



KEY TECHNOLOGIES FOR THE

1990s

An Overview

Aerospace Industries Association of America, Inc.



KEY TECHNOLOGIES FOR THE 1990s

An Industry Study of High-Leverage, Enabling Aerospace Technologies
and Roadmaps To Attain Them

“America’s competitiveness in world markets is critical to maintaining and expanding our standard of living and the national security. I have established a national goal of assuring American competitive preeminence into the 21st century. Achieving that goal is the responsibility of all Americans.”

**President Ronald Reagan
State of the Union Address
January 27, 1987**



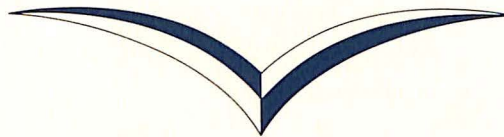
A Report of the Aerospace Technical Council of AIA

NOVEMBER 1987

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.
1250 EYE STREET N.W. • WASHINGTON, D.C. 20005

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AIA AEROSPACE TECHNICAL COUNCIL STUDY GROUP

AIA represents the major U.S. aerospace companies engaged in the research, development and manufacture of aircraft, missiles and space systems and related propulsion, guidance, control and other equipment. The association functions on national and international levels.

The Aerospace Technical Council is the industry's senior technical body and is chartered to focus on the development of high-technology systems.

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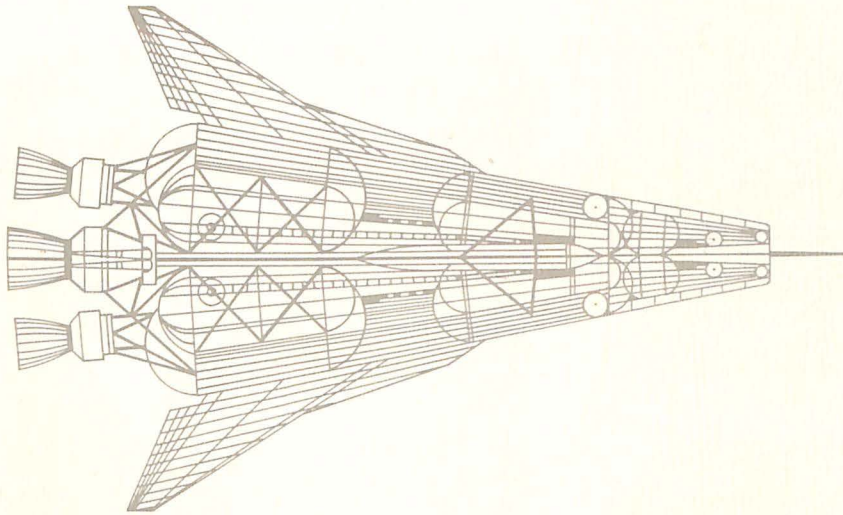
ULTRARELIABLE ELECTRONICS SYSTEMS

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CONTENTS



U.S. AEROSPACE COMPETITIVENESS INITIATIVE ..	4
INTRODUCTION	5
COMPOSITE MATERIALS	7
VERY LARGE SCALE INTEGRATED CIRCUITS	11
SOFTWARE DEVELOPMENT	15
PROPULSION SYSTEMS	19
ADVANCED SENSORS	25
OPTICAL INFORMATION PROCESSING	29
ARTIFICIAL INTELLIGENCE	33
ULTRARELIABLE ELECTRONICS	37
THE NATIONAL CHALLENGE ...	40
SUMMARY	42
RECOMMENDATIONS	43

U.S. AEROSPACE COMPETITIVENESS INITIATIVE

PLANS

Validate key technologies roadmaps for development in the 1990s

Cooperative preparation of technology development program

- Policy strategy
- Technical plan
- Resources

ACTIONS

New Programs

New, focused national efforts by government, industry and academia

New Policies

More cohesive national policies regarding technology development and incentives

New Mechanisms

Development of creative ways to encourage cooperative R&D planning and implementation

PAYOFFS

Markedly superior new U.S. aerospace products

Stronger position in world markets

More rapid maturation of priority technologies

Better and more cohesive policies to enhance entire national technology development process

INTRODUCTION

The U.S. aerospace industry is in danger of losing its competitive position in world markets and its superiority in military capability. Although the industry has consistently maintained a substantial positive trade balance, aerospace imports are increasing rapidly and U.S. aerospace competitiveness is eroding.

Foreign competitors have worked diligently to upgrade their technology and the capabilities of their products now equal or exceed ours in several important fields.

For the past five years, the AIA Aerospace Technical Council has been studying the developmental status of aerospace technologies. Of the over 100 technologies reviewed, eight key technologies were identified as needing

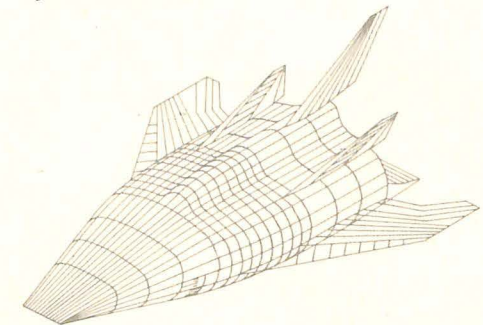
immediate and special attention based on selection criteria of highest leverage, potential payoff and broadest application.

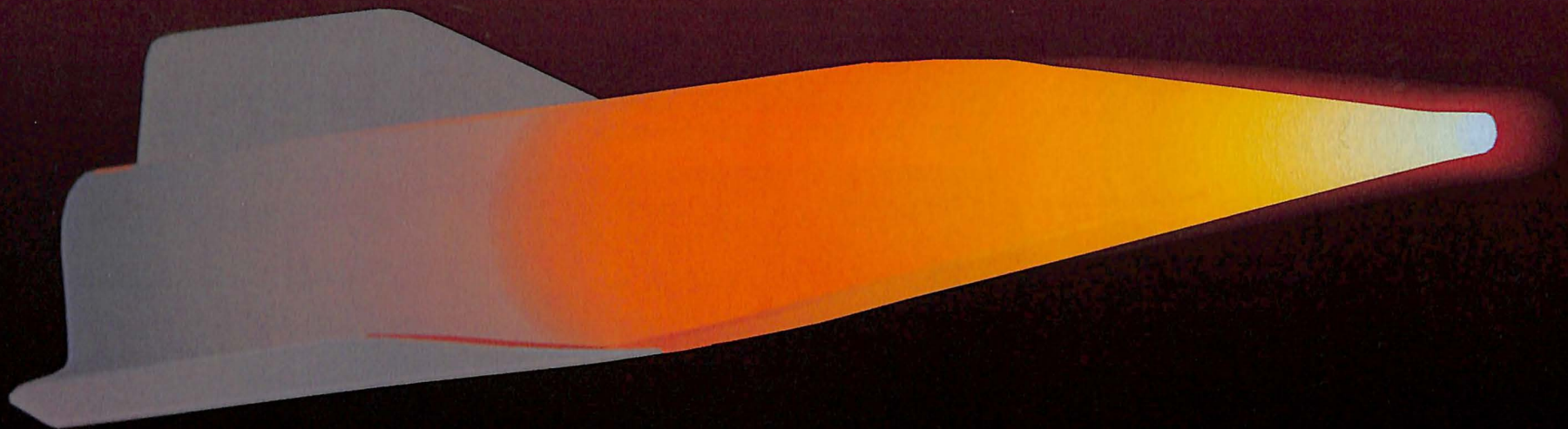
In the aerospace industry, technology development is the key to international competitiveness.

This report proposes a national strategy to improve the U.S. competitive position in the global trade arena by creating a new national effort—one which cooperatively harnesses industry, government and academia together on the focused development of key enabling technologies to regain the U.S. aerospace industry's world leadership.

The overall intent of this report is to:

- 1. Present an overview of the eight technologies***
- 2. Encourage federal endorsement of a long-term cooperative research and development effort including the participation of government, industry and academia***
- 3. Provide a basis for a truly national effort enhancing the technology development process***





COMPOSITE MATERIALS

Advanced composites make up a family of lightweight aerospace structural materials that offer significant weight savings, as well as structural integrity, in comparison to current metal alloys. Their use is predicted to result in more fuel-efficient aircraft, lighter missile and spacecraft structure, reduced manufacturing and labor costs and a more innovative approach to aerospace design. Since emerging aerospace systems are in need of such benefits, advanced composites technology can have a great effect on many programs of national interest.

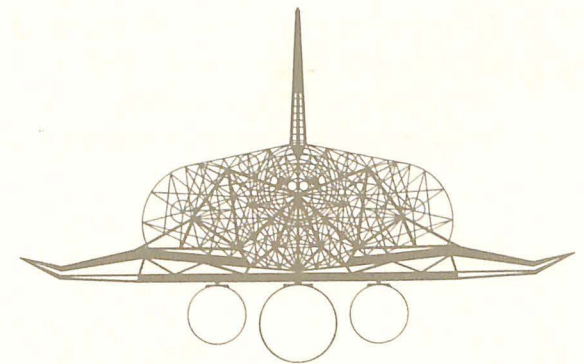
At present, a number of application barriers still exist, even though advanced composites have been studied for some time. Confidence in this relatively untested technology is not yet strong, and many costs still remain prohibitive. However, advanced

composites exhibit such an excellent strength-to-weight ratio that the potential future market is quite large. This factor alone is enough to encourage significant cost reduction through competition between suppliers.

Aspects of this technology, such as lower structural weight and greater component heat resistance, make advanced composites a required area of development for future aerospace applications, such as high-speed aircraft and advanced propulsion systems. Currently, development is concentrating on improving the performance of the basic materials and identifying cost-effective applications. Due to the complexities of composite materials, such as their directional properties, their low ductility and fiber/matrix interface problems, there is a need for advanced automated design and manufacturing techniques, as well

as more highly skilled engineers who are familiar with the developmental problems of composites technology.

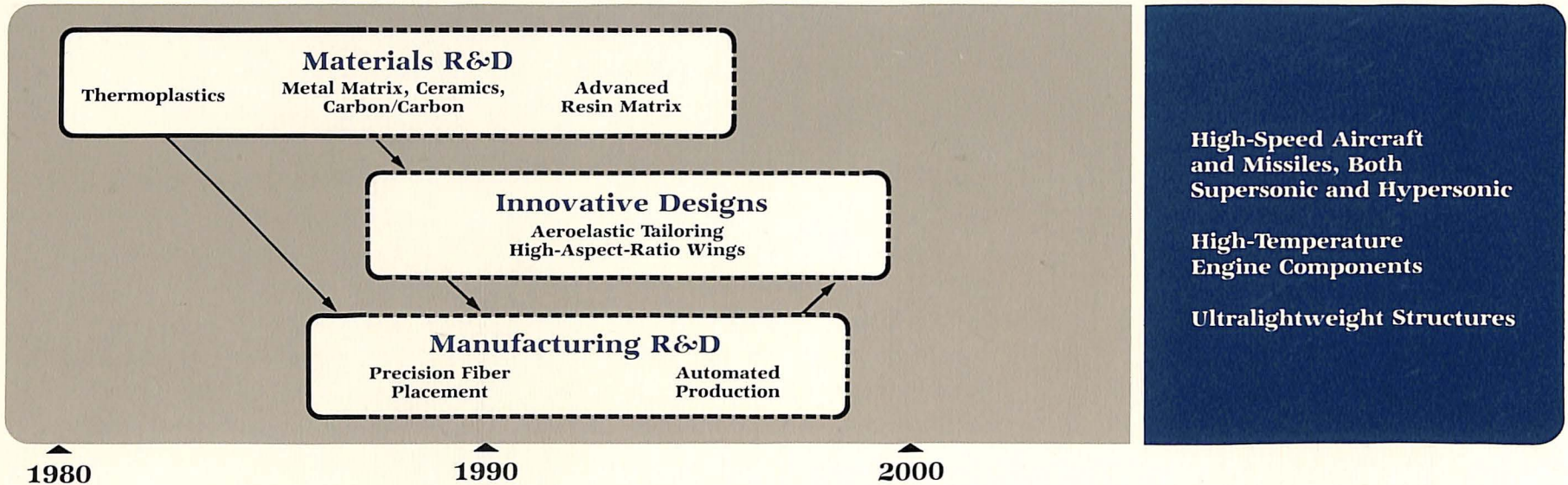
Encouragement of this R&D effort would help the U.S. composites industry maintain its lead. Future program requirements demand that immediate attention should be given to the fabrication of materials exhibiting even greater toughness, utility and resistance to higher temperature. With a sufficient effort, a 25% to 50% reduction in production costs for most aerospace structures could be realized before the year 2000.



COMPOSITE MATERIALS

ACTIVITIES

PAYOFFS



ADVANCEMENT INHIBITORS

- Materials and processes are still evolving
- Questions of long-term durability
- Raw material and processing costs are high
- More skilled engineering resources are needed

REQUIRED DEVELOPMENT

- High-temperature materials
- Refined structural analysis methods
- Unified technical data base
- Improved environmental durability
- Innovative, low-cost manufacturing methods
- Simplified repair methods
- Advanced automated design techniques

COMPOSITE MATERIALS

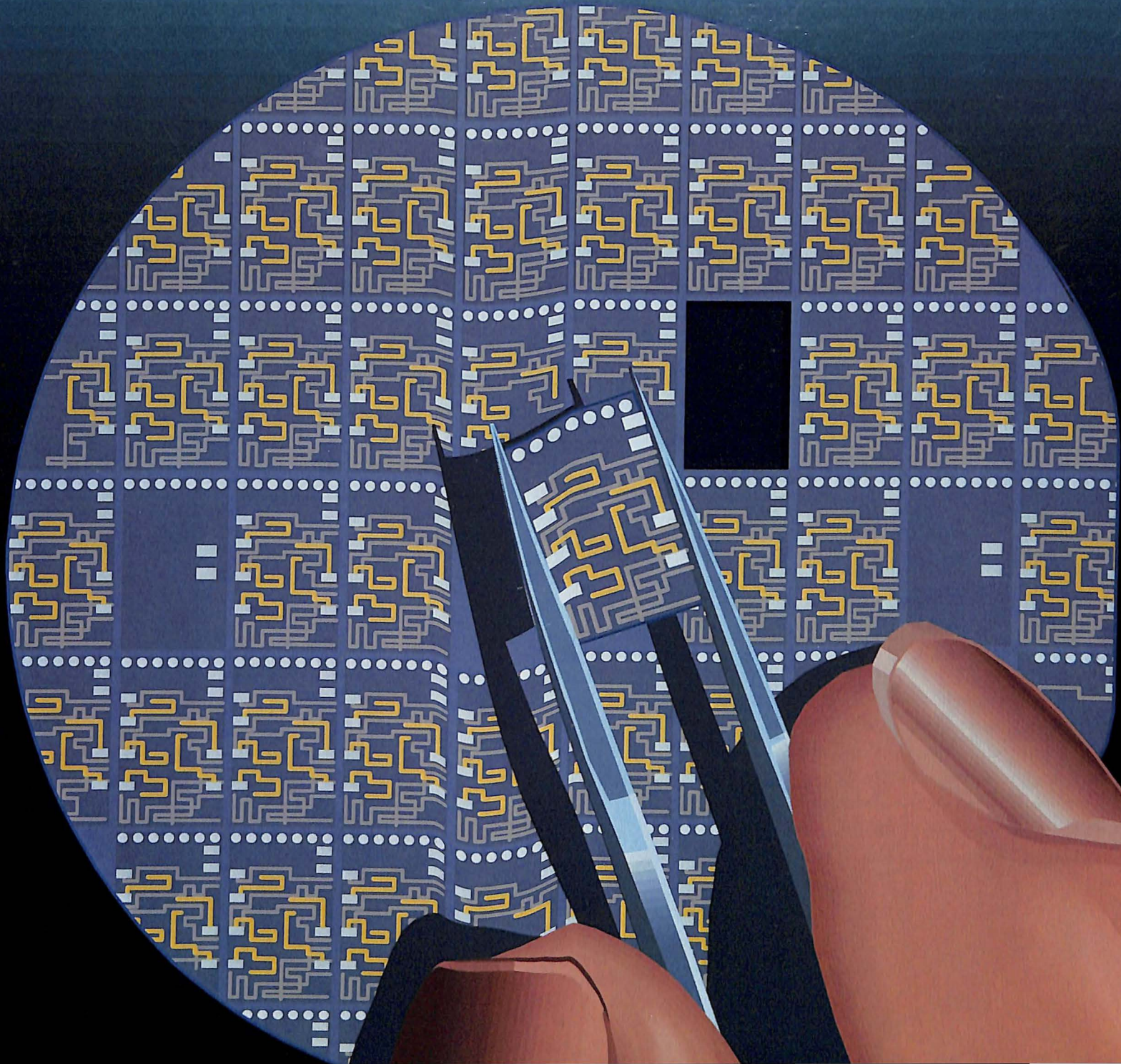
RECOMMENDATIONS

- Institute a major national program to accelerate development of a broad technology base with active government, industry and university support
- Demonstrate maintainability and cost-effectiveness of advanced composites
- Pursue new and innovative material forms and processes to exploit potential of advanced composites
- Continue development of advanced automated design and analysis methods for effective and efficient fulfillment of system requirements

MAJOR BENEFITS

The application of advanced composite materials represents the potential for major improvement in the weight and integrity of aerospace structure

Benefits	Applications			
	Primary Vehicle Structure	Advanced Propulsion Systems Components	Space Structure	Ground Vehicles
Significant Weight Savings	●	●	●	●
High-Temperature Resistance	●	●		
Reduced Life Cycle Cost	●	●		●
Improved Survivability and Maintainability	●	●	●	●
Corrosion Resistance	●	●	●	



VERY LARGE SCALE INTEGRATED (VLSI) CIRCUITS

The revolutionary advances made in aerospace electronics have been driven by the advances in integrated circuits. The staggering amount of expertise focused on electronics microminiaturization has provided very large scale integrated (VLSI) circuits. By the turn of the century, the number of transistors per chip will reach into the tens of millions. Additionally, new materials are emerging, particularly gallium arsenide (GaAs), that have the promise to further increase the electronic speed on a chip by a factor of three or more. Recently announced achievements in superconductivity might provide further advances in VLSI circuit performance.

Such compact circuitry will provide computers with an even greater computational capability, and yet they will be smaller, more reliable and easier to maintain.

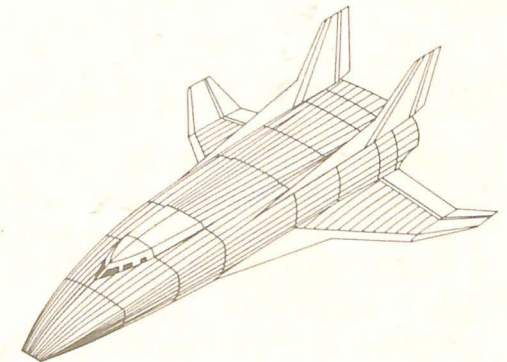
They will give unprecedented performance in aerospace and many other fields, providing the "brains" for aircraft, satellites and weapons. Additionally, they will play a pivotal role in the development of other newly emerging fields, such as artificial intelligence, and will be applied broadly throughout the civil economy.

Although the U.S. pioneered integrated circuits, foreign manufacturers now dominate production of commercial semiconductor devices and have rapidly implemented new technology, including VLSI. The DOD VHSIC and MIMIC programs are promoting significant advances in U.S. capability, and a recent industry/government program, SEMATECH, is helping to ensure domestic manufacturing sources.

It is essential that these initiatives be sustained. Major new emphasis

is needed so we can achieve improved design simulation; submicron scale device fabrication; enhanced aerospace attributes such as ruggedness, testability and radiation hardness; advanced semiconductor materials; and interconnecting and packaging.

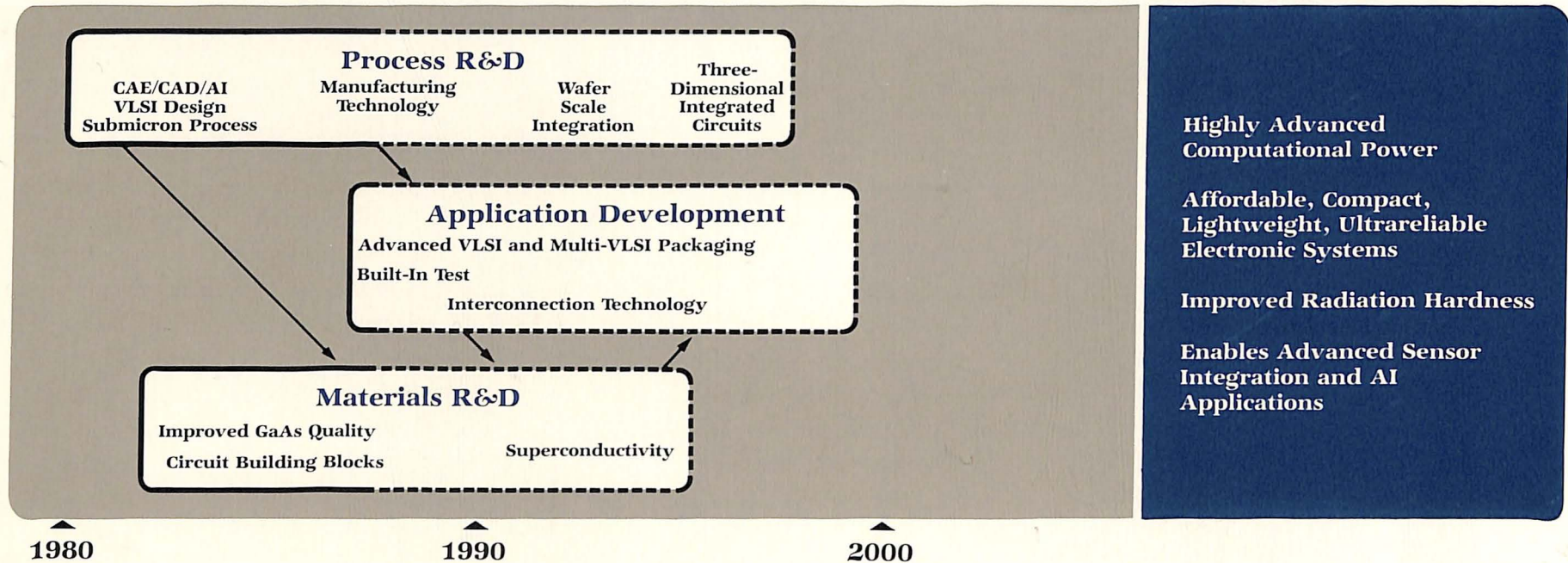
These challenges can be met by key, focused programs designed to cooperatively advance these vital areas. Without such initiatives, the U.S. may not achieve its essential technological goals and leadership will continue to remain with foreign interests.



VERY LARGE SCALE INTEGRATED (VLSI) CIRCUITS

ACTIVITIES

PAYOFFS



ADVANCEMENT INHIBITORS

- Aggressive foreign investment
- Insufficient risk-sharing partnership between industry and government
- Neglect of some technology areas limits application
- Government specifications inhibit commercial advances and applications

REQUIRED DEVELOPMENT

- Continued advances in submicron process technology
- Major, rapid advances in manufacturing processes and equipment
- Advances in specific areas: integrated circuit design, packaging, interconnection, printed wiring boards, built-in test, GaAs and other advanced materials

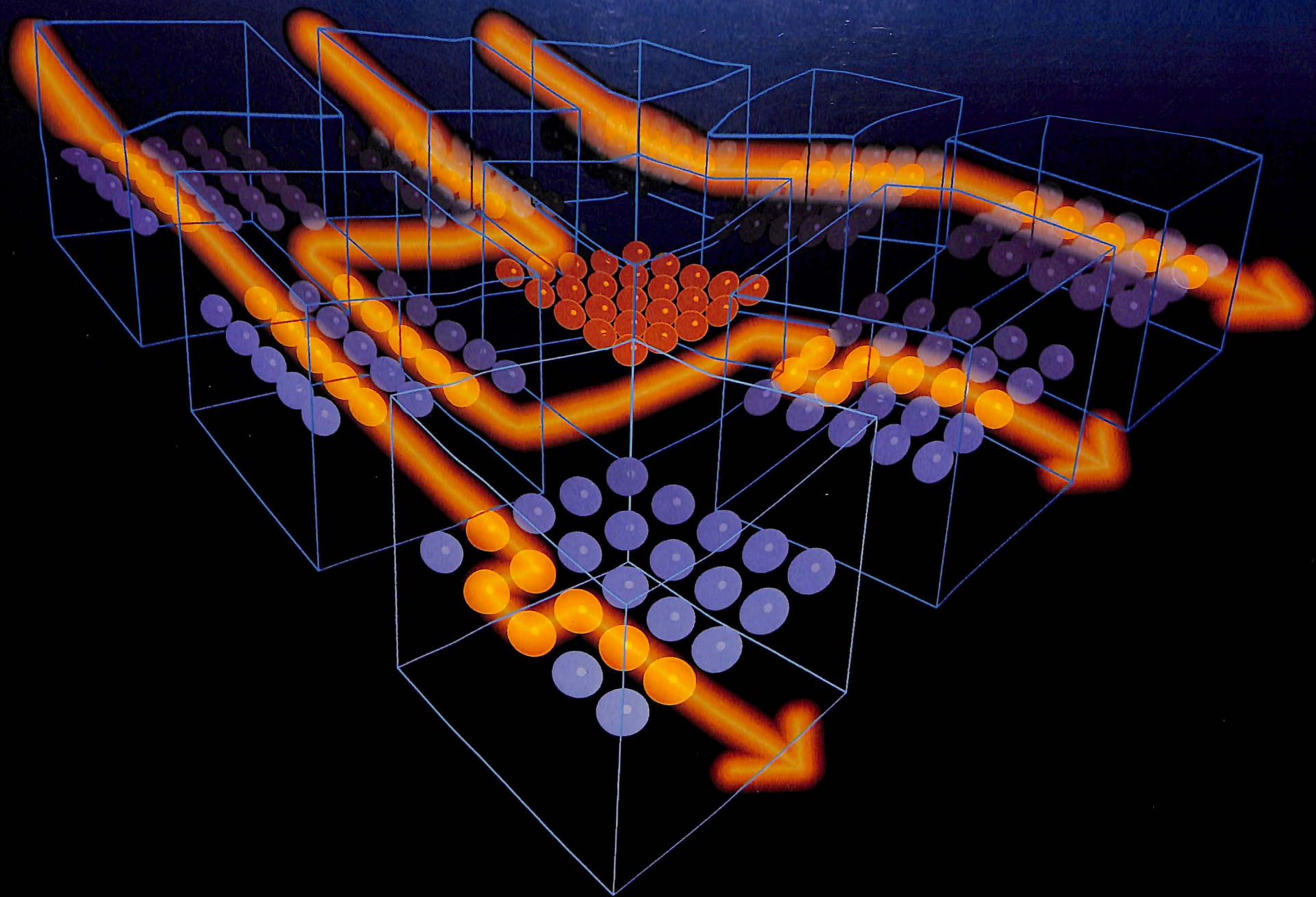
VERY LARGE SCALE INTEGRATED (VLSI) CIRCUITS

RECOMMENDATIONS

- Major new emphasis on submicron process development
- Increased emphasis on new, improved materials and processes such as gallium arsenide and superconductivity
- Focused programs on:
 - VLSI packaging
 - VLSI built-in test
 - GaAs materials, design and packaging
 - Interconnections

MAJOR BENEFITS

Major advances in VLSI capability will provide remarkably pervasive benefits for all aerospace systems					
Benefits	Applications				
	Aircraft	Missiles	Helicopters	Space Systems	Ground Vehicles
Increased Systems Capability	●	●	●	●	●
Increased Reliability	●	●	●	●	●
Reduced Size	●	●	●	●	●
Reduced Power	●	●	●	●	●



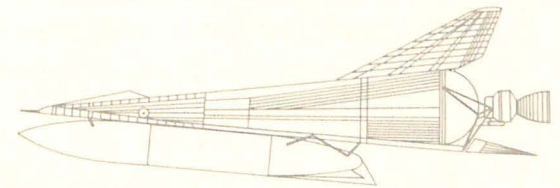
SOFTWARE DEVELOPMENT

Computer systems are currently generating more data than we can process. Without significant gains in software development, the sheer volume of information and the increasing complexity of computer systems will become liabilities rather than assets. Therefore software, the language and logic of computer operation, is rapidly becoming the key to the automated world of the 21st century. The ultimate usefulness of such future U.S. projects as the space station and strategic defense systems will be crucially dependent on our advanced software capabilities. Further, the success of automated factories, air traffic control networks, banking systems and numerous other complex computer applications is dependent on software for control and support. A vigorous, sustained software research effort is essential to meet the requirements of the future.

Because of their interrelatedness and versatility, some software technology areas offer particularly high payoffs. These areas include support environments, very high level languages and computer-aided software requirements and design capabilities. The recent Ada initiative has provided a foundation for making progress in these areas. Other important software technologies, in terms of their leverage on aerospace capabilities, are data base management systems, multilevel security and artificial intelligence (AI). Recent experience with AI applications has indicated that major payoffs require combinations of AI and conventional software capabilities. This implies that greater investments in conventional software technologies are needed to realize fully the payoffs from investments in AI technology.

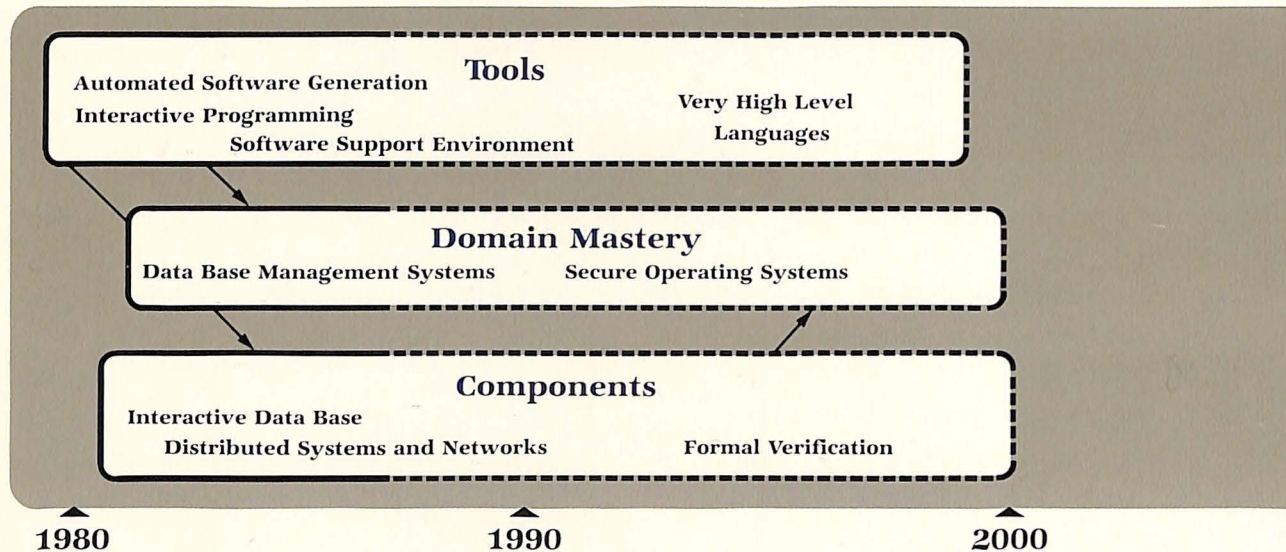
Development of advanced

software technology is currently limited by the level of funding, the degree of formal understanding, the lack of focused research efforts and the availability of key personnel. While the United States is in the forefront of this technology, major foreign consortiums already exist, and European countries are currently leading the United States in certain areas of software development. An R&D thrust centered on advanced software could lead to an order-of-magnitude increase in the productivity of computer systems and an equal decrease in error rates before the end of the century.



SOFTWARE DEVELOPMENT

ACTIVITIES



PAYOFFS

Highly Secure Systems
 Increased Productivity at Lower Cost
 Fault-Tolerant Systems
 Multiple-System Interaction

ADVANCEMENT INHIBITORS

- Lack of focused developmental efforts to accelerate advances in software support environments and very high level languages
- Lack of personnel skilled in various technology development areas
- Interoperability between AI and conventional software capabilities
- Ineffective cooperation between academia and industry
- DOD software acquisition practices

REQUIRED DEVELOPMENT

- Software for parallel and distributed processors
- Software support environments
- Efficient formal software capabilities
- Automated software generation capabilities
- Formal principles for multilevel security, data base inferencing and proof of correctness
- Aerospace-oriented very high level languages
- Hybrid AI/conventional software systems

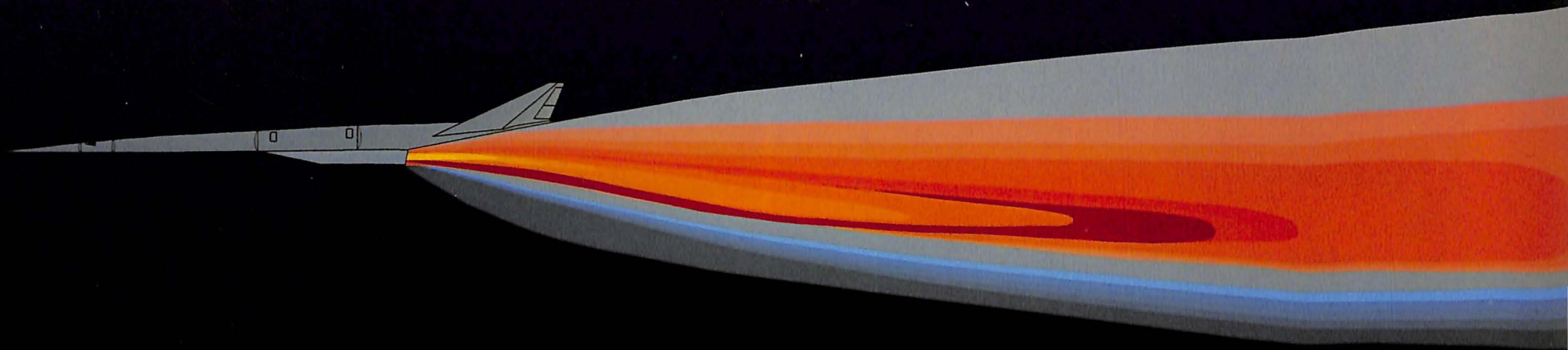
SOFTWARE DEVELOPMENT

RECOMMENDATIONS

- Modernize software acquisition practices through joint government/industry development
- Reinforce Software Engineering Institute's role as technology transfer agent
- Create incentives for academia and industry to work cooperatively on different aspects of the same problem or idea
- Expand and reorient software/AI R&D program
- Take greater advantage of available software technology

MAJOR BENEFITS

Order-of-magnitude increase in security, productivity and reliability					
Benefits	Applications				
	Avionics	Command, Control and Intelligence	Communi-cations	Sensor Systems	Smart Components
Increased Productivity	●	●	●	●	●
Decreased Error Rate	●	●	●	●	●
Rapid Reconfiguration	●	●	●	●	
Improved Decision Support/Data Fusion	●	●			
Reduced Size, Weight and Power	●		●	●	●



PROPULSION SYSTEMS

Within 20 years, advancements in propulsion technology could result in the design of subsonic transports requiring 30% less fuel and fighter aircraft with sustained Mach 3+ capability. New propulsion concept developments are critical to future designs such as an advanced supersonic civil transport and hypersonic or transatmospheric vehicles. For space flight, improved durability and performance capability of rocket engines could enable an order-of-magnitude cost reduction for placing payloads into low earth orbit. Advanced technology will also enable more versatile and cost-effective missile systems. Concepts already exist that would enable many of the cited advancements, but capability is yet to be proven.

Current propulsion programs include the National Aerospace Plane (NASP), the Advanced

Launch System (ALS) and the Integrated High Performance Turbine Engine Technology (IHPTET) programs. The AIA agrees with the goals of these programs and views their continuation over the next decade as essential. However, even though these programs will provide substantial benefit to aircraft propulsion requirements, they will not provide answers in all key areas.

For example, a dedicated initiative is needed for further development of gas turbine power plants, the mainstays of commercial and military aircraft, and to explore the potential of much higher flight speeds. Rocket engines also need accelerated development to reestablish the U.S. position of preeminence in space. Current and planned space propulsion systems are based on 20-year-old technology. A sustained

national commitment is required to investigate and demonstrate new designs that will benefit U.S. missions.

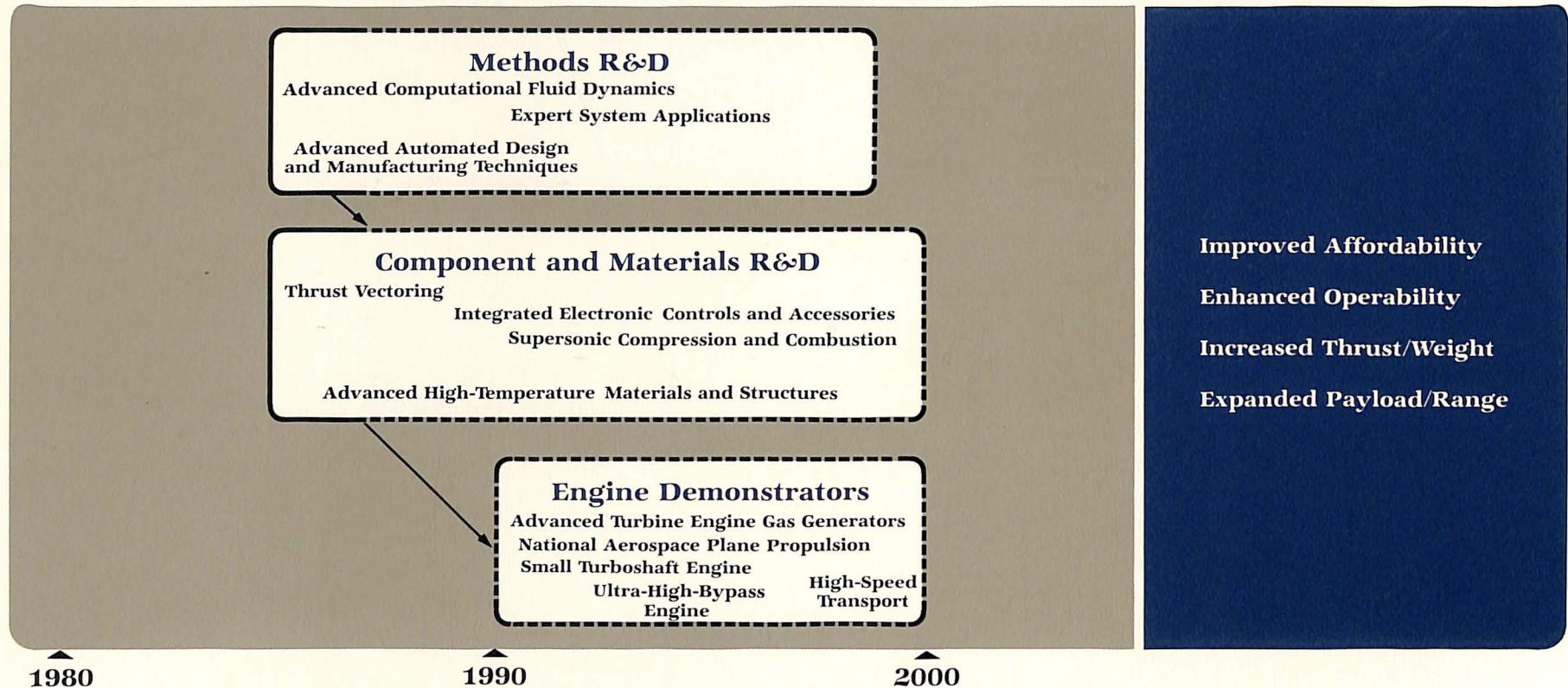
Advances forecast for both airbreathing and rocket engine types make it clear that a complete reevaluation of engine architecture, fuels and materials must take place. The schedule of progress in propulsion technology development may hinge on the ability to fabricate complex propulsion systems from high-temperature composite materials. This is one more indication of the criticality of key technologies and the benefits to be gained by focusing on their development.

PROPULSION SYSTEMS

Airbreathing Engines

ACTIVITIES

PAYOFFS



ADVANCEMENT INHIBITORS

- Absence of national plan for advanced subsonic and supersonic commercial aircraft propulsion development
- Unavailability of advanced high-temperature materials
- Insufficient development funds
- Lack of skilled engineering resources

REQUIRED DEVELOPMENT

- Turbomachinery
- Combustors/augmentors
- Inlets and exhaust systems
- Controls, accessories and mechanical systems
- Advanced automated methods

PROPULSION SYSTEMS

Airbreathing Engines

RECOMMENDATIONS

- Continue planned technology base programs for IHPDET, NASP and high-speed commercial transport (HSCT)
- Pursue new and innovative material forms and processes in all temperature ranges
- Develop knowledge-based computer systems for propulsion applications
- Exploit technology demonstrator vehicles with challenging systems objective as a key development strategy
- Develop advanced automated design, manufacturing, test and analysis methods

MAJOR BENEFITS

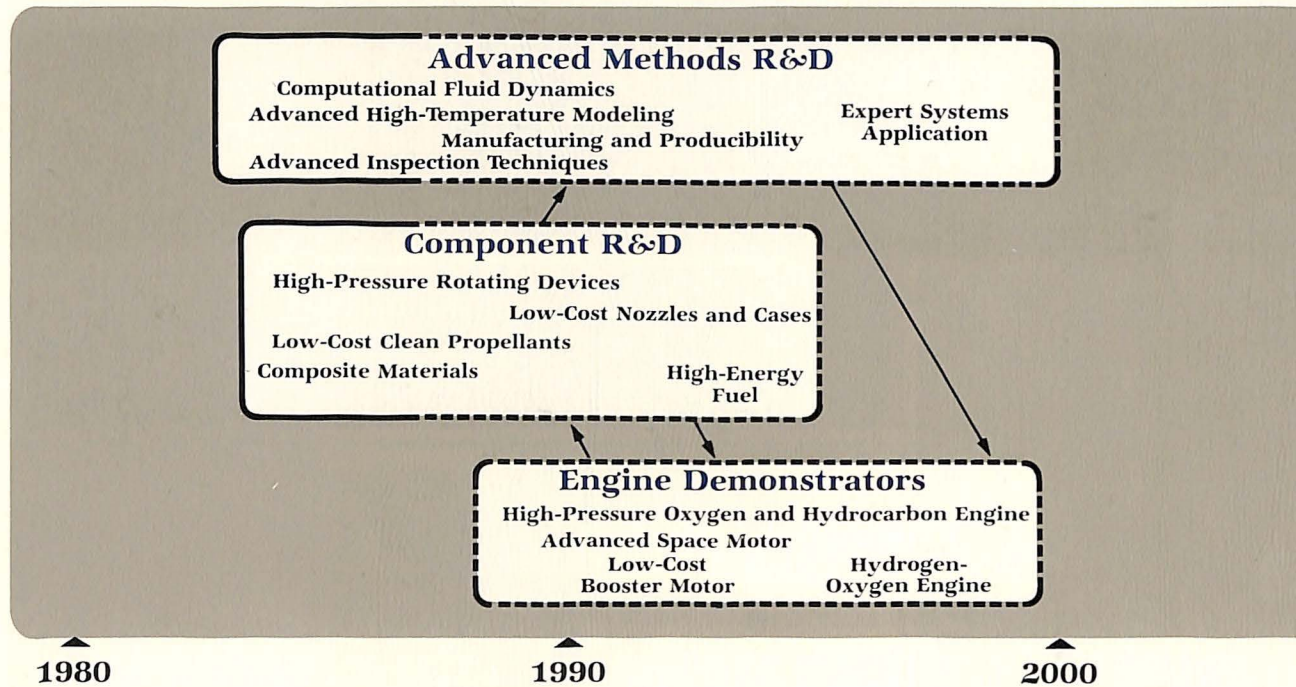
New propulsion technology developments will provide major gains in propulsion system capability for a wide range of potential applications

Benefits	Applications		
	Aircraft	Missiles	NASP and HSCT
Increased Affordability	●	●	
Lower Life Cycle Cost	●	●	●
Reduced Weight, Improved Range, Reduced Fuel Consumption	●	●	●
Increased Survivability	●		
Enhanced Operability	●	●	●
Increased Speed	●	●	●

PROPULSION SYSTEMS

Rocket Engines

ACTIVITIES



PAYOFFS

Order-of-Magnitude Reduction in Cost To Orbit

Extended Engine Operating Life

Higher Safety and Reliability

Heavier Orbital Payload

ADVANCEMENT INHIBITORS

- Perceived as technically mature
- Inadequate development funds
- Growing foreign competition
- No longer a glamorous technology
- Shortage of skilled engineers
- Lack of sustained support and specific, long-range U.S space goals
- Inadequate test facilities

REQUIRED DEVELOPMENT

- Advanced automated methods
- Cost-driven design methods
- Improved materials
- Improved manufacturing methods
- Nondestructive testing techniques
- Technology demonstrators

PROPULSION SYSTEMS

Rocket Engines

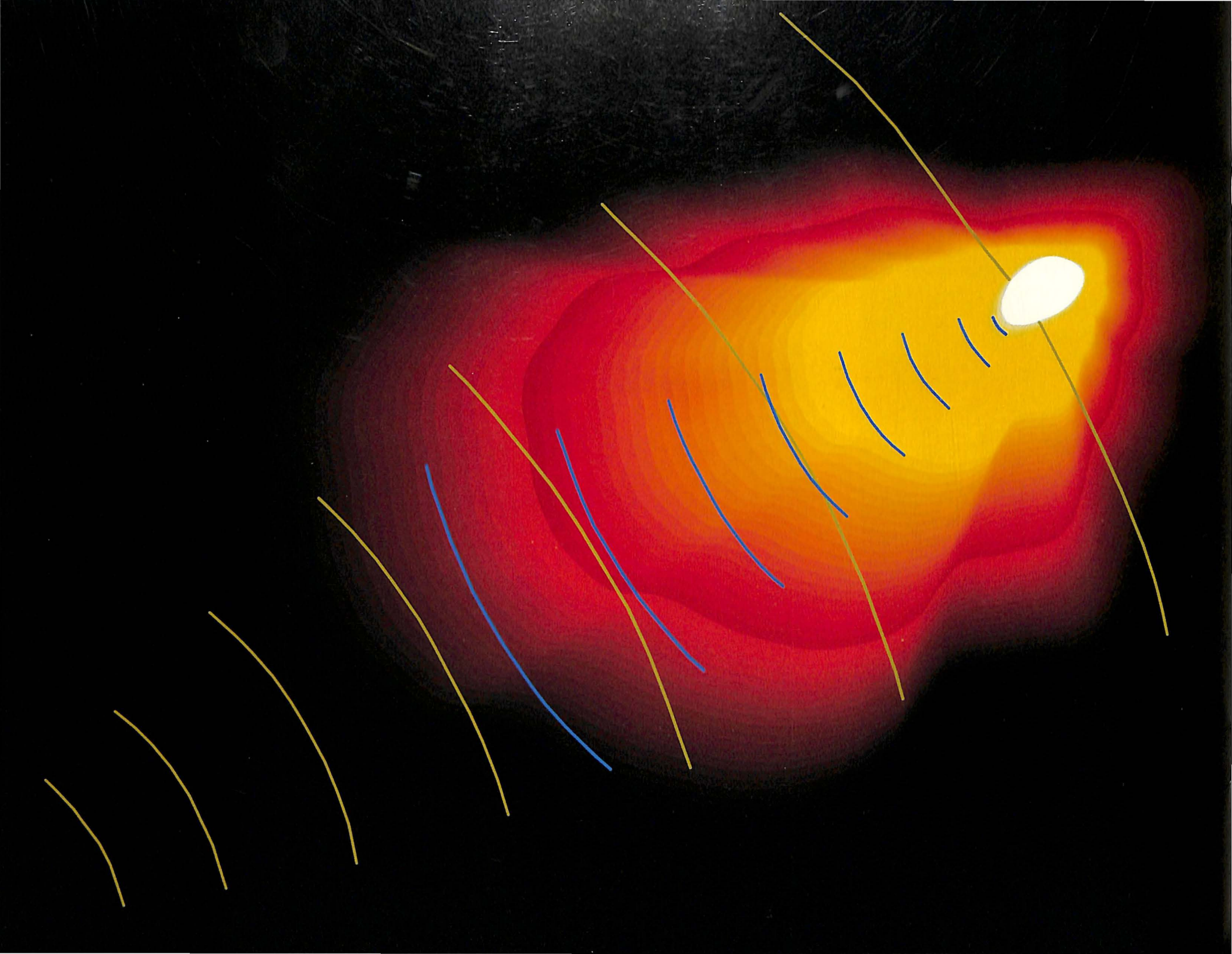
RECOMMENDATIONS

- Reestablish a national commitment to foster the advances necessary to maintain technological excellence
- Expand national propulsion technology programs to advance analytical and computational methods
- Investigate new materials and fuels, methods of manufacture and inspection techniques
- Expand health monitoring and control systems to enhance low-cost operations
- Investigate combustion phenomena and advanced heat-transfer techniques
- Test engine demonstrators to verify technology gains
- Develop advanced automated design, manufacturing, test and analysis methods

MAJOR BENEFITS

Propulsion technology advances will produce order-of-magnitude reductions in cost-to-orbit and reductions in engine costs with improved performance

Benefits	Applications				
	Space Launch Vehicles	Orbit Transfer Vehicles	Ballistic and Tactical Missiles	Space Intercepts	On-Orbit Planetary
Improved Payload and Range	●	●	●	●	
Improved Safety	●		●		
Reduced Maintenance	●	●	●		
Improved Environmental Effects	●	●			
Extended Operating Life and Reusability	●	●			●
Reduced Life Cycle Cost	●	●	●	●	●



ADVANCED SENSORS

As the operational environment becomes increasingly complex, sensors will have to detect and relay more and more information related to flightpath selection. Certainly future scenarios imply a critical need for more effective and affordable sensors. Strategic systems, including the Strategic Defense Initiative, demand sensors that automatically detect and identify very distant threats. For survivability of aircraft operating at low altitude, all threats must be sensed, recognized and countered automatically or presented to the pilot for verification and immediately counteraction.

Advanced sensors can aid both commercial and military aviation by providing increased flight safety and performance. Further development of this technology could also enable the design of much lighter weight, more affordable and reliable onboard

equipment for a variety of applications.

Significant advances have recently been made in both high-performance infrared detectors, radar transceiver components and laser sensors. Proof-of-concept work needs to proceed. Improved sensor arrays have not yet been produced in great enough numbers to accurately measure their reliability. For those components to be broadly used, production costs must be significantly decreased.

Emphasis is being placed on linear gallium arsenide through the MIMIC program, and infrared has been highlighted by the Defense Projects Engineering Standards Office thrust. However, a continuing focus is required across a broader front, especially in infrared and fused sensor systems, to seize and widen our initiative.

Compared to the level of sensor technology development held by several other major world powers, U.S. development is lagging. For example, as a result of advances in IR and radar sensor technologies made by France and the United Kingdom, we no longer have a competitive edge within NATO. The U.S.S.R. and certain other Iron Curtain countries announced significant breakthroughs in other sensor technologies in the early part of this decade; they have since halted publication of their research, but we must assume that they are at least competitive. If the United States is to be a leader in military and commercial sensor development, immediate emphasis must be placed on this technology.

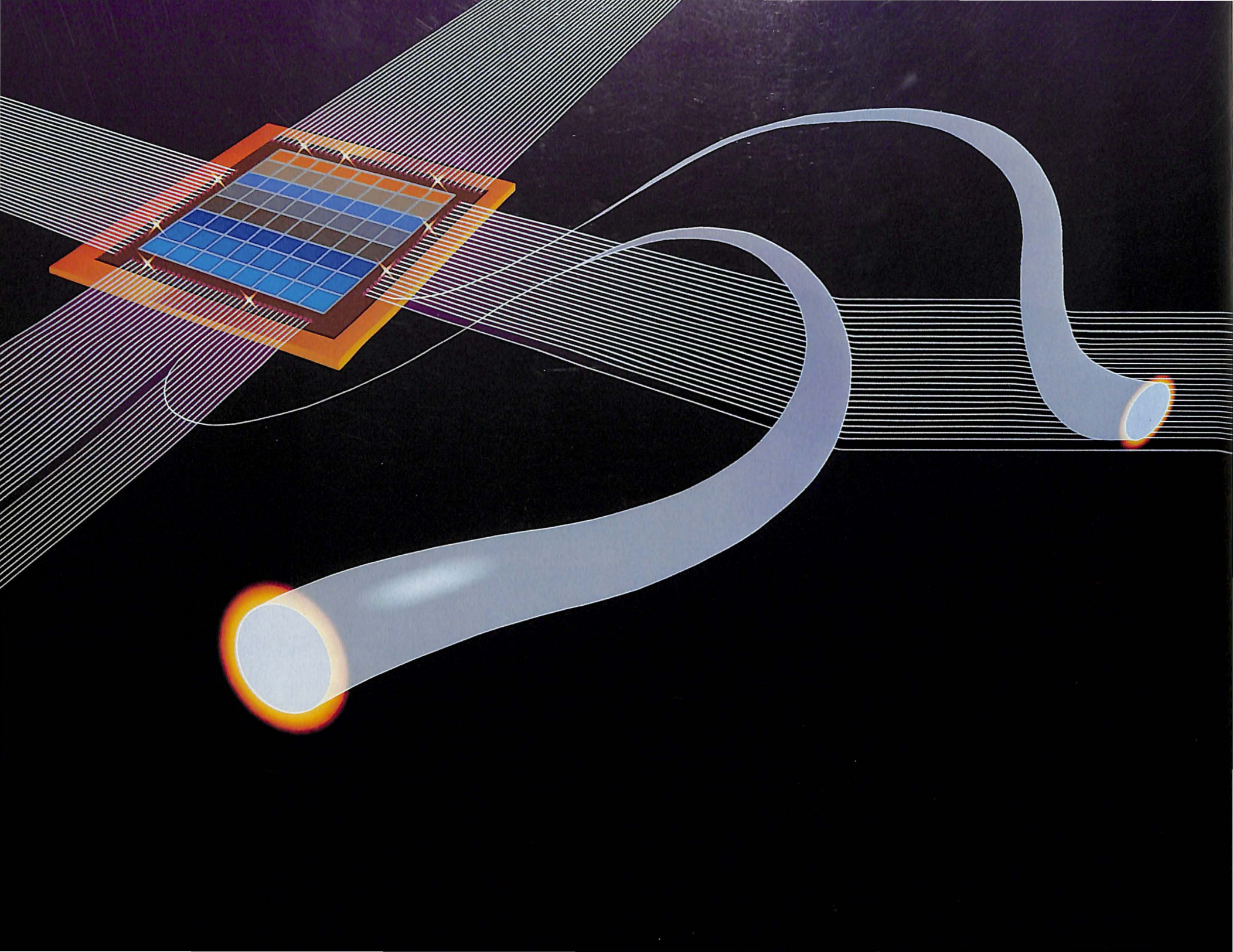
ADVANCED SENSORS

RECOMMENDATIONS

- Develop advanced systems architecture directed at multisensor solutions to overcome basic limitations of standard sensors
- Develop multiapplication microwave/millimeter-wave integrated circuits needed to support these multisensor systems
- Develop multiapplication, high-performance focal-plane arrays based on recent breakthroughs
- Explore and broaden sensor spectral limits beyond current areas, including future breakthroughs anticipated through developments in high-temperature superconductive materials
- Incorporate the new arrays and integrated circuits into integrated avionics systems for stealth, force multiplication and affordability

MAJOR BENEFITS

Advanced sensor development offers both improvements to the individual systems and the possibility of combining information to enhance performance to match ever-increasing requirements and challenges				
Benefits	Applications			
	Commercial and Military Aircraft and Helicopters	Missiles	Space Vehicles	Ships and Ground Vehicles
Computer-Integrated Detection-Reaction Capability	●	●	●	●
Improved Survivability	●			●
Increased System Affordability	●	●	●	●
Reduced Equipment Size and Weight	●	●	●	●
Reduced Life Cycle Cost	●	●	●	●



OPTICAL INFORMATION PROCESSING

Early in the 21st century, aerospace information processing requirements may exceed the practical performance and reliability limits of conventional electronics. Fortunately, the use of optical information processing, as compared to current electronic methods, is expected to provide a thousandfold improvement in performance and possibly reliability as well.

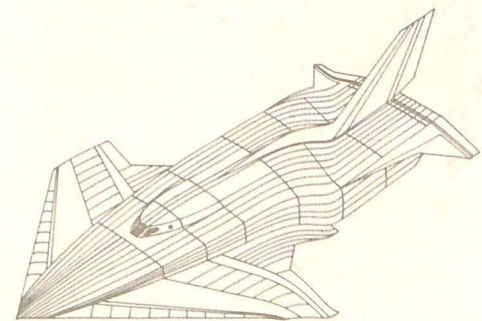
Optical information processing is concerned with the storage and manipulation of data by optical devices. This technology includes signal, image, numerical data and symbolic data processing. The key to this new technology is the use of light as opposed to the charged electron flow used in conventional electronics. The electromagnetically neutral light particles, or photons, move much faster and are unaffected by electromagnetic interference or

strong electromagnetic pulses. Since virtually all types of future aerospace systems will require much faster real-time information processing, optical information processing is of global interest.

Current technology development is focusing on two approaches. For the near term, optoelectronics, a blend of optical methodologies, electronic methodologies and optical interconnection techniques, offers the potential of a smooth technological transition from electronics to pure optics. For the longer term, researchers are working on the development of an "optical transistor." This device will form the basis for optical integrated circuits and memory devices.

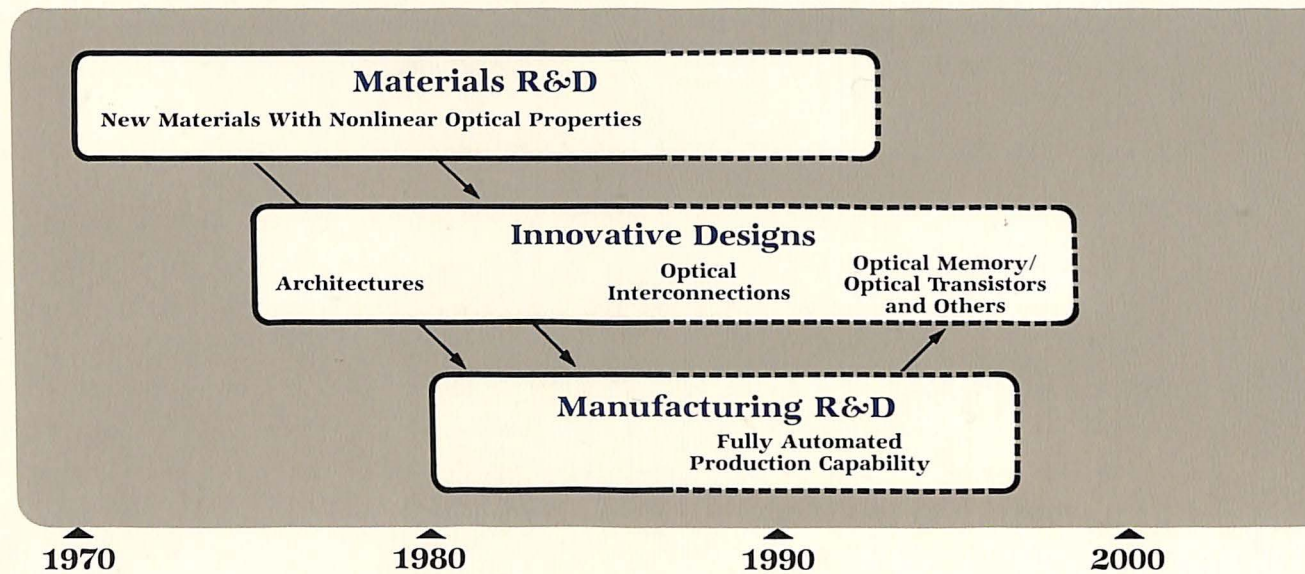
Recent advances in the three major areas of materials and devices technology, algorithm development and system architectures should help to

produce machines capable of greater information processing capability in the next several years. The successful integration of optical data processors into commercial and military systems will depend heavily on continued research. With an increase in resources, the development time could be reduced by 25% or more. This could provide an optoelectronic solution within 10 years and an all-optical solution within 20 years.



OPTICAL INFORMATION PROCESSING

ACTIVITIES



PAYOFFS

Optical Computers for Higher Speed Information Processing and Greater Reliability

An Order-of-Magnitude Reduction in the Number and Size of Component Interconnections

Lower Maintenance and Longer Life for Inaccessible Systems

ADVANCEMENT INHIBITORS

- **Technical maturation is slow**
 - Material/processes still evolving
 - Customers slow to accept
- **Inefficient technology transfer**
 - Each company tends to "do their own thing"
 - DOD data transfer to industry
- **High costs**
 - Specialized material compounds
 - Construction of clean room facilities
- **Shortage of skilled engineers and technicians**

REQUIRED DEVELOPMENT

- **Specialized material compounds with nonlinear optical properties**
- **Creation of optical system architectures**
- **Innovative, low-cost manufacturing methods**
- **Simplified repair methods**
- **New, innovative device/component designs**

OPTICAL INFORMATION PROCESSING

RECOMMENDATIONS

- Increase R&D emphasis on both optoelectronics and optical approaches
- Develop skilled human resources for all levels: R&D, engineering and manufacturing
- Attempt integration with real systems that require optical information processing beyond the capabilities of conventional electronic processors
- Establish and prioritize real-system requirements that go beyond requests for “more speed and parallelism”
- Form private U.S. consortiums to address specific technical issues but with direct ties to:
 - Key DOD agencies
 - Key technical universities

MAJOR BENEFITS

Optical information processing offers a thousandfold improvement in information processing performance and possibly reliability as well					
Benefits	Applications				
	Expert/AI Systems	Missile Guidance and Control	Super-computers	Autonomous Space Probes and Satellites	Surveillance and C ³ Systems
Improved System Performance	●	●	●	●	●
Improved System Reliability and Safety	●	●	●	●	●
Reduced Equipment Size and Weight	●		●		●
Reduced Life Cycle Costs and Maintenance	●	●	●	●	●



ARTIFICIAL INTELLIGENCE

History may judge artificial intelligence (AI) to be the most pivotal technology of this century. The success of many U.S. efforts is dependent upon computers that evaluate complex situations; therefore, the progress of AI development is crucial.

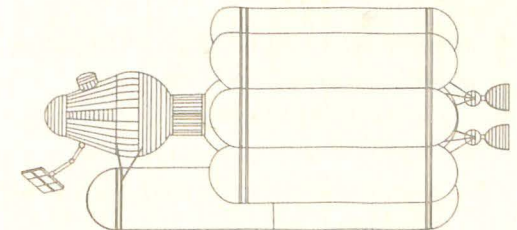
This advanced technology is concerned with complicated data processing problems and the development of problem-solving capabilities that elaborate on a model of human intelligence. AI covers a number of computer-based activities, one of the most common being the design of "expert" systems. Traditional computing techniques required hours of laborious programming to load a data base with all possible solutions to each problem. In today's expert systems, computers use selected knowledge from one or more human experts to solve problems in much the same way

as a human might. The only drawback is that such a system only "learns" from new human input. Future AI systems will be capable of machine learning; their data bases will be continuously updated by the outcome of their own problem-solving operations.

The impact of AI technology on both military and civilian aerospace systems will be considerable. Human productivity will be increased, system performance and reliability will be improved and life cycle costs will be reduced. By the turn of the century, applications of AI are expected to revolutionize a variety of aerospace products, as well as the way in which those products are manufactured.

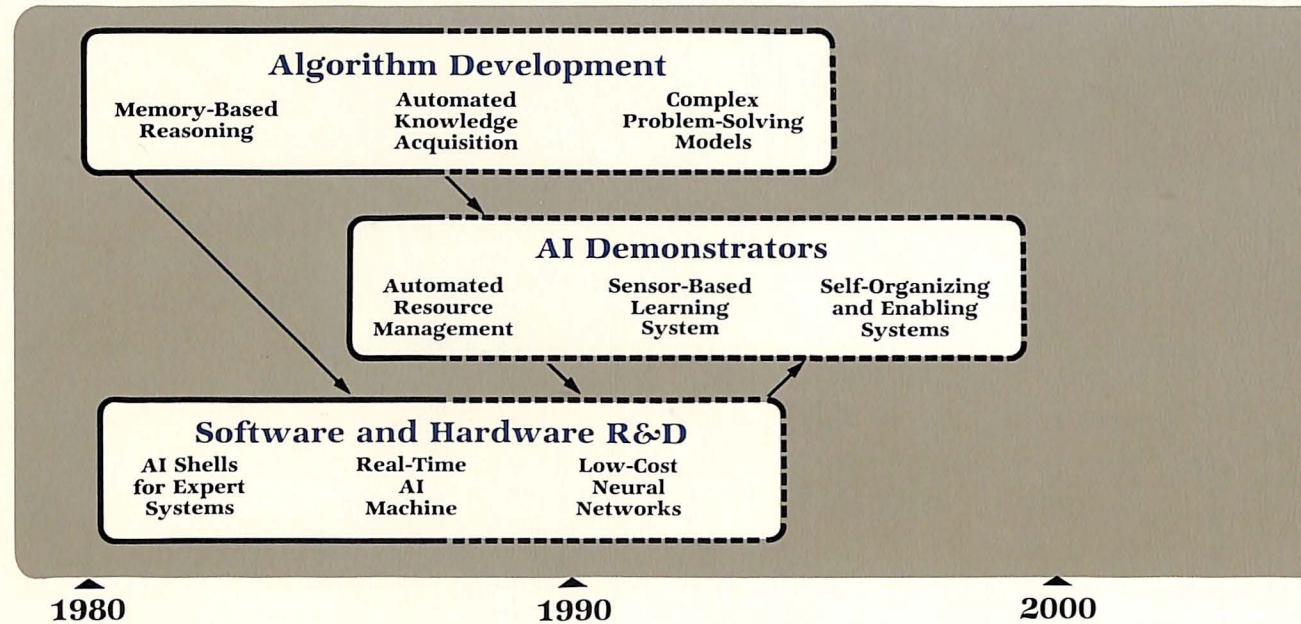
Applications of AI technology are heavily dependent on the availability of other newly emerging key technologies, such as advanced computer software.

AI will also be easier to implement with further development of computer hardware, very large scale integrated circuitry and optical information processing. We need to encourage further advances in both computing hardware and theory, as well as develop demonstrators to illustrate AI applicability as the technology moves from theory to practice. Despite strong challenges from the Soviets and the Japanese, the United States still enjoys a lead in this technology, but without focused attention this lead will undoubtedly disappear.



ARTIFICIAL INTELLIGENCE

ACTIVITIES



PAYOFFS

- Faster, More Reliable Information Gathering and Sorting
- Improved Performance for Man/Machine Systems
- Greater Mission Flexibility and Reliability
- Increased Adaptability Means Longer Life for Inaccessible Systems

ADVANCEMENT INHIBITORS

- Insufficient knowledge of human problem-solving process
- New AI technologies suffer from:
 - Unpredictable performance
 - Lack of design tools that need to be developed and proven
 - Different risk perceptions between AI and system developers
 - Divergence between academic and nonacademic technology trends

REQUIRED DEVELOPMENT

- Ultrareliable software validation methods for expert systems
- Advanced computer system for problem formulations, solution design and software design, development and maintenance
- Improved techniques for modeling and processing information contaminated by uncertainty
- Software capable of commonsense reasoning

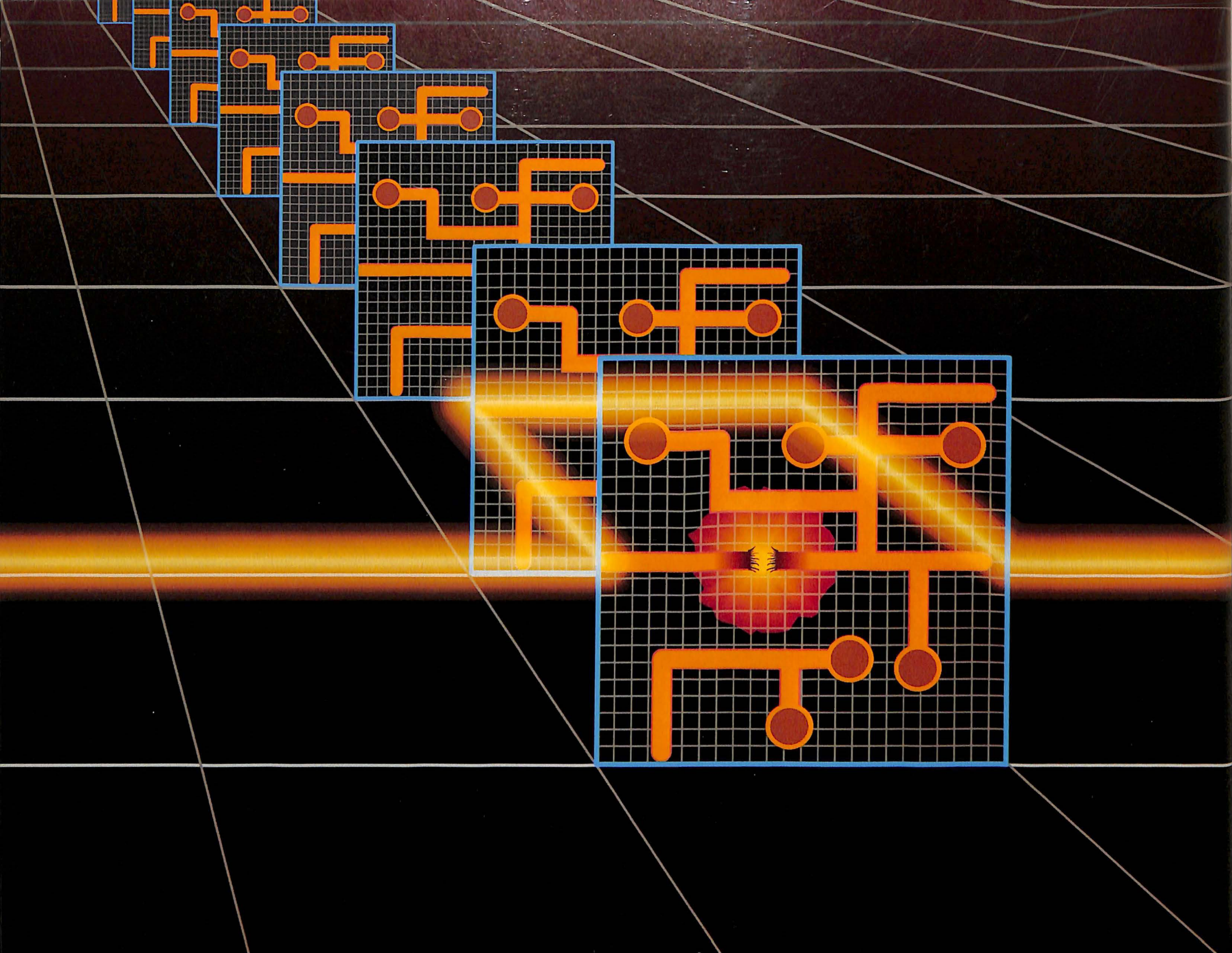
ARTIFICIAL INTELLIGENCE

RECOMMENDATIONS

- Place more emphasis on relevant, real demonstrators to encourage acceptance by system developers and enable AI to become specific in real systems
- Encourage AI content in selected systems, as with automation and robotics, for space station
- Expand government-sponsored industry internship programs for university faculty members on sabbatical
- Using the Software Engineering Institute as model, organize similar efforts to encourage communication between AI, data-based management systems and software engineering technologies

MAJOR BENEFITS

Application of artificial intelligence will result in revolutionary productivity improvements for man/machine systems					
Benefits	Applications				
	Vehicle	Sensors	Mission Support	Weapon Systems	Manu- facturing
Increased Human Productivity	●	●	●	●	●
Reduced Human Risk	●			●	
Greater Functional Performance	●	●	●	●	
Greater System Autonomy	●	●		●	
Reduced Life Cycle Cost	●	●	●	●	●



ULTRARELIABLE ELECTRONIC SYSTEMS

The next generation of flight control systems will require a level of reliability that far surpasses today's capabilities: a maximum of only one total system failure will be allowed for every 100,000 years of continuous system operation. Although the reliability of electronics has improved remarkably over the past 25 years, the increasing complexity of system designs demands that much greater emphasis be placed on the development of methodologies for producing provably correct designs for ultrareliable systems.

Currently, the reliability of a new system cannot be adequately predicted because the prediction methodology and simulation for complex systems is still too imprecise. We know too little about system failure modes to correctly focus efforts on reliability during system design. Methodologies are needed to design effective environmental

testing. Fault-tolerant architectures, hierarchical maintenance systems and self-healing systems are still evolving.

Achievement of ultrareliable electronic systems (URES) requires improvements in many separate technologies. In particular, advancements in the other five electronic technologies described in this brochure are essential for URES. Learning how to blend the applications of these technologies will further enhance our ability to increase the reliability of complex systems.

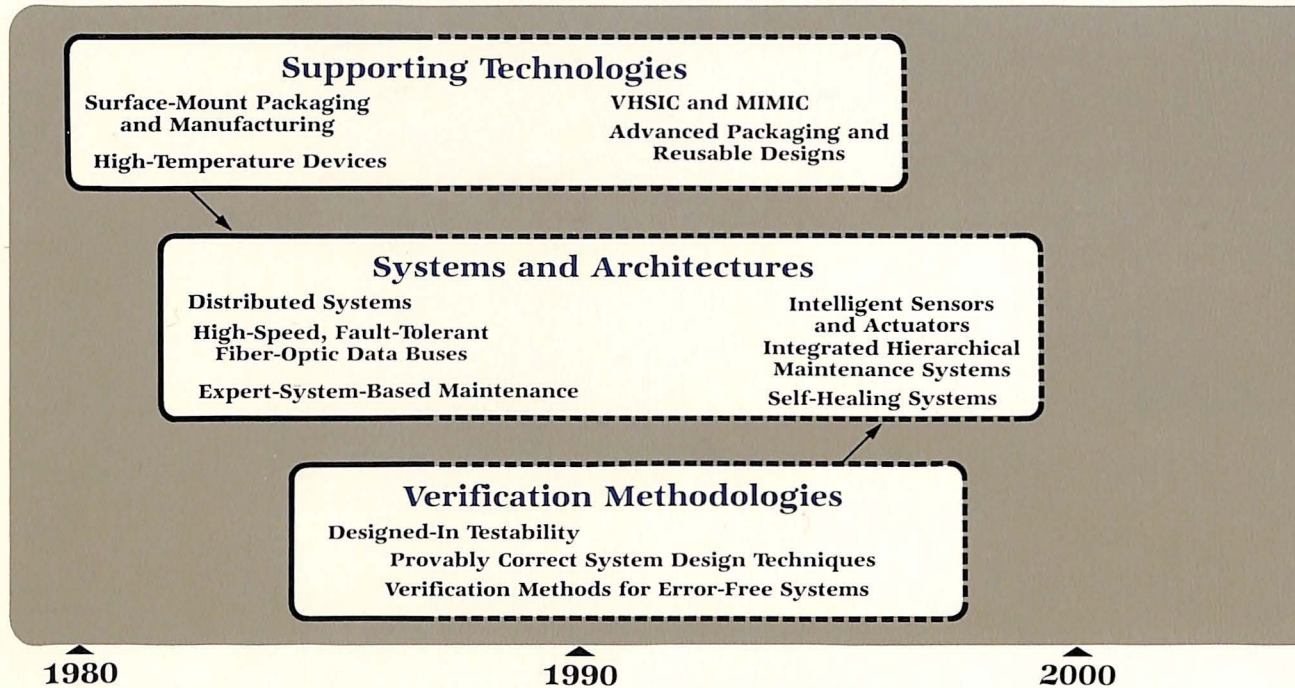
Today, a tenfold improvement can be achieved in reliability, but the price is high. In space and strategic applications, for example, components go through extensive screening, special production lines are established, lengthy testing procedures are employed and multiple redundancy is used for subassemblies. Accordingly, one goal of this key technology is to

achieve greatly increased reliability, but at an affordable cost.

The benefits of URES are applicable to an imposing array of vehicles and platforms. Greatly improved electronic reliability contributes to cost reductions in military and commercial applications, longer life and operability in space and surveillance applications, and increased safety in critical process-control applications. However, the attainment of these benefits will only be ensured by a long-term R&D effort in URES and related technologies. In addition, we recommend that the development of URES be addressed in a cooperative effort on a national level to ensure improvement in the manner in which systems are specified, procured and certified.

ULTRARELIABLE ELECTRONIC SYSTEMS

ACTIVITIES



PAYOFFS

Lifetime Maintenance-Free Systems

No Breakdowns at the Wrong Time

Reduced Life Cycle System Costs

Improved Safety

ADVANCEMENT INHIBITORS

- Continuing dependence upon costly and massive redundancy
- Lack of quantitative understanding of relationships between reliability and environment
- Microsystem management philosophy vs. a systems approach

REQUIRED DEVELOPMENT

- Packaging and manufacturing technology (e.g., SMT, VLSI, VHSIC and MIMIC)
- Methods for designing and testing error-free systems and environmental test screening
- Hardware and software failure models and system reliability prediction methodology
- Advanced CAD tools for simulation
- Self-healing and automated maintenance

ULTRARELIABLE ELECTRONIC SYSTEMS

RECOMMENDATIONS

- Promote an integrated reliability management approach emphasizing reliability methodologies, inhibitors and contractual approaches
- Emphasize proven components and software designs, as well as self-test capability
- Develop viable, rapid simulation and prototyping capability for achievement of error-free designs
- Accelerate development of advanced automated design, test and manufacturing analysis methods

MAJOR BENEFITS

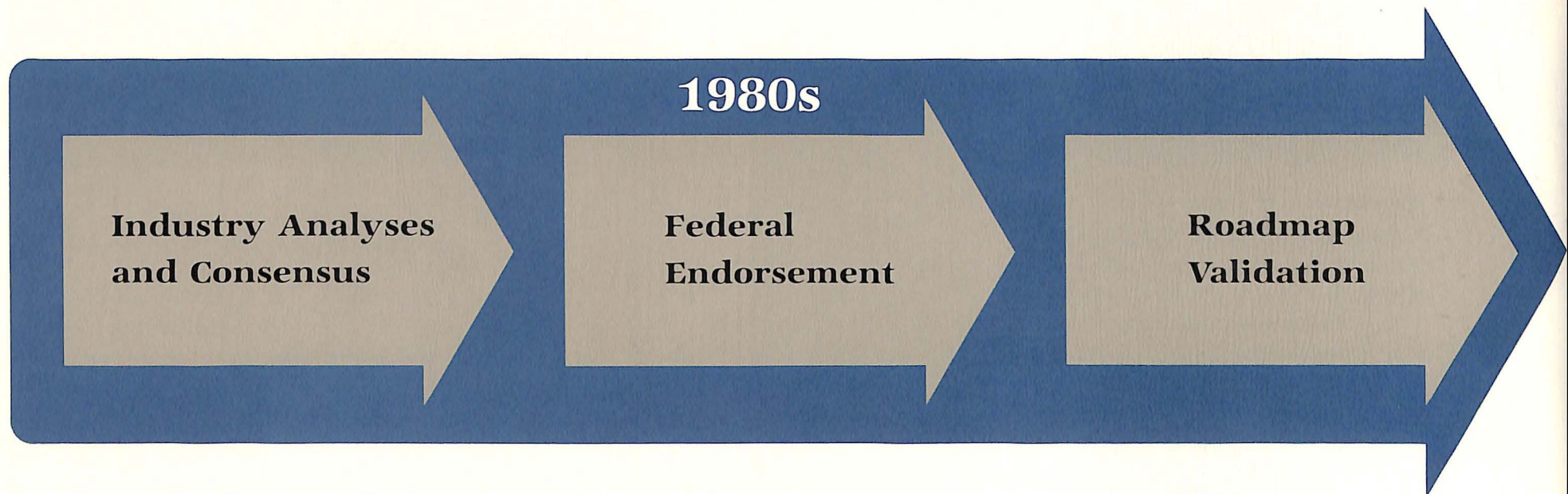
Ultrareliable electronics enable improved performance, integrity, availability and affordability of platform and vehicle systems

Benefits	Applications						
	Manned Avionics Systems			Unmanned Systems		Process Control Systems	
	Flight Controls	Sensors	Displays	Mines, Sono-Buoys, Etc.	Space Probes	Reactors	Communication
Increased Affordability (Life Cycle)	●	●	●	●	●	●	●
Increased Safety/Reliability	●	●	●			●	●
Increased Survivability	●				●		
Extended Life	●	●	●	●	●	●	●
Extended Endurance	●			●	●		
Reduced Maintenance	●	●	●	●	●	●	●

AIA studies suggest U.S. industry must exhibit strong R&D initiatives and bold leadership if we are to regain our national dominance of the international aerospace market. By industry consensus, it was agreed that the development of eight key technologies requires a more focused effort to ensure timely realization of their pivotal role in future aerospace products.

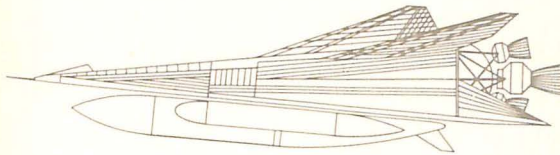
The key technology program will require broad support from the government, as well as industry and academia. Interchange with such agencies as OSTP, NASA and DOD is essential to the success of this cooperative national effort.

Following formal acceptance of the program, review teams would evaluate detailed roadmaps of each key technology to determine the most effective and appropriate actions to be taken.



L CHALLENGE

The world is on the threshold of an era that promises dramatic and, in some cases, revolutionary technological advances.



AIA studies indicate that the decade of the 1990s is a critical period in the overall scheme for regaining U.S. position in the global marketplace.

The key technologies were selected because they were higher leverage and enabling with good long-term potential. If available in the 1990s, these technologies would furnish our industry with the tools it needs to pull ahead of foreign competition.

1990s

**Cooperative National
Technology Development
Program**

Year 2000 Goal

**Global Superiority
of U.S. Aerospace
Products**

SUMMARY

The erosion of the competitive position of the U.S. aerospace industry needs immediate attention by national leadership. Current policies will not put the U.S. in a leadership position in the world aerospace industry.

Better and more cohesive national policies must be established immediately if they are to provide turn-of-the-century benefit, both to our economy and to our national security.

Initiating a strong U.S. technology development effort requires the creation of a new, long-term national perspective. This is much too large an undertaking for industry alone. If U.S. competitiveness is to be enhanced, industry, government and academia must renew the national spirit of cooperation and partnership to facilitate the prioritizing and focusing of effort.

The challenge is to make such an organized national effort work as never before in peacetime.

In the aerospace industry, technology development is the key to international competitiveness.

We see three major results as potential payoffs of a nationally focused technology program. *First, there will obviously be a more rapid maturation of priority technologies. Second, better and more cohesive policies will be established to enhance the entire national technology development process. Finally, markedly superior new products will become available by the turn of the century.*

Only if government and industry move promptly, as members of a team, will these statements become realities.

This is a long-term effort, and more than a decade will pass before most of the major technological benefits are available to new products. Considering the rate of their technology expansion, the position of our foreign competitors in the world market will most likely continue to improve. The Aerospace Technical Council offers immediate leadership to initiate and sponsor joint meetings between government, industry and university representatives. If we are to accept this international challenge, a dynamic and cooperative new national effort must be initiated immediately.

RECOMMENDATIONS

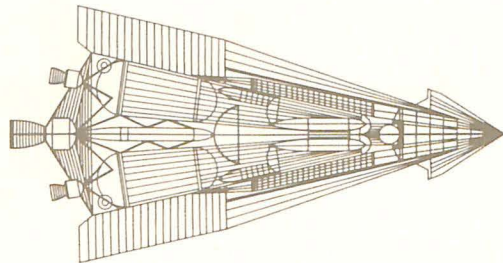
To meet the goal of regaining worldwide U.S. aerospace product superiority by the turn of the century, the AIA Aerospace Technical Council recommends that:

- **A national aerospace key technology program, led by industry, endorsed by government and supported by academia, be immediately undertaken**
- **All parties should assign high priority to this national program, at both policy and technical levels**
- **Cooperative ways should be sought to facilitate and encourage this unique technology development effort through new actions and approaches**
- **The aerospace industry should provide its collective design and manufacturing experience and its long-term focus on international competitive challenges**



“A strategic focus on key technologies is critical to U.S. leadership in the competition of new products in the global marketplace. As a nation, we must get started now.”

**Don Fuqua, President
Aerospace Industries Association**



AIA KEY TECHNOLOGIES RESOLUTIONS

WHEREAS: *Development of advanced technologies is key to the future global competitiveness of U.S. aerospace products, and*

WHEREAS: *The aerospace industry has declared its firm commitment to foster and support a bolder national research and development program, and*

WHEREAS: *Immense benefit to U.S. national security and international trade can be realized through a cooperative national technology development program endorsed by U.S. government and supported by academia.*

NOW, THEREFORE, BE IT RESOLVED: *That the Board of Governors of the Aerospace Industries Association of America hereby endorses and supports the proposal for national action initiated by the AIA Aerospace Technical Council and entitled **Key Technologies for the 1990s**.*

BE IT FURTHER RESOLVED: *That the aerospace industry will provide its available resources and leadership to work cooperatively with government and academia to attain the **Key Technologies for the 1990s** goal of ensuring worldwide U.S. aerospace product superiority by the end of this century.*

Unanimously adopted by the AIA Board of Governors, November 21, 1987.



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