Introduction to the Special Section on F-16XL Flight Aerodynamics Predictions at a High Angle-of-Attack

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A third and final international project has been completed for the assessment of state-of-the-art Computational Fluid Dynamics (CFD) capabilities to predict flight data obtained with an F-16XL aircraft. This work built upon two prior campaigns associated with the Cranked Arrow-Wing Aerodynamics Project International (CAWAPI). The second CAWAPI project, CAWAPI-2, focused on predictions for low-speed/high angle-of-attack and transonic/low-to-moderate angle-of-attack conditions, and eight articles from this effort were published in Volume 54, Number 2, of the *Journal of Aircraft*:

1. Luckring, J. M., and Lee-Rausch, E., "Introduction to the Special Section on the Prediction of F-16XL In-Flight Aerodynamics," *Journal of Aircraft*, Vol. 54, No. 2, 2017, p. 377.

2. Luckring, J. M., Rizzi, A., and Davis, M. B., "Toward Improved Predictions of Slender Airframe Aerodynamics Using the F-16XL Aircraft," *Journal of Aircraft*, Vol. 54, No. 2, 2017, pp. 378-387.

3. Boelens, O. J., "Flow Analysis of the F-16XL Aircraft at Transonic Flow Conditions," *Journal of Aircraft*, Vol. 54, No. 2, 2017, pp. 388-394.

4. Tomac, M., Rizzi, A., and Jirásek, A., "Computational Fluid Dynamics Predictions of Control-Surface Effects for F-16XL Aircraft," *Journal of Aircraft*, Vol. 54, No. 2, 2017, pp. 395-408.

5. Rizzi, A., Tomac, M., Jirásek, A., Cavagna, L., Riccobene, L., and Ricci, S., "Computation of Aeroelastic Effects on F-16XL at Flight Conditions FC70 and FC25," *Journal of Aircraft*, Vol. 54, No. 2, 2017, pp. 409-416.

6. Elmiligui, A., Abdol-Hamid, K., Cavallo, P. A., and Parlette, E. B., "USM3D Simulations for the F-16XL Aircraft Configuration," *Journal of Aircraft*, Vol. 54, No. 2, 2017, pp. 417-427.

7. Hitzel, S. M., "Sub- and Transonic Vortex Breakdown Flight Condition Simulations of the F-16XL Aircraft," *Journal of Aircraft*, Vol. 54, No. 2, 2017, pp. 428-443.

8. Rizzi, A., and Luckring, J. M., "What Was Learned in Predicting Slender Airframe Aerodynamics with the F-16XL Aircraft," *Journal of Aircraft*, Vol. 54, No. 2, 2017, pp. 444-455.

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The CAWAPI-2 foci had been identified in the first CAWAPI project, CAWAPI-1, as unyielding problems which all CAWAPI-1 CFD failed to predict. CAWAPI-1 also included analysis at moderate-speed/moderate-angle-of-attack conditions, and the introductory CAWAPI-2 article shown above, by Luckring and Lee-Rausch, includes a listing of the seven CAWAPI-1 articles that were published in Volume 46, Issue 2, of the *Journal of Aircraft* in 2009 (pp. 354-441). All of these efforts compared CFD simulations with a unique flight data set that was created with an F-16XL aircraft by NASA in the 1990s [Lamar, J. E., Obara, C. J., Fisher, B. D., and Fisher, D. F., "Flight, Wind-Tunnel, and Computational Fluid Dynamics Comparison for Cranked Arrow Wing (F-16XL-1) at Subsonic and Transonic Speeds," NASA TP 2001-210629, Feb. 2001]. The data set spanned subsonic to supersonic Mach numbers, included cruise and maneuver conditions, and included a suite of flow-physics measurements not typically obtained in flight.

This third CFD campaign, designated CAWAPI-3, focused on one particular Flight Condition (FC-25, M = 0.242 and α = 19.84º) that was also studied in the prior CAWAPI projects. The CFD emphasis was on unsteady simulations using hybrid Reynolds-Averaged-Navier-Stokes/Large-Eddy-Simulation (RANS-LES) technologies. The partners in this effort were Airbus Defense and Space in Germany, FS Dynamics in Sweden, FOI Swedish Defense Research Agency in Sweden, KTH Royal Institute of Technology in Sweden, Department of Defense HPCMP/CREATE Kestrel Team in the United States, NASA Langley in the United States, and United States Air Force Academy in the United States. Space Act Agreements facilitated work between NASA and the foreign partners, and the activity spanned roughly four years. This special section provides the summary findings from the CAWAPI-3 effort. The first five articles all present comparisons of CFD results from various hybrid RANS-LES formulations against flight test data for the target condition. The work was coordinated so that common analyses were included among the articles, and the sixth article presents a synthesis of the individual results. Unsteady aerodynamic effects appear to be important for modeling the flow on the outboard wing panel of the F-16XL aircraft at the condition of this study.

The CAWAPI-3 contributors appreciate the opportunity provided through the AIAA, and with the support of the Applied Aerodynamics Technical Committee, to disseminate the findings from this research campaign. Six conference papers were presented in a special session at the AIAA Aviation 2015 meeting, and now six articles are provided in this special section of the *Journal of Aircraft*. The authors also appreciate the many contributions realized through the *Journal of Aircraft* editorial process. Remarkable progress has been realized in predicting

slender-wing aerodynamics over the approximately 14 years of the CAWAPI work, and this editor would like to express his appreciation to all of the individuals who helped realize these accomplishments.