SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2000 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERO-SPACE TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1998 OPLAN 9/29/98	FY 1999 OPLAN 12/22/98	FY 2000 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Aeronautical research and technology	920,100	768,900	620,000	SAT 4.1-1
Advanced space transportation technology	417,100	429,600	254,000	SAT 4.2-1
Commercial technology programs	146,700	140,400	132,500	SAT 4.3-1
Total	1,483,900	1,338,900	1,006,500	

PROGRAM GOALS

NASA is responsible for addressing aeronautics and space priorities as outlined by the National Science and Technology Council in national aeronautics and space policies. The responsibility of industry and operational government agencies is to meet their near-term customer requirements through evolutionary advancements to their products. The Aero-Space Technology Enterprise's responsibility is to provide revolutionary advancements in science and technology that sustain global U.S. leadership in civil aeronautics and space. To meet this challenge, the Enterprise's objectives are grouped into three synergistic goal areas or "pillars": Global Civil Aviation, Revolutionary Technology Leaps and Access to Space. The objectives within these goals are framed in terms of final outcomes once NASA-developed technology is integrated with, and further developed by, its partners. The technologies associated with these goals and objectives are pre-competitive, long-term, high-risk research endeavors with high-payoff in terms of market growth, safety, low acquisition cost, consumer affordability and cleaner environment. The goals and objectives are ambitions and stretch the boundaries of our current knowledge and capabilities. Given available funding, NASA recognizes that they are not all achievable within the stated timeframes. As a result, priorities were established and resources realigned to enable achievement of the highest payoff objectives on a timely basis. Progress will be made toward the remaining objectives, but at a slower rate, by concentrating on fundamental research.

Pillar One: Global Civil Aviation

Global civil aviation provides the backbone for global transportation, the very basis of global economic and cultural exchange and integration. It is a large and growing market that the U.S. has traditionally led. Projected growth approaches a tripling of air traffic over the next twenty years. Moreover, examination of various alternative futures suggests that there is also the potential for greater dispersion of operations, very high value for flexible, ultra-reliable operations, and increasing utilization of aircraft with unique operational characteristics.

A need exists to address the fundamental, systemic issues for the aviation system to ensure the continued growth and development appropriate to the needs of the national and global economies. These systemic issues—safety, capacity, environmental compatibility, and affordability cut across markets including large subsonic civil transports, air cargo, commuter and general aviation, and rotorcraft. To ensure these systemic issues do not become constraints, dramatic improvements should be aggressively pursued. Therefore, the Enterprise has worked with its partners to identify five enabling technology objectives to sustain the United States aeronautics leadership by providing high-risk technology that cuts across all markets in Global Civil Aviation:

- Reduce the aircraft accident rate by a factor of five within 10 years and by a factor of 10 within 25 years.
- Reduce emissions of future aircraft by a factor of three within 10 years, and by a factor of five within 25 years.
- Reduce the perceived noise levels of future aircraft by a factor of two from today's subsonic aircraft within 10 years, and by a factor of four within 25 years.
- While maintaining safety, triple the aviation system throughput, in all weather conditions, within 10 years.
- Reduce the cost of air travel by 25 percent within 10 years and by 50 percent within 25 years.

Pillar Two: Revolutionary Technology Leaps

In addition to the systemic issues associated with the global civil aviation system, there is tremendous opportunity to explore high-risk technology to revitalize existing markets and open new markets. Examination of future trends and various alternatives highlighted the opportunities in high-speed civil transportation, general aviation and experimental aircraft. In addition to new market opportunities, there exist opportunities to revolutionize the way aircraft and space transportation systems are designed and developed. It is also critical to recognize that achieving the goals in all three pillars requires the rapid exploration and validation of concepts and technologies in the flight environment.

The Enterprise and its partners have identified three high-risk enabling technology objectives that can revolutionize air travel and the way in which aerospace vehicles are designed, built and operated:

- Reduce the travel time to the Far East and Europe by 50 percent within 25 years, and do so at today's subsonic ticket prices.
- Invigorate the general aviation industry, delivering 10,000 aircraft annually within 10 years and 20,000 aircraft annually within 25 years.

- Provide next-generation design tools and experimental aircraft to increase design confidence, and cut the development cycle time in half for aircraft and space transportation vehicles.

Pillar Three: Access to Space

NASA's primary space launch role is to develop and demonstrate pre-competitive next-generation technology that will enable the commercial launch industry to provide truly affordable and reliable access to space. NASA and the U.S. aerospace companies have embarked on an unprecedented partnership aimed at attaining revolutionary improvements in launch system cost, performance, and reliability. In response to National Space Policy and the NASA Strategic Plan, two enabling technology objectives have been identified to dramatically increase the contribution to the National goals in space:

- Develop and demonstrate pre-competitive, next generation technology that will enable U.S. industry to reduce costs by an order of magnitude (to $1000 per pound) within 10 years, and additional order of magnitude (to $100's per pound) within 25 years.
- Achieve a factor-of-ten reduction in the cost of Earth orbital transportation and a factor-of-two-to-three reduction in propulsion system mass and travel time required for planetary missions, within 15 years, and enable bold new missions to the edge of the solar system and beyond by reducing travel times by one to two orders of magnitude, within 25 years.

STRATEGY FOR ACHIEVING GOALS

When the Enterprise identified these three pillars and ten enabling technology objectives, it was recognized that they are highly ambitious and will stretch the boundaries of the U.S. knowledge and capabilities. In order to achieve these National objectives, NASA carries out its aero-space technology mission in close partnership with U.S. industry, academia and other Federal agencies, such as the Department of Defense (DoD) and the Federal Aviation Administration (FAA). During FY 1998, the Enterprise developed detailed roadmaps to define the path that it would need to follow in order to allow this partnership to achieve these objectives. Based upon the current status of our technology development efforts, the scope of what still needs to be accomplished, and given the Agency budget constraints, it is not realistic to expect the accomplishment of all the Enterprise's objectives on the schedule originally envisioned. While all the objectives are being retained, the Enterprise budget has been realigned to concentrate resources on the timely accomplishment of several high-payoff objectives (i.e., aviation safety, capacity, next generation design tools and experimental aircraft, and access to space) that directly impact the general public, have potential for true leapfrog advancements or support NASA's space mission. Progress toward the remaining objectives will be constrained, limiting our effort to fundamental research. This change has necessitated some hard choices in several areas, including the termination of the High-Speed Research (HSR) and Advanced Subsonic Technology (AST) focused programs.

- Although dramatic advances were made against the original program goals, recent market analyses coupled with estimated industry costs for development of $15 to 18 billion have made the high-speed civil transport considerably less attractive to NASA's industry partners. Increasing stringency of noise constraints to ensure an environmentally compatible high-speed civil transport (HSCT) added considerably to the technological risk. Based on the cost of development and the increased risk, market analyses now project the introduction of an HSCT cannot reasonably occur prior to the year 2020.

Consequently, industry has reduced their commitment to this area by scaling back their investments, leading to the decision to terminate the focused HSR program at the end of FY 1999.

- Although AST has been a very successful program, budget constraints coupled with the need to refocus our technology efforts toward other objectives resulted in the decision to terminate the program at the end of FY 1999. AST has been the major research and technology activity contributing to progress toward the objectives of the Civil Aviation pillar. The impact on those objectives is:

  - Aircraft emissions: Combustor technologies being developed to address the local regional issue of smog resulting from the emissions of oxides of nitrogen will be reassessed, with the most critical technologies being carried further in the new aircraft engine program described below. However, the effort to assess the impact of aircraft emissions on the atmosphere will be curtailed and the final flight campaign to gather data for that assessment will not be conducted.
  - Noise reduction: Due to the commitments to NASA's partner in noise reduction, the FAA, this work will continue toward its original objective, but no further work is anticipated beyond that objective.
  - Affordable air travel: Those elements focused on the development of pre-competitive, high-risk technologies for low-cost, lighter weight airframe materials and structures and for improved aerodynamic performance, will be terminated. The research directed toward improving the cost and performance of aircraft engines will be examined to determine the most critical technology activities to transfer to the new aircraft engine program described below.

As part of this realignment, the following additions have been made to our program:

- Initiation of a focused effort in Aviation Safety to contribute to the national goal by developing technologies to improve aviation safety through reductions in both aircraft accident and fatality rates. The Aviation Safety program will emphasize not only accident rate reduction, but also a decrease in injuries and fatalities when accidents do occur. The program will also develop and integrate information technologies needed to build a safer aviation system—to support pilots and air traffic controllers—as well as provide information to assess situations and trends that might indicate unsafe conditions before they lead to accidents.
- Augmentation of the Aeronautics Base R&T program to include Revolutionary Concepts (REVCON) and Intelligent Synthesis Environment (ISE) activities. REVCON, a new project in the Flight Research program, will provide the capability to evaluate revolutionary vehicle concepts and advanced high-risk technologies rapidly. ISE, contained within the Information Technology program, will revolutionize the way aircraft and space transportation vehicles are designed by providing new modeling tools and methods to enable rapid in-depth computation of system life-cycles in a networked environment.
- Augmentation of the Advanced Space Transportation program to expand and accelerate Future X/Pathfinder experiments of high-risk, revolutionary space transportation technologies, and cross-cutting synergistic technology developments that have space exploration applications. The additional activities will enhance our ability to investigate the orbit-to-Earth and in-space regime of the flight spectrum to complement existing Earth-to-orbit activities.
- Focusing of remaining propulsion technology into an Ultra-Efficient Engine Technology program to address the critical propulsion issues facing the Nation in the new millennium.

Aeronautical Research and Technology

The aeronautics research and technology program addresses critical aeronautical safety, environmental, airspace productivity, and aircraft performance needs at national and global levels. The necessity to strengthen technology development in selected high-payoff areas is vital to the nation's long-term leadership in aviation, as well as to the value of the national air transportation system.

Pillar One: Global Civil Aviation

Great strides have been made over the last 40 years to make flying the safest of all the major modes of transportation. However, even today's low accident rate is not good enough. In the future, if air traffic triples as predicted, this accident rate will be totally unacceptable. The impact on domestic and international travel will have adverse economic consequences well beyond the American transportation sector. Dramatic steps, through joint FAA, DoD, and NASA research, will assure unquestioned safety for the traveling public.

Aircraft produce a relatively small fraction of the world's air pollution compared to other sources: however, the impacts are often focused, i.e. NO_x emissions around airports, and will continue to grow with the increase in traffic. The U.S. must demonstrate leadership in setting and meeting challenging environmental goals for aircraft. We believe there are technological solutions that will significantly reduce aircraft emissions that contribute to local air quality, global warming and ozone depletion, even as travel volume increases. The NO_x reduction element in the AST program will end with the demonstration of a 50 percent reduction in a full annular combustor versus the Enterprise enabling technology objective of 70 percent reduction in a full-scale engine.

Aircraft noise is the other area where future environmental regulations will challenge us to provide advanced technology concepts and innovations. Previous NASA noise-reduction research is now embodied in new aircraft entering the fleet, and in modifications to existing aircraft. The budgeted program will complete the noise reduction program that was included in the AST program, but this effort will end about 50 percent short of accomplishing the Enterprise goal for perceived noise.

Airlines and businesses lose billions of dollars annually from delays and lost productivity due to weather and congestion in our severely constrained airspace system. In the next two decades 12,000 new commercial airplanes will be required to accommodate the projected growth in travel and to replace older aircraft. Joint NASA and FAA research into unrestricted flight routing, or "free flight," will allow more aircraft to navigate safely in adverse weather conditions throughout more of the Nation's underutilized airspace.

For the aircraft manufacturers, a major challenge is to reverse the trend of increasing costs associated with aircraft ownership and operations that are then passed on to the traveling public. Dramatic time and cost savings in development, production, and certification are needed. The Reduced Seat Cost element of the AST program was formulated to respond to this need. However, budgetary decisions resulted in the cessation of this activity in FY 1999. Significant progress in demonstrating the application of advanced airframe materials to airframe and engine structures and reductions in design cycle time have been made, but short of the Enterprise objective of reducing the cost of air travel.

Pillar Two: Revolutionary Technology Leaps

In the early 1990's, studies indicated that an environmentally compatible and economically competitive High Speed Civil Transport (HSCT) could be possible through aggressive technology development. Since then, NASA concentrated its investments in the required pre-competitive, high-risk technologies. While NASA has continued to be successful and was on track to meet the original program goals, technology advancements in subsonic commercial transports have resulted in a much quieter fleet. The original noise requirements are, therefore, now insufficient for the HSCT to blend into the surrounding aircraft noise levels, and further significant investments in technology development are required to ensure an economically and environmentally viable HSCT. As a result, industry development schedules for an HSCT have significantly lengthened and the likelihood that industry commitment to invest more than $15 billion to launch an HSCT is many years away. For these reasons the HSR program will conclude by the end of FY 1999. The Enterprise's objective in this area will not be accomplished as planned. If the business case improves in the future, activities in high-speed research may be re-evaluated.

As the hub-spoke system congestion increases and air carriers consolidate into larger server providers for larger markets, the general aviation segment of air travel will become increasingly important for travel to and from the Nation's 20,000 suburban, rural and remote communities. This segment of air travel has tremendous potential for growth if several technical issues can be resolved. At its peak in 1978, the U.S. general aviation industry delivered 14,398 aircraft. In 1994, the number of aircraft delivered had fallen to 444, an all-time low. During 1997, the efforts of tort reform in 1994 and the NASA technology investments initiated in general aviation were being felt as deliveries began to increase for the first time in over 15 years. NASA will complete the set of technologies and systems improvements begun under the Advanced General Aviation Technology Experiments project.

Experimental aircraft are invaluable tools for exploring new concepts, and for complementing and strengthening laboratory research. In the very demanding environment of flight, "X-planes" are used to test innovative, high-risk concepts, accelerating their development into design and technology applications. In addition to the tools of flight, next-generation design tools will revolutionize the aviation industry. Design was once solely applying pencil to paper. Research in information technology will leverage the power of computing tools to reduce time and costs associated with aeronautics research through the use of fuzzy logic and artificial intelligence. An Intelligent Synthesis Environment initiative has a long-term vision of an immersive virtual environment in which humans and analytical models can interact visually in a computationally rich mission life-cycle simulation. These tools will integrate multidisciplinary product teams, linking design, operations, and training databases to dramatically cut design cycle times for both aeronautics and space transportation applications.

Advanced Space Transportation Technology

The advanced space transportation technology program addresses the critical technologies required to reduce the costs of access to space, as well as those required for the development of in-space transportation to enable bold new space science and exploration missions.

Pillar Three: Access to Space

High cost and low reliability of today's launch systems hinder the future of the U.S. space program. The cost of access to space is roughly $10,000 per pound of payload delivered to low-Earth orbit. The growth of an otherwise dynamic, creative, and productive

U.S. space enterprise is severely impeded by this daunting price tag. Such high cost, for example, severely limits access to the unique properties of orbital space, thereby significantly reducing the abundant promise of scientific, environmental, and commercial applications that enrich our quality of life on Earth. High cost also means fewer missions of deep-space science and exploration that expand our knowledge of the solar system. In the last 25 years, the U.S. has developed just one major launch vehicle and rocket engine. During the same time frame, our international competitors have developed 27 rocket engines and many more launch vehicles. Our launchers, once preeminent, now supply only 30 percent of the worldwide commercial market. In the world's rapidly expanding launch business, the U.S. continues to lose market share. To realize the full potential for research and commerce in space, America must achieve one imperative, overarching goal: affordable access to space.

Consistent with the National Space Transportation Policy, NASA, as a member of a national team, will develop technology for the next generation space transportation systems, with a target of reducing launch vehicle development and operations costs dramatically after the year 2000. The Reusable Launch Vehicle (RLV) program utilizes innovative, industry-led cooperative agreements to accomplish technology development research and conduct the technology demonstrations necessary to prove the feasibility of the enabling technologies that will lead to significant reductions in launch vehicle development and operations costs. These technologies will be demonstrated by the end of the decade, both on the ground and in flight. The RLV program is structured to respond to the industry's need to reduce or eliminate the technology risk of building a new system. The centerpiece of the program is a series of flight demonstrators (X-33, X-34 and new Future X vehicles) that serve to force technologies from the laboratory into real-world operating environments. Innovative partnerships have been formed that strengthen the alliance between industry and Government, thus eliminating unfocused technology and assuring convergence between commercial capabilities and national needs.

The Advanced Space Transportation Program (ASTP) is developing key technologies to dramatically reduce space transportation costs across the mission spectrum. ASTP will focus on technological advances with the potential of reducing launch costs beyond RLV goals, as well as on developing technology required to support NASA strategic needs to reduce the cost of Earth-orbital transportation and the propulsion system mass and travel time required for planetary missions. The ASTP consists of focused, core and research projects. Focused projects have a strong technology pull based on near-term operational system developments. Core projects push the state of the art in propulsion and airframe systems toward the long-term program goals and objectives. The research projects concentrate on very advanced, breakthrough concepts for revolutionizing space travel.

Industry led Future Space Launch Studies are also underway to provide input to NASA and the Administration for end-of-the-decade decisions on approaches to reducing NASA's launch costs.

Commercial Technology Programs

The third major program area of the Aero-Space Technology Enterprise is the commercial technology program. Since its inception in 1958, NASA has been charged with ensuring that NASA-developed technology is transferred to the U.S. industrial community to improve the competitive position of the U.S. in the world community. The scope of the commercialization effort encompasses all NASA technologies created at NASA centers by civil servants, as well as innovations from NASA contractors. The technology commercialization program consists of: (1) a continuous inventory of newly developed NASA technologies; (2) an up-to-date searchable database of this inventory; (3) assessments of the commercial value of each technology; (4) dissemination of knowledge of these NASA technology opportunities to the private sector; and (5) support of an efficient system for licensing NASA

technologies to private companies. In addition, NASA commercialization efforts also include the operation of the Small Business Innovation Research program, which is designed to enhance NASA's use of small business technology innovators and lead to increased commercialization of NASA technology with small firms.

SCHEDULE & OUTPUTS

The Enterprise has developed, utilizes, and is continually applying and refining a family of performance measures to assess both program progress and relevance to external customer requirements. These measures include:

Program Performance. Measures of program performance that contribute to the achievement of the Enterprise goals:

- Implement the Aero-Space Technology Enterprise programs in an effective and efficient manner and complete customer-negotiated product and service deliverables (identified as milestones in formal program plans) within three months of plan.
- Increase technology transfer activities with the aerospace community by transferring at least twelve new technologies and processes to industry during the fiscal year.

Customer Satisfaction. Measures of customer satisfaction with respect to Enterprise products and services:

- Ensure the availability of quality facilities for the Enterprise's customers by measuring levels of satisfaction with capabilities and services through conduct of exit interviews at selected facilities.
- Satisfy the Enterprise's customers with quality products and services by measuring overall customer satisfaction through formal, triennial customer surveys.

Other Organizational Goals and Processes. Measures of performance relative to other policies and goals:

- Provide important contributions to education and public understanding of air and space transportation by developing an education outreach plan for all new programs that includes and results in an educational product.