Introduction: Prediction of F-16XL Flight Flow Physics

by

John E. Lamar✦
NASA Langley Research Center (Retired), Hampton, VA 23681-2199 USA

This special section is the result of fruitful endeavors by an international group of researchers in industry, government laboratories and university-led efforts to improve the technology readiness level of their CFD solvers through comparisons with flight data collected on the F-16XL-1 aircraft at a variety of test conditions. These 1996 flight data were documented[1] and detailed the flight-flow physics of this aircraft through surface tufts and pressures, boundary-layer rakes and skin-friction measurements. The flight project was called the 'Cranked Wing Aerodynamics Project' (CAWAP), due to its leading-edge sweep crank (70° inboard, 50° outboard), and served as a basis for the 'I'nternational comparisons to be made, called CAWAPI. This highly focused effort was one of two vortical flow studies facilitated by the NATO Research and Technology Organization through its Applied Vehicle Panel with a title of "Understanding and Modeling Vortical Flows to Improve the Technology Readiness Level for Military Aircraft". It was given a task group number of AVT-113 and had an official start date of Spring 2003. The companion part of this task group dealt with fundamentals of vortical flow from both an experimental and numerical perspective on an analytically describable 65° delta-wing model — for which much surface pressure data had already been measured at NASA Langley Research Center at a variety of Mach and Reynolds numbers — and is called the 'Vortex Flow Experiment - 2' (VFE-2). These two parts or facets

✦ CAWAP Principal Investigator, Co-Chairman of AVT-113, Associate Fellow AIAA

helped one another in understanding the predictions and data that had been or were being collected.

The CAWAPI facet had the distinction of using actual aircraft geometry, which is restricted by 'International Traffic in Arms Regulations', and required much cooperation between NASA Langley, NASA Headquarters and the leadership of the various NATO or Partners-for-Peace participating organizations in establishing how the geometry and grids could be shared. This and other background information are contained in the first article[2] that follows. The second article[3] discusses how the supplied geometry was processed into acceptable computational grids for both the structured and unstructured solver communities, articles three-to-five[4-6] detail the comparisons of three classes of grid solutions with flight data, and article six[7] provides what has been learned from CAWAPI.

The author is extremely proud of the many outstanding researchers and organizations that have had a part in the CAWAPI facet. These RTO task groups do not come with funded support, so each participating organization had to anticipate that the benefit accrued would be greater than the expense encountered. The participating researchers accommodated the work, often on their own time, under the benevolent eye of their employers who saw this work to be of importance and provided an opportunity for their staff to make a novel contribution, as well as to test their own solvers. We have also benefited from significant graduate student involvement; in particular, CAWAPI has lasted long enough for some to complete their advanced degrees and to be co-authors of two of the following articles.

The author also wishes to thank the AIAA for providing a means of rapid dissemination of results obtained during CAWAPI through two special sessions at the

45th AIAA Aerospace Sciences Meeting and Exhibit (January, 2007), and now through the Journal of Aircraft. In particular, Prof. Frank Coton (University of Glasgow) and the Applied Aerodynamics Technical Committee are thanked for advocating and facilitating these special sessions at the general meeting in which results from nine organizations were reported in thirteen papers. The themes of these papers are carried over as articles in this special section, either individually or in combination. The Journal of Aircraft editors, editorial staff, and reviewers are also thanked for the many helpful suggestions made during the publication process.

[1]Lamar, John E.; Obara, Clifford J.; Fisher, Bruce D.; and Fisher, David F.: *Flight, Wind-Tunnel, and a Computational Fluid Dynamics Comparison for Cranked Arrow Wing (F-16XL-1) at Subsonic and Transonic Speeds*. NASA/TP-2001-210629, February 2001.

[2]Obara, C.J.; and Lamar, J.E.: *Overview of the Cranked-Arrow Wing Aerodynamics Project International*. AIAA Journal of Aircraft, __________.

[3]Boelens, O.J.; Badcock, K.J.; Goertz, S.; Morton, S.A.; Fritz, W.; Karman, S.L., Jr; Michal, T.; and Lamar, J.E.: *Description of the F-16XL Geometry and Computational Grids Used in CAWAPI.* AIAA Journal of Aircraft, __________ .

[4]Boelens, O.J.; Badcock, K.J.; Elmilgui, A.; Abdol-Hamid, K.S.; and Massey, S.J.: *Comparison of Measured and Block Structured Simulations for the F-16XL Aircraft*. AIAA Journal of Aircraft, __________ .

[5]Goertz, S.; Jirasek, A.; Morton, S.A.; McDaniels, D.R.; Cummings, R.M.; Lamar, J.E.; and Abdol-Hamid, K.S.: *Standard Unstructured Grid Solutions for CAWAPI F-16XL*. AIAA Journal of Aircraft, __________ .

[6]Fritz, W.; Davis, M.B.; Karman, S.L., Jr.; and Michal, T.: *RANS Solutions for the CAWAPI F-16XL Using Different Hybrid Grids.* AIAA Journal of Aircraft, __________ .

[7]Rizzi, A.; Jirasek, A.; Lamar, J.E.; Badcock, K.J.; Boelens, O.J.; and Crippa, S.: *What Was Learned from Numerical Simulations of F-16XL (CAWAPI) at Flight Conditions.* AIAA Journal of Aircraft, __________