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# Transonic Aerodynamic Characteristics of a Proposed Wing-Body Reusable Launch Vehicle Concept

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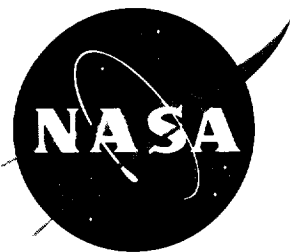
(NASA-TM-108489) TRANSONIC  
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PROPOSED WING-BODY REUSABLE LAUNCH  
VEHICLE CONCEPT (NASA, Marshall  
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# Transonic Aerodynamic Characteristics of a Proposed Wing-Body Reusable Launch Vehicle Concept

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March 1995

## **ACKNOWLEDGMENTS**

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## NOMENCLATURE

<u>Symbol</u>	<u>Description</u>
alpha, $\alpha$	angle-of-attack, degrees
beta, $\beta$	angle-of-slideslip, degrees
$C_A$	axial force coefficient
$C_{AB}$	power-off base axial force coefficient
$C_{Af}$	forebody axial force coefficient
$C_\ell$	rolling moment coefficient
$C_M$	pitching moment coefficient
$C_N$	normal force coefficient
$C_{YN}$	yawing moment coefficient
$C_Y$	side force coefficient
$F_{AT}$	total axial force
$F_{AB_{ref}}$	power-on base axial force, aerodynamic reference trajectory
$L_{ref}$	reference length, 185.6 ft (full scale)
MACH	Mach number
MRP ( $X_T, Y_T, Z_T$ )	moment reference point, (127.32 ft, 0, 0) 68.6 percent $L_{ref}$
$q$	dynamic pressure
$S_{ref}$	reference area, 4,211 ft <sup>2</sup> (full scale)
$X_{CP}$	model center of pressure from MRP, inches



## TECHNICAL MEMORANDUM

# TRANSONIC AERODYNAMIC CHARACTERISTICS OF A PROPOSED WING-BODY REUSABLE LAUNCH VEHICLE CONCEPT

## INTRODUCTION

As an outcome of NASA's 1993 Access to Space study, a more indepth follow-on study was undertaken. Three candidate reusable launch vehicle configurations that would provide reusable single-stage-to-orbit capability were selected. A wing-body configuration was one of these candidate concepts; the other two concepts being a vertical lander and a lifting body. The wing-body configuration was a direct outgrowth of the access to space option three reference single-stage-to-orbit rocket vehicle. This vehicle matured during the subsequent reusable launch vehicle (RLV) study into the vehicle which was tested. Initially, the vehicle's aerodynamic characteristics were determined using aerodynamic prediction codes. To obtain a better fidelity in the aerodynamic data, a series of scale models of the proposed wing body vehicle were tested at NASA Marshall Space Flight Center (MSFC) and NASA Langley Research Center (LaRC). The vehicle was tested at low subsonic and hypersonic conditions at LaRC and at subsonic, transonic, and supersonic conditions at MSFC. The results of the transonic testing in MSFC's 14×14-in trisonic wind tunnel (TWT) facility are presented herein.

A 0.004-scale RLV wind tunnel model (fig. 1) was tested during the winter of 1994 at the MSFC 14×14-in TWT. The subsonic and transonic, Mach 0.3 to Mach 2.0, aerodynamic characteristics of the WB001 reference wing-body vehicle were determined. This wind tunnel test provided aerodynamic data for the basic vehicle, wing and body contributions, and control surface increments. The data derived from this test were used to construct an aerodynamic data base for flight mechanics and structural loads studies on the wing body vehicle.

## TEST

### Facility Description

The MSFC 14×14-in TWT is an intermittent blowdown tunnel which operates by high-pressure air flowing from storage to either vacuum or atmosphere conditions. The transonic test section provides a Mach number range from 0.2 to 2.0. Mach numbers between 0.2 and 0.9 are obtained by using a controllable diffuser. The Mach range from 0.95 to 1.3 is achieved through the use of plenum suction and perforated walls. Each Mach number above 1.30 requires a specific set of two-dimensional contoured nozzle blocks. A solid-wall supersonic test section provides the entire range from 2.74 to 5.0 with one set of fixed-contour variable symmetry nozzle blocks. Air is supplied to a 6,000-ft<sup>3</sup> storage tank at approximately -40 °F dew point and 425 lb/in<sup>2</sup> gauge. The compressor is a three-stage reciprocating unit driven by a 1,500-hp motor. The tunnel flow is established and controlled with a servo-actuated gate valve. The controlled air flows through the valve diffuser into the stilling chamber and heat exchanger where the air temperature can be controlled from ambient to approximately 180 °F. The air then passes through the test section, which contains the nozzle blocks and test region. Downstream of the test section is a hydraulically controlled pitch sector that provides the capability of testing up to 20 angles-of-attack from -10° to +10° during each run. Sting offsets are available for obtaining various maximum

angles-of-attack up to 90°. The diffuser section has movable floor and ceiling panels, which are the primary means of controlling the subsonic Mach numbers and permit more efficient running supersonically. Tunnel flow is exhausted through an acoustically damped tower to atmosphere or into the vacuum field of 42,000 ft<sup>3</sup>. The vacuum tanks are evacuated by vacuum pumps driven by a total of 500 hp.

The data acquisition system is a Hewlett-Packard (HP) 3497A™ controller with a HP 3456A™ digitizer. The unit is equipped with various control modules for facility system control, angle-of-attack readout, pressure measuring system, etc. Currently the system is configured to 40 low-level strain gauge, thermocouple, or pressure channels per second, with a 2- or 3-s recycle time to change angle-of-attack and allow for settling. Low-pass filters are available for all channels and are routinely used on strain-gauge balance channels. System control and data reduction are by a HP 200-series™ computer with a 1-mbyte memory. Data are reduced after each run, and tabulated and plotted data are available after each run using a HP laser jet printer. All data are stored on disk for subsequent transfer to another computer for further analysis or data base construction.<sup>1</sup>

### **Model Descriptions**

The WB001 vehicle is generically a wing-body combination. The body consists of a drooped nose followed by a cylindrical core section 28.55 ft in diameter, full scale, with a total body length of 185.6 ft, full scale. The wing is a NACA-0010 airfoil at the root linearly varying to a NACA-0012 airfoil at the tip with a 54° leading edge sweep, 3.5° of dihedral, and an aspect ratio of 1.91. Control surfaces for this configuration consist of ailerons, elevons, and tip fins. The NASA wing-body 001 RLV configuration is shown in figure 2.

The WB001 model is a 0.4-percent scale model. The model consists of three main parts: a nose assembly, a core body, and the wing. The model has multiple movable control surfaces and filler blocks for future control surface additions, such as canards and a vertical tail. Control surfaces consisted of elevons with 0°, +10°, and -10° deflections; ailerons with 0°, +10°, and -10° deflections; a body flap with 0°, +10°, and -10° deflections; and tip fins with 0°, +10°, and +20° outward deflections. The control surface deflection sign convention is shown in figure 3.

### **Test Procedure**

Testing extended over the subsonic and transonic Mach ranges, Mach 0.3 to 1.96, at Mach numbers of 0.3, 0.6, 0.8, 0.9, 0.95, 1.05, 1.10, 1.15, 1.25, 1.46, and 1.96. The angle-of-attack range was -10° to +26° in 2° increments for the basic model, with subassemblies at reduced ranges and angle-of-sideslip ranges of -10° to +10° in 2° increments.

The six-component balance on which the model was mounted measured total vehicle forces and moments. Six-component force and moment coefficients were computed from the main balance about its axis system and then transferred to the moment reference point shown in figure 4. Forebody coefficients were calculated using the element base pressure results. Angles-of-attack and angles-of-sideslip were calculated from the sector reading, taking into account the sting and balance deflections determined using pretest calibrations.

A more detailed description of this wind tunnel test, TWT 741, can be found in reference 2.

## RESULTS

The presented WB001 aerodynamic characteristics consist of basic vehicle aerodynamic coefficients and control deflection effect increments determined as a result of the test performed in the MSFC 14-in TWT.<sup>2</sup> These coefficients are normal force, axial force, pitching moment, side force, yawing moment, and rolling moment. The raw wind tunnel data were validated then interpolated to even angles for ease of usage. The presented data are to be applied about the moment reference point of the vehicle located at 68.6 percent (127.32 ft) aft of the nose on the centerline. This point is shown in figure 4, along with the aerodynamic axis system and sign convention.

The aerodynamic forces and moments acting on the vehicle may be determined from the presented coefficients using the following formula:

Longitudinal coefficients:

$$\text{Force} = \text{Coeff.}(C_N, C_{Af}) * q * S_{\text{ref}} ,$$

$$\text{Moment} = \text{Coeff.}(C_M) * q * S_{\text{ref}} * L_{\text{ref}} .$$

Lateral coefficients:

$$\text{Force} = \text{Coeff.}(C_Y) * q * S_{\text{ref}} ,$$

$$\text{Moment} = \text{Coeff.}(C_{YN}, C_l) * q * S_{\text{ref}} * L_{\text{ref}} .$$

Control surface deflections are defined as positive trailing edge downward for ailerons, elevons, and body flap and positive as outward for the tip fins. This sign convention is shown in figure 4. All control surface increments are vehicle coefficient increments. Thus, they are added to the basic vehicle coefficient data. The basic vehicle coefficient data set is for control surfaces at zero deflection. The given control deflection increments are for the set of control surfaces right and left.

If multiple control surfaces are deflected, the individual increments for each surface must be summed to obtain the total control surface deflection increment and added to the basic vehicle data set, the zero control surface deflection data. Control deflection increments are added to the coefficients using the following formula:

$$C_N = C_{N0} + \Delta C_N (\text{surface 1}) + \Delta C_N (\text{surface 2}) , \text{ etc.}$$

Power-on base axial force data,  $F_{AB}$  was determined using an empirical prediction code based on flight data. The power-on base axial force data are presented as a function of altitude, along with the reference dynamic pressure,  $q$ , and Mach. This base force was derived from the WB001 reference ascent flight trajectory. Base axial force,  $F_{AB}$  versus altitude is shown in figure 5. Figure 6 shows the reference dynamic pressure versus altitude.

The total axial force is determined by the sum of the base axial force and the forebody axial force as shown below:

$$F_{AT} = C_{A0} * q * S_{\text{ref}} + F_{AB\text{ref}} .$$

If a trajectory (new to WB001) other than the specified trajectory is used, the power-on base axial force must be adjusted using a  $q$ -ratio for the trajectory desired to obtain a usable power-on base axial force:

$$F_{AB} = F_{AB_{ref}} (q_{new}/q_{WB001}) .$$

If the vehicle is resized, the  $F_{AB}$  must be ratioed to correspond to the new vehicle size. To do this, a ratio of reference areas must be used, similar to the  $q$ -ratio performed above.

The data derived from this test are shown graphically in section I: longitudinal aerodynamics with control deflections, and section II: lateral aerodynamics with tip fin deflections. Graphs of vehicle aerodynamic coefficients of normal force, pitching moment, forebody axial force, and base axial force for a given Mach number versus angle-of-attack are presented in section I (figs. 7 through 50). Data are presented for the basic vehicle, no control surface deflections, the vehicle with the body flap deflected  $-10^\circ$  up, the vehicle with the body flap at  $-10^\circ$  along with the elevons at  $-10^\circ$ , and the vehicle with the body flap, elevons, and ailerons at  $-10^\circ$ . Graphs of vehicle aerodynamic coefficients of side force, yawing moment, and rolling moment for a given Mach number versus angle-of-sideslip are presented in section II (figs. 51 through 83). Data are presented for the basic vehicle along with data for right tip fin deflections of  $10^\circ$  and  $20^\circ$ .

The transonic aerodynamic characteristics of the WB001 configuration are presented in tabular format in the appendix . The appendix consists of nine tables. A basic set of vehicle data with control surfaces set at  $0^\circ$  is presented for both the longitudinal and lateral directions. Along with these basic sets of data, the control deflection incremental files are included.

## CONCLUSIONS

The vehicle is longitudinally stable and can be trimmed at both subsonic and transonic Mach numbers. This assumes a vehicle center of gravity at 68.6-percent body length or 127.32-ft aft of the nose. At subsonic Mach numbers, the vehicle is stable in trim for all control deflections. The vehicle for the subsonic Mach range can be trimmed at the desired angle-of-attack for entry, approximately  $15^\circ$ . This trim angle is accomplished through various control surface deflections (fig. 84). The vehicle for the transonic Mach range, Mach 0.95 to 2.0, has stable trim points but not at the desired angle-of-attack, approximately  $15^\circ$  angle-of-attack. It can be extrapolated from the current data trends that for a larger elevon deflection between  $20^\circ$  and  $30^\circ$ , the vehicle will be neutrally stable at the desired trim point of  $15^\circ$ .

The WB001 vehicle is laterally unstable for the subsonic and transonic Mach range. The tip fin deflections provide a trim angle range of approximately  $1^\circ$  to  $2^\circ$ , therefore, larger tip fins and deflectable surfaces are desirable. Enlarging the tip fins by an approximate geometric factor of 3 to 4 should result in the vehicle being neutrally stable.

The data presented herein are for a proposed wing body reusable launch vehicle configuration, WB001. The provided data are applicable for this configuration or can be used for a similar configuration in a preliminary design phase. The control surface increments derived are applicable for vehicles with similar wing geometry and control surface areas and locations. These data are of use in current and future reusable launch vehicle work.



## REFERENCES

1. Simon, E.: "The George C. Marshall Space Flight Center's 14×14-Inch Trisonic Wind Tunnel Technical Handbook." NASA TM X-64624, November 5, 1971.
2. Springer, A.M.: "Pretest Report for Wing Body 1 (WB001) Reusable Launch Vehicle (RLV) Configuration 14-Inch Trisonic Wind Tunnel Test, TWT 741." ED34-41-94, 1994.

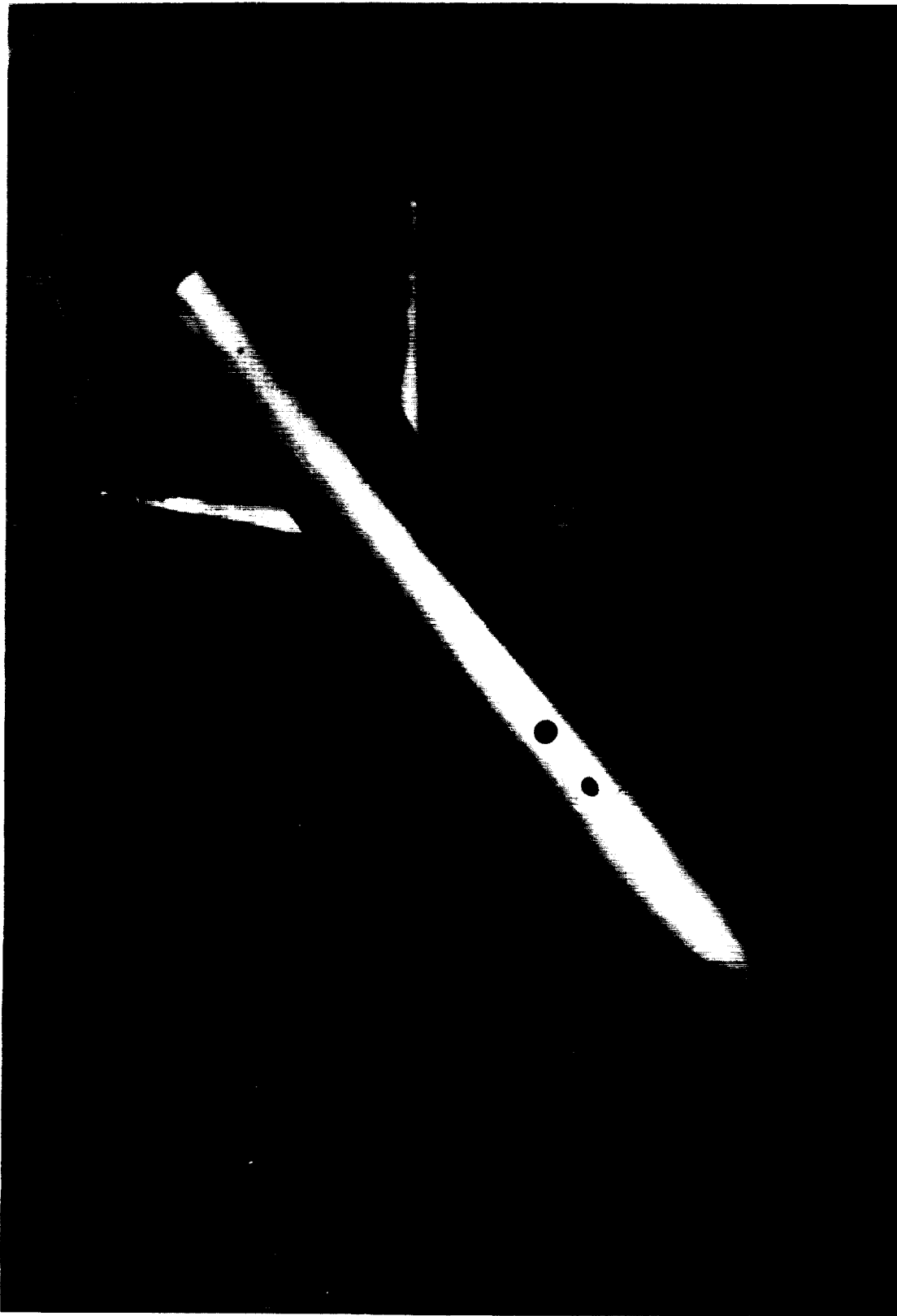


Figure 1. NASA wing-body (WB001) 14x14-in trisonic wind tunnel model.

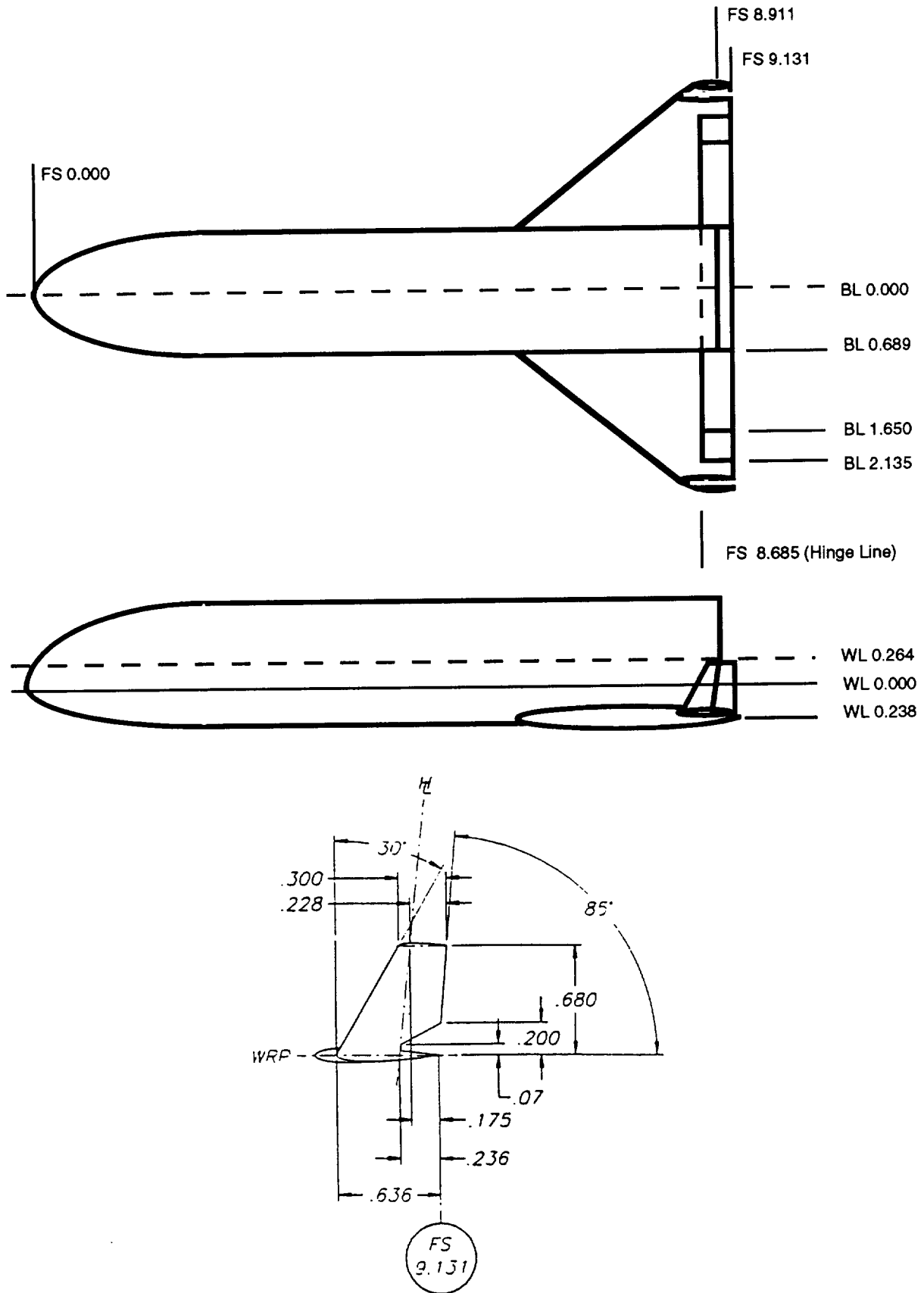


Figure 2. NASA wing-body (WB001) vehicle geometry.

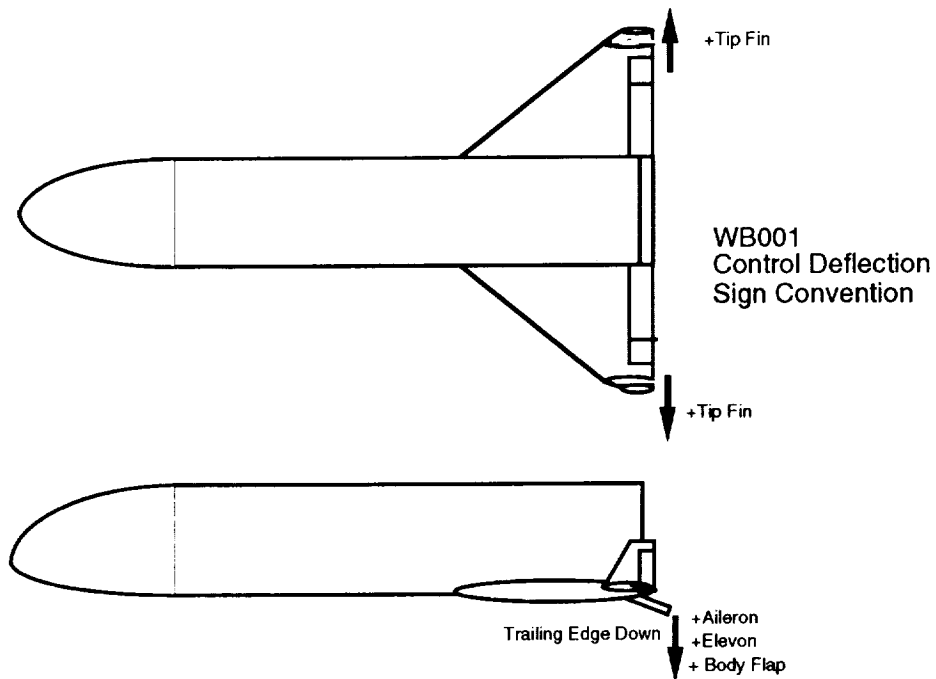


Figure 3. WB001 control deflection sign convention.

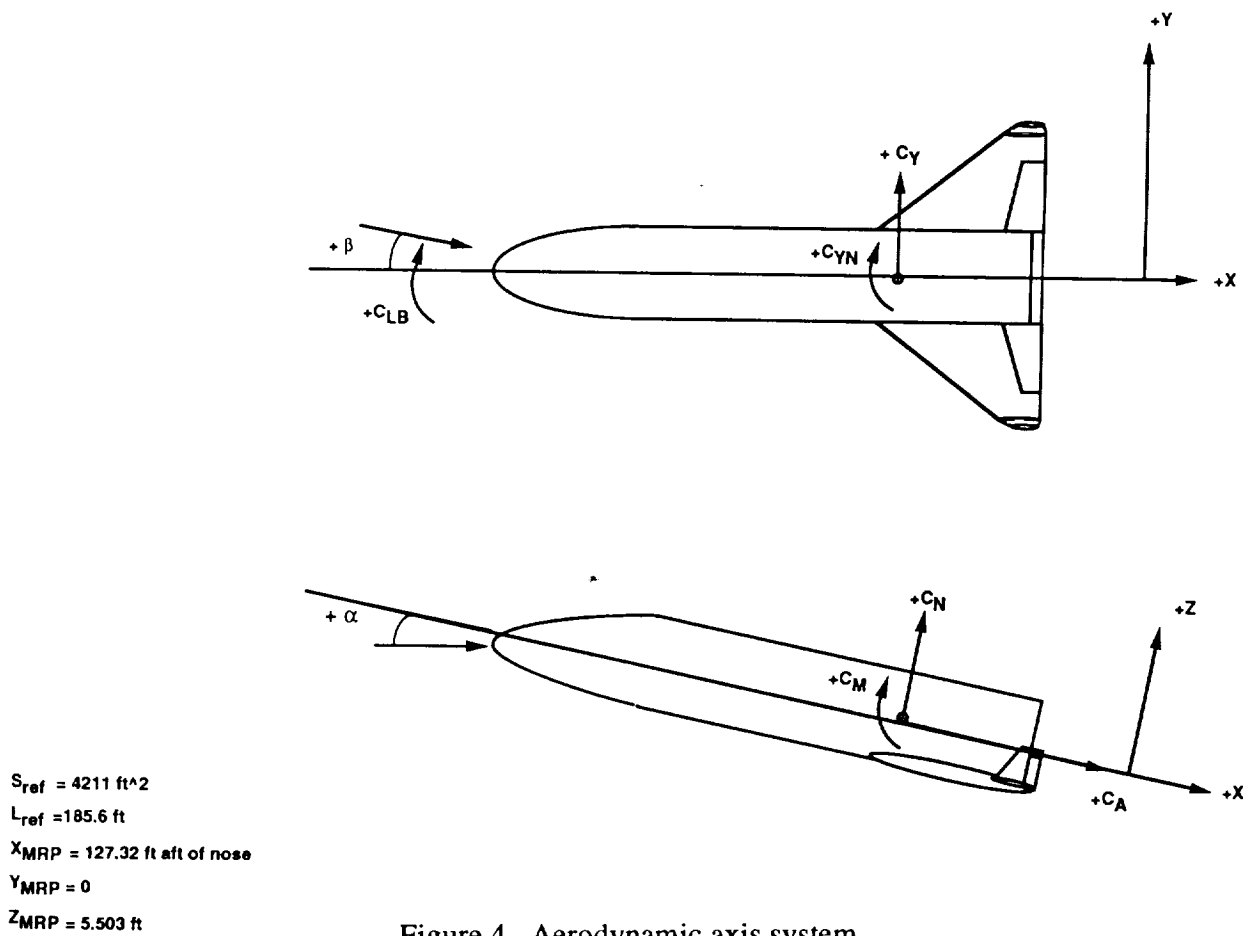


Figure 4. Aerodynamic axis system.

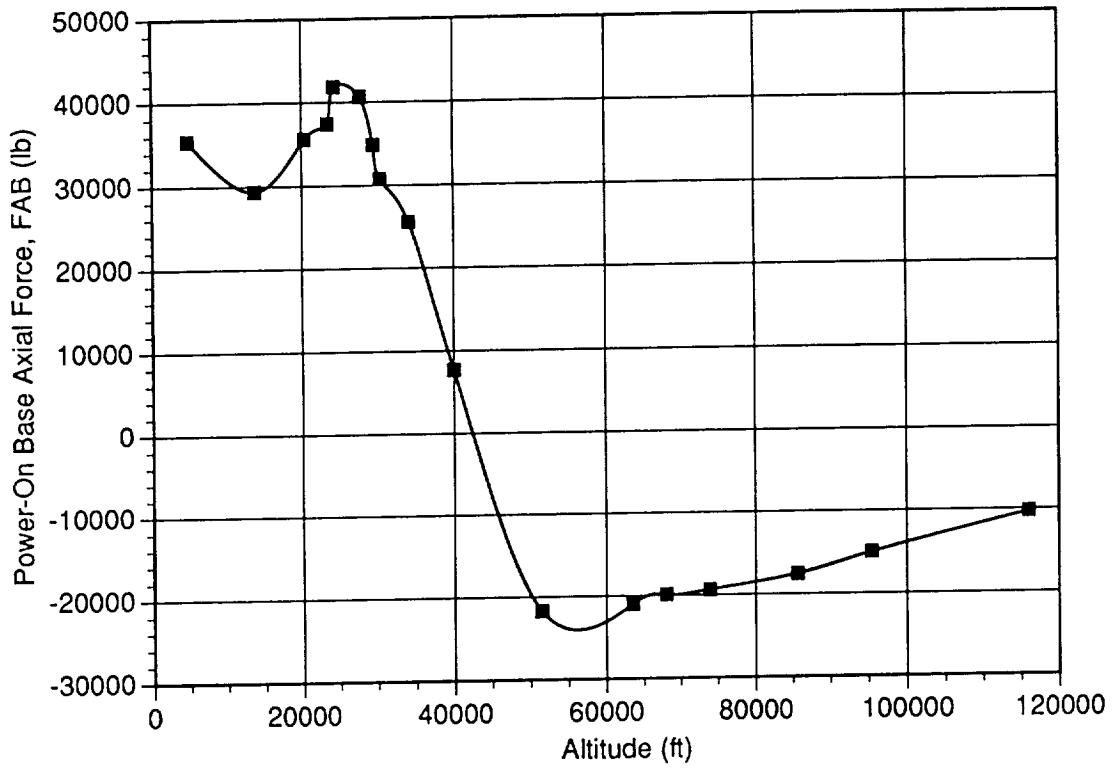


Figure 5. Base axial force,  $F_{AB}$  versus altitude .

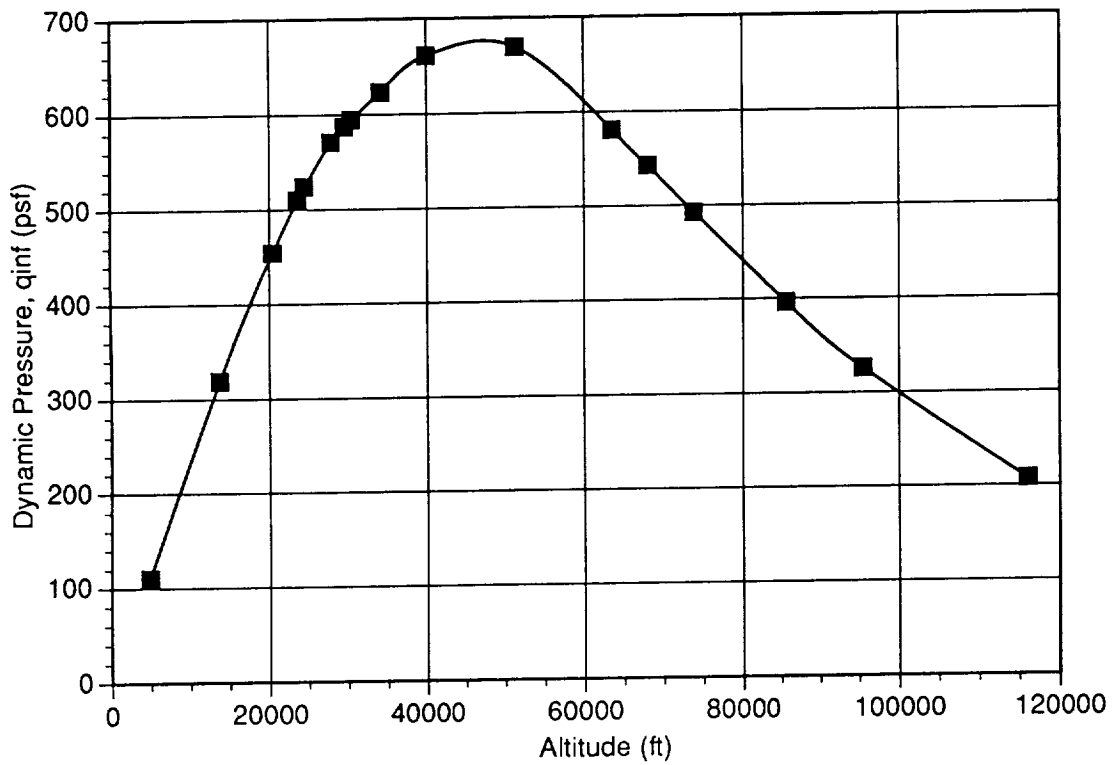


Figure 6. Dynamic pressure versus altitude.



**SECTION I. LONGITUDINAL AERODYNAMIC CHARACTERISTICS  
AND CONTROL DEFLECTIONS**

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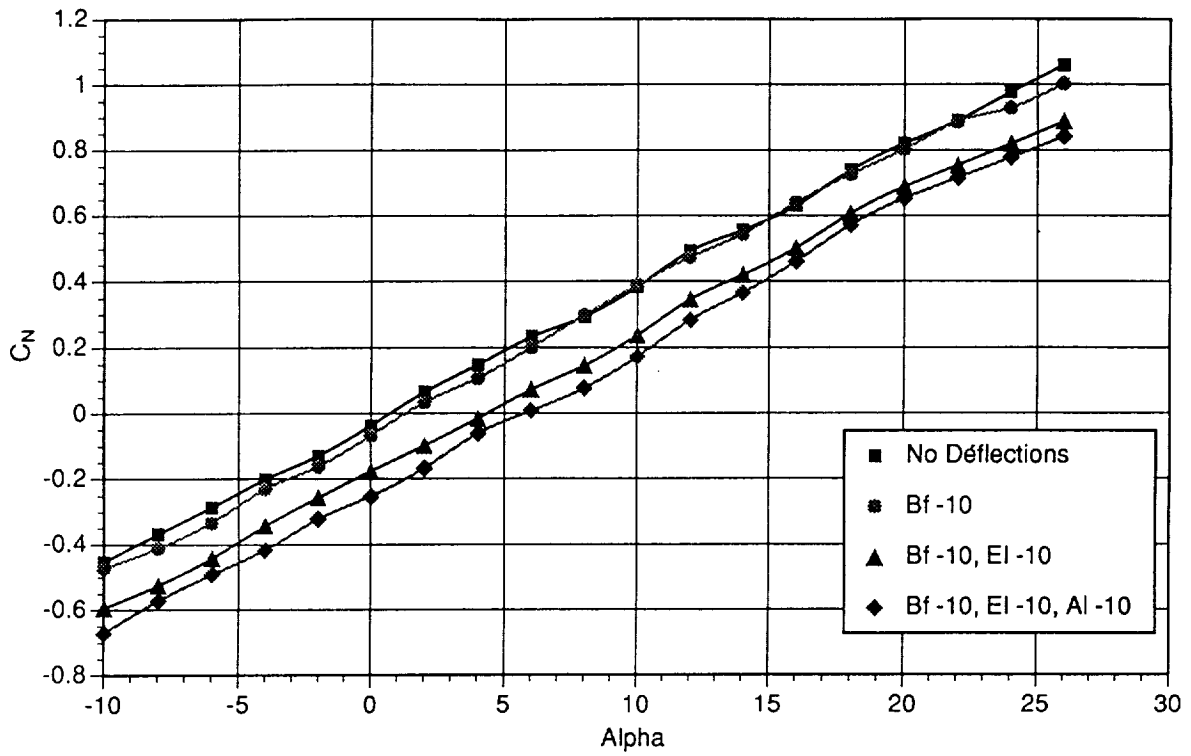


Figure 7. Mach 0.3,  $C_N$  versus angle-of-attack.

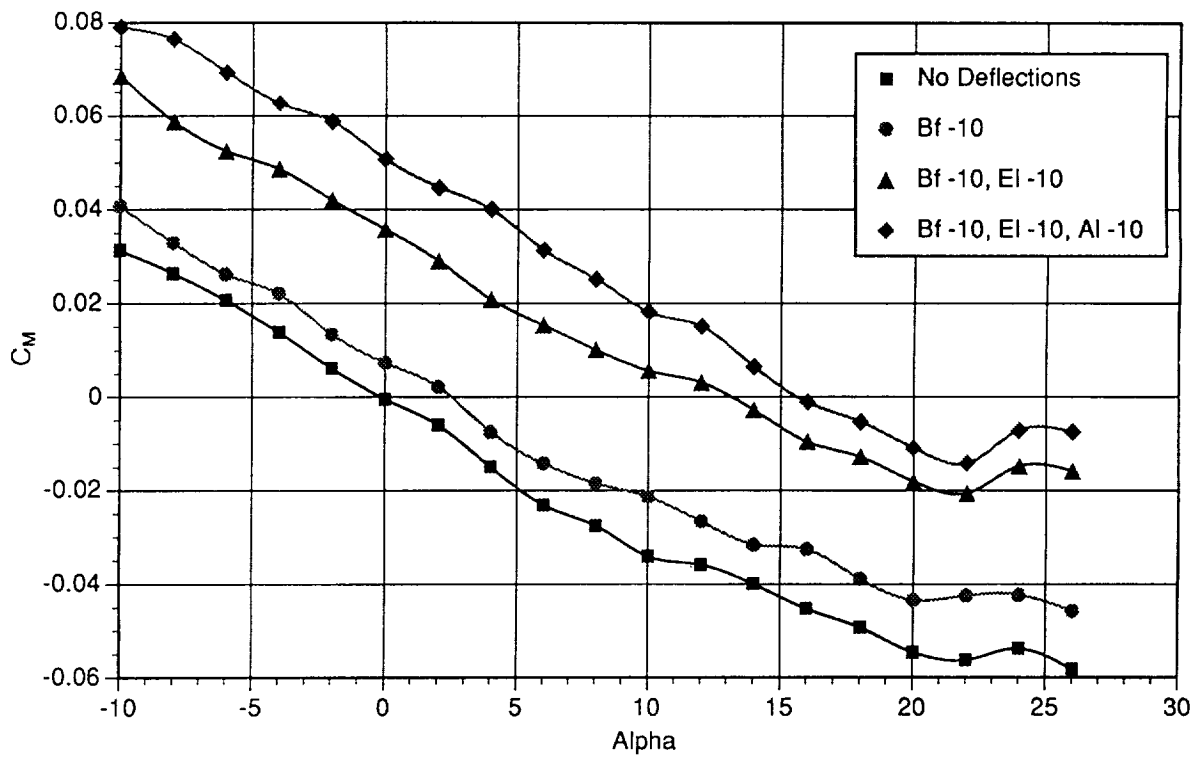


Figure 8. Mach 0.3,  $C_M$  versus angle-of-attack.



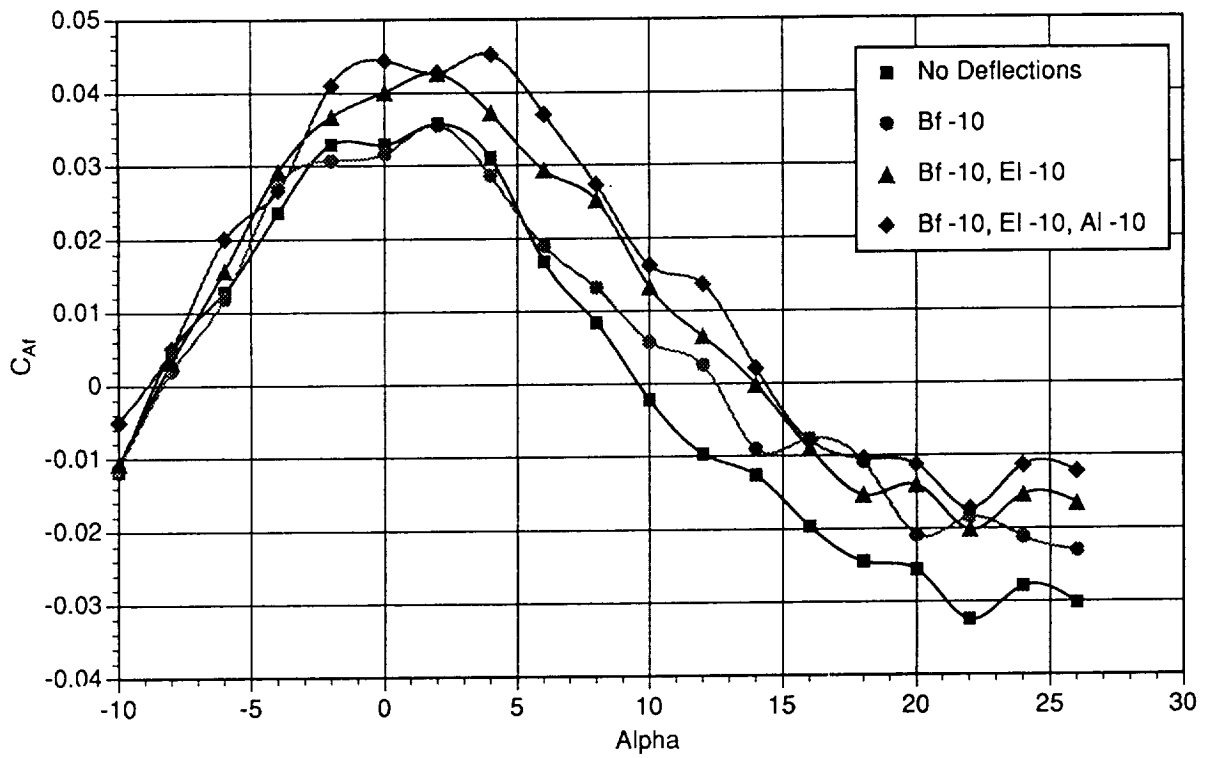


Figure 9. Mach 0.3,  $C_{Af}$  versus angle-of-attack.

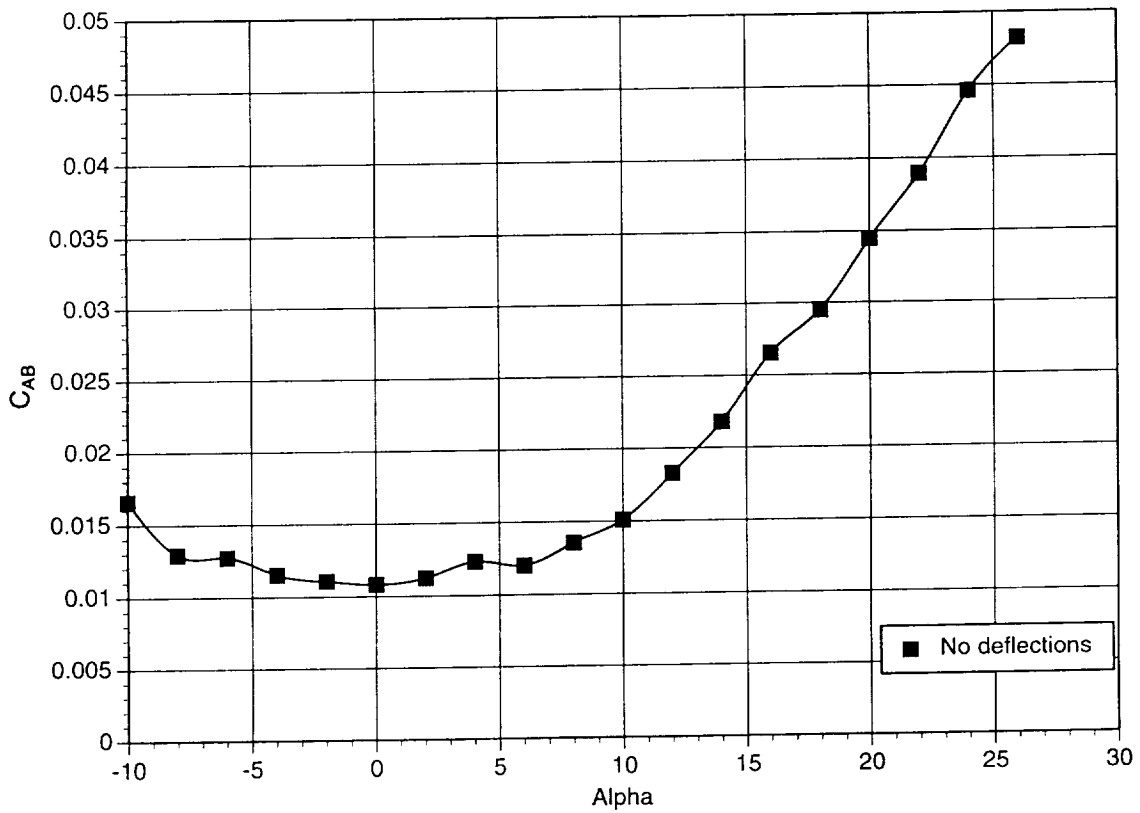


Figure 10. Mach 0.3,  $C_{AB}$  versus angle-of-attack.

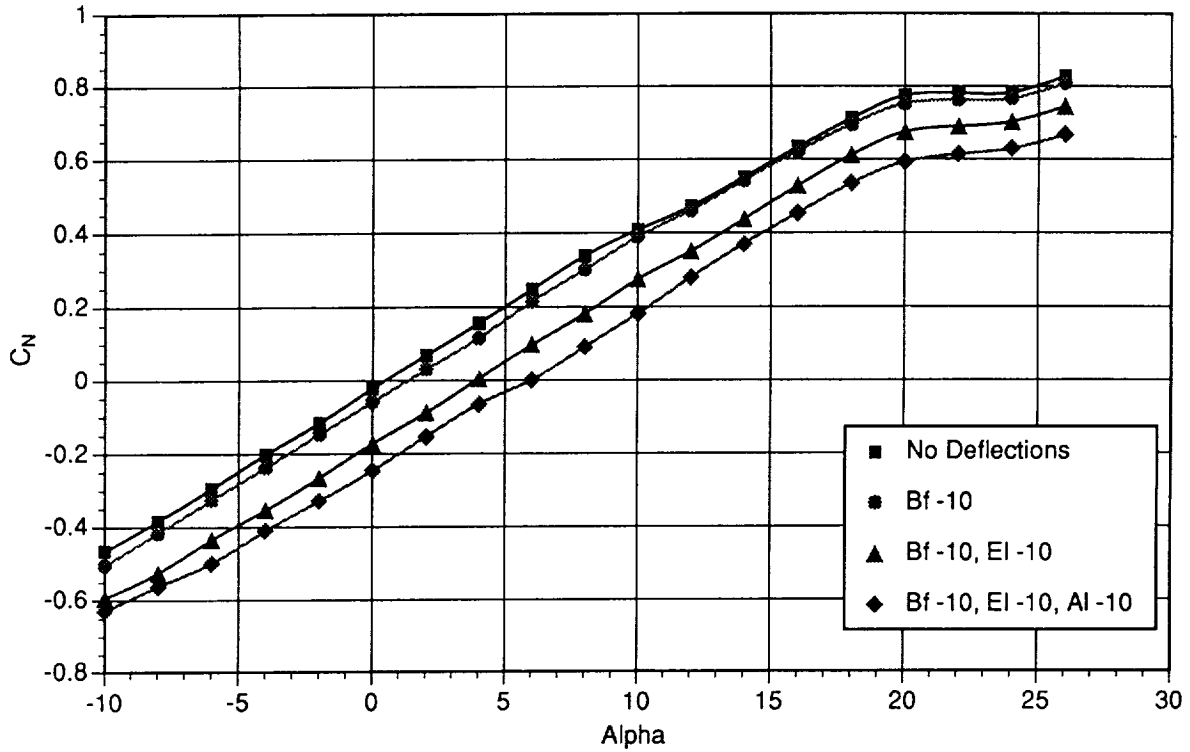


Figure 11. Mach 0.6,  $C_N$  versus angle-of-attack.

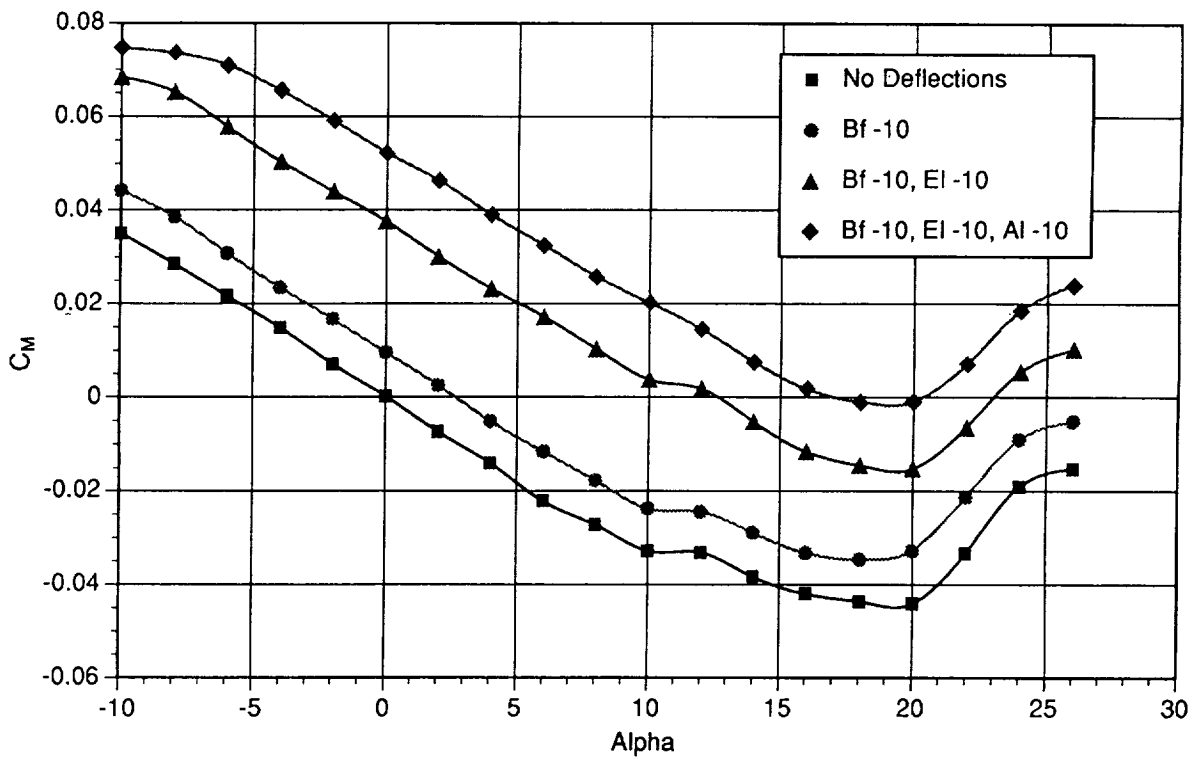


Figure 12. Mach 0.6,  $C_M$  versus angle-of-attack.

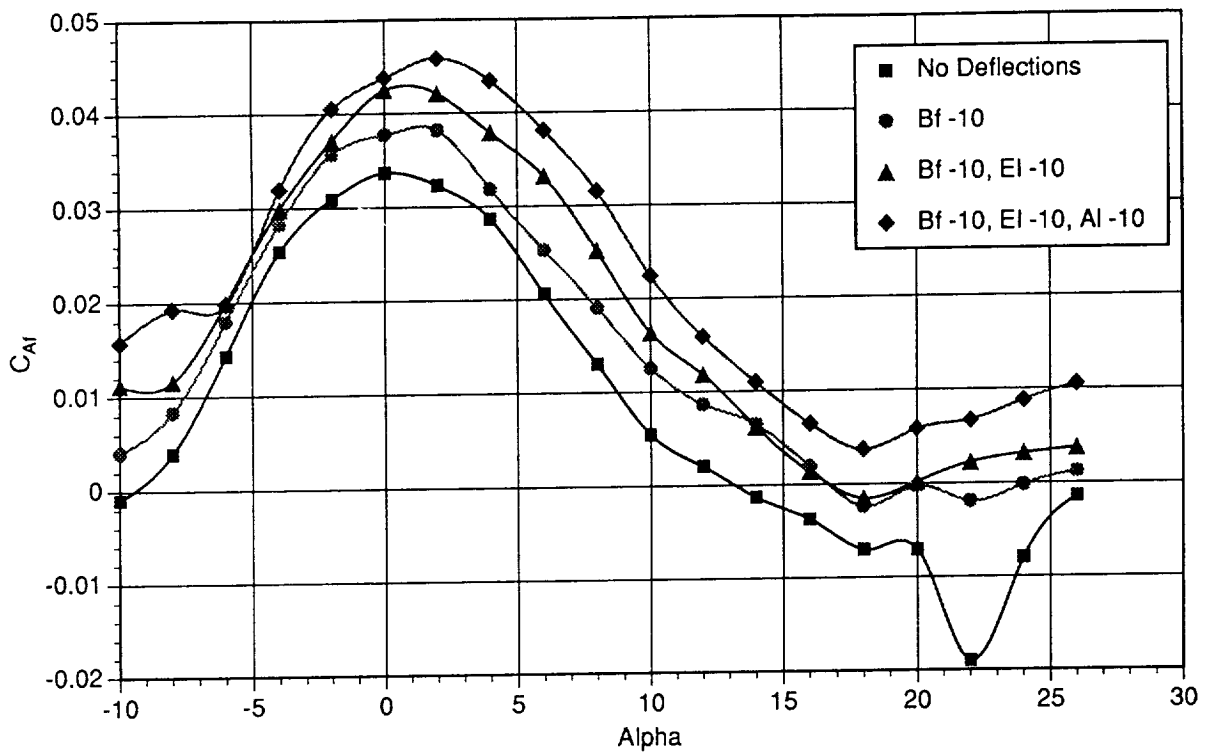


Figure 13. Mach 0.6,  $C_{Af}$  versus angle-of-attack.

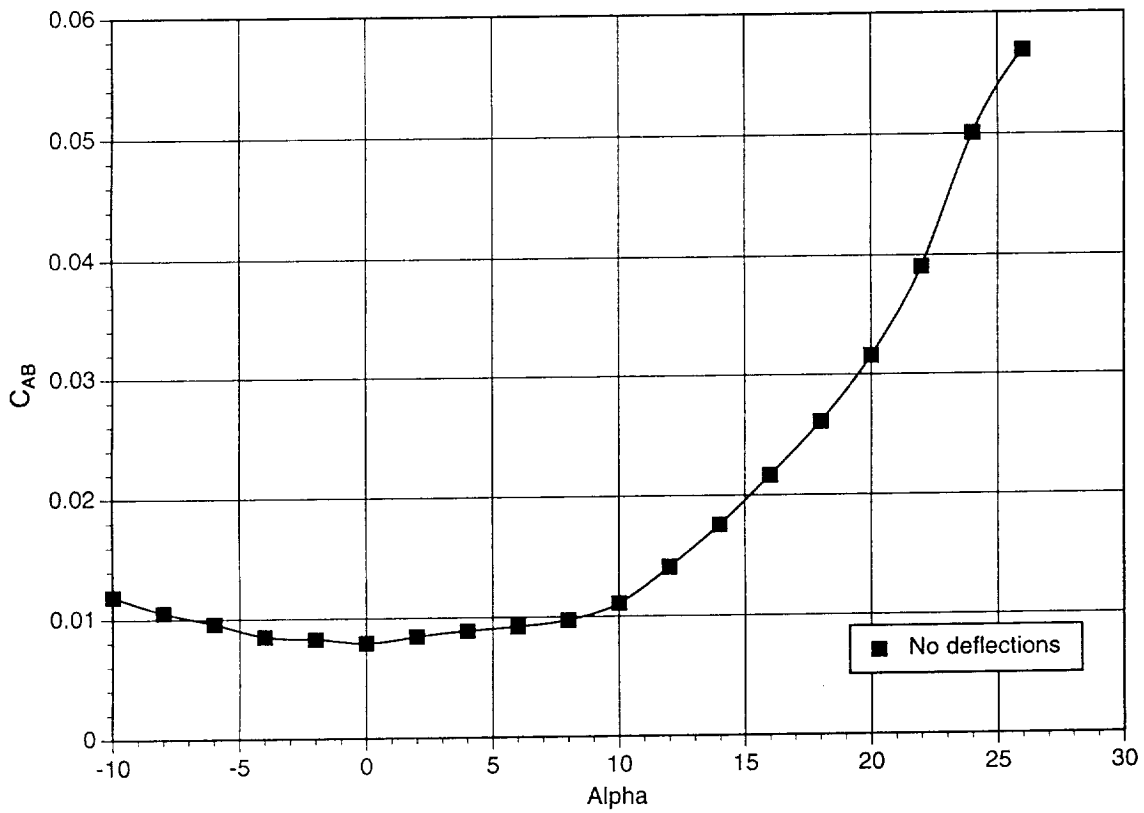


Figure 14. Mach 0.6,  $C_{AB}$  versus angle-of-attack.

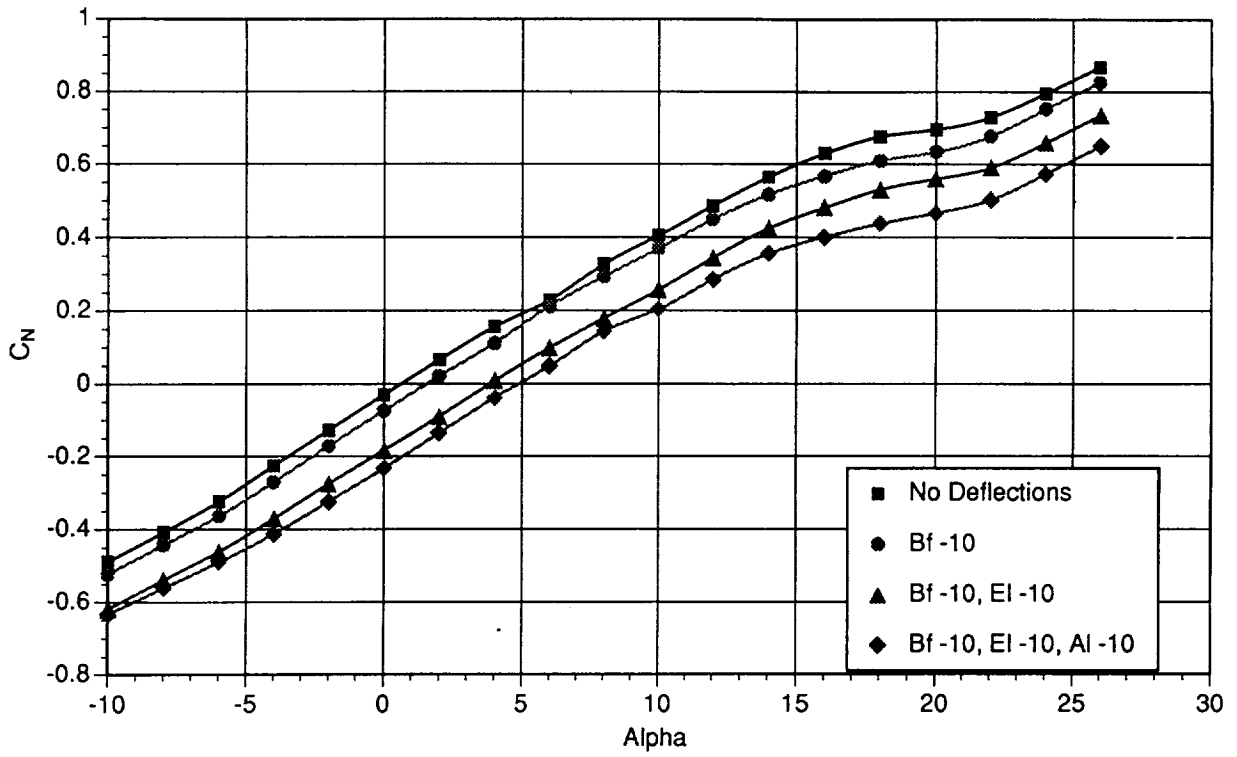


Figure 15. Mach 0.8,  $C_N$  versus angle-of-attack.

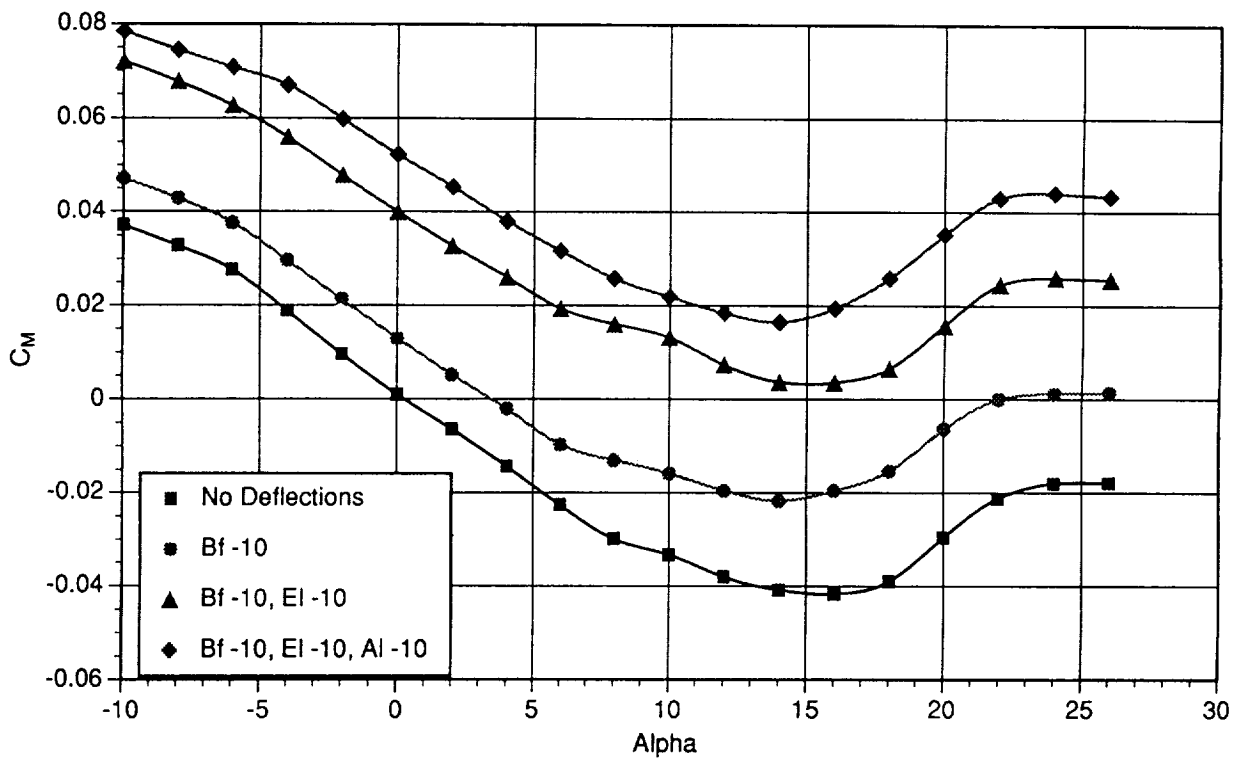


Figure 16. Mach 0.8,  $C_M$  versus angle-of-attack.

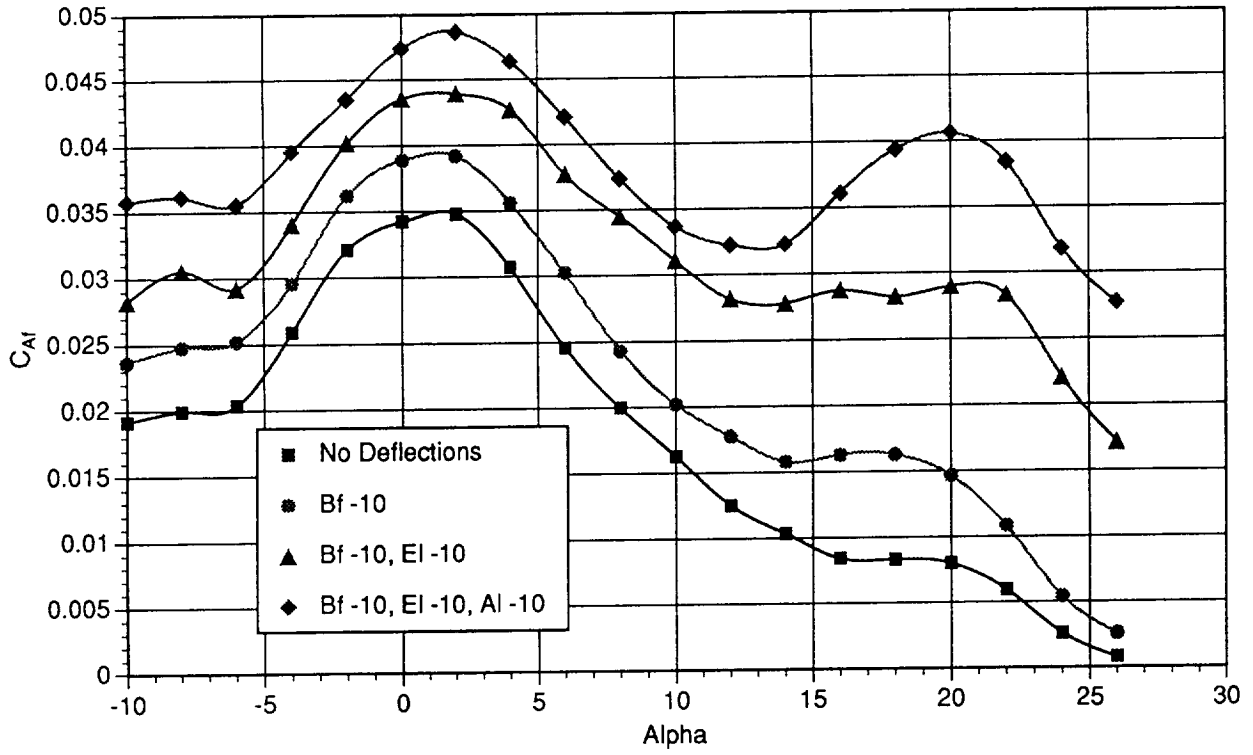


Figure 17. Mach 0.8,  $C_{Af}$  versus angle-of-attack.

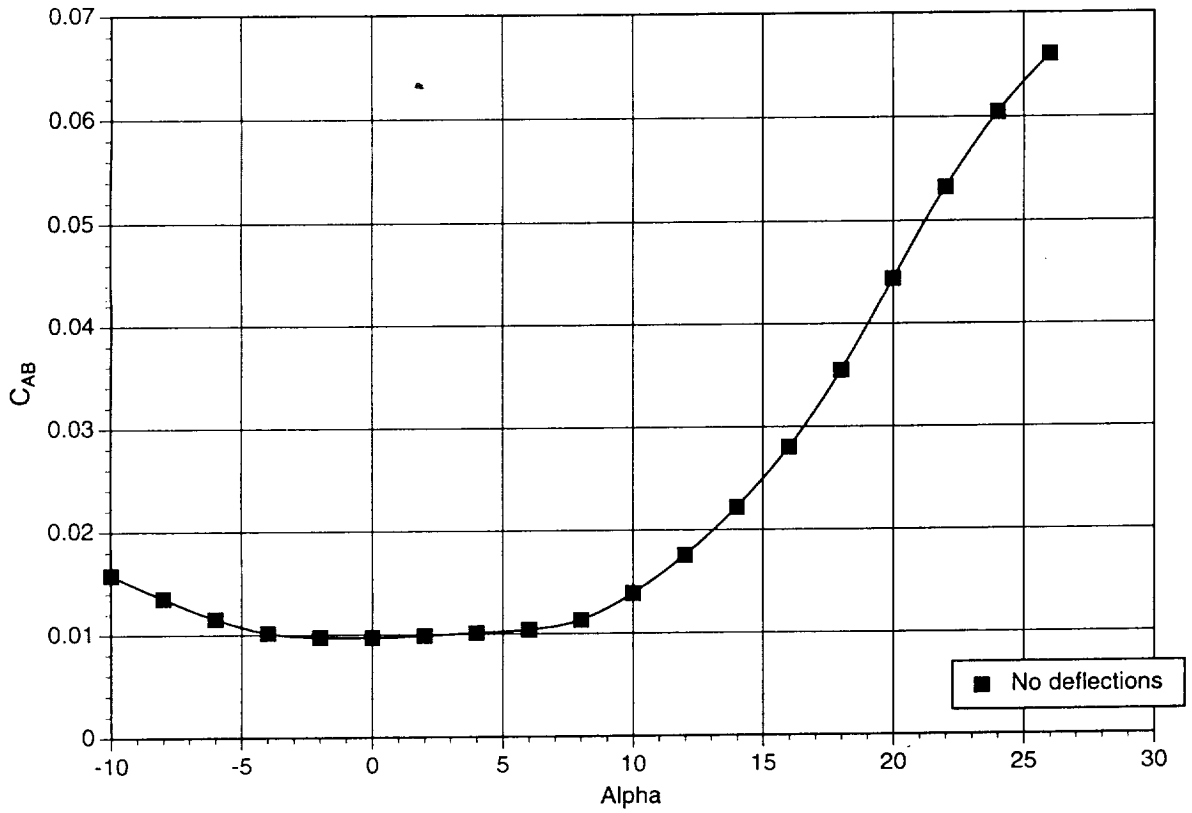


Figure 18. Mach 0.8,  $C_{AB}$  versus angle-of-attack.

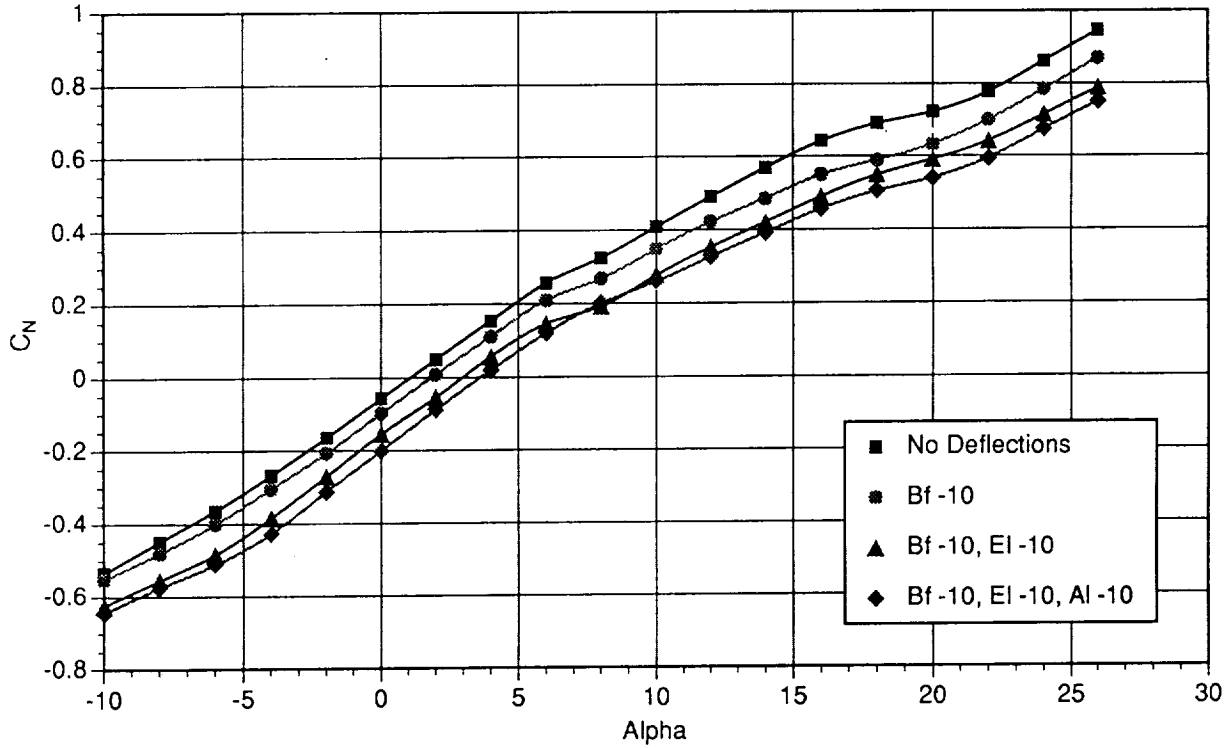


Figure 19. Mach 0.9,  $C_N$  versus angle-of-attack.

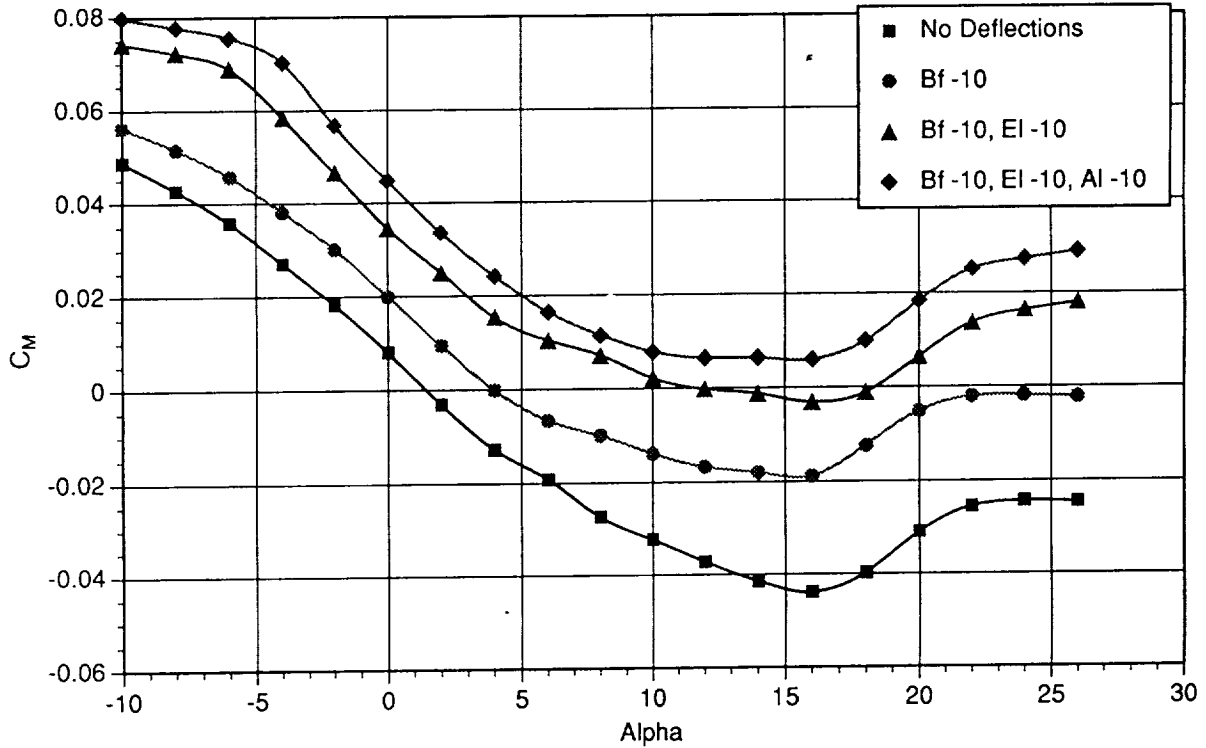


Figure 20. Mach 0.9,  $C_M$  versus angle-of-attack.

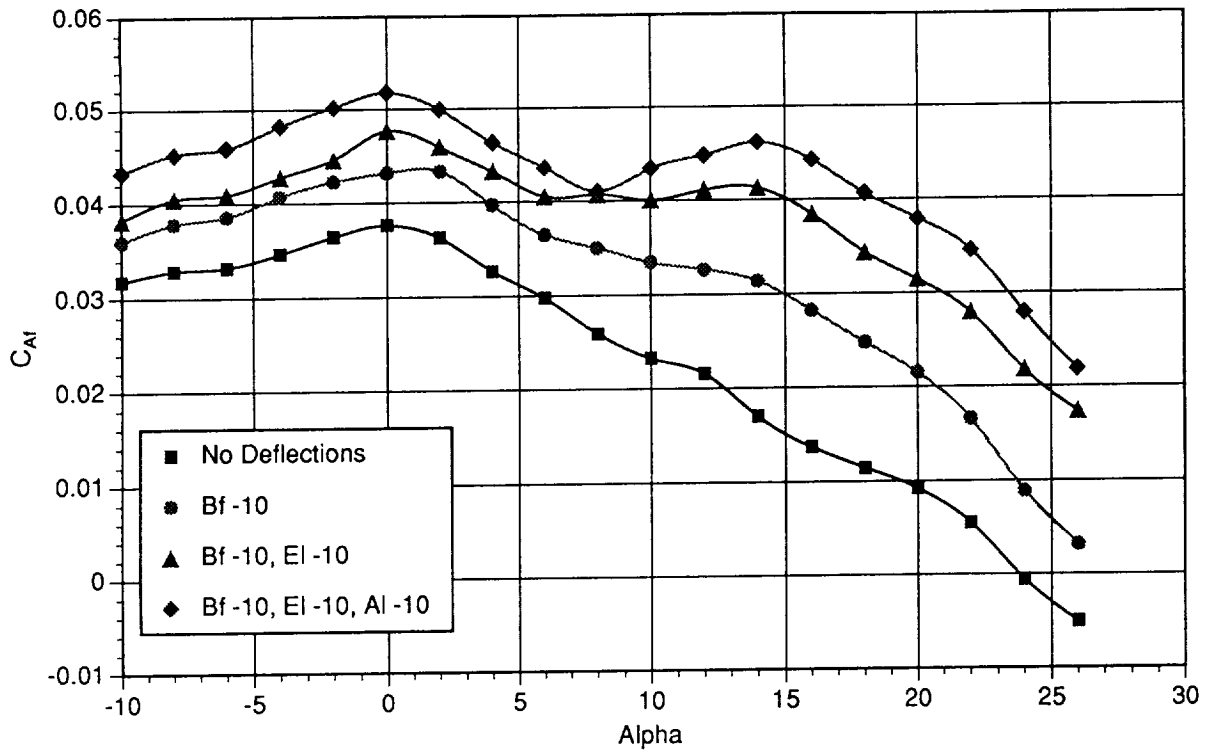


Figure 21. Mach 0.9,  $C_{Af}$  versus angle-of-attack.

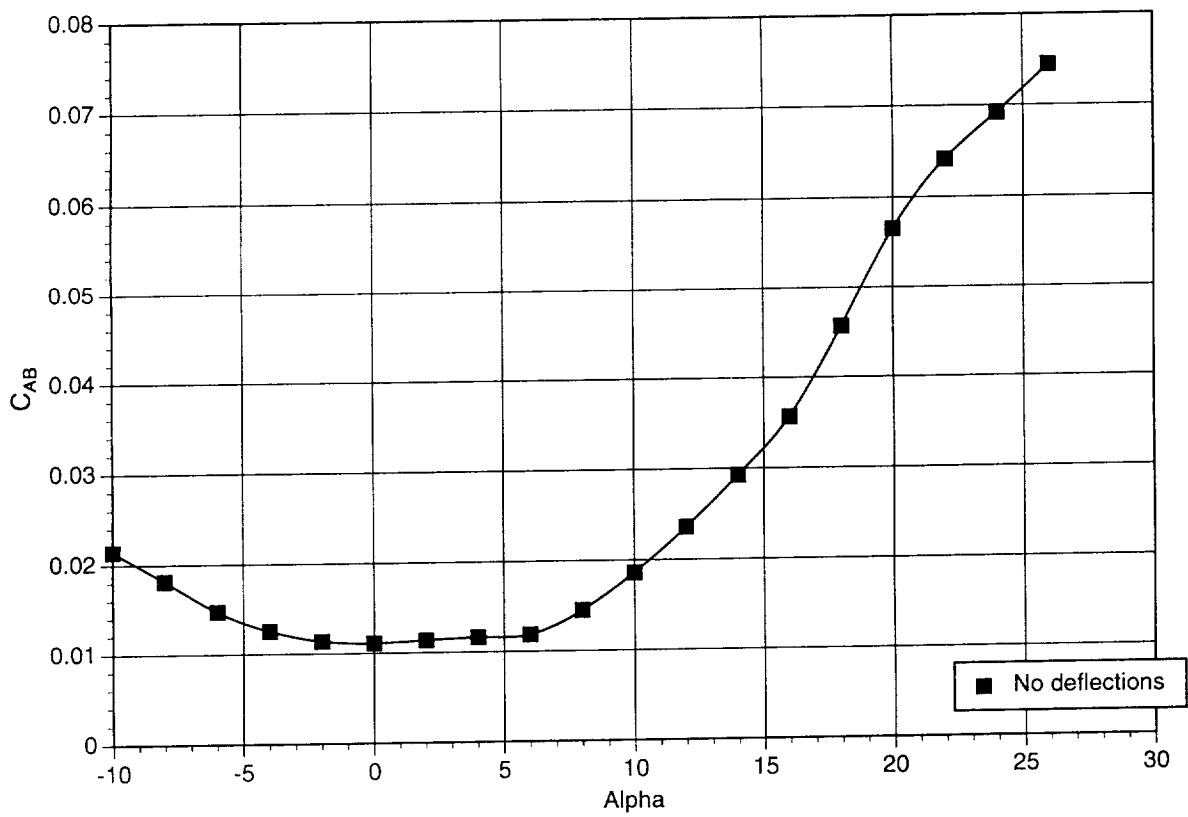


Figure 22. Mach 0.9,  $C_{AB}$  versus angle-of-attack.

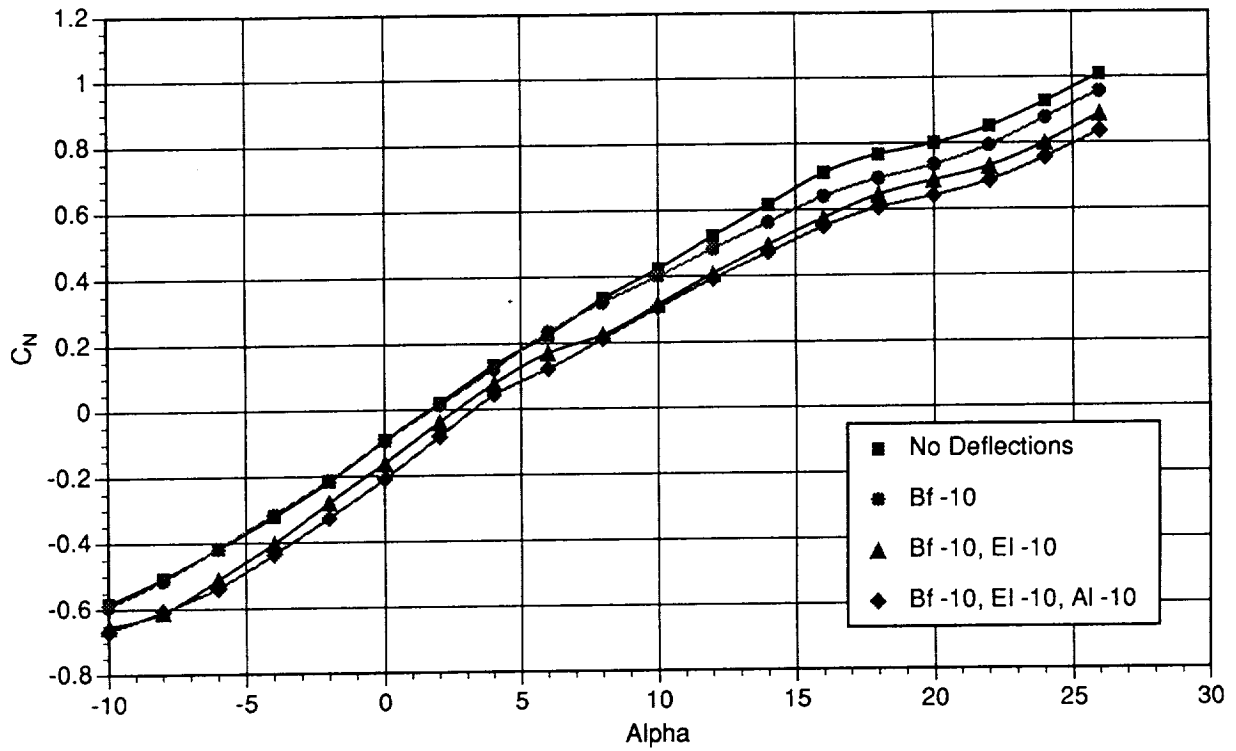


Figure 23. Mach 0.95,  $C_N$  versus angle-of-attack.

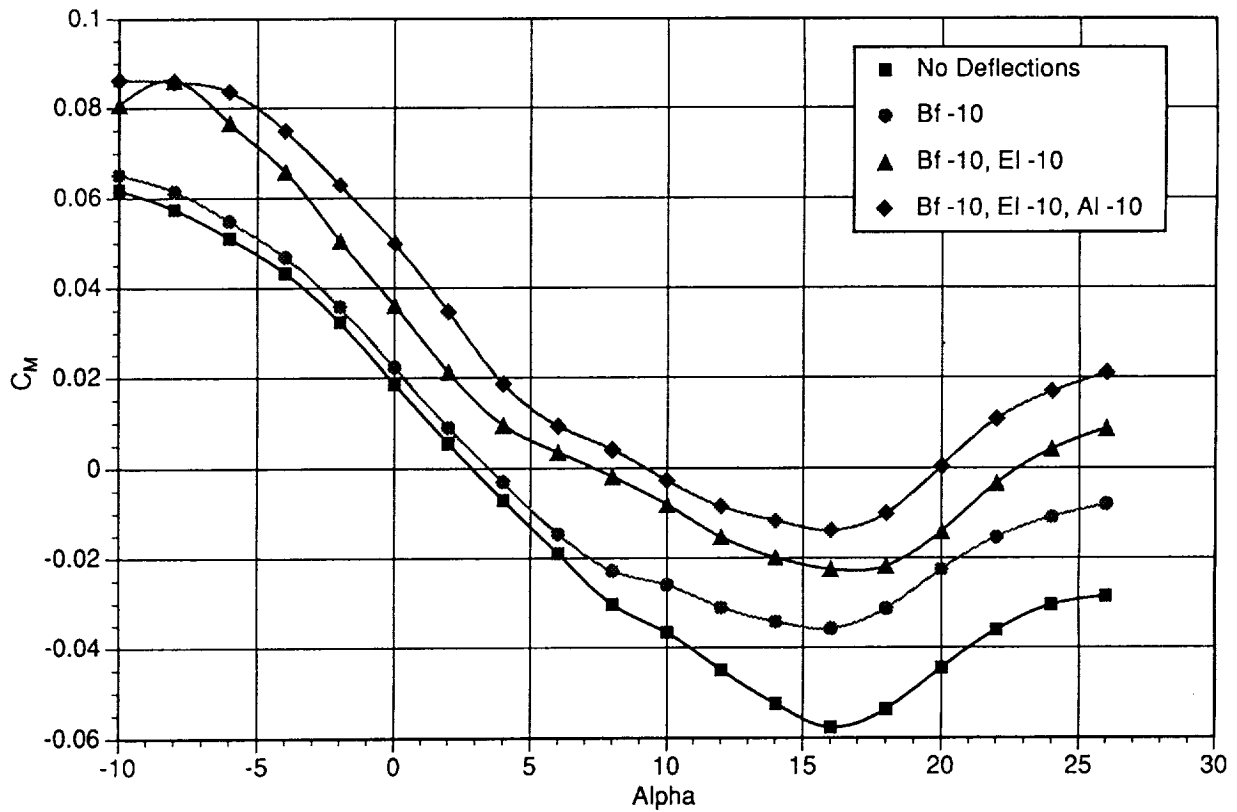


Figure 24. Mach 0.95,  $C_M$  versus angle-of-attack.



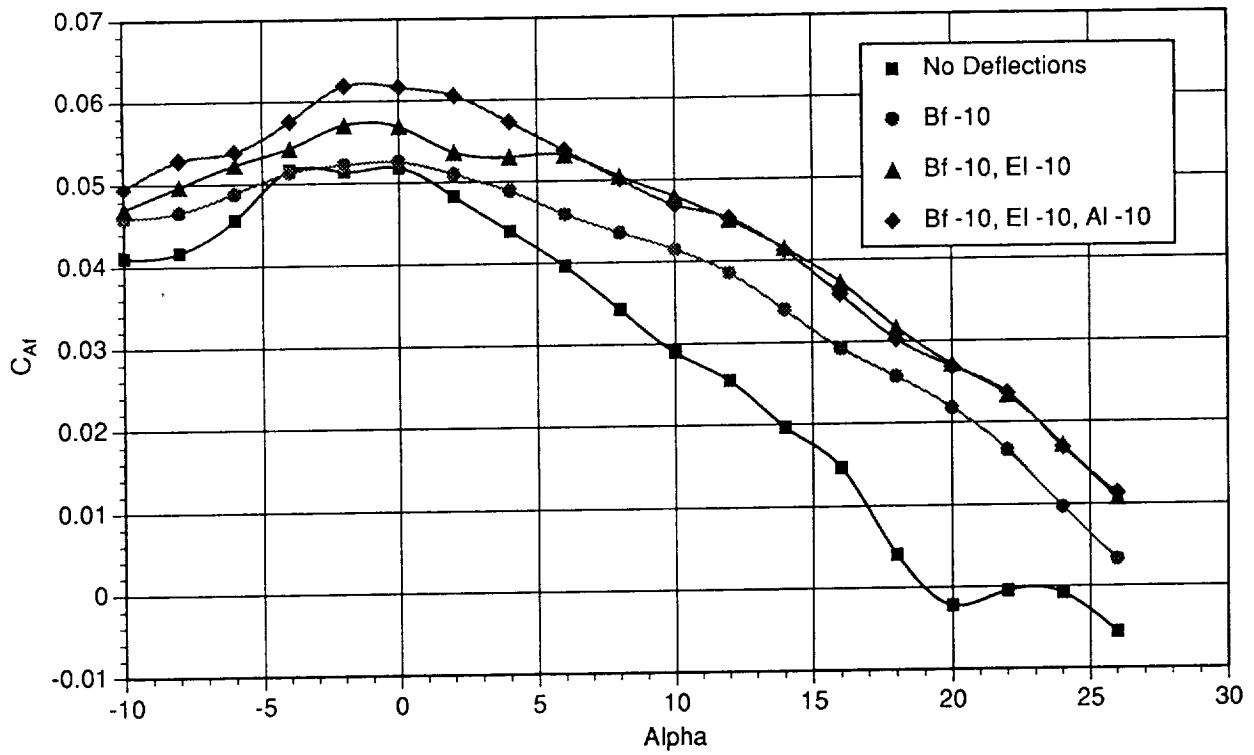


Figure 25. Mach 0.95,  $C_{Af}$  versus angle-of-attack.

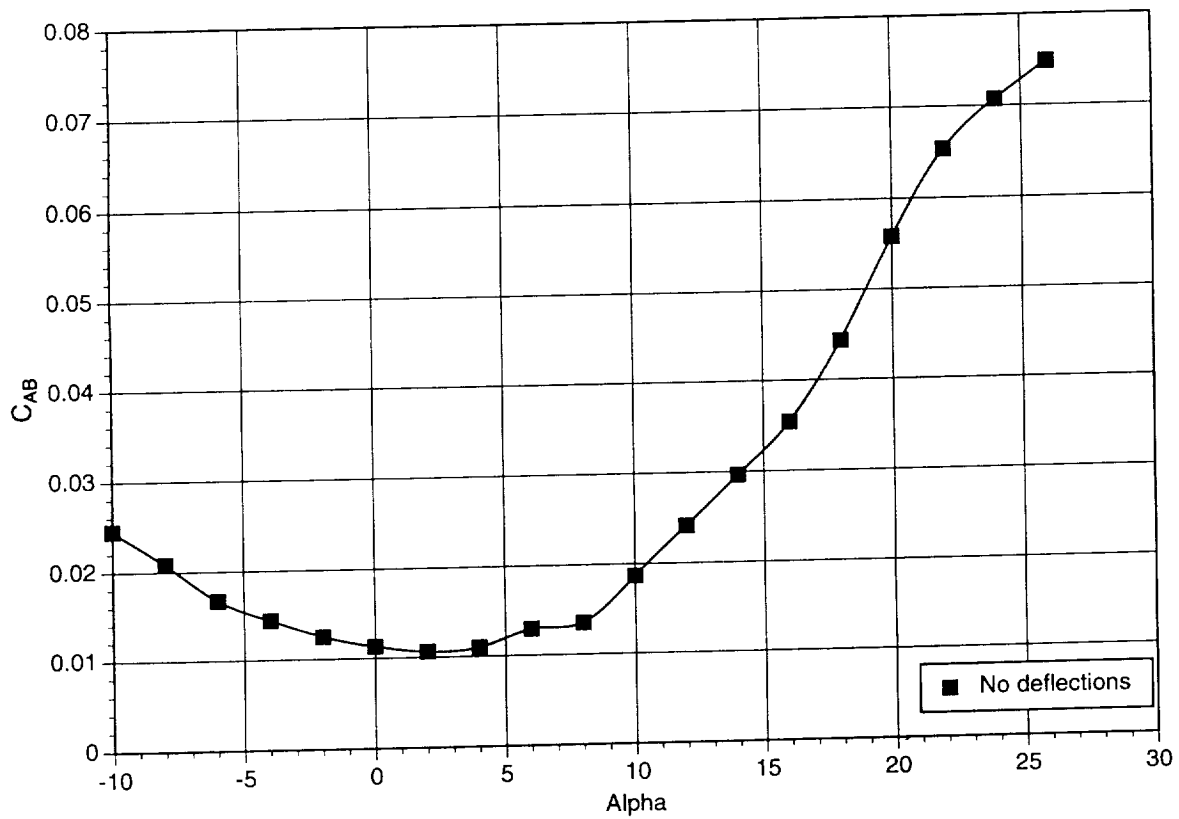


Figure 26. Mach 0.95,  $C_{AB}$  versus angle-of-attack.

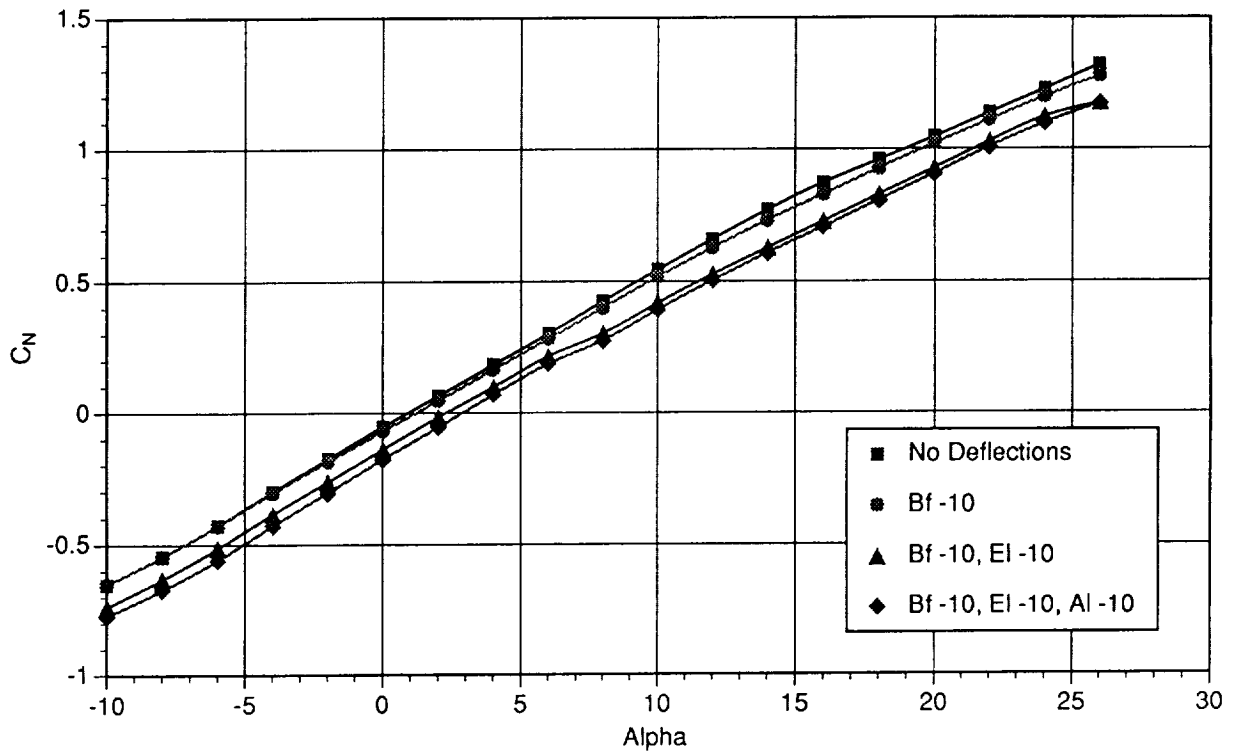


Figure 27. Mach 1.05,  $C_N$  versus angle-of-attack.

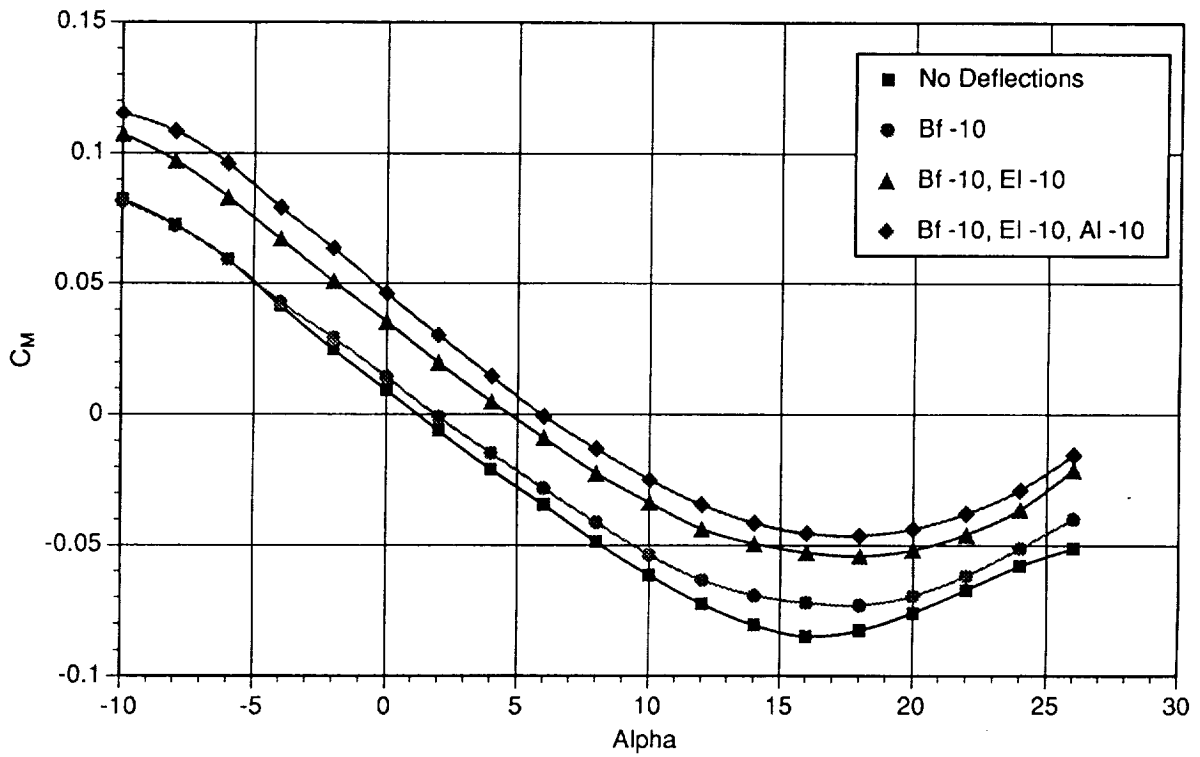


Figure 28. Mach 1.05,  $C_M$  versus angle-of-attack.

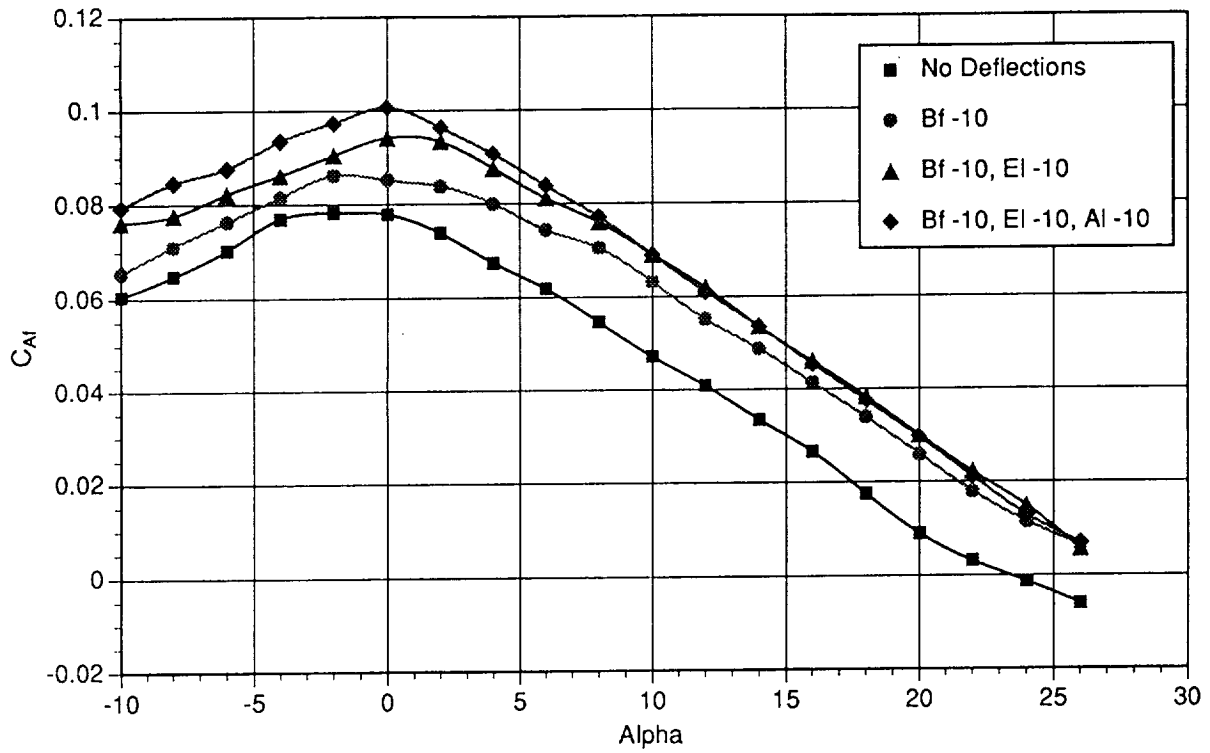


Figure 29. Mach 1.05,  $C_{Af}$  versus angle-of-attack.

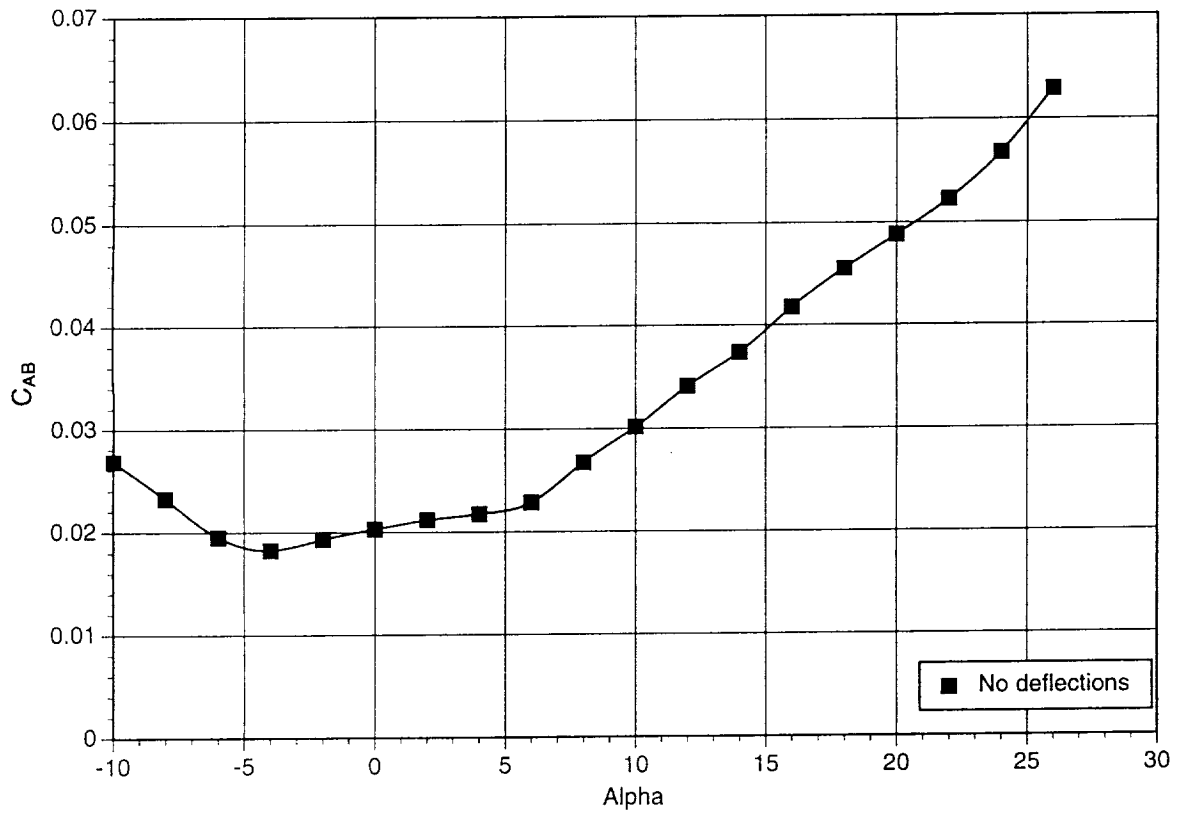


Figure 30. Mach 1.05,  $C_{AB}$  versus angle-of-attack.

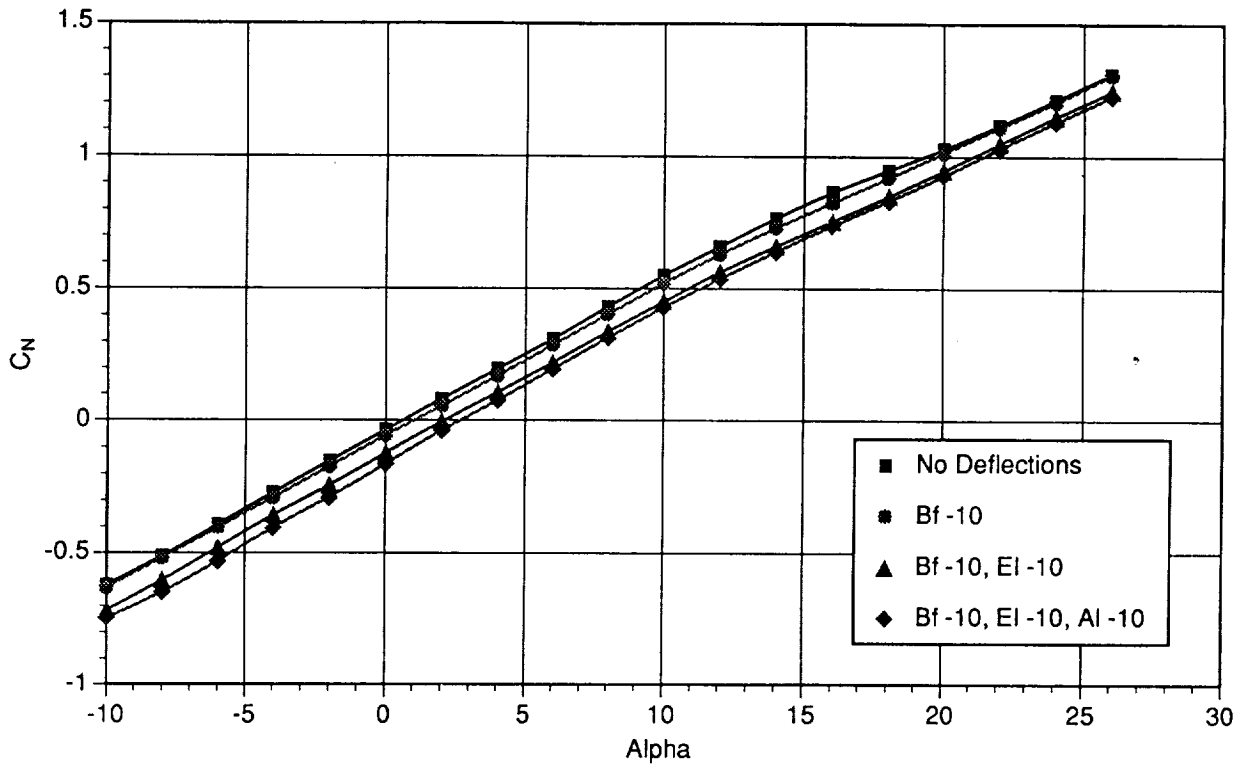


Figure 31. Mach 1.10,  $C_N$  versus angle-of-attack.

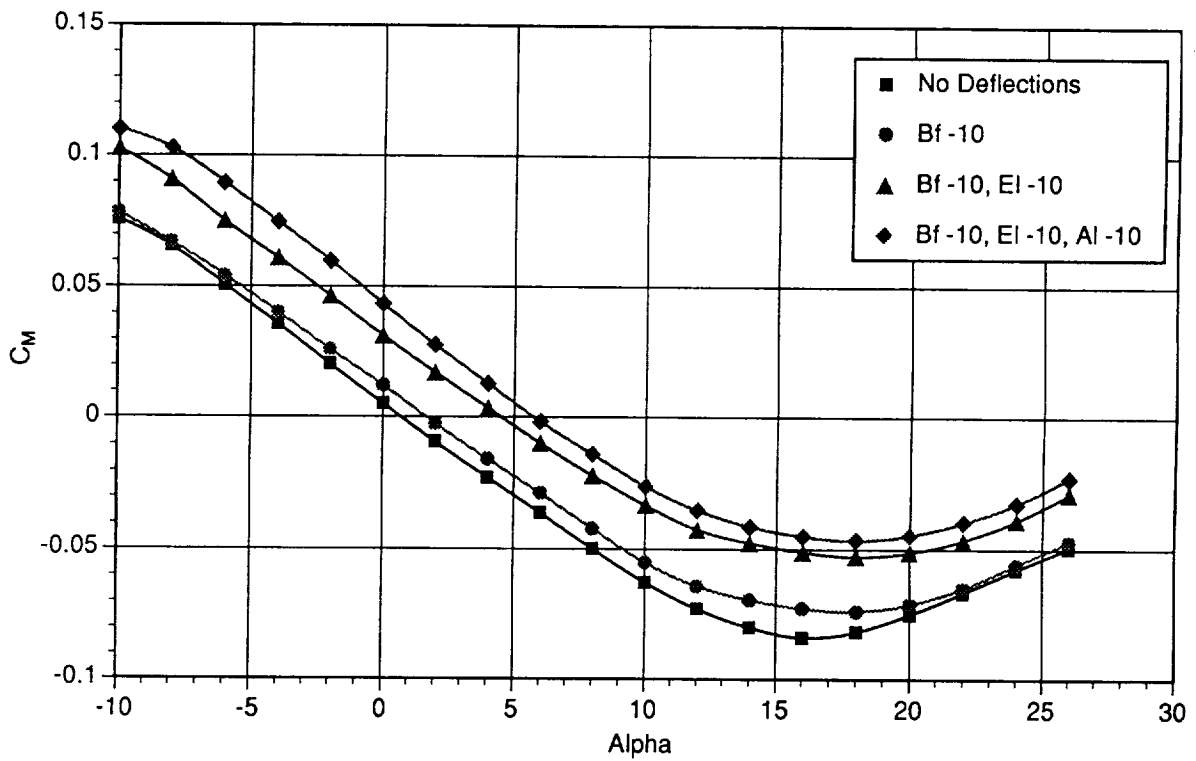


Figure 32. Mach 1.10,  $C_M$  versus angle-of-attack.

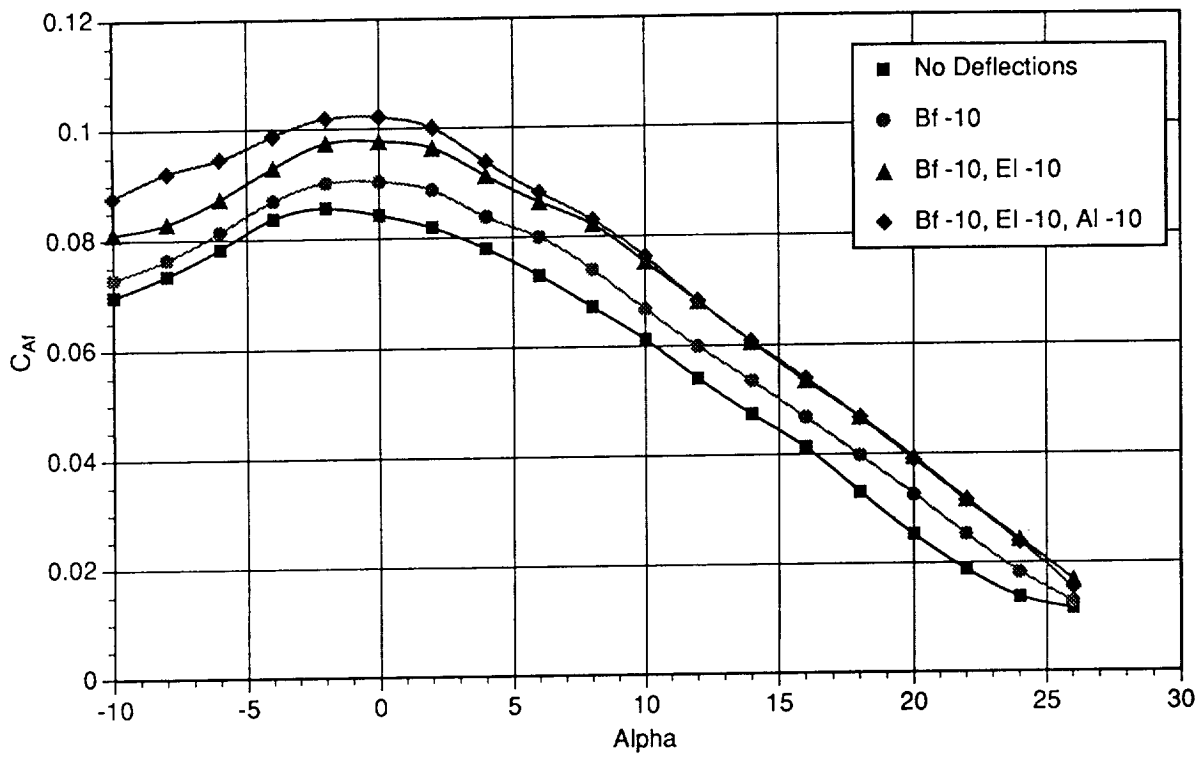


Figure 33. Mach 1.10,  $C_{Af}$  versus angle-of-attack.

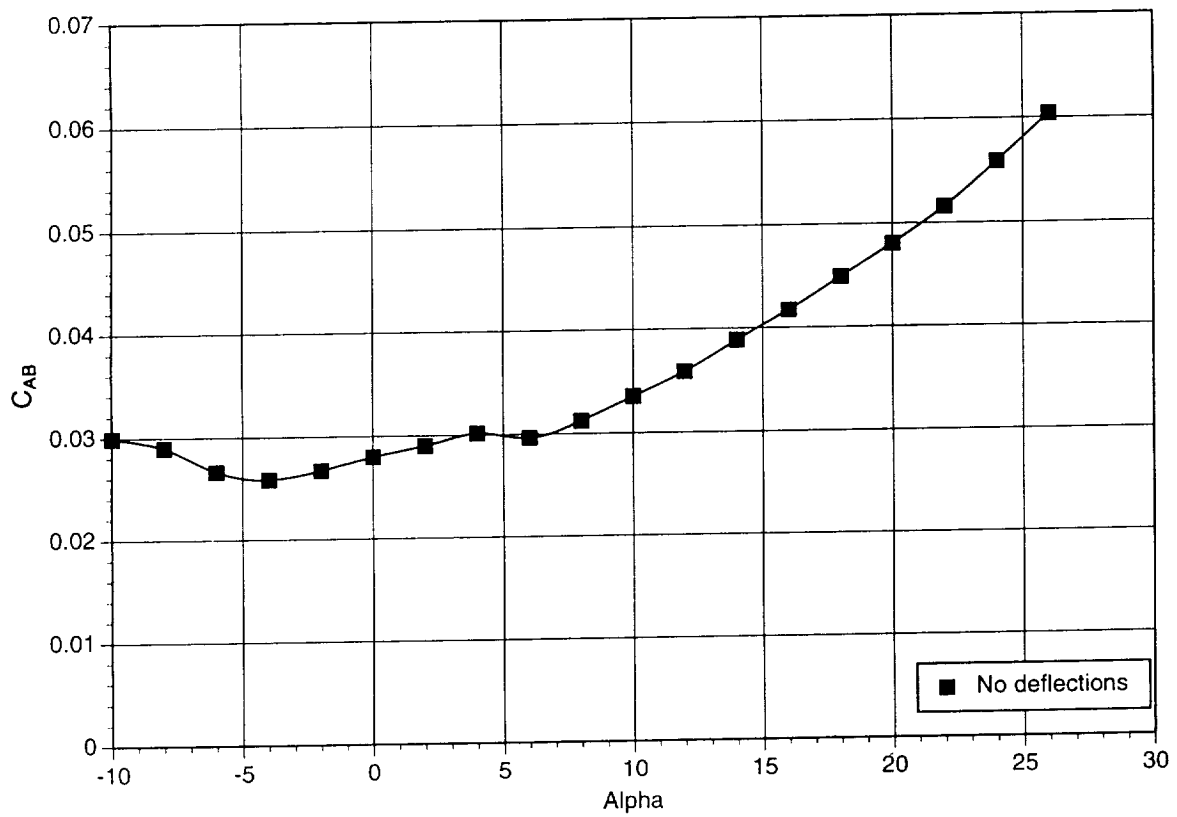


Figure 34. Mach 1.10,  $C_{AB}$  versus angle-of-attack.

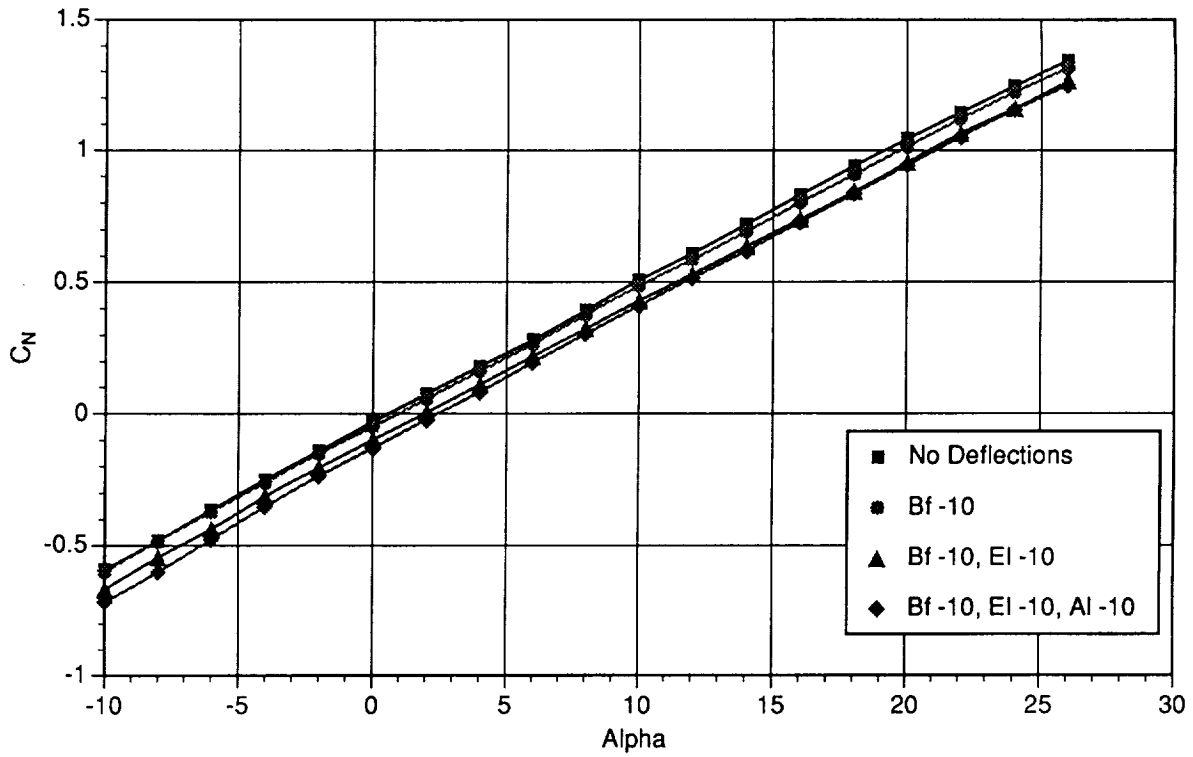


Figure 35. Mach 1.15,  $C_N$  versus angle-of-attack.

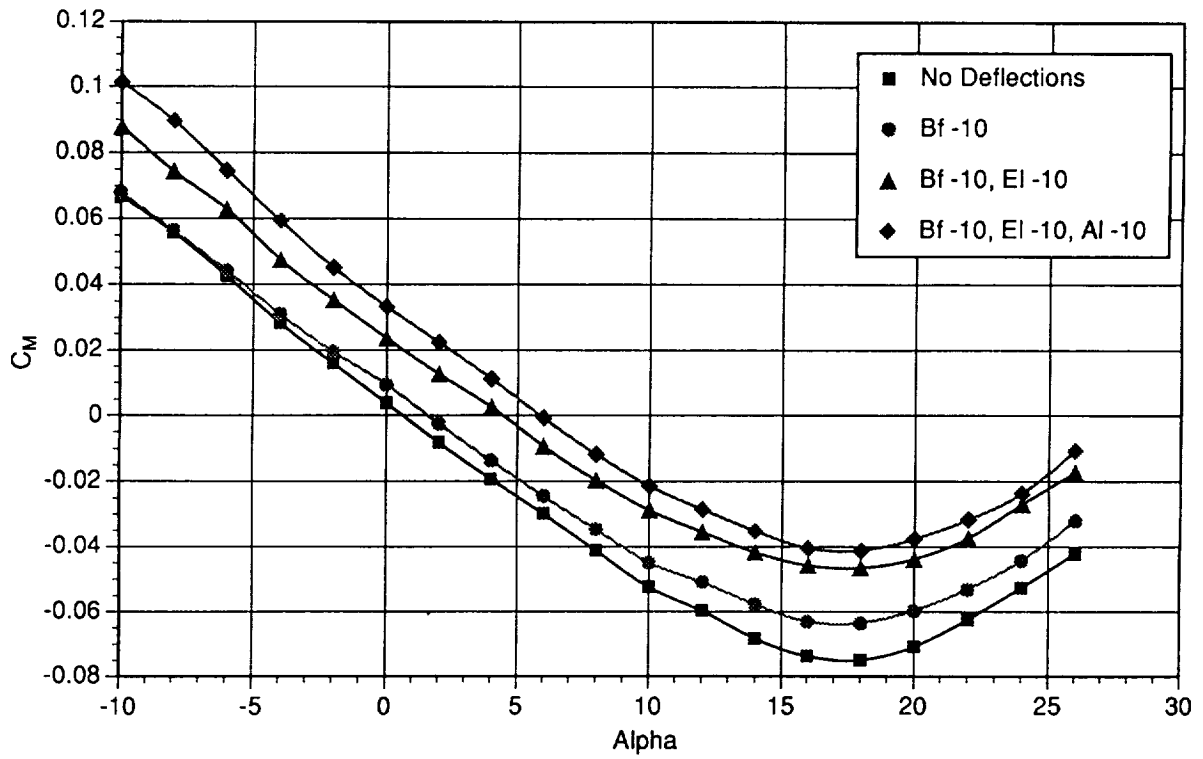


Figure 36. Mach 1.15,  $C_M$  versus angle-of-attack.

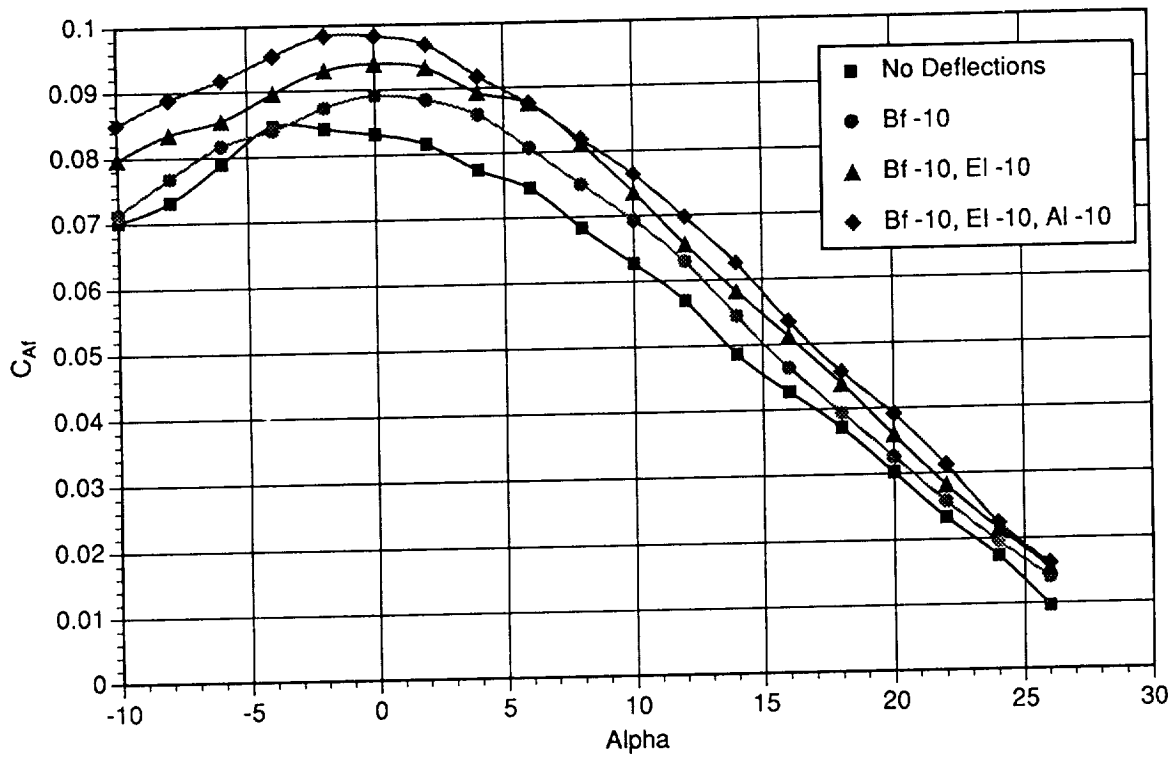


Figure 37. Mach 1.15,  $C_{Af}$  versus angle-of-attack.

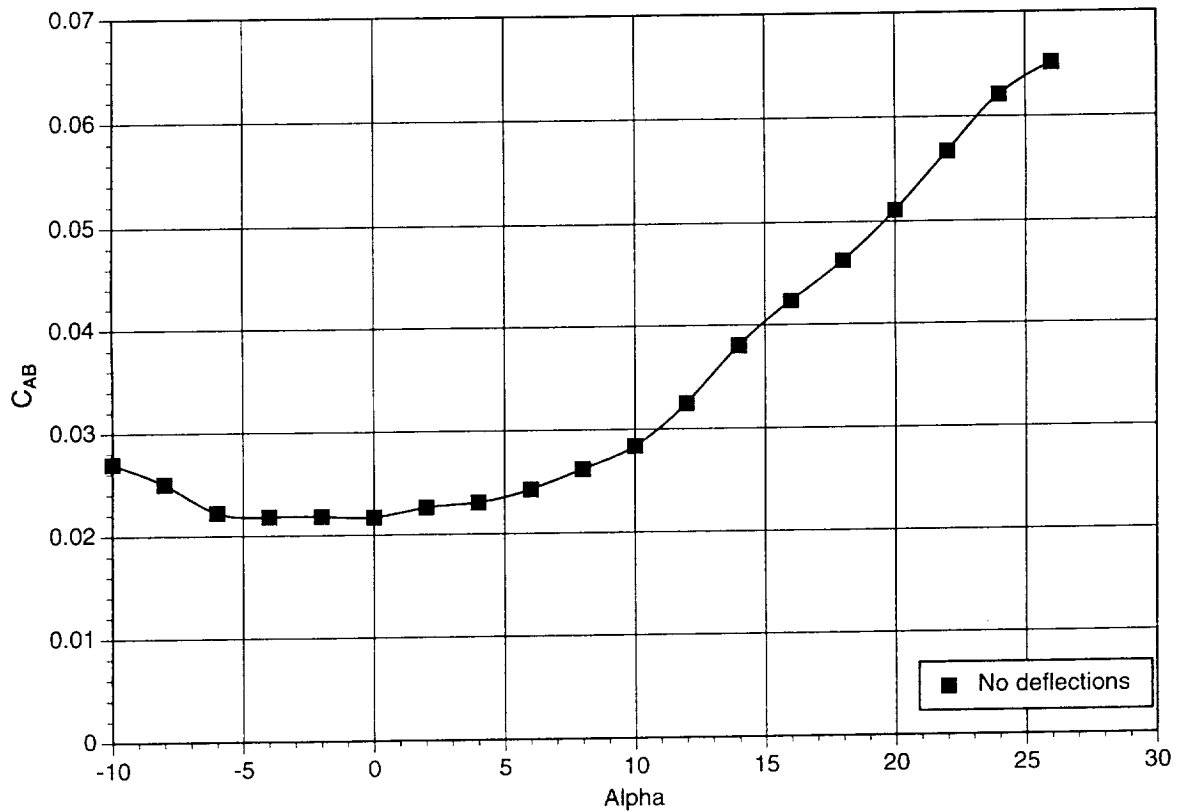


Figure 38. Mach 1.15,  $C_{AB}$  versus angle-of-attack.

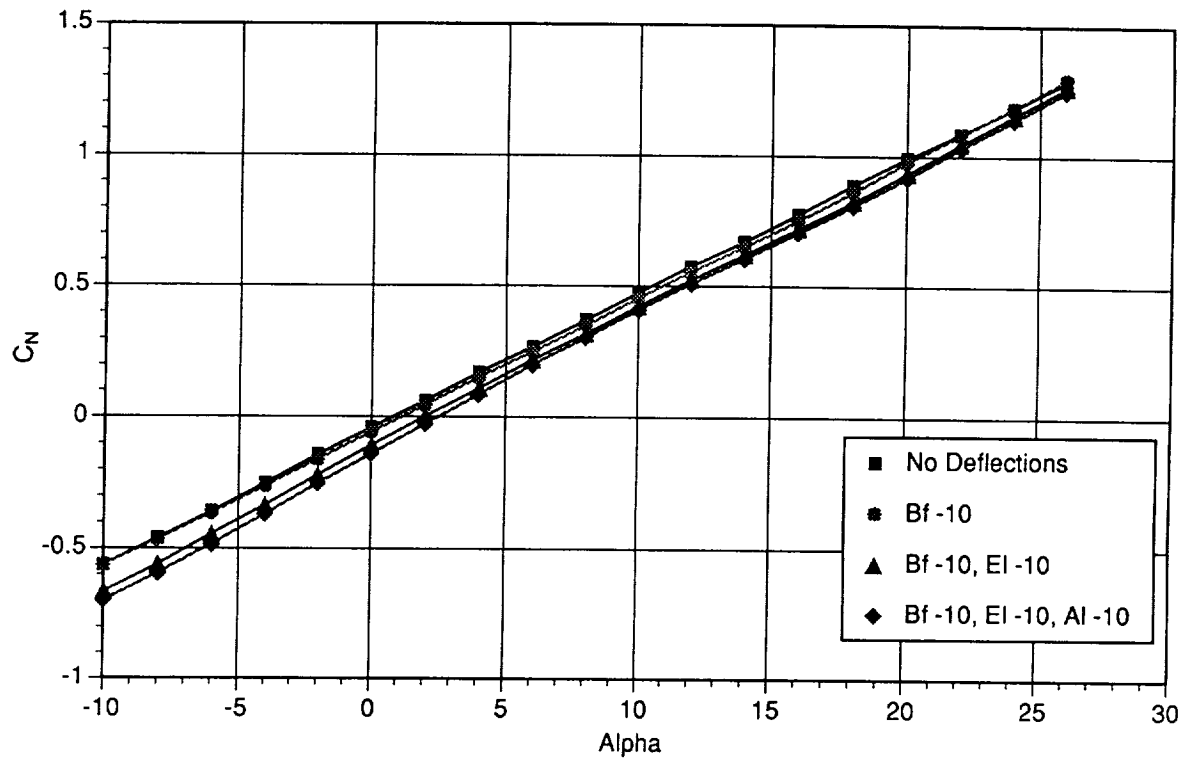


Figure 39. Mach 1.25,  $C_N$  versus angle-of-attack.

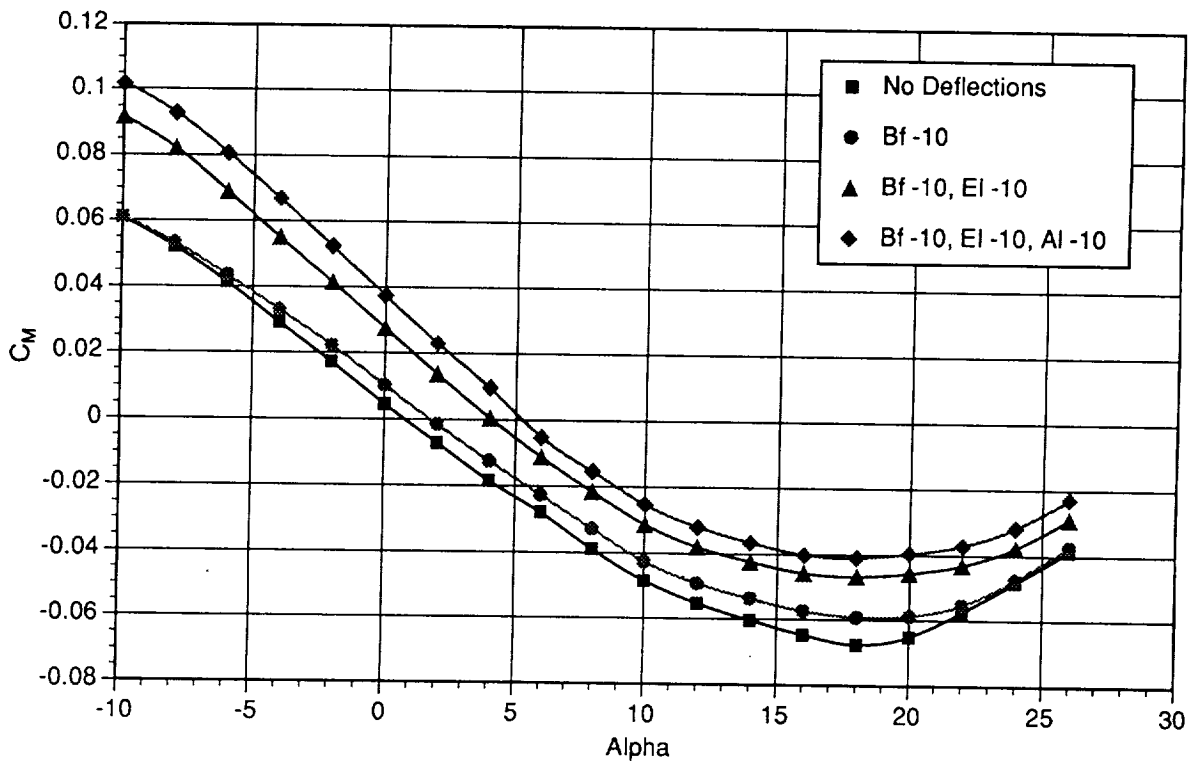


Figure 40. Mach 1.25,  $C_M$  versus angle-of-attack.



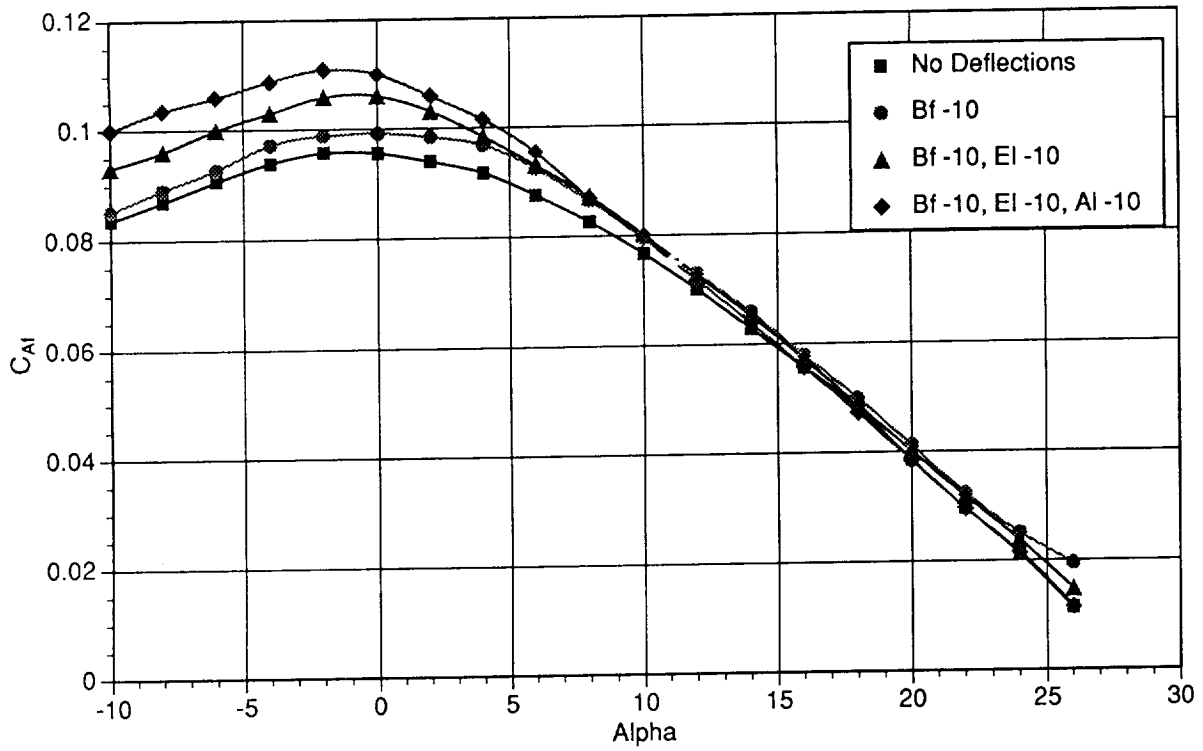


Figure 41. Mach 1.25,  $C_{Af}$  versus angle-of-attack.

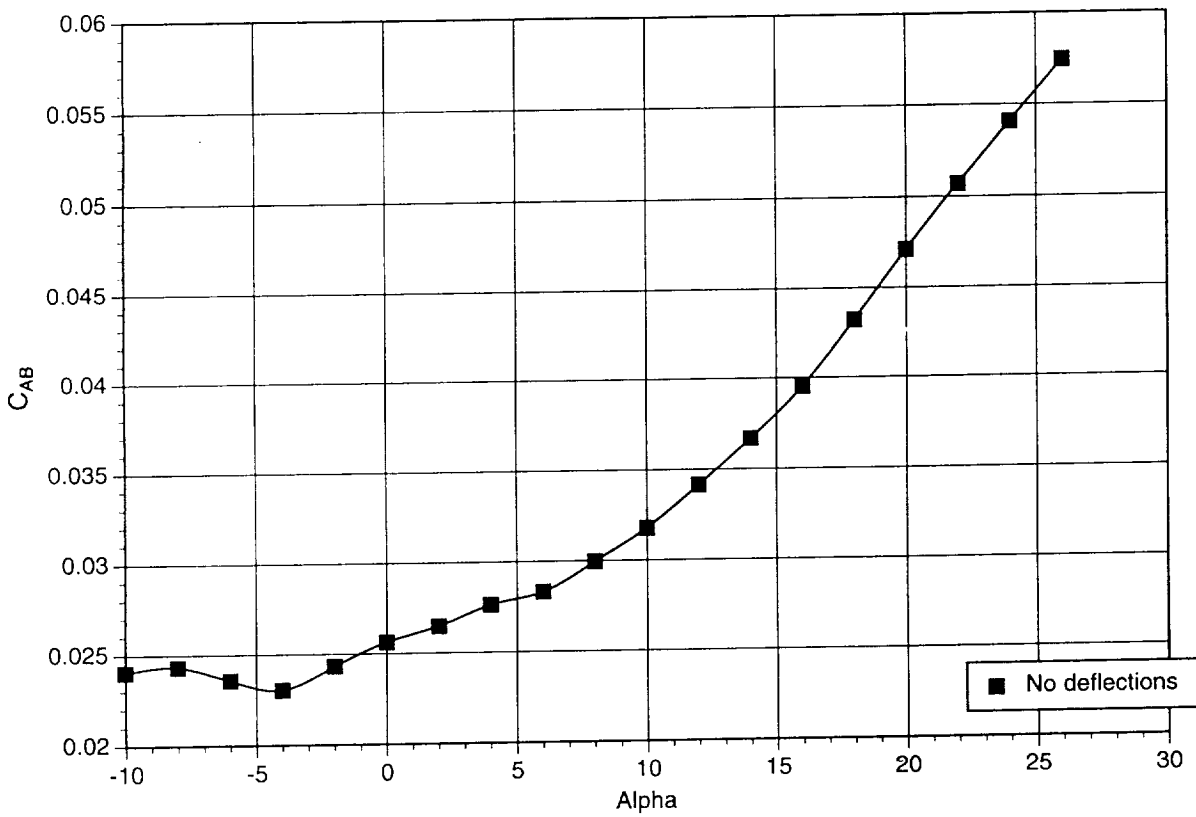


Figure 42. Mach 1.25,  $C_{AB}$  versus angle-of-attack.

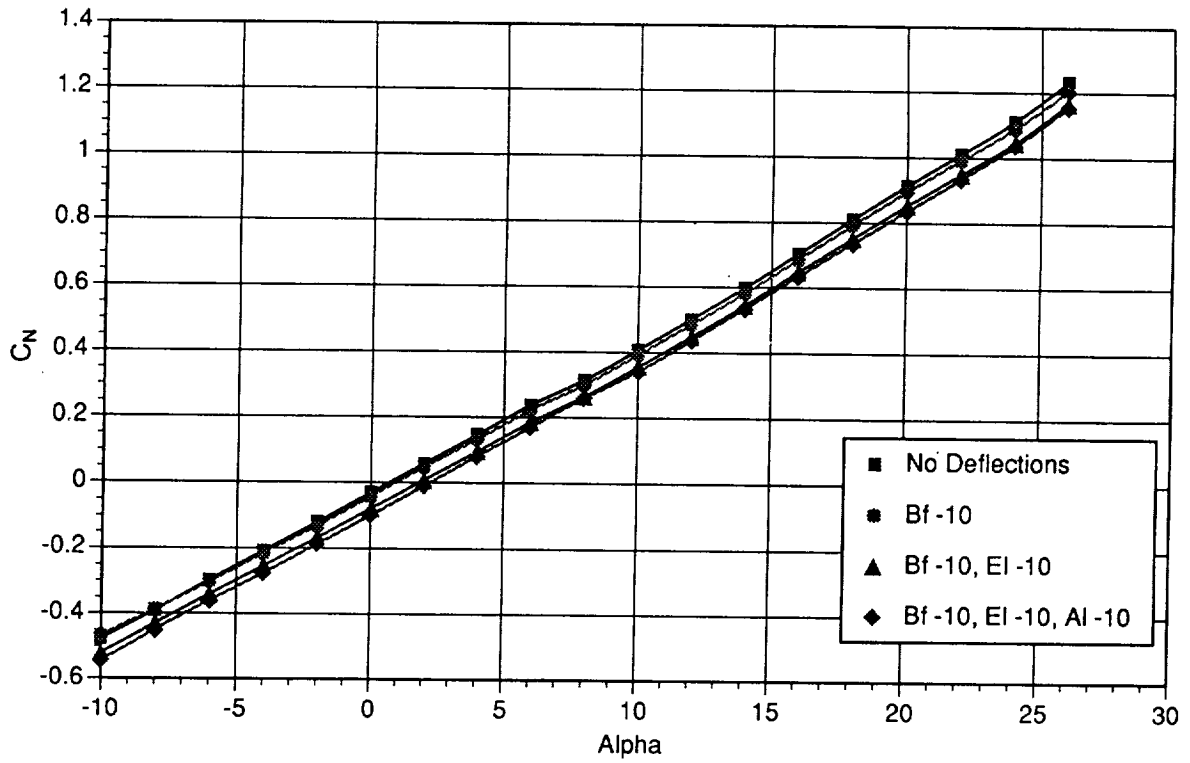


Figure 43. Mach 1.46,  $C_N$  versus angle-of-attack.

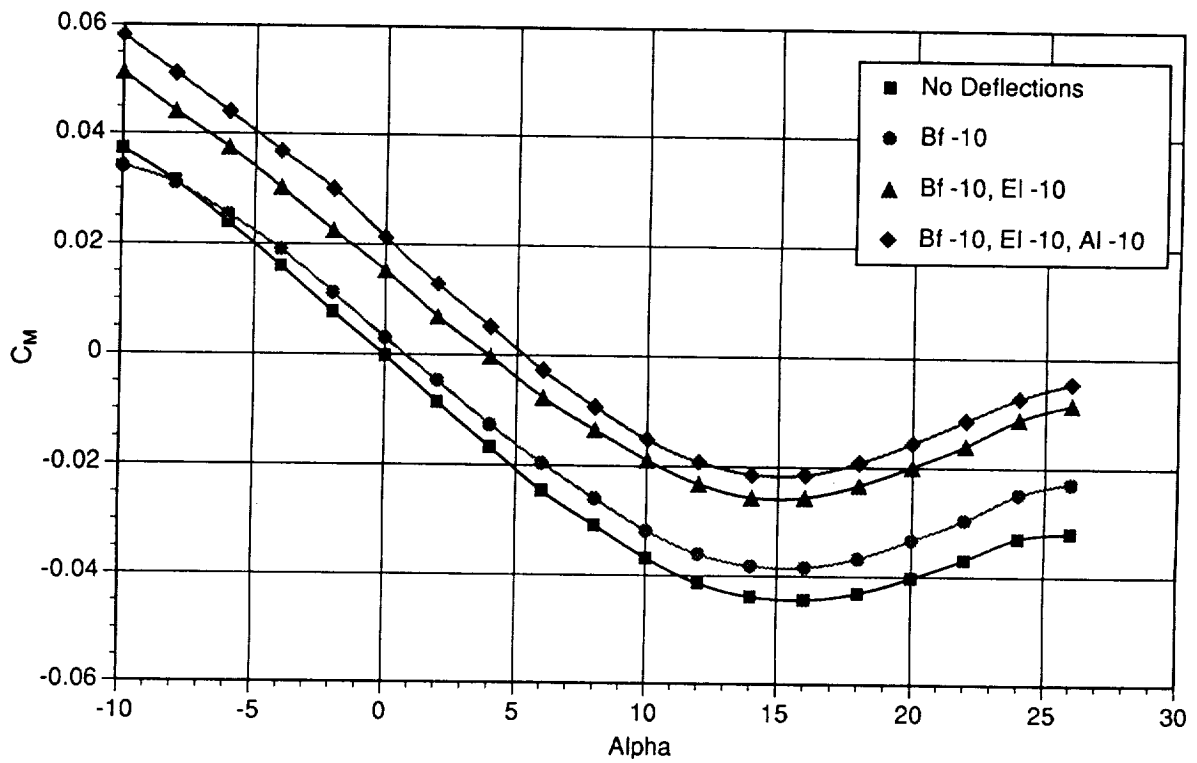


Figure 44. Mach 1.46,  $C_M$  versus angle-of-attack.

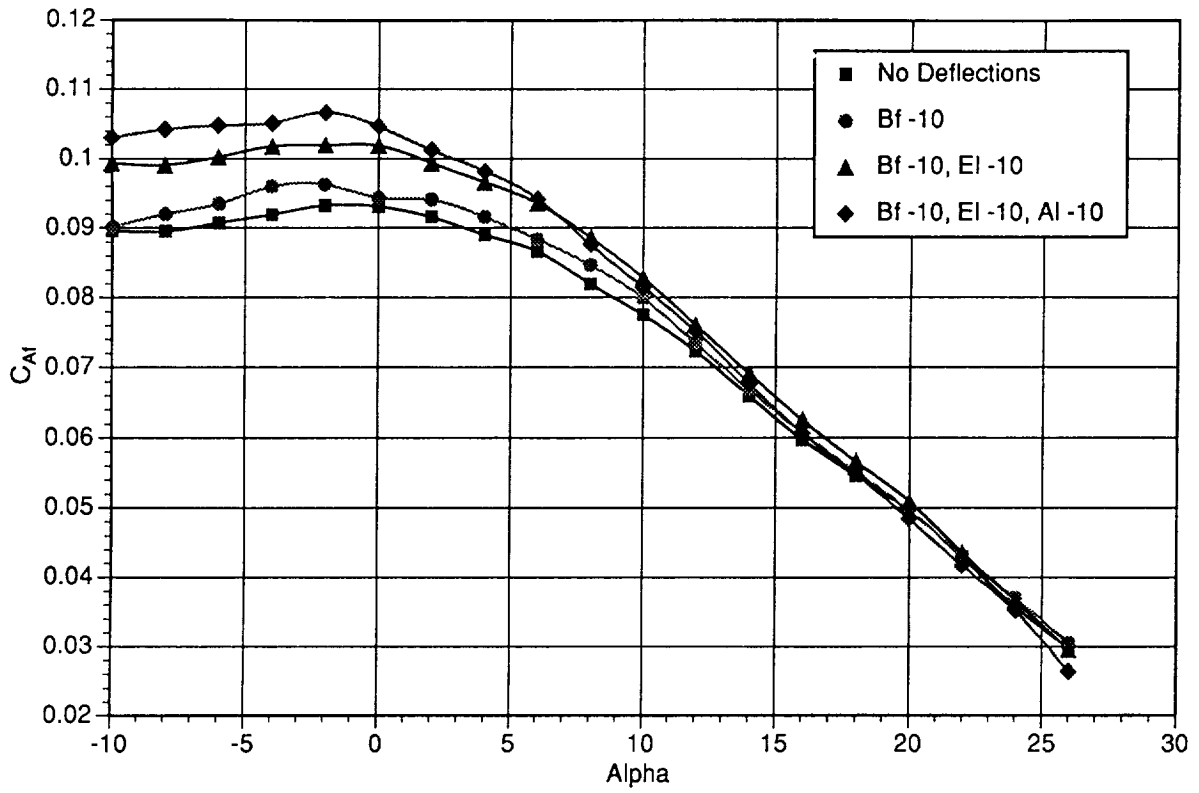


Figure 45. Mach 1.46,  $C_{Ai}$  versus angle-of-attack.

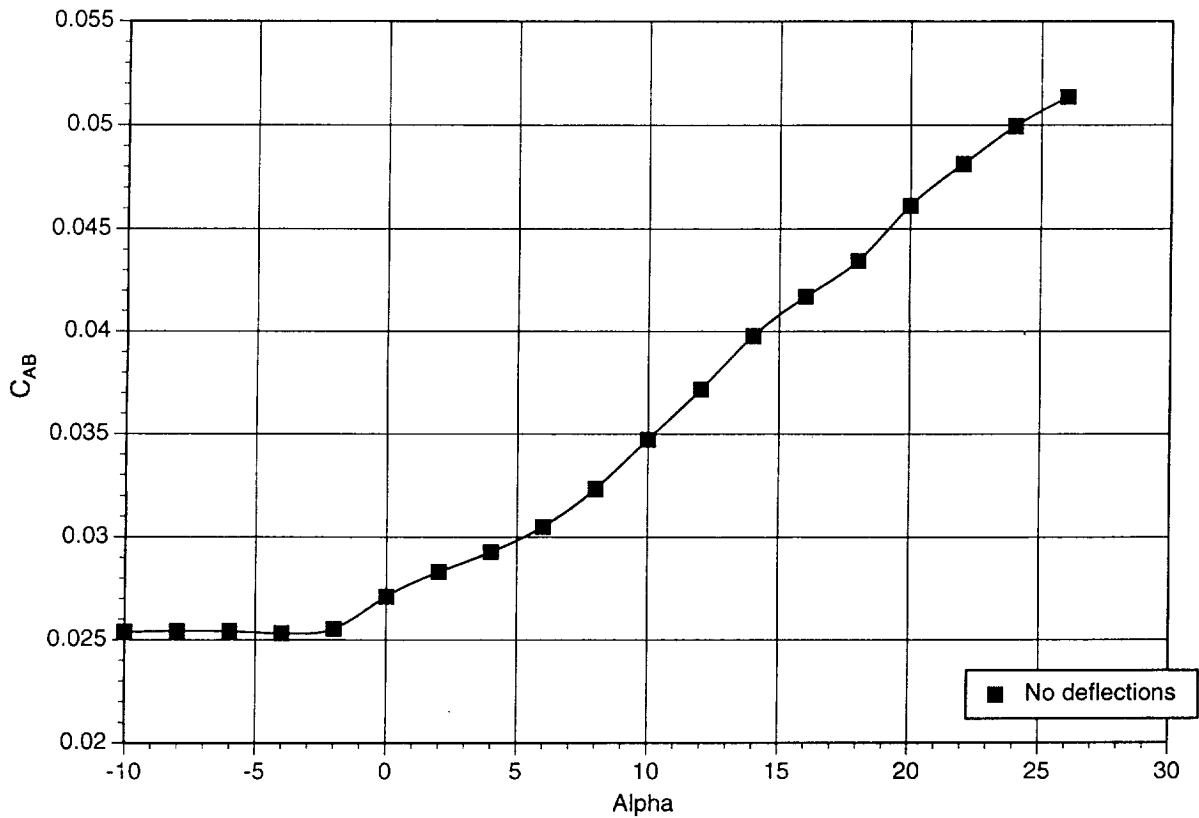


Figure 46. Mach 1.46,  $C_{AB}$  versus angle-of-attack.

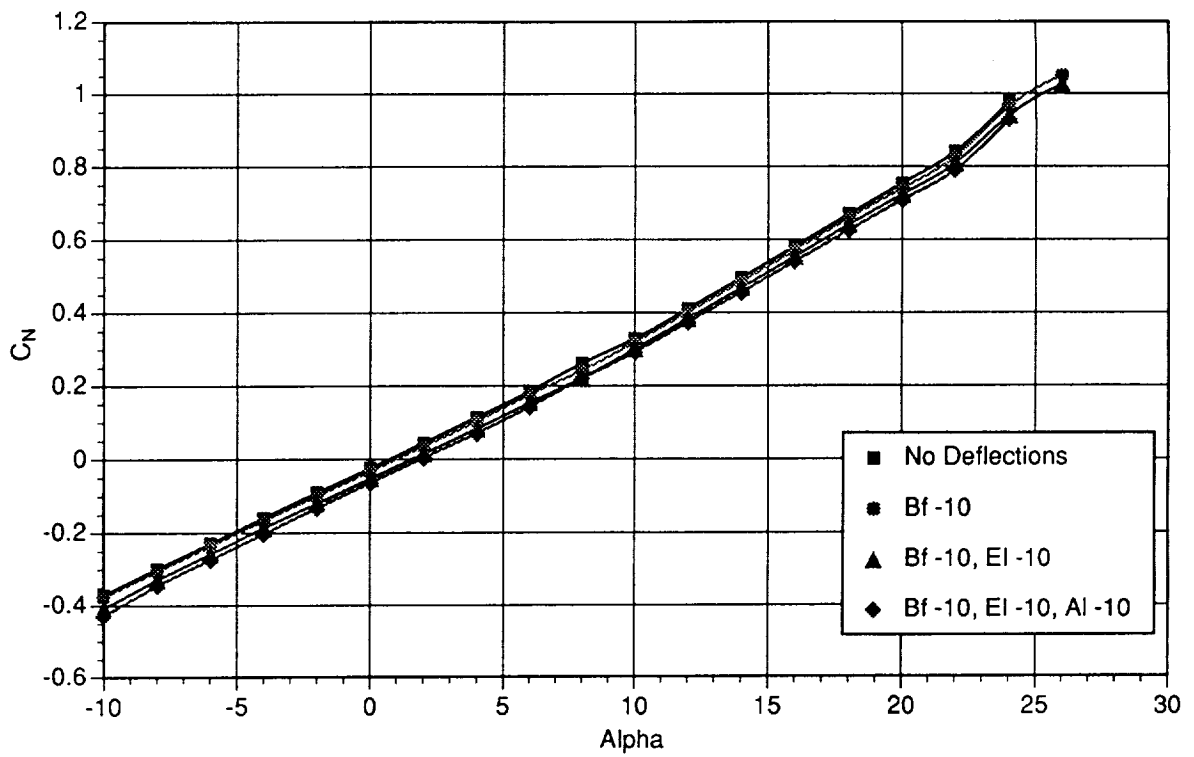


Figure 47. Mach 1.96,  $C_N$  versus angle-of-attack.

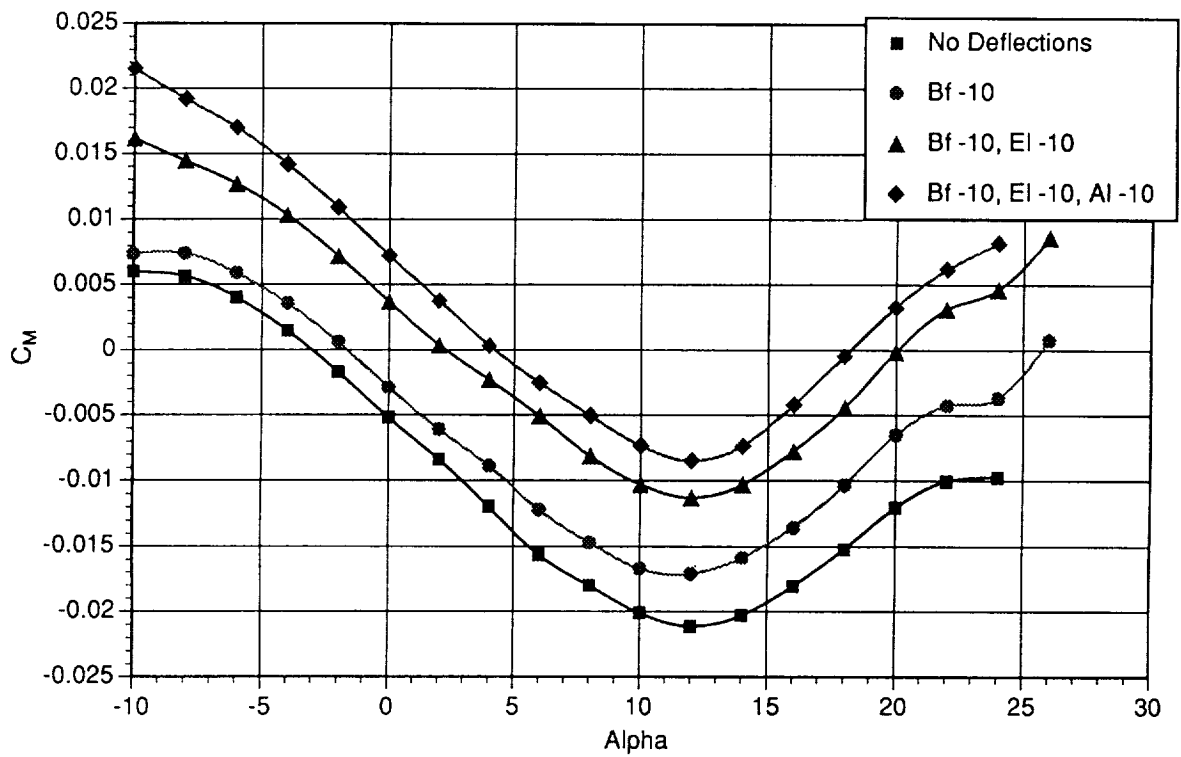


Figure 48. Mach 1.96,  $C_M$  versus angle-of-attack.

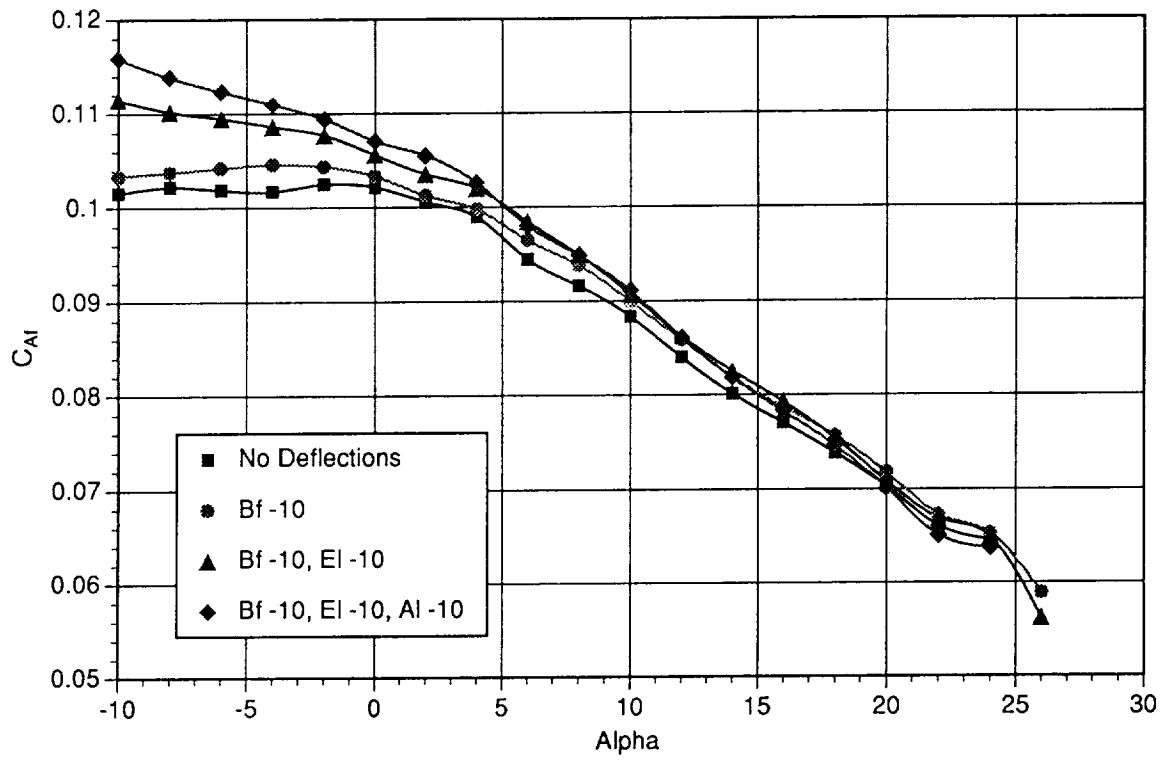


Figure 49. Mach 1.96,  $C_{Af}$  versus angle-of-attack.

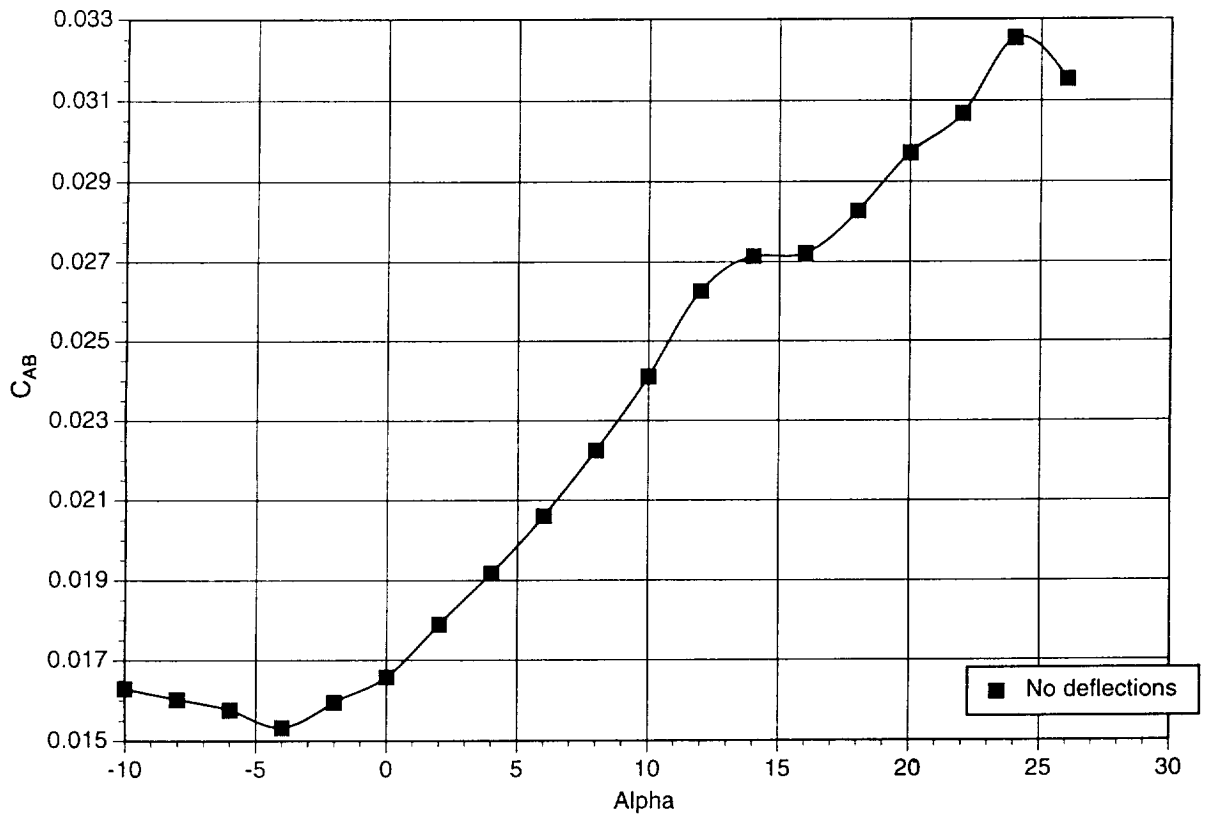


Figure 50. Mach 1.96,  $C_{AB}$  versus angle-of-attack.



**SECTION II. LATERAL AERODYNAMIC CHARACTERISTICS  
AND TIP FIN DEFLECTIONS**

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35

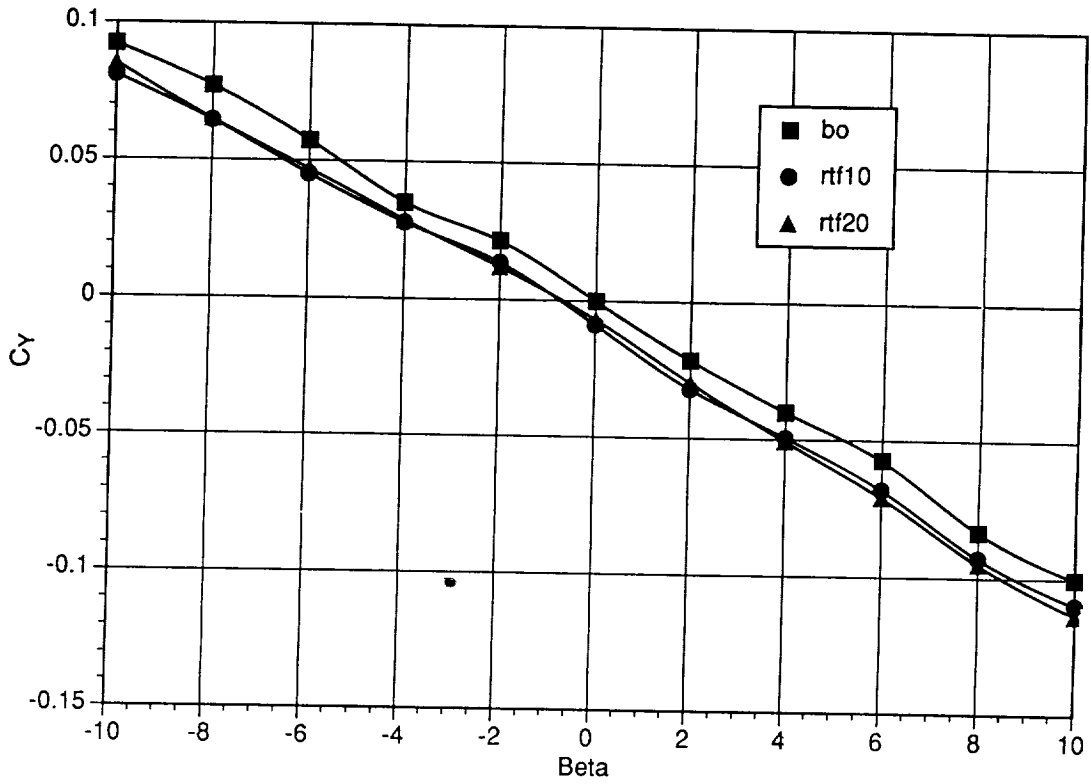


Figure 51. Mach 0.3,  $C_y$  versus angle-of-sideslip.

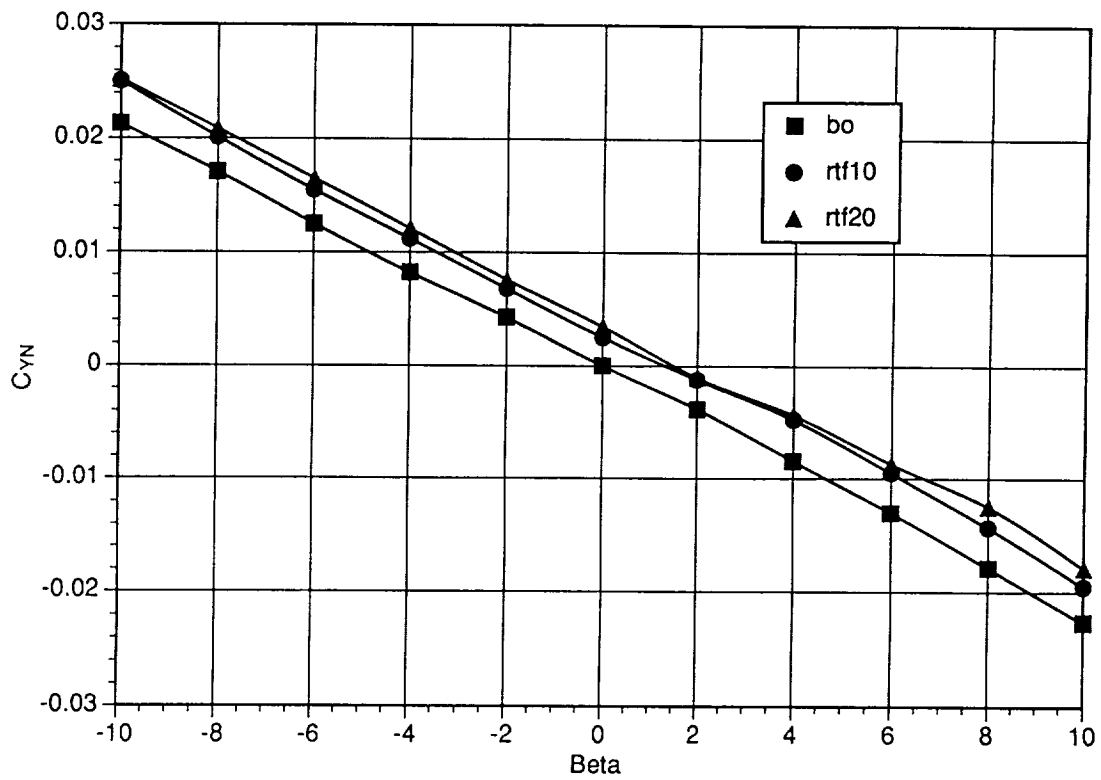


Figure 52. Mach 0.3,  $C_{YN}$  versus angle-of-sideslip.



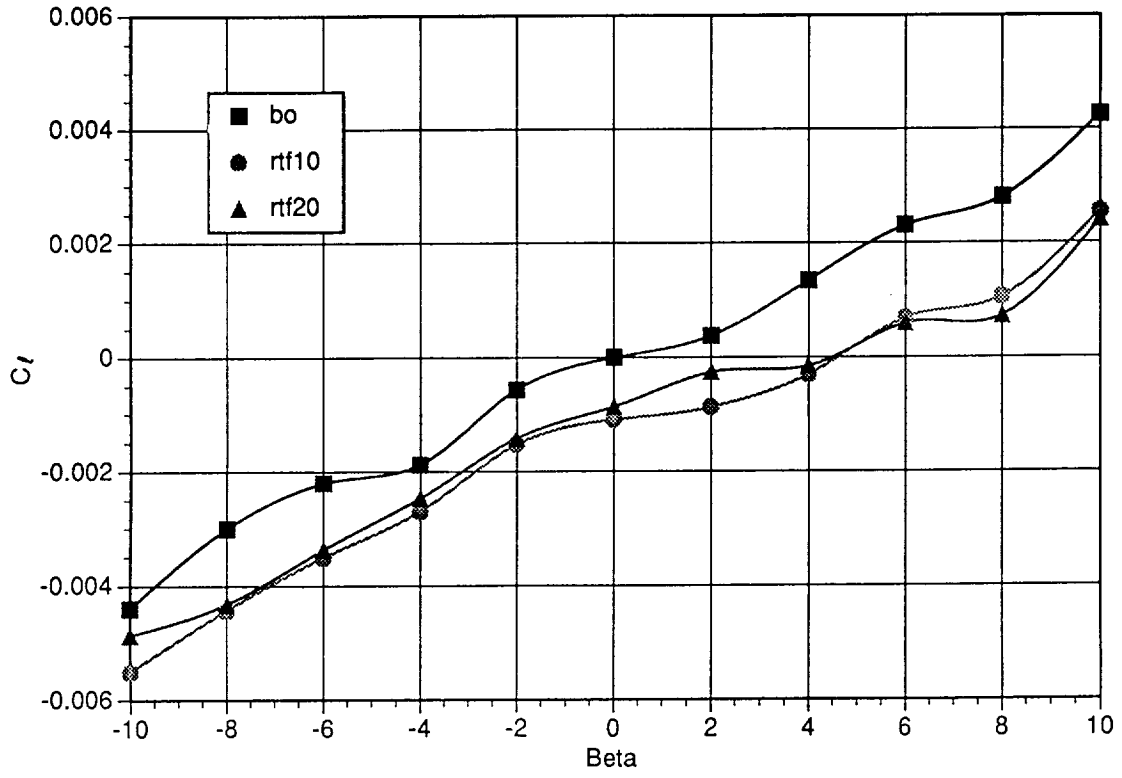


Figure 53. Mach 0.3,  $C_l$  versus angle-of-sideslip.

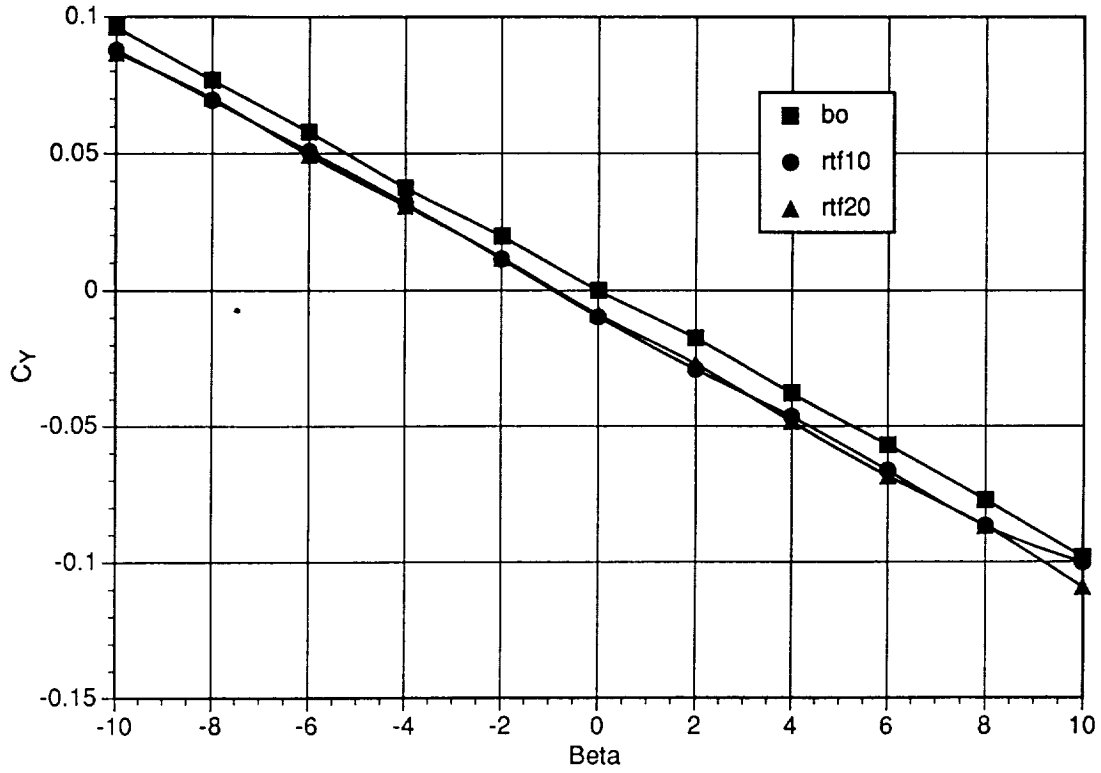


Figure 54. Mach 0.6,  $C_Y$  versus angle-of-sideslip.

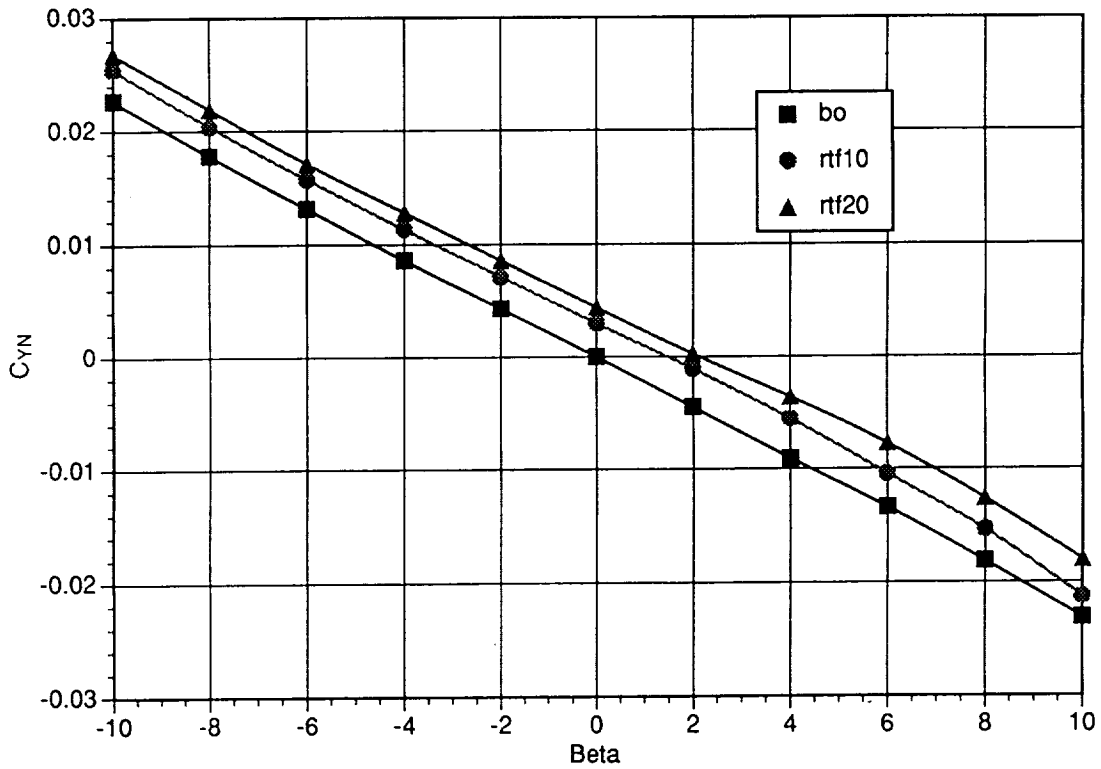


Figure 55. Mach 0.6,  $C_{YN}$  versus angle-of-sideslip.

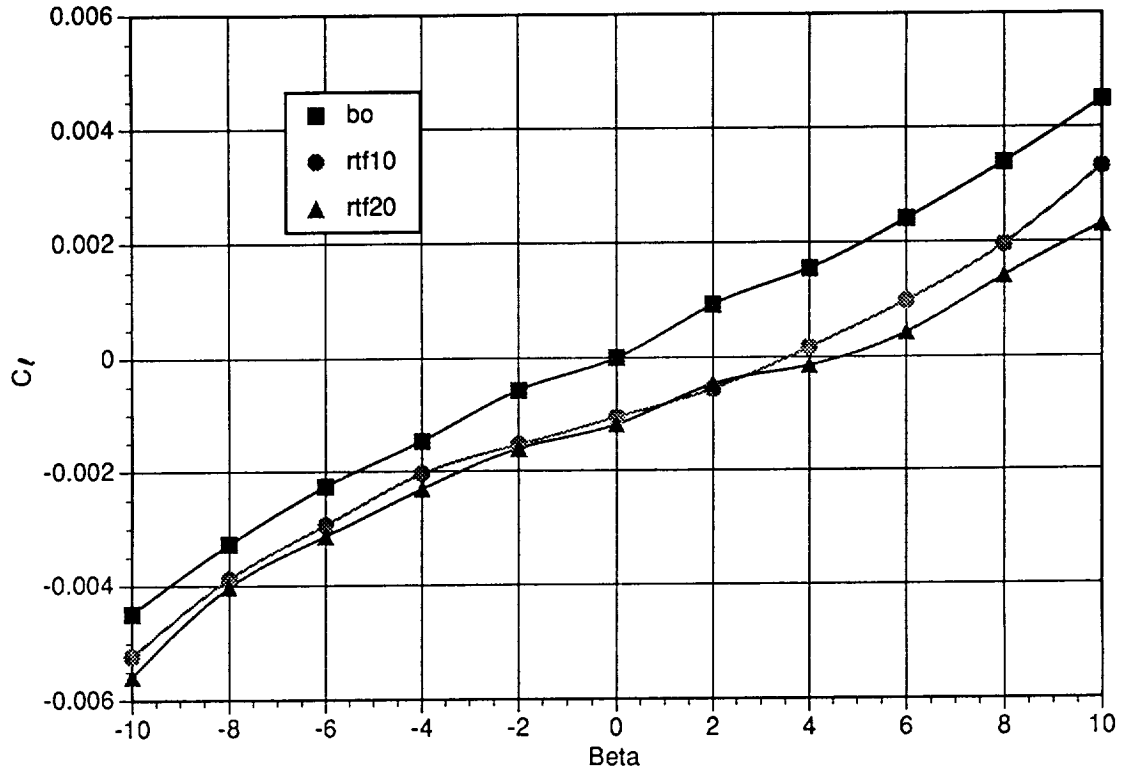


Figure 56. Mach 0.6,  $C_l$  versus angle-of-sideslip.

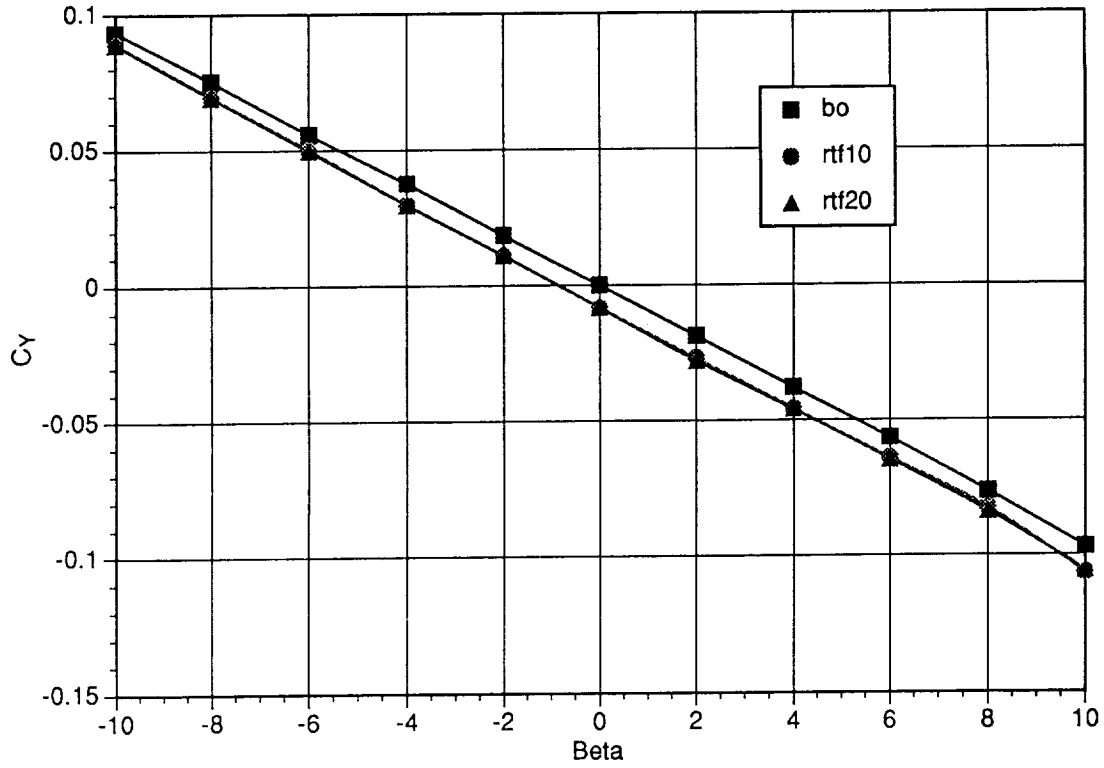


Figure 57. Mach 0.8,  $C_Y$  versus angle-of-sideslip.

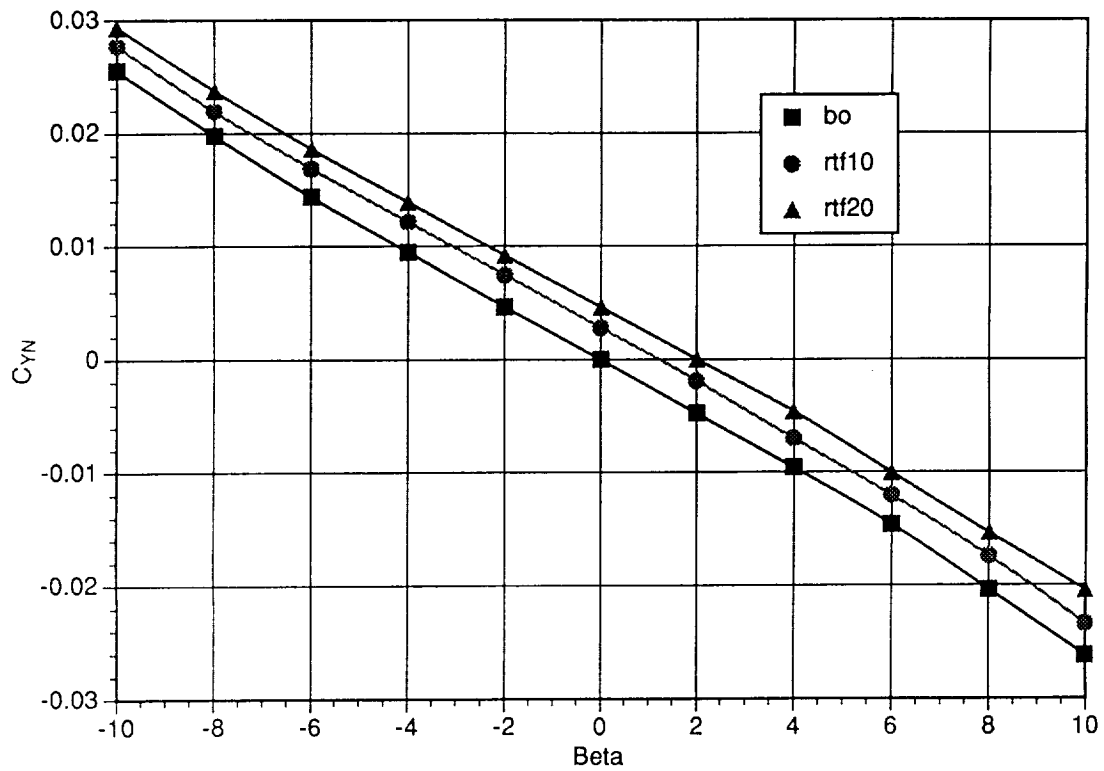


Figure 58. Mach 0.8,  $C_{YN}$  versus angle-of-sideslip.

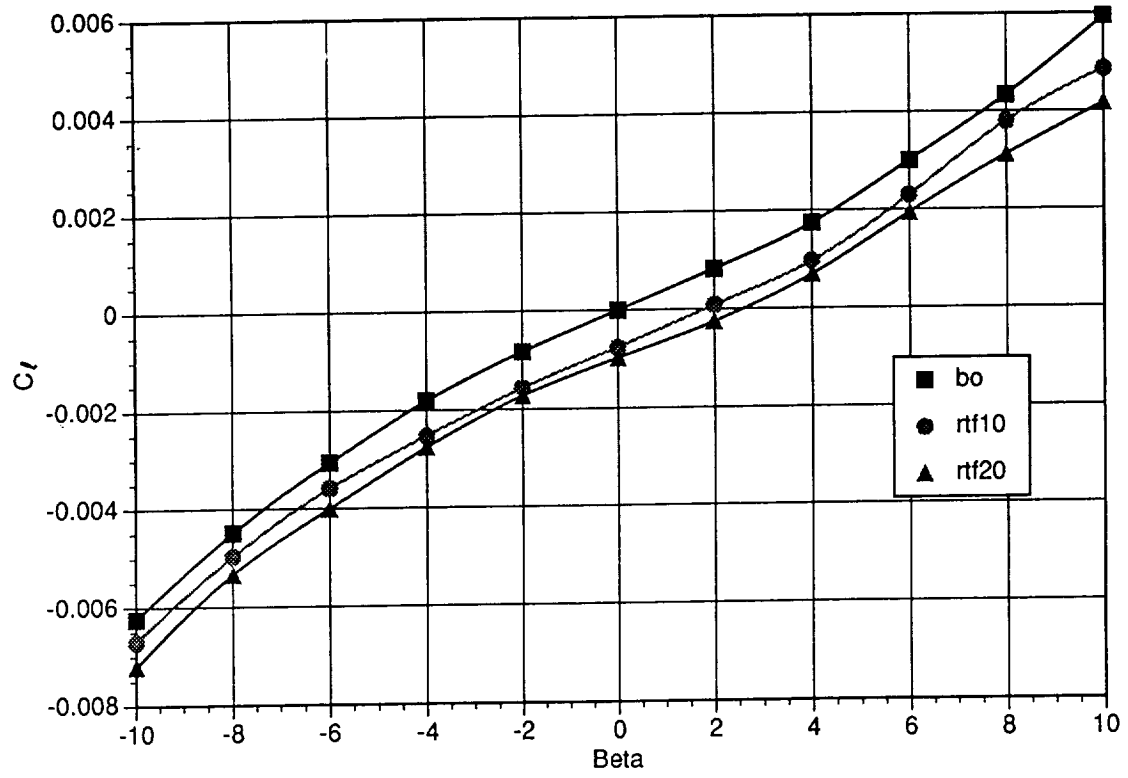


Figure 59. Mach 0.8,  $C_l$  versus angle-of-sideslip.

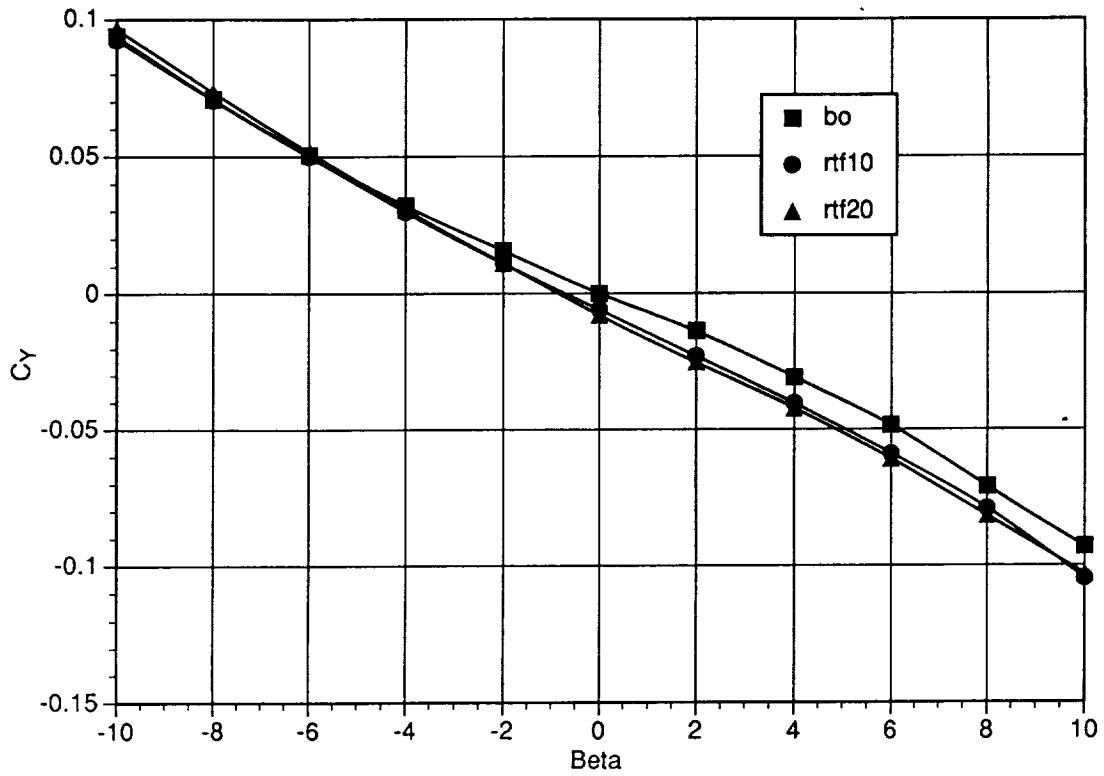


Figure 60. Mach 0.9,  $C_Y$  versus angle-of-sideslip.

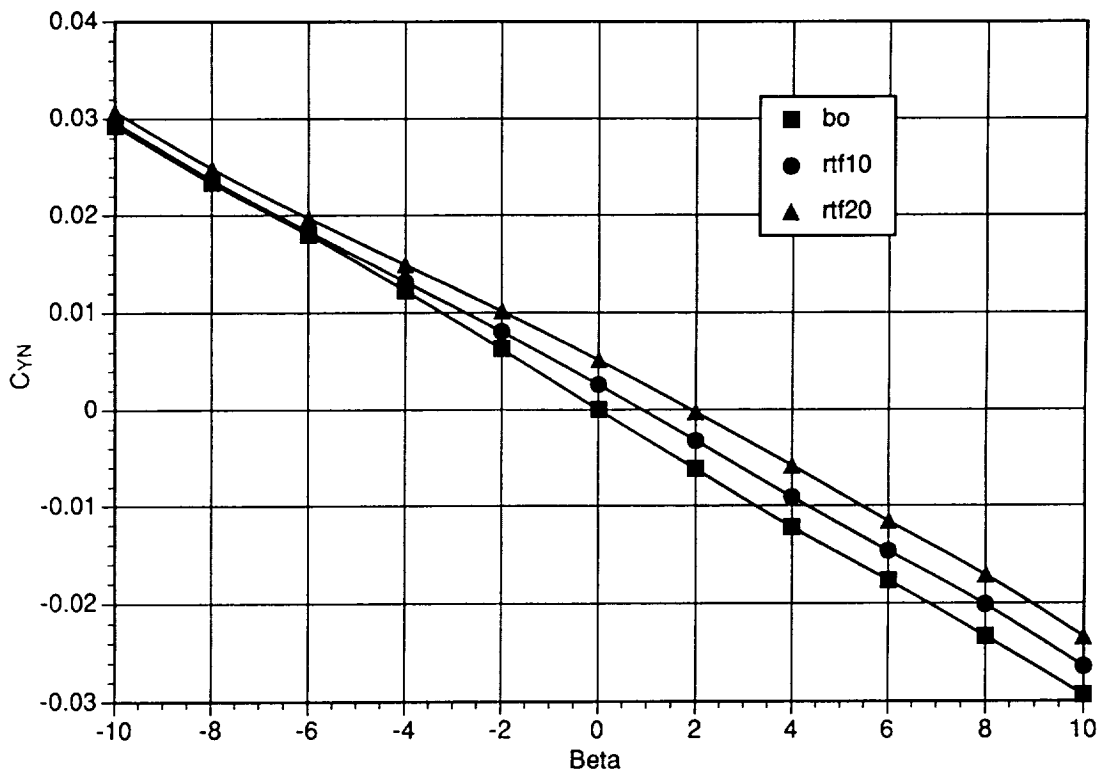


Figure 61. Mach 0.9,  $C_{YN}$  versus angle-of-sideslip.

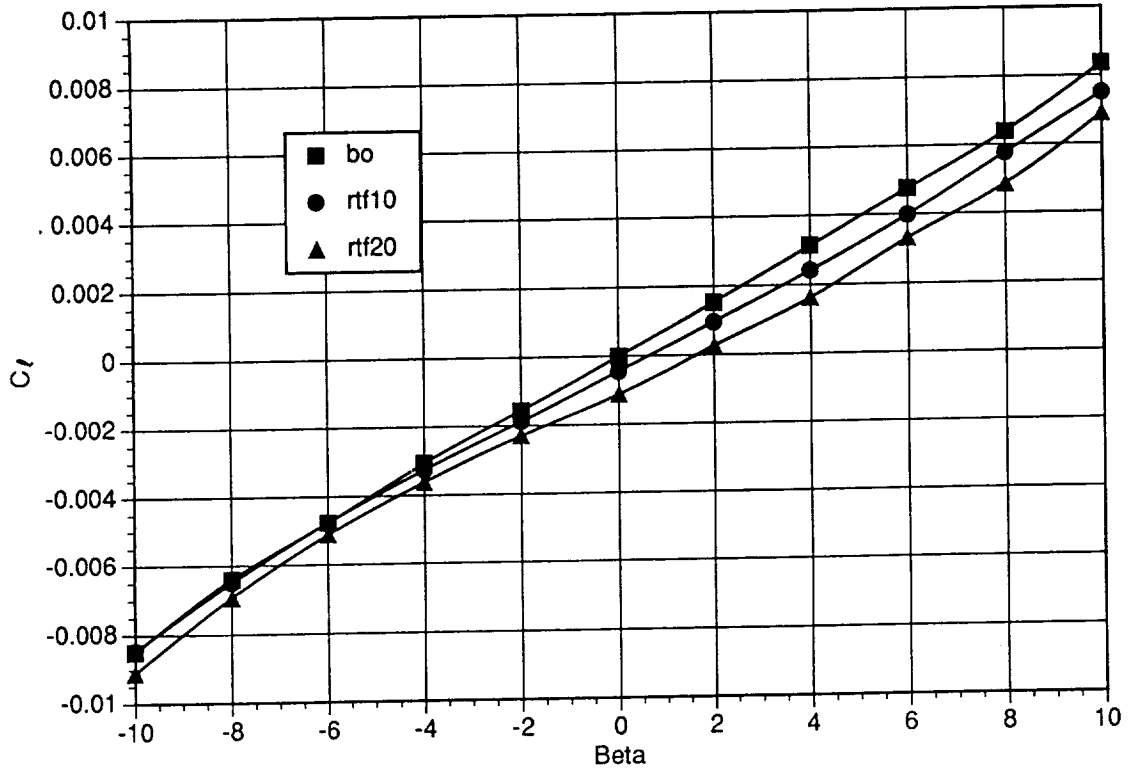


Figure 62. Mach 0.9,  $C_l$  versus angle-of-sideslip.

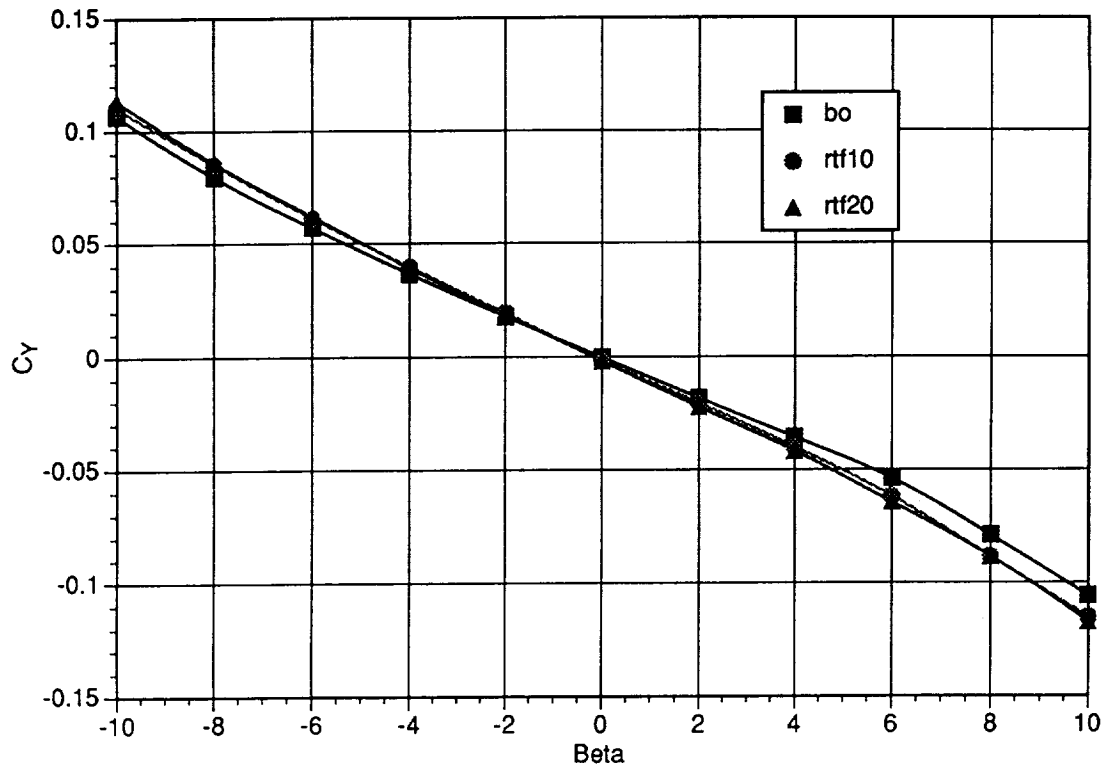


Figure 63. Mach 0.95,  $C_Y$  versus angle-of-sideslip.

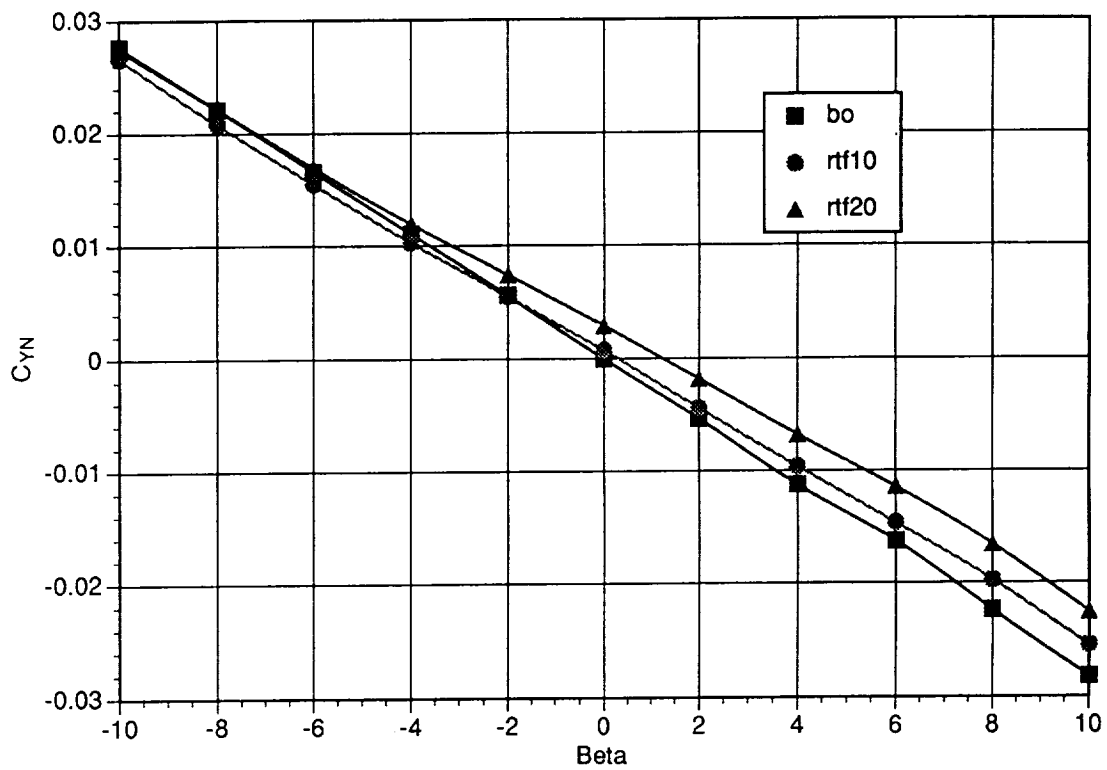


Figure 64. Mach 0.95,  $C_{YN}$  versus angle-of-sideslip.



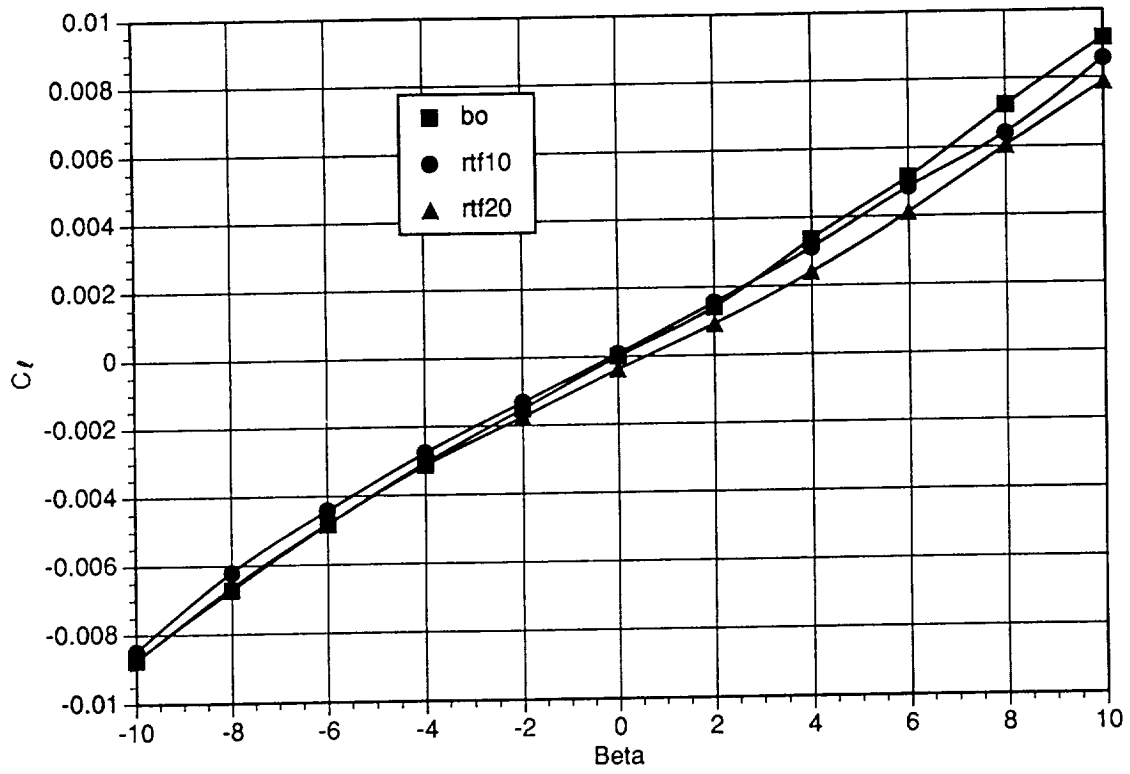


Figure 65. Mach 0.95,  $C_l$  versus angle-of-sideslip.

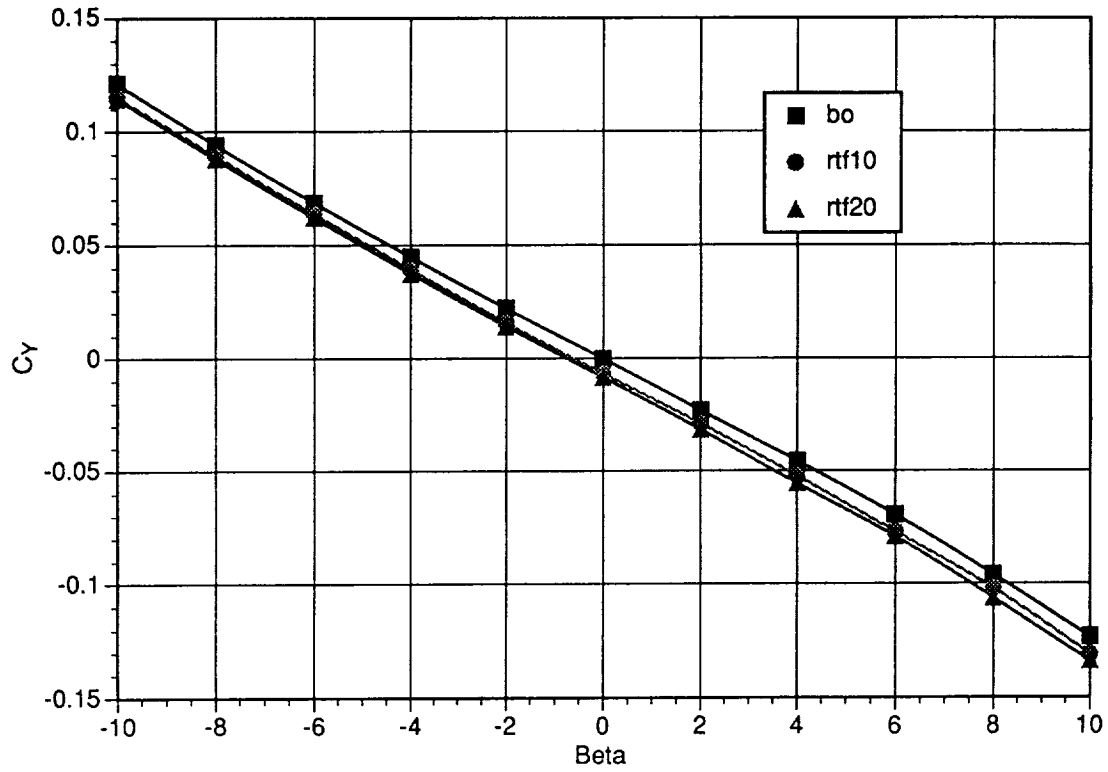


Figure 66. Mach 1.05,  $C_Y$  versus angle-of-sideslip.

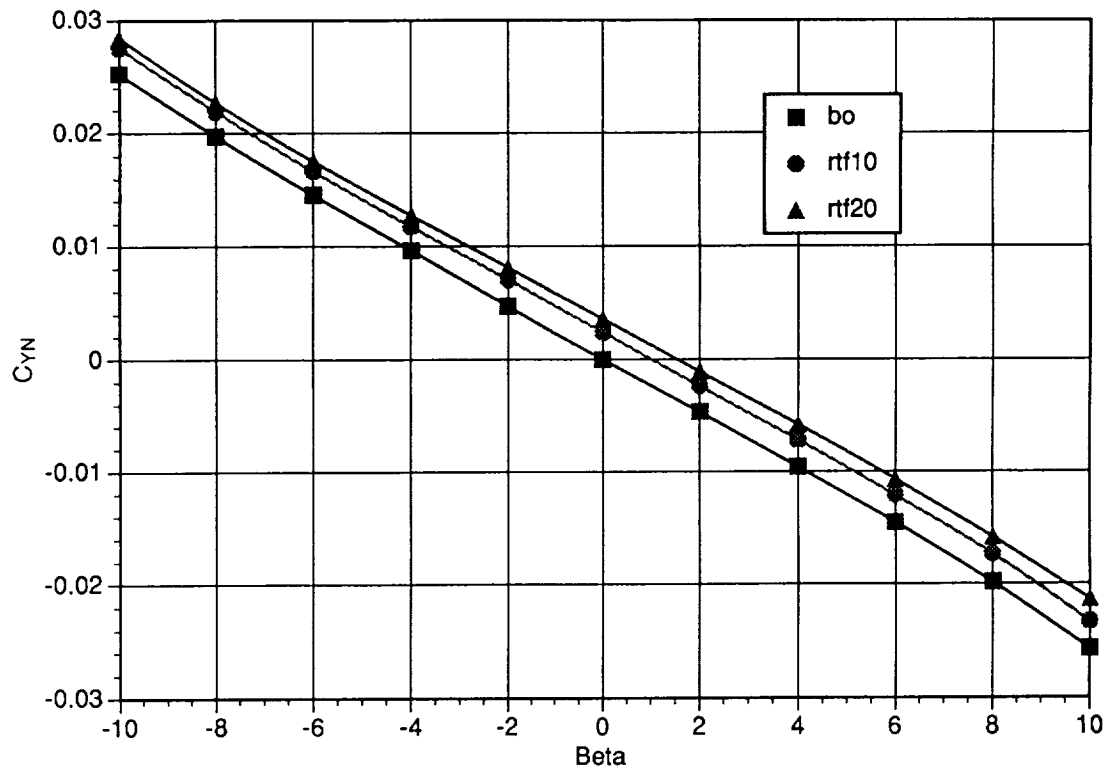


Figure 67. Mach 1.05,  $C_{YN}$  versus angle-of-sideslip.

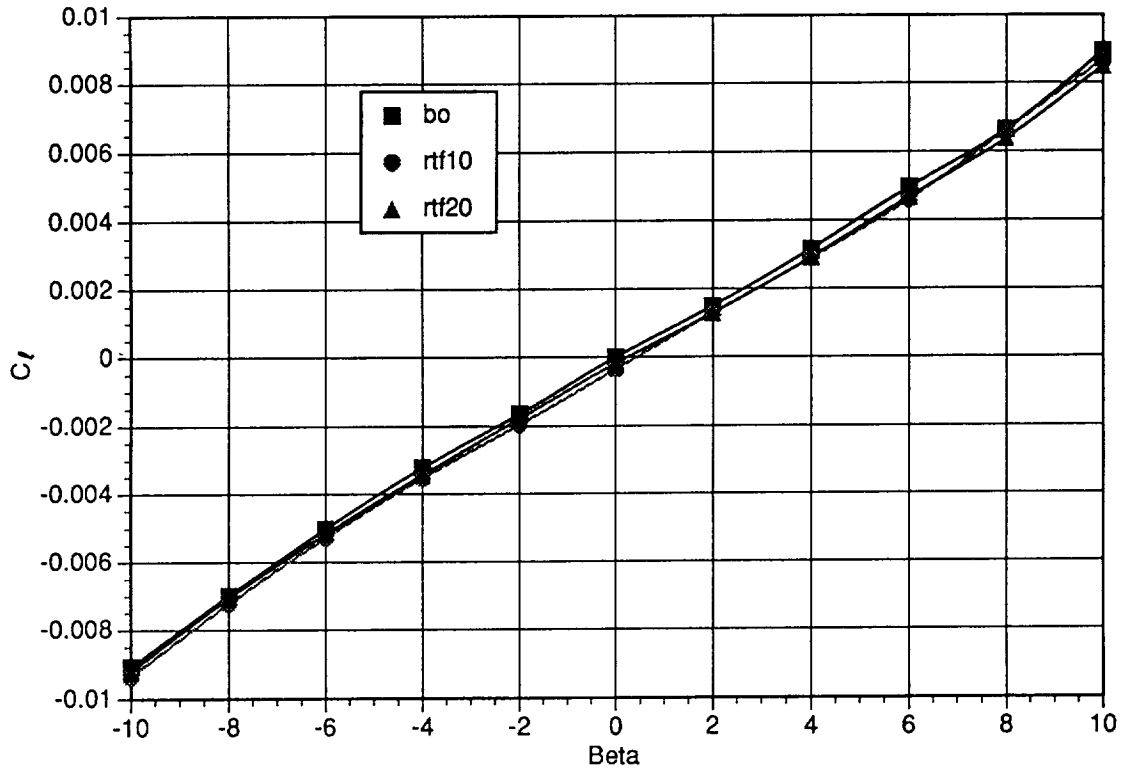


Figure 68. Mach 1.05,  $C_l$  versus angle-of-sideslip.

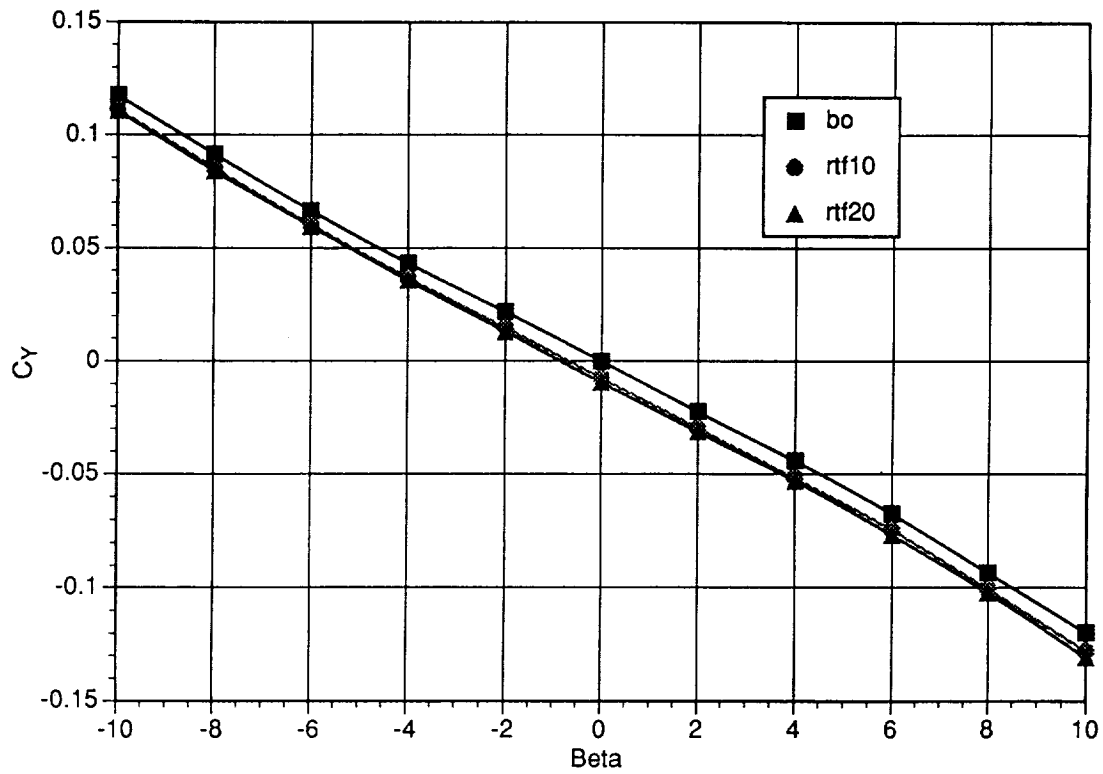


Figure 69. Mach 1.10,  $C_Y$  versus angle-of-sideslip.

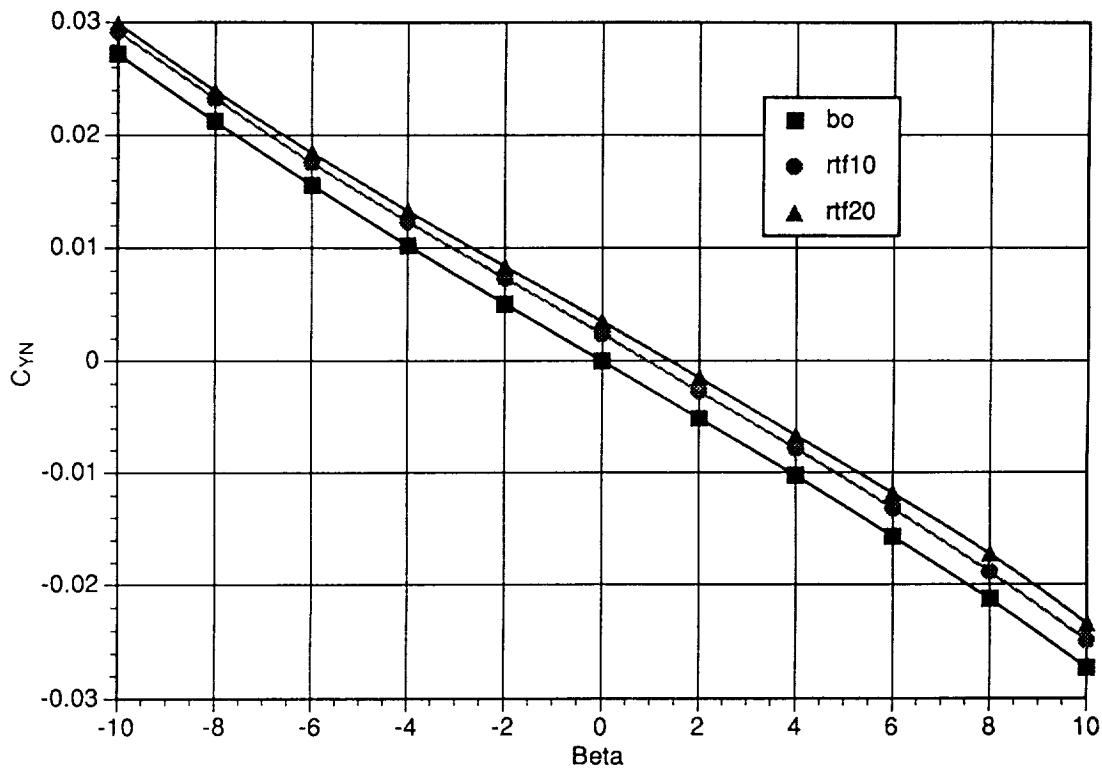


Figure 70. Mach 1.10,  $C_{YN}$  versus angle-of-sideslip.

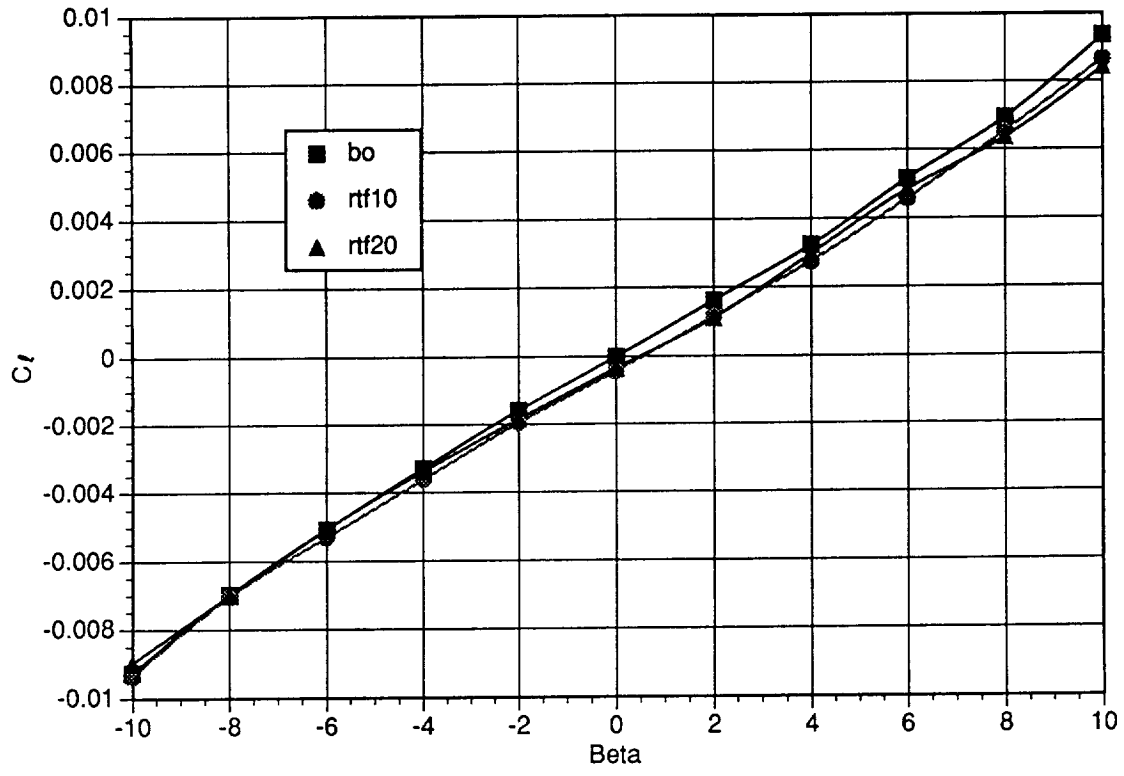


Figure 71. Mach 1.10,  $C_l$  versus angle-of-sideslip.

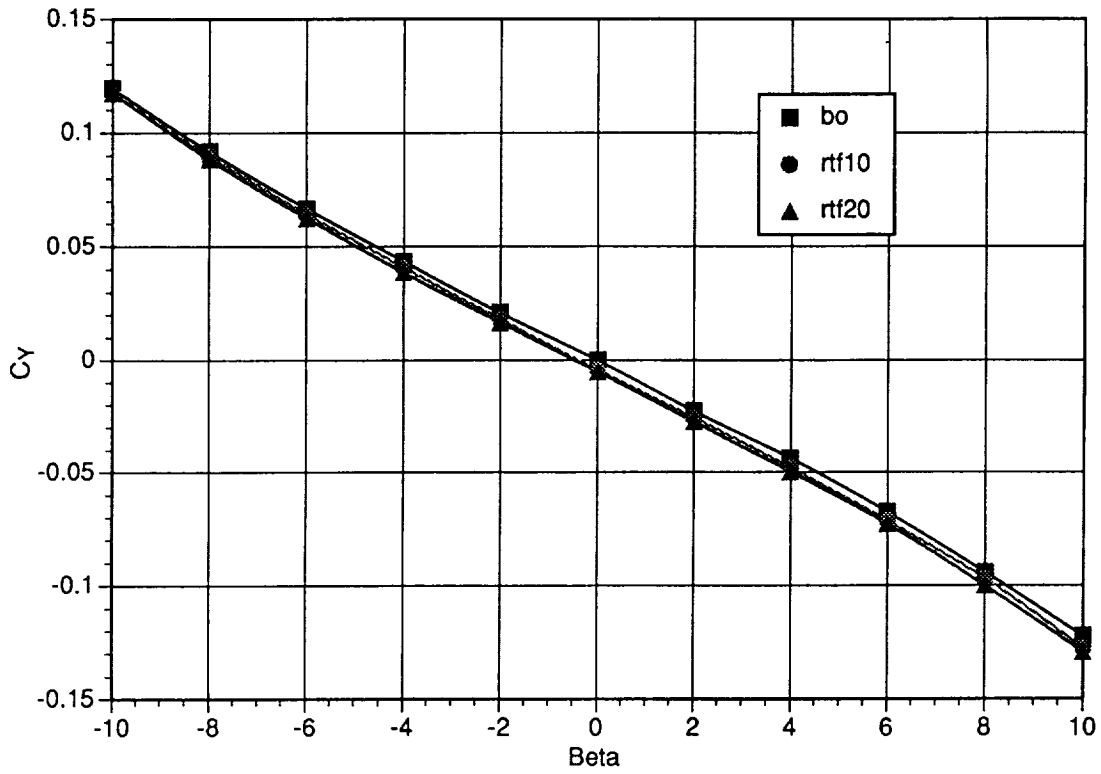


Figure 72. Mach 1.15,  $C_Y$  versus angle-of-sideslip.

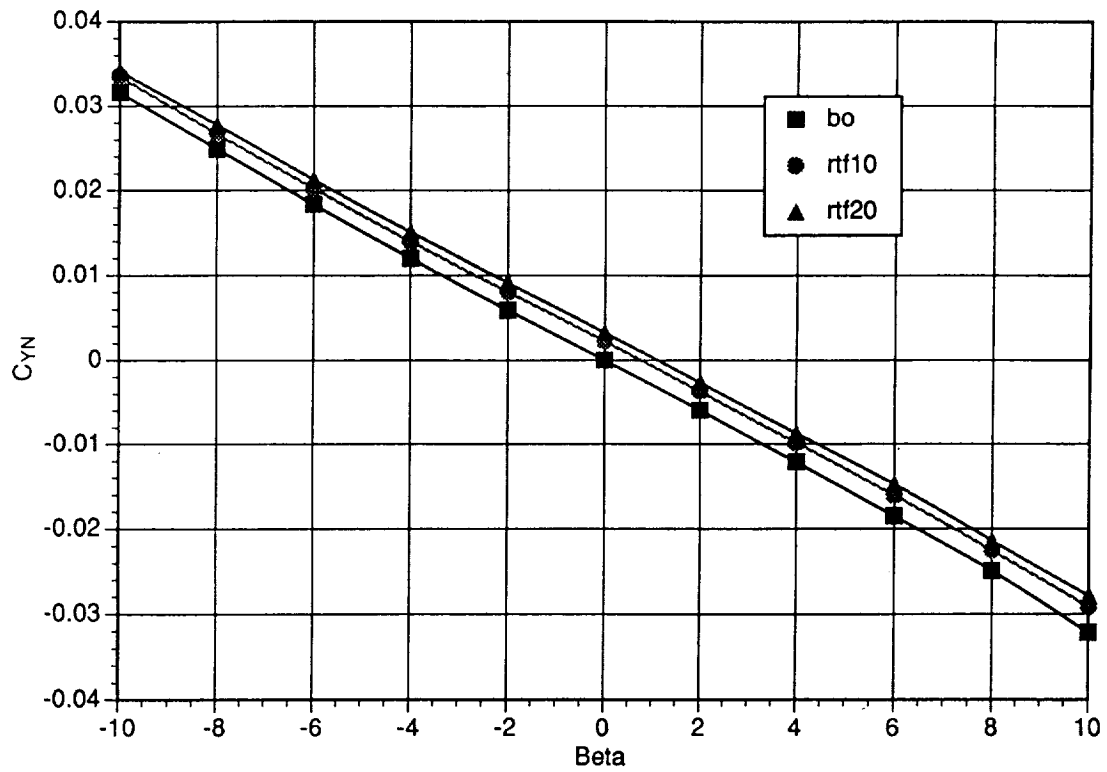


Figure 73. Mach 1.15,  $C_{Y_N}$  versus angle-of-sideslip.

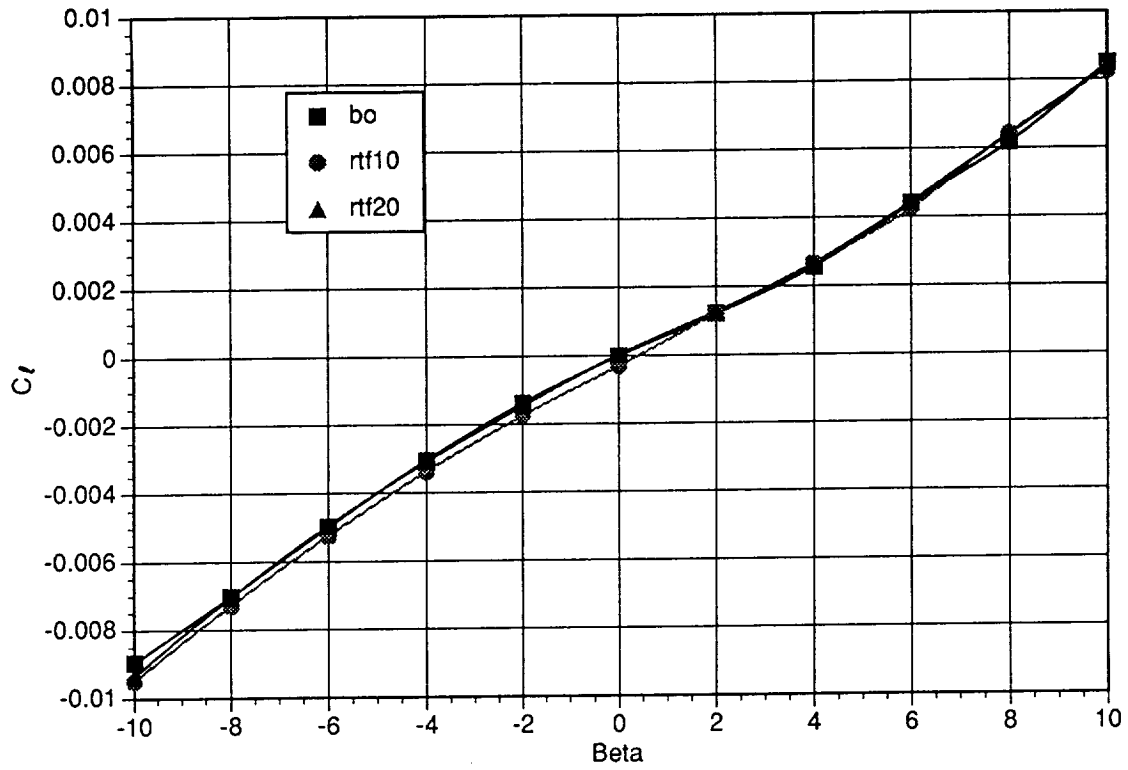


Figure 74. Mach 1.15,  $C_l$  versus angle-of-sideslip.

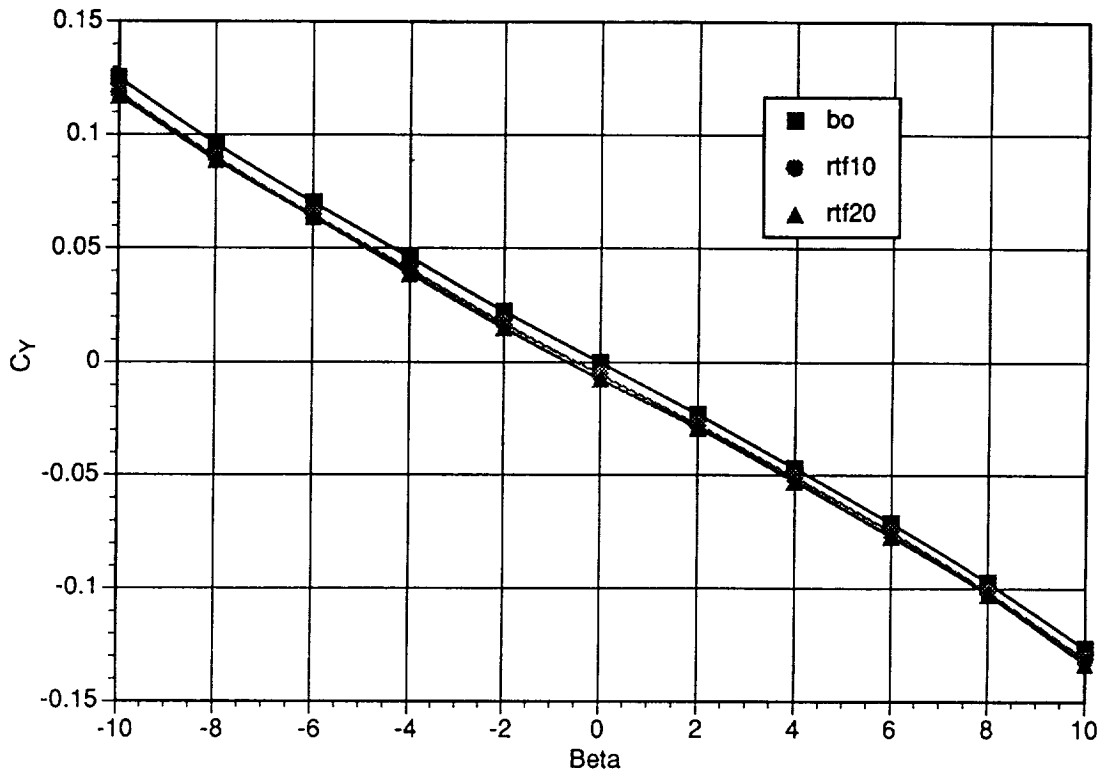


Figure 75. Mach 1.25,  $C_Y$  versus angle-of-sideslip.

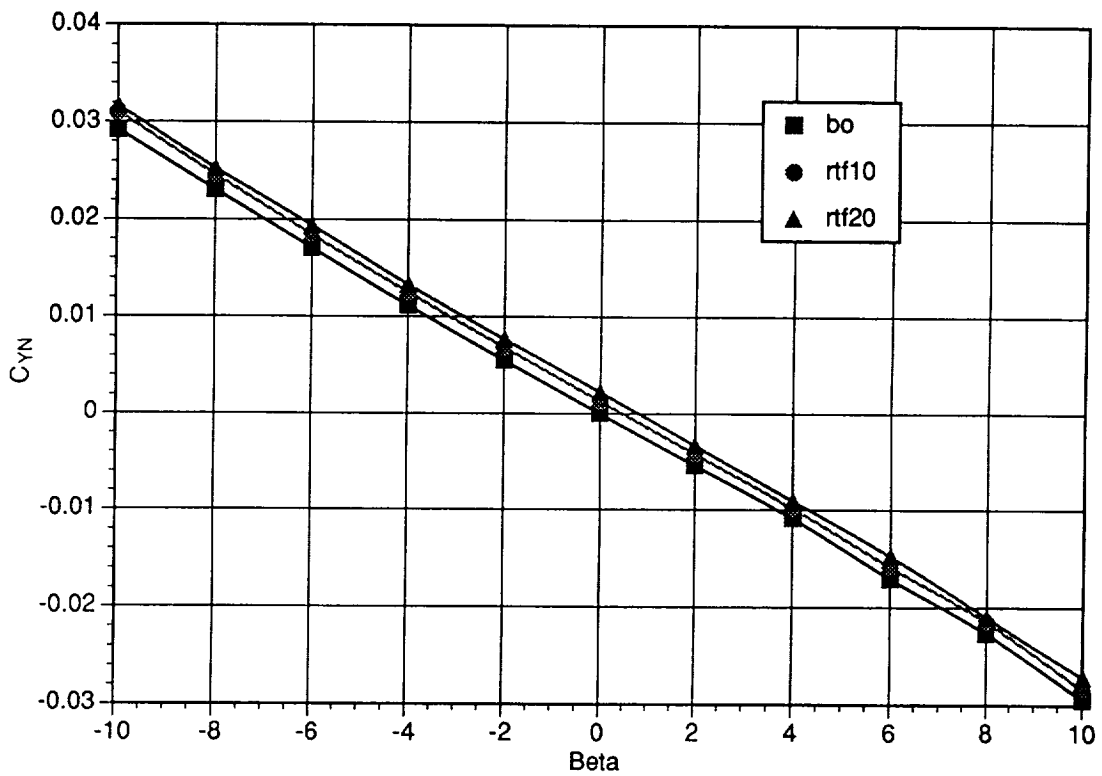


Figure 76. Mach 1.25,  $C_{YN}$  versus angle-of-sideslip.



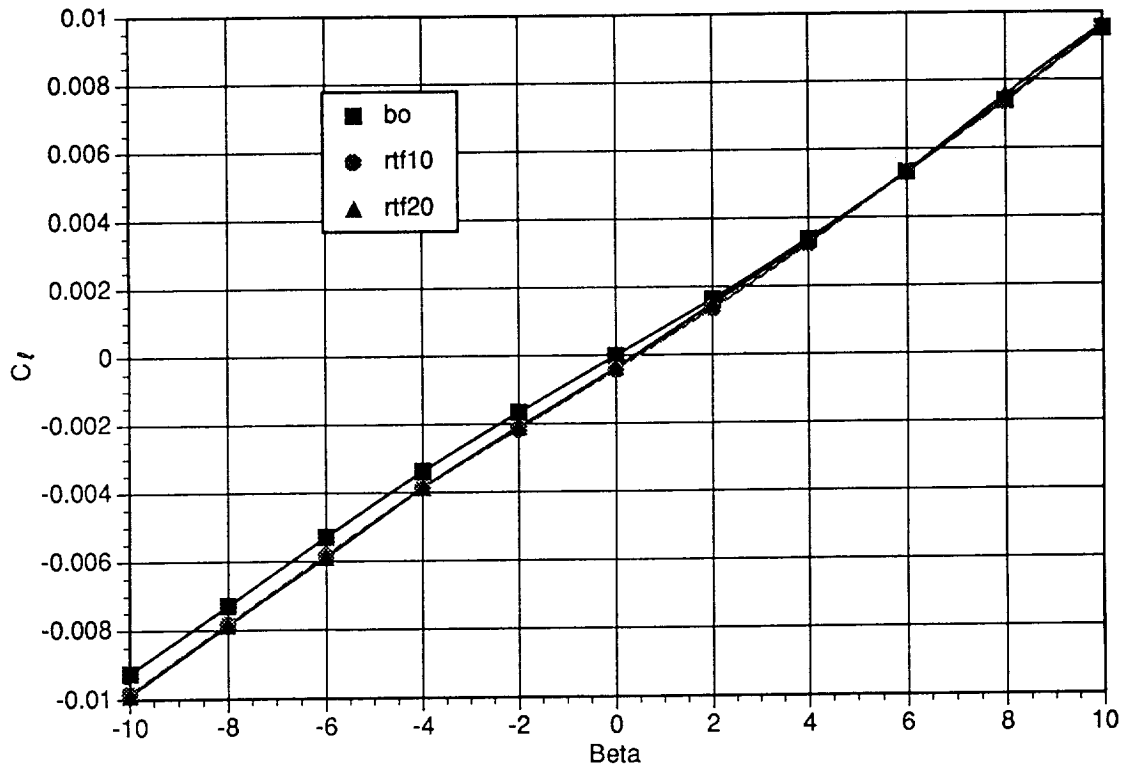


Figure 77. Mach 1.25,  $C_l$  versus angle-of-sideslip.

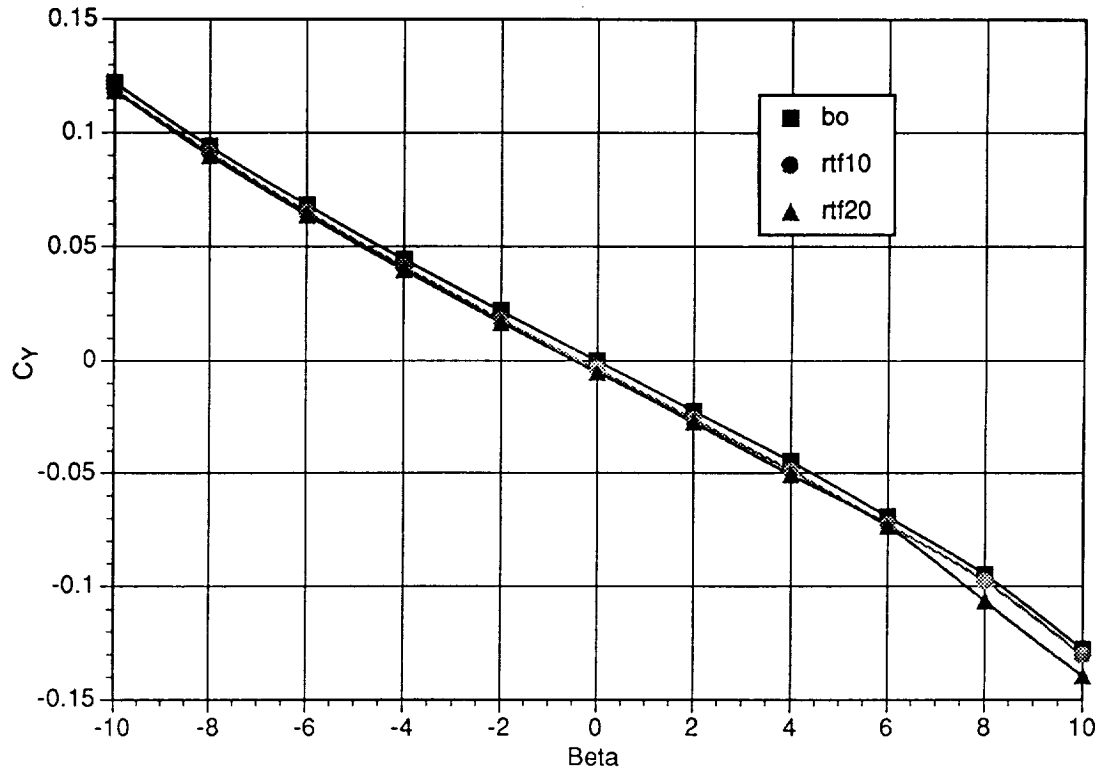


Figure 78. Mach 1.46,  $C_Y$  versus angle-of-sideslip.

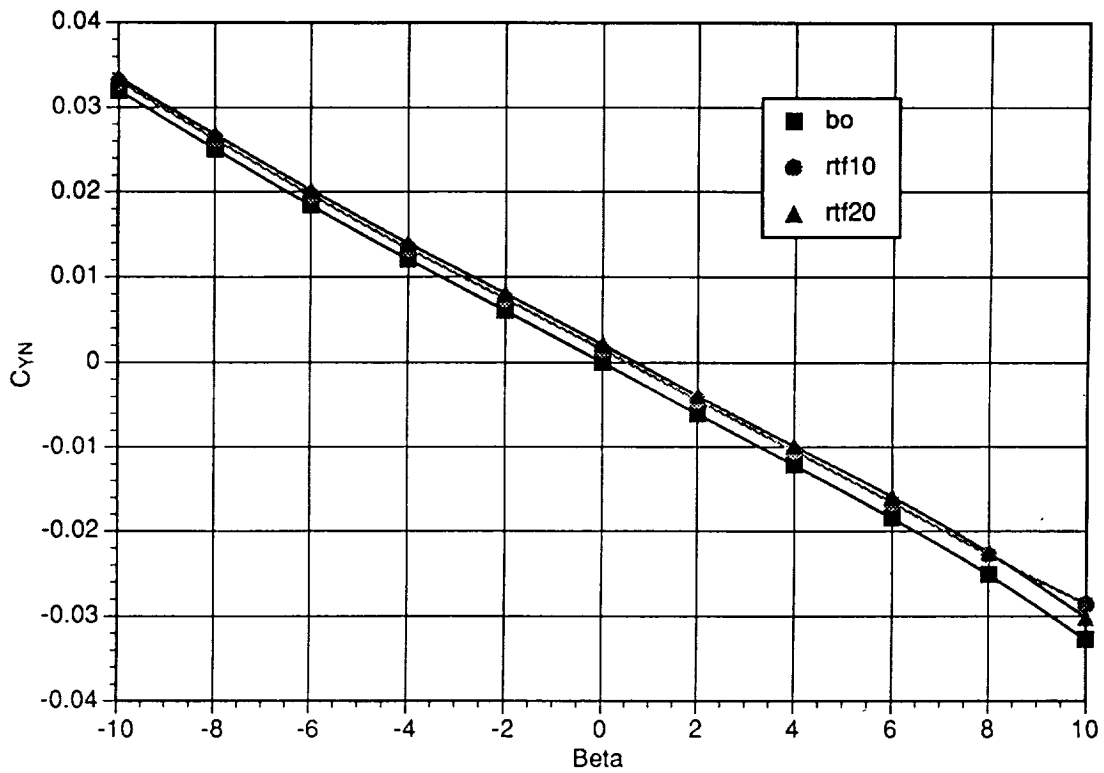


Figure 79. Mach 1.46,  $C_{Y_N}$  versus angle-of-sideslip.

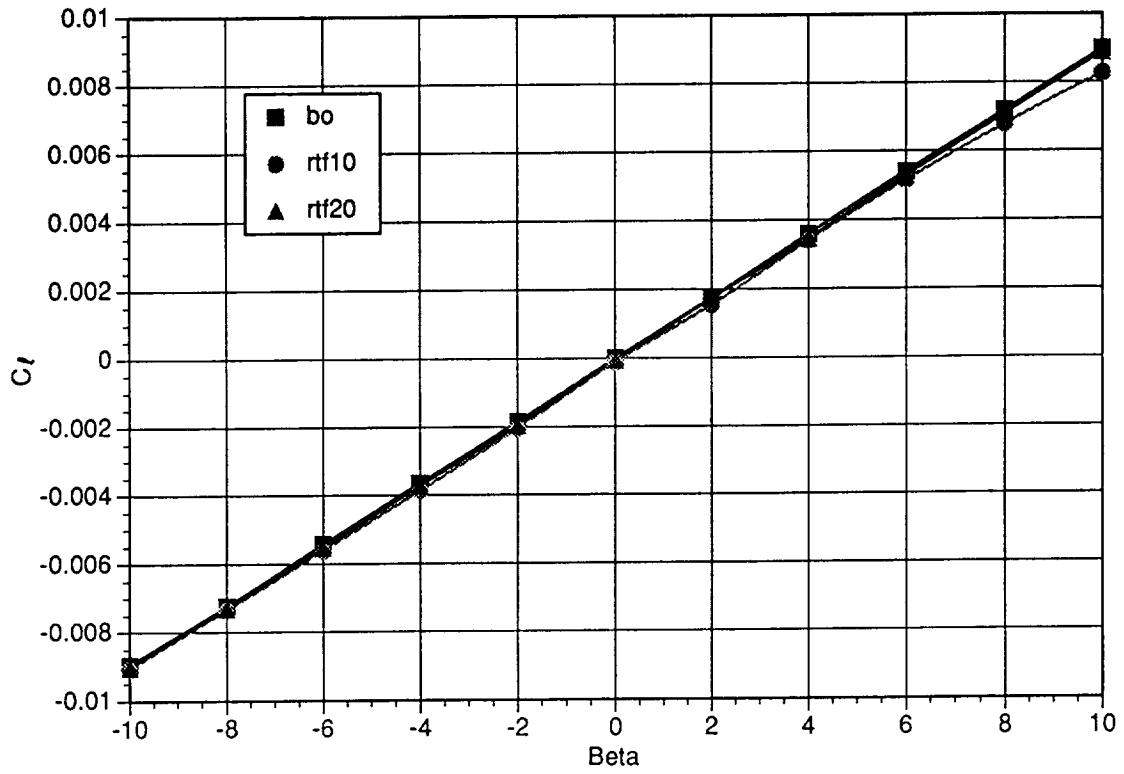


Figure 80. Mach 1.46,  $C_l$  versus angle-of-sideslip.

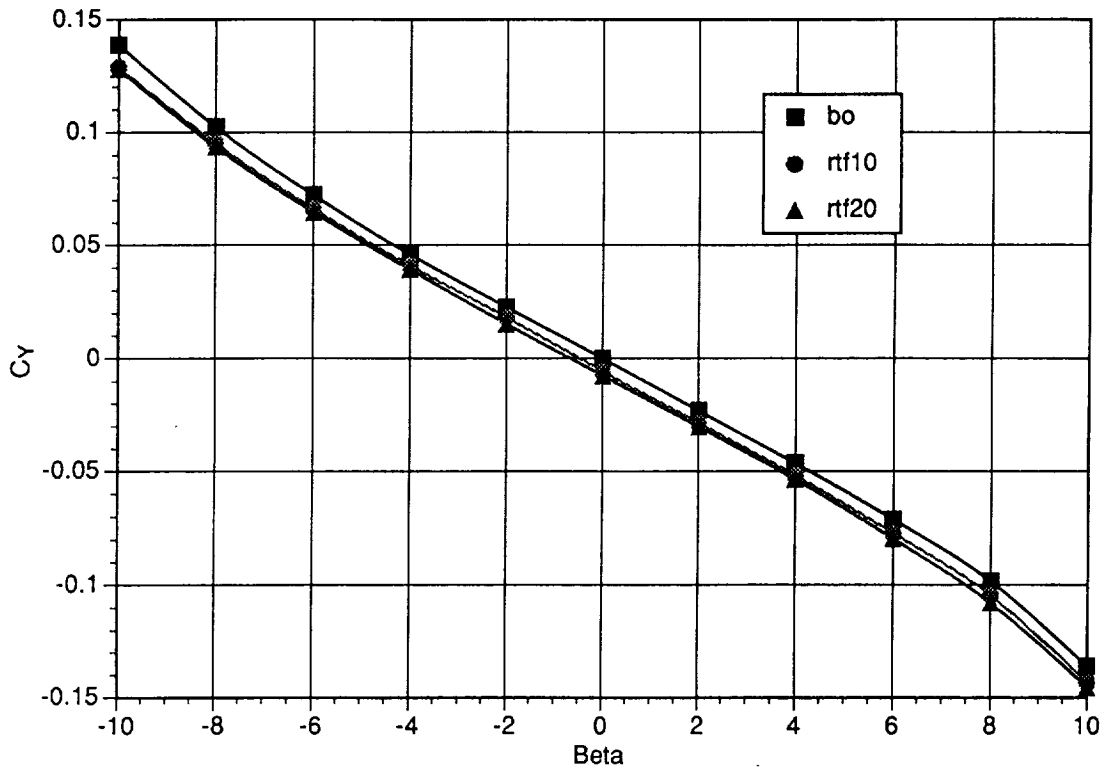


Figure 81. Mach 1.96,  $C_Y$  versus angle-of-sideslip.

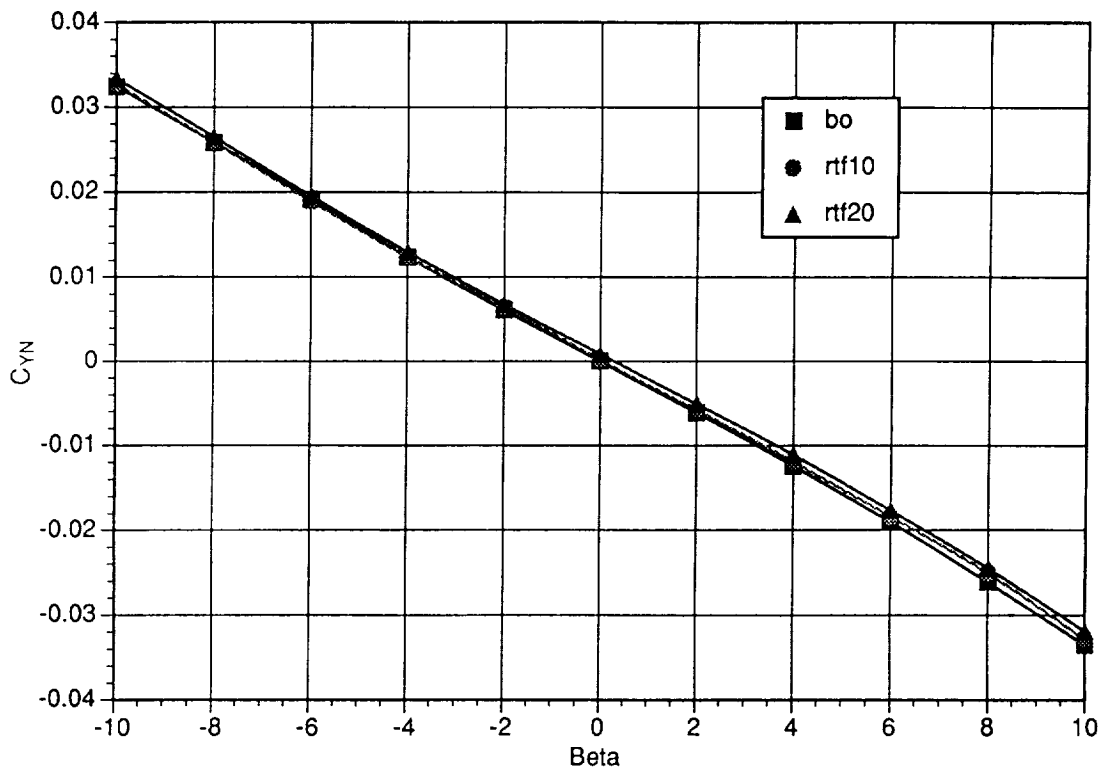


Figure 82. Mach 1.96,  $C_{Y\dot{N}}$  versus angle-of-sideslip.

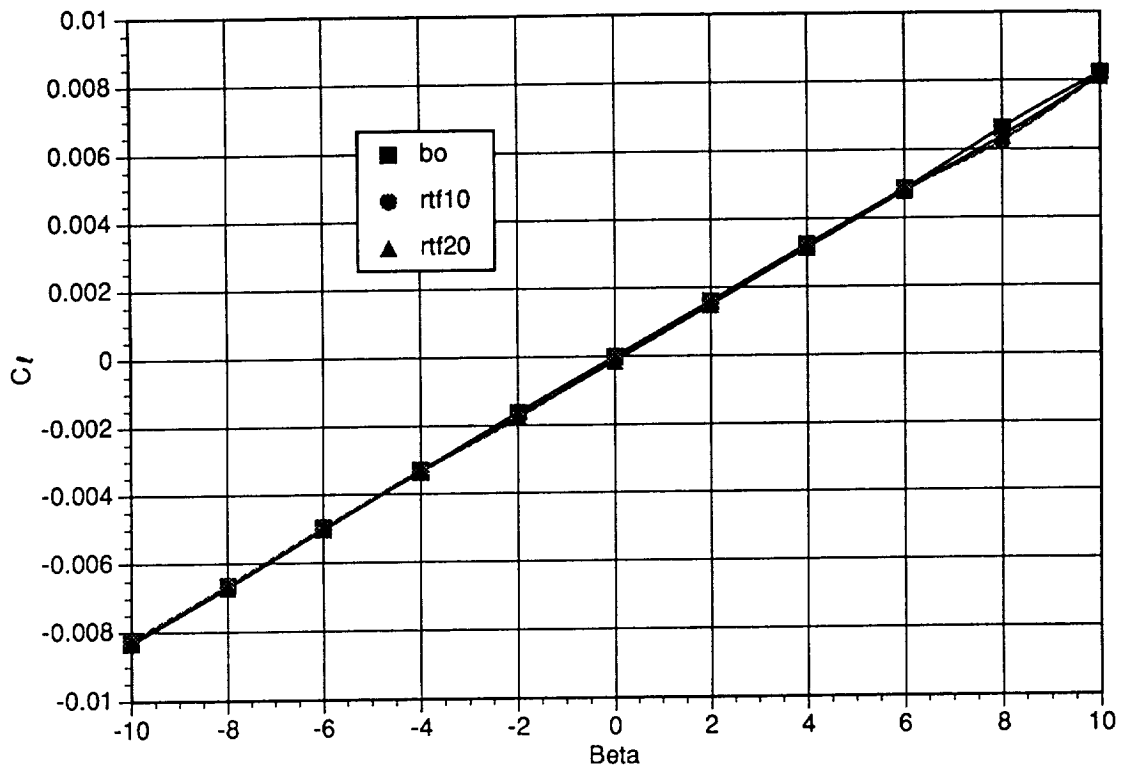


Figure 83. Mach 1.96,  $C_l$  versus angle-of-sideslip.

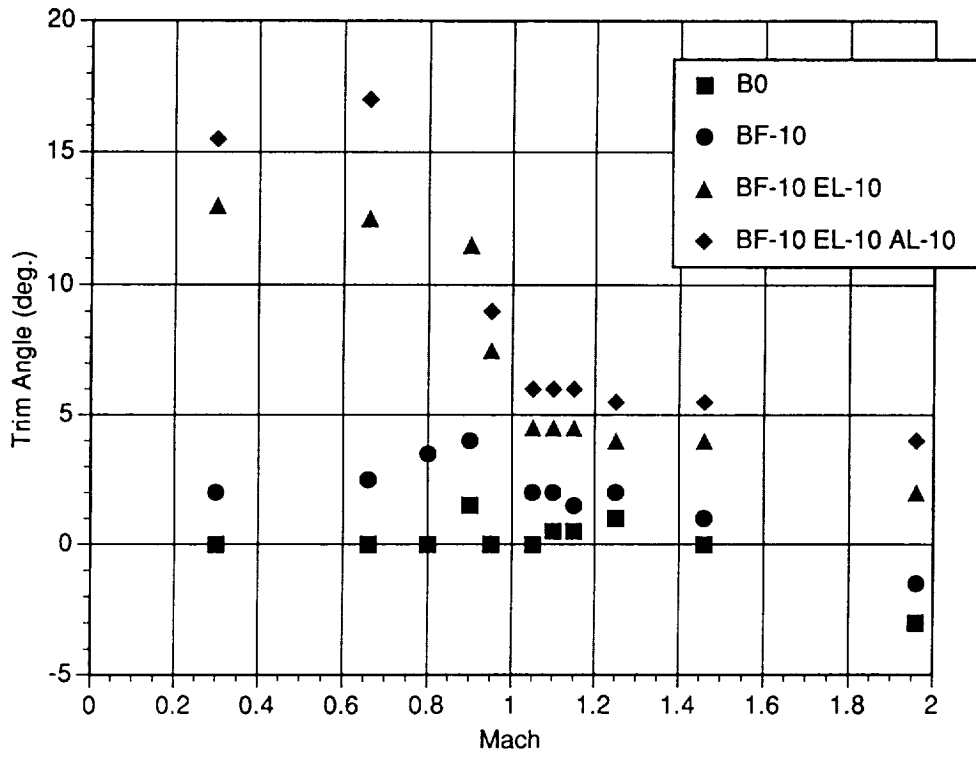


Figure 84. WB001 trim angle at c.g. = 68.6 percent.

## APPENDIX

Table 1. WB001 basic vehicle longitudinal aerodynamic coefficients.

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.3	-10	0	-0.4537432	-0.0118401	0.03132843
0.3	-8	0	-0.3675611	0.00472069	0.0263989
0.3	-6	0	-0.2867354	0.01278424	0.02068194
0.3	-4	0	-0.2012676	0.02365124	0.0138853
0.3	-2	0	-0.1299555	0.03292575	0.00621
0.3	0	0	-0.0371036	0.03288485	-0.0004453
0.3	2	0	0.06546213	0.03574605	-0.0059424
0.3	4	0	0.14833848	0.03109738	-0.0148889
0.3	6	0	0.23266759	0.01686341	-0.0230863
0.3	8	0	0.29369783	0.00843052	-0.0274883
0.3	10	0	0.38384596	-0.0021939	-0.0340554
0.3	12	0	0.49218437	-0.0096363	-0.0358393
0.3	14	0	0.5555511	-0.0125779	-0.0398945
0.3	16	0	0.63119716	-0.019597	-0.0452133
0.3	18	0	0.73919956	-0.0244272	-0.0492318
0.3	20	0	0.82017539	-0.025573	-0.0545385
0.3	22	0	0.89004073	-0.0324449	-0.0562225
0.3	24	0	0.97716667	-0.0279169	-0.0537317
0.3	26	0	1.05862943	-0.0302041	-0.0581691
0.6	-10	0	-0.4651649	-0.0009624	0.03504387
0.6	-8	0	-0.3838434	0.00393868	0.02855755
0.6	-6	0	-0.2952822	0.01431864	0.0217528
0.6	-4	0	-0.2013804	0.02537304	0.01492151
0.6	-2	0	-0.1167609	0.03091981	0.00702265
0.6	0	0	-0.0219689	0.03368429	0.00017387
0.6	2	0	0.06840163	0.03230389	-0.0072927
0.6	4	0	0.15624787	0.02871453	-0.0139833
0.6	6	0	0.24709298	0.02062482	-0.022158
0.6	8	0	0.33880159	0.01304517	-0.0271863
0.6	10	0	0.40793797	0.0054942	-0.0327996
0.6	12	0	0.47201914	0.00204999	-0.0331229
0.6	14	0	0.55138443	-0.0012863	-0.0382739
0.6	16	0	0.6338505	-0.0037074	-0.0419769
0.6	18	0	0.71210971	-0.0070405	-0.0436462
0.6	20	0	0.77376249	-0.0070606	-0.0441289
0.6	22	0	0.78061485	-0.0189716	-0.0334007

Table 1. WB001 basic vehicle longitudinal aerodynamic coefficients—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.6	24	0	0.7825565	-0.008005	-0.019098
0.6	26	0	0.82767034	-0.0014095	-0.0152854
0.8	-10	0	-0.4889992	0.01915409	0.03713918
0.8	-8	0	-0.4078411	0.01995573	0.03279775
0.8	-6	0	-0.3242115	0.02036318	0.02769181
0.8	-4	0	-0.225979	0.02589192	0.01887601
0.8	-2	0	-0.1274656	0.03210303	0.00957438
0.8	0	0	-0.030244	0.03423574	0.00094817
0.8	2	0	0.0649934	0.03479154	-0.0063469
0.8	4	0	0.15539456	0.03071672	-0.0142925
0.8	6	0	0.22876168	0.02458322	-0.0225784
0.8	8	0	0.32643273	0.01997426	-0.0298308
0.8	10	0	0.40467298	0.01628572	-0.0332328
0.8	12	0	0.4857379	0.01253267	-0.0380113
0.8	14	0	0.5645236	0.01035586	-0.0408073
0.8	16	0	0.63002009	0.00841135	-0.041695
0.8	18	0	0.67673018	0.00831187	-0.0390519
0.8	20	0	0.69576538	0.00798719	-0.0296161
0.8	22	0	0.72911554	0.00596156	-0.0212268
0.8	24	0	0.7947815	0.00263635	-0.0179937
0.8	26	0	0.86703225	0.00079206	-0.0178993
0.9	-10	0	-0.5363472	0.03182385	0.04875917
0.9	-8	0	-0.4488394	0.03292343	0.04271299
0.9	-6	0	-0.3644143	0.03325314	0.03583866
0.9	-4	0	-0.2677386	0.03466909	0.02712679
0.9	-2	0	-0.1642071	0.03645434	0.01821094
0.9	0	0	-0.0575887	0.03766538	0.00802409
0.9	2	0	0.04938684	0.03629093	-0.0031267
0.9	4	0	0.15336824	0.0327031	-0.012787
0.9	6	0	0.25666897	0.02981308	-0.0191922
0.9	8	0	0.3248039	0.02594066	-0.0273584
0.9	10	0	0.40904309	0.02326671	-0.0323415
0.9	12	0	0.49066562	0.02157544	-0.0372273
0.9	14	0	0.56961791	0.01697668	-0.0414652
0.9	16	0	0.64250307	0.01367751	-0.0438994
0.9	18	0	0.69095362	0.01143954	-0.0397407
0.9	20	0	0.72247431	0.00925793	-0.0309041
0.9	22	0	0.77726633	0.00553712	-0.0254807



Table 1. WB001 basic vehicle longitudinal aerodynamic coefficients—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.9	24	0	0.86192539	-0.00056	-0.0243138
0.9	26	0	0.94577418	-0.005041	-0.0245191
0.95	-10	0	-0.582931	0.04104992	0.06180366
0.95	-8	0	-0.5079064	0.04167938	0.05745745
0.95	-6	0	-0.4185485	0.04564659	0.05105139
0.95	-4	0	-0.3211633	0.05163036	0.04330363
0.95	-2	0	-0.2147615	0.0514114	0.032358
0.95	0	0	-0.0926369	0.0518387	0.0186161
0.95	2	0	0.01967649	0.04830729	0.00556205
0.95	4	0	0.13348706	0.04399143	-0.0070485
0.95	6	0	0.22614959	0.03964127	-0.0189659
0.95	8	0	0.33454546	0.03424726	-0.0302801
0.95	10	0	0.42319487	0.02895444	-0.0366311
0.95	12	0	0.52213442	0.02540305	-0.0450156
0.95	14	0	0.61620848	0.01970267	-0.0525489
0.95	16	0	0.71165981	0.01476451	-0.0577272
0.95	18	0	0.76677005	0.00405752	-0.0537788
0.95	20	0	0.79998696	-0.0022012	-0.0445692
0.95	22	0	0.85051481	-0.0004614	-0.0360567
0.95	24	0	0.92648702	-0.0008049	-0.0304307
0.95	26	0	1.00923735	-0.0055372	-0.0285532
1.05	-10	0	-0.6512518	0.06049225	0.0825039
1.05	-8	0	-0.5455491	0.06479904	0.07269093
1.05	-6	0	-0.4282005	0.07029489	0.05945297
1.05	-4	0	-0.3005558	0.07700187	0.04150802
1.05	-2	0	-0.1753561	0.07829873	0.02477171
1.05	0	0	-0.052767	0.07794235	0.00931245
1.05	2	0	0.0649795	0.0739144	-0.0061146
1.05	4	0	0.18394063	0.06746067	-0.0209536
1.05	6	0	0.30234898	0.06196554	-0.0343044
1.05	8	0	0.42552383	0.0547679	-0.048664
1.05	10	0	0.54511947	0.04728018	-0.0614889
1.05	12	0	0.66011367	0.0409077	-0.0725328
1.05	14	0	0.77129361	0.03348671	-0.0805048
1.05	16	0	0.87276573	0.02657501	-0.0848577
1.05	18	0	0.95932383	0.01754644	-0.0826408
1.05	20	0	1.04612573	0.00901618	-0.0760037
1.05	22	0	1.13697346	0.00312403	-0.0672673

Table 1. WB001 basic vehicle longitudinal aerodynamic coefficients—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.05	24	0	1.22792157	-0.0012397	-0.0579622
1.05	26	0	1.31936556	-0.0060205	-0.0511474
1.1	-10	0	-0.6206439	0.06974816	0.07593194
1.1	-8	0	-0.5119827	0.07348122	0.06552561
1.1	-6	0	-0.3926169	0.0783326	0.05075298
1.1	-4	0	-0.2716514	0.08376356	0.03587385
1.1	-2	0	-0.1526731	0.08568813	0.02032624
1.1	0	0	-0.0357669	0.08434086	0.0050691
1.1	2	0	0.08081981	0.08196971	-0.0092396
1.1	4	0	0.195878	0.07799034	-0.0226919
1.1	6	0	0.30969904	0.07302663	-0.0360704
1.1	8	0	0.43104367	0.06721617	-0.0498342
1.1	10	0	0.54989337	0.06122656	-0.0626871
1.1	12	0	0.65918982	0.05410115	-0.0728049
1.1	14	0	0.7670237	0.04748577	-0.0799568
1.1	16	0	0.86581555	0.04133289	-0.0839451
1.1	18	0	0.94799227	0.03313211	-0.0816548
1.1	20	0	1.02882347	0.02531726	-0.0749928
1.1	22	0	1.11750569	0.01882004	-0.066738
1.1	24	0	1.21314838	0.0137683	-0.0577714
1.1	26	0	1.31164945	0.01161466	-0.0495154
1.15	-10	0	-0.5923422	0.07022439	0.0670364
1.15	-8	0	-0.4826718	0.07313509	0.05589744
1.15	-6	0	-0.3650067	0.07895621	0.04271923
1.15	-4	0	-0.249744	0.08456939	0.02833899
1.15	-2	0	-0.1421291	0.08412334	0.01592841
1.15	0	0	-0.0310601	0.08316114	0.00377228
1.15	2	0	0.07499534	0.08152396	-0.0081311
1.15	4	0	0.17963667	0.07744211	-0.0191844
1.15	6	0	0.28114999	0.07449158	-0.0298123
1.15	8	0	0.39283818	0.0683234	-0.0410941
1.15	10	0	0.5068594	0.06274845	-0.0523419
1.15	12	0	0.60853453	0.05694548	-0.059646
1.15	14	0	0.71978661	0.04865211	-0.0682199
1.15	16	0	0.83089972	0.04273828	-0.0737011
1.15	18	0	0.94036566	0.0371434	-0.0749056
1.15	20	0	1.04371193	0.03026498	-0.0707746
1.15	22	0	1.14309816	0.0233214	-0.0623931

Table 1. WB001 basic vehicle longitudinal aerodynamic coefficients—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.15	24	0	1.24528111	0.01735826	-0.0526408
1.15	26	0	1.34290254	0.00965161	-0.0422742
1.25	-10	0	-0.5628575	0.08365225	0.06095355
1.25	-8	0	-0.4616018	0.08699733	0.05216482
1.25	-6	0	-0.3586864	0.0906801	0.04147041
1.25	-4	0	-0.2525112	0.09390059	0.02922078
1.25	-2	0	-0.1443282	0.09578337	0.01719849
1.25	0	0	-0.0396195	0.09563706	0.0046386
1.25	2	0	0.06134607	0.09402506	-0.0069689
1.25	4	0	0.16904317	0.09184404	-0.0183566
1.25	6	0	0.26845092	0.08766131	-0.0278235
1.25	8	0	0.37136755	0.08267724	-0.0388179
1.25	10	0	0.47503002	0.07671306	-0.0483958
1.25	12	0	0.57501395	0.07012813	-0.0552017
1.25	14	0	0.67097517	0.06284109	-0.0603386
1.25	16	0	0.77596968	0.0556798	-0.0646761
1.25	18	0	0.88882429	0.04807801	-0.0675698
1.25	20	0	0.99162958	0.03857765	-0.0651404
1.25	22	0	1.08522739	0.02967387	-0.0575614
1.25	24	0	1.18415817	0.0213262	-0.0483518
1.25	26	0	1.28754451	0.01136581	-0.0387081
1.46	-10	0	-0.4764491	0.08961821	0.03728902
1.46	-8	0	-0.389989	0.0895406	0.03143596
1.46	-6	0	-0.298311	0.09072572	0.02403063
1.46	-4	0	-0.2081856	0.09192259	0.0160829
1.46	-2	0	-0.1195548	0.09324329	0.00774446
1.46	0	0	-0.029987	0.09307459	-0.0001633
1.46	2	0	0.05738929	0.09158429	-0.0085684
1.46	4	0	0.1466375	0.08903432	-0.0166831
1.46	6	0	0.23700142	0.08664898	-0.0245129
1.46	8	0	0.31402952	0.08195837	-0.0307634
1.46	10	0	0.406588	0.07754149	-0.0367769
1.46	12	0	0.50124728	0.07233296	-0.0413598
1.46	14	0	0.5989758	0.06596198	-0.0437821
1.46	16	0	0.70329924	0.05978049	-0.0443421
1.46	18	0	0.81037834	0.05465839	-0.0431007
1.46	20	0	0.91268809	0.04964711	-0.0402686
1.46	22	0	1.01048985	0.04293748	-0.0368801

Table 1. WB001 basic vehicle longitudinal aerodynamic coefficients—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.46	24	0	1.1115103	0.03581562	-0.0329044
1.46	26	0	1.23314431	0.02978169	-0.0318979
1.96	-10	0	-0.3712542	0.10155461	0.00599331
1.96	-8	0	-0.2988087	0.10219902	0.005656
1.96	-6	0	-0.2289252	0.10186916	0.00402936
1.96	-4	0	-0.1589705	0.10171595	0.00148392
1.96	-2	0	-0.0907472	0.10247463	-0.0016811
1.96	0	0	-0.0242635	0.10216774	-0.0051871
1.96	2	0	0.04459317	0.10061701	-0.0083737
1.96	4	0	0.11409558	0.09901414	-0.01194
1.96	6	0	0.18440969	0.09450079	-0.0156304
1.96	8	0	0.26011259	0.09165178	-0.0180209
1.96	10	0	0.32808859	0.08837319	-0.0201011
1.96	12	0	0.41012796	0.08401393	-0.0211205
1.96	14	0	0.49499196	0.08012013	-0.0203025
1.96	16	0	0.58237888	0.07708395	-0.0180634
1.96	18	0	0.66976678	0.07386967	-0.0152214
1.96	20	0	0.75434315	0.07032791	-0.0120169
1.96	22	0	0.84109047	0.06611425	-0.0100248
1.96	24	0	0.97606039	0.06460668	-0.0097303

Table 2. WB001 body flap deflected  $-10^\circ$  increments.

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.3	-10	0	-0.0187301	0.0004845	0.00941319
0.3	-8	0	-0.0433232	-0.0027471	0.0065186
0.3	-6	0	-0.0462675	-0.0009248	0.00553221
0.3	-4	0	-0.0294458	0.00355719	0.00822873
0.3	-2	0	-0.0315968	-0.002173	0.00727128
0.3	0	0	-0.0304538	-0.0012727	0.00781491
0.3	2	0	-0.030994	-0.0002208	0.0081582
0.3	4	0	-0.0402829	-0.0024844	0.0074818
0.3	6	0	-0.0315483	0.00207805	0.0144328
0.3	8	0	0.00407148	0.00483988	0.0126267
0.3	10	0	0.00642272	0.00795392	0.012786
0.3	12	0	-0.0186563	0.01219327	0.0092358
0.3	14	0	-0.0112303	0.0035838	0.0083629
0.3	16	0	0.00792875	0.0119647	0.0126776
0.3	18	0	-0.0122303	0.0136319	0.0103817
0.3	20	0	-0.0175899	0.0047312	0.0112013
0.3	22	0	-0.0030994	0.014	0.0137932
0.3	24	0	-0.0475607	0.0067357	0.011494
0.3	26	0	-0.0546892	0.007242	0.0124721
0.6	-10	0	-0.0390847	0.00500553	0.00912328
0.6	-8	0	-0.0324435	0.00438149	0.01004453
0.6	-6	0	-0.0310064	0.00362694	0.00906143
0.6	-4	0	-0.0353014	0.00293907	0.00858351
0.6	-2	0	-0.0302319	0.00475239	0.00963159
0.6	0	0	-0.0372096	0.00403992	0.00939278
0.6	2	0	-0.0383937	0.00586581	0.00983531
0.6	4	0	-0.0404716	0.00318161	0.0089477
0.6	6	0	-0.0326633	0.00469852	0.010583
0.6	8	0	-0.0375946	0.0060562	0.0094877
0.6	10	0	-0.0184007	0.00708558	0.0090316
0.6	12	0	-0.0112968	0.0066191	0.0086497
0.6	14	0	-0.0085925	0.00777998	0.009421
0.6	16	0	-0.0116327	0.00563819	0.0087533
0.6	18	0	-0.0160568	0.0046683	0.0090371
0.6	20	0	-0.0216673	0.0067942	0.0114213
0.6	22	0	-0.0188004	0.0170615	0.0120361
0.6	24	0	-0.0166833	0.0078586	0.0101519
0.6	26	0	-0.019563	0.00265473	0.0101075

Table 2. WB001 body flap deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.8	-10	0	-0.0336583	0.00447314	0.01007668
0.8	-8	0	-0.0349902	0.00480257	0.01006874
0.8	-6	0	-0.0397255	0.00484065	0.01003571
0.8	-4	0	-0.0448815	0.00369658	0.01082416
0.8	-2	0	-0.043449	0.00410889	0.01172857
0.8	0	0	-0.0436446	0.00463822	0.0120136
0.8	2	0	-0.0444688	0.00440456	0.01149413
0.8	4	0	-0.0446515	0.00487772	0.0122529
0.8	6	0	-0.0169553	0.00566725	0.0129237
0.8	8	0	-0.0332726	0.00433987	0.0167992
0.8	10	0	-0.0349138	0.0038996	0.0174085
0.8	12	0	-0.0369581	0.0052344	0.018494
0.8	14	0	-0.0475059	0.00545118	0.0191213
0.8	16	0	-0.0622559	0.00789866	0.02209
0.8	18	0	-0.0659744	0.00799638	0.0236805
0.8	20	0	-0.0617559	0.00669905	0.0232113
0.8	22	0	-0.0518039	0.00488537	0.02122065
0.8	24	0	-0.0426821	0.00279863	0.01925114
0.8	26	0	-0.0423441	0.00180809	0.01923482
0.9	-10	0	-0.0161929	0.00421979	0.00748643
0.9	-8	0	-0.0324474	0.00496122	0.00887139
0.9	-6	0	-0.036763	0.00536931	0.00991125
0.9	-4	0	-0.0366246	0.00604698	0.01106356
0.9	-2	0	-0.0424616	0.00582809	0.01204654
0.9	0	0	-0.040836	0.00556249	0.01194999
0.9	2	0	-0.0409401	0.00706223	0.0125246
0.9	4	0	-0.0422117	0.00698752	0.0127169
0.9	6	0	-0.0469637	0.00669624	0.0125183
0.9	8	0	-0.0571348	0.00912178	0.0174368
0.9	10	0	-0.0606402	0.01023337	0.0184726
0.9	12	0	-0.0685543	0.01111988	0.0205018
0.9	14	0	-0.0839194	0.01444796	0.0234677
0.9	16	0	-0.0924743	0.01461099	0.0251103
0.9	18	0	-0.1013987	0.01338017	0.0273709
0.9	20	0	-0.0892738	0.01227793	0.0258606
0.9	22	0	-0.0774175	0.01106846	0.023476
0.9	24	0	-0.0773764	0.00946356	0.0225319
0.9	26	0	-0.0761718	0.00825159	0.0223369

Table 2. WB001 body flap deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.95	-10	0	-0.0093436	0.00486377	0.00334225
0.95	-8	0	-0.0059595	0.00491971	0.00403735
0.95	-6	0	0.0014658	0.00323121	0.00372962
0.95	-4	0	0.006693	-0.0003037	0.00357254
0.95	-2	0	0.0034485	0.00082988	0.00345659
0.95	0	0	-0.0004733	0.00073628	0.00343249
0.95	2	0	-0.0053416	0.00268206	0.00342247
0.95	4	0	-0.0109208	0.00491417	0.0040677
0.95	6	0	0.00707992	0.00637315	0.0043951
0.95	8	0	-0.011878	0.00942159	0.0074837
0.95	10	0	-0.0224452	0.01255905	0.0106304
0.95	12	0	-0.0387582	0.01316839	0.0140267
0.95	14	0	-0.0535806	0.01431083	0.0183539
0.95	16	0	-0.071269	0.0144455	0.0219659
0.95	18	0	-0.0725911	0.02164485	0.0225527
0.95	20	0	-0.0661281	0.02403905	0.0219878
0.95	22	0	-0.0574352	0.01716849	0.0207071
0.95	24	0	-0.049925	0.01053552	0.019571
0.95	26	0	-0.0513945	0.0088335	0.0205276
1.05	-10	0	0.0006417	0.0049831	-0.0009201
1.05	-8	0	0.0009194	0.00632161	-0.0002166
1.05	-6	0	-0.0003937	0.00612412	-9.57E-05
1.05	-4	0	-0.0042344	0.00461113	0.00136996
1.05	-2	0	-0.0125243	0.00793018	0.00446971
1.05	0	0	-0.0171715	0.0072883	0.00506751
1.05	2	0	-0.0186267	0.00997738	0.0051352
1.05	4	0	-0.0189238	0.01266373	0.0062797
1.05	6	0	-0.0204512	0.01249061	0.0061503
1.05	8	0	-0.0263792	0.01580803	0.0075581
1.05	10	0	-0.0272749	0.01599824	0.0079038
1.05	12	0	-0.0319858	0.01435563	0.0091891
1.05	14	0	-0.0393632	0.0153979	0.0112665
1.05	16	0	-0.0441348	0.01486403	0.0127386
1.05	18	0	-0.0324203	0.01641108	0.0096803
1.05	20	0	-0.0261996	0.01687836	0.006496
1.05	22	0	-0.0272858	0.01485743	0.0054814
1.05	24	0	-0.029689	0.01273533	0.0068088
1.05	26	0	-0.0423866	0.01246792	0.0113226

Table 2. WB001 body flap deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.1	-10	0	-0.0107313	0.00316125	0.00229826
1.1	-8	0	-0.0070132	0.00293284	0.00162071
1.1	-6	0	-0.0113848	0.00310022	0.00345862
1.1	-4	0	-0.0194445	0.00329096	0.00445931
1.1	-2	0	-0.0206664	0.00457001	0.00562221
1.1	0	0	-0.0223301	0.00614182	0.00703819
1.1	2	0	-0.0261971	0.00684841	0.006811
1.1	4	0	-0.0266543	0.00582332	0.0070159
1.1	6	0	-0.0237984	0.00698905	0.0075011
1.1	8	0	-0.0286848	0.00681061	0.007682
1.1	10	0	-0.030105	0.00549741	0.0076914
1.1	12	0	-0.0295108	0.00581013	0.0086966
1.1	14	0	-0.0367304	0.00608412	0.0106612
1.1	16	0	-0.0396402	0.00544229	0.0112561
1.1	18	0	-0.0280678	0.00671976	0.007959
1.1	20	0	-0.0152595	0.00733594	0.0039605
1.1	22	0	-0.0097375	0.00646477	0.0018901
1.1	24	0	-0.0083076	0.00450361	0.0018638
1.1	26	0	-0.0038806	0.0012517	0.0023829
1.15	-10	0	-0.0088256	0.00113301	0.0008417
1.15	-8	0	-0.0013672	0.00366749	0.00057744
1.15	-6	0	-0.0065803	0.00272142	0.00152995
1.15	-4	0	-0.0103552	-0.0006144	0.00270095
1.15	-2	0	-0.0085319	0.0031771	0.00359544
1.15	0	0	-0.0189177	0.00595335	0.00558874
1.15	2	0	-0.0188769	0.00684284	0.0055969
1.15	4	0	-0.0187105	0.00846996	0.0055984
1.15	6	0	-0.0164668	0.0061734	0.0054037
1.15	8	0	-0.0169157	0.00663885	0.0065057
1.15	10	0	-0.0213214	0.00660585	0.0075669
1.15	12	0	-0.0226652	0.00604658	0.0087727
1.15	14	0	-0.0279005	0.00591698	0.0105683
1.15	16	0	-0.0293534	0.00371981	0.0107416
1.15	18	0	-0.0319018	0.00229683	0.0114753
1.15	20	0	-0.0298688	0.00237068	0.0111778
1.15	22	0	-0.0236763	0.00246592	0.0093264
1.15	24	0	-0.0233003	0.0022167	0.0083809
1.15	26	0	-0.0284731	0.00441652	0.0102858



Table 2. WB001 body flap deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.25	-10	0	8.05E-05	0.0016248	0.00019292
1.25	-8	0	-0.0032309	0.00215399	0.00116037
1.25	-6	0	-0.0061329	0.00209386	0.00216762
1.25	-4	0	-0.0099083	0.00332797	0.00391494
1.25	-2	0	-0.0172081	0.0030915	0.00507018
1.25	0	0	-0.0184907	0.00362667	0.00560936
1.25	2	0	-0.0161173	0.00447594	0.005574
1.25	4	0	-0.0189234	0.00505054	0.0059939
1.25	6	0	-0.018355	0.00490782	0.0053184
1.25	8	0	-0.0211425	0.00383502	0.0061923
1.25	10	0	-0.0203486	0.00323057	0.0059165
1.25	12	0	-0.0210646	0.0028483	0.0060391
1.25	14	0	-0.0203697	0.00303992	0.0066634
1.25	16	0	-0.0246213	0.00226693	0.0073158
1.25	18	0	-0.0262951	0.0018136	0.00846
1.25	20	0	-0.016001	0.00267892	0.0064158
1.25	22	0	-0.0027452	0.00273396	0.0022422
1.25	24	0	0.00159718	0.00380776	0.0009688
1.25	26	0	0.00689491	0.00816887	0.0013399
1.46	-10	0	0.0100535	0.00053447	-0.0031345
1.46	-8	0	0.0025751	0.00243549	-0.0003691
1.46	-6	0	-0.005292	0.00272352	0.0014502
1.46	-4	0	-0.0081662	0.00404762	0.00303435
1.46	-2	0	-0.0118289	0.00300213	0.00351428
1.46	0	0	-0.0116144	0.00128334	0.0032088
1.46	2	0	-0.0103641	0.00246876	0.0038914
1.46	4	0	-0.0146857	0.00256542	0.0040994
1.46	6	0	-0.0155322	0.00175417	0.004978
1.46	8	0	-0.0149003	0.00276483	0.0049803
1.46	10	0	-0.01475	0.00238516	0.005088
1.46	12	0	-0.0166779	0.00117339	0.00538
1.46	14	0	-0.0171096	0.00089383	0.0056573
1.46	16	0	-0.0169754	0.00096958	0.0059783
1.46	18	0	-0.0177154	0.00052304	0.0064345
1.46	20	0	-0.0182228	6.23E-06	0.0070038
1.46	22	0	-0.0193513	0.00021832	0.0073421
1.46	24	0	-0.0214703	0.00128204	0.0081303
1.46	26	0	-0.0281095	0.00075753	0.009195

Table 2. WB001 body flap deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.96	-10	0	-0.0052234	0.00179773	0.00141606
1.96	-8	0	-0.0070499	0.00156335	0.00174185
1.96	-6	0	-0.0077862	0.00233181	0.00188269
1.96	-4	0	-0.0072864	0.0028559	0.00209749
1.96	-2	0	-0.0087478	0.0018878	0.00228917
1.96	0	0	-0.0081871	0.00118107	0.0023083
1.96	2	0	-0.0100708	0.00067564	0.0022887
1.96	4	0	-0.0108372	0.00080362	0.0030691
1.96	6	0	-0.0088336	0.00201101	0.0034398
1.96	8	0	-0.0190737	0.00220236	0.0033342
1.96	10	0	-0.010124	0.00160977	0.0034008
1.96	12	0	-0.0098483	0.00186649	0.0040304
1.96	14	0	-0.0107863	0.00176733	0.0044438
1.96	16	0	-0.0116966	0.00160406	0.0045506
1.96	18	0	-0.0103838	0.00183814	0.0048849
1.96	20	0	-0.0137445	0.00146859	0.0055287
1.96	22	0	-0.0147973	0.00120036	0.0057555
1.96	24	0	-0.0112011	0.00066452	0.0060497

Table 3. WB001 elevons deflected  $-10^\circ$  increments.

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.3	-10	0	-0.1224748	0.0006969	0.02774023
0.3	-8	0	-0.1140941	0.00128865	0.02583517
0.3	-6	0	-0.1091401	0.00388148	0.02624027
0.3	-4	0	-0.112189	0.00200502	0.0265577
0.3	-2	0	-0.0948995	0.00601441	0.02857404
0.3	0	0	-0.1089123	0.0084883	0.02841585
0.3	2	0	-0.1329815	0.0070912	0.02675641
0.3	4	0	-0.1236108	0.00857976	0.02828227
0.3	6	0	-0.1276919	0.01039465	0.02403666
0.3	8	0	-0.1519292	0.01195506	0.02497998
0.3	10	0	-0.1532771	0.00752875	0.0269126
0.3	12	0	-0.1280718	0.00396618	0.02969373
0.3	14	0	-0.124963	0.008816	0.0287965
0.3	16	0	-0.1373166	-0.001374	0.0230626
0.3	18	0	-0.119733	-0.0045405	0.0261216
0.3	20	0	-0.1144391	0.0068566	0.0252153
0.3	22	0	-0.1330247	-0.0016753	0.0218652
0.3	24	0	-0.1101468	0.0058013	0.0274962
0.3	26	0	-0.1162508	0.006429	0.0298771
0.6	-10	0	-0.0898668	0.00718848	0.02423086
0.6	-8	0	-0.1094519	0.0032612	0.02655589
0.6	-6	0	-0.1083597	0.00202965	0.02699394
0.6	-4	0	-0.1168033	0.00159689	0.02686661
0.6	-2	0	-0.1183493	0.00142113	0.02733453
0.6	0	0	-0.112805	0.00476742	0.02801046
0.6	2	0	-0.1182565	0.00391172	0.02752505
0.6	4	0	-0.1114107	0.00594846	0.02827891
0.6	6	0	-0.1173687	0.00786203	0.02876681
0.6	8	0	-0.1197785	0.00605483	0.02795026
0.6	10	0	-0.1146748	0.00380722	0.02746844
0.6	12	0	-0.1102804	0.0031665	0.02621709
0.6	14	0	-0.1058074	-0.0003003	0.0236657
0.6	16	0	-0.0937673	-0.0005337	0.0216925
0.6	18	0	-0.08338	0.0008671	0.0201145
0.6	20	0	-0.0767459	0.00046284	0.0174851
0.6	22	0	-0.0711761	0.00416443	0.0149675
0.6	24	0	-0.0627798	0.00333365	0.01428789
0.6	26	0	-0.0633296	0.00251955	0.01537154

Table 3. WB001 elevons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.8	-10	0	-0.0976144	0.00461426	0.02482561
0.8	-8	0	-0.0957926	0.0057955	0.02488582
0.8	-6	0	-0.0977129	0.00403172	0.02495292
0.8	-4	0	-0.0999201	0.00445938	0.02630235
0.8	-2	0	-0.1040658	0.00397255	0.02653836
0.8	0	0	-0.1097066	0.00468176	0.02705357
0.8	2	0	-0.1103401	0.00474137	0.0276417
0.8	4	0	-0.1029451	0.00708857	0.02809491
0.8	6	0	-0.1138057	0.00746339	0.02897918
0.8	8	0	-0.1148763	0.01016535	0.02903096
0.8	10	0	-0.1126801	0.01091663	0.02896239
0.8	12	0	-0.1045097	0.0103884	0.02682548
0.8	14	0	-0.0930334	0.01198359	0.02533916
0.8	16	0	-0.0868406	0.01243279	0.02317021
0.8	18	0	-0.0799365	0.01193404	0.02182792
0.8	20	0	-0.0737349	0.01428547	0.02206752
0.8	22	0	-0.0862434	0.01750382	0.0245006
0.8	24	0	-0.0928287	0.0166479	0.02472071
0.8	26	0	-0.0895442	0.01456684	0.02431197
0.9	-10	0	-0.0731143	0.00223315	0.0179861
0.9	-8	0	-0.0739721	0.00262836	0.02061769
0.9	-6	0	-0.0843349	0.00231023	0.02312607
0.9	-4	0	-0.0801414	0.0020664	0.02021689
0.9	-2	0	-0.0638042	0.00232856	0.01633001
0.9	0	0	-0.0566887	0.00445234	0.01466428
0.9	2	0	-0.0631502	0.00257014	0.01570248
0.9	4	0	-0.0549302	0.00360274	0.01547289
0.9	6	0	-0.0646418	0.00403224	0.01703417
0.9	8	0	-0.0754524	0.00565754	0.0170603
0.9	10	0	-0.0720857	0.00658084	0.01604298
0.9	12	0	-0.0687398	0.00842598	0.0165382
0.9	14	0	-0.0654675	0.00987727	0.0167747
0.9	16	0	-0.0598274	0.01021346	0.0157197
0.9	18	0	-0.0401702	0.00957354	0.0113093
0.9	20	0	-0.0417312	0.00994745	0.01153705
0.9	22	0	-0.0583597	0.01137446	0.01563156
0.9	24	0	-0.0694453	0.01288517	0.01813276
0.9	26	0	-0.0806816	0.01416099	0.02017079

Table 3. WB001 elevons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.95	-10	0	-0.0603934	0.00111669	0.015611
0.95	-8	0	-0.0964617	0.00310989	0.02460729
0.95	-6	0	-0.0944825	0.00344672	0.02187109
0.95	-4	0	-0.0888382	0.00294614	0.01900035
0.95	-2	0	-0.0684349	0.00482096	0.0146988
0.95	0	0	-0.0677817	0.00426545	0.01410787
0.95	2	0	-0.0521435	0.00265244	0.01223792
0.95	4	0	-0.0450809	0.00410676	0.01245122
0.95	6	0	-0.0624631	0.00712554	0.01809417
0.95	8	0	-0.0980908	0.00682584	0.020919
0.95	10	0	-0.0858707	0.00651646	0.0179359
0.95	12	0	-0.0757338	0.00647685	0.0157081
0.95	14	0	-0.0686104	0.00751519	0.0143041
0.95	16	0	-0.0651642	0.00804371	0.0132648
0.95	18	0	-0.0493491	0.00598377	0.0094457
0.95	20	0	-0.045386	0.00530054	0.0084836
0.95	22	0	-0.0639685	0.00662786	0.0119891
0.95	24	0	-0.0759765	0.00751992	0.01502677
0.95	26	0	-0.069783	0.00753107	0.01671824
1.05	-10	0	-0.0868717	0.01073048	0.02571823
1.05	-8	0	-0.0867638	0.00655459	0.02469696
1.05	-6	0	-0.0847369	0.00585237	0.02385664
1.05	-4	0	-0.0800223	0.00458419	0.02438415
1.05	-2	0	-0.0757936	0.00424533	0.02167
1.05	0	0	-0.069855	0.00893896	0.02090266
1.05	2	0	-0.0619407	0.00950189	0.02076963
1.05	4	0	-0.0670367	0.00746582	0.01963701
1.05	6	0	-0.0657689	0.00680837	0.0193584
1.05	8	0	-0.0966262	0.00551512	0.0186733
1.05	10	0	-0.0997329	0.00581667	0.0200678
1.05	12	0	-0.0998744	0.00678984	0.0196461
1.05	14	0	-0.1039748	0.00477973	0.0199011
1.05	16	0	-0.1006366	0.00463172	0.0194177
1.05	18	0	-0.098427	0.00440949	0.0189349
1.05	20	0	-0.0927726	0.00410399	0.0177618
1.05	22	0	-0.0817711	0.00420876	0.0159213
1.05	24	0	-0.0762235	0.0034546	0.0149163
1.05	26	0	-0.1013803	-0.0008141	0.0187179

Table 3. WB001 elevons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.1	-10	0	-0.0858618	0.0082328	0.02441422
1.1	-8	0	-0.0837358	0.00656701	0.02380964
1.1	-6	0	-0.0745024	0.0060276	0.0208704
1.1	-4	0	-0.0663727	0.00605214	0.02066537
1.1	-2	0	-0.0701985	0.00718626	0.02053356
1.1	0	0	-0.0649336	0.0073159	0.01911981
1.1	2	0	-0.0595742	0.00765975	0.01938019
1.1	4	0	-0.0633601	0.00754335	0.01912686
1.1	6	0	-0.0660517	0.00645901	0.0187828
1.1	8	0	-0.0652364	0.00821832	0.0202054
1.1	10	0	-0.0685537	0.00857831	0.0218012
1.1	12	0	-0.0672279	0.0081879	0.0215574
1.1	14	0	-0.0703026	0.00704119	0.0216833
1.1	16	0	-0.0709481	0.00671869	0.0215801
1.1	18	0	-0.0694049	0.00696742	0.0209741
1.1	20	0	-0.0658456	0.00683994	0.0198288
1.1	22	0	-0.059404	0.00640657	0.0182596
1.1	24	0	-0.0555386	0.00606022	0.0168937
1.1	26	0	-0.0610424	0.00404147	0.0182202
1.15	-10	0	-0.0680956	0.00838282	0.02003264
1.15	-8	0	-0.0623545	0.00669021	0.01795464
1.15	-6	0	-0.0660331	0.0038161	0.01861489
1.15	-4	0	-0.0521706	0.00567718	0.01655855
1.15	-2	0	-0.05382	0.00575861	0.01586537
1.15	0	0	-0.049521	0.00491626	0.01425993
1.15	2	0	-0.0513061	0.00491806	0.01514509
1.15	4	0	-0.0509955	0.00343191	0.01618741
1.15	6	0	-0.0472181	0.00689987	0.0151111
1.15	8	0	-0.0523112	0.00628304	0.0149607
1.15	10	0	-0.0566431	0.00425842	0.0160936
1.15	12	0	-0.0564204	0.00257527	0.015405
1.15	14	0	-0.0565656	0.00370484	0.0159576
1.15	16	0	-0.0625868	0.00478088	0.0172327
1.15	18	0	-0.0658552	0.00439631	0.0169443
1.15	20	0	-0.0605182	0.00335574	0.0157829
1.15	22	0	-0.055165	0.0024883	0.0157072
1.15	24	0	-0.0634031	0.00195357	0.0172582
1.15	26	0	-0.0504777	0.0015301	0.0146956

Table 3. WB001 elevons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.25	-10	0	-0.1013638	0.00791315	0.03050652
1.25	-8	0	-0.0950746	0.0069134	0.02886285
1.25	-6	0	-0.0801627	0.00718136	0.02531344
1.25	-4	0	-0.0725558	0.00579006	0.02191483
1.25	-2	0	-0.0595181	0.00704948	0.01924879
1.25	0	0	-0.0506138	0.00680794	0.01730477
1.25	2	0	-0.0438839	0.00466904	0.01501859
1.25	4	0	-0.0424672	0.00156992	0.01297675
1.25	6	0	-0.0324123	0.0005825	0.011424
1.25	8	0	-0.0314503	0.00079388	0.0111831
1.25	10	0	-0.0317116	0.00028475	0.0112472
1.25	12	0	-0.0300387	-0.000313	0.0111829
1.25	14	0	-0.030435	-0.0006635	0.0112889
1.25	16	0	-0.0310272	-0.0007602	0.0116376
1.25	18	0	-0.0383567	-0.0012002	0.0124476
1.25	20	0	-0.0428228	-0.0011014	0.0131757
1.25	22	0	-0.0367133	-0.0005892	0.0122612
1.25	24	0	-0.0308521	-0.0013271	0.0096974
1.25	26	0	-0.0301617	-0.0046951	0.0085272
1.46	-10	0	-0.0540832	0.00920333	0.01711447
1.46	-8	0	-0.0431784	0.00710954	0.01305518
1.46	-6	0	-0.0380995	0.00680273	0.01214247
1.46	-4	0	-0.037551	0.00581079	0.01121153
1.46	-2	0	-0.0359302	0.00570679	0.01133709
1.46	0	0	-0.0372686	0.00751418	0.01224531
1.46	2	0	-0.0389627	0.00529501	0.01167293
1.46	4	0	-0.0367845	0.00497668	0.0123228
1.46	6	0	-0.0364104	0.00515728	0.0118559
1.46	8	0	-0.0349968	0.00393985	0.0123325
1.46	10	0	-0.0367785	0.00294817	0.0128422
1.46	12	0	-0.0378308	0.00261728	0.0128575
1.46	14	0	-0.0371199	0.00229371	0.012632
1.46	16	0	-0.0381427	0.00181166	0.0129007
1.46	18	0	-0.041188	0.00146483	0.0134626
1.46	20	0	-0.0425235	0.00125495	0.0134497
1.46	22	0	-0.0435047	0.00043967	0.0135871
1.46	24	0	-0.0450465	-0.0004167	0.0136413
1.46	26	0	-0.0393117	-0.0009817	0.0142525

Table 3. WB001 elevons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.96	-10	0	-0.0323655	0.00810753	0.00875898
1.96	-8	0	-0.0239983	0.00641114	0.00705437
1.96	-6	0	-0.0218597	0.00526868	0.00678198
1.96	-4	0	-0.0204938	0.00403871	0.00675784
1.96	-2	0	-0.0194686	0.00332673	0.00659465
1.96	0	0	-0.0197893	0.0022692	0.00658372
1.96	2	0	-0.0189291	0.002244	0.00645611
1.96	4	0	-0.0198137	0.00219929	0.0065931
1.96	6	0	-0.0220411	0.00197852	0.0071184
1.96	8	0	-0.0211729	0.00108335	0.0065728
1.96	10	0	-0.0183991	0.00077006	0.006428
1.96	12	0	-0.0169556	0.00039697	0.0058189
1.96	14	0	-0.016167	0.00064884	0.0055768
1.96	16	0	-0.0169904	0.00062453	0.0057928
1.96	18	0	-0.0181864	-0.0002667	0.0058995
1.96	20	0	-0.0169676	-0.0009185	0.0063512
1.96	22	0	-0.0173508	-0.0004181	0.00740763
1.96	24	0	-0.0248404	-0.0003798	0.00832518



Table 4. WB001 ailerons deflected  $-10^\circ$  increments.

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.3	-10	0	-0.0767876	0.005656	0.01049468
0.3	-8	0	-0.0473388	0.00184241	0.0176427
0.3	-6	0	-0.0493763	0.00432059	0.01687795
0.3	-4	0	-0.0736714	-0.0026167	0.01402911
0.3	-2	0	-0.0651791	0.00428215	0.01676349
0.3	0	0	-0.0762506	0.00429854	0.01496691
0.3	2	0	-0.0690045	7.34E-05	0.01578923
0.3	4	0	-0.0465978	0.00802631	0.01917048
0.3	6	0	-0.0652251	0.00767881	0.01593893
0.3	8	0	-0.0679759	0.00208328	0.01507054
0.3	10	0	-0.0655378	0.00300378	0.01257364
0.3	12	0	-0.0624184	0.00715658	0.01206586
0.3	14	0	-0.0540261	0.00227015	0.00927245
0.3	16	0	-0.0404326	0.0011348	0.0083728
0.3	18	0	-0.0346084	0.0049687	0.0074928
0.3	20	0	-0.0353452	0.0027756	0.0072651
0.3	22	0	-0.0387484	0.0028648	0.0063851
0.3	24	0	-0.042135	0.0039974	0.0076779
0.3	26	0	-0.0456462	0.0043547	0.0083397
0.6	-10	0	-0.0356951	0.0045397	0.00629169
0.6	-8	0	-0.036444	0.00773833	0.00841063
0.6	-6	0	-0.0648321	-0.0001528	0.01314034
0.6	-4	0	-0.0563985	0.00206692	0.01508381
0.6	-2	0	-0.0639215	0.00341525	0.01512816
0.6	0	0	-0.0735719	0.00128505	0.01466107
0.6	2	0	-0.0647101	0.0037753	0.01629191
0.6	4	0	-0.0696035	0.00558188	0.0157506
0.6	6	0	-0.0962277	0.0048471	0.01522686
0.6	8	0	-0.0897178	0.00638296	0.01546159
0.6	10	0	-0.0934063	0.00605788	0.01654079
0.6	12	0	-0.0706549	0.00410428	0.01279418
0.6	14	0	-0.0666887	0.00477422	0.01266811
0.6	16	0	-0.0748284	0.00511783	0.01324275
0.6	18	0	-0.0771293	0.00522133	0.0134927
0.6	20	0	-0.0818567	0.00563997	0.0142775
0.6	22	0	-0.0756527	0.00448125	0.01347474
0.6	24	0	-0.0734024	0.00564034	0.01316088
0.6	26	0	-0.0764884	0.00678405	0.01378362

Table 4. WB001 ailerons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.8	-10	0	-0.0129191	0.00753018	0.00640852
0.8	-8	0	-0.0226734	0.00556727	0.00675554
0.8	-6	0	-0.0288273	0.00632326	0.00813847
0.8	-4	0	-0.0423666	0.00546684	0.01100695
0.8	-2	0	-0.0491825	0.00331592	0.0120477
0.8	0	0	-0.0496423	0.00386489	0.01225242
0.8	2	0	-0.0461786	0.00476506	0.01262716
0.8	4	0	-0.0467212	0.00374338	0.01199094
0.8	6	0	-0.0501	0.00436757	0.01243248
0.8	8	0	-0.0352552	0.00287389	0.00976821
0.8	10	0	-0.0534722	0.002576	0.00876079
0.8	12	0	-0.0589337	0.00408868	0.01107416
0.8	14	0	-0.0685852	0.0044841	0.0128077
0.8	16	0	-0.0801606	0.0073608	0.01587021
0.8	18	0	-0.093277	0.01113248	0.01947437
0.8	20	0	-0.094123	0.01163295	0.01951813
0.8	22	0	-0.0889395	0.01007579	0.01852638
0.8	24	0	-0.0859985	0.00974828	0.01808927
0.8	26	0	-0.0849224	0.01056856	0.01775381
0.9	-10	0	-0.0191899	0.00498085	0.00555015
0.9	-8	0	-0.020463	0.00473554	0.0055635
0.9	-6	0	-0.0270287	0.00495133	0.00663724
0.9	-4	0	-0.0432257	0.00542471	0.01186336
0.9	-2	0	-0.0418302	0.00559147	0.01019458
0.9	0	0	-0.0455754	0.00407234	0.01016086
0.9	2	0	-0.0336197	0.00400473	0.00858758
0.9	4	0	-0.0368674	0.00306756	0.00892155
0.9	6	0	-0.0254363	0.00308007	0.00613708
0.9	8	0	0.00864669	0.00034594	0.00429613
0.9	10	0	-0.0171459	0.00334274	0.00557379
0.9	12	0	-0.0264742	0.0036919	0.00662082
0.9	14	0	-0.0287984	0.00489575	0.00762534
0.9	16	0	-0.0331077	0.00579636	0.00906679
0.9	18	0	-0.0438693	0.00628229	0.0109271
0.9	20	0	-0.0502008	0.00646049	0.01192856
0.9	22	0	-0.0472098	0.0066621	0.01158439
0.9	24	0	-0.0411797	0.00614816	0.01102465
0.9	26	0	-0.0378979	0.00446684	0.01105598

Table 4. WB001 ailerons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
0.95	-10	0	-0.0142994	0.002423	0.00545276
0.95	-8	0	0.0030284	0.00313541	-0.0002625
0.95	-6	0	-0.0253157	0.00155166	0.00696654
0.95	-4	0	-0.0323756	0.00321724	0.00903662
0.95	-2	0	-0.0470007	0.00475338	0.01243088
0.95	0	0	-0.0477834	0.00482611	0.0137594
0.95	2	0	-0.0440081	0.00692642	0.01350821
0.95	4	0	-0.0345564	0.00423292	0.00912001
0.95	6	0	-0.0486037	0.0006112	0.00581912
0.95	8	0	-0.0125751	-0.0003587	0.00594742
0.95	10	0	-0.0103355	-0.0010716	0.0053755
0.95	12	0	-0.0144134	0.00024712	0.0067969
0.95	14	0	-0.0235452	-0.0002553	0.0082399
0.95	16	0	-0.0263901	-0.0014713	0.0086941
0.95	18	0	-0.039019	-0.0014474	0.0117902
0.95	20	0	-0.04666	-0.000273	0.01446967
0.95	22	0	-0.0427434	0.00029186	0.01409762
0.95	24	0	-0.0443763	-0.0002583	0.01263617
0.95	26	0	-0.053537	0.00056103	0.01231009
1.05	-10	0	-0.0349585	0.00321661	0.00798471
1.05	-8	0	-0.0411265	0.00690104	0.01131506
1.05	-6	0	-0.0455447	0.00542109	0.01286229
1.05	-4	0	-0.0440223	0.00730691	0.01211754
1.05	-2	0	-0.0402051	0.0068447	0.01279276
1.05	0	0	-0.0385124	0.00649698	0.01086135
1.05	2	0	-0.0379389	0.00294425	0.0103368
1.05	4	0	-0.0281259	0.00311177	0.00972329
1.05	6	0	-0.0285614	0.00260763	0.0081217
1.05	8	0	-0.0266376	0.00116652	0.0093659
1.05	10	0	-0.0255795	-3.09E-05	0.0087018
1.05	12	0	-0.0238108	-0.0009569	0.0093285
1.05	14	0	-0.0200531	-2.79E-05	0.007965
1.05	16	0	-0.0202674	-0.000583	0.0073033
1.05	18	0	-0.0212921	-0.0008228	0.0077858
1.05	20	0	-0.0199228	-0.0003892	0.0080896
1.05	22	0	-0.0217439	-0.0010528	0.0079703
1.05	24	0	-0.0246127	-0.0019597	0.0073875
1.05	26	0	-0.0025975	0.00131302	0.0057171

Table 4. WB001 ailerons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.1	-10	0	-0.0289064	0.00661357	0.00745146
1.1	-8	0	-0.044879	0.00919078	0.01192227
1.1	-6	0	-0.0518777	0.00720722	0.01451752
1.1	-4	0	-0.0476641	0.00569694	0.0137094
1.1	-2	0	-0.0453166	0.00447542	0.01337759
1.1	0	0	-0.0414461	0.00439702	0.01222428
1.1	2	0	-0.0338829	0.00368682	0.01076376
1.1	4	0	-0.030407	0.00250127	0.00929421
1.1	6	0	-0.0240058	0.00173418	0.0080227
1.1	8	0	-0.0243189	0.00086744	0.0080247
1.1	10	0	-0.0219459	0.00101987	0.0071886
1.1	12	0	-0.025305	5.39E-05	0.0074127
1.1	14	0	-0.0194957	9.83E-05	0.0063498
1.1	16	0	-0.0163825	0.00047431	0.0060149
1.1	18	0	-0.0184241	-9.22E-05	0.0061176
1.1	20	0	-0.0197623	-0.000427	0.0064889
1.1	22	0	-0.0191121	-0.0001564	0.0068729
1.1	24	0	-0.0190533	-0.0005244	0.0064173
1.1	26	0	-0.0198378	-0.0015676	0.0062209
1.15	-10	0	-0.0481173	0.00523443	0.01343103
1.15	-8	0	-0.0555745	0.00537312	0.01523532
1.15	-6	0	-0.0394891	0.00623483	0.01174718
1.15	-4	0	-0.0389251	0.0057488	0.01180594
1.15	-2	0	-0.0318093	0.00530051	0.0098014
1.15	0	0	-0.0303417	0.0042669	0.00969448
1.15	2	0	-0.0270011	0.00361584	0.00978033
1.15	4	0	-0.0277912	0.00250135	0.00861648
1.15	6	0	-0.0231782	-6.92E-06	0.0085274
1.15	8	0	-0.0204665	0.00070961	0.0078987
1.15	10	0	-0.01866	0.00279123	0.007425
1.15	12	0	-0.0146633	0.0041353	0.0069538
1.15	14	0	-0.0160225	0.00433056	0.0065598
1.15	16	0	-0.0107105	0.00232414	0.0053269
1.15	18	0	-0.0061934	0.00182169	0.0052994
1.15	20	0	-0.0104733	0.00314136	0.0062173
1.15	22	0	-0.0138659	0.00303719	0.005668
1.15	24	0	-0.0037983	0.00090246	0.003359
1.15	26	0	-0.0164004	0.00061051	0.00659

Table 4. WB001 ailerons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.25	-10	0	-0.0354562	0.00676792	0.01017727
1.25	-8	0	-0.0339087	0.00742144	0.01069189
1.25	-6	0	-0.0387017	0.00593719	0.01170374
1.25	-4	0	-0.0341759	0.00580033	0.01176076
1.25	-2	0	-0.0326964	0.00496231	0.01088315
1.25	0	0	-0.0314589	0.00394488	0.0098731
1.25	2	0	-0.0285175	0.00278483	0.00926275
1.25	4	0	-0.0232328	0.00309111	0.0089929
1.25	6	0	-0.0194581	0.00235206	0.0059403
1.25	8	0	-0.0146717	-0.0002073	0.0061051
1.25	10	0	-0.0135249	-0.0008002	0.00605
1.25	12	0	-0.0158194	-0.0008838	0.0060595
1.25	14	0	-0.0157537	-0.0013061	0.0058338
1.25	16	0	-0.0157391	-0.0014751	0.0056137
1.25	18	0	-0.016511	-0.0014505	0.0057728
1.25	20	0	-0.016304	-0.001718	0.0060256
1.25	22	0	-0.0148245	-0.002161	0.0059613
1.25	24	0	-0.0158494	-0.0022794	0.0061012
1.25	26	0	-0.0149065	-0.0032712	0.0060338
1.46	-10	0	-0.024895	0.00368677	0.00687258
1.46	-8	0	-0.019222	0.00514396	0.00700549
1.46	-6	0	-0.0194059	0.00452503	0.0065115
1.46	-4	0	-0.0216184	0.00334337	0.00661643
1.46	-2	0	-0.0205188	0.0047119	0.00758398
1.46	0	0	-0.0191612	0.00275504	0.00599938
1.46	2	0	-0.018058	0.00187486	0.00584724
1.46	4	0	-0.0149094	0.00160975	0.0054366
1.46	6	0	-0.0152713	0.00063418	0.00499
1.46	8	0	-0.0053221	-0.0010276	0.004134
1.46	10	0	-0.0147523	-0.0013669	0.0036831
1.46	12	0	-0.0114972	-0.0009226	0.00397
1.46	14	0	-0.011117	-0.0013873	0.004177
1.46	16	0	-0.013389	-0.0019053	0.0040898
1.46	18	0	-0.0154381	-0.0018267	0.0040925
1.46	20	0	-0.0171609	-0.0024637	0.0042559
1.46	22	0	-0.0142827	-0.0018927	0.0045025
1.46	24	0	-0.0092344	-0.0014564	0.003865
1.46	26	0	-0.0106258	-0.0031398	0.0038623

Table 4. WB001 ailerons deflected  $-10^\circ$  increments—Continued

Mach	$\alpha$	$\beta$	$C_N$	$C_{Af}$	$C_M$
1.96	-10	0	-0.0201295	0.00435722	0.00535679
1.96	-8	0	-0.0156825	0.00366121	0.00473969
1.96	-6	0	-0.0148281	0.00285947	0.00429411
1.96	-4	0	-0.0154274	0.00232565	0.00383459
1.96	-2	0	-0.0130731	0.0017287	0.00368028
1.96	0	0	-0.0109656	0.00146331	0.00354137
1.96	2	0	-0.010975	0.00199057	0.00341899
1.96	4	0	-0.0128164	0.00059079	0.00259794
1.96	6	0	-0.0110762	-0.0004604	0.0025616
1.96	8	0	-0.0017546	-6.36E-05	0.0030762
1.96	10	0	-0.0090838	0.00041286	0.0029464
1.96	12	0	-0.0102262	-0.0001293	0.0027939
1.96	14	0	-0.0121183	-0.0007424	0.0029495
1.96	16	0	-0.0137829	-0.0010206	0.0035292
1.96	18	0	-0.0150151	-0.0007863	0.0039775
1.96	20	0	-0.0150662	-0.0007489	0.00343362
1.96	22	0	-0.0179625	-0.0017913	0.00308189
1.96	24	0	-0.0118243	-0.0011558	0.00356768

Table 5. Power-off base axial force coefficient.

Mach	$\alpha$	$C_{AB}$
0.3	-10	0.01661523
0.3	-8	0.01293501
0.3	-6	0.01274746
0.3	-4	0.01153712
0.3	-2	0.01107388
0.3	0	0.01082182
0.3	2	0.0112482
0.3	4	0.01233539
0.3	6	0.01203242
0.3	8	0.01355856
0.3	10	0.01509937
0.3	12	0.01829086
0.3	14	0.02181141
0.3	16	0.02656594
0.3	18	0.0295327
0.3	20	0.03448927
0.3	22	0.03893872
0.3	24	0.04460543
0.3	26	0.04822585
0.6	-10	0.01191676
0.6	-8	0.01056174
0.6	-6	0.00961892
0.6	-4	0.00851265
0.6	-2	0.00828199
0.6	0	0.00790868
0.6	2	0.00844973
0.6	4	0.00889606
0.6	6	0.00922006
0.6	8	0.00974182
0.6	10	0.01110534
0.6	12	0.01412715
0.6	14	0.01759602
0.6	16	0.02166693
0.6	18	0.0261301
0.6	20	0.03158629
0.6	22	0.03906045
0.6	24	0.05008982
0.6	26	0.05689626

Table 5. Power-off base axial force coefficient—Continued

Mach	$\alpha$	$C_{AB}$
0.8	-10	0.01582543
0.8	-8	0.01356452
0.8	-6	0.01155703
0.8	-4	0.01016097
0.8	-2	0.00973888
0.8	0	0.00969274
0.8	2	0.00986129
0.8	4	0.01013079
0.8	6	0.01040434
0.8	8	0.01133882
0.8	10	0.01393101
0.8	12	0.0175926
0.8	14	0.02220832
0.8	16	0.02804355
0.8	18	0.03549342
0.8	20	0.04441701
0.8	22	0.05327425
0.8	24	0.06045352
0.8	26	0.06604583
0.9	-10	0.02144539
0.9	-8	0.01817082
0.9	-6	0.01476618
0.9	-4	0.01256981
0.9	-2	0.01139004
0.9	0	0.01112033
0.9	2	0.01138786
0.9	4	0.01164882
0.9	6	0.0118892
0.9	8	0.01451863
0.9	10	0.01861985
0.9	12	0.02361037
0.9	14	0.02927628
0.9	16	0.03571021
0.9	18	0.04569066
0.9	20	0.05658331
0.9	22	0.06418505
0.9	24	0.06923027
0.9	26	0.07449334



Table 5. Power-off base axial force coefficient—Continued

Mach	$\alpha$	$C_{AB}$
0.95	-10	0.02454045
0.95	-8	0.02084026
0.95	-6	0.01674378
0.95	-4	0.01444562
0.95	-2	0.0125282
0.95	0	0.01132775
0.95	2	0.01065449
0.95	4	0.01102496
0.95	6	0.01297117
0.95	8	0.01357653
0.95	10	0.0186919
0.95	12	0.02416555
0.95	14	0.02967571
0.95	16	0.03542125
0.95	18	0.04436986
0.95	20	0.0558438
0.95	22	0.06536671
0.95	24	0.07073765
0.95	26	0.07485062
1.05	-10	0.02684789
1.05	-8	0.0232584
1.05	-6	0.01954943
1.05	-4	0.0182899
1.05	-2	0.01933625
1.05	0	0.0203056
1.05	2	0.02118486
1.05	4	0.02172921
1.05	6	0.02282905
1.05	8	0.02669587
1.05	10	0.03015354
1.05	12	0.03412374
1.05	14	0.03738214
1.05	16	0.04173643
1.05	18	0.04556767
1.05	20	0.04885279
1.05	22	0.05227381
1.05	24	0.05678051
1.05	26	0.06290684

Table 5. Power-off base axial force coefficient—Continued

Mach	$\alpha$	$C_{AB}$
1.1	-10	0.02993089
1.1	-8	0.02897779
1.1	-6	0.02665115
1.1	-4	0.02585049
1.1	-2	0.02669507
1.1	0	0.02799158
1.1	2	0.02900546
1.1	4	0.03014652
1.1	6	0.02964773
1.1	8	0.03121768
1.1	10	0.03352184
1.1	12	0.03587051
1.1	14	0.03886995
1.1	16	0.04173764
1.1	18	0.04494564
1.1	20	0.04809126
1.1	22	0.05159609
1.1	24	0.05590073
1.1	26	0.06037962
1.15	-10	0.02698709
1.15	-8	0.02500626
1.15	-6	0.02222932
1.15	-4	0.02182584
1.15	-2	0.02184225
1.15	0	0.02172412
1.15	2	0.02262657
1.15	4	0.02305422
1.15	6	0.02426658
1.15	8	0.02617985
1.15	10	0.02835869
1.15	12	0.03250419
1.15	14	0.0380509
1.15	16	0.04234619
1.15	18	0.04629713
1.15	20	0.0511042
1.15	22	0.0567052
1.15	24	0.06210404
1.15	26	0.06516981

Table 5. Power-off base axial force coefficient—Continued

Mach	$\alpha$	$C_{AB}$
1.25	-10	0.02404751
1.25	-8	0.02433611
1.25	-6	0.02358118
1.25	-4	0.02304086
1.25	-2	0.0243241
1.25	0	0.02564296
1.25	2	0.02649165
1.25	4	0.02764009
1.25	6	0.02832344
1.25	8	0.02996405
1.25	10	0.03178396
1.25	12	0.03414841
1.25	14	0.03669987
1.25	16	0.03954094
1.25	18	0.04321172
1.25	20	0.04711926
1.25	22	0.05072204
1.25	24	0.05407894
1.25	26	0.05744336
1.46	-10	0.02539353
1.46	-8	0.0254349
1.46	-6	0.0254334
1.46	-4	0.02532553
1.46	-2	0.02554298
1.46	0	0.02711887
1.46	2	0.02831239
1.46	4	0.02928395
1.46	6	0.03051164
1.46	8	0.03233715
1.46	10	0.03473306
1.46	12	0.03716489
1.46	14	0.03978852
1.46	16	0.04170359
1.46	18	0.04344758
1.46	20	0.04613315
1.46	22	0.04813634
1.46	24	0.04996089
1.46	26	0.05136327

Table 5. Power-off base axial force coefficient—Continued

Mach	$\alpha$	$C_{AB}$
1.96	-10	0.01629634
1.96	-8	0.01603133
1.96	-6	0.01576895
1.96	-4	0.01533049
1.96	-2	0.0159538
1.96	0	0.01658104
1.96	2	0.01789892
1.96	4	0.01917921
1.96	6	0.0206092
1.96	8	0.02225417
1.96	10	0.02410831
1.96	12	0.02626743
1.96	14	0.02714236
1.96	16	0.02722189
1.96	18	0.02827346
1.96	20	0.02971747
1.96	22	0.0306784
1.96	24	0.03253991

Table 6. Power-on base axial force.

alt(ft)	qinf(psf)	Mach	$F_{AB}$ (lb)
4,830	110	0.3	35,482
13,700	319	0.6	29,358
20,400	454	0.8	35,630
23,500	510	0.9	37,431
24,400	524	0.95	41,870
27,800	571	1.05	40,665
29,500	587	1.1	34,933
30,400	594	1.15	30,787
34,100	623	1.25	25,591
40,000	661	1.5	7,693
51,400	669	2.0	-21,656
63,500	581	2.5	-20,998
68,000	543	2.75	-19,907
73,800	493	3.0	-19,333
85,600	396	3.5	-17,548
95,400	326	4.0	-14,983
116,000	208	5.0	-10,218

Table 7. WB001 basic vehicle lateral aerodynamic coefficients.

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
0.3	0	-10	0.09211816	0.02128972	-0.0043886
0.3	0	-8	0.07713205	0.01706818	-0.0030053
0.3	0	-6	0.05740642	0.01250544	-0.0022023
0.3	0	-4	0.03500592	0.00823213	-0.0018746
0.3	0	-2	0.02146718	0.00425327	-0.0005706
0.3	0	0	0	0	0
0.3	0	2	-0.021269	-0.0038193	0.00038116
0.3	0	4	-0.0399275	-0.0084285	0.00134819
0.3	0	6	-0.0573406	-0.0129857	0.00230566
0.3	0	8	-0.0833672	-0.0178668	0.00280071
0.3	0	10	-0.100326	-0.0226264	0.00425187
0.6	0	-10	0.09617204	0.02267448	-0.0044876
0.6	0	-8	0.07678446	0.01779083	-0.0032751
0.6	0	-6	0.05792256	0.01313578	-0.0022617
0.6	0	-4	0.03742751	0.00862551	-0.0014626
0.6	0	-2	0.01952274	0.00432401	-0.000568
0.6	0	0	0	0	0
0.6	0	2	-0.0175081	-0.0044837	0.00092328
0.6	0	4	-0.0378732	-0.0090608	0.00155032
0.6	0	6	-0.0569692	-0.0133883	0.00240429
0.6	0	8	-0.0772523	-0.0181236	0.00339204
0.6	0	10	-0.0981845	-0.0231147	0.00449179
0.8	0	-10	0.09354368	0.02549774	-0.0062484
0.8	0	-8	0.07533115	0.01979298	-0.0044824
0.8	0	-6	0.0558087	0.01435377	-0.0030624
0.8	0	-4	0.03747969	0.00950797	-0.0018078
0.8	0	-2	0.01832342	0.00465565	-0.000824
0.8	0	0	0	0	0
0.8	0	2	-0.0186515	-0.0047401	0.00082563
0.8	0	4	-0.03779	-0.0095809	0.00173746
0.8	0	6	-0.0564162	-0.0146073	0.00300503
0.8	0	8	-0.0763392	-0.0203776	0.00433011
0.8	0	10	-0.0968208	-0.0261872	0.00594174
0.9	0	-10	0.09379367	0.02923523	-0.0085022
0.9	0	-8	0.07093089	0.02336418	-0.0064017
0.9	0	-6	0.05050946	0.01800878	-0.004763
0.9	0	-4	0.03194892	0.01224282	-0.0030586
0.9	0	-2	0.01565233	0.00629859	-0.0015523

Table 7. WB001 basic vehicle lateral aerodynamic coefficients—Continued

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
0.9	0	0	0	0	0
0.9	0	2	-0.013744	-0.0061714	0.00153144
0.9	0	4	-0.0307902	-0.0122363	0.00313362
0.9	0	6	-0.0485895	-0.0176761	0.00474889
0.9	0	8	-0.0710433	-0.0233133	0.00637547
0.9	0	10	-0.0931057	-0.0293326	0.00835459
0.95	0	-10	0.10662714	0.0276517	-0.008709
0.95	0	-8	0.07954016	0.02213861	-0.0067186
0.95	0	-6	0.05709153	0.01663822	-0.0048283
0.95	0	-4	0.03662795	0.01110461	-0.0030568
0.95	0	-2	0.01786359	0.00559731	-0.001514
0.95	0	0	0	0	0
0.95	0	2	-0.0182561	-0.0053822	0.00141906
0.95	0	4	-0.0357703	-0.0112543	0.00337438
0.95	0	6	-0.0538163	-0.0163009	0.00515737
0.95	0	8	-0.0788744	-0.0223597	0.00722663
0.95	0	10	-0.1056769	-0.028183	0.0091723
1.05	0	-10	0.12136188	0.02524633	-0.0090748
1.05	0	-8	0.09408075	0.01971559	-0.006988
1.05	0	-6	0.06866358	0.01455698	-0.005023
1.05	0	-4	0.04481683	0.00960661	-0.0032246
1.05	0	-2	0.02203364	0.00468559	-0.0016421
1.05	0	0	0	0	0
1.05	0	2	-0.0231286	-0.0046718	0.00149152
1.05	0	4	-0.0456501	-0.0095962	0.00316485
1.05	0	6	-0.0693685	-0.0145448	0.00495857
1.05	0	8	-0.0957678	-0.0198371	0.00663565
1.05	0	10	-0.1230719	-0.0256734	0.00892516
1.1	0	-10	0.1175493	0.02718947	-0.0092541
1.1	0	-8	0.0914574	0.02123698	-0.0069852
1.1	0	-6	0.06641475	0.01557698	-0.0050681
1.1	0	-4	0.04322503	0.01021129	-0.0032794
1.1	0	-2	0.02180885	0.00502269	-0.0015768
1.1	0	0	0	0	0
1.1	0	2	-0.0225166	-0.0051492	0.00162662
1.1	0	4	-0.0441894	-0.0102608	0.00322649
1.1	0	6	-0.0674326	-0.0156888	0.00516062
1.1	0	8	-0.093365	-0.0212725	0.00694193

Table 7. WB001 basic vehicle lateral aerodynamic coefficients—Continued

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
1.1	0	10	-0.1198226	-0.0272864	0.00935536
1.15	0	-10	0.11936397	0.03158798	-0.0089577
1.15	0	-8	0.09187765	0.02489892	-0.0070293
1.15	0	-6	0.06674206	0.01837087	-0.0049915
1.15	0	-4	0.04349163	0.01201259	-0.0030405
1.15	0	-2	0.02102067	0.00592464	-0.0013712
1.15	0	0	0	0	0
1.15	0	2	-0.0226243	-0.0059595	0.0012173
1.15	0	4	-0.0437072	-0.012123	0.00256251
1.15	0	6	-0.0675336	-0.01851	0.00438725
1.15	0	8	-0.094086	-0.0249202	0.00616406
1.15	0	10	-0.1223806	-0.0321542	0.00847629
1.25	0	-10	0.12506498	0.02921642	-0.0092424
1.25	0	-8	0.09619159	0.02308378	-0.0072994
1.25	0	-6	0.07026376	0.01704778	-0.0052936
1.25	0	-4	0.0459336	0.0111819	-0.0033906
1.25	0	-2	0.0225031	0.00553204	-0.0016633
1.25	0	0	0	0	0
1.25	0	2	-0.0231735	-0.0053877	0.00163961
1.25	0	4	-0.0468595	-0.010848	0.00338964
1.25	0	6	-0.0711278	-0.017042	0.00531633
1.25	0	8	-0.0972482	-0.0226532	0.00739798
1.25	0	10	-0.1263187	-0.0294588	0.00952924
1.46	0	-10	0.12188023	0.03199649	-0.0089515
1.46	0	-8	0.09397177	0.02506653	-0.0072306
1.46	0	-6	0.06833304	0.01840639	-0.0054206
1.46	0	-4	0.04441782	0.01207797	-0.0036449
1.46	0	-2	0.02191644	0.00607182	-0.0018429
1.46	0	0	0	0	0
1.46	0	2	-0.0224582	-0.0060544	0.00175183
1.46	0	4	-0.0447283	-0.0121107	0.00359048
1.46	0	6	-0.0692745	-0.0184515	0.00540613
1.46	0	8	-0.0949413	-0.0251236	0.00719214
1.46	0	10	-0.1276385	-0.0327688	0.00899583
1.96	0	-10	0.13887566	0.03242082	-0.0083199
1.96	0	-8	0.10249764	0.02587073	-0.0066409
1.96	0	-6	0.07226122	0.01914974	-0.0049629
1.96	0	-4	0.04589929	0.01238428	-0.0033027

Table 7. WB001 basic vehicle lateral aerodynamic coefficients—Continued

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
1.96	0	-2	0.0225565	0.00609456	-0.0016135
1.96	0	0	0	0	0
1.96	0	2	-0.0230219	-0.0061168	0.00159513
1.96	0	4	-0.0464601	-0.0124219	0.00324782
1.96	0	6	-0.0711987	-0.019053	0.0048487
1.96	0	8	-0.098359	-0.0261175	0.00661921
1.96	0	10	-0.136111	-0.0334947	0.00821788



Table 8. WB001 right tip fin deflected 10° increments.

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
0.3	0	-10	-0.0111738	0.00375296	-0.0011108
0.3	0	-8	-0.0126768	0.00304514	-0.0014212
0.3	0	-6	-0.0122751	0.00295581	-0.0013075
0.3	0	-4	-0.0072022	0.00298777	-0.0008283
0.3	0	-2	-0.0078669	0.00253887	-0.0009525
0.3	0	0	-0.0087567	0.00249208	-0.001095
0.3	0	2	-0.0105315	0.00261196	-0.0012594
0.3	0	4	-0.0093151	0.0036748	-0.0016552
0.3	0	6	-0.0108885	0.00349147	-0.0016149
0.3	0	8	-0.0093648	0.00359704	-0.0017401
0.3	0	10	-0.0094791	0.003114	-0.001706
0.6	0	-10	-0.0083334	0.00277886	-0.0007422
0.6	0	-8	-0.0073891	0.00261466	-0.0006113
0.6	0	-6	-0.0071011	0.00259734	-0.0006782
0.6	0	-4	-0.0057492	0.00270679	-0.0005789
0.6	0	-2	-0.008231	0.00284216	-0.0009681
0.6	0	0	-0.0097614	0.00298447	-0.0010534
0.6	0	2	-0.0116812	0.00338545	-0.0014785
0.6	0	4	-0.0086506	0.00352151	-0.0013835
0.6	0	6	-0.009477	0.00294019	-0.0014253
0.6	0	8	-0.0094652	0.00276306	-0.0014307
0.6	0	10	-0.0019978	0.00179838	-0.001178
0.8	0	-10	-0.0042189	0.00218118	-0.0004545
0.8	0	-8	-0.0056046	0.00217927	-0.0004813
0.8	0	-6	-0.0055411	0.00252384	-0.0005222
0.8	0	-4	-0.0078707	0.00265379	-0.0007207
0.8	0	-2	-0.0073769	0.00282838	-0.0007373
0.8	0	0	-0.0081524	0.00282725	-7.53E-04
0.8	0	2	-0.0082313	0.00287864	-0.0007364
0.8	0	4	-0.0078056	0.00258033	-0.0007707
0.8	0	6	-0.0075109	0.0025822	-0.0007167
0.8	0	8	-0.0061062	0.00296325	-0.0005324
0.8	0	10	-0.0096459	0.00279543	-0.0010797
0.9	0	-10	-0.0012561	0.00038941	3.79E-05
0.9	0	-8	-0.0003424	0.00032921	-9.93E-05
0.9	0	-6	-0.0004719	0.000327	5.82E-06
0.9	0	-4	-0.0022357	0.00091006	-0.0001936
0.9	0	-2	-0.0046795	0.00178119	-0.0003209

Table 8. WB001 right tip fin deflected 10° increments—Continued

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
0.9	0	0	-0.0059143	0.00257686	-0.0004376
0.9	0	2	-0.0091836	0.00293973	-0.0005659
0.9	0	4	-0.0096375	0.00313209	-0.0007177
0.9	0	6	-0.0103552	0.002999	-0.000769
0.9	0	8	-0.0080313	0.00319344	-0.0006207
0.9	0	10	-0.0116019	0.00289181	-0.0008485
0.95	0	-10	0.0035408	-0.001056	0.00022604
0.95	0	-8	0.00561405	-0.0013229	0.00052017
0.95	0	-6	0.00412647	-0.001118	0.00040431
0.95	0	-4	0.00310902	-0.0008094	0.00029427
0.95	0	-2	0.0016516	-8.99E-05	0.00019938
0.95	0	0	-0.0013122	0.00077437	8.99E-05
0.95	0	2	-0.0023197	0.00094664	0.00014038
0.95	0	4	-0.0041737	0.00162497	-0.0002486
0.95	0	6	-0.007959	0.00163384	-0.0003003
0.95	0	8	-0.0095102	0.00262007	-0.0008109
0.95	0	10	-0.009494	0.00273605	-0.0006002
1.05	0	-10	-0.0060629	0.00229879	-0.0002862
1.05	0	-8	-0.0048408	0.00219394	-0.0002387
1.05	0	-6	-0.0048272	0.00209164	-0.0002619
1.05	0	-4	-0.005522	0.00213996	-0.0003138
1.05	0	-2	-0.0062264	0.00233024	-0.000322
1.05	0	0	-0.0066634	0.00240276	-0.0003514
1.05	0	2	-0.0059135	0.00231338	-0.0002086
1.05	0	4	-0.0065402	0.00238644	-0.0002673
1.05	0	6	-0.0075382	0.00242227	-0.000358
1.05	0	8	-0.0060989	0.00250444	-2.16E-05
1.05	0	10	-0.0076873	0.00237822	-0.0002767
1.1	0	-10	-0.0062844	0.00196872	-9.04E-05
1.1	0	-8	-0.0061472	0.00203261	-5.76E-05
1.1	0	-6	-0.0061071	0.00198542	-0.0002396
1.1	0	-4	-0.0063937	0.00212996	-0.0003219
1.1	0	-2	-0.0070678	0.00227253	-0.0003724
1.1	0	0	-0.00747	0.00238645	-4.22E-04
1.1	0	2	-0.0072931	0.00245853	-0.0004593
1.1	0	4	-0.0076421	0.00240743	-0.0004781
1.1	0	6	-0.0070226	0.00252614	-0.0005798
1.1	0	8	-0.0072766	0.00240256	-0.000412

Table 8. WB001 right tip fin deflected 10° increments—Continued

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
1.1	0	10	-0.0080572	0.00239783	-0.0007033
1.15	0	-10	-0.0021647	0.0019209	-0.0005358
1.15	0	-8	-0.0019734	0.00180098	-0.0002624
1.15	0	-6	-0.0023012	0.00186086	-0.0002609
1.15	0	-4	-0.002634	0.00195849	-0.0003281
1.15	0	-2	-0.0028483	0.00215168	-0.0003643
1.15	0	0	-0.0043552	0.00226381	-0.0002899
1.15	0	2	-0.0029	0.00222437	-1.05E-05
1.15	0	4	-0.0041214	0.00229583	0.00010207
1.15	0	6	-0.0038771	0.00246541	-0.0001486
1.15	0	8	-0.0028773	0.00243176	0.00027299
1.15	0	10	-0.0051648	0.00303017	-0.0002189
1.25	0	-10	-0.0065413	0.00177627	-0.0005916
1.25	0	-8	-0.0059301	0.00150813	-0.0005157
1.25	0	-6	-0.0055956	0.00138851	-0.000533
1.25	0	-4	-0.0053624	0.00131636	-0.0004742
1.25	0	-2	-0.0052481	0.00132421	-0.0004986
1.25	0	0	-0.0053597	0.00132287	-0.0004108
1.25	0	2	-0.0044948	0.00122808	-0.0002801
1.25	0	4	-0.0038708	0.00103112	-0.0001364
1.25	0	6	-0.0038858	0.00121384	2.17E-05
1.25	0	8	-0.0040725	0.00118702	-2.74E-05
1.25	0	10	-0.0048289	0.00107912	3.61E-05
1.46	0	-10	-0.0030636	0.00105356	-0.0001138
1.46	0	-8	-0.0027028	0.00115934	-0.0001222
1.46	0	-6	-0.0031035	0.00122058	-0.0001937
1.46	0	-4	-0.0032976	0.00126348	-0.0002159
1.46	0	-2	-0.003722	0.00133657	-0.0002
1.46	0	0	-0.0037205	0.0014965	-0.0001145
1.46	0	2	-0.0035971	0.00162819	-0.0002066
1.46	0	4	-0.0041082	0.00166556	-0.0001861
1.46	0	6	-0.0033996	0.00186349	-0.0002485
1.46	0	8	-0.0028214	0.00230546	-0.0004032
1.46	0	10	-0.0028214	0.00421481	-0.000723
1.96	0	-10	-0.0099718	0.0002377	8.23E-05
1.96	0	-8	-0.0071801	-5.85E-06	9.49E-06
1.96	0	-6	-0.0059614	-0.0002229	-5.77E-06
1.96	0	-4	-0.0049424	1.70E-05	-2.96E-05

Table 8. WB001 right tip fin deflected 10° increments—Continued

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
1.96	0	-2	-0.0044202	0.00036892	-0.0001748
1.96	0	0	-0.0056904	0.00017219	-4.74E-05
1.96	0	2	-0.0054315	0.00033154	-7.87E-05
1.96	0	4	-0.0053676	0.00051241	-8.20E-05
1.96	0	6	-0.0060195	0.00065291	-5.02E-05
1.96	0	8	-0.0062908	0.00105859	-0.0003811
1.96	0	10	-0.0071324	0.00067757	-9.83E-05

Table 9. WB001 right tip fin deflected 20° increments.

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
0.3	0	-10	-0.0069905	0.00392766	-0.0004699
0.3	0	-8	-0.0122227	0.00382402	-0.0013108
0.3	0	-6	-0.0103791	0.00398152	-0.0011716
0.3	0	-4	-0.0063241	0.00389138	-0.0005948
0.3	0	-2	-0.0094562	0.00333872	-0.0008494
0.3	0	0	-0.006752	0.00344821	-0.0008689
0.3	0	2	-0.0082173	0.00279146	-0.0006432
0.3	0	4	-0.0107304	0.004093	-0.0015021
0.3	0	6	-0.0135961	0.00427897	-0.0017085
0.3	0	8	-0.0116212	0.00543524	-0.0020723
0.3	0	10	-0.0132329	0.0047377	-0.0018476
0.6	0	-10	-0.0094778	0.00409699	-0.0010937
0.6	0	-8	-0.006578	0.00414216	-0.0007546
0.6	0	-6	-0.0085705	0.0039538	-0.000876
0.6	0	-4	-0.006843	0.00417573	-0.0008467
0.6	0	-2	-0.0076806	0.00426692	-0.0010414
0.6	0	0	-0.0087929	0.00442351	-0.0011811
0.6	0	2	-0.0095691	4.72E-03	-0.0013918
0.6	0	4	-0.010467	0.00545471	-0.0016963
0.6	0	6	-0.0115991	0.00563929	-0.0019786
0.6	0	8	-0.0095648	0.00550936	-0.0019797
0.6	0	10	-0.0110925	0.00510078	-0.0021879
0.8	0	-10	-0.0045466	0.00383138	-0.0009607
0.8	0	-8	-0.0058929	0.00398292	-0.0008514
0.8	0	-6	-0.006083	0.00426636	-0.0009379
0.8	0	-4	-0.0078678	0.00438166	-0.0009549
0.8	0	-2	-0.0072917	0.00452458	-0.0009009
0.8	0	0	-0.0081611	0.00462828	-0.0009686
0.8	0	2	-0.0092173	0.00475764	-0.0010729
0.8	0	4	-0.0080549	0.00500133	-0.0010416
0.8	0	6	-0.0081067	0.004562	-0.0010695
0.8	0	8	-0.0074268	0.00503925	-0.0012121
0.8	0	10	-0.0086039	0.00574593	-0.0017742
0.9	0	-10	0.00267109	0.00147704	-0.0006098
0.9	0	-8	0.00256634	0.00149439	-0.0005317
0.9	0	-6	0.00121611	0.00172437	-0.0003475
0.9	0	-4	-0.0013457	0.00267852	-0.0005497
0.9	0	-2	-0.0045638	0.00386925	-0.0007391

Table 9. WB001 right tip fin deflected 20° increments—Continued

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
0.9	0	0	-0.0079484	0.00515983	-0.0011124
0.9	0	2	-0.0115265	0.00591073	-0.001266
0.9	0	4	-0.0115362	0.00640329	-0.0015035
0.9	0	6	-0.0123424	0.0060825	-0.0014353
0.9	0	8	-0.0107296	0.00617424	-0.001535
0.9	0	10	-0.0099517	0.00595681	-0.0014596
0.95	0	-10	0.00682909	-0.000261	-3.48E-05
0.95	0	-8	0.00641302	1.76E-05	8.11E-05
0.95	0	-6	0.00512706	0.0003273	1.50E-05
0.95	0	-4	0.00263107	0.00086663	-7.74E-05
0.95	0	-2	0.00089393	0.00181735	-0.000231
0.95	0	0	-0.0018033	0.00293388	-3.87E-04
0.95	0	2	-0.0040778	0.00357614	-0.0004913
0.95	0	4	-0.0061422	0.00444227	-0.00096
0.95	0	6	-0.0105691	0.00485474	-0.001041
0.95	0	8	-0.0094808	0.00576457	-0.0011941
0.95	0	10	-0.0114142	0.00568435	-0.0012862
1.05	0	-10	-0.0068349	0.00319054	-0.0001411
1.05	0	-8	-0.0062582	0.00298005	-7.60E-05
1.05	0	-6	-0.0065329	0.00296928	-0.0001431
1.05	0	-4	-0.0074338	0.00314912	-0.0002077
1.05	0	-2	-0.007866	0.00340075	-0.0001448
1.05	0	0	-0.0085245	0.00357047	-0.0001805
1.05	0	2	-0.0085505	0.00362768	-0.0002102
1.05	0	4	-0.0098971	0.00378234	-0.0002477
1.05	0	6	-0.0096516	0.00386197	-0.0002814
1.05	0	8	-0.0104035	0.00399524	-0.0002599
1.05	0	10	-0.0106714	0.00435822	-0.0004381
1.1	0	-10	-0.0069657	0.00269635	0.00029139
1.1	0	-8	-0.007431	0.00269552	-2.02E-05
1.1	0	-6	-0.0068833	0.00288393	5.99E-07
1.1	0	-4	-0.0075673	0.00309407	-9.38E-05
1.1	0	-2	-0.0088024	0.00333511	-0.0002601
1.1	0	0	-0.0095596	0.00346351	-0.0003314
1.1	0	2	-0.0088772	0.00369483	-0.0005084
1.1	0	4	-0.0087864	0.00358153	-0.0002522
1.1	0	6	-0.0093347	0.00386684	-0.0003096
1.1	0	8	-0.0089329	0.00404456	-0.0005814

Table 9. WB001 right tip fin deflected 20° increments—Continued

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
1.1	0	10	-0.0109537	0.00387053	-0.0009414
1.15	0	-10	-0.0020874	0.00250423	-0.0003819
1.15	0	-8	-0.0034998	0.00285265	-2.26E-05
1.15	0	-6	-0.0042896	0.00290641	4.03E-05
1.15	0	-4	-0.0048274	0.00308127	-3.80E-05
1.15	0	-2	-0.004356	0.00324769	-9.37E-05
1.15	0	0	-0.0053079	0.00325809	4.02E-05
1.15	0	2	-0.0048142	0.00331817	6.06E-05
1.15	0	4	-0.0060908	0.00342973	0.00010037
1.15	0	6	-0.0053353	0.00375381	4.65E-05
1.15	0	8	-0.0058547	0.00356516	0.00023919
1.15	0	10	-0.007047	0.00432237	-0.000108
1.25	0	-10	-0.0079619	0.00247008	-0.0006415
1.25	0	-8	-0.0072397	0.00219206	-0.0005624
1.25	0	-6	-0.0063387	0.00233423	-0.0005892
1.25	0	-4	-0.0071272	0.00213018	-0.0004766
1.25	0	-2	-0.0072705	0.00219993	-0.0004328
1.25	0	0	-0.0075682	0.00225784	-0.0003519
1.25	0	2	-0.0060187	0.00210668	-0.0001389
1.25	0	4	-0.0057941	0.00179402	-2.45E-05
1.25	0	6	-0.0059288	0.00231834	1.36E-05
1.25	0	8	-0.0053228	0.00168502	0.00017363
1.25	0	10	-0.0071179	0.00233892	9.89E-05
1.46	0	-10	-0.0035214	0.00152393	-7.32E-05
1.46	0	-8	-0.0040309	0.00175389	-8.87E-05
1.46	0	-6	-0.0044363	0.00183977	-0.000108
1.46	0	-4	-0.0045979	0.00189354	-7.43E-05
1.46	0	-2	-0.0050543	0.00200182	-0.0001197
1.46	0	0	-0.0051885	0.00212758	-7.61E-05
1.46	0	2	-0.0049888	0.00216599	-2.10E-05
1.46	0	4	-0.0060537	0.00225146	-0.0001346
1.46	0	6	-0.0043248	0.00255659	-0.0001202
1.46	0	8	-0.0115496	0.00258675	-0.000115
1.46	0	10	-0.0119075	0.00260059	-0.0001022
1.96	0	-10	-0.0109035	0.00099445	-8.07E-06
1.96	0	-8	-0.0089807	0.00064134	-7.43E-05
1.96	0	-6	-0.0076745	0.00041573	-6.01E-05
1.96	0	-4	-0.006725	0.00060469	-5.26E-05

Table 9. WB001 right tip fin deflected 20° increments—Continued

Mach	$\alpha$	$\beta$	$C_Y$	$C_{YN}$	$C_l$
1.96	0	-2	-0.0074423	0.00070409	-0.0001123
1.96	0	0	-0.0076832	0.00086269	-1.40E-04
1.96	0	2	-0.0072356	0.00104684	-0.0001053
1.96	0	4	-0.0071603	0.00132861	-0.0001052
1.96	0	6	-0.0084529	0.00140761	-7.02E-05
1.96	0	8	-0.0095972	0.00162939	-0.0002386
1.96	0	10	-0.0093337	0.00161197	-0.0001063



## ERRATA

The presented side force coefficient increments for a tip fin deflection of 10 degrees are incorrect for Mach numbers of 0.3, 0.6, and 0.8, and should not be used. In place of the presented data, the following data should be used.

$\beta$	$\Delta C_y$		
	Mach 0.3	Mach 0.6	Mach 0.8
-10	-0.0039013	-0.0082006	-0.0077229
-8	-0.0039013	-0.0082006	-0.0077229
-6	-0.0039013	-0.0082006	-0.0077229
-4	-0.0039013	-0.0082006	-0.0077229
-2	-0.0039013	-0.0082006	-0.0077229
0	-0.0039013	-0.0082006	-0.0077229
2	-0.0039013	-0.0082006	-0.0077229
4	-0.0039013	-0.0082006	-0.0077229
6	-0.0039013	-0.0082006	-0.0077229
8	-0.0039013	-0.0082006	-0.0077229
10	-0.0039013	-0.0082006	-0.0077229



## APPROVAL

# TRANSONIC AERODYNAMIC CHARACTERISTICS OF A PROPOSED WING-BODY REUSABLE LAUNCH VEHICLE

By A.M. Springer

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.



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J.C. BLAIR

Director, Structures and Dynamics Laboratory

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