Preface

This volume contains the 2005 annual progress reports of the research staff of the Center for Turbulence Research. Over the past several years, CTR's research agenda has been intimately connected with the Department of Energy's ASC program at Stanford which has provided sustained support for the development of large, scalable numerical prediction technology for complex flow systems. The ASC Program has also provided generous access to its advanced supercomputers: In December, CTR researchers conducted a monumental calculation of homogeneous turbulence with rotation and mean shear deformation using 65000 processors of the Blue Gene computer at Livermore, which was dedicated for an entire week to this fundamental study of the mechanics of the formation of planets! This unprecedented computational power is leading to a new paradigm in computational science and the ability to simulate highly complex engineering systems.

There are thirty two individual contributions in this volume. The general theme for virtually all of the reports is prediction of complex effects in turbulent flows which includes chemical reactions, multi-phase flows, complex geometry, electromagnetic forces, compressibility effects and acoustics. Particular attention was paid to computational engineering and the development of numerical technology and programming environment for integration of codes that simulate different physics using different numerical methodologies. This technology is critical for simulation of complex systems, as are rigorous methods for validation and verification of numerical results. Validation of numerical results by comparison to experiments has always been an integral part of CTR's numerical studies. With the development of large complex codes at CTR, we have embarked on a new research initiative in error estimation and uncertainty quantification. The objective is to have uncertainty bars on numerical output that reflect uncertainties in computational parameters such as in turbulence models, boundary conditions, geometry definition and numerical errors.

This year the NASA Office of Aeronautics has advanced a new vision and renewed interest in fundamental research in aeronautics. The specific areas of interest include hypersonic, supersonic and subsonic fixed wing and rotorcraft technology. Clearly, transition, turbulence and computational predictability are important pacing items for advances in these areas. These positive developments in NASA will undoubtedly lead to enhancement and strengthening of research in fluid mechanics and turbulence. We expect CTR, which has maintained a critical mass in these areas, to be a major contributor in support of the new vision for aeronautics research.

Special thanks are due to Dr. Xiaohua Wu and his assistant Ms. Anne Sage for the skillful editing, compilation and timely processing of this report. The CTR roster for 2005 is provided in the Appendix. This report is available on CTR's site on the world wide web (http://www.stanford.edu/group/ctr/).

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