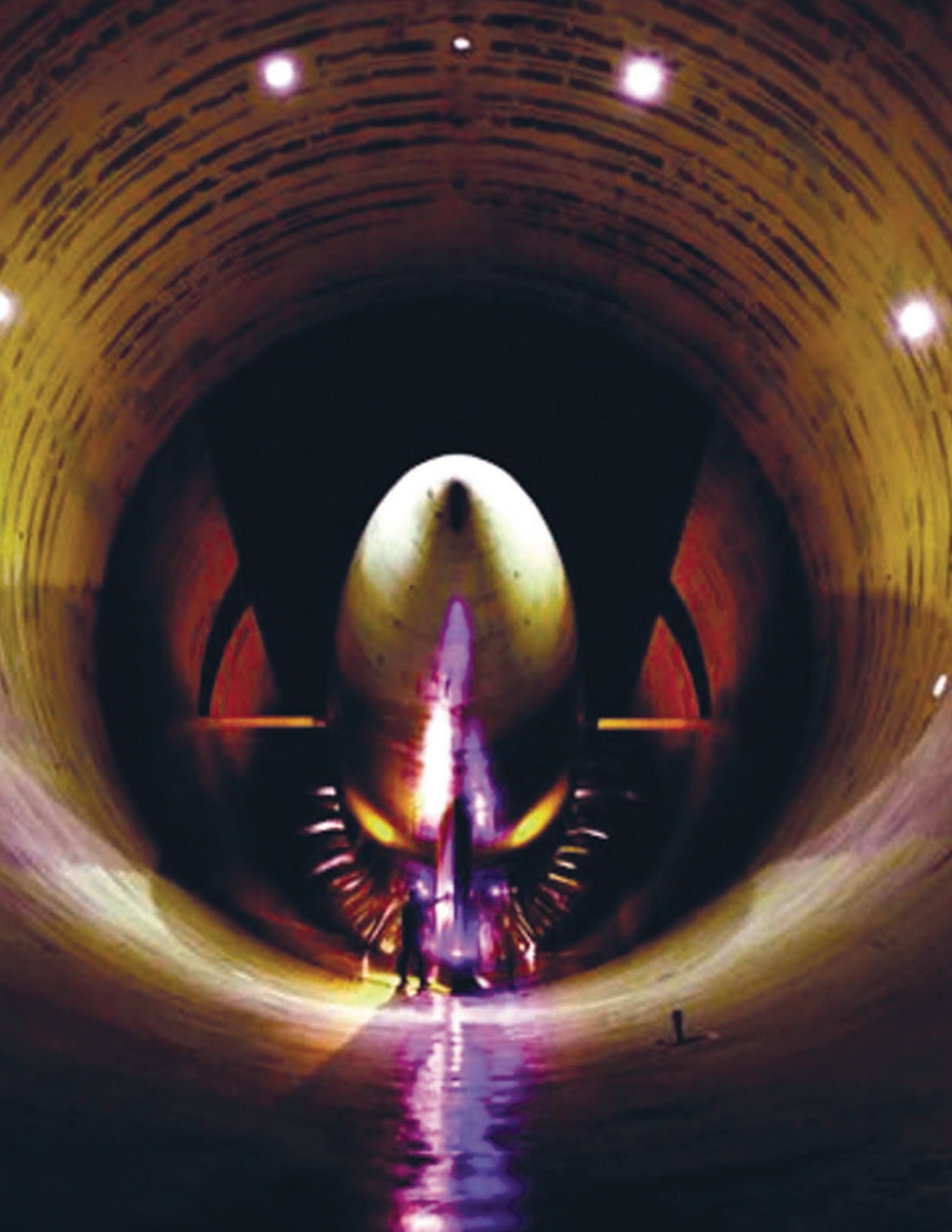
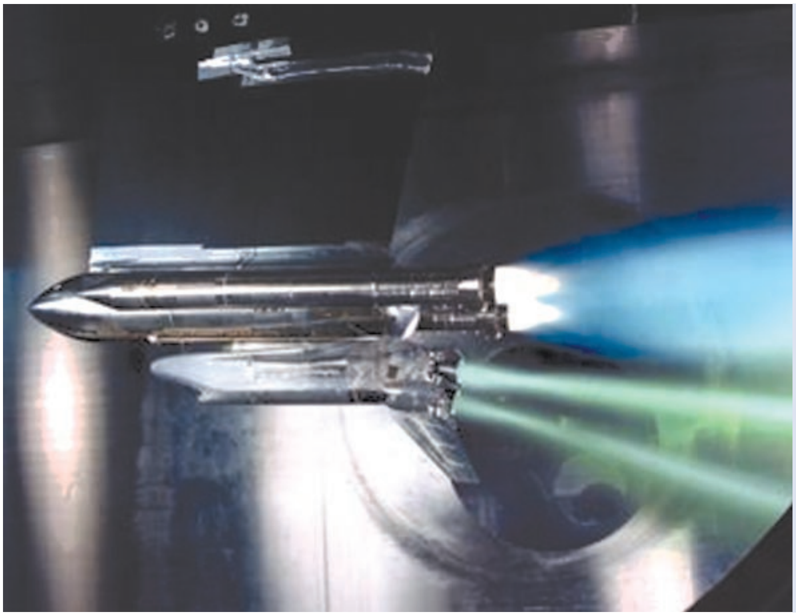




RECOMMENDATION #9: The Commission recommends that the federal government significantly increase its investment in basic aerospace research, which enhances U.S. national security, enables breakthrough capabilities, and fosters an efficient, secure and safe aerospace transportation system. The U.S. aerospace industry should take a leading role in applying research to product development.

Chapter 9

Research: Enable Breakthrough Aerospace Capabilities

Aerospace is a technology-driven industry. Long-term research and innovation are the fuel for technology. U.S. aerospace leadership is a direct result of our preeminence in research and innovation.

Think of what we have achieved since the Wright brothers first flew. Aerospace technology has transformed the way we live, work and play. Today, we routinely travel thousands of miles by air in a matter of hours; mail and cargo can be delivered almost anywhere in the world overnight; people can communicate with others around the world instantaneously; and air and space systems play an integral role in our national security and homeland defense. Satellites monitor the health of the planet and its atmosphere and provide global information about the weather; robotic spacecraft visit the planets; space telescopes look back at the origins of the solar system; and the International Space Station orbits the Earth as the first permanent international habitat in space.

RESEARCH: Scientific investigation aimed at discovering and applying new facts, techniques and natural laws.

McGraw-Hill Dictionary of Scientific and Technical Terms

The U.S. aerospace sector has achieved many firsts over the last century, but it could have done even more. Man walked on the moon 30 years ago, but we have failed to return. We built the SR-71 “Blackbird” aircraft, and 30 years later it still holds the speed record. Aerospace infrastructure built decades ago is still the mainstay of our capability. If our next 100 years are to be as exciting as the last, we must continue to sustain the U.S. research capability to produce new breakthroughs in technology.

Government policies and investments in long-term research are essential if the United States is going to maintain its global aerospace technology leadership. Long-term research enables breakthroughs in new capabilities and concepts and provides new knowledge and understanding, often resulting in unexpected applications in other industries, and in the creation of new markets. Research is an indispensable part of the U.S. innovation engine for generating new ideas and knowledge and for accelerating their transformation into new products, processes and services. But, government and private investments in long-term research have not kept pace with the nation's technological needs.

Industry has the responsibility for leveraging government and university research and for transforming it into new products and services, quickly and affordably. But, the U.S. aerospace industry has not invested sufficiently to transition research into marketable products and services.

Academia has the responsibility for educating the nation's scientists and engineers and for partnering with government and industry on long-term, high-risk research. But, they are dependent on government and industry investments.

Objective: U.S. Preeminence in Research and Innovation

U.S. preeminence in research and innovation will provide revolutionary aerospace capabilities in the 21st century—safe, secure, fast, clean, quiet.

Imagine a future in which:

- You can travel wherever and whenever you want on Earth or in space;
- You will be able to get from your doorstep to your destination on time and without delay;
- You will be able to have customized products delivered to you where and when you need them;
- You will know the weather accurately days in advance;
- Rogue nations and terrorists will no longer threaten the free world because their actions are monitored continuously and, if necessary, are responded to instantaneously wherever they are, day or night;
- We will have not only answered fundamental questions about our universe but also will have explored new worlds and reaped their untold treasures;
- You have clean and quiet aerospace vehicles; and
- Our nation's "best and brightest" seek out the excitement provided by careers in aerospace.

All of these are possible if the nation invests in the future.

Issues

Over the last several decades, the U.S. aerospace sector has been living off the research investments made primarily for defense during the Cold War, which enabled intercontinental ballistic missiles, the Saturn V, SR-71, space-based reconnaissance, missile defense systems, global positioning systems, stealth, and unmanned aerial vehicles. In the past, the aerospace sector led the technology revolution primarily because of large public investments in research directed at national security imperatives and goals.

Today, we have no integrated national aerospace consensus to guide policies and programs. This has resulted in unfocused government and industry investments spread over a broad range of long-range research programs and associated aging infrastructure. Meanwhile, foreign governments realize the importance of public investments in research and infrastructure. As a result, they are defining their

ISSUES

- Public Funding For Long-Term Research and Infrastructure
  - Long-Term Research
  - Infrastructure
- National Technology Demonstration Goals
- Transition of Government Research to Aerospace Sector
  - Information Transfer
  - Public-Private Partnerships
  - Product Development Process

> "But it is not really necessary to look too far into the future; we see enough already to be certain that it will be magnificent. Only let us hurry and open the roads."
>
> Wilbur Wright
> Speaking to the Aero-Club de France
> November 5, 1908

priorities and increasing their investments.[1] The European Union, for example, has made increased funding of civil aeronautics research a priority in its openly stated drive for world leadership in the aerospace industry. Asia, likewise, has targeted aerospace as a strategic industry and increased government research and development (R&D) investments in its national manufacturers.

The war on terrorism has created a new national imperative that demands we make aerospace a national priority again and focus our resources on developing new products and processes as fast as possible. Because of the unique capabilities it can provide, aerospace can help us win the war on terrorism while simultaneously strengthening our economy. This can only be done if we unleash the aerospace sector's full potential.

Public Funding for Long-Term Research and Infrastructure: Insufficient and Unfocused

Many in government and on Wall Street view the aerospace sector as "mature." They view government investments in research as "corporate welfare" and not as an opportunity to make major breakthroughs in aerospace capabilities that could open new markets and usher in a new era of U.S. global aerospace leadership. The lack of sufficient and sustained public funding for research and associated research, development, test and evaluation (RDT&E) infrastructure limits the nation's ability to address critical national challenges and to enable breakthrough aerospace capabilities.

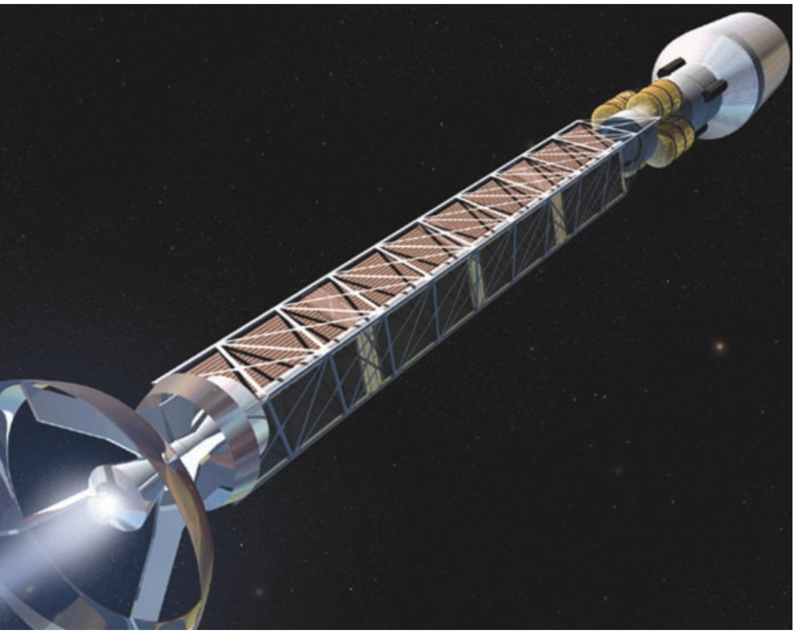
Long-Term Research. Most of our aerospace capabilities today are the result of breakthrough technologies developed in the 1940-1960s for military applications, including the jet engine, radar, space launch, and satellites. In many cases, these capabilities gradually migrated into civil and commercial applications in the 1960s through the 1990s. This includes commercial jet aircraft, the air traffic control system, telecommunications, and space-based commercial remote sensing.

Countless breakthrough capabilities are possible over the next 100 years. But, they will only be of military and economic benefit, if the United States maintains its preeminence in conducting long-term basic research that delivers revolutionary, breakthrough aerospace capabilities to market faster than its international competition. Aerospace research that will enable these breakthrough capabilities include:

LONG-TERM AEROSPACE RESEARCH

- Information Technology
- Propulsion and Power
- Noise and Emissions
- Breakthrough Energy Sources
- Human Factors
- Nanotechnology

Information Technology. The information revolution will ultimately be as important to transportation as the invention of the automobile and the jet engine.[2] High performance computers will enable us to model and simulate new aerospace vehicle designs, prototype them and field them quickly. High confidence systems and high-bandwidth communications, including lasers, will ensure that communication links between space, air and ground elements are secure from cyber attack. Large-scale networks will enable the development of system-of-systems solutions for defending America, projecting power globally, and moving aircraft around the world when and where needed.



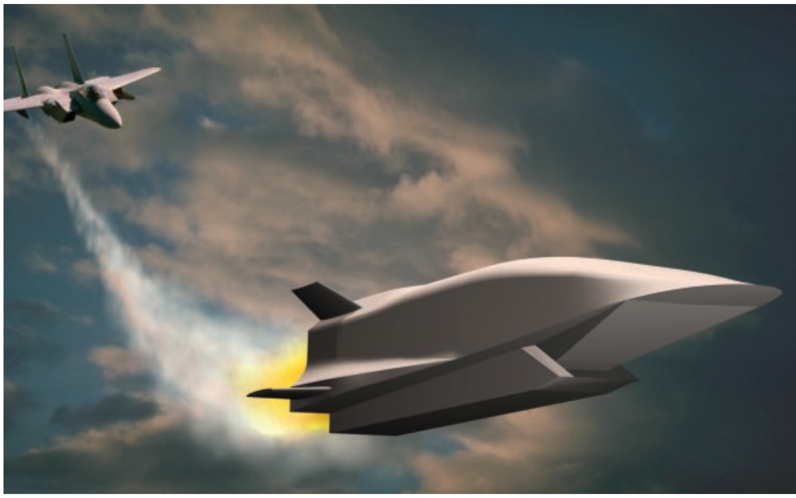
Advances in propulsion will remain the critical enabling technology to revolutionary aerospace capabilities. Anti-matter propulsion holds promise as a means of enabling faster travel through space.

Advanced engineering tools will make software more reliable, robust and fault tolerant. Micro- and nano-computers and sensors will revolutionize flight systems, enabling them to acquire, process, and automatically fly aerospace vehicles. New integrated air, space and ground networks will enable us to acquire large volumes of data, process that data and then make it available to decision makers anywhere in the world, in near-real time. Computer and network technologies will revolutionize the workplace, increasing individual and organizational productivity.

Propulsion and Power. Advances in aerospace propulsion and power have been foundational in achieving nearly every significant breakthrough in aerospace capability over the past century. The piston engine enabled the Wright brothers to inaugurate the age of powered flight. Development of the turbine engine ushered in the jet age. Rocket propulsion opened our access to space. And nuclear generated electric power made possible our initial exploration of the solar system.

In the next century, advances in propulsion and power will remain the critical enabling technology to revolutionary aerospace capabilities. These advances will come in four flight regimes: subsonic and supersonic flight (gas turbine/pulse detonation engines), hypersonic flight (ramjets/scramjets), access-to-space (rocket/combined cycle systems), and travel through space (nuclear, plasma, and anti-matter propulsion and power).

- *Subsonic and Supersonic Flight.* Advanced air-breathing propulsion systems will enable a new generation of quiet, clean, affordable, and highly capable military and civil aircraft. Since the 1950s, aggressive gas turbine engine technology efforts have increased production engine performance by a factor of three and improved fuel efficiency by 70 percent. Further substantial improvements in the capability and cost of hydrocarbon-fueled turbine engines are being actively pursued under the newly formed Versatile, Affordable, Advanced Turbine Engines (VAATE) Program, which focuses Department of Defense (DoD), National Aeronautics and Space Administration (NASA), and industry investments on a common set of national goals.
- *Hypersonic Flight.* Ramjet/scramjet technology offers the potential for new classes of aircraft and weapons that can provide the military with global reach and time critical strike capabilities. In addition, dual-use benefits can be derived within the civil aviation sector, permitting significantly reduced transit times around the world. U.S.



Artist concept of a hypersonic missile.

THE NATIONAL AEROSPACE INITIATIVE

- High-Speed/Hypersonics
- Space Access
- Space Technology

ramjet/scramjet technology efforts over the past decade have been limited and unfocused. An aggressive and sustained investment is needed in this arena, with the objective of overcoming the critical technical barriers of high-speed flight and providing the demonstrations necessary to validate the operational feasibility of hypersonic systems. The Commission supports the joint DoD and NASA National Aerospace Initiative objective of achieving Mach 12 capability by 2012. This initiative should begin as soon as possible.

- *Access-to-Space.* Affordability will be key to seamless, on-demand space access, as well as the future successful commercialization of space. New families of rocket-based and air-breathing propulsion technologies are needed to support development of the reusable and expendable launch vehicle concepts that can provide order-of-magnitude reductions in payload-to-orbit cost. Single- and two-stage-to-orbit configurations offer the potential for airline-like operations not achievable with current launch systems.

- *Travel Through Space.* The lengthy transit times that result from the use of currently available propulsion systems make human exploration of our solar system difficult, if not infeasible. While propulsion concepts, such as ion and plasma, and power sources, such as nuclear, offer the potential of cutting transit times for space exploration by half or more—they are unable to significantly reduce the duration of deep-space missions. New propulsion concepts based on breakthrough energy sources, such as anti-matter energy systems, could result in a new propulsion paradigm that will revolutionize space transportation. See Figure 9-1.

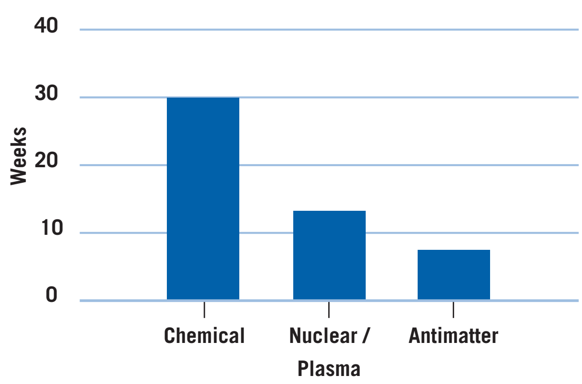
THE COMING HYDROGEN ECONOMY:

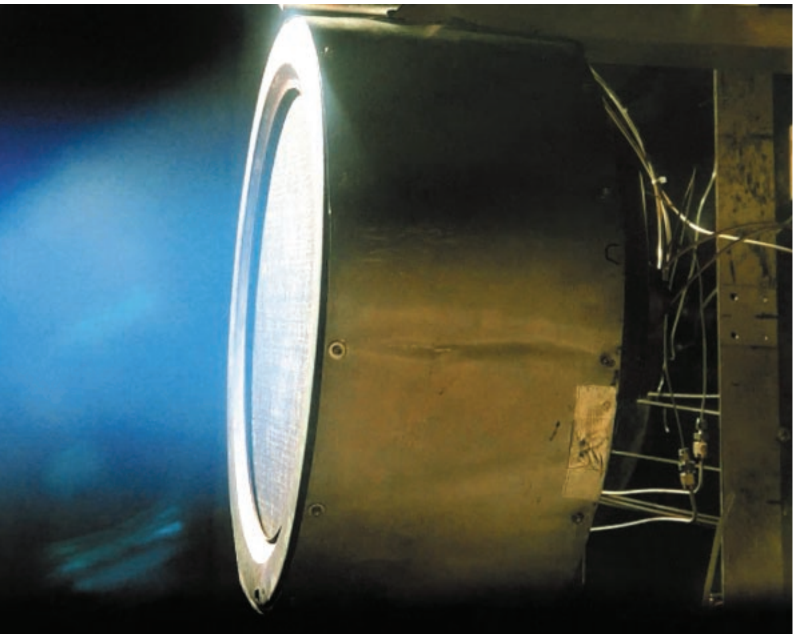
Hydrogen may be the next breakthrough energy source for aircraft. Hydrogen-fueled engines produce zero emissions of carbon dioxide, the primary gas of concern for global warming. Hydrogen-fuel-cell-powered aircraft would eliminate the combustion cycle altogether, thereby producing no combustion emissions and drastically reducing engine noise.

Noise and Emissions. Quiet and clean aircraft offer the potential to greatly expand the capacity of the national airspace system—making airports sought-after centers of economic activity. With the advent of the high-bypass turbofan engine, aircraft propulsion systems noise and emissions have been greatly reduced. Advanced vehicle concepts—such as blended-wing-body, strutbrace-wing, and noise cancellation technologies—could produce further reductions. Research investments are needed to further mitigate jet noise, sonic boom, and emissions. Near zero-emissions aircraft may someday be possible through the introduction of breakthrough energy sources, such as hydrogen.

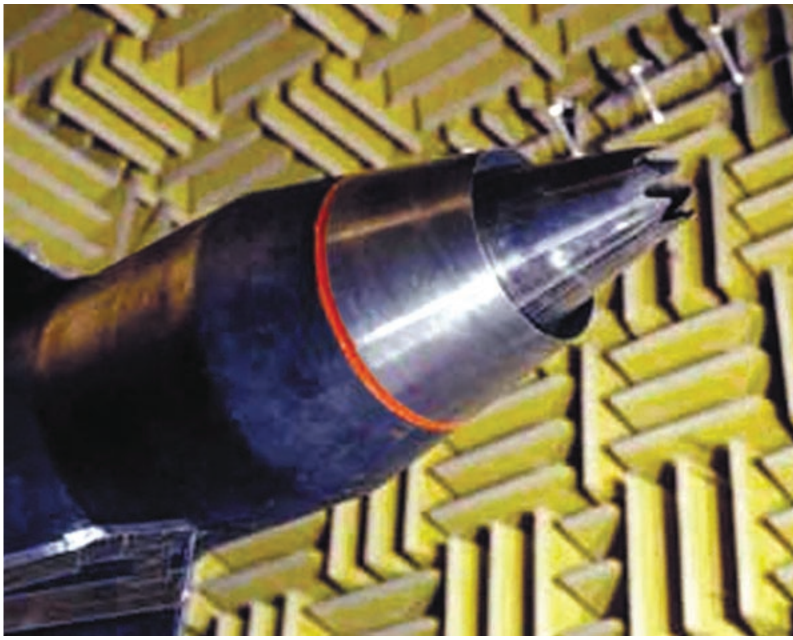
Breakthrough Energy Sources. In the 20th century, hydrocarbon-based fuels served as the predominant energy sources for aerospace applications. In the 21st century, new energy sources must be developed in order to achieve revolutionary new air and space capabilities.

Figure 9-1 Transit Time From Earth to Mars





Ion engines may propel future spacecraft.



Advanced engine exhaust nozzles like the one in this NASA test chamber will help reduce the noise near airports.

- *Air Applications.* In the near term, hydrogen fuel cell technology can be used to provide aircraft auxiliary power, increasing aircraft safety and propulsion system efficiency. Aircraft use of hydrogen can be an important step in establishing a hydrogen economy that could free the U.S. from dependence on foreign sources of energy. The benefits of moving from hydrocarbon-fueled to hydrogen-powered aircraft clearly justify an expanded and accelerated program to make aerospace a leader in hydrogen energy research.

New cockpits will be radically different from those of today.

- *Space Applications.* In the nearer-term, nuclear fission and plasma sources should be actively pursued for space applications. In the longer-term, breakthrough energy sources that go beyond our current understanding of physical laws, such as nuclear fusion and anti-matter, must be credibly investigated in order for us to practically pursue human exploration of the solar system and beyond. These energy sources should be the topic of a focused basic research effort.

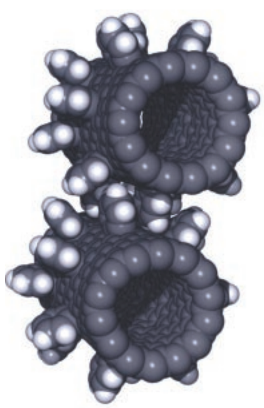
Human Factors. In the final analysis, all technology involves the human.

- *Human-Centered Design.* Automated systems can increase capacity and safety of aerospace systems, but not without human factors research. In air traffic management, for example, one of the main constraints on system capacity is human cognitive workload limitations. A typical air traffic controller can only maintain awareness of four to seven aircraft at a time. Automation could remove this limitation but would change the controllers' function. This will require human factors research to examine: human-automation interaction; the display, exchange and interpretation of information; the role of the operator; and operator selection and training.

Improving safety is possible using automation to compensate for and to assist humans. To achieve this, human factors research is needed to advance our fundamental understanding of how people process information, make decisions, and collaborate with human and machine systems. The result will be enhanced performance and situational awareness of the human—in and out of the cockpit.

- *Space Radiation Effects.* Radiation is a significant limiting factor for long-duration human space missions. Human factors research is needed to better understand and counteract/overcome the effects of radiation to maximize crew physical health, psychological integrity, protection and survival during long-duration space flight.

Nanotechnology. Not only did microtechnology lead to computers and the Internet during the second half of the 20th century, but it also brought us to the beginning of an exciting scientific revolution we now call "nanotechnology." Microtechnology helped develop scientific instruments that make it possible for the first time to image, manipulate, and probe objects that can be more than one thousand times smaller than the microcircuits of the most advanced computers. These objects have dimensions on the scale of nanometers, 1/100,000th the width of a human hair.



Nanotechnology is the creation of functional devices on the nanometer length scale (1-100 nanometers).

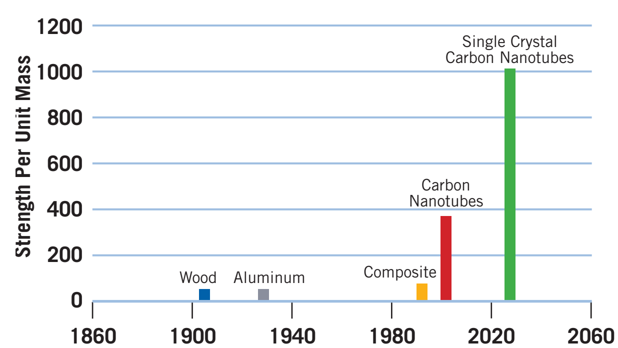
Recent discoveries indicate that, at the nano scale, devices and systems have completely different electrical, mechanical, magnetic, and optical properties from those of the same material in bulk form. This could lead to over an order of magnitude increase in material strength which could revolutionize aerospace vehicle structural design and performance. See Figure 9-2. In addition, they will enable the development of miniaturized, inherently radiation-hardened materials and electronic components. They could also help eliminate aviation noise, provide morphing-capable airframes, reduce the cost of space access and help bring about a new, highly advanced generation of small satellites for surveillance and atmospheric monitoring.

The benefits of research may not be realized for decades but are critical to innovation and to keeping the nation's intellectual capital "ever green." Research needs to be world-class and be increasingly interdisciplinary in nature.

INFRASTRUCTURE. Maintaining a world-class national aerospace RDT&E infrastructure is needed to ensure that this country's research programs can be performed successfully. Testimony before the Commission and studies conducted by the federal government over the last decade have found that the nation's research infrastructure is aging, locally optimized, and unable to meet our future needs.

Aging. Much of the U.S. RDT&E infrastructure is 40 to 50 years old and marginally maintained. The nation must properly fund: routine maintenance and upgrades; the development of advanced computational/simulation tools and the integration into the research facilities and test processes; the development of new test technology and associated instrumentation; and the implementation of these new technologies in national research assets.

Figure 9-2 Past and Projected Strength of Materials for Air and Spacecraft Structures



Source: Langley Research Center, NASA

Locally Optimized. Government and industry managers optimize their infrastructure resources locally and not from a national perspective. The federal government needs a process to ensure that the U.S. aerospace RDT&E infrastructure is right-sized, state-of-the-art, affordable, and supports joint government-industry use in achieving our national objectives.

Unable to Meet Future Needs. The nation needs to identify and invest in a new infrastructure that supports U.S. government and aerospace industry needs so our infrastructure does not become a constraint on our country's technology advancement. For example, the nation will need production-oriented wind tunnels, with test capabilities beyond those currently available, to design and test new hypersonic vehicles and systems.

The Commission believes that the White House and the Congress must increase and sustain funding in long-term research and associated RDT&E infrastructure to develop and demonstrate new breakthrough aerospace capabilities.

National Technology Demonstration Goals: Do Not Exist

Long-term research and the associated RDT&E infrastructure are the building blocks for developing breakthrough aerospace capabilities and is an indispensable part of the U.S. innovation process. Just as the government invested in aerospace capabilities that transformed the second half of the 20th century (e.g., jets, radar, space launch, satellites), it must invest in capabilities that will transform the first part of the 21st century. To focus our aerospace research investments on developing these breakthrough capabilities, the Commission suggests the Administration adopt—as a national priority—the achievement of the following aerospace technology demonstration goals by 2010.

Wind tunnels at NASA's Ames Research Center, some of which are over 50 years old.

Air Transportation

- Demonstrate an automated and integrated air transportation capability that would triple capacity by 2025;
- Reduce aviation noise and emissions by 90 percent;
- Reduce aviation fatal accident rate by 90 percent; and
- Reduce transit time between any two points on earth by 50 percent.

Space

- Reduce cost and time to access space by 50 percent;
- Reduce transit time between two points in space by 50 percent; and
- Demonstrate the capability to continuously monitor and surveil the earth, its atmosphere and space for a wide range of military, intelligence, civil and commercial applications.

Time to Market and Product Cycle Time

- Cut the transition time from technology demonstration to operational capability from years and decades to weeks and months.

Figure 9-3 shows how the research areas discussed earlier support the demonstration goals.

Transition of Government Research to Aerospace Sector: Slow

The Commission believes that the U.S. aerospace industry must take the leadership role in transitioning research into products and services for the nation and the world. To assist them, the government must provide industry with insight into its long-term research goals and programs. With this information, the industry needs to develop business strategies that can incorporate this research into new products and services. Industry also needs to provide an input to the government on its research priorities. Lastly, government and industry need to create an environment that will facilitate acceleration of technology transition into application.

Information Transfer. The government has attempted to transfer technology that it develops for its unique department and agency missions to indus-

Figure 9-3 Aerospace Research Areas vs. Demonstration Goals

Research Areas	Aerospace Demonstration Goals for 2010							
	Air Transportation				Space			Cycle Time
	Automate and integrate air transportation to triple capacity (by 2025)	Reduce aviation noise and emissions by 90 percent	Reduce aviation fatal accident rate by 90 percent	Reduce transit time between two points on earth by half	Reduce cost and time to access space by half	Reduce transit time between two points in space by half	Continuously monitor and surveil the earth, atmosphere and space	Reduce technology-to-system transition time from months to weeks
Information Technology Modeling and simulation Software engineering HPCC Large scale networks Smart and brilliant Individualized instruction	Primary Contributor	Supporting Contributor	Supporting Contributor	Supporting Contributor	Supporting Contributor		Primary Contributor	Primary Contributor
Propulsion and Power Subsonic / Supersonic Hypersonic Access to space Travel through space		Primary Contributor		Primary Contributor	Primary Contributor	Primary Contributor		Supporting Contributor
Breakthrough Energy Sources Hydrogen Nuclear (fusion) / Plasma Anti-matter, zero-point		Supporting Contributor		Primary Contributor	Supporting Contributor	Primary Contributor		
Human Factors Radiation effects of space Automated systems Assisting humans	Primary Contributor		Primary Contributor					Supporting Contributor
Noise and Emissions New sources of power Vehicle design Active / passive surface control		Primary Contributor		Supporting Contributor	Supporting Contributor			
Nanotechnology Intrinsically radiation hardened New structure (morphing) Energy storage Sensors and computers		Supporting Contributor	Supporting Contributor	Supporting Contributor	Supporting Contributor	Supporting Contributor		

try through various mechanisms, such as cooperative agreements. These mechanisms, however, tend to be cumbersome and slow, which many times results in technology being obsolete before the agreements are signed and the products fielded. In addition, industry has been slow to utilize technology from federal laboratories as part of their products and services. Government and industry need to develop new ways of transferring research and technology developed in federal laboratories and in academia.

In the future, new ideas and knowledge will be translated directly into prototype products and services for customer testing. Industrial design, modeling, simulation, and computer-aided manufacturing and software development will become major elements in an integrated and streamlined innovation process that can apply "tomorrow's ideas to today's products and services."

These opportunities, plus the dramatic improvements in individual and group productivity through automation, networking, and modeling, will radically alter the way we apply research to develop new and innovative products and services. Information (and intellectual capital) will become the new "transfer" function of the 21st century. This new function will enable industry to transition research into new products and services quickly.

Public-Private Partnerships. Government, industry, labor and academia need incentives that encourage them to think and act in the common interest of the nation. They need to be motivated and rewarded for performing world-class research, for reengineering product-development processes, for taking a national perspective and for delivering quality products and services quickly and affordably. In short, they need incentives for change, so that they can deliver more for less, quickly and affordably.

For example, to encourage industry and academia to work together, the government should consider providing tax incentives to the industry for both research sponsorship and capital investments that they make in universities. This would provide trained technical staff and focused research products for the industry, while providing more resources for academia to perform cutting-edge research.

Under the leadership of the White House, the government, industry, labor and academia need to work together to transform the way they do business, allowing the nation to capitalize on the best ideas available and apply them rapidly to new products, processes and services. Each plays an important role in the process, but each often has conflicting goals and objectives. These goals and objectives need to be reconciled and an environment established that permits joint governance over the process. The government and industry should jointly publish these goals and objectives with a set of metrics and milestones to measure the success of the process.

Product Development Process. Government, industry, labor and academia view long-range science and technology research as a separate function from acquisition, rather than an integral part of a larger product-development process. Furthermore, they view science ("S") and technology ("T") as separate functions, further hindering the application of new ideas and concepts to the development and manufacture of new products and services. See Figure 9-4.

VAATE: A MODEL FOR PUBLIC-PRIVATE PARTNERSHIPS

- Addresses a critical dual-use technology
- Has well-defined goals, objectives, and milestones
- Integrates a variety of disciplines (e.g., materials and structures, aerodynamics, computational fluid dynamics, etc.)
- Coordinates government/industry efforts
- Provides near-term payoffs to existing systems and enabling technologies for new systems
- Possesses strong government (DoD/NASA) leadership/oversight

Figure 9-4 Traditional Linear U.S. Science & Technology and Acquisition Model

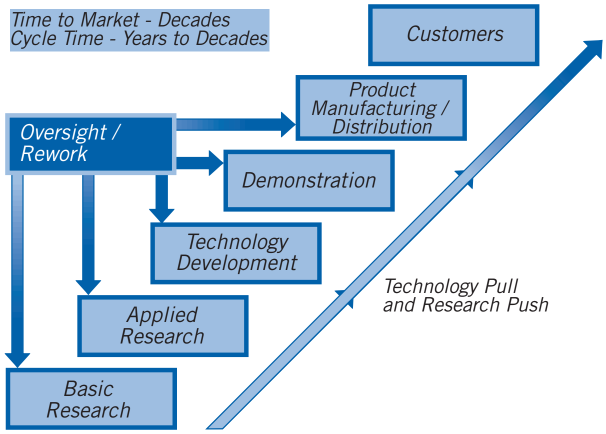
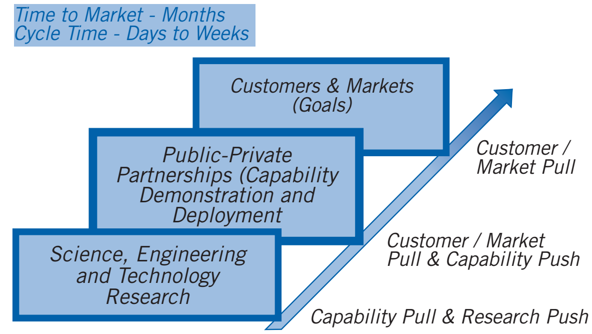


Figure 9-5 New Innovation Process for the Aerospace Sector



The aerospace sector in the 21st century will be driven by the need for speed, quality, service, cost and innovation. If government is to help industry be competitive, it must think and act on the same time scale as industry—days, weeks and months as opposed to years and decades.

Global competition dictates that the U.S. transition from a research, development and acquisition process that is fragmented, serial, and functionally-oriented to an innovative process that is dramatically simpler, integrated, and streamlined. The public and private sectors need a process that enables them to apply the best ideas available domestically and internationally in order to provide the very best quality products and services to their customers faster and cheaper. See Figure 9-5.

Government… must think and act on the same time scale as the industry—days, weeks and months as opposed to years and decades.

The Commission believes that the nation needs a new, more flexible and integrated product-development process that stimulates new ideas and turns them into new aerospace products and services faster than our international competition. Essential characteristics of this new process are:

- Coordinated national goals;
- The aggressive use of information technologies;
- Incentives for real government, industry, labor and academia partnering; and
- An acquisition process that integrates science and technology as part of the acquisition—or product development—process.

Conclusions

The United States must maintain its preeminence in aerospace research and innovation to be the global aerospace leader in the 21st century. This can only be achieved through proactive government policies and sustained public investments in long-term research and state-of-the-art RDT&E infrastructure that will result in new breakthrough aerospace capabilities.

Over the last several decades, the U.S. aerospace sector has been living off the research investments made primarily for defense during the Cold War—intercontinental ballistic missiles, the Saturn V, space-based reconnaissance, the global positioning system, stealth and unmanned aerial vehicles. The challenges posed by our rapidly changing world—asymmetric threats, international competition, environmental awareness, advances in technology—demand that we, like the Wright brothers 100 years ago, look at the challenges as opportunities for aerospace and turn them into reality.

Government policies and investments in long-term research have not kept pace with the changing world. Our nation does not have bold national aerospace technology goals to focus and sustain federal research and related infrastructure investments. It lacks a streamlined innovation process to transform those investments rapidly into new aerospace products, processes and services.

The United States has unlimited opportunities to revolutionize aerospace in the 21st century, opening up new markets and launching a new era of U.S. global aerospace leadership. The nation needs to capitalize on these opportunities, and the federal government needs to lead the effort. Specifically, it needs to invest in long-term enabling research and related RDT&E infrastructure, establish national aerospace technology demonstration goals, create an environment that fosters innovation and provide the incentives necessary to encourage risk taking and rapid introduction of new products and services.

Increase Public Funding for Long-Term Research and RDT&E Infrastructure. The Administration and Congress need to sustain significant and stable funding in order to achieve national technology demonstration goals, especially in the area of long-term research and related RDT&E infrastructure. Research areas that provide the potential for breakthroughs in aerospace capabilities include:

- Information Technology;
- Propulsion and Power;
- Noise and Emissions;
- Breakthrough Energy Sources;
- Human Factors; and
- Nanotechnology.

Establish National Technology Demonstration Goals. The Administration and Congress should adopt the following aerospace technology demonstration goals for 2010 as a national priority. These goals, if achieved, could revolutionize aerospace in the next half century much like the development of the jet, radar, space launch, and satellites did over the last half-century.

Air Transportation

- Demonstrate an automated and integrated air transportation capability that would triple capacity by 2025;
- Reduce aviation noise and emissions by 90 percent;
- Reduce aviation fatal accident rate by 90 percent; and
- Reduce transit time between any two points on earth by 50 percent.

Space

- Reduce cost and time to access space by 50 percent;
- Reduce transit time between two points in space by 50 percent; and
- Demonstrate the capability to continuously monitor and surveil the earth, its atmosphere and space for a wide range of military, intelligence, civil and commercial applications.

Time to Market and Product Cycle Time

- Reduce the transition time from technology demonstration to operational capability from years and decades to weeks and months.

Accelerate the Transition of Government Research to the Aerospace Sector. The U.S. aerospace industry must take the leadership role in transitioning research into products and services for the nation and the world. Government must assist by providing them with insight into its long-term research programs. The industry must aggressively develop business strategies that can incorporate this research into new products and services. Industry also needs to provide input to government on its research priorities. Together industry and government need to create an environment that will accelerate the transition of research into application. The Departments of Defense, Transportation, Commerce and Energy, NASA, and others need to work with industry and academia to create new partnerships and transform the way they do business.

RECOMMENDATION #9

The Commission recommends that the federal government significantly increase its investment in basic aerospace research, which enhances U.S. national security, enables breakthrough capabilities, and fosters an efficient, secure and safe aerospace transportation system. The U.S. aerospace industry should take a leading role in applying research to product development.