SCIENCE, AERONAUTICS AND TECHNOLOGY
FISCAL YEAR 1998 ESTIMATES
BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY
AERONAUTICAL RESEARCH & TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

AERONAUTICAL RESEARCH & TECHNOLOGY	FY 1996	FY 1997	FY 1998
Research and technology base	430,600	404,200	418,300
Aeronautical focused programs	435,300	440,000	501,800
Total	**865,900**	**844,200**	**920,100**

Distribution of Program Amount by Installation	FY 1996	FY 1997	FY 1998
Marshall Space Flight Center	5,008	3,856	3,865
Ames Research Center	203,388	186,560	220,349
Dryden Flight Research Center	62,575	55,487	72,594
Langley Research Center	312,647	319,753	344,040
Lewis Research Center	247,677	245,055	249,171
Goddard Space Flight Center	7,044	7,995	4,129
Jet Propulsion Laboratory	2,292	1,781	2,160
Headquarters	25,269	23,713	23,792
Total	**865,900**	**844,200**	**920,100**

AERONAUTICS RESEARCH AND TECHNOLOGY BASE

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	**FY 1996**	**FY 1997**	**FY 1998**
Information Technology	72,300	73,400	78,600
Airframe Systems	161,000	134,700	125,100
Propulsion Systems	77,300	77,000	82,600
Flight Research	67,700	69,600	82,100
Aviation Operations Systems	18,900	17,000	17,300
Rotorcraft	33,400	32,500	32,600
Total	**430,600**	**404,200**	**418,300**

PROGRAM GOALS

The goal for NASA's Aeronautics Research and Technology (R&T) Base program is to serve as the vital foundation of expertise and facilities that consistently meets a wide range of aeronautical technology challenges for the nation. The program is intended to provide the high-technology, diverse-discipline environment that enables the development of new, even revolutionary, aerospace concepts and methodologies for applications in industry. Work within the R&T Base must lay the foundation for new focused programs -- to address specific, high-value national needs and opportunities. This work must constitute a national resource of expertise and facilities that responds quickly to critical issues in safety, security, and the environment. The same technological resources contribute to the overall U.S. defense and non-defense product design and development capabilities.

STRATEGY FOR ACHIEVING GOALS

The technology environment for success in aerospace is characterized by continuous advances across a wide range of disciplines, as well as occasional developments of revolutionary technology. With the downsizing of research facilities and basic research capabilities in both industry and government agencies, the NASA R&T Base plays a critical role in the continual struggle for technological preeminence in the world-wide aerospace scene. The key to the strategic approach of the R&T Base is the synergistic use of facilities and expertise in a wide array of frequently related, but independently targeted, challenges.

advanced high-lift systems). The R&T Base program is designed to accelerate technology development, validation, and transfer. The program also provides the capability for NASA to respond quickly and effectively to critical problems identified by other agencies, industry or the public. Examples of these challenges are found in: aging aircraft; aircraft accident investigations; lightning effects on avionics; flight safety and security; wind shear; crew fatigue; structural fatigue; and aircraft stall/spin. The same R&T Base project teams that conduct broadly applicable disciplinary research can provide the infrastructure to support future, large-scale, focused programs. An array of major research facilities and services are located at the four aeronautical Centers of Excellence -- Ames Research Center, Dryden Flight Research Center, Langley Research Center, and Lewis Research Center. Many facilities (such as the National Transonic Facility) and expertise are unique in the U.S. and even the world.

Today, the magnitude of the challenge to the U.S. industry leadership position in aeronautics is indicated by the market share now lost to aggressive international competition. The R&T Base is designed to enhance U.S. competitiveness in aerospace technologies in both general and very specific areas. Critical elements of NASA's contribution to the aviation industry are the flow of new ideas and concepts, the ability to react quickly to unanticipated technical challenges, and the growth in fundamental knowledge that can reveal new opportunities. Key factors in the dominant role of NASA in aeronautical research include: the extensive array of research facilities required; the large disincentives for private-sector investment in long-term, high-risk aeronautical R&T -- since an individual company can rarely capture the full benefit; the length of time for the aircraft research-and-development cycle and the total investment-recoupment period; the extensive breadth and depth of technologies required to produce a superior aircraft; the public-good character of much of the research (safety, environment, certification, national security); and the unique cadre of experienced NASA technical personnel.

In FY 1997, the R&T Base Program was reorganized into six systems-oriented, customer-driven programs that serve the needs of the full range of aeronautical vehicle classes. NASA extended the ongoing research within the disciplinary areas for potential system-level benefits and then programmatically reorganized into appropriate new programs. Previously stated high-level program milestones are now tracked within the new programs. Airframe and Propulsion Systems programs derive naturally from typical vehicle research; the Aviation Operations Systems program addresses important interactions between vehicles and their operational environment; the Information Technology program advances and enables the infusion of computer science into information age aeronautics. The Flight Research and Rotorcraft Systems programs provide the special treatment needed for unique aspects of research operations and powered lift vehicle technologies, respectively. The R&T Base is now organized to be more flexible and responsive to its customers as agency downsizing implements measures intended to achieve enhanced efficiency and effectiveness with available research resources. The R&T Base Program continues to sponsor and conduct research using a variety of cooperative mechanisms, not only to leverage resources for technology development, but also to ensure timely technology transfers to U.S. customers.

MEASURES OF PERFORMANCE

Information Technology

Performance Metric	Plan	Actual/Revised	Description/Status
Acquire and install a distributed network storage system (Mass Storage 3) in the NAS facility to replace the current CPU-based system with at least double the capacity.	June 1996	June 1996	Evaluate disk and network technology for a non-front-end solution with the objective to improve access time, and at the same time, increase capacity to at least double the current 1.6 terabyte capacity System upgrade exceeded 3.2 terabyte capacity. Completed installation of high-capacity tape robots. Increased capacity by a factor of five, to more than 500 terabytes; access time was held constant.
Acquire and install High Speed Processor 4	March 1997	September 1998	Deliver to the NAS community at least a four-fold increase in computational hours. Rephased to be consistent with processor need date.
Deploy Asynchronous Transfer Mode (ATM) technology in Aeronet to increase bandwidth.	August 1997	--	Increase ATM bandwidth by factor of 3 at a cost less than or equal to that of 1994.
Demonstrate knowledge system prototype in test facility.	June 1998	--	Demonstrate reduction in design cycle time by the application of intelligent information analysis and unified instrumentation.

Airframe Systems

Performance Metric	**Plan**	**Actual/Revised**	**Description/Status**
Demonstrate accuracy of flutter prediction.	September 1996	September 1996	Demonstrate through benchmark tests that calculations of transonic wing flutter are accurate to within 5% through the inclusion of viscous effects. An intensive coupling was used to model boundary layers in flows near-sound speed flows. Flutter instabilities of a thin, swept wing and a typical business-jet wing near sound speed were predicted. They compared within 5 percent with wind-tunnel data. This capability has been requested by and transferred to U.S. aircraft companies.
Demonstrate strength and toughness of emerging aluminum alloys.	March 1996	March 1996	Confirm that data from validation coupon testing predicts properties of new aluminum alloys produced by novel intermediate rate solidification process. Slab-cast ingots produced in-house and properties characterized.
Incorporate economic and risk subroutines into systems analysis methodology.	January 1997	--	Demonstrate that method is operational and predicts effects of economics and risk on critical design parameters.
Complete flight validation of multi-axis control power requirements/design criteria.	September 1997	--	Validate multi-axis control-power predictions and transfer both design criteria and guidelines to industry.

Demonstrate multidisciplinary modeling, synthesis, and analysis methods to enable efficient and accurate design of control systems for aircraft with complex structural, aerodynamic, and propulsion interactions	March 1997	--	Complete and distribute the beta version of software code to industry for application.
Develop turbulence model for two-dimensional high-lift flows at realistic Reynolds numbers.	June 1997	--	Create a turbulence model that predicts wake spreading and slat effects implemented into a 2-dimensional Reynolds-Averaged Navier-Stokes (RANS) code and compare results with 737 flight-test data.
Validate preliminary design concepts for non-circular composite structures	September 1998	--	Fabricate and test a non-circular, composite, pressurized structural subcomponent; compare the resulting performance with analytical predictions.
Complete Mach 7 Research Vehicle tests in LaRC's 8-foot High-Temperature Tunnel.	February 1998	--	Complete system check-out in Mach-7,-flight-type environment and obtain ground based data for direct comparison with flight.

Propulsion Systems

Performance Metric	**Plan**	**Actual/Revised**	**Description/Status**
Demonstrate advanced, small gas-turbine combustor operating at 3,000 degrees Fahrenheit (+600 degrees Fahrenheit improvement) with minimally cooled liner.	March 1997	--	Establish design criteria and concept for small engine combustor. Validate combustor in component rig testing. Transfer results to U.S. industry.

Develop advanced thermal barrier coatings for ceramic composites and transfer to industry	February 1997	--	Demonstrate effective coating in a lab-scale test environment (coated ceramic room temperature strength retained after 100 hours at 1,052 degrees centigrade hot corrosion).
Deliver a preliminary conceptual analysis and design version of the Numerical Propulsion System Simulator (NPSS).	March 1996	June 1997	Deliver the NPSS to the propulsion and aircraft industry and ensure all critical capabilities are fully functional as judged by the NASA/Industry cooperative technical focus group. Milestone was delayed at recommendation of technical focus group to include additional design capability.
Provide materials systems and processing to enable compressor discharge temperatures of 1,500 degrees Fahrenheit (currently 1,200 degrees Fahrenheit).	April 1997	--	Demonstrate a compressor disc in a spin-pit test at 1,500 degrees Fahrenheit. Transfer compressor material technology to U.S. engine companies.
Complete engine fabrication for advanced general aviation turbine and internal combustion engines.	September 1998	--	Complete fabrication in time to meet FY 1999 flight test schedules.

Flight Research

Performance Metric	Plan	Actual/Revised	Description/Status

Demonstrate use of computer-controlled engine thrust.	September 1996	January 1996	Using an MD-11 aircraft, demonstrate the ability to land safely in a simulated emergency, using computer-controlled engine thrust only. Goal achieved ahead of schedule and under cost. Propulsion Controlled Aircraft (PCA) system proved with four landings of an MD-11 transport without using normal flight controls. PCA was flown by 25 NASA/FAA/DoD/airline/industry pilots.
Complete flight assessment of aerodynamic control concepts.	September 1996	July 1996	The F-18 High Angle-of Attack Research Vehicle was used to identify and qualify strength and weaknesses of advanced control schemes, which can enhance thrust vectoring fighter aircraft performance and enable tailless configurations. The forebody flow field of controllable strakes was explored in ground-based and flight tests. Strakes were found to be an effective yaw-power producer at high angles of attack.
Complete initial flight evaluation of neural-network flight controls.	September 1996	November 1996	Demonstrate capability to identify key aircraft parameters in flight using a neural-net flight controller.
Demonstrate operability and real-time performance optimization of thrust vectoring exhaust nozzles.	September 1996	December 1996	Using the F-15 research aircraft, quantify performance of "care-free" engine/nozzle operation throughout the flight envelope and demonstrate performance improvements.

Mach 6.5 scramjet ground test (Russian Central Institute of Aviation Motors (CIAM) contract).	February 1996	February 1997	Demonstrate system performance and operability in a simulated environment. Tests delayed due to funding difficulties within Russia.
Mach 6.5 scramjet flight test (Russian CIAM contract).	November 1996	April 1997	Demonstrate system performance and operability in flight. A flight test in January 1997 with an unpowered engine, boosted to test conditions by the regular rocket booster, will reduce risk; funding delays within Russia caused a schedule slip.
Complete X-36 flight evaluation.	June 1997	--	Complete flight objectives and analysis of vehicle performance.
Demonstrate solar-powered remotely piloted aircraft (Pathfinder) to 70,000 feet.	September 1997	--	Using upgraded solar cells, sunlight and FY 1997 configuration/technology on Pathfinder II airplane, achieve maximum possible altitude and duration.
Flight-demonstrate an inlet- distortion-tolerant control system.	September 1998	--	Evaluate in flight, on the Advanced Control Technology Integrated Vehicle (ACTIVE) aircraft, a high-stability, integrated control system using sensed inlet distortion to enhance stability.
Complete unconventional-control tests for "falling leaf" flight experiment.	September 1998	--	Determine effectiveness of innovative control algorithm to recover from uncontrolled spin/ "falling-leaf" mode using F-18 Advanced Control Research Aircraft (ACRA).
Complete piston-powered flight for 8 hours at 60,000 feet.	September 1998	--	Demonstrate record-breaking high-altitude duration with hydro-carbon fueled, multi-staged turbocharged piston engine.

Aviation Operations Systems

Performance Metric	Plan	Actual/Revised	Description/Status
Complete field evaluation of extended-terminal-area air-traffic-controller aids.	September 1996	September 1996	Evaluate concepts, technologies and procedures which will support the FAA development plans. Technology field evaluation finished by target completion date. Provided FAA with implementation recommendations including airspace safety and efficiency improvements. Evaluations at Denver and Dallas resulted in a 25 percent increase in landing rates during low visibility.
Demonstrate human alertness monitoring concept.	March 1997	--	Demonstrate an operational concept for human alertness monitoring.
Complete flight tests for the NASA/FAA tailplane icing program.	June 1997	September 1997	Complete the flight-test development of tailplane aerodynamics in the presence of various ice shapes for several aircraft configuration and flight conditions. Original completion date delayed by urgent national need related to the 1994 Eagle ATR-72 accident attributed to icing.
Complete icing-tunnel database of ice shapes for modern airfoils.	June 1998	--	Develop a database of ice shapes for modern airfoils based on testing in the NASA Lewis Icing Research Tunnel.

Rotorcraft

Performance Metric	Plan	Actual/Revised	Description/Status
Assess tiltrotor noise alleviation	June 1996	June 1996	Complete a computational method for noise control and evaluate the method with experimental data. Advanced computational methods for tiltrotor noise prediction were validatedand presented at two technical conferences. The codes were provided to industry with documentation. Tiltrotor noise experiment was conducted in FY 1996, but was terminated prematurely due to wind tunnel system failure. As a result, the computational codes were validated using previously acquired small-scale wind tunnel test data.
Implement Rotorcraft Centers of Excellence (COE) Program.	December 1996	June 1996	Announce selections and implement cooperative agreements with up to three universities as Rotorcraft Centers of Excellence. National Rotorcraft Technology Center (NRTC) issued a request for proposals and completed evaluation of proposals. Cooperative agreements were implemented with three universities: Pennsylvania State University, University of Maryland, and Georgia Institute of Technology.

Complete initial civil tiltrotor terminal area simulation using Man/Machine Integrated Design and Analysis System (MIDAS) to analyze proposed cockpit designs and crew procedures.	September 1996	June 1997	Obtain human performance and workload data resulting from a notional civil tiltrotor cockpit design applied to a selection of feasible terminal area scenarios. Static geometry analysis completed December 1996. Crew procedural simulation delayed due to Boeing IR&D stop-work order. Planned resumption in January 1997.
Flight qualify Rotorcraft Aircrew Systems Concept Airborne Laboratory (RASCAL) research flight control system.	September 1997	--	Complete airworthiness checks and flight qualification.
Demonstrate Master Cure Simulation System (MCSS) for manufacturing thick-composite rotorcraft structures.	December 1997	--	Under National Rotorcraft Technology Center (NRTC), validate and demonstrate that master cure process molding and controller accurately predict/control thick-composite-material behavior and its rate of cure.
Validate advanced computational methods for the prediction of rotor/airframe interaction and unsteady aerodynamics with data acquired from advanced laser-velocimetry techniques.	January 1998	--	Publish an assessment of the accuracy of unsteady computational aerodynamic predictions of rotor/fuselage aerodynamic interference, based on validation using advanced, non-intrusive, three-dimensional flow measurements.

effects on control surfaces were established in the National Transonic Facility and results have been transferred to industry for use in future large-transport control system designs. Large Eddy Simulation (LES) calculations of the flow over an airfoil produced pressure distributions that agreed well with the experiment, offering the prospect of lower-cost analysis. In addition, incorporation of viscous effects into a transonic wing flutter prediction/analysis technique significantly improved its accuracy. In the pursuit of enhanced performance and service life, a novel solidification approach to materials processing was shown to produce aluminum alloys with superior combinations of strength and toughness. A technology assessment of the benefits of replacing riveted metallic structures with large, integral metallic structures was initiated. The assessment identified key materials processing technologies aimed at 30- to 50-percent reduction in metallic fuselage structures. Additionally, damage tolerance of the first fuselage composite-sandwich side panel with window belts was evaluated under load, demonstrating the feasibility of composite technology for large fuselage structure and potentially providing significant weight/cost savings. In safety, critical wake-vortex hazard-relationship data and expertise were provided to the National Transportation Safety Board (NTSB), the FAA, and industry to support their assessment of recent accidents. Systems studies identified superior vehicle designs for flight up to Mach 10 to guide configuration definition for the Hypersonic Experimental (Hyper-X) Aircraft Program to fly a series of scramjet-powered, subscale hypersonic vehicles.

During FY 1997, investigation will begin of the feasibility of large, integral, metallic structural panels for fuselage applications. The critical technology needs for resolving issues on aging aircraft will be assessed. A fatigue crack growth model will be developed, as will non-destructive inspection methods that focus on thick materials and hidden corrosion. Methods will be developed for the comprehensive assessment of the susceptibility of critical digital control computers to electromagnetic environments. Subsonic high-lift flow physics, transition prediction, and the influence of Reynolds number on skin friction will be studied, as will the benefits of blended wing/body configurations, with applications focused on very large (greater than 800 passengers) subsonic commercial transports. Survivability efforts will include development of advanced signature analysis and measurement techniques, as well as advanced concepts. The technologies required for active airframe control systems, including smart materials and integrated active control algorithms, will be studied and developed. NASA resources will be available to industry and other agencies for solving problems encountered in aircraft development and test programs. Hyper-X will begin fabrication of the first scramjet powered, subscale, "free-flyer" vehicles.

In FY 1998, the Airframe Systems program will address key technology needs to enable future subsonic, very large, long range commercial transports, including the understanding of viscous scaling for high Reynolds numbers, non-circular pressure structures, and noise-reduction issues. Integral airframe structures technology will reduce manufacturing cost through reduced part count, enabled by improved durability and damage-tolerance-analysis methodology. Advanced life-extension efforts will build upon developments from the Aging

Aircraft element of the Advanced Subsonic Technology (AST) program in the areas of fatigue-crack-growth analysis and non-destructive test methods for fuselages; it will shift its focus to areas defined in the FY 1997 assessment. New design approaches for flight decks, designed to minimize human-operational errors and be error-tolerant, will be evaluated through human-error analysis. In the high-performance area, technologies will be developed that contribute to reduced gross weight and increased agility, while still maintaining compatibility with survivability requirements. These include innovative control-effector concepts, multi-element control-law design methods, active buffet alleviation and aeroelastic control. Development of new air vehicles and concepts will be actively supported through technical cooperation with DOD and industry. Aircraft systems concept-to-test efforts will address reduction of the aircraft design cycle through reduced time/cost of analytical solutions, reduced user interaction, increased fidelity, and integrated analyses. Development of smart materials, aeroacoustic analyses, and fundamental aerodynamics of laminar-flow control and high-lift systems will support these goals. The program will also pioneer long-term, high-risk fundamental technologies that offer potential high payoff and leverage. System studies will be conducted, with industry partners, to review and assess projected performance and evaluate potential payoffs. The first Hyper-X vehicle will have completed powered pre-flight in Mach-7 flow in a large-scale wind tunnel test and will be integrated with the rocket-booster for flight.

The Propulsion Systems Program acted on recommendations from the Rayleigh Scattering Diagnostics Workshop and made significant progress during FY 1996 in measuring gas flow in confined locations such as the interior of an aircraft engine. The ultraviolet laser that was used provided stronger scattering with weaker reflections. Gas-flow parameters were measured in supersonic flow conditions. As a result of favorable systems studies, a new sub-element for General Aviation Propulsion Technologies and Manufacturing Processes was established to develop and flight demonstrate revolutionary, low-cost, environmentally-compliant propulsion systems. Cooperative agreements with the U.S. aviation industry to accomplish this were negotiated at the end of FY 1996. A requirements analysis for the Numerical Propulsion System Simulator (NPSS) was completed in July 1996. This analysis incorporated additional needs from industrial customers. The preliminary/conceptual analysis version of NPSS will be released in June 1997.

Propulsion Systems program plans for FY 1997 include the demonstration of advanced, small gas-turbine combustors operating at 3,000 degrees Fahrenheit (+600 degree improvement) with a minimally cooled liner. The program will also validate combustor computational methods that will enable combustor designs with reduced emissions. The cooperative program with the U.S. Air Force and major engine companies on metal-matrix-composite life prediction will continue to develop "modules" in support of materials and structures efforts aimed at 1,500-degree-Fahrenheit compressor components. A physics-based model of the forging process for engine components will be developed for industry review and evaluation. Such models are designed to provide faster and more efficient transformation of new concepts into prototypes. A demonstration of active stall control in a single-stage transonic compressor will target a 25% improvement in stall margin in the presence of distorted inflow. This technology will be extended to multistage compressors and engines in future years. An engine turbocooler will be demonstrated that uses conventional jet fuel as a heat sink up to 1,000 degrees Fahrenheit. This system requires a coating to prevent fuel coking products from depositing in the fuel lines and injectors.

During FY 1998, Propulsion Systems will focus on lower-cost alternatives to current fibers for composite materials. The program will demonstrate the alternatives in ceramic-matrix composites and document the results for use in future engine-component design. The technology barriers related to increased turbine temperature will be addressed by using advanced materials and processes to produce systems capable of temperatures above 2400 degrees Fahrenheit, as well as by developing greatly improved computational design methods for turbines with reduced cooling-flow requirements. General Aviation Propulsion will focus on component testing and fabrication of the internal-combustion and turbine engines scheduled for flight testing in FY 1999 and FY 2000.

The Flight Research program for FY 1996 accomplished flight demonstrations of several new technologies, including forebody devices for flight control in high angle-of-attack attitudes. Vectoring exhaust nozzles were also flight-demonstrated, and their performance benefits quantified. The successful use of computer-controlled engine thrust alone for emergency flight control was demonstrated. The feasibility of in-flight development of flight control laws using a neural network approach was shown. The Environmental Research Aircraft and Sensor Technology (ERAST) project has been transferred from the High Speed Research Program into the Flight Research program. In one of many activities, ERAST has provided an advanced vehicle for flight-demonstration missions with the Department of Energy. During FY 1996, the F-18 Systems Research Aircraft (SRA) accomplished several flight demonstrations, making significant state-of-the-art advancements in such technologies as: electrically powered actuators; unique, fiber-optic, fly-by-light components and position measurement devices; a laser-based Pilot Alert System (PAS) supporting the B-2 Program in detecting contrails; and an innovative, real-time structural monitoring system.

In FY 1997, the Flight Research program will complete its flight evaluation of power requirements for multi-axis control systems and will demonstrate in-flight an advanced high-stability (distortion-tolerant) integrated flight/engine control system that allows increased thrust or improved fuel economy. With these technologies, the emphasis is on demonstrating dramatic improvement in operational maneuverability performance. Operations of the ERAST remotely piloted aircraft (RPA) will be increased. The range of ERAST activities will include record-breaking flights up to altitudes of 70,000 feet by a solar-electric RPA. Another focus is the demonstration of smart aircraft that could lead to reduced operating costs as well as reduced design-cycle time. The SRA will be used to evaluate advanced control-system components including fiber optics and electrical actuators. In high-performance aircraft, the principal emphasis is the demonstration of technologies to enhance aircraft survivability. In support of safety goals, research will be directed to the application of control-system strategies to allow confident recovery from the dangerous uncontrollable spin ("falling-leaf") mode of flight. A cooperative effort with universities and industry uses formation-flight technology as an enabler of very-long-endurance flight. The capability of NASA's flight-research testbed aircraft fleet will be enhanced through the upgrading of a supersonic cruise F-16XL to digital flight-control-system configuration. Two international cooperative programs will reach the flight-test stage. A scramjet built by the Russian Central Institute of Aviation Motors (CIAM) will investigate transitioning from subsonic (ramjet) to supersonic (scramjet) modes. In the Hypersonics Physics Experiments (PHYSX) test program, a Pegasus missile with a wing glove fixture will provide measurements of the cross-flow boundary layer at hypersonic (Mach 8) speed.

The Flight Research program in FY 1998 will continue with ERAST to demonstrate, in flight, advanced technologies such as turbocharged/piston-engine flight targeted for 80,000 feet and above. Another objective is to demonstrate aircraft technologies that lead to reduced operating costs as well as reduced design-cycle time. Included will be the Active Aeroelastic Wing (AAW), which will demonstrate the concept of aircraft control through wing twist on a high-performance aircraft. The SRA will continue to be used to evaluate advanced control-system components including fiber optics, electrical actuators and air-data systems for enhanced aircraft survivability. Flight research makes use of vehicles designed specifically for technology demonstrations under the Cloaking for Survivability (CLOSUR) project. That program will emphasize the demonstration of technologies that enhance aircraft safety by application of aerodynamic and/or propulsion controls to ensure recovery from perilous combat flight situations.

During FY 1996, the Aviation Operations Systems program pursued improvments in the capacity of the nation's air-transportation system through two major field evaluations of automation aids for air traffic controllers at the Dallas-Fort Worth air-traffic control facilities. The Traffic Management Advisor (TMA) provided optimal schedule time for arriving flights, and the Final Approach Spacing Tool (FAST) recommended runway assignment and landing sequences for arriving flights. Additionally, key wind-tunnel and flight tests validated a computer model of an aircraft encounter with a wake vortex. In the pursuit of improved aviation safety, a study of Super-cooled Large Droplet (SLD) icing (the condition in the American Eagle ATR-72 crash in 1994) in the NASA Lewis Icing Research Tunnel defined the effects of SLD parameters on ice accretion. Additionally, a series of icing-tunnel tests provided data on various configurations and systems on the Department of Defense Predator (unpiloted aerial vehicle). NASA co-sponsored a symposium with the National Transportation Safety Board on "Managing Fatigue in Transportation: Promoting Safety and Productivity." The conference was structured around the NASA Fatigue Countermeasures program to transfer the lessons learned from aviation research to the other modes of transportation.

The Aviation Operations Systems program in FY 1997 will provide a database and guidelines for achieving robust air-ground communications for air traffic control with varying combinations of voice and datalink communications under differing levels of automation. The initial field test of an advanced wake-vortex sensing system will be tested at the Dallas-Fort Worth airport. In pursuit of improved aviation safety, flight tests of the NASA/FAA tailplane-icing program will be completed and will define a database of tailplane aerodynamics with and without icing for various airplane configurations and flight conditions.

Completion of the first set of flight tests for the Super-cooled Large Droplet (SLD) icing program will define the environment and support the development of simulation tools and weather forecasting/prediction tools. An operational concept for a new system will monitor human alertness.

In FY 1998, the Aviation Operations System program will address key barriers to improving the capacity and safety of the nation's air-transportation system. To improve safety, error-tolerant air-ground-systems integration will use human-performance principles to develop error-detecting/correcting technologies. The physiological and psychological stresses on humans will be studied, their impact defined and counter-measures explored. Methods for analyzing the stability and safety of Air Traffic Management (ATM) systems will be investigated and developed in order to enable introduction of increased automation with increased safety. Validated technologies to predict and detect wake vortex hazards will be developed to reduce operational constraints to capacity. Modeling, wind-tunnel and flight studies will be pursued to understand and forecast the icing environment, to predict its effect on aircraft flight, and to enable design of icing avoidance and protection systems in order to eliminate icing accidents and reduce operational constraints. Advanced air-traffic management concepts and technologies will be pursued in collaboration with the university community.

With the reorganization of the R&T Base, the Information Technology program now includes the Numerical Aerodynamic Simulation (NAS) Program. In FY 1996, NAS Storage (NAStore) significantly upgraded its large-scale data storage system with the use of high-density tape technology. The NAStore tape system now provides a capacity of over 500 terabytes, an order of magnitude increase in robot-accessible storage. NAStore disk capacity was also increased from 1.6 to 3.2 terabytes. NASA released a request for information to supercomputer vendors as a precursor to a request for offers on the next-generation high-speed processor. Information gathered from the responses was used to refine requirements and specifications. NASA successfully deployed its Portable Batch System (PBS) on Cray C90s, on a Cray J90, on an IBM SP2, and on the Silicon Graphics workstation cluster. This system provides batch and cluster control across all computer platforms running UNIX, including workstation clusters, shared-memory processors, and distributed-memory processors. The PBS has also been used by the High Performance Computing and Communications program to manage distributed systems. Remote access capability for aeronautical facilities users has been created by application of information-system methodologies to speed the aircraft design-and-development process.

The Information Technology program will further upgrade its NAStore data storage system by replacing controlling processors with more economic workstation systems in FY 1997. NASA will continue the research and development of a unified system-software environment for the operation of heterogeneous, distributed computer systems. Software subsystems to be studied include multi-platform accounting, Open Systems Foundation's Distributed Computing Environment (OSFDCE) and Distributed File System (DFS), and portable administration tools. The metacenter concept (a computer protocol system to most efficiently process tasks - regardless of where the computers are located), demonstrated with the PBS on the IBM SP2, will be extended to the Cray J90 system located at ARC and GSFC. Additionally, an "aerocentric" information system will be developed by combining test techniques, instrumentation, computation, and simulation capabilities for more effective use of NASA aeronautical resources. Development of the system will be supported by emerging technology tools and an intelligent design environment to demonstrate active control systems for crucial aeronautics applications.

During FY 1998, the Information Technology program will acquire and install the High Speed Processor 4 (HSP-4) to develop Extended Operation Configuration 3 (EOC-3). Active neural control systems for crucial aeronautical applications will be developed and demonstrated, leading to significant design-cycle-time reductions and improved knowledge interfaces to aeronautical information.

The Rotorcraft program made significant progress in FY 1996 in rotor-system aeromechanics in the areas of noise reduction, vibration reduction and aerodynamic prediction capabilities for both conventional helicopters and tiltrotor configurations. The first version of the Tiltrotor Aeroacoustic Code (TRAC1) was validated, showing excellent prediction abilities for rotor blade/vortex interaction noise. Progress with advanced computational-fluid-dynamics methods allowed predictions of rotor/airframe interaction aerodynamics and assessments of the complex aerodynamic flowfields of unique new rotor/anti-torque devices. Wind-tunnel studies demonstrated greatly improved tiltrotor cruise speed using an advanced, tailored, thin tiltrotor/wing concept. Significant reductions in tiltrotor airframe vibrations were achieved using active hub-and-flap control methods. New analytical techniques for gear crack detection and failure progression were developed and validated to improve safety. NASA and Sikorsky filed a patent application for a split-torque transmission concept that reduces weight about 20 percent compared to conventional transmissions. Major progress was made by the cooperative government/industry/academia National Rotorcraft Technology Center (NRTC) program that combines the capabilities of NASA, DOD (Army and Navy), FAA, the Rotorcraft Industry Technology Association (RITA) and academia in a cooperative rotorcraft research and technology program. Technology development programs emphasized reductions in manufacturing and operating costs, low-cost composite structures, increased vehicle performance, increased reliability, and reduced noise and vibration. In addition, the Army's Rotorcraft Centers of Excellence program was integrated with NRTC.

The FY 1997 Rotorcraft program will provide two national resources for rotorcraft test activities by completing a full-span tiltrotor acoustic model (TRAM) wind-tunnel test system, and flight-qualifying a programmable-control helicopter. Work on fundamental issues in aerodynamics will be applied and validated for new configurations, and the development of modules for design tools using this knowledge and information technologies will begin. The tiltrotor wind-tunnel testing will cover active noise control and the program will work on other active and passive noise-and-vibration-reduction design techniques for both conventional helicopters and tiltrotors. Additionally, flight tests will gather data on the noise-reduction potential of optimized, low-noise, operational procedures for civil helicopters. The second full year of the NRTC will see a significant increase in multi-company industry technology projects and will encourage technology transfer between the industry participants and the government labs associated with the NRTC research program.

In FY 1998, the Rotorcraft program will focus several integrated programs. Design for Efficient and Affordable Rotorcraft (DEAR) will include new analytic tools with emphasis on composite structures. Safe All-weather Flight Operations of Rotorcraft (SAFOR) will emphasize cockpit integration/flight-control simplification, gear-train health monitoring through Health and Usage Monitoring Systems (HUMS) and predictive technologies. New, innovative rotorcraft-flight concepts will be supported through technical cooperation with the Department of Defense and industry. This work will also include evaluation of a rotor that has significantly fewer mechanical components, yet can maintain required helicopter operational control (swashplate-less rotor). The NRTC will focus on technologies to reduce costs and increase activities in flight safety and reliability. The NRTC will be used in conjunction with alliances among the FAA, DOD, and NASA to assess the Rotorcraft program against national needs, with a view to maximizing the leverage of the NASA investment.

AERONAUTICAL FOCUSED PROGRAMS

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	**FY 1996**	**FY 1997**	**FY 1998**
High-performance computing and communications	32,200	23,300	45,700
High-speed research	233,300	243,100	245,000
Advanced subsonic technology	169,800	173,600	211,100
Total	**435,300**	**440,000**	**501,800**

NASA's Aeronautics focused programs address selected national needs, clearly defined customer requirements and deliverables, critical program decision and completion dates, and a specified class of research with potential application. Each of the focused programs are discussed in detail on the following pages. In previous years, the focused programs included Numerical Aerodynamics Simulation (NAS) program and the Environmental Research Aircraft and Sensor Technology (ERAST) element of the High Speed Research Program. Both NAS asnd ERAST are now included within the Research and Technology Base Program -- NAS is contained within Information Technology, and ERAST is included within Flight Research.

HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	**FY 1996**	**FY 1997**	**FY 1998**
High-performance computing and communications - Computational Aerosciences	32,200	23,300	45,700

PROGRAM GOALS

Studies have shown that high performance computing technologies have a significant positive impact on job creation, economic growth, national security, world leadership in science and engineering, health care, education, and environmental resource management. These technologies also enable the missions of many Federal agencies. The goals of the NASA High Performance Computing and Communications (HPCC) program are to accelerate the development, application and transfer of high performance computing technologies to meet the engineering and science needs of the U.S. aeronautics, Earth science and space science communities, and to accelerate the implementation of a National Information Infrastructure.

STRATEGY FOR ACHIEVING GOALS

The HPCC program goals are supported by five specific objectives:

1) Develop algorithm and architecture testbeds that are able to fully utilize high performance computing concepts and increase end-to-end performance;

2) Develop high performance computing architectures scaleable to sustained TeraFLOPS performance;

3) Demonstrate HPCC technologies on U.S. aeronautics, Earth science and space science research problems;

4) Develop services, tools, and interfaces essential to the National Information Infrastructure;

5) Conduct pilot programs in public use of remote sensing data that demonstrate innovative use of the National Information Infrastructure.

The NASA HPCC program was authorized by the High Performance Computing and Communications Act of 1991 and work began in FY 1992. In the first five years, progress was made towards solving "Grand Challenge" problems in science and engineering. Teams were openly and competitively selected to address "Grand Challenge" problems such as supersonic passenger aircraft simulation and global climate modeling. Major national computational testbeds were installed at Ames Research Center and Goddard Space Flight Center to study next-generation high performance computational systems and to support "Grand Challenge" research teams. In FY 1994, a new component was added to the NASA Program called Information Infrastructure Technology and Applications (IITA). It used HPCC technologies to solve National challenges in education, training, and lifelong learning; health care; environmental monitoring; digital libraries; manufacturing and design; and access to government information. IITA activities are scheduled to end in FY 1998.

The current NASA HPCC program consists of three commonly planned projects that share an underlying work breakdown structure. These projects are: Computational Aerosciences (CAS), managed and funded by the Office of Aeronautics and Space Transportation Technology; Earth and Space Sciences (ESS), managed and funded by the Office of Mission to Planet Earth; and Remote Exploration and Experimentation (REE), managed and funded by the Office of Space Science. The primary objective of the CAS project is to significantly shorten the design cycle for advanced aerospace products such as future high-speed civil transports. The ESS project strives to enable the comprehensive modeling of large-scale, long-duration phenomenology such as global climate change or galactic evolutionary processes. REE has the goal of developing and demonstrating a space-qualified, spaceborne computing architecture that requires less than ten watts per billion operations per second. The Office of Education and Human Resources and the Office of Equal Opportunity Programs manage and fund the educational components of HPCC. Total direct Agency funding for the HPCC program is shown below.

Total HPCC Agency Funding (Thousands of Dollars)	**FY 1996**	**FY 1997**	**FY 1998**
Aeronautical R&T	32,200	23,300	45,700
Mission to Planet Earth	26,100	28,300	18,300
Space Science	600	3,200	5,600
Education Programs	2,200	1,400	4,200
Minority University & Education	2,500	2,700	--
Total direct HPCC (NASA-wide)	**63,600**	**58,900**	**73,800**

The NASA HPCC program is planned and executed in cooperation with Federal agencies, industry, and academia to exchange information about technical and programmatic needs, issues, and trends. Interagency collaboration is fostered through the National Coordination Office which has a full time staff to support the main HPCC coordinating body--the Computing, Information, and Communication R&D Subcommittee (CIC) (part of the National Science and Technology Council).

The Program Manager at Ames Research Center is responsible for the overall implementation of the NASA HPCC Program. NASA Headquarters provides strategic guidance on program content and direction with assistance from the NASA HPCC Executive Committee. The Committee consists of senior-level managers from the major HPCC centers and representatives from the Headquarters "stakeholder" offices: the Office of Aeronautics & Space Transportation Technology, the Office of Space Science, the Office of Mission to Planet Earth, the Office of Education and Human Resources, and the Office of Equal Opportunity Programs. The technical program is documented via a HPCC Level I Program Plan that is updated annually. Quarterly reviews are held by Headquarters to ensure that the program is achieving its stated goals and is staying within schedule and budget.

NASA has conferred with senior executives from major U.S. aerospace companies to plan the Computational Aerosciences (CAS) project to best respond to long-term customer requirements. Managers of the CAS program periodically visit and interact with industry leaders to better understand industry's critical long-term needs for computational aeroscience technologies.

The CAS program has attracted significant participation from external sources who bring expertise and resources to achieve common goals. There are two categories of involvement-Interagency Cooperative Programs and Cooperative Agreement Programs.

Interagency Cooperative Programs:

NSF/DARPA/NASA Digital Library Joint Research Initiative - The National Science Foundation (NSF), the Defense Advanced Research Projects Agency (DARPA), and NASA jointly sponsor the Digital Library Joint Research Initiative in order to demonstrate technologies needed to build digital libraries to electronically access NASA science data. This four-year, multi-agency effort was initiated in FY 1994 and continues through FY 1998. NASA, in conjunction with NSF and DARPA, now co-fund six research and development projects.

Scaleable Input/Output Initiative - This initiative concentrates on research to move massive amounts of data into and out of parallel computers efficiently. Working together, IBM Research, Lawrence Livermore Laboratory, Argonne National Laboratory, and NASA Ames developed a draft standard interface for parallel computer file access. By June 1997 the Message Passing Interface (MPI) is expected to be standardized by the world-recognized MPI Forum, a standards-making organization.

High Performance Networking - Compatible requirements of NASA and the Department of Energy (DOE) for high-bandwidth, wide-area experimental networkingled to a joint solicitation and award to Sprint on August 25, 1994, for the incremental delivery of 45 megabits per second (Mbps), 155 Mbps, and 622 Mbps Asynchronous Transfer Mode (ATM)/Synchronous Optical Network Transmission (SONET) service to five NASA centers. The project is scheduled to be completed in September, 1997.

National HPCC Software Exchange (NHSE) - The Federal HPCC agencies working in concert with academia and DOE laboratories developed a National HPCC Software Exchange to provide an infrastructure that encourages software reuse and the sharing of software modules across organizations through an interconnected set of software repositories. This multi-agency effort was initiated in FY 1992 and continues through FY 1998.

PetaFLOPS Initiative - The current Federal High Performance Computing and Communications Program is working toward achieving teraFLOPS (one trillion floating operations per second) computing. However, far-sighted individuals in government, academia and industry have realized that teraFLOP-level computing systems will be inadequate in the future. As a result, NASA, NSF, DOE, DARPA, National Security Agency, and the Ballistic Missile Defense Organization are developing technologies to support PetaFLOP (one million-billion floating operations per second) computing systems.

Cooperative Agreement Programs:

NASA established a cooperative agreement in the fall of 1994 with a consortium led by IBM to develop a high performance computing capability in computational aerosciences. Additional agreements will be awarded, as required, to meet future research needs.

The Affordable High Performance Computing (AHPC) Project, initiated May 31, 1995, supported jointly by Pratt & Whitney, United Technologies Research Center, Platform Computing, CFD Research Corporation, Massachusetts Institute of Technology, State University of New York at Buffalo, MacNeal Schwendler Corporation, and NASA, is striving to prove the affordability and practicality of high performance computing using a distributed network of workstations. This cooperative agreement supports a major FY 1997 milestone to demonstrate that a distributed network of workstations is a cost-effective, reliable, high-performance computing platform for production use.

MEASURES OF PERFORMANCE

Performance Metric	Plan	Actual/Revised	Description/Status
Demonstrate multidisciplinary applications on 10-50 GigaFLOP testbed	September 1996	September 1996	Demonstrate execution of CAS Grand Challenge applications at negotiated performance metric levels for scalability or speedup, portability, and performance. (Note: NASA Program Management Council approved change to combine CAS & ESS milestones)
Demonstrate end-to-end reductions in cost and time to solutions for aerospace design applications on heterogeneous systems	September 1996	September 1997	Demonstrate at least 25% cost reduction in time to solution for 5 applications and a 5-to-1 reduction in time to solution for combustor design application Date was tied to Cooperative Agreement Notice (CAN) completion that was delayed following lengthy approval/procurement process.
Demonstrate 622 Mbps interconnects over NREN.	September 1997	--	Demonstrate 550 Mbps network performance at a minimum of three NASA centers. Note: The term "high-speed" was used last year instead of the correct, more descriptive terminology "622 Mbps".

Demonstrate cost-effective, high-performance computing at performance and reliability levels equivalent to 1994 Vector Supercomputers at 25% of the capital cost	September 1996	September 1997	Solve CAS Grand Challenge problems using a workstation cluster that performs at 250 MegaFLOPS (millions of floating operations per second) at a capital cost of less than $2.5 million. Date was tied to CAN completion that was delayed following lengthy approval/procurement process.
Demonstrate integrated, multidisciplinary aerosciences applications on TeraFLOPS-scaleable testbeds.	September 1997	--	Demonstrate execution of 50% of CAS Grand Challenge applications on teraFLOPS-scaleable testbeds, where applications meet scalability, portability and performance success criteria.
Install 200-250 GigaFLOPS sustained, TeraFLOPS-scaleable testbed	June 1998	--	Install testbed and measure scaleability and performance against success criteria.
Demonstrate a portable, scaleable programming and runtime environment for Grand Challenge applications on a TeraFLOPS-scaleable system	September 1998	--	Demonstrate that applications scale logarithmically with the number of processors and are portable to all current testbeds.

adoption by the MPI Standards Forum. This enhancement affords users a practical, portable, efficient, and flexible message passing capability for parallel processing. The installation of the 155 Mbps network service and the creation of a microeconomic job scheduler for parallel computers have enabled metacenter administration of NASA's experimental supercomputers, which are physically dispersed across the U.S. Because of our ability to share jobs across systems, turnaround times are lower, computational capability is enhanced and utilization has increased.

Computational Aeroscience activities planned for FY 1997 include: (1) demonstrating end-to-end reductions in cost and time to solution for aerospace design applications on TeraFLOPS-scaleable testbeds; (2) demonstrating integrated, multidisciplinary applications on TeraFLOPS-scaleable testbeds; (3) demonstrating cost-effective, high-performance computing at performance and reliability levels equivalent to 1994 Vector Supercompuers at 25 percent of the capital cost [note that the initial target date for this milestone, September 1996, was set early in the planning phase, but was not corrected following the lengthy approval/procurement process]; (4) providing a production system software environment that integrates distributed workstations with TeraFLOPS-scaleable machines, and (5) demonstrating 622 Mbps National Research and Education Network interconnections.

Computational Aeroscience activities planned for FY 1998 include: (1) installing a third generation, sustained TeraFLOPS testbed to continue work in high-performance scaleable systems; (2) demonstrating a portable, scaleable programming and runtime environment for Grand Challenge applications on a TeraFLOPS-scaleable system to enhance system software development; and (3) supporting the federally coordinated Large Scale Networking Initiative -- Next Generation Internet (NGI) -- to help create the foundation for the 21st Century networks.

HIGH SPEED RESEARCH

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	FY 1996	FY 1997	FY 1998
High-speed research	233,300	243,100	245,000

PROGRAM GOALS

Studies have identified a substantial market for a future supersonic airliner - or High-Speed Civil Transport (HSCT) - to meet the rapidly growing demand for long-haul travel, particularly across the Pacific. Over the period from 2005 to 2015, this market could support 500 to 1,000 HSCT aircraft, creating a multi-billion dollar sales opportunity for its producers. Such an aircraft will be essential for capturing the valuable long-haul Pacific Rim market. Market studies indicate that the successful development of a domestic HSCT will result in $200 billion in sales and 140,000 jobs for U.S. industry. As currently envisioned, an HSCT aircraft would carry 300 passengers at Mach 2.4 on transoceanic routes over distances up to 6,000 nautical miles at fares comparable to subsonic transports.

NASA is developing the technologies that industry needs to design and build an environmentally compatible and economically competitive HSCT for the 21st century. The High-Speed Research (HSR) Program goal is to have the technology available to enable an industry decision on aircraft production.

STRATEGY FOR ACHIEVING GOALS

While current technology is insufficient, studies indicate that an environmentally compatible and economically competitive HSCT could be possible through aggressive technology development. NASA is concentrating its investments in the early, high-risk stages of development and the aircraft manufacturing industry has indicated that it is willing to make a substantial investment in this program as the technological risk decreases.

NASA's HSR Program is providing a public-sector catalyst in addressing this important opportunity with U.S. industry through a two-phase approach. The first phase defined HSCT environmental compatibility requirements in the critical areas of atmospheric effects, community noise and sonic boom and established a technology foundation to meet these requirements. The second and current phase is a cooperative program with U.S. industry and is directed at developing and validating designs, design methodologies and manufacturing process technology for subsequent application by industry in future HSCT aircraft programs to ensure environmental compatibility and economic viability.

Langley Research Center (LaRC), the lead center, is responsible for policy and program implementation, project planning and funding allocation, vehicle systems engineering and integration, and direct airframe contractor interface and management. At the NASA Aeronautics Centers (Ames Research Center (ARC), Dryden Flight Research Center (DFRC), LaRC and Lewis Research Center (LeRC)), the Center Directors provide personnel and facilities to conduct research, analysis and program management in support of the program. LeRC is also responsible for the propulsion contractor interface and management.

The team of primary HSR contractors consists of airframe, propulsion system and advanced flight deck companies. These contractors are responsible for: the research, development and validation of specific technologies; the development and assessment of a next-generation High-Speed Civil Transport (HSCT) concept and configuration; the system-level integration of the advanced technologies being developed; and the conduct of associated tasks, such as mission analysis and data base development. The primary propulsion contractors are the team of Pratt & Whitney and General Electric Aircraft Engines. The primary airframe contractors are the team of Boeing and McDonnell Douglas. The advanced flight deck contractor is

Honeywell International. ARC provides significant support directly to LaRC in advanced flight deck development, in computer modeling and simulation, and in economic analysis. DFRC provides support for flight-related activities including the F-16XL. LaRC is responsible for integration of all elements of the program and LeRC is responsible for propulsion systems technology integration.

The HSR Program is enhanced by participation, in coordination and cooperative efforts to exchange information and data, with other NASA organizations and federal agencies that include:

The Atmospheric Effects of Stratospheric Aircraft Panel, which includes participation by NASA's Office of Mission to Planet Earth, Environmental Protection Agency, Federal Aviation Administration, National Oceanic and Atmospheric Administration, National Science Foundation and Department of Defense. The panel provides guidance and evaluation of research related to the effects of high-speed civil transports on the upper atmosphere;

The FAA/NASA Coordinating Committee, which provides the framework for developing and defining HSCT certification requirements; and

The Department of Defense, which provides a cooperative forum for advanced engine technology development via its Integrated High Performance Turbine Engine Technology (IHPTET) initiative.

MEASURES OF PERFORMANCE

Performance Metric	Plan	Actual/Revised	Description/Status

Select Airframre Subcomponent Materials	December 1995	December 1995	Materials, processes and structural concepts were selected for wing and fuselage subcomponent test articles. The selection was based on material performance, structural efficiency, producibility, estimated production costs and technical risks as determined by materials testing, structural element tests, design integration trade studies and other analytical studies. Combination of polymeric matrix composites and titanium sandwich materials were selected as primary and alternate wing and fuselage materials for further technology development.
Select Preliminary Engine Nozzle and Inlet Designs	December 1995	December 1995	The engine cycle was selected based on systems analyses which account for experimental test results. The cycle chosen provides the best combination of direct operating cost, operability, robustness, and environmental acceptability when matched to the current aircraft configuration. Nozzle selection was based on small-scale aero-acoustic testing, material feasibility and manufacturing infrastructure assessment, systems analyses, and preliminary design data for the most promising low-noise nozzle concepts. Inlet selection was based on small-scale testing, systems analyses, and historical data fior the most promising inlet concepts. Mixed flow turbofan cycle, two-dimensional mixer-ejector nozzle and axisymmetric inlet were selected for further technology development.

Select HSCT Preliminary Concept	December 1995	Decemebr 1995	Define a NASA/Industry technology baseline airplane that includes an optimized propulsion system and wing planform/high-lift combination. The selection will be based on weight, environmental requirements, robustness to changing requirements, and economic viability. The Technology Concept Airplane defined based on technology elements satisfies weight and mission goals.
Supersonic Laminar Flow Control (SLFC) Flight Test Complete	April 1996	September 1996	Complete SLFC flight experiments on F-16XL-2. Acquire critical laminar flow data over a Mach number range and altitudes for computational fluid dynamics code validation and SLFC Configuration design code development. Minor wing glove redesign resulted in a schedule slip (not expected to impact the overall HSR program completion date). All the SLFC flight test objectives were met. Laminar flow was achieved over the speed range of Mach1.7 to 2.0 and altitudes up to 55,000 ft. Suction requirements to maintain the laminar flow were established. SLFC is not incorporated in the baseline Technology Concept Airplane, but will be considered as an option should the technology be required in the future for the airplane to meet weight and range goals.
Combustor Rig (Sector) Verification Tests	June 1996	November 1995	Verification of ultra-low NOx formation (goal: 5 grams/kilogram of fuel burned) in engine combustor sector tests. Met emissions index goal of less than 5 grams NOx per kilogram of fuel for both the rich-burn, quick-quench, lean-burn and the lean, pre-mixed, pre-vaporized concepts.

SLFC Baseline Decision	March 1997	September 1996	The decision on whether to incorporate Supersonic Laminar Flow Control (SLFC) technology into the baseline airplane was to be based on design, production and economic system integration studies resulting from F-16XL flight experiments. The industry HSR team evaluated the results of the SLFC completed in September 1996. This drag reduction technology has the potential of reducing vehicle gross weight by over 6percent; however, since the potential benefits are far outweighed by the technical risk and extensive systems impact, the HSR program team does not envision using SLFC on the first generation HSCT.
Testbed Exhaust Nozzle Designed - Configuration & Materials	March 1997	December 1997	Complete detailed design of selected nozzle concept and release drawings for fabrication. Small scale tests met both aerodynamic performance and noise goals, with separate designs, but work replanned and milestone delayed in order to complete further nozzle tests required to meet both goals in one design. (Delay is not expected to impact overall HSR program completion date.)
Flight Controller Selection (Flight Deck Systems)	April 1997	--	Make the final program determination of sidestick or wheel and column control inceptor as pilot control mechanism. Include examination of applicable data and studies, potential simulation evaluations, an internal industry review, and a final NASA/industry program selection.

Component Materials Selection	May 1997	September 1998	Materials and structural concepts will be selected for wing and fuselage component test articles. Selections will be based on material performance, structural efficiency, and production costs as determined by testing and analytical studies. Budget rephasing provided an opportunity to remove parallel schedules of subcomponent program and component program. The Component Materials Selection milestone now coincides with the preliminary design review. (Delay is not expected to impact overall HSR program completion date.)
Combustor Configuration Selected	August 1997	May 1998	Combustor selection will be based on results of sector testing with advanced metallic and ceramic matrix composite liners, annular rig testing, manufacturing infrastructure assessment, analyses, and preliminary designs of the two most promising combustors. The date was revised as part of the overall combustor subelement replanning in March 1996. Delay in combustor configuration selection is due to schedule delays associated with sector testing and technical concerns associated with emission levels for one combustor concept. Overall combustor subelement technical, cost and schedule goals are expected to be met.
AESA Phase II (Flight Campaign Complete)	August 1997	--	Complete on-site atmospheric observations with Northern Hemisphere Summer ER-2 flights.
Subcomponent Test Articles	July 1998	--	Delivery and preparation of several wing and fuselage subcomponent articles for structural testing.

Preliminary Flight Deck Configuration Selected	July 1998	--	Downselection of preliminary flight deck configuration including: choice of control inceptor; selection of basic External Visibility System concept; evaluation of terminal area guidance and control concepts; development of decision-aiding concepts; confirmation of flight deck design and automation philosophy; and provision of both electronic and physical cockpit mock-ups.
Subcomponent Test Data (Materials and Structures)	July 1998	--	Release of data acquired during static and damage-tolerant testing of wing and fuselage subcomponent articles.
Phase II Assessment of Atmospheric Impact	September 1998	--	Complete the assessment of environmental compatibility of HSCT incorporating HSR emissions reduction technology.

ACCOMPLISHMENTS AND PLANS

In FY 1996, the High Speed Research (HSR) program continued to develop technologies to establish the viability of an economical and environmentally-sound High Speed Civil Transport (HSCT). Wind tunnel tests of a 13.5-percent scale model with combined noise-suppression engine nozzle and high lift wing were completed. Initial analyses indicate that nozzle noise and performance characteristics (critical to an environmentally-acceptable HSCT) were undiminished by the presence of the high lift wing (also critical to a successful HSCT). Assessments of the effects that a fleet of supersonic aircraft may have on stratospheric ozone continued. Atmospheric sampling by high-altitude NASA aircraft has been completed; enhancements to atmospheric models are nearing completion; and emission scenarios for a mature HSCT fleet (i.e., 1,000 aircraft) have been completed. Finally, verification of the capability of an HSCT to meet FAA noise standards is on plan.

Major technology downselects were completed leading to the integration of the Technology Concept Airplane -- a consensus NASA/industry configuration for focusing and measuring technology development. The propulsion downselects included axisymmetric mixed-compression inlets, mixed-flow turbofan engines, and 2-dimensional mixer ejector nozzles. The airframe downselects included the high-lift concept, primary and secondary structural concepts using titanium and polyimide materials, and definition of the wing planform. Community noise is driving both engine and wing sizing based on potential future requirements for a fleet of HSCTs. The Supersonic Laminar Flow Control (SLFC) experiment on the F-16XL has shown that wing suction at supersonic speeds can significantly reduce drag and thus offers a potential 6-percent reduction in HSCT gross takeoff weight. However, because of the complex technology needs in structures and materials, as well as suction/power system design and integration issues, the industry decided that the SLFC technology risk could not be mitigated before the program launch of the HSCT. A combination of high- and low-resolution video sensors with a 40x50-degree field-of-view display has been selected for the synthetic vision flight deck. Two low-NOx combustor concepts are still below anticipated required emission levels based on results from sector and rig tests. The Atmospheric Effects of Stratospheric Aircraft (AESA) flight campaign has been augmented to reduce the uncertainties of global ozone predictions. Extensive NASA high-altitude aircraft and satellite atmospheric measurements will verify the 3-dimensional transport models being developed.

In FY 1997, the High Speed Research program will select the materials and structural concepts that will be used in the fabrication of the subcomponent test articles of the wing and fuselage. Concept selection will be based upon material performance, structural efficiency, and risks as determined by tests and analyses. Detailed design of the testbed exhaust nozzle concept will be initiated to begin fabrication of the nozzle. The Atmospheric Effects of Stratospheric Aircraft (AESA) flight campaigns will conclude. Final sampling of the stratosphere in the Northern Hemisphere by NASA high-altitude aircraft will complete the observational database as a precursor for the final assessment of High-Speed Civil Transport environmental compatibility. The Tu-144 ground tests will be completed to provide propulsion inlet design data to calibrate prediction engineering codes.

In FY 1998, each of the technology areas will focus their results for integration into the Technology Configuration program milestone, scheduled for December 1998. In particular, the airframe wing and fuselage subcomponents will be fabricated and tested, and the Preliminary Design Review of the fuselage and wing large-scale components will be completed. Detailed design of the testbed exhaust nozzle concept will be completed and design drawings will be released to begin fabrication of the nozzle, which when completed will be fitted to and tested with the selected testbed engine. The selection of the core engine combustor will also be made, based upon results of completed sector testing with advanced metallic and ceramic matrix composite liners; annular rig testing; manufacturing assessment; and analyses and preliminary designs of two alternative combustors. The flight deck configuration will be selected including the control inceptor, basic external visibility system, terminal area guidance and control, decision aids, design and automation philosophy. The aerodynamics of the Technology Concept Airplane (defined in December, 1995) will be completed and nonlinear design codes will be validated for the definition of the optimized aeroelastic concept leading to the Technology Configuration Airplane (scheduled for completion in December, 1998). In addition, the Tu-144 flight tests for aerodynamics, aerothermodynamics, acoustics, and flying qualities will be completed, and the atmospheric impact of a fleet of HSCTs will be assessed using two-dimensional and three-dimensional global atmospheric models calibrated by atmospheric sampling from previous high-altitude NASA aircraft flights.

ADVANCED SUBSONIC TECHNOLOGY

BASIS OF FY 1998 FUNDING REQUIREMENT (Thousands of Dollars)	FY 1996	FY 1997	FY 1998
Advanced subsonic technology	169,800	173,600	211,100

PROGRAM GOALS

NASA's role in civil aeronautics is to develop technology to ensure that U.S. industry is prepared to meet the demands and increasing constraints being placed on the aviation system by new safety requirements, increasingly stringent noise and emissions standards, and growing air traffic volume. These constraints slow the introduction of new technology offering improvements in aircraft performance and international competitiveness, because they increase the risk and cost of applying the technology. The goal of NASA's Advanced Subsonic Technology (AST) program is to develop high payoff technologies, in cooperation with the Federal Aviation Administration (FAA) and the U.S. aeronautics industry, to benefit the civil aviation industry and the flying public. These technologies are aimed at reducing industry costs while increasing safety, reducing civil aircraft impact on the environment and increasing the capacity of the airspace system. Success will be measured by how well NASA contributes to: (1) technology readiness that will enable U.S. manufacturers to capture a larger share of the world market for civil aircraft; and (2) the effectiveness and capacity of the national air transportation system.

With competition from foreign competitors greatly increasing, technology is critically needed to help preserve the U.S. aeronautics industry market share, jobs, and balance of trade. Exports in large commercial transports make a significant contribution to the U.S. balance of trade. However, according to industry estimates, the U.S. worldwide market share has slipped from a high of 91% during the 1960's to about 67% today. Increasing congestion in the aviation system and growing concerns about the environmental compatibility of aircraft may limit the projected growth. According to airline representatives, delays in the Air Traffic Control System cost U.S. operators approximately $3.5 billion per year in excess fuel burned and additional operational costs. Also, more stringent noise curfews and engine emissions standards are expected before the end of this century.

During a series of meetings with aviation industry CEOs in late 1996, NASA agreed that the dramatic reduction of airplane acquisition cost is a high-priority need. To better address this need, NASA is in the process of refocusing the Integrated Wing Design, Propulsion and Composite Wing elements of the AST program to satisfy the early milestones of a more revolutionary technology to satisfy this goal.

STRATEGY FOR ACHIEVING GOALS

The program was planned with the full involvement of both industry and the FAA. Close coordination exists between NASA and the FAA for the entire program, but particularly in those areas where there is a strong agency synergy: terminal area productivity (TAP), short-haul aircraft, noise reduction, propulsion, and environmental assessment. An ad hoc management review team, comprised of industry and governmental representatives, provided strategic oversight during the developmental stage. Industry is invited to review progress on a continuing basis to ensure that the program continues to meet those needs. The critical elements were selected on the basis of industry technology requirements to provide a focused and balanced foundation for U.S. leadership in aircraft manufacturing, aviation system efficiency and safety, and protection of the environment. In FY 1996, the TAP element was expanded to include the Advanced Air Traffic Technology program to develop technologies critical to enhancing the efficiency and productivity of aircraft/airspace operations for all users of the next generation airspace system.

A change in the program is being planned to shift the emphasis from economics to revolutionary advances in the tools necessary to design, manufacture and certify aviation systems. New integrated tools are envisioned, to enable greater reductions in the cycle time for aircraft design, manufacturing, and certification. Our objective is to place greater emphasis on revolutionary airframe design and manufacturing processes beginning with the extension of this technology to revolutionary aircraft concepts such as the Blended Wing Body (BWB). Propulsion design and manufacturing methods are expected to emphasize reduced cycle time for flow-path component design, as well as manufacturing methods technologies for fan and turbine components. Refocusing and combining all the AST Integrated Tool technologies is anticipated in order to provide significant total reductions in aircraft costs, while future efforts conducted in the next decade would bring to fruition the goal of a dramatic reduction of aircraft seat costs.

Aging Aircraft

The industry standard practice of inspecting the civil transport airframes visually for damage is labor intensive and highly subjective. The goal of this element is to develop advanced technology that may be used by the U.S. airline operators and aircraft manufacturers to safely and economically extend the life of airplanes in the commercial jet transport fleet. The approach is to develop the prediction methodology necessary to calculate the residual strength in airframes and the advanced nondestructive evaluation technology to reliably and economically detect debonds, fatigue cracks, and corrosion. This will provide the industry with the tools to economically address the aging aircraft structural safety concerns. The program is strategically linked with complementary programs in the FAA.

Noise Reduction

Aircraft noise is an issue, both nationally and internationally, prompting airports to operate with strict noise budgets and curfews that restrict airline operations. International treaty organizations are actively considering more stringent noise standards which will impact the growth of the aerospace industry. This program element, in cooperation with U.S. industry and the FAA, targets technologies to reduce, by the year 2000, the noise levels for future subsonic transports by 10 decibels (dB) relative to the 1992 state-of-the-art. The approach is designed to develop noise reduction technology for engine source noise, nacelle aeroacoustics, engine/airframe integration, interior noise, and flight procedures to reduce airport community noise impact, while maintaining high efficiency. The objectives will be achieved via systematic development and validation of noise reduction technology. The timing of the technology development is consistent with the anticipated timing of recommendations for increased stringency.

Terminal Area Productivity (TAP)

The U.S. aviation industry is investing $6 billion over 20 years to increase airport capacity. However, a gap exists between the industry's desired capacity and the ability of the National Airspace System to handle the increased air traffic. Additionally, current FAA standards require reduced terminal operations during instrument-weather conditions, causing delays, reducing airport productivity and increasing the cost of operating aircraft. The objective is to safely achieve clear-weather capacity in instrument-weather conditions by eliminating inefficiencies associated with runway operations conducted under instrument flight rules. In cooperation with the FAA, NASA's approach is to develop and demonstrate airborne and ground technology and procedures to reduce spacing requirements, enhance terminal air traffic management, improve low-visibility landing and surface operations, and integrate aircraft and air traffic systems while maintaining safety.

The TAP element includes development of critical air traffic technologies -- Advanced Air Transportation Technology (AATT) -- which will enable a revolutionized U.S. air traffic capability and the development of innovative concepts for countries with immature systems. The benefits are reduced costs and a larger aviation market both nationally and in countries where air traffic efficiency is limited. NASA will use its expertise in aircraft human factors and automation technologies to develop and validate high-risk technology elements of the new air traffic architecture. To assure national coordination, a blue ribbon steering committee consisting of senior government and private sector participants is guiding these activities.

Integrated Wing Design

Currently, the U.S. commercial transport aircraft manufacturing industry is focused on reduced costs and improved time to market through reduced product development cycle time. In cooperation with U.S. industry, NASA is developing efficient, integrated design and test procedures focused on streamlining the aerodynamic design cycle and reducing cycle times by 50 percent. This will provide an overall reduction in the total aircraft development time of one year compared to an established 1995 baseline product development cycle time. In addition, the new design and test procedures will be used to deliver validated, highly efficient wing designs for cruise and low-speed operation which include the effects of propulsion system integration. The designs will yield a four-percent reduction in Total Airplane Related Operating Costs (TAROC) relative to established 1995 baseline technology levels. Exit strategy includes final validation of cycle time and TAROC objectives by the U.S. industry. Finally, it is anticipated that the validated design and test procedures will enable industry to implement technology delivered by other AST elements rapidly, leading to a 10- to 15-percent overall improvement in TAROC over the baseline.

Propulsion

In cooperation with the U.S. industry, NASA is developing propulsion technology with the objectives of reducing the environmental impact of future commercial engines through reduced combustor emissions and increasing the competitiveness and market share of the U.S. propulsion industry. The goals of this element are to reduce nitrogen oxide emissions, by at least 70 percent for large engines and 50 percent for regional engines over 1996 International Civil Avionics Organization (ICAO) Standards and to improve the direct operating cost (DOC) by three percent for large engines and five percent for regional engines with fuel efficiency improvements of eight to ten percent. Research and development is focusing on low-emission combustors; affordable advanced turbomachinery; high-temperature disk and blade materials; improved controls and accessories; advanced propulsion mechanical components; and light weight, affordable engine static structures. Aerodynamic, aeroelastic, and cooling analytical models and computational tools are being developed and validated using affordable advanced turbomachinery components (which are expected to result in a 30-percent reduction in development time and manufacturing cost of cooled airfoils) and engine testing. The products of this element will be incorporated into the next generation of very-high-bypass ratio commercial engines and derivatives or enhancements of engines currently in service.

Short Haul Aircraft

General Aviation in the U.S. represents approximately 45 percent of the nine billion air miles flown by all civil aviation annually. However, annual U.S. production of general aviation aircraft has fallen to approximately five percent of the 1978 level. In cooperation with U.S. industry, through a 50/50 cost-share venture, NASA seeks to support revitalization of U.S. general aviation through development and deployment of advanced technologies for enhanced small aircraft transportation system capabilities. Technologies are targeted to improve the utility, safety, ease-of-use, reliability, environmental compatibility, and affordability of the next generation of general aviation aircraft for business and personal transportation. Key enabling technologies include satellite navigation, flat-panel displays, small computers, expert systems, digital data link communications, low-cost manufacturing, and ice protection. By reducing the cost of manufacturing aircraft and the time required to obtain and maintain safe, all-weather flying skills, expanded use of general aviation is expected to fuel expansion of the national economy by bringing the "off-airways" communities into the mainstream of U.S. commerce.

While the civil tiltrotor has been shown to be a viable military aircraft (e.g., V-22 Osprey), insufficient research has been undertaken on technologies critical to civil applications such as noise, terminal area operations, safety, passenger acceptance, weight reduction, and reliability. NASA's effort relating to the civil tiltrotor emphasizes development of technology for civil tiltrotor configurations, and focuses on noise reduction; cockpit technology for safe, efficient terminal area operations; and contingency power. To achieve acceptable levels of external noise in the terminal area, proprotor noise must be reduced by 6 decibels A-weighted (dBA) over current technology. Complex flight profiles involving steep approach angles and multi-segmented approach paths will be developed to provide an additional 6 dBA reduction. To enable these approaches to be safely flown under all weather conditions, integrated and automated control laws and displays will be developed. The capability to recover from an engine failure requires the development of contingency power options that can provide single-engine hover capability without excessive engine weight.

Environmental Impact and Technology Integration

Environmental Impact and Technology Integration is a combination of two elements identified in previous years -- the Technology Integration and Environmental Impact element, and the Environmental Research Aircraft & Sensor Technology element.

Environmental Impact develops a scientific basis for assessing the atmospheric impact of subsonic commercial aircraft. The goals are to determine the current and future impact of aviation on the atmosphere; and to provide assessment reports of future international ozone and climate to serve as the basis for possible cruise emissions standards to be recommended by the International Civil Aviation Organization. Overall program direction and selection of investigators will be guided by an advisory panel comprised of respected members of the scientific and aviation communities. Elements of atmospheric research (e.g. modeling, laboratory studies, and atmospheric observations) are being complemented by studies unique to the aviation problem (engine exhaust characterization, near-field interactions, and operational scenarios). Sensors will be developed to perform atmospheric observations to determine the chemical and physical characteristics of the atmosphere relative to possible effects of aircraft chemistry (i.e., primarily ozone) and climate. The sensors will be used aboard the NASA DC-8 flying laboratory during field campaigns.

Technology Integration allows for a full understanding of the relative payoff of emerging technologies. A systems analysis capability is essential in the development of a credible assessment of the impact of NASA aeronautics technologies on the U.S. industry. As this capability evolves, it supports the Office of Aeronautics and Space Transportation Technology and NASA Research Centers in planning and managing the aeronautics program. Understanding the implication of NASA's technology investment on the aviation system minimizes the time intervals from idea generation to implementation, to industry development, and most importantly, to technology transfer.

Composites

The aircraft industry's resistance to using composites is related to economics and reparability/maintainability. While the current demonstrated level of composites technology can promise improved aircraft performance and lower operating costs through reduced structural weight, it does so with increased manufacturing costs, currently twice the cost of aluminum. The program goal is full-scale verification of affordable composite primary wing structures with an additional goal of demonstrated structure robustness through simulated service experience and repair by airline personnel. The primary objectives of the composites element are to reduce the weight of civil transports by 10 to 30 percent and their acquisition cost by 10 to 20 percent compared to today's metallic transports. This translates into a potential five percent reduction in total aircraft-related operating costs (TAROC) to the airlines and increases the competitiveness of the U.S. built transports. In cooperation with industry and the FAA, research is performed to validate the technology for the application of new composites manufacturing techniques.

MEASURES OF PERFORMANCE

Aging Aircraft

Performance Metric	Plan	Actual/Revised	Description/Status
Verify methodology to predict the residual strength of airframe structures.	June 1996	June 1996	Deliver to industry verified (under combined loads) structural integrity analysis codes (FRANC3D/STAGS) able to predict reduction in residual strength of a fuselage with widespread fuselage damage and accidental discrete source damage. Computer codes (FASTRAN, FADD, FRANC2D and FRANC3D/ STAGS) have been verified and transferred to industry along with engineering handbooks.
Complete field demos for tech transfer to industry	April 1998	--	Develop specialized engineering analysis tools to quantitatively evaluate inspection findings by computing remaining life, inspection intervals, and the residual strength of structural repairs. Complete field demonstrations of non-destructive evaluation (NDE) prototype instruments to illustrate technology utilization, and conduct focused workshops to transfer all technology to the instrument manufacturing industrial community.

Noise Reduction

Performance Metric	Plan	Actual/Revised	Description/Status
Validate concepts for 3-decibel jet and fan noise reduction relative to 1992 technology.	September 1996	December 1996	Experimental verification through high-fidelity, scale model, 1.5-6 bypass ratio engine simulator concepts (e.g. optimized fan/stator geometries, improved nacelle duct treatment). First quarter FY 1996 furlough caused a three-month delay in testing models in the Lewis Research Center 9x15 tunnel due to wind tunnel scheduling.

Terminal Area Productivity

Performance Metric	Plan	Actual/Revised	Description/Status
Transport Systems Research Vehicle (TSRV) ready to perform terminal area research	April 1998	--	Provide flight research capability for support of Terminal Area Productivity technology development and demonstration.

Integrated Wing Design

Performance Metric	Plan	Actual/Revised	Description/Status
Establish swept wing suction panel design criteria	September 1996	September 1996	Establish hole size, spacing and orientation for optimized suction requirements for laminar flow aircraft. Reductions in overall suction requirements of up to 15% were obtained via wind tunnel tests using 75% fewer holes than previous technology.
Mid-term assessment of impact on TAROC and design-cycle time compared to the baseline configuration.	September 1997	--	Evaluation of technology improvements will result in at least 1% improvement in TAROC and 20% improvement in aero design-cycle time.

Propulsion

Performance Metric	Plan	Actual/Revised	Description/Status
Complete 60-Atmosphere Combustion Test Rig	March 1996	March 1996	Operate national facility for testing large-engine sector combustors and full annular combustors for regional engines. Full facility systems testing completed and system operational for testing low emissions flametube concepts. Provides new, world class capability.
Evaluate flame tube combustor concepts	March 1998	--	Advanced tube combustor concepts will be evaluated for their potential to reduce NOx by conducting flame tube experimental tests at 60 atmospheres to simulate engine combustor operating conditions.

Short Haul Aircraft

Performance Metric	Plan	Actual/Revised	Description/Status
Complete flight acoustic database for the civil tiltrotor.	January 1996	January 1996	Comprehensive flight acoustic database acquired for XV-15 aircraft, including conventional and step approach paths. Sufficient flight acoustic data acquired for V-22 to enable scaling law validation. Early flight test results using optimized flight procedures indicate potential for a 3.2 dBA reduction (30%) in proprotor noise. These early results show good potential for meeting the final goal of 6 dBA reduction from optimized flight procedures.
Define general aviation transportation system operational, functional and performance requirements.	February 1997	--	Define and publish small-aircraft transportation system requirements for users, aircraft and infrastructure.

Environmental Impact and Technology Assessment

Performance Metric	Plan	Actual/Revised	Description/Status
Atmospheric observations from DC-8 Flying Laboratory.	September 1996	September 1996	Gather data from the first on-site observations dedicated to subsonic scientific assessment of the effects of contrails on Earth's radiation and the potential environmental effect of aircraft soot or sulfate. The aircraft succeeded in sampling environmental conditions needed to fulfill all five of the primary mission objectives. Instrumentation obtained a data set of unprecedented scope on cirrus cloud particles, cloud radiative properties, and aircraft exhaust particles and contrails. Emissions of an advanced engine were characterized over a range of simulated cruise conditions. Wake/vortex dynamics models were validated with ground-based lidar observations of LaRC B-737 exhaust.
Release first-generation aviation system analysis capability.	December 1996	January 1997	Deliver a computerized process that provides AST management with easy access to analysis and data bases for identifying potential benefits of AST technologies.

Composites

Performance Metric	Plan	Actual/Revised	Description/Status
Document wing configuration requirements.	Decemebr 1996	September 1996	Document composite wing design that meets all technical requirements, and all cost and weight targets. Wing design documented. Current analysis indicated wing will meet goals of 5-20% reduction in wing manufacturing cost, 25-40% reduction in wing weight and 5-10% reduction in aircraft direct operating cost (relative to 190-passenger airplane with an aluminum wing).

ACCOMPLISHMENTS AND PLANS

Fly-By-Light/Power-By-Wire (FBL/PBW)

In FY 1996, the detailed design of the selected PBW system was completed for a two-engine civil transport. The electromagnetic environment modeling code was validated using results from Transport Systems Research Vehicle (TSRV) flight tests. A preliminary flight test assessment of the integration of basic FBL components was completed and provided to industry. The results were incorporated in the commercial transport verification and validation plan. On October 1, 1996, the FBL/PBW element was terminated in response to FY 1997 budget reductions.

Aging Aircraft

In FY 1996, the analytical tools to predict the residual strength of a fuselage with widespread fatigue damage and accidental discrete source damage was experimentally verified through large-scale panel testing in cooperation with industry. After verification and subsequent refinement, the codes were provided to industry. Starting in FY 1996, and continuing through FY 1997, field testing and refinement of signal-processing techniques for all of the prototype activities included the completion of an engine noise database; the release of the community noise impact model; and a demonstration of an active structural acoustic control system on a business aircraft. In FY 1997, the most promising low-noise concepts for fan/jet/core will be selected based on advanced acoustic analyses and model tests. Additional planned work includes validating passive and adaptive linear treatment models; modeling and quantifying the flap-edge noise source; selection of an active noise control concept for engine demonstration; and demonstrating active control of boundary-layer-induced interior noise. In FY 1998, validation of the most promising active noise control concepts to reduce engine fan noise will be conducted. Benefit assessments on airframe noise reduction concepts will be completed. Other activities include identifying the most practical airframe noise reduction concepts by using subscale testing.

Terminal Area Productivity

In FY 1996, a flight demonstration of integrated airport surface automation concepts was conducted to identify inter-system issues between Global Positioning System (GPS), radar and other surface movement technologies. In FY 1997, cockpit systems flight tests will be performed for landing, roll-out, take-off and taxi to develop algorithms, displays and data bases for control systems to minimize runway occupancy time. The cockpit systems flight tests will be performed to demonstrate the Taxi-Navigation And Situation Awareness (T-NASA) System to assist the crew in maintaining (or improving) the safety and efficiency of taxi operations in visibility down to 300 feet runway visual range. T-NASA is a 3-component system comprised of an electronic moving map display, a head-up perspective taxi display, and a 3-D audio alert system. The system is being developed to provide navigation and situation awareness information in the flight deck for taxi on the airport surface. In FY 1998, the 757 flight research capability buildup will be completed, thereby making the aircraft ready for TAP demonstrations.

In FY 1996, the AATT effort began with system concept studies addressing both airborne and ground elements of candidate system architectures created through integration of aircraft guidance and air traffic controls technology. Study results provided a sound basis for future concepts and technology selection and for defining the next generation air traffic system requirements. In FY 1997, analyses, simulations, and experiments will be conducted to quantify the probability of conflicts, define requirements, and accelerate the development of conflict-probe and other technologies to prepare for their evaluation under a future field deployment at an FAA Air Route Traffic Control Center. In FY 1998, efforts will continue to explore distributed air/ground traffic separation concepts; expand air traffic concepts to include all user classes; and initiate a study to extend the decision science tools to the Northeastern Corrdidor.

Integrated Wing Design

In FY 1996, a NASA/Industry team conducted analysis of the Laminar Flow Control (LFC) database to establish swept-wing suction panel design criteria for a future, low-drag laminar flow aircraft design. Model fabrication of the externally blown flap configuration was completed in preparation for FY 1997 wind tunnel testing. In FY 1997, a low-speed, pressure-sensitive paint (PSP) diagnostic and preliminary load system will be developed to significantly reduce wind-tunnel test cost. An integrated computer aided design/computational fluid dynamics (CAD/CFD) grid generation scheme will also be pursued to reduce computational process time. Inverse pylon/nacelle design tools will be available to incorporate new engine installations on existing wings. Reynolds number effects for externally blown flaps will be established in order to develop simpler high-lift systems at current performance levels. U.S. aircraft manufacturing industry will conduct a mid-term assessment on progress toward reduced cycle time and TAROC objectives. In FY 1998, multipoint wing design tools and cruise multicomponent wing/propulsion airframe integration design tools will be calibrated.

Propulsion

In FY 1996, a new and unique high-pressure and high-temperature Advanced Subsonic Combustor Rig (ASCR) was checked out and readied to provide valuable assessments of low-emission combustors for advanced engines. The combustor rig has significantly improved the U.S. capability in cumbustor testing by providing a capability to operate at pressures in excess of 50 atmospheres, temperatures of more than 3000°F, and air flows of 38 pounds per second. The first test evaluated a lean direct injector low-emission combustion concept for future aircraft engines. In FY 1996, aerodynamic, aeroelastic, and cooling technology was aimed at developing and validating industry's affordable advanced turbomachinery. Technology development efforts were initiated for advanced propulsion mechanical components, controls, and materials. In FY 1997, extensive screening tests of advanced low-emission combustor concepts for both large and regional engine applications will be conducted. In FY 1998, a low-cost polymer matrix composite manufacturing process will be demonstrated, flame tube combustor concepts will be evaluated by experiments in the ASCR, and prototype disk manufacturing will be demonstrated.

Short Haul Aircraft

In FY 1996, the computer operating architecture for future general aviation controls and displays was identified. Displays and communication hardware were integrated in the testbed. The NDE processes were validated for use in certifying manufacturing of small composite components. Icing protection system design guidelines for safe operation of general aviation aircraft were developed. In early FY 1996, a comprehensive flight acoustics database was acquired for the XV-15 civil tiltrotor, including conventional and steep approach paths. This flight database of ground noise footprints was used to develop low noise approach profiles that provide a 6- dBA reduction over conventional approaches, and will be used as inputs to the

Vertiport Noise Impact model. An investigation of low-noise flight procedures began in the vertical motion simulator, and contingency engine power concepts were selected for preliminary design.

In FY 1997, the transportation systems operational, functional and performance requirements for general aviation aircraft will be defined and published for users, aircraft and infrastructure. The noise reduction provided by the low-noise proprietor concepts will be evaluated through wind tunnel testing and the isolated rotor configuration database will be completed to validate the blade vortex interaction prediction code. During model scale testing, multiple proprotor concepts, to be developed by several of the U.S. rotorcraft manufacturers, will demonstrate noise reduction of 6 dBA. From this database of rotor tests, concepts will be selected for more extensive full-span testing. The initial evaluation of low-noise approach profiles will be completed in FY 1997.

In FY 1998, system components for general aviation aircraft will be downselected for further evaluation. The best contingency engine civil tiltrotor power concepts will be also be downselected in FY 1998 for more detailed design and further analysis.

Technology Integration & Environmental Impact

In early 1996, a quick-response report server was established on the Internet to provide a single, integrated source of data needed to perform aviation system analyses. The incremental development of the aviation system analysis capability continued with the development of an executive architecture and an economic analysis module. In FY 1997, the first generation Aviation System Analysis Capability (ASAC) will be released. ASAC is envisioned primarily as a process for understanding and evaluating the impact of advanced aviation technologies on the U.S. economy. ASAC will consist of a diverse collection of models, data bases, and analysts from both the public and private sectors brought together in varying combinations to work issues of common interest to NASA and other organizations within the aviation community. ASAC will provide this support through information system resources, models and analytical expertise, as well as through its role as a conductor and organizer of large-scale studies of the aviation system and advanced technologies. In FY 1998, the second-generation aviation system analysis capability will be released.

The first program-level assessment report on the atmospheric impact of subsonic aviation was completed in FY 1996, leading to participation by principal investigators in preparation of the 1997 United Nations Environment Program/World Meteorological Organization (UNEP/WMO) ozone assessment report. Data that was analyzed from the first in-situ atmospheric observations were released, and a fundamental study of combustion product interaction will be completed in FY 1997. In FY 1996, the first in-situ atmospheric observations dedicated to subsonic aviation assessment were completed when climate-related measurements were performed aboard the DC-8 flying laboratory. The second field campaign with the DC-8 flying laboratory made ozone chemistry measurements to characterize sources of reactive nitrogen in frequently traveled regions. In FY 1998, the third DC-8 flying laboratory field campaign will be performed to measure tropical convection.

Composites

In FY 1996, the application of composites to commercial transport wings was validated by completing the baseline aircraft and requirements document for composite airframes, identifying candidate materials, and carrying out cost and weight trades and sensitivity studies. In FY 1997, a manufacturing plan for the production of multiple composite components that meet all cost and weight goals, as well as a structural development plan, will be developed. Manufacturing equipment will be fully operational, fabrication and assembly processes will be defined, and manufacturing cost allocations will be revised demonstrating the capability to fabricate and assemble composite wings below the cost of conventional aluminum wings. In FY 1998, a critical design review will be held and component tests will be completed.