NASA-TM-87711 19860015232

NASA Technical Memorandum 87711

LATERAL AND LONGITUDINAL AERODYNAMIC STABILITY AND CONTROL PARAMETERS OF THE BASIC VORTEX FLAP RESEARCH AIRCRAFT AS DETERMINED FROM FLIGHT TEST DATA

William T. Suit and
James G. Batterson

April 1986

NASA
National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665

INTRODUCTION

Wind tunnel investigations have indicated that for swept wings a leading edge flap can improve the L/D of the wing by as much as 30 to 40 percent in the .6 to .9 Mach range. The flap causes the leading edge vortex of the swept wing to keep the flow at the leading edge attached at higher angles-of-attack, increasing the lift from the wing while not significantly increasing the drag.

The F106B aircraft was selected as a test bed for flight testing the leading edge vortex flap. There were three primary reasons for using this aircraft. First, the delta wing was simple, and modifying the leading edge should not be extremely difficult. Second, the speed envelope of the aircraft covered the speed range where the vortex flap should be effective. Third, the 60° leading edge sweep fell in the sweep range where the flap was effective.

So that the improvement from the vortex flap could be assessed, the basic aircraft must be documented. To do this, all available information on the aerodynamics of the F106B is being assembled. One part of this collection of aerodynamic characteristics is the flight-determined stability and control derivatives. These parameters can be correlated with the results obtained from wind tunnels and used to determine aerodynamics for areas in the flight envelope where wind tunnel tests were not run. Flight tests can also be used to estimate rotary derivatives that cannot be obtained from many tunnels. Finally, agreement between wind tunnel and flight-determined aerodynamic parameters for the basic airplane will be an important factor in determining how the flight data from the modified aircraft can be used.

An important step in the assessment of the possible effect of the flap on the handling of the basic F106B is the development of a realistic simulation of the vehicle. Flight test results will be used in conjunction with the wind tunnel data to develop a realistic simulation of the basic aircraft. This basic simulation will then be modified to reflect the expected impact on the performance and handling qualities of the aircraft of adding a leading edge flap. Flight data from the modified aircraft will then be used to refine the simulation.

The purpose of this paper is to present the aerodynamics of the basic F106B as determined at selected points in the flight envelope. In this paper, the test aircraft and the flight test procedure will be presented. Thus, the aircraft instrumentation and the data system will be discussed. This will be followed by a presentation of the parameter extraction procedure and a discussion of flight test results. These results will then be used to predict the aircraft motions for maneuvers that were not used to determine the vehicle aerodynamics. The control inputs used to maneuver the aircraft to get data for the determination of the aerodynamic parameters will be discussed in the Flight Test Procedure section. The results from the current flight tests will be compared with the results from wind tunnel tests of the basic F106B, where comparisons can be made, and based on these comparisons, the need for additional data was concluded.

TEST AIRCRAFT

The aircraft used in this investigation was a slightly altered F106B. The configuration tested had a nose boom for measuring angle-of-attack and angle-of-sideslip. Also, a light source was mounted in the left side of the aircraft to illuminate the vortices on the wing. A photograph of the test aircraft is shown as figure 1. The physical characteristics that affect the parameter identification procedure are given as table I. The inertias for the subject aircraft as tested are not known. The inertias used are from manufacturer's data for a similar configuration and their accuracy is not known.

FLIGHT TEST PROCEDURE

Maneuvers were made from steady conditions, either from 1 "g" flight or from a higher "g" coordinated turn. Since the aircraft could not maintain altitude in these steady turns, the maneuvers were actually perturbations from a descending spiral. In this maneuver, the greatest rate of descent was approximatly 300 ft/sec. The assumption of a constant density for each run could result in an error of up to 3 percent at the final part of a run. Elevon doublets were used to perturb the vehicle for the identification of longitudinal parameters. The amount of elevon deflection used was determined by the variation in normal acceleration.

The maneuvers used for determining the lateral parameters consisted of a rudder doublet followed by an aileron doublet. The critical parameters during the lateral maneuvers were sideslip angle due to danger of departure and roll rate due to instrument limits. In practice, roll rate usually was the variable that established the limits on the magnitude of the inputs since the range of roll rate instrument was ±1 radian per second and moderate rudder or aileron inputs could easily cause responses that would exceed these limits. In most runs, the sideslip angle did not become excessive. Also, the yaw rate tended to be small and in some early runs, was marginal for good identification of the yaw rate and yaw moment derivatives.

For runs designated as flight 13, the input design was to put in the first half of the rudder doublet at a magnitude that would result in a 60 deg/sec roll rate in hopes of getting a 10°-15° per second yaw rate. Then, on the second part of the rudder doublet, start the aileron doublet early to try to keep the roll rate from exceeding 60° per second after the rudder switch. Then the second part of the aileron doublet would be large enough to give at least a 30° per second roll rate. This design generally kept the roll rate in limits and did not result in excessive sideslip, but the yaw rate still did not exceed 10° per second and was still marginal for good identification.

INSTRUMENTATION AND DATA PROCESSING

On the F106B aircraft the instrument channels were accessed using a pulse code modulation (PCM) system that processed the data at 82 samples per second (sps). This data was then recorded on magnetic tape for processing. The data on this tape were converted to engineering units, and quantities such as true airspeed were calculated. Selected channels that are required for parameter identification were recorded at a rate of 41 sps (one-half the original data rate) and corrections for instrument location relative to the vehicle center-of-gravity and instrument alignment were made. This process resulted in a data tape that was suitable for use with the parameter identification program. The quantities recorded and their ranges are given in table II. The assumed accuracy of these measurements was 1 percent of full scale of the measuring instrument.

PARAMETER EXTRACTION PROCEDURE

Maximum Likelihood and Linear Regression Parameter Extraction Programs were used to examine the flight test data. These programs are described in references 1 and 2. For both extraction programs, a linear aerodynamic model describing a rigid airplane was assumed. The parameter values obtained using the extraction programs are given in tables that include the parameter value and the estimated sensitivity for each parameter. The estimated standard deviation and sensitivity are indicators of the identifiability of the different parameters. If the estimated standard deviation is less than 10 percent of the extracted value for the parameter, then the parameter is identified, less the 5 percent well identified. The larger the sensitivity, the more identifiable the parameter and the greater the influence of the parameter value on the vehicle motion.

RESULTS AND DISCUSSION

Maneuvers were made to independently excite the longitudinal and lateral modes of the test vehicle. The parameters determined from the longitudinal modes will be discussed first. The longitudinal parameter values for the assumed longitudinal mathematical model are given as table III. Selected longitudinal parameters are plotted versus trim angle-of-attack (Fig. 2). In addition to the runs that resulted in the parameter values shown in figure 2 and referred to as "surface" in table III, runs were made in earlier flights before the actual control surface deflections were instrumented. During these flights, stick position was measured and the corresponding control surface position calculated. The results of these maneuvers are referred to as "stick" in table III. Since the parameters plotted account for over 90 percent of the vehicle's response to pilot's inputs, the discussion will center on these parameters.

There were maneuvers performed at four different Mach numbers. At Mach numbers of .6 and .9 maneuvers were performed at several different trim angles-of-attack. Each maneuver was examined using the two parameter extraction methods mentioned in the Parameter Extraction Procedure Section. The results for the four parameters shown in figure 2 will now be discussed.

C_{z_α} - The values determined by both extraction methods agreed well, indicating confidence in these results. Also, the values obtained showed trends that were similar to those of other investigators, and their magnitudes seemed reasonable. An examination of table III showed C_{z_α} to be well identified for most runs, but in general, it was not the longitudinal parameter that was most identifiable.

C_{m_α} - The values obtained for both extraction methods agreed well, and for Mach numbers to .6, the values were close to those predicted by other investigators. For the Mach .9 cases, the values of C_{m_α} became more negative as expected. There were no data to check the magnitude of the increase; however, the estimated standard deviations and sensitivities implied that the parameter was generally well determined (table III) and had a significant effect on the vehicle motion. A repeat run at an angle-of-attack around 15.5 degrees gave a more negative value for the parameter. When assessing the C_{m_α} values from the two runs, the maximum likelihood, regression and estimated standard deviations were all considered, and for the Mach equals .9 case, a value of aproximately -.27 seemed reasonable.

C_{m_q} - The values obtained for both extraction methods agreed for most runs. The values extracted generally were close to those predicted by other investigators for the Mach .6 case. The trends of the data were reasonable except for two points at the highest angles-of-attack. These two points both have larger magnitudes than might be expected from the other runs examined. A trend to more damping such as that seen in the regression results is reasonable, but the large jump seen in the maximum likelihood results is questionable. The values of estimated standard deviation and sensitivity shown in table III indicate that the parameter is not as well identified as the past two and does not have a great influence on the vehicle motion for many of the runs examined.

$C_{m_{\delta e}}$ - As with C_{m_q}, the values obtained for both extraction methods agreed for most of the runs. The values for $C_{m_{\delta e}}$ determined by other investigators varied widely and the values for the Mach .6 runs generally fell between the extremes. The values showed a definite Mach effect between Mach .6 and Mach .9. Also, a trend toward greater effectiveness with angle-of-attack was seen. Both trends are reasonable, although the amount of variation seen at the largest angles-of-attack for the Mach .9 data was greater than expected. Based on the estimated standard deviation and sensitivity values, $C_{m_{\delta e}}$ was considered to be well identified and to have a significant influence on the vehicle motions.

A comparison of the results of longitudinal runs using actual and calculated surface positions for Mach .6 are given in figure 3. Also shown in the figure are the Mach .6 results from a run where only calculated control position was available. The results from the actual and calculated control surface position runs agree reasonably well for all parameters. The results from Mach .6 runs from the flight where only calculated surface deflection was available show the same trends and magnitudes as the runs where the actual surface positions were measured. For the longitudinal aerodynamics, these additional runs definitely add to the definition of the parameters identified.

As an additional test of the model determined using flight tests, a run at Mach .6 that was not used for determining values for the parameters was used for prediction. In this case, values for the various parameters in the mathematical model describing the vehicle were picked from figure 2 for the specific Mach number and trim angle-of-attack of the prediction run. This model was then perturbed by the actual input time history from the flight test and the resulting motions compared with the motions measured in flight. The results of this prediction are shown as figure 4a and b. The assumed model is seen to do a good job of predicting the vehicle motions.

LATERAL PARAMETERS

Next we will discuss the lateral parameters. Parameter values for the assumed lateral model are given in table IV. As was the case with table III, the designation "surface" or "stick" indicated how the control input was determined. The lateral parameters that have the greatest effect on the vehicle motion and which describe approximately 90 percent of the vehicle's response motion are shown as figure 5. The estimated standard deviations and sensitivities of the parameters that had the most effect on the vehicle motion are given in table IV. An examination of these values indicated that C_{ℓ_β}, C_{n_β}, and $C_{n_{\delta r}}$ are very well identified; the parameters C_{ℓ_p} and $C_{\ell_{\delta a}}$ are well identified; and that these five parameters describe most of the vehicle's motion. The parameters $C_{\ell_{\delta r}}$, C_{y_β} and $C_{n_{\delta a}}$ are not as well identified and do not have much influence on the vehicle motion. The parameters shown in this figure will now be discussed individually as to their trends with angle-of-attack and actual parameter values extracted.

C_{ℓ_β} - The parameter showed consistent trends with angle-of-attack for all Mach numbers. These trends were similar to those of other investigations. The magnitudes of the extracted parameters fell within the range of the values predicted by other investigators, but in general, were less negative then expected. However, since both the Regression and Maximum Likelihood extraction programs gave similar results, the values seem reasonable.

C_{n_β} - The parameter showed similar trends as indicated by the results from other investigators. The trend to larger C_{n_β} values with increased Mach number in the Mach .6 to Mach .9 range is also seen. The agreement between the values determined by the two extraction methods was poor, which reduced the confidence in the values determined. However, in general, the values seemed to fall in a reasonable range when compared to other results.

C_{y_β} - The trends of the parameter values with angle-of-attack and Mach number were reasonable. The magnitude of the change appeared to be greater than anticipated. Also, the agreement between the values determined using the two extraction methods was not good for most maneuvers. The values for the parameter were also reasonable, but possibly were not negative enough in most cases.

C_{ℓ_p} - The magnitudes of the extracted parameters seemed reasonable, but the scatter in the parameters precluded establishing any definite trends with angle-of-attack on Mach number. At the largest angles of attack the two extraction methods agreed fairly well giving some confidence in the values obtained.

$C_{\ell_{\delta a}}$ - The magnitudes determined for the parameter seemed reasonable. However, the parameter values for the Mach .9 runs seemed to show a trend with angle-of-attack which was not predicted by other investigators. There also appeared to be a trend toward more effectiveness with increasing Mach number which was greater than expected. The two extraction methods did not agree well, but the trends noted were clearly defined. The scatter in the Mach .6 results prevented any definite comments on the trend of that data.

$C_{\ell_{\delta r}}$ - There was considerable scatter in the extracted parameter values, so no trends were obvious. The parameter showed less effectiveness than was predicted by other investigators. Since the two extraction methods gave different values in most cases, the confidence in the values for this parameter was reduced.

$C_{n_{\delta a}}$ - The values for this parameter were generally reasonable but showed considerable scatter. The trend of the parameter values was to be less effective than predicted by other investigators. However, the scatter in the values and the lack of agreement between the two extraction methods imply a reduced confidence in the parameter values obtained.

$C_{n_{\delta r}}$ - The values determined for this parameter had magnitudes and trends as expected, and the agreement with the predictions of other investigators was good. Both extraction methods gave similar results, increasing the confidence in the values extracted.

Figure 6 shows the results of comparing runs where the actual surface deflection was measured with runs where the surface deflection was calculated based on stick position or rudder pedal position. Also shown are runs where only stick position and rudder pedal position were measured. The figure shows that the trends for all the calculated deflections seen are the same as those seen in figure 5. Also, where the scatter was such that trends were not detectable, the same was true for the runs using calculated deflections. In general, with one exception, the additional runs where surface deflections were calculated were a reasonable addition to the parameter data base.

The one exception is the rudder deflection. The rudder pedal position to surface deflection calibration was done at 0 Mach. The results indicate that for a given pedal position, the deflections of the rudder decrease above Mach .5. At Mach .6 the deflections are about two-thirds of the Mach 0 deflection, and at Mach .9 the rudder deflection is about one half to Mach 0 deflection. The parameter values extracted for $C_{\ell_{\delta r}}$ and $C_{n_{\delta r}}$ reflect this reduced rudder deflection in that a greater δ_r was calculated than actually existed, so the parameter values showed less effectiveness by about two-thirds.

The predictive capability of the lateral model was also checked and the results are shown as figures 7a and b. As with the longitudinal model check, a run that was not used for extraction was used for prediction. As can be seen in figures 7a and b, two mathematical models were used for prediction. The first used values determined from extraction runs made at similar angles-of-attack and Mach number, and the second used parameter values determined by wind tunnel tests where values were available and extracted values where wind tunnel values were not available. The actual values used for the parameters are shown on the figure. The prediction using extracted values was fairly good (Fig. 7a). However, the response to input using the wind tunnel parameters had a different phase than that of the actual vehicle (Fig. 7b). Figure 8 shows the fit and parameter values obtained when the prediction data set was used with the Maximum Likelihood program to estimate parameter values.

CONCLUSIONS

Flight tests were conducted using the F106B that will be used for a leading edge vortex flap study. These flight tests used the basic aircraft and were run at several conditions with emphasis on Mach numbers of .6 and .9 and at angles-of-attack greater than 10°. The trends of the parameters that describe up to 90 percent of the vehicle motion were established and were reasonable. For the majority of the runs, the magnitudes of parameters were reasonable as evidenced by the fact that when these values were used in a mathematical description of the vehicle, that mathematical model had good prediction capability. Additional runs should be made to get more data points at angles-of-attack above 12° at Mach numbers of .6 and .9. Three additional points at each Mach number should be sufficient to document the basic aircraft in the high angle-of-attack region. This documentation will then serve as a basis for evaluation of the modified aircraft.

TABLE I.- PHYSICAL CHARACTERISTICS OF THE F106B

Mass Range During Test:
1050 slug to 900 slug

Assumed Inertias

I_X	19,000 slug-ft^2
I_Y	185,000 slug-ft^2
I_Z	200,000 slug-ft^2
I_{XZ}	60,000 slug-ft^2

Dimensional Characteristics:

Wing Area (S)	695.0 ft^2
Chord (C)	23.76 ft
Span (b)	38.13 ft

TABLE II.- F106B INSTRUMENTATION SYSTEM

Variables	Range
(Time, Sec)	
V, ft/sec	0.0 to 1300.00
β, rad	± 0.52
α, rad	± 0.52
p, rad/sec	± 1.0
q, rad/sec	± 1.0
r, rad/sec	± 1.0
θ, rad/sec	± 0.52
ϕ, rad/sec	± 1.4
A_x, "G" units	± 1.0
A_y, "G" units	± 1.0
A_z, "G" units	+ 1.0 to - 7.0
δ_a, rad	± 0.122
δ_e, rad	+ 0.28 to - .42
δ_r, rad	± 0.42

Estimated accuracy 1 percent of full scale

TABLE III. - LONGITUDINAL PARAMETER IDENTIFICATION RESULTS

	ML; Surface $\alpha_T = 8.7°$ M = .4			ML; Stick $\alpha_T = 8.7°$ M = .4			Regression; Surface $\alpha_T = 8.7°$ M = .4		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{x_α}	.53	.093	.16E3	.65	.040	.9E3	.275	.0021	
C_{z_0}	-.23	.0037	.17E6	-.22	.00055	.46E6	.224	.001	
C_{z_α}	-2.11	.113	.31E4	-2.32	.021	.30E5	-2.15	.009	
C_{z_q}	-6.61	2.25	.29E3	.69	.37	7.3	-3.27	.17	
$C_{z_{\delta e}}$	-.66	.24	.21E2	-.34	.029	.25E3	-.663	.015	
C_{m_α}	-.131	.0039	.32E5	-.12	.00057	.1E6	-.127	.0023	
C_{m_q}	-.87	.235	.77E3	-.73	.018	.85E4	-.60	.043	
$C_{m_{\delta e}}$	-.36	.021	.114E5	-.31	.0019	.1E6	-.35	.004	

* (1) Surface denotes runs where actual control surface position was measured.
(2) Stick denotes runs where stick position was measured and corresponding surface position calculated.
(3) Regression denotes runs examined using the regression program of reference 2.
ML denotes runs examined using the maximum likelihood program of reference 1.

TABLE III. - LONGITUDINAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 8.5°			α_T = 8.5°			α_T = 8.5°		
	M = .4			M = .4			M = .4		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{x_α}	.404	.087	.29E2	.426	.04	.17E3	.29	.0017	
C_{z_0}	-.226	.0073	.17E5	-.217	.0015	.2E6	-.215	.003	
C_{z_α}	-2.22	.215	.19E3	-2.49	.03	.14E7	-2.22	.013	
C_{z_q}	-3.6	3.9	1.7	7.67	.95	.34E4	-3.38	.25	
$C_{z_{\delta e}}$	-.30	.36	1.2	.118	.056	.55E2	-5.8	.02	
C_{m_α}	-.14	.0062	.105E4	-.135	.00096	.9E6	-.133	.0025	
C_{m_q}	-1.0	.20	.12E3	-.64	.034	.25E4	-.65	.049	
$C_{m_{\delta e}}$	-.35	.02	.104E4	-.28	.0032	.92E6	-.33	.0043	

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 11.5°			α_T = 11.5°			α_T = 11.5°		
	M = .6			M = .6			M = .6		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{x_α}	.61	.052	.3E3	.48	.036	.7E6	.2	.004	
C_{z_0}	-.34	.0046	.11E6	-.34	.0057	.13E8	-.34	.002	
C_{z_α}	-2.46	.12	.19E4	-2.32	.13	.17E6	-2.5	.013	
C_{z_q}	-13.1	3.7	.86E2	-8.8	3.9	.27E5	-6.0	.35	
$C_{z_{\delta e}}$	-.56	.29	.15E2	-.33	.26	.68E4	-.6	.026	
C_{m_α}	-.15	.0016	.23E5	-.147	.0024	.21E6	-.15	.0023	
C_{m_q}	-1.31	.15	.28E3	-.6	.17	.79E5	-.96	.062	
$C_{m_{\delta e}}$	-.41	.014	.62E4	-.32	.015	.25E5	-.37	.0046	

TABLE III. - LONGITUDINAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 14.3°			α_T = 14.3°			α_T = 14.3°		
	M = .6			M = .6			M = .6		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{x_α}	.85	.08	.17E5	.40	.88	.3E2	.134	.0041	
C_{z_0}	-.46	.0023	.72E6	-.51	.027	.7E4	-.45	.003	
C_{z_α}	-2.88	.041	.34E5	-3.52	.54	.6E3	-2.74	.0096	
C_{z_q}	-1.28	.87	9.0	14.2	11.4	.14E2	-7.15	.21	
$C_{z_{\delta e}}$	-.51	.056	.25E3	1.5	.58	.25E2	-.73	.014	
C_{m_α}	-.205	.0011	.16E6	-.20	.012	.28E4	-.193	.0034	
C_{m_q}	-1.04	.03	.58E4	-.21	.31	4.6	-1.03	.075	
$C_{m_{\delta e}}$	-.39	.0026	.92E5	-.31	.02	.13E4	-.38	.0048	

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 13.7°			α_T = 13.7°			α_T = 13.7°		
	M = .32			M = .32			M = .32		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{x_α}	.445	.31	3.1	.47	.32	.23E2	.309	.0038	
C_{z_0}	-.373	.0043	.44E5	-.375	.0044	.25E6	-.38	.002	
C_{z_α}	-2.32	.23	.18E3	-2.42	.19	.28E5	-2.26	.016	
C_{z_q}	-2.7	3.2	1.4	1.47	3.18	.71E2	-4.48	.26	
$C_{z_{\delta e}}$	-.67	.22	.18E2	-.453	.18	.25E3	-.71	.018	
C_{m_α}	-.16	.009	.84E3	-.149	.0085	.22E4	-.144	.0038	
C_{m_q}	-1.01	.22	.98E2	-.57	.22	.64E2	-.744	.062	
$C_{m_{\delta e}}$	-.355	.019	.12E4	-.29	.016	.49E5	-.35	.0042	

TABLE III. - LONGITUDINAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface α_T = 5.7° M = .9			ML; Stick α_T = 5.7° M = .9			Regression; Surface α_T = 5.7° M = .9		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{x_α}	.45	.048	.98E2	.55	.12	.26E2	.195	.0023	
C_{z_0}	-.134	.0005	.22E6	-1.33	.0054	.18E5	-.135	.0008	
C_{z_α}	-2.7	.027	.15E5	-2.80	.32	.19E3	-2.70	.011	
C_{z_q}	-2.66	.64	.28E2	1.90	6.3	.21	-8.05	.25	
$C_{z_{\delta e}}$	-.65	.054	.26E3	.225	.44	.41	-.674	.022	
C_{m_α}	-.254	.0008	.14E6	-.246	.0077	.24E4	-.262	.0044	
C_{m_q}	-1.42	.032	.76E4	-.75	.31	.25E2	-1.14	.096	
$C_{m_{\delta e}}$	-.456	.0035	.58E5	-.34	.027	.65E3	-.443	.0084	
	ML; Surface α_T = 17° M = .6			ML; Stick α_T = 17° M = .6			Regression; Surface α_T = 17° M = .6		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{x_α}	-.97	.094	.22E4	-.55	.076	.17E4	.052	.009	
C_{z_0}	-.638	.012	.19E6	-.69	.0064	.21E6	-.604	.003	
C_{z_α}	-2.93	.097	.29E4	-3.4	.084	.73E4	-2.84	.032	
C_{z_q}	3.45	3.8	.37E2	18.7	1.98	.68E4	-9.16	.85	
$C_{z_{\delta e}}$	-.501	.165	.31E2	-.083	.083	2.4	-.72	.043	
C_{m_α}	-.194	.0037	.18E5	-.157	.0014	.43E8	-.19	.0055	
C_{m_q}	-2.95	.14	.14E5	-2.59	.10	.23E5	-1.25	.145	
$C_{m_{\delta e}}$	-.458	.011	.24E5	-.43	.007	.52E5	-.40	.0073	

TABLE III. - LONGITUDINAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface $\alpha_T = 15.7°$ M = .9			ML; Stick $\alpha_T = 15.7°$ M = .9			Regression; Surface $\alpha_T = 15.7°$ M = .9		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{x_α}	1.38	.12	.15E5	1.6	.4	.6E6	-.03	.0057	
C_{z_0}	-.578	.0045	.34E6	-.64	.06	.31E5	-.573	.003	
C_{z_α}	-2.92	.049	.29E5	-2.84	.48	.13E6	-2.86	.026	
C_{z_q}	-14.6	.78	.35E4	7.4	26.8	.13E4	-11.5	.66	
$C_{z_{\delta e}}$	-.637	.072	.38E3	.83	1.4	.15E3	-.836	.042	
C_{m_α}	-.31	.0028	.14E6	-.23	.024	.13E7	-.287	.008	
C_{m_q}	-.77	.056	.64E3	-.46	.81	.3E5	-1.22	.20	
$C_{m_{\delta e}}$	-.61	.0065	.12E6	-.47	.081	.12E5	-.51	.013	

	ML; Surface $\alpha_T = 15.5°$ M = .9			ML; Stick $\alpha_T = 15.5°$ M = .9			Regression; Surface $\alpha_T = 15.5°$ M = .9		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{x_α}	.69	.33	.25E3	.67	.069	.52E4	.013	.0036	
C_{z_0}	-.55	.05	.79E4	-.54	.009	.17E6	.504	.003	
C_{z_α}	-2.91	.7	.41E3	-2.97	.095	.87E4	-2.8	.019	
C_{z_q}	-1.41	15.3	.18	-1.31	2.4	2.7	-8.7	.44	
$C_{z_{\delta e}}$	1.2	.88	23.6	.43	.19	68.4	-.69	.033	
C_{m_α}	-.25	.016	.21E4	-.24	.0028	.21E5	-.24	.006	
C_{m_q}	-2.42	.53	.35E3	-2.08	.10	.29E4	-1.27	.13	
$C_{m_{\delta e}}$	-.58	.046	.27E4	-.55	.0093	.24E5	-.45	.01	

TABLE IV. - LATERAL PARAMETER IDENTIFICATION RESULTS

	ML; Surface $\alpha_T = 8.7°$ M = .4			ML; Stick $\alpha_T = 8.7°$ M = .4			Regression; Surface $\alpha_T = 8.7°$ M = .4		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{y_β}	-.468	.02	.75E3	-.49	.01	.37E4	-.50	.006	
C_{y_p}	0	---	---	0	---	---	.021	.023	
C_{y_r}	0	---	---	0	---	---	.27	.105	
$C_{y_{\delta a}}$	.19	.049	.17E2	.16	.02	.7E2	.164	.014	
$C_{y_{\delta r}}$	.064	.011	.37E2	.028	.0033	.9E2	.056	.0032	
C_{ℓ_β}	-.053	.0009	.15E5	-.054	.0006	.14E8	-.054	.0006	
C_{ℓ_p}	-.124	.0061	.41E4	-.116	.0018	.12E8	-.107	.0024	
C_{ℓ_r}	.106	.026	.17E3	-.006	.009	7.3	.194	.011	
$C_{\ell_{\delta a}}$	-.086	.004	.11E5	-.072	.0017	.25E5	-.088	.0014	
$C_{\ell_{\delta r}}$	.015	.0007	.92E3	.007	.0002	.11E5	.012	.0003	
C_{n_β}	.08	.0015	.2E5	.082	.001	.17E6	.090	.0019	
C_{n_p}	-.027	.0097	.11E3	.068	.004	.12E5	.018	.007	
C_{n_r}	-.20	.033	.33E3	.29	.014	.12E5	-.107	.032	
$C_{n_{\delta a}}$	-.057	.0065	.36E3	-.068	.0052	.14E5	-.046	.0043	
$C_{n_{\delta r}}$	-.054	.0005	.24E6	-.037	.0003	.14E6	-.051	.001	

* (1) Surface denotes runs where actual control surface position was measured.
(2) Stick denotes runs where stick position was measured and corresponding surface position calculated.
(3) Regression denotes runs examined using the regression program of reference 2.
ML denotes runs examined using the maximum likelihood program of reference 1.

TABLE IV. - LATERAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 8.5°			α_T = 8.5°			α_T = 8.5°		
	M = .4			M = .4			M = .4		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{y_β}	-.486	.0046	.16E5	-.51	.009	.6E4	-.51	.0032	
C_{y_p}	0	---	---	0	---	---	0	---	
C_{y_r}	0	---	---	0	---	---	.225	.055	
$C_{y_{\delta a}}$	.182	.0089	.45E3	.17	.015	.15E3	.16	.0067	
$C_{y_{\delta r}}$	.056	.0022	.77E3	.023	.0025	.95E2	.055	.0016	
C_{ℓ_β}	-.054	.0003	.2E6	-.056	.00002	.12E7	-.054	.0006	
C_{ℓ_p}	-.143	.0008	.25E6	-.135	.0006	.7E5	-.12	.0021	
C_{ℓ_r}	.045	.0071	.18E3	-.138	.0027	.7E4	.15	.011	
$C_{\ell_{\delta a}}$	-.095	.0009	.32E5	-.080	.011	.12E6	-.089	.0014	
$C_{\ell_{\delta r}}$	.014	.0002	.16E5	.006	.0018	.18E5	.012	.0003	
C_{n_β}	.080	.0005	.24E6	.080	.0008	.14E7	.093	.0016	
C_{n_p}	.016	.0033	.48E3	.113	.005	.26E5	.043	.0051	
C_{n_r}	-.302	.013	.51E4	.36	.018	.36E5	-.025	.027	
$C_{n_{\delta a}}$	-.040	.0023	.28E4	-.001	.0038	.27E2	-.045	.0033	
$C_{n_{\delta r}}$	-.059	.0004	.13E6	-.042	.0004	.5E6	-.051	.0008	

TABLE IV. - LATERAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 13.7°			α_T = 13.7°			α_T = 13.7°		
	M = .32			M = .32			M = .32		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{y_β}	-.51	.016	.3E4	-.48	.021	.21E4	-.436	.009	
C_{y_p}	0	---	---	0	---	---	.151	.018	
C_{y_r}	0	---	---	0	---	---	1.08	.14	
$C_{y_{\delta a}}$	.19	.013	.36E3	.16	.017	.18E3	.138	.008	
$C_{y_{\delta r}}$	.05	.003	.40E3	.26	.0031	.12E3	.039	.002	
C_{ℓ_β}	-.067	.0015	.81E6	-.066	.0023	.33E6	-.058	.0014	
C_{ℓ_p}	-.111	.0013	.6E5	-.062	.0021	.19E5	-.117	.0027	
C_{ℓ_r}	-.013	.02	.45E2	-.263	.028	.16E5	.139	.02	
$C_{\ell_{\delta a}}$	-.090	.0008	.17E6	-.095	.0011	.11E6	-.095	.0012	
$C_{\ell_{\delta r}}$	.009	.0002	.25E5	.004	.0003	.64E4	.009	.0003	
C_{n_β}	.11	.0051	.53E6	.067	.0082	.98E5	.062	.004	
C_{n_p}	.006	.0061	.41E2	-.063	.0085	.36E4	.01	.0076	
C_{n_r}	.114	.072	.136E4	.109	.091	.96E3	-.133	.060	
$C_{n_{\delta a}}$	-.09	.0016	.72E5	-.070	.0026	.31E5	-.030	.0035	
$C_{n_{\delta r}}$	-.03	.0013	.96E5	-.023	.0015	.43E5	-.036	.0009	

TABLE IV. – LATERAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 5.7°			α_T = 5.7°			α_T = 5.7°		
	M = .9			M = .9			M = .9		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{y_β}	-.52	.0035	.4E5	-.51	.0069	.89E4	-.59	.002	
C_{y_p}	0	---	---	0	---	---	.16	.008	
C_{y_r}	0	---	---	0	---	---	.70	.047	
$C_{y_{\delta a}}$	.23	.013	.5E3	.117	.022	.4E2	.19	.0077	
$C_{y_{\delta r}}$	.067	.0024	.9E3	.036	.0025	.25E3	.046	.0017	
C_{ℓ_β}	-.053	.0005	.54E6	-.054	.0006	.27E6	-.051	.0005	
C_{ℓ_p}	-.147	.0032	.8E5	-.142	.0021	.17E5	-.124	.0019	
C_{ℓ_r}	-.123	.019	.47E5	.10	---	---	.37	.011	
$C_{\ell_{\delta a}}$	-.094	.0015	.8E5	-.072	.0024	.3E5	-.108	.0018	
$C_{\ell_{\delta r}}$	.020	.0002	.47E5	.013	.0002	.44E5	.017	.0004	
C_{n_β}	.098	.0007	.95E6	.099	.0005	.42E6	.14	.0009	
C_{n_p}	-.089	.0045	.3E5	-.047	.002	.27E4	.123	.0036	
C_{n_r}	.657	.027	.41E5	-.40	---	---	-.022	.022	
$C_{n_{\delta a}}$	-.092	.0026	.26E5	-.09	---	---	-.039	.0035	
$C_{n_{\delta r}}$	-.061	.0004	.22E6	-.027	.00034	.7E5	-.054	.0008	

TABLE IV. - LATERAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface $\alpha_T = 11.5°$ M = .6			ML; Stick $\alpha_T = 11.5°$ M = .6			Regression; Surface $\alpha_T = 11.5°$ M = .6		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{y_β}	-.53	.0064	.72E6	-.48	.04	.4E6	-.5	.0024	
C_{y_p}	0	---	---	0	---	---	.087	.010	
C_{y_r}	0	---	---	0	---	---	1.32	.061	
$C_{y_{\delta a}}$	.173	.016	.20E3	.35	.12	.2E4	.2	.0078	
$C_{y_{\delta r}}$	.067	.0026	.19E5	.055	.015	.2E4	.064	.0012	
C_{ℓ_β}	-.064	.0011	.21E7	-.074	.006	.96E6	-.071	.0005	
C_{ℓ_p}	-.17	.0041	.26E6	-.18	.019	.19E7	-.145	.002	
C_{ℓ_r}	-.32	.023	.98E4	-.089	.082	.35E5	.227	.012	
$C_{\ell_{\delta a}}$	-.086	.0037	.12E7	-.075	.017	.46E6	-.115	.0015	
$C_{\ell_{\delta r}}$	.019	.0005	.18E6	.013	.0017	.37E6	.015	.00023	
C_{n_β}	.069	.0021	.8E6	.064	.012	.16E5	.083	.0012	
C_{n_p}	-.007	.0063	.24E2	-.006	.044	.51E2	.002	.005	
C_{n_r}	-.503	.042	.9E5	-.017	.22	.5	-.34	.030	
$C_{n_{\delta a}}$	-.133	.0076	.7E6	-.096	.031	.15E5	-.045	.0038	
$C_{n_{\delta r}}$	-.056	.0009	.18E7	-.038	.0035	.87E5	-.055	.00057	

TABLE IV. - LATERAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 14.3°			α_T = 14.3°			α_T = 14.3°		
	M = .6			M = .6			M = .6		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{y_β}	.42	.31	.44E2	-.43	.0095	.34E4	-.45	.0055	
C_{y_p}	0	---	---	0	---	---	-.024	.019	
C_{y_r}	0	---	---	0	---	---	-.84	.134	
$C_{y_{\delta a}}$	1.98	.48	.61E2	.24	.014	.57E3	.24	.011	
$C_{y_{\delta r}}$	-.49	.10	.11E3	.061	.0031	.47E3	.066	.0026	
C_{ℓ_β}	-.107	.0029	.22E5	-.108	.0015	.58E5	-.11	.0009	
C_{ℓ_p}	-.18	.0092	.51E4	-.17	.0043	.8E4	-.176	.003	
C_{ℓ_r}	.19	.072	.15E3	-.41	.038	.23E4	.287	.022	
$C_{\ell_{\delta a}}$	-.118	.0042	.28E4	-.083	.0026	.6E4	-.127	.0017	
$C_{\ell_{\delta r}}$	.017	.0010	.15E4	.008	.00042	.15E4	.015	.0004	
C_{n_β}	.051	.0057	.19E4	.062	.0026	.19E5	.067	.0018	
C_{n_p}	.034	.020	.37E2	.032	.0065	.12E3	.037	.0062	
C_{n_r}	-.5	.113	.79E3	.19	.057	.11E4	-.013	.043	
$C_{n_{\delta a}}$	-.035	.0079	.22E3	.0022	.0025	.1E2	-.035	.0034	
$C_{n_{\delta r}}$	-.059	.0030	.45E4	-.040	.00074	.27E5	-.055	.0008	

TABLE IV. - LATERAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 14.5°			α_T = 14.5°			α_T = 14.5°		
	M = .6			M = .6			M = .6		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{y_β}	-.43	.014	.12E4	-.38	.01	.2E4	-.38	.0054	
C_{y_p}	0	---	---	0	---	---	.12	.02	
C_{y_r}	0	---	---	0	---	---	1.4	.107	
$C_{y_{\delta a}}$	.21	.019	.14E3	.23	.011	.7E3	.186	.0075	
$C_{y_{\delta r}}$	.07	.0058	.23E3	.054	.0028	.54E3	.07	.0024	
C_{ℓ_β}	-.098	.001	.9E5	-.085	.0009	.23E6	-.105	.0009	
C_{ℓ_p}	-.16	.0048	.1E5	-.103	.0037	.15E5	-.145	.0035	
C_{ℓ_r}	.27	.015	.46E4	.57	.013	.8E6	.29	.019	
$C_{\ell_{\delta a}}$	-.11	.0011	.4E5	-.097	.0008	.9E6	-.13	.0013	
$C_{\ell_{\delta r}}$	.019	.0004	.31E5	.015	.0003	.25E6	.015	.0004	
C_{n_β}	.082	.0014	.25E5	.065	.0013	.46E5	.08	.0016	
C_{n_p}	.0057	.0075	6.8	-.019	.0054	.54E3	.015	.006	
C_{n_r}	-.034	.02	.24E3	.25	.017	.36E6	.14	.032	
$C_{n_{\delta a}}$	-.048	.0016	.4E4	-.05	.0012	.7E6	-.035	.0023	
$C_{n_{\delta r}}$	-.052	.00067	.24E6	-.033	.0004	.23E7	-.054	.0007	

TABLE IV. - LATERAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface α_T = 15.7° M = .9			ML; Stick α_T = 15.7° M = .9			Regression; Surface α_T = 15.7° M = .9		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{y_β}	-.26	.27	3.6	-.46	.014	.13E4	-.5	.009	
C_{y_p}	0	---	---	0	---	---	-.08	.022	
C_{y_r}	0	---	---	0	---	---	.19	.18	
$C_{y_{\delta a}}$	.71	.38	.22E2	.13	.016	.9E2	.17	.012	
$C_{y_{\delta r}}$	-.086	.136	7.1	.22	.0043	.3E2	.03	.005	
C_{ℓ_β}	-.107	.0092	.35E4	-.086	.0015	.94E5	-.116	.002	
C_{ℓ_p}	-.18	.023	.15E5	-.08	.0035	.41E4	-.164	.005	
C_{ℓ_r}	.43	.17	.26E3	.55	.033	.62E5	.38	.04	
$C_{\ell_{\delta a}}$	-.14	.0089	.55E4	-.114	.0012	.15E6	-.146	.0025	
$C_{\ell_{\delta r}}$	.024	.0027	.46E4	.012	.0005	.99E4	.017	.001	
C_{n_β}	.082	.011	.11E4	.089	.0024	.73E5	.098	.0026	
C_{n_p}	-.01	.025	.10E3	-.004	.006	3.0	.031	.006	
C_{n_r}	-.48	.22	.15E3	.19	.053	.74E4	-.14	.050	
$C_{n_{\delta a}}$	-.061	.013	.44E3	-.056	.0021	.3E5	-.035	.0032	
$C_{n_{\delta r}}$	-.058	.0066	.44E5	-.024	.0008	.14E5	-.054	.0013	

TABLE IV. - LATERAL PARAMETER IDENTIFICATION RESULTS (CONTINUED)

	ML; Surface			ML; Stick			Regression; Surface		
	α_T = 15.5°			α_T = 15.5°			α_T = 15.5°		
	M = .9			M = .9			M = .9		
Parameter	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity	Value	Standard Deviation	Sensitivity
C_{y_β}	-.51	.016	.13E4	-.57	.27	9.4	-.56	.0064	
C_{y_p}	0	---	---	0	---	---	-.12	.02	
C_{y_r}	0	---	---	0	---	---	.008	.11	
$C_{y_{\delta a}}$	.26	.024	.15E3	.45	.38	11.6	.19	.0093	
$C_{y_{\delta r}}$	.068	.0071	.11E3	-.086	.077	13.4	.053	.0027	
C_{ℓ_β}	-.11	.0009	.1E6	-.17	.011	.27E4	-.11	.002	
C_{ℓ_p}	-.17	.0028	.22E5	-.08	.032	.15E3	-.18	.006	
C_{ℓ_r}	.34	.018	.15E5	.18	.21	41.0	.61	.034	
$C_{\ell_{\delta a}}$	-.15	.001	.84E5	-.13	.011	.41E4	-.17	.0028	
$C_{\ell_{\delta r}}$	.018	.0035	.13E5	.013	.0026	.38E3	.017	.0008	
C_{n_β}	.076	.0019	.46E4	.08	.024	.3E3	.093	.0019	
C_{n_p}	.011	.0071	20.0	.083	.072	18.0	.0016	.0059	
C_{n_r}	-.61	.029	.42E5	.37	.42	54.7	-.28	.033	
$C_{n_{\delta a}}$	-.10	.002	.17E5	-.073	.026	.28E3	-.057	.0027	
$C_{n_{\delta r}}$	-.064	.0007	.54E5	-.031	.005	.38E3	-.060	.0008	

REFERENCES

1. Murphy, Patrick C.: An Algorithm for Maximum Likelihood Estimation Using an Efficient Method for Approximating Sensitivities. NASA TP-2311, June 1984.

2. Klein, V.; Batterson, J. G.; and Murphy, P. C.: Determination of Airplane Model Structure from Flight Data by Using Modified Stepwise Regression. NASA TP-1916, October 1981.

3. Eulrich, B. J.; Govindaraj, K. S.; and Harrington, W. W.: Estimation of the Aerodynamic Stability and Control Parameters for the F106A Aircraft from Flight Data: Maneuver Design and Flight Data Analysis. AIAA Paper 78-1326.

4. Frostman, David L.: An Investigation of the Tracking Performance of the Fire Fly Manual Director Gunsight for Air-to-Air Gunnery. AFIT/GGC/EE/77-5, December 1977.

5. Hallissy, J. B.; Frink, N. T.; and Huffman, J. K.: Aerodynamic Testing and Analysis of Vortex Flap Configurations for the Five Percent Scale F-106B. Vortex Flow Aerodynamics Conference, Volume 2. NASA CP-2417, 1986.

NASA
L-85-1578

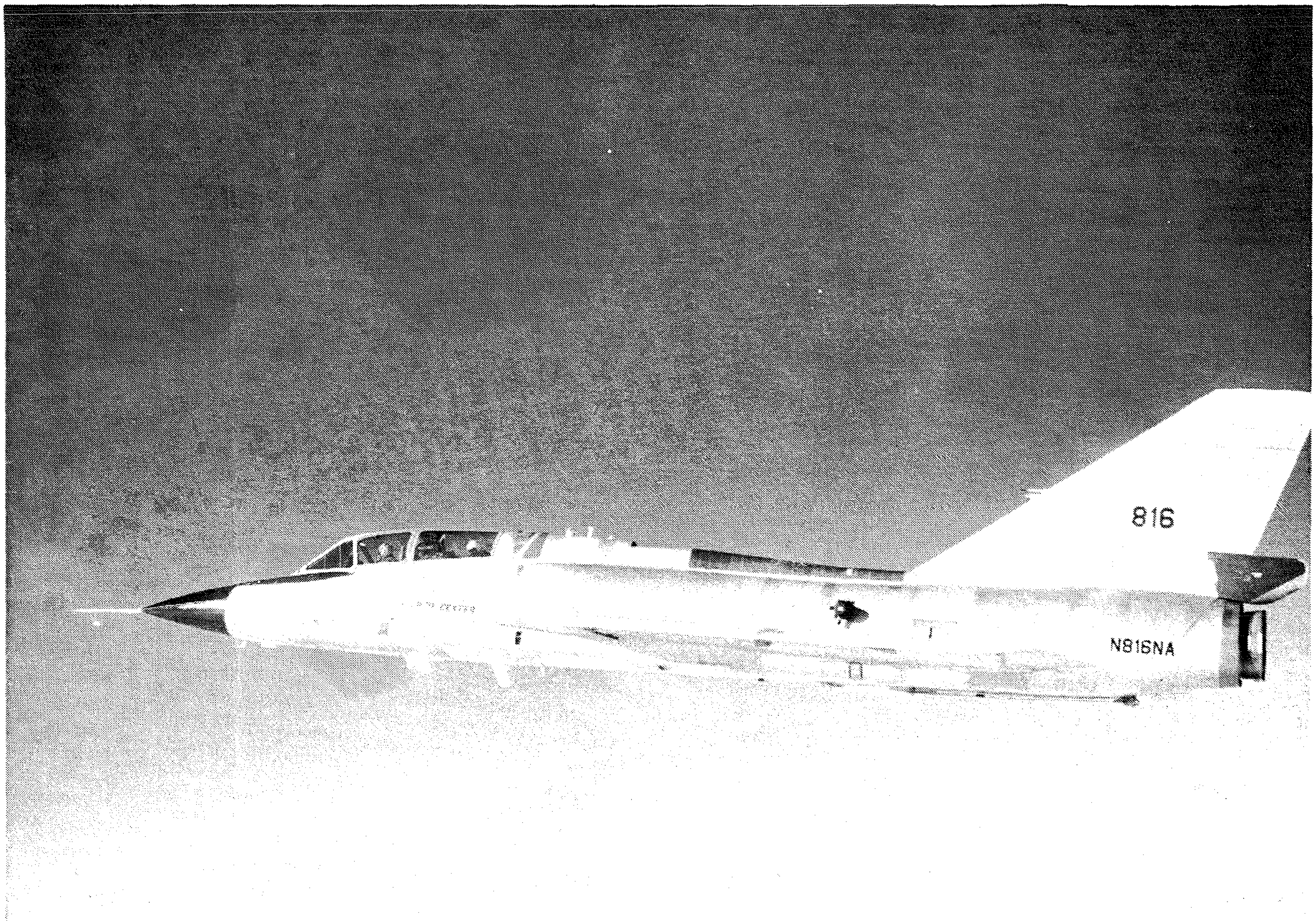


Figure 1. Photo of Basic Vortex Flap Research Aircraft.

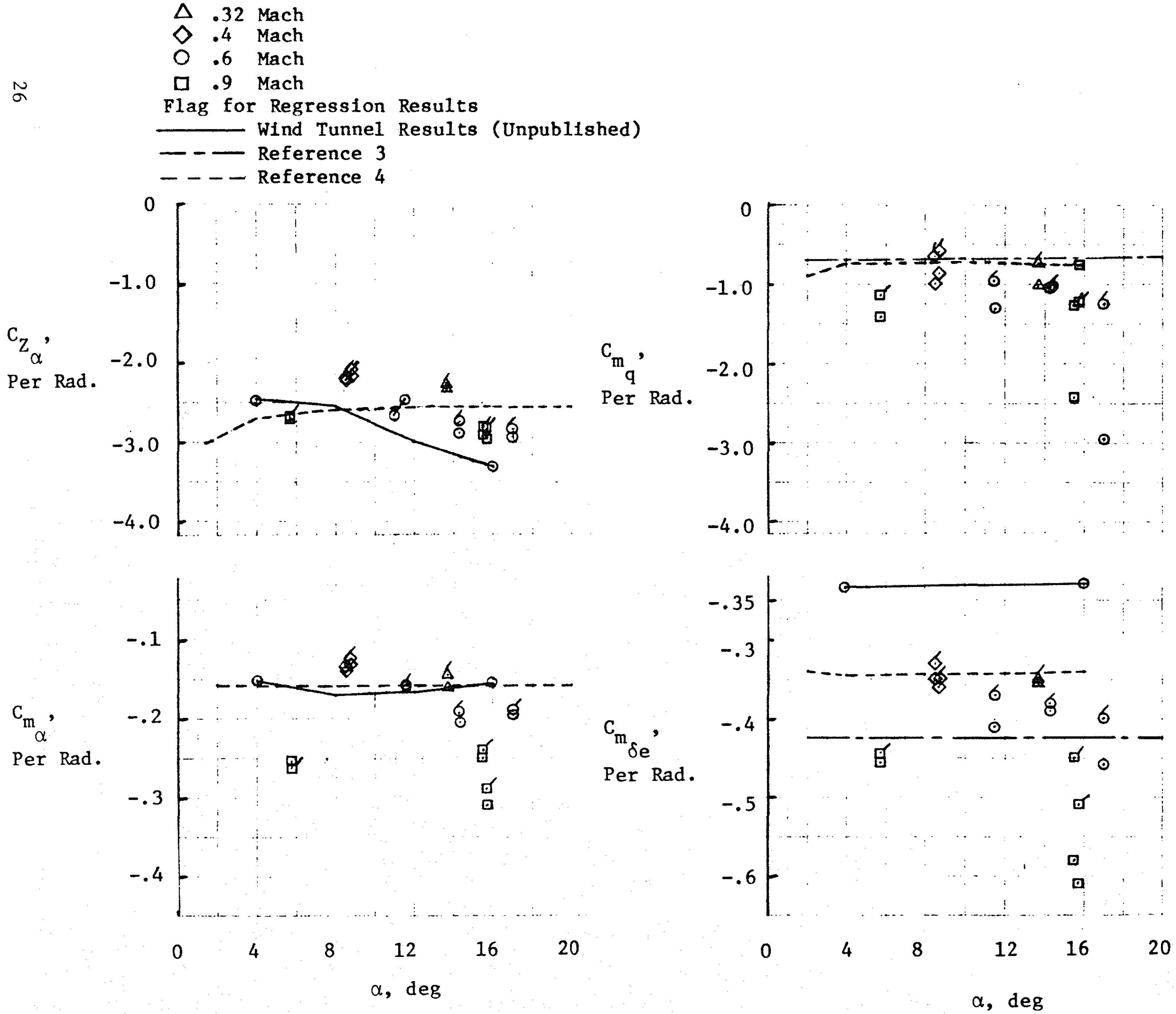


Figure 2. Longitudinal Aerodynamic Parameters plotted against trim angle-of-attack for several Mach Numbers.

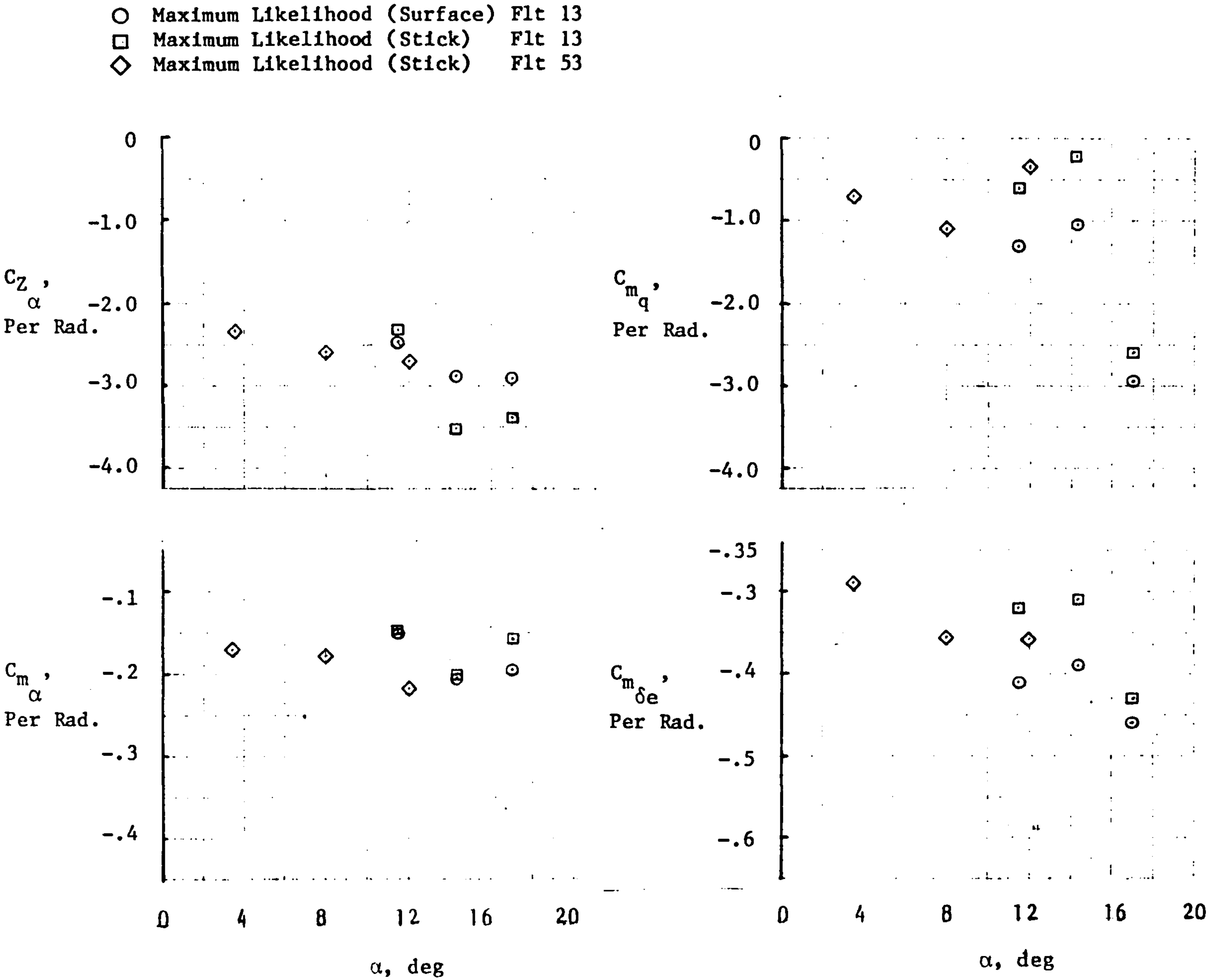
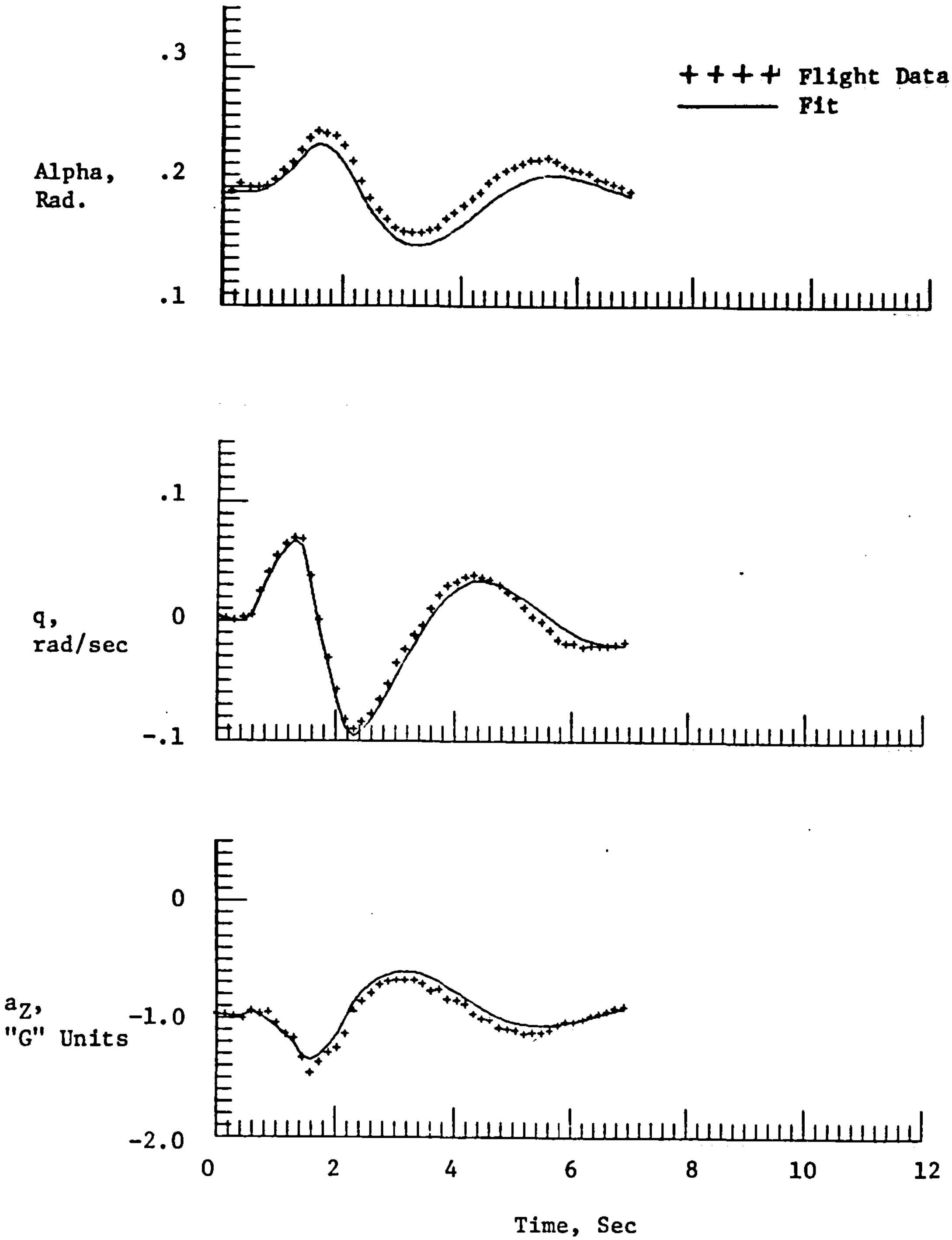


Figure 3. Longitudinal Aerodynamic Parameters for Mach .6 runs using both stick motion and actual surface motion time histories as control effectors.



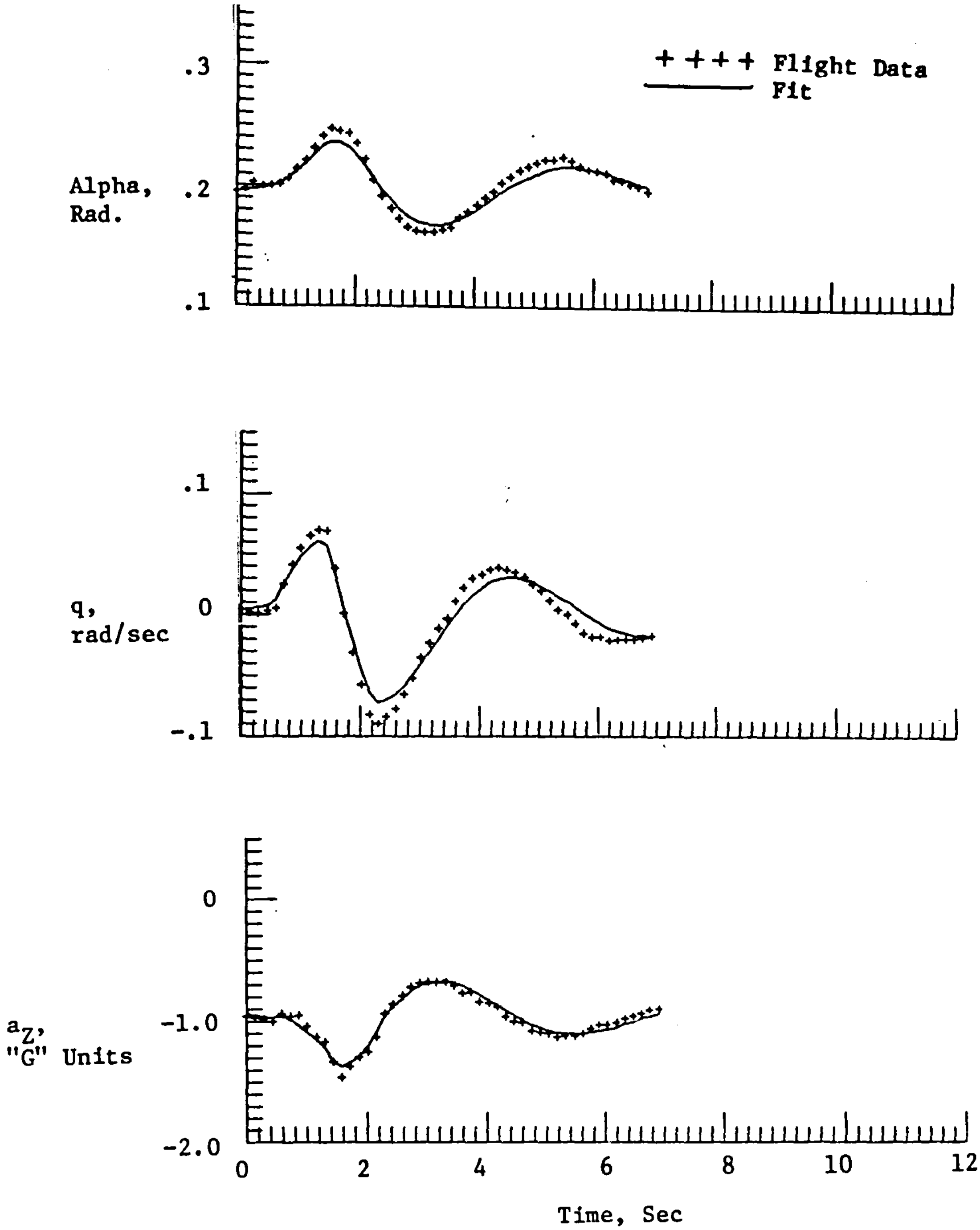
C_{x_α} = .61 C_{z_0} = −.316 C_{z_α} = −2.46

C_{z_q} = −13.10 $C_{z_{\delta e}}$ = −.56 C_{m_α} = −.15

C_{m_q} = −1.13 $C_{m_{\delta e}}$ = −.41

(a) Values obtained from other parameter extraction runs. M=.6, α_T=11.5°.

Figure 4. Longitudinal Predictions Runs



C_{x_α} = .61 ML C_{z_0} = -.316 ML C_{z_α} = -2.80 WT

C_{z_q} = -13.10 ML $C_{z_{\delta e}}$ = -.56 ML C_{m_α} = -.16 WT

C_{m_q} = -.70 REFS. $C_{m_{\delta e}}$ = -.30 WT

ML-Maximum Likelihood
WT-Wind Tunnel

(b) Values obtained from wind tunnel data where available and from parameter extraction when wind tunnel values were not available. M=.6, α_T=11.5°.

Figure 4 (Concluded)

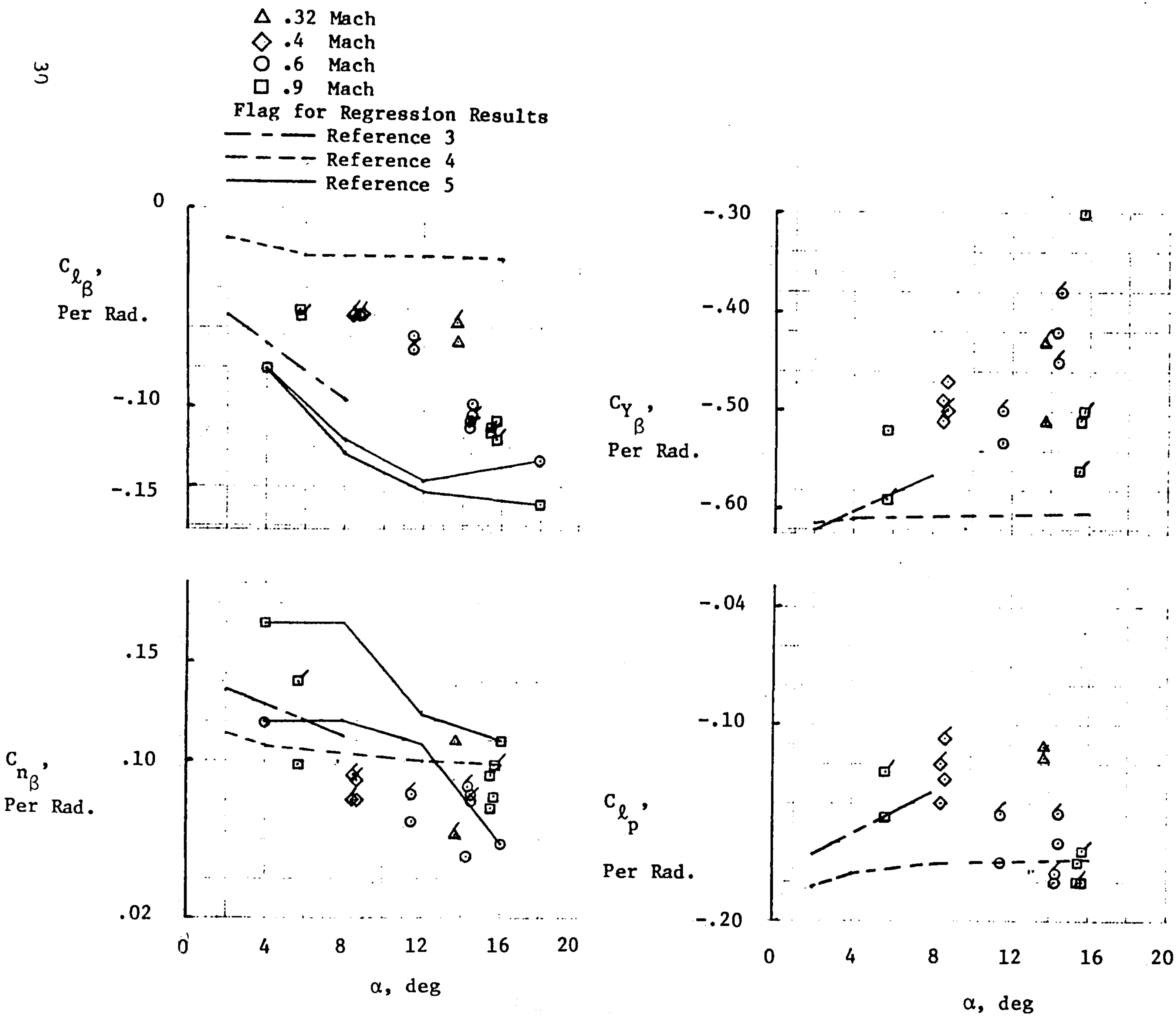


Figure 5. Lateral Aerodynamic Parameters plotted against trim angle-of-attack for several Mach Numbers.

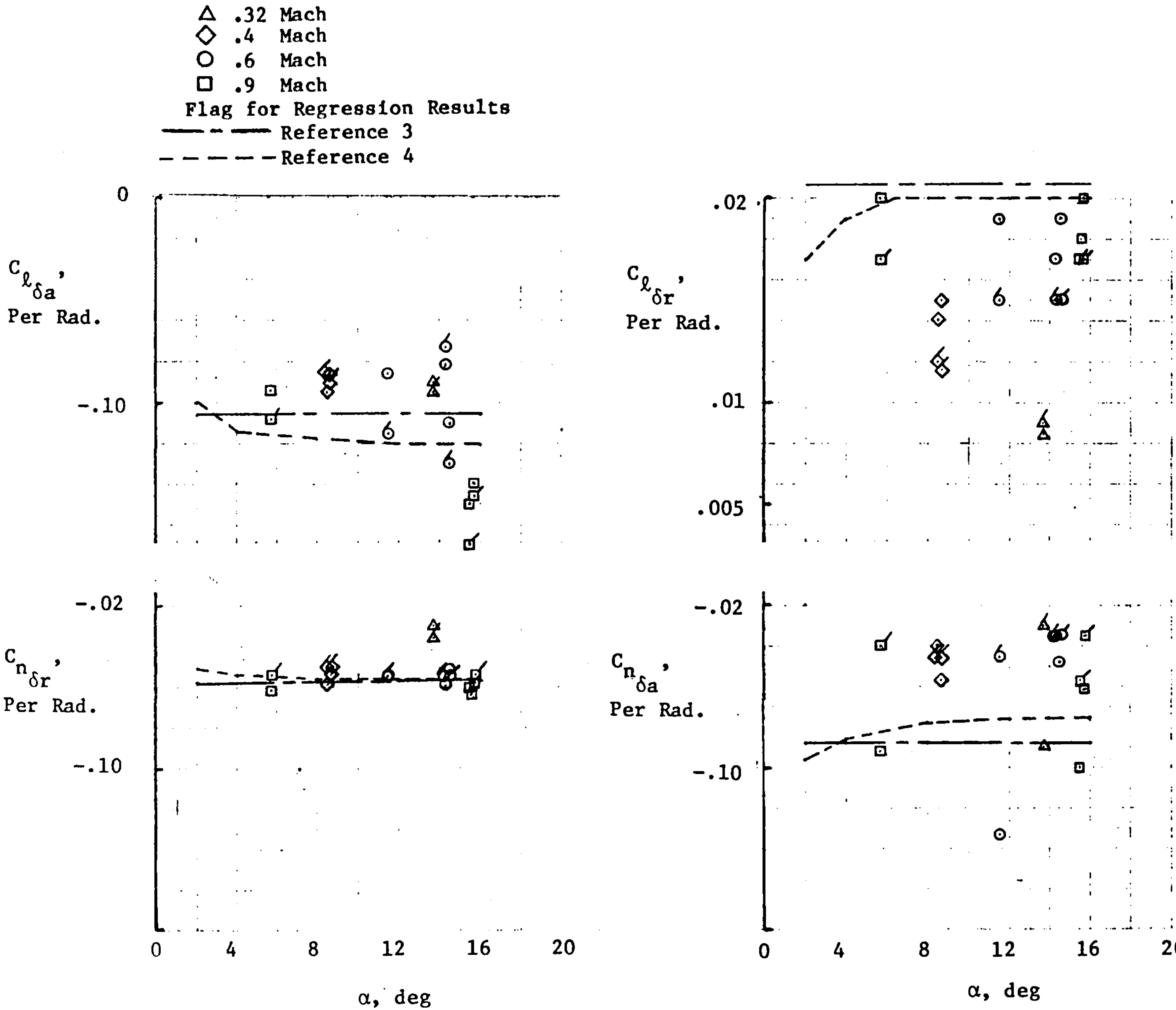


Figure 5. (Concluded)

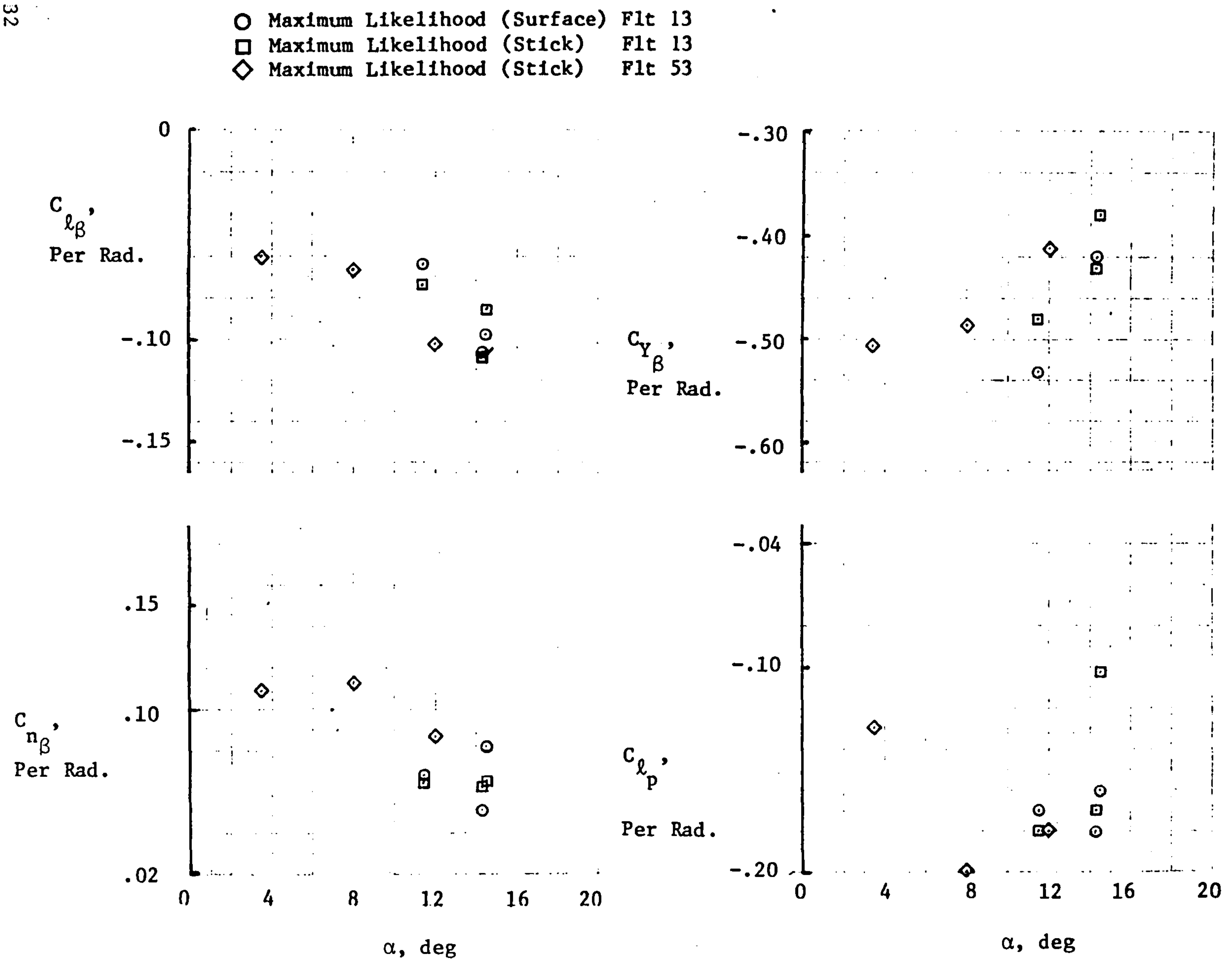


Figure 6. Lateral Aerodynamic Parameters for Mach .6 runs using both stick motion and actual surface motion time histories as control effectors.

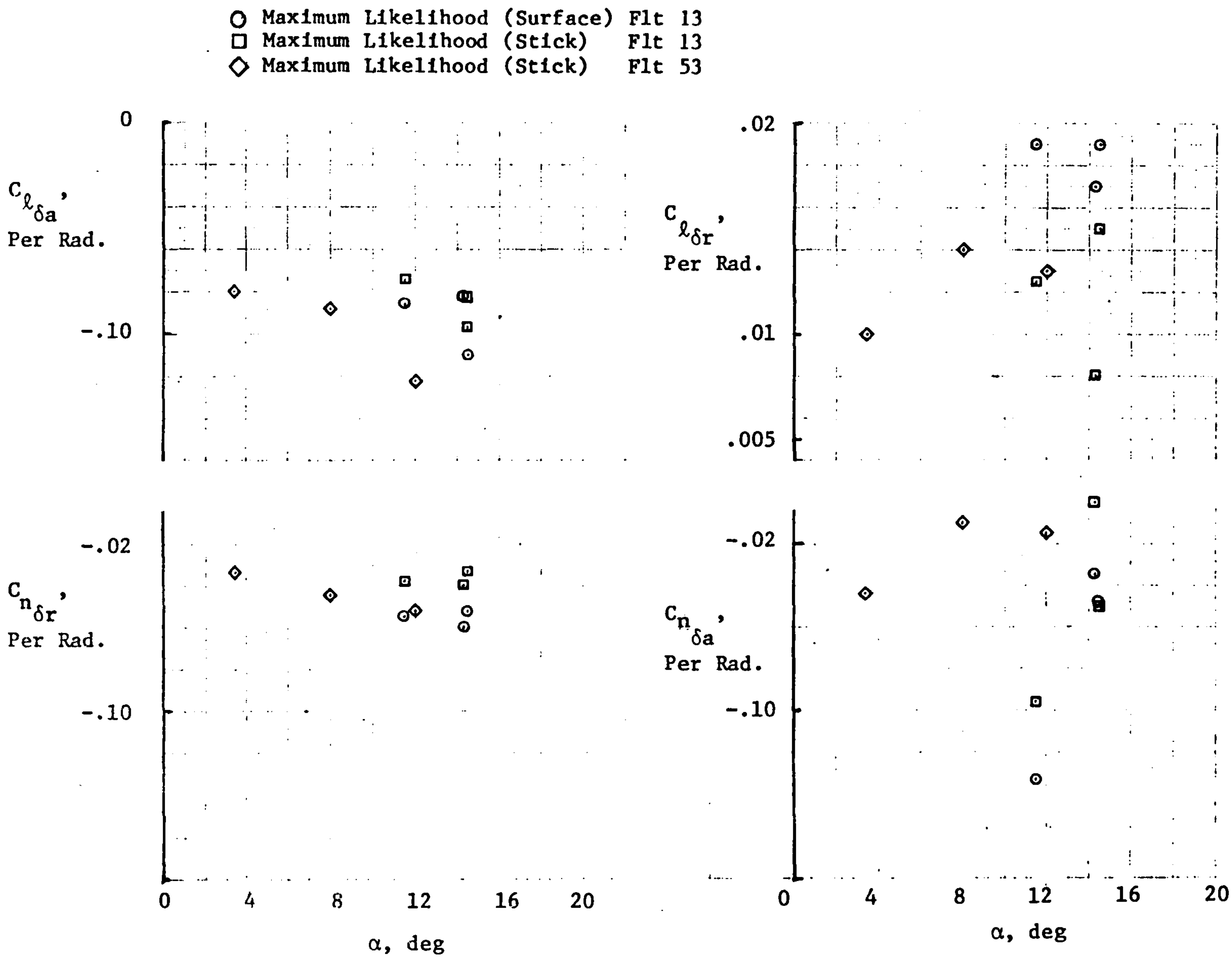
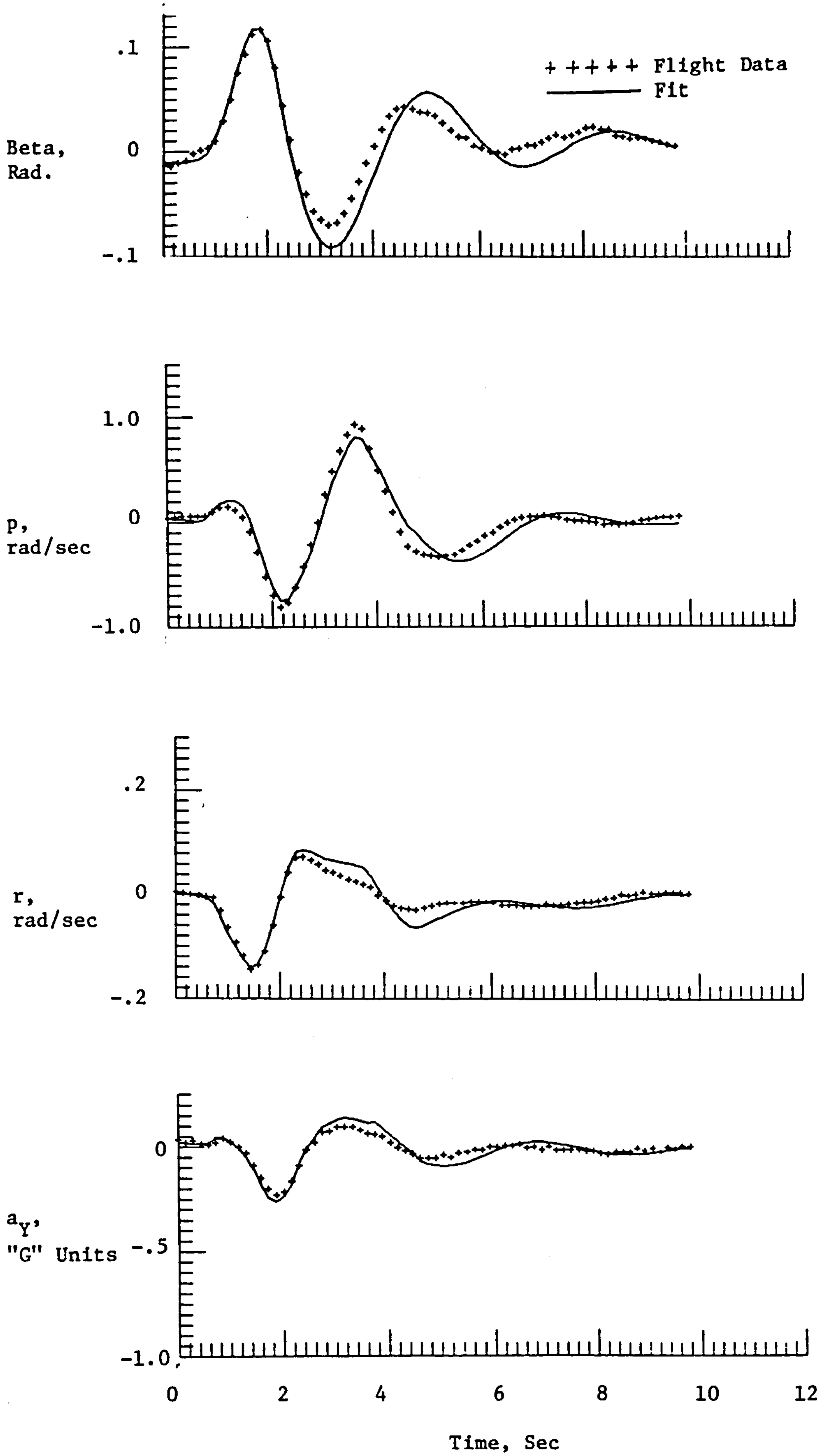


Figure 6 (Concluded)



$C_{Y_\beta} = -.53$

$C_{Y_{\delta a}} = .17$

$C_{Y_{\delta r}} = .067$

$C_{\ell_\beta} = -.064$

$C_{\ell_p} = -.17$

$C_{\ell_r} = 0.0$

$C_{\ell_{\delta a}} = -.086$

$C_{\ell_{\delta r}} = .014$

$C_{n_\beta} = .069$

$C_{n_p} = 0.0$

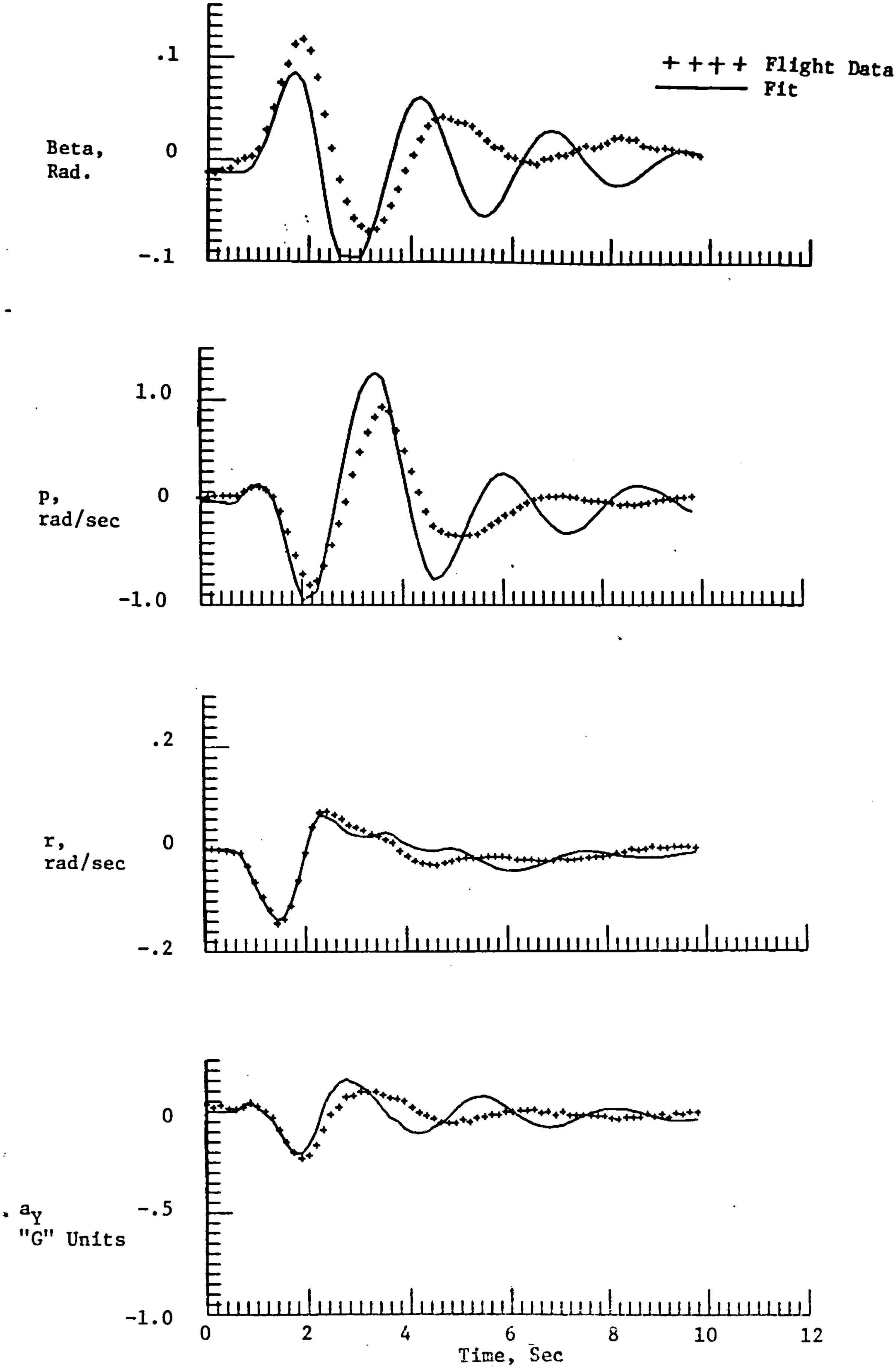
$C_{n_r} = -.50$

$C_{n_{\delta a}} = -.113$

$C_{n_{\delta r}} = -.056$

(a) Values for other parameter extraction runs. M=.6, α_T=11.5°.

Figure 7. Lateral Prediction Runs



C_{Y_β} = -.6 WT

$C_{Y_{\delta a}}$ = .17 ML

$C_{Y_{\delta r}}$ = .067 ML

C_{ℓ_β} = -.12 WT

C_{ℓ_p} = -.17 ML

C_{ℓ_r} = 0.0

$C_{\ell_{\delta a}}$ = -.11 WT

$C_{\ell_{\delta r}}$ = .02 WT

C_{n_β} = .09 WT

C_{n_p} = 0.0

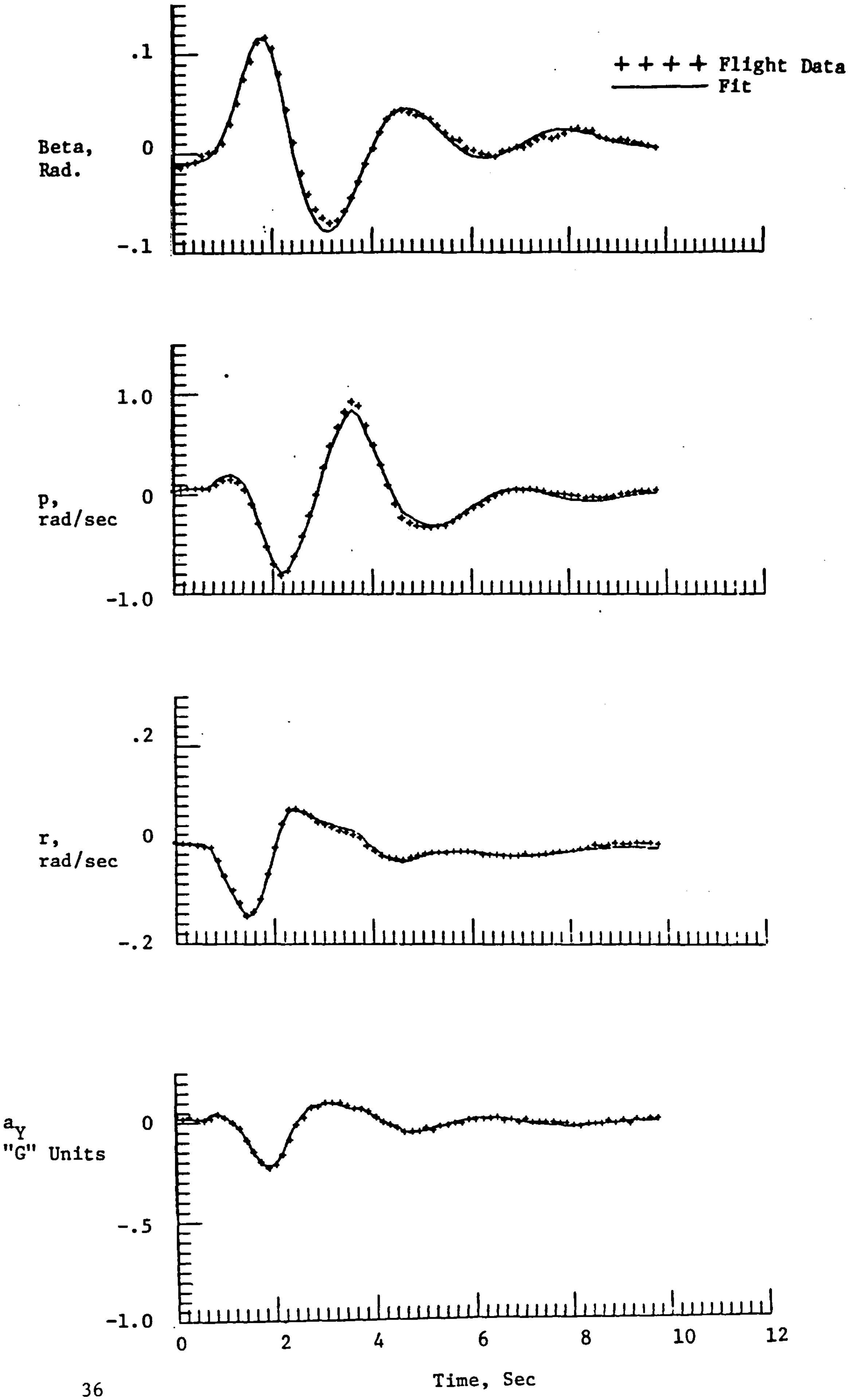
C_{n_r} = -.50 ML

$C_{n_{\delta a}}$ = -.085 WT

$C_{n_{\delta r}}$ = -.058 WT

(b) Values obtained from wind tunnel data (as given in Fig. 5) where wind tunnel values were available and from parameter extraction where wind tunnel values were not available. M=.6, α_T=11.5°.

Figure 7 (Concluded)



$C_{Y_\beta} = -.50$

$C_{Y_{\delta a}} = .23$

$C_{Y_{\delta r}} = .068$

$C_{\ell_\beta} = -.079$

$C_{\ell_p} = -.178$

$C_{\ell_r} = -.084$

$C_{\ell_{\delta a}} = .087$

$C_{\ell_{\delta r}} = .015$

$C_{n_\beta} = .069$

$C_{n_p} = .0079$

$C_{n_r} = -.39$

$C_{n_{\delta a}} = -.055$

$C_{n_{\delta r}} = -.057$

Figure 8. Lateral Aerodynamic Parameters extracted from the prediction run. M=.6, α_T=11.5°.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-87711		

4. Title and Subtitle	
LATERAL AND LONGITUDINAL AERODYNAMIC STABILITY AND CONTROL PARAMETERS OF THE BASIC VORTEX FLAP RESEARCH AIRCRAFT AS DETERMINED FROM FLIGHT TEST DATA	5. Report Date April 1986 6. Performing Organization Code 506-46-21-01
7. Author(s) William T. Suit James G. Batterson	8. Performing Organization Report No.
9. Performing Organization Name and Address NASA Langley Research Center Hampton, VA 23665	10. Work Unit No. 11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	13. Type of Report and Period Covered Technical Memorandum 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Longitudinal and lateral stability and control parameters were estimated from flight data for an F106B aircraft. Parameters were estimated from test maneuvers performed at selected points in the flight envelope. Since the subject aircraft is to be fitted with a leading edge flap, the data obtained will serve as a documentation of the basic aircraft. The parameter values estimated were compared with values from other sources to obtain as complete a documentation of the basic airplane as possible at selected flight conditions.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Parameter Estimation Stability and Control Parameters Maximum Likelihood	Unclassified--Unlimited Subject Category--08

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	37	A03

End of Document