National Aeronautics and Space Administration

1. Computational Fluid Dynamics (CFD)

Starting in the 1970s, NASA began developing sophisticated computer codes that could accurately predict the flow of fluids, such as the flow of air over an aircraft's wing or fuel through a space shuttle's main engine.

Those ideas and codes became CFD, which today is considered a vital tool for the study of fluid dynamics and the development of new aircraft. CFD greatly reduces the time and cost required for designing and testing nearly any type of aircraft.

2. Glass Cockpit

During the 1970s and 1980s, NASA created and tested the concept of an advanced cockpit configuration that replaced dial and gauge instruments with flat panel digital displays. The digital displays presented information more efficiently and provided the flight crew with a more integrated, easily understood picture of the vehicle situation.

Glass cockpits are in use on military, commercial and general aviation aircraft, and NASA's space shuttle fleet.

3. Digital Fly-By-Wire

During the 1960s and 1970s, NASA helped develop and flight test a digital "fly-by-wire" system to replace heavier, less reliable hydraulics systems and control linkages with a lighter system using a digital computer and electric wires.

The system sends signals from the pilot to the control surfaces of the aircraft, adding redundancy and improving control.

4. Intelligent Flight Control Systems (IFCS)

From the 1970s through the 1990s, NASA and the U.S. Air Force conducted joint research on whether a flight control system built on an artificial neural network could help pilots recover from loss of control situations.

Flight tests proved that the system—IFCS, which backs up the digital fly-by-wire system—could automatically and instantly reconfigure an aircraft to help pilots retain control. (IFCS is currently used on the F-18 E/F Super Hornet.)

5. Area Rule

In the 1950s, NASA scientist Richard Whitcomb discovered several fundamental solutions to key aerodynamics challenges. One of the most revolutionary was the "area rule," a concept that helped aircraft designers avoid the disruption in air flow and resulting drag caused by the attachment of the wings to the fuselage.

By using the area rule, aircraft designers for decades have been able to make aircraft fly more efficiently at high speeds.

6. Lightning Protection Standards

During the 1970s and 1980s, NASA conducted extensive research and flight tests to identify the conditions that cause lightning strikes and the effects of in-flight strikes on aircraft. NASA's knowledge base was used to improve lightning protection standards for aircraft electrical and avionics systems.

7. NASA Structural Analysis (NASTRAN)

In the 1960s, NASA partnered with industry to develop a common generic software program that engineers could use to model and analyze different aerospace structures, including any kind of spacecraft or aircraft. Today, NASTRAN is an "industry-standard" tool for computer-aided engineering of all types of structures.

8. Composite Structures

NASA first partnered with industry during the 1970s to conduct research on how to develop high-strength, nonmetallic materials that could replace heavier metals on aircraft. Gradually used to replace metals on parts of aircraft tails, wings, engines, cowlings and parts of the fuselage, composites reduce overall aircraft weight and improve operational efficiency.

9. Thrust Vectoring

From the 1970s through the 1990s, NASA played a vital role in developing rotatable engine nozzles that could deflect an engine's thrust and maneuver the aircraft in directions other than parallel to its centerline.

Thrust vectoring provides unprecedented maneuvering and control for extreme angles of attack in air-to-air combat. (It is currently used on the F-22 Raptor.)

10. TURBO-AE Code

During the 1990s, NASA developed a computer code that generates two-dimensional simulations of potential aeroelastic (AE) problems that can occur in jet engine blades. Such problems include flutter or fatigue that can eventually cause engine fan blades to stall or fail.

With TURBO-AE, engineers can more efficiently design thinner, lighter, faster rotating blades for today's jet engines built for higher performance.

11. Supercritical Airfoil

During the 1960s and 1970s, NASA scientist Richard Whitcomb led a team of researchers to develop and test a series of unique geometric shapes of airfoils or wing sections that could be applied to subsonic transports to improve lift and reduce drag.

The resulting "supercritical airfoil" shape, when integrated with the aircraft wing, significantly improves the aircraft's cruise efficiency.

12. Short Takeoff and Landing (STOL)

From the 1950s through the 1990s, NASA conducted research that resulted in an innovative wing/engine concept that significantly increased lift for aircraft taking off or landing on short runway spaces, such as the military's C-17 transport plane.

The system directs engine thrust to a set of external flaps to provide the extra lift. This externally-blown flap system also allows aircraft with heavy cargo loads to make slow, steep approaches and touch down precisely on limited runway surfaces.

13. Vertical/Short Takeoff and Landing (V/STOL)

From the 1950s through the 1990s, NASA led development of an engine system that could transition a vehicle from helicopter-like vertical flight for takeoffs and landings to conventional forward flight.

NASA's role in developing a nozzle design that could deflect thrust from the engines to change directions, called "thrust vectoring," helped gain acceptance for the concept used on the AV-8 Harrier jet that flies in both U.S. and British military services.

14. Variable-Sweep Wing

During the 1960s and 1970s, NASA researchers contributed to the development of a wing that can be moved on pivots to change its degree of sweep. The adjustable wing proved to be exceptionally aerodynamic both at low speeds (the non-swept position) and at high speeds (the fully swept-back position).

Testing in NASA wind tunnels produced the key breakthrough in where to locate the wing pivot that allowed the varied sweep positions.

15. Winglets

During the 1970s and 1980s, NASA studies led to the development of vertical extensions that can be attached to wing tips in order to reduce aerodynamic drag without having to increase wing span.

Winglets help increase an aircraft's range and decrease fuel consumption, and are in use on the C-17 military transport aircraft.

16. Wind Tunnels

As early as the 1930s, wind tunnels built and operated by NASA's predecessor, the National Advisory Committee on Aeronautics, or NACA, played a critical role in the design and improvement of all military aircraft.

Through the decades, NASA's expanded suite of tunnels continued to host valuable foundational testing in all speed regimes for areas such as vortex lift, maneuvering flaps performance, stall characteristics and avoidance, aerodynamics for low-level and high angle of attack maneuvers, flutter prediction and avoidance, spin characteristics and recovery, cruise performance and in-flight icing.

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