Modeling Tool Advances Rotorcraft Design

Originating Technology/NASA Contribution

Often times, when people think of NASA, they think of space travel. The first "A" in NASA, however, is for "Aeronautics," and the Agency has always held as one of its tenets to explore, define, and solve issues in aircraft design. Just as often as NASA is associated with space travel, when people hear aeronautics, they often think of airplanes, but part of NASA's aeronautics program is one of the most advanced rotorcraft design and test programs in the world.

Located at Ames Research Center, the Aeromechanics Branch of the Flight Vehicle Research and Technology Division conducts theoretical and experimental research in support of the U.S. helicopter industry and the U.S. Department of Defense. At this research site, engineers study all aspects of the rotorcraft that directly influence the vehicle's performance, structural and dynamic responses, external acoustics, vibration, and aeroelastic stability.

They use modern wind tunnels and advanced computational methodologies to calculate fluid dynamics and perform multidisciplinary, comprehensive analyses in the quest to further understand the complete rotorcraft's operating environment and to develop analytical models to predict aerodynamic, aeroacoustic, and dynamic behavior. The experimental research also seeks to obtain accurate data to validate these analyses, investigate phenomena currently beyond predictive capability, and achieve rapid solutions to flight vehicle problems.

Partnership

Founded in 1979, Continuum Dynamics Inc. (CDI), of Ewing, New Jersey, specializes in advanced engineering services, including fluid dynamic modeling and analysis for aeronautics research. Its clients include government agencies, as well as the aerospace, nuclear, and pharmaceutical industries, and it has been partnering with NASA since its inception.

The company has converted years of NASA-funded research efforts into a variety of commercial products. For example, 1987 and 1992 NASA **Small Business Innovation Research (SBIR)** grants on helicopter wake modeling resulted in software code used in a blade redesign program for Carson Helicopters, of Perkasie, Pennsylvania, that simultaneously increased the payload of its Sikorsky S-61 helicopter by 2,000 pounds and increased cruise speeds at 10,000 feet by 15 knots.

Follow-on development of this same rotorcraft model, based on 1999 and 2002 NASA SBIR work, resulted in a $24 million revenue increase for Sikorsky Aircraft Corporation, of Stratford, Connecticut, as part of the company's rotor design efforts.

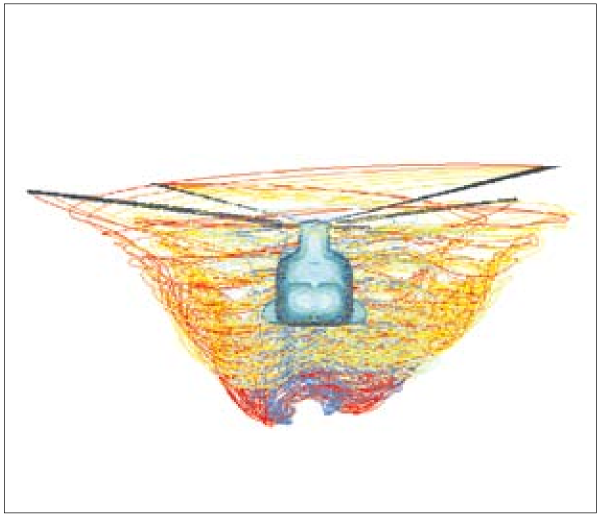
Altogether, the company has completed a number of SBIR projects with NASA, including early rotorcraft work done through Langley Research Center, but more recently, out of Ames.

This rotorcraft model software code, marketed by CDI as the Comprehensive Hierarchical Aeromechanics Rotorcraft Model (CHARM), is a tool for studying helicopter and tiltrotor unsteady free wake modeling, including distributed and integrated loads, and performance prediction.

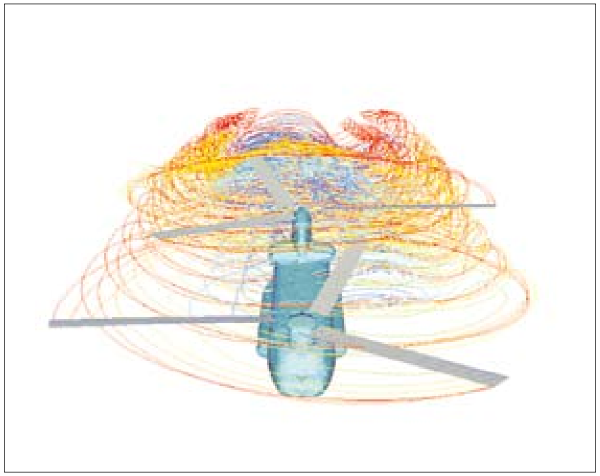
Product Outcome

Under continuous development at CDI for more than 25 years, CHARM analyzes the complete aerodynamics and dynamics of rotorcraft in general flight conditions. CHARM has been used to model a broad spectrum of rotorcraft attributes, including performance, blade loading, blade-vortex interaction noise, air flow fields, and hub loads. The highly accurate software is currently in use by all major rotorcraft manufacturers, NASA, the U.S. Army, and the U.S. Navy.

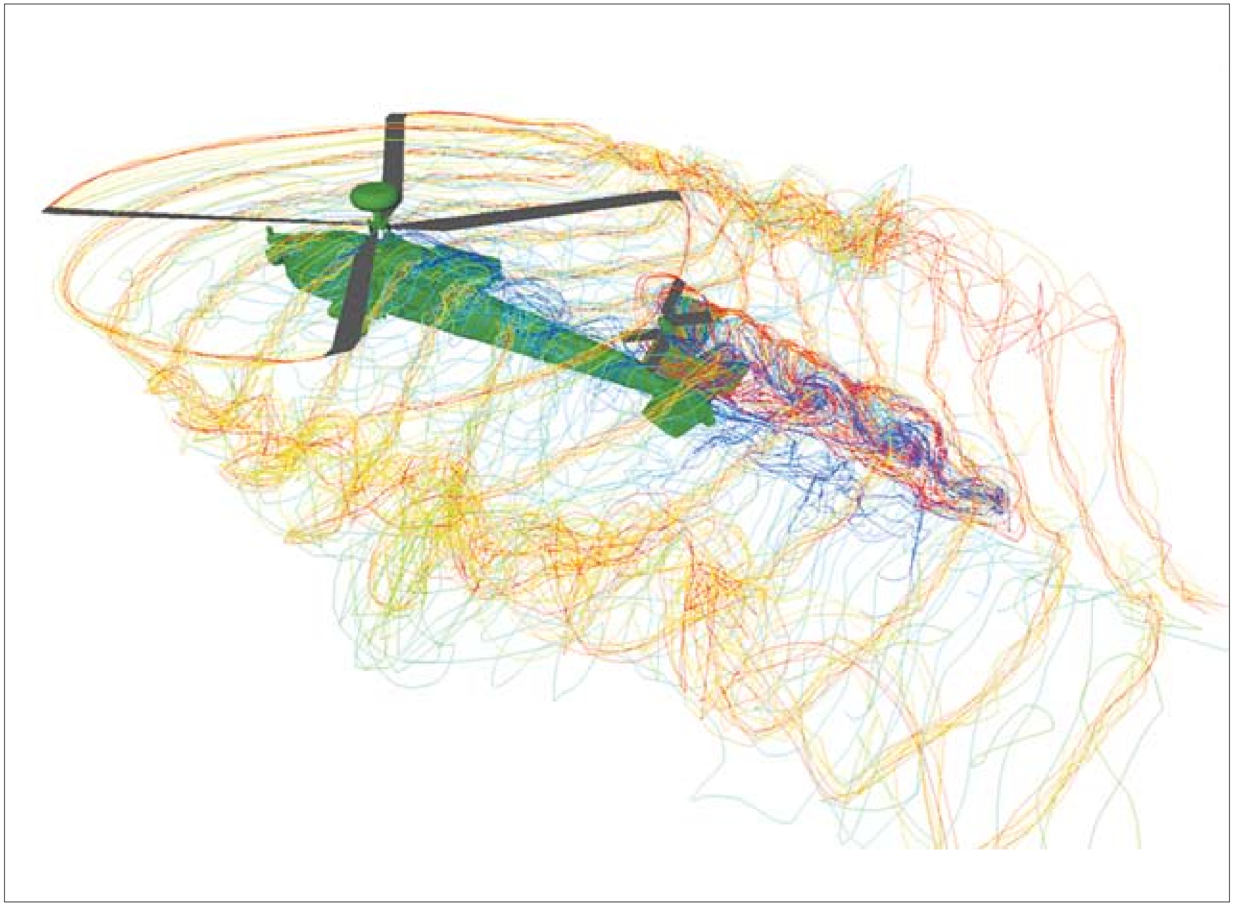
Available as a stand-alone product or adaptable to existing simulator and analysis systems, this software code is well suited for performing analysis on advanced aerodynamic design as well as for research on new designs.



CHARM is a computer software product that models the complete aerodynamics and dynamics of rotorcraft in general flight conditions.



CHARM represents the culmination of over 25 years of continuous development of rotorcraft modeling technologies at Continuum Dynamics Inc., and incorporates landmark technical achievements from a variety of NASA, U.S. Department of Defense, and company-sponsored initiatives.



CHARM is available for licensing as a stand-alone analysis program or as a module that couples directly into existing flight simulation or analysis software.

The software includes extensive 3-D graphics capabilities that allow highly detailed visualization of the rotor/wake motion and wake/surface interaction. Easy to use and reliable, CHARM plugs directly into alternate rotorcraft analysis or flight simulation software.

CHARM incorporates one of the most advanced wake models currently available, combining a full-span, freely distorting, constant vorticity contour wake model and an analytical tip vortex roll-up model to provide accurate wake simulation. Without the software, designers would have to guess the proper empirical constants in order to approximate wake characteristics.

According to CDI, the new fast vortex and fast panel technologies implemented within CHARM provide a great advancement in computational performance when compared to existing panel codes currently available. This increased performance allows the designer to explore high-risk technologies, expand design parameter ranges, and evaluate critical components at a level of detail never before possible.

According to CDI, CHARM features the most advanced free vortex wake model currently available that directly computes wake roll-up and vortex core properties from first principles. In addition, no empirical constants are required, which is a distinct advantage for design work and modeling transient maneuvering flight for which wake characteristics are continually changing. The software code has also been coupled with acoustic prediction software to provide fast prediction of rotor loading and thickness noise.

CHARM's lifting surface blade aerodynamics model is well suited for analysis of complex tip shapes and other 3-D effects, and its coupled wake/panel calculation is unique—incorporating state-of-the-art fast vortex and fast panel methods to allow fully coupled rotor/wake/airframe solutions.

Most recently, the software has been incorporated into a joint CDI-Army study for incorporation into flight simulation software to practice landing rotorcraft in sandy or dusty conditions. Known as brownout, the effect of sand, dust, and debris kicked up by a helicopter during takeoff and landing can temporarily blind a pilot, as well as damage moving parts. The simulator is designed to identify, characterize, and evaluate brownout conditions for general aircraft, wind, ground topology, and flight maneuvers. The study seeks to improve pilot training for these dangerous conditions, help in mission planning, decrease damage to rotorcraft components, and improve sensor technologies most affected by these conditions. ❖