portable terminal will require terabyte-level storage capacity
- Ultra compact WORM memories with terabyte capacity and gigabyte/sec data transfer rates will not be available in year 2000
- Optical storage R&D must be accelerated
-

BATTERIES

- The energy density of batteries will improve by at most 25 percent by the year 2000
- R&D must concentrate on improved means of energy storage and power reduction of displays, RF transmitters, etc.

Bottom Line: NEMI roadmaps must continuously link to those of related component technologies and vice-versa, so as to produce a dynamic synergy that can meet the objectives of the initiative.

The right people; the right time; the right focus

NEMI National Electronics Manufacturing Initiative

Participating Firms from the Electronics Industry

OEMS
Motorola
AT&T
IBM
Hewlett Packard
Eastman Kodak
GTT Communications
Delco Electronics
United Technologies
DEC
Ford
Xerox
Sun
ACG
Boeing

PWB Manufacturers
Continental Circuits
Litton
Hadco

Semiconductor Manufacturers
Intel
Motorola
Texas Instruments
National Semiconductor

Equipment Vendors
Universal Instruments
Adept Technology
Orbotech
Four Pi Systems
Perceptron

Package Vendors
Coors

Material Vendors
ADI/Isola
DuPont
Morton
Gould Electronics

Software Vendors
Pritsker Associates
Bolt, Beranck & Newman

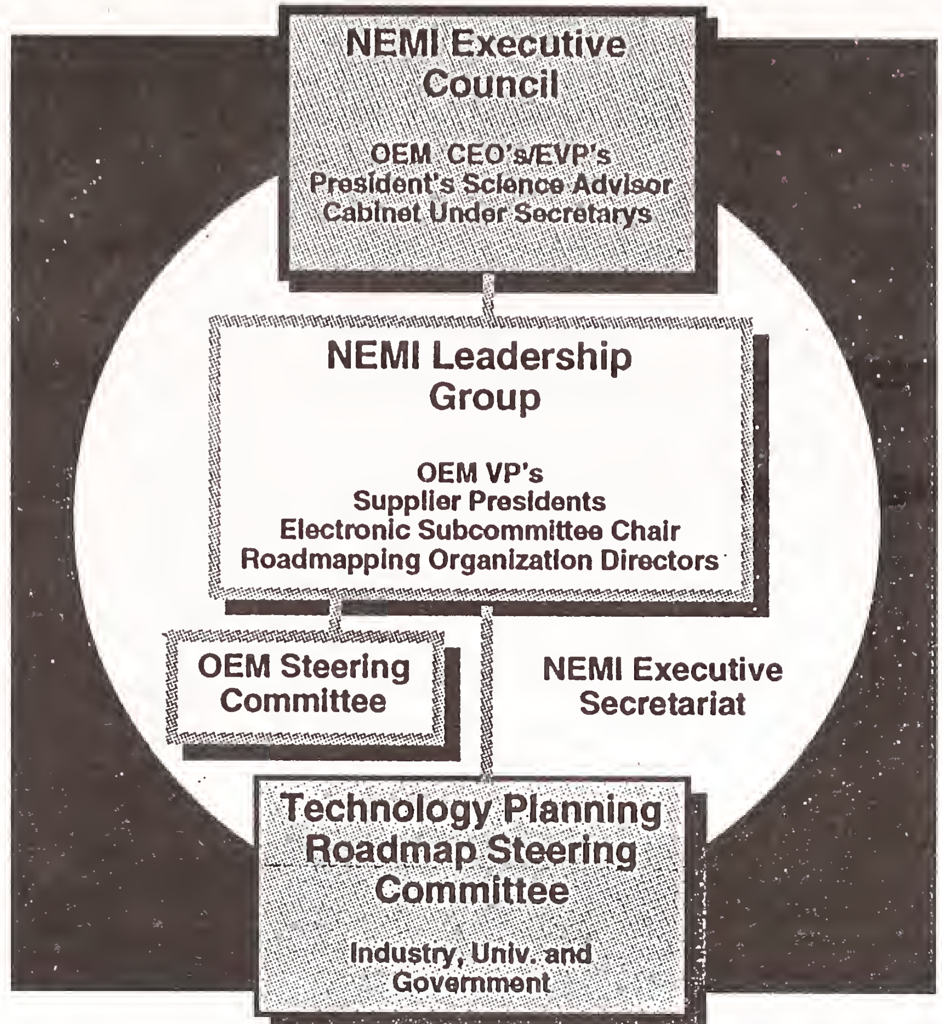
The right people; the right time; the right focus

Participating Consortia, Universities and Government Organizations

Consortia	Universities	Government Organizations
MCC	Stanford	NSF
SEMATECH	USC	Sandia
NCMS	CMU	NIST
ITRI	NJIT	ARPA
IPC		Wright Paterson Labs
SRC		IDA
SIA		DOE

The right people; the right time; the right focus

NEMI Leadership Organization



The right people; the right time; the right focus

NEMI Executive Council

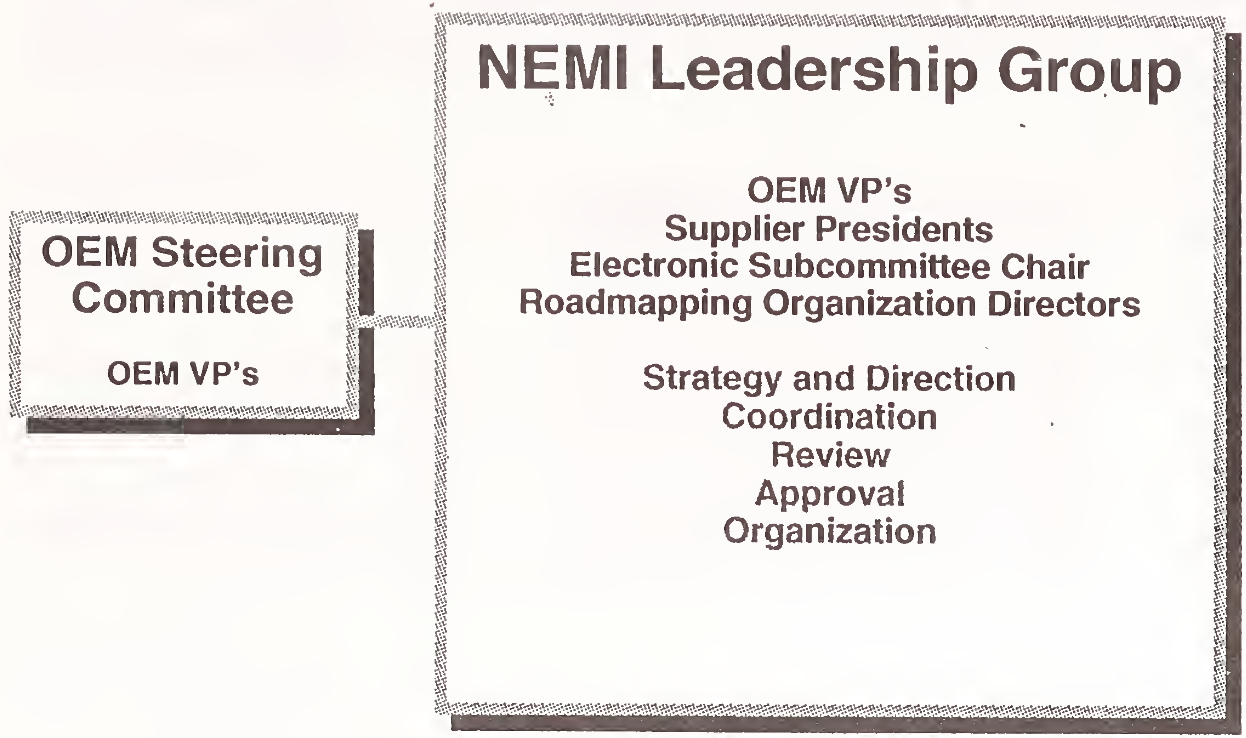
NEMI Executive Council

OEM CEO's/EVP's
President's Science Advisor
Cabinet Under Secretarys

Vision
Policy

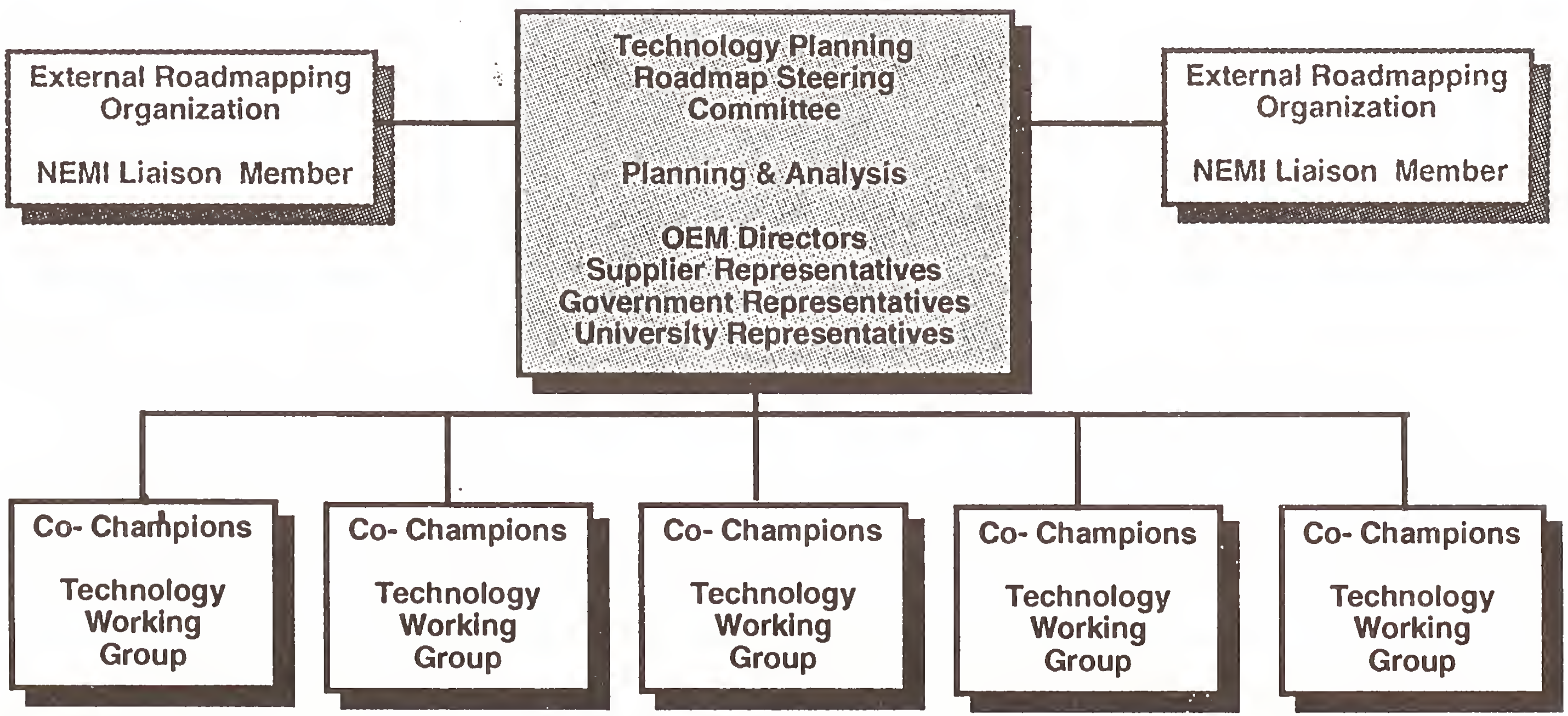
The right people; the right time; the right focus

NEMI Leadership Group



The right people; the right time; the right focus

NEMI Roadmapping Organization



The right people; the right time; the right focus

Proposed NEMI Strategies

1. In Order to Achieve Industry Ownership, Resources and Program Management will Originate, For the Most Part, From the Members of the Program. NEMI Will Not Include a Separate Program Management Organization.

2. In Order to Reduce Incremental Funding by U.S. Electronic Firms, NEMI Will Instead Depend on Utilization of Current Resources Through:

   A. Focus on a small number of technical approaches so as to reduce duplication.

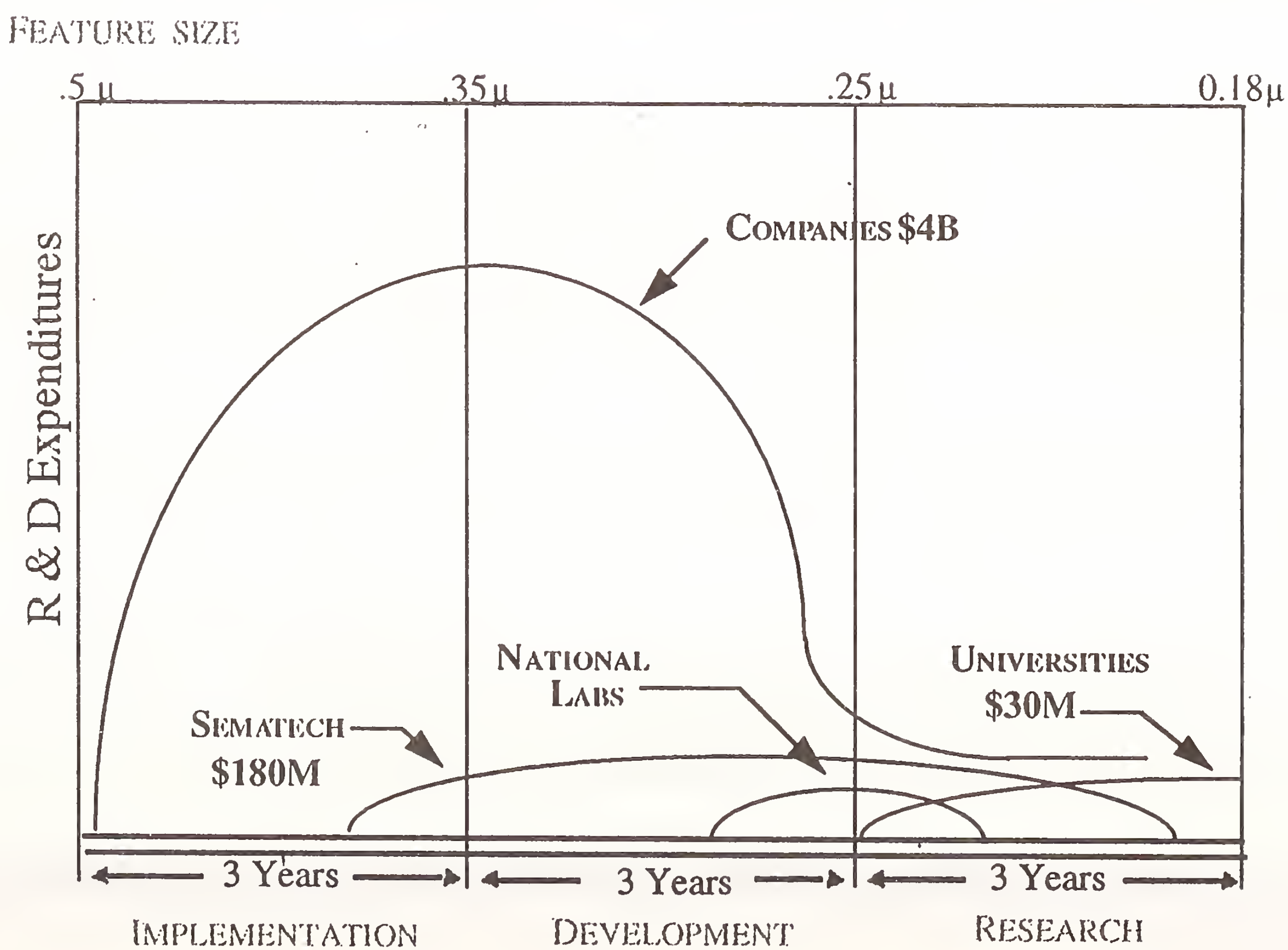
   B. Coordinate at both OEM and Supplier levels and make best use of current resources.

   C. Generate investment from the U.S. financial community by creation of confidence in U.S. electronic food chain suppliers through focused OEM commitment and support.

The right people; the right time; the right focus

National Electronics Manufacturing Initiative (NEMI)

Semiconductor R&D



The right people; the right time; the right focus

Proposed NEMI Program Operating Methods

1. Technology Planning Group Will Recommend and, After Securing Leadership Group Approval and With the Assistance of the Secretariat, Will Organize Programs with OEM and Supplier Participants and Leadership.

2. Programs Will Consist Of:

   A. Development Shared by In Kind Contributors of Groups or OEMs and/or Suppliers.

   B. Equipment, Component and Other Technology Evaluation Accomplished Through "Round Robin" Exercises.

   C. OEM and Higher Level Suppliers Supporting Suppliers and Lower Level Suppliers Through Outright Development and Deployment Funding, Purchase Orders, Combined Letters of Intent, or Commitment to NRE Charges.

The right people; the right time; the right focus

Proposed NEMI Program Operating Methods

Continued . . .

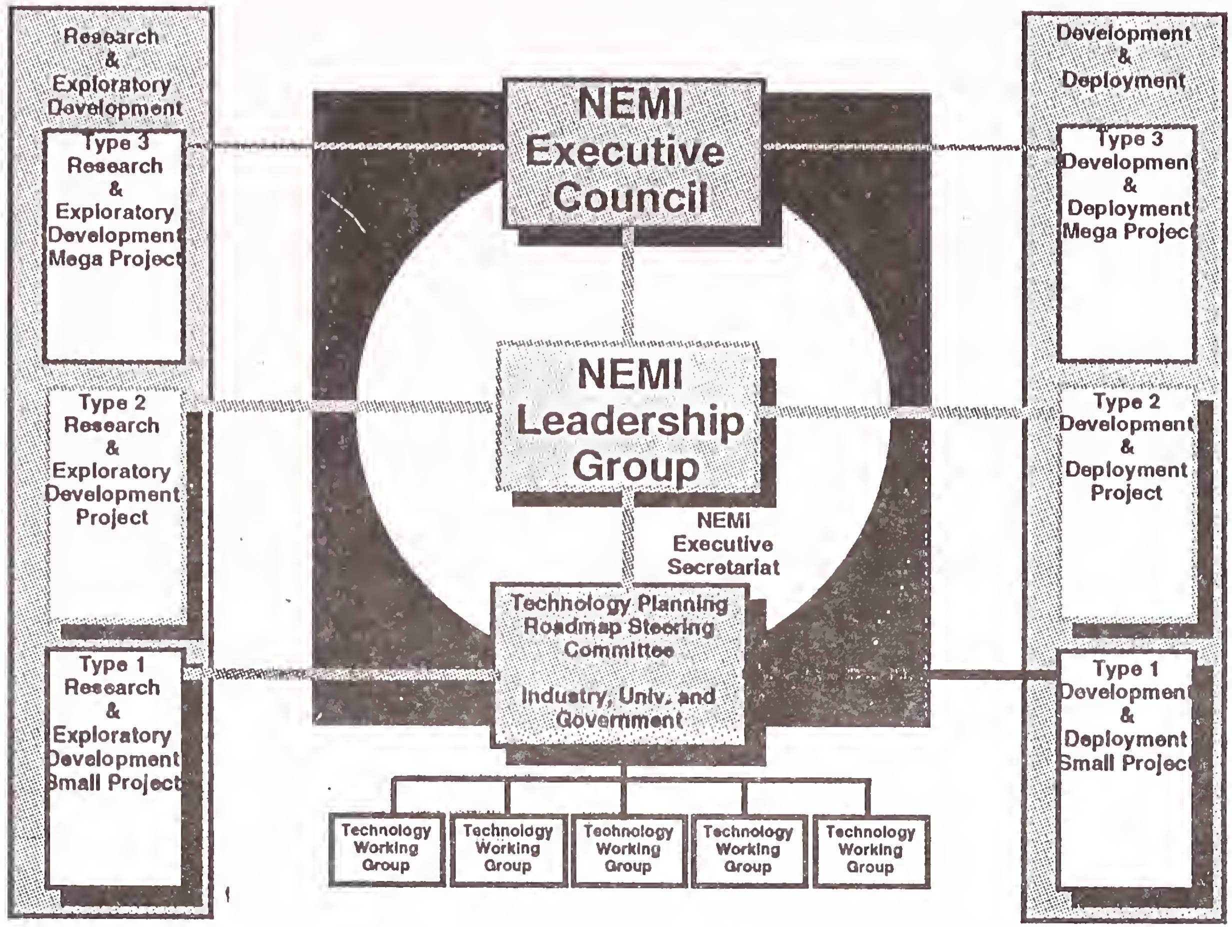
3. Deployment Programs Could Involve Selection of One of a Few Model Suppliers for Focus of Development Program Output and Future Purchase (Most Likely These Will Be The Program Participants). It May Also Involve OEM Loan Guarantees or Other Financial Support.

4. The Programs Should Emphasize Use of U.S. Suppliers When Possible or Foreign Suppliers Who Agree to Supply the U.S. Market from U.S. Manufacturing.

The right people; the right time; the right focus

National Electronics Manufacturing Initiative

NEMI Organization



The right people; the right time; the right focus

Frank J. Ewasyshyn
Vice President
Advanced Manufacturing Eng.
Chrysler, Corporation

"Needs and Opportunities: A Chrysler Perspective"

Frank J. Ewasyshyn
Vice-president, Advance Manufacturing Engineering
Chrysler Corporation
Auburn Hills, Michigan

Presented at the 2nd Annual Manufacturing Technology Conference:
Toward a Common Agenda
April 18, 1995
NIST Gaithersburg, Maryland

Thank you John (Decaire) and good afternoon to all of you.

It is my pleasure today to represent Chrysler Corporation and I welcome the opportunity to comment on the technology policies being drafted by the Committee on Civilian Industrial Technology.

I am going to structure my comments within the framework of the six themes developed by the Subcommittee. First I would like to give you a few facts about Chrysler and the domestic automobile industry. Chrysler Corporation is made up of 121,000 men and women who design, engineer and produce 2.8 million vehicles annually. In 1994, we had over 52 billion dollars in sales. Last year, the domestic industry together employed 1.4 million people, sold a total of 12.6 million vehicles and contributed 4.5% of the Gross Domestic Product. When including suppliers, dealers and others related to the automobile business, the automobile industry accounts for one in six jobs in the US.

Competition in this industry is, to say the least, fierce. Currently there are over 30 nameplates being sold in the US. Customer needs and market requirements are constantly changing. No one recognizes the need for flexible and responsive systems more than we do. But manufacturing a new automobile or truck is a very complex and expensive process and can cost from one to several billion dollars. To guess wrong can be financially devastating - to us and our shareholders. So when we make changes in the way we do business, we try to do it carefully. We get everyone's input and then we focus as a team to make sure that we'll be successful.

To better understand the magnitude and complexity, let me briefly describe for you Chrysler's process for developing a new car or truck. It begins about 30 months before actual production. Designs both in clay and in digital form result from extensive market research and customer comment. When a final design is chosen, the product engineers, our purchasing people, our financial people and our manufacturing process and plant people go to work. About 20 months before scheduled production, component designs are basically complete, manufacturing processes have been chosen, tooling is starting to be designed and an engineering prototype vehicle is on the road. Tool construction starts about 16 months before launch and production prototypes are built to verify our processes. Pilot production vehicles are made using the production tools at about 11 months. The new tooling is then installed at our stamping, powertrain and assembly plants and our suppliers are doing the same. When just a few weeks away from actual volume production, another set of pilot vehicles is produced to validate the production system and identify and fix the unforeseen but inevitable problems. Production begins with a careful ramp up to planned rates with continuous monitoring of quality levels.

Our success in these efforts is measured in terms of:

Quality	- Are we meeting *and exceeding* customer expectations?
Cost	- Are we making money for future product development and for our shareholders?
and Timing	- Are our new vehicles ahead of the competition in terms of style, features and function?

So when we talk about Advanced Manufacturing Systems, which is the first theme, it has to be within the context of improving quality, reducing cost and speeding up our time to market. For example, our decision to reorganize into a Platform-based organization or our decision to adopt one set of system-wide advanced computing tools - topics on which I will talk more later - were major decisions and were only made because they would obviously improve our chances for success. Now I agree that we need advanced systems to improve but developing these is beyond what a Chrysler alone can do. In the working papers I counted at least 20 or 30 different initiatives being sponsored by various arms of our government. I will be honest with you - we cannot support every strategic or tactical plan to adapt or develop technology for manufacturing. We have to keep focussed on the customer. A major effort is needed to develop mechanisms for industry involvement and information dissemination.

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Next, I would like to talk a little bit about the kinds of tools we are using for product and process development, the subject of Theme 2. But remember that, while the technologies are neat and never cease to amaze this engineer, any body can buy technology. The larger need that has to be addressed is the skill level of our people. But I will talk more on that when we address Theme 4.

One of the first tools we use in the vehicle development process is our Conceptual Design and Rendering System - CDRS for short. Developed jointly with Evans and Sutherland, our stylists in the Design Office use CDRS to make photo-realistic models of new designs. This technology has saved us hundreds of thousands of dollars by reducing the number of physical models made for evaluation.

While still in the concept stage, our stamping engineers can evaluate the manufacturability of those swoopy curves with both proprietary and purchased stamping formability codes. We can determine much earlier than before how easy or hard it will be to form a panel and advise the stylist where changes in shape can improve quality or cost.

Almost all of our vehicles' stamped sheetmetal parts are designed using CATIA computer aided design software from Dassault Systemes, a French company. And for each new model program, more of the powertrain, chassis and trim components are digitally designed.

Cray computers are used for impact simulation and structural analysis.

Further into the vehicle development process we are applying generative design software to the design of our stamping dies. And CATIA is used extensively for assembly tool design. We are extending these tools now into process design.

Kinematic simulations of the stamping and assembly processes, like this robot workcell, allows the engineer to validate his design before tooling is constructed. An added benefit is that the simulation model automatically generates the control codes for the robots and, in the future, for all of the automation.

Discrete modelling tools are used to evaluate material and tooling flow, identify bottlenecks and verify that planned production rates can be met.

In production, we monitor dimensional integrity using machine vision systems and computer controlled coordinate measuring machines. And our factory floor networks feed information about machine and product status to the engineers and maintenance personnel to insure maximum production uptime.

But as I said, all of this technology is of little use if the operators on the floor do not understand it. We need to make equal investments in our people. There is a tremendous opportunity for all of the stakeholders in this process - the companies, the researchers, the universities, the government - to partner in identifying new and emerging technologies and to provide both our current and future workforce with the tools to effectively apply them.

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(theme 3)

For almost as long as I can remember, we have always had the latest buzzword technologies that would launch us to a new level of manufacturing productivity. Things like CNC, CAD, then CAM, and then CIM and now it's IMS (Intelligent Manufacturing Systems) and STEP (Standard for the exchange of Product Information) and IPPD (Integrated Product and Process Design). Let me give you an example of good, old-fashioned engineering.

> Instrument panel installation has traditionally been an "ugly" operation, with the panel hanging half-installed on temporary hooks while two operators, kneeling in the car, route and connect all the wires, cables and hoses. They finally roll the panel up into position and drive the attaching screws, hoping that nothing got pinched in the process. Further down the line, an operator installed the steering column and drove the attaching bolts while lying on their back on the floor.

For the "LH" process, the "LH" is our Chrysler Concorde, Dodge Intrepid and Eagle Vision line of vehicles, the panel was designed so it would be loaded horizontally into place. There are no cables, hoses or wiring bundles to get pinched. This allows us to use an assist arm device to carry the load of the heavy instrument panel and load it straight into position on the cowl using master locating pins.

The process and design were further refined for the Neon. The steering column was designed to be part of the instrument panel. A more sophisticated assist arm with built in nut runners automatically positions and attaches the panel. In another station, another arm locates the steering column in position and drives its attaching bolts.

The process was further refined for the Cirrus and Stratus by adding the in car heating, ventilating and air conditioning unit to the instrument panel / steering column assembly. All are assembled to the vehicle at one time.

I use this example because there is nothing high tech about it. It illustrates the kind of thinking that will separate the winners from the losers. It's what we call Continuous Improvement. We do not need "home run" technology. Just a steady stream of base hits with every new model. We need proven and effective technology. Our goal is for each new generation of process equipment to be 20% more capable, 20% more efficient and 20% more reliable. To achieve this we will depend heavily on our suppliers. Chrysler buys about 70% of its manufacturing tools. Ford and GM are a little more self-sufficient but still rely on their suppliers for anywhere from 30% to 50% of their needs. So our supply base has to be brought into this process more than they are.

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Let's talk next about Manufacturing Training and Education. This is probably the most important of the six themes we will discuss today. Here are some of the things we are doing to address technical skill building.

- Chrysler Manufacturing invested over $185 million in 1994 to upgrade technical and "soft-side" skills. We will spend more in 1995.

- We have established a Technical Training Center in partnership with the United Automobile Workers to focus on upgrading the capabilities of our skilled trades workforce to keep abreast of the new technologies we are introducing.

- Prior to the launch of our new small car, the Neon, 50% of the Belvidere, Illinois Assembly Plant hourly and salary workforce - about 1500 people - worked on site at our Technology Center in Auburn Hills, Michigan building prototype and pre-pilot cars. Belvidere was involved in every decision that affected their process and layout. This effort developed plant ownership right from the beginning of the product, the process and the tools.

- We are actively involved with Focus:Hope and its NSF-sponsored Coalition for a New Manufacturing Education which is addressing the non-traditional and at-risk students.

- We have coaxed young engineers and researchers out of the university and on to the plant floor with our 2mm Variation Reduction Program - a joint venture between ourselves, General Motors, several tooling suppliers, and the University of Michigan and Wayne State University. This set of projects, partially funded through a NIST ATP, benefits both the manufacturers and the students. We benefit from the science that they bring to the plant floor. They get a chance to exercise more than just their theories and they experience the real and often intractable world of manufacturing.

- We are active with MIT and its Leaders For Manufacturing program. Candidates for a dual masters degree from the College of Engineering and from the Sloan School spend time with us analyzing real manufacturing problems. These are not co-op jobs. Expectations on our part are quite high.

Now I am not using these as examples to show how involved we are in training and education. I only want to point out that we recognize the need for relevance in today's engineering curricula. Relevance which is only possible from real exposure to the manufacturing environment.

We would like to see an initiative that addresses the perception that manufacturing engineering is somehow second class. We need to examine how the NSF, NIST, the national labs and our universities - and even K through 12 education - can encourage our fine young minds to seek the challenges of manufacturing. We need to address improving education in general with national standards and methods of certifying teacher competency.

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Theme 5 deals with deployment. I mentioned before that Chrysler is heavily dependent on its suppliers for parts and tools. Therefore, the use of advanced technologies within our company will have only marginal impact on our competitiveness if our supply base does not have access to the same technologies. For example, at Chrysler, early involvement as part of a platform team exposes our tooling suppliers to CATIA, simulation modelling and other technologies. Often we will require that they use the same CAE, CAD and CAM tools that we employ. They are even networked to our corporate systems to insure rapid communication of design information.

Now this can create problems when large suppliers who service all three of the domestic car companies are forced to acquire and master several different systems. Issues like data translation and hardware standards are being addressed by the AIAG, the Automotive Industry Action Group. The AIAG was founded in 1982 by the automotive OEMs and suppliers to "increases U.S. automotive industry productivity and competitiveness by improving manufacturing and materials management through a cooperative effort of automotive manufacturers and suppliers." AIAG's membership includes 15 automotive and heavy truck OEMs, over 600 suppliers, and a variety of government agencies, vendors, military establishments, academic organizations and trade associations. The AIAG has developed and published over 60 standards and guidelines used in automated manufacturing and communications processes.

Another organization doing significant work in communicating new methods and in standardizing existing ones is the Auto/Steel Partnership. This consortium was formed in 1987 to increase the level of interaction between the North American steel industry and the domestic Big 3. Joint committees have been set up to investigate various applications of steel in the automobile body. Recent projects in design, testing, high strength steels, lubrication and spot welding have had significant impact on the quality of service provided by the steel companies to the auto companies.

The last group I want to mention is the United States Council for Automotive Research, or USCAR. This group, made up of representatives of Chrysler, Ford and General Motors oversees the 14 partnerships and consortia shown here. While most deal with product issues, several involve manufacturing technologies, such as the Automotive Composites Consortium, the CAD/CAM Partnership and the Low Emissions Paint Consortium. Also of particular interest is the Partnership For the Next Generation Vehicle. Goal One of this effort is to identify manufacturing enablers for the high mileage vehicles of the year 2000 and beyond. Through the NIST Advanced Technology Program, we along with Ford, GM and major automotive suppliers, have submited proposals for joint research in areas including sheetmetal springback, aluminum diecasting and welding, open architecture control systems and others. (Your support for them will be greatly appreciated.)

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The last theme deals with business practices. I have two illustrations of how changes in our business - real infrastructural changes - can have a significant effect on a company's success.

The first example is our Platform Organization. For decades, prior to the reorganization of Chrysler's product development activities into Platform teams, we had a traditional sequential process, with "over-the-wall" handoffs between key functional disciplines, which were separated both geographically and philosophically. Communication between these "chimneys" was difficult, usually took place at the top, and Manufacturing was always at the bottom of the funnel, facing the launch deadline come hell or high water.

Engineering built their own prototypes with crude tools about 65 weeks before launch. A small group of so-called "manufacturing feasibility engineers" got their first look at the released production design as it went together for the first time on a surface plate deep in the Engineering experimental build shop. Every problem they found became a change to a released drawing that had to be fought through the Engineering and Procurement systems. These carried cost and timing penalties and had to be effective for the C-1 pilot build, conducted ten miles away at the Manufacturing pilot facility, at 22 weeks before launch. More problems were uncovered at pilot with final designs and parts. A wild scramble ensued to get "fixes" in place for the first in-plant build at PVP (Pre-Volume Production), six weeks before launch. This was usually the first time that the assembly plant people ever saw the product.

The net result of all this, of course, was that most of the first model-year was spent resolving build and quality issues on the fly, with even more costly changes to the product, the process and supplier tools. Predictably, quality and reliability suffered, warranty costs went up, the customers fled to our competitors in droves, and the black ink turned to red.

Then we woke up and reorganized our technical and support resources into platform teams, co-located together under one roof, including all the various disciplines necessary to conceive, develop and launch new programs. Manufacturing became a partner in the development process - Teamwork, in pursuit of shared goals with the customer as the focus.

This new way of doing business opened the door to up-front exposure and participation during the clay concept stage, and resulted in major improvements in design for manufacturability. We became part of the daily face-to-face communication process involving decisions affecting quality, cost, weight, investment and the customer. The platform team environment provided the forum for up-front plant involvement, most importantly with hourly employees, to establish plant <u>ownership</u> of the product, the process and the tools.

This up-front involvement made "Process-driven design" a reality. This permits the product design to be developed in concert with the criteria for an advantageous manufacturing process, instead of adapting <u>pieces</u> of a good process after-the-fact to fit a particular product design. This joint product and process development team method of operating began with the "LH" cars, and refinement has continued through the Ram truck, the Neon, the Cirrus and Stratus, and the recently launched all-new "NS" minivans.

My second example of how a business practice can affect competitiveness is our adoption of a single CAD/CAM system as our sole representation of our product and process designs. CATIA is our core system for product and process representation starting at Styling and then into Product Engineering, Manufacturing, Purchasing and even into Service and Parts. It is our intention to use this single - but multifaceted - system end-to-end in the vehicle development process, tightly integrated with both internally and externally developed software tools.

The advantages of a single digital representation are numerous. In the past, a clay model represented the stylists' vision. It was manually digitized on Mylar. The engineers added internal structure, again using drawings and manual drafting techniques. Wooden models were made by artisans and mechanically traced by Kellering machines to form the dies. Assembly tooling was mastered to duplicates of the wooden models. Coordinating adjacent body panel fit in the past was a long, laborious and imperfect process. Errors crept into the design and the tools and much effort was expended "correcting" the parts and fixtures. Not to mention the "nightmare" of managing the change process.

The digital representation today eliminates all of those intermediate forms of product and tool definition. Numerical control milling machines, driven by our CATIA CAD database, reproduces the part shapes exactly for stamping and assembly tools. Coordinate measuring machines check relative to the digital master. Everyone who works on the vehicle can reference the same product definition from the master database. There is never a question as to how up to date a drawing is - everyone "sees" the latest changes the instant they are released. There is much less delay and the quality of the data is never compromised by translation through intermediate forms.

We have over 2300 CATIA terminals and workstations in use within Chrysler. All of our stamping, assembly and powertrain plants have direct access to the CATIA database of product and tooling data. There are 195 Chrysler owned CATIA seats at 16 outside design shops. Over 290 suppliers have mailbox access to our system and 15 suppliers are directly connected to our mainframes.

The advantage of having a single CAD/CAM system, and in particular one like CATIA, lies primarily in the fact that the entire enterprise can easily access and communicate product and process definition without the ever present fear that it will be misinterpreted either because of translation errors or not up to date. We can directly trace much of our improved quality and reduced cost to our implementation of a single CAD system. And the time savings, as compared to the old days when we spent months and years building models and "fixing" tools, are truly significant.

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In conclusion, I compliment the Manufacturing Infrastructure Subcommittee on their work in developing the framework for this discussion. It is a nice piece of work. But I would like to tweak it a little bit. Here are my ideas.

First, there is a lot of overlap among the various themes. We need to develop a more focussed strategy in dealing with the concerns in each area. I do not disagree with the identified needs but the same kinds of problems surface in each thrust area. We cannot have everyone trying to solve the same problems.

Second, you are going to need a lot of input from industry. I will try to get my people more involved but you have to remember that we are customer driven and results oriented. So the benefits will have to be quantifiable and realizable in a reasonable timeframe. We cannot and will not work on things that are "nice to do".

Third, we need to do a better job of measuring how well we are deploying new technologies and systems. We are all in business and are measured in part by return on investment. These programs should be measured the same way. This not only insures financial integrity but it helps me when I have to make decisions about participating in new projects.

Lastly, a significant area, that received little mention in the working papers, was the impact of the regulatory process on our competitiveness. There are about 202 volumes of regulations that cost businesses $500 billion per year. In the automotive sector this represents about $2000 per vehicle. A re-assessment of the regulatory process could be addressed in the Business Practices theme where we can reconcile "good intentions" with the actual benefits. To compete globally, the productivity gains from integrating advanced manufacturing technology with a re-trained and empowered workforce must reach our customers in the form of better value and not be siphoned off in the form of arbitrary regulations.

Of particular note are the electric vehicle sales mandates in California, New York and Massachusetts and the CAFE (Corporate Average Fuel Economy) standards. Both EV mandates and CAFE have the same premise - that we are supposed to sell products that our customer does not want, such as low range electric vehicles or smaller, underpowered pick-up trucks. If you want to save gasoline, raise its price. Don't tell us to go to war with our customers.

That concludes my prepared remarks. I thank you for your attention and I am looking forward to the general discussion.

Richard Thompson
Group President
Caterpillar, Inc.

R. L. Thompson
National Institute Of Standards and Technology
National Manufacturing Technology Conference --

"Toward A Common Agenda"

Technology Section Theme: Productivity through Technology
April 18, 1995

Thank you, ... I am pleased to have the opportunity to address this distinguished group of representatives from government, industry, and academia on a subject of such critical importance to my company, Caterpillar, and for that matter to all of U.S. industry and the country as a whole. The future economic strength of our manufacturing sector, and in turn our overall economy, will depend almost entirely on our ability to be a winner against increasingly tough global competition. In this future, no company will have the luxury of serving protected markets. NAFTA and GATT are already in place, and other regional and worldwide free-trade agreements are forming rapidly. For Caterpillar today, as I will describe to you, global competition is already a reality. Success in this environment is essential to assure the survival and continuity of our enterprise; but, equally, open dramatic new areas of opportunity for growth and market leadership.

Rapid development and deployment of new technology in both product and process is a strategic imperative for becoming and remaining globally competitive. U.S. manufacturers are up against highly capable competitors whose extensive internal resources are supplemented and supported by tight-knit partnerships with their governments and national institutions. Thus, the need for partnering among our own public and private sectors has never been more critical, with each of us -- industry, government, and academia forming a solid leg of the stool upon which rests U.S. competitiveness.

Cooperation among our public and private sectors can be highly effective, without violating the principles of independence and open competition that are fundamental strengths of our free-market system.

For example, in the commercial arena the Energy, Commerce, and State Departments have recently placed expanded emphasis on supporting private industry initiatives in other countries through high-level trade missions, diplomatic efforts to encourage business practices and business environments in which U.S. companies can compete fairly, and direct lobbying for U.S. company projects -- an area in which foreign governments have long been intensely active. The Ex-Im Bank, OPIC, and the Trade Development Agency work with industry to assure a level playing field for U.S. companies by offsetting financial guarantees and grants offered by foreign governments. University and industry collaboration can also enhance the efforts of both parties. For example, in our case, Bradley University, located near our corporate headquarters in Peoria, Illinois, has established a cooperative educational and exchange program with the University of Samara in Russia. We have supported their activities in minor ways which has led to the availability of knowledgeable advice and high-level introductions from a prestigious Russian academic institution. We also are now drawing upon Bradley professors, with their Russian experience, to develop comprehensive quality systems for our Russian partner in order to achieve world class quality objectives in our manufacturing joint venture for oil well drilling rigs.

We now need to expand such partnering efforts, drawing upon our unique strengths, into technology development and application where the dramatic rates of change and sheer magnitude of resources and expertise required present an overwhelming challenge for us to take on individually.

Throughout my remarks today, I'll be citing Caterpillar's experience within the global heavy equipment industry as a means of illustrating my points. I'll talk about how Caterpillar has gotten to be the global leader in our industry -- discuss a few of the key technologies we are developing to meet the increasing requirements of our global customers and governmental regulatory agencies -- and conclude by highlighting some specific areas as candidates for cooperative efforts with government and academia. I don't presume to speak for other companies within the industry, but Caterpillar's experience should provide a pretty good indication of what's happening in our business and what we need to be globally competitive from a U.S. base.

(PAUSE)

Caterpillar is the world's largest manufacturer of construction equipment and a major producer of diesel and natural gas engines. Our subsidiary, Solar Turbines, is a leader in industrial gas turbines. Since its founding in 1925, Cat products have built a worldwide reputation for durability, productivity and life-cycle value. It's a rare project around the world where Cat isn't present ... from a small backhoe digging a trench ... to the most important infrastructure projects ... the Three Gorges Dam in China ... the toll highways of Mexico ... the Kuwaiti oil well fires .... the 1994 winter Olympics in Lillehammer ... and the list goes on.

In 1994, Caterpillar's total sales reached a record 14.3 billion dollars. While we make about 75 percent of our products in the United States, sales outside the U.S. usually make up about 50 percent of our sales. We believe this percentage will increase steadily over the next decade as infrastructure development accelerates in developing countries and Russia and China begin to realize their vast potential.

We're number 41 in the *Fortune* 50 -- and looking at exports as a percentage of sales, we're the third largest U.S. exporter -- behind Boeing and Intel. In terms of total export sales, *Fortune* ranks Caterpillar tenth.

Our U.S. operations, while important, are only part of our story. Our markets are worldwide, and we have no choice but to be a global competitor. We operate manufacturing locations in 15 countries and employ nearly 54,000 people. Our products are sold and supported by a network of 187 independent dealers with 69,000 employees and more than 1,000 locations -- serving customers in virtually every country. Our distribution and product support system is at the heart of our strategy to differentiate ourselves from competition and employs a host of advanced technologies in logistics, data management, communications, condition monitoring and machine diagnostics.

The list of our international competitors reads like a Who's Who of world industry and represents a formidable array of technology, commercial presence and financial strength -- Komatsu, Hitachi, Furukawa, Daewoo, Kobelco, Kawasaki, Fiat, JCB, Volvo, Mercedes ...

"Productivity Through Technology" for us is much more than just a catchy phrase. It is the essence of what we must offer our customers through our products and services if we are to retain their buying preference ... and it is exactly how we must continually transform our internal operations if we are to remain cost competitive on a global basis. While we have long emphasized technology and productivity leadership, the difficult lessons of the 1980s taught us much about customer-driven technology. Perhaps describing the impact of the 80s and our response will help me portray our vision of where we are headed and the critical role of partnering in our future.

For decades, Caterpillar sat comfortably on top of the heap. Demand for our products exceeded capacity ... as we grew, we built more plants and hired more people ... and on and on it went. We drove technology -- all we had to do was build a new product, and our customers lined up to buy it.

All that early and sustained success quite naturally led to a "hint of complacency." But then, suddenly, as the 80s hit, we watched helplessly as worldwide demand in our industry plummeted 40 percent. By 1984, Caterpillar had lost a billion dollars -- and although we had managed to protect our leading share of market, we were in danger of sacrificing it to our competitors. Our immediate reaction was to reduce our costs through downsizing, plant closings, inventory reductions. We reduced capacity, and our workforce dropped from its peak of over 90,000 in the late 70s -- to 58,000 by 1983.

Meanwhile, a host of new, cost-efficient, quality-focused international competitors came on the scene -- highly capable companies who could offer advanced technology at lower cost than we could. This appealed to our customers, who were faced with maintaining their own economic viability. In response to their own pressures and what they perceived competitors could offer, they began to demand more of our equipment and product support services -- raising the bar to higher and higher levels of durability, reliability, and productivity. "Do more than help us lower our owning and operating costs," they said, "guarantee the products' cost of operation. Give us new product features to improve our efficiency and increase productivity, right down to operator ease and comfort. Support those products 24 hours a day and keep downtime to a minimum, or eliminate it altogether. And while you're at it, make sure you help us meet increasingly strict environmental regulations for emissions, noise, vibration, and safety."

And so we began planning how to satisfy this increasing list of customer demands -- and how to use the more demanding customer as a forcing function to cause us to poke a permanent hole in the competitive net tightening around us. We initiated a set of aggressive strategies that have made us far leaner and somewhat meaner than we were 10 or 15 years ago. Our technology thrust pointed solely at customer needs; and we completely changed our internal culture from collegial functionality to an intense, action-oriented, personally accountable, focus on the customer.

One of the first lessons we learned (as we downsized and reduced capacity) was that we needed to modernize our manufacturing facilities and processes in a way that would keep us on the cutting edge of our industry -- not just for the present -- but on a permanent basis. The cyclical nature of our business dictated that flexibility and agility must become the keys to sustained global competitiveness in the new world of the 90s and beyond.

So in the mid-80s we began a worldwide plant modernization program, the magnitude of which was unprecedented in our industry -- and finished it up at year-end 1993. We selected 77 key areas in 17 facilities worldwide -- those most critical to our success -- and concentrated our 1.8 billion dollar investment on these. We updated tooling, machining, and assembly systems. We simplified operations ... reduced set-up time to minutes ... put into place computerized cellular manufacturing ... robotics ... lasers ... and just-in-time supply. Sixty-nine of these modernized areas are sites for Flexible Manufacturing Systems that have significantly improved our quality and process control while creating a crucial new ability to respond rapidly to changing market needs.

As a result, we've cut the average time to process a component from 25 days -- to 6. Our in-process inventories have been cut by 60%. Employment in the project areas was reduced by 30%. Perhaps most importantly, we have put into place the basis for continual improvement of our manufacturing systems and processes -- so that we may continue to set the pace rather than respond to the demands of global competition.

The benefits of factory modernization became crystal clear in 1994. We were able to produce the same physical volume with about 54,000 employees as we did in the late 70s with 90,000 people. We have achieved a tremendous ramp-up in production during the past twelve months. In the midst of a labor dispute at eight of our U.S. facilities, we created a virtually brand new U.S. factory work force ... trained them ... and churned out record volumes of products with record quality.

Today's manufacturing technology has empowered our factory workers even beyond our expectations. With this new empowerment comes new demands for expertise and involvement, consistent with a greatly expanded role in the business. Unlike yesterday's skill-based worker, today's knowledge worker is creating and interpreting information in addition to manipulating product and process. Factory workers now are equally tuned into the total manufacturing process, the competitive environment, and individual customer requirements. "How can we work together to win the business and satisfy the customer?" has replaced cries of "That's not my job."

Although the modernization of our factories and processes was in itself a massive undertaking for us, it was only one part of the job to be done to regain the lead in serving our global customers. While it was important to focus on how we produced our products -- we also needed to turn our attention to how we developed them as well -- and for the first time to truly take into account the close interaction and linkage between product development and process development. Much effort and a great deal of additional cultural change has translated the well-touted theory of Concurrent Product and Process Development (or CPPD) into a competitive reality.

The needed cultural change was helped immeasurably by a sweeping reorganization which transformed our 65-year old functional organization -- in which engineering, manufacturing, marketing and finance were separate towers of independent expertise and sequential baton hand-offs were the order of the day -- into four groups of product-based, decentralized business units. Product managers now have full accountability for the market and financial success of their product groups, and multi-functional teams whose members blend their particular areas of expertise to serve, for example, customers of hydraulic excavators ... wheel loaders ... track-type tractors ... on-highway truck engines ... or electrical power generation sets.

This visual illustrates the process we use to get from concept to an end product. The scope of our product and process design leverages advanced technologies (such as simulation and automated processing) to meet demanding customer needs ... to accommodate the capability of our suppliers ... and to meet new business metrics -- all in a compressed time frame. Our product development teams accomplish this by keeping our customers, operators, suppliers in the loop. So, with the end product, we're meeting target cost ... exceeding customer expectations ... and meeting reliability goals.

Our progress with Concurrent Product and Process Development has slashed Caterpillar's entire new product introduction time by more than half. Customers used to see a new product every seven years or so ... now they're getting them in three years -- and increasingly, even less. Our product line has never been more responsive to the needs of our global customers than it is today. While Caterpillar has made significant progress toward achieving our vision of CPPD, the work is far from done. Continued improvement in CPPD is one of the major keys to our future success.

To achieve new breakthroughs in CPPD, we need major advances in the tools we use in the process. These are the kind of tools that no single company -- including Caterpillar -- is or will be able to develop on its own. We need the help of government to focus the energies and capabilities of our national labs -- and to foster industrial consortia to create tools that will allow American industry to remain leaders in innovative product design. This kind of partnering enables sharing of risk and pooling of resources -- so U.S.-based global competitors like Caterpillar can leapfrog foreign competition in getting our products to market. Such a concept of shared risk and priority effort between industry and government is not a new idea -- it's what our toughest Japanese and European competitors are famous for!

With that in mind, let me describe some of the specific tools Caterpillar is using and developing to fulfill our CPPD vision.

First, advanced simulation technology. Computer-based simulation to evaluate dynamic stiffness and durability of welded structures ... dynamic analysis of the drive train in our vehicles ... manufacturing processes ... material flow through our factories ... and even total business simulations are all areas where simulation technologies are in use today ... making our product and process design efforts much more efficient and cost effective and compressing time to market.

We are currently developing Virtual Reality design tools in partnership with government and academia. Our Virtual Prototyping System, featuring the CAVE automatic virtual environment, lets engineers quickly evaluate many designs and identify problems early in the design cycle -- saving time and money and encouraging innovative approaches to machine design for more efficient equipment. Just two weeks ago at the world's largest construction industry trade show, Bauma, in Germany -- Caterpillar introduced its first product designed using virtual reality technology ... a mid-sized wheel loader redesigned with improved cab comfort and operator visibility for improved productivity. Our use of this technology in advance of our competitors wouldn't be possible without our partnership with the NCSA -- the National Center for Supercomputing Applications -- at the University of Illinois.

It has also become necessary to link our design process and manufacturing operations directly with our suppliers as we have speeded up cycle time. We don't just rely on suppliers for products and services -- we rely on their know-how. Whether it's generator design, or tires, or turbochargers, they often know more about some aspects of our products than we do. In selected cases, we rely on our suppliers to provide us with key technologies that we need to be competitive. No longer can our suppliers operate at the perimeters of Caterpillar's systems. Now they must be an integral part of those systems ... we must bring them into the process ... and the process must be seamless. They can't just keep up with our needs -- they must stay far ahead of our needs, anticipating changing customer demands and advancements in technology. This extent of supplier involvement and reliance has tremendous ramifications for our industry and for U.S. competitiveness as a whole. In order to improve our global competitiveness, we must make it a priority to strengthen our supplier base, if we are to successfully depend upon them for world-class product technology and world-class manufacturing expertise.

Ideally, with the tools in place and our vision of CPPD fully realized, we expect to fully overcome historical barriers of time and geography ... and enable designers and suppliers who are oceans apart to work as efficiently as if they were at the same table.

A good example of the application of CPPD across global markets is the approach we take to developing our most popular piece of construction equipment -- the hydraulic excavator.

Hydraulic excavators make up more than 40% of the worldwide construction equipment opportunity ... and sales are growing each year in all markets. Japan makes and buys the most excavators in the world -- so our hottest competition in the worldwide marketplace is from Japanese excavator manufacturers.

In the late 80s Caterpillar began an aggressive excavator development strategy to penetrate the high-growth excavator market from within Japan. Our best excavator design, marketing, purchasing, and manufacturing people from the U.S., Europe, and Japan were gathered together to work at our Hydraulic Excavator Development Center located in Akashi, Japan. The Development Center is a part of Shin Caterpillar Mitsubishi (SCM) -- our highly successful, 30-year-old joint venture with Mitsubishi Heavy Industries.

CPPD is emphasized throughout our excavator strategy. Used in a global context, it has given us a solid competitive advantage. The HEDC has developed a whole new line of excavators for Caterpillar -- the 300 Family. The HEDC designs products for manufacture in factories in Europe and the U.S. as well as Japan -- and is a key example of how we have been able to transcend time zones, existing manufacturing systems, cultural barriers, and so on -- to bring quality product to market in record time.

In 1992, the HEDC kicked off the 300 Family program ... and by year-end 1994, the first generation of ten models of excavators was completed. We had replaced an entire product line on a worldwide basis within three years. That's totally unprecedented in the industry. We've had great success so far with our new line of excavators, surpassing all of our forecasts and increasing market share in all worldwide markets -- including Japan. The work isn't done yet -- but we've seen firsthand now what kind of efficiencies are possible with such an approach. Now we need to learn how to implement and speed up the process for our other product lines.

The simultaneous introduction of products on three continents was made possible by the use of strong CAD / CAM and product modeling tools -- high speed data networks that move everything from E-mail to design data ... the liberal use of video conferencing ... and, oh, yes -- until our full vision of CPPD is realized -- a lot of plane tickets, too!

(PAUSE)

So, we have fought back from the low point of the mid-80s. Our worldwide market share today is considerably stronger than before the competitive onslaught on Caterpillar began over a decade ago. This comeback has been fueled by the aggressive application of state-of-the-art technology as exemplified by our thrusts in factory modernization and CPPD.

One thing we know for sure -- we can't rest on our laurels. We must keep driving forward even harder than when we were coming from behind. And, technology will be an even more determining competitive factor in the future.

Effective partnerships between government, industry, and academia are critical to advancing the competitiveness of American industry in the global marketplace. I'd like to mention a few of the strategic R&D programs currently in place at Caterpillar that depend on partnering. They include:

- The Autonomous Mining Truck -- a driverless truck that operates with the Global Positioning Satellite System.
- We are using partnerships to extend this technology to autonomous earthmoving sites -- for example, with ARPA's Technology Reinvestment Project for computer-aided earthmoving -- partnering with Leica-Torrance, Spectra-Physics, and the U.S. Army Corps of Engineers.
- Advanced Turbine Systems -- a worldwide market-driven program to increase fuel efficiency, reduce emissions, and lower operating costs of electric power generation. Caterpillar works with the Department of Energy, the Morgantown Energy Technology Center, the Oak Ridge National Lab, six turbine manufacturers, and the Electric Power Research Institute.
- Precision Laser Machining -- a program to develop breakthrough laser machining capability to yield higher quality, and lower cost products. We partner with ARPA plus about fifteen companies including TRW, Boeing, GM-Hughes, GE, Cummins, Ford, Chrysler, and Utilase.

The ability to team with such sources including U.S. government labs and agencies, in the long term, will be the key to the timely development and application of the technologies needed to maintain U.S. leadership in emerging commercial applications of technology in our industry. The days are probably past when this -- or any -- industry can afford the time or cost of bringing all the necessary technology "in-house." Teaming for technology development will have to become a way of life if we are going to realize the productivity gains needed and expected by our global customers -- and cost effectively meet increasing governmental regulations.

In closing, I would like to suggest several areas for consideration for Technology Development Teaming:

- On the shop floor, we need manufacturing technology that reduces the variability in manufacturing processes and still provides improvements in flexibility and availability.
- In our factories, we need standards for manufacturing systems that can communicate with each other and with our suppliers.

- In our development processes, we need new simulation tools for product and process performance linked with accurate costing models, so we can produce machines and engines that meet customer expectations, target costs, and reliability/durability goals -- without the extensive and costly testing and validation programs needed today.
- For our new products, we will need continued advancement in core technologies such as materials, electronics, sensors, and software development tools.
- We and our suppliers need to learn to develop effective partnerships and alliances with universities, government agencies, and customers to gain access to the world-class technology necessary for global industry leadership.
- And we will all benefit from communication standards and policies allowing the free flow of information across national and international boundaries -- as I have illustrated from our own experience with the HEDC.

The plans being put into place at this conference can help provide the technology strategy necessary to ensure that all the potential partners can see where their contributions and investments fit into the overall goal of improving U.S. global competitiveness. We at Caterpillar welcome the opportunity to participate in this process.

Thank you.

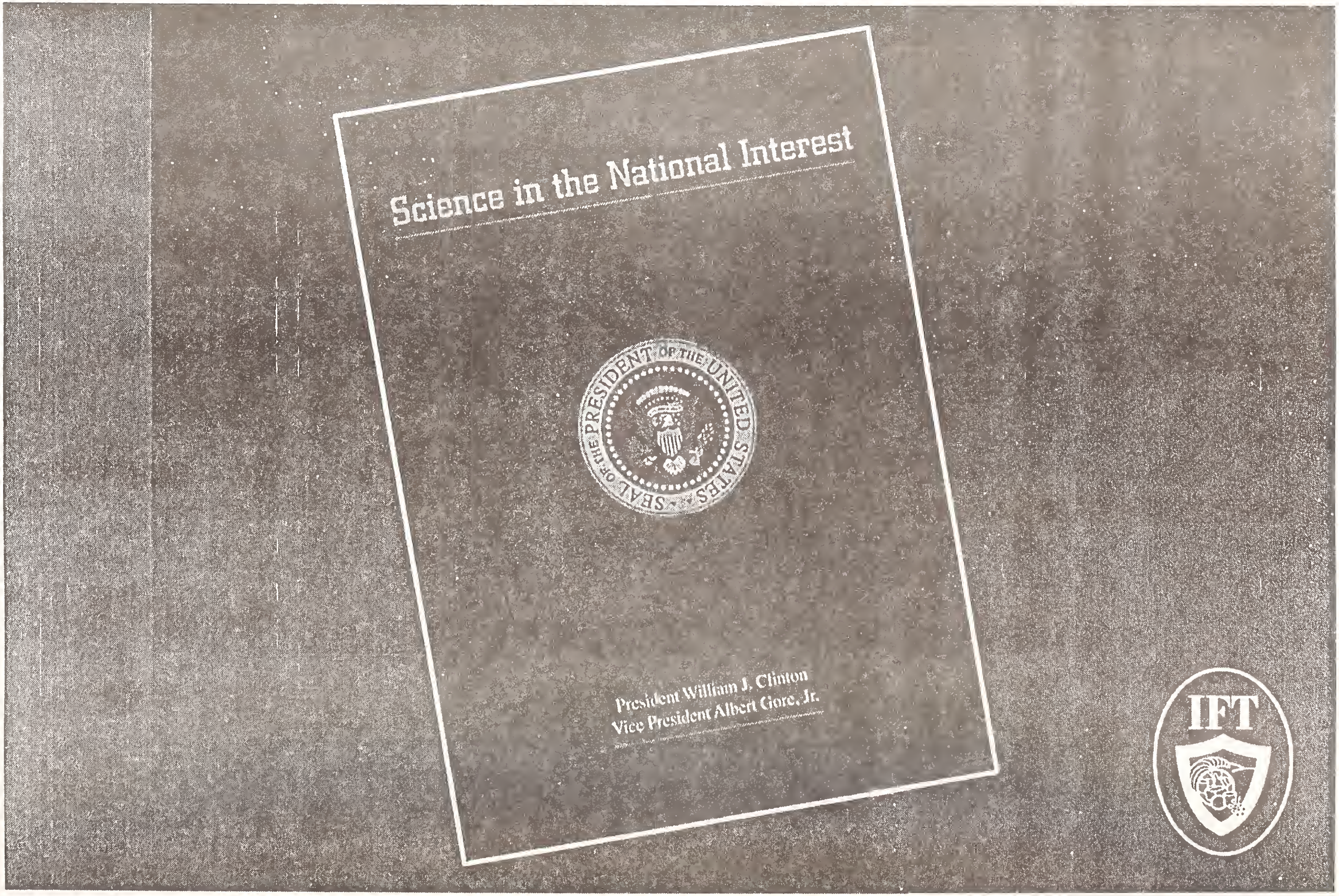
Al Clausi
Past-President
Institute of Food Technologists

USFEAST: A Collaborative Approach for a Cleaner, Safer, Healthier and More Competitive America

IFT

National Priorities for the U.S. Food System

- Enhance global competitiveness
- Improve food safety
- Develop better processes and products that promote health
- Implement new technologies to reduce waste and conserve resources


Science in the National Interest
SEAL OF THE PRESIDENT OF THE UNITED STATES
President William J. Clinton
Vice President Albert Gore, Jr.
IFT

Contribution of Food Manufacturing to the U.S. Food System

Year	Total Food System* Value Added in $Billion
1947	71.7
1982	347.3
1992	494.4

* Includes agriculture, food processing, tobacco, transportation, retail and food service.

Source: Connor, J.M. and Schiek, W.A. 1996. Food Processing. Forthcoming.

IFT

Size of Manufacturing Industries, 1991

Industry	Value of Shipments ($Billion)	Value Added ($Billion)
Food Processing	$387.6	$145.3
Chemicals	$292.3	$154.8
Nonelectrical Machinery	$243.5	$124.2
Motor Vehicles	$206.1	$73.3
Electrical/Electronic Machinery	$197.9	$106.7

Source: Connor, J.M. and Schiek, W.A. 1996. Food Processing. Forthcoming.

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U.S. Food Experts Alliance for Science and Technology

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Top Issues Facing the Food System

- Improved food safety especially through the control of foodborne pathogens
- Enhanced nutritional quality and healthfulness of foods that will promote wellness and reduced the risk of disease
- Improved industrial ecology through conservation of inputs and reduction of waste outputs
- Global competitiveness in food science, technology, manufacturing systems, and waste products

IFT

Competitiveness

Research Consortia

	Percent of Total R&D Expenditure	Public/Private Cost Sharing
Europe	6	50/50
Japan	4	50/50
U.S.	1	25/75

Source: Gibson, D.V. and Rogers, E.H. 1994. Collaboration on Trial

R&D Investment, 1992

	Private Sector % Net Sales	Federal R&D
All Manufacturing Industries	3.3	1.1
Food, Kindred Products (excludes agriculture production)	0.5	Not measurable

Source: National Science Foundation. Research and Development in Industry: 1992. In press.

Food Safety

IFT

Environmentally Responsible Food Processing

IFT

Environmentally Responsible Food Processing

- Management ⇨ prevention
- Consumption ⇨ conservation
- Minimizing ⇨ avoiding

The Food Processing System Seeks to:

- Prevent Pollution
- Reduce or eliminate waste
- Use water and energy more efficiently
- Reduce operating costs
- Increase outputs

IFT

Food and Health

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The National Agenda

- Economic growth
- Environmental protection
- More efficient government
- World leadership in science, mathematics, engineering

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of
Food
Technologists

USFEAST:

A collaborative approach for a cleaner, safer, healthier, and more competitive America

Remarks delivered by

Al S. Clausi
1993-94 President
Institute of Food Technologists

At

The National Institute of Standards and Technology's
National Manufacturing Technology Conference
Gaithersburg, Maryland

April 18, 1995

USFEAST:
A collaborative approach for a cleaner, safer, healthier, and more competitive America

Introduction

Thank you for your kind introduction. I am pleased to be meeting with you again this year on behalf of the Institute of Food Technologists, the 28,000 member society for food scientists and technologists working throughout the food system in industry, academia and government.

At this meeting a year ago, I described the challenge currently facing the food system as it beholds the 21st century. The challenge is this: how can we best achieve the scientific and technological breakthroughs needed to catapult the U.S. food system to the highest level of scientific and technological achievement.

We issued a wake up call and it looked like this: [VIDEO]

As you saw in the video, it is of national priority that we in the food sector:

- Enhance global competitiveness
- Improve food safety
- Develop better processes and products that promote health
- Invent new technologies to reduce waste and conserve resources

I believe it is fair to say that, at this time last year, the nation's food system was a distant blur on the nation's radar screen of priorities. This year, I am proud to say that President Clinton, in his August 1994 policy statement on "Science in the National Interest," recognized in his opening sentence the importance of feeding our growing population, improving human health, and protecting the environment.

Further, the President's Committee of Advisors on Science and Technology in conjunction with the National Science and Technology Council have recognized health, safety and food research among its highest priorities for national investment in science and technology. In his March 31st report to Congress on science and technology, President Clinton again reiterated the priority of food research. We welcome the arrival of food science on the national research agenda and strongly support the public and private efforts that have underlined the critical importance of the food system to our nation's economy, security, health, and well-being.

Many in this audience last year were astonished to learn that, at nearly $500 billion annually, food manufacturing is our nation's largest manufacturing sector. From 1982 to 1992 food manufacturing increased the economy by nearly $150 billion in terms of "valued added." And, in terms of absolute dollars of "value added" to our economy the food processing segment is second only to the chemical industry, which includes pharmaceuticals.

We wish to emphasize that food must remain a load-bearing pillar in the nation's technostructure for the 21st century. America's industrial superiority in food distinguishes our world leadership, supports our military strength, and aids our peace initiatives through humanitarian aid. We take for granted our domestic bounty and our country's ability to export commodities and value-added foods at globally competitive costs. And we assume that our food will be safe, wholesome and nutritious.

While the U.S. food industry leads the world in its ability to convert raw commodities to finished products, there are troubling signs that America's competitive edge may be eroding. These include further losses in the manufacture of food processing equipment and packaging to overseas competitors, and a decline in investment in food science and technology research. Both are bellwethers of erosion in technological leadership and innovation.

At this conference last year, we proposed creating a collaborative alliance involving industry, academia, and government that we called "USFEAST" – The U.S. Food Experts Alliance for Science and Technology. The proposal received strong encouragement from all parties, and today, I report tangible progress in our efforts to establish meaningful collaboration to meet the challenges facing our food system.

Under the leadership of the Institute of Food Technologists, whose members are drawn from industry, academia and government, USFEAST has established a Steering Committee and five working committees to tackle our priority issues. The Steering Committee is chaired by Larry Kuzminski, vice president for technical research and development at Ocean Spray Cranberries. Leading scientists in industry and academia chair the remaining committees.

The top issues facing the food system and hence, delineating our roadmap, are:

- Improved <u>food safety</u> especially through the control of foodborne pathogens
- Enhanced nutritional quality and <u>healthfulness of foods</u> that will promote wellness and reduce the risk of disease
- Improved <u>industrial ecology</u> through conservation of inputs and reduction of waste outputs
- <u>Global competitiveness</u> in food science, technology, manufacturing systems and products

Competitiveness

First, let's address the issue of competitiveness. It is important to note that exports of U.S. high-value food and agricultural products remain a leading bright spot in the U.S. trade balance. Demand for these products abroad is growing. High value products are of two types—partially-processed commodities, such as soybean meal or corn sweeteners, and value added consumer foods ready for consumption in retail or food service markets. Rising incomes in countries in Asia and Latin America coupled with changing lifestyles are generating greater demand for U.S. consumer foods. From 1988 to 1993, exports increased an average of 14 percent annually, many times the rate of growth of domestic markets for consumer foods during those years. Exports of high-value products led bulk commodities for the first time in the mid-1980's. And, in the early 1990's, growth in exports of consumer food products outstripped partially processed products for the first time. Clearly, U.S. food processors are doing something right in the global marketplace. We believe these international marketing opportunities will stimulate U.S. economic growth.

There are major challenges ahead, however, and signs that, if ignored, could cause us to falter in our global competitiveness. One of the leading insights of the USFEAST Competitiveness Committee is that, while American food companies have both business and market development strategies, they have not integrated their core technology strategies into their business management plans. In direct contrast to their competitors in Europe, Asia, Australia and Canada, research and technological development largely remain outside the development of business strategies. Integration of strategic technology planning with business goals assures ongoing process improvements, as other high technology industries have proven time and again.

Corroborating the Competitiveness Committee's finding, the White House Office of Science and Technology Policy issued a report to the President last month assessing the status of 27 technologies considered critical to the nation. Overall, the report characterized as "slight" the U.S. lead in food and agricultural technologies over competitor nations in Europe and the Far East.

A recent study on U.S. research and development consortia noted that in Europe, consortia activities across industries represent 6 percent of total research and development expenditures; in Japan the figure was 4 percent. The comparable figure for the U.S. was 1 percent. In Europe and Japan such consortia are funded 50/50 by government and industry. In the U.S. the proportion was 25 percent from government, 75 percent from industry.

Comparing private and public sector investment in food manufacturing research and development in 1992, the National Science Foundation found, in essence, that federal investment in food manufacturing was immeasurably small.

These figures make it clear that our own short-term thinking hands over to our competitors the advantages of leveraging research dollars, pooling expertise, and investing in long-term strategies.

The U.S. food system is climbing a steep learning curve. Except for bilateral cooperative agreements between individual food companies and academic research institutions, of which there are many, the 16,000 food companies that comprise the food industry are used to "going it alone." They compete with each other and with foreign competitors largely on an individual basis. Only recently are multi-party research initiatives emerging in the food sector. Thus, while we may have lagged our overseas counterparts in developing a common food research agenda and the mechanisms to work collectively, USFEAST is poised to capitalize on its unsurpassed research strength, its world class technological capability, and its global vision.

Food Safety

Recognizing that the U.S. has one of the safest food supplies in the world, yet at the same time our world includes microbial pathogens, those of us in the food system must always be vigilant against food borne pathogens. New and emerging harmful organisms ensure that the task is never completed. Scientists are unanimous in their agreement that microorganisms are by far the greatest danger to food safety. Of course, other threats to food safety, such as toxicants and contaminants, also warrant safeguards.

The USFEAST Food Safety Committee foresees major technological achievements in assuring food safety. For example, the DuPont microbial typing technology featured in the video is, to our knowledge, the first to win an award through the NIST Advanced Technology Program last fall. This technology and others in development offer promise for improved microbial quality assurance as well as more rapid drug and pesticide residue detection. Minimizing the risks of foodborne pathogens, however, hinges on greatly advancing our understanding of microbial ecology: how organisms enter the food supply, what makes them flourish, why one strain is virulent while another closely related one is harmless, and what makes organisms pathogenic. These are some of the questions for which there are no firm answers and hence only limited control measures. Predictive microbial modelling, however, based on what we know about microbial behavior, has become an increasingly powerful tool for designing foods and controlling processes to ensure safety.

The Office of Science and Technology Policy has found that the U.S. either lags or is on par with major competitor nations in food safety. OSTP recognizes, for example, that no technology for processing food is universally protective. Its recent report to the President stated:

> "The application of advanced technologies to monitor food quality and test bacteria, viruses, parasites, or chemical contaminants is still quite limited in the processing/production environment. While techniques including flow cytometry, immuno-assays, and DNA-hybridization including polymerase chain reaction have demonstrated capabilities in the laboratory, it is not currently economic to deploy them in the large volume production environment in today's [U.S.] food processing plants."

Food safety is receiving increasing attention in international trade, where harmonization of safety standards and the adoption of HACCP programs are deemed crucial for smooth world trade. It is clear that cross-cutting research accomplishments in this field will pay great dividends in both food quality and competitiveness.

Environmentally Responsible Food Processing

The U.S. food industry and global industrial development in general confront a growing dilemma. We face a climate of increasing public and government concern over depletion of non-renewable resources and the growing environmental threat from industrial pollutants and wastes. At the same time we strive for industrial growth and increasing competitiveness. Increasingly, industry, government and the public recognize the need [SLIDE] to shift from managing environmental problems to preventing them; from consuming to conserving resources; and from minimizing to avoiding harmful consequences to the environment.

Specifically, we need to prevent pollution, reduce or eliminate waste, make more efficient use of energy and water, while at the same time reduce operating/unit costs and increase output. Not surprisingly, the path to overcoming these challenges lies in advanced technologies. For example, food processing uses prodigious quantities of water. Without novel technologies which could replace these traditional processes—technologies with improved energy efficiency—it is difficult to appreciably reduce water consumption. Similarly, new technologies applied to food processing, such as the laser potato peeler illustrated in the video, actually eliminate waste by converting the byproduct (potato peels) to carbon dioxide and water.

Success in the development of innovative, environmentally responsible food processes foreshadow changes not only in food processing but in agricultural practices, energy utilization, water management, transportation, and consumer behavior. New food technologies with environmental advantages will also have economic benefits and provide an important link with sustainable development.

Food and Health

Just about everyone knows that diet can be a powerful influence in deterring and delaying the major chronic diseases that affect affluent countries. That said, however, food choices are far from being a magic bullet. As we expand our understanding of the array of foods that not only meets nutrition needs but contributes positively to wellbeing without compromising risk of health, we are better able to develop the kind of convenient, healthful, and palate-pleasing foods that meet today's busy lifestyles. Already, two thirds of adults consume "light" products an average of four times a week. But the food system faces the challenge not only of lightening the fat, calorie and sodium load, but in boosting the fiber and calcium content, and determining optimum levels of such factors as anti-oxidant vitamins, various fatty acids, and micronutrients such as folic acid, copper and zinc. At the same time, the sobering observation that more Americans than ever are overweight—approximately one-third of all adults are obese—makes it clear that the challenge of ensuring wholesome nutritious food choices goes far beyond the contents of a particular package.

We in the food manufacturing sector see a golden opportunity to build on the science and technology base created in nutrition, food science, engineering, clinical studies and education to meld the talents of government, academia and industry to make real progress not only in creating tasty, convenient, and healthful food choices but in ensuring that such choices are part of everyday lifestyles as an important means to achieve greater health, happiness and productivity.

Food Science and Technology on the National Agenda

The Honorable John Gibbons, Director of the Office of Science and Technology Policy, enunciated to the House Committee on Science and Policy three goals of science and technology policy for the nation. They were:

- Long term economic growth that creates jobs and protects the environment

- More efficient and responsive government

- World leadership in basic science, mathematics and engineering

We wholeheartedly agree that science and technology are national agenda items. We would add the word food not only to science but also to technology, for there are other aspects of technology that are very important to enhancing the strength of the U.S.'s future food manufacturing base, as are aptly identified by the Center for Advanced Food Technology (CAFT) at Rutgers University. These include shop floor training, computerization, and automation within existing know-how and technology. A developmental thrust is needed in addition to research. We also need to get young people interested in food science and technology, and this has to start at a very early age.

Future innovations in the industry require the skills, talents, brains, and creativity that spawn new industries, generate ideas, and develop new products that result in high-paying jobs for American workers. Already the drive for "green" technologies is forging new industrial development and creating jobs. Advanced technologies such as time temperature integrators for tracking the temperature exposure of foods, pulsed light technology for pasteurization, and on-line nuclear magnetic resonance and video imaging for quality control herald a new level of sophistication in our food processing systems. These are the types of advancements rightly expected of American research.

The lean budgets experienced by government, universities and companies have fostered the search for collaborations that leverage research investment dollars and human talent. They are everywhere forcing tough choices for establishing priorities in research and investment. Cooperative agreements among government, industry and academia are a logical outcome of the search for ways to leverage tight dollars, to focus on the most strategic research investments and to streamline the processes leading to achievements. The President's "Reinventing Government" initiative has already stimulated much closer cooperation and activity within government agencies, with USDA undergoing its second major overhaul towards streamlining in the past year.

Third, world leadership in basic science, mathematics, and engineering underpins America's stunning achievements in physics, chemistry, medicine, transportation, and food science, to name just a few jewels. It is no secret however, that our scientific leadership in food—to select just one area—in such aspects as biotechnology, packaging, thermal processing, and filtration technology is being significantly eroded. These are the technologies upon which the prospects for significant achievement in health, safety, and security of food production rely; these are the pillars which anchor the economic strength, competitiveness, jobs and environmental protection of the food system.

In the food system the easy problems have been solved. It is the formidable gauntlet of complex, long term, fundamental scientific questions, such as those involved in understanding the interactions of food chemicals, the determinants of pathogenicity in microorganisms, and the complex interplay among genes, food and the environment in human health, that constitute the barriers to breakthroughs in food technology.

USFEAST believes that collaboration among government, industry and academia is the most effective way to solve the cross-cutting, precompetitive, long term research and development technological problems challenging the food system. Compared with our global competitors, America vastly underinvests in civilian research and development by both the federal and private sectors. President Clinton said in his biennial report to Congress on Science and Technology, on average, money invested in science and technology brings a 50 percent rate of return—about double the average private rate of return. As you can see, the collaborative approach is not only good business practice but, in all likelihood, the only way to achieve the scientific advancements needed to develop the successful food technologies of the future.

USFEAST
Institute of Food Technologists
221 N. LaSalle Street, Suite 300
Chicago, IL 60601-1291
Telephone: 312/782-8424
Fax: 312/782-8348

Craig Long
Director of Quality
Milliken and Company

MANUFACTURING TECHNOLOGY CONFERENCE

Craig Long
Director of Quality
Milliken & Co.

SLIDE #1

Ladies and Gentlemen, Thank you and Good Afternoon.

It is my honor and privilege this afternoon to speak on behalf of our nation's very large, multi-level, totally vertical, fibers, textiles, and fabricated products industry.

Like many industries represented here today, this industry is undergoing tremendous change like it has never seen in it's history.

At Milliken & Company, we have many sayings on the wall, I would like to begin with this one:

SLIDE #2

"Our greatest fear should not be change, but failure to employ change."

My message today is twofold. Number one: To update you on the global competition that threatens so many jobs;

and Number Two: to share with you some of our industry's fundamental changes this very large industry is making to address this competitive environment.

SLIDE #3

Specifically, today, I will address how the industry is uniting with academia and government to attack these huge challenges.

I believe the greatest contribution our industry could make to this Conference is to share the success we are experiencing in this united partnership--we call **THE AMTEX PARTNERSHIP.**

SLIDE #4

This industrial complex is made up of 3 key areas--first is fibers, represented by 39 companies; **textiles,** represented by 4,982 companies; and **fabricated products**, mostly small cut and sew operations for apparel--21,301 companies.

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SLIDE #4

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SLIDE #5

The industry is characterized by fiber and textiles being capital intensive, and fabricated products--labor intensive, but overall, an industry of **HIGH TECHNOLOGY,** with each segment having the **HIGHEST PRODUCTIVITY** of any other nation in the world!

SLIDE #6

We believe our industry to be one of national strategic importance employing approximately 2 million people and accounting for 4% of manufacturing gross domestic product.

SLIDE #7

In terms on national importance, this equates to approximately 12% of all manufacturing jobs.

> Our consumer sales are $219 billion dollars per year.

> Our industry wholesale shipments are $137 billion dollars per year.

> We invest about $4 billion dollars per year in capital equipment.

> We pay about $4.0 billion dollars per year in state and federal taxes.

> The 2 million people we employ work in operations in all 50 states.

> We spend $3.5 billion o R&D each year.

SLIDE #8

Our industry generated $58.9 billion dollars in gross domestic product. More than all major manufacturing industries except for the aerospace industry.

SLIDE #9

And, our consumer sales were the largest in 1993 of all manufacturing industries at $227 billion dollars.

SLIDE #10

Now, a look at our challenges.

The U.S. apparel market continues to grow in billions of square meters, but domestic production is declining, while imports now exceed our domestic production.

SLIDE #11

In fact, our trade deficit in 1994 was over $36 billion dollars.

The net affect of these massive imports is the loss or unrealization of 1,240,000 jobs.

We believe this is important. We believe the challenge is real and we believe there is a lot at stake for our industry and our nation.

SLIDE #12

Before I go on, I want to talk about the customer. We get involved in so many issues sometimes we often forget about who ultimately drives change--the customer.

The model on this slide is very simple, the intersection of the circles made up of Quality, Cost and Delivery.

As we have studied great industries around the world, we have found the customer to be the focal point of everything they do.

As the customer, in the end, only sees 3 things:

QUALITY, COST, and DELIVERY.

In terms of Quality, the textile industry has made tremendous strides in quality, as many industries have also done.

For Milliken & Company, winning the Malcolm Baldrige Quality Award in 1989 reinforced this position. Our research tells us that Quality continues to be the number one rated attribute of our products by our customers.

What we are finding is Quality alone will not win the game. It is becoming a basic requirement to play in the game. Your must be cost competitive and deliver what the customer wants and when he wants it.

<u>SLIDE #13</u>

So, lets talk about cost next. This is another quote we like:

"Driving down cost is the ultimate competitive weapon."

SLIDE #14

The chart shows that both our textile and apparel segments have increased productivity annually more than the average of all USA manufacturing--3.4% for textiles and 3.1% for apparel, versus the USA average of 2.5% per year.

SLIDE #15

Look at what has happened in technological advancements in yarn formation--in productivity an 8.2 fold increase in 2 decades.

SLIDE #16

And fabric formation technology, a 6.7 fold improvement in 20 years.

There's just one problem, the major machinery developments that have brought about these enormous productivity increases in large part, have been by a few companies, all non-USA companies, and they are selling the new generation equipment worldwide.

<u>SLIDE #17</u>

On Delivery, our research shows that Delivery--that is delivering the right product when the customer wants it--is only exceeded in importance by Quality.

To address Delivery, the industry created the ***"CRAFTED WITH PRIDE COUNCIL"*** in 1984 because of the rising import situation.

One objective of this industry consortium was to study our total vertical industry <u>AS A SYSTEM to</u> determine how we could best increase our domestic industry's competitiveness.

This industry-wide initiative developed some stunning learnings. Despite the fact that each segment of the industry had the best quality and highest productivity in the world, there was an enormous loss--or waste--in the vertical supply chain from the manufacturers to the retailers and to the consumers.

These studies revealed that there was typically a 66-week apparel supply pipeline from raw fiber to the consumer!

SLIDE #19

Specifically, there was a $25 billion dollar loss--or 25% of our sales resulting from markdowns, out-of stock and inventory costs--not **delivering** the right product at the right time.

These losses were a direct result of our industry's inflexible manufacturing and inadequate forecasting, planning and scheduling capabilities.

These studies led to the formal launching of what was labeled **"QUICK RESPONSE"** throughout our industry. Studies showed that at least 12 billion dollars of cost could be eliminated. By putting into place point-of-sale information as the starting point for a **"CONSUMER PULL SYSTEM"** as opposed to the **"MANUFACTURING PUSH SYSTEM"** that has prevailed in the USA.

In recent years, a new label has been given to "**QUICK RESPONSE**" by many in the industry-- ***"DEMAND ACTIVATED MANUFACTURING" (DAM).***

SLIDE #20

In the end, the customer demands quality, cost, delivery and ultimately innovative new products.

SLIDE #21

We concluded inspite of the tremendous efforts made by the industry that we desperately need world class collaboration and research and development similar to what we are seeing in other countries.

We concluded that we needed collaboration of our total industry with our world class government research laboratories, universities and other organizations.

SLIDE #22

What is needed for world class technology leadership? We believe it is simply an issue of **LINKAGE and LEVERAGE.**

Linkage and leverage of the fundamental pieces already in place

-- Basic Research - in our universities

-- Applied Research - in place in our National Labs.

SLIDE #23

To make this work, the entire industry had to come to the table united. Our industry is unique because of its extraordinary integration, horizontally and vertically.

We are made up of 27 trade associations.

SLIDE #24

The industry research, education and technology transfer organizations (RETT) almost totally supported by the industry, focus on providing industry leadership, education, process research and development, technology road maps, technology assessment, competitive technology transfer from around the world into the domestic industry.

And, these organizations have been in place supporting the industry for years.

> Cotton Incorporated - supporting cotton growers for 32 years.

> Institute of Textile Technology - supporting textile manufacturers for 50 years.

> Textile/Clothing Technology Corporation (TC2) - supporting apparel manufacturers for 13 years.

> Textile Research Institute - supporting fiber producers for 64 years.

These unique industry organizations, or consortia, have been led by the industry's leaders with a passion for driving our industry's competitiveness to a world class level.

SLIDE #25

The National Textile Center was created in 1991, driven by the industry's vision of expanded research needs. The National Textile Center was formed with four universities that graduate approximately 90% of the textile related students for the industry.

SLIDE #26

With this industry structure in place, in March of 1992, Secretary of Energy Hazel O'Leary signed the AMTEX Agreement, initiating a consortium with the textile industry and the Department of Energy involving all 12 of the National Laboratories (the first agreement of this type ever!) to do large-scale, applied research, which these government laboratories have done so extraordinarily well for our nation's defense and energy initiatives.

SLIDE #27

The AMTEX Partnership is based on 7 principles:

1. Engages the entire industry and is industry driven
2. Projects are industry selected to minimize duplication
3. Initiatives do not pick winners--all companies can participate
4. Research is focused on basic process technologies (not competitive or proprietary products).

SLIDE #28

5. Projects are organized to capitalize on core strengths and technologies of the National Laboratories
6. AMTEX initiatives are in full alignment with the National Laboratories core missions
7. All projects have quantifiable economic objectives with regular reviews

SLIDE #29

The major AMTEX initiatives are to create leapfrog breakthroughs that will ultimately drive Quality, Cost, and Delivery using:

1. Information highway
2. Flexible Manufacturing Processes
3. Waste Materials Utilization

SLIDE #30

There are currently 8 projects underway in AMTEX

1. DAMA (Demand Activated Manufacturing Architecture) -- will design the textile industry's electronic marketplace of the future. DAMA will link the industry supply chain to produce apparel on demand.

2. **CAFE (Computer Aided Fabric Evaluation)** -- will provide automated inspection capabilities of all fabrics (Cost)
3. **TreC (Textile Resource Conservation)** -- will work on resource efficient manufacturing processes, including reducing energy consumption and manufacturing products without introducing waste into the environment (Cost)
4. **RCI (Rapid Cutting Initiative)** -- will work with fabric cutting technology to assist with flexible, small lot manufacturing.
5. **EEF (Electronic Embedded Fingerprints)** -- will develop miniature electronic tags that will be used to identify a product's history and track the product through the supply chain.
6. **SFAM (Sensors for Agile Manufacturing)** -- will identify sensors and develop feedback controls for flexible, fast and safe sewing.
7. **CBI (Cotton Biology Institute)** -- will assist with identifying genes that are associated with improved fiber and textile properties.
8. **OPCon (Online Process Control)** -- will use sensors for real-time monitoring of critical fiber manufacturing process parameters.

SLIDE #31

All of the projects just mentioned draw on one or more of the National Laboratory's core competencies:

National Laboratories Core Competencies Applied

1. Modeling of Complex Systems
2. Computer Networking
3. Information Analysis
4. Image Recognition Sensors
5. Closed Loop Control Systems

SLIDE #32

National Laboratories Core Competencies Applied (cont'd)

6. Laser Technology
7. Advanced Coatings and Materials
8. Miniaturization
9. Gene Sequencing

SLIDE #33

DAMA - The Demand Activated Manufacturing Architecture project is the largest project in AMTEX, involving 7 of the National Laboratories and currently having 34 industry research partners.

SLIDE #34

Based on a study done by Kurt Salmon & Associates in 1985, it takes 66 weeks to bring apparel products to market; from the time the initial order is placed until the item is purchased in a retail store. This very long lead time is the main reason there is so much waste, and opportunity, in the domestic textile product pipeline. It is also a reason why offshore competition has been so effective in gaining US market share. If it takes us 66 weeks to get a product into the consumers' hands, the few weeks it takes to ship garments from the Pacific Basin to the US is somewhat insignificant.

SLIDE #35

DAMA Vision: By the end of the decade, DAMA will link the U.S. integrated textile complex enabling effective and responsive decisions resulting in a net gain in the global marketplace.

SLIDE #36

DAMA has 3 main goals:

1. Determine the strategic business structure changes needed
2. Establish a textile industry electronic marketplace
3. Engage the industry in DAMA

SLIDE #37

A recently completed study on men's wrinkle resistant cotton slacks tracked the slacks from the cotton field

SLIDE #38

Through the fabric formation and dyeing sector,

SLIDE #39

Then, through the apparel manufacturing sector, and

SLIDE #40

Through retail sector. The industry model will then be used to simulate the effects of changes to current business practices.

SLIDE #41

The second goal of **DAMA** is to provide an electronic marketplace, where all sectors of the supply chain, including customers, can interact to buy, sell, negotiate, identify customers and suppliers, and form partnerships to provide demand activated responses unlike the customer has ever seen.

SLIDE #42

The **third goal of DAMA** is to engage the industry. There are currently 29 industry partners (representing all sectors of the industry). This goal is to communicate to the entire industry the accomplishments of DAMA.

SLIDE #43

(DAMA National Laboratories) - DAMA has 7 National Laboratories involved in the project. After only little more than a year since the project has been funded, these laboratories are working cooperatively and effectively together for the sake of the industry.

SLIDE #44

MAJOR ACCOMPLISHMENTS. And the accomplishments made on the DAMA Project already make an impressive list.

We have developed a simulation of the 66 week supply chain pipeline. This simulation resides in the DAMA Learning Lab, and has been used by the industry to see how changes in forecasts and inventory levels impact on cost and service levels.

A comprehensive model of the industry is under development, using product line investigations and "Best of Class" benchmarking from within the industry.

SLIDE #45

MAJOR ACCOMPLISHMENTS (CONT'D) - An apparel manufacturing sourcing database is about to be brought on-line, with the help of Apparel Manufacturers

Associations.

TEXNET, a prototype of how point-of-sale data can be effectively summarized and sent back down the supply chain. The research partners regularly working on the project are exchanging information through the internet.

SLIDE #46

AMTEX, a role model partnership of government and industry working together to strengthen an entire industry

> 110 Scientist and Engineers from 12 of the National Laboratories
> 120 Scientist and Engineers from 150 industry companies
> Coordination of the applied research efforts through the industry
> Research/Education/Technology training organizations that have been serving the industry for years
> And coordination with the basic research efforts going on in our universities under the National Textile Center.

A PROVEN ROLE MODEL OF GOVERNMENT AND INDUSTRY WORKING TOGETHER!

A few weeks ago, we had a review of the AMTEX Projects.

I would like to share with you Secretary Hazel O'Leary's comments on the progress to-date:

FILM - 6 Minutes

In closing, I would like to thank you for the opportunity to share with you the lessons learned from the fibers, textiles, and fabricated products industry and the AMTEX Partnership.

As barriers come down, and we begin to work together, our industry believes we will develop "LEAPFROG" technology that will fundamentally change the industry in such a way the consumer will see the finest Quality, Cost, Delivery and Innovative products made in the United States of America!!

THANK YOU!!!!!!!!!!!!!!

James Schoonover
Director of Operations
DuPont, Co.

James D. Schoonover
Director of Operations
DuPont Co.

Transformation of DuPont

Chemical and Specialties

DuPont - 1994

Sales	$ 39 B
Net Income	$ 2.7 B
Total Assets	$ 37 B
Return on Equity	23%

	Chemicals & Specialties	Petroleum (Conoco)
Sales & Transfers	$ 22B	$ 17 B
After Tax Operating Income	2.4 B	$ .7B

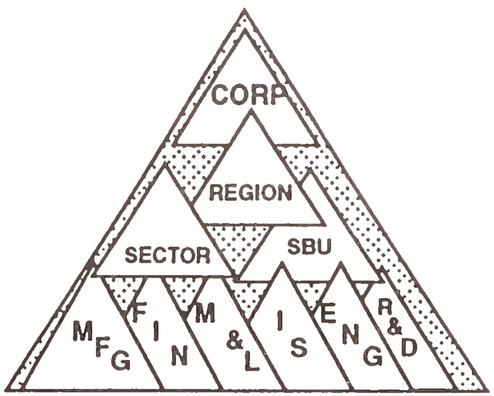
C & S Major Product Lines

- Fibers
  - Nylon
  - Dacron®
  - Lycra®
- Polymers
  - Engineering
  - Packaging / Industrial
  - Automotive
- Chemicals
  - Ti-Pure®
  - Fluorochemicals
  - Specialties
- Diversified
  - Agriculture
  - Electronics
  - Films / Medical / Printing

NIST
4/7/95

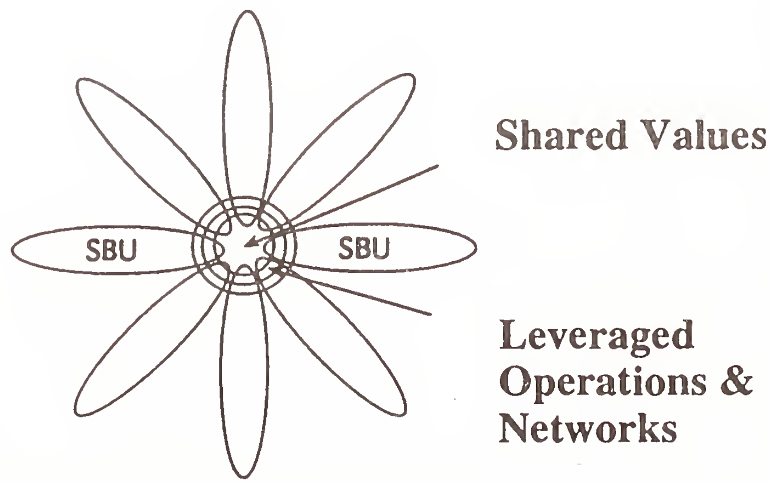
Re-Engineering DuPont

From: Sectors, Functions



1991

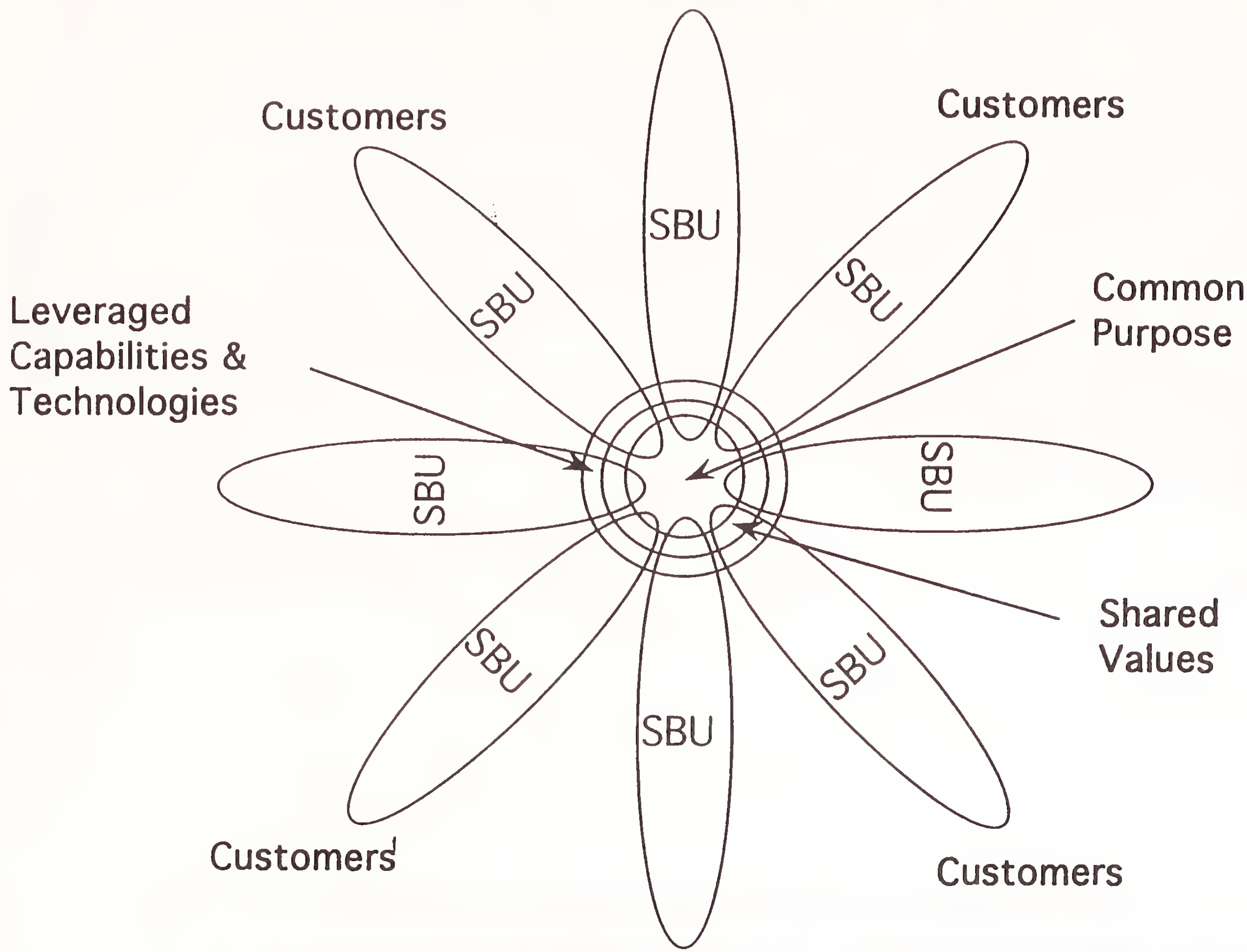
To: SBU's, Leveraged Operations



1993

NIST
4/7/95

DuPont C & S



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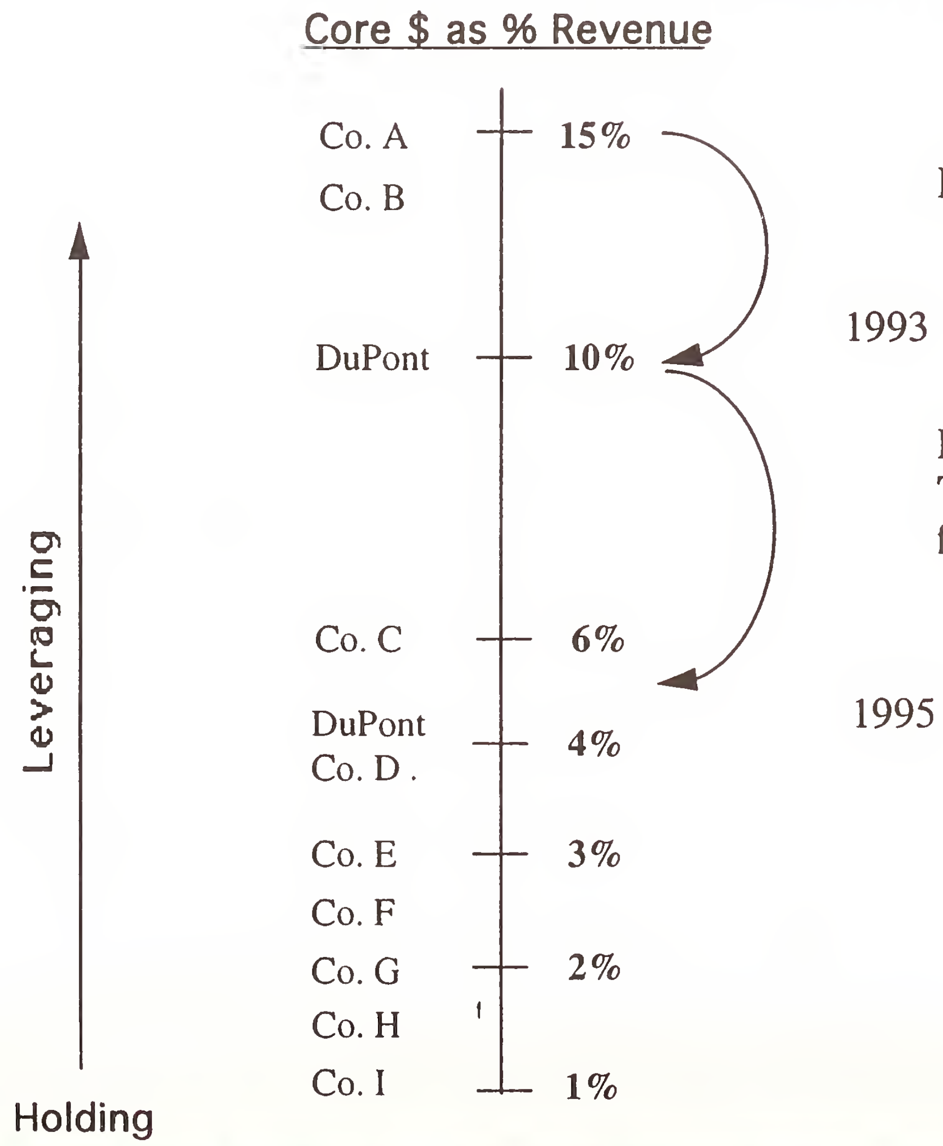
Corporate Staff

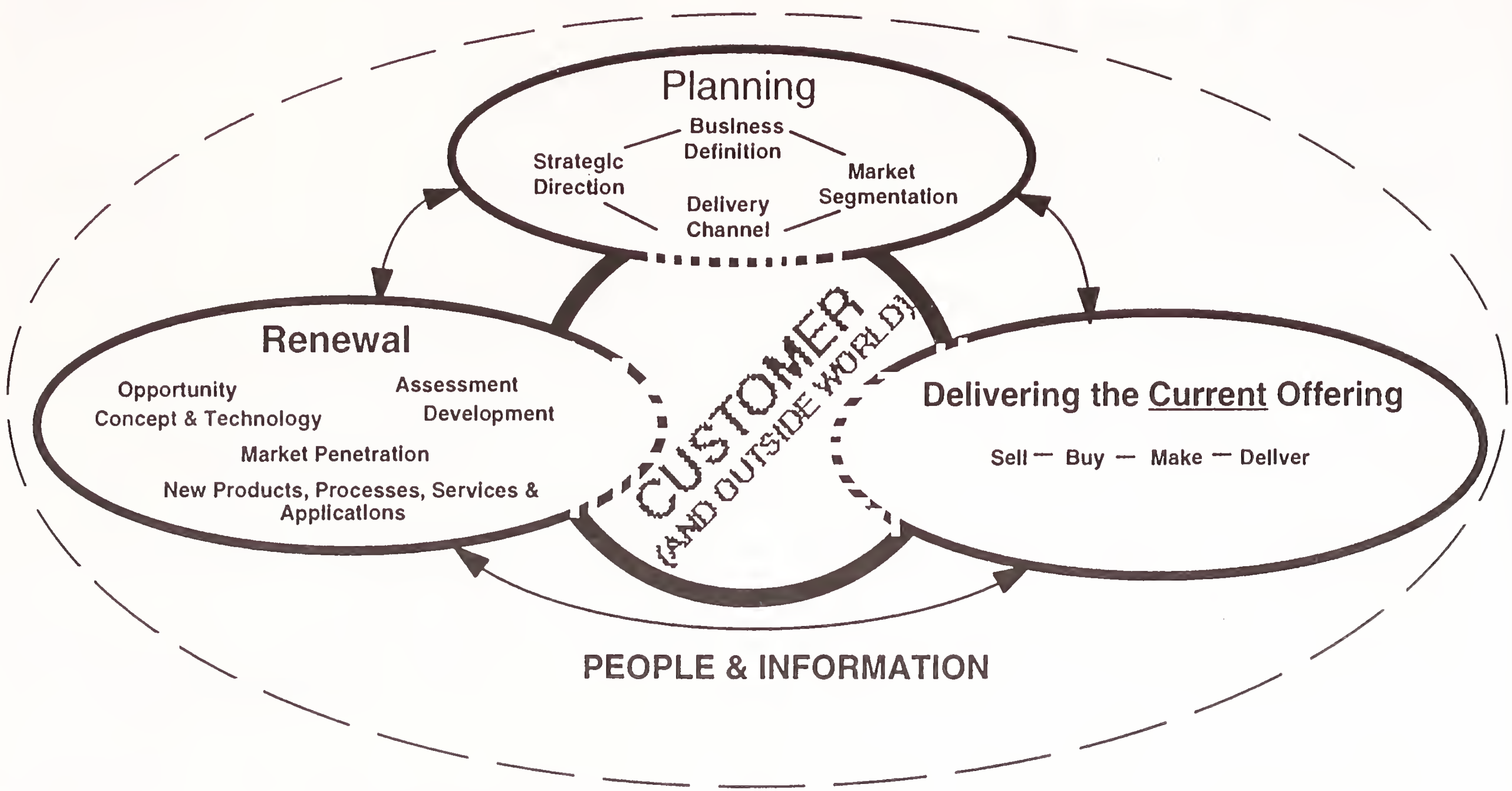


Loop #1 (1991 - 1994) $1BN

Loop #2 (1994 - 1995) $1BN
To be up with leaders, DuPont needs to further focus and reduce (~$1BN)

NIST
4/7/95

Business Work Processes



Business model based on People, Organizations and Processes

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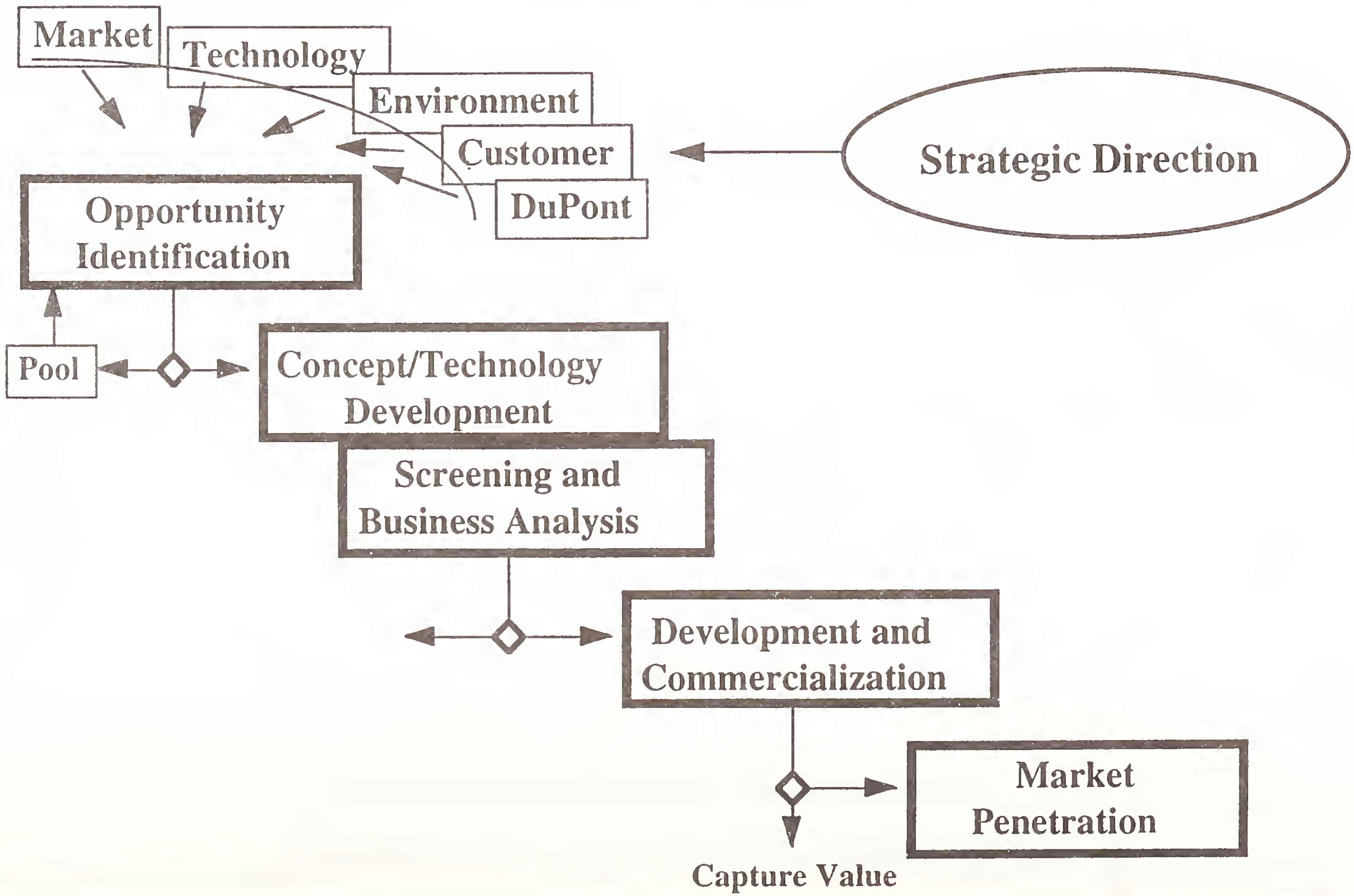
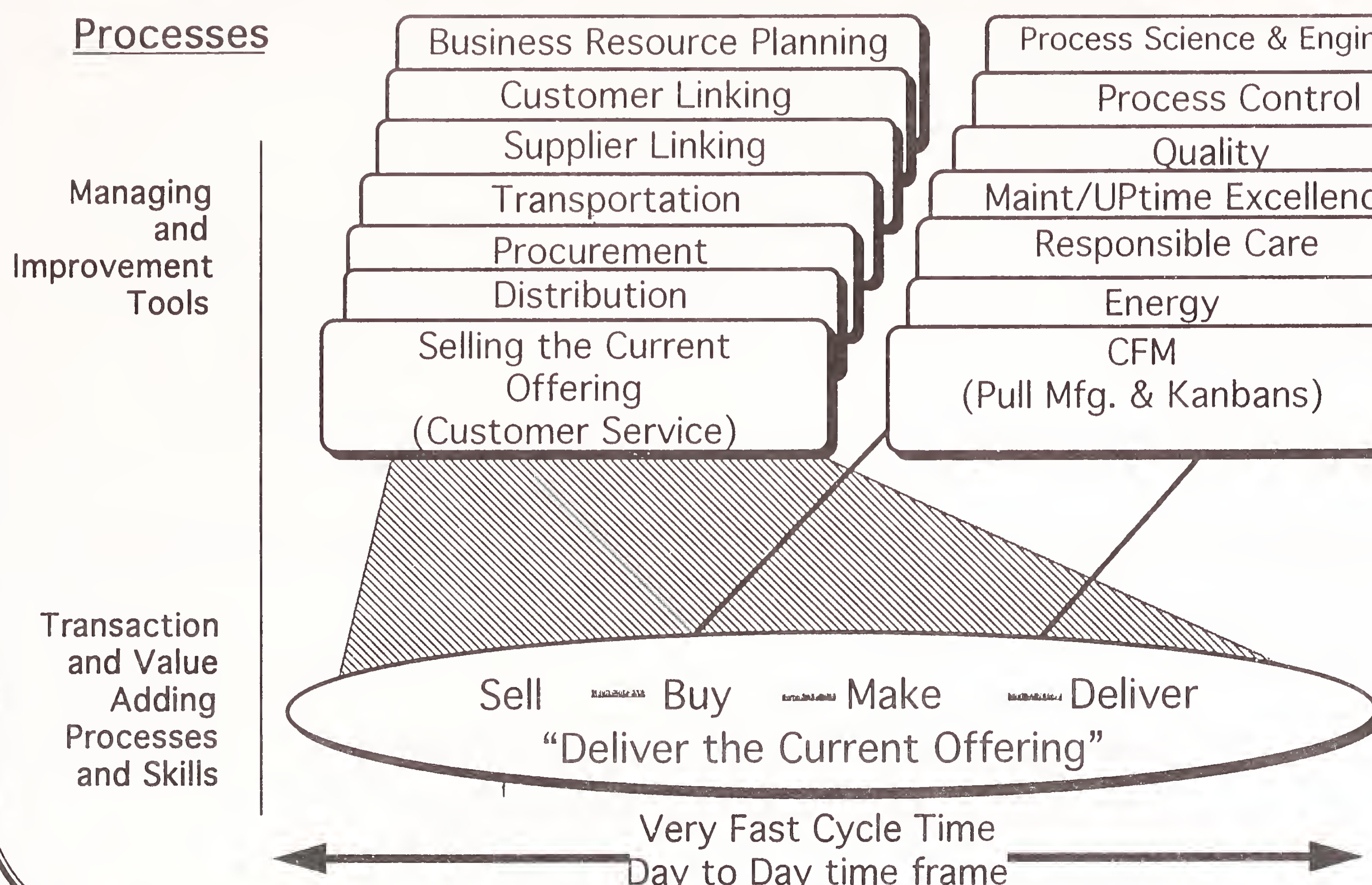
Renewel Process Model



Alignment of the Supply Chain and Manufacturing Tools and Skills to Deliver the Current Offering



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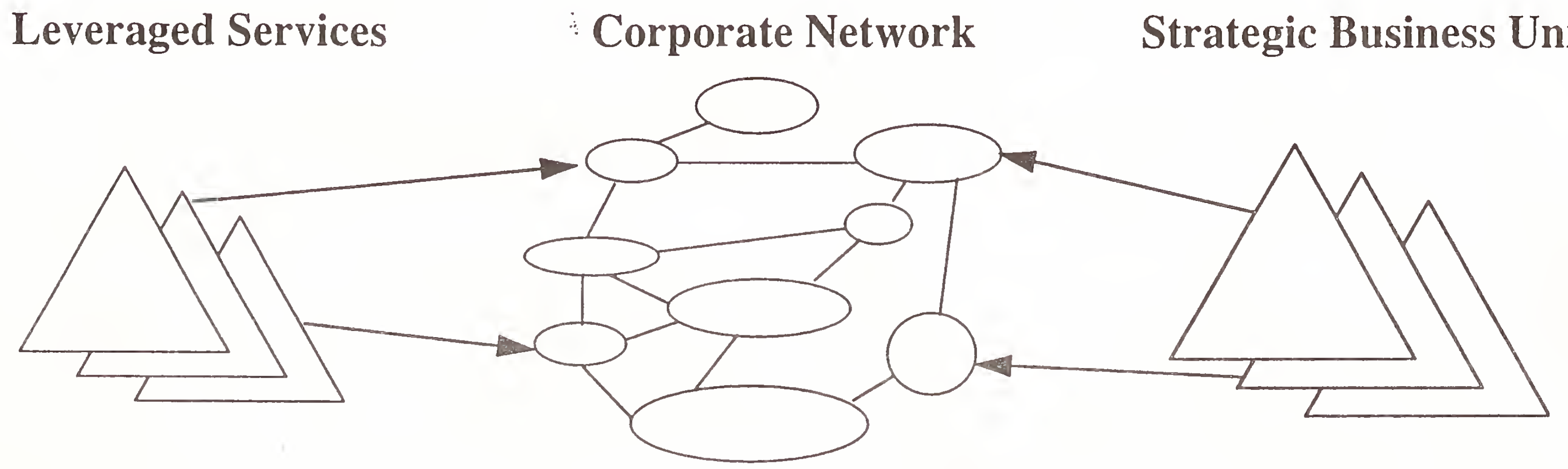
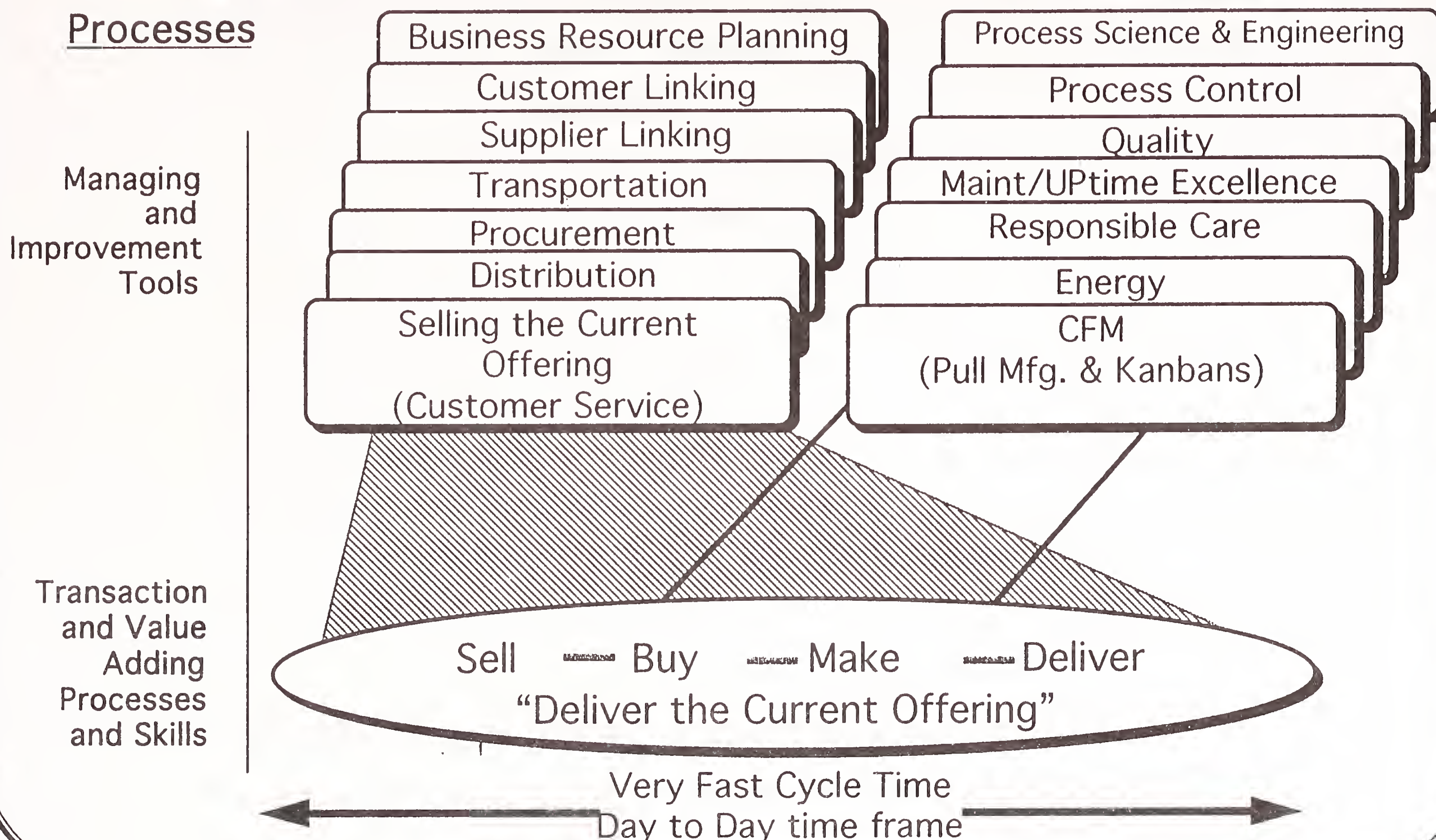
Networking is a Key



Alignment of the Supply Chain and Manufacturing Tools and Skills to Deliver the Current Offering



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Manufacture Process Technologies

- [ ] Environmental Engineering
- [ ] Experimental Design & Empirical Modeling
- [ ] Hazards Evaluation & Control
- [ ] Materials Engineering
- [x] Modeling & Simulation
- [ ] Operations Optimization
- [ ] Particle Technology
- [ ] Process Development / Scale-up
- [x] Process Measurement & Control
- [ ] Process Synthesis / Conceptual Design / Evaluations
- [ ] Reaction Engineering
- [ ] Thermodynamics, Kinetics, Mechanisms
- [ ] Transport Phenomena
- [ ] Unit Operations

Six Key Attributes of High Performing Work Systems

NIST
4/7/95

HOW ARE WE DOING AND WHAT IS NEXT?

- Better at "Delivering the Current Offering"
- Working of "Renewal"
- Improving our Portfolio
- People/Leadership Development

Panel Sessions

Panels evaluated the manufacturing framework proposed by the CCIT subcommittee on Manufacturing Infrastructure. Each panel focused on a specific theme, defined appropriate public - and private-sector rolesand recommended areas or activities for collaboration. Chaired by representatives from industry and government, each session provided a context-setting presentation by speakers from industry. Each panel prepared feedback reports to the general session.

Advanced Manufacturing Systems (AMS)

Chairs:

Michael J. Wozny, NIST
Richard Engwall, Westinghouse

Flexible and responsive manufacturing systems and enterprises are needed toreact to rapidly-changing customer needs and market requirements. Advanced systems incorporate new technologies and innovative business practices that allow companies to rapidly form alliances.

White Paper on Advanced Manufacturing Systems (AMS)

Industry Feedback Report

AMS Working Group

Manufacturing Infrastructure (MI) Subcommittee

Civilian Industrial Technology (CIT) Committee

National Science and Technology Council (NSTC)

April 19, 1995

Third Manufacturing Infrastructure Workshop

National Manufacturing Technology Conference

Break-out Session

NSTC Mfg. Infra. 3/1/95
AMS G/I/A Team Members

- **Government:**

Mike Wozny	NIST (Chair)
Cheryl Albus	NIST
Dudley Caswell	DoD
Mike McGrath	ARPA
Pius Egbelu	NSF
Karen Richter	IDA

- **Industry:**

Dick Engwall	Westinghouse (Chair)
Gene Meieran	Intel
Fred Michel	Self (SME)
Deborah Carr	CIMS
Dick Hartke	NCAT
Jim Jordan	CAM-I
Richard Neal	MMES (Oak Ridge) - TEAM

- **University:**

Richard Wysk	Penn State

Advance Manufacturing Systems

AMS GROUP 1:

Gene Meieran	Intel
Ed Hensel	N.M. State University
Dick Hartke	NCAT
Paul Sheng	Lawrence Berkeley Labs / UCB
Jim Sperling	Solar Turbines, Inc.
Ted Saito	LLNL
Ed Saloman	NIST
Jeane Ford	NIST

Advance Manufacturing Systems

AMS GROUP 2:

Hank Noel	NCMS
Howard Bloom	NIST
Mike Mastracci	Techmatics
Tom Young	Sandia National Labs
John Ferguson	EDS
Mike Michaelis	DoE

Advance Manufacturing Systems

AMS GROUP 3:

Ed Morris	Loral Vought Systems
Maurice Shamash	Westinghouse
Robert Epstein	Sikorsky Aircraft
Bob Van Husen	HQ U.S. Army Materiel CMD
Larry Buxton	Sandia National Laboratories /NM
Deborah Carr	CIMS
Paul Kugelman	Dupont, Corp
Sandra Novinger	Rockwell - Collins

Advance Manufacturing Systems

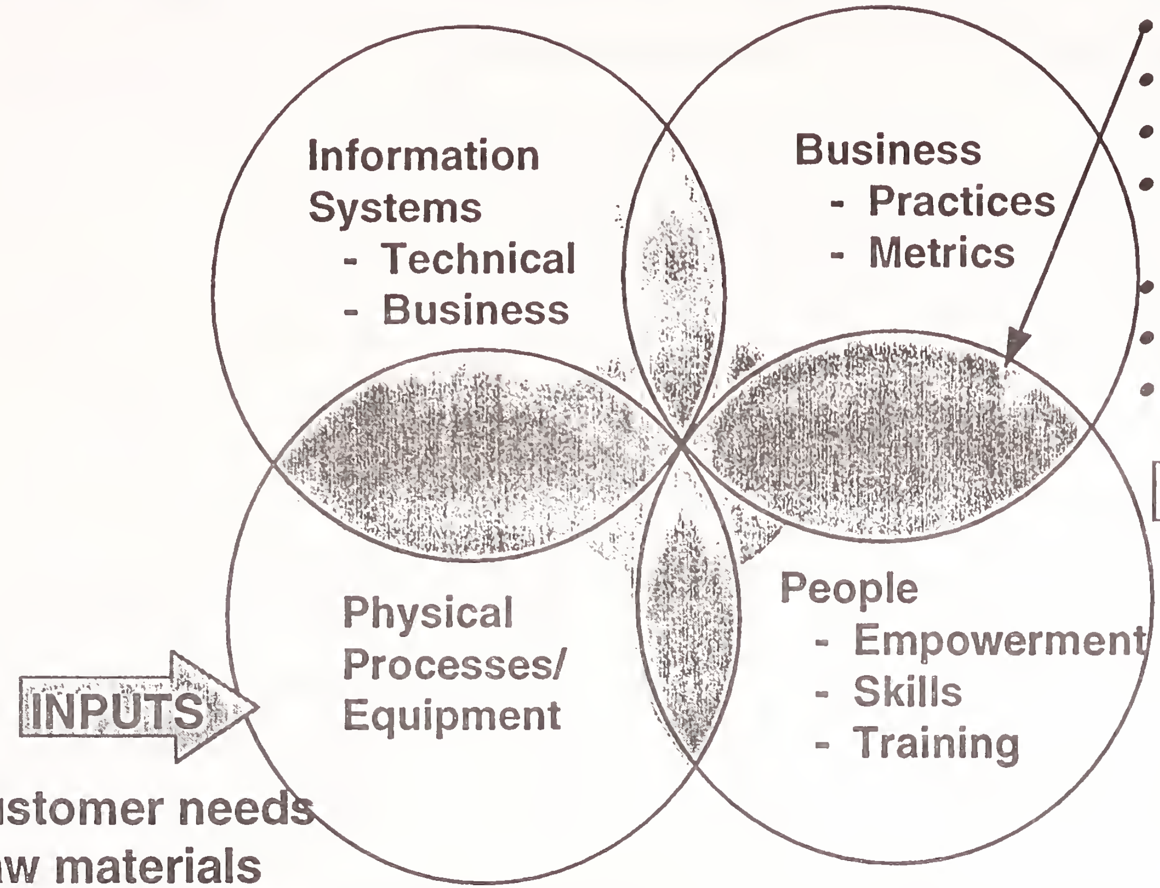
AMS GROUP 4:

Dick Engwall	Westinghouse
Dan LaPlant	Solar Turbines (CAT)
Gary Conkel	CAMP (Cleveland MTC)
Bill Muir	Eaton
Al Elkins	NSM (Support Co.)
Sungho Hong	KIMM (Korean Inst., Wash. DC)
Bill Alzheimer	Sandia National Lab
Dwayne Brown	KCD

Advanced Manufacturing Systems

AMS

- *Integration of resources*
- *Company(ies) Food Chain*
- *Product Life Cycle View*
- *Performance and Partnering mechanisms*
- *Technology based standards*
- *Evaluation test methods*
- *Framework*



OUTPUTS

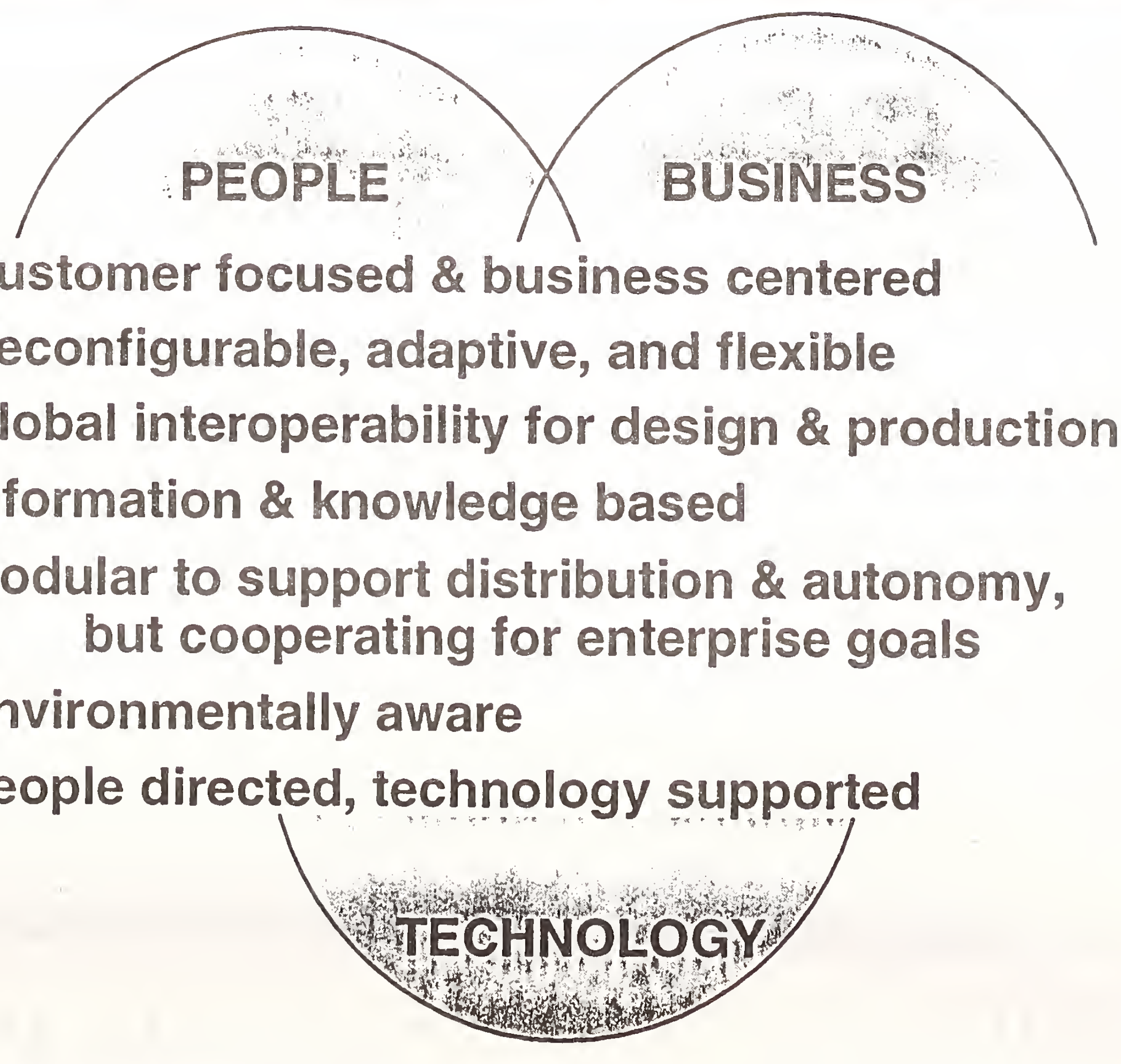
- Value-added Products
  - Quantity - Time
  - Quality
  - Cost
- Knowledge

- Customer needs
- Raw materials
- Purchased components
- Skills
- Data, information, knowledge
- *Regulatory*

= Advanced Manufacturing Systems

Vision *Characteristics*

Quantity ←→ Time
Quality
Cost Competitiveness
Product, Performance
& Functionality



- Customer focused & business centered
- Reconfigurable, adaptive, and flexible
- Global interoperability for design & production
- Information & knowledge based
- Modular to support distribution & autonomy, but cooperating for enterprise goals
- Environmentally aware
- People directed, technology supported

Interdependency Model

Industry Characteristics / Industry Goals	Customer focused & business centered	Reconfigurable, adaptive, and flexible	Global for design & production	Information & knowledge based	Modular to support distribution & autonomy but cooperation for enterprise goals	Environmentally Aware	People Directed Technology Supported
Quantity & Time	●	●	◐	●	●	◐	◕
Quality	●	◐	◐	●	◐	◐	◐
Cost Competitiveness	●	●	●	●	●	◐	●
Product Performance & Functionality	●	◐	◕	◕	◐	●	◐
	Business People	People Technology	Business Technology	Technology People	Business Technology	Business Technology	

Enablers

Industry Characteristics	*Resource Elements*	*Enabler Category*	*Enabler Actions*
Customer focused and business centered	Culture Organization	Practice Modeling	Match customer requirements and core competencies to business needs
Reconfigurable, adaptive, and flexible	Culture Organization	Practice	Information Integration (Rep) Automation & Intelligent Control Standards (Open Sys. Arch.)
Global interoperability for design and production		Modeling	Agility / Simulation Information Integration (Elec. Com Networking & Communication
Information and knowledge based	Skill	Modeling	Knowledge Systems Object bases Visualization & Human/Machine Interfaces
Modular to support distribution and autonomy, but cooperating for enterprise goals			Cooperative/Group Systems Concurrent Engineering Standards (Object Bases)
Environmentally Aware		Practice	Physical and Chemical Processing Design for Recyclability
People directed Technology supported		Practice	User-friendly environments

Largest Opportunity is in Systems Level Integration

- **Business**
  - » globalization
  - » design for customer expectations (life cycle, use; "picky")
  - » environmentally conscious
  - » timely market access > nominal development cost savings
  - » software competed globally
  - » information cost is growing
  - » engineering competed globally
- **People**
  - » education/training is a strategic necessity
  - » empowered/enabled work teams
  - » human/machine interfaces (visualization, easier to use, . . .)
- **Technology**
  - » large increase in computer power (double every 3 years)
  - » faster-than-real-time experiments (predictive)
  - » networking and communication enables distributive systems

Grand Challenges

- ***Establish Government Industry MI Investment Strategy***
- **Innovative Systems Concepts**
  - » Requirements Definition (Business, Worker, Technology)
    - – Concept not well understood
  - » Agility
  - » Information Integration in Virtual Enterprise
    - – agent-based methods
    - – self-organizing customer/supplier networks
- **Enabling Science and Technologies**
  - » Understand within context of Business and Worker Systems
- **Technology Demonstrations**
  - » Integrated business, cultural, technological
  - » Can be domain specific
- **International Cooperation**
- **Share a Common Vision**

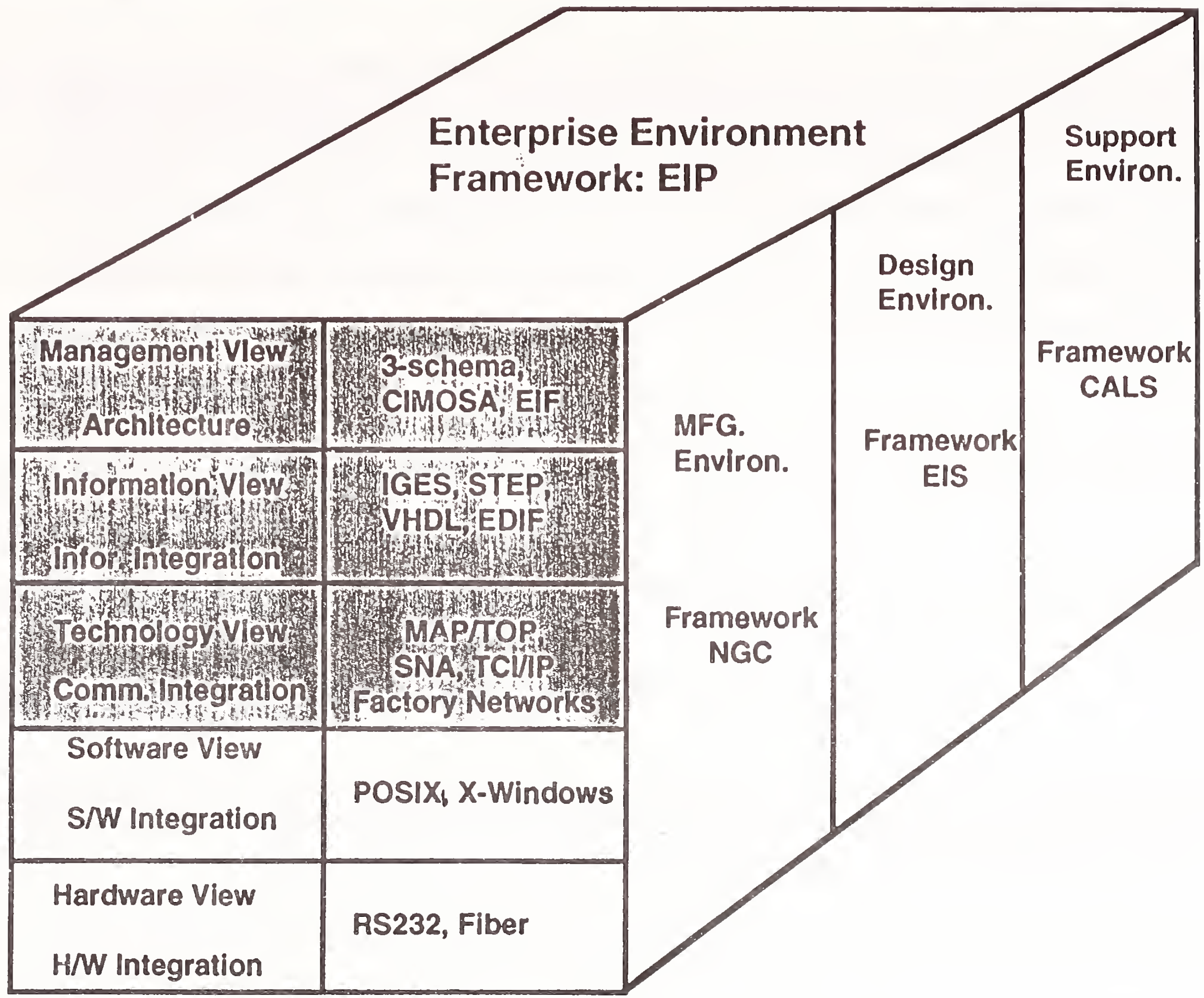
Enabling Science and Technologies

- *National* Information Infrastructure (distribution)
  - *neutral*, seamless and timely flow of *all data and* information *(Electronic Commerce ⟶ Product Life Cycle Processes*
  - mechanisms for integrating
    - marketing, team collaborations, imbedded supplier technical systems
    - user acceptability, information conversion, reliability, integrity, security, . . .
    - *NII must meet manufacturers needs not technology solution*
- *National* Integration Frameworks & Standards
  - common architecture
  - interoperability with legacy systems (migration)
  - standards for all technical subsystems
  - must address legacy systems

Enabling Science and Technologies
(continued)

- Integration Tools
  - »specify, design, evaluate, implement, and monitor system performa
  - »reuse, benchmarks and performance metrics
- Modeling and Simulation (impact analysis)
  - »levels of abstraction, representations
- Intelligent Controls and Sensor
  - »machine controller framework (NGC), sensor network protocols, rea
- Business Practices, Services and Culture

Information Integration Environment



NSTC/CIT
Advanced Manufacturing Systems (AMS) - 1/13/95 White Paper Evaluation

Key Findings/Recommendations:

- Need to establish Manufacturing Infrastructure environment for five MI thrust areas
  - » Common Vision Statement - (Lean/Agile Mfg. Next Generation Vision)
  - » Virtual and Distributed Network
  - » Integrated Customer/Supplier network including SME's
  - » Product Life Cycle (customer through product disposal view)
  - » Total/International Integrated Enterprise Model/Data Base consisting of product, process, operations, and business viewpoints that can be seamlessly interfaced by any size organization from any domain viewpoint for whatever individual needs applicable to business situation

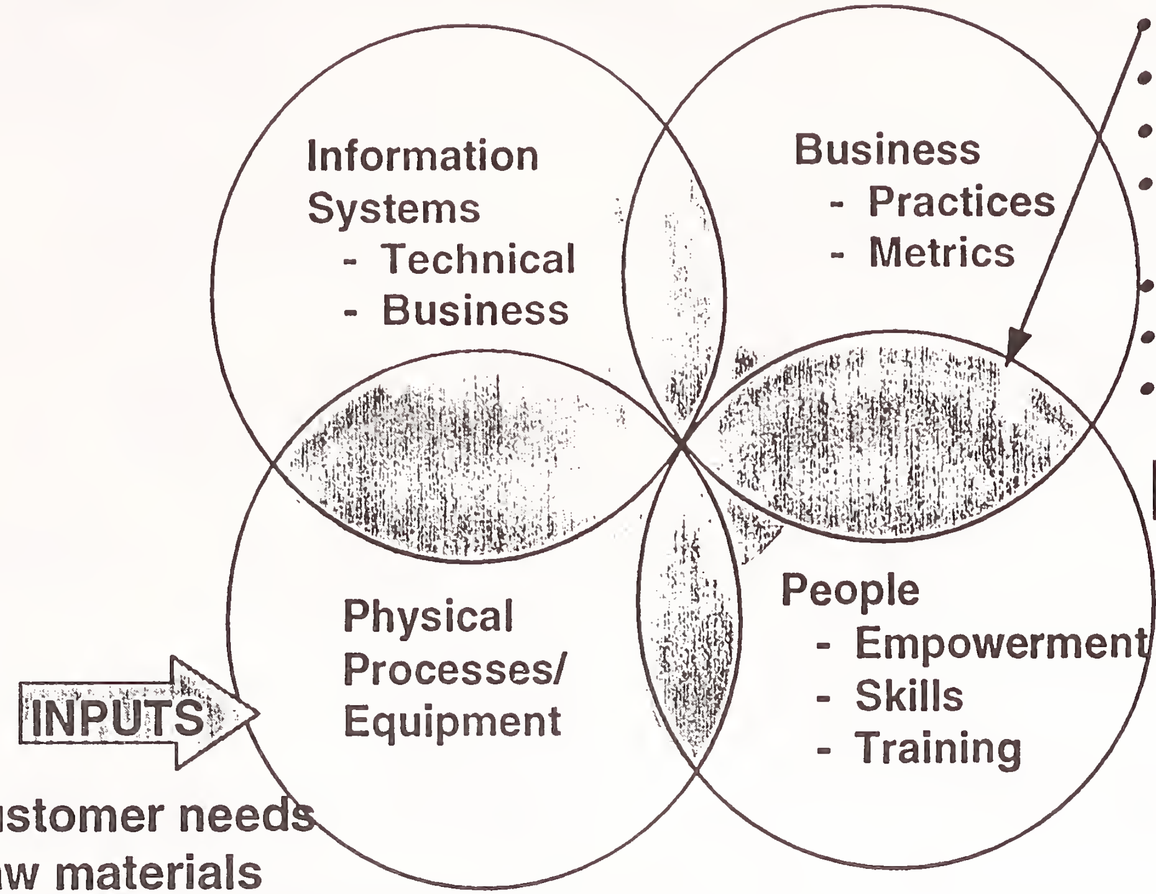
NSTC/CIT
Advanced Manufacturing Systems (AMS) - 1/13/95 White Paper Evaluation (continued)

- Need to add to AMS Background section a context statement from which view AMS White Paper is addressing - AMS single organization enterprise view and/or the national enterprise view (multiple organizations enterprise view for all industries)
  - » Private Industry can better address single organization view
  - » Industries should form partnerships (PNGV, Semiconductor, Textile, Food, etc.) to leverage like companies needs
  - » Federal Government can best address national/international total enterprise issues that individual industries/organizations can't cost effectively do alone

Business Practices are an essential part of Manufacturing Infrastructure!

- Poor U.S. Business Practices impede U.S. industry's global competitiveness.
  - » Conflicting Practices and Cultures
  - » Restrictive Regulations
- The U.S. needs *Business Practices R&D* for next generation manufacturing enterprises just as much as the U.S. needs *Systems R&D and Technology R&D*

Advanced Manufacturing Systems



AMS

- *Integration of resources*
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- *Product Life Cycle View*
- *Performance and Partnering mechanisms*
- *Technology based standards*
- *Evaluation test methods*
- *Framework*

OUTPUTS

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- Knowledge

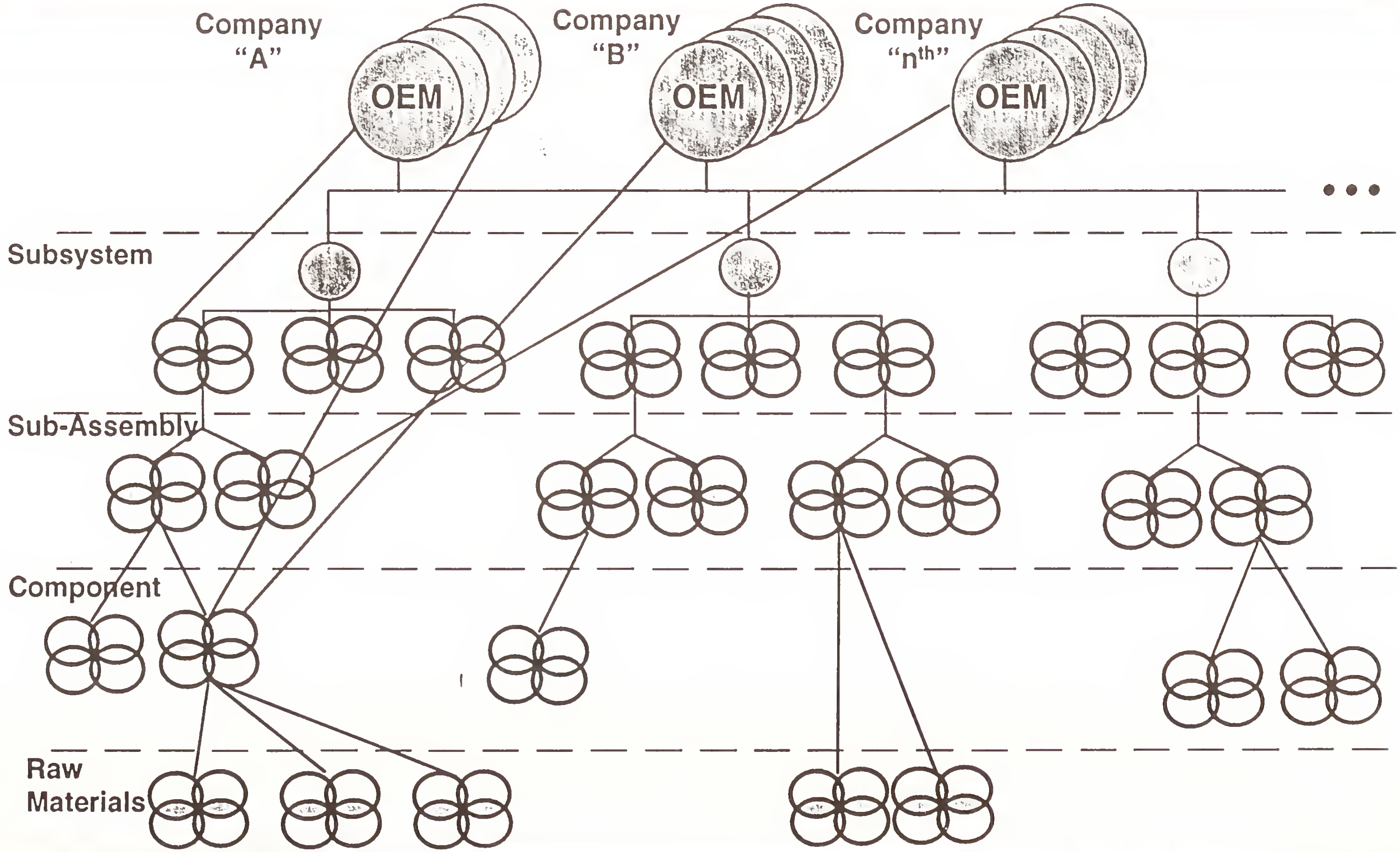
INPUTS

- Customer needs
- Raw materials
- Purchased components
- Skills
- Data, information, knowledge
- *Regulatory*

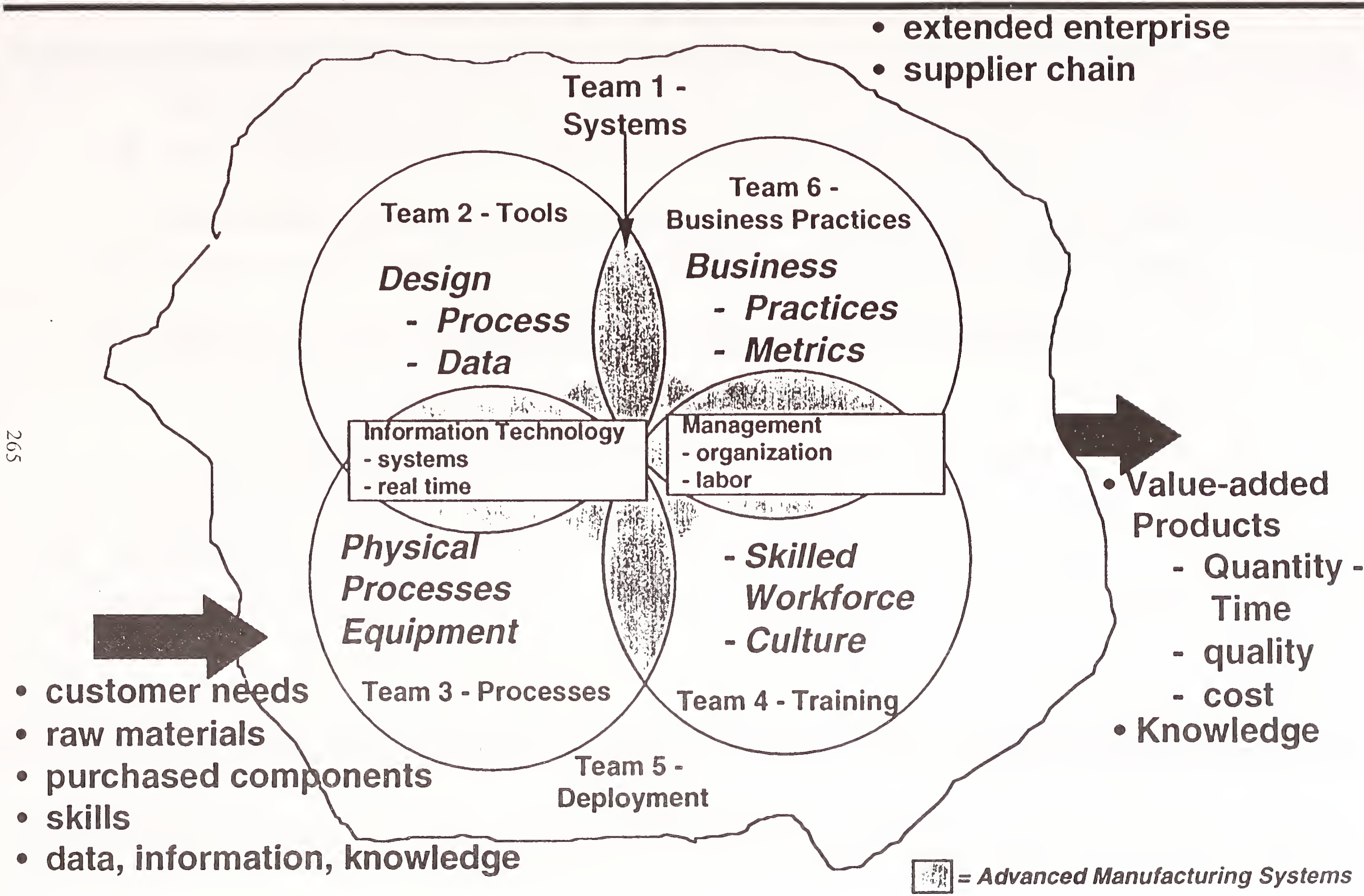
▒ = ***Advanced Manufacturing Systems***

Global Enterprise

(Active importance of JME supplier base in "food chain", "bottoms-up" view as well as "top-down" view



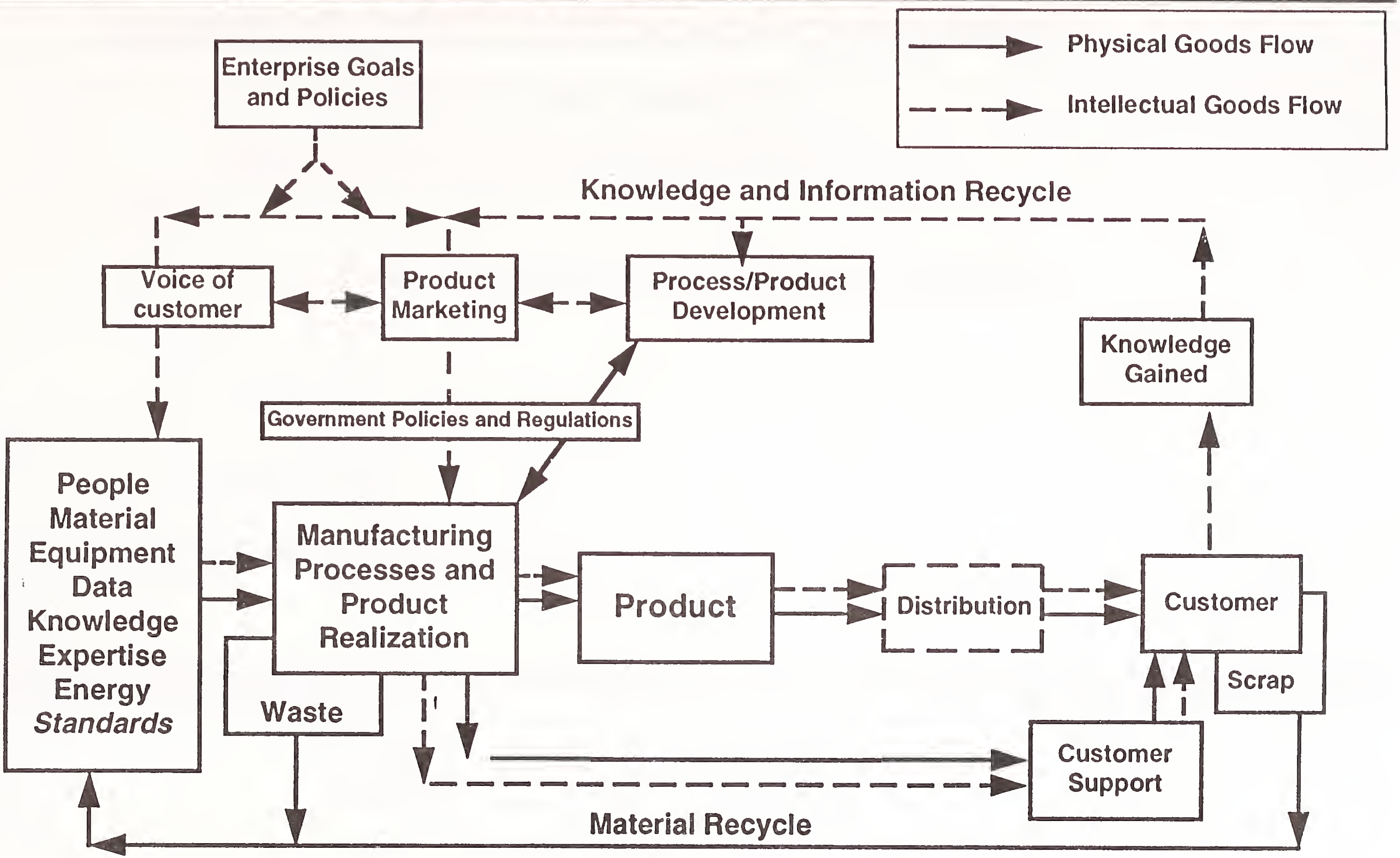
NSTC/CCIT Manufacturing Infrastructure
Adv. Mfg. Sys. ➡ Big "M" Integration



Ignorance and Arrogance will Destroy us!

- Global competition is as good (technologically) proficient and sophisticated) as we are and getting better every day. This is true of both:
  - » Traditional competitors: Japan, Europe,Asian Tiger
  - » New competitors: China, India, etc.
- There is <u>no</u> escape from global competition.
- If the U.S. is to survive, let alone thrive, we must leverage intellectual resources from all sources.
- The International IMS Program gives us a sanctioned way of learning from our strongest competitors

Infrastructure Enables the Smooth Flow of Knowledge and Materials to Improve Manufacturing Performance

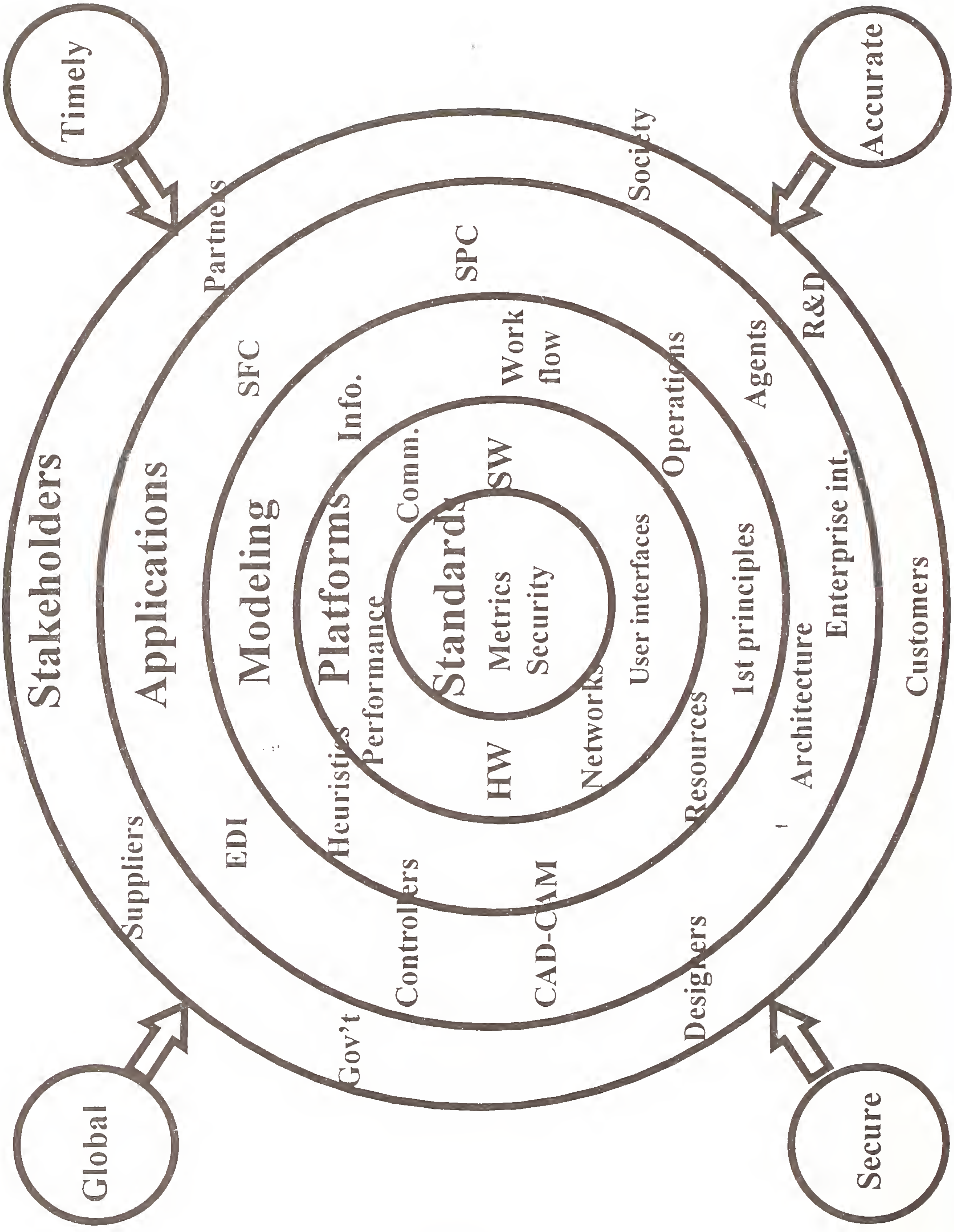


AMS / MI Additions

- **AMS relative to MI**
  - » Reason for
    - – Definition
    - – Intent
    - – Goals
    - – Product (external) versus Process (internal)
- **MI**
  - » National Mission, goals, strategies
  - » Global Enterprise view whitepaper
- **Mapping data structure of government/ industry activities**

The Role of Government

1. Facilitate interactions between stakeholders
    - Government
    - Academia
    - Industry
    - Consortia
2. Manage and improve regulatory influences
    - Environmental
    - Health
    - Transportation
    - Society
3. Provide funding for the "right" technologies
    - Meet strategic needs
    - Help risky but worthwhile industrial ventures
    - Fundamental knowledge creation
4. Be a repository for global knowledge
    - Regulations
    - History
5. Provide appropriate standards and standards methodology
    - Facilitation
    - Creation
    - Metrology


Timely
Accurate
Global
Secure
Stakeholders
Applications
Modeling
Platforms
Standards
Metrics
Security
Partners
Society
Suppliers
Gov't
Designers
Customers
SFC
SPC
EDI
Controllers
CAD-CAM
R&D
Enterprise int.
Architecture
Agents
1st principles
Heuristics
Info.
Work
flow
Operations
Resources
Comm.
SW
HW
Performance
Networks
User interfaces

Standards

Platforms

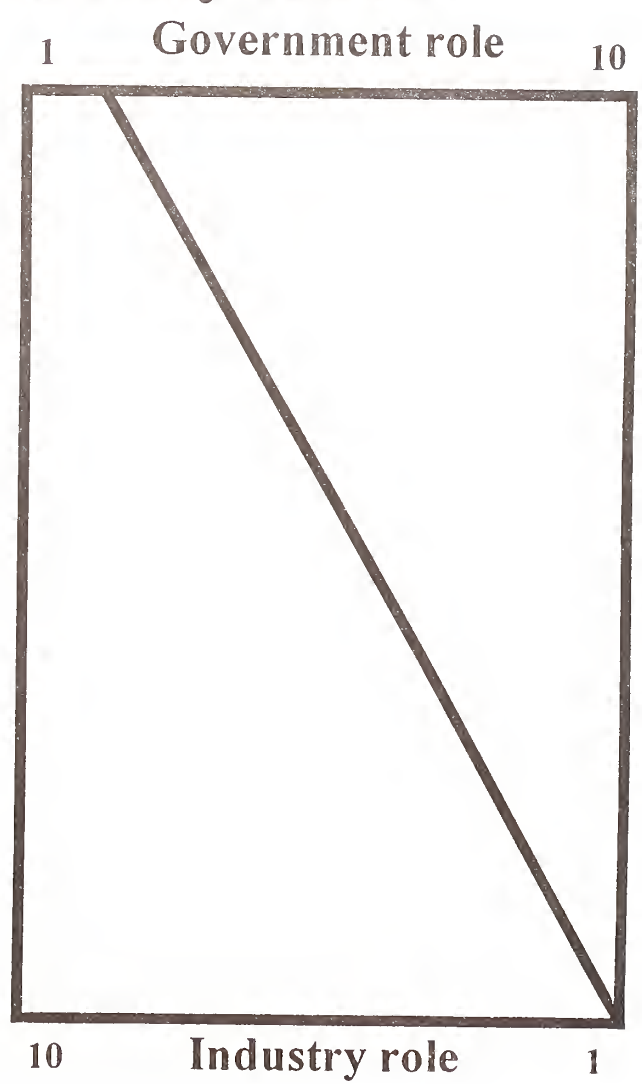
Modeling

Applications

Stakeholders

Government and Industry Roles

- National policy and goals
- Fundamental knowledge
- Regulations
- Strategic planning
- High risk (SMEs)
- National strategic needs
- Infrastructure development
- Standards.
- Facilitation and coordination
- Metrology
- Benchmarking
- Product famnily needs
- Business core competencies



Issues

- **Communication**
  - Inter agency development programs
  - Intra-department needs
- **Getting SME participation**
  - Funding
  - Geography
  - Core competency
- **Systems**
  - Bandwidth
  - Standards

Engineering Tools for Design and Manufacturing

Chairs:

Peter Brown, NIST

Joseph Erkes, General Electric

Engineering techniques for rapid and simultaneous development of new products, processes, and production systems are critical elements in reducing product development times, lowering manufacturing costs, eliminating inefficiencies, increasing product quality, and minimizing environmental impact. Examples of such tools are rapid prototyping, simulation, and modeling.

Engineering Tools for Design and Manufacturing

- Overall Comments
- Our Process
- Constraints
- Key Issues
- What Next

Overall Comments

- Nailed the right issues, but..
- Very broad
- Priorities not clear
- Not clear what next steps were

Our Process

- Brief presentations
- Spirited round-robin participation
  - Key issues
  - Priorities

Constraints

- Live within existing industry frameworks
  - tools
  - data
- Validate developed tools in industry
- Address supplier chain integration
- Make it affordable
  - Cost
  - e.g. the Block Buster Video paradigm
- Encourage market-driven commercialization

Key Issues

- **Process Modeling**
  - model development
  - process characterization
  - validation
  - standards for plug and play
  - integration/interoperation
  - provided by equipment vendor

- **Hierarchical level of abstraction (seamless transition between levels)**
  - performance
  - process
  - cost
  - multiple views of both product and process models
  - reduced order models

Key Issues (continued)

- **Validation**
  - understand process model uncertainty
  - understand where model has been validated
  - metrics & guidelines

- **Requirements Traceability**
  - linking of requirements to design features
  - preservation of design intent
  - flowdown of requirements & requirements tracking
  - propagation of consequences (validate requirements)

- **Manufacturing Database Interoperation**
  - legacy data
  - where is it, how do I get to it,
  - transparent access
  - consistency in creation and use of data

Key Issues (continued)

- **Enterprise product realization process (workflow)**
  - needed to help organize the design process
  - manage design process including supply chain & feedback critical issues
  - consequences of design decisions

- **Multi-Disciplinary optimization**
  - performance (structural, fluid, thermal)
  - life-cycle (cost, logistics, etc)

- **Preserve Corporate Knowledge**
  - not losing through downsizing
  - recognition that a company's real value is its knowledge (Design & Mfg Rules)
  - intellectual property and security

Key Issues (continued)

- **Design Methodology & Theory**
  - structure design process/templates (workflow)
  - how/when to use tools
  - “cowboy” vs. formal methods for design

- **Libraries**
  - software components
  - process models
  - simulation

What Next

- Government Compendium

Manufacturing Processes and Equipment

Chairs:

Diane Bird, DoE
John DeCaire, NCMS

Improved manufacturing processes and equipment are required for the low-cost fabrication of products made for advanced materials and for exploiting breakthoughts in processing concepts and underlying technologies in areas such as intelligent controls, sensors, and actuators.

Advanced Manufacturing Processes and Equipment Working Group

Diane Bird, DOE
Dan Cundiff, DoD
Bruce Kramer, NSF
Wilda Martinez, USDA
Connie Sosala, EPA

Scope

Advanced manufacturing processes and equipment and the R&D activities required to enable:

- Cost effective, agile manufacturing
- Low cost processing/fabrication of new materials
- Incorporation of new processing concepts and emerging technologies such as intelligent controls, actuators, sensors and information technologies

Manufacturing Processes - include both discrete and continuous manufacturing processes.

Manufacturing Equipment - includes a broad range of computer controlled equipment capable of carrying out a wide array of manufacturing processes.

Focus Topics

Intelligent Control Systems

Integration of fast computing, intelligent controllers and intelligent sensors and actuators into manufacturing processes.

Real time Sensor Based Control

- Imbedded intelligence for sensor feedback
- Open architecture controllers
- Knowledge based artificial intelligence systems

Process Modeling and Simulation

- Detailed understanding and characterization of manufacturing processes
- Development of standard process models (both public and company proprietary)
- Feedback of real-time process sensing into process models to improve their accuracy

Rapid Prototyping Methods

Development of additional technology to extend the current concept of rapid prototyping to include the fabrication of functional hardware.

- Improved part accuracy and fabrication speed
- New processes that enable fabrication of functional parts in metals, ceramics, and composites.

New Processing Methods and Equipment

- Processes for manufacturing low cost, advanced engineering materials
- Versatile equipment and sensors
- Flexible and modular tooling
- Non-traditional technologies, i.e. beam technologies and nano-fabrication

Major Issues

Declining R&D budgets in the private sector and lack of a short term return on investment has inhibited development.

Lack of understanding of the fundamental relationships between sensed variables and required controls has delayed the integration of these technologies into manufacturing equipment.

Affordable, robust sensors and "user friendly" controllers aren't readily accessible to small, medium and large firms.

Closer relationships are needed between U.S. equipment builders and users for early introduction of new processes and equipment in U.S. factories.

Recommendations/Industry Feedback

	Near Term 1-3 yrs	Mid Tern 3-5 yrs	Long Term 5-10 yrs
Intelligent Control Systems	Sensors, process/material models and knowledge based algorithms Cooperative national effort to characterize process parameters in a standard format Develop verification methodology for process models	Expand process models to include additional manufacturing processes and "non-traditional" processes Develop/deploy "standard" open architecture controls	Develop neural networks for intelligent manufacturing equipment Develop/demonstrate knowledge based AI manufacturing systems in small, medium, and large companies in several sectors
Rapid Prototyping	Improve part accuracy and fabrication speed Introduce new materials and processes to create functional parts, i.e., metals, ceramics, composites	Demonstrate systems developed in near-term activities Demonstrate RP technologies for new materials	Develop "rapid fabrication" of production quality functional parts made on a similar time scale to rapid prototyping
New Processing Methods and Equipment	Develop processes to reduce cost of advanced engineered materials for structural applications by a factor of at least 10. Develop flexible/ modular tooling and equipment adaptable to a variety of sensors and controls	Develop/demonstrate a reconfigurable manufacturing system with modular hardware, tooling, sensors and controls Develop control systems for retrofit an existing manufacturing equipment	Develop processes which reduce the cost of advanced engineered materials for structural applications by a factor of at least 100. Develop/demonstrate precision manufacturing systems which can be reconfigured for both low and high volume processes

Benefits

Improvements in manufacturing cost, quality, throughput, and flexibility for low to moderate volume applications.

Significant advances will take place when the individual technologies can be integrated into advanced processing systems.

New processing technologies for rapid prototyping that produce components with a broader range of mechanical properties could evolve into "rapid fabrication" of production quality, functional parts.

- potential production of parts at least 10 times faster than possible by conventional manufacturing practices.

Provide significant competitive advantage in an era when time-to-market for new products is increasingly critical.

Recommended Programs

R&D areas have been identified as critical to the realization of "next generation" manufacturing processes and equipment. Programs are required to:

Catalog ongoing activities in these R&D areas, identify high priority gaps that aren't being addressed and accelerate efforts in those areas.

Identify and engage key industrial sectors where accelerated diffusion of "next generation" manufacturing processes and equipment will provide significant competitive advantage.

Cooperative programs between industry, government and academe should be established to implement defined development and demonstration activities.

Recommended Programs (cont'd)

Existing partnerships and consortia should serve as the building blocks for future federally sponsored activities where possible.

Apply it to the widespread implementation of new and improved manufacturing techniques.

Development of next generation manufacturing processes and equipment will support the activities already underway in other NSTC working groups:

Next Generation Vehicle, Electronics, Aeronautics Materials and Manufacturing, and Construction and Building.

Recommendations/Industry Feedback

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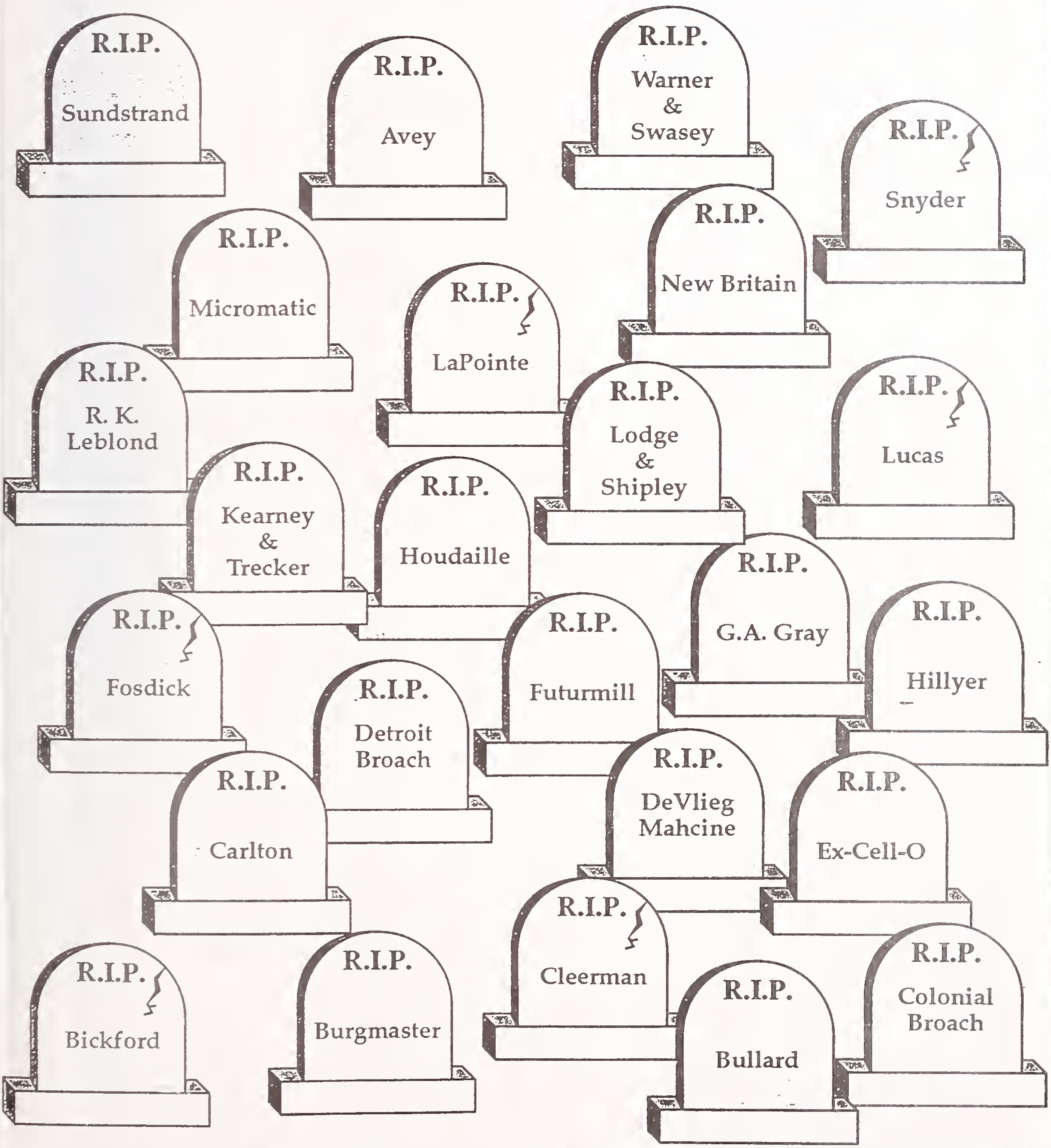
P&E Content

- Valid - High Impact Infrastructure Initiatives - Not Comprehensive
- Build Stronger Case
  - Technology vs. Market
  - Quantify Technical Goals/Milestones
  - Customer/User Needs and Benefits
  - Examples (Sectors and Threats)
  - Inventory of Activities Already Underway
  - Links
- Utilize Legacy Systems

A VIEWPOINT FROM THE MACHINE TOOL INDUSTRY

Dead American Machine Tool Companies



NEW MACHINE TOOL TECHNOLOGIES

- Stewart Platform Machines
- Open Architecture PC-Based CNC's
- Increased Machine Accuracy
- High Speed Spindles and Servos
- Cells for Rapid Throughput

Four Deadly Mistakes

in Manufacturing Technology Implementation

1. Solution looking for a problem –
   "support your local professor"

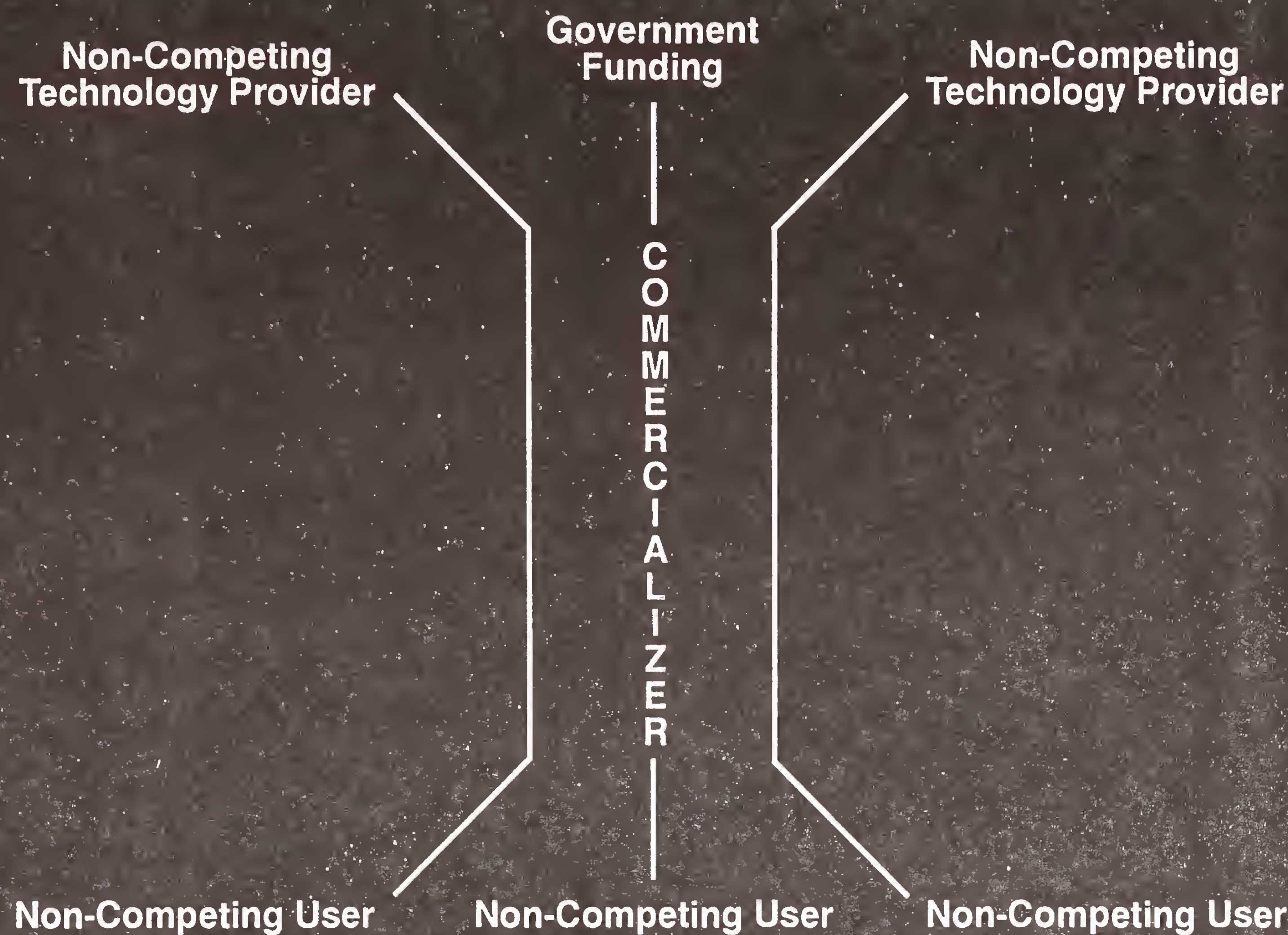
2. Solution looking for a problem –
   hire a representative to find the needs

3. "Pre-competitive" research

4. Exclude the commercializer

Cincinnati Milacron Virtual R & D

Vertical Alliance for Technology Implementations



Group #1 Neil Weil

- Valid infrastructure initiatives
  - enhance I, G, A role discussion
  - link barriers and enabling technologies
  - clarify interdependencies
- Open architecture controllers
  - need broad market
  - need interface standards
- Rapid Proto-typing
  - rate differentiation
  - clarify direct fabrication objectives
- Highlight assembly technology

Group #2 Howard McCue

- Style and content
  - problem statement
  - sure of urgency (threat)
  - rationale for selection
- Rapid prototyping
  - size, accuracy, time parameters
  - service bureau
  - standard interfaces
- Open architecture controllers
  - common application protocol interfaces
  - move from controllers suppliers
- Better integration of U.S. manufacturing help
  - navigation focal point

Group #3 Chuck Rice

- Roles, priorities, current initiatives
  - industry
  - government
  - academe
- Assure conventional process improvement
- Strengthen process design
  - link to product design
  - IPPD as process
- Rapid proto-typing
  - apply to tools and fixtures

Group #4 Bob Barnett

- Controllers
  - SOA, standards-based architecture
  - robust integrated process/tool control
  - ease of use, operator programmable
  - graphical simulation
  - links to concurrent engineering
- Rapid prototyping
  - CAD (solid model) directly to functional part
  - modular tools and fixtures
  - CAD/CMM integration
  - friendly conversational programming

(continued)

Group #4 Bob Barnett

(continued)

- New Processes and Equipment
  - IPPD as process
  - multi-functional machining/equipment
  - tooling selection/optimization
- Other
  - modeling/simulation of processes
  - central database of processes

Group #5 Bob Reuter

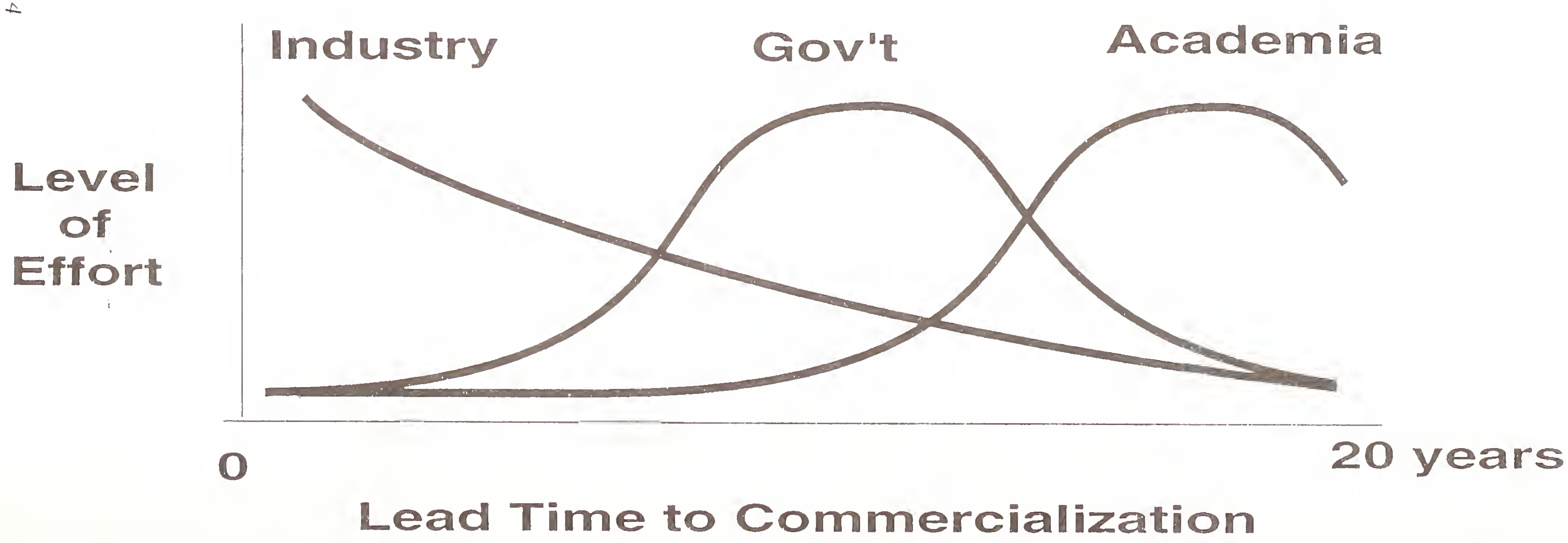
- Qualitative roles model
- List of current initiatives
- Style and content
  - more economic justification
  - broader processes coverage
- Other
  - more academic participation
  - stay alert for technology surprises

Investment Strategy

- needs
- prototyping
- commercialization
- infrastructure (build, use, supply)

- emerging tech's.
- standards
- testbeds for verification, valid., bnchmk.

- basic science
- education & training



Manufacturing Training and Education

Chairs:

Marshall Lih, NSF

Daniel Schrage, Georgia Tech

Workforce training and education activities at all levels -- shop floor, technical, managerial, and pre-employment -- are needed to enable businesses to make effective use of the latest production technologies.

Manufacturing Training and Education

Industry / Academia Panel

Manufacturing Technology Conference

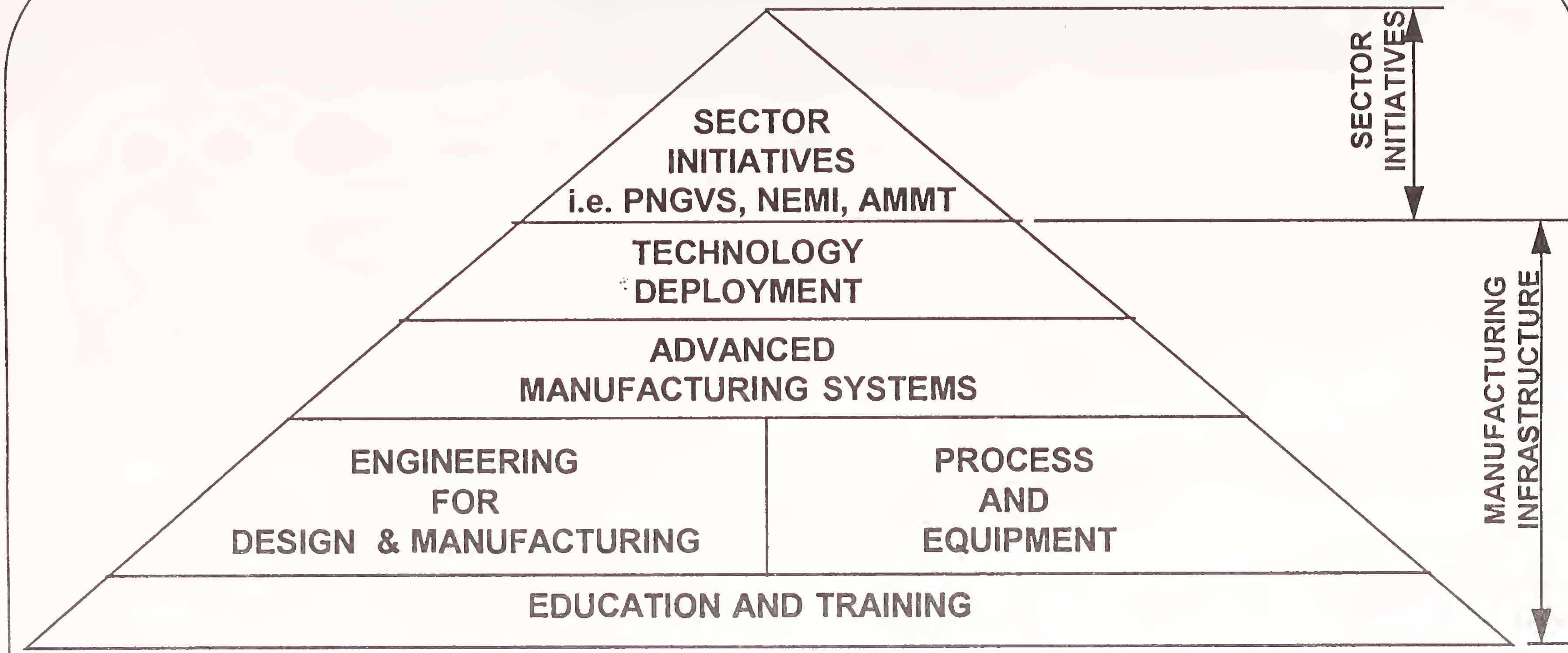
April 19, 1995

D. Schrage, Chair

Manufacturing Training & Education Panel General Comments

- Training and Education form the foundation base for the manufacturing infrastructure
- A well trained and educated workforce will become the ultimate manufacturing weapon in global competitiveness, both in domestic and export trade (the next step in the quality revolution
- The white paper thus far addresses Training & Education from a Government, Academia, and Industry perspective. For a more customer focused implementation, it should be from Industry, Academia, and Government perspective
  - Use Industry Associations to:
    - Leverage Congress - i.e. Ways & Means Committee for taxation policy changes
    - Provide cooperative life-long learning w/i and across industry sectors

MANUFACTURING EDUCATION & TRAINING



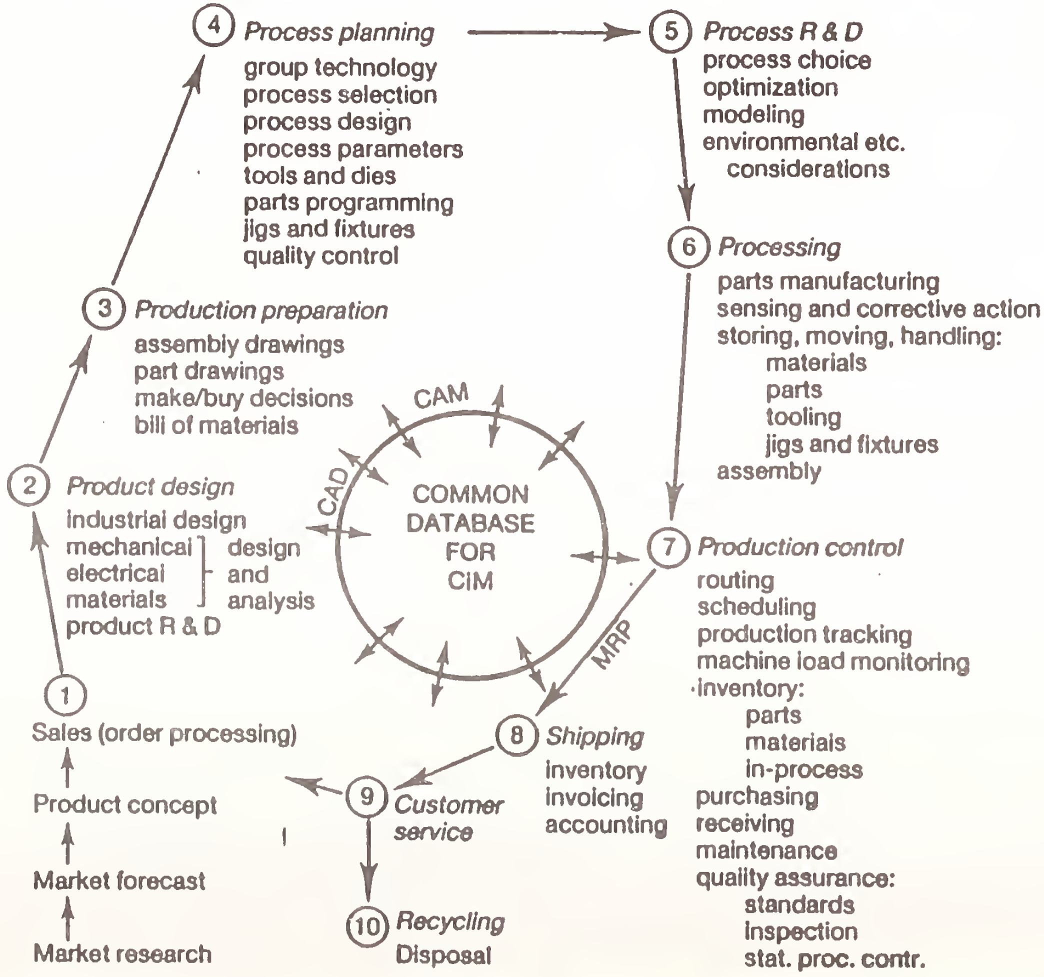
- MANUFACTURING INFRASTRUCTURE PROVIDES THE FOUNDATION FOR SECTOR INITIATIVES IN MANUFACTURING
- EDUCATION AND TRAINING PROVIDE THE FOUNDATION FOR THE MANUFACTURING INFRASTRUCTURE

INDUSTRY/ACADEMIA PANEL

ENCLOSURE 2

GEORGIA TECH

SPECTRUM OF ACTIVITIES WHICH ARE ENCOMPASSED BY MANUFACTURING



Aerospace Engineering

MANUFACTURING EDUCATION & TRAINING

MANUFACTURING INFRASTRUCTURE & THE IPPD MANAGEMENT SYSTEM

INTEGRATED PRODUCT/PROCESS DESIGN /DEVELOPMENT (IPPD):

IS WIDELY RECOGNIZED AS A MANAGEMENT METHODOLOGY THAT INCORPORATES A SYSTEMATIC APPROACH TO THE EARLY INTEGRATION AND CONCURRENT APPLICATION OF ALL THE DISCIPLINES THAT PLAY A PART THROUGHOUT THE LIFE CYCLE OF A SYSTEM .

INCLUDES THE ELEMENTS: PROCESS/METHODOLOGY, INTEGRATED PRODUCT TEAMS (IPTs) AND TOOLS

IPPD ELEMENTS	NSTC MANUFACTURING INFRASTRUCTURE SUBCOMMITTEE				
	PANELS/WORKING GROUPS				
	ADVANCED MANUFACTURING SYSTEMS	MANUFACTURING DEPLOYMENT & IMPLEMENTATION	TOOLS FOR DESIGN, MANUF. & INTEGRATION	MANUFACTURING PROCESSES & EQUIPMENT	MANUFACTURING EDUCATION & TRAINING
PROCESS/ METHODOLOGY	L	S	S	S	S
INTEGRATED PRODUCT TEAMS (IPTs)	S	S	S	~~L~~ S	~~S~~ L
TOOLS	S	~~L~~ S	~~S~~ L	S	S

L = LEAD, S = SUPPORT

INDUSTRY/ACADEMIA PANEL

Manufacturing Training & Education Panel Approach

- Government & Industry chairs presented evolution of current white paper, including inputs from previous workshops
- A keynote presentation was made on "global competitiveness through investment in the quality of the workforce" by Bruno Weinschel
- A handout was provided on Boeing's perspective on "Quality vs Quality Education (vs. training)" and "A proposed learning structure for engineers"
- The panel was broken into two groups to address the six strategic priorities in the proposed action plan

Manufacturing Training & Education Panel Group Breakouts to Address Six Strategic Priorities

- Group 1 (Strategic Priorities 1,4,&5)
  - B. Weinschel (IEEE) - Chair
  - J. Surette (NIST)
  - M. McDermott (Carice Assoc.)
  - P. Buetenhoff (Textile/Cloth. Tech. Corp)
  - D. Schrage (Georgia Tech)
- Group II (Strategic Priorities 2,3,&6)
  - W. P. Bailey (Boeing) - Chair
  - V. Rhoder (Deneb Robotics)
  - B.H. Squier (CAM-I)
  - J. Rossen (Rutgers University)
  - D. Lovett (NIST)
  - M. Lih (NSF)

Strategic Priority 1: Design a Coherent Framework

- Major Industry Action Incentive:
  - Recognize the manufacturing workforce with its education and training as a capitol asset as well as a national asset in the production process in order to provide tax incentives to preserve the continuing value of the asset
- Add (from Strategic Priority 5):
  - Encourage changes in taxation policies that would provide market incentives for financing life long learning by industry
- Add:
  - Report annually cost of training and education for public companies
- Add:
  - Congress Ways and Means Committee as an action implementer

Manufacturing Training and Education
Changes for Sections 2, 3 and 6:

STRATEGIC PRIORITY 2- *IMPROVE THE QUALITY OF EDUCATION AND TRAINING FOR WORK*

1. First paragraph:

- Move second sentence to become the first sentence.
- Add "systemic" to the beginning of the new second sentence.

2. Add a new action priority:

- Educate and enable the educators to participate in the paradigm shift..

3. Replace "with emphasis on manufacturing industry projects" to the third bullet at the end starting with text after the word "program."

4. Add the new action priority after the original x bullet:

- Support academic and corporate participation in the international IMS program.

5. Change references to the action "encourage" to "do."

6. Add new action priority:

- Replicate successful large industry models of distance learning access to reduce infrastructure costs and lower the costs and time constraint barriers of small and medium sized businesses.

7. Add new action priority: (Add from strategic priority 5)

- Provide cooperative lifelong learning within and across industry sectors.

STRATEGIC PRIORITY 3- *ENSURE ACCESS TO ALL POPULATIONS*

1. Add the action priority:

- Use of NII to give teachers access to education and training on demand, any time and any place.

2. Add the action priority:

- Encourage HBCUs alliances with forefront sciences through major corporations, National Labs and research universities.

3. Add the action priority:

- All government labs should be encouraged to require collaborative researchers to include a K-12 component as well as HBCUs.

4. Add new action priority: (Add from strategic priority 5)

- Disseminate descriptions and results of innovative, high performance lifelong learning.

Strategic Priority 4: Leverage Federal Policy to Use Scarce Dollars where they have the Greatest Impact

- Change “tax credits” in action priority 1 to “tax incentives
- Add:
  - Provide Faculty Reward systems for improving the quality of undergraduate/graduate teaching and lifelong learning
- Add:
  - Provide Industry Reward systems for industrial sabbaticals to educational institutions

Strategic Priority 5: Create Supportive Market Mechanisms to Finance Manufacturing Training (Recommend Elimination and Adding Action Priorities to other Strategic Priorities)

STRATEGIC PRIORITY 6 - *MEASURE PRIORITY*

1. Add the action priority:

- A documented portfolio should be required as a measure of performance of achievement.

2. Add the action priority:

- The evolution of standards to match the paradigm shift should be structured to meet ever changing industry needs.

Manufacturing Deployment

Chairs:

Kevin Carr, NIST
Bill Morin, NAM

Modern technology's great potential to enhance American manufacturing will be realized only if it is properly applied and widely used. Thus, extension programs and other technology deployment mechanisms are important elements of the manufacturing infrastructure.

A NEW CONTEXT

- The fall workshop context:
  - Deployment programs should be **coordinated** among federal agencies in order to support industry needs.
- Given new political realities:
  - **Justify** government's role in deployment
  - **Demonstrate** how deployment addresses the needs of industry and contributes to U.S. competitiveness.

STRUCTURE OF PAPER

Executive Summary

I: National Needs

II: Barriers to Change

III: Who is Doing What

- A. Private
- B. Public (Federal, State and Local)

IV: Rationale for a Federal role

V: Looking Ahead

VI: Recommendations

Federal Role

- The ultimate customer is the U.S. manufacturing base.
- The immediate customer is the extension network of service providers.

CORE VALUES

The Manufacturing Extension Partnership...

- Is industry-driven and market defined
- Builds upon existing state & local industrial extension resources
- Focuses services on activities where economies of scale do not exist in the marketplace
- Committed to performance measurement which focuses on the bottom-line economic impact for client companies
- Exploring innovative alternative approaches toward accomplishing its mission

CORE PROCESSES AND PRODUCTS

- Establishment of manufacturing extension service delivery partnerships
- Maintenance of manufacturing extension service delivery partnerships
- Integration of service delivery into a national system
- Add value through the establishment of strategic partnerships for products & services which complement the national system
- Continuous innovation of the manufacturing extension service delivery process

CORE RECOMMENDATION

- Looking ahead at the Federal role in technology deployment, the federal government, with NIST MEP playing a capacity-building and coordinating role, should work to fill the gaps in the infrastructure of technical assistance programs to all tiers of the industrial base.
- The federal government should leverage both public and private resources, serving as a catalyst for action rather than duplicating functions offered elsewhere in the market.
- Given its national perspective, the federal role lends itself particularly well to such functions as: information dissemination, performance metrics, and standards, best practices, electronic linkages, lessons learned, information on national and global benchmarking--all to insure service providers are equipped with up-to-date tools for serving the industrial base.
- The federal government will provide the mechanism for incorporating the needs of SMEs in the national research agenda (technology pull).
- As the gaps fill with competent service providers and small manufacturers overcome the barriers to change, the federal role will evolve as the market and economy absorb technical assistance functions.

Industry Feedback

PURPOSE OF WHITE PAPER

To justify federal activities supporting the accelerated deployment of modern manufacturing technologies and business practices into all tiers of the nation's manufacturing base.

BARRIERS TO CHANGE

- Lack of information
- Isolation
- Where to Seek Advice
- Regulatory burden
- Financing

NSTC Deployment Panel

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NIST MANUFACTURING EXTENSION PARTNERSHIP

CORE VALUES

The Manufacturing Extension Partnership...

- Is industry-driven and market defined
- Builds upon existing state & local industrial extension resources
- Awards funding using merit-based competitive process
- Focuses services on activities where economies of scale do not exist in the marketplace
- Focuses service on only those firms which demonstrate a commitment to their own growth and development
- Seeks maximum leverage in the expenditure of program resources
- Committed to performance measurement which focuses on the bottom-line economic impact for client companies
- Committed to delivering the highest quality service, continuous improvement of that service, and exploring innovative alternative approaches toward accomplishing its mission

NIST MANUFACTURING EXTENSION PARTNERSHIP

CORE PROCESSES

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- Given new political realities:
  - **Justify** government's role in deployment
  - **Demonstrate** how deployment addresses the needs of industry and contributes to U.S. competitiveness.

Business Practices

Chairs:

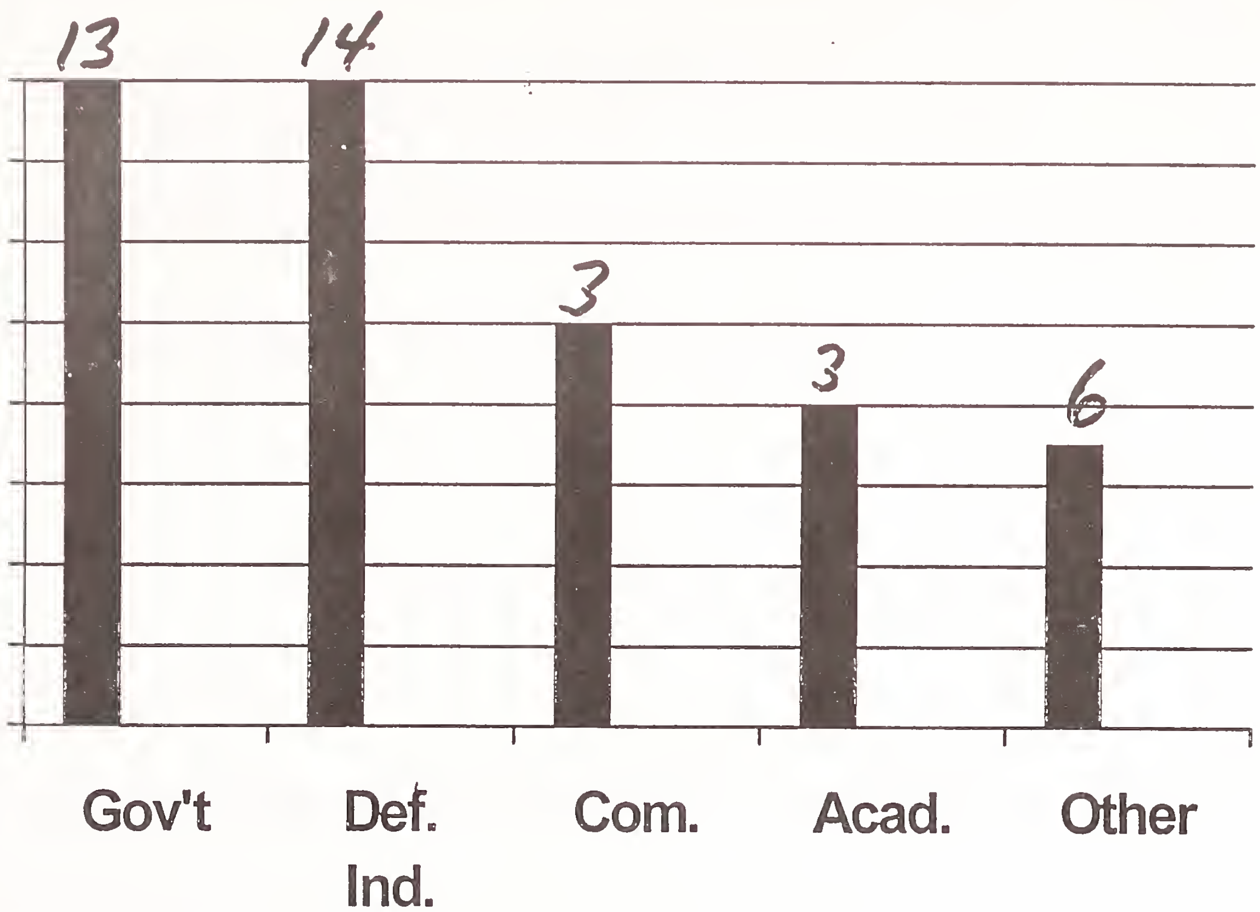
Michael McGrath, ARPA
Dale Hartman, CAM-I

Practices that permit companies to create flexible and readily-adaptable enterprises, such as new "lean" and "agile" manufacturing concepts, are rapidly changing the ways in which companies assemble production resources, interact with their suppliers, and respond to changing customer needs.

“The soft stuff is really the hard stuff”

P. Roether

ATTENDEE DEMOGRAPICS



2nd National Manufacturing Technology Conference

April 19, 1995

Panel 6: Business Practices

Agenda

0830 Introduction and Panel Objectives

0845 Integrated Perspectives from Industry, Government, Academe
- -- Dale Hartman, CAM-I
- -- Mike McGrath, ARPA
- -- Steve Goldman, Agility Forum

0930 Workshop Discussion: Inputs for a "White Paper"
- -- Framework for Business Practice Improvements
- -- Break
- -- Issues and Needs
- -- Recommended Roles for Government, Industry

1230 Adjourn

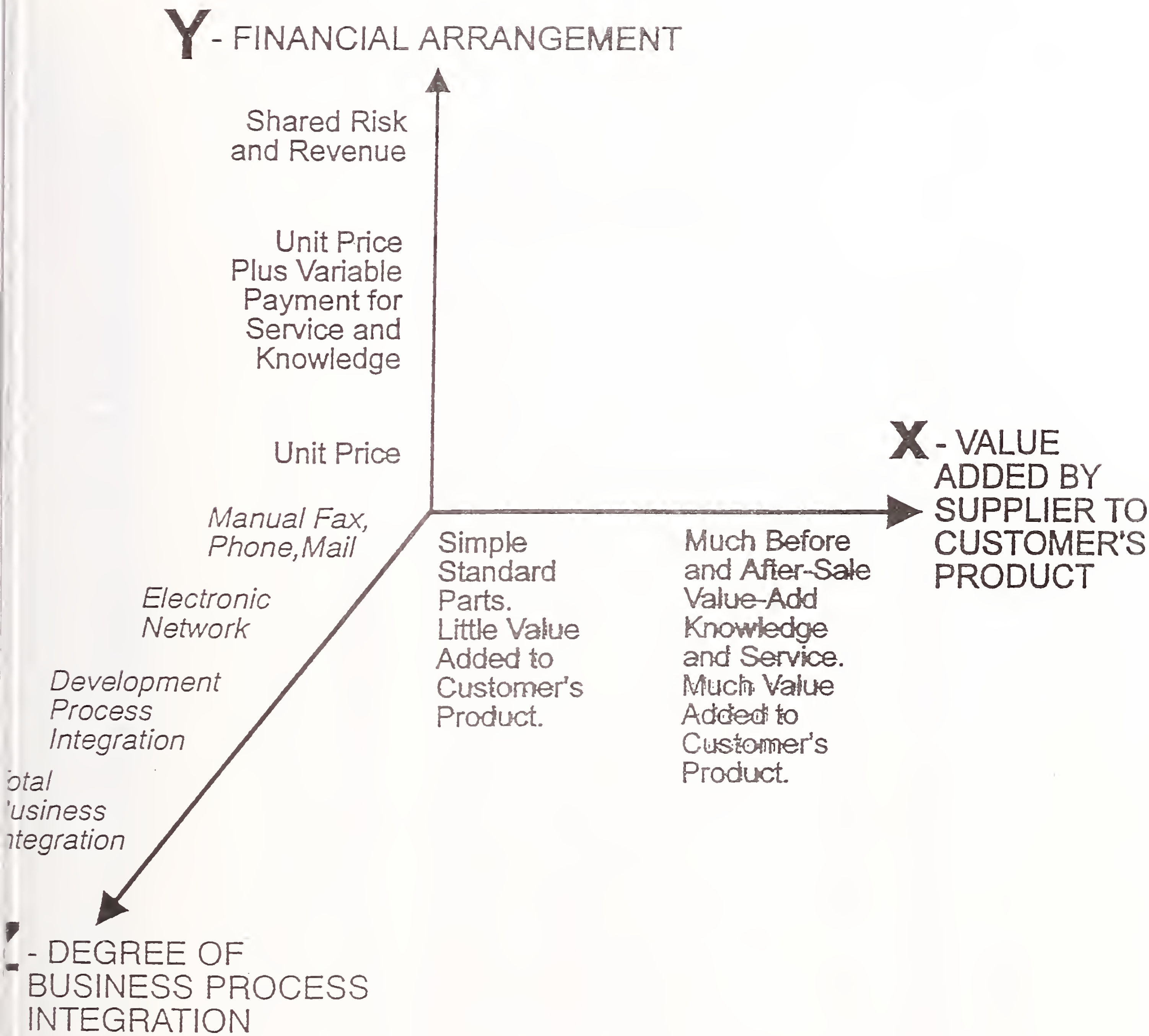
NEXT GENERATION

KEY CHARACTERISTICS OF NGMS:

- CUSTOMER FOCUSED, BUSINESS ORIENTED
- RECONFIGURABLE, ADAPTABLE, FLEXIBLE
- MODULAR TO SUPPORT DISTRIBUTION AND AUTONOMY
- SUPPORT FOR GLOBAL DESIGN AND PRODUCTION
- HUMAN INTELLIGENCE RICH
- COOPERATIVE TO SUPPORT ENTERPRISE GOALS
- SUPPORT FOR VIRTUAL ENTERPRISE
- INFORMATION AND KNOWLEDGE BASED
- ENVIRONMENTALLY AWARE

Agile Supplier-Customer Relationships

- Enabling Subsystems
  - Continuous Learning
  - Performance Metrics and Benchmarks
  - Empowered Individuals in Teams
  - Organizational Practices/Policies/Procedures
  - Customer Interactive systems
  - Pre-Qualified Partnering
  - Rapid Coordination Mechanisms
  - Networking and Information Subsystems
  - National Manufacturing Support Infrastructure



The Parameters of a Customer - Supplier Relationship

Improving Business Practices in Manufacturing

Government interests:

1. Economic growth (97%)
2. Fairness and other social goals
3. Affordability, stewardship (where gov't is customer) (3%)

Modes of Gov't/Industry Collaboration

1. Government as facilitator/catalyst/stimulus
   - Workshops, benchmarking > What, How

   Examples: LAI, PNGV
2. Government funded (cost shared) demos
   - Validate new paradigms

   Examples: ATP, TRP, Agile, AM^3
3. Industry-initiated process change
   - Implement world class practices

   Examples: Proposed acquisition reform for F-16
4. Outreach & Deployment, Training & Education

   Examples: MEP, ECRC, NSF...

Mode 2 (Gov't funded demos) needed when:

- Risk is beyond industry threshold, or
- Government customer dominates market, or
- Competitive Pressures are insufficient near term motivator

Issues & Opportunities

- General Business Practices
- Government Regulations & Oversight
- Acquisition Issues
- Financial Issues
- Supplier Issues
- Metrics Issues
- People Issues
- Comp. Policy Issues

Conclusions

- Government behavior as a customer (3%) is a hot button
- Addressing Commercial business practices (97%) is essential to success of the other five NSTC Manufacturing Infrastructure thrusts
- "Business Practices" merits a white paper

Recommendations

1. Add "Business Practices" as a 6th element of the NSTC framework
2. Establish a group under the Manufacturing Infrastructure subcommittee to draft a white paper. Focus on:
   a. New business practices that are essential to the success of S&T investments
   b. New business practices that exploit the capabilities provided by S&T
3. Convene a workshop with balanced participation to critique and refine the draft white paper

Overview of Manufacturing Programs

Representatives of NIST, the Department of Energy, the Department of Defense, and the U.S. Secretariat of the international Intelligent Manufacturing Systems Program provided overviews of ongoing and planned manufacturing-related activities.

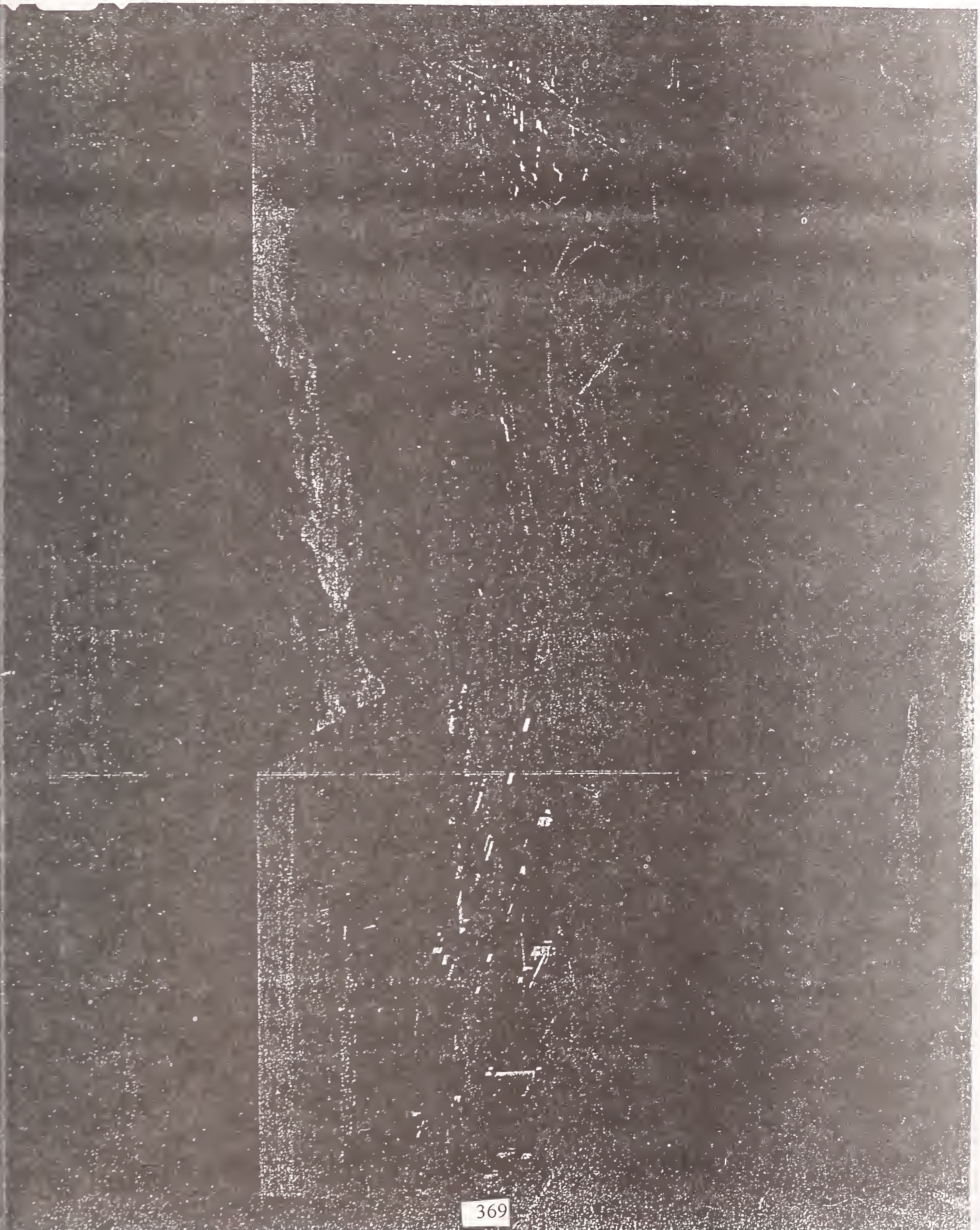
Richard H.F. Jackson
Deputy Director
Manufacturing Engineering Lab
NIST

An Overview of Manufacturing Programs at NIST

Richard H.F. Jackson

Deputy Director
Manufacturing Engineering Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

MEL NIST

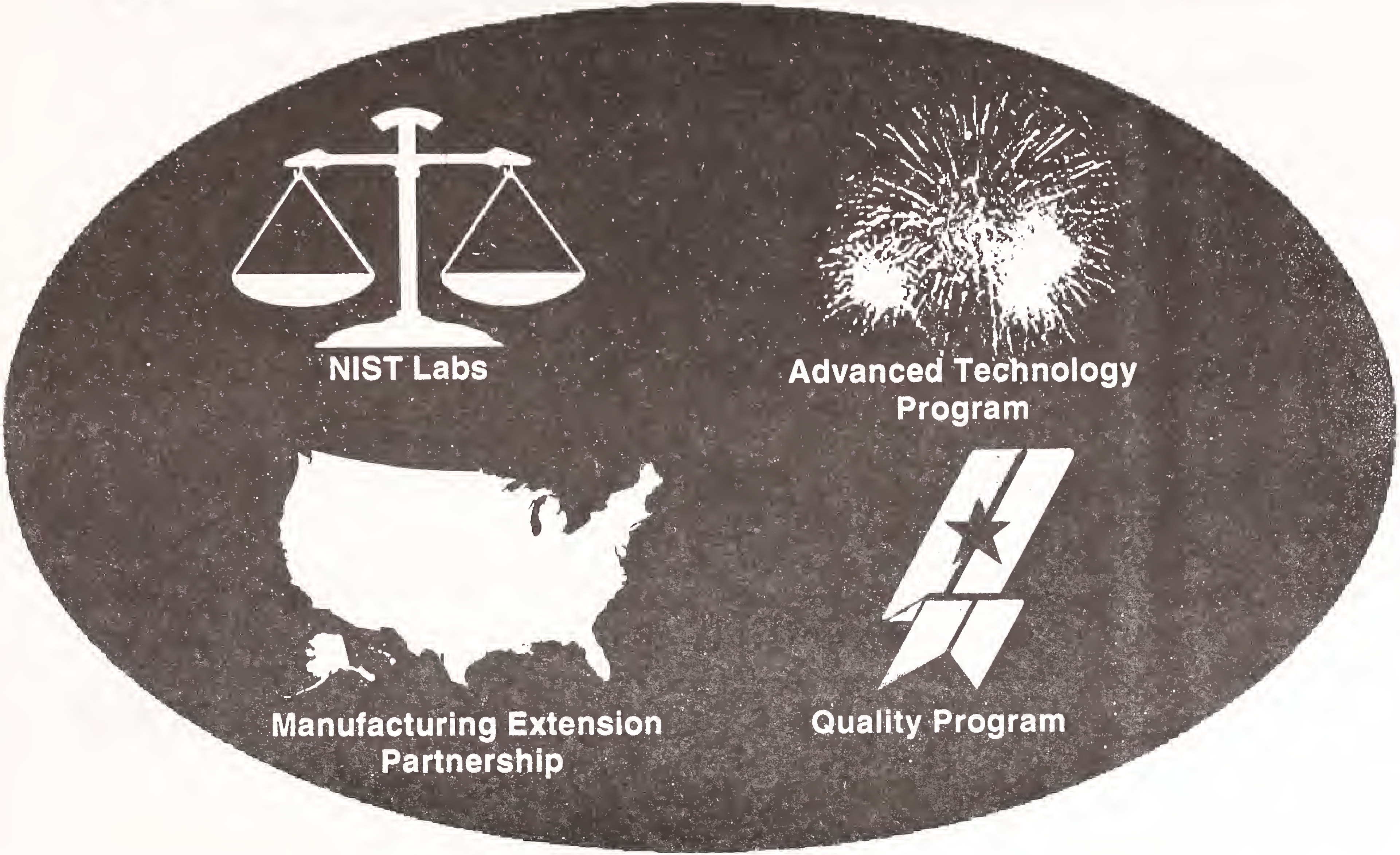


RESOURCES

Fiscal Year 1995

- 3339 Employees
- About 1300 Guest Researchers
- $994.3M Operating Budget
- $64.6M for Construction of Research Facilities

National Institute of Standards and Technology



Advanced Technology Program

Mission Stimulate U.S. economic growth by promoting the development of high-risk, enabling technologies through programs and projects proposed and cost shared by industry

Strategy Work with U.S. industry to plan, execute, and cofund development programs for high-risk technologies that are:

Enabling – provide technical bases for process- and product-specific applications.

High-Value – offer large and/or strategic long-term benefits to the U.S. economy.

Unique Features

- Focus on high-risk generic technologies
- Direct funding of companies only
- R&D priorities set by industry
- Cost sharing required for all projects
- Selection based on **both** technical and business merit
- Automatic sunset provisions -- funding limit on single-company projects
- Broad scope
- Promotes cooperative research and strategic business alliances
- Substantial support to small businesses (including startups)
- Intellectual property rights assigned to awardees
- Proprietary information protected

ATP Technology Areas

- Machine Tools
- Image Recognition & Processing
- Semiconductor Processing
- Genetic & Tissue Engineering
- Flat Panel Displays
- Lasers, Optics & Electro-optics
- High Performance Computers
- Optical Communications
- Ceramics, Composites, & Polymers
- Speech Recognition & Processing
- Illumination
- Disease Modeling
- Automated Mfg. & Robotics
- Motor Vehicle Assembly
- Plastic Recycling
- Superconductors
- Energy Conservation & Dist.
- X-Ray Lithography & Optics
- Optical & Magnetic Storage
- Printed Wiring Boards
- Networking
- Tissue Engineering
- Enzyme Development
- Chemical Processing

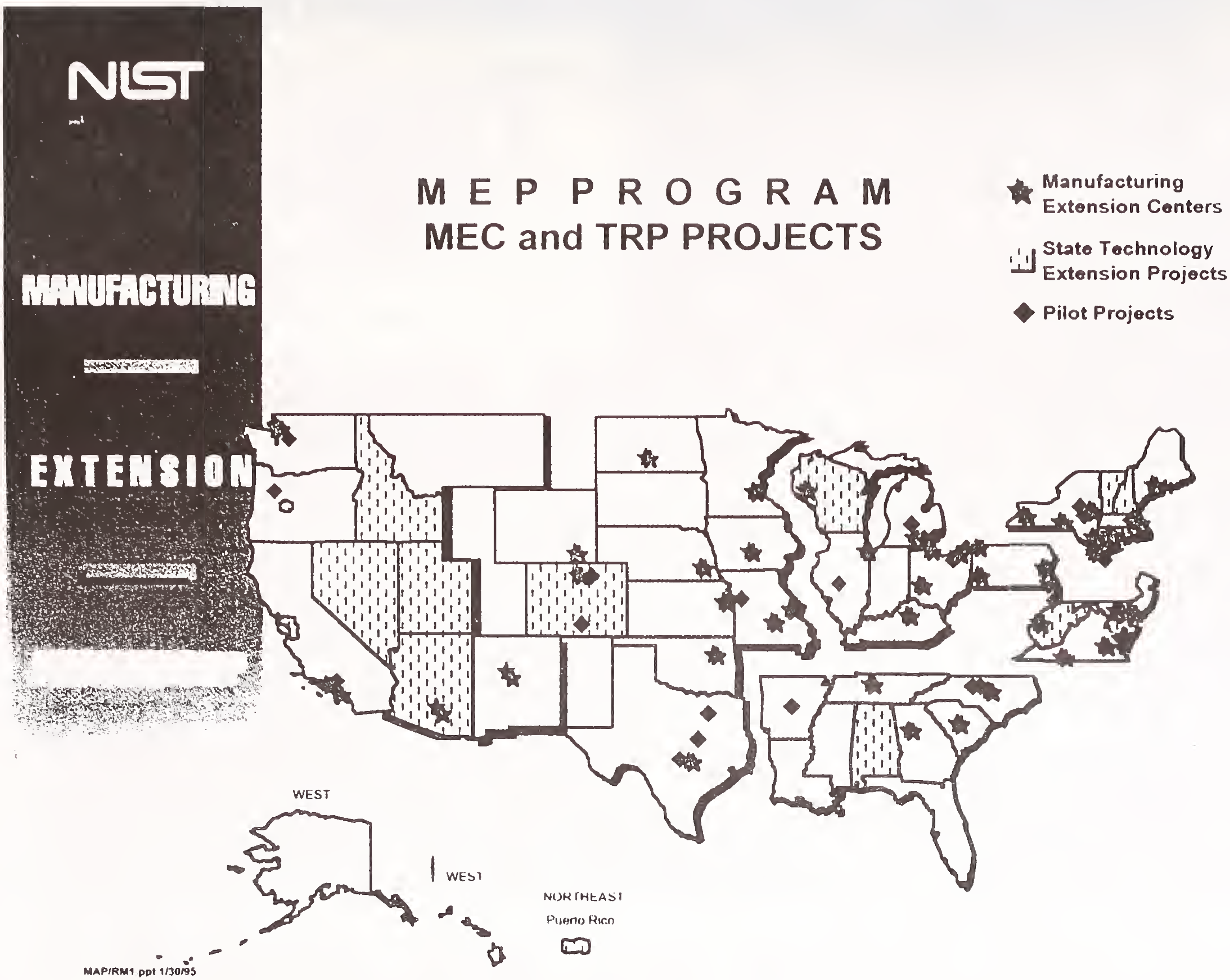
ATP Focused Programs

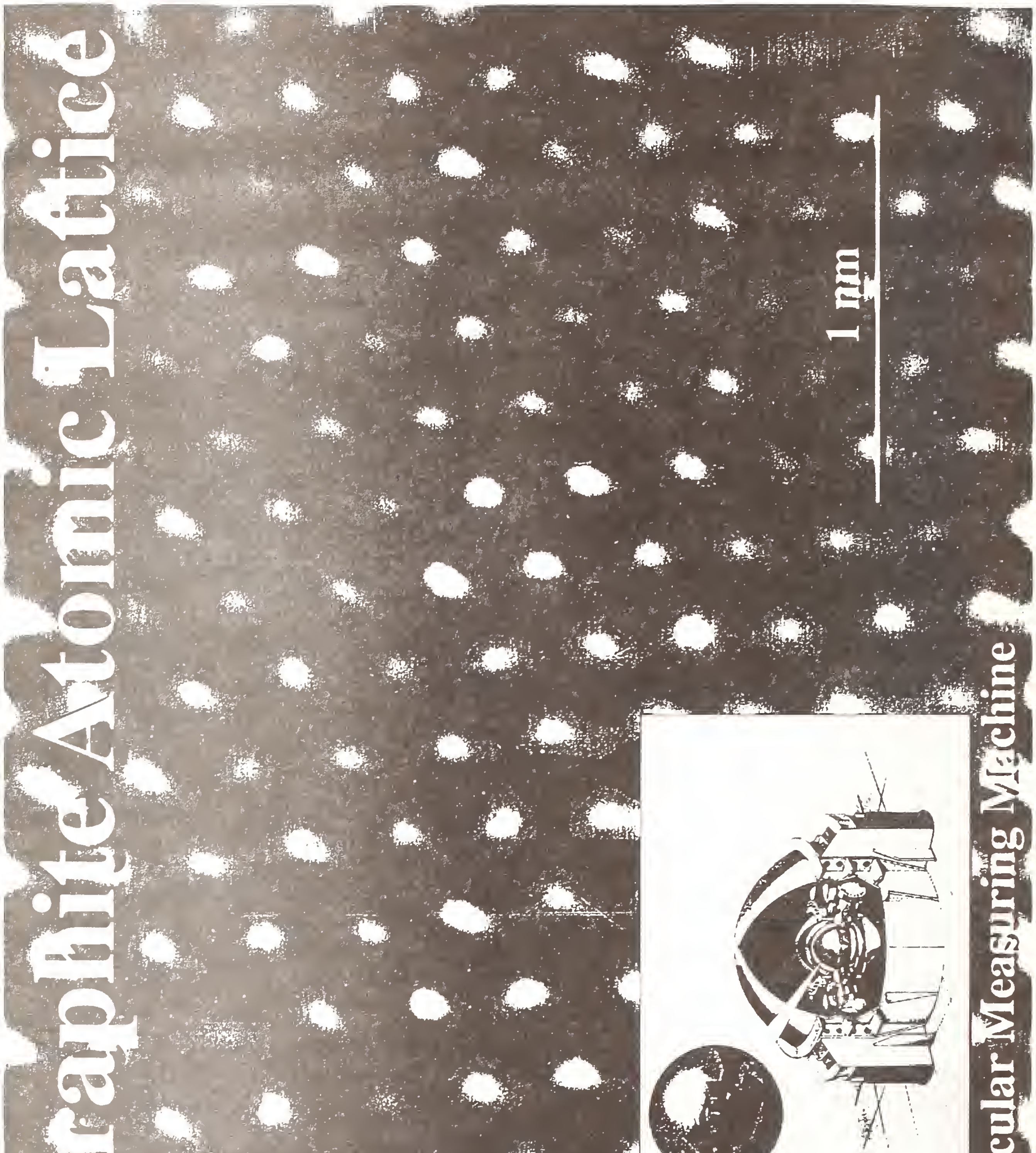
April 1994

- Tools for DNA Diagnostics
- Information Infrastructure for Healthcare
- Manufacturing Composite Structures
- Component Based Software
- Computer Integrated Manufacturing for Electronics

November 1994

- Catalysis and Biocatalysis Technology
- Motor Vehicle Manufacturing Technology
- Digital Data Storage
- Digital Video in Information Networks
- Materials Processing for Heavy Manufacturing
- Advanced Vapor Compression Refrigeration Systems


NIST
MANUFACTURING
EXTENSION
M E P P R O G R A M
MEC and TRP PROJECTS
Manufacturing Extension Centers
State Technology Extension Projects
Pilot Projects
WEST
WEST
NORTHEAST
Puerto Rico
MAP/RM1 ppt 1/30/95

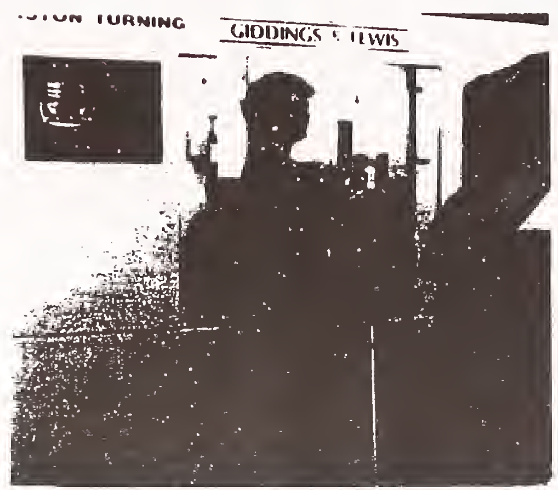

Graphite Atomic Lattice
1 nm
Molecular Measuring Machine

Manufacturing Processes and Equipment Program

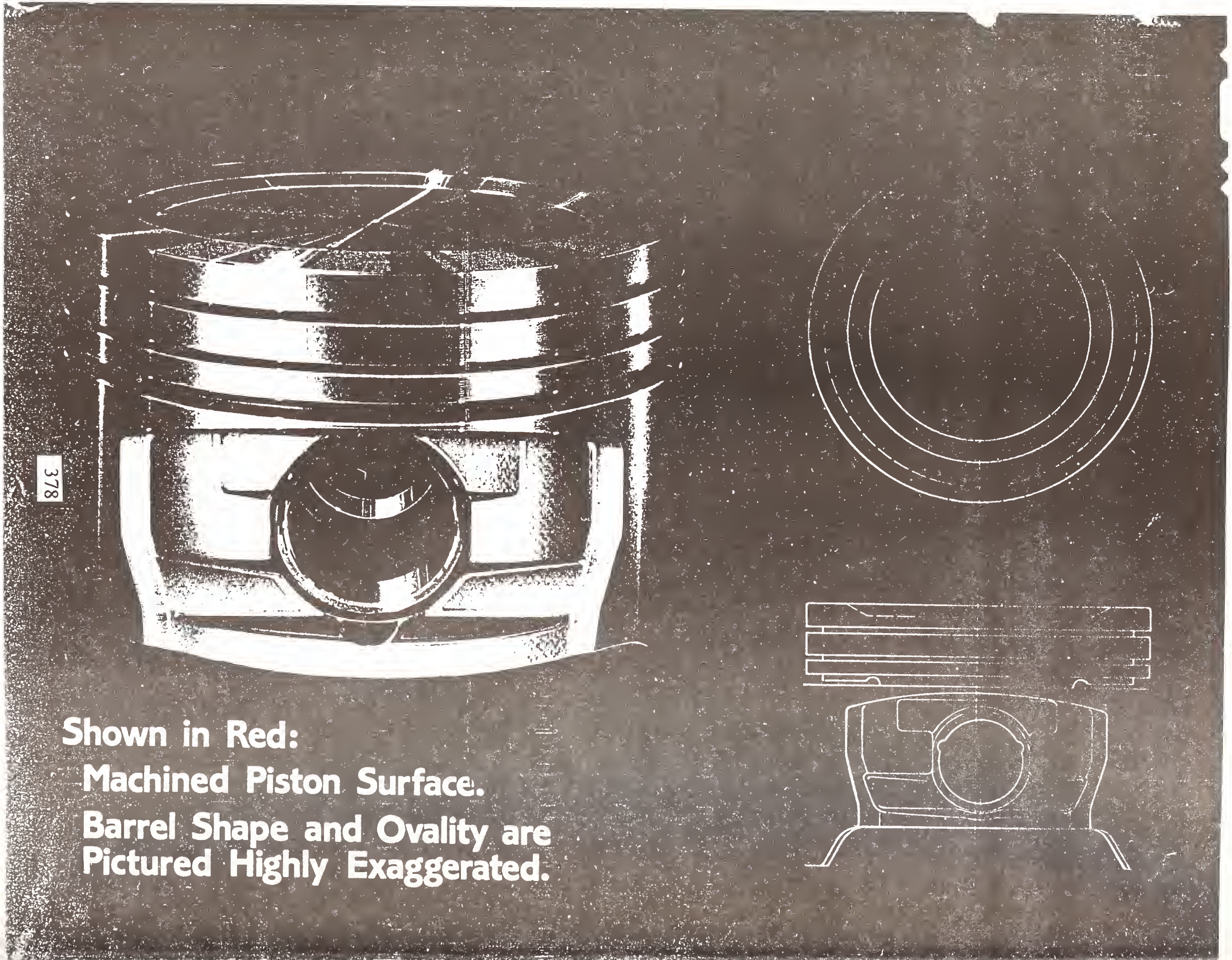
Advance the state of the art of high-speed and high-precision manufacturing by sensor-based metrology, process modeling, and process control

Technical areas:

- *Sensor-based manufacturing*
- *Precision machining*
- *Advanced machine tool structures*
- *Intelligent nanomanufacturing*
- *Advanced material processing*
- *Machine tool characterization and calibration*



MEL NIST

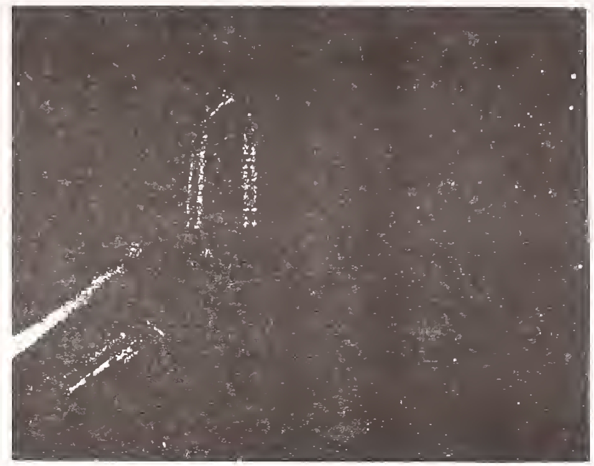

Shown in Red:
Machined Piston Surface.
Barrel Shape and Ovality are
Pictured Highly Exaggerated.

Intelligent Machines and Systems Program

Develop performance measures and interface standards to support industry needs for intelligent systems and sensor-based automation in manufacturing

Technical areas:

- *Enhanced machine controller*
- *Reference model architecture*
- *Intelligent manufacturing systems*
- *Intelligent systems integration testbeds*
- *Large scale manufacturing*



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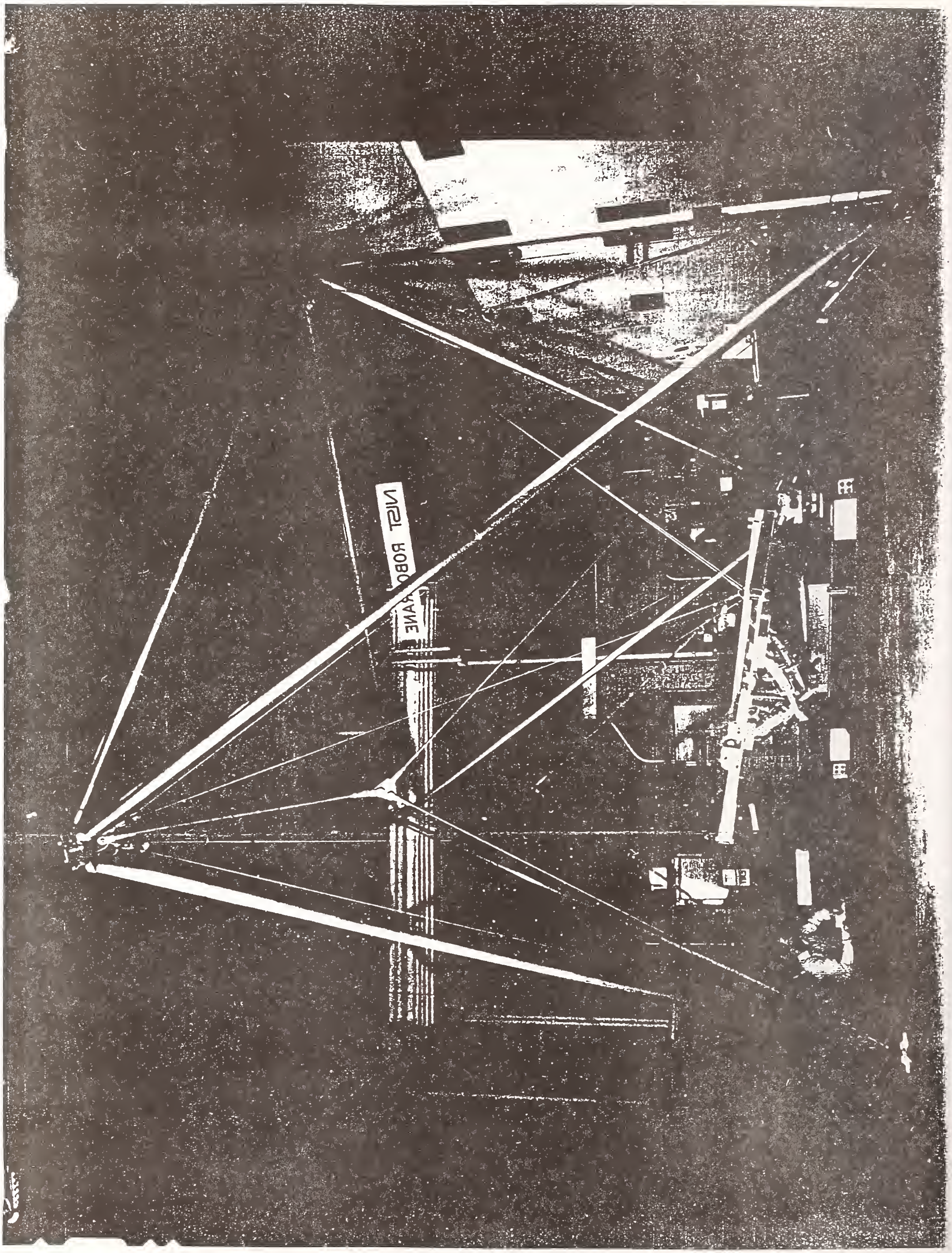
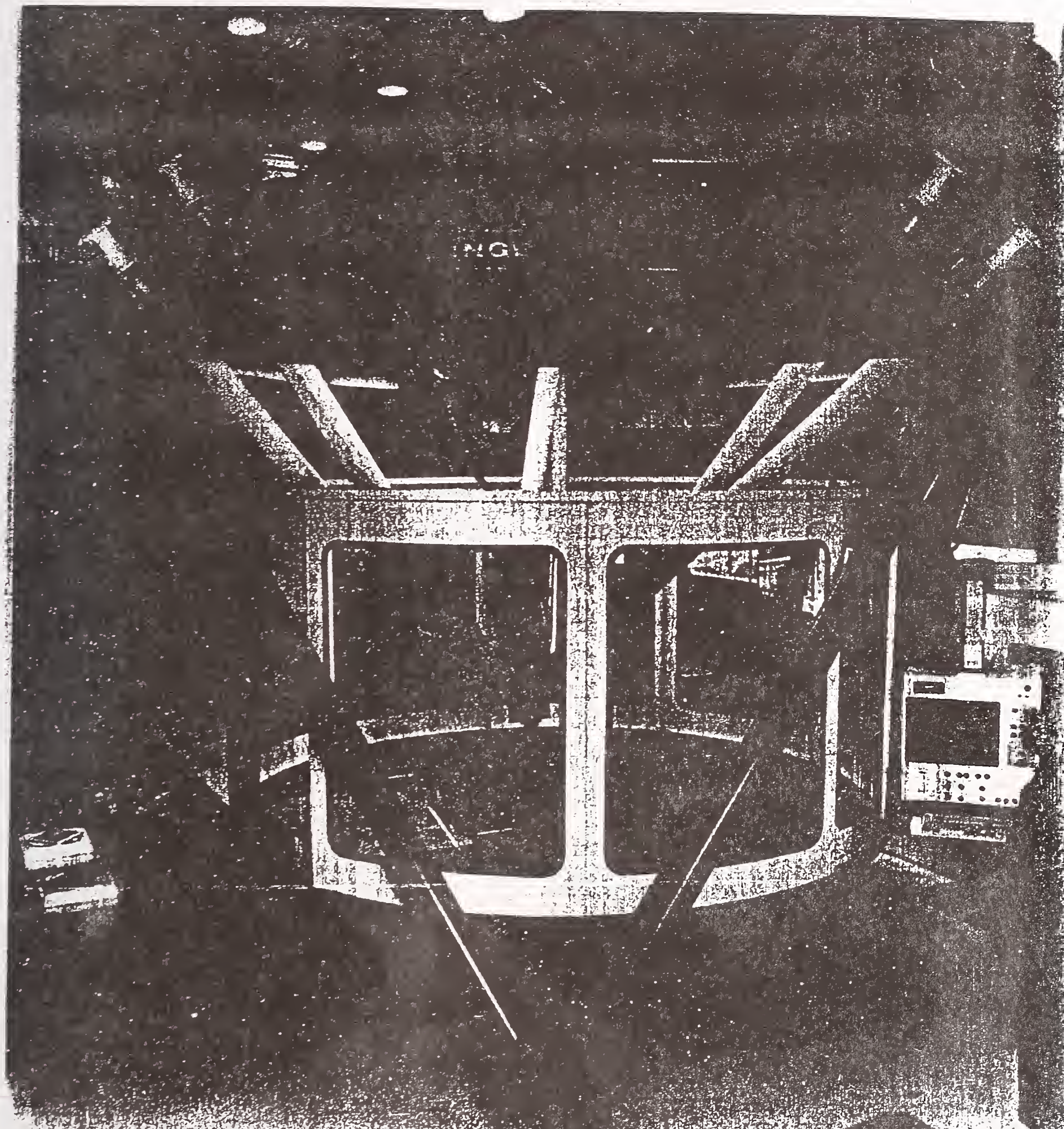
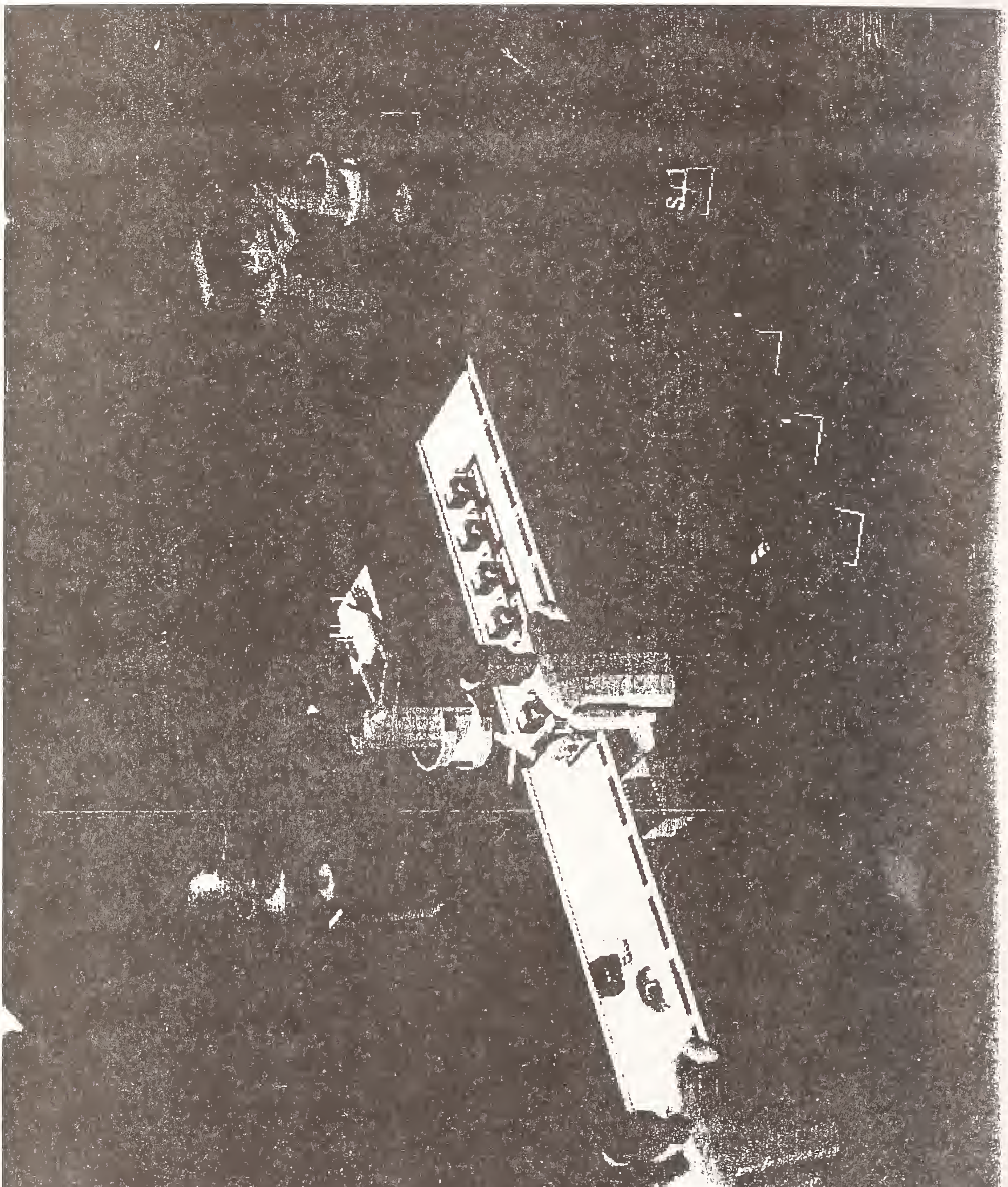
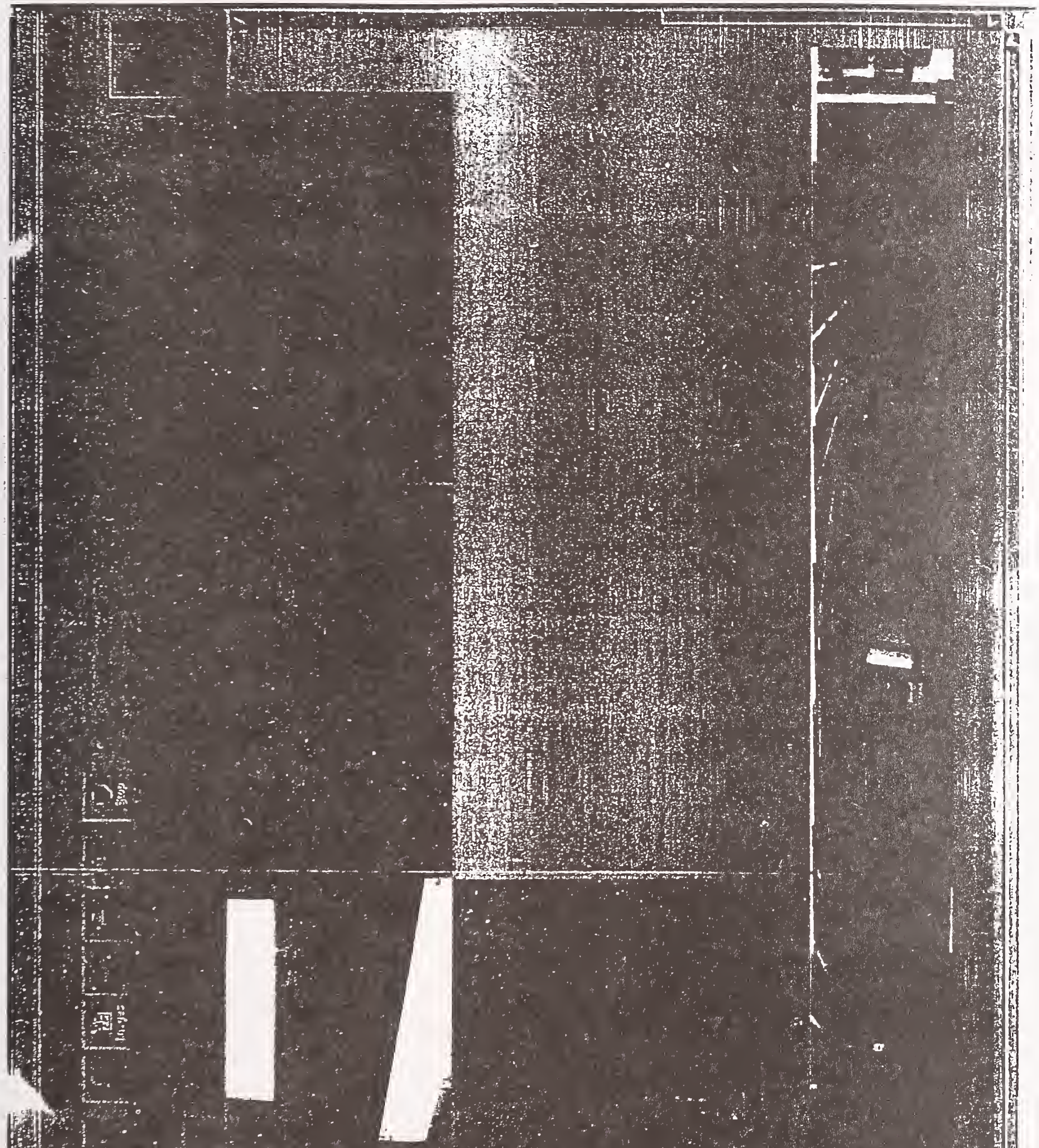


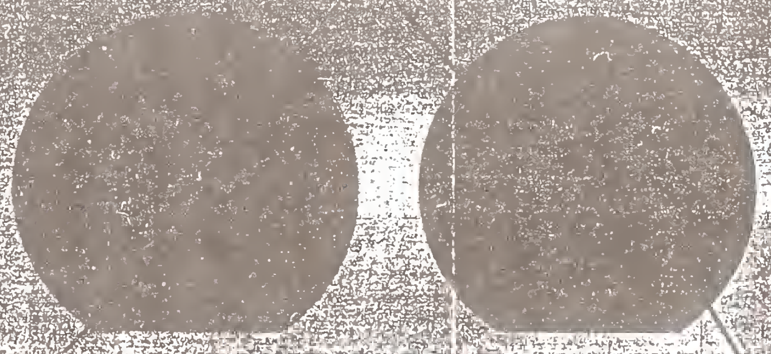






Microwaves

- [illegible] consortium for [illegible] integrated circuit on-wafer measurements
- Introduced new measurement methods and disclosed errors in existing industrial measurements; results commercialized
- Widely recognized by awards, including IEEE [illegible] Award



[illegible] TRL calibration artifacts   Modified LRM calibration artifacts

[illegible] 1995-1996

- Primary EEEL response to "wireless revolution" is in Electromagnetic Fields Division
- Develop the microcircuit measurement technology needed by wireless communications industry

Changes [illegible]

Division has taken [illegible] to respond under severe conditions

- Reduced staff (about [illegible]%) since 1991
- Strengthened [illegible]
- Improved standards services
- New work in materials and devices is now competitive worldwide

Semiconductors

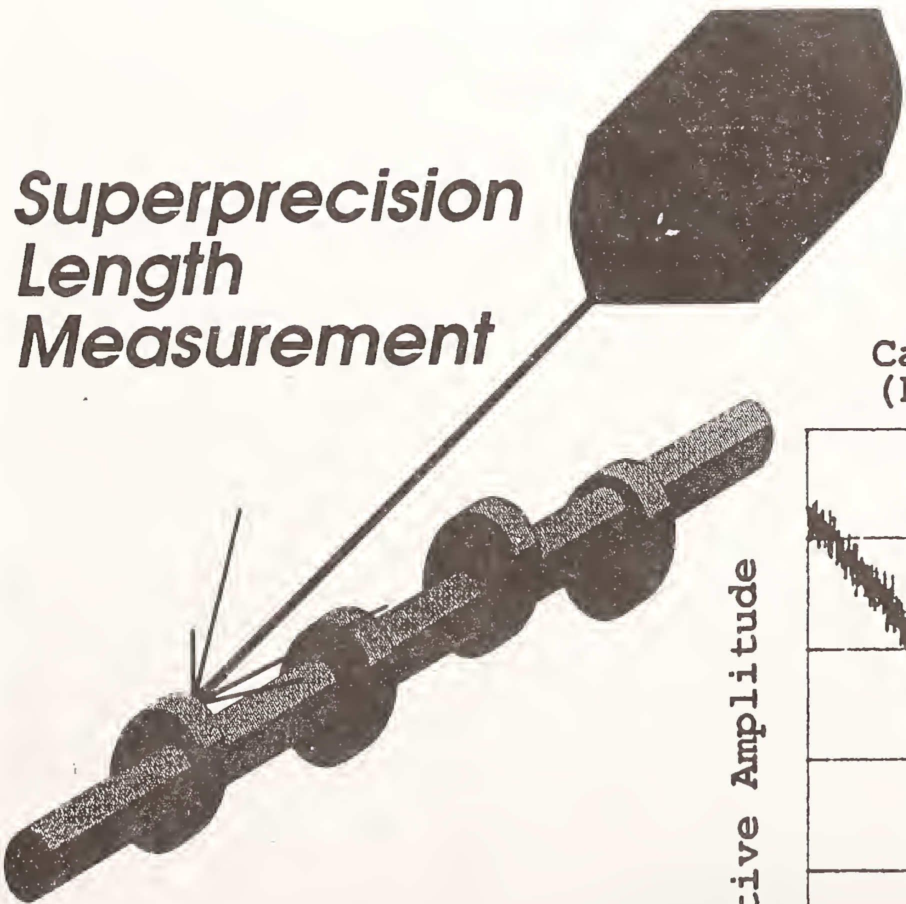
Highlight
- EEEL provides industry with technique to control thickness of 6.5 nm gate oxides with uncertainty of 0.3 nm
- Round robin with major U.S. manufacturers proves and disseminates capability

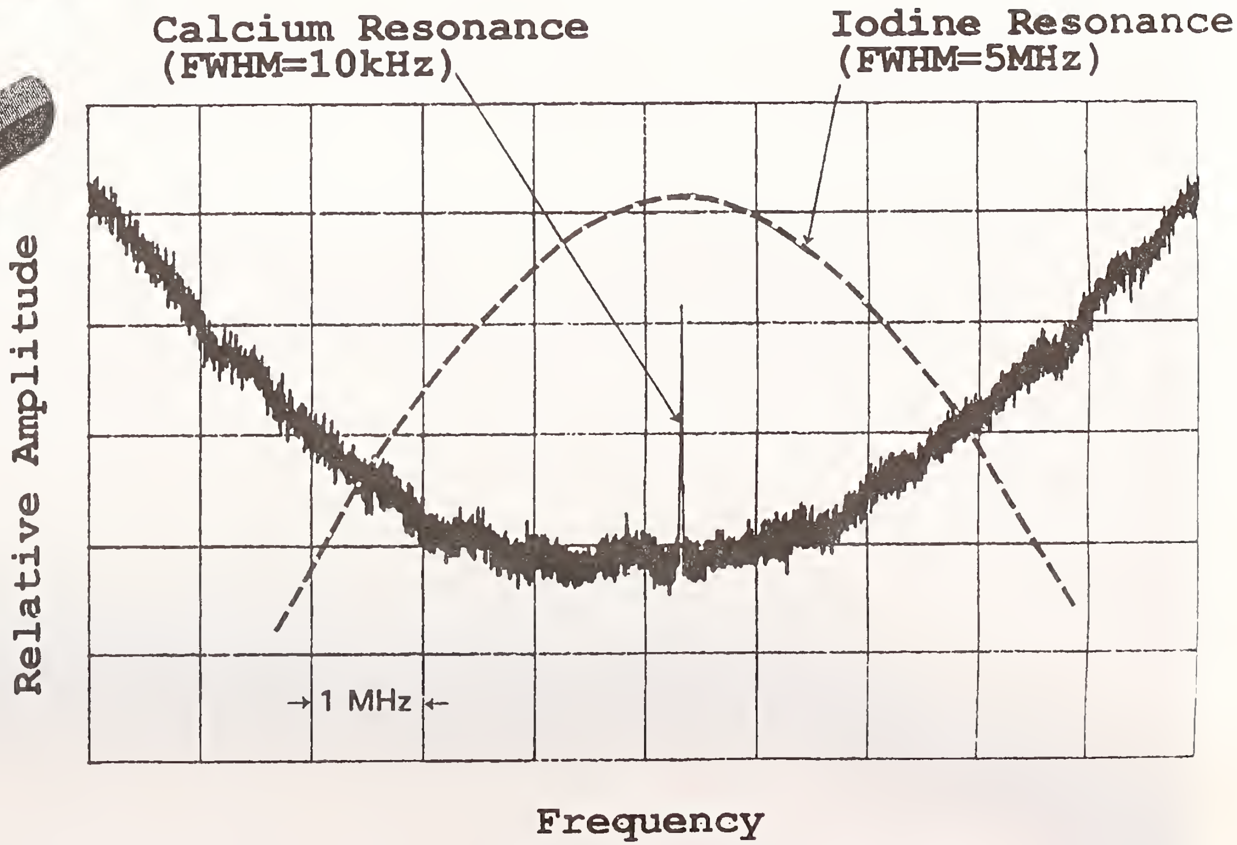
[illegible] 1995-1996
- Meet National Roadmap metrology needs particularly for dopant profiles, film thickness, linewidth, and overlay
- Respond to new roadmap for compound semiconductors
- Help focus modeling and computer aided design projects nationwide on [illegible]

Changes 1994-1995
- Shifted from internal production of SRMs to commercial artifacts and standard test methods
- Developed metrology for and database of material properties at processing temperatures needed for real-time process control

STABILIZED Ca LASER AS A PRACTICAL LENGTH STANDARD

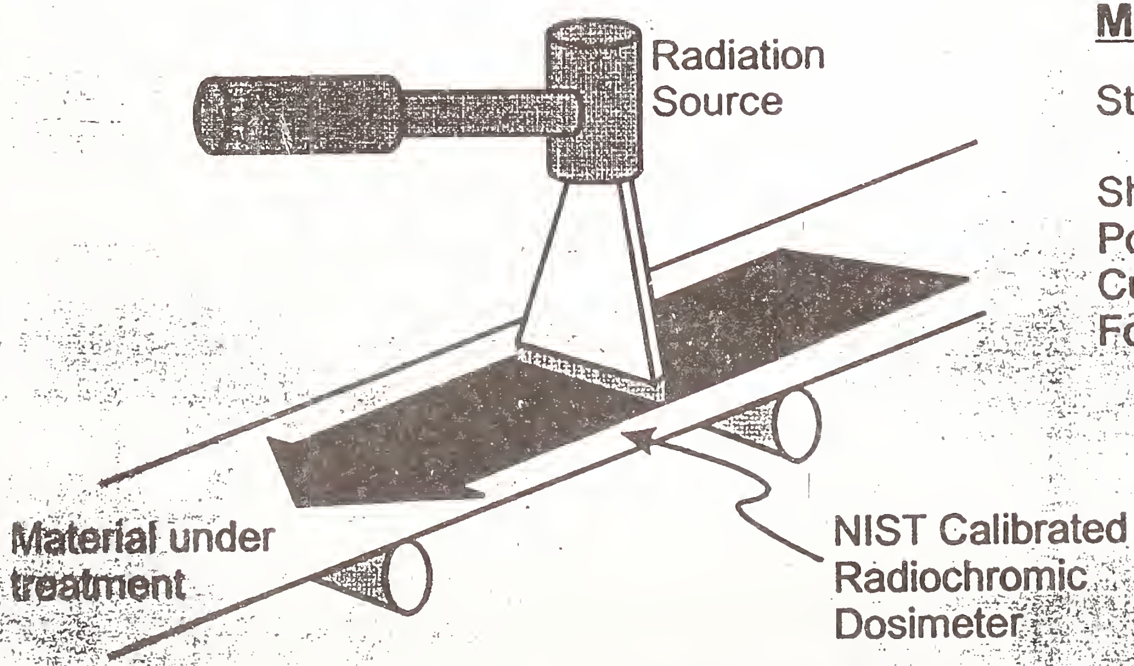
Superprecision Length Measurement





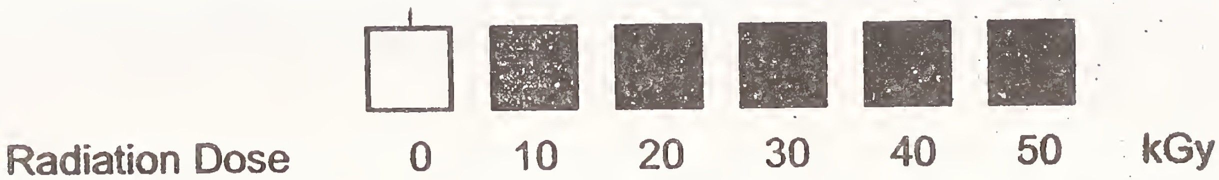

Radiation Source
NIST Calibrated Radiochromic Dosimeter

RADIATION PROCESSING



Manufactured Products

Sterilized Medical Devices & Disposables
Shrink Wrap & Tubing
Polymers & Composites
Cured Inks & Coatings
Foodstuffs & Spices



National Advanced Manufacturing Testbed

Accelerate the use of distributed and virtual manufacturing technologies; provide systems integration and interoperability for suppliers, vendors, and manufactures

Distributed and virtual manufacturing (DVM) technologies for:

- *Integration and interoperability standards*
- *Manufacturing control systems*
- *Machines, systems, and software tools*
- *Rapid prototyping and product evaluation*

MEL NIST

GOVERNMENT ★ ACADEMIA ★ INDUSTRY ★

MANUFACTURING TECHNOLOGY

Heinz Schmitt
Vice President
Sandia National Laboratory

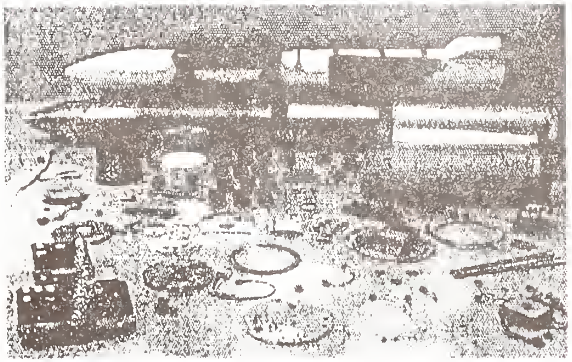
Overview of DOE Programs in Advanced Manufacturing

Heinz W. Schmitt
Vice President
Sandia National Laboratories

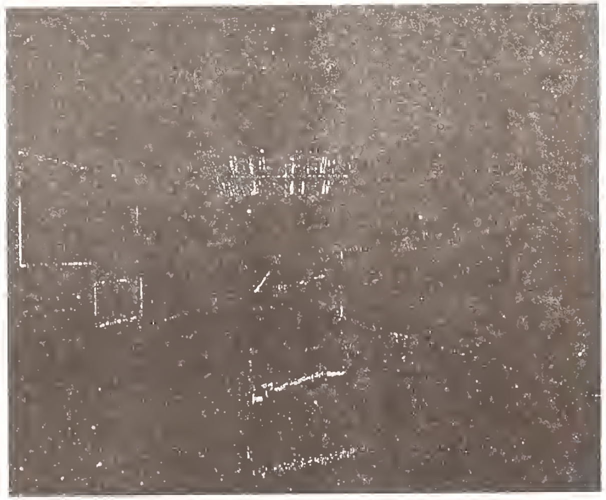
Presentation to: 2nd Annual Manufacturing Technology Conference

Gaithersburg, MD
April 19, 1995

DOE Has Missions That Bind It to Advanced Manufacturing

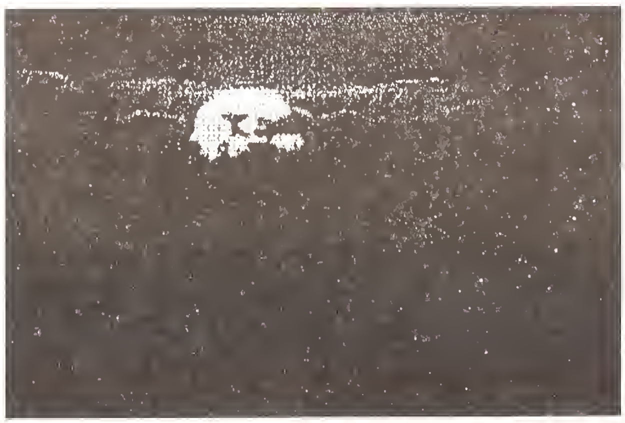


National Security



Science & Technology

Energy Resources



Environmental Quality

Evolution of DOE's Product Realization Process

- DOE's Unique Responsibility: "Cradle To Grave"
- DOE Originally Evolved Its Capabilities and Competencies for This Mission
- DOE Also Has Missions in Energy and Environment
- Now "Big M" Manufacturing
- Industry is a Partner in DOE Manufacturing

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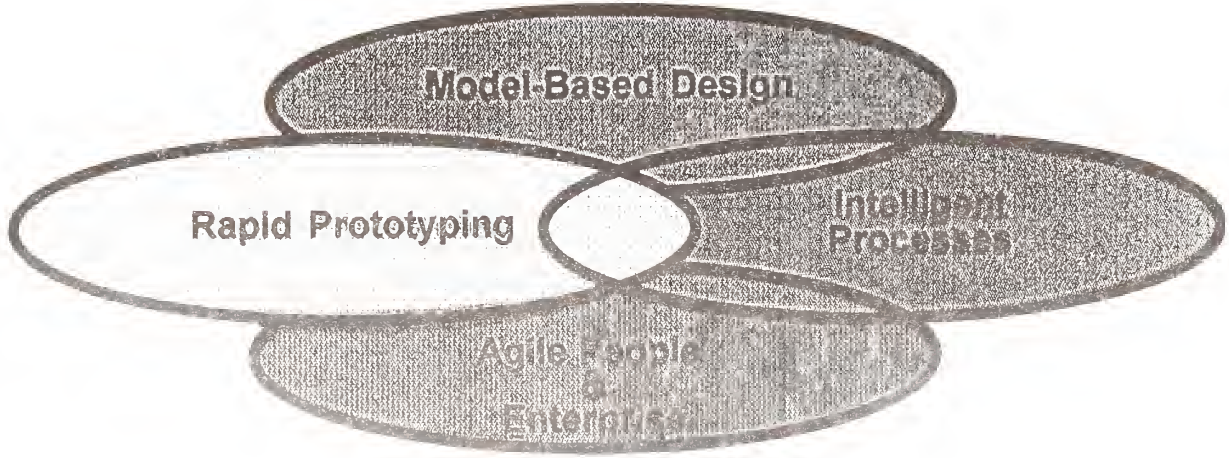
In DOE's Advanced Manufacturing Technology, Manufacturing is Big "M"

- R&D
- Design
- Prototype and Simulation
- Test and Evaluation
- Process Development and Qualification
- Production/Fabrication
- Training
- Product Evaluation and Improvement
- Recycle and Disposal

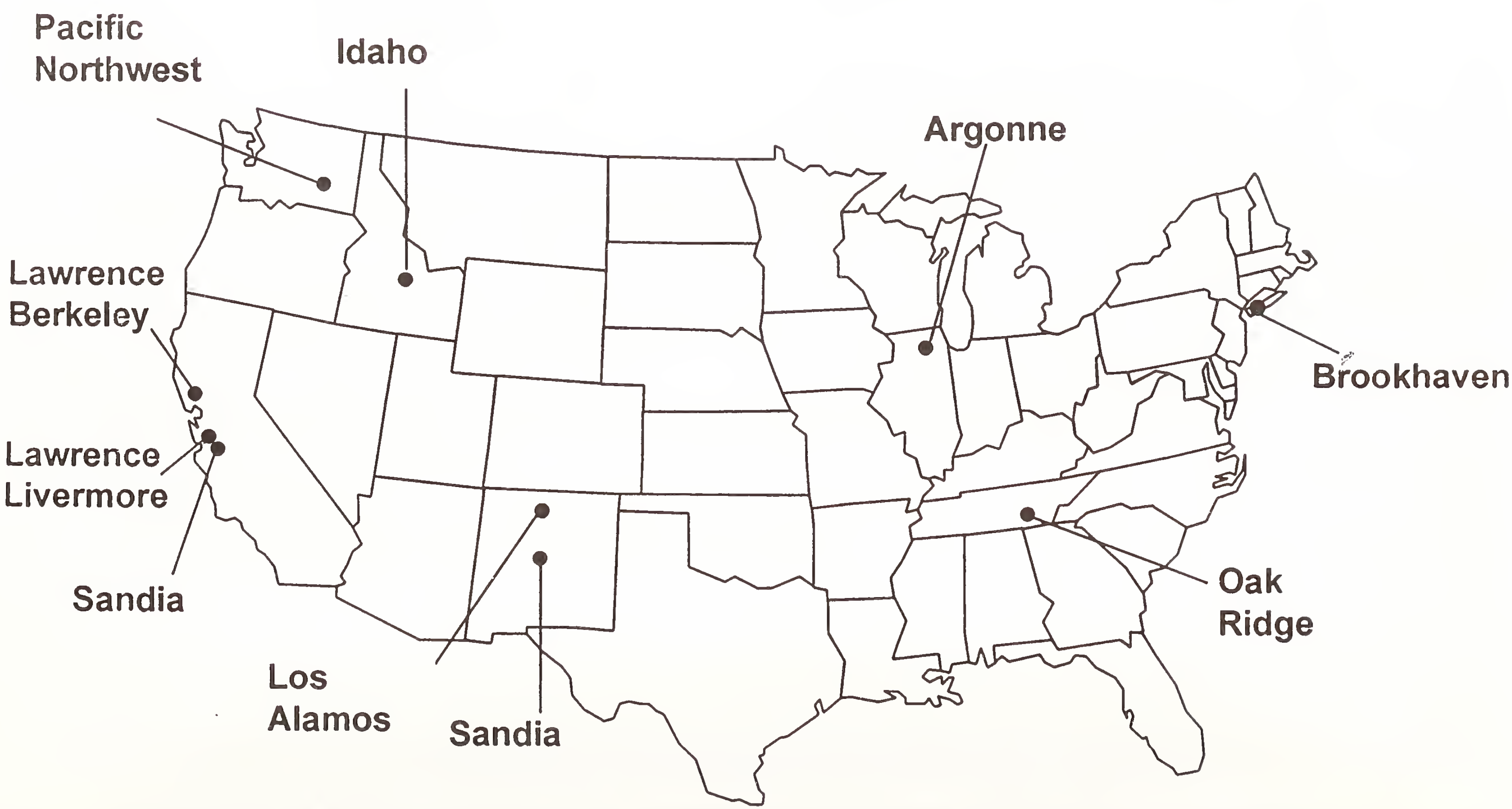


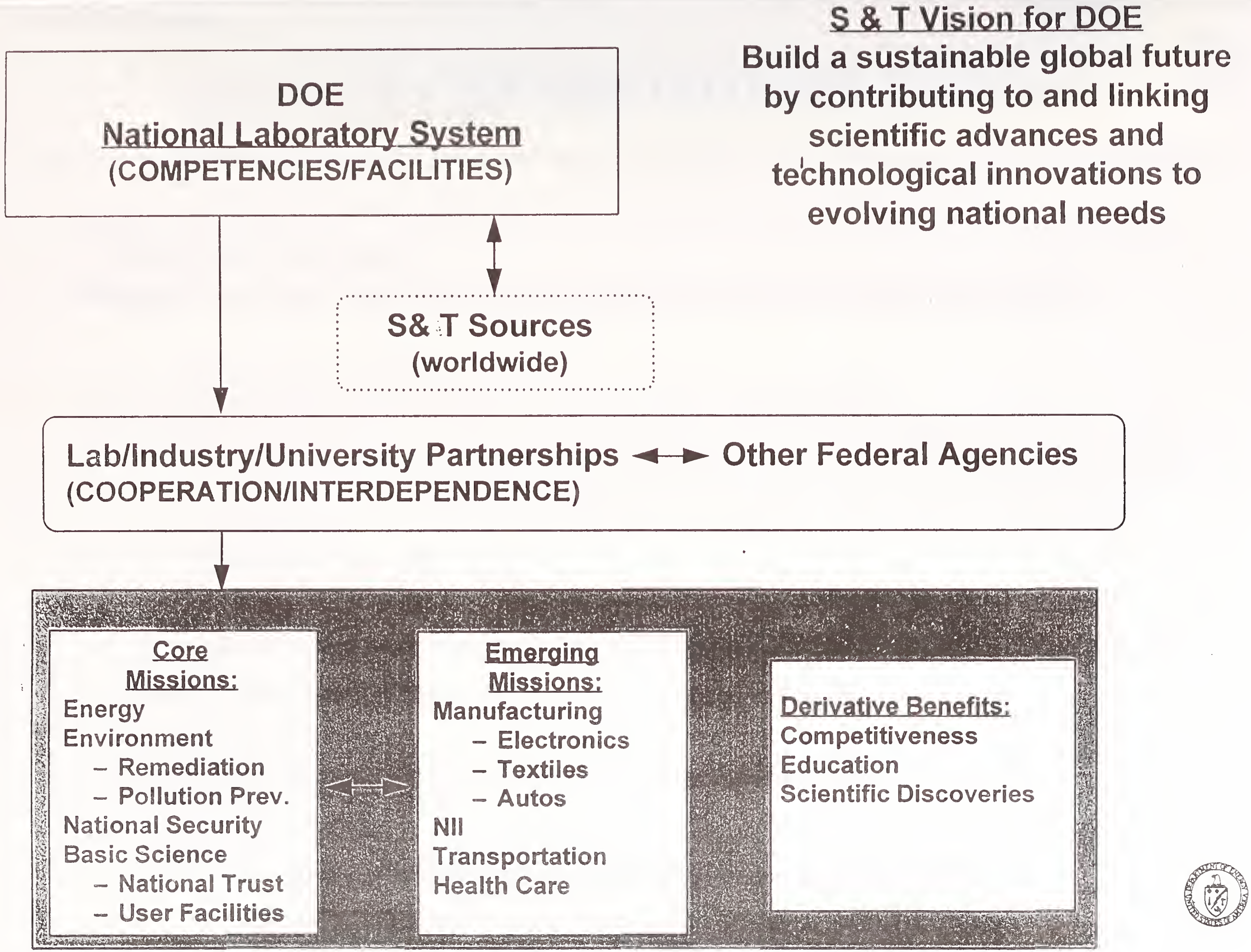
Product Realization Process

Enabling DOE's Product Realization Process

- Unique, Useful, Accessible Facilities
- Agile People and Valuable Intellectual Property
- Captive Production Base Now Consolidating
- DOE Also Needs U. S. Industry Capabilities for Future Needs

DOE Multiprogram Laboratories




S & T Vision for DOE
Build a sustainable global future by contributing to and linking scientific advances and technological innovations to evolving national needs
DOE
National Laboratory System
(COMPETENCIES/FACILITIES)
S& T Sources
(worldwide)
Lab/Industry/University Partnerships
(COOPERATION/INTERDEPENDENCE)
Other Federal Agencies
Core Missions:
Energy
Environment
– Remediation
– Pollution Prev.
National Security
Basic Science
– National Trust
– User Facilities
Emerging Missions:
Manufacturing
– Electronics
– Textiles
– Autos
NII
Transportation
Health Care
Derivative Benefits:
Competitiveness
Education
Scientific Discoveries

DOE Energy Research (ER) Laboratory Technology Applications Program

- **ER-LTAP'S focus on agility in manufacturing**
- **Current agile technology focus areas are:**
  - Rapid prototyping utilizing ceramics and composite materials for structural and bio-medical applications and metals for molds (Argonne, Pacific NW)
  - Intelligent processing-welding processes with expert systems, sensors and adaptive controls (Idaho National Engineering Lab)
  - In-process control-neural nets and fuzzy logic for stamping metal parts (Oak Ridge)
- **ER projects with Agile Manufacturing focus are planned to increase in FY96**
  - Future project plans include building on existing agile manufacturing projects and initiating new collaborations leading to virtual manufacturing

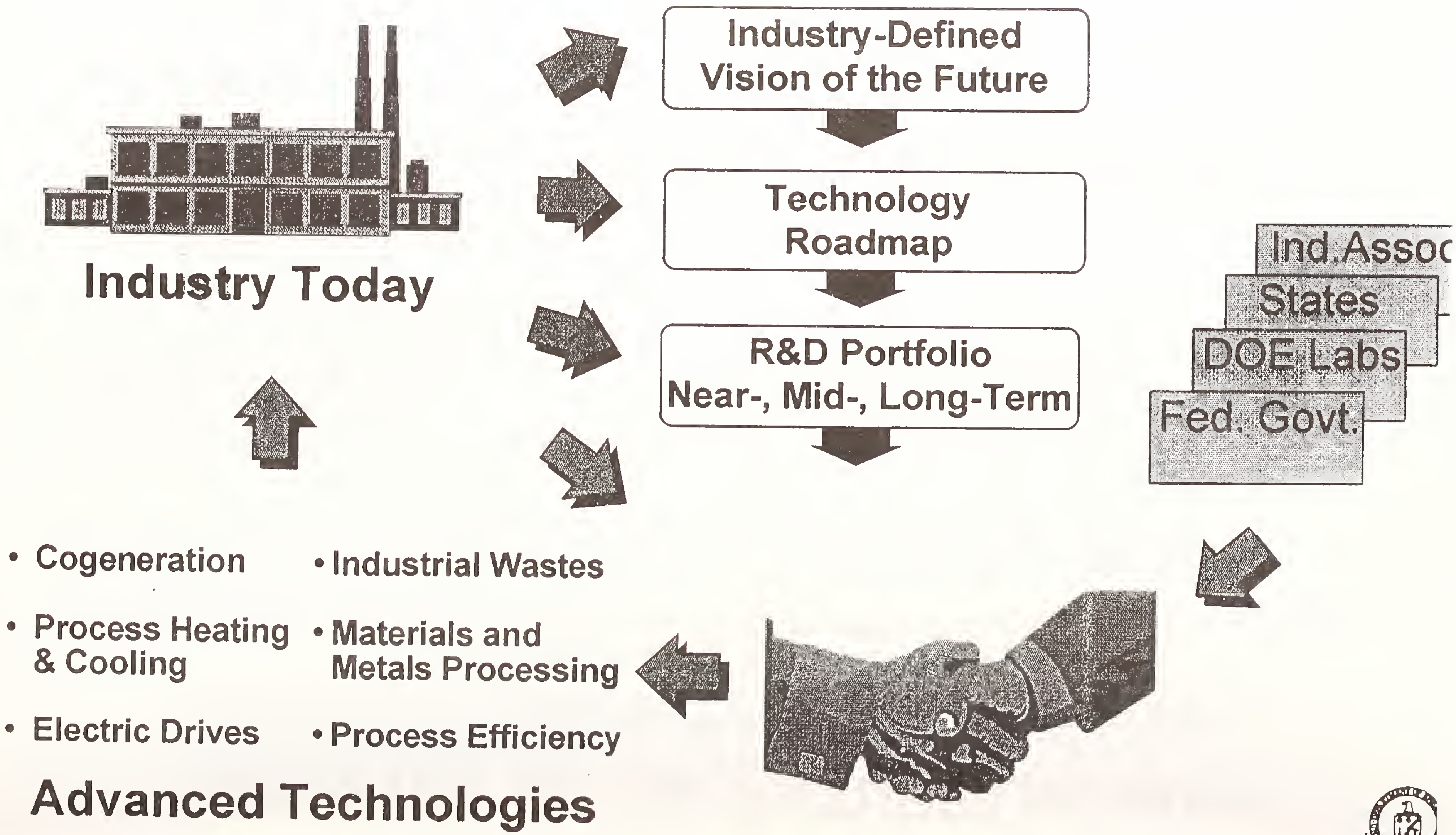
“INDUSTRY OF THE FUTURE” Initiative

DOE facilitates manufacturing participants in realizing their “vision” of the factors affecting their sectors.

Concentrates on industries with greatest opportunities for improved energy efficiency:

- Chemical
- Petroleum Refining
- Forest & Paper Products
- Steel
- Aluminum
- Metal Foundry
- Glass

DOE's INDUSTRY OF THE FUTURE Strategy

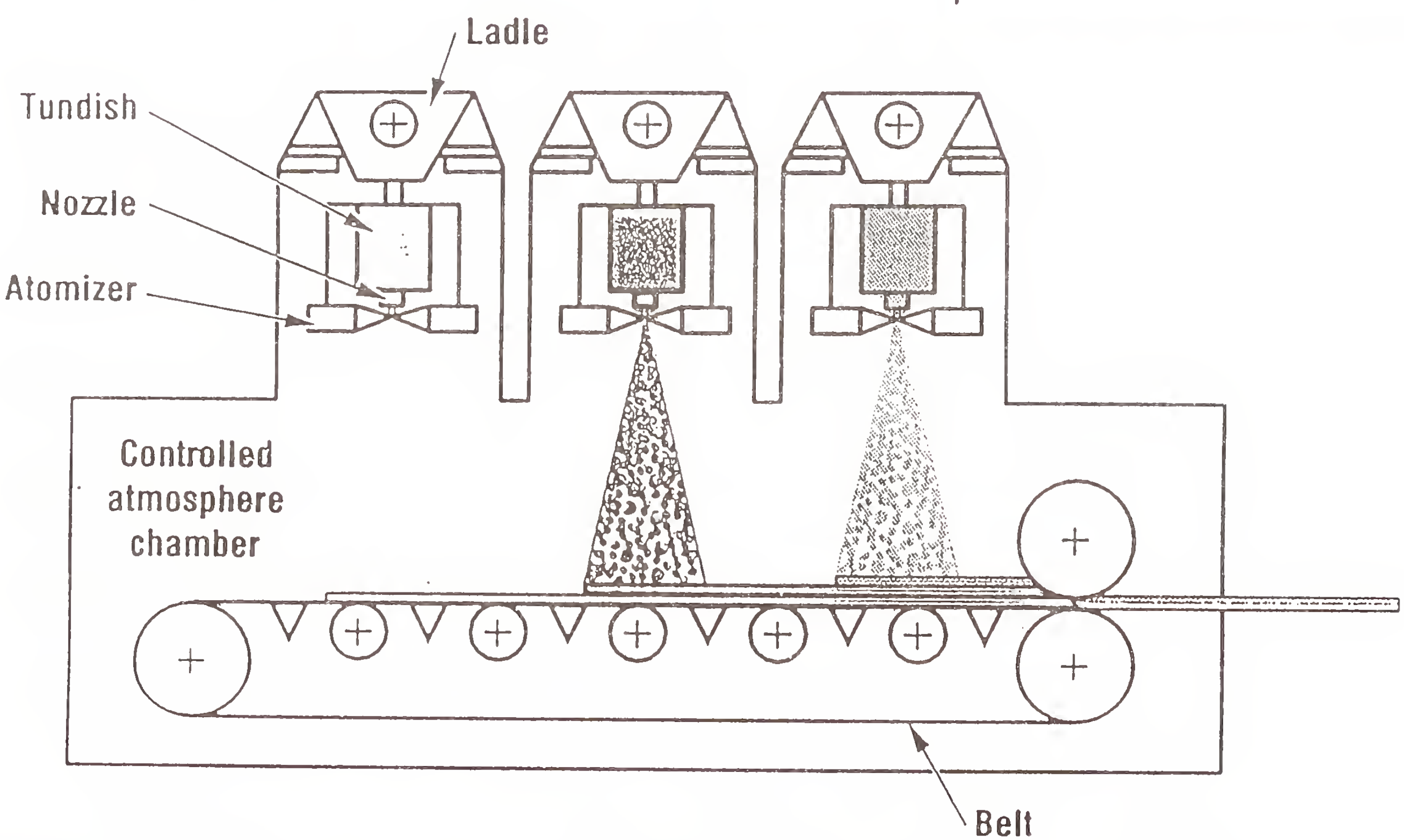


DOE's Office of Industrial Technology R&D Program

National Laboratories

- Lawrence Berkeley Laboratory
- Los Alamos National Laboratory
- Argonne National Laboratory
- Idaho National Energy Laboratory
- National Renewable Energy Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest Laboratory
- Sandia National Laboratory

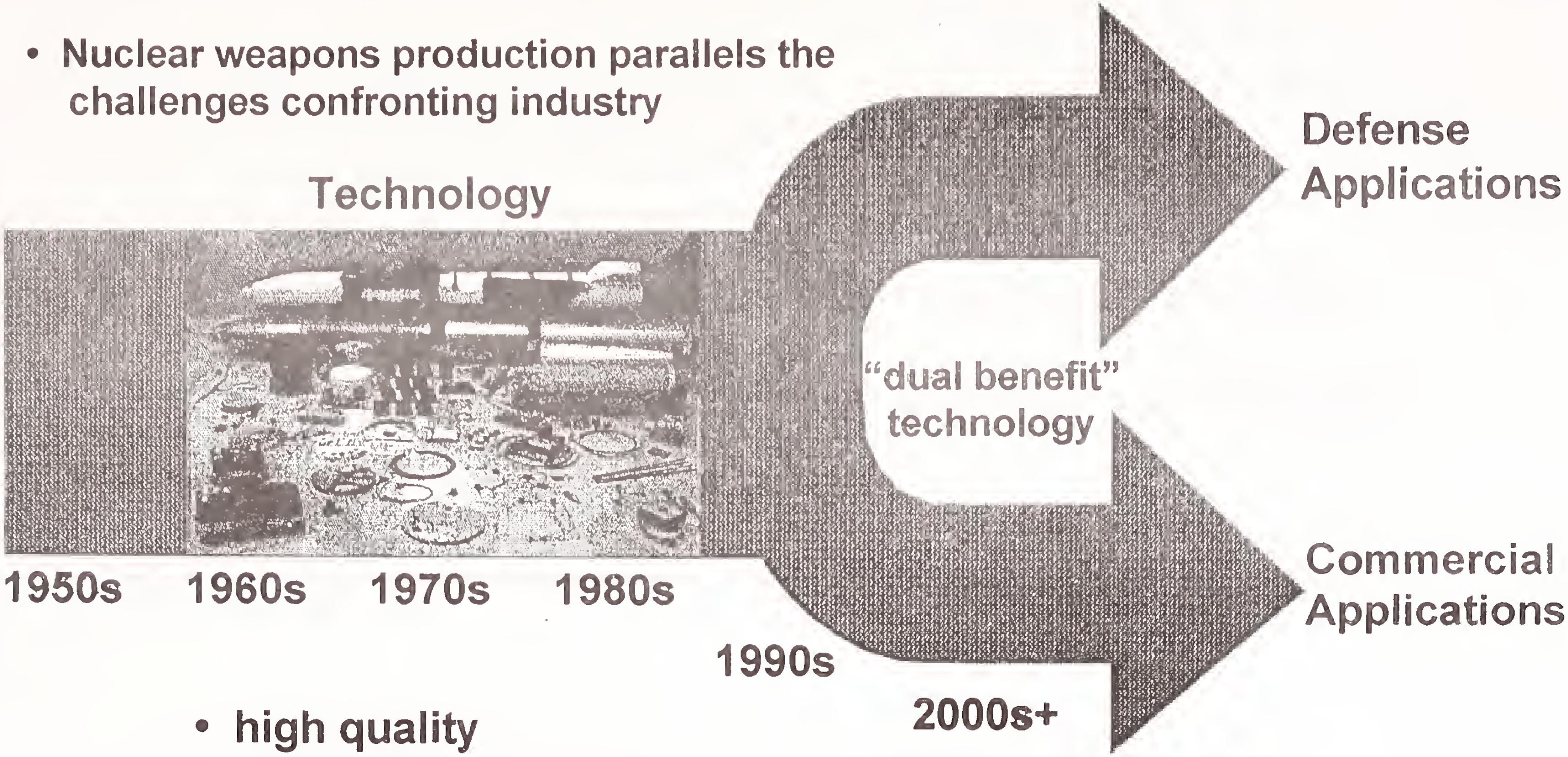
Large Scale Manufacturing Spray Forming



Reinforced Aluminum concepts will be producted on a commercial scale by spray forming, a process under active development at Alcoa.

The Role of DOE is Changing to Emphasize "Dual Benefit" Technology

- Nuclear weapons production parallels the challenges confronting industry



- high quality
- ultra-high reliability
- total life cycle
- environmental constraints
- customized products
- small production runs

The DOE Future Needs Mirror Those of Industry

- Total Production Realization Process
- Cost Effective Manufacturing of
  - Small Lots
  - Diverse Customized Products
- Integrated Design of Product and Processes
- Demand Driven Manufacturing
- Agile Enterprise

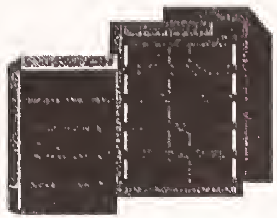
ADAPT: Advanced Design And Production Technologies

An agile, flexible network of manufacturing facilities with a common infrastructure and information system that produces qualified products

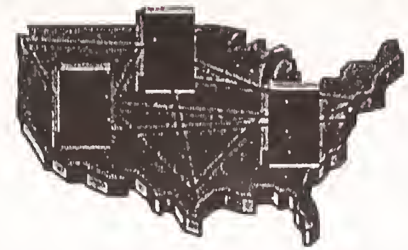
ADAPT: Advanced Design and Production Technologies

- "Factory of the Future"
- "Apply today's technology to assure deterrence tomorrow
- Maintain strengths
- Utilize resources
- Obtain, maintain and retain technical experts and their expertise

ADAPT Cost Saving Estimate



1980-90 NWC



2010 Nuclear Weapon Enterprise

Without ADAPT

- 5 Builds
- 4-5 year phase 3-4
- Paper based design
- Travel-based communication
- Serial Design-produce-verify
- Design/Test Process
- Max testing
- Human memory to avoid problems
- Some Industry Involvement
- Rigid Production Lines
- Dedicated Testers

ADAPT capabilities

- 1 Build
- 2+year phase 3-4
- Information system use
- Info System communication
- Concurrent Engineering
- Model Based Design
- Model Based Verification
- Knowledge Preservation
- Maximum practical industry use
- Agile Manufacturing
- Open Testing

FY95/FY96 Changes to Program Structure

"Sharpen The Weapons Focus"

New technology partnerships will directly support the transition to:

- Advanced Design And Production Technologies (ADAPT) for the future weapons complex
- Accelerated Strategic Computing Initiative (ASCI)

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DOE Defense Programs Focus

Goal: ***To support the DP defense mission through dual-benefit technology partnerships with industry:***

- **Leveraging of industrial and DOE capital**
- **Support of industries critical to the supply base**
- **Infusion of knowledge, ideas, and skills from companies at the leading edge**

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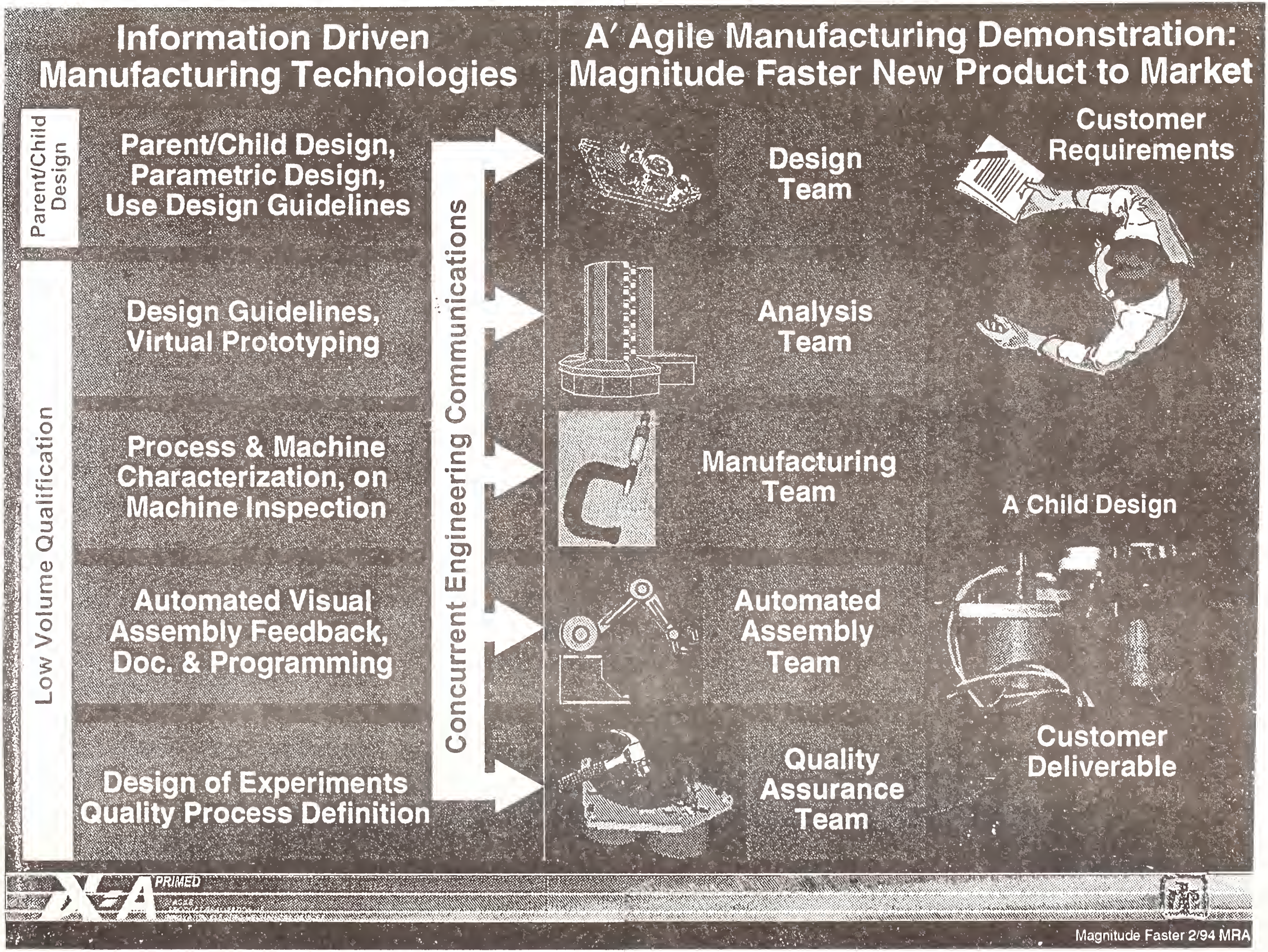
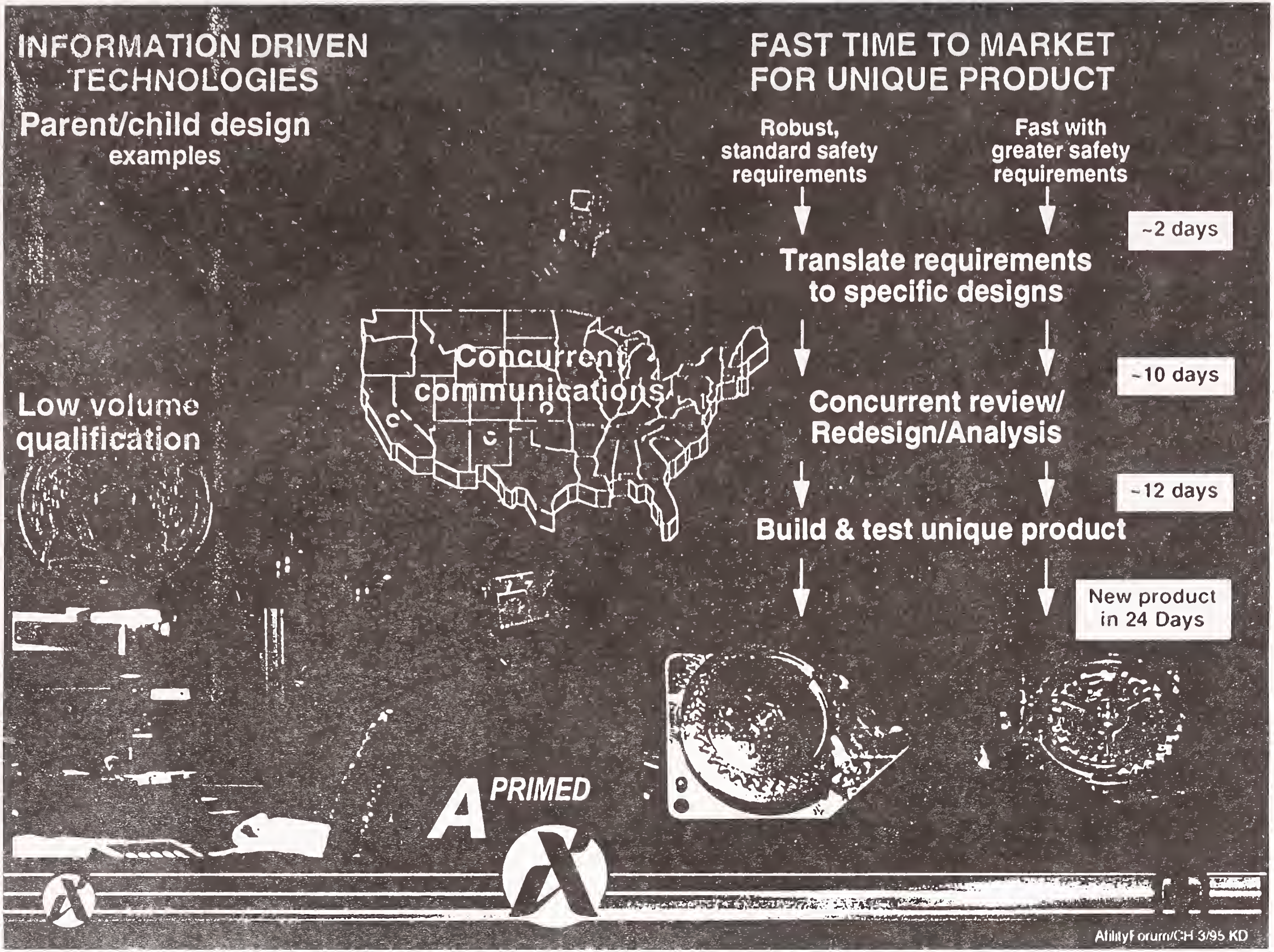
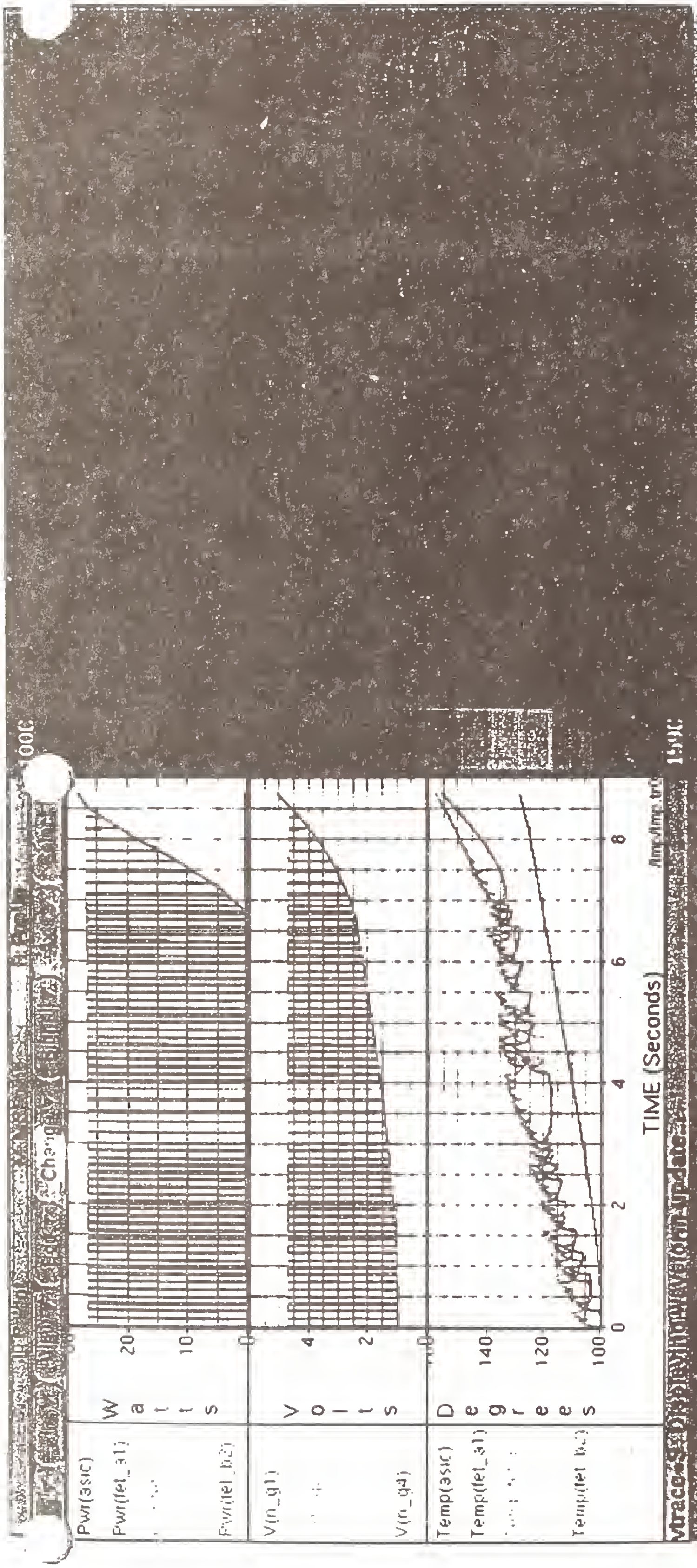
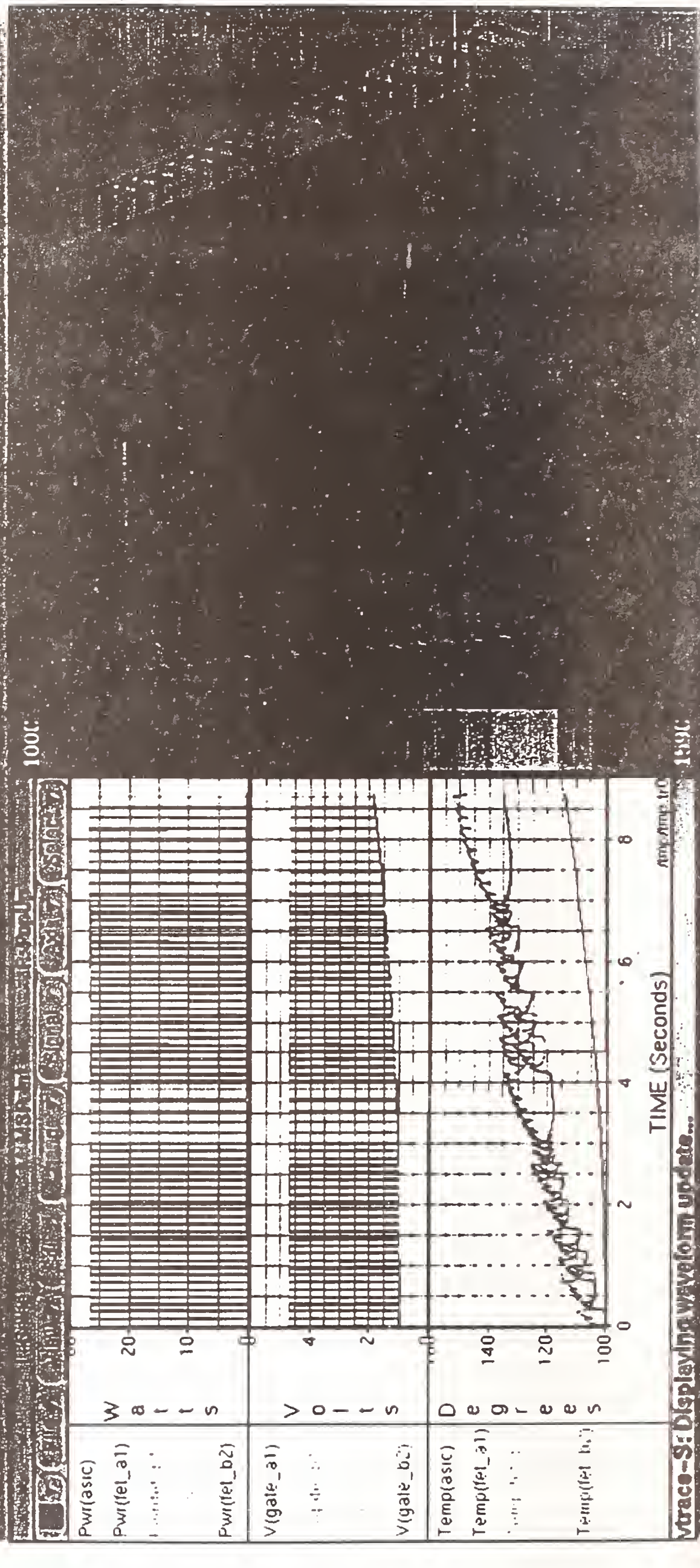
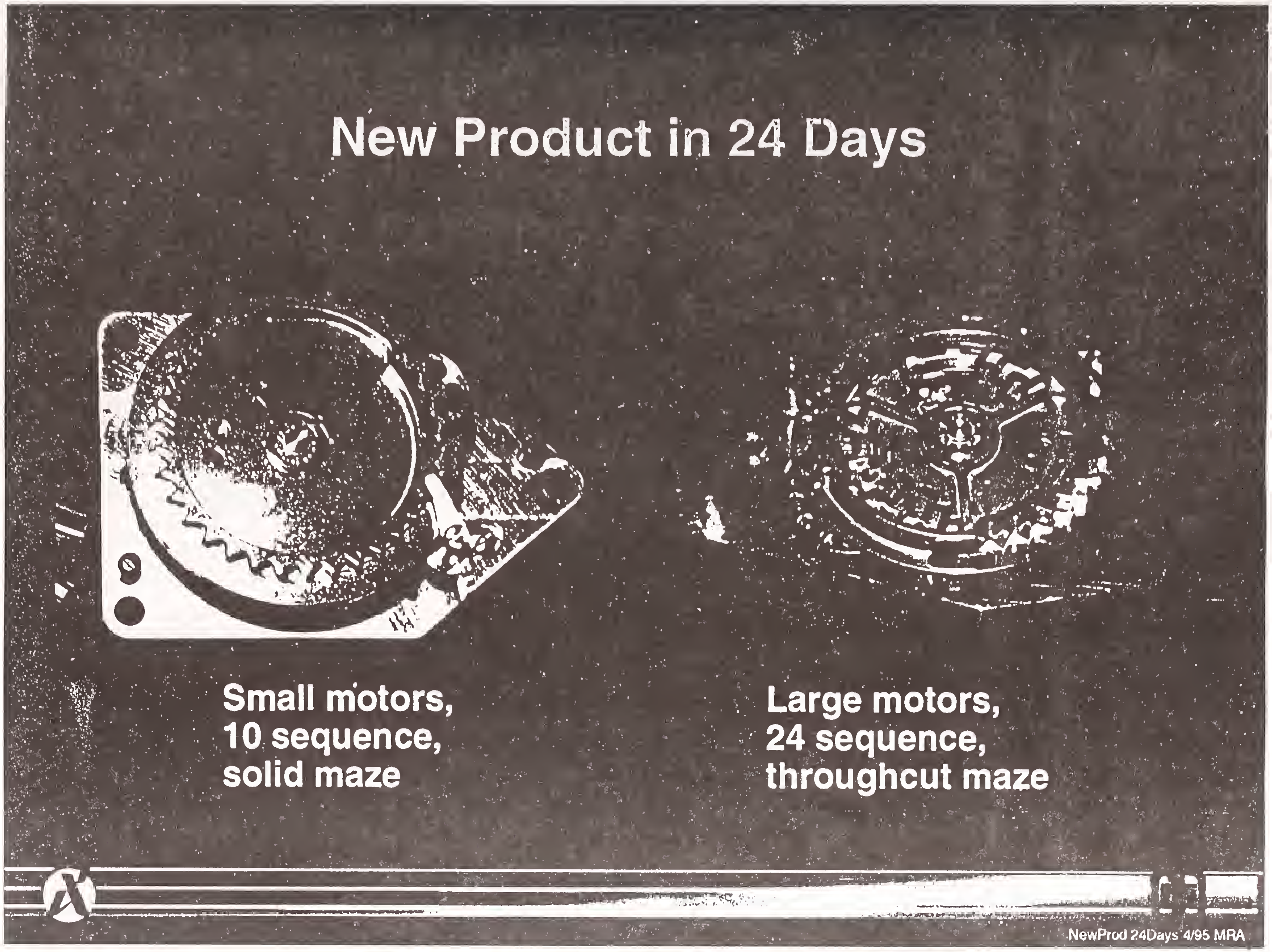

Information Driven
Manufacturing Technologies
A′ Agile Manufacturing Demonstration:
Magnitude Faster New Product to Market
Parent/Child Design
Low Volume Qualification
Parent/Child Design,
Parametric Design,
Use Design Guidelines
Design Guidelines,
Virtual Prototyping
Process & Machine
Characterization, on
Machine Inspection
Automated Visual
Assembly Feedback,
Doc. & Programming
Design of Experiments
Quality Process Definition
Concurrent Engineering Communications
Design
Team
Analysis
Team
Manufacturing
Team
Automated
Assembly
Team
Quality
Assurance
Team
Customer
Requirements
A Child Design
Customer
Deliverable
PRIMED
Magnitude Faster 2/94 MRA

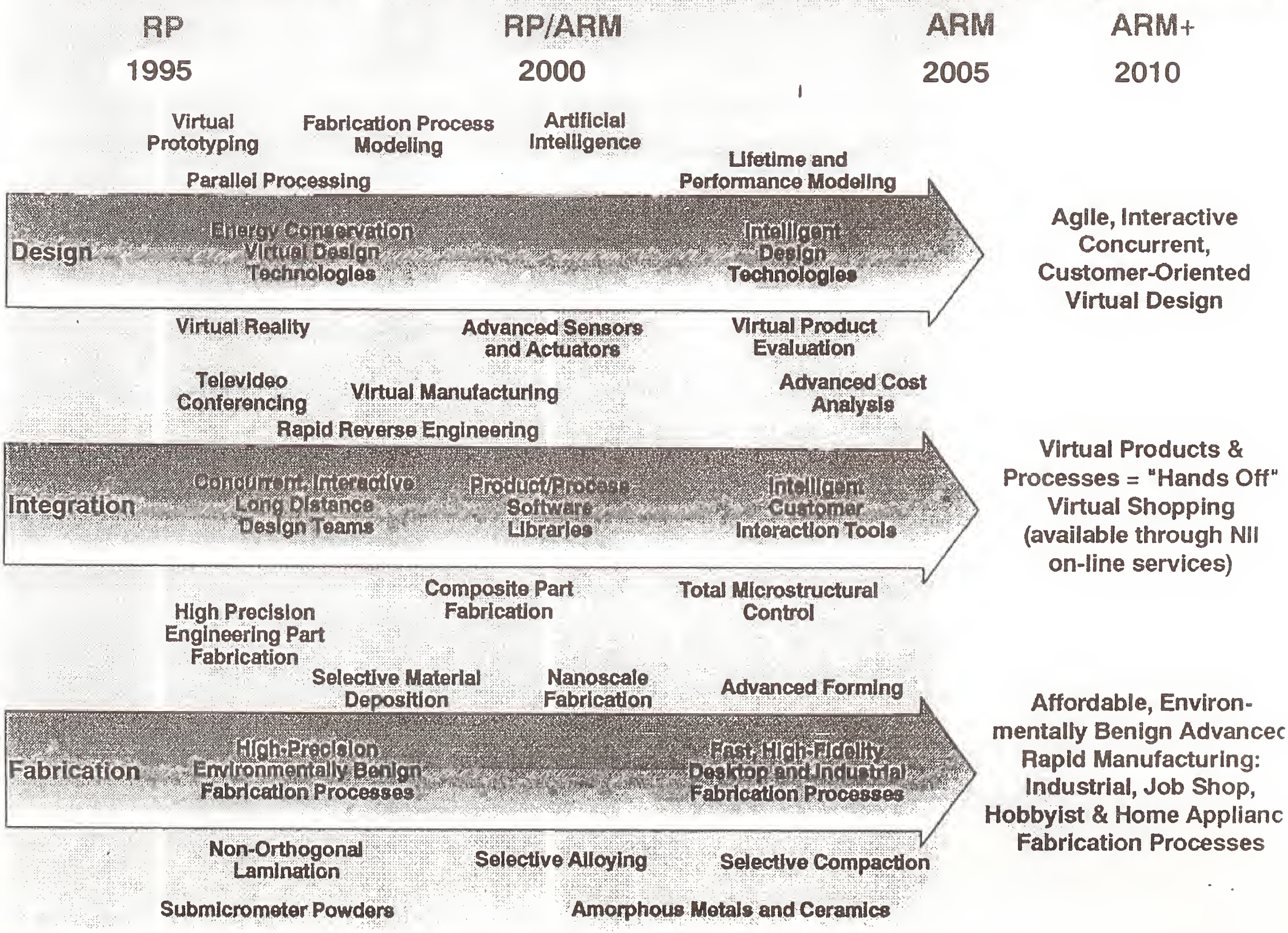

INFORMATION DRIVEN TECHNOLOGIES
Parent/child design examples
Low volume qualification
Concurrent communications
FAST TIME TO MARKET FOR UNIQUE PRODUCT
Robust, standard safety requirements
Fast with greater safety requirements
~2 days
Translate requirements to specific designs
~10 days
Concurrent review/ Redesign/Analysis
~12 days
Build & test unique product
New product in 24 Days
A PRIMED
AbilityForum/CH 3/95 KD


Pwr(asic)
Pwr(fet_a1)
Pwr(fet_b2)
V(n_g1)
V(n_g4)
Temp(asic)
Temp(fet_a1)
Temp(fet_b2)
Watts
Volts
Degrees
TIME (Seconds)


Pwr(asic)
Pwr(fet_a1)
Pwr(fet_b2)
V(gate_a1)
V(gate_b2)
Temp(asic)
Temp(fet_a1)
Watts
Volts
Degrees
TIME (Seconds)
Vtrace-S: Displaying waveform update...


New Product in 24 Days
Small motors,
10 sequence,
solid maze
Large motors,
24 sequence,
throughcut maze
NewProd 24Days 4/95 MRA

Rapid Prototyping En Route to Advanced Rapid Manufacturing Roadmap



Videos

Multi-Chip Module Discriminator

Major Partnerships

- National Information Infrastructure (NII)
- Integrated Circuit Manufacturing Program
- Automotive-Partnership for a New Generation of Vehicles (PNGV)
- High Performance Computing Program
- Flat Panel Displays
- American Textile Partnership (AMTEX)
- Technologies Enabling Agile Manufacturing (TEAM)
- National Machine Tool Partnership (NMTP)
- National Center for Advanced Information Component Manufacturing (NCAICM)

Technologies Enabling Agile Manufacturing Geam

Goal:

Develop and deploy integrated technologies and business practices that enable manufacturing enterprises to rapidly bring quality, cost-effective products to market

- Cooperative research effort between DOE, industry, universities and other Federal agencies

- 3 - 5 year duration

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Technologies Enabling Agile Manufacturing

- Product Design and Enterprise Concurrency
- Virtual Manufacturing
- Manufacturing Planning and Control
- Intelligent Closed-Loop Processing
- Integration

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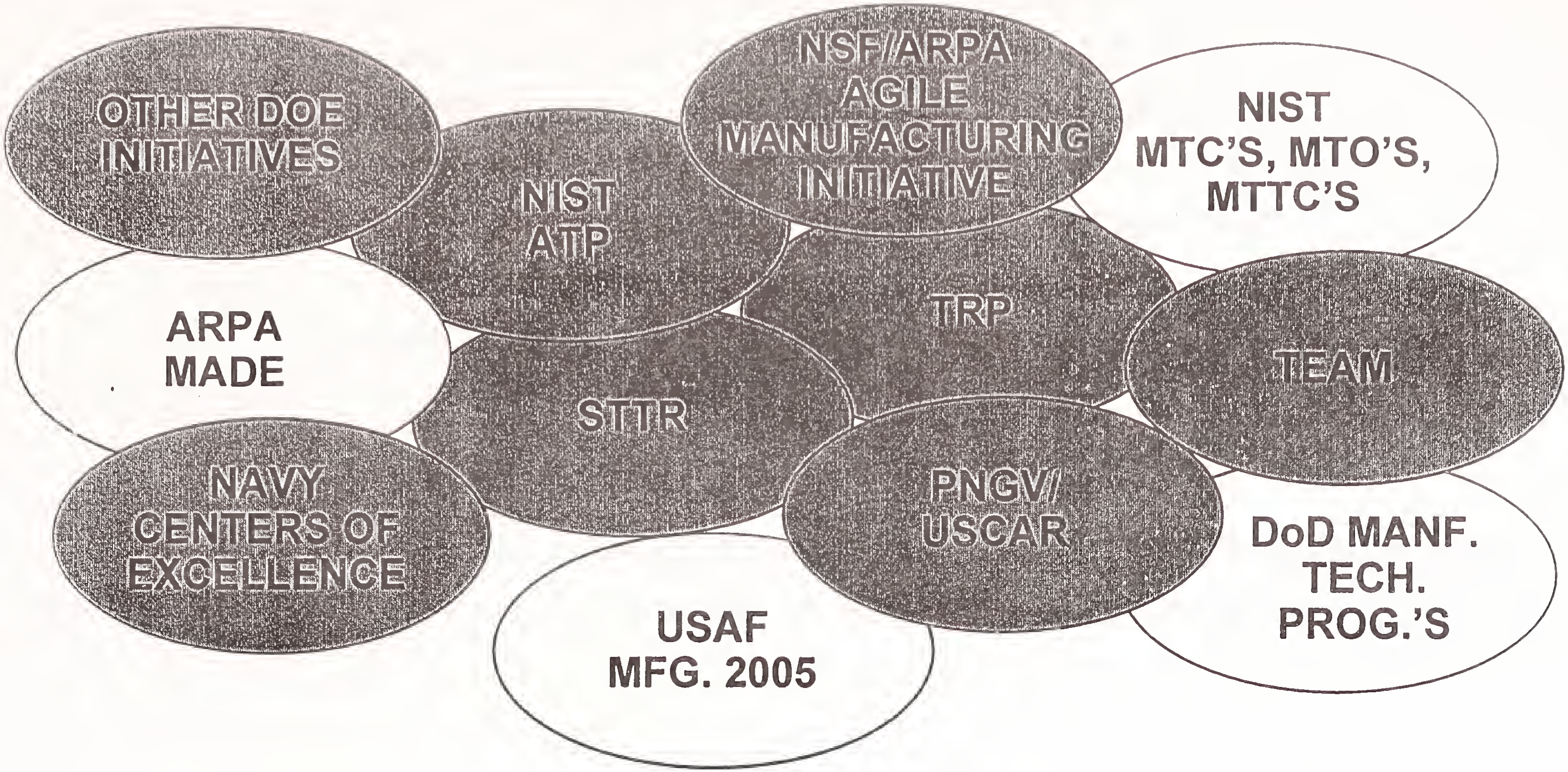
Technologies Enabling Agile Manufacturing Part of the Emerging National Agenda



Federal Opportunities

National Center For Advanced Information Components Manufacturing (NCAICM)

Goal:	Apply technology to improve competitiveness of U.S. flat panel display and associated microelectronics industry
Participants:	Government - ARPA/DOE Industry Universities National Laboratories - LANL, LLNL, SNL
Status:	Experiment in new working arrangements Industry/Government Advisory Board Precompetitive projects initiated Competitive projects in award process

ARMaC - Advanced Rapid Manufacturing Consortium (Proposed)

- Industry led activity for national program to transition from rapid prototyping to rapid manufacturing
- Industry/universities/DOE labs
- Industry and university support letters:

Industry	Universities
Baxter	MIT
The Gillette Company	University of Texas
Kodak	University of Michigan
Chrysler Corporation	University of California, Irvine
Allied-Signal	Clemson University
Ethicon Endo-Surgery	University of Dayton
Delco Electronics	
LORAL Vought Systems	
LASERFORM, Inc.	
Wohlers Associates	

Examples of Industry/DOE CRADAs

Large Companies		Consortia	Small Businesses
Intel	Alcoa	USCAR	Oceania Health Care
IBM	Goodyear	USABC	MicroDexterity
GM	Signetics	SEMATECH	EMCORE
Ford	Texas Instruments	NCMS	DENEB Robotics
Dow	Hewlett Packard	SMPC	BPLW Architects
Dupont	Mobil	FASTCAST	Permacharge
Cray	Citibank	AMTEX	Kaehr Plating
AT&T	Motorola	MCC	BIOSYM
GE	Pratt & Whitney	CSPP	Photonics Imaging
Shell	Amoco		Conductus
Rocketdyne			RIMtech

The Future of DOE Manufacturing

Focus on external partnering--
Industry, Universities and Other Federal Agencies:

- In *Defense Programs*, obtain >70% of products from U.S. industry
- In *Energy Research*, work in consortia with U.S. industry
- In *Environmental Quality*, inter-agency programs and consortia
- In *Science and Technology,* balance DOE's "Portfolio" between basic and applied research

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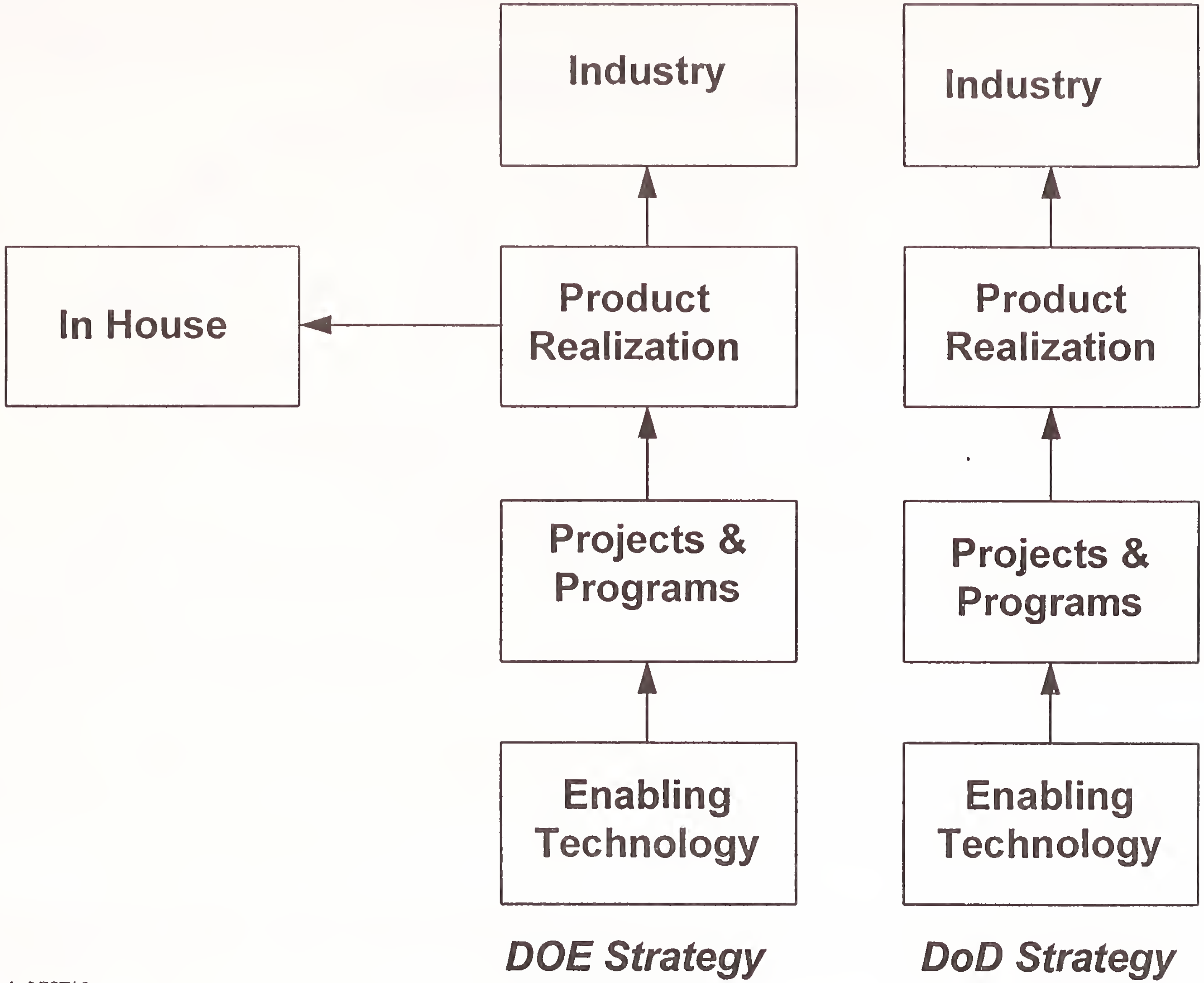
The DoD and DOE (and others) Share a Number of Objectives

- **Common DoD/DOE Needs**
  - More affordable products, processes, enterprises (complexes)
  - More accurate tradeoffs, faster response times, improved predictability and quality
  - Environmentally responsible
- **DoD/DOE utilize some of the same Defense Industrial Base**
- **DoD/DOE are both investing in improved product realization processes**
- **DoC is a natural partner for many of these common activities**
- **DoC's needs and capabilities complement DoD/DOE's**

DoD and DOE also have similar strategies



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Duane Adams
Deputy Director
ARPA

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

ARPA

ARPA

NIST Manufacturing Technology Conference

ARPA Programs in Manufacturing Technology

Duane A. Adams
Deputy Director

April 19, 1995

ARPA Investment Strategy

- Develop and transition systems to the warfighter
  - Advanced Concept Technology Demonstrations
  - Exploit information technology
- Maintain technical superiority
  - High-payoff breakthrough technologies
  - Sustained investments in critical areas
  - Exploit commercial capabilities
- Affordability is an overarching goal
  - Focus on life cycle costs
  - New business practices
  - Dual use technologies

Affordability

Design for Life Cycle (IPPD)

- *Simulation-Based Design*
- *RASSP*

Reduced Product Manufacturing Costs

- *IR Focal Plane Arrays*
- *Affordable Composites for Propulsion*

New Business Practices

- *Tier II+*
- *AM3*
- *Agile Manufacturing*

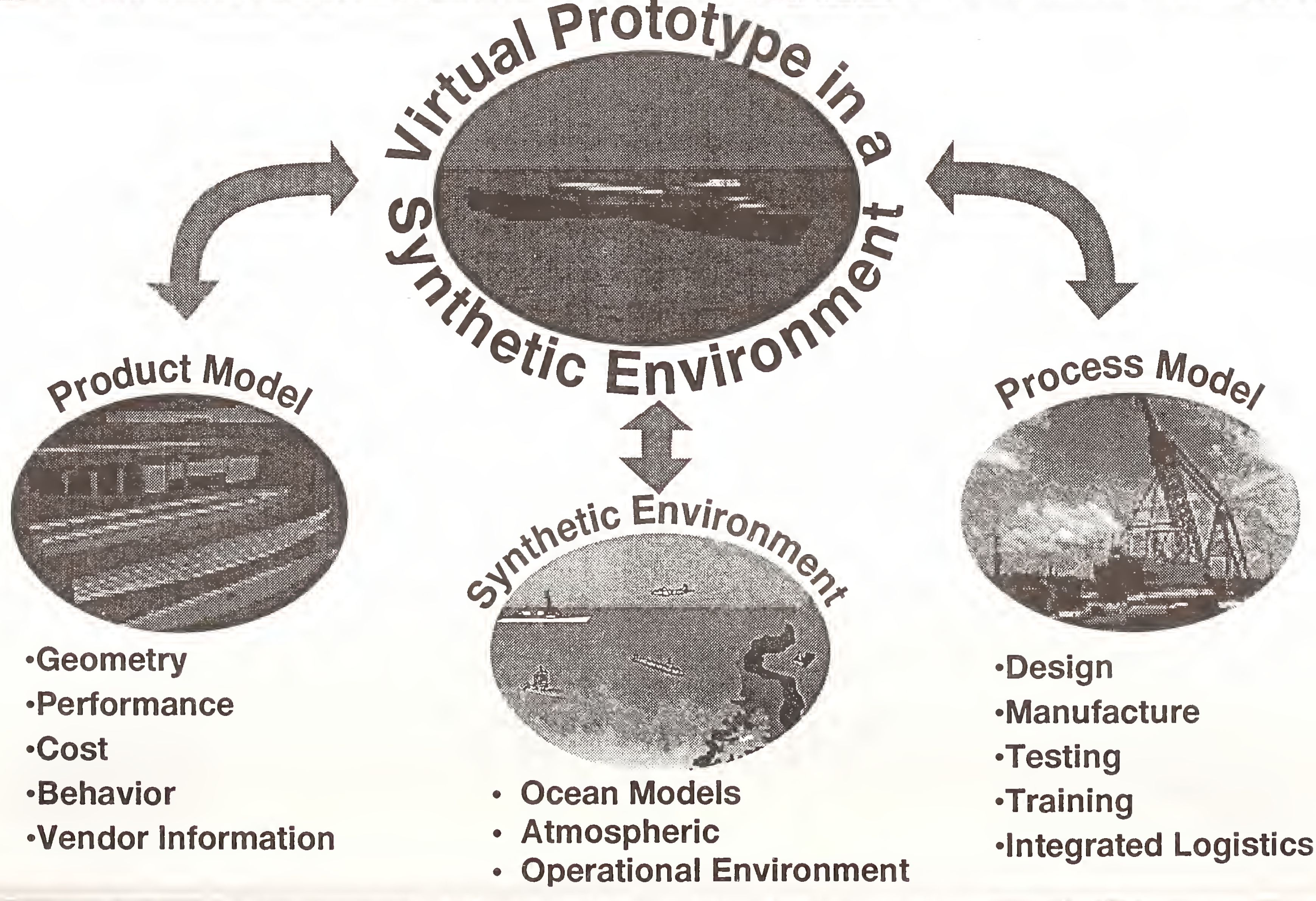
Generic Tools and Technology

- *Precision Laser Machining*
- *MADE*

Infrastructure

- *Electronic Packaging*
- *Commerce Net*

Simulation-Based Design



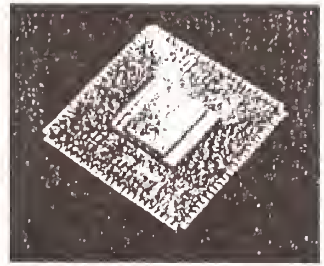
ARPA IR FOCAL PLANE ARRAY PROGRAM (MTO)

OBJECTIVES

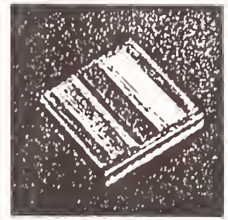
- Reduce infrared focal plane array cost by a factor of 100 and make advanced arrays available for Defense Systems
- Demonstrate flexible manufacturing for infrared imaging sensors

IRFPA CONFIGURATIONS

240x1



480x640



480x4

(64x64 and 128x128 not shown)

ACCOMPLISHMENTS

Several Industry Firsts, including:

- Demonstrated system spec. compliant IRFPAs 64x64, 128x128, 480x4, 240x1(2) at reduced cost
- Integrated 240x2 and 480x4 scanning IRFPAs into imaging system demos for ground applications
- Demonstrated 640x480 long wavelength staring array with 30mk sensitivity
- Established feasibility of IR detector manufacturing processes
- System demo of special application, high speed arrays

PLANS FY95/FY96

- Validate ten times cost reduction for system spec. compliant IRFPAs
- Integrate advanced manufacturing into an IR focal plane process
- Establish reproducability of long wave staring arrays (256x256; 640x480)
- Conduct IRFPA demos of Advanced Land Combat; Missile Seekers; Airborne: Search and Track IRFPAs
- Establish techniques for flexible manufacturing of cooled and uncooled arrays

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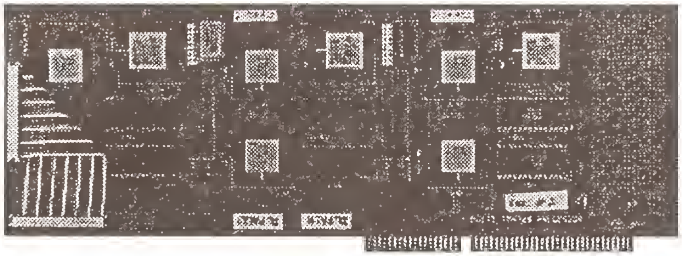
Multi-Chip Module (MCM)

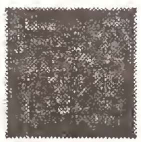
ESTO

from: Printed Circuit Board



125% Increase in Clock Speed
+
33% More Processor Chips
+
93% Reduction in Size
=

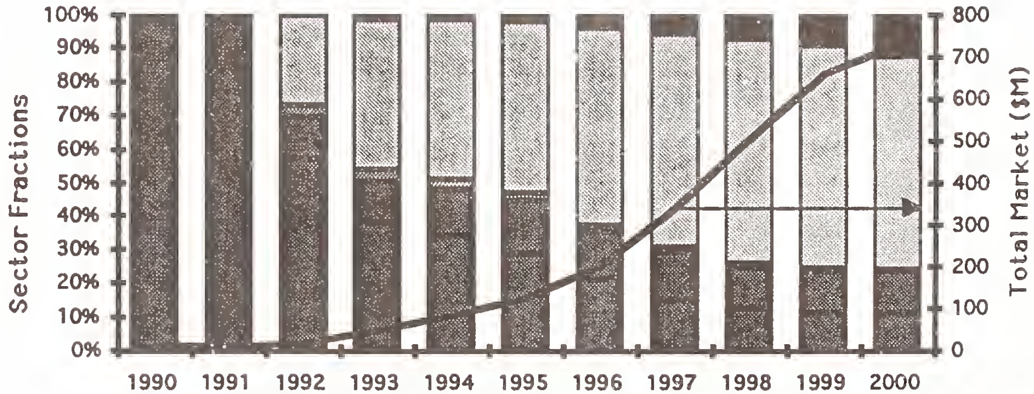
to: MCM



GE High Density Interconnect (HDI)

40X the Functional Density

Worldwide Merchant Market by Sector



Source: from TechSearch International

- Military is leading development of merchant MCM market and new MCM technologies (nChip, TI/GE, Hughes)
- As commercial demand grows, military share will be reduced to less than 10% of the total market
- Military can leverage explosive commercial growth

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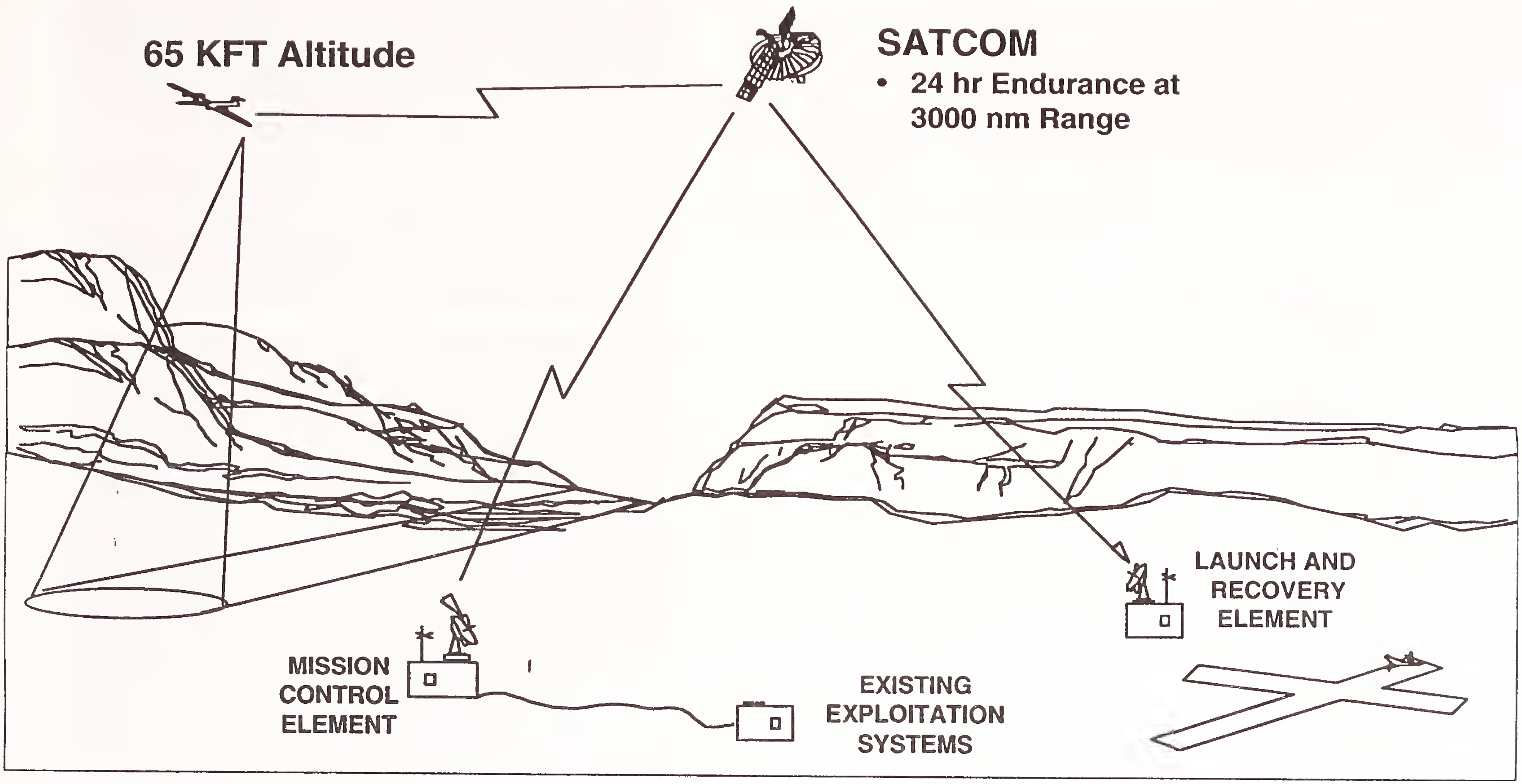
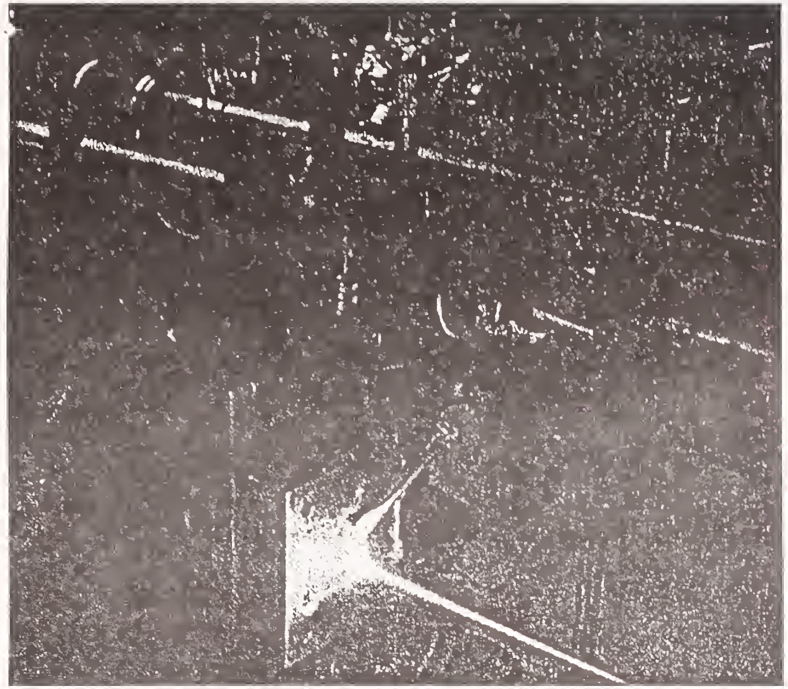
High Altitude Endurance Unmanned Aerial Vehicle ACTD

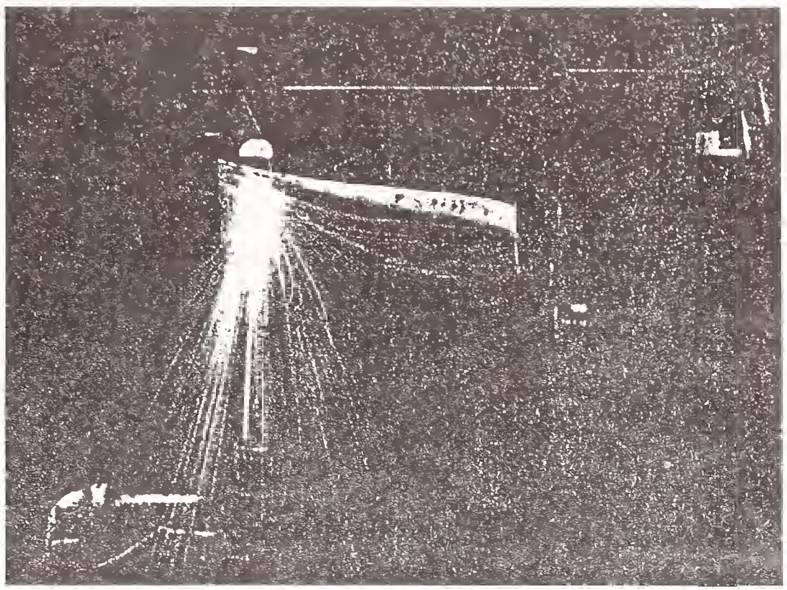


Tier II Plus Acquisition

$10M Unit Flyaway Price (Air Vehicle)

- Section 845 Authority (Non-Procurement Agreements)
  - Prototypes Projects Directly Relevent to Weapon Systems
  - 3 Year Authority to ARPA
- Implications of Section 845
  - Procurement Regulations (FARS) Not Applicable
  - Existing Regulations and MILSPECS Need Not Be Applied
  - Cost Sharing Not Required
- Management
  - New Partnership Paradigm between Government and Industry
  - Integrated Management Framework





TECHNOLOGY REINVESTMENT PROJECT

Precision Laser Machining (PLM)

- Develop affordable advanced laser machining capabilities
  - System development
  - End user application demonstration
- Enhance manufacturing industrial base for defense and commercial applications

R1M 94.0119.02a

Revised FY95 TRP Competition

- $300M withdrawn from TRP ($77M in FY94, $223M in FY95)
- Original FY95 Plan
  - Development Competition
  - Regional Technology Alliances (RTA) Competition
  - Manufacturing Educations &Training (MET) Competition
  - Small Business Innovative Research (SBIR) Competition
- Revised FY95 Plan
  - Reduced Number of Topics for Development
  - Drop RTA
  - Drop MET
  - SBIR

Revised FY95 TRP Competition Schedule

12 May 1995: Announce Revised Program

29 June 1995: Proposals Due

September 1995: Publication of Selections

December 1995: Completion of Negotiations

Robert Cattoi
Senior V.P.
Rockwell International

U. S. INTELLIGENT MANUFACTURING SYSTEMS

(IMS)

R. L. Cattoi
NIST Conference
Gaithersburg, MD
April 19, 1995

THANK YOU ___________

IT'S A PLEASURE TO BE HERE TODAY TO GIVE YOU AN OVERVIEW OF THE IMS ACTIVITY.

AS MANY OF YOU KNOW, IMS IS A GLOBAL, INDUSTRY LED ACTIVITY OF INTERNATIONAL COOPERATION FOR THE DEVELOPMENT OF MANUFACTURING TECHNOLOGIES AND SYSTEMS.

IT WAS FIRST PROPOSED BY THE JAPANESE IN 1989, AND AFTER SUBSEQUENT MEETINGS OF MITI, THE U.S. DEPARTMENT OF COMMERCE, AND THE COMMISSION OF THE EUROPEAN COMMUNITIES, A FEASIBILITY STUDY FOR IMS WAS INAUGURATED IN 1991. THE GEOGRAPHIC/POLITICAL REGIONS THAT AGREED TO PARTICIPATE IN THIS STUDY WERE THE U.S., CANADA, THE EUROPEAN UNION, THE EUROPEAN FREE TRADE ASSOCIATION, JAPAN, AND AUSTRALIA.

THE GOAL WAS TO USE SHARED INVESTMENT IN DEVELOPING PRE-COMPETITIVE OR NON-COMPETITIVE MANUFACTURING TECHNOLOGIES AND SYSTEMS TO IMPROVE THE EFFECTIVENESS -- AND HOPEFULLY SEAMLESSNESS -- OF GLOBAL MANUFACTURING OPERATIONS.

COROLLARY OBJECTIVES INCLUDED THE DEVELOPMENT OF MANUFACTURING PROCESSES THAT WOULD BE ENVIRONMENTALLY FRIENDLY AND THE ESTABLISHMENT OF AN INTERNATIONAL MANAGEMENT STRUCTURE THAT WOULD MOTIVATE AND FACILITATE THE FORMATION OF INTERNATIONAL CONSORTIA.

THE FEASIBILITY STUDY, WHICH INCLUDED THE ESTABLISHMENT AND MONITORING OF SIX INTERNATIONAL CONSORTIA CALLED "TEST CASES" CONCLUDED IN EARLY 1994. THESE SIX TEST CASES INVOLVED 21 COUNTRIES AND 140 PROJECT PARTNERS OF ALL SIZES. AFTER A REVIEW OF THE STUDY, THE INTERNATIONAL STEERING COMMITTEE, WHICH GOVERNED THIS ACTIVITY, DECLARED

THAT THE OBJECTIVES OF IMS WERE VALID, THAT INTERNATIONAL CONSORTIA INVOLVING LARGE COMPANIES, SMALL COMPANIES, UNIVERSITIES AND GOVERNMENT LABORATORIES COULD BE EFFECTIVELY ESTABLISHED AND MANAGED BOTH EQUITABLY AND BENEFICIALLY, AND THAT THE IMS CONCEPT WAS FEASIBLE.

A RECOMMENDATION FOR A FULL SCALE, 10 YEAR IMS INITIATIVE WAS PASSED ON TO THE SIX PARTICIPATING GOVERNMENTS.

THE TERMS OF REFERENCE FOR SUCH A FULL SCALE ACTIVITY WERE SUBSEQUENTLY RATIFIED BY THE U.S., JAPAN, AUSTRALIA, AND CANADA, WITH THE RATIFICATION BY EUROPE EXPECTED SOON. BY AGREEMENT, CANADA WILL CHAIR THE INTERNATIONAL STEERING COMMITTEE FOR THE FIRST TWO YEARS.

THE TECHNICAL THEMES PROPOSED FOR THE FULL SCALE IMS ACTIVITY ARE: (Fig. 1)

- TOTAL PRODUCT LIFE CYCLE ISSUES
- CLEAN, ENERGY EFFICIENT MANUFACTURING PROCESSES
- VIRTUAL/EXTENDED ENTERPRISES
- STRATEGY/PLANNING/DESIGN TOOLS
- HUMAN/ORGANIZATIONAL/SOCIAL ISSUES

OBVIOUSLY, THIS SHORT LIST IS NOT INTENDED TO LIMIT THE SCOPE OF PROJECTS. FURTHER DETAIL ON THE PROPOSED THEMES CAN BE OBTAINED FROM THE IMS SECRETARIAT AT DoC.

NOTING THAT SUMMARY BACKGROUND, WE ARE NOW READY TO LAUNCH OUR FULL SCALE IMS ACTIVITY HERE IN THE U.S.

A THREE PERSON U.S. STEERING COMMITTEE HAS BEEN APPOINTED BY THE SECRETARY OF COMMERCE. MEMBERS ARE:

DR. JOHN WHITE - GEORGIA TECH - REPRESENTING THE UNIVERSITY COMMUNITY

DR. GRAHAM MITCHELL - DoC - REPRESENTING GOVERNMENT

AND I WILL REPRESENT INDUSTRY AND BE THE CHAIR OF THIS DELEGATION.

THE INTERNATIONAL STEERING COMMITTEE IS SHOWN IN FIG. 2. THE GOVERNMENT MEMBERS OF THE NATIONAL COMMITTEES ARE OBSERVERS ON THE INTERNATIONAL COMMITTEE.

I MUST -- UP FRONT IN MY COMMENTS - CLARIFY WHAT IS OFTEN A MISCONCEPTION REGARDING IMS.

I WILL ADMIT THAT MY CONCERN INVOLVES SEMANTICS, BUT SEMANTICS ISSUES CAN CAUSE SIGNIFICANT MISUNDERSTANDINGS -- AND I DON'T WANT TO BASE MY TALK ON A FOUNDATION OF MISUNDERSTANDING.

SIMPLY PUT, DESPITE WHAT YOU OFTEN SEE IN PRINT, IMS IN THE UNITED STATES IS NOT, IN THE NORMAL GOVERNMENT SENSE OF THE WORD, A *PROGRAM*. IT IS AN ORGANIZED (HOPEFULLY) *ACTIVITY* OR *INITIATIVE* UNDER THE COLLECTIVE GUIDANCE OF INDUSTRY, GOVERNMENT, AND ACADEMIA.

CONTRARY TO WHAT IS TYPICALLY IMPLIED BY A GOVERNMENT PROGRAM, THERE IS NO LINE ITEM IN SOME GOVERNMENT AGENCY BUDGET THAT SUPPORTS THE COLLECTION OF RESEARCH PROJECTS THAT WILL BE CARRIED OUT UNDER THE IMS BANNER.

THERE WILL BE NO COMPETITIVE BIDDING UNDER THE AUSPICES OF THE IMS MANAGEMENT STRUCTURE. THERE WILL BE NO "CUSTOMER SPECIFIED" REQUIREMENTS GOVERNING RESEARCH OR DEVELOPMENT CONTENT. THERE ARE NO CONTRACTUAL REQUIREMENTS OR RELATED OVERSIGHT.

AS INDICATED EARLIER, IMS IS INTENDED TO BE AN *INDUSTRY* LED ACTIVITY, WITH THE MAJORITY OF INVESTMENT COMING FROM

INDUSTRY -- WITH PRIORITIES ESTABLISHED BY INDUSTRY -- AND WITH INDUSTRY GETTING THE GREATEST BENEFITS FROM THE RESULTS.

OUR GOVERNMENT -- THE DEPARTMENT OF COMMERCE ACTING AS LEAD IN THIS CASE -- ACTS IN A MOST IMPORTANT GUIDANCE AND SUPPORT ROLE. BY THIS, I MEAN THAT IT:

- FACILITATES THE PROCESS OF ESTABLISHING INTERNATIONAL CONSORTIA WITHIN THE LEGAL AND REGULATORY FRAMEWORK THAT GOVERNS SUCH ACTIVITIES.
- MANAGES THE GOVERNMENT TO GOVERNMENT RELATIONSHIPS THAT INVOLVE AGREEMENTS ON INTELLECTUAL PROPERTY CONTROL, TECHNOLOGY EXPORT, OR ISSUES OF TREATIES OR MOU'S.
- PROVIDES A SECRETARIAT TO HANDLE ISSUES OF INTERNATIONAL MEETING LOGISTICS, AGENDA MANAGEMENT, AND -- IMPORTANTLY -- INFORMATION DISSEMINATION.

AND OUR GOVERNMENT IS WORKING TO ESTABLISH A COHESIVE NETWORK OF RELATED, NATIONAL LEVEL MANUFACTURING ACTIVITIES -- SUCH AS NIST's MEP, DoD's

MS&T PROGRAM, AND NSF's MANUFACTURING RESEARCH PROGRAMS, ALLOWING IMS TO BE A COMPATIBLE, COMPLEMENTARY, NON REDUNDANT PART OF THIS NATIONAL ACTIVITY SET -- REALLY ADDING THE *GLOBAL* DIMENSION TO THIS NETWORK OF NATIONAL MANUFACTURING ACTIVITIES.

OUR UNIVERSITIES AND COLLEGES WILL PARTICIPATE WITH INDUSTRY IN RELEVANT GLOBAL MANUFACTURING PROCESS AND SYSTEM RESEARCH, AND WILL USE THIS COLLABORATION TO STRENGTHEN THEIR INDUSTRIAL TIES.

SUCH PARTICIPATION WILL ALLOW THEM TO FURTHER IMPROVE THEIR DEVELOPMENT OF THE EDUCATION CURRICULA REQUIRED TO MAKE OUR MANUFACTURING ENGINEERS THE BEST IN THE WORLD.

IN SO DOING, OUR UNIVERSITIES CAN PLAY A MAJOR ROLE IN RAISING THE PROFESSIONAL STATURE OF MANUFACTURING ENGINEERING WHICH SHOULD ENTICE SOME OF OUR BRIGHTEST STUDENTS TO ENTER THIS FIELD.

NOW LET ME GET BACK TO THE QUESTION OF "WHY IMS?" -- OR "HOW DOES IMS ADD A GLOBAL DIMENSION TO THE COLLECTION OF THE OTHER NATIONAL MANUFACTURING INITIATIVES?"

I THINK WE CAN ALL AGREE THAT U.S. MANUFACTURING MUST BECOME INCREASINGLY GLOBAL IF, IN FACT, WE WANT TO BE GLOBALLY COMPETITIVE. AND I MEAN, AS NOEL LONGUEMARE OVER IN DoD WOULD SAY, MANUFACTURING WITH A BIG "M".

THE OBJECTIVES OF THE U.S. IMS ACTIVITY ARE CLOSELY ALIGNED WITH THIS GOAL. LET ME SUMMARIZE THEM FOR YOU.

THE FIRST OBJECTIVE IS TO ESTABLISH - REPEAT, ESTABLISH, NOT REACT TO - GLOBAL MANUFACTURING STANDARDS. THESE INCLUDE STANDARDS FOR INDUSTRIAL AUTOMATION SYSTEMS, CAE /CAM TOOLS, CONTROL ARCHITECTURES, MANUFACTURING PROCESSES, ELECTRONIC COMMERCE, ETC. I SHOULD NOTE THAT THIS SEGMENT OF THE ACTIVITY IS FULLY COMPLEMENTARY WITH CALS AND PRODUCT DATA EXCHANGE INITIATIVES.

ANOTHER OBJECTIVE IS TO DEVELOP THE MOST EFFECTIVE PROCESSES FOR GLOBAL CONCURRENT ENGINEERING. GLOBAL MANUFACTURING IS NOT A MUTUALLY EXCLUSIVE FUNCTION -- DESIGNING FOR MANUFACTURABILITY IN CONJUNCTION WITH DESIGNING MANUFACTURING PROCESSES IS AN IMPERATIVE.

WE HAVE AN OBJECTIVE TO ESTABLISH A FRAMEWORK FOR INTELLECTUAL PROPERTY RIGHTS PROTECTION THAT TRANSCENDS NATIONAL BORDERS AND IS FAIR AND BINDING FOR COMPANIES LARGE AND SMALL, AS WELL AS FOR ACADEMIC INSTITUTIONS LARGE AND SMALL. MAJOR HEADWAY WAS MADE IN THE FEASIBILITY STUDY -- MORE NEEDS TO BE DONE.

THERE IS AN OBJECTIVE TO PROVIDE FOR A CADRE OF PROPERLY TRAINED ENGINEERS FOR OUR U.S. COMPANIES IN ALL OF THE GEOGRAPHIES OF INTEREST TO THEM -- ALL OF THESE ENGINEERS WORKING IN AN ENVIRONMENT THAT RESPECTS THEIR PROFESSIONALISM.

AND AN OBJECTIVE TO PROVIDE AN ENVIRONMENT FOR EFFICIENT, EFFECTIVE BENCHMARKING OF GLOBAL MANUFACTURING OPERATIONS. THIS CONTRIBUTES TO INCREASING KNOWLEDGE OF -- OR EVEN AWARENESS OF -- THE STATE OF GLOBAL COMPETITION.

AND MOST IMPORTANTLY, AN OBJECTIVE THAT REALLY SHOULD BE AT THE TOP OF THE LIST -- THAT OF INVOLVING OUR U.S. 2ND AND 3RD TIER COMPANIES, THE SME's, IN ACTIVITIES THAT CAN RAISE THE LEVEL OF THEIR MANUFACTURING COMPETENCIES AND INCREASE THEIR ABILITY TO BE GLOBALLY COMPETITIVE -- DIRECTLY OR INDIRECTLY.

IT IS OUR INTENT, AND IT IS AN IMS IMPERATIVE, TO INVOLVE SIGNIFICANT SME PARTICIPATION IN ALL CONSORTIA WE ARE A PART OF.

ALLOW ME TO GIVE YOU SOME THOUGHTS ON THE MANAGEMENT PROCESS REQUIRED TO ACHIEVE OUR OBJECTIVES.

FIRST, LET ME TOUCH ON INDUSTRY LEADERSHIP AND INVOLVEMENT. THOSE FAMILIAR WITH THE IMS FEASIBILITY STUDY KNOW THAT AN INDUSTRY ORGANIZATION CALLED CIMS - COALITION FOR INTELLIGENT MANUFACTURING SYSTEMS - PROVIDED THE REAL INDUSTRIAL SUPPORT FOR IMS. CIMS' MEMBERSHIP INCLUDES A REASONABLE CROSS SECTION OF U.S. COMPANIES ALONG WITH INDUSTRY ASSOCIATIONS SUCH AS NAM AND NACFAM, AND CENTERS SUCH AS NCMS.

I FEEL THAT THE FUTURE SUCCESS OF THE FULL SCALE IMS INITIATIVE WILL DEPEND HEAVILY ON THE FUTURE SUCCESS OF CIMS, AS IT PROVIDES THE NERVE CENTER AND MUSCLE FOR A BROAD IMS INITIATIVE. THE SUCCESS OF CIMS, IN TURN, WILL DEPEND HEAVILY ON THE LEVEL OF SUPPORT IT WILL GET FROM ITS INDUSTRIAL MEMBERS -- AND THAT MEANS CRITICAL SUPPORT FROM THE CEO LEVEL AND THE NECESSARY SUPPORT FROM THE VP's OF ENGINEERING AND MANUFACTURING. A PRIORITY TASK OF THE IMS MANAGEMENT TEAM IS TO HELP ENSURE THAT SUPPORT.

TURNING TO UNIVERSITY INVOLVEMENT, THERE IS CURRENTLY IN FORMATION AN ORGANIZATION CALLED A-CIMS OR ACADEMIC COALITION FOR IMS. MEMBERSHIP WILL CONSIST OF UNIVERSITIES AND COLLEGES THROUGHOUT THE U.S. THIS IS OBVIOUSLY PATTERNED AFTER AND IS A SISTER ORGANIZATION TO CIMS. ACADEMIC REACHOUT TO ASSOCIATIONS SUCH AS THE ENGINEERING DEAN's INSTITUTE, ASEE, AND STATE UNIVERSITY/ COLLEGE EXTENSION PROGRAMS COULD BE COORDINATED BY THIS ACTIVITY.

NOW LET ME TOUCH ON THE MANAGEMENT ISSUES RELATED TO THE INVOLVEMENT OF -- MORE IMPORTANTLY THE UPGRADING OF -- SME's -- SMALL AND MEDIUM SIZE ENTERPRISES. OBVIOUSLY, ONLY A RELATIVELY SMALL PERCENTAGE OF THE MANY THOUSANDS OF SME's WILL BE DIRECTLY INVOLVED IN THE MANUFACTURING RESEARCH CONSORTIA ESTABLISHED AS PART OF THE IMS INITIATIVE. WE CAN ASSUME THESE RELATIVELY FEW WILL BENEFIT FROM THEIR PARTICIPATION, BUT THE STANDING QUESTION IS, "HOW ABOUT ALL THE OTHERS? -- HOW RESTRICTIVE IS THE IMS STRUCTURE?"

ALLOW ME TO MAKE TWO POINTS.

FIRST, A SIGNIFICANT PORTION OF THE IMS PROCESS AND SYSTEM RESEARCH OUTPUT WILL BE AVAILABLE TO INDUSTRY AT LARGE. OF COURSE, THERE WILL BE SOME PROPRIETARY, PROTECTED OUTPUT, BUT THAT WHICH IS _NOT_ CAN STILL GIVE GREAT LEVERAGE TO THOSE WHO ACCEPT AND USE IT. ALSO, THE INCREASED AWARENESS OF GLOBAL MANUFACTURING TECHNOLOGIES AND PROCESSES AND THE RELATED GLOBAL BENCHMARKING PROVIDED BY IMS PROJECTS WILL BE AVAILABLE TO U.S. INDUSTRY. THE ISSUE WILL BE THE EFFECTIVE DISSEMINATION OF THIS KNOWLEDGE, ESPECIALLY TO OUR SME's.

MY SECOND POINT. I INDICATED EARLIER THAT IMS MUST BE A COMPLEMENTARY, INTEGRAL PART OF OUR TOTAL SET OF NATIONAL MANUFACTURING ACTIVITIES -- ADDING A GLOBAL DIMENSION TO THIS NETWORK. IF, FOR IMS OUTREACH AND KNOWLEDGE DISSEMINATION PURPOSES, WE CAN USE THE EXISTING INFRASTRUCTURES OF NIST's MANUFACTURING EXTENSION CENTERS, NSF's ENGINEERING RESEARCH CENTERS, NCMS, AND IMPORTANTLY THE MANY STATE UNIVERSITY EXTENSION PROGRAMS, WE HAVE A HIGH PROBABILITY OF SUCCESSFULLY REACHING OUT TO A HIGH PERCENTAGE OF SME's.

THUS, ANOTHER PRIORITY OF THE IMS MANAGEMENT TEAM IS TO DEVELOP THE COUPLING TO THESE INFRASTRUCTURES AND TO PROVIDE AN EFFECTIVE WORKABLE NETWORK.

THE CHART THAT'S UP ON THE SCREEN (Fig. 3) SHOWS THE MANAGEMENT WIRING DIAGRAM FOR IMS. AS I INDICATED, THERE IS AN INTERNATIONAL STEERING COMMITTEE AT THE TOP, WITH THE NEXT LEVEL U.S. ORGANIZATION STRUCTURE SHOWN IN MORE DETAIL.

WE INTEND TO HAVE A HIGH LEVEL POLICY AND STRATEGY BOARD TO PROVIDE GUIDANCE TO THE STEERING COMMITTEE, WITH THE TOP PEOPLE FROM ORGANIZATIONS SUCH AS THE COUNCIL ON COMPETITIVENESS, NSF, NAM AND/OR NACFAM, NIST, NCMS AND CIMS AS MEMBERS. WE WILL ALSO HAVE A SET OF STANDING COMMITTEES TO DEAL WITH TOPICS SUCH AS MANUFACTURING TECHNOLOGIES, IPR, AND COMMUNICATIONS.

SECRETARIAT SUPPORT WILL COME FROM THE DEPARTMENT OF COMMERCE. YOU CAN SEE THE IMPORTANCE OF CIMS AND ACIMS FROM AN OPERATIONAL VIEWPOINT. CIMS WILL HAVE STANDING COMMITTEES THAT MIRROR THOSE OF THE STEERING COMMITTEE. THESE CIMS COMMITTEES WILL BE STAFFED WITH VOLUNTEERS FROM INDUSTRY WHO WILL CONDUCT NECESSARY STUDIES, PERFORM ANALYSES, BRING INDUSTRY VIEWS TO THE SURFACE, AND PROVIDE EVALUATIONS OF RESEARCH PROJECTS.

CIMS AND ACIMS WILL ALSO PROVIDE THE LINKS TO TRADE ASSOCIATIONS, ACADEMIC ASSOCIATIONS AND INTER AGENCY GROUPS TO HELP KEEP IMS ON THE PROPER TRACK.

MY LAST TOPIC IS THE ONE THAT ALWAYS GETS THE MOST QUESTIONS AND DISCUSSIONS -- FUNDING.

IF WE CAN FIRST ESTABLISH THAT THERE IS AN IMPORTANT REASON FOR IMS TO EXIST AS PART OF THE NATIONAL FRAMEWORK TO IMPROVE GLOBAL COMPETITIVENESS -- AND THEN ESTABLISH AN

EFFECTIVE PROCESS TO MANAGE IMS -- CAN WE REALLY GET THE NECESSARY FUNDING FROM THE LARGER INDUSTRIAL PARTNERS TO SUPPORT THE PARTICIPATION OF SME's AND UNIVERSITIES -- THE SMALLER GUYS WHO CAN'T AFFORD TO PROCEED WITHOUT RESOURCE HELP? THIS WORKED IN THE IMS TEST CASES -- BUT HOW ABOUT A ***FULL SCALE*** INITIATIVE.

CAN WE, IN THESE BUDGET SLICING TIMES, GET ANY SEED MONEY FROM U.S. GOVERNMENT SOURCES THAT SMALL COMPANIES OR UNIVERSITIES COULD TAP TO SUPPORT THEIR COLLABORATIVE EFFORTS? I REFER TO DIRECT GRANT MONIES, AS WELL AS RESOURCES EMBEDDED IN APPROVED PROGRAMS THAT SUPPORT NATIONAL MANUFACTURING EFFORTS, AND THAT CAN BE COMPETED FOR BY INDIVIDUAL PROJECT TEAMS.

ARE THERE FUNDS IN MAJOR FOUNDATIONS OR TRUSTS OR IN INDUSTRY ASSOCIATIONS THAT COULD HELP?

OBVIOUSLY, THE JURY IS OUT ON THE ANSWERS TO THESE QUESTIONS -- AND THE THIRD MAJOR CHALLENGE OR PRIORITY OF THE IMS MANAGEMENT TEAM IS TO GET A WORKABLE SOLUTION TO THE FUNDING ISSUE.

MY PERSONAL BELIEF IS THAT THOSE LARGER COMPANIES WHO ARE TRUTHFULLY PROGRESSIVE, WHO ARE OR ARE EMERGING AS LEADERS, WILL STEP UP AND PROVIDE REASONABLE SUPPORT. I THINK THEY WILL RECOGNIZE THE FUTURE LEVERAGE TO THEMSELVES AND TO THEIR SUPPLIER BASE WHEN OPERATING IN A GLOBAL MARKETPLACE.

THERE ARE, ON THE OTHER HAND, THOSE WHO FEEL WE CAN'T WIN -- THAT THE U.S. INDUSTRIAL PARTNERS ALWAYS LOSE WHEN COLLABORATING WITH THOSE FROM OFFSHORE. THOSE WHO THINK *THAT* WAY ARE INHERENTLY *NOT* WINNERS, AND FIT BEST IN A FOLLOWER ROLE. NOT MUCH FUNDING SUPPORT WILL COME FROM THIS SEGMENT.

AS TO GOVERNMENT SOURCES OR FOUNDATIONS SOURCES, TIME WILL TELL. I THINK THERE ARE OPPORTUNITIES, BUT THEY MUST BE WORKED AGGRESSIVELY.

AS MARY GOOD COMMENTED -- "NOBODY SAID IT WOULD BE EASY."

LADIES AND GENTLEMEN, THAT CONCLUDES MY REMARKS. I HOPE THEY HAVE BEEN HELPFUL IN YOUR UNDERSTANDING OF IMS.

THANK YOU.

I M S

The Technical Themes Proposed for the Full Scale IMS Activity Are:

- Total Product Life Cycle Issues
- Clean, Energy Efficient Manufacturing Processes
- Virtual / Extended Enterprises
- Strategy / Planning / Design Tools
- Human / Organizational / Social Issues

Fig. 1

I M S

International Steering Committee

JAPAN	
DR. H. YOSHIKAWA -	President, University of Tokyo
MR. J. AOI - Chairman & CEO -	Toshiba Corporation
AUSTRALIA	
MR. DON WILLIAMS -	Chair of Australian Rail
MR. EDWIN VAN LEEUWEN -	Manager, External Research & Development
CANADA	
MR. BILL HETHERINGTON -	President, Allen-Bradley Canada Ltd. (International Chairman)
MR. STEVE VAN HOUTEN -	President, Canadian Manufacturers Association
U.S.	
DR. JOHN WHITE -	Dean, College of Engineering, Georgia Tech
MR. R.L. CATTOI -	Technical Consultant to the Office of the Chairman, Rockwell International Corporation
EUROPE	
TBD	

Fig. 2

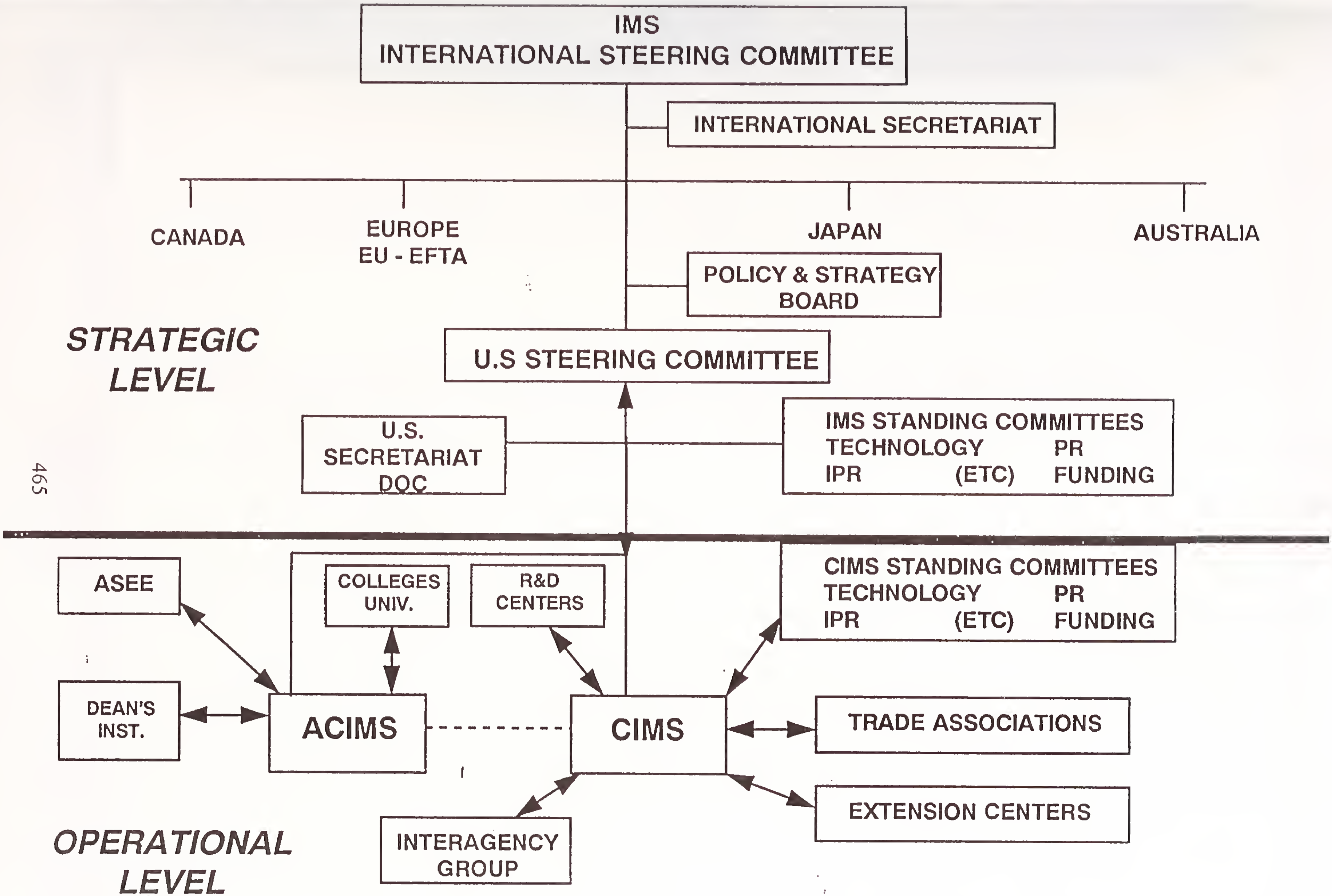

IMS
INTERNATIONAL STEERING COMMITTEE
INTERNATIONAL SECRETARIAT
CANADA
EUROPE
EU - EFTA
JAPAN
AUSTRALIA
POLICY & STRATEGY BOARD
STRATEGIC LEVEL
U.S STEERING COMMITTEE
U.S. SECRETARIAT DOC
IMS STANDING COMMITTEES
TECHNOLOGY PR
IPR (ETC) FUNDING
ASEE
COLLEGES UNIV.
R&D CENTERS
CIMS STANDING COMMITTEES
TECHNOLOGY PR
IPR (ETC) FUNDING
DEAN'S INST.
ACIMS
CIMS
TRADE ASSOCIATIONS
EXTENSION CENTERS
INTERAGENCY GROUP
OPERATIONAL LEVEL

Fig. 3

Other Manufacturing Programs

Representatives of federal agencies described the goals and activities of specific manufacturing and technology programs.

Advanced Technology Program

John Gudas
NIST

NIST

ADVANCED TECHNOLOGY PROGRAM

John P. Gudas

Technology Administration
Department of Commerce

NIST UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standardand Technology

DR. JOHN P. GUDAS
Program Manager for Advanced Materials
Advanced Technology Program

Room A 603, Administration
Gaithersburg, MD 20899

Office: 301-975-4641
Fax: 301-869-1150
gudas@micf.nist.gov

ATP MISSION

- Stimulate U.S. economic growth by developing high-risk and enabling technologies through programs proposed and cost shared by industry

ATP ELIGIBILITY

- Individual companies
  - No more than 3 years
  - Up to $2M total
  - NIST pays only direct costs
- Joint ventures
  - No more than 5 years
  - No limit on award amount
  - NIST share less than 50%
- No direct funding to universities, government agencies or non-profit independent research institutes

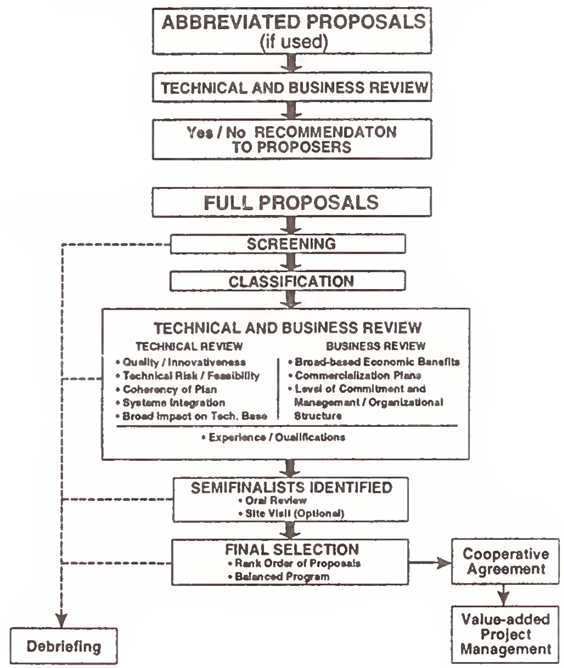
FOREIGN COMPANY PARTICIPATION

- Project must result in economic benefits to the U.S.
  - R&D and manufacturing in the U.S.
  - Increase U.S. employment
  - Promote U.S. supplier infrastructure
  - U.S. - owned companies also must meet these requirements
- Country of origin must grant opportunities to U.S. - owned companies comparable to any other company in that country and protect intellectual property
- PL 102-245 authorizes suspension of award if criteria no longer satisfied

INTELLECTUAL PROPERTY PROVISIONS

- Companies incorporated in the U.S. keep intellectual property rights
- Companies can license
- Government reserves the right to a royalty-free non-exclusive license for government use
  - Non-disclosure (trade secrets protected)
  - Government rights rarely invoked

ATP PROJECT SELECTION PROCESS



ATP PROJECT SELECTION CRITERIA (Weight)

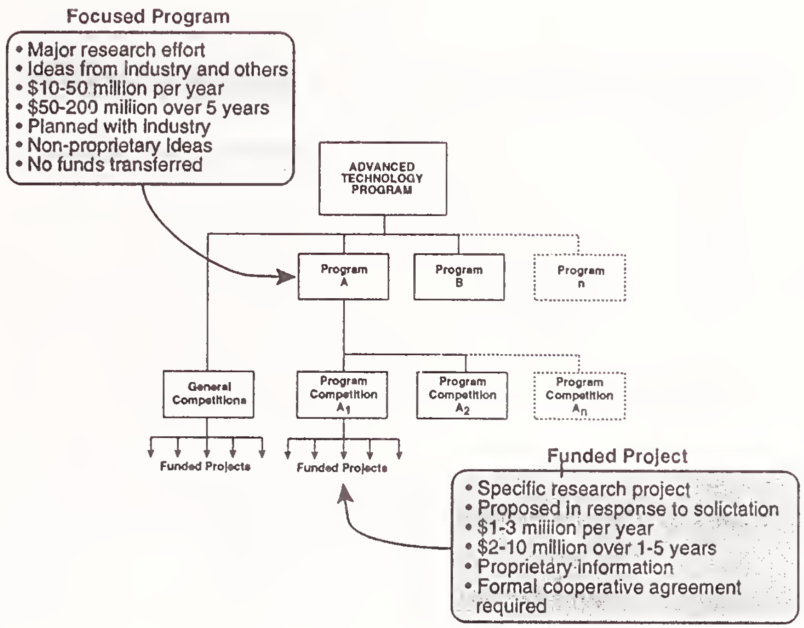
- Scientific and technical merit (30%)
- Potential broad-based economic benefits (20%)
- Adequacy of plans for eventual commercialization (20%)
- Level of commitment and organizational structure (20%)
- Experience and qualifications (10%)

WHAT HAPPENS IF YOU RECEIVE AN AWARD?

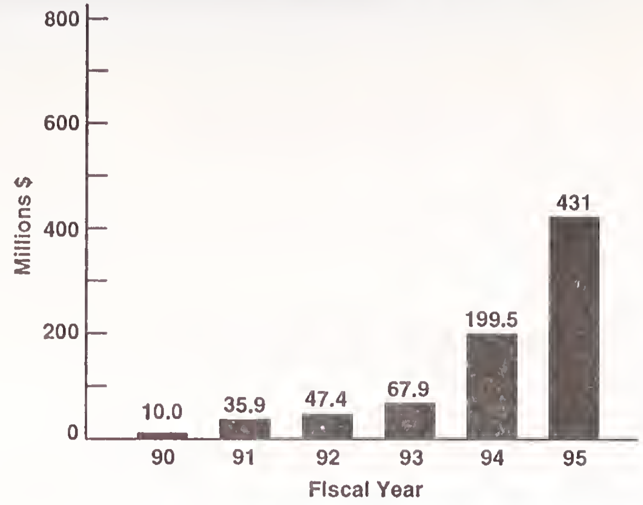
- Name checks, company checks
- Cooperative agreement signed (with standard terms and conditions)
- ATP project manager assigned
- Monitoring, but not micromanagement (written quarterly project reports, visits and phone calls by project manager, economic assessment staff, etc.) Technical assistance from NIST where appropriate.
- Final report
- Willingness to share data with ATP for impact assessment
- Auditing by Inspector General or CPA

ATP EVALUATION PLAN

1. Evaluating ATP operational activities
2. Profiling for portfolio management
3. Evaluating company implementation of R&D and business plans
4. Tracking short-term and intermediate project results
5. Measuring long-term economic impacts



ATP BUDGET PROFILE



FOCUSED PROGRAMS

	Program	Manager	Est. Total Funding ($ Millions)
April 1994	• DNA Diagnostics	Stan Abramowitz	145
	• Healthcare Inf. Infra.	Bettijoyce Lide	185
	• Mfg. Composite Structures	John Gudas	160
	• Component-Based Software	David Fisher	150
	• CIM for Electronics	Barbara Goldstein	105
November 1994	• Catalysis and Biocatalysis	Linda Schilling	160
	• Motor Vehicle Mfg. Tech.	Jack Boudreaux	185
	• Digital Data Storage	Tom Leedy	125
	• Digital Video in Info. Networks	Hanafy Meleis	120
	• Vapor Compression Refrigeration	Jim Hill	50
	• Matls. Proc. for Heavy Mfg.	John Gudas/Harry McHenry	145

Estimated ATP share is $1.53 billion over about 6 years

Advanced Technology Program

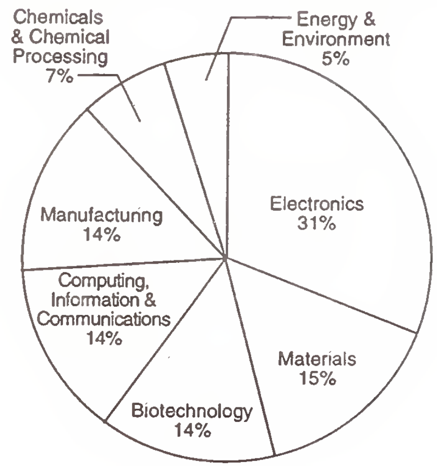
IMPORTANT STATISTICS
5 GENERAL COMPETITIONS 1990-1994

Proposals Submitted	1307
Participating Organizations*	2352
Total ATP Funding Requested	$2.4 B
Total Estimated Cost Share	$2.3 B
Number of Awards	121
(Joint Ventures)	(38)
(Single Applicants)	(83)
Participating Organizations*	271
Total ATP Funds Committed	$332 M
Total Estimated Cost Sharing	$370 M
Award Size - - Range	$500 K - $20 M

* Excludes Subcontractors

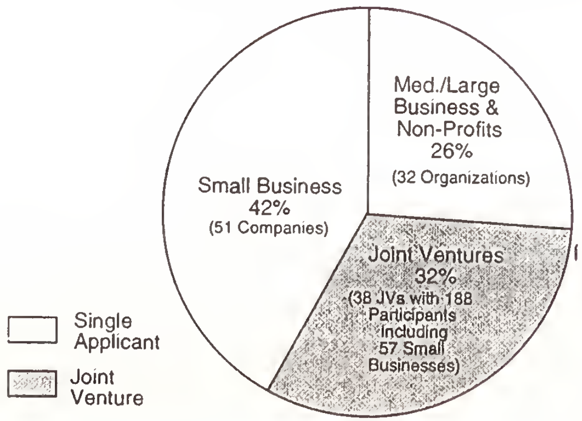
Five General Competitions 1990-1994

ATP 121 AWARDS BY TECHNOLOGY AREA
AS A PERCENT OF $332 M AWARDED



Five General Competitions 1990-1994

ATP 121 AWARDS
By Type of Organization



1994 FOCUSED PROGRAM AWARDS

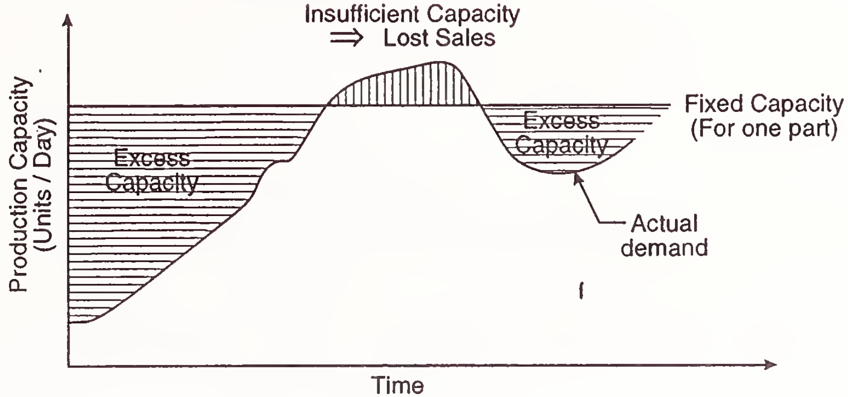
	Awards	Joint Ventures	Single Companies	Number of Participants	$ Million ATP Funds	$ Million Ind. Funds
Mfg. Composite Struct.	15	9	6	51	53	56
DNA Diagnostics	13	4	9	19	57	54
Healthcare Inf. Infra.	16	8	8	46	72	76
Comp.-Based Software	11	2	9	23	40	42
CIM for Electronics	1	0	1	1	2	1
Totals	56	23	33	140	224	229

MOTOR VEHICLE MANUFACTURING TECHNOLOGY

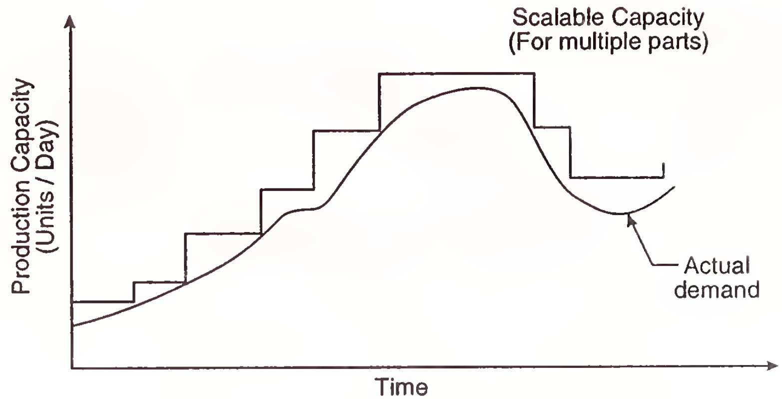
BUSINESS GOALS

1. Reduce manufacturing and capital equipment cost of introducing a new vehicle model by an order of magnitude
2. Reduce the time to market from the current U.S. industry standard of 42 to 48 months to 24 months
3. Strengthen U.S. industry's future ability to team with suppliers

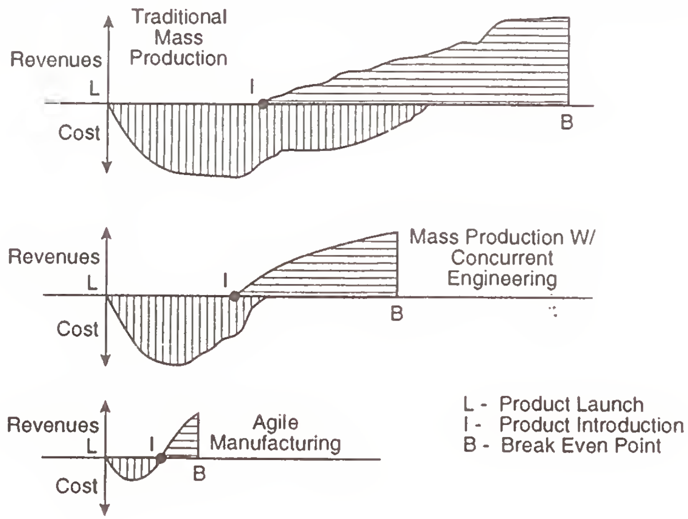
MASS PRODUCTION USING DEDICATED LINES



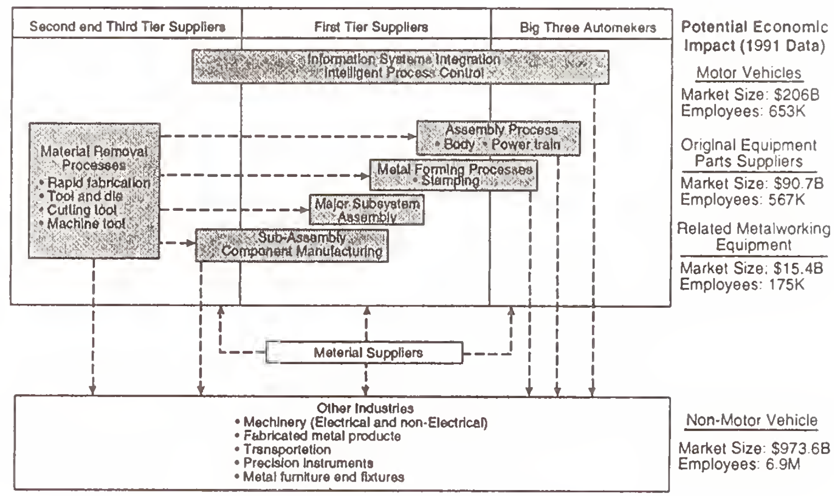
SCALABLE, AGILE MANUFACTURING



PRODUCT CYCLE - LAUNCH TO BREAK EVEN



ATP Potential Economic Impact MOTOR VEHICLE INDUSTRY



TECHNICAL GOALS

1. Concentrate on specific technical improvements in manufacturing processes and in process monitoring and control
2. Develop flexible, reconfigurable equipment to produce diverse product families
3. Develop agile manufacturing systems to permit rapid, low-cost product conversion and efficient equipment re-utilization

TECHNICAL THRUST AREAS

- Material Forming Processes
  - Stamping and metal forming processes
  - Forming of advanced materials
- Assembly Processes
  - Body assembly
  - Powertrain assembly
  - Paint and coating process control
- Information Systems Integration
  - Intelligent process monitoring and control
  - System integration
- Material Removal Processes
  - Advanced machining
  - Abrasive machining
  - Rapid fabrication of production tooling

PLANNED PROGRAM FUNDING

- ~$370M total
  $185M ATP
  $185M industry
- 5-year duration
- Multiple solicitations (3 over 3 years)
- Conditions
  - Future Congressional appropriations
  - Satisfactory technical performance

Motor Vehicle Manufacturing Technology

ATP CONTACTS

Jack Boudreaux, Program Manager
Phone: (301) 975-3560
Fax: (301) 926-9524
EMail: jackb@enh.nist.gov

Mike Daum, Business Manager
Phone: (301) 975-5487
Fax: (301) 926-9524
EMail: daum@micf.nist.gov

Proposer's Kit / ATP mail lists
1-800-ATP-FUND or 1-800-287-3863

Motor Vehicle Manufacturing Technology

PROGRAM EXECUTION

- Solicitation close - - April 11, 1995
- Funding decisions - - July, 1995
- Debriefings - - October, 1995
- Second competition - - 1996
- Annual workshops for non-proprietary results discussion

NIST

Advanced Technology Program

MATERIALS PROCESSING FOR HEAVY MANUFACTURING

Tom Siewert | Harry McHenry | Sandy Dapkunas | Frank Gayle | David McColskey

Program Manager

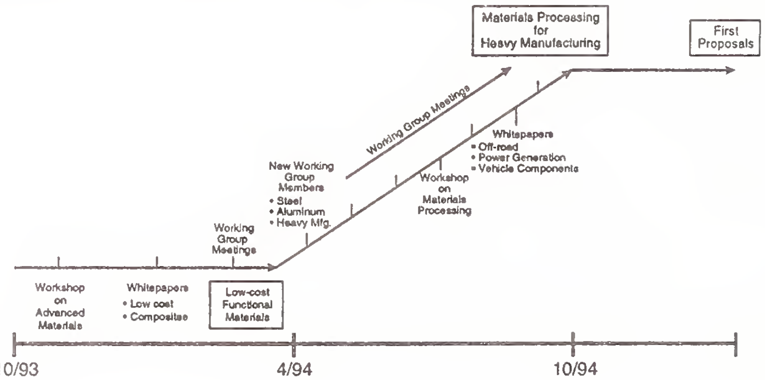
John P. Gudas
gudas@micf.nist.gov
301-975-3214

Business Manager

Subhash Kuvelker
kuvelker@micf.nist.gov
301-975-5498

Materials Processing for Heavy Manufacturing

PROGRAM DEVELOPMENT



Materials Processing for Heavy Manufacturing

YEAR 2000 - 2005 Business Goals

U.S. value leadership for products of heavy manufacturing
- Product Differentiation
- Lower Cost

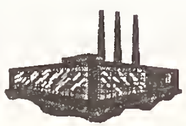
Heavy Equipment — $100 B/yr Worldwide

Market Growth Rate: 2X

Vehicle Engine, Power Train and Chassis — $60 B/yr Domestic

Manufacturing Cost Reduction Rate: 2X

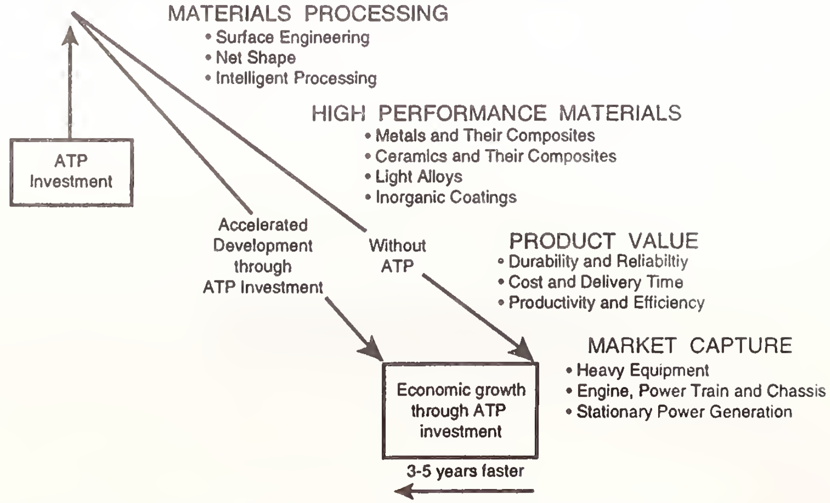
Stationary Power Generating Equipment — $45 B/yr Worldwide



Growth In Market Share: 40%

Materials Processing for Heavy Manufacturing

TECHNOLOGY FLOW AND IMPACT



Materials Processing for Heavy Manufacturing

GOAL

Accelerate Introduction of:

- Advanced Materials into Heavy Manufacturing
- Advanced Manufacturing into Materials Processing

Materials Processing for Heavy Manufacturing

PROGRAM TECHNICAL GOALS

Develop and demonstrate innovative materials processing technologies which enable:

- Product differentiation
  - Durability
  - Reliability
  - Efficiency

- Manufacturing cost reduction
  - Eliminate process steps
  - Eliminate waste
  - Reduce manufacturing cycle time

Materials Processing for Heavy Manufacturing

SCOPE: MARKET SECTORS

- Surface transportation vehicles
  - Engines
  - Power trains
  - Chassis

- Heavy equipment (construction, mining, agriculture, oil/gas field)
  - Engines
  - Power transmission
  - Abrasion and wear surfaces

- Stationary power generating equipment
  - Engines
  - Turbines
  - Rotors

Materials Processing for Heavy Manufacturing

SCOPE - MATERIALS

- Metals
- Metal matrix composites
- Ceramics
- Ceramic matrix composites
- Coatings

OUT OF SCOPE

- Polymer matrix composites
- Building materials
- Organic materials
- New materials discovery

SCOPE: PROCESSING AREAS

- Intelligent processing
- Surface engineering
- Net shape processing
- Welding and joining
- Waste elimination

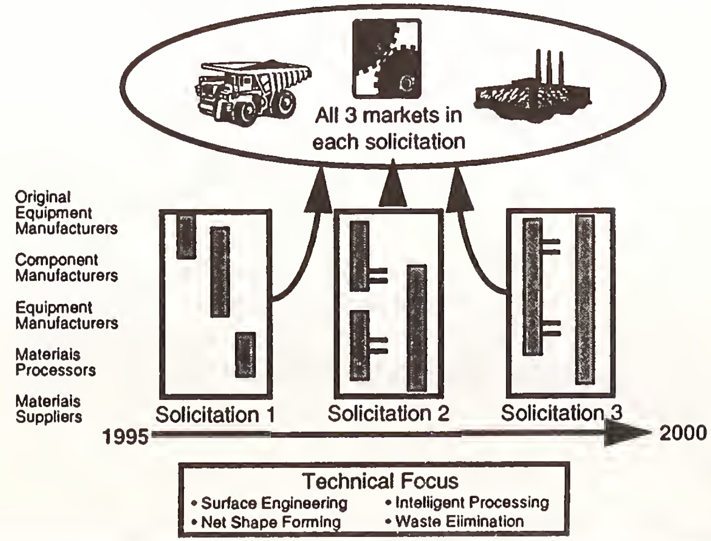
CONCEPTS DERIVED FROM INDUSTRY WHITEPAPERS

- Intelligent processing
  - Microstructural control
  - Morphology control of ceramic composites
  - Scale-up of turbine blades
  - Model-based die design
  - On-line control
- Waste elimination
  - Steel waste to cement feedstock
  - Recover iron from dust and slag
  - Replace acid cleaning
  - Stabilize heavy metals in residues
  - Increase process efficiencies

CONCEPTS DERIVED FROM INDUSTRY WHITEPAPERS

- Surface engineering
  - Surface modification
  - Ion implantation
  - Functionally gradient materials
  - Rapid solidification
  - Chemical vapor infiltration
- Net shape forming
  - Casting of sheet
  - High purity castings
  - Stir casting of composites
  - Ceramics with toughened structures
  - Injection molding of ceramics

PROGRAM EXECUTION



Materials Processing for Heavy Manufacturing

TEAMING OPPORTUNITIES

Vertical Integration

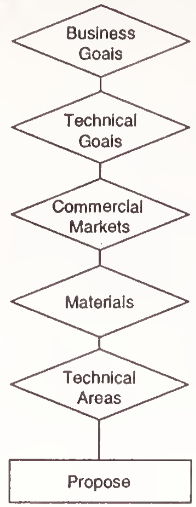
- OEM
- Component Manufacturers
- Equipment Manufacturers
- Materials Processors
- Materials Producers

Horizontal Integration

Shared Technology Needs
- Surface Engineering
- Intelligent Processing of Mat.
- Net Shape Forming
- Welding and Joining
- Waste Elimination

Materials Processing for Heavy Manufacturing

PROPOSAL DECISION PATH
"Should you propose?"



- Value leadership
- Accelerated product introduction
- Market share

- Product differentiation
- Manufacturing cost reduction

- Surface transportation power train
- Heavy equipment
- Stationary power generation equipment

- Metals/metal matrix composites
- Ceramics/ceramic matrix composites
- Inorganic coatings

- Intelligent processing
- Surface engineering
- Net shape processing
- Welding and joining
- Waste elimination

Materials Processing for Heavy Manufacturing

PLANNED PROGRAM FUNDING

- ~$290M total
  - $145M ATP
  - $145M industry
- 5-year duration
- Multiple solicitations (3 over 3 years)
- Conditions
  - Future Congressional appropriations
  - Satisfactory technical performance

Materials Processing for Heavy Manufacturing

PROGRAM EXECUTION

- Solicitation opens - - February 2, 1995
- Solicitation closes - - 3:00 p.m., May 3, 1995
- Funding decisions - - July, 1995
- Debriefings - - October, 1995
- Second competition - - 1996

CONTACTS

John P. Gudas	gudas@micf.nist.gov 301-975-3214
Harry I. McHenry	mchenry@micf.nist.gov 303-497-3258
Subhash Kuvelker	kuvelker@micf.nist.gov 301-975-5498
Tom Siewert Sandy Dapkunas Frank Gayle David McColskey	@micf.nist.gov

NIST

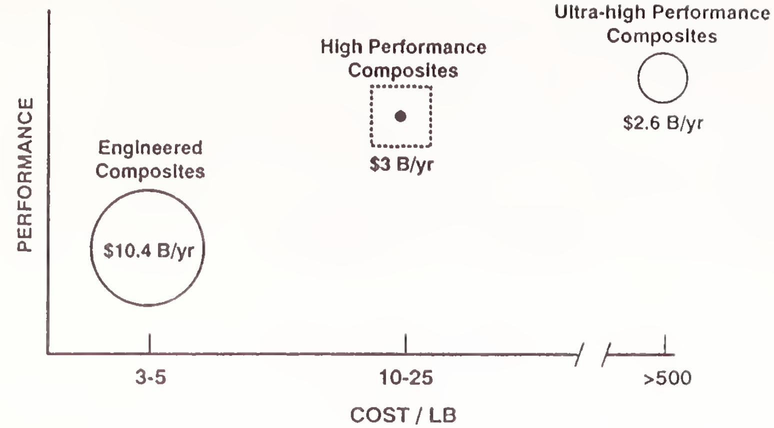
Advanced Technology Program

MANUFACTURING COMPOSITE STRUCTURES
Solicitation 94-02 Results
November 1994

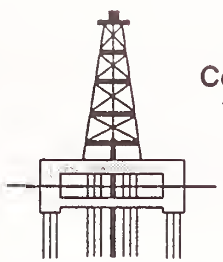
National Institute of Standards and Technology

Carol L. Schutte
schutte@micf.nist.gov
301-975-6846; Facsimile 301-925-9524

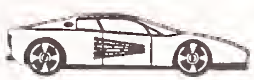
YEAR 2000 BUSINESS GOALS



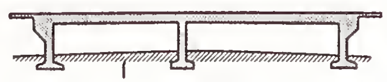
COMMERCIAL BUSINESS GOALS



Construction Capital
⇓
15-20%



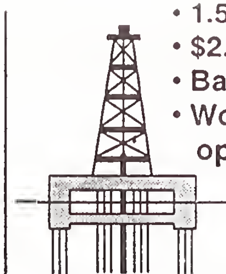
Investment Cost
⇓
25%



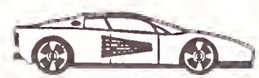
Commercial Acceptance Period
⇓
50%

ECONOMIC BENEFITS

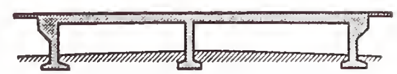
10 YEARS AFTER ATP INVESTS



- 1.5 bbl oil equiv.
- $2.96 B components
- Balance of trade
- World-wide const. opportunities



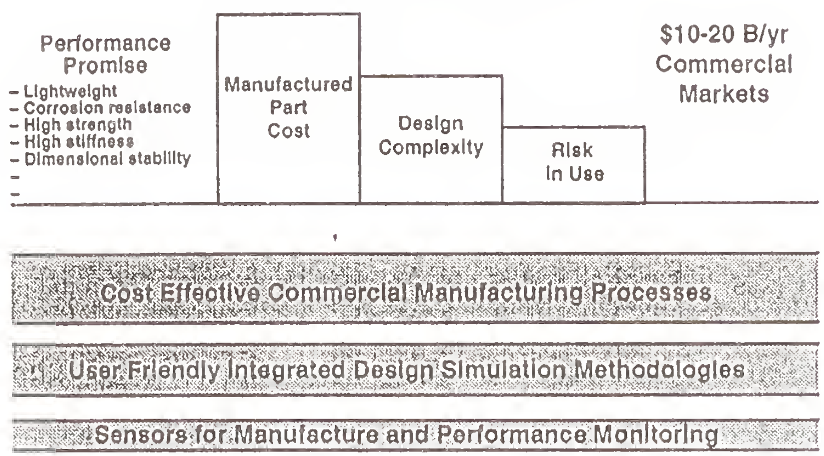
- $1300 composite parts per automobile
- $20 B/yr manufacturing
- Electric vehicle
- CAFE standards



- $130 B Repair deficit
  - Longer life structures
  - Seismic protection

MANUFACTURING COMPOSITE STRUCTURES

TECHNICAL GOALS



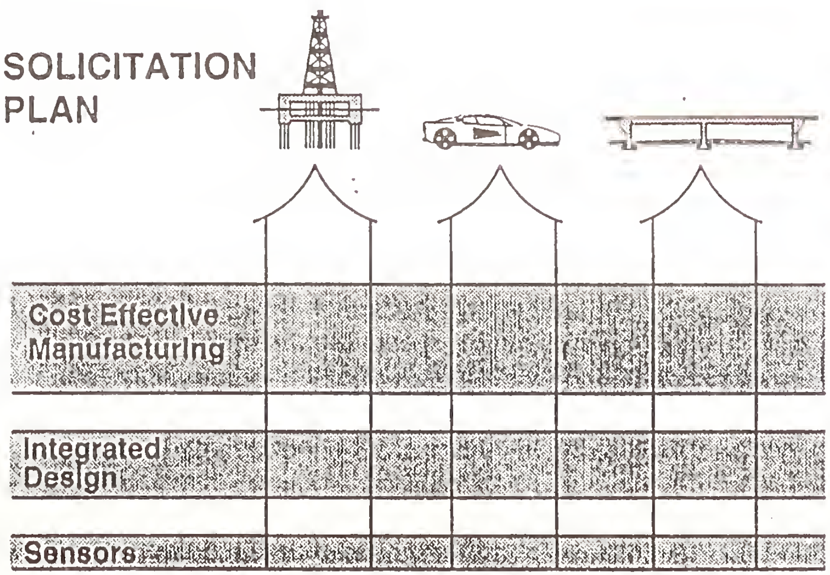
MANUFACTURING COMPOSITE STRUCTURES

TECHNICAL OBJECTIVES

- Establish commercial benchmarks with cost and performance detail for business decisions
  - Lower investment cost autos and land transportation vehicles
  - Accelerated code and commercial acceptance of large civil structures
  - Reduction in capital for deep-water oil production

MANUFACTURING COMPOSITE STRUCTURES

SOLICITATION PLAN



MANUFACTURING COMPOSITE STRUCTURES

TECHNICAL SCOPE

- Develop high risk, generic technologies
  - Cost-effective manufacturing processes
  - User-friendly integrated design simulation methodologies
  - Application of sensors in manufacture and performance monitoring

MANUFACTURING COMPOSITE STRUCTURES

SCOPE

- Generic technical developments
  - Manufacturing processes
  - Design methodologies
  - Sensors applications
- Integration of technologies
  - Complex demonstrations
  - Commercialization paths
  - Cost competitiveness validation

MANUFACTURING COMPOSITE STRUCTURES

SCOPE - MATERIALS

- Fibers
  - Carbon
  - Polymeric
  - Glass
- Fiber forms
  - Continuous
  - Chopped strands
  - Fabric
  - Others
- Organic matrix resins
  - Thermoplastic
  - Thermoset

MANUFACTURING COMPOSITE STRUCTURES

~~SCOPE~~

- Non-polymeric composites
- Fundamentally new materials
  - Fibers
  - Resins
- Basic, decoupled failure mechanism studies
- Data base generation
- Aerospace structures/engines
- Electronic packaging
- e.g., surface ships/submarines

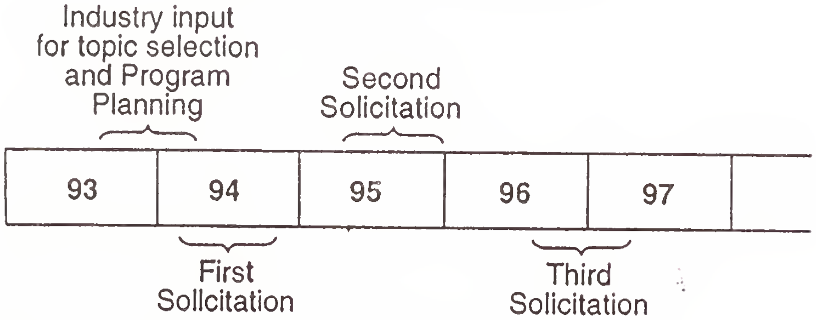
MANUFACTURING COMPOSITE STRUCTURES

PLANNED PROGRAM FUNDING

- ~$320M total
  - $160M ATP
  - $160M industry
- 5-year duration
- Multiple solicitations (3 over 3 years)
- Future Congressional appropriations
- Satisfactory technical performance

MANUFACTURING COMPOSITE STRUCTURES

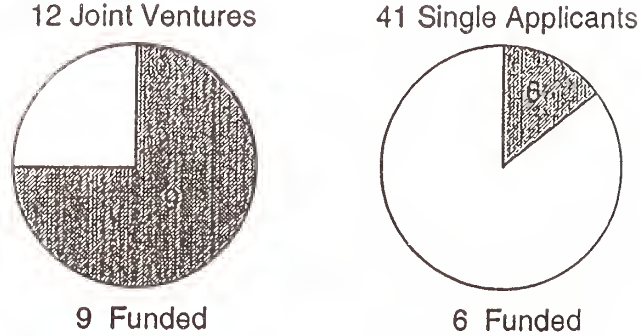
PROGRAM SCHEDULE



MANUFACTURING COMPOSITE STRUCTURES

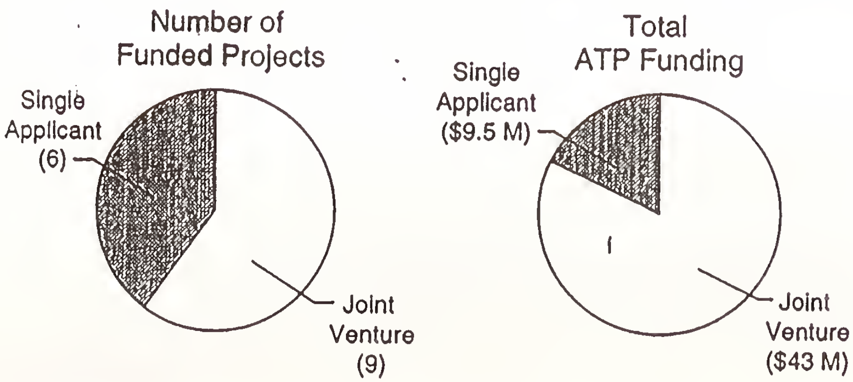
SOLICITATION 94-02 STATISTICS

Number of Proposals Submitted



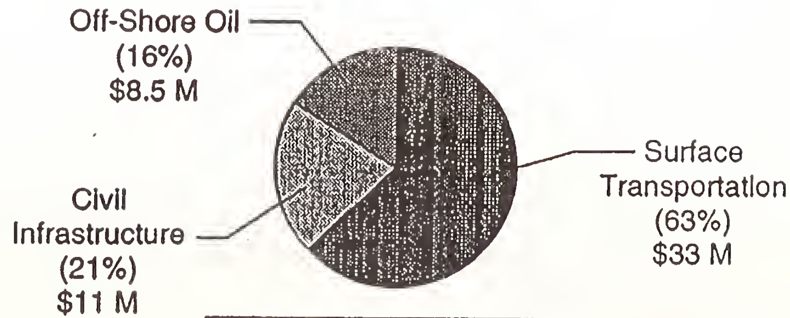
MANUFACTURING COMPOSITE STRUCTURES

SOLICITATION 94-02
Funding Breakdown



MANUFACTURING COMPOSITE STRUCTURES

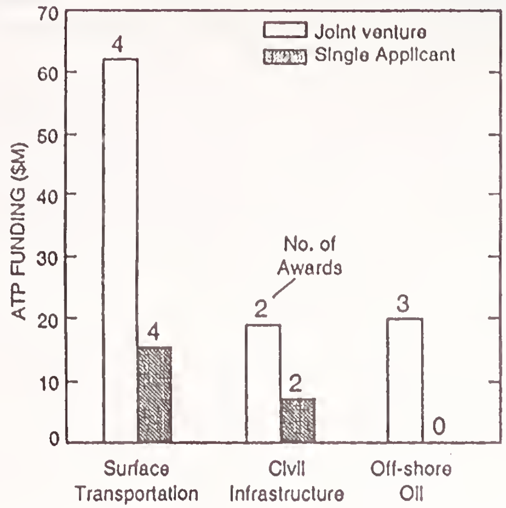
SOLICITATION 94-02
Total Planned ATP Funding



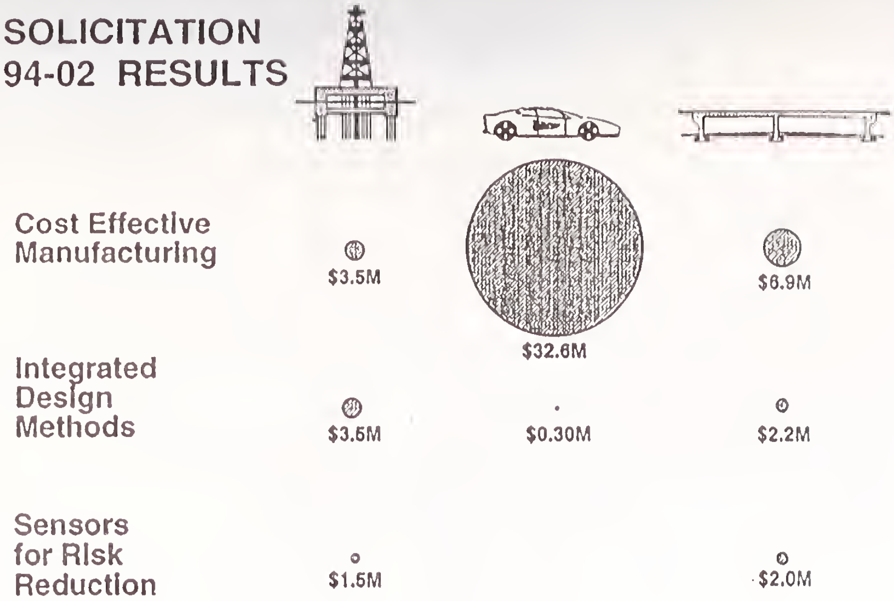
ATP Support	$52.5 M
Total Funding	$109.1 M

SOLICITATION 94-02

Funding by Commercial Focus and Recipient Type



SOLICITATION 94-02 RESULTS



SOLICITATION 94-02

Funded Projects: Offshore Oil Structures

- Tubular structure design, life prediction, performance validation
  - *Westinghouse Marine Division J/V*
- Production riser design, analysis, and monitoring
  - *Composite Production Riser J/V*
- Spoolable tubing manufacturing
  - *SpoolableTubing J/V*

SOLICITATION 94-02

Funded Projects: Surface Transportation

- Preform assembly technology
  - *Gencorp Inc.*
- Long-fiber injection molded automotive panels and structural members
  - *AlliedSignal Inc.*
- Full-scale processing of SRIM prototype truck box and tailgate assembly
  - *Automotive Composites Consortium J/V*
- Power transmission device design and manufacturing
  - *New Venture Gear Inc. J/V*

MANUFACTURING COMPOSITE STRUCTURES

SOLICITATION 94-02

Funded Projects: Surface Transportation

- Moldable sheet thermoplastic manufacturing
  – *DuPont / Cambridge Industries J/V*
- Manufacturability of moderate volume structural and semistructural components for electric vehicles
  – *U.S. Electricar J/V*
- Manufacturing methods for vehicular frames
  – *Budd Company*
- Polar weave / RTM for flywheels
  – *Dow-United Technologies Composite Products Inc.*

MANUFACTURING COMPOSITE STRUCTURES

SOLICITATION 94-02

Funded Projects: Civil Infrastructure

- Manufacturing, design, and sensor technologies for retrofitting of bridge columns
  – *Composite Retrofit Corporation J/V*
- Composite manufacturing processes for large scale bridge decking
  – *Dupont / Hardcore J/V*
- Synchronous in-line CNC machining of pultruded lineal shapes
  – *Ebert Composites Corporation*
- Manufacturing techniques for large phenolic beam structures
  – *Morrison Molded Fiber Glass Company*

MANUFACTURING COMPOSITE STRUCTURES

SOLICITATION 94-02

Funded Projects by Technical Focus

	Number (ATP Funding, $ M)		
Technologies	Surface Transportation	Off-Shore Oil	Civil Infrastructure
Manufacturing	7 (32.4)	–	2 (3.0)
Manufacturing & Design	1 (0.5)	1 (3.6)	–
Manufacturing, Design & Sensors	–	2 (4.9)	2 (8.1)

MANUFACTURING COMPOSITE STRUCTURES

SOLICITATION 94-02

Funded Projects by Processing Methods

	Number (ATP Funding, $ M)		
Processing Method	Surface Transportation	Off-Shore Oil	Civil Infrastructure
Liquid Molding			
SRIM	3 (7.3)		
Vac. RTM			1 (6.7)
RTM	1 (0.5)		
Pultrusion		1 (2.5)	2 (3.0)
Filament Winding		2 (5.9)	1 (1.4)
Pressure Molding / Other	3 (23.2)		
Long Fiber Inj. Molding	1 (2.0)		

SOLICITATION 94-02

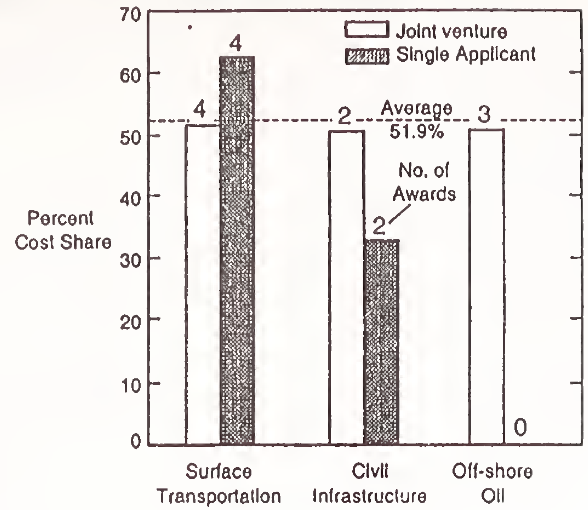
Total Funding by Processing Method

Processing Method	Number	ATP Funding, $M
Liquid Molding		
SRIM	3	7.3
Vac. RTM	1	6.7
RTM	1	0.5
Pultrusion	3	5.5
Filament Winding	3	7.3
Pressure Molding / Other	3	23.2
Long Fiber Injection Molding	1	2.0
Total		52.5

MANUFACTURING COMPOSITE STRUCTURES

SOLICITATION 94-02

Cost Share by Industry



CONTACTS

TECHNICAL

Carol L. Schutte
(301) 975-6846
schutte@micf.nist.gov

BUSINESS

Subhash Kuvelker
(301) 975-5498
kuvelker@micf.nist.gov

NIST

Advanced Technology Program

MANUFACTURING COMPOSITE STRUCTURES

Solicitation 94-02 Results
November 1994

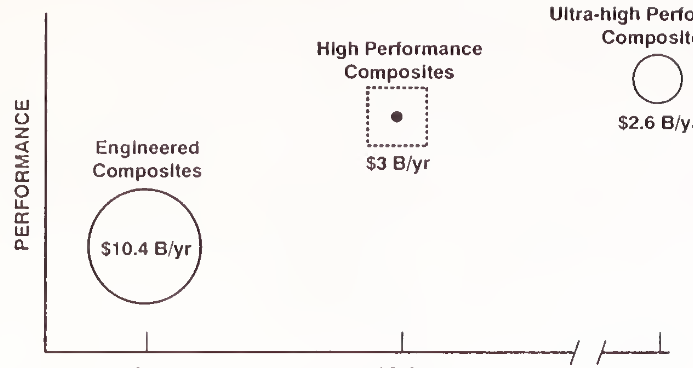
National Institute of Standards and Technology

Carol L. Schutte

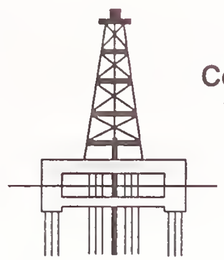
schutte@micf.nist.gov

301-975-6846; Facsimile 301-925-9524

YEAR 2000 BUSINESS GOALS



COMMERCIAL BUSINESS GOALS



Construction Capital

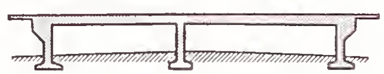
⇓

15-20%

Investment Cost

⇓

25%



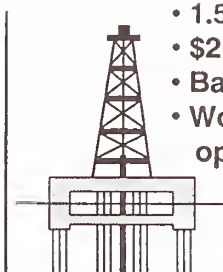
Commercial Acceptance Period

⇓

50%

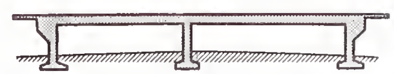
ECONOMIC BENEFITS

10 YEARS AFTER ATP INVESTS



- 1.5 bbl oil equiv.
- $2.96 B components
- Balance of trade
- World-wide const. opportunities

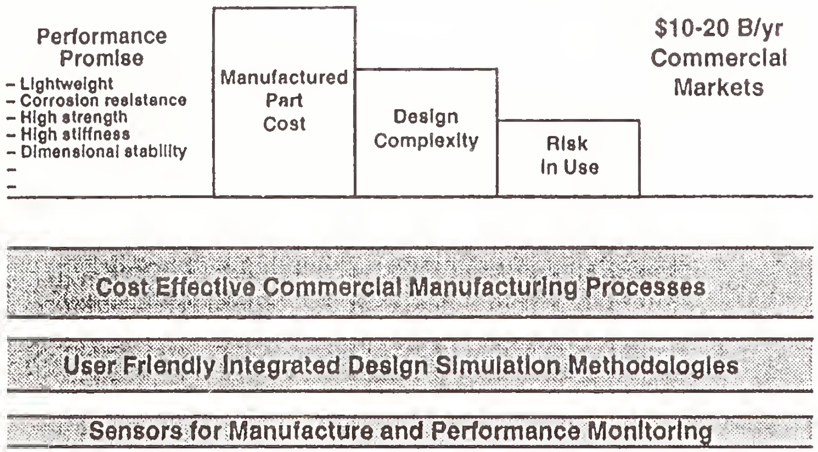
- $1300 composite parts per automobile
- $20 B/yr manufacturing
- Electric vehicle
- CAFE standards



- $130 B Repair deficit
  - Longer life structures
  - Seismic protection

MANUFACTURING COMPOSITE STRUCTURES

TECHNICAL GOALS



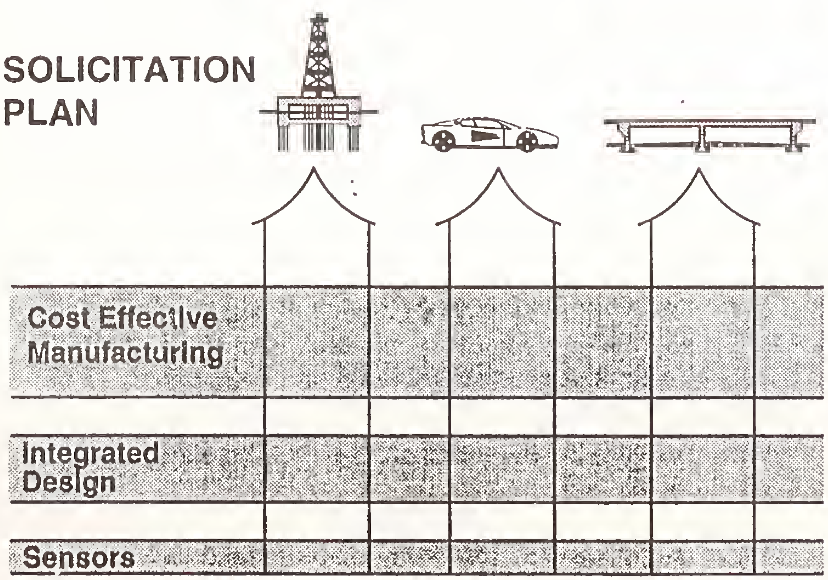
MANUFACTURING COMPOSITE STRUCTURES

TECHNICAL OBJECTIVES

- Establish commercial benchmarks with cost and performance detail for business decisions
  - Lower investment cost autos and land transportation vehicles
  - Accelerated code and commercial acceptance of large civil structures
  - Reduction in capital for deep-water oil production

MANUFACTURING COMPOSITE STRUCTURES

SOLICITATION PLAN



MANUFACTURING COMPOSITE STRUCTURES

TECHNICAL SCOPE

- Develop high risk, generic technologies
  - Cost-effective manufacturing processes
  - User-friendly integrated design simulation methodologies
  - Application of sensors in manufacture and performance monitoring

MANUFACTURING COMPOSITE STRUCTURES

SCOPE

- Generic technical developments
  - Manufacturing processes
  - Design methodologies
  - Sensors applications
- Integration of technologies
  - Complex demonstrations
  - Commercialization paths
  - Cost competitiveness validation

MANUFACTURING COMPOSITE STRUCTURES

SCOPE - MATERIALS

- Fibers
  - Carbon
  - Polymeric
  - Glass
- Fiber forms
  - Continuous
  - Chopped strands
  - Fabric
  - Others
- Organic matrix resins
  - Thermoplastic
  - Thermoset

MANUFACTURING COMPOSITE STRUCTURES

~~SCOPE~~

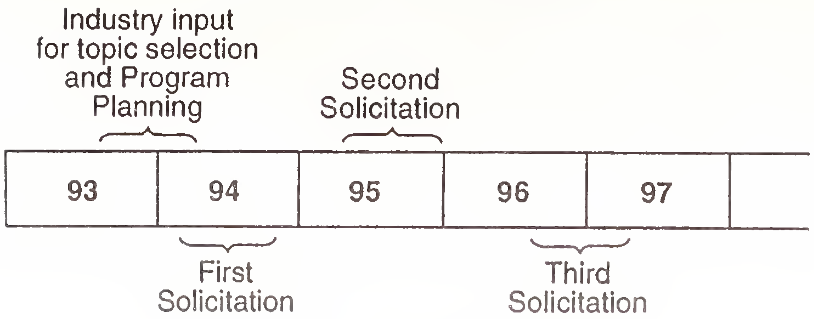
- Non-polymeric composites
- Fundamentally new materials
  - Fibers
  - Resins
- Basic, decoupled failure mechanism studies
- Data base generation
- Aerospace structures/engines
- Electronic packaging
- e.g., surface ships/submarines

MANUFACTURING COMPOSITE STRUCTURES

PLANNED PROGRAM FUNDING

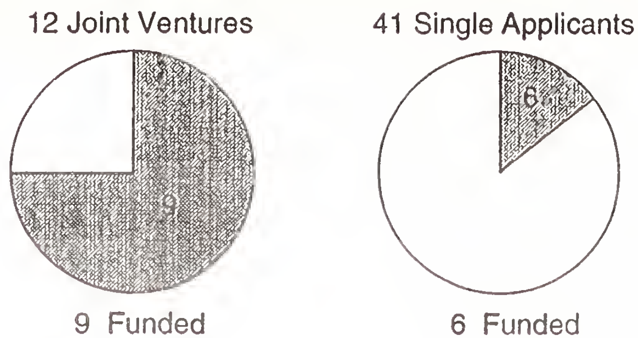
- ~$320M total
  - $160M ATP
  - $160M Industry
- 5-year duration
- Multiple solicitations (3 over 3 years)
- Future Congressional appropriations
- Satisfactory technical performance

PROGRAM SCHEDULE

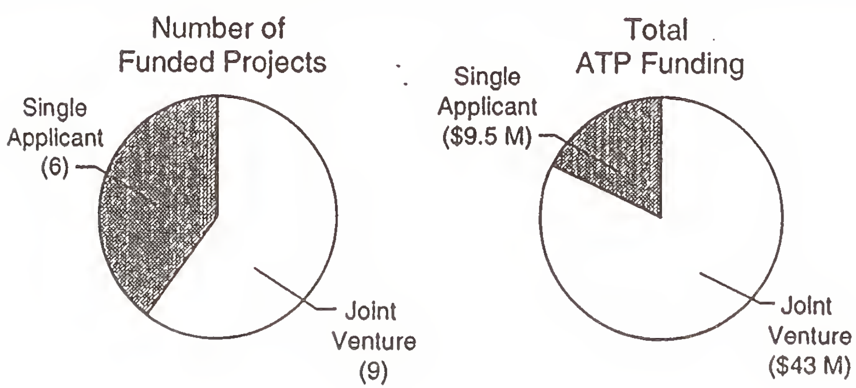


SOLICITATION 94-02 STATISTICS

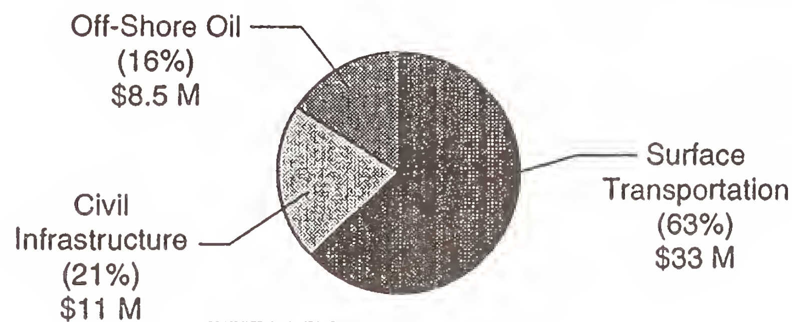
Number of Proposals Submitted



SOLICITATION 94-02
Funding Breakdown



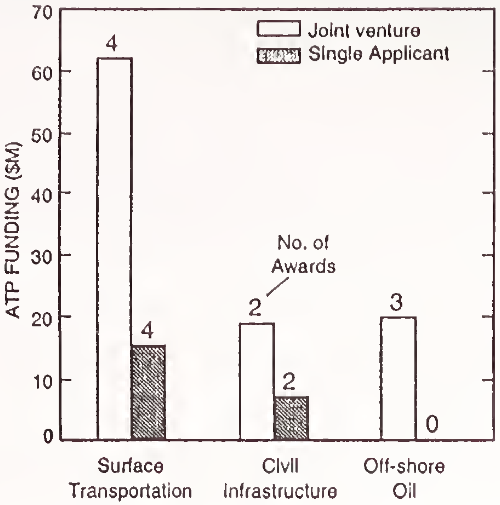
SOLICITATION 94-02
Total Planned ATP Funding



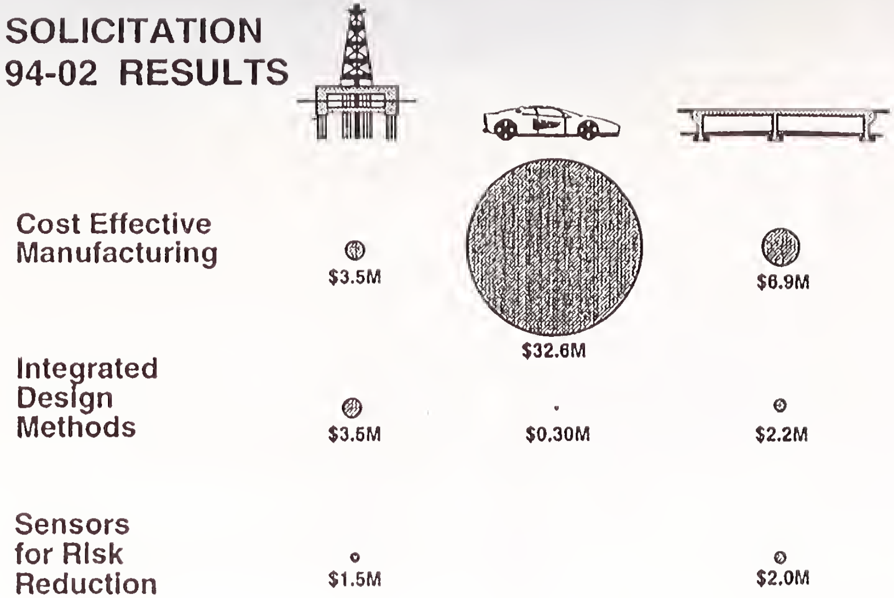
ATP Support	$52.5 M
Total Funding	$109.1 M

SOLICITATION 94-02

Funding by Commercial Focus and Recipient Type



SOLICITATION 94-02 RESULTS



SOLICITATION 94-02

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SOLICITATION 94-02

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SOLICITATION 94-02

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SOLICITATION 94-02

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SOLICITATION 94-02

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SOLICITATION 94-02

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SOLICITATION 94-02
Total Funding by Processing Method

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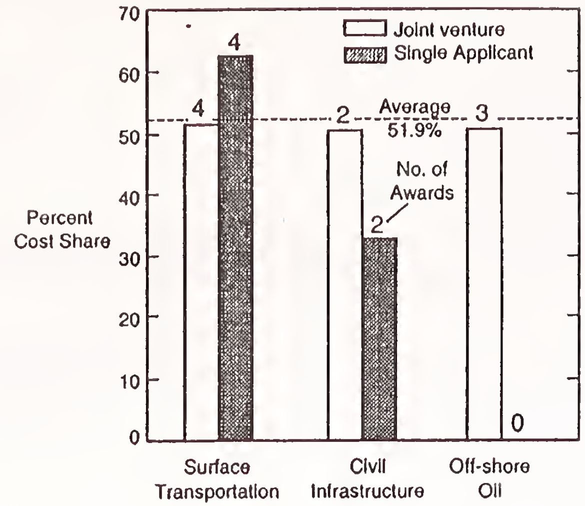
Total		52.5

MANUFACTURING COMPOSITE STRUCTURES

SOLICITATION 94-02
Cost Share by Industry



CONTACTS

TECHNICAL

Carol L. Schutte
(301) 975-6846
schutte@micf.nist.gov

BUSINESS

Subhash Kuvelker
(301) 975-5498
kuvelker@micf.nist.gov

Manufacturing Extension Partnership (MEP)

Ruth Haines
NIST

Manufacturing Extension Partnership (MEP)

Building a National Manufacturing Extension System

NIST

MANUFACTURING

EXTENSION

PARTNERSHIP

Ruth Haines
(301) 975-3593
ruth@mep.nist.gov

Mission

To strengthen the global competitiveness of smaller U.S. manufacturers.

Vision

MEP's efforts are directed at achieving a common vision: that the 370,000 small and medium-size U.S. manufacturers will be using the most suitable industrial resources, the most appropriate technologies, and the most practical solutions to continuously improve themselves, to re-energize their positions in the marketplace, and to provide high-wage jobs for a skilled and diverse workforce.

Values

- **Industry-driven and market-defined**
- Structure, strategies and services build upon **state and local resources**
- Extension centers, supporting programs and related projects are all established through **merit-based, competitive processes**
- Commitment to **high quality, continuous improvement, and innovation**
- Commitment to **performance measurement which focuses on bottom-line results** realized by client companies
- **Focus services on only those companies which demonstrate a commitment to investing in their own growth and development**
- **Focus services on activities which assist SMEs in overcoming their unique barriers to improved competitiveness**

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Ruth Haines
(301) 975-3593
ruth@mep.nist.gov

Modernizations Barriers Faced By Small Manufacturers*

- Lack of awareness of changing technology, production techniques, and business management practices
- Difficulty for owners and managers of small companies to find high-quality unbiased information, advice, and assistance
- Isolation of smaller manufacturers, which have too few opportunities for interaction with other companies in similar situations
- Regulatory environment which creates a disproportionate burden for smaller firms
- Difficulty of obtaining operating capital and investment funds for modernization

From Learning to Change: Opportunities to Improve the Performance of Smaller Manufacturers, National Academy Press, 1993

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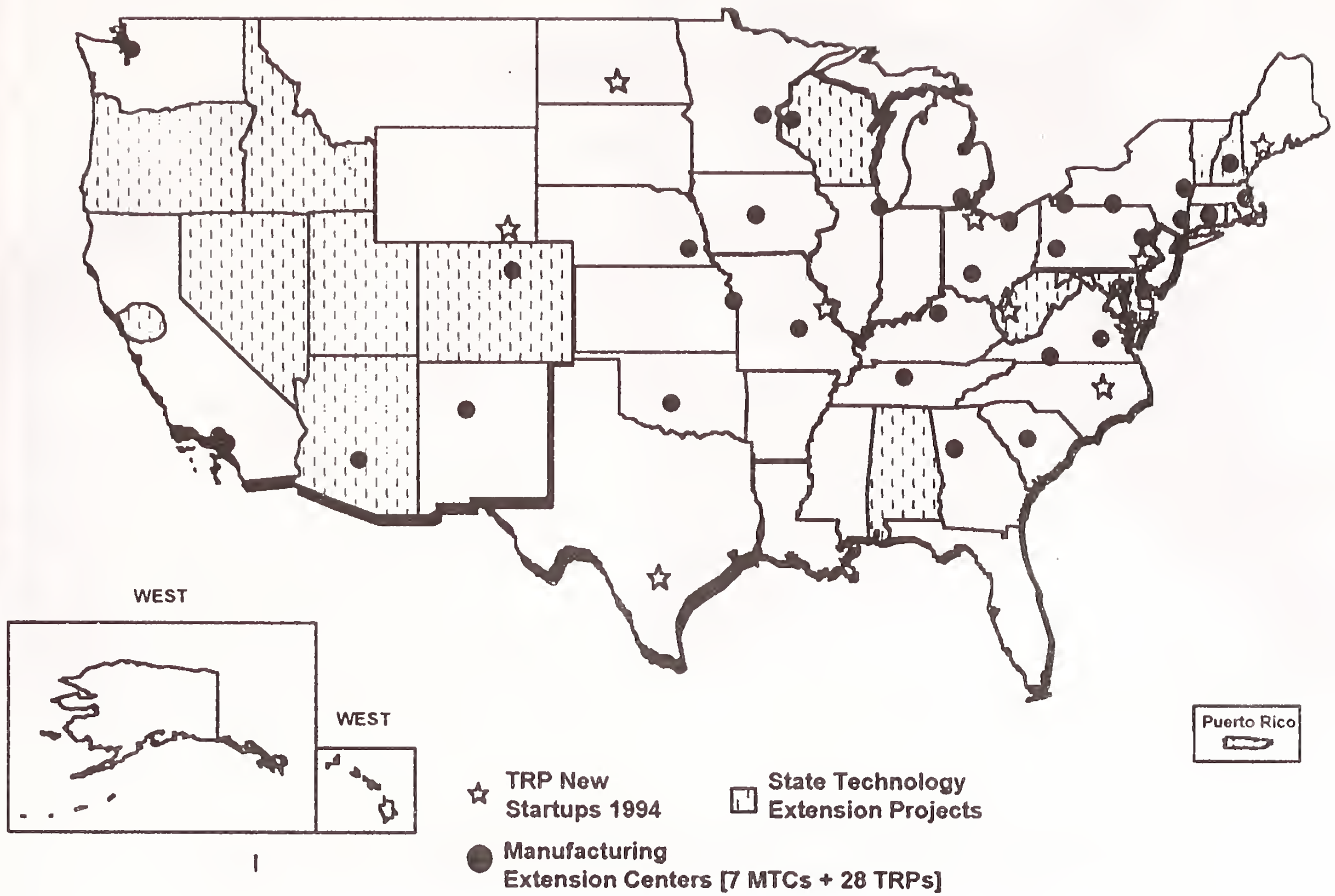
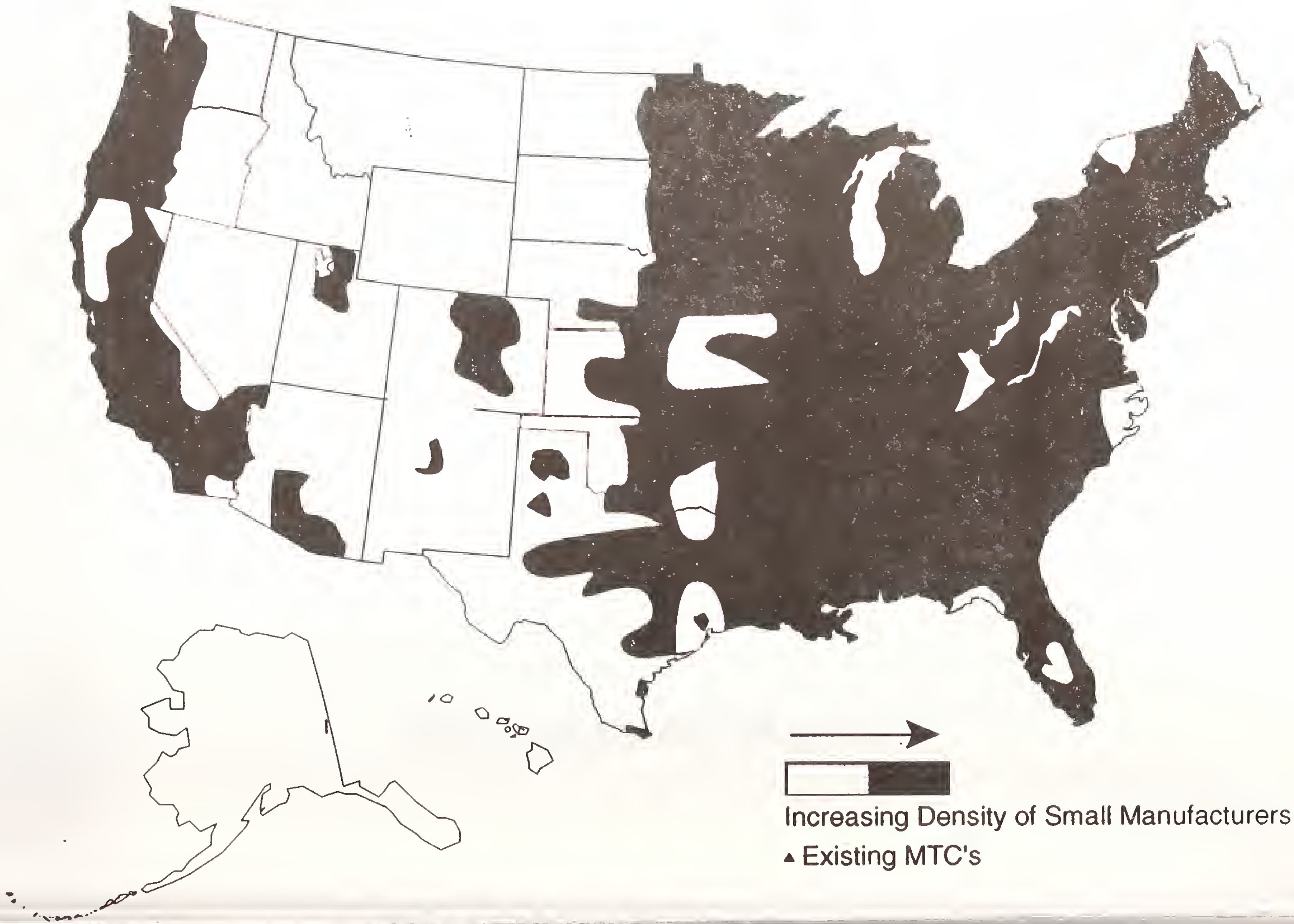
MEP National System



Ruth Haines
(301) 975-3693
March 1995

Density of Small Manufacturers in the U.S.



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BUDGET HISTORY-PROJECTIONS

($ in Millions)

Funding Source	FY 94	FY 95	FY 96
MEP	30.20	90.60	146.60
TRP	55.30	63.40	30.10
OTHER	8.60	6.50	?
TOTAL	94.10	160.50	176.70

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GROWTH CHART

Funding Source	FY 94	FY 95	FY 96	FY 97
MEP Funded	7	43	54	87
TRP Rollover to MEP	0	1	23	13
TRP Funded	28	36	13	0
TOTAL	35	80	90	100

FY95 AWARDS THROUGH COMPETITIONS

	No. of Awards	$'s (in Millions)
Manufacturing Extension Centers	est. 36	41.0
Planning Grants	TBD	6.0
TRP Awards	9	25.0

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PRIORITY SETTING

- GUIDING PRINCIPLES
  - MERIT BASED COMPETITION
  - PROVIDERS FREE TO TAILOR ASSISTANCE TO LOCAL NEEDS
  - MEP NETWORK CONCENTRATES ON DEPLOYMENT

- SELECTION CRITERIA
  - KNOWLEDGE OF TARGET FIRMS
  - DELIVERY MECHANISMS, ACCESSIBILITY OF SERVICES
  - TECHNOLOGY SOURCES
  - COORDINATION AND ELIMINATION OF DUPLICATION
  - MANAGEMENT AND FINANCIAL PLANS

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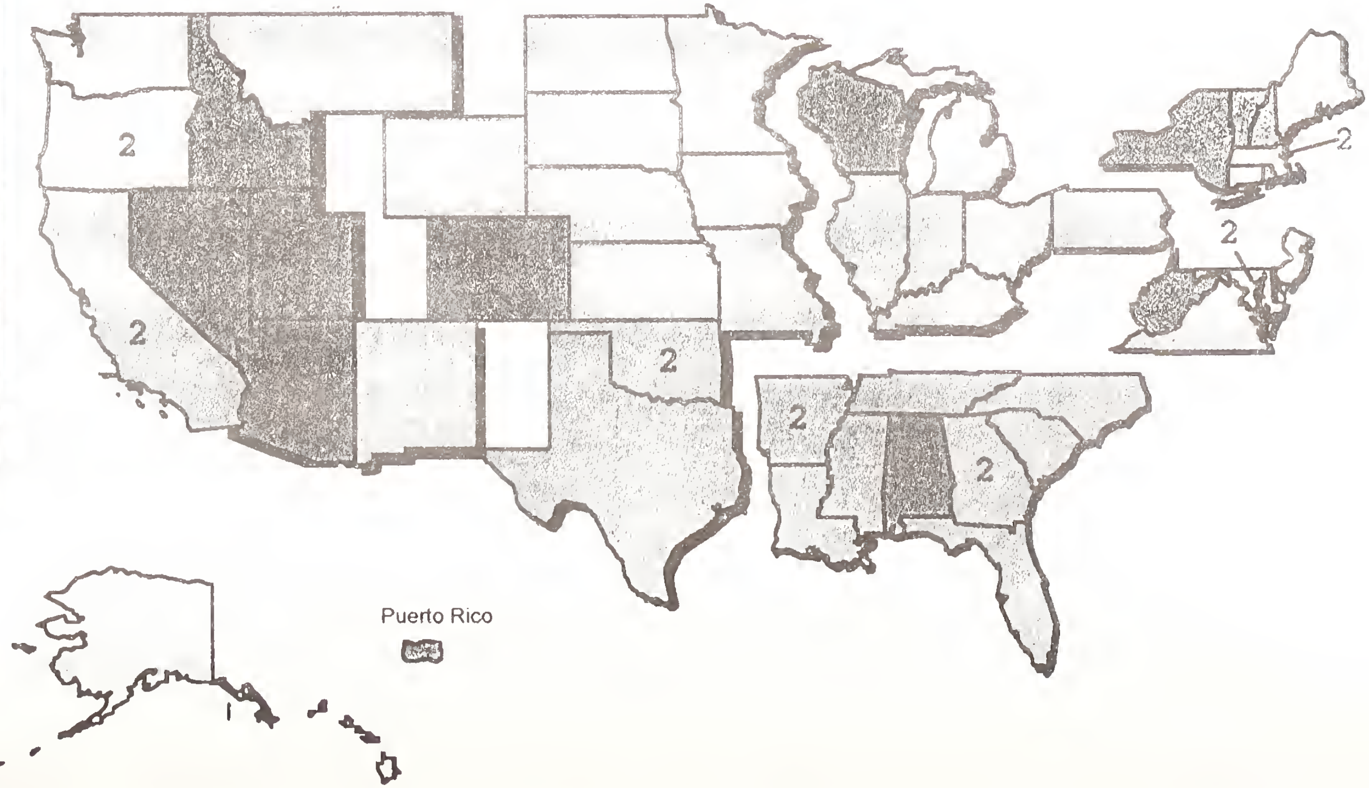
STEPS: PAST AND PRESENT

Current State Technology Extension Projects (STEPs)

STEPs Awarded Since 1991



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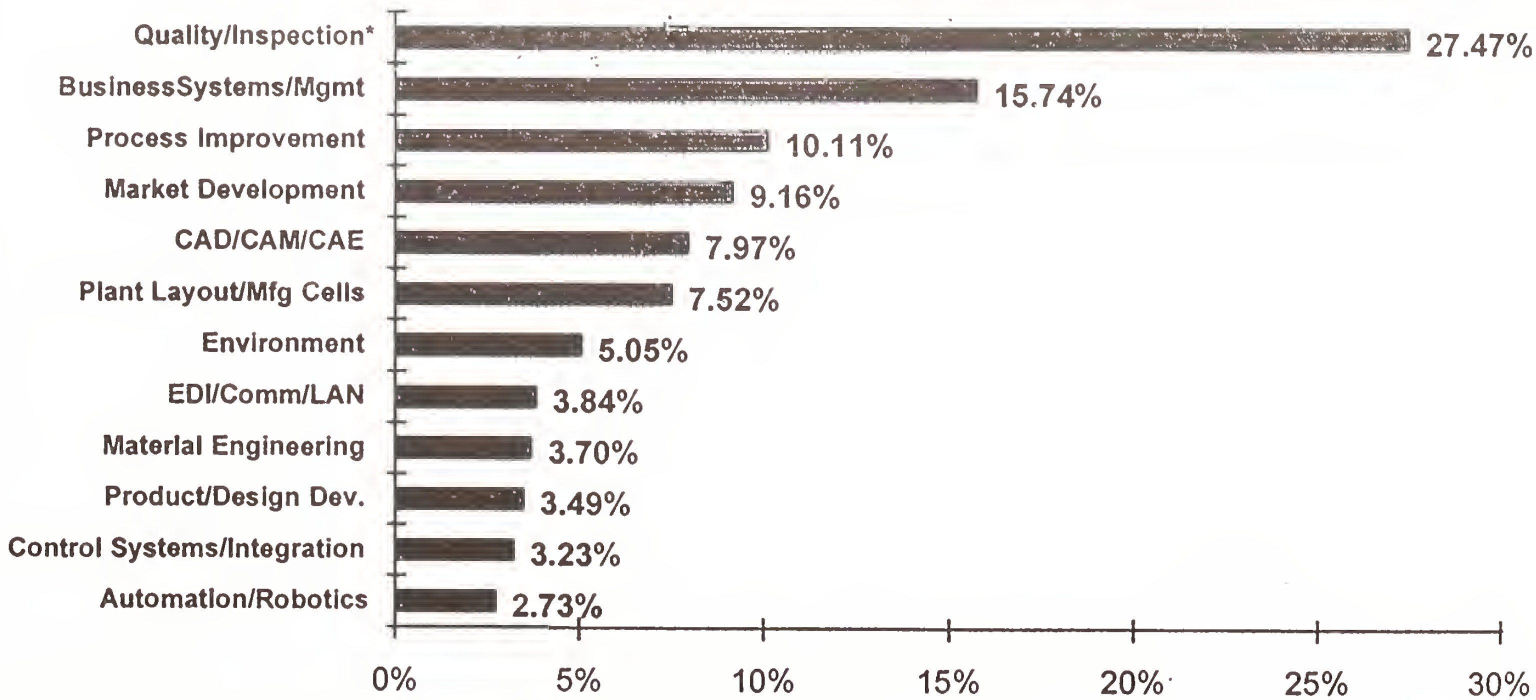
GLMTC Services

Assessments	-	Wastes Reduction Human Resource	Regulatory Operations (SITE/Quickview)
Information Resource	-	Linked to 3,000 Electronic Databases	
Shop Floor	-	Capital Equipment Planning Mfg Process Improvement	Setup Reduction Machine Downtime Reduction
Quality System	-	ISO 9000 Pre-certification SPC Vendor Qualification	Quality Audits TQM Quality Plans
Business Management	-	Software Selection Audits JIT	EDI Data Collection and Barcoding MRP II
Environmental	-	Energy Audits Recycling Audits	Waste Management Regulation Translation
Mfg Engineering	-	Plant Floor Layout Cellular Mfg	Automation CAD/CAM/CAE
Human Resource	-	Communication Systems Skills Training	Management Training
Consortia Management	-	ISO 9000 Surface Finishers	

Type of Activities Performed by Seven Original Manufacturing Technology Centers

(July, 1993 - June, 1994)



*690 of all projects mentioned quality/inspection as one of the purposes of the project (Double counting was allowed)

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Bottom-Line Impacts

- To date, the MEP program has reached more than 25,000 small manufacturers.
- Client companies have reported benefits of more than $8 for every federal dollar centers have received .
- Clients who report benefits from MEP service, on an average per project basis, report 5 and half jobs added or saved, $43,000 savings in labor and material costs, and an increase of over $369,000 in sales.
- Client companies are up to six times more likely to plan technical improvements than similar unserved companies.
- 1,700 improvement projects were initiated last quarter, and 5,600 over the last calendar year.
- The MEP system currently includes 44 centers with over 250 affiliates and more than 500 public and private "linked" organizations providing quality services directly to small manufactures.

Ruth Haines
(301) 975-3593
March 1995

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Profile of MEP Client Companies

- Median size of MEP Client Company is <u>50 employees.</u>
- Median sales of MEP Client Company is <u>$5.4 million.</u>
- Median Age of MEP Client Company is <u>26 years old.</u>
- Of all the MEP manufacturing clients, <u>63% are in SIC Code 34-38</u>

Ruth Haines
(301) 975-3593
March 1995

Note: SIC34: Fabricated Metal Products, 35: Industry Machinery & Equip., 36: Electronic and Other Electric Equip., 37: Transportation Equip., 38: Measuring and Controlling Devices

Source: Dun & Bradstreet's 1994 survey of original seven Center's clients

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Ruth Haines
(301) 975-3593
ruth@mep.nist.gov

Action Areas of MEP Client Companies

Most frequent actions over the past five years...

- CAD/CAE
- Overall assessment of business operations
- Implementation of health and safety programs
- Computer-based information systems/networks
- Market development and market strategy

Top actions planned over the next 5 years...

- Certification or quality standards (e.g. ISO 9000)
- Development or expansion of worker technical training
- Development or expansion of management training
- Empowerment
- Compensation and benefits systems
- Electronic data interchange (EDI)

Source: Dun & Bradstreet's 1994 survey of original seven Center's clients

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MEP Impacts in 1994:
13 of 35 Reporting Centers

As a direct result of activities with MEP, companies reporting benefits anticipated the following impacts...

	Yearly Totals	Project Average for Year
Change in Sales	$225,000,000	$369,000
Capital Spending	$54,000,000	$88,000
Capital Avoidance	$4,000,000	$7,000
Reduction in Inventory	$13,000,000	$22,000
Labor&Material Savings	$26,000,000	$43,000
Jobs Created or Saved	3,417	5.60

Total Impact* for 13 Centers in 1994: $167,000,000

Federal Funds for 13 Centers in 1994: $20,000,000

*: This includes 60% of sales, capital avoidance, 10% of inventory and labor & material savings

Source: 610 companies returning surveys, January 1994 - December 1994, from 13 reporting centers

Ruth Haines
(301) 975-3593
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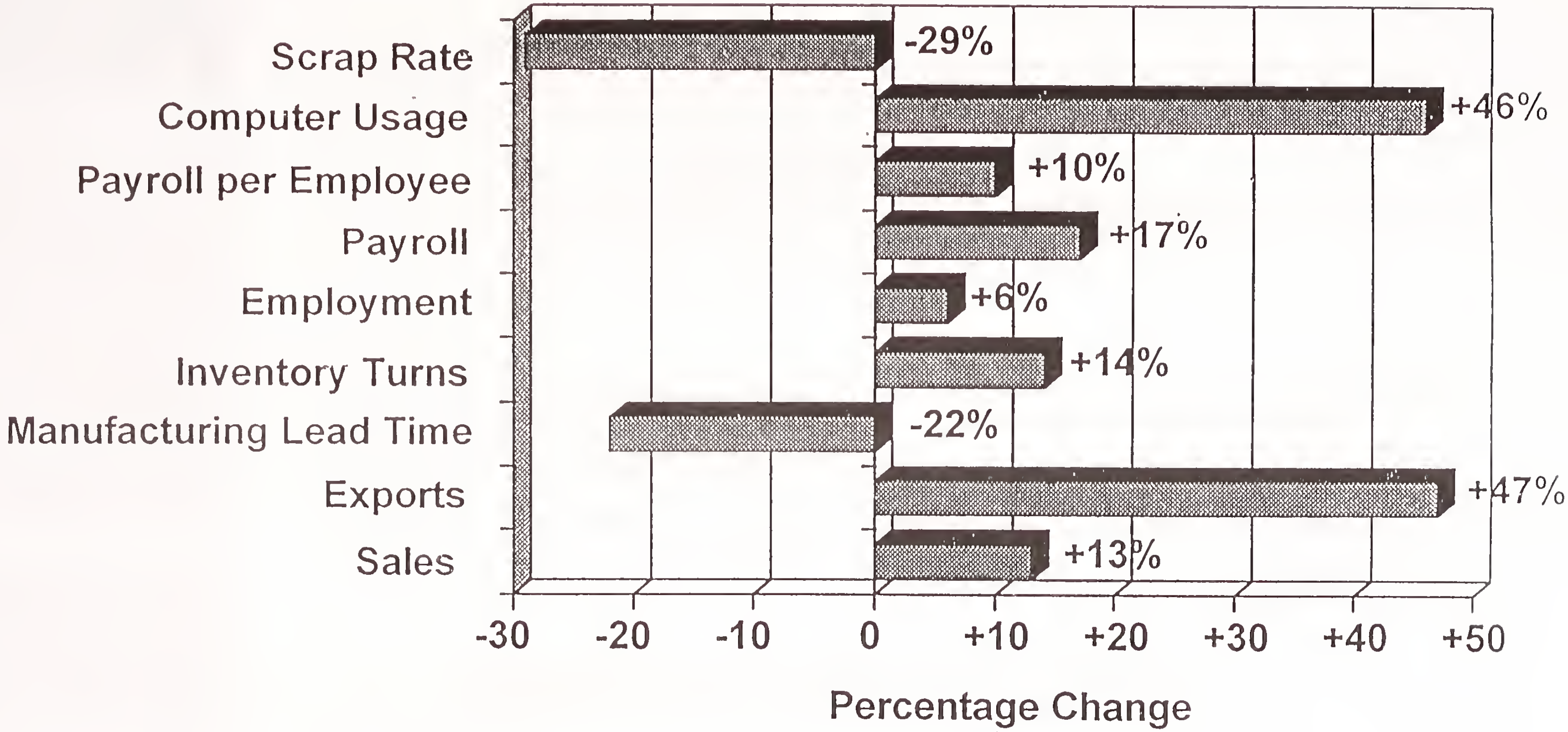
MEP Outcomes: Client Progress Surveys



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Return on Federal Dollars

Total company reported impacts in 1994 of $167 million, compared with $20 million in Federal Funding for 13 reporting Extension Center translates into...

$8 company impact for every $1 federal dollar

...received by reporting Extension Centers

Ruth Haines
(301) 975-3593
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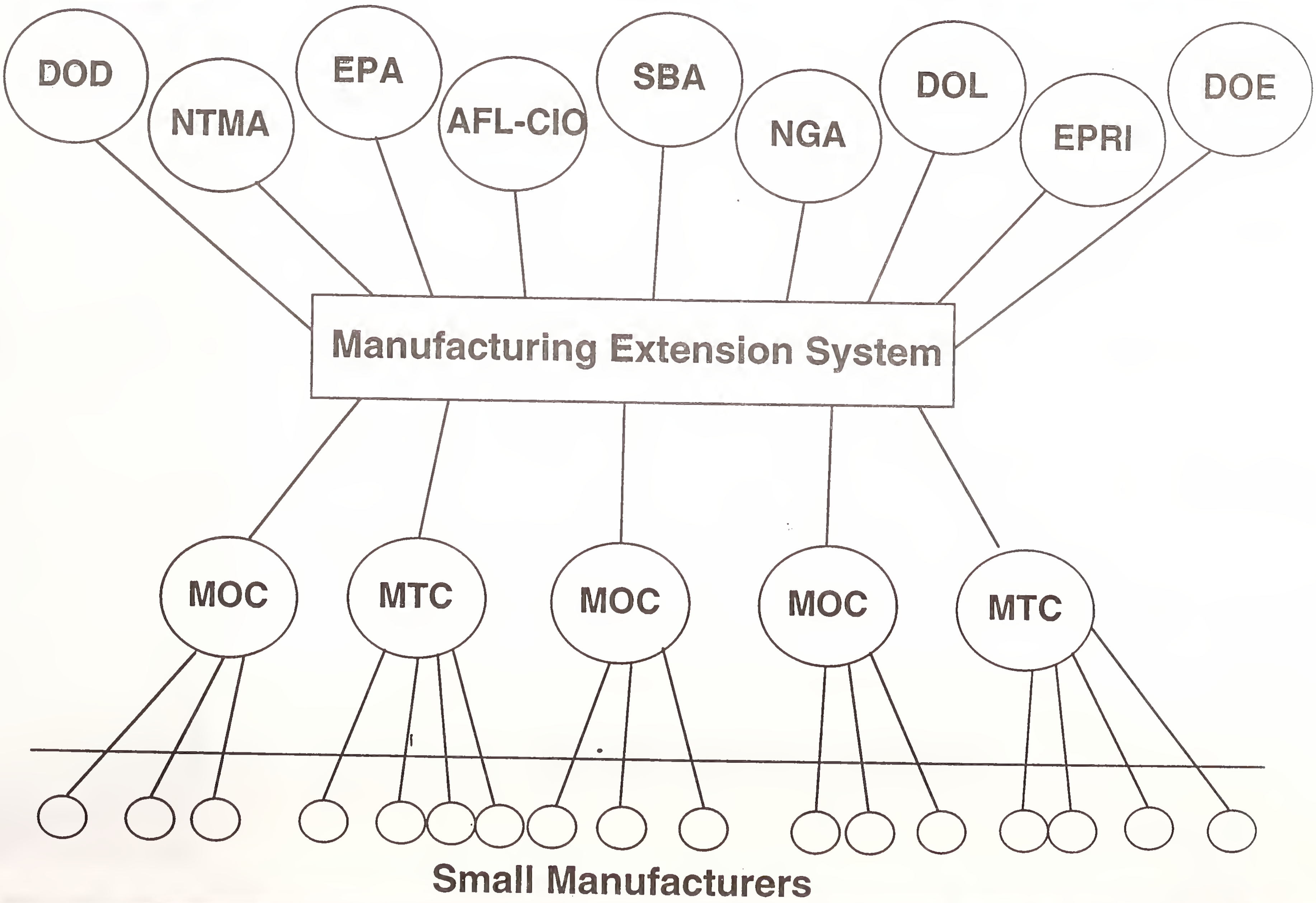
CORE PROCESSES

- Establishment of manufacturing extension service delivery partnerships
- Maintenance of manufacturing extension service delivery partnerships
- Integration of service delivery into a national system
- Add value through the establishment of strategic partnerships for products & services which complement the national system
- Continuous innovation of the manufacturing extension service delivery process

Coordinated Service Delivery Through MEP



NIST

MANUFACTURING

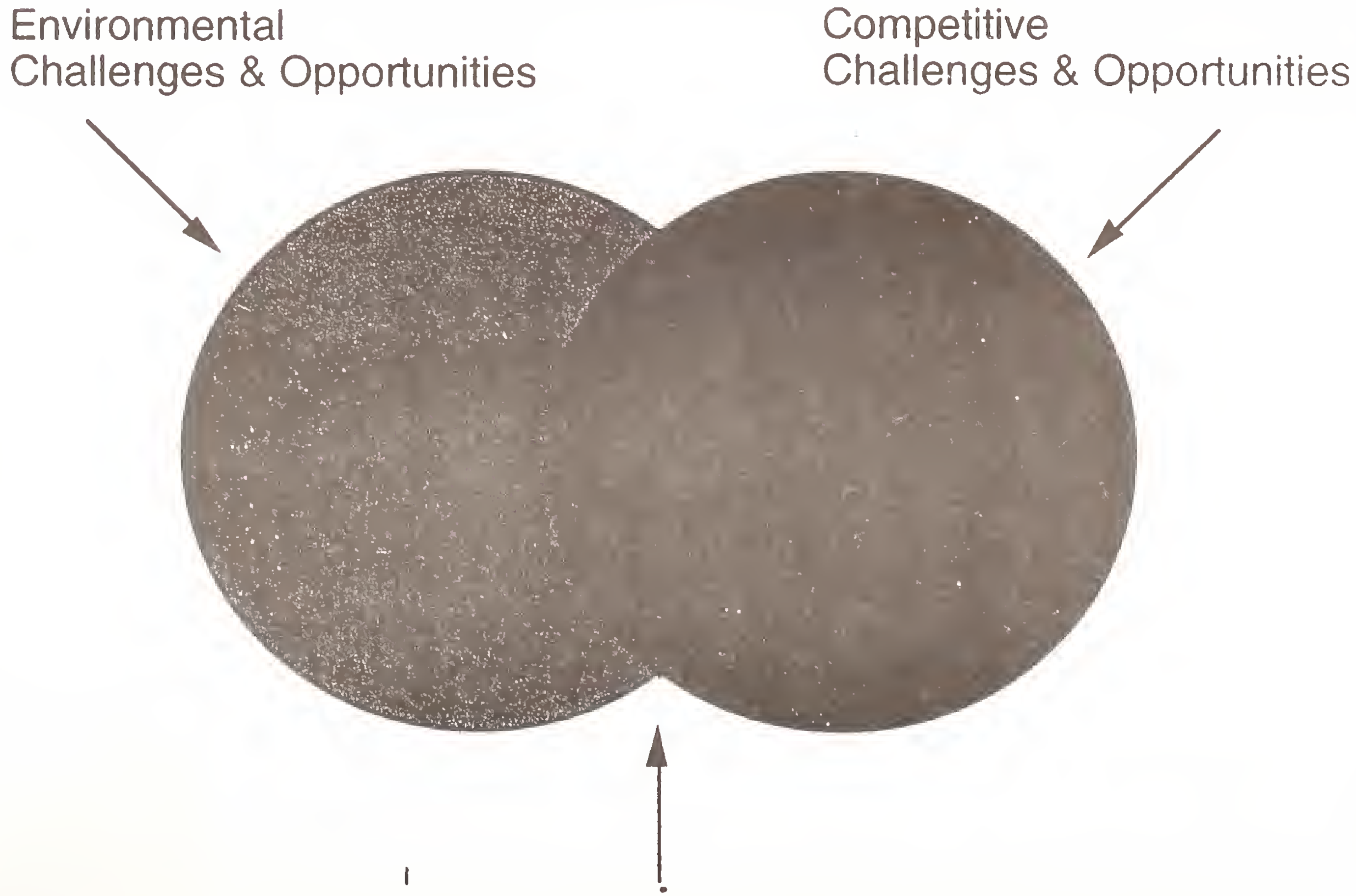
EXTENSION

PARTNERSHIP

Environmental Objective of MEP

Enable smaller manufacturers to implement technologies and techniques which allow them to be environmentally competitive.

Environmental Competitiveness



NIST *Manufacturing Extension Partnership*

NIST

MANUFACTURING EXTENSION PARTNERSHIP

Environmental Strategic Plan

MEP's Strategies for Overcoming these Barriers

■ = has an effect

Barriers to Environmentally Conscious Manufacturing

		Technical Knowledge Barriers	Technical Barriers	Regulatory Knowledge Barriers	Regulatory Barriers	Financial Barriers	Institutional Barriers
1.	Increase Access to and Use of High Quality Environmental Assistance	■	■	■	■	■	■
2.	Create Access to Seamless Coordinated Environmental Technical Assistance	■	■	■	■	■	■
3.	Create, Integrate & Increase Access to Intellectual & Informational Tools	■		■			
4.	Catalyze Initiation of Needed R & D		■				
5.	Catalyze Changes in Regulatory Enforcement				■		
6.	Create Mechanisms for Reducing Financial Barriers						

MEP's Environmental Solicitation

- For cooperative agreements on projects which will promote the competitiveness and environmental soundness of smaller U.S. manufacturers.
- 3 Areas
  - Integration of environmental services into centers
  - Development of environmentally related technical assistance tools and techniques
  - Pilot for National Metal Finishing P2 and Environmental Compliance Information Center

Coordination of Technical Assistance

- Co-sponsorship of National P2 Roundtable
- Joint EPA-NIST brochure promoting cooperation
- Letters to P2 Programs in states with MEP planning awards.
- MEP/state P2 program cooperation/integration in several states
- MEP Environmental Operations Group
- Process for Joint Selection of Future Awards
- Visiting Staff from RREL

NIST MANUFACTURING EXTENSION PARTNERSHIP

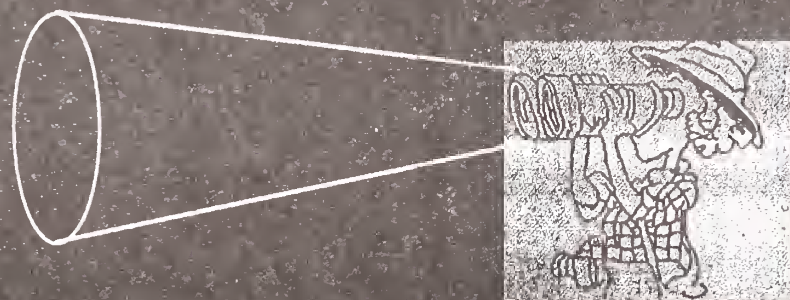
Current Environmental Activities

- Recycling Technology Assistance Partnership
- Los Angeles Pollution Prevention Center
- Energy Environment and Manufacturing assessment methodology and environmental benchmarking project
- Pollution prevention & environmental assistance at an increasing number of MECs

Access to Services

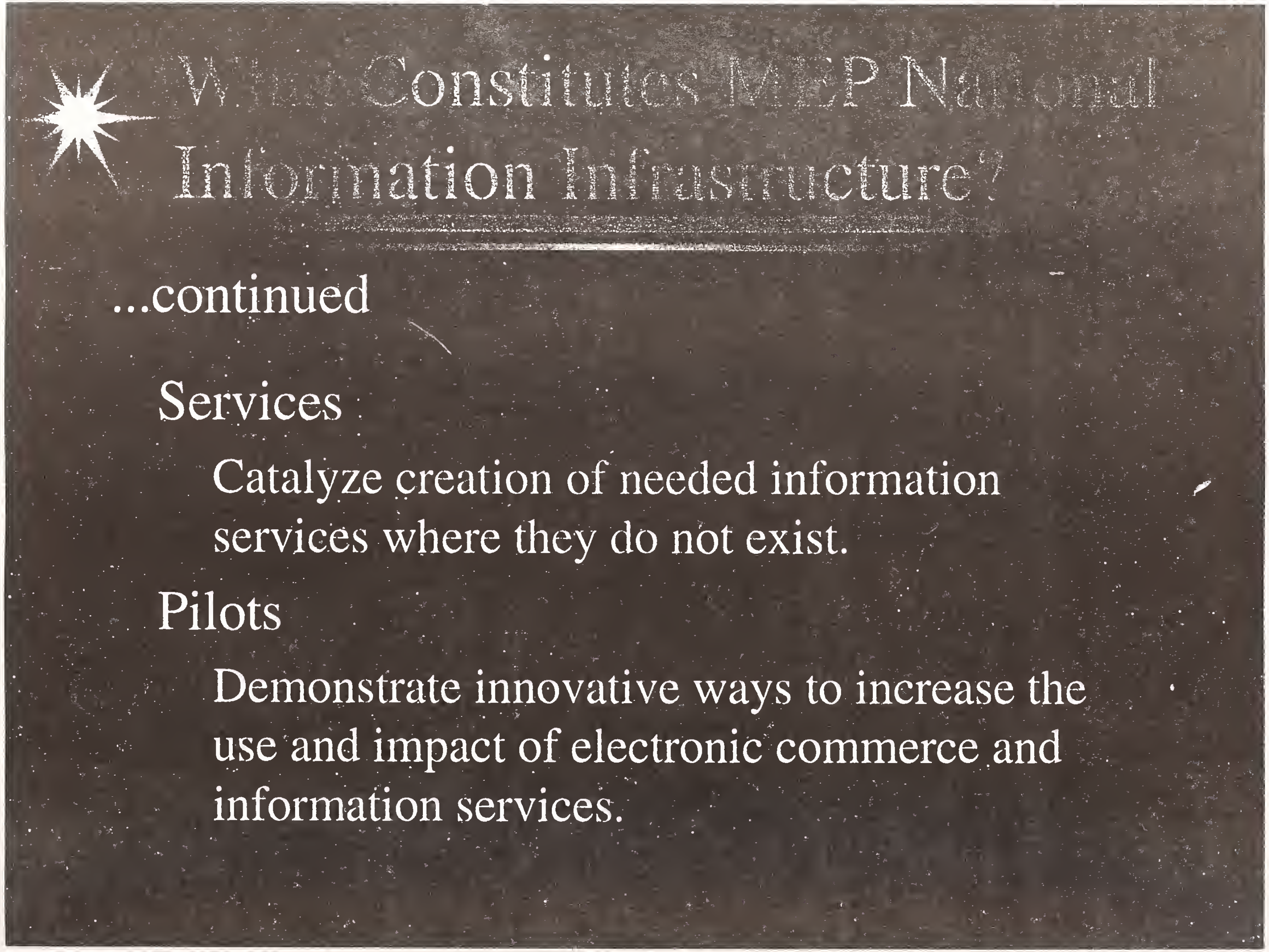
WWW

- Access to enormous volume of information (too much?) .



Focused and Specialized Services

- Focused access to useful information.
- Access to some proprietary data sets.
- Specialized services for MEP field engineers.


What Constitutes MEP National Information Infrastructure?
...continued
Services
Catalyze creation of needed information services where they do not exist.
Pilots
Demonstrate innovative ways to increase the use and impact of electronic commerce and information services.

The MEP Electronic Network

- A Virtual Network
  - Internet based.
  - World Wide Web (WWW) technology.
- Why Not a Proprietary Network?
  - No major security issues that cannot be addressed on Internet.
  - Internet can handle expected data volume.
  - Industry movement is towards Internet.
  - Internet access is relatively inexpensive.

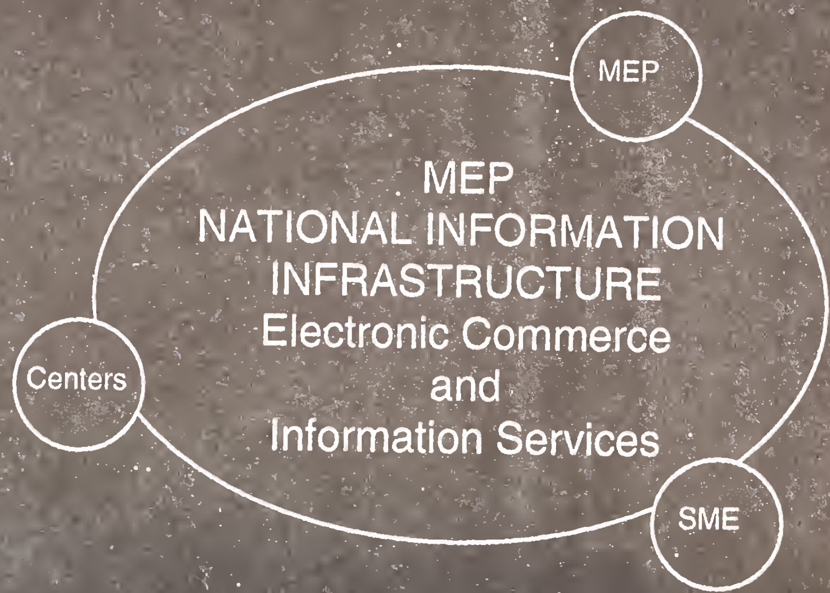
What Constitutes MEP National Information Infrastructure?

Connectivity

Centers have the needed electronic network connections.

Access

Centers have access to existing useful information services.



continued...

Manufacturing Science and Technology Program (MS&T)

Dudley Caswell - DDR&E/DTAO
Dan Cundiff - DDR&E/DTAO
Col. Steve Maness - Army
Richard L. Remski - Wright Patterson AFB
Michael Hitchcock - Wright Patterson AFB
John Fenter - Wright Patterson AFB

Manufacturing Science and Technology

DoD Initiaives

Dudley Caswell
DDR&E/DTAO
(703) 756-8975

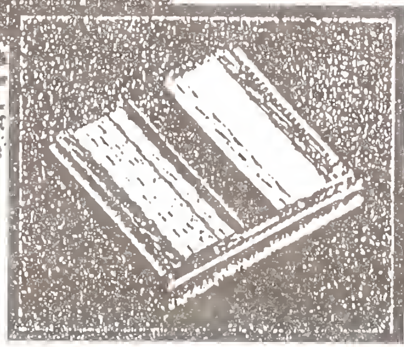
March 8, 1995

IRFPAs ADDRESS A WIDE RANGE OF MILITARY SYSTEMS

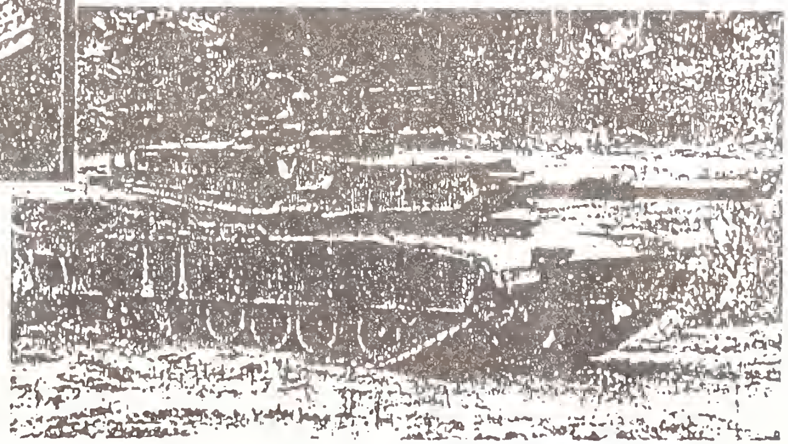
ARPA MTO

IRFPA Cost Reductions and Product Improvements Enable a New Generation of Infrared Systems

- Address IR material, array fabrication, and packaging
- Support advanced system requirements



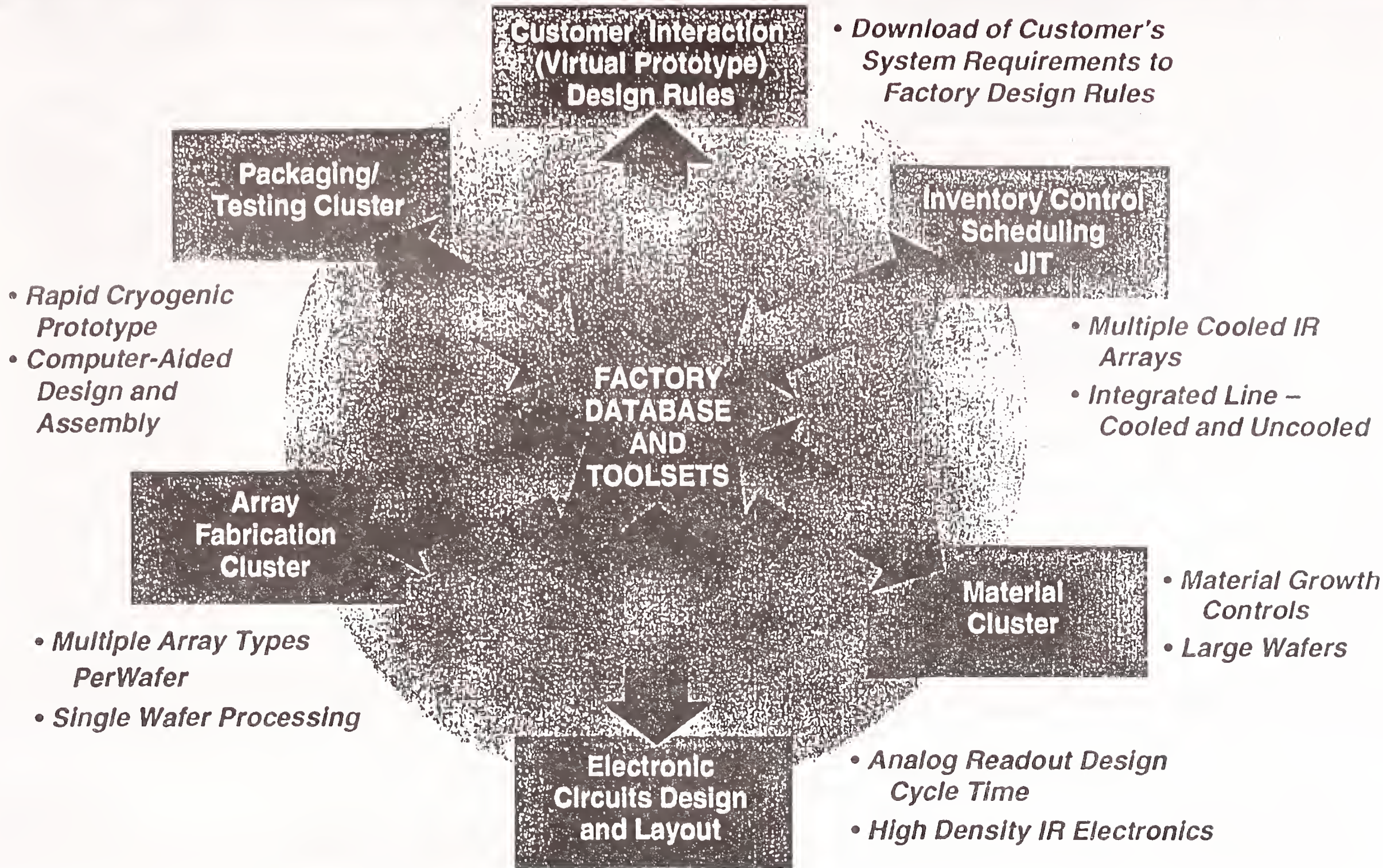
- IRFPA products achieve state-of-the-art performance



- Faster frame rate for wider field of view and faster update
- Higher sensitivity
- Higher MTF and correctability for improved image quality

4008-3-31--95-21

MAJOR COMPONENTS OF FLEXIBLE IRFPA PROCESSING AND ASSEMBLY



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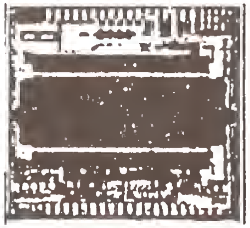
SCANNING IRFPA PRODUCTS

A Family of IRFPA Modules for IR Systems

ARPA — MTO

IRFPA

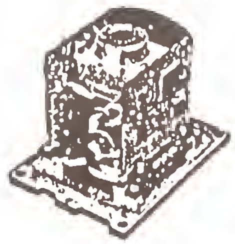
Photodiode technology
- 1 mm CMOS ROIC
- Single-chip IRPFA
- Pixel deselect and auto gain adjust
- Proven performance



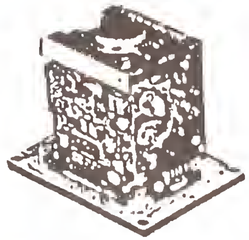
240x1 or x2

240/288x4

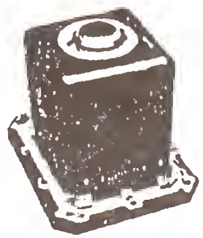
480x5



SADA IIIA



SADA IIIB



SADA II

Dewar Modules

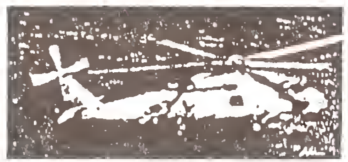
- Broad family of modules
- Commonality
  - Design
  - Components
  - Processes
- Industry standard
- Products available

Applications

- Manportable IR sights
- Smart weapons
- Navigation and targeting FLIR
- Advanced fire control
- Infrared search and track
- Advanced target acquisiton

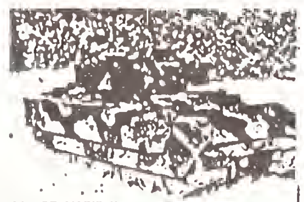
JAVELIN CLU

JAVELIN
JSOW P3I
Mini FLIR



LAMPS

LAMPS
DNTSS
Special Ops
V-22
P3/S3

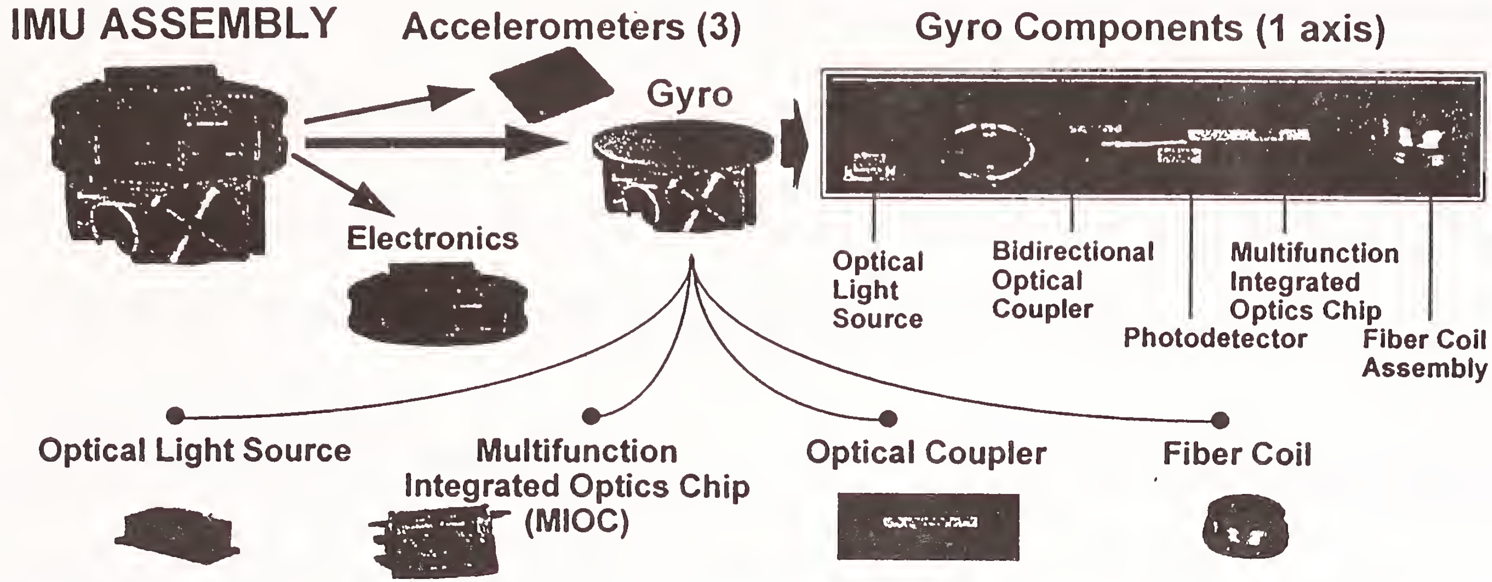


IBAS

HTI
IBAS
ITAS
CITV
LOSAT

4008-3-31-95-19

INTERFEROMETRIC FIBER OPTIC GYROSCOPES



Optical Light Source
- Device screening
- Testing
- Pigtailing & Packaging
- Thermal stability

Multifunction Integrated Optics Chip (MIOC)
- Batch fabrication processing
- Automated die testing
- Pigtailing & Packaging
- Die-to-die connection

Optical Coupler
- Improve processes
- Cost & yield
- Pigtailing & Packaging
- Optimize miniaturization

Fiber Coil
- Automated winding
- Reproducibility
- Coil miniaturization
- Minimize environmental effects

Photo Courtesy of MICOM Manufacturing Technology Office

Program Objectives

Objectives:

- Develop Technologies to Support Cost Effective, Automated, Flexible IFOG Fabrication
  - Large Volume Batch Processing of Optical Parts
  - Robotic Assembly and Automatic Test
  - Multi-Grade IFOG Production Capable
  - Production Costs: <$1500/axis for Navigation-Grade Instruments

Program Approach

Approach:

- Automated Precision Interconnects (Splices)
  - Optical Parts
  - Subassemblies

  ⇒
  - Maintain Polarization
  - Very Low Losses
  - Minimize Cross Coupling
- Environmentally Robust Packaging
  - Sources
  - Coils
- Effective Automated Precision Winding
- Volume Production of Integrated Optic Chips
- Automated Assembly and Test

Admin/13Apr93/4

Accomplishments to Date

- Established a Tri-Service Team - Nov 93
- Conducted Workshop to Obtain Industry Views - Mar 94
  - Critical Areas for Additional Efforts
  - Approaches to Achieve Low Cost, High Performance IFOGS
  - Automated Assembly and Test
- Published BAA for White Papers - Nov 94
- Evaluated White Papers and Proposals Responding to BAA
  - Selections Made
  - Awards Underway

Transition Opportunities

IFOG Insertions into GGP

- ARPA/NAVAIR MoA Signed 20 Dec 1994 to Transition to Aircraft Applications in FY98
- Draft MoA in Progress with Army for Guided MLRS/ATACMS
- Draft MoA in Progress with JAST for Precision Strike Demonstration
- ACC/DR Supports Exploiting Technology for Precision Strike Applications

ARPA

Affordable Multi-Missile Manufacturing (AM3)

- Missile procurement has dropped since late 1980's
  - **3:1 reduction in funding ($9B → $3B)**
  - **7:1 reduction in quantities**
- DoD program managers attack costs one program at a time
  - **Constrained by current factories and procurement regulations**
- ARPA/Tri-Service AM3 objectives
  - **Demonstrate ways to get economies of scale from missile mix ("family of parts" designs, flexible programmable factories)**
  - **Demonstrate combined effects of new technology and new business practices**
  - **Reduce the total cost of the tactical missile portfolio in 2000-2005**
    - » Save 25% in ongoing programs, 50% in new development and modification programs

ARPA

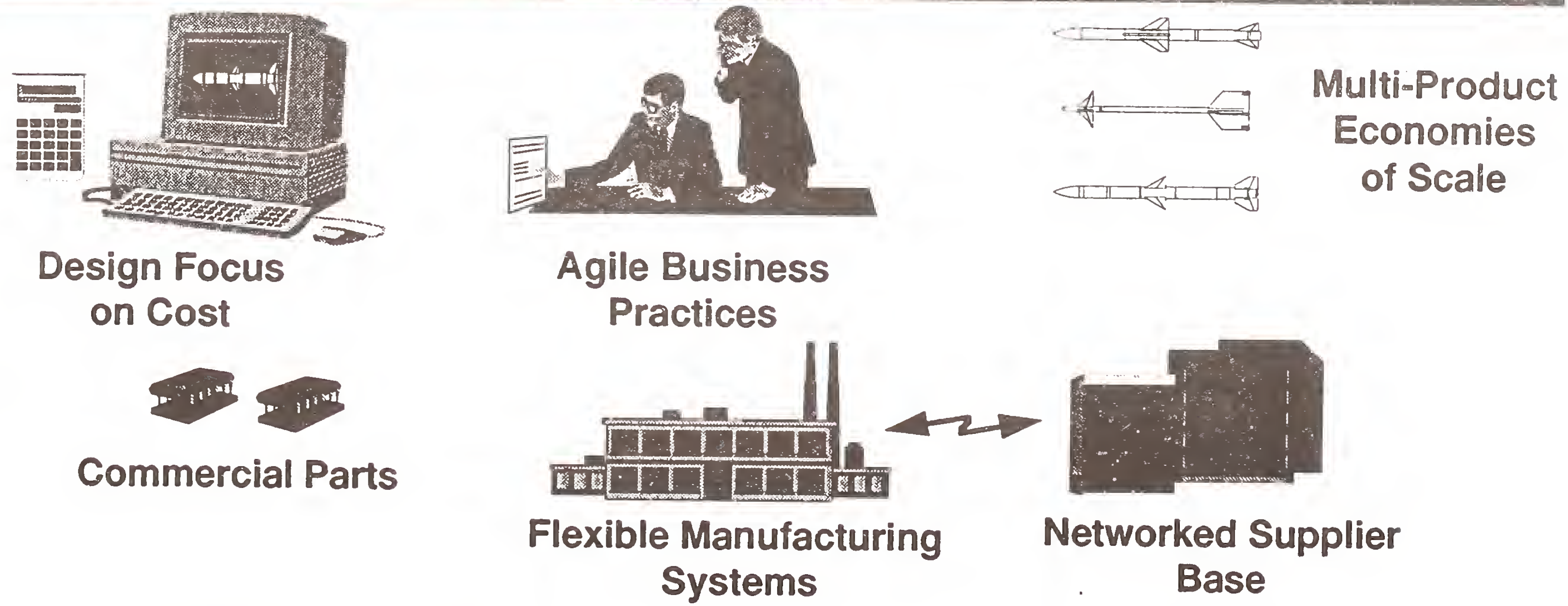
AM3 Concepts for Cost Reduction

- Common Modules/Components
  - Scaleable families of parts for missile seekers
- Integrated Flexible Factories
  - Multi-Product Centers (IR, RF, All-Up-Round)
- Enterprise Systems
  - Networked Linkage with Suppliers and Customers
  - Extensive use of commercial parts, commercial manufacturing sources
- IPPD Environment
  - Collaborative design, virtual prototyping, virtual factories
  - Use enabling technologies from other ARPA programs (MADE, RASSP, SBD, IRFPA,...)
- Acquisition Reform
  - Alternatives to MILSPECs, ISO 9001 Quality System, Activity-Based Costing

ARPA

Affordable Multi-Missile Manufacturing

AM3



Objective

- Demonstrate feasibility of saving 25-50% through
  - -- Scalable family-of-parts designs for IR and RF seekers
  - -- Flexible, progammable multi-product factories
  - -- Maximum use of commercial parts and practices

ARPA

Teams Selected for AM3 Awards

- Loral Vought Systems

  Loral Aeronutronic, Rockwell, McDonnell Douglas, Northrop Grumman, Loral Infrared, Honeywell, Lucas, Loral Fairchild, Westinghouse, Kodak, CTA, ARRI

- Martin Marietta Electronics and Missiles

  Alliant Techsystems, Martin Marietta Advanced Technology Labs, LIRIS, General Electric Corporate R&D, Hewlett Packard, Lockheed AI Center, Enterprise Integration Technology

- Raytheon Company

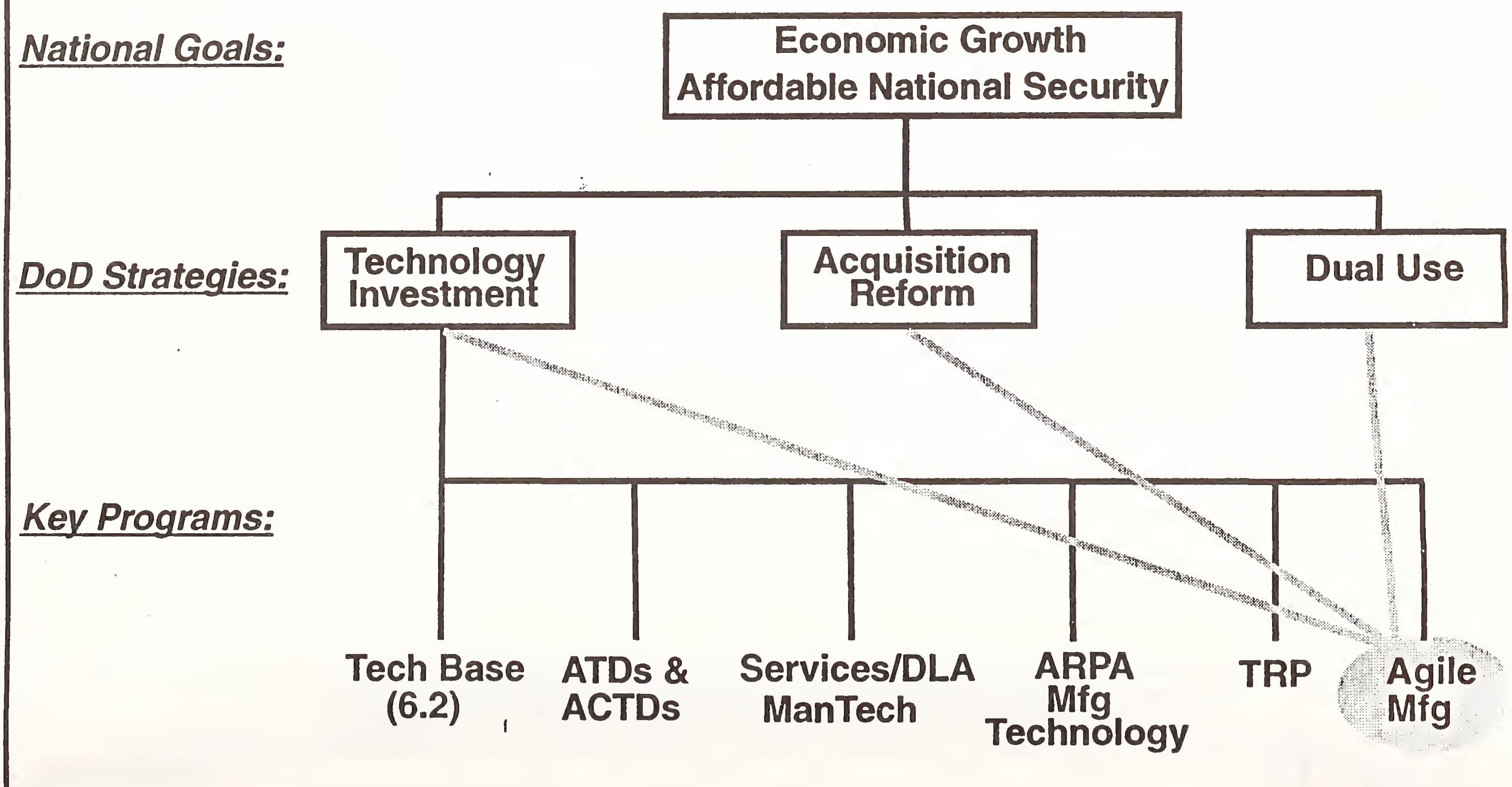
  Amber Engineering, Kearfott, Photronics, Rockwell-Collins, SRT, Carnegie Mellon University, DENEB Robotics, Motorola University, STEP Tools, Inc.

- Texas Instrument/Hughes Missile Systems Company

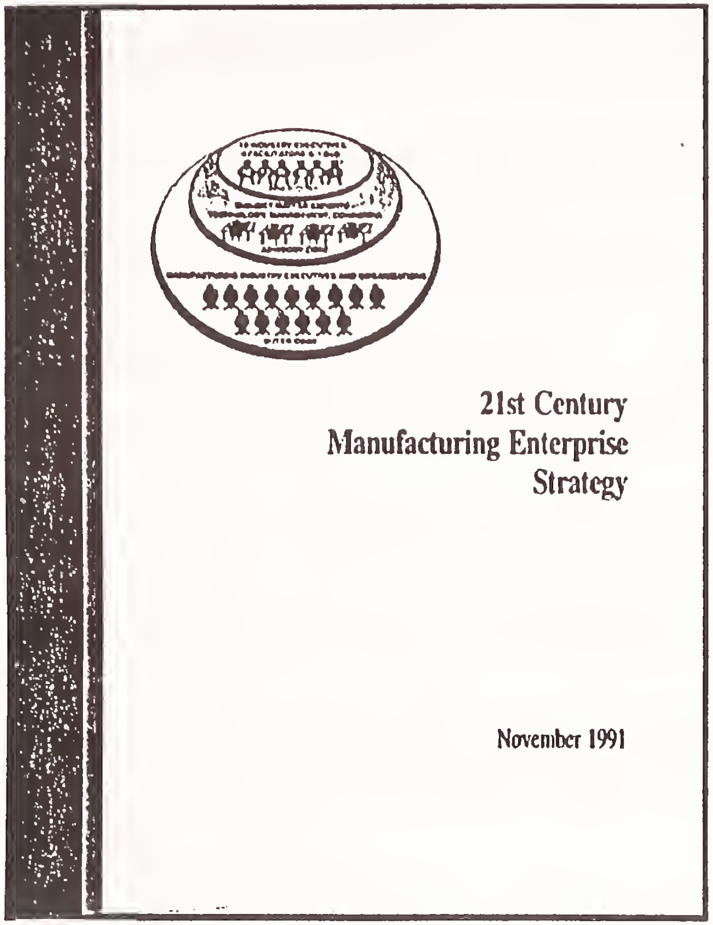
  Motorola, SAIC, Arizona State University, NCMS, Stanford, Texas A&M, PTC, Mentor Graphics, ACI, TI Semiconductor, GM, Merkle & Mears

  Optional Partners: Sandia National Lab, NIST

Strategies for Affordable Defense



Background


21st Century
Manufacturing Enterprise
Strategy

November 1991

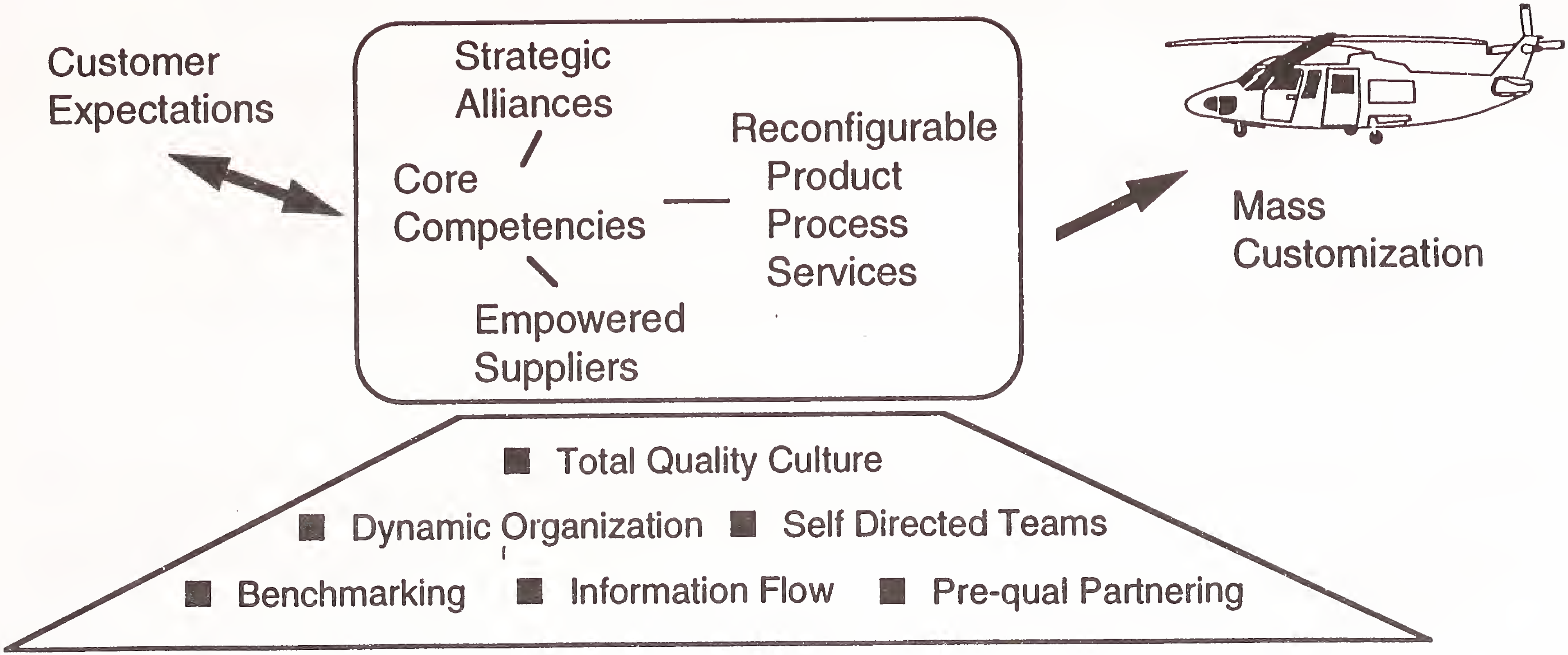
- DoD Sponsored, Industry-Led Study (1991)
- New Paradigm: Agile Manufacturing
- Strong, Industry and Congressional Support
- Multi-Agency Involvement

VISION

- Increasing global competition and technological advances are creating a dramatic shift in manufacturing technologies and business practices.
- These changes require more competitive manufacturing enterprises, with core business strategies focused on assuring the ability to succeed in an environment of continuous, dynamic change.
- Enterprise survival will depend increasingly on the ability to respond quickly to demands for high-quality, market-driven products at the lowest possible cost.

Virtual Enterprise Strategy

Virtual Enterprise: a Reconfigurable, Computer-Networked, Customer Solutions Delivery System



Impact on DoD

- Expanded Envelope for Defense Products from Commercial Enterprises
- Reduced Time and Costs for New/Modified Weapon Systems
- Robust Industrial Base for Future Military Needs
- Enhanced Readiness and Rapid Response in Times of Crisis

Agility and Related Terms

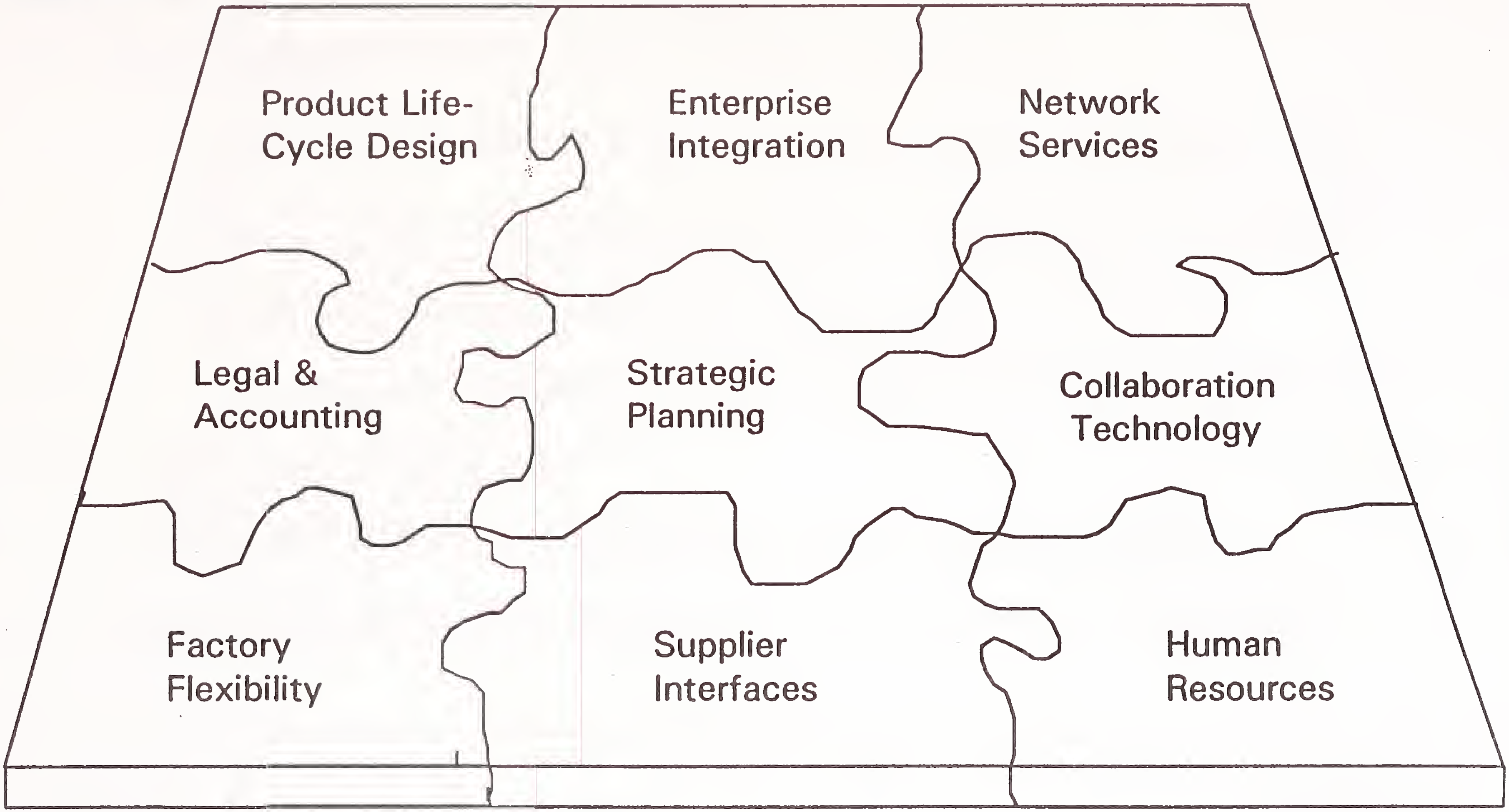
Different Aspects of World Class Manufacturing

- **Flexible Manufacturing**
  - Structure
  - Shop Floor Focus: Process Adaptability
  - "Lot Size of One with First Pass Success"
- **Lean Manufacturing**
  - Set of Practices
  - Interior Focus: Cost Reduction Throughout the Enterprise
  - "Eliminate Waste"
- **Agile Manufacturing**
  - Strategy
  - Exterior Focus: Enterprise Ability to Thrive on Unpredictable Change
  - "Reconfigurable Everything"

AGILE MANUFACTURING

- FY 93
  - Agile Manufacturing Network (Agile Web (EINet)) Pilot
  - Agile Manufacturing Enterprise Forum (AMEF)
  - Manufacturing Research Initiatives (AMRIs - NSF)
  - 4 Pathfinder Projects
- FY 94
  - Maintained funding for AMEF, IFAM, and projects
  - Established BAA for Agile Manufacturing
    - Agile Business Practices
    - Enabling Technology Development/Demonstrations
    - Agile Manufacturing Pilot Demonstrations
- FY 95 & Outyears
  - Expect to maintain existing programs plus broaden program
  - Revised BAA with focus on Electronics

Fitting the Pieces Together



The Agility Forum will play a major role in integration

Agility Forum

- Focal point for industry input and guidance
- Advocate and facilitator for accelerated implementation
  - Develop, deepen, and disseminate vision
  - Promote the vision, gain CEO support
  - Provide self-assessment tools and training
  - Integrate research results into “toolkit” for agility
  - Education and training

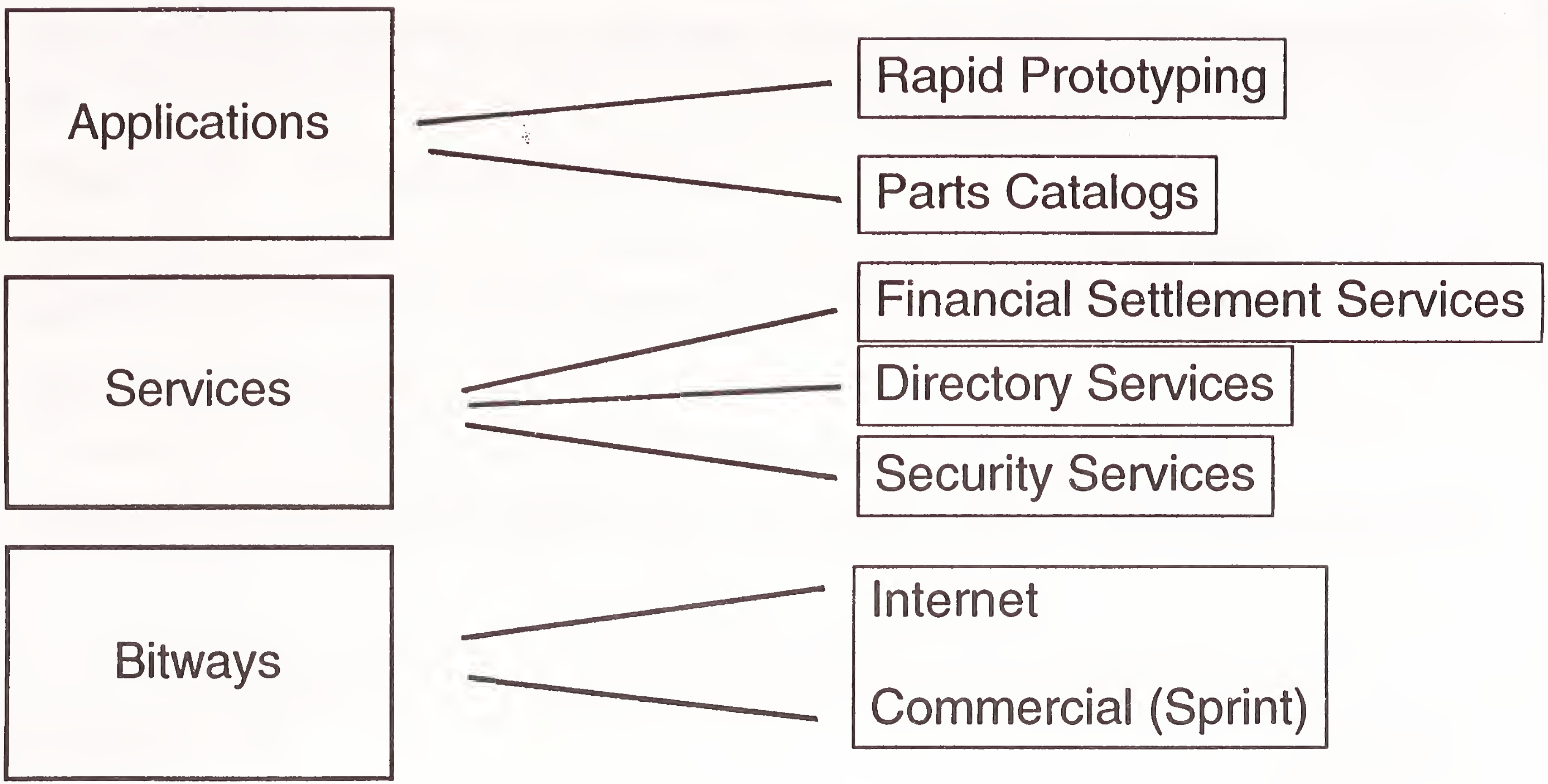
AMEF ACTIVITIES

- Agile Manufacturing Focus Groups
  - Strategic Analysis
  - Agile People
  - Agile Business Practices
    - Accounting & Financial Management
      - Includes Performance measures, Legal practices, Agile virtual enterprise, and Marketing & customer interactions
  - Agile Operations
    - IPPD, Supply Chain Mgt, Info & Control Systems
- Agile Advisory Groups
  - Agile Education and Training
  - Small and Medium Enterprise
  - Channels of Communication

AGILE MANUFACTURING RESEARCH INSTITUTES

- Agile Manufacturing Research Institutes (AMRIs) are focused on providing in-depth research for application of agile manufacturing in specific industrial sectors
- 3 AMRIs have been awarded by the National Science Foundation
  - Rensselaer Polytechnic Institute - Electronics Design and Manufacturing
  - Advanced Robotics Research Institute under the University of Texas at Arlington - Aerospace Design and Manufacturing
  - University of Illinois at Urbana-Champaign - Machine Tool Design and Manufacturing
- More AMRIs are to be awarded as additional sectors are identified as part of a national sector analysis for agile manufacturing needs

Agile Manufacturing Information Infrastrucutre—MCC Led Team



Pathfinders

ARPA

- Methodologies to analyze design and manufacturing processes for the aerospace and automotive industries—MIT
- State-of-the-art manufacturing and information management techniques in the textile/apparel industry—Georgia Tech
- An electronic commerce network linking federal labs and repair depots to electronics sector manufacturers and suppliers—Arizona State

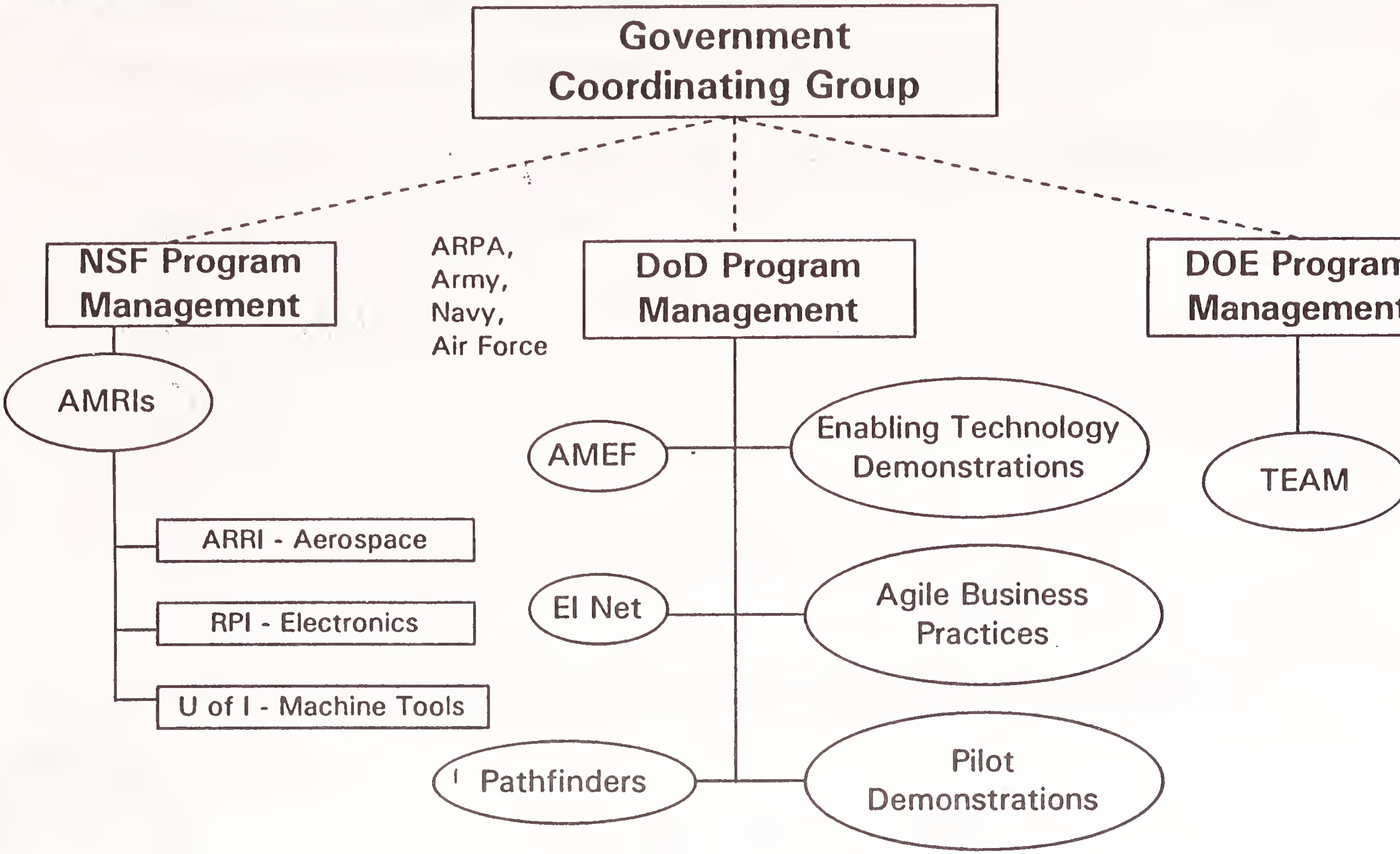
AGENCY COOPERATION

- **AGENCIES ARE PLAYING TOGETHER**
- Agile manufacturing
  - DoD BAA - DoE, NSF,NIST helping evaluate proposals
  - TRP - Five agencies cooperating
  - DoE efforts - DoD, NIST, NSF on steering board and evaluation groups
  - NSF - DoD, NIST, DoE cooperating
  - USAF Pilots - Army, Navy, OSD cooperating to evaluate proposals

A M I G

- Agile Manufacturing Implementation Group
- Informal Coordination
  - DoD
  - DOE
  - DOC (NIST)
  - NSF
- Increase awareness of agile manufacturing programs across Agencies & Industry

AMIG ORGANIZATION



ARPA BAA94-31

- Agile Manufacturing Pilot Demonstrations (AMP)
  - Integrated enterprise-level demos to set new benchmarks
  - Advanced technology and business practices
  - 3-4 years, $15-24M each (Gov't share)
- Enabling Technology Developments and Demos (ETDD)
  - Advance key technologies (e.g., Industrial C3I)
  - Include users, tool vendors, technologists
  - Phase 2 demo in pilots or ongoing programs
  - 12-24 mos, $1.5 - 3.0M each. Anticipate 5-8 awards
- Agile Business Practices Demos (ABP)
  - Combine existing technology, new business, & org concepts
  - Measures benefits in tightly focused demo
  - Insert in Pilot or ongoing programs
  - 12-18 mos, $0.5 - 1.5M each. Anticipate 5-8 awards

BAA 94-31 CRITERIA

- Provide compelling evidence to accelerate implementation
- Demonstrated technical merit & level of innovation of proposed concepts
- Magnitude and pervasiveness of impact of successful development on target user and integrated manufacturing base
- Plans/capability to quantitatively assess merits
- Credibility and thoroughness of program
- Offerrors' capabilities & related experience
- Cost realism

ARPA BAA94-31 Winners

9 - Agile Business Practices

- Labor Infrastructure for Agile High Performance Transformations
  - Work & Technology Institute
- Migration Strategies for an Agile Logistics Infrastructure
  - The Analytical Science Corporation, Inc. (TASC)
- AIAG Manufacturing Assembly Pilot Project
  - Automotive Industry Action Group
- Strategic Planning & Operating Tools for Agile Enterprises
  - Competitive Technologies, Inc. (CTI)
- Activity Based Costing for Agile Manufacturing Control
  - Industrial Technology Institute
- Metrics for the Agile Virtual Enterprises
  - Sirius-Beta
- Qualification Criteria for Agile Enterprises (QCAE) Project
  - Consortia for Advanced Manufacturing - International (CAM-I)
- Electronic Purchasing & Automated Quotation (EPAQ) System
  - EDI Integration Corporation
- MEREOS
  - ONTEK Corporation

ARPA BAA94-31 Winners

9 - Enabling Technology Development & Demos

- Agile Manufacturing Decision Support Systems
  - AT&T Advanced Technology Systems
- Hierarchical Enterprise Decision Support
  - Metron, Inc.
- Enterprise C3I Decision Support System
  - TRACOR Applied Sciences
- Process Tools for Virtual Enterprise Management
  - CTA Inc.
- Decision Support System for the Management of Agile Supply Chains
  - Phillips Labs
- Large Scale Sys Simulation & Resource Sched Based on Autonomous Agents
  - Intelligent Automation Inc..
- Chemical Management Information System
  - Martin Marietta
- Integrated Process Planning/Production Scheduling System
  - Raytheon
- Enabling Next Generation Mechanical Design (ENGEN)
  - SCRA

ARPA BAA94-31 Winners

2 - Agile Pilot Demonstrations

- Agile Infrastructure for Manufacturing Systems (AIMS)
  - Virtual Corporation formed using Launch Vehicle testbed with plans to incorporate and leverage the Agile Business Practices and Enabling Technology Development and Demonstrations projects
  - Lockheed Missile & Space Systems, Rockwell International Corporation, TI, NTMA, Stanford, SantaClara Univ, USC, D&H Mfg, RSP Mfg, Elcon Inc
- Agile Manufacturing Pilot for Development of Castings
  - Dual Use demo of two families of automotive parts and two families of armored vehicle parts - Standardizing information content and exchange mechanisms in the casting supply chain
  - GE Transportation Systems, United Defense, Keokuk Steel Castings, Knight & Packer, Clinkenbeard & Associates, Watervliet Arsenal, GE Corporate R&D, GE Power Generation, ATLAS Foundry, National Inst of Flexible Manufacturing, BIRL Northwestern University

ARPA

BAA 94-31 Revision A
23 March 1995

- Retains the 3 technical areas of original BAA
  - Agile Manufacturing Pilots (AMPs)
  - Enabling Technology Development and Demonstrations (ETDDs)
  - Agile Business Practice demonstrations (ABPs)
- AMPs focused on military applications of "electronic information products"
  - ULTRACOM Scenario
- $30M Planned, FY 95-96
- Proposals due 23 May 1995

For further information send e-mail to baa-info@arpa.mil

JDL MS&T Panel

APRIL '95

Col Steve Maness, Army
Steve Linder, Navy
Dr. Bill Kessler, Air Force, Chairman
Don O'Brien, DLA

TOPICS

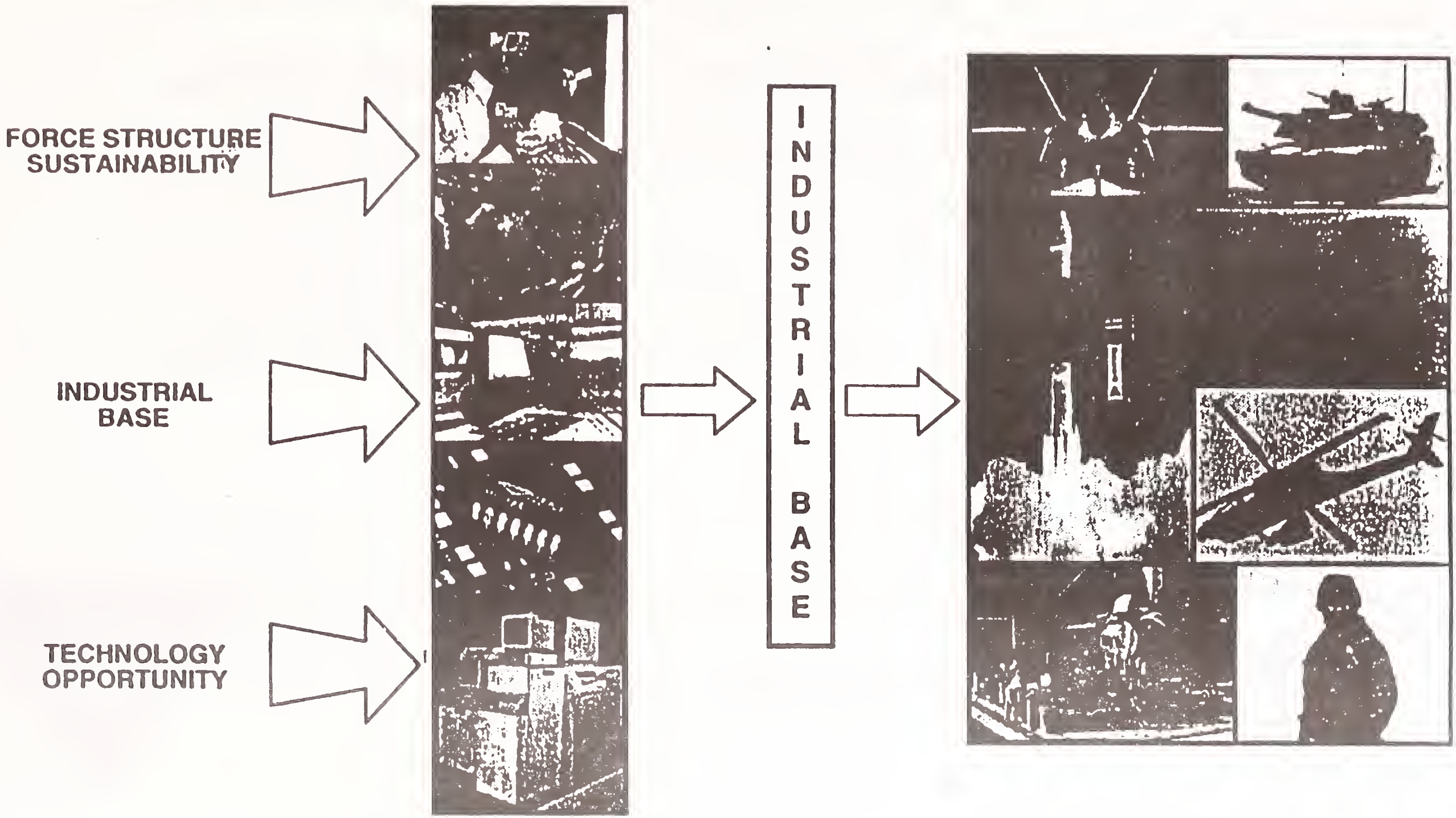
- Background & Rationale for MS&T Program
- Jointness & the Joint Planning Process
- Execution Strategy

TOPICS

- Background & Rationale for MS&T Program
- Jointness & the Joint Planning Process
- Execution Strategy

Joint Directors of Laboratories

Manufacturing Science & Technology



MS&T MISSION

"To identify and integrate requirements conduct joint program planning, develop joint strategies, and oversee execution of MS&T programs conducted by the Army, Navy, Air Force, and Defense Logistics Agency."*

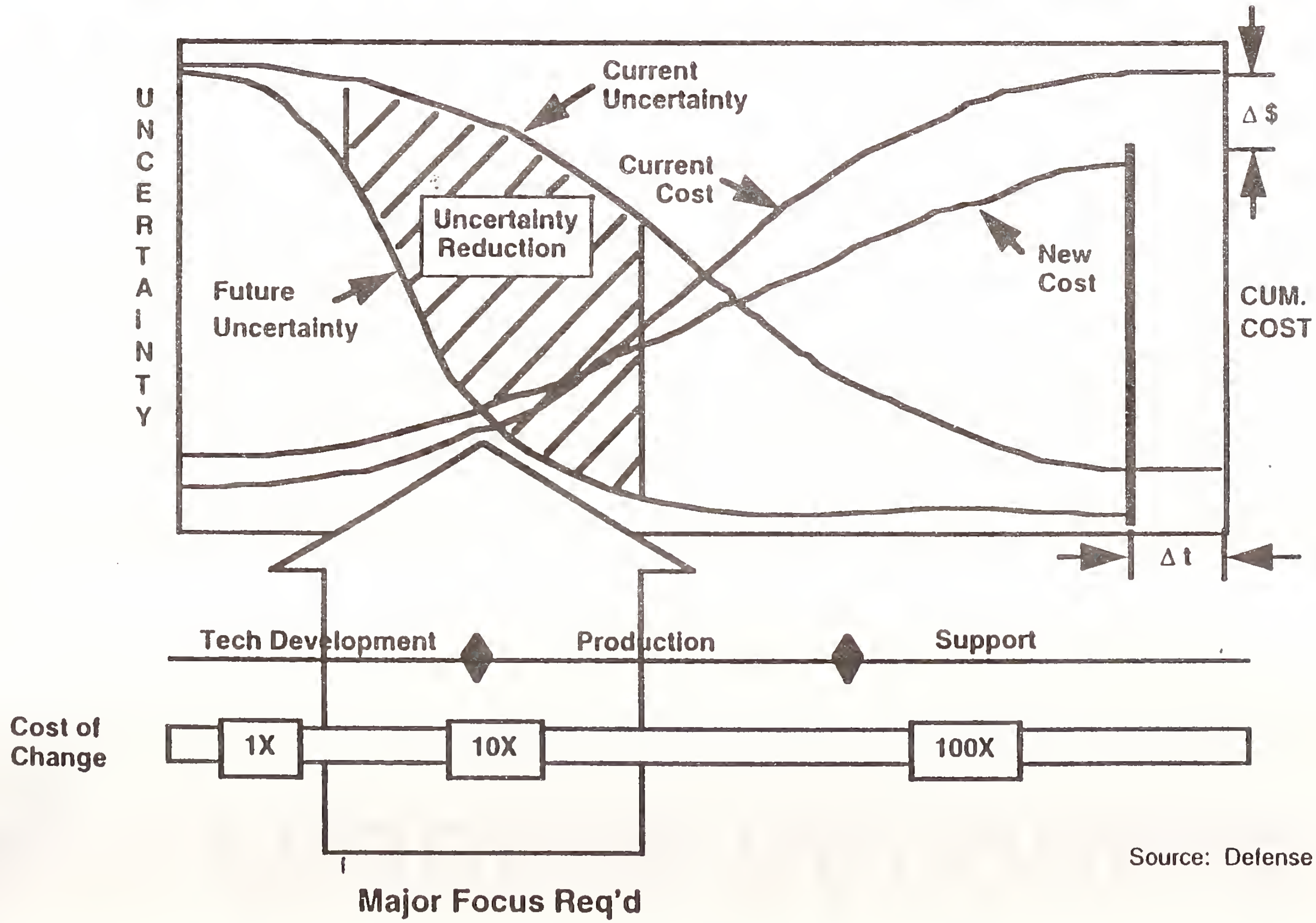
* MS&T Technology Panel Charter

PROGRAM RATIONALE

- Emphasize process understanding and maturation to minimize cost/ schedule risks in the production environment

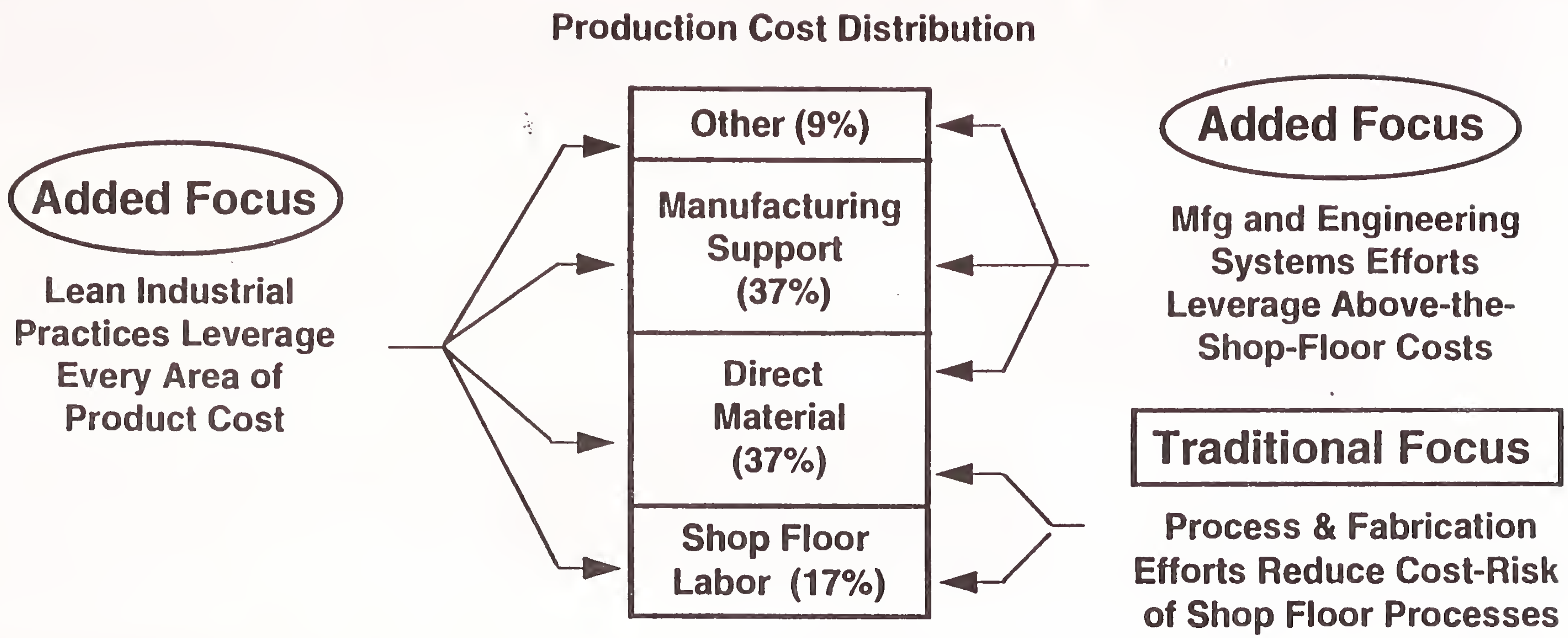
- Emphasize the employment of processes & practices which dramatically reduce DoD product realization costs

PROCESSING & FABRICATION MATURATION IS KEY TO REDUCING COST RISKS



Source: Defense Science Board

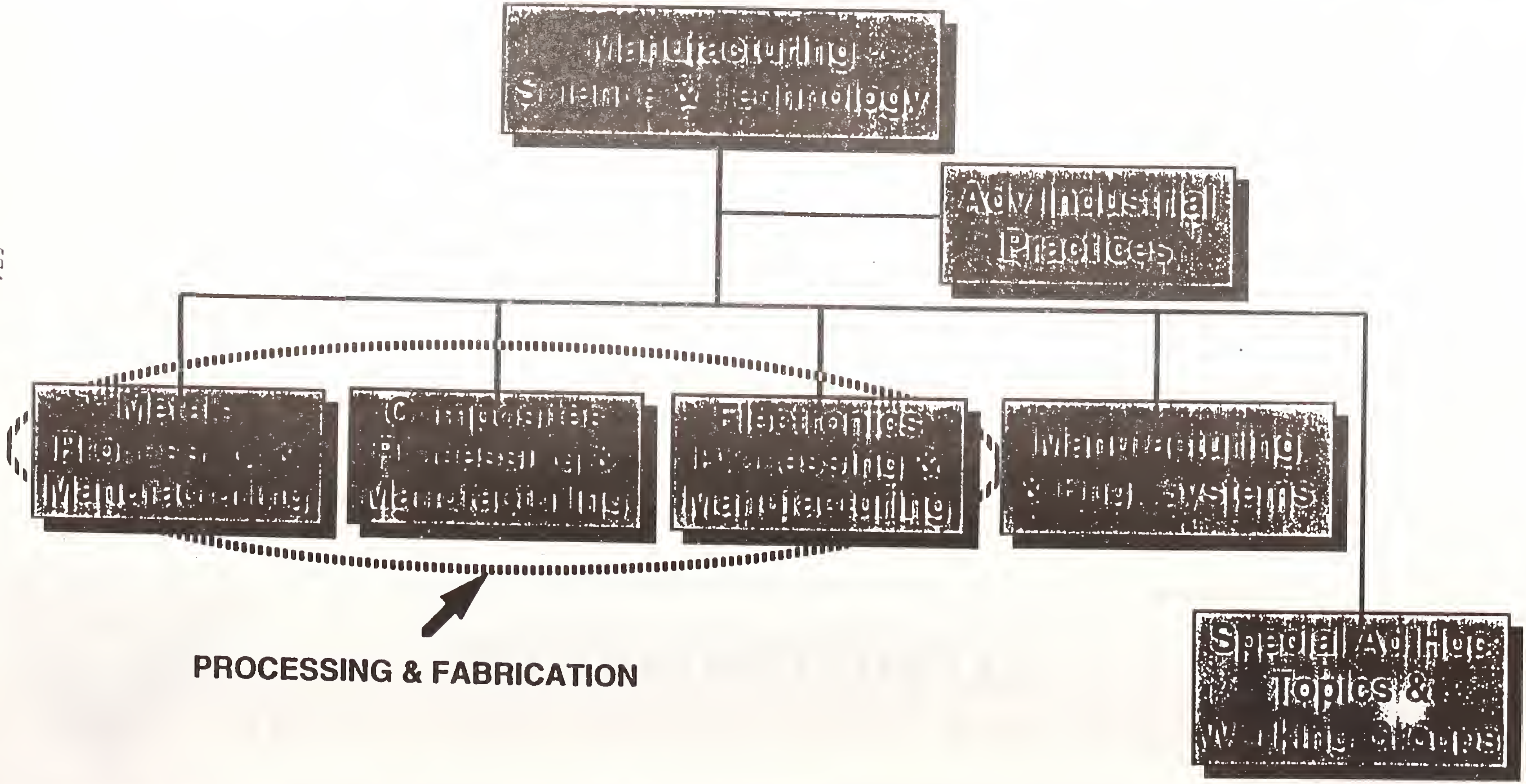
MS&T HAS INCREASED EMPHASIS ON AFFORDABILITY



Cost Coverage

~ 20% of Product Costs ⟶ Approaching 100%

MS&T TAXONOMY



MS&T KEY PLAYERS

Principals:

- Col Steve Maness, Army
- Steve Linder, Navy
- Dr. Bill Kessler, AF - Chairman
- Don O'Brien, DLA

Ex-officio:

- Dan Cundiff, DDR&E
- Dr. Mike McGrath, ARPA

Subpanel Chairmen:

- Walter Roy. Army
- Dave Beeler, AF
- John Fenter, AF
- Leo Plonsky, Navy
- Dick Remski, AF

Industry:

- Joe Syslo, NCAT

MANAGEMENT CHALLENGES

Accomplished

- Streamlined JDL-MS&T Organization to Enhance Collaboration
- Interdisciplinary MS&T Panel Built On Past Experience

In Process

- Articulating The Defense MS&T "Niche" Within The National Manufacturing Agenda
- Leveraging With "Big M" (ARPA, NIST, DOE, NSF, Etc.)
- Integrating With Service S&T Strategy

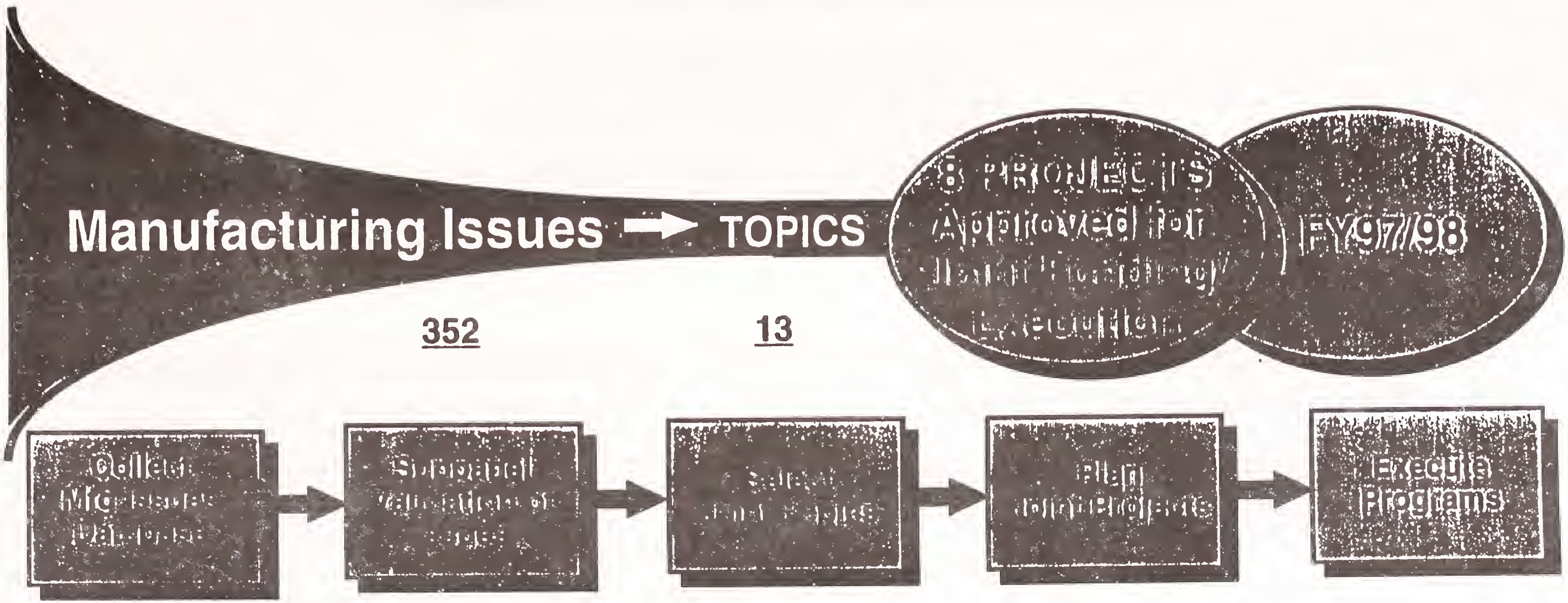
TOPICS

- Background & Rationale for MS&T Program
- Jointness & the Joint Planning Process
- Execution Strategy

PROCESS FOR JOINT SERVICE/ DLA MS&T PLANNING

- **Purpose**
  - Focus on Defense-Essential Capability
  - Achieve A Unified Tri-Service/DLA MS&T Program Plan
  - Enhance Collaboration And Coordination
- **Based On Service/DLA Requirements**
  - Weapon System-Driven Acquisition And Repair
  - Industry Needs
  - Science & Technology Base Opportunities
- **Output Is A Joint MS&T Panel Program Plan Consisting Of:**
  - Service-Specific Projects
  - Joint Service/DLA MS&T Projects

JOINT PLANNING
• FY97/98



- Unconstrained
- Industry Needs
- Military Needs
- Technology Opportunities

- MS&T Mission
- Benefits
- Consolidation

- Jointness
- DoD Benefits
- $$ & Schedule
- Implementation Potential
- Technical Feasibility
- Leverage

- Execution Strategy
- Implementation Strategy
- Detailed Joint Roadmaps

- Collaboration
- Joint Execution/ Oversight
- Tech Transfer & Implementation

EXTERNAL INITIATIVES

√ ***TITLE III PROGRAM***

Developing a MOU to interface MS&T and Title III project planning and development

√ ***ADVANCED RESEARCH PROJECTS AGENCY (ARPA)***

Dialog opened with ARPA to develop mutual opportunities

√ ***JOINT DIRECTORS OF LABORATORIES (JDL) MATERIALS PANEL***

Meetings between panels have identified a set of topics to work together on for process maturation & transitions

TOPICS

- Background & Rationale for MS&T Program
- Jointness & the Joint Planning Process
- Execution Strategy

MS&T EXECUTION STRATEGY

- Performing Organizations
  - Industry
  - "Centers of Excellence"
  - Academia
  - Government

- Procurement Approaches
  - Contracts
  - Cooperative Agreements
  - Grants

- Exploring Appropriate Level for Cost Sharing Within the Defense Environment
  - Defense Essential Need
  - Beyond the Normal Business Risk of Performer

THE ROLE OF CENTERS

- DDR&E
  - All Dollars In Defense Budget To Be Spent On Defense Needs
  - Centers Are A Reality In The Defense Budget
  - Centers Should Focus On Critical Defense Issues
    - > Provide Excellence In Technology
    - > Improve Military Effectiveness
    - > Reduce DoD Costs

- Centers Are A Key Element Of The MS&T Program
  - $300M Invested From FY90-93
  - 50% Of Service MS&T In FY94
  - 550 People Employed, Access To 600 Companies
  - Centers Are Supported By Congress

SUMMARY

- Joint Planning & Executing
  - Industry Involved
- Enhancing Focus on Cost Reduction
  - Mfg Consideration in Design
  - Process Maturation/Understanding
  - Best Practices in Realizing Defense Products
- Leverage is Key
  - Cost Share Considerations
  - Tri Services/DLA
  - ARPA
  - Materials - MS&T - Title III

JDL MS&T
Processing & Fabrication

Composites

Electronics

Metals

Richard L. Remski
Wright Patterson AFB, OH

April 20, 1995

MS&T FOCUS FOR THE FUTURE

VISION: To ren[illegible] responsive world-class manufacturing capability to affordably meet the warfighters' needs throughout the defense system life cycle.

MANUFACTURING SCIENCE & TECHNOLOGY

Mfg & Engr Systems

- Mfg Involved Early In Reqmt's & Design
- Design For 6σ Mfg
  - Low Risk To Mfg The Design
  - Supplier Involvement
  - Deploy Concept & Tools
- Mfg & Engr Tools
- Enterprise Simulation & Modeling

Processing & Fabrication

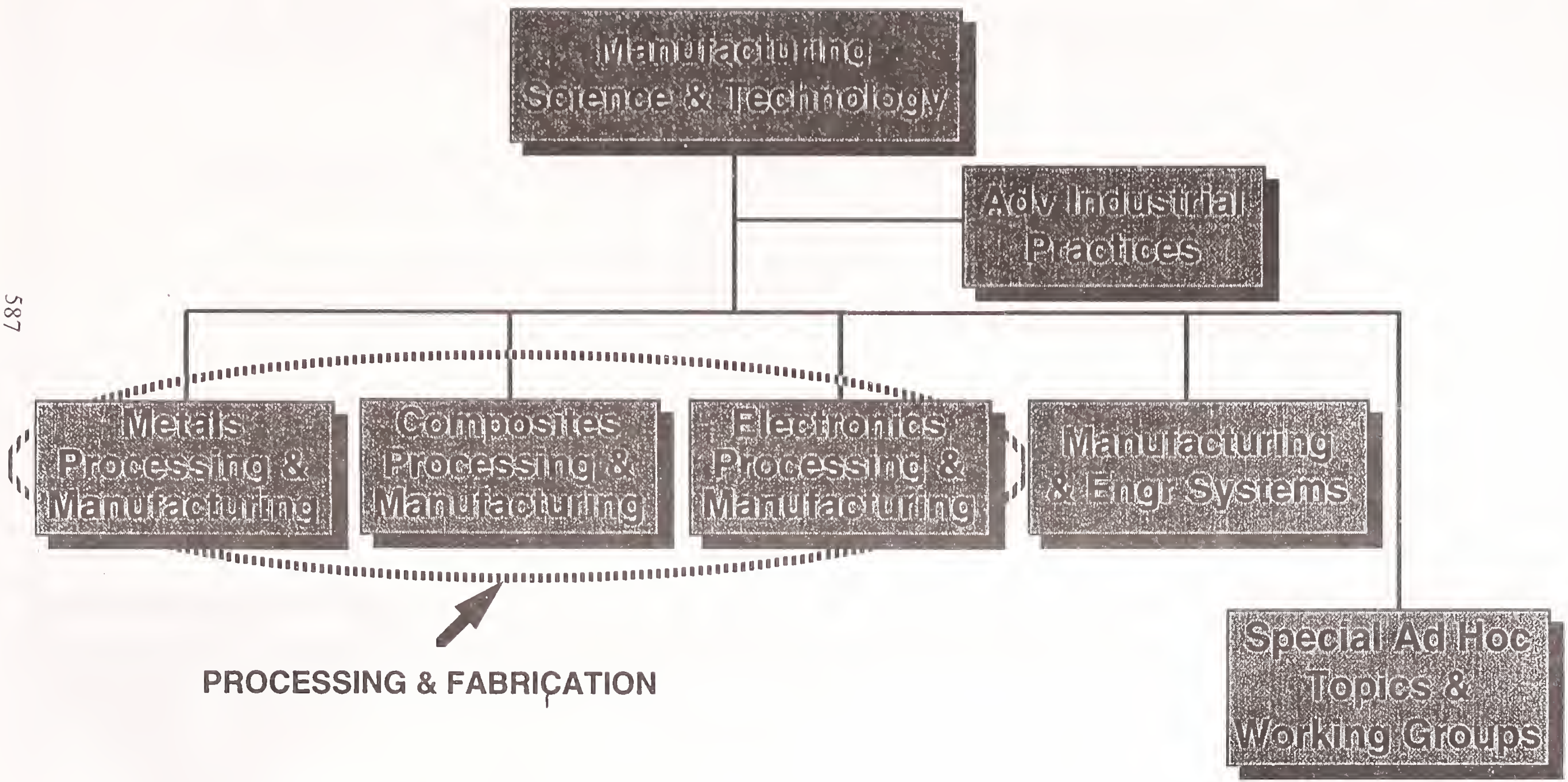
- Process Maturation
  - Understand & Measure Uncertainty Via Variability Metrics (e.g.., Cp, Cp_k)
  - Unit Process Modeling
- Defense Essential Capability

Advanced Industrial Practices

- Culture Change
  - Employ World's Best Practices For Defense Systems
  - Industrial Base Sector Collaboration
- Step Function Improvements
  - Cost, Cycle Time, And Quality
- Demos To Prove And Deploy Results
- Technology Implementation & Deployment

As Measured by: Affordability, Low Risk Transition, Defense Essential Capability

MS&T TAXONOMY



Joint Directors of Laboratories

SUBPANEL CHAIRMEN

COMPOSITES - DAVE BEELER - AIR FORCE WRIGHT LAB

ELECTRONICS - DICK REMSKI - AIR FORCE WRIGHT LAB

METALS - WALTER ROY - ARMY RESEARCH LAB

COMPOSITES
PROCESSING & MANUFACTURING

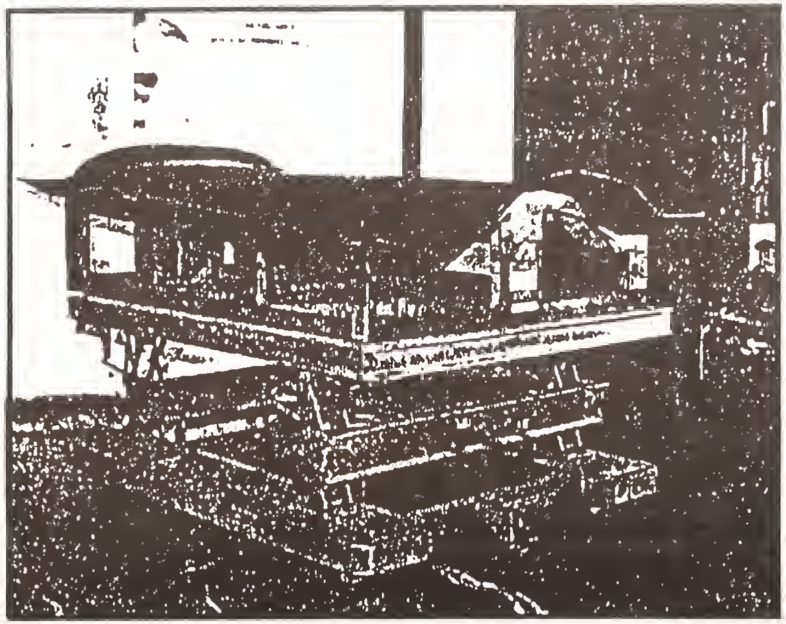
SUBPANEL TAXONOMY

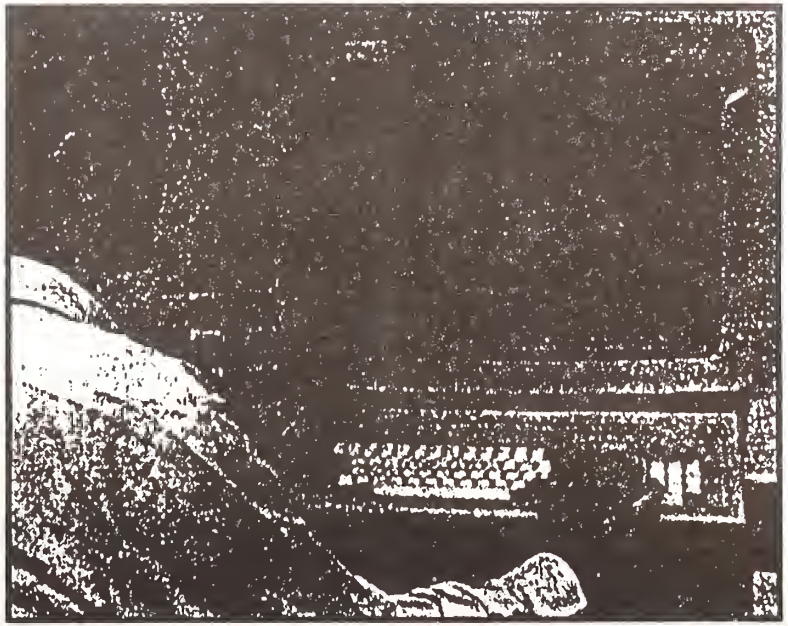
- POLYMERIC COMPOSITES
  - MATRICES
  - FIBERS
- METAL MATRIX COMPOSITES
  - FIBERS
- CERAMIC MATRIX COMPOSITES
  - MATRICES
  - FIBERS
- CARBON-CARBON COMPOSITES
  - MATRICES
  - FIBERS

ADVANCED TOOLING MANUFACTURE FOR COMPOSITE STRUCTURES

MANUFACTURING TECHNOLOGY DIRECTORATE — PROCESSING AND FABRICATION

OBJECTIVE: TO ESTABLISH AND VALIDATE AN INTEGRATED METHOD FOR TOOL CONCEPT SELECTION AND DESIGN, FOR THE MANUFACTURE OF THE TOOLS REQUIRED IN THE PRODUCTION OF COMPOSITE STRUCTURES.





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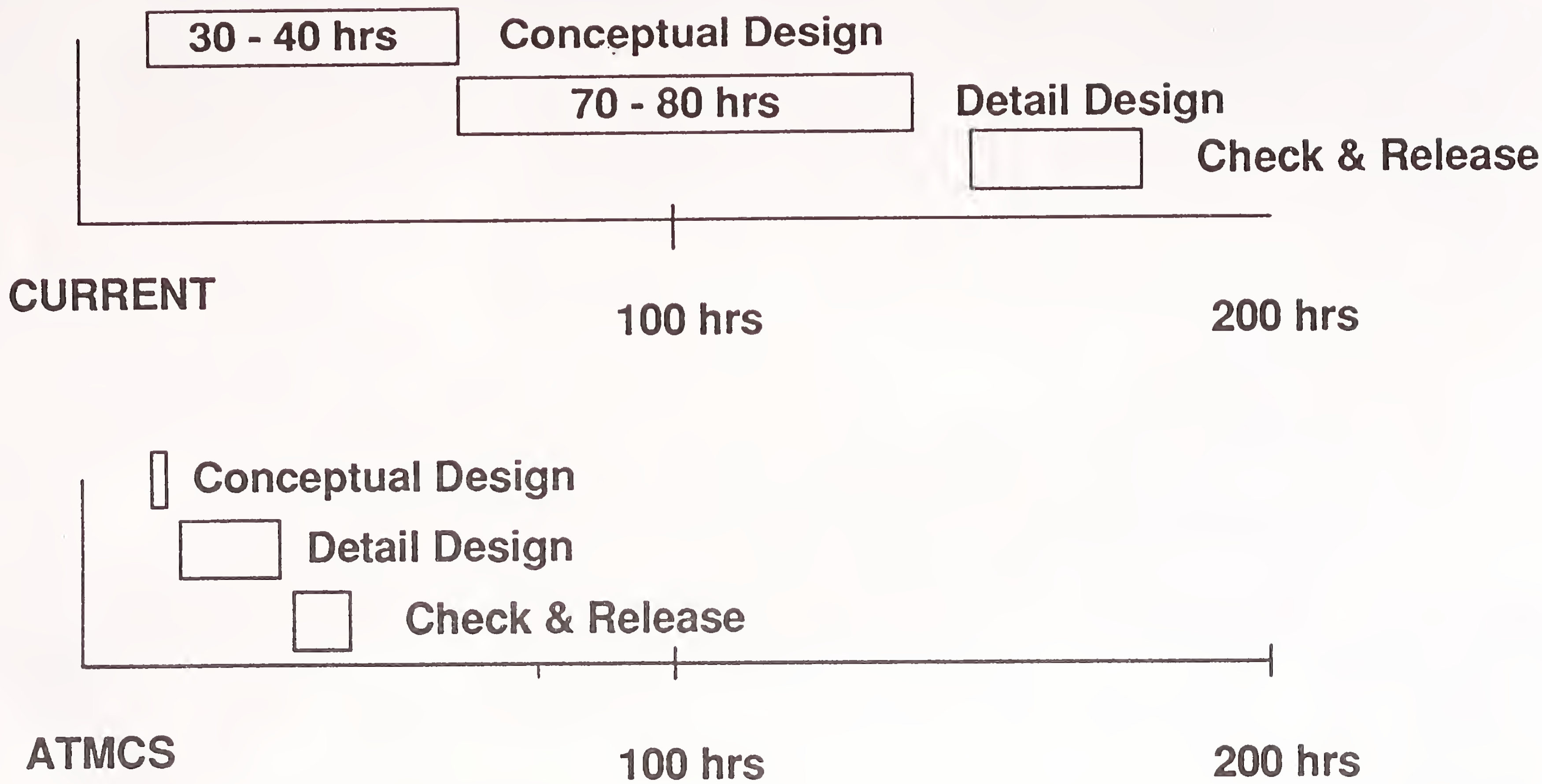
ADVANCED TOOLING MANUFACTURE FOR COMPOSITE STRUCTURES

Manufacturing Technology Directorate — Processing and Fabrication

TIME FLOW COMPARISON FOR MASTER MODELS



ELECTRONICS PROCESSING AND FABRICATION

Joint Directors of Laboratories

ELECTRONICS PROCESSING AND MANUFACTURING

Electro-Optics

- Fiber-Optics
- Opto-Electronics
- Laser
- Micro-and Adv. Optics
- IFOG

IR Focal Plane Arrays

RF Electronics

- Microwave Power
- T/R Module Dev.
- Solar State Apertures

Packaging and Assembly

- Assembly
- Automation
- Board Additive Processes
- Commercial Processes
- Conformal Coating
- Interconnects
- No-Clean
- Packaging
- Process Control
- Testing

Environmentally Conscious Electronic Mfg

- Design
- PWB/Components
- PWA/Rework
- Use/Repair
- Disposition
- General

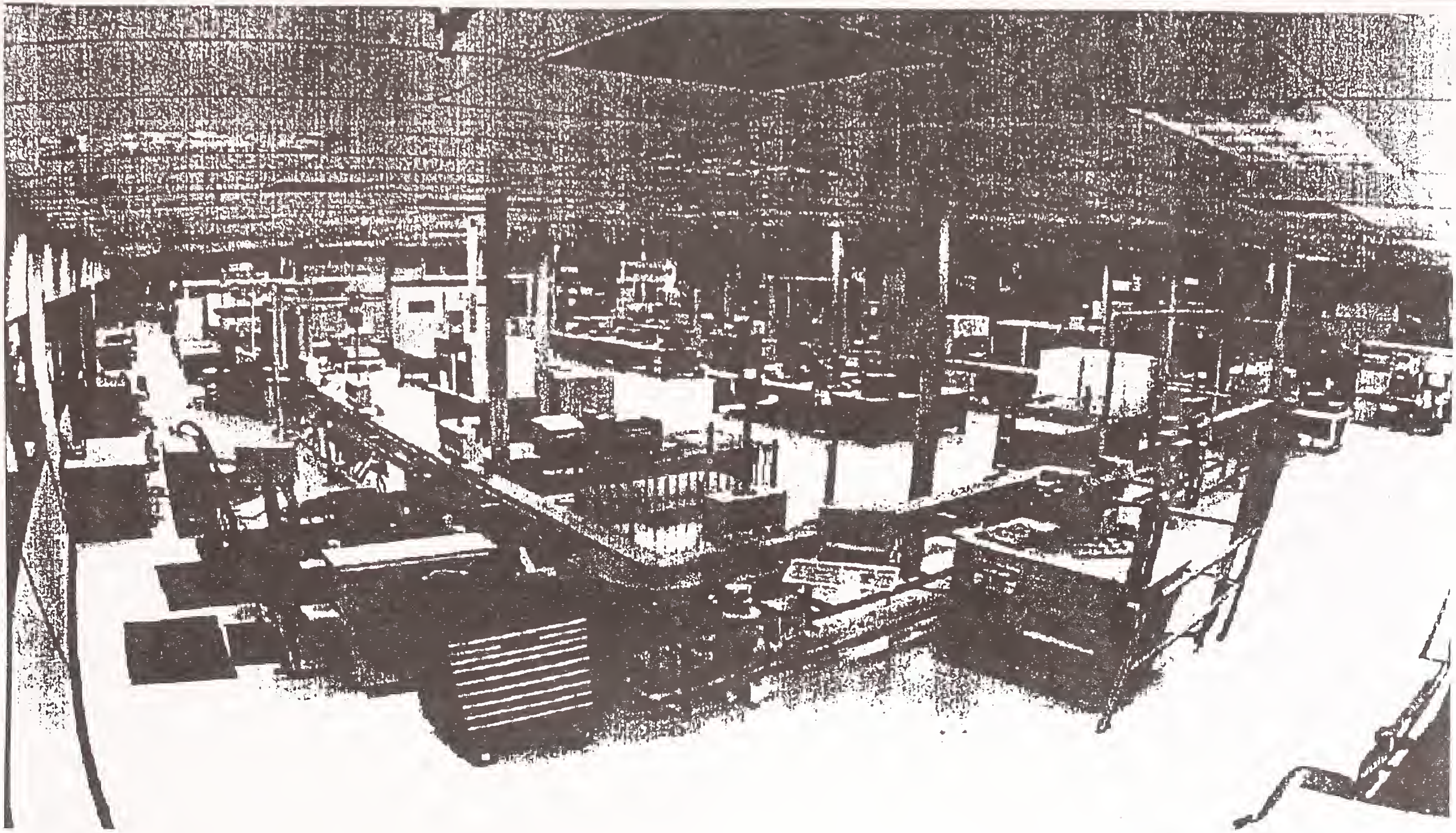
Domes, Windows and Coatings

- Window/Dome Fab
- EMI/CM Coatings
- Environmental Coatings
- Final Assembly and Testing
- Design and Manufacturing Engineering

MANUFACTURING TECHNOLOGY FOR T/R MODULES

AF MANUFACTURING TECHNOLOGY DIRECTORATE

ELECTRONICS DEVISION (WL/MTE)



ELECTRONICS DIVISION ——→ WL/MTE

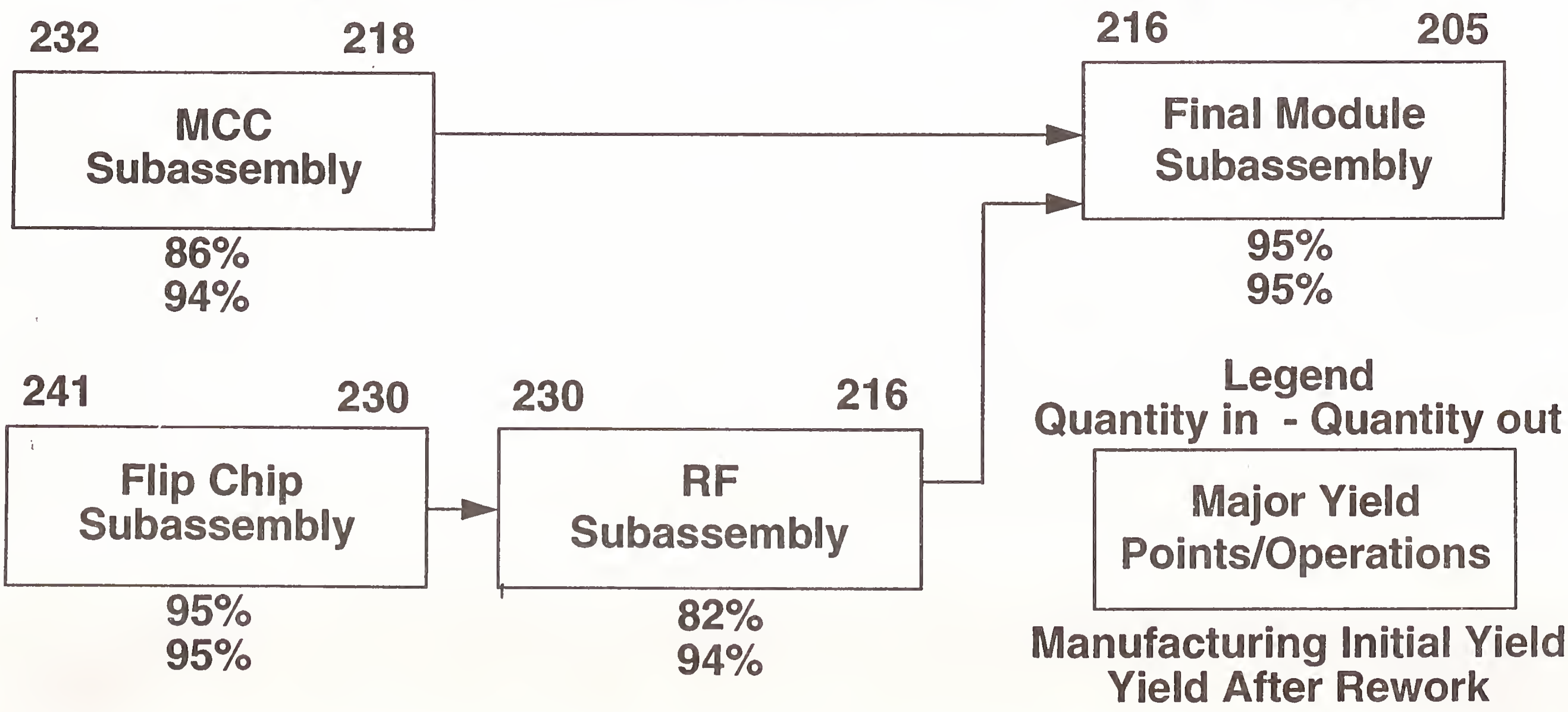
Manufacturing Technology for Transmit/Receive Modules

Manufacturing Technology USAF

232 MCC Submodules Started; 218 Sealed and Tested Good (4 Days)

241 RF Submodule Started; 216 Sealed and Tested Good

205 T/R Modules Mated and Tested Good - Total of 14 Days



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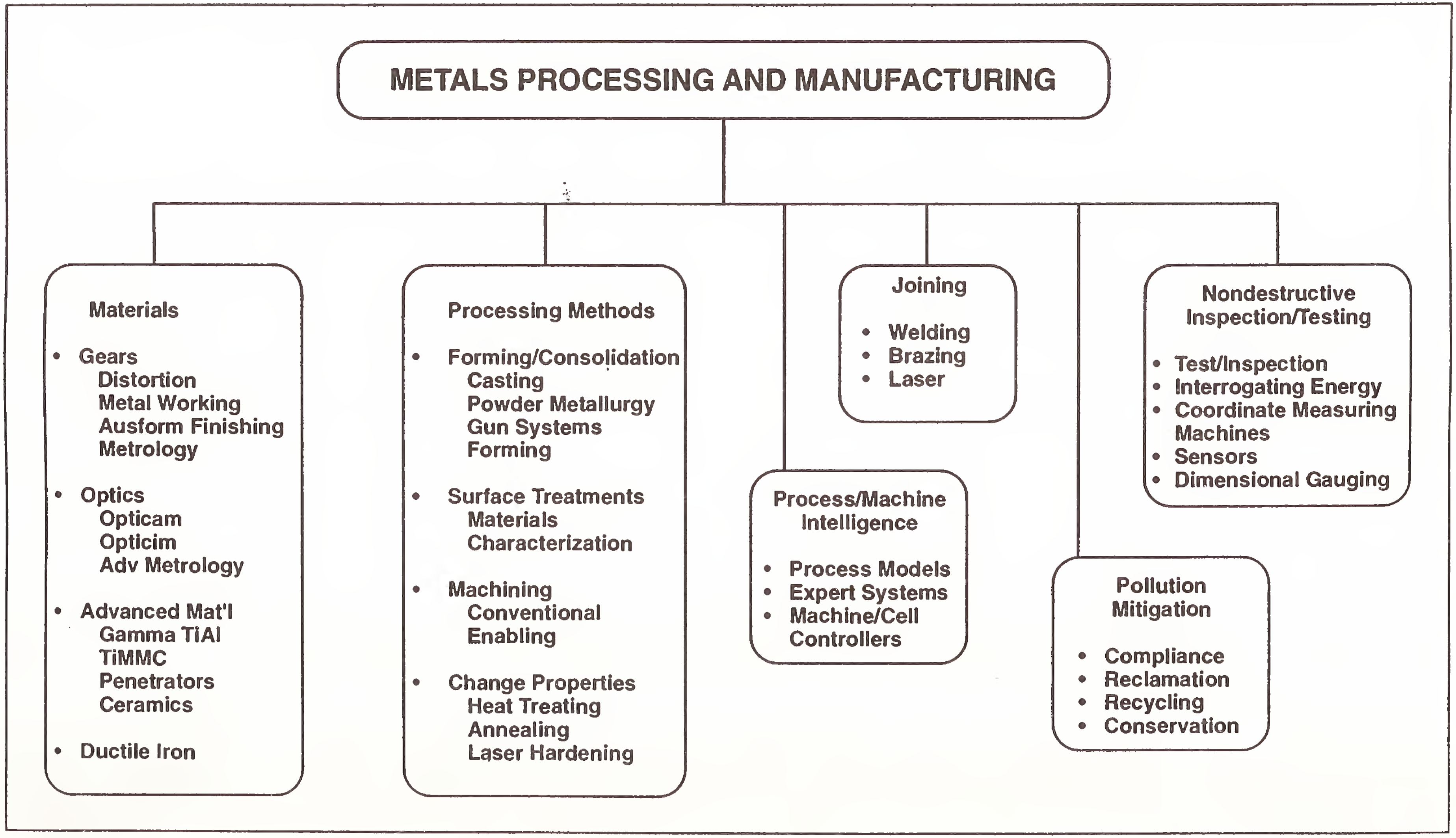
GENERALIZED EMULATION of MICROCIRCUITS (GEM)

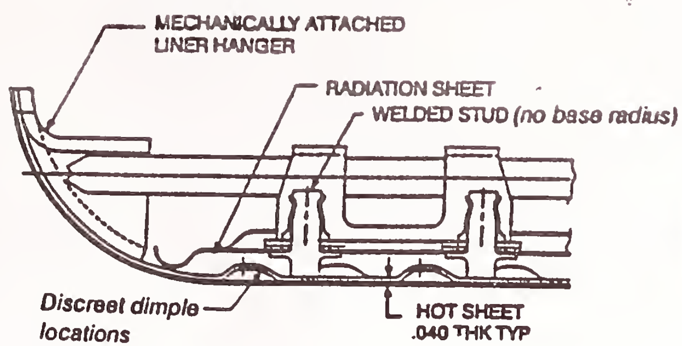
Metals Subpanel Taxonomy



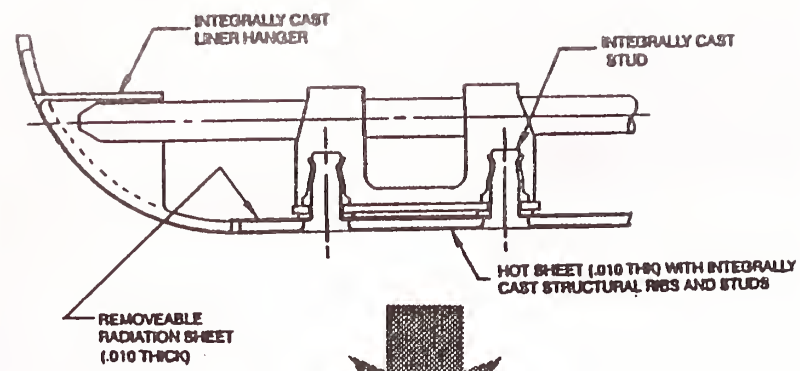
MANTECH - ULTRA THIN CAST NICKEL BASE ALLOY STRUCTURES

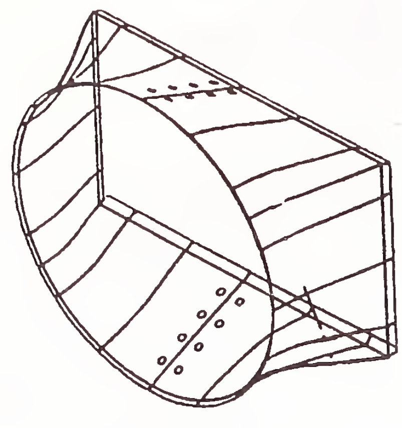
Reduced Weight

Wrought
Baseline ACS



Cast Metered
Multi-Hole



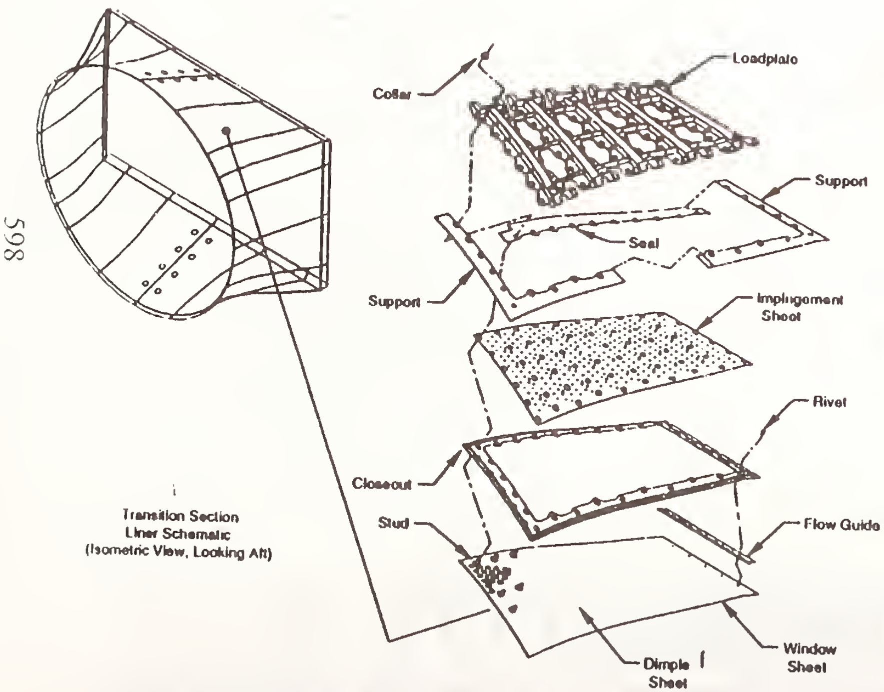


T-Duct Liner

-10 lbs.

MANTECH - ULTRA THIN CAST NICKEL BASE ALLOY STRUCTURES

Reduced Manufacturing Complexity



Current System

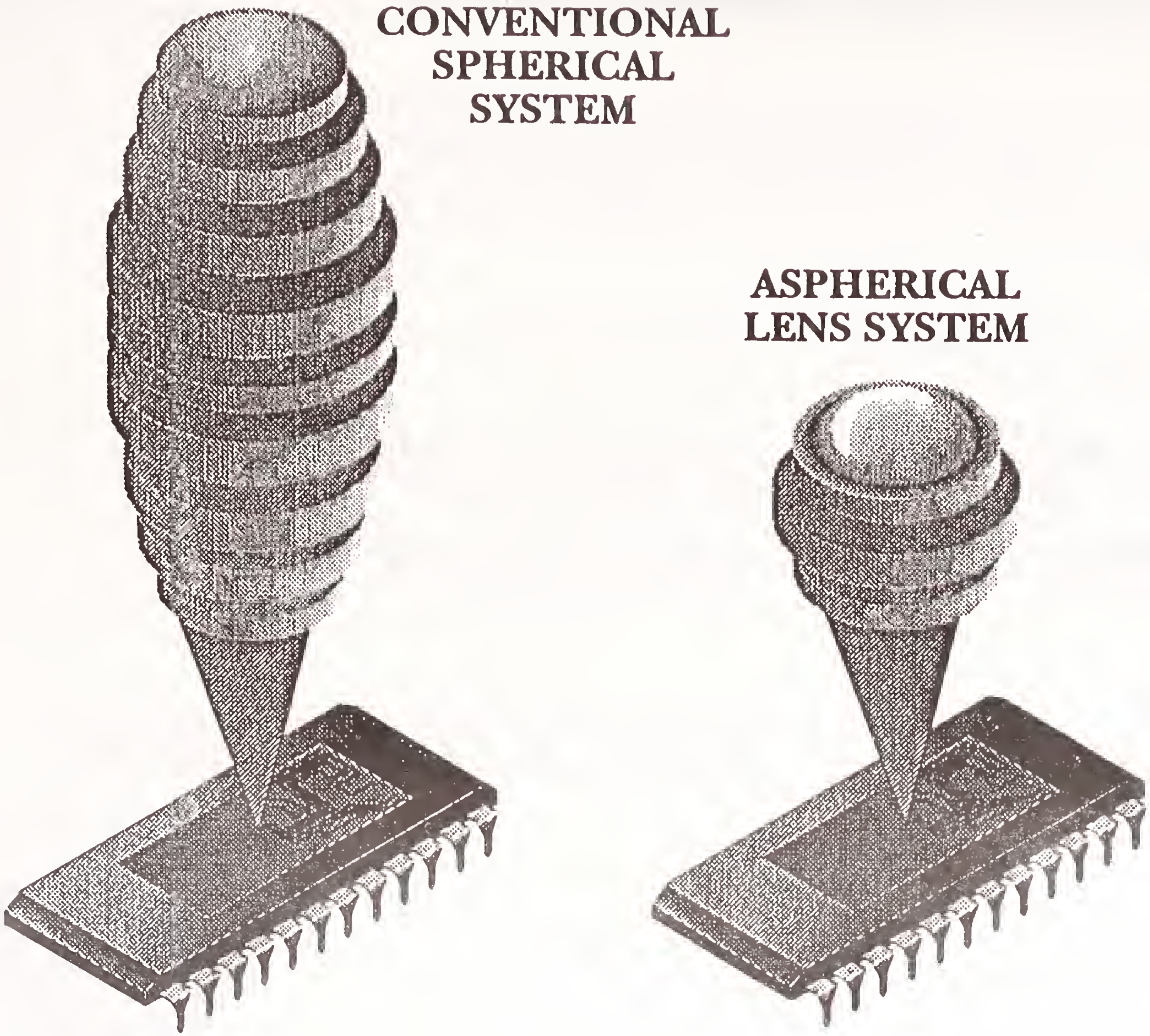
Manufacturing Operations

- Stud Welding
- Brazing
- Diffusion Bonding
- Riveting
- Laser Trim
- Machining

Goal → Casting, Machining

Part Name	No. Required
– Closeout	1
– Rivets	5
– Flow Guide	1
– Studs	60
– Dimple Sheet	1
– Window Sheet	1
TOTAL	**69**

Goal → 1



ASPHERICAL LENS SYSTEM

BENEFITS

- Reduced Cost
- Less Weight
- Smaller Size
- Less Complex

Joint Directors of Laboratories

MS&T PROCESS AND FAB GOALS

- Focus on Defense Essential Processes and Products
- Flexibility, Agility, Reduced Cycle Time
- Spin-On Commercial - Processes, Products, and Practices
- Utilize Integrated Industrial Base

AFFORDABILITY

Joint Directors of Laboratories

JDL MANUFACTURING SCIENCE & TECHNOLOGY PANEL

MANUFACTURING & ENGINEERING SYSTEMS SUB-PANEL

Michael Hitchcock

20 April 1995

Outline

- Sub-Panel Overview
- Thrust Area Plans
- Example Projects
- Summary

Sub-Panel Membership

Primary Members

- Leo Plonsky -- Navy -- Chair
- Jeffrey Parks -- Army
- Gerald Shumaker -- Air Force
- Julie Tsao -- DLA

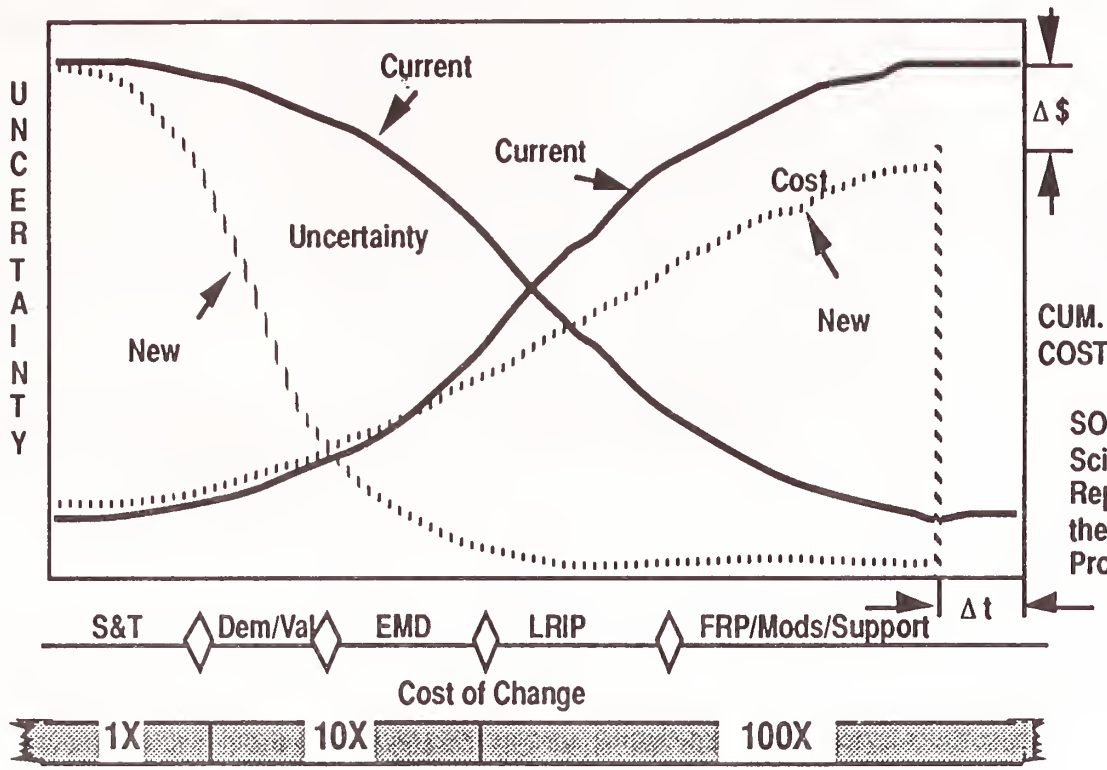
Regular Members

- Lorna Estep -- Navy
- Michael Hitchcock -- Air Force
- Mark Luce -- NIST
- John Meyer -- NSF
- Patrick Sincebaugh -- Army

M & ES Scope

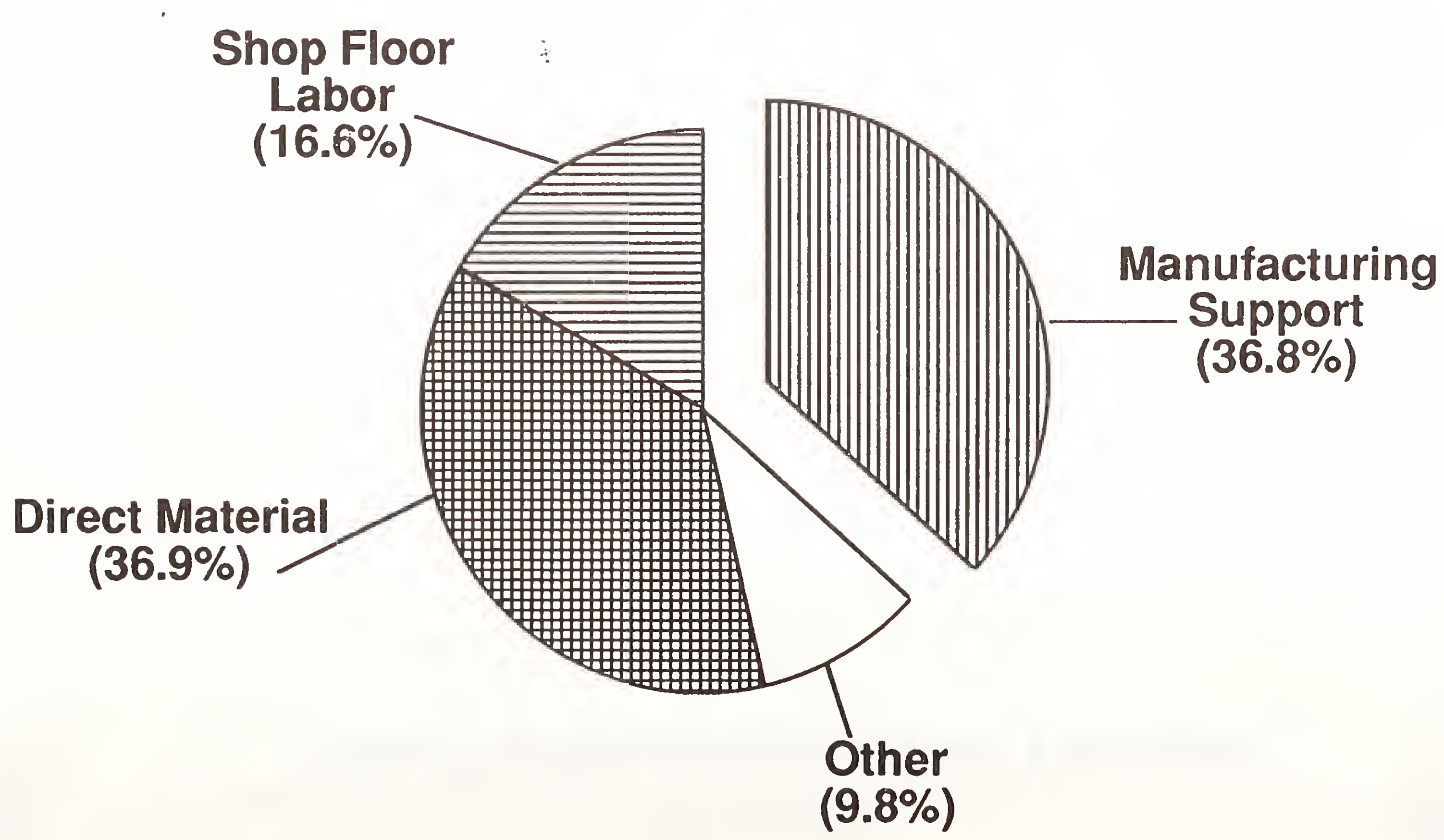
- Address *cost, schedule and risk constraints* driven by the activities which:
  - design the products, and
  - plan, schedule and control the operation of an enterprise
- Establish *environment and interfaces* to link diverse departments, such as
  - design and manufacturing engineering
  - accounting and finance
  - factory operations
  - personnel management
- Stress *methods and tools* which
  - reduce product realization leadtime
  - increase affordability and producibility
  - provide for tighter coupling among enterprise functions

Benefits
• Readily Manufacturable Designs



SOURCE: Defense Science BoardTask Force Report, "Engineering in the Manufacturing Process", Mar 93

Benefits
• Sources of Cost

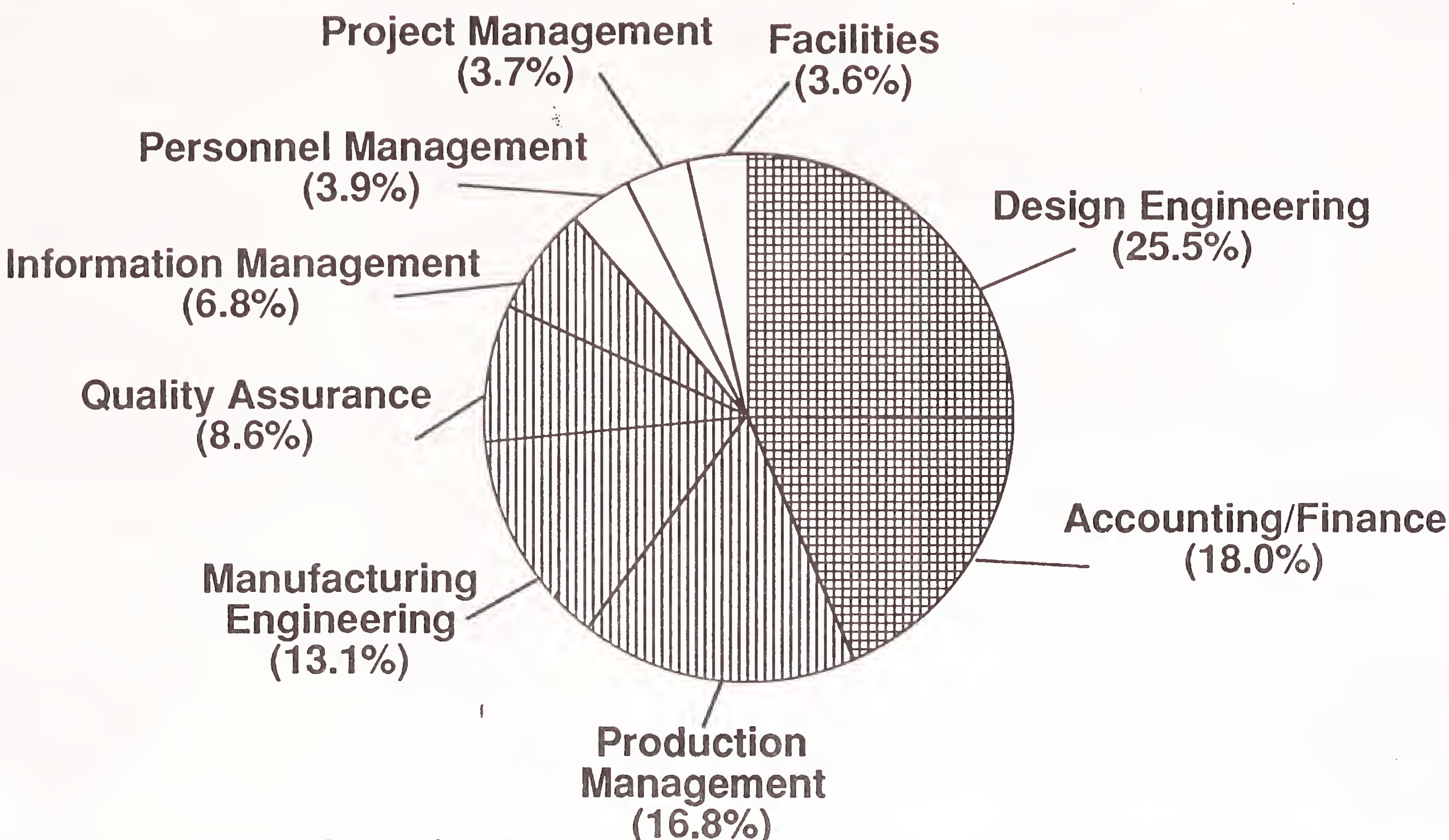


Source: DoD Manufacturing Systems Committee
Strategic Plan, March 1993

Manufacturing and Engineering Systems

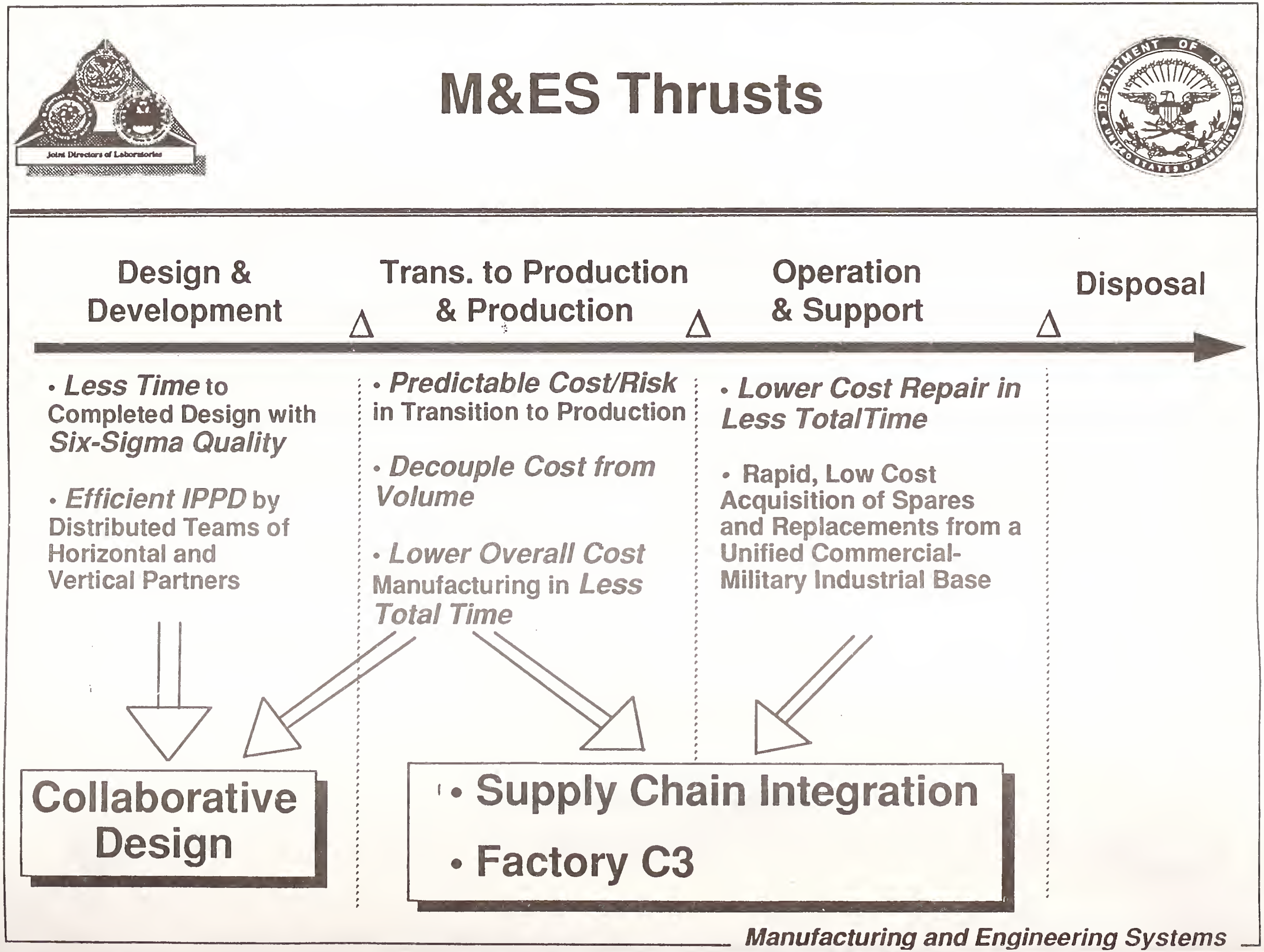
Benefits

• Sources of Cost



Source: DoD Manufacturing Systems Committee Strategic Plan, March 1993

Manufacturing and Engineering Systems

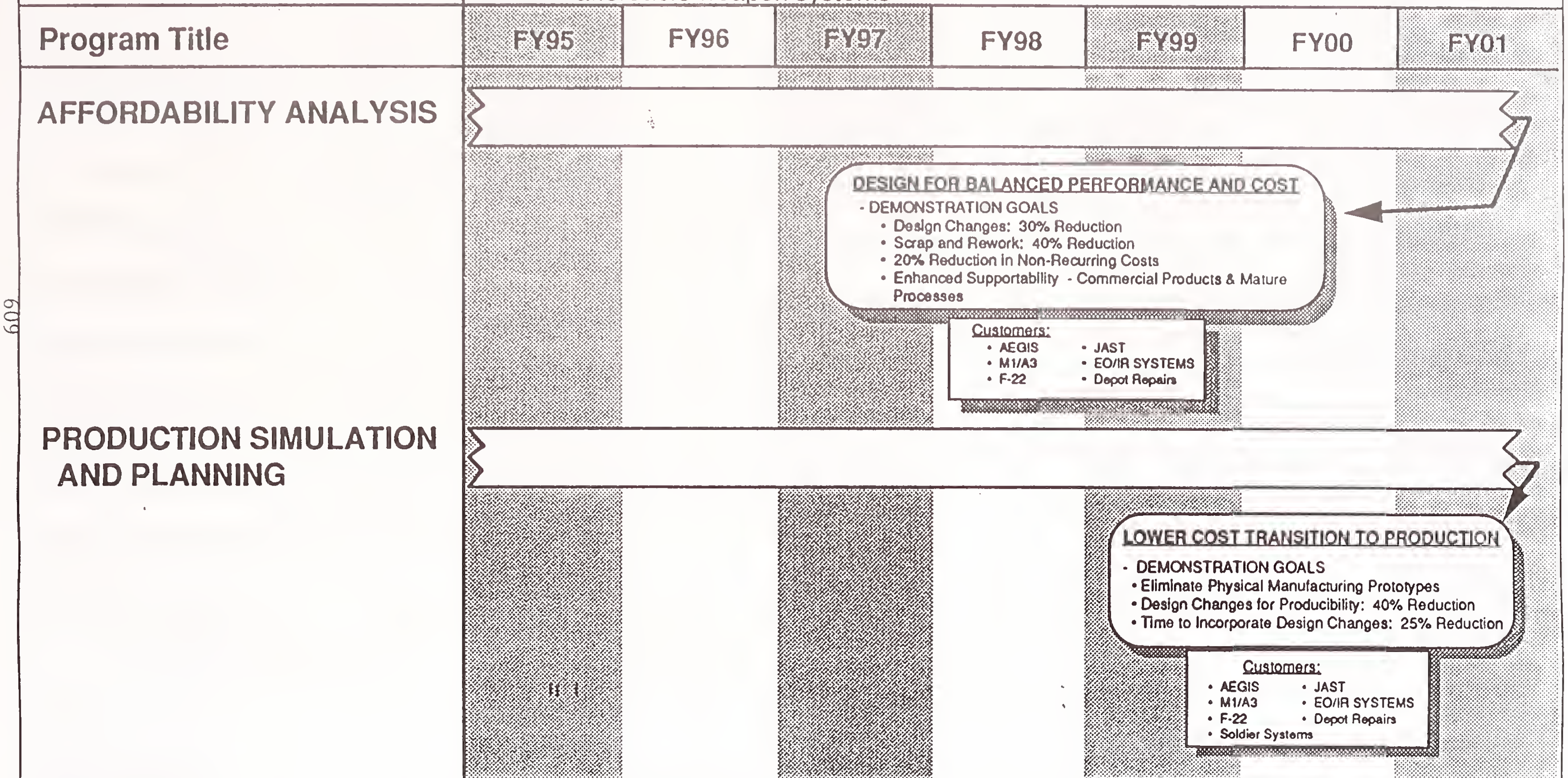

Joint Directors of Laboratories
M&ES Thrusts
Design & Development
Trans. to Production & Production
Operation & Support
Disposal
• Less Time to Completed Design with Six-Sigma Quality
• Efficient IPPD by Distributed Teams of Horizontal and Vertical Partners
• Predictable Cost/Risk in Transition to Production
• Decouple Cost from Volume
• Lower Overall Cost Manufacturing in Less Total Time
• Lower Cost Repair in Less TotalTime
• Rapid, Low Cost Acquisition of Spares and Replacements from a Unified Commercial-Military Industrial Base
Collaborative Design
• Supply Chain Integration
• Factory C3
Manufacturing and Engineering Systems

Manufacturing & Engineering Systems - Level 1

COLLABORATIVE DESIGN

Technical Area: Collaborative Design

Goal: Geographically distributed design teams involving many different disciplines and firms balance performance with manufacturing cost, time and quality to create affordable weapon systems

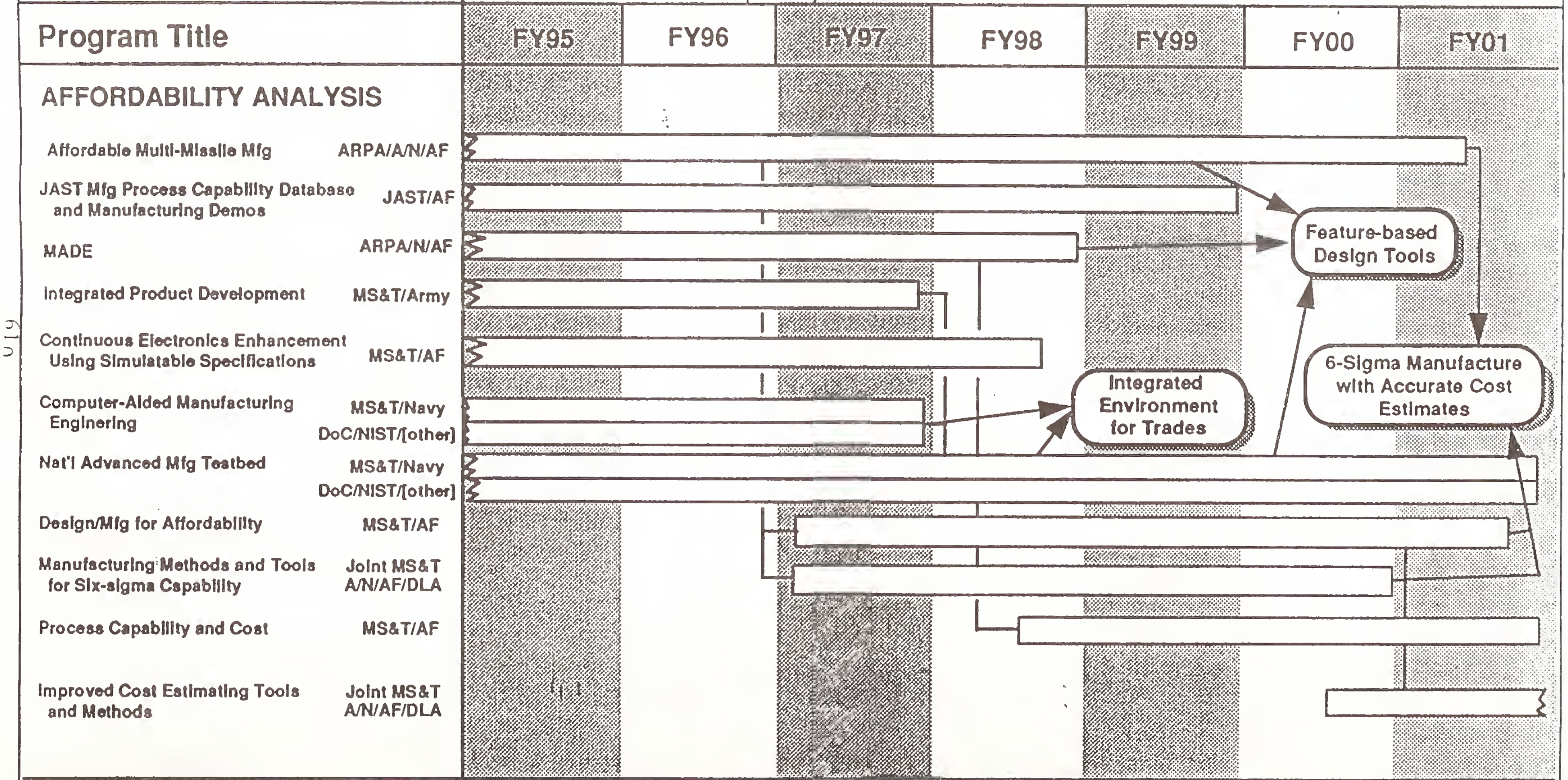


Manufacturing & Engineering Systems - Level 2

COLLABORATIVE DESIGN

Technical Area: Collaborative Design

Goal: Geographically distributed design teams involving many different disciplines and firms balance performance with manufacturing cost, time and quality to create affordable weapon systems



Manufacturing & Engineering Systems - Level 2

COLLABORATIVE DESIGN

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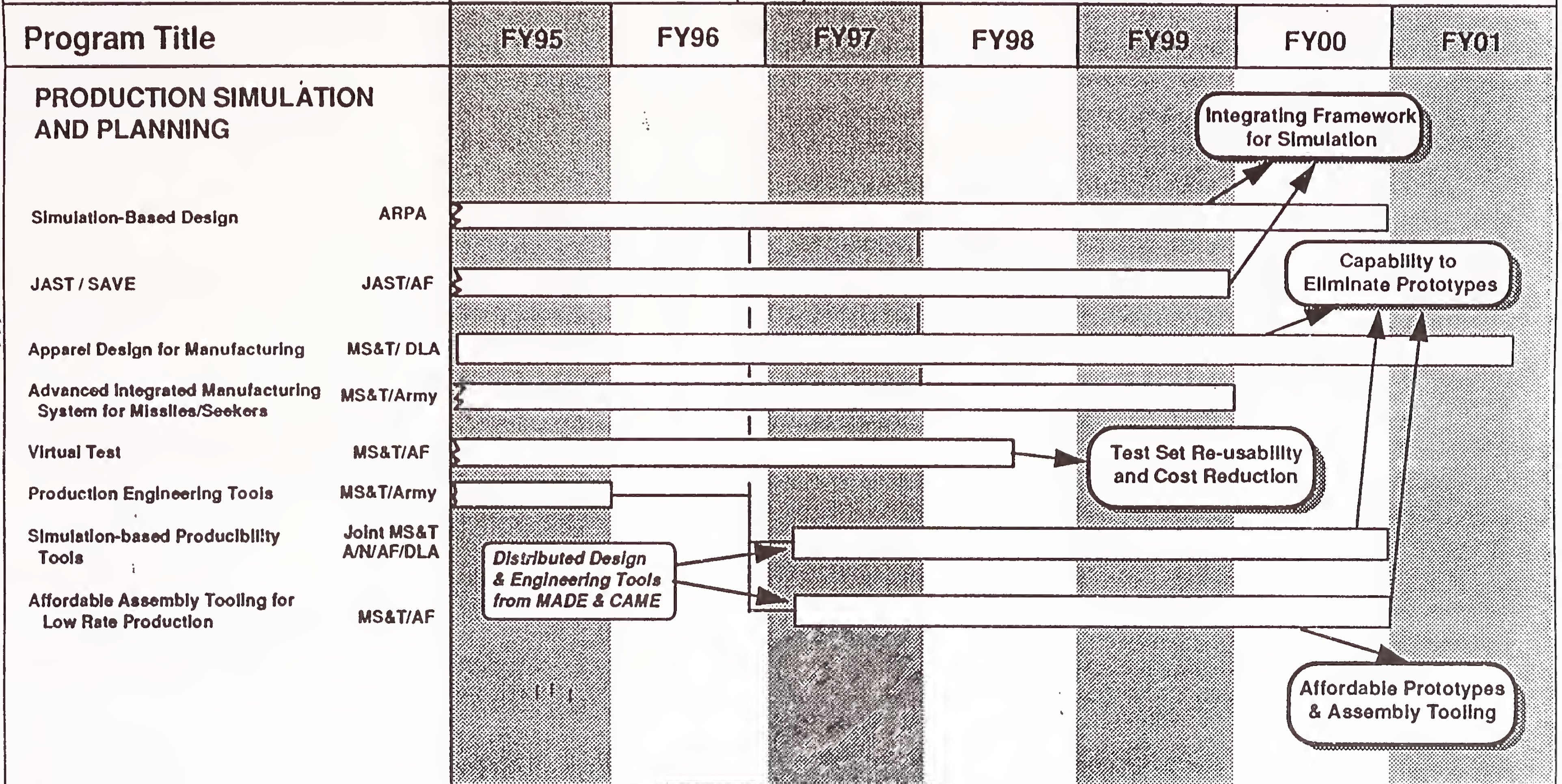


Manufacturing & Engineering Systems - Level 1

SUPPLY CHAIN INTEGRATION

Joint Directors of Laboratories

Technical Area: Supply Chain Integration

Goal: All tiers of the supplier base operate as a unified entity for most efficient total production and rapid, efficient response to change at any point in the supply chain

Program Title	FY95	FY96	FY97	FY98	FY99	FY00	FY01
BUSINESS AND TECHNICAL SYSTEMS INTEGRATION							
MULTI-ENTERPRISE INTEGRATION							

AFFORDABLE PURCHASED PRODUCTS AND SERVICES

- DEMONSTRATION GOALS
  - Suppliers: 20% Price Reduction with Increased Profitability
  - Supplier Management Personnel: 30% Reduction
  - Re-scheduling Time: 10X Reduction
  - Supplier Contracting Time: 75% Reduction
  - Enable Direct Vendor Delivery

Customers:

- All Acquisition of Spares/ Replacements
- All Production Programs
- DLA Apparel Acquisition

IMPROVED SUPPLIER RESPONSE TIME

- DEMONSTRATION GOALS
  - Reduced Design Cycle Time - 25%
  - Reduced Time for Design Changes - 25%
  - Delivery Lead Times: 50% Reduction

Customers:

- Apparel Supply Tiers
- Composites Suppliers
- Electronics Suppliers

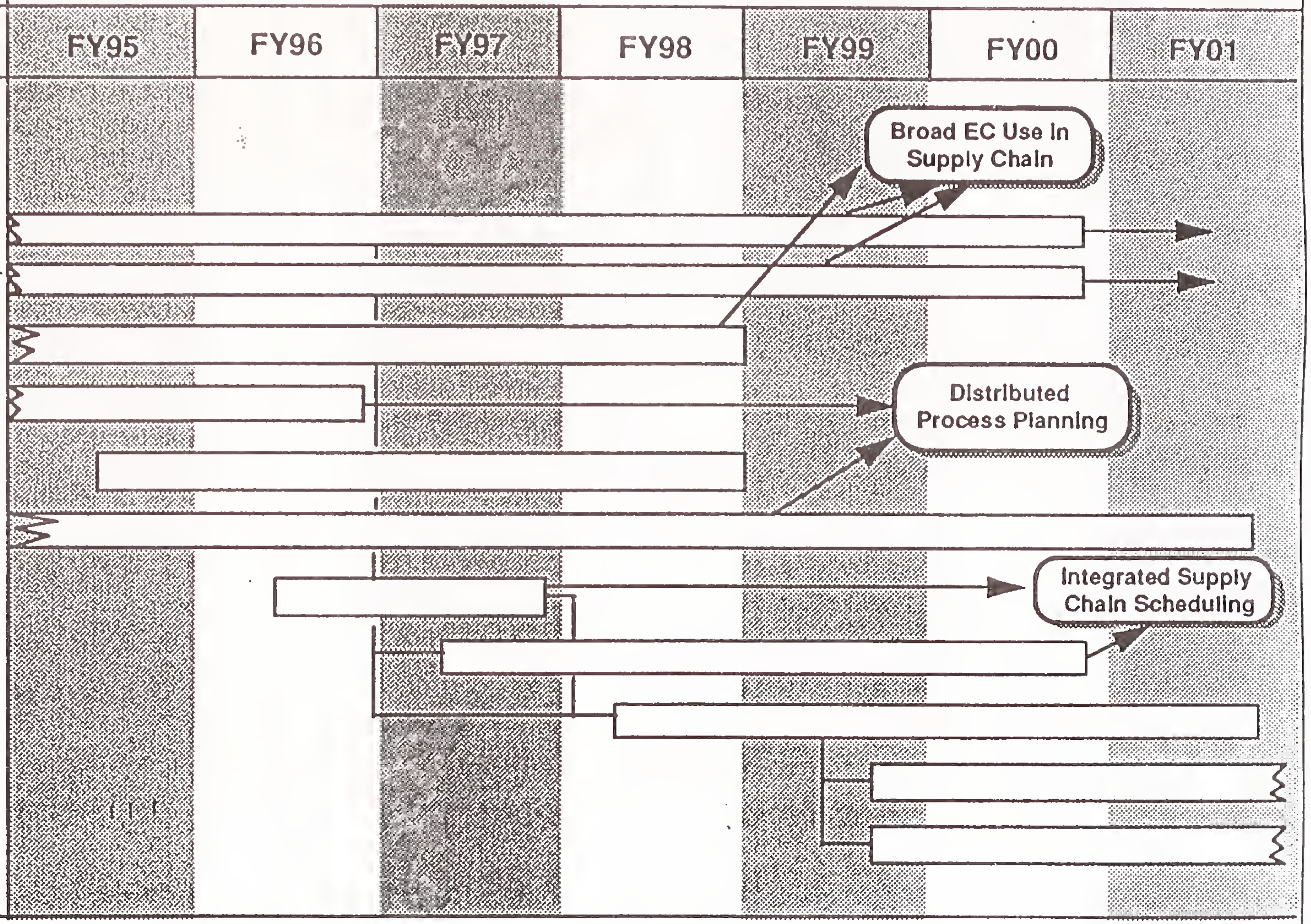
Manufacturing & Engineering Systems - Level 2

SUPPLY CHAIN INTEGRATION

Technical Area: Supply Chain Integration

Goal: All tiers of the supplier base operate as a unified entity for most efficient total production and rapid, efficient response to change at any point in the supply chain

Program Title	
BUSINESS AND TECHNICAL SYSTEMS INTEGRATION	
Commercial EC & EC Standards Activities	
Systems Integration for Mfg Appl'ns	DoC/NIST
Electronic Commerce Resource Centers	ARPA/Navy
Agile Manufacturing Enabling Techs	ARPA
Lean Aircraft Initiative Implementation	MS&T/AF
Apparel Enterprise Systems Integration	MS&T/DLA
SPARES Tech. Transition	MS&T/AF
Supply Chain Integrated Scheduling	Joint MS&T A/N/AF/DLA
Supplier Chain Support	MS&T/AF
Distributed Resource Planning and Control	Joint MS&T A/N/AF/DLA
DoD Inventory Control Systems	Joint MS&T A/N/AF/DLA



Manufacturing & Engineering Systems - Level 2

SUPPLY CHAIN INTEGRATION

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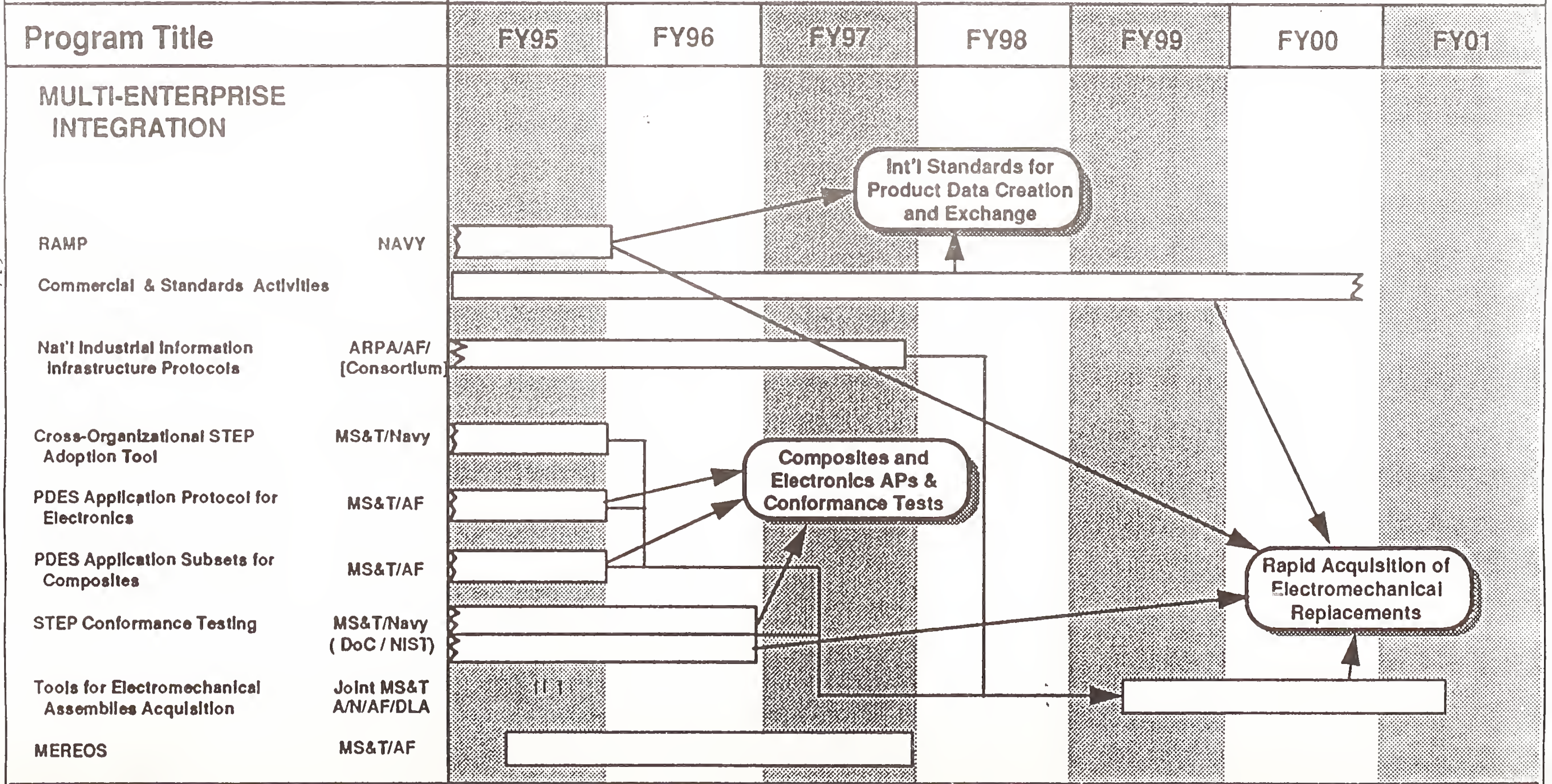
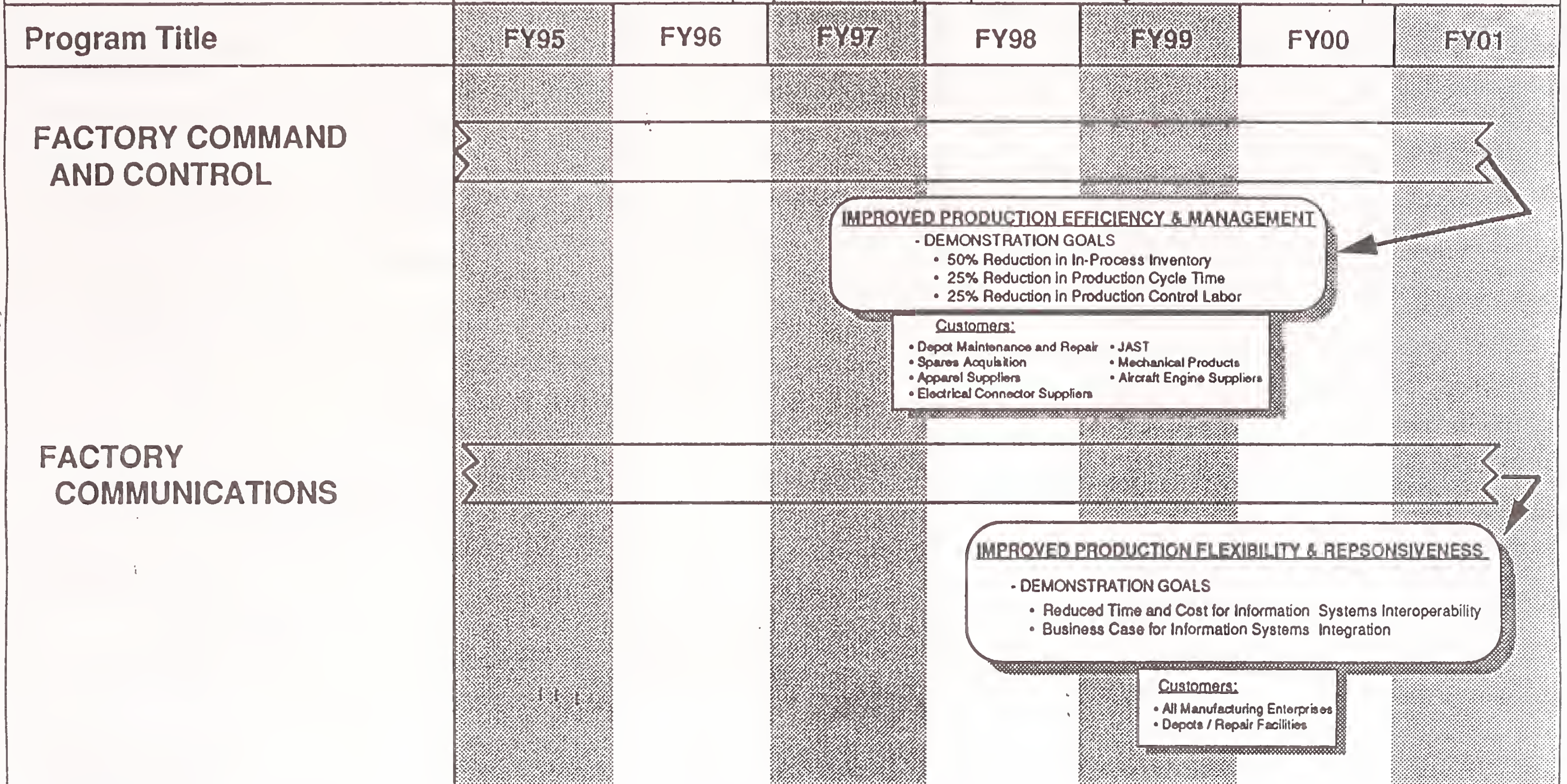


Manufacturing & Engineering Systems - Level 1

FACTORY C^3

Technical Area: Factory C^3

Goal: Factory and maintenance/repair operations are planned, scheduled and controlled to efficiently manufacture single and multiple products, minimize effects of production volume, and rapidly & efficiently respond to changed conditions or requirements



Manufacturing & Engineering Systems - Level 2

FACTORY C^3

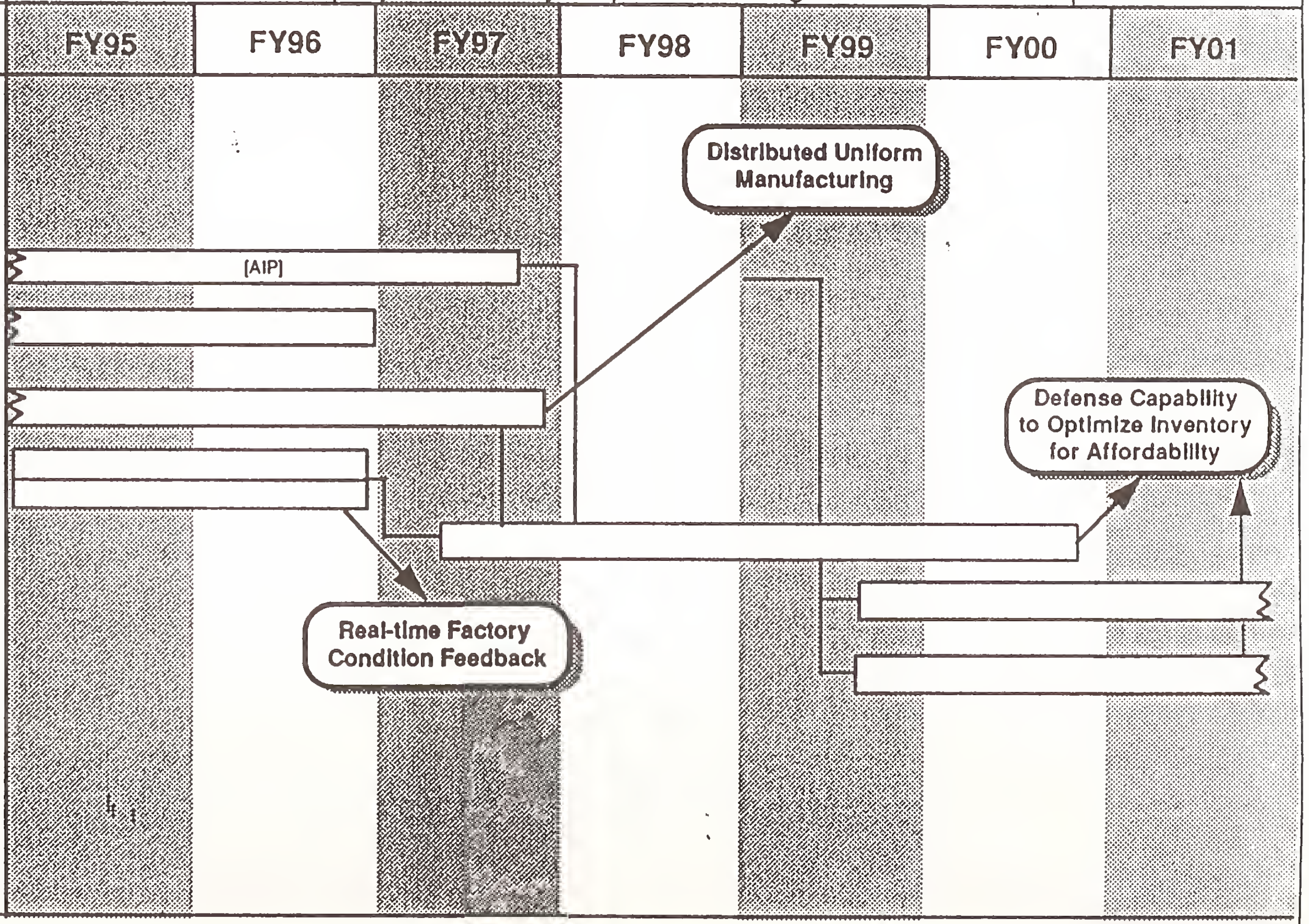
Technical Area: Factory C^3

Goal: Factory and maintenance/repair operations are planned, scheduled and controlled to efficiently manufacture single and multiple products, minimize effects of production volume, and rapidly & efficiently respond to changed conditions or requirements

Program Title

FACTORY COMMAND AND CONTROL

Program Title	
Lean Aircraft Initiative	MS&T/AF
Agile Manufacturing Enabling Technologies	ARPA/A/N/AF/DLA
Apparel Production Scheduling and Control	MS&T/DLA
Scheduling/Shop Floor Data Collection and Integration	MS&T/Navy (DoC/NIST)
Inventory Optimization	Joint MS&T A/N/AF/DLA
Dynamic Rescheduling	Joint MS&T A/N/AF/DLA
Decision Support for Throughput Optimization	Joint MS&T A/N/AF/DLA



Manufacturing & Engineering Systems - Level 2

FACTORY C^3

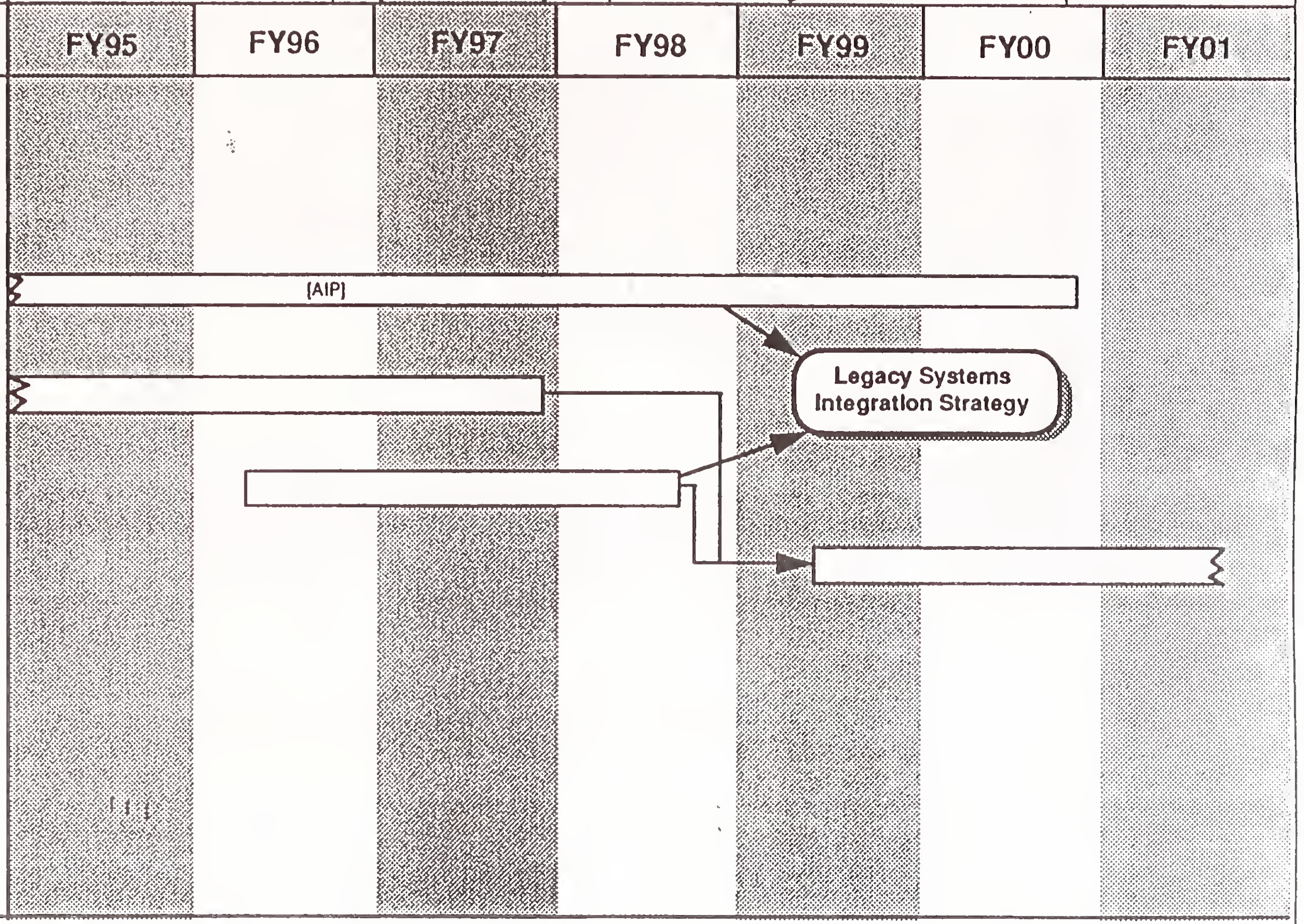
Technical Area: Factory C^3

Goal: Factory and maintenance/repair operations are planned, scheduled and controlled to efficiently manufacture single and multiple products, minimize effects of production volume, and rapidly & efficiently respond to changed conditions or requirements

Program Title

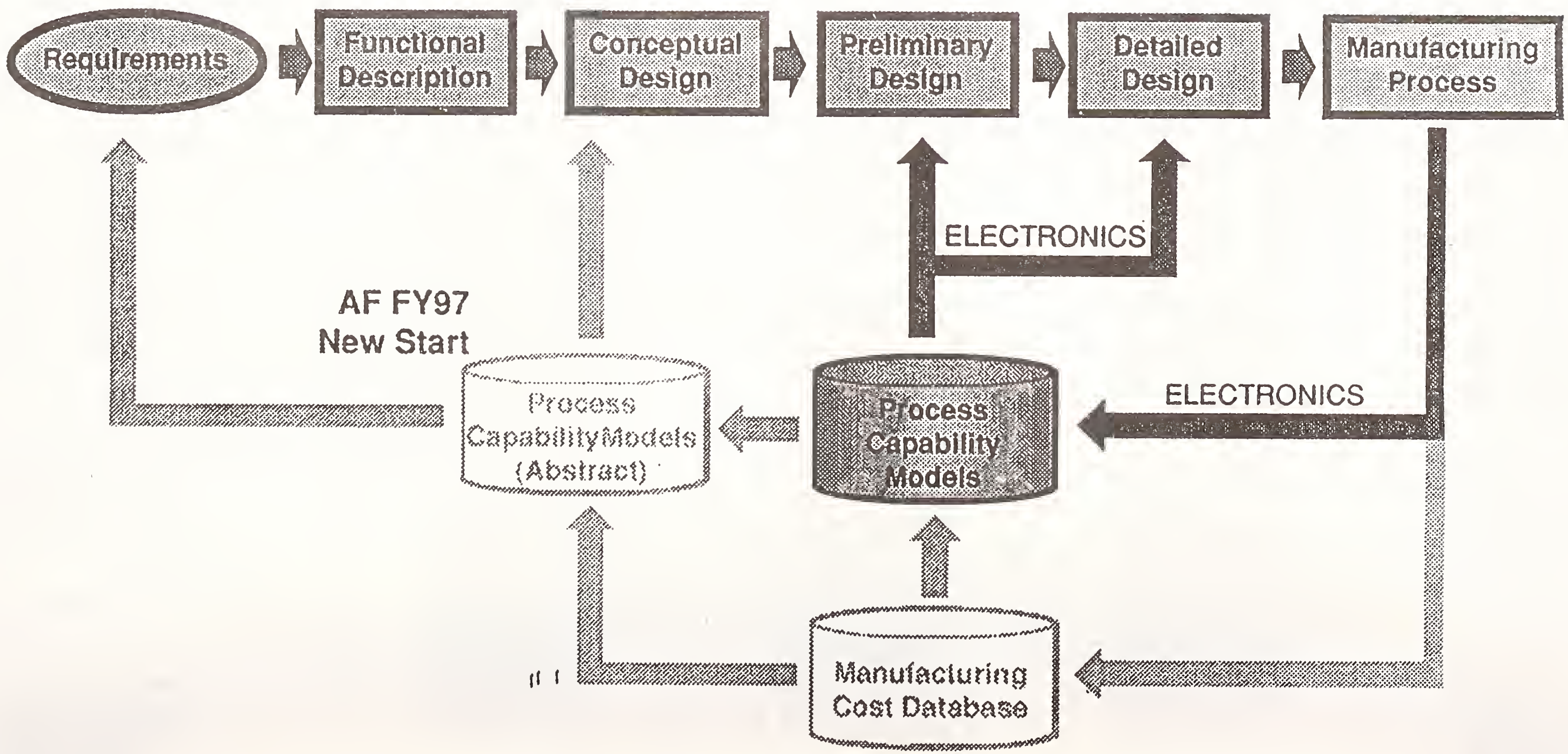
FACTORY COMMUNICATIONS

Program Title	
Affordable Multi-Missile Manufacturing	ARPA/A/N/AF
Integration & Management of Manufacturing Information Systems	MS&T/Army
Legacy Systems Integration	MS&T/Army
Legacy Systems Integration	Joint MS&T A/N/AF/DLA



Manufacturing Engineering Methods & Tools for Six Sigma Capability

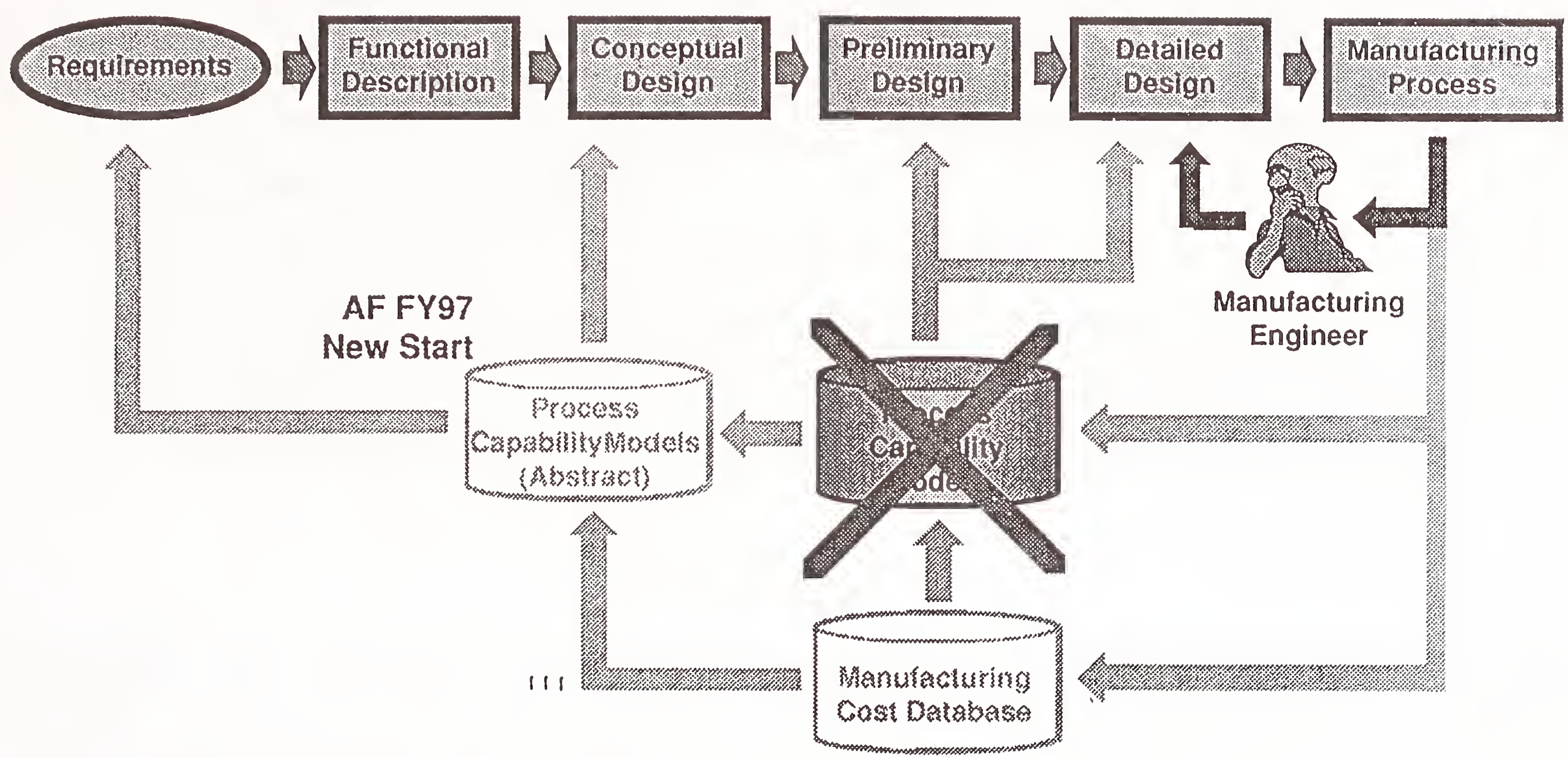
Electronics/Electro-Mechanical Systems



Manufacturing Engineering Methods & Tools for Six Sigma Capability

Joint Directors of Laboratories

Structural Components & Systems



Manufacturing Engineering Methods & Tools for Six Sigma Capability

Joint Directors of Laboratories

Products

- Methodologies to:
  - Characterize processes, create process capability libraries
  - Identify critical processes, cost and defect drivers
  - Link design to manufacturing capability in "real time"
- Tools that support:
  - Design decisions that access process capability libraries, cost databases
  - Feature based design, modeling & simulation, Six Sigma design
- Multiple (incremental) Demonstrations that show:
  - "Real time" designer use of manufacturing engineering tools
  - Application to military airframe domain
  - Business case to motivate commercial tools development and long-term support

Summary

Joint Directors of Laboratories

- The M&ES Sub-panel is a team
- Focus is on the high cost / high payoff defense product realization functions
- A solid project planning and execution strategy is in place
- Tight linkages are established with related federal programs in DoD, NIST, and DoE

Manufacturing
Science & Technology

Advanced Industrial Practices

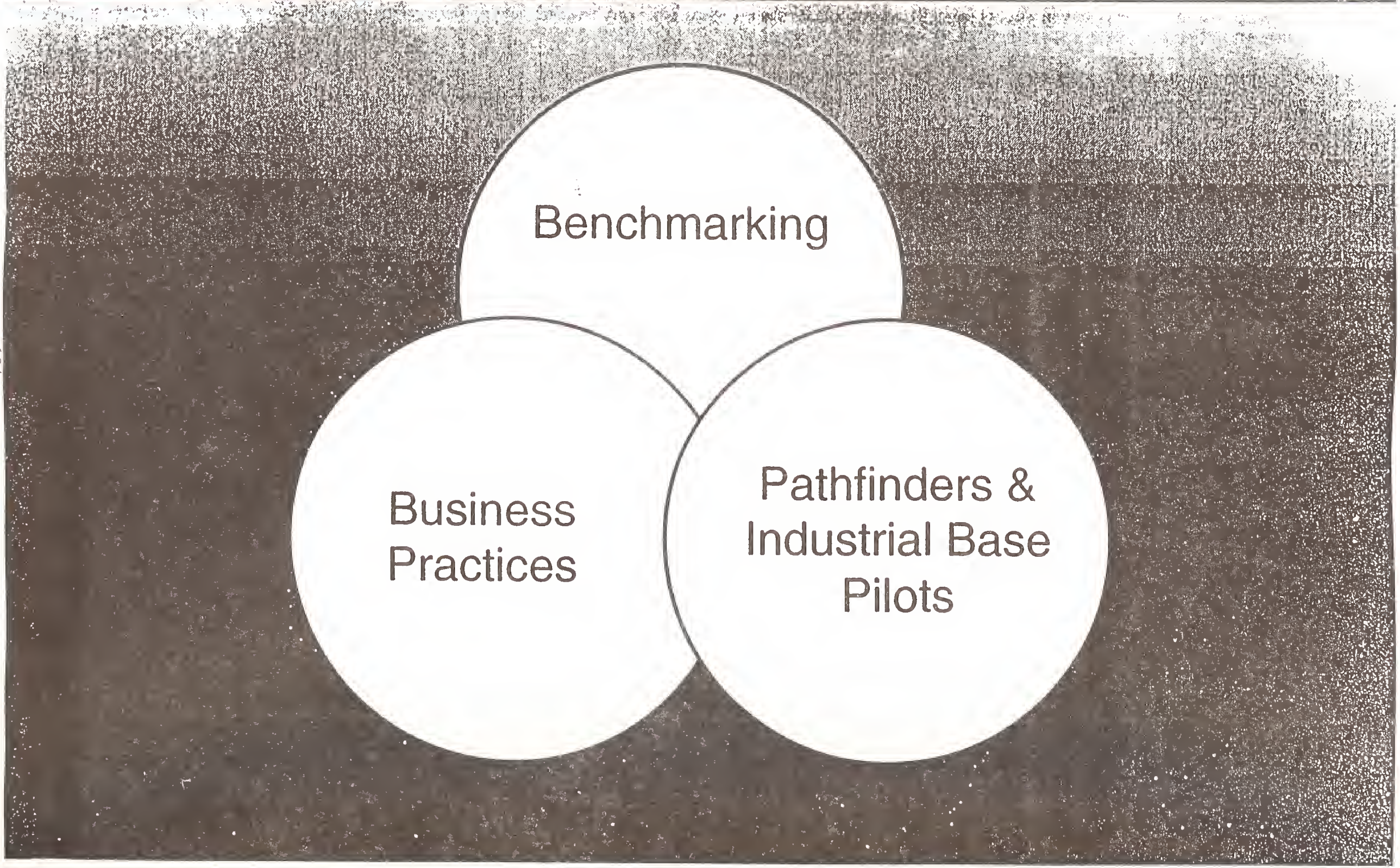
Presentation at
The National Manufacturing Technology Conference
National Institute of Standards and Technology

20 April 1995
John R. Fenter

Outline

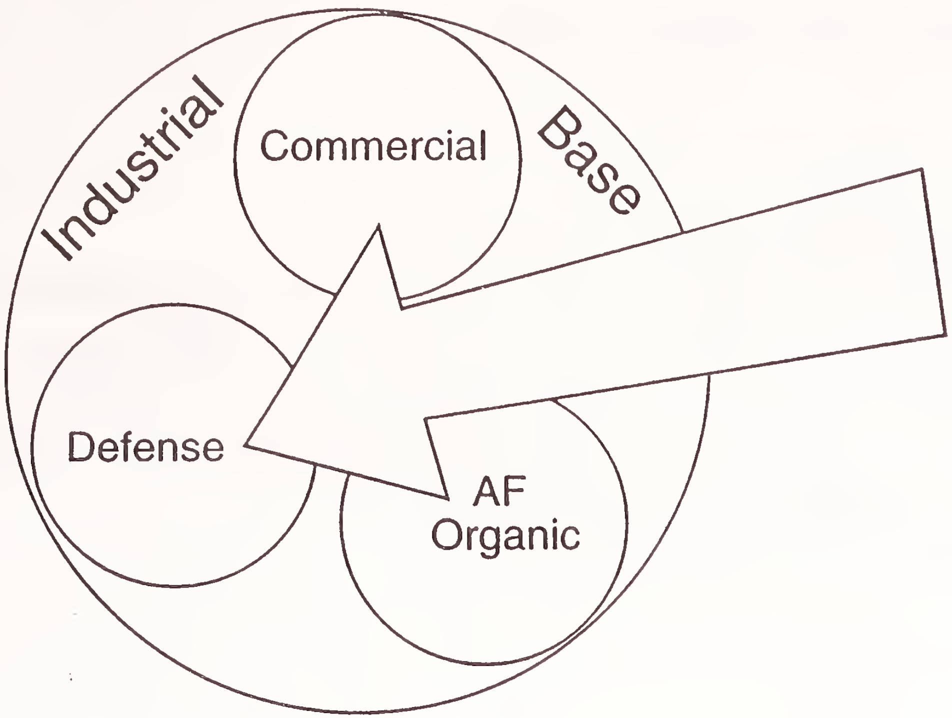
- Background
- Taxonomy and Goals
- Benchmarking
  - Lean Aircraft Initiative
- Business Practices
  - Quality System
- Industrial Base Pilots
- Summary

Advanced Industrial Practices



Mfg 2005 Guidance & Strategy

- **Single Industrial Base**



TRENDS

Quality	Com'l/Mil Integration
Flex Mfg	Vertical Partnering
IP/PD	International Sourcing

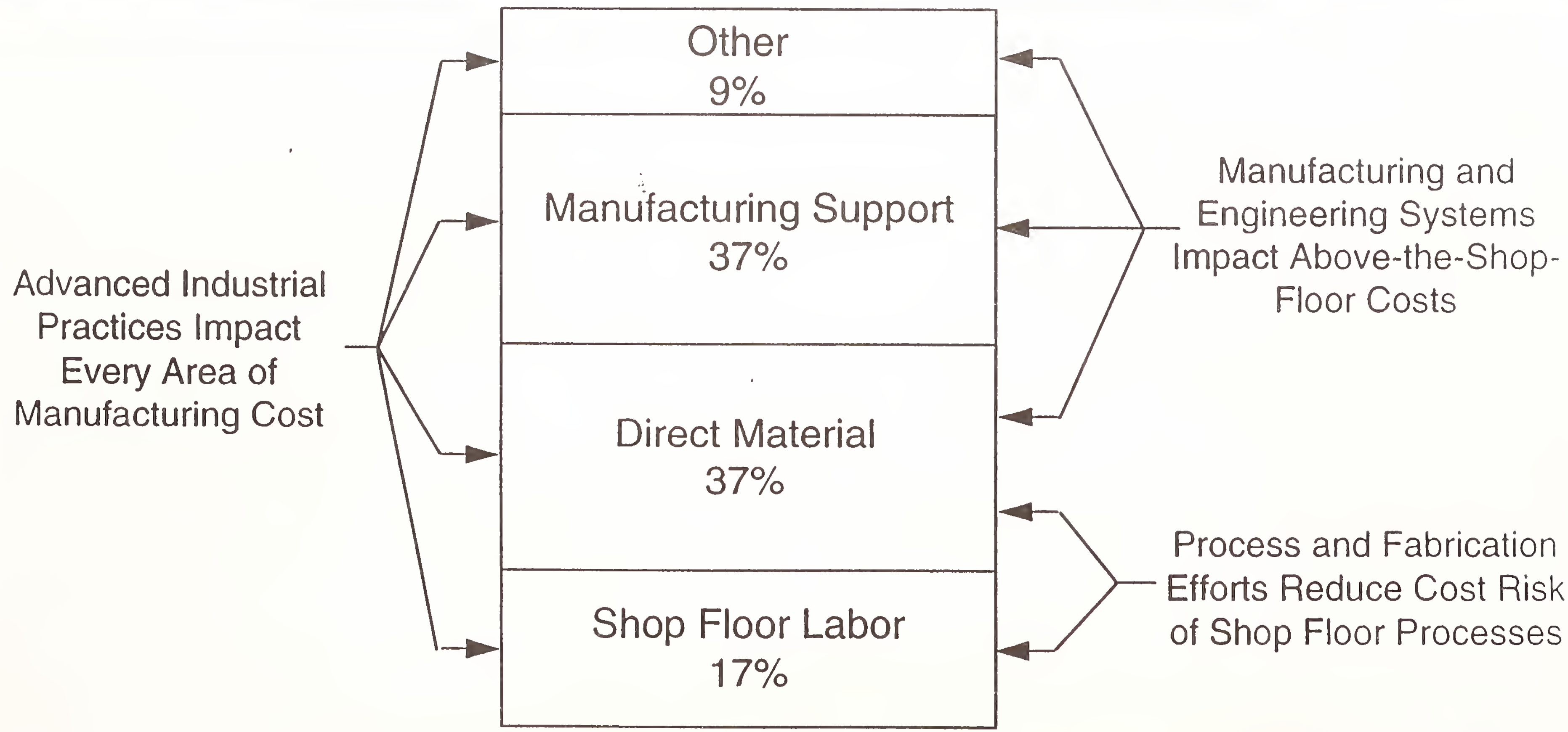
Goal

- Stimulate robust manufacturing base supporting AF requirements
  - Low Cost
  - Shorten time to low risk production
  - Technologically superior systems

Initiatives

- Policies and business practices
- Manufacturing infrastructures
- Process technologies

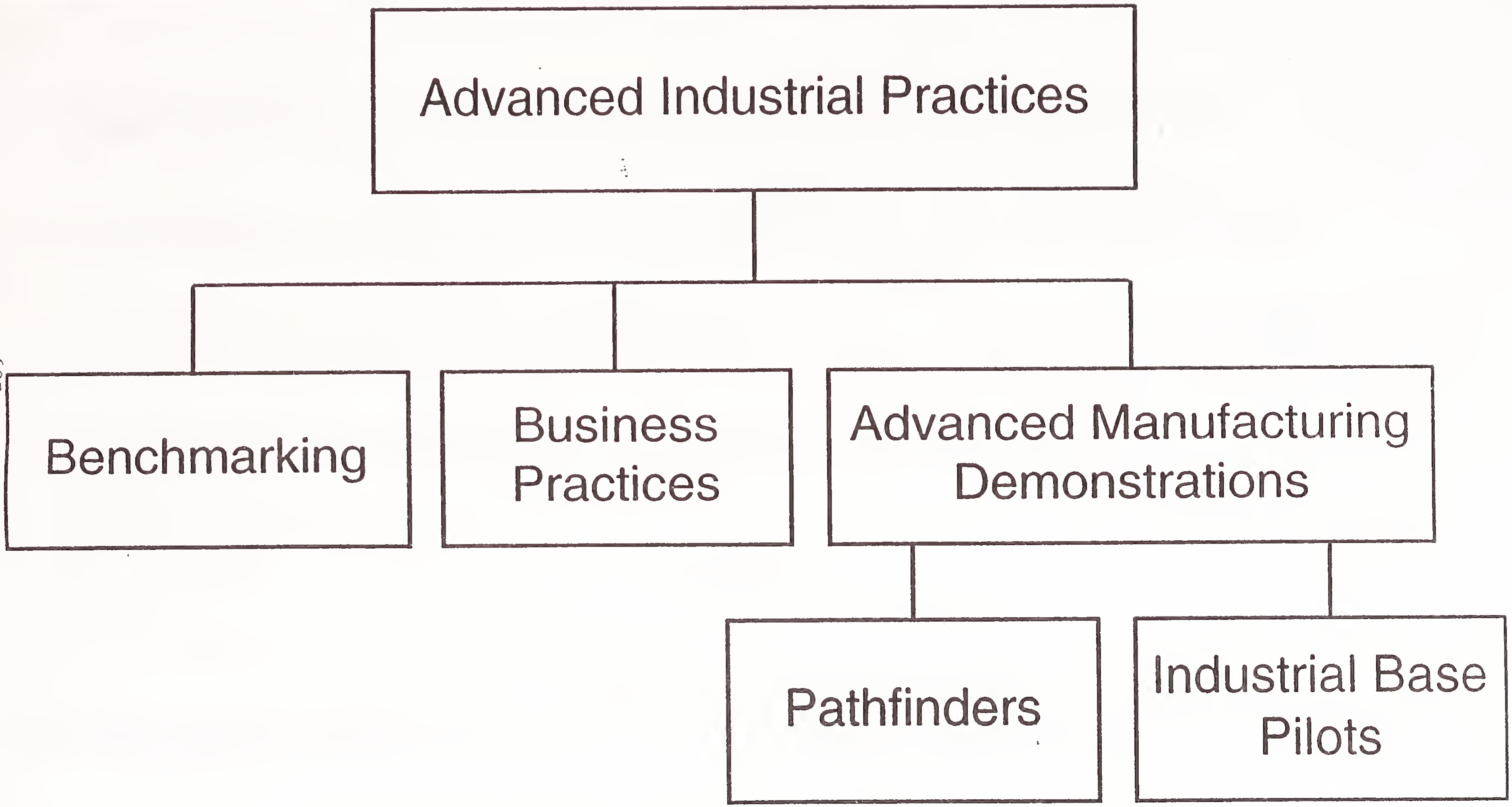
Advanced Industrial Practices



Advanced Industrial Practices Impact All Areas of Weapon System Manufacturing Costs

Advanced Industrial Practices

Taxonomy

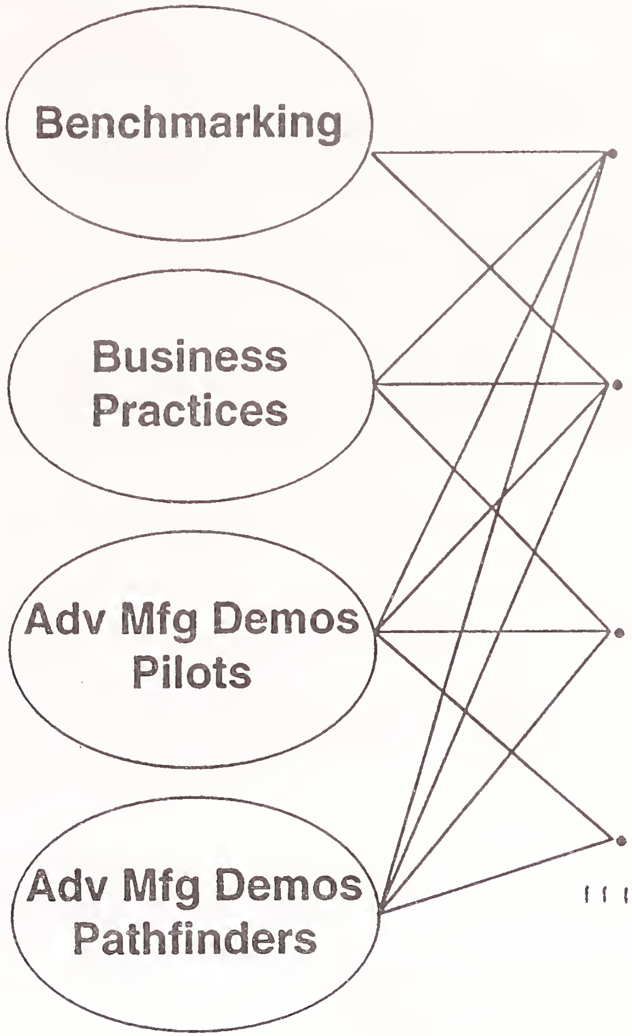


Advanced Industrial Practices

GOALS

- Business Partnerships for Defense Production
- Defense Production Capabilities with World Class Benchmarks
- Integrated Production of Military and Commercial Items
- Affordable, Timely Response to DoD Requirements

Taxonomy vs. Goals



AIP Goals

- Business Partnerships for Defense Production
  - Contracts with Commercial Producer
  - Common Spec, Stds, and Methods
  - Vertical Partnering
- Defense Production Capabilities with World Class Benchmarks
  - Lean Factory Operations
  - Quality Supplier Management
  - Inventory Optimization
  - Single Accounting System
- Integrated Production of Military and Commercial Items
  - One Quality System for a Facility
  - Comingling of Inventory
  - Lean/Flexible Manufacturing
- Affordable, Timely Response to DoD Requirements
  - IPPD Systems
  - Shortened Design-to-Production Transition
  - Life Cycle Support

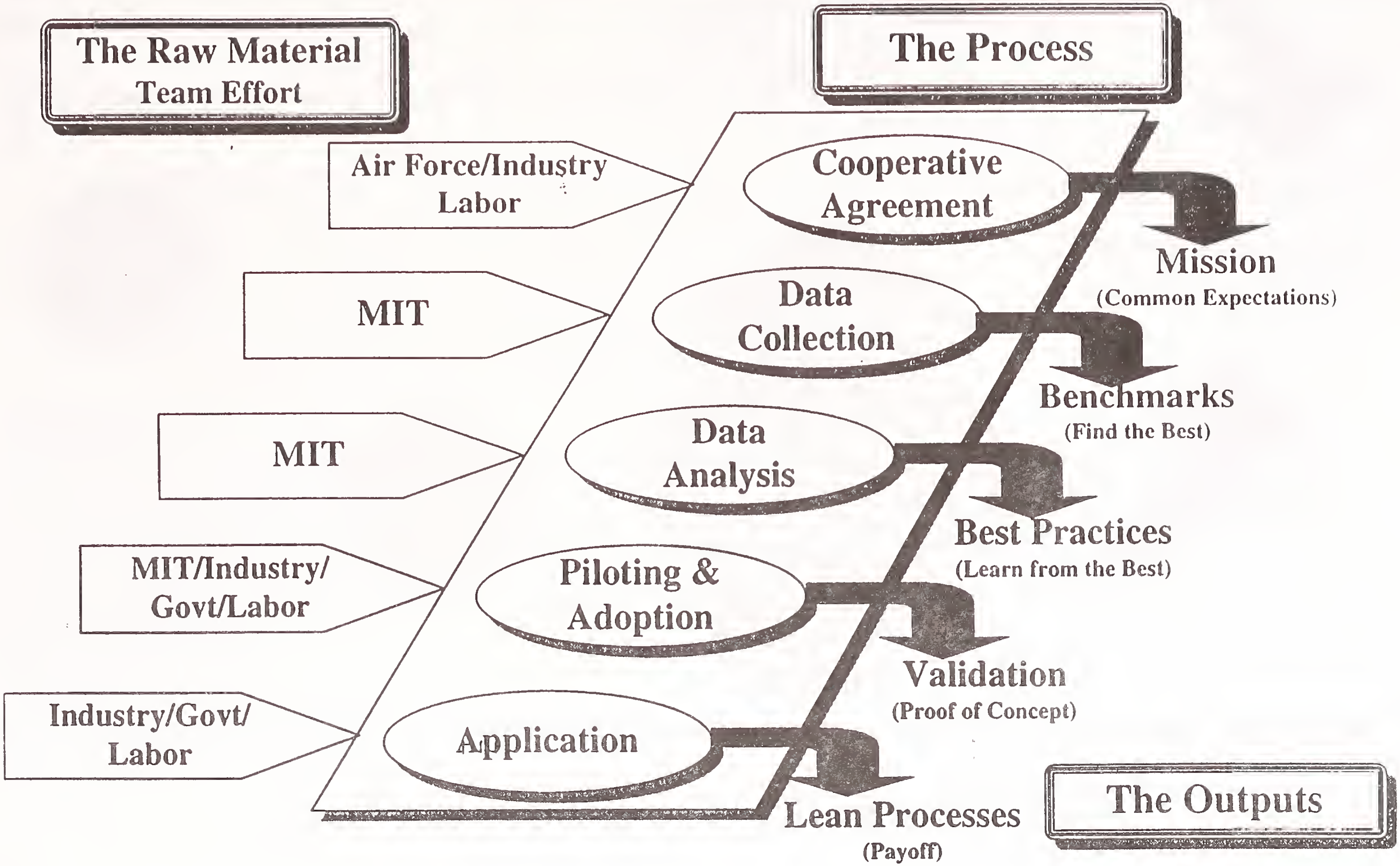
Baselining & Benchmarking

Lean Aircraft Initiative

- Gain an In-depth Knowledge of Lean Principles
  - -- Cooperative venture between Industry-Government-Labor-Academia
  - -- Focus on Data Analysis

- Influence and Mold Future Acquisition Environment
  - -- Compare Benchmarks with Individual Practices
  - -- Drive to Implementation

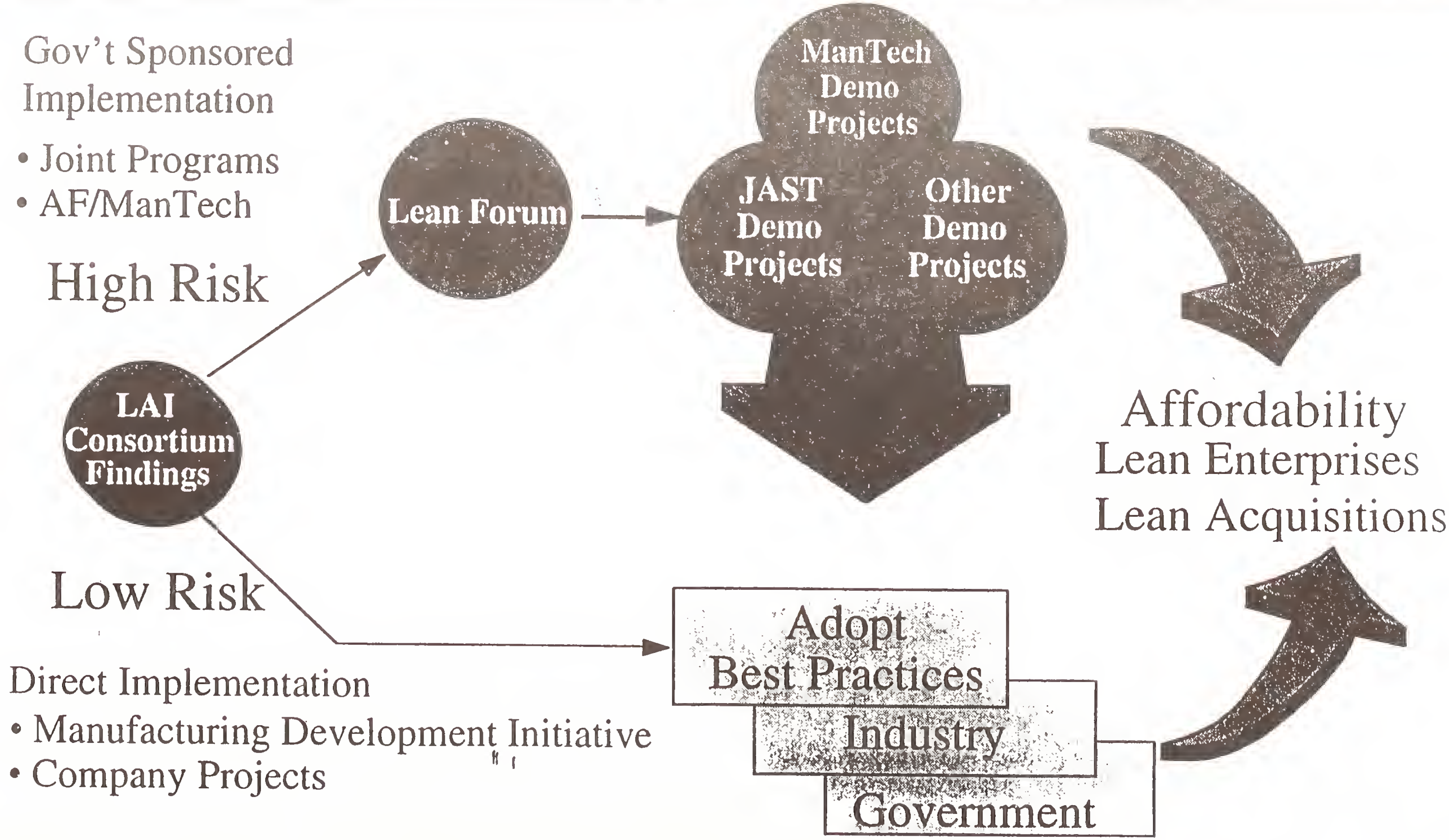
LAI Execution Framework



4/11/95

NIST/LAT/A/10

Implementing Lean Findings



Challenges for Advanced Industrial Practices

Business Policies & Practices

DoD Goal: Reduce Acquisition Cost While Maintaining Technological Superiority

- DoD Mil Spec reform effort includes actions to change the acquisition culture:
  - Ensure long term, top-management support
  - Provide training to workforce
  - Secure adequate funding and personnel resources
  - Establish incentive for desired behavior

- Acceptance by DoD and contractor's offices may be difficult without
  - Improved data on the benefits of implementing the recommendations
  - Better focus on areas with the greatest opportunities for benefits
  - Adequate indicators, metrics, to measure progress toward goals

Reference: Acquisition Reform, DoD Begins Program to Reform Specifications and Standards, GAO Report, October 1994

4/11/95

NIST/LAT/A/12

Quality System Implementation

Background

Held Special Gov't/Industry Panel at DMC–Dec 94

Panel Members:	Questioners:
F. Doherty/OSD	R. Cormack/NAWC
R. Zell/DCMC	D. Misczynski/Motorola
K. Reed/MDA	G. Engbretson/Rockwell
S. Hutchens, Jr/Intertek	G. Colbert/ASC
	D. Ling/Hewlett-Packard

Current Activities

White Paper from Panel with Recommendations for Action

Workshop to Expand Recommendations and Develop Strategies for Implementation

Validate a Single Quality System having Process- Based Management, Continuous Improvement, Self-Certification, and Integrated with DCMC Services

Quality System Implementation

DMC'94 Advanced Industrial Practices Discussion Panel

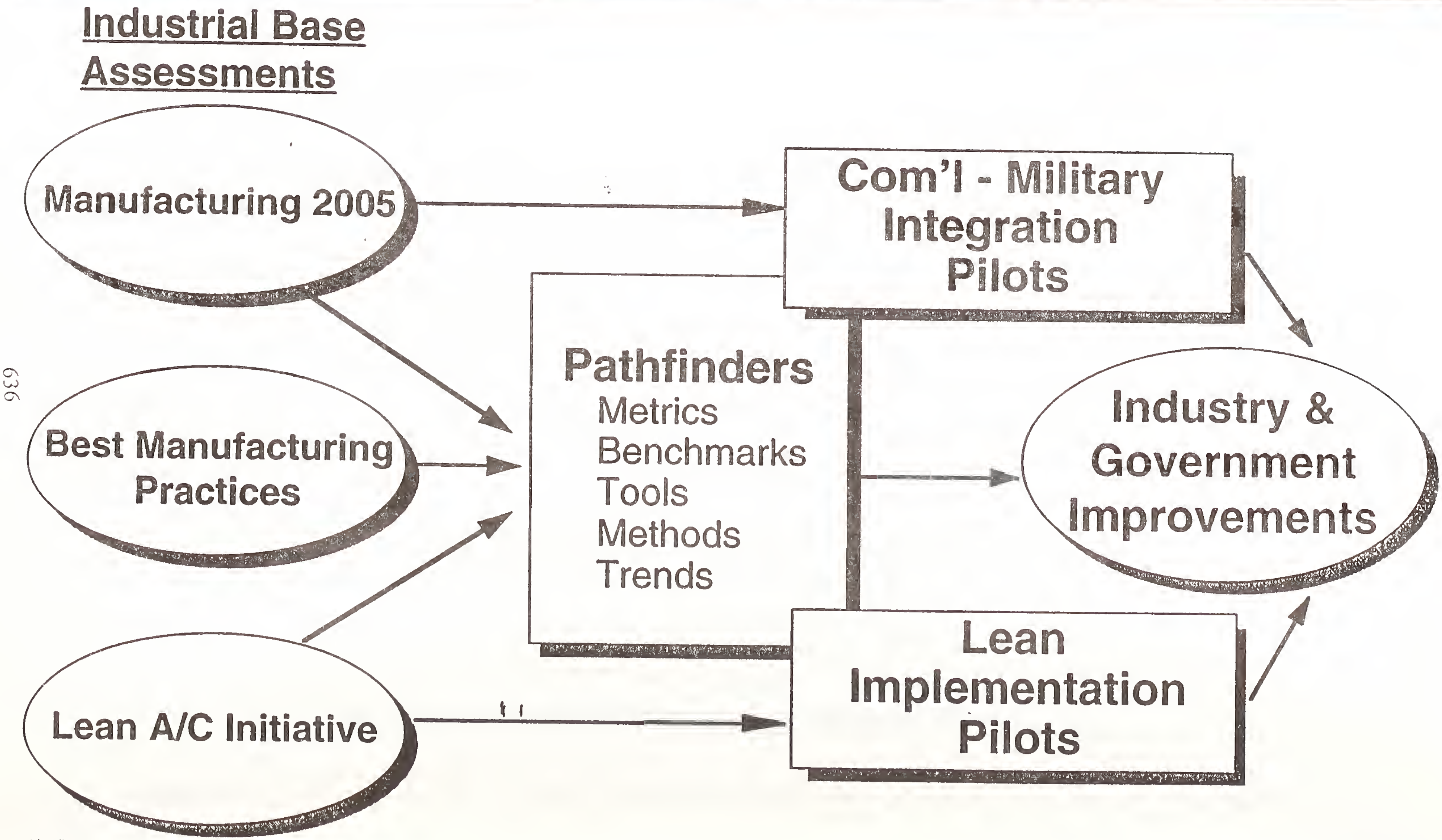
<u>Baseline Assessment</u>

- ISO 9000 Minimal Benefit to DoD Products
- Complexity of a Product Dictates Complexity of Quality System
- Corporate Strategies Address Quality Culture and Product Quality
- Supplier Management Key to Common Com'l and Military Industrial Base
- Cooperative Gov't/Industry Panels Working for Broad Acceptance

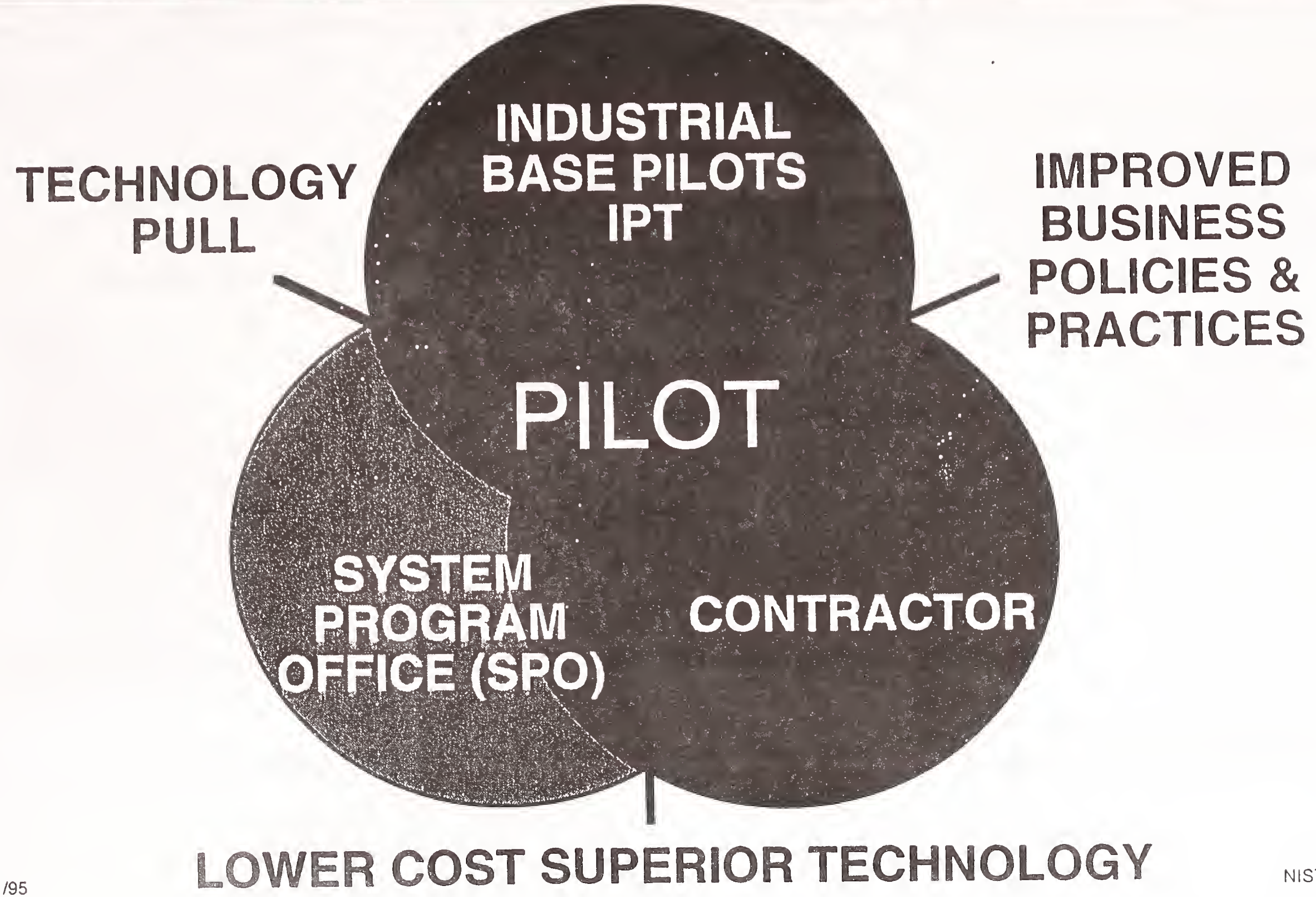
<u>Recommendations</u>

- Establish Collaborative Interface with Industry
  - Co-sponsor Workshop with Industry
  - Develop Gov't/Industry Roadmap
- Support Joint Gov't/Industry Quality Liaison Panel
  - Provide Path/Process for Demonstration & Implementation
- Demonstrate Single Quality System
  - All Sectors, Multiple Sites, Large & Small Contractors, Multiple Products

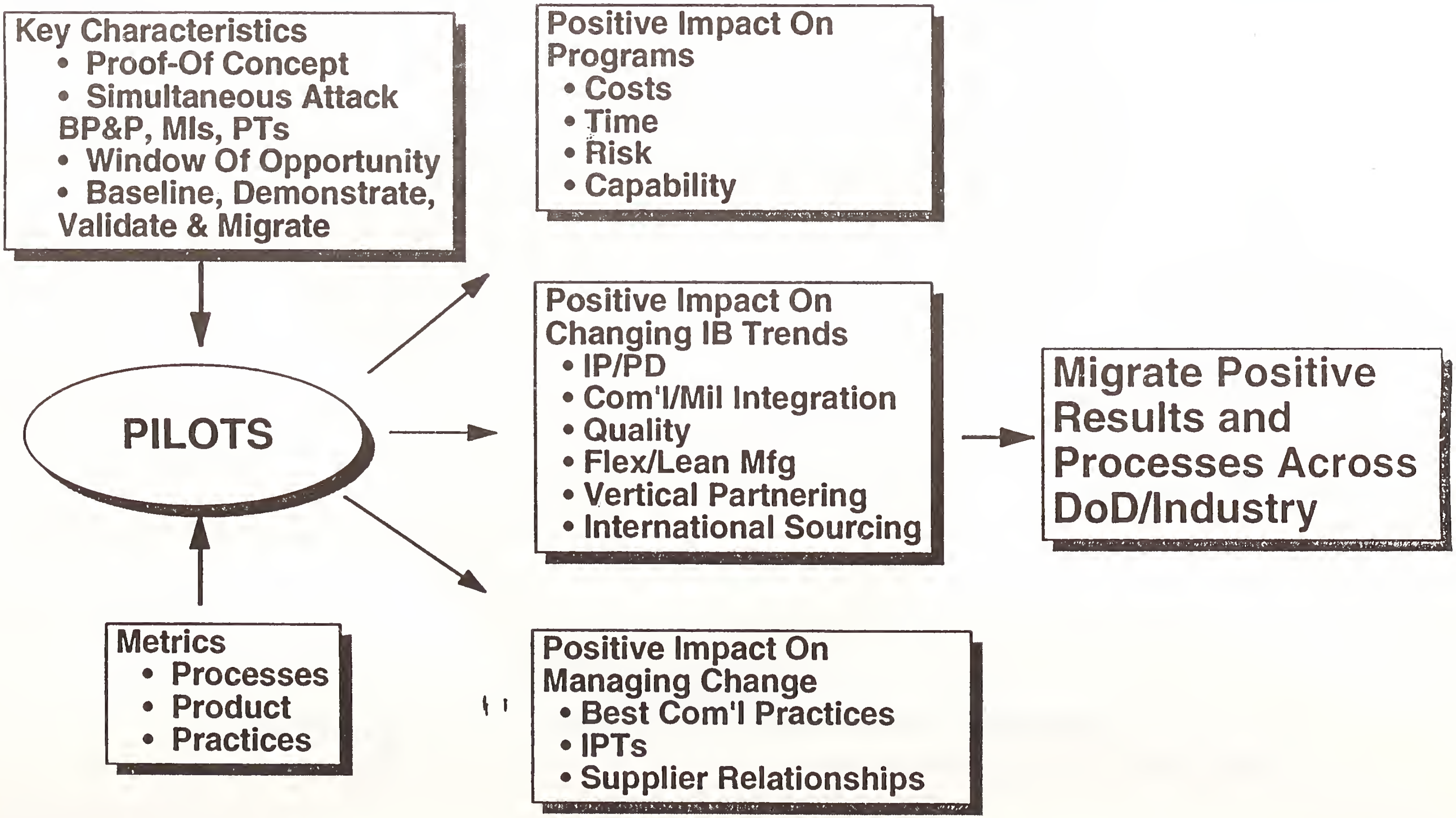
Program Relationships



Pilot Programs



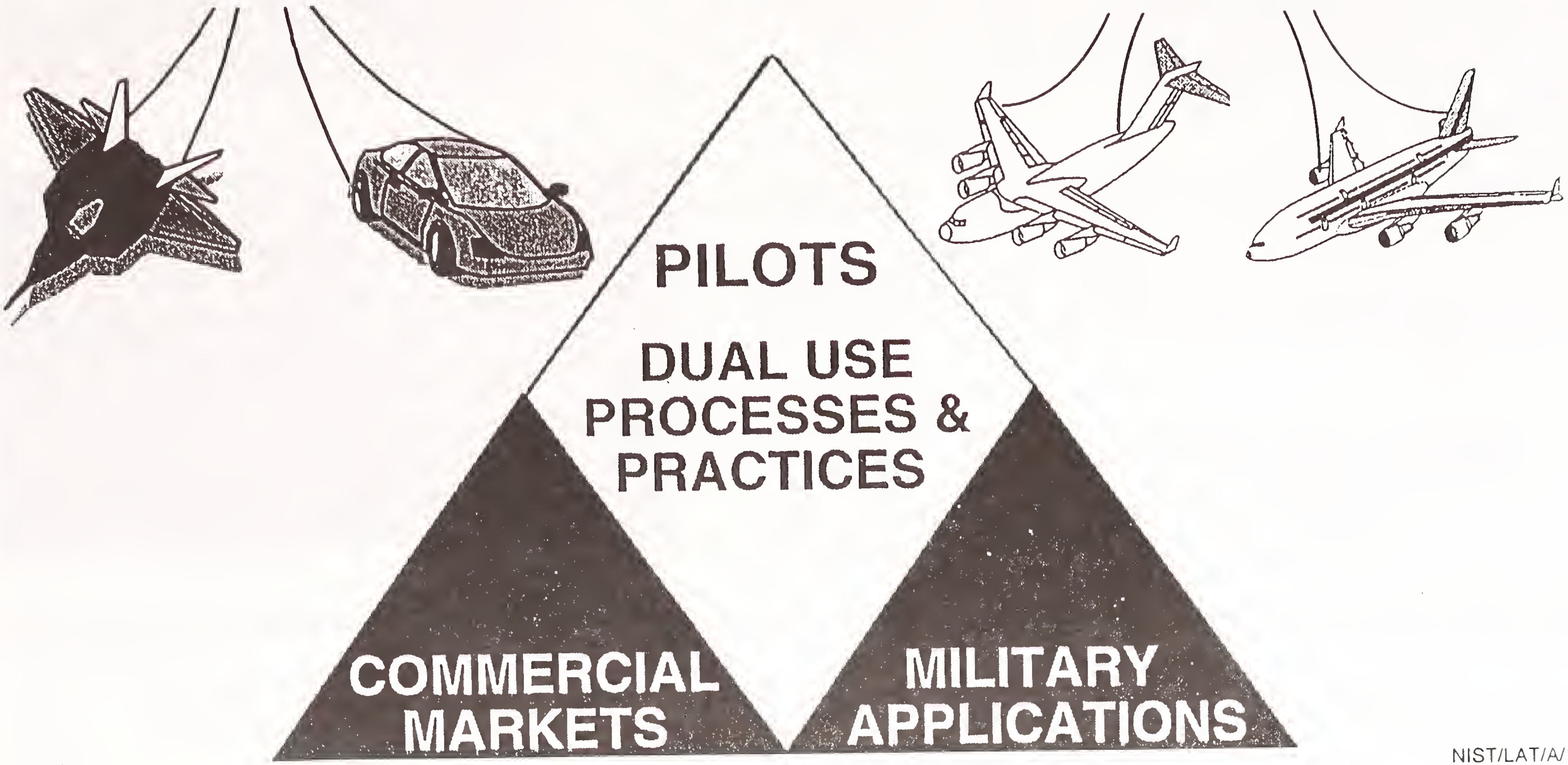
Elements of Mfg 2005 Pilots



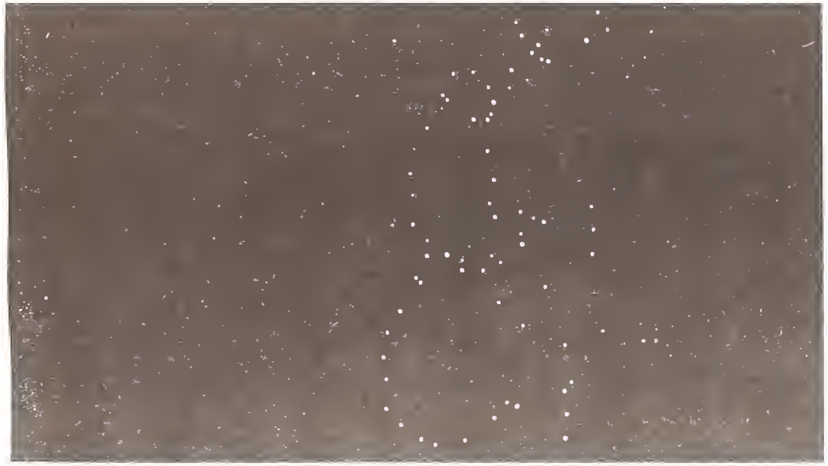
Pilot Programs

Military Products from Commercial Lines

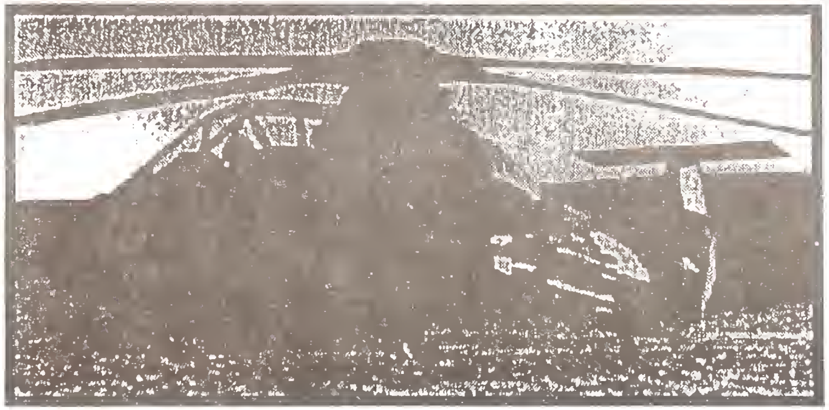
Military Products Using Best Commercial/Military Practices



Military Products from Commercial Lines



F-22 Advanced Tactical Fighter



RAH - 66 Comanche

Communications, Navigation, Identification Avionics for F-22 & RAH-66

- Exploit Flexibility on High Volume Commercial Lines
- Higher Quality Levels through Automation
- Supplier Material Management
- Design for Manufacturability

Awarded to TRW MEAD
Total: $21.5M

Military Products from Commercial Lines
Pilot Charter

VISION

Seamless Integration of Commercial and Military Processes Leading to Military Acquisition

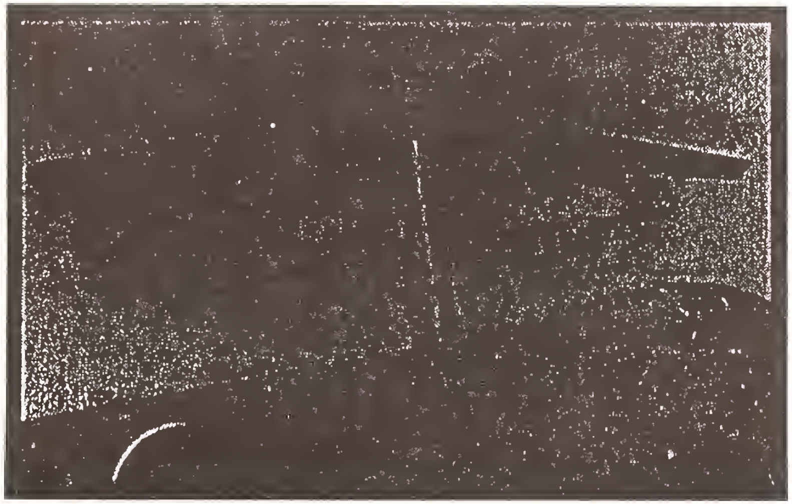
MISSION

Apply Lean Principles to Demonstrate Commercial Manufacture of Military Electronics Modules, and Measure and Migrate Results

GOALS

- Demonstrate Dual Use Lean Enterprise
  - Lean Management Through Best Commercial Business Policies and Practices
  - Lean Design Through Concurrent Engineering Design Tools, Process Technology, and Design for Manufacturability
  - Lean Production Through "Lot Size of One" Flexible Manufacturing
- Demonstrate that Above Processes Can Be Used by the Military Customer with Confidence
  - 30% to 50% Lower Cost
  - Higher Quality: <20 ppm defects (world class)
  - Equivalent Functionality/Durability
- Migrate Results to Government/Industry

Military Products Using Best Commercial/Military Practices



C-17 Horizontal Stabilizer

Best Commercial Practices for Large Airframe Manufacture

- Commercial Quality System
- Commercial Contracting & Financial Reporting Approaches
- Demonstrate IPT Management & Development
- More Affordable Horizontal Stabilizer

McDonnell Douglas Aerospace & Vought Aircraft Company
Total: $37.5M

Military Products Using Best Commercial/Military Practices

Team Partners

Wright Laboratory
- Manufacturing Technology
- Mfg 2005 Philosophy
- Gov't Contracts and Finance

C-17 SPO
- System Management
- Operational Requirements

MDA-E
- Phantom Works
- Composite Design
- Composite Manufacturing
- DPRO

Vought
- Commercial/Military Business
- Metal Baseline
- Composite Manufacturing
- Vertical Partnering
- DPRO

MDA-W
- C-17 Program
- Commercial Integration

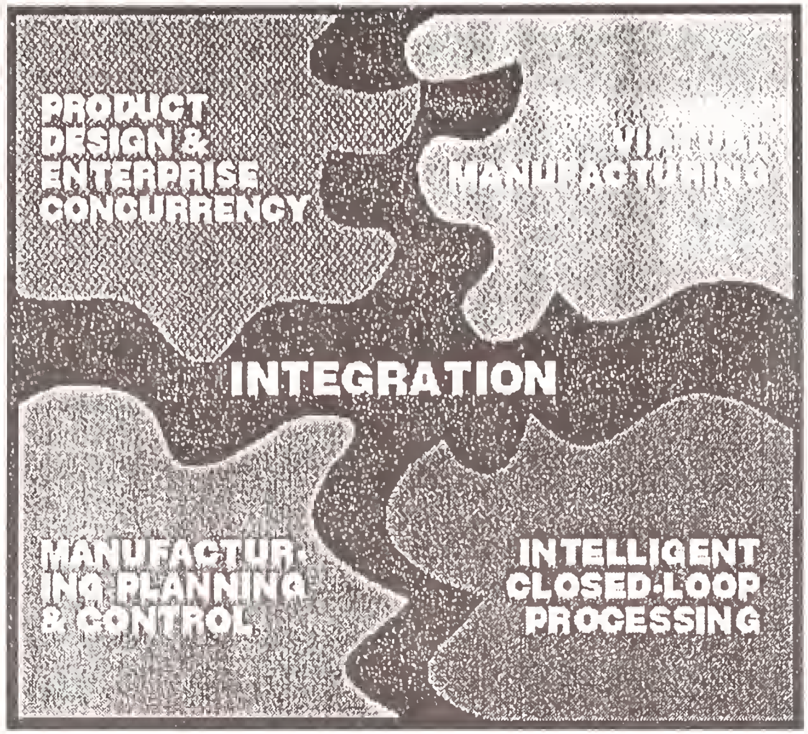
Summary

- The Advanced Industrial Practices Thrust evolved from the Manufacturing 2005 study. The Thrust is providing the focus for cultural changes within business and enterprise management practices.
- The Lean Aircraft Initiative provides collaborative industry benchmark findings and best practices in inventory, scheduling, quality, and supplier relationships.
- Supplier management with quality products, long term relationships, and affordability will develop into a major initiative.
- The results of the industrial base pilot programs can provide valuable information to the acquisition reform community.
- Commercial - military integration will be validated using pathfinder and industrial base pilot projects.
- The JDL activities will initiate a number of joint program efforts in quality and lean manufacturing.

Technologies Enabling Agile Manufacturing (TEAM)

Diane Bird, DoE
Richard Neal, Oakridge
Tom Young, Sandia

TEAM



Technologies Enabling Agile Manufacturing

TEAM and the National Agenda

Diane Bird
DOE Defense Programs

TEAM

- TEAM Program Overview
- The TEAM Technical Agenda and Deliverables
- The Business Case
- TEAM and the National Agenda
- Wrap Up

DOE Strategy

- Multi-year program (3-5 years)
- Coordinated development, integration and demonstration of agile manufacturing technologies ready for commercialization
- $5M per year of resources at 5 DOE facilities for at least 3 years:
  - Y-12, Kansas City, LANL, LLNL, and SNL
- In-kind matching from industry partners, federal partners and university partners
- Coordination with other Federal Agencies and programs:
  - DoD, DoC-NIST, NSF, STTR

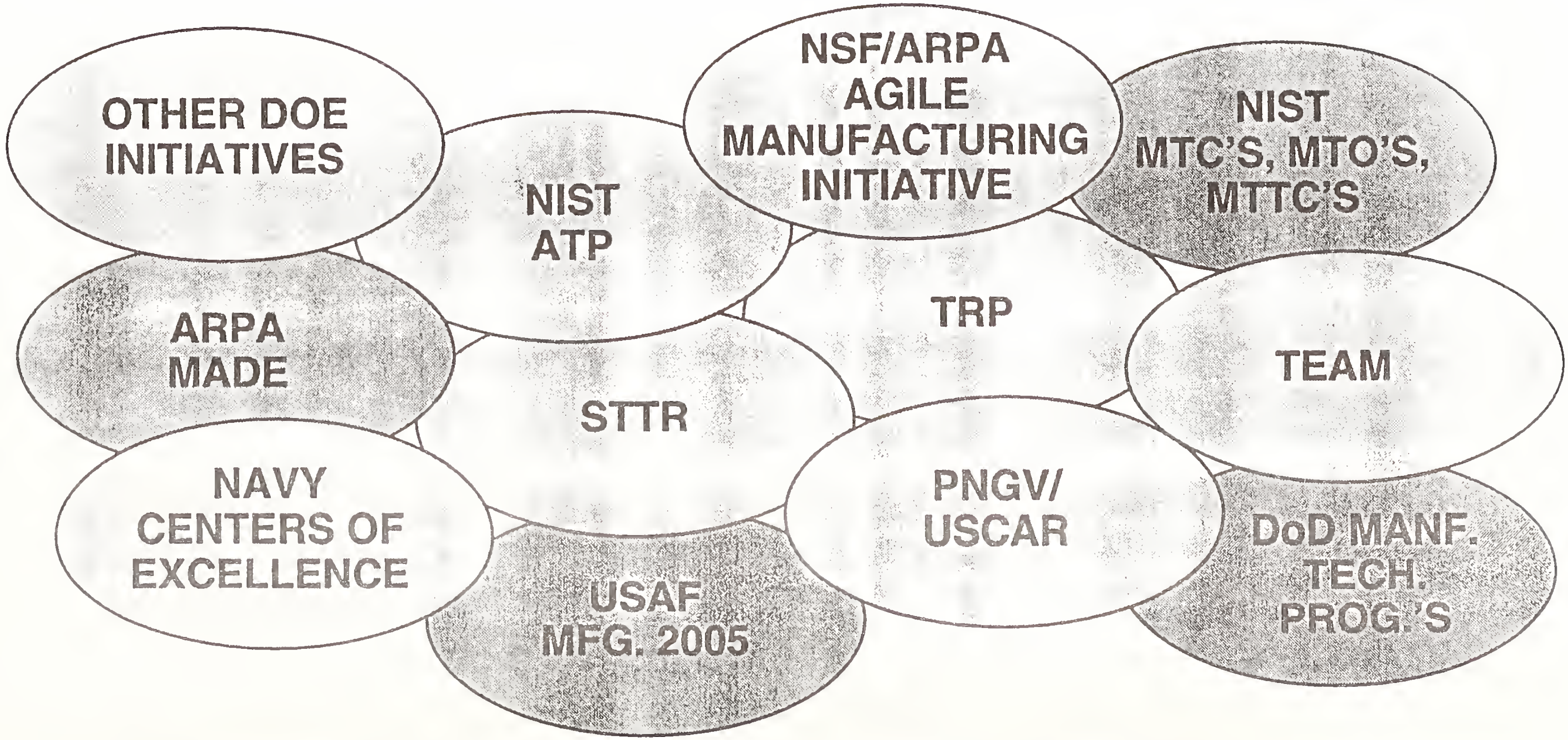
DOE Defense Programs
Technology Transfer Focus

"Support the DP defense mission through dual-benefit technology partnerships with industry"

- Leveraging of industrial capital
- Support of industries critical to the supply base
- Infusion of knowledge, ideas, and skills from companies at the leading edge
- Focus on advanced design and production technologies for the weapons complex

TEAM is well aligned with this new focus

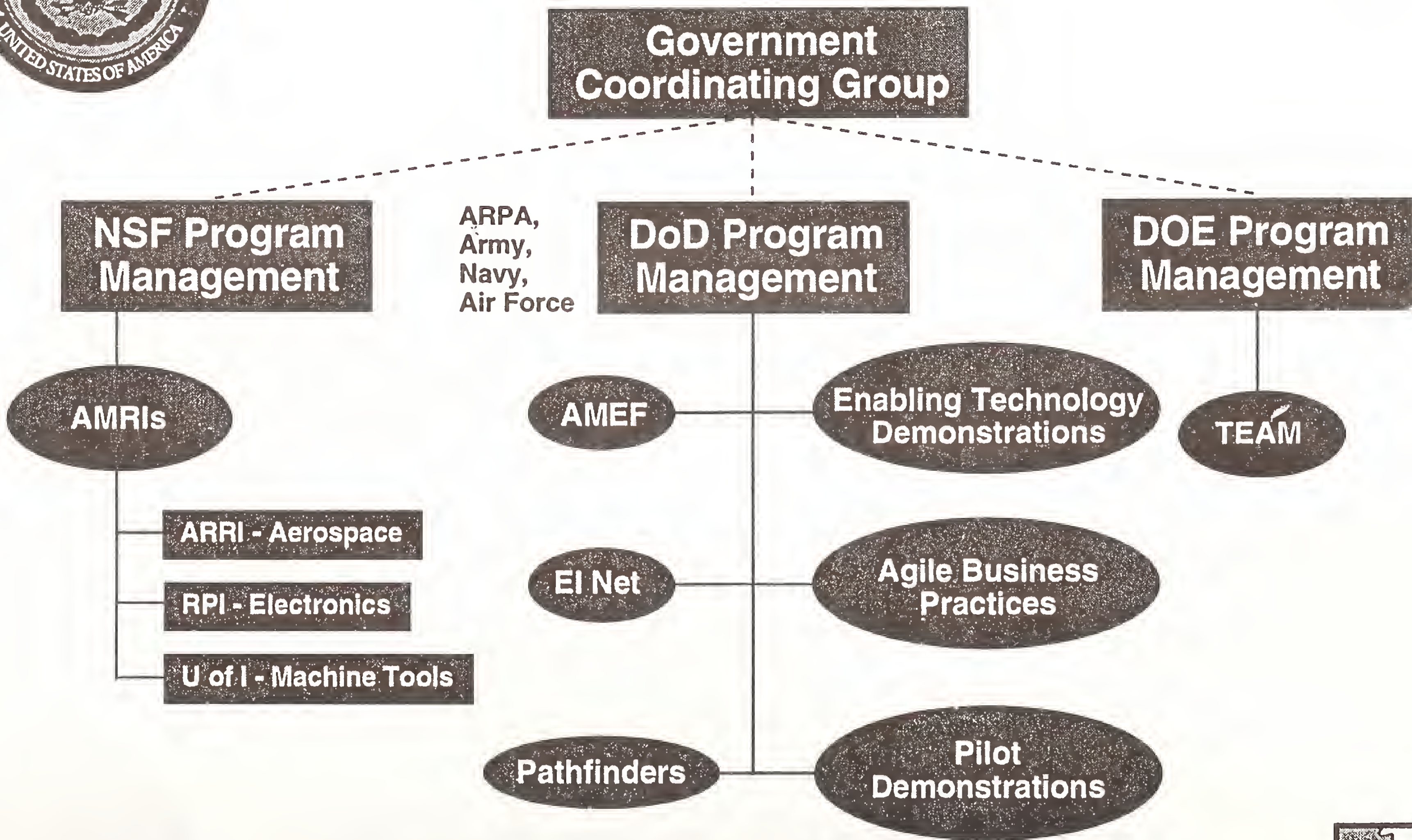
Technologies Enabling Agile Manufacturing is a Part of the Emerging National Agenda



Agile Manufacturing Implementation Group (AMIG)

- Informal Coordination
  - DoD
  - DOE
  - DoC (NIST)
  - NSF
- Increase awareness of agile manufacturing programs across Agencies & Industry

AMIG Organization



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TEAM

Coordination Between Agencies

DoD: Dovetail ongoing DoD & TEAM activities

Cross-participation in initiatives

Leverage Agile Pathfinders/Agile Pilots

NIST: AMRF personnel and NIST laboratories participate in TEAM task sets

Coordinating activities with the Manufacturing Extension Program and the ATP program

NSF: Coordinate with the Agile Manufacturing Initiative

AMRIs participate in TEAM task sets

Agency Cooperation
Agile/Advanced Manufacturing

- DoD BAA
  - DOE, NSF, NIST helping evaluate proposals
- TRP
  - Five agencies cooperating
- DOE efforts
  - DoD, NIST, NSF on steering board and evaluation groups
- National Science and Technology Council, Manufacturing Infrastructure Subcommittee
- Next Generation Manufacturing Roadmap

TEAM

- Brings the resources of the DOE Defense Programs facilities into alliance with private industry
- Will accelerate the development, integration and demonstration of agile manufacturing technologies to the point where they will be ready for commercialization
- Will leverage and coordinate with existing programs in agile technologies in DOE and other federal agencies

TEAM will NOT "reinvent the wheel"

TEAM Program Overview

Richard Neal
Program Manager

Situation Analysis

- Increasing global competitiveness and technological advances are creating a dramatic shift in manufacturing technologies and business practices.
- These changes require more competitive manufacturing enterprises with core business strategies focused on assuring the ability to succeed in an environment of continuous, dynamic change.
- Enterprise survival will depend increasingly on the ability to respond quickly to demands for high-quality, market driven products at the lowest possible cost.

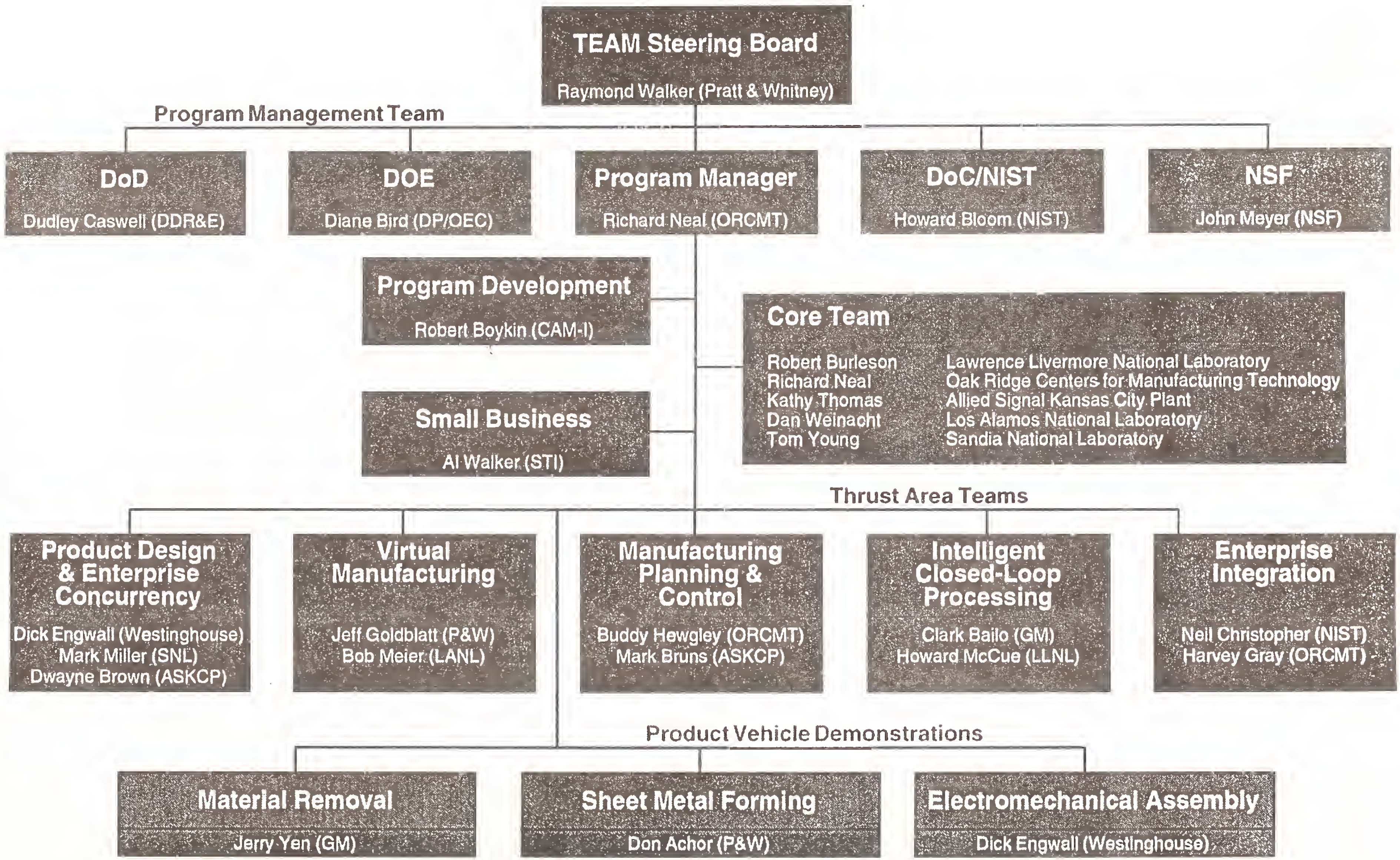
The TEAM Mission

- TEAM will provide American industry with the critical, enabling technologies needed to implement Agile Manufacturing concepts that will enhance the global competitiveness of US industry and support the evolving weapons missions of the national defense complex.
- TEAM will develop and demonstrate solutions to high priority needs and bring the enabling technologies to the point of commercialization for widespread implementation in both commercial and defense applications.

TEAM Goals

- **TEAM will develop, validate, and deploy technologies that enable an information-driven, agile industrial base.**

  Key goals are to:
  - Integrate design and manufacturing processes to streamline product development, thus reducing costs, enhancing quality, and shorting time-to-market
  - Provide robust, flexible, modular tools that are readily accessible and implementable
  - Maximize near-term deployment of enabling technologies within the evolving framework of TEAM's long-term vision



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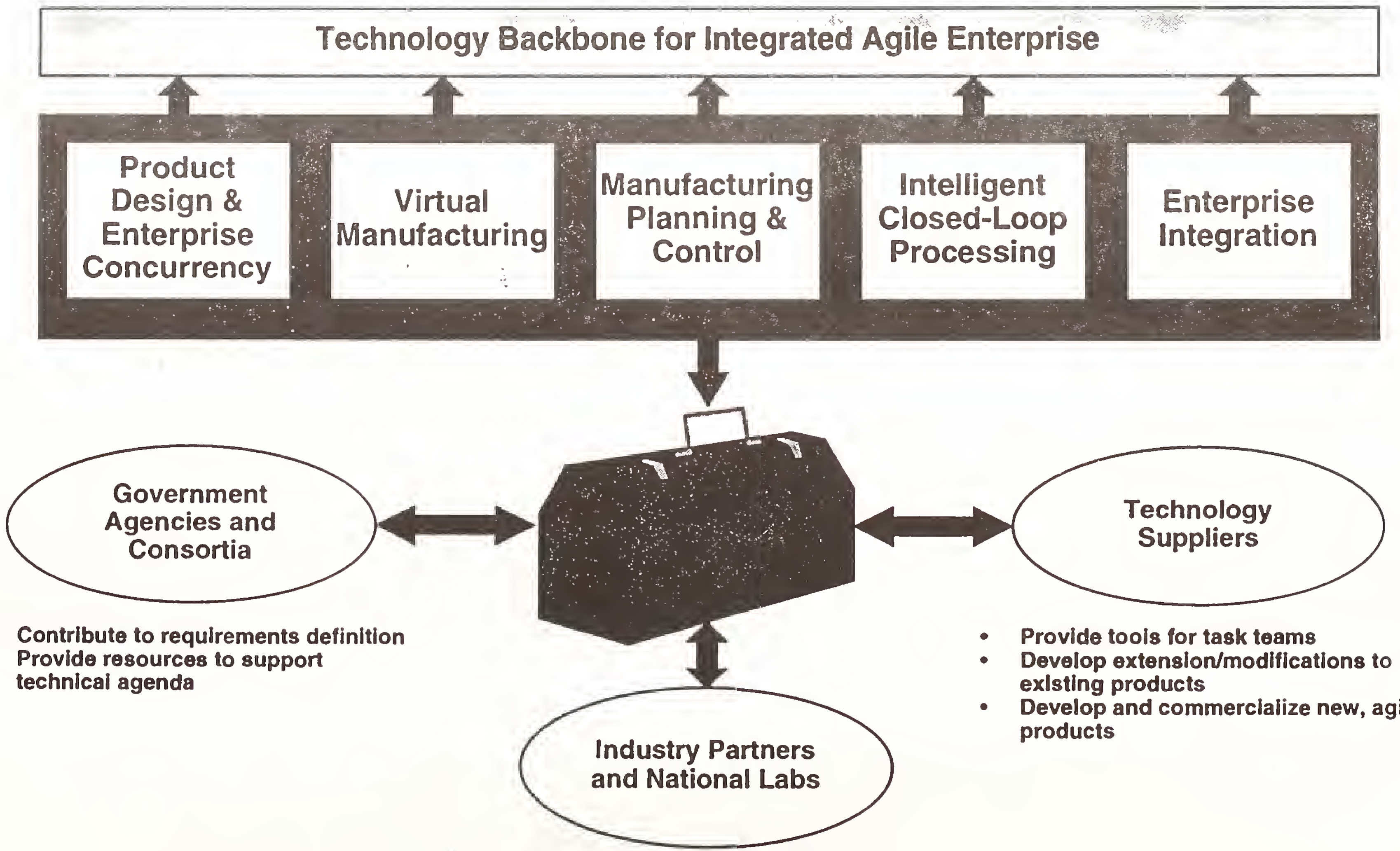
TEAM

TEAM Will Deliver

- Enabling Technology Toolbox
- Implementation of the Toolbox in a virtual enterprise
  - Backbone for agility
  - Virtual Enterprise
- Validating demos of TEAM technologies via Product Demonstrations
- Low-cost, easy access to capabilities needed by industry - but not now configured for value-added exploitation

The TEAM Concept



Government Agencies and Consortia

- Contribute to requirements definition
- Provide resources to support technical agenda

Technology Suppliers

- Provide tools for task teams
- Develop extension/modifications to existing products
- Develop and commercialize new, agile products

Industry Partners and National Labs

- Define technical agenda requirements
- Contribute to accomplishment of thrust area tasks
- Host demonstrations to validate tools/approaches

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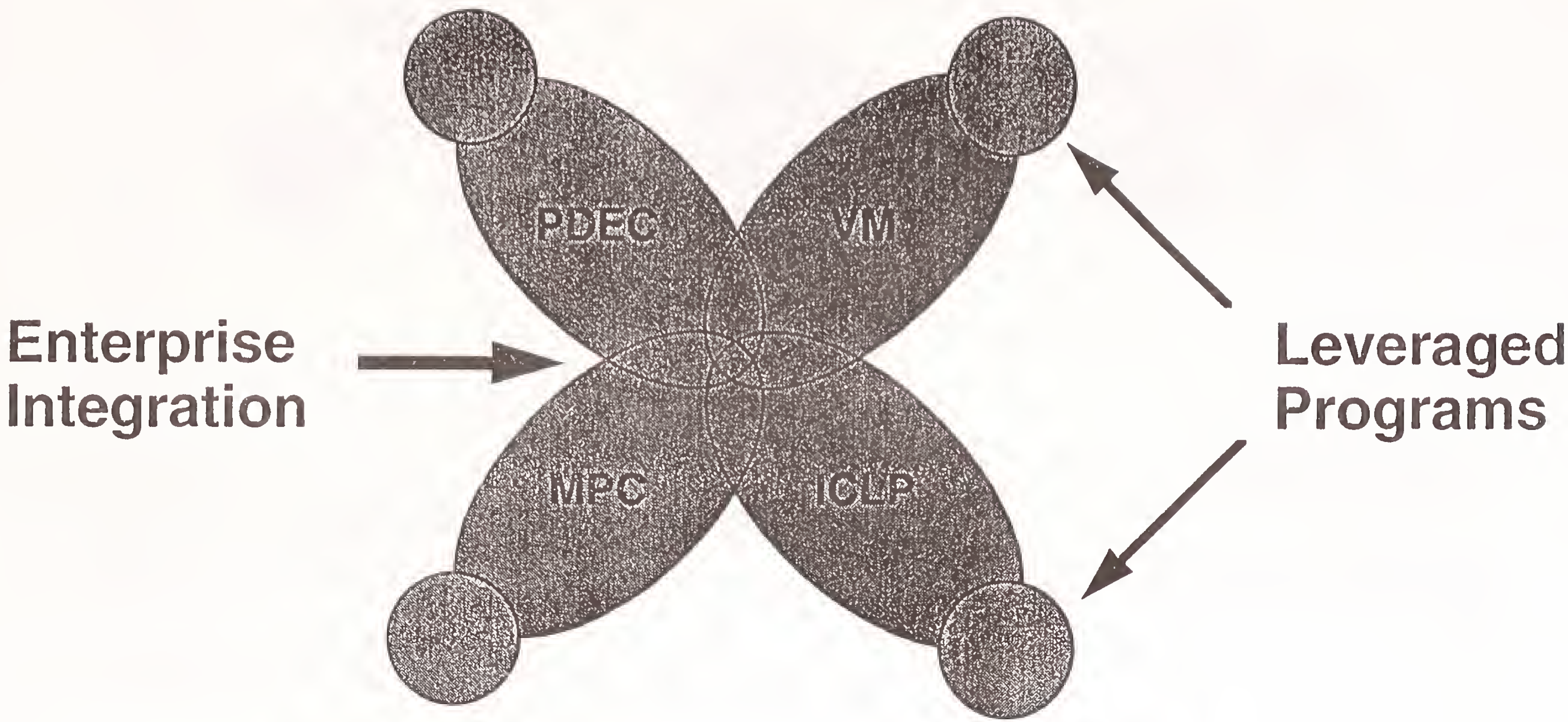
TEAM

Thrust Areas are a Mechanism for Focused Integrated Response



TEAM is a Program

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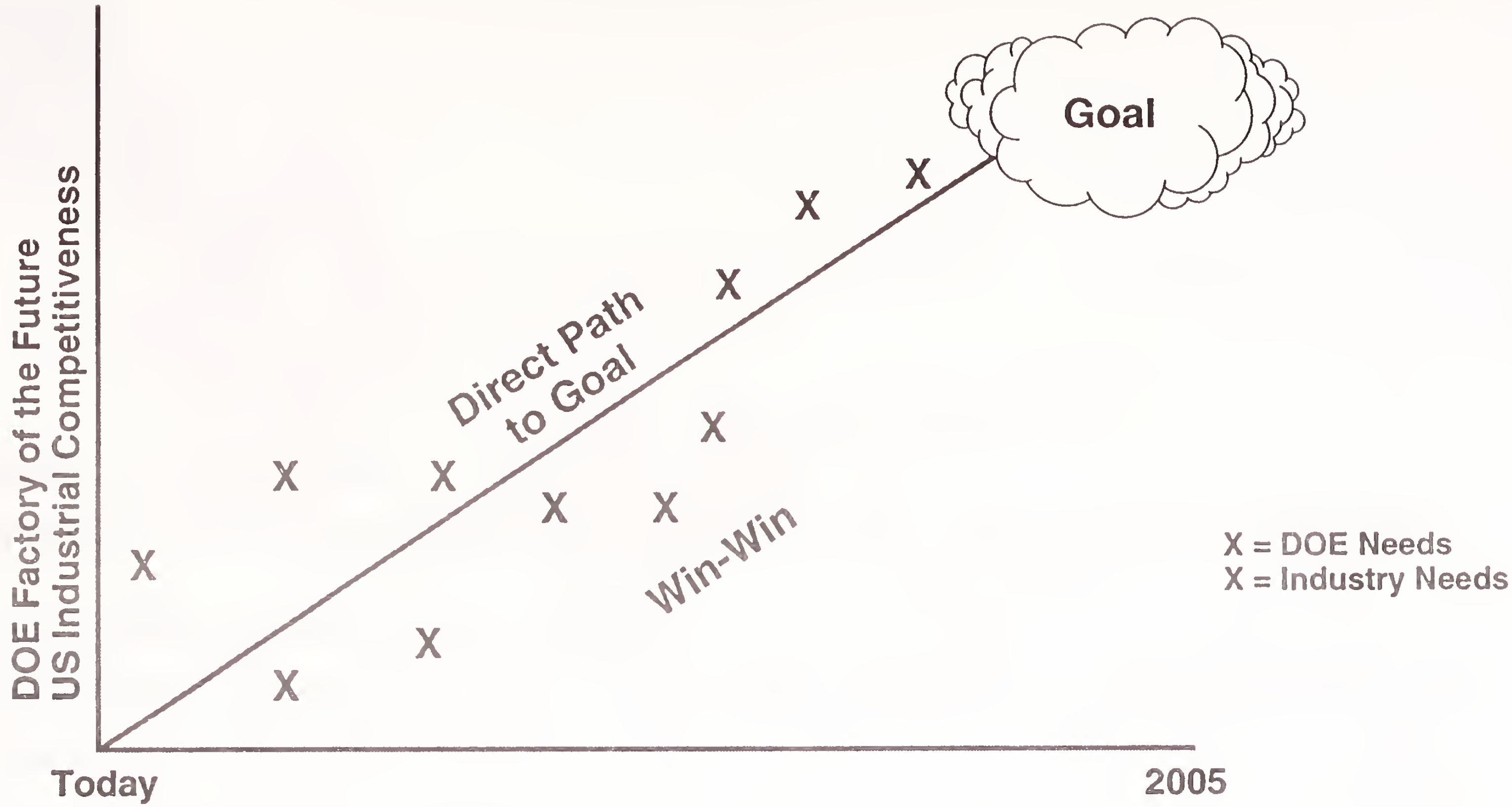
TEAM

The "TEAM Vision"

- Evaluate and optimize Product, Process, and Resource Design
- Create a Manufacturing Script
- Manufacture by executing a process control model in an intelligent environment

A Strategy for Success

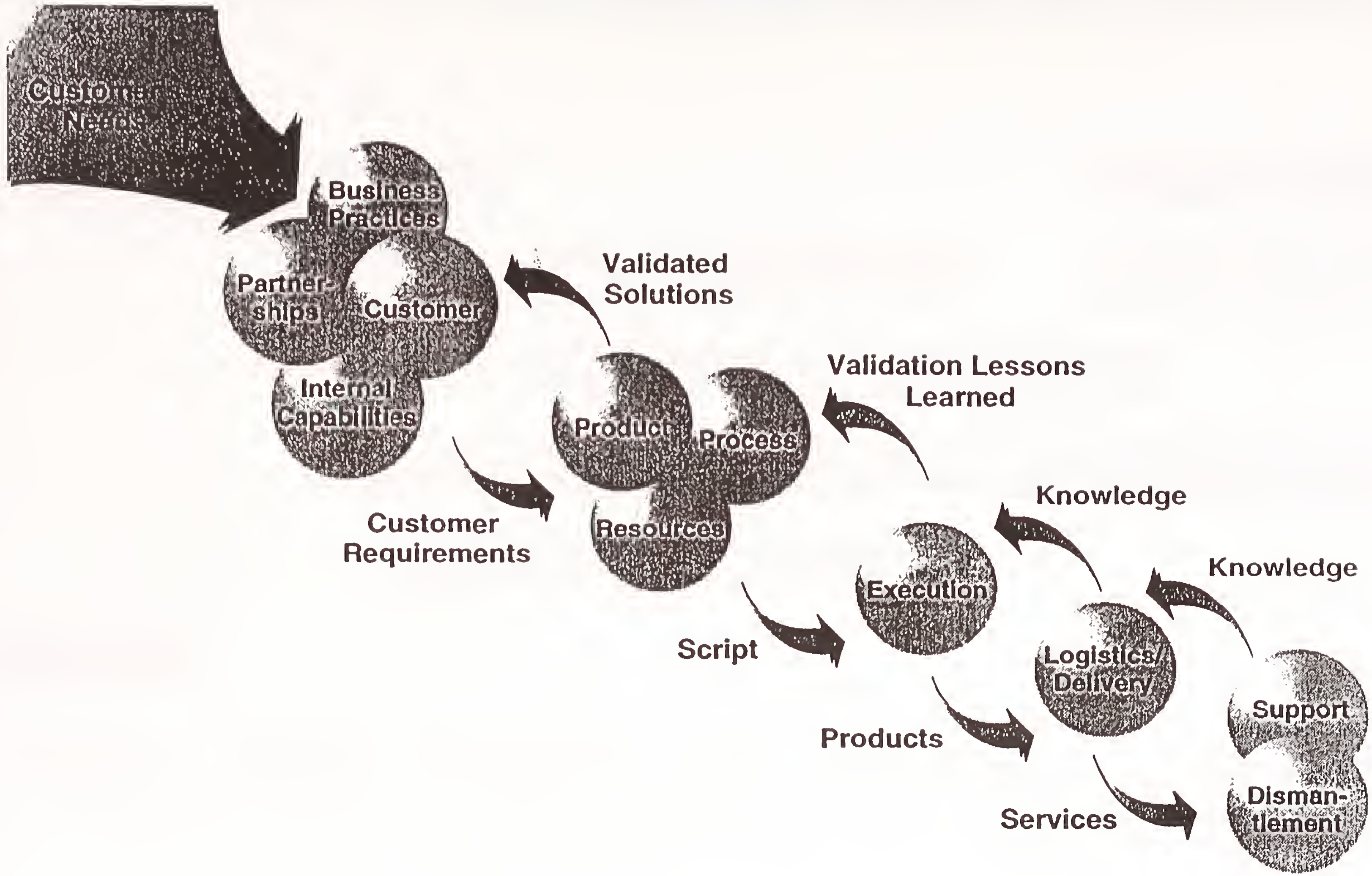


- Satisfy today's needs
- Keep solutions consistent with the path to the future

A Virtual and Distributed Enterprise in an Agile Environment

- TEAM seeks to understand the entire enterprise
- TEAM is only a piece of that enterprise
- There are many other initiatives that are also working the Agile Environment and TEAM seeks to leverage those activities
- TEAM has setup active links with several of these other activities

A Virtual and Distributed Enterprise in an Agile Environment



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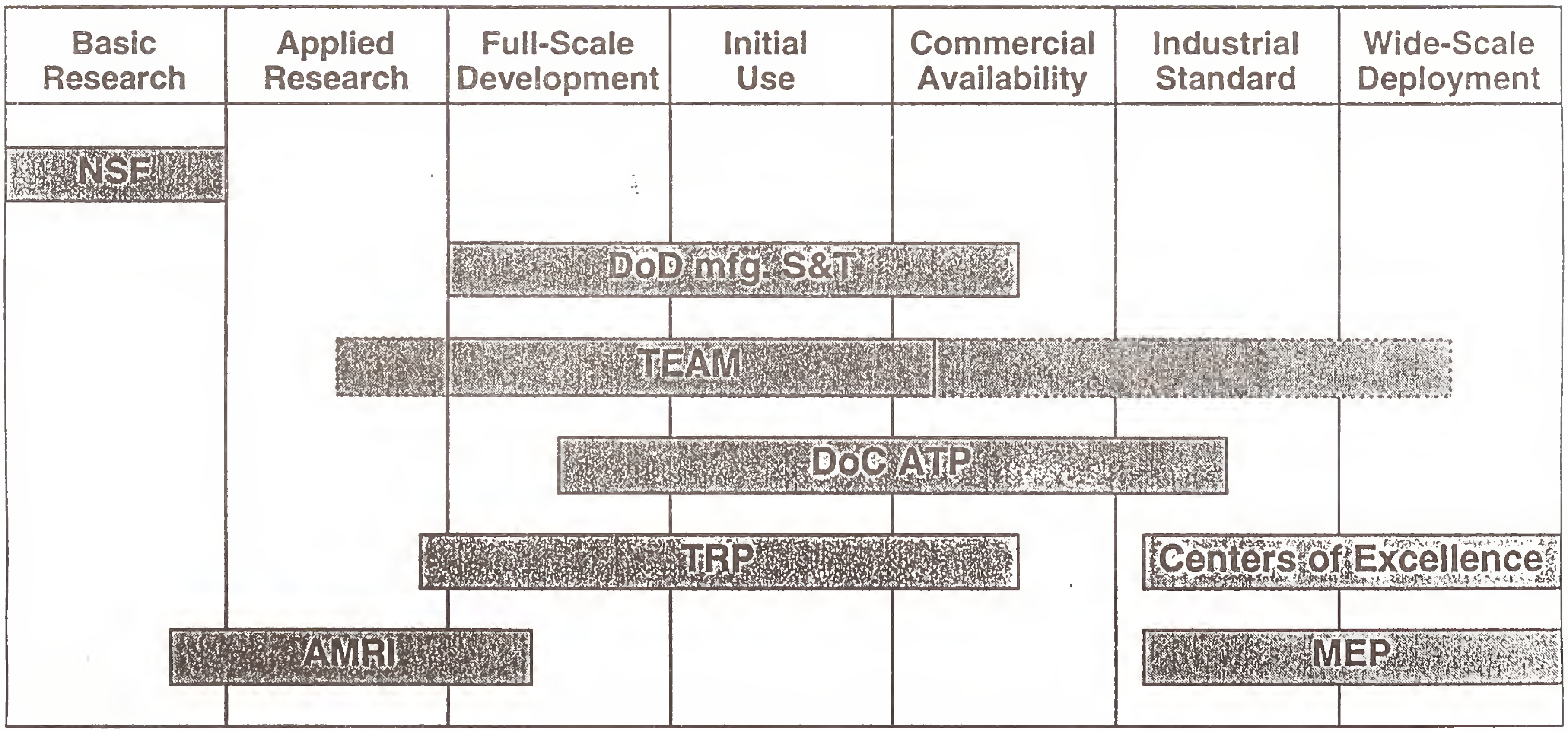
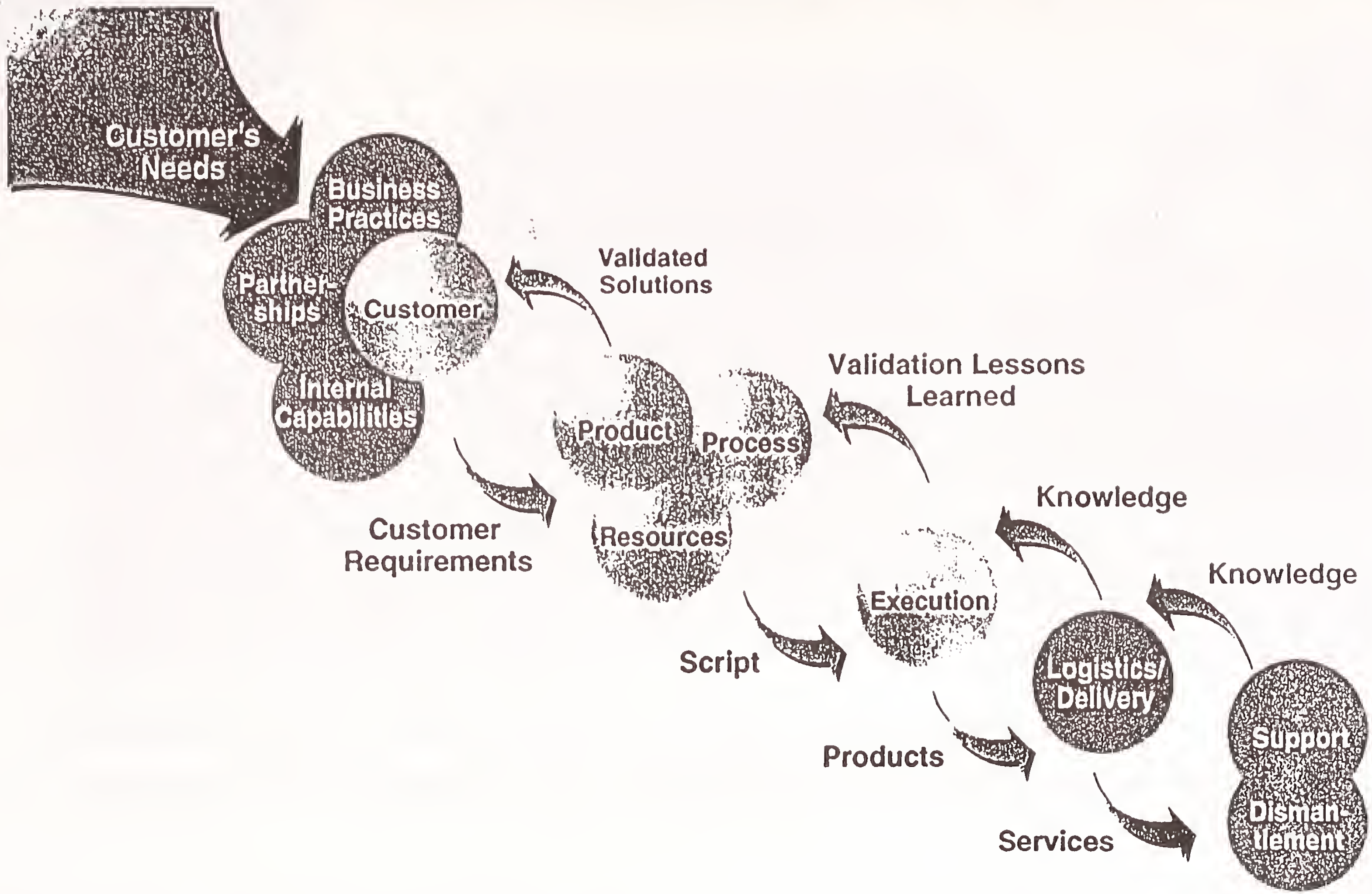
TEAM

Manufacturing Technology Life Cycle



TEAM is working a piece of the Virtual and Distributed Enterprise in an Agile Environment



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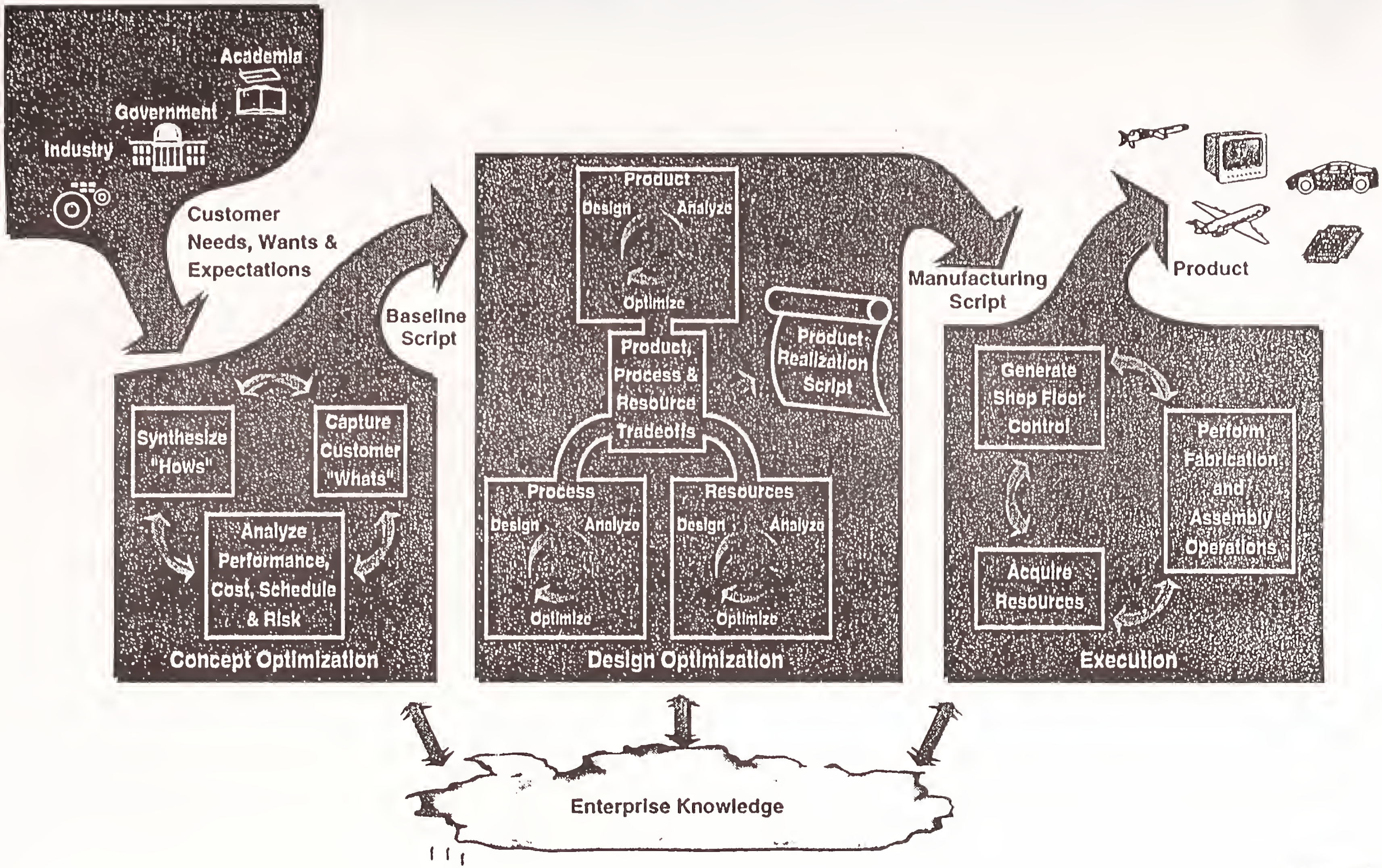
TEAM

TEAM is working a piece of the Virtual and Distributed Enterprise in an Agile Environment

- TEAM has chosen to address those parts of the model that are a match with the national laboratories capability
- TEAM has developed a Product Realization Model to help explain their activities
- A Toolbox of Technologies was also Developed that contains the technologies necessary to implement the Product Realization Model
  - The first set of tools was taken from the WBS
  - More tools will be added as needed

The TEAM Product Realization Model



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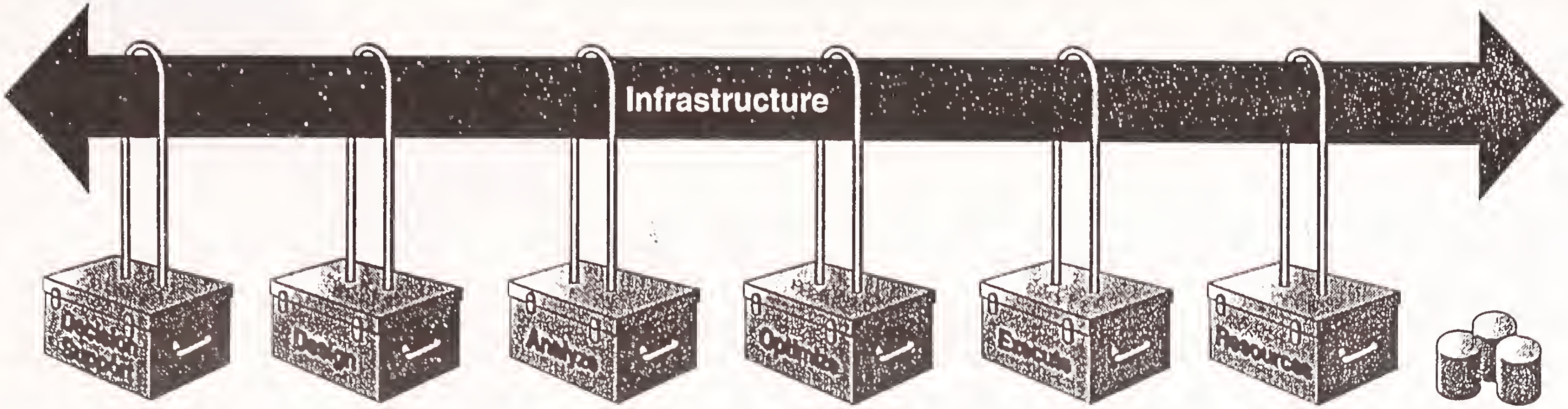
TEAM

TEAM will create an integrated agile enterprise and populate a "toolbox" of modular manufacturing technologies

The TEAM Technology Toolbox



Decision Support	Design	Analyze	Optimize	Execute	Resources	
Requirements Management Matrix	Manufacturing Feature Catalog	Enterprise Modeling	PAM	Shop Floor Control	Mosaic Home Page	Enterprise Knowledge
SLATE		Milling/ Drilling Simulation	MacroPlanner	Open Architecture Controller	Technical Architecture Specification	
IDEA		Forming Simulation	Milling/Drilling Micro Planner	High Throughput & Reliability Machining	CORBA	
		Electro-Mechanical Simulation	CMM Micro Planner		STEP	
					AMTnet	

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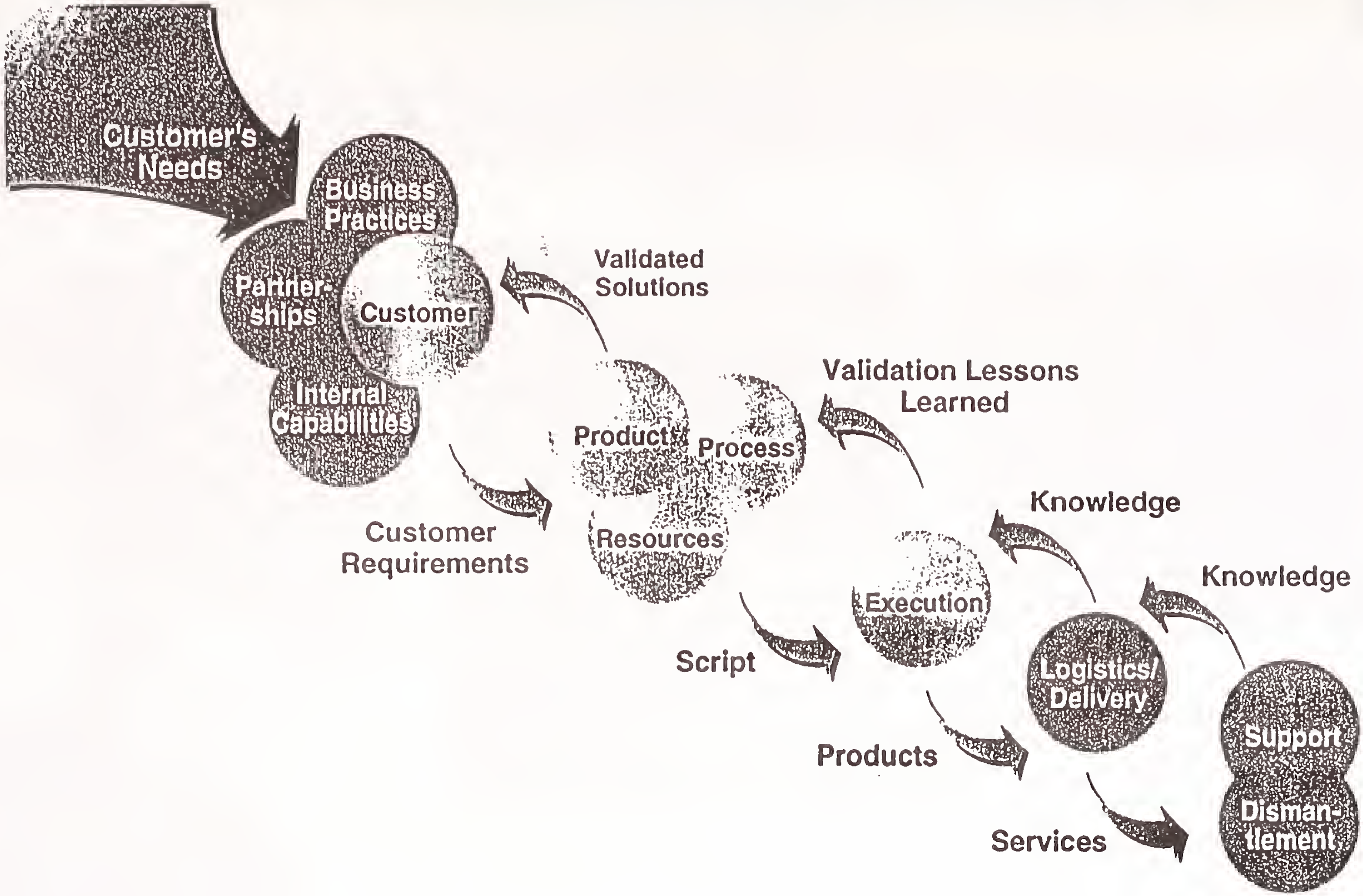
TEAM

TEAM Technical Agenda

Tom Young

TEAM's piece of the Virtual and Distributed Enterprise in an Agile Environment



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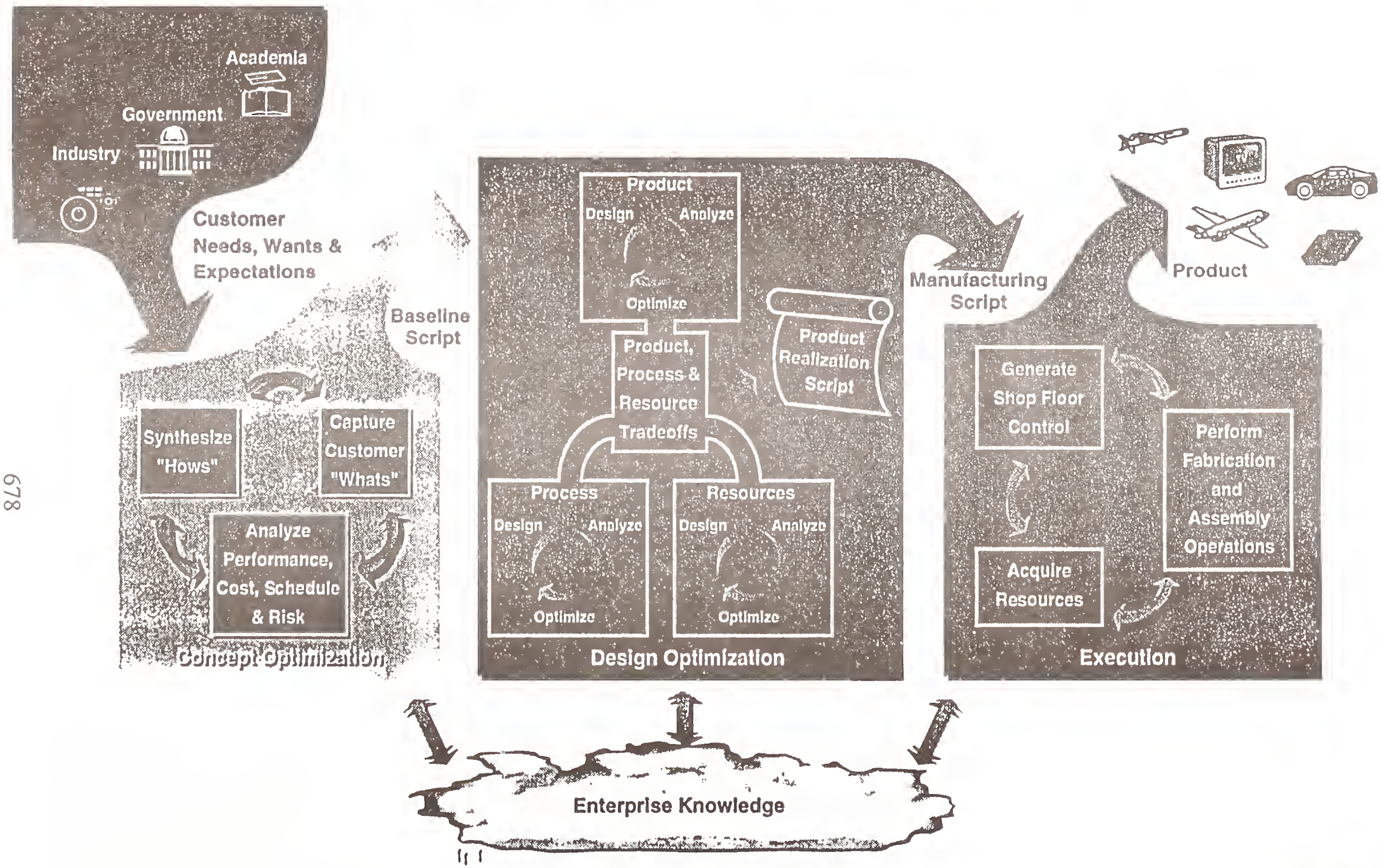
TEAM

Concept Optimization Model



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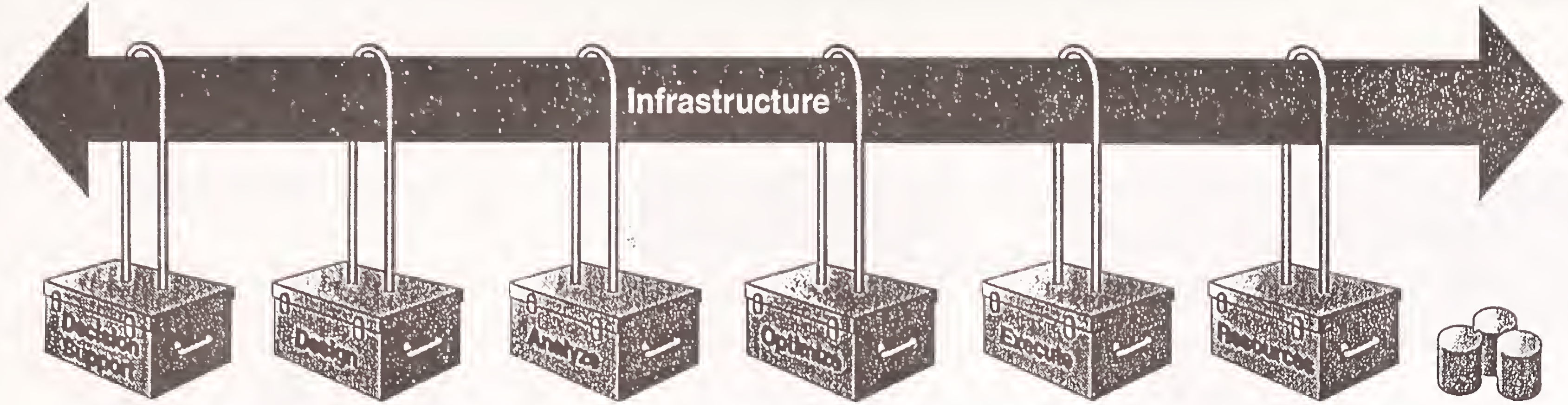
TEAM

Concept Optimization Toolbox



Requirements Management Matrix

SLATE

IDEA

Manufacturing Feature Catalog

Enterprise Modeling

Milling/ Drilling Simulation

Forming Simulation

Electro-Mechanical Simulation

PAM

MacroPlanner

Milling/Drilling Micro Planner

CMM Micro Planner

Shop Floor Control

Open Architecture Controller

High Throughput & Reliability Machining

Mosaic Home Page

Technical Architecture Specification

CORBA

STEP

AMTnet

Enterprise Knowledge

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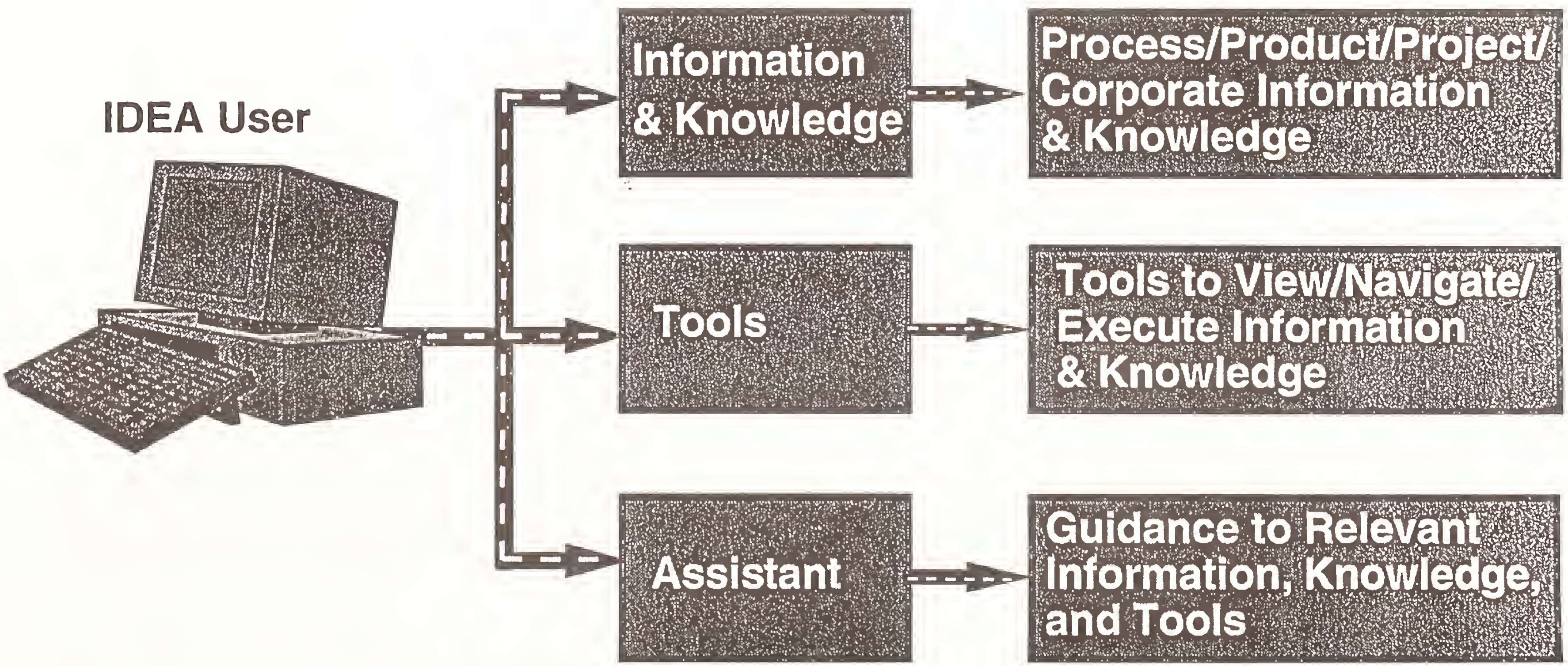
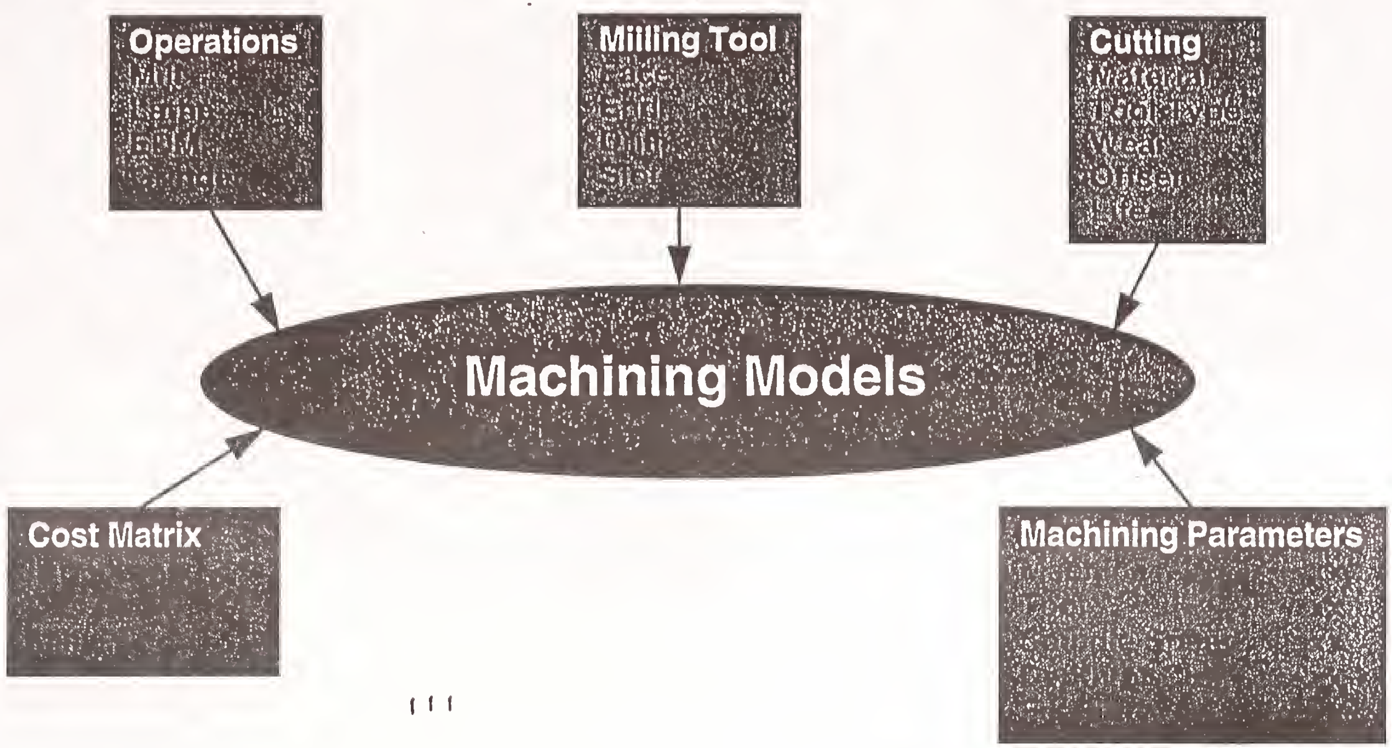
TEAM

Integrated Design Environment and Assistant

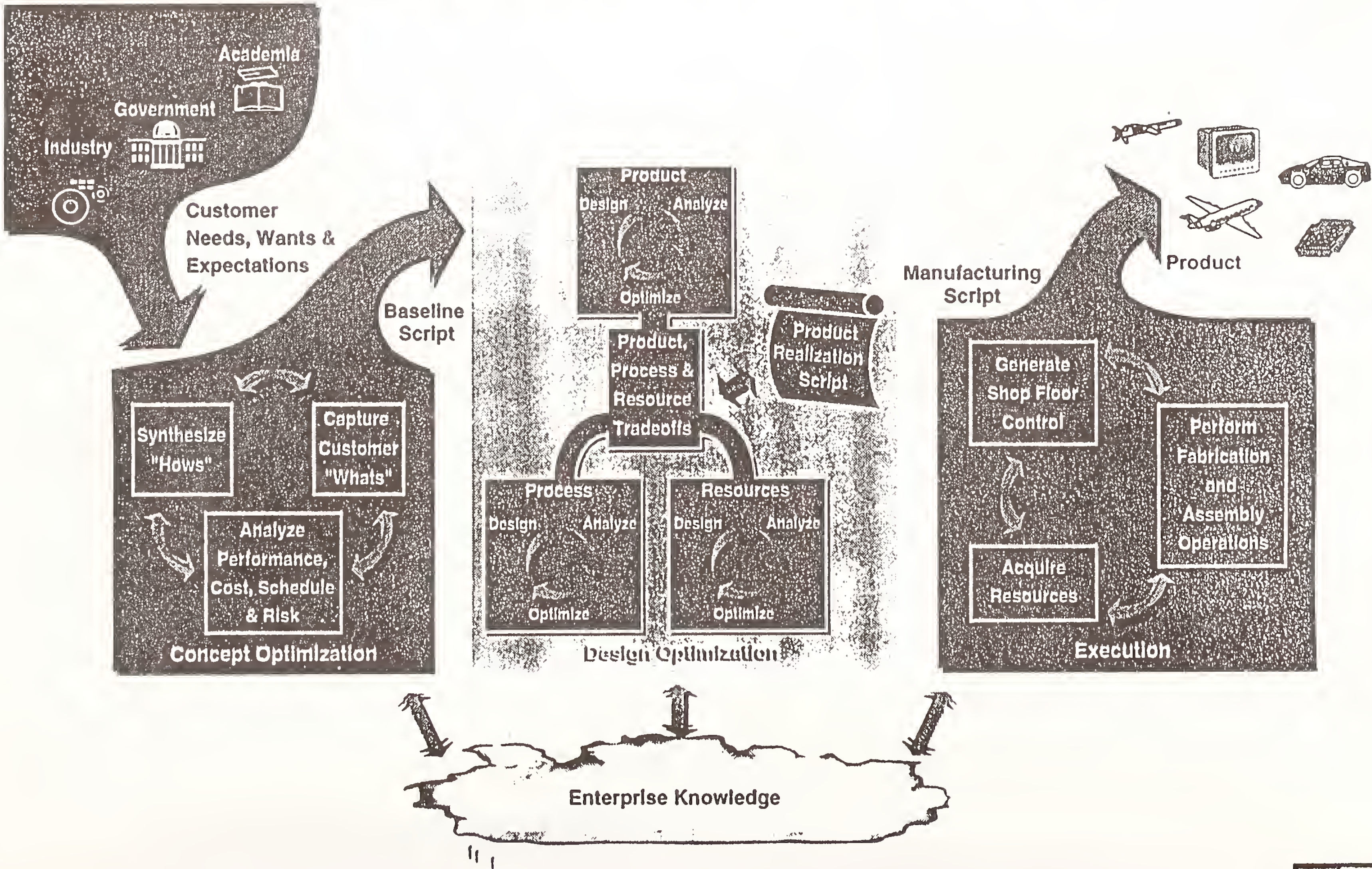


Parametric Analysis Modeling

- A spreadsheet tool for analyzing system tradeoffs/sensitivities
- Method to relate requirements and other driver parameters to cost, flow time, and performance



Design Optimization Model



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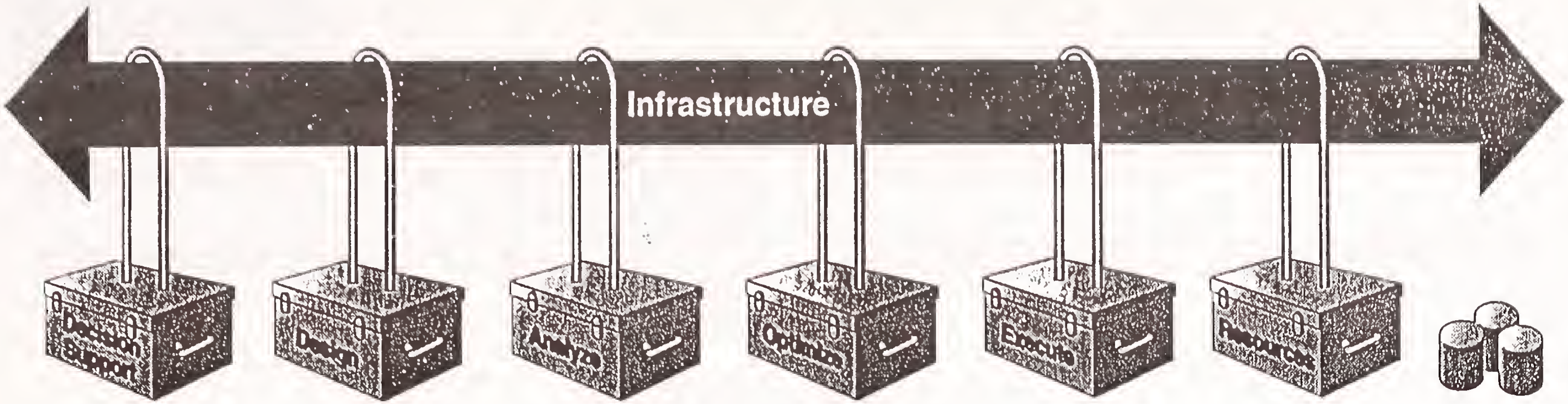
TEAM

Design Optimization Toolbox



Requirements Management Matrix
SLATE
IDEA

Manufacturing Feature Catalog

Enterprise Modeling
Milling/ Drilling Simulation
Forming Simulation
Electro-Mechanical Simulation

PAM
MacroPlanner
Milling/Drilling Micro Planner
CMM Micro Planner

Shop Floor Control
Open Architecture Controller
High Throughput & Reliability Machining

Mosaic Home Page
Technical Architecture Specification
CORBA
STEP
AMTnet

Enterprise Knowledge

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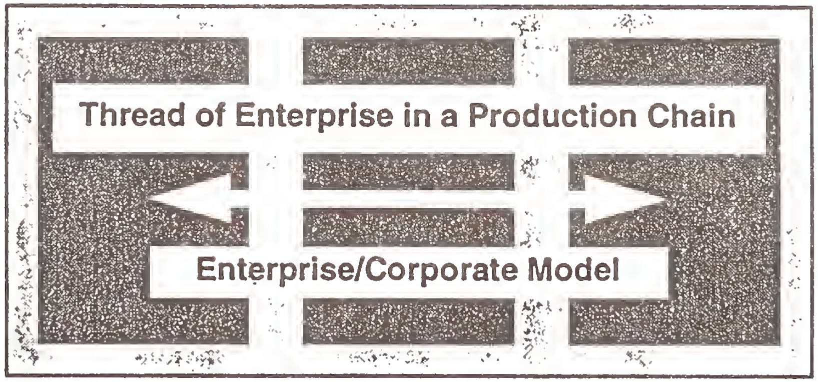
TEAM

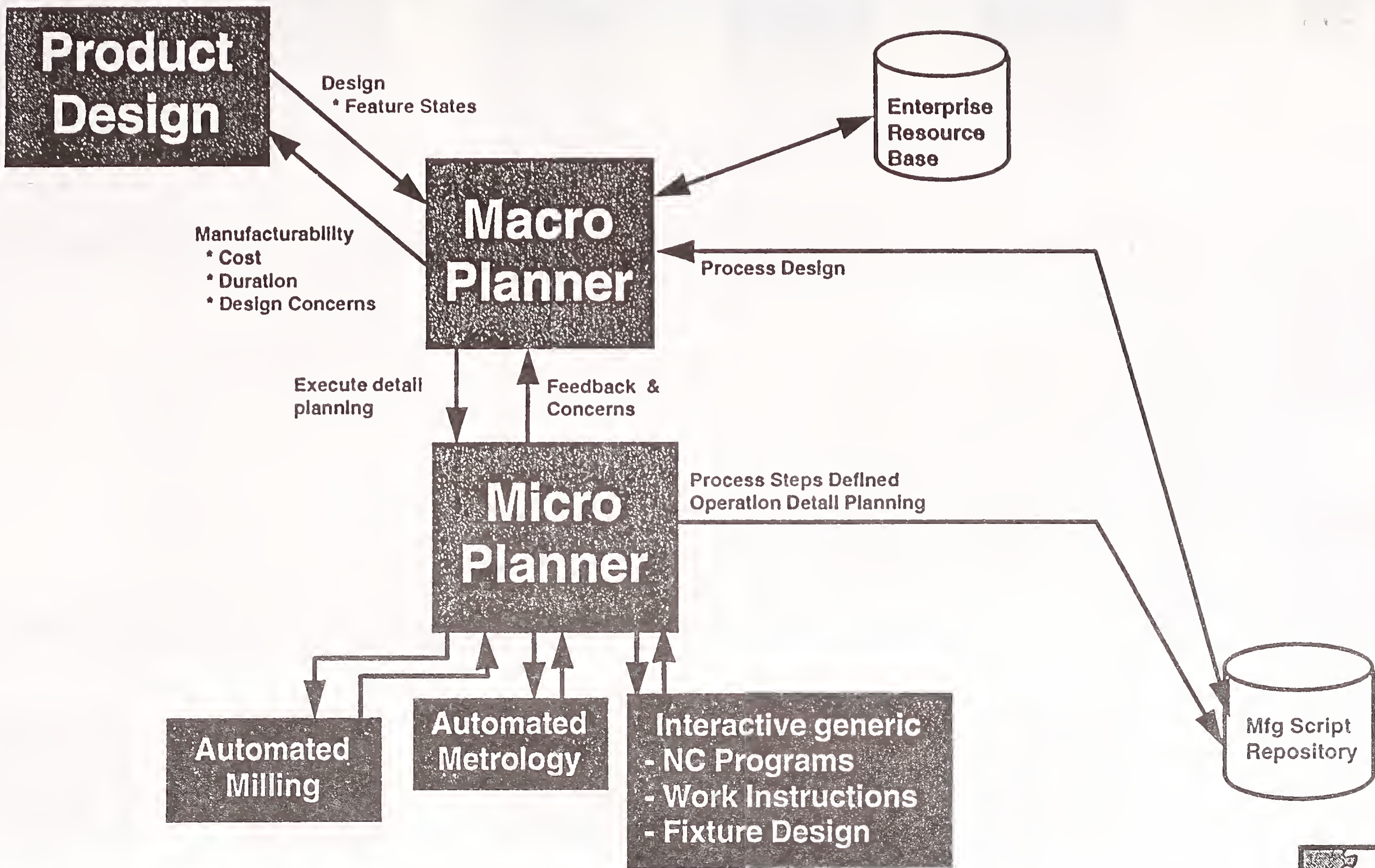
Enterprise Modeling provides Simulation of Functions, Services, and Processes



Elements Included:

Corporate Strategies	Supplies/Integrator Relations
Manufacturing Performance	Cost Leverage
Business Process Examination	Customer Preference

Macro Planning Functional Diagram



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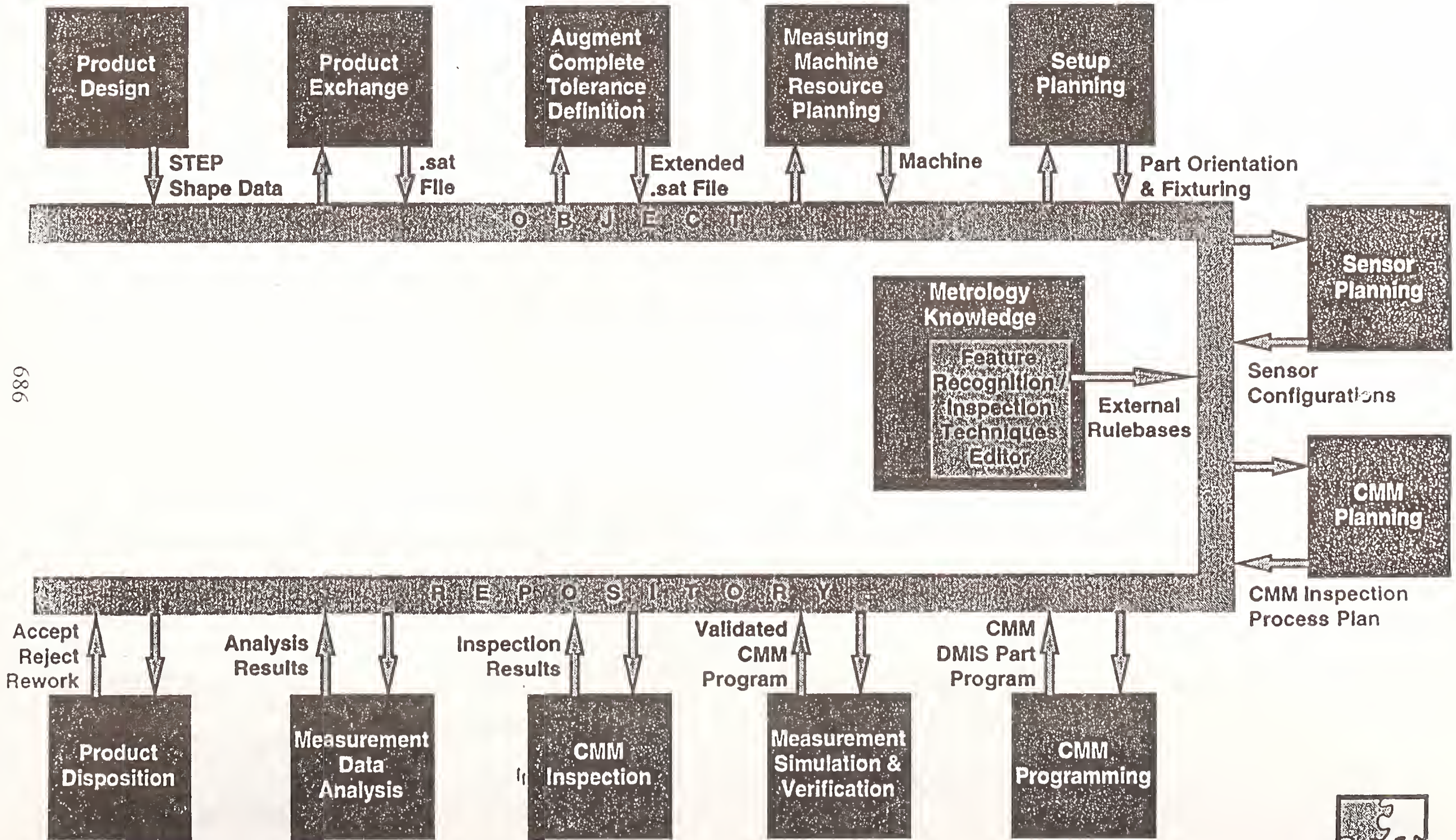
TEAM

Metrology Micro Planner
Feature-Based Tolerance Definition



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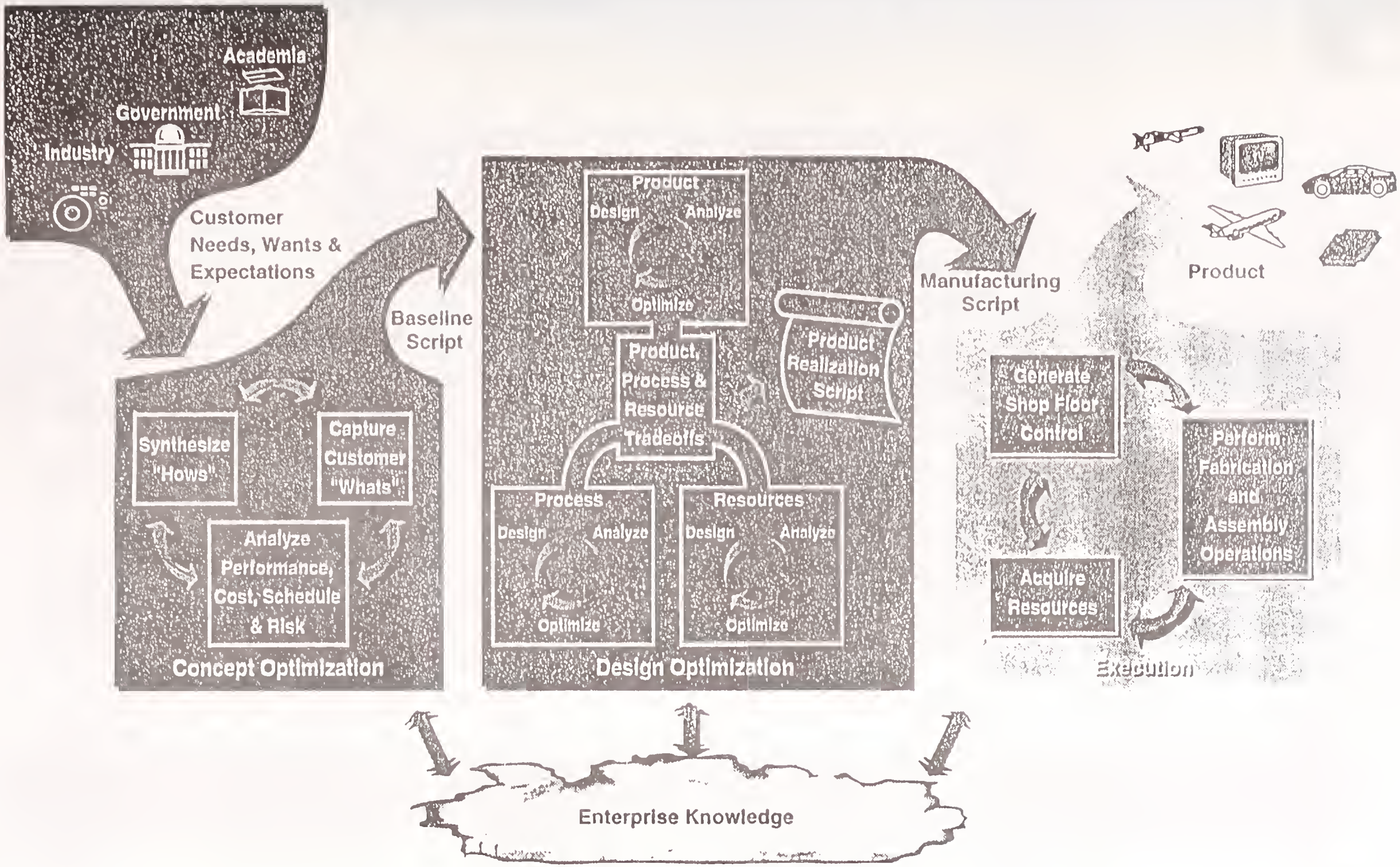
TEAM

Execution Model



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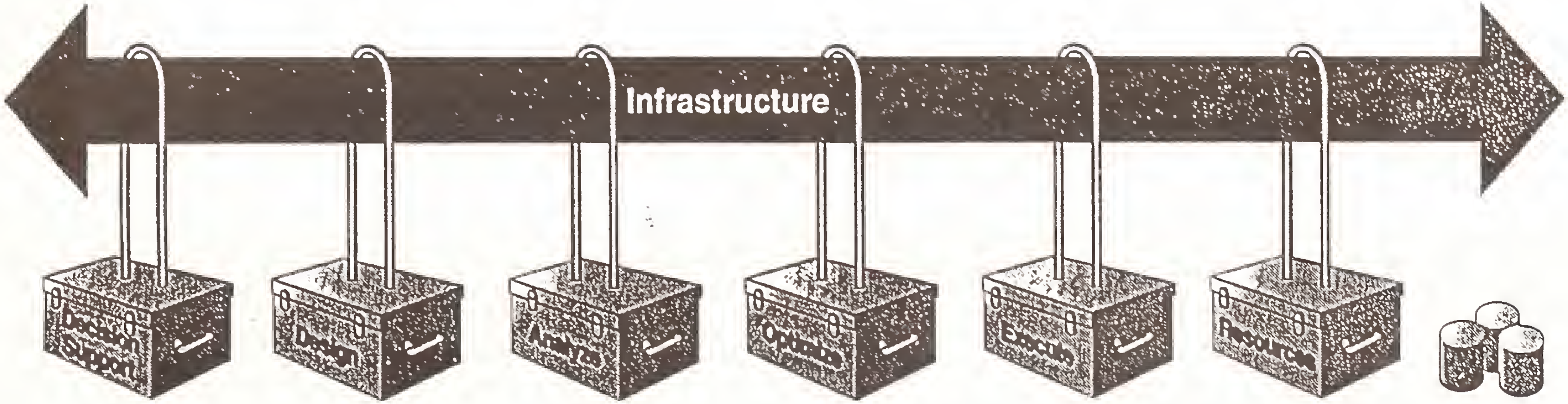
TEAM

Execution Toolbox



Requirements Management Matrix

SLATE

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Mosaic Home Page

Technical Architecture Specification

CORBA

STEP

AMTnet

Enterprise Knowledge

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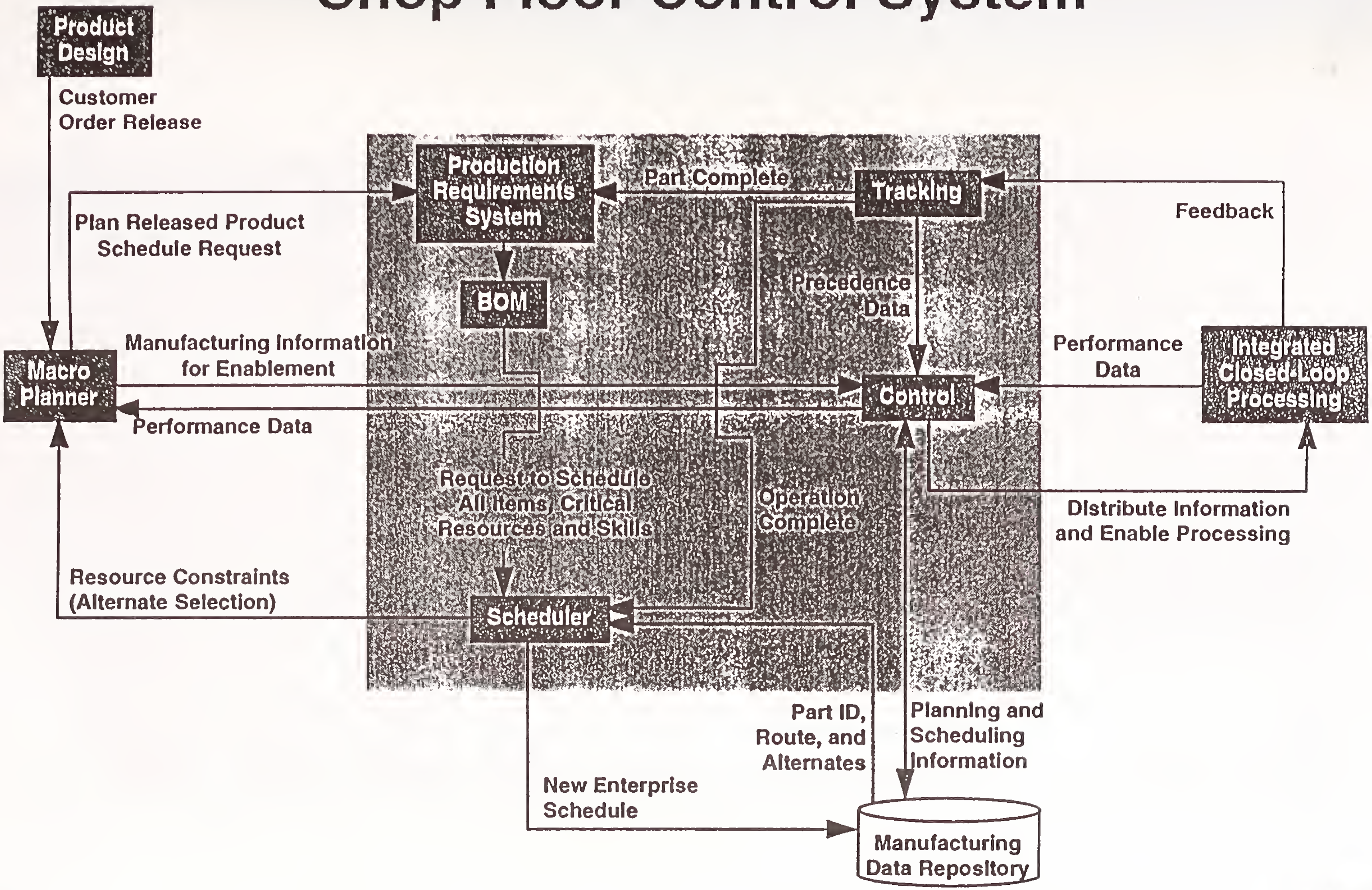
TEAM

Shop Floor Control System



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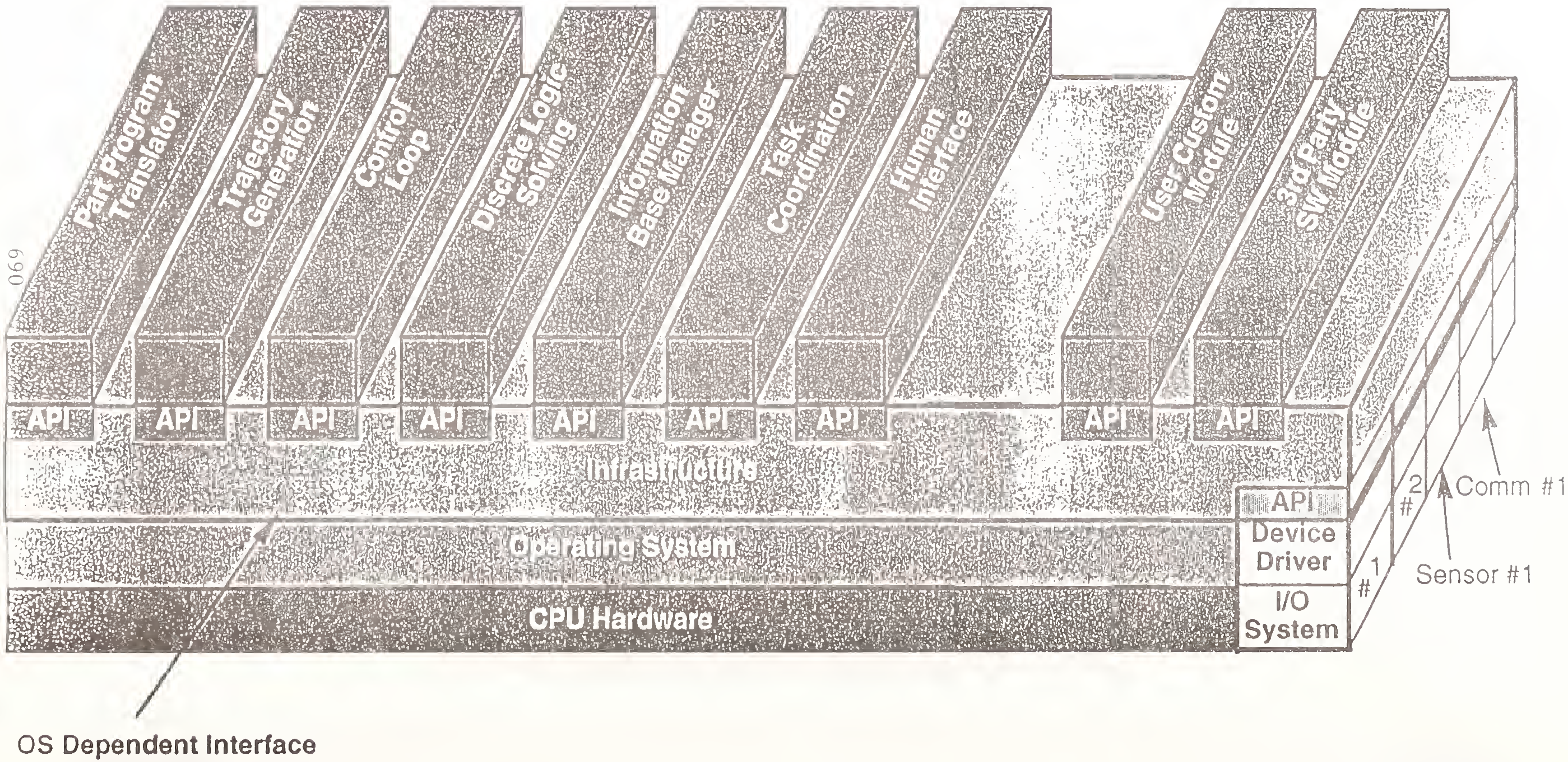
TEAM

TEAM Supports OAC Development by Defining Common Application Programming Interfaces



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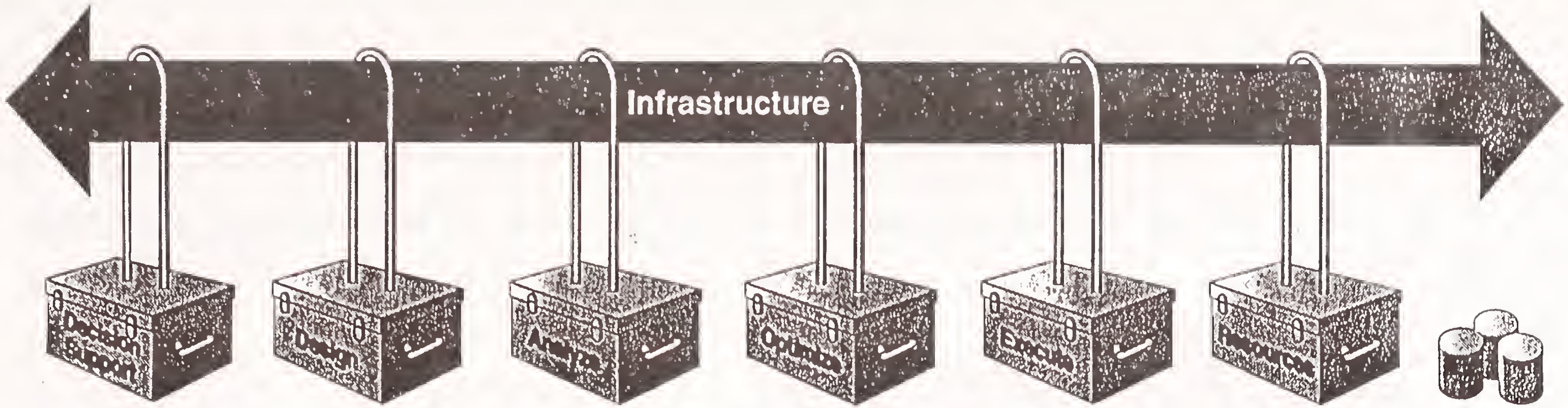
TEAM

Infrastructure Toolbox



Requirements Management Matrix

SLATE

IDEA

Manufacturing Feature Catalog

Enterprise Modeling

Milling/ Drilling Simulation

Forming Simulation

Electro-Mechanical Simulation

PAM

MacroPlanner

Milling/Drilling Micro Planner

CMM Micro Planner

Shop Floor Control

Open Architecture Controller

High Throughput & Reliability Machining

Mosaic Home Page

Technical Architecture Specification

CORBA

STEP

AMTnet

Enterprise Knowledge

Technologies Enabling Agile Manufacturing

3/30/95

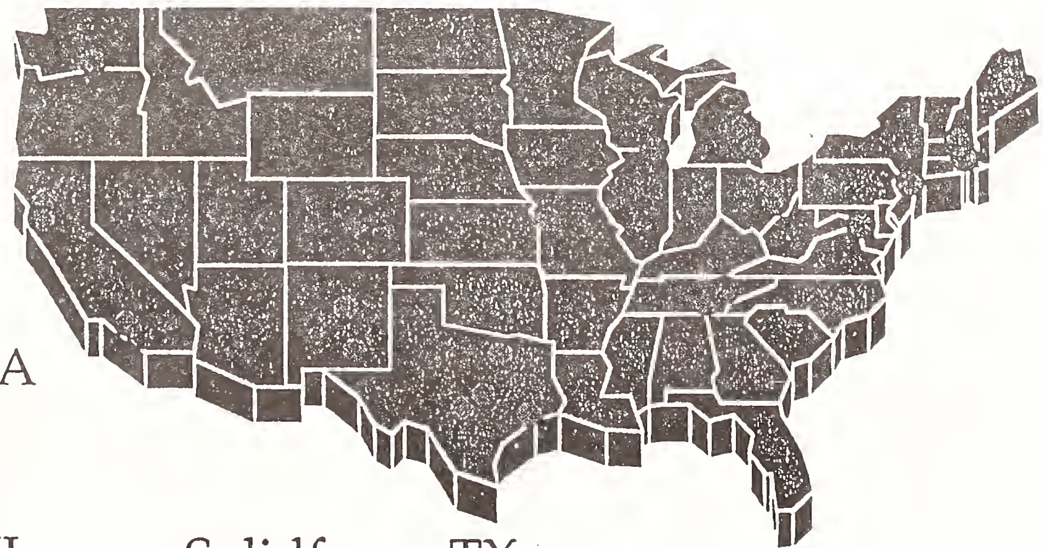
TEAM

Advanced Manufacturing Technology Network

Manufacturing Science Corporation, TN
Truecast Precision Casting, KY
DTM Corporation, TX
3d Systems, CA
Laserform, MI
Komtek, MA
WIPP, NM
NIST, DC
PNL, WA
ATI, TX
Kovatch Castings, OH
Walworth Foundries, Inc., WI
Sandia National Laboratories, NM
Sandia National Laboratories, CA

Ford, MI
ORNL, TN
Texcast, TX
Plynetics, CA

Osteonics, NJ
Goodyear, OH



Solidform, TX
AlliedSignal, MO
Laserfare, Inc., RI
Miller Castings, OH

Technologies Enabling Agile Manufacturing

3/30/95

TEAM

Product Demonstrations are built on Thrust Area Technology

	Core	Material Removal	Forming	Assembly
PDEC	√	√		√
VM	√	√	√	√
MPC	√	√		
ICLP	√	√	√	
EI	√			

TEAM Technical Program

Thrust Areas:

- Product Design and Enterprise Concurrency
- Virtual Manufacturing
- Manufacturing Planning and Control
- Intelligent Closed-Loop Processing
- Enterprise Integration

Technology Demonstration Areas:

- Material Removal
- Sheet Metal Forming
- Electromechanical Assembly

Product:

- Robust, flexible, enabling tools deployed in a distributed, integrated environment. Each tool has modular standalone value.

Program Milestones:

– Existing Modules	02/95
– Interconnected Demonstration	12/95
– Pilot Enterprise	06/97

Manufacturing Programs Research at NSF

Bruce Kramer, NSF

2nd Annual Manufacturing Technology Conference: Toward a Common Agenda

NSF Programs in Manufacturing Research and Education

Bruce M. Kramer, Director
Division of Design, Manufacture and Industrial Innovation
Directorate for Engineering
National Science Foundation

R&D Issues in a Changed World

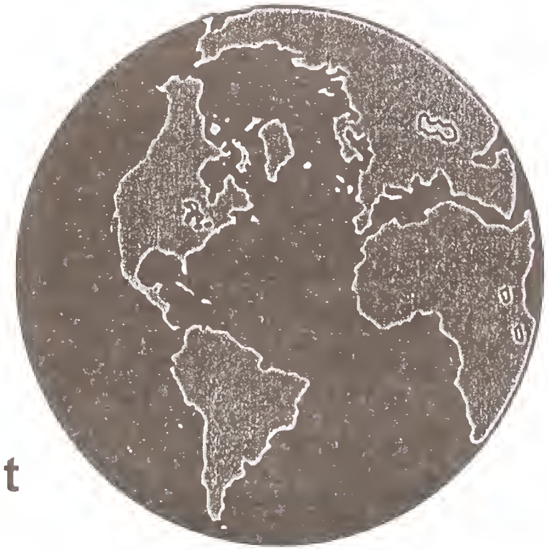
Data Explosion

Technology Reinvestment

Global Economy

Cognitive Revolution

International Partnerships



Diverse Workforce

Finite Resources

Defense Reinvestment

Environmental Imperatives

Shared Wealth

Dual Use

Demographic Shifts

Manufacturing: The Vision

To enable the next generation of manufacturing systems and enterprises that are:

- Highly resource-efficient, environmentally conscious
- Intelligent, fully computer-integrated
- Rapidly configurable, flexible, responsive, agile
- Focused on quality, safety, customer satisfaction
- Technologically innovative
- Supported by a diverse, highly skilled, technologically literate, and motivated workforce

NSF Advanced Manufacturing Technology Initiative ($ million)

	FY 1994	FY 1995	FY 1996
Comp. & Info.	16.19	16.49	17.40
Engineering	70.00	74.85	79.21
Math. & Phys.	29.60	34.75	36.77
SB & Econ.	2.00	2.33	2.96
AMT Total	117.79	128.42	136.39

NSF Historical Context

1960	$5M
1970	$10M
1980	$20M
1990	$80M
1995	$135M

- Engineering Division (automation, control, processing)
- Materials Research Division
- RANN Adv. Industrial Processes
- IUCRCs
- Computer Engineering Program
- Production Research Program
- ERCs and STCs
- Eng Design & Mfg. Division
- CISE Pgms. in automation, robotics, and info. processing
- MPS/ENG Environ. Benign Chem. Synthesis and Processing
- SBE established
- TRPs
- AIM cross-directorate initiative
- FCCSET AMT Program
- MRLS to MRSECs
- NSTC Mfg. Infrastructure

NSF Advanced Materials Processing Initiative ($ million)

	FY 1994	FY 1995	FY 1996
Biological	4.75	4.75	4.78
Engineering	25.31	25.31	27.44
Geological	3.37	3.37	3.37
Math. & Phys.	177.72	179.19	189.84
SB & Econ.	0.70	0.70	0.70
AMP Total	211.85	213.32	226.12

The NSF Program
Role in Interagency Effort

- Manufacturing poses a set of very complex, interdisciplinary issues because of its integrative nature.
- NSF addresses this complexity within the context of a broad, coherent, interdisciplinary program.
- NSF develops fundamental knowledge base for manufacturing technologies.
- NSF catalyzes creative linkages between universities and industry because of its ties to academe.

NSF Strategic Vision:

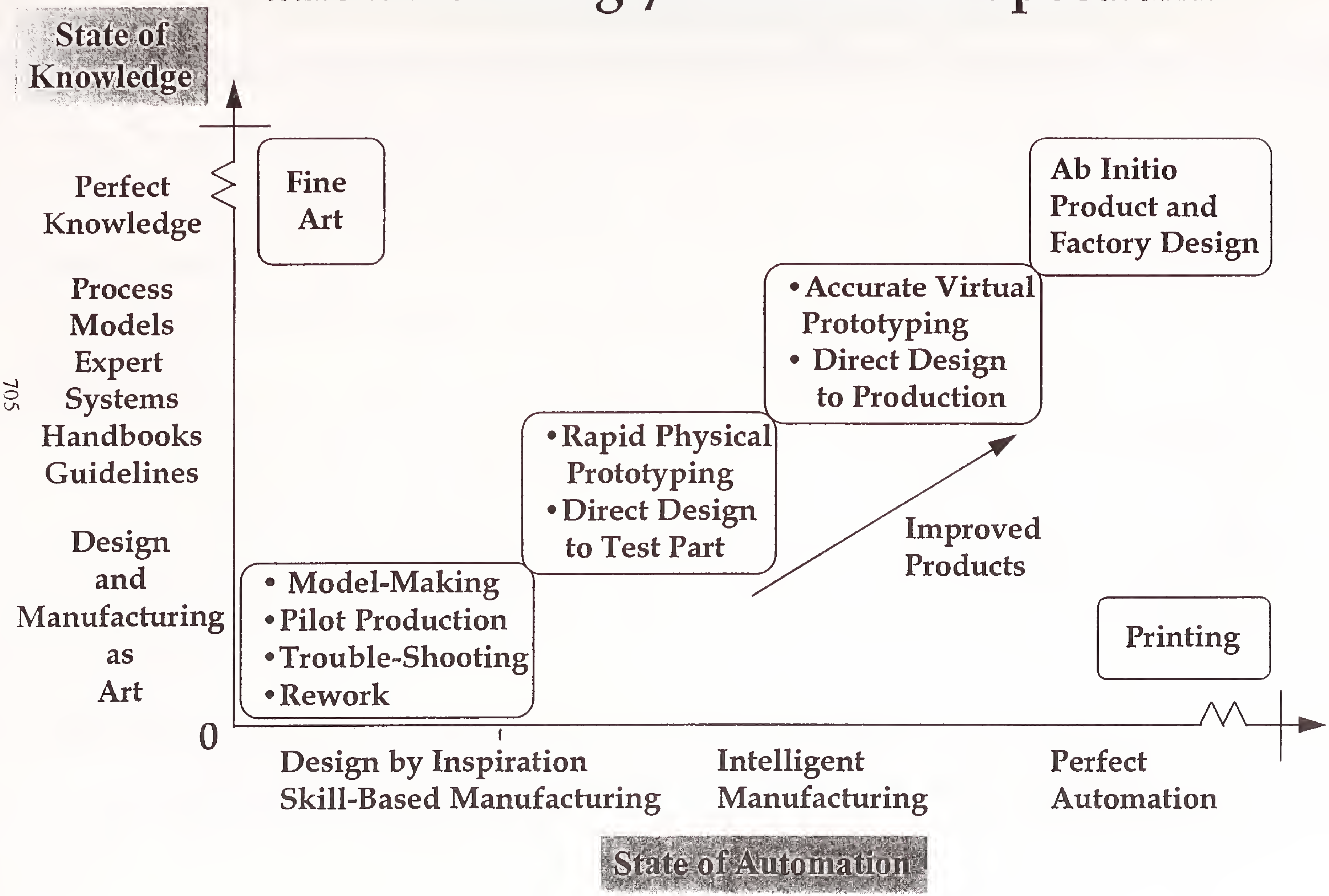
To enable the next generation of manufacturing systems through discovery, knowledge integration, education, and knowledge transfer.

Manufacturing Systems Focus

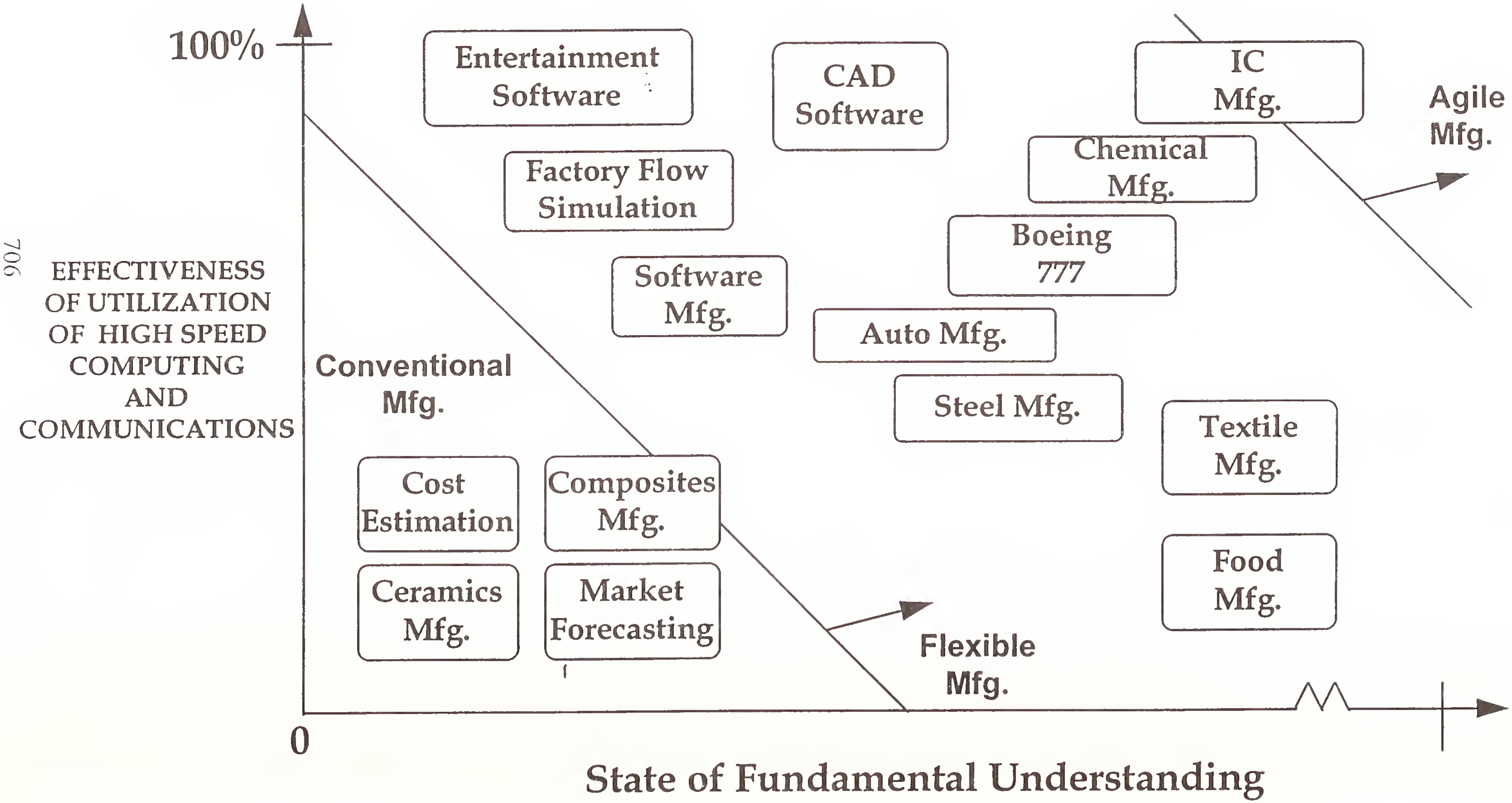
- Manufacturing Infrastructure Elements:
  - Engineering Tools for Design and Manufacturing
  - Advanced Manufacturing Systems
  - Advanced Processes and Equipment
  - Manufacturing Training and Education
  - Technology Deployment

- FY96 High Priority Research Areas:
  - Agile/Flexible Manufacturing
  - Rapid Prototyping (Virtual and Physical)
  - Intelligent Controls and Sensors
  - Environmentally Conscious Manufacturing

Design and Manufacturing: The Knowledge/Automation Spectrum



The Effective Utilization of High Speed Computing and Communications Depends on New Knowledge



Examples of Needed Knowledge

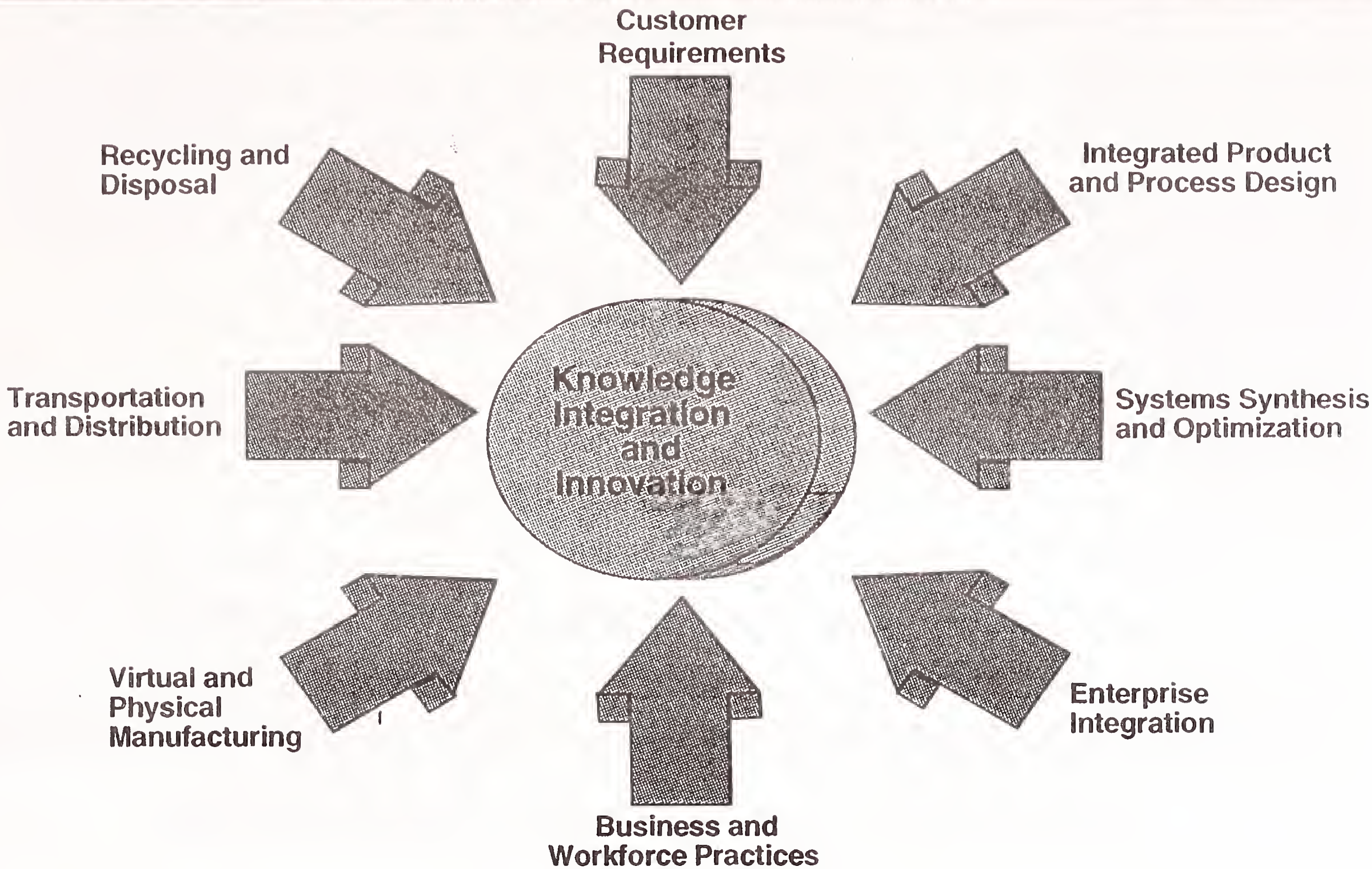
- The fundamental physics and chemistry of interfaces are not well understood.
- Computer-Aided Design software is inexact and computationally intensive.
- Accurate understanding of socioeconomic interactions requires the development and testing of dynamic models.
- Optimal design of complex mechanical systems requires new multivariable optimization techniques.
- Design possibilities are constrained by the capabilities of existing manufacturing equipment.

Trends for FY 1995

Time to refocus on <u>fundamental</u> issues:

- modeling of interfaces and material behavior
- reduced order process models <u>for control</u>
- sensor development for simplified control
- theory of design
- theory of machine design for computer control
- theory of manufacturing systems design
- life cycle cost estimation
- integration of societal issues in design

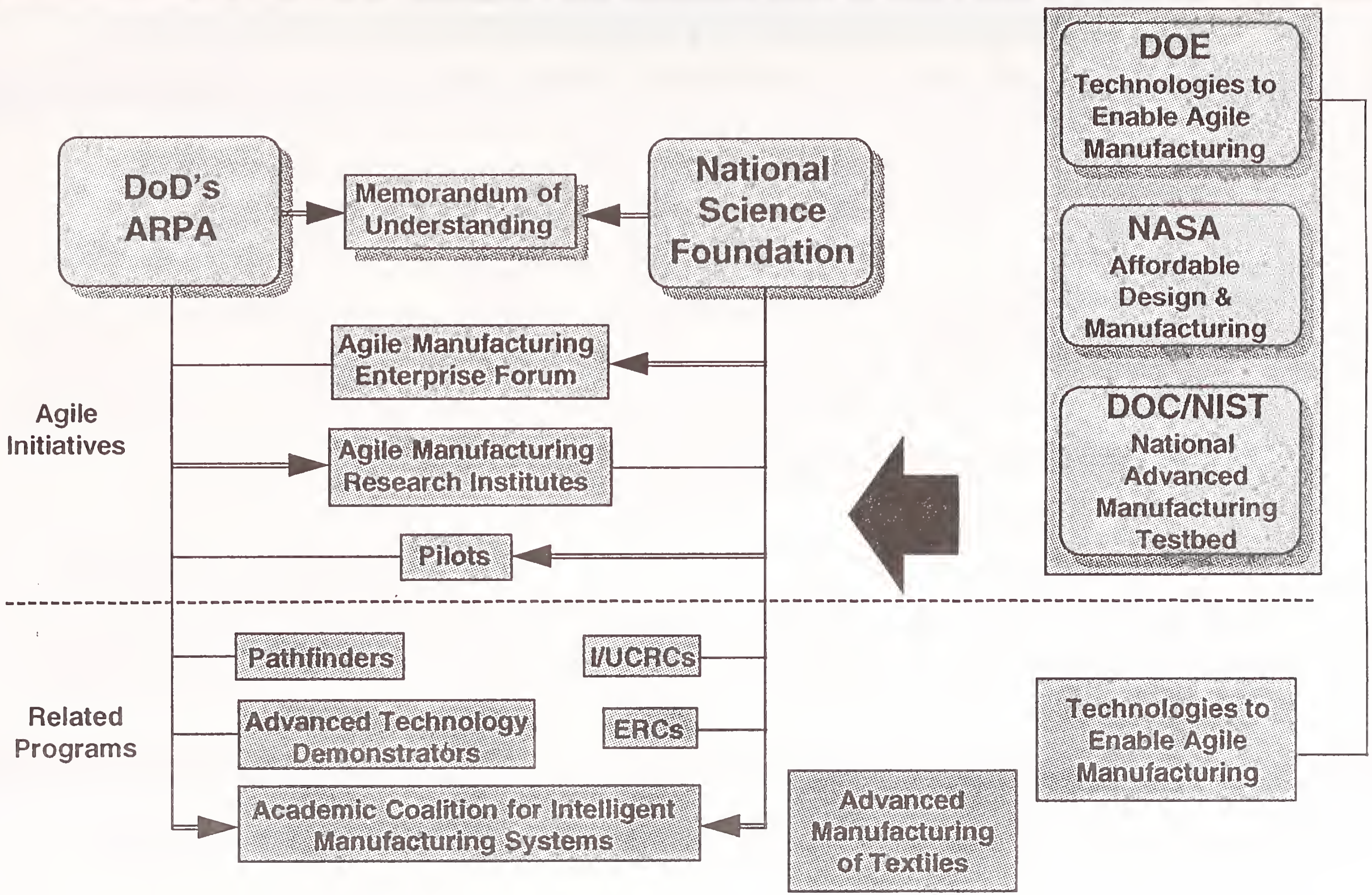
Knowledge Integration Challenge



NSF/ENG Centers, Coalitions & Groups Involved in Manufacturing/Design

- University of Maryland - Systems Research Center
- Carnegie Mellon U. - Engineering Design Research Center
- Mississippi St. U. - Computational Field Simluation Center
- Ohio State University - ERC for Net Shape Manufacturing
- Purdue U. - ERC for Collaborative Manufacturing Systems
- U. of Wisconsin - ERC for Plasma-Aided Manufacturing
- N.C.St.U. - ERC for Adv. Electronic Material Processing
- M.I.T. - Biotechnology Process Engineering Center
- Georgia Tech - ERC for Low-Cost Electronic Packaging
- University of Florida - Particle Science and Technology
- State/Industry/University Cooperative Research Centers (5)
- Industry/University Cooperative Research Centers (15)
- The New Manufacturing Engineering Education Coalition
- Technology Reinvestment Project - Mfg. Education &Training (Multi-Agency: incl. 2 Coalitions; 57 projects)

Agile Manufacturing Interagency Collaboration

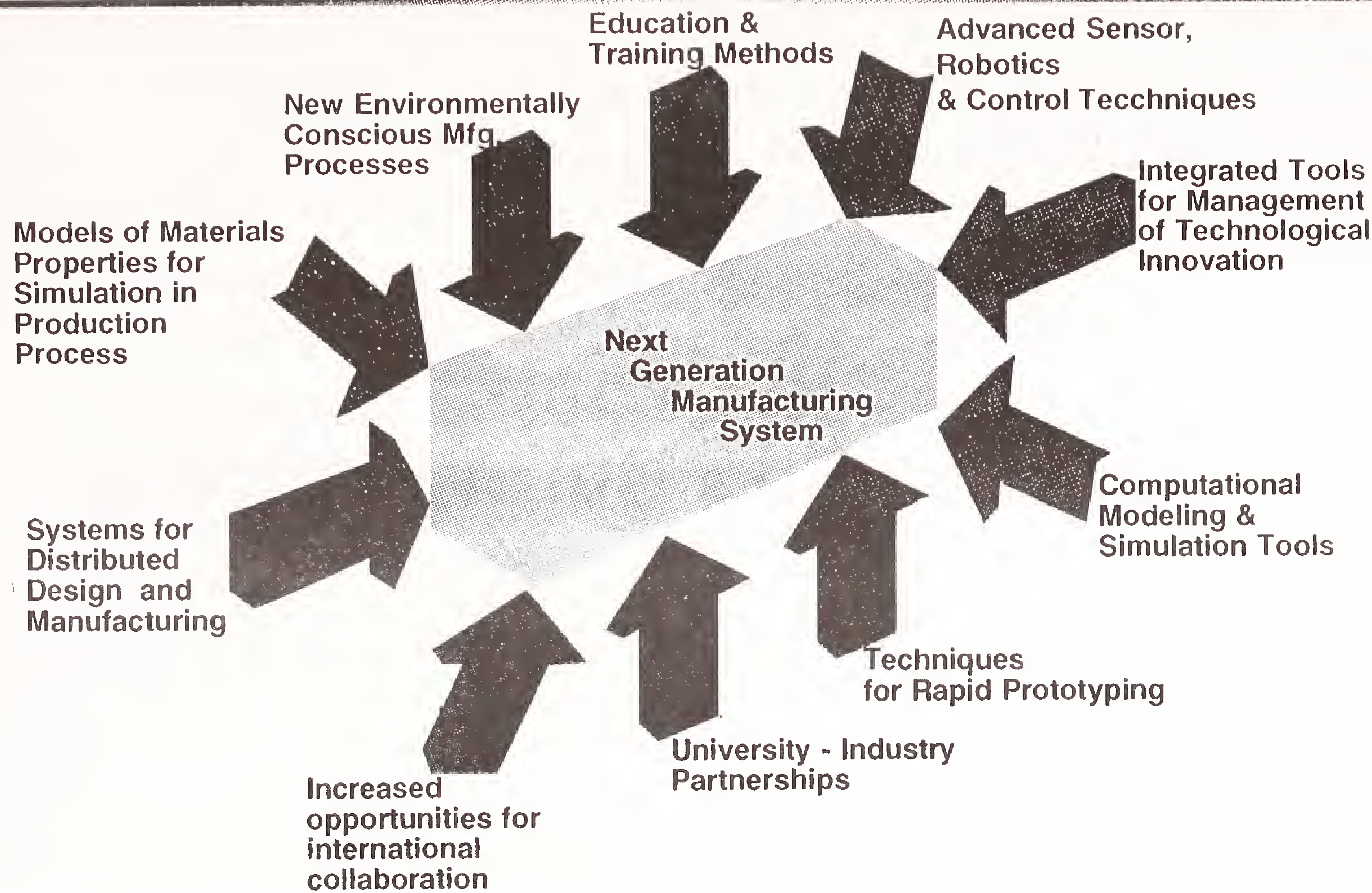


ARPA/NSF Agile Manufacturing Initiative

- **Challenge: Accelerate the development and use of key technologies enabling "agile" manufacturing**
- **NSF response:**
  - » Form joint initiative with ARPA
  - » Create Agile Manufacturing Enterprise Forum (AMEF) at Lehigh
  - » Establish Agile Manufacturing Research Institutes (AMRIs):
    - – Aerospace (University of Texas at Arlington)
    - – Electronics (Rensselaer Polytechnic Institute)
    - – Machine tools (University of Illinois)
  - » Fund additional AMRIs in FY95 if funds available
  - » Broaden collaboration with other agencies, industry, the workforce, state and local governments, and academe
- **Impact: Dramatic improvement in the ability of American manufacturers to quickly and effectively respond to rapidly changing customer needs**

The Payoff: Innovation through Integration

"enabling the nation's next generation manufacturing system"



Manufacturing Engineering Education

Manufacturing: The Educational Challenge

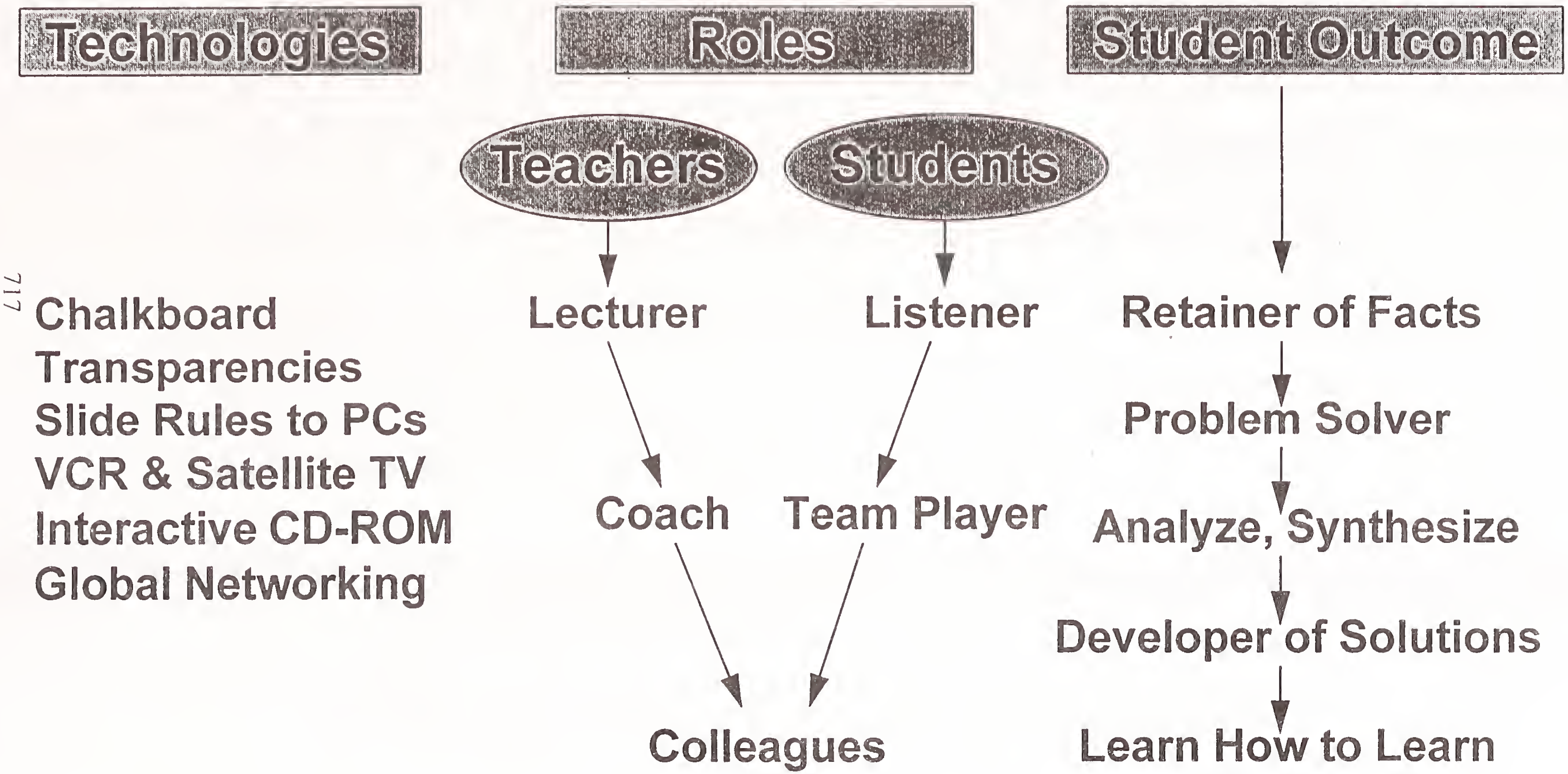
- Integration and synthesis, so critical to manufacturing success, are not adequately addressed in current academic curricula.
- General workforce is not sufficiently scientifically or technologically literate.
- Advanced technology education lacks the academic-industry partnership necessary to train a 21st century workforce.

Components of an Engineering Education

Vertical (In-depth) Thinking	Lateral (Functional) Thinking
Abstract Learning	Experiential Learning
Reductionism	Integration
Develop Order	Correlate Chaos
Understand Certainty	Handle Ambiguity
Analysis	Synthesis
Research	Design/Process/Manufacture
Solve Problems	Formulate Problems
Develop Ideas	Implement Ideas
Independence	Teamwork
Techno-Scientific Base	**Societal Context**
Engineering Science	**Functional Core of Engineering**

Evolution of Engineering Education

from Passive Learning to Collaborative Learning



NSF Programs to Enhance Engineering Education

* Engineering Education Coalitions
* Combined Research Curriculum Development
* Engineering Research Centers
* Manufacturing Education and Training (TRP)
* Faculty Early Career Development (CAREER)
* Research Experience for Undergraduates
* Grant Opportunities for Academic Liaison with Industry (GOALI)

FY1993-(part)1994 Technology Reinvestment Project
Manufacturing Education and Training - NSF

	Total MET		NSF-MET	
	Awds.	$M	Awds.	$M
• Eng. Ed. in Mfg. Acrs. the Curr.	9	16.5	7	12.3
• Practice-Oriented M. Degrees	7	5.4	4	2.4
• Retraining the Mfg. Workforce	12	12.3	10	10.0
• Ed. Trnships for Def. Ind. Engrs.	6	3.9	6	3.9
• Mfg. Eng. Ed. Coalitions	2	8.0	2	8.0
• Suppl'mts to Ctrs. & Coalitions	6	6.4	6	6.4
• Indv'l/Grp. Innov. in Mfg. E. Ed.	12	6.2	9	5.1
• Mfg. Experts in Clssrm. (MEC)*	3	*1.4	2	0.8
Total FY93-94 Awards	57	**60.1	46	48.9

* MEC also being supported in other categories, totaling $4.6M FY1993

** FY1993 - $48.2M; FY1994 - $11.9M (remainder in FY95 competition)

Trends for FY 1995

Time to team with industry:

- fundamental breakthroughs require real data
- team in SBIR (up to 30% to University)
- team in an ATP project (NSF GOALI/IUCRP)
- team in a TRP project (NSF GOALI/IUCRP)
- spend time in industry (GOALI/EFI)
- send a postdoc to industry (GOALI/PIF)
- send students to industry (GOALI/GSA)
- bring industry experts to campus (GOALI/IPC)
- have more industry RAs (GOALI/IBGA)
- ERC, IUCRC, MOTI, TQO, ECDM, any proposal

Industry - University Partnership

Knowledge	Knowledge
Experience	New Ideas
Real Data	New Models
Customer Needs	New Students
Strategic Vision	Future Focus

Environmental Technology Initiative (ETI) at EPA

Brendan Doyle, EPA

EPA'S ENVIRONMENTAL TECHNOLOGY INITIATIVE
FACT SHEET

April-May, 1995

- The President's Environmental Technology Initiative (ETI) was announced by President Clinton in his first *State of the Union* address on February 17, 1993. The initiative, an interagency effort spearheaded by the Environmental Protection Agency, was funded at $36 million in Fiscal Year 1994, $68 million in FY 1995.

- Reflecting his high aspirations for the mission of the Environmental Technology Initiative, President Clinton has requested a 76% increase in the FY1996 ETI budget to $120 million.

- The goal of the Environmental Technology Initiative is to promote improved levels of health and environmental protection by accelerating the development and use of innovative environmental technologies. The Initiative will also enhance the competitiveness of the U.S. environmental technology industry. The President believes that catalytic public-private partnerships can and must be forged to help American technology companies win in today's rapidly growing global marketplace.

- Environmental technology is a high-wage, high-growth industry. More than 1,000,000 Americans are employed in the industry today. Our key trade competitors Japan and Germany recognize environmental technology as a leading 21st Century industry and are positioning themselves to compete aggressively in the global market. President Clinton launched the ETI in the belief that American innovators deserve the same opportunity to succeed.

- The United States comprises by far the largest single market for environmental technology, estimated by Environmental Business International (EBI), a private industry analyst, at $134-billion in 1992, as compared to $161-billion in the rest of the world. EBI projects that the global market will grow from that 1992 sum of nearly $300 billion to as much as $500 billion by the year 2000.

- *Environmental technologies* prevent pollution, control and treat air and water pollution, remediate contaminated soil and groundwater, assess and monitor exposure levels and and manage environmental information.

- Exports of environmental technology create high-wage U.S. jobs and will be a key source of employment expansion as Americans increasingly capitalize on opportunities abroad. Research shows that for every $1 billion worth of exports, 17,000 U.S. jobs are created.

What environmental problems is ETI solving?

The ETI promotes technology innovation as a means to better, more reliable, cleaner, and lower cost ways to protect the environment and public health. For example, the Initiative focusses on ways to lower the cost of monitoring and treating drinking water quality, preventing pollution in small and medium-sized businesses, reducing harmful exposures to air and water pollution and clean-up contaminated sites sooner, at lower cost. As an integral component of EPA's "Common Sense Initiative" and commitment to re-inventing regulation, the ETI focusses on opportunities where better technological solutions yield better environmental quality and public health protection through innovative public-private partnerships that will:

- reduce the barriers in federal and state environmental policies and regulations that inhibit technology development (e.g., technology-specific standards, risk-adverse permitting, compliance deadlines that preclude the adoption of new technologies, etc.);

- overcome barriers to demonstrating technologies and developing credible performance (e.g., lack of test sites; and verification of performance and cost data);

- address financing and commercialization barriers (e.g., lack of funds for full-scale testing, and lack of business acumen in small development companies); and,

- facilitate information dissemination/technology transfer (e.g., no concerted effort to diffuse information on new technologies and successful applications).

In November, 1993, EPA released a draft, Technology Initiative Strategy (EPA/542/k-93/002). The Agency's strategic technology policy goals are to:

- Adapt EPA's policies, regulatory, and compliance framework in coordination with state and local agencies to promote innovation;

- Strengthen the capacity of technology developers and users to succeed in environmental technology innovation;

- Accelerate the diffusion and transfer of innovative technologies from developers to users both at home and through exports abroad, and

- Catalyze the development and commercialization of promising new technologies.

By promoting the development, commercialization, and use of environmental technology, ETI will improve environmental quality while fostering the creation of new jobs and businesses. Early ETI results indicate that technology developers and users can lower the cost of solving environmental problems and move "beyond compliance" while winning in today's marketplace.

FY1995 Funding: $68-million

Implement the Global Climate Change Action Plan: $17-million

Implement the Administration's Technology for a Sustainable Future Strategy: $4-million

Provide funding via four solicitations:

$40-million:
Federal agencies, states and tribes
Closed September 21, 1994
1500 proposals; 500 are being peer-reviewed
25 Project awards will be announced in April-May and remaining awards will be announced in July, 1995

$6.5-million ($1.5-million ETI):
Non-profits, colleges and universities
Green chemistry--basic pollution prevention technology research; administered by National Science Foundation & EPA
Closes on May 1, 1995

$3.5-million:
Non-profits, colleges and universities
Socio-economic, pollution prevention,policy framework, capacity building and diffusion projects; administered by EPA
Closes on May 16, 1995

$2.5-million:
EPA Small Business Innovative Research Program
$1.6-million, ETI solicitation for Phase III, commercialization projects (due to be released)

What is the EPA planning to do in Fiscal Year 1996?

In Fiscal Year 1996, EPA's Environmental Technology Initiative will emphasize projects aimed at improving public health and environmental protection by empowering the private sector to move innovative technologies into the marketplace. This policy objective is based on an extensive effort to listen, first hand, to the ideas of industry and other key initiative stakeholders. This effort included participating in numerous public meetings and conferences such as the White House Conference on Technologies for a Sustainable Future (December 1994). EPA heard representatives of industry, academia, non-governmental, environmental, and labor organizations along with states and local governments stress the importance of EPA and state policies in creating and shaping the market for environmental technologies. As a result of this effort, EPA has identified several significant policy and regulatory barriers to technology development and use. Once these barriers are reduced or eliminated, EPA and states would be positioned to support the private sector without impeding the development and use of environmental technology markets.

In Fiscal Year 1996, EPA will emphasize ways in which the Agency's and state technology policies can be reformed to make better environmental solutions available by :

- **Shattering Permitting Barriers** by working with States, and other regulatory reinvention efforts to streamline permitting processes. Permit approval processes must not penalize those willing to try new, cheaper solutions to control pollution especially technologies that provide superior results.

- **Removing Regulatory Barriers** by developing regulations that do not "lock-in" existing technologies.

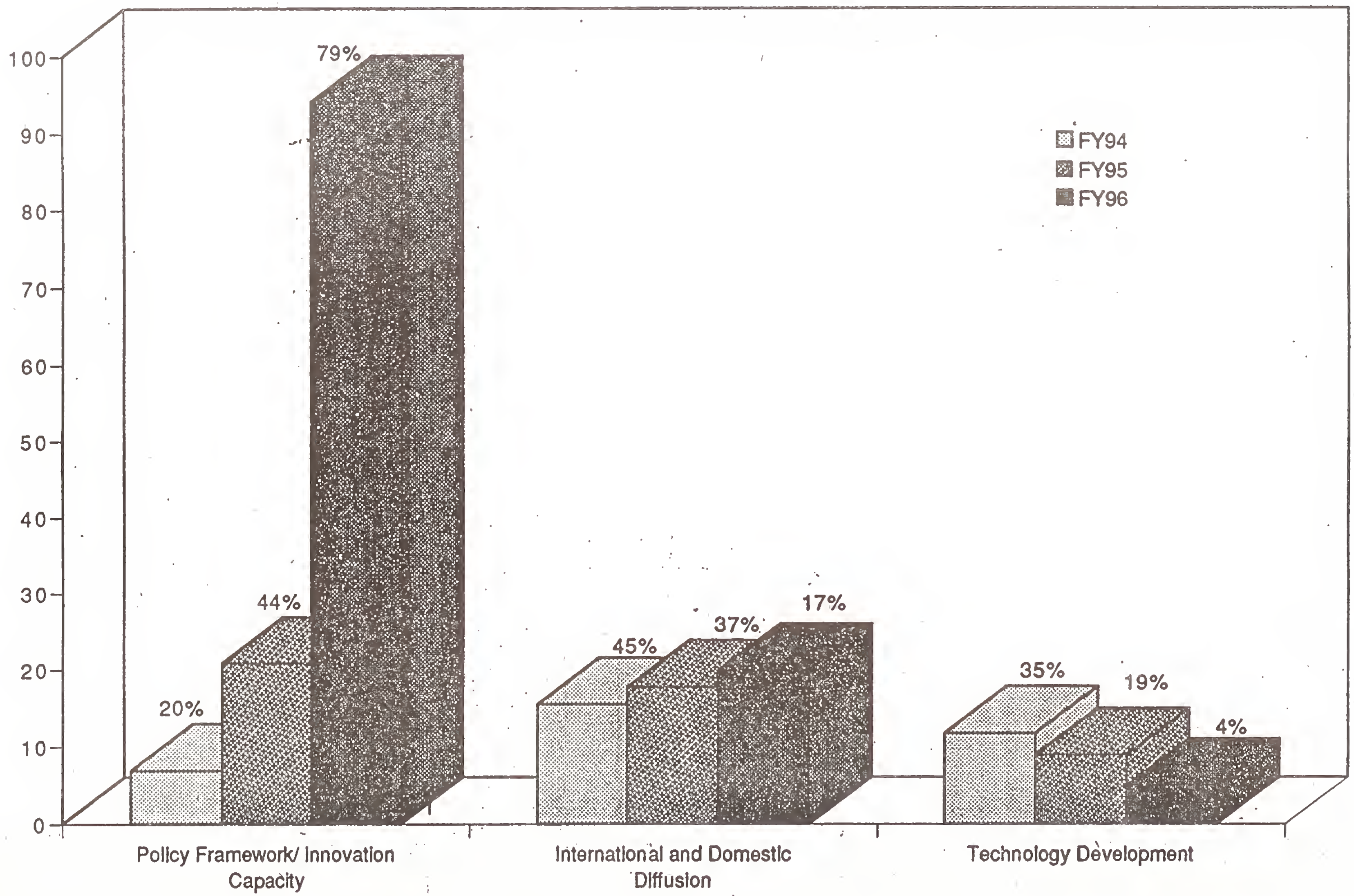
- **Establishing Flexible Compliance Practices** by providing the flexibility to use a wide variety of environmental technologies and enforcement policies fostering new, better solutions to national environmental problems.

- **Diffusing U.S. Technologies for International Environmental Solutions** by coordinating several governmental programs including those involving climate change, technical assistance, export promotion, training and technology demonstrations, we can enhance the U.S. environmental technology industry's position worldwide.

- **Enhance the Credibility and Performance of the U.S. Environmental Technology Industry** by sponsoring pilot technology verification centers at State, non-profit, and Federal laboratories. These centers will evaluate the costs and performance of new promising technologies. Armed with an EPA-sponsored verification, vendors should be able to sell new, now proven, technologies both here and abroad.

FY94 - FY96 ETI INVESTMENTS

($ millions, % are of FY total)



EARLY ETI RESULTS

A few examples follow from among the 78 projects funded in Fiscal Year 1994:

BARRIERS/GAPS/INCENTIVES:

"AIR QUALITY PERMIT REINVENTION DEMONSTRATION PROJECT"

- EPA has traditionally used permits to regulate facilities that discharge, treat, store, and /or transport pollutants. Historically, these permits have yielded substantial reductions in pollutants released to the environment.

- Regulatory barriers to the permitting and use of innovative technologies are being identified and addressed through a variety of proposed statutory and regulatory changes. However, some flexibility for technology innovation is embodied within the permitting framework already.

- Present permit programs are often cumbersome and generally do not encourage the use of innovative alternatives, such as new treatment or pollution prevention technology.

- Partners involved in the project include EPA headquarters and regional staff, the permits improvement team, the Environmental Law Institute, state and industry representatives.

- To pilot-test solutions to these problems, the ETI has funded a permitting "reinvention lab" demonstration project (under the 1990 Clean Air Act) to address is intended to implement identified permitting barriers to innovative technologies, and demonstrate the solutions by generating a "real" facility permit.

- The permitting reinvention demonstration project takes a bold step in demonstrating the revised air quality New Source Review program based upon the proposed regulation and writing a permit for an innovative technology.

- Success will come through proving that the New Source Review reform is viable for innovative technologies as proposed, or that any problems identified in the permitting process will be used as input for the final regulation.

BUILDING STATE AND LOCAL CAPACITY:

"MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION HIRES TECHNOLOGY PERMITTING COORDINATOR"

- Permitting flexibility which already exists under current laws and regulations is not being exercised for a variety of reasons, including the lack of clearly identified alternative permit pathways for innovative technologies (e.g., variances, R&D permits, conditional permits, temporary permits); the lack of clearly defined permit standards (e.g., how much testing is necessary, independent verification of test results); and hesitation on the part of permitting personnel to focus their limited time and resources on encouraging the development and use of innovative technologies.

- This project explores existing permitting flexibility to further technology innovation efforts in the Commonwealth of Massachusetts. ETI funding has established an Innovative Technology Coordinator (IT Coordinator) position in the Commissioner's Office of the Massachusetts Department of Environmental Protection (DEP). This coordinator acts as primary facilitator between DEP permit writers, the technology developer, the public and municipality, the Massachusetts Strategic Envirotechnology Partnership (STEP), and the US EPA.

- The IT Coordinator will utilize the Massachusetts Envirotechnology Committee (an advisory committee STEP established to guide the states), and the DEP's Workgroup to find six new pollution prevention technologies to guide through the DEP permitting process and if warranted, through the partnership process.

POLLUTION PREVENTION FOR SMALL BUSINESS:

"PRINTING INDUSTRY-WATER BASED INKS"

- MPI Label Systems, Inc. (MPI) is an Illinois label maker with seven (7) plants. MPI management wanted to eliminate employee exposure to any liquid/gaseous hazards. As a result of the change, solvent emissions to the plant air are changed from potentially hazardous to essentially harmless and solid waste generation has been reduced.

- MPI worked with the Illinois Department of Environment & Natural Resources and the US EPA to start the WRITE project (Waste Reduction Innovative Technology Evaluation) to review the technological and economic benefits of the change from alcohol-based to water-based inks and cleaners.

- MPI reported $16,500 in annual savings in one plant from using water based-inks and aqueous cleaners. Potentially hazardous solvent emissions were also substantially reduced. If applied industry-wide, a 150,000,000 pounds per year reduction in toxic solvents emissions, and a decrease in solid wastes.

ENVIRONMENTAL RESTORATION:

"CONTAMINATED SOILS CLEANUP"

- Soil contamination is a pervasive environmental problem that potentially affects public health. Contaminants in soil can leach into ground water and drinking water supplies.

- Terra-Kleen of Oklahoma City, OK has developed a technology that is designed to remove organic contaminants from soil. Soil cleaning is accomplished in a self contained mobile unit that may be transported to the site.

- The process mixes soil with non-toxic solvents, all approved by Food and Drug Administration as food additives for human consumption, to make a slurry. The soil is then dried, and solvents recovered for either reuse, or disposal, as necessary.

- This project was conducted under EPA's Superfund Innovative Technology Evaluation Program (SITE), a public-private partnership which demonstrated the environmental benefits from this technology such as improved cleanup levels at numerous Naval Stations including the Naval Communication Station in Stockton, California, were less than two parts per million PCBs and less than one part per million DDT, respectively.

- The Navy subsequently gave Terra-Kleen a full-scale cleanup job at their facility in Stockton. After the demonstration, 1994 sales increased to $600,000 and 4 high wage employees were hired. For 1995, Terra-Kleen has commitments of $2 million in sales, with a goal of $5 million. Additionally, the company plans to hire as many as 10 new high wage employees.

TECHNOLOGY DIFFUSION AT HOME AND ABROAD:

"ECO-INDUSTRIAL PARK PROJECT ON THE US-MEXICO BORDER"

- EPA, in partnership with the National Association of Industrial and Office Parks, the Urban Land Institute, Environmental Defense Fund and local business and utilities in Brownsville, Texas, and Matamoros, Mexico to address their common environmental problems in a unique way.

- Funded by the Environmental Technology Initiative (ETI), the project partners are assessing the economic and environmental benefits of applying "industrial ecology" to the businesses in the Brownsville-Matamoros border area.

- Many businesses are scouting the border area each week, attracted by the economic incentives under the Maquiladoro and NAFTA policies.

- The project team is assessing the environmental technologies and new businesses that are needed to make waste exchange efficient, particularly in the oil refining, apparel, plastics and metal recycling and several light manufacturing industries. The project partners are also examining the environmental benefits and cost savings associated with water and energy conservation in the area. A national workshop is being convened in May, 1995 to diffuse the results of the studies among other Border area communities, and to more than a dozen other cities around the country who are also involved in eco-industrial park developments.

How Does ETI work?

Working through a network of technology advocates in every office of the Agency and EPA's Innovative Technology Council (comprising more than 50 staff Agency-wide and representatives of other federal agencies), EPA is integrating putting Strategy to work in every aspect of the Agency's programs: by funding and supporting public-private technology innovation partnerships, in writing regulations, in approving the use of new technologies for monitoring and compliance, carrying out enforcement, in providing technical assistance, in research and development, and in piloting a new verification program.

AIR TECHNOLOGY ADVOCATE
Keith Mason
202/260-1360
202/260-9766 (fax)

REMEDIATION TECHNOLOGY ADVOCATE
Walter W. Kovalick, Jr.
703/308-8800
703/308-8528 (fax)

INTERNATIONAL MARKET ADVOCATE
Mark Kasman
202/260-0424
202/260-4470

PREVENTION, PESTICIDES and TOXIC SUBSTANCES ADVOCATE
Joe Carra
202/260-1815
2102/260-0575 (fax)

RESEARCH and DEVELOPMENT VERIFICATION ADVOCATE
Penelope Hansen
202/260-4073
202/260-3861 (fax)

ENFORCEMENT POLICIES ADVOCATE
Susan Bromm
202/564-2310
202/564-0037

WATER TECHNOLOGY ADVOCATE
Bill Kramer
202/260-5824
202/260-5394 (fax)

ENVIRONMENTAL TECHNOLOGY INITIATIVE/POLICY FRAMEWORK ADVOCATE
Albert McGartland
Office of Policy, Planning and Evaluation
U.S. EPA, 401 M Street, SW
Mail Code 2127
Washington, DC 20460
202/260-2686

SMALL BUSINESS INNOVATIVE RESEARCH (SBIR) AND EXPLORATORY RESEARCH GRANTS
Don Carey, OER
U.S. EPA, 401 M Street, SW
Mail Code RD-675
Washington, D.C. 20460
202/260-7899

SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION (SITE)
John Martin
EPA Risk Reduction Engineering Laboratory
26 West Martin Luther King Dr.
Cincinnati, Ohio 45268
513/569-7696

COOPERATIVE RESEARCH & DEVELOPMENT AGREEMENTS (CRADAs)
Larry Fradkin
Office of Science Planning and Regulatory Evaluation
26 W. Martin Luther King Drive, RM-175
Cincinnati, OH 45268
513/569-7960

GROUND-WATER TECHNOLOGY DEMONSTRATIONS
Dick Scalf
Robert S. Kerr Environmental Research Laboratory
P.O. Box 1198
Ada, OK 74820
405/436-8580

SITE-SPECIFIC, PERMITTING or COMPLIANCE ASSISTANCE

U.S. EPA Region 1
(Connecticut, Maine, Massachusetts,
New Hampshire, Rhode Island, Vermont)
Center for Environmental Industry and Technology
John F. Kennedy Federal Building
One Congress Street
Boston, MA 02203
800/575-CEIT

U.S. EPA Region 2
(New Jersey, New York, Puerto Rico, Virgin Islands)
Jacob K. Javits Federal Building
26 Federal Plaza
New York, NY 10278
908/906-6988

U.S. EPA Region 3
(Delaware, District of Columbia, Maryland,
Pennsylvania, Virginia, West Virginia)
841 Chestnut Building
Philadelphia, PA 19107
215/597-1113

U.S. EPA Region 4
(Alabama, Florida, Georgia, Kentucky, Mississippi,
North Carolina, South Carolina, Tennessee)
345 Courtland Street, NE
Atlanta, GA 30365
404/347-1767

U.S. EPA Region 5
(Illinois, Indiana, Michigan, Minnesota,
Ohio, Wisconsin)
77 West Jackson Boulevard
Chicago, IL 60604-3507
312/886-6104

SCIENTIFIC AND TECHNICAL INFORMATION EXCHANGE

Calvin Lawrence
Center for Environmental Research
Information (CERI)
26 W Martin Luther King Dr., G-75
Cincinnati, OH 45268
513/569-7391

U.S. EPA Region 6
(Arkansas, Louisiana, New Mexico, Oklahoma,
Texas)
First Interstate Bank Tower
at Fountain Place
1445 Ross Avenue, 12th Floor, Suite 1200
Dallas, TX 75202-2733
214/665-8349

U.S. EPA Region 7
(Iowa, Kansas, Missouri, Nebraska)
726 Minnesota Avenue
Kansas City, KS 66101
913/55-5064

U.S. EPA Region 8
(Colorado, Montana, North Dakota, South Dakota,
Utah, Wyoming)
999 Eighteenth Street, Suite 500
Denver, CO 80202-2405
303/293-1475

U.S. EPA Region 9
(Arizona, California, Hawaii, Nevada, American
Samoa, Guam)
75 Hawthorne Street
San Francisco, CA 94105
415/744-1021

U.S. EPA Region 10
(Alaska, Idaho, Oregon, Washington)
1200 Sixth Avenue
Seattle, WA 98101
206/553-8562

U.S. ENVIRONMENTAL PROTECTION AGENCY'S
Environmental Technology Initiative

ENVIRONMENTAL TECHNOLOGY INITIATIVE

- o Presidential initiative

- o Four strategic objectives:

  --adapt policy and regulatory framework
  --strengthen capacity of developers and users to succeed
  --catalyze development and commercialization
  --accelerate diffusion at home and abroad

- o Funding is tied to statutory authority to provide grants to other federal agencies, states, tribes, non-profits, universities and colleges and participants in EPA's Small Business Innovative Research programs

- o Congress mandated public-private partnerships and "spending plan"

- o November, 1993: EPA <u>Technology Innovation Strategy</u> released

- o FY1994:

  -- $36-million
  -- 78 projects funded , $1.6-million to NIST

- o Coordinated through Innovative Technology Council with representation of all other federal agencies

U.S. ENVIRONMENTAL PROTECTION AGENCY'S
Environmental Technology Initiative

ENVIRONMENTAL TECHNOLOGY INDUSTRY OVERVIEW:

"*Environmental technologies*" include technologies, goods and services whose development is triggered primarily by environmental improvement objectives. These include products and services to:

- o monitor and assess pollutant releases and exposure levels,
- o innovative technologies that prevent pollution,
- o control air and water pollution,
- o safely manage waste and remediate contaminated soil and groundwater,
- o and manage environmental data.

Annual Sales:

1992:	Domestic:	$134-billion; 1,070,000 employed
	Rest of the World:	$161-billion; ??? employed
2000:	Global:	$600-billion global

U.S. ENVIRONMENTAL PROTECTION AGENCY'S
Environmental Technology Initiative

FY1995 Funding: $68-million

Four solicitations:

$40-million:
- Federal agencies, states and tribes
- Closed September 21, 1994
- 1500 proposals; 500 peer-review
- Awards in April and July, 1995

$6.5-million ($1.5-million ETI):
- Non-profits, colleges and universities
- Green chemistry--basic pollution prevention technology research; administered by National Science Foundation & EPA
- **Closes on May 1, 1995**

$3.5-million:
- Non-profits, colleges and universities
- Socio-economic, pollution prevention,policy framework, capacity building and diffusion project; administered by EPA
- **Closes on May 16, 1995**

$2.5-million:
- EPA Small Business Innovative Research
- Phase III, commercialization projects
- Due to be released

U.S. ENVIRONMENTAL PROTECTION AGENCY'S
Environmental Technology Initiative

Other actions that can enhance technology financing:

--reducing policy and regulatory barriers--provides more certainty for investors;

--bridging the "Valley of Death" with SBA

--Verification pilots: cost and performance data key to building credibility

--Rapid Commercialization Initiative (w/ Commerce Department): EPA and states integrate new technologies with environmental permitting

--EPA and state-sponsored technology development and finance centers

--Procurements:

--Other federal agencies have 3-9 times more funding than EPA:

--$4-billion government-wide; EPA $$$ small

Exports:

--Ex-Im Bank and Trade Promotion Coordinating Committe support

FY1996 President's ETI Budget Request: $120-million

Focus on reducing regulatory and policy barriers, capacity-building and diffusion

Intelligent Manufacturing Systems (IMS)

Andy Wan

Intelligent Manufacturing Systems

IMS

Providing a framework for industry-led international collaborative R&D in advanced manufacturing

CIMS *ACIMS* *U.S. Department of Commerce*

SUPPORTING INFRASTRUCTURE

JAPAN -- MITI and IMS Promotion Center

EUROPE -- EC Technical Community - Esprit model development

U.S. -- Industry Coalition for Intelligent Manufacturing Systems (CIMS), Academic-CIMS (A-CIMS), Department of Commerce, Technology Administration

AUSTRALIA-- Department of Industry, Technology and Commerce

CANADA -- National Research Council Interaction

IMS TEST CASES

Global Concurrent Engineering

Canada	Northern Telecom
Europe (EC)	Technology Transfer Group
United States	North Carolina State University

Globeman21: Enterprise Integration for Global Manufacturing towards the 21st Century

Australia	CSIRO
Europe	British Aerospace/Ahlstrom
Japan	Toyo Engineering
United States	Newport News Shipbuilding

Holonic Control Systems: System Components of Autonomous Modules and their Distributed Control

Australia	Allen-Bradley-BHP
Canada	Queens University
Europe	Softing GmbH
Japan	Hitachi LTD
United States	Allen Bradley

Rapid Product Development

Australia	Modflow
Canada	Pratt & Whitney Canada
Europe (EC)	Daimler-Benz AG
United States	United Technologies Corp.

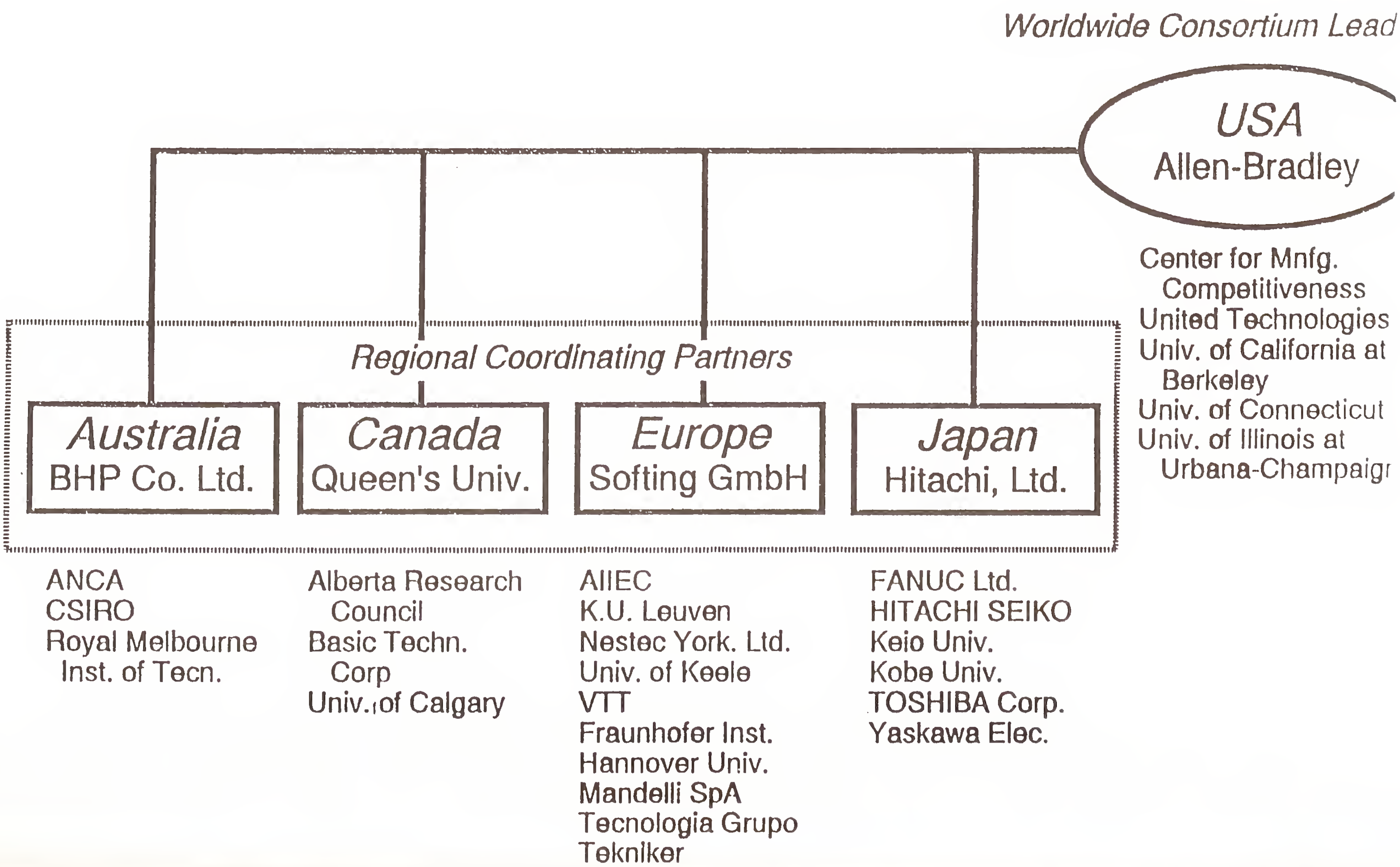
Systemization of Functional Knowledge

Canada	Alberta Research Council
Europe	ASEPA/ABB
Japan	Mitsubishi Electric
United States	Deneb, Inc.

Study: Clean Manufacturing in the Process Industry

Australia	ICI Australia
Canada	Ahitibi-Price
Europe	ICI Engr/Finnish Forest Industry Assn.
United States	DuPont

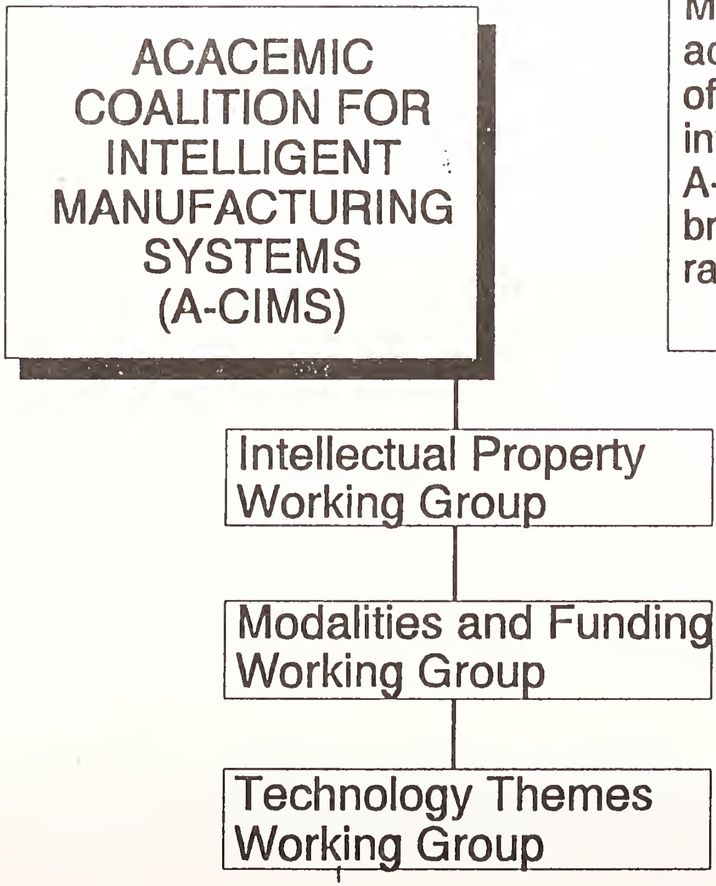
Consortium for Holonic Manufacturing Systems



Interim Test Case Assessment:
Institutional Participation by Region

	Austral.	Can.	Europe	Japan	USA	Total
Industry	5	8	47	19	9	88
Other	6	13	17	9	10	55
Total	11	21	64	28	19	143

U.S. Supporting Infrastructure



The Academic Coalition for Intelligent Manufacturing Systems (CIMS) is a broad-based academic organization formed to further the interest of U.S. Academia in the context of the proposed international Intelligent Manufacturing Systems... A-CIMS activities will focus initially on providing broad American Academic input during the IMS ratification period to government and industry.....

- Development of Guidelines and Supporting Processes
  - Intellectual Property
  - Technical Project Development
  - Evaluation and Selection Criteria
- Linkage to Government and Industry
- Information Dissemination
- Mirror Image to CIMS

A-CIMS Objectives

- Provide Information to Academia, Industry and Government,
- Facillitate Active Participation and Inter-University exchanges.
- Assist Partnership Development between the sectors,
- Influence Domestic and International IMS Policy,
- Influence funding of IMS projects.

Develop new Curriculum
Raise Professionalism of Mfg. as a
Involve all le
Universities

TEST CASE SELECTION CRITERIA

1) Relevance and participation
   - Scientific and technical merit
   - Industrial relevance
   - Degree of interregional collaboration and participation.

2) Effectiveness
   - Adoption and deployment strategies
   - Technology transfer methods (Standards and Products)
   - Evaluation methodology

3) IPR (Intellectual Property Rights) provisions
   - Consistent with ISC Guidelines

4) Consortium resources and qualfications for test cases.

5) Balanced & equitable collaboration
   - Contributions
   - Benefits
   - Number & Types of participants

Why Not IMS?

- The most advanced R&D might move to other regions and some critical technologies might be compromised
- Joint IMS programs could be held-hostage to international trade disputes
- International R&D may prove more expensive than domestic partnerships
- Corporate best-practice competitive advantages could be compromised
- Academic programs could become too focused upon short term results

WHY IMS?

Academic Arguments - IMS Can:

- Provide more real world opportunities for manufacturing R&D.
- Stimulate additional funds for manufacturing R&D from industry and government.
- Raise the professionalism and stature of manufacturing as a discipline.
- Improve educational curricula.

WHY IMS?

Corporate Arguments - IMS Can:

- Stimulate international cooperation between companies leading to other business partnerships for mutual profit.
- Achieve first-to-market advantages for participants.
- Give corporations early strategic information about their international competitors.
- Allow small companies to share benefits enjoyed by large companies (many of which have international subsidiaries or already participate in joint ventures with international partners).

WHY IMS?

Regional Arguments - IMS Can:

- Implement domestic strategies within a working international context.
- Focus regional plans.
- Stimulate industry leadership in manufacturing R&D (e.g. CIMS).
- Foster industry, academic (e.g. A-CIMS) and government collaboration.
- Lead to common Industry/Academia/Government goals and coordinated strategies.
- Leverage R&D funds of corporations and governments.
- Prevent "cherry picking" of key domestic technologies.
- Provide a mechanism for regional inter-agency cooperation (e.g. a TRP-like IMS program).

What is the IMS Program?

- **A series of joint international research programs in Intelligent Manufacturing Systems**

- **Originally proposed by Japan in 1989**

- **The proposal was brought under the auspices of the U.S. - Japan Science and Technology Agreement**

- **An IMS 'feasibility study' was launched in 1992 involving six 'regions'**
  - U.S. / Japan / EEC / EFTA / Australia / Canada
  - Six 'test case' international research activities (consortia) were evaluated from a substance, management, IPR, and economic effectiveness viewpoint

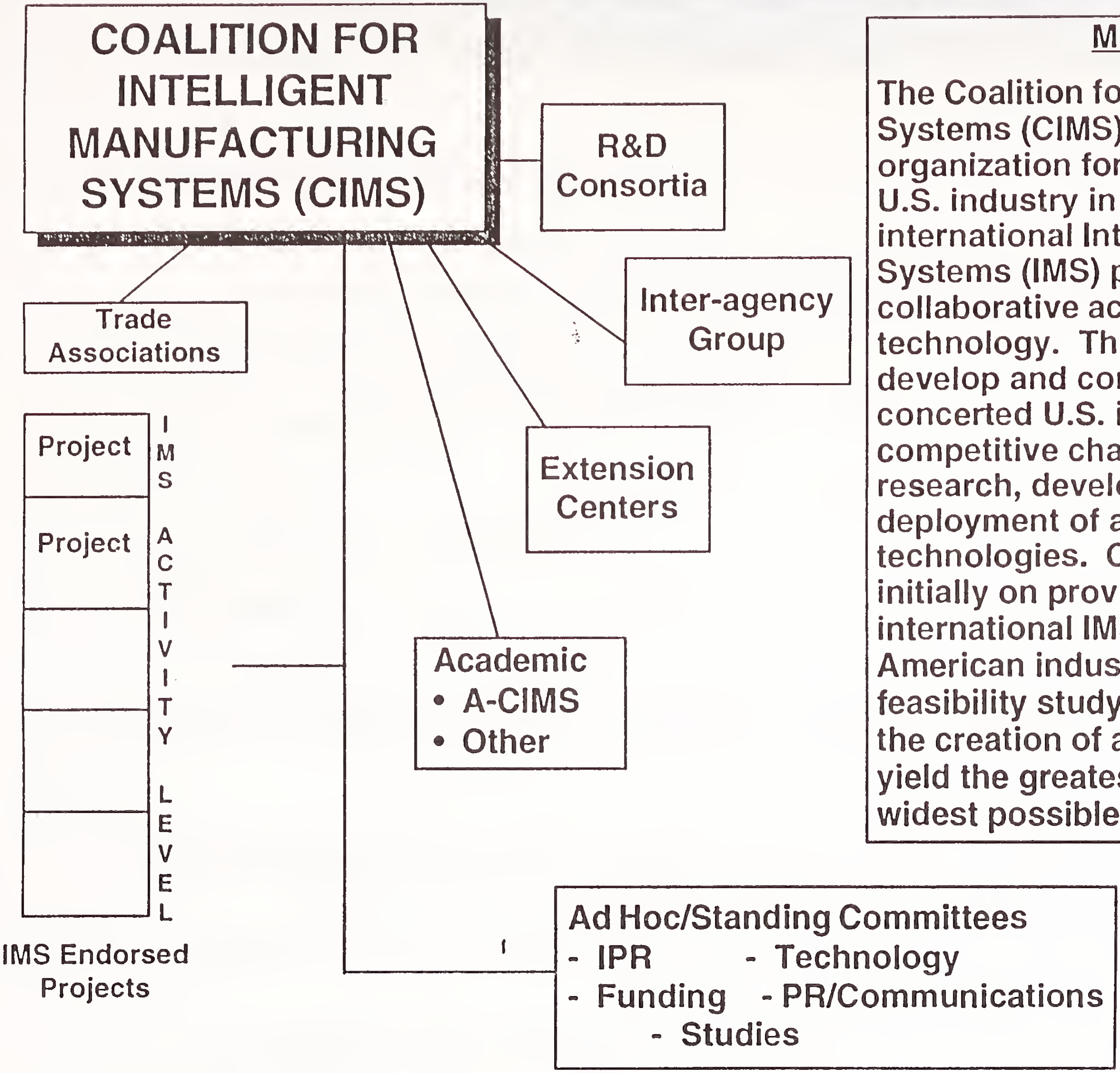
- **A full-scale IMS program was declared 'feasible' by the International Steering Committee in Jan. 1994 with a recommendation to launch such a program by Jan. 1995 with those 'regions' who have ratified the terms-of-reference.**

The U.S. Must Compete with the Best the World has to Offer

IMS offers:

- A way to evaluate and import the world's best manufacturing systems and technologies
- A mechanism for improving the integration of U.S. suppliers (SME's) into the global process
- A way to influence research directions for next-generation systems
- A way for U.S. industry to influence future international product standards
- A mechanism for strengthening U.S. manufacturing education and raising the stature of the manufacturing profession

U.S. Supporting Infrastructure



Linkage to policy and oversight committee

Mission Statement

The Coalition for Intelligent Manufacturing Systems (CIMS) is a broad-based industry organization formed to further the interests of U.S. industry in the context of the proposed international Intelligent Manufacturing Systems (IMS) project and of global collaborative activities in manufacturing technology. The purpose of CIMS is to develop and communicate coherent and concerted U.S. industry input regarding the competitive challenges inherent in global research, development, application and deployment of advanced manufacturing technologies. CIMS activities will focus initially on providing U.S. members of the international IMS committees with broad American industry input during the IMS feasibility study. The ultimate goal of CIMS is the creation of an IMS framework that will yield the greatest possible benefit to the widest possible spectrum of U.S. industry.

Coalition for Intelligent Manufacturing Systems (CIMS) Goals & Objectives

- Keep IMS growing, viable, and *industrially relevant*

- Communicate value of IMS to U.S. industry
  - Outreach and dissemination of information
  - Newsletters
  - Periodic workshops

- Promote SME participation in IMS
  - MTC involvement
  - Workshops via industry associations (NAM, IPC, SEMI), and consortia (NCMS, CAM-I)
  - Supplier linkages

- Support U. S. activities in implementing full-scale program
  - Technical, IPR, modalities, public relations committees

Coalition for Intelligent Manufacturing Systems (CIMS) Goals & Objectives (Cont'd)

- Promote/develop linkage to academia
- Integration into U.S. manufacturing strategy
  - Reduce duplication of efforts
  - Consistent with IMS themes
  - National Science and Technology Council (NSTC)
- International benchmarking

<u>Build/Evolve a Solid U.S. Framework for Success</u>

- Maintain industry leadership
- Strong academic participation
- Proactive government

CIMS REVIEW

Volume 3
Issue 1
March/April, 1995

A periodic update on CIMS/IMS activities

The Coalition for Intelligent
Manufacturing Systems
Washington D.C.

Message from the Executive Director:

After a great deal of time and a remarkable amount of effort have been put into achieving agreements between interested parties with very different agendas, all the pieces are finally beginning to fall into place as we approach the commencement of the International IMS program. The fact that we have found strong, workable agreement on the nature of our country's involvement with IMS is something for which all involved are to be commended.

As our "IMS Implementation Workshop" in mid-March demonstrated, we have many issues yet to be resolved but when we come together, we can make giant strides in a short amount of time. This meeting was one of the most productive in recent memory and it is our hope to carry this momentum through with another follow-up meeting within the next couple of months to truly get the ball rolling.

Since our last newsletter, the U.S. IMS Delegation has been named and is currently preparing for the first International Steering Committee meeting scheduled for late April in Toronto. We will be very fortunate to have three outstanding individuals representing us at the international level. Few have done more than delegate Bob Cattoi in keeping the IMS program afloat and moving forward. Bob will be heading the U.S. delegation to the ISC. Accompanying him as the other delegate will be another accomplished individual, Dr. John White of Georgia Tech University. Rounding out the delegation will be the U.S. Observer, Assistant Secretary for Technology at the Commerce Department, Graham Mitchell. All of these gentlemen have earned and deserve our full support as they head into the first meeting of the ISC which will inaugurate the full-scale IMS program.

While we take time to recognize what we have done, we must realize that there is still a great deal yet to be accomplished. Our efforts at reaching out to small- and medium-sized companies, still in the nascent stage, must be brought to fruition. CIMS, with the support of the Department of Commerce, will be organizing a number of regional IMS workshops in the near future to begin helping this segment of the U.S. manufacturing base realize its potential through IMS.

Finding an avenue though which universities will participate is also an issue which must be solidified. As such, we are eager to see A-CIMS become a reality.

And although the International portion of IMS is set to kick off, we cannot ease up on our CIMS membership recruitment efforts. We must follow up on all these issues and more if we are to realize all that IMS has to offer our nation's manufacturing interests.

IN THIS ISSUE

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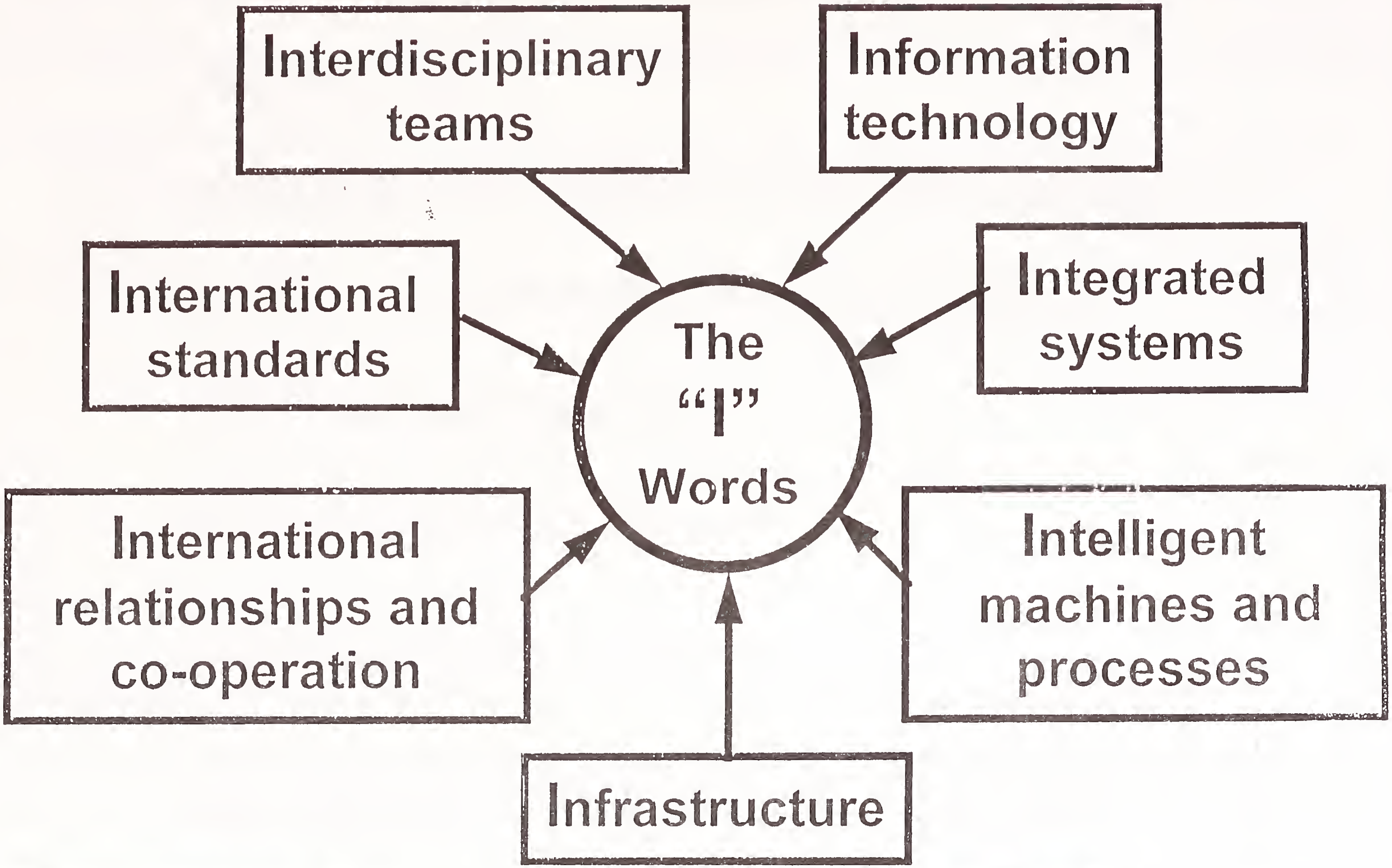
Manufacturing in the 21st Century



IMS

Gene Meieran Page 2 6/20/94 CIMSTALK.P

"I" Words Replace "Q" Words

- Interdisciplinary teams
- Information technology
- Integrated systems
- Intelligent machines and processes
- International relationships and co-operation
- Infrastructure
- International standards

Interdisciplinary Teams

- Most easy manufacturing problems have been solved
- This has been done mostly by individual contributors
- More difficult problems do not lend themselves to methodologies used to solve "easy" problems
- These often requires an inter-discipline approach:
  - Computer and information technology
  - Sophisticated processing technology
  - Manufacturing systems technology
  - Equipment technology
  - Quality management technology
- Interdisciplinary approach requires teamwork:
  - Replace adversarial positions with co-operative teams
  - Geographically dispersed

Information Technology

- The need for rapid access to information on the factory floor is exponentially increasing
  - For process control
  - For flexible manufacturing
  - For better decision making
- The technology to manage information is also rapidly advancing
  - Computation tools
  - Communication tools
  - Storage tools
  - Analysis tools
  - Display tools
- The competitive value of having responsive information management and delivery systems is being recognized

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Integrated Systems

- Systems are becoming much more complex:
  - IC technology approaching 10,000,000 active elements per chip
  - Automobiles continually expanding driver/passenger services:
    - Climate control
    - Entertainment control
    - Safety control
    - Fuel efficiency
    - User friendliness
  - Airplanes are becoming flying hotels
- Such systems are made up of a number of (software dependent) sub-systems
  - Integration of these systems is becoming a critical bottleneck
  - Each individual sub-system seems to be fairly well optimized
  - The more sub-systems, the more interfaces to manage
  - More complex systems require more efficient integration

IMS

Intelligent Machines and Processes

- Processes are getting more complex
  - Control of mono-layer thick films
  - Control of critical dimensions at the limit of detection capability
  - Manipulation of micron (and Angstrom!) size objects
- Systems are getting more complex
  - Intelligent passenger vehicle control systems
  - Automatic teller machines
  - AGVs
  - Millions of active elements per system (ICs to airplanes)
- Humans cannot cope with this much complexity
  - Items physically too small to handle
  - Issues too mentally complex to comprehend
  - Situations requiring very fast responses
  - Technology changing too rapidly to assimilate

Intelligent Machines and Processes

Intelligent machines and tools provide one useful answer

- Technology now available (expert systems, neural nets, AI, etc.
- Technology being developed (active agents)
- Hardware and software becoming very inexpensive
- Displays getting large and cheap
- Communications capabilities expanding exponentially

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International Relations

- Businesses are becoming multi-national (e.g., Intel)
  - Design and manufacturing sites (3 continents, 9 countries)
  - Marketing sites (5 continents, hundreds of countries)
- Business partnerships and markets are multi-national
  - Automotive
  - Textiles
  - Pharmaceuticals
  - Telecommunications
  - Entertainment
  - International standards are emerging
- Expertise is multi-national
  - Japan is a display technology center
  - The US is the microprocessor technology center
  - Korea is the memory technology center

International Relations

- Having good International relationships is a key success factor
  - Different cultures
  - Different customs
  - Different languages
  - Different time zones
  - Different expertise

Infrastructure

- Infrastructure is what holds all this together
- Interfaced and Integrated are two ends of a spectrum
- Infrastructure provides the glue:
  - Machines
  - Processes
  - Automation
  - Information
  - Equipment
  - People
  - Customers
  - Suppliers

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International Standards

- Manufacturing depends on standards
  - Software
  - Communications
  - Interfaces
  - Protocols
  - Terminology
  - Electrical
- International standards emerge from co-operative efforts
  - Committees
  - Joint ventures
  - Supplier-customer partnerships

IMS

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The Role of IMS

- Five international consortia
- Hundreds of involved companies
- Dozens of involved universities
- Dozens of involved countries
- Hundreds of involved disciplines
- Dozens of potential product areas
- Potentially, hundreds of international teams

All these focus on some aspect of the "I" words

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If not IMS or CIMS, then:

Who??????

Where????

How????

THE "I's" HAVE IT!

Intelligent Manufacturing Systems Partnership

The Intelligent Manufacturing Systems Partnership is real. It starts on April 27 with the first IMS International Steering Committee Meeting in Toronto, Canada.

What is IMS?

It is an industry-led partnership involving companies, government and academia.

IMS provides the framework for a world-wide set of alliances to conduct research and promote a technological and organizational agenda to meet the needs of a global manufacturing society.

Think of it as a facilitative vehicle to address a myriad of challenges facing globally competitive manufacturers.

How did IMS arise?

In late 1989 Japan approached some American companies and universities about participating in their IMS Program. The IMS almost the first attempt by Japan to internationalize its domestic R&D programs.

By February 1990, U.S. industry came to OSTP and DOC with concerns about IPR, funding, structure and targeting. If IMS was to be a truly international cooperative program, rather than a domestic Japanese program with a few targeted international participants, then its terms had to be changed in order for everyone to contribute and to benefit.

We began a process of intensive industry consultations and multilateral meetings that resulted in a 2 year feasibility study. Australia, Canada, EU, EFTA, Japan and the United States participated to configure a balanced international program.

- o unique because talks were industry-led to make sure IMS would be industrially relevant
- o three committees -- Steering, Technical, IPR
- o addressed a new subject; multilateral cooperation in a very commercially relevant technology
- o undertook six test cases; 143 participants
- o explored modes of cooperation/groundbreaking IPR

yoshida/4-20-95

The feasibility study ended in 1994 with the conclusion that IMS was possible under the new model. The Committees asked their governments to endorse -- U.S. has endorsed, as has everyone but the EU (expected). Also, regions worked on building their domestic support organizations.

DOC Role

DOC has been a convening and facilitating body at the request of industry and the White House Office of Science and Technology Policy.

Two officials from Commerce's Technology participated on the feasibility study negotiating teams. Commerce served as Secretariat to assist the teams.

Assistant Secretary Graham Mitchell will be observer on IMS International Steering Committee. Other members will be Bob Cattoi, former Senior VP of Rockwell, and John White, Dean of Engineering at Georgia Tech.

Commerce will continue as Secretariat -- supporting negotiators, disseminating and gathering information, outreach activities, counseling of potential participants, providing technical assessments, etc.

During the IMS Partnership, we will continue to work closely with the Coalition for Intelligent Manufacturing Systems (CIMS) and the Academic Coalition for Intelligent Manufacturing Systems (ACIMS), and with other interested in IMS.

yoshida/4-20-95

Agility Forum

Ray Patterson

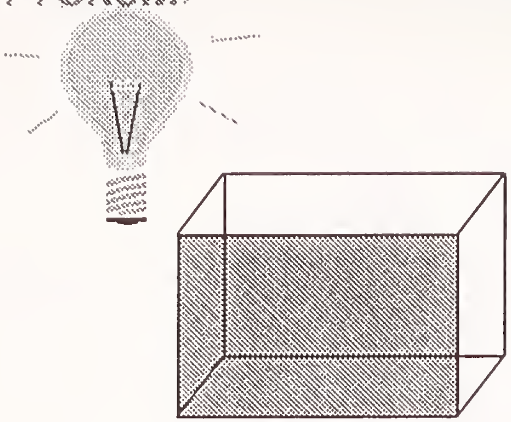
AGILITY FORUM

Agility 201

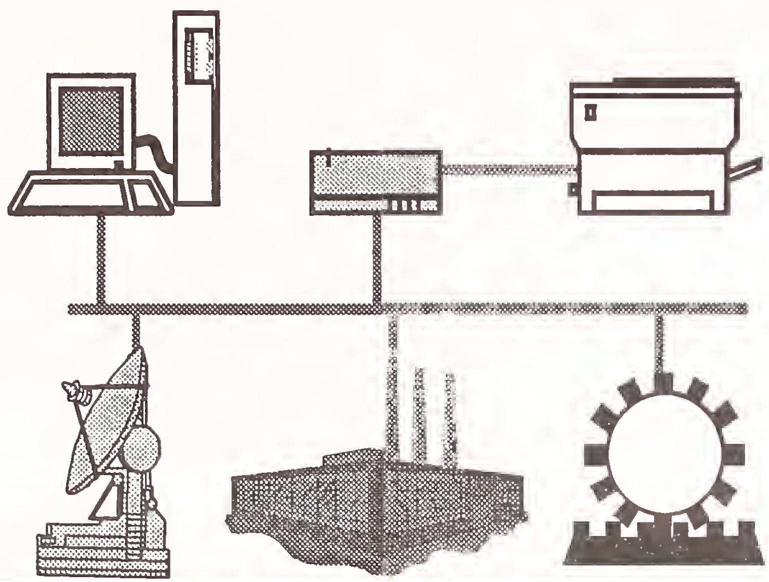
NIST Conference

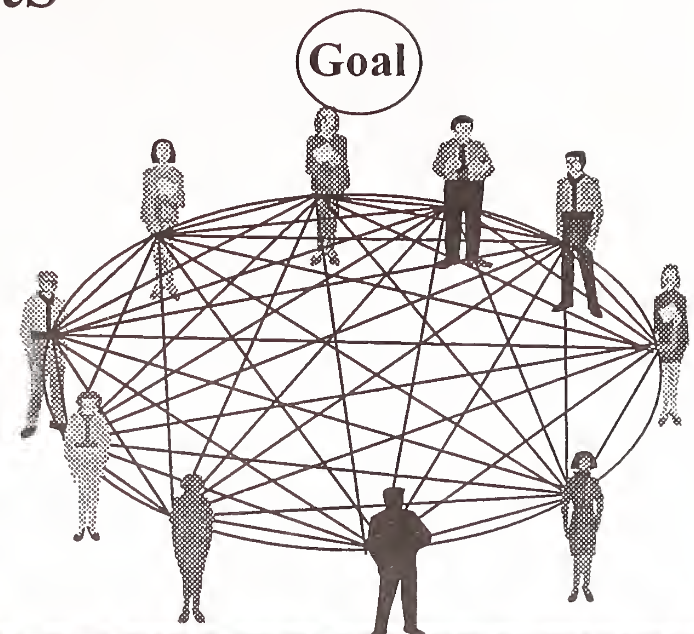
April 20, 1995

AGILITY FORUM

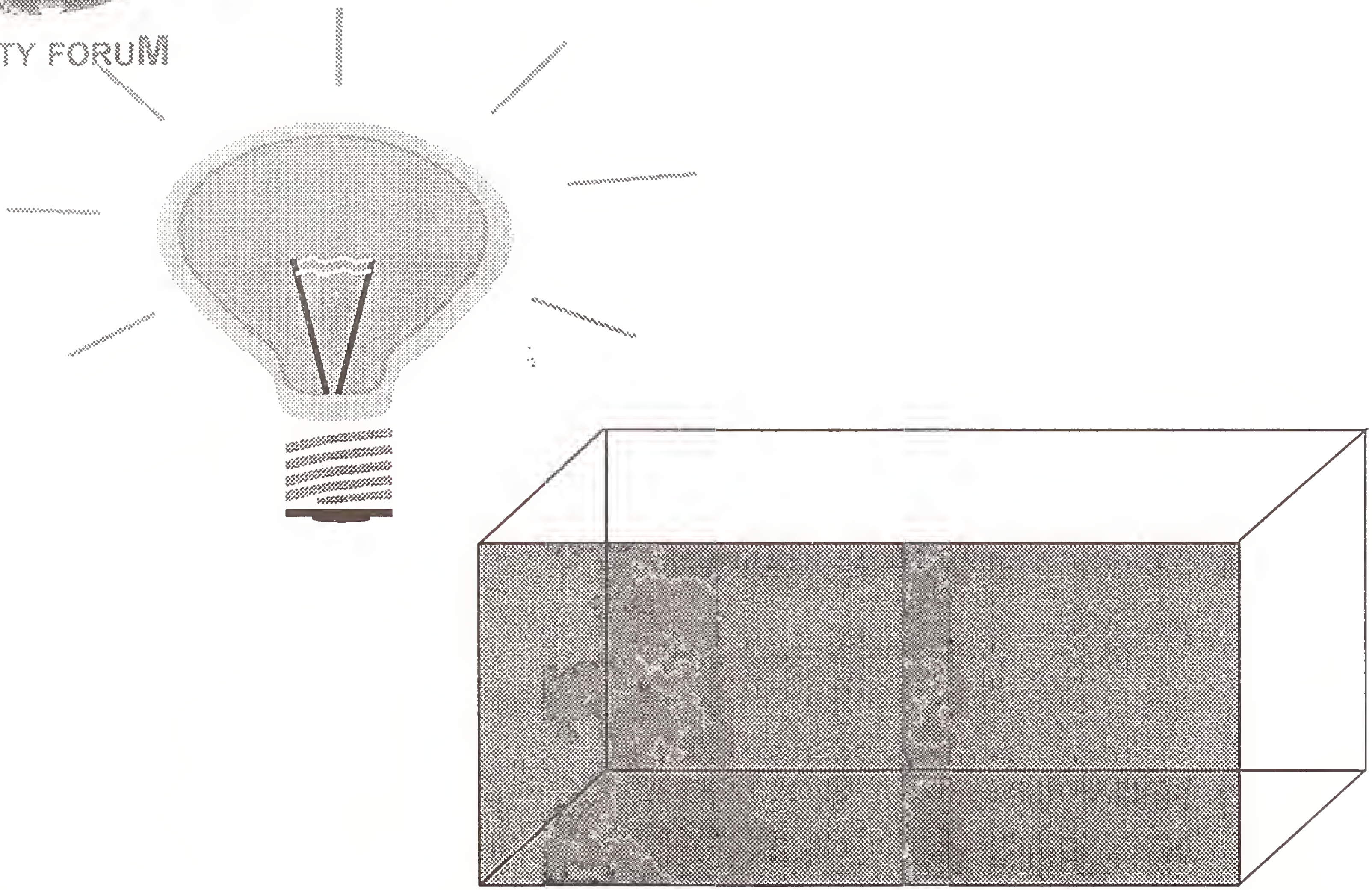


Basic Elements



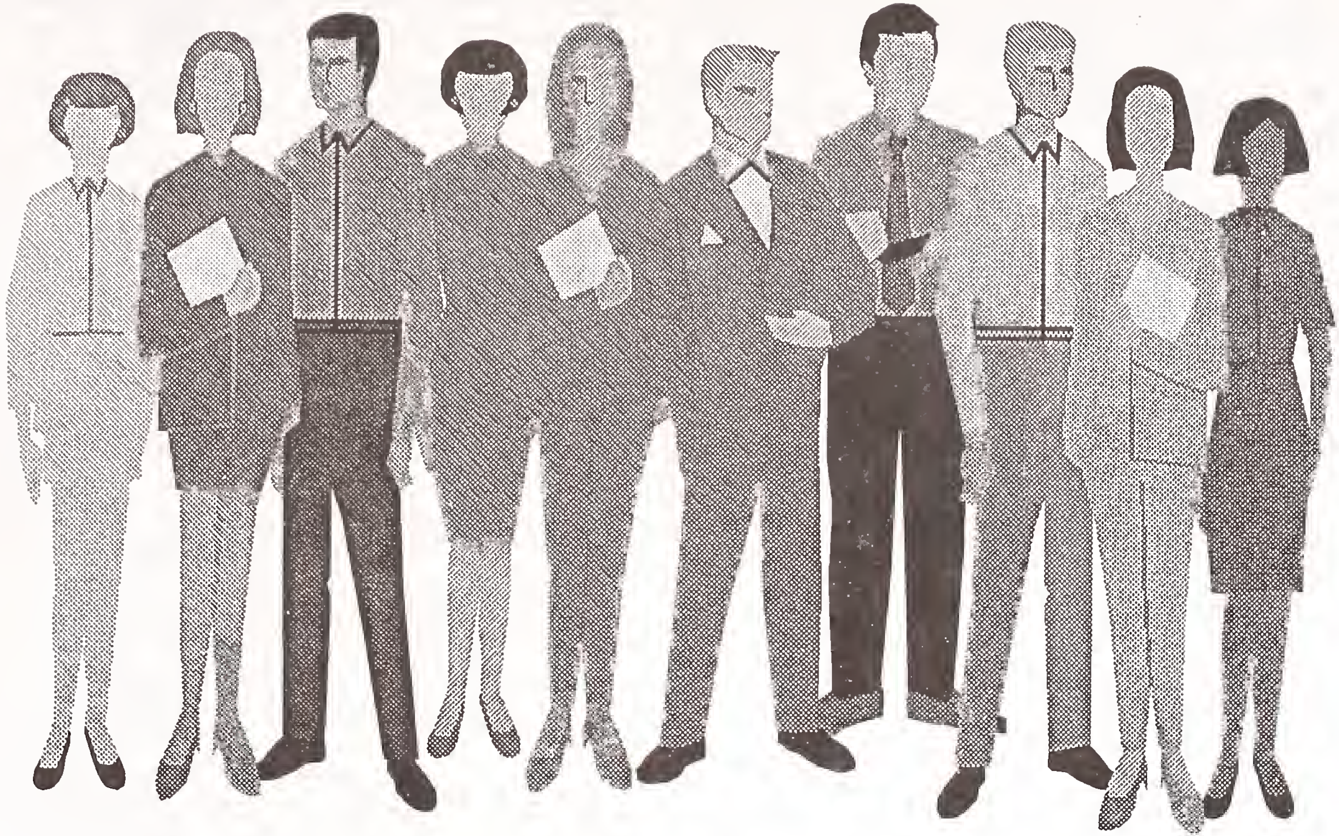


AGILITY FORUM



Creativity - "Thinking Outside of the Box"

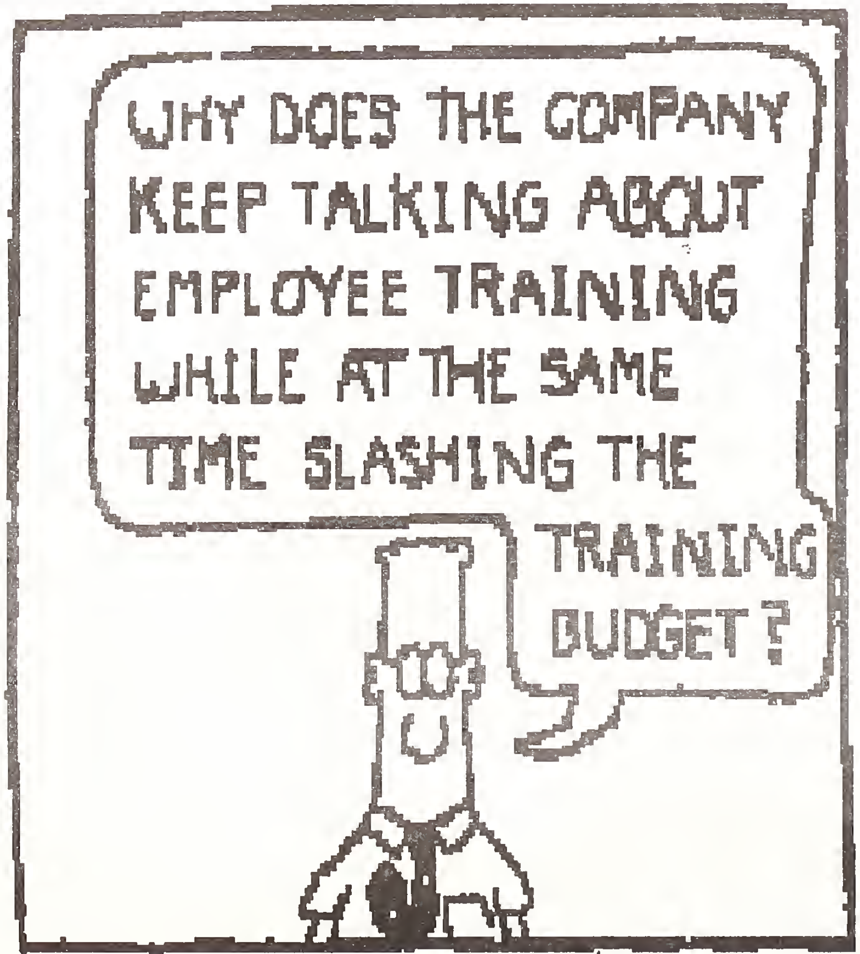
The Court Jester



Valued - Empowered Workforce

How much can I spend on improvements?

ENGRAINED HIERARCHICAL MANAGEMENT



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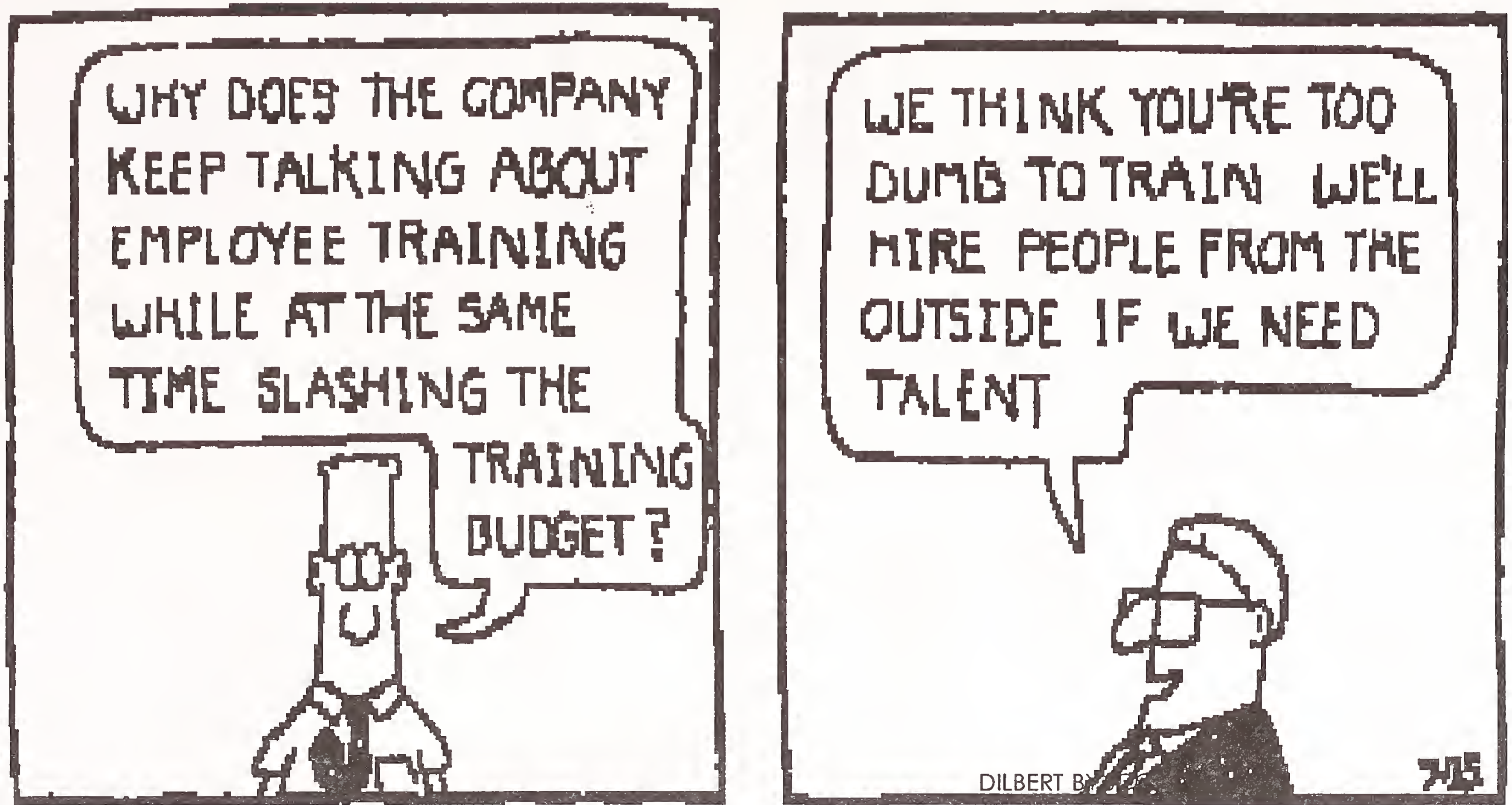
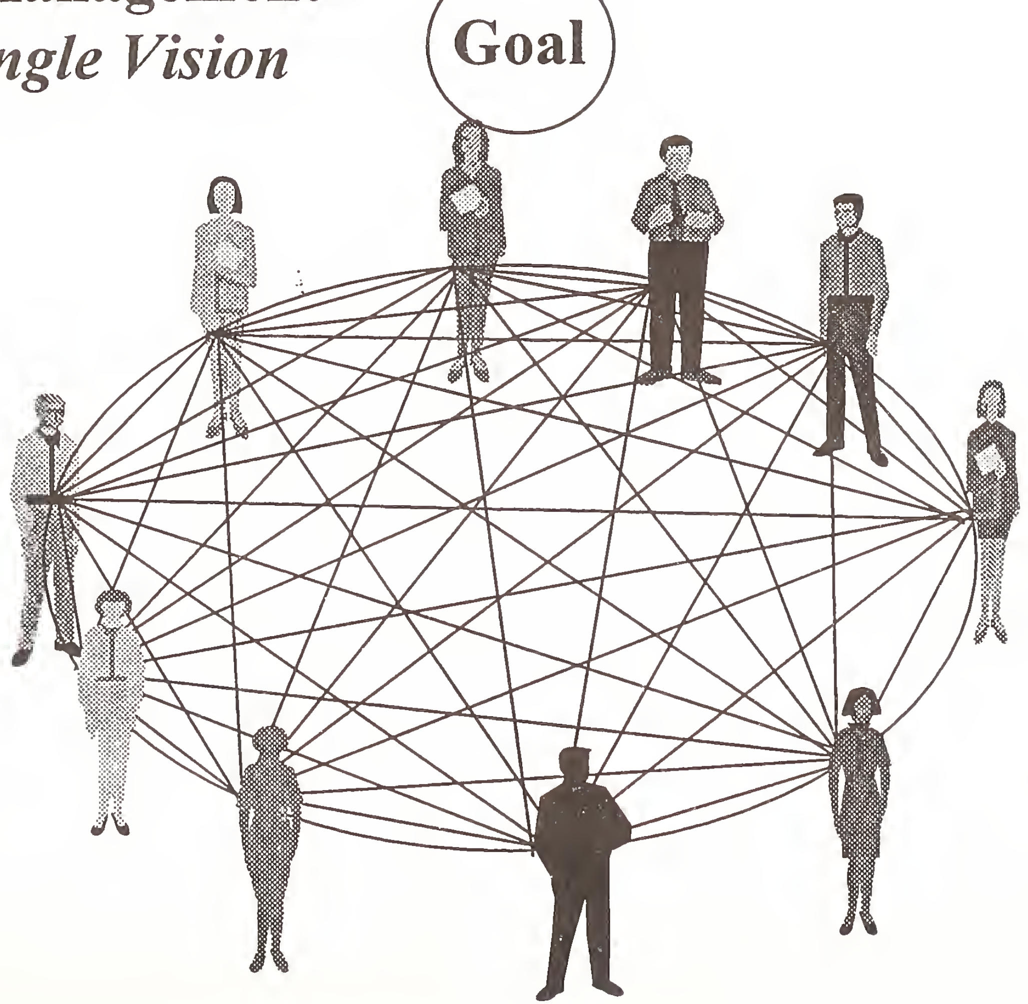
ENGRAINED HIERARCHICAL MANAGEMENT



AGILITY FORUM

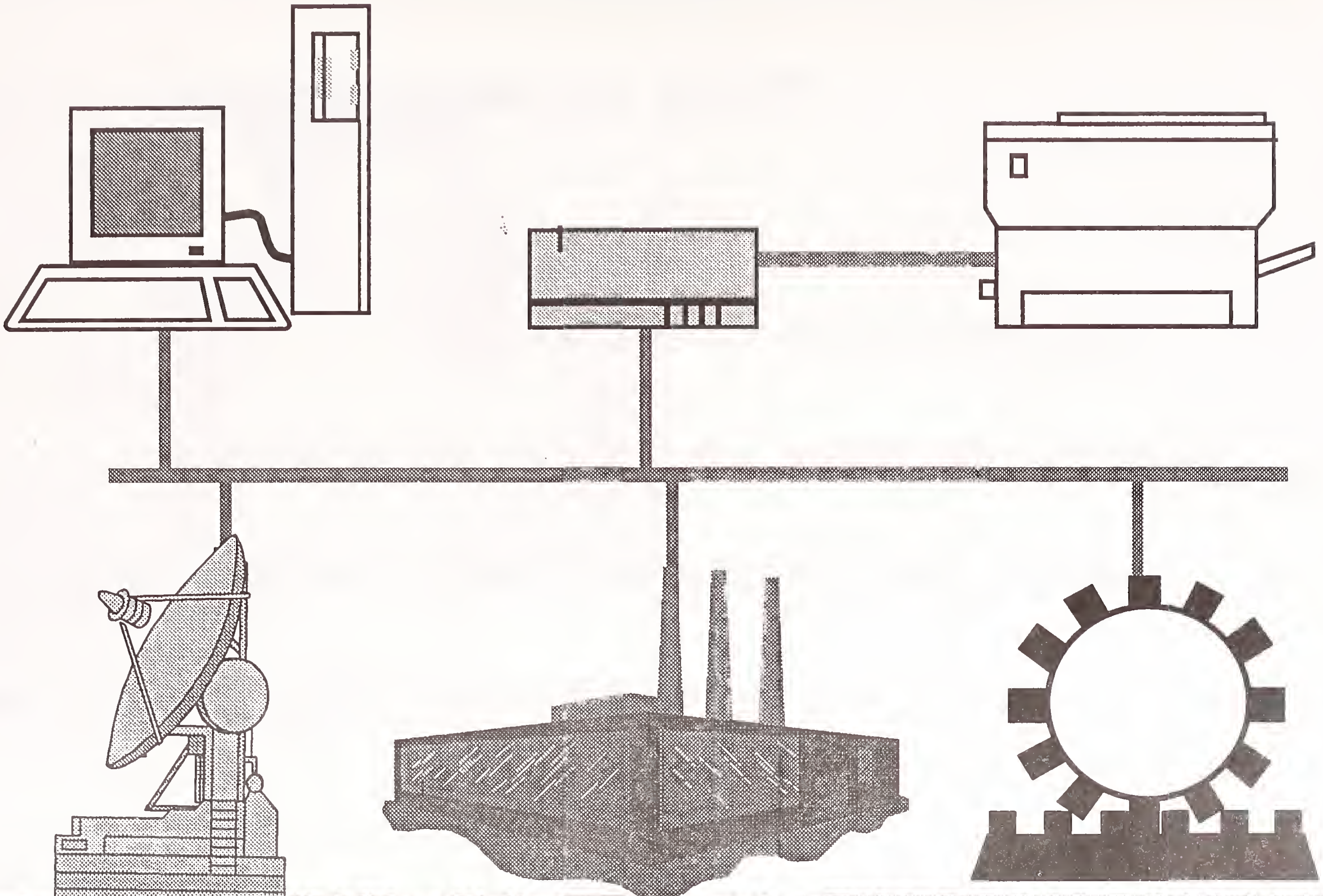
Concurrent Management

Focused - Single Vision



Freedom to Perform

Information Driving Technology
Management of the Marketspace



PROBLEM vs SOLUTION

We Assume People Recognize the Problem,

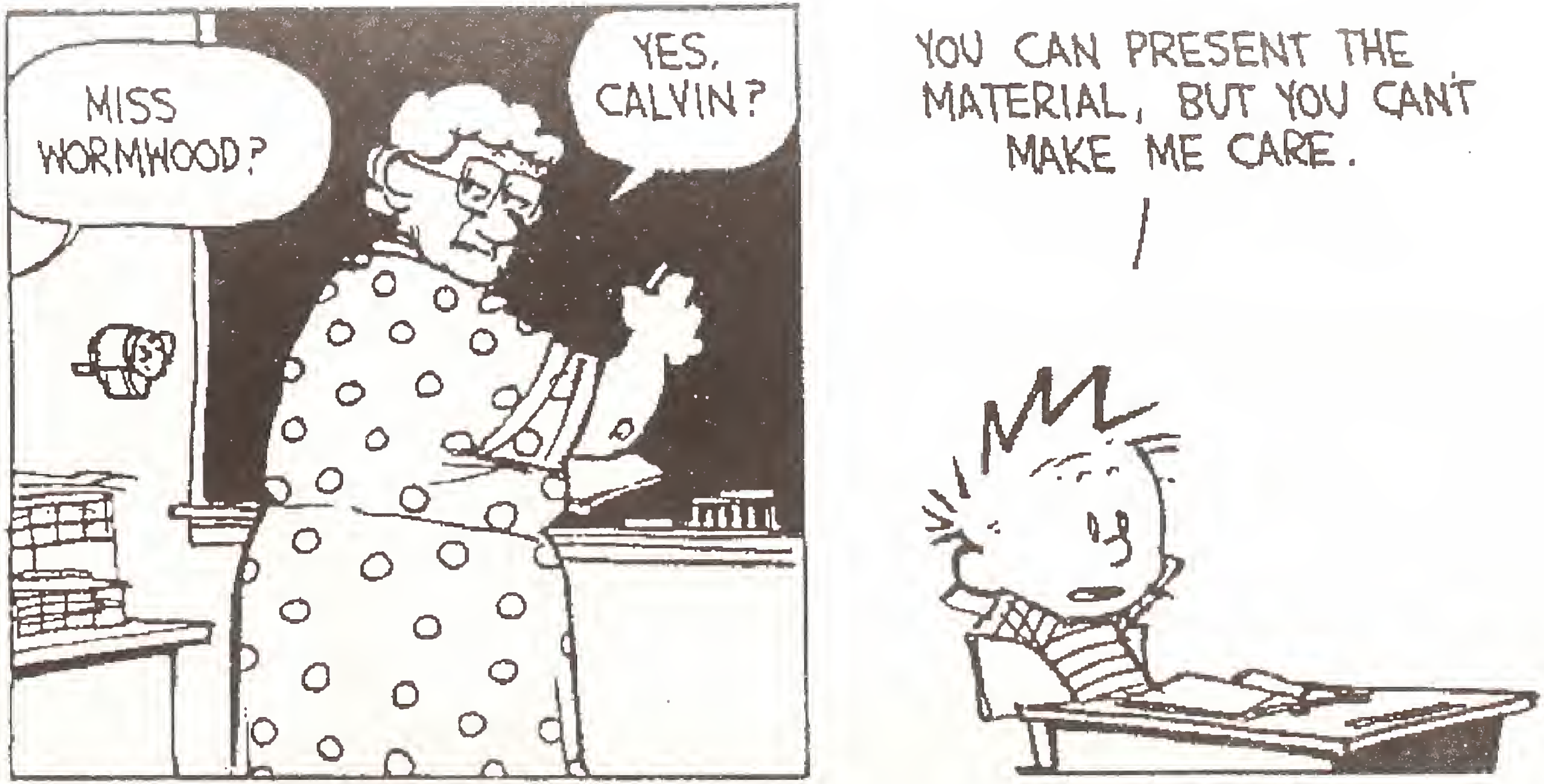
We Assume People Understand the Problem,

We Assume People will Value the Solution,

. . . So We Focus on the Solution.

We Are Wrong.

CALVIN AND HOBBES BY BILL WATERSON



CALVIN AND HOBBES BY BILL WATERSON

AGILITY FORUM

Strategic Principles

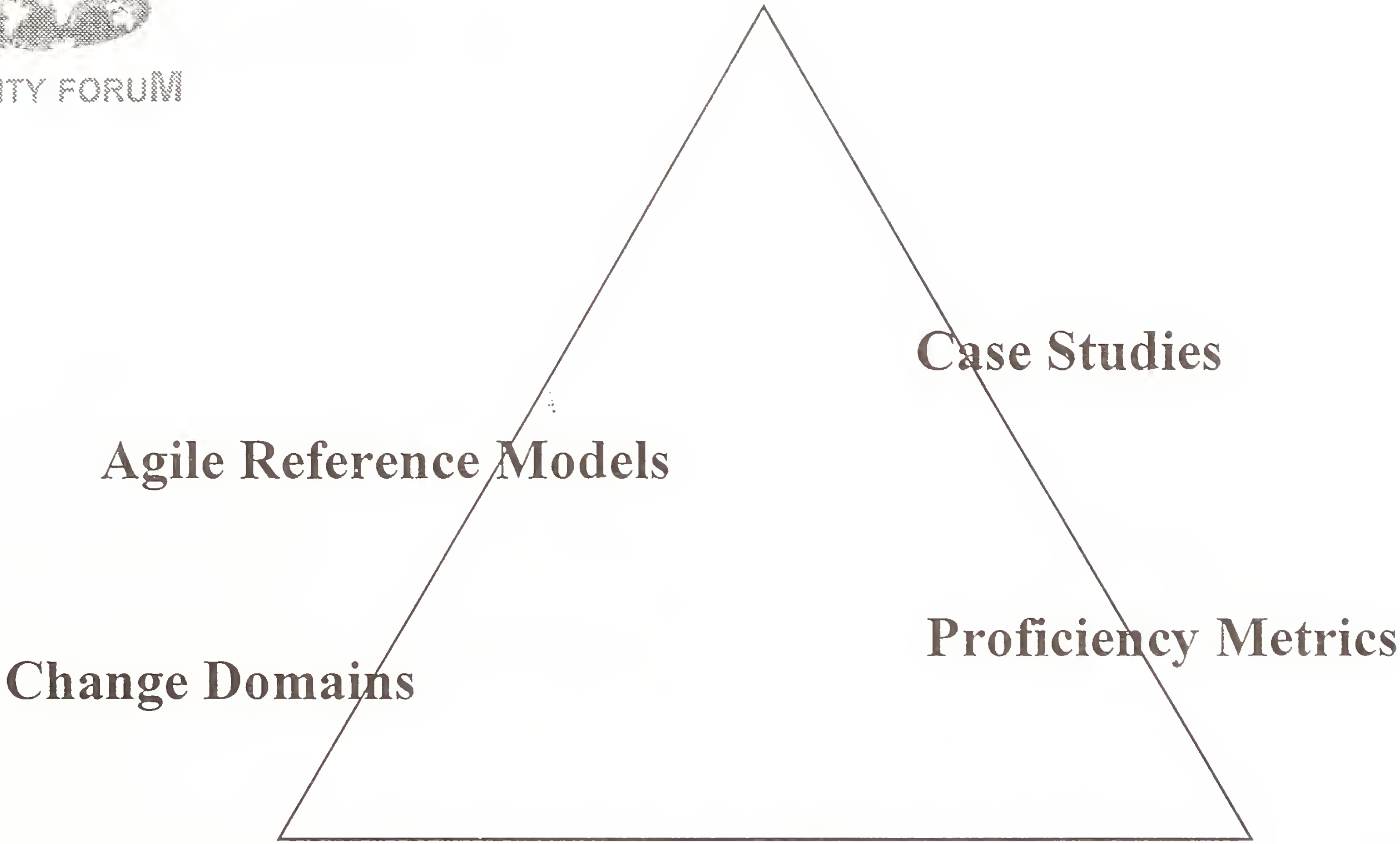
Enriching Customers
Solutions vs. Product

Proficient with Change
Entrepreneurial Organization

Cooperating to Compete
- Virtual Organization

Leveraging People
and Information

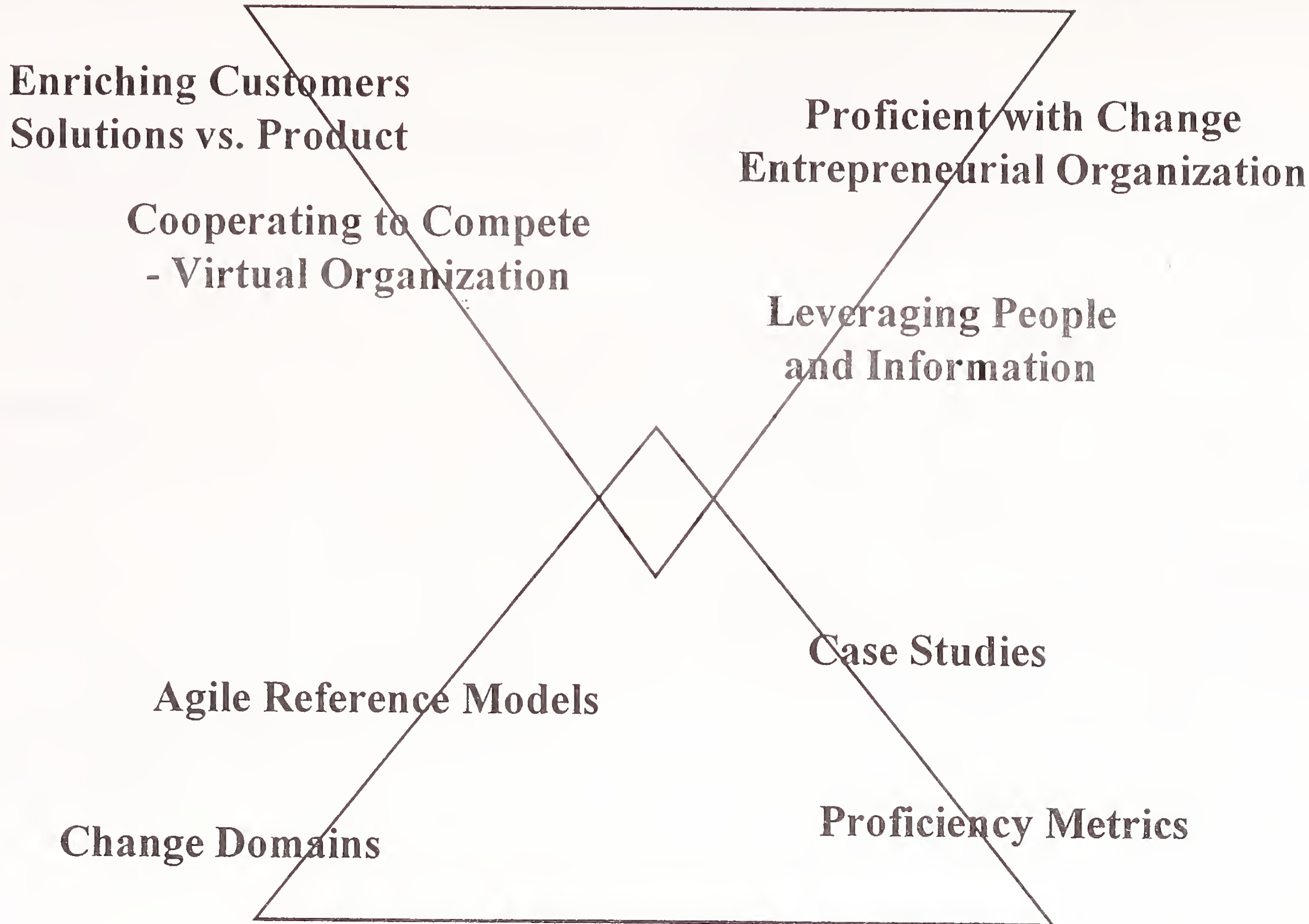
AGILITY FORUM



Implementation

AGILITY FORUM

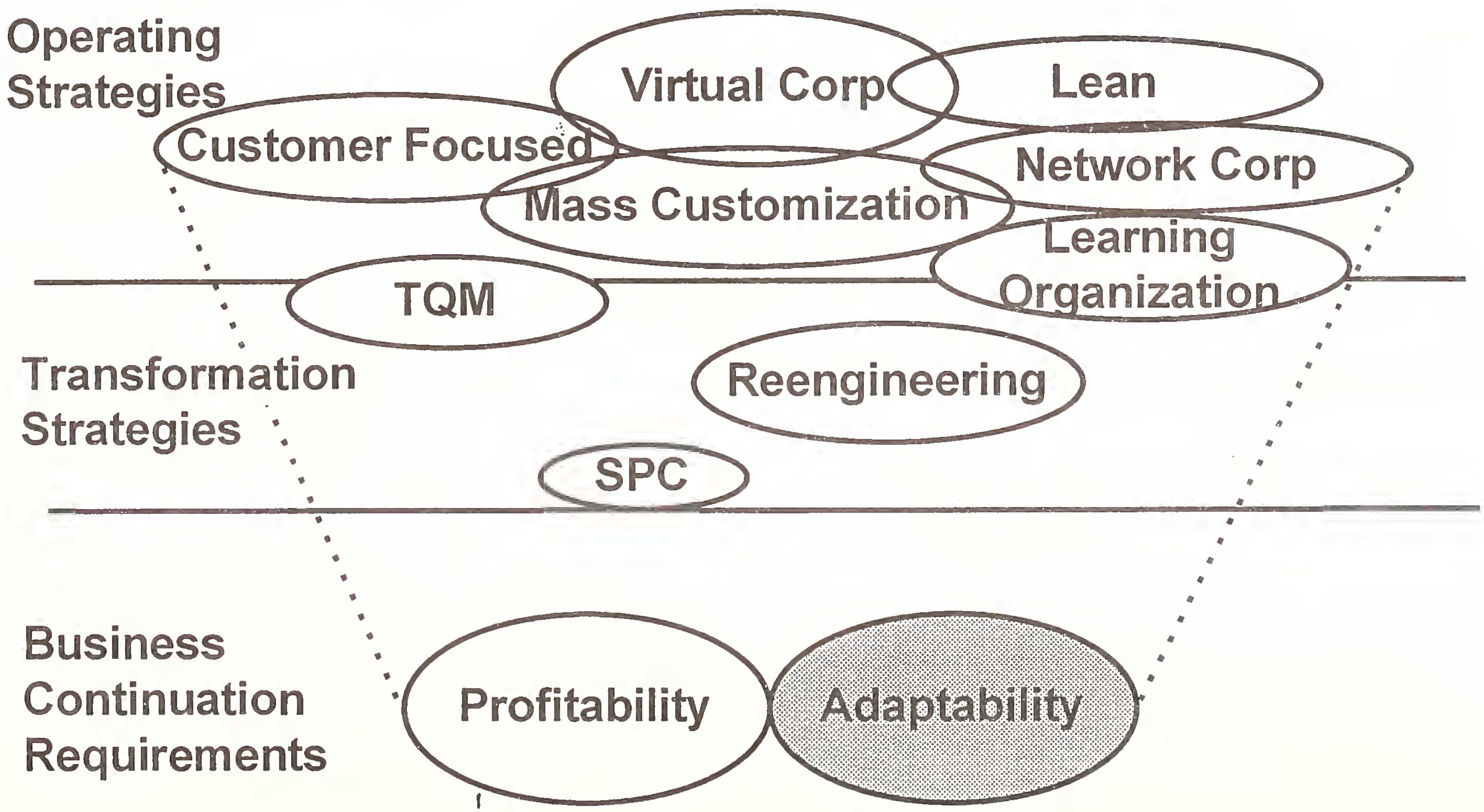
Strategic Principles



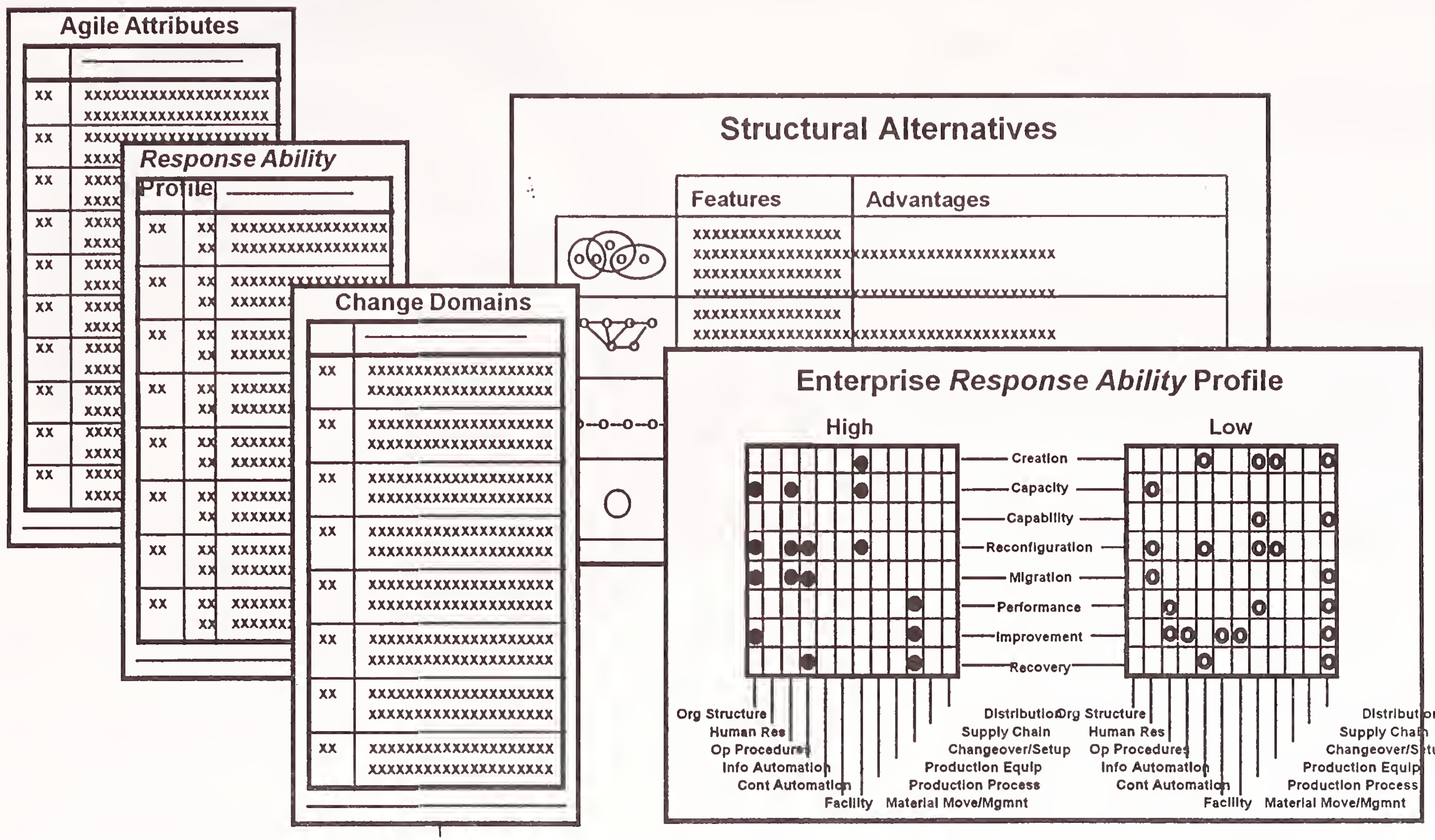
Implementation

Agility Forum

ADAPTABILITY IS THE OBJECTIVE

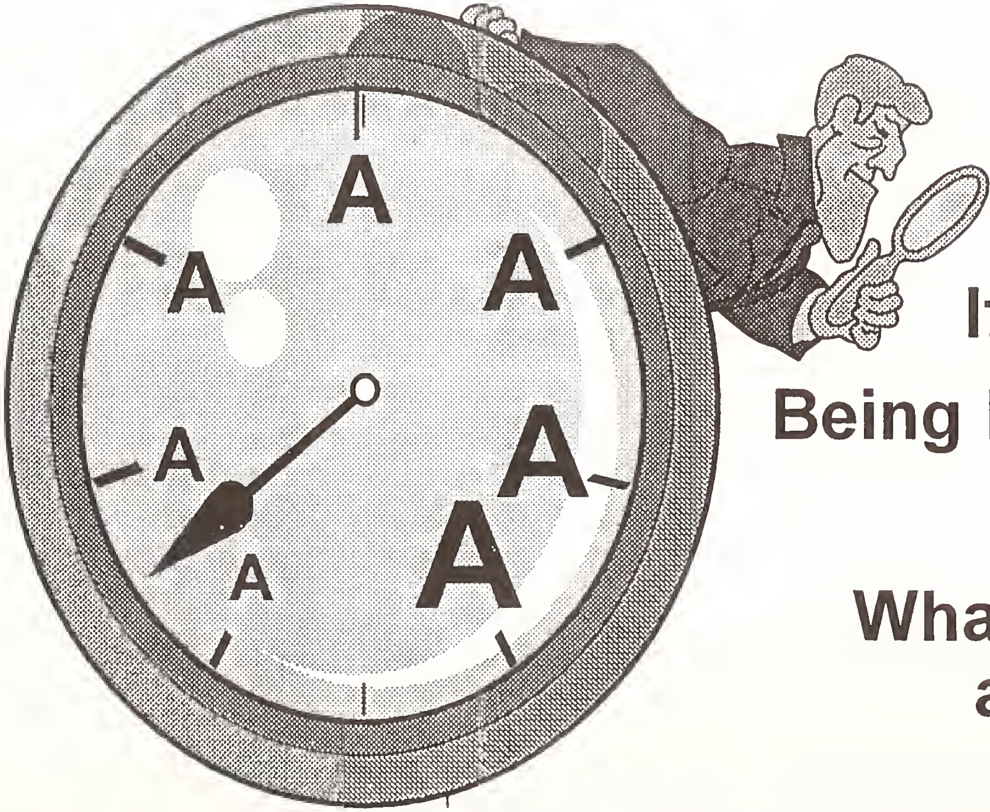


ANALYTICAL TOOLS



AGILITY FORUM

BUILDING THE AGILE METER



If Being Agile is Being Proficient at Change,

What Kinds of Change are of Interest?

AGILITY FORUM

AGILE MEANS PROFICIENCY IN 8 CHANGE DOMAINS

Change Domains:	Modes:
❑ Creation	Build New Capability.
❑ Capacity	Increase/Decrease Existing Capability.
❑ Capability	Add/Delete Unique Capability.
❑ Reconfiguration	Change Relationships Among Modules.
❑ Migration	Transformation of Basic Concepts.
❑ Performance	Real-Time Operating Surprise.
❑ Improvement	Continuous, Daily Incremental Upgrade.
❑ Recovery	Failure Corrections and Alternatives.

PRODUCTION PROCESS EXAMPLE

Change Domains:	Modes:
❑ Creation	Build New Production Capability.
❑ Capacity	Add More Production Capacity.
❑ Capability	Add Different Production Capability.
❑ Reconfiguration	Convert Existing Line for New Purpose.
❑ Migration	Convert to bid-based cellular scheduling.
❑ Performance	Setup/Changeover for Unscheduled Part.
❑ Improvement	Daily Control System Upgrades.
❑ Recovery	Return Broken Workstation to Service.

HUMAN RESOURCES EXAMPLE

Change Domains:	Modes:
❑ Creation	Hire all new people for a new facility.
❑ Capacity	Increase/decrease employee head count.
❑ Capability	Add people with new and different skills.
❑ Reconfiguration	Merge two departments into one.
❑ Migration	Institute on-the-job continuous learning.
❑ Performance	Deal with a strike.
❑ Improvement	Institute a new reward system.
❑ Recovery	Return to EEOC compliance.

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THRIVING ON CHANGE

(Resource Management) FEATURE (Proficiency at:)	ADVANTAGE	BENEFIT
Creation Capability Change	Proactive	<u>Leadership</u> (Innovation Management)
Improvement Migration	Progressive	
Capacity Change Reconfiguration	Reactive	<u>Viability</u> (Opportunity Management)
Performance Change Recovery	Resilient	

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PROFICIENCY?

If We Can Change Instantly,

are We Agile . . .

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PROFICIENCY?

If We Can Change Instantly,

are We Agile . . .

If It Costs $1 Billion to Accomplish the Change?

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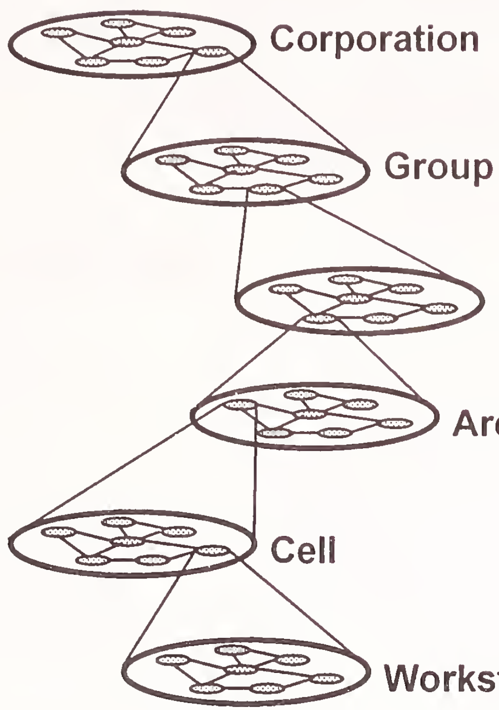
APPLYING CHANGE-PROFICIENCY METRICS

At All Levels - In All Change Domains



<u>Cost of Change:</u>

- ☐ Cost to Completion.

<u>Time to Change:</u>

- ☐ Time to Completion.

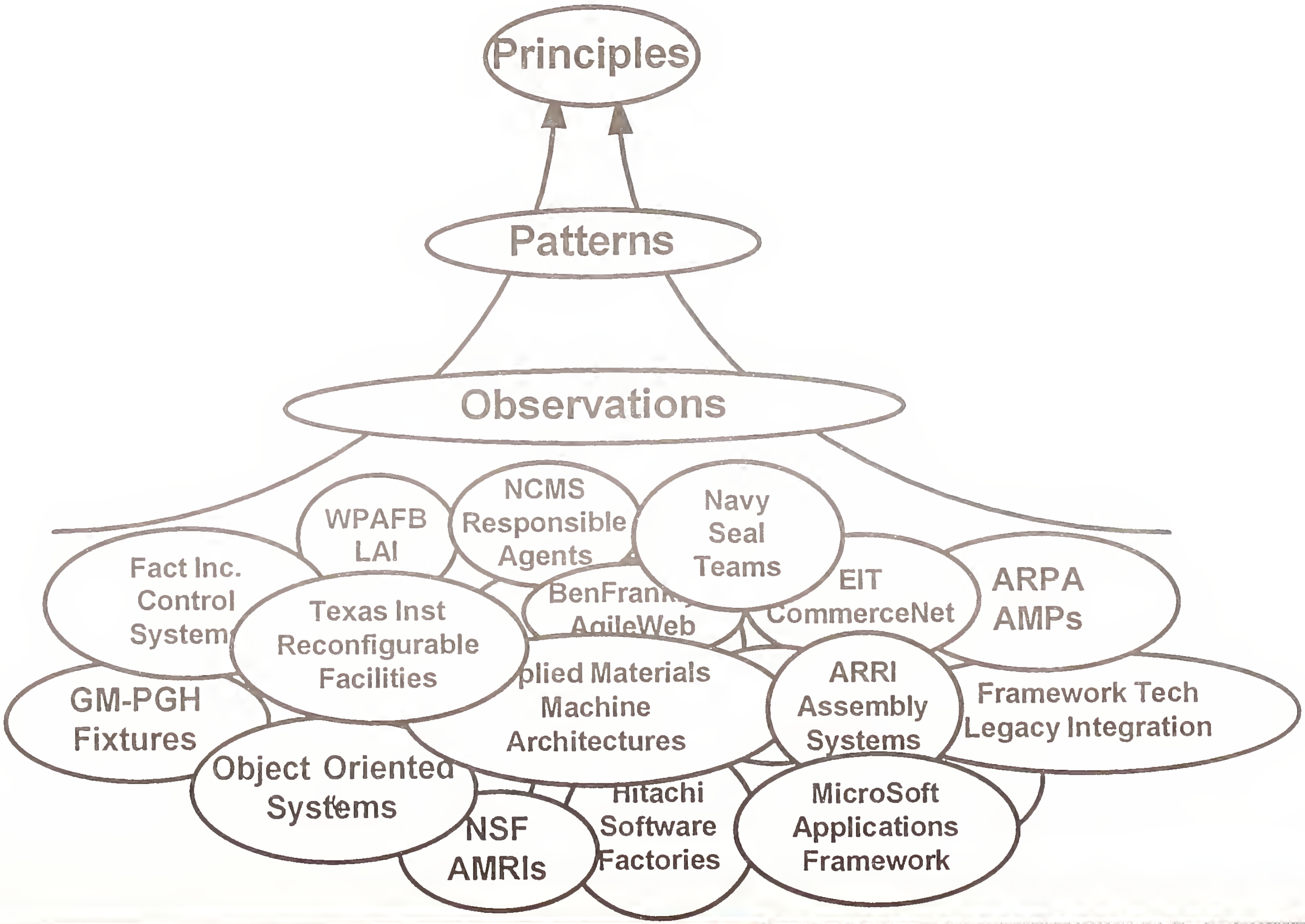
<u>Robustness of Change:</u>

- ☐ Post-Change Functional Quality.
- ☐ Post-Change Scrap/Rework.

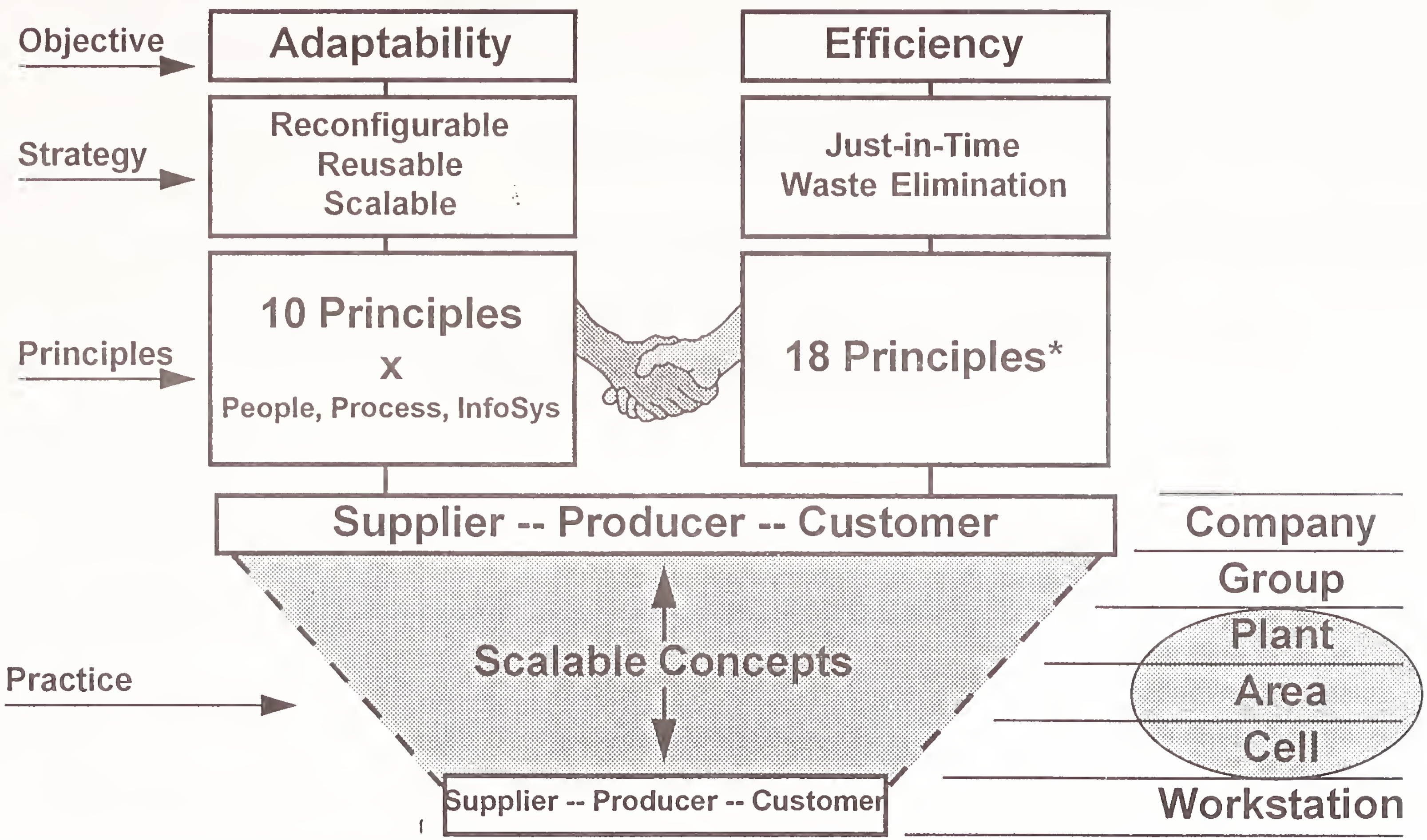
<u>Scope of Change:</u>

- ☐ Completion Predictability.
- ☐ Lost Opportunity Count.
- ☐ Market Innovation Count.

LOOKING FOR AGILE PRINCIPLES



AGILE and LEAN



*Implementation at American Auto Company

BEST AGILE PRACTICE REFERENCE BASE - 1994

CHALLENGE MODELS

AND

BENCHMARKS

DEFINITIONS

Reference Base:

A data base of Agile practice cases,.

Reference Model:

A comprehensive set of categories and subcategories for an area of business that designates the key Agility issues.

Case-Framework:

Similar to a reference model but not necessarily comprehensive.

Case:

An example of a real industrial practice that is qualified as having some noteworthy proficiency at change.

AGILITY FORUM

Best Agile Practice Reference Model

OBJECTIVES

Promote an Emergent Picture of Agility.

Repository of Implementation Examples.

Identify Gaps that Need to be Addressed.

Observe Patterns and Discover Principles.

Define & Refine a Benchmarking Procedure.

Eventually

Develop Self Administered Benchmarking Procedure.

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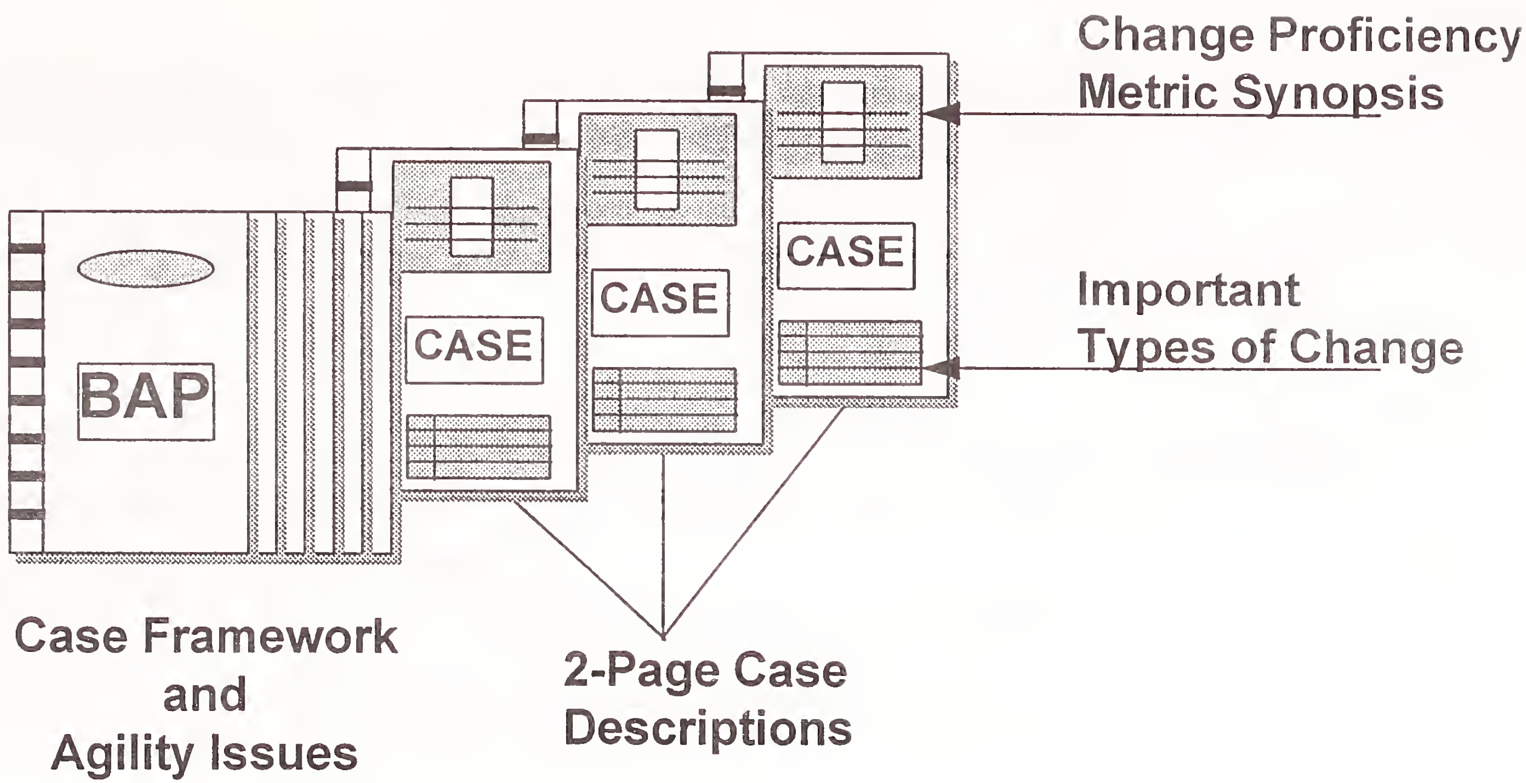
FORMAT of EACH REFERENCE MODEL



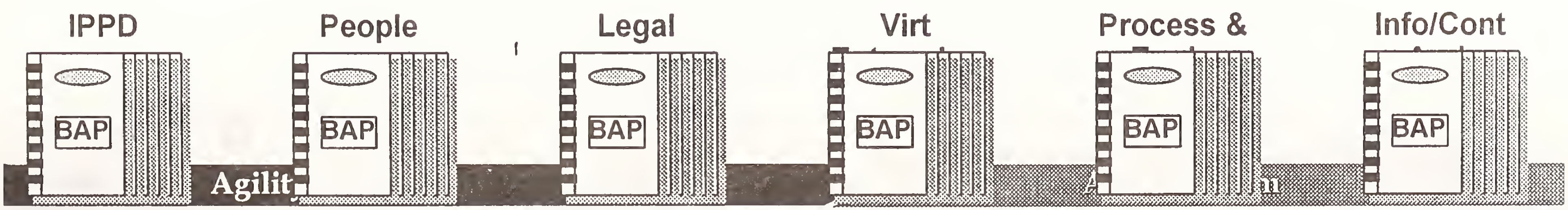
AGILITY FORUM

BEST AGILE PRACTICE
1994 Reference Base

- ❑ Data Base of Agile-Practice Case Examples.
- ❑ 2-Page Standard-Format Executive Summary.
- ❑ Electronically Accessible.
- ❑ Case-Search Prioritized by Industry Focus Groups.
- ❑ Case-Qualification Established by Industry Focus Groups.

<u>Phase 1: 1994</u>
In-Practice Cases Only
Test of Procedures
Challenge Models
March 95 Publication

<u>Phase 2: 1995+</u>
Include Lab and Research
Professional Mgmnt
Self Administration Kit
Continuous Publication



1994/95 REFERENCE MODELS

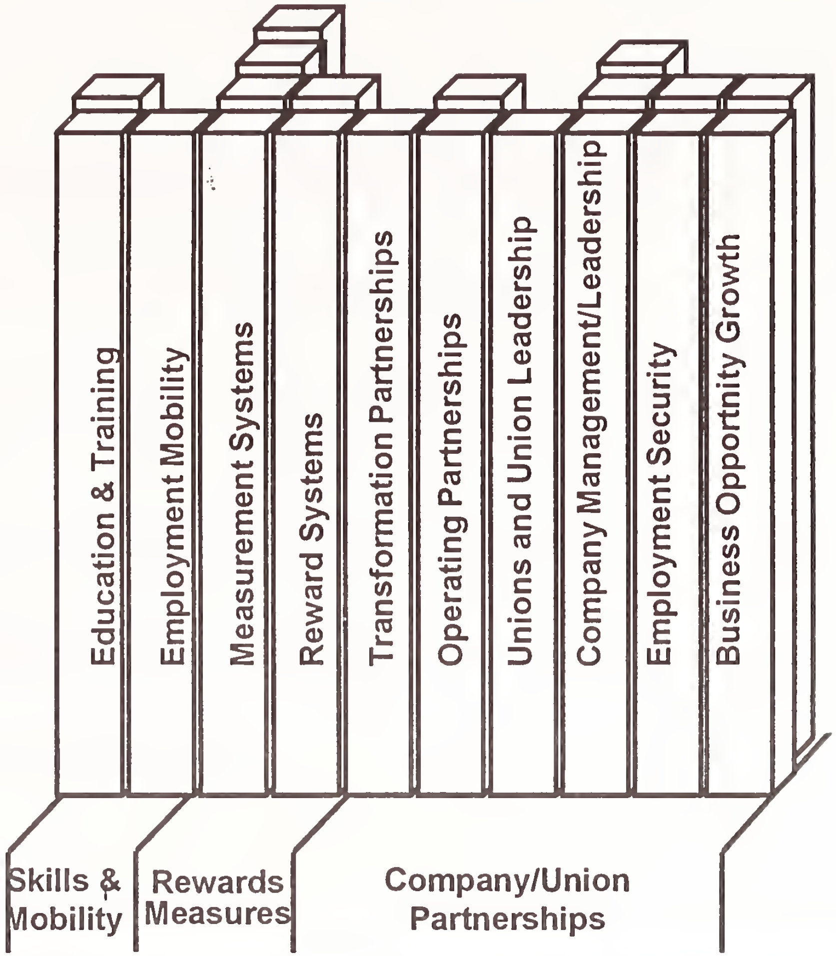
- ❑ Agile People Systems
- ❑ Agile Virtual Enterprise
- ❑ Agile Process & Equipment
- ❑ Agile Business Practices - IPPD
- ❑ Agile Information & Control Systems
- ❑ Agile Working Agreements - Barriers

FRAMEWORK/MODULE EXAMPLES 1/4

Element	Production Equip.	Facility	Organization
System	Modular Fixtures	Plant	X-Functional Teams
Case	Watervleit	Texas Instruments	Xerox
Modules	Clamps/Components	Workstations	Multi-Skilled Workers
Framework	Fixture Base Plate	Physical Facility	Labor Contract

AGILE PEOPLE SYSTEMS

1994 BAP Reference Model



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Agile People Skills

Two Types of Individual Skills:

- Basic
- Performance

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Individual Skills: Basic

1. Communicating Ideas
2. Literacy/Numeracy
3. Mastering Technology
4. Analyzing & Synthesizing Information
5. Negotiation

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Individual Skills: Performance

I. Experimentation
II. Systems Thinking
III. Analyzing Plans
IV. Problem Solving
V. Synthesizing Plans
VI. Pattern Thinking
VII. Reflective Thinking
VIII. Decision Making

Inter- and Intra-Group Skills

- Individual & Group Accountability (Integrity)
- Positive Interdependence (Responsibility)
- Promotive Interaction (Altruism, Adaptability)
- Individual & Group Processing (Introspection)
- Leadership (Creativity, Imagination)
- Communication (Curiosity, Flexibility)
- Trust (Diversity, Integrity)
- Conflict Management (Tolerance, Flexibility)

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IPPD Implementation

IPPD	PERFORMANCE SKILL	BASIC SKILL
Requirements Definition	I. Experimentation	1, 3, 4
	II. Systems Thinking	2, 3
Detail Design	III. Analyzing Plans	4
	IV. Problem Solving	1, 5
Integration, Test and Validation	V. Synthesizing Plans	1, 4
- Hardware/ Software	II. Systems Thinking	2, 3
- Simulation & Prototyping	I. Experimentation	1, 3, 4

IPPD Implementation (Continued)

IPPD	PERFORMANCE SKILL		BASIC SKILL
Production	VI.	Pattern Thinking	1, 4
Readiness	V.	Synthesizing Plans	1, 4
	IV.	Problem Solving	1, 5
Found in All	VII.	Reflective Thinking	4
	VIII.	Decision Making	1, 4, 5

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Frequency Chart

	Performance Skill	Frequency
I.	Experimentation	2
II.	Systems Thinking	2
III.	Analyzing Plans	1
IV.	Problem Solving	2
V.	Synthesizing Plans	2
VI.	Pattern Thinking	1
VII.	Reflective Thinking	5
VIII.	Decision Making	5

Frequency Chart

Basic Skill		Frequency
1.	Communicating Ideas	8
2.	Literacy/Numeracy	2
3.	Mastering Technology	4
4.	Analysis/Synthesis	8
5.	Negotiation	3

Benchmarking Agility Attempts to

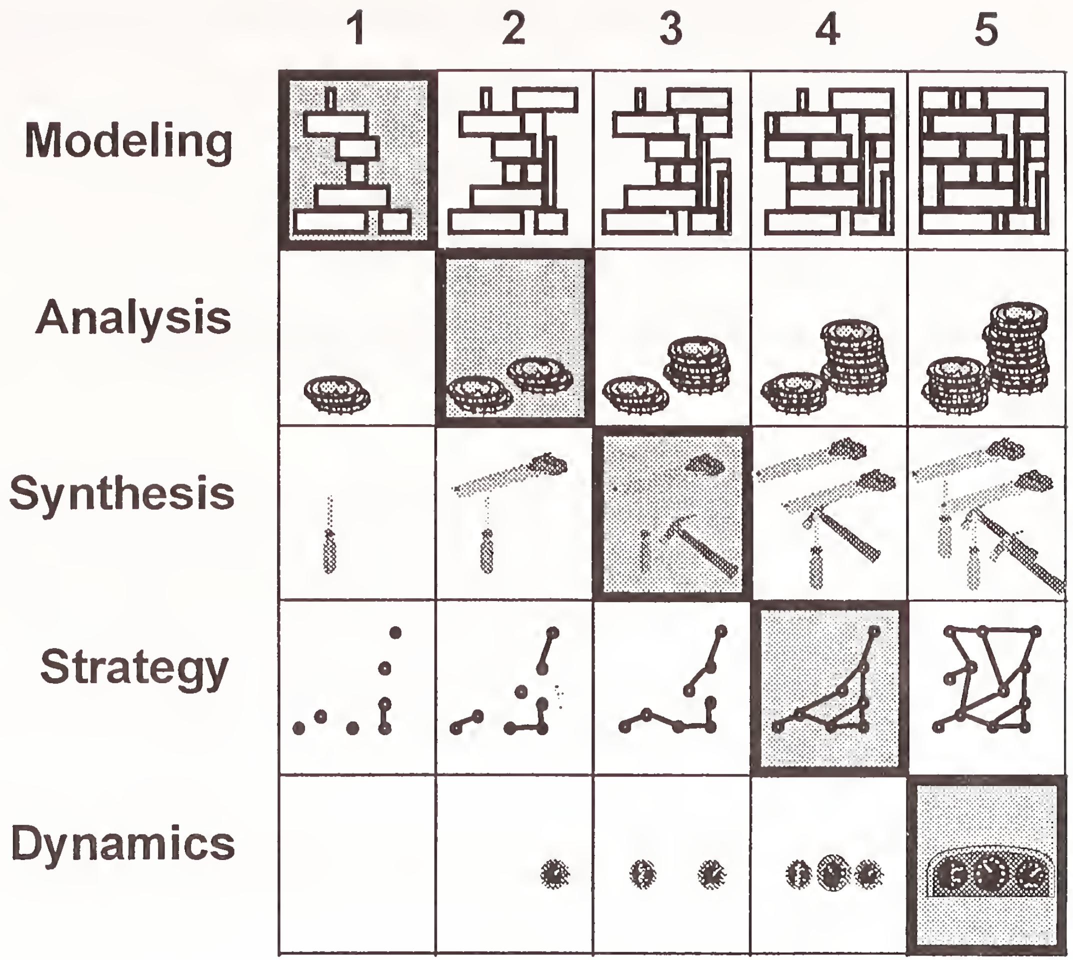
Capture <u>Potential</u> to Respond,

as well as

Demonstrable and Measurable Response History.

ROADMAP FOR PROGRESS

Progressive Emphasis



AGILITY FORUM

1994 RESULTS

- First Agile Benchmarking Process in Validation Mode.
- 80+ Cases from Industry in Reference Base.
- Legal Barrier-Model Defined.
- Agile Virtual Enterprise Reference Model Defined.
- 12 Domain Experts Created in the Process.
- 150+ Focus Group Participants Involved in the Definitional, Investigatory, and Qualifying Activity.

1995 PLANS

- Analyze and Refine Information About Initial 80+ Cases.
- Refine Group Benchmarking Procedure into a Standard Tool.
- Add More Cases with Continued Site Investigations.
- Create Self Administered Benchmarking Procedure.

AGILITY FORUM

Primary Functions

OUTREACH

DISSEMINATION

KNOWLEDGE GENERATION

OUTREACH

Industry Relations	Annual Conference
Public Relations	Regional Meetings
Industry Support	Agility Days

Education & Training

DISSEMINATION

Print -- Agility Reports

Perspectives on Agility

Journal of Agility

Electronic -- AgileNet

Communication

Databases

AGILITY FORUM

KNOWLEDGE GENERATION

SAWG

Federally-Funded Initiatives

Forum Initiatives

Industry Initiatives

FORUM INITIATIVES

Focus Groups	Deployment Groups	Development Groups	Agile Research Contracts
• Operations	• Accounting	• Enterprise Performance Metrics	• FEMA
• People	• Information & Control Systems	• Virtual Enterprise	• Sandia
• Business Practices	• IPPD	• Marketing	• AgileWeb
	• Supply-Chain-Small Business	• Legal	• LFM

FEDERALLY-FUNDED INITIATIVES

AMRIs

- UIUC
  Machine Tools
- Rensselaer
  Electronics
- UTA
  Aerospace

AMEF

EINET

AMPs

- GE
  Castings
- Lockheed
  AIMS

PATHFINDERS

- Automotive
- Aerospace
- Textile/Apparel
- Electronic Commerce

ETDDS & ABPs

- ATT
- Metron
- TRACOR
- CTA
- Phillips Labs
- IAI
- Martin Marietta
- Raytheon
- Ford - SCRA
- TASC
- AIAG
- WTI
- University Patents
- ITI
- Sirius-Beta
- CAM-I
- EDI Integration Group
- Ontek

Appendix A: White Papers

Advanced Manufacturing Systems

White Paper Draft 1/13/95

1 Background

The term "manufacturing systems" defines the collection of information, procedures and processes, physical equipment, business practices, culture and organization, and a skilled workforce needed to transform raw materials and purchased components into value-added products that satisfy customer needs. Although this broad definition normally refers to manufacturing enterprises or groups of companies, smaller collections of people, machines and information within individual firms that work together to produce intermediate parts or assemblies are also often referred to as manufacturing systems or subsystems. For example, the coupling of computer aided design techniques with automated methods for programming computer controlled machine tools to produce highly automated systems for production of machined parts is commonly referred to as a computer integrated manufacturing system. Other examples include enterprises, systems and subsystems of people and automated equipment to manufacture such diverse products as chemicals, metals, electronic devices, textiles and apparel, and processed foods and fibers.

Because of the large diversity in types, components and business practices, contemporary manufacturing systems are probably best characterized as parochial, with very little consensus among suppliers, users and researchers as to the most appropriate system for a particular application. Furthermore, most leading manufacturing systems and subsystems in use today are more like islands of automation rather than tightly coupled, monolithic operations. Effectively interfacing these islands, or legacy systems, into integrated systems and enterprises is still largely an unmet challenge in American industry or elsewhere in the world.

Only in relatively recent times have manufacturing systems become highly automated machines and information technology-based. Most successful system solutions in industry involve first understanding the people/organization interaction, then implementing a technology solution.

There is general agreement that manufacturing systems will play an important, if not the most important, role in increasing the effectiveness of manufacturing enterprises in the future.

1.1 Contemporary Scope

The purpose of the manufacturing enterprise is to produce the right product quantity, at the right time, that is cost competitive and of the right quality to meet customer expectations. The enablers are the right people skills and culture, right physical equipment and processes, right information at the right time to the right people/equipment to make informed decisions, and the right business practices. Given customer needs, a manufacturing enterprise uses knowledge and skill to transform raw materials and purchased components into value-added products. The following figure illustrates this overall process.

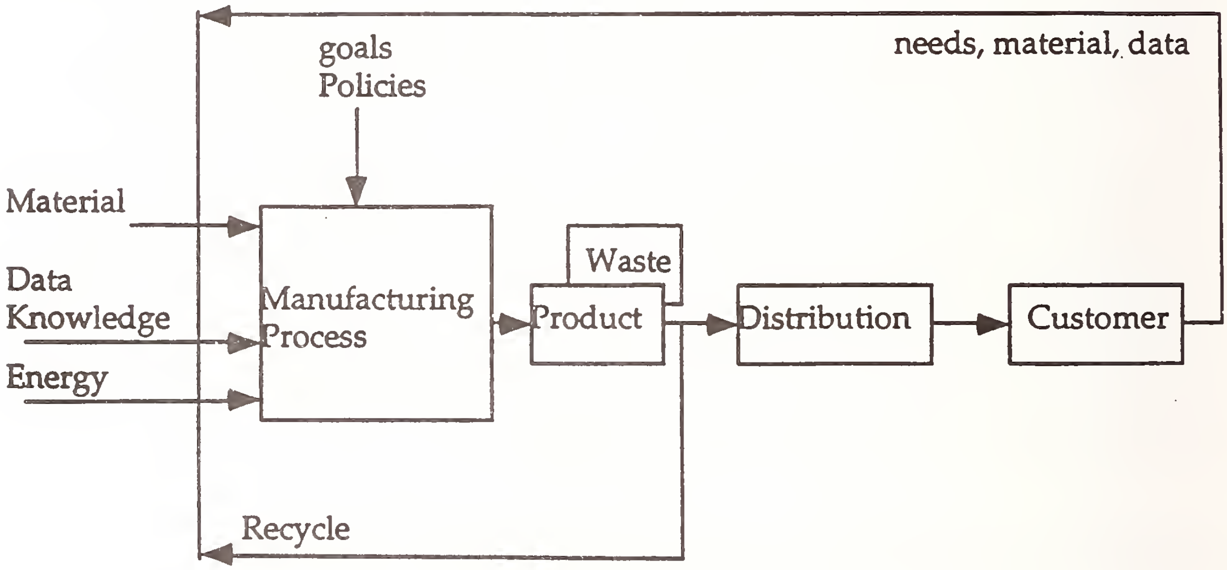


Figure 1. Total Process

In general a manufacturing enterprise is characterized by quality, quantity and time, and cost. Quality deals with customer expectations which are realized by various tools and methodologies. Cost competitiveness deals with issues such as productivity, process yield, and equipment modernization. Delivery of appropriate quantities of product at the right time deals with scheduling and integration. These attributes are enabled by people, physical assets, information and the business picture. The people issues deal with skills, cultural setting and organization. The physical assets deal with equipment and processes such as designing, producing, and distributing. Information deals with its collection, use and distribution.

1.2 Major Issues and Opportunities

The fundamental issue in advanced manufacturing systems is the integration of technology, people and business. This integration issue cuts across all aspects of this report. How do we integrate engineering tools for design and manufacturing (panel 2), advanced manufacturing processes and equipment (panel 3), a skilled workforce (panel 4), business practices and metrics as well as business information systems, transcended by effective deployment (panel 5) to achieve a unified, meaningful whole?

There are many factors to consider. The U.S. is no longer competitive on most low cost, mass produced items. Software and Engineering, our value-added strengths, are now being competed globally. Information costs are growing. We lag in technicians and skilled factory workers. In fact, education and training is now a competitive weapon.

Some of these problems will be solved by technology. The need for flexibility via reconfigurable systems is causing software costs to exceed computer hardware costs. The high logistics and maintenance costs (greater than the material costs) are forcing equipment to become easier to use. Time is perhaps the single greatest factor. In many cases, timely market access is more important than relatively lower development costs. Direct labor costs continue to be a smaller and smaller share of the total development and production cost. Environmentally conscious issues are becoming very important. Empowered/enabled work teams are needed to address the needs of the new breed of sophisticated, knowledgeable customers. Process reengineering is paving the way toward lean, efficient operations.

It is clear that technology, by itself, is not the total solution. However, systems related technology trends are awesome. Computer power is increasing at phenomenal rates, doubling every three years. Such a capability allows us to work in a predictive, as opposed to a prescriptive, mode, where insight to complex situations is gained by faster-than-real-time computer simulations. High speed networking and sophisticated communication and visualization technologies are growing exponentially, leading to more distributed and virtual manufacturing. Design now involves all enterprise components, which may be geographically dispersed or a many-tiered supplier chain, and considers customer expectations throughout the product life cycle. Globalization has forced the need to pay more attention to the business case.

Next generation manufacturing systems will be/have:

- -- customer focused and business centered
- -- reconfigerable, adaptive, and flexible
- -- global support for design and production by virtual enterprises

-- information and knowledge based, human intelligence oriented
-- modular to support distribution and autonomy, but cooperating for enterprise goals
-- environmentally aware.

2 Infrastructure Needs and Benefits

A major transformation in how manufacturing companies respond to the marketplace is underway, and this transformation will affect almost every aspect of the enterprise, from engineering tools and production equipment to customer/supplier relationships and the workforce. Over the next decade, it will result in the creation of a new generation of manufacturing systems that will dramatically improve the way companies react to rapidly changing customer needs and requirements. This transformation or "paradigm shift" is inevitable and will radically alter the fundamental parameters for success in domestic and international markets in the future.

2.1 High Impact Implementation Enablers

The next generation of manufacturing companies will require high impact enablers found among the following important emerging technologies:

- The need to significantly reduce development times and improve designs from the standpoint of product features and manufacturability will require new product development concepts.

- The need for effective manufacturing systems, both within and among organizations, will require innovative information, computing and networking techniques.

- The need for increased production efficiency and product quality, not only for individual machines and processes but also for manufacturing systems and subsystems, will require new approaches to automation and intelligent controls.

- The need for flexible and adaptive enterprises which effectively utilize knowledgeable workforces will require pioneering organizational concepts and business practices.

The need for manufacturers to respond to customer needs will result in fundamental systemic changes. Companies that support and embrace such new technologies and integration methodologies stand to gain most from such paradigm shifts. Figure 2 illustrates interdependencies among systemic solutions for meeting industry goals and objectives.

Table 1. Interdependencies

	Industry Needs				
Industry Goals & Objectives	Reduced Development Time	More Effective Systems	Increased Production Efficiency & Quality	Flexible & Adaptive Enterprise	Enterprise Utilization of Workforce
Quantity/ Time	High	Low	Low	High	Low
Quality	High	High	High	High	High
Cost Competitiveness	High	High	High	High	High

2.2 Grand Challenges in Leadership

History has shown that the nation that actively takes leadership in accelerating the development and use of technologies supporting new manufacturing paradigms is also the nation whose manufacturers benefit the most from the paradigm shift. Although such paradigm shifts are inevitable and all nations benefit to some extent, there is a clear correlation between leadership and major beneficiaries on a national level. It is imperative that the United States assume an aggressive leadership position in bringing about the paradigm shift to next generation manufacturing systems so our nation can benefit from such technology.

There are two national "grand challenges" related to leadership. First, we must accelerate the identification and development of technologies and integration methodologies that will enable American firms to design and implement future manufacturing systems. And second, we must be proactive in insuring that significant numbers of U.S. companies implement this technology in the coming decades. As a minimum, we should strive to achieve a leadership position for American manufacturers in all key industrial sectors within the next decade.

Achieving the benefits of next generation manufacturing systems will not be easy. Developing and implementing this technology is beyond the abilities of individual firms or government agencies. Therefore, to achieve these grand challenges, a true partnership and cooperative effort between industry, government and academe--on both a domestic and international basis--will be required, with each member contributing key parts of the total solution in accordance with their strengths and resources. It will require a dedicated and disciplined cooperative effort to develop, demonstrate and implement a number of important infrastructural technologies and new business concepts and practices.

2.3 Integrated Program Areas

In response to these "grand challenges" we will need to collectively address in four integrated and interrelated program areas for next generation manufacturing systems:

Innovative systems concepts, and requirements definition. During the past few years several innovative concepts for next generation manufacturing systems have emerged, most notably the paradigm of agile manufacturing in which companies can respond to and even thrive on an environment of continual and unpredictable change. Another example is the notion of the virtual corporation that relies on self-organizing customer/supplier networks and agent-based methods for actual fulfillment of customer orders. Although these and similar concepts are important in establishing attributes and alternatives for next generation manufacturing systems, they are not well defined and their implications in terms of needed enabling technologies and most suitable applications are not well understood. As a minimum, these alternative concepts need to be refined and evaluated more thoroughly in terms of their potential impact on both individual companies and the national economy. As needs are better understood, it is likely that additional concepts will be put forth that may hold even greater promise. This search for solutions needs to be encouraged.

Enabling science and technology. The growing consensus about the nature of next generation manufacturing systems provides a basis for defining enabling systemic technologies that will be required. The underlying premise is to understand the interrelationship of technology, the social system impact along with human effectiveness, and the business case impact. We also need to better understand what enabling technologies and development efforts are available in government, academia and both commercial as well as DoD industry.

Information infrastructures . Next generation manufacturing systems will rely heavily on the seamless flow of information within companies and between customers and suppliers. Thus, the infrastructure to enable this information flow will be critical. Although some of this will be provided by commercial suppliers and the National Information Infrastructure (NII) Program, several manufacturing-related aspects of this infrastructure will still need to be established, including new mechanisms for linking customers and suppliers for such purposes as marketing, business negotiations, design collaboration, production, user training, operations, maintenance and product disposal.

Integration frameworks and standards. Cost effective implementation of next generation manufacturing systems will require the development of integration architectures and frameworks that will enable manufacturers to tie together current islands of automation and provide confidence that future investments in information and automation systems will interoperate with existing legacy systems. Standards for interfacing subsystems and exchanging product and business data will also be needed.

Integration tools. The ability to design, evaluate, implement and monitor the performance of integrated manufacturing systems and subsystems is a critical issue in achieving widespread use of next generation manufacturing systems, and very few tools exist today to facilitate this task. Today, integrated systems must be almost totally custom designed and in many cases this is prohibitively expensive. Tools for designing, analyzing and specifying such systems based on industry standards and the reuse of existing system modules and application programs are necessary. Similarly, tools are needed for re-engineering existing subsystems and business functions, as well as for developing benchmarks and performance metrics that can be used later for assessing the benefits from next generation systems.

Modeling and simulation. The ability to model, simulate and visualize the operations of future manufacturing systems will be a key factor in the design, acceptance and day-to-day use of such systems. In the long term such modeling and simulation would provide a "virtual manufacturing" capability that would enable companies to explore all aspects of the system's operations without actually implementing the system, thereby providing an ability to evaluate both the system and the manufacturability of new products quickly and inexpensively. In turn, this capability would result in much shorter market entry times and products that are easier to manufacture. Such modeling and simulation abilities would also improve the operation of future systems because they provide a mechanism for baselining system performance and quickly evaluating alternative changes.

Intelligent controls and sensors. Although control and sensor technologies are often linked to improvements in factory processes and equipment, advances in this field are also needed at the system and subsystem level. In particular, advanced control techniques and sensors are needed at the workcell level and above in order to monitor performance and change operations on a real-time basis. This would include, for example, advanced techniques for real-time production scheduling and control.

Business practices and culture. Next generation manufacturing systems will be built upon a wide range of emerging business practices and services, from innovative concepts for empowering workforce teams to new third-party services that will enable customers and suppliers to interact more effectively. We need to understand the impact of business practices on advanced manufacturing systems. We need to understand the impact of self empowerment of individuals (worker/manager), teams and organizations on advanced manufacturing systems. We need to understand the role(s) of component suppliers/partners, as well as the technology systems of component suppliers/partners. Finally, we need to understand the impact of environmental regulations on advanced manufacturing systems, including state, local, regional and Federal differences.

Technology demonstrations. Implementing next generation manufacturing concepts will be expensive, and few firms will be willing to embrace such changes without a realistic understanding of the risks and potential benefits involved. Large-scale demonstrations of next generation systems, funded in part by the government, would provide researchers, suppliers and users of such systems with the important insight they will need about advantages and lessons learned from using this new technology. This would include testbeds for refining and demonstrating future systems technology.

It is clear that related business and cultural infrastructure enablers need to be integrated with any technology enablers, in order to have an active and viable demonstration. Improvement measures, before and after, are essential to developing a business case for implementation. Lastly, both vertical and horizontal partner integration are necessary, along with a common vision, to achieve an agile virtual enterprise.

International cooperation. During the past two decades, America has lost its leadership in many areas of manufacturing technology and it is very important that it not do so in next generation manufacturing systems. Other nations are investing in advanced manufacturing research, and the U.S. needs to participate in, and even lead, these international programs. As a minimum, American researchers should participate in international efforts to benefit from these technology developments. We cannot afford to ignore the fact that future manufacturing enterprises will be increasingly international in scope in terms of both the location of operations and the sources of production technology.

Each of these program areas needs to be coordinated with the others, as well as across agencies and between industry, government and academe.

2.4 Priorities

Although some research is underway in each of the above program areas, it is insufficient and not well coordinated to achieve an American leadership position in this critical field.

These existing activities must continue, but in the near term (one to two years), priority should be given to achieving a better requirements definition of next generation manufacturing systems, and of the role of infrastructural technologies and their relationship to business practices and human systems.

In the mid term (two to three years), emphasis should be placed on the actual development of key infrastructural technologies that will be needed to support future manufacturing systems across a variety of industries, i.e., look for generic approaches.

In the long term (three to five years), priority should be given to demonstrating industry-specific applications of next generation manufacturing systems, further refining the infrastructural technologies, and achieving widespread implementation of this technology among both large and small manufacturing firms.

In order to implement these priorities, it may be necessary to create new mechanisms and organizations for building partnerships between industry, government and academe. It may also be appropriate to develop and maintain a national plan defining the required infrastructural technologies and addressing how they will be developed, including the role of the various participants and the required level of resources.

Finally, international competitiveness is comparable to a race without a finish line. The above five year effort does not mean that the problem is solved. It only means that we have been able to hold our relative position and gain on our competition. But our competition is not standing still. They are continually adapting to and leveraging our success. It is clear that we need to maintain a strategy of continuous change into the foreseeable future.

3 Benefits

3.1 Economic Impact

If America can achieve a leadership position in developing and implementing next generation manufacturing systems, then our companies will benefit the most from the paradigm shift. As a result, domestic suppliers will become more competitive, manufacturing revenues will increase, and trade deficits will decline. Although estimating empirical benefits is difficult at this stage of program definition, it is clear that future manufacturing systems have the potential to provide significant levels of economic benefits to both individual firms and the nation.

3.2 Other Benefits

In addition to direct economic benefits, next generation manufacturing systems have a variety of non-economic and indirect benefits. For example, manufacturing has a major impact on employment because it provides jobs about 21 million people, about 17% of the total workforce. Manufacturing jobs also pay 20 to 30% higher wages than service sector positions. Furthermore, each 100 manufacturing jobs supports an additional 60 non-manufacturing positions. Thus, the health of the manufacturing sector of the economy directly affects the standard of living and quality of life of the average American.

Manufacturing also has other important non-economic benefits. For example, it affects the military strength of our nation because the production of most weapons systems is predicated on the existence of a viable, state-of-the-art industrial base. Similarly, other sectors of the economy are also dependent on the manufacturing sector for many of their essential products. What would happen to our service industries if we did not have domestic sources of transportation equipment and computers? It would also be difficult to imagine a strong U.S. agricultural sector without tractors, farm implements and chemicals, or a telecommunications industry without domestic suppliers of electronics equipment. Manufacturing is also important to our scientific and technical base since this sector employs about 75% of the nation's scientists and engineers, and approximately 90% of all private, non-defense research and development is performed by manufacturing firms.

4 Other Issues

4.1 National Information Infrastructure (NII)

The development, implementation, and use of the national information infrastructure (NII) for manufacturing applications holds one critical key to sustained economic growth and manufacturing competitiveness. An advanced NII will enable manufacturers to transform and significantly improve all stages of manufacturing operations, from technology/market assessment and R&D to after-sales support and product disposal or reuse.

Manufacturers will be able to use the NII to quickly and efficiently transfer data within and among operations; to effectively and sensibly transact business and collaborate with customers and partners; to rapidly and "virtually" prototype, simulate, and test products and processes; and to make easily and readily available the best manufacturing tools, knowledge bases, product information, and training materials regardless of location.

Despite the efforts of many of America's finest companies, the development and use of the NII in manufacturing cannot occur without continued and expanded governmental support in a number of areas. As a result, in cooperation with private industry, the Administration has initiated, expanded, and redirected programs designed to unleash the potential of the NII in a variety of civilian manufacturing areas. These efforts include research and development in support of advanced manufacturing technology (AMT) and high performance computing and communications (HPCC); programs to demonstrate, test, and deploy NII manufacturing applications into the private sector; expansion of programs to stimulate private sector investment in high-risk technologies and manufacturing extension; and lastly, programs designed to improve manufacturing education and training.

It is clear that for the NII to succeed, the private sector must own and operate it; develop, design, and implement its applications; and make the vast majority of investments. While there are many government sponsored programs designed to facilitate the development, demonstration, and deployment of NII manufacturing applications, there are areas where the government should be investing more time and effort. For example, there is a need to accelerate the development and testing of industry-led standards for product data exchange, electronic commerce, and interoperabilty. There is also the need to provide more testbeds where NII applications can be prototyped and demonstrated as well as the initiation focused efforts in the areas of user-acceptability, information conversion, and reliability, security, and privacy safeguards. Lastly, and perhaps most importantly, the government needs to expand its technical assistance programs and to initiate serious efforts to address industry's needs in the areas of organizational learning and worker training, areas critical to enabling companies to implement NII technologists well as carry forth the existing technologies, but where little government attention has been invested to date.

4.2 Current Government Programs and Initiatives

There are a variety of government efforts underway that are addressing aspects of next generation systems technology needs. These can be categorized as research and development, deployment, and education and training. Research and development programs include infrastructure development that supports manufacturing applications. In addition to the base programs within the agencies there are two key thrust areas that are part of the research and development efforts within the National Science and Technology Council (NSTC): The High Performance Computing, Communications and Information Technology (HPCCIT) Subcommittee is promoting the application of information technology to the national challenge of manufacturing using the Information Infrastructure Technology and Applications (IITA) Initiative, and the Civilian Industrial Technologies (CIT) Committee is promoting a coordinated interagency effort to promote the development of advanced manufacturing technologies.

Deployment programs include initiatives that bring useful technologies into the marketplace and further their adoption by the private sector. Education and training programs are treated in another white paper, although several related initiatives are listed here for completeness.

Specific programs and initiatives are:

DoD-ARPA Manufacturing Automation and Design Engineering (MADE). This program focuses on the development and demonstration of key software elements for Integrated Product/Process Development (IPPD) and agile manufacturing applications for the NII. The primary emphasis is on mechanical parts and electro-mechanical assemblies, where today's automation environment is neither integrated or flexible compared to electronics design and manufacturing. As a result, the program addresses the following areas: (1) development of tools for conceptual design, (2) demonstration of tools for interoperability, and (3) demonstration of a scalable capability to share multiple types of distributed information among networked applications.

DoC-NIST Systems Integration for Manufacturing Applications (SIMA). This program is a collaborative multi-year technology development program involving NIST, U.S. industry, universities, and other government agencies in an effort to develop, refine, test, and transfer advanced, computer-integrated, electronicallynetworked manufacturing technologies and associated applications. Research activities will focus on developing integration technologies, architectures, communication protocols and interface specifications for manufacturing software applications that support design, planning and production of products in the mechanical, apparel and process plant industries. A standards-based data exchange effort will target flexible computer integrated manufacturing issues to alleviate the lack of data exchange capability between manufacturing applications.

NSF and DoD-ARPA Agile Manufacturing Initiative. This initiative includes a prototype of an information infrastructure to support distributed concurrent engineering, flexible manufacturing, and electronic commerce in manufacturing applications. The vision of agile manufacturing is to enable virtual companies to be formed by linking design and manufacturing operations that are physically distributed among a group of companies. Specific components of the initiative include:

The Agile Manufacturing Enterprise Forum (AMEF), funded by industry and ARPA and jointly managed by NSF, and located at Lehigh's Iacocca Institute is aimed at refining the vision of agility, providing tools to help firms become more agile, and widely disseminating information about agile manufacturing to interested organizations.

The Agile Manufacturing Research Institutes (AMRIs) are funded by NSF and industry and co-managed by ARPA. They are located at universities and have a specific industrial sector focus and industry participation. There are currently three AMRIs in operation: (1) University of Texas at Arlington (aerospace), (2) University of Illinois at Urbana Champaign (machine tools), and (3) Rensselaer Polytechnic Institute (electronics).

The Agile Manufacturing Pilots are funded by ARPA and managed by the Air Force. Specific pilots are currently being selected for funding.

DoD-AF Lean Manufacturing Initiative. This is an Air Force program involving the Massachusetts Institute of Technology and a number of aerospace and defense manufacturing firms.

DoD Flexible Computer Integrated Manufacturing (FCIM). This program is funded by DoD and the Services and is aimed at rapid acquisition and manufacturing of repair parts.

DoE Technologies Enabling Agile Manufacturing (TEAM) This program will enhance industrial competitiveness by advancing and deploying manufacturing technologies that promote agility. Addressing a technical plan developed in consultation with major U.S. manufacturers and technology developers, TEAM is leveraging the expertise and resources of private industry and federal agencies to develop, integrate, and deploy leap-ahead technologies enhancing the responsiveness, flexibility, and cost-effectiveness of U.S. industry. The technologies and methodologies deployed by TEAM in the five thrust areas of Product Design and Enterprise Concurrency, Virtual Manufacturing, Manufacturing Planning and Control, Intelligent Closed-Loop Processing, and Integration will enable manufacturers to transition products from design to production faster, more efficiently, and at lower cost.

DoD's National Industrial Information Infrastructure Protocols (NIIIP) Consortium. This consortium, led by IBM and including participants from the software industry, private and public research organizations, universities, and defense and commercial products companies, is developing a series of computer-based protocols to enable the widespread deployment and use of virtual enterprises within the America's industrial community. Sponsored in part by the TRP, the NIIIP will provide the software architecture, tools, and mechanisms to allow diverse organizations to work together as a virtual enterprise towards common goals by means of computer technology. The NIIIP will use pilot projects to demonstrate concurrent product and process design, project control, and distributed manufacturing.

DoC-NIST ATP Computer-Integrated Manufacturing (CIM) for Electronics This focused program will increase substantially the base of suppliers of third-party electronics manufacturing software. The intention is that this supplier base would serve not only electronics manufacturers, but also other major manufacturing sectors such as automotive and aerospace. These goals will be achieved by encouraging electronics manufacturers to define and adopt an open CIM framework which will provide a market for others to design compliant software systems that require minimal manufacturers to rapidly respond to new market opportunities by being able to easily reconfigure their shop floor systems.

DoD Continuous Acquisition and Life-Cycle Support (CALS). The CALS initiative to enable more effective generation, exchange, management, and use of digital data supporting the life cycle of a product through the use of international standards, business process change, and advanced technology application. A key part of this program is the effort by the CALS/CE Industry Steering Group that works closely with the CALS program to facilitate the development, implementation, and deployment of the technologies defined by the CALS information standards.

DoC-NIST Manufacturing Extension Partnership (MEP). The MEP program in an industrial extension service is designed to help U.S. manufacturers acquire technologies that will allow them to compete in the 20th century marketplace. The MEP is sponsoring a specific pilot program - LINKS which is aimed at demonstrating the potential value of linking the extension centers using a major network system.

DoE's Technology Information Environment for Industry, TIE-IN. TIE-IN is a new mechanism being developed by Sandia Labs for technology transfer that can realistically reach a large percentage of the small to mid-sized companies in the U.S. It has two primary goals: 1) to reach thousands of establishments, and 2) to reduce the industry investment required to use National Laboratory technologies. TIE-IN will utilize the NII and information technologies to build smart front-ends for many existing DOE technical capabilities and electronically guide users through the process of obtaining solutions. By using these smart front-ends both the required amount of direct staff interaction with the users, and the investment required by industry can be minimized. TIE-IN will operate as an electronic extension service accessible from Internet or modem to allow the user to quickly obtain solutions to problems from remote locations.

A number of other related programs are being funded by such organizations as:

– DoD and Services Manufacturing Technology (ManTech) Programs.

– NIST Advanced Technology Program (ATP).

– DoE Technology Transfer Program.

– The DoD-led interagency Technology Reinvestment Program (TRP).

– NSF Engineering Research Centers (ERCs) and Industry/University Cooperative Research

Centers (I/UCRCs).

-- National Center for Manufacturing Sciences (NCMS).

-- Consortium for Advanced Manufacturing - International (CAM-I).

-- NIST Manufacturing Engineering Laboratory (MEL).

4.3 Intelligent Manufacturing Systems (IMS)

IMS is a world wide (subdivided into 6 major geographic regions, thus far) cooperative effort being mobilized to attack manufacturing technical problems confronting industry for the gain of society. The six test cases pursued last year as vehicles for better understanding modes of international cooperation are complete, and have been termed an overwhelming success for international cooperation.

The last major issue, namely, intellectual property rights (IPR) has been resolved. In January, 1994 the International IMS Steering Committee drafted proposed terms-of-reference, has been ratified by all? of the respective governments in the six regions.

In the U.S. the Department of Commerce which handled the successful ratification process for the U.S., has now established the U.S. IMS Secretariat. U.S. representatives to the International Committee have also been chosen.

What does this mean to American Industry? The U.S. IMS Steering Committee identified the following, among its list of advantages, in addition to progress on specific technologies. The first is a greater U.S. voice in the setting of international manufacturing standards. In the past, the lack of a coordinated effort by U.S. industry allowed foreign-led efforts to structure standards in a way that are not in the best interests of U.S. industry. Such a coordination involves active information dissemination of positions, activities, etc..

The committee also felt that the U.S. supplier industry would be able to compete more favorably if broad guidelines for international cooperation were easily accessible to them.

Finally, U.S. universities would gain by raising the stature of the manufacturing profession (where it is highly regarded in some countries), and by strengthening academic programs and laboratories in manufacturing. International technical societies already provide the means for the discussion of research results, and additional means of information dissemination will be developed.

IMS is expected to foster greater international win-win cooperation in manufacturing technology. America is a leading, but no longer the only major, player in manufacturing technology. Today, understanding international competition, and establishing cooperative ventures is essential for being the best. Large American corporations already have extensive international cooperative agreements in manufacturing R&D and practice. However, few include small to medium enterprises (such as suppliers) and universities as participants. Thus the value added by IMS for larger companies comes through the leverage they receive from a strengthened supplier base and from more relevant education provided by the University community.

Clearly the advantage of international cooperation goes to the best positioned and prepared. The question of involvement is no longer if, but when and how. IMS offers one way.

4.4 Synergy with NSTC Activities

Next generation manufacturing systems technology will be particularly important to the following NSTC initiatives and working groups:

- Partnership for a New Generation of Vehicles (PNGV).
- National Electronics Manufacturing Initiative.
- High Performance Computing and Communications (manufacturing applications).
- Aeronautics Materials and Manufacturing.

To a lesser but still important extent advanced manufacturing systems technology will also be useful for the following NSTC efforts:

- Advanced Materials.
- Building and Construction.
- Environmental Technologies.

4.4 Government-Industry-University Partnerships

There are already a number of partnerships underway between industry, government and educational institutions in the area of next generation manufacturing systems. These include such previously discussed programs as the AMEF, AMRIs and TEAM. There also a number of other partnerships, such as the joint NSF/industry program on Transformations to Quality Organizations (TQO) that is aimed at improved business practices in the area of quality science and technology, and other that are governed by specific NIST, DoE and DoD

CRADA's and contracts. Although these partnerships are important, additional linkages between industry, government and academe need to be created.

4.5 Policy Focus

Policy issues that need to be addressed for advanced manufacturing systems technology include:

-- Mechanisms for forming partnerships among agencies and between industry, academia and government agencies. Experiments such as the partnership for a new generation of vehicles (PNGV) should be carefully studied for replication in other endeavors.

-- Mechanisms for jointly (industry, government and academe) determining research needs and priorities. It is clear that this issue requires all sides working from a common agenda and ultimately a common roadmap. This effort will require an understanding of where each government agency fits with respect to each other, including what broad efforts should be funded by government versus what by industry.

-- The feasibility and desirability of creating a cooperative national plan for the development and implementation of next generation manufacturing systems.

-- Mechanisms for and extent of international cooperation, such as the international Intelligent Manufacturing Systems (IMS) effort.

4.6 Impact Assessment Metrics

The development of impact assessment metrics will be essential to understand the long term health of U.S. manufacturers. The competitiveness dynamics today are so fast that traditional measures are not sufficient.

In the long term, the success of advanced manufacturing systems technologies can be measured in terms of the health of U.S. manufacturers. Although it may be difficult to establish definite cause and effect relationships, next generation manufacturing systems technology will definitely allow American companies to grow and increase their market shares. This would then lead to an increase in manufacturing GDP and a lessening of trade deficits in manufactured products. The majority of employment growth will most likely take place in the derivative industries that will emerge to service the primary product.

In the long term, this is a race without a finish line. Companies, world-wide are very adaptive, and quickly adopt and improve upon whatever innovations propel a particular company into the forefront. Thus the next generation manufacturing system will gain U.S. companies an advantage only until it becomes understood worldwide and replicated. It is clear that U.S. industry cannot take on the total technology development burden but must concentrate on areas of maximum added advantage. Looking at the trends, many of our companies are becoming high end integrators, and subcontracting component manufacturing to domestic and international suppliers. In such a situation the systems aspects become extremely important, since the OEM and its suppliers must act as a single enterprise.

5 Recommendations

5.1 Program Areas and Priorities

As discussed previously, emphasis should be given to four program areas:

- Innovative systems concepts (short term, one to two years).
- Supporting technologies (mid term, two to three years).
- Technology demonstrations (long-term, three to five years).
- International cooperation (throughout, one to five years).

DRAFT

TOOLS FOR DESIGN, MANUFACTURING, AND INTEGRATION

Comments to Dr. Pradeep K. Khosla, ARPA/SISTO. E-Mail: pkhosla@arpa.mil

SUMMARY

The NSTC Subcommittee on Manufacturing Infrastructure recommends the creation of a national project to develop an information infrastructure capability to support collaborative design and manufacture. The infrastructure will enable customers to make product performance and cost tradeoffs to optimize their personal purchasing power. The infrastructure will allow customers to be interactively integrated into the product design, fabrication, and distribution environments. The establishment of this infrastructure capability presents many technological challenges. Research will be needed in the following areas:

-- Improved Simulation and Modeling Tools
-- User Interfaces and Software Engineering for Modeling and Simulation
- Collaborative Design Methodologies
-- Hybrid Prototyping
-- Design Documentation and Change Coordination
-- Tools for Relating Design and Manufacturing Technology to Business Practice
-- Standards for Unambiguous Product/Process Digital Data Representation and Exchange

The creation of the Manufacturing Infrastructure national project will require executive level support, the development of tools, new information integration capabilities, culture and educational reforms, and changes in the financial infrastructure. Detailed research requirements and specific recommendations for action are outlined in this report.

1 BACKGROUND

A new competitive environment for industrial products and services is emerging which is placing tremendous pressures on manufacturing organizations. In this new environment, customers expect complex, sophisticated products and services that can be tailored to individual needs and delivered at a low cost. Markets and economic factors have become extremely dynamic and unpredictable. Long delivery times are no longer acceptable -- products and services must be conceived, designed, delivered and serviced before needs change. Standards for product quality, reliability and maintainability are increasing. Customers are becoming less tolerant of products that must be removed from service and replaced after a few years.

Demands are increasing for durable, flexible products that can be maintained and adapted to new uses over a long life. The competitive advantage in this new environment will belong to enterprises that can adapt to these pressures and deliver products and services that meet increasingly stringent demands. In this paper, we identify some steps that should be taken to enable US manufacturing organizations to survive and thrive in this environment. The focus of this paper is on engineering tools for design and manufacture. Design involves a systematic exploration of all possible forms and configurations with the goal of finding an optimal product meeting all requirements and satisfying all constraints. However, this description oversimplifies the complexity and ambiguity of most design tasks. Often, the requirements are not explicitly shown but must be inferred from a detailed understanding of the customer's application. Designs must simultaneously achieve many goals involving engineering and physical properties, manufacturability, reliability, maintainability, cost, esthetics, safety and environmental impact. It is frequently difficult or impossible to estimate all of the important qualities of a device (or a system) from its preliminary design drawings. Product design and the manufacturing and maintenance operations to produce them, must comply with a host of regulations (for example, concerning safety and the environment); tracking and understanding the necessary requirements is a major challenge. Once delivered to the customer, products may be subjected to unpredictable, harsh conditions that will alter it's characteristics. The pressure to simultaneously reduce costs and time-to-market while also improving quality, reliability and maintainability will require new scientific or engineering discoveries.

1.2 RECENT DEVELOPMENTS AND TECHNOLOGY TRENDS

Recent developments and technology trends can enable a major transformation in the way that products and services are designed, if given the proper stimulus. We briefly discuss those factors here:

– Computing Power: Faster and cheaper computing has made it possible to use more sophisticated models and analytical tools and to explore the design space more extensively than was possible before.
– Models: A better understanding of material properties, the behavior of components under different conditions, and the behavior of systems in different configurations has resulted in better engineering models. Software tools that model business processes provide some useful capabilities.
– Design Methodologies: The concepts of IPPD (Integrated Product and Process Design) and CFDT (Cross Functional Design Teams) are being refined and there are good examples of success. An excellent example of an integrated environment and its use in design and manufacture is the environment put in place by the Boeing Company for its 777 family of commercial aircraft.

-- Downsizing: Due to significant downsizing of companies, groups with "critical mass" are being disintegrated. While this has caused significant concern, it should be looked upon as an opportunity. Most downsizing efforts were preceded by extensive business analysis and re-engineering programs. As a result, corporations now have a better understanding of their core capabilities and business processes, and they are operating lean and efficient organizations. Instead of maintaining critical mass within a single organization, we are in an excellent position to create the critical mass out of multi-enterprise virtual corporations.
-- Internet Services: Internet services are rapidly growing and becoming more powerful. Initially designed primarily for the needs of the US military, the Internet grew to serve the academic and research communities. Recently, there has been tremendous expansion of the network both internationally and into the commercial sector. An important development has been the emergence of powerful information tools permitting access and retrieval of information distributed over the Internet as well as supporting user collaboration (e. g., the World Wide Web). Recently, commercial firms have announced plans to extend services for purchase and payment of products over the Internet (CommerceNet).
-- Integration: System integration frameworks have emerged and are gaining widespread support from product developers and end-users (e. g. the Common Object Request Broker Architecture, CORBA). This technology enables applications to plug-and-play. Integrated environments that combine modeling (e. g. solid modeling systems), multi-disciplinary optimization tools (finite element, thermal, etc.) and shop control systems have been recognized to be important for creating better designs faster. Even though a fully integrated environment is still a few years and significant investment away, several vendors now market tools that work together to provide capabilities unavailable in the past.
-- Standards: Engineering data standards have emerged which support the electronic exchange of product information. A notable example is STEP (Standard for The Exchange of Product Model Data) whose goal is to provide a complete, computer-interpretable representation of product data throughout the life-cycle (design, engineering analysis, manufacture, support, maintenance and disposal). Such standards will enable all people contributing to the acquisition, design and fabrication of a product to share its information.
-- Research: A large body of research exists which has produced concepts, representations and algorithms for negotiation, constraint management, engineering task activity modeling, design process modeling, product visualization, design rationale capture and knowledge sharing, to cite a few.
-- Policy: Government, industry, and academia have a general understanding of the needs and technologies to improve product realization practice. State, local, and federal governments are aggressively searching for, funding, developing and implementing methods for disseminating the appropriate information required to revitalize industry. [Manufacturing Technology

Centers, state programs] This unprecedented combination of events and trends constitutes an opportunity that should not be missed.

2 INFRASTRUCTURE NEEDS

2.1 VISION

A typical design scenario in 2005 would begin with a customer needing a new device who would browse a publicly available, distributed database seeking an appropriate supplier. The customer would have easy access to data concerning product forms, engineering properties, prices, minimum order sizes, performance data, producer credentials and corporate reputation. The customer would be able to simulate the behavior of various commercial products within his own application environment. If the customer decided that no existing devices completely satisfied his needs, he would initiate negotiations for the development of a customized product, giving greatest priority to those firms having a strong reputation for quality design and customer satisfaction. The customer and potential suppliers would engage in a product definition task that would be greatly eased by Internet services. The product definition might take the form of an on-line product development storyboard ("reality board") or a simulation (including the product look and feel).

The selected producer would quickly assemble a team consisting of marketing, design and manufacturing specialists across multiple enterprises (i. e., including subcontractors and suppliers). That team would experiment with alternate designs in a virtual, electronic laboratory. Models would estimate properties and costs, assess designs, simulate fabrication, verify compliance with government regulations and corporate policies, and identify problems. The performance of the device would be completely validated before fabrication. Collaborative Engineering services would alert appropriate team members to problems, recognize opportunities, ease the discussion of alternatives, propose options for resolving conflicts and manage the shared records of the evolving product design. Design detail and rationale would be captured and preserved over the life of the product. The customer would have visibility into this process and would be encouraged to express his preferences as tradeoffs were made.

During the formulation of the new product, engineers and manufacturing specialists would have access to an extensive library of scientific research, engineering test data and past designs. Some of this information would reside on a personal, multimedia database -- in effect, an electronic notebook of professional experiences and accomplishments that could be tapped for future ideas. The engineer would create this database as a student at the university and enhance it throughout his professional life. Some information would reside in a corporate database and would be made available to the team after negotiation of ownership and disclosure conditions. The vast majority of the information would come from a national electronic library, containing the accumulated experiences of years of engineering analysis, research and product development. These libraries would be well indexed and easy to navigate. Furthermore, sophisticated tools would be available to analyze the data, synthesize the information to an appropriate level of detail, and transform the data into an appropriate user context.

2.2 GRAND CHALLENGE

The grand challenge is to create a national project that will develop an infrastructure for the above vision, test its validity on practical design projects, and transfer the technology to the commercial sector within 10 years. This project will be called Project Aura. Project Aura will build on the idea of Agile Manufacturing. In Agile Manufacturing companies with core competencies collaborate to form "Virtual Companies" to respond to a market need and dissolve afterwards. In the design arena, the opportunity is to pursue the notion of "Agile Design." In an Agile Design environment, it will be possible to create teams of designers who are distributed in both time and space and to enable them to work together and attack a specific design problem. It will be possible to have tools collaborate with each other and with humans to arrive at a solution to a specific design problem. And importantly, it will be possible to do this cheaply and easily.

An environment like this is analogous to the interstate road system in the US that provided humans with the agility to move from location to location and transfer products. Design Net will be the analog in the design domain. Design Net will support two kinds of components: Personal Webs and Design Webs. Personal Webs will belong to individuals and will include information that the person wishes to capture, store, and share with either a predefined group or the public. An engineer participating in a design team will likely encode his product concepts, experimental data, model results, tradeoff analyses and other technical notes in his Web. He will share those results with other member of his design team, the manufacturing organization and the customers. Team members will be encouraged to understand different views of the design through the Web, evaluate options, and work through solutions to common problems. As design choices are solidified, data from the Personal Webs will be incorporated into a Design Web, which will be associated with a particular artifact. It will contain the product specifications, composition, structure, function and manufacturing requirements. The resource will be available to both producers and users who make decisions about fabrication, maintenance, disposal and uses in new applications. These networks will connect to an electronic registry of components and materials. The component entries will be intelligent and modular, so it will be easy to glue them together to produce a simulation of a large-scale artifact and an analysis of production effects.

2.3 PRIORITIES

The following are critical infrastructure needs and research areas that must be supported:

– Improved Simulation and Modeling Tools: Accurate representations of physical reality are necessary if tools are to be of any use. Full understanding with the ability to mathematically represent processes and product interactions will continue to need research and development. Robust models need to be developed in which material and process data are characterized by equations which reflect realistic operating conditions as opposed to single discrete values for properties. Assembly modeling needs development. Models to accurately reflect the cost of designing, fabricating, supporting, and disposing products need to be developed. The development of tools for modeling vendor capabilities and operational performance is needed to enable distributed product development. Enterprise level modeling and IPPD maturity model (self assessment) tools also need development.
– User Interfaces: Key to involving customers and ultimately consumers in Project Aura is the development of user friendly interfaces for simulation and modeling tools. Advanced visualization techniques and virtual reality may play a prominent role.
– Increased Processing Speed: Computational speeds that provide near real-time response to users are needed to realize Project Aura.
– Alternate Design Concepts, Including Collaborative Design Methodologies: New design processes are needed which incorporate fabrication process tradeoffs, product life-cycle analysis and disposal considerations. We need to study the social aspects of team dynamics in order to better understand how design groups share ideas, communicate, compromise, learn together and reach consensus. A thorough understanding of these interactions will be required for us to develop appropriate tools.
– Design Models: We need better computational prototying and modeling tools to support Project Aura. At this time, models that support the initial, conceptual phases of design are inadequate. Such tools need to operate at the abstract level, supporting least-commitment problem-solving techniques and providing rough predictions from indefinite design parameter values. Tools are need to evaluate processing alternatives. More accurate models of down-stream concerns are also needed (manufacturability, reliability, maintainability, application flexibility, total life-cycle costs).
– Software Engineering for Modeling and Simulation: Simulation will be one key to reducing costs and maintaining competitiveness. Present emphasis in this area is mainly on characterizing behavior and creating models. Emphasis must also be placed on software engineering methodologies for developing complex simulation environments. Such an emphasis would contribute

toward satisfying the long term vision of reducing the costs, time and programming effort required to integrate a new simulation or analysis tool into the IPPD environment. This area not only requires the integration of research in several different areas but also new paradigms for developing simulation systems. One potential effort that must be supported is the creation of "Intelligent Thomas Register" that would include active models bound to the individual simulations.

– Hybrid Prototyping: The current emphasis is on "virtual prototyping" in which devices and systems are "manufactured" digitally. This assumes that all aspects of the behavior of a device and system are well understood and can be modeled which often is not true. Consequently, research is needed in which digital representations (or models) can interact with physical prototypes to model the complete behavior of a system. Such a paradigm combines "virtual" and "physical" prototyping and uses the power and utility of both forms of prototypes to better understand and evaluate the devices and systems.

– Technology Costs: There is a pressing need to reduce the costs of information systems technologies that support design operations. Engineering analysis tools are expensive to acquire and time-consuming to operate. Many powerful tools are unavailable to small firms that lack the funds and staff to make initial investments. Collaborative engineering and electronic commerce services may smooth the transition into virtual corporations, but the costs of setting up and using those services frequently exceeds the benefits.

– Discovering Resources: There are many resources on the Internet, but finding them is difficult. As larger numbers of engineering and commercial services become available, we will need to develop ways that enable companies and individuals to find the products and services they need. We will also need to address issues of security, privacy, user identification and verification before many organizations will accept electronic commerce.

– Design Documentation and Change Coordination: In the design of a complex system, understanding the impact of a change (due to customer specifications, new market needs, proposed design changes, etc.) is a major challenge. Frequently changing work teams composed of thousands of people or organizations adds to the challenge. We are currently limited by the necessity for each participant to maintain situation awareness in his/her head. This barrier becomes even more important as we move toward distributed, multi-enterprise projects. Coordination services need to be active: They should not only do "bookkeeping," but also notify people of significant changes. Some of the most promising design documentation systems focus on facilities for dependency maintenance and for producing sharable self explaining design models and process simulations.

– Tools for Relating Design and Manufacturing Technology to Business Practice: Research is needed that recognizes the connection between design and manufacturing (technology oriented functions) and business practices. This research would create models that relate design and manufacturing practices to business models of an enterprise. For example, models that relate quality of a product to cost would be an invaluable asset in making decisions regarding both design and manufacture of a product.

– Standards for Unambiguous Product/Process Digital Data Representation and Exchange: Most of today's Computer-Aided Design (CAD) systems are not able to easily exchange data. Some engineering data standards are emerging and are gaining widespread use as neutral formats. The next step is to use such standards for shared, consistent product data in multi-enterprise, concurrent design exploration projects. This will require sophisticated tools for version management, configuration control, data ownership and release control. Representations are needed that go beyond part geometries and material properties to cover constraints, dependencies, design intent and rationale. Ensuring that product data standards are complete, easy-to-use, and unambiguous is a continuing development need.

– Integration: Information systems need to be developed which will integrate across disciplines, vendors, customers, etc., and be accessible through the National Information Infrastructure. A key requirements will be to migrate present legacy systems.

3 BENEFITS

This project is expected to achieve the following economic benefits:

– improve the ability of US industries to compete in an increasingly dynamic and demanding marketplace
– reduce the time-to-market for new and modified products
– eliminate duplication of effort in product and process design
– reduce prototype costs
– reduce total production costs
– improve product quality and reliability, thereby reducing operational costs
– better integrate the military and civilian production capability
– provide safer and more environmentally sensitive products

4 OTHER ISSUES

Since the publication of the NRC study titled "Improving Engineering Design: Designing for Competitive Advantage" there has been an increase in investment in this general area. However, the total investment across all federal agencies is still short of what is needed to develop an infrastructure. Further, a lack of coordination across federal agencies may result in reduced impact due to duplication of efforts.

As mentioned earlier, the tools for design are improving and several are available commercially. Many of these tools provide capabilities that are better than what was available a few years ago but they do not compare very favorably with capabilities of tools in research laboratories. This clearly points to a lack of rapid technology insertion and transition from the research to the commercial domain. Further, since these tools seldom work together, it is often easier to not use them than use them. This raises the issues of not only making better use of existing tools but also developing new ones so that they are interoperable. The development of PDES/STEP standards is a positive step aimed at overcoming the interoperability hurdle but it is happening at a pace slower than the development of tools themselves.

5 RECOMMENDATIONS

The following actions are recommended to implement the Manufacturing Infrastructure national project:

1. Executive Level Support
-- Generate government and private executive level support for the project by having the White House coordinate with CEOs of select Fortune 500 companies to establish performance objectives for the nation's businesses that can be met only through the Manufacturing Infrastructure project.
-- Establish focused experiments through pilot programs in which one or more government agency teams are empowered to develop and apply technology tools in the acquisition of a needed product. The government team should have a specific objective (such as developing a sensor, material, process, or other product), have a fixed budget (no more than $10 to $25 million) and fixed duration (one year). The experiments should empower the government team to work with commercial industries and exempt them from government accounting and acquisition regulations. The ability of the teams to achieve results will be the basis for changing government regulations and policies to use tools and technologies from Project Aura. Areas needing further research and development will also be identified from these experiments.
-- Establish unambiguous, recognizable metrics to monitor the benefits resulting from manufacturing infrastructure tools.

2. Tools
-- Increase emphasis on developing interoperable seamless computer software tools - product and process depiction, visualization, analysis & animation.
-- Emphasize additional development of more sophisticated modeling and simulation.
-- Fund the development tools (particularly improved software simulation models and user friendly interfaces) through the TRP, ATP, and/or MS&T programs.
-- Develop an on-line catalog, continuously updated, of what government engineering tool development is being done, by whom, with what goals, and what accomplishments.
-- Fund research into improving the software development process

3. Information Integration

- Develop a National Systems Engineering Framework for developing unambiguous digital representations of products and processes using STEP and current CAE/CAD/CAM/CAT/CAI tools. Integrate these tools in a distributed open systems environment (Internet) for all enterprise users.
- Support standardization initiatives such as STEP and CORBA to evolve information exchange standards.
- Enhance HPCC and NII programs to develop and demonstrate distributed design, analysis, and manufacture capabilities. The programs should involve interaction with customers and suppliers.

4. Culture and Education Changes
-- Develop education and training support at all levels. Fund an educational infrastructure for kindergarten through vocational training and university education. (e. g. Harvard Business School, Junior Colleges, Government and Industry training programs) Provide incentives and infrastructure support for multidisciplinary education and specialty cross training.
-- Review the way engineering schools teach design. Encourage the teaching of system engineering concepts and the technologies required to realize new design concepts.
- Address these specific elements in training programs:
  - Recognize manufacturing as a key discipline, coequal with design, marketing, and sales.
  - Integrate manufacturing processes with design. Revise the way we design products and business processes.
  - Study the manufacturing enterprise culture.
  - Balance objectives in the enterprise. Analyze the "Big Picture" instead of optimizing stovepipes.
  - Recognize the importance of total customer satisfaction.
-- Provide incentives to evolve commercial accounting and administrative practices so they promote the use of tools and methods.
-- Support ISO 9000.

5. Financial Infrastructure
-- Develop engineering based cost estimating processes for affordability to enhance classical financial approaches.
-- Provide incentives to the nation's financial institutions to support commercialization of research.
-- Provide ideas to the FASB to enhance incentives for implementing infrastructure tools.

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12/16

Manufacturing Processes and Equipment Working Group

White Paper Draft
December 13. 1994

1 Background

Manufacturing is a cornerstone of the U.S. economy. Manufacturing directly accounts for approximately 22% of U.S. gross domestic product (GDP). When indirect contributions from industry sectors that are closely linked to manufacturing are included. it is clear that almost half of the GDP is generated from the manufacturing sector. However, a new competitive environment for U.S. manufacturers is emerging. International competition is more intense than ever before. and U.S. manufacturers have fallen behind their competitors in a number of key areas. Today's market is being driven by customers who expect complex products and services tailored to their needs, which can be delivered rapidly and at low cost. Manufacturers who are responsive to large product varieties and rapid introduction of new products are gaining competitive advantage. In the past, the use of highly skilled and experienced machine operators was the only approach available to produce low volume, high-variety products - a costly approach, which is no longer effective in this country. U.S. manufacturers must now move toward more rapid product realization, increased flexibility, and integrated design-production-quality control in order to remain competitive.

The focus of this paper is on manufacturing processes and equipment. Advanced manufacturing processes and equipment will be a key enabler to rapid, agile manufacturing. As an integral part of the U.S. manufacturing infrastructure, innovative manufacturing processes and equipment offer great potential to improve productivity and competitiveness. The manufacturing processes considered are primarily the discrete processes which include machining, forming, welding, etc., but also include continuous manufacturing processes related to metals/composites and soft goods such as foods, paper, chemical, textiles, etc. Manufacturing equipment includes a broad range of computer controlled equipment capable of carrying out a wide array of manufacturing processes. Flexibility, programmability, controllability and sensor feedback are inherent attributes of such equipment.

To maintain competitive manufacturing capabilities, particularly in high technology fields, U.S. industry must have access to a broad range of state of the art processes and equipment. Equipment suppliers in the U.S. are losing market share to international competitors in a number of fields, including fabrication equipment, machine tools, semi-conductor manufacturing and test equipment, and chemical, food and textile processing equipment. As more equipment suppliers move offshore, there is a risk that U.S. manufacturers will not have access to the latest technology. This is due to the fact that manufacturing equipment suppliers tend to sell their newest products close to home first to ensure that any problems are easily fixed. Although effective management can offset some of the disadvantages of less than competitive equipment, foreign competitors have access to both effective management and the most up-to-date equipment. Further development and deployment of intelligent manufacturing technology will be required for U.S. manufacturers to remain competitive in the global marketplace.

1.1 Contemporary scope

Today's market demands a broad range of "custom products" with a level of performance, reliability, value, delivery, and price that cannot easily be met using traditional production methods and current industry infrastructure. As the introduction of new products accelerates, especially in high technology fields, the product life cycle is shortened and as little as 18 months may pass before a new generation of product is obsolete. In addition, the size of production runs for advanced products is decreasing because of shortened production life cycles, the growing demand for a variety of parts and increased "just in time" manufacturing and purchasing practices. To meet these competitive pressures, manufacturers must implement new manufacturing systems that are flexible enough to respond quickly to product and demand changes. Increasingly, economics will dictate that life cycles of manufacturing systems must span several life cycles. Approximately 75% of total production in the mechanical components industry is batch type, or small lot production (production of 50 or fewer parts). This requires more flexibility and capability than is economical for traditional automated systems.

The recent trend in manufacturing has been toward more rapid product realization, increased flexibility, and integrated design-production-quality control. High speed, high performance computing capabilities have evolved to the point where they are widely available to the U.S. manufacturing community at a reasonable price. Information and communication technologies are evolving as key elements to enable real-time control of production processes. Manufacturers are increasingly demanding intelligent manufacturing capabilities to remain competitive.

We now have the potential to monitor various machining and process parameters and automatically adjust machine motions in real time to stay within process parameters. Modular tooling and equipment concepts are developing which will allow rapid reconfiguration of manufacturing processes. The advent of knowledge-based digital control systems has accelerated the need to transition manufacturing from an art to a science. Manufacturing processes of the future will be carefully studied and characterized to accommodate intelligent control similar to that employed manually by skilled craftsmen in past decades.

A large number of manufacturing technologies will be required to adequately support our manufacturing base. As an illustration, advances in control devices and sensors represent a great potential for increasing the capability of intelligent processing equipment in the future. Improvements in processing speed and supporting technologies such as graphical programming and high level languages are allowing more and more functions to be performed by controllers as an integral part of the manufacturing process. These advances contribute to increased productivity, more versatility and higher, more repeatable quality which give users a competitive edge. It is anticipated that spin-offs from intelligent processing technologies will impact other segments of the U.S. economy such as agriculture, the environmental sector and the service sector. Examples include smart tractors, intelligent equipment for environmental clean-up, and service robots for health care, security, cleaning and fire fighting.

While individual companies may determine isolated solutions to specific product realization problems, the effort required to develop fundamental knowledge in manufacturing processes and apply it to the widespread implementation of new and improved manufacturing techniques clearly exceeds the capabilities of any one company or agency. U.S. industry now has a window of opportunity to gain competitive advantage by leading the transition of manufacturing from an art to a science. In order to accomplish this, the resources of industry, government and academe must be applied in a coordinated manner.

1.2 Major Issues and Opportunities

The use of intelligent manufacturing processes and equipment in U.S. industry is not yet very widespread. Some of the barriers to implementation and opportunities to accelerate implementation are listed below.

The cost of developing new technology and reducing it to practice is becoming prohibitive due to the extensive needs for capital and equipment to prove concepts, develop and test prototypes, and demonstrate scalable production processes. The breadth of expertise required today for equipment and process development is beyond that available in small business and start-up companies, and even beyond that available in many large companies. Government/industry /academe partnerships are needed to develop technology and knowledge bases and to make facilities and expertise available at affordable costs to both small and large businesses.

Declining R&D budgets in the private sector, lack of a short term return on investment, and the scarcity of inexpensive, robust sensors and controllers have inhibited widespread development of these technologies throughout the world.

Use of intelligent manufacturing systems diverges from manufacturing strategies that are commonly practiced in this country today and requires alterations in most firms' operating philosophies. In order for U.S. manufacturers to take the lead in global markets, these new technologies and their associated management systems must be developed and integrated into the U.S. manufacturing infrastructure. The technology must be made accessible and affordable to small and medium sized companies as well as large companies.

"Next generation" manufacturing equipment will require the integration of fast computing, intelligent controllers, and intelligent sensors and actuators. The incorporation of intelligent processing features into production equipment will also require the development of software to manage numerous discrete events that are understood by multiple intelligent sensors and controls, particularly when fabrication requires many serial and parallel processes. Overcoming existing limitations in these areas will result in more capable systems that can be used for a broader range of applications.

Numerous manufacturing processes must be studied and characterized in detail to transform manufacturing from an "art" to a science. Lack of understanding of the fundamental relationships between sensed variables and required controls has delayed the integration of these technologies into manufacturing equipment. A better understanding of critical parameters which must be monitored and controlled is required before intelligent sensors and controls can be broadly employed in the manufacturing environment.

The innovative development and implementation of new processing methods, and their associated sensors, actuators, and controllers, is also required. New processes for fabricating composites and engineered materials quickly and inexpensively could lead to revolutionary developments in the automotive, aerospace and electronics industry. Further development of processing technology is necessary for widespread utilization of intelligent processing equipment, especially for the new engineered materials being developed. Such added knowledge will lead to the development of new machines and processes aimed at improvements in agility, productivity and process precision.

Rapid prototyping is an emerging field of new technologies that can produce hardware of great complexity in hours that would otherwise require days or weeks using traditional methods. With additional technology development, the current concept of rapid prototyping could be extended to include the fabrication of functional hardware. Imagine a manufacturer with an advanced Rapid Prototyping system, capable of fabricating a functional replacement part from an electronically communicated file sent from anywhere in the world. Spare part inventories would be a thing of the past. The replacement parts become virtual, until needed. A critically important technology such as Rapid Prototyping requires additional development in order to achieve its full potential, and move the manufacturing industry further along the learning curve. Speed, accuracy, size, and fabrication using structural materials represent immediate technological development needs in this globally competitive field.

The health of the U.S. manufacturing equipment sector and other manufacturing sectors within the U.S. are closely related. The importance of a strong domestic manufacturing equipment industry increases as manufacturers focus more closely on process innovations as a means of sustained competitiveness. Close proximity between manufacturing equipment builders and users can aid in developing new tools and processes tailored to specific customer needs and can smooth introduction of new processes onto the factory floor. In the plastics industry for example, close cooperation between plastic-machinery makers, the producers of plastic bottles, and soft drink firms has enabled the U.S. to remain a world leader. Closer relationships need to be developed between U.S. equipment makers and users to ensure the health of all U.S. manufacturing sectors.

2.1 Vision

Over the next decade an integrated national manufacturing infrastructure is expected to emerge that can produce a wide variety of highly reliable, efficient, and market responsive products, quickly, at low cost, and with minimum environmental impact. Information and communication technologies will allow distributed design and manufacturing facilities to interface electronically. This will enable the integration of product design with complex manufacturing processes. Manufacturers, both large and small will utilize "next generation intelligent machines and processes" with adaptive control which is self-inspecting and self-correcting, to create high quality products rapidly. Knowledge gained during machining and manufacturing processes will be captured and fed back to design and manufacturing data bases to enhance process understanding and improve product quality. This information will be collected in a set of electronic libraries and cataloged for future use. Some of this information will be generally available to manufacturers through the internet, while other information will be archived in company proprietary data bases. Manufacturers could then use this data to refine and improve product development and manufacturing processes.

U.S. industry will integrate highly sophisticated, next generation components into downstream products and services through close working relationships among component and end-product manufacturers and service suppliers. A strong, internationally competitive U.S. equipment builder base will provide U.S. manufacturers immediate access to the most advanced equipment and technology.

U.S. industry will be the first to develop and employ these technologies broadly and therefore will gain the primary benefits from this new approach to manufacturing.

2.2 Grand Challenge

The grand challenge is to accelerate the creation of "next generation manufacturing processes and equipment" by identifying and developing the technologies necessary to make the above vision a reality. Those technologies must then be validated and transferred rapidly to a wide spectrum of American manufacturers (both large and small) within the next ten years.

Since no single company or agency has all of the resources necessary to implement this vision, a series of partnerships and cooperative efforts among industry, government, and academe will be required. All parties will have to find new ways to work together, each contributing in their areas of greatest strength. Cultural barriers must be broken and greater trust must be developed. If this grand challenge is to be met in the next decade, a greater degree of information sharing among the participants must be fostered in order to minimize duplicate or conflicting activities.

2.3 Priorities

In response to the grand challenge, the following research and development areas have been identified as critical to the realization of "next generation manufacturing processes and equipment".

Intelligent Control Systems

Real time sensor-based control - Current sensor-based controls are most effective in continuous flow or highly repetitive manufacturing, where control systems can learn the appropriate ranges of sensor readings that characterize acceptable and unacceptable output for distinct product. Real-time sensor based control is superior to off-line programmed control of processes principally because it avoids the differences between process modeling and reality. It also provides valuable feedback to process models, thus enabling improvements with time. Manufacturing equipment and machine tools with sensor-based control must accommodate a varied mix of product designs and quantities, and therefore require more capability in the form of imbedded intelligence. This intelligence will not only be expected to gather more information, but, to perform more advanced functions as well. These functions include the assimilation, organization, understanding and communication of information, the ability to detect intangible as well as tangible variables, and the ability to detect and diagnose problems and process errors, make decisions, send higher quality information to controllers, and off-load controllers by communicating directly with actuators.

Open architecture controllers which allow users to easily interface with and modify the control software are needed to provide the flexibility to respond rapidly to changes in production demand. Controllers will also be expected to communicate with other intelligent sensors, thus requiring the development of discrete event management software. Knowledge based artificial intelligence systems, rich with rules and facts, will play a key role in the realization of this form of intelligent manufacturing, as will the application of neural networks that enable an artificial intelligence system to teach itself in real time to facilitate process understanding and decision making capability of the intelligent sensor.

Process modeling and simulation - Research in this area is essential to achieving the detailed understanding necessary to develop the knowledge bases required to accomplish the level of manufacturing process intelligence envisioned. Machining and manufacturing process parameters and behaviors must be characterized in a standard format and documented in both public and company proprietary data bases. Data from real-time process sensing can then be fed back into the process models to improve their accuracy.

A fundamental concept behind this technology is that the intelligent manufacturing process includes the ability to sense the desired (or the undesirable) characteristics or properties of a product, and has enough local intelligence to control these properties. Computer based control requires a far more detailed understanding and characterization of the fundamental behavior of manufacturing processes than was sufficient to produce acceptable product from equipment tended by a human operator. The human operator functioned partly from knowledge, but, also from experience and intuition, which must now be captured and reproduced in order to achieve the automated operation expected of intelligent control.

Rapid Prototyping Methods

Advances in rapid prototyping technologies are also needed to attain the vision of a responsive, integrated national manufacturing infrastructure. Currently, there is the need for real product prototyping as an integral part of the product realization cycle. The past decade has seen the introduction, development, and deployment of new, specialized technologies that address this need. Commonly known as Rapid Prototyping, these technologies permit the fabrication of breadbox sized, complex parts in a fraction of the time otherwise required by traditional prototype fabrication methods. No special tooling is required to make parts using this technology which further reduces process time and cost. These technologies produce parts that fulfill many of the objectives of the prototyping process, such as conceptualization, feasibility, fit check, and manufacturability assessment. While a few of the parts are functional, most are made of materials that are not structurally adequate to be used in performance applications. These technologies are finding their place in the product prototyping process, however, there is a great need to advance Rapid Prototyping technologies to improve part accuracy and fabrication speed, and introduce new materials and processes that expand the application to functional parts fabricated using these advanced techniques. Metals, ceramics, and composites are examples of engineering materials that have potential for many new applications if producible by Rapid Prototyping methods that would permit part complexities and fabrication speed not allowable using traditional methods.

New Processing Methods and Equipment

In order to make the use of composites and advanced engineered materials economical, new non-traditional processes must be developed. These new processes and technologies differ from traditional manufacturing processes because they are not feasible under manual control - they rely on modern computer aided manufacturing methods. However, their control and full integration into a complete product realization cycle will depend upon successful implementation of intelligent manufacturing processes and equipment. Equipment and sensors for new processing methods will have to be more versatile. Flexible and modular tooling will be an integral part of new processing methods.

Further development of existing non-traditional process technologies is also required. Beam technologies and nano-fabrication technologies are examples of non-traditional processes which could be used in future production environments. Data bases which include processing parameters for composites and advanced engineering materials must be created and made readily available to U.S. manufacturers in support of these technologies.

The next generation vehicle requires light weight, high strength structure that can probably only be provided by composites or other advanced, engineered materials. Current technology for composites manufacturing derives almost exclusively from the aerospace industry where manufacturing costs for advanced composites exceed $500 per pound, approximately 10 times the raw material costs. The automotive industry needs processes and materials from which it can manufacture recyclable automobile structures for $2 per pound. Low cost, composite structures might also find broad application in the construction, rail, marine, and consumer product industries.

3 Benefits

If the U.S. can take the lead in developing an advanced manufacturing infrastructure which includes "next generation" manufacturing processes and equipment the impact on international competitiveness and economic growth will be enormous. Domestic suppliers will become more competitive, manufacturing revenues will increase and trade deficits will decline. Production costs will be reduced, time to market will be improved and product quality and reliability will be enhanced.

"Next generation" intelligent manufacturing processes and equipment based on advances in underlying technologies such as computer hardware and software, sensors and controls, information processing, and innovative machining and tooling concepts will offer dramatic improvements in manufacturing cost, quality, throughput, and flexibility for low to moderate volume applications. Advanced, intelligent sensors and controls, and innovative actuators with advanced, imbedded intelligence will be vital elements of future manufacturing process and equipment systems. Individual advances in these technology areas will move the manufacturing industry closer to the goals of agility. However, the significant advances will take place when the individual technologies can be integrated into truly advanced processing systems.

New processing technologies for rapid prototyping that produce components with a broader range of mechanical properties could evolve into a new approach to manufacturing. That is, "rapid fabrication" of production quality, functional parts in a similar time scale to rapid prototyping. This could ultimately lead to the production of parts at least 10 times faster than possible by conventional manufacturing practices. This would provide significant competitive advantage in an era when time-to-market for new products is increasingly critical.

4 Other Issues

4.1 Current Government Programs and Initiatives

Development of next generation manufacturing processes and equipment will support the activities already underway in other NSTC working groups such as Partnership for Next Generation Vehicle, National Electronics Manufacturing initiative, Aeronautics Materials and Manufacturing, and Construction and

Building. There are already numerous government, industry, university, and consortium activities in progress in this area. These include:

FCIM - DoD
Agile Web Pilot Program - TRP, Ben Franklin Technology Center
AMRI's - NSF
Manufacturing Extension Partnership - NIST
Manufacturing Technology Programs. Air Force and Navy
TEAM Program - DOE
Rapid Response Manufacturing Program - NCMS/NIST ATP
Automated Manufacturing Research Facilities - NIST
LEAN Aircraft Initiative - DoD, MIT, Industry
MADE -DoD
Dual Use Reconfigurable Factory - DoD
Fastcast - DOE
Motor Vehicle Manufacturing Technology - NIST ATP

An early activity for this working group to undertake is to catalog ongoing activities, identify high priority gaps that aren't being addressed and develop a strategy to accelerate efforts in those areas. Existing partnerships and consortia should serve as the building blocks for future federally sponsored activities where possible.

4.2 Policy Focus

There has been a lot of effort in the last ten years to develop enabling technology and infrastructure for next generation manufacturing. These capabilities have not permeated industry, however because effective processes for deployment of new technology have not been implemented in the U.S. Low investment, adoption and diffusion rates are most acute for small and medium sized manufacturers. A mechanism for broad deployment of new manufacturing technologies and equipment which is affordable, easy to install, and easy to use must be developed. The government needs to expand deployment programs and develop other incentives to address this issue.

5 Recommendations

5.1 Program Areas and Priorities

A limited amount of research is already underway in the development of new manufacturing processes and equipment. However, these efforts are not well coordinated and are insufficient to achieve a significant impact on U.S. manufacturing.

The following are the research and development activities that the federal government, in cooperation with industry and academe could take to accelerate the adoption of "next generation" manufacturing processes and equipment throughout U.S. industry. Program areas have been identified along with their near term (one to three years), mid term (three to five years) and long term (five to ten years) priorities.

Intelligent Control Systems:

Near Term - Development of sensors, process-material models, and knowledge based algorithms to enable distributed control for accuracy, flexibility, and reliability in conventional manufacturing processes. Develop a cooperative national effort to characterize machining and manufacturing process parameters and behaviors in a standard format and document in both public and company proprietary data bases. Develop an integration framework and verification-validation methodology for process-material models.

Mid Term - Expand the development of process models and characterization of process parameters to additional manufacturing processes and "non-traditional" processes. Develop/deploy readily available standard open architecture controllers which allow users to easily interface with and modify the control software for manufacturing processes and equipment.

Long Term - Develop and validate neural networks that - 1) facilitate the process understanding and decision making capability of intelligent sensors and 2) enable intelligent manufacturing equipment and systems to teach themselves in real time. Develop/demonstrate knowledge based artificial intelligence manufacturing systems in small, medium and large companies in several manufacturing sectors.

Rapid Prototyping:

Near Term - Develop/demonstrate processes that improve part accuracy and fabrication speed. Introduce new materials and processes that expand the application to functional parts fabricated using these advanced techniques. Metals, ceramics, and composites are examples of engineering materials that have potential for many new applications.

Mid-Term - Demonstrate implementation of equipment/systems that are successfully developed during the near term activities. Also develop/demonstrate rapid prototyping technologies for other material classes and multi-material capabilities.

Long Term - Develop technologies for part complexities and fabrication speed not allowable using current methods. That is, "rapid fabrication" of production quality, functional parts in a similar time scale to rapid prototyping. The goal is the production of parts at least 10 times faster than possible by conventional manufacturing practices.

New Processing Methods and Equipment:

Near Term - Develop processes which reduce the cost of advanced engineered and composite materials for structural applications by a factor of at least ten. Develop flexible/modular tooling and equipment which can be adapted to a variety of sensors and controls.

Mid Term - Develop and demonstrate a reconfigurable manufacturing system with modular hardware, tooling, sensors and controls. Develop and demonstrate versatile tooling, sensors and controls which can be retrofit inexpensively and quickly onto existing manufacturing equipment.

Long Term - Develop processes which reduce the cost of advanced engineered materials for structural materials by a factor of at least 100. Develop and demonstrate intelligent precision manufacturing systems which are flexible enough to be reconfigured for low volume processes and robust enough for high volume processes.

5.3 Next Steps

Key industrial sectors should be identified where accelerated diffusion of "next generation" manufacturing processes and equipment will provide significant competitive advantage. Cooperative programs between industry, government and academe should then be established to implement the development and demonstration activities defined above.

Metrics should be established to evaluate investment, adoption and diffusion rates of new manufacturing processes and equipment in small, medium and large manufacturers. Improved competitiveness in those industries should be assessed based on metrics such as increases in sales and increase in total market share.

DRAFT

MANUFACTURING EDUCATION AND TRAINING: DEVELOPING AN EFFECTIVE MANUFACTURING WORK FORCE

Executive Summary

Our most formidable international competitors have outstanding education systems. They challenge our industrial productivity and quality to a large extent through a more highly-skilled workforce. Thus, any effective strategy to enhance competitiveness must address education and training issues.

Many factors -- the increase in global competition, the ways work is being organized and front-line workers are being deployed, the use of flexible manufacturing methods, the demand for higher quality goods, the introduction of new technologies -- have come together to change forever the dynamics of the American manufacturing workplace and require increased worker skills and education.

At the same time, the United States has been falling behind its international competitors in the technical preparation of its entry-level, non-college trained work force. Even its college-educated engineers need better preparation in integrating knowledge and focusing it on the engineering process from design through process and product realization. Furthermore, it is not sufficient simply to improve the skills of new workforce entrants; to build a workforce that can successfully compete in the world marketplace, we must also improve the skills of existing workers. Thus, education and training can no longer be viewed as a one-time, school-based problem, but must now be recognized as an ongoing necessity for lifelong learning.

To maintain its competitiveness in manufacturing the United States needs to pursue a long term strategy for building a world class workforce. This strategy should be aimed at developing a *coherent, high-quality system of education and training for manufacturing that begins in the primary and secondary schools and extends into technical schools, community colleges, and universities, empowering individuals and firms to engage in skill-building that translates into better jobs and lifelong learning for individuals, along with greater productivity and competitiveness for the nation as a whole.*

This is a systems problem; its solution requires a systems approach. While the problems to be addressed are complex and varied, six broad systemic issues stand out:

1. **The current system of workforce education and training lacks coherence.**

2. **National training policy does not directly address current workers' needs.**

3. **Workforce training programs at all levels are lacking in focus and quality.**

4. **Our educational system does not provide adequate preparation for the manufacturing workplace.**

5. Consumer information about workforce education and training is insufficient.

6. At-risk groups do not fare well in the current system.

To address these problems and achieve its strategic aims, the United States must take actions on various fronts. Workforce education and training initiatives are already underway in the Departments of Labor and Education and the National Science Foundation. The multi-agency Technology Reinvestment Project (TRP) has begun to mobilize its constituent agencies to address workforce competency and training issues as well.

The National Science and Technology Council (NSTC) can play an important role in support of this effort by funding research and training and assisting government, educational institutions, and industry to collaborate on workforce issues and to pursue research on training technologies, prototypes, and models. Following are some specific recommendations for strategies and action priorities appropriate to the NSTC:

1. **Design a Coherent Framework.** *Actions*:

- Recognize the manufacturing workforce as an input equal to technology in the production process.
- Establish a public-private partnership for implementing education/training goals.
- Prepare an annual report on Employment, Education, and Training to the President in his role as Chair of the NSTC.
- Consolidate government training programs as specified in the Re-Employment Act.

2. **Improve the Quality of Education and Training for Work.** *Actions:*

- Encourage workforce-management collaborations that involve workers from the inception in the development of education and training programs, organization of work, and employment of new technology.
- Encourage and support the development of new, innovative programs to train current workers and managers in the analytic, problem-solving, team-building capabilities increasingly needed in the new, flexible workplace.
- Support rapid implementation of the School-to-Work program.
- Encourage major reforms in lower-division college technology, science, engineering, and mathematics courses and curricula with emphasis on two-year colleges.
- Encourage K-12 schools, industry, and universities to collaborate in providing early knowledge and hands-on experience in design and manufacturing systems.
- Urge engineering schools to develop "practice-oriented" master's degree programs in manufacturing and take appropriate steps to infuse manufacturing experience across the engineering curriculum.
- Form a public-private task force to promote the development of new learning technologies and low-cost delivery systems using expert systems, interactive video, etc.

3. **Develop an Effective Consumer Information System.** *Actions:*

- Promote continued development of an electronic labor market information (LMI) system making information on the nation's training resources widely and easily available. Ensure that the system provides information about the potential impact of each option on wages, job security, and promotion opportunities, as well as productivity and other business benefits.

- Build the appropriate "information highway" linkages between the means employed to disseminate advanced manufacturing technology (e.g., Sematech, ATC's, MTC's,) and the human resources needed to make these technologies work.

4. **Ensure Access to At-Risk Populations.** *Actions:*

- Encourage restructuring the way in which elementary and secondary schooling provides workforce preparation, especially for at-risk populations, to ensure world-class standards of academic preparation, particularly in mathematics and science, and to instill the notion of manufacturing as an exciting and rewarding career.
- Urge educational systems at all levels, from kindergarten to college, to employ the best available learning strategies adapted to the learning styles of different individuals and populations.
- Provide financial incentives and support for individually-motivated training choices, including child care provision and low-interest loans.

5. **Leverage Federal Policy to Use Scarce Dollars Where They Have the Greatest Impact.** *Actions:*

- Encourage industry tax credits for participating in existing but endangered management/union apprenticeship programs.
- Incorporate training and workplace modernization into expanded federal and state manufacturing extension programs to make them user-friendly, one-stop shopping centers for both workers and managers for training and industrial modernization.
- Fund demonstration projects which implement creative, effective methods to incorporate workers and managers in training design and which promote training that firms do not usually consider to their short-term benefit.

6. **Create Supportive Market Mechanisms to Finance Manufacturing Training.** *Actions:*

- Encourage changes in taxation policies that would provide market incentives for financing manufacturing training by industry.
- Disseminate descriptions and results of innovative, high performance training
- Support cooperative training across firms.

7. **Measure Results.** *Develop, validate, and deploy assessment metrics, such as:*

- Program output (e.g., program participants and related performance data such as training/education courses completed, certifications obtained, placements in job. new degree programs, short courses, delivery systems etc.).
- Program impacts (e.g., comparing pre- and post-program wages by crossmatching Unemployment Insurance wage records with program participants).
- Industry-specific skill standards and nationally recognized means of determining and certifying whether an individual has achieved those skill levels.

- New metrics/models for measuring the economic, societal, and learning impacts of manufacturing education and training, for example, gains in real income (workers), productivity (industry), worker skills, and basic literacy (e.g., follow-on studies to National Assessment of Educational Progress (NEAP) research).
- Deployment of models/tools (percentage of companies affected).

Background And Context

Since the time of the first Industrial Revolution, manufacturing has been the basis for a strong, diverse, and growing US economy. That fact has not changed. However, many factors -- changes in the workforce and to the economy, more global competition, changes in how work is being organized, the introduction of flexible manufacturing, the demand for higher quality goods, the introduction of new technology -- have come together to change the dynamics of the American manufacturing workplace and to create a need for new and higher skills in Americans workers

Some key points can be made about today's manufacturing work place and the environment for manufacturing:

- Manufacturing covers a wide range of technologies and concepts, and encompasses the full spectrum of materials, products, and processes upon which the American industrial enterprise is based. It includes a broad range of economic activities from chemical and biotechnology processing to electronic component and system fabrication, durable goods production, fabrication of structures, and other sectors.

- The intellectual and physical resources which underpin all manufacturing must now be viewed as including not only plant and equipment but also a *skilled workforce*. The ability of businesses to expand and succeed in the emerging, high-technology, global economy depends not only on trade agreements, technology, capital investment, and physical infrastructure, but also on the skills, creativity, and ingenuity of their workforce.

- There has been an immense increase in the demand for *higher quality* and *customized* products; these require more flexible manufacturing methods.

- There have been dramatic changes in manufacturing technologies and in the way these technologies are used. Significant constraints have also been placed upon manufacturing by new standards, environmental laws, and regulations.

- More and more industrial products and processes are science- or advanced technology-based. That means that all those employed in manufacturing need to know more about the basic science and mathematics underlying their roles in the manufacturing process (e.g., materials science, metallurgy, chemistry, digital processing theory, statistics and probability theory). These disciplines were previously considered to be the province of engineers and research professionals.

- The economics of investing in new technologies and complying with environmental regulations also require very different manager and worker capabilities. The training resources and structures needed to impart these capabilities have also changed (e.g., more emphasis on use of teams and team building, lateral thinking as well as vertical thinking, synthesis as well as analysis, flexibility as well as efficiency, experiential as well as abstract learning).

- The way in which front line workers are being used in manufacturing has also changed: organizational structures are leaner, flatter, more flexible; greater use is made of teams; workers are being empowered. As a result, many manufacturers are down-sizing their workforces, but higher skills are required of those front line workers who remain on the job.

- These changes, taken as a whole, have led to an increase in the requirements for worker skills and education. At the same time, the US has been falling behind its international competitors in the technical preparation of its entry-level, non-college-educated work force. Many of our workers are only at a 5th-grade competency level.

- While the US still leads the world in graduate education and in research, it does not provide sufficient practical experience for its college-trained engineers and technicians.

- Demographics tell us that it is not sufficient simply to improve the skills of new workforce entrants. To build a workforce that can compete successfully in the world marketplace, we must also improve the skills of existing workers.

- Thus, education and training can no longer be viewed as a school-based problem alone but must now be addressed as a ongoing issue requiring lifelong learning.

Systemic Issues

This is a systems problem, and its solution requires a systems approach. There are six broad, systemic problems with the way in which the United States currently educates and trains its manufacturing workforce:

1. **The current system lacks coherence.** We have neither a clear vision of a framework within which people are prepared for the modern manufacturing workplace nor a coordinated strategy for achieving the vision. In fact, many manufacturers still do not recognize or accept that there is a whole new domain of competence within which the manufacturing workforce from the shop floor through engineering to management must operate. There is a need for government, industry, and education at all levels to come together to conceptualize, internalize, accept, and act upon their long-term responsibility for developing manufacturing and maintaining a highly skilled, flexible, diverse workforce. The strategy ought to begin at the pre-college levels and continue on through higher education and practice. At present, too many suggested approaches

focus only on the short-term, too many programs have separate requirements and contradictory purposes, and too little coordination across programs occurs.

2. **National training policy does not directly address current workers' needs.** Historically, US public investments in the workforce have emphasized training the disadvantaged, retraining the unemployed, and preparing new workers. Economic necessity now dictates that we place a higher value on training incumbent workers. Traditionally, responsibility for this training has been left to the individual employer, yet most small and mid-sized businesses have neither the resources nor the know-how to carry out that responsibility. We must recognize this reality and develop training policies that take this into consideration.

3. **Efforts to provide education and training to the existing workforce are unfocused and of uneven or unknown quality.** The quality of many government-sponsored training programs is suspect. Moreover, there are no generally accepted standards against which to measure the outcomes of these programs to determine whether they are successes or failures. The US trails other industrialized nations in shop floor workforce competence and in non-college workforce preparation, some by as much as 6 to 7 years in terms of competency test level.

4. **Our educational system does not adequately prepare students to meet the requirements of the manufacturing workplace.** Our nation's school systems, which provide the new supply of workers to manufacturing, are still focused primarily on the college-bound student and do not devote sufficient resources or prestige to technical preparation in scientific, mathematical, and engineering principles for the non-college bound student. In contrast, many of our international competitors have outstanding education systems for non-college bound students and, through strong ties to the business community, enable an excellent school-to-work transition. Moreover, the scientific focus of contemporary engineering educational programs neglects training in integrating knowledge to solve problems and make things. Engineering students lack experience with the continuum from design through process or product realization.

5. **There is a lack of good, easily available information for consumers on workforce education and training programs, their admission standards, costs, and effectiveness.** Students and workers have no way of knowing whether a given course or program of study is likely to raise their incomes by helping them get a new job or a better job or improve their skills for their existing job. Employers lack related information on how such courses or programs will meet their needs for workforce skill development. There is no easily accessible source of reliable information about different training vendors, the skill requirements of available jobs, or the sources of financial assistance for training. Moreover, we lack the metrics to gauge whether our public and private workforce investment decisions are sound and whether they provide a sufficient return on investment.

6. **At-risk groups do not fare well in the current system.** Programs for at-risk populations appear to have had mixed success; many have not been effective in raising levels of achievement, increasing wages, or improving employment levels.

The systemic nature of the problem means that efforts to improve manufacturing education and training must be part of an overall, coordinated strategy for optimizing the system involving various sectors, organizations, disciplines, etc.

Challenges And Constraints

Significant constraints impede the improvement of manufacturing education and training; overcoming these is the primary challenge facing any initiative for change.

1. **Recognition.** Many US manufacturers do not recognize or accept that there is a problem with the education and training of their workforce. Many still treat workforce as a cost not as an asset, using measures such as "revenue per employee." On the other hand, the lay public still holds to the old-fashioned notion of manufacturing as a mundane operation, one not very attractive to bright young minds.

2. **Resources.** Many small- and medium-sized manufacturers do not have the resources or know-how to train/retrain their existing workforce, nor do they have the sophistication needed to determine what kind of training is required or how it can best be delivered. While many consultants can provide this service, their cost may discourage utilization. Community college training programs are gaining in sophistication but are not yet equal to those offered by professional consulting firms. Further, managers will increasingly channel training resources to transmitting firm- and technology-specific skills rather than the development of the conceptual skills increasingly needed in high performance, rapid response manufacturing -- problem-solving, analytic, and communication skills. The market does not provide strong enough incentives to fund an adequate supply of programs that develop these critical capabilities.

3. **Return on Investment.** Even in companies where the necessary resources are available, workforce training must compete with other investment priorities, such as new plant and equipment, which are known to provide a positive return on investment. A broad, general connection between dollars invested in training and dollars returned has not yet been demonstrated.

4. **Infrastructure.** Most manufacturing firms have neither the technical infrastructure to apply technology to training at the factory site (for example, interactive, computer-based instruction, distance learning) nor the in-house expertise to apply the latest learning theory for adult learners to their workforce. "Information highway" linkages are needed to facilitate the use of available training technology. Further, neither schools nor private sector training programs have viewed generic analytic, problem-solving, and communication skills as part of their mission, yet these capabilities are urgently needed throughout the workforce to support competitive manufacturing.

5. Competition. Some companies fear that investments in the skills of workers are too portable and that they may lose those investments to competitors. To reduce this risk, strategies need to be developed that reduce inter-firm competition for trained workers, e.g., using consortia of firms that make training investments, developing a process for establishing skill standards for similar manufacturing jobs in order to enhance skill transferability, certification of worker skills. The TRP and the Departments of Labor (DOL) and Defense (DOD) have begun such efforts in collaboration with, and with support from, industrial firms.

6. Incentives. Many workers, managers, and trade associations are already overcommitted; adding an additional training burden may be overwhelming to them. Incentive systems need to be devised that reward workers for continuous learning, e.g., pay-for-learning, skills-based instead of seniority-based pay, tying promotions to training.

7. Information. Currently there is no one place that manufacturers and workers can go for easy access to information about resources available to them, what works and what doesn't, or how they should structure future investments in information technology infrastructure to ensure access to training-related innovations.

8. Marketing. There is a need to establish throughout American society the ability to understand, value, and identify with modern manufacturing so as to gain the interest of youngsters and attract the best young minds to manufacturing.

9. Integration. We must find ways to emphasize integration over priorities; the former embraces while the latter divide, even though some prioritization is needed. We can build strength through integration of disciplines, of different types of manufacturing, of different skill sets.

10. Values. Value, judgment, and character-building (in addition to knowledge and know-how) must become a significant part of the manufacturing education and training agenda; they are key factors in creating teamwork, mutual responsibility, communal good, and positive work ethics in any systems endeavor such as manufacturing.

11. New Ideas. We must find ways to identify, teach, and/or deploy relevant concepts and good practices from research and from overseas regarding both management and technology, e.g., organization of work, metrics, new educational methodologies, new instructional technologies.

12. Credentialing. Government, education, and industry must collaborate to establish both the skill standards needed if the US is to have a world-class technical workforce in the 21st century and the portable credentials by which those skills can be measured and recognized by prospective employers. Credentialing of unconventional skills presents a special challenge. DOL and the Department of Education (DOED) have begun such a skills standards program under the auspices of Goals 2000 legislation.

Current Initiatives

Federal Government

Eight Federal Departments and agencies support current initiatives in manufacturing education and training: the Departments of Defense, Education, Commerce, Energy, Labor, and Veterans Affairs; the National Aeronautics and Space Administration; and the National Science Foundation. Specific initiatives include:

- New and proposed statutes: "The Goals 2000: Educate America Act," "The School-to-Work Opportunities Act," and "The Reemployment Act" to establish one-stop shops and a National Labor Market Information System.
- The National Institute of Standards and Technology (NIST) Advanced Technology Projects (ATP) program.
- The expansion of the NIST Manufacturing Technology Centers (MTC) program; in this regard, NIST and DOL have developed a partnership to enhance the capacity of the MTC's by establishing linkages to workforce development services.
- The DOL demonstration project with the American Association of Community and Junior Colleges (AACJC).
- The Advanced Technological Education program of the National Science Foundation (NSF).
- Manufacturing education programs in several of the NSF-sponsored Engineering Education Coalitions, including the New Manufacturing Education Coalition, which will have as its focus the integration of engineering education with work experience in advanced manufacturing processes.
- National Workforce Assistance Collaborative; a project funded by DOL to create tools for and provide assistance to small and medium sized businesses that help them address literacy, technical training, labor-management relations, and work restructuring issues. Participants include state and local governments, industries, community colleges, and universities.
- Government/Industry partnerships under the interagency Technology Reinvestment Project (TRP); investments through the TRP in developing educational programs that support manufacturing industry needs, including practice-oriented master's degrees, workforce training, and traineeships for displaced defense workers. An example is the Manufacturing Education and Training (MET) competition.
- The Office of Technology Assessment (OTA) is creating a national data base on best workforce practices.
- ETA (spell out) funds a Technology Training Resources Clearinghouse.
- DOL's Office of the American Workplace promotes high-performance workplace practices, including training, employee involvement, and worker-manager partnerships.

Education

Efforts by the educational system to alleviate some of the problems described earlier are documented in the draft report, "Using Telecommunications to Support Learners and Achieve the National Education Goals," prepared under the USE-IT project of the CCSSO (spell out), dated December 1993

A variety of curricular projects focused on manufacturing are underway and in planning stages in response to federal funding initiatives noted above. Additional programs in this area are being supported by private industry, foundations, and the institutions themselves.

<u>Industry</u>
Relevant industry efforts are documented in several reports issued between 1992 and 1994 as products of the Work Force Readiness Project, a joint effort of the National Association of Manufacturers and the Department of Labor.

One excellent example is the "Learning Consortia Projects." This is a DOL-funded program to encourage partnerships among small (mostly manufacturing) companies combining to leverage training resources and achieve economies of scale to upgrade the skills of their workforces.

Proposed Action Plan

<u>**Vision**</u>
Advanced manufacturing systems will require a coherent, high-quality system of manufacturing education and training that begins in the elementary and secondary schools and extends into technical schools, community colleges, universities, and the workplace. This education and training system will build workforce skills that translate into better jobs and lifelong learning for individuals, greater productivity for industry, and sustainable prosperity for the nation.

<u>**Target Populations**</u>
Federal programs and policies must address the needs of four primary groups:

- in-school youth in grades K-20, including those in school-to-work programs;
- youth and young adults without a high school diploma or with limited English-language skills;
- unemployed youth and older adults with a high school diploma or equivalent training and/or job experience; and
- workers who need updated or new skills to perform a current job or advance.

In addition, of course, there is a continuing need to attract bright young people to pursue careers in manufacturing.

<u>**Strategic Priorities**</u>
There are six broad strategies which can provide an integrated Federal approach to addressing the workforce education and training needs of these target populations. These strategies, along with recommended action priorities, are as follows:

1. Design a Coherent Framework. Education and training programs must work in a coherent and coordinated manner. Duplicative or ineffective programs should be eliminated, and multiple programs with similar purposes and target populations, consolidated. This framework should use, modify, and strengthen existing social institutions, e.g., find ways to encourage businesses to train incumbent workers and managers and, at the same time, provide incentives for workers to upgrade their skills or acquire new skills. Transitions from one part of the system to another should be as smooth and as clear as possible. There is need for greater transparency in the objectives, methods, and expected results of each training program. The depth of skills or capabilities and the quality of programs need to be clear for managers and workers to make informed choices among the many competing suppliers and types of training. *Action priorities include*:

- Recognize the manufacturing workforce as an input equal to technology in the production process.
- Establish a public-private partnership for implementing education/training goals.
- Prepare an annual report on Employment, Education, and Training to the President in his role as Chair of the NSTC.
- Consolidate government training programs as specified in the Re-Employment Act.

2. Improve the Quality of Education and Training for Work. Education and training for manufacturing workers must meet high standards of program quality and outcome. Flexible firms will increasingly require analytic and creative thinking capabilities for problem-solving, along with communication skills for working in new ways with colleagues. These are goals that our training programs do not conventionally address. Information and instructional technology should be used to improve the productivity of learning systems for both youth and adults. Learning can be enhanced using simulations, tutorials, expert systems, and networking for professional development as well. Urgently needed are curricula and course modules for workforce training that integrate science, mathematics, statistics, and engineering principles into workforce training materials. Involving workers in curriculum development will improve both the methodologies and the appropriateness of training programs. *Action priorities include:*

- Encourage workforce-management collaborations that involve workers from the inception in the development of education and training programs, organization of work, and employment of new technology.
- Encourage and support the development of new, innovative programs to train current workers and managers in the analytic, problem-solving, team-building capabilities increasingly needed in the new, flexible workplace.
- Support rapid implementation of the School-to-Work program.
- Encourage major reforms in lower-division college technology, science, engineering, and mathematics courses and curricula with emphasis on two-year colleges.
- Encourage K-12 schools, industry, and universities to collaborate in providing early knowledge and hands-on experience in design and manufacturing systems.
- Urge engineering schools to develop "practice-oriented" master's degree programs in manufacturing and take appropriate steps to infuse manufacturing experience across the engineering curriculum.
- Form a public-private task force to promote the development of new learning technologies and low-cost delivery systems using expert systems, interactive video, etc.

3. Develop an Effective Consumer Information System. Clear, consistent, and current information about local job markets, skill requirements of potential jobs, costs and outcomes of available education and training programs and services, and sources of financial assistance must be easily accessible to all consumers, including both workers and company managers. The Federal Government has a role in supporting the development of, and in diffusing, appropriate management tools that effectively estimate the value of returns from training investments. The system must allow individuals to make informed choices. For example, the electronic access to Labor Market Information currently under development in the Department of Labor could be expanded to offer customized and local information on training options. *Action priorities include:*

- Promote continued development of an electronic labor market information (LMI) system making information on the nation's training resources widely and easily available. Ensure that the system provides information about the potential impact of each option on wages, job security, and promotion opportunities, as well as productivity and other business benefits.
- Build the appropriate "information highway" linkages between the means employed to disseminate advanced manufacturing technology (e.g., Sematech, ATC's, MTC's,) and the human resources needed to make these technologies work.

4. Ensure Access to At-Risk Populations. While a federal workforce training policy should address the broad needs of a coherent, high quality system for all, it should retain a focus on ensuring access for at-risk populations, which are least likely to receive training in the private sector. Federal training programs for at-risk populations must be of sufficient intensity and quality that youth and adults acquire the skills needed for long-term self-sufficiency. *Action priorities include:*

- Encourage restructuring the way in which elementary and secondary schooling provides workforce preparation, especially for at-risk populations, to ensure world-class standards of academic preparation, particularly in mathematics and science, and to instill the notion of manufacturing as an exciting and rewarding career.
- Urge educational systems at all levels, from kindergarten to college, to employ the best available learning strategies adapted to the learning styles of different individuals and populations.
- Provide financial incentives and support for individually-motivated training choices, including child care provision and low-interest loans.

5. Leverage Federal Policy to Use Scarce Dollars Where They Have the Greatest Impact. Innovative approaches are required to assure that limited Federal funds support actions with the greatest potential return on investment. Support should be directed at research in learning theory, advanced delivery systems, and metrics. Tax credits for participating in management-union apprenticeship programs should be considered, along with the use of existing industry-specific business-government collaborative groups as a medium to inform managers of apprenticeship programs. Expanding these programs to include union or other representatives of the workforce would make them an effective means to modernize apprenticeship and other training efforts as technologies change. Access to training programs and program information can be dramatically widened through the soon-to-be-expanded MTC/extension service system; the MTC's can become, in effect, one-stop shopping centers for manufacturing education and training programs. *Action priorities include:*

- Encourage industry tax credits for participating in existing but endangered management/union apprenticeship programs.
- Incorporate training and workplace modernization into expanded federal and state manufacturing extension programs to make them user-friendly, one-stop shopping centers for both workers and managers for training and industrial modernization.
- Fund demonstration projects which implement creative, effective methods to incorporate workers and managers in training design and which promote training that firms do not usually consider to their short-term benefit.

6. Create Supportive Market Mechanisms to Finance Manufacturing Training. Competitive pressures and the short-term framework that limits business options discourage firms from training adequately if at all. The Federal Government can give leadership in developing new, creative methods to encourage firms and individuals to train for the new demands of the workplace. Possibilities include changing the tax system so that firms can treat training expenses as capital investments rather than one-time costs, tax credits for assessments of an employer's skills and training needs, and loan programs (guarantees, deferred payback, or subsidized interest rates) for workers in firms that do not finance their own training. *Action priorities include:*

- Encourage changes in taxation policies that would provide market incentives for financing manufacturing training by industry.
- Disseminate descriptions and results of innovative, high performance training.
- Support cooperative training across firms.

7. Measure Results. In a time of budgetary austerities and pressing social needs, the effectiveness of Federal investments must be measured and understood. For manufacturing education and training programs the following types of assessment metrics should be developed, validated, and deployed.

- Program output (e.g., program participants and related performance data such as training/education courses completed, certifications obtained, placements in job. new degree programs, short courses, delivery systems etc.)
- Program impacts (e.g., comparing pre- and post-program wages by crossmatching Unemployment Insurance wage records with program participants)
- Industry-specific skill standards and nationally recognized means of determining and certifying whether an individual has achieved those skill levels
- New metrics/models for measuring the economic, societal, and learning impacts of manufacturing education and training, for example, gains in real income (workers), productivity (industry), worker skills, and basic literacy (e.g., follow-on studies to National Assessment of Educational Progress (NEAP) research)
- Deployment of models/tools (percentage of companies affected)

The subcommittee recommends that the NSTC pursue the above strategies and action priorities in the context of *teaming, sharing, leveraging, and integrating.*

DRAFT

Manufacturing Deployment and Implementation: Helping Companies Modernize

1. Background

Manufacturing is Important to the U.S. Economy

Manufacturing is an especially vital segment of the U.S. economy, representing about a fifth of the U.S. Gross National Product over the past 40 years. Almost 19 million Americans (over 20% of the private sector workforce) are employed directly in manufacturing firms.[1] Numerous other firms provide services to this sector and are indirectly responsible for millions more jobs and substantial economic activity.

Smaller Manufacturers are Important

Manufacturers with fewer than 500 employees are an especially important part of the manufacturing enterprise. These small manufacturing establishments contribute more than half (54.5%) of the value added in manufacturing and employ 63% of all manufacturing employees - approximately 12 million Americans.

Smaller shops and factories supply many of the component parts needed by larger firms, and are an integral part of the supply chain for both commercial and defense products. About 80% of their output is in the form of parts used in higher value-added products, such as machine tools, computers, and consumer goods.[2] As more major manufacturers make the shift to distributed manufacturing - essentially outsourcing production of parts and subassemblies to suppliers - the role of these smaller suppliers becomes even more important.

Global Trends

Even a cursory look at the global trends in manufacturing businesses shows significant changes in the technologies and how they are employed. The changes range from the introduction of new equipment and manufacturing methods to new business and management practices. They are occurring on the individual factory floor as well as in entire industry sectors. They include the concepts of increasing agility/flexibility of the operation and "batches of one", as well as an increasing distributedness of the processes. More and more, larger companies are focusing their operations and relying on their suppliers for the design and engineering aspects of their products as well as the creation of the components, subassemblies, and systems.

These trends affect the climate in which smaller manufacturers function in a global economy. Unfortunately, they are not responding to these changes as quickly as needed to remain competitive in this environment.

Small Manufacturers Face Barriers to Change

Many small manufacturers are operating far below their potential. An estimated 70% of U.S. smaller firms lag behind larger companies and international competitors in adopting modern manufacturing equipment and practices. In addition, small firms have clear cut problems establishing networks of contacts with external sources of scientific and technological expertise.[3]

The National Research Council, in its report *Learning to Change: Opportunities to Improve the Performance of Smaller Manufacturers,* identified five barriers to change and modernization that afflict our nation's small manufacturers.[4]

1) *Lack of awareness.* **Small firms are often unfamiliar with changing technologies, production techniques, and business management**

practices. Since they must devote most of their time and energies to managing day-to-day operations, small firms are less likely to be aware of best manufacturing practices, innovative applications of new technologies, and fresh approaches to improved production efficiency. With less relevant experience and expertise, small manufacturers are unlikely to risk investing in major management restructuring or new relationships within their business.

2) *Isolation.* **Small manufacturers have few opportunities to interact with other companies in similar situations.** Exposure to other firms is essential for continuous improvement and imperative for understanding new practices, technologies and services. Small firms have insufficient opportunities to trade information and network.

3) *Where to seek advice.* **Owners and managers of small firms often have great difficulty finding and identifying sources of high-quality unbiased advice, information and assistance.** The expertise of educational institutions, experts for hire, and other private sector service providers is often geared towards serving large companies. Many consultants do not market their services to small companies because the payoff is too small. Vendors often push technologies that are neither appropriate nor affordable for small companies. Accessing public sector resources such as federal and state programs can prove confusing. These problems lead to a general feeling among small business owners that assistance is neither affordable nor easily found.

4) *Disproportionately burdensome regulatory environment.* **National, state and local regulations and initiatives on issues from trade to the environment have a direct impact on the operations of small manufacturers.** The amount of time and effort required to comply with such regulations is much greater for small shops as a percentage of capital investment than it is for larger companies. There is a general feeling that regulations are so cumbersome and difficult to track that small businesses may be in violation unknowingly. Small companies have few places they can go for advice in this area, either due to the lack of affordable consulting or because they are afraid that inquiries will result in plant visits and subsequent citations.

5) *Financing.* **Difficulty obtaining operating capital and investment funds for modernization is a pervasive problem for small manufacturers.** Larger firms enjoy greater access to certain forms of financial credit like equity and debt issues.[5] The financial community often does not readily understand manufacturing, especially small, more risky companies. This community often perceives loans for new equipment, quality programs such as TQM or ISO 9000[6], and worker training as unattractively high risk. To make matters worse, small firms are not only unlikely to have the capabilities needed to put together funding proposals, but also are often slow to recognize the need or economic justification for making investments in technology and people required to remain competitive.

As a result of these five barriers, small U.S. companies are adopting technology at comparably lower rates than large U.S. firms. A 1988 U.S. Census Bureau survey of manufacturers found that of the 17 technologies included in the study, numerical and computer-numerical control (NC/CNC) was the only technology in which the usage rate for plants with 20-99 employees was more than half that of plants with more than 500 employees (large companies).[7] This problem is also observable when U.S. small firms are compared to foreign counterparts, such as for NC/CNC machine tools, the adoption rate among small Japanese firms is one and half times faster than the rate of U.S. small companies.[8]

Small manufacturers frequently are also slow to adopt modern business approaches and workforce practices: advanced workforce training, empowerment, modern workplace organization, modern business and information systems, and additional issues related to marketing and finance. They are less likely to see their operations in terms of continuous improvement, requiring the constant upgrading of business and operational approaches related to their competitiveness in the market place.

Mechanisms of Deployment

The Federal government has long recognized the need to fund or co-fund technology research and development in support of agency missions. Historically, the emphasis has been on basic research with funding support provided to universities and Federal laboratories. More recently, there has been an effort to more fully capture the fruits of that R&D by transferring technology developments into the marketplace. In the 1980's, the Federal government implemented the Stephenson-Wydler Act and the Federal Technology Transfer Act which created technology transfer mechanisms that included the Cooperative Research and Development Agreements (CRADAs) in addition to the more traditional mechanisms employed by the Federal agencies and laboratories: publication and presentation of R&D results, and direct funding of R&D by companies, joint ventures, and consortia. These mechanisms assume that the technologies created by these agencies in support of their missions are of value to companies beyond those associated with that mission. The identification of and interactions with appropriate recipients for these technologies requires a substantial investment on the part of the agencies, both of the R&D staff and technology transfer specialists, for development of technology descriptions, intellectual property licenses, and other aspects of the technology transfer process.

A second mechanism relies on the training and subsequent placement of undergraduates and graduate students in industrial organizations and organizations which interact extensively with industry. This takes the knowledge created in the nation's university system and moves it via individuals to the manufacturing enterprise. While very effective, it relies on companies being in a position to hire these new graduates and integrate them into their operations. Manufacturing training and education aspects are discussed in a different white paper.

More recently, the Federal government, in collaboration with the States, has focused on manufacturing extension centers and services which use a combination of technical generalists and specialists, in concert with other types of resources, to directly assist companies in identifying and implementing appropriate technology in their operations. These operations can more quickly and effectively reach substantial numbers of manufacturers than can the other two mechanisms, and help them realize the value of newer technologies.

Manufacturing extension services, as they have evolved, are more focused on the broad array of needs of the client companies from the client companies' perspective, whether technological, business, or training-oriented, than are other technology deployment mechanisms. The underlying assumption is that technology implementation must be complemented by changes in other aspects of the manufacturing operation/business such as workforce training and business/management systems, and that the acquisition of new equipment and the associated processes of change will require financial resources, either from internal cash flows or external sources. In this respect, they complement other types of technology deployment or technology transfer activities by providing an orderly, focused, and disciplined set of distribution channels which can identify both useful technologies for companies, and "first-implementor", or risk-taking companies willing to invest in applications of new technologies, business and management practices, etc. A comprehensive system of such centers and services provides opportunities for smaller manufacturers to acquire the skills and tools needed to modernize their operations and businesses and for technology vendors to more readily access the aggregate market of smaller manufacturers.

The U.S.' extension services reflect the experiences of several models. The first is the cooperative extension service (CES), created some 70 years ago[9] primarily to assist the agricultural industries, and co-funded by the Federal government, the states, and localities. In this model, extension agents work with both individual farmers and groups of farmers in all aspects of their operations: agricultural technologies as well as business and community development aspects.

The second set of models are those found in the international arena, in particular, Japan and Germany. The Japanese model includes 170 Kohsetsushi centers, funded by the national government and the local prefectures, which provide technical assistance to smaller companies. The German model includes collaborative applied research between the Federal government and companies through the Fraunhofer Institutes, and an extensive apprenticeship program. Other international models include manufacturing networks such as those found in Italy and Denmark to share resources and capabilities.

2. Closing the Gap: Helping Small Manufacturers to Modernize

Federal Programs and the Manufacturing Extension Partnership

At the federal level, an array of government initiatives are beginning to help manufacturers to adopt modern technologies, techniques and workforce approaches (see Box 1 below). The Manufacturing Extension Partnership (MEP), managed by the Commerce Department's National Institute of Standards and Technology, is the primary federal activity in industrial extension targeted at small manufacturers.

The national MEP is a direct response to the problems small manufacturers face. The program's mission is to help small manufacturers adopt appropriate technologies, techniques, and business and workforce approaches in order to improve product quality, cost and time to market. To achieve this, the MEP provides small manufacturers with a point of entry or "gateway" to the nation's service providers and technology sources, including:

- Federal agencies, federal laboratories and other national-level organizations
- State and local economic development programs
- Private consultants, experts and equipment vendors
- Universities, community colleges and technical schools
- Large companies, trade associations, and professional societies

BOX 1: FEDERAL MANUFACTURING DEPLOYMENT ACTIVITIES

Department of Defense (DOD). The largest federal sponsor of manufacturing-related R&D and still the largest single consumer of manufactured products, the DOD has increasingly funded activities in manufacturing technology deployment. For example, a large portion of the Advanced Research Projects Agency's budget for example is devoted to manufacturing, funding programs such as agile manufacturing. Many manufacturing initiatives also have been managed through the Manufacturing Technology Program (ManTech), and the Best Manufacturing Practices program. The Technology Reinvestment Project (TRP), a six agency collaboration including NIST and its MEP and chaired by DOD, targets defense reinvestment and the adoption and dissemination of dual-use technologies. Many of the TRP-funded projects in manufacturing deployment are managed by the MEP.

Department of Labor (DOL). With the responsibility for workforce well-being, concerns about the competitiveness of U.S. firms has led DOL to expand its efforts in the critical area of human resource development. DOL has launched three new initiatives designed to assist firms enhance the skill level of U.S. workers: the improvement of high school graduates' job preparedness level, a system of industry-based skill standards, and creative efforts to help small companies meet their needs for a highly skilled and flexible workforce.

The national MEP is working with the Office of the American Workplace and the Employment and Training Administration, to further integrate workforce training and advanced workplace practices into extension center activities. With support from MEP and DOL, many extension centers have plans to address the specific training needs of client manufacturers, including the development of a Human Resource Assessment Tool for extension agents working directly with companies, Learning Consortia projects to help small businesses access worker training resources, state planning grants to integrate workforce training and technology deployment, and pilot projects in the development of supplier networks and related training programs.

Environmental Protection Agency (EPA). With a traditional focus on reducing risk to human health and the environment, protecting ecosystems, and preventing pollution, the EPA has embarked on a new Environmental Technology Initiative (ETI) to accelerate environmental protection, strengthen America's industrial base, and increase exports of U.S. technologies and expertise. One of the primary areas in this initiative calls for accelerating the commercialization and diffusion of environmental technologies domestically, particularly focused at the manufacturing base.

The EPA and the national MEP are collaborating in a number of areas, including formal joint projects in environmentally conscious manufacturing and source reduction which are important components of national extension activities. In addition, the EPA is directly participating in the development of a set of protocols and other tools for assessing manufacturing operations which integrate energy, environmental and competitiveness factors.

Small Business Administration (SBA). With a mission to foster the general development of U.S. small businesses of all types – with no particular focus on manufacturing or technology – the SBA generally emphasis loan guarantees, start-ups, and minority businesses. Small Business Investment Corporations (SBICs) serve to develop partnerships between the American entrepreneur and the venture capital community. Small Business Development Centers (SBDCs) provide assistance to start-ups and existing business in the areas of business plan development and financial planning.

The SBA is working with the MEP to co-locate manufacturing field offices of the SBDCs at MEP extension centers. This gives small manufacturing firms, through the national MEP, expanded access to the modernization resources of the SBDCs and the wider resources of SBA.

Department of Energy (DOE). As manager of a large network of research laboratories, DOE develops advanced manufacturing technologies, primarily to support its energy and defense missions. DOE has expertise in various advanced manufacturing disciplines, and many DOE national laboratories have full-time technology transfer staff who have begun to emphasize helping smaller manufacturers access laboratory technologies. They also are linking up with the MEP.

BOX 1: FEDERAL MANUFACTURING DEPLOYMENT ACTIVITIES, CONTINUED

Oak Ridge National Laboratory and the MEP-funded Southeast MTC are exploring ways to transfer laboratory expertise and technology in precision machining to the bearing industry. Allied-Signal, which operates a DOE production facility in Kansas City, MO has a relationship with the Mid-America MTC allowing service providers and client firm access to the facility. Lawrence National Laboratory and the California MTC have developed seminars on "environmental manufacturing." Great Lakes MTC recently transferred a hydrogen sensor developed at the Sandia National Laboratories to a small company's monitoring system, greatly reducing the cost of the system.

National Aeronautics and Space Agency (NASA). NASA maintains a network of technology access centers that help industry identify problems that are being addressed at NASA or in other federal agencies or laboratories.

The NASA-Lewis Research Center is working with the MEP-funded Great Lakes extension center to identify technologies that will be appropriate for the Center's clients; the NASA center is seeking to gain a better feel for the needs of small manufacturers. In addition, joint training programs for outreach agents and linkages between electronic databases soon will be established between NASA and the MEP.

U.S. Department of Agriculture (USDA). The USDA maintains a large network of cooperative extension agents to help farmers in every aspect of the agriculture enterprise, such as new technology adoption, dissemination of new discoveries and the application of organization and planning techniques. With the number of farms steadily declining, USDA cooperative extension agents are increasingly delivering services that would traditionally be referred to as industrial extension, working in the areas of industrial agriculture, food processing and wood product industries.

In order to expand its technology orientation the USDA plans to work more closely with the MEPs to better utilize USDA's cooperative extension agents and the national MEP's network of extension organizations.

Department of Commerce (DOC). Several DOC manufacturing deployment programs assist small companies. In particular, both the National Institute of Standards and Technologies (NIST) and the National Technical Information Service (NTIS) have roles in helping U.S. manufacturers' improve their competitive capabilities. Over the past decade, NIST has been the primary federal agency focusing on the technological needs of small manufacturers. In addition to managing the expanding MEP, NIST's activities include the Advanced Manufacturing Research Facility and other laboratory activities, the Malcolm Baldrige National Quality Award, and the Advanced Technology Program. The NTIS, a centralized source of information exchange is expected increasingly to be an efficient clearinghouse of technical information, markets and other learning opportunities for industry.

The national MEP fulfills the technology-oriented needs of small manufacturers first and foremost through manufacturing extension centers. These centers are "locally grown", non-profit organizations that are not part of the federal government. Federal funding is at most half of a center's total budget, so centers are coalitions of local, state and regional organizations - both public and private sector - united to fulfill the needs of small manufacturers. Centers often have direct ties to larger manufacturers as well.

The Clinton Administration has set the goal of creating a nationwide network of 100 extension centers by 1997 within reach of all 373,000 U.S. small manufacturers and serving all fifty states. With the added support provided recently through the Technology Reinvestment Project (TRP), there are currently 44 MEP extension centers across the U.S. with a cadre of well over 500 field agents and specialists, mostly professional engineers or experts with manufacturing or business experience (See Box 2 below). With MEP guidance and assistance, many states are planning or implementing programs that will likely evolve into MEP extension centers in the near future.

BOX 2: ONE-STOP SHOPPING OHIO STYLE

The Great Lakes Manufacturing Technology Center (GLMTC), a non-profit technology deployment program based in Cleveland, Ohio, provides one-stop shopping for Northern Ohio manufacturers. With 11 field engineers and 25 in-house technical specialists, GLMTC provides services in a variety of areas demanded by small companies. This includes:

- Assessments evaluating overall needs of a company, benchmarking services and appraisals of human resource practices.
- Information services, including an in-house information center which has access to more than 3,000 databases worldwide.
- Technical consulting services in a variety of areas including quality systems, manufacturing engineering and design, CAD/CAM/CAE, and business management systems.
- Environmental programs, offering services ranging from waste reduction and environmental assessments to recycling advice and energy audits.
- Technology events including tours, seminars, workshops, monthly luncheon forums and teleconferences.

Working directly with companies, the GLMTC staff helps companies identify areas of need. The first eight hours of service is always free. Once an improvement project has been identified, service is provided by GLMTC staff directly or through other resource partners at market prices. GLMTC's partnerships with industry, academia and government allow clients to access nearly any technology service they need and provide true one-stop shopping for local small manufacturers.

Each center has a unique structure and service delivery approach based on the needs of local client companies. Interactions with these companies are tailored to specific needs, from in-depth assessments of entire business operations to specialized training seminars and follow-on assistance as new technology, techniques and processes are brought on-line.

Example: Implement New Technologies
Legion Lighting, Inc. requested help from the New York extension center to seek alternatives to using a chlorinated solvent which releases volatile organic compounds (VOCs) into the air. The New York field engineers are currently providing their technical experience, and knowledge of appropriate service providers in the area, to help the Brooklyn-based company implement cleaning and coating technologies that will meet both the rigorous standards of the Clean Air Act and the competitive demands of their market.

Example: Adoption of Modern Business and Workforce Approaches
Manufacturing Development, Inc., was told by Boeing it needed to meet Boeing's stringent quality standards – or risk losing their business. The company contacted the Mid-America Manufacturing Technology Center (MAMTC) in Overland Park, Kansas, which provided on-site training in Statistical Process Control, required under the Boeing program. The training program was coordinated with both in-plant data collection and the development of capability studies, all required by Boeing. The company received certification and retained its Boeing account.

Example: Use Best Manufacturing Practices
Photo Sciences, Inc., a producer of photomasks used to produce microchips, found that the increasing cost of required technologies and fierce foreign competition meant the company was losing money. The owner asked for an overall assessment of his company by the California Manufacturing Technology Center (CMTC). The assessment uncovered a higher than previously estimated rework and scrap problem. Photo Sciences worked with a CMTC staff member to implement the controls and tracking systems to identify specific causes of the scrap problem until a full-time engineer could be hired.

In addition to its extension centers, the national MEP manages a network of extension support systems – mostly pilot projects funded through TRP – designed to enhance the ability of the national MEP to deliver high quality, high impact extension services. Examples include:

- Electronic communication among extension organizations and the MEP, eventually evolving to include all national service providers as well as client companies.
- National interactive satellite telecasts designed to meet specific needs of client companies (See Box 3 below).
- National training programs for extension agents and forums for discussion of issues pertaining to service delivery.
- Common extension tools, such as automated assessment protocols for assisting extension agents working with companies, benchmarking services for companies, and service modules for common training programs.
- Management tools for extension centers such as information systems and databases and evaluation metrics and approaches.

BOX 3: NATIONAL INTERACTIVE TELECASTS

The National Technological University, a non-profit educational organization, is leading an effort to provide national interactive satellite telecasts on topics of interest to small manufacturers attempting to improve their manufacturing competitiveness. Lawrence Livermore and Oak Ridge/Y-12 National Laboratories, the American Society of Mechanical Engineers and other technical societies, MEP extension centers, and private companies will serve as the source of technical expertise for the telecasts. Access to the telecasts nationwide will be provided through MEP extension centers, educational institutions, and other technology providers.

The MEP is constantly exploring new technology sources, delivery mechanisms and communication routes in order to provide the most appropriate services *in the most appropriate manner* to small manufacturing clients. The partnership program is involved in a number of TRP-funded alternative deployment pilot projects and other new ventures focused in the following areas:

- Electronic commerce
- Group services (see Box 4 below)
- Large company partnering and supplier chain activities
- Sector-specific service approaches

- National-level delivery systems

BOX 4: MANUFACTURING NETWORKS
When small manufacturers organize into units that jointly produce, market, learn or tackle problems, each participant has greater exposure to information, technology trends, skills and resources. Companies that collaborate are better placed to improve performance, capture new or expanding markets, and generally to overcome barriers to modernization.
Regional Technology Services, Inc. (RTS) in Chapel Hill, North Carolina, is looking to spur the design and implementation of manufacturing networks and other approaches to inter-firm cooperation. In partnership with 15 states (and growing), RTS is providing manufacturing network services, including customized technical assistance, education and training, performance metrics, interstate learning groups, a resource center, and linkages to international expertise. These services are delivered primarily by private sector experts from companies and organizations that use collaboration as an integral business strategy. Lessons learned from this pilot project will be disseminated nationally.

3. Benefits and Measuring Results

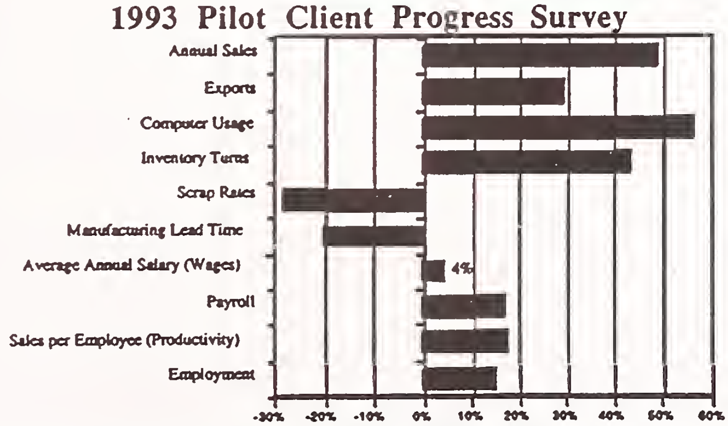
Program Impacts

Although the MEP is a young and rapidly growing program with a limited scale of manufacturing extension efforts undertaken thus far, the results of analyses --supplemented by case studies and anecdotal evidence -- illustrate the large potential for significant benefits to companies and the economy. Fifteen months of evaluation data from the seven oldest centers and three months of data from five newer centers show that manufacturing firms are reporting total economic benefits of almost $7 for every federal dollar that the centers receive. This conservative estimate undervalues the impact of extension center services, including only technical assistance projects and associated activities of the extension services. It does not include the "soft" services, such as seminars and informational interactions and referrals, which many firms consider very beneficial, even though their impacts are extremely difficult to quantify.

Company-level Impacts

A recent pilot survey provides some insight into the company-level impacts of MEP activities. A group of client companies served in 1991 were surveyed on various performance measures in the years before and after service, as summarized in Chart 1.

Chart 1:
1993 Pilot Client Progress Survey



Note: 55 Returned Surveys from GLMTC, NYMEP and SMTC client companies who received service in 1991. Percentages compare actual company performance from 1990 and 1992 mean company data.

In addition, at the end of company engagements all client firms are asked to estimate, as a direct result of the services provided, the impacts they perceive from working with the MEP extension center. Chart 2 illustrates the most recent totals from reporting extension centers for both average impacts and on a per project bases.

Chart 2:
Self-Reported Company Totals

	Yearly total	Project Average for Year
Change in Sales	$60,122,400	$191,473
Capital Spending	$15,650,648	$49,843
Capital Avoidance	$3,738,100	$11,905
Reduction in Inventory	$5,500,797	$17,518
Labor&Material Savings	$7,465,681	$23,776
Jobs Created or Saved	1,491	4.75

Note: 314 companies returning surveys, July, 1993 - June, 1994

National Evaluation System

In addition to impact data, the MEP is developing a national evaluation system designed to assess the effectiveness of service coordination at the local, regional and national levels, and apply evaluation as a management tool for continuous improvement of service mixes and service delivery approaches. In order to meet the goal of delivering high impact services that meet the needs of small manufacturers, many evaluation tools and systems are under development including standard reporting systems, client surveys, assessment tools, information data systems, benchmarking services, extension center evaluation plans, and evaluation awareness training programs. These evaluation tools should be usable to all organizations involved in providing extension services and products to smaller manufacturers.

4. Next Steps...

Strategic Thinking

To be successful, technology deployment activities must be committed to several key principles. First and foremost, they must be industry-driven and market-defined. In the absence of this feature, these activities are only so much "technology push", the effectiveness of which will be limited. Second, the structure, strategies, and services have to be integrated with the state and local resources, which define the economic community of which each individual firm is a part. Third, there must be a commitment to high quality, continuous improvement, and innovation. Fourth, there must be a commitment to performance measurement which focuses on the bottom-line results realized by the companies. Fifth, the technologies, products and services have to be focused on those companies which demonstrate a commitment to investing in their own growth and development. Finally, the services provided have to focus on activities which assist the companies in overcoming their unique barriers to improved competitiveness. The future of an effective technology deployment system relies on expanding and weaving together a group of extension programs and extension support activities into a coherent national system that is proactive and forward looking, meeting the needs of small manufacturers. To the extent that additional extension centers, supporting programs, and other related projects are added to the national system, they should be established through merit-based, competitive processes.

MEP's legislative mandate,[10] and the mandate for most of the Federal laboratories under the Stephenson-Wydler Technology Transfer Act,[11] focused narrowly on the transfer of advanced laboratory technologies. A comprehensive technology deployment system has begun to emerge and its strategic focus has changed considerably. Growth areas are outlined below.

- Strengthen and integrate related and specialized services to small manufacturers through the expansion of:
  - Workforce reorganization, the upgrade of technical skills, and the implementation of high performance workplace environments
  - Marketing and product development services
  - Expansion of access to financing
- Leverage and improve on the existing infrastructure of enabling services to extension centers, which involves:
  - Packaging and disseminating existing manufacturing assessment and educational tools
  - Creating new tools that help in the comprehensive identification and assessment of manufacturing problems, including the areas of business management, advanced workforce practices, and energy and the environment
- Expand the use of leveraged delivery mechanisms that utilize:
  - Supplier chains
  - Manufacturing networks (group activities)
  - Continuous improvement working groups
  - Electronic networks (information resources & electronic commerce)
- Remain agile and flexible, and thus:
  - Continuously evaluate customer needs
  - Utilize training and continuously upgrade extension staff skills

These activities involve the continuation and expansion of cooperative efforts with all national resources, including other federal technology development and deployment programs, state extension activities, educational institutions, private sector consultants and experts, trade associations and societies, and large companies.

Institutional Feedback

In order to build a nationally-coordinated system, the MEP recommends the following changes:

- Identify administrative and technical requirements, associated with environmental regulations that are difficult for small companies to achieve.

- Better utilize the talents and resources within the Energy Department's national laboratory system to help small manufacturers and service providers access lab technologies that best fulfill their needs in a timely and affordable fashion.

- Incorporate the unique needs of small manufacturers into the workforce skills and workplace reorganization programs implemented by the Department of Labor and the nation's community colleges, among others.

- Improve methods to assess the risk and feasibility of technology and other modernization activities in small companies, helping the Small Business Administration and the U.S. banking industry to improve small manufacturers' access to capital.

- Reflect, to a greater degree, the modernization needs of small companies in the national R&D infrastructure, including at federal agencies and in educational institutions.

Streamline collection, access and use of data in the area of manufacturing dynamics, characteristics and technologies. Expand the sampling of small manufacturers in federal databases, including, among others, the Bureau of Census' Longitudinal Research Datafile (LRD) and the Bureau of Labor Statistics' Unemployment Insurance (UI) database.

Notes

[1]The percentage of employment cited is for manufacturing *establishments* for the year 1990, as cited in County Business Patterns, Bureau of the Census. It should be noted that small manufacturing *enterprises* (which, unlike establishments, do not count branch plants) accounted for 35% of manufacturing employment for the period 1972-88 as a whole, as cited in *Gross Job Flows in U.S. Manufacturing*, 1994, page 18.

[2]"Helping Manufacturers Build a Technological Advantage", NIST Manufacturing Extension Partnership, U.S. Department of Commerce, March 1993.

[3]Roy Rothwell and Mark Dodgson; "External Linkages and innovation in small and medium sized enterprises" R&D Management 21,2 1991.

[4]The five barriers are cited directly from *Learning to Change*: *Opportunities to Improve Performance of Smaller Manufacturers*, National Research Council (Washington, DC: National Academy Press), 1993.

[5]*Gross Job Flows in US Manufacturing, 1994.* On the relationship between firm size and financing patterns, see Walker (1989) and Gaston (1989).

[6]TQM stands for Total Quality Management, a program designed to bring systematic quality programs to all facets of a company. ISO9000 is a set of standards created by the International Standards Organization for certifying the quality of production.

[7]*Manufacturing Technology: Factors Affecting Adoption 1988*, Bureau of the Census, DOC; as cited in *Learning to Change*, op. cit., page 20.

[8]"Helping Manufacturers Build A Technological Advantage," NIST MEP, U.S. DOC, March 1993.

[9]Dorothy Schwieder, *75 Years of Service: Cooperative Extension in Iowa*, Iowa State University Press, Ames, 1993.

[10]The enabling legislation of the original Manufacturing Technology Center (MTC) Program and the State Technology Extension Program (STEP) – subsequently combined to form the MEP – was the 1988 Omnibus Trade and Competitiveness Act.

[11]The Stephenson-Wydler Technological Innovation Act of 1980, the Federal Technology Transfer Act of 1986, and their amendments provide the basic legislative framework under which Federal agencies may transfer their technologies to industry.

Final Participants List

2nd Annual Manufacturing Technology Conference: Toward a Common Agenda
April 18-20, 1995
National Institute of Standards and Technology (NIST)
Gaithersburg, Maryland

John Adams
Honda Engineering
24,000 Honda Pkwy.
Marysville, OH 43040-9251
USA

Cheryl Albus
NIST
Bldg. 304, Rm. 142
Gaithersburg, MD 20899-0001
USA

James Albus
NIST
Bldg. 220, Rm. B124
Gaithersburg, MD 20899-0001
USA

Gene Allen
The Maneal-Schwendler Corp.
11911 Freedom Dr.
Ste. 750
Reston, VA 22090
USA

Bruce Allison
Resources, Trade & Tech.
Fairfax, VA
USA

William Alzheimer
Sandia National Labs.
P.O. Box 5800
MS 0953
Albuquerque, NM 87185-0953
USA

Edward Amatucci
NIST
Bldg. 220, Rm. B124
Gaithersburg, MD 20899-0001
USA

Gary Bachula
U.S. Dept. of Commerce
14th & Constitution Ave., NW
MS HCHE-4822
Washington, DC 20230
USA

John E. Bafford
Westinghouse
P.O. Box 746
MS 124
Baltimore, MD 21203
USA

William Bailey
The Boeing Co.
20403 68th Ave.
P.O. Box 3999, MS 87-95
Seattle, WA 98124-2499
USA

Bob Barnett
Texas Instruments
P.O. Box 650311
MC 540
Dallas, TX 75265
USA

Vern Bean
NIST
Bldg. 222, Rm. A317
Gaithersburg, MD 20899-0001
USA

Frank Beard
Marine Mechanical Corp.
23555 Euclo Ave.
Cleveland, OH 44117
USA

Donald Beard
Consultant
9201 Gue Rd.
Damascus, MD 20872
USA

Gilbert Benavides
Sandia National Labs.
P.O. Box 5800
MS 0958
Albuquerque, NM 87185
USA

John Berkowitch
National Textile Center
3352 Morningside Rd.
Wilmington, DE 19810
USA

Jack Berry
Westinghouse
P.O. Box 746
MS 131
Baltimore, MD 21203
USA

Robert Bescher
Pratt & Whitney
17900 Beeline Hwy.
MS 717-11
Jupiter, FL 33458
USA

Diane Bird
U.S. Dept. of Energy
1000 Independence Ave., SW
DP-14, GP-180
Washington, DC 20585
USA

Donald Blomquist
NIST
Bldg. 233, Rm. B108
Gaithersburg, MD 20899-0001
USA

Howard Bloom
NIST
Bldg. 220, Rm. A127
Gaithersburg, MD 20899-0001
USA

S. Howard Bluth
U.S. Navy BMP
2231 Crystal Dr.
Ste. 815
Arlington, VA
USA

Howard Bluth
Martin Marietta Energy
P.O. Box 2009
MS 8011
Oak Ridge, TN 37931-8011

Mark Bohannon
U.S. Dept. of Commerce
Washington, DC 20230
USA

Brad Botwin
U.S. Dept. of Commerce/BXA
Washington, DC 20230
USA

Douglas Braithwaite
MIT
One Amherst St.
MS E40-422
Cambridge, MA 02139-4307
USA

Peter Brown
NIST
Bldg. 304, Rm. 12
Gaithersburg, MD 20899-0001
USA

Bob Brown
Deneb Robotics, Inc.
3285 Lapeer Rd., West
P.O. Box 214687
Auburn Hills, MI 49321-4687
USA

Joe Brown
Battelle
505 King Ave.
Columbus, OH 43201
USA

Dewayne Brown
AlliedSignal-Kansas City Div.
2000 E. 95th St.
MS D1824/BW31
Kansas City, MO 64141-6159
USA

Peter Butenhoff
Textile Clothing Tech. Corp.
211 Gregson Dr.
Cary, NC 27511
USA

Neil Carlson
The Timken Co.
1000 Timken Place
Lincolnton Bearing Pl.
Iron Station, NC 28080
USA

Kevin Carr
NIST
Bldg. 301, Rm. B121
Gaithersburg, MD 20899-0001
USA

Deborah Carr
CIMS
1400 Eye St.
Ste. 540
Washington, DC 20005
USA

Peter Carroll
Solar Turbines, Inc.
818 Connecticut Ave., NW
Ste. 600
Washington, DC 20006
USA

Gary Carver
NIST
Bldg. 220, Rm. B322
Gaithersburg, MD 20899-0001
USA

Esther Cassidy
NIST
Bldg. 101, Rm. A1111
Gaithersburg, MD 20899-0001
USA

Dudley Caswell
U.S. Dept. of Defense
1110 Artic Quill
Herndon, VA 22070
USA

Alan Claflin
DOE-ERLTT
1000 Independence Ave., SW
Washington, DC 20585
USA

Dorothy Comassar
GE Aircraft Engines
One Neumann Way
MD C67
Cincinnati, OH 45215-1988
USA

Gary Conkol
CAMP
2415 Woodland Ave.
Cleve, OH 44115
USA

Jack Cook
Martin Marietta
P.O. Box 2009
Bldg. 9737, MS 8091
Oak Ridge, TN 37831-8091
USA

Peter Corte
SAIC
1710 Goodridge Dr.
MS 2-3-1
McLean, VA 22102
USA

Robert Cottriel
ECS Composites
3560 Rogue River Hwy.
Grants Pass, OR 97527
USA

John Coulter
Lehigh University
19 Memorial Dr., West
Packard Laboratory
Bethlehem, PA 18015-3085
USA

Tim Crawford
EMPF
714 N. Senate Ave.
Indianapolis, IN 46202
USA

Dan Cundiff
Defense Research & Engineering
3030 Defense Pentagon
Rm. 3D367
Washington, DC
USA

Nicholas Dagalakis
NIST
Bldg. 220, Rm. B124
Gaithersburg, MD 20899-0001
USA

Ralph Day
Applied Research Lab.-PA Univ.
P.O. Box 30
Penn State Universty
State College, PA 16804
USA

John DeCaire
NCMS
3025 Boardwalk
Ann Arbor, MI 48108
USA

Richard Dewey
ERDEC
Bldg. E3549
MS SCBRD-EN
Aberdeen Prov. Grnd., MD 21010
USA

George Dieter
Univ. of Maryland
1 Locksly Court
Silver Spring, MD 20904
USA

Alkan Donmez
NIST
Bldg. 233, Rm. B106
Gaithersburg, MD 20899-0001
USA

Brendan Doyle
U.S. EPA
401 M St., SW
Washington, DC 20460
USA

Kenneth Dreitlein
United Technologies Research
411 Silver Spring Lane
MS-129-14
East Hartford, CT 06108
USA

Arthur Dunning
Dyn Corp., ATS
4401 Ford Ave.
Ste. 300
Alexandria, VA 22302
USA

Dean Eatedali
Westinghouse
P.O. Box 746
Baltimore, MD 21203
USA

William Eikenberg
Westinghouse Electric
P.O. Box 746
MS 126
Baltimore, MD 21203
USA

Al Elkins
National Systems Management Corp.
4600-H Pinecrest Office Park Dr.
Alexandria, VA 22312
USA

Donald Elson
Black & Decker
701 E. Joppa Rd.
TW 070
Towson, MD 21286
USA

Dick Engwell
Westinghouse Electric Corp.
P.O. Box 746
MS G-15
Baltimore, MD 21203
USA

Bill Ennen
Univ. of Mass.
Donahue Inst., Middlesex House
P.O. Box 35520
Amherst, MA 41354-2005
USA

Robert Epstein
Sikorsky Aircraft
6900 Main Street
MS 305A
Stratford, CT 06499
USA

Clifford Erickson
Honeywell, Inc.
3660 Technology Dr.
MS MN65-2300
Minneapolis, MN 55418
USA

Kathy Erickson
Sandia National Labs.
1401 Wilson Blvd.
Ste. 1000
Arlington, VA 22209
USA

Donald Esterling
Microcompatibles
301 Prelude Dr.
Silver Spring, MD 20901
USA

Klaus Evele
NUWC, KPT
610 Dowell St.
Keyport, WA 98345
USA

Frank Ewasyshyn
Chrysler Corp.

Joe Falco
NIST
Bldg. 220, Rm. B127
Gaithersburg, MD 20899-0001
USA

Peter Farbaniec
E.J. Brooks Company
164 N. 13th St.
Newark, NJ 07107
USA

James Farmer
Martin Marietta
P.O. Box 2009
9737, MS 8091
Oak Ridge, TN 37831
USA

John Felton
DuPont Electronics
14 T.W. Alexander Dr.
RTP, NC 27709
USA

John Ferguson
EDS
5555 New King St.
Troy, MI 48098
USA

Thomas Fiorino
Production Tehcnology, Inc.
2231 Crystal Dr.
Suite 815
Arlington, VA 22202
USA

S. Jeane Ford
NIST
Bldg. 220, Rm. A127
Gaithersburg, MD 20899-0001
USA

Donald Foster
Lawrence Berkeley Laboratory
One Cyclotron Rd.
MS 90-2148
Berkeley, CA 94720
USA

Donald Fowler
F&F Associates, Inc.
2063 S. Glebe Rd.
Arlington, VA 22204
USA

Leon Fuller
U.S. Dept. of Commerce/BXA
Washington, DC 20230
USA

Frederick Funk
Westinghouse
8377 Tamar Dr.
Ste. 627
Columbia, MD 21045
USA

Cita M. Furlani
NIST
Bldg. 415, Rm. 102
Gaithersburg, MD 20899-0001
USA

Francis X. Gavigan
Argonne National Lab.
1 Bank Street
Ste. 250
Gaitherbsurg, MD
USA

Demetria Giannisis
Chicago Manufacturing Center
3333 W. Arthington
Chicago, IL 60624
USA

Paul Giles
NACFAM
1331 Pennsylvania Ave., NW
Ste. 1410, North Tower
Washington, DC 20004-1703
USA

Dave Gilsinn
NIST
Bldg. 233, Rm. B102
Gaithersburg, MD 20899-0001
USA

David Godfrey
Manufacturing Resources
7813 First Place
Cleveland, OH 44146
USA

Steven Goldman
Agility Forum
125 Goodman Dr.
Bethlehem, PA 18015
USA

Kenneth Goodwin
NIST
Bldg. 220, Rm. B124
Gaithersburg, MD 20899-0001
USA

Robert Graham
Boeing Defense & Space Group
P.O. Box 3999
MS 3E-28
Seattle, WA 98124-2499
USA

Cary Gravatt
U.S. Dept. of Commerce/TA
HCHB, Rm. 4841
Washington, DC 20280
USA

Michael Gresalfi
MMES
14506 Ascot Sq.
Boyds, MD 20841
USA

Maurice Gritzman
Chicago Manufacturing Center
3333 W. Arthington
Chicago, IL 60624
USA

John Gudas
NIST
Bldg. 101, Rm. A430
Gaithersburg, MD 20899-0001
USA

David Gulley
State of Illinois
100 W. Randolph
Ste. 3-400
Chicago, IL 60601
USA

Greg Guy
Radiodetection Corp.
4102 Deepwoods Dr.
Austin, TX 78731
USA

Ruth Haines
NIST
Bldg. 224, Rm. B115
Gaithersburg, MD 20899-0001
USA

William Hanson
MIT/Leaders for Manuf. Program
One Amherst St.
Ste. E40-422
Cambridge, MA 02139-4307
USA

Richard Hartke
National Center for Advanced Tech.
1250 Eye St., NW
Ste. 1100
Washington, DC 20005
USA

Dale Hartman
CAM-I
1250 E. Copeland Rd.
Ste. 500
Arlington, ~~VA~~ TX 76011
USA

Barry Hass
Raytheon Company
50 Apple Hill Dr.
MS T3TN46
Tewksbury, MA 01876
USA

Wayne Hawkins
Center for Innovative Tech.
2214 Rockhill Rd.
Ste. 600
Herndon, VA 22070-4005
USA

Jorma Helin
Technology Development Center
Halminkatn 34
MS 0100
Helsinki
FINLAND

Jim Henderson
OCIDM
203 Engineering North
Stillwater, OK 74078
USA

Edward Hensel
New Mexico State Univ.
P.O. Box 30001
Dept. 3450, Rm. 113
Las Cruces, NM 88003-0001
USA

Martin Herman
NIST
Bldg. 220, Rm. B124
Gaithersburg, MD 20899-0001
USA

Merrill Hessel
NIST
Bldg. 245, Rm. B102
Gaithersburg, MD 20899-0001
USA

Nathan Higginbotham
McDonnell Douglas Aerospace
P.O. Box 516
MS 064 1420
Saint Louis, MO 63166
USA

Donald Hitchcock
Harris Corp.
P.O. Box 99000
MS M1N-2401
Melbourne, FL 32902
USA

Michael Hitchcock
U.S. Air Force
WL/MTI
2977 P St.
WPAFB, OH 45431
USA

Maynard Holliday
LLNL
20201 Century Blvd.
First Floor
Germantown, MD
USA

Sungho Hong
KIMM
8301 Greensboro Dr.
Ste. 470
McLean, VA 22102
USA

Clyde Hopkins
Martin Marietta Energy Group
1099 Commerce Park
Oak Ridge, TN 37830
USA

John Horst
NIST
Bldg. 220, Rm. B124
Gaithersburg, MD 20899-0001
USA

Alex Hou
U.S. Dept. of Commerce
14th & Constitution Ave., NW
Rm. 7060
Washington, DC 20230
USA

William Hull
McDonnell Douglas Aerospace
1510 Hughes Way
MS 54-25
Long Beach, CA 90810
USA

Paul Huray
Univ. of South Carolina
300 South Main St.
MS A-139B
Columbia, SC 29208
USA

Shirley Hurwitz
NIST
Bldg. 225, Rm. A266
Gaithersburg, MD 20899-0001
USA

Kate Ingle
U.S. Dept. of Commerce
14th & Constitution Ave., NW
Rm. 7064
Washington, DC 20230
USA

Martin Jackson
DOE Kansas City Plant
2000 E. 95 St.
MS D/392 E2E7
Kansas City, MO 64141-6159
USA

Richard Jackson
NIST/MEL
Bldg. 220, Rm. B322
Gaithersburg, MD 20899-0001
USA

Raymond Kammer
NIST
Bldg. 101, Rm. A1134
Gaithersburg, MD 20899-0001
USA

Ramesh Karne
Univ. of Maryland
A.V. Williams Bldg.
Inst. for Systems Res.
College Park, MD 20742
USA

Richard Kegg
Cincinnati Milacron
4701 Marburg Ave.
Cincinnati, OH 45209
USA

Charles Keith
Loral Vought Systems
P.O. Box 650003
MS L-53-06
Dallas, TX 75265-0003
USA

Ernest Kerzicnik
GE Aircraft Engines
One Neumann Way
MS G408
Cincinnati, OH 45215-6301
USA

Christopher Kim
U.S. Dept. of Commerce
14th Street, N.W.
MS 7064
Washington, DC 20230
USA

Byung Kim
Univ. of Mass.
219 E. Lab.
Dept. of Mech. Eng.
Amherst, MA 41354-2005
USA

Brad Kirkwood
Boeing Defense & Space
3417 S. 120th Place
Bldg. 2103, Door N3
Tukwilla, WA 98168
USA

Bob Kleiber
Caterpillar, Inc.
P.O. Box 1875
TC-K Fab. Struct.
Peoria, IL 61656-1875
USA

David Koegel
DOE-Office of Energy Research
1000 Independence Ave., SW
ER-80/Rm. GA-155
Washington, DC 20585
USA

Stephen Koknat
Dyn Corp. ATS
4401 Ford Ave.
Ste. 300
Alexandria, VA 22302
USA

Sean Krieger
NUWC, KPT
610 Dowell St.
MS C/2012
Keyport, WA 98345
USA

Norm Kuchar
GE Corporate R&D
River Rd.
MS KWD227
Schenectady, NY 12301
USA

Paul Kugelman
DuPont Co.
Delaware Tech. Park
Rm. 426, 1 Innovation Way
Newark, DE 19714-6108
USA

Daniel LaPlant
Solar Turbines, Inc.
2200 Pacific Hwy.
M/Z V-1
San Diego, CA 92186
USA

John Lampe
Lockheed Martin
5600 Sandlake Rd.
MS MP150
Orlando, FL 32819-8907
USA

Neal Laurance
Ford Motor Co.
P.O. Box 2053
MS 2247 SRL
Dearborn, MI 48121
USA

Tina Lee
NIST
Bldg. 220, Rm. A127
Gaithersburg, MD 20899-0001
USA

Douglas Lemon
Pacific Northwest Lab.
3320 Q St.
P.O. Box 999, 219/K7-80
Richaland, WA 99352
USA

John Lepore
Technology Services, Corp.
982 Wayne Ave.
Ste. 800
Silver Spring, MD 20910
USA

Lionel Levinson
General Electric
River Rd.
Bldg. K1-MB, 159
Schenectady, NY 12301
USA

William Lewandowski
Aerospace Industries Assoc.
1250 Eye St., NW
Washington, DC 20005
USA

Marshall Lih
NSF

Alice Ling
NIST
Bldg. 233, Rm. B114
Gaithersburg, MD 20899-0001
USA

Joe Lombardo
Johns Hopkins University
Johns Hopkins Rd.
Laurel, MD 20723
USA

Craig Long
Milliken & Co.
920 Milliken Rd.
MC M-186
Spartanburg, SC 29303
USA

Denver Lovett
NIST
Bldg. 304, Rm. 142
Gaithersburg, MD 20899-0001
USA

Mark Luce
NIST
Bldg. 304, Rm. 12
Gaithersburg, MD 20899-0001
USA

George Lundberg
E.J. Brooks Company
164 N. 13th St.
Newark, NJ 07107
USA

Susan Lusi
U.S. International Trade Co.
500 East St., SW
MS 511E
Washington, DC 20436
USA

Robert Mandl
DOE Kansas City Plant
2000 E. 95 St.
MS D/281 E2E7
Kansas City, MO 64141-6159
USA

Stephen Maness
U.S. Army Material Command
5001 Eisenhower Ave.
Attn: AMCRD-IE, Rm. 8S44
Alexandria, VA 22333-0001
USA

Larry Martin
Lockheed Fort Worth Co.
P.O. Box 7487
MS 1420
Fort Worth, TX 76101-0748
USA

Michael Mastracci
Techmatics, Inc.
12450 Fairlakes Circle
Suite 800
Fairfax, VA 22033-3832
USA

Howard McCue
Lawrence Livermore Lab.
7000 East Ave.
MS L-792
Livermore, CA 94550
USA

Michael McDermott
Carice Associates
18948 Whetstone Cir.
Gaithersburg, MD 20879
USA

Charles McLean
NIST
Bldg. 220, Rm. A127
Gaithersburg, MD 20899-0001
USA

Matthew McLean
Resources, Trade & Tech.
Fairfax, VA
USA

Robert Meier
Los Alamos National Lab.
ESA-EA
MS P946
Los Alamos, NM 87544
USA

Eugene Meieran
Intel
5000 W. Chandler
MS C3-63
Chandler, AZ 85226
USA

Aris Melissaratos
Westinghouse Electric Corp.
1310 Beulah Rd.
Bldg. 801-3C54
Pittsburgh, PA 15235-5098
USA

Steve Mercer
Caterpillar, Inc.
Tech Center-K
P.O. Box 1875
Peoria, IL 61656
USA

Elena Messina
NIST
Bldg. 220, Rm. B124
Gaithersburg, MD 20899-0001
USA

John Meyer
National Science Foundation
4201 Wilson Blvd.
MS 590
Arlington, VA 22230
USA

Mike Michaelis
U.S. Dept. of Energy
1000 Independence Ave., SW
MS DP-14/GP-180
Washington, DC 20585
USA

Kevin Miller
Society of Manuf. Eng.
1101 Wilson Blvd.
Ste. 1100
Arlington, VA 22209
USA

Charles Millick
BDM Federal
555 Quince Orchard Rd.
Ste. 400
Gaithersburg, MD 20878
USA

John Mills
Univ. of Texas at Arlington
7300 Jack Newell Blvd., S.
Forth Worth, TX 76118-7115
USA

Howard Moncarz
NIST
Bldg. 220, Rm. A127
Gaithersburg, MD 20899-0001
USA

Cynthia Montgomery
NIST
Bldg. 220, Rm. B322
Gaithersburg, MD 20899-0001
USA

Edward Morris
Loral Vought Systems
P.O. Box 650003
MS L53-03
Dallas, TX 75265-0003
USA

William Muir
Eaton Corp.
1111 Superior Ave.
Cleveland, OH 44114
USA

Tom Munns
NAS/Manufacturing Studies Board
2101 Constitution Ave., NW
Washington, DC 20418
USA

Richard Neal
Martin Marietta
P.O. Box 2009
MS 8068
Oak Ridge, TN 37831-8068
USA

Joyce Nettleton
Inst. of Food Technologies
221 N. LaSalle St.
Ste. 300
Chicago, IL 60601-1291
USA

Herman Nied
LeHigh University
19 Memorial Dr., West
Packard Laboratory
Bethlehem, PA 19015-3045
USA

Raoul Noel
NCMS
3213 Whispering Pine Dr.
Ste. 13
Silver Spring, MD
USA

Sandra Novinger
Rockwell Collins
855 35th St., NE
MS 137-108
Cedar Rapids, IA 52498
USA

James O'Connor
Kennametal, Inc.
Route 981, South
P.O. Box 231
Lantrobe, PA 15650
USA

Rand Oliver
Martin Marietta Energy Systems
1099 Commerce Park
Oak Ridge, TN 37830
USA

Jean Owen
SME
1 SME Dr.
Dearborn, MI 48069
USA

Joel Pacheco
IIT Research Institute
10 West 35th St.
Chicago, IL 60616
USA

Ronald Parsons
NIST/MEP
Bldg. 301, Rm. C121
Gaithersburg, MD 20899-0001
USA

Anand Paul
Concurrent Technologies Corp.
11605 Bedfordshire Ave.
Potomac, MD 20854
USA

Gordon Pavy
AFL-CIO
815 Sixteenth St., NW
Ste. 301
Washington, DC 20006
USA

Jim Peoples
Lockheed Fort Worth Co.
P.O. Box 748
MS 2492
Fort Worth, TX 76101
USA

Louisa Perdieu
AlliedSignal, KCP
2000 E. 95th St.
MD 40
Kansas City, MO
USA

Cornelia Pernik
Actionline Magazine
AIAG
26200 Lasher Rd.
Southfield, MI 48034
USA

Thaddeus Pertowski
GEC-Marconi
150 Parish Dr.
MS 18A 86
Wayne, NJ 07474-0936
USA

Steven Phillips
NIST
Bldg. 220, Rm. B113
Gaithersburg, MD 20899-0001
USA

Robert Pierce
Lockheed Martin
1 Plastics Ave.
MS 1756A
Pittsfield, MA 01201
USA

Jack Pokrzywa
AIAG
26200 Lahser Rd.
Ste. 200
Southfield, MI 48034
USA

Arati Prabhakar
NIST
Bldg. 101, Rm. A1134
Gaithersburg, MD 20899-0001
USA

Fred Proctor
NIST
Bldg. 220, Rm. B127
Gaithersburg, MD 20899-0001
USA

Dan Prono
Los Alamos National Lab.
P.O. Box 1663, MS K571
Los Alamos, NM 87545
USA

Jean Pustis
PTI
Three Crystal Park
2231 Crystal Dr., Ste. 815
Arlington, VA 22202
USA

Richard Quintero
NIST
Bldg. 101, Rm. A1000
Gaithersburg, MD 20899-0001
USA

Herbert Rabin
Univ. of Maryland
Engineering Research
Potomac Bldg., Rm. 2120
College Park, MD 20742
USA

Bill Radcliffe
NIST
Bldg. 304, Rm. 142
Gaithersburg, MD 20899-0001
USA

Steven Ray
NIST
Bldg. 220, Rm. A127
Gaithersburg, MD 20899-0001
USA

Brenda Ray
NIST
Bldg. 304, Rm. 142
Gaithersburg, MD 20899-0001
USA

Danny Reed
Inst. for Defense Analyses
1801 N. Beauregard St.
Rm. 201
Alexandria, VA 22311-1772
USA

Ernest Renner
Office of Naval Research
800 North Quincy St.
Rm. 633, Code 36
Arlington, VA 22217-5600
USA

Robert Reuter
U.S. Dept. of Energy
1000 Independence Ave., SW
MS GP180/DP-14
Washington, DC 20585
USA

Victor Rhoder
Deneb Robotics, Inc.
3285 Lapeer Rd., West
P.O. Box 214687
Auburn Hills, MI 49321-4687
USA

Chuck Rice
Chrysler Corp.
30900 Stephenson Hwy.
MS CIMS 463-00-00
Madison Heights, MI 48071
USA

Karen Richter
IDA
1801 N. Beauregard St.
Alexandria, VA 22311-1772
USA

Harold Rife
EMPF
714 N. Senate Ave.
Indianapolis, IN 46202
USA

Kamie Roberts
NIST
Bldg. 225, Rm. A231
Gaithersburg, MD 20899-0001
USA

Phillip Roether
Texas Instruments
8505 Forest Lane
MS 3131
Dallas, TX 75243
USA

Robert Rolfe
Inst. for Defense Analyses
1801 N. Beauregard St.
MS CSEO/Rm. 300
Alexandria, VA 22311
USA

Jack Rossen
Rutgers Univ.-CAFT
120 New England Ave.
Piscataway, NJ 08854
USA

Glenn Rossi
Boeing Co.
P.O. Box 16858
MC P32-10
Philadelphia, PA 19142
USA

Jeff Ruckman
Center for Optics Manufacturing
240 E. River Rd.
Rochester, NY 14623
USA

Alvin Sabroff
Eaton Corp.
32500 Chardon Rd.
Willoughby Hills, OH 44094-9137
USA

Michal Safar
IIT Research Institute
10 West 35th St.
Chicago, IL 60616
USA

Edward Saloman
NIST
Bldg. 245, Rm. B119
Gaithersburg, MD 20899-0001
USA

Patrica M. Sanchez
Sandia National Labs.
P.O. Box 5800
MS 095
Albuqerque, NM 87185
USA

Robert Schafrik
NAS/Manufacturing Studies Board
2101 Constitution Ave., NW
Washington, DC 20418
USA

Roger Schappell
CTA, Inc.
5670 Greenwood Plaza Blvd.
Ste. 200
Englewood, CO 80111
USA

Heinz W. Schmitt
Sandia National Labs.
P.O. Box 5800
MS 0513
Albuquerque, NM 87185
USA

Lyle Schwartz
NIST
Bldg. 223, Rm. B309
Gaithersburg, MD 20899-0001
USA

Donald Sebastian
New Jersey Inst. of Tech.
University Heights
MS 3200 !TC
Newark, NJ 07102-1982
USA

Maurice Shamash
Westinghouse Electric
P.O. Box 746
MS P-13
Baltimore, MD 21203
USA

Paul Sheng
Lawrence Berkeley Laboratory
One Cyclotron Rd.
MS 90-2148
Berkeley, CA 94720
USA

Dan Siewiorek
School for Computer Science
5000 Forbes Ave.
Pittsburgh, PA 15213-3890
USA

Bob Simon
Texas Instruments
2501 W. University
MS 8019
McKinney, TX
USA

Gene Simons
Rensselaer Poly. Inst.
CII 9117
Troy, NY 12180-3590
USA

Sallie Smith
Agility Forum
125 Goodman Dr.
Bethlehem, PA 18015
USA

Jim Snyder
Martin Marietta
P.O. Box 2009
MS 8201
Oak Ridge, TN 37831-8201
USA

Carrie Snyder
I.T.T.A.
1330 Connecticut Ave., NW
Ste. 210
Washington, DC
USA

Jim Sperling
Solar Turbines, Inc.
2200 Pacific Hwy.
MS P-4
San Diego, CA 92186
USA

Bailey Squier
CAM-I
1250 E. Copeland Rd.
Ste. 500
Arlington, TX
USA

Ram Sriram
NIST
Bldg. 220, Rm. A127
Gaithersburg, MD 20899-0001
USA

Philip Staas
Lehigh University
200 W. Packer Ave.
CIM Lab.
Bethlehem, PA 18015-1582
USA

George Staerker
Grote Industries, Inc.
2600 Lanier Dr.
Madison, IN 47250
USA

K. John Stahl
Storage Technology Corp.
2270 S. 88th St.
Louisville, CO 80028-4276
USA

Stephanie Stearns
Great Lakes Composites Co.
8400 LakeView Pkwy.
Ste. 200
Kenosha, WI 53142
USA

David Stieren
NIST
Bldg. 304, Rm. 142
Gaithersburg, MD 20899-0001
USA

Paul Stone
Dow Chemical, Co.
1776 Eye St., NW
Ste. 575
Washington, DC 20006
USA

Keith Stouffer
NIST
Bldg. 220, Rm. B124
Gaithersburg, MD 20899-0001
USA

JoAnne Surette
NIST
Bldg. 220, Rm. B358
Gaithersburg, MD 20899-0001
USA

Robert Swanson
Concurrent Technologies Corp.
1450 Scale Ave.
Johnstown, PA 15904
USA

Joseph Syslo
National Center for Advanced Tech.
1250 Eye St., NW
Ste. 1100
Washington, DC 20005
USA

Nicholas Tarnoff
NIST
Bldg. 220, Rm. B127
Gaithersburg, MD 20899-0001
USA

Clayton Teague
NIST
Bldg. 220, Rm. A117
Gaithersburg, MD 20899-0001
USA

Daniel Thompson
Lawrence Livermore Lab.
East Ave. L-644
Livermore, CA 94550
USA

Thomas Tobey
The Boeing Co.
P.O. Box 3707
Seattle, WA 98124
USA

Mark Traband
Penn State University
P.O. Box 30
State College, PA 16804
USA

Julie Tsao
Defense Logistics Agency
Cameron Station
AQPOT 4B190
Alexandria, VA 22304-6100
USA

Rheal Turcotte
Chicago Manufacturing Center
3333 W. Arthington
Chicago, IL 60624
USA

Laurens Van der Sande
Royal Netherlands Embassy
4200 Wisconsin Ave., NW
Washington, DC
USA

Stephen Varanay
Sikorsky Aircraft
6900 North Main St.
MS 305A
Stratford, CT 06601
USA

Ted Vojnovich
DOE-ERLTT
1000 Independence Ave., SW
Forrestal Bldg., 3F-877
Washington, DC 20585
USA

Robert Von Husen
U.S. Army Materiel Command
5001 Eisenhower Ave.
MS 8522/AMCRD-IEM
Alexandria, VA 22333-0001
USA

Mauro Walker
Motorola
1303 E. Algonquin Rd.
4th Floor
Schaumburg, IL
USA

Andy Wan
U.S. Dept. of Commerce/TA
14th & Constitution Ave., NW
Rm. 706
Washington, DC 20230
USA

Cecilia Wasterlid
Embassy of Sweden
Office of Science & Technology
1501 M St., NW
Washington, DC 20005
USA

Kurt Webster
Boeing Co.
P.O. Box 3707
MS 5K-14
Seattle, WA 98124
USA

Nicholas Weil
NCMS
3025 Boardwalk Dr.
Ann Arbor, MI 48105
USA

Bruno Weinschel
Weinschel Res. Foundation
P.O. Box 2092
Gaithersburg, MD 20886
USA

Tom Wheatley
NIST
Bldg. 220, Rm. B124
Gaithersburg, MD 20899-0001
USA

Michael White
Pratt & Whitney
400 Main St.
MS 118-39
East Hartford, CT 06108
USA

Don Willyard
AlliedSignal
2000 E. 95th St.
P.O. Box 419159
Kansas City, MO 64141-6159
USA

Joseph Wirth
Rayhem Corp.
300 Constitution Dr.
MS 122/8505
Menlo Park, CA 94051
USA

Michael Wozny
NIST
Bldg. 220, Rm. B322
Gaithersburg, MD 20899-0001
USA

Colman Wright
Consultant (Martin Marietta)
494 Poplar Springs Rd.
Kingston, TN 37763
USA

Simone Yaniv
NIST
Bldg. 233, Rm. B108
Gaithersburg, MD 20899-0001
USA

Isaac Yeboah
B&C Corp.
366 Fairview
Barberton, OH 44203
USA

Thomas Young
Sandia National Labs.
P.O. Box 5800
MS 0955
Albuquerque, NM 87185
USA

Gene Zeiszler
AMT-Assoc. for Maun. Tech.
7901 Westpark Dr.
McLean, VA 22102
USA

Anne Marie Zerega
U.S. Dept. of Energy
1000 Independence Ave., SW
Rm. 3F-088 ER-80
Washington, DC 20585
USA

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