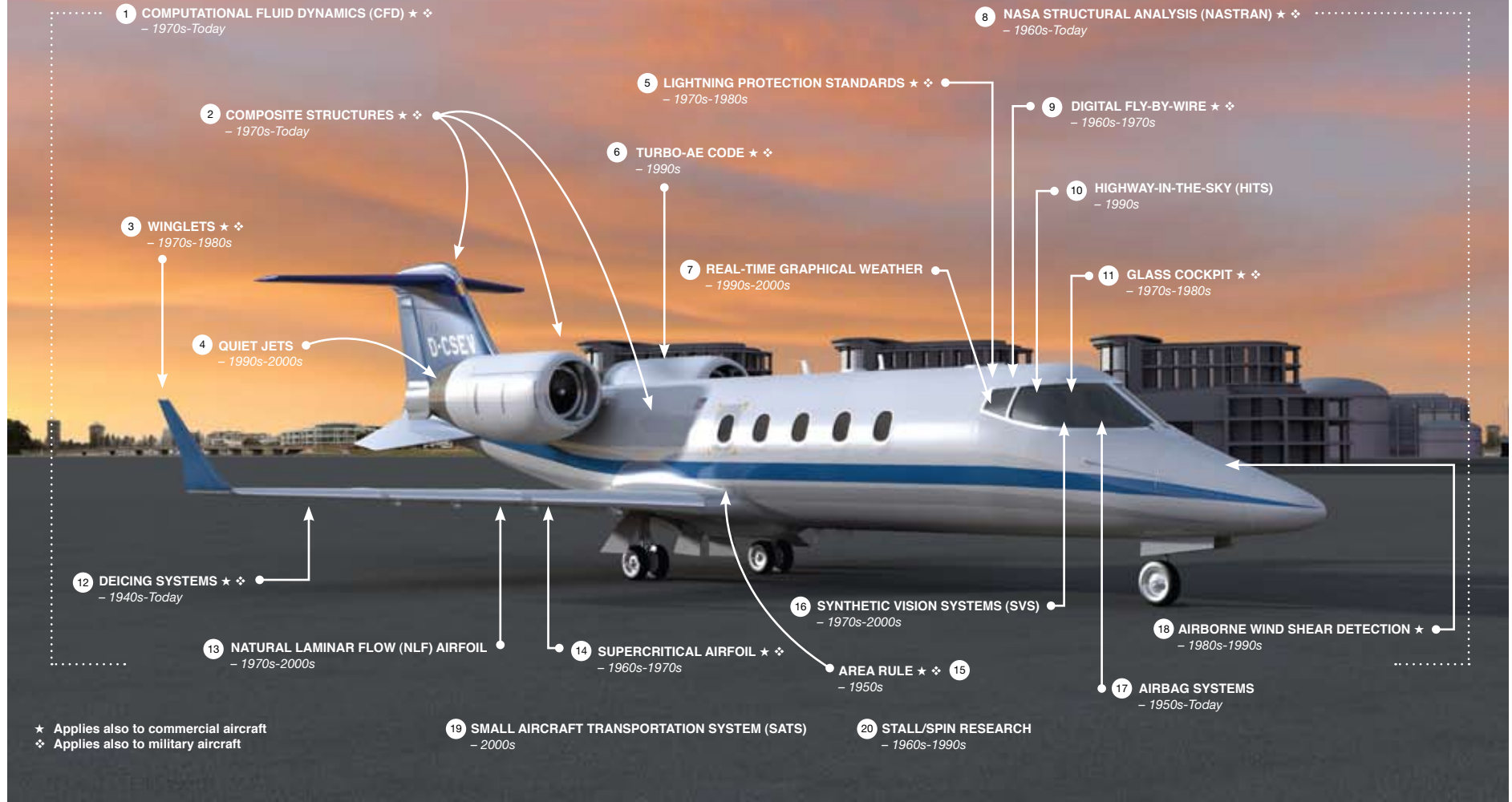


# NASA AERONAUTICS RESEARCH ONBOARD DECADES OF CONTRIBUTIONS TO GENERAL AVIATION



## 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. 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.

## 3. 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.

## 4. Quiet Jets

During the 1990s and 2000s, tests were conducted in NASA flight research facilities to validate technologies to dramatically reduce the level of noise generated by turbofan engines typically used on small business jets.

The research enabled the development of engines with much lower decibel levels, which have now been adapted for use on the Eclipse 500, the first Very Light Jet (VLJ) to go into production.

## 5. 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.

## 6. 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, lower emissions and lower noise.

## 7. Real-Time Graphical Weather

During the 1990s and 2000s, NASA research drove the development of cockpit displays that provide real-time ground or in-flight weather information to the flight crew. Since not all small aircraft can fly "above the weather," the data is of particular help to pilots in avoiding weather-related accidents.

## 8. 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.

## 9. Digital Fly-By-Wire

During the 1960s and 1970s, NASA helped develop and flight test a digital "fly-by-wire" (DFBW) 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. DFBW is used today on the Gulfstream G350/G450.

## 10. Highway-in-the-Sky (HITS)

During the 1990s, a NASA research program contributed to the development of advanced electronic displays that deliver point-to-point, on-demand communication, navigation and weather data to pilots. The system was commonly referred to as a "highway-in-the-sky."

Technology derived from HITS also provides pilots with graphically-represented guidance all along the aircraft's route, including airport departure, approach and arrival.

## 11. 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 general aviation, commercial and military aircraft, and on NASA's space shuttle fleet.

## 12. Deicing Systems

As early as the 1940s through NASA's predecessor, the National Advisory Committee on Aeronautics, or NACA, research on the causes and prevention of icing on the ground or in the air has been a focus.

Using icing research tunnels, wind tunnels and flight tests, NASA research has contributed to the development of icing protection systems and operational methods for icing conditions.

## 13. Natural Laminar Flow (NLF) Airfoil

From the 1970s to the 2000s, NASA researchers have worked to develop airfoil (wing) designs that allow smooth air flow for maximum lift and minimum drag at low and medium cruise speeds. The application of NLF techniques has helped reduce fuel consumption and landing speeds, and increase aircraft speed and range.

## 14. 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.

## 15. 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.

## 16. Synthetic Vision Systems (SVS)

From the 1970s to the 2000s, NASA researchers developed and flight-tested a class of computer database-derived systems that include head-up displays and other new pictorial format avionics that can aid pilots in low visibility conditions. The most recent design concepts for SVS can create three-dimensional pictures of the world outside the aircraft, day or night, using GPS, terrain models, sensors and a runway incursion warning system.

## 17. Airbag Systems

In the 1950s, NASA explored a variety of crew protection systems including airbags. Later adapted to protect robotic spacecraft during landings, they have now been further tested by NASA and adapted for use as an airbag system on passenger aircraft (as seen on the ATi RT-700, a twin-engine business aircraft).

## 18. Airborne Wind Shear Detection

During the 1980s and 1990s, NASA led a comprehensive research program to identify the characteristics of dangerous wind shear, and validated technologies that can predict its severity while in flight. Today, aircraft are equipped with forward-looking sensors that alert pilots to wind shear hazards.

## 19. Small Aircraft Transportation System (SATS)

During the first few years of the 21st century, NASA and the FAA partnered on a project targeting technologies that could increase small aircraft travel between small airports. There are many more small airports in the United States than traditional airports, but they can be under-utilized due to lack of control towers or radar.

Ultimately, the SATS project enabled the application of beneficial technologies to help overcome that challenge, including Synthetic Vision Systems and Highway-in-the-Sky.

## 20. Stall/Spin Research

From the 1960s through the 1990s, NASA wind tunnels, flight tests, and a special facility constructed to study aircraft stall and spin characteristics were used to identify the causes of small aircraft stalls and spins and ways to recover from them.

NASA research led to solutions for general aviation aircraft including spin resistant wings and leading-edge devices for unswept wings.