NBSIR 87-3671
ISSUED NOVEMBER 1987

FINAL REPORT

The Status of Emerging Technologies: An Economic/ Technological Assessment to the Year 2000

JUNE 1987

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Gaithersburg, MD 20899

NBSIR 87-3671
ISSUED NOVEMBER 1987

FINAL REPORT

The Status of Emerging Technologies: An Economic/ Technological Assessment to the Year 2000

JUNE 1987

U.S. DEPARTMENT OF COMMERCE
C. William Verity, Secretary
National Bureau of Standards
Ernest Ambler, Director

The Department of Commerce has concluded, in a review of emerging technologies and their future impact on the economy, that American businesses lag behind many of their foreign competitors, especially the Japanese, in exploiting technological breakthroughs.

The review was ordered by Deputy Secretary Clarence J. Brown in April 1986 to identify the new technologies that will lead to new products or processes, analyze their commercialization, and recommend means of reducing the barriers. It is based on an assessment by technical experts and agency heads within the Department. They studied scientific and industrial plans and the commercialization process here and abroad.

Once the list of technologies was determined, the experts determined their probable contribution to the gross national product by the year 2000. While recognizing this as an imprecise measure requiring some subjective forecasting, the Department believes it to be the best proxy to judge economic impact. Although the technologies are ranked in terms of high, moderate or low impact, the terms are relative; all are expected to play a significant role in future growth.

Identifying the technological opportunities and their probable economic effect is not difficult. The real problem facing U.S. companies is converting these opportunities into real economic success. The review's primary focus is upon identifying ten barriers to commercialization and making recommendations for overcoming them. The recommendations require action by all sectors of American life, sometimes unilaterally and occasionally together.

The barriers to commercialization are also ranked in order of importance. The two most important are inadequate tax incentives and the high cost of capital. The remaining barriers include two that require actions by individual companies. The Department found that there is a lack of integration and communication among functions within companies, and it also cites companies for being too complacent and dependent on the domestic market for growth opportunities.

The recommendations include fostering participative management by employees, training managers in the production process, eliminating provisions in foreign tax laws that discriminate against U.S. products, and updating business school curricula. They also reiterate recommendations of President Reagan's competitiveness initiative, such as those regarding improving export controls, reforming product liability and tort laws, and lifting antitrust restrictions.

Since the list of technologies was determined, there have been significant and highly publicized breakthroughs in the field

of superconductors -- materials that have zero electrical resistance. Several developments must be achieved before their economic potential can be realized, particularly an improvement in the current-carrying capacity of these materials. Until it is known whether this is possible, superconductors should be considered a potential emerging technology.

The accompanying appendices describe in detail the technologies, barriers, and recommendations.

APPENDICES

APPENDIX A - DESCRIPTIVE TABLES

Table 1 - Emerging Technologies (4 pages)

Table 2 - Emerging Technologies Ranked by Economic Impact

Table 3 - Generic Barriers to Achieving Maximum Benefits from Emerging Technologies

APPENDIX B - DETAILED DESCRIPTIONS OF BARRIERS

APPENDIX C - RECOMMENDATIONS OF METHODS TO OVERCOME BARRIERS

Table 1

EMERGING TECHNOLOGIES

Technology	What does it do new or better?	Applied to what products or processes?	Used by What Major Industries?
1. Advanced Materials			
A. Ceramics (high performance structural and electronic ceramics)	Better high temperature strength-to-weight properties	Heat engine components, turbine blades, heat shields	Automotive & aircraft engines
	Better dielectric & optical properties	Electronic substrates, integrated optics	Electronic components
B. Polymer Composites	Higher strength-to-weight ratio	Structural components	Aerospace, automotive, ind. const.
(high strength fiber reinforced plastic resin)	Design flexibility because of spatial asymmetry	Structural components	Aerospace, automotive, ind. const.
C. Metals (rapid solidification, & metal matrix composites)	Improved strength & high-temp performance	Structural components Super conducting components	Manufactured components
	Improved magnetic properties	Electro-magnetic equipment	Electrical machinery
2. Electronics			
A. Advanced Microelectronics (enhanced VLSI and VHSIC chips)	Improved performance in speed, size	Semiconductor devices	Electronic & optical components & systems
	Improved magnetic properties	Information storage	Information processing
	Higher efficiency photovoltaic conversion	Solar cells	Energy generation

Technology	What does it do new or better?	Applied to what products or processes?	Used by What Major Industries?
B. Optoelectronics (optical fiber and light wave processing)	Improved performance in speed, size, capacity, and security	Electronic equipment, information processing	Communications & computers
	Higher density information storage	Computer systems of all sizes	Computers
C. Millimeter Wave Technology	When replacing radio systems it frees RF spectrum for other uses	Voice & data communication systems	Telecommunications carriers & corporate use for private circuits
3. Automation			
A. Manufacturing (computer integrated and flexible systems)	Flexible reconfiguration of production processes	All manufacturing processes	All manufacturing
	Integrated control of all production operations		
B. Business and Office Systems (computer applications within an organization)	Efficient information storage, retrieval, & exchange	Networking, word processing, & data base management	All organizations
C. Technical Services (computer applications in the provision of commercial services)	Efficient high-volume information storage, retrieval & exchange	Information retrieval and distribution, data base management, education and training	Financial services, electronic mail, telecommunications, professional service

Technology	What does it do new or better?	Applied to what products or processes?	Used by What Major Industries?
4. Biotechnology			
A. Genetic Engineering (design & production of highly selective agents)	Improved diagnostic and therapeutic drugs	Health Services	Medicine, Pharmaceuticals
	Improved plants, pesticides, & animal supplements	Foods and pesticides	Agriculture Food processing
	Neutralize pollutants	Environmental control processes	Chemical manufacturing & treatment
B. Biochemical Processing	Improved control of chemical processes, outputs, and yields	Chemical separations and reactions, biosensors	Chemical manufacturing
5. Computing			
A. Computing Equipment (supercomputers, parallel processing, computer arch.)	Faster, lower-cost computing	Information processing and computer control	Potentially all
B. Artificial Intelligence Techniques (includes expert systems, natural language, and robotic control)	Improved computer replication of human judgment	Information processing and computer control	All applications using computers

Technology	What does it do new or better?	Applied to what products or processes?	Used by What Major Industries?
6. Medical Technology			
A. Drugs (other drugs are included in category 4 - Biotechnology)	Improved immunology and treatment	Health Services	Medicine, Pharmaceuticals
B. Instruments & Devices	Improved diagnostic and therapeutic systems	Magnetic Resonance Imaging & CAT scanning, radiation treatment	Medicine
7. Thin Layer Technology (semiconductor applications also are included in Electronics)			
A. Surfaces & Interfaces	Improved control and yield of chemical reactions	Chemical catalysis	Chemical manufacturing, food processing
	New electronic & optical properties	Semiconductor devices, surface modification and coatings	Electronic components, computers
B. Membranes	New chemical properties, better chemical separation techniques	Chemical separations	Chemical manufacturing, food processing

Table 2

EMERGING TECHNOLOGIES RANKED BY ECONOMIC IMPACT

Group A	(Highest)	Advanced Materials; Composites
		Biotechnology; Genetic Engineering
		Electronics; Optoelectronics
		Electronics; Advanced Microelectronics
		Computing; Computing equipment
		Automation; Manufacturing
Group B		Automation; Business and Office Systems
		Biotechnology; Biochemical Processing
		Medical Technology; Drugs
		Advanced Materials; Ceramics
		Automation; Technical Services
		Computing; Artificial Intelligence Tech.
		Medical Technology; Devices
Group C		Thin Layer Technology; Membranes
		Advanced Materials; Metals
		Thin Layer Tech.; Surfaces & Interfaces
		Electronics; Millimeter Wave Technology

Table 3

GENERIC BARRIERS TO ACHIEVING MAXIMUM ECONOMIC BENEFITS FROM EMERGING TECHNOLOGIES

1. High costs of capital funds in the U.S. relative to foreign competitors.

2. Tax incentives for U.S. companies relative to foreign competitors to deploy emerging technologies (including the stability of tax regulations).

3. Poor integration of manufacturing, design, and R&D functions.

4. Inadequate laws, regulations, and enforcement protecting intellectual property rights in the U.S. or overseas.

5. Complacency and dependence on the domestic market.

6. Restrictive trade policies in foreign markets.

7. Federal or State regulations on corporate activities intended to protect the public health and safety (e.g., building codes, environmental laws, drug approval regulations, and occupational health regulations).

8. Export controls on advanced technologies and high-technology products.

9. Restraints and uncertainty caused by product liability and tort laws.

10. Anti-trust restrictions against cooperative ventures for marketing or production methods. There may still be perceived barriers against cooperative R&D, but legal restrictions against procompetitive R&D were eased by legislation in 1984.

APPENDIX B

DETAILED DESCRIPTIONS OF GENERIC BARRIERS TO ACHIEVING MAXIMUM ECONOMIC BENEFITS FROM EMERGING TECHNOLOGIES

1. High costs of capital funds in the U.S. relative to foreign competitors.

Higher interest rates, lower debt-equity ratios, cultural practices, and tax laws combine to make the effective cost of capital funds for U.S. firms up to twice as high as their Japanese competitors. For example, U.S. savings rates, as a percentage of GNP, have historically been, and continue to be, among the lowest of developed countries (and about half that of Japan). Recent declines in the value of the dollar relative to foreign currencies have reduced some capital cost differentials, but the above factors combine to keep that differential high.

2. Tax incentives for U.S. companies relative to foreign competitors to deploy emerging technologies (including the stability of tax regulations).

Foreign countries continue to employ a variety of incentives to encourage the growth of new technologies. These range from subsidies for the conduct of R&D to import protection of the products derived from the new technologies, at least in their early marketing stages. U.S. firms receive few such subsidies. Some predict that recent changes in the tax law will have a stultifying effect upon venture capital, thus denying U.S. firms access to a previously major source of funding for new high-technology firms.

Frequent changes have made it difficult for U.S. businessmen. Drafting of regulations often lag behind legislation significantly. These changes and delays have created an air of uncertainty in business planning: uncertainty is always an anathema to the businessman.

3. Poor integration of manufacturing, design, and R&D functions.

For rapid movement of new technologies through the functions of R&D, design, product development, and production, it is necessary to have effective communication among these functions. Lack of willingness and opportunity of key technical staff to move with the emerging technology from R&D into manufacturing, for example, has been common in U.S.

organizations, although much improvement has occurred in recent years. A contributing factor in the U.S. has been the lower status, reflected in lower salaries and recognition, given to manufacturing relative to other branches of engineering.

Lack of cooperation and integration among institutions in the U.S. is just as important a barrier as among functions within a firm. For example, more rapid application of new technologies could be the result of closer coupling of firms to technical activities in Universities and Federal laboratories, and from intercompany cooperation to jointly address generic or structural technical problems of a longer-term nature. In this category would fall the classic Government research (carried out by NBS, NOAA, and NTIA) to provide technical data and standards that industry needs to design reliable new products/processes, but single firms do not have the incentive, expertise, or funds to develop themselves.

The Japanese are said to be particularly strong in integrating functions; this may partly account for the rapid speed with which their firms introduce new products into the market. Rotation of staff among these functions in Japan also helps this integration process.

4. Inadequate laws, regulations, and enforcement protecting intellectual property rights in the U.S. or overseas.

U.S. businesses rely upon strong intellectual property protection to realize the benefits of emerging technologies. In fact, the rate of development of emerging technologies may well depend upon patents as incentives and security for R&D or marketing investment, and upon trademarks to build and protect reputations for quality. Barriers exist where laws, regulations or enforcement procedures are inadequate. When innovation is neither rewarded nor encouraged, markets are either forfeited, left untapped, or are underdeveloped. Examples of domestic barriers include (1) the inadequacy of the statutory 17-year patent term for certain agricultural and pharmaceutical products which are subject to extensive premarket testing, and (2) the absence of effective protection for process patent holders against imports of products made abroad under the patented process.

On the international front, it is well recognized that many countries do not offer adequate intellectual property protection and, in some cases, actually sanction abuse of intellectual property rights. This would include, for example, a nation's outright appropriation of foreign-owned technologies or of creative and artistic works. This robs

the inventor or creator and, of course, the associated business concern of any possibilities of realization of world market potential.

5. Complacency and Dependance on the Domestic Market

This barrier encompasses the attitudinal problems generated by the size and ready availability of the U.S. market for new products and services -- the lack of an immediately apparent need to compete with Japan and other countries head-to-head in the international marketplace. American companies, separately and in joint ventures, must aggressively seek export opportunities abroad and anticipate challenges in the U.S. from new foreign competitors. This barrier also encompasses the attitudinal differences toward "risk taking" between U.S. and Japanese firms and the cultural differences in approaches to production and marketing. The Japanese preference is to produce and market technological improvements in small increments, thereby gaining a foothold and experience in the marketplace. The U.S. approach is to complete as much research and development as possible before producing and marketing a new product which "leapfrogs" existing technology.

6. Restrictive Trade Policies in Foreign Markets

Restrictive trade policies take many forms -- laws, regulations and practices -- with an overriding consequence of protecting a home market from foreign products. Although most of these policies are sponsored by governments, business practices and social mores may also act as significant trade barriers.

<u>Direct Government Practices</u> are one type of policy affecting trade. Included here are:

- Tariffs and other import duties designed to protect a domestic market rather than to raise revenues.
- Import licensing designed to create uncertainty, delays, and discrimination for foreign products.
- Government procurement (i.e., buy national products)
- Product development and export subsidies programs.

<u>Indirect Government Practices</u> are a second type of policy. Included here are:

- Standards codes, testing, labeling, and certification requirements which interfere with market availability and acceptance of foreign products.
- Local or domestic content (e.g. rules or origin)

requirements on foreign products which adversely affect technology and process innovations.
- Market reserve policies that designate certain markets for domestic products only.
- Disregard of intellectual property rights by foreign governments which undermine the ability to exploit markets with new products.

Non-trade and Non-government Measures and Practices are a third type. Included here are:

- Public health and safety laws that indirectly restrict the importation of foreign products.
- Local and national distribution systems that discriminate against foreign products through interlocking relationships among manufacturers, wholesalers, and financial institutions.

7. Federal or State regulations on corporate activities intended to protect the public health and safety (e.g., building codes, environmental laws, occupational health regulations, and drug approvals).

Emerging technologies generally require, somewhere in their development and production, some form of environmental and/or health clearance or regulation. This will occur on the Federal or State levels depending on which of the Federal regulation(s) apply.

Those technologies involving large-scale use of new materials, particularly in the broader electronics categories, will have to continue to meet the existing water, air and disposal requirements. In the case of new and exotic materials, such as the new semiconductor compounds (e.g. Gallium Arsenide), OSHA regulations are constantly being revised to protect against potential hazards, while EPA has control of various emissions through clean air and clean water legislation.

Solid waste reclamation also will enter into the cost of using new technologies. Disposal of new composite materials as scrap in products that have reached the end of their useful life, will impose a new set of costs and possible barriers. The present case of what to do with worn-out lead storage batteries is a good example of what might happen to a higher technology material with end-of-cycle toxicity.

For those technologies involved in medical and health care, regulations covering production, product certification, standards, OSHA considerations and disposal add to the burden of time/testing, as well as to the cost of meeting

stringent health and environmental standards. The current issues surrounding the regulation and testing of genetically-altered naturally occurring organisms is a prime example of an emerging technology in the early stages of development.

The costs and time delays involved are further exacerbated if competing countries have less stringent certification and environmental requirements. Technologies in those countries are often put into production faster, thus putting U.S. suppliers at a competitive disadvantage. There are several recent examples in the pharmaceutical industry of the effect of these differences.

8. Export controls on advanced technologies and high-technology products.

While the need for control of the export of technology for purposes of U.S. national security has been clearly established, the costs attributable to "over-control" are also now becoming more apparent. That is, the Executive Branch's inability to decontrol goods and technology -- that are no longer strategic or are available from foreign competitors--is now seen as inhibiting our ability to remain technologically superior to our international competitors as well as contributing to the erosion of our defense industrial base . The Department of Commerce is trying to establish interagency procedures that will facilitate the decontrol to take place as Congress intended.

9. Restraints and uncertainty caused by product liability and tort laws.

With increasing frequency, claims are made that innovation and ability to compete are retarded in the U.S. by product liability and tort laws. The resulting uncertainty and instability have brought about a need for reform. Reasons include:

-- A patchwork of 50 different state laws on product liability. Cases based on similar facts, but tried in different states, can produce strikingly different and contradictory results.

-- The enormous transaction costs for all parties involved in litigation.

-- The high costs of insurance for product-liability related protection.

Over the past 20 years our product liability law has moved away from fault as its basic guiding principle. The Commerce Department has taken the position that as a matter of fairness to manufacturers and as an incentive to them to construct new and safe products, businesses should generally be held liable only for behavior based on fault.

10. Anti-trust restrictions against cooperative ventures for marketing or production. There may still be perceived barriers against cooperative R&D, but legal restrictions against procompetitive R&D were eased by legislation in 1984.

Many U.S. anti-trust restrictions have been in place, substantially unchanged, for over 75 years. In these times of strong foreign competition and worldwide markets, U.S. firms are at a disadvantage when compared to foreign firms not subject to such strong, legal strictures. Production economies not envisaged when the original laws were enacted are now possible. These economics permit firms jointly to build and operate facilities at lower cost, thus improving world-competitive positions. Facilities housing flexible automated manufacturing systems are one example, but other shared facilities are also possible. Joint production by large firms, joint marketing of the products, and mergers of such large firms are subject to close scrutiny by U.S. Federal agencies, even though they may increase efficiency. This is viewed as an anachronism, particularly in the light of foreign practice.

Cooperative funding of procompetitive R&D was eased by changes enacted in 1984 which, among other things, reduced damages to be assessed to losses actually incurred. These changes are still not as widely known as they might be, with the result that some cooperative U.S. ventures are not being undertaken in fear of anti-trust prosecution.

APPENDIX C

RECOMMENDATIONS OF METHODS TO OVERCOME BARRIERS

BARRIER: HIGH COST OF CAPITAL IN THE U.S. RELATIVE TO FOREIGN COMPETITORS

Efforts to reduce Federal budget deficits should continue because of negative effects of the high deficits on capital markets and on interest rates.

State and local level efforts to meet local capital needs should be encouraged. The creation of venture capital pools would help increase the availability of capital for the new, high-risk developments that sometimes have very large innovation and competitive payoffs. Investment rebates and other incentives might also be used.

Actions should be taken to increase aggregate savings in the U.S. Additional tax incentives (beyond the recent tax reform), direct appeal to savers, and other actions could increase savers willingness to save rather than consume. Increased savings levels are necessary to help increase capital supply and lower interest rates. The U.S. savings level is much lower than in competitor nations.

BARRIER: TAX INCENTIVES FOR DEVELOPMENT OF NEW TECHNOLOGIES

In order to encourage rapid commercialization of technological advances, any future changes in the tax law should focus on the incentives available for long-term investment in all factors of the production, marketing, and distribution processes. Changes in cost recovery provisions should not force U.S. companies into a competitive disadvantage. American businesses must have confidence that major tax changes will not be made repeatedly.

The tax laws of foreign countries should be analyzed to determine if they discriminate against U.S. products being sold there. Discriminatory effects should be alleviated through negotiation or, if necessary, compensated through legislation.

BARRIER: POOR INTEGRATION OF MANUFACTURING, DESIGN, AND R&D MARKETING FUNCTIONS

All managers should have a grounding in the basic production process of the company. Beyond this, managers should receive cross-functional training so they have at least a

minimal appreciation of finance, personnel, technology development, marketing, as well as production.

Top management must foster attitudes throughout management staff that foster flexibility, change, innovation and adaptability.

Business schools must update curricula to train business students in the total process -- from R&D to marketing and servicing. Business students must see any particular specialization within the fullest context of what is required for corporations to achieve maximum productivity.

BARRIER: INTELLECTUAL PROPERTY PROTECTION

Industrial firms in the U.S should take great care in transferring their technology and other intellectual property to foreign firms. For protecting the competitiveness of the nation as a whole, firms should establish safeguards against non-economic transfers.

Export control procedures should be changed to include intellectual property protection agreements and concerns, so that sales by U.S. firms are protected and enhanced.

Insist other nations protect U.S-owned intellectual property. Treaties, reciprocal agreements, tariffs, and other mechanisms used by the U.S. government in dealing with other nations should incorporate strong intellectual property provisions. U.S. laws could be strengthened to insure reciprocity and to prevent unapproved imports of products made abroad by processes patented in the U.S. Enforcement in other countries is often the weakest link in the protection process.

Ownership of rights stemming from collaborative research should be clarified. The goal is to eliminate uncertainty and thus maximize the incentives to rapidly commercialize technological developments by U.S. firms. Similarly, actions should be taken to assure that ownership rights and other benefits from Federally-funded research flow to U.S. organizations.

Ways should be sought to obtain payments from foreign graduate students for the intellectual property they benefit from while doing research in the U.S.

BARRIER: COMPLACENCY AND DEPENDENCE ON THE DOMESTIC MARKET

We must foster entrepreneurial risk-taking. Several steps can be taken. Promote greater ownership by executives of corporate stock so that executives become owners, not simply

managers. Include employees in "participative management" so that more decisions are made by those closest to production operations. Incentive systems must be improved so that more employees feel they have a greater stake in the success of the company.

Shift emphasis in our business schools so that executive responsibilities are taught more within the context of "owners" responsibilities rather than "management" responsibilities.

We must promote a greater sense of the "common good" so that government, management and labor interact on a basis of achieving positive goals rather than on the historic adversarial basis.

We must foster the awareness that there is no longer anything such as a purely "domestic" market. What we think of as the U.S. domestic market is, in fact, part of the global market. Thus as soon as a product leaves the shipping dock, it has hit the world market, even if it is only being shipped across town. This perspective must permeate all management levels.

BARRIER: RESTRICTIVE TRADE POLICIES IN FOREIGN MARKETS

Adaptability to foreign preferences should be improved by U.S. firms. The result should be U.S.-made products that better meet the special preferences of consumers in other nations and better performance in the marketing/distribution systems overseas. Increased exports and reduced trade deficits are the obvious goal.

Foreign languages should be introduced earlier into the U.S. educational process, so that our citizens will have a greater ability to understand foreign needs/preferences, and have an increased ability to successfully do business overseas.

BARRIER: FEDERAL AND STATE REGULATIONS FOR PROTECTION OF HEALTH AND SAFETY

Wherever possible, domestic regulations (from such sources as EPA, OSHA, FDA, and SEC) should be reduced and simplified in order to minimize their negative effects on industry's use of new technology. In some cases, foreign competitors have an advantage of less stringent or loosely enforced regulations.

A better balance should be achieved between the desirable safety goals of domestic regulations and the economic costs to U.S. manufacturers and businesses. In addition to the

added costs, firms often have the application of new technology or marketing of new products delayed significantly. In the current global economy, we should recognize that economic viability is as important a national goal as public safety. The key is to balance these goals in a meaningful way.

BARRIER: EXPORT CONTROLS ON ADVANCED TECHNOLOGIES AND HIGH-TECHNOLOGY PRODUCTS

The January 1987 President's Competitiveness Initiative directs the Cabinet to review the export controls program and provide recommendations to achieve the following:

- Decontrolling those technologies that offer no serious threat to U.S. security;
- Strengthening enforcement controls on those technologies that could harm U.S. security;
- Eliminating unilateral controls in those areas where there is widespread foreign availability;
- Reducing the time required to acquire a license by at least one-third and implementing a fair, equitable, and timely dispute resolution process;
- Seeking agreement with our allies for concrete actions to be taken which will make export control procedures more uniform and enforcement more rigorous;
- Seeking overall to level the competitive playing field while strengthening multinational controls over products and technologies that can contribute to Soviet military capabilities; and
- Recognizing the continued improvement in U.S./People's Republic of China (PRC) relations and the commitment of the PRC to protect sensitive technology, and working with our allies to further liberalize high technology trade with China.

BARRIER: RESTRAINTS AND UNCERTAINTY CAUSED BY PRODUCT LIABILITY LAWS

The January 1987 President's Competitiveness Initiative proposes several methods to overcome this barrier. Proposed legislation would:

- Retain a fault-based standard of liability;

- Eliminate joint and several liability except in cases where defendants have acted in concert;

- Limit noneconomic damages to a fair and reasonable amount;

- Provide for periodic, instead of lump sum, payments of damages for future medical care or lost income;

- Reduce awards in cases where a plaintiff also is compensated by other sources, such as government benefits;

- Reduce transaction costs by limiting attorneys' contingent fees to reasonable amounts on a sliding scale; and

- Encourage litigants to resolve more cases out of court.

BARRIER: ANTI-TRUST RESTRICTION AGAINST COOPERATIVE VENTURES

The January 1987 President's Competitiveness Initiative proposes several methods to overcome this barrier. The statutory proposals include:

- Amending Section 7 of the Clayton Act to distinguish more clearly between pro-competitive mergers and mergers that would create a significant probability of increased prices to consumers;

- Limiting private and Government antitrust actions to actual (rather than treble) damages, except for damages caused by overcharges or underpayments;

- Removing unwarranted and cumbersome restrictions on interlocking directorates;

- Clarifying the application of U.S. antitrust laws in private cases involving international trade; and

- Requiring that any antitrust claims remaining against other defendants after a partial settlement in a case be appropriately reduced.

Remarks by Deputy Secretary of Commerce Clarence J. Brown
News Briefing on Emerging Technologies
June 9, 1987

Good morning. It is no secret that this country has a trade problem. Likewise, it is no secret that at least part of the problem has been our inability to take full commercial advantage of scientific and technological developments made in the United States. Time and time again we have seen foreign competitors, most notably, but not exclusively, the Japanese, turn our technological developments into their commercial product successes.

I think it is fair to say that the country has awakened to this dilemma. The national attention to the general subject of competitiveness is evidence of our awakening. The President has put forward a comprehensive package of proposals to deal with this problem, and the Administration is taking a series of steps to improve our situation.

This morning, I want to take a longer view of our trade and technology position. I want to draw attention to the future and to the technologies that just now are emerging from the laboratory and seem particularly promising in both a scientific and commercial context.

I am firmly convinced that America's ability to exploit a new set of emerging technologies with huge market potential in the year 2000 and beyond will play a big role in determining the country's economic successes or failures well into the next century.

Recognizing the importance of these technologies, I asked a group of technical experts and top officials from Commerce Department agencies to examine the latest scientific and technological advancements and to report to me on which technologies seemed especially important, what barriers stood in the way of their commercialization within the United States, and what steps could be taken to remove those obstacles.

This group, headed by Dr. Ernest Ambler, director of the National Bureau of Standards, who is with us this morning, studied scientific and industrial plans and the commercialization process here and abroad.

They identified 17 emerging technologies in 7 major groups which are expected to lead to new products or processes in the future. Among other things, the review panel considered the expected contribution of each technology to the gross national product.

Here is the list the group came up with:

SHOW POSTERBOARD WITH EMERGING TECHNOLOGIES LIST

Advanced materials. These include high-performance ceramics, polymer composites, and advanced metals. They will bring improvements in automotive and aircraft engines, electronic components, electrical machinery, and manufactured components.

Electronics. Here the panel singled out advanced microelectronics critical to semiconductor devices, optoelectronics -- which covers optical fiber and lightwave processing vital to advances in communications and computers -- and millimeter wave technology, which can be used in voice and data communication systems.

Automation. Computer-integrated and flexible systems for manufacturing are on the list, as are computer applications in business and office systems as well as applications for commercial services such as financial transactions and electronic mail.

Biotechnology. Both genetic engineering -- for improved diagnostic and therapeutic drugs and agricultural and food applications -- as well as biochemical processing for chemical manufacturing, are critical technologies.

Computing. Supercomputers, artificial intelligence, and a variety of other computing techniques deserve a category of their own, with potential applications to literally every industry in the United States.

Medical Technology. Progress in new medical drugs and instruments and devices for improved diagnosis and treatment of illness is fast-paced and promises to continue into the next century. We are certain to see new technologies that are nothing more than scientific concepts today.

Thin Layer Technologies. Electronic components, chemical manufacturing and food processing, and a variety of other industrial operations are expected to benefit from rapid advances in using ultra-thin layers of chemicals to improve the capabilities of devices and products.

The list is not meant to be cast in concrete. For example, in the few weeks since the original list was put together, there have been significant and highly publicized breakthroughs in the development of superconductors -- materials that have absolutely no electrical resistance. Basic scientific questions and great technical problems need to be solved before we can realize the economic potential of these high-temperature superconductors, so for now they must remain a potential emerging technology.

But all you have to do is to look at one possible application for these superconductors, the transmission of electrical energy, to realize the enormity of their promise. We now spend $160 billion a year on electrical power in this country, and we waste a full 20 percent of that power due to losses in transmissions. If high-temperature superconductors can be developed to the point where they can be substituted for conventional electrical transmission wires, we could save more than $30 billion a year.

When I talk about the potential of emerging technologies, that is what I am talking about, a revolution that could affect every industry in America and around the globe.

But there are barriers.

SHOW POSTERBOARD WITH GENERIC BARRIERS

This list of generic barriers to achieving maximum economic benefits from emerging technologies should look familiar.

The relatively high costs of capital funds and the less favorable tax incentives in the United States compared to foreign competitors top the list.

Management's focus on short-term, rather than longer range, goals for returns on investments, poor integration of manufacturing,

design, and research and development functions within U.S. firms, and the lack of cooperation among American institutions, hurt our chances of exploiting emerging technologies.

So do inadequate laws, regulations, and enforcement protecting intellectual property rights in the United States or overseas.

Complacency and a dependence on the domestic market -- the lack of awareness of the need to compete with Japan and other countries head-to-head in the international marketplace -- are a basic stumbling block.

Restrictive trade policies in foreign markets,

Federal or state regulations on corporate activities,

Export controls on advanced technologies and high-technology products,

Restraints and uncertainty caused by product liability and tort laws, and

Anti-trust restrictions -- real and perceived -- against cooperative ventures for R&D, marketing, or production.

All are formidable barriers to the commercialization of these

emerging technologies.

Now, what do we do about breaking down these barriers? You have a description of the recommendations in your press kits. They include:

-- continued vigilance to reduce federal budget deficits and to avoid high interest rates which affect the cost of capital

-- creation of venture capital pools at the state and local levels

-- additional tax incentives and other actions to increase aggregate savings

-- a commitment to making future changes in the tax laws focus on the incentives available for modernization investment in all stages of production, marketing, and distribution

-- fostering participative management by employees

-- training managers in the production process and updating business school curricula

-- eliminating provisions in foreign tax laws and regulations that discriminate against U.S. products, and

-- improving export controls, reforming product liability and tort laws, and lifting antitrust restrictions.

In a recent hearing before his Committee on Commerce, Science and Transportation, Senator Fritz Hollings complained, "America may still invest enough in research to win most of the Nobel Prizes, but the Japanese make all the profits on them." Well, we cannot let that continue to happen. As you can see by looking at the barriers and recommendations for commercializing emerging technologies, the government has an important role to play. But the private sector -- the people who work in and run America's factories and board rooms -- must take the lead.

This country has done enough looking back and talking about how many different areas of technology we have already lost to the commercial competition. Our look ahead at critical emerging technologies should be a warning that unless we pull together and take swift action now to break down the barriers to the commercialization of new technologies, we are going to be facing the same international trade problems we confront today right on into the next century.

We have made some progress. Although we neither talk nor read enough about them, this country has some wonderful success stories and some good things happening to show that businesses and even entire industrial sectors can and are taking decisive actions to improve the situation. We have firms joining together in research consortia, corporations cutting down on excessive managerial positions, and companies finding new market niches overseas.

We simply must be vigilant and make additional changes now if the country's economic future is to be bright when the new century arrives.

Now, I'd be happy to take any questions you may have.

NBS-114A (REV. 2-8C)

U.S. DEPT. OF COMM. **BIBLIOGRAPHIC DATA SHEET** *(See instructions)*	1. PUBLICATION OR REPORT NO. NBSIR 87-3671	2. Performing Organ. Report No. Dept. of Comm.	3. Publication Date June 1987

4. TITLE AND SUBTITLE

Final Report The Status of Emerging Technologies: An Economic/ Technological Assessment to the Year 2000

5. AUTHOR(S)

Ernest Ambler, et al.

6. PERFORMING ORGANIZATION *(If joint or other than NBS, see instructions)*

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

The Department of Commerce has concluded, in a review of emerging technologies and their future impacts on the economy, that American businesses lag behind many of their foreign competitors, especially the Japanese, in exploiting technological breakthroughs.

The review was ordered by Deputy Secretary Clarence J. Brown in April 1986 to identify the new technologies that will lead to new products or processes, analyze their commercialization, and recommend means of reducing the barriers. It is based on an assessment by technical experts and agency heads within the Department. They studied scientific and industrial plans and the commercialization process here and abroad.

Remarks by Deputy Secretary Brown in releasing the report are included.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

advanced materials; automation; biotechnology; computing; electronics; emerging technologies; medical technology; thin layer technology

13. AVAILABILITY

☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

33

15. Price

$11.95