TO THOSE WHO DEVOTE THEIR LIVES
TO THE PURSUIT OF KNOWLEDGE FOR THE
ENRICHMENT OF MANKIND
The rapid advance of the aeronautical sciences continues in much the same way from the early days of transonic developments through the formal establishment of the National Advisory Committee for Aeronautics (NACA) and an aeronautical research development program

The X-1 breaks the sound barrier.

North American XB-70 SuperSonic Transport

Korean War Jet Fighter - The Banshee

The X-29 Experimental Forward Swept Wing Aircraft

The Concorde - First of the NASA Contributions

The Future National Aerospace Plane (NASP)

Lifting Body Undergoing Wind Tunnel Testing

Entry Ballistics on a Blunt Body

Computed Space Shuttle Flow Field

Banshee / Heat Shield

Jovian Atmospheric Probe (Galileo Heat Shield)

First Meeting of the National Advisory Committee for Aeronautics 1915

Computational Fluid Dynamics Begins Using the Illiac IV Computer

Douglas DC-3

Boeing 707

X-1 Breaks the Sound Barrier

The Rocket Powered X-15

Glider Tests Precede the "Wright Flyer"

Boeing 707

Douglas DC-3

X-1 Breaks the Sound Barrier

The Concorde - First of the NASA Contributions

Korean War Jet Fighter - The Banshee

The X-29 Experimental Forward Swept Wing Aircraft

The Future National Aerospace Plane (NASP)
The use of computational fluid dynamics in modern aircraft design is a dream that has become a reality. Past aerodynamical developments could not explore all of the dimensions of fluid mechanics during the design process. Numerical Aerodynamic Simulation (NAS) establishes the capability to conduct modern design explorations using the most advanced computers. Opportunities for the advancement of U.S. leadership in aerodynamics are intimately tied to exploitation of the science of computational fluid dynamics. The tempo of aeronautical research and design has increased dramatically in the United States. The scope of problems and applications that can now be addressed continues to inspire technology projections.

The supercomputer is a time machine. Design iterations that formerly required years of developmental with wind tunnels and experimental flight tests can now be completed on compressed time scales. Today, wind tunnel and experimental flight tests assume a new, more confident and productive role. Wind tunnels evolve models at a mature stage of design and are used to verify and improve numerical codes. Flight testing is proceed with more confidence due to the range and extent of dynamic simulations that have been provided by the computer. The long-range goal of CFD is to develop software tools that will compare to a few minutes, the several months of around realistic computational models of aircraft and aerospace vehicles. This capability will simulate local flow phenomena as well as define the stability and control performance and loads for complete systems, including aircraft, helicopters, missiles and spacecraft. Increased understanding of these phenomena will result in advanced vehicle designs with substantially improved performance and efficiency.

NAS is a national resource available to support research and development for commercial and military aircraft. Designs can now be modeled with very high fidelity. Design revisions can be evaluated on time scales that were unheard of only a decade ago. Implementation of fluid dynamics algorithms, once thought of as mathematical curiosities, are now commonplace. The full promise of this marriage between two of our most advanced technologies is yet to be realized.
The NAS capability combines several necessary elements to produce an unparalleled scientific computing environment. The ingredients include:

2. High-speed processors.
4. Support processing systems.
5. Workstations.
7. Long haul communications.

The high-speed processors that form the heart of the NAS system can be effectively used when they can be efficiently accessed by local and remote users. The interactive systems that link users to processors provide a common operating communication system, reducing the complexities of computations to understandable outputs creatively deployed.

The NAS Processing System Network (NPSN) is accessible to a nationwide community of researchers. The computing capability is provided by high-speed computer for a United States aeronautics research and development program. The NAS program has three goals:

1. Establish a national computational capability, available to NASA, the Department of Defense (DOD) and other government agencies, industry, and universities as a necessary element in pursuing continuing leadership in computational fluid dynamics and related areas.
2. Be a partner in advanced, large scale computer systems through the systematic incorporation of leading-edge improvements in computer hardware and software technologies.
3. Provide a testing research tool for the NASA Office of Aeronautics and Space Technology.

The initial operating phase began in the summer of 1986 and continues with the introduction of advanced systems and new facilities. Implementation planning is evolutionary. The NAS strategy is to incorporate a sequence of successively more powerful prototype and early production systems into high-speed processors. In this way, NAS will continue to meet the expanding needs and capabilities of its users.

System access is provided to users at geographically dispersed NASA centers, DOD and other government research installations, aerospace industry sites and universities. Effective use is made of existing communications networks such as ETHERNET, ARPANET and NSFNET.

A broad range of communications bandwidth and services allow users access via terminals, workstations, or other host computer systems.
The ongoing evolution of digital computers supports the progress of technology in many areas. Computers can be used to gain insight into physical phenomena too complicated to explore experimentally.

For over a century, the equations governing physical phenomena of fluid flow were understood, but we lacked the tools to obtain analytical solutions. Experimental observation was a means of solution, but many problems were too complex to allow investigation. Computers serve as a bridge to the future, providing a capability for studying the basic physics of turbulence, cavity flow, chemical and nuclear reactions, weather prediction, molecular modeling, and other engineering and scientific science requiring large scale computations. Computational and experimental techniques can now be applied from complementary perspectives leading to an improved understanding of physical behavior.

This is a stimulating time for fluid dynamicists able to take advantage of the confluence of supercomputers, advances in applied mathematics and the improved science of fluid physics. Innovative computational architectures, coupled with the explosive growth in storage capacity and reductions in operating speeds, make it possible to observe complex three-dimensional flows at increasingly realistic scales and geometries. According to the advances in computer technology, it has been numerical aerodynamic simulation will continue to require increasingly more powerful computers to sustain the rate of progress in the aeronautics sciences.

Computers are a part of contemporary life at many levels. Casual observers of this technology usually equate computational progress with speed. The speed of modern computers eclipse their predecessors every few years. At the same time, computers become smaller. However, the unrecognized leaders of computational design are storage capacity and problem specific architectures. Memory capacity has grown at an even faster rate than processing speed and powerful original architectures have arisen to match the problems that they are designed to solve. It is difficult to project the conclusion of this countertop between applications and computing devices except to recognize that the unfolding scenario has just begun.
It is not the supercomputing machines that will make history, but the people using them. The salient characteristic of the computer age may be the general availability of a relatively rare localized resource.

This availability is in itself the result of another expanding technology, communications. Users are linked to the nucleus machine via high speed communication links that support interactive access for terminals, graphics work stations and other computers. Computers are playing an increasingly important role in all science and engineering disciplines.

World leadership is indelibly linked to computer use in activities ranging from the day-to-day conduct of commerce to the heights of scientific discovery.

At the centerpoint of these endeavors are humans pursuing commercial and scientific goals. Their success is directly tied to the organic link that must exist between mind and machine. In the hands of an explorer, the computer can stimulate global transformation, economic and social revision, and scientific advancement.
Accuracy, fidelity, congruency; words that convey the ability to monitor and perceive the true characteristics of an event usually result from careful observations or simulations within relevant temporal, spectral and spatial scales. Improvements result from an ability to sample finer spatial grids on closely separated time steps. For example, the uppermost exhibit is consistent with three-dimensional flow simulations associated with the grid density possible in 1978.

Observations became more refined as time progressed and the intricacies of flow were further revealed for even the simplest of structures. Finally, three-dimensional simulations were achieved permitting new revelations about the flow around real world structures.

Detailed structural analysis of the Space Shuttle's solid rocket booster is a complex problem. A 83,000 degree-of-freedom shell model was developed to evaluate overall booster stresses and to study geometric imperfections on shell response. Results of the simulations have been used to guide the redesign activity that is part of the shuttle booster requalification program.
Aerospace Plane places special emphasis on boundary layer interactions on hypersonic being used to study the effects of shock cowl and ramp of a mach-5 inlet. Numerical demonstrate the calculated skin friction on a mixed benchmark experiments to verify the computer code. The hypersonic environment of the National compression inlets. Surface plots will be compared with data from mach·2 between the jet exhaust and the surrounding understanding of the complex interactions density and pressure traces with the solution adapted grid. Field interactions become nonlinear in critical locations during of the pressure surface are shown for a modal of deformation, stresses and vibratory natural normal operation. Structural blade performance is assessed numerically in terms frequencies. Constant displacement contours frequency of 4487 Hz. Three dimensional simulations improve Turbine blade material characteristics flow field. Displayed mach·2.5 Improvements in these flow will result in reduced drag jet flow is shown In order are to evaluate propeller aerodynamic interference design. High pressure, low velocity regions are representing subsonic stagnation, yellow sonic shown section depicts freestream velocities and red supersonic velocities. The velocity field for the wing Surface panel analysis techniques are used in blue and low pressure, high velocity a helicopter rotor blade designs. Particles Numerical simulation technologies are used roll up as they 11ft off the vertice. This technique permits the dynamic identification and improvement of separated flow regions which might lead to stall and flow. The modeled condition is a degree angle of sensor pod installation to assess the affect of various pod geometries flow rate passing through each inlet. Engineers have used locations of harmonic and subharmonic acoustic noise. Researchers are using three-dimensional surface plots of calculated static pressure and skin friction for the transition section of a benchmark nozzle. Computational results are being used to to provide the required thrust vectoring highly maneuverable, supersonic aircraft. The modeled condition is engine exhaust ducts and nozzles depend engine exhaust ducts and nozzles on chemical reactions, but the small scale of streamwise vortex structures make detailed simulations provide a "microscope" for predicting aerodynamic and heat transfer characteristics. The figures show distributions, indicating that the boundary layer along the nozzle wall can grow faster than the nozzle expansion. This results in a Reynolds number nozzle used for space-based attitude control Two dimensional codes calculate mach number...
The prediction of future accomplishments made possible by the computer is a challenge. The pattern of exponential growth in computational capabilities is expected to continue for some time as a result of large scale electronics integration, storage capacity and computer architecture technologies.

Advancements in computer performance have been closely paralleled by improvements in numerical algorithms.

The results of this partnership have provided five orders of magnitude decrease in the cost of performing a computation in the last fifteen years.
Theory and experimentation are entwined in a reinforcing way. In some cases, the physical observation comes first, in others the situation is reversed.

The relative roles of theory and experiment have reached a new plateau with the introduction of the digital computer.

In the past, computers represented a new tool for the scientist and engineer. They are now indispensable.

Together, the computational and experimental disciplines will yield a more complete understanding of physical phenomena, leading to rapid advances in many areas of human endeavor.
WE GRATEFULLY ACKNOWLEDGE THE CONTRIBUTIONS OF:

AMES RESEARCH CENTER

BOEING CORPORATION

COLORADO STATE UNIVERSITY

DEPARTMENT OF DEFENSE

GENERAL DYNAMICS CORPORATION

GRUMMAN CORPORATION

LANGLEY RESEARCH CENTER

LEWIS RESEARCH CENTER

McDONNELL DOUGLAS CORPORATION
Numerical aerodynamic simulation often enters the domain of art. These particle flows provide the viewer with dashes of color as if from the brushstroke of an artist.

Shown are particle traces of a candidate configuration of the future national aerospace plane. Subsonic, supersonic and hypersonic flow fields about complex vehicles with wings, tails, fins, etc., can be accurately predicted and shown in a very physical manner.