ATA ENGINEERING, INC.

www.ata-e.com
sales@ata-e.com | 858.480.2000

Rotorcraft Capabilities

OVERVIEW

ATA Engineering (ATA) provides innovative test- and analysis-driven design solutions across many engineering disciplines, including aerodynamics, structural mechanics and dynamics, kinematics, acoustics, thermodynamics, fluid dynamics, controls, mechatronics, and multidisciplinary analysis and optimization. A wide range of advanced rotorcraft analysis tools and know-how has been developed through a combination of customer projects, Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) awards, and internal research and development, positioning ATA at the forefront of rotorcraft technology.

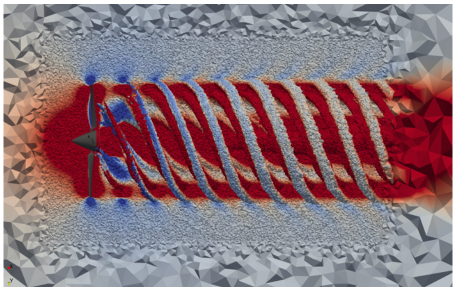
AEROMECHANICS

Aeromechanics Modeling

ATA has extensive experience in aeromechanics modeling. Our specific capabilities include:

- Developing rotor comprehensive models in support of design and analysis.
- Obtaining high-fidelity aeromechanics solutions that utilize computational fluid dynamics (CFD)-derived loads.
- Applying CFD solutions within comprehensive analyses in both loosely and tightly coupled manners.
- Deploying comprehensive analysis tools to assess metrics such as rotor stability, performance, vibrations, loads, fatigue, and acoustics, as well as to act as virtual test beds for performance enhancements and risk mitigation techniques.

Lead–Lag and Whirl-Flutter Stability Analysis

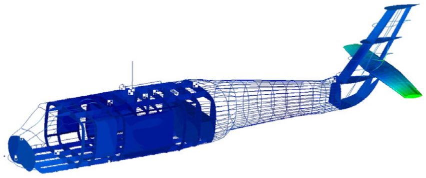


CFD solution to windmilling propeller using blade-resolved meshes for whirl-flutter analysis

ATA has developed a novel method for obtaining stability data from prescribed time-domain CFD simulations that differs significantly from current state-of-the-art approaches. Benefits of the new prescribed motion stability analysis include the following:

- For rotary-wing simulations, the method is compatible with existing loose-coupling architectures and can be implemented without necessitating modifications to the CFD solver or the comprehensive tool.
- The method significantly reduces computational expenses by eliminating the need for domain-based sub-iterations.
- Rather than providing only frequency and damping estimates, the method also provides finely detailed surface stability data that reveals the spatial distribution of damping, and it can be readily extended to exploit adjoint methods.

Empennage Buffet Loads Prediction



UH-60A fuselage structural response to empennage buffeting

In rotorcraft, empennage buffeting is caused by the interactional aerodynamics between the main rotor(s) and the empennage, generating a vibration load that can become significant, limiting rotorcraft performance and sometimes necessitating costly redesigns. To avoid these negative responses, ATA has developed a first-principles approach for predicting vibratory loads from empennage buffeting that utilizes a two-way coupled aeroelastic approach in which a CFD solver is coupled to a structural solver.

Systematic Fatigue Test Spectrum Editing Through Wavelet Transformations

ATA has developed and validated a wavelet-based signal-editing methodology capable of generating optimally compressed fatigue test signals containing both high- and low-frequency and high- and low-amplitude content. This demonstrated method aims to achieve equivalent fatigue damage over the shortest allowable duration governed by physical constraints, greatly reducing the time and cost of component and airframe fatigue testing while improving overall test reliability of new rotorcraft configurations, ultimately accelerating their development and fielding.

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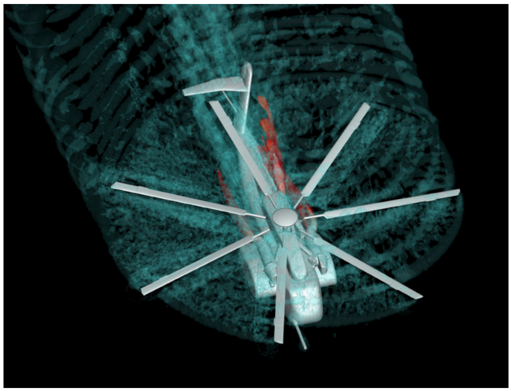
Rotorcraft Capabilities (continued)

COMPUTATIONAL FLUID DYNAMICS AND FLUID–STRUCTURE INTERACTION



CFD solution of an MH-53E helicopter depicting iso-surfaces of q-criterion in transparent blue and engine exhaust temperatures in yellow/red

ATA is well versed in performing CFD- and fluid–structure interaction (FSI)-based aeromechanics simulations with comprehensive analysis including blade aerodynamic load definitions, blade structural loading, rotor and hub loads, acoustics, and performance metrics. The following projects represent our team's key capabilities in this discipline:

- Plume Analysis for Planetary Rotorcraft – CFD analysis of a novel Entry, Descent, and Landing (EDL) architecture for Mars exploration was conducted by simulating plumes generated by a delivery jetpack designed to slow down a future Martian rotorcraft. Simulations included jet plumes and virtual disk rotors, with and without wind-tunnel-generated crosswinds, to investigate the interactions between the rotors and jets, validate the flow field against measurements, and verify the potential for controllability of the rotorcraft in jet-entrained flow.
- CFD Analysis of eVTOL Steep Descent – A study of fixed pitch rotors was performed using two different methods (blade-resolved DDES and actuator line modeled LES) on a range of eVTOL descent conditions, including the vortex ring state, and simulation results between the two approaches were compared.
- Tail Sitter Transition – Rotor/wing aerodynamic loads and static stability were determined for a commercial eVTOL aircraft to ensure a successful vertical-to-horizontal cruise transition.
- Computational Investigations of Side-by-Side Rotors in Ground Effect – An analysis of the interactional aerodynamics of hovering side-by-side rotors was conducted to determine the effect of rotor position (e.g., rotors-to-ground height, rotor-to-rotor distance) on a range of performance parameters, including vibratory loads, thrust, and side-to-side drift.

COMPOSITES ANALYSIS

ATA has extensive experience in the design and analysis of complex composite structures. Key analysis programs have included structural analysis of a composite cargo pallet for a fluid tank carried on a helicopter, CFD and structural analysis of a helicopter-borne launch canister for air-to-ground precision weapons, and aeroelastic stability analysis of a rotorcraft bomb bay door.

ACOUSTICS

ATA is a recognized expert in the development and interpretation of vibroacoustic environments, with extensive experience in transferring best practices for acoustic modeling and testing to our customers. Notable projects include:

- Continuous Scan Acoustic Array – This ATA patented technology is an array of microphones mounted on a 1-meter diameter disk, which rotates on its central axis. Benefits of this technology include:
  - Nearly infinite spatial resolution using a relatively small number of microphones.
  - Complex source characterization (such as noise from rotors) measured in a way that can be represented in analysis (e.g., measure rotorcraft noise in a lab to predict comparable noise in a canyon).
- Helicopter Cabin Internal Noise Prediction and Mitigation – ATA supported noise prediction for the interior cabin of the presidential helicopter. This work was completed through Statistical Energy Analysis (SEA).

RESEARCH AND DEVELOPMENT: HERMES

ATA has worked to develop a tool called Hermes, a Python-based coupling framework designed to radically modernize comprehensive analysis, with the immediate purpose of supporting aeromechanics. Hermes provides a decentralized framework that aggregates multiple independently developed solvers into a unified platform that is realized during model development, execution, and postprocessing. The framework is open-source and highly extensible and allows anyone to contribute a solver module that can selectively modify a solution sequence via an open-source Python coupling interface.