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EVALUATION OF LATERAL-DIRECTIONAL HANDLING QUALITIES AND ROLL-SIDESLIP COUPLING OF FIGHTER CLASS AIRPLANES

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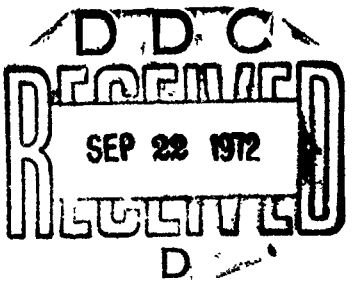

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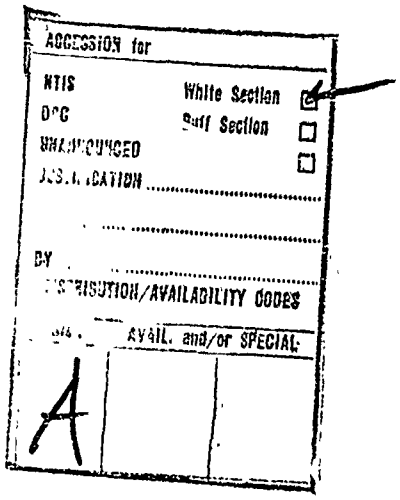

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FOREWORD

This report was prepared for the United States Air Force by Cornell Aeronautical Laboratory, Inc. (CAL), Buffalo, New York in partial fulfillment of Contract F33615-71-C-1240, Project No. 8219, Task No. 05 "Simulation of the Handling Qualities Characteristics Critical to Advanced Military Aircraft Through Use of the Variable Stability NT-33A Aircraft."

The program was performed by the Flight Research Department of CAL under the sponsorship of the Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. Mr. J.L. Lockenour was project engineer for the USAF.

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This report was submitted by the authors in March of 1972.

This technical report has been reviewed and approved.

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Chief, Control Criteria Branch
Air Force Flight Dynamics Laboratory

ABSTRACT

Lateral-directional handling qualities for Class IV airplanes in Flight Phase Category A were investigated in the USAF/CAL variable stability NT-33A airplane. The primary purpose was to extend the data base for roll-sideslip coupling requirements specified by MIL-F-8785B(ASG) for this Class of airplanes. Other purposes included evaluation of the minimum Dutch roll frequency and damping requirements of MIL-F-8785B(ASG) for Class IV airplanes in Flight Phase Category A and an investigation of the applicability of MIL-F-83300 roll-sideslip requirements to airplanes in high speed flight conditions. Maneuvering tasks representative of the fighter mission and a precision bank angle tracking task were performed for evaluation. Evaluations were conducted at three Dutch roll frequencies, three roll-to-sideslip ratios and at values of Dutch roll damping on either side of the MIL-F-8785B(ASG) boundary. Satisfactory flying qualities were not obtained for any of the low Dutch roll frequency ($\omega_d \approx 1.0$ rad/sec) configurations investigated in this experiment. The Dutch roll damping requirements were found to be adequate, especially when the additional increment of damping as a function of Dutch roll frequency and roll-to-sideslip ratio is added. The roll-sideslip coupling requirements in terms of sideslip excursions were found to be conservative, especially at low to moderate values of roll-to-sideslip ratio. For the configurations evaluated, roll rate oscillations were quite small, even when sideslip excursions exceeded the specified limits, therefore the validity of the roll rate oscillations criteria boundaries was not sufficiently evaluated. The roll-sideslip coupling requirements of MIL-F-83300 were found to be generally not applicable to Class IV airplanes in Flight Phase Category A and high speed flight. Volume I of this report contains the body of the text; Volume II contains the appendices.

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Appendix I

LATERAL-DIRECTIONAL EQUATIONS OF MOTION

The lateral-directional equations are written in Laplace notation for a set of body axes using the following basic assumptions:

- The airplane is a rigid body.
- The mass of the airplane does not change during the period of dynamic analysis.
- The airplane is initially in unaccelerated flight and maintains constant altitude.
- The earth is considered to be a flat, inertial, nonrotating, space fixed body.
- The air mass is nonaccelerating.
- The x-z plane is considered to be a plane of symmetry.
- The perturbations from the equilibrium or steady state condition are small enough that the products and squares of the variations are small in comparison with the variations themselves and can be neglected. Also, the perturbation angles are small enough that the sines of these angles may be set equal to the angles and the cosines equal to one. Products of these angles are also negligibly small.
- In the steady flight condition, the airplane is in wings level, symmetric flight with no angular velocity.
- The elevators and ailerons are symmetrically located with respect to the x-z plane and the rudder is located parallel to the x-z plane.
- The control surfaces are movable rigid components attached to a rigid body.
- The airflow around the airplane is quasisteady.
- The initial pitch angle is zero.

The lateral-directional equations using primed derivatives are as follows:

$$\begin{aligned}
&(Y_\beta - s)\beta + (Y_r - 1)r + \left[\frac{g}{V} + (Y_p + \alpha_o)s\right]\phi = -Y_{\delta_{AS}}\,\delta_{AS} - Y_{\delta_{RP}}\,\delta_{RP} \\
&L'_\beta\beta + L'_r r + \left(L'_p s - s^2\right)\phi = -L'_{\delta_{AS}}\,\delta_{AS} - L'_{\delta_{RP}}\,\delta_{RP} \\
&N'_\beta\beta + (N'_r - s)r + N'_p s\phi = -N'_{\delta_{AS}}\,\delta_{AS} - N'_{\delta_{RP}}\,\delta_{RP}
\end{aligned} \tag{I-1}$$

In matrix form:

$$\begin{bmatrix} Y_\beta - s & Y_r - 1 & \frac{g}{V} + (Y_p + \alpha_o)s \\ L'_\beta & L'_r & L'_p s - s^2 \\ N'_\beta & N'_r - s & N'_p s \end{bmatrix} \begin{bmatrix} \beta \\ r \\ \phi \end{bmatrix} = \begin{bmatrix} -Y_{\delta_{AS}} & -Y_{\delta_{RP}} \\ -L'_{\delta_{AS}} & -L'_{\delta_{RP}} \\ -N'_{\delta_{AS}} & -N'_{\delta_{RP}} \end{bmatrix} \begin{bmatrix} \delta_{AS} \\ \delta_{RP} \end{bmatrix} \tag{I-2}$$

The characteristic equation can then be written as:

$$\begin{aligned}
|\Delta| = s^4 &- \left[Y_\beta + N'_r + L'_p\right] s^3 + \left[L'_p N'_r - L'_r N'_p + Y_\beta (N'_r + L'_p)\right. \\
&\left. - (Y_r - 1)N'_\beta - (Y_p + \alpha_o)L'_\beta\right] s^2 + \left[Y_\beta (L'_r N'_p - L'_p N'_r)\right. \\
&+ (Y_r - 1)(L'_p N'_\beta - L'_\beta N'_p) + (Y_p + \alpha_o)(L'_\beta N'_r - L'_r N'_\beta) - \left.\frac{g}{V} L'_\beta\right] s \\
&+ \frac{g}{V}(L'_\beta N'_r - L'_r N'_\beta)
\end{aligned} \tag{I-3}$$

Using Cramer's rule, the ϕ, r and β transfer functions can be written as follows:

For an aileron stick input:

$$\begin{aligned}
\frac{\phi}{\delta_{AS}} = \frac{1}{|\Delta|}\Big\{ &L'_{\delta_{AS}}\, s^2 + \left[Y_{\delta_{AS}} L'_\beta - L'_{\delta_{AS}}\,(N'_r + Y_\beta) + N'_{\delta_{AS}} L'_r\right] s \\
&+ Y_{\delta_{AS}}\,(L'_r N'_\beta - N'_r L'_\beta) + L'_{\delta_{AS}}\left[\, Y_\beta N'_r - (Y_r - 1)N'_\beta \,\right] \\
&+ N'_{\delta_{AS}}\left[\, (Y_r - 1)L'_\beta - L'_r Y_\beta \,\right]\Big\}
\end{aligned} \tag{I-4}$$

which can be written as

$$\frac{\phi}{\delta_{AS}} = \frac{A_{\phi\delta_{AS}}\left(s^2+2\zeta_\phi\omega_\phi s+\omega_\phi^2\right)}{\left(s+\frac{1}{\tau_S}\right)\left(s+\frac{1}{\tau_R}\right)\left(s^2+2\zeta_d\omega_d s+\omega_d^2\right)} \tag{I-5}$$

where $A_{\phi\delta_{AS}} = L'_{\delta_{AS}}$

$$\frac{r}{\delta_{AS}} = \frac{1}{|\Delta|}\Bigg\{ N'_{\delta_{AS}} s^3 + \left[Y_{\delta_{AS}} N'_\beta + L'_{\delta_{AS}} N'_p - N'_{\delta_{AS}}\left(L'_p + Y_\beta\right)\right] s^2$$

$$+\left[L'_{\delta_{AS}}\left(N'_\beta\left(Y_p+\alpha_0\right)-Y_\beta N'_p\right)+N'_{\delta_{AS}}\left(L'_p N'_\beta-\left(Y_p+\alpha_0\right)L'_\beta\right)\right. \tag{I-6}$$

$$\left.+\,Y_{\delta_{AS}}\left(L'_\beta N'_p-N'_\beta L'_p\right)\right] s+\left[L'_{\delta_{AS}} N'_\beta \frac{g}{V}-N'_{\delta_{AS}} L'_\beta \frac{g}{V}\right]\Bigg\}$$

which can be written as:

$$\frac{r}{\delta_{AS}} = \frac{A_{r\delta_{AS}}\left(s+\frac{1}{\tau_{r_1}}\right)\left(s^2+2\zeta_r\omega_r s+\omega_r^2\right)}{\left(s+\frac{1}{\tau_S}\right)\left(s+\frac{1}{\tau_R}\right)\left(s^2+2\zeta_d\omega_d s+\omega_d^2\right)} \tag{I-7}$$

where

$$A_{r\delta_{AS}} = N'_{\delta_{AS}}$$

For $N'_{\delta_{AS}} = 0.$, the following equation applied:

$$\frac{r}{\delta_{AS}} = \frac{A_{r\delta_{AS}}\left(s^2+2\zeta_r\omega_r s+\omega_r^2\right)}{\left(s+\frac{1}{\tau_S}\right)\left(s+\frac{1}{\tau_R}\right)\left(s^2+2\zeta_d\omega_d s+\omega_d^2\right)} \tag{I-8}$$

where

$$A_{r\delta_{AS}} = Y_{\delta_{AS}} N'_\beta + L'_{\delta_{AS}} N'_p$$

$$\frac{\beta}{\delta_{AS}} = \frac{1}{|\Delta|}\Big\{ Y_{\delta_{AS}}\, s^3 + \Big[L'_{\delta_{AS}} (Y_p + \alpha_o) + N'_{\delta_{AS}} (Y_r - 1) - Y_{\delta_{AS}} (N'_r + L'_p) \Big] s^2$$
$$+ \Big[L'_{\delta_{AS}} \Big(\frac{g}{V} - N'_r (Y_p + \alpha_o) + (Y_r - 1) N'_p \Big) + N'_{\delta_{AS}} \Big((Y_p + \alpha_o) L'_r$$
$$- (Y_r - 1) L'_p \Big) + Y_{\delta_{AS}} (L'_p N'_r - L'_r N'_p) \Big] s \qquad \text{(I-9)}$$
$$+ \Big(N'_{\delta_{AS}} L'_r \frac{g}{V} - L'_{\delta_{AS}} N'_r \frac{g}{V} \Big) \Big\}$$

which can be written as:

$$\frac{\beta}{\delta_{AS}} = \frac{A_{\beta\delta_{AS}} \left(s + \frac{1}{\tau_{\beta_1}} \right) (s^2 + 2\zeta_\beta \omega_\beta s + \omega_\beta^2)}{\left(s + \frac{1}{\tau_s} \right) \left(s + \frac{1}{\tau_R} \right) (s^2 + 2\zeta_d \omega_d s + \omega_d^2)} \qquad \text{(I-10)}$$

where $A_{\beta\delta_{AS}} = Y_{\delta_{AS}}$

For $Y_{\delta_{AS}} = 0$, the following equation applied

$$\frac{\beta}{\delta_{AS}} = \frac{A_{\beta\delta_{AS}} (s^2 + 2\zeta_\beta \omega_\beta s + \omega_\beta^2)}{(s + 1/\tau_s)(s + 1/\tau_R)(s^2 + 2\zeta_d \omega_d s + \omega_d^2)} \qquad \text{(I-11)}$$

where:

$$A_{\beta\delta_{AS}} = L'_{\delta_{AS}} (Y_p + \alpha_o) + N'_{\delta_{AS}} (Y_r - 1)$$

If it is further assumed that the spiral root is at the origin and that $Y_p \approx Y_r \approx \alpha_o \approx \left(N'_{\delta_{AS}} L'_r \frac{g}{V} - L'_{\delta_{AS}} N'_r \frac{g}{V} \right) \approx 0$, the sideslip per aileron input transfer function can be written as:

$$\frac{\beta}{\delta_{AS}} = \frac{-N'_{\delta_{AS}} \left[s - L'_p + \frac{L'_{\delta_{AS}}}{N'_{\delta_{AS}}} \left(N'_p - \frac{g}{V} \right) \right]}{\left(s + \frac{1}{\tau_R} \right) \left(s^2 + 2\zeta_d \omega_d s + \omega_d^2 \right)} \qquad \text{(I-12)}$$

when $N'_{\delta_{AS}} = 0$

$$\frac{\beta}{\delta_{AS}} = \frac{-L'_{\delta_{AS}} \left(N'_p - \frac{g}{V} \right)}{\left(s + \frac{1}{\tau_R} \right) \left(s^2 + 2\zeta_d \omega_d s + \omega_d^2 \right)} \qquad \text{(I-13)}$$

The ratio of ϕ/β can be obtained by dividing the Equation I-4 by Equation I-9. For $L'_{\delta_{AS}} = Y_{\delta_{AS}} = 0$ and $N'_{\delta_{AS}} > 0$.

$$\frac{\phi}{\beta} = \frac{L'_r s + (Y_r - 1)L'_\beta - L'_r Y_\beta}{(Y_r - 1)s^2 + \left[(Y_p + \alpha_0)L'_r - (Y_r - 1)L'_p\right]s + L'_r\left(\frac{g}{V}\right)} \tag{I-14}$$

For $Y_r \approx Y_p \approx 0$ and for equations referenced to body axes with $\alpha_o = 0$

$$\frac{\phi}{\beta} = -\frac{L'_r s - (L'_\beta + L_r Y_\beta)}{s^2 - L_p s - L'_r \frac{g}{V}} \tag{I-15}$$

From equation I-4

$$\frac{p}{\delta_{AS}} = \frac{\dot{\phi}}{\delta_{AS}} = \frac{A_{\phi\delta_{AS}}\, s\left(s^2 + 2\zeta_\phi \omega_\phi s + \omega_\phi^2\right)}{\left(s + \frac{1}{\tau_S}\right)\left(s + \frac{1}{\tau_R}\right)\left(s^2 + 2\zeta_d \omega_d s + \omega_d^2\right)} \tag{I-16}$$

where: $A_{\phi\delta_{AS}} = L'_{\delta_{AS}}$

For the spiral root at the origin, the above equation becomes:

$$\frac{p}{\delta_{AS}} = \frac{A_{\phi\delta_{AS}}\left(s^2 + 2\zeta_\phi \omega_\phi s + \omega_\phi^2\right)}{\left(s + \frac{1}{\tau_R}\right)\left(s^2 + 2\zeta_d \omega_d s + \omega_d^2\right)} = \left(\frac{L'_{\delta_{AS}} \cdot \tau_R \omega_\phi^2}{(\tau_R s + 1)\omega_d^2}\right)\left(\frac{\frac{s^2}{\omega_\phi^2} + \frac{2\zeta_\phi s}{\omega_\phi} + 1}{\frac{s^2}{\omega_d^2} + \frac{2\zeta_d s}{\omega_d} + 1}\right) \tag{I-17}$$

Thus the steady-state roll rate per aileron stick input becomes:

$$\frac{p_{ss}}{\delta_{AS}} = \tau_R \left[L'_{\delta_{AS}}\right]\left(\frac{\omega_\phi}{\omega_d}\right)^2 \tag{I-18}$$

The following relationships can be written from the $\phi(s)/\delta_{AS}(s)$ transfer function:

$$\omega_\phi^2 = \frac{Y_{\delta_{AS}}}{L'_{\delta_{AS}}}\left(L'_r N'_\beta - N'_r L'_\beta\right) + \left[Y_\beta N'_r - (Y_r - 1)N'_\beta\right] + \frac{N'_{\delta_{AS}}}{L'_{\delta_{AS}}}\left[(Y_r - 1)L'_\beta - L'_r Y_\beta\right] \tag{I-19}$$

$$2\zeta_\phi \omega_\phi = \left(\frac{Y_{\delta_{AS}}}{L'_{\delta_{AS}}}\right)L'_\beta - N'_r - Y_\beta + \left(\frac{N'_{\delta_{AS}}}{L'_{\delta_{AS}}}\right)L'_r \tag{I-20}$$

In this experiment, for a given configuration; i.e., a set of stability derivatives, the control derivatives $N'_{\delta_{AS}}$ and $L'_{\delta_{AS}}$ were varied to change the numerator zeros in the ϕ/δ_{AS} transfer function thus:

$$\omega_\phi^2 = C_1 + C_2 \frac{N'_{\delta_{AS}}}{L'_{\delta_{AS}}} \quad \text{and} \quad 2\zeta_\phi \omega_\phi = C_3 + C_4 \frac{N'_{\delta_{AS}}}{L'_{\delta_{AS}}} \tag{I-21}$$

where the constants are determined by the stability derivatives with the major contributions shown below for $Y_{\delta_{AS}} \approx Y_r \approx 0$:

$$C_1 \approx N'_r Y_\beta + N'_\beta \qquad C_2 \approx -L_\beta - L'_r Y_\beta$$

$$C_3 \approx -N'_r - Y_\beta \qquad C_4 \approx L'_r \tag{I-22}$$

from Equation I-3 for $Y_p \approx Y_r \approx \alpha_o \approx 0$

$$|\Delta| = s^4 - \left[Y_\beta + N'_r + L'_p\right] s^3 + \left[L'_p N'_r - L'_r N'_p + Y_\beta (N'_r + L'_p) + N'_\beta\right] s^2 + \left[Y_\beta (L'_r N'_p - L'_p N'_r) - (L'_p N'_\beta - L'_\beta N'_p) - \frac{g}{V} L'_\beta\right] s + \frac{g}{V}(L'_\beta N'_r - L'_r N'_\beta) \tag{I-23}$$

Carrying out the multiplication in the denominator of Equation I-5.

$$|\Delta| = s^4 + \left[\frac{1}{\tau_S} + \frac{1}{\tau_R} + 2\zeta_d \omega_d\right] s^3 + \left[\frac{1}{\tau_S}\frac{1}{\tau_R} + 2\zeta_d \omega_d \left(\frac{1}{\tau_S} + \frac{1}{\tau_R}\right) + \omega_d^2\right] s^2 + \left[2\left(\frac{1}{\tau_S}\frac{1}{\tau_R}\right)\zeta_d \omega_d + \omega_d^2 \left(\frac{1}{\tau_S} + \frac{1}{\tau_R}\right)\right] s + \left(\frac{1}{\tau_S}\frac{1}{\tau_R}\right)\omega_d^2 \tag{I-24}$$

Since $\frac{1}{\tau_s}$ and ζ_d are generally much smaller in magnitude than $\frac{1}{\tau_R}$ and ω_d, the following assumptions can be made:

$$\omega_d^2 >> \frac{1}{\tau_s}\,\frac{1}{\tau_R} + 2\zeta_d\,\omega_d\left(\frac{1}{\tau_s}+\frac{1}{\tau_R}\right)$$

and

$$\frac{\omega_d^2}{\tau_R} >> \frac{\omega_d^2}{\tau_s} + 2\left(\frac{1}{\tau_s}\,\frac{1}{\tau_R}\right)\zeta_d\,\omega_d$$

Thus

$$\Delta \approx s^4 + \left[\frac{1}{\tau_s}+\frac{1}{\tau_R}+2\zeta_d\,\omega_d\right]\,s^3 + \left[\omega_d^2\right]s^2 + \left[\frac{\omega_d^2}{\tau_R}\right]s + \left(\frac{1}{\tau_s}\,\frac{1}{\tau_R}\right)\omega_d^2 \qquad \text{(I-25)}$$

Equating the coefficients of the terms of Equations I-23 and I-25

$$\omega_d^2 \approx L'_p N'_r - L'_r N'_p + Y_\beta\left(N'_r + L'_p\right) + N'_\beta \qquad \text{(I-26)}$$

$$\frac{1}{\tau_R} \approx \frac{Y_\beta\left(L'_r N'_p - L'_p N'_r\right) - L'_p N'_\beta + L'_\beta\left(N'_p - \frac{g}{V}\right)}{L'_p N'_r - L'_r N'_p + Y_\beta\left(N'_r + L'_p\right) + N'_\beta} \qquad \text{(I-27)}$$

$$\frac{1}{\tau_s} \approx \frac{\frac{g}{V}\left(L'_\beta N'_r - L'_r N'_\beta\right)}{Y_\beta\left(L'_r N'_p - L'_p N'_r\right) - L'_p N'_\beta + L'_\beta\left(N'_p - \frac{g}{V}\right)} \qquad \text{(I-28)}$$

$$2\zeta_d\omega_d = -Y_\beta - N'_r - L'_p - \frac{1}{\tau_s} - \frac{1}{\tau_R} \qquad \text{(I-29)}$$

Substituting Equations I-27 and I-28 into I-29, carrying the appropriate crossmultiplication and neglecting multiples of small derivatives, Equation I-29 reduces to:

$$2\zeta_d\omega_d = -Y_\beta - N'_r - \frac{L'_\beta}{N'_\beta}\left(N'_p - \frac{g}{V}\right) \qquad \text{(I-30)}$$

Subtracting Equation I-30 from I-20

$$2\zeta_\phi\omega_\phi - 2\zeta_d\omega_d = \frac{L'_\beta}{N'_\beta}\left(N'_p - \frac{g}{V}\right) + \frac{Y_{\delta_{AS}}}{L'_{\delta_{AS}}}L'_\beta + \frac{N'_{\delta_{AS}}}{L'_{\delta_{AS}}}L'_r \qquad \text{(I-31)}$$

In view of the pilot comments for the low Dutch roll frequency configurations concerning the large magnitude sideslips excited with an aileron input, it was of interest to briefly investigate the contribution of the spiral and roll modes to the total sideslip response.

For a case with complex zeros in the numerator of the $\frac{\beta(s)}{\delta_a(s)}$ transfer function and with $Y_{\delta_{AS}} \neq 0$, Equation I-10, repeated below, describes the sideslip response to an aileron step input.

$$\frac{\beta(s)}{\delta_{AS}(s)} = \frac{A_{\beta_{\delta_{AS}}}\left(s+\frac{1}{\tau_{\beta_1}}\right)\left(s^2+2\zeta_\beta\omega_\beta s+\omega_\beta^2\right)}{s\left(s+\frac{1}{\tau_s}\right)\left(s+\frac{1}{\tau_R}\right)\left(s^2+2\zeta_d\omega_d s+\omega_d^2\right)} \qquad \text{(I-10)}$$

In the time domain, this expression may be written, from Reference 3, for an aileron step input as:

$$\left.\frac{\beta(t)}{\delta_{AS}}\right|_{STEP} = C_0 + C_s e^{-t/\tau_s} + C_R e^{-t/\tau_R} + C_d e^{-\zeta_d\omega_d t}\cos\left(\omega_d\sqrt{1-\zeta_d^2}\,t + \psi_\beta\right)$$

The modal response coefficients, C_s, C_R and C_d, and the constant term C_0 may be evaluated using partial fraction expansion techniques. For config-

uration 9 with $N'_{\delta_{RS}}/L'_{\delta_{RS}} = -0.07$ the following values were obtained for the coefficients shown.

C_0 = 12.84 = Steady State Component

C_S = -12.63 = Spiral Mode Coefficient

C_R = 0.0546 = Roll Mode Coefficient

C_d , the Dutch roll mode coefficient, was not evaluated since the total sideslip response was already known from computer generated time histories and therefore the Dutch roll contribution to the time history could easily be obtained by addition. Figure I-1, shows the total sideslip response and the components of the response resulting from the residues in the spiral, roll and Dutch roll modes as well as the steady state value of sideslip for an aileron step input.

From Figure I-1 it appears that the character of the total sideslip response in the first three seconds of the transient response is heavily affected by both the Dutch roll mode and the spiral mode. The growth of sideslip in the spiral mode is shown on Figure I-1 as $C_S e^{-\lambda_S t} - C_S e^{0}$, plotted to the same scale as the total β response, and the roll and Dutch roll components of the β response for comparison. From this it is evident that the pilot must cope with large residues of sideslip in the spiral mode and that the sideslip in the spiral mode will continue long after the Dutch roll component has subsided. The phasing of rudder inputs for turn coordination, however, is still determined by the phase of the Dutch roll component but additional magnitude is required to also remove the spiral mode sideslip. Hence, the parameter, ψ_β , still maintains importance in the coordination problem, especially for lightly damped Dutch roll characteristics. The spiral mode, however, helps account for the

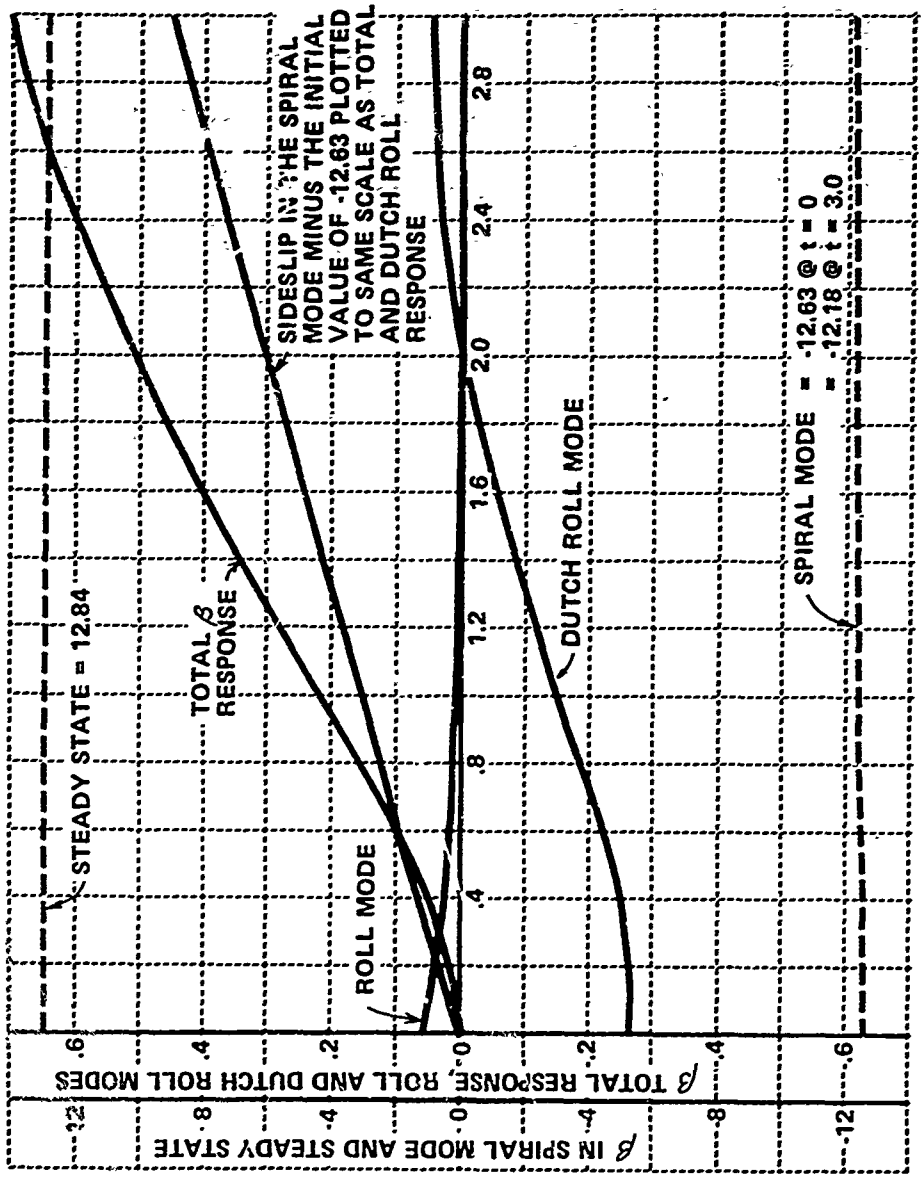


Figure I-1 Components of Sideslip Response to an Aileron Step Input for Configuration 9 With $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.07$

many pilot comments concerning the insidious buildup of sideslip during the evaluation of the low Dutch roll frequency configurations of this investigation. The effects of the roll mode appear minimal for the short roll mode time constant evaluated in this investigation.

APPENDIX II

RANDOM NOISE TURBULENCE SIMULATION

The mechanization of the random noise disturbance input system is described in Section II. Each of the random noise signals were passed through a second-order filter. The filters had the frequency response shown in Figure II-1. The amplitudes of the uncorrelated disturbance signals going to the ailerons, elevator and rudder were varied independently by gain controls in the NT-33A safety cockpit. Figure II-2 is a time history of the three uncorrelated signals before being independently attenuated by the cockpit gain controls. Figure II-3 is a time history of the in-flight control surface deflections with the random noise system turned on during a simulation of Configuration 8 of the investigation reported herein. The time histories of Figure II-3 are not purely random noise inputs since the variable stability system signals were also going to each of the control system actuators. However, during the recording of Figure II-3, the airplane was trimmed for straight and level flight.

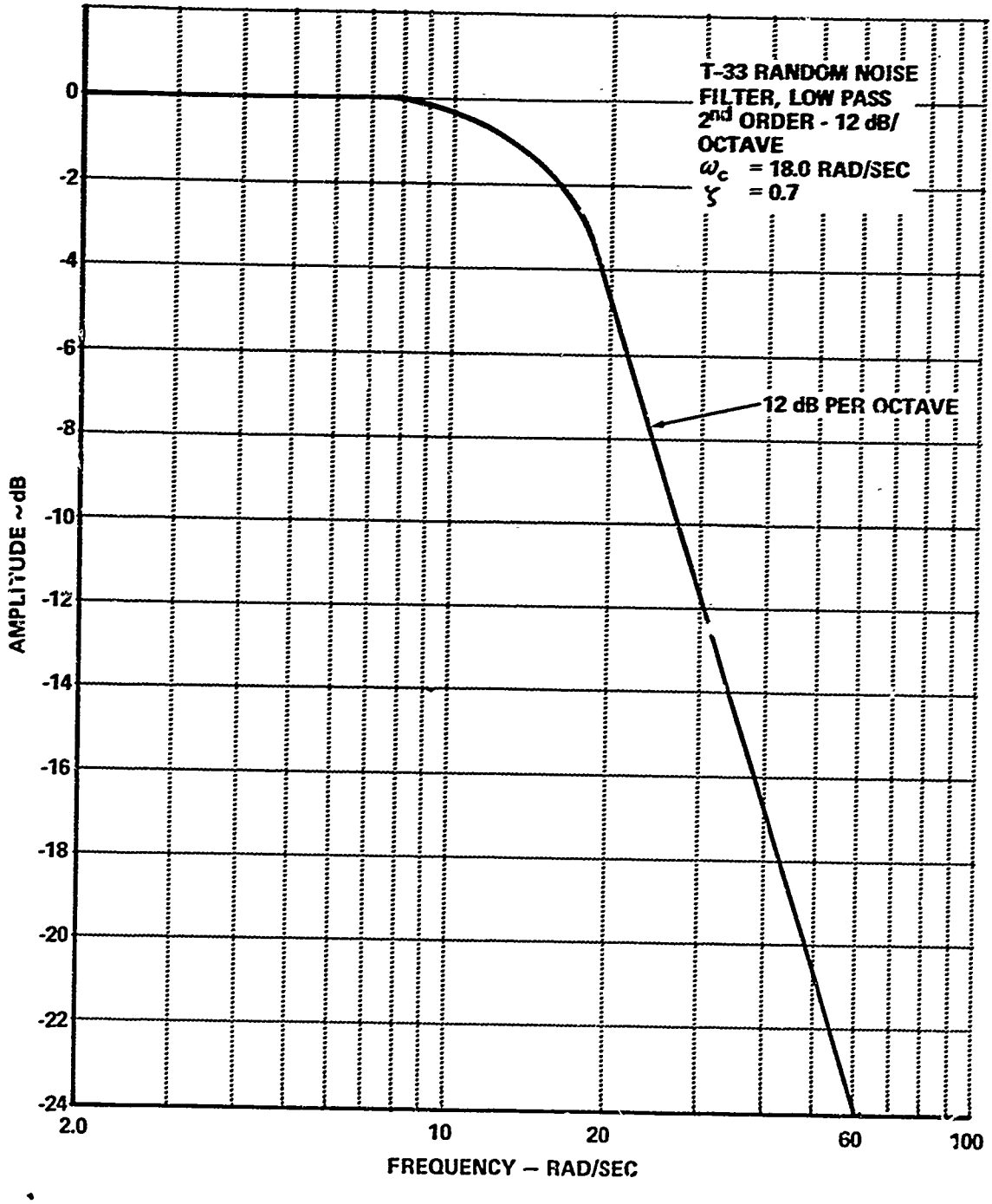


Figure II-1 RANDOM NOISE FILTER FREQUENCY RESPONSE

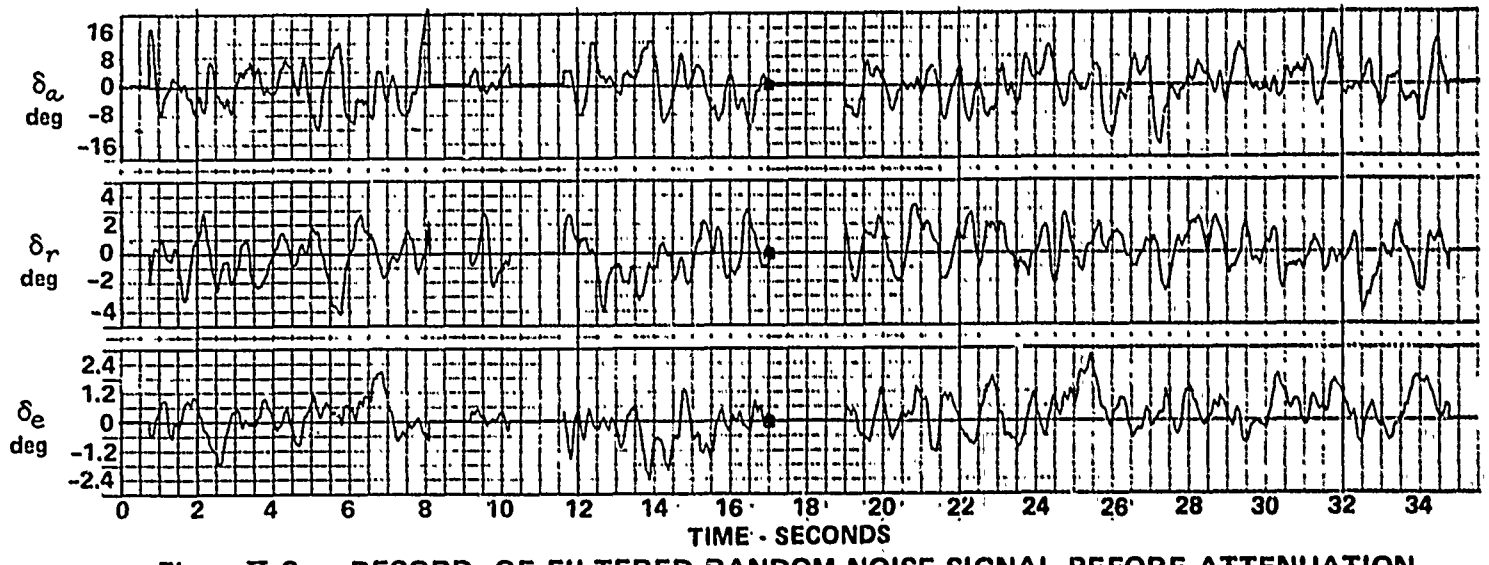


Figure II-2 RECORD OF FILTERED RANDOM NOISE SIGNAL BEFORE ATTENUATION BY COCKPIT GAIN CONTROLS

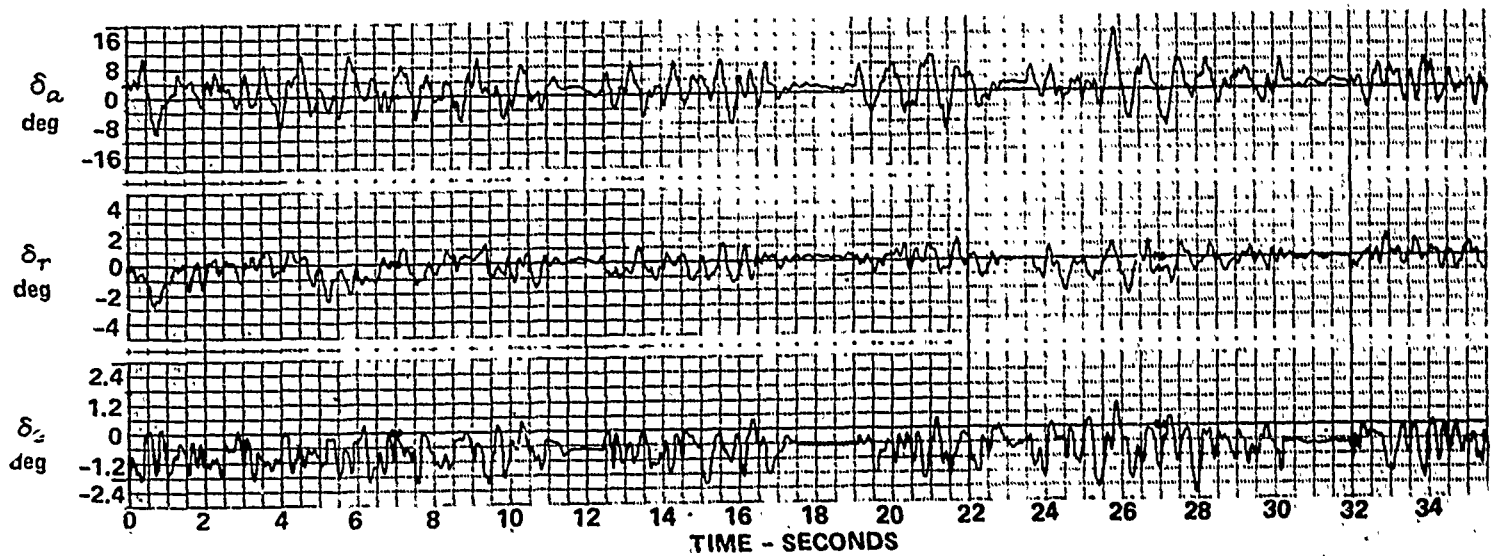


Figure II-3 SAMPLE OF CONTROL SURFACE DEFLECTIONS FOR CONFIGURATION 8 IN FLIGHT WITH RANDOM NOISE ON

APPENDIX III
DATA RECORDING

A digital recording system and oscillograph recording equipment mounted in the variable stability airplane were used for the acquisition of quantitative data. The following listed variables were recorded on both systems.

$\Delta\alpha_v$	δ_{AS}	$\bar{q}_c$ (airspeed)
β_v	δ_{RP}	n_z
p	δ_{ES}	n_y
q	δ_r	bank angle tracking task error
r	δ_a	
$\dot{p}$	δ_e	
$\dot{r}$	F_{AS}	
ϕ	F_{RP}	
θ	F_{ES}	

In addition to the variables listed above, $\dot{q}$ and $\dot{w}_v$ were recorded on the oscillograph only. Other variables or quantities peculiar to the variable stability system were also recorded on the oscillograph.

Pilot comments and ratings were recorded in flight by use of tape recording equipment installed in the variable stability airplane. The system operator/safety pilot recorded the evaluation pilot's selected value of aileron and rudder control sensitivities. The assigned pilot rating and turbulence rating given by the evaluation pilot were hand recorded for backup of the tape recording equipment.

Pilot ratings and comments are included in Appendix IV.

APPENDIX IV

CONFIGURATION IDENTIFICATION AND FLIGHT DATA TABULATION

TRANSIENT RESPONSES

PILOT COMMENTS

This appendix is arranged in three sections in accordance with the three values of Dutch roll frequency investigated in this experiment. The first section, IV.1, contains data pertinent to the low Dutch roll frequency configurations and the second and third sections, IV.2 and IV.3, contain the medium and high Dutch roll frequency configurations, respectively. The roll-sideslip coupling data shown was measured from actual flight data unless otherwise indicated. Computer generated transient responses are presented. Selected flight recorded transient responses are also presented. The edited pilot comments are presented in their entirety for each configuration immediately following the transient responses for that configuration.

To simplify the presentation of tabular data in this appendix, units of the various parameters will not be presented on each table. A listing of the parameters and their units of measurement is shown here for the convenience of the reader.

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	~ nondimensional	$\lvert\phi/\beta\rvert_d$	~ nondimensional
PR	~ pilot rating	$\measuredangle(\phi/\beta)_d$	~ degrees
TR	~ turbulence rating	N'_β	~ seconds^{-2}
ω_ϕ	~ radians per second	N'_r	~ seconds^{-1}
ψ/β	~ degrees	N'_p	~ seconds^{-1}
p_{osc}/p_{AV}	~ nondimensional	g/V	~ seconds^{-1}
$\Delta\beta_{MAX}/t_c$	~ degrees	Y_r	~ radians^{-1}
$\lvert\Delta\beta/\phi_1\rvert \times \lvert\phi/\beta\rvert_d$	~ nondimensional	Y_p	~ radians^{-1}
$L'_{\delta_{AS}}$	~ degrees/second^2-inch	L'_β	~ seconds^{-2}
$N'_{\delta_{RP}}$	~ degrees/second^2-inch	L'_r	~ seconds^{-1}
ω_d	~ radians per second	L'_p	~ seconds^{-1}
τ_R	~ seconds	Y_β	~ seconds^{-1}
τ_s	~ seconds	$Y_{\dot\beta}$	~ radians^{-1}

APPENDIX IV.1

LOW DUTCH ROLL FREQUENCY CONFIGURATIONS

CONFIGURATION IDENTIFICATION AND FLIGHT DATA TABULATION

TRANSIENT RESPONSES

PILOT COMMENTS

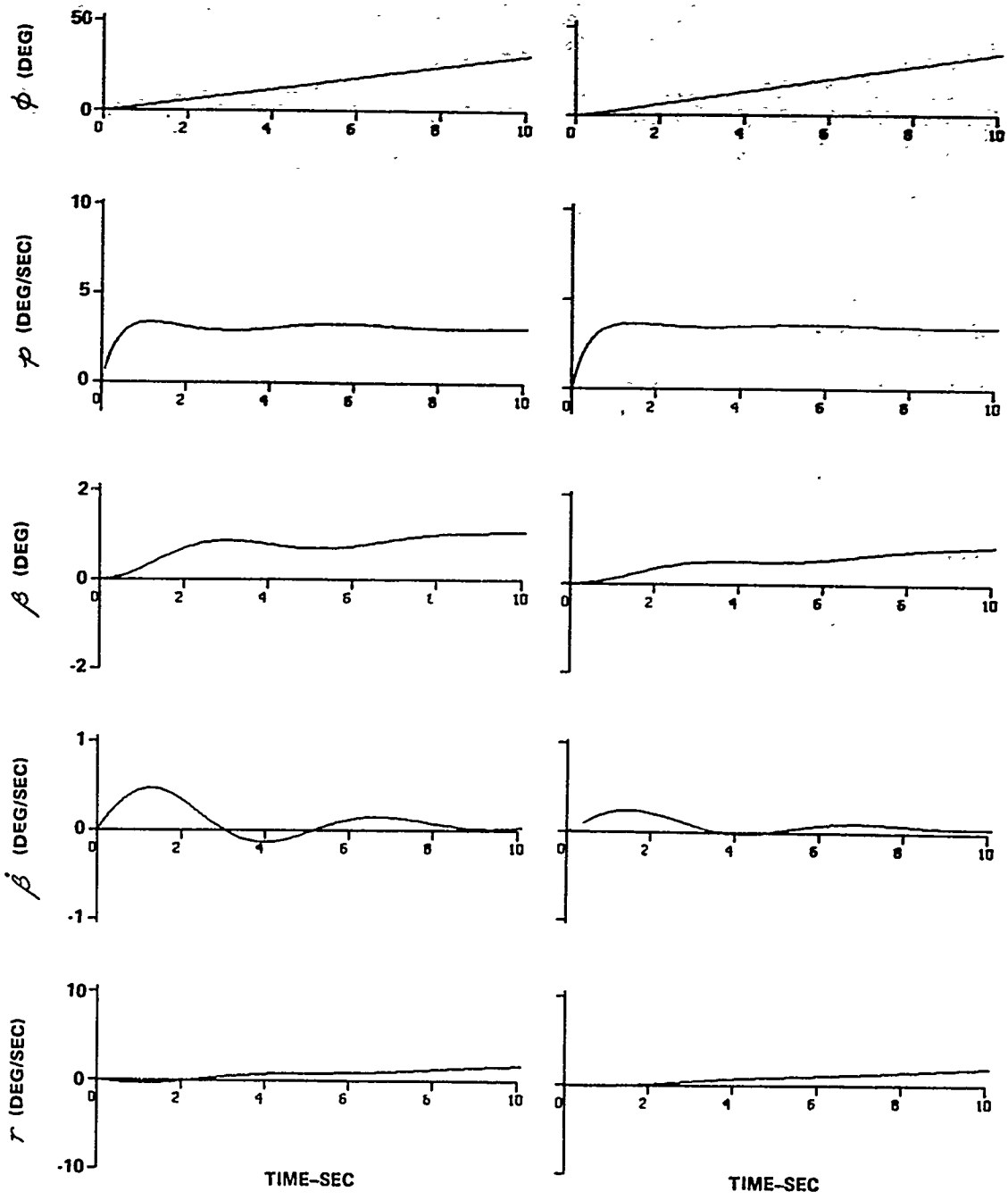
CONFIGURATION 2 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/k$ LEVEL 1	$\Delta\beta_{max}/k$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.06	8.5	B	0.24	1.09	-200	0.130	26.6	18.7	0.16*	355	28.0
-0.02	4.5	D	0.24	1.15	-195	0.0	13.5	8.4	0.08*	305	19.5
+0.01	4.5	C	0.25	1.19	-305	0.025	6.2	4.0	0.04*	226	14.5
+0.04	6	A	0.25	1.24	-305	0.030	6.3	4.2	0.09	220	15.5
+0.06	8	B	0.25	1.27	-320	0.051	7.5	5.3	0.14	227	19.5

*INDICATES DATA FROM COMPUTER GENERATED TIME HISTORIES

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

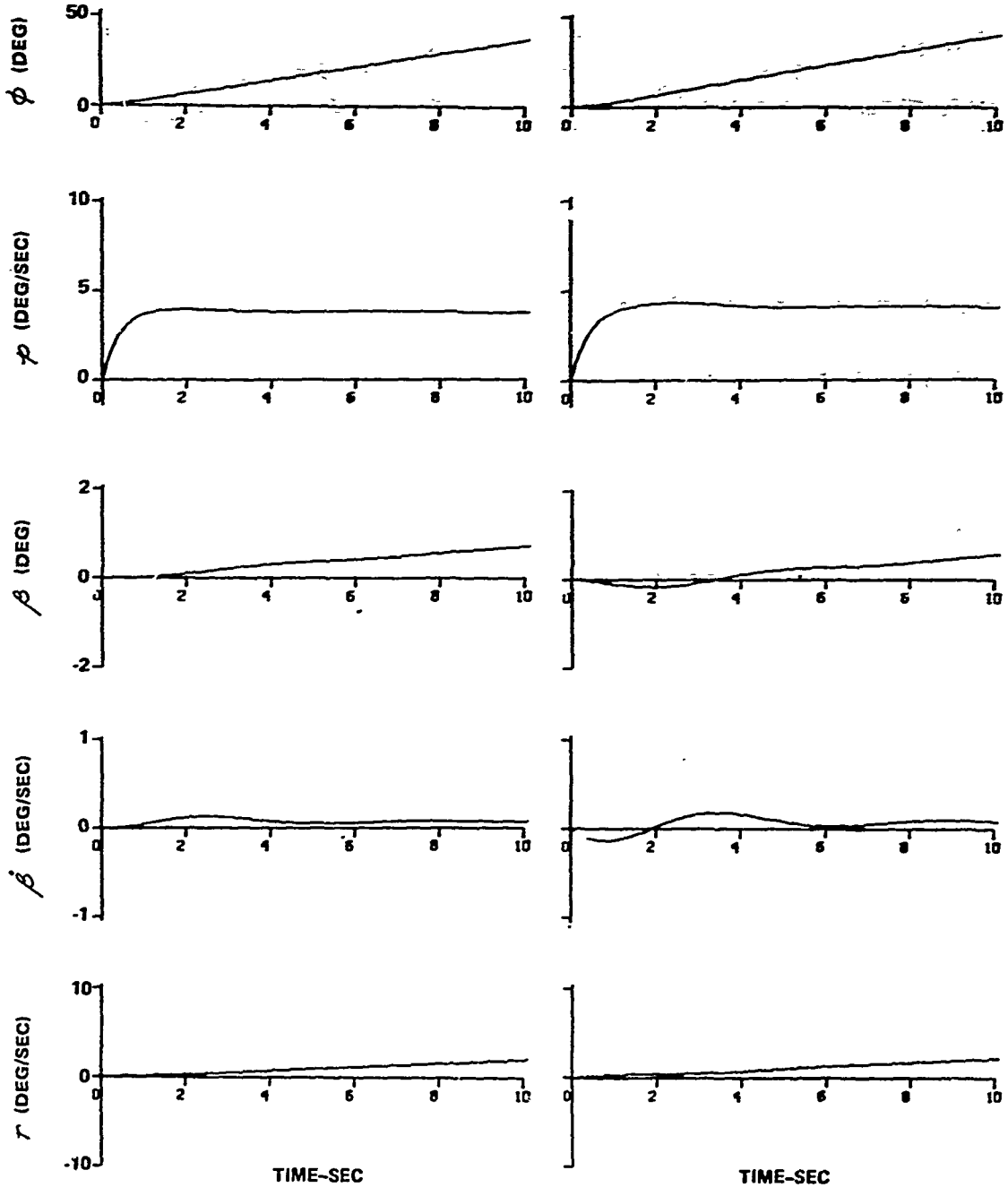
ω_d	= 1.20	N'_β	= 1.37	L'_β	= -3.49
ζ_d	= 0.23	N'_r	= -0.459	L'_r	= 0.937
τ_R	= 0.39	N'_p	= 0.0172	L'_p	= -2.51
τ_S	= 200	$\frac{g}{V}$	= 0.0586	Y_β	= -0.122
$\left\|\frac{\phi}{\beta}\right\|_d$	= 1.15	$Y_r - 1$	= -0.995	$Y_{\dot\beta}$	= -1.015
$\measuredangle \left(\frac{\phi}{\beta}\right)_d$	= 66.8	$Y_p + \alpha_o$	= 0.00343		



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.06$

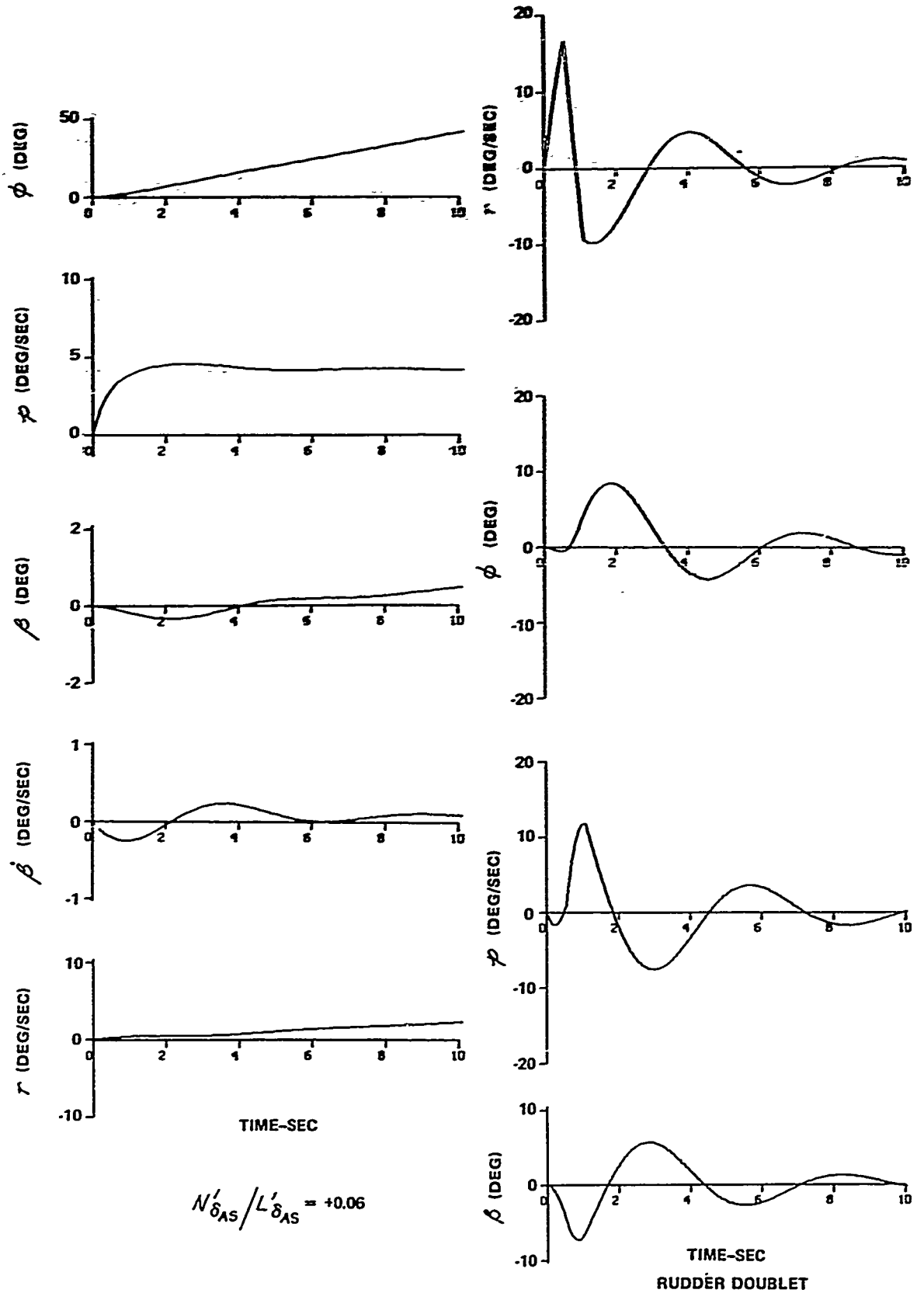
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.02$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 2



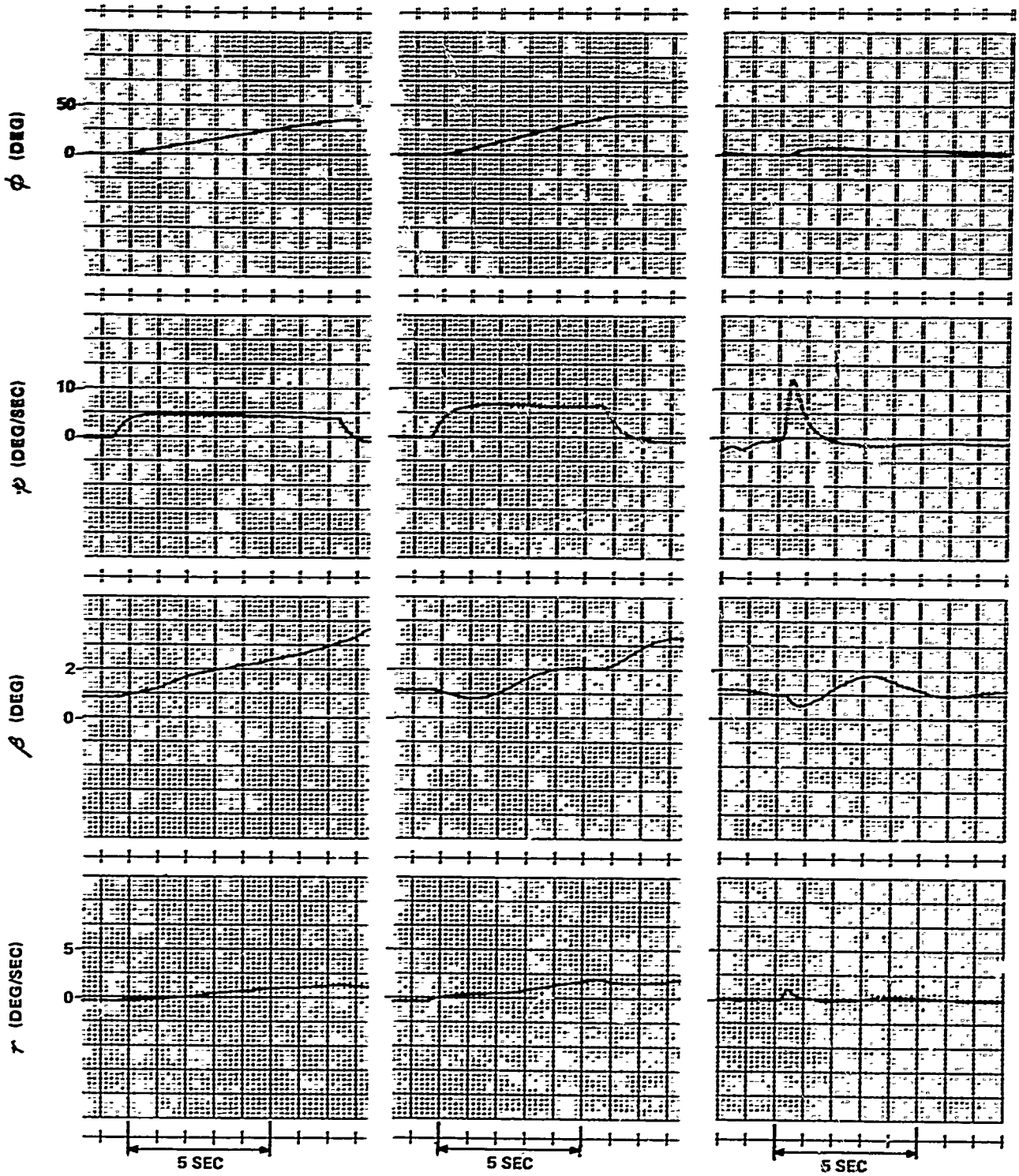
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.01$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.04$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 2



$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.06$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR CONFIGURATION 2



$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.02

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.04

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.04

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 2

CONFIGURATION 2 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.06 PILOT RATING 8.5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression was that it was going to be a really bad configuration.

ABILITY TO TRIM

Surprisingly enough it was pretty good in both lateral and directional modes, even though the directional seemed to be very slow responding. Longitudinal trim was okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 355 deg/sec^2-in. $N'_{\delta_{RP}}$ = 28.0 deg/sec^2-in.

I purposely kept the aileron sensitivity low because it was not the kind of airplane you could maneuver very rapidly and rapid maneuvers resulted in very large sideslip angles. I felt like I could easily lose control directionally if I didn't really keep at it. Primarily the aileron selection reflected the fact that it was not an airplane that I could maneuver rapidly so keeping sensitivities low was compatible with that. Rudder, it's kind of strange, I needed a lot of rudder to control the large sideslip angle that I was getting so I started out getting larger rudder forces and then found out that I easily overcontrolled the sideslip with the rudder. So, I came back down on the rudder sensitivities. The forces that I came up with really weren't heavy, but they were not as light as I would have liked them. I could not get an airplane that was maneuverable. I don't think gear ratio selection here would really have helped me much in any direction except not to go too high. So the displacements I ended up with were reasonable, they were small, the control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

The response to aileron only input was very poor. I got a large amount of sideslip and pretty close to roll reversal on the roll rate if I just put in a step input and hold it. I had a lot of sideslip, and I mean a lot in the adverse direction. When I tried to coordinate and just concentrated purely on the coordination I could do it but usually I ended up overcontrolling the sideslip. The airplane didn't seem to be oscillatory and the Dutch roll characteristics seemed to be well damped. I never really found myself in a large oscillation. Maneuvering coordination requirements were very stringent and you really couldn't maneuver the airplane very rapidly because I personally could not keep up with the sideslip disturbances that I was observing. When I tried to maneuver the airplane without concentrating purely on the sideslip I was having a problem with controllability.

BANK ANGLE CONTROLLABILITY

Ability to achieve a bank angle was good only if you got it very slowly. You can't fly the airplane aggressively.

HEADING CONTROLLABILITY

Achieving a heading is difficult because of the slow directional response and a large amount of sideslip that results from an aileron or rudder input.

BANK ANGLE COMMAND TRACKING TASK

Performance was reasonable but only because I could only go at it very, very slowly. In other words, I couldn't do the bank angle tracking task very aggressively. I had to take it very easy. And going very easily the bank angle was not oscillatory at all so I could stop the needle where I wanted to but I generated sideslip which really didn't show up very much in the roll rate so that bank angle tracking task performance probably wasn't too bad. The problems encountered with sideslip and the fact that I had to devote a fair amount of my attention to sideslip control detracted from my ability to follow the needle in bank angle very well.

RESPONSE TO DISTURBANCE INPUTS

The response to disturbance inputs, surprisingly enough, was not very significant. The sideslip and the roll rate generating by the disturbance inputs were slow and didn't even begin to compare with, in sideslip at least, those generated with the aileron inputs.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities did not degrade lateral-directional. They were good.

SUITABILITY OF THE AIRPLANE CHAPACTERISTICS FOR THE FIGHTER MISSION

These characteristics are not suitable in my estimation for the fighter mission. Particularly in the air-to-air- role you've got such large sideslip generated that it's doubtful to me that you could fly the airplane at all in an air-to-air fight. Air-to-ground similar comments. The sideslip generation is just so great that I doubt if you would hit anything.

GOOD FEATURES

The only good features I can think of is the Dutch roll characteristics. It was well damped so that you don't have a big oscillation along with all this other problems that you've got.

OBJECTIONABLE FEATURES

The primary ones that I have been complaining about all along, the large amount of adverse yaw due to aileron input, the slow directional response and my inability to coordinate the airplane without overcontrolling.

SPECIAL PILOTING TECHNIQUES

You've got to spend much, much time attacking the sideslip to keep it under control. Really not possible to lose control of this but to keep the sideslip under control.

PRIMARY REASON FOR THE PILOT RATING

There is no doubt in my mind that you cannot perform the fighter mission, or at least have an adequate performance. The deficiencies certainly require improvement. The deficiencies are certainly major. It's more than just considerable pilot compensation required to control here because you really have to stay at it and you have to almost abandon your task to jump in there to fight the sideslip. Turbulence, not much of a problem, really not too significant even though a little more effort is required.

CONFIGURATION 2 $N'_{\delta_{RS}}/L'_{\delta_{RS}} = -.02$ PILOT RATING 4.5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

The airplane seems to be a little less directionally stiff than perhaps I would like in that I can move the nose quite easily and I don't think it's just that I have selected light rudder forces. As a matter of fact, I didn't really play around with the rudder forces very much because I liked the ones that we started out with.

ABILITY TO TRIM

My ability to trim, lateral-directional trim, it's good, but it's not outstanding. But, I have no trouble trimming up the wings or keeping the airplane trimmed directionally. More trouble with the longitudinal trim than I did with the lateral trim, but again, that's not bad and it's not something that's detracting from my evaluation here.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{RS}} = 305\ deg/sec^2\text{-in.}$ $N'_{\delta_{RS}} = 19.5\ deg/sec^2\text{-in.}$

I have nice light ailerons. There's no compromise that I've made here, in other words I haven't selected lighter or heavier ailerons than what I think that I'd like to have purely as a personal preference because of some of the airplane dynamics. In other words aileron selection is again based purely on what I would like and not, I believe on some peculiar dynamic characteristics of the airplane. If anything, I have selected them too light and I find that I tend to couple, I think, with the Dutch roll a little bit and get an additional oscillation superimposed on what looks like a normal Dutch roll because every little movement of my hand shows up as an aileron input and it's distracting at first, although I'm getting better at it now. I don't seem to be doing it quite so bad as I was before. But if anything on the aileron gearing selection, it's a little high. Now the rudder pedals are light, but I find that I need that because I find myself working the rudder a fair amount while I'm maneuvering the airplane because sideslip for some reason was very easy to excite and I'd find that I'd have to work my feet a fair amount to work the sideslip back to the center.

AIRPLANE RESPONSE TO PILOT INPUTS

When I put in an aileron-only input without the rudder, the sideslip stays pretty close to zero for the initial roll input and then takes off in the adverse direction. It looks like to me, if I have to put that in terms for you, if the yaw due to aileron is either zero or a little bit proverse followed by adverse yaw due to roll. So that, initially, I find that there's no requirement for coordination, however as the airplane rolls up then there seems to be a little bit of an increase in requirement to coordinate the sideslip. I find it very easy to overcontrol the sideslip and force it in the opposite direction. Looking at the airplane in the steady turn, it looks like a little rudder is required to keep the sideslip near zero, but not very much at all, as a matter of fact, not enough to get concerned about. So the coordination problem isn't as easy as I would like to see and the requirement for having to feed in rudder which looks a little bit like a function of roll rate, I find, not the greatest.

BANK ANGLE CONTROLLABILITY

As far as my ability to roll the airplane and stop at a bank angle, I played it up quite a bit and I'm really very good at it as a matter of fact. I can stop right where I want to in roll and not really excite an awful lot of Dutch roll, although if I don't keep up with it with my feet, then I tend to get the sideslip excitations in the Dutch roll, but as far as the roll and being able to stop the airplane at a given bank angle, it's really very good. As a matter of fact the roll rate itself is very smooth and I see very little Dutch roll superimposed in the roll characteristics.

HEADING CONTROLLABILITY

So the bank angle is no problem, but to coordinate it is a bit of a problem and consequently rolling out and stopping the thing right on the heading, I tend to get a nose wander around the particular heading that I'm after.

BANK ANGLE COMMAND TRACKING TASK

I'd like to say that I thought the performance was pretty good and I could stop the needle right where I wanted to, didn't really have any problems with it. So I'm really in a little bit of a dilemma here. I find that my bank angle control is very good. I think from what I've seen, but my sideslip control is not quite so good and that's what is giving me problems at the moment. If I try to fly the airplane without coordinating at all, the sideslip really gets out of hand. Not that it's dangerous or anything, it's just that it's back and forth – the nose is moving back and forth sufficiently enough that I don't believe I could hit the target very well with this. If I coordinate even for the rapid maneuvers and concentrate on it a little bit, I seem to be able to keep the sideslip quite small.

RESPONSE TO DISTURBANCE INPUTS

The airplane is considerably more difficult to fly in turbulence or in the random disturbance than it was without and this is particularly noticeable in the directional response. I find that quite a bit of sideslip was excited during the turbulence, and a requirement for getting into the loop with the rudder to take the sideslip out.

LONGITUDINAL CHARACTERISTICS

I noticed another thing on tracking, it's the first time I think I've seen an airplane where I have a longitudinal-lateral frequency mismatch where the longitudinal is pretty fast and if anything, I tend to bobble about the target, while on the lateral, the airplane tends to kind of move slowly, kind of just slide from one spot to the other, and it's very interesting to watch. Again, that hasn't been a problem for me.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I will say that it's certainly not satisfactory the way it is now and primarily because of the large sideslip response.

GOOD FEATURES

I think the bank angle or roll control is really quite good. My ability to roll to and establish and hold a given bank angle, I think is excellent. And also my ability to perform the tracking task is likewise quite good.

OBJECTIONABLE FEATURES

Primary objection is the inability to control the sideslip as well as I would like and the fact that when I stop the airplane somewhere, the nose wants to very slowly move off from where I wanted it to be, and oscillate maybe one or two times through the heading that I had hoped to achieve. I find that if I maneuver the airplane rapidly without coordinating, sideslip disturbances are quite large and if I coordinate, I can keep the sideslip disturbances down, but I have to spend more time working at the coordination than I would like to. The sideslip disturbance in the presence of the random disturbances is also quite large and a bit difficult to handle.

SPECIAL PILOTING TECHNIQUES

You've got to stay in the loop with your feet most of the time in order to control the sideslip and if you forget then the airplane wants to set up fairly large sideslip angles.

PRIMARY REASON FOR THE PILOT RATING

I think if I stay in there with my feet I can very definitely get an adequate performance so that I'm talking about a mid-range rated airplane and I think that the characteristics that I've seen are more than just minor. The redeeming feature, of course being the excellent roll control and the detraction being the large sideslip oscillation that I see. Although I seem to be able to get the airplane back to center quite easily with my feet so that the airplane doesn't oscillate around very much, the deficiencies that I see are more than just minor. The fact that I can get the sideslip under control with my feet and do it fairly rapidly is not enough to make it much worse than that. There certainly is more effort required flying the airplane in the presence of the random disturbances and I think there's certainly a moderate deterioration in my ability to perform the fighter mission.

CONFIGURATION 2 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +.01$ PILOT RATING 4.5 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression of this particular configuration was that it wasn't quite as good as I would like to have seen because I was having some difficulty controlling the sideslip.

ABILITY TO TRIM

My ability to trim was quite good, laterally and directionally and longitudinally, it was okay. No real problem longitudinally but just not quite as good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 226$ deg/sec^2-in. $N'_{\delta_{RP}} = 14.5$ deg/sec^2-in.

The ailerons, I think I selected relatively light, maybe not quite as light as I would like, so that I could feel that I was having to put in a little force with the aileron and I prefer really just to look at the airplane and kind of make the airplane go the way I want it to go just by sensing an input in that direction, not really having to feel that I'm having to roll the airplane and put in an input. So perhaps that was a little bit of a compromise, but not very much. Okay, the forces are light and comfortable. On the rudder, I started out with lighter rudders than perhaps was necessary and had the safety pilot, later, increase the rudder forces because I was having not very much success with controlling the sideslip. And I was tending to overcontrol the sideslip during rapid rolls and roll reversals and I cut down the rudder sensitivity a little bit. It got a little better but I never really got very good at controlling the sideslip. So the forces on the rudder were comfortable. Displacements in all three axes were quite small and the harmony of the controls with the longitudinal were pretty good.

AIRPLANE RESPONSE TO PILOT INPUTS

The sideslip response seemed to be relatively slow and didn't always go as rapidly with the aileron inputs as I thought it might have done. It seemed to lag behind a bit. I did notice that when I coordinated the airplane in a normal manner, I invariably ended up with a fair amount of sideslip into the turn indicating that I was holding too much rudder into the turn. So that the coordination was a bit difficult. I could never get to the point where I could make a nice smooth coordinated turn without generating sideslip in one direction or the other. The sideslip was a bit oscillatory and never really seemed to just consistently go in one direction so that it was requiring a little bit of rudder manipulation in addition to what I was doing with the aileron control. So that in maneuvering the airplane, I never really could keep the thing perfectly coordinated and I found that there was a little bit of a requirement for rudder reversals, but they seemed to be very slow and uncoupled somewhat from aileron inputs.

BANK ANGLE CONTROLLABILITY

My roll control seemed to be smooth and I could roll the airplane and stop at a bank angle reasonably well.

HEADING CONTROLLABILITY

A little bit of a problem with the heading control here. Even after I've gotten the bank angle stopped, I still had the sideslip problem, which I never was really able to coordinate to my satisfaction and I'd get a slight nose wander out of the airplane, so it wasn't always pointed at exactly the spot that I would like. And I think this is a real detriment to the fighter mission, particularly if we're including the firing of guns, because it's very difficult to hit something if you can't keep the airplane pointed in the direction that you want.

BANK ANGLE COMMAND TRACKING TASK

The bank angle tracking task seemed to be relatively easy. Again, I didn't control the sideslip as well as I would like, but no problem centering the needle, no oscillatory characteristics in roll, that made the needle wander off one way or the other so that I thought my bank angle tracking task was good and I didn't really encounter any problems.

RESPONSE TO DISTURBANCE INPUTS

The response to the disturbance inputs were really not significant, no more than I would have expected for the fighter mission, and really didn't seem to create any problems that I hadn't seen before. A little bit more sideslip wander than I would like but that really wasn't tied very directly to the random disturbance inputs.

LONGITUDINAL CHARACTERISTICS

Longitudinal characteristics were in harmony with the lateral-directional and did not interfere or degrade the lateral-directional handling qualities.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I find that I don't think they are satisfactory as they are and primarily because when I roll the airplane and try to stop it on a given target, the nose wants to wander a bit more in sideslip than I would like and would much prefer it to have the nose stop right on the target. Attacking ground targets, when you roll in and try to stop the airplane, you've got this noticeable sideslip disturbance. Now these are not wild things, they're just things that are disconcerting and it moves off just enough that I think it would reduce my accuracy. So that as far as both air-to-air and the air-to-ground role is concerned, the biggest problem again is this sideslip wander that I see and not the bank angle control.

GOOD FEATURES

I like the roll control and I like the fact that I can stop on a given bank angle with ease. I like the fact that the sideslip disturbances that I see don't seem to show up very much in roll so the bank angle control is good. I like the fact that I could pick light forces on the airplane and that I can move the airplane quite rapidly without creating any problems in roll.

OBJECTIONABLE FEATURES

There's only one and it's more than just a minor objection and it's primarily my inability to coordinate the airplane as well as I would like. The fact that I never really could aggressively fly the airplane in roll and keep the sideslip zero and the fact that I had to make a conscientious effort once I had started a maneuver to zero out the sideslip and then when I had completed, say a bank angle change or a bank angle reversal, and established an attitude that I want, that the nose would wander a bit away.

SPECIAL PILOTING TECHNIQUES

The airplane does require a bit more thought on the rudders than I would like to see and you have to pay attention to the sideslip to keep it near zero.

PRIMARY REASON FOR THE PILOT RATING

I do not feel the airplane is satisfactory without improvement. I do feel that it's acceptable, however and that the deficiencies that I see are at least moderate, particularly in sideslip and that I think you have to put a lot more pilot compensation into it than I would like, although it's only a moderate compensation. The deficiency is more than just minor, but the pilot compensation required is only moderate. As far as the turbulence is concerned, there is a bit more effort required to keep the airplane on an even keel, but really only a minor deterioration in my ability to perform the mission.

CONFIGURATION 2 $N'_{\delta_{RS}}/L'_{\delta_{RS}}$ = 40.04 PILOT RATING 6 TURBULENCE RATING A

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression on that was that it wasn't going to be really too bad. It seemed to have a lot of sideslip associated with it, but the sideslip kind of looked like it was wandering all around, pretty much on its own. I first flew the airplane without a lot of aggression, it wasn't too much of a problem, I could take my time and get the sideslip back to the center. However, when I got to the point where I was flying the airplane more aggressively the sideslip apparently created some problem in the roll.

ABILITY TO TRIM

Ability to trim, laterally and directionally was good. Longitudinally was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{RS}}$ = 220 deg/sec^2-in. $N'_{\delta_{RP}}$ = 15.5 deg/sec^2-in.

There seemed to be quite a bit of proverse yaw associated with an aileron input. I increased the sensitivity and ended up in overcontrol problems in roll so that I selected a sensitivity that was a little heavier than I would like and probably not as sensitive as I have been selecting. There was not really much of a compromise. I left the rudder sensitivity pretty much where it was, I thought that that was good. I had a problem with large sideslip angles that were generated so that a noticeable amount of rudder was required to get the sideslip needle back in the center, but the selection that I started out with I thought was comfortable. The displacements on both roll and yaw channels were good. Control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

An aileron only input produced quite a bit of proverse yaw however, it didn't seem to affect the roll very much. The roll appeared to be quite smooth. Coordinating the sideslip required cross controlling with the rudder. Oscillatory characteristics, the Dutch roll seemed to be well damped. Didn't seem to have any Dutch roll oscillation however, there did seem to be a pilot induced airplane oscillation when tracking in bank angle tightly. This was more noticeable, the more aggressively I went at it. As far as maneuvering coordination requirements are concerned, it's interesting, you do have to end up paying attention to the sideslip, but not so much to make the airplane do what you want to do, but just to take out what I am calling the wandering sideslip that I see, so you end up spending a lot more time on sideslip control than I think is absolutely necessary, but it didn't seem to be creating very much of a problem to me in the bank angle control.

BANK ANGLE CONTROLLABILITY

Ability to achieve desired bank angle is quite a bit of function of how aggressively one wishes to attempt bank angle control. Flying the airplane slowly and smoothly it's pretty good, but when you go at it any more aggressively there is a quite noticeable tendency to overshoot and I had one or two cycle oscillation about the bank angle, so my bank angle control is not as good as I would like it to be.

HEADING CONTROLLABILITY

The heading control was also a bit of a problem because of the large sideslip that was generated. When you look up at the nose it is kind of wandering back and forth. I think that this is quite disconcerting and I think it detracts considerably from the fighter mission.

BANK ANGLE COMMAND TRACKING TASK

I thought my performance only fair. Again, the tendency I noted about overcontrolling, overshooting in bank angle applies, and it was taking me one or two cycle oscillations to settle down. I lost quite a bit of time looking at the bank angle tracking task because it seemed to be a major factor in this particular configuration.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs was barely noticeable. I don't think there was any significant effect on my performance, no more effort required than flying without turbulence.

LONGITUDINAL CHARACTERISTICS

The longitudinal handling qualities were good. They didn't detract or degrade from the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I'm willing to say that it is marginally acceptable. If you calm down your inputs you can get your bank angle control to what I think is a reasonable performance, however, when you go at it in an aggressive manner, there is a very strong tendency for your bank angle to be quite poor. In the air-to-air mission, I put quite a lot of emphasis on being able to control bank angle with precision and I think my precision is reduced here, although I think I'm willing to say that it probably can be done. Another thing that detracts from the air-to-air mission are these slow sideslip responses and the fact that large sideslip angles are generated and the pilot has to spend more time than I think is desirable putting the sideslip needle back in the center. I don't think there is any problem getting to such a large degree that the pilot will begin to lose control in sideslip because it happens so slowly, it's just a matter of realizing that the airplane is sideslipping out in one direction and make a conscientious effort in getting it back. On the air-to-ground mode, I think the slow sideslip would also be detrimental to what you are trying to do and I think it really would degrade your performance in the air-to-ground mode.

GOOD FEATURES

I like the roll performance, you could roll the airplane quite nicely.

OBJECTIONABLE FEATURES

The large sideslip angles you generate I think is the primary objection and the second objection, if not equally as strong, is the tendency to overcontrol and overshoot in bank angle when you track bank angle quite tightly.

SPECIAL PILOTING TECHNIQUES

If you wish to coordinate this configuration and keep it coordinated through a continuous rolling maneuver it would require opposite rudder initially and not much rudder in the other direction, but in a steady turn I noticed that I ended up using a little bit of rudder into the turn. Other than the cross control I really don't think there is an acceptable way to fly the airplane but I think that is what you would have to do.

PRIMARY REASON FOR THE PILOT RATING

The deficiencies I see are quite objectionable, certainly very objectionable. I do have to compromise my performance a bit and I interpret that as extensive pilot compensation. I'd worry a little bit about the slow sideslip response and I worry about the bank angle overcontrol.

CONFIGURATION 2 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.06 PILOT RATING 8 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression was that it was going to be a bad configuration and that held throughout. The most obvious thing about the configuration was the extreme amount of proverse sideslip that accompanied any aileron input and it was really quite large, it created a number of problems.

ABILITY TO TRIM

Lateral-directional was okay in both modes. In longitudinal it was likewise okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 227 deg/sec^2-in. $N'_{\delta_{RP}}$ = 19.5 deg/sec^2-in.

To be honest I took what I started out with on the aileron and the rudder because they are comfortable, heavy a bit, but it was a configuration where you didn't really want to go up on the gearing because I was generating what I thought were quite large sideslip angles. It was also a configuration which I couldn't fly very aggressively and did not tend to fly it aggressively because of these large sideslip angles. So even though I haven't had a good look at all the other possibilities I'd say that there is a compromise on the aileron, I couldn't have it as light as I wanted because of the very large sideslip generated. The rudders were about right, if I made nice slow inputs and concentrated on putting the rudder in the opposite direction, I could control the sideslip with the rudder forces and rudder sensitivities that I had quite well. So the forces were moderate, they weren't really heavy, nor were they light. But the control harmony that I had between the controls was good and displacements were good also.

AIRPLANE RESPONSE TO PILOT INPUTS

Quite large sideslip angles generated in the proverse direction with the aileron only inputs. It's a slow responding airplane so that the sideslip wanted to persist a little bit. The sideslip generated was so large that it took you a while to get it back to zero. I wouldn't really consider it an oscillatory configuration because the sideslip response which was the major response here tended to be very slow and I could keep up with it. Coordination requirements were all in the wrong direction, very difficult to do and I couldn't do it unless I made a conscientious effort and thought about what I was doing. Just for driving around and general type maneuvering - if anything I tended to increase the sideslip rather than reduce it.

BANK ANGLE CONTROLLABILITY

Bank angle controllability was only fair, if you tried to do anything aggressively and you could keep the sideslip under control, then you overshot on the bank angle so I ended up flying the airplane at quite a bit less than I think is an adequate performance for a fighter and that was the only way I could do a reasonable bank angle task. My bank angle controllability, using aggressive inputs was poor.

HEADING CONTROLLABILITY

Heading control was very poor, the sideslips generated were quite large and the wrong direction to coordinate very well, so I ended up having quite a bit of difficulty getting the airplane pointed in the direction I wanted it to go.

BANK ANGLE COMMAND TRACKING TASK

Performance was only fair - again I could not perform the task aggressively so that even though I was keeping the sideslip needle pretty much near the center, the amount of time it was taking me to get back to center was excessive. During the tracking task the sideslip got away from me and I had to spend a lot of time working on the sideslip and occasionally the bank angle would creep off so that the command tracking task performance was really not very good.

RESPONSE TO DISTURBANCE INPUTS

The airplane really didn't have much of a turbulence response- it really wasn't a factor. I'm going to say that there is a minimal effort required but really no significant deterioration in my ability to do the task, which was already poor. The major response in disturbance inputs was in the sideslip and mostly a low frequency type buildup of sideslip.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were okay and they didn't detract or degrade the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I do not feel that these characteristics are suitable, the sideslip response is much too large and much too slow. The fact that you can't maneuver the airplane aggressively I think really detracts from my ability to do the fighter mission. In the air-to-air role, quite large rapid inputs are required, probably more so than in the ground attack mode, so that I think you would have a more difficult problem in the air-to-air tracking maneuver simply because of the large bank angle changes required and the rapidity at which these things have to be accomplished. Air-to-ground you might be able to do a little better simply because you are going at things a little slower.

GOOD FEATURES

There are really no outstanding good features. Fortunately the airplane seemed to be damped enough so that I didn't end up with continuous sideslip oscillation.

OBJECTIONABLE FEATURES

The outstanding objection is the quite large proverse sideslip generated in the aileron control inputs. The fact that these sideslips generated are so large, it cuts down my ability to maneuver the airplane aggressively without overcontrolling or losing control in the sideslip direction. You spend so much time controlling the sideslip, which is first of all in the proverse direction, that you can't control your bank angle simply because you can't divert your attention to it.

SPECIAL PILOTING TECHNIQUES

You have to fly the airplane in what I think would be considered a low gain and to coordinate the machine takes quite a bit of rudder in the opposite direction to an aileron input, a difficult input for me to do consistently. The only way I could do it was to do it conscientiously and slowly.

PRIMARY REASON FOR THE PILOT RATING

I think that the airplane is not acceptable. I don't think adequate performance is attainable. I think we are getting into the point on the sideslip where control is getting to be a bit of a problem because if you are really doing it aggressively, you can generate quite large sideslip angles and quite a bit of compensation is required to control the sideslip.

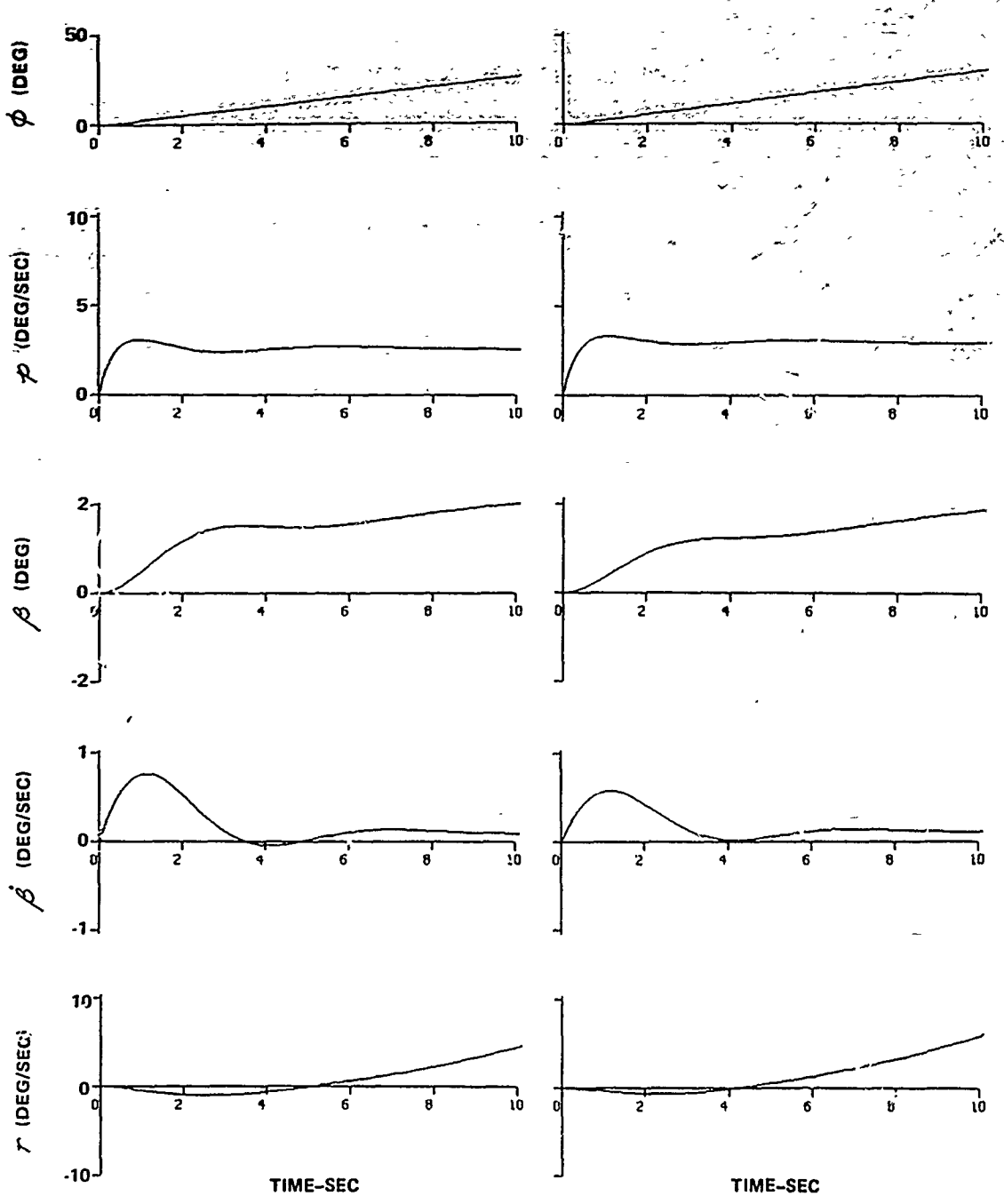
CONFIGURATION 3 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}} / L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	Ψ'_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/\epsilon$ LEVEL 1	$\Delta\beta_{max}/\epsilon$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_i}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.14	8	C	0.41	0.964	-175	0.06	57.0	42.3	0.29*	182	25.0
-0.10	7	A	0.42	1.03	-225	0.01	44.0	31.0	0.21	240	25.0
-0.05	5	A	0.44	1.10	-225	0.0	22.0	15.4	0.09	250	20.5
+0.02	4.5	A	0.46	1.20	-325	0.01	7.4	5.0	0.07	266	19.5
+0.10	8	A	0.48	1.31	-355	0.04	18.0	10.6	0.14	272	22.5

*INDICATES DATA FROM COMPUTER GENERATED TIME HISTORIES

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

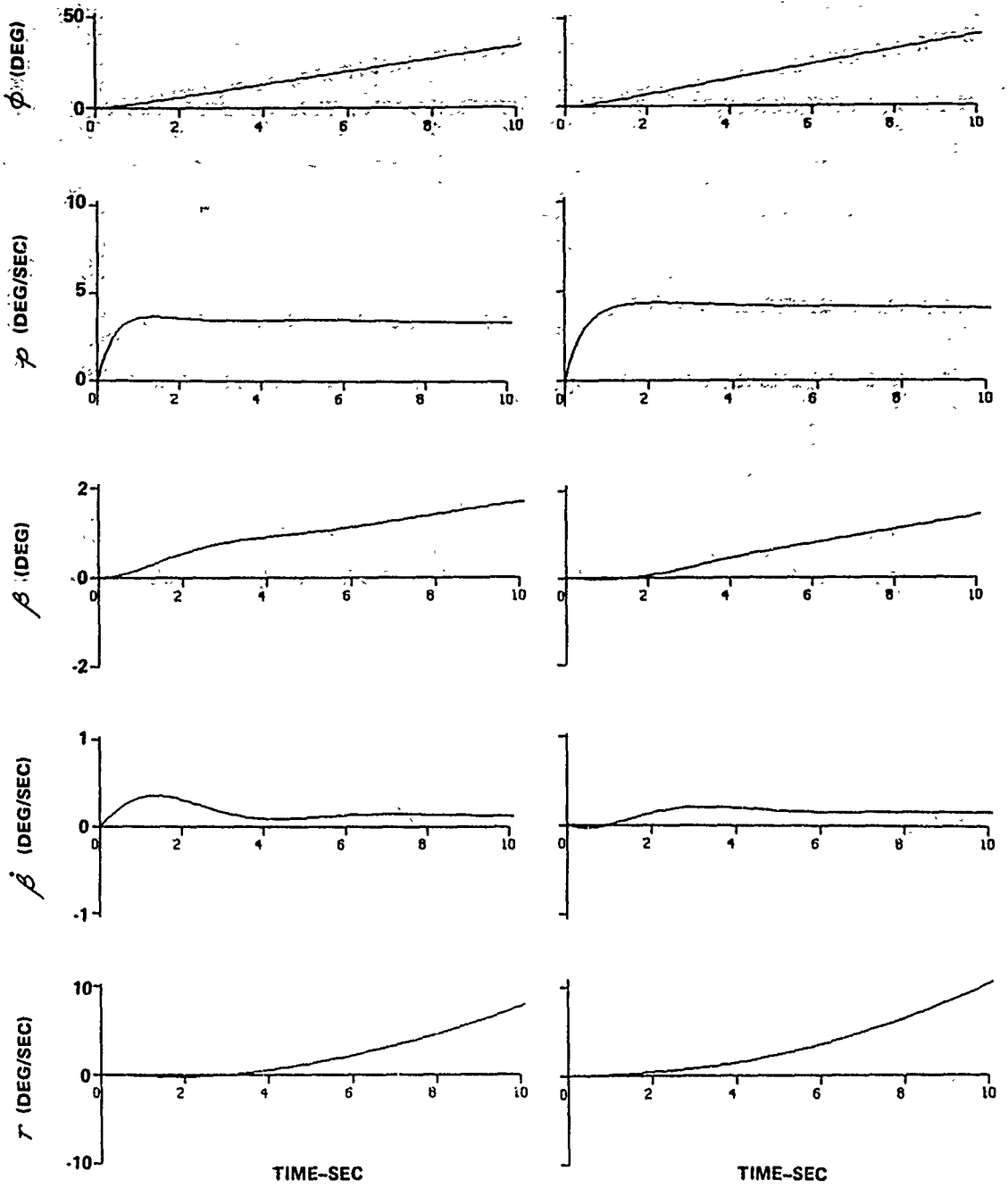
ω_d =	1.18	N'_β =	1.25	L'_β =	-3.10
ζ_d =	0.43	N'_r =	-0.910	L'_r =	-1.86
τ_R =	0.42	N'_p =	-0.0026	L'_p =	-2.38
τ_s =	115	$\frac{g}{V}$ =	0.0586	Y_β =	-0.119
$\left\|\frac{\phi}{\beta}\right\|_d$ =	1.20	$Y_r - 1$ =	-0.990	$Y_{\dot\beta}$ =	-1.015
$\angle\left(\frac{\phi}{\beta}\right)_d$ =	73.7	$Y_p + \alpha_o$ =	0.0214		



$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.14$

$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.10$

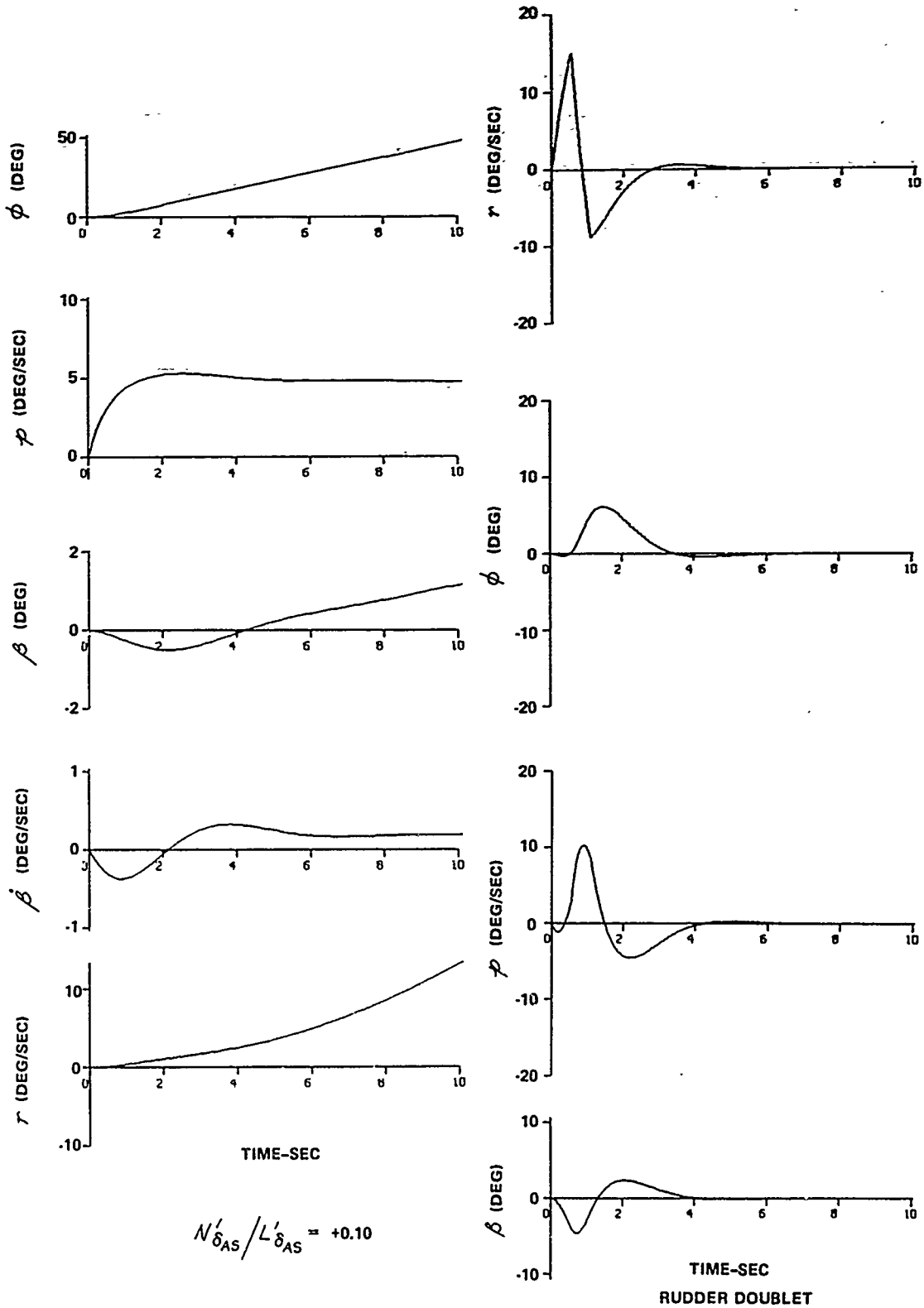
COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 3



$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.05$

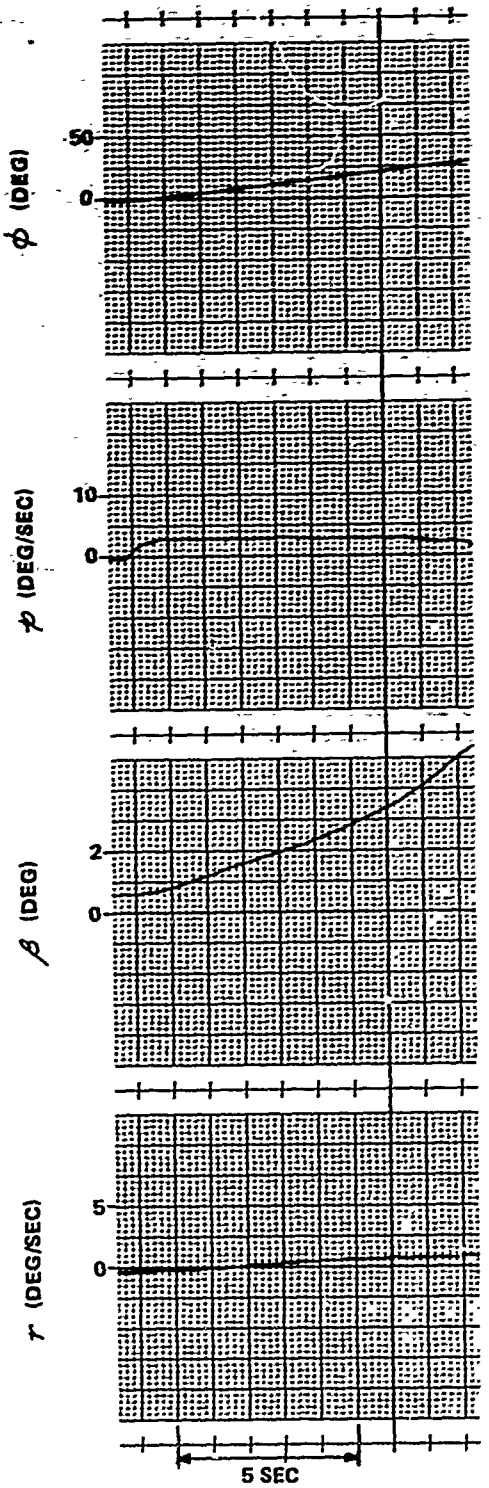
$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.02$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 3



$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.10$

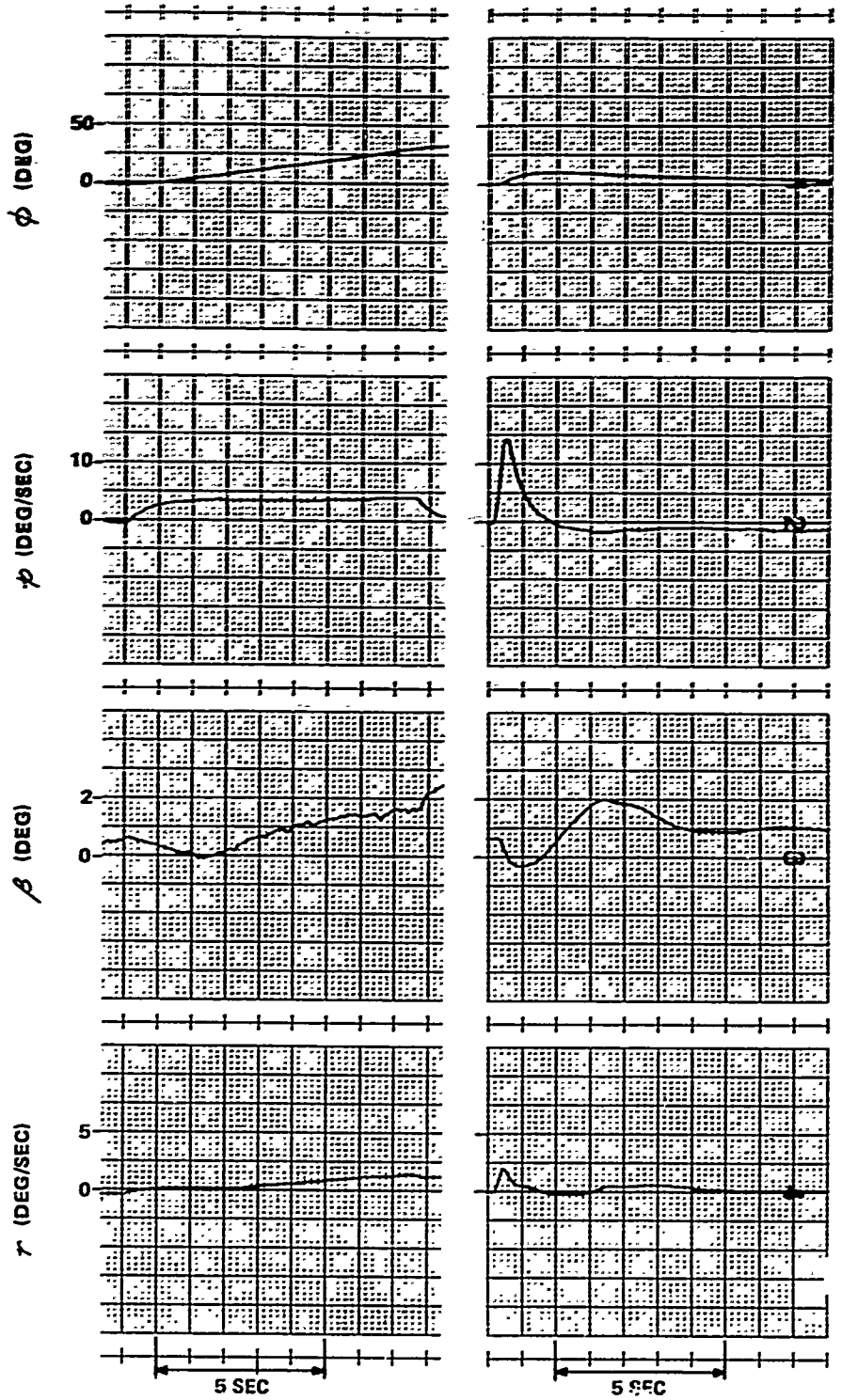
COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR CONFIGURATION 3



$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.05$

AILERON STEP INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 3



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.10$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.10$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 3

CONFIGURATION 3 $N'_{\delta_{RS}}/L'_{\delta_{RS}} = -0.14$ PILOT RATING 8 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression was also my final impression, it really was bad.

ABILITY TO TRIM

Lateral is good. Directional not as good, but even though there seemed to be a relatively low frequency Dutch roll it seemed to be damped and I could get the sideslip trimmed and the airplane would hold it. The trim capability was pretty good. Longitudinal was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$$L'_{\delta_{RS}} = 182 \text{ deg/sec}^2\text{-in.} \qquad N'_{\delta_{RS}} = 25.0 \text{ deg/sec}^2\text{-in.}$$

There were some compromises made in this. There was quite a bit of sideslip generated on aileron input, so that I had to come up on the rudder sensitivity to make the rudder lighter than perhaps I would have normally liked. I started out coming up on the rudder, and I found that I was overcontrolling the airplane quite a bit in sideslip. Somewhere I reached a compromise that gave me light enough rudder to control a large amount of sideslip that occurred anytime I put in an aileron input and heavy enough so that I didn't overcontrol every time. The aileron, I was definitely not able to put in as large as I liked because of the large sideslips generated so that somewhere in there I got a reasonable balance at least enough to fly the airplane. The aileron force is really not so heavy, but they are not as light as I would like. Displacements were reasonable with the forces that I had. Harmony of controls, still no problem.

AIRPLANE RESPONSE TO PILOT INPUTS

With an aileron only input, you generate a lot of sideslip in the adverse direction. It also appears to me that it cuts down the roll rate that i am expecting but it's over such a long period of time that it's not too noticeable. When I coordinate the aileron with the rudder I can do better, but I never could coordinate very well. There really doesn't seem to be much of an oscillation. It seems the airplane just wants to go out there and slowly come back. Maneuvering coordination requirements are quite severe, you have to spend most of your time operating on the sideslip with the rudder pedals.

BANK ANGLE CONTROLLABILITY

The large sideslip that I saw didn't really seem to carry over into the bank angle very much but I had to spend so much time coming back to the sideslip trying to control it with my feet that my ability to achieve a bank angle wasn't very good.

HEADING CONTROLLABILITY

My ability to achieve a heading was extremely poor. The airplane, once you got it rolled out would have this very slow oscillation back to center and was very slow coming back to a given heading.

BANK ANGLE COMMAND TRACKING TASK

My performance was really bad because I didn't realize until I went to the bank angle tracking task how much I was relying on the sideslip indicator and I had to keep the sideslip within even sufficient bounds to keep from dumping the system. Once I lost the sideslip indicator during the tracking task,I dumped the airplane a number of times on sideslip. So that my major problems are associated with the bank angle tracking task. Not so much that I couldn't control the airplane laterally but because I couldn't control the airplane directionally.

RESPONSE TO DISTURBANCE INPUTS

Disturbance inputs really weren't too severe. It does excite this low frequency Dutch roll and I find that I spend an over abundance of time using the rudder trying to keep the sideslip somewhere near the center.

LONGITUDINAL CHARACTERISTICS

Longitudinal characteristics were good, about the best thing about the configuration.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

For the fighter mission the characteristics were completely unacceptable and I think we are getting into controllability problems on the directional stability of this configuration. I don't think that it's satisfactory for the air-to-air or the air-to-ground mission primarily because I cannot control the direction of the airplane. It is the major problem with the airplane. The large sideslips generated, my inability to coordinate the sideslip very well, and my tendency to over-coordinate.

GOOD FEATURES

The large sideslip disturbances that I saw were not oscillatory but were damped. The longitudinal was one of the best features. The sideslip disturbances did not carry over into the bank angle controllability.

OBJECTIONABLE FEATURES

The strongest objection of course is the large amount of sideslip generated with any aileron stick input and the inability on my part to coordinate this and the fact that you have to spend an inordinate amount of time controlling the sideslip so that you really couldn't perform the fighter mission.

SPECIAL PILOTING TECHNIQUES

Sideslip becomes the dominant factor in the control and in this configuration we found that you really can't accomplish the mission because you spend more time working on controllability.

PRIMARY REASON FOR THE PILOT RATING

I do not feel that adequate performance is attainable no matter how hard I worked at it and I think that considerable pilot compensation is required and I would say that this is a major deficiency. Turbulence really didn't increase the efforts very much. The roll didn't seem to be disturbed too much by the turbulence. I would say that more effort is required but the deterioration in my already poor performance was only minor.

CONFIGURATION 3 $N'_{\delta_{RS}}/L'_{\delta_{RS}} = -0.10$ PILOT RATING 7 TURBULENCE RATING A

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression of this one is that it's really not very good at all. There are large sideslips generated, anytime you put in an aileron input, and one fortunate thing is they are in the adverse direction so you can at least coordinate in the proper direction and try to keep the sideslip somewhere near a small amount. When I think I've got a bank angle established, and I think I've got the sideslip under control, it slowly moves off in the other direction, or in one direction or the other, it is very difficult for me to control. This airplane seems to have very small directional stiffness and consequently the airplane just wants to drift one way or the other, it kind of slides first in one direction and then the other and it's kind of touchy on the rudder control to get the thing back to center. So, that's my initial impression.

ABILITY TO TRIM

Ability to trim laterally is pretty good, directionally is not as good as it is laterally. Small trim changes cause fairly large sideslip changes. You have to be very ginger with directional trim in order to get the sideslip trimmed up to zero. Once you get it there and as long as you are in smooth air, it's no problem. Longitudinal is okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{LS}} = 240$ deg/sec^2-in. $N'_{\delta_{RP}} = 25.0$ deg/sec^2-in.

I tended to select a slightly heavier gearing than perhaps I would have liked because the less sensitivity on the ailerons tended to cut down the amount of sideslip that was generated and I think in general I tended not to maneuver the airplane as rapidly as I think is necessary for the fighter mission because of that. But, even at that, the forces were reasonable, they were still light. Rudder pedal - I worked with that because I needed a lot of rudder to control the large sideslip angles I was seeing, but when I got the rudder sensitivity too light there was a strong tendency to overcontrol about the neutral point, so that there was a compromise there I needed what I thought were high sensitivities to help me control the large sideslips generated by the aileron but I needed lesser sensitivity to be able to control the sideslip for small angles about the zero sideslip condition. So I guess you might say there is a compromise in both axes. The forces on the rudder were light enough to be comfortable. Displacements were noticeable because it's a lot of rudder required but they were still not unsatisfactory. Harmony of control in general was okay.

AIRPLANE RESPONSE TO PILOT INPUTS

When I put in my aileron without the rudder, I can very definitely see a reduced roll rate and a very large amount of adverse yaw created. The sideslip is not something that is rapid and abrupt,it's very slow but again that's something that I coordinate very well. When I coordinate the airplane, the roll response is smooth even with the uncoordinated aileron inputs, the roll rate is smooth, I don't see any oscillatory characteristic there or anything that I noticed in the time span that I put the inputs in. The airplane seems to be quite well damped in the Dutch roll, so that the sideslip responses and the Dutch roll response that I see is really not of an oscillatory character, more of a slow sliding maneuver and there seems to be a relatively low roll to sideslip. The sideslip doesn't show up excessively in the roll. The maneuvering coordination requirements are quite stringent. You've got to discipline yourself to put in the amount of rudder every time you put in an aileron input and you have to continually come back to sideslip to see that you haven't overcontrolled in the other direction. So to fly this airplane you really have to pay attention to the ball or the sideslip needle or the string. At le st I do, I have to have some indication of sideslip or you can very easily build up quite a large sideslip angle.

BANK ANGLE CONTROLLABILITY

Bank angle capability is pretty good. I think primarily because the sideslip does not tend to affect the roll very much.

HEADING CONTROLLABILITY

Getting a heading is another problem, when you roll out you have to make a conscientious effort to use your feet to zero the sideslip and get the airplane pointed in the direction you wish to go. So that heading control is quite poor.

BANK ANGLE COMMAND TRACKING TASK

I thought my performance was at least good, nothing outstanding I think partly because I tended to maneuver the airplane less aggressively than I like to do and the reason I was doing that of course is to preclude building up the very large sideslip disturbances that accompany an aileron input. Sideslip was still a problem here, but my ability to roll to and stop at a bank angle didn't seem to be too degraded.

RESPONSE TO DISTURBANCE INPUTS

The response to disturbance inputs seemed to be quite low in all axes, as a matter of fact, really no significant deterioration in what I was attempting to do.

LONGITUDINAL CHARACTERISTICS

No comments.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they are unacceptable because of the extremely large sideslip angles that are generated and the very slow response of the thing which I think degrades my ability to get the sideslip zeroed. I think I have to spend too much time working the rudders to keep the sideslip somewhere near center and you have to consequently devote time to that that should be devoted to other facets of the mission. It was extremely poor for tracking ground targets and you are continually working the rudder and the airplane responds so slowly that I wandered about the target quite a bit before I ever got settled on. I think it's also unacceptable for the air-to-ground.

GOOD FEATURES

I think there are really no outstanding good features and roll control isn't too bad and the only reason it isn't too bad is because the roll to sideslip ratio. These large sideslip angles that I've seen do not spill over into the roll control.

OBJECTIONABLE FEATURES

Primary objection is the very sloppy directional control of the airplane, the large sideslip angles that are generated with an aileron input and the fact that you have to spend much too much time controlling sideslip and not being able to devote that time to rapidly maneuvering the airplane.

SPECIAL PILOTING TECHNIQUES

Lots and lots of rudder is required; very easy to overcontrol on the rudder so that you do have to spend a lot of time working at the sideslip control.

PRIMARY REASON FOR THE PILOT RATING

I don't think controllability is a problem and I don't feel that I could fly this and give an adequate performance with this configuration. As far as the turbulence is concerned I don't think there is any real significant increase in my effort required.

CONFIGURATION 3 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.05$ PILOT RATING 5 TURBULENCE RATING A

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression on that one is that it was not really very good, it wasn't very bad either because I could maneuver the airplane around pretty well and it only seemed to have the one problem that was outstanding on it and that's the slow directional response and the large residual sideslip angles that I would occasionally find myself at.

ABILITY TO TRIM

Ability to trim in all three axes, I thought was good. There was no problem there.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 250$ deg/sec^2-in. $N'_{\delta_{RP}} = 20.5$ deg/sec^2-in.

I ended up increasing the aileron sensitivity from what we started out with, but still it was a bit heavy. Even with the final selection that I had, and I couldn't really tell whether that was because of the sideslip angles I was generating or what, but the sensitivity was a little lower than I would have liked. As far as a compromise there, I don't think I really compromised on anything. On the rudders, I had a bit of a problem. Quite large sideslip angles

were generated, fortunately, they were in the adverse direction so that when I got the rudder sensitivity up enough to be comfortable for large rolling maneuvers and in turns I would quite occasionally overcontrol and drive the sideslip out the other direction. So I backed off on the sensitivity after maneuvering the airplane more aggressively. The forces on the ailerons are a little heavier than I've been used to. Displacements were not noticeable in either control, and the control harmony generally was good.

AIRPLANE RESPONSE TO PILOT INPUTS

With aileron-only inputs I found that quite large sideslip was generated in the adverse direction for an aileron input. However, this doesn't seem to affect the roll rate very much. The roll seems to be smooth even though large sideslip angles are generated. Coordination is required, it's required in the normal or adverse direction and it's not too difficult to do. The only problem that I find is that it takes quite a bit of attention to sideslip per se, in other words, it's not something that I just do automatically and I think this stems from the fact that the sideslip response is very slow and things don't happen as fast as I would like and I tend to put in an input and the next thing I know, it's too much and the sideslip has been driven out in the opposite direction. So that the sideslip response is a bit of a problem. Okay, when I do coordinate, if I concentrate on it, I can keep the sideslip needle pretty close to the center. There seem to be no oscillatory characteristics, either in bank angle or sideslip, response is so slow that it's primarily something that I can keep up if I wish to concentrate on it. Because it is slow, I think that's what allows it to get away from me. As far as maneuvering coordination requirements; that's the biggest problem in this configuration. I have to spend a lot more time and a lot more concentration on sideslip control than I like and I can do it, but it's quite a bit of a compromise on my part to have to spend that much time controlling sideslip. What you find is that you need coordination in the adverse direction when you maneuver the airplane, but then you can't just kind of make an automatic input because you have to come back and take out these, sometimes quite large residual sideslip angles that develop.

BANK ANGLE CONTROLLABILITY

I thought that was good, primarily a function of how aggressively you wish to go at it. The biggest problem with bank angle control is the inordinate amount of concentration I have to put on the sideslip control and consequently my bank angle control gets away from me.

HEADING CONTROLLABILITY

Heading control is quite a bit of a problem with this configuration because you roll out, you get the wings level, but you can develop quite large sideslip angles so it's quite possible for the airplane not to be headed in the direction that you wish for it to be headed.

BANK ANGLE COMMAND TRACKING TASK

I think my performance was only fair on that, not so much because the roll control was bad, but now I'm having to use a little ball to get the sideslip under control, then my attention is diverted from putting the tracking needle in the center down to getting the ball back in the middle and occasionally I'm quite slow on keeping up with the tracking or letting the tracking needle move off the center as I'm concentrating on the sideslip.

RESPONSE TO DISTURBANCE INPUTS

This particular configuration has a very low response in both sideslip and roll to the random disturbance. As a matter of fact I think it's really no significant increase in my effort required and certainly no significant deterioration in performance with it.

LONGITUDINAL CHARACTERISTICS

The longitudinal handling qualities were good. I don't think they detracted from the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they're probably acceptable. They're certainly not satisfactory as I see them now and I find that again the big problem is the slow directional response and the fact that large sideslip angles are generated, I think would greatly reduce my precision, at least in tracking a target. I found however I could maneuver the airplane quite aggressively and quite rapidly and that the bank angle control is pretty good. Again the big problem is the sideslip. On the air-to-ground, I think the sideslip control could also be a significant problem but perhaps you've got a little better control because things are happening a little slower.

GOOD FEATURES

I thought the roll capability was good and I thought that the bank angle control was good. The turbulence response or random disturbance response is quite low.

OBJECTIONABLE FEATURES

Only one real major objection and that is the slow sideslip response, the fact that the coordination requirements are large and because of the slowness of the response, it's possible to end up with quite large residual sideslip angles. I have to spend more time than I want looking at the sideslip and getting the sideslip needle back in the center.

SPECIAL PILOTING TECHNIQUES

Normal coordination is required for all the maneuvers and it's quite substantial and you have to keep including in your scan the sideslip disturbance.

PRIMARY REASON FOR THE PILOT RATING

I think I'm willing to say the airplane is acceptable, however, the characteristics that I talk about on the sideslip are certainly a moderately objectionable deficiency and I think requires considerable compensation on the part of the pilot.

CONFIGURATION 3 $N'_{\zeta_{RS}}/L'_{\zeta_{RS}} = +0.02$ PILOT RATING 4.5 TURBULENCE RATING A

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression of that configuration was that it wasn't going to be a very good one because of the slow directional response. And it turned out it really wasn't very bad either. I guess I'd put it in the mediocre category.

ABILITY TO TRIM

Ability to trim laterally was good. Directionally, not quite as good as it was laterally because of this very slow directional response, it doesn't quite want to come around as fast as I want, but once I got it there and got it trimmed, the airplane held its trim quite well. Longitudinal trim was okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\zeta_{RS}} = 266$ deg/sec^2-in. $N'_{\zeta_{RP}} = 19.5$ deg/sec^2-in.

I was able to select light ailerons on that one, but not overly light because there were a couple of problems there. Sideslip was generated and it looked like it was initially in the proverse direction. There's a bit of a tendency for the airplane to accelerate in roll, and a little bit of a tendency perhaps to overcontrol in bank angle. So you might interpret those as a small compromise in the lateral aileron gear selection. I had to back off on what I started out initially on the rudder sensitivity. As an airplane, it doesn't have very much of a tendency to want to stay pointed in the direction you're going, or it's not very stiff so that a little bit of rudder causes the nose to move quite a bit and picks up quite a large sideslip angle. There was a need for some coordination with the proverse yaw primarily not during the rolling maneuvers, but at the end of a rolling maneuver where the nose would just want to slide, first one direction and then the other and you have to put it back with the rudder. With the initial gearing selections, there was a quite marked tendency on my part to overcontrol that so I heavied up the rudder and that helped a bit. The control forces are good in all three axes. The displacements I thought were good and no problems with control harmony.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron-only inputs produced a little bit of proverse yaw and you could feel the airplane accelerate a little bit in roll, but in general the roll response was smooth and didn't really notice much difference between with and without rudder. I wasn't able to coordinate the proverse yaw because it comes in very slowly and then tends to go out in the adverse direction, either at the end of the rolling maneuver or during a rolling maneuver. I didn't really have to coordinate very much during the actual rolling maneuvers, but at the end of a rolling maneuver, particularly if I ended up in a sizable bank angle, I would usually end up with quite a bit of sideslip into the turn. I found myself having to hold rudder in the direction of the turn for a steady turn maneuver. Mostly you end up just controlling your sideslip with the rudder and doing whatever is necessary without really tying into a given aileron input. As far as oscillatory characteristics are concerned the Dutch roll seems to be very well damped, it was no problem with oscillations either in roll or in sideslip.

BANK ANGLE CONTROLLABILITY

Ability to achieve a bank angle wasn't quite as good as I would have liked. The airplane had a bit of a tendency for a rapid rolling maneuver to want to accelerate in roll and caused me a very slight tendency to overshoot the bank angle a little bit and I would like to emphasize that that's very small, but it was there.

HEADING CONTROLLABILITY

Heading control was one of the poorer features. The airplane tended to slide quite slowly in the directional sense, and I found myself spending quite a bit of time using the rudders just to bring it back. This is a very slow responding airplane so you just kind of have to feel it back with the rudders until you got the sideslip centered. The rudders were very strong in creating sideslip even at the reduced control sensitivities so that you had to take it fairly easy with the rudder.

BANK ANGLE COMMAND TRACKING TASK

Performance was fair to good, no real oscillatory problems, but a little bit of a tendency to overshoot particularly for a large bank angle change, but again this is real slight. The biggest problem again was picking up sideslip and having to make a conscientious effort to put it back toward the center.

RESPONSE TO DISTURBANCE INPUTS

Response to turbulence inputs was barely noticeable. The airplane has a very low turbulence response and as a matter of fact, I don't think there was really any significant increase in my work requirements in the presence of the disturbances.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good. I didn't think they interfered with the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I don't believe that these characteristics are satisfactory. I think they're acceptable, but not satisfactory. In the air-to-air role, you have to spend quite a bit of time working on the sideslip and this slow movement one way or the other, although you can put it back to the center. It's annoying and I think increases the amount of work, certainly a moderate amount you have to continually perform that sideslip centering. One good feature about these characteristics on the air-to-ground would be the lack of turbulence response so that I think you could handle that part of it pretty well.

GOOD FEATURES

You had good roll performance and fortunately you didn't have much of an oscillation to have to contend with in the sideslip.

OBJECTIONABLE FEATURES

Primary objection is the drifting off in sideslip, the fact that you have to hold steady rudder in the turn, and the fact that the airplane accelerates up in roll.

SPECIAL PILOTING TECHNIQUES

You have to pay considerable attention to the sideslip and continually put it back toward the center, but this was really not too difficult to accomplish, so the biggest problem was how rapidly you'd be able to get it back towards the center.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable, however I do not feel these characteristics are satisfactory. I think the deficiencies are slightly more than minor, moderate compensation is required.

CONFIGURATION 3 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.10$ PILOT RATING 8 TURBULENCE RATING A

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression was that I wasn't going to like it and that it wasn't going to be very good. Lot of proverse yaw every time you put in an aileron control input and a relatively low frequency, it looks like to me that large sideslip angles were built up. Had a hard time coordinating the proverse yaw - in the steady turns the sideslip comes into the turn and you end up holding rudder in the normal directions. Quite a bit of coordination is required and quite large sideslip angles are developed.

ABILITY TO TRIM

Ability to trim laterally and directionally - I thought were both good. Longitudinal trim was likewise OK.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 272$ deg/sec^2-in. $N'_{\delta_{RP}} = 22.5$ deg/sec^2-in.

I ended up keeping what we started out with on aileron sensitivity because it seemed to be just about kind of a moderate type selection, as I mentioned large sideslip angles were developed with an aileron control input which are aggravated by the higher aileron control sensitivity so that the value I had seemed to be in a range that I could control the airplane in roll to a reasonable degree with forces that were only moderately light. I was able to keep the sideslip under control somewhat so that there was a bit of a compromise on the aileron gearing selection keeping it lower than I would probably normally like in order to keep down the large sideslip angles that were generated. There was also a tendency on the aileron on the roll control to overshoot and oscillate. A very squeamish airplane in roll so that keeping the gearing a little lower than normal would help that situation somewhat so there were a couple of compromises involved in aileron gearing selection. Rudder I ended up going to lighter forces on the rudder in order to be able to coordinate the large adverse sideslip that seemed to be there during a steady turn. In other words when you would initially put in an aileron control input you would get a quite large proverse yaw but then when you got into a steady turn, the airplane required steady rudder into the turn and the rudder selection was primarily based on my desire to have light forces since I was having to hold steady rudder in turns. Displacements were small, control harmony I thought was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Using aileron input without the rudder, most noticeable thing was that there was enough proverse yaw that you could actually see it in the roll control even though there seemed to be a relatively small roll to sideslip - you could feel the airplane accelerate up in roll and generated a quite large proverse sideslip initially then as the airplane rolled and began to pick up a steady turn, the sideslip came back into the adverse direction. Coordinating this was difficult, such large sideslip angles were generated in both the proverse and adverse direction if you wish to keep the airplane under control in sideslip you had to make an attempt to cross control initially followed by normal coordination, this was a difficult task to do. The airplane, in the Dutch roll, didn't seem to be oscillatory directionally however there was an oscillatory tendency in bank angle when you attempted to control bank angle tightly. It takes I think an inordinate amount of your time attacking the coordination requirements in cross controlling followed by the normal rudder inputs so that the maneuvering coordination requirements were quite stringent.

BANK ANGLE CONTROLLABILITY

It's difficult when done aggressively. There is a definite tendency to overshoot and also a tendency to oscillate about the bank angle so that you really have to turn down your input on the bank angle and go at it quite a bit slower in order to achieve the proper bank angle.

HEADING CONTROLLABILITY

Heading control is quite poor on this airplane and the large sideslip angles that are generated seem to be at a relatively low frequency so that you end up kind of pushing the nose around with your feet.

BANK ANGLE COMMAND TRACKING TASK

When I lose the cue of the sideslip needle I have more difficulty because I find that I was relying on the displacement of the sideslip needle and making a conscientious effort to put the needle back in the center in order to keep the sideslip under control. When I went to the bank angle tracking task and attempted to use just the ball then I wasn't quite so good at it. So that the bank angle tracking task performance was only fair and I think the only reason I could do it fair is by going at it quite slowly.

RESPONSE TO DISTURBANCE INPUTS

The airplane has a very negligible turbulence response, both laterally and directionally so that it was really no problem there.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were probably the best thing about the configuration. They did not degrade or detract from the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I do not feel that these characteristics as I see them are acceptable for the fighter task. The quite large sideslips generated I think would completely negate any ability on the pilot's part to be able to suit him in a target air-to-air or air-to-ground. You just have to spend too much time controlling the sideslip. Also, the tendency to overcontrol and oscillate in bank angle I think is a great detriment to the air-to-air task in particular, perhaps less so on the air-to-ground.

GOOD FEATURES

There were really no good features, longitudinal was perhaps only good feature.

OBJECTIONABLE FEATURES

The major ones, the large sideslip angles generated starting initially in the proverse direction and ending up in the adverse direction - difficult to coordinate.

SPECIAL PILOTING TECHNIQUES

You do have to spend more than the normal amount of time tracking the sideslip in order to keep it under control. You do have to try to coordinate the proverse and the adverse yaw.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is not adequate - you cannot do the job, it's not acceptable, however, I do feel that it is controllable. However, you do have to spend a lot of time controlling the sideslip so that you have to detract quite a bit from your task just to keep sideslip under control.

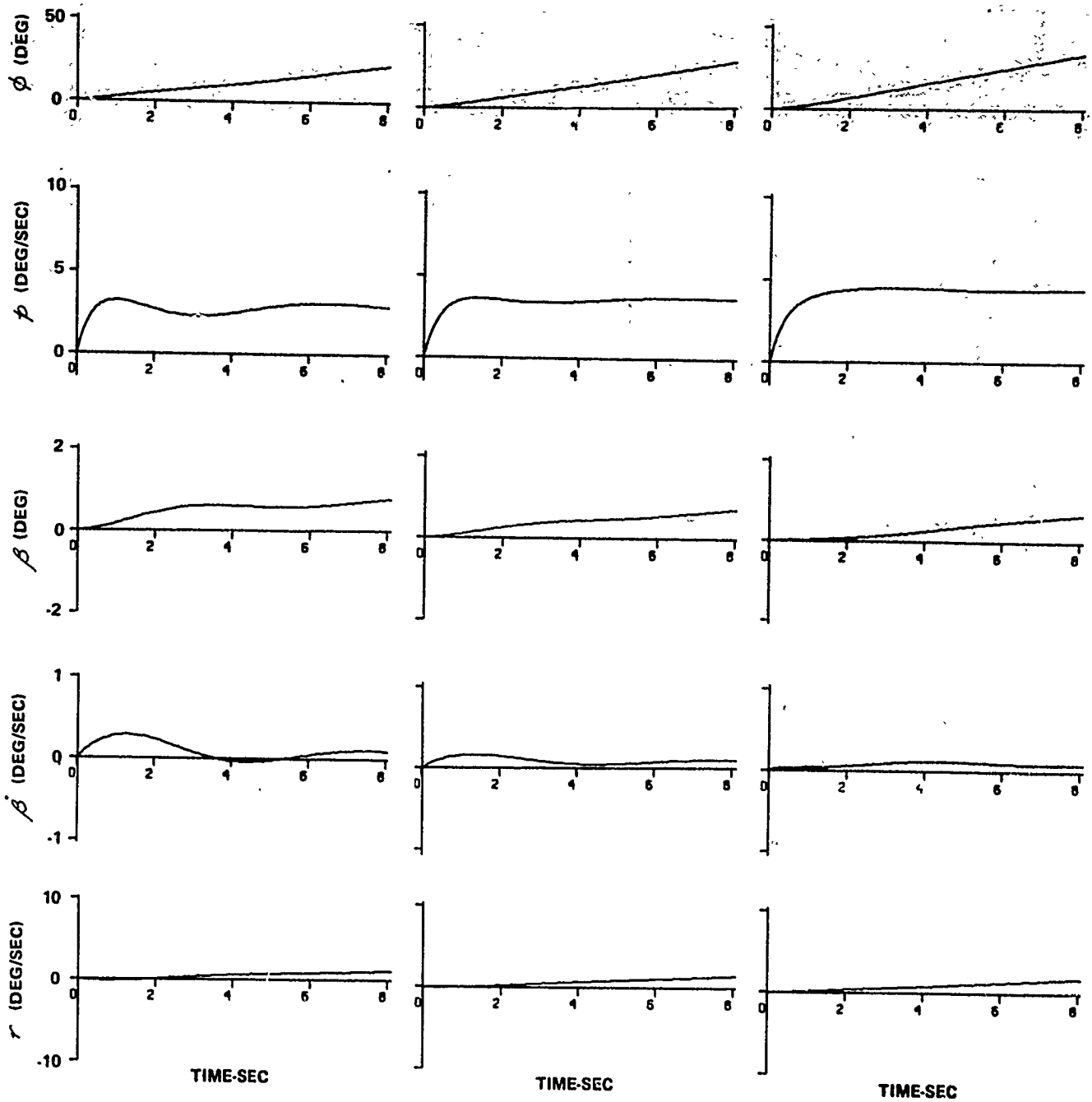
CONFIGURATION 8 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}} / L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	γ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/\phi$ LEVEL 1	$\Delta\beta_{max}/\phi$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_i}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.05	8	C	0.23	0.865	-195	0.15	17.0	11.3	0.38	304	17.0
-0.03	5	D	0.24	0.976	-220	0.10	11.3	8.0	0.22	287	14.0
-0.01	4	B	0.26	1.08	-295	0.0	5.5	3.4	0.11	297	16.0
-0.01	4	C	0.26	1.08	-295	0.0	5.5	3.4	0.11	262	10.0
+0.02	4	B	0.28	1.21	-335	0.07	5.1	3.2	0.24	226	15.5
+0.07	8	C	0.31	1.41	-325	0.18	8.7	5.6	0.32	240	22.5

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

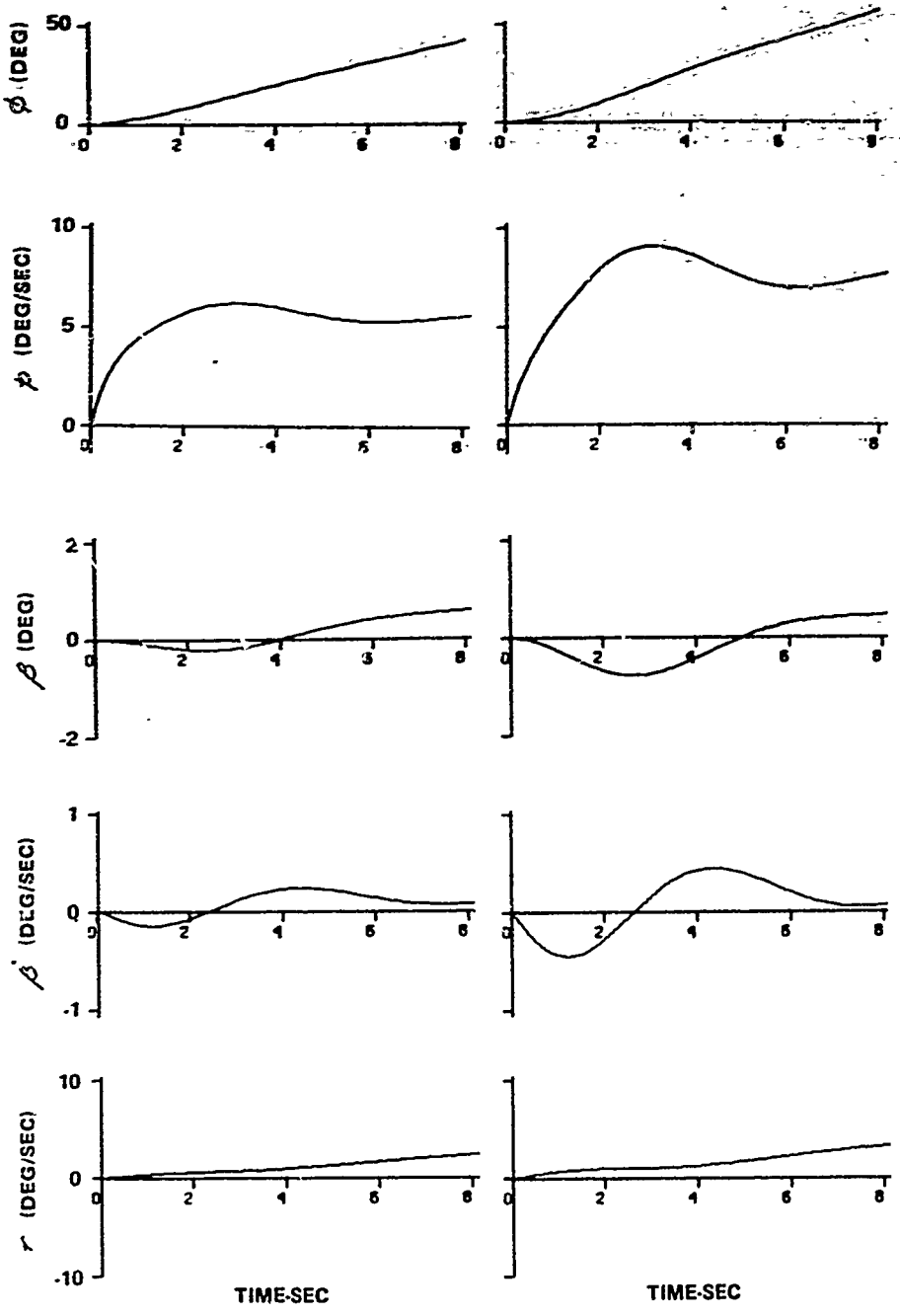
ω_d	= 1.04	N'_β	= 1.23	L'_β	= -9.99
ζ_d	= 0.25	N'_r	= -0.483	L'_r	= 4.01
τ_R	= 0.41	N'_p	= 0.0893	L'_p	= -2.36
τ_s	= -450 *	$\frac{g}{V}$	= 0.0586	Y_β	= -0.119
$\left\|\frac{\phi}{\beta}\right\|_d$	= 4.0	$Y_r - 1$	= -0.995	$Y_{\dot\beta}$	= -1.015
$\angle\left(\frac{\phi}{\beta}\right)_d$	= 69.4	$Y_p + \alpha_o$	= 0.00258		

*UNSTABLE SPIRAL



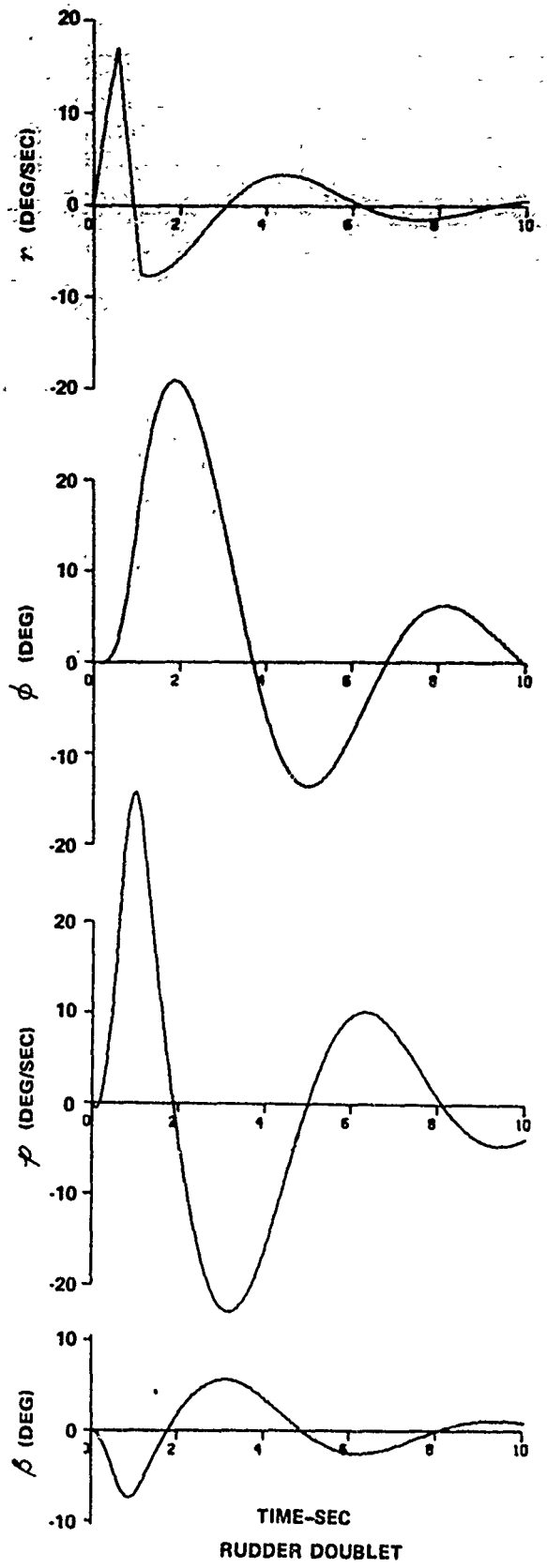
$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.05 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.03 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.01

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 8

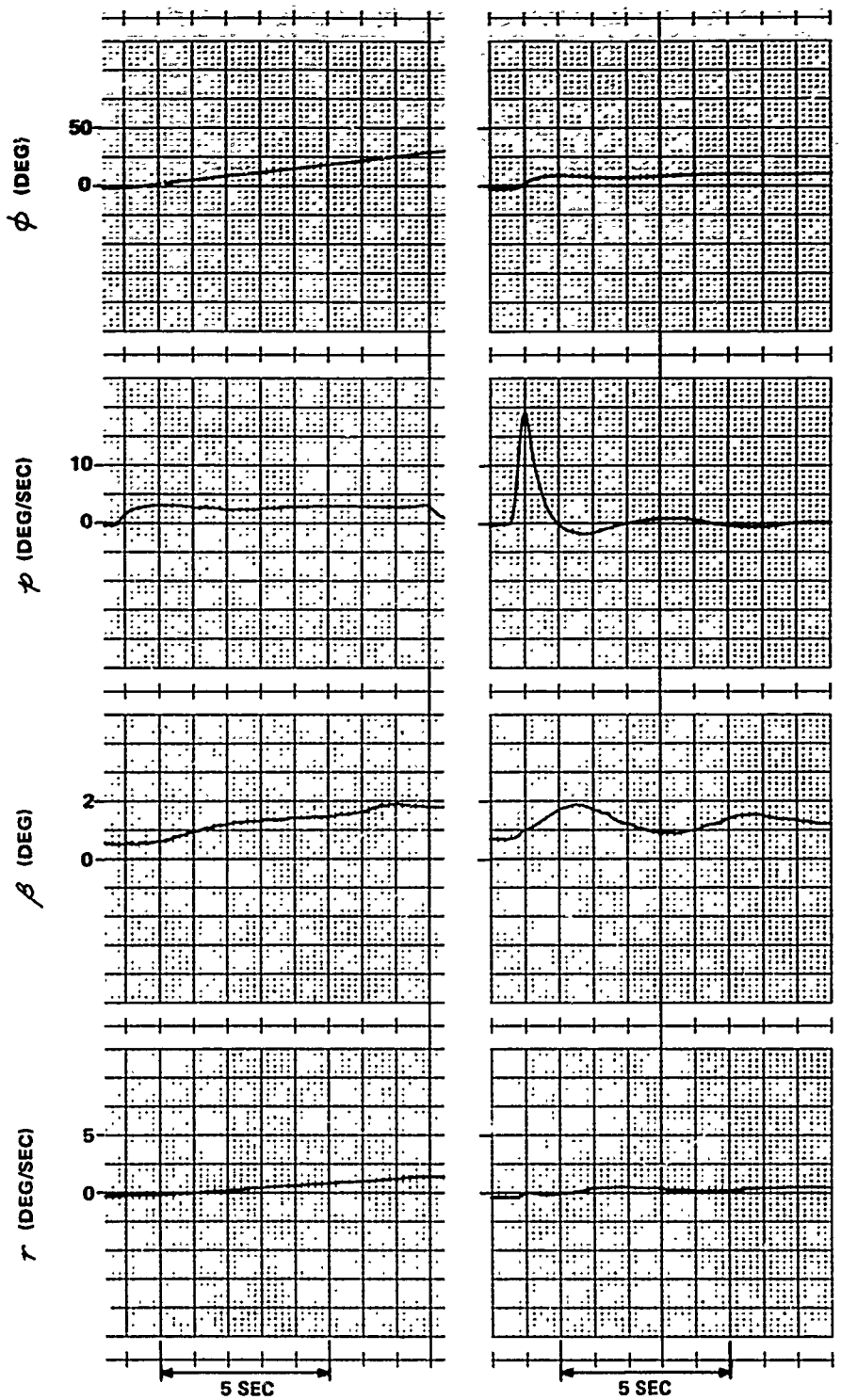


$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.02$ $N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.07$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 8



COMPUTER GENERATED TRANSIENT RESPONSES TO RUDDER DOUBLET FOR CONFIGURATION 8



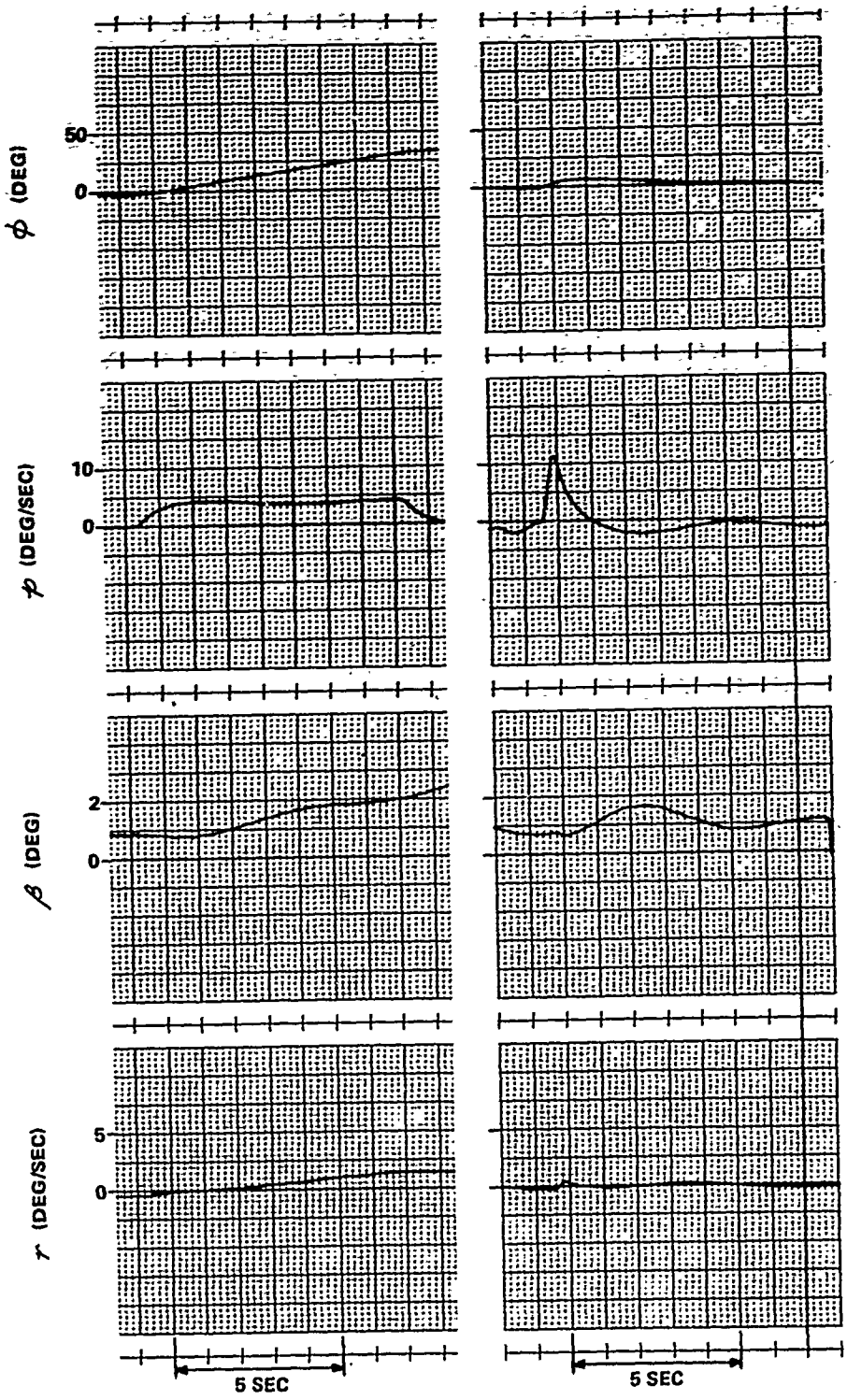
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.03$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.03$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 8



$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.02

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.02

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 8

CONFIGURATION 8 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.05$ PILOT RATING 8 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Voice recorder malfunctioned. Pilot comments were therefore lost.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 304$ deg/sec^2-in. $N'_{\delta_{RP}} = 17.0$ deg/sec^2-in.

CONFIGURATION 8 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.03$ PILOT RATING 5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

It was a confusing configuration because there are some interesting things going on and it's kind of hard to sort them out.

ABILITY TO TRIM

Trim wasn't difficult in either axis. Directional, if anything, a little degraded from the lateral, but still okay. Longitudinal trim was okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 287$ deg/sec^2-in. $N'_{\delta_{RP}} = 14.0$ deg/sec^2-in.

There was a lot of sideslip generated to a roll control input. Very difficult to tell if it was coming from the ailerons or from the roll rate. But I purposely kept the gearing a little lower than I would possibly like in order to cut down on this sideslip problem. It wasn't an airplane that you could really be overly aggressive with. I ended up with the rudder sensitivity that I started out with. It was real easy to overcontrol the sideslip. By heavying it up I found I had a little better coordination. In other words, better harmony between the ailerons and rudder input with the heavier rudder selection. Forces were noticeable. Displacements were still small. Control harmony in general was good.

AIRPLANE RESPONSE TO PILOT INPUTS

I didn't look at that closely but what I think I was seeing was a little bit of proverse yaw due to the aileron input and then a fairly strong adverse yaw due to roll rate. Anyway, it turns out that coordination required is in the adverse direction. It's a problem, but not too difficult to do. You have to stick with it because of the fact that you can generate quite a large sideslip if you don't coordinate. But the coordination required is in the proper direction so that I was able to accomplish it at least. The airplane seemed to be very heavily damped, oscillations were not a problem, at least in the classic Dutch roll. Rudder is required in the normal direction for most rolling maneuvers. That surprisingly was not too difficult to achieve.

BANK ANGLE CONTROLLABILITY

Ability to achieve desired bank angle control surprised me a little bit. The roll rate was not real smooth even with coordination and I had a tendency to kind of work my way up to the bank angle and if I went at it aggressively enough then I tended to overshoot and I felt that it would take me 2 or 3 tries to settle down on the bank angle. Anyway, the bank angle control is not as good as I would have liked or has been.

HEADING CONTROLLABILITY

Heading control was not even as good as bank angle control because of the sideslip angles that were generated and the fact that I had to pay attention to sideslip and put the ball back into the center.

BANK ANGLE COMMAND TRACKING TASK

Performance was not particularly good, only fair. I noticed a tendency to work my way up to the bank angle, a tendency to overshoot. It's kind of difficult to explain. It's not what I would call a classic oscillation about the bank angle. I think it was the fact that I wasn't able to pinpoint the thing as nicely as I would have wanted to. Sideslip was a bit of a problem there. Sideslip seems to have a fairly strong rolling moment associated with it. Maybe the coupling of those two was getting me.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs was mostly in roll. They weren't as bad as I had expected them to be. It did cause a moderate deterioration in my performance and in my bank angle controllability.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were okay. No problems there.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they are acceptable. They certainly are not satisfactory, because you don't have as fine a bank angle control as you would like and you don't have as good a maneuvering capability as I would like to see. The other reason is because of the large sideslip angles that can be generated without coordination. Air-to-ground role I think the bank angle response to turbulence would be a factor. However, I think that the roll frequency might allow you to get things on target in enough time to keep from having these large disturbances to really affect what you were doing.

GOOD FEATURES

Nothing really outstandingly good. I think the fact that the coordination required is in the proper direction and therefore you have a chance at least to keep the sideslip somewhere in bounds by using just normal control techniques is perhaps a good feature. Then the fact that the Dutch roll is so well damped is a good feature.

OBJECTIONABLE FEATURES

Objectionable features revolve primarily around the not really slow directional response, but perhaps it is, and the fact that a large sideslip angle can be generated if you don't coordinate and the fact that you have to spend a considerable amount of time working at the coordination. I think that the bank angle response to disturbance inputs falls into the objectionable features category.

SPECIAL PILOTING TECHNIQUES

You need to coordinate with the rudder for any maneuvering task and if you don't coordinate, quite large sideslip angles are generated.

PRIMARY REASON FOR THE PILOT RATING

I think that it is acceptable, however, I don't think that it is satisfactory. I think that the sideslip that I am seeing and the fact that I have to keep working them out certainly falls in the moderately objectionable category; considerable pilot compensation was required.

CONFIGURATION 8 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = - 0.01 PILOT RATING 4 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

It's one where I'm really having difficulty making up my mind. It's got some good points and then it's got some bad points and the bad points don't show up all the time and that's what concerns me and I'll talk about that later. My initial impression of the configuration was that it wasn't going to be very good.

ABILITY TO TRIM

Lateral-directional is really very good. The airplane is a little slow responding directionally, but once I get a trim, it doesn't seem to want to wander away. Longitudinal trim is okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 297 deg/sec^2-in. $N'_{\delta_{RP}}$ = 16.0 deg/sec^2-in.

I had a low frequency, lazy feeling airplane that I couldn't maneuver aggressively. I felt like I was tuning myself to the airplane somewhat with the aileron gear ratio selections that I wanted. So they were quite satisfactory, I had no complaints about the selection that I made. This really wasn't a compromise. The rudders, I heavied up a bit because it was very easy to overcontrol directionally. With the heavier rudders, there was less tendency on my part to disturb the sideslip. The forces on the rudder then were a little heavier than perhaps I would have liked, and if you call anything a compromise, it would be that. Displacements were small in all three axes, control harmony seemed to be good.

AIRPLANE RESPONSE TO PILOT INPUTS

The response to an aileron without rudder, the roll response seemed to be very smooth and there was a little bit of sideslip generated. It seemed to come about primarily due to the roll rate, but it was not excessive. I coordinated the airplane, the yaw that I was seeing was in the adverse or normal coordination direction. When I did coordinate the airplane, I had a tendency to overcontrol and forced the sideslip out the other direction. So I think I tended to keep my feet on the rudders, but probably putting in very small, if any inputs. So in maneuvering, if I tried to coordinate the airplane as I rolled it, I usually overcontrol, however, if I'd stop the airplane abruptly and maneuver abruptly, it'd look like I occasionally ended up with fairly large sideslip angles which were relatively slow in coming back to center. That took some conscious attention on my part, had to go into coordinating the sideslip as it built up just because it was there and not because I seemed to be putting it there with my aileron control. Coordinating aileron and rudder together is pretty easy to do with a slight tendency to overcontrol. However on an abrupt maneuver, when I've stopped putting in inputs, the airplane would occasionally end up in a large sideslip angle and had to take the rudder to bring the ball back to the center.

BANK ANGLE CONTROLLABILITY

Ability to achieve bank angle was fair to good. A little bit of tendency to overcontrol, particularly when sideslip did get into the picture. Was having a little more difficulty than I would like to see because the airplane, directionally is very slow to respond so that when I roll the wings level and expect the nose to be right where I want it, occasionally it's slowly drifting back from the sideslip disturbance.

HEADING CONTROLLABILITY

The heading control is not as good as the bank angle control.

BANK ANGLE COMMAND TRACKING TASK

Bank angle tracking task, surprisingly, was I thought pretty good. I purposely left the tracking task on so that the sideslip needle would go away or not indicate sideslip to me, maneuver the airplane abruptly, and we seemed to be doing pretty good. If I worked at the sideslips or don't coordinate at all even, the sideslip seems to stay relatively small, but on occasion I end up with these real large sideslip angles.

RESPONSE TO DISTURBANCE INPUTS

The airplane didn't seem to be excited very much by the random disturbance. If anything I'm seeing a little more in the bank angle than in the directional channel, but even that wasn't too bad and we had an airborne target which we tracked for a while and that was reasonably fair except for the sideslip and the disturbance when I try to keep the nose right on the target, I'd overcontrol in sideslip. So the response to disturbance didn't cause major disruption in my ability to perform the task.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Air-to-air - I don't really think they're very good. I think the slow directional response really would cut down my ability to get right on a target and hold it there. Air-to-ground, I think you'd have similar problems. The airplane is so slow responding that it just takes too long for it to come back by itself and when I get in there with the rudder, I tend to overcontrol the directional response and that's not good. So the special problems involved are in those two things. When I do get a sideslip disturbance and I let the airplane take care of itself, it's slow coming back. If I try to take care of it myself, a strong tendency to overcontrol.

GOOD FEATURES

The roll control is certainly a good feature and also the fact that there is only a small amount of sideslip generated if you roll the airplane at reasonable, but not necessarily the very rapid, roll rates.

OBJECTIONABLE FEATURES

It's an objection on my part that I don't get in there and fly the airplane as aggressively as I like to fly it in the fighter mission because of a slow directional response and a tendency to excite large sideslip angles. It's objectionable to me that, when I do try to coordinate the airplane, I overcontrol in sideslip and again excite large sideslip angles.

SPECIAL PILOTING TECHNIQUES

You have to pay considerable attention, I think, to the sideslip response and keep checking it to make sure that the sideslip is near zero.

PRIMARY REASON FOR THE PILOT RATING

I'm going to say that this configuration, as it stands, is not satisfactory without improvement. I think that the sideslip response that I see is certainly annoying. I don't think it's a real moderate objection, but I think it does require, on my part, a moderate amount of pilot compensation to keep checking, getting the sideslip back to zero.

CONFIGURATION 8 $N'_{\delta_{AS}}, L'_{\delta_{AS}} = -0.01$ PILOT RATING 4 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression of the configuration was that I wasn't going to particularly like it, then I kept going through phases with the thing where there were some things about it that I liked and some things that I didn't like. I tried maneuvering the thing aggressively and less aggressively and working without the random noise a number of times just to see what was going on and frankly I found it a very difficult configuration to evaluate.

ABILITY TO TRIM

Ability to trim laterally seems to be a little better than it is directionally. Directionally the airplane seems to be relatively slow although it seems to be well damped. You have to spend a considerable amount of time looking at the sideslip and making sure you've got it squared away. There were a couple of times there when I thought I had it trimmed, when it seemed to drift off a little bit on me. So the directional trim wasn't quite as good as the lateral. Longitudinal trim was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{LA}} = 262$ deg/sec^2-in. $N'_{\delta_{LA}} = 10$ deg/sec^2-in.

I selected an aileron gearing that was probably a little less than what I had in the past but it seemed that I needed that in order to keep from overcontrolling and as I went up on the aileron gearing, I seemed to excite a little more sideslip, although not a lot, and the sideslip turned out to be the biggest problem in this configuration. There was a very slight compromise in aileron gearing, but to my thinking, not very significant. I did find that I have to cut down the rudder sensitivity I think a significant amount from the initial rudder sensitivity that we had, and primarily because it was very easy to excite sideslip with the rudder with this configuration. I found that there was a need for a little coordination and I was overcontrolling the sideslip quite a bit and by cutting down the rudder sensitivity, it made my turn coordination a lot easier to perform. So the forces were satisfactory in all three axes. Displacements were small and in general the harmony of the controls was good.

AIRPLANE RESPONSE TO PILOT INPUTS

With aileron-only inputs it seemed to have a smooth roll rate. At least what little changes I was seeing were small enough or slow enough that they didn't make much difference. A little bit on coordination required in the normal or adverse direction, but it was relatively easy to perform and once I got the gearing set somewhere near the proper value, I didn't have too much difficulty with that. The airplane, during rapid maneuvering, did seem to break into a little bit of an oscillation. It was very slow and it didn't persist, but there was about one or two overshoots and it took me quite a bit of time for these couple of oscillations that I saw to die out. So that was a bit of a problem.

BANK ANGLE CONTROLLABILITY

Bank angle controllability is only good. A tendency for this kind of residual sideslip, I think is probably a good way to describe it, causes the airplane to roll a little bit away from the bank angle that I just got, and I could control it, but it required kind of a secondary input in order to be able to hold the bank angle right on. It wasn't something that was really difficult to do but something that was noticeable.

HEADING CONTROLLABILITY

Heading control was only good also. You'd stop the airplane then you'd have this little bit of residual sideslip or this very slow oscillation with the nose.

RESPONSE TO DISTURBANCE INPUTS

I seemed to have a fairly noticeable roll response to the disturbance inputs. But more noticeable were the sideslip angles that I was seeing as I maneuvered. I don't know whether that built up or what, but I would tend to end up in a lot greater sideslip angle than I really wanted to be. The random disturbance did cause, at least a minor deterioration in my performance.

LONGITUDINAL CHARACTERISTICS

The longitudinal handling qualities were good, didn't interfere with the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I don't think they're suitable for the air-to-air mission primarily because of my poor directional control or poor sideslip control and when you're trying to shoot another airplane, particularly with guns, sideslip can be quite critical and here the airplane is very slow responding in sideslip. Air-to-ground, you'd have similar problems, perhaps you'd have a little more time to keep the sideslip in the center. I would think for this configuration you'd definitely want some type of sideslip indication whether it's string in the front or needle or something because the sideslip is a little bit insidious and it's not oscillatory to the extent that it's noticeable and you're getting side accelerations which tend to be very slow.

GOOD FEATURES

The airplane had, I thought, good roll and bank angle control. I could maneuver the airplane aggressively and I could fly it like a fighter.

OBJECTIONABLE FEATURES

Objectionable features - just one that I've been talking about mostly and that's this tendency to generate or end up with a residual sideslip angle which I found required more attention than I thought was necessary in order to be able to perform the fighter mission. I thought the sideslip angles generated in the turbulence were noticeable and excessive for protracted maneuvering.

SPECIAL PILOTING TECHNIQUES

You do have to pay more attention to maneuvering the airplane directionally than I think is desirable. Coordination, however, is in the proper direction and if you're concentrating on it you can keep the needle pretty close to center for making rapid turns, I tend to get behind on the sideslip.

PRIMARY REASON FOR THE PILOT RATING

I don't think this airplane is satisfactory as it is. I think sideslip or directional control would have to be improved, and it's a minor but annoying deficiency but it does require I think moderate pilot compensation.

CONFIGURATION 8 $N'_{\delta_{RS}}/L'_{\delta_{RS}} = +0.02$ PILOT RATING 4 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression was that it wasn't too bad, not good, but not too bad. In general I could perform the task.

ABILITY TO TRIM

Ability to trim I thought was pretty good both lateral and directionally.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{RS}} = 226$ deg/sec^2-in. $N'_{\delta_{RP}} = 15.5$ deg/sec^2-in.

I tried aileron with a few different numbers trying to get the sensitivity that would allow me to maneuver the airplane rapidly and yet keep the sideslip down to more reasonable values. When I went too high on the gear selection there was a very slight tendency to overcontrol in bank, this is very small. I ended up with a very slight compromise I would say on the gear selection and one that would give me the opportunity to have good, light aileron and at the same time keep from producing too large a sideslip angle. On the rudder, I didn't really play with the rudder very much, I was not able to coordinate the airplane very well, at least initially, to an aileron input. It required steady rudder in the turn. I didn't want to hold a lot of force there. I found that, because of the light directional stiffness, it was easy to move the sideslip around with your feet so there was a bit of a compromise in trying to get something that was sensitive enough to give me reasonable forces in the turn but not too sensitive causing me to overcontrol the sideslip. Forces that I ended up with on the rudder were a little heavy but okay, the aileron forces were light, no problem. Displacements on bank were reasonable, in fact I didn't even notice them. Control harmony was good in all three axes.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron response without the rudder was relatively smooth roll rate, but a considerable amount of sideslip generated in the proverse direction at least initially followed by a very slow migration back to adverse direction once you have reached the steady bank angle. Trying to coordinate the initial sideslip, wasn't very good although you could do it if you thought about it. I ended up having to coordinate the airplane in the adverse direction once I reached steady state turn. As far as oscillatory characteristics are concerned the airplane seemed to be well damped and no real oscillations to speak of. The sideslip disturbances are slow enough so that you end up having to push them back in. Maneuvering coordination requirements you do have to pay more attention to sideslip than I would like simply because it seems to hang up and you have to keep pushing it back. The airplane seems to have a moderate roll to sideslip ratio so the sideslip does spill over into the roll but it seems to be generated slow enough so that I can make aileron corrections necessary to keep it from being a big factor.

BANK ANGLE CONTROLLABILITY

Ability to control bank angle I thought was good, not super, but good.

HEADING CONTROLLABILITY

Heading control a little bit more of a problem than the bank angle control simply because of the slow directional response.

BANK ANGLE COMMAND TRACKING TASK

The bank angle tracking task, I thought my performance was good, the only problem that I had, again, was keeping up with the steady sideslips.

RESPONSE TO DISTURBANCE INPUTS

Tracking response to disturbance inputs was I thought relatively small, a little more in roll perhaps than in the other channel but I think there was no significant deterioration in my performance although a little more effort was required.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good and not a factor in the evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they are acceptable, I don't think at this point they are satisfactory. I think the slow directional response is too slow so that it is very difficult to get the nose pointed where you would like it to precisely go. Also,

the steady sideslip angles that you end up generating occasionally get quite large and you have to spend more time working on sideslip than is necessary. On the air-to-ground role, the low directional stiffness has been a problem tracking ground target, the nose seems to have a mind of its own, it wants to wander one way and then the other.

GOOD FEATURES

The bank angle controllability was good. I thought it was a reasonable maneuvering airplane and the disturbance response was small.

OBJECTIONABLE FEATURES

Primary objection centered around the slow directional stiffness of the airplane, the fact that sideslip angles are occasionally generated, and the fact that I have to put more continuous monitoring on sideslip than is necessary because it's very slow moving and it's very hard to keep up with.

SPECIAL PILOTING TECHNIQUES

No comments.

PRIMARY REASON FOR THE PILOT RATING

I think these deficiencies abandon the minor but annoying category. I think that desired performance certainly requires moderate pilot compensation, primarily in the form of looking at the sideslip needle and keeping it centered.

CONFIGURATION 8 $N'_{\delta_{RS}}/L'_{\delta_{RS}} = +0.07$ PILOT RATING 8 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression of that one was that it was going to be quite bad. That impression remained throughout the evaluation.

ABILITY TO TRIM

Directional was better than lateral, however, it didn't detract from the evaluation. Longitudinal trim was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{RS}} = 240$ deg/sec^2-in. $N'_{\delta_{RP}} = 22.5$ deg/sec^2-in.

The aileron sensitivity selection allowed me not to generate such excessive sideslip angles as tended to be generated with this configuration, but allowed me light enough forces to maneuver the airplane around. On the rudder it was a matter of just getting the rudder feel that allowed me to keep under control the large sideslip angles that were generated and not overcontrol the sideslip. So the forces, both rudder and the aileron, I thought were acceptable. Displacements were small, control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

An aileron-only input resulted in quite a large amount of proverse yaw and a significant acceleration type feeling in the roll rate. Coordinating this kind of inputs required substantial rudder in the opposite directions and then as the airplane got banked up, a few seconds later, you ended up holding rudder into the turn, so that coordination requirements were quite bad. The airplane seems to be quite low frequency so that there is a lazy oscillation; it's something you can control, if you concentrate on it. You really had to pay attention to sideslip control and every time you maneuvered, which you couldn't do very rapidly, you had to make sure that you put in rudder opposite to the aileron input or the sideslip would go right off the scale.

BANK ANGLE CONTROLLABILITY

Ability to achieve a desired bank angle was poor. The large sideslip angle does influence the roll control and you end up fishing around for the bank angle quite a bit, also, because of having to devote an essential amount of time to sideslip control, my bank angle control deteriorated.

HEADING CONTROLLABILITY

Heading control I thought was poor. I spent a considerable amount of time pushing the sideslip back to zero.

BANK ANGLE COMMAND TRACKING TASK

I found that my performance was poor, primarily because of sideslip control and I was unable to keep the needle in the center because I was trying to concentrate on getting the sideslip back to zero.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs showed up primarily in the roll rather than the sideslip. Even at that, only more effort was required with no more than a minor deterioration in an already poor performance.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good, and didn't detract from lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I do not feel that the airplane is acceptable for the fighter mission. I think that the quite large sideslip angles generated, the fact that I had to devote an inordinate amount of time to sideslip control, the fact that I had to make a conscientious effort to cross control with the rudder in order to keep the sideslip under control all detract from my ability to do the fighter mission. Air-to-ground, I think the sideslip would be the major problem although the turbulence response in roll would be a contributing factor.

GOOD FEATURES

There are no really good features about it. You could maneuver the thing by cross controlling, but you couldn't really do it with any precision.

OBJECTIONABLE FEATURES

Primary objection was the quite large proverse yaw generated with an aileron input. The fact that you had to devote a considerable amount of your time to just keeping the sideslip under control was objectionable. I thought the roll response to the disturbance input was quite objectionable.

SPECIAL PILOTING TECHNIQUES

I had to make a conscientious effort to make sure I put in rudder opposite to the aileron input; in roll control input I would generate enough sideslip to consider that I had a controllability problem.

PRIMARY REASON FOR THE PILOT RATING

As far as the pilot rating is concerned, it was not acceptable. I think considerable pilot compensation is required to keep the sideslip under control.

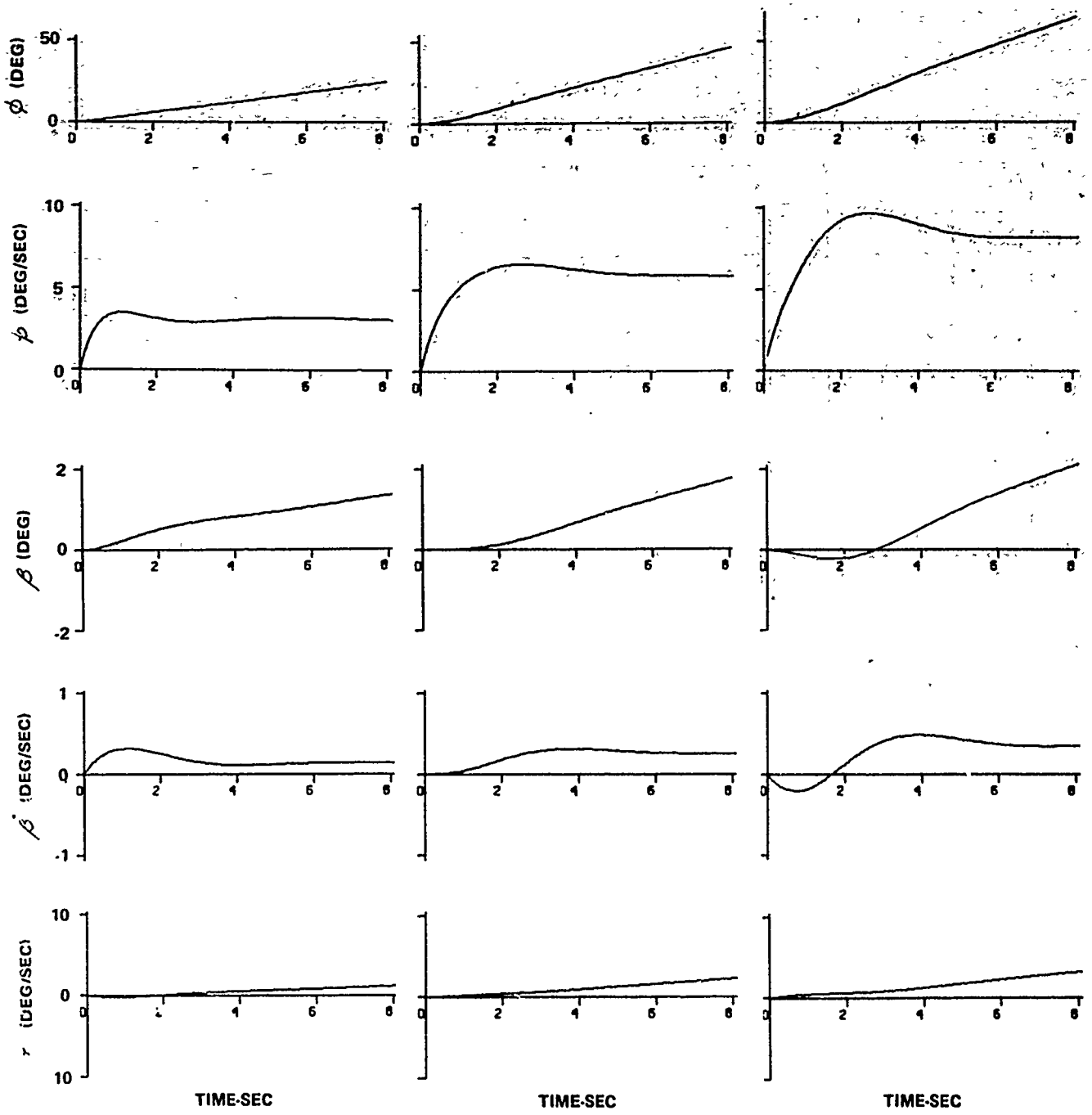
CONFIGURATION 9 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$\frac{N'_{\delta_{AS}}}{L'_{\delta_{AS}}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	γ_β STEP	$\frac{p_{osc}}{p_{AV}}$	$\Delta\beta_{max}/\phi$ LEVEL 1	$\Delta\beta_{max}/\phi$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.14*	6	C	—	—	-200	0.22	22.3	17.0	0.82	213	28.0
-0.07	5	B	0.43	0.946	-230	0.14	25.0	17.2	0.42	310	22.0
0.0	5	B	0.54	1.30	-265	0.0	12.0	7.9	0.27	300	17.5
+0.06	4	B	0.62	1.54	-315	0.07	7.0	4.5	0.40	195	25.5
+0.14	7.5	B	0.71	1.81	-348	0.08	12.6	7.4	0.50	262	27.5

*THE CONFIGURATION FOR THIS VALUE OF $\frac{N'_{\delta_{AS}}}{L'_{\delta_{AS}}}$ DID NOT HAVE THE MODAL PARAMETER OR DERIVATIVES LISTED BELOW, SEE TEXT PAGE 33.

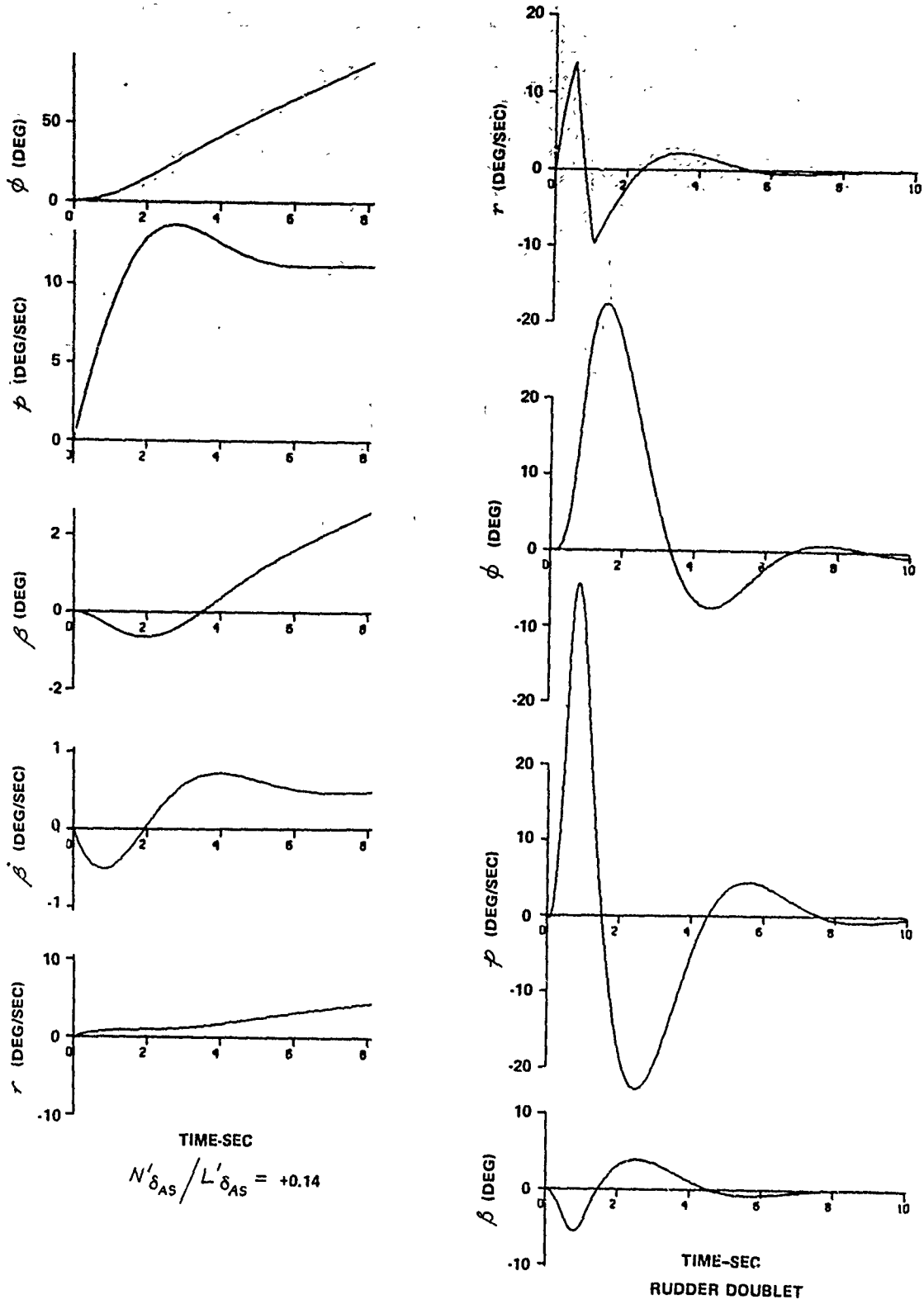
LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

ω_d	= 1.14	N'_β	= 1.58	L'_β	= -10.6
ζ_d	= 0.47	N'_r	= -1.28	L'_r	= 8.26
τ_R	= 0.40	N'_p	= 0.0734	L'_p	= -1.73
τ_s	= 83	$\frac{g}{V}$	= 0.0586	Y_β	= -0.120
$\left\|\frac{\phi}{\beta}\right\|_d$	= 5.0	$Y_r - 1$	= -0.988	$Y_{\dot\beta}$	= -1.015
$\angle\left(\frac{\phi}{\beta}\right)_d$	= 67.0	$Y_p + \alpha_0$	= 0.00308		

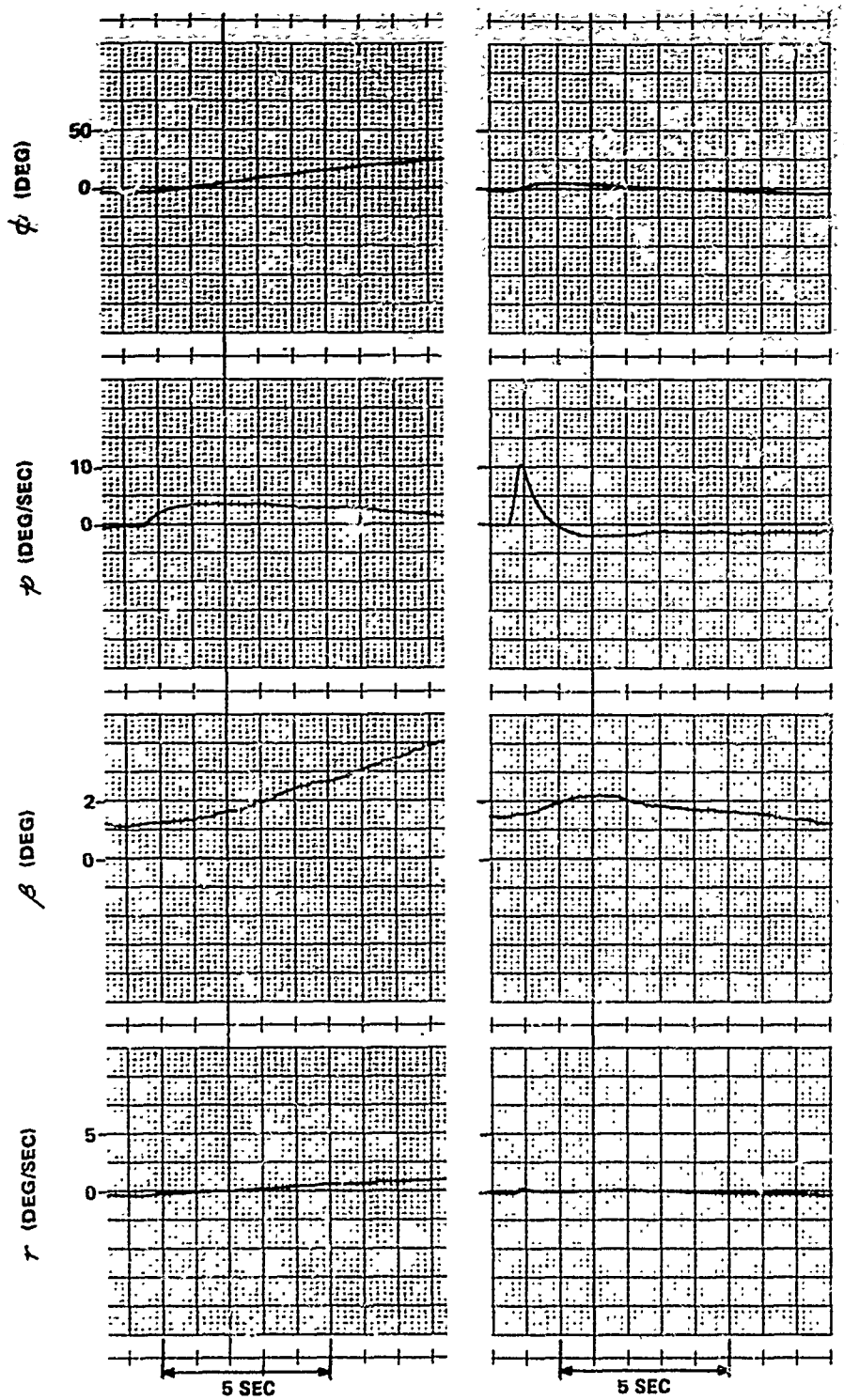


$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.07$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.06$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 9



COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR CONFIGURATION 9



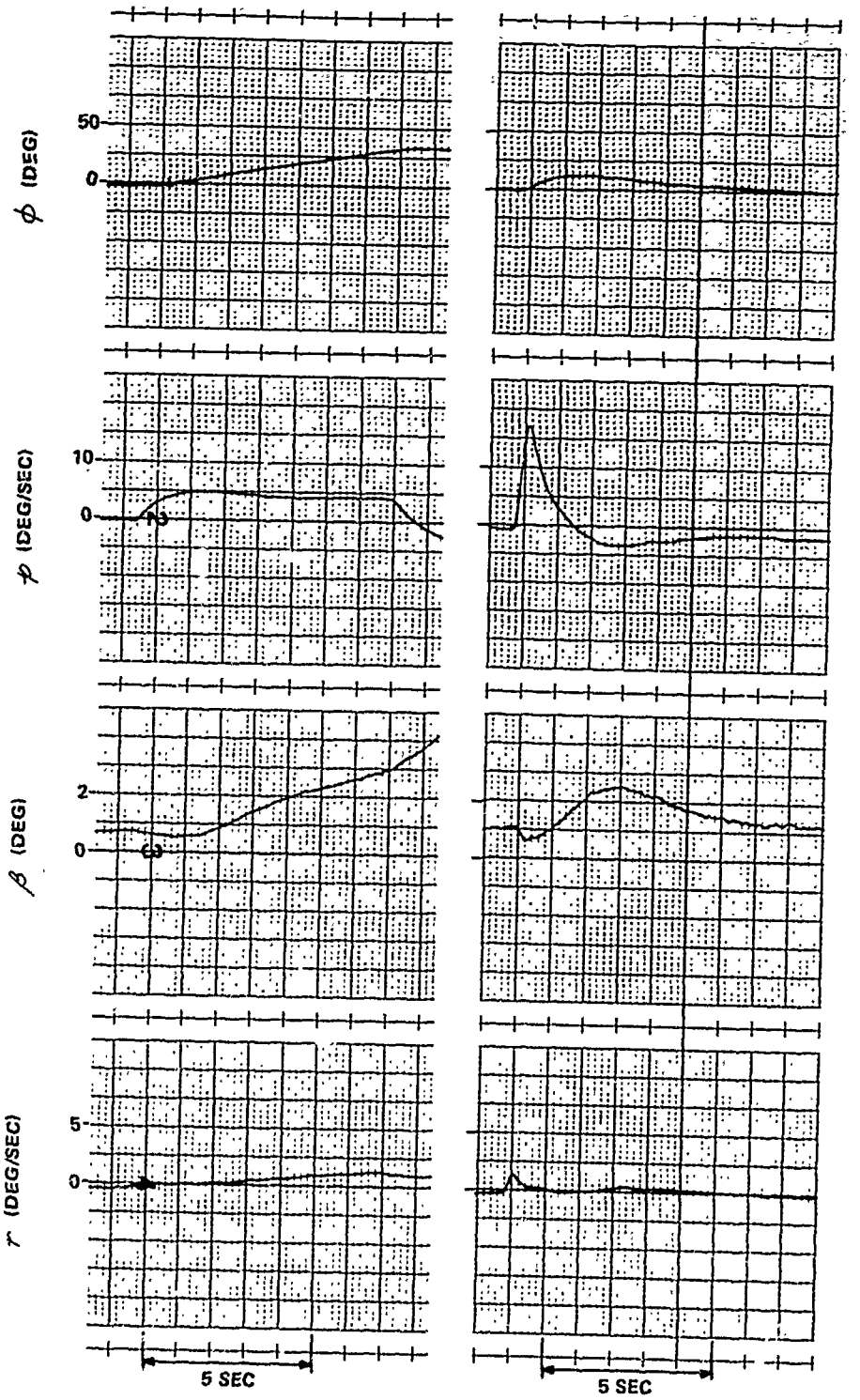
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 9



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.06$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.06$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 9

CONFIGURATION 9 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -.14$ PILOT RATING 6 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought it wasn't going to be very good, primarily because every time I put in an aileron input I got quite a large sideslip disturbance and that required a lot of rudder to be able to fly the airplane.

ABILITY TO TRIM

Ability to trim the airplane, both laterally and directionally was very good. Held its trim very nicely and longitudinally the trim was good also.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 213$ deg/sec^2-in. $N'_{\delta_{RP}} = 28$ deg/sec^2-in.

Selection of aileron rudder sensitivities did required a little bit of a compromise on my part. First of all an aileron stick input resulted in a quite large sideslip disturbance, and consequently I had a fair amount of difficulty getting a rudder-aileron combination that allowed me to do the job somewhere near adequately. I won't say good because my performance really wasn't that good. So, in general, I got the ailerons where I wanted them, but really fiddled around with the rudder trying to get something that was light enough to be able to control the sideslip disturbance, but not too light to keep me from overcontrolling it. And that's pretty much what happened most of the time. Once I'd get the rudders to the point where I could control the initial sideslip disturbance as I began to stop my roll rate, invariably I ended up with the sideslip needle out to the other direction indicating overcontrol on my part. So I think the final compromise was that the aileron forces were a bit heavier than I would like. The rudder felt heavy initially, but light toward the end or as I began to reach a steady state. Aileron stick input displacement seemed to be noticeable and a bit larger than I would like. Harmony of the controls - it was okay, nothing super. Aileron-elevator combination was okay. Rudder combination tended to be a little heavier by comparison with the other two controls.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron-only input resulted in a quite large sideslip disturbance in the adverse direction. When I coordinated the airplane, I could keep the sideslip near zero during the initial part of a rolling maneuver, however, during the roll, I could feel slightly the effects of the Dutch roll coming in requiring a little phasing problem with the rudder. As I reached the steady state value, I usually got too much rudder input and the sideslip would head out in the proverse direction. I flew this configuration both with and without the advantage of the sideslip needle, and because it was in the proper direction, coordination in general was acceptable, but really not very good. The airplane does seem to be a bit more oscillatory than I would like in that I could feel, at least in the rudder requirements, a need for other than a pure step-type input into the rudder for a corresponding step input into the aileron. This was noticeable enough to make it feel like I could feel the Dutch roll feeding into the sideslip response. So the maneuvering coordination requirements were quite large. I find that the rudder inputs required are much larger than I would like for them to be, and that my ability to coordinate is not really very good.

BANK ANGLE CONTROLLABILITY

Bank angle achievability is really pretty good. I didn't have any oscillatory problems in bank angle. The sideslip that I'm seeing doesn't seem to feed into the roll very much so that I was able to acquire a given bank angle reasonably well.

HEADING CONTROLLABILITY

When I got the airplane wings level, it was not unusual for the nose to have a sideslip angle, and therefore, not be pointed precisely where I would like and would require a rudder input to get it back. I'd like to explain that the sideslip oscillations that I see seem to occur at a reasonable or moderate frequency, and that the damping is not overly light, but I'm not complaining about the damping so much, but just the fact that the airplane is usually not pointed in the direction that I want it to go and requires a rudder input to get it where I want it to be.

BANK ANGLE COMMAND TRACKING TASK

I thought my performance was reasonably good, however, I could not attack the task as aggressively as I would have liked because I stirred up too much sideslip, and therefore, my good performance has to be considered in the light that I was really not flying the task as aggressively as I would like. The large sideslip disturbances were noticeable and did require that I cut down my gain on the tracking task in order to keep the sideslip under control.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance input - really not too bad, not too much more than I would expect for an airplane in this class. It does increase my effort a bit, but the deterioration in my performance is really not very great.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good, they didn't interfere with the lateral. There was no significant mismatch so that the longitudinal handling qualities were not a factor.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I don't particularly feel these airplane characteristics are anywhere near satisfactor for the air-to-air mission. My inability to control the sideslip would certainly degrade my weapons capability or some of my ability to fire a gun. The large sideslip disturbances decrease the aggression with which I'm willing to fly the airplane because the sideslip slips away from me if I fly the airplane really aggressively. And I think these comments also go along with the air-to-ground mission. Special problems, again, centered around the large sideslip disturbance due to aileron control input.

GOOD FEATURES

Longitudinal handling qualities were good. Lateral - I didn't have an awful lot good to say about it. The bank angle controllability is probably a good feature.

OBJECTIONABLE FEATURES

One strong and outstanding objection - the large sideslip disturbance following an aileron control input. Fortunately, this disturbance is in the adverse direction so that I do stand some chance of coordinating the airplane. By programming my rudder inputs in this, kind of overemphasizing them as I maneuver the airplane, I could keep the sideslip somewhere near zero, although not really very well. Also this tendency to overcontrol the sideslip as I begin to phase out my roll rate and the requirement for the rudder input in order to keep the sideslip at zero during a rolling maneuver.

SPECIAL PILOTING TECHNIQUES

A large amount of normal coordination is required and it's required every time you maneuver the airplane.

PRIMARY REASON FOR THE PILOT RATING

I don't feel that these handling qualities are satisfactory as they are, however, I do feel they're acceptable if we can get them improved a bit. I think the deficiencies that I see are certainly very objectionable although tolerable and it requires an excessive pilot compensation on my part to get an adequate performance out of the airplane. I indicated earlier that the random disturbance really didn't cause much more than a minor deterioration in my performance even though more effort was required.

CONFIGURATION 9 $N'_{\delta_{RS}}/L'_{\delta_{AS}}$ = - .07 PILOT RATING 5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

My first impression was that the handling qualities weren't going to be very good. Turned out that they weren't really as bad as I thought, but still they weren't very good.

ABILITY TO TRIM

Ability to trim was good both lateral and directional and the longitudinal was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 310 deg/sec^2-in. $N'_{\delta_{RP}}$ = 22 deg/sec^2-in.

I selected light forces. There were no compromises on the aileron. I had to lighten up the rudder forces a little bit. When I get the rudder sensitivity large enough to hold the sideslip near zero for a rapid aileron step input I find that in the steady state I tend to hold too much rudder and overcontrol the sideslip in the other direction. I'm not real sure what my problem is but this particular configuration had a quite noticeable amount of adverse yaw, so I did need the rudder and a quite large amount every time I tried to coordinate a maneuver. But then I would find out that in the steady state, I guess I was holding in the rudder, still, particularly on some of these protracted high g maneuvers with the other airplane, I would push the sideslip quite smartly in the other direction and I never really got very good. The forces on the rudder seemed to be little more than what I would like. I think that is probably because I just have to use more rudder than I would like and if I had lightened up the rudder forces much more then I would have overcontrolled the rudder that much more. Displacements for all three axes I thought were large.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron input without the rudder is quite unsatisfactory. You put in aileron input and sideslip builds up and I'm almost reaching roll reversal with this configuration. If I coordinate the rudder with the aileron I can get rid of this roll reversal and get reasonable roll rate out of the airplane. Manuevering coordinating requirements are quite large. It is more rudder than what I would like to use in the fighter mission. The only problem I was having was the large sideslip angle that I was generating while trying to track the other airplane.

BANK ANGLE CONTROLLABILITY

Bank angle control is pretty good - I didn't seem to have any oscillatory problems or difficulty in achieving bank angle.

EADING CONTROLLABILITY

Heading control - quite a bit more difficult because you have to make a conscientious effort to get the sideslip back to zero to make sure the airplane was pointed in the direction you wanted it to be.

BANK ANGLE COMMAND TRACKING TASK

I thought my performance was fair to good. No problem in tracking the bank angle. Again, the one noticeable problem was the large sideslip angles that I was achieving.

RESPONSE TO DISTURBANCE INPUTS

Response to random disturbances really weren't that great in any of the axes. It didn't cause any more of a noticeable deterioration in my performance than I would have expected.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good. They did not degrade or interfere with my lat al-directional evaluations.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I don't feel that they are satisfactory for the fighter mission. You have one singular problem: a large amount of adverse yaw and the sideslip angles that I generated either with an aileron input or by holding too much rudder after I had taken an input out. Air-to-ground, perhaps a little better suited than the air-to-air, but the sideslip I think would still be a problem and you would introduce, I think, significant errors in your weapons delivery because of the sideslip angle.

GOOD FEATURES

I think the lack of oscillatory characteristics and the Dutch roll characteristics are good features. The fact that I can maneuver the airplane in roll quite aggressively is a good feature.

OBJECTIONABLE FEATURES

The good features are very much overwhelmed by that one outstanding objectionable feature and that's the large sideslip angles generated with the aileron control inputs, and my inability to coordinate these maneuvers as well as I would like. Fortunately the sideslip that's generated is in the adverse direction and so the coordination requirements are normal and I could keep the sideslip usually within bounds as long as I paid attention to it. When I didn't pay attention to it, then I generated some fairly large sideslip angles.

SPECIAL PILOTING TECHNIQUES

Coordination is required for all rolling maneuvers. Coordination itself is not very easy and you have to watch the tendency to overcontrol with the rudder.

PRIMARY REASON FOR THE PILOT RATING

I think adequate performance is attainable but I do not feel that it's satisfactory without some improvements. I find that this much yaw is certainly moderately objectionable and I think it requires considerable pilot compensation in the context of the fighter mission in order to be able to fly the airplane aggressively and keep the sideslip response at a reasonable balance. Turbulence really didn't cause that much of a deterioration in my performance.

CONFIGURATION 9 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0.0$ PILOT RATING 5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression was that I wasn't particularly going to like it and primarily based on the quick look, a lot of sideslip generated with the control input and then the fact that the sideslip did seem to show up a little bit in the roll rate.

ABILITY TO TRIM

Ability to trim in all three axes was good, didn't present a significant problem in this configuration

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 300 deg/sec^2-in. $N'_{\delta_{RP}}$ = 17.5 deg/sec^2-in.

Didn't really feel there was a compromise on the aileron, however, there was on the rudder. On the ai ron I selected a gear ratio which I thought was reasonable, wasn't necessarily very light because I was generating some larger sideslip angles and the higher gear ratio tended to antagonize that situation a little bit. I didn't really come up with what I thought was a significant compromise in order to be able to do the task, so aileron

gearing was good. On the rudder, however, there was a lot of sideslip generated. However, when I went up on the rudder sensitivity, there was a strong tendency on my part to overcontrol sideslip, somewhere around the neutral point, then I backed down on the sensitivity and it was better coordinating but there was a requirement on this configuration to hold a substantial amount of rudder in a steady turn and holding a fairly high bank angle turn required a noticeable amount of force on the rudder in order to be able to do it. So that, there was kind of a compromise on the rudder trying to come up with something that would fit the sensitivity about the small bank angles and still not have excessive forces about the large bank angles, or when holding a steady turn. So, generally, forces on the ailerons were reasonable but not particularly light. The forces on the rudder seemed to me to be light about the small bank angles, near neutral, and heavy on the large turns. Displacements: they are noticeable on the rudder, displacements on the ailerons were OK. Control harmony in general, though, is good, being a little heavier on the rudder in comparison with the aileron required in the steady turn.

AIRPLANE RESPONSE TO PILOT INPUTS

The airplane response to aileron without the rudder seemed to be quite a bit of sideslip generated. It did seem to show up in the roll rate and if we didn't get roll reversal to an aileron input, we were pretty close. When you coordinated with the rudder, the roll rate picked up considerably and was quite a bit smoother. Oscillatory characteristics: the airplane is very highly damped in the Dutch roll and so really wasn't much of an oscillation for this particular configuration. Maneuvering coordination requirements are quite stringent, you need a lot of rudder.

BANK ANGLE CONTROLLABILITY

Ability to achieve a bank angle was actually pretty good.

HEADING CONTROLLABILITY

The heading control wasn't particularly good because I would build up a sideslip angle. Even though the Dutch roll was well damped, it seemed to take a while for the sideslip to come back to zero and even when I jumped in there with the rudder it took a little longer than I would like to get the sideslip back to zero.

BANK ANGLE COMMAND TRACKING TASK

The bank angle tracking task performance was only fair to good, leaning toward the good side. Again, problems with the sideslip and the rudder requirements were large, but in general I could take the bank angle reasonably well.

RESPONSE TO DISTURBANCE INPUTS

The airplane didn't seem to respond excessively in either axis to the disturbance inputs. If any a little more in the roll channels than in the sideslip and I think that is attributed though somewhat to the high damping that is apparent in the Dutch roll.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good, they didn't interfere or degrade the lateral directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think it is acceptable but I think it is not satisfactory as it is. Primary reasons are the slow directional response to the airplane and the large sideslip angles that are generated with an aileron input. The requirements for excessive rudder for coordination and requirement for steady rudder in a turn all add up not to make an unacceptable airplane, but certainly an airplane that is not satisfactory as it is. In the air-to-air role, I think the slowness of the directional response is a problem because you would really like to pin down the bank angle and the directional response of the airplane much faster than I can do here. In the air-to-ground role, I think you have a little more time than you do in the air-to-air fighting. You might be able to get away with these characteristics a little better.

GOOD FEATURES

A combination rudder and aileron coordinated rolling maneuver gives you good roll performance, bank angle control, although not excellent, is I think good.

OBJECTIONABLE FEATURES

Objectionable features primarily revolve around the slow directional response and the amount of coordination that you need to keep the ball somewhere near the center. I worked with that quite a bit and found that just for general maneuvering I could do a reasonably good job, but when I tried to do it without my feet I did build up a large sideslip angle.

SPECIAL PILOTING TECHNIQUES

Rudder is required for all maneuvers and a bit more attention to sideslip control than I think is warranted.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is probably acceptable. I don't feel that it is satisfactory. I think certainly deficiencies that I see are moderately objectionable and I think considerable pilot compensation is required. With random disturbances a little more effort was required in the roll channel but I didn't think there was any really significant deterioration from what was already not a really good performance.

CONFIGURATION 9 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.06$ PILOT RATING 4 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought initially that it was going to be pretty good and that held pretty much through the evaluation, except there are a couple of things that bother me and present a little bit of a dilemma for me as to whether or not it's satisfactory.

ABILITY TO TRIM

Ability to trim was better than most in both the lateral and directional. Longitudinal was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 195$ deg/sec^2-in. $N'_{\delta_{RP}} = 25.5$ deg/sec^2-in.

There was a very slight compromise in the aileron sensitivity selection in that when I went to higher aileron sensitivities or lighter ailerons, I tended to pick up a slight tendency to overshoot in bank angle. So I ended up I think backing off from the maximum value that I looked at. Sensitive ailerons result in a tendency to overcontrol in bank angle. A little bit of a problem on the rudder. The airplane appeared to me to have proverse yaw due to ailerons, however, it had a requirement for adverse rudder in a steady turn. What I'm saying is, initially the needle would go out of the turn and once I got into the turn and established in the turn, there was a requirement for steady rudder into the turn. So that I ended up selecting the gearing that allowed me to hold a reasonable rudder force in the steady turn rather than having to hold a lot of force for a high bank angle turn. However, when I did this I ended up with a real strong tendency to overcontrol the rudder initially. The forces I ended up with on the rudder felt a little heavy holding them in a steady turn, and they felt light initially, upon turn entry if I happened to inadvertently coordinate in the proper direction for an aileron input. The aileron forces were not real light, they were noticeable; I could feel that I was having to put in a little force. So that they weren't as light perhaps as some that I have selected. Displacements, however, were not a problem with either rudder or aileron and the control harmony I thought was still good.

AIRPLANE RESPONSE TO PILOT INPUTS

With aileron-only inputs it looked like there was proverse yaw initially followed by adverse yaw as we got into the turn. The roll rate seemed to be pretty smooth, however, if I didn't coordinate, or if the proverse yaw seemed to give me enough, the fact that you could feel the airplane accelerate a little bit in roll and this was more pronounced when I coordinated in the proper direction initially, the airplane would really wind up in bank angle. Okay, when I coordinated it, at first I have to put rudder out of the turn and then rudder into the turn, but surprisingly enough, that wasn't too difficult to do and I could, as long as I'm thinking about it keep the sideslip needle pretty well near the center and actually got, it was kind of a 1-2 thing, right rudder, left rudder, say for a left turn. So that if that's all you wanted to is to make a rapid turn, you could coordinate the thing pretty well. However in doing things like the tracking task and so forth where I can't devote my full attention to controlling sideslip then there was a tendency to coordinate only in the proper direction and have the airplane accelerate in roll. As far as oscillatory characteristics, there were no significant or noticeable ones. The Dutch roll seemed to be very well damped. Coordination is really the thing that's causing me the biggest problem here. To do it properly, you do need cross-coordination initially followed by coordination in the proper direction and as long as you're not doing anything but thinking about that, you do a pretty reasonable job. But when I get to the point where I'm doing other things and distracted, I almost invariably ended up coordinating in the proper direction and accelerating the airplane up in roll and that wasn't very good. When you maneuver the airplane then, you do need opposite rudder initially followed by holding steadier rudder in a turn.

BANK ANGLE CONTROLLABILITY

Ability to achieve a bank angle was pretty good, depending on what I was doing. If I was just working to achieve a bank angle, I could roll up and stop, then the sideslip would be excited and I could easily put that back in the center, so that wasn't much of a problem. But bank angle control in general was okay, or pretty good I would say.

HEADING CONTROLLABILITY

Heading control was good. No special problem encountered there.

BANK ANGLE COMMAND TRACKING TASK

The bank angle tracking task was a bit more of a problem than when I had a good sideslip reference like the sideslip needle and I tended to overshoot the bank angles a little bit. So that my performance there, although good, was certainly not excellent. Biggest problem again was tendency to overshoot bank angle.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance input didn't seem to be a major problem. A little more effort required, but no real significant deterioration in my task performance.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good, did not detract or degrade the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they're acceptable, there's no doubt there, but I think really we're kind of on the borderline for satisfactory. I'm even willing to say it's not satisfactory without some improvement and as far as the air-to-air role, I think this tendency to accelerate in roll, if you don't coordinate properly, so that I think in the air-to-air role where the fights get a little hot, there'd be less than a tendency to be able to coordinate this thing properly and your bank angle control would be somewhat degraded. On the air-to-ground role, you might get along a little easier because you can use your feet to control the sideslip more directly, so I think it would probably be a better air-to-ground weapons system than air-to-air.

GOOD FEATURES

The airplane was quite maneuverable. Could fling the airplane and the sideslip it would generate didn't get too far out of hand. The fact that I could get the sideslip back to center pretty well is also a good feature.

OBJECTIONABLE FEATURES

The requirement for cross-coordination initially followed by proper coordination which you can do and you can keep the sideslip near zero, if that's all you're trying to do. But when you try to maneuver the airplane rapidly, there's a tendency for the thing to roll up on you.

SPECIAL PILOTING TECHNIQUES

You need opposite rudder initially followed by rudder in the normal or adverse direction and you can do that if that's all you're trying to do.

PRIMARY REASON FOR THE PILOT RATING

I think I'm going to say that certainly the deficiencies are minor, they're a bit annoying and I'm stuck on whether it's moderate pilot compensation, I'm not real sure it is.

CONFIGURATION 9 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +.14$ PILOT RATING 7.5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought it was really going to be a bad one and that held. It seemed to have quite large proverse yaw generated to an aileron control input and seemed to be relatively low frequency, and quite large sideslip angles were generated if you didn't really work to keep up with it.

ABILITY TO TRIM

It was easier to trim directionally than it was laterally which surprised me a little bit. Directionally it was pretty good, but the lateral was not so good but not to the point that it caused any real problem with the configuration. Longitudinal trim I thought was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 262$ deg/sec^2-in. $N'_{\delta_{RP}} = 27.5$ deg/sec^2-in.

It was one of those kind of configurations where sensitivity wasn't going to solve many of my problems; however I did find that I needed more sensitive rudders than what I started out with simply because the sideslip angles were so large that it took a lot of rudder to get the sideslip needle back to the center. I didn't really look at aileron sensitivity too much, it was comfortable. I worked mostly just to get an aileron sensitivity that allowed me to do the job and that didn't generate such large sideslip angles that I couldn't keep the airplane under control. I didn't work very hard at getting an optimum aileron sensitivity because it was one of those configurations that I'm not really sure an optimum aileron sensitivity exists. I ended up with forces on both the aileron and the rudder which were acceptable; the rudder seemed a bit heavy because of the large sideslip angles that were generated but it was still okay. Displacements I thought were small in both controls. Control harmony was good, not a factor.

AIRPLANE RESPONSE TO PILOT INPUTS

Without using the rudder, the most noticeable thing was a very large amount of proverse yaw generated. The airplane seemed to be sensitive in roll somewhat to the sideslip generated, however, the sideslip that was generated, although quite large, seemed to come on relatively slowly, so that it was something you could keep up with using roll control. Trying to coordinate the airplane required rudder in the opposite direction to the aileron input - something I'm not very good at. The airplane seemed to be well damped and the Dutch roll did seem to be very slow but no real oscillatory characteristics to speak of. Half of your time is spent chasing the sideslip, if you do wish to coordinate you can make a conscientious effort and put in rudder opposite to the aileron but I can't do that when I'm doing rapid maneuvering. I spend too much time coming back to and correcting for these quite large sideslip angles.

BANK ANGLE CONTROLLABILITY

Because the large sideslip does spill over into the roll control, my bank angle control is not particularly good. On the good side of the ledger you find that because the sideslip that's generated is quite slow you can keep up with the roll control. When you try to do things rapidly there was a tendency to overshoot the bank angle, it's not so much to oscillate about them but to overshoot them. I was having more difficulty holding the bank angle than I was achieving the bank angle because I'd have to devote my attention to the sideslip and I would lose track a little bit of the roll control.

NOTE: No further comments because of malfunction of tape recorder

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APPENDIX IV.2

MEDIUM DUTCH ROLL FREQUENCY CONFIGURATIONS

CONFIGURATION IDENTIFICATION AND FLIGHT DATA TABULATION

TRANSIENT RESPONSES

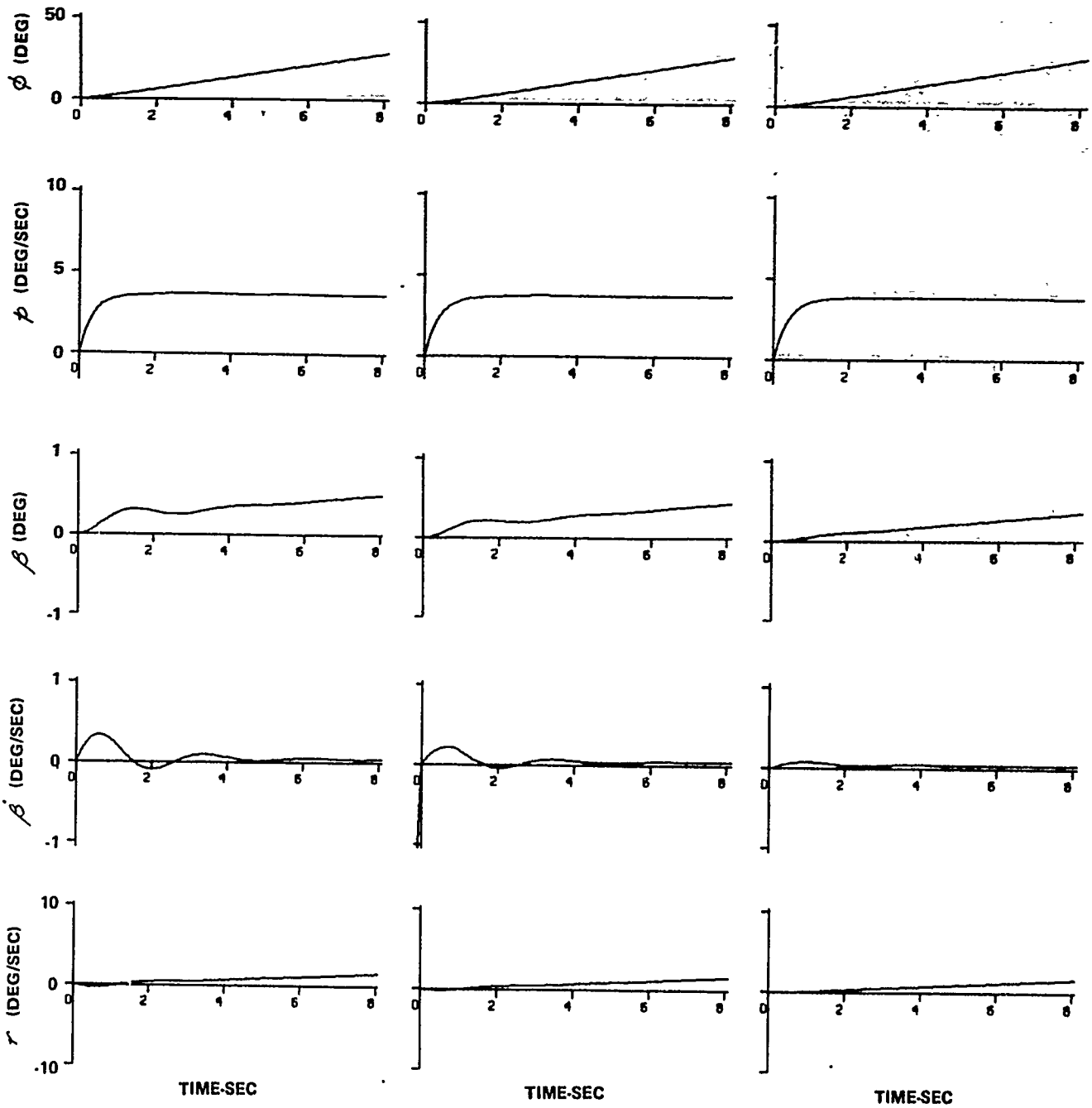
PILOT COMMENTS

CONFIGURATION 1 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

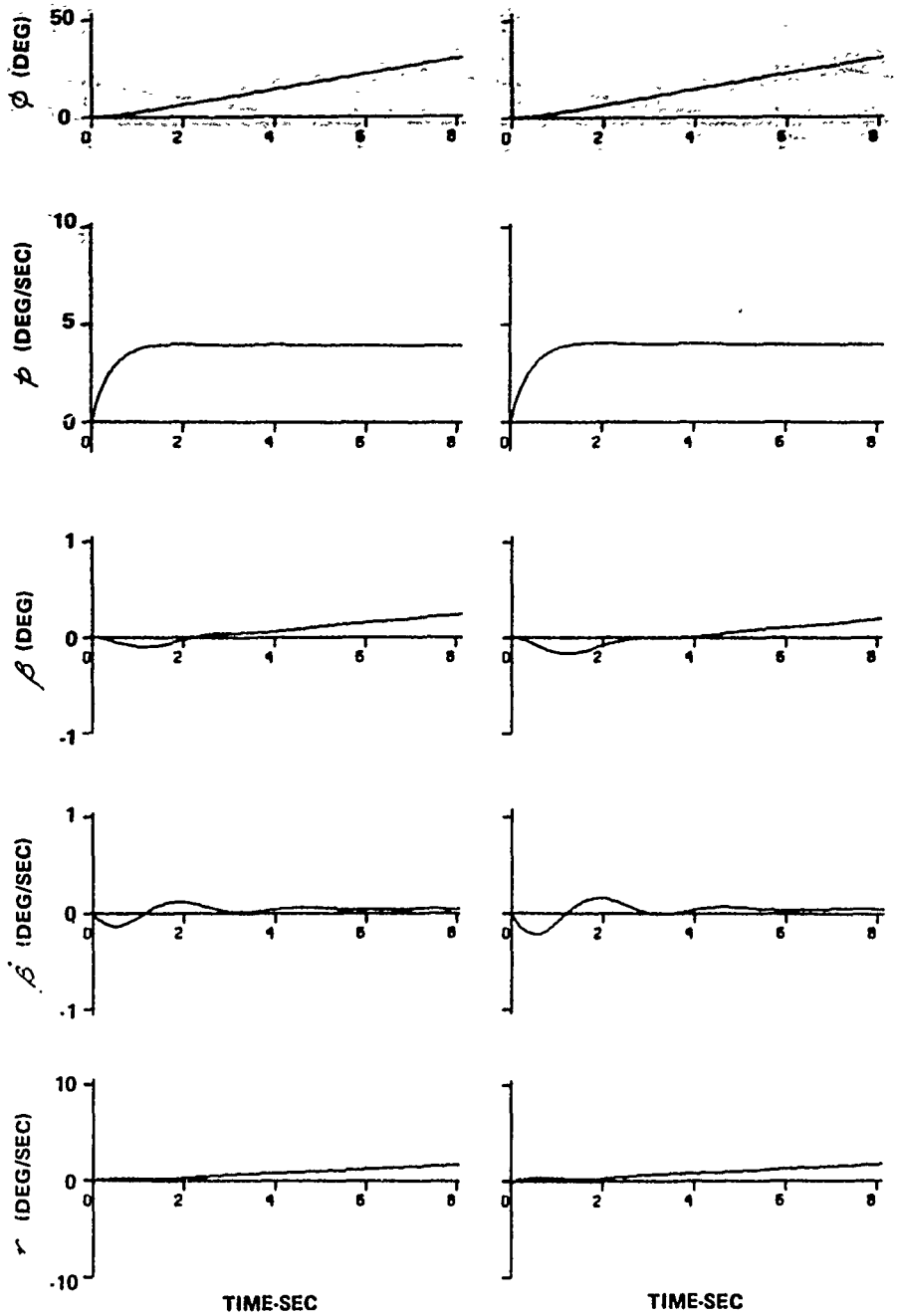
$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/\phi$ LEVEL 1	$\Delta\beta_{max}/\phi$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.10	6.5	D	0.25	2.30	-200	0.004	11.5	8.0	0.03	310	64.0
-0.06	3.5	B	0.25	2.33	-200	0.003	7.8	5.2	0.02	360	55.0
-0.01	3	B	0.26	2.35	-260	0.0	3.7	2.5	0.01	355	27.5
-0.01	2	A	0.26	2.35	-260	0.0	3.7	2.5	0.01	162	19.5
+0.06	6	C	0.26	2.39	-330	0.002	3.2	2.2	0.02	358	27.5
+0.06	3.5	B	0.26	2.39	-330	0.002	3.2	2.2	0.02	275	39.0
+0.09	7	B	0.26	2.41	-355	0.006	5.4	3.9	0.05	370	21.5

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR CONFIGURATION 1

ω_d	= 2.36	N'_β	= 5.53	L'_β	= -2.55
ζ_d	= 0.25	N'_r	= -1.04	L'_r	= 0.393
τ_R	= 0.39	N'_p	= 0.0194	L'_p	= -2.55
τ_s	= 504	$\frac{g}{V}$	= 0.0586	Y_β	= -0.165
$\left\|\frac{\phi}{\beta}\right\|_d$	= 0.36	$Y_r - 1$	= -0.939	$Y_{\dot\beta}$	= -1.015
$\angle\left(\frac{\phi}{\beta}\right)_d$	= 47.0	$Y_p + \alpha_o$	= 0.0038		

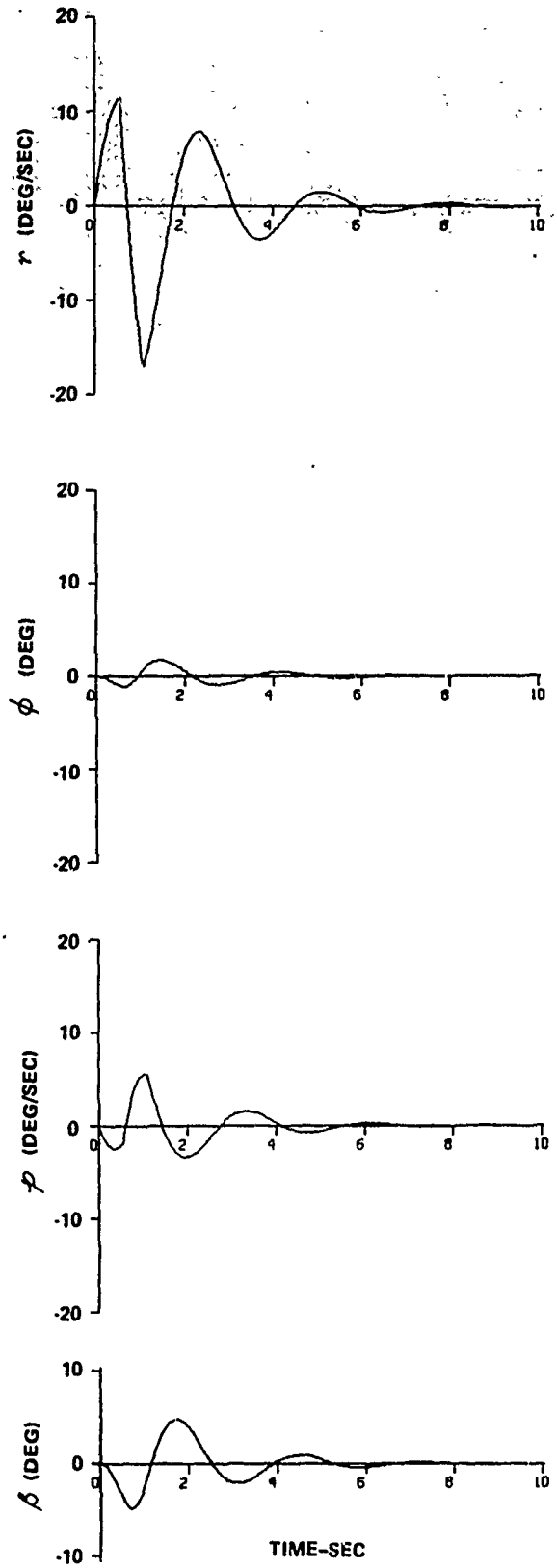


COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR CONFIGURATION 1

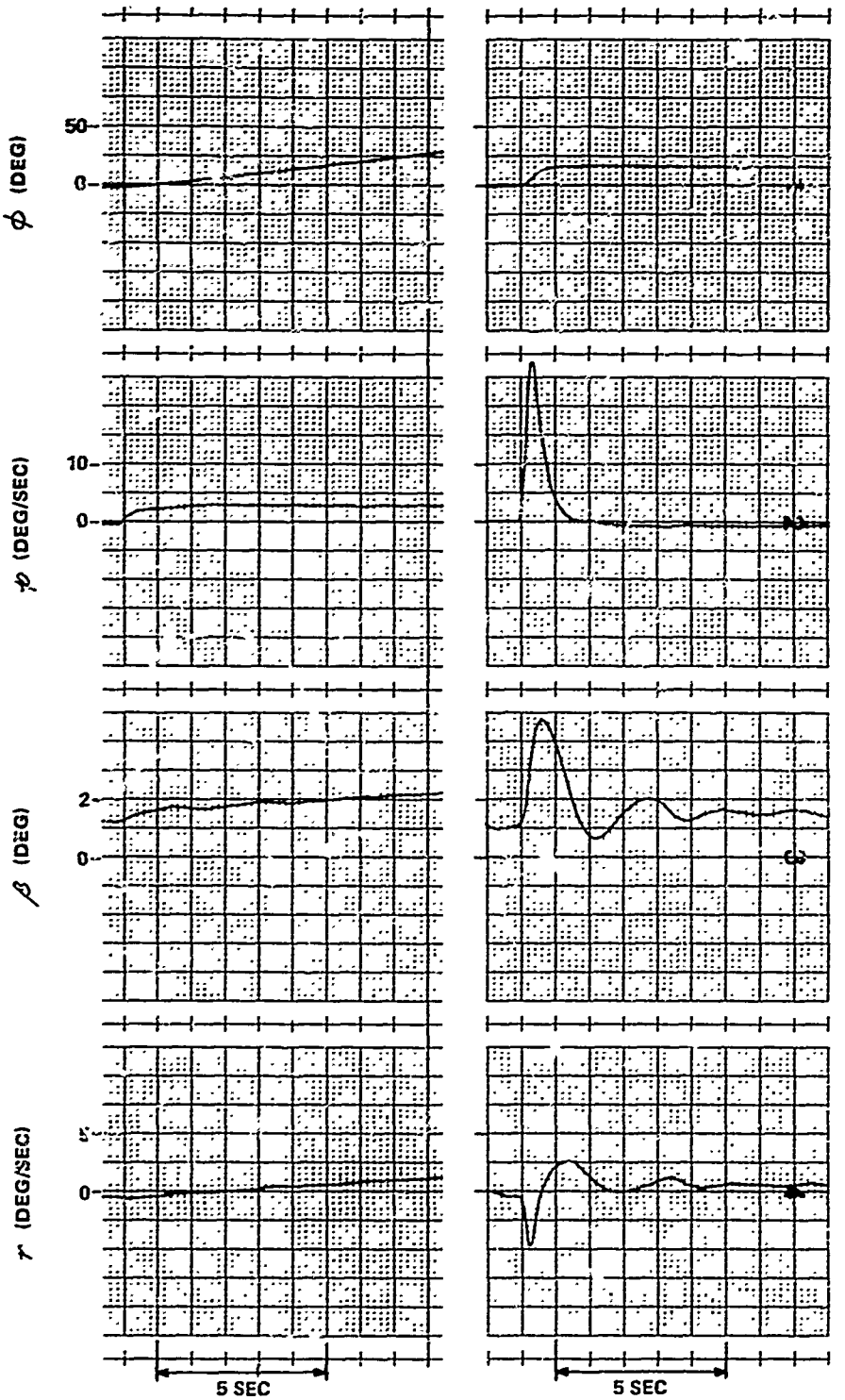


$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.06$ $N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.09$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 1



COMPUTER GENERATED TRANSIENT RESPONSES TO RUDDER DOUBLET FOR CONFIGURATION 1



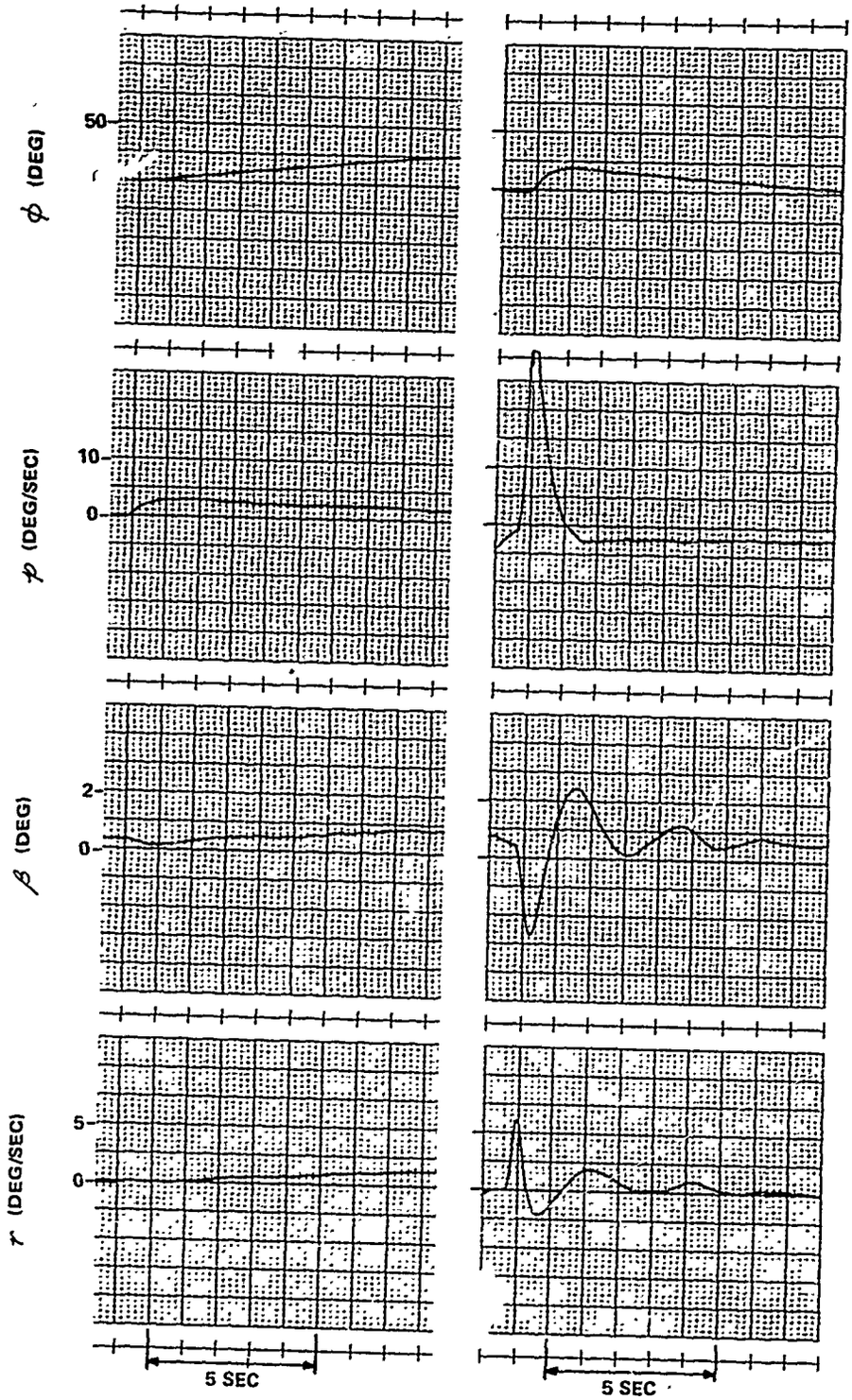
$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.10

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.10

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 1



TRANSIENT RESPONSES FOR CONFIGURATION 1

CONFIGURATION 1 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.10 PILOT RATING 6.5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

It had a lot of adverse yaw. At first I thought I was going to be able to coordinate this, it got better as we went along. I had the rudder gearing turned up quite a bit to stay with it, but there were times that we got quite a large sideslip angle built up.

ABILITY TO TRIM

Laterally and directionally were both good. Longitudinal trim was okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 310 deg/sec^2-in. $N'_{\delta_{RP}}$ = 64 deg/sec^2-in.

I went one high on the rudder from what we started out with in trying to trim out this very large adverse yaw that seemed to be generated every time a roll control input was put in. There was quite a compromise on that and I again feel that I didn't get really good at it but I think I was getting better as the flight went on. On the aileron: from where we started out, I think I went up a little bit on the ailerons but not very much because the larger the aileron input the more sideslip I generated and I also got to the point on the aileron sensitivity at the high values where the controls were getting too sensitive and getting very jerky. The airplane was getting twitchy in roll so I had to back off on that. Forces: ailerons were medium - they were good though. Rudder forces were heavy even at the higher sensitivities because of the large yaw that was generated. Displacements were noticeable on the rudder. Control harmony not quite as good because the ailerons were a little lighter than the rudder. But it was still okay. It's not a major gripe.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron only - as I mentioned, quite a bit of adverse yaw generated from an aileron input. So quite large sideslip angles were generated if one didn't coordinate. I couldn't really feel any effect in the roll control because the airplane didn't seem to have a very large roll to sideslip ratio so that roll control wasn't all that bad. Coordination requirements are quite stringent. Lots and lots of rudder, fortunately in the normal or adverse direction. Then again I wasn't very good at it but I was getting better as the flight went along. As far as oscillatory characteristics are concerned, the airplane seems to be well damped in the Dutch roll and wasn't a real oscillatory airplane to fly.

BANK ANGLE CONTROLLABILITY

Only fair to good and primarily because you had to spend, I think, too much attention on the sideslip to be able to peg the bank angle as well as I would have liked.

HEADING CONTROLLABILITY

There was a problem there because every time you put in an aileron input the nose really wanted to move and you have to keep up with it on the rudder. So heading control I'm going to say is poor.

BANK ANGLE COMMAND TRACKING TASK

Performance is still in the fair to good category. Sideslip, again, the biggest problem that is encountered, and because you have to divert attention to that I found that I wasn't keeping the needle for the tracking task as near center as I would have liked.

RESPONSE TO DISTURBANCE INPUTS

Mostly in the directional modes. So it was hard for me to tell whether it was turbulence or whether it was my aileron inputs. Anyway, it's quite noticeable that large sideslip angles are generated in the presence of disturbances.

LONGITUDINAL CHARACTERISTICS

Good. Didn't interfere with or degrade lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think that the characteristics as I see them are marginally acceptable for the fighter mission. Pretty much borderline case. The biggest problem is the large adverse sideslip that's generated. Fortunately it's in the adverse or normal coordination direction. I think that a guy could eventually get to the point where he could hack it. Heading control is not all that good but I think you could possibly learn to fly this thing well enough to hack the program. Air-to-ground, I think you would have lots of problems there because you tend to make small corrections. With the aileron generating such large sideslip I think you would generate more sideslip to make your air-to-ground tracking quite poor.

GOOD FEATURES

Roll control is fair to good, not outstanding. Your roll performance is cut down a bit because of the large adverse yaw. You really have to step on the rudder in order to keep your roll rate up. I think that it is fortunate that the sideslip does not tend to degrade the lateral any more than it does.

OBJECTIONABLE FEATURES

Primary objection is the quite large adverse sideslip generated any time you put in a control input. The fact that it takes lots and lots of rudder to coordinate the thing and the fact that I have to spend more attention to sideslip control than certainly I would like to. It kind of detracts from my ability to maneuver the airplane as aggressively as I think I would like to be able to do the job.

SPECIAL PILOTING TECHNIQUES

Lots and lots of rudder in the adverse direction required for any aileron input and you really can't fly the airplane without coordinating it.

PRIMARY REASON FOR THE PILOT RATING

I'm going to give you a borderline rating on this one because I think that the deficiencies that I see are somewhere between the very objectionable or intolerable to being somewhere where my performance is not quite good enough. Turbulence I think compounds the already poor sideslip control problem that I see. There is at least a moderate deterioration in my performance; certainly more effort is required.

CONFIGURATION 1 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.06 PILOT RATING 3.5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought I was going to like it. It was quite maneuverable, good roll performance. There was however a little sideslip generated which was necessary to contend with. The airplane seemed to be stiffer directionally than the previous one and seemed to have a little bit of an oscillatory Dutch roll response, but in general you could maneuver the airplane quite well.

ABILITY TO TRIM

Good on all three axes.

SELECTION OF AILERON AND RUDDER CONTROL SENSIVITITIES

$L'_{\delta_{AS}}$ = 360 deg/sec^2-in. $N'_{\delta_{RP}}$ = 55 deg/sec^2-in.

Aileron gear selection: was able to pick nice high aileron gearings without what I considered any compromise. There seemed to be initially a very small amount of proverse yaw followed by what seemed to be quite a bit of adverse yaw so that most of the coordination required was in the adverse direction. Consequently, I had to lighten up the rudders quite a bit from what I started out with initially to be able to coordinate it. I flew, can I guess three-quarters of the evaluation with the one sensitivity and then had to lighten them up again because the sideslip in the adverse direction was quite large, and for the rapid roll maneuvers the sideslip got to be significant. So by lightening up the rudders, I was more able to coordinate it. Fortunately most of this coordination was in the proper direction so that I was able to keep the sideslip down. So with the second selection on the rudders, the forces were bet[illegible], not quite as heavy as on the first selection. So the forces ended up to be quite reasonable. A fair amount of rudder was required, however. The forces were, I might say, noticeable but not heavy. Displacements seemed to be small for all three axes. Control harmony I thought was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Response to aileron-only input: there seems to be a very small amount of proverse yaw followed by what I thought, a fairly healthy amount of adverse yaw. When I coordinated it (you get coordinated almost immediately) rudder and aileron in the proper direction I could keep the sideslip small. I never was able to keep it quite perfect, but it was small. Oscillatory characteristics: the Dutch roll really wasn't overly oscillatory, but there was enough there to see that the airplane was responding. However, it was not objectionable. In maneuvering coordination was required and it took quite a bit of rudder during most of the rolling maneuvers. However, the rudder requirements weren't necessarily out of line.

BANK ANGLE CONTROLLABILITY

I could go at it quite aggressively. If I went at it too rapidly, there was a little tendency to overshoot. but going at it a little more normal manner, I could stop the bank angle pretty well. So I'd say my bank angle control was good.

HEADING CONTROLLABILITY

Good. The airplane, as I said, had a little bit of an oscillatory tendency, but it dampened itself out quite rapidly and the sideslip that was generated did seem to die out quite rapidly so that I didn't end up with any large sideslip angles during the maneuvering.

BANK ANGLE COMMAND TRACKING TASK

I thought the performance was not outstanding, but good. I could do it quite rapidly and get the needle in the center reasonably well. The only problems encountered there again were the sideslip and I just had to make a conscientious effort to coordinate that each time.

RESPONSE TO DISTURBANCE INPUTS

About what I could consider normal for this type of airplane. There was a little more effort required, but I didn't think any real significant deterioration in my performance with the presence of the random disturbances.

LONGITUDINAL CHARACTERISTICS

Good; they didn't degrade or interfere with the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they're acceptable, marginally satisfactory. I could really maneuver this airplane. I did, however, generate quite large sideslip angles if I didn't coordinate. Fortunately the coordination was in the proper direction. The Dutch roll was stiff enough that the sideslip angles didn't persist and they tended to dampen themselves out reasonably well. So I think it's on the borderline for being satisfactory without improvement in the air-to-air mission. In the air-to-ground, I think you'd probably have a little easier task with it because your maneuvering requirements are not quite as strong.

GOOD FEATURES

I like the maneuverability of the thing. I could really maneuver the airplane around. I thought the bank angle controllability was good.

OBJECTIONABLE FEATURES

The large sideslip that was generated if one didn't coordinate and the fact that it did take quite a bit of rudder for coordination and you had to kind of make sure you stayed with it all the time.

SPECIAL PILOTING TECHNIQUES

The one I just mentioned, you do need to coordinate the airplane for all maneuvers, fortunately the coordination is in the normal or proper direction.

PRIMARY REASON FOR THE PILOT RATING

I think the deficiencies are just slightly more than fair. I think that some pilot compensation is required. It's a borderline case.

CONFIGURATION 1 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.01 PILOT RATING 3 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought that it was going to be pretty good.

ABILITY TO TRIM

Laterally wasn't as good as it was directionally, but it wasn't bad. It wasn't a factor, anyway. Longitudinal trim was okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 355 deg/sec^2-in. $N'_{\delta_{RP}}$ = 27.5 deg/sec^2-in.

On the aileron I was able to pick nice light forces. I don't think I ever went back down on the gearings from what I started out. It felt to me like when I coordinated the airplane, my roll control heavied up a bit, so I ended up picking a light force. Coordination was for the most part in the adverse direction, but I didn't have any problem with feeling that it was heavying up on me with the forces that I selected. What I was really trying to say was that the rudder, when coordinated in the normal direction, had a tendency to cut down the roll rate, so I picked an aileron sensitivity that allowed me to coordinate the airplane and not feel like it was being cut down by coordinating. On the rudder: a little coordination was required, but when I lightened the rudder up, I tended to overcontrol a bit and using rudder in the normal direction had a tendency to cut down the roll rate so that I picked a sensitivity that was kind of a blend between being able to coordinate the airplane well and not being overly sensitive so that I didn't over-coordinate. Forces on both the aileron and the rudder were good. Displacements were small. Control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron-only, the roll rate seemed to be quite smooth without using the rudder. However, adverse yaw was generated ultimately and I'm willing to speculate that there was just a little bit of proverse yaw initially, but not very much, followed by adverse yaw. So that the predominant sideslip response was in the adverse direction, requiring coordination in the normal direction. When I coordinated it, I could feel that the roll rate was reduced a little bit. These things that I'm talking about are kind of minor, but I was able to keep the sideslip in the normal direction and what little proverse yaw, if there was any, was quite small and the predominant yaw response was in the adverse direction. As far as oscillations are concerned, the airplane was well damped in the Dutch roll and

no oscillatory characteristics to speak of. Maneuvering coordination requirements were definitely in the adverse direction and it was noticeable that you had to coordinate the thing, but you could do a pretty good job with it. It was a pretty reasonable blend with the ailerons to get the thing to do what you want and keep the sideslip in the middle.

BANK ANGLE CONTROLLABILITY

Quite good. You could roll right up and stop and do it aggressively with, if anything, a little bit of a tendency to overshoot, but that was very, very minor.

HEADING CONTROLLABILITY

Good. That was no problem. Dutch roll was well damped and you could point the airplane right where you wanted to.

BANK ANGLE COMMAND TRACKING TASK

My performance was quite good and I was going at it quite aggressively. So the aggression probably accounts for the small overshoot as much as anything else. Okay, problems encountered; sideslip was the only one and you had to coordinate the thing for each maneuver or you ended up with a fair amount of sideslip into the turn and when you didn't coordinate you could feel a little bit of reduction in the roll rate and this wasn't particularly good, but the coordination wasn't much of a problem.

RESPONSE TO DISTURBANCE INPUTS

Reasonable. I would say there was really no significant deterioration in my task performance, a little more effort required.

LONGITUDINAL CHARACTERISTICS

Good, didn't detract or degrade or interfere with the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they're acceptable; I think they are also satisfactory as they are. In the air-to-air role, the bank angle controllability is quite good. You do have to keep up with the sideslip. Fortunately the coordination requirements are in the normal direction so that I think a guy could get quite good at controlling the airplane. Air-to-ground, I think the same thing holds. Looking at the ground target, I was able to put the nose pretty much where I wanted to. So, no special problems included in either one of those.

GOOD FEATURES

The airplane is quite maneuverable. I can really rack the airplane around the sky and I can get performance that I want.

OBJECTIONABLE FEATURES

A minor objection is the fact that you do have to coordinate; it's a little more coordination than I would like to see. If you don't coordinate, your roll rate is not as smooth as it should be and causes you a bit of a problem.

SPECIAL PILOTING TECHNIQUES

Normal coordination required for all maneuvers, but that's pretty straightforward, so I'm not sure that's special.

PRIMARY REASON FOR THE PILOT RATING

The airplane is acceptable, I think it's satisfactory, however, I think it's only fair, I think the coordination requirements are certainly mildly unpleasant. Very little pilot compensation required.

CONFIGURATION 1 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.01 PILOT RATING 2 TURBULENCE RATING A

INITIAL IMPRESSION AND GENERAL COMMENTS

In the lateral-directional, handling qualities were very good, excellent roll control and very little oscillatory characteristics to put up with and the coordination requirements were small.

ABILITY TO TRIM

Directional was quite good, lateral was good, but not as good as the directional. The longitudinal tends to be worse than both of them. It's just that for some reason I don't seem to be able to put the nose right where I want it and I get a little up or a little down out of the thing each time on the longitudinal. So the ability to trim there is good but it's not as good as it could be.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 162 deg/sec^2-in. $N'_{\delta_{RP}}$ = 19.5 deg/sec^2-in.

Aileron control sensitivity: I liked and picked very light aileron sensitivities here. The tendency to couple with the aileron response seemed to be less for this configuration than for others. So that again there was no compromise on my selection. It was strictly what I thought I would like to have as far as forces and roll control capability with this particular airplane. Because the dynamics were so good, I was able to select the light aileron forces that I would like to fly the airplane with.

AIRPLANE RESPONSE TO PILOT INPUTS

With the aileron-only inputs, what I'm seeing is very little yaw due to aileron in the initial input and then as the roll rate picks up, I'm seeing very small amount of yaw due to roll rate. So that as the airplane begins to roll, there's a need to feed in rudder in the proper coordination direction. In other words, it looks like the sideslip is adverse due to roll, but it's very easy to coordinate here and with a little coordination, I can stop it. Making coordinated inputs, if I come on with the rudder as soon as I start to roll the airplane, then I seem to overcontrol the sideslip in the proverse direction. So that really what I need to do is feed in the rudder as I roll the airplane. That's natural in this configuration and not too difficult to do. The roll rate itself is very, very smooth and I was able to roll the airplane up, stop at a bank angle with ease. In the steady state, there is little or no requirement for rudder and I found that it was rather easy to coordinate the airplane.

BANK ANGLE CONTROLLABILITY

Outstanding. I really like the roll control particularly because on this one I don't get any sideslip built up with it.

HEADING CONTROLLABILITY

I can stop the airplane on a given heading and the nose will stay pretty much where I want it to.

BANK ANGLE COMMAND TRACKING TASK

Quite easy to perform and my performance was relatively good. There were no real problems encountered.

RESPONSE TO DISTURBANCE INPUTS

Seemed to be quite compatible with the lateral-directional. Certainly they do not degrade or interfere with the evaluation of the lateral-directional handling qualities.

LONGITUDINAL CHARACTERISTICS

Quite suitable for the fighter mission and acceptable and satisfactory without any improvement required.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Noticeable, but no more than what I would expect to see for a fighter class of airplane so that my performance is not as good as I can do in smooth air, but there's a certain amount of degradation that I expected to see.

GOOD FEATURES

Quite excellent roll control and the small amount of sideslip oscillation or Dutch roll oscillations that I see. The smooth roll rates following an aileron input are outstanding.

OBJECTIONABLE FEATURES

A very minor objection is the small requirement for coordination in the turns but if you don't coordinate, the sideslip really doesn't build up very much. However, it does require a little bit of rudder input to keep the ball in the center.

SPECIAL PILOTING TECHNIQUES

No special piloting techniques involved. Fly this airplane as aggressively as you would like with no problem. In general it was quite pleasurable to fly.

PRIMARY REASON FOR THE PILOT RATING

It has only negligible deficiencies and the only one that I can see is that small requirement for coordination as you roll and the fact that the faster you roll, the more input that you need. I like the airplane very much, it's certainly satisfactory as it is and pilot compensation is certainly not a factor.

CONFIGURATION 1 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.06 PILOT RATING 6 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Kind of mediocre, it was going to be very good or it was going to be very bad. Surprisingly, the more I flew it, the more little things I'd begun to notice about it that seemed to be problems.

ABILITY TO TRIM

Surprisingly good, both laterally and directionally. Longitudinal trim likewise was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 358 deg/sec^2-in. $N'_{\delta_{RP}}$ = 27.5 deg/sec^2-in.

On the aileron there was a little bit of a compromise because of the quite large proverse yaw that seemed to be associated with this configuration so that when I went up on the sensitivity, even though I didn't get into the more classical bank angle oscillatory characteristics, there was a tendency to overshoot in bank angle. But, the primary factor was just the fact that quite large sideslip was generated and the airplane kind of felt that it was scooping; I could feel the airplane kind of fly sideways when you made a rapid bank angle input because of the substantial proverse yaw generated. It didn't look like the sideslip had much effect on the roll control. So, the gearing was selected to make the forces light without allowing the sideslip from getting too great. On the rudder, the coordination requirements were kind of fritty. There was a fair amount of proverse initially, followed quite rapidly by a sideslip in the adverse direction. It was really a 1,2 type of thing and rudder sensitivity allowed me to cope with the adverse, not the proverse, because I really wasn't able to keep up with it that well. Forces that we ended up with were reasonable in both axes. I thought the displacements were small, control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Without the rudder, didn't put an awful lot of sideslip effect on the roll control. However, you did generate quite a substantial proverse yaw. Probably saw about an equal amount in adverse yaw in the other direction. However, roll control seemed to remain relatively smooth. Trying to coordinate this situation was really screwy because you had to kind of switch feet in the middle of an input and I find that very difficult to do. It was almost rudder in one direction, followed by an equal amount of rudder in the other direction for a given aileron control input so that the coordination problem was significant, I think. As far as oscillatory characteristics are concerned, the airplane seemed to be pretty well damped in the Dutch roll. The oscillation that I really had to contend with was this change in sideslip from proverse to adverse. Maneuvering I really couldn't keep up with the proverse, I ended up using mostly coordination in the normal direction and consequently I was overcontrolling the airplane from the initial control input and then keeping up with it pretty well once I got established in the turn maneuver. The coordination requirements were stringent, difficult for me to do.

BANK ANGLE CONTROLLABILITY

Fair to good, a little bit of a tendency to overshoot but it wasn't very difficult and primarily a function of my aggression.

HEADING CONTROLLABILITY

Wasn't as good as the bank angle control because of the sideslip that was generated but fortunately it did take itself out rapidly so you didn't feel that you had to come in and force the airplane to the point where you wanted to. The airplane was kind of sashaying back and forth, and I found that degrading on the heading control.

BANK ANGLE COMMAND TRACKING TASK

Performance was fair. Again, I kept having to devote some attention to the sideslip problem which I really did make worse for each initial aileron input. I think you could generate some rather large sideslip angles when you went at this one aggressively.

RESPONSE TO DISTURBANCE INPUTS

Wasn't very great; it shows up more in the sideslip than the roll. Only a minor deterioration in the performance resulted although more effort was required.

LONGITUDINAL CHARACTERISTICS

Good. They didn't detract or degrade lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

The characteristics are acceptable; however, they are not satisfactory. You've got quite a bit of sideslip to contend with. Every time you put in an aileron input it is something that you can't coordinate, at least I couldn't coordinate very well. In particular, I didn't like the requirement to change rudder from one direction to another, and if you didn't do this quite right you ended aggravating the sideslip. So I think in the air-to-air role the sideslips and repeatability with which they are coming in would greatly degrade your ability to track Air-to-ground, I think you have similar problems in the fact that sideslip gets to be important and this continuous movement back and forth for every aileron input I think would degrade your air-to-ground capabilities.

GOOD FEATURES

It was reasonably maneuverable. The sideslip that was generated didn't seem to have a real significant effect on the roll control.

OBJECTIONABLE FEATURES

I didn't like the fact that the sideslip coordination problem was a complicated one that I really couldn't accomplish very well. The large amount of proverse yaw associated with each initial aileron input was quite a detractor and I think it greatly reduced my accuracy.

SPECIAL PILOTING TECHNIQUES

Coordination was a problem; you had to use a cross-control followed by normal coordinating control inputs. I found that very disconcerting and difficult to do.

PRIMARY REASON FOR THE PILOT RATING

I think the characteristics as I see them here are certainly wanting improvement. I think they are objectionable and you could probably get along with them. How essential pilot compensation is, is difficult to say.

CONFIGURATION 1 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.06 PILOT RATING 3.5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought it was going to be a pretty good configuration. We had another T-33 to chase this afternoon and it worked out real well. It gave us the chance to do a couple of things. It was kind of interesting. As I said, my initial impression was that they were going to be pretty good. As I flew the thing more, my impression deteriorated a little bit from what I had at the beginning.

ABILITY TO TRIM

Lateral-directional and longitudinal, they're all good, no special problems involved there.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 275 deg/sec^2-in. $N'_{\delta_{RP}}$ = 39 deg/sec^2-in.

On the aileron sensitivity selection, I was able to pick nice light aileron forces. It's kind of interesting that while tracking another airplane I'd find that I probably didn't select as high a gear ratio as I have been. But it was nice and light and comfortable. Small displacements and no compromise involved because of the airplane dynamics. Rudder wasn't much of a problem because I didn't use the rudder very much and kind of accepted the forces that I started out with without very much iteration there on. Okay, the forces are light, the displacements are small, the control harmony is good. Toward the end of the chase of the other airplane, we joined and flew formation on him for a bit and it was obvious that the aileron sensitivity was quite light in that trying to make very small corrections that you normally make in formation, I could feel the jerkiness in the airplane. Now, that wasn't unacceptable, it wasn't uncomfortable, but just worthwhile pointing out to you that I noticed that the sensitivity was light at that point. Then, we looked at the longitudinal and it was obvious that my longitudinal characteristics were different from the other airplane and the sensitivity was a little light, but it was just barely noticeable that I was a little more jerky in pitch than the other airplane was.

AIRPLANE RESPONSE TO PILOT INPUTS

With aileron only, it appears to me that I have a slight amount of proverse yaw followed by adverse yaw as the airplane begins to roll. Trying to coordinate that kind of maneuver is difficult for me because if you wanted to keep the needle in the center all the time, you'd find yourself having to change rudder inputs from one foot to the other. So it was very difficult to do without thinking about it and only if I'm flying straight and level or thinking which way I'm going to turn can I even begin to keep up with it. It looked like the adverse yaw overwhelmed the proverse a little bit so that to get reasonable coordination, if I just delayed my rudder input a bit after I put in an aileron input I could coordinate the airplane pretty well. When I was tracking the other airplane, I felt the need for rudder and just kind of ended up see-sawing the rudders and not really accomplishing very much. I guess that I probably brought up some pretty noticeable sideslip angles. Nothing ever got out of hand or was really a problem, but I didn't keep the needle anywhere near the center or keep the ball anywhere near the center while tracking that other airplane. And really found out that I can do just as well without coordinating as I can with coordinating the airplane.

BANK ANGLE CONTROLLABILITY

Pretty good. There was no tendency to overshoot; I could fly the airplane aggressively, but it looked like when I did, the tendency to overshoot was more a function of my aggression than of the airplane dynamics themselves.

HEADING

Good. When I roll out, I have created some sideslip, the airplane does pick up about one or two cycles of oscillation, it looks like, but then dampens out real well. The heading control is good even when I don't coordinate.

BANK ANGLE COMMAND TRACKING TASK

I thought my performance was pretty good. I got carried away with aggression there and tried to outguess the needle, and so gave you a pilot induced, non-minimum phase response. So there were no real problems involved. I could feel the sideslip generated, but the sideslip didn't seem to carry over into the roll very much. One problem that I had when I stopped on a bank angle was that I could feel the Dutch roll, but mostly in sideslip, and it would settle down real quick. It was annoying certainly, but whether it really affected my bank angle tracking task - I don't believe that it did.

RESPONSE TO DISTURBANCE INPUTS

I thought they were reasonable and just about what I had expected of the fighter class of airplane and didn't seem to deteriorate my performance to a significant degree. It did require more effort because the airplane is now bouncing around and I'm having to put in additional inputs but it was not a major factor in this evaluation.

LONGITUDINAL CHARACTERISTICS

Good. They didn't detract or degrade the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they were suitable with some reservations. In other words, I don't think it's really an outstanding configuration, but I think it's at least an adequate or acceptable configuration, and at this point, I'm willing to say that it's marginally satisfactory. In the air-to-air role, I had good roll capabilities, good roll performance and no real problems created by the airplane dynamics in bank angle. I did have problems created in sideslip response which was excited every time I put in a control input and really was not able to coordinate these sideslip disturbances that I saw very well. I think it is probably a little better suited for the air-to-ground role than for the air-to-air role simply because you're normally not as aggressive and and you have a little more time for your sideslip response to die out. Fortunately, the sideslip disturbance dampens itself out in a nice reasonable length of time without a bunch of oscillations and that's kind of a saving thing for this configuration.

GOOD FEATURES

I like the roll control, I like the roll capability and I like the fact that I can fly the airplane aggressively even without coordinating it, and not generate large sideslip angles.

OBJECTIONABLE FEATURES

I dislike the requirement for cross-controlling followed by normal coordination to keep the ball in the center and, as a matter of fact, that's an objection because I don't do it very well and I don't think most people would. I noticed that when I did track the other airplane, that I didn't even attempt to do that. It was mostly rolling the airplane. The adverse yaw seemed to overwhelm the proverse so that the coordination I used was generally in the normal direction which created some problems initially, but tended to help out as the rolling maneuver developed. But in general, the coordination requirements, I think, are too great for a pilot to follow without a strong conscientious effort.

SPECIAL PILOTING TECHNIQUES

If you want to coordinate, you have to cross-control and then put normal rudder in to keep the needle in the center and I can only do that if I'm just concentrating on doing just that and not on something else.

PRIMARY REASON FOR THE PILOT RATING

It's kind of a tough one because I really think it's a borderline case. I think the coordination requirements and the amount of sideslip that I saw is more than just mildly unpleasant and I really couldn't compensate for it very well. It's a borderline between being satisfactory and not being satisfactory for the fighter mission, primarily because there may be times in there when you'd like to shoot your gun as soon as you get on the target and if you can't coordinate it, you end up with a lot of sideslip and you're not going to end up with the weapons trained on the other airplane. Okay, turbulence rating, as I said I didn't think there was any significant deterioration in my performance although there was more effort required.

CONFIGURATION 1 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.09 PILOT RATING 7 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

Wasn't going to be too bad. When we engaged, I seemed to be doing pretty good; then, as I tried to be aggressive with the airplane and tried to do tight tracking maneuvers, the real problems began to show up. So I had real trouble figuring out where this one was going to lie.

ABILITY TO TRIM

All three-axes, I thought was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 370 deg/sec^2-in. $N'_{\delta_{RP}}$ = 21.5 deg/sec^2-in.

On the aileron; I looked at values both above and below the initially given values and ended up taking the lower value because it tended to reduce some of this overcontrol tendency although I never could really get rid of it with this airplane. It gave me nice light forces because the airplane itself was quite maneuverable. You could fly the airplane around the sky quite aggressively, if you were careful about what happened to the sideslip. On the rudder; that was kind of a strange one. The airplane seemed to have proverse yaw associated with it and maybe a little bit of adverse toward the end, but the sideslip really needed coordinating. It took quite a bit of cross control initially and I'm not very good at doing that consistently. I think I tended to overcontrol the sideslip with the rudder somewhat, so I ended up not using an awful lot of rudder except to make corrections on the sideslip when it got too far away. So I don't think I even changed the rudder gearing from what was initially given. The forces were light and the displacements were small. The control harmony, in general, was good.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron only, quite a bit of noticeable proverse sideslip was generated on initial input and you could feel that the roll control, or the roll rate itself was not very smooth. There was a little bit of tendency for it to accelerate. Trying to coordinate that was difficult, the sideslip would go way out in the proverse direction and start coming back to the adverse direction. So that I wasn't very good at coordinating, and usually what I ended up doing was augmenting the sideslip. The Dutch roll itself directionally didn't seem to be oscillatory. However it was quite noticeable in a tight tracking task. You will be able to see that from the tracking task records. There is a quite dramatic tendency toward bank angle oscillation - not real PIO's since the thing is convergent. But, it is oscillatory in bank angle. In maneuvering coordination, quite a bit of cross coordination is required - I wasn't very good at doing that, I think I tended to augment the sideslip.

BANK ANGLE CONTROLLABILITY

With any degree of aggression this airplane is quite poor. You can feel the airplane oscillate both laterally and directionally, in other words, kind of like in the bottom of a dish, sloshing back and forth when you try to track the bank angle tightly. I think that was happening back there when we were tail-chasing 101's, and maneuvers were fairly general, i.e., I wasn't trying to be very precise, you just kind of keep up with them, these problems didn't show up. You can maneuver the airplane, do a pretty good job until you try to do something tightly and then bank angle problems show up; and I had significant ones there.

HEADING CONTROLLABILITY

The Dutch roll seemed to be fast enough that the sideslip angles that were generated pretty much took care of themselves. So I didn't have any trouble getting the airplane pointed in the direction I wanted to go. It was interesting though when I tried to make any corrections about the level flight attitude you could see the nose move back and forth off the target. So rather than saying heading control is good, we will call it fair.

BANK ANGLE COMMAND TRACKING TASK

Performance was lousy - it was very poor, primarily because of this tendency to overshoot and oscillate about the bank angle and I think that will come out quite dramatically for you on the records. Problems encountered there resulted primarily from the proverse yaw, and the fact that I wasn't able to coordinate that, created significant bank angle control problems.

RESPONSE TO DISTURBANCE INPUTS

Kind of about what one would expect I think for a fighter type airplane. There was really no significant deterioration although a little more effort was required in my performance.

LONGITUDINAL CHARACTERISTICS

Good; did not detract or degrade from the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Not very good and I think I'm willing to say they are not acceptable. I think the poor bank angle tracking capabilities and the large sideslip angle that I saw generated in the proverse direction were sufficient to call this not acceptable. It's kind of a borderline but I would say that in the air-to-air role where I put quite a bit of emphasis on good bank angle tracking, this airplane doesn't hack it. In the air-to-ground role, you might have a little better chance where things tend to be done a little less rapidly in bank angle. But you've got this nose moving back and forth with aileron control inputs on the ground tracking, so that's not very good either. Primarily, the problems that you encounter are the oscillatory tendencies in bank angle, the large proverse yaw which gives you, I think, quite noticeable nose displacements.

GOOD FEATURES

You had what I thought was reasonably good roll performance. You could maneuver the airplane around and if you didn't try to do things very tightly, you could probably put up a good get-away flight.

OBJECTIONABLE FEATURES

Major objection is the large proverse yaw which causes bank angle control problems. The oscillatory tendency in bank angle, and the fact that I can't coordinate the sideslip are objectionable features.

SPECIAL PILOTING TECHNIQUES

You might be able to learn to coordinate the proverse yaw but I didn't do a very good job in the short time I had to fly.

PRIMARY REASON FOR THE PILOT RATING

It's kind of really on the borderline. My dilemma is whether or not you could really do the job with it. The control problems that I see are objectionable, whether I can do an adequate performance in the sense of pilot compensation and interpreting that in this case, toning down my inputs and doing things more slowly -- I don't think I can do that. I'm going to take a stand and rate this a 7 rather than a 6.5 and say adequate performance is not obtainable when I maneuver the airplane aggressively. These bank angle oscillations are quite noticeable. I would say that that's not adequate performance, and I will give you a pilot rating of 7. As far as the turbulence rating - it really wasn't much effort required - I will give you a turbulence rating of B.

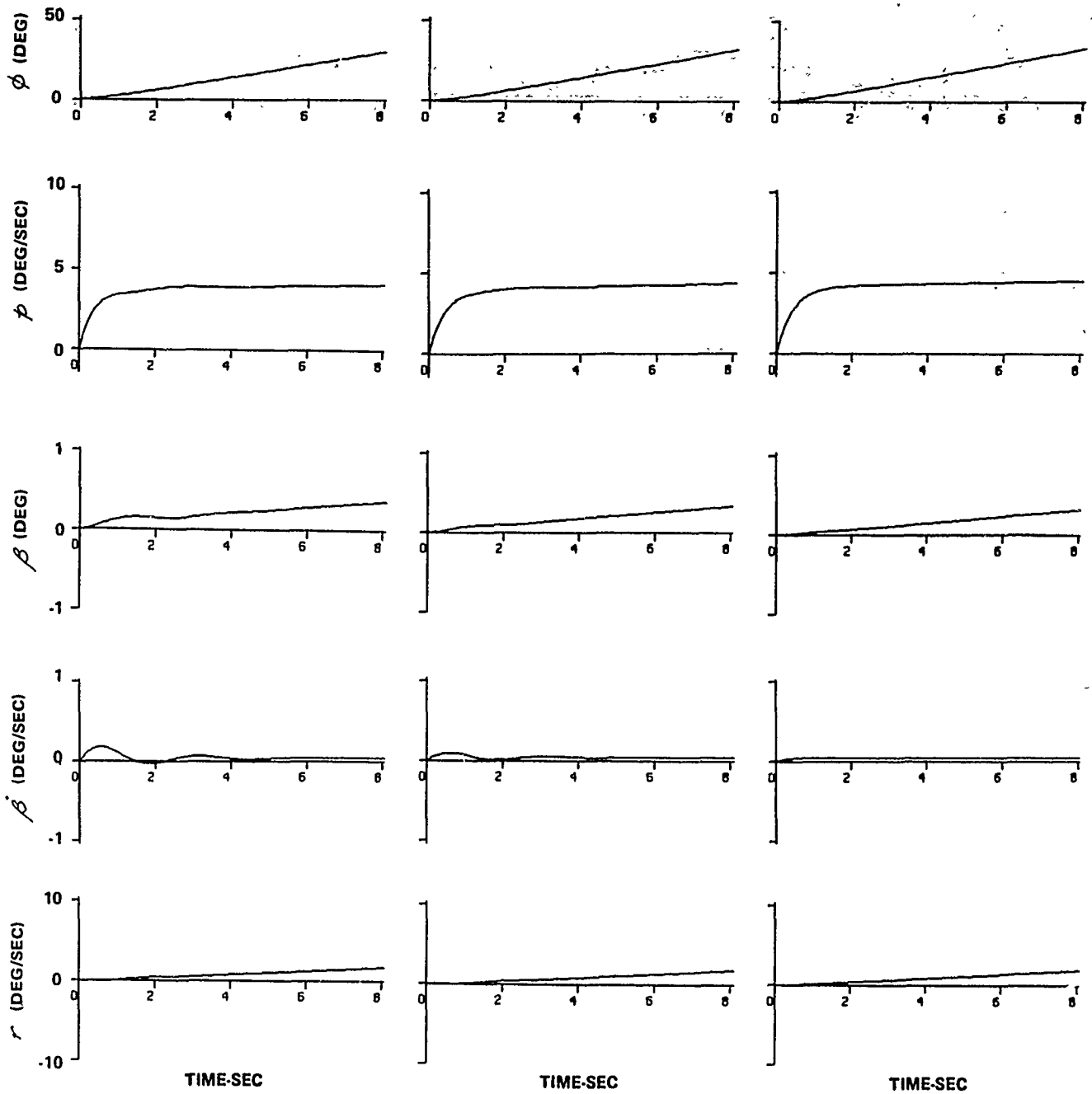
CONFIGURATION 5 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}} / L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/t$ LEVEL 1	$\Delta\beta_{max}/t$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.06	4	C	0.23	2.37	-190	0.005	6.0	4.0	0.13	425	32
-0.03	3	B	0.23	2.45	-225	0	4.4	3.0	0.04	425	29
-0.01	2.5	B	0.24	2.49	-255	0	4.0	2.6	0.04	404	26
-0.01	2.5	B	0.24	2.49	-255	0	4.0	2.6	0.04	125	19.5
+0.05	3	B	0.26	2.54	-320	0.020	3.9	2.5	0.07	380	26.5
+0.05	3	B	0.26	2.54	-320	0.020	3.9	2.5	0.07	304	20
+0.08	5	C	0.26	2.70	-350	0.025	4.4	3.0	0.12	295	24

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

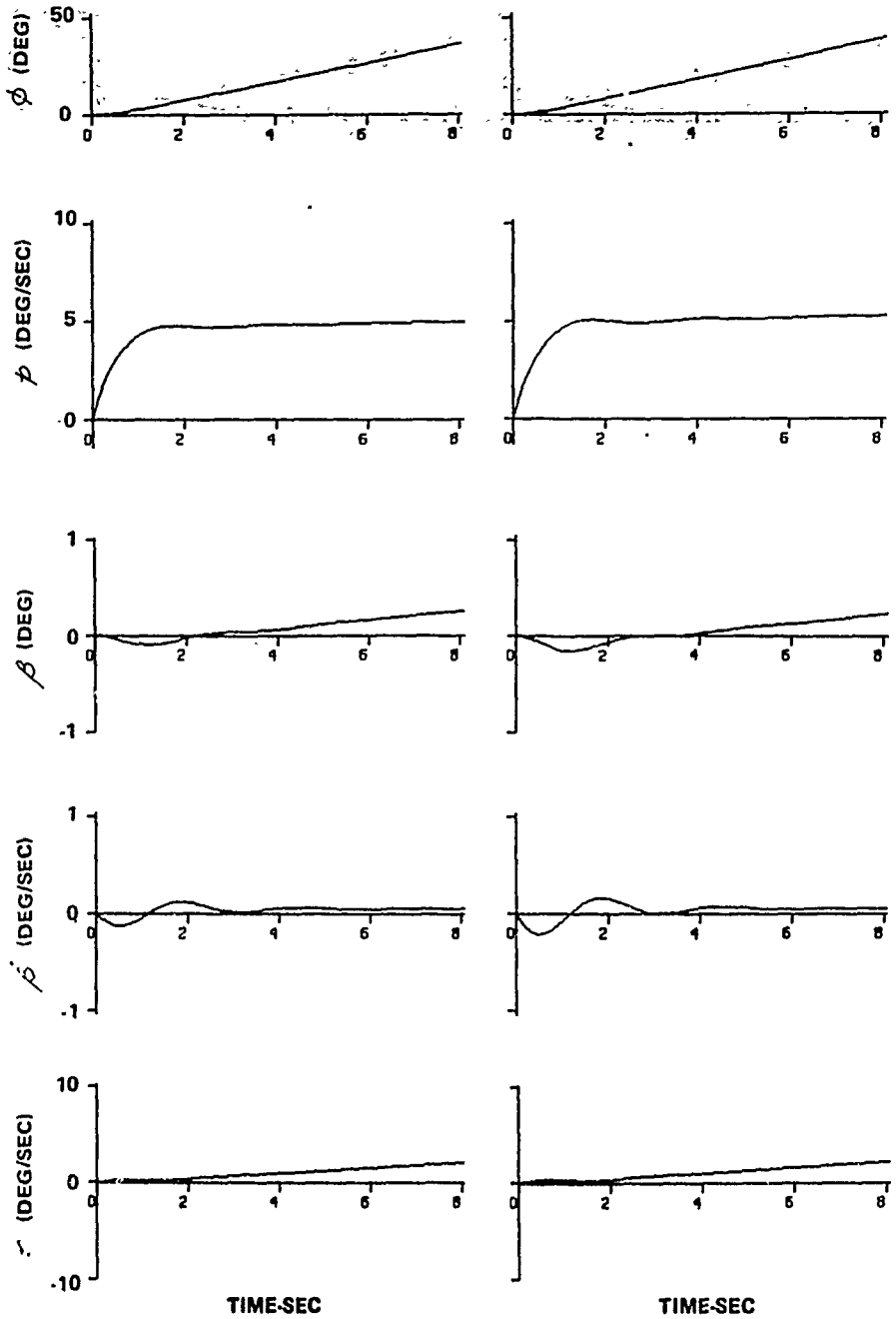
ω_d	= 2.50	N'_β	= 6.31	L'_β	= -11.8
ζ_d	= 0.24	N'_r	= -1.05	L'_r	= 2.36
τ_R	= 0.42	N'_p	= -0.068	L'_p	= -2.36
τ_s	= -100*	$\frac{g}{V}$	= 0.0586	Y_β	= -0.172
$\left\|\frac{\phi}{\beta}\right\|_d$	= 1.61	$Y_r - 1$	= -0.99	$Y_{\dot\beta}$	= -1.015
$\measuredangle \left(\frac{\phi}{\beta}\right)_d$	= 50.2	$Y_p + \alpha_o$	= 0.0029		

*UNSTABLE SPIRAL



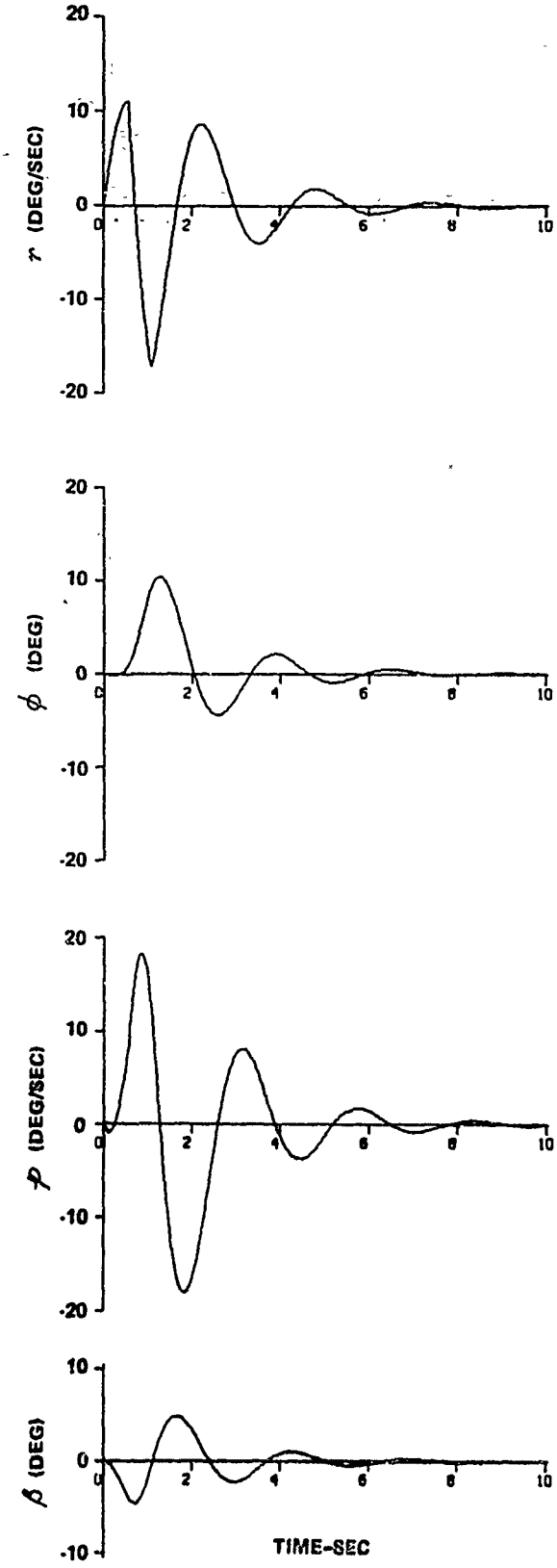
$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.06 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.03 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.01

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 5

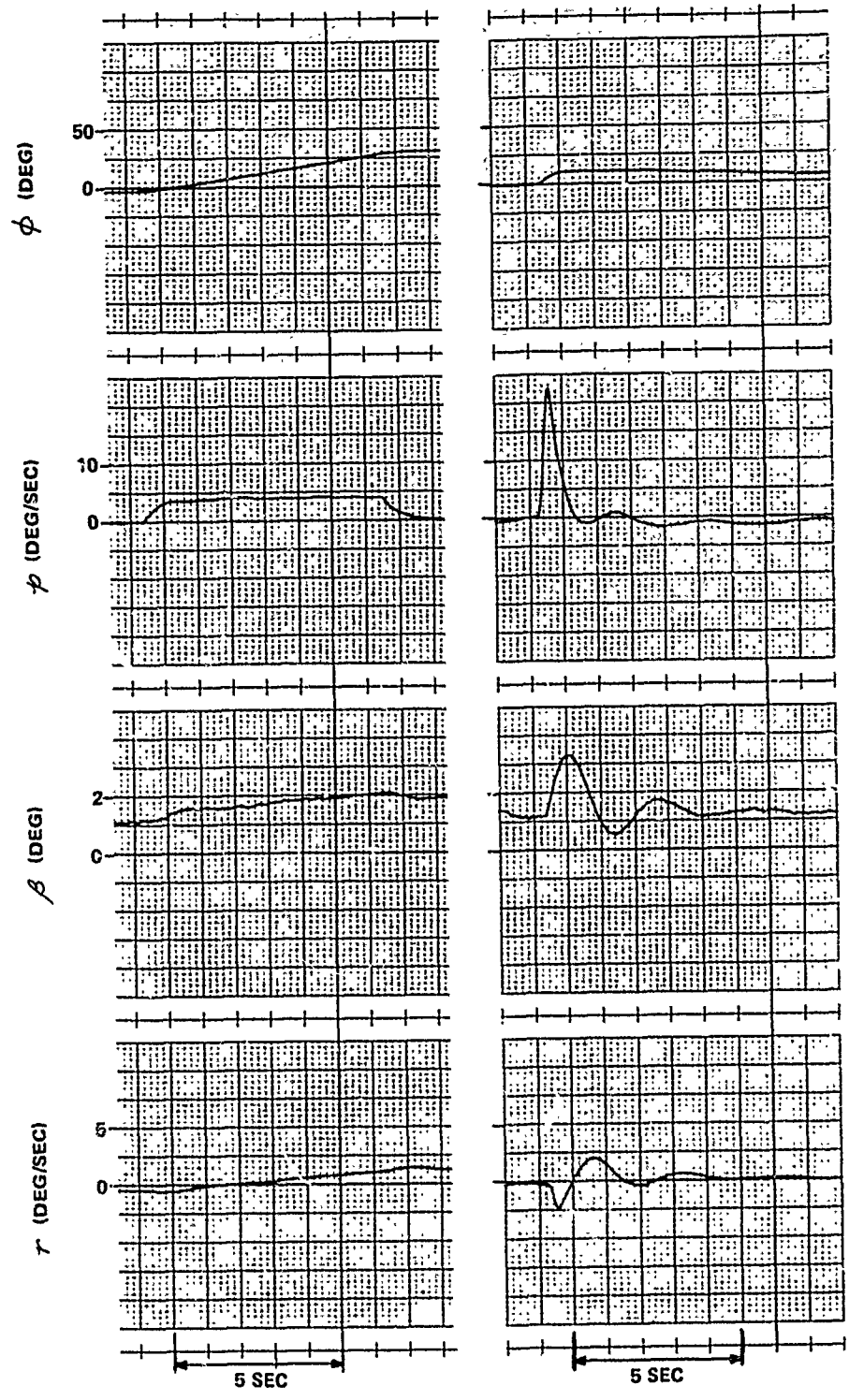


$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.05$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.08$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 5



COMPUTER GENERATED TRANSIENT RESPONSES TO RUDDER DOUBLET FOR CONFIGURATION 5



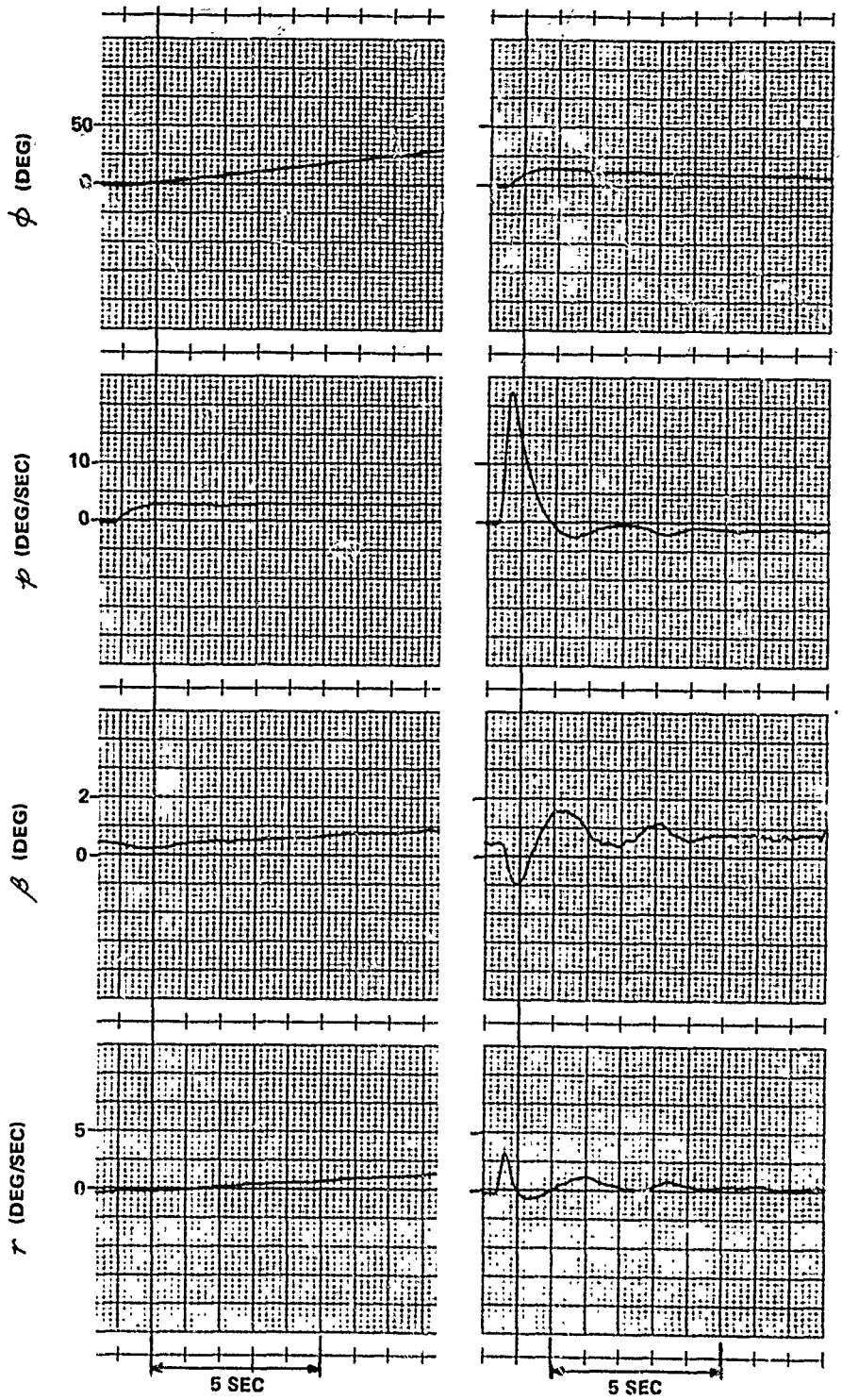
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.06$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.06$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 5



$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.08

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.08

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 5

CONFIGURATION 5. $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.06 PILOT RATING 4 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression was that it wasn't going to be too bad but wasn't going to be very good either because it did have kind of a funny sideslip response. It turned out to be "coordinatab. ", but the airplane did have some problems.

ABILITY TO TRIM

Laterally and directionally good, as it was longitudinally.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 425 deg/sec^2-in. $N'_{\delta_{RP}}$ = 32 deg/sec^2-in.

On the aileron, no real compromise there. The Dutch roll that I saw didn't seem to affect the roll control very much, so that I was selecting the value of aileron sensitivity that I liked. The rudder, however, presented a problem because for rapid maneuvering it looked like I needed a fair amount to coordinate the sideslip but then, when I did that, at the start of a roll maneuver, I was pushing the sideslip out the other side. It took me a while to figure out that the airplane seemed to have a small amount of initial proverse yaw due to aileron. This was creating a problem for me both starting maneuvers and also around the small or near zero sideslip conditions. So I had to back down on the rudder sensitivity, and that made life a little better. The forces in all three axes were good and in general light; displacements were small; control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

For an aileron-only input, there seemed to be fairly smooth roll rate with no real problems with Dutch roll showing up in roll rate. However, you did get fair amount of sideslip going out in the adverse direction although it looked like initially it was proverse followed by a stronger adverse response. To coordinate that with the rudder you just kind of delayed a little bit and then came in with the rudder. I could keep the sideslip reasonably small but I never was able to keep it right at zero. The airplane did seem to have a little bit of an oscillation to it, but it was showing up almost exclusively in sideslip and very little in roll. In maneuvering for the most part the coordination requirements were in the normal or adverse direction and not too difficult to accomplish. However, I was not able to be very precise with keeping the sideslip near zero.

BANK ANGLE CONTROLLABILITY

Pretty good, and there were no outstanding problems involved there. I could roll to and stop at a bank angle with ease.

HEADING CONTROLLABILITY

Little bit of a different story, although not too bad. The airplane was oscillatory at a medium frequency but sideslip was excited both starting and stopping roll rates and you noticeably felt the airplane move in the directional axis. This happened to me every time I put an input in, kind of shook your head around a little bit.

BANK ANGLE COMMAND TRACKING TASK

My performance was good; no real problems there with the exception of the sideslip. It was just that I wasn't able to coordinate the sideslip very well, either because it was doing something I didn't expect it to do, or I wasn't very good at it with my feet.

RESPONSE TO DISTURBANCE INPUTS

The airplane had about a normal response for the fighter mission. I don't think it really caused more than a minor deterioration in my ability to perform the fighter mission.

LONGITUDINAL CHARACTERISTICS

Good and did not detract from the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

The characteristics are acceptable, but I'm going to say they are not satisfactory primarily because of the goings on in the sideslip response. I never was very good at making sideslip come out precisely and occasionally when I got distracted from other things, I built up some fairly large sideslip angles. In the air-to-air role, moving around in heading every time you put in an aileron input or took one out, it would be enough to degrade my precision with which I could attack an air-to-air target. Air-to-ground I think you've got similar problems because every time I move the stick, the nose would do something that was a little bit different to what I would like for it to do and I think that would cause you some problems in hitting ground targets.

GOOD FEATURES

The roll control was good; the roll performance was good.

OBJECTIONABLE FEATURES

I couldn't coordinate the sideslip; the nose did things other than what I would have liked for it to do and I seemed to have very little control over being able to make it do something differently.

SPECIAL PILOTING TECHNIQUES

You do need coordination in the adverse direction. It was not the easiest thing to do and I couldn't always keep the ball in the center. When you didn't coordinate, you could end up with some large sideslip angles.

PRIMARY REASON FOR THE PILOT RATING

The airplane is acceptable. However, I do not feel that it is satisfactory and I think the deficiencies that I have talked about warrant improvement. They are really minor but I think they are annoying. In turbulence, more effort is required but there is only a minor deterioration in task and again that's primarily in the directional mode.

CONFIGURATION 5 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.03 PILOT RATING 3 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

It was a pretty reasonable fighter-type airplane in that the lateral-directional handling qualities in general would be pretty good.

ABILITY TO TRIM

Lateral-directionally was good. I still have a little problem with the lateral getting it trimmed just as perfectly as I would like. On the longitudinal, the trim was okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 425 deg/sec^2-in. $N'_{\delta_{RP}}$ = 29 deg/sec^2-in.

No compromise whatsoever on the ailerons. I picked nice and light forces like I like so that I have good roll performance with very light and very small displacement inputs. The rudder, however, was a bit more of a problem. Because I was exciting a little sideslip, my first thought was to heavy up the rudder but that made things worse. I started out heavy and then lightened them up a bit. The final selection was of course, pretty good. Control harmony in all three axes was good. The displacements were small.

AIRPLANE RESPONSE TO PILOT INPUTS

Roll response seemed to be very smooth and I thought I had good roll control, both with and without rudder inputs. There did seem to be adverse yaw associated with aileron input requiring rudder coordination into the turn and a little more than I would like, but not bad. The airplane had only one or two overshoot oscillations associated with very rapid maneuvering. The airplane dampened itself out in yaw very easily. I did have to coordinate the airplane to keep the sideslip small, but it was in the proper direction and not difficult to do. If I maneuvered without coordinating, I would generate sideslip but the airplane seemed to be damped enough that the sideslip went away reasonably fast.

BANK ANGLE CONTROLLABILITY

Very good and had no problems getting the bank angles that I wanted, doing it quite aggressively.

HEADING CONTROLLABILITY

No problem either. I could achieve a bank angle, roll the airplane out and I'd get a very small overshoot in sideslip but the airplane would settle down pretty much where I wanted it to go.

BANK ANGLE COMMAND TRACKING TASK

I wasn't quite as good as I wanted. I don't know why. I tended to oscillate just ever so slightly when I tried to stop the needle right in the center. And I never could really figure out why. If I toned down my gain on my aggressiveness a bit, that overshoot tendency went away. Performance was nevertheless good and really there were no serious problems involved.

RESPONSE TO DISTURBANCE INPUTS

Showed up mostly in the sideslip and a little in roll. In the sideslip, disturbances that were there damped out reasonably quick.

LONGITUDINAL CHARACTERISTICS

Good; a good match with the lateral that I had.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

They're quite acceptable and I think they're satisfactory for the fighter mission. In the air-to-air role, my initial stop on the target is not quite as precise as I would like because of this small sideslip disturbance. I saw the same thing when attacking ground targets. I think it's less of a problem on the ground mission than it is on the air-to-air because on the former you usually have more time in that initial stopping; it is not as critical.

GOOD FEATURES

I like the fact that the roll was very smooth, that I could maneuver the airplane aggressively, and select nice light forces without any problems. I like the fact that the sideslip disturbances that I do see tended to dampen themselves out quite nicely and my roll control was good.

OBJECTIONABLE FEATURES

The only real objection was the fact that sideslip was generated during abrupt rolling maneuvers. I could coordinate this, coordination was in the proper direction, but I would prefer to see an airplane without any sideslip generated.

SPECIAL PILOTING TECHNIQUES

No special piloting techniques required.

PRIMARY REASON FOR THE PILOT RATING

The airplane is acceptable and satisfactory without improvement. The sideslip disturbances that I see fall in the category of being mildly unpleasant. I think that very minimal pilot compensation is required. Turbulence did increase the effort because it increased the amount of rudder that I required, but really no significant deterioration in my performance.

CONFIGURATION 5 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.01 PILOT RATING 2.5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

This was indeed a good airplane and fun to fly.

ABILITY TO TRIM

Lateral-directionally was good. I don't know if it's because the aileron trim gain is too high or what, but I don't seem to be able to put the airplane right on an even keel and it doesn't look like it's the spiral characteristics. I think it's just the fact that I overcontrol with the trim. The directional trim was real good, though. Longitudinal trim was also good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 404 deg/sec^2-in. $N'_{\delta_{RP}}$ = 26 deg/sec^2-in.

On aileron sensitivity, no compromise is involved. I just selected the light forces so I could make the airplane do what I wanted it to with very small inputs. You kind of think the airplane through. If anything, I feel like I'm a little high. In the tracking task, I have a tendency to overshoot a little bit in roll, primarily, I think, because of the light sensitivities and my aggressiveness. But, there were no compromises really on the aileron. There was a little sideslip generated but I never could really keep it zero. Fortunately the airplane was stiff enough so that the sideslip never really got very large. The forces, all three axes, were light. Displacements were small. Harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Roll rate was very smooth. The little bit of sideslip generated with roll seemed to be in the adverse direction. Coordinating really didn't seem to make too much difference. The sideslip generated was small enough that I couldn't really see any significant change either in the roll rate or the Dutch roll with the coordinated inputs. The airplane seemed to be well damped, no oscillatory characteristics really stood out. In maneuvering, it looked like it needed a little bit of coordination in the proper direction. However, when I did coordinate, I didn't really help things very much and if anything tended to get as much sideslip in the other direction.

BANK ANGLE CONTROLLABILITY

Very good. I could roll up, stop the airplane wherever I wanted to and the overshoots that I did see in bank angle were primarily a function of the aggression with which I attacked the rolling maneuvers and not so much of the configuration.

HEADING CONTROLLABILITY

Good; the airplane seemed to be well damped directionally and the little bit of sideslip that I was seeing dampened itself out rapidly enough not to become a problem.

BANK ANGLE COMMAND TRACKING TASK

My performance was good and, as I mentioned earlier, when I really went at it aggressively, which I could do, there was a slight tendency to overcontrol primarily due to the light sensitivity of the controls and the fact that I could put in abrupt inputs to do the task. So no real problems were encountered.

RESPONSE TO DISTURBANCE INPUTS

No outstanding feature stood out in turbulence. Effects seemed to be about all equal in the three axes and not much more than what I would expect to find for a fighter-type airplane.

LONGITUDINAL CHARACTERISTICS

Good. Good combination, good harmony with the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

These characteristics are suitable; I like the nice smooth roll control, I think you would do a good job in the air-to-air. A little bit of sideslip is excited, but it's not a major problem. Air-to-ground, I think you could probably do an even better job than you could in the air-to-air because the small amount of sideslip that I see dampens itself out so rapidly and you've got a little more time in an air-to-ground run.

GOOD FEATURES

I like the smooth roll control; I like the fact that very little sideslip was generated and that it was in the adverse or proper coordination direction making it easy to coordinate. I like the fact that the Dutch roll was well damped so that there were no real oscillatory characteristics.

OBJECTIONABLE FEATURES

The only minor objection is the fact that some sideslip is generated; I was never really quite capable of keeping exactly at zero as I maneuver the airplane abruptly.

SPECIAL PILOTING TECHNIQUES

No special piloting techniques involved. You could fly the airplane by coordinating the sideslip that was generated or simply by not coordinating it.

PRIMARY REASON FOR THE PILOT RATING

The airplane is acceptable and satisfactory as it stands. I think the small amount of sideslip that I did see is a negligible deficiency. In turbulence, I think the little more effort required, but no significant deterioration in my performance.

CONFIGURATION 5 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.01 PILOT RATING 2.5 TURBULENCE RATING -not available

INITIAL IMPRESSION AND GENERAL COMMENTS

This was a practice evaluation and no artificial turbulence was available.

ABILITY TO TRIM

Both laterally and directionally quite good. It holds its trim well and natural turbulence seemed to be quite compatible with the airplane that I have. So the ability to trim is very good. Longitudinal trim is likewise good, now that I've cut the elevator sensitivity down.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 125 deg/sec^2-in. $N'_{\delta_{RP}}$ = 19.5 deg/sec^2-in.

The forces are light, quite comfortable on both the aileron and the elevator. Rudder seems to be pretty good. The control harmony is very good. It was interesting, we started off with heavy aileron forces and the light elevator. I was bobbling the airplane in pitch every time I made a turn. Now that I've gotten the aileron forces lightened up, elevator forces are quite compatible. On the aileron I just selected control forces that I thought were light enough to roll the airplane at any rapid rate that I wanted to. There was no compromise with airplane characteristics. When I initially lightened them up, I found that I tended to overcontrol in yaw a little bit. When I initially roll into the turn, I don't seem to need any rudder inputs. As a matter of fact it looks like the yaw is ever so slightly proverse on initial aileron input and then as I roll, the yaw is very definitely adverse so that I kind of have to feed in the rudder as I pick up the roll rates, and end up in a steady turn holding a little bit of rudder to keep the needle in the center. It's very easy to accomplish and hasn't bothered me too much although it's noticeable.

AIRPLANE RESPONSE TO PILOT INPUTS

For an aileron-only input, I get the impression that the nose starts off ever so slightly in the proverse direction or in the direction of the turn and then the sideslip needle stays pretty close to the center. As the roll rate picks up however, the needle comes into the turn indicating adverse yaw. If I coordinate the airplane with the rudder, I can keep the needle in the center. The airplane seems to have no oscillatory response that results from my inputs. The airplane is well damped and I haven't gotten myself into any lateral or directional oscillations ever when I maneuver the airplane somewhat rapidly. However, coordination is required if I want to keep the sideslip perfectly zero in constant bank angle turns, say 60°.

BANK ANGLE CONTROLLABILITY

Bank angle controllability is very good. I find that I can stop the airplane most anywhere in roll that I want.

HEADING CONTROLLABILITY

No comments.

BANK ANGLE COMMAND TRACKING TASK

My ability to track bank angle is very good, although with the high sensitivity that I have selected, I do tend to overshoot when I go at it aggressively. However, that is no real problem.

RESPONSE TO DISTURBANCE INPUTS

No comments.

LONGITUDINAL CHARACTERISTICS

In general the longitudinal handling qualities do not detract or degrade the lateral-directional at all. I like the light stick forces.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

They're very good. I like the rapid roll capabilities. I have good bank angle control to stop the airplane almost any place that I want. I can track ground targets laterally quite well. The only objection that I see is the little bit of coordination required on the rolls and the little bit of requirement to hold the steady state rudder in the turn.

GOOD FEATURES

I like the smooth roll rates, the fact that there is very little or no Dutch roll showing up in the roll rate, giving me nice smooth bank angle control. I like the fact that I don't see any oscillatory characteristics as I maneuver abruptly. I like the fact that I can pick light aileron forces.

OBJECTIONABLE FEATURES

Minor objection: the requirement for rudder during the rolls and the fact that it appears to me to be a function of roll rate. Again the amount of sideslip that I'm seeing is very small.

SPECIAL PILOTING TECHNIQUES

A little bit of technique in that for aileron inputs you just hesitate a moment on the rudder and you come in with rudder as the roll rate picks up.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is satisfactory without any improvement as it is. I think that the deficiencies that I see are somewhere between negligible and mildly unpleasant. A real good airplane, I enjoyed flying it.

CONFIGURATION 5 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +.05$ PILOT RATING 3 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

As I flew the thing, it was a little better than I had initially thought it was going to be.

ABILITY TO TRIM

Good, in all three axes.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 380$ deg/sec^2-in. $N'_{\delta_{RP}} = 26.5$ deg/sec^2-in.

I was able to select nice light aileron and rudder sensitivities. On the aileron, light sensitivities didn't create any problems. Rudder created problems for me because I started out trying to coordinate the sideslip that I was generating with the ailerons and then finally gave up, decided the airplane was doing a better job of coordinating than I was. So rudder sensitivity really doesn't have a lot of meaning. The forces were light, displacements were small in all three axes.

AIRPLANE RESPONSE TO PILOT INPUTS

For an aileron-only input, it appeared that I was generating a slight amount of proverse yaw and that I could indeed feel the roll rate accelerate a little bit for rapid roll maneuvers. One of the good things about the configuration was the rapid roll capability for this configuration. I tried to coordinate and I only made things worse because when I flew the airplane aggressively, in general, I tended to coordinate in the normal direction and with the slight amount of proverse yaw this would only make things worse. Without coordination, the sideslip never got very much out of hand and really didn't seem to feed into the roll response very much. So, it turned out better not to coordinate. There weren't really any oscillatory characteristics that were bothersome, although they were noticeable. For maneuvering, coordination requirements were nil. Sideslip was, in fact, generated for each rolling maneuver. It's just that when I tried to coordinate, I generally made it worse.

BANK ANGLE CONTROLLABILITY

Good, but not excellent by any means due to a very slight tendency to overshoot sometimes on the bank angle.

HEADING CONTROLLABILITY

Only good. I would roll out and have the slight sideslip oscillation which would dampen out in a very few cycles.

BANK ANGLE COMMAND TRACKING TASK

Performance was, in general, good. If anything I had a very slight tendency to overcontrol in bank angle, but this I emphasize was only very small. Sideslip again didn't create any significant problem, but it was noticeable.

RESPONSE TO DISTURBANCE INPUTS

Relatively small and didn't seem to create any particular problems in either axis and only a minor problem as far as task deterioration is concerned.

LONGITUDINAL CHARACTERISTICS

Did not affect the lateral-directional; they were good.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Acceptable, and satisfactory, but only marginally satisfactory for the air-to-air role. You've got real good roll capability, you don't have real good sideslip control, but the sideslip angles generated are not really large. Air-to-ground, I think you'd probably have a reasonably good airplane too. So no real special problems with either of those two roles.

GOOD FEATURES

The roll capability I think is really great. Bank angle controllability is good, but not outstanding.

OBJECTIONABLE FEATURES

The small amount of proverse yaw that's generated and the fact that enough sideslip is generated that I feel like I'd like to coordinate it, but when I try to coordinate it I seem to make things worse, so I ended up just putting up with the sideslip that was generated.

SPECIAL PILOTING TECHNIQUES

I ended up flying feet on the floor.

PRIMARY REASON FOR THE PILOT RATING

The airplane is acceptable and it's only marginally satisfactory, it falls in the fair category. In turbulence, more effort is required but no significant deterioration.

CONFIGURATION 5 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +.05$ PILOT RATING 3 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

It was a reasonably good configuration. I couldn't maneuver the thing as rapidly as I wanted to for some reason and I don't understand why.

ABILITY TO TRIM

Good on all three axes, there was no problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{RS}}$ = 304 deg/sec²-in. $N'_{\delta_{RP}}$ = 20 deg/sec²-in.

Didn't seem to be any compromise involved. I selected quite light ailerons; still didn't get quite as light as I would have liked. I had to wait for the fuel to come down in order to get what I thought were good aileron forces. It seemed to me that some proverse yaw was generated every time I put in an aileron input, followed by some adverse yaw once I got into the turn. The sideslip that was generated in either direction wasn't very much so that I really didn't spend an awful lot of time coordinating. So I accepted the initial rudder sensitivity selection. Forces on ailerons were a little heavier than I would have liked and I had some problem because I couldn't maneuver the airplane as rapidly as I would like. Rudder forces were really not too noticeable because I didn't use the rudder that much. Displacements were small on both controls. Control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron input without the rudder resulted in a fairly smooth roll rate generating a little bit of proverse yaw followed by adverse yaw. When I tried to coordinate this, there was a cross control maneuver. I wasn't very good at it. The Dutch roll seemed to be of reasonable enough frequency that the sideslip was centering itself before I really had a chance to keep up with it. So sideslip was generated but it didn't seem to be a major factor. The airplane seemed to be very well damped in the Dutch roll and oscillations didn't seem to be a problem. In maneuvering, there wasn't much rudder required and you could fly the airplane essentially with your feet off the rudder and do just as good as you could by using the rudder. So coordination requirements were very small.

BANK ANGLE CONTROLLABILITY

A little puzzling. When I really went at it, it looked like I would have a tendency to overshoot the bank angle. But for the most part I was able to roll up and stop with the roll rates that I was able to achieve, so that the bank angle control I thought was good. However, I think if I had been able to maneuver the airplane more rapidly I could have gotten myself into some slight overcontrol problems.

HEADING CONTROLLABILITY

Good. The Dutch roll was well damped. The frequency was moderate so that the heading control didn't seem to be a problem.

BANK ANGLE COMMAND TRACKING TASK

Performance was pretty good. I could stop the bank angle quite nicely.

RESPONSE TO DISTURBANCE INPUTS

Seemed to be fairly minimal. I really didn't think there was any significant deterioration in my task performance and only a very slight more effort required.

LONGITUDINAL CHARACTERISTICS

Didn't detract from the lateral-directional evaluation; they were good.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they are acceptable. I think they are satisfactory. I think for the air-to-air role, we've got a little bit more sideslip than I would like to see generated and this would cut down on your precision a little bit, but I think it is something you could live with. In the air-to-ground role, I suspect the airplane to be a little better. The turbulence response is low and the sideslip generated is low so there are no special problems involved.

GOOD FEATURES

I like the fact that you could maneuver the airplane without having a lot of rudder coordination required. I like the maneuverability.

OBJECTIONABLE FEATURES

The small amount of proverse yaw followed by the adverse yaw is objectionable because you can't coordinate it effectively. It is there and I think it would have a tendency to cut down your precision.

SPECIAL PILOTING TECHNIQUES

To coordinate the airplane requires rudder out of the turn and into the turn if you want to keep the sideslip in the center. That's very difficult for me to do unless I am concentrating specifically on that task.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable. I think it is satisfactory. I think the sideslip that I see generated falls into the mildly unpleasant category.

CONFIGURATION 5 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.08 PILOT RATING 5 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought it wasn't going to be too bad. It looked like a good maneuverable type airplane. Sideslip generated wasn't too bad. However, it was obvious that it was in the proverse direction. As I flew the thing I began to have misgivings either way, good and bad. I did have a tendency to overshoot and get one or two oscillations about the bank angle.

ABILITY TO TRIM

Good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 295 deg/sec^2-in. $N'_{\delta_{RP}}$ = 24 deg/sec^2-in.

I think I went up a bit, just a little bit from what I started out with in the aileron, to see what increased sensitivity might do for me. It turned out that I liked that a little better so I ended up picking a sensitivity that I thought allowed me to keep from overcontrolling the airplane too dramatically, and at the same time gave me nice light forces for maneuvering. There really was not much of a compromise there. I think that if I hadn't had the sideslip problem and the overcontrolling problem I might have gone higher on the gearing. On the rudder I had to decrease the sensitivity from what we started out with because I was overcontrolling the sideslip initially. The reason is because there was proverse yaw initially which gave way to adverse yaw and I ended up having to hold a little bit of rudder into the turn. With the lighter rudder sensitivity I was overcontrolling, making the initial sideslip excursion greater and then pushing the sideslip away from the turn. So, decreasing the sensitivity on the rudder helped that problem somewhat. The forces that I ended up with were a little lighter than medium; displacements were small; control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron only, there was proverse sideslip generated initially and ended up in the adverse sense. I didn't get a whole bunch of oscillations, nor did it take a lot of time for the oscillations to die out. Although I really felt the need to coordinate, I wasn't able to keep the needle in the center. So, I ended up accepting the initial sideslip excursion in the proverse direction and then using just a little rudder to tone up the sideslip in the steady state, i.e., help the sideslip to get back to the center sooner. This had a tendency to reduce the accuracy that I think one might be able to achieve with this airplane.

BANK ANGLE CONTROLLABILITY

Only fair; there was a tendency in flying the airplane aggressively to overshoot causing about one or two oscillations before it would settle down on the bank angle that I wanted. The sideslips generated however didn't seem to affect my roll control all that much.

HEADING CONTROLLABILITY

At least fair; it is certainly in the 4 category because the oscillations are there. However, they are quite reasonably damped and the frequency is fast enough so that I don't end up with the airplane pointed in a direction that I didn't want it to go.

BANK ANGLE COMMAND TRACKING TASK

Only fair again. I had a tendency to overcontrol slightly and set up a one or two oscillations before it would settle down on a bank angle, but I could perform the task.

RESPONSE TO DISTURBANCE INPUTS

Just about what I might expect for a fighter type machine - it didn't seem to cause much of a problem. If anything, a little more effort is required but it causes only a minor deterioration in my ability to perform the task.

LONGITUDINAL CHARACTERISTICS

Okay; didn't detract from the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I'm willing to say the characteristics are acceptable. They are not good; they are certainly not satisfactory as they are. The sideslip that's generated would cut down my ability to put guns on the target as well as I would like. However, I think I could do it because the sideslip excursions are small enough and seem to be fast enough. Air-to-ground, I think you might do a little better job because you can take things a little slower.

GOOD FEATURES

The airplane has good roll performance; you can really rack the airplane around. Turbulence response wasn't bad.

OBJECTIONABLE FEATURES

Primary objection is the proverse yaw which is the thing on which I am blaming my control problems in bank angle. The fact that my bank angle control isn't as precise as I like, and the fact that enough sideslip is generated degrades my accuracy but I think I can still do the job.

SPECIAL PILOTING TECHNIQUES

You might be able to coordinate the proverse yaw. However, I wasn't good enough to do it.

PRIMARY REASON FOR THE PILOT RATING

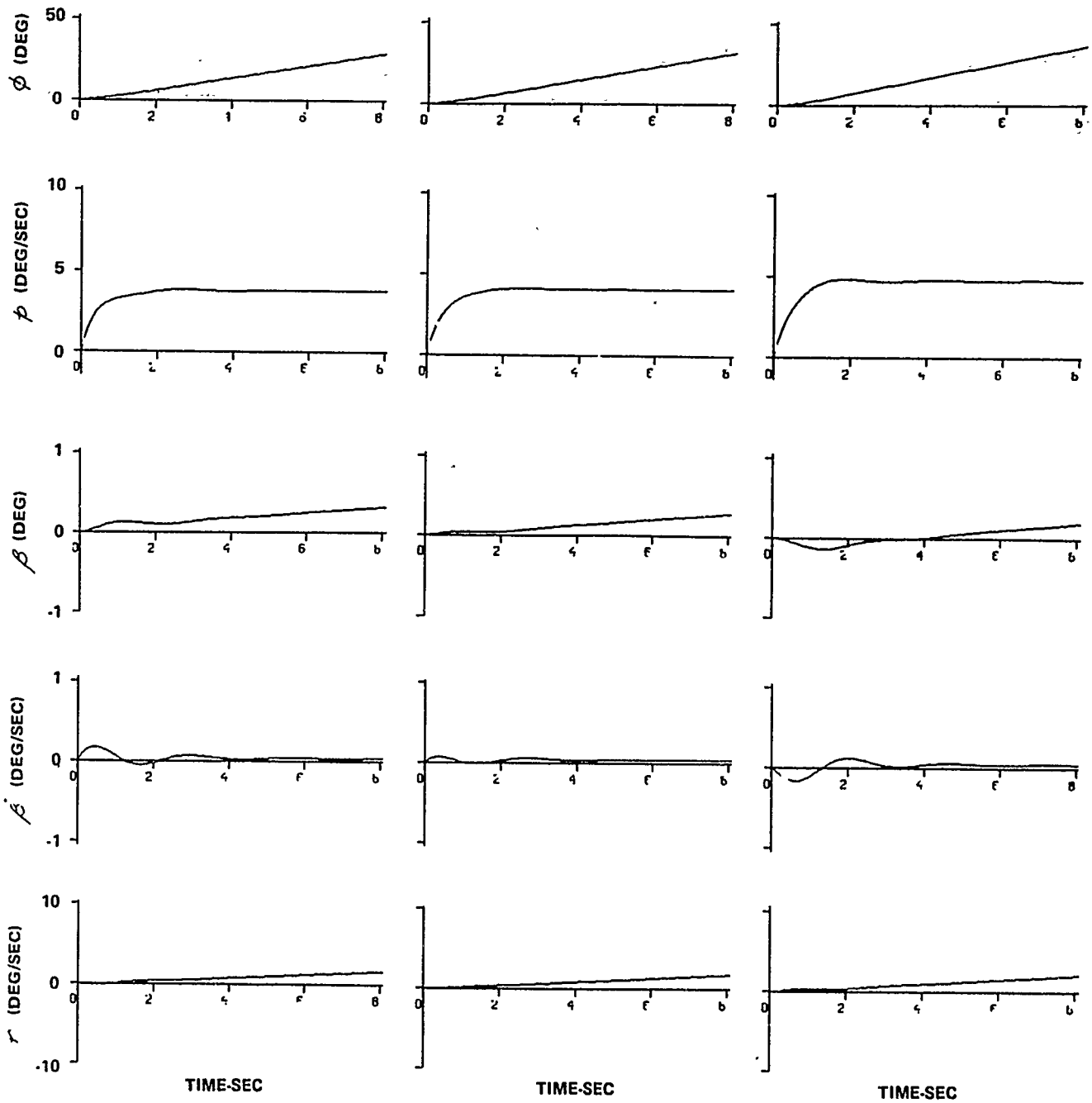
I think the airplane is acceptable. However I don't think that it is really very good. Certainly I think the characteristics that I see are to the point of being moderately objectionable and would have to be improved. For adequate performance, this is up in the "considerable pilot compensation" category.

CONFIGURATION 5A IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}} / L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/k$ LEVEL 1	LEVEL 2	$\lvert\Delta\beta/\phi_1\rvert \times \lvert\phi/\beta\rvert_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.08	6	B	0.23	2.38	-178	0.009	4.7	3.2	0.10	480	45
-0.04	3	C	0.23	2.48	-110	0.004	1.6	1.1	0.02	430	25
+0.04	3.5	B	0.25	2.67	0	0.013	4.1	2.8	0.06	295	15.5
+0.13	6	C	0.26	2.86	-60	0.034	7.5	4.8	0.13	450	32

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

ω_d	= 2.50	N'_β	= 6.60	L'_β	= -12.1
ζ_d	= 0.26	N'_r	= -1.06	L'_r	= 1.95
τ_R	= 0.42	N'_p	= 0.164	L'_p	= -2.44
τ_s	= ∞	$\frac{g}{V}$	= 0.0586	Y_β	= -0.175
$\lvert\frac{\phi}{\beta}\rvert_d$	= 1.60	$Y_r - 1$	= -0.989	$Y_{\dot\beta}$	= -1.015
$\angle\left(\frac{\phi}{\beta}\right)_d$	= 44.6	$Y_p + \alpha_0$	= 0.0020		

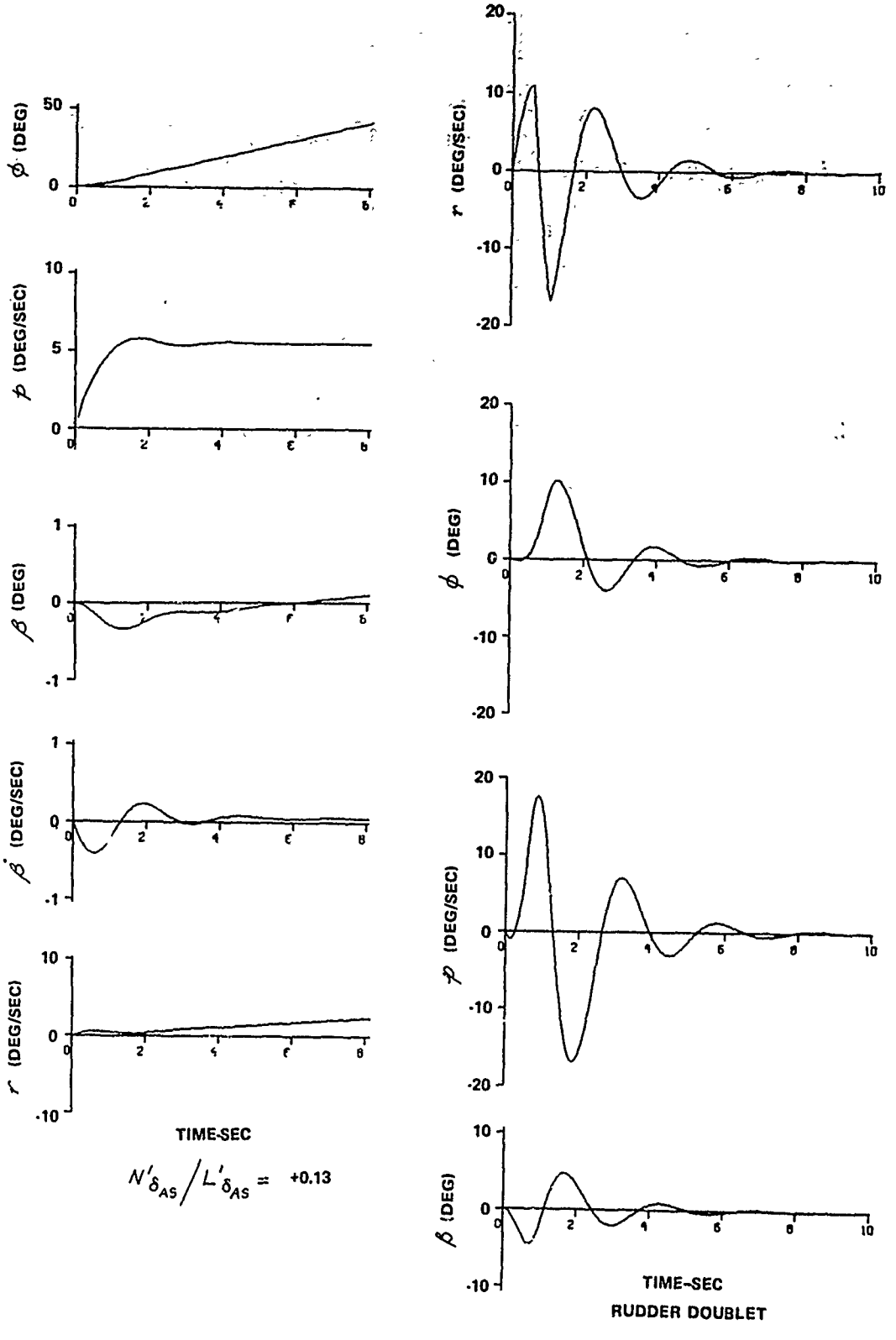


$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.08

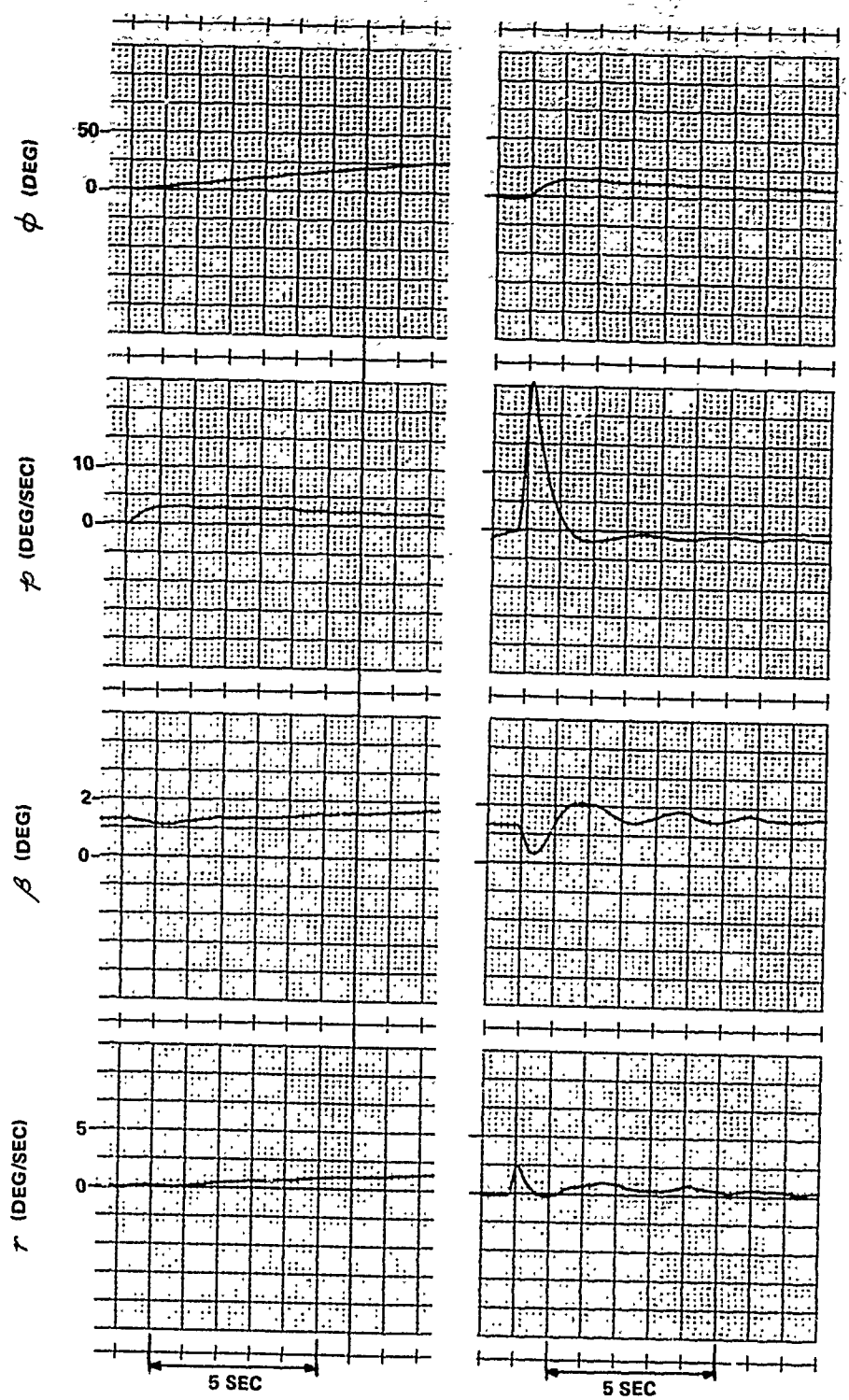
$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.04

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.04

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 5A



COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR CONFIGURATION 5A



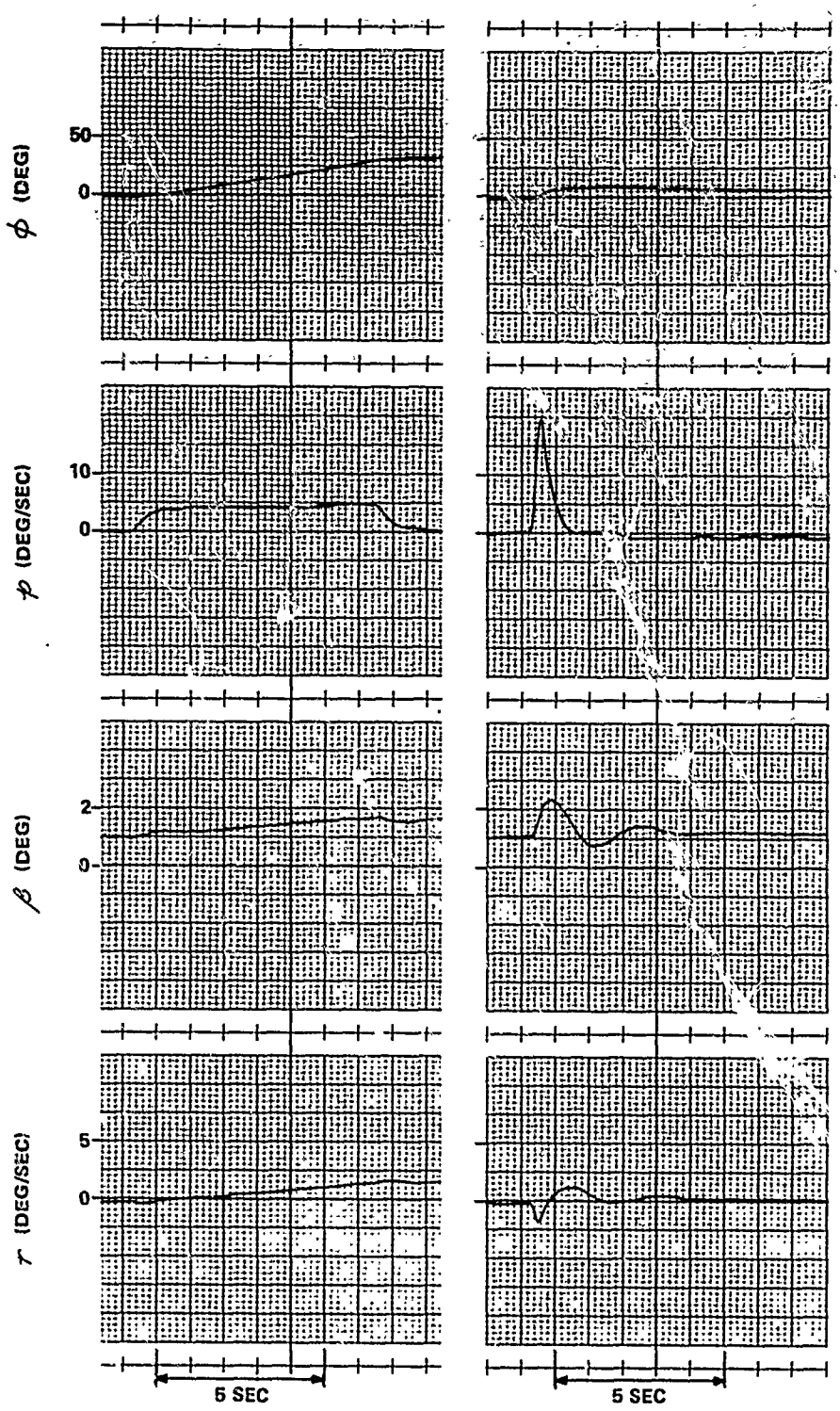
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.04$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.04$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 5A



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.08$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.08$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 5A

CONFIGURATION 5A $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.08$ PILOT RATING 6 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

It wasn't going to be a very good configuration because it seemed to have a lot of sideslip excited with aileron inputs. Turned out the coordination was in proper direction so I could do a little better job with it than I initially thought that I might be able to do.

ABILITY TO TRIM

Lateral and directional: seemed to be okay. However on a lot of these records, you start off in a reasonable trim and develop a quite large rolloff to the left and you don't know why. Longitudinal: trim was okay, not a problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 480$ deg/sec^2-in. $N'_{\delta_{RP}} = 45$ deg/sec^2-in.

Aileron sensitivity probably not quite as light as would have liked because of the large amount of adverse sideslip that's generated to an aileron input; there's a slight compromise there. Rudder sensitivity - I had to lighten it up, I think a fair amount. From what I saw you ought to be able to control this large amount of adverse sideslip. Forces that I ended up with were light on both controls, displacements were small. In general, the control harmony was quite good.

AIRPLANE RESPONSE TO PILOT INPUTS

An aileron input without rudder resulted in a quite large sideslip disturbance; however, it didn't seem to be an awful lot of carryover into the roll response. Coordinating aileron with rudder inputs, you could feel that the roll rate was faster and a bit smoother. Coordination that was required was in the proper direction and required quite a bit of rudder input. To maneuver the airplane, you had to coordinate it in the proper direction. It's more difficult than I would like, but not too excessive.

BANK ANGLE CONTROLLABILITY

Fair to good, no tendency to oscillate about a bank angle, however you did get a slight sideslip oscillation. Although the oscillations damp out quite rapidly, the sideslip was noticeable and I could feel the side acceleration when I maneuvered abruptly and tried to stop smartly at a bank angle.

HEADING CONTROLLABILITY

Reasonably good. Oscillations that I saw died out quickly and in general you can get the airplane pointed pretty much where you wanted to go.

BANK ANGLE COMMAND TRACKING TASK

Performance was only good. I could stop at the bank angles, but I'd get a sideslip disturbance going which was uncomfortable. So, I consider that a problem and something that should be fixed.

RESPONSE TO DISTURBANCE INPUTS

Really wasn't much greater than what I would have expected. There was more effort required, but no real significant deterioration due to turbulence itself.

LONGITUDINAL CHARACTERISTICS

Good, they did not interfere with the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think these characteristics are acceptable, but only marginally acceptable. The large sideslip disturbance to an aileron input requires an awful lot of coordination, fortunately it is in the proper direction and I never really got good at keeping the airplane coordinated, but I could keep it in the ball park. Air-to-air, I don't think your performance would be very good, although I think adequate performance could be attained. Air-to-ground, similar problems, a lot of adverse yaw so that you'd have to watch your weapons and then your release points and make sure you weren't making rolling maneuvers at this point.

GOOD FEATURES

The roll control, and the bank angle control are certainly fair to good, you could swing the airplane around, coordinate it sufficiently enough to adequately perform the task, but certainly not very good at it.

OBJECTIONABLE FEATURES

Major objection is the large sideslip generated with an aileron input and the fact that this excites enough sideslip to cause a slight sideslip oscillation when attempting to maneuver the airplane aggressively and stop at a given bank angle.

SPECIAL PILOTING TECHNIQUES

Lots of rudder with the aileron inputs to coordinate it.

PRIMARY REASON FOR THE PILOT RATING

Airplane is only barely acceptable. The sideslip that I see is getting to be in the very objectionable category. Adequate performance, I think requires a lot of rudder and I think extensive pilot compensation. Turbulence didn't really cause much of a problem. More effort is required. However, as far as deterioration due to the disturbance itself, it's not very much.

CONFIGURATION 5A $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -.04$ PILOT RATING 3 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression: I was really going to like it. As I flew it a little bit there were a couple of minor things about it that I didn't like and I'll point them out as we go along, but in general, it's a good configuration.

ABILITY TO TRIM

Good, no problems there.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 430$ deg/sec^2-in. $N'_{\delta_{RP}} = 25$ deg/sec^2-in.

Aileron sensitivity - no compromise involved; was able to select a high sensitivity so I could maneuver the airplane aggressively and with small light forces. Rudder sensitivity - I had to heavy-up the rudders from what we started out with. There was a small amount of sideslip so it looked like it needed a little bit of coordination. However, when I tried to coordinate it with high sensitivity I overcontrolled and got more sideslip in the other direction. Heavying up the rudder allowed me to put in a small amount of coordination with a compatible aileron/rudder combination and keep the sideslip quite small. The forces I ended up with were heavy on the rudder, light on the aileron. Displacements were small and control harmony in general was good.

AIRPLANE RESPONSE TO PILOT INPUTS

An aileron input only resulted in a very smooth roll rate; there seemed to be a very small amount of adverse yaw generated following a control input. I don't really know if that was yaw due to roll or yaw due to aileron or what. When I coordinated I really didn't see too much difference because the sideslip generated was quite small. The Dutch roll seemed to be reasonably well damped but when I flew the airplane aggressively, I would occasionally see a small Dutch roll oscillation primarily in sideslip as I attempted to abruptly stop at a given bank angle, and this caused me a little bit of a problem. Maneuvering coordination requirements - I could fly the airplane without coordinating. It would help to coordinate the sideslip. Coordination was in the normal or adverse direction and not difficult to accomplish.

BANK ANGLE CONTROLLABILITY

Good, a little bit of a tendency for me to overshoot and I think that was primarily because of the aggression with which I was going at the task. So the bank angle control wasn't really as good perhaps as I would like for it to have been.

HEADING CONTROLLABILITY

Good; Dutch roll seemed to dampen out rapidly, seemed to be a reasonably high frequency so that the airplane was usually headed pretty much where I wanted it to go.

BANK ANGLE COMMAND TRACKING TASK

Not quite as good as I would like and I'm not sure whether that's the combination of the high sensitivities and aggression or whether there was something going on with the Dutch roll, but still quite good.

RESPONSE TO DISTURBANCE INPUTS

Pretty close to what I might expect for an airplane like this; there was more effort required; and I think there was a minor deterioration in my performance which was particularly noticeable on the air-to-ground run.

LONGITUDINAL CHARACTERISTICS

Good, did not detract from the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they are acceptable and satisfactory. In the air-to-air role, I would like to feel that I had a little better control of bank angle and I would like to get rid of this small Dutch roll oscillation in sideslip so that

there is no real coordination requirement. Air-to-ground I thought was quite good. The sideslip angles generated were quite small and the turbulence response perhaps detracts from that just a little bit, but I don't think that is significant.

GOOD FEATURES

I liked the fact that I could really maneuver this configuration; I liked the fact that the sideslips generated were small and I liked the fact that the little bit of sideslip that was generated was in the normal or adverse direction and could be coordinated.

OBJECTIONABLE FEATURES

They are minor objections. I would like to feel that I had better bank angle controllability. It wasn't as good as I would like and I would like to see a little less sideslip generated for control inputs.

SPECIAL PILOTING TECHNIQUES

No special piloting techniques required. Normal coordination is a help but not absolutely necessary.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable, I think it's satisfactory, I think it has some minor, mildly unpleasant deficiencies.

CONFIGURATION 5A $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.05$ PILOT RATING 3.5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought it was going to be pretty good. It had real good roll performance. It was quite noticeable that there was a pretty good amount of proverse yaw due to an aileron input and this created a little bit of a problem.

ABILITY TO TRIM

Pretty good directionally and longitudinally and little bit sensitive laterally but still okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$$L'_{\delta_{AS}} = 295 \text{ deg/sec}^2\text{-in.} \qquad N'_{\delta_{RP}} = 15.5 \text{ deg/sec}^2\text{-in.}$$

Aileron selection; I was able to select nice light aileron sensitivities. However, they weren't really high because there was a very, very slight tendency to overshoot, but I really flew that configuration quite aggressively, I think. So whether or not it was my over-aggressiveness or the sensitivity, that's difficult to say. I don't think there was any real compromise, even with the substantial amount of proverse yaw generated. On the rudder selection - I had to have the rudder heavied up from what we started out with because there was a tendency to put the rudder in the same direction as the aileron and this only aggravated what was already a substantial amount of proverse yaw. I didn't use very much rudder, but for what I used, the forces were not necessarily light, but certainly reasonable. Control harmony was good and I thought the displacements were small in both axes.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron-only inputs, the airplane rolled quite rapidly. Proverse yaw was generated. However, the proverse yaw didn't seem to affect the roll control all that much. Trying to coordinate the thing, you needed to cross-control and I played around with that a bit and only by making a conscientious effort could I keep it coordinated by putting in rudder opposite to aileron. Maybe if you had a chance to fly this airplane day in and day out, you would eventually get so you could fly the thing like that. But, I don't think it's really desirable. There didn't seem to be any real noticeable oscillations, either in bank angle or sideslip. Dutch roll seemed to be a high enough frequency or the airplane was stiff enough so that the sideslip angles that were generated tended to dampen themselves out quite rapidly. For maneuvering, you would really like to learn to cross-control because when you did you could keep the sideslip quite a bit smaller than when you didn't coordinate. But, if you did coordinate in the normal adverse direction, you certainly aggravated the situation, as I did a number of times.

BANK ANGLE CONTROLLABILITY

Quite good; a very, very slight tendency to overshoot but hardly noticeable. It's probably as much a function of my aggression as airplane characteristics.

HEADING CONTROLLABILITY

Only good, primarily because sideslip was generated and it would take a little time for it to take itself out, but really wasn't that much of a problem.

BANK ANGLE COMMAND TRACKING TASK

My performance was pretty good. The generated sideslip was noticeable. However, I flew the task quite aggressively, and could keep the needle centered pretty well.

RESPONSE TO DISTURBANCE INPUTS

Airplane responded only moderately to the random disturbance inputs. I don't think there was any real significant deterioration in my performance. I think that more effort was required, but that's all.

LONGITUDINAL CHARACTERISTICS

Okay, they didn't detract from the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Air-to-air, they're certainly acceptable; whether they're satisfactory is the question. I think that I'm willing to say they are satisfactory. Got another one of those borderline jobs, but take a stand and say it's satisfactory. In the air-to-air role, you've got real good maneuverability. A little bit of a problem with the sideslip that's generated and I guess occasionally it was quite large. In the air-to-ground role - again sideslip is a bit of a problem because every time you put in an aileron input, you tend to excite sideslip in the proverse direction. Fortunately, it doesn't seem to affect the roll control very much. The random disturbance effects are quite small, so that possibly in the air-to-ground role, you could do that pretty well.

GOOD FEATURES

Really had good roll performance.

OBJECTIONABLE FEATURES

One major one, and that's the fairly substantial proverse yaw generated with this configuration. I couldn't coordinate very well, but it doesn't seem to affect the roll control very much, and the airplane seems to be stiff enough so that it comes back.

SPECIAL PILOTING TECHNIQUES

If you can learn to do it, you can cross-control this configuration and keep the sideslip reasonably small.

PRIMARY REASON FOR THE PILOT RATING

I'll give you a marginal rating on that. When I look at the rating scale, the sideslip that's generated is, I guess, more than just mildly unpleasant, but not down to the point where it's moderate pilot compensation required.

CONFIGURATION 5A $N'_{\delta_{AC}}/L'_{\delta_{AS}}$ = +0.13 PILOT RATING 6 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Really wasn't going to be a very good configuration, primarily because it appeared to me to have a fair amount of proverse yaw due to aileron inputs.

ABILITY TO TRIM

Good, in both directions, laterally and directionally. Longitudinal trim was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 450 deg/sec^2-in. $N'_{\delta_{RP}}$ = 32 deg/sec^2-in.

Had almost a tendency to accelerate a little bit in roll and you can feel that as you started around it and it seemed to pick up just a little bit, but it really wasn't dramatic and the roll felt relatively smooth so that I could pick fairly high aileron gearing. However, the sideslip generated in the proverse direction due to aileron input seemed to be quite excessive so I think I would have picked a slightly lighter aileron force than what I might have liked to cut down on the sideslip disturbance that resulted from the aileron input. So that's a compromise but a very small one. Forces on the ailerons were light. I think I'd make light forces on the rudder to try and combat this sideslip disturbance that I saw even though the coordination requirements were in the wrong direction. So that the forces on the rudder were perhaps a little lighter than I would have liked in order to try and get the coordination. The displacements were good. Harmony of the control forces was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Roll rate itself was reasonably smooth but a large amount of proverse yaw was generated. When I coordinated this, I could actually do a pretty good job, but I had to think and make a conscientious effort to do that. The airplane seemed to be not well but sufficiently damped in the Dutch roll so that lateral or directional oscillations were not a significant problem. When I tried to maneuver the airplane the coordination requirements were very difficult because of the reversal required between the rudder and the aileron input.

BANK ANGLE CONTROLLABILITY

Poor. There was a definite tendency to overcontrol the bank angle and a tendency to oscillate about a given bank angle.

HEADING CONTROLLABILITY

Pretty good because when I did freeze the ailerons it damped itself out reasonably well. The Dutch roll seemed to be fast enough so that heading control didn't seem that much of a problem.

BANK ANGLE COMMAND TRACKING TASK

Difficult and I thought my performance was poor. The problems that I saw were a tendency to overcontrol and to oscillate somewhat about the bank angle and my tendency to generate sideslip disturbances was the second problem. The sideslip that was generated really didn't seem to feed that much into the roll response, not as an oscillation anyway.

RESPONSE TO DISTURBANCE INPUTS

Noticeable; the airplane moved equal amounts in all three axes but really required little more effort. Only a moderate deterioration from what I have already concluded was a poor performance on the fighter mission.

LONGITUDINAL CHARACTERISTICS

Okay; a better part of the configuration.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Air-to-air role, really not very suitable. The oscillatory bank angle tendencies and the large sideslip disturbances certainly wouldn't allow you to perform the fighter mission without some improvements. You would have to improve this in order to make the airplane a good airplane. In the air-to-air you've got problems with being able to control the bank angle to fire on other airplanes with the tendency to oscillate about the bank angle. You have similar problems in the air-to-ground. When I flew the airplane aggressively I would invariably coordinate the airplane in normal direction and this compounded my problem. Fortunately the airplane seemed to be directionally stiff enough that the sideslip disturbances didn't really ever get completely out of hand. So that I think that it is possible to do the task but you wouldn't do it very well.

GOOD FEATURES

There are no rare outstanding good features on this one. The fact that the airplane is stiff enough so that the sideslip disturbances don't get excessively large and that they dampen themselves out in a reasonable length of time may be considered good features.

OBJECTIONABLE FEATURES

There are a number of objectionable features. The inability to control bank angle precisely and the tendency to get slight bank angle oscillation when tracking bank angle tightly are objectionable features. My inability to coordinate the airplane in the proper direction is an objectionable feature. Of course these all stem from the major objectionable feature and that is the large amount of proverse yaw generated to an aileron control input.

SPECIAL PILOTING TECHNIQUES

You can coordinate the airplane if you make a conscientious effort to get rudder in opposite to your aileron input and spin your thoughts therein. So that would certainly be considered a special piloting technique, but one that was very difficult to do.

PRIMARY REASON FOR THE PILOT RATING

The controllability is not in question. It's very marginal but I think I can get adequate performance out of this thing if you learn to control the "miscoordinations" in here. In turbulence, as I said there was more effort required but with only a minor deterioration of what was already a poor performance.

CONFIGURATION 5B IDENTIFICATION AND FLIGHT TEST DATA TABULATION

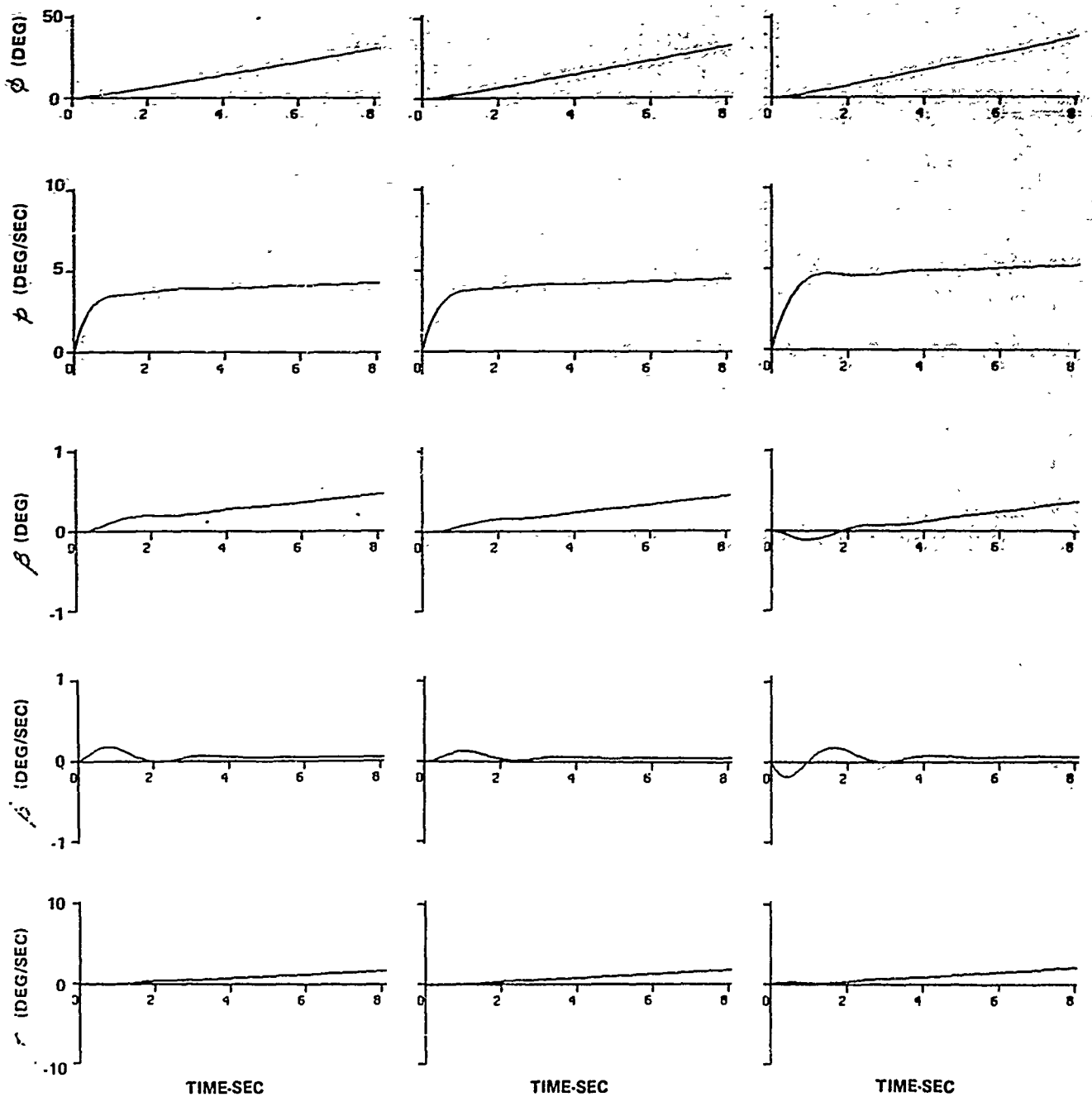
$\frac{N'_{\delta_{AS}}}{L'_{\delta_{AS}}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	Ψ_β STEP	$\frac{p_{osc}}{p_{AV}}$	$\Delta\beta_{max}/t$ LEVEL 1	$\Delta\beta_{max}/t$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.02	3	B	0.27	2.40	-215	0.010	6.9	5.0	0.08	315	39
+0.01	3.5	B	0.28	2.46	-300	0.016	6.2	3.8	0.06	265	32
+0.01	3.5	B	0.29	2.46	-300	0.016	6.2	3.8	0.06	245	28.5
+0.10	4	B	0.31	2.65	-325	0.017	5.8	4.0	0.13	292	22
+0.15	6	C	0.33	2.75	-360	0.038	6.4	4.0	0.15*	364	26.5

* INDICATES DATA FROM COMPUTER GENERATED TIME HISTORIES

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

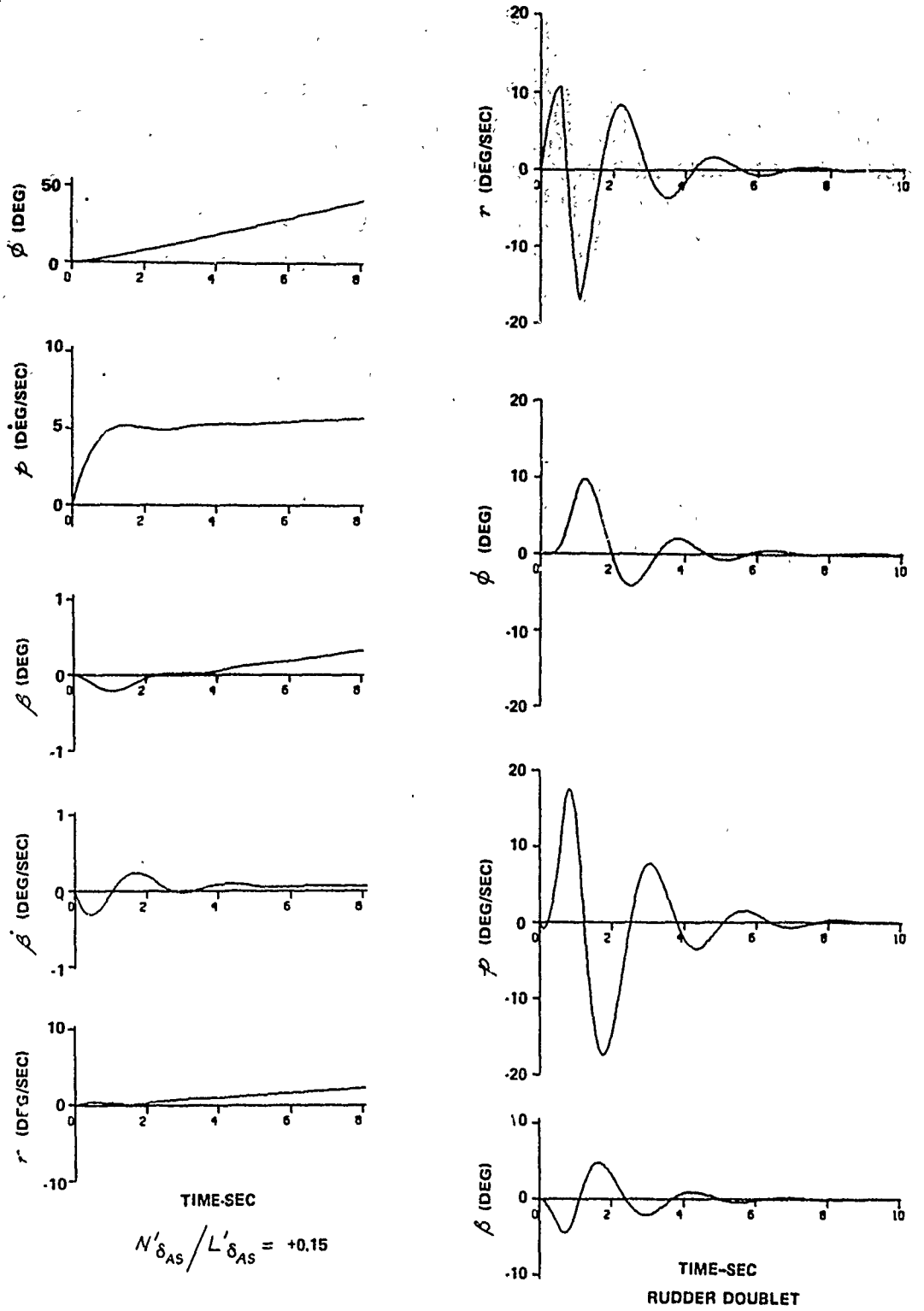
ω_d	= 2.52	N'_β	= 5.91	L'_β	= -10.6
ζ_d	= 0.25	N'_r	= -1.17	L'_r	= 3.01
τ_R	= 0.41	N'_p	= -0.073	L'_p	= -2.34
τ_S	= -50 **	$\frac{g}{V}$	= 0.0586	Y_β	= -0.168
$\left\|\frac{\phi}{\beta}\right\|_d$	= 1.55	$Y_r - 1$	= -0.988	$Y_{\dot\beta}$	= -1.015
$\angle\left(\frac{\phi}{\beta}\right)_d$	= 59.3	$Y_p + \alpha_0$	= 0.0043		

** UNSTABLE SPIRAL

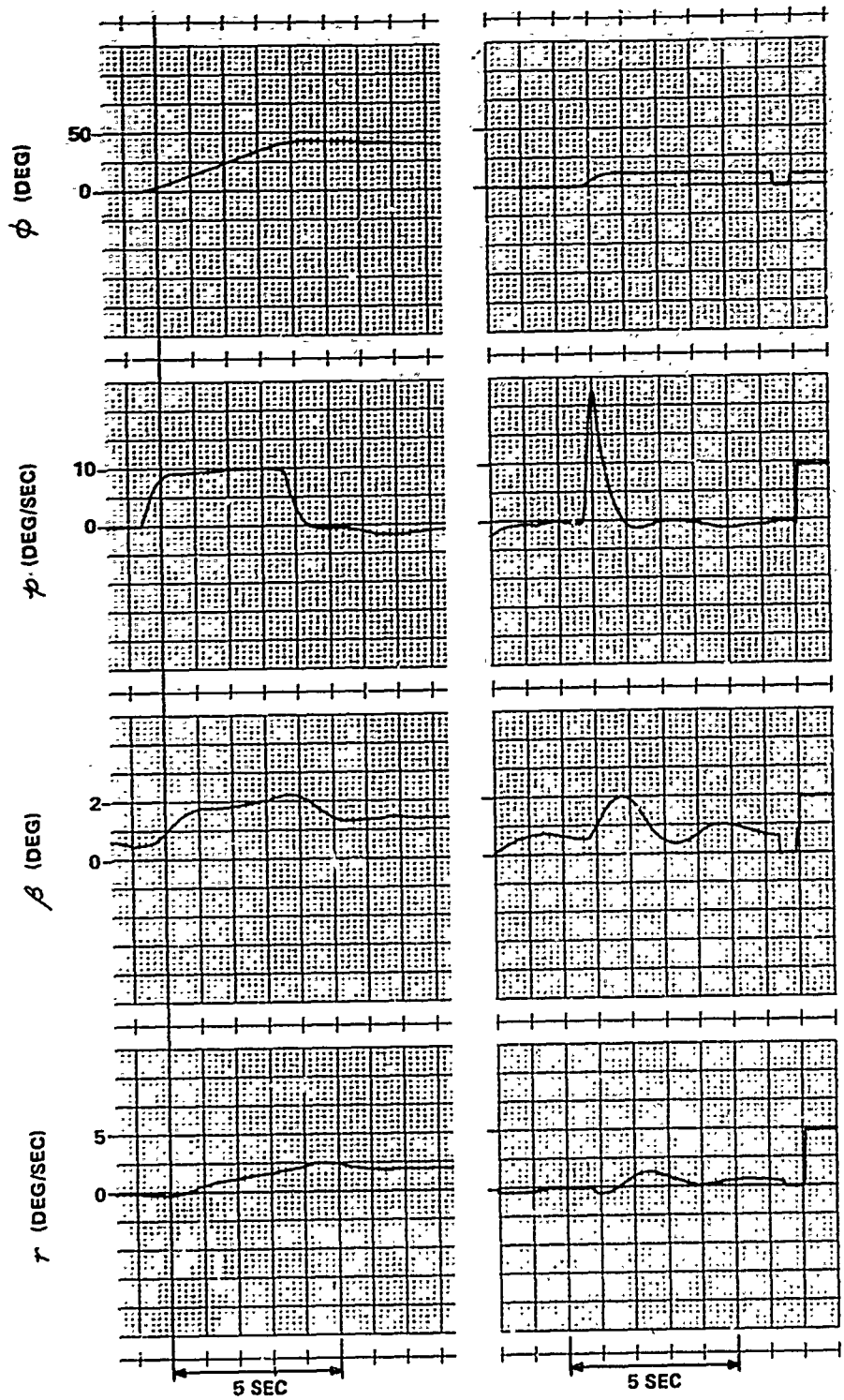


$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.02 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.01 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.10

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 5B



COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR CONFIGURATION 5B



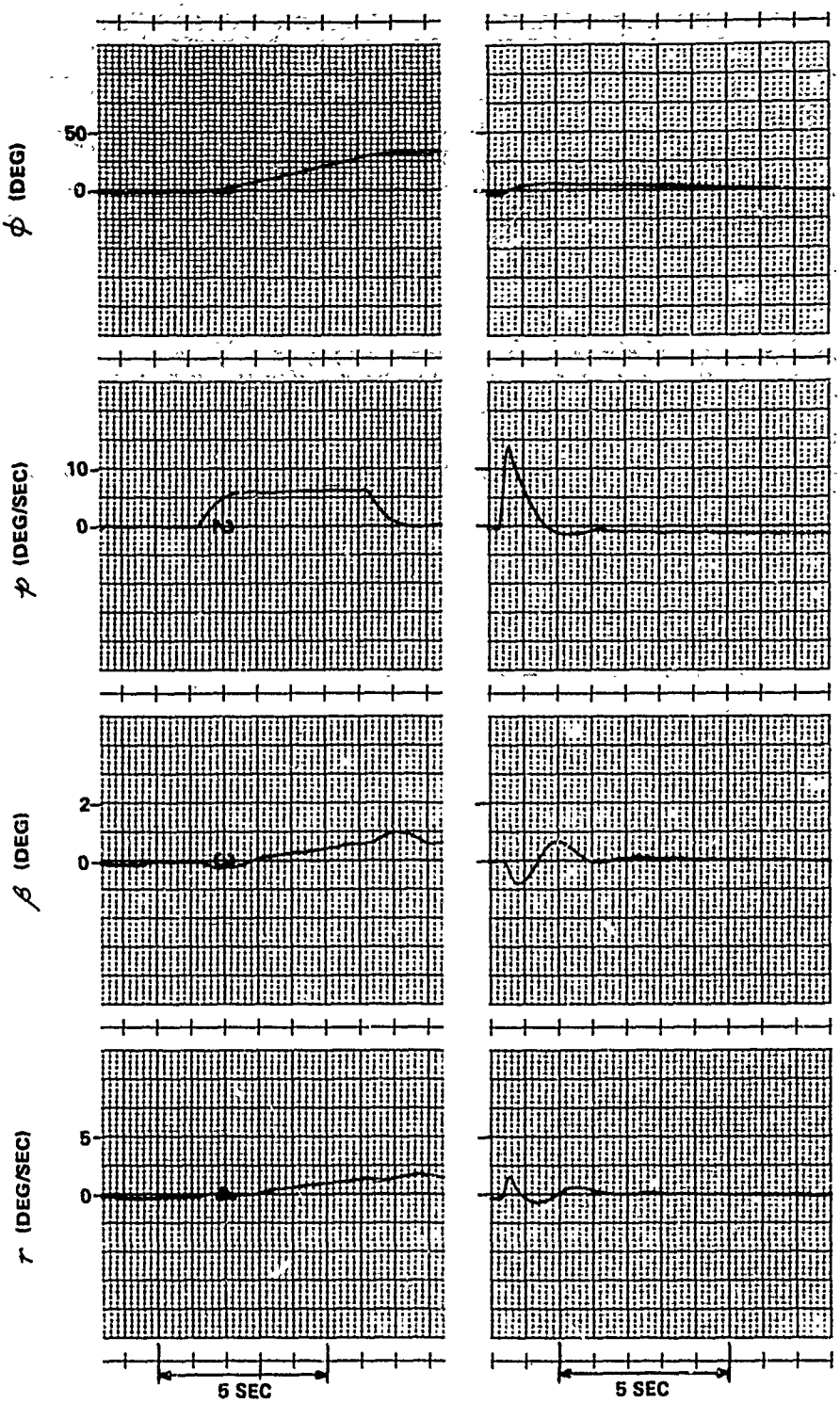
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.02$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.02$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 5B



$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.10

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.10

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 5B

CONFIGURATION 5B $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.02$ PILOT RATING 3 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought that was going to be a pretty good airplane, turned out it was.

ABILITY TO TRIM

Good in all three axes, no problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 315$ deg/sec^2-in. $N'_{\delta_{RP}} = -39$ deg/sec^2-in.

No compromise at all on the ailerons. You could pick nice light forces. On the rudder, however, I'm still having a bit of a problem. This configuration seemed to have adverse yaw, so it required coordination in the normal direction and for large rolling maneuvers, it required quite a bit of rudder. So I had a tendency to go up on the gearing to make the rudders more sensitive, but when I did, I got the problem of overcontrolling around the near-zero sideslip. Particularly when I terminate a rolling maneuver, I have a tendency to push the sideslip out in the proverse direction. So the rudder gearing is a bit of a compromise there where you're trying to find something that's good enough so that the forces aren't too heavy when you make large rolling maneuvers and not too light when you're in the near-zero sideslip position. The forces on the ailerons were nice and light. The rudder forces I thought were light. The displacements are small for both and the control harmony for the combination of all three axes, I thought was quite good.

AIRPLANE RESPONSE TO PILOT INPUTS

Seemed to be a noticeable amount of adverse yaw generated with an aileron control input. However, the roll rate seemed to be reasonably smooth. When I coordinated, didn't seem to make too much difference in the roll characteristics and fortunately the coordination was in the normal direction and I could do a pretty fair job with it, not perfect, but fair. Didn't seem to be any real oscillatory characteristics; it's all in my mind because I was overcontrolling with the rudder. I occasionally ended up in a slight sideslip and would have to work that off, but the damping in the Dutch roll seems to be reasonably good. Frequency seems to be reasonable enough so that it wasn't a serious problem. For maneuvering, you do require rudder coordination in the direction of the turn and if you don't put it in you can build up some pretty good size sideslips.

BANK ANGLE CONTROLLABILITY

Really quite good. I could do it abruptly and I could stop at the bank angle. The only problem I had was a little bit of residual sideslip either in the adverse or proverse direction, depending on whether or not I had overcontrolled with the rudder.

HEADING CONTROLLABILITY

Good, No problem with getting the proper heading and like I say the Dutch roll seemed to be damped reasonably well at a high enough frequency so that the airplane would settle down without my having to work at it very much.

BANK ANGLE COMMAND TRACKING TASK

My performance was really quite good on that. I can fly the airplane aggressively in the task; I got carried away a couple of times and I dumped the system; but could really go at it and stop the bank angle quite nicely. So no problems except again some of the residual sideslips that I didn't particularly like.

RESPONSE TO DISTURBANCE INPUTS

Really not significant, pretty much along the lines of what I might expect for a fighter-type machine. So there was a little more effort required, with no real significant deterioration in my task performance.

LONGITUDINAL CHARACTERISTICS

Good, they didn't degrade or detract from the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

These characteristics are acceptable. I also feel they're satisfactory. I think they're also satisfactory for the air-to-ground. I put a lot of emphasis on the ability to control bank angle and this configuration has good bank angle control. Objections I have are the fact that I have to coordinate the sideslip and I can't do that as perfectly as I would like, so I ended up with sideslip disturbances in one direction or the other most of the time. Air-to-ground, I think the sideslip is more of a problem than it is in the air-to-air.

GOOD FEATURES

Bank angle controllability is quite good. Roll performance is good. You can really fly the airplane aggressively. The Dutch roll seems to be well damped so that you don't have any oscillatory characteristics.

OBJECTIONABLE FEATURES

The sideslip I could not coordinate anywhere near as perfectly as I would have liked. There's a fair amount of adverse sideslip generated for each roll control input and this created some problems because I have a tendency to overcontrol it a bit and end up with sideslips that I think would reduce my accuracy a little bit.

SPECIAL PILOTING TECHNIQUES

You do need to coordinate each maneuver. Fortunately, it's in the proper direction so it's not too difficult to do.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable. I think it's satisfactory. The deficiencies that I name fall in the mildly unpleasant and minimal pilot compensation is required.

CONFIGURATION 5B $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.01$ PILOT RATING 3.5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

It wasn't going to be too bad, did have a couple of problems.

ABILITY TO TRIM

Surprisingly good. The lateral and directional trim I thought was better than most. The longitudinal trim - likewise was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 265$ deg/sec^2-in. $N'_{\delta_{RP}} = 32$ deg/sec^2-in.

I ended up increasing the sensitivity on the ailerons from what we started. Didn't seem to be any real compromise involved. There appeared to be proverse yaw initially on an aileron input followed by adverse yaw as the roll rate began to develop. The sideslips that were generated were not large, but they were certainly noticeable, enough that I wanted to try to do something about them. On the rudder, had a bit of a problem there because I wanted a rudder that was sensitive enough to be able to handle the predominant sideslip which was the adverse part. But because I did end up having just a little bit of rudder in the steady turn, getting a sensitivity that was light enough to make that comfortable, I ended up with overcontrolling the sideslip initially probably due to the initial proverse yaw that I saw. The forces that I ended up with on the ailerons were quite a bit heavier than what I think I've been used to flying. They were still comfortable. Displacements were small, control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

There was initial proverse yaw followed by about an equal amount of adverse in the other direction. Didn't seem to have a real tremendous effect on the roll. The roll seemed to be reasonably smooth. Trying to coordinate the thing required a cross-control maneuver which wasn't particularly easy to do. I think I finally ended up just using coordination in the adverse direction, kind of delaying the input; a little bit of a complicated input, but something you can do. As far as oscillatory characteristics are concerned, the fact that the sideslip starts out in one direction and comes back and centers itself giving you the feeling that you can feel the sideslip in motion really as you make rolling maneuvers, but it's really not an oscillation that persists, you can feel it come across and go back. The Dutch roll seems to be fast enough that the yaw dampens itself reasonably well. Okay, maneuvering coordination requirements, primarily adverse required for the most part in turning maneuvers with a tendency to overcontrol the sideslip initially.

BANK ANGLE CONTROLLABILITY

Reasonably good, you could roll right up and stop. Ever so slight tendency to overshoot, but this wasn't much of a problem, primarily a function of the aggression.

HEADING CONTROLLABILITY

Fair. Tendency for the airplane when you're stopped rolling wings level to kind of sashay in sideslip back and forth, reducing the heading controllability to only fair, I would say. It did dampen itself out in what I thought was a reasonable period of time because the frequency seemed to be good.

BANK ANGLE COMMAND TRACKING TASK

Performance was pretty good, I thought. Again, you can feel the sideslip moving around, but it doesn't affect the roll control very much.

RESPONSE TO DISTURBANCE INPUTS

Really didn't think there was any significant deterioration in my performance, perhaps a little more effort required, but not, certainly not an outstanding feature either way for this configuration.

LONGITUDINAL CHARACTERISTICS

Good, didn't detract or degrade the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

It bothers me a little bit. In the air-to-air role, I don't particularly like the fact that the sideslip is sashaying around. I think it would degrade my performance, but I certainly can do the task. I think the airplane is acceptable as it is. The question I have in mind is whether or not it's marginally satisfactory and I think I'm willing to say that it's marginally satisfactory. Your roll performance is good, your bank angle controllability is good, the biggest problem is the fact that the sideslip is moving back and forth. Okay, in the air-to-ground role, I think the sideslip is probably more of a problem for this configuration than the roll control. In turbulence, seemed to be more sideslip response than roll response and perhaps this would be detrimental or degrade your air-to-ground tracking capability.

GOOD FEATURES

The roll performance was good and the bank angle controllability was good.

OBJECTIONABLE FEATURES

Center around the fact that the sideslip is generated first in the proverse direction and then in the adverse direction so that it's not something that I could coordinate easily. Fortunately the sideslip is not very large, seems to dampen itself out in a reasonable amount of time and it doesn't seem to affect the roll control very much.

SPECIAL PILOTING TECHNIQUES

I think it's a difficult airplane to coordinate properly because you require kind of switching feet in the middle of a roll maneuver and that's not easy to do. Ended up using coordination almost solely in the adverse direction.

PRIMARY REASON FOR THE PILOT RATING

The airplane is acceptable and I'm going to say it's marginally satisfactory, but you have to spend more time controlling the sideslip than I would like. Sideslip response is somewhere between mildly unpleasant and annoying.

CONFIGURATION 5B $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.01$ PILOT RATING 3.5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

It wasn't going to be too bad, however, there did seem to be adverse yaw associated with the configuration which was going to require coordination. In general, it didn't look like it was going to be too bad.

ABILITY TO TRIM

Good about all axes.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 245$ deg/sec^2-in. $N'_{\delta_{RP}} = 28.5$ deg/sec^2-in.

As I came up on the aileron gear selection making it more sensitive, I seemed to also have to increase the rudder sensitivity to help take care of the adverse sideslip that seemed to be generated to an aileron input. It really wasn't a compromise, it was just a matter of keeping up with the configuration. So I was able to select light aileron forces and, I would say moderate rudder forces with displacements that were small. The control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron-only input resulted in fairly smooth roll rate. However, I did excite the sideslip. Sideslip did seem to be in the adverse or normal direction. When I coordinated the airplane I could reduce the sideslip, although I never could quite keep it at zero. This was one of my biggest problems. There seemed to be a changing requirement for rudder as roll rate picked up. In other words, if I put in a combination step aileron and rudder inputs, I usually overcontrolled in sideslip pushing it out in the proverse direction. But as a rule I picked up more sideslip in the adverse direction with the requirement for more rudder. This is beginning to be a bit difficult for me to do with my feet. I couldn't keep the sideslip at zero during a rapid rolling maneuver because there seemed to be some changing requirements for a rudder input as the airplane rolls. The Dutch roll itself seemed to be relatively well damped, and what few oscillations I saw showed up mostly in sideslip that lasted one or two cycles. Maneuvering coordination requirements I thought were a bit of a problem, and for the reason I just mentioned the kind of changing rudder requirements as the airplane picked up in roll rate was something I never really got the hang of.

BANK ANGLE CONTROLLABILITY

Pretty good. The sideslip that was generated didn't seem to carry over into the roll very much. Consequently, any oscillatory characteristics I saw appeared to be in sideslip rather than roll rate.

HEADING CONTROLLABILITY

Fair to good. The sideslip oscillations that I saw seemed to be well damped, and didn't seem to persist and the frequency seemed to be fast enough that the sideslip did come back pretty close to zero in a relatively short period of time.

BANK ANGLE COMMAND TRACKING TASK

Performance was good. I could roll the airplane and stop the bank angle right where I want it. I did, on occation however, encounter a sideslip buildup and you could feel a side acceleration as this sideslip centered itself through its own damping or through my coordination.

RESPONSE TO DISTURBANCE INPUTS

Just about what I might expect, maybe a bit more in sideslip than in roll but didn't really create any significant problems on it's own.

LONGITUDINAL CHARACTERISTICS

Good, did not tend to interfere or degrade the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Looks like a borderline case to me as far as being acceptable and satisfactory. In the air-to-air role, the inability to coordinate the sideslip precisely for rapid rolling maneuvers I think would degrade your ability to hit another airplane somewhat and even though the coordination requirements were in the proper direction, this kind of changing rudder requirement as the airplane rolls was difficult for me to keep up with so that usually when I tried to stop the airplane at a given bank angle there was a residual sideslip buildup with an oscillation or two which died out but it could be the critical moments in there when you are trying to hit someone. Air-to-ground role, similar comments for that. No problem stopping the airplane in bank angle or rolling out on the target but then again this slight problem due to my inability to coordinate the airplane precisely would still be there.

GOOD FEATURES

I have got to have good roll control. I think the fact that the sideslip that I see does not affect the roll very much is a good feature. I can roll the airplane aggressively, stop it pretty close to the bank angles that I wish.

OBJECTIONABLE FEATURES

Only one, and that is my inability to coordinate the airplane properly and the requirement for a changing rudder input as the airplane rolls.

SPECIAL PILOTING TECHNIQUES

Do need rudder in the direction of the turn but it is in the normal direction. But again it is difficult to do because there seems to be a changing requirement on the rudder.

PRIMARY REASON FOR THE PILOT RATING

A borderline case; marginal and not quite satisfactory. Really no real significant deterioration in performance with turbulence. More effort is required however.

CONFIGURATION 5B $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +.10 PILOT RATING 4 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

No pilot comments due to malfunction of tape.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 292 deg/sec^2-in. $N'_{\delta_{RP}}$ = 22 deg/sec^2-in.

CONFIGURATION 5B $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.15 PILOT RATING 6 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Wasn't going to particularly like it. That also was my final impression. Most noticeable thing about the configuration, there appears to be a fair amount of proverse yaw due to aileron control input. It was very difficult to cross-control the airplane to keep the sideslip near zero. Any time I tried to do anything without concentrating on keeping the sideslip zero, this airplane dumped in the sideslip. It indicated to me that the sideslip was quite a problem.

ABILITY TO TRIM

No comments.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 364 deg/sec²-in. $N'_{\delta_{RP}}$ = 26.5 deg/sec²-in.

Nice light aileron control forces that I liked. On the rudder - I heavied them up a little bit because I was tending to coordinate in the same direction a lot of times. With heavier rudders, my inputs tended to be less so I think that there was a small compromise on the rudder and I made them heavier to cut down on my overcontrol in sideslip. Forces on ailerons were quite light. The displacements were small. On the rudder, the forces were medium. They weren't heavy by any stretch of the imagination. Displacements likewise were small. Control harmony in general was pretty good.

AIRPLANE RESPONSE TO PILOT INPUTS

Roll response, seemed to be reasonably smooth. I didn't see very much oscillation superimposed. The sideslip looked like it went in the proverse direction smartly initially. The airplane didn't seem to be very oscillatory in the Dutch roll; seemed to be well damped. Coordination requirements - I think were excessive and in the wrong direction which is very difficult for me to get used to in a short period of time. I have been speculating whether or not a pilot flying an airplane like that continuously just might get used to it. I don't know. I'm assuming that that's not the case.

BANK ANGLE CONTROLLABILITY

I had some difficulty achieving bank angle; a bit of tendency to oscillate about the bank angle when I roll up and stop and this is particularly noticeable. I think you will notice it on the flight records that we took, there was a tendency to oscillate about the bank angle rather than being able to roll right up and tack it. The roll rate itself seemed to look reasonably smooth so it's hard for me to justify.

HEADING CONTROLLABILITY

Only as good as the bank angle control; the airplane oscillated about the heading once I tried to stop but the Dutch roll seemed to be reasonably damped. Primarily a function of the tendency to overcontrol in bank angle which is also related to rolling wings level.

BANK ANGLE COMMAND TRACKING TASK

Performance is very poor on that. Trying to roll up and hold a bank angle, I did oscillate about the bank angle. Problems encountered were primarily that I was unable to apparently coordinate the airplane well enough in the bank angle tracking task to keep from oscillating in bank angle.

RESPONSE TO DISTURBANCE INPUTS

Disturbance inputs didn't seem to be excessive in any axis and really wasn't much more than a minor decay in my performance which wasn't very good to start with.

LONGITUDINAL CHARACTERISTICS

Were okay. Didn't create any particular problems.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Air-to-air, I think not very good. The sideslipping tendency which I thought was relatively large with the reasonable amount of input and the fact that it was in the wrong direction and I was having extreme difficulty in coordinating the thing, really degrades from my ability to track and set an air-to-air target. Air-to-ground, I think you would have similar problems to a lesser degree. Even if you are off a little bit and the Dutch roll is damped enough and the frequency is high enough so that the sideslip I think would die out in time to hit air-to-ground targets. Special problems relate back to my getting aggressive with the airplane and not thinking directly about cross controlling the airplane. It was easy to have the airplane pick up excessive sideslip angle.

GOOD FEATURES

The roll control was reasonably good. Longitudinal was good.

OBJECTIONABLE FEATURES

One primary objection and that is the proverse yaw which I couldn't coordinate very well. The bank angle oscillation that I got myself into on the tracking task and the tendency to lose the airplane in sideslip when flying the airplane aggressively and not concentrating directly on the sideslip.

SPECIAL PILOTING TECHNIQUES

You do have to cross-control the airplane to keep the sideslip near zero.

PRIMARY REASON FOR THE PILOT RATING

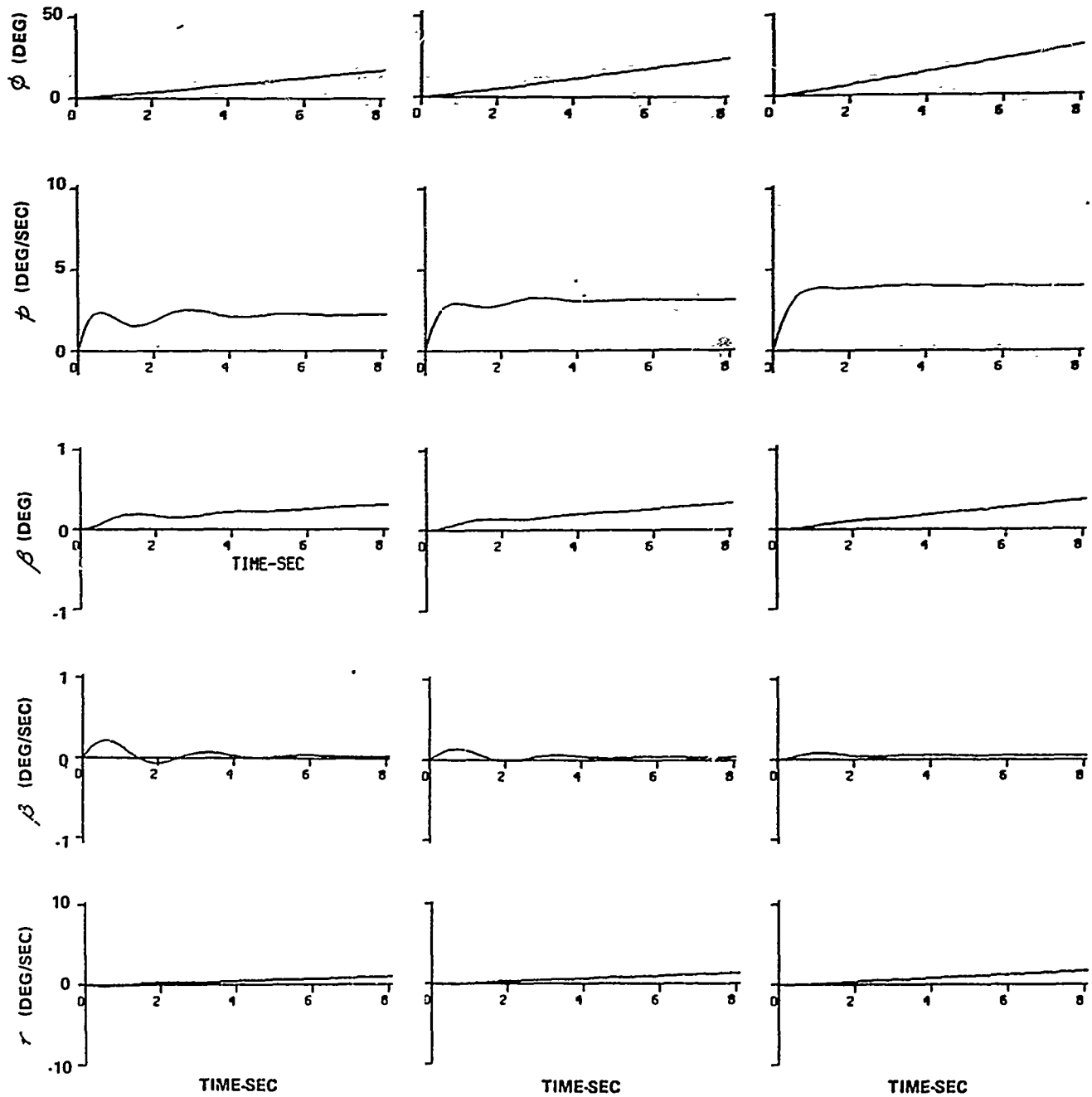
I do think that adequate performance is marginally attainable if I concentrate on cross-controlling the airplane. But there is a fairly healthy amount of sideslip generated and you really have to work at it with your feet and I found that when I stopped concentrating on it I tended to lose the airplane. So I'm going to say that adequate performance is attainable, however, it apparently is not satisfactory without improvement. I think the deficiencies are tolerable but fall in the very objectionable range. Adequate performance does require extensive pilot compensation. Turbulence response as I said earlier wasn't bad. More effort is required but it's only a minor deterioration from an already poor performance.

CONFIGURATION 11 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

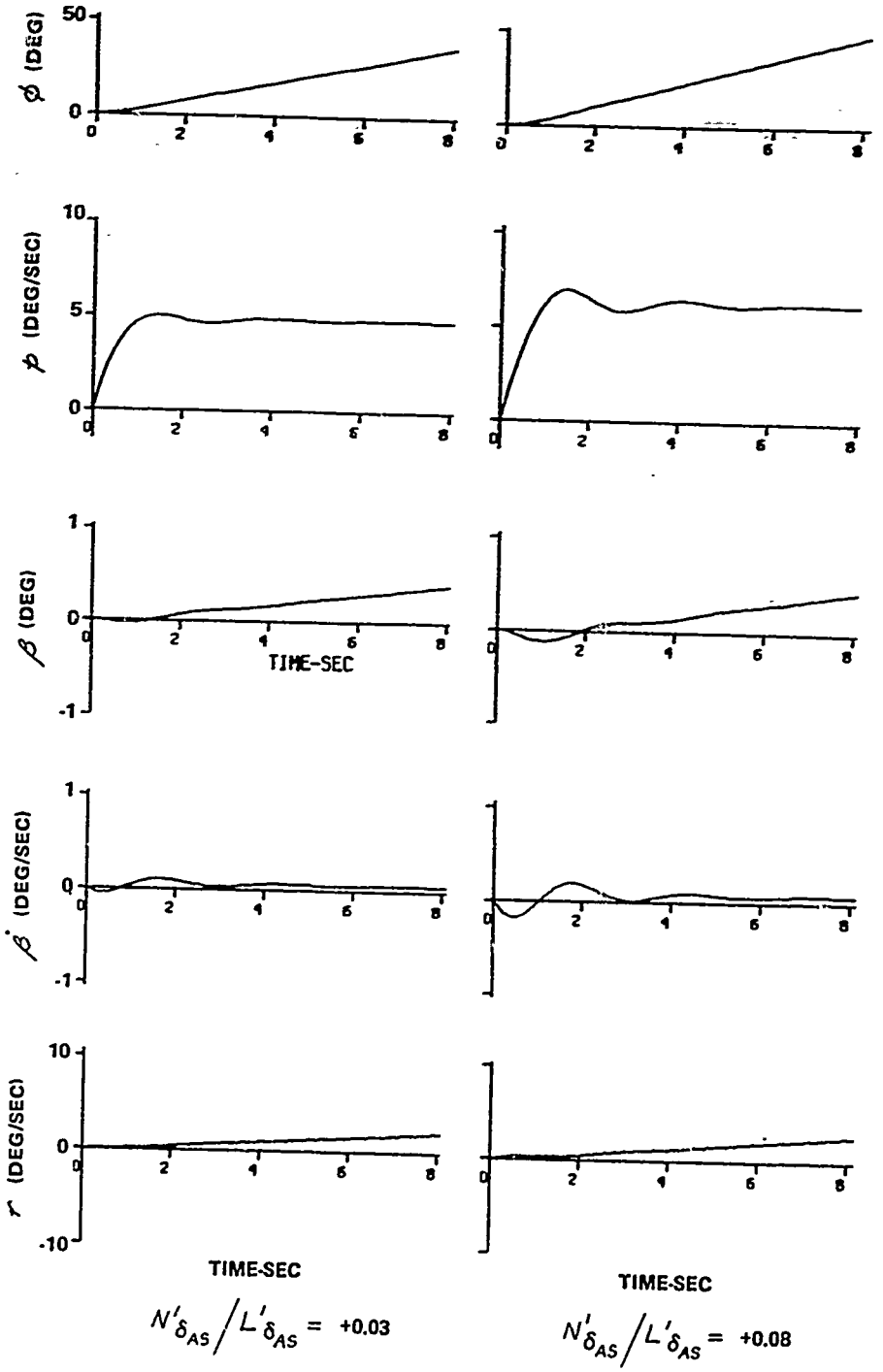
$N'_{\delta_{AS}} / L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/\alpha$ LEVEL 1	$\Delta\beta_{max}/\alpha$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.06	5	D	0.22	[illegible]	-180	0.22	7.6	5.8	0.51	315	47.0
-0.03	4	D	0.24	2.11	-215	0.07	5.5	4.1	0.29	360	30.0
0	3.5	C	0.27	2.39	-268	0.05	3.8	2.6	0.11	330	24.5
+0.03	4.5	D	0.29	2.63	-337	0.09	3.1	2.1	0.17	355	24.0
+0.08	7	E	0.33	3.0	-365	0.09	3.1	2.1	0.31	203	24.5

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

ω_d = 2.44	N'_β = 5.65	L'_β = -40.9
ζ_d = 0.22	N'_r = -1.12	L'_r = 8.10
τ_R = 0.42	N'_p = 0.0131	L'_p = -2.20
τ_s = ∞	$\frac{g}{V}$ = 0.0586	Y_β = -0.165
$\left\|\frac{\phi}{\beta}\right\|_d$ = 5.7	$Y_r - 1$ = -0.989	$Y_{\dot\beta}$ = -1.015
$\angle\left(\frac{\phi}{\beta}\right)_d$ = 48.0	$Y_p + \alpha_0$ = 0.0035	



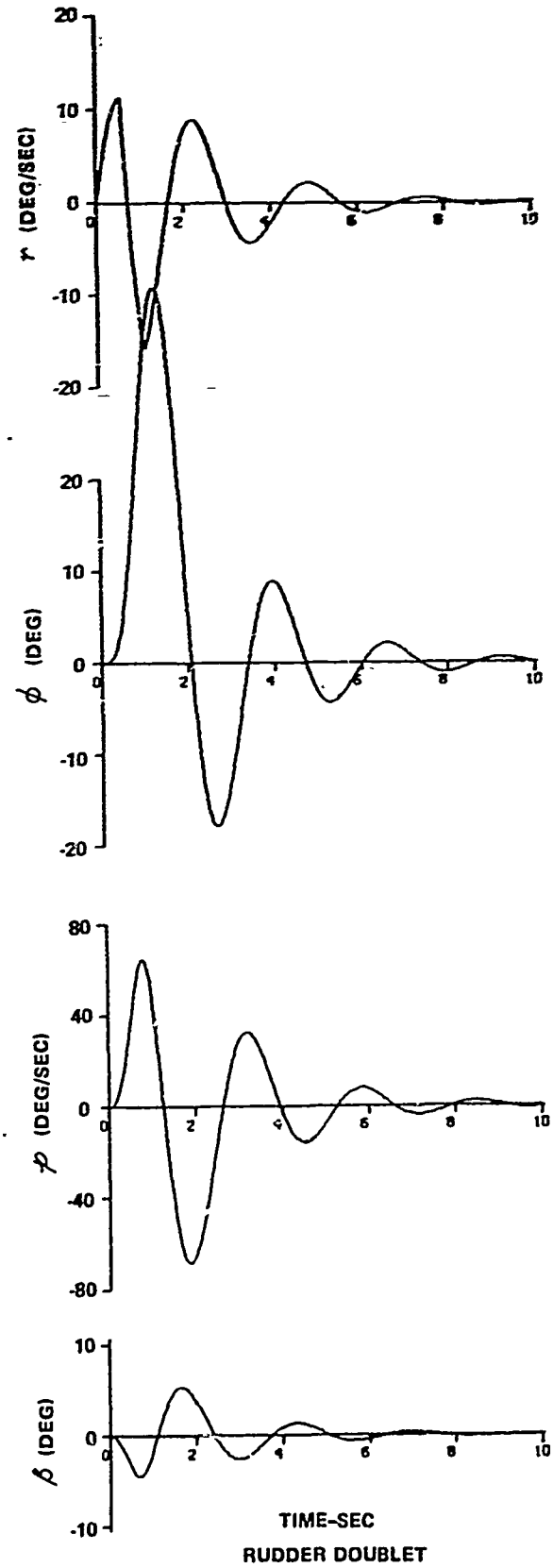
COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 11



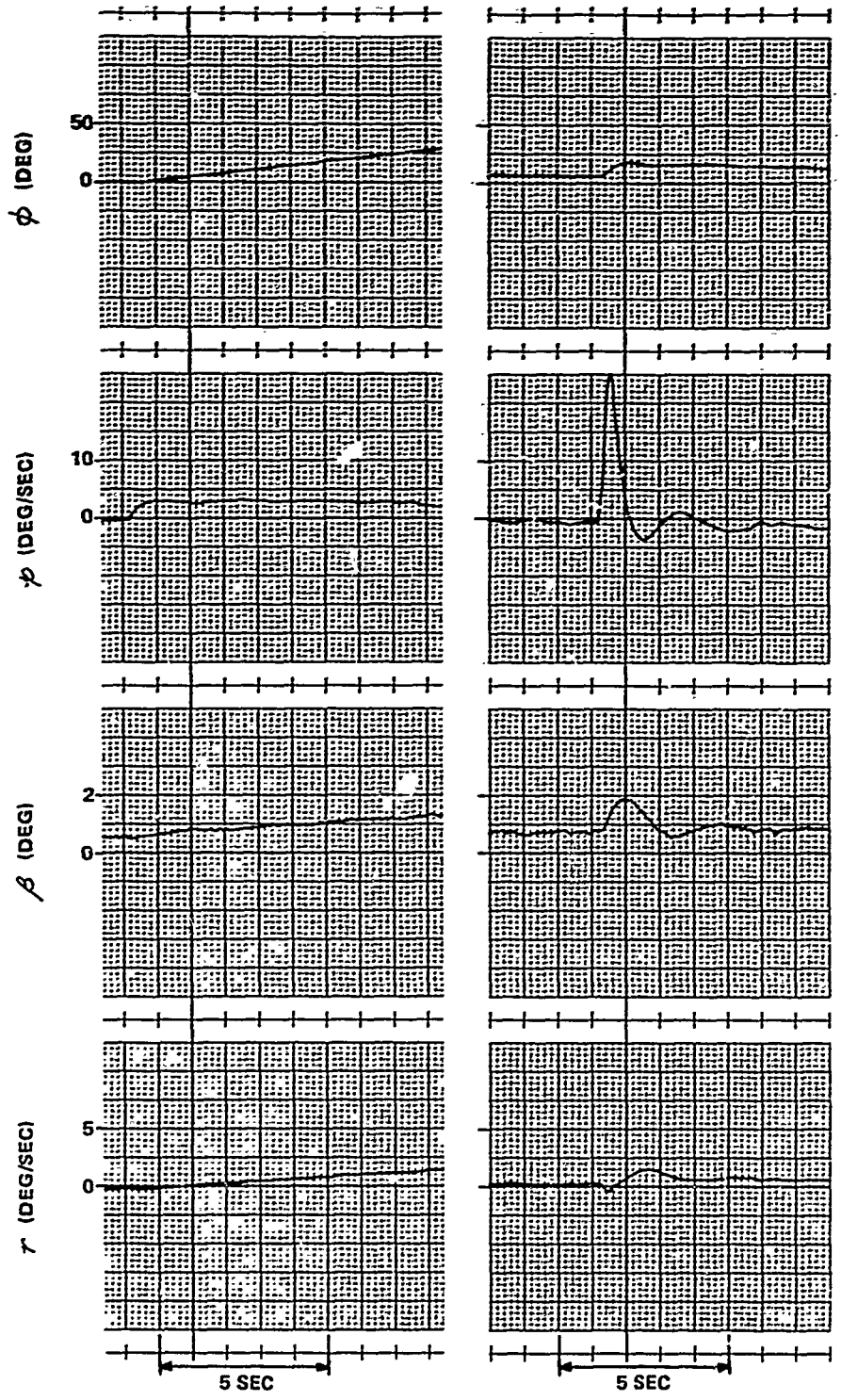
$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.03$

$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.08$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 11



COMPUTER GENERATED TRANSIENT RESPONSES TO RUDDER DOUBLET FOR CONFIGURATION 11



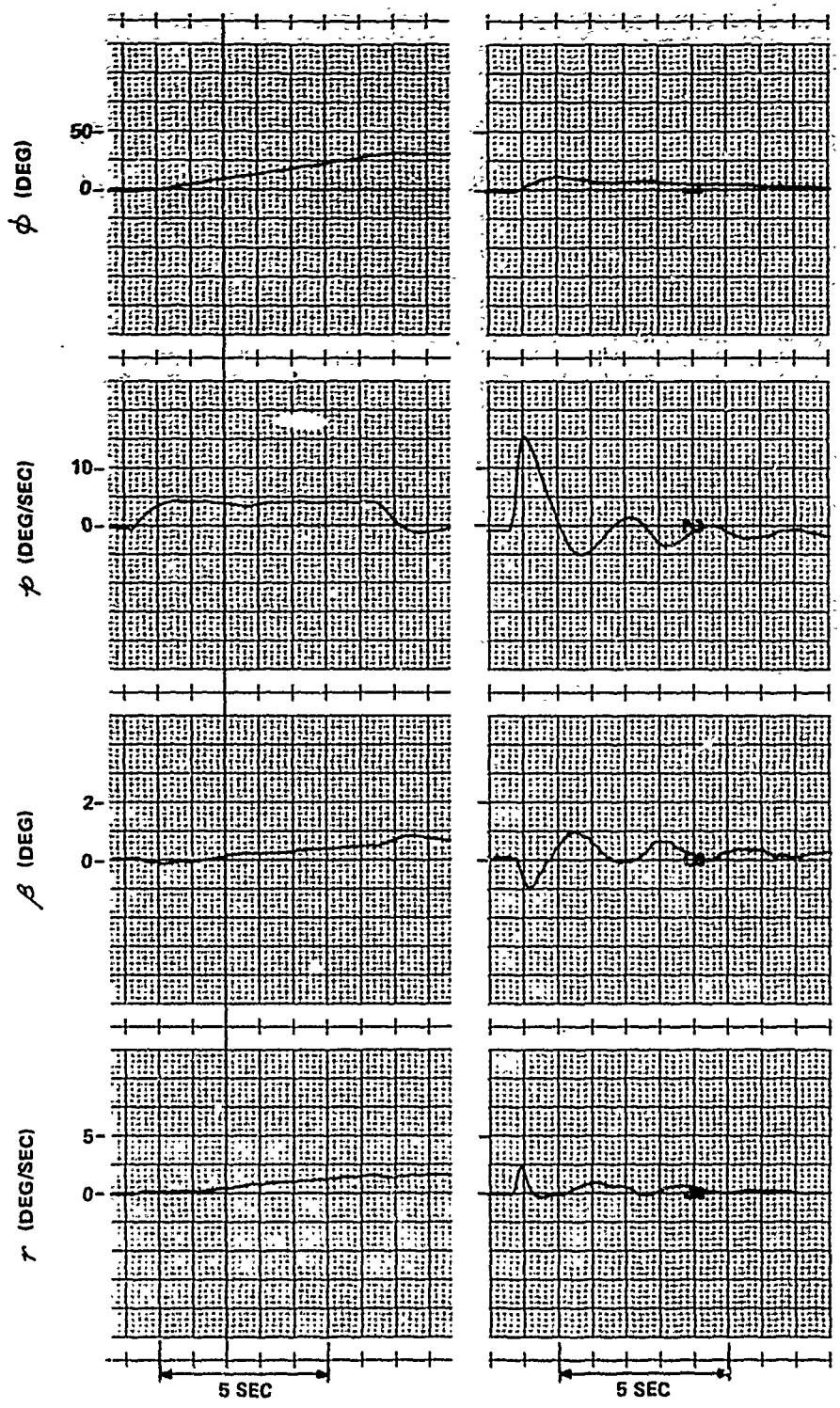
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.03$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.03$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 11



$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.08

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.08

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 11

CONFIGURATION 11 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.06 PILOT RATING 5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression was that I wasn't going to like it. That turned out to be my final impression also.

ABILITY TO TRIM

It was quite good, as a matter of fact. You had to pay a good amount of attention to the directional trim because the directional had considerable effect on the lateral trim, but once you got the directional trimmed up, the lateral was easy to trim up. Longitudinal trim was not a problem, and was okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 315 deg/sec^2-in. $N'_{\delta_{RP}}$ = 47 deg/sec^2-in.

It was a bit more of a problem on this configuration than some that I've seen in the past. I could not get the aileron quite as light as I would like, but there was a certain amount of compromise between the aileron sensitivity and the rudder sensitivity. So by making the rudder sensitivity a little lighter, I was able to get an acceptable aileron configuration. I did run out of gain on the aileron initially and simply waited until the fuel was down toward the end of the evaluation where the aileron gearing felt pretty good. It wasn't much of a problem even with the fact that we did run out of gain on the aileron. It was not a significant problem to me. Okay, aileron forces were light. However, the amount of roll rate that I was able to get out of the airplane for a given input on the ailerons was a strong function of whether or not I coordinated the airplane. In other words, the rudder was quite strong in producing roll rate, so if I did coordinate the airplane, the roll rates for the force input I put on the aileron were quite good. If I did not coordinate, there seemed to be a fair amount of adverse yaw due to aileron and I would find that the roll rate for the given amount of force was not enough and made the forces feel heavy. So in coordinated turns, the aileron forces were quite good and I was very happy with them. In uncoordinated turns, the aileron forces were heavy and I didn't like that. In general, the force combination including the coordination, was good. The displacements were small. The harmony of the controls in all three axes were quite acceptable and also satisfactory.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron response without rudder, the airplane had a very low amount of roll rate for a reasonable size input as I generated considerable amount of sideslip. If I coordinated the airplane and the coordination was in the proper direction, the roll rate was much smoother, the rates were a lot more compatible with the size input than I thought I should have. The airplane doesn't seem very oscillatory, although sideslip is generated. It dampens out reasonably quick, but the effects of the sideslip that I see are quite strong and we'll talk about that. Coordination was required to do any reasonable job with the airplane. The coordination was in the normal direction, although, it was tied a little bit to the roll rate. I'd put in an input and as I began to slow down the roll rate, if I didn't take out the rudder that I had in, the sideslip would overshoot and I'd get one or two oscillations in bank angle, about the desired bank angle. So that coordination was required and it was not really as easy to do as I would like even though it was in the proper direction.

BANK ANGLE CONTROLLABILITY

Somewhat degraded because of my inability to coordinate the airplane as well as I would like, but it wasn't completely unreasonable.

HEADING CONTROLLABILITY

That was no problem. The sideslip that was generated dampened itself out reasonably well by itself and if I coordinated the airplane properly, sideslip generated was not excessive. It really wasn't very difficult to achieve a desired heading.

BANK ANGLE COMMAND TRACKING TASK

It surprised me a little bit. I thought my performance was reasonably good. I didn't see this tendency to oscillate about the bank angle when I was aggressively making reversals up to 60° one way to 60° the other. So perhaps I flew the bank angle tracking task at a lower gain and my performance was reasonably good. When I tried to fly the tracking task coordinating, I thought the performance was good.

RESPONSE TO DISTURBANCE INPUTS

Quite noticeable in roll and the airplane oscillated in bank angle. With the high gearing that I had selected I tended to overcontrol the random disturbances in roll and consequently, the airplane was quite affected, I thought by the combination of the turbulence and my inputs. Sideslip response to the random disturbance didn't seem to be too great in that I didn't feel that I had to attack that by itself since the major effect was in roll.

LONGITUDINAL CHARACTERISTICS

Not a problem and I thought were quite compatible with the lateral-directional that I have and did not detract from the evaluation at all.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

A bit of a question. The airplane is certainly not as precise in bank angle control as I would like. A lot of sideslip is generated for an aileron-only input. The coordination required is more difficult than I would like to see and I never was really very good at it. So I don't think these characteristics are particularly well suited for the

fighter mission. I think it would be more of a problem in the air-to-air combat role, where you're required to make less programmed inputs and stand a chance of not getting the airplane coordinated as well as you would like. And I think, therefore, that these characteristics are less suited for the air-to-air mission than perhaps for the air-to-ground where you're a little more aware and have a little more lead time as to what you're doing. The biggest problems, again, if you didn't coordinate the airplane, the roll rates were low. The bank angle was not really ratchetty because the airplane Dutch roll characteristics seemed to be reasonably well damped. The roll rates were low but when the sideslip did oscillate, it did change your bank angle. I couldn't really keep the sideslip in the center for aggressive maneuvers. So I would consider those special problems.

GOOD FEATURES

It had good roll performance in that using the combination of rudder and aileron to roll the airplane, you can roll the airplane quite well. The fact that the sideslip was in the adverse direction so that the coordination required was in the normal manner, would be a good feature.

OBJECTIONABLE FEATURES

Primarily the large amount of sideslip that's generated and the fact that I couldn't coordinate the sideslip as well as I would like coupled with the fact that the sideslip seems to have a strong effect upon the bank angle controllability of the airplane. I'd also include the fact that the random disturbance seems to have a quite significant effect upon my ability to control the bank angle.

SPECIAL PILOTING TECHNIQUES

Coordination is a must and a fair amount of rudder was required to keep the sideslip disturbances low.

PRIMARY REASON FOR THE PILOT RATING

The characteristics as I see them are adequate. However, I do not feel that they are satisfactory without improvements. I would say that the deficiencies, and primarily the sideslip control was certainly a moderate objection and that it requires, I think considerable pilot compensation to give you even adequate performance and even that performance is really not sterling. It's, I think, flyable in the mission, if I had a real high performance super-duper airplane, I wouldn't like it, but I could do the job. I think that there is certainly more effort required in the presence of the random disturbance and that it gives me at least a moderate deterioration in my performance.

CONFIGURATION 11 $N'_{\delta_{RS}}/L'_{\delta_{AS}}$ =-0.03 PILOT RATING 4 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

It wasn't going to be very good, but it wasn't going to be very bad either. And as a matter of fact it turned out, I thought, to be a little worse than I initially thought it might be. Problems were in the gearing selection.

ABILITY TO TRIM

Lateral-directional; both axes, is good. Longitudinal is also good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 360 deg/sec^2-in. $N'_{\delta_{RP}}$ = 30 deg/sec^2-in.

Started flying the airplane with a relatively low gearing and because of the low gearing, I wasn't maneuvering the airplane very rapidly nor was I exciting very much sideslip with aileron control inputs. As I got the gear ratio up to what I thought was a more desirable gear ratio, I began to notice that I was exciting a substantial amount of adverse yaw with each aileron control input and this began to create a few problems for me although they weren't really tremendous problems. So don't really think I compromised on the aileron. I think I ended up probably just bringing up the rudder control power to make things better. In other words, I gave myself more sensitivity on the rudder pedals so that I could coordinate the sideslip response that I saw. The forces turned out to be light in all three axes and the displacements relatively small and the control harmony between the three axes was good.

AIRPLANE RESPONSE TO PILOT INPUTS

To an aileron stick input without the rudder, I did excite some adverse yaw and it got stirred up. I think, not an inordinate amount but certainly a noticeable amount in the roll rate. When I coordinated with the rudder, I noticed that my roll rates were considerably greater and smoother. Okay, as far as oscillatory characteristics, they weren't overwhelming. I did notice on the tracking task, when I would have to operate the rudders to get the sideslip back to zero, that I would get a one or two oscillation in bank angle going, so that there is a very slight oscillatory tendency here, but not again really overwhelming. The airplane did require coordination. The sideslip tended to show up in roll rate more in this configuration than some I've seen and consequently, it was to my advantage for a couple of reasons to coordinate. One, I could increase the roll rate, and two, I could smooth out the roll rate with coordination.

BANK ANGLE CONTROLLABILITY

Fair to good. As I mentioned earlier I noticed sometimes when I tried to stop at a bank angle without having the sideslip near zero, that I would oscillate a couple of times before the bank angle would settle down.

HEADING CONTROLLABILITY

Seemed to be pretty good. The sideslip oscillations I'm talking about really weren't tremendous. So that I could achieve a heading and hold it quite well.

BANK ANGLE COMMAND TRACKING TASK

Performance is only fair to good also. Again, because of my inability to control the sideslip which tended to cause me some bank angle problems.

RESPONSE TO DISTURBANCE INPUTS

The airplane has a quite strong roll response to random disturbance inputs and does affect my ability to track, at least to a moderate degree.

LONGITUDINAL CHARACTERISTICS

They were good, did not interfere with the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they're acceptable, at this point. I don't believe they're satisfactory. In the air-to-air role, the inability to maintain and achieve precise bank angles rapidly, I think would be a bit of a problem for tracking other airplanes. I think the fact that I do excite a noticeable amount of sideslip with each aileron input, is also a factor. In air-to-ground, I think the turbulence response would tend to degrade the air-to-ground capabilities of this machine quite noticeably. Special problems involved in both of these missions is coordinating the sideslip generated to an aileron input and smoothing out the roll rate so that you can be precise.

GOOD FEATURES

I like the fact that I have a real good roll performance with this configuration. I like the fact that I can augment the roll with the rudder inputs.

OBJECTIONABLE FEATURES

I think the random disturbance inputs in roll are objectionable and I think the fact that the sideslip that is excited, even though it's not a whole lot, does tend to show up in bank angle, is also objectionable.

SPECIAL PILOTING TECHNIQUES

Coordination is required. Coordination is in the proper direction so that it's not difficult to do, but you do have to pay attention to it.

PRIMARY REASON FOR THE PILOT RATING

I don't believe the airplane is satisfactory without improvements, however, the deficiencies that I have pointed out, I feel are only minor, certainly annoying, but it does require a moderate amount of pilot compensation to fly the airplane. In turbulence more effort is required; there's at least a moderate deterioration.

CONFIGURATION 11 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$ PILOT RATING 3.5 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Pilot comments lost due to malfunction of voice recorder.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 330$ deg/sec^2-in. $N'_{\delta_{RP}} = 24.5$ deg/sec^2-in.

CONFIGURATION 11 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +.03$ PILOT RATING 4.5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

It wasn't going to be too bad. Seemed to have good roll performance. Had a bit of proverse yaw but a relatively fast Dutch roll and relatively good stiffness so that I couldn't coordinate the thing. But the sideslip angles that were generated were not very large and so I pretty much flew the thing feet-on-the-floor.

ABILITY TO TRIM

Good in all three axes. No particular problems either way. A little bit sensitive to directional trim in that the directional trim seemed to have a strong influence on the lateral response. Longitudinal trim was OK.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 355 deg/sec^2-in. $N'_{\delta_{RP}}$ = 24 deg/sec^2-in.

A little bit of a compromise on the aileron but it was only slight. There was a tendency at a high sensitivity on the ailerons to set up a little bit of an overshooting tendency on bank angle control and to oscillate a little bit about a given bank angle. So by cutting down on the aileron sensitivity just a little bit I could alleviate some of this overshooting tendency although I never could completely get rid of it, nor could I completely get rid of the tendency to oscillate about the bank angles. On the rudder, I really couldn't coordinate the thing so I didn't use very much rudder. Consequently, I ended up taking pretty much what I was given, although I think I did back off on the sensitivity a little bit. This was because you did end up with a slight amount of adverse yaw toward the end of a rolling maneuver and so it helped a little bit to be able to control that and by cutting down on the sensitivity I didn't tend to overcontrol. So the forces on the aileron ended up to be comfortable and light. On the rudder they were comfortable, again you didn't use them very much. Displacements were good and control harmony in general among those three controls was quite good.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron only; roll rate seemed to be pretty smooth, as I mentioned earlier there was a noticeable amount of proverse yaw due to an initial aileron input and it tended to back off a little bit and I think become slightly adverse although I didn't really look at it that closely. As I mentioned, normal coordination tended to aggravate the proverse yaw situation, so I ended up not coordinating at all. The airplane is not overdamped but seems to be reasonably well damped so that oscillatory tendencies weren't very great and didn't seem to cause much of a problem. In maneuvering, coordination was required but it wasn't something that I could accomplish because it was a left-right type of thing depending on which way you were rolling, so I tended to accept the amount of sideslip that I saw.

BANK ANGLE CONTROLLABILITY

A little bit degraded because as I mentioned, there is a very slight tendency to overshoot, or overcontrol in bank angle. It's not something dramatic but a slight tendency to oscillate about a couple times before the airplane settles down on the bank angle.

HEADING CONTROLLABILITY

Good, the Dutch roll was fast enough and reasonably well damped so that I didn't have any real problem getting the airplane to point in the direction I wished to go.

BANK ANGLE COMMAND TRACKING TASK

The performance wasn't really super, again because of these bank angle overshooting and overcontrolling problems. Sideslip was not much of a problem because I couldn't do anything about it anyway.

RESPONSE TO DISTURBANCE INPUTS

Were a bit dramatic in roll, the airplane had a fairly strong roll response to the disturbance inputs and did cause at least a moderate deterioration in my ability to perform the fighter task because the airplane was moving quite a bit in roll.

LONGITUDINAL CHARACTERISTICS

Did not interfere or detract from the lateral-directional - not a factor.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

They are acceptable, however I don't feel that they are satisfactory. In the air-to-air role I think you would like to have real fine control of bank angle and be able to pinpoint the bank angle precisely and not have to worry about overcontrolling or overshooting so that my performance in the air-to-air mission is degraded a bit because of this bank angle problem. On the air-to-ground role, similar problems, but I think the main problem there would be the turbulence response which I thought was quite noticeable on this configuration and I think would cause you difficulties in pursuing the target with the wings rocking as much as they were here.

GOOD FEATURES

The roll capability and roll performance I thought were good, there was no problem doing anything I wanted to with the airplane.

OBJECTIONABLE FEATURES

As I mentioned, I could not keep the sideslip at zero. When I tried I only made it worse, so it's objectionable to me that I have to end up accepting a sideslip disturbance and one that I really can't do anything about.

SPECIAL PILOTING TECHNIQUES

It may be possible to come up with a technique to coordinate that crazy sideslip response - I wasn't able to do it.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable I don't feel however that the airplane is satisfactory for the fighter mission, and I think that the characteristics that I'm seeing are somewhere between minor and moderate, I think you could put up with them. With turbulence, certainly more effort is required with a moderate deterioration in task performance.

CONFIGURATION 11 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ =+0.08 PILOT RATING 7 TURBULENCE RATING E

INITIAL IMPRESSION AND GENERAL COMMENTS

That it's not going to be too bad. It had good roll performance and it was obvious that it had a lot of proverse yaw with aileron input. It didn't look like it was going to be too bad. However, as I flew the thing it was quite obvious that there was quite a dramatic tendency to overshoot, overcontrol and oscillate in bank angle. I think I concluded that it was too much to be able to do the job well.

ABILITY TO TRIM

Lateral-directionally was very good. It was one of the easiest to trim that I had for a while. Longitudinal trim was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 203 deg/sec^2-in. $N'_{\delta_{RP}}$ = 24.5 deg/sec^2-in.

On the ailerons, I think I ended up accepting what I started out with. I did try both higher and lower gearings on the ailerons. When I went to higher gearings, my overcontrol and oscillatory tendencies during closed loop bank angle tracking got quite a bit worse. Backing down on the sensitivity helped a little bit. I never really could track bank angles tightly without setting up a bit of an oscillation. So I ended up accepting not a heavy aileron force but perhaps a little heavier than what I would prefer.

AIRPLANE RESPONSE TO PILOT INPUTS

I really couldn't coordinate this airplane. It required cross coordination initially followed by coordination in the proper direction, the major sideslip response being in the proverse direction. So that I really couldn't coordinate it. However, the sideslips that were generated were within bounds so that I wasn't getting any real large sideslip angles. But there seemed to be enough sideslip generated that it did affect my roll control. Oscillatory characteristics - the Dutch roll is not heavily damped but it's not what I consider light damping either. There does seem to be a tendency for a closed loop oscillation with this configuration which is quite marked. Maneuvering - I did better if I left my feet on the floor because invariably I tended to overcontrol by coordinating. I decided not to use my feet for maneuvering.

BANK ANGLE CONTROLLABILITY

It's very poor. You can't do it aggressively. You can ease into it if you come up on it. But if you try to roll right up and stop on a bank angle, you set up 5 or 6 oscillations before you get settled down and then if you get disturbed from that, you go through the same procedure again. So the bank angle control is what's unacceptable for this airplane.

HEADING CONTROLLABILITY

It's tied to the bank angle control but the oscillations are pretty much symmetrical about a selected bank angle, such as trying to hold wing level. No problem once you get there, you can just let go and stay there. But trying to roll rapidly to zero bank angle and stop it, there is a tendency to oscillate. These oscillations are pretty symmetrical so heading control really isn't affected that much if you are just talking about pointing the airplane at a point up in the sky.

BANK ANGLE COMMAND TRACKING TASK

Performance was quite poor. You should be able to see from the records that there is a marked tendency to overcontrol and oscillate in bank angle.

RESPONSE TO DISTURBANCE INPUTS

Tends to complicate the bank angle control problem so that the turbulence, although it's not moving the airplane around that much, disturbs the airplane sufficiently from a given bank angle that I think the combination of the pilot, airplane, and running disturbances are quite significant in the lateral mode anyway.

LONGITUDINAL CHARACTERISTICS

Good. It certainly did not detract from the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I don't think they are acceptable for the air-to-air role in particular because I put a strong emphasis on being able to control bank angle because if you are going to track another airplane and launch weapons, fire guns at it, you've got to have good bank angle control and this airplanes doesn't have it. There's too much coupling between the airplane and the pilot when trying to track bank angle tightly and I think a significant enough oscillation to say that it is unacceptable. Air-to-ground I think you would have similar problems perhaps to a lesser degree because you are probably using heading and bank angle changes to a lesser degree and probably tracking bank angle less tightly. The special problems involved are the oscillations in bank angle. Very poor bank angle control.

GOOD FEATURES

It has good roll performance, you can roll the airplane around, you can maneuver it. Do a pretty good job until you try to do something precisely.

OBJECTIONABLE FEATURES

The imprecise bank angle control and the fact that I set up pilot induced oscillations. The fact that the sideslip that was generated was in the proverse direction. I really can't coordinate that very well.

SPECIAL PILOTING TECHNIQUES

I didn't use my feet because I usually tended to make the sideslip worse rather than better when I tried to coordinate the thing.

PRIMARY REASON FOR THE PILOT RATING

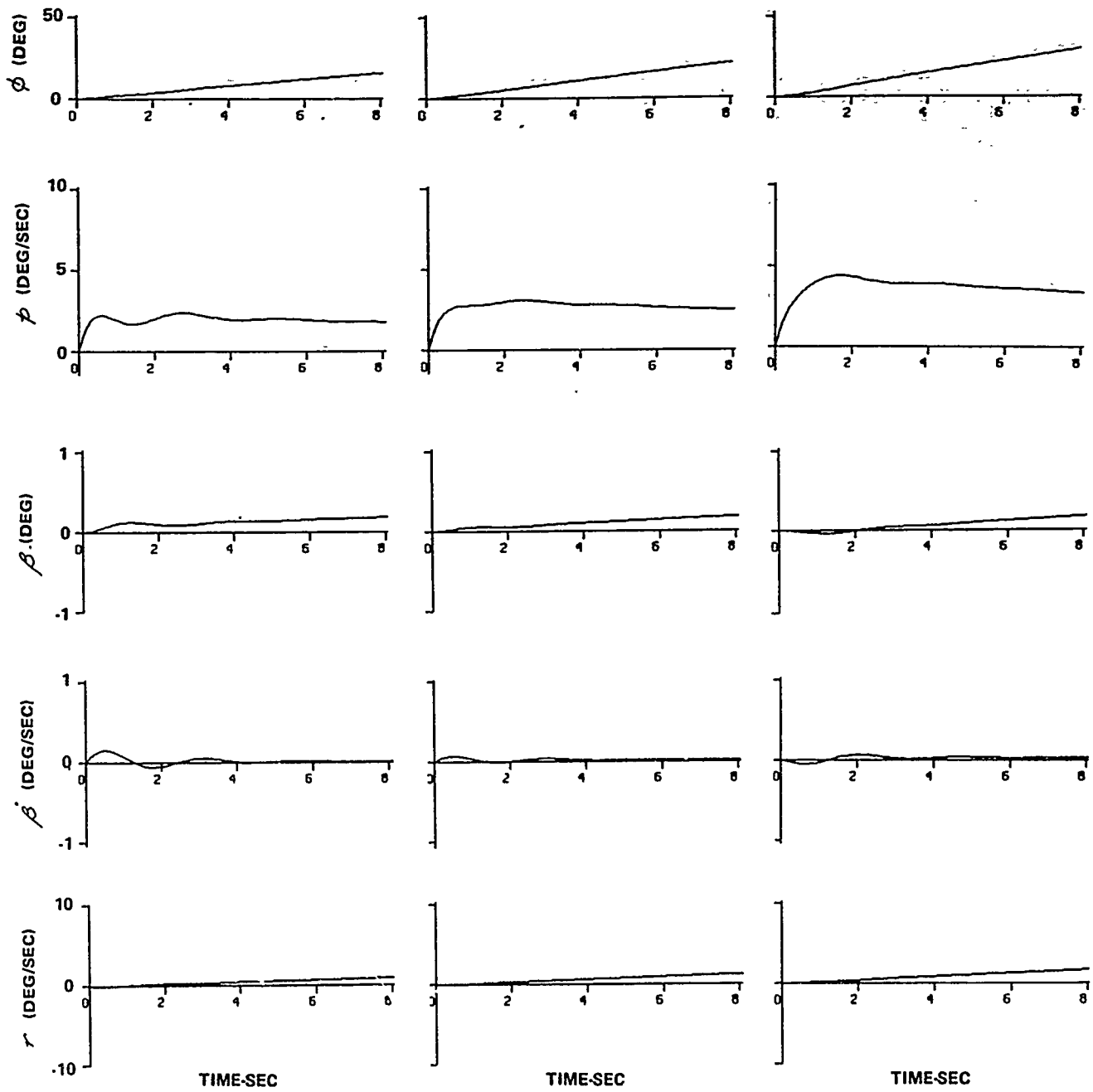
Main reasons for the pilot rating is that I don't think that I could get adequate performance because of the very poor bank angle tracking capability of this airplane. In turbulence - I think more effort is required. I think I'm going to say that the best efforts are required. The turbulence does tend to compound the lateral oscillations that I am seeing.

CONFIGURATION 11A IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	$\dot{\psi}_\beta$ STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/\phi$ LEVEL 1	$\Delta\beta_{max}/\phi$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.06	5.5	E	0.18	1.96	-175	0.13	6.4	4.9	0.42	305	39
-0.03	4.5	D	0.19	2.30	-160	0.03	2.5	1.8	0.10	325	32
-0.03	2	C	0.19	2.30	-160	0.03	2.5	1.8	0.10	360	19
+0.01	2.5	B	0.20	2.68	-310	0.07	1.8	1.2	0.10	276	23
+0.03	3.5	C	0.21	285	-005	0.12	3.2	2.2	0.13	288	19.5

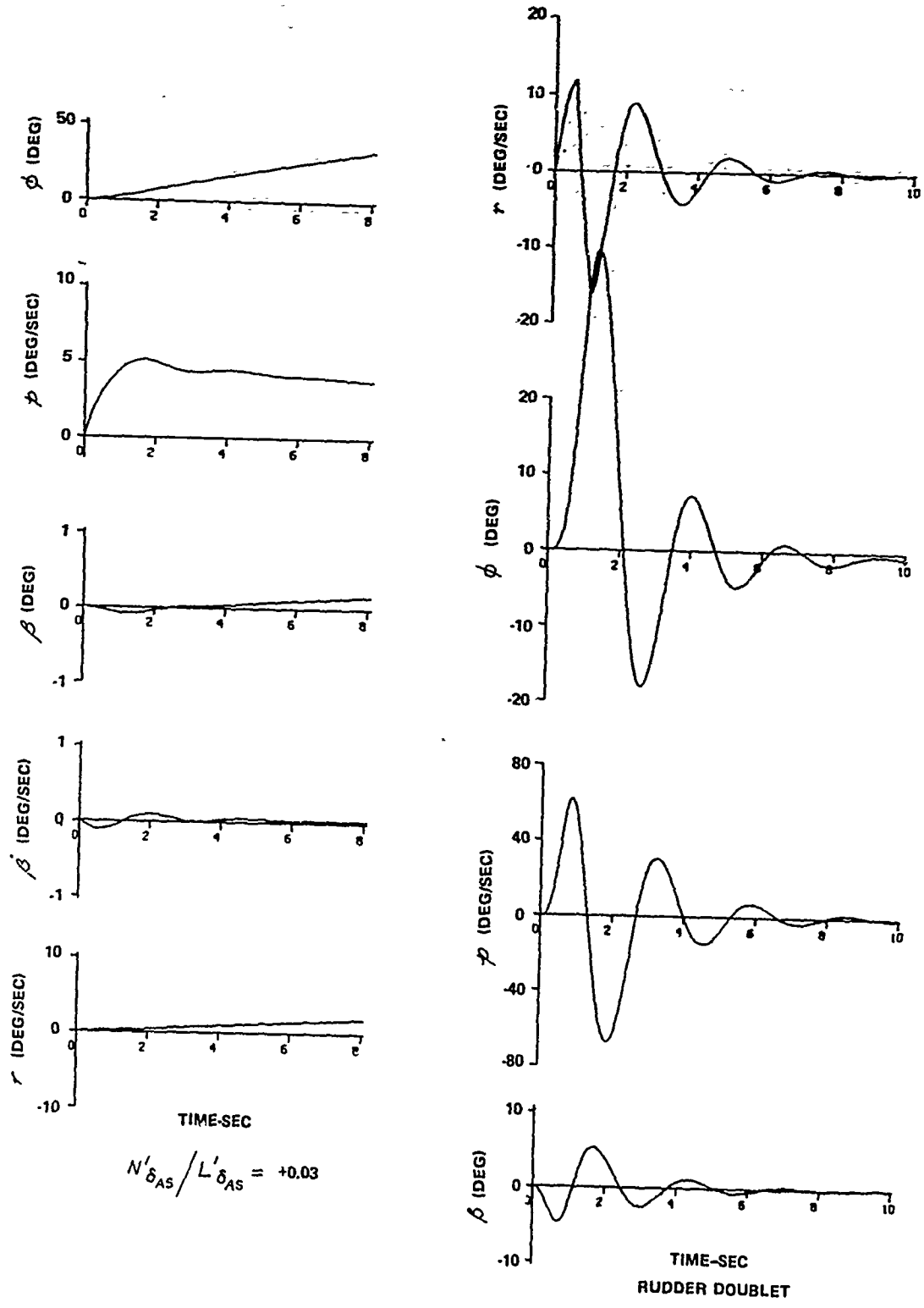
LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

ω_d	= 2.46	N'_β	= 6.72	L'_β	= -48.0
ζ_d	= 0.23	N'_r	= -0.853	L'_r	= 4.65
τ_R	= 0.37	N'_p	= 0.109	L'_p	= -2.84
τ_S	= 29	$\frac{g}{V}$	= 0.0586	Y_β	= -0.176
$\left\|\frac{\phi}{\beta}\right\|_d$	= 5.7	$Y_r - 1$	= -0.99	$Y_{\dot{\beta}}$	= -1.015
$\angle\left(\frac{\phi}{\beta}\right)_d$	= 43.0	$Y_p + \alpha_o$	= 0.0025		

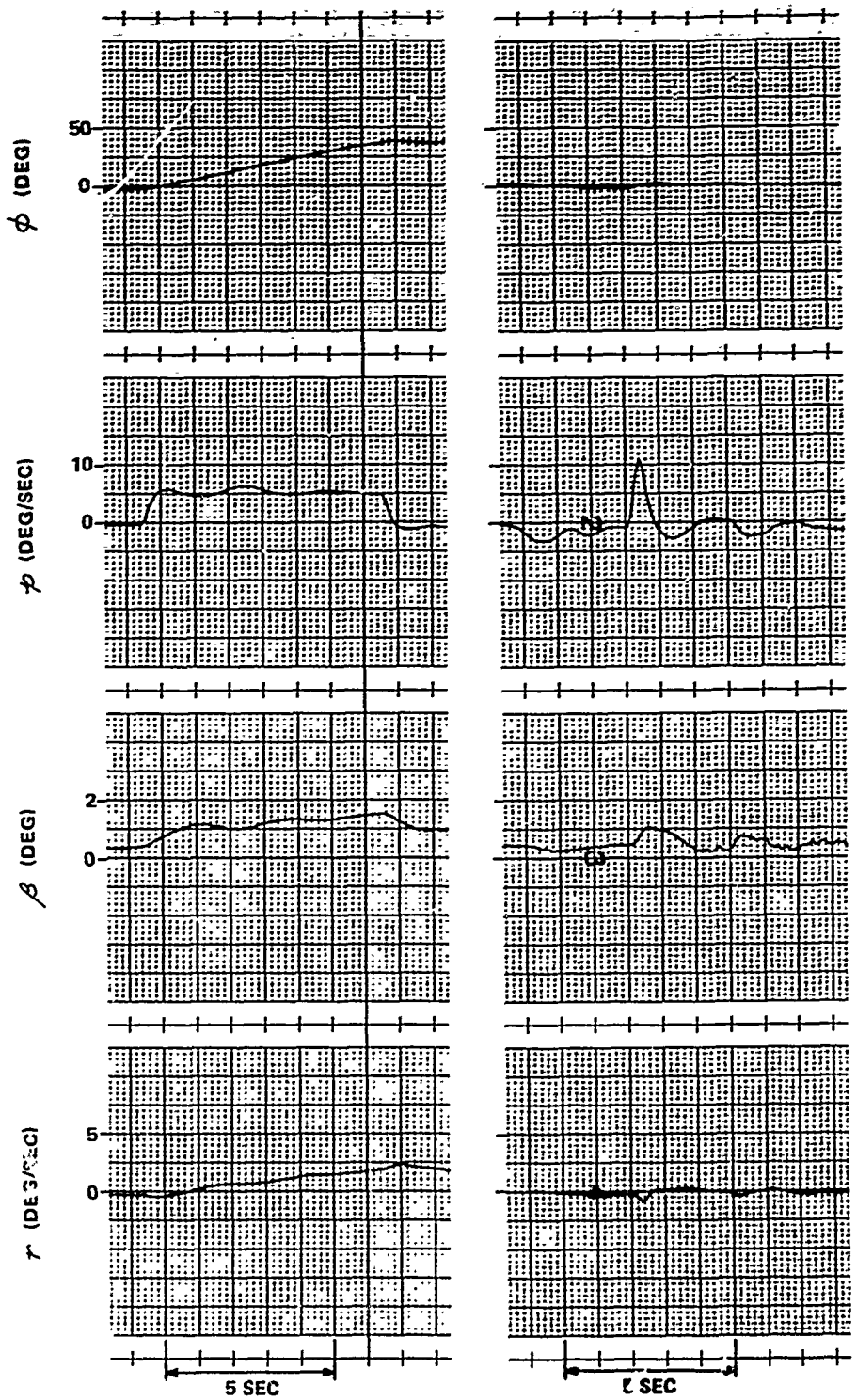


$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.06$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.03$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.01$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 11A



COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR CONFIGURATION 11A



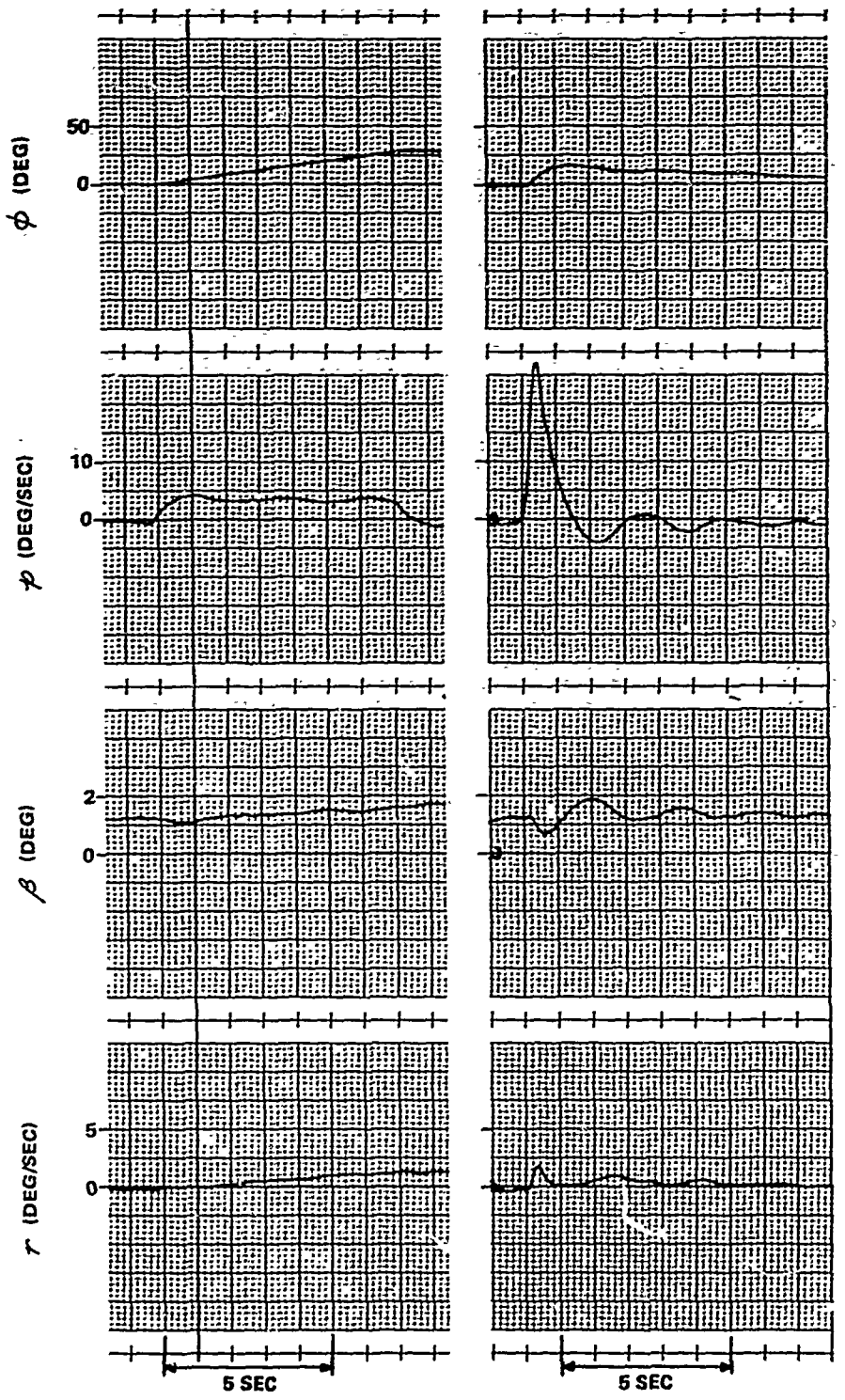
$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.06

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.08

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 11A



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.03$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.03$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 11A

CONFIGURATION 11A $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -.06$ PILOT RATING 5.5 TURBULENCE RATING E

INITIAL IMPRESSIONS AND GENERAL COMMENTS

I didn't think that I was going to particularly like it. It seemed to have a lot of adverse yaw associated with an aileron control input and it seemed to have a fairly high roll to sideslip ratio and the combination of the two made for a pretty heavy airplane in roll. I think this is brought out by virtue of the fact that I selected maximum aileron gearing and then had to wait till the fuel burned down till I really got the gearing effect that I thought was acceptable.

ABILITY TO TRIM

All three axes were good, was no problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 305$ deg/sec^2-in. $N'_{\delta_{RP}} = 39$ deg/sec^2-in.

On the aileron there was no real compromise. I wanted high aileron gearing because the airplane seemed to feel heavy in roll and I speculate that that's probably because of the adverse yaw associated with the high roll to sideslip ratio. I ended up with a gearing that gave me a little heavier ailerons than I'm used to having, but it was okay and no problem. The rudder was a bit of a problem. There was a lot of adverse yaw associated with the aileron inputs, so that I felt that I wanted light rudders to be able to handle that. However, when I got the rudders light enough, I had a real tendency to overcontrol the sideslip about the center position of the sideslip needle. There was also a tendency on my part to want to use the rudder to augment the roll which felt heavy with the ailerons only, so that I ended up using a fair amount of rudder. There was a bit of a compromise on the rudder. I backed down, making them heavier than with the initial setting that we had. Okay, the forces that I ended up with weren't real light, but they were okay for what we were trying to do. Displacements were small. The control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron-only, there was what looked like to be a fair amount of adverse yaw associated with an aileron control input which showed up very definitely in the roll characteristics in that the roll rate was noticeably ratchety. When I coordinated the inputs, the roll performance was better and some of the ratchetiness went away, but as I mentioned, I had a tendency to overcontrol somewhat with rudder. As far as oscillatory characteristics are concerned, the bank angle wasn't smooth, but it wasn't something that I would have to describe as oscillatory. The airplane had kind of a funny sashaying feeling about it, but never really uncomfortable. The airplane felt like it was in a combination of roll and sideslip most of the time when I was maneuvering it and this was a little bit uncomfortable. In maneuvering a lot of rudder is required. Fortunately it's in the adverse direction so that I was reasonably able to keep up with it.

BANK ANGLE CONTROLLABILITY

Wasn't as good as I would have liked. The roll rate wasn't particularly smooth and if I tended to overcontrol with the rudder, then I could occasionally go past the bank angle that I wanted. So the bank angle control seemed to be a strong function of how good I was with my feet. Since I had to use my feet almost continuously when I was maneuvering, I wasn't particularly good at it. So the bank angle controllability wasn't as good as I would like, with a tendency to either end up working my way up to the bank angle or stepping in too much rudder and overcontrolling.

HEADING CONTROLLABILITY

Wasn't much of a problem. The Dutch roll seemed to be reasonably well damped, not over-damped but certainly good enough. The bank angle excursions, even with the large sideslip inputs, died out rapidly so that it was no problem.

BANK ANGLE COMMAND TRACKING TASK

As far as keeping the errors low, it's no problem, but I wasn't able to get right on the bank angle and stop it. I had a tendency to end up either working my way up to it or backing down to it from having overcontrolled it. So even though the errors may have been small, I wasn't really able to roll right up and stop at the bank angle as well as I would have liked.

RESPONSE TO DISTURBANCE

The airplane has a quite noticeable roll response to the disturbance input so that you're almost continually fighting the ailerons. And I kind of feel like you're down in the "best efforts required with probably a moderate deterioration" of my task performance. That's particularly noticeable when attacking a ground target. There was a tendency for my wings to be wobbly and then as I attempted to counter these rolling disturbances, the nose would move back and forth because I was not able to perfectly coordinate the sideslip generated from my aileron inputs.

LONGITUDINAL CHARACTERISTICS

Okay, they didn't seem to detract from the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they're probably acceptable. They're certainly not satisfactory. In the air-to-air role, this continuous roll-sideslip motion that I find myself in would detract considerably from my ability to get bullets into a target.

The fact that the bank angle control or roll control is not smooth detracts from the air-to-air capabilities of the machine. Air-to-ground, I think one of the biggest factors would be the large roll response to the random disturbance inputs. So in general, I don't think my accuracy for this configuration was as good as I would like for it to be.

GOOD FEATURES

Really no outstanding good features about it. Fortunately the sideslip that was generated is in the adverse direction and therefore I had some chance of being able to counter these sideslip disturbances.

OBJECTIONABLE FEATURES

I think this continuous kind of roll-sideslip motion, that seemed to be present most of the time when I'm maneuvering the airplane, is objectionable. The large amount of adverse yaw is objectionable and I think the roll disturbances to turbulence inputs are quite objectionable. Another objection and the one that really detracts from the mission is the kind of ratchety roll response that I have and the fact that I can't roll right up to and stop on a bank angle.

SPECIAL PILOTING TECHNIQUES

You very definitely need a lot of rudder to coordinate this configuration. Fortunately it's in the adverse direction. You do have to be a little bit careful, however, about the near zero sideslips.

PRIMARY REASON FOR THE PILOT RATING

I think it's acceptable. I don't feel, however, that it's satisfactory. The deficiencies that I see are somewhere between moderately objectionable, maybe a little stronger than that. Adequate performance requires, I'd say slightly more than just considerable pilot compensation because you really have to stay on the rudder. Just not quite as good in there as I'd like to be.

CONFIGURATION 11A $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -.03$ PILOT RATING 4.5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

I was going to like it pretty well, however, as I flew it, there were a couple of things about it that I didn't like that I think warrant a little fixing.

ABILITY TO TRIM

Reasonably good but I would like to point out that I have some trouble getting the thing trimmed perfectly, even after we've reduced the gear ratios. Longitudinal trim was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 325$ deg/sec^2-in. $N'_{\delta_{RP}} = 32$ deg/sec^2-in.

I don't believe there was any compromise on the ailerons, could pick them nice and light. There did seem to be a little bit of tiny adverse yaw due to an aileron input, but it didn't seem to be excessive. Selection of the aileron gear ratio was strictly to give me nice light aileron forces which I like for maneuvering. On the rudder however, I had the gearing cranked down quite a bit because I needed just a little bit of rudder. With the initial sensitivity that I had I was overcontrolling so by making the rudder less sensitive I could get a more compatible rudder/aileron input combination that allowed me to coordinate the little bit of sideslip that I was seeing reasonably well. The forces were light on the aileron. Displacements were small in both axes and control harmony was good. An aileron-only input seemed to generate a reasonably smooth roll rate. There did seem to be a small amount of adverse yaw due to the aileron input. Coordinating with the rudder definitely tended to speed up the roll response but its smoothness didn't change very much. The Dutch roll seemed to be well damped; it wasn't much of a problem. I didn't even notice it until I started trying to track bank angle tightly and there was a slight tendency to set up a 1 or 2 cycle oscillation about a bank angle as I tried to stop it. In other words it was hard to pin down a bank angle as perfectly as I would like. In maneuvering it helped to coordinate. If you did coordinate you could feel that you did speed the airplane up in roll and it made for a real maneuverable airplane.

BANK ANGLE CONTROLLABILITY

I wasn't able to pinpoint bank anywhere near as good as I would have liked. There was a tendency to overshoot and have to hunt around to get the airplane to stop precisely where I wanted it. This showed up also in the bank angle tracking task.

HEADING CONTROLLABILITY

Good. The Dutch roll seemed to be reasonably fast and well damped, so that the airplane in general was pointed pretty much where you wanted it to go.

BANK ANGLE COMMAND TRACKING TASK

My performance was only fair. I would roll up to a bank angle, and think I had it pinned down, when it would move a little bit one way or the other and I would have to correct for this. I suspect that this may be due to my exciting a little bit of sideslip and with what seemed a relatively high roll to sideslip ratio, this sideslip would reflect in bank angle and cause me a bit of a problem.

RESPONSE TO DISTURBANCE INPUTS

The airplane had a very marked roll response due to disturbance inputs -- this is particularly noticeable in tracking ground targets. It really moved around and tended to degrade my performance a moderate amount.

LONGITUDINAL CHARACTERISTICS

Did not degrade or interfere with the evaluation of the lateral-directional -- they were good.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

They are acceptable. However, I do not feel that they are satisfactory without some improvement. For an aileron roll, my inability to track bank angle precisely or roll to and stop at a bank angle is a bit degrading as is the large roll response to disturbance inputs. Air-to-ground - similar problems, mostly due to the roll response. So that as far as my ability to perform the fighter mission, it leaves a little bit to be desired.

GOOD FEATURES

I like the fact that the Dutch roll excitation was well damped and that the sideslip angles that were generated were small and I liked, in general, the maneuverability of the airplane and also my ability to speed up the roll rate with the rudder inputs.

OBJECTIONABLE FEATURES

Primary objection is the impreciseness of my bank angle control and the fact that what little sideslip I'm generating and what little Dutch roll I see tends to show up primarily in roll. This tends to degrade my ability to roll to and precisely stop at a bank angle. I think the larger roll response to disturbance inputs is likewise objectionable.

SPECIAL PILOTING TECHNIQUES

A little bit of normal coordination helps. However, it's not absolutely necessary. The sideslip angles that we generated were reasonably small.

PRIMARY REASON FOR THE PILOT RATING

The airplane is acceptable, but I don't feel it's satisfactory for the fighter mission. The deficiencies that I note are somewhere between minor and moderate. Moderate pilot compensation is required and the deficiencies are getting a little more than minor principally in the bank angle control and the disturbance response. I think there is quite a bit of work required keeping the bank angle under control with certainly a moderate deterioration in performance.

CONFIGURATION 11A $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -.03$ PILOT RATING 2 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

I was going to like it and that remained throughout.

ABILITY TO TRIM

Good directionally but I had a problem laterally. Longitudinal trim was good, no problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 360$ deg/sec^2-in. $N'_{\delta_{RP}} = 19$ deg/sec^2-in.

I was able to select nice light aileron forces with no compromise there. I did crank up the aileron gearing and then I ended right back where I started from. What I found was a tendency to overcontrol the airplane essentially about a midpoint for the high gearing selection, not anything serious but just the fact that the aileron was too light. I was able to select what I thought was a nice comfortable gearing. It gave me nice light forces. Rudder was required in the normal direction for coordination. I ended up heavying up the rudder so that I didn't overcontrol, because when I did overcontrol with the rudder I could feel it in the roll rate; the airplane accelerated up on me. Heavying up on the rudder allowed me to get a more harmonious input with the aileron and keep the sideslip somewhat near the center. Forces, quite light on the ailerons. On the rudders, forces were not really light but comfortable. Displacements were small and control harmony I thought was good.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron only, there seemed to be very little sideslip generated. For the most part the sideslip ended up in the adverse direction and the roll rate to aileron input was quite smooth. Coordinating the small amount of adverse yaw that I saw helped a little bit, but didn't make too much difference because there wasn't much sideslip generated. It was quite noticeable that using rudder into the turn you could really increase your roll rate. As far as oscillatory characteristics, there were none in roll or bank angle worth mentioning. In maneuvering, you just have to use a little rudder, in the normal adverse direction.

BANK ANGLE CONTROLLABILITY

I thought was good. You could roll right up and stop on a bank angle quite well.

HEADING CONTROLLABILITY

Was good. The Dutch roll seemed to be of high enough frequency and well damped so that there was no tendency to wander at all.

BANK ANGLE COMMAND TRACKING TASK

Performance was quite good. I found that I was flying quite aggressively and there was a little tendency to overshoot simply because I was getting the airplane to roll quite rapidly. No real problems encountered there. I think I did coordinate the rudder with the ailerons in the tracking task but I really wouldn't stake too much money on that.

RESPONSE TO DISTURBANCE INPUTS

Most noticeable response is the roll and that's kind of interesting. I noticed that with the sensitivity that I had and hence the airplane getting these rather crisp roll inputs, that I coupled with the response every now and then. I don't know whether I was helping or making it worse. The airplane is quite responsive in roll to disturbance inputs.

LONGITUDINAL CHARACTERISTICS

Good, didn't detract from the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Quite good. I think you've got good maneuverability in roll and I think you've got good bank angle control and very small sideslip generated. I like the idea of being able to bolster up the roll rate with the rudder to speed things up because you can really get good performance and thus you don't have to have the aileron sensitivity up really high to do that. Air-to-ground, I worry a little bit about the crisp response to the disturbance input on how it might be in turbulence. However, you've got real good control, so I think you could probably put those out.

GOOD FEATURES

Good roll maneuverability coupled with the good roll control. I like the fact that very small sideslip is generated and what is generated can be coordinated by putting rudder in the proper direction.

OBJECTIONABLE FEATURES

If I had to give any objection I would say it would be the quite crisp, quite noticeable response in roll to the disturbance input.

SPECIAL PILOTING TECHNIQUES

There are none.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable, I think everything is satisfactory. I don't consider the airplane an excellent one, I think the only deficiency I can see is the turbulence response in roll; pilot compensation is not a factor. More effort is required in turbulence. However, I think because of the good roll capability there was only a minor deterioration in my performance.

CONFIGURATION 11A $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.010$ PILOT RATING 2.5 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I didn't think I was g[illegible] to like it. Then as I got to flying it, I found out that I really enjoyed it.

ABILITY TO TRIM

Lateral-directionally was really very good. After I got the airplane trimmed up, it just didn't seem to want to move in sideslip. Laterally, I didn't have any problem either. Longitudinal was a more difficult trimming problem than was the lateral-directional, but that is not a degrading thing, I don't believe.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 138$ deg/sec^2-in. $N'_{\delta_{RP}} = 23$ deg/sec^2-in.

My selection of the ailerons was not dictated by any particular airplane characteristic in that no compromise had to be made. I selected the ailerons nice and light like I like them, primarily to give me smooth flying light ailerons. This coupled with the light elevator forces gave me a real harmonious set of controls. The displacements seemed to be very low which I like and the forces seem to be very light. So that I think that pretty well explains the gearing selection, it was purely my personal desire and not something that was a result of a characteristic that I had to compromise around.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron without the rudder, there's very little sideslip excited and what little bit I see initially seems to be proverse, in other words, as soon as I put in an aileron input, the turn needle wants to take off in that direction right away, so it looks like a little bit of initial proverse. It's very difficult to see sideslip in the steady state because what little Dutch roll I see seems to dampen out in such a short period of time that I don't really see much yaw going as the roll develops. I would like to talk about one point though. When I first started flying this airplane, making rapid rolls say from 90° one way to 90° to the other, it seemed to be a little bit nonlinear. In other words, the airplane felt like it wanted to take off a little bit right in the middle of the roll. I felt the roll wasn't as smooth as I would like and when I first started flying the airplane, I had some difficulty stopping it right on the bank angle that I wanted. After I practiced a bit, I seemed to be able to do it pretty well. I do just as well or better if I keep my feet off the rudder. When I did try to coordinate, I tended to overcontrol the sideslip a little bit. So I was just as guilty of not using the rudder as I was to use the rudder. I find it . very easy configuration to coordinate, so I simply didn't coordinate.

BANK ANGLE CONTROLLABILITY

Good to very good. I tended to overshoot the bank angle a bit initially and then as I began to catch on as to how to fly the configuration better, I got so I could tag the bank angles pretty well, but for some reason, still not quite as good as I would have liked to have seen.

HEADING CONTROLLABILITY

Very good because the airplane has very little tendency to oscillate or to move even in sideslip, so that once you get it in the direction you want to go, it looks like it's there to stay.

BANK ANGLE COMMAND TRACKING TASK

I thought that was very easy to do. There were no problems encountered with that, no sideslip to speak of excited during aggressive attempts to get the needle back to the center. So in general, the bank angle tracking task was very easy and I thought my performance was good.

RESPONSE TO DISTURBANCE INPUTS

The airplane was really not too bothered by the amount of turbulence that we had, which I thought was quite reasonable, if anything on the high side, but as far as my having to really work at it, the airplane seems to be directionally stiff enough that it wants to keep pointed in that direction and again the sideslip exciters were small.

LONGITUDINAL CHARACTERISTICS

Does not degrade or interfere with the lateral-directional. I still don't like my poor trimmability, longitudinally, it's really not poor, but just not as good as I would like.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

These particular characteristics are quite suitable for the fighter mission. I like the rapid roll capability and I like the fact that very little sideslip is excited.

GOOD FEATURES

The sideslip that I see is very small, and the airplane tends to dampen it out in a very short period of time. I don't have to coordinate and the fact that the sideslip stays very small are good features.

OBJECTIONABLE FEATURES

Only had one minor objection. It was the tendency to overcontrol in bank angle a bit and the fact that the roll didn't seem to be quite as linear as I would have liked.

SPECIAL PILOTING TECHNIQUES

No real special piloting techniques involved. If you want to say not having to use your feet for coordination is a special piloting technique, that might fall in that category.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is satisfactory without improvement. I think that the nonlinearity that I find in roll falls into the negligible to mildly unpleasant category primarily coming about from not being quite as precise in roll as I would like it to be. So I'm going to say that there was a little more effort required, but no real significant deterioration.

CONFIGURATION 11A $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.03$ PILOT RATING 3.5 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought that it was going to be a pretty reasonable configuration. I thought that it had good roll performance. It has one problem that really is bugging me and I'll talk about that as we go along.

ABILITY TO TRIM

Directional was good. Lateral was only fair. Longitudinal was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 288$ deg/sec^2-in. $N'_{\delta_{RP}} = 19.5$ deg/sec^2-in.

I looked at values both more sensitive and less sensitive than the initial starting value on the ailerons. Turned out that when I went more sensitive, I had a real strong tendency to overcontrol the airplane in roll and set up a noticeable two or three cycles of oscillation prior to settling down on a bank angle. I then backed down and went below what we started out with and found that it cut down on that tendency but then the ailerons felt heavy to me. So that I think I ended up going back to what we started out with on the aileron gearing. You might say that there is a bit of a compromise here. If you get them too sensitive, you overemphasize this tendency to overcontrol in bank angle and if I go below that, it's too heavy for me. I didn't want to use a rudder on that configuration. The sideslip that was generated was in the proverse direction but not very much, and it seemed to dampen itself out pretty well. I didn't get very much adverse sideslip, and I didn't really attempt to keep up with the airplane, crosscontrolling to get rid of that small sideslip angle. Sideslip seemed to dampen itself out reasonably quick, so that I didn't see where that was much of a problem. What I'm really telling you is I didn't fiddle with rudder gearing because I didn't use it. Control harmony I thought was good. The control forces that I ended up with were light. Again I didn't use the rudders so it wasn't really worth commenting on.

AIRPLANE RESPONSE TO PILOT INPUTS

With the aileron-only, the airplane has proverse yaw associated with an aileron input. Seems to be reasonably fast though and it wasn't something that I even would attempt to coordinate. It did, however, seem to influence the roll, and I notice that on some of the roll maneuvers, I could really feel the airplane kind of accelerate up on me, particularly rolling say from 90° one way to 90° of bank the other. You could feel the airplane noticeably have a speeding up effect in the middle of the roll. Okay, as I mentioned, you could coordinate the sideslip by crosscontrolling and that really just kind of made life a little easier for you, didn't help an awful lot. The Dutch roll seemed to be well damped. The only oscillations I saw were what resulted from rapid aileron inputs. I pretty much didn't use the rudder and just accepted the sideslip that was generated in the proverse direction.

BANK ANGLE CONTROLLABILITY

Wasn't as good as I would have liked. Tendency to overshoot in bank angle and set up one or two cycle oscillation. This wasn't something that was tremendous, but it was certainly noticeable.

HEADING CONTROLLABILITY

I thought it was good. No real problem achieving any desired heading. The Dutch roll seemed to be reasonably well damped and a high enough frequency that the sideslip angles that were generated did not persist.

BANK ANGLE COMMAND TRACKING TASK

Caused me more of a problem than I would like. This overshooting tendency was noticeable and that's the thing that's bugging me about the whole configuration. I like the airplane for other than the bank angle controllability and I'm worried about how much emphasis to put on that.

RESPONSE TO DISTURBANCE INPUTS

Seemed to be predominant in roll and tended to aggravate my bank angle controllability problems. However, from what I had seen, there really wasn't much more than the minor deterioration with more effort required.

LONGITUDINAL CHARACTERISTICS

Good. They didn't detract or degrade from the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

For the air-to-air role, I would like to see better bank angle controllability than what I've got here, but I really like the maneuvering characteristics of the airplane. I didn't particularly like the fact that a fair amount of proverse yaw was generated each time I put in an aileron input and I think that this might detract from my ability to get a real good performance out of the machine. Air-to-ground, I think the turbulence response in roll is a bit of a problem. When correcting for the turbulence input with the aileron you produce proverse sideslip.

GOOD FEATURES

I like the maneuverability. I thought the rolling maneuver capability was quite good. The fact that the sideslip that is generated is not excessive and dampens itself out quite rapidly is a good feature.

OBJECTIONABLE FEATURES

Revolved primarily around the tendency to overcontrol in bank angle and to get one or two cycles of oscillation going there. It's objectionable that the sideslip that is generated is in the proverse direction and not really something that I can coordinate very well.

SPECIAL PILOTING TECHNIQUES

I tended not to coordinate the sideslip because often times I would coordinate in the normal direction and simply make the sideslip problem worse than it was.

PRIMARY REASON FOR THE PILOT RATING

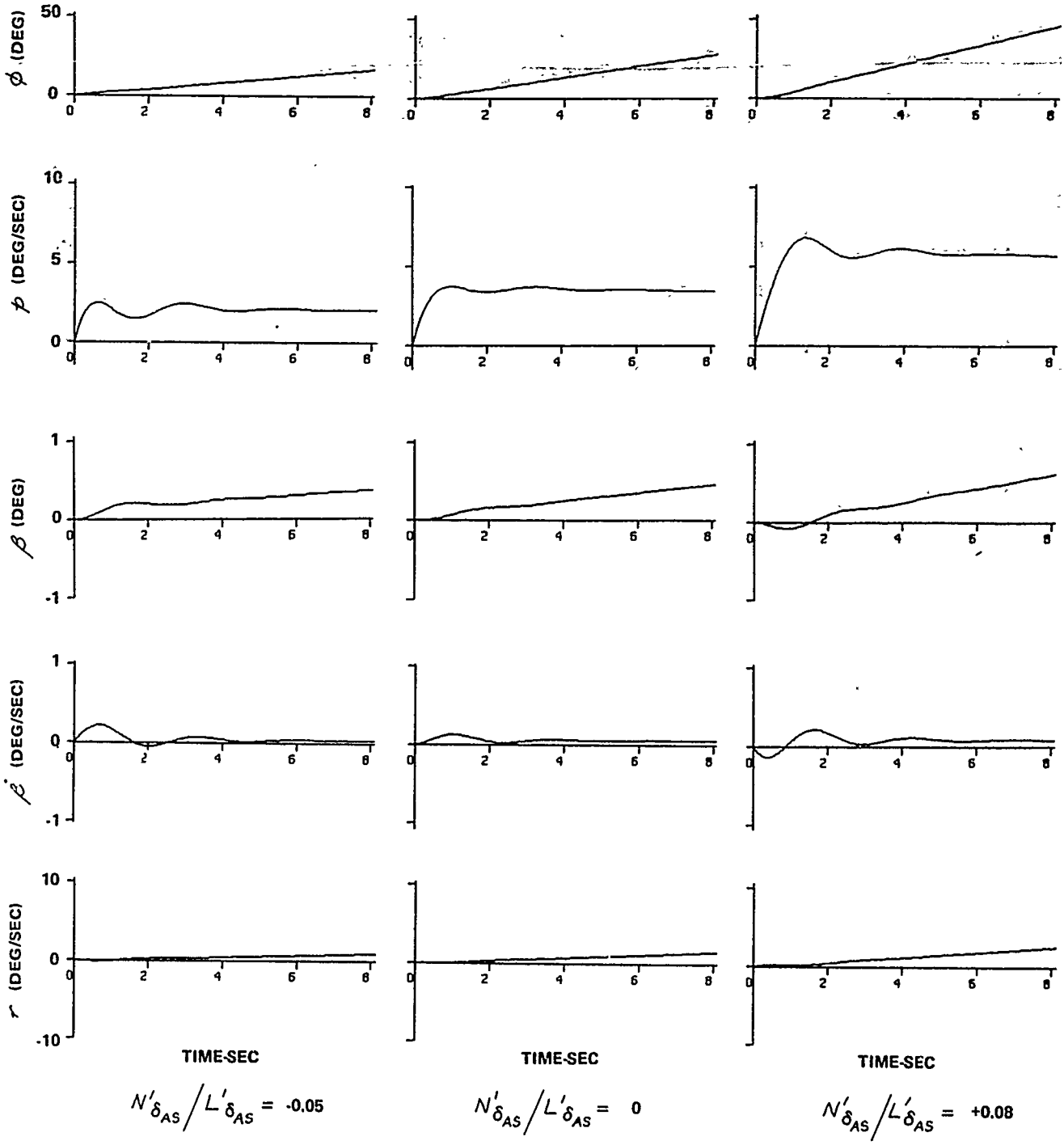
I still don't like the fact that the bank angle controllability isn't as good as I would like. I think, however, backing off on my gain can help that a bit. Certainly not moderate pilot compensation is required. I say that I would buy that. I really like that. Okay, I'm going to rate this one on the borderline, I sure hate to have to do that, but the bank angle controllability isn't very good. This proverse sideslip that's generated is noticeable.

CONFIGURATION 11B IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}} / L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	$\frac{p_{osc}}{p_{AV}}$	$\Delta\beta_{max}/\dot{\phi}$ LEVEL 1	LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
[illegible]	5	D	0.27	1.76	-205	0.22	9.0	7.2	0.57	328	52.0
[illegible]	5	D	0.33	2.29	-285	0.105	5.5	3.8	0.24	305	42.0
[illegible]	4.5	D	0.33	2.29	-285	0.105	5.5	3.8	0.24	350	43.0
[illegible]	7	B	0.41	2.94	-320	0.13	5.4	3.3	0.25	425	20.5

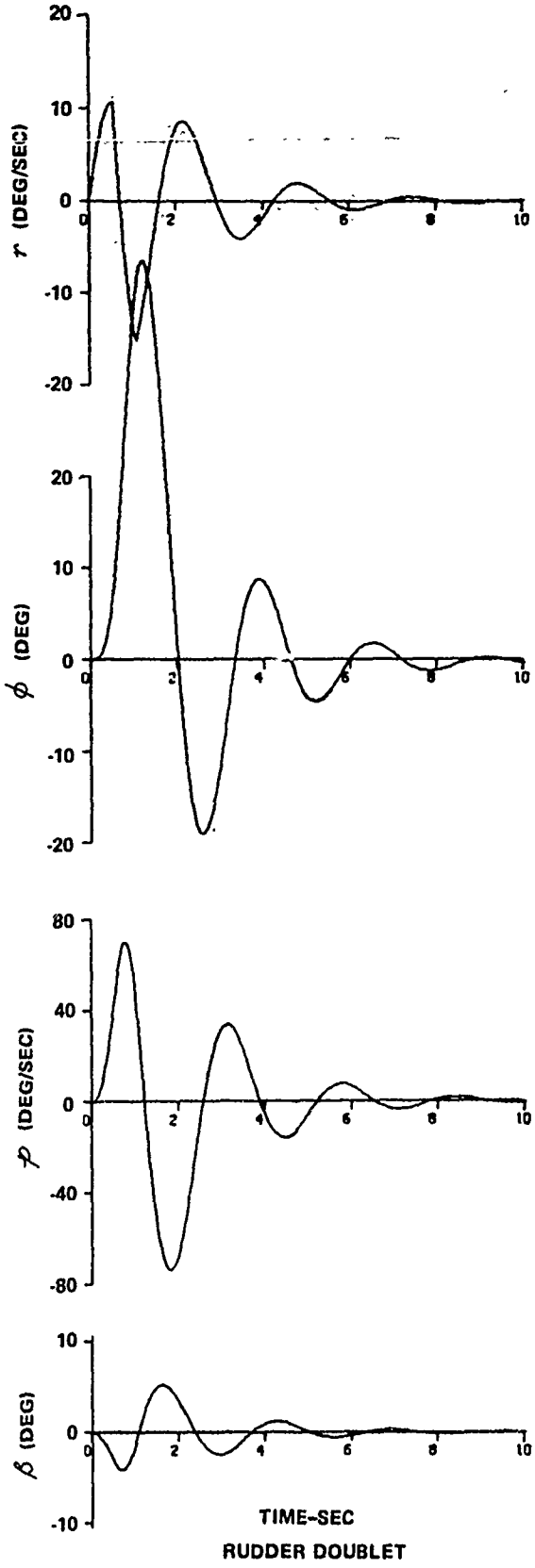
LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

ω_d	= 2.46	N'_β	= 5.16	L'_β	= -42.0
ζ_d	= 0.23	N'_r	= -1.35	L'_r	= 10.5
τ_R	= 0.43	N'_p	= -0.035	L'_p	= -1.96
τ_S	= 100	$\frac{g}{V}$	= 0.0586	Y_β	= -0.160
$\left\|\frac{\phi}{\beta}\right\|_d$	= 6.2	$Y_r - 1$	= -0.987	$Y_{\dot{\beta}}$	= -1.015
$\measuredangle \left(\frac{\phi}{\beta}\right)_d$	= 49.4	$Y_p + \alpha_o$	= 0.0040		

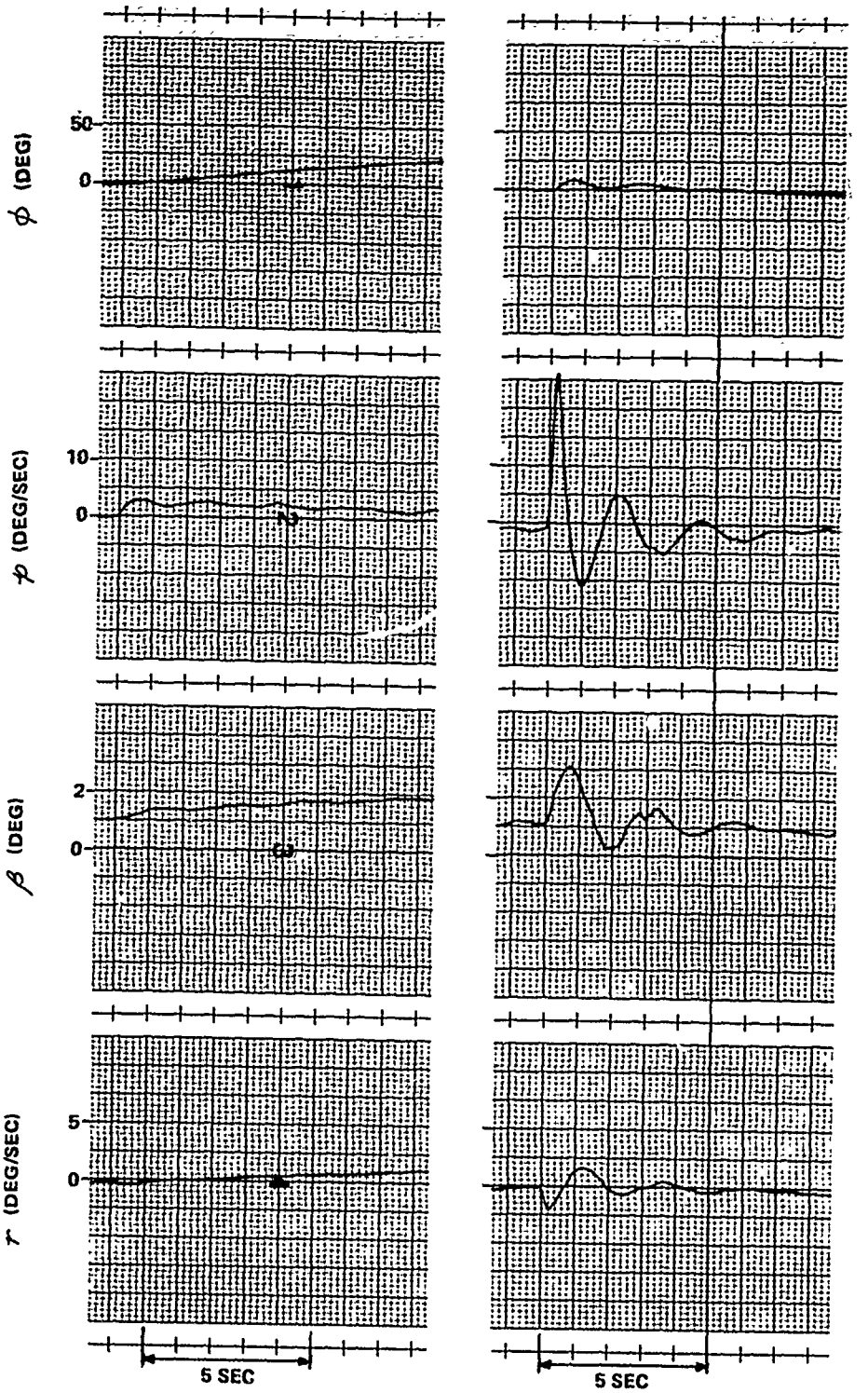


$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.05 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = 0 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.08

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 11B



COMPUTER GENERATED TRANSIENT RESPONSES TO RUDDER DOUBLET FOR CONFIGURATION 11B



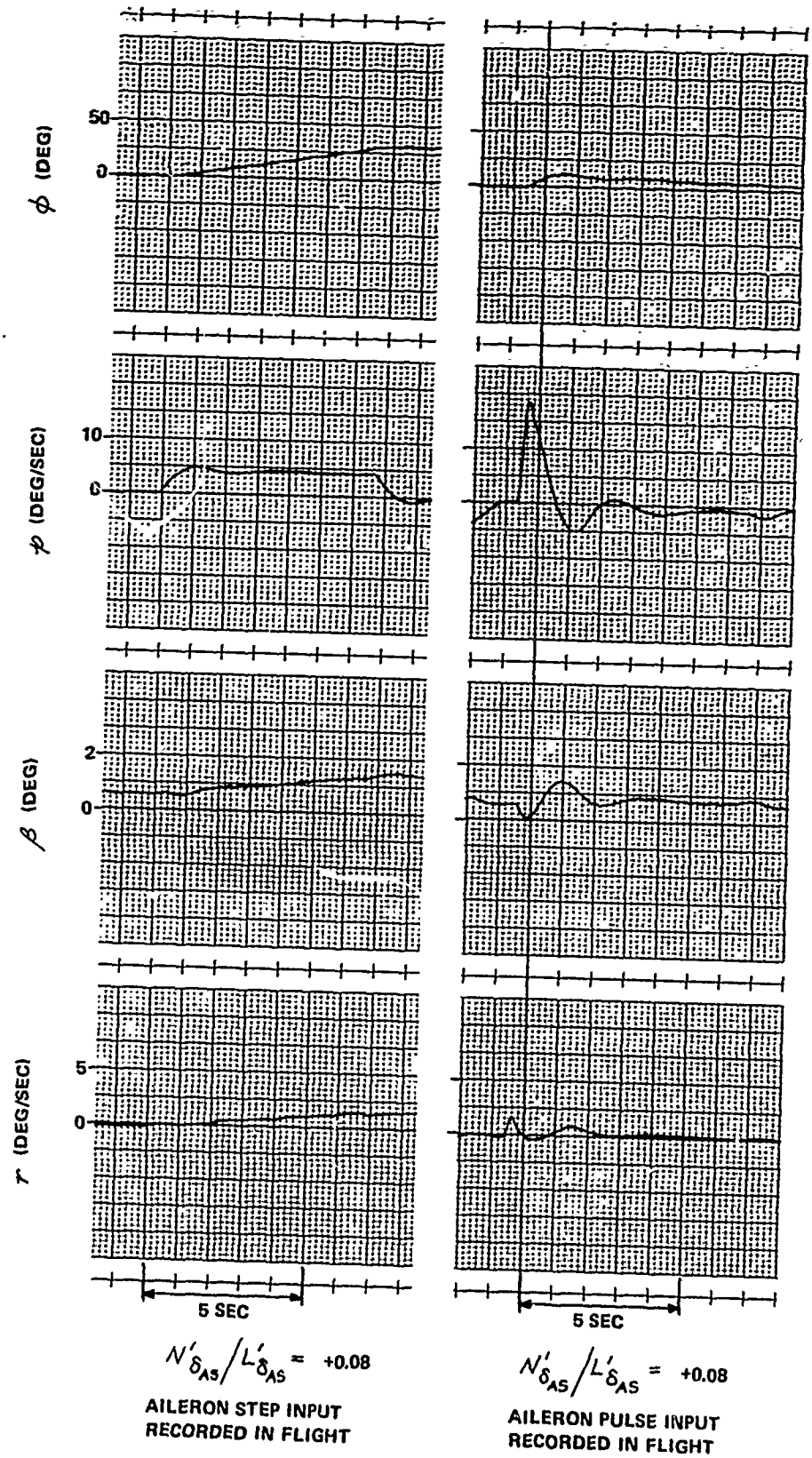
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.05$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.05$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 11B



$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.08

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.08

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 11B

CONFIGURATION 11B $N'_{\delta_{RS}}/L'_{\delta_{AS}}$ = -0.05 PILOT RATING 5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

No pilot comments due to malfunction of tape.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 328 deg/sec²-in. $N'_{\delta_{RP}}$ = 52 deg/sec²-in.

CONFIGURATION 11B $N'_{\delta_{RS}}/L'_{\delta_{AS}}$ = 0 PILOT RATING 5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

It was going to be a bit confusing because there were a couple of things going on that I couldn't understand.

ABILITY TO TRIM

Good for both lateral and directional axes; longitudinal is good also.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 305 deg/sec²-in. $N'_{\delta_{RP}}$ = 42 deg/sec²-in.

I thought I would get a very light gearing selection using all the gearing gain that was available. I, then, waited until the fuel got down a bit and I was really happy with that. For some reason, the amount of roll rate that I got for the amount of control that I was putting in still didn't seem to be quite enough. But I got aileron sensitivity up so high that I was beginning to have some bank angle problems trying to hold a given bank angle. It was due to the airplane or the gearing selection, I'm not quite sure. On rudder, adverse yaw required rudder coordination and the coordination was in the proper direction. But I really wasn't very good at coordinating . In other words, the coordination wasn't straightforward. The forces that I ended up with were light in all three axes. Displacements were no problem. Control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

For an aileron input, the roll rate was relatively smooth but not as smooth as some I've seen. Also, the roll rate seemed to be lower for a reasonable size aileron input than I would have liked. Coordinating with the rudder seemed to smooth it up and the roll rate also seemed to pick up. No oscillatory characteristics when I started to fly this thing but when I got to the tracking task I had a tendency to oscillate the airplane in bank. It occurred when I abruptly rolled the airplane and tried to stop the bank angle right on the spot. It was noticeable enough for me to go back and go through the tracking task a couple of times.

BANK ANGLE CONTROLLABILITY

Bank angle control therefore is really not very good. It doesn't appear to me that this is a pilot induced oscillation like I've seen before but kind of a residual oscillation due to the Dutch roll being excited.

HEADING CONTROLLABILITY

Not bad, but it's not good either. My sideslip excursions due to the Dutch roll are relatively small but the corresponding bank angle response seems to be large.

BANK ANGLE COMMAND TRACKING TASK

Performance was poor; primarily because of the oscillation that I was seeing in bank angle, again more due to the Dutch roll characteristics than to a pilot induced oscillation. When I coordinated the airplane I tended to overshoot a little bit in bank angle.

RESPONSE TO DISTURBANCE INPUTS

Quite noticeable; in both axes, lateral and directional, particularly noticeable in roll. This does deteriorate my capabilities quite a bit in turbulence.

LONGITUDINAL CHARACTERISTICS

Good; they didn't interfere or degrade the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I don't think that in their present form they are really suitable. I think you can perform the fighter mission, I don't think you can do a stunning job or something other than a satisfactory job with these characteristics. In the air-to-air situation, your bank angle control is not precise and your ability to roll the airplane ailerons-only is not very good, although augmenting the airplane with the rudder you can get some pretty tremendous roll rates out of the thing. I wasn't particularly very good at getting the precise bank angle control. Air-to-ground I think you can do a little better job. The large roll excursions for turbulence inputs bother me.

GOOD FEATURES

I think you've got a lot of roll capability with this machine if you combine the rudder and the ailerons. The longitudinal was good.

OBJECTIONABLE FEATURES

Primary objectionable feature was the residual roll oscillation I saw when attempting to track bank angle or to stop at a bank angle. It seems to be more a function of the Dutch roll characteristics than it does the pilot-airplane combination. The fact that I couldn't coordinate the sideslip as well as I would like even though it would be in the adverse direction I would call a minor objection. I think the roll response to yaw disturbance inputs is excessive.

SPECIAL PILOTING TECHNIQUES

I don't think I can fly the airplane as aggressively as I would like and I couldn't coordinate the airplane as well as I would like. You have to tone down your aggressiveness and be careful on how you coordinate with the rudder.

PRIMARY REASON FOR THE PILOT RATING

I don't believe that this airplane is satisfactory as it is. I think it is possible, however, to perform an adequate fighter mission. Considerable compensation was required on my part. You really have to stay in the loop and try to keep the sideslip down. The residual roll oscillations bother me quite a bit. In turbulence, there is considerable more effort required and I think a moderate deterioration of my performance.

CONFIGURATION 11B $N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$ PILOT RATING 4.5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought that it wasn't going to be too bad. The more I flew it the less I seemed to like it, probably because of an increase in my aggressive tendencies.

ABILITY TO TRIM

The directional was easier to trim than the lateral, a little bit of a tendency to roll off in the lateral but that's not a factor in the evaluation. Longitudinal trim was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 350$ deg/sec^2-in. $N'_{\delta_{RP}} = 43$ deg/sec^2-in.

When I first started flying, the ailerons felt heavy so I had the sensitivity on the ailerons increased. Then I was getting myself into quite noticeable overcontrol and osci'latory tendencies in bank angle, so I had him back down on the gear ratio to the point to minimize the amount of bank angle overcontrol. But then when I went at things aggressively, the tendency was still there. So there is a compromise on the aileron gear selection. The forces I ended up with were light but still perhaps a little heavier than I would have liked. On rudder, it was kind of an interesting situation. It seemed to me there was a very slight amount of proverse yaw initially, followed by quite a significant amount of adverse yaw. So, the primary rudder coordination required was in the adverse direction. I set up the rudder sensitivities so that I could control this adverse yaw. Then I noticed that when I put in an aileron input and coordinated it with the rudder right away, that I would get a rather significant proverse sideslip generated initially. So by compromising on the rudder a little, by making it a little heavier than I would like, I was able to cut down on the initial proverse transient. The forces that I ended up with were reasonable, perhaps not as light as I would have liked them. Displacements were small. Control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron without the rudder, there seemed to be a little amount of proverse yaw followed by adverse yaw. The adverse yaw went quite a bit in the adverse direction and seemed to influence roll control quite a bit, i.e., it seemed to cut down the roll control. By coordinating with the rudder, I certainly can speed up the roll. I was able to control the sideslip, not really too well, but coordination was in the proper direction I could keep the sideslip down somewhere near a small amount. The airplane didn't seem to be very oscillatory in the Dutch roll. However, you did have to watch the initial tendency to overcontrol the sideslip.

BANK ANGLE CONTROLLABILITY

Fair; a function of my aggressiveness with a tendency to overcontrol slightly and to set up a one or two cycle oscillation about the bank angle.

HEADING CONTROLLABILITY

Good. The airplane seemed to be reasonably well damped in the Dutch roll, not over-damped. Sideslip excursions didn't seem to persist.

BANK ANGLE COMMAND TRACKING TASK

Performance was fair to good with the tendency to overshoot and overcontrol. The task, however, was easy to perform even though there was a tendency to overshoot.

RESPONSE TO DISTURBANCE INPUTS

More noticeable in the roll than in the yaw. I felt that there was quite a bit more effort required and a somewhat moderate deterioration in my performance. The tendency to set up a bank angle oscillation while operating in the turbulent environment was quite noticeable. So I really think that best efforts are required.

LONGITUDINAL CHARACTERISTICS

Were good; they didn't detract or degrade from the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they were acceptable. I think in the air-to-air role, performance is degraded a bit because of the little bit of uncertainty in the bank angle control particularly in the presence of turbulence. In the air-to-ground role, I think your turbulence response is a little bit too much in roll and I think it would reduce your accuracy of getting weapons on target. Sideslip was not a major problem. Tendency to overcontrol sideslip adds to the roll control difficulties because the sideslip does seem to have a significant influence on the roll capability and the roll controllability.

GOOD FEATURES

It was maneuverable, had pretty good roll capability. The other good feature is the fact that the sideslip that was generated didn't seem to persist.

OBJECTIONABLE FEATURES

The coordination that I've talked about, namely initial proverse followed by the adverse, was objectionable. The tendency to overshoot and overcontrol in bank angle and to oscillate about it is also objectionable. Furthermore, the roll response to the disturbance inputs is likewise objectionable.

SPECIAL PILOTING TECHNIQUES

I felt that I did have to coordinate maneuvers and the coordination was in the adverse direction. There was a tendency on my part to overcontrol the sideslip initially and you just have to watch out for this.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable, I don't feel however that it is satisfactory. I think it needs to be improved. The deficiencies that I've talked about are more than just minor, perhaps not down to the objectionable category yet.

CONFIGURATION 11B $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +.08$ PILOT RATING 7 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought it wasn't going to be good and it wasn't going to be very bad. The more I flew the thing and the more aggressively I tended to fly, the worse it seemed to get. Primarily the problem is my inability to track bank angle precisely.

ABILITY TO TRIM

Laterally and directionally were both good. Longitudinal trim was okay, also.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 425$ deg/sec^2-in. $N'_{\delta_{RP}} = 20.5$ deg/sec^2-in.

I was able to select nice and light forces. Perhaps the lightness created some of my tracking problems, but they were comfortable. It was a very maneuverable configuration. I just wasn't very accurate in my ability to track bank angle. Okay, so there was no real compromise involved on the aileron gear selection. On the rudder, I had to have the rudder sensitivity turned down, but even when I did that, it was one of these airplanes where the coordination requirement seemed to change, you put in a roll control input, it looked like to me initially the sideslip would go a little bit in the proverse direction and then come smartly back in the adverse direction and I wasn't able to coordinate it very well. You needed a time delay in between the aileron input and the rudder took effect and I wasn't very good at that. It's quite easy to make things worse, at least initially because of what looked like to me to be initial proverse yaw. The displacements that ended up on the rudder and the aileron were small, forces were comfortable and the control harmony was good for all three axes.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron only, a little bit of a tendency to take off in roll rate when you put in an aileron input and this was noticeable but it really made the airplane feel quite maneuverable and quite rolly, you could really rack the thing around. Okay, coordination was difficult to achieve. I wasn't really able to cross-control it initially and then put in the coordination in the adverse direction at the end, so that usually I'd get a sideslip oscillation following an aileron input, couldn't keep up with it, but then ended up coordinating it in the proper direction finally. The Dutch roll doesn't seem to be oscillatory, so certainly in the bank angle tracking, I created the oscillation I guess pretty much on my own. In maneuvering, coordination requirements are there and they're difficult to achieve because to keep the airplane perfectly coordinated, you end up having to cross-control and I couldn't do that very well, particularly for continuous maneuvering.

BANK ANGLE CONTROLLABILITY

Very, very difficult and the harder I worked at it, the worse it seemed to get. The factor that really kills this airplane was my inability to achieve the bank angle and hold it very well.

HEADING CONTROLLABILITY

Because I couldn't control the bank angle well, I wouldn't control the heading very well. I don't think the problem is so much the lightly damped Dutch roll as it is pilot-airplane interaction.

BANK ANGLE COMMAND TRACKING TASK

My performance was really very poor on that. When I went at it aggressively, it was not unusual to oscillate about a given bank angle 3 or 4 times before I got the needle to settle down. Like I said, this is a serious problem.

RESPONSE TO DISTURBANCE INPUTS

Didn't seem to be out of line, no real serious problems noted with the random disturbance. I think there was more effort required, but really it was no more difficult to perform the task.

LONGITUDINAL CHARACTERISTICS

Good. Did not interfere with the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Air-to-air, I think they are unacceptable because of the poor bank angle tracking capabilities, something that I put a high regard on for air-to-air task. Similarly, for air-to-ground where you've got to close tight attitude loops or roll attitude loops, you'd have serious problems because you tend to lighten the damping in roll and I have a hard time getting the bank angle to settle down.

GOOD FEATURES

I liked the fact that it was really maneuverable in roll, you could really roll this airplane around and do the high roll rate maneuvers.

OBJECTIONABLE FEATURES

One very strong objection is my poor bank angle controllability and the fact that I tend to oscillate about and overcontrol in bank angle. The inability to coordinate the screwy sideslip response, starting out in one direction, ending up in the other is certainly an objectionable feature and probably part of my problem.

SPECIAL PILOTING TECHNIQUES

I have to try to fly the airplane with a little less aggression than I was perhaps but then you have trouble doing the fighter mission. So really there's not much you can do about it.

PRIMARY REASON FOR THE PILOT RATING

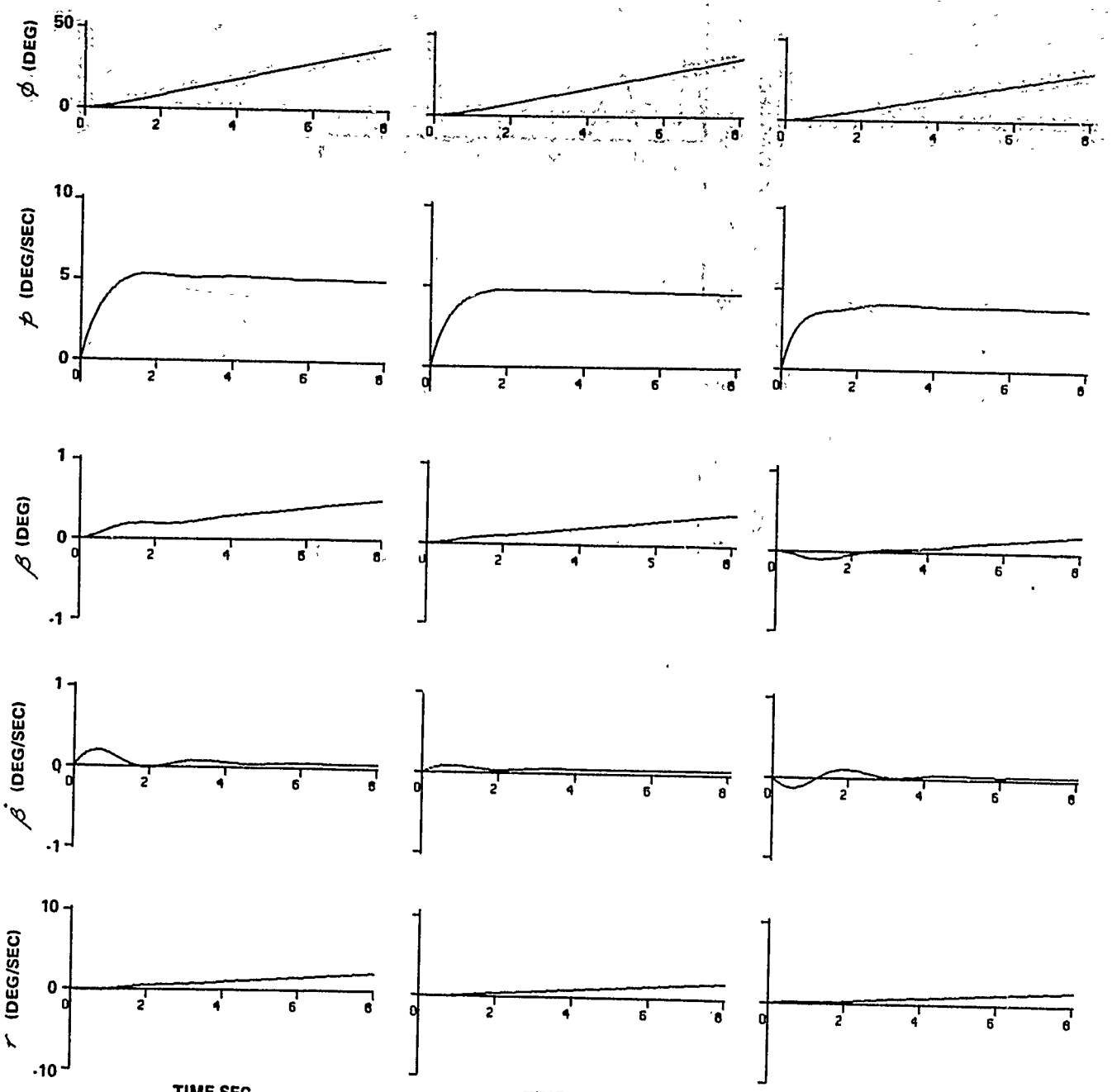
I don't feel that these characteristics as I see them are acceptable for the fighter mission. I think, when I really work at it, I set up a bank angle oscillation that's too severe. The airplane really wasn't too bad or different in turbulence than what I would expect.

CONFIGURATION 5ND IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/\alpha$ LEVEL 1	$\Delta\beta_{max}/\alpha$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.06	6	D	0.26	2.55	-210	0.019	5.7	3.8	0.09	355	38
-0.02	2	C	0.25	2.44	-240	0	4.0	2.7	0.05	450	39
-0.02	3	D	0.25	2.44	-240	0	4.0	2.7	0.05	305	24
+0.05	3	B	0.23	2.24	-10	0.02	4.3	2.9	0.11	340	17

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

ω_d	= 2.40	N'_β	= 5.68	L'_β	= -13.6
ζ_d	= 0.25	N'_r	= -1.02	L'_r	= -2.77
τ_R	= 0.475	N'_p	= 0.0549	L'_p	= -2.14
τ_S	= 100	$\frac{g}{V}$	= 0.0586	Y_β	= -0.169
$\left\|\frac{\phi}{\beta}\right\|_d$	= 2.14	$Y_r - 1$	= -0.989	$Y_{\dot\beta}$	= -1.015
$\measuredangle\left(\frac{\phi}{\beta}\right)_d$	= -132.0	$Y_p + \alpha_o$	= +0.0134		

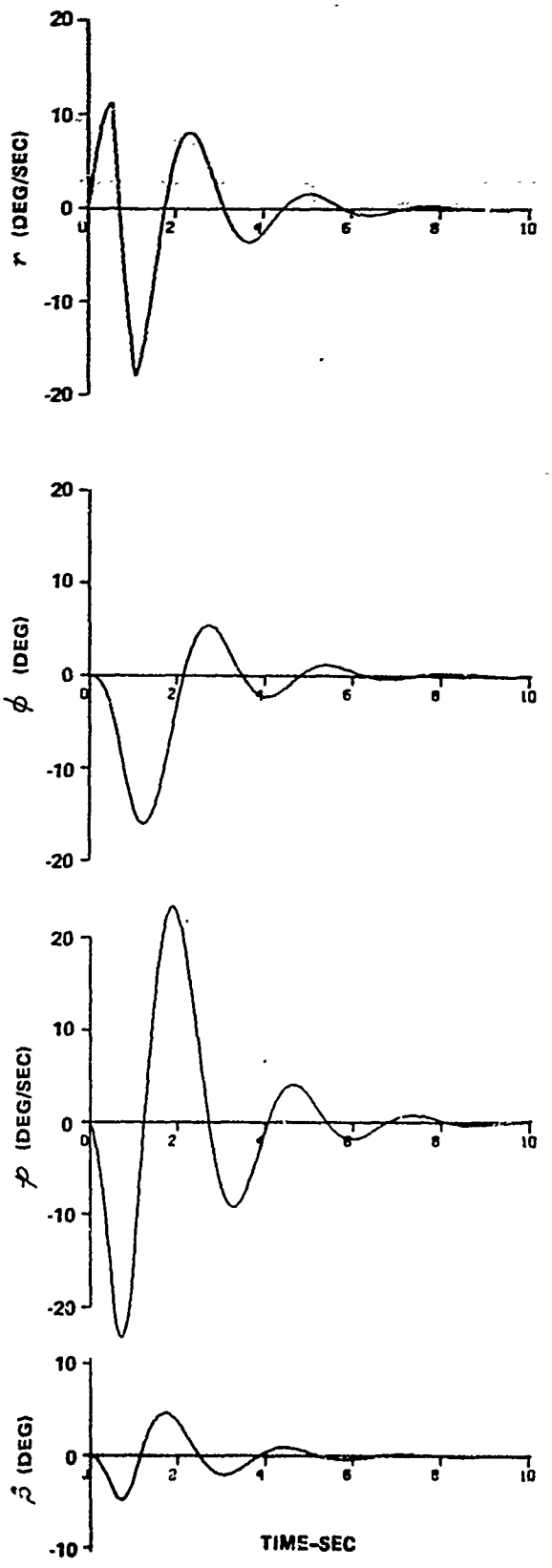


$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.06$

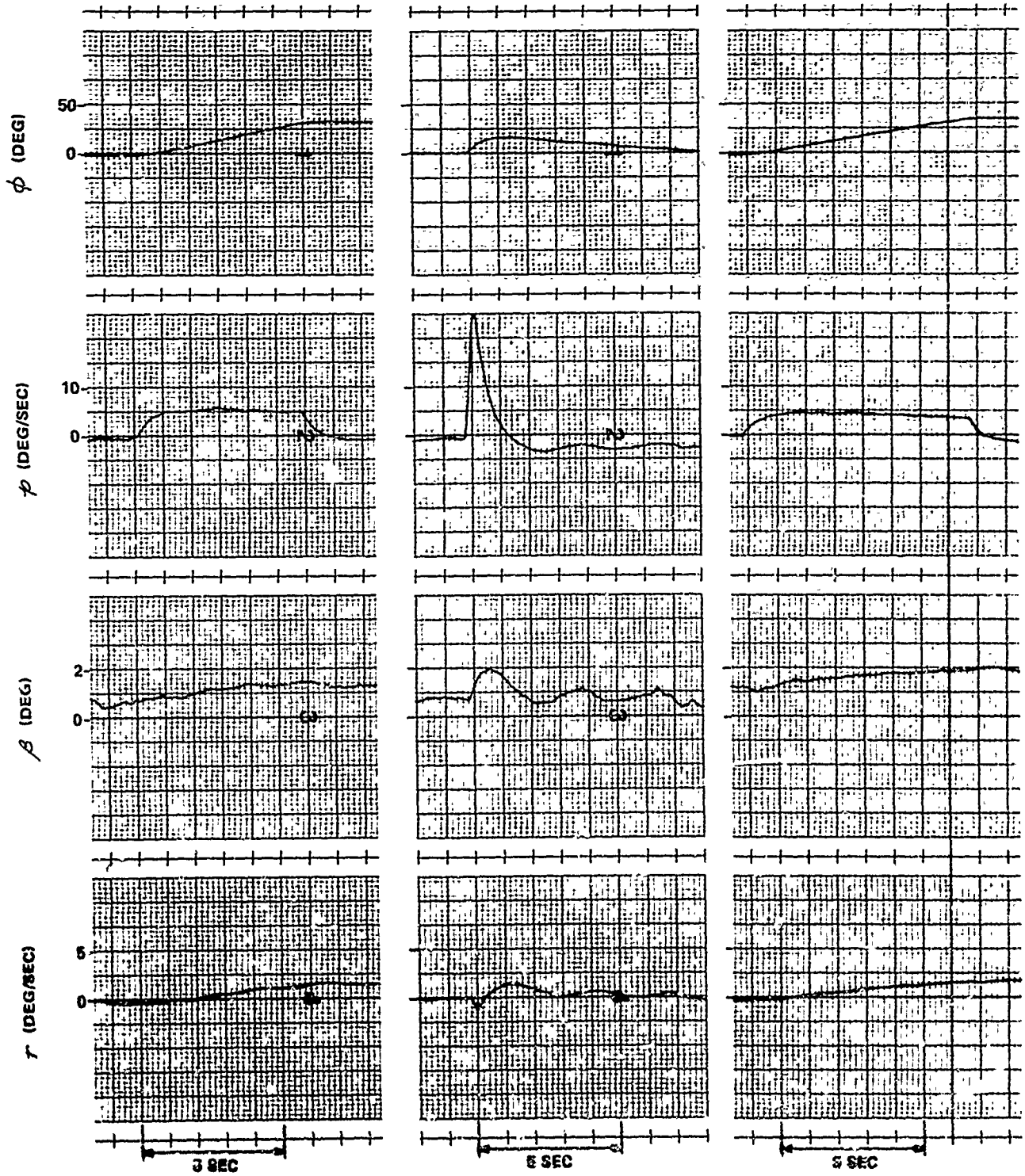
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.02$

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.05$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 5ND



COMPUTER GENERATED TRANSIENT RESPONSES TO RUDDER DOUBLET FOR CONFIGURATION 5ND



$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.08

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.06

AILERON PULSE INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = +0.03

AILERON STEP INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 5ND

CONFIGURATION 5ND $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -.06 PILOT RATING 6 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

That really was a screwy one. With so many things going on it's kind of hard to sort out. First of all, I noted that I had a dihedral effect. The yaw for an aileron input looked initially proverse followed by adverse, making coordination difficult and giving me a tendency to oscillate in bank angle. A whole bunch of little things adding up to make a rather not very good airplane.

ABILITY TO TRIM

The trim wasn't very good laterally. Directionally it seemed to be okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 355 deg/sec^2-in. $N'_{\delta_{RP}}$ = 38 deg/sec^2-in.

Aileron gearing selection was a compromise. When I chose a high sensitivity to keep roll rate up in face of adverse yaw and tried to make small corrections about the level flight, where I didn't really coordinate, then the airplane was very sensitive. I had a tendency to oscillate it or bobble in roll so I had to cut down the sensitivity a little more. The excitation in the yaw was in the adverse direction so that I just used the normal coordination for aileron inputs. Forces on the aileron were a little heavier than I would have liked for large rolling maneuvers, while a little too light for small bank angle corrections. Rudder control was satisfactory in both instances. Displacements were small, and control harmony still was not a problem.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron only, it looked like a little bit of initial proverse yaw and followed by adverse yaw, making it very difficult to coordinate. It looks to me that as the roll rate started to pick up it was predominantly adverse so that the coordination requirements were in the normal direction. When I coordinated the airplane, there was a tendency to cut down my roll rate. I could feel this when I was trying to roll. If I didn't coordinate, I could feel the roll rate pick up, but then I built up quite a large sideslip angle. There was also a tendency for me to set up a slight oscillation in bank angle, in particular, when I was trying to make small corrections. So you did have to coordinate, otherwise you get quite substantial sideslips.

BANK ANGLE CONTROLLABILITY

Not as good as I would like because of these tendencies for oscillating about the bank angle in level flight; not sizable oscillations but they are there and they make my bank angle control imprecise.

HEADING CONTROLLABILITY

A bit of a problem. The airplane had a funny swing and an out-of-phase feeling. With the relationship between sideslip and roll that this airplane had, the heading was a bit difficult to control.

BANK ANGLE COMMAND TRACKING TASK

Performance was only fair. I had two slight instances where I thought I set up a slight overcontrol and then began to oscillate somewhat about the bank angle. I did have to coordinate the airplane, otherwise I would build up noticeable sideslip angles.

RESPONSE TO DISTURBANCE INPUTS

It had a more noticeable roll response than sideslip response. It was again an out-of-phase feeling that caused me to have more problems with the random disturbances than I thought I should have had. So it did certainly cause me at least moderate deterioration in task performance and I put that in the "more effort required" category.

LONGITUDINAL CHARACTERISTICS

Not much of a problem. It didn't degrade or detract from lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Only marginally acceptable. I think, perhaps, with a little practice you might be able to handle these characteristics. I think you might still perform an adequate mission although I was certainly not as good at it as I would like to be. In the air-to-air role, the phasing of the Dutch roll is a bit of a problem. This impreciseness in bank angle is a result. Air-to-ground, I anticipate more of a problem with this because I think there is a greater tendency to use the rudders to help move the nose of the airplane around as you attack ground targets. The fact that you do have to coordinate the sideslip and hence have to use the rudder, I think, degrades my ability to fly this airplane.

GOOD FEATURES

There are really no outstanding good features. The roll performance isn't as good as I would like. The controllability isn't as good as I would like. I really didn't find any good features.

OBJECTIONABLE FEATURES

The screwy sideslip response and the fact that I have to coordinate the sideslip was objectionable in that when I do coordinate the sideslip, I can noticeably cut down my roll performance. The bank oscillation and the sideslip disturbance were just weird to me.

SPECIAL PILOTING TECHNIQUES

Coordination is required. The major part of the coordination is in the proper or adverse direction. I can keep up with it but I'm not very good at that. Control inputs require some weird phasing and when you put in a rudder input it does seem to change the roll input that you have made so that you feel the two controls are working against each other.

PRIMARY REASON FOR THE PILOT RATING

I think that these deficiencies are certainly very objectionable. I do think you could get along with them if you had to.

CONFIGURATION 5ND $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -.02$ PILOT RATING 3 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

I thought it was going to be a reasonable airplane although I've got some problems with it.

ABILITY TO TRIM

Laterally and directionally, I thought, were reasonably good. My longitudinal trim was okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 305$ deg/sec^2-in. $N'_{\delta_{RP}} = 24$ deg/sec^2-in.

On ailerons, I started out going to higher sensitivities than the initial selection, and had to back down quite a bit. There was quite a bit of adverse yaw generated and it seemed to cut down my roll rate a bit. So, initially I went up on the sensitivity and then it got oversensitive. I kept backing down and backing down so I wouldn't be surprised if I ended up right where I've started. I ended up with a sensitivity that I felt was quite reasonable and quite good. It's really hard to say if you can interpret that as a compromise. On rudder; the airplane needed coordination in the adverse normal direction but it wasn't an awful lot and I ended up getting a little heavier rudder in order to keep the sideslip where I wanted it. Naturally, I was reasonably good at coordinating this configuration. The forces that I ended up with on the aileron weren't really light but they were quite satisfactory. The displacements were small on both controls and the control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron only, there seemed to be a small amount of adverse yaw generated and it didn't seem to have too much effect on the roll rate although it did seem to just cut down the roll rate. The coordination required was fairly easy to do, and the difference between coordinated and uncoordinated wasn't all that different. The airplane seemed to be nicely damped in the Dutch roll. In maneuvering, you did need to coordinate the airplane, but coordination required was in the normal direction and was relatively easy to do.

BANK ANGLE CONTROLLABILITY

Good. Once I got the sensitivity squared away, my bank angle control, although not outstanding, was certainly good.

HEADING CONTROLLABILITY

Good; only problem there was getting the sideslip under control. The sideslip response was fast enough so that the heading came right back to pretty much where I wanted it.

BANK ANGLE COMMAND TRACKING TASK

Performance was good; not super, but good. I felt that I flew it quite aggressively. When I tried to get the needle somewhere right away there was a tendency to overshoot but this wasn't much of a problem.

RESPONSE TO DISTURBANCE INPUTS

Kind of interesting. The response seemed to be affecting my sideslip control more than anything else. This happened primarily when I would roll into a turn and try to hold a steady spiral speed turn. I would be working the rudders or the aileron, whichever, in order to control my bank angle more precisely and I set up a sideslip oscillation. I attributed it pretty much to the turbulence. I could say that more effort was required and probably a moderate deterioration in performance.

LONGITUDINAL CHARACTERISTICS

Good; did not interfere with the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they are certainly acceptable, they are satisfactory but at the lower end of the scale. Although it wasn't an outstanding airplane it was one that I could think would satisfactorily do the task. In the air-to-ground role, it was a bit more of a problem because when I tried to make small corrections with the rudder for heading, it looked like the airplane had a negative dihedral effect.

GOOD FEATURES

I thought the bank angle control was good. I thought the maneuvering capabilities were good.

OBJECTIONABLE FEATURES

The sideslip that is generated requires coordination but in the adverse direction, so that it wasn't too difficult to do. I can feel some effect of the relationship of roll to inputs and it was indeed opposite to what one would expect.

SPECIAL PILOTING TECHNIQUES

You did have to coordinate the airplane for roll maneuvers. Coordination was mostly in the proper direction.

PRIMARY REASON FOR THE PILOT RATING

Acceptable. I think it is satisfactory. The objections I have I'll put in the "mildly unpleasant deficiency" category and say that minimum pilot compensation is required.

CONFIGURATION 5ND $L'_{\delta_{AS}}/N'_{\delta_{AS}} = -.02$ PILOT RATING 2 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

This is going to be interesting because it was pretty obvious to me the airplane had a negative dihedral effect and I wanted to be very sure that I didn't let any preconceived notions influence my thinking. So I tried very hard to do whatever is necessary to our mission and give a fair evaluation.

ABILITY TO TRIM

Lateral-directional, longitudinal seemed good. I still have some trouble getting it trimmed laterally as well as I would like.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 450$ deg/sec^2-in. $N'_{\delta_{RP}} = 39$ deg/sec^2-in.

I was able to pick nice light ailerons without any compromise whatsoever, a selection based purely on what I might enjoy or like to fly. The rudder was the same way. There appeared to me to be noticeable amount of adverse yaw, although it wasn't a lot and required a lot of coordination in the proper direction. The forces were light; the displacements were small; the control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

For aileron without the rudder, the response was good, the roll was smooth and there was a little bit of sideslip generated in the adverse direction. I was able to coordinate and keep the sideslip pretty close to zero with normal coordination. There didn't seem to be any real oscillations set up with this airplane. The Dutch roll seemed to be well damped. Coordination was required but it was in the normal direction and felt quite good to me.

BANK ANGLE CONTROLLABILITY

Perhaps the best I've seen; I was really impressed with my ability to roll up and stop quite aggressively at a given bank angle. I could really put the bank angle right where I wanted without any tendency to overshoot or oscillate about. My bank angle controllability was really outstanding.

HEADING CONTROLLABILITY

Good; even if I didn't coordinate, the Dutch roll was well damped and the airplane heading seemed to stop pretty close to where I would want it to be.

BANK ANGLE COMMAND TRACKING TASK

My performance was really outstanding, one of the best that I have seen and there were no problems involved. On most of the maneuvers, I coordinated because the coordination was easy to do and in the proper direction.

RESPONSE TO DISTURBANCE INPUTS

Seemed to be a little bit more noticeable to me in roll than in sideslip although I occasionally got a large sideslip disturbance. The roll disturbance was noticeable and I think tended to cause at least a minor deterioration in my performance and certainly required more effort.

LONGITUDINAL CHARACTERISTICS

Good and did not detract or degrade the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

They're quite suitable for the fighter mission, particularly for the air-to-air with the precise bank angle control that you have, the ability to coordinate the sideslip so that it's not a problem and the good damping of the Dutch roll. For the air-to-ground, similar comments apply. The airplane has a negative dihedral effect so that I was unable to augment my roll beyond what the ailerons were giving me. Normally, you're able to augment your roll somewhat using the rudder and aileron in the same direction. In this case, if I overcontrolled with the rudder, I tended to cut down my aileron roll rate. However, I had completely adequate roll rate with the ailerons only and therefore that's not really a factor. Also, I wouldn't be able to pick up the wing with the rudder unless I cross-control.

GOOD FEATURES

Really an outstanding feature was the bank angle controllability. I like the fact that I can fly the airplane aggressively. I like the fact that the coordination required was very easy and very natural.

OBJECTIONABLE FEATURES

No major objections at all. The turbulence response in roll could use a little improvement but I can dive with it as is.

SPECIAL PILOTING TECHNIQUES

No really special piloting techniques. You do need to coordinate the thing but the coordination is in the proper direction and it's, I think, very easy to do.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable and satisfactory as it is. I don't believe pilot compensation is a factor. No problems with it whatsoever and certainly negligible deficiencies. I did feel that there's a minor deterioration in my performance in the presence of turbulence.

CONFIGURATION 5ND $L'_{\delta_{AS}}/N'_{\delta_{AS}} = +.05$ PILOT RATING 3 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

I wasn't going to like it, it turned out that I did and it was a reasonably good airplane to fly.

ABILITY TO TRIM

Good, both laterally and directionally. The longitudinal gave me no problems.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 340$ deg/sec^2-in. $N'_{\delta_{RP}} = 17$ deg/sec^2-in.

There was a little matching up to be done between the rudder and the aileron. When I stepped on the rudder the airplane tended to roll opposite to the way an airplane would normally roll but there was very little sideslip generated due to aileron. So that rudder wasn't required that much to keep the sideslip in the center. I backed down on the rudder sensitivity to get heavier forces because I found that I was initially overcontrolling with the rudder a bit and tending to slow down my lateral response. I found that with those I could more easily control the little bit of sideslip that I was seeing without overcontrolling it. On the ailerons, I think I was able to pick forces as light as I wanted. Forces were light on the aileron. On the rudder, forces just a little bit heavy but I didn't require very much rudder so that they were compatible with the other axes and just about right. The displacements were small in all three axes and not a problem.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron input alone provided smooth roll control and generated a little bit of sideslip in the roll but not enough to worry about. With the very little coordination that is required, the lateral response doesn't seem to be too different. Oscillations were never a problem. The airplane seemed to be well damped. In maneuvers, there was a requirement for a little bit of coordination in the proper direction during rapid rolls and that was purely a nicety to keep the sideslip near zero. It wasn't a necessity.

BANK ANGLE CONTROLLABILITY

Good. I could roll up and stop the airplane anywhere I wanted to.

HEADING CONTROLLABILITY

I didn't have any problems with headings because the Dutch roll that I was seeing was well damped and never really showed itself as a significant oscillatory problem.

BANK ANGLE COMMAND TRACKING TASK

Good, maybe not quite as good as I would like but there were no real problems because of the airplane dynamics themselves.

RESPONSE TO DISTURBANCE INPUTS

Response to turbulence was about what I would expect. It was nothing significant in any of the axes and only a minor deterioration in my ability to perform the mission.

LONGITUDINAL CHARACTERISTICS

Good, did not interfere with lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Good. Seems to me a couple of problems come to mind. First of all, I cannot augment roll rate with the rudder as I have with other airplanes. I guess I could do that by cross controlling but that is difficult to do. So I am pretty well stuck with the roll control with aileron that I have but that is sufficient. In the air-to-ground role, it looks good. The fact that I don't have to use the rudders gets me away from the negative dihedral effect so I haven't incurred any problems.

GOOD FEATURES

I like the roll control; I like the fact that I don't have to coordinate very much and I like the fact that the Dutch roll that I see here is well damped.

OBJECTIONABLE FEATURES

Negative dihedral effect, not really a major objection here because it really doesn't enter into the picture. However, from a maneuvering standpoint I think it might be a problem on my inability to augment my roll rate with rudder.

SPECIAL PILOTING TECHNIQUES

None that I required. The coordination that I used was in the proper direction even with the negative dihedral effect and coordinating the airplane didn't affect my lateral control.

PRIMARY REASON FOR THE PILOT RATING

Acceptable and satisfactory. I think that the deficiencies that I see fall in the mildly unpleasant category. When I over-coordinate it does slow down my roll rate. A little bit more effort required in turbulence, but not much. No significant deterioration in performance.

APPENDIX IV.3

HIGH DUTCH ROLL FREQUENCY CONFIGURATIONS

CONFIGURATION IDENTIFICATION AND FLIGHT DATA TABULATION

TRANSIENT RESPONSES

PILOT COMMENTS

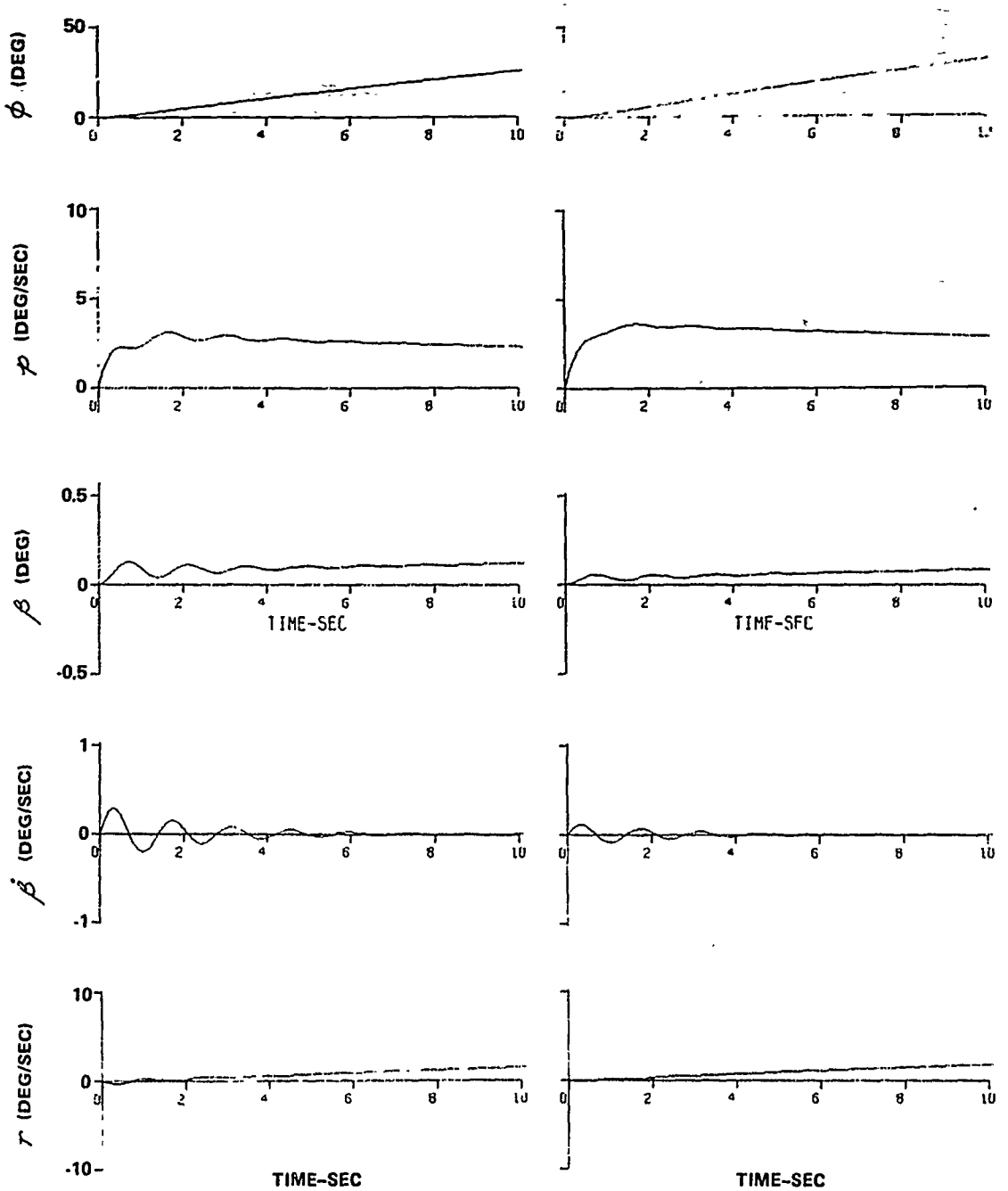
CONFIGURATION 6 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}} / L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/t$ LEVEL 1	$\Delta\beta_{max}/t$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.15*	8	C	0.11	3.83	-185*	0.090*	6.1*	4.4*	0.29*	455	40.5
-0.06	5.5	E	0.11	4.24	-185	0.033	2.1	1.4	0.06	364	34.5
0.0	4.5	E	0.10	4.50	-325	0.014	1.2	0.8	0.03	430	26.5
0.0	2.5	D	0.10	4.50	-325	0.0	1.2	0.8	0.03	380	21.0
+0.05	4	E	0.10	4.69	-350	0.013	1.6	1.1	0.05*	450	39.0
+0.10	7	E	0.098	4.88	-350	0.020	2.2	1.5	0.07	425	26.5

*INDICATES ROLL-SIDESLIP DATA FROM COMPUTER GENERATED TIME HISTORIES

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

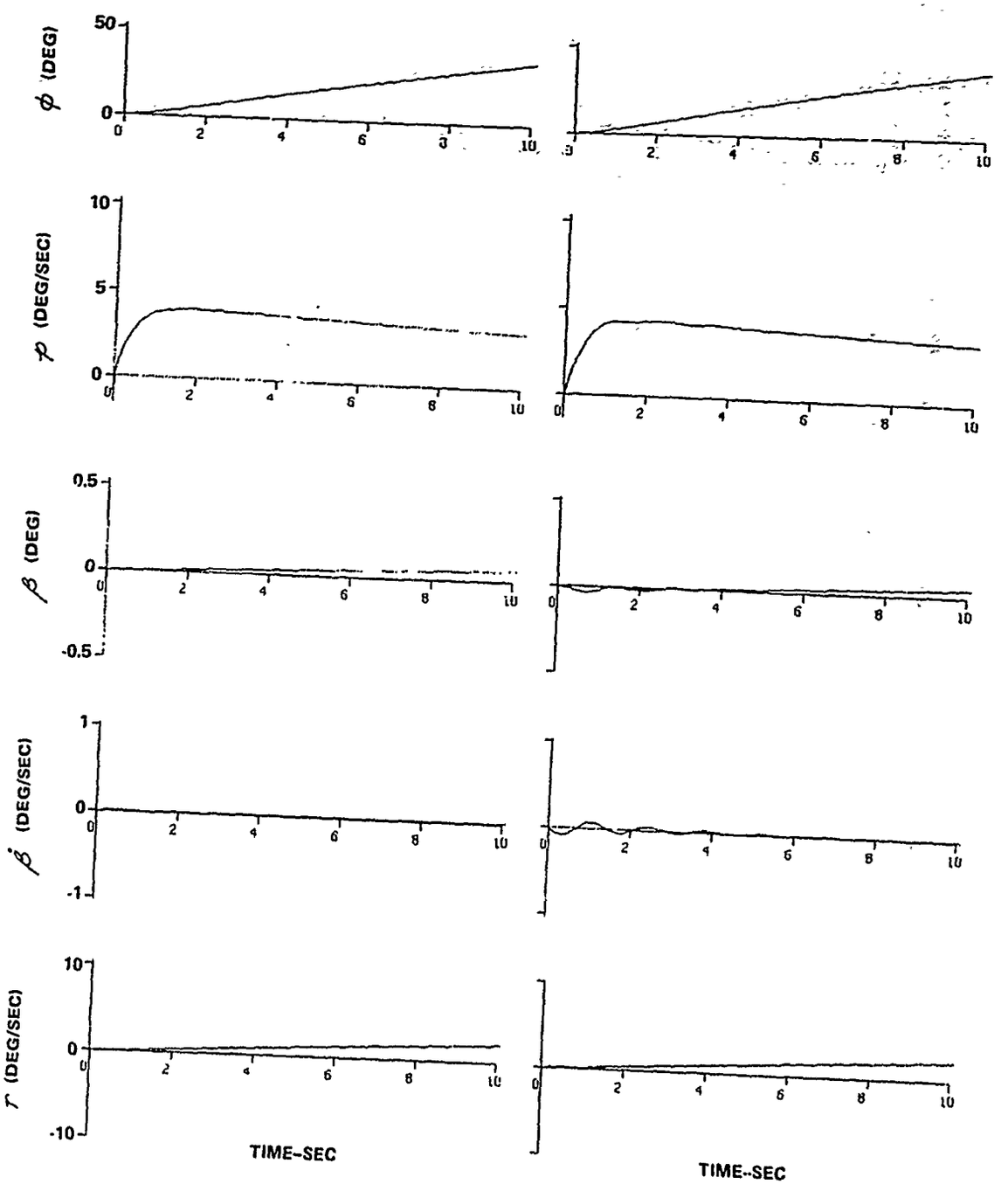
ω_d	= 4.50	N'_β	= 20.4	L'_β	= -36.9
ζ_d	= 0.10	N'_r	= -0.607	L'_r	= -0.0619
τ_R	= 0.42	N'_p	= 0.042	L'_p	= -2.39
τ_S	= 35	$\frac{g}{V}$	= 0.0586	Y_β	= -0.319
$\left\|\frac{\phi}{\beta}\right\|_d$	= 1.68	$Y_r - 1$	= -0.994	$Y_{\dot\beta}$	= -1.015
$\measuredangle \left(\frac{\phi}{\beta}\right)_d$	= 17.2	$Y_p + \alpha_o$	= 0.0036		



$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.15$

$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.06$

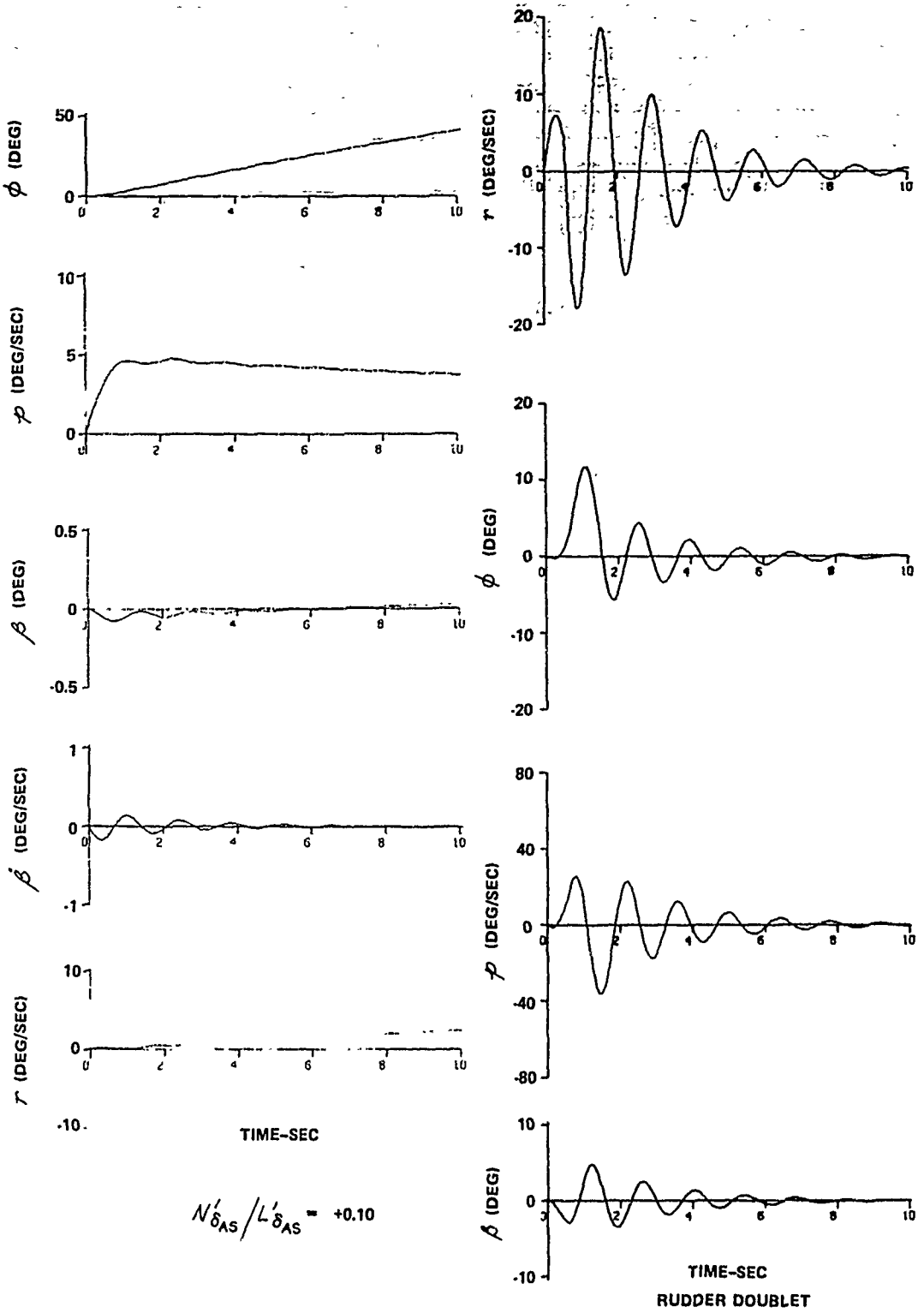
COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 6



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$

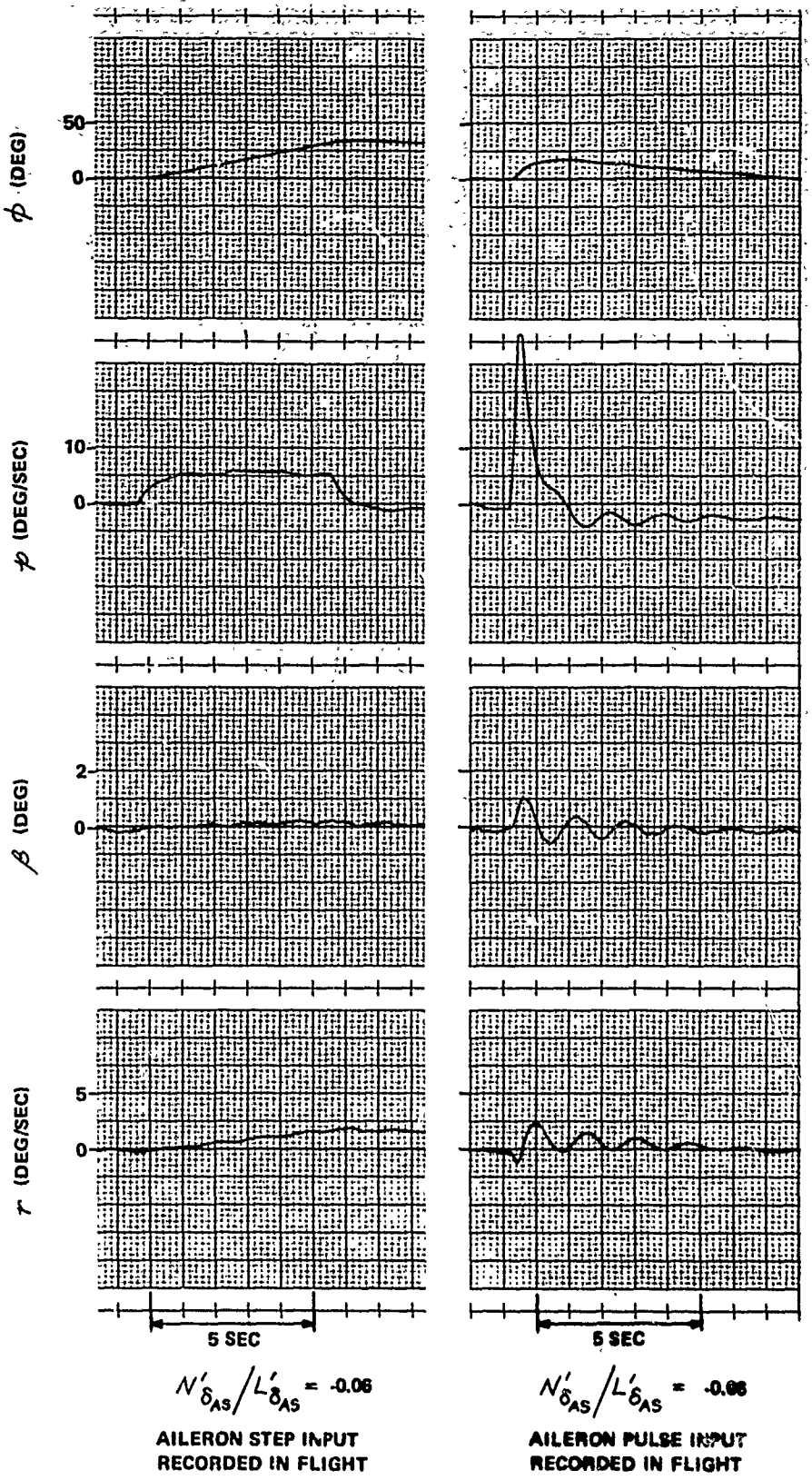
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.05$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 6

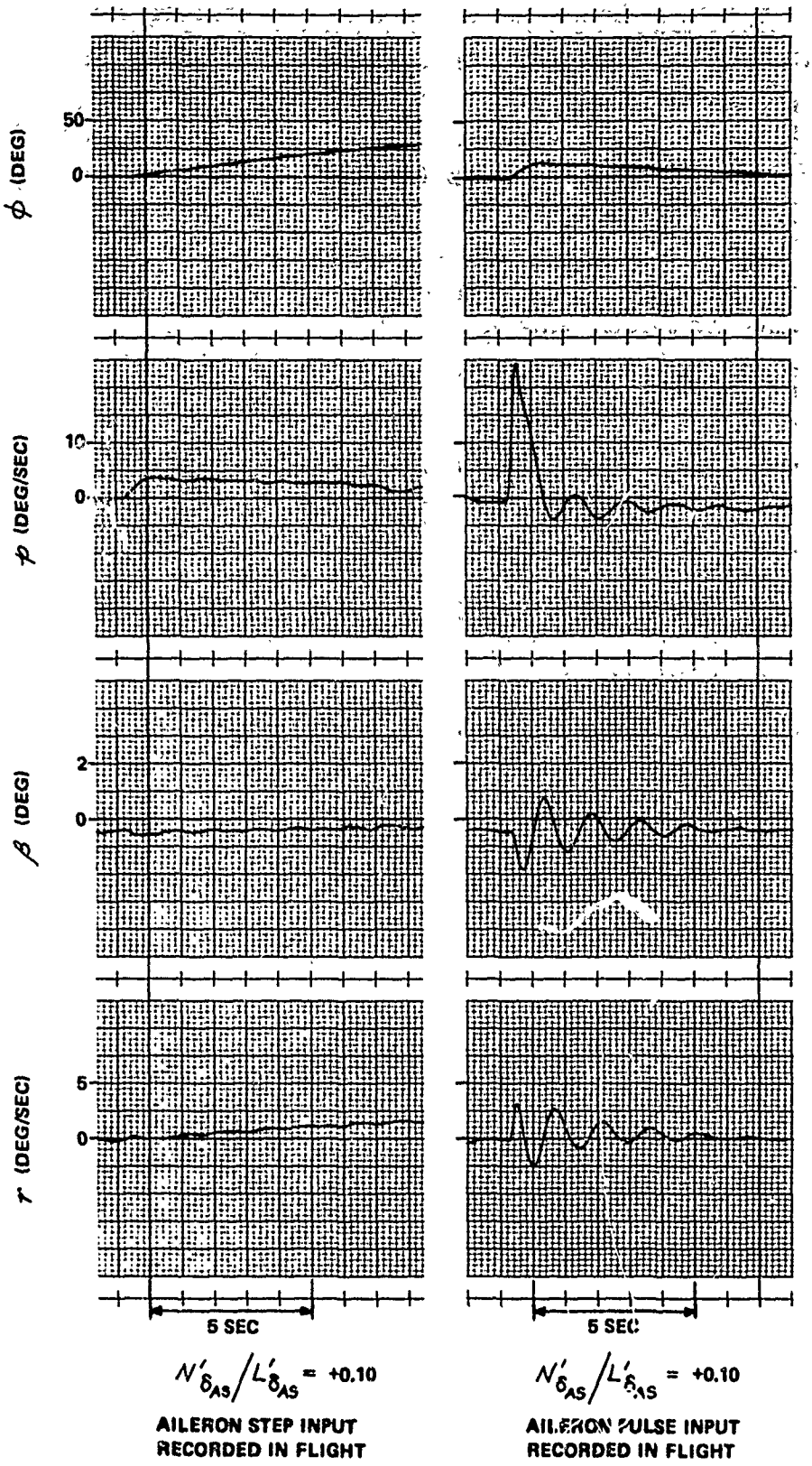


$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.10$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR CONFIGURATION 6



TRANSIENT RESPONSES FOR CONFIGURATION 6



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.10$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.10$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 6

CONFIGURATION 6 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.15$ PILOT RATING 8 TURBULENCE RATING G

INITIAL IMPRESSION AND GENERAL COMMENTS

Pilot comments on this evaluation were lost because of a fouled tape in the voice recorder.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 455$ deg/sec^2-in. $N'_{\delta_{RP}} = 40.5$ deg/sec^2-in.

CONFIGURATION 5 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.09$ PILOT RATING 5.5 TURBULENCE RATING E

INITIAL IMPRESSION AND GENERAL COMMENTS

First impression was that it wasn't going to be too bad. It was obvious that it had a lightly damped Dutch roll but the roll for itself didn't seem to be too bad.

ABILITY TO TRIM

Ability to trim was good laterally and directionally. The longitudinal was also good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 364$ deg/sec^2 - in. $N'_{\delta_{RP}} = 34.5$ deg/sec^2 - in.

Rudder sensitivity and aileron selections; no real compromises involved in either selection. The aileron sensitivity selection gave me light forces and gave me lots of roll capability. The rudder I lightened up so that I could coordinate the little bit of adverse yaw that seemed inherent with an aileron control input with this configuration The forces ended up light, the displacements were small, the control harmony in general was quite good.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron input alone was accompanied by a small amount of adverse yaw and a little bit of the Dutch roll slipping over into the roll rate. The roll itself was relatively smooth. The Dutch roll oscillation that I got seemed to be relatively high frequency and relatively lightly damped. Coordinating the configuration seemed to cut down the oscillatory tendency a little bit. The oscillatory tendencies were more in sideslip than in roll.

BANK ANGLE CONTROLLABILITY

Ability to achieve bank angle was pretty good. When I stopped on a desired bank angle, I excited the lightly damped Dutch roll which because of its high frequency died out in a respectable amount of time but it was enough to be quite a nuisance factor. It didn't affect the bank angle control very much.

HEADING CONTROLLABILITY

The Dutch roll oscillation did affect the heading control and it would take a while for the airplane to settle down on a given heading.

BANK ANGLE COMMAND TRACKING TASK

Bank angle performance was pretty good. The one problem that was encountered was the lightly damped Dutch roll oscillation. This oscillation occurred anytime I did anything abruptly with the airplane whether I coordinated it or not.

RESPONSE TO DISTURBANCE INPUTS

Random disturbance input response was really exaggerated in the directional response. The excursions were large and persistent so that the airplane's overall response to the amount of disturbance was really noticeable and really deteriorated what was a reasonable performance up to that point. So, response to disturbance here is really a major factor.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good and did not interfere or detract from the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think, in smooth air, you would have a chance of doing, not a good job, but maybe a reasonable job of air tracking. Still have this lightly damped Dutch roll to put up with, but the frequency seems to be high enough that the oscillations die out in a relatively short period of time and the sideslip excursions that I see are really not large. But in the presence of turbulence, based on what I have seen, the air-to-air role in this airplane would really be not very good, primarily because of the large sideslip disturbances. The air-to-ground mission I think would probably be worse than the air-to-air because of the great probability of being in turbulence.

GOOD FEATURES

I think the roll control is good and I think the fact that I could select light forces and get lots of roll performance are the good features.

OBJECTIONABLE FEATURES

The primary objection was the airplane response to the random disturbance inputs which I think is coupled with the lightly damped Dutch roll oscillation. It's objectionable that I excite the oscillation anytime I maneuver the airplane abruptly and it's objectionable that I can't keep the sideslip small enough with coordination to prevent exciting the Dutch roll. Major objection, and the one that really destroys this configuration is the response to random disturbance inputs.

SPECIAL PILOTING TECHNIQUES

Rudder cordination is required. The rudder coordination is in the normal direction and not too difficult to do.

PRIMARY REASON FOR THE PILOT RATING

I don't think it was satisfactory in smooth air because of the lightly damped Dutch roll disturbance but I think I could have done a reasonable job. Response to random disturbance inputs was really a moderate objection to this configuration, and perhaps slightly worse than that, and required slightly more than considerable pilot compensation. I think increase in pilot effort in turbulence is in the best efforts required category with a moderate deterioration in task.

CONFIGURATION 5 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.0$ PILOT RATING 4.5 TURBULENCE RATING E

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression of the third configuration was that it was going to be a pretty good one. Seemed to be very low sideslip generated. Looked like it was a little bit proverse initially, however, the sideslip generation wasn't very large, the airplane was quite stiff directionally so that sideslip excursions tended to be small.

ABILITY TO TRIM

Ability to trim was good in all three axes, was no problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 430 \text{ deg/sec}^2 \text{ - in.}$ $N'_{\delta_{RP}} = 26.5 \text{ deg/sec}^2 \text{ - in.}$

Bank angle controllability did seem to be a little bit sensitive to the gear selection. However, the sensitivity I picked was nice and light and didn't present any real compromise, in my gear selection. Forces that ended up on the ailerons were light. Coordination wasn't really a factor so that selection of rudder sensitivity probably doesn't mean very much because I hardly used the rudder.

AIRPLANE RESPONSE TO PILOT INPUTS

The airplane was quite oscillatory in the Dutch roll, seemed to be very high frequency and I think that is a major problem on this configuration. Heading coordination requirements were small, the airplane was stiff enough directionally, I really couldn't coordinate it as fast as it was doing it itself, so I didn't really have to coordinate the airplane very much.

BANK ANGLE CONTROLLABILITY

Ability to achieve the desired bank angle was only fair to good. There was a tendency on my part to overshoot the bank angle and then very small but I think noticeable oscillat s about the bank angle.

HEADING CONTROLLABILITY

Heading control was good, the airplane very stiff directionally and even though it was lightly damped the oscillations that I saw, except for what I will talk about in turbulence later, were not very great.

BANK ANGLE COMMAND TRACKING TASK

I could really go at the tracking task aggressively but when I did, I found a tendency to overshoot. Then the bank angle would go through one or two oscillations before it got right on center so that the tracking task performance was only fair.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs was quite significant on this configuration. There were quite large bank angle and sideslip disturbances so that you tend to pick up quite noticeable side accelerations in the cockpit and it really causes best efforts required and moderate deterioration in performance so that turbulence response was quite poor.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities didn't detract from the lateral-directional;very good.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think these characteristics are probably acceptable, I don't feel however they are satisfactory. In the air-to-air role, the slushing around of the nose in turbulence, and to pilot inputs, resulting from the lightly damped Dutch roll would cause you to not be as precise at hitting the target as you would like and certainly that is true of the bank angle control. Air-to-ground I think you have probably worse problems air-to-ground because I think you increase your chances of hitting a lot of turbulence in air-to-ground role.

GOOD FEATURES

I liked the fact that you had good roll control, I liked the fact that the sideslip disturbances were small and that you really didn't have to coordinate the airplane to keep the sideslip small.

OBJECTIONABLE FEATURES

Primary objection is the response to the random disturbance and also the fact that I had what I thought was poorer bank angle controllability than I would like to see in a fighter airplane.

SPECIAL PILOTING TECHNIQUES

I found that I really couldn't coordinate the airplane because the Dutch roll oscillations were so rapid that they were back to the center before I had a chance to do anything about them.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable. I don't feel however that it is satisfactory. I think that the deficiencies were more than minor, I don't think they're all that moderately objectionable.

CONFIGURATION 6 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.0$ PILOT RATING 2.5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression of that one was that it was going to be a pretty good one, and that seemed to hold throughout the rest of the evaluation.

ABILITY TO TRIM

It was easy to trim directional. A little tendency to want to roll one way and then the other on the lateral trim, but it was good. It was not something that detracted from the evaluation. Longitudinal trim was also good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 380$ deg/sec^2 - in. $N'_{\delta_{RP}} = 21.0$ deg/sec^2 - in.

I looked at values more sensitive than what we started out with and I was very much overcontrolling the airplane in roll. So backed down to where I started out and even that was a little too sensitive as I discovered as I continued to fly. When I'd try making very small bank angle corrections and try to hold the bank angle, any little bit of turbulence in the airplane would tend to bobble it in roll just a little bit. And I think that's primarily due to my, perhaps too high aileron gear selection. Forces, however, were quite light on the ailerons, real good maneuverability on that one. I didn't really use the rudders so the gear selection that I've got there is simply what we started out with. Displacements are small, control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

With aileron-only inputs, the airplane seemed to have very little sideslip generated. It looked like it was initially just a little bit proverse, but only a very small amount of sideslip was generated. Didn't seem to have an awful lot of influence on the roll. The roll seemed to be smooth. The airplane was more oscillatory directionally than some that I'd seen and it seemed to have relatively high frequency. This was noticeable mostly in the presence of the random disturbance. Maneuvering and coordination requirements were nil.

BANK ANGLE CONTROLLABILITY

Ability to achieve a bank angle was good, A tendency to overshoot it on my part I think, because I was really flying the airplane aggressively and I think perhaps I had the gear ratio a little too light.

HEADING CONTROLLABILITY

Heading control was good in smooth air, in turbulence you get a little bit of nose wandering back and forth.

BANK ANGLE COMMAND TRACKING TASK

Bank angle tracking task performance was good I think because I was going at it aggressively I was over-controlling it a little bit. The reason I was thinking the sensitivity was too light was that in a constant banked turn, I would sit there and bobble the airplane a little bit in roll.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs is quite noticeable, particularly directional oscillations tend to set up. I think it's in the more effort required category and perhaps probably at least a moderate deterioration in my task performance.

LONGITUDINAL CHARACTERISTICS

The longitudinal handling qualities were good. No factor.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they're quite good. I think it's acceptable, I think it's a satisfactory airplane. In air-to-ground role, I think the turbulence response is a little more than I would like to see, particularly in the sideslip mode, but again, still not much of a problem.

GOOD FEATURES

The roll control is really good, the roll maneuverability is really good. The fact that very little or no sideslip is generated is a good feature and the fact that no coordination is required is a good feature.

OBJECTIONABLE FEATURES

Really I have only very minor objections. I think the turbulence response, at least directionally is a little more than I would like and a little less damped than I would like to see.

SPECIAL PILOTING TECHNIQUES

You can fly the airplane without coordinating and I like that idea.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is good. Negligible deficiencies; however, I think the turbulence response falls in the mildly unpleasant category.

CONFIGURATION 6 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = + 0.05 PILOT RATING 4 TURBULENCE RATING E

INITIAL IMPRESSION AND GENERAL COMMENTS

My impression, when I first looked at the configuration was that it was obvious that the Dutch roll was relatively lightly damped and I thought that was going to be a problem. It turned out that the more I flew it the more I thought it was pretty good.

ABILITY TO TRIM

Ability to trim was good laterally and directionally and longitudinally.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 450 deg/sec^2 - in. $N'_{\delta_{AP}}$ = 39.0 deg/sec^2 - in.

The roll rate was so smooth that I think I could have selected most any aileron gearing and would have been in real good shape. I selected a very light gearing initially and then part way through the evaluation I had to decrease sensitivity because I was overcontrolling in bank angle and it was my own inputs and not the dynamics of the airplane. The airplane flew better if I didn't coordinate. I decreased the rudder sensitivity, but really didn't end up using the rudder very much at all. So I won't guarantee that there's any meaning to the forces on the rudder that I've selected. The aileron forces were nice and light, displacements were very small and the harmony of the controls was very good.

AIRPLANE RESPONSE TO PILOT INPUTS

Using aileron input without rudder, the roll rate was just really smooth. I couldn't believe that you can roll that airplane 360° and the sideslip would hardly move and there was no oscillation or anything involved in the roll. I did two rolls, a little bit of sideslip was excited. I didn't coordinate with the rudder. Attempts to coordinate didn't do anything but excite that small amplitude lightly damped Dutch roll oscillation, so I was better off without being on the rudder pedals, so that really coordination wasn't a factor.

BANK ANGLE CONTROLLABILITY

Ability to achieve bank angle was really quite easy. You can roll up and stop that airplane most anywhere you want to.

HEADING CONTROLLABILITY

Ability to achieve heading was good.

BANK ANGLE COMMAND TRACKING TASK

The performance I thought was good. I kept overcontrolling at first. Came down on the gearing a bit and things were better. So there are really no problems involved there.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs was a problem. The airplane was excited quite a bit directionally and oscillated almost continuously in the disturbance inputs. So that the random disturbance is really very distracting influence here and has influenced my evaluation of this particular configuration, I think quite strongly.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good. They did not detract at all from the lateral-directional, and in general a very harmonious longitudinal control, quite fighter-like.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

Suitability of these characteristics for the fighter mission is a little bit questionable for two reasons. First of all, there is a very lightly damped Dutch roll so that even with any little bit of sideslip disturbance, the airplane has a relatively high frequency with lightly damped oscillation and I'm sure that that would detract from my ability to fire guns, particularly air-to-air. Air-to-ground, I think it would be a problem in any turbulence, it would certainly degrade my ability to hit targets, as it would also do in random disturbances in the air-to-air tracking. That's really the only problem.

GOOD FEATURES

Roll control is outstanding, very smooth, some of the best I've seen. The lack of coordination is excellent and just, in general, the kind of coordination requirement that I like to see in the fighter, which is none.

OBJECTIONABLE FEATURES

The response to the disturbance inputs directionally was severe. The airplane is just in a continuous directional oscillation. The lightly damped Dutch roll rears its head not just in the disturbance inputs but anytime you stop the airplane, you get this small, high frequency, lightly damped oscillation which I think detracts from the pilot's ability to hit a target, particularly with guns. It's also objectionable because I couldn't stop it. When I got into the loop, I was not fast enough to stop the directional oscillation and if anything, tended to make it worse by putting in my own rudder pedals.

SPECIAL PILOTING TECHNIQUES

The directional problem was there. I was not able to do anything about it and I was better off if I didn't coordinate the airplane.

PRIMARY REASON FOR THE PILOT RATING

I'm going to say that this configuration is not satisfactory for the fighter mission as it is. I think it's acceptable. I think that if you could just get rid of that lightly damped oscillation, and cut down its response to random disturbances, you'd have a real fine airplane, but I don't really know whether to call that a *minor deficiency* because I really can't improve very much on it by my own pilot compensation so it's a bit of a problem to say that moderate pilot compensation is required because I really couldn't compensate for the problem that I had even though I think it would detract from my ability to hit targets. Turbulence really deteriorated my ability to attack. More effort is required, but those efforts are not good enough to alleviate the problem, but the deterioration in task performance is quite marked.

CONFIGURATION 6 $N'_{\delta_A}/L'_{\delta_A} = +0.10$ PILOT RATING 7 TURBULENCE RATING E

INITIAL IMPRESSION AND GENERAL COMMENTS

It was an interesting one because more than once my assessment of the configuration changed dramatically from beginning to the end. And I say that because my initial impression was that it was really nice, you could do 360° rolls and get very little sideslip and the roll performance was going to be really good, I think. But then as I began to fly it, two things were obvious - one that the bank angle precision was extremely poor and, two, the large proverse yaw gererated set up bank angle oscillations. The Dutch roll was very lightly damped and relatively flat. So that there are a number of things that added up to be an extremely poor airplane.

ABILITY TO TRIM

Ability to trim, directionally was good. Longitudinal was good. It was sensitive on the roll control, but this didn't seem to be a factor in my evaluation.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 425 deg/sec^2 - in. $N'_{\delta_{RP}}$ = 26.5 deg/sec^2 - in.

On the aileron sensitivity selection, I ended up accepting what we started out with. Looked at a little lower sensitivity, didn't seem to make too much difference to my problems, so ended up using the lighter aileron gear selection simply because the roll performance was very good. Didn't seem to make an awful lot of difference to my precision whether I had it more or less sensitive. On the rudder, the Dutch roll was fast, the yaw was in the proverse direction and it oscillated back so I really didn't stand a chance of coordinating this configuration, so really didn't do anything with the rudders.

AIRPLANE RESPONSE TO PILOT INPUTS

Using aileron input without the rudder, surprisingly enough, the roll was pretty smooth, it didn't seem to accelerate or anything like that. As far as coordination was concerned, I wasn't able to coordinate it, it was too fast, too high a frequency for me, and in the wrong direction. So that I kind of just left the coordination alone. Oscillatory characteristics; that's a pretty good description of this configuration. There are oscillations in both roll and the yaw for this configuration. The roll primarily from the closed loop bank angle tracking and the yaw pretty much from just the Dutch roll excitation which seems to be relatively flat. Maneuvering coordination requirements, I could say I really kind of flew it with my feet off the rudder because I wasn't helping the situation and if anything, was only stirring up the Dutch roll more than it already was stirred up.

BANK ANGLE CONTROLLABILITY

Bank angle controllability was extremely poor. It has tendencies to overshoot and overcontrol and oscillate about a given bank angle when trying to track precisely and the harder I worked at it the worse it seemed to get, so I really wasn't very good at controlling the bank angle.

HEADING CONTROLLABILITY

Heading control was poor because the airplane kept going back and forth directionally without an awful lot of roll and I can sit here and just move the stick back and forth and really displace the nose left and right. And because of the sideslip oscillations which were high frequency and relatively lightly damped, your precision in heading control was completely reduced.

BANK ANGLE COMMAND TRACKING TASK

Bank angle tracking task performance was poor. Quite a large tendency to overshoot and to oscillate about the bank angles, which I think was a bit, in roll due to my fault, in yaw due to the lightly damped Dutch roll.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs was quite dramatic in sideslip, didn't seem to be in roll. The airplane really did get kicked around directionally. So I think this would be a real poor airplane in turbulence, at least in the directional sense anyway. Let's put it in the best efforts category with a moderate deterioration in task performance because that thing really was flipping around up there directionally.

LONGITUDINAL CHARACTERISTICS

I thought the longitudinal handling qualities were good, not a factor in the evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

In the air-to-air role, I'm willing to say that it's not acceptable. I think the bank angle oscillations and the quite large sideslip disturbance which is quite oscillatory would really negate my ability to perform the fighter mission. Air-to-ground, I think if you run into turbulence with this thing, you would likely never get any weapon launched in the direction you wish to go because the airplane is really whipping back and forth directionally in turbulence.

GOOD FEATURES

I have to admit the airplane has real good roll performance and if all you want to do is roll the airplane, you can do it without generating a lot of sideslip provided you're in smooth air.

OBJECTIONABLE FEATURES

The two strongest objections - one, the bank angle controllability is extremely poor when tracking precisely. Certainly you end up with a lateral pilot-induced oscillation, which is damped, I'll admit, but not very good and the light damping of the Dutch roll and the high frequency which results in a quite rapid and large sideslip oscillation in the presence of the random disturbance, and I'm relating that to turbulence. And those two factors, I think are sufficient to make the airplane unacceptable.

SPECIAL PILOTING TECHNIQUES

There's really not an awful lot you can do. You can't coordinate the thing. I couldn't because it was too rapid. So pretty much flew with my feet on floor for that one.

PRIMARY REASON FOR THE PILOT RATING

I'm not willing to buy that for the fighter mission. I think that adequate performance is not attainable. I don't feel that controllability is in question.

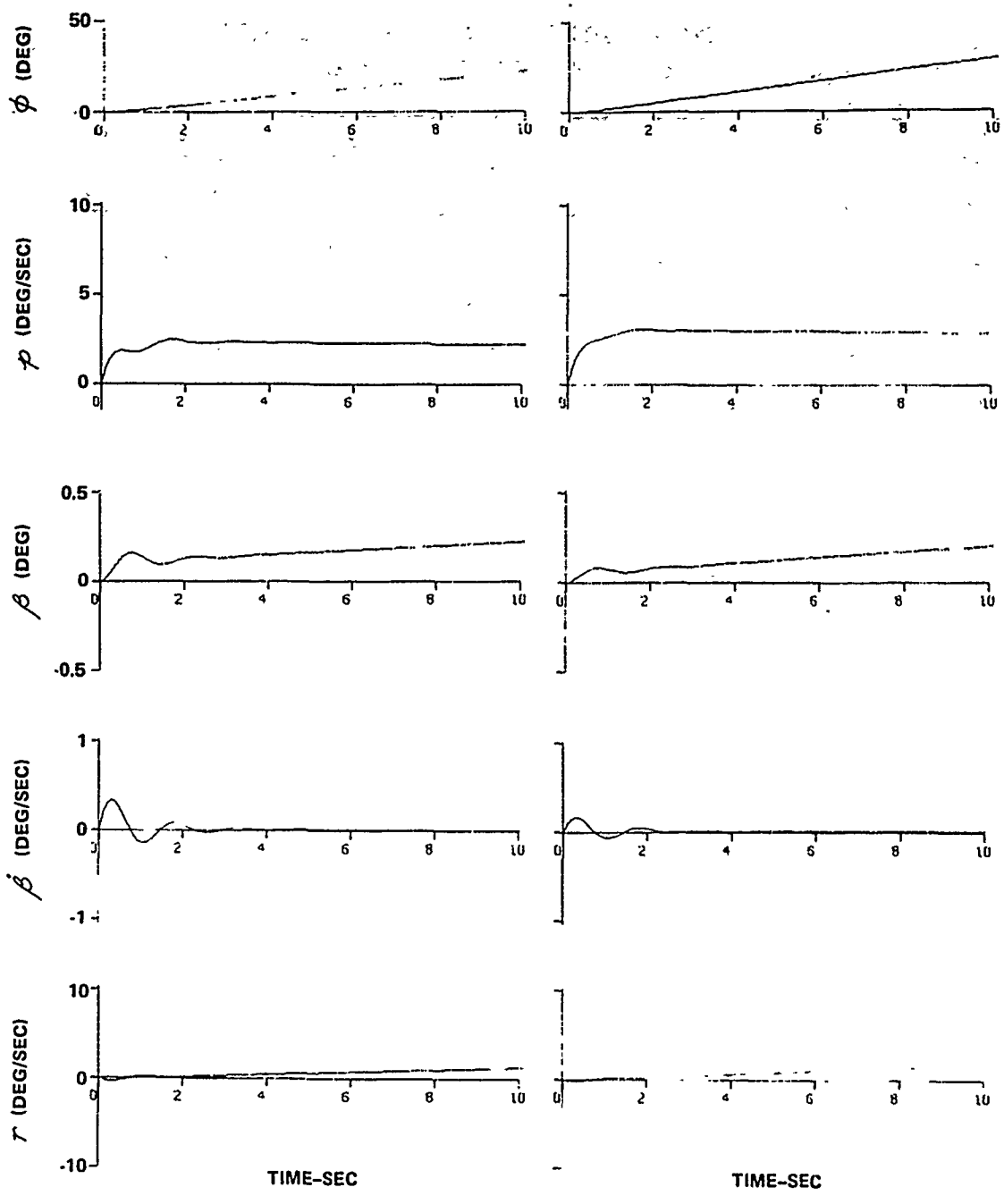
CONFIGURATION 7 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/k$ LEVEL 1	LEVEL 2	$\lvert\Delta\beta/\phi_1\rvert \times \lvert\phi/\beta\rvert_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.20	7	E	0.20	3.42	-205	0.090	9.0*	6.5*	0.40	440	75.0
-0.10	3	C	0.21	3.89	-193	0.019	3.6	2.5	0.08	600	72.0
-0.10	5	D	0.21	3.89	-193	0.034	3.7	2.5	0.12*	553	45.0
0.0	1.5	B	0.23	4.30	-035	0.00	1.7	1.1	0.02	500	29.5
+0.07	1.5	C	0.24	4.58	-065	0.00	1.6	1.1	0.07	455	26.5
+0.15	4	B	0.25	4.87	-335	0.016	3.2	2.1	0.12	315	22.5

*INDICATES DATA FROM COMPUTER GENERATED TIME HISTORIES

LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

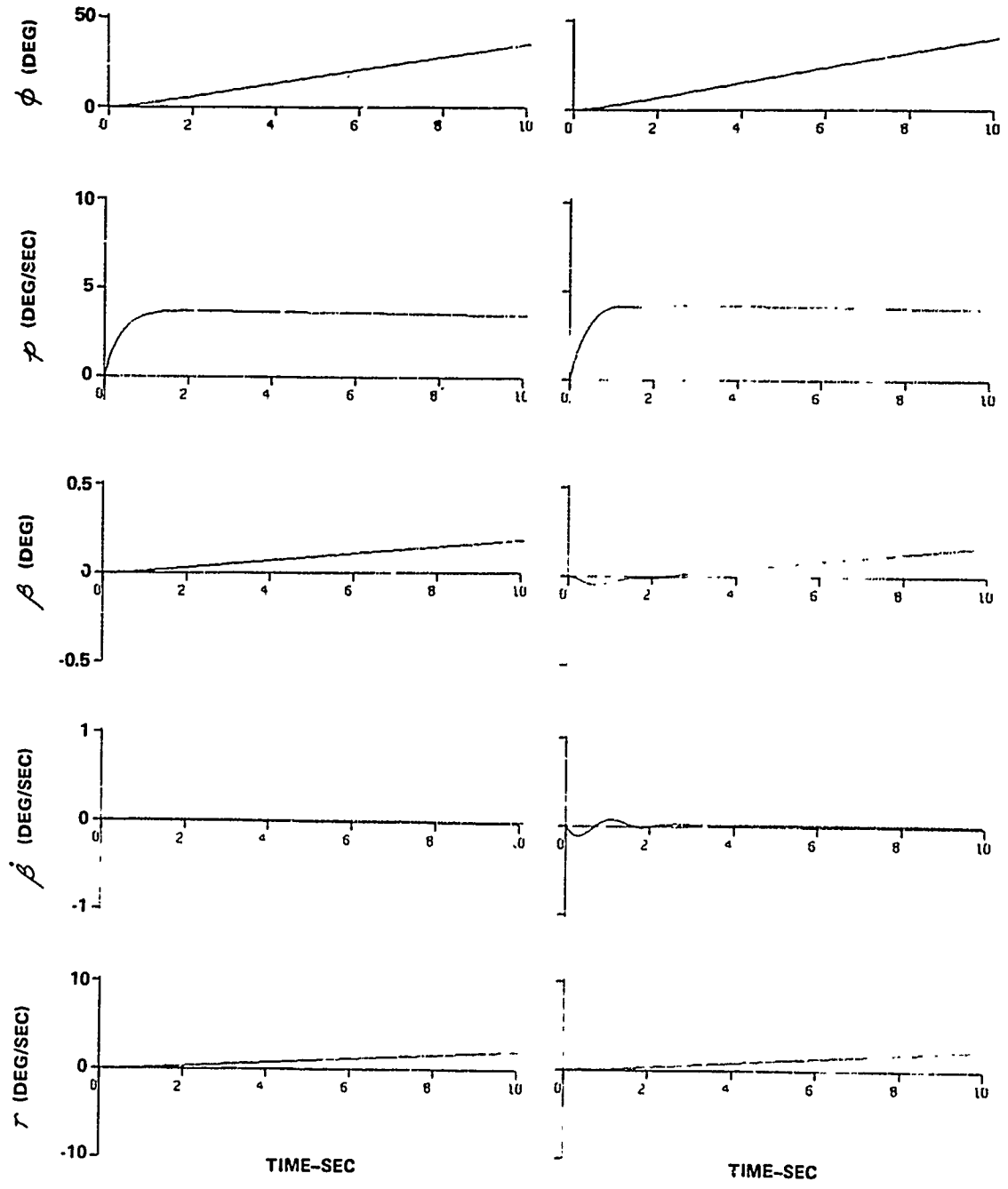
ω_d	= 4.30	N'_β	= 18.7	L'_β	= -34.6
ζ_d	= 0.23	N'_r	= -1.68	L'_r	= 2.79
τ_R	= 0.38	N'_p	= 0.0635	L'_p	= -2.64
τ_S	= 136	$\frac{g}{V}$	= 0.0586	Y_β	= -0.300
$\lvert\frac{\phi}{\beta}\rvert_d$	= 1.78	$Y_r - 1$	= -0.983	$Y_{\dot\beta}$	= -1.015
$\angle\left(\frac{\phi}{\beta}\right)_d$	= 28.3	$Y_p + \alpha_o$	= 0.0033		



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.20$

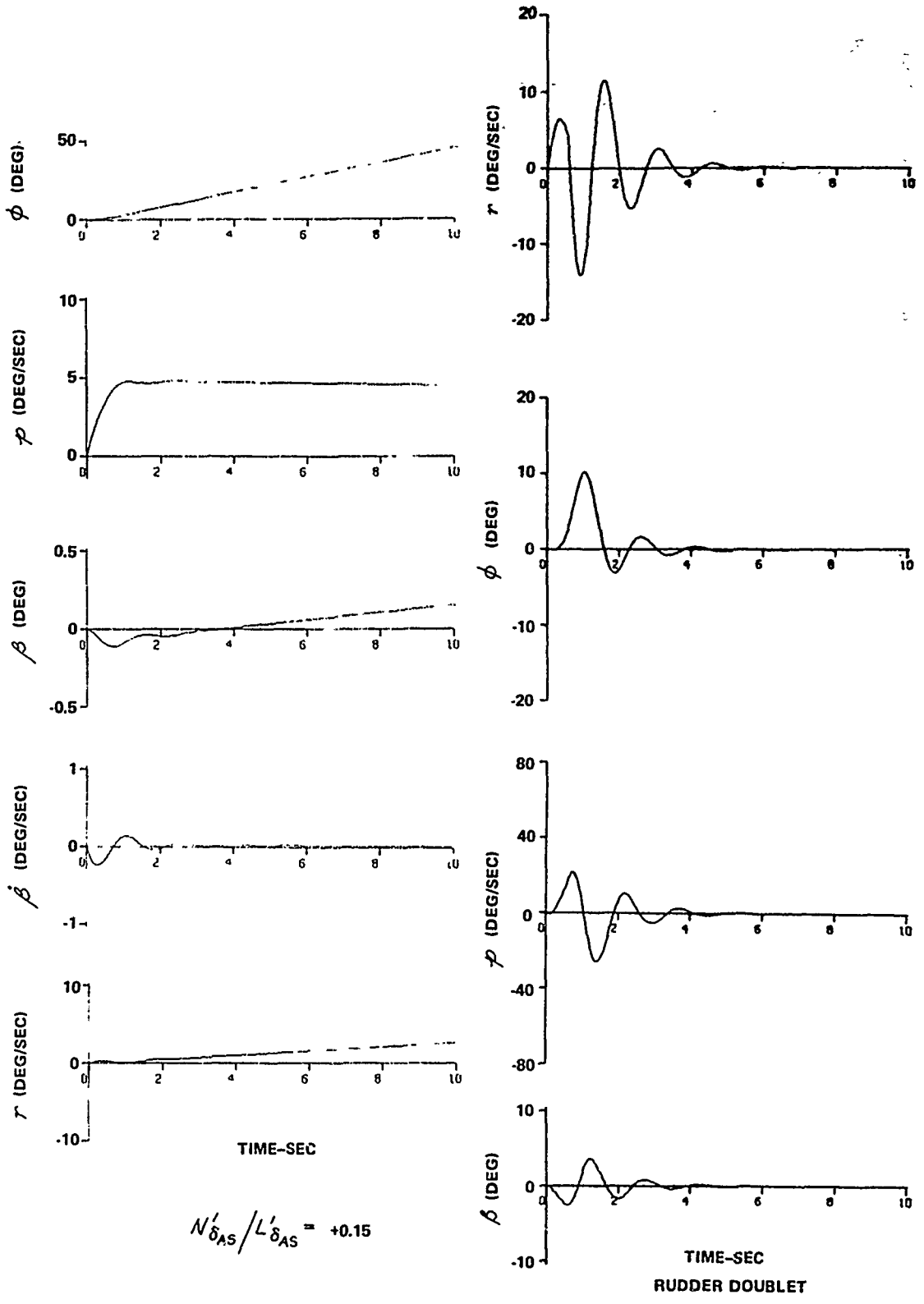
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.10$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 7

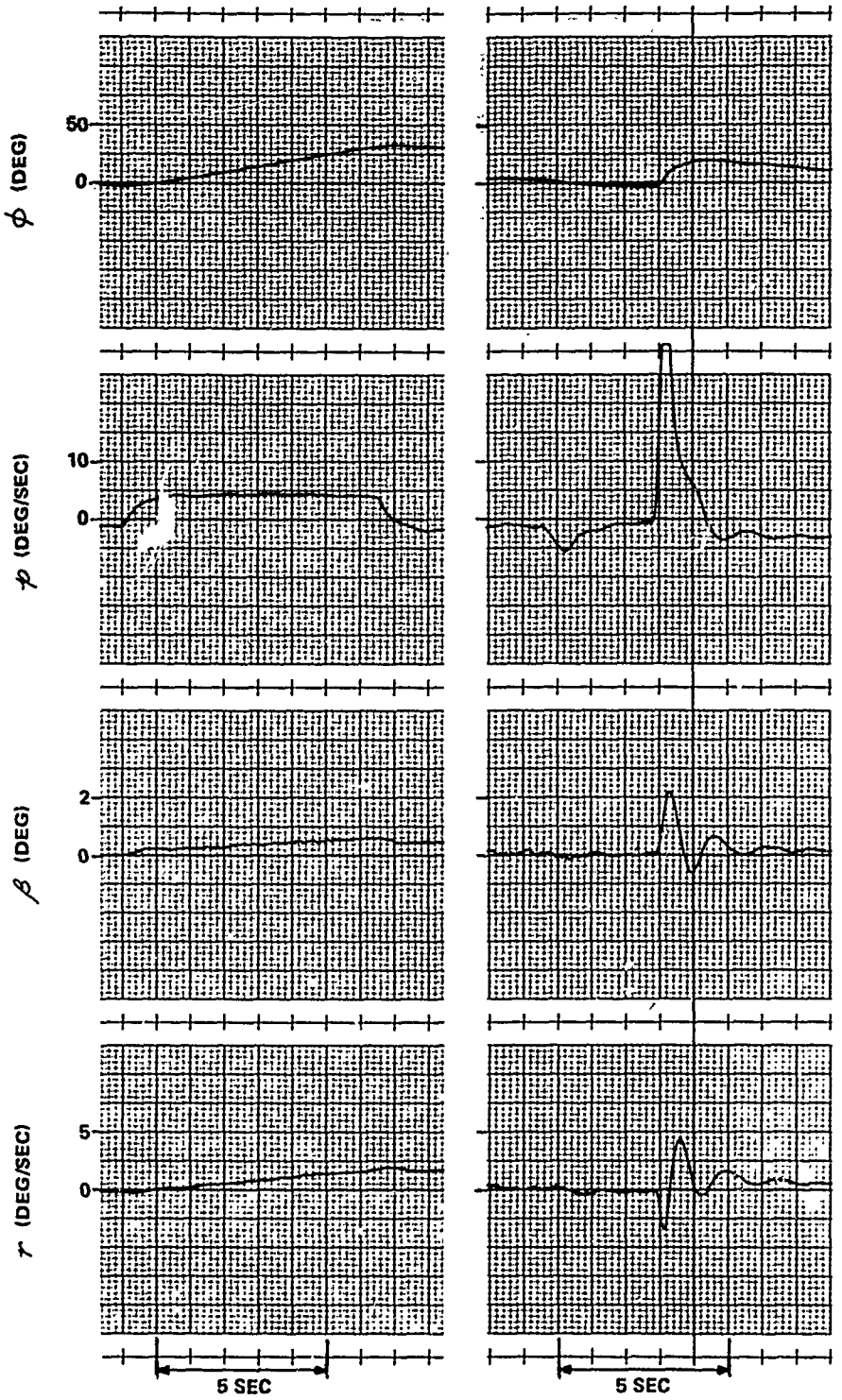


$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.07$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 7



COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR CONFIGURATION 7



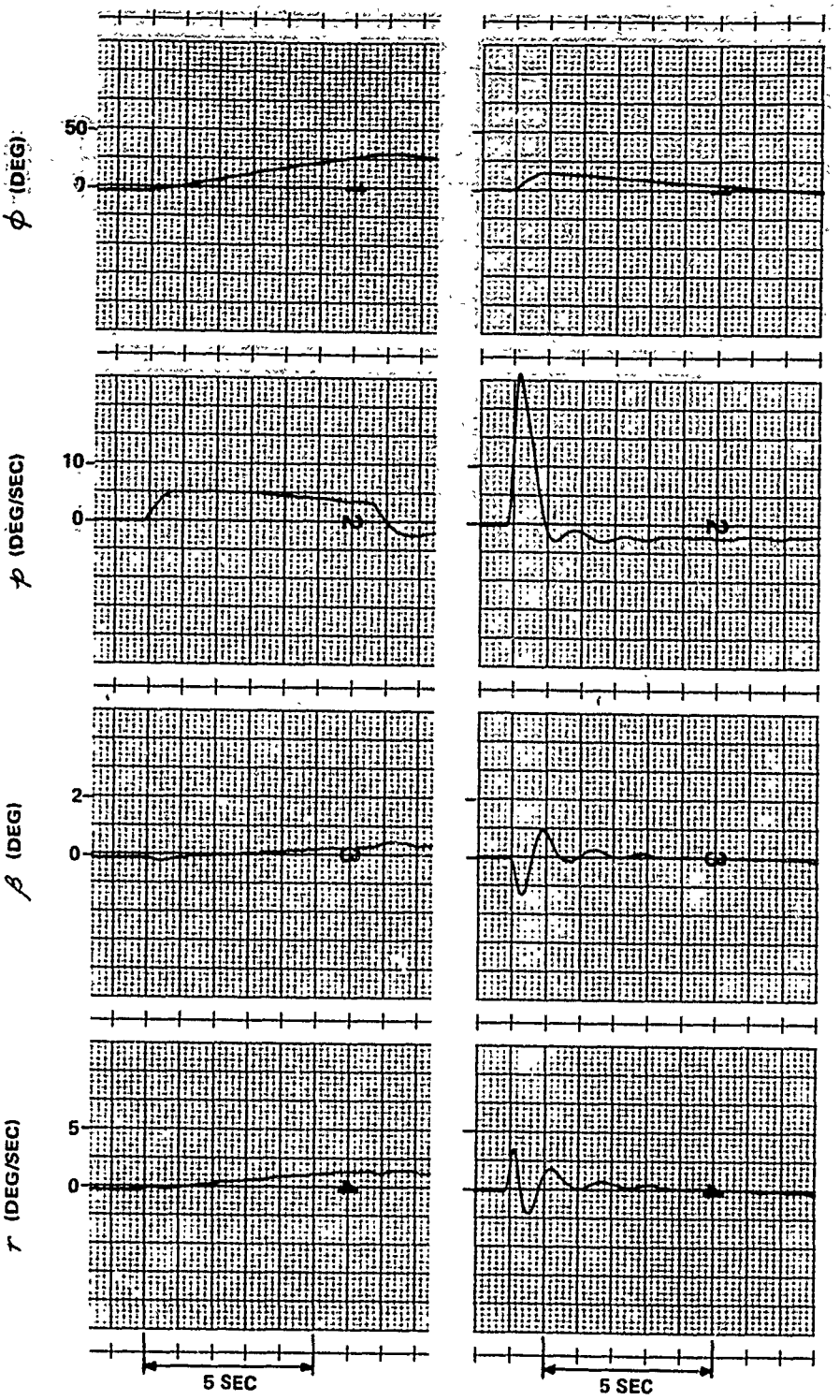
$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.10

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.10

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 7



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.15$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.15$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 7

CONFIGURATION 7 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.20$ PILOT RATING 7 TURBULENCE RATING E

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression was that I wasn't going to like it and my convictions were confirmed as we continued to fly the configuration.

ABILITY TO TRIM

Ability to trim in general is pretty good and in all three axes, no special problems involved with trimming.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 440$ deg/sec^2 - in. $N'_{\delta_{RP}} = 75.0$ deg/sec^2 - in.

I purposely selected a lower aileron gearing because there seems to be a lot of adverse yaw, and a relatively lightly damped, high frequency Dutch roll. Everytime I put in an aileron input, the nose almost wanted to move as much as the wings did and it was quite disconcerting. Then I'd set up this high frequency oscillation, it was a real, squeamish airplane that seemed to want to slosh back and forth at quite a high rate. It was quite uncomfortable. A lot of rudder was required to coordinate the sideslip. So I came up on the rudder sensitivity to make the forces lighter. So, there was really a compromise on the ailerons in order to cut down the large amount of sideslip and a higher rudder sensitivity to try to coordinate the sideslip. The forces on the ailerons, although not heavy were not in the category of being light. So if there's such a category as medium forces, that's where I was. The rudder forces, even with the higher gear ratio selection that I made tended to be heavy and the displacements on the rudder were beginning to get noticeable. The control harmony, although not poor was not as good as I would like to have had.

AIRPLANE RESPONSE TO PILOT INPUTS

An aileron input without the rudder resulted in a large amount of adverse sideslip and a quite high frequency lightly damped oscillation which showed up in both roll and sideslip. Coordinating the aileron inputs, helped a bit because the smaller the input the less triggering of that oscillation. This particular configuration exhibited almost a continual Dutch roll oscillation for any rapid and continuous maneuvering. They weren't divergent but they were just there and persistent and high frequency. Maneuvering coordination requirements, lots of rudder in the direction of the aileron inputs was required and I guess I'm getting tired, but it really worked me, that was one of my dislikes.

BANK ANGLE CONTROLLABILITY

Ability to achieve a bank angle was poor because everytime I'd roll up there, this oscillation will get triggered off and it was showing up in both roll and sideslip and consequently my bank angle control wasn't very good.

HEADING CONTROLLABILITY

Heading control was fair to good because the oscillations that I was seeing were high frequency and relatively small amplitude so that the nose didn't swing way away from the given heading, it would in general stay pointed where I had directed the nose, but I don't think that you would have very much success hitting anything with, let's say an air-to-air cannon with this configuration because of these persistent oscillations.

BANK ANGLE COMMAND TRACKING TASK

I was not able to perform the task as aggressively as I would like, kept dumping the system, I think primarily on rudder inputs. In general I had to slow down my performance on the bank angle tracking task and encountered again oscillatory problems in both bank and sideslip.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs was quite dramatic in both sideslip and roll and quite instrumental in triggering this lightly damped high frequency oscillation, so that in the presence of random disturbances, I think you're getting down to best efforts required to certainly moderate deterioration.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities are okay, did not degrade or interfere with the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I don't think these characteristics are suitable. The large sideslip disturbance and the continual lightly damped oscillation coupled with the turbulence response of this configuration, I think makes it an unacceptable airplane. And those comments hold in general for the air-to-ground mission also. I think air-to-ground in turbulence, it would be a matter of luck if you hit anything with this configuration.

GOOD FEATURES

No really outstanding or particularly good features about it.

OBJECTIONABLE FEATURES

The lightly damped Dutch roll oscillation which shows up in roll and sideslip, the large amount of adverse sideslip due to an aileron input, and the large rudder inputs and heavy forces required to coordinate it, even with the light sensitivity, and this continual nose wing-rock oscillation any time you put in a small input were really disconcerting.

SPECIAL PILOTING TECHNIQUES

You do need to use a lot of rudder in the direction of the aileron input, and I mean a lot.

PRIMARY REASON FOR THE PILOT RATING

I am not fast enough with the rudder to dampen out these oscillations that I see and my bank angle controllability is poor and my disturbance inputs are large. I think that adds up to major deficiencies. Controllability really wasn't in question, the airplane was stiff enough directionally that the oscillations never got out of hand so I don't think that that's a problem. In turbulence, best efforts required, moderate deterioration.

CONFIGURATION 7 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.10 PILOT RATING 3 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression was that this was a reasonable airplane to fly.

ABILITY TO TRIM

I had a little bit of difficulty with the lateral trim on this configuration. I selected the aileron gearing quite high, therefore, making the trim quite sensitive so that usually I was rolling slightly one way or to the other. I had a little difficulty getting the airplane trimmed as well longitudinally as I would like but not a significant factor.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 600 deg/sec^2 - in. $N'_{\delta_{RP}}$ = 72.0 deg/sec^2 - in.

I was able to select, at least the aileron gearing without too much regard to the roll characteristics or the dynamics of the airplane. I selected the rudder gearing a little lighter perhaps, than I normally would have liked because there appeared to me to be a noticeable amount of adverse yaw and it was to my advantage to have slightly lighter rudder forces in order to be able to take care of this adverse yaw. So the forces that I ended up with were quite light. The displacements were small, which I liked, and the harmony of the controls in all three axes was quite good.

AIRPLANE RESPONSE TO PILOT INPUTS

There initially seems to be a fair amount of adverse yaw during an aileron only input. Whatever yaw due to roll there is, is really not significant to me. When I put in an aileron-only input, sideslip does build up in the adverse direction, however, because it is in the adverse direction, it's relatively easy to coordinate and the rudder inputs required are quite normal. As for oscillatory characteristics, there does seem to be a Dutch roll excited, but it seems to be quite high in frequency and damps out in a short period of time. As far as turn coordination is concerned, you do need to coordinate, it appears to be quite natural so that I don't really have any difficulty coordinating the airplane and I don't find that I have to hold any rudder in the steady state.

BANK ANGLE CONTROLLABILITY

It was relatively easy to achieve a given bank angle and I could roll smartly from one bank angle to the other and I noticed a little bit more this slight feeling of nonlinearity in roll, where the airplane just wanted to pick up just a little bit in roll, but I was able to adapt to that and I could stop the airplane from rolling quite easily at the bank angle that I wanted.

HEADING CONTROLLABILITY

I could achieve a heading with this airplane quite easily and I did find that the airplane would oscillate noticeably, maybe a couple of times, before it would settle down right where I wanted to, but this happens in such a short period of time that it really wasn't much of a problem.

BANK ANGLE COMMAND TRACKING TASK

My performance, I thought was good and I didn't really have any problems doing it with a high degree of aggressiveness. I could stop the needle right in the center pretty much where I wanted it and very little oscillatory characteristics when attempting the tracking task.

RESPONSE TO DISTURBANCE INPUTS

Response to the disturbance inputs on this configuration were quite noticeable in sideslip. There didn't seem to be very much roll due to the disturbance input, but the sideslip excursions were quite noticeable and the airplane moved almost a half a nose width to some of the disturbance inputs and it was a little bit more distracting than I would like for it to have been.

LONGITUDINAL CHARACTERISTICS

No comments.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think the characteristics that I've seen in this configuration are quite suitable for the fighter mission and I think they are suitable without improvement.

GOOD FEATURES

I liked the fact that I had good roll control, that I could snap the airplane around and fly it aggressively, the fact that the sideslip excursions that I did see were small and that they damped out in a very short period of time. The lack of roll due to disturbance inputs I would add as a good feature.

OBJECTIONABLE FEATURES

The adverse yaw, and I find that I have to coordinate all the maneuvers to keep the sideslip down. I would also add to that, however, if I didn't coordinate, sideslip never got out of hand and it wasn't something that was going to cause much of a problem, but certainly my gunnery accuracy would be reduced if I didn't coordinate.

SPECIAL PILOTING TECHNIQUES

None really required, even though you do have to coordinate the airplane, it's in the proper direction and relatively easy to accomplish.

PRIMARY REASON FOR THE PILOT RATING

I think these requirements are satisfactory without improvement. I think the discrepancies that I have talked about are certainly mildly unpleasant deficiencies and that some pilot compensation is required, but it's only minimal. On the turbulence response, certainly more effort was required and particularly in the directional. The sideslip disturbances that I saw certainly put me in the "more effort required" however, it was only a minor deterioration in performance.

CONFIGURATION 7 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.10$ PILOT RATING 5 TURBULENCE RATING D

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression was that I wasn't going to particularly like it as it seemed to have quite a bit of sideslip generated with an aileron input, one of those kind of configurations where the nose of the airplane seems to be connected to the stick, moves back and forth with the stick. The sideslip was in the adverse direction, it wasn't all that difficult to coordinate so I could keep the sideslip relatively small. Couldn't do an outstanding job with it or even a good job, but I could keep it down, I could maneuver the airplane without feeling that the sideslip was getting out of control and as I played with it more my technique got better.

ABILITY TO TRIM

The lateral seemed to be not as good as the directional. I had a tendency to roll a little bit one way or the other. It did not detract or interfere with my evaluation. My longitudinal trim was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 553$ deg/sec^2 - in. $N'_{\delta_{RP}} = 45.0$ deg/sec^2 - in.

I had to increase sensitivity quite a lot on the rudder and the aileron over what we started with, more on the rudder than on the aileron. On the rudder I increased it quite a bit in order to counter this rather large amount of adverse yaw that I was generating. The forces on the aileron were light, the forces on the rudder were heavy. Displacements were reasonable on both. Control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

With aileron only inputs, roll seemed to be reasonably smooth; however, quite a bit of adverse yaw was generated and required rudder coordination to keep it from getting out of hand. The sideslip didn't seem to affect the roll all that much which surprises me a little bit and the roll was relatively smooth. When I coordinated I was able to do a much better job with the roll and to keep the sideslip under control. Oscillatory characteristics, the airplane seemed to be quite high frequency Dutch roll, not very heavily damped, but not lightly either. Oscillations show up mostly in the turbulence response where the airplane is quite oscillatory, particularly directionally. As far as maneuvering coordination requirements are concerned, rudder is required in the direction of the turn and if you don't coordinate you end up getting quite large sideslip angles generated.

BANK ANGLE CONTROLLABILITY

Ability to achieve bank angle I thought was fair to good. A little bit of a problem there because the sideslip that is generated does feed into the roll but not an awful lot. When I didn't coordinate the airplane, I could feel it affect my roll control and it's at such a high frequency that I'm not able to keep up with it very well.

HEADING CONTROLLABILITY

Heading control was a bit of a problem because of the size of the sideslip angle that was generated from an aileron only input if I didn't coordinate and I wasn't very good at coordinating the small inputs, the nose would move back and forth as I would move the stick so that the heading control really wasn't all that great.

BANK ANGLE COMMAND TRACKING TASK.

Performance again was fair to good, I was able to do it pretty well, had a slight tendency to oscillate, I think primarily because of the excitation of the sideslip.

RESPONSE TO DISTURBANCE INPUTS

Really quite noticeable directionally and a quite high frequency directional oscillation showed up. It did affect the roll a little bit and there is a greater tendency to overcontrol in bank angle in the presence of turbulence. I think perhaps more effort is required, at least a moderate deterioration in my performance was noted.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities I thought were good, they didn't detract or degrade the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I'm willing to say that they are acceptable, they're not satisfactory primarily because of the large sideslip angles that could be generated when you didn't coordinate and the quite high frequency but quite significant oscillation in the presence of turbulence and the fact that sideslip is generated everytime I put in an aileron input are sufficient to preclude my really doing a good job in the air-to-air role. In the air-to-ground, I think the turbulence response directionally is quite degrading on that and it's not something I could really do very much about.

GOOD FEATURES

I think the roll performance was good, you did have to coordinate the aileron input with a lot of rudder.

OBJECTIONABLE FEATURES

I think the large sideslip itself is objectionable, I think it's probably good that it's in the adverse direction so that you could coordinate and do a reasonable job with it. I think the directional response to the disturbance inputs falls in the objectionable category.

SPECIAL PILOTING TECHNIQUES

Lots and lots of rudder is required in the direction of the turn, and if you don't coordinate there is a good chance that you will get a quite large sideslip angle developed.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable, I think that the deficiencies that I see are down in the moderately objectionable category and that considerable pilot compensation is required.

CONFIGURATION 7 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0.0$ PILOT RATING 1.5 TURBULENCE RATING 3

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression was that I was going to like it quite a bit and that remained.

ABILITY TO TRIM

Ability to trim in all three axes I thought was good, no problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 500$ deg/sec^2 - in. $N'_{\delta_{RP}} = 29.5$ deg/sec^2 - in.

On the aileron sensitivities, no real problem there, I think I could have selected most any gearing. My selection gave me nice light aileron forces. It was a very maneuverable configuration. Sideslip excitation was quite minimal. So that there was no compromise in the aileron. On the rudder, there was very little sideslip generated, and it really didn't need coordinating, but a little normal coordination seemed to help. The forces in all three axes, I thought were good. They were light.

AIRPLANE RESPONSE TO PILOT INPUTS

Displacements were small. Control harmony was likewise good. Using aileron input without rudder, in general it seemed to be smooth, if anything a very slight amount of acceleration could be felt, but in general it was very, very smooth. Very little sideslip generated, didn't spend all my time looking at it, but it seemed to be a very slight amount of proverse followed by a slight amount of adverse. Coordination wasn't really required. The airplane seemed to be very stiff directionally so that any oscillations you did see occurred in a very short period of time and dampened out very nicely. Maneuvering coordination requirements, none really required.

BANK ANGLE CONTROLLABILITY

Bank angle controllability I thought was very good. Didn't seem to be a tendency to overcontrol or oscillate about the bank angle so I thought I could do a good job.

HEADING CONTROLLABILITY

Heading control was likewise, I thought excellent.

BANK ANGLE COMMAND TRACKING TASK

I thought my performance was good. I could attack the tracking task with exuberance.

RESPONSE TO DISTURBANCE INPUTS

The response to disturbance inputs seemed to be mostly in the directional sense, seemed to dampen itself out quite rapidly so it didn't seem to be much of a problem. Did increase the effort required a little bit, but not a significant deterioration.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good and did not detract from the lateral-directional. In general, the combination there was very good.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

So I think these characteristics are quite suitable for the air-to-air mission. I like the fact that very little sideslip is generated and what little is generated is taken out quite rapidly by the airplane dynamics. I think the roll performance was outstanding and the bank angle controllability was likewise good. Air-to-ground role, very similar comments. Disturbed me a little bit about the quite noticeable directional response to turbulence. May cause a little problem in the air-to-ground but I don't think that's, again, significant.

GOOD FEATURES

I certainly like the roll capability of the airplane. I like the fact that very little sideslip was generated and the fact that what little was generated seemed to dampen itself out quite rapidly and was not a significant factor.

OBJECTIONABLE FEATURES

No real objectionable features.

SPECIAL PILOTING TECHNIQUES

The airplane could be flown without rudder coordination, however, I found a little bit of adverse coordination seemed to help.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is quite acceptable, quite satisfactory. I think it's approaching the highly desirable category. The directional response to the turbulence required minimal effort but significant deterioration.

CONFIGURATION 7 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.07$ PILOT RATING 1.5 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression was that it was going to be a quite good airplane and that the lateral-directional handling qualities would be good.

ABILITY TO TRIM

Ability to trim was better than most in both lateral and directional modes. Longitudinal trim was likewise good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 455 deg/sec^2-in. $N'_{\delta_{RP}}$ = 26.5 deg/sec^2-in.

There was no compromise on the ailerons, just matter of getting sensitive control, so that I could get good roll with very light forces. The rudder, it was really one of those things where you didn't really need the rudder. So I accepted with what I had started out with. Aileron displacements quite small, rudder, as I said, not used. The control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Airplane response to aileron input without the rudder, was quite smooth, there seemed to be a little bit of proverse yaw generated, but not enough to make much of a difference. I really didn't coordinate that. As far as oscillatory characteristics, the Dutch roll seemed to be very stiff, and very well damped. There is no problem. Maneuvering coordination was really not required.

BANK ANGLE CONTROLLABILITY

Ability to achieve a desired bank angle was quite good. A little bit of tendency to overshoot but I think that was more related to the aggressiveness at which I went at it, because I tended to fly this configuration quite aggressively, than a function of the airplane itself.

HEADING CONTROLLABILITY

Heading control was quite good, the airplane seemed to be quite stiff directionally. So the heading you could stop pretty much where you wanted it. It also seemed to be well damped.

BANK ANGLE COMMAND TRACKING TASK

I thought the performance was good. No real problems involved. The only problems would be my own aggression.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs showed up mostly in sideslip and you could feel the airplane move quite a bit, with quite a bit of side acceleration, I think it was in the more effort required out minor deterioration in performance if even that much.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities no problem. Did not detract from lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

In the air-to-air role I think that it is quite good. I like the snappy roll response, I like the maneuverability, I like the fact that very little sideslip is generated and the fact that what sideslip is generated seems to have a high enough frequency so that it is taken out quite rapidly so even though you could see the sideslip needle move back and forth there isn't much I could do about it. I think the air-to-ground role, the only problem that I could foresee would be the sideslip response to turbulence. In general, I think it is a pretty good airplane for both roles.

GOOD FEATURES

I like the fact that my bank angle control was good, precise, I like the fact that very little sideslip was generated. I didn't have to coordinate so I didn't really have to worry about the sideslip very much.

OBJECTIONABLE FEATURES

The major response was in sideslip, it was quite crisp to turbulence or random disturbance for this configuration.

SPECIAL PILOTING TECHNIQUES

No real special piloting techniques involved.

PRIMARY REASON FOR THE PILOT RATING

I think the deficiencies that I see here are negligible, I think that it is a real good airplane, pilot compensation not a factor. I would like to see a little less sideslip generated I think in the proverse direction and I would like to see a little less turbulence response in the sideslip.

CONFIGURATION 7 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = + 0.15 PILOT RATING 4 TURBULENCE RATING B

INITIAL IMPRESSION AND GENERAL COMMENTS

First impression was that it wasn't going to be too bad. The combination of the roll sideslip coupling and the high frequency of the Dutch roll were interesting. Some things were good, some things were bad.

ABILITY TO TRIM

Ability to trim in all three axes was good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 315 deg/sec^2-in. $N'_{\delta_{RP}}$ = 22.5 deg/sec^2-in.

Aileron was a bit of a compromise; I started going up in sensitivity to the point where I got the aileron too sensitive and had to back off. There seemed to be a noticeable connection between light sensitivity and bank angle controllability. With high sensitivity there was greater tendency to overcontrol and oscillate in bank angle. On the rudder, there seemed to be a small amount of proverse yaw initially, followed by a kind of large amount of adverse yaw so it was one of those things where the sideslip goes back and forth and I am not that good with my feet to coordinate something like that. Consequently, the rudder didn't do much work because there wasn't much that I could do to help the problems by using the rudder. In general, the aileron forces that I came up with were satisfactory, they were light. Displacements were small, same on the rudder, and control harmony in general was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Response to aileron input without rudder, there was a tendency for the sideslip to start out on the proverse direction and come back in the adverse direction and it didn't seem to have a tremendous effect on my roll response but there was a noticeable tendency for the airplane to speed up a little bit in roll. I really couldn't coordinate very well because of this changing requirement on the rudder, first one direction than the other and the fact that it seemed to be a high frequency configuration. Seemed to be very little oscillation in this, but the little oscillation you did feel was very high frequency and you could feel the side acceleration quite a bit. As far as maneuvering coordination requirements, coordination was required and difficult to do.

BANK ANGLE CONTROLLABILITY

Ability to achieve a bank angle, depended quite a bit on how aggressively you wished to go after things. I could roll around, and stop reasonably close to the attitude that I wanted.

HEADING CONTROLLABILITY

Heading control really wasn't very difficult although sideslip was excited for an aileron input, both starting and stopping rolling maneuvers. The Dutch roll was high frequency and well damped so that the airplane stopped pretty much where you would want it.

BANK ANGLE COMMAND TRACKING TASK

Performance was fair to good with a very slight tendency to overcontrol and a very slight tendency to oscillate about the bank angle.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs was noticeable, mostly directionally. The airplane really seemed to move directionally but come right back. The airplane damped itself out quickly enough directionally that it wasn't much of a problem.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities did not interfere degrading the lateral directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I am willing to say that it is not satisfactory, primarily because of the cross coordination requirements and the fact that the nose has this high frequency oscillation everytime you start and stop bank angles. Not an awful lot I can do to compensate for it except to cut down my gains. Air-to-ground - I think you would have very similar problems there, but because of the stiffness it might be a better air-to-ground vehicle than air-to-air.

GOOD FEATURES

You can maneuver the airplane rapidly, but not as precisely as you would like.

OBJECTIONABLE FEATURES

They lie mostly in the coordination requirements, coordination with rudder one way and then the other, which happens so fast it is very difficult to do. My ability to improve upon the accuracy of the vehicle is very poor in the directional sense. The impreciseness of the bank angle control is a minor objection.

SPECIAL PILOTING TECHNIQUES

I guess you could work at learning to coordinate the thing, I couldn't do it very well.

PRIMARY REASON FOR THE PILOT RATING

The airplane is not satisfactory as it is. It certainly has some minor but annoying deficiencies. In turbulence the biggest problems were directional problems, but really not a significant deterioration of my performance.

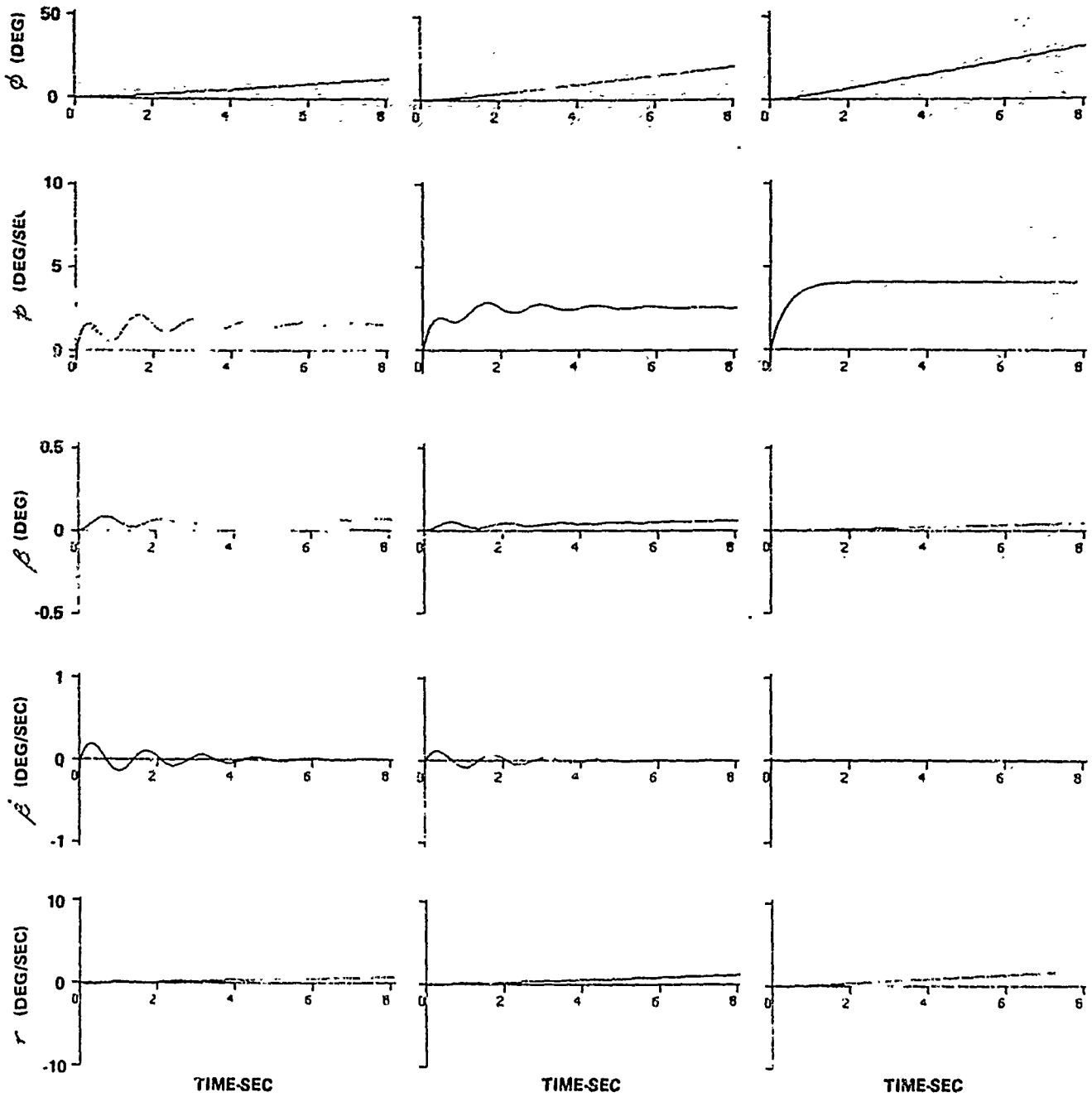
CONFIGURATION 12 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	ψ_β STEP	p_{osc}/p_{AV}	$\Delta\beta_{max}/\phi$ LEVEL 1	LEVEL 2	$\lvert\Delta\beta/\phi_1\rvert \times \lvert\phi/\beta\rvert_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.10	9	G	0.067	2.79	-198	0.56	6.9	5.6	0.90	370	42.0
-0.06	7	G	0.078	3.56	-185*	0.16	3.0*	2.1*	0.47*	380	31.6
0.0	6.5	G	0.092	4.50	-116	0.0	0.33*	0.23*	0.03	349	25.5
+0.10	9.5	G	0.112	5.69	-360	0.12	1.7	1.1	0.17	276	24.0
+0.20	7.5	E	0.129	6.68	-005	0.13	2.6	1.8	0.34	341	24.0

* INDICATES DATA FROM COMPUTER GENERATED TIME HISTORIES

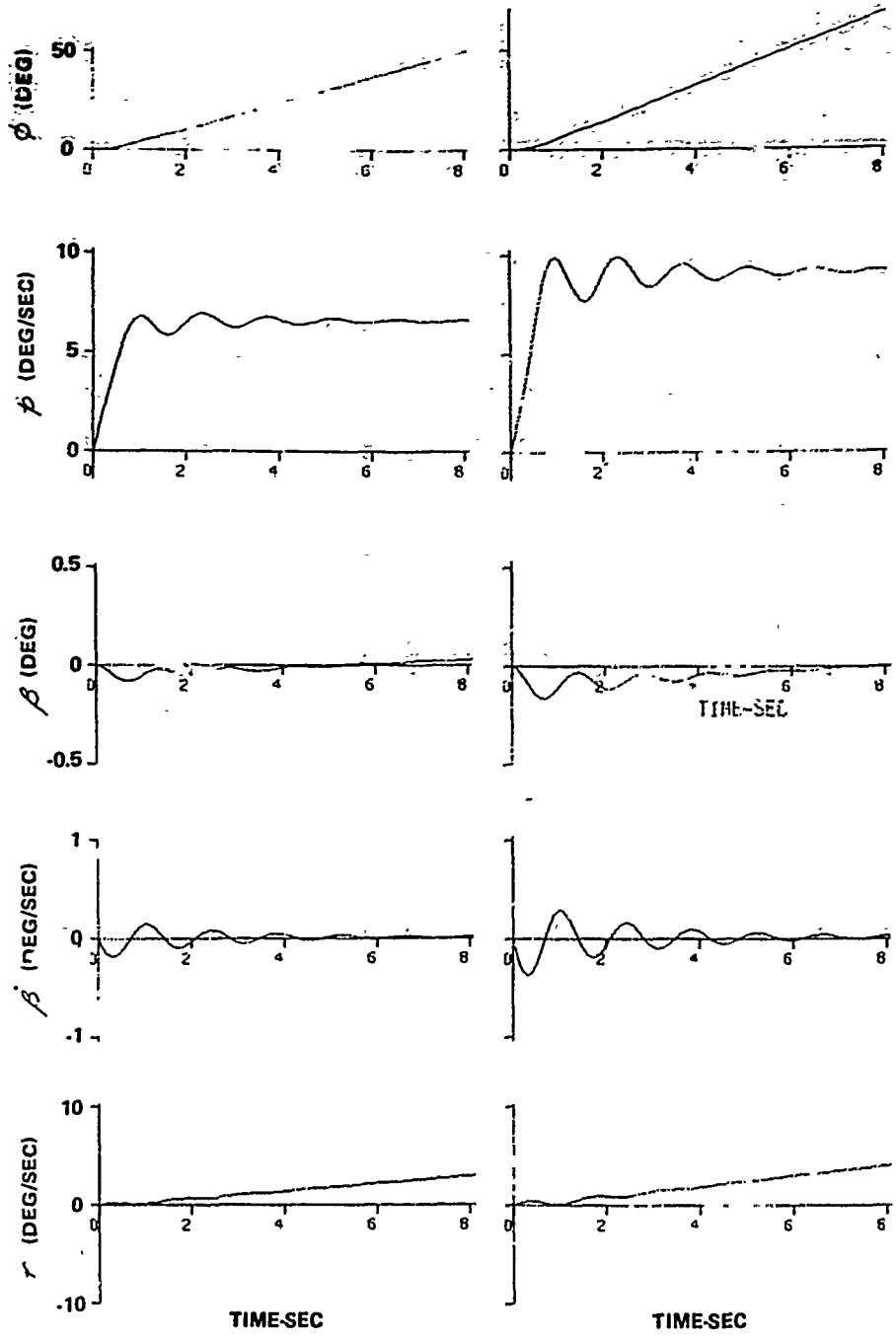
LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

ω_d	= 4.50	N'_β	= 20.3	L'_β	= -124.0
ζ_d	= 0.095	N'_r	= -0.529	L'_r	= 3.27
τ_R	= 0.41	N'_p	= 0.060	L'_p	= -2.47
τ_S	= ∞	g/V	= 0.0586	Y_β	= -0.301
$\lvert\phi/\beta\rvert_d$	= 5.6	$Y_r - 1$	= -0.995	$Y_{\dot\beta}$	= -1.015
$\measuredangle(\phi/\beta)_d$	= 25.6	$Y_p + \alpha_o$	= 0.00337		



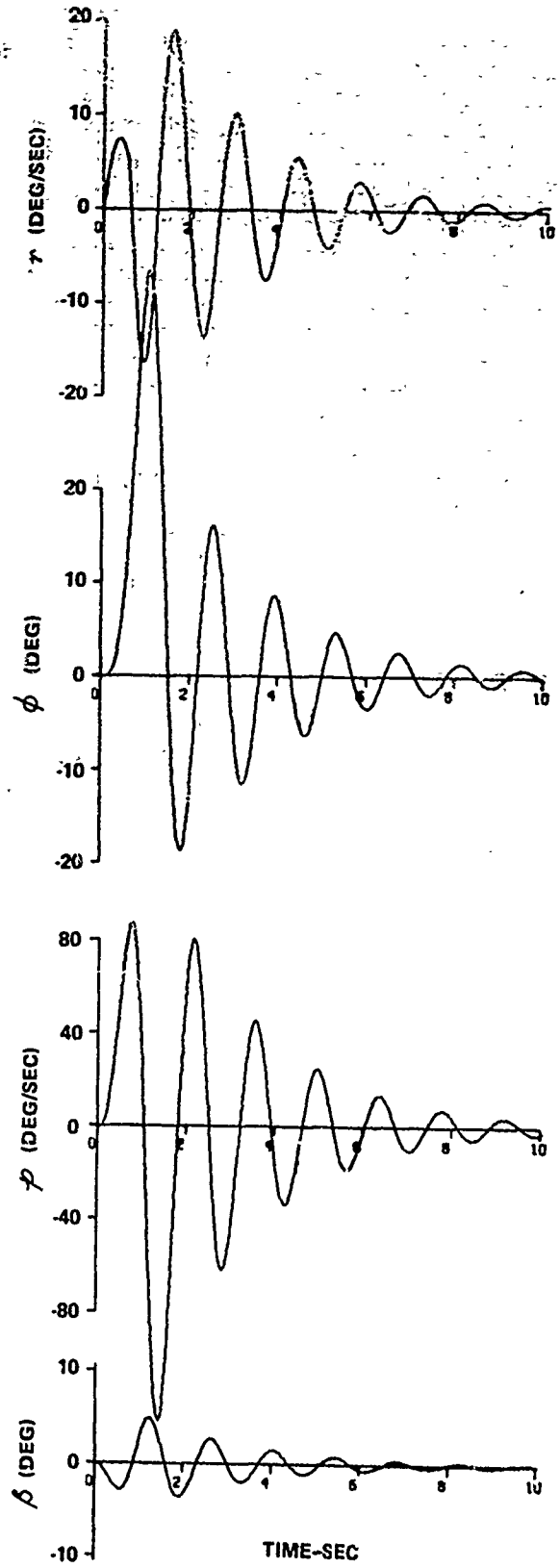
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.10$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.06$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 12

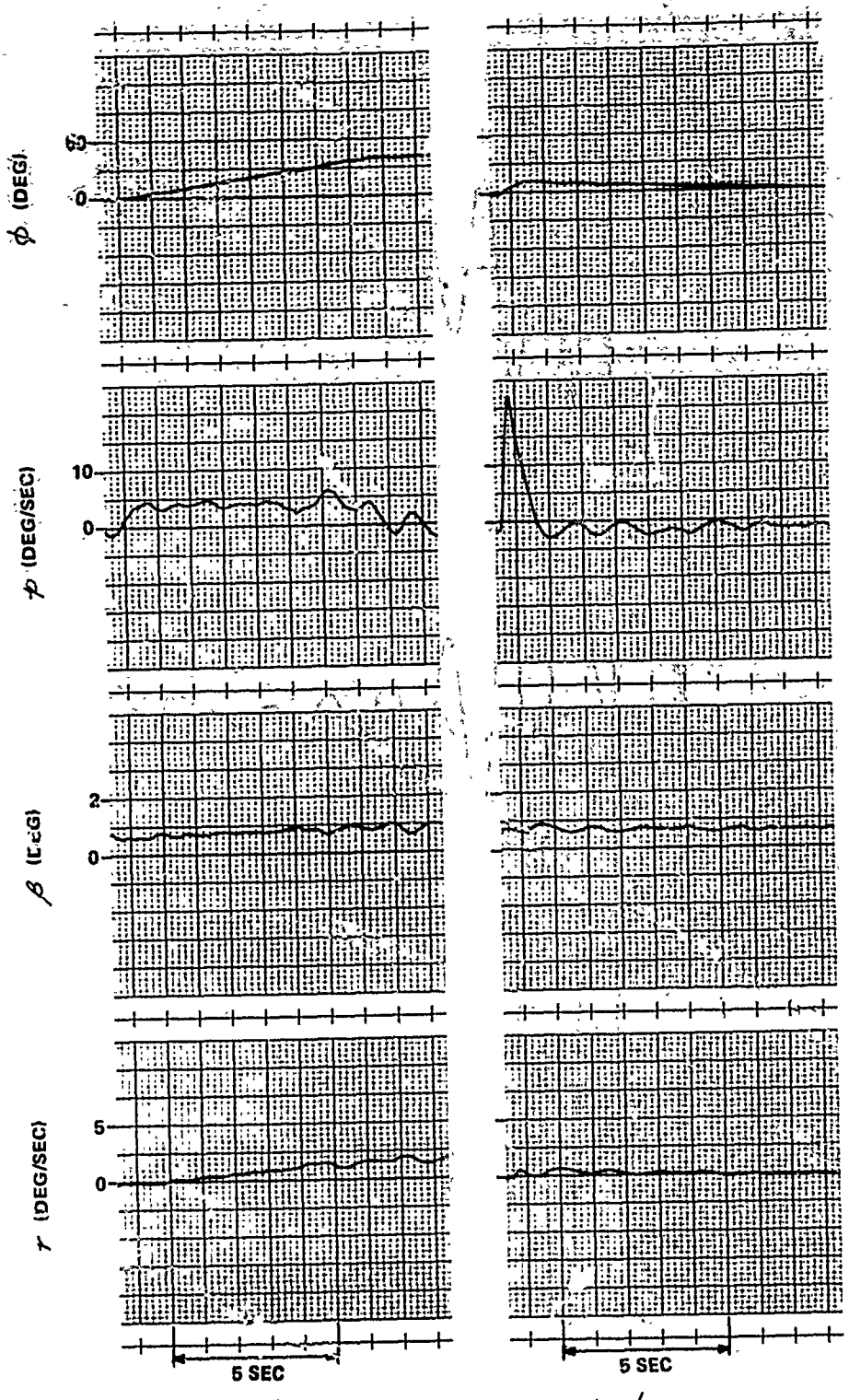


$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.10$ $N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.20$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 12



COMPUTER GENERATED TRANSIENT RESPONSES TO RUDDER DOUBLET FOR CONFIGURATION 12



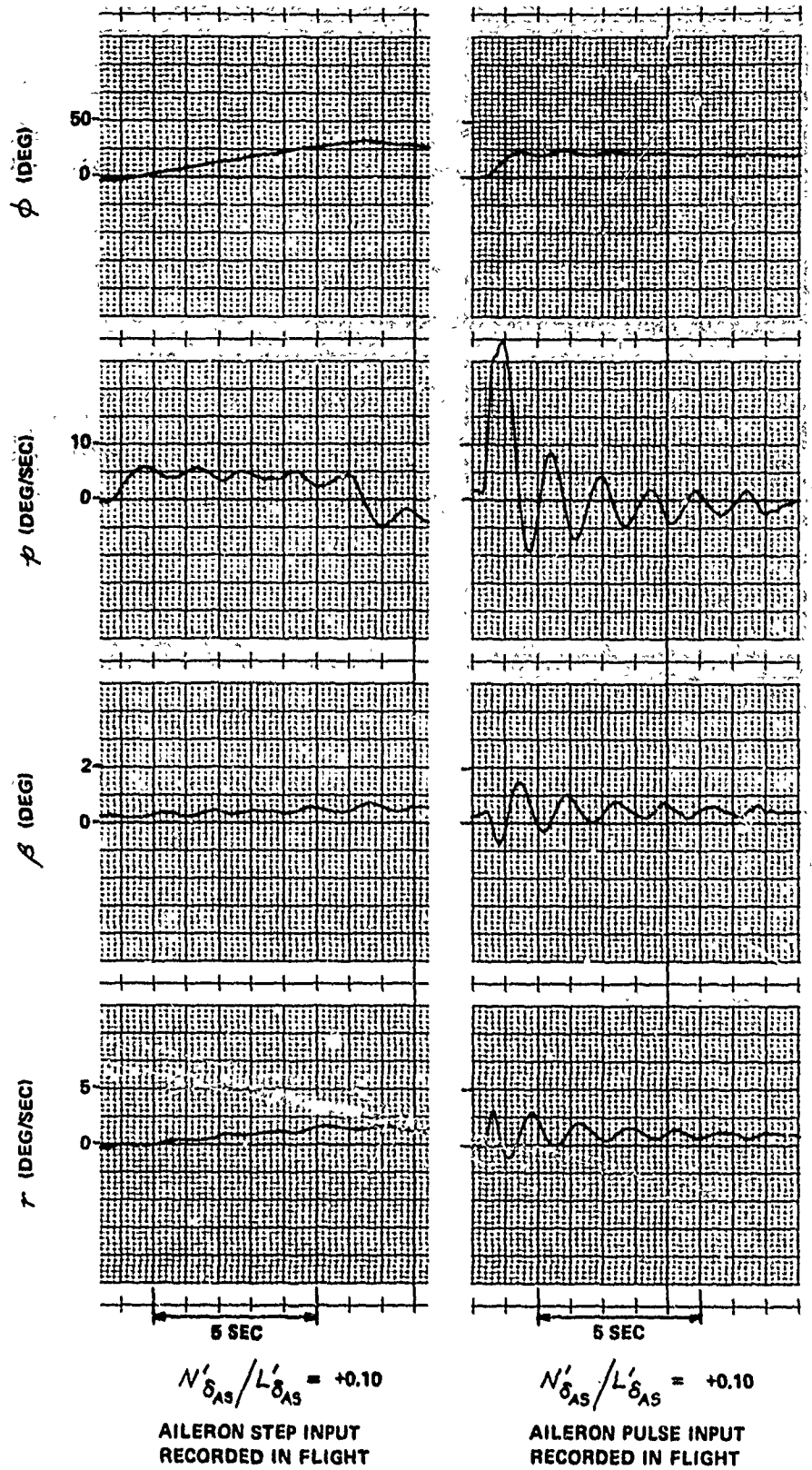
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 12



TRANSIENT RESPONSES FOR CONFIGURATION 12

CONFIGURATION 12 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ =-0.10 PILOT RATING 9 TURBULENCE RATING G

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression that it was going to be an impossible configuration and that is what it turned out to be.

ABILITY TO TRIM

Directional trim seemed to be all right laterally, not so good. In smooth air you could do it but in any little bit of turbulence you got a roll oscillation going. Response to trim was good, no problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 370 deg/sec^2-in. $N'_{\delta_{RP}}$ = 42 deg/sec^2-in.

I started out the aileron with a relatively low sensitivity and stayed there because the rapid roll responses tended to couple me with the airplane and I just looked like I was making things worse. So keeping the lower sensitivities helped reduce some of these oscillations that resulted from turbulence. So compromise was just a matter of keeping them low because there is really no way you could do the fighter task with this configuration. Rudder, there seemed to be adverse yaw and I kept going up on the sensitivity in order to control that a little better. So I ended up with heavier forces on both the aileron and the rudder than I would have liked. Control harmony was good, displacements were okay.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron only produced a very rapid roll response with a lot of Dutch roll superimposed at very high frequency and a little bit of sideslip generated in the adverse direction. It was in the noticeable category so that you would want to try to coordinate it to keep the sideslip lower than what it would go to by itself. Oscillatory characteristics, that's the name of this configuration. There was a continuous high frequency lightly damped oscillation. Maneuvering coordination requirements require use of the rudder in the normal direction and I think quite a bit to keep the sideslip down where you would like. Not that you are getting very large sideslip angles but the fact that it is there, it's creating a problem.

BANK ANGLE CONTROLLABILITY

Bank angle controllability is practically nil, because of the continuous roll oscillation. It was very uncomfortable, with very high accleration experienced at the pilot station and almost divergent oscillations in bank angle.

HEADING CONTROLLABILITY

The heading control, the oscillations that you see are pretty symmetrical, the airplane seems to be stiff directionally so that heading control is no problem but to turn and roll out on a point that you want is not so easy. Heading control is degraded but it's not the kind of problem that you see where you are generating lots of sideslip angle. Here you have very high frequency but not very much movement directionally.

BANK ANGLE COMMAND TRACKING TASK

Bank angle tracking task was almost impossible. The major problem was the quite high frequency, roll oscillation aggravated by the pilot to the point that sometimes it was near divergent.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance input - really out of this world. We were in quite a bit of real turbulence and the response is very similar but I think there is more roll response to random disturbance than there was to the real turbulence. Anyway, the response to disturbance is really degrading, down to where the best efforts required and to where some tasks could not be performed without quite a large deterioration in performance.

LONGITUDINAL CHARACTERISTICS

Longitudinal characteristics were good. They didn't degrade the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I do not feel that they are acceptable, controllability is really in question with continuous bank angle oscillations of the magnitude that I was seeing. Air-to-ground, I think it would be nearly impossible trying to attack a ground target in even a small amount of turbulence, so it's not possible to perform the fighter mission with these characteristics.

GOOD FEATURES

There were none.

OBJECTIONABLE FEATURES

The quite large roll oscillation, the high frequency, the large side accelerations experienced and the light damping of the Dutch roll are objectionable. The fact that you can't even do mild bank angle turns with any degree

of precision is objectionable and the turbulence response is likewise objectionable, just a very uncomfortable airplane all the way around, and very difficult to fly.

SPECIAL PILOTING TECHNIQUES

A little bit of coordination in the adverse direction is required. It's a help, but really not much is going to help this configuration.

PRIMARY REASON FOR THE PILOT RATING

Controllability really is in question, intense concentration is required for control. You can ease up on the control and the oscillations will die out eventually, and unless you really persist in what you are doing, you won't lose control.

CONFIGURATION 12 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -.06 PILOT RATING 7 TURBULENCE RATING G

INITIAL IMPRESSION AND GENERAL COMMENTS

Most outstanding thing about the configuration was the really large lateral acceleration. They were high frequency and in general it made for a difficult and uncomfortable ride.

ABILITY TO TRIM

Ability to trim on that one was pretty good, both laterally and directionally. The longitudinal was also good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 380 deg/sec^2-in. $N'_{\delta_{RP}}$ = 31.6 deg/sec^2-in.

I cut down the sensitivity on the ailerons to try to reduce the large lateral accelerations, following an aileron input, but not to the point that it was really heavy to fly, still had relatively light ailerons. There was a bit of a compromise there. There was a little, what appeared to me to be adverse yaw due to an aileron input and this required coordination in the proper direction, so I lightened up the rudder so that I could get the coordination. Displacements were small, in both the rudder and the ailerons and control harmony in general was pretty good.

AIRPLANE RESPONSE TO PILOT INPUTS

Airplane response to an aileron input, the most noticeable thing was the high side acceleration that accompanied any aileron input. There was a Dutch roll excitation which seemed to be high frequency and lightly damped and seemed to carry over into the roll rate quite noticeably. I coordinated but I was not good enough with my feet to perfectly coordinate. So consequently I did excite the Dutch roll on almost every aileron input. Oscillatory characteristics were a predominant feature. Coordination requirements - you did need to coordinate the airplane and you needed to coordinate it in the proper direction.

BANK ANGLE CONTROLLABILITY

My ability to achieve the desired bank angle was very poor. As I mentioned, any time I put in an aileron input I did excite the Dutch roll. The Dutch roll with its high frequency, lightly damped character and its relatively high roll to sideslip ratio did stir up the bank angle so that you never could really roll to and stop precisely on the bank angle.

HEADING CONTROLLABILITY

Heading control wasn't any better than the bank angle control. The oscillations tended to occur about the the wings level or, whatever attitude you were at, so that you could keep the heading pretty well.

BANK ANGLE COMMAND TRACKING TASK

Bank angle tracking task, performance was poor and the roll rate was very rachety so that it looks like I am doing the thing in steps. Rolling from one bank angle to the other was difficult, not a very smooth maneuver, and then stopping at the bank angle was poor.

RESPONSE TO DISTURBANCE INPUTS

Fantastic in their magnitude and their sharpness and the lateral acceleration associated with them. It is very poor.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were probably one of the best things about the configuration. It did not interfere or detract from the lateral directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

These characteristics for the fighter mission are completely unacceptable either for the air-to-air or the air-to-ground and the primary reasons being the large lateral accelerations, the impreciseness of the bank angle control and the extremely large disturbance response both laterally and directionally.

GOOD FEATURES

There weren't any good features to speak of.

OBJECTIONABLE FEATURES

First of all my major objection, I can't make it strong enough, the extreme lateral accelerations involved with any kind of an input is quite objectionable. The impreciseness with the bank angle control is a strong objection and the very rachety type roll control is objectionable. Then the light damping associated with the Dutch roll, all combined to make a very objectionable configuration.

SPECIAL PILOTING TECHNIQUES

Special piloting techniques - all you can do is fly the airplane less aggressively and try to avoid these large lateral accelerations and stay out of turbulence.

PRIMARY REASON FOR THE PILOT RATING

Tape ended here - further comments lost.

CONFIGURATION 12 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0.0$ PILOT RATING 6.5 TURBULENCE RATING G

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression of the configuration was that I wasn't particularly going to like it. Then when I flew it in smooth air I liked it pretty well. But in any turbulence or even slightly natural turbulence it's a pretty wild airplane.

ABILITY TO TRIM

It was pretty good.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 340$ deg/sec^2-in. $N'_{\delta_{RP}} = 25.5$ deg/sec^2-in.

On the aileron I was able to select nice light ailerons. Perhaps I had them too light because my precision of control was very poor. I cut down on the sensitivity, precision didn't get any better but the roll control got very heavy so I went back to the light and so I had to put up with imprecision. Really didn't need much rudder control on that one. Sideslip was very close to center even though it was oscillatory when it was disturbed. Forces in general were light both laterally and directionally. Displacements were small, the control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

With aileron only, the roll rate in smooth air was reasonably smooth and sideslip disturbances were small. I didn't have to coordinate so there wasn't any difference with the rudder. The airplane is quite oscillatory. Seems to be quite high frequency and quite lightly damped. Maneuvering coordination requirements were minimum.

BANK ANGLE CONTROLLABILITY

Ability to achieve a desired bank angle was relatively poor because I had a tendency to both overcontrol and to set up a small oscillation about the desired bank angle. I wasn't too bad in smooth air; in any turbulence or just a little disturbance in the air my precision in bank angle control deteriorated rapidly.

HEADING CONTROLLABILITY

Heading control is no problem. The oscillations are pretty much symmetrical so that they didn't create any heading problems.

BANK ANGLE COMMAND TRACKING TASK

During the bank angle tracking task I had a tendency to overcontrol in bank angle and to oscillate about the bank angle. To a lesser degree in smooth air, but really dramatic in rough air.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs was fantastic. Random disturbance inputs are quite strong in rolling and sideslip. Accelerations experienced by the pilot particularly in the head region were quite high.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were okay. It did not detract from or degrade lateral-directional evaluations.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

In smooth air, if you can guarantee flying in smooth air all the time, with these characteristics they are acceptable. I think the inprecision that you see in bank is on the acceptable range in smooth air. However, in turbulence I don't feel that the characteristics are satisfactory or acceptable even; in the air-to-air role you wouldn't be able to track; in turbulence air-to-ground, it would be even worse since chances of encountering turbulence are greater.

GOOD FEATURES

The fact that in smooth air the sideslip disturbances were small, the airplane was stiff directionally so that you can maneuver without having to coordinate. The roll performance was good.

OBJECTIONABLE FEATURES

The major objections are the random disturbance phenomenon in the roll and sideslip and the severe side accelerations experienced during these disturbance maneuvers. One objection is the slight tendency to overcontrol, a little tendency to oscillate in bank angle. It really picks up when you get into any kind of disturbance.

SPECIAL PILOTING TECHNIQUES

Rudders weren't really required. You could maneuver the airplane quite aggressively with just the ailerons alone.

PRIMARY REASON FOR THE PILOT RATING

I think in smooth air you could do a reasonable job but in turbulence adequate performance is really not obtainable. I'm going to give you a borderline rating on that just for that reason.

CONFIGURATION 12 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +9.10$ PILOT RATING 9.5 TURBULENCE RATING G

INITIAL IMPRESSION AND GENERAL COMMENTS

In general, it was a pretty miserable configuration, which was not at all flyable. It was controllable, but not flyable in the context of the mission.

ABILITY TO TRIM

Directional was pretty good, laterally is good, but you have to wait for the oscillations in bank angle to die out.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 276$ deg/sec^2-in. $N'_{\delta_{RP}} = 24.0$ deg/sec^2-in.

On the ailerons I locked at gear ratios lower than what we started out with in an attempt to cut down some of this continuous lateral PIO but it just took more effort to get in the control inputs so that we went back to what I think was the original gear selection and stuck with that. Forces that I ended up with are OK, displacements OK, both rudder and the aileron. The airplane had quite a high frequency Dutch roll oscillation, I didn't stand much of a chance of keeping up with it with the rudder so I really didn't use the rudder. I'm not sure that the rudder sensitivity selection has any meaning. Control harmony was good - again not using rudder.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron only, there was a quite noticeable oscillation in bank angle any time you put in aileron. It looked like the little bit of sideslip that was generated was in the proverse direction initially. The airplane is highly oscillatory in bank angle. Maneuvering coordination is not required, the sideslips generated are small, and fast, it made things worse when I tried to coordinate.

BANK ANGLE CONTROLLABILITY

Ability to achieve a bank angle is impossible unless you are willing to wait and just accept what you get - anytime you do anything, even with a slight bit of aggression, you set up a PIO and as you crank up on your gain it tends to go divergent, so bank angle controllability with any degree of precision is practically nil. Simply trying to fly level, the airplane was oscillating in bank angle.

HEADING CONTROLLABILITY

The airplane stays pointed in the direction you are going but oscillates about that heading if you try to keep the wings level.

BANK ANGLE COMMAND TRACKING TASK

It was not possible to do the bank angle tracking task with any degree of precision and keeping the needle in the center was about the best I could do.

RESPONSE TO DISTURBANCE INPUTS

Random disturbance responses were really out of this world. Large bank angles are developed and the airplane just seems like it flies itself and when I get in and try to stop the large bank angle oscillations I tend to make things worse, so response to random disturbance is really bad and the best efforts required.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities are okay, didn't detract in the already poor lateral.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

They are definitely not suitable. I think you are approaching the point where the airplane is questionable whether it would really be controllable when you are doing the task aggressively in bank angle because some of these oscillations that I saw in the tracking task were approaching divergent. All I had to do was ease up on my gain and it went away - so it's not to the point where it's uncontrollable, but it's pretty close to it. Air-to-ground the turbulence I think would really ruin this configuration. The bank angle control is not sufficient to do anything with precision.

GOOD FEATURES

No good features to speak of.

OBJECTIONABLE FEATURES

Continuous pilot induced roll oscillation and inability to control bank angle even mildly precisely is quite objectionable - it's just not possible to do the fighter mission with these characteristics. There are quite large side accelerations felt at the pilot stations, large disturbance in bank angle to random disturbance inputs are fairly objectionable.

SPECIAL PILOTING TECHNIQUES

You have to fly the airplane with quite low gain and you just end up bracketing various bank angles so that you still don't have very good control of it.

PRIMARY REASON FOR THE PILOT RATING

You can control the airplane - it's not uncontrollable but when you try to get into a tight tracking situation, the airplane goes divergent in bank angle. Quite a bit of pilot compensation is required to retain control. In turbulence, it's really down in the best efforts required.

CONFIGURATION 12 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.20$ PILOT RATING 7.5 TURBULENCE RATING E

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression was that the configuration wasn't going to be very good. Obviously a configuration that I can't maintain a precise bank angle with is not very good for the fighter mission.

ABILITY TO TRIM

Laterally trim was poor because as I tried to get the airplane wings level, there was a tendency to PIO in roll. When I took my hands off the control, it would dampen itself out and it was obvious that I was causing the oscillatory tendency. It seemed to be a pretty stiff airplane so getting it trimmed directionally was no problem. The longitudinal trim was okay, no problems.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 341$ deg/sec^2-in. $N'_{\delta_{RP}} = 24$ deg/sec^2-in.

I selected relatively light ailerons initially and then had to cut them down because it looked like the lighter the forces, the greater the tendency to lateral PIO. Perhaps I didn't cut them down enough because the tendency to PIO was still there. So that was a little bit of a compromise although the forces that I ended up with were quite light. Displacements were small. There was a little bit of proverse yaw, but the magnitude was so small that I really couldn't coordinate it anyway and it oscillated so fast that I didn't have a chance to coordinate it. I just accepted the rudder sensitivity that was given to me because I wasn't using the rudder. But the forces, displacements, and harmony of the rudders compared to the other two axes was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Airplane response to an aileron input without the rudder, it looked like a very small amount of proverse yaw generated to an aileron input, but the dynamics excited the Dutch roll which was quite oscillatory, so that the roll rate itself was quite ratchety. I really didn't have to coordinate it because the sideslip disturbances were quite small. Maneuver coordination requirements were minimal because the coordination attempts that I made really didn't help the situation.

BANK ANGLE CONTROLLABILITY

A desired bank angle is just impossible to acquire and hold very tightly without setting up a quite noticeable lateral PIO. It didn't seem to really be divergent, but it would get at least to neutrally damped.

HEADING CONTROLLABILITY

When I tried to roll it on the heading, the airplane would oscillate in bank angle, so my ability to hold a heading really wasn't very good and that's not because of the sideslip disturbances, just the fact that trying to hold a heading with the airplane oscillating 5 or 10° bank either side is not very good.

BANK ANGLE COMMAND TRACKING TASK

Bank angle command tracking was nearly impossible. My performance there was extremely poor and the problem is primarily the lateral oscillation.

RESPONSE TO DISTURBANCE INPUTS

The response to disturbance inputs was quite large, as a matter of fact we dumped the system. I was getting large roll disturbances with this configuration so that random disturbances really did complicate the problem.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were okay and didn't detract from the lateral-directional.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

These characteristics are not at all suitable for the air-to-air or air-to-ground mission. Inability to track a given bank angle, to coordinate the sideslip, and the tendencies toward lateral PIO just negate my ability to perform those tasks.

GOOD FEATURES

The only good feature was the longitudinal. Another good feature I think we could put into that category is the fact that the sideslip disturbances weren't very large and the fact that the lateral PIO's didn't tend to go divergent.

OBJECTIONABLE FEATURES

The primary objectionable feature is the lateral PIO tendency, the very lightly damped Dutch roll characteristics and the fact that these Dutch roll characteristics show up quite smartly in roll. I couldn't track a bank angle without setting up a lateral PIO and the fact that the frequency of the Dutch roll was so high that I didn't stand a chance of dampening it out with the rudders.

SPECIAL PILOTING TECHNIQUES

I had to fly the airplane with very low gain, it really didn't take much of a gain increase to set up a lateral PIO.

PRIMARY REASON FOR THE PILOT RATING

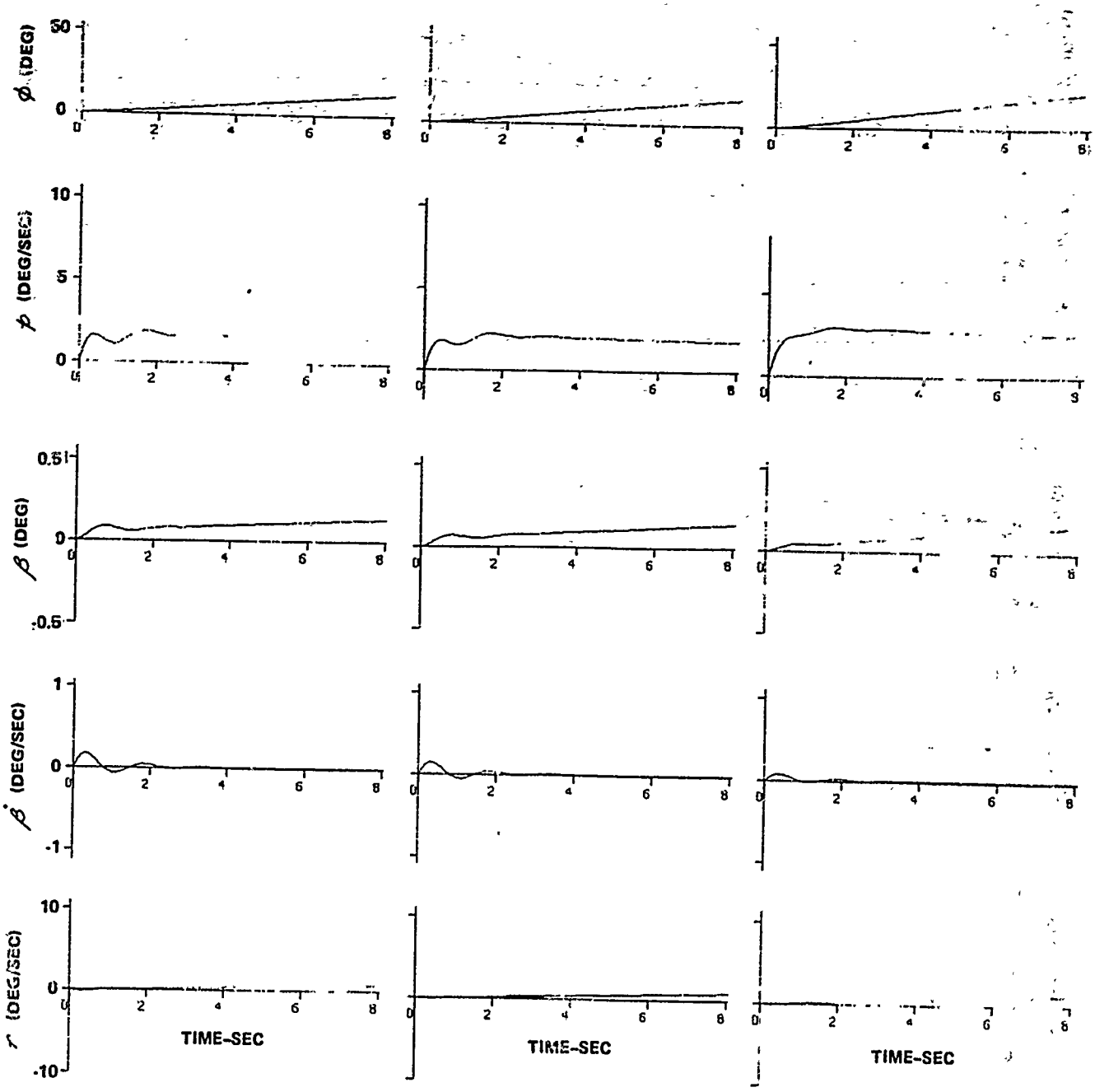
I didn't feel the airplane was acceptable. Certainly I was unable to perform the mission no matter how hard I worked at it. I never felt I was going to lose control, but I never really had very good control. I was not able to stop the lateral PIO if I really went aggressively at it, but I could relax my inputs and the PIO would go away. In turbulence, best effort is required to keep the airplane somewhere near a proper performance, but only a moderate deterioration in an already poor situation.

CONFIGURATION 13 IDENTIFICATION AND FLIGHT TEST DATA TABULATION

$\frac{N'_{\delta_{AS}}}{L'_{\delta_{AS}}}$	P.R.	T.R.	ζ_ϕ	ω_ϕ	$\frac{\psi_\beta}{\text{STEP}}$	$\frac{p_{osc}}{p_{AV.}}$	$\Delta\beta_{max}/t$ LEVEL 1	$\Delta\beta_{max}/t$ LEVEL 2	$\left\|\frac{\Delta\beta}{\phi_1}\right\| \times \left\|\frac{\phi}{\beta}\right\|_d$	$L'_{\delta_{AS}}$	$N'_{\delta_{RP}}$
-0.10	7	F	0.21	2.90	-205	0.18	5.0	3.7	0.65	375	47.0
-0.08	6	F	0.22	3.23	-195	0.08	4.2	2.6	0.37	420	27.0
-0.04	4	E	0.25	3.81	-195	0.04	2.3	1.6	0.08	532	34.0
0.00	2	C	0.27	4.31	-255	0.0	1.6	1.1	0.06	490	35.5
+0.05	5	E	0.30	4.86	-360	0.05	1.6	1.1	0.14	370	25.0
+0.12	8	F	0.33	5.55	-015	0.07	2.0	1.4	0.17	370	22.0

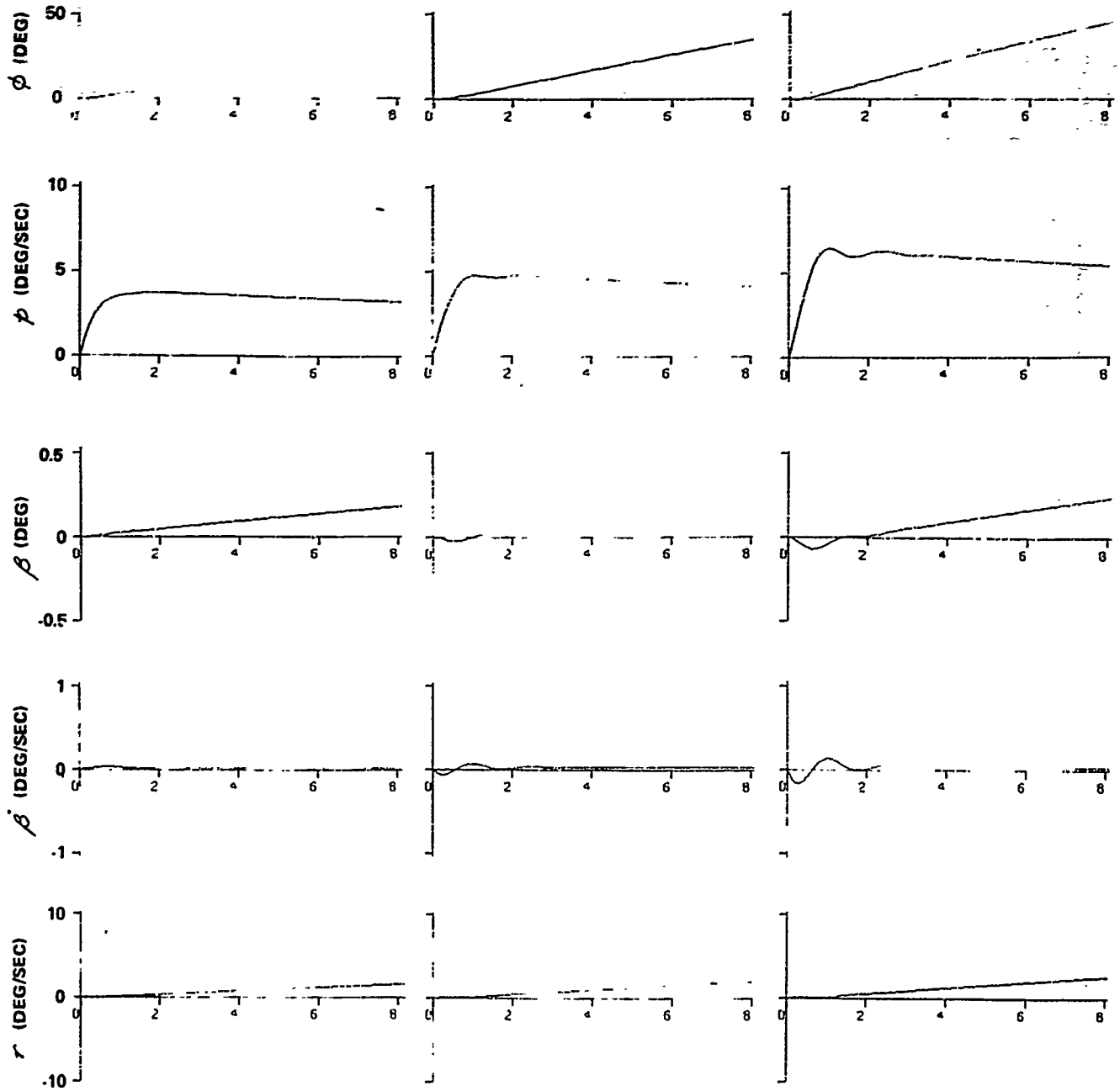
LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES

ω_d	= 4.34	N'_β	= 18.6	L'_β	= -102.0
ζ_d	= 0.24	N'_r	= -2.03	L'_r	= 10.1
τ_R	= 0.00	N'_p	= 0.0063	L'_p	= -2.28
τ_S	= 40	$\frac{g}{V}$	= 0.0586	Y_β	= -0.295
$\left\|\frac{\phi}{\beta}\right\|_d$	= 5.3	$Y_r - 1$	= -0.980	$Y_{\dot\beta}$	= -1.015
$\measuredangle \left(\frac{\phi}{\beta}\right)_d$	= 27.0	$Y_p + \alpha_0$	= 0.00353		



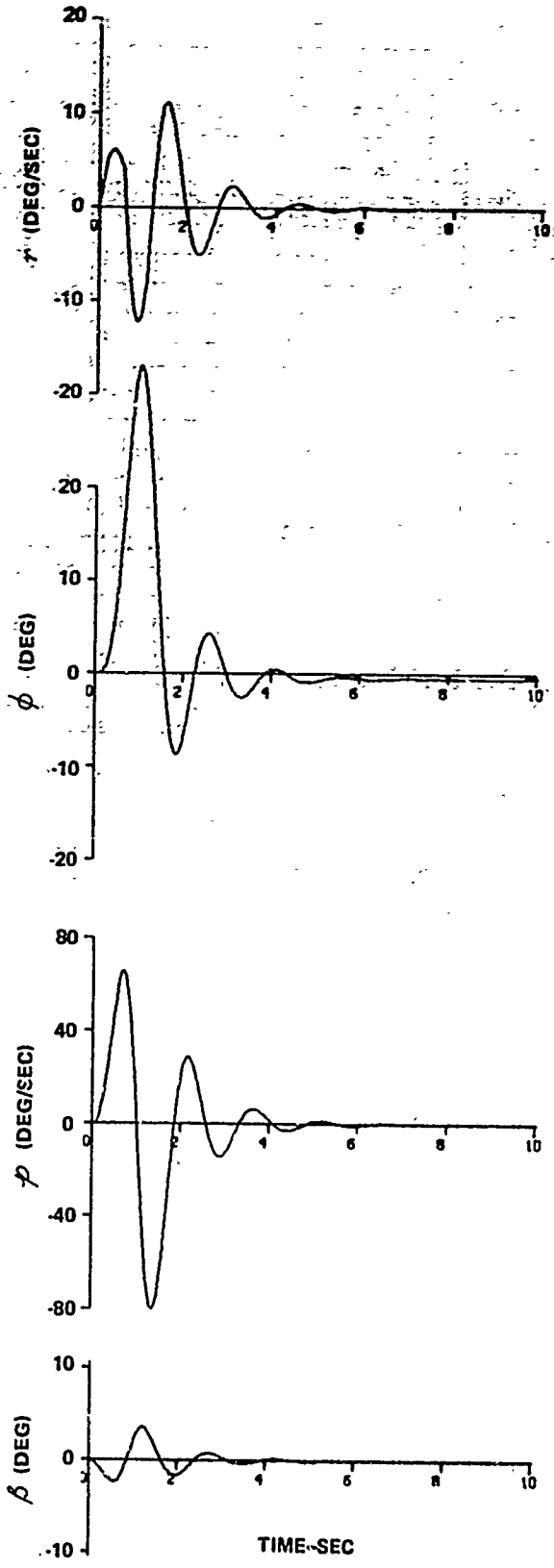
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.10$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.08$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.04$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 13

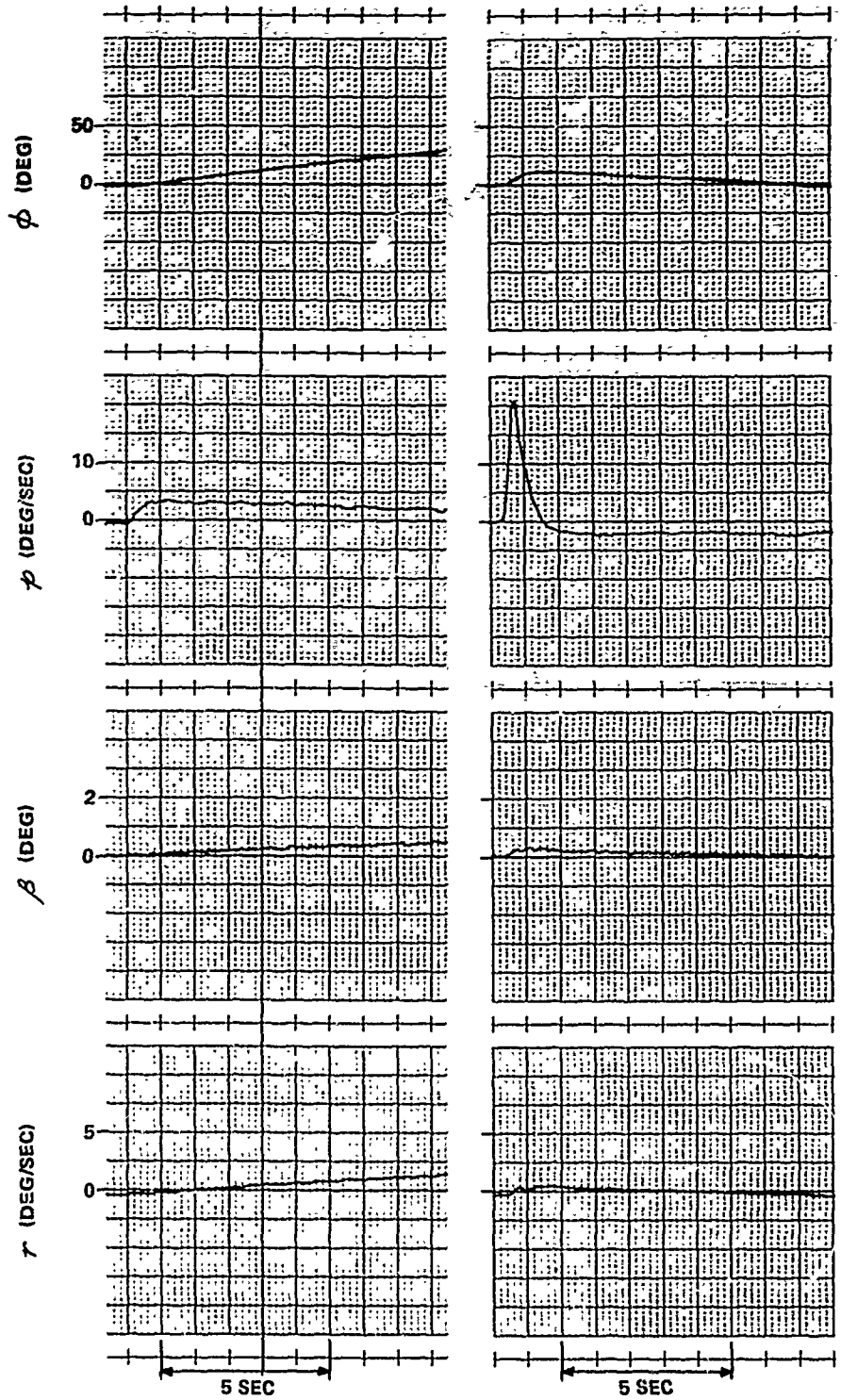


$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.05$ $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.12$

COMPUTER GENERATED TRANSIENT RESPONSES TO AILERON STEP FOR CONFIGURATION 13



COMPUTER GENERATED TRANSIENT RESPONSES TO RUDDER DOUBLET FOR CONFIGURATION 13



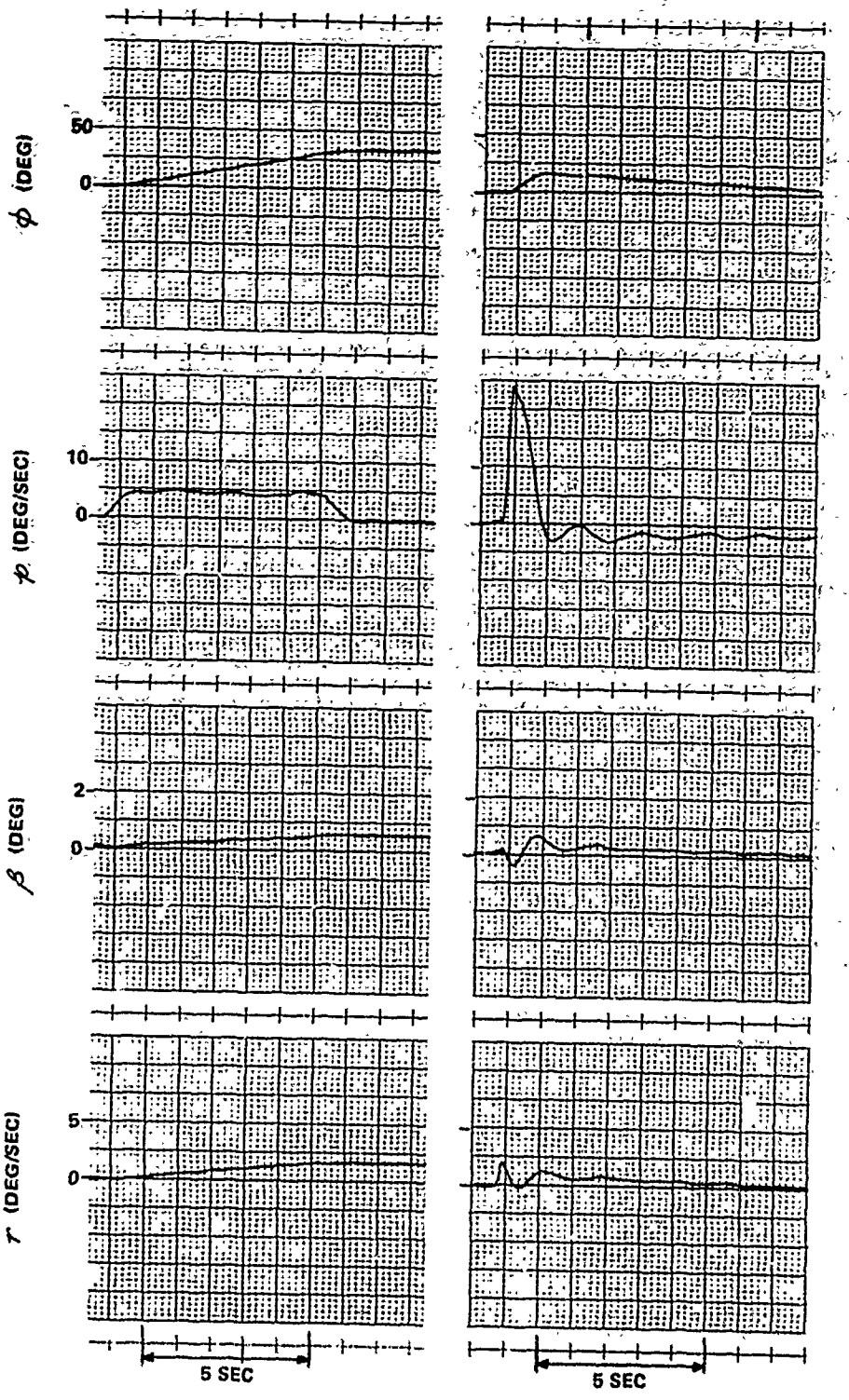
$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 13



$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.05$

AILERON STEP INPUT
RECORDED IN FLIGHT

$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.05$

AILERON PULSE INPUT
RECORDED IN FLIGHT

TRANSIENT RESPONSES FOR CONFIGURATION 13

CONFIGURATION 13; $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = -0.10 PILOT RATING 7 TURBULENCE RATING F

INITIAL IMPRESSION AND GENERAL COMMENTS

There were quite large side accelerations noticed, particularly about the pilot's head and shoulders and it was kind of interesting because the configuration first started off and it didn't look like it was going to be a real good one, but it didn't look like it was going to be bad. I could maneuver the airplane around the sky and I could see that it had a fair amount of adverse yaw, but it looked like I could keep that under control but when I got to the bank angle tracking task things were really bad, and I couldn't figure out why.

ABILITY TO TRIM

Ability to trim was quite good on that configuration, better than most, both laterally and directionally. The lateral trim was a strong function of the directional trim, a little bit of directional requires quite a bit of aileron trim. But it's easy to accomplish, no problems, longitudinal trim was okay.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 375 deg/sec^2-in. $N'_{\delta_{RP}}$ = 47.0 deg/sec^2-in.

First I had to go up quite a bit on the rudder sensitivity, from where I started, in order to be able to stand a chance of coordinating that adverse sideslip. I had to go up on the aileron too, but it was obvious that the higher I went on the aileron, the more sensitive the airplane got for small bank angle corrections. So right in the middle of all this I jumped quite substantially down getting less sensitive on ailerons while still doing the tracking task to see if that made much of a difference and it didn't really seem to help my problem. So on the ailerons, I selected a gearing that allowed me to maneuver the airplane quite markedly, but I did end up with considerable oscillation in bank angle, at least when trying to achieve a bank angle and trying to do it tightly, but even coming down on the sensitivity didn't seem to take out my problem very much. It still seemed I was seeing bank angle tracking difficulties. So can't really say there was a compromise on the ailerons, I ended up selecting aileron sensitivity that allowed me to maneuver the airplane quite nicely with light forces. Rudder forces, still a little heavy, but if I got the rudders any lighter, then I tended to overcontrol the sideslip. So the displacements were noticeable on the rudders, the aileron displacements were small and they were comfortable. Control harmony, even with the heavier rudders was okay.

AIRPLANE RESPONSE TO PILOT INPUTS

Using aileron without the rudder, there was adverse sideslip generated and the airplane had a rather high frequency oscillation as it tended to center itself, but it was a very still airplane and it was damped, it wasn't very lightly damped situation, you'd get two or three overshoots before the thing would settle down. When I coordinated the rudder, it would noticeably speed up the roll response and make it quite a bit smoother than it was without coordinating. Oscillatory characteristics, really showed up in the tight bank angle tracking maneuver. As far as maneuvering and coordination requirements, you do need to use rudder in the direction of turn for each input. A turn generates what I think is a quite noticeable amount of sideslip.

BANK ANGLE CONTROLLABILITY

Ability to achieve a bank angle is really quite poor and it surprised me. In a tight bank angle tracking task where I had quite high frequency oscillations about that bank angle I could also feel it in sideslip and with quite large side accelerations at the pilot station.

HEADING CONTROLLABILITY

Heading control was no problem, I could get the airplane pointed pretty much where I wanted to.

BANK ANGLE COMMAND TRACKING TASK

My performance I thought was unsatisfactory, completely, with quite rapid bank angle oscillations and with a large amount of side acceleration.

RESPONSE TO DISTURBANCE INPUTS

Response to the random disturbance inputs is really quite noticeable. Again, with the large side accelerations that accompany this configuration. Then, in the best efforts required category I think the evaluation task can still be accomplished to the degree that I could do it without the disturbance but really it was quite noticeable.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were okay, probably that was the best thing about the configuration.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I don't feel these characteristics as I see them are suitable for the fighter mission. I'm not sure you'd ever hit anything with this airplane, but your bullets might spray a good wide pattern coming out in step inputs left and right. The extreme difficulty with the bank angle tracking capability negates using this airplane in the air-to-air mission. In the air-to-ground, I think you would have severe problems with the turbulence effects and I'm not sure you'd ever get anything on target there.

GOOD FEATURES

You could maneuver the airplane abruptly, you could roll it and I guess that's a good feature.

OBJECTIONABLE FEATURES

The strongest objection is the quite noticeable oscillation in bank angle when you track bank angle tightly. Another major objection is the quite large side accelerations experienced at the pilot station and the quite large and rapid roll with the disturbance input. There was quite a large amount of adverse yaw generated with a roll control input.

SPECIAL PILOTING TECHNIQUES

You do need to coordinate with the rudder in the direction of turn and you kind of have to ride out these oscillations and they're quite a beating with the thing.

PRIMARY REASON FOR THE PILOT RATING

I don't think these are acceptable for the fighter mission, don't really think controllability is a problem, but you just can't, I think, do the mission certainly to my satisfaction.

CONFIGURATION 13 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = - 0.08 PILOT RATING 6 TURBULENCE RATING F

INITIAL IMPRESSION AND GENERAL COMMENTS

My initial impression was that it was going to be probably not too bad. It had good roll performance, could maneuver the airplane around quite nicely. As it turned out I had some very serious tracking problems with bank angle control and a very uncomfortable airplane around disturbances, particularly in the roll situation.

ABILITY TO TRIM

Ability to trim I thought was good in all three axes - no problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 420 deg/sec^2-in. $N'_{\delta_{RP}}$ = 27.0 deg/sec^2-in.

I tried to go up on the aileron because I wanted to get a little more roll performance and I only compounded my bank angle control problems. Backed down on that a bit and it helped some but I never could eliminate the tendency that was there to overshoot and oscillate in bank angle. There was a bit of compromise on aileron gearing just to help eliminate some of the sensitivity about bank angle, about precise bank angles. On the rudder, the airplane seemed to be initially proverse followed by adverse with a little adverse coordination helping but you could get away without coordinating which I think I tended to do for the most part. So I pretty much accepted what rudder I had because rudder didn't play a significant roll. Forces even with cutting down on the sensitivity on the ailerons was still good. They were still light. Rudder forces reasonable as I said you didn't use the rudder very much. Harmony in general was good.

AIRPLANE RESPONSE TO PILOT INPUTS

The response to an aileron input without the rudder seemed to be a little bit of proverse yaw followed by adverse yaw. Trying to roll the airplane, it really wanted to roll up on you. Sideslip did seem to carry over into the roll rate so that the roll rate wasn't as smooth as I would have liked. Trying to coordinate once you put in the initial aileron input, it seemed to help, tended to speed up the roll quite a bit. The configuration itself did not seem to be oscillatory, however, the pilot airplane combination for a tight bank angle tracking seemed to be oscillatory. Manuevering coordination requirements - hard to say. I think I did end up with a combination of not coordinating or coordinating in the adverse direction.

BANK ANGLE CONTROLLABILITY

Bank angle control is the worse part of the configuration. The more aggressively you fly the airplane the poorer your bank angle control seems to get. There is a quite marked tendency to overcontrol in bank angle and to set up small oscillations about a given bank angle.

HEADING CONTROLLABILITY

Heading control is good. The oscillations didn't seem to be very fast. Sideslip generated didn't seem to be large so that the heading control wasn't all that bad.

BANK ANGLE COMMAND TRACKING TASK

Bank angle tracking performance. My performance was only fair. You will probably be able to see from your records the tendency to overcontrol and oscillate in bank angle. The biggest problems I think were just those two.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs was really dramatic for this configuration. They compounded my roll control problems, the airplane had some sharp (feeling) inputs. The side accelerations were quite noticeable in the cockpit. The response to disturbance inputs was I think really a degrading factor on this configuration.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities did not degrade or detract from the lateral-directional evaluation. They were good.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

These characteristics are marginally acceptable for the fighter mission. Primarily because of two big factors - one the poor bank angle control, the tendency to oscillate about and the inability to be real precise with bank angle. The other is the quite large random disturbance inputs that show up quite markedly in the lateral. Air-to-ground I think that the turbulence response would really be a degrading factor on the air-to-ground role where there is a very good chance of encountering turbulence.

GOOD FEATURES

The airplane was a quite maneuverable airplane. You could really swing that airplane around in the sky.

OBJECTIONABLE FEATURES

The poor bank angle control, the inability to be precise, and the tendency to oscillate at bank angle. Another major objection is the very sharp response to turbulence or disturbance inputs and the quite large side accelerations experienced from the cockpit.

SPECIAL PILOTING TECHNIQUES

You could get along without coordinating and adverse coordination did seem to help.

PRIMARY REASON FOR THE PILOT RATING

These characteristics that I have mentioned are certainly very objectionable. I think you could possibly get along with them but extensive pilot compensation is required. Turbulence really falls in the "best efforts required", I think there is major deterioration in task performance.

CONFIGURATION 13 $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ = - 0.04 PILOT RATING 4 TURBULENCE RATING E

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression of that configuration was that I was going to like it very much. That impression lasted most of the flight until we did the turbulence. Then the turbulence made me think that I didn't like it quite as much as I did without the turbulence.

ABILITY TO TRIM

The ability to trim on that one was pretty good. The directional was a little better than the lateral and the longitudinal was good, trim was not a significant problem.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}}$ = 532 deg/sec^2-in. $N'_{\delta_{RP}}$ = 34.0 deg/sec^2-in.

I started out with a quite large, light sensitivity on the ailerons and ended up having to back down on that because I was overcontrolling the airplane. It wasn't because of any airplane dynamics, I think I just selected it too high, so I really don't think that's a compromise. The rudder, there was adverse yaw associated with that configuration, had to boost the rudder up from what we started out with just to get the forces a little more comfortable. So the aileron rudder forces were good, the ailerons were light, displacements were small in bank, control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Using aileron without the rudder, a bit of adverse yaw was associated with the configuration, it wasn't excessive, it was however a spill-over of the sideslip in the roll control and although it wasn't really smooth, it was okay. Coordinating the configuration tended to speed up the roll a bit, coordination wasn't really difficult to do; although the sideslip that was generated wasn't large it did help to coordinate the airplane. As far as oscillatory characteristics are concerned, the airplane seemed to be pretty well damped in the Dutch roll so no oscillations involved until we got into turbulence. Maneuvering coordination requirements, coordination was required in the normal direction and wasn't too difficult to accomplish but you had to do it all the time.

BANK ANGLE CONTROLLABILITY

Bank angle control I thought was good. A little bit of tendency to overcontrol was based primarily on my aggression with the configuration rather than airplane dynamics.

HEADING CONTROLLABILITY

The heading control was good, degraded somewhat in the turbulence because the nose really moved back and forth quite rapidly. Quite large side accelerations are experienced at the pilot's station, reaching gigantic proportions during the turbulence.

BANK ANGLE COMMAND TRACKING TASK

Bank angle tracking task performance I thought was good. No problems encountered there. What little bit of overshoot you saw I think was primarily due to my aggression.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance was about the worst thing about the configuration, the airplane was quite responsive in roll and sideslip both so that the pilot really gets jostled around. I think it's been in the best efforts required with a moderate deterioration in task performance because of the quite rapid and crisp roll in sideslip response.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good. Didn't interfere with or degrade the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think they are acceptable, I think they are satisfactory, I liked it very much without the random disturbance, liked it less with the disturbance. In the air-to-air role I think good roll performance and good bank angle control is a plus and the turbulence I think you've got more difficult problems because of the large side accelerations and the crisp roll control. Air-to-ground I think is a problem because of the turbulence.

GOOD FEATURES

I like the roll control, I like the good control of bank angle that I had, I like the maneuverability. I like the fact that the sideslip that was generated was in the normal direction and that coordination wasn't difficult to achieve.

OBJECTIONABLE FEATURES

The crisp roll and sideslip response to the random disturbance inputs is certainly objectionable, I think degrading the characteristics a bit.

SPECIAL PILOTING TECHNIQUES

Normal coordination is required for mild inputs; if you don't make them sideslip isn't going to be any problem but it sure makes life a little more comfortable if you do coordinate the rudder with the roll.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is acceptable. That is a problem, I really liked it out of turbulence but the turbulence is certainly annoying to say the least. Okay, I think because of the turbulence response per se, that it's not satisfactory, certainly the turbulence is more than just annoying.

CONFIGURATION 13 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$ PILOT RATING 2 TURBULENCE RATING C

INITIAL IMPRESSION AND GENERAL COMMENTS

That was a good one. Initial impression was that it would be good and it was confirmed that it would be good through the evaluation.

ABILITY TO TRIM

Ability to trim was good lateral-directional and longitudinal.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 490$ deg/sec^2-in. $N'_{\delta_{RP}} = 35.5$ deg/sec^2-in.

No compromises whatsoever involved. I could select the ailerons as light as I wanted and did just that, selecting for my personal preference a nice light aileron force gradient. Rudder, there was a small amount of

adverse yaw, so when I started out on the rudder I had to lighten up the forces so that I could coordinate a little bit of sideslip. Forces were light, displacements small, control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

The response to aileron input without the rudder; smooth roll response and a slight amount of adverse yaw. I'm not sure whether that was due to the aileron input or to the roll input but it was there. Coordinating with a little bit of rudder didn't seem to make much difference in the shape or the feel of the response and it turned out that I could fly the airplane pretty well without coordinating the sideslip and it never got very large. No oscillatory characteristics to speak of. The Dutch roll seemed to be wel damped. Whatever Dutch roll that I saw went away very quickly. During maneuvering there was a slight requirement for coordination in the proper direction but it was very easy to accomplish and very little tendency on my part to overcontrol. I flew the airplane without coordinating, the small sideslips that were there didn't seem to cause much of a problem.

BANK ANGLE CONTROLLABILITY

Bank angle control was good. No problem whatsoever. Aggressively and rapidly rolling to a given bank angle and stopping was not difficult. Small overshoots that I did get were primarily just my overcontrolling rather than some of the airplane characteristics.

HEADING CONTROLLABILITY

Heading control was good. Very little oscillation so that the heading was pretty much timed to the bank angle and my ability to roll the airplane wings level or to any degree of bank that I wished.

BANK ANGLE COMMAND TRACKING TASK

I think that my performance was good. It was easy to perform. There were no problems encountered.

RESPONSE TO DISTURBANCE INPUTS

Here I had a little bit more of a sideslip response than I was expecting to see and in general I thought that the random disturbance inputs were a little bit larger than what I had expected for this particular configuration. They weren't a degrading factor.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities did not interfere with the evaluation and were good.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think that these characteristics were quite well suited to the air-to-air mission. I liked the fact that I had good roll performance and good smooth roll control and I could stop the bank angle pretty much where I wanted to. And likewise for the air-to-ground role. I think that well damped Dutch roll is particularly well suited to flying the airplane through turbulence in the air-to-ground mission. No special problems in either of those two missions.

GOOD FEATURES

The smooth roll control, the requirement for a little coordination and the fact that a little coordination was required in the proper direction. My ability to fly the airplane aggressively without setting up any oscillatory characteristics and that it was in general a very good smooth flying airplane lateral-directionally.

OBJECTIONABLE FEATURES

A minor one I would like to mention and that's a fact I prefer to fly the airplane without having to coordinate with the rudder and this does require a little bit of rudder coordination.

SPECIAL PILOTING TECHNIQUES

No special piloting techniques.

PRIMARY REASON FOR THE PILOT RATING

I think it is acceptable and satisfactory as it stands, pilot compensation really not a factor. I want to mention that I didn't have to coordinate, but coordination when it was made was in the proper direction. There was a minor deterioration of my ability to perform the task in the presence of random disturbances.

CONFIGURATION 13 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.05$ PILOT RATING 5 TURBULENCE RATING E

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression was, it really is great. It sure does have great roll capability. You could roll the airplane around with very little coordination requirement. I had a bit of a problem in the bank angle tracking, tendency to overshoot and overcontrol and set up a small oscillation wnen controlling bank angle.

ABILITY TO TRIM

Laterally trim wasn't very good. Directional seemed to be quite good. Had some difficulty with the lateral trim in keeping the wings level. Longitudinal trim was okay, didn't create any problems there.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 370$ deg/sec^2-in. $N'_{\delta_{RP}} = 25.0$ deg/sec^2-in.

Aileron gear selection, no compromises involved there, simply a matter of getting nice light forces like I like to do the job. Had real good roll performance and sideslip wasn't a major factor so that a matter of selecting sensitivity there was just compatible with having nice smooth light control forces. The forces were light, the displacements were small.

AIRPLANE RESPONSE TO PILOT INPUTS

Airplane response to pilot inputs, aileron input developed a nice smooth roll rate. Looked like to me initially on the sideslip, a little proverse yaw followed by a little adverse yaw, but the sideslip excursions never were very great. A little coordination was required in the adverse direction, but I can fly the airplane pretty well without coordinating at all. If you did coordinate, you had to watch it initially or you could really speed up the roll rate even faster than it already was. There was a little bit of a tendency to oscillate in bank angle, very little tendency to oscillate in sideslip or at least to a degree that I could see, but the bank angle oscillations tended to be coupled with the pilot-airplane combination rather than by the airplane by itself. Coordination required during maneuvering was small, not very much required. What little bit I did end up using tended to be more in the adverse direction and more, a requirement during a steady turn rather than a maneuvering coordination requirement.

BANK ANGLE CONTROLLABILITY

Bank angle controllability was a problem. I mentioned that the airplane had real good roll performance. I really fling the airplane around so likely I was really flying the airplane quite aggressively, but in bank angle, there was a tendency to overshoot and get a 2 or 3 cycle oscillation going before it settled down when I did things abruptly or did them aggressively. When I flew the airplane a little smoother, I could cut down the number of oscillations. So that presents a bit of a problem for me as to whether or not I'm creating the problem.

HEADING CONTROLLABILITY

Heading control was no problem. The Dutch roll was very high frequency, it's a very still airplane.

BANK ANGLE COMMAND TRACKING TASK

On the bank angle tracking task, I had similar problems as I mentioned with initial bank angle control. Tendency to overshoot and get a 1 or 2 cycle oscillation before the thing settled down on the bank angle. Sideslip, no factor, no other problems involved.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs, quite dramatic, particularly in roll, very abrupt, creates a lot of side acceleration at the pilot station, primarily my head and it's quite uncomfortable. So I would say that's in the best efforts required with moderate deterioration in performance in turbulence.

LONGITUDINAL CHARACTERISTICS

Longitudinal handling qualities were good and didn't detract or degrade the lateral-directional evaluation.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

I think that the characteristics that I've seen are probably acceptable. They're not satisfactory because of the poor bank control and the response to the random disturbance in roll. Air-to-air, I think you've got real good performance here. Somewhat degraded bank angle tracking capability so that that's the reason it's not satisfactory in the air-to-air role. Air-to-ground, I think the rapid and very crisp roll response to disturbance inputs would really be a factor in trying to attack a ground target in turbulence.

GOOD FEATURES

The roll performance is really great and the lack of sideslip generated is quite good.

OBJECTIONABLE FEATURES

The tendency to overshoot and oscillate in bank angle, cutting down my bank angle tracking performance, I think it objectionable and I think that very crisp rapid roll response to a disturbance input is a quite large objection also.

SPECIAL PILOTING TECHNIQUES

You could fly the airplane without coordination if you wish, however a very slight amount of adverse coordination seemed to help.

PRIMARY REASON FOR THE PILOT RATING

I don't think the airplane is satisfactory, however, I do feel it's acceptable. I think those two objections that I had are certainly moderate.

CONFIGURATION 13 $N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.12$ PILOT RATING 8 TURBULENCE RATING F

INITIAL IMPRESSION AND GENERAL COMMENTS

Initial impression of that configuration was that it was going to be an impossible configuration because it was very difficult to fly the airplane even straight and level or in a constant banked turn without setting up big, quite significant and fairly high frequency pilot-induced oscillations.

ABILITY TO TRIM

Ability to trim was somewhat degraded in the lateral. Directional was better than the lateral. Longitudinal was good. Trim not really considered a factor.

SELECTION OF AILERON AND RUDDER CONTROL SENSITIVITIES

$L'_{\delta_{AS}} = 370$ deg/sec^2-in. $N'_{\delta_{RP}} = 22.0$ deg/sec^2-in.

On the aileron, I had to back down from what we started out with in an attempt to try to cut down the tendency to PIO laterally. Even that didn't seem to help. It looked like one of those configurations where aileron sensitivity was not enough, felt too much either way. But, with the lower sensitivity there was less of a tendency to PIO than with the higher. Forces, even at that, were light. The rudder wasn't required, very little sideslip seemed to be generated and it looked like it was proverse yaw but not enough that I had to coordinate so I really didn't select a rudder gearing. The number you've got is simply what we started out with. Displacements were small, control harmony was good.

AIRPLANE RESPONSE TO PILOT INPUTS

Aileron-only resulted in a little bit of sideslip generated. There's quite a bit of roll rate generated and really it wasn't much I could say about it. I couldn't coordinate the sideslip so it didn't make any difference whether I used rudder or not. Very high frequency Dutch roll, reasonably damped, seemed to be a high roll to sideslip ratio. The airplane is quite oscillatory in turbulence, it's also quite oscillatory any time the pilot tends to do any kind of bank angle tracking, including flying straight and level. Maneuvering coordination requirements were nil. The Dutch roll was fast enough and sideslip small enough that I couldn't begin to coordinate it.

BANK ANGLE CONTROLLABILITY

Bank angle controllability is unacceptable. You can't even fly normal 30 to 60° banked turns without setting up a pilot-induced oscillation, however, you can stop the oscillation, just ease up and stop tracking and let the airplane seeks its own bank angle.

HEADING CONTROLLABILITY

Heading control is a function of the bank angle control because you can't stop the airplane where you want to. Once you get it pointed in a given direction, it will stay there. But getting to a particular heading is difficult.

BANK ANGLE COMMAND TRACKING TASK

Bank angle tracking task performance was extremely poor. One continuous pilot induced oscillation in roll as I attempted to track bank angle.

RESPONSE TO DISTURBANCE INPUTS

Response to disturbance inputs is quite noticeable, in both the roll and sideslip modes. Turbulence really makes things worse. I think that there's a major deterioration.

LONGITUDINAL CHARACTERISTICS

Longitudinal is okay, not a factor.

SUITABILITY OF THE AIRPLANE CHARACTERISTICS FOR THE FIGHTER MISSION

These characteristics are completely unacceptable and I think you'd end in a controllability situation because as you try to do the mission, you set up quite significant pilot-induced oscillations. Air-to-ground role, the turbulence and the pilot-induced oscillations would prevent you from performing the task.

GOOD FEATURES

The roll maneuverability is really tremendous if that's all you want to do.

OBJECTIONABLE FEATURES

The continuous pilot-induced oscillation as one attempts to track bank angles is certainly objectionable. The turbulence response is objectionable and it's objectionable that you can't perform the mission per se.

SPECIAL PILOTING TECHNIQUES

You have to fly the airplane with very low gain, as you approach a bank angle, you just almost have to ease up on the controls in order for the bank angle to seek some nominal value.

PRIMARY REASON FOR THE PILOT RATING

I think the airplane is unacceptable. I think we're down into the controllability problem. I don't think more than considerable pilot compensation is required.