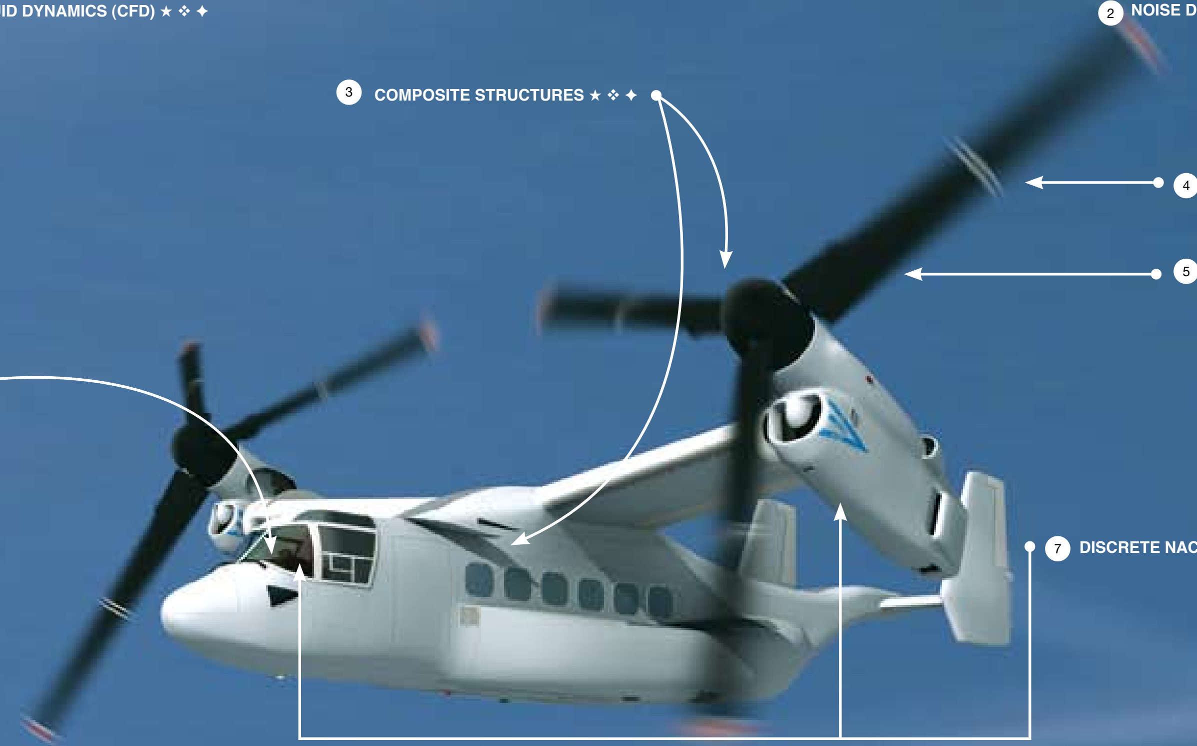
National Aeronautics and Space Administration

NASA AERONAUTICS RESEARCH ONBOARD

DECADES OF CONTRIBUTIONS TO TILT ROTOR AVIATION

1950s—1990s



★ Applies also to commercial aircraft
✣ Applies also to military aircraft
✦ Applies also to general aviation aircraft

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, fuel through a space shuttle's main engine, or the complex interactions between a rotorcraft's main rotor blades, fuselage and its tail rotor.

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.

NASA-developed computer software products are critical for modeling the tilt rotor in both hover and airplane modes.

2. Noise Database

Rotor blades generate noise and vibration inside and outside all rotary wing aircraft including the tilt rotor. NASA research validated that noise levels could be reduced with the aid of advanced rotor designs and new flight path approaches.

3. 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, these materials have replaced metals in helicopter fuselages and rotor blades, and have become critical for reducing the weight of vertical-flight vehicles.

4. Aeroelastic Stability

During the decades of research conducted by NASA on the development of tilt rotor aircraft, a key area of study was discovering ways to prevent the unstable flexing of the tilt rotor, its wing and pylon. As a result, NASA developed a system of unique actuators that dampen motion and lessen instability in the proprotor.

5. Proprotors

NASA research enabled development of a combination, highly-twisted propeller/rotor that provides the thrust needed for vertical lift as well as forward flight. The blades of this propeller/rotor were eventually constructed from stronger, lighter and quieter composite materials.

6. Flight Control System

The ability to operate a vehicle in both vertical and horizontal modes of flight required a revolutionary flight control system. NASA research enabled the development of a system that blends and phases flight controls for both helicopter and fixed-wing airplane modes of flight. The system includes a tilt rotor pilot station with controls for pitch, roll, yaw and thrust in all modes (helicopter, tilt and airplane).

7. Discrete Nacelle Position Control System

NASA research enabled development of a system that would automatically advance a tilt rotor's nacelles to new positions at modest rates so that the pilot could focus on primary flight control. The discrete nacelle position control system, used today on the Bell/Agusta 609, makes operation of tilt rotor aircraft more predictable during instrumented flight and approach to landing.

8. Data Acquisition System

During the tilt rotor research program, NASA developed a digital data acquisition system that could capture multiple streams of wind tunnel and flight test data. The system was able to withstand the oscillation forces generated by test apparatus while still accurately capturing and transmitting pressure, temperature, load, torque and position data.

9. Wind Tunnel Tests

NASA wind tunnels were, and continue to be, used to test tilt rotor models and research aircraft for: aerodynamic performance; structural load capacity; mechanical, electrical or hydraulic systems performance; aeroelastic stability; and noise reduction.

10. Tilt Rotor Proof of Concept

Flight tests using the XV-15 tilt rotor research aircraft and simulations conducted by NASA, the U.S. Army and Bell Helicopter were vital to proving the feasibility and practicality of the tilt rotor concept. Decades of research from the tilt rotor program led to production of the world's first operational tilt rotor, the V-22 Osprey for the U.S. military, and the first civil application, the Bell/Agusta 609.

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