

A History of Rotorcraft Comprehensive Analyses

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Abstract

The history of the development of rotorcraft comprehensive analyses will be presented. The development of the major codes of the last five decades from industry, government, and universities will be described.

The digital computer programs that calculate the aeromechanical behavior of rotorcraft are called comprehensive analyses. Comprehensive analyses should bring together the most advanced models of the geometry, structure, dynamics, and aerodynamics available in rotary wing technology, subject to the requirements for accuracy and the constraints of economy. These computer programs calculate rotorcraft performance and trim, blade motion and airloading, structural loads, vibration, noise, aeroelastic stability, and flight dynamics. The multidisciplinary nature of rotorcraft problems means that similar models are required for all of these jobs. A comprehensive analysis performs these calculations with a consistent, balanced, yet high level of technology. Because the tasks require a similar level of technology and similar models, they are best performed with a single tool. The history of development of computer programs for rotorcraft started with the alternative approach of developing multiple codes separately for individual disciplines, such as performance, dynamics, and handling qualities. Often the range of application of a particular analysis was restricted, perhaps to improve efficiency, but more often for historical reasons. Such experience with early codes provided solid evidence of the resulting inefficient use of development and application resources, and inevitable disparity of treatment of the various problems.

There are several implications of the word “comprehensive” in rotorcraft aeromechanics, all encompassed by the ideal analysis. Comprehensive refers to the need for a single tool to perform all computations, for all operating conditions and all rotorcraft configurations, at all stages of the design process. The technology is comprehensive, covering all disciplines with a high technology level. The models are comprehensive, covering a wide range of problems, a wide range of rotorcraft configurations and rotor types, and dealing with the entire aircraft. The analysis is readily adapted to new configurations and new designs. The software is comprehensive, with the flexibility to adapt or extend the codes to new problems and new models. The software is reliable and accurate, yet efficient and economical, characteristics achieved through correlation and verification. The software is built with good programming practices and extensive documentation, ensuring ease of test and maintenance. Helicopter

problems are inherently complex and multidisciplinary, so helicopter analyses are always driven toward consideration of these “comprehensive” issues.

Design and development of rotorcraft requires the capability to calculate rotor performance and maneuver loads. To provide such calculations, a comprehensive analysis has a rotor wake model, accounts for drag and stall and compressibility of the rotor aerodynamics, includes nonlinear dynamics and elasticity of the rotor blades and airframe, and models the entire aircraft. The entire aircraft in flight is analyzed, although often the code treats just the rotor. Calculating vibration, aeroelastic stability, and flight dynamics within the comprehensive analysis is best, but may be accomplished with separate codes. The aeromechanics of a rotor alone in a steady operating condition are certainly complicated, but the capability to analyze multiple rotors and maneuvers is very important.

Comprehensive analyses have their origins in the programs developed as soon as digital computers first became available to engineers in the 1960s. Figure 1 identifies some major comprehensive analyses, with the developer and approximately the time the code was introduced.

The paper will describe the development of these codes. A number of common themes observed in this history will be discussed.

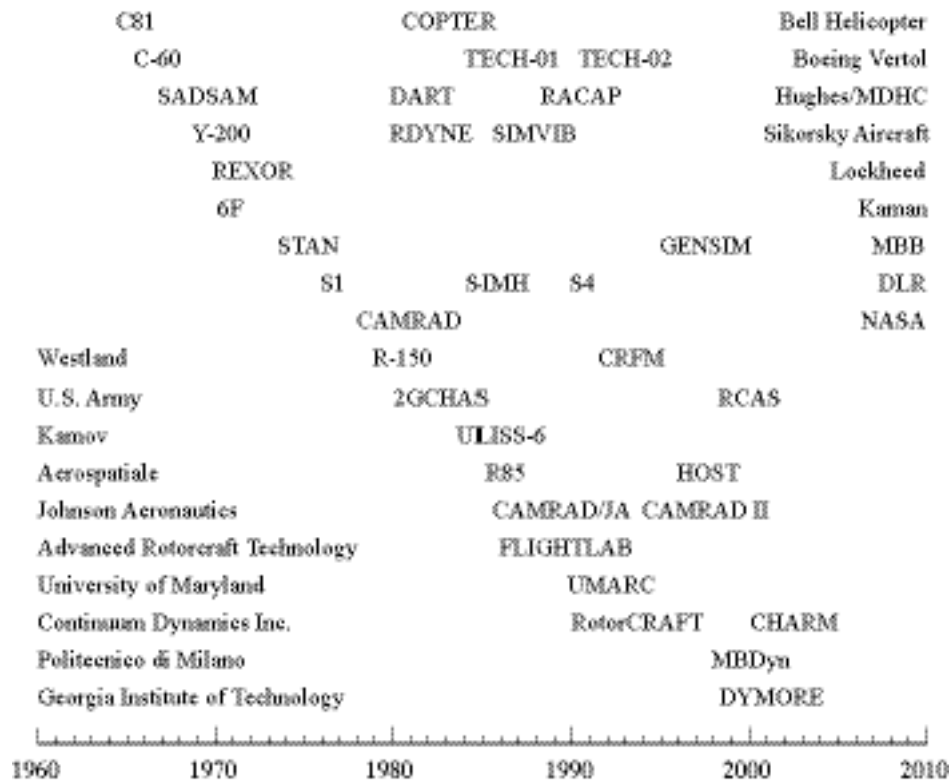


Figure 1. Comprehensive analyses.