Technical Comments

Comment on "Numerical Optimization Design of Advanced Transonic Wing Configurations"

R. C. Lock*
The City University, London, England

HAVING read Ref. 1 with great interest, I was surprised to find apparent signs of serious inaccuracy in the tables of numerical results. This can be seen from Tables 1 and 2, in which the numbers are identical with those of the paper, except for the additional lines $C_L^2/\pi A$ and $C_D/(C_L^2/\pi A)$.

From Tables 1 and 2, it will be seen that for both wings, even before optimization, the quoted values of the inviscid drag coefficient C_D are well below the ideal minimum induced drag values for the appropriate values of C_L and aspect ratio A. After optimization, the improved values are only about half the theoretical minimum.

Assuming that these apparent errors are not just the result of some numerical slip, this does cast doubt on the accuracy of the authors' method of calculating their "objective function" (L/D) by integrating the appropriate component of pressure over the wing surface. Earlier in the paper (p. 194, top of second column), they state correctly that "for efficient operation in the transonic regime the wave drag must be minimized ..." In my opinion it is, therefore, better to use a method of drag prediction that deals separately with the wave drag and vortex ("induced") drag components (and, in a real flow, the viscous drag). For this purpose, a method such as those suggested in Refs. 2 or 3 could be used.

In mentioning these doubts about the numerical accuracy of the published results, I do not, of course, intend to detract from the undoubted value of the authors' method as a design tool. It is worth stressing, however, the importance of checking the validity of any purely inviscid method such as this by subsequent calculations by a suitable "viscous" code, to make sure that any reductions in inviscid drag have not been outweighed by corresponding increases in viscous drag.

Table 1 Lockheed model C-141B (aspect ratio = 7.89)

Parameter	Original wing	New wing
C_L	0.585	0.558
$C_L^2/\pi A$	0.0138	0.0126
C_D	0.00967	0.00723
$C_D/(C_L^2/\pi A)$	0.70	0.58

Table 2 Cessna model 650 (aspect ratio = 9.0)

Parameter	Original wing	New wing
C_L	0.565	0.506
$C_L^2/\pi A$	0.0113	0.00905
C_D	0.00909	0.00438
$C_D/(C_L^2/\pi A)$	0.81	0.48

Received June 5, 1986.

*Visiting Professor of Aerodynamics.

References

[1]Cosentino, G. B. and Holst, T. L., "Numerical Optimization Design of Advanced Transonic Wing Configurations," *Journal of Aircraft*, Vol. 23, March 1986, pp. 192–199.

[2]Yu, N. J., Chen, H. C., Samant, S. S., and Rubbert, P. E., "Inviscid Drag Calculations for Transonic Flows," AIAA Paper 83-1928, 1983.

[3]Lock, R. C., "Prediction of the Drag of Wings at Subsonic Speeds by Viscous/Inviscid Interaction Techniques," AGARD-R-723, Paper 10, 1985.

Reply by Authors to R. C. Lock

G. B. Cosentino*
Sterling Software, Palo Alto, California
and
T. L. Holst†
NASA Ames Research Center
Moffett Field, California

AS pointed out in the comment by Lock, the inviscid drag values published in Ref. 1 show considerable error. This error is truncation error and behaves in a consistent fashion. That is, the inviscid drag is always too small. The inviscid drag values associated with the analysis code (TWING) always result in a small negative value for subcritical nonlifting calculations or an underprediction of inviscid drag for supercritical lifting cases. This error, as expected with truncation error, can be reduced with grid refinement. However, to keep the computer time requirements for the numerical optimization procedure at a minimum, the results presented in Ref. 1 were obtained on a very coarse grid (89×25×18); thus, the absolute drag errors were larger than desired. However, in numerical optimization, the accurate prediction of absolute drag is not important. The accurate prediction of drag increments is the important quantity and is crucial to the success of numerical optimization. This point will be discussed shortly.

Since the results appearing in Ref. 1 were completed, a new version of TWING with improved truncation error characteristics has been developed and is described in Ref. 3. (This new version is used in the TWING/QNM design pro-

Table 1 Comparison of drag coefficients computed for an ONERA M6 wing at $M_\infty = 0.2$ and $\alpha = 0$ deg

Code description	Inviscid drag
Ref. 2 result	0.0005
TWING (CY=3) (89×25×18)	−0.0018
TWING (CY=4) (89×25×18)	−0.0004
TWING (CY=4) (89×25×31)	0.0001

Submitted June 30, 1986.

*Research Scientist. Member AIAA.
†Chief, Applied Computational Fluids Branch. Associate Fellow AIAA.