AN IN-FLIGHT INVESTIGATION OF LATERAL-DIRECTIONAL DYNAMICS FOR THE LANDING APPROACH

G. WARREN HALL
EDWARD M. BOOTHE

CORNELL AERONAUTICAL LABORATORY, INC.

FOREWORD

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C. B. Westbrook
Chief, Control Criteria Branch
Air Force Flight Dynamics Laboratory

ABSTRACT

Lateral-directional handling qualities and roll control power requirements for executive jet and military Class II Airplanes in the landing approach flight phase were investigated in the USAF/CAL variable stability T-33 airplane. Particular emphasis was placed on the effects of crosswinds and turbulence. Simulated IFR ILS approaches and VFR offset and crosswind approaches were made. Specifically, two Dutch roll frequencies, three Dutch roll damping ratios, three roll-to-sideslip ratios and three roll mode time constants were investigated. It was found that lateral-directional dynamics do not establish a limiting crosswind value; however, they do determine the ease or difficulty with which a crosswind approach can be accomplished. Roll control power requirements were determined from actual control usage data obtained throughout the evaluation program. In addition, a number of configurations were reevaluated with limited roll control power to determine minimum acceptable levels. Available roll control power can establish a limiting crosswind component. A number of configurations were evaluated with a stick controller in place of the normally used wheel controller to determine if the type of controller affected the lateral-directional dynamics for acceptable handling qualities. No difference was found to exist. A detailed comparison with MIL-F-8785B (ASG) requirements is included and generally shows the present requirements to be too conservative in the landing approach flight phase.

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F_{AS} - aileron stick force, lb
F_{AW} - aileron wheel force, lb
F_{ES} - elevator stick force, lb
F_{EW} - elevator wheel force, lb
F_{RP} - rudder pedal force, lb
g - acceleration of gravity, ft/sec^2
h - altitude, ft
I_x - moment of inertia about x axis, ft-lb sec^2
I_y - moment of inertia about y axis, ft-lb sec^2
I_z - moment of inertia about z axis, ft-lb sec^2
I_{xz} - product of inertia, ft-lb sec^2
$j = \sqrt{-1}$
k - ratio of "commanded roll performance" to "applicable roll performance requirement"
L - rolling moment, ft-lb

$L_\beta = \dfrac{1}{I_x}\dfrac{\partial L}{\partial \beta}$, sec^{-2}

$L_{\delta_a} = \dfrac{1}{I_x}\dfrac{\partial L}{\partial \delta_a}$, sec^{-2}

$L_{\delta_{AW}} = \dfrac{1}{I_x}\dfrac{\partial L}{\partial \delta_{AW}}$, sec^{-2} deg^{-1}

$L_{F_{AW}} = \dfrac{1}{I_x}\dfrac{\partial L}{\partial F_{AW}}$, sec^{-2} lb^{-1}

$L_{\delta_{RP}} = \dfrac{1}{I_x}\dfrac{\partial L}{\partial \delta_{RP}}$, sec^{-2} in.$^{-1}$

$L_p = \dfrac{1}{I_x}\dfrac{\partial L}{\partial p}$, sec^{-1}

$L_r = \dfrac{1}{I_x}\dfrac{\partial L}{\partial r}$, sec^{-1}

$L'_i = \left(1 - \dfrac{I_{xz}^2}{I_x I_z}\right)^{-1}\left(L_i + \dfrac{I_{xz}}{I_x} N_i\right);\ i = \beta, \delta_a, \delta_{AW}, \delta_r, \delta_{RP}, p, r$

m - mass of airplane, slugs

N - yawing moment, ft-lb

$N_\beta = \frac{1}{I_z}\frac{\partial N}{\partial \beta}$, $\sec^{-2}$

$N_{\delta_a} = \frac{1}{I_z}\frac{\partial N}{\partial \delta_a}$, $\sec^{-2}$

$N_{\delta_{AW}} = \frac{1}{I_z}\frac{\partial N}{\partial \delta_{AW}}$, $\sec^{-2}$ $\deg^{-1}$

$N_{\delta_r} = \frac{1}{I_z}\frac{\partial N}{\partial \delta_r}$, $\sec^{-2}$

$N_{\delta_{RP}} = \frac{1}{I_z}\frac{\partial N}{\partial \delta_{RP}}$, $\sec^{-2}$ in.^{-1}

$N_p = \frac{1}{I_z}\frac{\partial N}{\partial p}$, $\sec^{-1}$

$N_r = \frac{1}{I_z}\frac{\partial N}{\partial r}$, $\sec^{-1}$

$N_i' = \left(1 - \frac{I_{xz}^2}{I_x I_z}\right)^{-1}\left(N_i + \frac{I_{xz}}{I_z} L_i\right); \; i = \beta, \delta_a, \delta_{AW}, \delta_r, \delta_{RP}, p, r$

n_y - side acceleration, g units

n_z - normal acceleration, g units

p - roll rate, rad/sec or deg/sec

$\dot{p}$ - roll acceleration, rad/sec^2

p_{ss} - steady state roll rate, rad/sec or deg/sec

$\measuredangle \frac{p}{\beta}$ - phase angle between roll rate and sideslip in the free Dutch roll oscillation

$q_{\bar{c}}$ - $1/2\,\rho V^2$, dynamic pressure, lb/ft^2

r - yaw rate, rad/sec or deg/sec

$\dot{r}$ - yaw acceleration, rad/sec^2

s - Laplace operator

S - wing area, ft^2

t_{n_β} - time for the Dutch roll oscillation in the sideslip response to reach the nth local maximum for a step aileron control command

V - true velocity, ft/sec

Y - side force, lb

$Y_\beta = \frac{1}{mV} \frac{\partial Y}{\partial \beta}$, $\sec^{-1}$

$Y_{\delta_{AW}} = \frac{1}{mV} \frac{\partial Y}{\partial \delta_{AW}}$, $\sec^{-1} \deg^{-1}$

$Y_{\delta_{RP}} = \frac{1}{mV} \frac{\partial Y}{\partial \delta_{RP}}$, $\sec^{-1} \text{in}^{-1}$

$Y_p = \frac{1}{mV} \frac{\partial Y}{\partial p}$, rad^{-1}

$Y_r = \frac{1}{mV} \frac{\partial Y}{\partial r}$, rad^{-1}

x, y, z - stability axes (i.e., a right hand orthogonal body axis system with origin at the c.g., the z axis in the plane of symmetry and the x axis aligned with the relative wind at zero sideslip trimmed flight.)

α - angle of attack, radians

α_0 - trim angle of attack, radians

β - angle of sideslip, radians or degrees

β_V - angle of sideslip measured by the sideslip probe, radians or degrees

β_{ag} - sideslip generated by an artificial gust, radians or degrees

β_I - inertial sideslip, radians or degrees

$\dot{\beta}$ - sideslip rate, rad/sec

$\Delta\beta_{max}$ - maximum sideslip excursion at the c.g. occurring within two seconds or one-half period of the Dutch roll for a step aileron input, radians or degrees

δ_a - aileron deflection, radians

δ_{AC} - aileron controller deflection, stick or wheel

δ_{AS} - aileron stick deflection, inches

δ_{AW} - aileron wheel deflection, degrees

δ_{EW} - elevator wheel deflection, inches

δ_r - rudder deflection, radians

δ_{RP} - rudder pedal deflection, inches

ζ_β - damping ratio of numerator quadratic in sideslip to aileron input transfer function

ζ_{FS} - feel system damping ratio

ζ_ϕ - damping ratio of numerator quadratic in roll to aileron input transfer function

ζ_r - damping ratio of numerator quadratic in yaw rate to aileron input transfer function

ζ_{sp} - longitudinal short period damping ratio

ζ_d - Dutch roll damping ratio

$\lambda_{\beta_{1,2,3}}$ - real roots of numerator cubic in sideslip to aileron input transfer function

λ_r - roll mode root

τ_{r_1} - time constant of numerator cubic in yaw rate to aileron input transfer function

ρ - air density, slugs/ft^3

σ - real part of $s = \sigma + j\omega$

τ_R - roll mode time constant, seconds

τ_s - spiral mode time constant, seconds

ϕ - bank angle, radians or degrees

$|\phi/\beta|_d$ - magnitude of roll-to-sideslip ratio in the Dutch roll mode

ψ_β - phase angle of the Dutch roll oscillation in sideslip

ω - imaginary part of $s = \sigma + j\omega$

ω_β - undamped natural frequency of numerator quadratic in sideslip to aileron input transfer function, rad/sec

ω_ϕ - undamped natural frequency of numerator quadratic in bank angle to aileron input transfer function, rad/sec

ω_r - undamped natural frequency of numerator quadratic in yaw rate to aileron input transfer function, rad/sec

ω_d - Dutch roll undamped natural frequency, rad/sec

ω_{sp} - longitudinal short period undamped natural frequency, rad/sec

ω_{FS} - feel system undamped natural frequency, rad/sec

Abbreviations

deg - degrees

IAS - Indicated Airspeed

IFR - Instrument Flight Rules

kt - knots

lb - pounds

PR - pilot rating

R/C - rate of climb

RMI - Radio Magnetic Indicator

rad - radians

sec - seconds

VFR - Visual Flight Rules

Section 1
INTRODUCTION

The landing approach phase of flight is perhaps the most critical phase for executive jet and medium weight Class II airplanes. The routine demands placed on the pilot-airplane combination are greater and the margin for error less in the landing approach than in the up-and-away mission phase. Pilot workload is especially high when performing an instrument approach, in turbulence with the possibility of "breaking out" at a low altitude with a lateral offset from the runway and having to make the landing in a crosswind. Good handling qualities are desirable in order not to unnecessarily add to the pilot's workload during this critical flight phase.

The desire for low landing approach speeds means flight at high angles of attack and/or flight with various combinations of high lift devices. The reduction in dynamic pressure alone influences the stability characteristics of the basic airplane and reduces the effectiveness of the controls. The result is usually a deterioration in handling qualities. Reference 1, which addresses the problem of low landing speeds for STOL aircraft, reported, "of the various handling qualities, the lateral-directional characteristics were the most troublesome and, therefore, were considered to require immediate attention particularly for instrument flight operation." At the other end of the spectrum, Reference 2 investigated the low-speed characteristics of a powered-lift jet transport during the landing approach and reported, "although there were no large detrimental effects on flight characteristics resulting from the use of powered lift, there were areas in which the handling qualities did noticeably deteriorate." It was also noted that the deterioration in handling qualities was not a function of the particular test airplane, but rather was related to Dutch roll characteristics and lateral-directional cross coupling inherent at the lower approach speeds.

The objectives of this flight test investigation were two fold: one, to determine the effect of variations in the lateral-directional dynamics on the landing approach handling qualities when landing in crosswinds and atmospheric turbulence and two, the determination of roll control power requirements and the effect of limited roll control power on the handling qualities of executive jet and medium weight Class II airplanes.

Throughout the entire investigation, pilot control usage data were recorded which allowed the determination of roll control power requirements necessary to perform the landing approach task in varying crosswind and turbulence environment conditions. Additionally, a number of configurations were re-evaluated with varying degrees of limited roll control power to determine the effect on the handling qualities. Also, several configurations were re-evaluated using a stick controller in place of the wheel controller that was used for the majority of the investigation. Specifically, the effects of Dutch roll frequency and damping ratio, roll-to-sideslip ratio, roll mode time constant, and aileron yaw characteristics were examined. The flight investigation was accomplished by performing simulated IFR ILS approaches and VFR lateral offset and actual crosswind approaches in the USAF/CAL variable stability T-33 airplane. The longitudinal characteristics were held constant so that the evaluations of the lateral-directional dynamics would not be influenced by varying longitudinal handling qualities.

Section 2
TECHNICAL DISCUSSION

2.1 THE PROBLEM

As previously discussed, the landing approach is perhaps the most critical phase of flight for executive jet and Class II airplanes. This phase of flight is an exacting task requiring accurate positioning of the airplane relative to the runway with a limited margin for error. The landing approach is often complicated by IFR conditions requiring precise instrument flying, a transition to visual flight with a possible lateral offset from the runway, and landing in a limited period of time. Additional complications are turbulence and crosswinds. To perform such a demanding task, the pilot should be provided with the best possible handling qualities.

The requirement for low landing speeds often dictates flight at high angles of attack and/or with various high lift devices. The low speed tends to reduce the aerodynamic damping as well as the effectiveness of the control surfaces. The result is often a deterioration in lateral-directional as well as longitudinal handling qualities at a time when the task and environment are quite demanding. Therefore, the pilot should be provided with very good handling qualities. This experiment was directed toward determining acceptable lateral-directional handling qualities and roll control power requirements for the landing approach.

2.1.1 Crosswind Landings

A very important aspect of lateral-directional handling qualities in the landing approach is the ability to handle the crosswind landing problem. Two fundamentally different techniques are usually used in crosswind landings: the wing-down (crossed-controls) approach, and the drift (crabbed) approach. In the wing-down method, the airplane is headed down the runway and thus experiences a steady-state sideslip which is proportional to the strength of the crosswind and inversely proportional to the approach speed. The resulting aerodynamic side force is countered by banking the airplane into the wind and trimming out the sideslip-induced yawing and rolling moments by appropriate control movements. In the crabbed approach, the airplane is flown with zero sideslip but with a heading correction into the wind to keep the airplane from drifting with respect to the ground. Because of the lack of sideslip, the rudder and ailerons are essentially held neutral and the wings are level. Just before touchdown the airplane heading is aligned with the runway. Crossed controls are required in either type of approach. In the wing-down method, the rudder and ailerons are crossed during the entire approach; for the crabbed approach, during the decrab maneuver only. Reference 3 points out, however, that in practice the two techniques are usually combined.

2.1.2 Roll Control Power

In the landing approach the provision of adequate roll control power is necessary to cope with a combination of normal landing approach maneuvers while the pilot is simultaneously dealing with the problems of crosswinds and turbulence or gust upsets. A lateral offset may further make stringent demands on the roll control power available. The minimum acceptable approach speed can, and has been in some cases, dictated by the provision for adequate lateral control power.

In the landing approach configuration at the slow speed associated with the landing approach, the aerodynamic forces, including aileron effectiveness, are reduced from those acting at high speed cruise conditions. The use of small airports by high-speed executive jets requires low landing approach speeds. But approach speed cannot be reduced if adequate roll control power is not maintained at the low speeds. In a strong crosswind, both the wing-down and "decrab" approach make heavy demands on roll control; i.e., balancing the roll due to the sideslip and rudder with aileron control while maintaining runway alignment, or maintaining wings level with aileron while using the rudder to decrab. As the landing approach speed is reduced, the sideslip required to maintain runway alignment for a similar crosswind component is increased or the crab angle relative to the runway is increased. Hence, with either crosswind approach method, decreasing final approach airspeed increases the demands on lateral control power. Without adequate roll control power it would be impossible to maintain the necessary sideslip or to hold the wings level during the decrab maneuver. This would either restrict, possibly severely, the crosswind capability of the airplane or induce accidents since it would not be possible to precisely position the airplane relative to the runway.

Roll control power requirements are also related to the differences in gust response of various airplanes. If the airplane is susceptible to a large rolling response to side gusts, as with a large dihedral effect, then roll control power requirements may be greater than for airplanes with low dihedral. The gust response is of prime importance during the approach and landing. Lateral gust upsets from which a recovery cannot be made fast enough can lead to aborted landing attempts or to wing tips or wing tip fuel tanks actually striking the ground, possibly with catastrophic results.

2.2 PURPOSE

The primary purpose of this program was to investigate problems associated with the lateral-directional stability and control characteristics of executive jet and related military Class II airplanes during the landing approach in turbulence and crosswinds. This required:

a. Evaluating those lateral-directional parameters which may affect, or possibly limit, the capabilities of the pilot-airplane system in the performance of the landing approach flight phase in a modern high-performance jet airplane with particular emphasis on the crosswind landing problem.

b. Investigating the aileron control power requirements for the class of airplanes mentioned above and the effect on the landing qualities of limited roll control power.

Further objectives of the program included:

c. Fulfilling some of the additional data needs for current and future airplanes.

d. Acquiring additional data for comparison with the requirements of the latest revision of MIL-F-8785B (ASG).

e. Determining some areas of difference or commonality between stick and wheel controllers for airplanes.

2.3 SCOPE OF INVESTIGATION

To completely study the effects of lateral-directional dynamics on the handling qualities in the landing approach is not feasible in one investigation. Thus, it was necessary to select those dynamics which are considered most important. The parameters discussed below were chosen after analysis of available data on executive jet and medium weight, Class II airplanes in the landing approach. These data and past flight research indicate that these parameters, which cover the range of lateral-directional dynamics for this class of airplanes, are the most significant to low-speed lateral control in turbulence and crosswinds.

2.3.1 Roll Mode

The roll mode is a primary factor in the way the airplane rolls in response to aileron control inputs. It is usually a short term response and strongly influences the pilot's control of bank angle. Past research shows that the roll mode affects not only the precision with which the pilot can control bank angle but also the technique used. Short roll mode time constants, which are usually associated with high aspect-ratio, straight-wing airplanes, result in ailerons that are roll rate ordering. With this characteristic, roll rate is essentially proportional to aileron deflection. Long roll mode time constants are associated with low aspect ratio wings and the resulting low roll damping, or airplanes with high rolling inertias such as those caused by wing-mounted external fuel tanks. This characteristic results essentially in roll acceleration being proportional to aileron deflection, requiring the pilot to use pulse-like inputs to the ailerons to control roll rate. Many executive jet or Class II airplanes have swept wings and/or externally mounted wing or tip fuel tanks and thus have low roll damping and/or high rolling inertias resulting in long roll mode time constants. The roll mode time constant is a fundamental lateral-directional parameter and was considered a primary variable in this investigation. Three values were evaluated: a $\tau_R \approx 0.4$ second, which is representative of high roll damping and/or low rolling inertias, a moderate $\tau_R \approx 1.0$ second and a long $\tau_R \approx 2.0$ second, which is representative of airplanes with low damping and/or high rolling inertias.

2.3.2 Spiral Mode

The spiral mode is usually a long term response with little effect during a continuous closed-loop tracking maneuver. Since the landing approach falls into this category, the spiral mode may be less important than many of the other lateral-directional dynamics. Although the effects of the spiral mode are still not fully known for VFR or IFR landing approaches, the spiral root in this investigation was held essentially at the origin and thus the effects of varying spiral characteristics were not investigated.

2.3.3 Dutch Roll Mode

The Dutch roll characteristics strongly affect the control techniques that the pilot will employ. In the past, the Dutch roll mode has been considered a nuisance parameter, but increasing understanding of its importance to lateral-directional handling qualities calls for systematic consideration of its effects.

Dutch roll damping can significantly affect bank angle controllability in the presence of external disturbances. Reference 2 points out that increasing the Dutch roll damping significantly improved the handling qualities of the low dihedral effect configurations. Since Dutch roll damping is usually augmented when the damping itself becomes a problem, three values of Dutch roll damping ratio were investigated: $\zeta_d \approx 0.03$, $\zeta_d \approx 0.1$, and $\zeta_d \approx 0.3$. These values represent very light damping, normal damping, and augmented Dutch roll damping ratios, respectively.

Dutch roll frequency affects the pilot's ability to control heading. Excursions in sideslip and heading are in part determined by the level of directional stability, N'_β, and hence are related to ω_d. Excursions in sideslip can be a particular problem when sideslip and bank angle are being controlled in a coupled manner to hold a crosswind correction. As indicated in Reference 6, a low roll-to-sideslip ratio with high ω_d causes rapid snaking motions that are difficult to control with precision; with low ω_d, the large persistent yaw excursions require considerable pilot effort to control heading. Low Dutch roll frequency may complicate the pilot's ability to handle a crosswind because of the difficulty in quickly establishing the airplane's steady-state values. Consequently, two values of Dutch roll frequency were investigated: $\omega_d \approx 1.0$ rad/sec and $\omega_d \approx 2.0$ rad/sec. These values are representative of the extremes determined to exist for the executive jet and Class II airplanes in the landing approach.

2.3.4 Roll-to-Sideslip Ratio and Dihedral Effect

Because of the coupling required between the lateral and directional controls in the crosswind approach, the roll-to-sideslip ratio is also an important Dutch roll characteristic that has a strong effect on the airplane's handling qualities in a crosswind maneuver. It also affects the piloting technique used for bank angle control. With a low roll-to-sideslip ratio, very little rolling motion occurs from a sideslip disturbance. If the sideslip response becomes a problem, the pilot will find an increased need for rudder inputs since the ailerons are quite ineffective in controlling sideslip. In other words, for a low roll-to-sideslip ratio, the Dutch roll mode shows up mostly in sideslip and will be controlled primarily with the rudder. As the roll-to-sideslip ratio is increased, the Dutch roll oscillation will show up more and more predominantly in the roll response, in which case the pilot will primarily use the ailerons to control the Dutch roll.

Studies performed at Princeton, References 5 and 6, indicate that L'_β rather than $|\phi/\beta|_d$ may be a more important handling quality parameter. Roll-to-sideslip ratio and L'_β, as shown in Appendix I, are related as follows:

$$\left.\frac{\phi}{\beta}\right|_{\substack{s=\text{DUTCH ROLL}\\ \text{ROOT}}} = \frac{(L'_r)s - (L'_\beta + Y_\beta L'_r)}{s^2 - L'_p s - \frac{g}{V}L'_r}$$

which upon evaluation can be written,

$$\left|\frac{\phi}{\beta}\right|_d \approx \left|\frac{L'_\beta}{N'_\beta}\right| \left(\frac{1+\dfrac{N'_\beta L'^2_r}{L'^2_\beta}}{1+\dfrac{L'^2_p}{N'_\beta}} \right)^{1/2}$$

In a crosswind approach, especially when sideslip is not zero, dihedral effect is indeed important in both the wing-down approach and in the decrabbing maneuver because of the rolling response to rudder inputs.

Both L'_β and the magnitude of the roll-to-sideslip ratio strongly affect the susceptibility of a particular airplane to turbulence in the lateral-directional modes. As shown in Appendix I, when the term $N'_p - \frac{g}{V}$ is not equal to zero, a direct variation in L'_β can cause significant changes in the Dutch roll damping ratio and roll mode time constant as well as the magnitude of the roll-to-sideslip ratio. Thus, if changes are made only in L'_β, it is difficult to assess whether the effect on the handling qualities is due solely to the change in dihedral effect or to the changes in other important lateral-directional parameters. It is also true that holding the roll-to-sideslip ratio constant and constraining the Dutch roll damping ratio and roll mode time constant at preselected values results in attendant changes in L'_β . For the latter case, recognized handling qualities parameters are at least held fixed. Three values of roll-to-sideslip ratio were evaluated: $|\phi/\beta| \approx 0.25$, 1.5 and 3.0. These values cover the spectrum of roll-to-sideslip ratios of the executive jet and Class II airplanes for which data were available.

2.3.5 Yaw Coupling

The yaw coupling effects of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ and N'_p are important factors in the pilot's control of bank angle. These effects are manifested to the analyst by the locations of the numerator zeros relative to the Dutch roll poles in the bank angle to aileron input transfer function and to the pilot by Dutch roll excitation to aileron control inputs. Since the class of airplanes to be investigated incorporates both ailerons and spoilers or combinations of both, it was important to determine the effects of proverse as well as adverse yaw due to roll control inputs. A minimum of five values of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ was evaluated for each group of configurations representing both adverse and proverse yaw due to aileron and/or spoilers. A representative value of N'_p , based on a literature survey, was determined to be $N'_p \approx -0.08$. This value was held essentially constant throughout the program.

2.3.6 Control Sensitivities

Aileron and rudder sensitivities, $L'_{\delta_{AW}}$ and $N'_{\delta_{AW}}$ respectively, are important parameters because they largely determine the amounts of rudder and aileron control inputs that must be used. Reference 7 shows these control motions to be functions of the lateral-directional dynamics present in the system. To minimize the effect of control motion gradients on the evaluation of the given airplane dynamics, and to provide additional data on the selection of these parameters, the evaluation pilot was required to select both the aileron and rudder sensitivities for each evaluation configuration.

2.3.7 Turbulence

In the landing approach, consideration must be given to the importance of atmospheric turbulence. Characteristics acceptable in smooth air may be quite undesirable in turbulence. A turbulence field can be divided into side gust, vertical gust, and fore and aft gust components. Each of these components produces aerodynamic loads on the airplane resulting in forces and moments that excite the airplane dynamics. The airplane response to the gust component is related to the corresponding stability derivatives. The transfer functions of the airplane's lateral-directional responses to gust inputs are presented in Appendix I.

Two general approaches to the turbulence problem were considered. The first would be to always fly on calm days when the air is smooth and to simulate the turbulence and wind disturbances (see Refs. 5 and 7). This approach severely constrains flight operations. In addition, the lack of independent force-producing surfaces makes it impossible to simulate crosswind effects. The second approach would be to fly routinely from day to day, documenting the environment during each evaluation (see Ref. 8). This approach would have the disadvantage of introducing an uncontrolled variable into the experiment. To account for the important effects of the uncontrolled environment, it would be necessary to document the environment during each evaluation and to increase the number of evaluations or the sample size of the experiment. For this investigation these two approaches were combined. When the natural turbulence level was considered to be less than "moderate," random disturbance inputs to the control surfaces were used. When the natural turbulence level was moderate or greater, these inputs were not used. The random disturbance generator is discussed in Section 3.5.

2.3.8 Type of Cockpit Controller

The type of cockpit controller, wheel or stick, may be important. Reference 8, however, indicates that in evaluations of longitudinal handling qualities, a pilot's preference for acceptable airplane dynamics was essentially independent of whether a stick or wheel controller was used. In anticipation of a similar result for the lateral-directional dynamics and to be consistent with the type of controller normally found in executive jet and Class II airplanes, all configurations were evaluated with a wheel controller. In addition, selected groups which included two values of τ_R and three $|\phi/\beta|_d$ at one Dutch roll frequency and damping ratio were repeated with the stick controller.

2.3.9 Roll Control Power Requirements

Roll control power data for executive jet and Class II airplanes is somewhat limited. Therefore, it was important to study roll control power requirements and the effect limited roll control power may have on the landing approach handling qualities. To this end, the pilots' roll control usage was measured during each evaluation to determine the roll control power used to perform the landing approach under varying turbulence and crosswind conditions. Further, it was important to determine the minimum acceptable roll control power required. This was accomplished by methodically reducing the roll control power for different values of the roll mode time constant and the roll-to-sideslip ratio at constant values of Dutch roll frequency and damping ratio.

Section 3
DESCRIPTION OF EXPERIMENT

3.1 TEST PROGRAM

Existing relevant background data, References 1 through 66, were comprehensively reviewed to evaluate those parameters which predominantly affect airplane lateral-directional handling qualities during the landing approach flight phase and how these parameters affect the capabilities of the pilot-airplane combination to satisfactorily perform the task. A further purpose was to determine representative values of lateral-directional parameters of modern executive jet, and related medium weight and low to medium maneuverability airplanes in the landing approach. Numerical data were available on 13 airplanes, ranging from detailed stability derivatives to graphical airplane responses to control inputs.

On the basis of the data review and previous related flight research experience, a flight test program was developed. Table I describes the matrix of basic evaluation groups.

Table I EVALUATION GROUPS

ω_d	2.0 rad/sec			1.0 rad/sec				
τ_R	0.4 sec			0.4 sec			1.0 sec	2.0 sec
ζ_d	0.03	0.10	0.30	0.03	0.10	0.30	0.10	0.10
$\left\|\frac{\phi}{\beta}\right\|_d = 0.25$					$^{S}11_{L}$	12	13	
$\left\|\frac{\phi}{\beta}\right\|_d = 1.5$	1	2	3	5	$^{S}6_{L}$	7	$^{S}14_{L}$	16_{L}
$\left\|\frac{\phi}{\beta}\right\|_d = 3.0$		4		8	$^{S}9_{L}$	10	15	

S - REEVALUATED WITH STICK CONTROLLER
L - REEVALUATED WITH LIMITED AILERON CONTROL POWER

The values shown in Table I adequately cover the range of lateral-directional characteristics for the class of airplanes to be investigated and for which numerical data were available.

Numerals shown in the matrix of Table I are the identification numbers of the basic evaluation groups with their respective positions in the matrix identifying their modal parameters. Each basic group represents a minimum of five evaluation configurations consisting of different pole zero combinations in the bank angle-to-aileron input transfer function. The different locations of the zeros were obtained by varying the aileron yaw parameter, $N'_{\delta_{AW}}/L'_{\delta_{AW}}$, in the adverse and proverse senses. The evaluation configurations were identified by the basic group identification numeral followed by A3, A2, A1, NO, P1, P2, or P3, according to the value of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$: NO corresponding to $N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$; P3 to $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.15$, the most proverse aileron yaw case; A3 to $N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.15$, the most adverse aileron yaw case; and so on, through the range of zeros evaluated. The selected groups of configurations evaluated using both a stick controller and a wheel controller are indicated by an S in Table I. A number of configurations were re-evaluated with varying degrees of limited aileron control power. The groups from which these configurations were chosen are marked with an L in Table I.

3.2 EQUIPMENT

Evaluations for this program were performed in the USAF/CAL three-axis, variable-stability T-33 airplane, Figure 1, modified and operated by CAL for the AFFDL, Air Force Systems Command. Since most executive jet class airplanes are wheel controlled, a wheel controller was installed in the front cockpit (Figure 2) for most of the evaluations. The variable stability equipment is described in Reference 67.

Figure 1 USAF/CAL VARIABLE STABILITY T-33 AIRPLANE

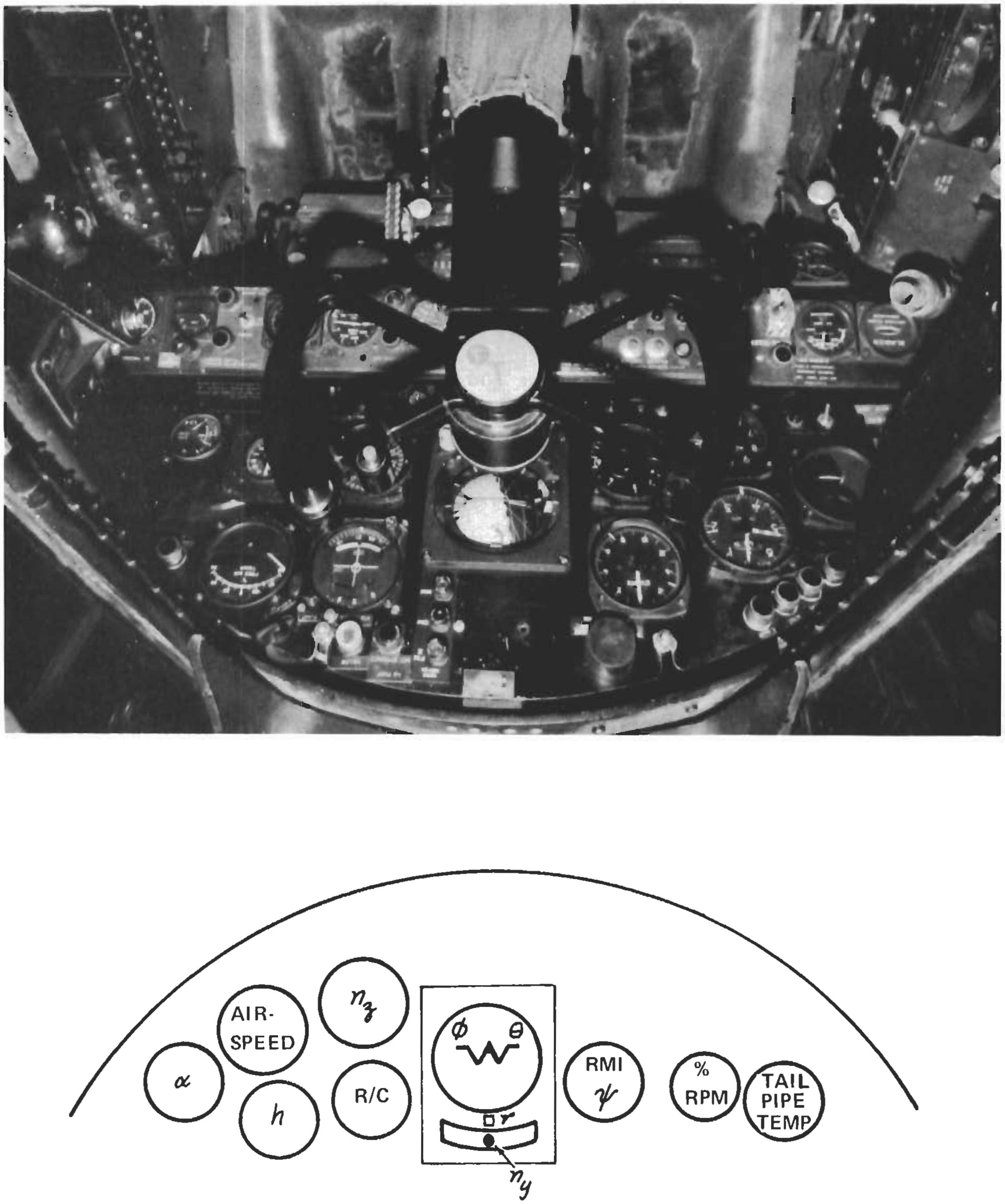

Figure 2 EVALUATION PILOT'S COCKPIT IN VARIABLE STABILITY T-33

In this airplane, the system operator, who is also the safety pilot in the rear cockpit, may modify the handling qualities about all three axes by changing the settings of response feedback gain controls. The evaluation pilot could not feel the control surface motions resulting from the variable stability system signals.

Control feel to the stick or wheel and rudder pedals was provided by electrically controlled hydraulic feel servos which provide opposing forces proportional to the control wheel, stick, or rudder pedal deflections; in effect, a simple linear spring feel system. The longitudinal and lateral control system had zero breakout force and no hysteresis. The feel system dynamics and spring rates were held constant at the values shown below:

Feel System

Aileron	Rudder	Elevator
ω_{FS} = 25 rad/sec	ω_{FS} = 25 rad/sec	ω_{FS} = 25 rad/sec
ζ_{FS} = 0.70	ζ_{FS} = 0.70	ζ_{FS} = 0.70
F_{AW}/δ_{AW} = 1.0 lb/deg		F_{EW}/δ_{EW} = 25 lb/in.
F_{AS}/δ_{AS} = 4.0 lb/in.	F_{RP}/δ_{RP} = 141.0 lb/in.	F_{ES}/δ_{ES} = 10 lb/in.

Since the purpose of the experiment was to study the lateral-directional handling qualities in the landing approach, the longitudinal characteristics were held constant throughout the program at sufficiently good values so as not to cause any degradation of pilot ratings. The longitudinal dynamics are listed below.

Longitudinal Characteristics

ω_{SP} = 1.6 rad/sec	n_z/α = 6.94 g/rad
ζ_{SP} = 0.5	$1/T_{\theta_2}$ = 0.91

To investigate the effects of limited aileron control power, the maximum rolling moment that the evaluation pilot could command was reduced by limiting the amount of aileron deflection he could command. Maximum wheel displacement was held constant at ± 45 degrees. Aileron deflection was limited by limiting the maximum electrical signal from the aileron wheel to the aileron surface servo actuator as shown in Figure 3.

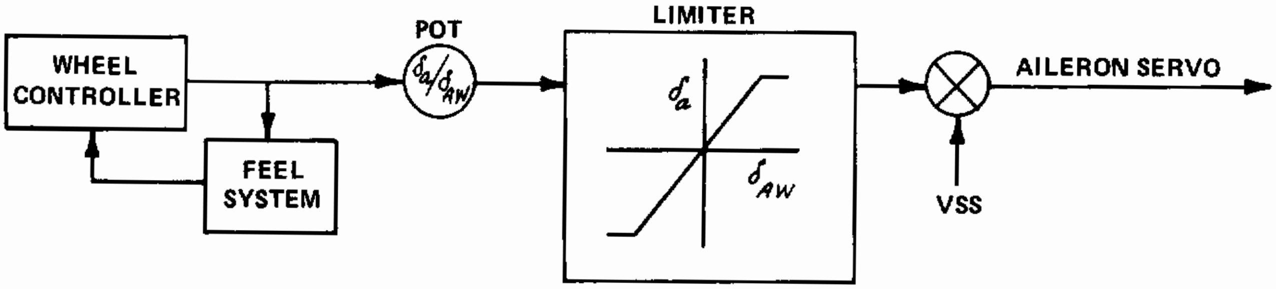

Figure 3 AILERON LIMITER SCHEMATIC

The response to turbulence and the turbulent environment experienced are of special significance. The T-33 does not have the capability to vary the lift response to gust-induced angle of attack changes; thus, the heaving motion normally associated with vertical gusts can not be simulated in still air. In natural turbulence the heaving motion will be that which is normally associated with the basic T-33 airplane. On the other hand, the lateral-directional responses to gusts are more realistically simulated in still air because they are primarily felt as angular accelerations of the airplane. Although it is not a true simulation of turbulence, a random noise source was used to provide an external disturbance to the airplane during the evaluations when the natural turbulence environment was not considered to be of moderate intensity. The random disturbances were obtained by driving the T-33 control surface actuators by a random noise signal. The signal was generated by a diode noise source passed through the bandpass filter shown in Appendix II. The amplitudes of the disturbance signals to the ailerons and rudder were determined to represent turbulence of moderate intensity for configuration 6NO and varied with roll-to-sideslip ratio and Dutch roll frequency, respectively, from the values selected as being representative.

3.3 EVALUATIONS

3.3.1 Mission Definition

The mission evaluated was strictly the terminal task of IFR and VFR landing approaches, including an ILS approach under the hood, a VFR lateral offset maneuver, and a crosswind approach. Special emphasis was placed on crosswind and turbulence considerations. All aspects of the mission were discussed at length with the evaluation pilots to ensure that both pilots were evaluating the simulated airplane for the same mission requirements.

3.3.2 Evaluation Procedure

Three evaluations were performed on each flight. Each evaluation included actual landing approaches under both simulated IFR and VFR conditions. The T-33 airplane was configured for the approach with the landing gear down, flaps at 30 degrees, and speed brakes extended. The final approach speed of 145 knots was dictated by the stall limits, and resulting safety of flight considerations, of the basic T-33 with high quantities of fuel remaining.

A total of 155 evaluations were performed. This included 108 evaluations with the wheel controller (84 different configurations and 24 repeats) with no limits on roll control power and 24 evaluations with the stick controller (19 different configurations and 5 repeats). Twenty-three configurations were evaluated with limited roll control power. Pilot A evaluated 75 configurations and Pilot B, 80 configurations.

3.3.3 Evaluation Tasks

The actual sequence of tasks during each evaluation was as follows:

1. Familiarization with the configuration.
    a. Select control sensitivities.
    b. Determine trimmability--ability to stabilize and trim.

c. Perform small maneuvers to determine ability to make precise changes in bank angle and heading.

2.* Radar vectored track to ILS final approach course.

3. Hooded ILS approach from outside the outer marker to published instrument minimums for the facility being used.

4. Visual final approach to flare.

5. Visual waveoff followed by a visual approach to the instrument runway for a 200-foot lateral offset approach to the flare.

6.* Visual waveoff followed by a visual circling approach to the most crosswind runway available. This approach was also carried to flare and included a level post-flare flight path to assess lineup and/or decrab capability.

7. Waveoff and climb for additional turning flight evaluation if required. Pilot comment and rating data were recorded at this time.

3.3.4 Pilots

Two evaluation pilots participated in the program. A summary of their experience is presented below:

Pilot A:	USAF pilot and graduate of the USAF Aerospace Research Pilot School with extensive experience in flight test. He served as a staff member and instructor at the USAF Aerospace Research Pilot School and had a total of 3800 hours in jet trainers and fighters.

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* If the natural turbulence level was sufficiently low to warrant the use of the random noise disturbance inputs, these inputs were used during the radar vector to the ILS final approach course, but not during the ILS or offset maneuver approaches. They were, however, again used on the crosswind approach.

Pilot B: CAL research pilot with experience as an evaluation pilot in handling qualities investigations employing variable stability aircraft and ground simulators. His flight experience of 2700 hours is mostly in jet trainers and fighters with 100 hours in current executive turbo-prop airplanes.

3.3.5 Pilot Comment and Rating Data

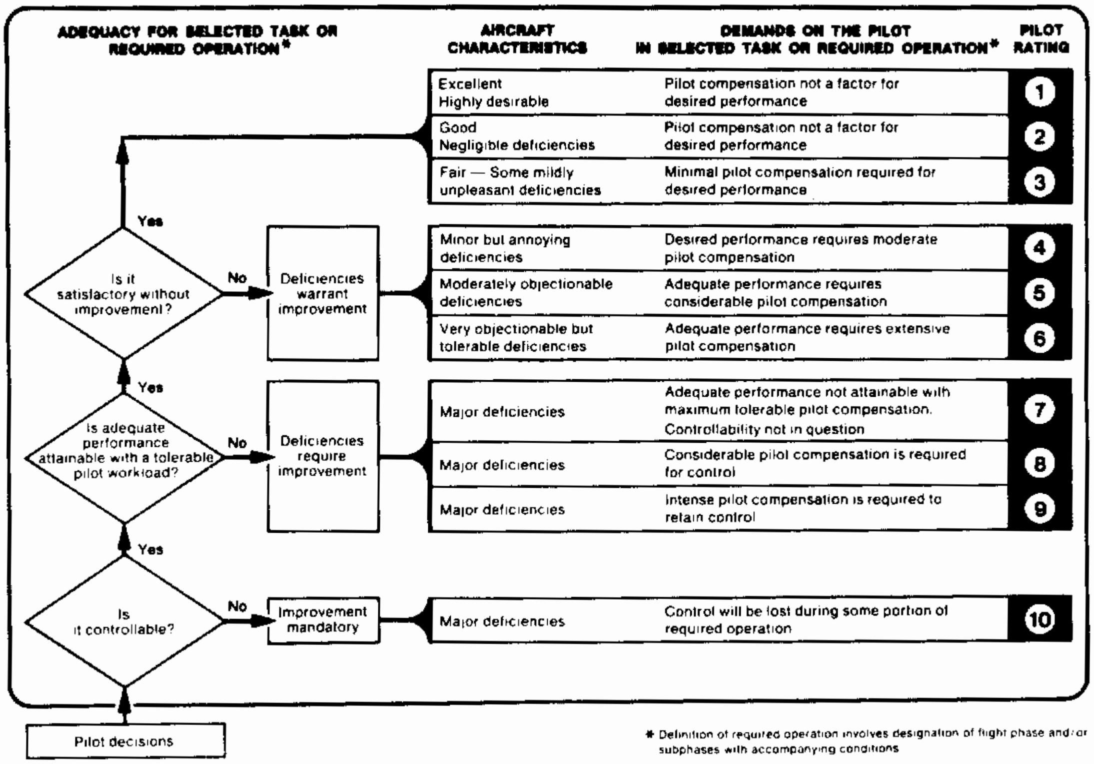
Pilot comments and ratings were the primary data source. The pilot rating can only be properly interpreted and objections properly assessed if good comments are obtained. Pilot comments were encouraged at any time during the evaluation that the pilot felt appropriate. For data consistency, it was required that the pilot comment on the items listed in Table II either during or at the completion of each evaluation.

Table II

PILOT COMMENT CARD

A. MAKE COMMENTS AT ANY TIME DESIRED.
B. COMMENT ON LATERAL-DIRECTIONAL HANDLING QUALITIES IN GENERAL.
C. COMMENT ON THE FOLLOWING SPECIFIC ITEMS:
    1. ABILITY TO TRIM.
        a. LATERAL.
        b. LONGITUDINAL.
    2. FEEL CHARACTERISTICS.
        a. FORCES.
        b. DISPLACEMENTS.
    3. COMMENT ON CONTROL SENSITIVITY.
        a. EXPLAIN.
        b. COMPROMISES.
    4. AIRPLANE RESPONSE TO PILOT INPUTS.
        a. ROLL CONTROL.
        b. YAW DUE TO ROLL RATE.
        c. COORDINATION.
        d. OSCILLATORY CHARACTERISTICS.
    5. HOW SUITABLE ARE THESE CHARACTERISTICS FOR THE LANDING APPROACH?
    6. DIFFERENCE BETWEEN IFR AND VFR FLIGHT.
    7. EFFECTS ON TURBULENCE.
        a. COMMENT ON TURBULENCE PRESENT DURING EVALUATION.
    8. ILS PERFORMANCE.
    9. HOW DOES A CROSSWIND AFFECT THE HANDLING QUALITIES?
D. SUMMARY COMMENTS.
    1. GOOD FEATURES.
    2. OBJECTIONABLE FEATURES.
    3. SPECIAL PILOTING TECHNIQUES.
    4. PILOT RATING BASED ON MISSION.
    5. PRIMARY REASON FOR RATING.
    6. TURBULENCE RATING.

An overall pilot rating was assigned by the pilot to each configuration in accordance with the Cooper-Harper rating scale established and described in Reference 68 and shown in Figure 4. The pilot rating assigned by the evaluation pilot to each configuration included the effects that natural turbulence and/or random noise disturbances may have had on the handling qualities.



* Definition of required operation involves designation of flight phase and/or subphases with accompanying conditions

Figure 4 COOPER-HARPER HANDLING QUALITIES RATING SCALE

In addition, an alphabetical turbulence rating was assigned which was solely an assessment of the combined effects on the handling qualities of natural turbulence and/or random noise disturbances. These ratings were established in accordance with the turbulence effect rating scale, Table III.

Table III

TURBULENCE EFFECT RATING SCALE

INCREASE OF PILOT EFFORT WITH TURBULENCE	DETERIORATION OF TASK PERFORMANCE WITH TURBULENCE	RATING
NO SIGNIFICANT INCREASE	NO SIGNIFICANT DETERIORATION	A
MORE EFFORT REQUIRED	NO SIGNIFICANT DETERIORATION	B
	MINOR	C
	MODERATE	D
BEST EFFORTS REQUIRED	MODERATE	E
	MAJOR (BUT EVALUATION TASKS CAN STILL BE ACCOMPLISHED)	F
	LARGE (SOME TASKS CANNOT BE PERFORMED)	G
UNABLE TO PERFORM TASKS		H

3.3.6 Supporting Data Acquisition

The intensity of natural turbulence present during the evaluations was assessed by the safety pilot, and reported using the standard descriptive terminology provided in the Department of Transportation, Federal Aviation Administration, "Airman's Information Manual," and Department of Defense Flight Information Publications. The turbulence reporting criteria table is shown in Appendix III.

The crosswind components were determined from wind velocities provided by air traffic control personnel during each landing approach. Oscillograph recordings and digital tape recordings were made during the ILS, lateral offset, and crosswind approaches. Variables recorded are listed in Appendix III.

Section 4
DISCUSSION OF RESULTS

4.1 EVALUATION GROUPS

The primary objective in defining a configuration matrix was to cover adequately the range of lateral-directional characteristics for the executive jet and related medium weight and low to medium maneuverability airplanes (Class II), in the landing approach. The evaluation matrix shown in Table I is repeated below for convenience:

Table I EVALUATION GROUPS

ω_d	2.0 rad/sec			1.0 rad/sec				
τ_R	0.4 sec			0.4 sec			1.0 sec	2.0 sec
ζ_d	0.03	0.10	0.30	0.03	0.10	0.30	0.10	0.10
$\left\|\frac{\phi}{\beta}\right\|_d = 0.25$					S 11 L	12	13	
$\left\|\frac{\phi}{\beta}\right\|_d = 1.5$	1	2	3	5	S 6 L	7	S 14 L	16 L
$\left\|\frac{\phi}{\beta}\right\|_d = 3.0$		4		8	S 9 L	10	15	

S - REEVALUATED WITH STICK CONTROLLER

L - REEVALUATED WITH LIMITED AILERON CONTROL POWER

Sixteen basic groups of configurations were evaluated representing variations in Dutch roll frequency and damping ratio, the magnitude of the roll-to-sideslip ratio in the Dutch roll mode, and the roll mode time constant. Each group consisted of a minimum of five evaluation configurations. The configurations were defined by the location of the numerator zero in the bank angle-to-aileron input transfer function. Variation in the locations of the numerator terms was obtained by varying the aileron yaw parameter, $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ in both the adverse and proverse senses, representing lateral control by ailerons and spoilers. N'_p was held essentially constant at a value representative of executive jet and Class II airplanes. The spiral root was held essentially at the origin.

The complete equations defining the interactions of the stability derivatives in forming the modal characteristics are presented in Appendix I. Because of the natural turbulence levels encountered during most of the evaluations, it was not possible to obtain useable calibration records on each flight. Therefore, the modal parameters listed for each group of configurations are the average values obtained from calibration records taken on smooth days, before, during, and at the end of the evaluation flight program. The Dutch roll frequency and damping ratio were measured from the airplane response to a rudder doublet input. The roll and spiral mode time constants were obtained by analog matching of the airplane response to an aileron step input using the technique presented in Reference 69. The short period longitudinal characteristics were obtained by analog matching the airplane response to an elevator step input by the technique explained in Reference 70.

Transient responses and pilot comments are presented in Appendices V and VI, respectively, for each configuration evaluated. The transient responses were calculated using the modal characteristics obtained for each group.

The natural turbulence level and crosswind components are listed for each configuration in Appendix V. The reader is reminded that when the natural turbulence level was less than moderate, random noise disturbances were used to the aileron, elevator and rudder to simulate external disturbances being applied to the airplane.

4.1.1 The Effect of N_p'

In this investigation, the value of N_p' was essentially constrained to be -0.08, a value that was determined to be representative of the class of airplanes to be evaluated. All but four groups of configurations had values within ±0.01 of -.08. Three of these groups were the moderate roll mode time constant ($\tau_R \approx 1.0$ seconds) groups, 13, 14, and 15, which had N_p' values of -.094, -.033 and -.105 respectively. The fourth group had an N_p' = -0.0515.

As shown in Appendix I, for fixed values of Dutch roll frequency, damping ratio, and $|\phi/\beta|_d$, the value of N'_p strongly influences the position of the ϕ/δ_{AW} numerator zero with respect to the Dutch roll pole along the real axis $(\zeta_d \omega_d - \zeta_\phi \omega_\phi)$. The vertical displacement of the zero is then determined by $N'_{\delta_{AW}}/L'_{\delta_{AW}}$.

It was shown in Reference 7 that the optimum value of $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ for a configuration is primarily a function of the yaw due to roll rate parameter, N'_p. For a low $|\phi/\beta|_d$ configuration the optimum value of $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ is the value that in combination with N'_p results in minimum sideslip response. For a higher $|\phi/\beta|_d$ configuration, where the pilot is concerned primarily with the roll response, the optimum value of $N'_{\delta_{AS}}/L'_{\delta_{AS}}$ is the value that in combination with N'_p produces the best roll rate response.

Investigation of the β/δ_{AW} transfer function shown in Appendix I indicates that when the spiral root is at the origin and

$$Y_{\delta_{AW}} \approx \alpha_0 \approx \frac{g}{V}\left(L'_{\delta_{AW}} N'_r - N'_{\delta_{AW}} L'_r\right) \approx 0$$

the β/δ_{AW} transfer function can be written as follows:

$$\frac{\beta}{\delta_{AW}} \approx \frac{-N'_{\delta_{AW}}\left\{s - L'_p + \frac{L'_{\delta_{AW}}}{N'_{\delta_{AW}}}\left(N'_p - \frac{g}{V}\right)\right\}}{\left(s + \frac{1}{\tau_R}\right)\left(s^2 + 2\zeta_d \omega_d s + \omega_d^2\right)}$$

From this expression, using the final value theorem, the steady-state sideslip for an aileron input is a minimum when:

$$\frac{N'_{\delta_{AW}}}{L'_{\delta_{AW}}} \approx \frac{N'_p - \frac{g}{V}}{L'_p}$$

Since L'_p is negative, it can be seen that for negative values of N'_p, minimum steady state sideslip will occur for positive values of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$

(i.e., proverse yaw due to aileron wheel inputs). The converse is true when N'_p is positive and greater than g/V, minimum steady-state sideslip will occur for negative values of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ (i.e., adverse yaw due to aileron wheel inputs).

In this investigation, all but four groups reached an optimum pilot rating for a positive or proverse value of yaw due to aileron wheel deflection. Two groups reached an optimum rating at $N'_{\delta_{AW}}/L'_{\delta_{AW}}=0$ and two groups for adverse yaw due to aileron wheel deflection. The latter two groups and one of those at which the optimum pilot rating occurred at $N'_{\delta_{AW}}/L'_{\delta_{AW}}=0$ were groups with very light Dutch roll damping ratios ($\zeta_d \approx .03$). For these three groups, the adverse yaw due to aileron wheel inputs tended to increase the closed loop Dutch roll damping ratio and consequently were rated better.

The results of this experiment agree with those of References 7, 46 and 50 in that proverse yaw due to roll control is desirable when the airplane has adverse yaw due to roll rate.

4.2 HIGH DUTCH ROLL FREQUENCY, LOW ROLL MODE TIME CONSTANT

The results obtained for the evaluations performed at a Dutch roll frequency of 2.0 rad/sec and a roll mode time constant of 0.4 seconds are discussed in the following four subsections.

4.2.1 Group 1 -- Low Dutch Roll Damping Ratio, Moderate $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 2.02 rad/sec $|\phi/\beta|_d$ = 1.62

ζ_d = 0.026 τ_R = 0.40 sec τ_s = 40 sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 5 and the experimental results in Figure 6.

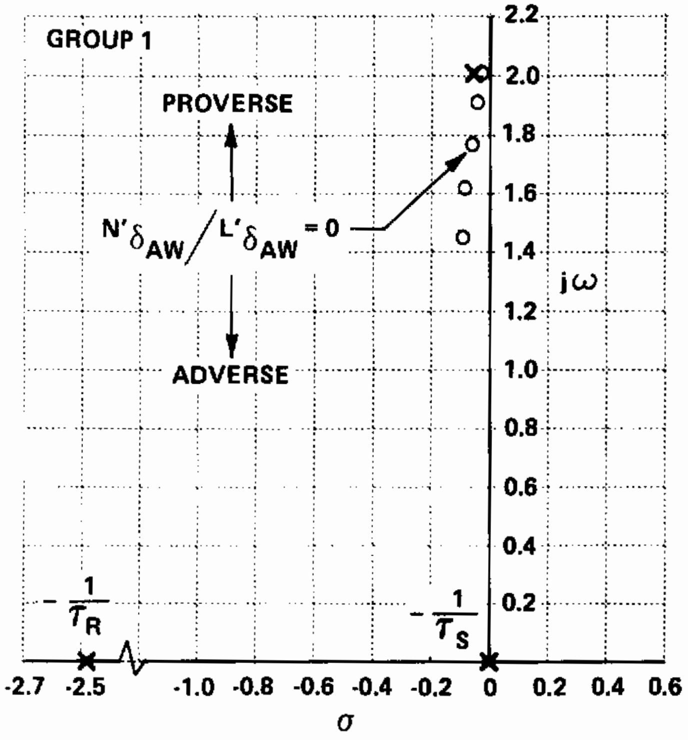


Figure 5 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 1

All configurations within this group except the most adverse aileron yaw case were reported to have good precise roll control and minor or no coordination requirements. Maneuverability was listed as a favorable feature. Pilot comments for the most adverse aileron-yaw case were lost because of recorder malfunction.

The overwhelming objection to this group of configurations was the airplane's response to turbulence. In turbulence there were oscillations, particularly in roll, but also in yaw. The objectionable turbulence response was a result of the low Dutch roll damping. One pilot comment indicated that it was only the turbulence response that made the configuration unsatisfactory for the landing approach. For all but the $N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$ case, the effects

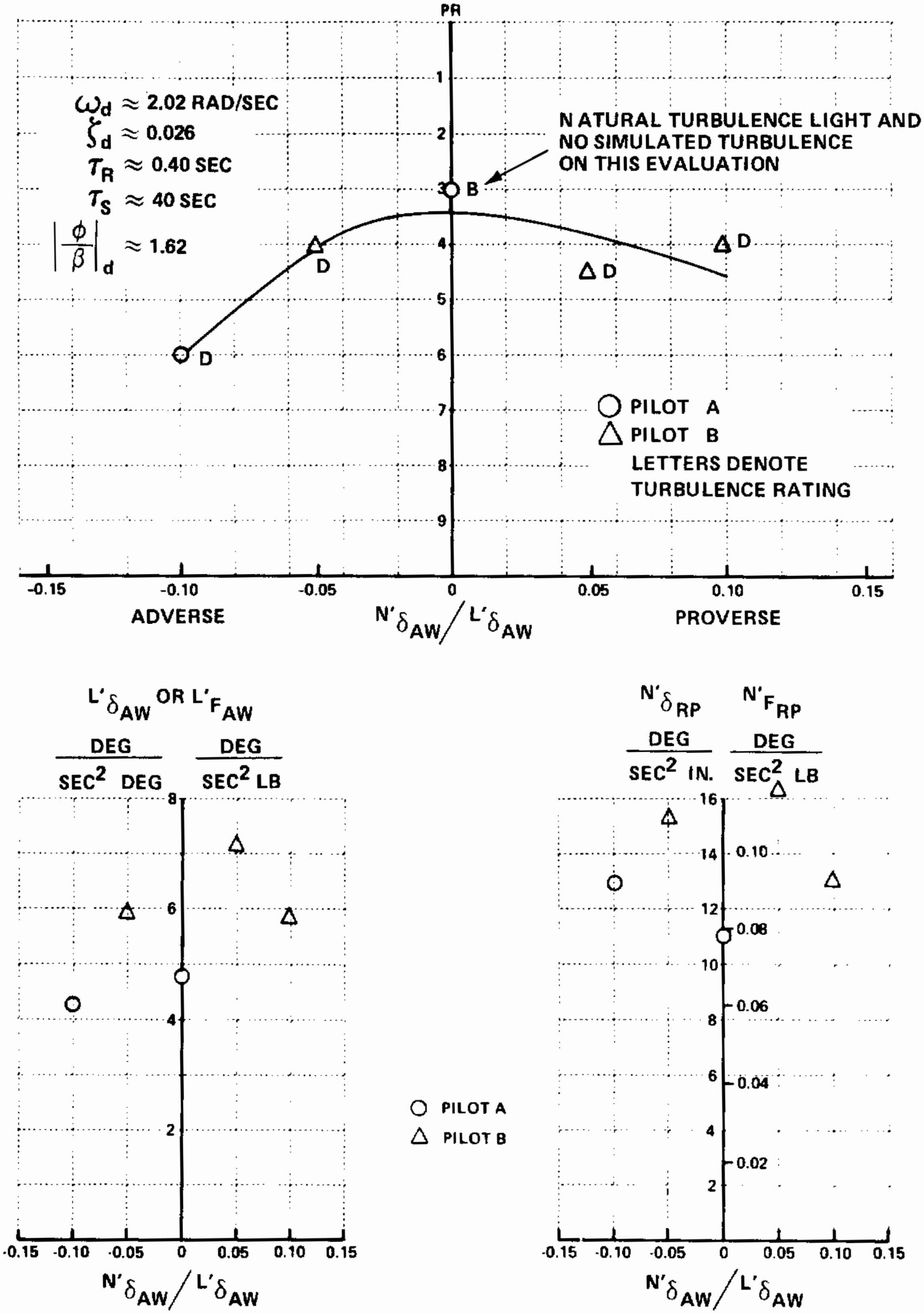


Figure 6 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 1 WHEEL CONTROLLER

of turbulence produced a moderate deterioration in task performance. The $N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$ case was evaluated during the very early part of the flight program without the benefit of the random noise disturbances to the controls. It is felt that this accounts for the apparent discrepancy in turbulence rating.

Pilot-selected values of control sensitivities show considerable scatter. In general, Pilot B selected higher sensitivities then Pilot A. Out of turbulence, the airplane was quite good. The roll control was excellent and very little rudder coordination was required. There was no difficulty in performing either the crabbed or wing low technique in the crosswind approaches.

4.2.2 Group 2 -- Medium Dutch Roll Damping Ratio, Moderate $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

$\omega_d = 1.98$ rad/sec $\quad |\phi/\beta|_d = 1.71$

$\zeta_d = 0.10 \quad \tau_R = 0.40$ sec $\quad \tau_S = \infty$ sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 7, and the experimental results in Figure 8.

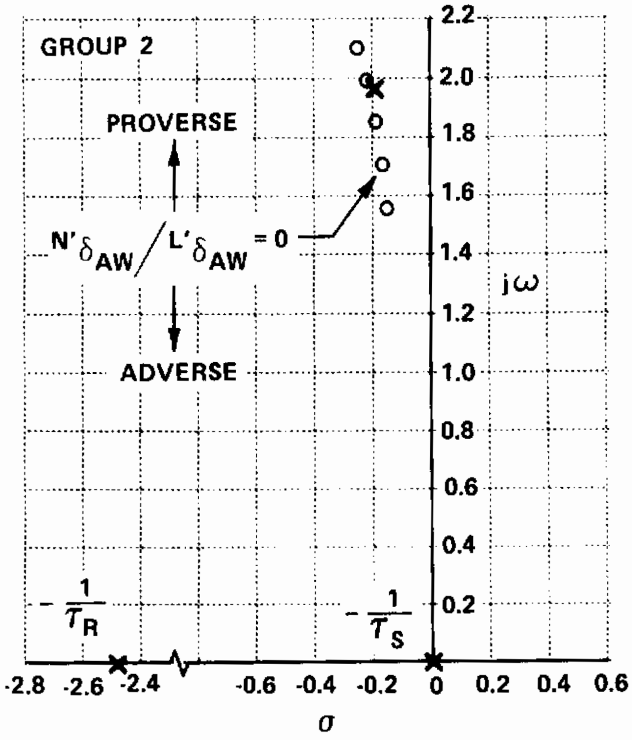


Figure 7 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 2

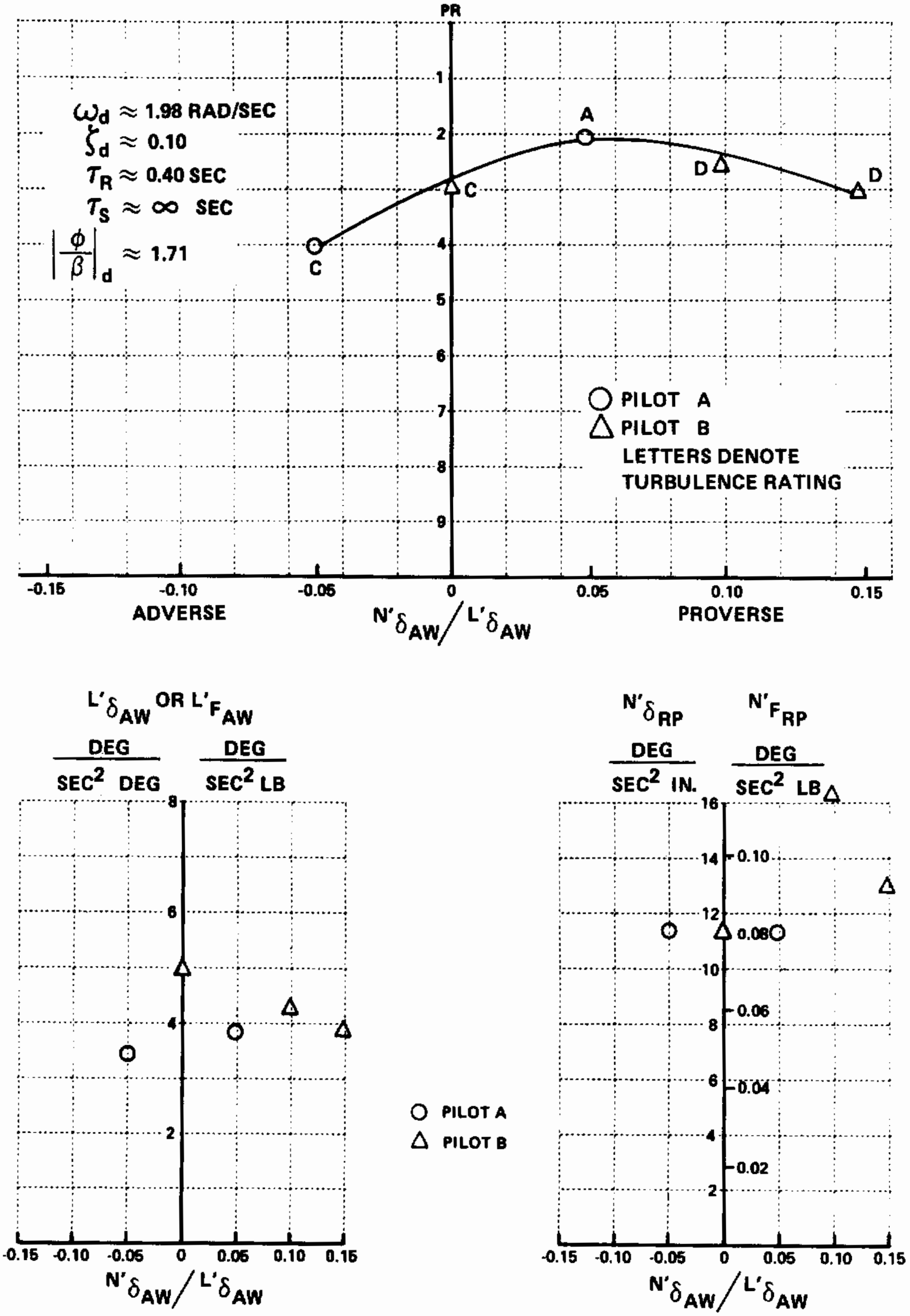


Figure 8 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 2 WHEEL CONTROLLER

The overall lateral-directional handling qualities for this group of configurations were considered to be quite good. The moderate frequency Dutch roll mode and reasonable damping ratio were liked by both evaluation pilots.

There was very little change in pilot rating over the range of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ evaluated. Only the most adverse yaw due to aileron configuration was rated as unsatisfactory. This was due primarily to roll rate oscillations that occurred following aileron inputs. This particular configuration was also the only one that required rudder coordination in a turn. The crosswind approaches presented no particular problem with these configurations for either technique.

The control sensitivities selected by both pilots were quite consistent. The high rudder control sensitivity for the moderate proverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ case was selected to provide light rudder pedal forces to combat the 20-knot crosswind which existed for that particular evaluation. The pilot commented that since rudder coordination was not required, the high rudder sensitivity was acceptable.

4.2.3 Group 3 -- High Dutch Roll Damping Ratio, Moderate $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 2.01 rad/sec $\quad |\phi/\beta|_d$ = 1.50

ζ_d = 0.24 $\quad \tau_R$ = 0.40 sec $\quad \tau_s$ = ∞ sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 9, and the experimental results in Figure 10.

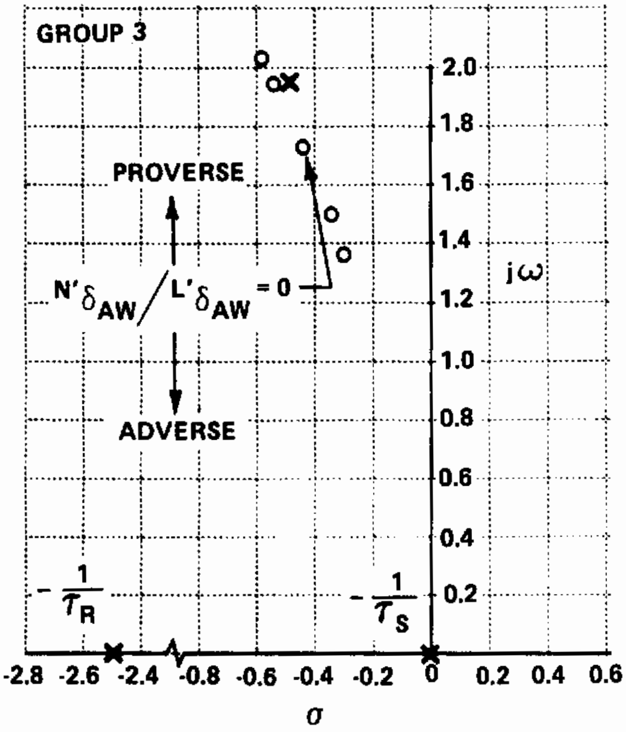


Figure 9 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 3

This group of configurations was the best evaluated. The combination of moderate Dutch roll frequency and relatively high damping ratio resulted in a smooth flying airplane with a minimal turbulence response. The directional stiffness of the airplane tended to minimize the coordination requirements. The roll control was good for all cases. Crosswind approaches presented no particular problems.

There was good agreement between pilots in their selection of control sensitivities. The pilot commented that the aileron sensitivity for the most proverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ configuration evaluated was a little too sensitive. The lack of a significant turbulence response was listed as a good feature for all the configurations in this group.

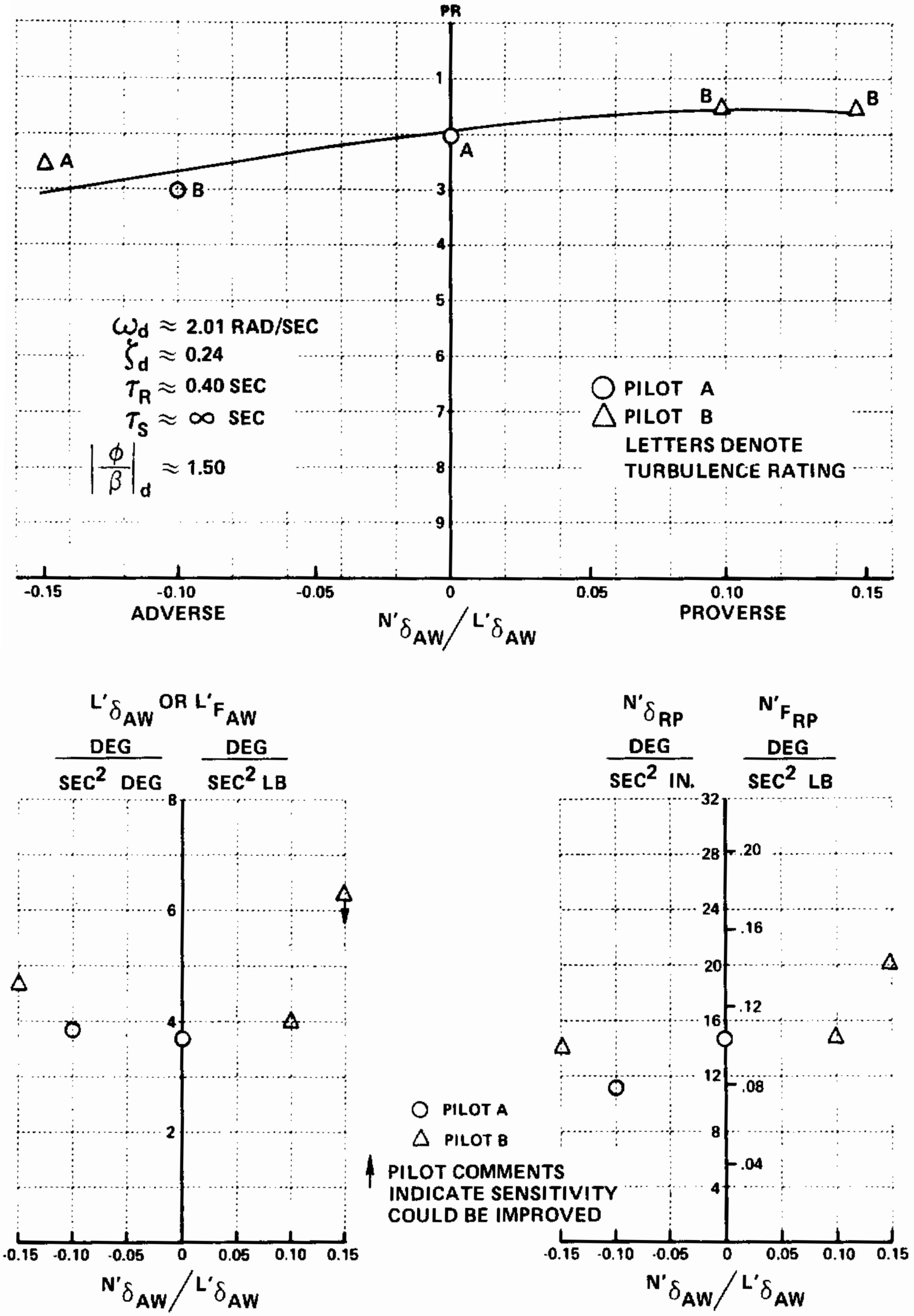


Figure 10 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 3 WHEEL CONTROLLER

4.2.4 Group 4 -- Moderate Dutch Roll Damping Ratio, High $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 2.02 rad/sec $|\phi/\beta|_d$ = 3.14

ζ_d = 0.10 τ_R = 0.40 sec τ_s = 100 sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 11, and the experimental results in Figure 12.

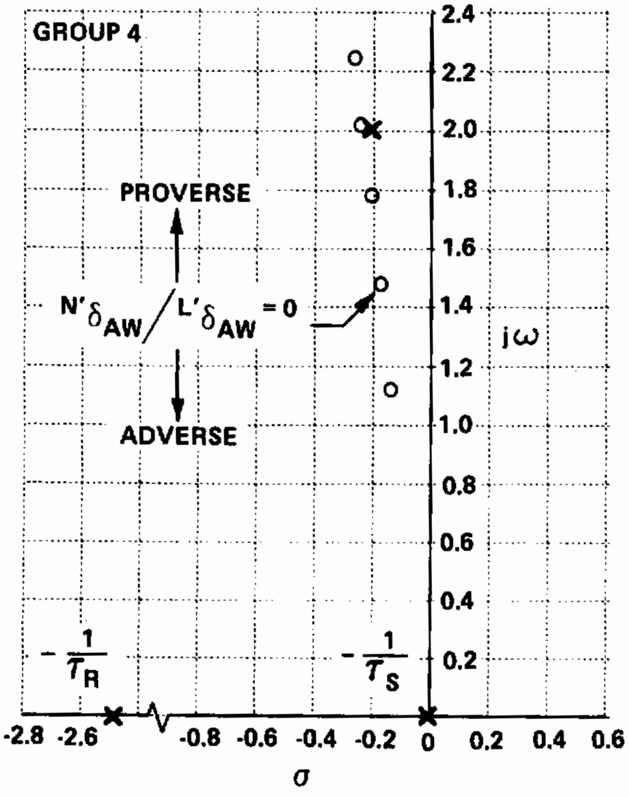


Figure 11 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 4

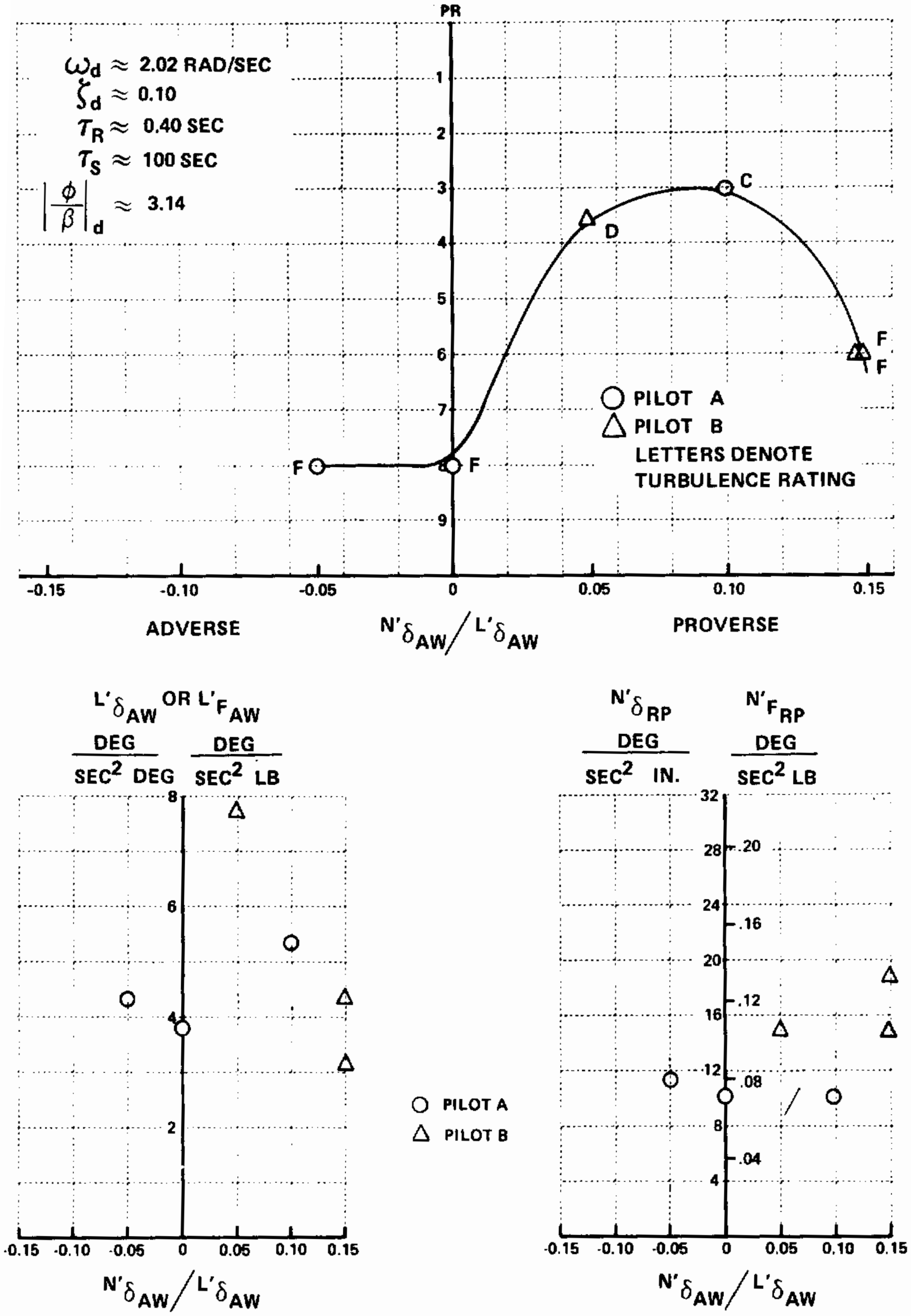


Figure 12 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 4 WHEEL CONTROLLER

The high roll-to-sideslip ratio of these configurations accentuated the roll response to turbulence. It also increased the effect of varying $N'_{\delta_{AW}}/L'_{\delta_{AW}}$, and caused a much larger movement of the numerator zeros in the ϕ/δ_{AW} transfer function. The result was a much larger variation in pilot rating as a function of the control variable, $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ due to greater excitation of the Dutch roll resulting from aileron inputs.

The major objection for all the configurations was the crisp, rapid roll response to turbulence. The Dutch roll mode primarily showed up as a roll oscillation. For the adverse and zero $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ values evaluated, the Dutch roll pole and numerator zero in the ϕ/δ_{AW} transfer function are widely separated. This means the ailerons are quite effective in exciting the Dutch roll mode. The pilot can actually compound the roll response to an external disturbance if he miscoordinates with the rudder or continues to excite the Dutch roll with the ailerons. In either case, the primary reason for the unacceptable ratings for these cases was the exaggerated aileron control motions required to counter the large rolling response generated by turbulence.

The turbulence response was equally as objectionable for the most proverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ case evaluated. In addition, there were increased complaints about the unpredictability of the basic roll control. It is evident from the transient responses shown in Appendix V that the phasing of the Dutch roll has effectively increased the apparent roll mode time constant. A root locus closure likewise indicates a lightening of the Dutch roll damping ratio as the pilot closes on bank angle with the ailerons, assuming the pilot to be a pure gain controller.

There was considerable scatter in the control sensitivities selected for these configurations, especially for the ailerons. No explanation was given by the evaluation pilot for the quite high aileron sensitivity selected for the slightly proverse aileron yaw configuration.

4.3 LOW DUTCH ROLL FREQUENCY, LOW ROLL MODE TIME CONSTANT

The results for evaluations performed at a Dutch roll frequency of 1.0 rad/sec and a roll mode time constant of 0.4 seconds are discussed in the following eight subsections.

4.3.1 Group 5 -- Low Dutch Roll Damping Ratio, Moderate $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 0.99 rad/sec $|\phi/\beta|_d$ = 1.54

ζ_d = 0.03 τ_R = 0.35 sec τ_S = 100 sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 13, and the experimental results in Figure 14.

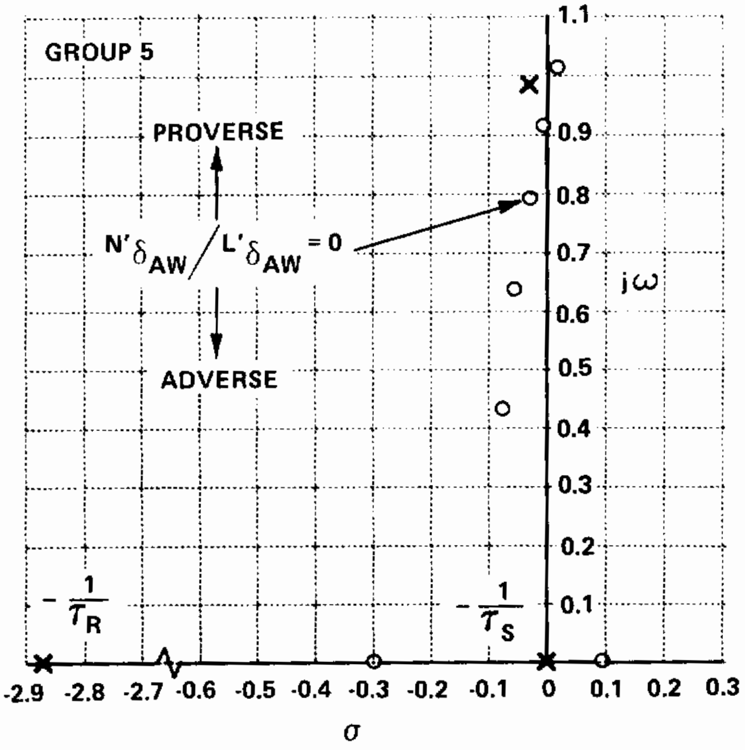


Figure 13 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 5

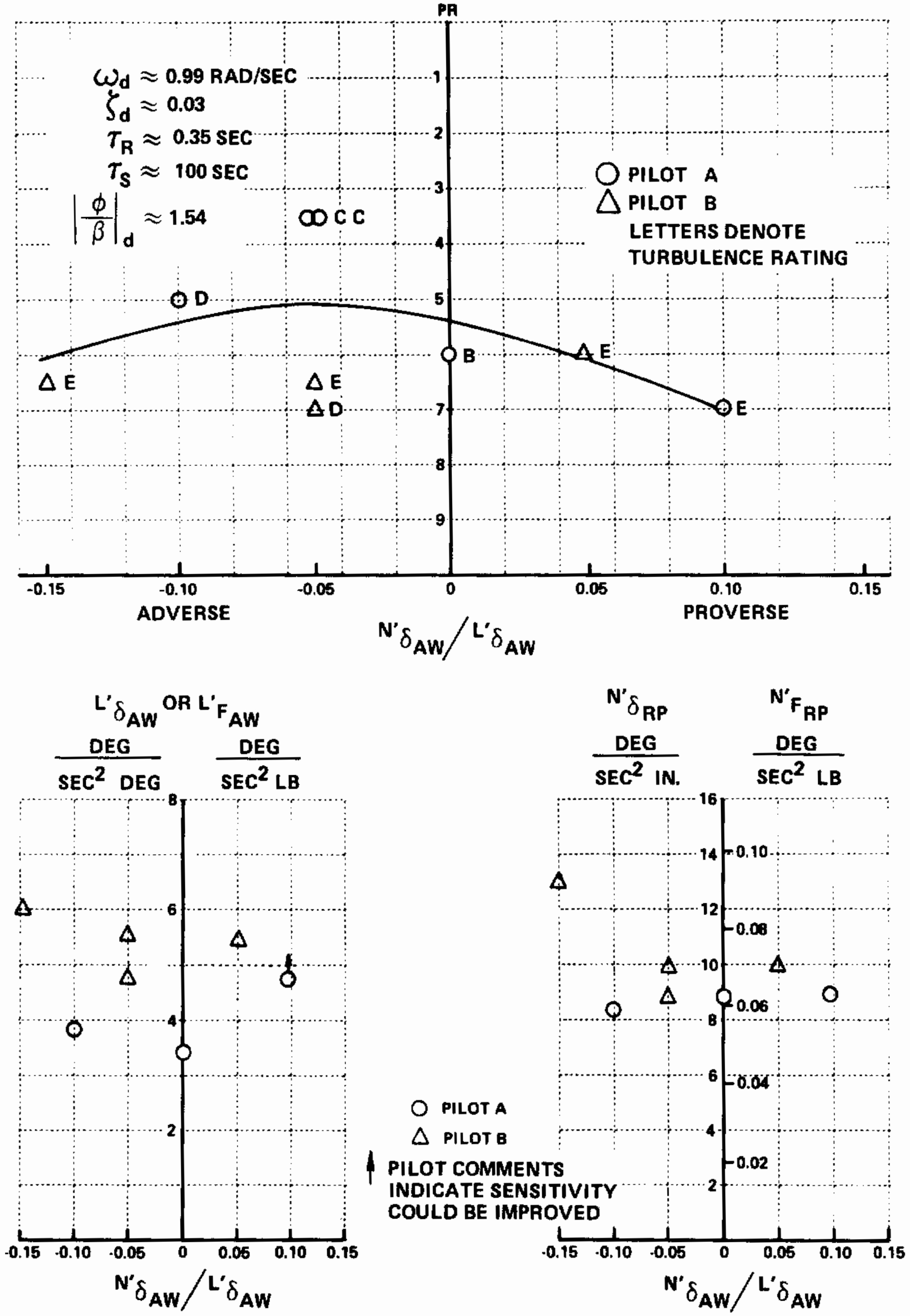


Figure 14 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 5 WHEEL CONTROL

These configurations were unsatisfactory for the landing approach at all tested values of the aileron yaw parameter, $N'_{\delta_{AW}}/L'_{\delta_{AW}}$. The optimum average pilot rating was five. From Figure 14, it is noted that the configuration with $N'_{\delta_{AW}}/L'_{\delta_{AW}} = -.05$ was twice rated as good as 3.5 and also at 6.5 and 7. This apparent discrepancy is believed to result from the pilots' assessment of the configuration's response to turbulence as indicated by the turbulence ratings accompanying the plotted pilot ratings.

There were three dominating pilot comments for all values of aileron yaw tested: (1) Coordination requirements were severe and difficult to achieve, often leading to overcontrolling with the rudder. (2) There were persistent directional oscillations which also compounded the coordination problem. (3) Response to turbulence was predominantly directional and easily excited; though slow, the nose excursions were large and difficult to control.

Reference to the time histories shown in Appendix V reveals that coordination difficulties in the most adverse aileron yaw case were caused by the large sideslip response and small bank angle response to an aileron input. The pilot commented that he would typically overcontrol with the rudder. When he tried to coordinate the large nose "hang-up" during turn initiation, the nose would swing in the opposite direction; i.e. into the turn, leading to further rudder use in attempting to zero the sideslip. As aileron yaw became more proverse, the time histories indicate that coordination should have become easier. However, as already mentioned, coordination and directional oscillations were problems at all values of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$.

If the pilot is assumed to be a simple proportional controller, a root locus closure indicates that for the proverse aileron yaw cases the pilot could actually drive the Dutch roll mode unstable by tightening his control through attempts to track bank angle more accurately and may induce bank angle oscillations. For the adverse aileron yaw cases, the pilot may actually increase the closed loop damping, hence, a reason for the optimum pilot rating occurring at a small value of adverse aileron yaw.

There was considerable variation between pilots in the selected values of $L'_{\delta_{AW}}$ The selected values of $N'_{\delta_{RP}}$ show less variation which can be attributed to the almost overwhelming coordination and directional control problems which made both pilots sensitive to rudder forces.

4.3.2 Group 6 -- Moderate Dutch Roll Damping Ratio, Moderate $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 1.00 rad/sec $|\phi/\beta|_d$ = 1.56

ζ_d = 0.11 τ_R = 0.40 sec τ_S = 100 sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 15, and the experimental results in Figures 16 and 17.

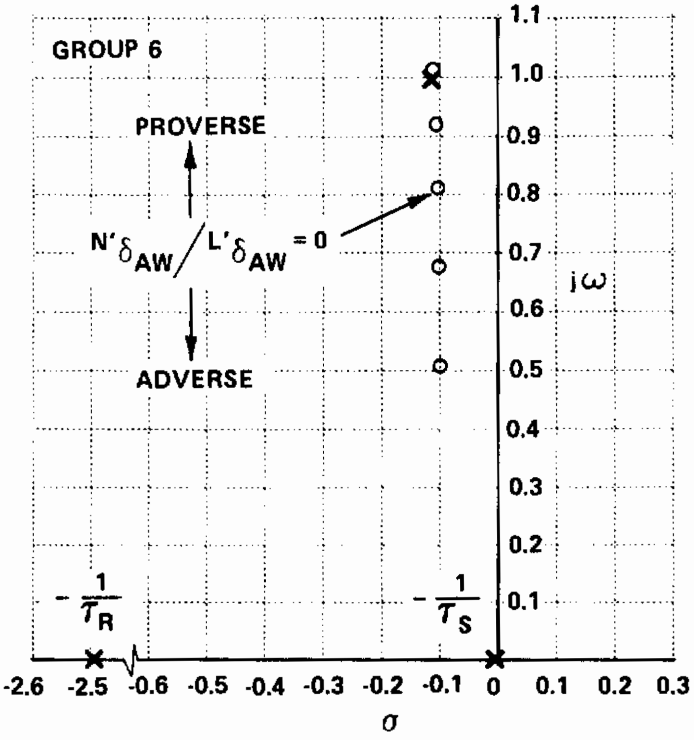


Figure 15 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 6

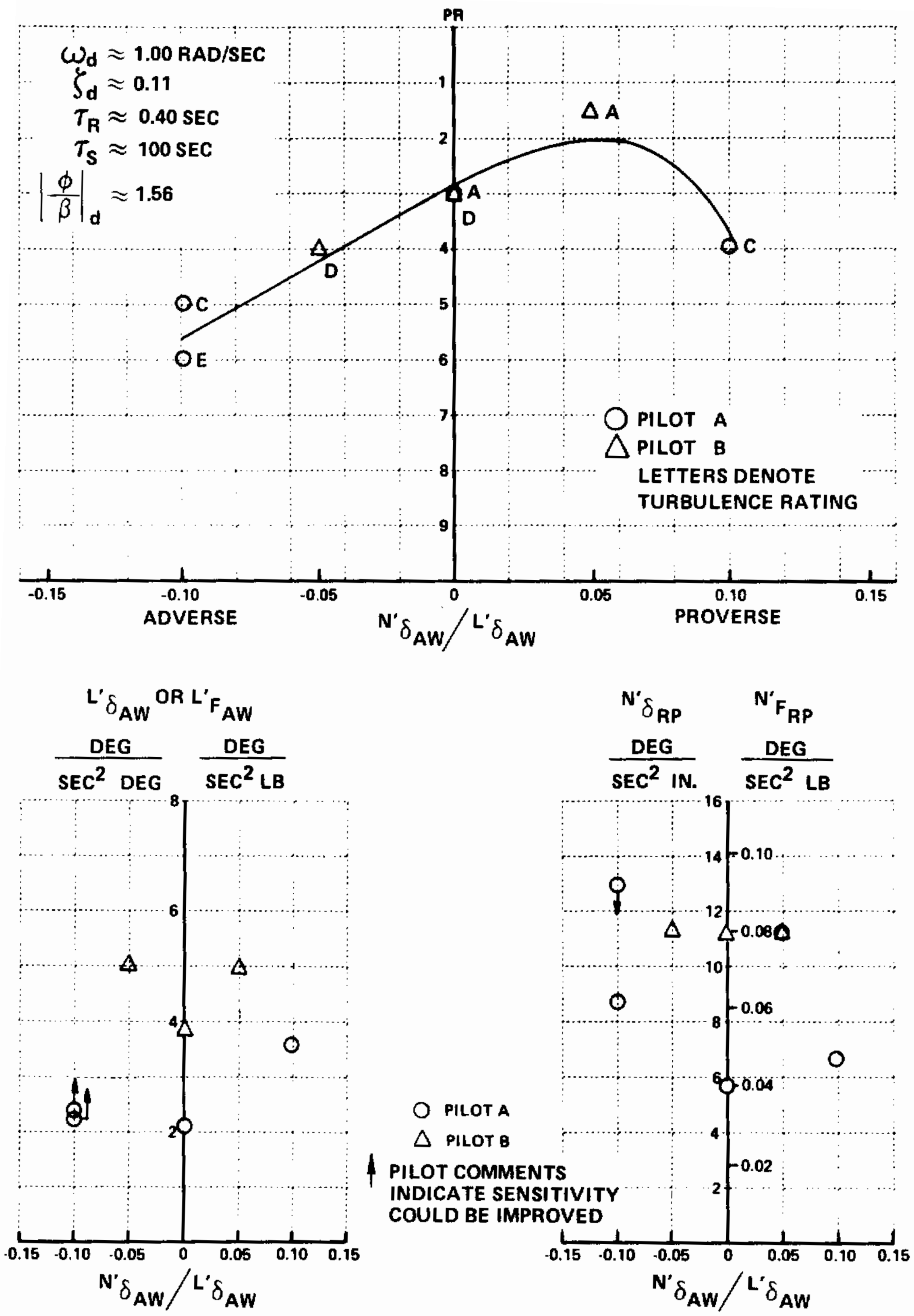


Figure 16 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 6 WHEEL CONTROLLER

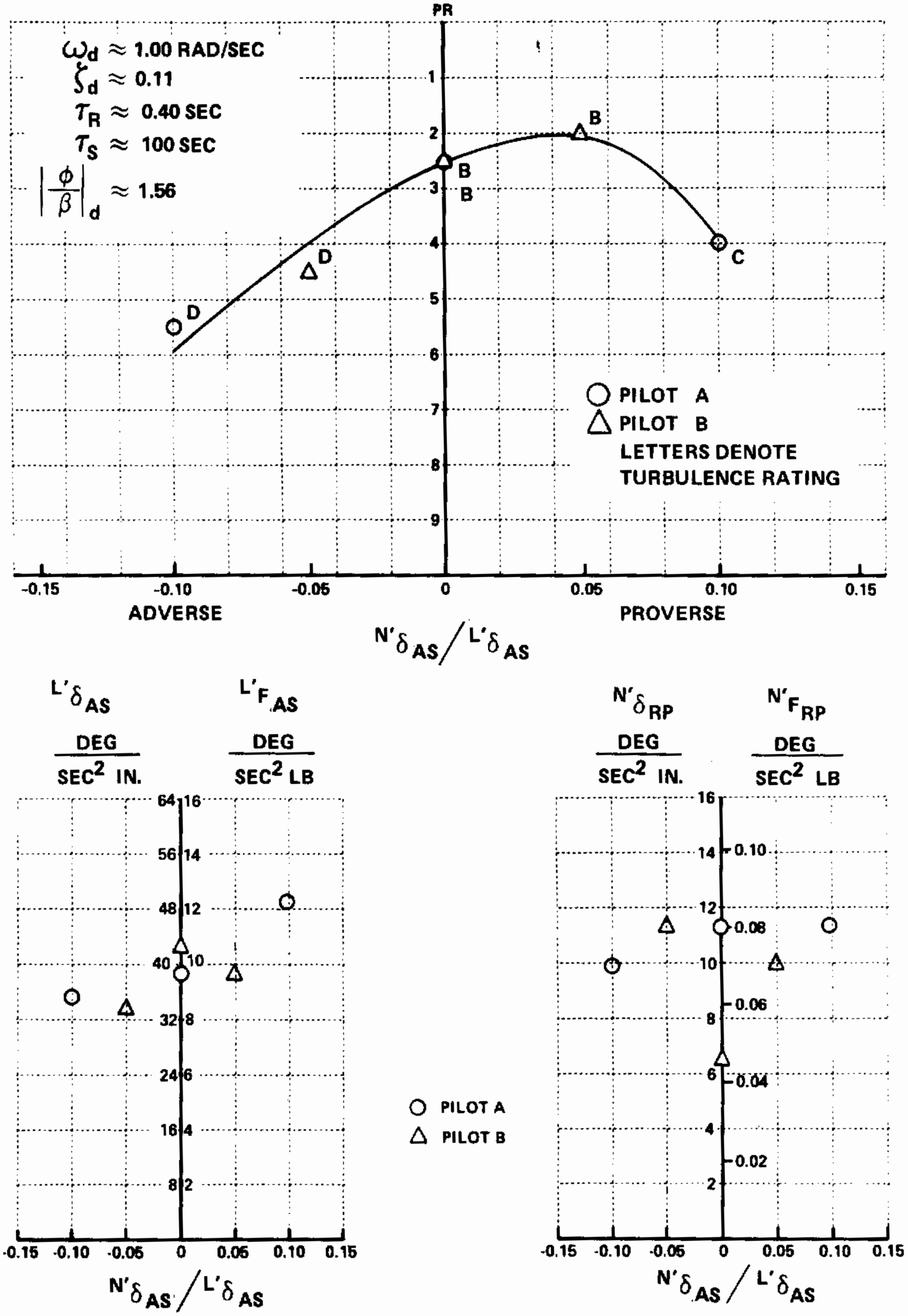


Figure 17 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 6 STICK CONTROLLER

This group was evaluated with both a stick and a wheel controller. The plots of pilot rating versus the aileron yaw parameter, $N'_{\delta_{AW}}/L'_{\delta_{AW}}$, indicate no significant differences between the ratings obtained with the two different controllers. The optimum pilot rating occurred at the small proverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ tested, where both pilots commented that the roll control was precise and predictable. Little or no turn coordination was required, but when required, it was in the normal sense, requiring rudder into the turn. Turbulence response was fast and small in magnitude causing no difficulty. Neither pilot expressed any difficulty with crosswinds.

For the most proverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ evaluated, the sideslip for an aileron input was very small, but the pilot comments indicate that there was difficulty with coordination, requiring frequent rudder use in the direction opposite the turn and a nose oscillation that continued for a considerable period of time. There was also difficulty in maintaining heading, especially in turbulence. The pilots realized that coordination was necessary and that it had to be applied in an unnatural manner. Upon turn entry, a slight amount of rudder was required in the direction opposite the turn because of the proverse aileron yaw, but as the roll rate developed, rudder into the turn was required to counteract the negative, or adverse, yaw due to roll rate, N'_p. Actual inflight records show that when the pilot was occupied with a tracking task, such as the ILS, he used the rudder in the normal manner; that is, right aileron inputs were accompanied by right rudder inputs and vice versa. In so doing he may have made the configuration appear to have even more proverse aileron yaw, thus driving the zero of the ϕ/δ_{AW} transfer function farther above the Dutch roll pole. A root locus closure indicates that if the pilot acts as a proportional controller in closing the bank angle loop, he could make the Dutch roll mode less stable. If he does, in fact, use the rudder in the normal coordination sense, he could further decrease the closed loop damping. Another objection in the most proverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ case was the response to turbulence and the difficulties it caused with directional control. It should be pointed out that although the turbulence response of the open loop airplane is independent of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$, the pilot rates the turbulence response of the closed loop pilot-airplane combination which is affected by changes in $N'_{\delta_{AW}}/L'_{\delta_{AW}}$.

In the adverse aileron yaw cases, the pilots' primary objections were the coordination difficulties and momentary heading excursions in the direction opposite to the intended turn, making small heading corrections very difficult. The time histories, Appendix IV, indicate that an aileron input resulted in a large sideslip development and initial yaw rate opposite to the turn direction.

The selection of $L'_{\delta_{AW}}$ values shows considerable scatter. In the most adverse aileron yaw case, the pilot stated that after he selected $L'_{\delta_{AW}}$, the forces and displacements were too large, indicating that his selection of sensitivity was too low. All other values selected were considered satisfactory by the pilots. It should be noted that there is a difference in the level of sensitivities selected at all values of aileron yaw by the two evaluation pilots, in that Pilot B had a definite tendency to select higher sensitivities than Pilot A. With the stick controller, there was much less scatter between the sensitivity values selected by the two evaluation pilots.

4.3.3 Group 7 -- High Dutch Roll Damping Ratio, Moderate $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 1.01 rad/sec $\quad |\phi/\beta|_d = 1.48$

ζ_d = 0.29 $\quad \tau_R$ = 0.40 sec $\quad \tau_S = \infty$ sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 18, and the experimental results in Figure 19.

Except for the extreme adverse and proverse aileron yaw cases, the evaluation pilots were pleased with the roll response and the precision with which they could maneuver. Coordination requirements were minimal, and there was no significant increase in pilot effort associated with the turbulence response. The pilot's primary objection in the most adverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ case

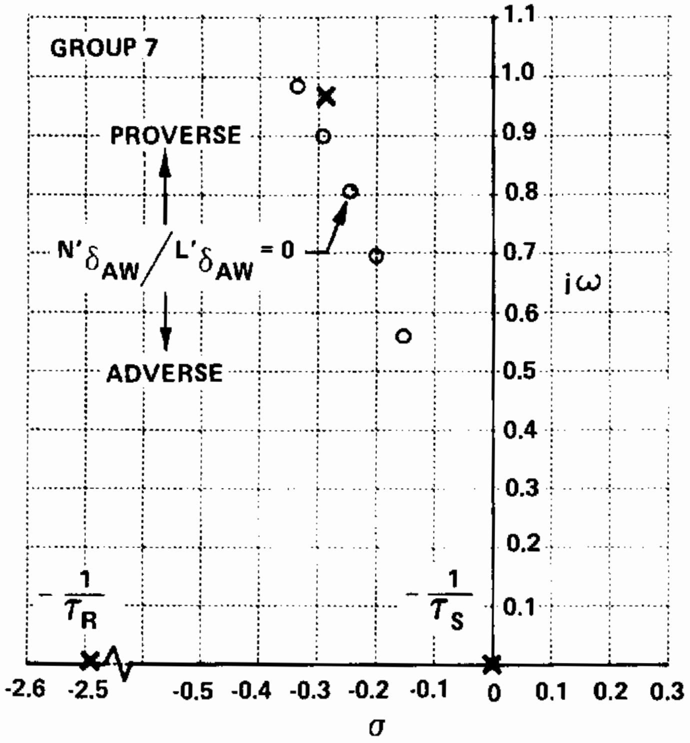


Figure 18 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 7

was the difficulty in maintaining directional control and coordinated flight. In the most proverse aileron yaw case, there was little need for coordination, but the pilot noticed that a slight amount of cross control was often necessary with the rudder. In both cases, the pilots objected to the slowness with which the airplane would return to coordinated flight after a heading disturbance.

There was considerable scatter in the selection of control sensitivities for both the aileron and rudder. Pilot B selected values at a more sensitive value than Pilot A, basing his selection on crosswind considerations and one-handed operation on the final approach. Pilot A had minor complaints about heavy aileron forces after making his selections based on normal maneuvering.

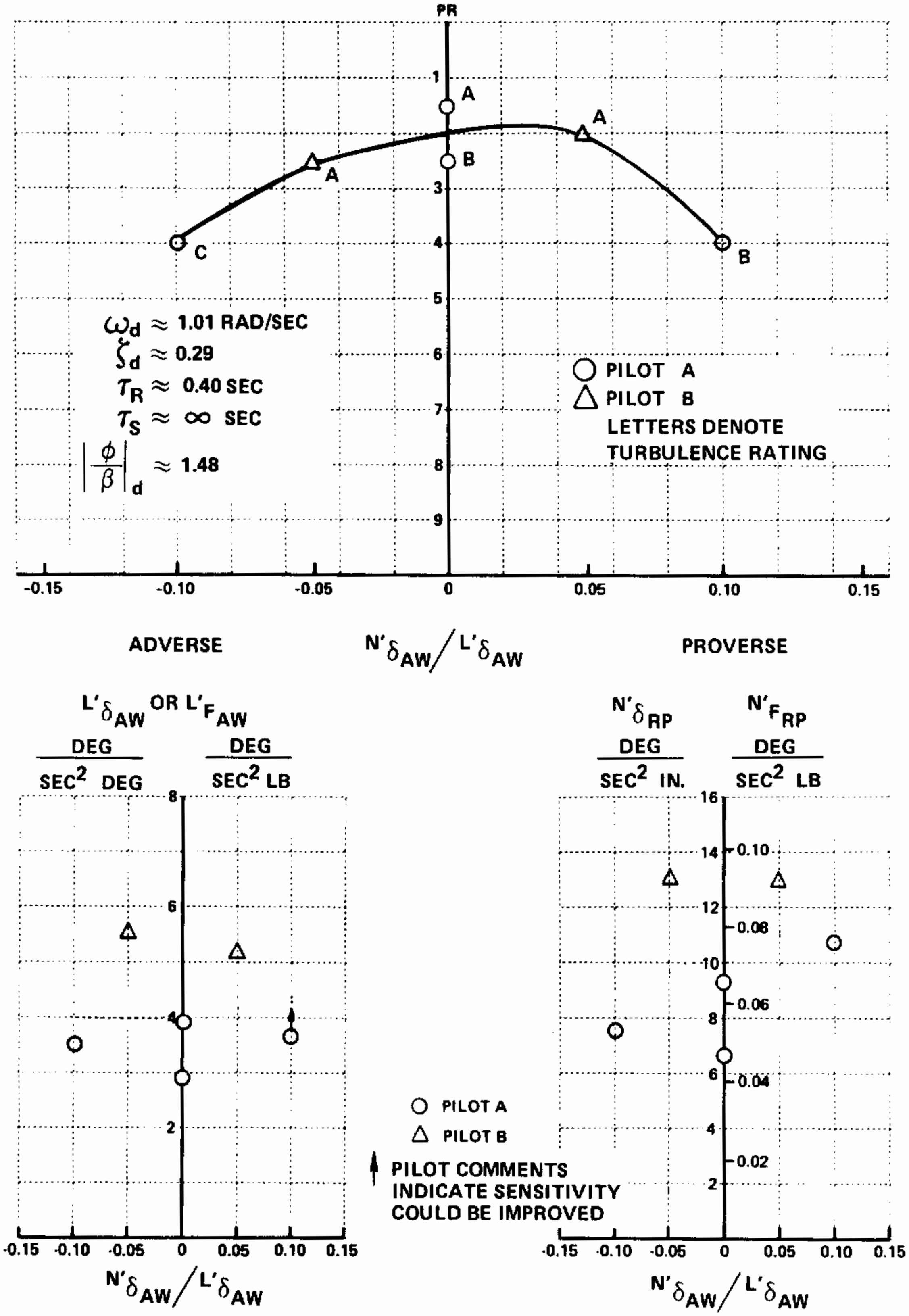


Figure 19 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 7 WHEEL CONTROLLER

4.3.4 Group 8 -- Low Dutch Roll Damping Ratio, High $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 1.04 rad/sec $|\phi/\beta|_d$ = 2.97

ζ_d = 0.031 τ_R = 0.45 sec τ_S = ∞ sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 20, and the experimental results in Figure 21.

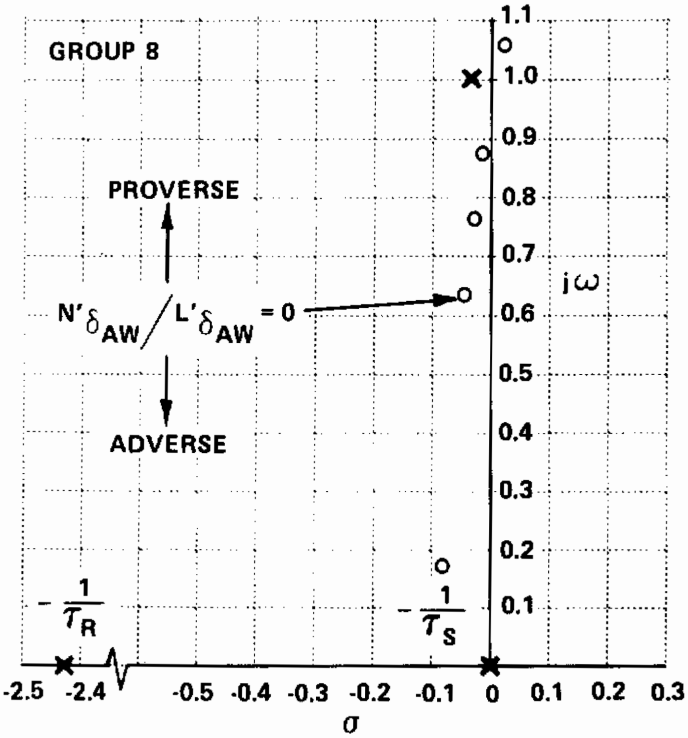


Figure 20 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 8

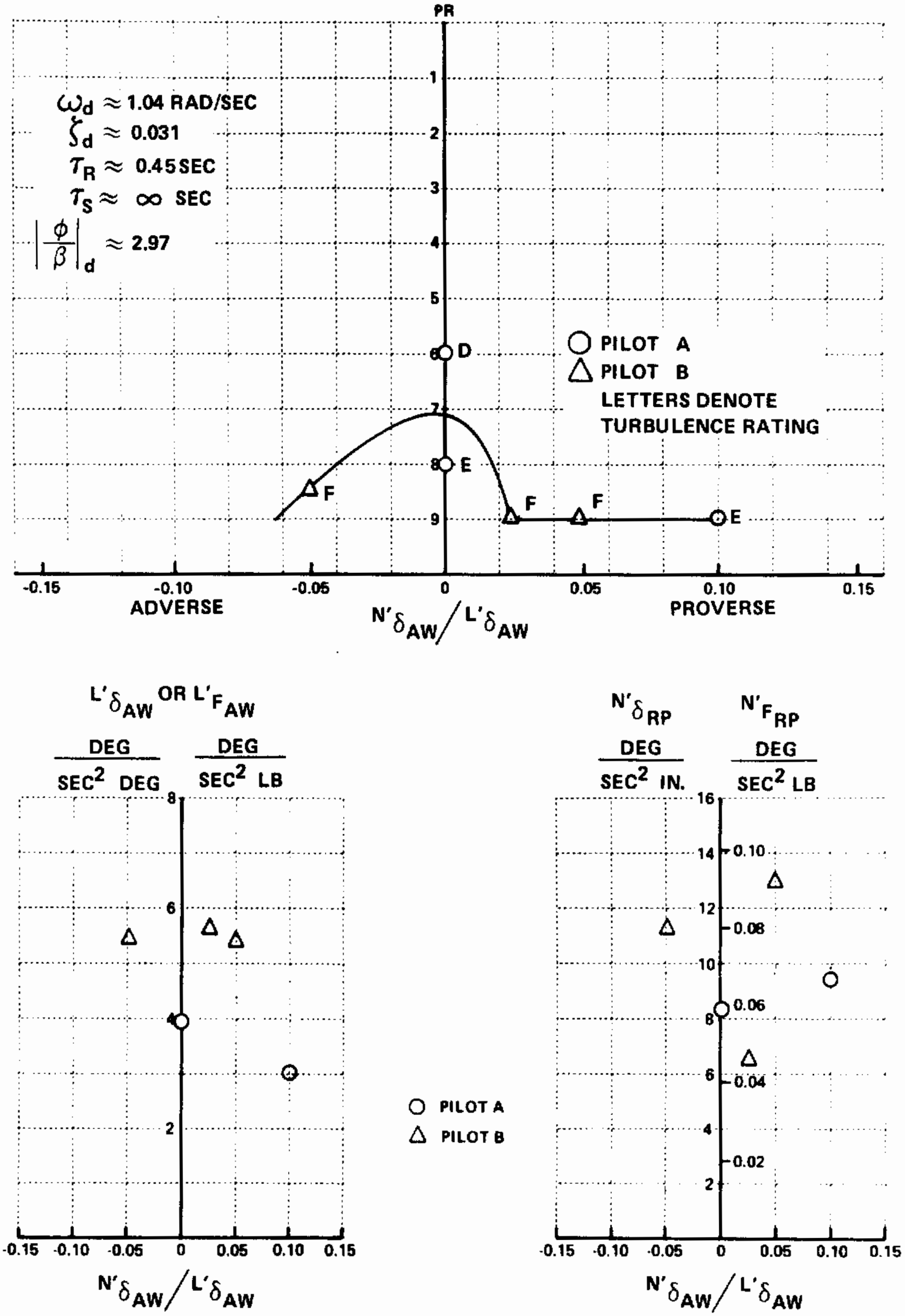


Figure 21 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 8 WHEEL CONTROLLER

The configurations in this group were unacceptable for all evaluation points. The main objections were severe coordination problems, large interaction between roll and sideslip, and difficulties with the response to turbulence. Both pilots commented that continuous rudder manipulation was required to even approach a coordinated flight maneuver and that just to control the airplane was laborious. During crosswind approaches, directional control was poor and led to difficulties in controlling bank angle because of the large roll response to small rudder inputs. The turbulence response was predominantly a sustained roll oscillation.

The control sensitivities shown reflect considerable spread between the two pilots. Pilot B based his selection on aileron forces during crosswind approaches so that he could fly with one hand. The pilot comments offered no explanation for the scatter in rudder sensitivity selections.

4.3.5 Group 9 -- Moderate Dutch Roll Damping Ratio, High $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 1.09 rad/sec $|\phi/\beta|_d$ = 3.11

ζ_d = 0.12 τ_R = 0.40 sec τ_S = ∞ sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 22, and the experimental results in Figures 23 and 24.

This group was evaluated with both a stick and a wheel controller. There were negligible differences in the ratings obtained with the different controllers. The optimum pilot ratings occurred at a quite large value of proverse aileron yaw and degraded sharply with changes in the aileron yaw parameter in either direction. None of these configurations were found to be satisfactory at any test condition.

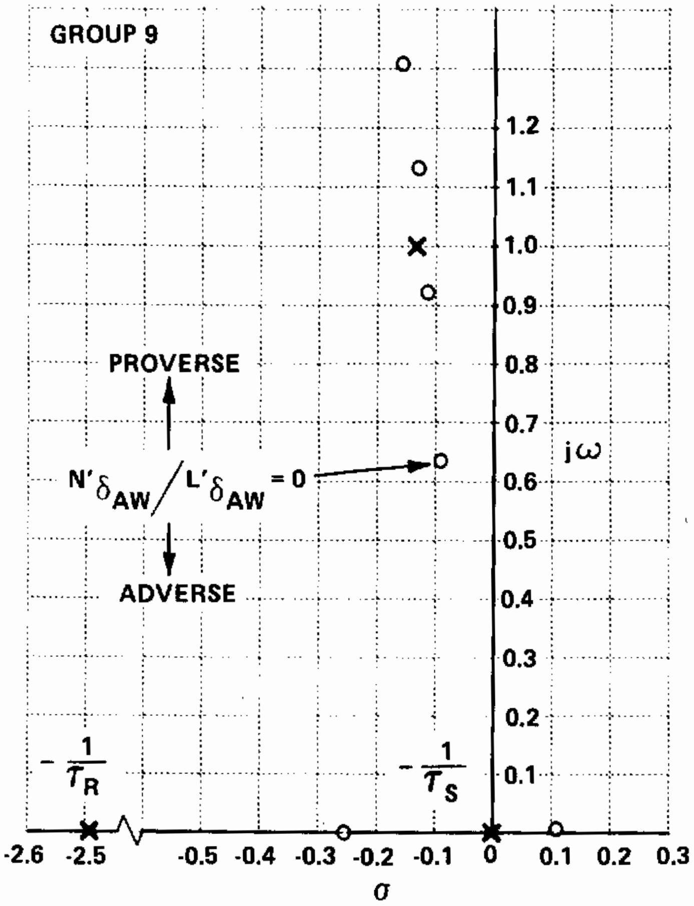


Figure 22 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 9

Near the optimum pilot rating there were moderate objections to the turbulence response, coordination requirements and trimmability. Turbulence disturbances resulted predominantly in rolling oscillations. The large roll response due to small rudder inputs complicated the coordination requirements. The pilots found it best to tolerate small sideslip angles rather than attempt precise coordination. Sideslip excursions caused variations in the aileron forces, but the roll control itself was acceptable.

Because the roll response to rudder inputs was so large, the pilots had difficulty with the crosswind approach. With the wing-down method, there was

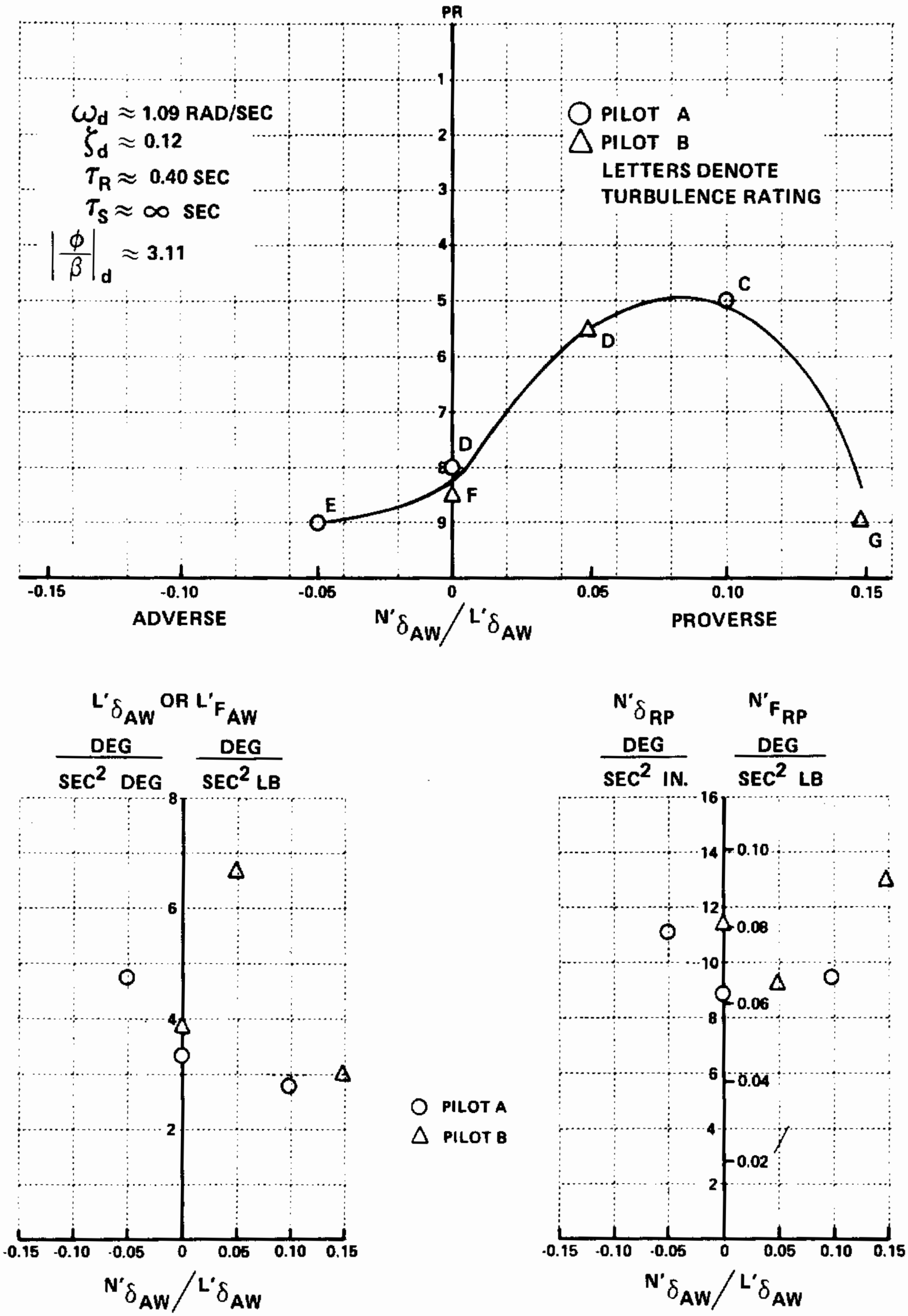


Figure 23 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 9 WHEEL CONTROLLER

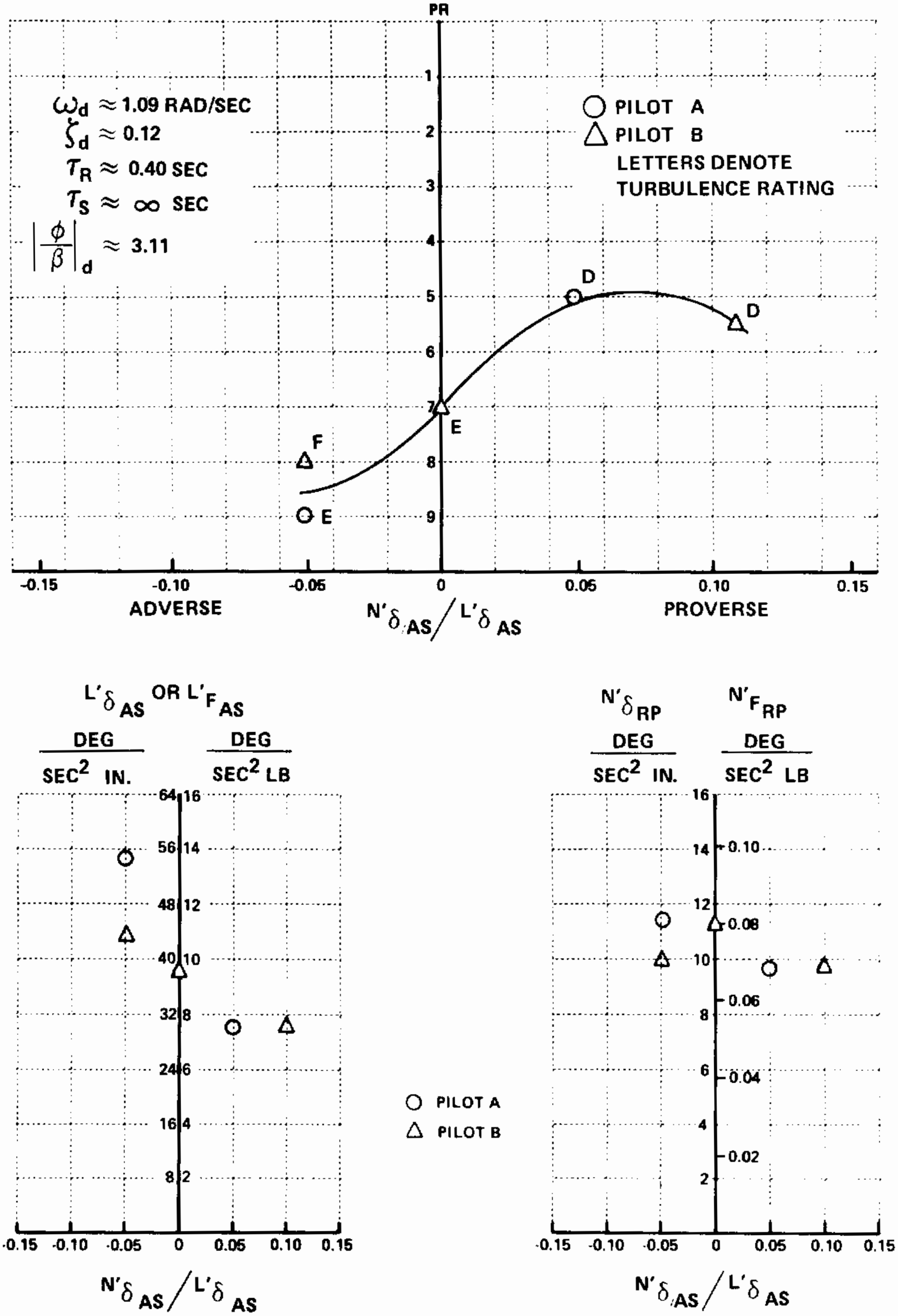


Figure 24 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 9 STICK CONTROLLER

difficulty holding the nose straight and holding the high aileron forces. With the crabbed approach method, abrupt rudder inputs required to de-crab, near the ground, produced large bank angle changes.

In the most proverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ case, which was evaluated only with the wheel, there was a tendency to overbank and for the roll rate to accelerate following an aileron input. Any rudder use resulted in such large roll rates that it had to be counteracted with large aileron inputs. From the time history for this case, Appendix V, it is obvious that the apparent roll mode time constant, τ_R, is about two seconds although the actual value of τ_R is only 0.4 seconds. This is a result of the phasing of the Dutch roll mode with roll mode, causing the bank angle to continue to accelerate and, from the pilot's point of view, producing an unpredictable roll control.

For the more adverse aileron yaw cases, the major complaints were also the result of the large roll-to-sideslip ratio. Pilot comments indicate that it was imperative to keep the sideslip near zero by rudder use, and it required constant attention. As a result, the required coordination was very difficult to achieve. Turbulence compounded the coordination problem.

With the exception of one point, the selection of control sensitivities followed a very definite trend. Generally there was a compromise in that aileron sensitivities were selected to provide high enough forces to prevent inadvertent inputs and overcontrol in normal maneuvering but this resulted in heavy forces in turbulence and during crosswind approaches.

4.3.6 Group 10 -- High Dutch Roll Damping Ratio, High $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

$\omega_d = 1.03$ rad/sec $\quad |\phi/\beta|_d = 2.90$

$\zeta_d = 0.25 \quad \tau_R = 0.40$ sec $\quad \tau_s = \infty$ sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 25 and the experimental results in Figure 26.

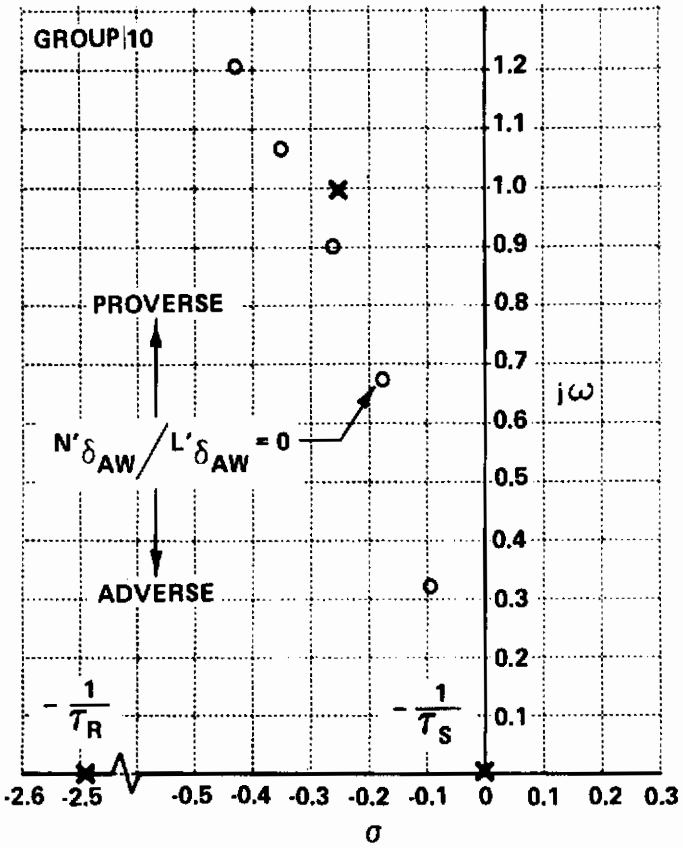


Figure 25 $\frac{\phi}{\delta_{AW}}$ **POLE-ZERO LOCATIONS FOR GROUP 10**

This group was marginally satisfactory for most test points. From the optimum pilot rating, the pilot ratings degraded very rapidly for increases in aileron yaw in the adverse direction. For increases in the proverse direction, the configuration remained marginally satisfactory at best. Near the optimum rating, the pilots liked the roll control. It was predictable and there was no tendency to overcontrol. They had no difficulties with the cross-wind approach and found the overall maneuverability good. There was some objection to the turbulence response where small excursions in sideslip were accompanied by large rolling motions. Coordination required constant rudder into the turn. This too was found somewhat objectionable since small rudder inputs produced large roll rates in the direction of the turn.

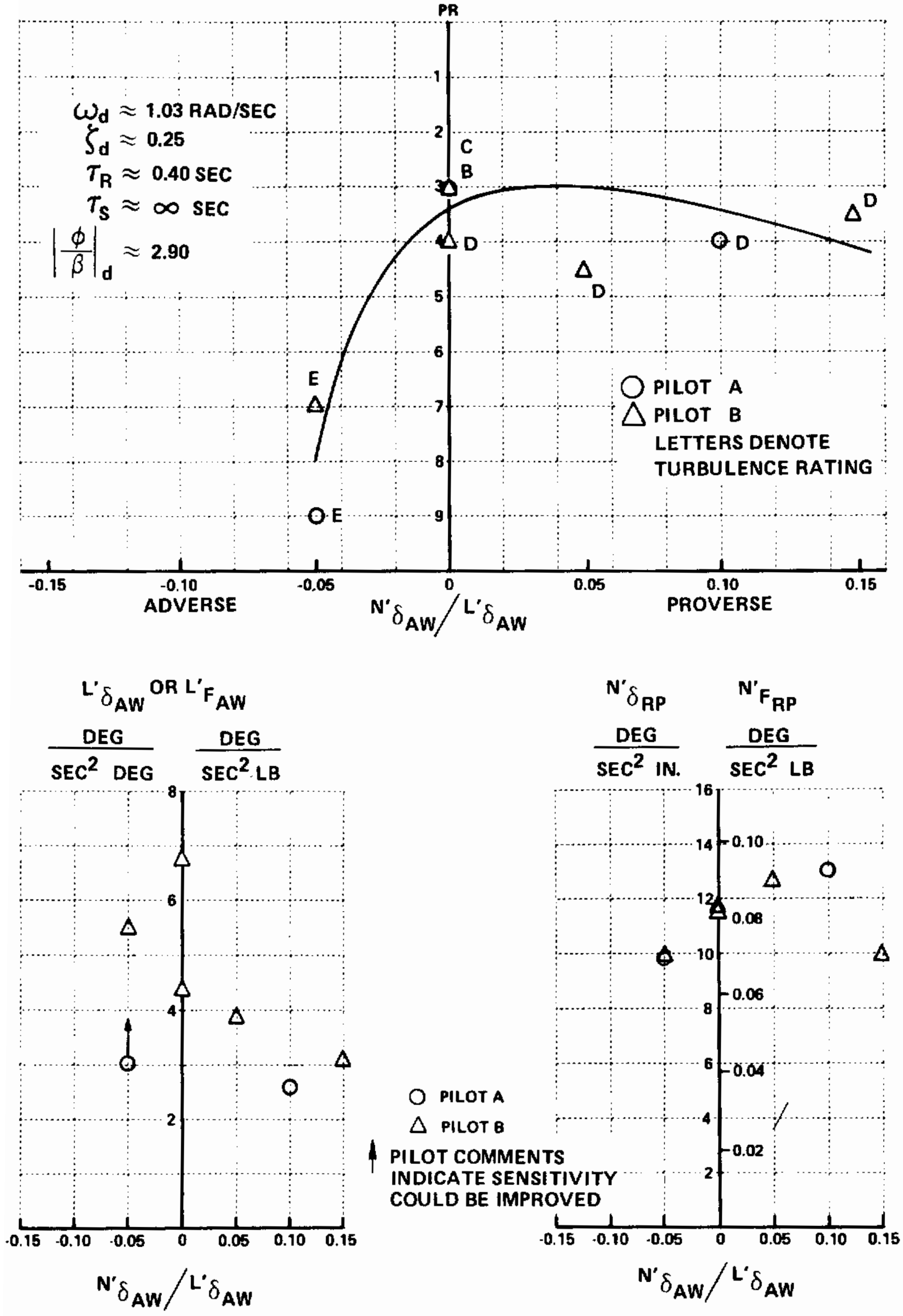


Figure 26 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 10 WHEEL CONTROLLER

In the most adverse aileron yaw case, coordination was very difficult. There was little tendency toward any oscillations; however, the nose appeared to diverge slowly to one side and would have to be returned with rudder, then it would begin going in the other direction. With the high $|\phi/\beta|_d$, rudder inputs had to be accompanied by large aileron inputs in the opposite direction.

Control sensitivity selections show considerable scatter for both the ailerons and rudder.

4.3.7 Group 11 -- Moderate Dutch Roll Damping Ratio, Low $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 0.98 rad/sec $|\phi/\beta|_d = 0.24$

ζ_d = 0.11 τ_R = 0.40 sec $\tau_S = \infty$ sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 27, and the experimental results in Figures 28 and 29.

This group was evaluated with both the wheel and the stick controllers. The optimum pilot ratings for both controllers occurred at a moderately proverse value of the aileron yaw parameter. There is a negligible difference in the pilot ratings obtained with the different controllers.

For these configurations, the pilots found that the roll control was good. The response was smooth and predictable, and there was no tendency to overcontrol. Except for the most adverse aileron yaw cases, coordination requirements were minimal. A little rudder helped to be more precise, but the airplane could be maneuvered very well without the use of rudder. The major objection to the most adverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ configurations was the large sideslip excitation following an aileron input which caused coordination difficulties and yawing oscillations. Neither pilot expressed any difficulty with any of

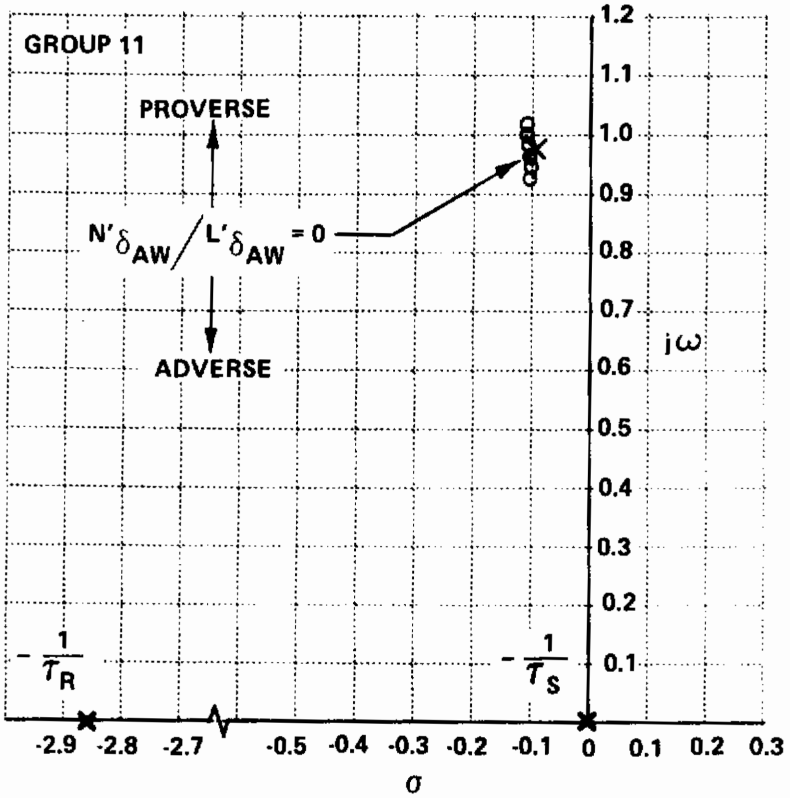


Figure 27 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 11

the configurations in coping with crosswinds and either method could be used with equal success. A minor objection was that the response to turbulence was largely a snaking oscillation of the nose, a result of the low dihedral effect, but it did not affect the pilot's ability to maintain heading.

Control sensitivity selections show fairly consistent trends. For the aileron wheel control sensitivities, the two selections which are obviously low resulted in pilot complaints about high wheel forces.

4.3.8 Group 12 -- High Dutch Roll Damping Ratio, Low $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 0.98 rad/sec $|\phi/\beta|_d$ = 0.24

ζ_d = 0.34 τ_R = 0.40 sec τ_s = ∞ sec

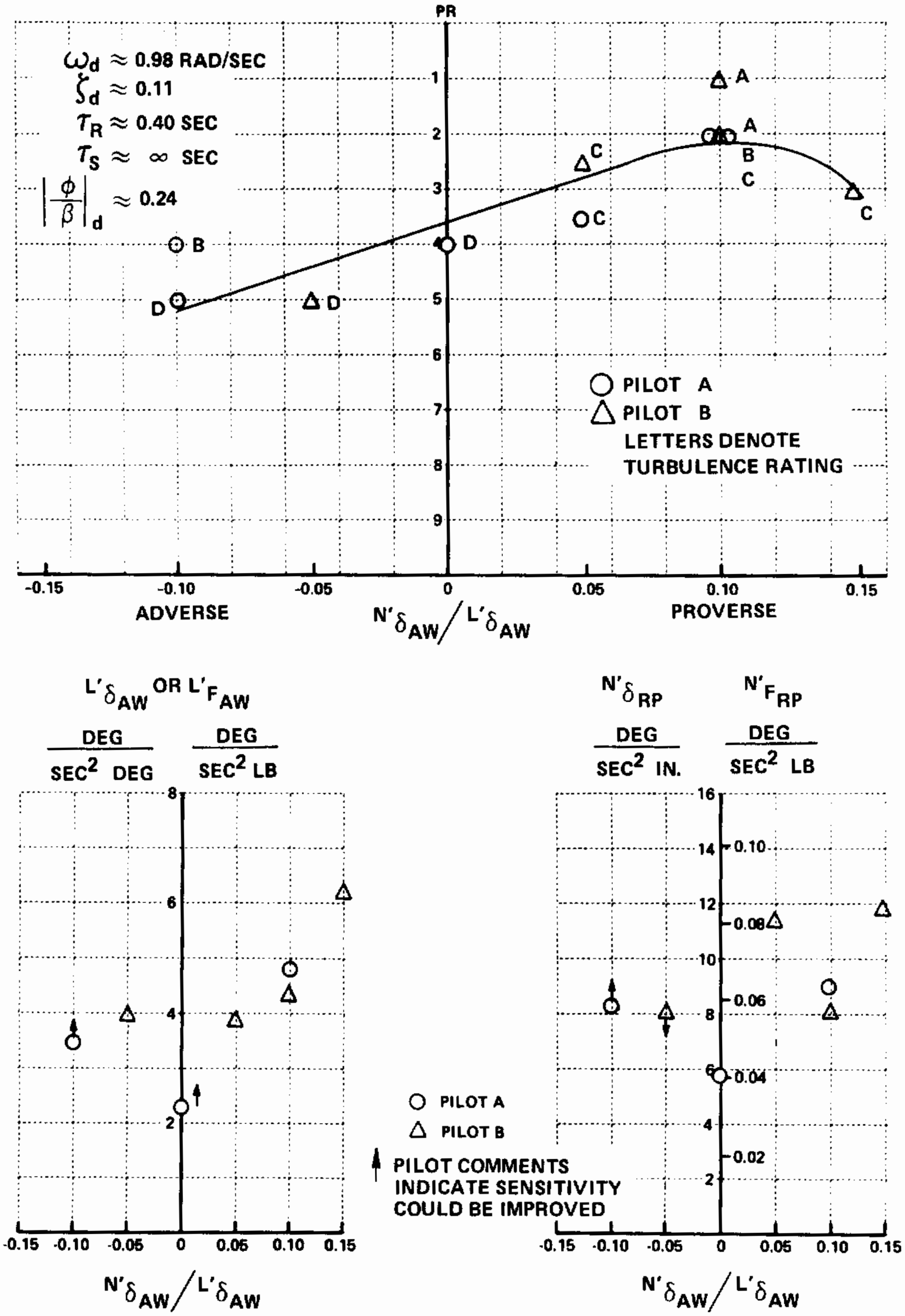


Figure 28 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 11 WHEEL CONTROLLER

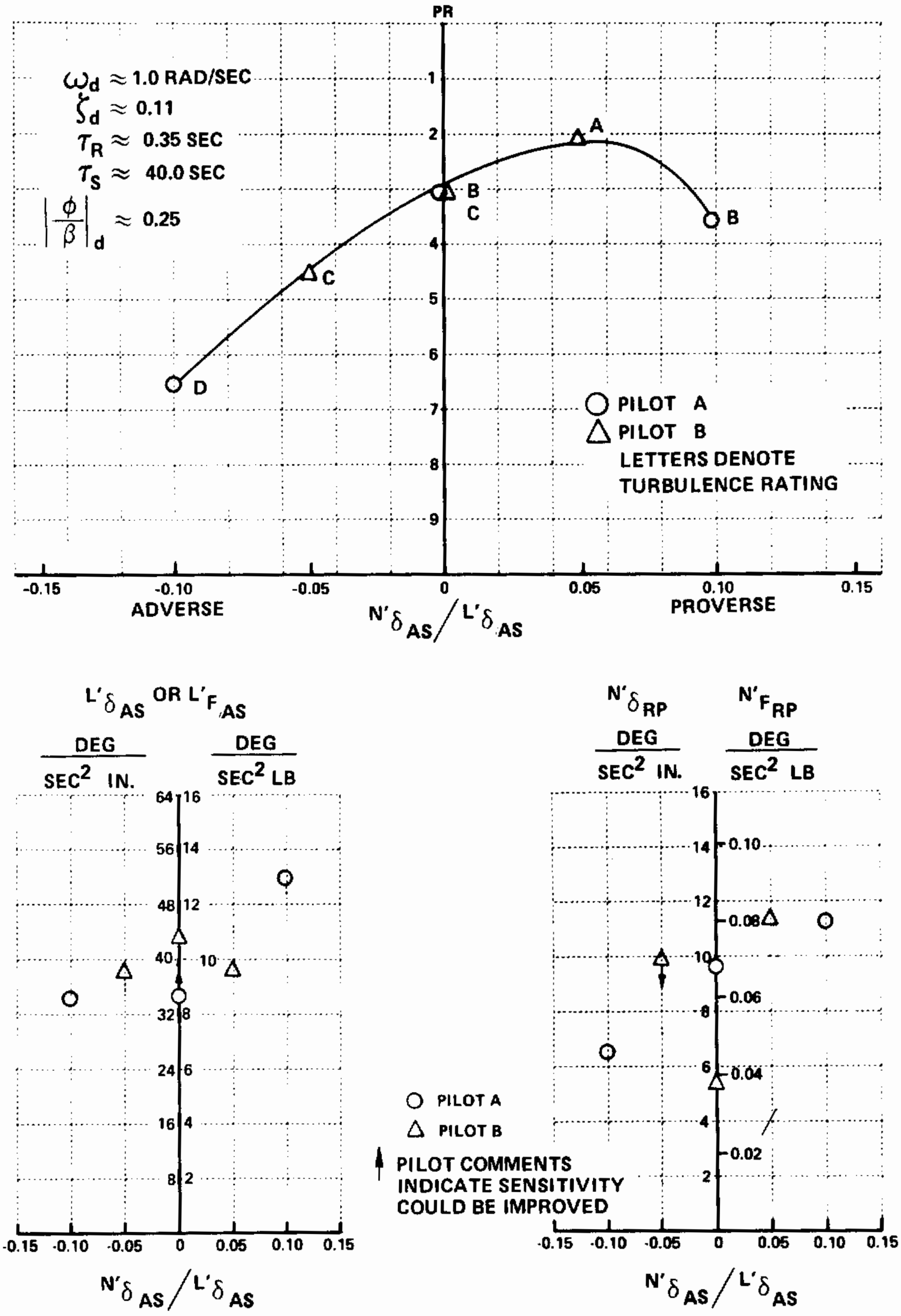


Figure 29 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 11 STICK CONTROLLER

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 30, and the experimental results in Figure 31.

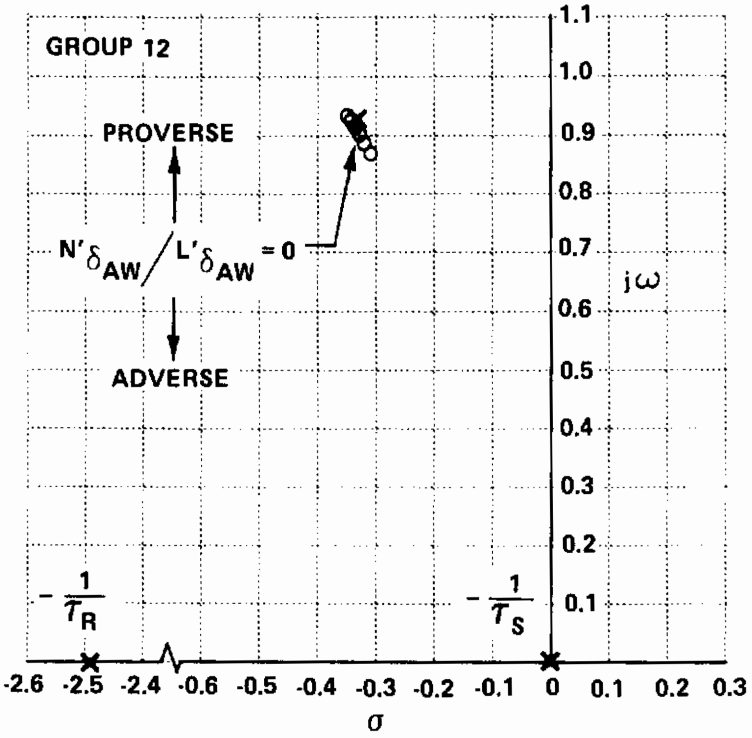


Figure 30 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 12

The pilots liked the smooth responsive roll control. Small heading corrections were easily accomplished. Directional and roll responses seemed to be separated, so there was little effect in roll from rudder use. Neither pilot expressed any difficulties with the crosswind approach. There was a small increase in pilot workload in turbulence, but it did not degrade pilot performance. For the case with the largest value of adverse aileron yaw, coordination was required, but it didn't have to be precise and was easily accomplished. In the most proverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ case, the pilot found the airplane highly desirable and reported no objections.

There was considerable difference in the selection of aileron control sensitivities between the two pilots; however, the pilot comments do not indicate that any compromises were involved; all selections were satisfactory.

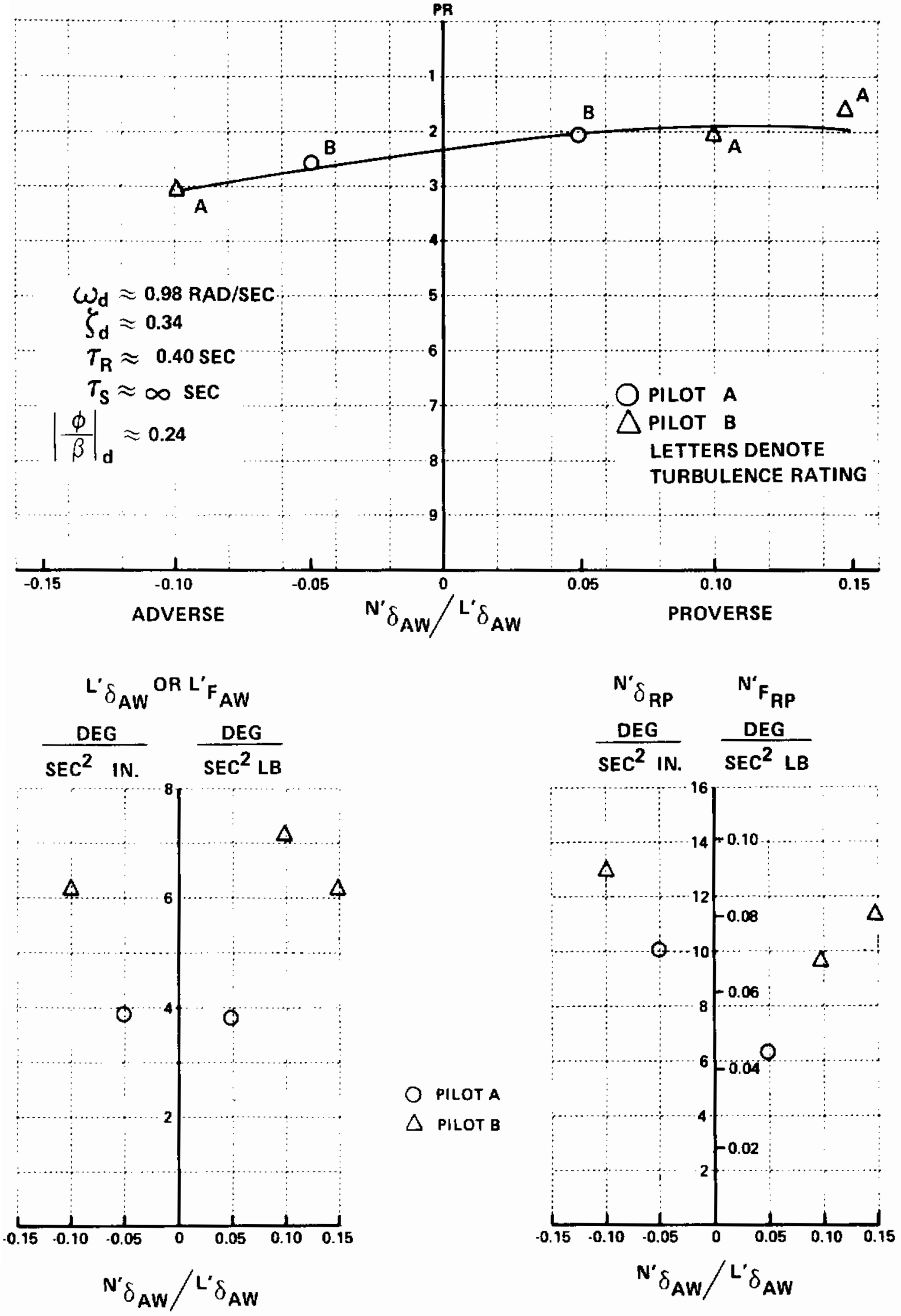


Figure 31 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 12 WHEEL CONTROLLER

4.4 LOW DUTCH ROLL FREQUENCY, MODERATE DUTCH ROLL DAMPING RATIO, MODERATE ROLL MODE TIME CONSTANT

The results for evaluations performed at a Dutch roll frequency of 1.0 rad/sec, a Dutch roll damping ratio of 0.1, and a roll mode time constant of 1.0 second are discussed in the following three subsections.

4.4.1 Group 13 - Moderate Roll Mode Time Constant, Low $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

$$\omega_d = 1.00 \text{ rad/sec} \quad |\phi/\beta|_d = 0.31$$

$$\zeta_d = 0.099 \quad \tau_R = 0.95 \text{ sec} \quad \tau_S = \infty \text{ sec}$$

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 32, and the experimental results in Figure 33.

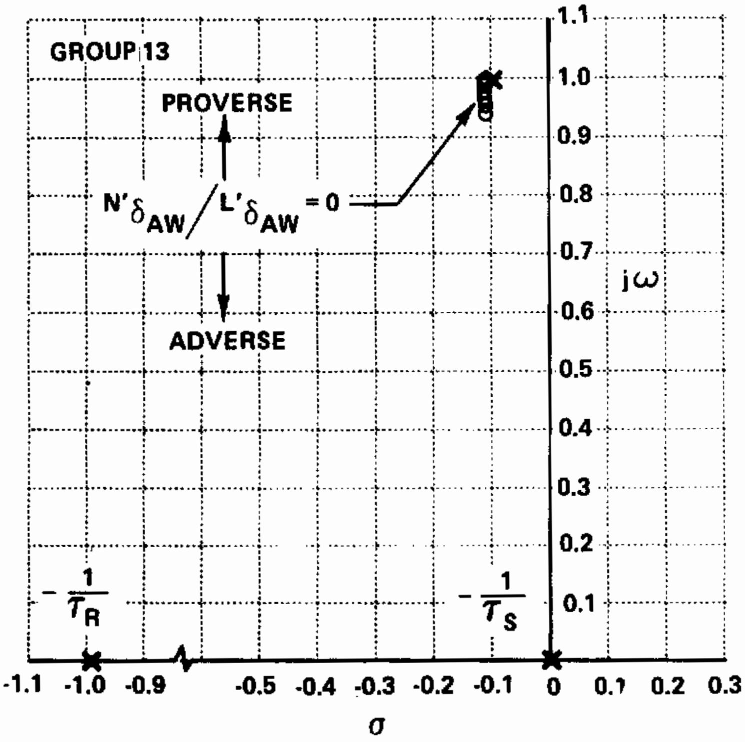


Figure 32 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 13

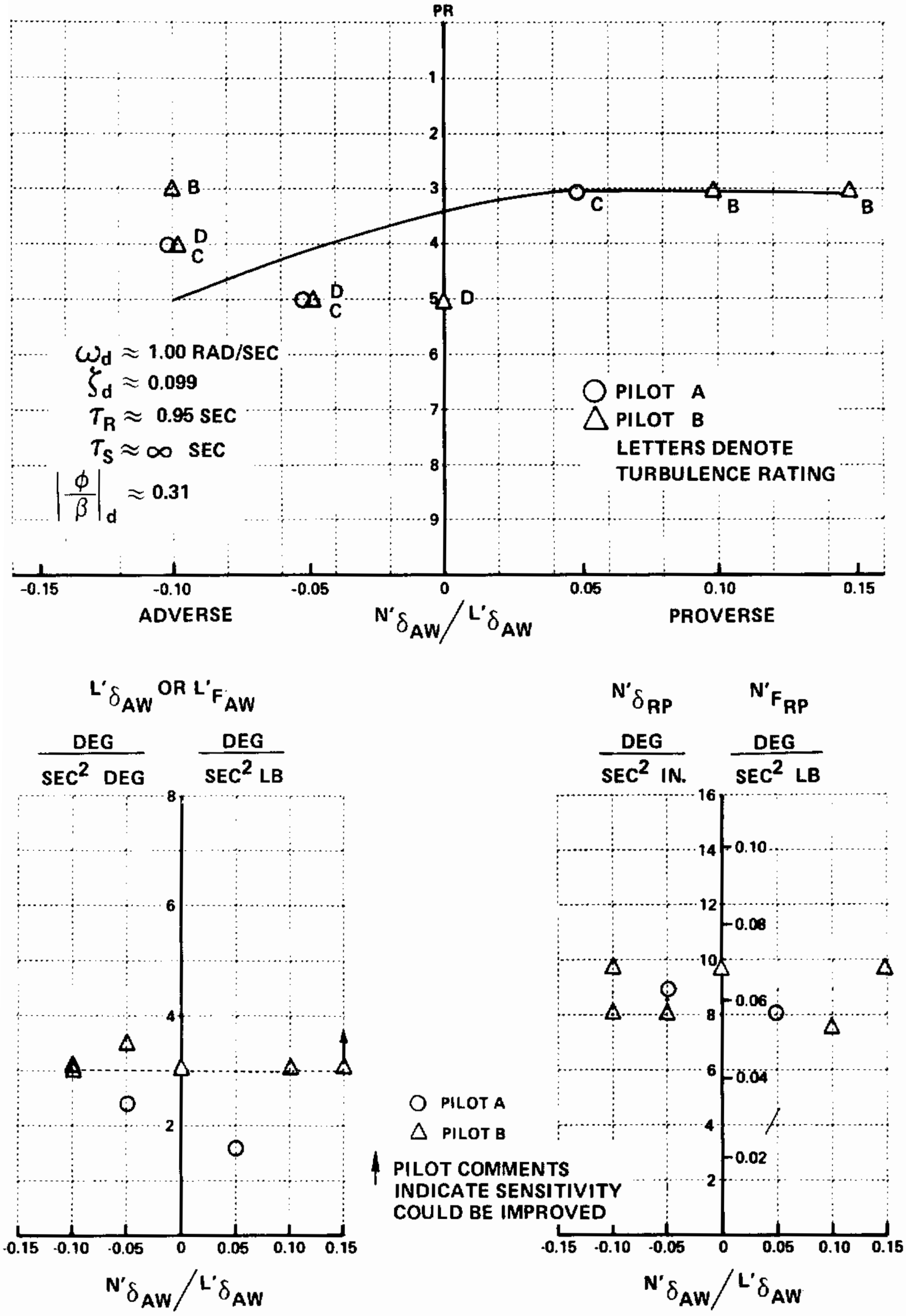


Figure 33 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 13 WHEEL CONTROLLER

In general, the pilots liked the smoothness and responsiveness of the roll control. Pilot B reported, however, a mild tendency to overcontrol in bank angle and that, on occasion, the airplane felt as if it were "taking off just a bit" in roll.

The low roll-to-sideslip ratio of the Dutch roll mode presented an interesting but possibly explainable variation in pilot rating as a function of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$. The zero and slightly adverse yaw due to aileron configurations are rated worse (one to two pilot ratings) than the most adverse aileron yaw case that was evaluated. For the most adverse $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ case, the initial nose displacement was quite opposite to the turn, but coordination was relatively easy and natural. For the zero and slightly adverse aileron yaw cases, coordination was required, but difficult to achieve, occasionally leading to overcontrolling tendencies. The conclusion was that it was best not to coordinate these configurations and just accept the resulting sideslip oscillations. Since the pilots were given the opportunity to select the rudder sensitivity, it would seem a simple matter to decrease the rudder sensitivity for these cases and to eliminate the overcontrolling tendencies. This was not possible, however, because the crosswind requirements dictated the desired rudder sensitivities. Although the rudder sensitivity selections, Figure 33, were quite consistent, Pilot A selected lower aileron sensitivities than Pilot B.

The turbulence response for these configurations was primarily in sideslip, requiring a conscientious effort by the pilot to suppress the resulting oscillations with the rudder. For the crosswind approaches, the crabbed technique was preferred by Pilot A and the wing-down method by Pilot B. Pilot B commented that he felt uncomfortable kicking out large crab angles near the ground with this configuration.

4.4.2 Group 14 - Moderate Roll Mode Time Constant, Moderate $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

$$\omega_d = 1.01 \text{ rad/sec} \quad |\phi/\beta|_d = 1.53$$
$$\zeta_d = 0.10 \quad \tau_R = 1.10 \text{ sec} \quad \tau_S = \infty \text{ sec}$$

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 34, and the experimental results in Figures 35 and 36.

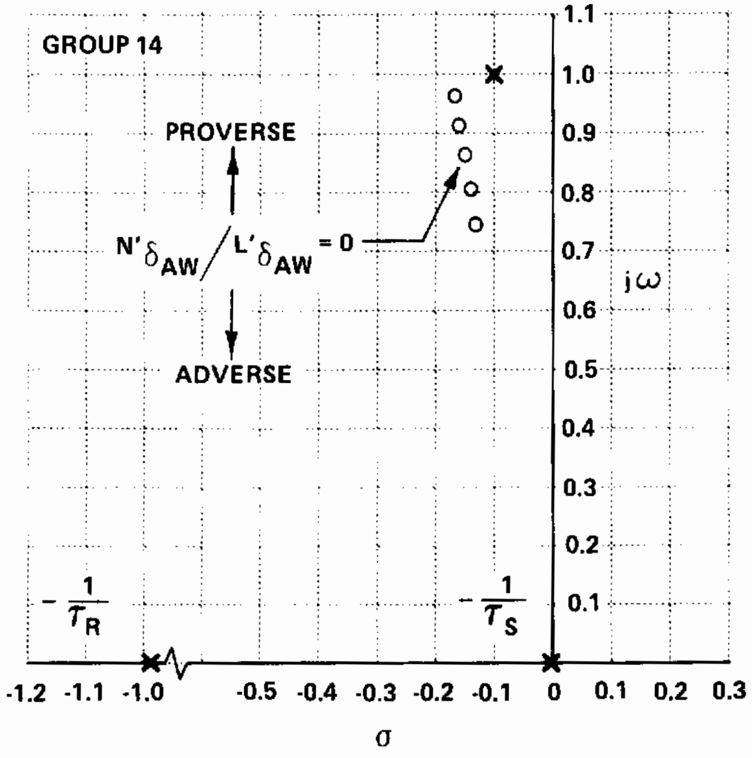


Figure 34 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 14

These configurations were evaluated with both the wheel and stick controller. The overall lateral-directional handling qualities of this group of configurations were considered to be quite good. Both pilots noted a small tendency to overshoot in bank angle but considered the roll control satisfactory. Pilot A commented that the airplane was slow to respond initially to an aileron input. The roll control, for the most adverse aileron yaw case evaluated, was considered unpredictable.

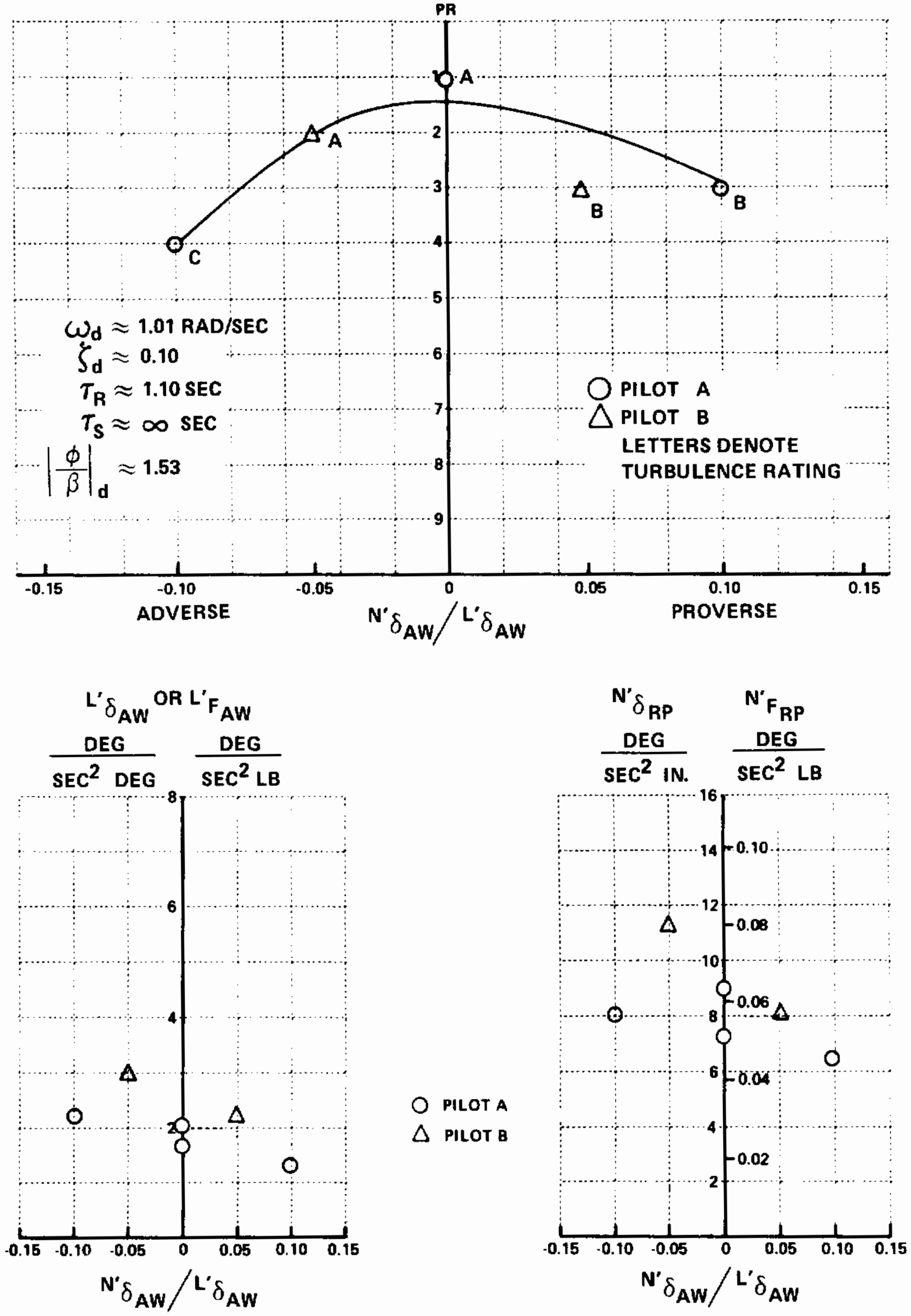


Figure 35 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 14 WHEEL CONTROLLER

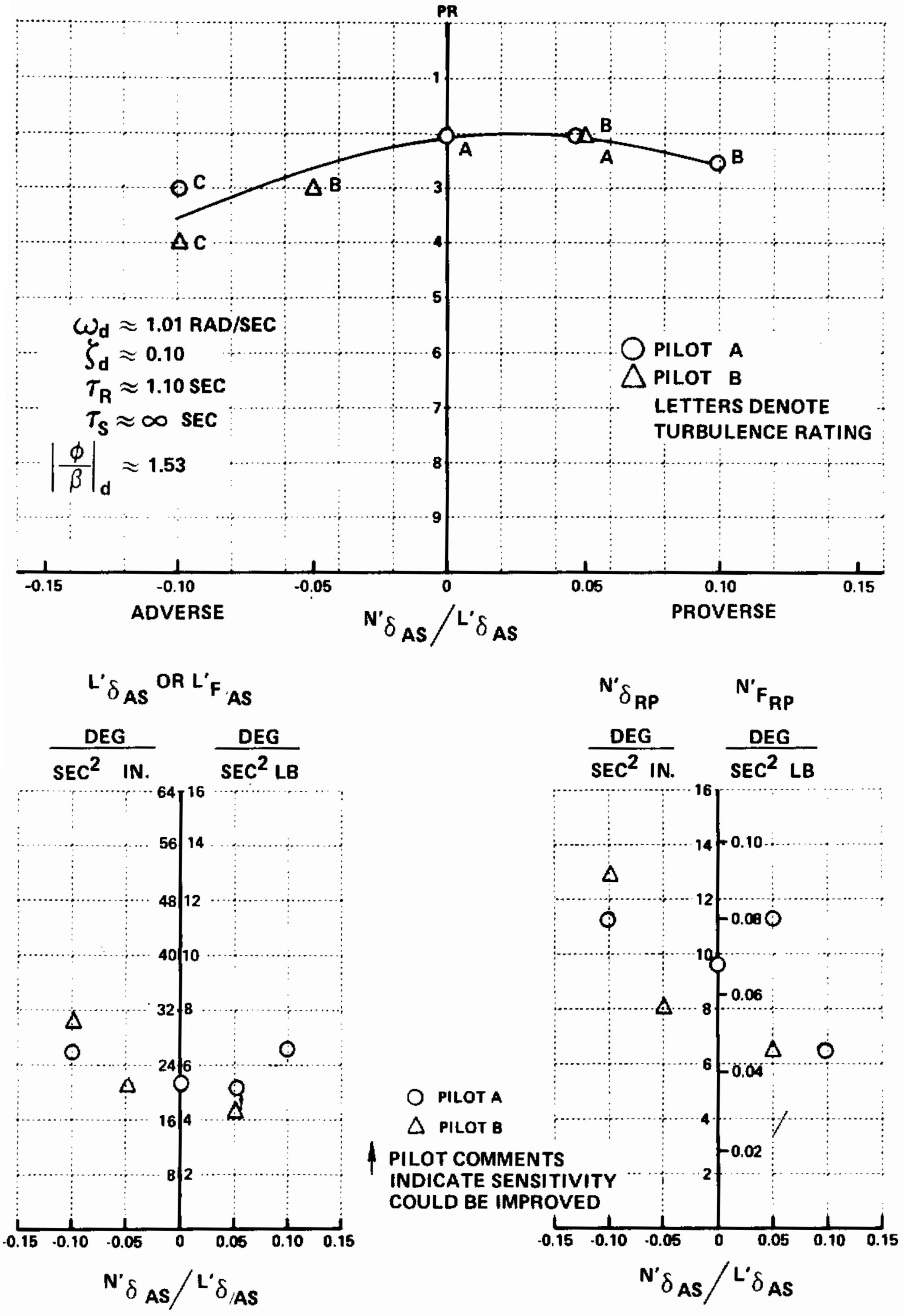


Figure 36 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 14 STICK CONTROLLER

The effects of turbulence were noticeable, but did not significantly deteriorate the handling qualities. Likewise, the crosswind approaches were easily accomplished and presented no particular problems. Both pilots were consistent in their selection of aileron control sensitivities.

4.4.3 Group 15 - Moderate Roll Mode Time Constant, High $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 1.13 rad/sec $\quad |\phi/\beta|_d = 3.50$

ζ_d = 0.09 $\quad \tau_R$ = 0.95 sec $\quad \tau_s = \infty$ sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 37, and the experimental results in Figure 38.

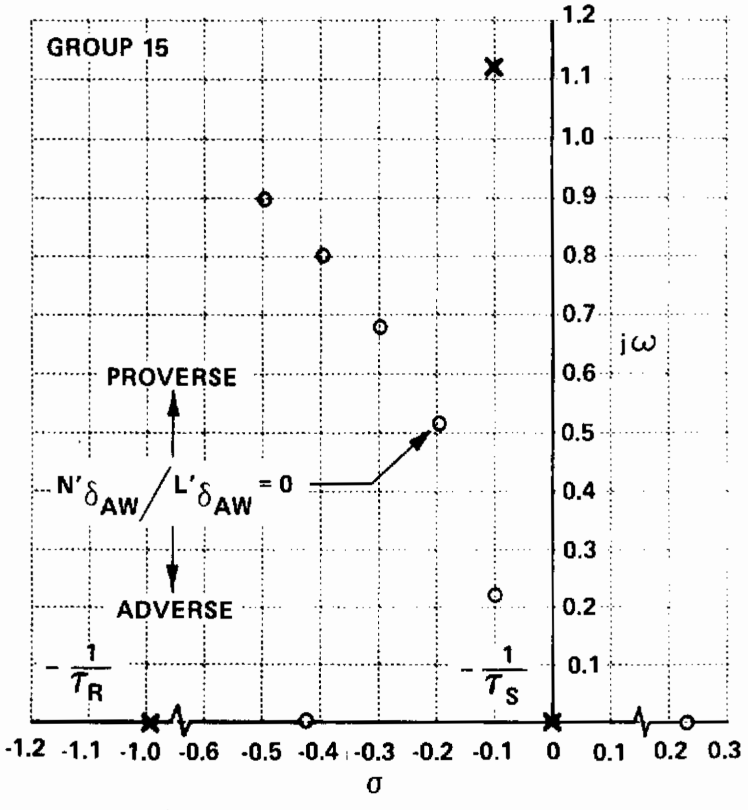


Figure 37 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 15

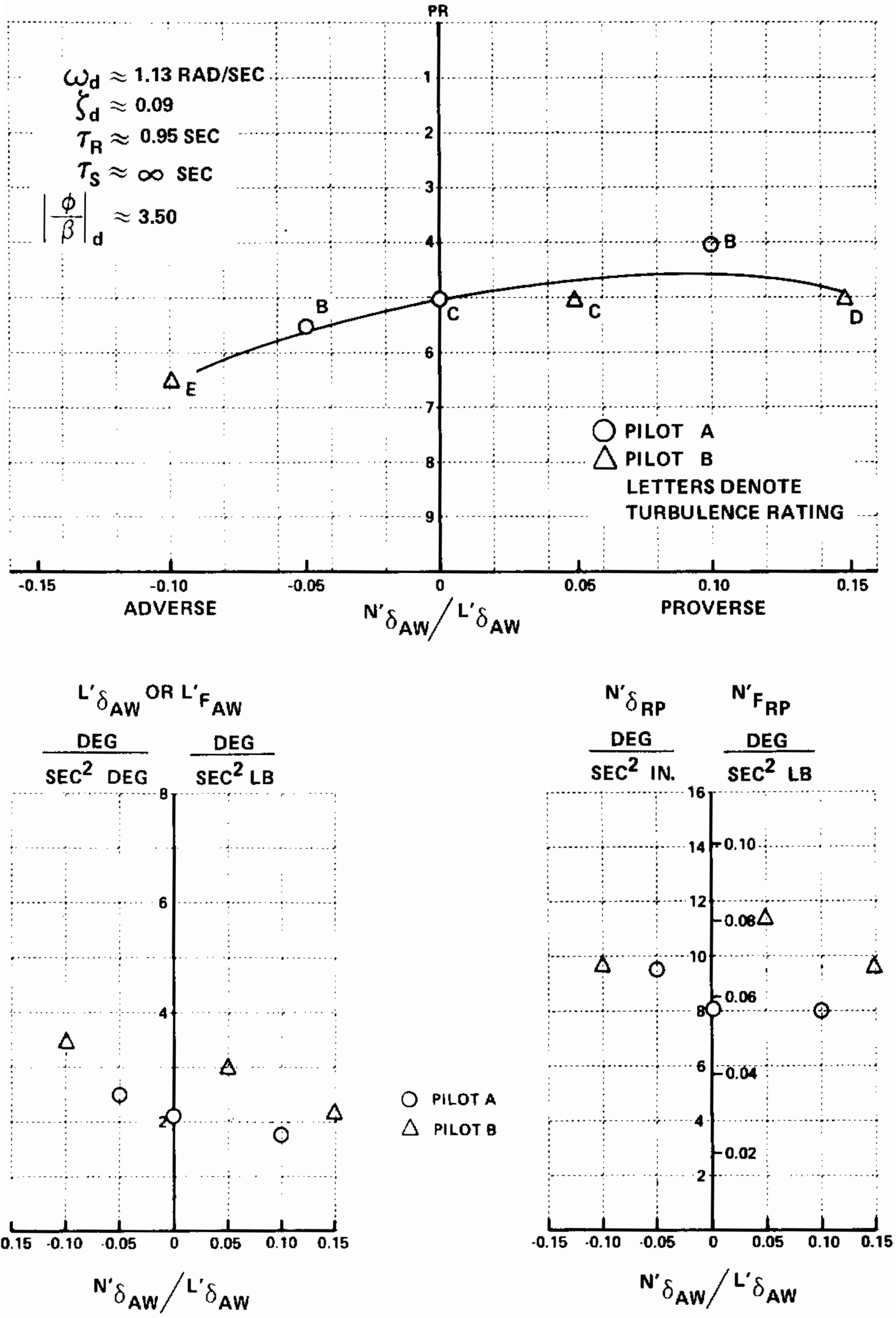


Figure 38 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 15 WHEEL CONTROLLER

None of the configurations in this group were considered to have satisfactory lateral-directional handling qualities. The roll control was the primary objection, with the rudder coordination requirements being almost equally objectionable. The combination of high roll-to-sideslip ratio and long roll mode time constant compounds the pilot's control of bank angle. Because of the high dihedral effect, the rudder was quite effective in producing a roll rate. Consequently, attempts to coordinate, which was a requirement for each of these configurations, tended to cause overbanking. The airplane was described as having a slow initial response and an unpredictable final response, with a tendency to accelerate in roll rate, resulting in overbanking.

The most adverse aileron yaw case evaluated had a non-minimum phase roll rate and bank angle response. Consequently, the pilot had to use the rudder for coordination to obtain a desired bank angle. The pilot commented that coordination was a definite requirement, and that he quickly learned to lead each turning maneuver with a rudder input. The requirement for constantly having to use the rudder was a major objection.

The large roll response associated with turbulence was considered objectionable. In turbulence it was considered a moderate control task just to maintain a given bank angle or to keep the wings level. The only complaint for the crosswind approaches was the large aileron forces encountered during a wing-down approach and in a decrab maneuver. Both pilots were quite consistent in their selection of control sensitivity for both the rudder and aileron.

4.5 LOW DUTCH ROLL FREQUENCY, MODERATE DUTCH ROLL DAMPING RATIO, LONG ROLL MODE TIME CONSTANT

The following section discusses the results for an evaluation group performed at a Dutch roll frequency of 1.0 rad/sec, a Dutch roll damping ratio of 0.1, and a roll mode time constant of two seconds.

4.5.1 Group 16 - Long Roll Mode Time Constant, Moderate $|\phi/\beta|_d$

These configurations had the following lateral-directional mode characteristics:

ω_d = 1.00 rad/sec $|\phi/\beta|_d$ = 1.55

ζ_d = 0.11 τ_R = 2.0 sec τ_s = ∞ sec

The ϕ/δ_{AW} transfer function zero locations with respect to the nominal Dutch roll pole are shown in Figure 39, and the experimental results in Figure 40.

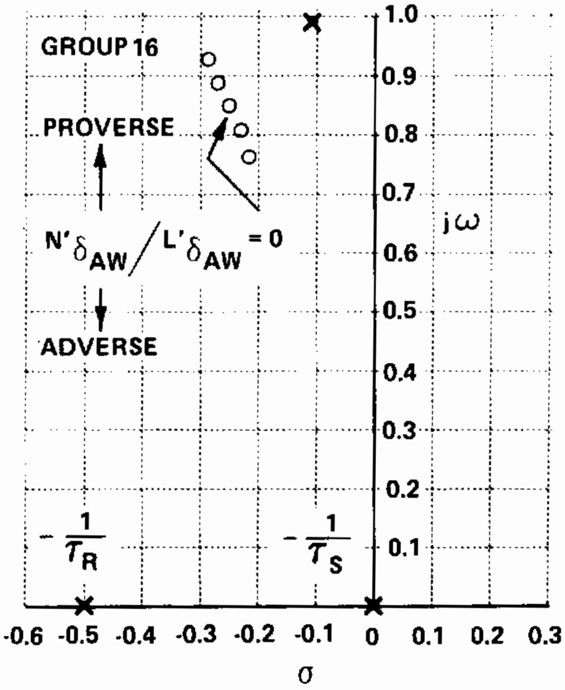


Figure 39 $\frac{\phi}{\delta_{AW}}$ POLE-ZERO LOCATIONS FOR GROUP 16

These configurations, at best, must be considered borderline cases. That is, they are between satisfactory (no improvement necessary) and unsatisfactory (deficiencies warrant improvement). There was little variation in pilot rating over the range of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ evaluated. This follows from the relatively small displacements of the numerator zeros in the ϕ/δ_{AW} transfer function, as shown in Figure 39.

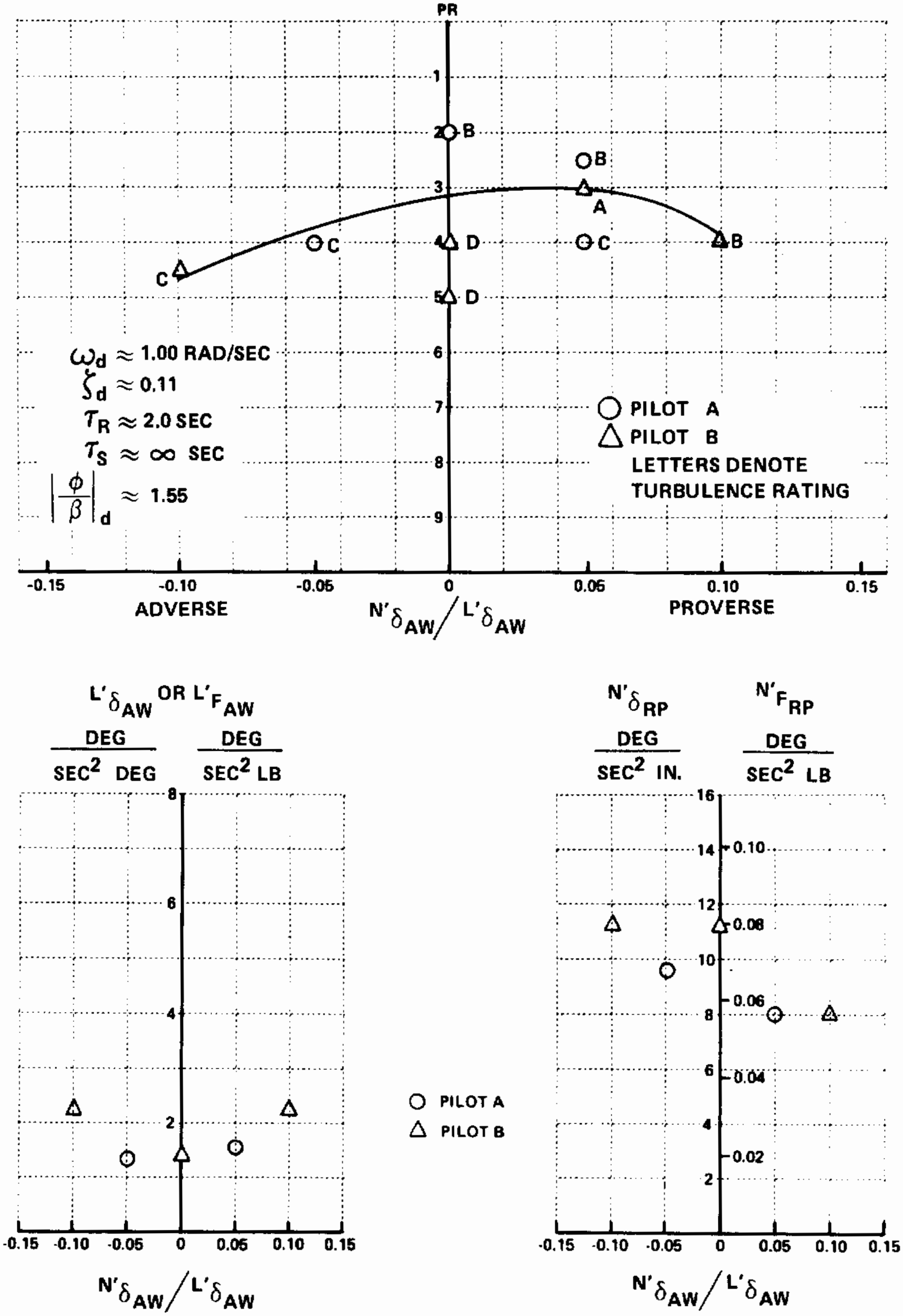


Figure 40 PILOT RATINGS AND PILOT SELECTED CONTROL SENSITIVITY GROUP 16 WHEEL CONTROLLER

The major problem with these configurations was the effect of the long roll mode time constant and not the effects of adverse or proverse yaw due to aileron. The roll control was described as unpredictable. There was a tendency for the initial roll response to be slow followed by an acceleration in roll rate, making the final response hard to predict, resulting in overbanking. This complicated the selection of aileron wheel sensitivity. If the sensitivity was sufficiently high to allow good control for small aileron inputs, then the overbanking tendency for large maneuvers was exaggerated; the converse was true if low sensitivities were selected. The resulting compromise made the aileron forces feel as if they were heavy for starting and stopping roll rates. The pilots were quite consistent in their selection of both the aileron and rudder sensitivities.

The effects of the long roll mode time constant were especially noticeable during the offset approach maneuver and the crosswind landings. The overbanking tendency, the feeling that the roll rate was going to "get away" from the pilot, and the requirement for large abrupt aileron inputs to start and stop roll rates were objectionable features. Rudder coordination in turns was listed as a requirement but did not present a major problem.

Turbulence primarily created problems with the roll control. The requirement for numerous aileron inputs tended to increase the pilot workload but the effect on the overall handling qualities was never worse than a minor deterioration in task performance. Neither evaluation pilot was satisfied with the slow initial roll response during the crosswind approaches. The wing-down method for correcting for crosswinds was preferred in order to avoid abrupt maneuvering near the ground.

4.6 COMPARISON OF PILOT RATINGS WITH VARIATIONS IN LATERAL-DIRECTIONAL DYNAMICS

The matrix of configurations evaluated allows a number of comparisons to be made. Comparisons of Dutch roll frequency, damping ratio, roll-to-sideslip ratio and roll mode time constant are presented.

4.6.1 Comparison of Pilot Rating Data Obtained at Two Dutch Roll Frequencies

Pilot rating data for Dutch roll frequencies of 1.0 and 2.0 radians per second are compared at three values of Dutch roll damping ratio in Figures 41a, b and c, and for two values of roll-to-sideslip ratio in Figure 42.

The most significant difference in pilot ratings for the two frequencies evaluated occurred at the low value of Dutch roll damping ratio (Figure 41a) where better pilot ratings were obtained at the high frequency than at the low. Although both groups were quite susceptible to turbulence, the low frequency configurations were further degraded because of the difficult coordination requirements associated with the slow directional response. This is consistent with References 4 and 29 which indicate that an increase in damping ratio is desirable as the Dutch roll frequency is reduced in order to keep the total damping of the system, $\zeta_d \omega_d$, above an acceptable level. Reference 71 requires a minimum $\zeta_d \omega_d = .15$ for Level 1 flying qualities.

As shown in Figure 41b, there is essentially no difference in the pilot ratings between those configurations evaluated at the two different Dutch roll frequencies for the moderate damping ratio. The pilot ratings do, however, show a more rapid deterioration at the highest proverse yaw due to aileron case for the low frequency than for the high. Since the closed loop Dutch roll damping ratio is reduced for these higher proverse configurations,

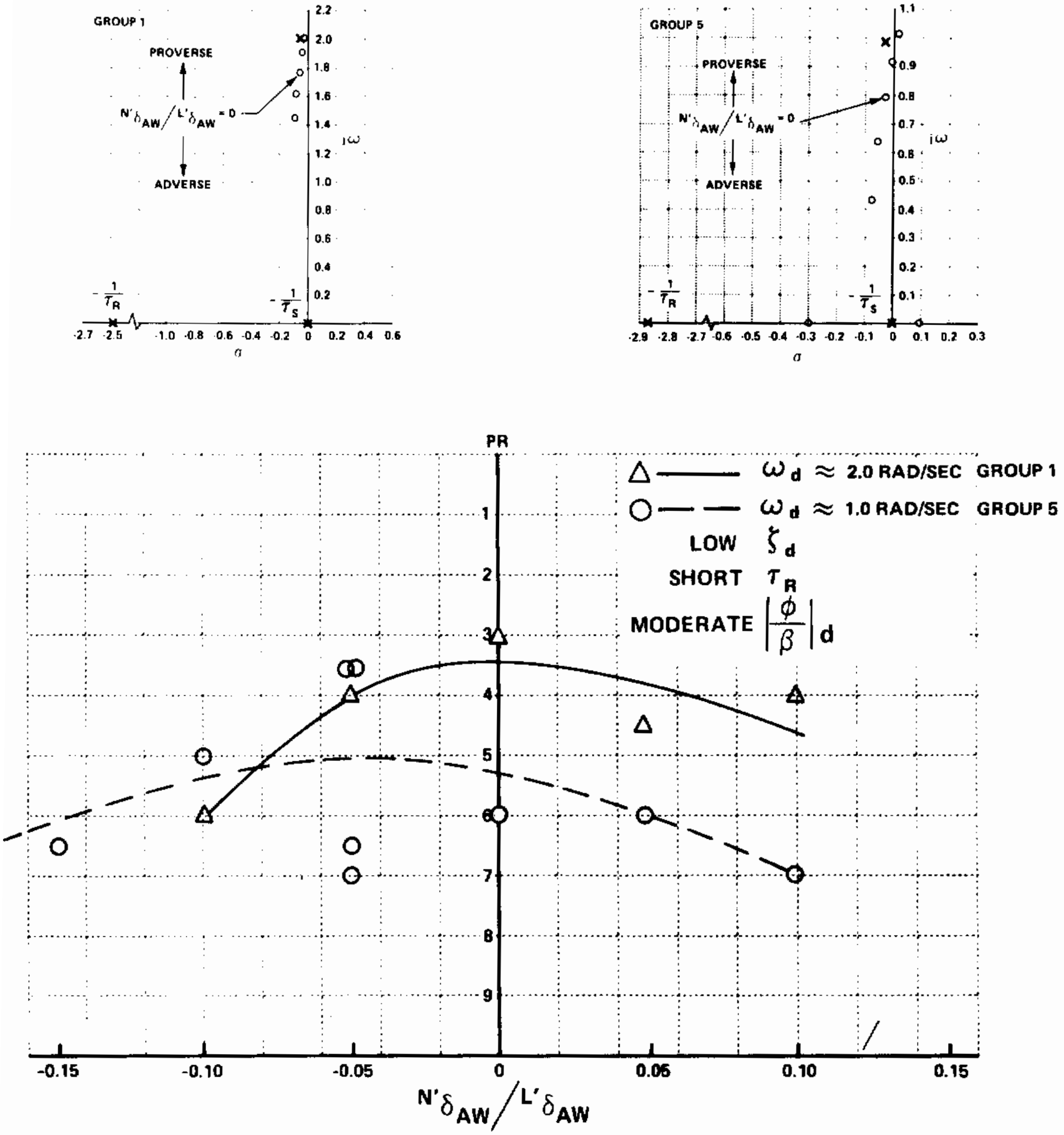


Figure 41a COMPARISON OF PILOT RATINGS AT TWO DIFFERENT FREQUENCIES WITH LOW ζ_d

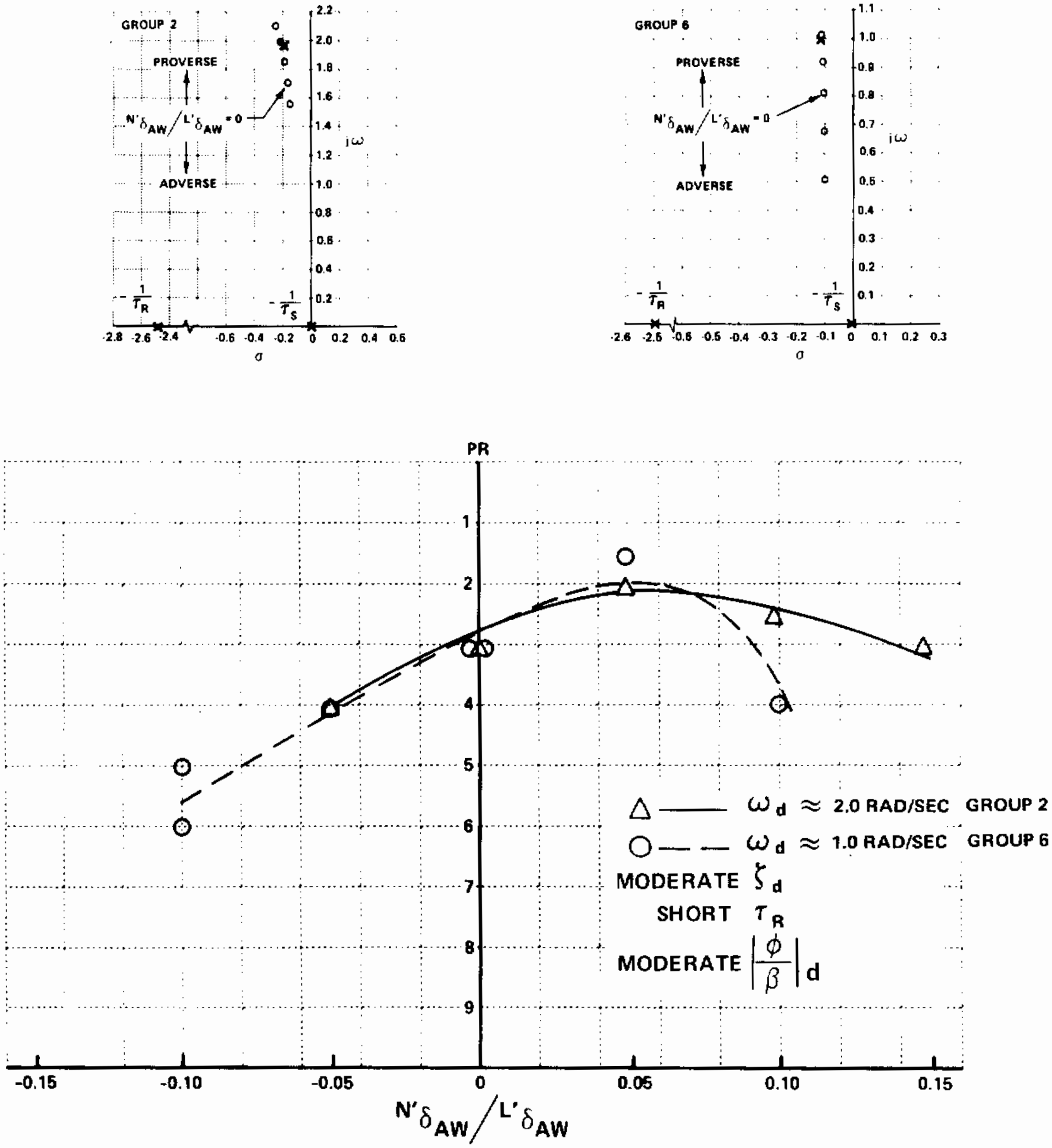


Figure 41b COMPARISON OF PILOT RATINGS AT TWO DIFFERENT FREQUENCIES WITH MODERATE ζ_d

the more rapid deterioration in pilot rating for the low-frequency case is consistent with the results for the low damping configurations described above, indicating that the pilot may be sensitive to small $\zeta_d \omega_d$.

At the higher Dutch roll damping ratio, $\zeta_d \approx 0.25$, (Figure 41c) the low Dutch roll frequency cases were rated equal with the high-frequency case at the "optimum" $N'_{\delta_{AW}}/L'_{\delta_{AW}}$, but show a more rapid deterioration for $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ values to either side. When the numerator zero is separated from the Dutch roll pole and coordination becomes a factor, the low-frequency configurations are downrated because of the slowness of the directional response.

Figure 42 compares the pilot rating data obtained for the high $|\phi/\beta|_d$, moderate ζ_d configurations at the two Dutch roll frequencies. The trend in pilot rating as a function of the control parameter $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ is essentially the same at both frequencies; however, the high-frequency cases are consistently rated one to two ratings better than the low. The lower directional stability associated with the low Dutch roll frequency leads to large sideslip excursions and, consequently, larger roll angles with a corresponding degradation in roll control. Since the turbulence response for the low-frequency configurations is also a major complaint, the combination of turbulence response and roll control difficulties makes these configurations less desirable than the higher frequency configurations.

4.6.2 Comparison of Pilot Rating Data Obtained at Different Dutch Roll Damping Ratios

Pilot rating data are compared for the three values of Dutch roll damping ratio at the moderate value of $|\phi/\beta|_d$ for both Dutch roll frequencies, and at the high $|\phi/\beta|_d$ for the low frequency. Data are also compared for the two higher values of ζ_d , for the lowest $|\phi/\beta|_d$ and low Dutch roll frequency.

As shown in Figures 43a and 43b, the handling qualities improved two or more pilot ratings at the optimum pilot rating, for a change in damping

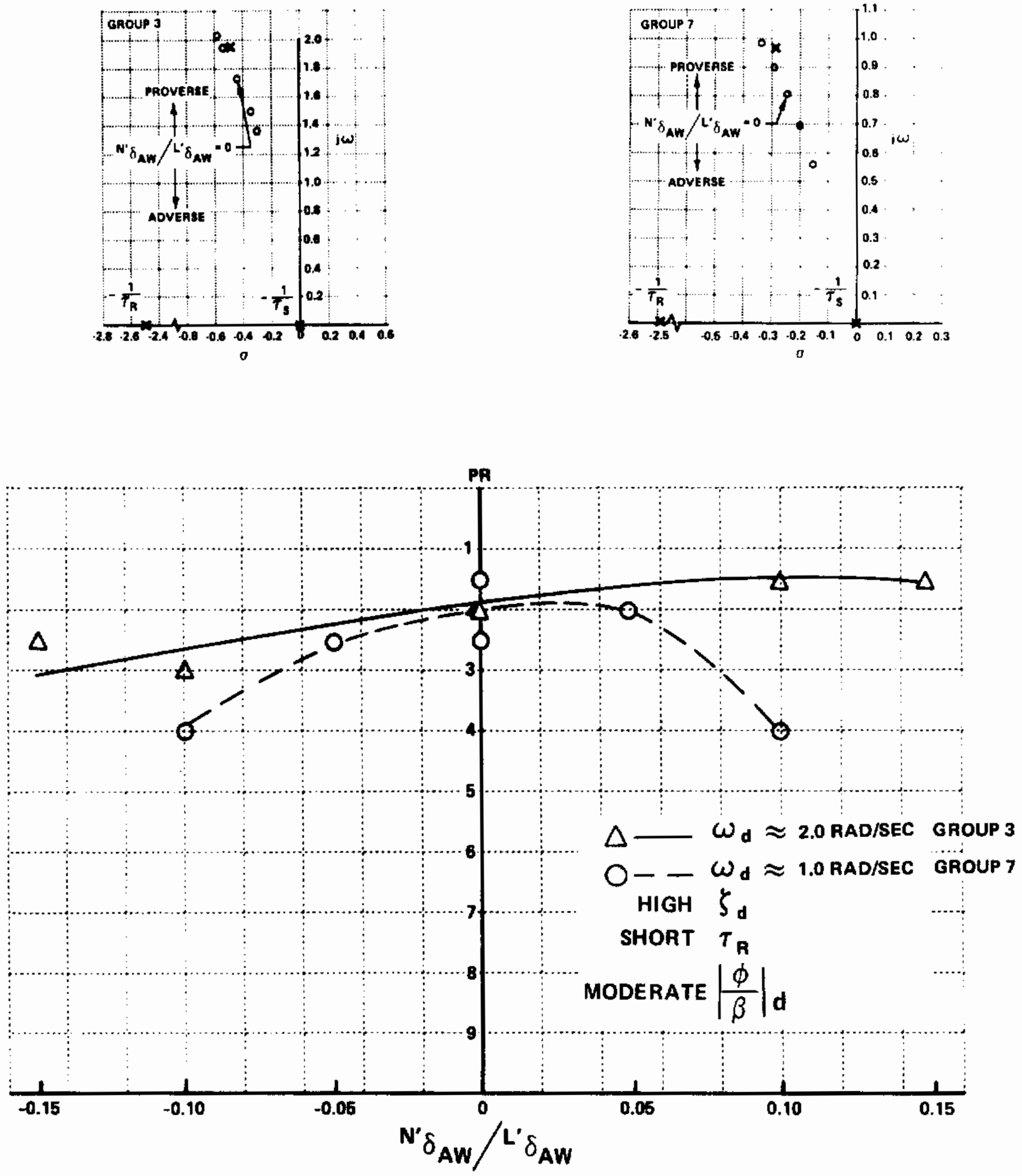


Figure 41c COMPARISON OF PILOT RATINGS AT TWO DIFFERENT FREQUENCIES WITH HIGH ζ_d

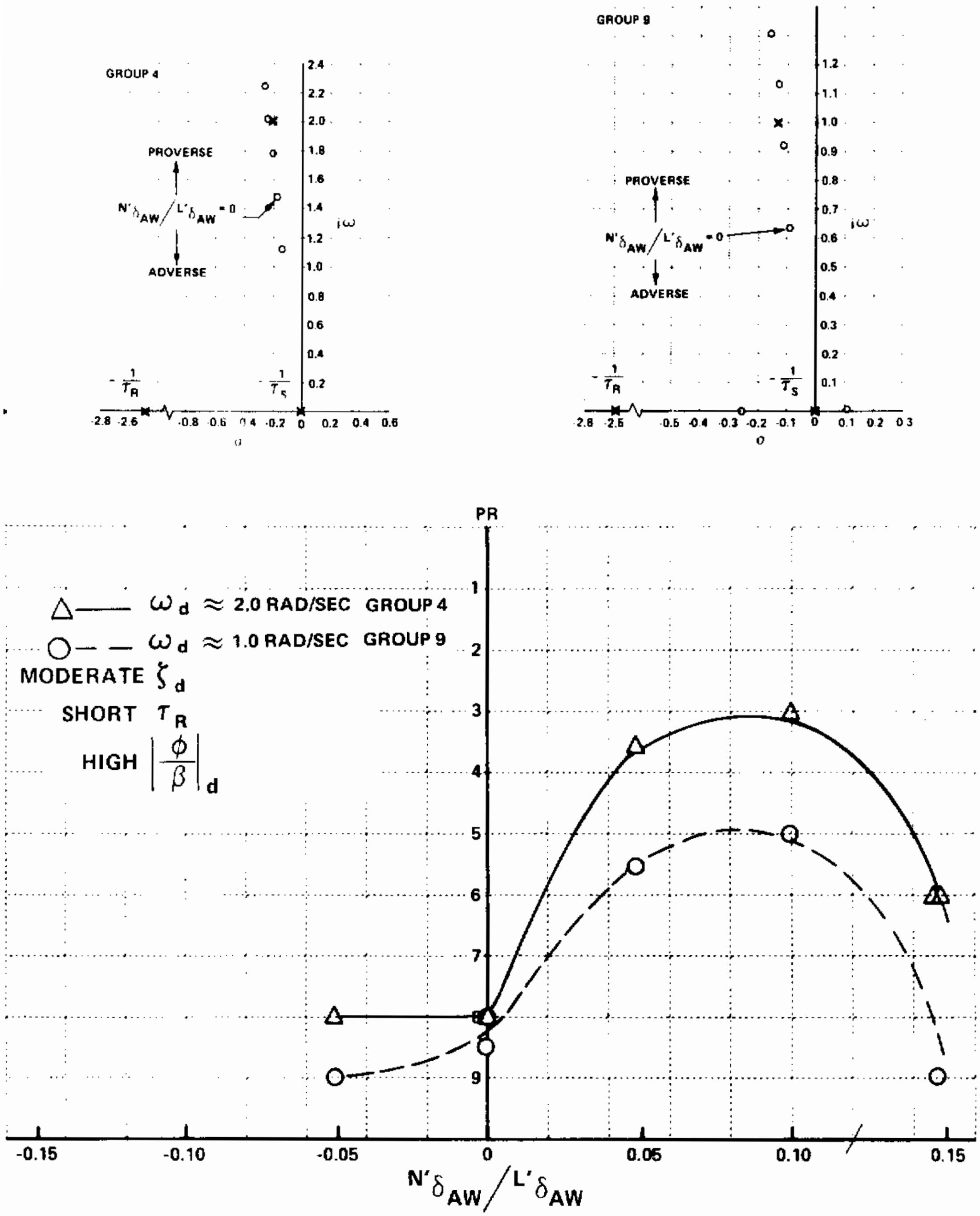


Figure 42 COMPARISON OF PILOT RATINGS AT TWO DIFFERENT FREQUENCIES WITH HIGH $\left|\frac{\phi}{\beta}\right|_d$

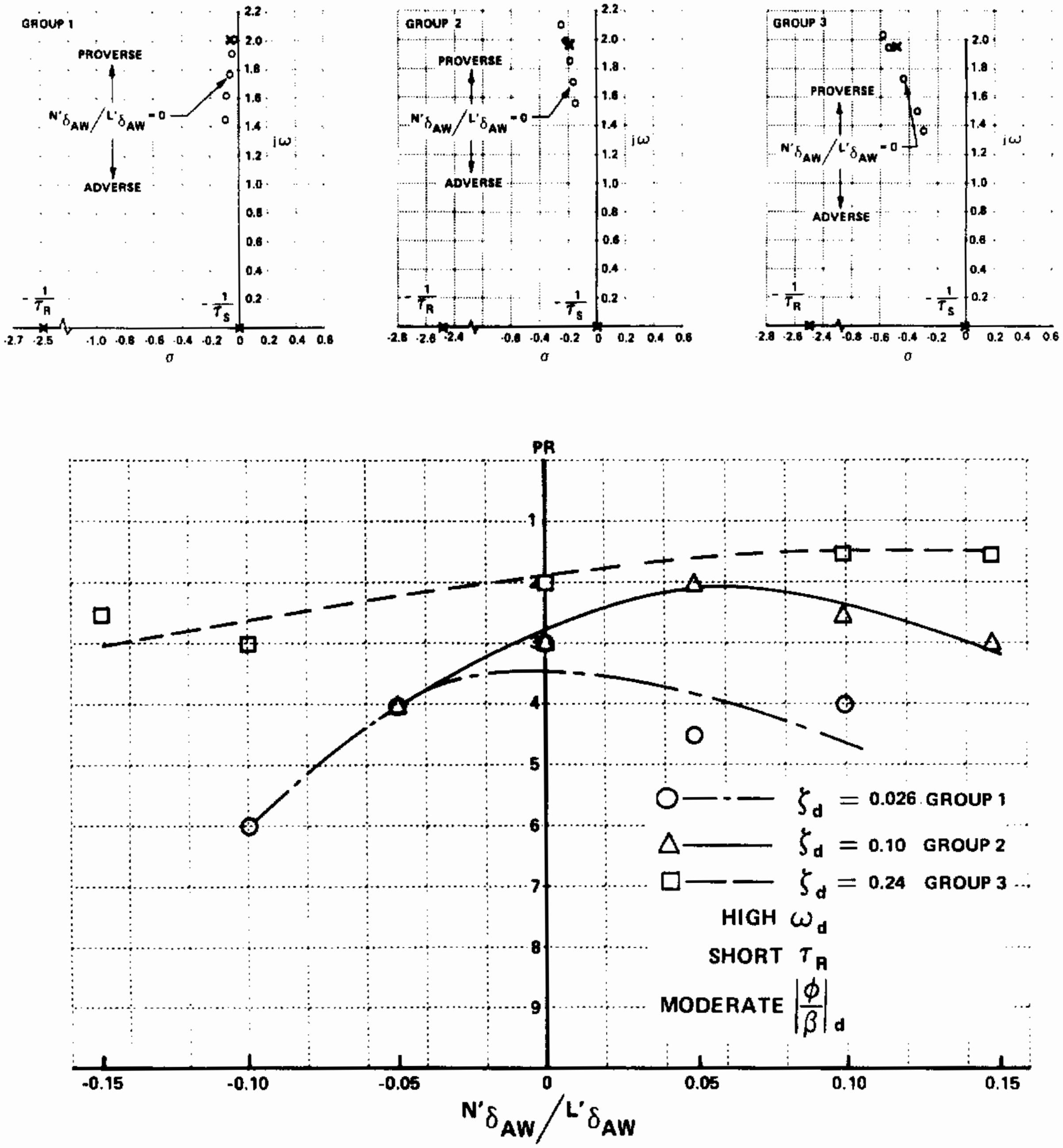


Figure 43a COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF ζ_d WITH HIGH ω_d

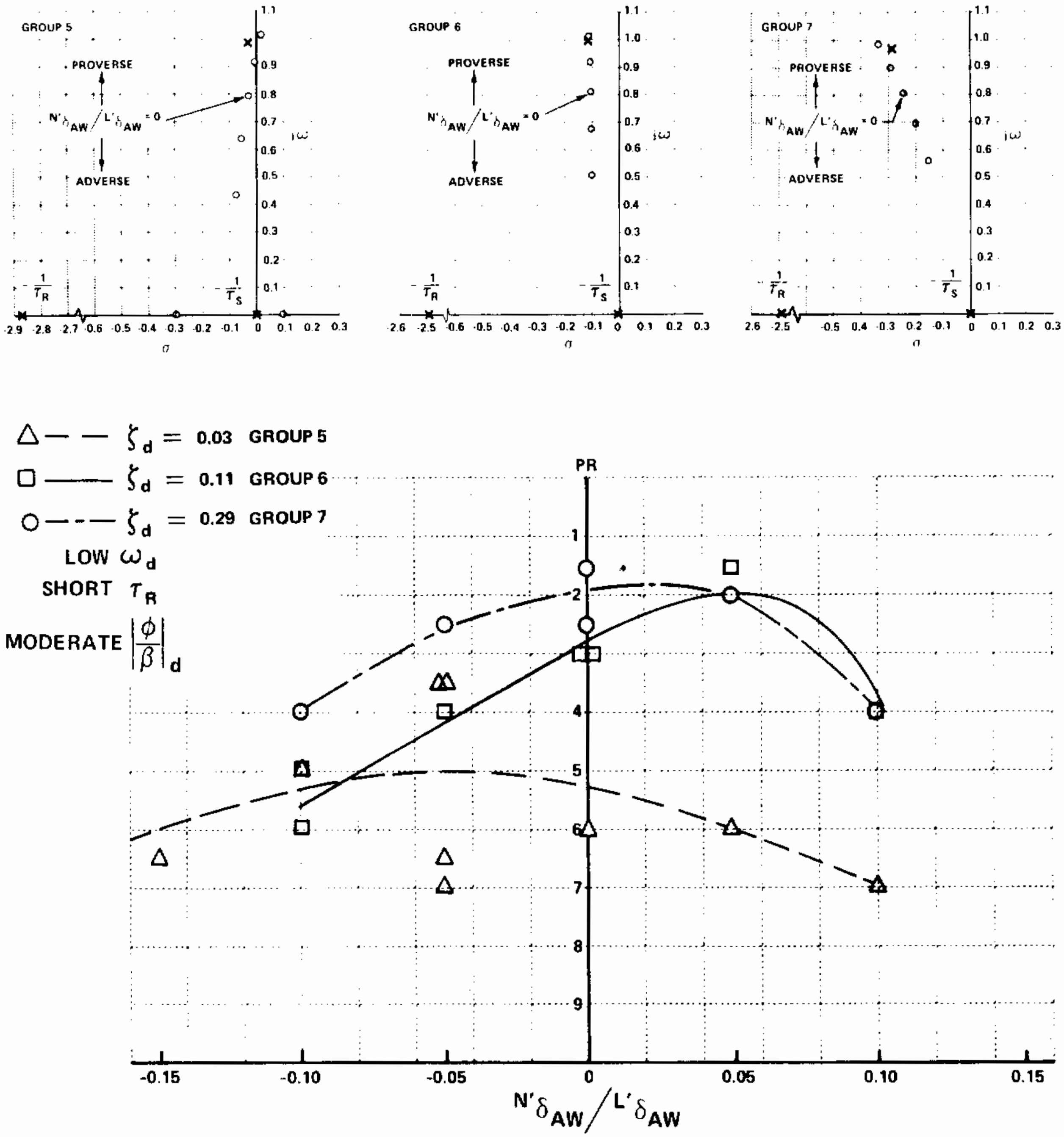


Figure 43b COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF ζ_d WITH LOW ω_d

ratio from $\zeta_d = 0.03$ to $\zeta_d = 0.1$ for the moderate $|\phi/\beta|_d$ configurations at both Dutch roll frequencies evaluated. A further increase in damping ratio to the high value of ζ_d shows no significant improvement in the optimum pilot rating; however, there was an improvement in the more adverse yaw configurations.

For both frequencies evaluated, the pilots accepted greater variations in $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ at the highest damping ratio than at the moderate or low. In this experiment, $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ primarily determined the amount of Dutch roll excitation to an aileron input. With the higher damping ratio, the Dutch roll oscillations decayed rapidly and, consequently, were less of a problem. The primary difference between the low and high damping ratios evaluated was the airplane's response to turbulence. In smooth air, even the lightly damped configurations were considered "not too bad"; however, in turbulence, both the riding qualities and the handling qualities deteriorated significantly. The reduction in turbulence response for an increase in damping ratio from $\zeta_d = 0.1$ to $\zeta_d = 0.3$ is quite significant. In many cases at the higher damping ratio, the lack of excitation due to turbulence was listed as a good feature. Thus, an increase in Dutch roll damping ratio above $\zeta_d = 0.1$ may not significantly improve the airplane handling qualities, but it does enhance the turbulence response and riding qualities of the airplane.

Figure 44a shows the pilot rating comparison for the high $|\phi/\beta|_d$ case as the damping ratio is varied from $\zeta_d = 0.03$ to $\zeta_d = 0.25$. In this comparison there is a much greater improvement in pilot rating with an increase in damping ratio than for the moderate $|\phi/\beta|_d$ configurations. Because of the low Dutch roll frequency, $\omega_d \approx 1.0$ rad/sec, the static directional stability is low and the airplane is quite susceptible to sideslip excursions. With the higher roll-to-sideslip coupling, these sideslip excursions manifest themselves as roll control problems. The turbulence response was not really liked by either evaluation pilot for any of these configurations. It is in the area of turbulence response that the increased damping ratio had its most beneficial

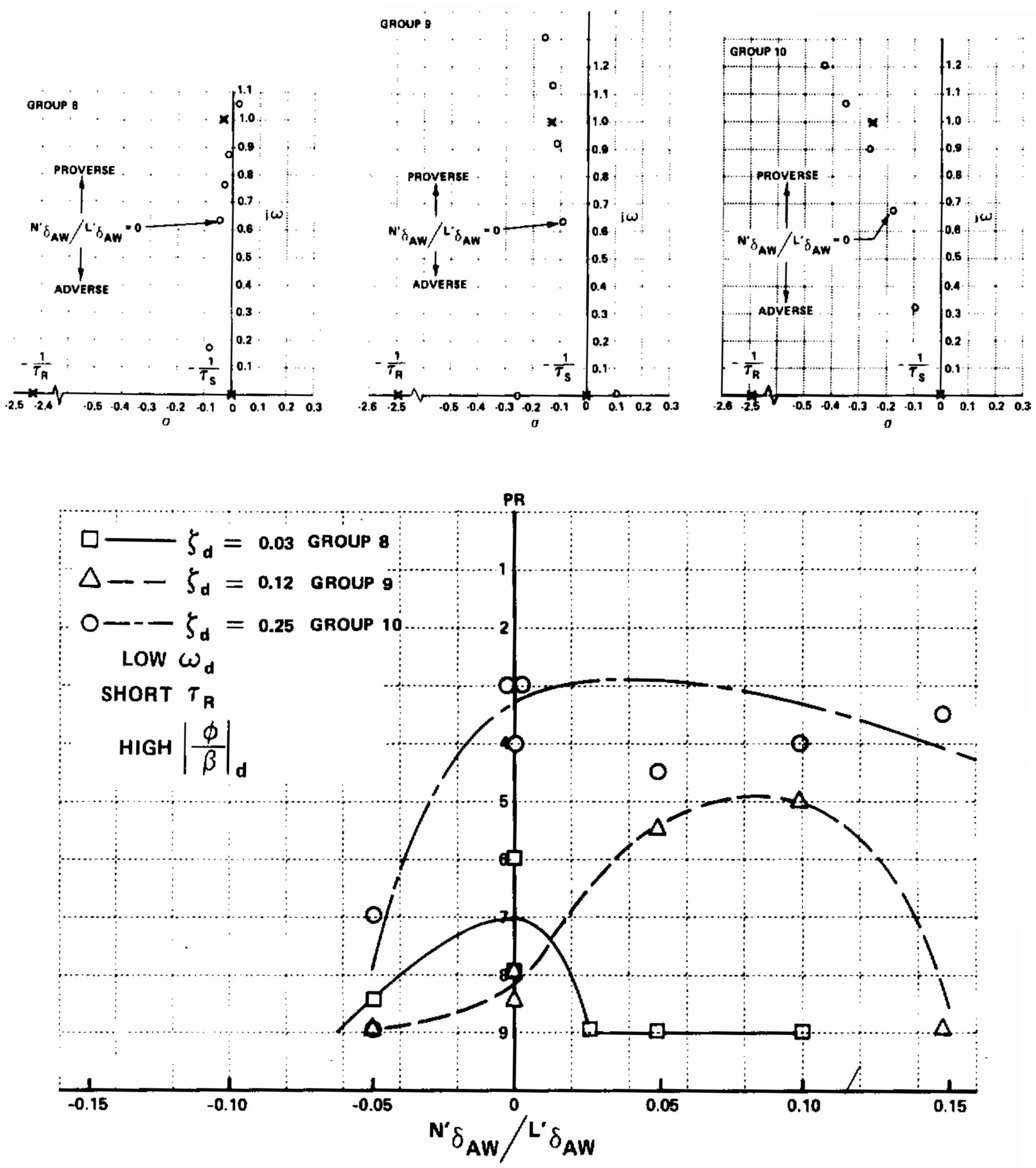


Figure 44a COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF ζ_d WITH HIGH $\left|\frac{\phi}{\beta}\right|_d$

effect. The only two pilot ratings that were satisfactory ($\zeta_d \approx 0.25$, $N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$) had turbulence ratings of B and C, with all others rated D or lower. It can be concluded that the desired level of Dutch roll damping ratio is strongly influenced by the amount of roll-to-sideslip coupling. An increase in damping ratio has a more significant and beneficial effect on the handling qualities as the roll-to-sideslip ratio increases.

Figure 44b compares moderate and high damping ratios for the low roll-to-sideslip ratio. The major improvement in handling qualities with an increase in damping ratio at this low dihedral effect is again in the turbulence response and riding qualities of the airplane. At the lower damping ratio, the turbulence response was considered a minor objection. At the higher damping ratio, the turbulence response was considered negligible and listed as a favorable feature. The higher damping ratio significantly reduced the snaking motion normally associated with low roll-to-sideslip airplanes and noticeably improved the riding qualities.

4.6.3 Comparison of Pilot Rating Data Obtained at Different Ratios of Roll-to-Sideslip in the Dutch Roll Mode

Pilot rating data are compared at two values of $|\phi/\beta|_d$ at the high Dutch roll frequency with the moderate damping ratio and also at the low Dutch roll frequency with the low damping ratio. Three values of $|\phi/\beta|_d$ are compared at the low Dutch roll frequency and short roll mode time constant, for the low and moderate damping ratios, and also at the low Dutch roll frequency with the moderate damping ratio and moderate roll mode time constant. These comparisons are shown in Figures 45 through 47.

Comparison of the moderate and high roll-to-sideslip ratios, at the high Dutch roll frequency and moderate damping ratio, Figure 45, shows only one pilot rating difference (with the lower roll-to-sideslip ratio rated better) at the optimum $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ value evaluated. The L'_β for the high roll-to-sideslip ratio was -19.4 and was -10.3 for the low. This combination of L'_β and Dutch roll frequency compares quite well with the results of the Princeton

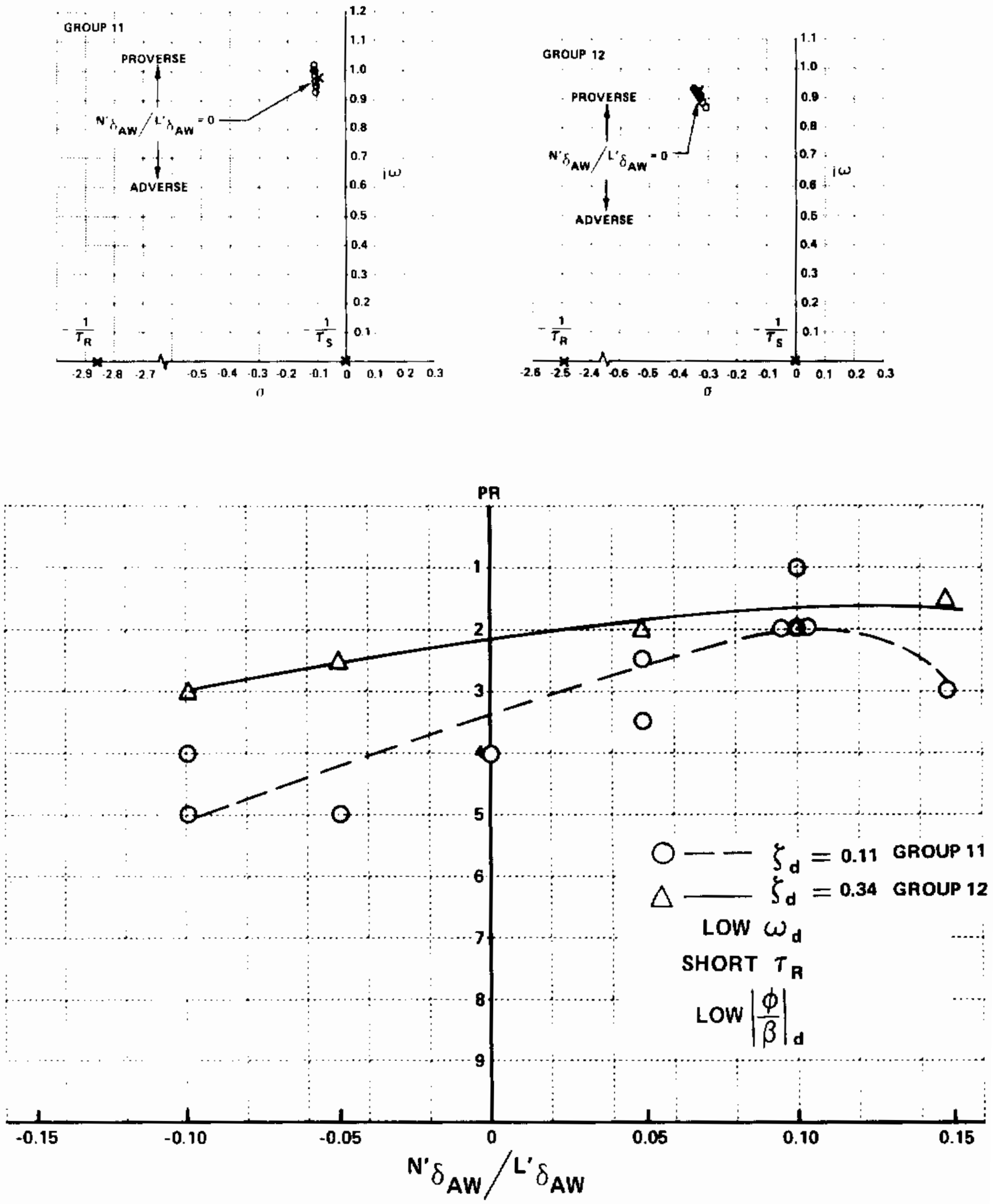


Figure 44b COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF ζ_d WITH LOW $\left|\frac{\phi}{\beta}\right|_d$

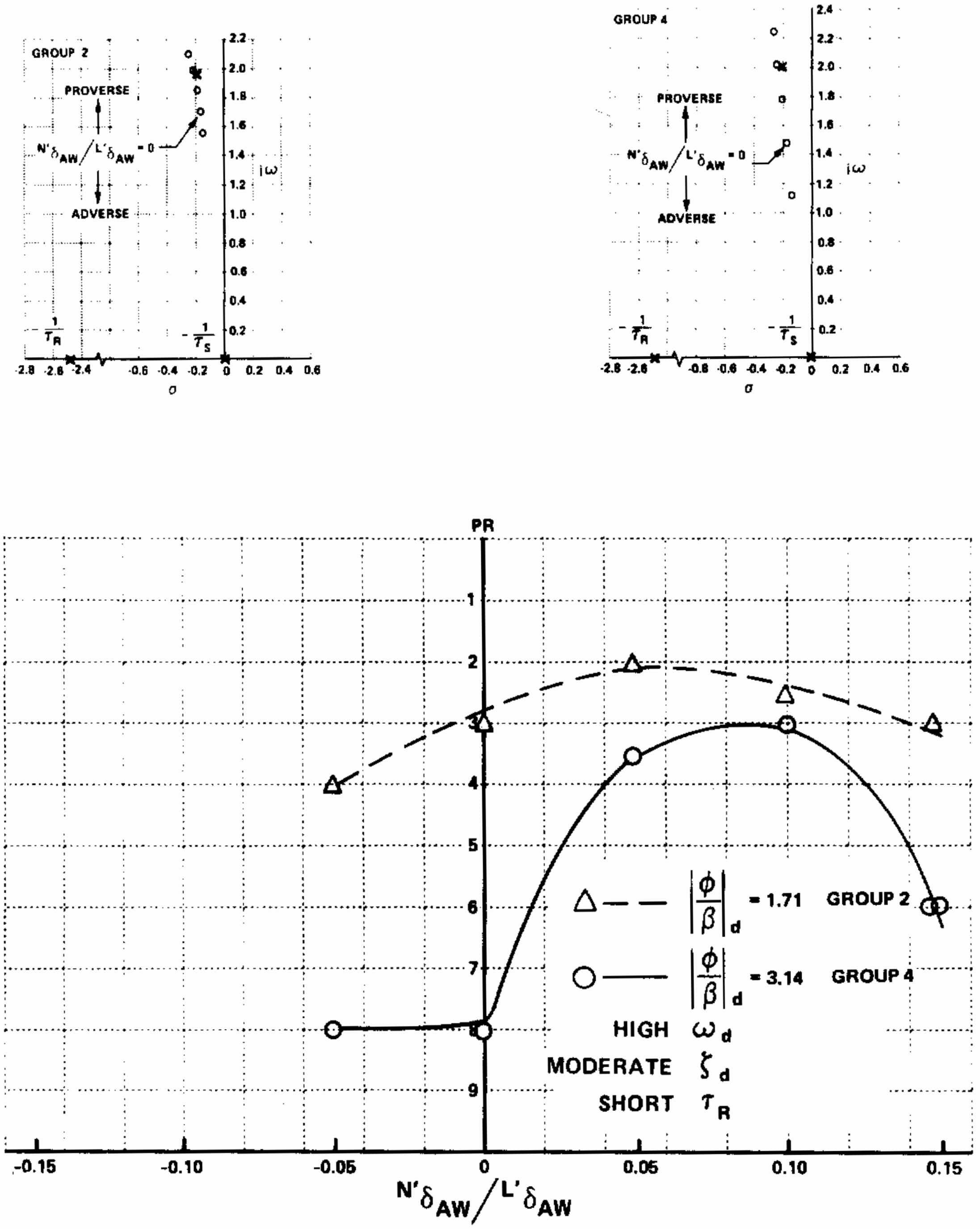


Figure 45 COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF $|\phi/\beta|_d$ WITH HIGH ω_d

data, Reference 72, which were obtained for an ILS task for small general aviation airplanes. The primary difference between these two groups was the roll response to turbulence which was considerably worse for the high roll-to-sideslip configurations. The greater amount of Dutch roll excitation with the high $|\phi/\beta|_d$ resulted in a rapid degradation in pilot ratings for values of aileron yaw more adverse or proverse than that for which the best pilot ratings occurred.

At the low frequency and low damping ratio, Figure 46a indicates that the moderate $|\phi/\beta|_d$ ratio is still preferred over the high value. Neither group of configurations was very good because of the low static directional stability and low damping ratio. This combination of characteristics precipitated continuous excursions in sideslip which, when coupled with the high roll-to-sideslip ratio, created roll as well as directional control problems. The turbulence response was considered excessive for both groups primarily because of the light Dutch roll damping.

Figure 46b compares the pilot ratings obtained for the three roll-to-sideslip ratios at the low Dutch roll frequency and moderate damping ratio. Although the best pilot rating occurs at a slightly different value of $N'_{\delta_{AW}}/L'_{\delta_{AW}}$, there is essentially no difference in the pilot's assessment of the handling qualities at the optimum configuration for the low and moderate roll-to-sideslip ratios. Although the turbulence response for the low $|\phi/\beta|_d$ configurations showed up primarily as a snaking motion and for the moderate $|\phi/\beta|_d$ cases as a coupled lateral-directional motion, the overall effect on the handling qualities was essentially the same. The pilot ratings for the high $|\phi/\beta|_d$ configurations were considerably degraded from either of the lower $|\phi/\beta|_d$ values. Again, the major objection was centered on the roll response to turbulence.

Figure 46c compares three roll-to-sideslip ratios at the low Dutch roll frequency but with the high damping ratio. There is essentially no difference in the optimum pilot rating obtained for the two lower roll-to-sideslip ratios. Both groups were rated slightly better than the high roll-to-sideslip ratio configurations. The improvement in turbulence response for

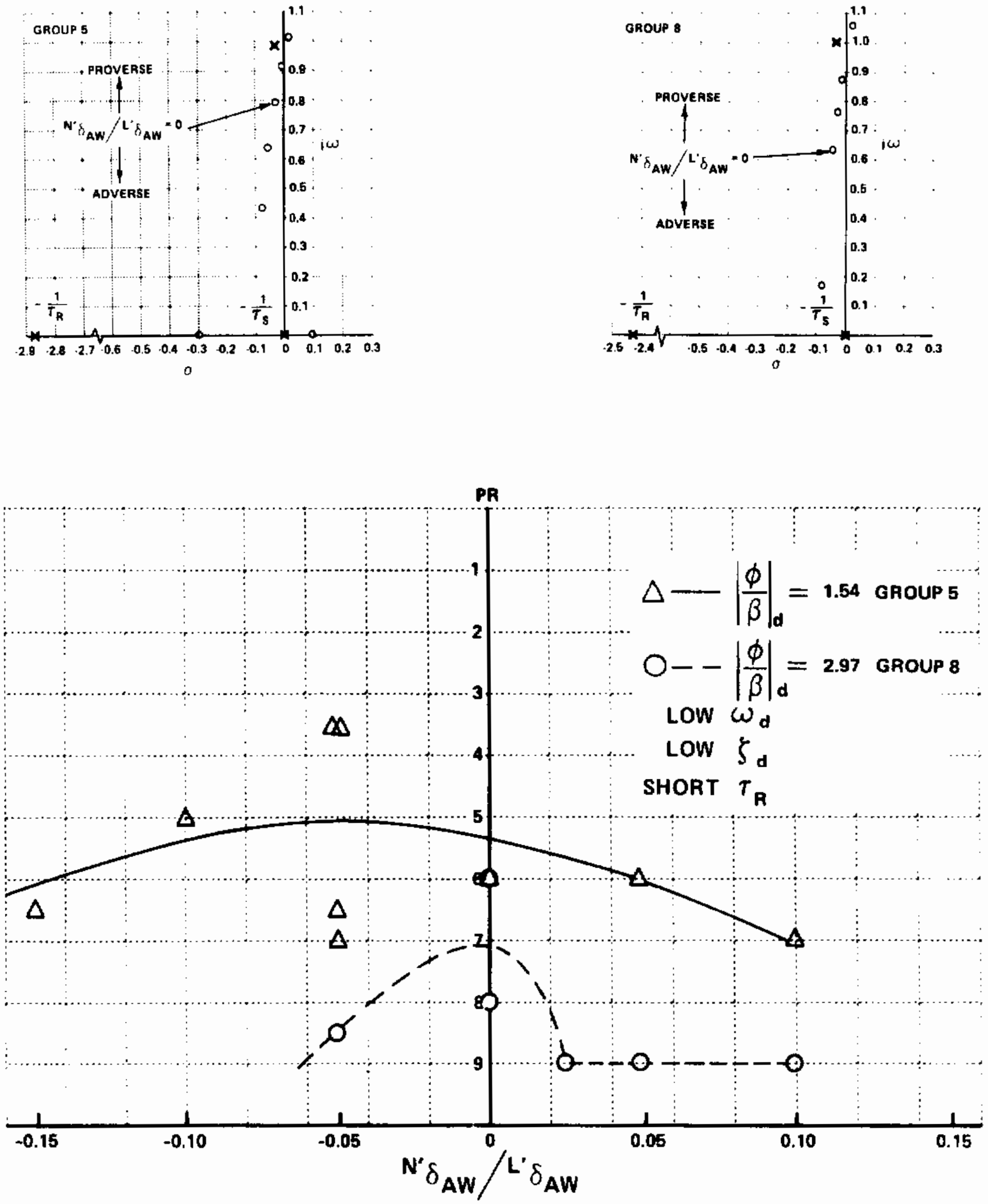


Figure 46a COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF $|\phi/\beta|_d$ WITH LOW ζ_d

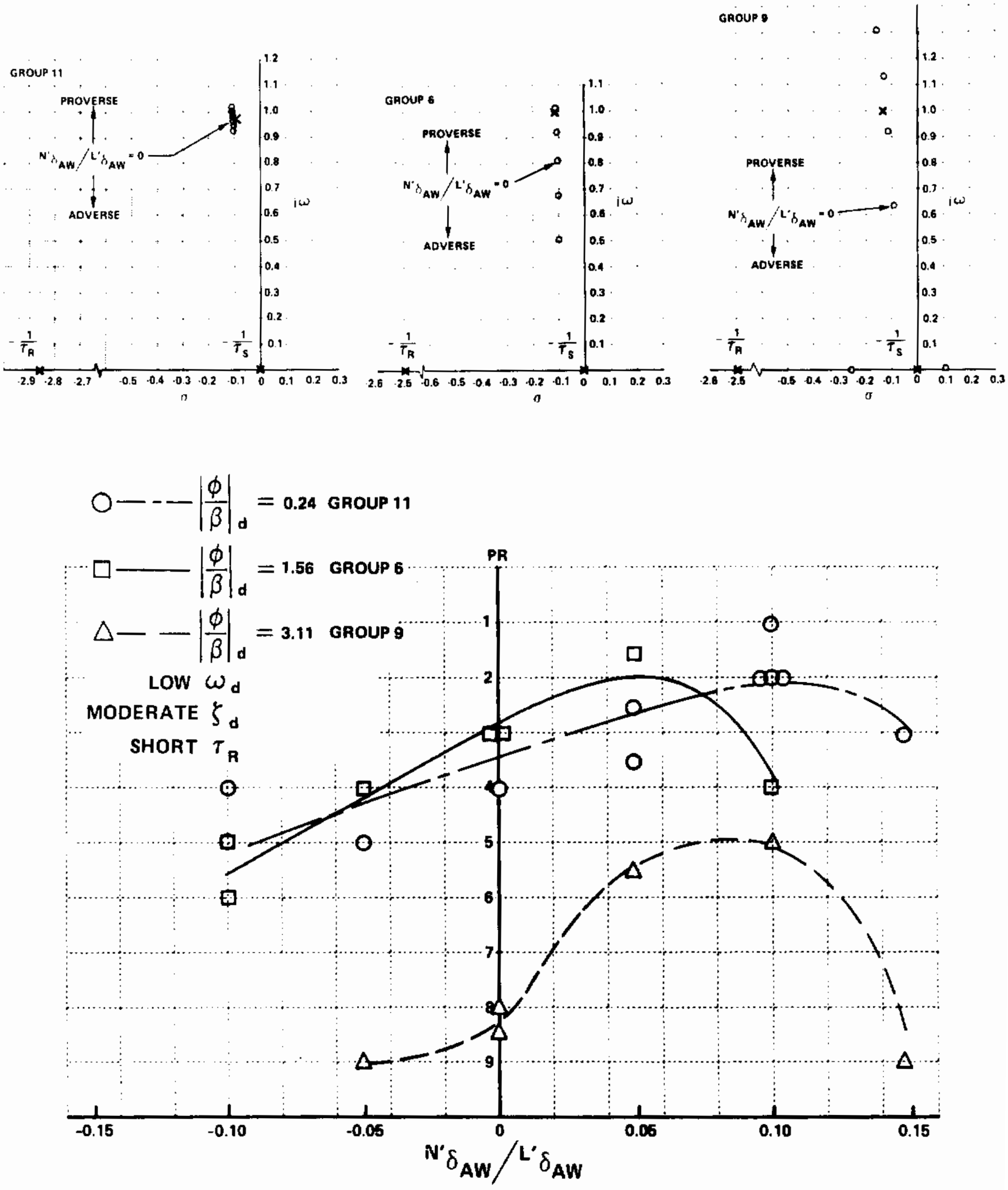


Figure 46b COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF $\left|\frac{\phi}{\beta}\right|_d$ WITH MODERATE ζ_d

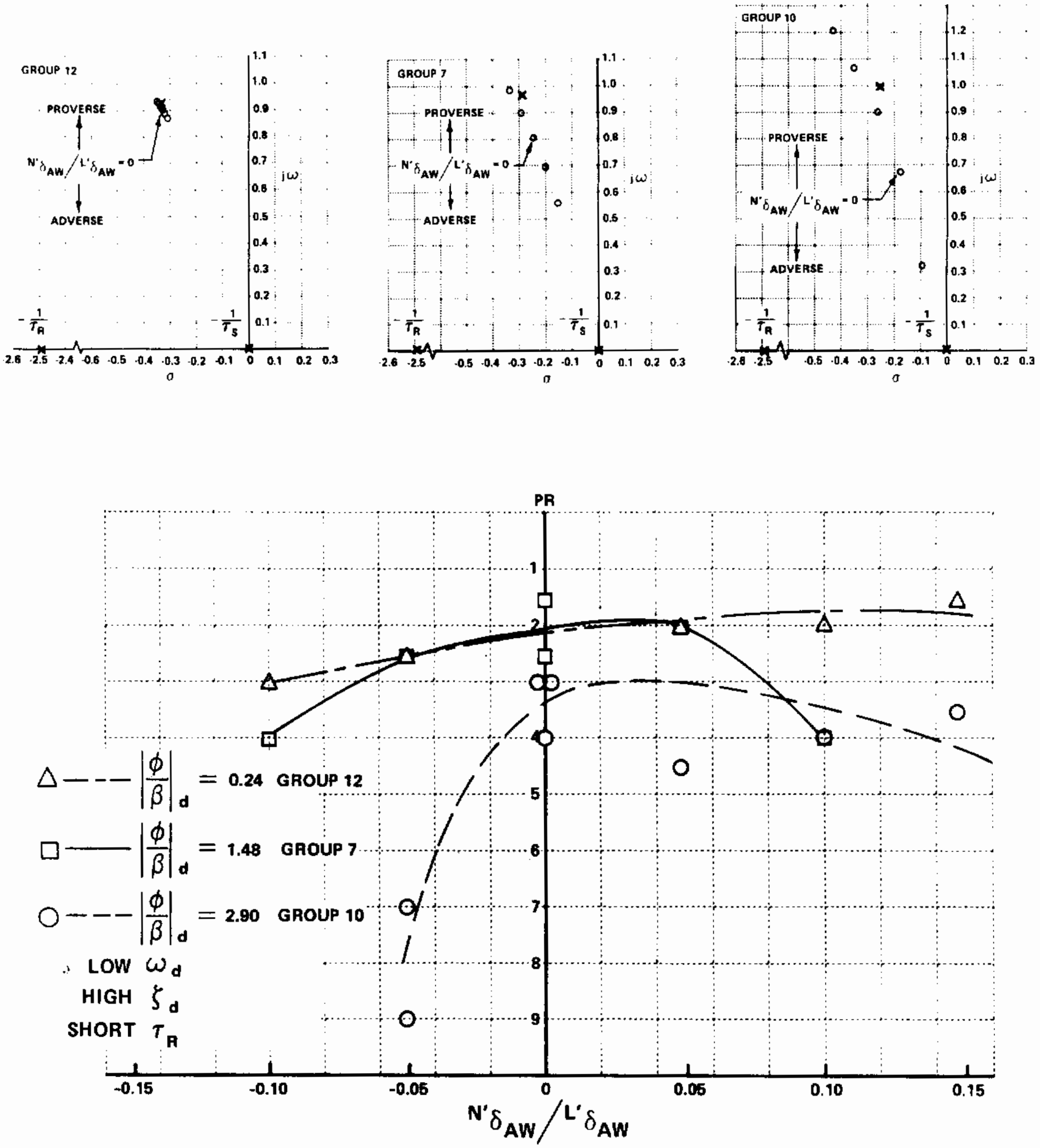


Figure 46c COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF $\left|\frac{\phi}{\beta}\right|_d$ WITH HIGH ζ_d

the high $|\phi/\beta|_d$ configurations accounts for the smaller differences in pilot ratings with the high damping ratio compared to those obtained at the moderate damping ratio.

All the previous comparisons were made for a short roll mode time constant of $\tau_R \approx 0.4$ seconds. Figure 47 compares dissimilar roll-to-sideslip ratios at the low Dutch roll frequency and moderate damping ratio for the moderate roll mode time constant of approximately 1.0 second. Comparing Figure 46b with Figure 47, it is immediately apparent that for the moderate roll mode time constant configurations there is less pilot rating variation for a corresponding change in $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ than there is for the short roll mode groups. This results from the respectively lower values of L'_β for the moderate roll mode time constant configurations. Since L'_p appears in the denominator of $|\phi/\beta|_d$ (see Appendix I) and L'_p is significantly less for the moderate roll mode time constant than for the short roll mode time constant configurations, there is a corresponding decrease in L'_β required to achieve the same $|\phi/\beta|_d$ relationships. The moderate $|\phi/\beta|_d$ configurations were rated better than the low $|\phi/\beta|_d$ configurations primarily because the adverse yaw due to aileron created a Dutch roll phase relationship in roll rate that tended to reduce the effect of the longer roll mode time constant. This can readily be seen in the transient responses shown in Appendix V. The zeroes in the ϕ/δ_a transfer function are quite widely separated from the Dutch roll pole for the high roll-to-sideslip ratio configurations, making a direct comparison with the two lower $|\phi/\beta|_d$ configurations less meaningful at the moderate roll mode time constant. The pole-zero separations are indicative of the Dutch roll excitation due to aileron inputs, and hence, any aileron input for the high $|\phi/\beta|_d$ case produced considerably more Dutch roll excitation than a corresponding input for the two lower $|\phi/\beta|_d$ groups./ Consequently, in this comparison, the difference in pilot rating between the high $|\phi/\beta|_d$ and the two lower $|\phi/\beta|_d$ values cannot be attributed solely to the effects of a change in $|\phi/\beta|_d$.

The following conclusions can be reached from the above comparisons. Roll-to-sideslip ratio is indeed a good measure of the lateral turbulence

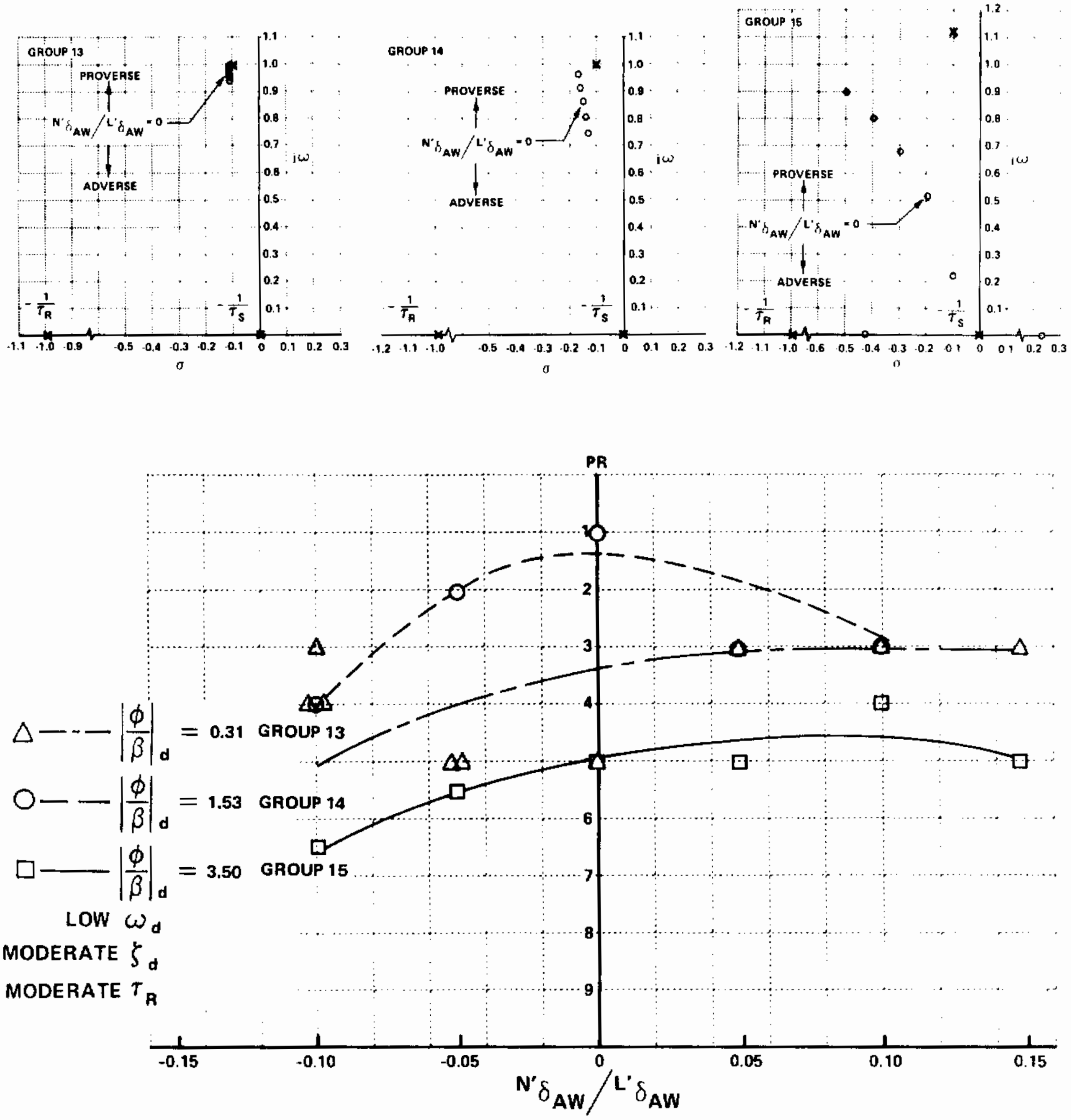


Figure 47 COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF $\left|\frac{\phi}{\beta}\right|_d$ WITH MODERATE τ_R

response that can be anticipated for a given airplane. The high roll-to-sideslip ratio was less degrading at the high Dutch roll frequency ($\omega_d \approx 2.0$ rad/sec) evaluated than at the low frequency. The combination of low Dutch roll frequency ($\omega_d \approx 1.0$ rad/sec), low Dutch roll damping ratio ($\zeta_d \approx 0.03$), and high roll-to-sideslip ratio ($|\phi/\beta|_d \approx 3.0$), was completely unacceptable. The same Dutch roll frequency and damping ratio with the moderate roll-to-sideslip ratio ($|\phi/\beta|_d \approx 1.5$) was rated barely acceptable, but unsatisfactory. Increasing the Dutch roll damping ratio can significantly improve the acceptability of the handling qualities of a high roll-to-sideslip configuration. There is essentially no difference in the desirability of the handling qualities between configurations with the same Dutch roll frequency and damping ratios and roll-to-sideslip ratios of about 0.25 to 1.50.

4.6.4 Comparison of Pilot Rating Data Obtained at Different Values of Roll Mode Time Constant

Pilot rating data are compared for three roll mode time constants, $\tau_R \approx 0.4$, 1.0, and 2.0 seconds at the low Dutch roll frequency, moderate damping ratio and moderate $|\phi/\beta|_d$. Two roll mode values, $\tau_R \approx 0.4$ and 1.0 seconds, are compared at the same Dutch roll frequency and damping ratio for the lowest and highest values of $|\phi/\beta|_d$.

Figure 48a compares three values of roll mode time constant at the moderate $|\phi/\beta|_d$. The pilots described the roll control for the short τ_R configurations as precise and predictable. For the moderate τ_R, the roll control was considered satisfactory and good with one minor complaint: the airplane was slow to respond initially and there was an occasional tendency to over control in bank angle. In general, there was very little, if any, difference in the roll control per se between these two groups of configurations. Analysis of the pilot comment data indicated that the major difference was in the turbulence response. For the short τ_R configurations, $L'_\beta \approx -4.07$, for the moderate τ_R, $L'_\beta \approx -1.88$, the approximate factor of two difference in L'_β primarily accounts for the more objectionable turbulence

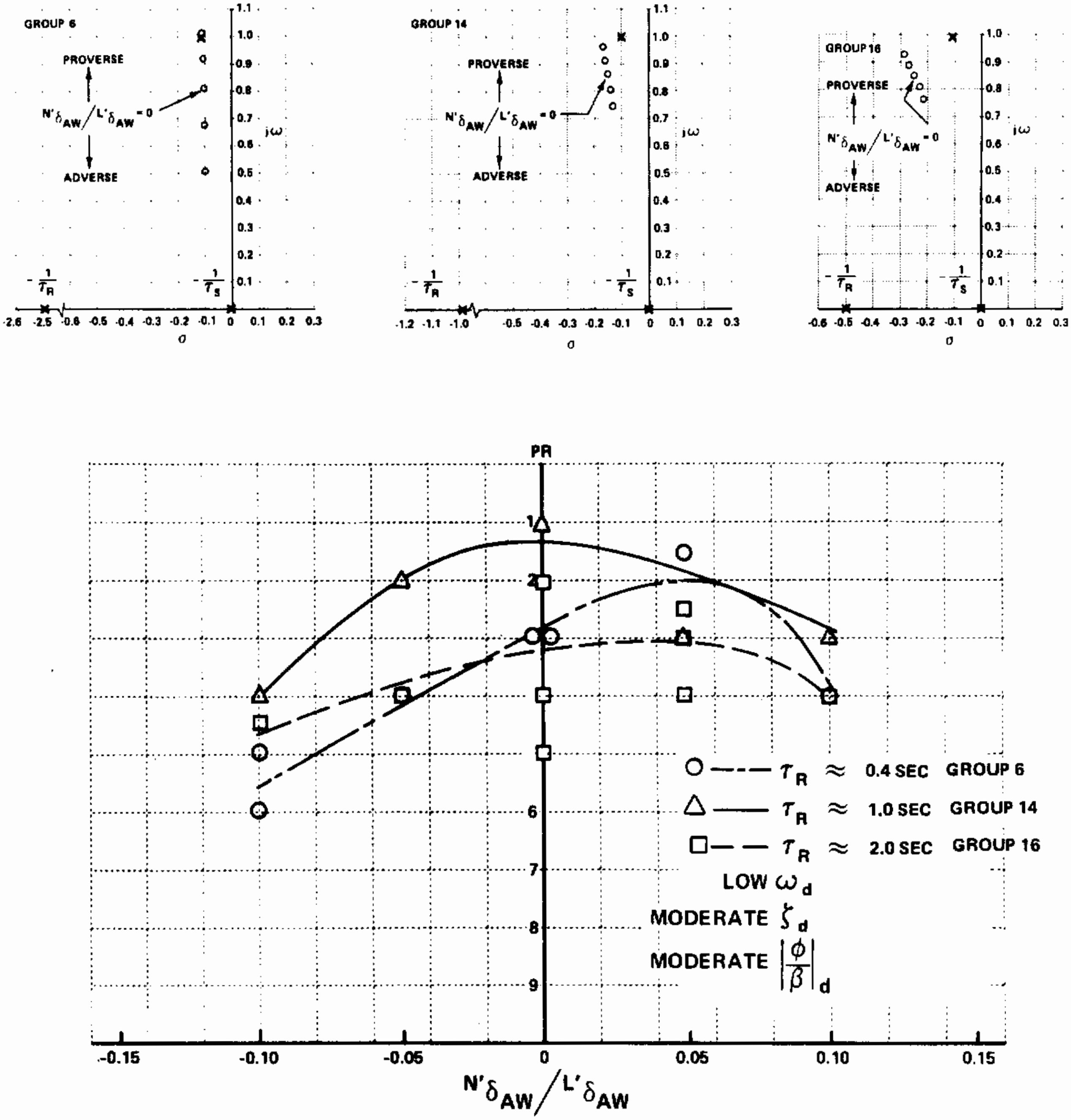


Figure 48a COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF τ_R WITH MODERATE $\left|\frac{\phi}{\beta}\right|_d$

ratings given to the low roll mode time constant configurations. The higher L'_β ($L'_\beta \approx -4.07$) also accounts for the greater pole zero separation in the ϕ/δ_a transfer function, resulting in greater Dutch roll excitation with the ailerons at the short roll mode time constant. This excitation is responsible for the more rapid deterioration in pilot rating with change in the aileron yaw parameter, $N'_{\delta_{AW}}/L'_{\delta_{AW}}$. The pilot comments for the long or two-second roll mode time constant were primarily directed at the roll control itself. The roll control was described as unpredictable with a slow initial response followed by an acceleration in roll rate with a resulting overbanking tendency. The turbulence response also created roll control difficulties requiring numerous aileron inputs, but caused very little degradation in the overall handling qualities. L'_β for these configurations was -1.50. Although there are differences in pilot ratings, Figure 48a, for the three roll mode time constants evaluated, differences are relatively minor, with all three optimum configurations rated as satisfactory, i.e., $PR \leq 3.5$.

Figure 48b compares the short and moderate roll mode time constants at the low Dutch roll frequency, moderate damping ratio, and high $|\phi/\beta|_d$. Here again, little difference in pilot rating can be directly attributed to the change in roll mode time constant. The L'_β for the moderate roll mode time constant configurations was -4.39, and for the 0.4-second configurations, -8.91. This accounts for the greater separation between the zeroes of the ϕ/δ_a transfer function for the short roll mode time constant configuration as the aileron yaw parameter was varied. Consequently, there is a more rapid degradation in pilot rating as $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ was varied from its "optimum" value. The turbulence response in roll was less for the moderate roll mode time constant configurations; however, the pole-zero separation was considerably greater in all cases, with a corresponding requirement for rudder coordination for each configuration.

The roll mode time constant comparison ($\tau_R \approx 0.4$ and 1.0 seconds) for the low $|\phi/\beta|_d$ configurations is shown in Figure 48c. The L'_β for the short roll mode time constant is approximately three times (-2.86 compared to -1.03)

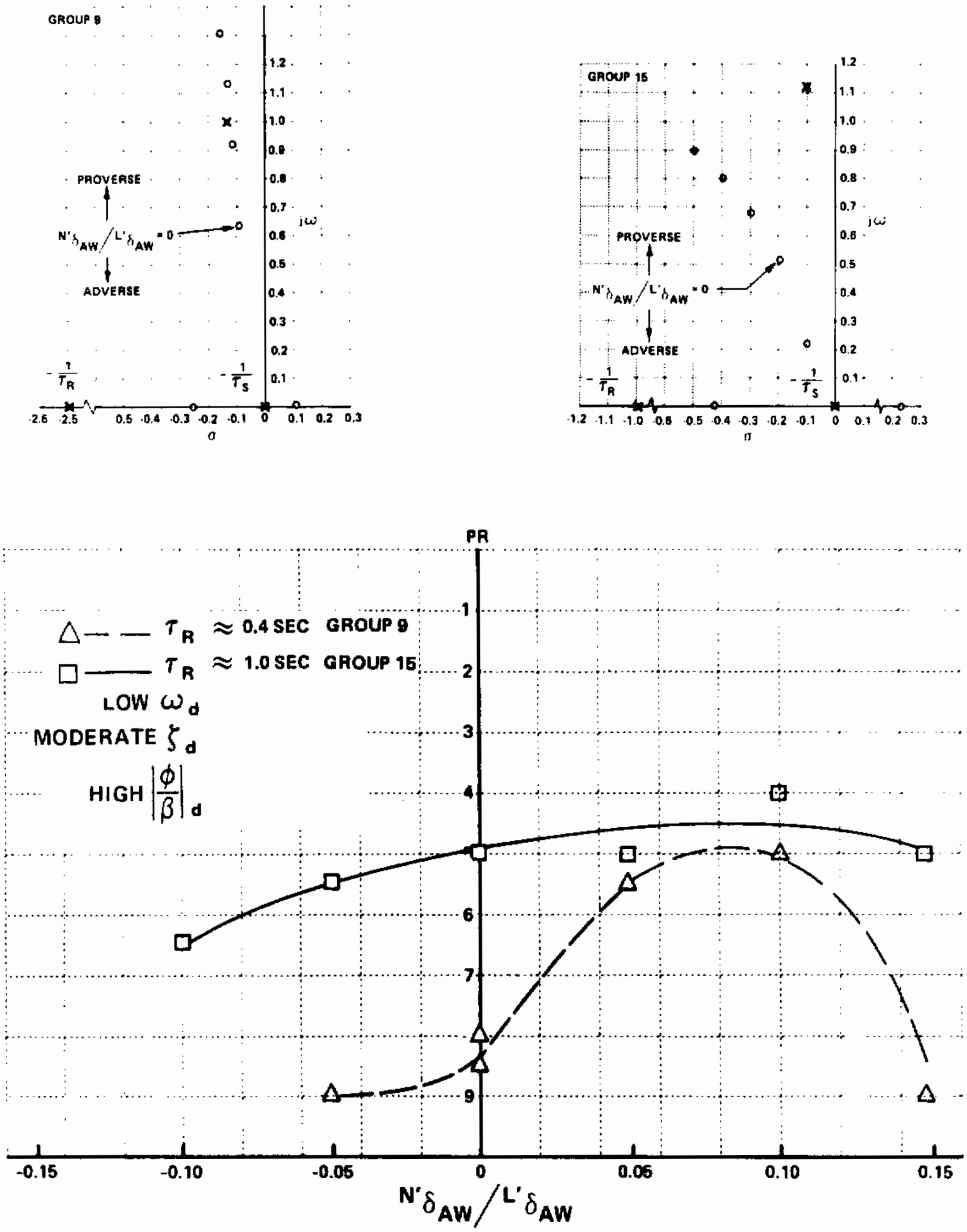


Figure 48b COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF τ_R WITH HIGH $\left|\frac{\phi}{\beta}\right|_d$

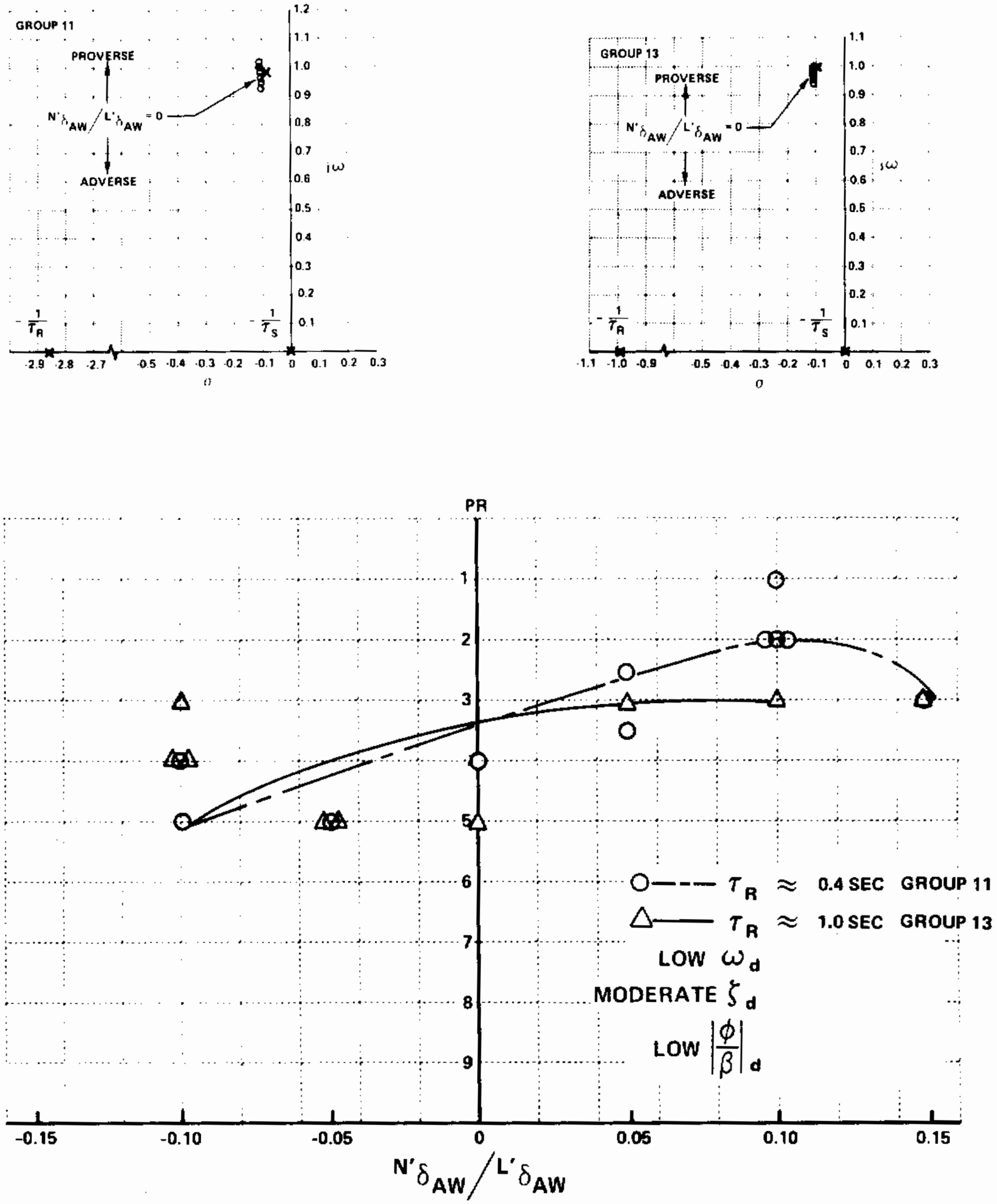


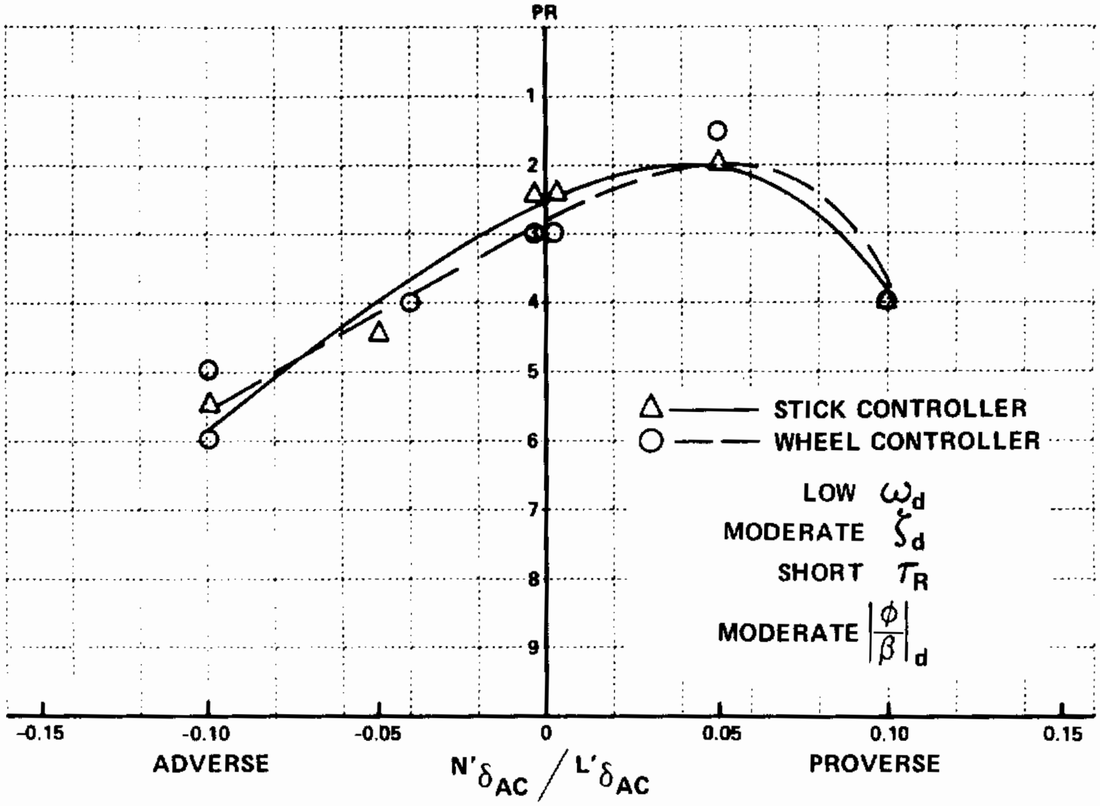
Figure 48c COMPARISON OF PILOT RATINGS WITH DIFFERENT VALUES OF τ_R WITH LOW $\left|\frac{\phi}{\beta}\right|_d$

that of the moderate roll mode time constant but the overall effect on the numerator terms in the ϕ/δ_a transfer function is relatively small. Because of the closeness of the numerator zeroes to the Dutch roll pole, the roll rate trace closely approximates a pure first-order response. The transient responses shown in Appendix V confirm this. The roll control was considered good for both values of roll mode time constant. The pilots liked the smoothness and predictability of the roll control. The airplane was considered to be responsive in roll at the longer roll mode time constant, and this was occasionally listed as a favorable feature.

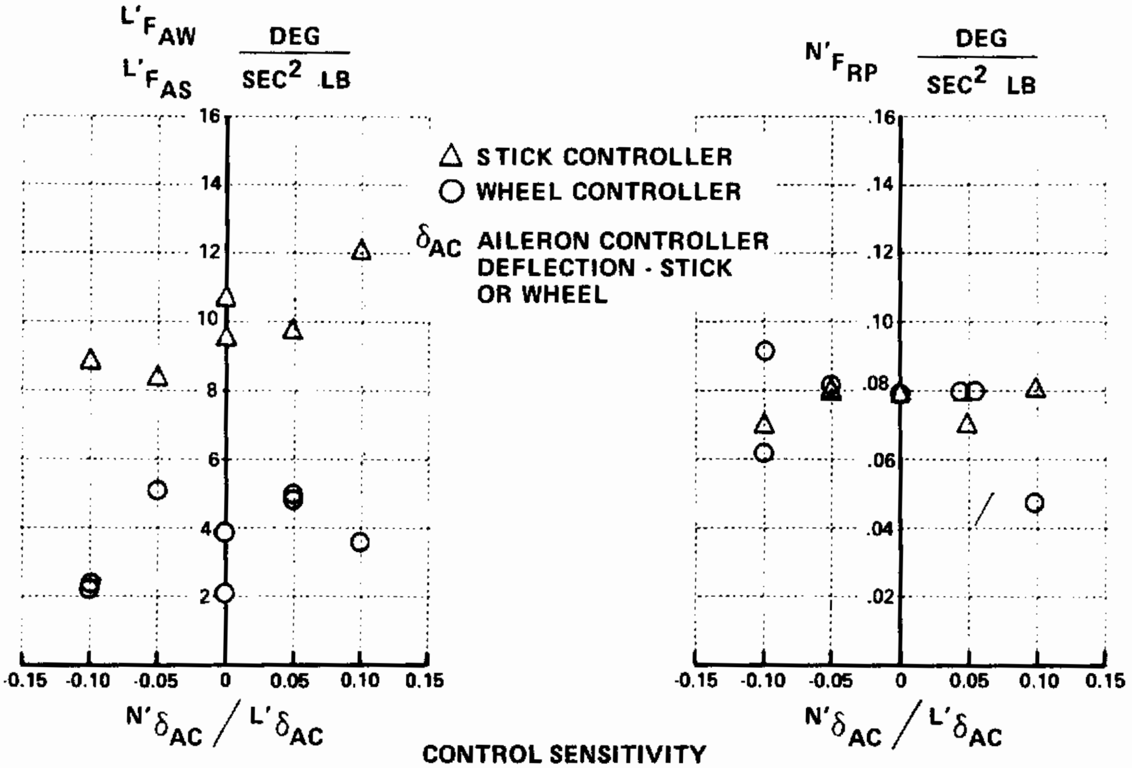
4.6.5 Comparison of Wheel and Stick Controllers

Four groups were evaluated with both a wheel and a stick controller. Comparative pilot rating and pilot-selected control sensitivity data are shown in Figures 49 through 52. There were no significant differences in the pilot ratings obtained for the stick and wheel controllers for any of the groups. The plots of pilot rating versus the aileron yaw parameter, $N'_{\delta_{AW}}/L'_{\delta_{AW}}$, where δ_{AC} represents controller deflection, stick or wheel, show similar trends for both controllers for all three groups. The differences between the stick and wheel controller that did occur were less than one pilot rating, certainly within the limits of intrapilot and interpilot variability. It can be concluded that desirable lateral-directional dynamics are not dependent upon the type of controller, stick or wheel, used.

The apparent major difference between stick and wheel controllers was the pilot selected values of aileron control sensitivity shown on Figures 49, 50, 51 and 52. These figures show that the aileron force sensitivities for the stick controller were selected greater than those for the wheel controller by a factor of approximately 2.5. The application of force by the pilot is, however, quite different between a wheel and a stick. For roll control with a wheel controller, essentially vertical force inputs are used while with a stick controller horizontal force inputs are used as indicated on Figure 53. Because of the difference in stick and wheel aileron control

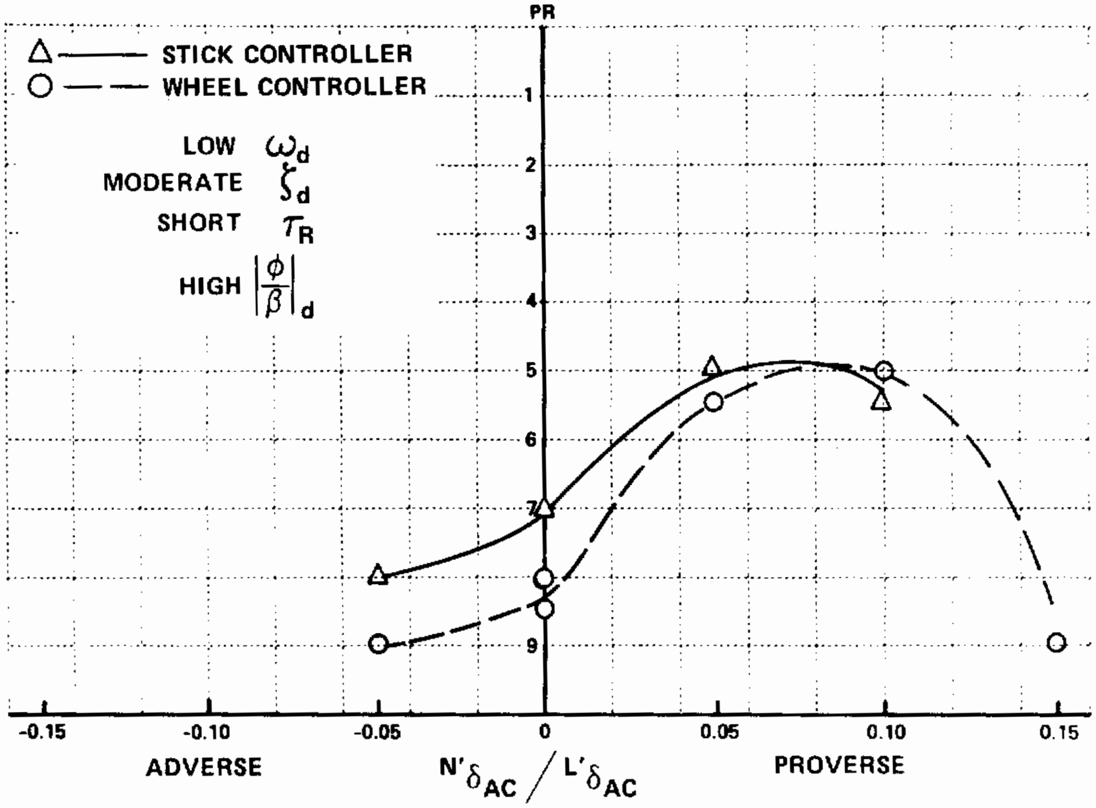


WHEEL AND STICK CONTROLLERS

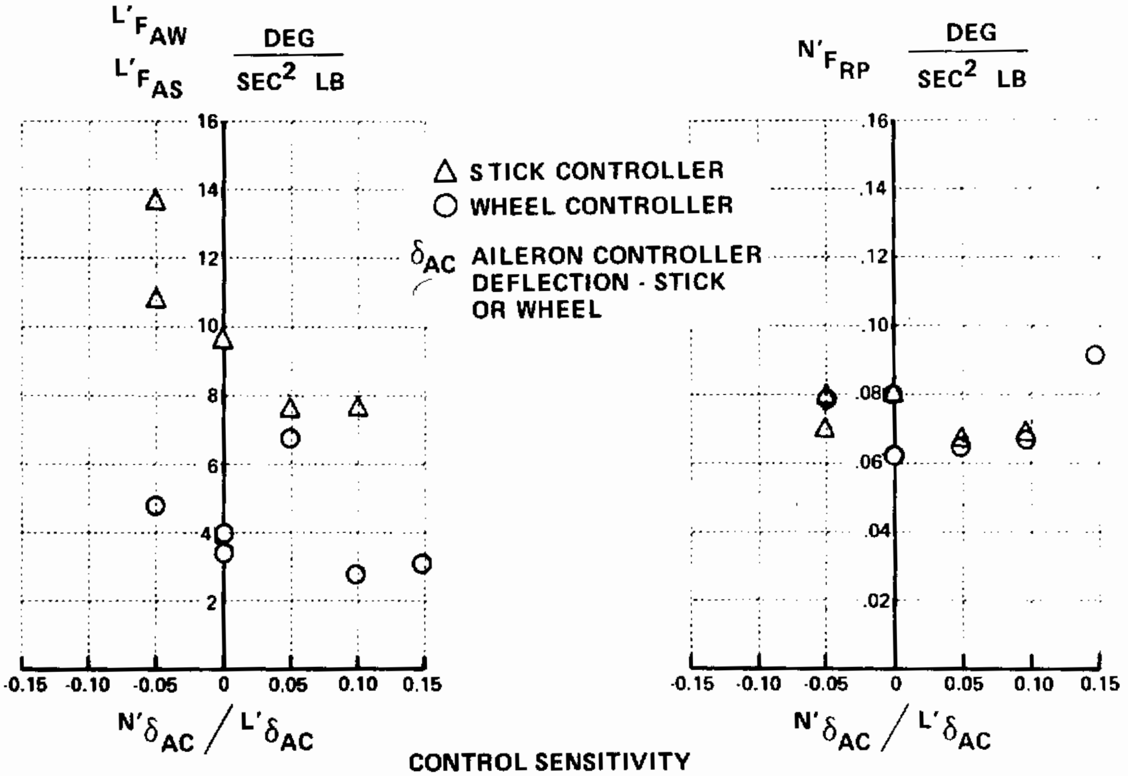


CONTROL SENSITIVITY

Figure 49 COMPARISON OF WHEEL AND STICK CONTROLLERS AND PILOT-SELECTED CONTROL SENSITIVITY - GROUP 6

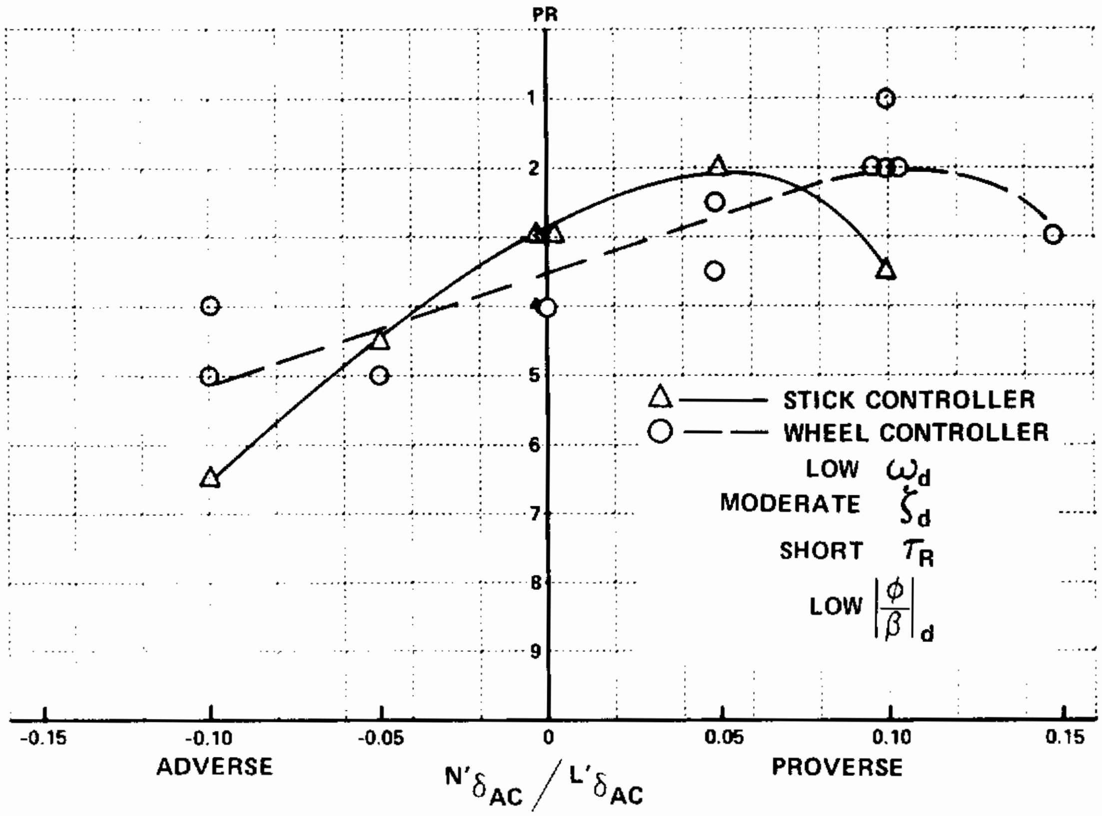


WHEEL AND STICK CONTROLLER

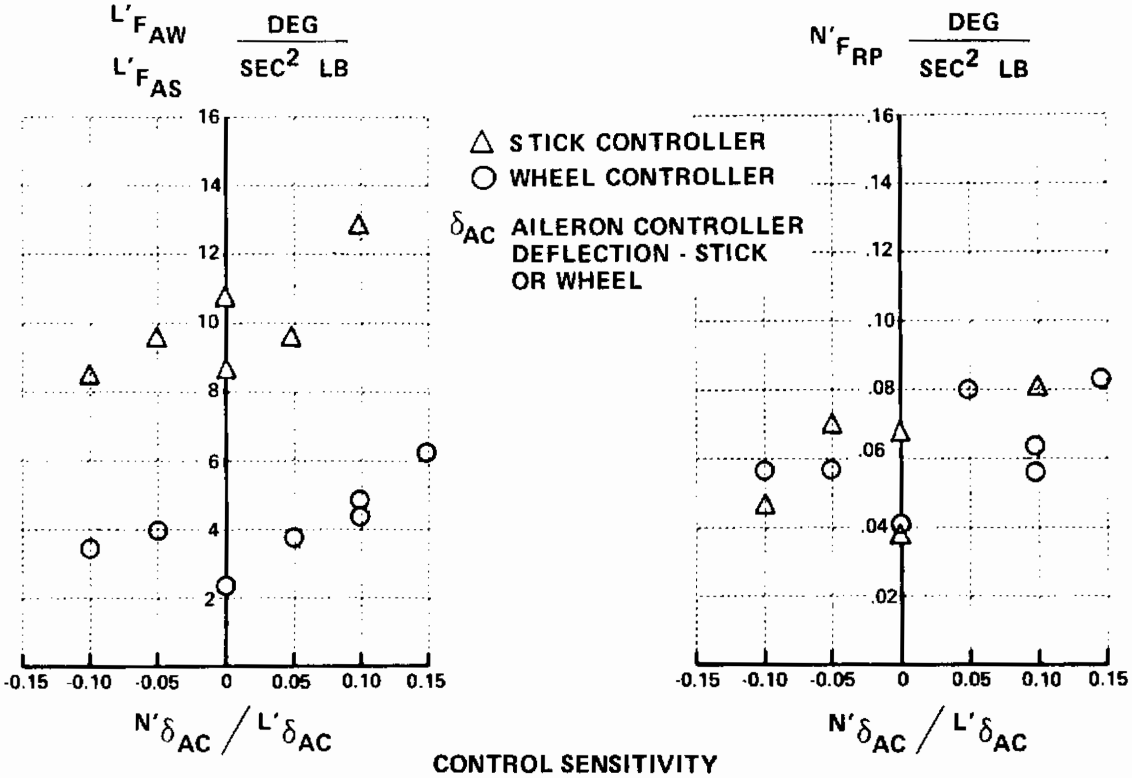


CONTROL SENSITIVITY

Figure 50 COMPARISON OF WHEEL AND STICK CONTROLLERS AND PILOT-SELECTED CONTROL SENSITIVITY - GROUP 9

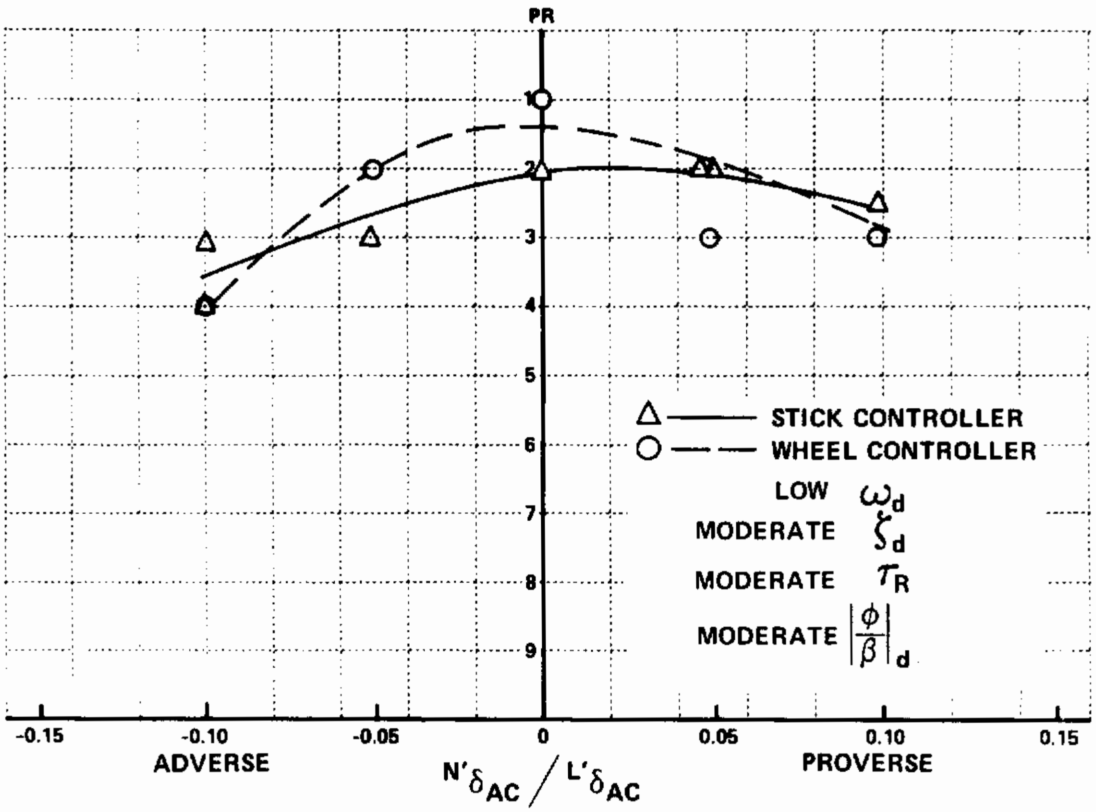


WHEEL AND STICK CONTROLLERS

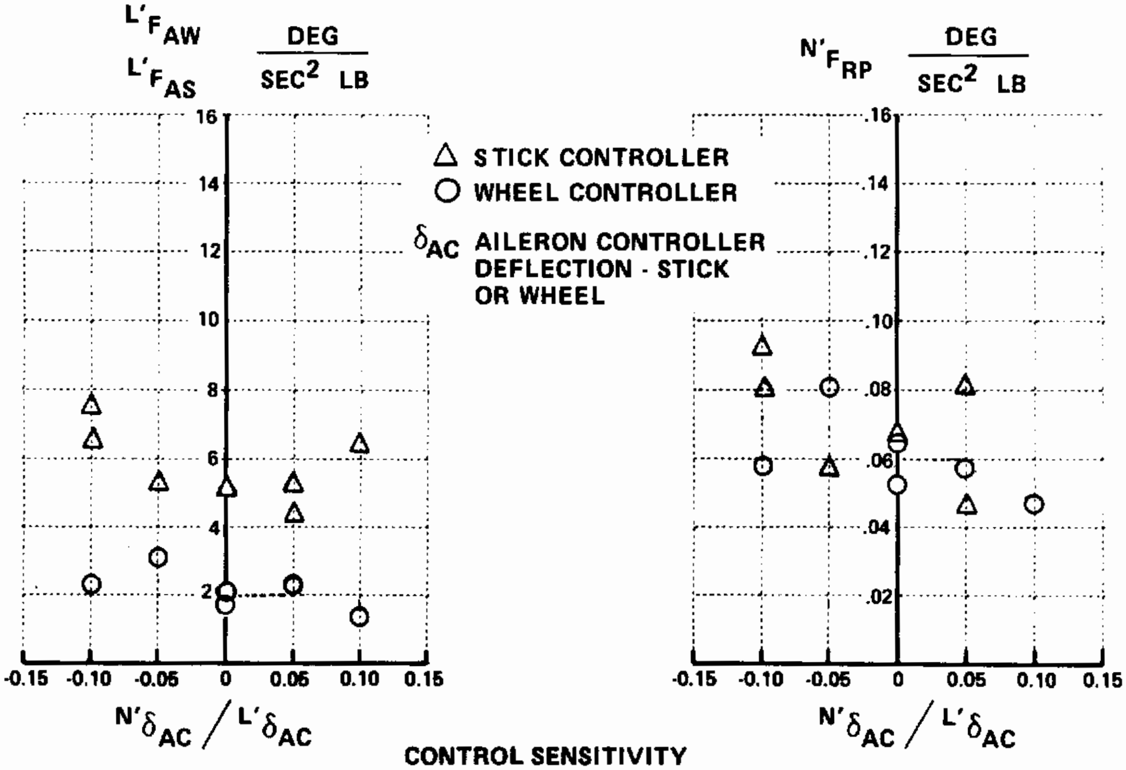


CONTROL SENSITIVITY

Figure 51 COMPARISON OF WHEEL AND STICK CONTROLLERS AND PILOT-SELECTED CONTROL SENSITIVITY - GROUP 11



WHEEL AND STICK CONTROLLERS



CONTROL SENSITIVITY

Figure 52 COMPARISON OF WHEEL AND STICK CONTROLLERS AND PILOT-SELECTED CONTROL SENSITIVITY - GROUP 14

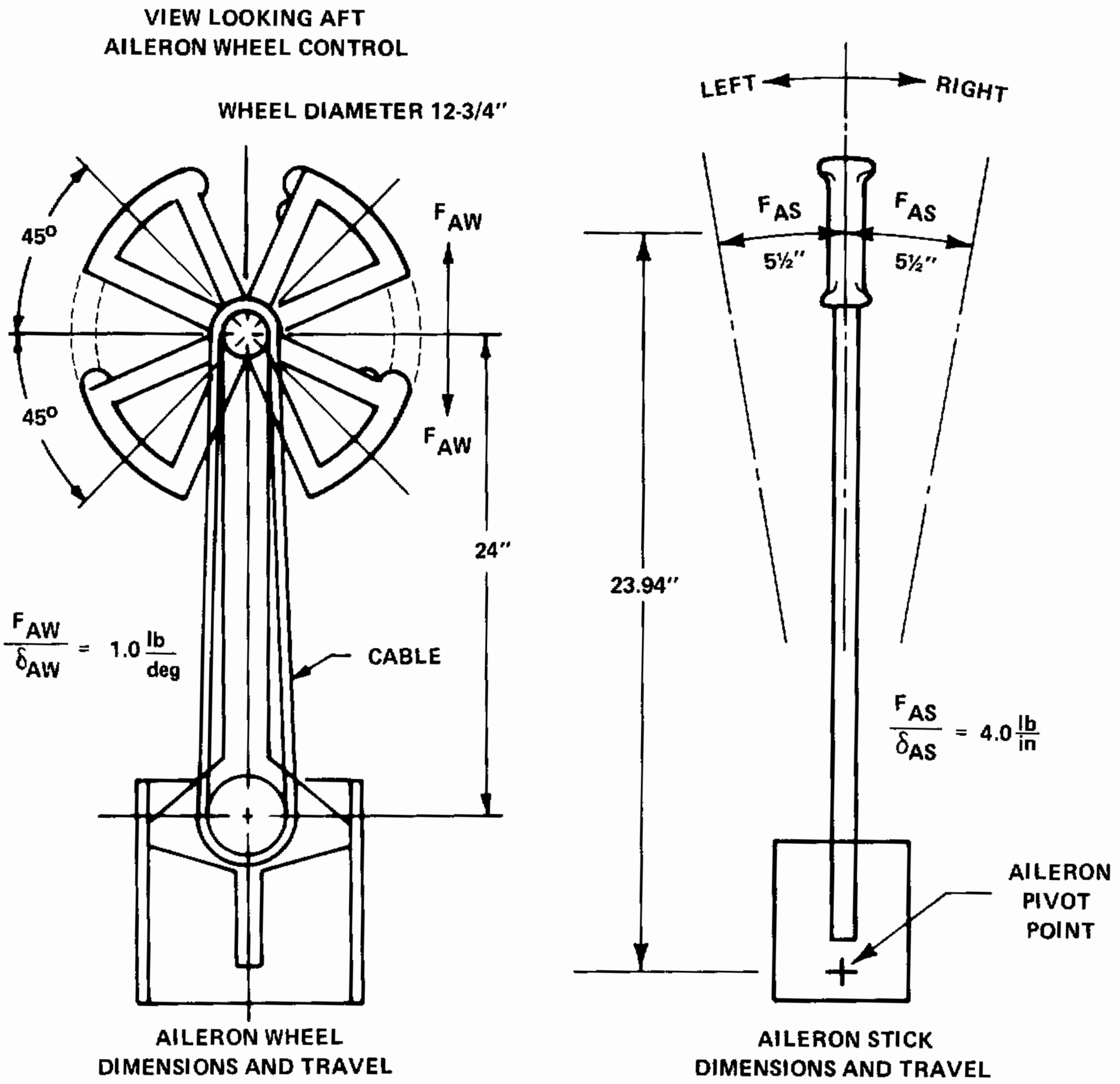


Figure 53 WHEEL AND STICK CONTROLLERS

sensitivities selected, the maximum rolling accelerations obtained with the two different controllers were compared to determine whether or not the pilot maneuvered any differently (in this case more rapidly) with the stick controller than with the wheel controller. Figures 54a and 54b were obtained from probability distribution of actual control force usage and show the probability of the pilot exceeding a given aileron control force input for the sensitivities shown. Comparison of Figures 54a and 54b shows that larger force inputs were used with the wheel controller for all four groups evaluated.

The following table shows those aileron control force inputs for which the probability of exceeding is 0.02 and the resulting rolling accelerations obtained for these inputs:

Table IV

COMPARISON OF ROLLING ACCELERATIONS FOR WHEEL AND STICK CONTROLLER

Group	Stick	$L'_{F_{AS}} F_{AS}$	Wheel	$L'_{F_{AW}} F_{AW}$
6	1.8 lb.	19.1 deg/sec^2	6.0 lb.	18.0 deg/sec^2
9	3.2 lb.	25.6 deg/sec^2	7.4 lb.	22.2 deg/sec^2
11	1.3 lb.	14.3 deg/sec^2	5.0 lb.	22.5 deg/sec^2
14	1.7 lb.	8.8 deg/sec^2	7.6 lb.	16.0 deg/sec^2

Rolling accelerations obtained for groups 11 and 14 were actually lower with the stick controller than with the wheel controller while those for groups 6 and 9 were slightly higher with the stick controller. Thus there is no evidence that the higher aileron force sensitivities selected with the stick controller resulted in any faster maneuvering in roll with the stick than with the wheel. To further support this conclusion, maximum roll rates from in-flight records were reviewed and showed no distinguishable differences between the stick and wheel controllers.

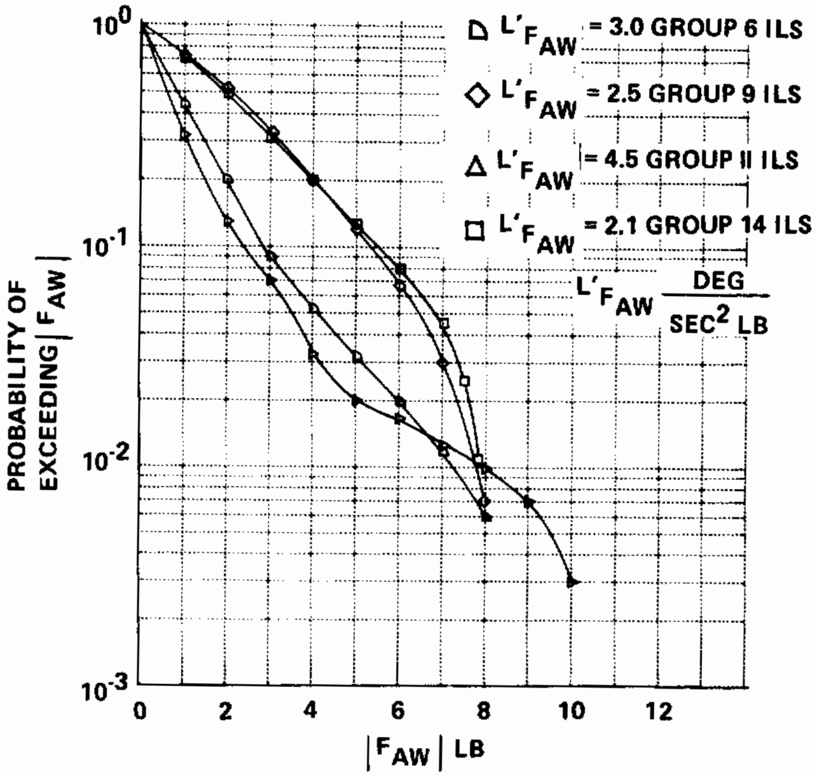


Figure 54a PROBABILITY OF EXCEEDING A GIVEN LATERAL CONTROL FORCE–WHEEL CONTROLLER

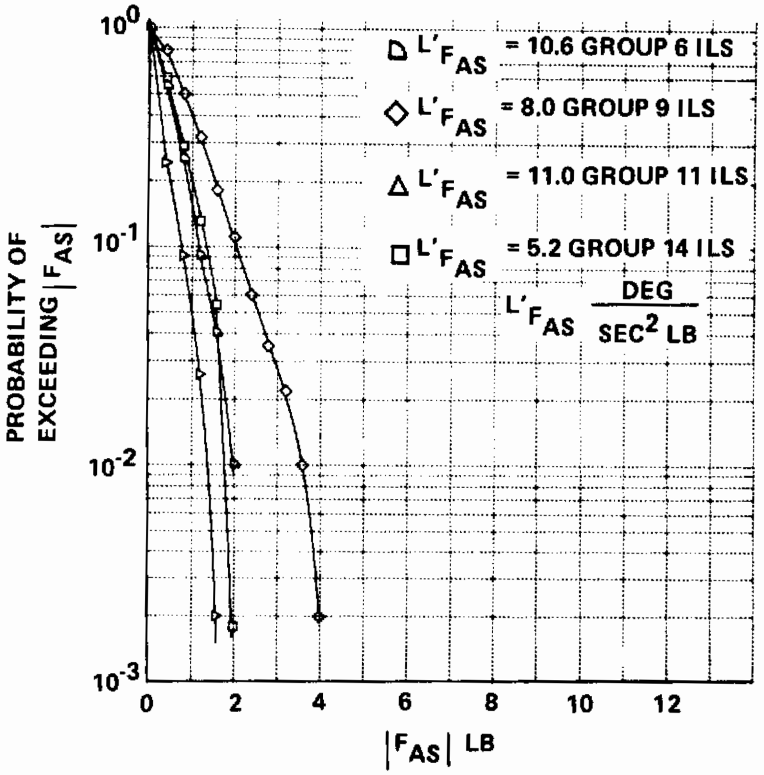


Figure 54b PROBABILITY OF EXCEEDING A GIVEN LATERAL CONTROL FORCE–STICK CONTROLLER

4.6.6 Control Sensitivity Selections

During each evaluation, the pilot selected aileron and rudder control sensitivities that he considered optimum for the configuration. The selected values are presented in Section 4.2 through 4.5. The selection of sensitivities was the first step in the evaluation procedure during the pilot's familiarization with the configuration. Arrows shown on the control sensitivity plots designate points that the evaluation pilots reported could be improved. For example, if the pilot comments indicated that the aileron control was a little heavy, an arrow was drawn to indicate that sensitivity should be increased. The plots of aileron control sensitivity reveal a tendency by pilot B to select higher sensitivities than pilot A. Most obvious differences occurred for those groups with the shortest roll mode time constant, $\tau_R \approx 0.4$. Similar differences in the pilots were also noted in the case of rudder sensitivities, although they were not as pronounced.

The differences in sensitivity selections are believed attributable to two factors. First, the physical difference in the two pilots. Pilot A, who is quite large but proportionately trim and muscular, seemed quite willing to accept higher forces than pilot B who, by comparison, is smaller and not as physically powerful as pilot A. Second, as a close examination of the pilot comments will reveal, pilot B was much more sensitive to compromises necessary between tolerable forces in one mission segment and overly sensitive control in another mission segment. This oversensitivity also may be due to pilot B's intolerance to high control forces. It is further evident from the pilot comments that pilot B, on several occasions, re-selected sensitivities after flying a crosswind or lateral offset landing approach and finding that lateral control forces were too heavy for one-handed operation. He considered one-handed operation an essential requirement for the landing approach phase for the class of airplanes being investigated. In one case with a low roll-to-sideslip ratio (Group 11 with $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$), pilot B commented that since the directional and lateral responses seemed to be separated, he could choose lateral control to suit his desires, and he liked it sensitive. In this case, he selected a very high sensitivity. Thus, it seems that what a pilot considers optimum sensitivity may be significantly influenced by personal preference if the configuration is amenable to a range. The flight experience and background of the two evaluation pilots is quite similar and hence offers no resolution as to their differences in acceptable sensitivities.

Selection of rudder control sensitivities was usually based on turn coordination requirements and often tailored, especially by pilot B, to offer reasonable forces on crosswind landing approaches and yet not be too sensitive for turn coordination during normal maneuvering. Rudder pedal sensitivity increased as Dutch roll frequency became higher. This increase is expected because directional static stability is greater with higher Dutch roll frequency. However, pilots do not wish to accept higher pedal forces with the greater static stability; thus prefer higher sensitivities.

Pilot-selected values of aileron control sensitivity showed variations with the roll mode time constant, τ_R , and variations between the two evaluation pilots. There was no discernible trend of variation with other dynamic modal characteristics. Although pilot comments indicate that crosswinds were occasionally a factor in the selection of control sensitivities, attempts to establish a meaningful correlation proved futile. In Reference 7, pilot-selected values of aileron and rudder sensitivity were shown to correlate with the aileron yaw parameter, $N'_{\delta_{AW}}/L'_{\delta_{AW}}$. Attempts to establish a consistent relationship between sensitivities and $N'_{\delta_{AW}}/L'_{\delta_{AW}}$ for the data obtained in this experiment were unsuccessful.

The control sensitivity plots in Sections 4.2 through 4.5 show that at the smallest value of roll mode time constant evaluated, $\tau_R \approx 0.4$, there is considerable scatter in the range of pilot-selected control sensitivity. For the moderate and long values of τ_R tested, $\tau_R \approx 1.0$ and $\tau_R \approx 2.0$, the range of selected sensitivities was smaller. At $\tau_R \approx 2.0$, the acceptable range of sensitivities was quite small. Reference 51 reported a similar trend in variations of pilot-selected control sensitivity with roll mode time constant.

At the moderate and long roll mode time constants, the pilots' comments indicate that control sensitivity selection was a compromise between sensitive enough ailerons to preclude heavy forces during the initiation and stopping of roll rates, and low enough sensitivity to prevent overcontrolling tendencies. Thus, if no compromise was required, the control sensitivity selections were strongly influenced by pilot preference; however, when a compromise was required both pilots tended to make uniform selections.

Figure 55 compares plots of pilot-selected values of aileron control sensitivity, $L'_{\delta_{AW}}$, versus the roll mode time constant τ_R. Points shown are only for configurations that received a PR of 3.5 or better. The figure shows the tendency of pilot A to select lower sensitivity values than pilot B, and that both pilots selected lower aileron control sensitivity for increasing values of τ_R. This trend is well established in past handling qualities research and is documented in Reference 10.

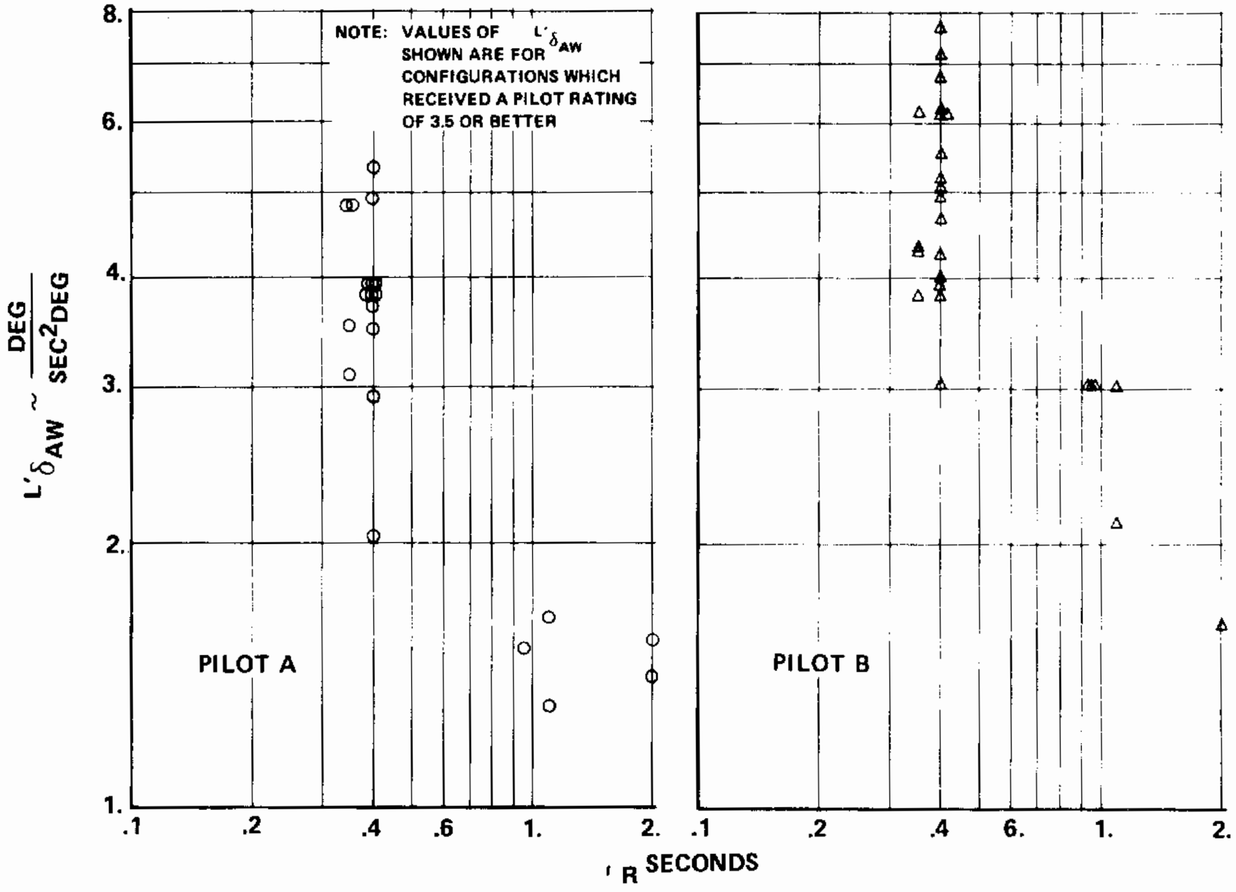


Figure 55 AILERON CONTROL SENSITIVITY VS ROLL MODE TIME CONSTANT

4.7 RESULTS OF CROSSWIND LANDINGS

The crosswind landing approach was considered a primary evaluation task. Since flights were performed on a day-to-day basis, the available wind provided the crosswind. The bar chart shown in Figure 56 indicates the number of configurations evaluated for 5-knot intervals of the crosswind component.

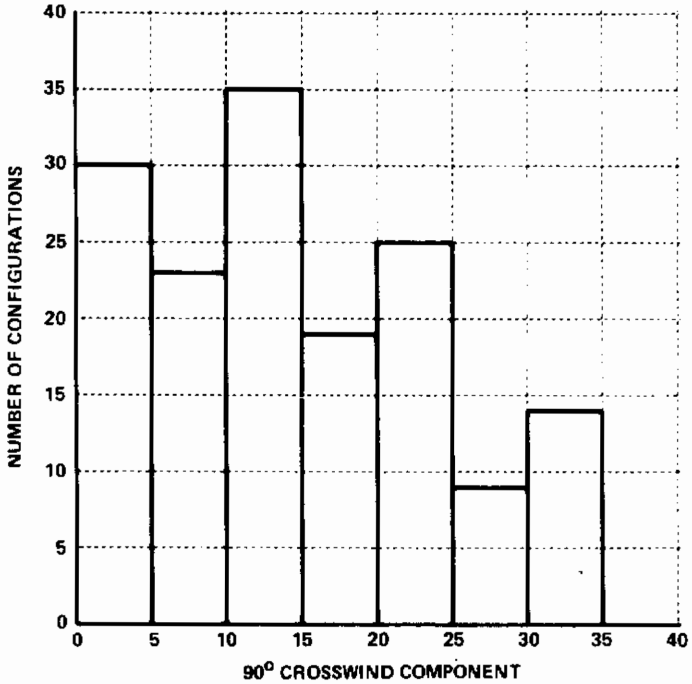


Figure 56 CONFIGURATIONS EVALUATED AT CROSSWIND COMPONENT INTERVALS

At least one configuration out of each group was evaluated with a 90° crosswind component exceeding fifteen knots, and at least one configuration in all but three groups was evaluated for a crosswind exceeding twenty knots. None of the approaches were flown to touchdown; however, all were flown to a level flare to assess the line-up and/or decrab capabilities of the configuration.

The various combinations of lateral-directional dynamics evaluated did not prevent completing the crosswind approach in any of the cases for which sufficient aileron and rudder control power were available. This does not mean, however, that the pilots found all combinations desirable or even acceptable, only that with sufficient control power they were able to perform the crosswind approach in the maximum crosswinds available.

Low Dutch roll damping ratio was not a serious problem in the crosswind approach at the high Dutch roll frequency, but became a major problem at the low frequency. The low static directional stability resulted in a slow directional response, making it difficult to be precise with heading control in either the wing-down or decrab maneuver. The continuous nose oscillations resulting from the low damping ratio required continuous rudder control during the final approach. There was a strong tendency to overcontrol directionally during the wing-down approaches and a tendency to set up a directional oscillation when attempting to execute the decrab maneuver.

One crosswind approach for the low Dutch roll frequency, low damping ratio and high $|\phi/\beta|_d$ configuration, 5A1, was described as "truly staggering." The aileron forces were described as large and uncomfortable even with two hands. Directional control required occasional rudder reversals, resulting in continuous manipulation of the aileron control. Because of the excessive lateral forces required for a wing-down approach, it was concluded that a combination of wing-down and crabbed approach was best. Even then, the workload required to perform a crosswind approach in even a modest crosswind of 10 to 15 knots was considered high.

The most significant effect on crosswind performance can be attributed to the $|\phi/\beta|_d$. At the low $|\phi/\beta|_d$ evaluated ($|\phi/\beta|_d \approx 0.25$), the ability to handle the crosswind, even under extreme conditions (26 gusting to 33 knots), was considered good with either technique. The low $|\phi/\beta|_d$ was not, however, evaluated for the low Dutch roll damping or the high Dutch roll frequency. The wing-down method was preferred in the heavy crosswinds because of the reluctance to kick out the resulting large crab angles near the ground, although either method was satisfactory. There were occasional complaints about high rudder forces as the crosswind component became 20 knots or greater, but no complaints about the aileron forces. The story was completely different for the high $|\phi/\beta|_d$ configurations ($|\phi/\beta| \approx 3.0$) evaluated. The large roll response to rudder required large aileron forces in the wing-down approach. The decrab maneuver also required large aileron forces to counteract the large and rapid roll response to rudder. Heavy aileron forces were a common complaint for these configurations even when the pilot stated that he had selected the aileron as sensitive as he thought compatible for small maneuvers. The large roll response due to rudder created an uncomfortable transient for most decrab maneuvers in even modest crosswinds. The effects of the high $|\phi/\beta|_d$ at the high Dutch roll frequency ($\omega_d \approx 2.0$ rad/sec) seemed less objectionable than at the low frequency; however, the maximum crosswind component evaluated was only 17 knots for the high frequency configurations. The higher directional stability tended to reduce the total bank angle excursions even though the initial roll response to a turbulence input was quite rapid. Pilot B pointed out that with the high $|\phi/\beta|_d$, it was possible to use up the available aileron control power with increasing rudder input. A discussion of roll control power requirements and how it relates to the crosswind landing problem can be found in Section 4.8.

There was little difference in the pilots' ability to handle the crosswind approaches for roll mode time constants of 0.4 seconds and 1.0 seconds. The effect of roll mode time constant did show up, however, for the configurations with $\tau_R \approx 2.0$ seconds. The tendency to overcontrol in roll was degrading when encountering gusty crosswinds near the ground.

It can be concluded that even though the lateral-directional dynamics per se, when flown with unlimited roll control power, did not establish a limiting crosswind value, they did in fact determine the difficulty or ease with which the pilot could counter crosswind effects. Low Dutch roll damping ratio combined with low Dutch roll frequency resulted in a tendency to overcontrol directionally during a wing-down approach and to set up a directional oscillation during the decrab maneuver. Low $|\phi/\beta|_d$ was desirable for the crosswind approach. High $|\phi/\beta|_d$ led to high aileron forces in the wing-down approach and a reluctance to kick off even modest crab angles near the ground because of the large, rapid roll response to rudder inputs. A long roll mode time constant also created crosswind control problems because of the inability to achieve precise roll control when encountering gusty crosswinds near the ground.

4.8 INVESTIGATION OF ROLL CONTROL POWER REQUIREMENTS

In this inflight investigation, the evaluations were performed under varying turbulence and crosswind conditions for a wide spectrum of lateral-directional dynamics. For this reason, the actual roll control usage should realistically determine the roll control power requirements for the executive jet in the landing approach. Table V shows the maximum, average, and minimum values of roll control power used for each evaluation group. These values were determined from the pilot-selected values of aileron sensitivity, $L'_{\delta_{AW}}$, and cumulative probability density plots of the pilots' aileron wheel inputs.

Table V

MAXIMUM, AVERAGE AND MINIMUM VALUES OF ROLL CONTROL POWER (DEG/SEC^2) USED BY THE PILOTS IN EVALUATION OF THE SIXTEEN BASIC GROUPS OF MODAL PARAMETERS

ω_d	2.0 rad/sec			1.0 rad/sec				
τ_R	0.4 sec			0.4 sec			1.0 sec	2.0 sec
ζ_d	0.03	0.10	0.30	0.03	0.10	0.30	0.10	0.10
$\lvert\phi/\beta\rvert_d = 0.25$					(57) 43* [25]	(58) 46* [37]	(45) 30* [21]	
$\lvert\phi/\beta\rvert_d = 1.5$	(51) 46* [38]	(50) 42* [31]	(59) 45* [30]	(61) 45* [34]	(42) 36* [30]	(56) 47* [35]	(32) 24* [17]	(24) 20* [14]
$\lvert\phi/\beta\rvert_d = 3.0$		(86) 44* [25]		(79) 61* [45]	(93) 50* [47]	(72) 43* [30]	(38) 31* [22]	

( ) Maximum values * Average values [ ] Minimum values

Having accumulated aileron wheel sensitivity data and aileron wheel deflection data, a basis was formed from which further investigation of roll control power requirements for selected configurations could progress. Additional evaluations were performed to investigate the effects of limited roll control power and to determine those parameters that are most significant in establishing minimum roll control power requirements.

Several options were available to limit the roll control power available, including:

1. Selection of aileron control sensitivities to limit the maximum roll control power.
2. Mechanical stops to limit the aileron wheel travel.
3. Limits on the electrical signal representing wheel deflection. In this case, the mechanical stops remain fixed at ±45°.

It was decided not to change the aileron wheel sensitivities from those previously selected by the evaluation pilots as optimum. Instead it was decided to maintain the sensitivity for small inputs at the value selected by the pilot when there was no control power limit, and to use option 3 to limit control power. A more complete experiment would have been to repeat each case with the control power limited and to allow the pilot to select the best control sensitivity for use with the limited control power. However, time did not permit these additional tests to be made. Limiting roll control power by mechanical stops was considered undesirable. Since the evaluation pilots would have been aware of hitting the stops, a psychological factor would have entered the experiment which would have been difficult, if not impossible, to evaluate. Therefore, the aileron control system was mechanized, as shown in Figure 57.

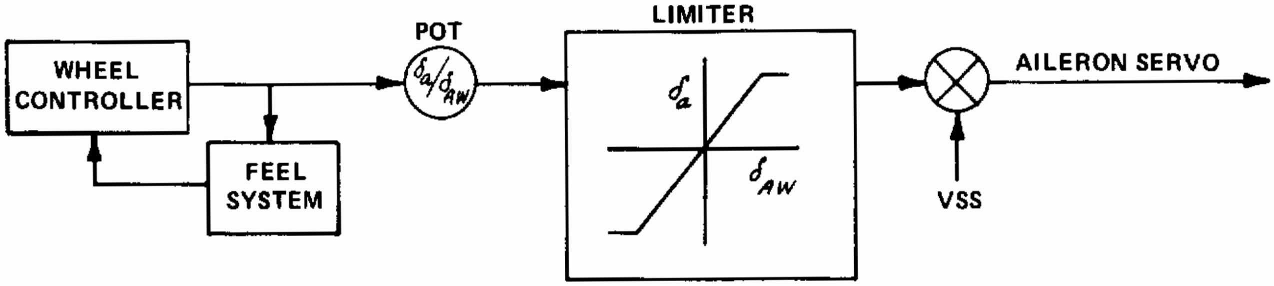


Figure 57 AILERON LIMITER SCHEMATIC

This mechanization allowed the system operator/safety pilot to select the effective aileron wheel deflection, $\delta_{AW_{EFF}}$. That is, the aileron wheel controller would command aileron deflections only through a predetermined range of its travel, $\delta_{AW_{EFF}}$. The evaluation pilot could continue rotating the control wheel to the stops, but after exceeding $\delta_{AW_{EFF}}$, no further aileron deflection could be obtained. Since the sensitivities used were those previously selected by each evaluation pilot, the only variable from previously evaluated configurations was $\delta_{AW_{EFF}}$, which limited $L'_{\delta_{AW}}\delta_{AW}$.

To limit roll control power at various incremental values, $\delta_{AW_{EFF}}$ was limited as shown in Figure 58. The same $\delta_{AW_{EFF}}$ provided each pilot with different values of $L'_{\delta_{AW}}\delta_{AW_{EFF}}$ because, as noted above, each pilot had previously selected the sensitivity he considered optimum. The selection of the values of $\delta_{AW_{EFF}}$ was based on examination of control usage data collected during the evaluations of the groups depicted in Table I, Section 3. These data indicated that $\delta_{AW} \geq 15$ degrees was seldom used in the highest $|\phi/\beta|_d$ case, and $\delta_{AW} \geq 10$ degrees was seldom used in other evaluations. Therefore, in this part of the study, $\delta_{AW_{EFF}}$ was limited to values less than or equal to 15 degrees.

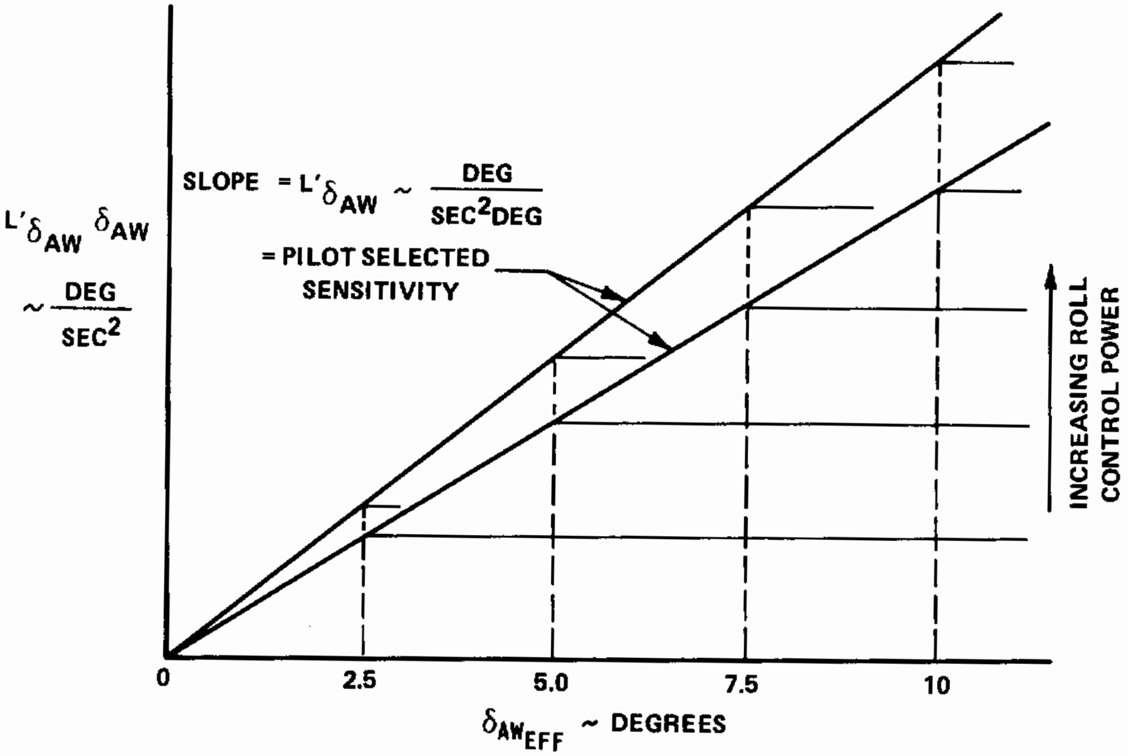


Figure 58 LIMITING OF $\delta_{AW_{EFF}}$

Evaluations were conducted for configurations 6P1, 9P1, 11P1, 14P1, and 16P1; that is, the proverse aileron yaw evaluation configuration, $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$, at which pilot ratings were near optimum from previous evaluations. This allowed limited roll control power data to be compared to near optimum pilot ratings for the unlimited roll control power cases previously evaluated.

The roll control power was always, of course, limited by the basic T-33 airplane; however, this does not constrain the evaluation so long as the maximum rolling acceleration capability of the T-33 is not exceeded by the combination of the pilot's control input, the variable stability response feedback, and the random disturbance turbulence simulation. For the configurations evaluated in this program, the maximum rolling acceleration capability of the T-33 airplane was not exceeded.

Because control usage data were recorded, it was possible to determine how much of the available roll control power was actually used by the pilot. Although time and funds did not allow power spectral densities of the control motions to be calculated, cumulative probability density functions were determined for a majority of the ILS, offset, and crosswind approaches. Cumulative probability density functions do not show how the controls were used, but they do determine how much control was used. In other words, a pilot may use smooth low-frequency inputs or rapid high-frequency inputs and achieve different airplane responses but still have a similar cumulative probability density function.

Figures 59 through 63 show the degradation of pilot rating with decreasing roll control power for the five groups evaluated. The roll control power numbers shown in these figures were determined from either: (1) the maximum δ_{AW} used if δ_{AW} was not limited, (2) the maximum δ_{AW} used if the maximum used was less than the limiting value of δ_{AW} , or (3) the limiting δ_{AW} if the actual control usage exceeded the limiting δ_{AW} value. The maximum values presented are the maximum values recorded during the particular evaluation. The probability of exceeding these values is only 0.02; they include the ILS, offset, and crosswind approaches. Values of ϕ_1 , $\phi_{1.8}$ and p_{ss} shown on these figures were determined using the same δ_{AW} criteria.

Both evaluation pilots generally tended to complain about decreased sensitivity as the effective aileron wheel throw was progressively limited, only occasionally mentioning the need for more aileron control power. As the wheel moved beyond the effective wheel throw against a constant spring gradient, the pilot would observe a reduced roll rate and consider the control sensitivity reduced. However, as the control power became more severely limited, both evaluation pilots commented on the low steady-state roll rates available. Even with severely limited roll control power, neither pilot encountered much difficulty with small magnitude maneuvers, but performing crosswind and lateral offset approaches, especially in turbulence, often became a formidable task. Neither pilot recognized that a nonlinearity existed in the control system.

CONF	PILOT/PR	$L'\delta_{AW}$ $(DEG/SEC^2\ DEG)$	ROLL CONTROL POWER USED (DEG/SEC^2)	MAXIMUM $\delta_{AW_{EFF}}$ (DEG)	MAXIMUM δ_{AW} USED (DEG)	ϕ_1* (DEG)	$\phi_{1.8}$* (DEG)	P_{SS}* (DEG/SEC)
1	A/3	4.78**	47.8	±10	11	12.2	26.1	17.1
2	B/4	4.78	35.8	±7.5	8	8.9	18.9	12.4
3	B/1.5	4.78	31.0	±45	6.5	7.7	16.4	10.8
4	A/3	3.08	30.8	±10	12	7.6	16.3	10.7
5	B/6	4.78	23.9	±5	17	5.9	12.6	8.3
6	A/9	3.08	7.7	±2.5	25	1.9	4.1	2.7

**INCORRECTLY FLOWN WITH SENSITIVITY SELECTED BY PILOT B.

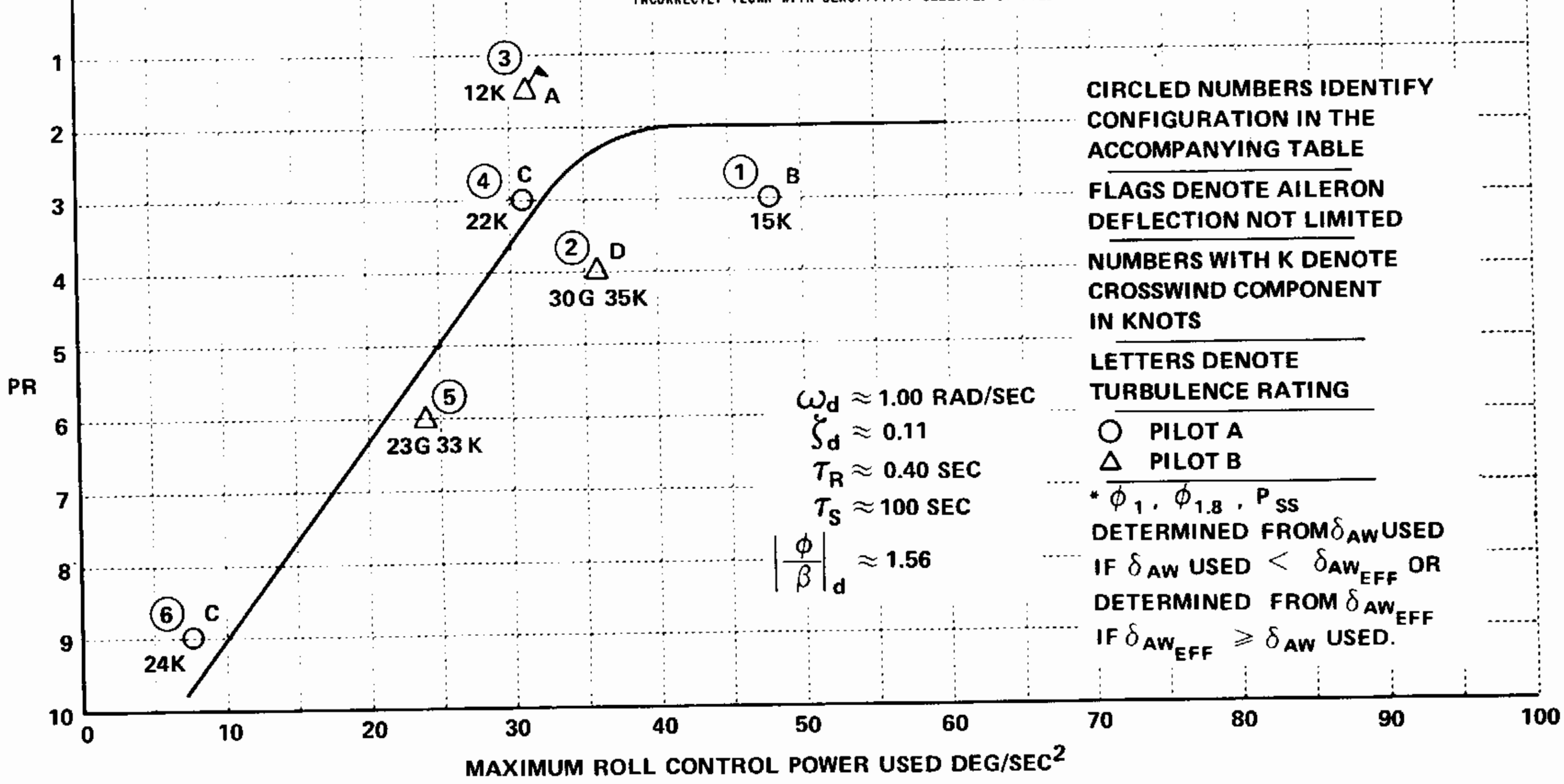


Figure 59 PILOT RATING VERSUS MAXIMUM ROLL CONTROL POWER USED--GROUP 6

CONF	PILOT/PR	L' δ_{AW} (DEG/SEC^2 DEG)	ROLL CONTROL POWER USED (DEG/SEC^2)	MAXIMUM $\delta_{AW_{EFF}}$ (DEG)	MAXIMUM δ_{AW} USED (DEG)	ϕ_1* (DEG)	$\phi_{1.8}$* (DEG)	P_{SS}* (DEG/SEC)
1	B/5	6.66	93.2	±15	14	22.3	46.3	27.0
2	B/8	6.66	66.6	±10	16	15.9	33.1	19.3
3	B/5.5	6.66	53.3	±45	8	12.7	26.5	15.4
4	B/10	6.66	50.0	±7.5	24	12.0	24.8	14.5
5	A/8	3.01	30.1	±10	26	7.2	15.0	8.7
6	B/8.5	6.66	16.6	±2.5	18	4.0	8.3	4.8
7	A/9	2.57	12.9	±5.0	30	3.1	6.4	3.7

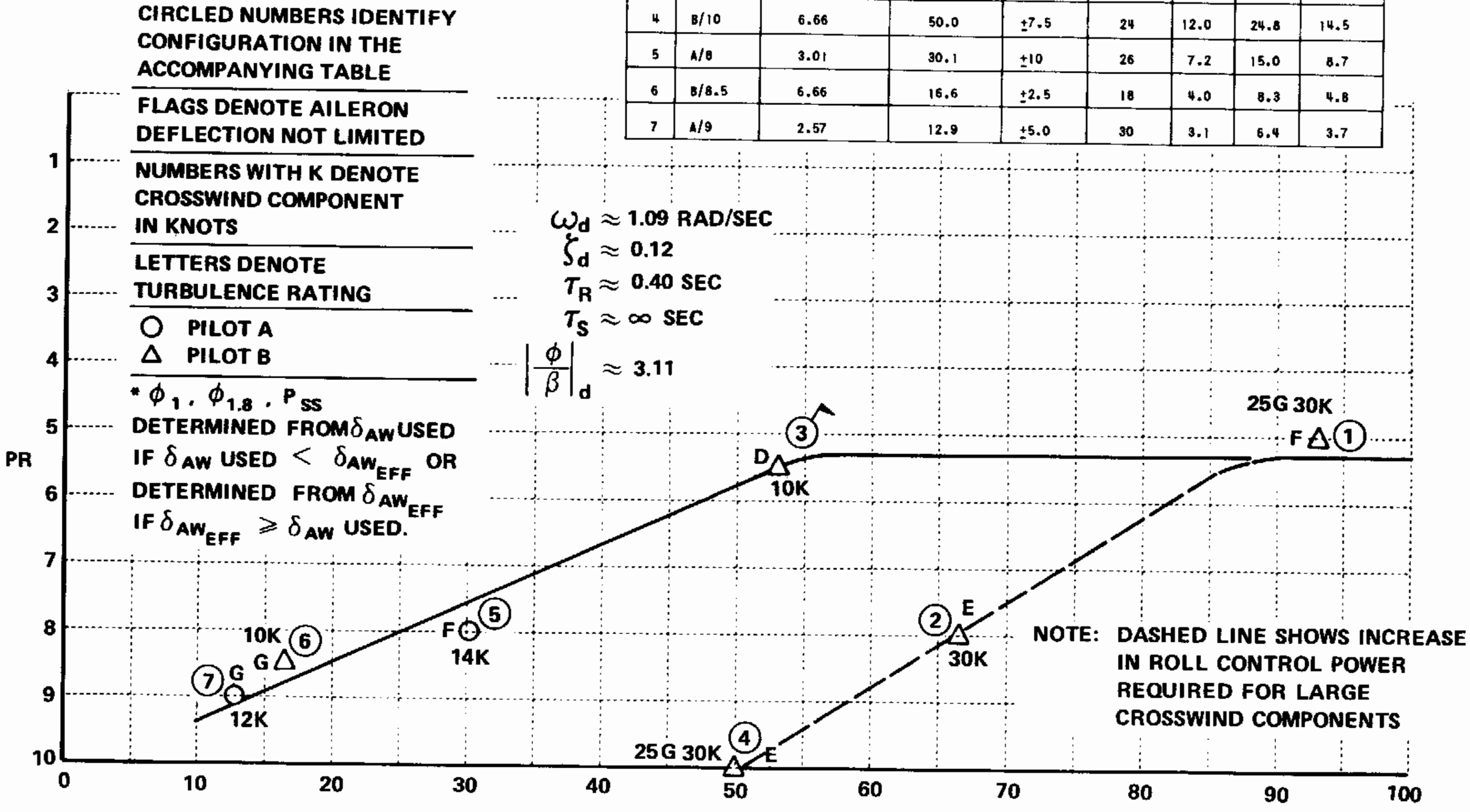


Figure 60 PILOT RATING VERSUS MAXIMUM ROLL CONTROL POWER USED--GROUP 9

CONF	PILOT/PR	$L'_{\delta_{AW}}$ (DEG/SEC^2 DEG)	ROLL CONTROL POWER USED (DEG/SEC^2)	MAXIMUM $\delta_{AW_{EFF}}$ (DEG)	MAXIMUM δ_{AW} USED (DEG)	ϕ_1* (DEG)	$\phi_{1.8}$* (DEG)	P_{SS}* (DEG/SEC)
1	A/3.5	3.08	49.3	±45	16	11.6	24.8	16.9
2	B/2.5	3.83	46.0	±45	12	10.8	23.2	15.8
3	B/2.5	3.83	30.6	±10	8	7.2	15.4	10.5
4	A/5	3.08	23.1	±7.5	29	5.4	11.6	7.8
5	A/7	3.08	15.4	±5	16	3.6	7.8	5.3
6	B/7	3.83	9.6	±2.5	14	2.3	4.8	3.3

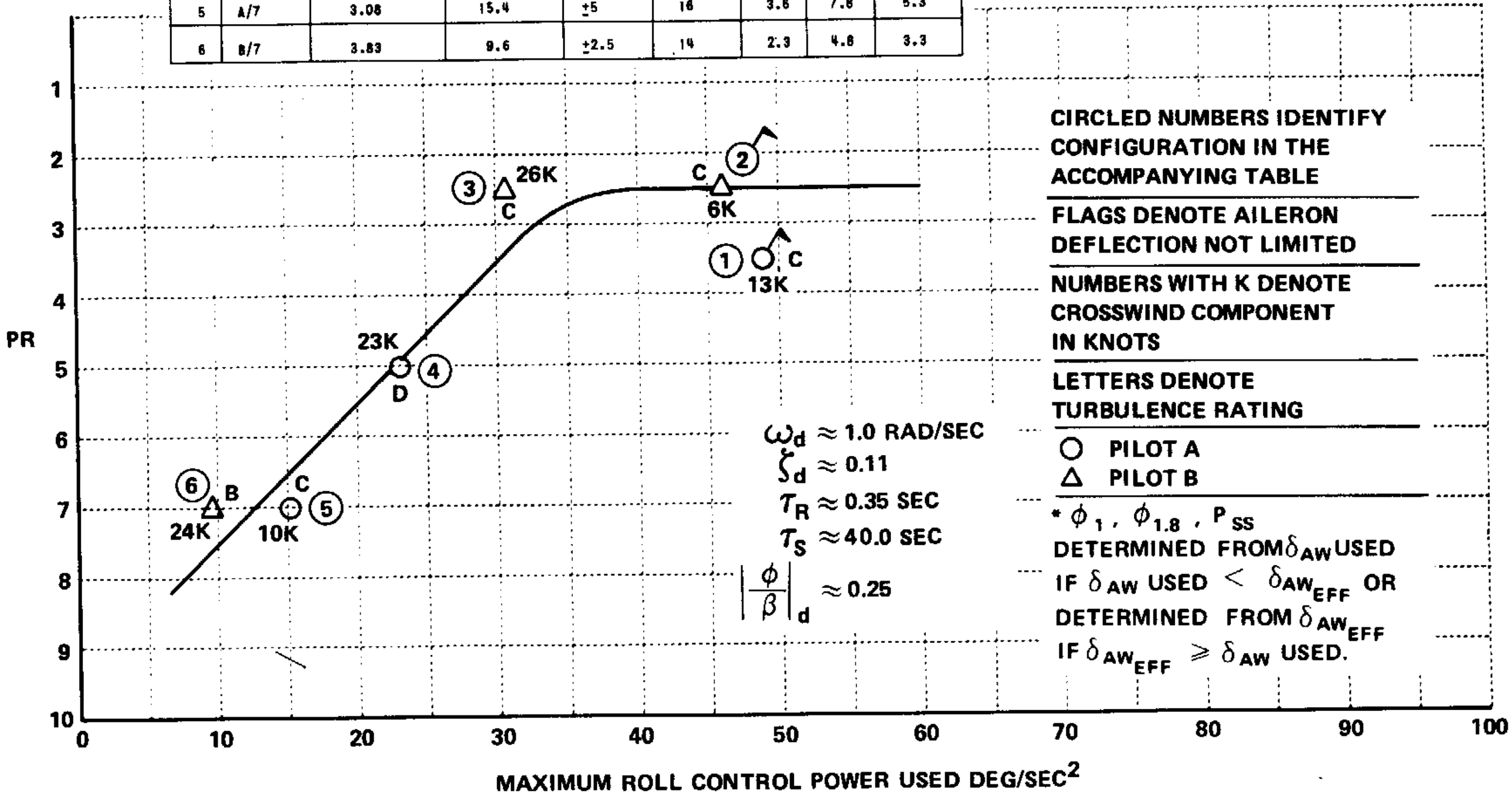
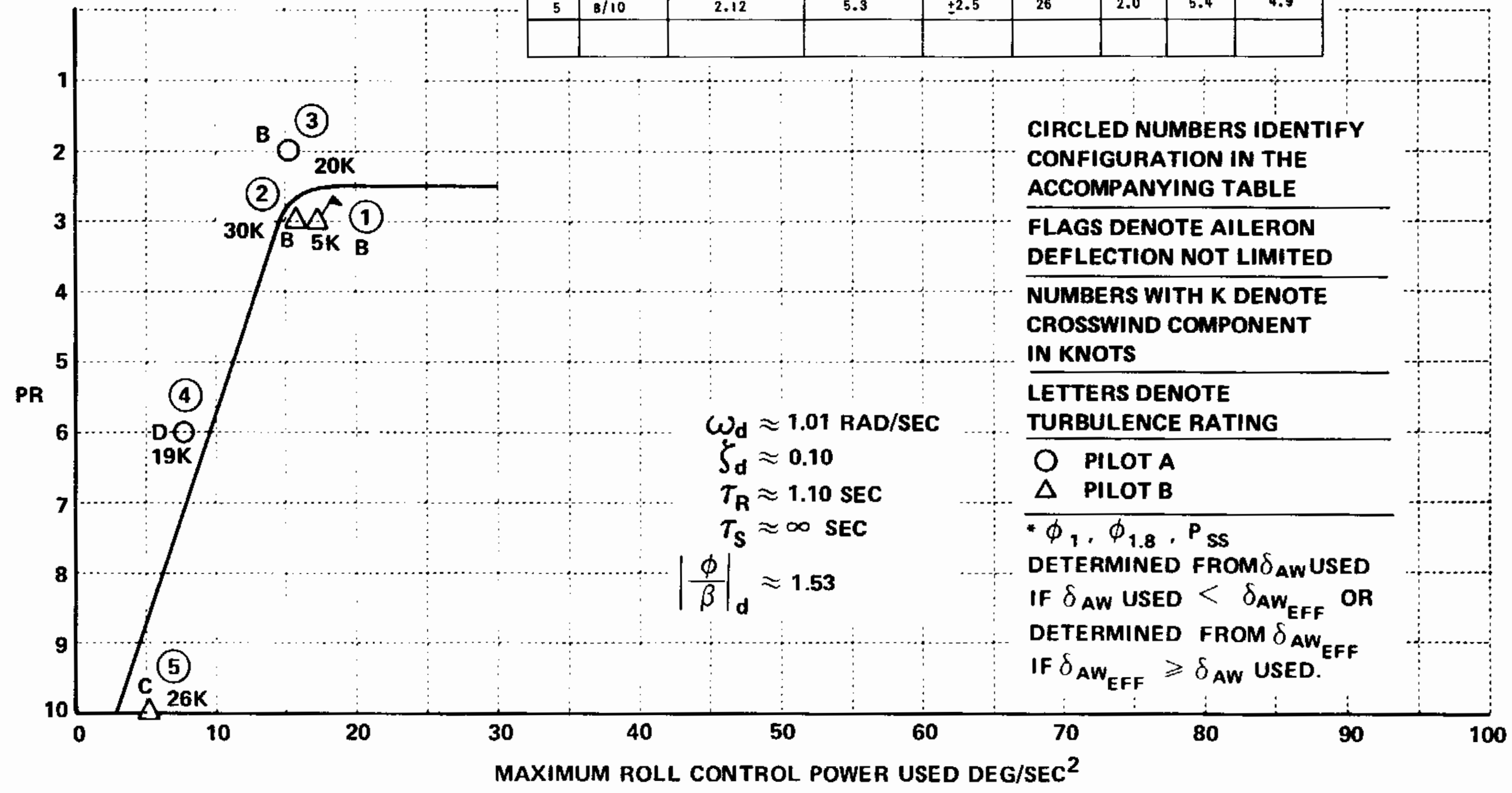


Figure 61 PILOT RATING VERSUS MAXIMUM ROLL CONTROL POWER USED--GROUP 11

CONF	PILOT/PR	$L'\delta_{AW}$ (DEG/SEC^2 DEG)	ROLL CONTROL POWER USED (DEG/SEC^2)	MAXIMUM $\delta_{AW_{EFF}}$ (DEG)	MAXIMUM δ_{AW} USED (DEG)	$\phi_1{}^*$ (DEG)	$\phi_{1.8}{}^*$ (DEG)	$P_{SS}{}^*$ (DEG/SEC)
1	B/3	2.12	17.0	±45	8	6.6	17.4	15.8
2	B/3	2.12	15.9	±7.5	9	6.1	16.3	14.8
3	A/2	1.57	15.7	±10	15	6.1	16.1	14.6
4	A/6	1.57	7.8	±6	24	3.0	8.0	7.3
5	B/10	2.12	5.3	±2.5	26	2.0	5.4	4.9



$\omega_d \approx 1.01$ RAD/SEC
$\zeta_d \approx 0.10$
$\tau_R \approx 1.10$ SEC
$\tau_S \approx \infty$ SEC
$\left|\frac{\phi}{\beta}\right|_d \approx 1.53$

CIRCLED NUMBERS IDENTIFY CONFIGURATION IN THE ACCOMPANYING TABLE

FLAGS DENOTE AILERON DEFLECTION NOT LIMITED

NUMBERS WITH K DENOTE CROSSWIND COMPONENT IN KNOTS

LETTERS DENOTE TURBULENCE RATING

○ PILOT A
△ PILOT B

* ϕ_1, $\phi_{1.8}$, P_{SS} DETERMINED FROM δ_{AW} USED IF δ_{AW} USED $<$ $\delta_{AW_{EFF}}$ OR DETERMINED FROM $\delta_{AW_{EFF}}$ IF $\delta_{AW_{EFF}} \geq \delta_{AW}$ USED.

Figure 62 PILOT RATING VERSUS MAXIMUM ROLL CONTROL POWER USED--GROUP 14

CONF	PILOT/PR	$L'\delta_{AW}$ (DEG/SEC^2 DEG)	ROLL CONTROL POWER USED (DEG/SEC^2)	MAXIMUM $\delta_{AW_{EFF}}$ (DEG)	MAXIMUM δ_{AW} USED (DEG)	ϕ_1* (DEG)	$\phi_{1.8}$* (DEG)	P_{SS}* (DEG/SEC)
1	A/2.5	1.54	24.6	±45	16	11.4	34.0	43.0
2	A/4	1.54	23.1	±45	15	10.7	32.0	40.4
3	B/4	1.61	16.1	±10	12	7.5	22.3	28.1
4	B/3	1.61	13.7	±45	8.5	6.4	19.0	23.9
5	A/3	1.54	11.5	±7.5	17	5.3	15.9	20.1
6	B/7	1.61	8.1	±5.0	20	3.8	11.2	14.1
7	A/9	1.54	3.9	±2.5	45	1.8	5.4	6.8

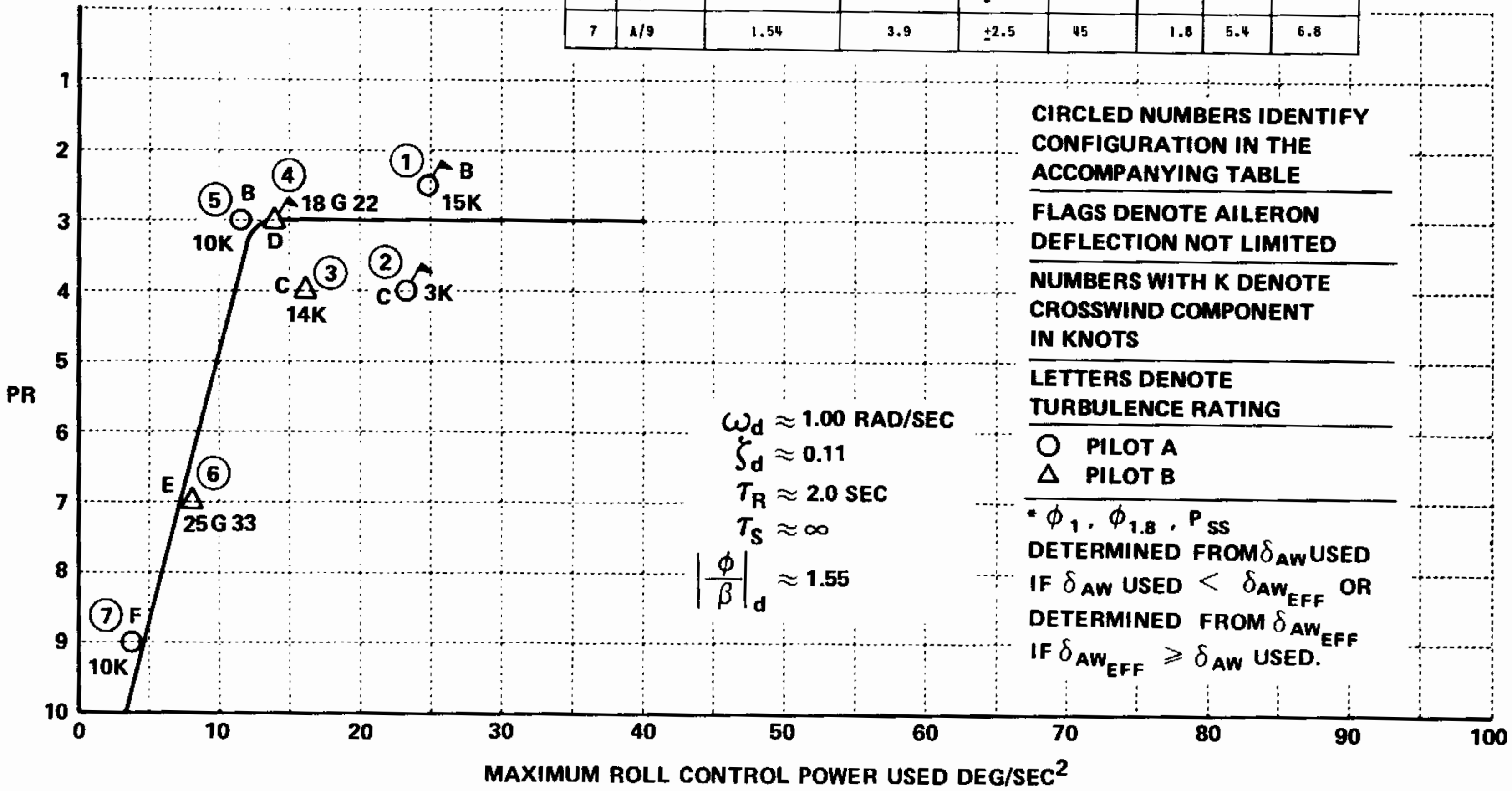


Figure 63 PILOT RATING VERSUS MAXIMUM ROLL CONTROL POWER USED--GROUP 16

Configurations 6P1 and 11P1, which have essentially the same roll mode time constant but respective roll-to-sideslip ratios of 1.5 and 0.25, show the same trend in pilot rating with decreasing roll control power. As shown in Figures 59 and 61, both configurations had a maximum roll control power usage of approximately 50 deg/sec^2. Both configurations were flown in crosswinds exceeding 20 knots and were rated satisfactory for roll control power as low as 30 deg/sec^2. In configuration 6P1 ② (circled numbers identify configurations on appropriate figures), which was limited to a roll control power of 35.7 deg/sec^2, the pilot could perform the crosswind approach in a 30 gusting to 35-knot crosswind, but he did not consider the overall configuration satisfactory (PR=4). A 6.5 pilot rating boundary for these two configurations (6P1 and 11P1) would be defined by roll control power requirements between 15 and 20 deg/sec^2. The similarity between the roll control power requirements for these two configurations is consistent with pilot comments and pilot rating data (Appendix VI) obtained for these two groups during the unlimited roll control power evaluations. There were essentially no differences between the two evaluation groups.

Group 9, Figure 60, had the same roll mode time constant as groups 6 and 11; however, in comparison it had a high roll-to-sideslip ratio, $|\phi/\beta|_d = 3.10$. The 9P1 configurations are interesting because they clearly show the effect of crosswind component on required roll control power for an airplane with appreciable dihedral. None of these configurations were rated satisfactory, making it impossible to define a PR=3.5 boundary, however, a PR=6.5 boundary for crosswinds of 10 to 15 knots and roll control power of 40 to 45 deg/sec^2 can be defined. Configurations ① , ② and ④ on Figure 60 which were evaluated in 25- to 30-knot crosswinds show much higher roll control power requirements. Pilot comments for configuration ② indicate that "control limits did not prevent you from doing the crosswind even though the crosswind component was staggering....the problem is handling large lateral upsets close to the ground....it takes a whole lot of aileron to get the wing up." Configurations ④ and ① were flown on the same flight. On configuration ④ the pilot commented that "...I don't think I could get it on the ground in the kind of crosswind (25, gusting to 30) we had today. You might be lucky enough to have it stabilize just as you hit the ground but you just might not. You get into severe overcontrolling in the crosswind when trying to land straight ahead in the wing-down method, and in the crabbed approach you've ultimately got to get straight so you have problems with the sideslip....It's mainly the roll due to rudder that hurts you in the crosswind....Because of the crosswind, I'm going to have to rate it a 10 because I don't think I could get it on the ground " The pilot followed his rating of 10 with the following comment, "If you want to know what it would be like out of the crosswind - without the crosswind -it's certainly in the controllable category and I think all things considered, if you didn't have to worry about the crosswind you could optimize the gearing a little better. I think it would be an acceptable airplane but unsatisfactory." Configuration ① was flown in the same crosswind conditions with increased roll control power available and the pilot commented, "I can handle the crosswind to my satisfaction and the wing-down method was what I would use and I could do it with no problems " A PR=6.5 boundary to handle a 25- to 30-knot crosswind for the Group 9 configuration is between 70 and 80 deg/sec^2

Configuration 14P1, Figure 62, was characterized by a moderate roll mode time constant (τ_R = 1.1) The maximum roll control power used for this configuration was 17 deg/sec^2 Satisfactory ratings were obtained in crosswinds of 20 to 30 knots With a roll control power limit of 8 deg/sec^2, the pilot was still able to cope with a 19-knot crosswind, but found his roll control barely adequate for the lateral offset approach and cautioned that rapid rolling maneuvers should be avoided When the roll control power was reduced to 5 deg/sec^2, the pilot could not perform the crosswind approach There was insufficient roll control power to perform a wing-down approach in the 26-knot crosswind When the pilot attempted to decrab on a crabbed approach, there was insufficient roll control to keep the airplane from being blown off the runway The pilot commented, "I'd lose control dramatically by making a hole in the ground somewhere off to the edge of the runway" and rated the airplane a PR = 10

Configuration 16P1, Figure 63, had a long roll mode time constant (τ_R = 2.0). The maximum control power used for this configuration was 25 deg/sec^2. Configuration ④ was evaluated in a crosswind of 18 gusting to 22 knots with no limits on the roll control power (within, of course, the constraints of the T-33 variable stability airplane) and was rated satisfactory with a maximum roll control power usage of 14 deg/sec^2. With the roll control power reduced to 8 deg/sec^2, ⑥ , the pilot had no difficulty with a 25 gusting to 33-knot crosswind. The major problem was the inability to stop a given roll rate with sufficient precision close to the ground. The configuration with a roll control power of 4 deg/sec^2, ⑦ , was only evaluated in a 10-knot crosswind but the pilot commented that once a roll was started it required full aileron and rudder opposite to the direction of turn to stop the roll, often leading to very uncoordinated situations. There were occasions when the pilot nearly lost control of the airplane because of the roll control.

The values of roll control power found to correspond to a PR = 3.5 in Table VI or, in the case of group 9 , roll control power values found to correspond to a PR = 6.5 shown in Table VII, agree well with the minimum values shown in Table V. Thus it was possible to limit the roll control power to minimum values recorded during the basic group evaluations without degrading the pilot ratings.

MIL-F-8785B(ASG) places a requirement on roll control power in the landing approach for Class II airplanes of 30° in 1.8 seconds for Level 1 flying qualities. References 38 and 59 discuss bank angle in 1.0 seconds as a measure of roll performance in the landing approach. The values of ϕ_1 and $\phi_{1.8}$ shown on the tables in Figures 59 through 63 were obtained by ratioing the appropriate bank angle obtained from the transient responses shown in Appendix V by the corresponding $L'_{\delta_{AW}} \delta_{AW}$. Thus, the values presented represent the actual airplane response with the rudder fixed and are those that would be experienced for the actual roll control power used. MIL-F-8785B(ASG) allows rudder inputs to minimize sideslip that retards roll

Table VI

ROLL PERFORMANCE MEASURES FOUND TO CORRESPOND TO PR = 3.5

$\omega_d \approx 1.0$ RAD/SEC, $\zeta_d \approx 0.10$, $\lvert\phi/\beta\rvert_d \approx 1.5$						
CONF	τ_R SEC	ROLL CONTROL POWER DEG/SEC	ϕ_1 DEG	$\phi_{1.8}$ DEG	P_{SS} DEG/SEC	MAXIMUM X-WIND KNOTS
6P1	0.4	30	7.4	15.9	10.4	22
11P1*	0.4	30	7.1	15.1	10.4	26
14P1	1.1	14	5.5	14.4	13.8	30
16P1	2.0	12	6.5	16.6	16.6	20
* $\lvert\phi/\beta\rvert_d = 0.25$ FOR CONFIGURATION 11P1.						

Table VII

ROLL PERFORMANCE MEASURES FOR CONFIGURATION 9P1*

$\omega_d \approx 1.0$ RAD/SEC, $\zeta_d \approx 0.10$, $\lvert\phi/\beta\rvert_d \approx 3.0$						
CONF	τ_R SEC	ROLL CONTROL POWER DEG/SEC	ϕ_1 DEG	$\phi_{1.8}$ DEG	P_{SS} DEG/SEC	MAXIMUM X-WIND KNOTS
9P1*	0.4	77	18.4	38.5	22.3	30
9P1*	0.4	42	10.1	20.8	12.2	10
*Configuration 9P1 was never rated better than PR = 5; thus, these numbers represent roll control power requirements for a PR = 6.5.						

rate in meeting the roll performance requirements. Because the configurations evaluated during the roll control power experiment were close to being the minimum sideslip configurations, obtaining $\phi_{1.8}$ with the rudder fixed is not considered inappropriate. For the moderate and low $|\phi/\beta|_d$ cases, it was found that values of ϕ_1 as low as 6.0 degrees were acceptable. The value of $\phi_{1.8} = 15°$ is only half the required value of $\phi_{1.8}$ for Level 1 flying qualities MIL-F-8785B(ASG). For approaches made in crosswinds of 30 knots with $|\phi/\beta|_d = 3.1$, the results indicate roll control power corresponding to $\phi_{1.8} = 38.5$ degrees would be required to avoid significant pilot rating degradation because of lack of roll control power. Table VI gives the approximate values of roll control power, ϕ_1 , $\phi_{1.8}$, and p_{ss} values found to be satisfactory ($PR \leq 3.5$) for the configurations evaluated in this investigation. Table VII shows the values that resulted for configuration 9P1 corresponding to a PR = 6.5. This configuration was never rated better than a PR = 5; therefore, it was not possible to determine the values of roll control power necessary for a satisfactory pilot rating.

In summary, adequate roll control power is a function of roll mode time constant as well as roll-to-sideslip ratio. As the roll mode time constant is increased, the requirement on roll control power is reduced. As the roll-to-sideslip ratio is increased, the requirements on roll control power are correspondingly increased. The roll control power available can establish a limiting crosswind value.

Steady-state roll rates of 10 deg/sec to 20 deg/sec were found to provide satisfactory roll performance. The values of p_{ss} were obtained from $p_{ss} = L'_{\delta_{AW}} \delta_{AW} \tau_R (\omega_\phi/\omega_d)^2$. This is in good agreement with Reference 58, which shows that in NASA simulator studies of SST approaches, values of 10-15 deg/sec roll performance were satisfactory. Peak roll rates near 10 deg/sec were reported in Reference 74 during the landing approach work with the XB-70.

4.9 COMPARISON OF EVALUATED CONFIGURATIONS WITH MIL-F-8785B(ASG)

The configurations evaluated during this flight program were considered to be Land Based (L), Class II airplanes in the terminal or landing approach Flight Phase (Category C).

MIL-F-8785B(ASG) requires the minimum Dutch roll frequency and damping for Level 1 flying qualities to be greater than $\zeta_d = 0.08$ or $\zeta_d \omega_d = 0.15$ rad/sec with the governing requirement being that which yields the larger value of ζ_d. Five groups of configurations (6, 11, 13, 14 and 16) received satisfactory pilot ratings (i.e., $PR \leq 3.5$) for a value of $\zeta_d \omega_d \approx 0.10$. These occurred for $\omega_d \approx 1.0$ rad/sec and $\zeta_d \approx 0.1$. The large number (41) of satisfactory pilot ratings obtained for this combination of Dutch roll frequency and damping ratio indicate that, for the landing approach flight phase, the MIL-F-8785B(ASG) requirements on minimum $\zeta_d \omega_d > 0.15$ for Level 1 may be too restrictive.

Groups 1 ($\omega_d = 2.0$ rad/sec, $\zeta_d \approx .03$) and 5 ($\omega_d \approx 1.0$, $\zeta_d \approx 0.03$) indicate that requiring a Level 2 minimum of $\zeta_d \geq 0.02$ is probably a good boundary but requiring a minimum $\zeta_d \omega_d \geq 0.05$ is possibly too restrictive for the landing approach.

The results of this experiment indicate that a roll mode time constant as long as 2.0 seconds may result in pilot ratings less than 3.5. This conclusion is in agreement with Reference 66 which suggests that a roll mode time constant as long as 2.3 seconds may be satisfactory for large airplanes in the landing approach. The reader is again cautioned, however, that in the present flight experiment the zeroes in the ϕ/δ_a transfer function were located such that the phasing of the Dutch roll mode tends to reduce the effect of the long roll mode time constant. To provide a more direct evaluation of the roll mode time constant per se, it would be best to evaluate configurations which have very little Dutch roll excitation due to aileron inputs.

MIL-F-8785B(ASG) does not establish numerical requirements on the lateral-directional response to atmospheric disturbances; however, the following observation was made during the present flight experiment. Out of 155 total evaluation configurations, 67 were rated satisfactory, i.e., $PR \leq 3.5$. Of these only six configurations were given a turbulence rating as poor as D;i.e., more pilot effort required in turbulence with a moderate deterioration of task performance experienced.

Configurations 3A2, 6N0, 7A1 and 10N0 were rated as satisfactory although they did not meet the requirement that the roll rate at the first minimum following the first peak for a step aileron input shall be greater than 60 percent for Level 1 flying qualities. The percentages for these four configurations were 47, 52, 44 and 32, respectively. Except for configuration 6N0 which was close to meeting the 60 percent requirement (i.e., 52%), the other three configurations had high Dutch roll damping ratios ($\zeta_d \approx 0.3$).

The parameter p_{osc}/p_{AV} was calculated for each of the evaluation configurations. These values were obtained from the calculated transient responses in Appendix V. In addition, the sideslip excursions were compared for the limits established in terms of $\Delta\beta_{MAX}/K$. $\Delta\beta_{MAX}$ is the maximum sideslip excursion at the c.g., occurring within two seconds or one-half period of the Dutch roll, whichever is greater, following a step aileron-control command. K is the ratio of the "commanded roll performance" to the "applicable roll performance requirement" established for the class and phase of the airplane being evaluated. The requirement on roll performance allows rudder pedals to be used to reduce sideslip that retards roll rate but not to produce sideslip that augments roll rate, provided rudder pedal inputs are simple, easily coordinated with aileron-control inputs, and are consistent with the piloting techniques for the particular airplane class and mission. For this reason, the commanded bank angle used to determine K for these configurations was determined to be the bank angle achieved for the configuration which had minimum sideslip but which was not in the proverse sense. This value of commanded bank angle was then used to compute the value of K for all configurations that had sideslip in the more adverse sense. For those configurations which did have proverse sideslip, the actual commanded bank angle was used to determine the desired value of K. The Level 1 roll requirement for land-based Class II airplanes in the landing approach was given in Reference 71 as 30° in 1.8 seconds. The values of p_{osc}/p_{AV} and $\Delta\beta_{MAX}/K$ are listed in Table VIII and shown on Figures 64 and 65, respectively. The pilot rating numbers listed in Table VIII and shown on the figures were obtained from the faired pilot rating curves.

The experimental results of this investigation indicate that the Dutch roll damping criteria requiring $\zeta_d \omega_d \geq 0.15$ for Level 1 flying qualities may be too restrictive. The minimum damping ratio requirement of $\zeta_d \geq 0.08$ could neither be confirmed nor refuted. For this reason, those configurations which did not meet the $\zeta_d \geq 0.08$ were not considered to meet the Level 1 requirements. Those configurations which met the $\zeta_d \geq 0.08$ but which did not satisfy the $\zeta_d \omega_d \geq 0.15$ were considered to meet the Level 1 criteria for the following presentation. Figure 64b shows the p_{osc}/p_{AV} locations of the configurations which meet the $\zeta_d \geq 0.08$ damping ratio requirement and the $\Delta\beta_{MAX}/K$ Level 1 criteria. Figure 65 shows the p_{osc}/p_{AV} locations for the configurations which meet the $\zeta_d \geq 0.08$ damping ratio requirement and p_{osc}/p_{AV} criteria. Only four configurations which pass the Level 1 test for both the p_{osc}/p_{AV} and $\Delta\beta_{MAX}/K$ criteria are rated worse than a pilot rating of 3.5 and three of these configurations fall on the Level 1 boundary for p_{OSC}/p_{AV} There are twelve configurations which are rated 3.5 or better which fail to meet the Level 1 criteria for either or both oscillatory requirements.

If the $\Delta\beta_{MAX}/K$ requirement, between ψ_β = -200° and -270° were raised from $\Delta\beta_{MAX}/K = 10$ to $\Delta\beta_{MAX}/K = 13$, Figure 65, six configurations that were rated PR = 3.5 or better would meet the Level 1 criteria. Only one point, configuration 16P2, which is rated worse than 3.5, PR = 4, would be included since all the other points which were rated worse than 3.5 in this

Table VIII

DATA USED FOR MIL-F-8785B(ASG) COMPARISON

CONF	PR**	T_d Sec	$t_{\pi\beta}$ Sec	ψ_β Deg	$\angle\frac{p}{\beta}$ Deg	k	$\Delta\beta_{max}$ Deg	$\frac{\Delta\beta_{max}}{k}$ Deg	LEVEL	$\frac{p_{osc}}{p_{av}}$	LEVEL	LEVEL FOR ALL
1-A2	6.0	3.12	1.5	-173	143.2	.072	.381	5.30	1	.663	NO	NO
1-A1	4.0	↓	1.5	-173	↓	.072	.280	3.90	1	.365	2	2*
1-NO	3.5	↓	1.5	-173	↓	.072	.177	2.46	1	.173	1	2*
1-P1	4.0	↓	1.4	-161	↓	.072	.074	1.03	1	.051	1	2*
1-P2	4.5	↓	3.4	-082	↓	.080	.034	.425	1	.042	1	2*
2-A1	4.0	3.18	1.60	-181	146.7	.083	.284	3.42	1	.281	2	2
2-NO	3.0	↓	1.65	-187	↓	.083	.191	2.30	1	.134	1	1
2-P1	2.0	↓	1.70	-192	↓	.083	.100	1.20	1	.041	1	1
2-P2	2.5	↓	2.24	-254	↓	.083	.017	0.21	1	0	1	1
2-P3	3.0	↓	3.30	-012	↓	.093	-.086	-0.92	1	.053	1	1
3-A3	3.0	3.22	1.70	-190	144.0	.083	.42	5.06	1	.349	2	2
3-A2	2.5	↓	1.70	-190	↓	.083	.351	4.23	1	.206	1	1
3-NO	2.0	↓	2.00	-224	↓	.083	.219	2.64	1	.022	1	1
3-P2	1.5	↓	2.60	-290	↓	.091	.098	1.16	1	0	1	1
3-P3	1.5	↓	3.00	-336	↓	.088	.068	0.75	1	.022	1	1
4-A1	8.0	3.12	1.60	-185	145.4	.084	.273	3.25	1	-5.74	NO	NO
4-NO	8.0	↓	1.80	-185	↓	.084	.188	2.24	1	.417	2	2
4-P1	3.5	↓	1.70	-196	↓	.084	.103	1.23	1	.110	1	1
4-P2	3.0	↓	1.80	-208	↓	.084	.029	0.34	1	.013	1	1
4-P3	6.0	↓	3.20	-009	↓	.101	-.072	-.71	1	.087	2	2
5-A3	6.0	6.34	3.10	-176	160.4	.096*	1.89	19.7*	NO	-13.8	NO	NO+
5-A2	5.5	↓	3.10	-174	↓	.096*	1.45	15.2*	NO	4.24	NO	NO+
5-A1	5.0	↓	3.10	-176	↓	.096*	1.00	10.4*	2	1.24	NO	NO+
5-NO	5.5	↓	2.90	-165	↓	.088	.56	8.54	2	.540	NO	NO+
5-P1	8.0	↓	2.40	-136	↓	.088	.14	2.06	1	.098	2	2+
5-P2	7.0	↓	6.60	-015	↓	.107*	-.34	-3.68*	2	.125	NO	NO+
6-A2	5.5	6.31	3.15	-180	157.5	.124*	1.35	10.9*	2	2.00	NO	NO
6-A1	4.0	↓	3.15	-180	↓	.082	.990	12.1	2	.753	NO	NO
6-NO	2.5	↓	3.15	-180	↓	.082	.628	7.66	1	.305	2	2
6-P1	2.0	↓	3.15	-180	↓	.082	.280	4.15	1	.079	1	1
6-P2	4.0	↓	6.90	-034	↓	.082	-.095	-1.16	1	.056	1	1
7-A2	4.0	6.51	3.40	-168	159.0	.087	1.18	13.6	2	.773	NO	NO
7-A1	2.5	↓	3.45	-190	↓	.087	.937	10.8	2	.341	2	2
7-NO	2.0	↓	3.50	-194	↓	.087	.694	7.97	1	.143	1	1
7-P1	2.0	↓	3.60	-199	↓	.087	.448	5.15	1	.044	1	1
7-P2	4.0	↓	5.60	-304	↓	.087	.210	2.41	1	.024	1	1
8-A1	8.5	6.03	3.00	-179	156.5	.104*	1.07	10.2*	2	-98.3	NO	NO+
8-NO	7.0	↓	2.90	-173	↓	.077	.645	8.38	2	1.48	NO	NO+
8-P1/2	9.0	↓	2.80	-167	↓	.077	.436	5.66	1	.692	NO	NO+
8-P1	9.0	↓	2.60	-155	↓	.077	.232	3.01	1	.308	2	NO+
8-P2	9.0	↓	6.25	-013	↓	.084	-.22	-2.62	1	.105	2	NO+
9-A1	9.0	5.80	2.90	-180	157.1	.085	.838	9.86	2	-10.0	NO	NO
9-NO	8.0	↓	2.90	-180	↓	.085	.552	6.50	1	.845	NO	NO
9-P1	5.5	↓	3.00	-186	↓	.085	.267	3.14	1	.207	1	1
9-P2	5.0	↓	6.00	-012	↓	.085	.028	.330	1	.047	1	1
9-P3	9.0	↓	6.10	-018	↓	.098	-.288	-2.98	1	.143	NO	NO
10-A1	8.0	6.28	3.15	-180	156.2	.094	.773	8.23	1	4.16	NO	NO
10-NO	3.5	↓	3.50	-200	↓	.094	.570	6.06	1	.461	2	2
10-P1	3.0	↓	4.00	-229	↓	.094	.370	3.94	1	.077	1	1
10-P2	3.5	↓	5.80	-332	↓	.094	.165	1.76	1	.050	1	1
10-P3	4.0	↓	6.00	-343	↓	.109	-.158	-1.45	1	.122	2	2
11-A2	5.0	6.33	3.15	-179	163.1	.110*	1.32	12.0*	2	.079	1	2
11-A1	4.0	↓	3.15	-179	↓	.110*	.957	8.7*	2	.053	1	2
11-NO	3.5	↓	3.15	-179	↓	.074	.593	8.03	1	.028	1	1
11-P1	2.5	↓	3.15	-179	↓	.074	.228	3.08	1	≈0	1	1
11-P2	2.0	↓	6.80	-027	↓	.074	.135	1.82	1	≈0	1	1
11-P3	2.0	↓	6.80	-027	↓	.112*	-.498	4.44*	NO	≈0	1	NO
12-A2	3.0	6.80	3.00	-159	170.3	.112*	1.39	12.4*	2	.028	1	2
12-A1	2.5	↓	3.15	-167	↓	.112*	1.23	11.0*	2	.019	1	2
12-NO	2.0	↓	3.40	-180	↓	.082	.82	10.0	2	≈0	1	2
12-P1	2.0	↓	3.80	-201	↓	.082	.54	6.6	1	≈0	1	1
12-P2	2.0	↓	5.50	-291	↓	.082	.26	3.17	1	≈0	1	1
12-P3	2.0	↓	6.30	-343	↓	.083	.118	1.42	1	≈0	1	1
13-A2	5.0	6.31	3.60	-200	138.0	2.26*	2.26*	9.33*	2	.038	1	2
13-A1	4.0	↓	3.60	-205	↓	.139	1.85	13.3	2	.028	1	2
13-NO	3.5	↓	3.70	-211	↓	.139	1.49	10.7	2	≈0	1	2
13-P1	3.0	↓	3.90	-222	↓	.139	1.13	8.14	1	≈0	1	1
13-P2	3.0	↓	4.20	-240	↓	.139	.770	5.54	1	≈0	1	1
13-P3	3.0	↓	4.80	-274	↓	.139	.440	3.17	1	≈0	1	1
14-A2	4.0	6.24	3.45	-199	134.7	.153	1.98	13.0	2	.328	2	2
14-A1	2.0	↓	3.60	-208	↓	.153	1.67	11.0	2	.211	1	2
14-NO	1.0	↓	3.80	-219	↓	.153	1.36	8.80	1	.131	1	1
14-P1	2.0	↓	4.20	-242	↓	.153	1.05	6.85	1	.054	1	1
14-P2	3.0	↓	4.90	-263	↓	.153	.745	4.97	1	.051	1	1
15-A2	6.5	5.50	2.90	-190	151.0	.183	1.46	8.10	1	-2.87	NO	NO
15-A1	5.5	↓	3.15	-206	↓	.183	1.46	7.98	1	92.0	NO	NO
15-NO	5.0	↓	3.50	-229	↓	.183	1.45	7.92	1	.767	NO	NO
15-P1	4.5	↓	3.60	-264	↓	.183	1.45	7.92	1	.561	2	2
15-P2	4.5	↓	4.00	-262	↓	.183	1.45	7.92	1	.491	2	2
15-P3	5.0	↓	4.20	-275	↓	.183	1.45	7.92	1	.392	2	2
16-A2	4.5	6.81	3.80	-217	116.9	.207	3.08	14.9	2	.173	1	2
16-A1	4.0	↓	3.95	-225	↓	.207	2.88	13.9	2	.131	1	2
16-NO	3.0	↓	4.20	-240	↓	.207	2.70	13.1	2	.103	1	2
16-P1	3.0	↓	4.40	-251	↓	.207	2.50	12.1	2	.088	1	2
16-P2	4.0	↓	4.60	-262	↓	.207	2.32	11.2	2	.080	1	2

* OBTAINED USING LEVEL 2 REQUIREMENTS

+ DO NOT MEET $\zeta_d > 0.08$ CRITERIA FOR LEVEL 1

** PILOT RATINGS WERE OBTAINED FROM FAIRED PILOT RATING LINES

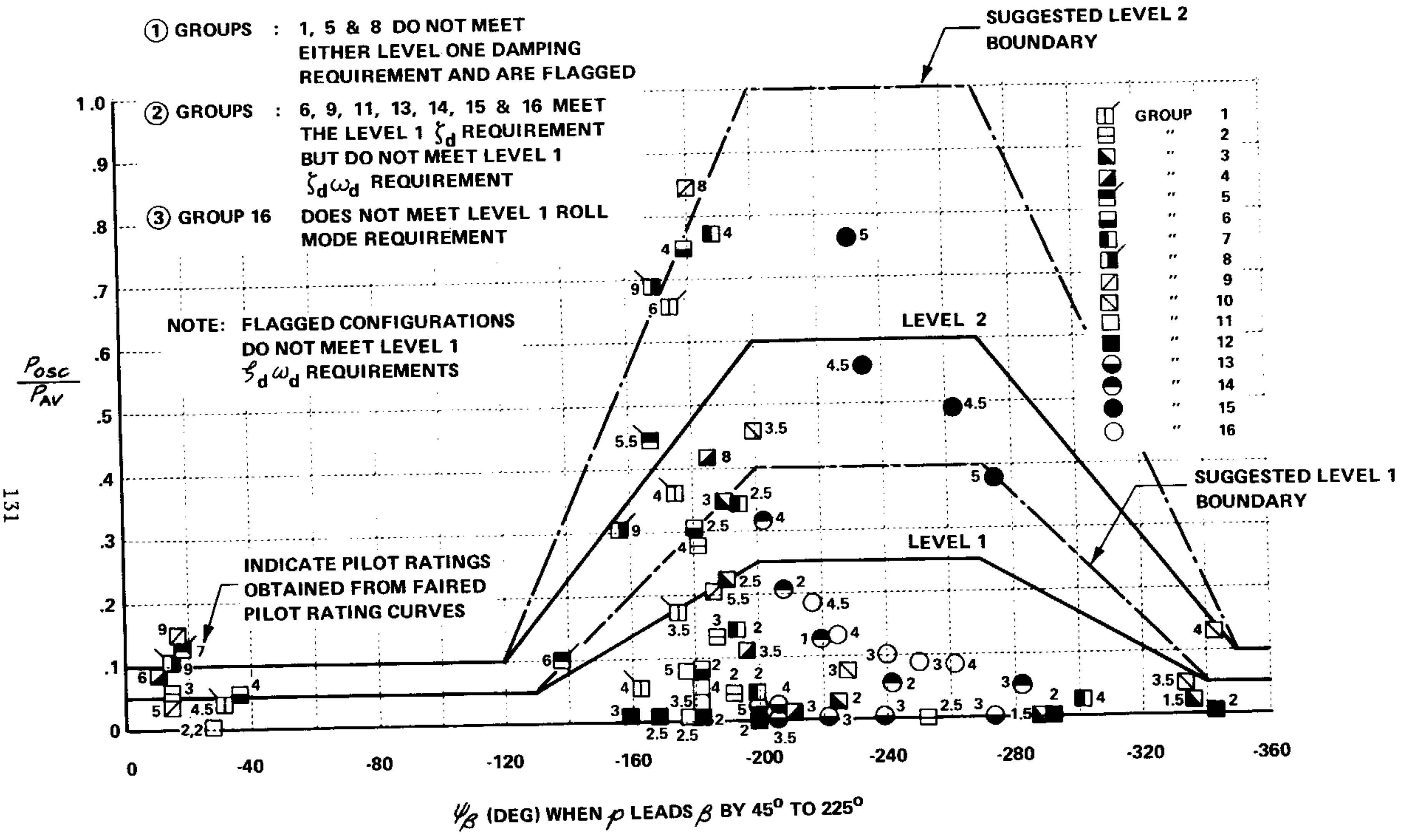
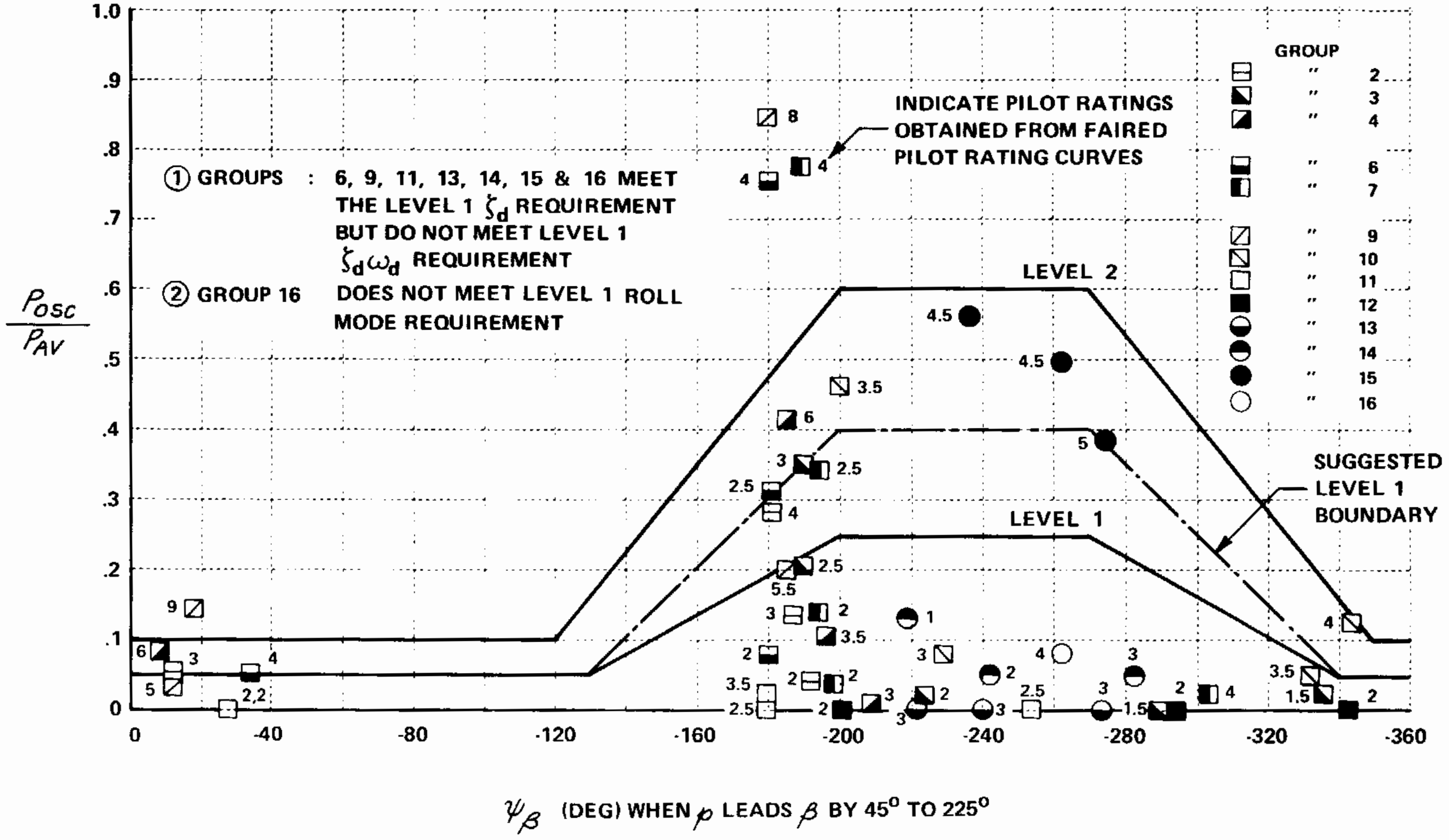


Figure 64a $\frac{P_{osc}}{P_{AV}}$ VERSUS ψ_β FOR ALL CONFIGURATIONS



① GROUPS : 6, 9, 11, 13, 14, 15 & 16 MEET THE LEVEL 1 ζ_d REQUIREMENT BUT DO NOT MEET LEVEL 1 $\zeta_d \omega_d$ REQUIREMENT

② GROUP 16 DOES NOT MEET LEVEL 1 ROLL MODE REQUIREMENT

Figure 64b $\frac{P_{OSC}}{P_{AV}}$ VERSUS ψ_β FOR CONFIGURATIONS WHICH MEET APPROPRIATE $\frac{\Delta\beta_{max}}{K}$ CRITERIA

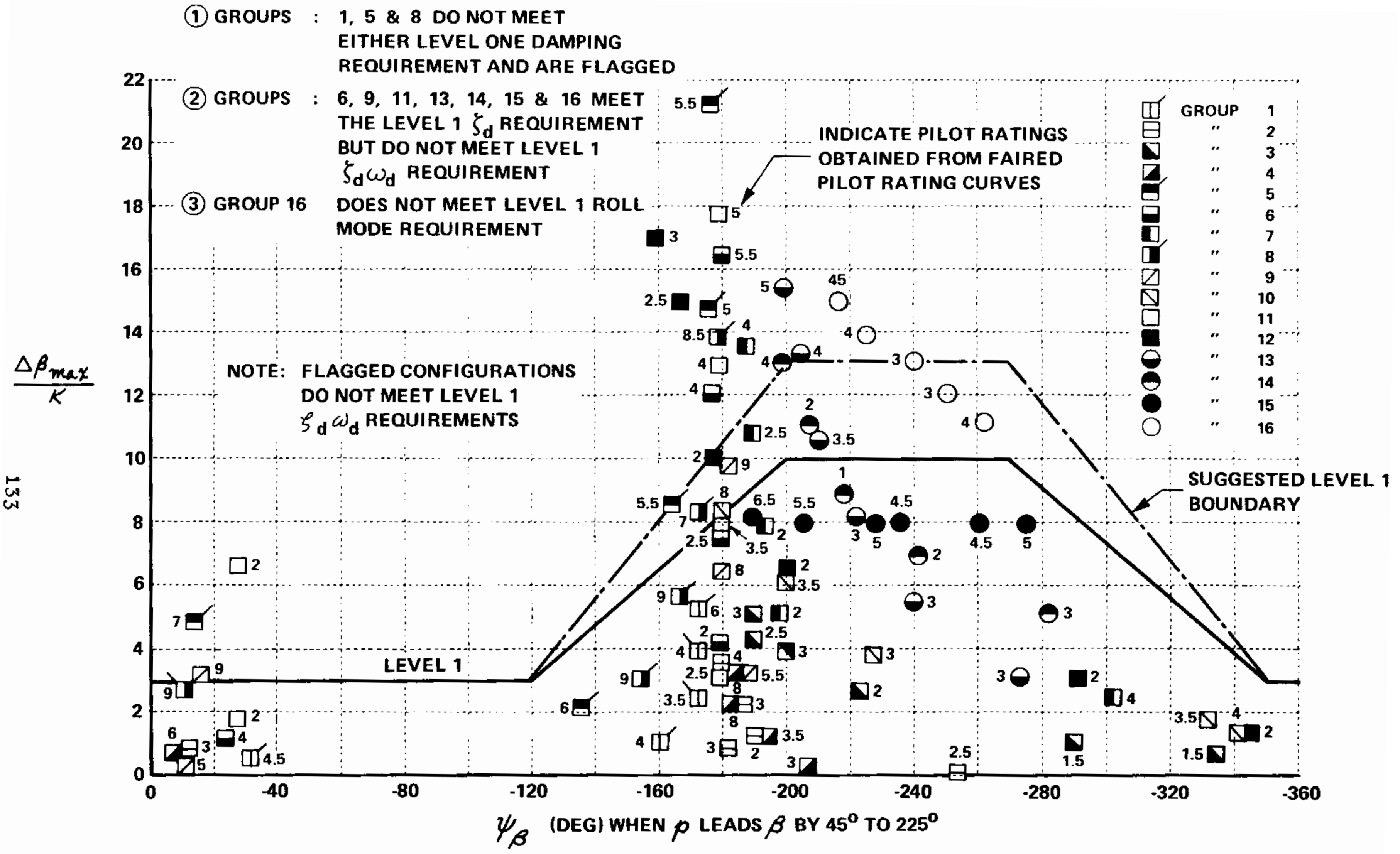


Figure 65a $\frac{\Delta\beta_{max}}{K}$ VERSUS ψ_β FOR ALL CONFIGURATIONS

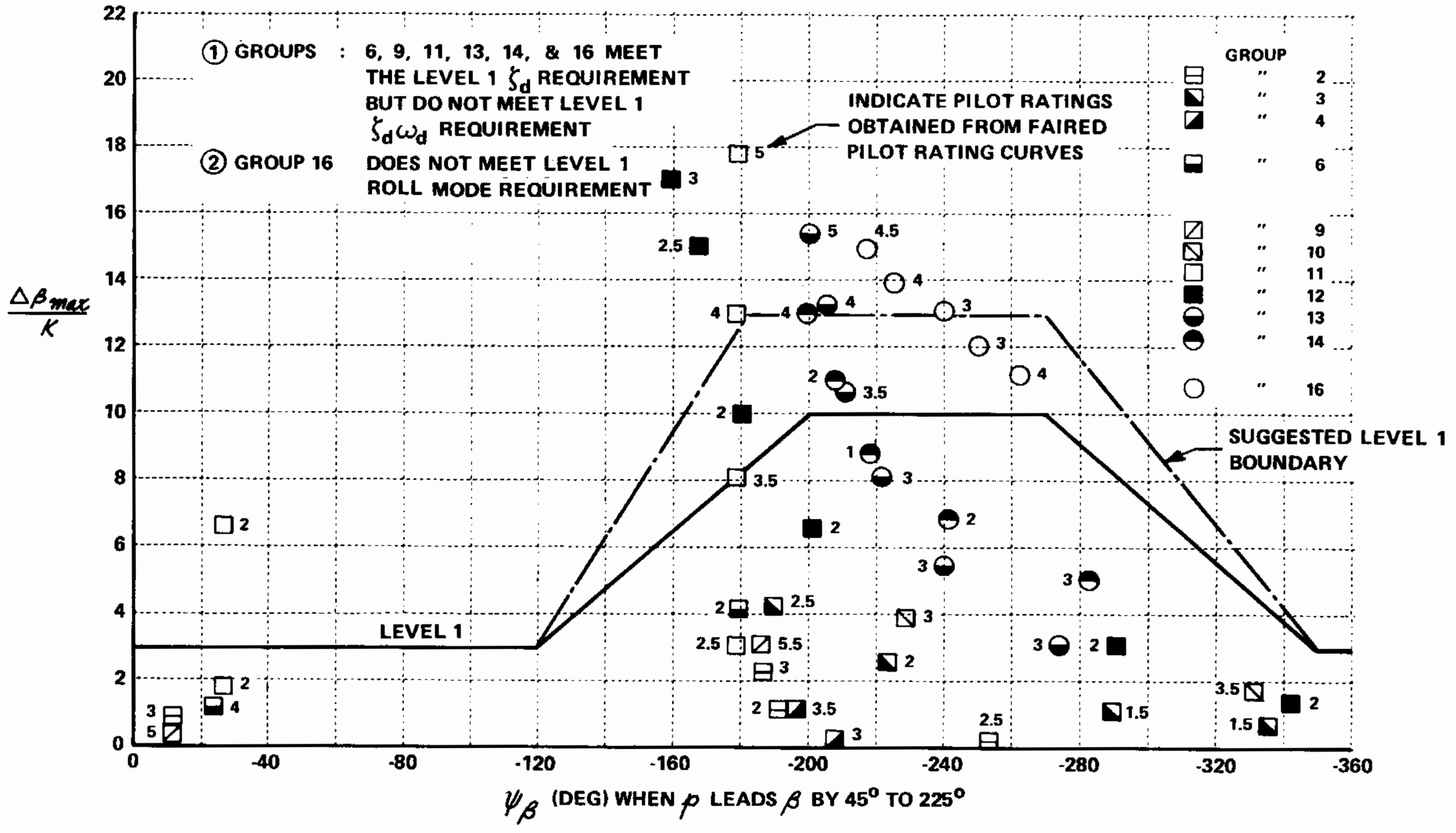


Figure 65b $\frac{\Delta\beta_{max}}{K}$ VERSUS ψ_β FOR CONFIGURATIONS WHICH MEET APPROPRIATE $\frac{P_{osc}}{P_{AV}}$ CRITERIA area either fail to meet the $\zeta_d \geq 0.08$ or p_{OSC}/p_{AV} criteria. Raising Level 1 boundary from .25 to .4 in the region between ψ_β = -200° and -270° would include three configurations rated better than 3.5 and three configurations rated worse than 3.5. Two of the points rated worse than 3.5 also meet the Level 1 $\Delta\beta_{MAX}/\kappa$ criteria.

Raising the Level 2 p_{OSC}/p_{AV} boundary from .6 to 1.0 in the region between ψ_β = -200° and -270° would include three configurations rated $3.5 < PR \leq 6.5$ and not pick up any rated $PR > 6.5$. Data from this experiment are sparse in this area, however.

It is not possible to compare the data with the Level 1 and Level 2 boundaries for $\Delta\beta_{MAX}/\kappa$ on the same plot since the κ value for the Level 1 criteria is different than the κ value for Level 2. The κ for Level 2 was always larger than the κ for Level 1, therefore, it was correct to consider that if a configuration meets Level 2 requirements using the Level 1 value of κ then it would also meet the Level 2 requirements using the Level 2 value of κ. Thus, only those $\Delta\beta_{MAX}/\kappa$ values which did not meet the Level 2 boundary when scaled with the Level 1 value of κ were reevaluated using the Level 2 value of κ. The roll requirement for Level 2 from Reference 71 was 30° in 2.5 seconds. Only three of the configurations which did not meet the Level 2 requirements using the Level 1 criteria failed to meet the Level 2 criteria when reevaluated using the κ for Level 2.

In general, the results of this investigation indicate that the present MIL-F-8785B(ASG) requirements on lateral-directional flying qualities parameters in the landing approach Flight Phase are conservative, i.e., only a few poorly rated configurations passed all of the requirements but several configurations were rejected by one or more of the requirements even though the pilot rating did not warrant rejection.

Section 5

SUMMARY AND CONCLUSIONS

An investigation to determine roll control power requirements and the effects of variations in lateral directional dynamics on landing approach handling qualities and cross-wind landing capabilities of executive jet and military Class-II airplanes was conducted in the USAF/CAL variable stability T-33 airplane. A summary of the results and the conclusions drawn are included in the following:

1. Low Dutch roll damping ratio ($\zeta_d \approx 0.03$) was more acceptable at the high Dutch roll frequency ($\omega_d \approx 2.0$ rad/sec) than at the low ($\omega_d \approx 1.0$ rad/sec). With $\zeta_d \approx 0.03$, both high- and low-frequency configurations were quite susceptible to turbulence. The low-frequency configurations were degraded because of coordination requirements associated with the slow directional response that resulted from the reduced static directional stability. The low-directional stability leads to over-control with the rudder, and the low damping ratio results in persistent directional oscillations.

2. The best configurations evaluated were those with the high Dutch roll frequency ($\omega_d \approx 2.0$ rad/sec), high damping ratio ($\zeta_d \approx 0.3$), low roll mode time constant ($\tau_R \approx 0.4$ sec), and moderate roll-to-sideslip ratio ($|\phi/\beta|_d \approx 1.50$).

3. There was essentially no difference in the pilot ratings obtained for the configurations evaluated at the low and high Dutch roll frequencies ($\omega_d \approx 1.0$ and $\omega_d \approx 2.0$ rad/sec) for a Dutch roll damping ratio of $\zeta_d \approx 0.1$ and a moderate roll-to-sideslip ratio ($|\phi/\beta|_d \approx 1.5$).

4. The effect of a high roll-to-sideslip ratio ($|\phi/\beta|_d \approx 3.0$) was less degrading at the high Dutch roll frequency ($\omega_d \approx 2.0$ rad/sec) than at the low frequency ($\omega_d \approx 1.0$ rad/sec). The low directional stability associated with the low Dutch roll frequency leads to larger sideslip excursions and consequently larger roll angles with a corresponding degradation in roll control. The large roll disturbance in turbulence was objectionable at both frequencies evaluated.

5. The combination of low Dutch roll frequency ($\omega_d \approx 1.0$ rad/sec) low damping ratio ($\zeta_d \approx 0.03$)and high roll-to-sideslip ratio was unacceptable for all evaluation points. The combination of low ζ_d and high $|\phi/\beta|_d$ created severe coordination problems and resulted in sustained lateral oscillations in turbulence.

6. For the medium roll-to-sideslip configurations, the majority of the improvement in pilot rating occurred when Dutch roll damping ratio was increased from $\zeta_d \approx 0.03$ to $\zeta_d \approx 0.1$. A further increase in damping ratio to $\zeta_d \approx 0.26$ did not improve the pilot rating proportionately.

7. Although an increase in Dutch roll damping ratio above $\zeta_d \approx 0.1$ does not significantly improve the handling qualities, it does produce a dramatic improvement in the turbulence response (i.e., turbulence rating) and riding qualities.

8. The desired level of Dutch roll damping ratio was strongly influenced by the amount of roll sideslip coupling. When the roll-to-sideslip ratio is high, the Dutch roll damping ratio should also be high.

9. There was essentially no difference in the desirability of the handling qualities between the configurations evaluated with the same Dutch roll frequency and damping ratio and roll mode time constant for roll-to-sideslip ratios in the order 0.25 to 1.5.

10. There was little difference in the pilot ratings and pilot comments for similar configurations evaluated at roll mode time constants of 0.4 and 1.0 seconds.

11. A roll mode time constant of 2.0 seconds is marginally satisfactory (i.e., $PR \approx 3.5$) for the landing approach phase of flight.

12. The combination of high roll-to-sideslip ratio $(|\phi/\beta|_d \approx 3.0)$ and moderate roll mode time constant ($\tau_R \approx 1.0$ seconds) is not satisfactory for the landing approach. The large roll rates that result from sideslip excursions or rudder inputs are difficult to counter with the longer roll mode time constant.

13. There is no difference in the desirable lateral-directional dynamics with a wheel or stick controller.

14. The pilots selected aileron force sensitivities for the stick controller which were approximately two and a half times those selected with the wheel controller. There was, however, no difference in maneuvering rates with the stick because the pilot used less force with the stick than with the wheel.

15. Lateral-directional dynamics do not impose a limit on the maximum crosswind component, provided sufficient aileron and rudder control power are available to perform the approach. This does not mean, however, that all combinations of lateral-directional dynamics are desirable or even acceptable.

16. The following conclusions were reached concerning the effects of lateral-directional dynamics on the pilot's ability to handle a crosswind approach:

    - Low Dutch roll damping ratio ($\zeta_d \approx 0.03$) did not present a serious problem at the high Dutch roll frequency ($\omega_d \approx 2.0$ rad/sec) but became a major problem at the low frequency ($\omega_d \approx 1.0$ rad/sec). The continuous nose oscillations resulting from the low damping ratio, coupled with the slow directional response, caused a tendency to overcontrol directionally in a wing-down approach and a tendency to set up directional oscillations during a decrab maneuver.

    - The magnitude of the roll-to-sideslip ratio significantly influences the pilot's ability to handle a crosswind approach. Low roll-to-sideslip ($|\phi/\beta|_d \approx 0.25$) was desirable, but high roll-to-sideslip ($|\phi/\beta|_d \approx 3.0$) led to high aileron forces in the wing-down approach and a reluctance to kick off even modest sideslip angles near the ground because of rapid and large roll response to rudder inputs.

    - Roll mode time constants as long as one second do not adversely affect the pilot's control in a crosswind; however, time constants of two seconds do create control problems. The tendency to overcontrol in bank angle associated with the long roll mode time constant ($\tau_R \approx 2.0$ seconds) was especially degrading when encountering gusty wind conditions near the ground.

17. The amount of roll control power available can directly establish the limiting crosswind component.

18. Roll control power requirements are a function of roll mode time constant and roll-to-sideslip ratio. As the roll mode time

constant is increased, roll control power requirements are reduced. As roll-to-sideslip ratio is increased, the requirements on roll control power are correspondingly increased.

19. For the low and moderate roll-to-sideslip cases evaluated, $|\phi/\beta|_d \approx 0.25$ and $|\phi/\beta|_d \approx 1.5$, steady-state roll rates as low as 10 deg/sec provided satisfactory roll performance. For the high roll-to-sideslip configuration, $|\phi/\beta|_d \approx 3.0$, a steady-state roll rate of 20 deg/sec was required.

20. For the low and moderate roll-to-sideslip configurations evaluated, $|\phi/\beta|_d \approx 0.25$ and $|\phi/\beta|_d \approx 1.5$, bank angles in 1.0 seconds as low as 6.0 degrees and bank angles in 1.8 seconds of 15 degrees were acceptable. The MIL-F-8785B (ASG) requirement on bank angle in 1.8 seconds is 30° for Class II airplanes. The results also indicate that for approaches made in 30-knot crosswinds, with $|\phi/\beta|_d \approx 3.0$, roll control power corresponding to a bank angle in one second of 18.4 degrees and a bank angle in 1.8 seconds of 38.5 degrees would be required to avoid significant pilot rating degradation because of lack of roll control power.

Section 6

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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:

$$\begin{aligned}
&(Y_\beta - s)\beta + (Y_r - 1)r + \left[\frac{g}{V} + (Y_p + \alpha_0)s\right]\phi = -Y_{\delta_{AW}}\delta_{AW} - Y_{\delta_{RP}}\delta_{RP} \\
&L'_\beta \beta + L'_r r + (L'_p s - s^2)\phi = -L'_{\delta_{AW}}\delta_{AW} - L'_{\delta_{RP}}\delta_{RP} \qquad \text{(I-1)} \\
&N'_\beta \beta + (N'_r - s)r + N'_p s\phi = -N'_{\delta_{AW}}\delta_{AW} - N'_{\delta_{RP}}\delta_{RP}
\end{aligned}$$

In matrix form:

$$\begin{bmatrix} Y_\beta - s & Y_r - 1 & \frac{g}{V} + (Y_p + \alpha_0)s \\ L'_\beta & L'_r & L'_p s - s^2 \\ N'_\beta & N'_r - s & N'_p s \end{bmatrix} \begin{bmatrix} \beta \\ r \\ \phi \end{bmatrix} = \begin{bmatrix} -Y_{\delta_{AW}} & -Y_{\delta_{RP}} \\ -L'_{\delta_{AW}} & -L'_{\delta_{RP}} \\ -N'_{\delta_{AW}} & -N'_{\delta_{RP}} \end{bmatrix} \begin{bmatrix} \delta_{AW} \\ \delta_{RP} \end{bmatrix} \qquad \text{(I-2)}$$

The characteristic equation can then be written as:

$$\begin{aligned}
|\Delta| = {} & s^4 - \left[Y_\beta + N'_r + L'_p\right] s^3 + \Big[L'_p N'_r - L'_r N'_p + Y_\beta (N'_r + L'_p) \\
& - (Y_r - 1)N'_\beta - (Y_p + \alpha_0)L'_\beta\Big] s^2 + \Big[Y_\beta (L'_r N'_p - L'_p N'_r) \\
& + (Y_r - 1)(L'_p N'_\beta - L'_\beta N'_p) + (Y_p + \alpha_0)(L'_\beta N'_r - L'_r N'_\beta) - \frac{g}{V} L'_\beta\Big] s \qquad \text{(I-3)} \\
& + \frac{g}{V}(L'_\beta N'_r - L'_r N'_\beta)
\end{aligned}$$

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

For an aileron wheel input:

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

which can be written as

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

where $A_{\phi_{\delta_{AW}}} = L'_{\delta_{AW}}$

$$\begin{aligned}\frac{r}{\delta_{AW}} = \frac{1}{|\Delta|}\Big\{ & N'_{\delta_{AW}} s^3 + \left[Y_{\delta_{AW}} N'_\beta + L'_{\delta_{AW}} N'_p - N'_{\delta_{AW}}\left(L'_p + Y_\beta\right)\right] s^2 \\ & + \Big[L'_{\delta_{AW}}\left(N'_\beta\left(Y_p+\alpha_0\right) - Y_\beta N'_p\right) + N'_{\delta_{AW}}\left(L'_p N'_\beta - \left(Y_p+\alpha_0\right)L'_\beta\right) \\ & + Y_{\delta_{AW}}\left(L'_\beta N'_p - N'_\beta L'_p\right)\Big] s + \left[L'_{\delta_{AW}} N'_\beta \frac{g}{V} - N'_{\delta_{AW}} L'_\beta \frac{g}{V}\right]\Big\}\end{aligned} \tag{I-6}$$

which can be written as:

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

where

$$A_{r_{\delta_{AW}}} = N'_{\delta_{AW}}$$

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

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

where

$$A_{r_{\delta_{AW}}} = Y_{\delta_{AW}} N'_\beta + L'_{\delta_{AW}} N'_p$$

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

$$+ \Big[L'_{\delta_{AW}} \Big(\frac{g}{V} - N'_r (Y_p + \alpha_o) + (Y_r - 1) N'_p \Big) + N'_{\delta_{AW}} \Big((Y_p + \alpha_o) L'_r$$

$$- (Y_r - 1) L'_p \Big) + Y_{\delta_{AW}} (L'_p N'_r - L'_r N'_p) \Big] s \tag{I-9}$$

$$+ \Big(N'_{\delta_{AW}} L'_r \frac{g}{V} - L'_{\delta_{AW}} N'_r \frac{g}{V} \Big) \Big\}$$

which can be written as:

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

where $A_{\beta_{\delta_{AW}}} = Y_{\delta_{AW}}$

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

$$\frac{\beta}{\delta_{AW}} = \frac{A_{\beta_{\delta_{AW}}} (s^2 + 2\zeta_\beta \omega_\beta s + \omega_\beta^2)}{(s + 1/\tau_S)(s + 1/\tau_R)(s^2 + 2\zeta_d \omega_d s + \omega_d^2)} \tag{I-11}$$

where:

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

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

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

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

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

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

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

For $Y_r \approx Y_p \approx 0$ and for equations referenced to body axes with $\alpha_0 = 0$

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

From equation I-4

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

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

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

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

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

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

The following relationships can be written from the ϕ/δ_{AW} transfer function:

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

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

In this experiment all configurations within a group had the same stability derivatives, however, the control derivatives $N'_{\delta_{AW}}$ and $L'_{\delta_{AW}}$ were varied to change the numerator zeros in the ϕ/δ_{AW} transfer function thus:

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

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

$$C_1 \approx N'_r Y_\beta + N'_\beta \qquad C_2 \approx -L_\beta - L'_r Y_\beta$$
$$C_3 \approx -N'_r - Y_\beta \qquad C_4 \approx L'_r \tag{I-22}$$

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

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

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

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

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 the 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

$$2\zeta_\phi \omega_\phi - 2\zeta_d \omega_d = \frac{L_\beta'}{N_\beta'}\left(N_p' - \frac{g}{V}\right) + \frac{Y_{\delta_{AW}}}{L'_{\delta_{AW}}} L_\beta' + \frac{N'_{\delta_{AW}}}{L'_{\delta_{AW}}} L_r' \qquad \text{(I-31)}$$

In view of the many pilot comments about the large roll response to external disturbances for the high roll-to-sideslip configurations, it was of interest to consider the bank angle-to-side gust transfer function.

For fixed controls, Equation I-2 becomes

$$\begin{bmatrix} Y_\beta - s & Y_r - 1 & \frac{g}{V} + (Y_p + \alpha_o)s \\ L_\beta' & L_r' & L_p' s - s^2 \\ N_\beta' & N_r' - s & N_p' s \end{bmatrix} \begin{bmatrix} \beta \\ r \\ \phi \end{bmatrix} = 0 \qquad \text{(I-32)}$$

Implicit in this equation is that the air is a satisfactory inertial reference since it is considered to be fixed to the earth. If we now allow the air mass to have motion along the y axis of the airplane, this must be accounted for in the basic set of equations. We now define:

β_V - the aerodynamic sideslip angle, or the velocity component of the airplane with respect to the air mass along the Y axis divided by V_0. (This will be the sideslip angle displayed to the pilot.)

β_G - the sideslip gust or the velocity of the air mass relative to the inertial axis or in this case the earth along the negative Y axis divided by V_0. Thus a positive β_G disturbance will give a positive β_V indication to the pilot.

On the basis of the above two definitions, the sideslip of the airplane relative to the earth, β_I is:

$$\beta_I = \beta_V - \beta_G$$

and
$$\dot{\beta}_I = \dot{\beta}_V - \dot{\beta}_G$$

but β_V is the total aerodynamic sideslip angle and from above $\beta_V = \beta_I + \beta_G$

We can now rewrite the above equations as follows:

$$\begin{aligned} &Y_\beta \beta_V - s(\beta_V - \beta_G) + (Y_r - 1)r + \left[\frac{g}{V} + (Y_p + \alpha_0)s\right]\phi = 0 \\ &L'_\beta \beta_V + L'_r r + (L'_p s - s^2)\phi = 0 \\ &N'_\beta \beta_V + (N'_r - s)r + N'_p s\,\phi = 0 \end{aligned} \qquad \text{(I-33)}$$

This set can then be written as follows where β_G appears as an input

$$\begin{bmatrix} Y_\beta - s & Y_r - 1 & \frac{g}{V_0} + (Y_p + \alpha_0)s \\ L'_\beta & L'_r & L'_p s - s^2 \\ N'_\beta & N'_r - s & N'_p s \end{bmatrix} \begin{bmatrix} \beta_V \\ r \\ \phi \end{bmatrix} = \begin{bmatrix} -s \\ 0 \\ 0 \end{bmatrix} \beta_G \qquad \text{(I-34)}$$

and the characteristic equation is the same as Equation I-3.

The transfer function for the bank angle response to a β_G input from Equation I-34 becomes

$$\frac{\phi}{\beta_G} = \left|\frac{1}{\Delta}\right| (s)\left[L'_\beta s + \left(L'_r N'_\beta - L'_\beta N'_r\right)\right] \tag{I-35}$$

$$\Delta = \left(s + \frac{1}{\tau_s}\right)\left(s + \frac{1}{\tau_R}\right)\left(s^2 + 2\zeta_d \omega_d s + \omega_d^2\right)$$

In this investigation the spiral root was near the origin, thus from Equation I-28 $\left(L'_r N'_\beta - L'_\beta N'_r\right) \approx 0$

The transfer function then becomes simply:

$$\frac{\phi}{\beta_G} = \frac{-L'_\beta s}{\left(s + \frac{1}{\tau_R}\right)\left(s^2 + 2\zeta_d \omega_d s + \omega_d^2\right)} \tag{I-36}$$

which can be written as

$$\frac{\phi}{\beta_G} \approx -\tau_R \left(\frac{L'_\beta}{\omega_d^2}\right) \frac{s}{\left(\tau_R s + 1\right)\left(\frac{s^2}{\omega_d^2} + \frac{2\zeta_d}{\omega_d} s + 1\right)} \tag{I-37}$$

From this expression it can be seen that the bank angle response to a β gust at high frequency is $\frac{-L'_\beta}{s^2}$. The response at all frequencies is proportional to the value of L'_β. At the low frequency the response is proportional to the roll mode time constant and inversely related to the Dutch roll frequency, ω_d. The Dutch roll damping ratio determines the amplification at the Dutch roll frequency.

The bank angle response to a random sideslip disturbance would of course be dependent on the power spectral density of the random disturbance together with the airplane transfer function. The pilot, however, rates the closed loop response to turbulence which is indeed more complicated than the open loop transfer functions developed above.

Appendix II

TURBULENCE SIMULATION

A. AIRPLANE RESPONSE TO A BETA GUST

In abbreviated form the equations for roll acceleration, $\dot{p}$, and yaw acceleration, $\dot{r}$, can be written as follows:

$$\dot{p} = L'_{\beta}\beta + L'_{p}p + L'_{r}r + L'_{\delta_a}\delta_a$$

and

$$\dot{r} = N'_{\beta}\beta + N'_{p}p + N'_{r}r + N'_{\delta_r}\delta_r \qquad \text{(II-1)}$$

In the variable stability airplane with random noise inputs to the aileron and rudder simulating an artificial side gust, the aileron and rudder inputs can be described as follows:

$$\delta_a = \frac{\delta_a}{\beta}\beta_V + \frac{\delta_a}{\delta_{AW}}\delta_{AW} + \frac{\delta_a}{\beta_{ag}}\beta_{ag}$$

and

$$\delta_r = \frac{\delta_r}{\beta}\beta_V + \frac{\delta_r}{\delta_{RP}}\delta_{RP} + \frac{\delta_r}{\beta_{ag}}\beta_{ag} \qquad \text{(II-2)}$$

where β_{ag} is the sideslip generated from an artificial gust and β_V is the angle of sideslip measured by the sideslip probe. Substituting these aileron and rudder inputs into equations II-1, there results:

$$\dot{p} = L'_{\beta}\beta + L'_{\delta_a}\left(\frac{\delta_a}{\beta}\right)\beta_V + L'_{p}p + L'_{r}r + L'_{\delta_a}\left(\frac{\delta_a}{\delta_{AW}}\right)\delta_{AW} + L'_{\delta_a}\left(\frac{\delta_a}{\beta_{ag}}\right)\beta_{ag} \qquad \text{(II-3)}$$

and

$$\dot{r} = N'_\beta \beta + N'_{\delta_r}\left(\frac{\delta_r}{\beta}\right)\beta_V + N'_p p + N'_r r + N'_{\delta_r}\left(\frac{\delta_r}{\delta_{RP}}\right)\delta_{RP} + N'_{\delta_r}\left(\frac{\delta_r}{\beta_{ag}}\right)\beta_{ag} \qquad \text{(II-4)}$$

where

$$\left(\frac{\delta_a}{\beta}\right),\ \left(\frac{\delta_a}{\delta_{AW}}\right),\ \left(\frac{\delta_a}{\beta_{ag}}\right),\ \left(\frac{\delta_r}{\beta}\right),\ \left(\frac{\delta_r}{\delta_{RP}}\right) \text{ and } \left(\frac{\delta_r}{\beta_{ag}}\right)$$

are variable stability gain settings. In smooth air $\beta = \beta_V$, in a real gust $\beta = \beta_V = \beta_I + \beta_G$ and in an artificial gust $\beta = \beta_V = \beta_I$ where β_I is the inertial sideslip. Consequently, in real gusts,

$$\dot{p} = \left(L'_\beta + L'_{\delta_a}\left(\frac{\delta_a}{\beta}\right)\right)\beta_I + L'_p p + L'_r r + \left(L'_\beta + L'_{\delta_a}\left(\frac{\delta_a}{\beta}\right)\right)\beta_G + L'_{\delta_a}\left(\frac{\delta_a}{\delta_{AW}}\right)\delta_{AW} \qquad \text{(II-5)}$$

and

$$\dot{r} = (N'_\beta + N'_{\delta_r}\frac{\delta_r}{\beta}))\beta_I + N'_p p + N'_r r + \left(N'_\beta + N'_{\delta_r}\left(\frac{\delta_r}{\beta}\right)\right)\beta_G + N'_{\delta_r}\left(\frac{\delta_r}{\delta_{RP}}\right)\delta_{RP}$$

where β_G is the sideslip due to the real gust.

In smooth air with artificial gusts

$$\dot{p} = (L'_\beta + L'_{\delta_a}\frac{\delta_a}{\beta}))\beta_I + L'_p p + L'_r r + \left(0 + L'_{\delta_a}\left(\frac{\delta_a}{\beta_{ag}}\right)\right)\beta_{ag} + L'_{\delta_a}\left(\frac{\delta_a}{\delta_{AW}}\right)\delta_{AW}$$

and

$$\dot{r} = \left(N'_\beta + N'_{\delta_r}\left(\frac{\delta_r}{\beta}\right)\right)\beta_I + N'_p p + N'_r r + \left(0 + N'_{\delta_r}\left(\frac{\delta_r}{\beta_{ag}}\right)\right)\beta_{ag} + N'_{\delta_r}\left(\frac{\delta_r}{\delta_{RP}}\right)\delta_{RP} \qquad \text{(II-6)}$$

Thus, the rolling acceleration due to a real side gust experienced by the augmented airplane is expressed by

$\left[L'_{\beta_{T-33}} + L'_{\delta_a}\left(\frac{\delta_a}{\beta}\right)\right]\beta_G$ and that due to an artificial gust by $\left[L'_{\delta_a}\left(\frac{\delta_a}{\beta_{ag}}\right)\right]\beta_{ag}$

The yawing acceleration due to a real side gust is expressed by

$\left[N'_{\beta_{T-33}} + N'_{\delta_r}\left(\frac{\delta_r}{\beta}\right)\right]\beta_G$ and that due to an aritificial gust by $\left[N'_{\delta_r}\left(\frac{\delta_r}{\beta_{ag}}\right)\right]\beta_{ag}$.

In this experiment an artificial gust level was chosen for the $\left|\frac{\phi}{\beta}\right|_d =$ 1.5 and $\omega_d = 1.0$ case to be representative of moderate turbulence. Since the rolling response to a side gust for any airplane is dependent upon L'_β and the yawing response is dependent upon N'_β , it was necessary to vary $\frac{\delta_a}{\beta_{ag}}$ and $\frac{\delta_r}{\beta_{ag}}$ to arrive at the proper level of artificial turbulence response for the simulated values of $\left|\frac{\phi}{\beta}\right|_d$ (which varies with L'_β) and the simulated values of ω_d (which varies with N'_β).

Hence, for the three values of $\left|\frac{\phi}{\beta}\right|_d$ tested in this experiment, it was necessary to satisfy the following relationship for each value of $|\phi/\beta|_d$

$$\left[L'_{\beta_{T-33}} + L'_{\delta_a}\left(\frac{\delta_a}{\beta}\right)\right]\beta_G = \left[L'_{\delta_a}\left(\frac{\delta_a}{\beta_{ag}}\right)\right]\beta_{ag} \qquad \text{(II-7)}$$

$\left(L'_{\beta_{T-33}} + L'_{\delta_a}\frac{\delta_a}{\beta}\right)$ is the simulated L'_β for the respective groups tested.

Since L'_β (simulated) is approximately doubled when going from $\left|\frac{\phi}{\beta}\right|_d$ = 1.5 to $\left|\frac{\phi}{\beta}\right|_d$ = 3.0, the value of $\frac{\delta_a}{\beta_{ag}}$ was doubled for the $\left|\frac{\phi}{\beta}\right|_d$ = 3.0 Groups over that used for the $\left|\frac{\phi}{\beta}\right|_d$ = 1.5 Groups. For the $\left|\frac{\phi}{\beta}\right|_d$ = 0.25 Groups, the value of $\frac{\delta_a}{\beta_{ag}}$ was reduced to one sixth of that used for the $\left|\frac{\phi}{\beta}\right|_d$ = 1.5 Groups.

Likewise for the two values of ω_d tested it was necessary that

$$\left[N'_{\beta_{T-33}} + N'_{\delta_r}\left(\frac{\delta_r}{\beta}\right)\right]\beta_G = \left[N'_{\delta_r}\left(\frac{\delta_r}{\beta_{ag}}\right)\right]\beta_{ag} \qquad \text{(II-8)}$$

for both values of ω_d tested.

where $\left[N'_{\beta_{T-33}} + N'_{\delta_r}\left(\frac{\delta_r}{\beta}\right)\right]\beta_G$ is the simulated N'_β for the respective groups tested. Since N'_β (simulated) is approximately doubled when going from ω_d = 1.0 to ω_d = 2.0, the $\frac{\delta_r}{\beta_{ag}}$ selected for the low frequency was doubled for the high frequency.

B. RANDOM NOISE TURBULENCE SIMULATION

A random noise source was used to provide an external disturbance to the airplane for turbulence simulation during those evaluations for which the natural turbulence level was less than moderate. Moderate turbulence is defined in Appendix III. Hence, an effort was made to augment natural turbulence so that all evaluations were conducted with nearly the same combined turbulence level.

The random disturbances were obtained by driving the T-33 control surface actuators by a random noise signal. The signal was generated by a diode noise source passed through a bandpass filter. The filter had the frequency response shown in Figure II-1. The amplitudes of the disturbance signals going to the elevator, ailerons and rudder were varied independently.

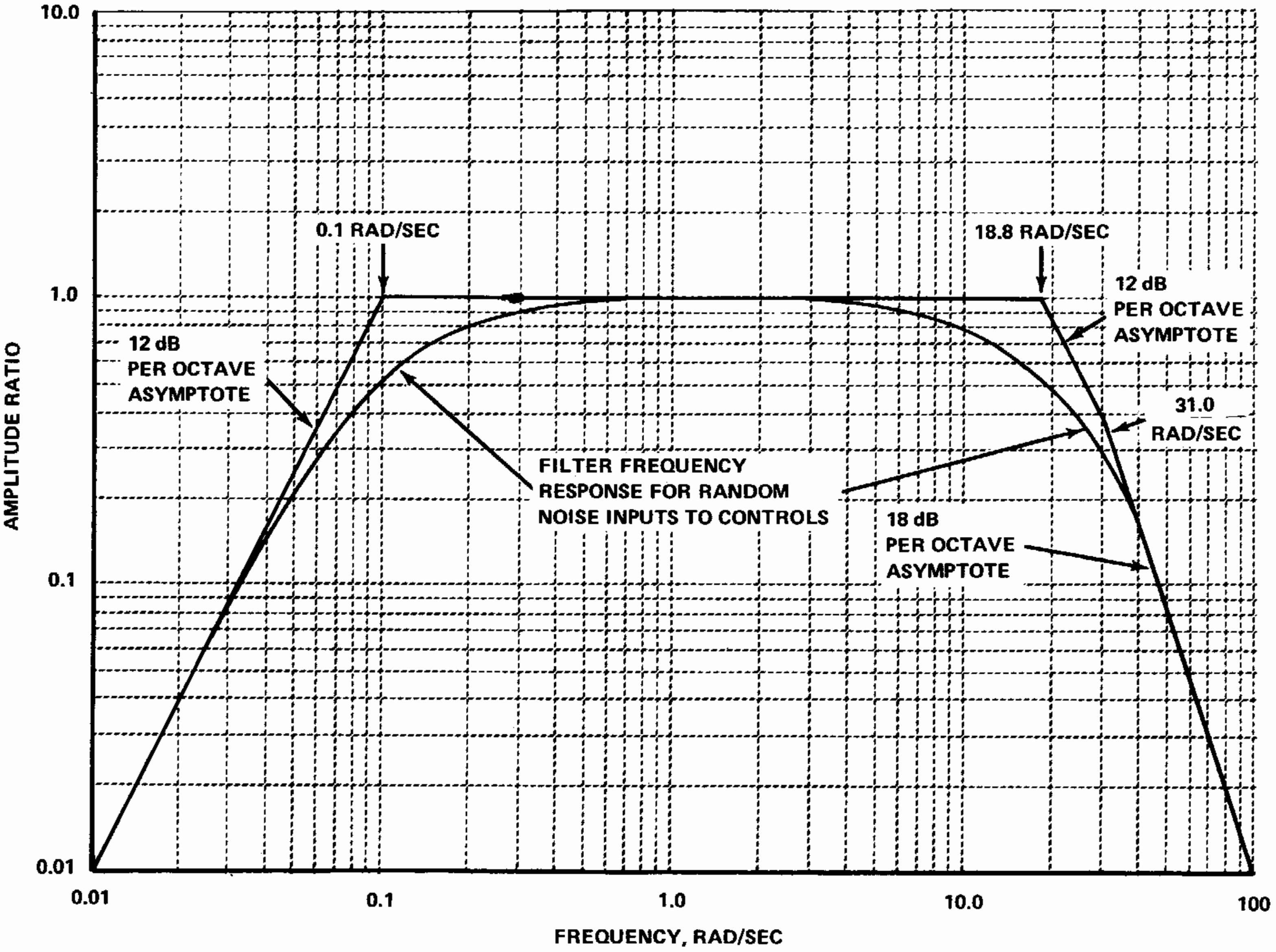


Figure II - 1 RANDOM NOISE FILTER FREQUENCY RESPONSE

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:

$\Delta\alpha_V$
β_V
p
q
r
$\dot{p}$
$\dot{r}$
ϕ
θ

δ_{AS} or δ_{AW}
δ_{RP}
δ_{ES}
δ_r
δ_a
δ_e
F_{AS} or F_{AW}
F_{RP}
F_{ES}

$\bar{q}_c$ (airspeed)
n_z
n_y
Altitude
ILS localizer
ILS glide slope
ILS outer marker

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

The intensity of natural turbulence present during each evaluation was assessed by the system operator/safety pilot in accordance with the descriptive terminology of the Federal Aviation Administration and Department of Defense "Turbulence Reporting Criteria Table" shown on the next page.

Table III-1 TURBULENCE REPORTING CRITERIA

INTENSITY	AIRCRAFT REACTION	REACTION INSIDE AIRCRAFT	REPORTING TERM	DEFINITION
LIGHT	TURBULENCE THAT MOMENTARILY CAUSES SLIGHT, ERRATIC CHANGES IN ALTITUDE AND/OR ATTITUDE (PITCH, ROLL, YAW). REPORT AS LIGHT TURBULENCE; OR TURBULENCE THAT CAUSES SLIGHT, RAPID AND SOMEWHAT RHYTHMIC BUMPINESS WITHOUT APPRECIABLE CHANGES IN ALTITUDE OR ATTITUDE. REPORT AS LIGHT CHOP.	OCCUPANTS MAY FEEL A SLIGHT STRAIN AGAINST SEAT BELTS OR SHOULDER STRAPS. UNSECURED OBJECTS MAY BE DISPLACED SLIGHTLY. FOOD SERVICE MAY BE CONDUCTED AND LITTLE OR NO DIFFICULTY IS ENCOUNTERED IN WALKING.	OCCASSIONAL INTERMITTENT CONTINUOUS	LESS THAN 1/3 OF THE TIME. 1/3 TO 2/3. MORE THAN 2/3.
MODERATE	TURBULENCE THAT IS SIMILAR TO LIGHT TURBULENCE BUT OF GREATER INTENSITY. CHANGES IN ALTITUDE AND/OR ATTITUDE OCCUR BUT THE AIRCRAFT REMAINS IN POSITIVE CONTROL AT ALL TIMES. IT USUALLY CAUSES VARIATIONS IN INDICATED AIRSPEED. REPORT AS MODERATE TURBULENCE; OR TURBULENCE THAT IS SIMILAR TO LIGHT CHOP BUT OF GREATER INTENSITY. IT CAUSES RAPID BUMPS OR JOLTS WITHOUT APPRECIABLE CHANGES IN AIRCRAFT ALTITUDE OR ATTITUDE. REPORT AS MODERATE CHOP.	OCCUPANTS FEEL DEFINITE STRAINS AGAINST SEAT BELTS OR SHOULDER STRAPS. UNSECURED OBJECTS ARE DISLODGED. FOOD SERVICE AND WALKING ARE DIFFICULT.		
SEVERE	TURBULENCE THAT CAUSES LARGE, ABRUPT CHANGES IN ALTITUDE AND/OR ATTITUDE. IT USUALLY CAUSES LARGE VARIATIONS IN INDICATED AIRSPEED. AIRCRAFT MAY BE MOMENTARILY OUT OF CONTROL. REPORT AS SEVERE TURBULENCE.	OCCUPANTS ARE FORCED VIOLENTLY AGAINST SEAT BELTS OR SHOULDER STRAPS. UNSECURED OBJECTS ARE TOSSED ABOUT. FOOD SERVICE AND WALKING ARE IMPOSSIBLE		
EXTREME	TURBULENCE IN WHICH THE AIRCRAFT VIOLENTLY TOSSED ABOUT AND IS PRACTICALLY IMPOSSIBLE TO CONTROL. IT MAY CAUSE STRUCTURAL DAMAGE. REPORT AS EXTREME TURBULENCE.			

Surface winds during each evaluation performed were obtained from control tower or approach control personnel as read from standard wind speed and direction measuring equipment. Wind information was later converted to the actual ninety degree crosswind component encountered in flight.

Pilot comments and ratings were recorded in flight by use of wire recording equipment installed in the variable stability airplane. The system operator/safety pilot kept handwritten records, during flight, of his turbulence level assessment and the reported surface wind velocity. He also 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 back-up of the wire recording equipment.

Natural turbulence levels and crosswind components are listed in Appendix V. Pilot ratings and comments are listed in Appendix VI.

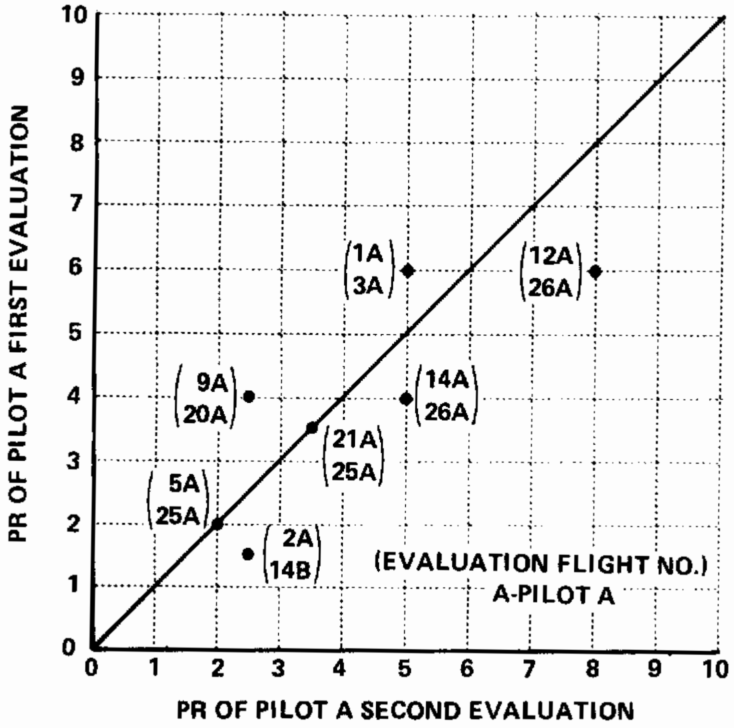
Appendix IV

INTERPILOT AND INTRAPILOT RATING COMPARISON

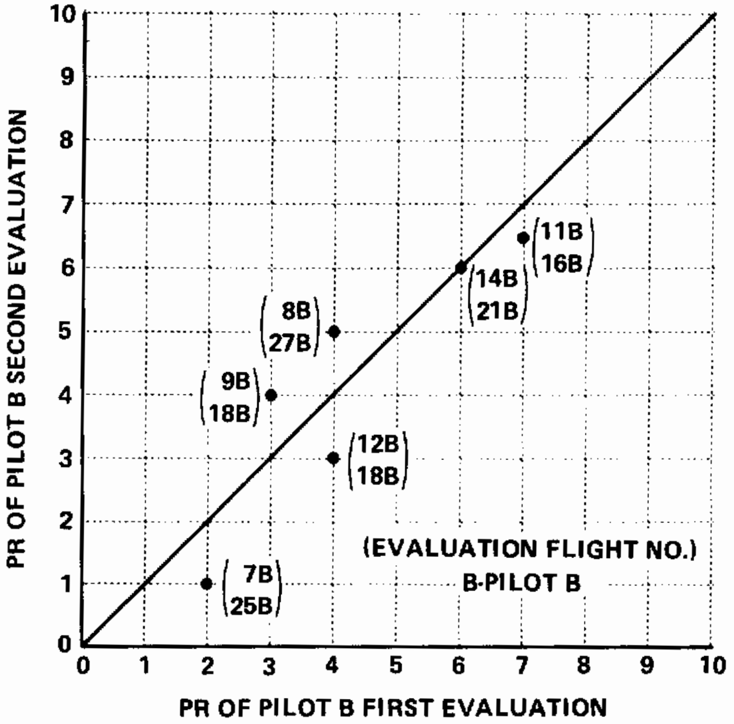
Thirty-four repeat evaluations representing 22 percent of the total configurations were performed. Pilot A repeated seven configurations and Pilot B six configurations. Twenty-one configurations were evaluated by both Pilot A and Pilot B.

The intrapilot variation for both pilots was very good, generally falling within past experience with handling qualities experiments, i.e., no more than plus or minus one pilot rating difference for a repeat evaluation. The one pilot rating for Pilot A which does not meet this criterion is felt to be the result of the pilot's assessment of the effects of turbulence. The configuration rated six was the only one in Group 8 with a turbulence rating of D; all the others were rated E or F.

The interpilot variation was greater than the intrapilot variation. Five out of 21 repeat evaluations did not fall within the one pilot rating difference. Four of these points are the results of two evaluations, each of two different configurations, where Pilot A rated both configurations higher than Pilot B. In both cases, the assessment by Pilot A of the turbulence effects was less degrading than Pilot B. For example, Pilot A gave one configuration a turbulence rating of B compared to a turbulence rating of D by Pilot B. For the other configuration, Pilot A gave a turbulence rating of C compared to ratings of D and E by Pilot B. Thus, the only explanation offered for the interpilot rating variation is the assessment of turbulence and the effect that turbulence had on the acceptability of the handling qualities.

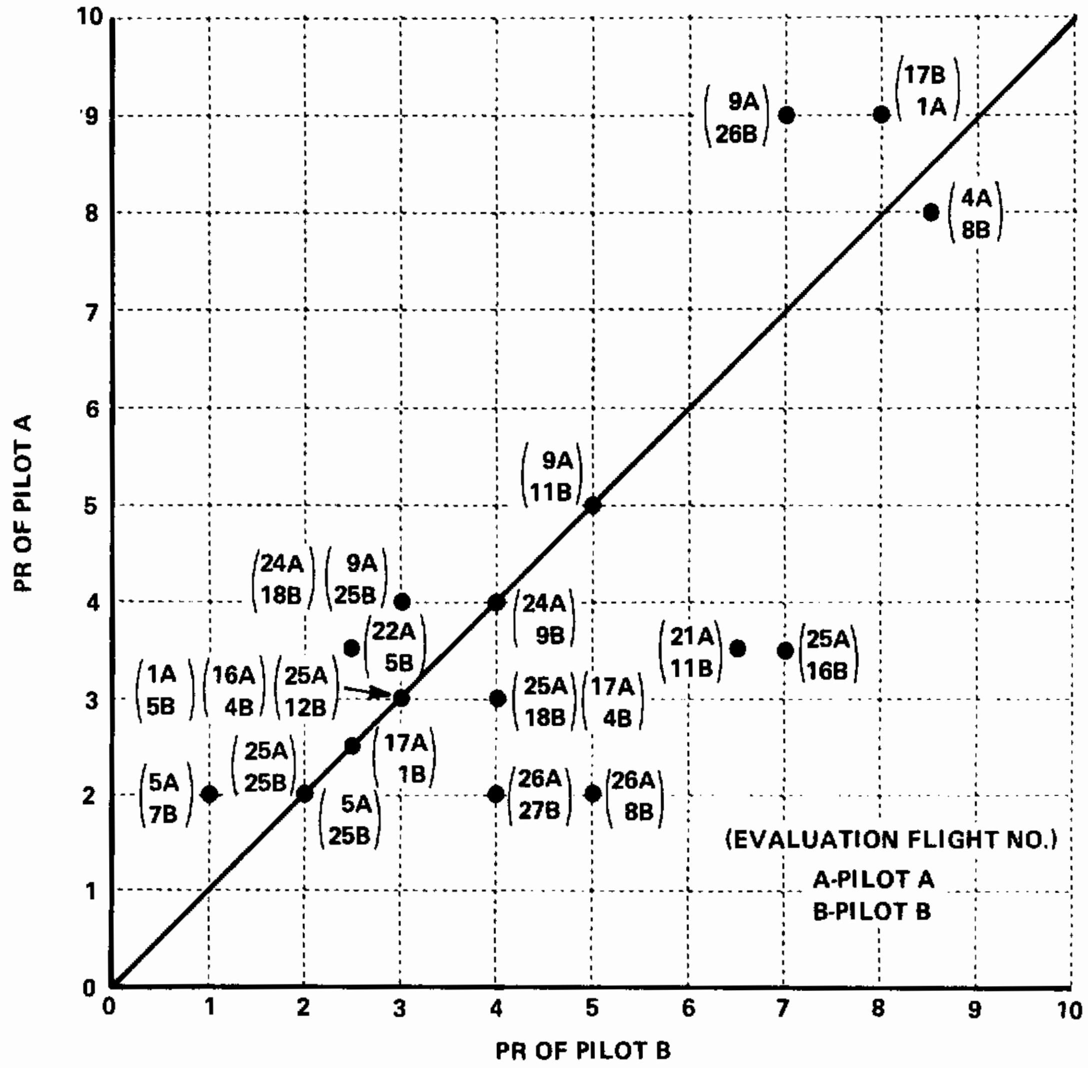


COMPARISON OF PILOT RATINGS FOR CONFIGURATIONS REPEATED BY PILOT A



COMPARISON OF PILOT RATINGS FOR CONFIGURATIONS REPEATED BY PILOT B

Figure IV-1 INTRAPILOT RATING COMPARISON



COMPARISON OF PILOT RATINGS FOR CONFIGURATIONS EVALUATED BY BOTH PILOT A AND PILOT B

Figure IV-2 INTERPILOT RATING COMPARISON

Appendix V

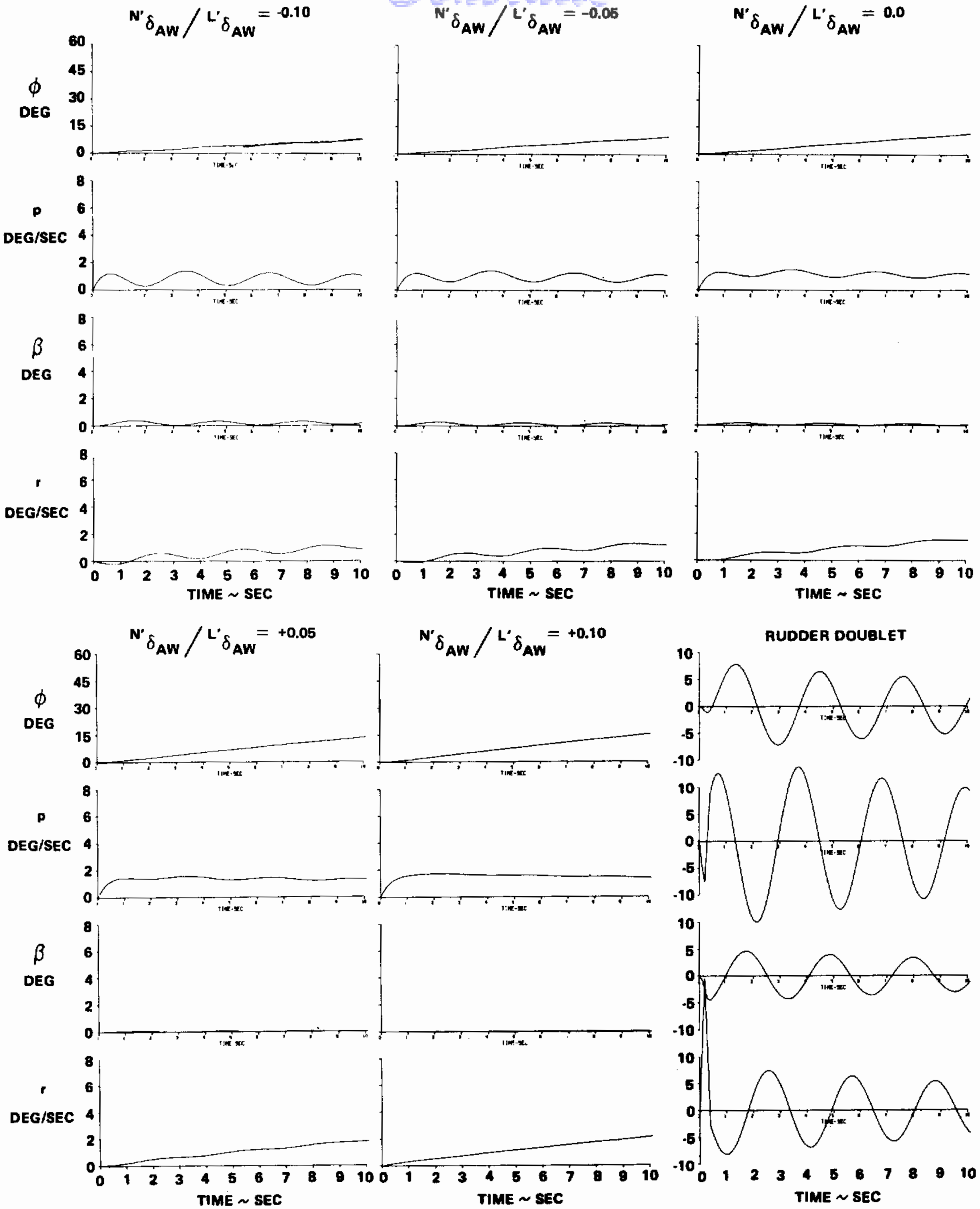
CONFIGURATION IDENTIFICATION AND TRANSIENT RESPONSES

GROUP 1 CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
1A2	-0.10	6.0	D	A	MODERATE	9	0.07	1.46	1120/2
1A1	-0.05	4.0	D	B	MODERATE	14	0.05	1.62	1139/2
1N0	0.0	3.0	B	A	LT. TO MOD.	14	0.04	1.77	1110/2
1P1	+0.05	4.5	D	B	MODERATE	18	0.03	1.91	1144/3
1P2	+0.10	4.0	D	B	MODERATE	4	0.014	2.04	1135/3

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 1 CONFIGURATIONS

ω_d ~ RAD/SEC	2.02	L'_r ~ SEC^{-1}	- 0.685
ζ_d	0.026	N'_β ~ SEC^{-2}	3.20
τ_R ~ SEC	0.40	N'_p ~ SEC^{-1}	- 0.090
τ_S ~ SEC	40	N'_r ~ SEC^{-1}	0.021
$\lvert\phi/\beta\rvert_d$	1.62	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	42.7	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_0$	0.098
L'_β ~ SEC^{-2}	-10.4	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.50		



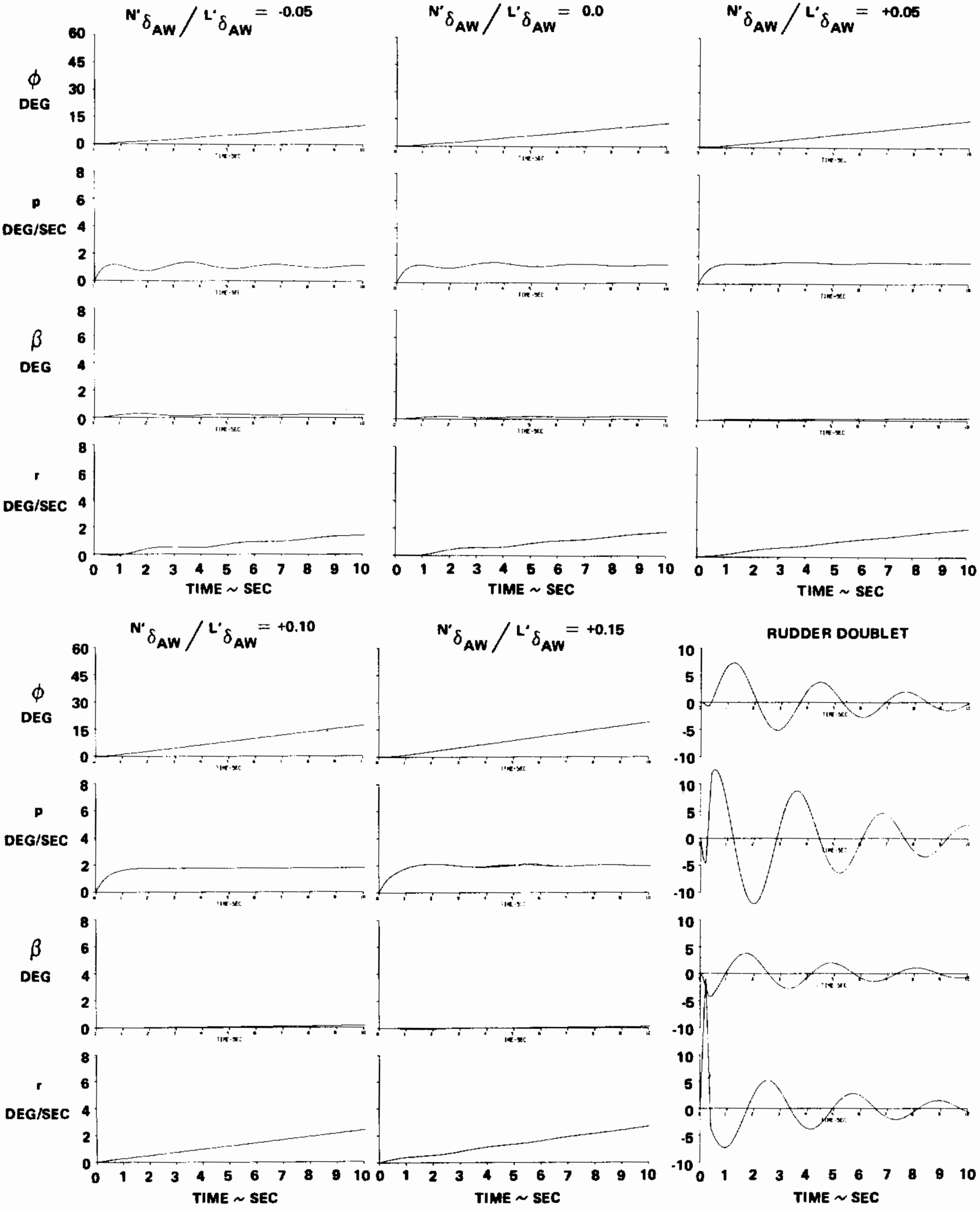
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 1 CONFIGURATIONS, $\omega_d \approx 2.02$ $\zeta_d \approx 0.026$ $\tau_R \approx 0.40$ $\tau_S \approx 40$ $|\phi/\beta|_d \approx 1.62$

GROUP 2 CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
2A1	-0.05	4.0	C	A	MODERATE(-)	14	0.10	1.57	1114/1
2N0	0.0	3.0	C	B	MODERATE	7	0.10	1.72	1135/1
2P1	+0.05	2.0	A	A	LT. TO MOD.	14	0.10	1.87	1110/1
2P2	+0.10	2.5	D	B	MODERATE	20G 26	0.10	2.00	1144/1
2P3	+0.15	3.0	D	B	MODERATE(-)	0	0.11	2.12	1146/3

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 2 CONFIGURATIONS

ω_d ~ RAD/SEC	1.98	L'_r ~ SEC^{-1}	0.678
ζ_d	0.10	N'_β ~ SEC^{-2}	2.99
τ_R ~ SEC	0.40	N'_p ~ SEC^{-1}	- 0.088
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.198
$\lvert\phi/\beta\rvert_d$	1.71	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	50.5	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_o$	0.098
L'_β ~ SEC^{-2}	-10.3	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.55		



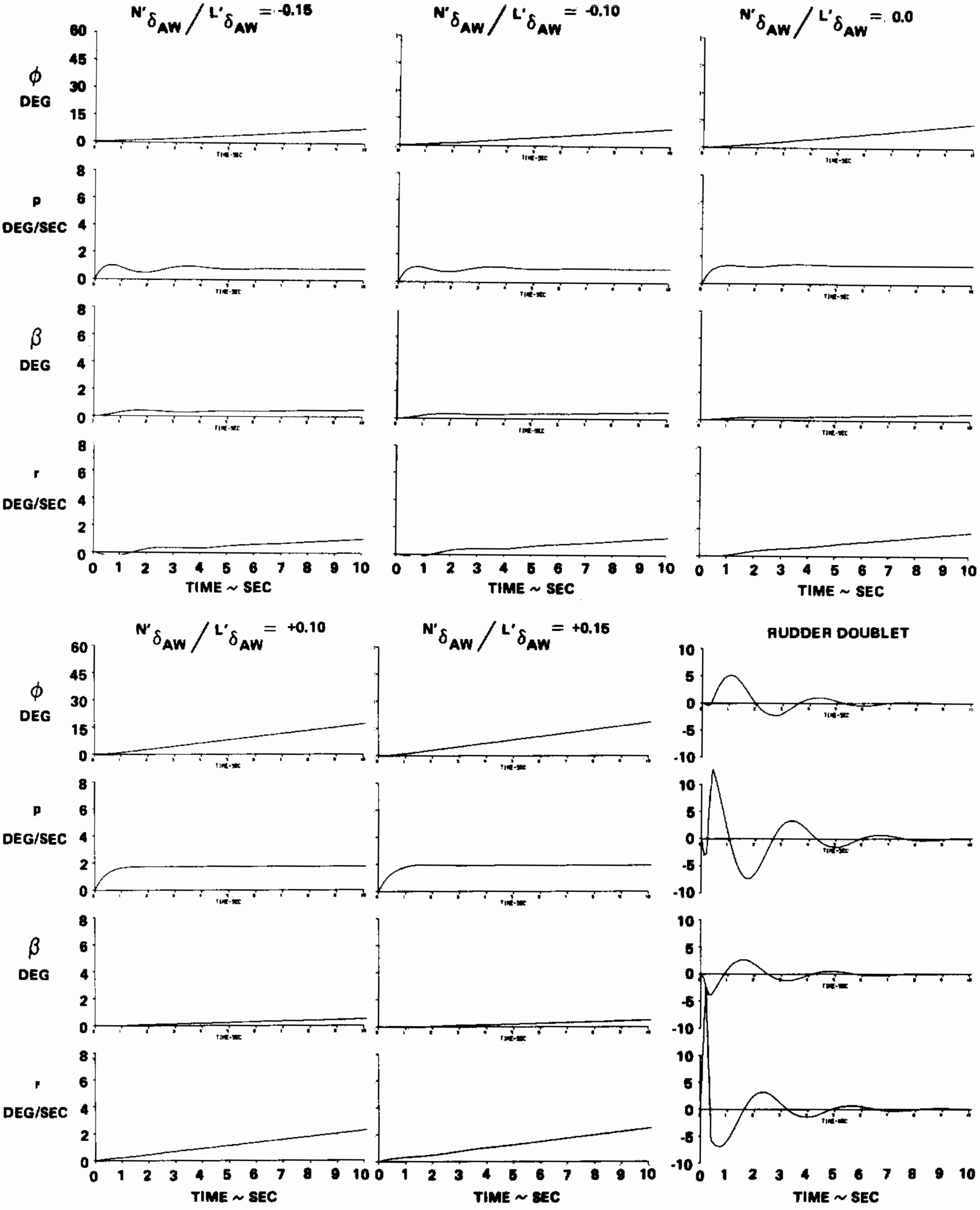
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 2 CONFIGURATIONS, $\omega_d \approx 1.98$ $\zeta_d \approx 0.10$ $\tau_R \approx 0.40$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 1.71$

GROUP 3 CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
3A3	-0.15	2.5	A	B	LT. TO MOD.	0	0.21	1.39	1146/1
3A2	-0.10	3.0	B	A	MODERATE(-)	18	0.22	1.53	1114/2
3N0	0.0	2.0	A	A	MODERATE	12	0.25	1.79	1120/1
3P2	+0.10	1.5	B	B	MODERATE	6	0.27	2.01	1139/1
3P3	+0.15	1.5	B	B	MODERATE	20 G 24	0.28	2.11	1144/2

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 3 CONFIGURATIONS

ω_d ~ RAD/SEC	2.01	L'_r ~ SEC^{-1}	1.93
ζ_d	0.24	N'_β ~ SEC^{-2}	3.14
τ_R ~ SEC	0.40	N'_p ~ SEC^{-1}	- 0.090
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.073
$\lvert\phi/\beta\rvert_d$	1.50	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	55.8	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_0$	0.098
L'_β ~ SEC^{-2}	- 8.32	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.58		



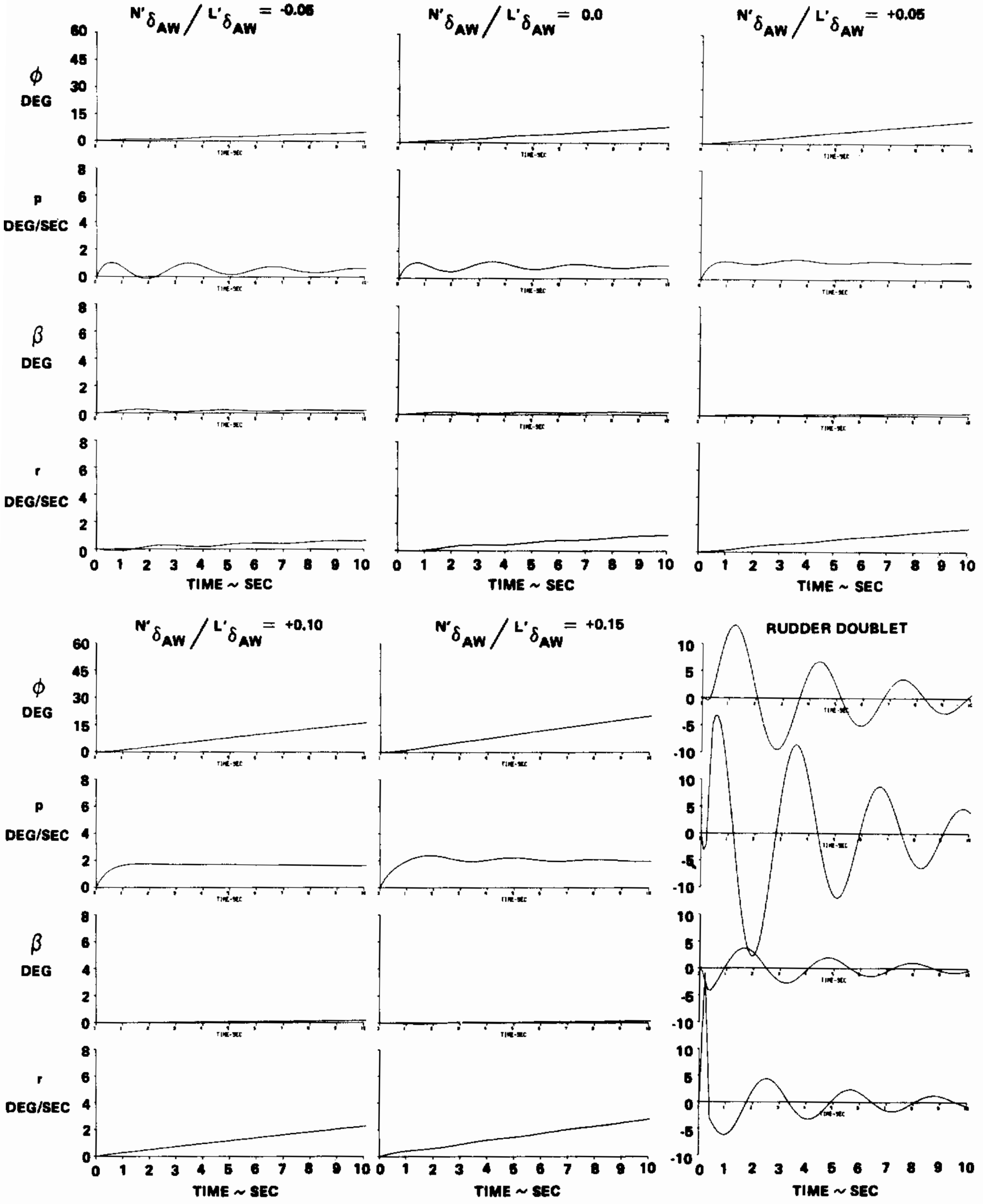
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 3 CONFIGURATIONS, $\omega_d \approx 2.01$ $\zeta_d \approx 0.24$ $\tau_R \approx 0.40$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 1.50$

GROUP 4 CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
4A1	-0.05	8.0	F	A	MODERATE	9	0.12	1.13	1120/3
4N0	0.0	8.0	F	A	MODERATE(-)	17	0.11	1.50	1114/3
4P1	+0.05	3.5	D	B	MODERATE	5	0.11	1.79	1135/2
4P2	+0.10	3.0	C	A	LIGHT(+)	14	0.11	2.04	1110/3
4P3	+0.15	6.0	F	B	MODERATE	12	0.13	2.26	1139/3
4P3	+0.15	6.0	F	B	MODERATE(-)	0	0.13	2.26	1146/2

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 4 CONFIGURATIONS

ω_d ~ RAD/SEC	2.02	L'_r ~ SEC^{-1}	1.29
ζ_d	0.10	N'_β ~ SEC^{-2}	2.25
τ_R ~ SEC	0.40	N'_p ~ SEC^{-1}	- 0.090
τ_S ~ SEC	100	N'_r ~ SEC^{-1}	- 0.190
$\lvert\phi/\beta\rvert_d$	3.14	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	49.2	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_0$	0.098
L'_β ~ SEC^{-2}	- 19.40	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.57		



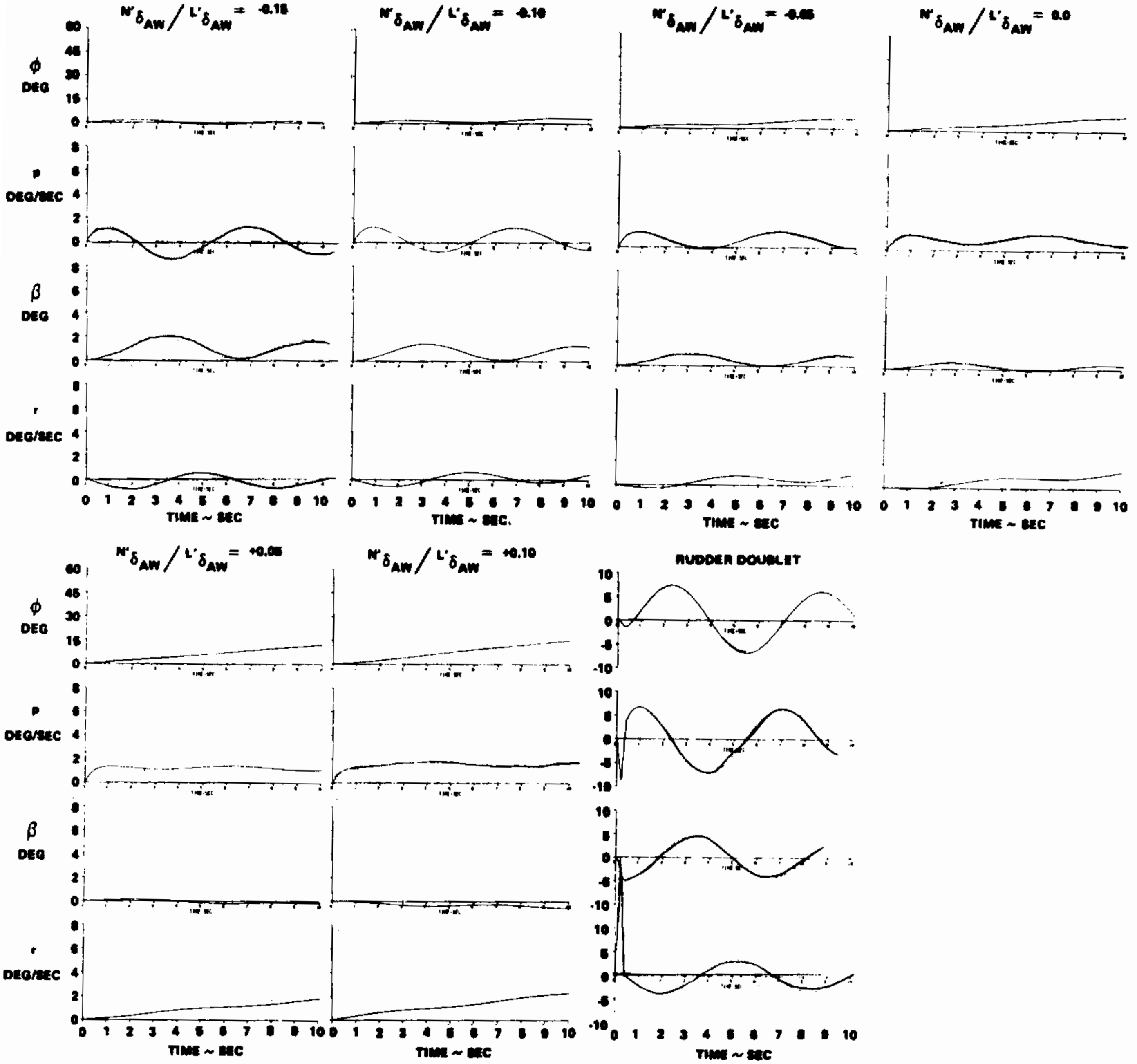
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 4 CONFIGURATIONS, $\omega_d \approx 2.02$ $\zeta_d \approx 0.10$ $\tau_R \approx 0.40$ $\tau_S \approx 100$ $|\phi/\beta|_d \approx 3.14$

GROUP 5 CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
5A3	-0.15	6.5	E	B	LIGHT	0	$\lambda_{\phi_1} = 0.097$	$\lambda_{\phi_2} = -0.30$	1145/2
5A2	-0.10	5.0	D	A	LIGHT(+)	8	0.18	0.44	1109/2
5A1	-0.05	3.5	C	A	MODERATE(-)	20	0.08	0.64	1156/2
5A1	-0.05	3.5	C	A	LIGHT(+)	14	0.08	0.64	1160/2
5A1	-0.05	6.5	E	B	LT. TO MOD.	20	0.08	0.64	1136/3
5A1	-0.05	7.0	D	B	MODERATE(-)	20	0.08	0.64	1141/3
5N0	0.0	6.0	B	A	LIGHT(+)	18	0.04	0.80	1107/3
5P1	+0.05	6.0	E	B	LIGHT(+)	9	0.005	0.93	1138/3
5P2	+0.10	7.0	E	A	MODERATE	18	-0.02	1.04	1115/3

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 5 CONFIGURATIONS

ω_d ~ RAD/SEC	0.990	L'_r ~ SEC^{-1}	- 0.964
ζ_d	0.03	N'_β ~ SEC^{-2}	0.662
τ_R ~ SEC	0.35	N'_p ~ SEC^{-1}	- 0.080
τ_S ~ SEC	100	N'_r ~ SEC^{-1}	0.090
$\left\|\phi/\beta\right\|_d$	1.54	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	59.9	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_0$	0.098
L'_β ~ SEC^{-2}	- 4.67	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.87		



TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 5 CONFIGURATIONS, $\omega_d \approx 0.99$ $\zeta_d \approx 0.03$ $\tau_R \approx 0.35$ $\tau_S \approx 100$ $|\phi/\beta|_d \approx 1.54$

GROUP 6 CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
6A2	-0.10	6.0	E	A	NIL	0	0.19	0.52	1105/3
6A2	-0.10	5.0	C	A	LIGHT	13	0.19	0.52	1107/1
6A1	-0.05	4.0	D	B	LT. TO MOD.	10	0.15	0.68	1131/2
6N0	0.0	3.0	A	A	NIL	0	0.12	0.82	1105/1
6N0	0.0	3.0	D	B	LT. TO MOD.	5	0.12	0.82	1130/1
6P1	+0.05	1.5	A	B	LT. TO MOD.	12	0.11	0.93	1132/2
6P2	+0.10	4.0	C	A	MODERATE	20	0.10	1.03	1116/3

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 6 CONFIGURATIONS

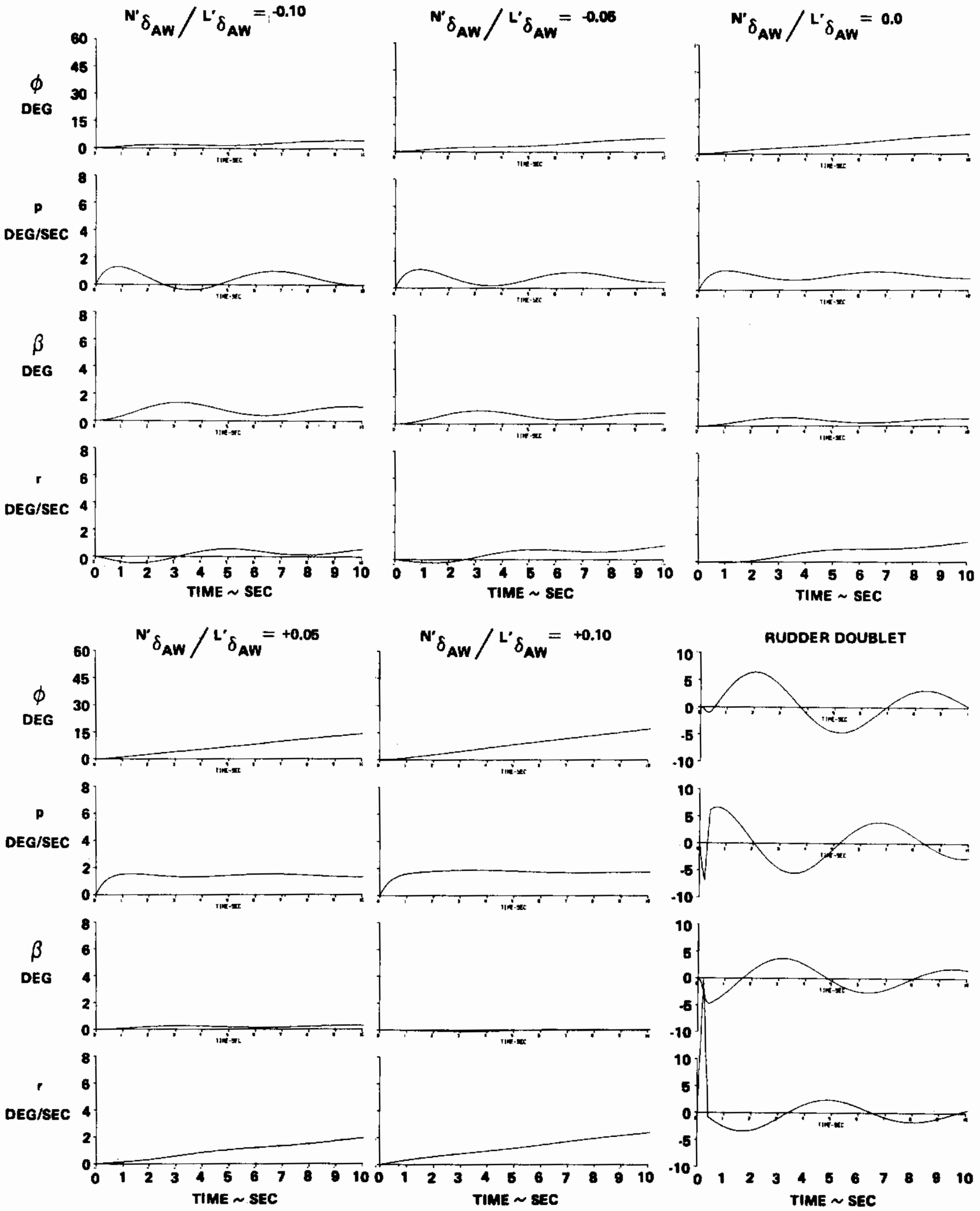
ω_d ~ RAD/SEC	1.00	L'_r ~ SEC^{-1}	0.040
ζ_d	0.11	N'_β ~ SEC^{-2}	0.671
τ_R ~ SEC	0.40	N'_p ~ SEC^{-1}	- 0.070
τ_S ~ SEC	100	N'_r ~ SEC^{-1}	- 0.054
$\lvert\phi/\beta\rvert_d$	1.56	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	61.8	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_o$	0.098
L'_β ~ SEC^{-2}	- 4.07	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.53		

GROUP 6 CONFIGURATION IDENTIFICATION
STICK CONTROLLER

CONFIG.	$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
6A2	-0.10	5.5	D	A	MOD.	28 G 33	0.19	0.52	1121/3
6A1	-0.10	4.5	D	B	NIL	0	0.15	0.68	1127/2
6N0	0.0	2.5	B	A	MODERATE	29	0.12	0.82	1122/2
6N0	0.0	2.5	B	B	LIGHT	04	0.12	0.82	1125/2
6P1	+0.05	2.0	B	B	MODERATE	16	0.11	0.93	1126/3
6P2	+0.10	4.0	C	A	MODERATE	18	0.10	1.03	1123/3

GROUP 6 ROLL CONTROL POWER EXPERIMENT
CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	δ_{AW} AUTHORITY	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
6P1	±45.°	+0.05	1.5	A	B	LT. TO MOD.	12	0.11	0.93	1132/2
6P1	±10.°	+0.05	3.0	C	A	LIGHT(+)	22	0.11	0.93	1158/3
6P1	±10.°	+0.05	3.0	B	A	MODERATE(-)	15	0.11	0.93	1155/3
6P1	±7.5°	+0.05	4.0	D	B	LIGHT(+)	30 G 35	0.11	0.93	1152/3
6P1	±5.0°	+0.05	6.0	C	B	MODERATE(-)	23 G 33	0.11	0.93	1150/1
6P1	±2.5°	+0.05	9.0	C	A	LIGHT(+)	24	0.11	0.93	1158/2



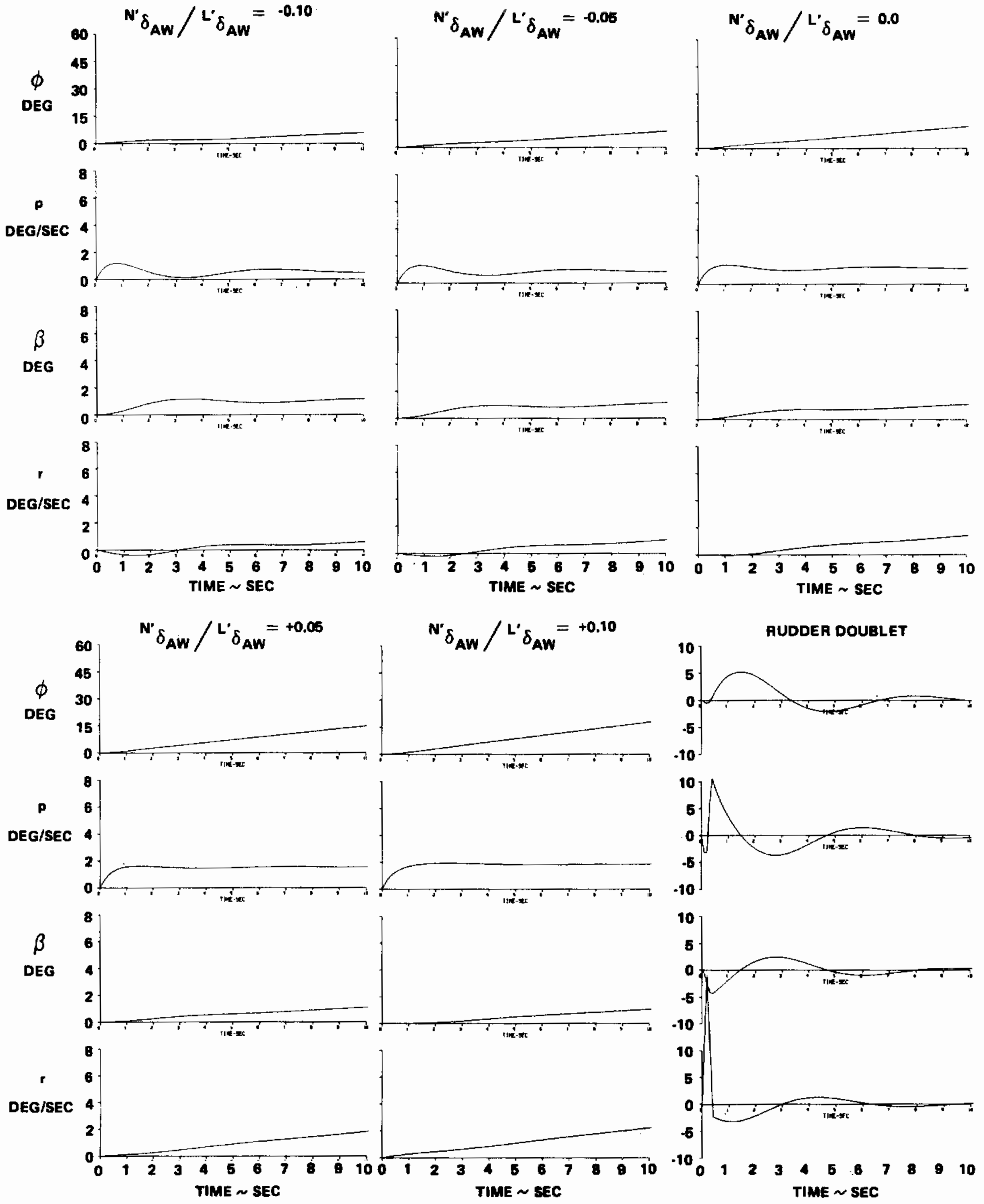
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 6 CONFIGURATIONS, $\omega_d \approx 1.00$ $\zeta_d \approx 0.11$ $\tau_R \approx 0.40$ $\tau_S \approx 100$ $|\phi/\beta|_d \approx 1.56$

GROUP 7 CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
7A2	-0.10	4.0	C	A	LIGHT(-)	0	0.27	0.58	1112/2
7A1	-0.05	2.5	A	B	LIGHT	0	0.28	0.72	1134/2
7N0	0.0	1.5	A	A	LT. TO MOD.	4	0.30	0.84	1118/2
7N0	0.0	2.5	B	A	LIGHT	0	0.30	0.84	1106/2
7P1	+0.05	2.0	A	B	LIGHT(+)	10	0.32	0.95	1131/3
7P2	+0.10	4.0	B	A	LIGHT(+)	18	0.33	1.04	1115/2

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 7 CONFIGURATIONS

ω_d ~ RAD/SEC	1.01	L'_r ~ SEC^{-1}	1.86
ζ_d	0.29	N'_β ~ SEC^{-2}	0.668
τ_R ~ SEC	0.40	N'_p ~ SEC^{-1}	- 0.072
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.356
$\lvert\phi/\beta\rvert_d$	1.48	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	73.9	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_0$	0.098
L'_β ~ SEC^{-2}	- 3.50	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.58		



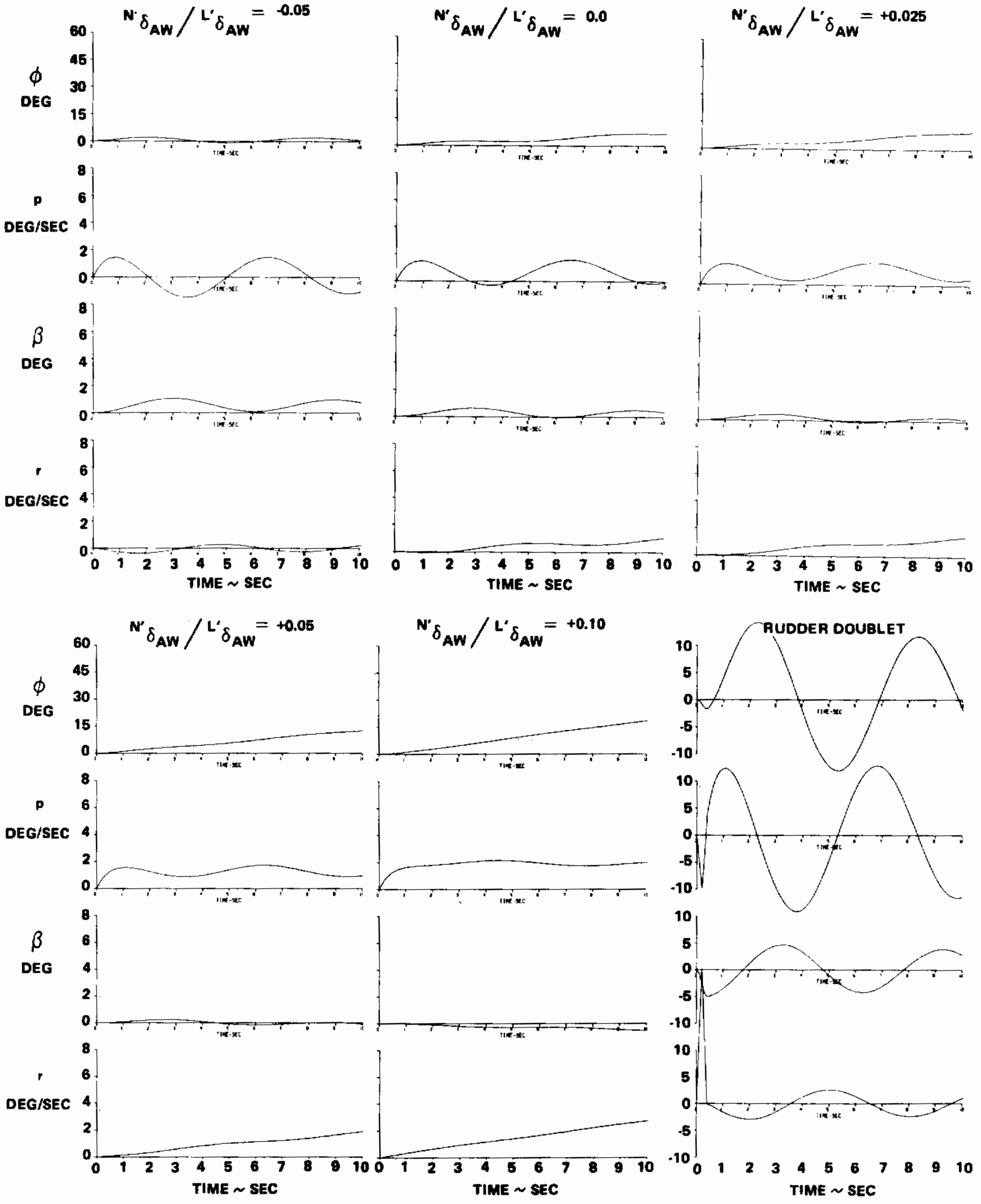
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 7 CONFIGURATIONS, $\omega_d \approx 1.01$ $\zeta_d \approx 0.29$ $\tau_R \approx 0.40$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 1.48$

GROUP 8 CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
8A1	-0.05	8.5	F	B	LT. TO MOD.	10	0.42	0.20	1140/2
8NO	0.0	6.0	D	A	MODERATE	20	0.07	0.64	1116/2
8NO	0.0	8.0	E	A	MODERATE	10	0.07	0.64	1161/3
8P1/2	+0.025	9.0	F	B	LIGHT(+)	20	0.04	0.77	1142/3
8P1	+0.05	9.0	F	B	LIGHT(+)	04	0.01	0.88	1134/3
8P2	+0.10	9.0	E	A	LIGHT(+)	03	-0.02	1.06	1111/3

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 8 CONFIGURATIONS

ω_d ~ RAD/SEC	1.04	L'_r ~ SEC^{-1}	- 1.42
ζ_d	0.031	N'_β ~ SEC^{-2}	0.419
τ_R ~ SEC	0.45	N'_p ~ SEC^{-1}	- 0.072
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	0.054
$\lvert \phi/\beta \rvert_d$	2.97	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	56.4	$Y_{\dot{\beta}} - 1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p + \alpha_0$	0.098
L'_β ~ SEC^{-2}	- 7.61	$Y_r - 1$	- 0.997
L'_p ~ SEC^{-1}	- 2.20		



TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 8 CONFIGURATIONS, $\omega_d \approx 1.04$ $\zeta_d \approx 0.031$ $\tau_R \approx 0.41$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 2.97$

GROUP 9 CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
9A1	-0.05	9.0	E	A	LIGHT	0	$\lambda_{\phi_1} = 0.11$	$\lambda_{\phi_2} = -0.26$	1112/3
9N0	0.0	8.0	D	A	LIGHT	13	0.15	0.64	1108/3
9N0	0.0	8.5	F	B	MODERATE	12	0.15	0.64	1133/2
9P1	+0.05	5.5	D	B	MODERATE	10	0.13	0.93	1140/3
9P2	+0.10	5.0	C	A	LIGHT	8	0.12	1.14	1117/3
9P3	+0.15	9.0	G	B	MODERATE(-)	22	0.12	1.32	1141/2

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 9 CONFIGURATIONS

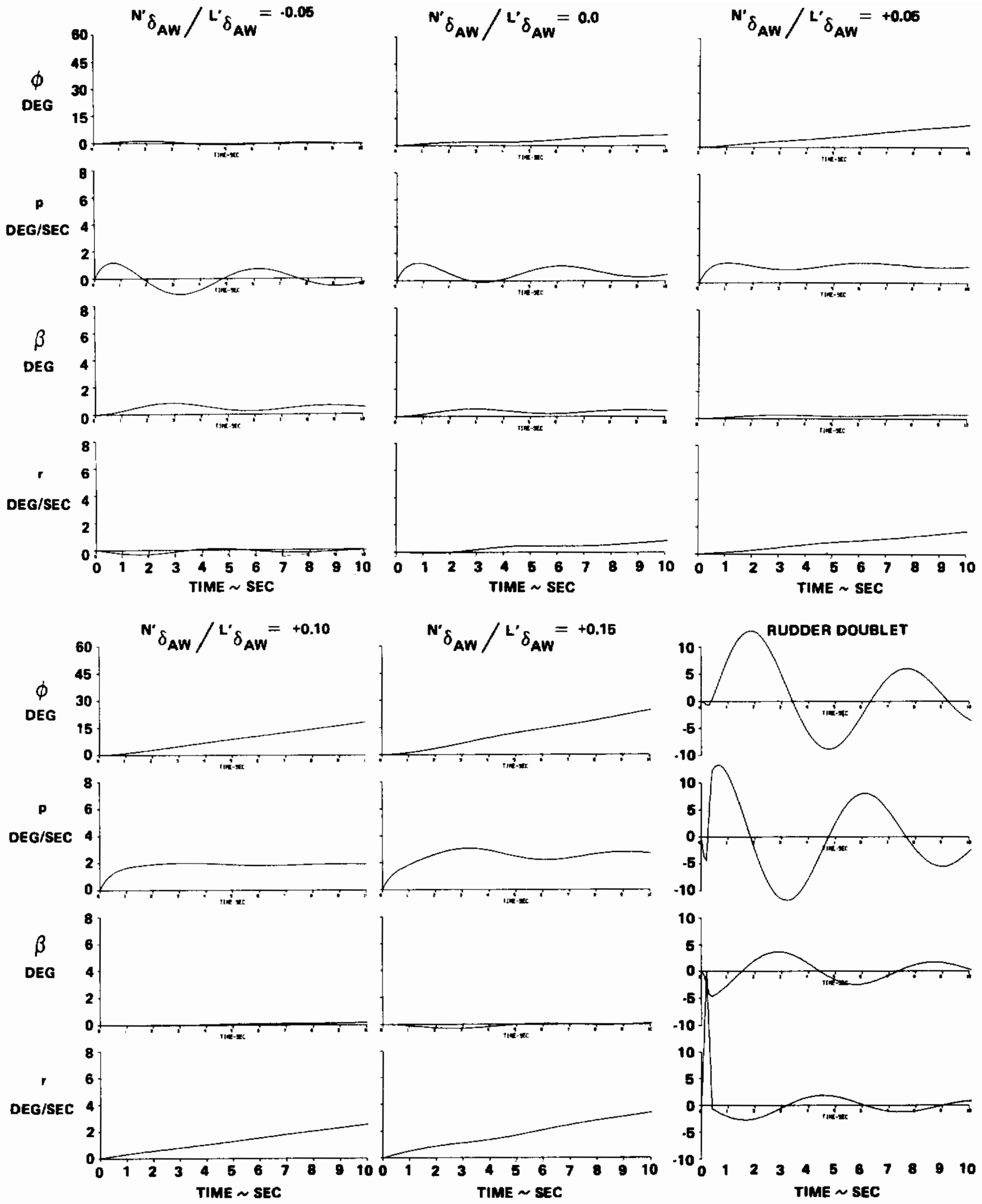
ω_d ~ RAD/SEC	1.09	L'_r ~ SEC^{-1}	0.881
ζ_d	0.12	N'_β ~ SEC^{-2}	0.417
τ_R ~ SEC	0.40	N'_p ~ SEC^{-1}	- 0.084
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.042
$\left\|\phi/\beta\right\|_d$	3.11	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	62.7	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_0$	0.098
L'_β ~ SEC^{-2}	- 8.91	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.57		

GROUP 9 CONFIGURATION IDENTIFICATION
STICK CONTROLLER

CONFIG.	$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
9A1	-0.05	8.0	F	B	LIGHT	7	$\lambda_{\phi_1} = 0.11$	$\lambda_{\phi_2} = -0.26$	1125/3
9A1	-0.05	9.0	E	A	MODERATE	30	$\lambda_{\phi_1} = 0.11$	$\lambda_{\phi_2} = -0.26$	1122/3
9N0	0.0	7.0	E	B	MODERATE	0	0.15	0.64	1128/2
9P1	+0.05	5.0	D	A	MODERATE	16	0.13	0.93	1124/2
9P2	+0.10	5.5	D	B	MODERATE	8	0.13	1.14	1126/2

GROUP 9 ROLL CONTROL POWER EXPERIMENT
CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	δ_{AW} AUTHORITY	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
9P1	±45.	+0.05	5.5	D	B	MODERATE	10	0.13	0.93	1140/3
9P1	±15.°	+0.05	5.0	F	B	MODERATE	25 G 30	0.13	0.93	1164/3
9P1	±10.°	+0.05	8.0	F	A	NIL	14	0.13	0.93	1157/2
9P1	±10.°	+0.05	8.0	F	B	MODERATE	30	0.13	0.93	1150/3
9P1	±7.5°	+0.05	10.0	E	B	MODERATE	25 G 30	0.13	0.93	1164/2
9P1	±5.0°	+0.05	9.0	G	A	MODERATE	12	0.13	0.93	1155/2
9P1	±2.5°	+0.05	8.5	G	B	LIGHT	10	0.13	0.93	1162/3



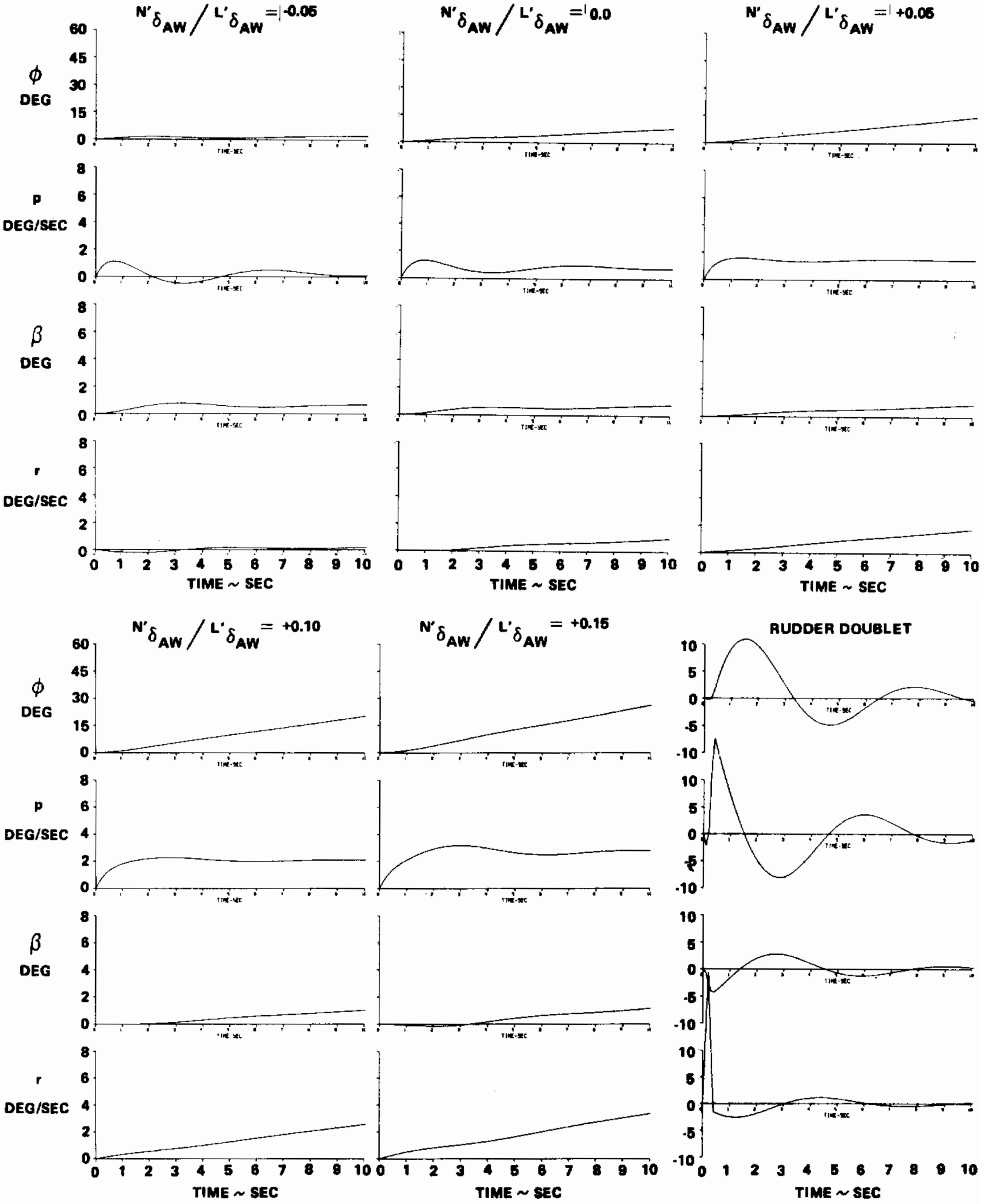
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 9 CONFIGURATIONS, $\omega_d \approx 1.09$ $\zeta_d \approx 0.12$ $\tau_R \approx 0.40$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 3.11$

GROUP 10 CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
10A1	-0.05	7.0	E	B	MODERATE	24 G 28	0.30	0.33	1154/3
10A1	-0.05	9.0	E	A	LIGHT(+)	16	0.30	0.33	1113/3
10N0	0.0	3.0	B	A	MODERATE(-)	15	0.26	0.70	1160/1
10N0	0.0	3.0	C	B	LIGHT(+)	20 G 24	0.26	0.70	1137/2
10N0	0.0	4.0	D	B	MODERATE(+)	26 G 32	0.26	0.70	1143/2
10P1	+0.05	4.5	D	B	MODERATE	10	0.29	0.94	1133/3
10P2	+0.10	4.0	D	A	LIGHT	01	0.31	1.12	1111/1
10P3	+0.15	3.5	D	B	LIGHT(+)	01	0.34	1.28	1145/3

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 10 CONFIGURATIONS

ω_d ~ RAD/SEC	1.03	L'_r ~ SEC^{-1}	3.38
ζ_d	0.25	N'_β ~ SEC^{-2}	0.471
τ_R ~ SEC	0.40	N'_p ~ SEC^{-1}	- 0.052
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.218
$\lvert\phi/\beta\rvert_d$	2.90	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	68.7	$Y_{\dot{\beta}}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_0$	0.098
L'_β ~ SEC^{-2}	- 7.30	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.65		



TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 10 CONFIGURATIONS, $\omega_d \approx 1.03$ $\zeta_d \approx 0.25$ $\tau_R \approx 0.04$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 2.90$

GROUP 11 CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
11A2	-0.10	4.0	B	A	LT. TO MOD.	2	0.11	0.93	1118/2
11A2	-0.10	5.0	D	A	LIGHT(+)	9	0.11	0.93	1161/2
11A1	-0.05	5.0	D	B	LT. TO MOD.	6	0.11	0.95	1130/3
11N0	0.0	4.0	D	A	NIL	0	0.11	0.97	1105/2
11P1	+0.05	2.5	C	B	LT. TO MOD.	6	0.11	0.99	1130/2
11P1	+0.05	3.5	C	A	LIGHT	13	0.11	0.99	1157/3
11P2	+0.10	1.0	A	B	MODERATE	12	0.11	1.01	1132/3
11P2	+0.10	2.0	A	A	LIGHT(+)	8	0.11	1.01	1109/3
11P2	+0.10	2.0	B	A	LIGHT(+)	15	0.11	1.01	1160/2
11P2	+0.10	2.0	B	B	LIGHT(+)	24 G 28	0.11	1.01	1153/3
11P3	+0.15	3.0	C	B	LIGHT(+)	20	0.11	1.03	1142/2

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 11 CONFIGURATIONS

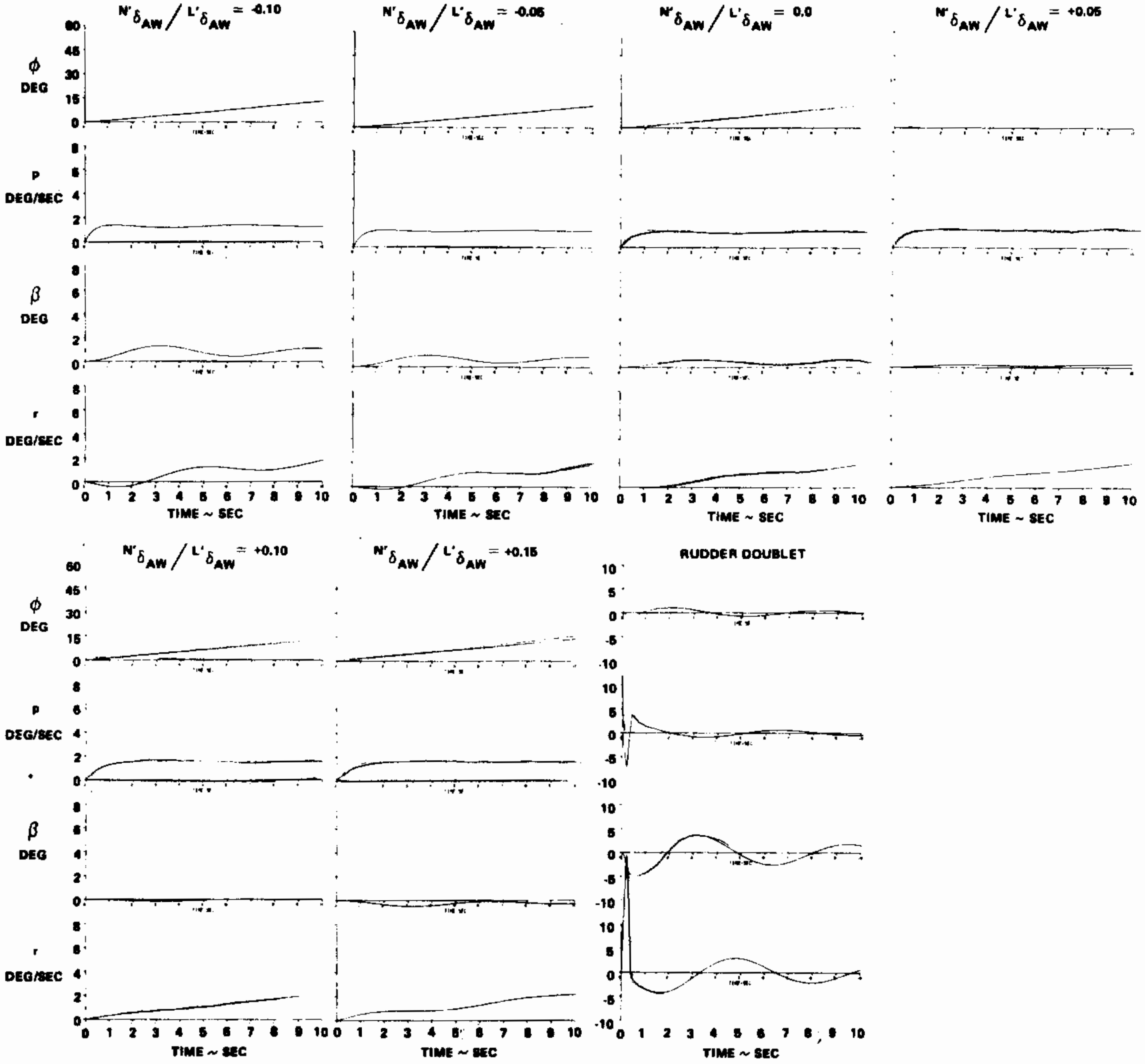
ω_d ~ RAD/SEC	1.00	L'_r ~ SEC^{-1}	- 0.047
ζ_d	0.11	N'_β ~ SEC^{-2}	0.951
τ_R ~ SEC	0.35	N'_p ~ SEC^{-1}	- 0.080
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.065
$\lvert\phi/\beta\rvert_d$	0.25	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	67.4	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_o$	0.098
L'_β ~ SEC^{-2}	- 0.728	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.86		

GROUP 11 CONFIGURATION IDENTIFICATION
STICK CONTROLLER

CONFIG.	$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
11A2	-0.10	6.5	D	A	MODERATE	16	0.11	0.93	1124/3
11A1	-0.05	4.5	C	B	NIL	0	0.11	0.95	1127/3
11N0	0.0	3.0	B	A	MODERATE	20 G 29	0.11	0.97	1121/2
11N0	0.0	3.0	C	B	MODERATE	0	0.11	0.97	1128/3
11P1	+0.05	2.0	A	B	NIL	0	0.11	0.99	1127/1
11P2	+0.10	3.5	B	A	LIGHT(+)	22	0.11	1.01	1123/2

GROUP 11 ROLL CONTROL POWER EXPERIMENT
CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	δ_{AW} AUTHORITY	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
11P1	±45.°	+0.05	2.5	C	B	LT. TO MOD	6	0.11	0.99	1130/2
11P1	±45.°	+0.05	3.5	C	A	LIGHT	13	0.11	0.99	1157/3
11P1	±10.°	+0.05	2.5	C	B	LIGHT(+)	26	0.11	0.99	1151/3
11P1	±7.5°	+0.05	5.0	D	A	MODERATE	19	0.11	0.99	1156/3
11P1	±5.0°	+0.05	7.0	C	A	LIGHT(+)	10	0.11	0.99	1159/2
11P1	±2.5°	+0.05	7.0	B	B	LIGHT	24	0.11	0.99	1153/2



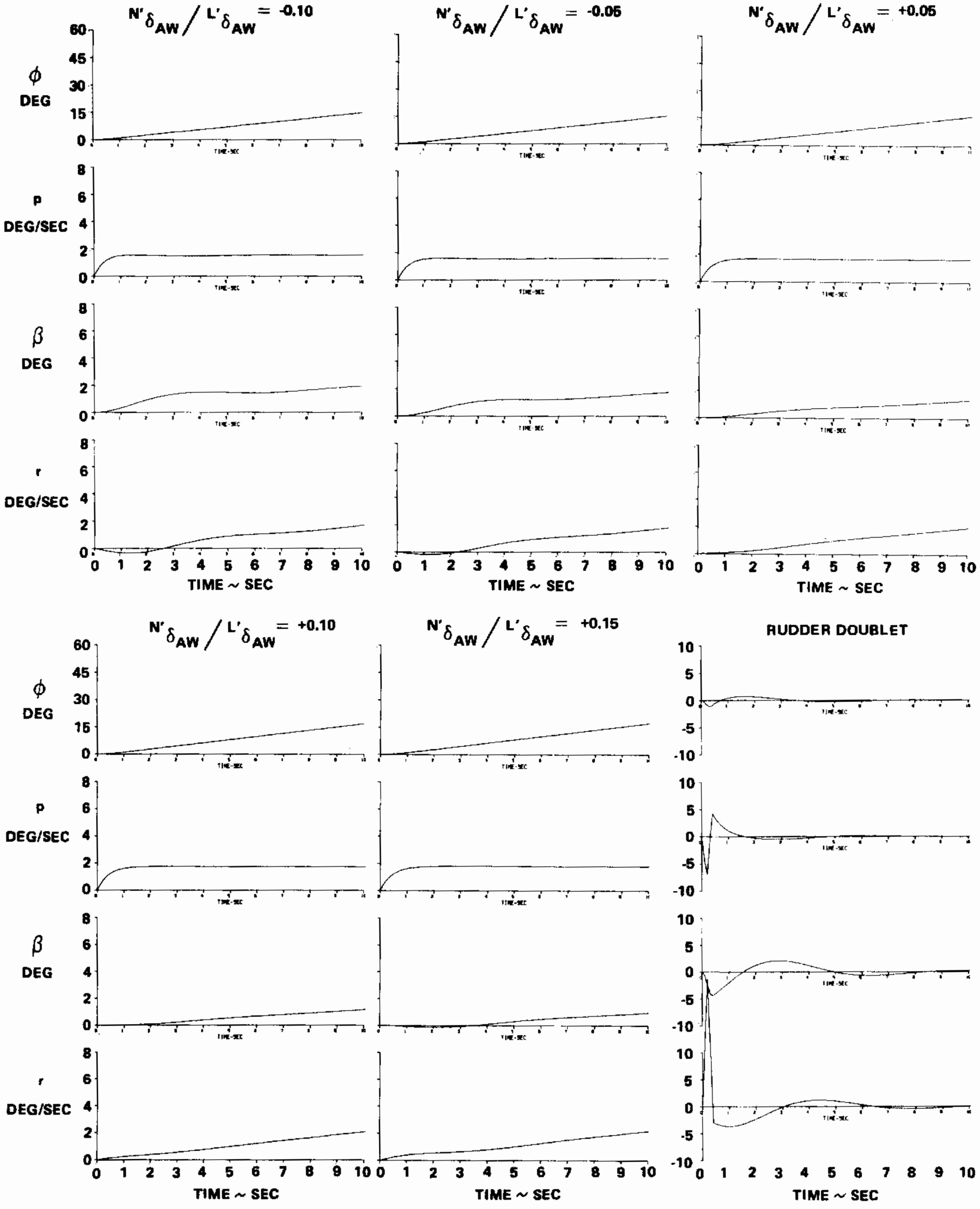
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 11 CONFIGURATIONS, $\omega_d \approx 1.00$ $\zeta_d \approx 0.11$ $\tau_R \approx 0.35$ $\tau_S \approx 40.0$ $|\phi/\beta|_d \approx 0.25$

GROUP 12 CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
12A2	-0.10	3.0	A	B	LIGHT	6	0.34	0.92	1138/2
12A1	-0.05	2.5	B	A	LIGHT	10	0.34	0.94	1117/2
12P1	+0.05	2.0	B	A	LIGHT	0	0.34	0.97	1106/3
12P2	+0.10	2.0	A	B	LIGHT(+)	22	0.34	0.98	1137/3
12P3	+0.15	1.5	A	B	MODERATE(+)	26 G 34	0.35	1.00	1143/3

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 12 CONFIGURATIONS

ω_d ~ RAD/SEC	0.98	L'_r ~ SEC^{-1}	0.314
ζ_d	0.34	N'_β ~ SEC^{-2}	0.847
τ_R ~ SEC	0.40	N'_p ~ SEC^{-1}	- 0.090
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.504
$\lvert \phi/\beta \rvert_d$	0.24	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	78.1	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_o$	0.099
L'_β ~ SEC^{-2}	- 0.532	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 2.51		



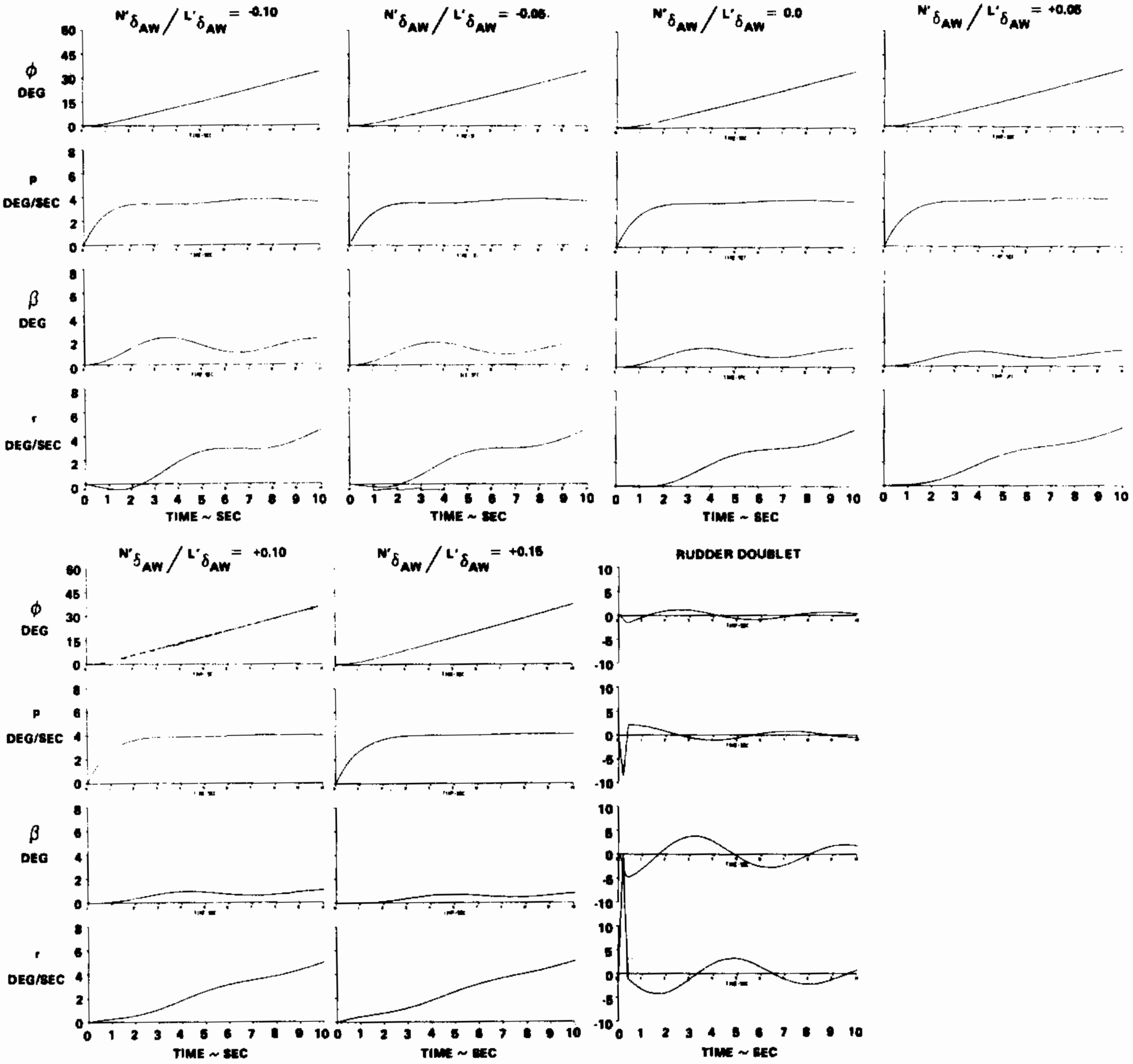
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 12 CONFIGURATIONS, $\omega_d \approx 0.98$ $\zeta_d \approx 0.34$ $\tau_R \approx 0.40$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 0.24$

GROUP 13 CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
13A2	-0.10	3.0	B	B	LIGHT(+)	26 G 32	0.12	0.94	1143/1
13A2	-0.10	4.0	D	A	LIGHT(+)	12	0.12	0.94	1159/3
13A2	-0.10	4.0	C	B	LIGHT	0	0.12	0.94	1134/1
13A1	-0.05	5.0	D	A	LIGHT(+)	14	0.12	0.96	1113/2
13A1	-0.05	5.0	C	B	LIGHT(+)	20	0.12	0.96	1136/2
13N0	0.0	5.0	D	B	LIGHT(+)	33	0.12	0.97	1152/2
13P1	+0.05	3.0	C	A	LIGHT(+)	8	0.12	0.98	1109/1
13P2	+0.10	3.0	B	B	LIGHT(+)	20	0.12	0.99	1137/1
13P3	+0.15	3.0	B	B	LIGHT	10	0.12	1.00	1140/1

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 13 CONFIGURATIONS

ω_d ~ RAD/SEC	1.00	L'_r ~ SEC^{-1}	0.034
ζ_d	0.099	N'_β ~ SEC^{-2}	0.939
τ_R ~ SEC	0.95	N'_p ~ SEC^{-1}	- 0.094
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.078
$\lvert\phi/\beta\rvert_d$	0.31	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	41.7	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_0$	0.098
L'_β ~ SEC^{-2}	- 0.419	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 1.03		



TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 13 CONFIGURATIONS, $\omega_d \approx 1.00$ $\zeta_d \approx 0.099$ $\tau_R \approx 0.95$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 0.31$

GROUP 14 CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
14A2	-0.10	4.0	C	A	LIGHT	0	0.17	0.76	1112/1
14A1	-0.05	2.0	A	B	LT. TO MOD.	12	0.17	0.76	1132/1
14N0	0.0	1.0	A	A	LIGHT	20	0.17	0.88	1107/2
14P1	+0.05	3.0	B	B	LIGHT	5	0.17	0.93	1131/1
14P2	+0.10	3.0	B	A	LIGHT	24 G 30	0.17	0.98	1108/1

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 14 CONFIGURATIONS

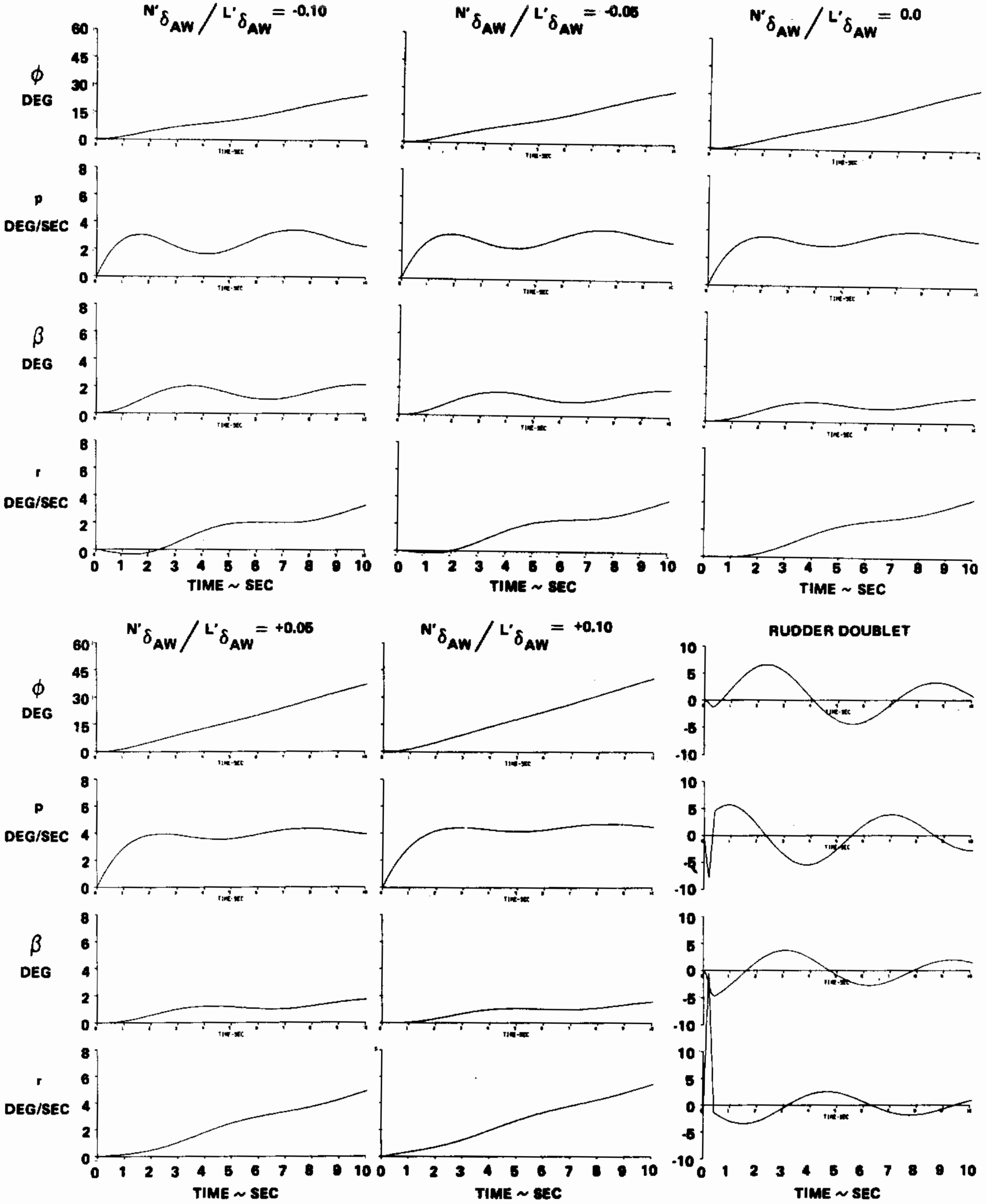
ω_d ~ RAD/SEC	1.01	L'_r ~ SEC^{-1}	0.037
ζ_d	0.10	N'_β ~ SEC^{-2}	0.757
τ_R ~ SEC	1.10	N'_p ~ SEC^{-1}	- 0.033
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.151
$\lvert\phi/\beta\rvert_d$	1.53	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	38.4	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_o$	0.098
L'_β ~ SEC^{-2}	- 1.88	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 0.812		

GROUP 14 CONFIGURATION IDENTIFICATION STICK CONTROLLER

CONFIG.	$N'_{\delta_{AS}}/L'_{\delta_{AS}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
14A2	-0.10	3.0	C	A	MODERATE	28	0.17	0.76	1122/1
14A2	-0.10	4.0	C	B	LIGHT	0	0.17	0.76	1128/1
14A1	-0.05	3.0	B	B	LT. TO MOD.	5	0.17	0.76	1126/1
14NO	0.0	2.0	A	A	MODERATE	20 G 26	0.17	0.88	1121/1
14P1	+0.05	2.0	B	A	MODERATE	20	0.17	0.93	1124/1
14P1	+0.05	2.0	A	B	NIL	4	0.17	0.93	1125/1
14P2	+0.10	2.5	B	A	LIGHT(+)	19	0.17	0.98	1123/1

GROUP 14 ROLL CONTROL POWER EXPERIMENT CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	δ_{AW} AUTHORITY	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
14P1	±45.°	+0.05	3.0	B	B	LIGHT	5	0.17	0.93	1131/1
14P1	±10.°	+0.05	2.0	B	A	LIGHT(+)	20	0.17	0.93	1158/1
14P1	±7.5°	+0.05	3.0	B	B	LIGHT(+)	30	0.17	0.93	1152/1
14P1	±5.0°	+0.05	6.0	D	A	MODERATE(-)	19	0.17	0.93	1156/1
14P1	±2.5°	+0.05	10.0	C	B	LIGHT(+)	26	0.17	0.93	1154/1



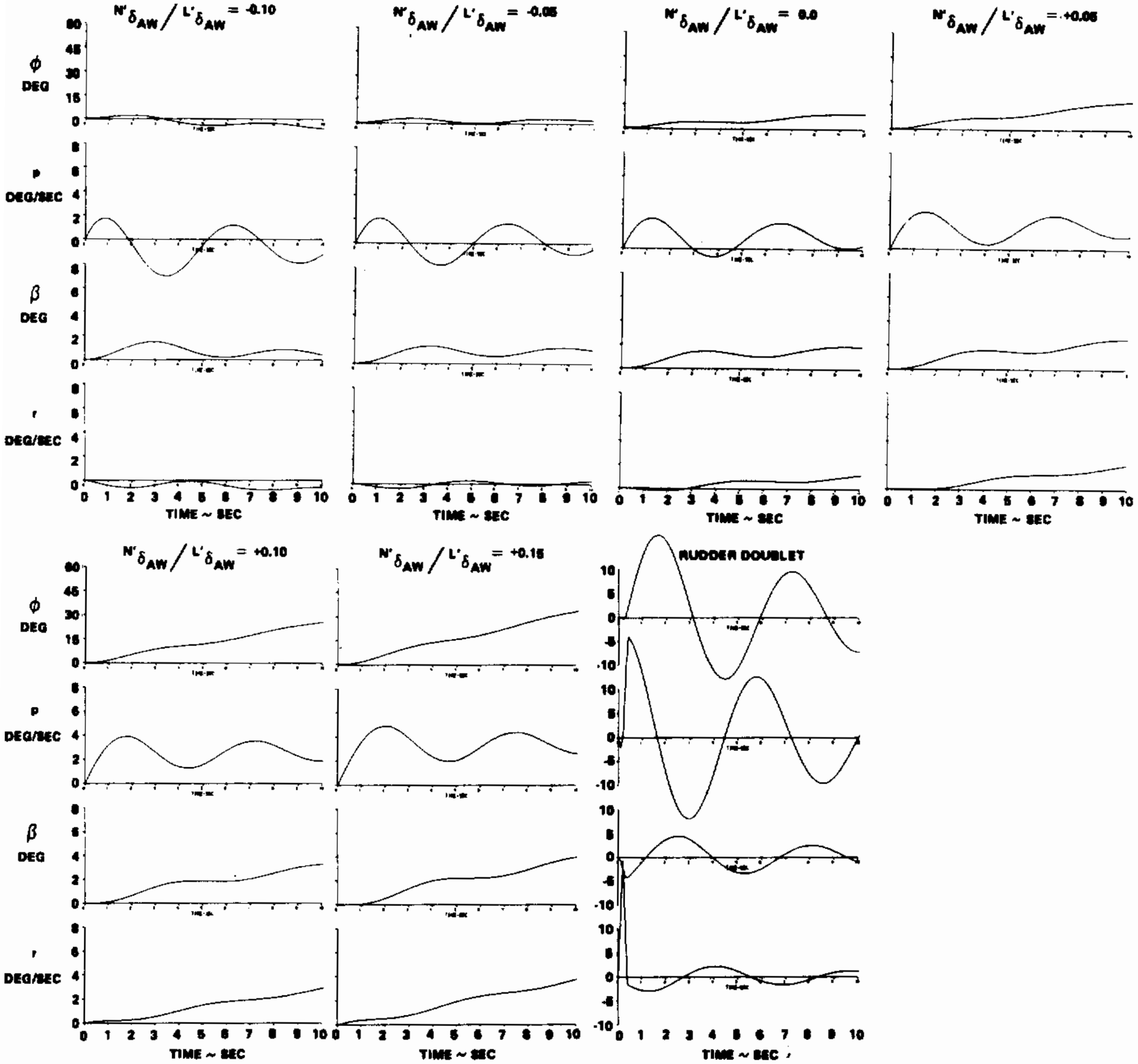
TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 14 CONFIGURATIONS, $\omega_d \approx 1.01$ $\zeta_d \approx 0.10$ $\tau_R \approx 1.10$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 1.53$

GROUP 15 CONFIGURATION IDENTIFICATION WHEEL CONTROLLER

CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
15A2	-0.10	6.5	E	B	LIGHT(+)	20	$\lambda_{\phi_1} = 0.44$	$\lambda_{\phi_2} = -0.43$	1142/1
15A1	-0.05	5.5	B	A	LIGHT(+)	9	0.41	0.24	1117/1
15NO	0.0	5.0	C	A	MODERATE	20	0.36	0.55	1116/1
15P1	+0.05	5.0	C	B	LIGHT	6	0.40	0.74	1138/1
15P2	+0.10	4.0	B	A	LIGHT	6	0.45	0.89	1118/1
15P3	+0.15	5.0	D	B	LIGHT	0	0.49	1.02	1145/1

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 15 CONFIGURATIONS

ω_d ~ RAD/SEC	1.13	L'_r ~ SEC^{-1}	4.02
ζ_d	0.09	N'_β ~ SEC^{-2}	0.271
τ_R ~ SEC	0.95	N'_p ~ SEC^{-1}	- 0.105
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.248
$\lvert\phi/\beta\rvert_d$	3.50	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	54.2	$Y_{\dot{\beta}} - 1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p + \alpha_0$	0.098
L'_β ~ SEC^{-2}	- 4.39	$Y_r - 1$	- 0.997
L'_p ~ SEC^{-1}	- 0.860		



TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 15 CONFIGURATIONS, $\omega_d \approx 1.13$ $\zeta_d \approx 0.09$ $\tau_R \approx 0.95$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 3.50$

GROUP 16 CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

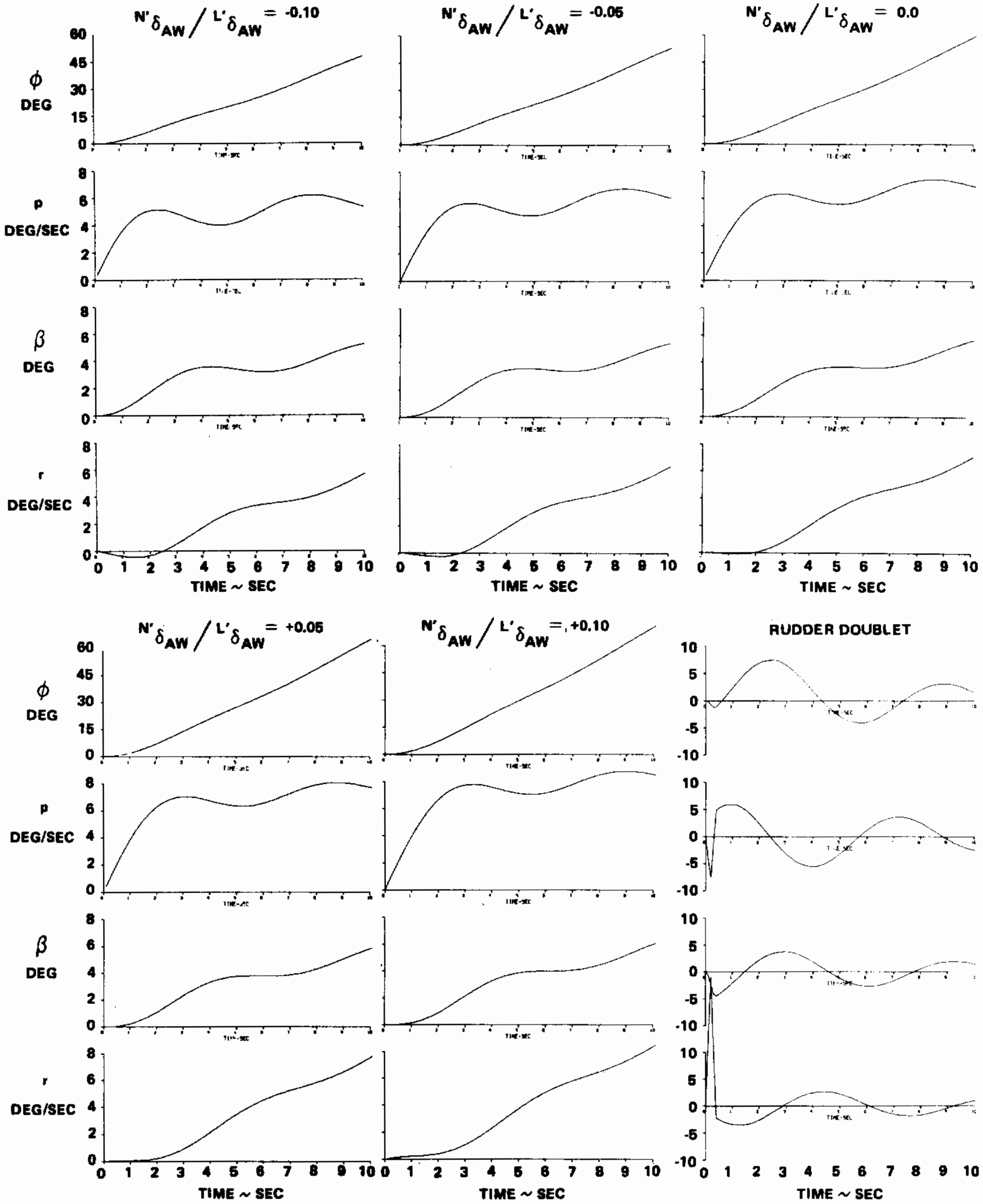
CONFIG.	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
16A2	-0.10	4.5	C	B	LIGHT(+)	20	0.27	0.80	1141/1
16A1	-0.05	4.0	C	A	LIGHT(+)	18	0.28	0.85	1115/1
16N0	0.0	2.0	B	A	LIGHT	9	0.29	0.89	1161/1
16N0	0.0	4.0	D	B	LIGHT	12	0.29	0.89	1162/2
16N0	0.0	5.0	D	B	LT. TO MOD.	10	0.29	0.89	1133/1
16P1	+0.05	2.5	B	A	LIGHT(+)	15	0.29	0.94	1155/1
16P1	+0.05	3.0	D	B	LIGHT(+)	18 G 22	0.29	0.94	1153/1
16P1	+0.05	4.0	C	A	LIGHT(+)	3	0.29	0.94	1113/1
16P2	+0.10	4.0	B	B	LIGHT(+)	20	0.30	0.98	1136/1

NOMINAL LATERAL-DIRECTIONAL MODAL PARAMETERS AND STABILITY DERIVATIVES FOR GROUP 16 CONFIGURATIONS

ω_d ~ RAD/SEC	1.00	L'_r ~ SEC^{-1}	0.715
ζ_d	0.11	N'_β ~ SEC^{-2}	0.754
τ_R ~ SEC	2.00	N'_p ~ SEC^{-1}	- 0.088
τ_S ~ SEC	∞	N'_r ~ SEC^{-1}	- 0.361
$\lvert\phi/\beta\rvert_d$	1.55	Y_β ~ SEC^{-1}	- 0.151
$\measuredangle(\phi/\beta)_d$ ~ DEG	21.2	$Y_{\dot\beta}-1$	- 1.01
g/V ~ SEC^{-1}	0.131	$Y_p+\alpha_0$	0.098
L'_β ~ SEC^{-2}	- 1.50	Y_r-1	- 0.997
L'_p ~ SEC^{-1}	- 0.211		

GROUP 16 ROLL CONTROL POWER EXPERIMENT
CONFIGURATION IDENTIFICATION
WHEEL CONTROLLER

CONFIG.	δ_{AW} AUTHORITY	$N'_{\delta_{AW}}/L'_{\delta_{AW}}$	P.R.	T.R.	PILOT	NATURAL TURBULENCE	CROSSWIND KNOTS	ζ_ϕ	ω_ϕ RAD/SEC	FLIGHT NO.
16P1	±45.°	+0.05	4.0	C	A	LIGHT(+)	3	0.292	0.94	1113/1
16P1	±45.°	+0.05	2.5	B	A	LIGHT(+)	15	0.292	0.94	1155/1
16P1	±45.°	+0.05	3.0	D	B	LIGHT(+)	18 G 22	0.292	0.94	1153/1
16P1	±10.°	+0.05	4.0	C	B	LIGHT	14	0.292	0.94	1162/1
16P1	±7.5°	+0.05	3.0	B	A	LIGHT	10	0.292	0.94	1159/1
16P1	±5.0°	+0.05	7.0	E	B	LIGHT(+)	25 G 33	0.292	0.94	1151/1
16P1	±2.5°	+0.05	9.0	F	A	NIL	10	0.292	0.94	1157/1



TRANSIENT RESPONSES TO AILERON STEP AND RUDDER DOUBLET FOR GROUP 16 CONFIGURATIONS, $\omega_d \approx 1.00$ $\zeta_d \approx 0.11$ $\tau_R \approx 2.0$ $\tau_S \approx \infty$ $|\phi/\beta|_d \approx 1.55$

Appendix VI

PILOT COMMENTS

A. Basic Experiment

All groups were evaluated with a wheel controller. Those groups that were also evaluated with a stick controller are so noted.

GROUP 1	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	MODERATE 9	MODERATE 14	LIGHT TO MODERATE. 14
PR/TR	6/D	4/D	3/8
GENERAL COMMENTS	WIRE RECORDER MALFUNCTION.	POTENTIALLY GOOD A/C. SUITABLE FOR LANDING APPROACH, OUT OF TURBULENCE.	OVERALL HANDLING QUALITIES GOOD. TURN COORDINATION NO PROBLEM.
ABILITY TO TRIM		NO DIFFICULTIES.	VERY GOOD. ILS - RUDDER FORCES A LITTLE HIGH, BUT NO BIG PROBLEM.
SELECTION OF CONTROL SENSITIVITIES		SELECTED RUDDER SENSITIVITY TOO LOW AT FIRST, ALTHOUGH COORDINATION NO PROBLEM. WHEN LOOKING AT IT IN CROSSWIND, SENSITIVITY HAD TO BE READJUSTED FOR SATISFACTORY RUDDER FORCES. SOME COMPROMISE IN SELECTING LATERAL SENSITIVITY WHEN SATISFACTORY MANEUVERING FORCES ATTAINED. TENDENCY TO OVERCONTROL.	FORCES AND DISPLACEMENTS ALL VERY GOOD.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	4.28 13.0	5.95 15.3	4.86 11.0
LATERAL AND DIRECTIONAL CONTROL		ROLL CONTROL SATISFACTORY, EXCEPT FOR SOME CHATTER AROUND DESIRED BANK ANGLE. COORDINATION WAS MINOR. APPARENTLY JITTERY LATERAL OSCILLATION.	A/C QUITE RESPONSIVE IN ROLL. YAW DUE TO ROLL NO REAL PROBLEM, BUT NOSE WILL HANG UP FOR A WHILE, AND THEN SEEMS TO ACCELERATE TO CATCH UP WITH COMMANDED TURN RATE. AT CONSTANT BANK ANGLE, SEEMS TO OSCILLATE IN HEADING: APPARENTLY A FAIRLY CONVENTIONAL DUTCH ROLL OSCILLATION VERY LIGHTLY DAMPED AND FAIRLY HIGH IN FREQUENCY, BUT CAN BE DAMPED OUT ALMOST INSTANTANEOUSLY. UNCERTAIN WHY SUCH ACCELERATION AND DECELERATION IN HEADING.
DIFFERENCES IN IFR AND VFR		NONE.	NOTHING REALLY NOTICEABLE
EFFECTS OF TURBULENCE		MUCH LATERAL AND DIRECTIONAL TURBULENCE RESPONSE. BALL DIDN'T MOVE MUCH, BUT YAW RATE WILDLY OSCILLATED.	NO SIMULATED TURBULENCE USED ON THIS FLIGHT. A/C NOSE WANDERED AROUND, BUT NOT EXCESSIVELY.
CONTROL IN CROSSWIND		WING-DOWN OR CRAB METHODS WERE EQUALLY SUCCESSFUL.	CRAB TECHNIQUE USED.
FAVORABLE FEATURES		OUT OF TURBULENCE, ROLL RESPONSE AND LACK OF COORDINATION REQUIRED WERE GOOD.	QUITE MANEUVERABLE AND VERY GOOD HANDLING QUALITIES.
OBJECTIONABLE FEATURES		TURBULENCE RESPONSE STOOD OUT. SLIGHT TENDENCY TO OVERCONTROL WHEN TRYING TO BE PRECISE IN ATTAINING A BANK ANGLE.	LIGHTLY DAMPED DUTCH ROLL OSCILLATION IS OBJECTIONABLE, BUT NO GREAT PROBLEM.
PRIMARY REASON FOR PILOT RATING		WITH LEVEL OF TURBULENCE SEEN, NOT SATISFACTORY; ALL ELSE REASONABLE AND SATISFACTORY.	MINIMUM PILOT COMPENSATION REQUIRED, EVEN WITH A LIGHTLY DAMPED DUTCH ROLL.

GROUP 1 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.10$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE 18	MODERATE 4
PR/TR	4.5/D	4/D
GENERAL COMMENTS	GOOD A/C OUT OF TURBULENCE. TURBULENCE RESPONSE EXCEEDED THAT FOR SATISFACTORY A/C; UNSAT. FOR LANDING APPROACH	FINE A/C EXCEPT FOR TURBULENCE RESPONSE. SUITABLE FOR LANDING APPROACH OUT OF TURBULENCE. WITH TURBULENCE, DEBATABLE.
ABILITY TO TRIM	SATISFACTORY.	SATISFACTORY.
SELECTION OF CONTROL SENSITIVITIES	RUDDER GEARING SELECTION SATISFACTORY. AT FIRST, SEEMED TO HAVE SELECTED REASONABLE AILERON SENSITIVITY, BUT COULDN'T FLY WING-DOWN CROSSWIND APPROACH WITH ONE HAND. RESELECTED AILERON GEARING AND ARRIVED AT A VALUE WITH NO TENDENCY TO OVER-CONTROL UP AND AWAY; CURED CROSSWIND PROBLEM SO THAT A/C WAS FLOWN COMFORTABLY WITH ONE HAND. FINAL GEARING SELECTION WAS SUITABLE.	NO PROBLEMS IN SELECTING SUITABLE GEARINGS.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	7.11 16.3	5.85 13.0
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL COMPLETELY SATISFACTORY. YAW DUE TO ROLL NOT NOTICED IN NORMAL MANEUVERS, COORDINATION NOT REQUIRED.	ROLL CONTROL EXCELLENT. INITIAL RESPONSE SATISFACTORY AND FINAL RESPONSE PREDICTABLE WITH NO TENDENCY TO OVERCONTROL. YAW DUE TO AILERON NOT NOTICEABLE, THEREFORE, COORDINATION NOT A FACTOR.
DIFFERENCES IN IFR AND VFR	NONE NOTICED.	NONE NOTICEABLE.
EFFECTS OF TURBULENCE	PREDOMINANTLY IN THE LATERAL; VERY BOTHERSOME. REALLY MOVED AROUND QUICKLY IN MODERATE MAGNITUDE BANK ANGLES DUE TO TURBULENCE. ALSO A DIRECTIONAL RESPONSE, BUT LATERAL RESPONSE WAS THE MAIN PROBLEM.	NOTICEABLE; EFFECTS WERE MODERATE AND BOTHERSOME. BY REALLY WORKING AT IT, PILOT COULD SUPPRESS TURBULENCE, WHICH WAS MIXED WITH ROLL AND DIRECTIONAL RESPONSE, PRODUCING UNCOMFORTABLE WALLOWING FEELING.
CONTROL IN CROSSWIND	NO PROBLEM WITH RIGHT GEARING SELECTION.	BOTH TECHNIQUES COULD BE USED, BUT LACKED SUFFICIENT CROSSWIND TO MAKE A JUDGMENT.
FAVORABLE FEATURES	ROLL CONTROL GOOD; NO COORDINATION REQUIRED.	EVERYTHING GOOD EXCEPT TURBULENCE RESPONSE.
OBJECTIONABLE FEATURES	EXCESSIVE TURBULENCE RESPONSE. ALTHOUGH NOT IMPOSSIBLE TO CONTEND WITH, PILOT REALLY HAD TO STAY ON TOP OF IT, OTHERWISE HE WALLOWED AROUND UNACCEPTABLY.	TURBULENCE RESPONSE WAS THE MAJOR OBJECTION. IT REALLY WALLOWED AROUND.
PRIMARY REASON FOR PILOT RATING	ADEQUATE PERFORMANCE ATTAINABLE, BUT A/C UNSATISFACTORY BECAUSE OF TURBULENCE RESPONSE.	ALTHOUGH ADEQUATE PERFORMANCE ATTAINABLE, TURBULENCE RESPONSE SHOULD BE IMPROVED. CONSIDERING IT AS REPRESENTATIVE, IT HAS MINOR BUT ANNOYING DEFICIENCIES. TURBULENCE RATING: "MORE EFFORT REQUIRED."

GROUP 2	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	MODERATE (–) 14	MODERATE 7	LIGHT TO MODERATE 14
PR/TR	4/D	3/C	2/A
GENERAL COMMENTS	PRETTY GOOD OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES.	FEELS LIKE PRETTY GOOD A/C, BUT EVERYTHING ABOUT IT IS HEAVY. ILS PERFORMANCE GOOD. SUITABLE FOR LANDING APPROACH; CAN BE FLOWN WITH FEET ON FLOOR.	OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES GOOD TO VERY GOOD.
ABILITY TO TRIM	NO PROBLEMS; HOWEVER, LATERAL TRIM A LITTLE SLOW.	GOOD.	SOME TROUBLE INITIALLY; HOWEVER, A/C TRIMMED VERY WELL OVERALL.
SELECTION OF CONTROL SENSITIVITIES	PRETTY GOOD FORCES AND DISPLACEMENTS. GEARING RATIOS APPEARED GOOD.	DIFFICULTY GETTING AILERONS LIGHT ENOUGH TO MANEUVER COMFORTABLY. TRIED TO LIGHTEN FORCES LATER IN FLIGHT, BUT AILERONS FELT HEAVY THROUGHOUT EVALUATION. COMPROMISE IN GEARING SELECTION BECAUSE PILOT COULDN'T GET ANY MORE GEARING. TO DO WHAT DESIRED WITH RUDDER, MUCH DISPLACEMENT AND FAIR AMOUNT OF FORCE HAD TO BE PUT IN.	SOME TROUBLE GETTING GEARING RATIOS SQUARED AWAY. FORCES AND DISPLACEMENTS APPEARED GOOD.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	3.42 11.4	INITIALLY AT 4.27, LATER 5.91 11.4	3.83 11.4
LATERAL AND DIRECTIONAL CONTROL	QUITE A BIT OF OSCILLATION CREEPS IN DURING A BANK. YAW DUE TO ROLL NOT TOO MUCH EITHER WAY, PERHAPS SOME ADVERSE YAW DUE TO ROLL. NOT MUCH OF A PROBLEM, HOWEVER, IN TERMS OF COORDINATING IN TURNS, AND BANK ANGLE EASILY MAINTAINED ONCE ESTABLISHED. NOSE WANDERED A BIT FROM A RUDDER INPUT WHEN RELEASED. SEEMS FAIRLY WELL DAMPED. HIGH FREQUENCY, BUT SET IN MOTION RELATIVELY EASY.	ROLL CONTROL GOOD. INITIAL RESPONSE SATISFACTORY AND FINAL RESPONSE PREDICTABLE. NO TENDENCY TO OVERCONTROL. COORDINATION REQUIREMENTS MINIMUM.	ROLL CONTROL GOOD; VERY LITTLE YAW DUE TO ROLL. COORDINATION IN TURNS VERY GOOD. ABILITY TO MAKE SMALL CORRECTIONS IN HEADING VERY GOOD. DUTCH ROLL COULD BE INDUCED BUT WAS DAMPED AND HAD HIGH ENOUGH FREQUENCY THAT RESPONSE TO CENTERING WAS GOOD AND DAMPED OUT IN JUST TWO TO THREE OSCILLATIONS.
DIFFERENCES IN IFR AND VFR	FAIRLY DECENT IN VFR, BUT DEGRADED CONSIDERABLY ON PRECISION APPROACH WITH LIGHT TO MODERATE TURBULENCE.	EXCELLENT A/C IN IFR BECAUSE WITH SMALL CONTROL INPUTS REQUIRED, FORCES NO PROBLEM. ON VFR, NOTICED FORCES A BIT UNCOMFORTABLE, PARTICULARLY WHEN COMING OUT OF TURN, AS IN OFFSET MANEUVER.	NONE.
EFFECTS OF TURBULENCE	A LITTLE BIT OF A ROLLING TENDENCY WITH TURBULENCE, REQUIRING SOME PILOT EFFORT. OVERALL EFFECT NOT TOO PRONOUNCED, BUT UNDER IFR CONDITIONS, CONSTANT ROLLING DUE TO TURBULENCE A LITTLE BIT MORE OF A PROBLEM TO CONTROL.	HIGH FREQUENCY SHAKING NOTICEABLE BUT NOT DISTRACTING. TURBULENCE PRODUCED BOTHERSOME ROLL TO CONTEND WITH. ANY PROBLEMS IN TURBULENCE WERE IN ROLL.	UNDER MODERATE TURBULENCE, NO EFFECTS OTHER THAN INCREASED NOSE WANDERING. HOWEVER, IT DAMPS ADEQUATELY WITH MINIMAL PILOT EFFORT. ON ILS, EASILY MANEUVERED, MAKING A/C OVERALL VERY GOOD.
CONTROL IN CROSSWIND	NO PROBLEM.	RECOMMEND CRAB METHOD HERE; NO PROBLEM. USING WING-DOWN METHOD, FELT AS THOUGH ADDITIONAL AILERON AND RUDDER INPUTS MADE NO DIFFERENCE. COULD KEEP COMING IN WITH BOTH AND END UP IN SAME PLACE.	EASILY CONTROLLED IN MODERATE CROSSWIND. COMBINATION CRAB AND WING-LOW USED, LEANING MORE ON CRAB.
FAVORABLE FEATURES	FAIRLY GOOD A/C IN VFR CONDITIONS.	COORDINATION NOT REQUIRED FOR LANDING APPROACH MANEUVERS INCLUDING TURN TO FINAL AND OFFSET MANEUVER. ROLL RESPONSE GOOD.	MINIMUM EFFORT REQUIRED IN TURN COORDINATION.
OBJECTIONABLE FEATURES	PRECISION TRACKING TASK PERFORMANCE UNDER TURBULENCE WORST FEATURE BECAUSE OF CONSTANT ROLLING AND WALLOWING MOTION OF NOSE ON HORIZON.	ONLY REAL OBJECTION WAS HEAVINESS IN LATERAL CONTROL. BIT OF WOBBLING IN TURBULENCE, BUT NOT A PRIMARY OBJECTION.	NONE.
PRIMARY REASON FOR PILOT RATING	CONSIDERABLE PILOT EFFORT REQUIRED TO PERFORM PRECISION TRACKING TASK IN TURBULENCE UNDER IFR CONDITIONS.	ADEQUATE PERFORMANCE ATTAINABLE; A/C SATISFACTORY. FORCES REQUIRED SEEM TO VARY AT TIMES. TURBULENCE RESPONSE NOTICEABLE IN ROLL; HAD TO BE CONTENDED WITH. MAYBE THE FORCES MADE IT MORE NOTICEABLE.	QUITE A GOOD A/C WITH NEGLIGIBLE DEFICIENCIES. NO EXTRA PILOT EFFORT REQUIRED TO COMPENSATE FOR A/C CHARACTERISTICS.

GROUP 2 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.10$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.15$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE 20, GUSTING TO 26	MODERATE (-) 0
PR/TR	2.5/D	3/D
GENERAL COMMENTS	VERY STIFF DIRECTIONALLY; PROBLEM IN CROSSWIND. RUDDER FORCES LARGE; TURBULENCE RESPONSE PRETTY NERVOUS. LOTS OF SLASHING AROUND IN TURN RATE, BUT NOTHING REALLY HAPPENS BECAUSE IT'S SO FAST. NOTHING COULD BE DONE ABOUT IT; HEADING DOESN'T GO ANYWHERE. SUITABLE FOR LANDING APPROACH.	FINE A/C EXCEPT FOR TURBULENCE RESPONSE. SUITABLE FOR LANDING APPROACH. NO OSCILLATORY CHARACTERISTICS NOTICED. ILS PERFORMANCE SEEMED GOOD.
ABILITY TO TRIM	SATISFACTORY; NO PROBLEMS.	NO PROBLEMS.
SELECTION OF CONTROL SENSITIVITIES	RAN OUT OF LATERAL SENSITIVITY INITIALLY, BUT ABLE TO SELECT A QUITE SATISFACTORY FINAL VALUE. DIRECTIONAL SENSITIVITY SET BY CROSSWIND CONSIDERATIONS. BECAUSE NO NEED TO USE RUDDER EXCEPT FOR CROSSWINDS, HIGHER RUDDER SENSITIVITY WOULD HAVE BEEN SELECTED, BASED ON CROSSWIND, IF PILOT COULD HAVE GOTTEN IT.	LATERAL GOOD, FORCES AND DISPLACEMENTS NO PROBLEM. PILOT SUSPECTS THAT RUDDER, SINCE IT DIDN'T HAVE TO BE USED, WOULD BE DETERMINED BY CROSSWIND CONSIDERATIONS. MIGHT NEED TO BE A LITTLE MORE SENSITIVE. NO COMPROMISES.
$L'_{\delta_{AW}}$ | $N'_{\delta_{RP}}$	4.24 | 16.3	3.93 | 13.0
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL QUITE NICE. SMOOTH. INITIAL RESPONSE GOOD. FINAL RESPONSE PREDICTABLE WITH NO TENDENCY TO OVERCONTROL. COORDINATION NOT A FACTOR	ROLL CONTROL GOOD. ON TURN INITIATION, BALL FIRST WENT OUT OF TURN BUT QUICKLY WENT BACK INSIDE JUST A LITTLE THEN RE CENTERED. ALL SO FAST THAT NOTHING COULD BE DONE ABOUT IT. SO COORDINATION WASN'T REQUIRED.
DIFFERENCES IN IFR AND VFR	NO REAL DIFFERENCES	ONLY PROBLEMS WERE IN TURBULENCE WHETHER IN IFR OR VFR.
EFFECTS OF TURBULENCE	DIDN'T REALLY AFFECT PERFORMANCE. A LITTLE LATERAL TASK TO CONTEND WITH. DIRECTIONAL RESPONSE VERY FAST, ALMOST NERVOUS. COULDN'T BE SUPPRESSED BECAUSE IT WAS TOO FAST	MODERATE, SEEMED AT FIRST TO BE A TWO AXIS WALLOWING AROUND BOTH DIRECTIONAL AND LATERAL. WITH A LITTLE EFFORT IT DIDN'T SEEM DIFFICULT TO CONTROL.
CONTROL IN CROSSWIND	RUDDER FORCES HIGH DURING CROSSWIND APPROACH, BUT SINCE RUDDER WASN'T NEEDED FOR TURN COORDINATION, COULD HAVE TAKEN CARE OF IT WITH MORE RUDDER SENSITIVITY.	NO CROSSWINDS ENCOUNTERED
FAVORABLE FEATURES	ROLL CONTROL GOOD, RUDDER COORDINATION NOT REQUIRED.	INITIAL AND FINAL ROLL RESPONSE GOOD, WITH NO TENDENCY TO OVERCONTROL. NO TURN COORDINATION REQUIRED.
OBJECTIONABLE FEATURES	NOTICEABLE, BUT MINOR COMPLAINT, RUDDER FORCES HIGH BUT JUST A MATTER OF MORE SENSITIVITY TO ELIMINATE PROBLEM WITHOUT DETRACTING FROM GENERAL FLYING.	TURBULENCE RESPONSE A LITTLE BOTHERSOME.
PRIMARY REASON FOR PILOT RATING	NEGLIGIBLE DEFICIENCIES. TURBULENCE RESPONSE SOMEWHAT DOWNGRADING. TURBULENCE IN "MORE EFFORT REQUIRED" CATEGORY, i.e., MODERATE.	SATISFACTORY. TURBULENCE CAN BE CONTROLLED; LITTLE ELSE TO DO IN THIS A/C. MILDLY UNPLEASANT

GROUP 3	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.15$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.10$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT TO MODERATE 0	MODERATE 18	MODERATE 12
PR/TR	2.5/A	3/B	2/A
GENERAL COMMENTS	PRETTY NICE A/C. CERTAINLY SUITABLE FOR LANDING APPROACH; NO PROBLEMS WITH ILS.	FAIRLY EASY TO COORDINATE IN TURNS. OVERALL FLYING QUALITIES GOOD.	WIRE RECORDER MALFUNCTION.
ABILITY TO TRIM	NO PROBLEMS.	AILERON TRIM RESPONSE QUITE SLOW, BUT NO PROBLEM.	
SELECTION OF CONTROL SENSITIVITIES	NOT TRULY HAPPY WITH FEEL, BUT SATISFACTORY BY END OF EVALUATION. MORE SENSITIVITY DESIRED, BUT NO COMPLAINT ABOUT ITS SLIGHT HEAVINESS. RUDDER FORCES DURING NORMAL FLYING QUITE NICE, BUT DURING SIDESLIPS A LITTLE HIGHER THAN DESIRED. NO COMPROMISES.	GOOD FORCES, DISPLACEMENTS AND CONTROL HARMONY.	
$L'_{\delta_{AW}}$	4.65	3.83	3.69
$N'_{\delta_{RP}}$	14.1	11.0	14.7
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL SOMEWHAT CLOUDED BY HEAVY FORCES, BUT SATISFACTORY. YAW DUE TO ROLL REQUIRED RUDDER INPUT SHORTLY AFTER INITIATING TURN WITH AILERON; SEEMED FAIRLY NATURAL. JUST A TINY BIT OF RUDDER WAS REQUIRED IN STEADY TURNS. COORDINATION EASY WITHOUT THINKING ABOUT IT.	YAW DUE TO ROLL PRESENT BUT VERY LIGHT. NOSE OSCILLATED ON HORIZON. ROLL CONTROL GOOD, WITH NEGLIGIBLE YAW DUE TO AILERON INPUTS.	
DIFFERENCES IN IFR AND VFR	NO DIFFERENCES.	NO COMMENT.	
EFFECTS OF TURBULENCE	RESPONSE TO TURBULENCE GOOD; i.e., NO RESPONSE.	MINOR. A/C EXCURSIONS SEEMED FAIRLY LIGHT. SEEMS TO BE WELL CENTERED BECAUSE DOESN'T CAUSE A/C HEADING TO CHANGE MUCH. RIDE A LITTLE UNCOMFORTABLE BUT ABILITY TO TRACK PRECISELY NOT MUCH AFFECTED.	
CONTROL IN CROSSWIND	NO CROSSWIND. SOME SIDESLIPS TRIED; NO PROBLEMS ANTICIPATED. FORCES COULD BE A LITTLE LIGHTER.	CRAB TECHNIQUE USED; NO PARTICULAR PROBLEM.	
FAVORABLE FEATURES	EASY TO FLY EVEN THOUGH COORDINATION REQUIRED; REASONABLE A/C. LACK OF TURBULENCE RESPONSE GOOD.	FAIRLY EASY TO MANEUVER IN ALL CONDITIONS.	
OBJECTIONABLE FEATURES	GENERAL HEAVINESS IN LATERAL CONTROL. SATISFACTORY BUT NOT OPTIMUM.	OSCILLATIONS IN TURBULENCE UNCOMFORTABLE, MINIMAL EFFECT ON HANDLING QUALITIES DURING PRECISION TRACKING TASK.	
PRIMARY REASON FOR PILOT RATING	A LITTLE PILOT COMPENSATION REQUIRED IN RUDDER USAGE. CONTROL HEAVINESS DIDN'T AFFECT RATING BECAUSE IT WAS ASSUMED HIGHER SENSITIVITY COULD BE GOTTEN WITHOUT ADVERSELY AFFECTING CONFIGURATION.	SOME MILDLY UNPLEASANT DEFICIENCIES WITH MINIMAL PILOT COMPENSATION REQUIRED. A/C WARRANTS IMPROVEMENT FOR PASSENGER COMFORT; PROBABLY WOULD BE DOWNGRADED ONE POINT.	

GROUP 3 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.15$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE 6	MODERATE 20, GUSTING TO 24
PR/TR	1.5/B	1.5/B
GENERAL COMMENTS	GOOD A/C WITH LITTLE RUDDER COORDINATION REQUIRED. PRETTY STIFF DIRECTIONALLY. PILOT COULD DO AS GOOD A JOB AS HE WANTED TO APPLY HIMSELF TO ON ILS. CERTAINLY SUITABLE FOR LANDING APPROACH.	VERY SMOOTH. NO COORDINATION REQUIRED. AILERON SENSITIVITIES COULD BE SELECTED TO ANY DESIRED VALUE. ILS PERFORMANCE GOOD; CERTAINLY SUITABLE FOR LANDING APPROACH.
ABILITY TO TRIM	SATISFACTORY.	SATISFACTORY; NO PROBLEMS.
SELECTION OF CONTROL SENSITIVITIES	DESIRED A LITTLE MORE SENSITIVITY THAN COULD GET INITIALLY. LATER IN FLIGHT, IT WAS SATISFACTORY FOR ONE-HAND OPERATION. INITIALLY SELECTED RUDDER GEARING TOO HEAVY; WHEN NEAR THE GROUND, COULDN'T MOVE NOSE. RE-SELECTED GEARING; GEARING SHOULD BE SELECTED BASED ON CROSSWIND REQUIREMENTS.	RUDDER NOT REQUIRED FOR COORDINATION, SO CROSSWIND ESTABLISHED RUDDER SENSITIVITY. SELECTIONS WERE SATISFACTORY, BOTH DIRECTIONALLY AND LATERALLY; NO COMPROMISES. ENDED UP WITH AILERONS POSSIBLY TOO SENSITIVE BUT SATISFACTORY.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	4.28 14.7	6.22 20.3
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL SATISFACTORY. ANY BALL MOTIONS WERE FAST; RE-CENTERED QUICKLY. COORDINATION A MINOR CONCERN.	ROLL CONTROL SMOOTH; INITIAL RESPONSE SATISFACTORY, FINAL RESPONSE PREDICTABLE; NO TENDENCY TO OVERCONTROL. YAW DUE TO ROLL NOT A PROBLEM, EVEN WITH VIOLENT MANEUVERS. BALL WOULD VERY QUICKLY MOVE BACK INTO CENTER, COORDINATION NO PROBLEM.
DIFFERENCES IN IFR AND VFR	NO DIFFERENCES.	VERY NICE TO FLY ON IFR ON VFR, SMOOTH; LATERAL OFFSET MANEUVER EASY TO DO.
EFFECTS OF TURBULENCE	MINOR; HARDLY NOTICEABLE. SEEMED TO BE CHATTER IN YAW RATE.	TURBULENCE NOTED DIRECTIONALLY BY A LITTLE BIT JITTER, MAINLY IN YAW RATE. NO LATERAL PROBLEMS TURBULENCE NOT A FACTOR IN FLYING A/C.
CONTROL IN CROSSWIND	NO PREFERENCE IN TECHNIQUES, EXCEPT PERSONAL PREFERENCE FOR WING-DOWN.	COULD USE EITHER METHOD. FORCE LEVELS IN RUDDERS OR AILERONS NO PROBLEM.
FAVORABLE FEATURES	ROLL CONTROL AND LACK OF COORDINATION REQUIREMENTS GOOD.	ROLL CONTROL VERY SMOOTH AND NICE TO FLY. TURBULENCE RESPONSE MINIMUM. PERHAPS NICEST FEATURE, REQUIREMENTS FOR COORDINATION WERE ZERO.
OBJECTIONABLE FEATURES	NONE.	NONE. A LITTLE DITHER IN NOSE DUE TO TURBULENCE, BUT DIDN'T MOVE VERY MUCH.
PRIMARY REASON FOR PILOT RATING	SATISFACTORY. PILOT SOMEWHAT CONCERNED ABOUT TURBULENCE RESPONSE.	CERTAINLY SATISFACTORY. TURBULENCE NOTICEABLE, BUT NO DETERIORATION.

<table>
<tr><th colspan="2">GROUP 4</th><th colspan="2">$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$
PILOT A</th><th colspan="2">$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$
PILOT A</th><th colspan="2">$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$
PILOT B</th></tr>
<tr><td colspan="2">NATURAL TURBULENCE
MAX. X-WIND (~KT)</td><td colspan="2">MODERATE
9</td><td colspan="2">MODERATE
17</td><td colspan="2">MODERATE
5</td></tr>
<tr><td colspan="2">PR/TR</td><td colspan="2">8/F</td><td colspan="2">8/F</td><td colspan="2">3.5/D</td></tr>
<tr><td colspan="2">GENERAL COMMENTS</td><td colspan="2">WIRE RECORDER MALFUNCTION</td><td colspan="2">AT FIRST, A/C SEEMED GOOD, RESPONDING FAIRLY RAPIDLY. LATER, DIFFICULT TO FLY, ESPECIALLY IN TURBULENCE.</td><td colspan="2">REAL FINE A/C IN SMOOTH AIR. SUITABLE FOR LANDING APPROACH BUT RESERVATIONS EXIST ABOUT ITS TURBULENCE RESPONSE. ILS PERFORMANCE GOOD.</td></tr>
<tr><td colspan="2">ABILITY TO TRIM</td><td colspan="2"></td><td colspan="2">AILERON TRIM RESPONSE A LITTLE SLOW.</td><td colspan="2">SATISFACTORY.</td></tr>
<tr><td colspan="2">SELECTION OF CONTROL SENSITIVITIES</td><td colspan="2"></td><td colspan="2">GOOD FORCES, DISPLACEMENTS, AND CONTROL HARMONY.</td><td colspan="2">LATERAL FORCES AND DISPLACEMENTS SATISFACTORY WITH GEARING SELECTED. NO COMPROMISE REQUIRED IN GEARING SELECTION. RUDDER GEARING SELECTED PROVIDED ADEQUATE FORCES AND SENSITIVITIES FOR CROSSWINDS.</td></tr>
<tr><td>$L'_{\delta_{AW}}$</td><td>$N'_{\delta_{RP}}$</td><td>4.31</td><td>11.2</td><td>3.76</td><td>10.0</td><td>7.70</td><td>14.6</td></tr>
<tr><td colspan="2">LATERAL AND DIRECTIONAL CONTROL</td><td colspan="2"></td><td colspan="2">MINIMAL ADVERSE YAW DUE TO ROLL. VERY GOOD OVERALL ROLL RESPONSE. POSITIVE DIHEDRAL EFFECT; GOOD ROLL WITH RUDDER INPUTS. IN DUTCH ROLL, FAIRLY HIGH FREQUENCY OSCILLATIONS, LIGHT TO MODERATELY DAMPED. A/C HAS A FAIRLY RAPID RESPONSE.</td><td colspan="2">GOOD INITIAL ROLL RESPONSE. FINAL RESPONSE PREDICTABLE; NO TENDENCY TO OVERCONTROL. YAW DUE TO AILERON NOT NOTICEABLE, AND COORDINATION NOT A FACTOR.</td></tr>
<tr><td colspan="2">DIFFERENCES IN IFR AND VFR</td><td colspan="2"></td><td colspan="2">NONE.</td><td colspan="2">WHEN FLYING IFR IN TURBULENCE, WINGS MUST BE KEPT LEVEL BECAUSE OF CRISP RESPONSE TO LATERAL GUST AND ROLL. ON VFR, ONLY PROBLEM WAS RELATED TO TURBULENCE RESPONSE.</td></tr>
<tr><td colspan="2">EFFECTS OF TURBULENCE</td><td colspan="2"></td><td colspan="2">A/C FLAKES AROUND. ROLLING MOTION WITH HIGH POSITIVE DIHEDRAL EFFECT PRODUCES UNPLEASANT RIDE. PILOT COMFORT BAD. ON ILS, EXCURSIONS UP TO 20-30° IN ANGLE OF BANK. SMALL HEADING CORRECTIONS EXTREMELY DIFFICULT TO MAKE. A/C DRASTICALLY AFFECTED BY TURBULENCE.</td><td colspan="2">CONSTANT WING CHATTER HAD TO BE COUNTERED TO HOLD CONSTANT BACK ANGLE. TURBULENCE RESPONSE FAST, OF MODERATE MAGNITUDE, AND PRINCIPALLY A PROBLEM IN ROLL.</td></tr>
<tr><td colspan="2">CONTROL IN CROSSWIND</td><td colspan="2"></td><td colspan="2">NOT MUCH OF A PROBLEM.</td><td colspan="2">ALTHOUGH BOTH METHODS TRIED, CRABBED APPROACH PREFERRED. IN WING-DOWN METHOD, WHEN ATTEMPTING TO HOLD NOSE STRAIGHT WITH RUDDER, A/C WOULD BEGIN TO ROLL WING UP, SO MORE AILERON WAS NEEDED. PILOT COULD HAVE KEPT PUTTING IN RIGHT AMOUNTS OF AILERON AND RUDDER AND END UP WITH CONTROLS COMPLETELY CROSSED.</td></tr>
<tr><td colspan="2">FAVORABLE FEATURES</td><td colspan="2"></td><td colspan="2">STRAIGHT CRAB AND A LITTLE WING-LOW USED. GOOD FLYING A/C OUT OF TURBULENCE.</td><td colspan="2">NO REQUIREMENT TO COORDINATE, ROLL RESPONSE GOOD.</td></tr>
<tr><td colspan="2">OBJECTIONABLE FEATURES</td><td colspan="2"></td><td colspan="2">RAPID DETERIORATION OF HANDLING QUALITIES IN TURBULENCE.</td><td colspan="2">TURBULENCE RESPONSE.</td></tr>
<tr><td colspan="2">PRIMARY REASON FOR PILOT RATING</td><td colspan="2"></td><td colspan="2">DRASTIC DETERIORATION AS A/C ENTERS TURBULENCE. IN NON-TURBULENT CONDITIONS, PR WOULD HAVE BEEN 2 OR 3. PILOT DETERIORATION OF TASK PERFORMANCE IN TURBULENCE IS MAJOR, BUT EVALUATED TASK CAN BE ACCOMPLISHED.</td><td colspan="2">CONTROLLABLE; ADEQUATE PERFORMANCE ATTAINABLE. IF NOT FOR TURBULENCE RESPONSE, PR WOULD EASILY BE A 2.</td></tr>
</table>

GROUP 4 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.10$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.15$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.15$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT 14	MODERATE 12	MODERATE (–) 0
PR/TR	3/C	6/F	6/F
GENERAL COMMENTS	OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES GOOD TO VERY GOOD. HIGHLY MANEUVERABLE A/C, PARTICULARLY FOR THIS CLASS. LANDING APPROACH NO PROBLEM.	SATISFACTORY A/C OUT OF TURBULENCE. IN TURBULENCE, A/C CLOSE TO BAD. UNSUITABLE FOR LANDING APPROACH.	RUDDER USE PRODUCED DIFFICULTIES. AIRCRAFT WAS STIFF DIRECTIONALLY. IF UNATTENDED, TURBULENCE USUALLY EXCITED A LATERAL OSCILLATION OF HIGH FREQUENCY AND MODERATE TO LARGE AMPLITUDE. A/C UNSATISFACTORY FOR LANDING APPROACH.
ABILITY TO TRIM	GOOD LATERALLY AND DIRECTIONALLY.	IN ANY TURBULENCE, DIFFICULT TO TRIM LATERALLY BECAUSE OF LARGE ROLL RESPONSE TO TURBULENCE.	GOOD.
SELECTION OF CONTROL SENSITIVITIES	GOOD FEEL CHARACTERISTICS, FORCES, AND DISPLACEMENTS.	RUDDER SENSITIVITY SELECTIONS WERE BASED ON A CROSSWIND SINCE NORMAL MANEUVERING REQUIRED NO COORDINATION. LOOKING AT ROLL RESPONSE, UP AND AWAY, LATERAL RESPONSE WAS AS SENSITIVE AS DESIRED, BUT LARGE STEADY FORCES REQUIRED ON CROSSWIND APPROACH CAUSED A COMPROMISE IN LATERAL GEARING.	SELECTED RUDDER SENSITIVITY WAS RIGHT. WITH DIRECTIONAL STIFFNESS, A/C FLOWN WITH SENSITIVE RUDDERS TO TRY TO GET CROSSWIND CONTROL USAGE. SINCE RUDDERS WERE NOT NORMALLY USED, GEARING SHOULD BE SET BY CROSSWIND CONSIDERATIONS. THERE WAS A COMPROMISE LATERALLY IN WING DOWN CROSSWIND METHOD. HIGH SENSITIVITY IS NEEDED TO KEEP FORCES DOWN. ALSO, TREMENDOUS ROLL RESPONSE DUE TO RUDDER REQUIRES LIGHTER LATERAL FORCES BUT PILOT HAD TO CONTINUALLY CONTROL TURBULENCE RESPONSE AND OVERSENSITIVE CONTROL IS UNDESIRABLE FOR THAT
$L'_{\delta_{AW}}$	5.30	4.28	3.08
$N'_{\delta_{RP}}$	9.95	14.7	17.6
LATERAL AND DIRECTIONAL CONTROL	GOOD ROLL CONTROL WITH VERY LITTLE YAW DUE TO ROLL. EASY TO COORDINATE IN TURNS. LIGHTLY DAMPED OSCILLATORY DUTCH ROLL MODE, YET NOT TOO OBJECTIONABLE.	ROLL VERY RESPONSIVE TO SMALL LATERAL DISTURBANCES. PILOT FELT AS IF HE WERE OVERDRIVING AND WOULD HAVE TO REDUCE AILERON INPUT. YAW DUE TO ROLL AND COORDINATION NO PROBLEM, LARGE ROLL RESPONSE DUE TO RUDDER.	WHEN SEPARABLE, ROLL CONTROL BY ITSELF SATISFACTORY. NO YAW DUE TO ROLL. COORDINATION NOT A FACTOR BECAUSE SLIGHT RUDDER FORCES AFFECT ROLL DRAMATICALLY. A/C IS TOUCHY LATERALLY NEAR THE GROUND.
DIFFERENCES IN IFR AND VFR	NONE.	NONE.	NO DIFFICULTIES IN IFR USING SMALL INPUTS. IN VFR DIFFICULTIES ENCOUNTERED WITH ROLL DUE TO RUDDER.
EFFECTS OF TURBULENCE	TURBULENCE DEGRADED HANDLING QUALITIES. ILS SOMEWHAT CHALLENGING, REQUIRING ALMOST CONSTANT LATERAL AND DIRECTIONAL CORRECTIONS.	RAPID ROLL RESPONSE TO TURBULENCE. CONTINUAL TASK TO HOLD CONSTANT BANK ANGLE. LATERAL GUST THAT CAUSED ROLL IN SAME DIRECTION AS A CONTROL INPUT PRODUCED UNPLEASANT RESPONSE NEAR THE GROUND, REQUIRING PILOT TO STAY ON TOP OF ROLL CONTROL.	DRAMATIC EFFECTS, MAINLY LATERAL. CONTINUAL CONTROL WAS NECESSARY. SHARP, QUICK LATERAL RESPONSE WITH MODERATE TO LARGE AMPLITUDE EXCURSIONS IN BANK ANGLE. A/C CONTINUALLY BOUNCED AROUND, NOT CHANGING HEADING MUCH, BUT SLOSHING BACK AND FORTH ±15° OF BANK.
CONTROL IN CROSSWIND	NO PROBLEM USING CRAB TECHNIQUE ON LANDING APPROACH IN GOOD CROSSWIND.	HEAVY LATERAL FORCES ENCOUNTERED ATTEMPTING WING-DOWN METHOD; i.e HOLDING NOSE STRAIGHT AND COUNTERACTING WITH AILERONS. CRAB TECHNIQUE PROBABLY BETTER HERE.	NO CROSSWIND. SOME STEADY SIDE SLIPS NEAR THE GROUND WERE TRIED. GUSTS PRODUCED RAPID ROLL RESPONSE, UNCOMFORTABLE NEAR THE GROUND. WITH EXTREME RESPONSE DUE TO RUDDER, A LITTLE CHANGE IN RUDDER DURING SIDESLIPS PRODUCED DRAMATIC ROLL RESPONSE.
FAVORABLE FEATURES	NO PROBLEMS IN CONTROLLING A/C; IT WAS QUITE MANEUVERABLE.	NO REQUIREMENT TO COORDINATE WITH RUDDER.	ROLL CONTROL SEEMED ALL RIGHT BY ITSELF BUT DIFFICULT TO SEPARATE OUT.
OBJECTIONABLE FEATURES	NONE.	LARGE LATERAL TURBULENCE RESPONSE. ROLL RESPONSE NOT AS PREDICTABLE AS IT SHOULD BE.	LATERAL TURBULENCE AND EXTREMELY LARGE ROLL DUE TO RUDDER. IF POSSIBLE, RUDDER WAS NOT USED
PRIMARY REASON FOR PILOT RATING	MINIMAL PILOT COMPENSATION REQUIRED. PR WOULD BE ONE HIGHER EXCEPT FOR DETERIORATED PERFORMANCE IN TURBULENCE.	RESPONSE TO TURBULENCE MAKES A/C ALMOST DANGEROUS NEAR THE GROUND, BUT IT'S ONLY A LATERAL PROBLEM. A/C IS MARGINALLY SATISFACTORY. FOR TURBULENCE, IT'S IN "BEST EFFORTS REQUIRED" CATEGORY.	ADEQUATE PERFORMANCE REQUIRES EXTENSIVE PILOT COMPENSATION. UNDESIRABLE OSCILLATIONS NEAR GROUND ARE ALSO EXPECTED IN TURBULENCE OR IN A CROSSWIND. TURBULENCE RESPONSE COMES OUT AS "BEST EFFORTS REQUIRED."

GROUP 5	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.15$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT 0	LIGHT (+) 7.5	MODERATE (-) 20
PR/TR	6.5/E	5/D	3.5/C
GENERAL COMMENTS	DIRECTIONALLY, EXTREMELY SLOPPY. VERY RESPONSIVE IN TURBULENCE IN DIRECTIONAL, BUT MOVES RATHER SLOWLY. A SUGGESTION OCCASIONALLY OF A REAL SLOW DIRECTIONAL OSCILLATION. A/C NOT SUITABLE FOR LANDING APPROACH. REALLY HAD TO PAY ATTENTION TO RUDDER AND BALL EXCURIONS TO KEEP IT REMOTELY COORDINATED.	THE MORE PILOT FLEW THIS CONFIGURATION, THE LESS HE LIKED IT, ESPECIALLY WITH TURBULENCE. QUITE WORMY TO FLY IN VFR CONDITIONS WITH TURBULENCE. ON APPROACH, NOSE WANDERS SLOWLY OFF AND A GOOD SIZE SIDESLIP BUILDS UP, REQUIRING EXCESSIVE RUDDER FORCES TO BRING A/C BACK TO COORDINATED MANEUVER. SUITABILITY FOR LANDING APPROACH FAIR TO POOR.	RELATIVELY GOOD A/C, SOMEWHAT DEGRADED IN THE FACE OF TURBULENCE.
ABILITY TO TRIM	DIDN'T NOTICE ANYTHING SPECIAL: SATISFACTORY.	MODERATELY DIFFICULT TO TRIM DIRECTIONALLY; SOMEWHAT EASIER, BUT STILL DIFFICULT TO TRIM LATERALLY.	A LITTLE BIT OF PROBLEM TRIMMING DIRECTIONALLY, HOWEVER, CAN BE DONE WITHOUT GREAT EFFORT.
SELECTION OF CONTROL SENSITIVITIES	DON'T REMEMBER MUCH ABOUT LATERAL FORCES, SO MUST HAVE BEEN SATISFACTORY. DIRECTIONALLY, SENSITIVITY SELECTED TO TRY TO MAKE COORDINATION EASIER, BUT STILL RAN INTO OVERCONTROL PROBLEMS. DIDN'T THINK IT WOULD HELP TO MAKE THE RUDDER ANY HEAVIER. WITH FINAL LATERAL SENSITIVITY SELECTION, REALLY DIDN'T NOTICE LATERAL CONTROL.	WHEEL FORCES AND DISPLACEMENTS APPEAR TO BE GOOD. GEAR RATIOS SELECTED SEEM ADEQUATE FOR VFR MANEUVERING.	GEARING SELECTIONS SEEM O.K. FEEL FORCES NOT TOO BAD AND THE DISPLACEMENTS GOOD.
$L'_{\delta_{AW}}$	6.09	3.83	3.52
$N'_{\delta_{RP}}$	13.0	8.29	9.21
LATERAL AND DIRECTIONAL CONTROL	YAW DUE TO ROLL CONTROL WAS LARGE. LARGE BALL DEFLECTION INSIDE THE TURN WOULD GRADUALLY BLEED OFF AND GET CLOSER TO CENTER, BUT NOSE WOULD HANG UP RATHER BADLY IN TURN INITIATION. WHEN RUDDER PUT IN TO CORRECT, TYPICALLY ENDED UP OVERCORRECTING WITH BALL DISPLACED OUT OTHERSIDE, LEADING TO FURTHER JOSTLING WITH RUDDER TO CENTER BALL. LOOSE DIRECTIONALLY, PILOT WOULD EASILY OVERCONTROL. COORDINATION A PROBLEM; REQUIRED A LOT OF COORDINATION.	YAW DUE TO ROLL APPEARS ADVERSE. QUITE A BIT OF ADVERSE YAW DUE TO AILERON INPUTS. A/C CENTERS ITSELF WITHOUT ANY GREAT AMOUNT OF EFFORT; HOWEVER, APPARENTLY SOME GOOD YAW ANGLES BUILD UP, MAKING ONE SORT OF SLIP SIDEWAYS. OSCILLATORY CHARACTERISTICS NOT TOO PRONOUNCED IN SMOOTH AIR BUT ACCENTUATED IN TURBULENCE.	ROLL CONTROL GOOD TO VERY GOOD. CONSIDERABLE ADVERSE YAW DUE TO ROLL AND A SMALL, BUT NOT SIGNIFICANT AMOUNT OF ADVERSE YAW DUE TO AILERONS MAKES TURN COORDINATION DIFFICULT TASK.
DIFFERENCES IN IFR AND VFR	ON IFR, PILOT RIGHT ON TOP OF THINGS USING SMALL DISPLACEMENTS; SLOPPINESS WASN'T REALLY BOTHERSOME PROBLEMS OVERCONTROLLING DURING VFR MANEUVERS.	NO COMMENT	NO SIGNIFICANT DIFFERENCES.
EFFECTS OF TURBULENCE	PREDOMINANTLY DIRECTIONAL. NOSE EXCURSIONS TENDED TO BE LARGE, SLOW, AND SOMEWHAT OF A PROBLEM TO SUPPRESS BECAUSE OF TENDENCY TO OVERCONTROL SLIGHTLY WITH RUDDER.	MODERATE TURBULENCE SEEMED TO DEGRADE A/C CONSIDERABLY. A/C GENERATED FAIRLY LARGE YAW ANGLES AND MAINTAINED ITSELF THERE WITHOUT CORRECTING BACK INITIALLY.	SIGNIFICANT DEGRADATION IN HANDLING QUALITIES WITH MODERATE TURBULENCE, MAINLY AS A CONSTANT SWINGING OF NOSE BACK AND FORTH ACROSS HORIZON. PILOT CAN DAMP OUT THESE OSCILLATIONS BUT MORE EFFORT REQUIRED THAN DESIRED.
CONTROL IN CROSSWIND	NO CROSSWINDS, BUT PROBABLY WOULD HAVE BEEN A PROBLEM WITH THIS A/C IN MOVING THE NOSE; i.e., TAKING OFF THE CRAB, OR GOING INTO OR COMING OUT OF THE WING-DOWN METHOD. WOULD PROBABLY OVERCONTROL DIRECTIONALLY AND THAT WOULD BE VERY POOR CLOSE TO THE GROUND.	A LOT OF RUDDER INPUTS REQUIRED TO COORDINATE DURING FINAL PHASES OF APPROACH, MAKING COORDINATION REALLY DIFFICULT.	NO PROBLEM AT ALL IN CONTROLLING A/C IN CROSSWIND.
FAVORABLE FEATURES	ROLL CONTROL MUST HAVE BEEN GOOD SINCE IT DOESN'T STAND OUT AS BEING BOTHERSOME.	NONE.	RELATIVELY GOOD A/C, DEGRADED SOMEWHAT IN TURBULENCE.
OBJECTIONABLE FEATURES	LARGE YAW DUE TO ROLL CONTROL. COORDINATION REQUIRED AND DIFFICULT TO ACHIEVE.	REALLY REQUIRED CLOSE TABS ON COORDINATION AND A LOT OF RUDDER TO KEEP A/C FROM DOING WHAT NOT DESIRED. PARTICULAR PROBLEMS NOTED WITH LANDING, MANEUVERING, AND TURN COORDINATION, i.e., VERY CLOSE ATTENTION TO RUDDER CONTROL REQUIRED AND SIDESLIP YAW ANGLES BUILT UP QUITE EASILY.	EFFECT OF TURBULENCE MAJOR OBJECTION. A LITTLE COORDINATION PROBLEM WHEN ROLLING INTO TURN.
PRIMARY REASON FOR PILOT RATING	NO WAY TO SAY IT'S GOOD A/C. ADEQUATE PERFORMANCE REQUIRES EXTENSIVE PILOT COMPENSATION. PRIMARILY, CLOSE TO THE GROUND IN ANY KIND OF TURBULENCE OR CROSSWIND WOULD BE A PROBLEM KEEPING A/C STRAIGHT. TURBULENCE REQUIRES BEST EFFORTS. NOT DIFFICULT TO SUPPRESS BECAUSE RESPONSE WAS SLOW BUT MAGNITUDES IT WOULD ACHIEVE, UNATTENDED, WERE ENORMOUS.	CONSIDERABLE PILOT COMPENSATION REQUIRED TO MAKE A/C PERFORM PARTICULAR TASK ADEQUATELY.	TURBULENCE EFFECT REQUIRES MORE EFFORT BY PILOT; NEEDS IMPROVEMENT

GROUP 5 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.05$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.05$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.05$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT (+) 14	LIGHT TO MODERATE 20	MODERATE (–) 20
PR/TR	3.5/C	6.5/E	7/D
GENERAL COMMENTS	SUITABILITY FOR LANDING APPROACH NOT TOO BAD. QUITE A BIT OF NOSE WANDERING	REAL BEAR FOR COORDINATION; DIRECTIONAL PROBLEMS. PROBLEMS MAGNIFIED IN TURBULENCE. COULD DO SATISFACTORY JOB ON ILS, BUT UNSUITABLE FOR LANDING APPROACH.	SLOPPY DIRECTIONALLY, NOSE COULD BE POKED AROUND TO LARGE SIDESLIPS WITH NO RESPONSE IN ROLL. UNSUITABLE FOR LANDING APPROACH. ATTEMPTING TO COORDINATE TURNS, EASILY OVER CONTROLLED, GETTING INTO LOW FREQUENCY DIRECTIONAL OSCILLATION BUT NOT SUSTAINED.
ABILITY TO TRIM	SOME DIFFICULTY DIRECTIONALLY. LATERAL NO PROBLEM ONCE DIRECTIONAL TRIM ESTABLISHED. LATERAL DID SEEM A LITTLE TOUCHY AND A BIT SLOW.	SATISFACTORY.	SEEMED TO TRIM UP ALL RIGHT; SATISFACTORY
SELECTION OF CONTROL SENSITIVITIES	(PREVIOUSLY SELECTED VALUES WERE ASSIGNED.) APPEARED GOOD.	RUDDER SENSITIVITY SELECTED GAVE LARGE FORCES WHEN TRYING TO DECRAB OR HOLD NOSE STRAIGHT ON WING-DOWN APPROACH, BUT ANY MORE SENSITIVITY WOULD GIVE COORDINATION PROBLEMS. LATERAL SENSITIVITIES SELECTED WERE SATISFACTORY	SELECTED RUDDER SENSITIVE ENOUGH TO HANDLE CROSSWIND. RUDDER SENSITIVITY PROBABLY DID NOT CONTRIBUTE TO COORDINATION PROBLEM. LATERAL FORCES AND DISPLACEMENTS ALL RIGHT.
$L'_{\delta_{AW}}$	3.59	4.75	5.54
$N'_{\delta_{RP}}$	8.60	11.8	9.95
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL QUITE RESPONSIVE. ON TURN INITIATION WITH AILERONS, NOSE WOULD SWING PRETTY FAR OPPOSITE THE TURN; HOWEVER, SMALL HEADING CORRECTIONS DIDN'T SEEM DIFFICULT. COORDINATION A PROBLEM; i.e., BALL WOULD OSCILLATE BACK AND FORTH, ESPECIALLY IN LIGHT TURBULENCE. CONSTANT RUDDER MANIPULATION REQUIRED TO KEEP BALL CENTERED. WITH RUDDER INPUT, DELAY IN GETTING ANY ROLL RESPONSE. QUITE A LARGE YAW ANGLE WAS BUILT UP, BUT THEN WITH AN OSCILLATION, STRONG ROLL WOULD DEVELOP.	ROLL CONTROL SATISFACTORY. YAW DUE TO ROLL MODERATE TO LARGE. YAW SEEMED TO BE LARGELY ADVERSE AFTER INITIATING A TURN THEN BALL WOULD SWING IN PROVERSE DIRECTION AND FINALLY BACK TO CENTER. SEEMED TO BE LITTLE ROLL WITH RUDDER INPUTS BUT LACK OF COORDINATION SEEMED TO INFLUENCE AILERON FORCES. SLIGHT OSCILLATION DIRECTIONALLY, BUT NOT VERY LONG SUSTAINED.	INITIAL ROLL RESPONSE SATISFACTORY, FINAL RESPONSE PREDICTABLE. NO TENDENCY TO OVERCONTROL. YAW DUE TO ROLL APPRECIABLE AND IN THE NORMAL SENSE, REQUIRING RUDDER INTO TURN. COORDINATION DIFFICULT WITHOUT ONE OR MORE OVERSHOOTS OF BALL BECAUSE OF LOOSE DIRECTIONAL CHARACTERISTICS. WITHOUT RUDDER INTO TURN, NOSE WOULD "HANG UP", THINKING CORRECTION HAD BEEN MADE ON ILS, PILOT WOULD FIND THAT HEADING HAD NOT CHANGED.
DIFFERENCES IN IFR AND VFR	EXCURSIONS IN HEADING AND LATERAL OSCILLATIONS COULD BE BETTER DAMPED OUT UNDER VFR CONDITIONS (BETTER REFERENCES). UNDER IFR, MORE DIFFICULT TO DAMP OSCILLATIONS.	ALL COORDINATION PROBLEMS SHOWED UP WITH LARGER INPUTS. PRINCIPALLY NOTICEABLE WHEN VFR.	NO COMMENTS.
EFFECTS OF TURBULENCE	TURBULENCE RESPONSE QUITE PRONOUNCED, BUT DIDN'T SIGNIFICANTLY DETERIORATE PERFORMANCE; CAUSED NO MAJOR CONTROL PROBLEMS IN TASK PERFORMANCE.	MODERATE; COMPOUNDED COORDINATION PROBLEMS.	TURBULENCE RESPONSE PREDOMINATELY DIRECTIONAL. SOME TROUBLE KEEPING UP WITH IT DIRECTIONALLY WITHOUT OVERCONTROLLING.
CONTROL IN CROSSWIND	NO PROBLEMS USING CRAB TECHNIQUE.	EITHER METHOD EQUALLY SUCCESSFUL. RUDDER FORCES HIGH IN BOTH	MAJOR PROBLEM WAS BEING PRECISE DIRECTIONALLY EITHER IN DE-CRABBING OR IN HOLDING NOSE STRAIGHT. DIFFICULT TO KEEP IT UNDER CONTROL. PILOT MAY HAVE CONTRIBUTED TO PROBLEM BY ANTICIPATING RUDDER AND STIRRING UP NOSE.
FAVORABLE FEATURES	NO PARTICULARLY OUTSTANDING GOOD FEATURES.	ROLL RESPONSE IN ITSELF SATISFACTORY IF BALL COULD EVER BE CENTERED LONG ENOUGH TO LOOK AT IT.	NO REALLY GOOD FEATURES TO COMMENT ON
OBJECTIONABLE FEATURES	SOME DIFFICULTY IN TRIMMING. NOSE EXCURSIONS OPPOSITE TURN DIRECTION OBJECTIONABLE, BUT DIDN'T CAUSE ANY APPRECIABLE PROBLEMS IN MAKING SMALL HEADING CORRECTIONS. TURN COORDINATION A BIT OF A FULL-TIME JOB BUT NOT AN INTOLERABLE WORKLOAD ON PILOT.	COORDINATION REQUIREMENTS LARGE AND DIFFICULT TO ACCOMPLISH. TURBULENCE RESPONSE BOTHERSOME AND COMPOUNDED OTHER PROBLEMS.	MAJOR OBJECTION WAS DIRECTIONAL SLOPPINESS COUPLED WITH COORDINATION REQUIREMENTS. TURBULENCE BOTHERSOME BUT NOT A REAL PROBLEM IN ITSELF; JUST CONTRIBUTED TO CONTROL TASKS.
PRIMARY REASON FOR PILOT RATING	WOULD LIKE TO SEE IT IMPROVED A BIT; HOWEVER, SEEMED ADEQUATE FOR TASK PERFORMANCE. TURBULENCE RESPONSE RESULTED IN MINOR TO MODERATE DETERIORATION OF TASK PERFORMANCE.	DEBATABLE WHETHER ADEQUATE PERFORMANCE OBTAINABLE, BUT SOME OF THESE PROBLEMS WOULD BE TOLERATED.	COORDINATION REQUIRED IS BOTHER SOME. UNACCEPTABLE; DEFICIENCIES REQUIRE IMPROVEMENT BECAUSE OF PROBLEMS WITH CROSSWIND APPROACHES AND GUST RESPONSE NEAR GROUND. TURBULENCE RATING IS DUE PRIMARILY TO DIRECTIONAL RESPONSE.

GROUP 5 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT (+) 18	LIGHT (+) 8	LIGHT (+) 18
PR/TR	6/E	6/E	7/E
GENERAL COMMENTS	VERY DIFFICULT TO MAKE SMALL CORRECTIONS IN HEADING AND TO MAINTAIN SMALL TURN RATES. A/C SEEMS TO WALLOW THROUGH AIR.	DISLIKED THIS A/C. QUITE SLOPPY DIRECTIONALLY AND DIFFICULT TO COORDINATE. UNSUITABLE FOR LANDING APPROACH.	IN SMOOTH AIR, LATERAL-DIRECTIONAL CHARACTERISTICS ARE GOOD, BUT IN TURBULENCE DUTCH ROLLS APPEAR UNSTABLE.
ABILITY TO TRIM	RUDDER TRIM SOMEWHAT DEGRADED, BUT AILERON TRIM NO PROBLEM.	SATISFACTORY.	NO COMMENT.
SELECTION OF CONTROL SENSITIVITIES	WHEEL FORCES AND DISPLACEMENTS SELECTED WERE GOOD.	LATERAL GEARING DIFFICULT TO COMMENT ON. LOT OF BALL MOTION WITH ANY LATERAL INPUT; BALL EXCURSIONS SEEMED TO MODULATE AILERON FORCES. SELECTION OF RUDDER SENSITIVITY A PROBLEM BECAUSE OF COORDINATION REQUIREMENTS AND SLOPPY DIRECTIONAL CHARACTERISTICS. ATTEMPTS TO PRECISE COORDINATION LED TO OVERCONTROL. ONLY WAY TO COORDINATE WAS TO KEEP EYES ON THE BALL AND USE RUDDER DIRECTLY TO KEEP BALL CENTERED. ARRIVING AT SATISFACTORY SENSITIVITY REQUIRED CONSIDERABLE TIME.	AILERON FORCES A LITTLE HIGHER THAN DESIRED. ALTHOUGH PILOT HAS PRETTY GOOD CONTROL, DISPLACEMENTS O.K.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	3.42 8.84	5.47 9.95	4.69 8.96
LATERAL AND DIRECTIONAL CONTROL	CONSIDERABLE OSCILLATION, WITH NOSE WANDERING BACK AND FORTH ON HORIZON. STEP INPUT OF RUDDER GETS NOSE OSCILLATING TO ALMOST DIVERGENT, BUT WITH SIZABLE BANK ANGLE OSCILLATION STOPS. VERY DIFFICULT TO MAINTAIN CONSTANT HEADING WITH THIS CONSTANT WALLOWING BACK AND FORTH ACROSS HORIZON. ROLL CONTROL ADEQUATE AND QUITE GOOD. YAW DUE TO ROLL NOT MUCH OF A PROBLEM; HOWEVER, COORDINATION IN MANEUVERING IS A PROBLEM. A/C ADEQUATELY CONTROLLABLE IN BOTH OFFSET MANEUVER AND STRAIGHT-IN APPROACH.	RESPONSE IN ROLL PREDICTABLE; INITIAL RESPONSE SATISFACTORY; NO OVERCONTROL TENDENCY. COORDINATION NECESSARY AND DIFFICULT; SOME VERY UNCOMFORTABLE MOTIONS RESULTED FROM NOT COORDINATING PROPERLY. YAW DUE TO ROLL QUITE LARGE; AFTER A SLIGHT HESITATION THERE WAS A LARGE ADVERSE BALL EXCURSION. TENDENCY TO OSCILLATE DIRECTIONALLY.	DUTCH ROLL FREQUENCY FAIRLY LOW AND NOT TOO WELL DAMPED; FAIRLY UNCOMFORTABLE FEELING IN COCKPIT. CONTROL COORDINATION NOT TOO DIFFICULT, BUT REQUIRES A LITTLE PILOT ATTENTION BECAUSE OF A LOT OF PEDAL ACTION REVERSAL IS REQUIRED TO KEEP COORDINATED FLIGHT WHILE ENTERING A TURN. TAKES A WHILE TO BUILD UP A ROLL RATE, BUT NOTHING BOTHERSOME.
DIFFERENCES IN IFR AND VFR	UNDER IFR, ALMOST CONSTANT OSCILLATION OF NOSE BACK AND FORTH ON HORIZON. UNDER VFR, NOT TOO OBJECTIONABLE DURING LANDING APPROACH WITH CROSSWIND, IF PILOT WATCHES RUDDER CLOSELY. ON IFR, ABILITY TO MAKE SMALL CORRECTIONS IN HEADING AND MAINTAIN CONSTANT HEADING SOMEWHAT MORE DIFFICULT AND OJBECTIONABLE. A/C MUCH BETTER UNDER VFR THAN IFR.	ON IFR, COULD DO THE JOB OUT OF TURBULENCE. ON VFR, IN TURBULENCE, SOME PROBLEM GETTING LINED UP. COULD OVERCONTROL DIRECTIONALLY BECAUSE NOSE WOULD MOVE FREELY BACK AND FORTH	DURING IFR IN TURBULENCE IT WAS PRETTY BAD IN TERMS OF RELATIVELY LARGE YAW ANGLES WHICH WOULD STAY IN RELATIVELY LONG TIME. DURING VFR, PILOT HAD MORE VISUAL CUES AND COULD MAKE CORRECTIONS ADEQUATELY TO KEEP DIRECTIONAL CONTROL PRETTY MUCH IN TOW
EFFECTS OF TURBULENCE	NONE REALLY DEGRADING.	TURBULENCE RESPONSE PREDOMINANTLY DIRECTIONAL, BUT INTERACTION WITH LATERAL. TRYING TO CONTROL IT WITH DIRECTIONAL SLOPPINESS OF A/C WOULD LEAD TO OVERCONTROL.	DUTCH ROLL MODE QUITE EASILY EXCITED. ABILITY TO MAINTAIN HEADING DEGRADED. BALL PRACTICALLY HITS STOPS ON ONE SIDE AND THEN THE OTHER AS A RESULT OF GUST INPUTS.
CONTROL IN CROSSWIND	VFR-OFFSET AND STRAIGHT-IN NO PARTICULAR PROBLEM BECAUSE VISUAL CUES AVAILABLE.	HAVING TO DE-CRAB OR HOLD NOSE STRAIGHT WITH RUDDER, LEADS TO OVERCONTROLLING. DIFFICULT TO KEEP NOSE WHERE DESIRED. LIKELY, THE WING-DOWN METHOD WOULD BE BEST SINCE TENDENCY TO OSCILLATE DIRECTIONALLY WOULD OCCUR DURING THE DE-CRAB MANEUVER.	NO PARTICULAR PROBLEM.
FAVORABLE FEATURES	NONE.	ROLL CONTROL ITSELF, IN A COORDINATED MANEUVER, WAS GOOD.	MODERATELY CONTROLLABLE A/C UNDER NON-TURBULENT CONDITIONS.
OBJECTIONABLE FEATURES	DUTCH ROLL CHARACTERISTICS DEGRADE A/C QUITE HEAVILY.	COORDINATION REQUIREMENTS, SLOPPY DIRECTIONAL CHARACTERISTICS AND TURBULENCE RESPONSES. PRIMARY OBJECTION - DIFFICULTY IN ACHIEVING COORDINATION.	HAS TENDENCY TO DIVERGE, IN TURBULENCE, DIRECTIONALLY IN DUTCH ROLL MODE OR APPEARS TO GO THAT WAY.
PRIMARY REASON FOR PILOT RATING	INADEQUATE PERFORMANCE OF A/C AND DUTCH ROLL CHARACTERISTICS, WHICH APPEARED TO DIVERGE FOR A WHILE AND THEN STOP. PILOT NEVER KNEW EXACTLY WHAT WAS GOING ON, DEGRADING HIS ABILITY TO FLY A/C ON IFR.	ADEQUATE PERFORMANCE ATTAINABLE IF PILOT WORKS AT IT, BUT A/C UNSATISFACTORY.	ADEQUATE PERFORMANCE NOT ATTAINABLE IN CERTAIN AREAS, REQUIRING MAXIMUM PILOT COMPENSATION, BUT CONTROLLABILITY WAS NEVER IN QUESTION. DIVERGING TENDENCY OF DUTCH ROLL MODE IN GUSTING CONDITIONS IS OBJECTIONABLE.

GROUP 6	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$ **PILOT A**	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$ **PILOT A**	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$ **PILOT B**
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	NONE CALM	LIGHT 13	LIGHT TO MODERATE 10
PR/TR	6/E	5/C	4/D
GENERAL COMMENTS	INITIAL COMMENT - A/C DIFFICULT TO COORDINATE IN TURNS. A/C WORMY.	ADEQUATE OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES. COORDINATION DIFFICULT.	SUITABLE FOR LANDING APPROACH BUT SOME DIFFICULTY EXISTS.
ABILITY TO TRIM	TRIMMING RUDDER TO NEUTRAL OR TRIMMING BALL TO CENTER EXCEPTIONALLY DIFFICULT.	AILERON AND RUDDER VERY DIFFICULT TO TRIM.	A LITTLE DIFFICULTY GETTING THE LATERAL TRIM JUST RIGHT, BUT NO GREAT PROBLEM
SELECTION OF CONTROL SENSITIVITIES	WHEEL FORCES HIGH TO GET DESIRED ROLL RESPONSE AND DIFFICULT TO MAKE SMALL CORRECTIONS IN HEADING. MUCH PILOT ATTENTION NEEDED. AILERON FORCES AND DISPLACEMENTS ARE QUITE HIGH TO GET PROPER ROLL RATES FOR RAPID ROLL CORRECTIONS. MORE ROLL CONTROL POWER NEEDED BUT WAS NOT NOTICED WHILE MANEUVERING AT ALTITUDE.	AILERON FORCES HIGH COMPARED TO RUDDER AND ELEVATOR. EVEN WITH HIGH AILERON FORCES, WHEEL DISPLACEMENTS NOT EXCESSIVE TO OBTAIN ADEQUATE AILERON.	CROSSFEED BETWEEN DIRECTIONAL AND LATERAL SO SIDESLIP RESULTING FROM AILERON ONLY TURNS CAUSES VARIATIONS IN ROLL RESPONSE. AILERONS NOT WANTED ANY MORE SENSITIVE. HAVING TO USE FEET, PILOT SELECTED RUDDER REASONABLY SENSITIVE. NOT CONSIDERED COMPROMISE
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	2.19 8.79	2.33 13.0	5.06 11.4
LATERAL AND DIRECTIONAL CONTROL	PROBLEM ON FINAL APPROACH PARTICULARLY IN TURBULENT CONDITIONS. BUT WAS WITHOUT CONSIDERABLE PILOT EFFORT TO OVERCOME A/C DEFICIENCIES. RESPONSE TO PILOT INPUT, MARGINAL PARTICULARLY THE QUICK-RESPONSE AREA. CONSIDERABLE YAW DUE TO ROLL CONTROL INPUTS. MAKING MANEUVERS VERY DIFFICULT TO COORDINATE AND COORDINATION WAS CONSTANT JOB FOR PILOT.	A/C HAS EXTREME YAW DUE TO ROLL CONTROL INPUTS. AILERON CONTROL INPUT RESULTS IN NOSE HANGING FOR LONG TIME ON HORIZON AND EVEN MOVING OFF IN OPPOSITE DIRECTION. MAKING CONTROL OF A/C VERY DIFFICULT. SMALL HEADING CORRECTIONS VERY DIFFICULT DUE TO LARGE ADVERSE YAW DUE TO ROLL, EVEN MAINTAINING HEADING RELATIVELY DIFFICULT. A/C RESPONSE TO PILOT INPUT ADEQUATE BUT FORCES HIGH AND YAW IS OPPOSITE TO DIRECTION OF ROLL	SATISFACTORY AILERON CONTROL. PREDICTABLE AND INITIAL RESPONSE FAST ENOUGH WITH NO TENDENCY TO OVERCONTROL. COORDINATION REQUIRED AND AT TIMES DIFFICULT, ESPECIALLY IN VFR MANEUVERS. IN TRYING TO CENTER BALL PILOT TENDED TO OVERCONTROL A BIT DIRECTIONALLY. FELT AWKWARD
DIFFERENCES IN IFR AND VFR	OSCILLATIONS IN DUTCH ROLL MORE PRONOUNCED UNDER VFR CONDITIONS.	NOT MUCH	IN VFR COORDINATION PROBLEMS, MORE THAN IN IFR WHERE SMALL INPUTS USED AND PILOT WAS A BIT SMOOTHER
EFFECTS OF TURBULENCE	DUTCH ROLL OSCILLATIONS QUITE LARGE PARTICULARLY UNDER GUSTING CONDITIONS AND ADVERSE IN IFR CONDITION. MAXIMUM PILOT EFFORT REQUIRED FOR PRECISE TRACKING IN LANDING APPROACH PARTICULARLY UNDER GUSTING CONDITIONS. TURBULENCE QUITE PRONOUNCED AND PLACED A/C IN A MARGINALLY MANEUVERABLE SITUATION, PARTICULARLY DURING TERMINAL PHASE OF LANDING APPROACH.	A/C A LITTLE BIT SHAKY ON FINAL. MASKS SOME OF BAD THINGS THAT WOULD OTHERWISE BE VISIBLE	CERTAINLY NOTICEABLE. WALLOWING FEELING. SIDESLIP RESPONSE TO GUSTS PRODUCES ROLL. NOT SEVERE, BUT ENOUGH TO GIVE PROBLEMS IN BOTH AXES. AN ANNOYANCE.
CONTROL IN CROSSWIND	NOT CHECKED.	ATTEMPTING TO MAINTAIN WING LOW TYPE CORRECTION, A/C UNDER CONTROL AND WITHOUT EXCEPTIONAL PILOT EFFORT	NO EFFECT
FAVORABLE FEATURES	NONE	NONE NOTED.	GOOD ROLL RESPONSE OUT OF TURBULENCE
OBJECTIONABLE FEATURES	LIGHT DAMPING OF DUTCH ROLL UNDER GUSTING CONDITIONS MAKES PILOT CONTINUALLY WORK THROUGHOUT ILS. PROBLEMS ARISE WITH CONTROL MAINLY FROM REDUCED CONTROL POWER AND INABILITY TO MAKE RAPID CORRECTIONS	LARGE ADVERSE YAW DUE TO ROLL. EXTRA CARE REQUIRED TO TRIM AND EXTREME DIFFICULTY IN MAKING SMALL CORRECTIONS ON PRECISION TRACKING TASK	COORDINATION REQUIRED IN VFR UNDESIRABLE. REQUIRED TOO MUCH PILOT THOUGHT
PRIMARY REASON FOR PILOT RATING	EXTENSIVE PILOT COMPENSATION REQUIRED. MODERATE PILOT EFFORT TO KEEP PERFORMANCE FROM DETERIORATING TO AN UNACCEPTABLE LEVEL IN TURBULENCE.	DIFFICULTIES IN TRIMMING, MAINTAINING HEADING AND MAKING SMALL HEADING CORRECTIONS DUE TO LARGE ADVERSE YAW DUE TO ROLL CAUSE A/C TO BE UNSATISFACTORY.	ADEQUATE PERFORMANCE CAN BE ACHIEVED BUT ITS UNSATISFACTORY. MINOR BUT ANNOYING DEFICIENCIES. WALLOWING IN TURBULENCE UNDESIRABLE AND COORDINATION REQUIREMENTS NOT LIKED.

GROUP 6 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0.05$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	NONE CALM	LIGHT-MODERATE 5	LIGHT TO MODERATE 12
PR/TR	3/A	3/D	1.5/A
GENERAL COMMENTS	GOOD LATERAL-DIRECTIONAL HANDLING QUALITIES. A/C CONTROLS WELL AT ALL TIMES. SUITABLE LANDING APPROACH CHARACTERISTICS.	A/C SUITABLE FOR LANDING APPROACH. INITIAL RESPONSE AND PREDICTABILITY OF RESPONSE SATISFACTORY.	SUITABLE FOR LANDING APPROACH. GOOD ILS PERFORMANCE, GOOD JOB WITH MINIMUM EFFORT.
ABILITY TO TRIM	NO PROBLEM LATERALLY OR DIRECTIONALLY. MORE PROBLEM TRIMMING WITH RUDDER THAN ANYTHING ELSE, BUT NO PROBLEM.	SOME DIFFICULTY LATERALLY, BUT SATISFACTORY.	SATISFACTORY.
SELECTION OF CONTROL SENSITIVITIES	FORCES AND DISPLACEMENTS NO PROBLEM. GEARING RATIO AND HARMONY CONTROLS O.K., BUT NOT EVALUATED IN CROSSWIND.	NO OBVIOUS COMPROMISES IN GEARING SELECTION. RUDDER USED IN INITIATING TURNS SO RUDDER LIGHTENED SO IT WASN'T NOTICEABLE PROBLEM DURING TURN ENTRY.	NO COMPROMISES IN GEAR SELECTIONS. LATERAL CONTROL SELECTED AS SENSITIVE AS DESIRED WITH NO TENDENCY TO OVERCONTROL.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	2.19 5.65	3.84 11.4	4.92 11.4
LATERAL AND DIRECTIONAL CONTROL	DUTCH ROLL OSCILLATION ANNOYING BECAUSE SLOWER THAN DESIRED YET FAST ENOUGH TO MAKE DIRECTION CORRECTIONS.	SATISFACTORY ROLL CONTROL, OCCASIONAL BUT MINOR TENDENCY TO OSCILLATE ABOUT DESIRED BANK ANGLE. YAW DUE TO ROLL REQUIRED RUDDER INTO TURN, DURING TURN INITIATION BUT NEUTRAL RUDDER DURING STEADY TURN. TENDENCY TO PUT IN A LITTLE TO MUCH RUDDER WITH SELECTED RUDDER PEDAL SENSITIVITIES.	EXCELLENT ROLL CONTROL, WITH THE SENSITIVITY SELECTED. INITIAL RESPONSE AND PREDICTABILITY EXCELLENT. NORMAL YAW DUE TO ROLL. WITH CRISP AILERON INPUT BALL WOULD FALL INTO TURN BUT IT WOULD RETURN CENTER QUITE RAPIDLY. DURING NORMAL MANEUVERS, BALL WOULD REMAIN CENTERED AND IF IT MOVED TO ONE SIDE IT WOULD QUICKLY RETURN TO CENTER. TURN COORDINATION WAS NOT REQUIREMENT, OCCASIONALLY A LITTLE RUDDER USED TO HELP THINGS OUT BUT WASN'T NECESSARY.
DIFFERENCES IN IFR AND VFR	NO COMMENT.	NO COMMENTS.	MORE COORDINATION REQUIRED IN VFR BECAUSE OF LARGER, MORE ABRUPT CONTROL INPUTS.
EFFECTS OF TURBULENCE	NO REAL PROBLEM FOR THE APPROACH.	IN SIDESLIP RESPONSE WAS MORE THAN SATISFACTORY. FEET USED WITH EFFORT TO SUPPRESS TURBULENCE TO ACCEPTABLE LEVEL. BALL SLOPPY AND HUNG TO ONE SIDE.	SLIGHTLY LONG PERIODS OF NO NATURAL TURBULENCE IN WHICH TURBULENCE RESPONSE SEEMED QUITE SMALL. BALL EXCURSIONS, DIRECTIONAL RESPONSE TO TURBULENCE, FAST AND SMALL. NO PROBLEM.
CONTROL IN CROSSWIND	NOT APPLICABLE.	EQUALLY SUCCESSFUL IN WING DOWN AND CRAB METHOD. CROSSWIND NO PROBLEM.	WING DOWN OR CRAB METHOD USED WITH EQUAL EASE. HAD PILOT SELECTED RUDDER SENSITIVITY FOR THE CROSSWIND APPROACH PILOT MIGHT HAVE TAILORED RUDDER SENSITIVITY TO CROSSWIND APPROACH BY SELECTING MORE SENSITIVE RUDDER. THAT WAY, LESS RUDDER FORCE WOULD HAVE BEEN REQUIRED DURING WING DOWN APPROACH. NO PROBLEMS IN DECRABBING FROM CRAB APPROACH. BOTH APPROACH METHODS USED AND WING DOWN METHOD PREFERRED BUT OTHER ONE JUST AS GOOD.
FAVORABLE FEATURES	NOTHING OUTSTANDING, GOOD OVERALL AIRPLANE CONTROL.	ROLL RESPONSE WAS SMOOTH AND PREDICTABLE. SATISFACTORY INITIAL RESPONSE.	OUTSTANDING LATERAL CONTROL. LACK OF NEED FOR TURN COORDINATION GOOD AND TURBULENCE RESPONSE MINIMAL. SMOOTH A/C AND CAME AROUND CORNERS VERY NICELY; i.e., DURING OFFSET MANEUVER.
OBJECTIONABLE FEATURES	YAW DUE TO ROLL GENERATED A MILD AND SLOW PERIOD OF DUTCH ROLL. QUITE DISCERNABLE DURING VFR TURNS.	TURN COORDINATION REQUIRED. IF SLOPPINESS WANTED, PILOT COULD DO WITHOUT COORDINATION AND THE BALL WOULD END UP IN THE CENTER. NOT HAPPY WITH TURBULENCE RESPONSE. BALL SEEMED SLOPPY AND WOULD HANG TO ONE SIDE. CORRELATES WITH TRIM PROBLEM. IN TURBULENCE, MODERATE BALL EXCURSIONS WHICH REQUIRED PILOT ATTENTION.	NO COMMENTS.
PRIMARY REASON FOR PILOT RATING	DUTCH ROLL PERIOD SLOW ENOUGH THAT NOSE WANDERING WAS SLOW ON HORIZON AND WAS NOT FAST ENOUGH THAT CORRECTIONS COULD BRING IT BACK TO PROPER HEADING VERY RAPIDLY.	ADEQUATE PERFORMANCE ATTAINABLE. SATISFACTORY, BUT TURBULENCE RESPONSE MAKES IT HAVE MILDLY UNPLEASANT DEFICIENCIES. MODERATELY MORE EFFORT REQUIRED IN TURBULENCE.	SATISFACTORY A/C. SLIGHT DOUBT ABOUT A/C IN TURBULENCE.

GROUP 6 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0.10$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	MODERATE 20
PR/TR	4/C
GENERAL COMMENTS	FAIRLY SUITABLE FOR LANDING APPROACH.
ABILITY TO TRIM	NO PROBLEM LATERALLY OR DIRECTIONALLY.
SELECTION OF CONTROL SENSITIVITIES	GOOD CONTROL FORCES, DISPLACEMENTS, AND CONTROL HARMONY.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	3.52 6.64
LATERAL AND DIRECTIONAL CONTROL	GOOD ROLL RESPONSE AND TURN COORDINATION FAIRLY EASY TO ACCOMPLISH. SMALL HEADING CORRECTIONS DIFFICULT ESPECIALLY IN TURBULENCE.
DIFFERENCES IN IFR AND VFR	NO LARGE DIFFERENCE.
EFFECTS OF TURBULENCE	A/C FLIES WELL IN SMOOTH AIR AND LIGHT TURBULENCE BUT MORE DIFFICULT IN MODERATE TURBULENCE. SIGNIFICANT DIFFERENCE BETWEEN TURBULENT AND NONTURBULENT CONDITIONS WITH SLIGHT DEGRADATION OF HANDLING QUALITIES IN TURBULENCE
CONTROL IN CROSSWIND	NO PARTICULAR PROBLEM IN CROSSWIND WITH CRAB TECHNIQUE.
FAVORABLE FEATURES	NO OUTSTANDINGLY GOOD FEATURES.
OBJECTIONABLE FEATURES	NOSE WANDERING IN TURBULENCE CONDITIONS.
PRIMARY REASON FOR PILOT RATING	DEFICIENCIES MINOR BUT ANNOYING AND HANDLING QUALITIES SHOULD BE IMPROVED. TURBULENCE INCREASES PILOT WORKLOAD WITH MINOR DETERIORATION IN TASK PERFORMANCE.

GROUP 6 STICK CONTROLLER	$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.10$ PILOT A	$N'_{\delta_{AS}}/L'_{\delta_{AS}} = -0.05$ PILOT B	$N'_{\delta_{AS}}/L'_{\delta_{AS}} = 0$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~ KT)	MODERATE 28, GUSTING TO 33	NONE 0	MODERATE 29
PR/TR	5.5/D	4.5/D	2.5/B
GENERAL COMMENTS	OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES APPEAR TO BE POOR. SUITABILITY FOR LANDING APPROACH FAIR, PERHAPS CLOSER TO POOR. ILS PERFORMANCE SURPRISINGLY GOOD.	SUITABLE, WITH SOME RESERVATIONS, FOR LANDING APPROACH. ILS PERFORMANCE GOOD. HAD TO USE FEET TO ADVANTAGE TO SQUEEZE ON A COUPLE OF DEGREES OF HEADING CHANGE.	OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES FAIR TO GOOD. SUITABILITY FOR LANDING APPROACH GOOD TO VERY GOOD.
ABILITY TO TRIM	VERY DIFFICULT TO TRIM DIRECTIONALLY. WITH THE SLIGHTEST LITTLE DISTURBANCE, BALL GOES OFF IN ONE DIRECTION AND STAYS OFF QUITE A WHILE.	LATERAL TRIM SATISFACTORY. HAD TO SPEND A LITTLE TIME BEING PRECISE ABOUT IT, BUT ONCE TRIMMED, IT STAYED THERE.	DOESN'T SEEM TO BE ANY PROBLEM TRIMMING LONGITUDINALLY, LATERALLY, OR DIRECTIONALLY.
SELECTION OF CONTROL SENSITIVITIES	FORCES AND DISPLACEMENTS APPEAR O.K. GEAR RATIO GOOD. CONTROL HARMONY O.K.	SELECTED AILERON GEARING SO THAT INITIAL ROLL RESPONSE WAS GOOD. SINCE RUDDER COORDINATION REQUIRED, SELECTED SENSITIVITY ON HIGH SIDE SO RUDDER COULD BE USED WITHOUT NOTICING FORCES.	FORCES, DISPLACEMENTS, AND CONTROL HARMONY ALL GOOD.
$L'_{\delta_{AS}}$ $N'_{\delta_{RP}}$	35.2 9.89	33.5 11.4	38.6 11.4
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL SOMEWHAT DEGRADED DUE TO LARGE ADVERSE YAW DUE TO AILERON. MAKING SMALL HEADING CORRECTIONS VERY DIFFICULT BECAUSE OF DELAYED RESPONSE IN INITIAL HEADING CHANGE FOLLOWED BY VERY RAPID INCREASE WITH A TENDENCY TO OVERSHOOT. DIRECTIONAL CONTROL NOT TOO GREAT. ONE COMPOUNDING PROBLEM IS ADVERSE YAW DUE TO AILERON INPUTS. COORDINATION IN TURNS QUITE DIFFICULT.	INITIAL ROLL RESPONSE GOOD; FINAL RESPONSE PREDICTABLE. COORDINATION INITIALLY REQUIRED TO COUNTERACT ADVERSE YAW. NOSE TENDS TO HANG UP; NEEDED RUDDER TO GET IT COMING AROUND TURN. PROBLEM HOLDS TRUE ON ILS, WHERE IF ONLY BANK WAS USED FOR CORRECTION, HEADING WOULDN'T CHANGE. PILOT COULD BE AS PRECISE AS NECESSARY, BUT REQUIRED SOME EFFORT.	QUITE RESPONSIVE IN ROLL WITH SLIGHT AMOUNT OF ADVERSE YAW DUE TO ROLL. COORDINATION FAIRLY EASY. COMBINATION OF DUTCH ROLL FREQUENCY AND DAMPING CAUSES NOSE TO HAVE A RATHER SLOW MOTION ON HORIZON ONCE DISTURBED. PILOT, HOWEVER, CAN MAINTAIN DESIRED HEADING FAIRLY WELL AND MAKE SMALL HEADING CORRECTIONS WITHOUT MUCH PROBLEM.
DIFFERENCES IN IFR AND VFR	VFR GIVES PILOT A LITTLE MORE HANDLE ON KEEPING LARGE OSCILLATIONS UNDER CONTROL. THE PROBLEM AND THE WORK LOAD SEEM MODERATELY INCREASED UNDER IFR DUE TO THE REDUCED REFERENCE FOR THE CORRECTIONS.	A MATTER OF MAGNITUDES. SAME PROBLEMS OCCUR ON VFR AND IFR, JUST IN DIFFERENT DEGREES.	NO DIFFERENCES.
EFFECTS OF TURBULENCE	TURBULENCE IS MOST SIGNIFICANT ASPECT THAT DEGRADES HANDLING QUALITIES, THIS WAS PROBABLY DUE TO EXCURSIONS FROM DESIRED HEADING SUSTAINING THEMSELVES LONGER THAN PILOT WOULD LIKE TO SEE. LARGE DISPLACEMENTS OF NOSE QUITE DISTRACTING IN TERMS OF INSTRUMENT FLYING TECHNIQUES.	REQUIRE SOME EFFORT TO COUNTERACT. COULD GET SOME RATHER WEIRD UNCOORDINATED FEELINGS WHILE FLYING IN TURBULENCE. WITH EFFORT THINGS COULD BE HELD QUITE NICELY, BOTH DIRECTIONALLY AND LATERALLY.	PRESENT, BUT NOT SIGNIFICANT. SMALL HEADING CORRECTIONS NOT MUCH OF A PROBLEM. MODERATE PILOT EFFORT REQUIRED WHEN UNDER THE HOOD.
CONTROL IN CROSSWIND	NO REAL PROBLEM. STRAIGHT CRAB TECHNIQUE USED WITH WING-LOW COMBINED TO CORRECT FOR ANY GUSTS. GOOD CONTROL IN X-WIND CONDITION.	NO COMMENTS.	NO PROBLEM. COMBINATION CRAB AND WING-LOW TECHNIQUE.
FAVORABLE FEATURES	NONE.	DIDN'T THINK ANYTHING OUTSTANDING IN THE GOOD SENSE.	A/C MANEUVERABLE; QUITE EASILY HANDLED IN PERFORMANCE OF TASKS.
OBJECTIONABLE FEATURES	TURBULENCE MOST SIGNIFICANTLY DEGRADES HANDLING QUALITIES WHERE LARGE HEADING EXCURSIONS ARE SUSTAINED FOR LONG PERIODS OF TIME. PILOT ANTICIPATION REQUIRED TO MAKE SMALL HEADING CORRECTIONS.	NOSE HANGS UP IN AILERON ONLY TURNS; RUDDER HAD TO BE USED TO GET NOSE TO COME AROUND AND THEN TAKE THE RUDDER OUT. TURBULENCE RESPONSE A BIT OBJECTIONABLE.	COMBINATION OF DUTCH ROLL FREQUENCY AND DAMPING CAUSES THE NOSE TO BE RATHER SLOW IN RETURNING TO A CENTRAL POSITION. APPARENTLY THE SLOWNESS IN THE DUTCH ROLL OSCILLATIONS DOESN'T HAVE TOO MUCH EFFECT ON PERFORMANCE OF THESE TASKS.
PRIMARY REASON FOR PILOT RATING	CONSIDERABLE PILOT COMPENSATION REQUIRED AND IN CERTAIN AREAS, EXTENSIVE COMPENSATION REQUIRED.	DISLIKED REQUIRED RUDDER COORDINATION AND TURBULENCE EFFECTS. MODERATE PILOT COMPENSATION REQUIRED. HAD TO WORK AT IT A BIT. RESPONSE TO TURBULENCE WAS IN CATEGORY OF "MORE EFFORT REQUIRED."	SLIGHT PILOT ANTICIPATION IN PREVENTING OVERSHOOTS WHEN MAKING SMALL HEADING CORRECTIONS.

<table>
<tr><th colspan="2">GROUP 6 (Cont.)
STICK CONTROLLER</th><th colspan="2">$N'_{\delta_{AS}} / L'_{\delta_{AS}} = 0$
PILOT B</th><th colspan="2">$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.05$
PILOT B</th><th colspan="2">$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.10$
PILOT A</th></tr>
<tr><td colspan="2">NATURAL TURBULENCE
MAX. X-WIND (~KT)</td><td colspan="2">LIGHT
4</td><td colspan="2">MODERATE (+)
16</td><td colspan="2">MODERATE
18</td></tr>
<tr><td colspan="2">PR/TR</td><td colspan="2">2.5/B</td><td colspan="2">2/B</td><td colspan="2">4/C</td></tr>
<tr><td colspan="2">GENERAL COMMENTS</td><td colspan="2">SATISFACTORY FOR LANDING APPROACH.</td><td colspan="2">NO COMMENTS - BROKEN WIRE RECORDER.</td><td colspan="2">LATERAL-DIRECTIONAL HANDLING QUALITIES SEEM FAIR TO GOOD. SUITABILITY FOR LANDING APPROACH FAIR.</td></tr>
<tr><td colspan="2">ABILITY TO TRIM</td><td colspan="2">LATERALLY, REQUIRED A LITTLE MORE THAN NORMAL ATTENTION, BUT NOT SERIOUS</td><td colspan="2"></td><td colspan="2">DIFFICULT TO TRIM DIRECTIONALLY AND NOT TOO DIFFICULT LATERALLY, ALTHOUGH A LITTLE MORE SENSITIVITY DESIRED.</td></tr>
<tr><td colspan="2">SELECTION OF CONTROL SENSITIVITIES</td><td colspan="2">LATERALLY, SENSITIVITIES WERE CHOSEN WHICH GAVE A SOLID FEELING WITHOUT ANY TENDENCY TO OVERCONTROL. NOTICED FORCES A LITTLE, BUT LIKED A/C. NO COMPROMISE.</td><td colspan="2"></td><td colspan="2">FORCES, DISPLACEMENTS AND CONTROL HARMONY ARE O K</td></tr>
<tr><td>$L'_{\delta_{AS}}$</td><td>$N'_{\delta_{RP}}$</td><td>42.8</td><td>6.45</td><td>38.6</td><td>9.89</td><td>48.6</td><td>11.4</td></tr>
<tr><td colspan="2">LATERAL AND DIRECTIONAL CONTROL</td><td colspan="2">ROLL CONTROL SATISFACTORY; QUICK ENOUGH, PRECISE, AND PREDICTABLE. YAW DUE TO ROLL WAS IN THE ADVERSE SENSE, ABOUT ONE BALL WIDTH REQUIRING SOME RUDDER TO COORDINATE THE TURNS, NOT DIFFICULT.</td><td colspan="2"></td><td colspan="2">ROLE CONTROL GOOD. MAY BE SOME ADVERSE YAW DUE TO ROLL BUT DOESN'T APPEAR TO BE A FACTOR IN CONTROL. APPEARS TO BE A SLIGHT BIT OF PROVERSE YAW DUE TO AILERON INPUT. A/C REQUIRES CONSTANT RUDDER REVERSALS FOR COORDINATION COMBINATION OF FAIRLY LIGHT DAMPING AND LOW FREQUENCY DUTCH ROLL FREQUENCY PRODUCES DISCONCERTING NOSE WANDERING, i.e., CONTINUES FOR CONSIDERABLE PERIOD OF TIME. MAINTAINING HEADING A LITTLE MORE DIFFICULT THAN DESIRED</td></tr>
<tr><td colspan="2">DIFFERENCES IN IFR AND VFR</td><td colspan="2">NO REAL PROBLEMS IN EITHER CONDITION.</td><td colspan="2"></td><td colspan="2">A/C PRESENTS LESS OF A PROBLEM IN VFR THAN IFR IN TERMS OF OVERALL HANDLING QUALITIES</td></tr>
<tr><td colspan="2">EFFECTS OF TURBULENCE</td><td colspan="2">WHEN FLYING IFR AND CLOSELY ON HEADING, TURBULENCE RESPONSE WAS MORE DISCONCERTING THAN DETRACTING. FELT A LITTLE WEIRD BUT NO REAL EFFORT TO STAY ON HEADING AND KEEP WINGS LEVEL. EFFECTS OF TURBULENCE NOTICEABLE AND MAINLY DIRECTIONAL BUT NOT REALLY DIFFICULT TO COUNTERACT.</td><td colspan="2"></td><td colspan="2">IN TURBULENCE, DIRECTIONAL CONTROL GETS TO BE A PROBLEM. OVERALL CONTROL PROBLEM NOT INCREASED MUCH.</td></tr>
<tr><td colspan="2">CONTROL IN CROSSWIND</td><td colspan="2">NOT ENOUGH CROSSWIND TO MAKE ANY JUDGMENTS ON WHAT TECHNIQUE TO USE OR WHAT EFFECTS WERE.</td><td colspan="2"></td><td colspan="2">HANDLED VERY NICELY IN CROSSWIND</td></tr>
<tr><td colspan="2">FAVORABLE FEATURES</td><td colspan="2">COULD BE FLOWN POSITIVELY AND GET RESPONSE REQUIRED IN ROLL. COULD BE PRECISE WITH NO TENDENCY TO OVERCONTROL. COORDINATION REQUIREMENTS SMALL AND IN THE NORMAL SENSE.</td><td colspan="2"></td><td colspan="2">NOTHING PARTICULARLY OUTSTANDING ROLL RESPONSE GOOD AND OVERALL HANDLING QUALITIES NOT TOO BAD</td></tr>
<tr><td colspan="2">OBJECTIONABLE FEATURES</td><td colspan="2">DISLIKED TURBULENCE RESPONSE. FELT A LITTLE FUNNY, ESPECIALLY UNDER THE HOOD, THE WAY WE WERE BOUNDING AROUND.</td><td colspan="2"></td><td colspan="2">PROBLEM OF COORDINATION, REQUIREMENT FOR RUDDER MANIPULATION FOR DIRECTIONAL CONTROL IN TURBULENT CONDITIONS.</td></tr>
<tr><td colspan="2">PRIMARY REASON FOR PILOT RATING</td><td colspan="2">GOOD A/C; FELT POSITIVE IN LATERAL SENSE. DIRECTIONAL EXCURSIONS OF NOSE DUE TO TURBULENCE WHICH WERE NOTICED ON VFR. NO SIGNIFICANT DETERIORATION IN PERFORMANCE OF TASK.</td><td colspan="2"></td><td colspan="2">PRIMARILY, MINOR BUT ANNOYING PROBLEM OF COORDINATION REQUIRING RUDDER MANIPULATION FOR DIRECTIONAL CONTROL. UNDER IFR CONDITIONS, GOOD PERFORMANCE REQUIRES MODERATE PILOT COMPENSATION</td></tr>
</table>

GROUP 7		$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$ PILOT A		$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$ PILOT B		$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT A	
NATURAL TURBULENCE **MAX. X-WIND (~KT)**		VERY LIGHT CALM		LIGHT 0		LIGHT 3	
PR/TR		4/C		2.5/A		2.5/B	
GENERAL COMMENTS		GOOD OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES. YAW DUE TO ROLL QUITE APPARENT. SURPRISINGLY ENOUGH A/C EASY TO MAKE SMALL HEADING CORRECTIONS. FLYING UNDER HOOD QUITE ANNOYING DUE TO GENERATED ANGLES OF YAW.		VERY GOOD ILS PERFORMANCE. A/C SUITABLE FOR LANDING APPROACH.		INITIAL COMMENT, A/C PRETTY GOOD OVERALL. GOOD TO VERY GOOD LATERAL DIRECTIONAL HANDLING QUALITIES. GOOD CONTROL OF A/C AT ALL TIMES EVEN WITH MODERATE TURBULENCE CRANKED IN.	
ABILITY TO TRIM		SOMEWHAT DEGRADED DIRECTIONALLY AND SLIGHTLY LATERALLY.		NO PROBLEM. SATISFACTORY.		TRIM IS GOOD THROUGHOUT ALL AXES.	
SELECTION OF CONTROL SENSITIVITIES		NO COMMENT.		HEAVY FORCES CAN MAKE CONFIGURATION LOOK VERY BAD. IF FORCES ARE HEAVY IT IS REALLY NOTICEABLE TO HOLD AILERON. PILOT LIGHTENED FORCES UNTIL WHAT SEEMED REASONABLE BUT FOUND THAT AT LANDING APPROACH, USING ONE HAND ON THE THROTTLE, AND PARTICULARLY ON THE OFFSET MANEUVER, THE FORCES SEEMED GIGANTIC. AFTER AGAIN ADJUSTING THE GEARING A/C WAS REASONABLE. HIGH FORCE PROBLEMS MAGNIFIED WITH THE LATERAL DIRECTIONAL INTERACTIONS. SELECTED RUDDER SENSITIVITIES SATISFACTORY.		NO COMMENT.	
$L'_{\delta_{AW}}$	$N'_{\delta_{RP}}$	3.52	7.55	4.34/6.74	13.1	3.90	9.39
LATERAL AND DIRECTIONAL CONTROL		ROLL CONTROL QUITE ADEQUATE BUT VERY DIFFICULT TO COORDINATE AND MUCH EFFORT NEEDED TO MAINTAIN COORDINATION. SOME DELAY IN COMMENCEMENT OF ANY HEADING CHANGE. NO PROBLEM WITH OSCILLATION. A/C SLOW TO RETURN TO CENTER REQUIRING CONSIDERABLE AMOUNT OF RUDDER. A/C MUST HAVE RELATIVELY LOW FREQUENCY WELL DAMPED DUTCH ROLL. USED A LOT MORE RUDDER THAN NORMAL.		GOOD ROLL CONTROL. INITIAL RESPONSE SATISFACTORY AND FINAL RESPONSE PREDICTABLE. PILOT QUITE PRECISE WITH IT. COORDINATION WASN'T REALLY HEAVY REQUIREMENT.		GOOD ROLL CONTROL. EXCELLENT RAPID ROLL RESPONSE, PARTICULARLY WHEN REQUIRED DURING FINAL PHASE OF OFFSET LANDING. DUTCH ROLL MODE WELL DAMPED AND PRESENTS NO PARTICULAR PILOT CONTROL PROBLEMS.	
DIFFERENCES IN IFR AND VFR		NOT MUCH DIFFERENCE BETWEEN VFR AND IFR. IN BOTH CASES MUCH RUDDER ACTION REQUIRED TO MAINTAIN DIRECTIONAL CONTROL, TO KEEP TURNS COORDINATED, AND TO MAINTAIN HEADING ON THE IFR APPROACH.		IN IFR, QUITE GOOD, IT WAS NICE A/C TO FLY ON ILS, OUT OF TURBULENCE. ON LARGER MANEUVERS, VFR, SOME PROBLEMS NOTICED WITH HEAVY CONTROL FORCES USING SENSITIVITY ORIGINALLY SELECTED DURING IFR MANEUVERS.		NO NOTICEABLE DIFFERENCE.	
EFFECTS OF TURBULENCE		PROBLEMS PRESENT IN NO TURBULENCE WERE MORE DIFFICULT TO COPE WITH IN TURBULENCE.		NOTHING SIGNIFICANT.		NEGLIGIBLE.	
CONTROL IN CROSSWIND		NOT OBSERVED.		NO COMMENT.		UNKNOWN.	
FAVORABLE FEATURES		NO PARTICULARLY OUTSTANDING FEATURE.		LACK OF MUCH TURBULENCE RESPONSE. WITHIN LANDING APPROACH MANEUVER, COORDINATION REQUIREMENTS MINIMUM AND THAT'S GOOD.		VERY GOOD A/C OVERALL.	
OBJECTIONABLE FEATURES		DIFFICULTY IN COORDINATION IN TERMS OF MAINTAINING HEADING UNDER TURBULENT CONDITIONS.		VERY IMPORTANT TO HAVE PROPER SENSITIVITY LATERALLY IN THIS A/C. IF HEAVY LATERAL WHEEL FORCES EXIST, IT COULD BE A VERY BOTHERSOME A/C.		NO REAL OBJECTIONABLE FEATURES. HOWEVER DUTCH ROLL RESPONSE COULD HAVE BEEN A LITTLE FASTER SO THE NOSE WOULD RETURN TO CENTER FASTER. THIS PRESENTED NO PROBLEMS ASSOCIATED WITH LANDING APPROACH TASK.	
PRIMARY REASON FOR PILOT RATING		REQUIREMENT FOR MODERATE COMPENSATION ON THE PART OF THE PILOT GIVES RISE TO DEFICIENCIES THAT WARRANT IMPROVEMENT. SLIGHT DEGRADATION IN PILOT'S ABILITY TO COPE WITH THE TASK UNDER TURBULENT CONDITIONS.		A/C SATISFACTORY. PROBLEMS DUE TO GEAR SELECTIONS AND NOT TO A/C. NO SIGNIFICANT INCREASE IN EFFORT WITH TURBULENCE.		SOME NEGLIGIBLE DEFICIENCIES. SLIGHT PROBLEM WITH LOW DUTCH ROLL FREQUENCY REQUIRING LONGER CENTERING TIME WHICH WAS MORE NOTICEABLE ON IFR, ILS APPROACH.	

GROUP 7 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.10$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	MODERATE 4	LIGHT (+) 10	LIGHT (+) 18
PR/TR	1.5/A	2/A	4/B
GENERAL COMMENTS	GOOD TO VERY GOOD OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES. VERY GOOD TO EXCELLENT SUITABILITY FOR LANDING APPROACH. EXCELLENT ILS PERFORMANCE.	SUITABLE FOR LANDING APPROACH.	OVERALL FLYING CAPABILITIES, LATERAL DIRECTIONALLY, GOOD. OFFSET APPROACH EASILY PERFORMED.
ABILITY TO TRIM	NO PROBLEM.	NO PROBLEMS.	NO COMMENT
SELECTION OF CONTROL SENSITIVITIES	FORCES, DISPLACEMENTS, GEAR RATIOS AND CONTROL HARMONY GOOD.	ABLE TO CHOOSE SENSITIVITIES SUCH THAT SENSITIVITIES, FORCES AND DISPLACEMENTS WERE GOOD. RUDDER REQUIREMENTS SO SMALL THAT WITH THE SENSITIVITIES SELECTED PILOT JUST "SQUEEZED" ON REQUIRED COORDINATION IN STEADY TURNS.	FORCES, DISPLACEMENTS WITHIN REASON. AILERON FORCES NOTICEABLE SOMETIME BUT NOT UNCOMFORTABLE.
$L'_{\delta_{AW}}$	2.91	5.20	3.66
$N'_{\delta_{RP}}$	6.63	13.0	10.8
LATERAL AND DIRECTIONAL CONTROL	GOOD ROLL CONTROL. SLIGHT AMOUNT OF ADVERSE YAW DUE TO ROLL AND ESSENTIALLY NO YAW DUE TO AILERON INPUTS. SLIGHT EFFORT REQUIRED TO COORDINATE TURNS. DUTCH ROLL MODE HAS LOW FREQUENCY BUT APPEARS PRETTY WELL DAMPED.	GOOD ROLL CONTROL. INITIAL AND FINAL RESPONSE GOOD AND PREDICTABLE. INITIAL BALL EXCURSIONS DURING ROLL. BALL SEEMED TO SNAP-OUT AND MOST OF WAY BACK. QUITE RAPID. PILOT ONLY CONTENDED WITH SMALL RESIDUAL BALL DISPLACEMENTS, AND NOT BOTHERSOME TO HAVE BALL DISPLACED. COORDINATION MORE DESIRED THAN REQUIRED.	A LITTLE EFFORT REQUIRED TO COORDINATE TURNS. AT TIMES CROSS CONTROLLING SEEMINGLY REQUIRED FOR COORDINATION BUT VERY LITTLE RUDDER PEDAL REQUIRED. A/C HAS RELATIVELY LOW FREQUENCY DUTCH ROLL BUT WELL DAMPED. ROLL CONTROL REQUIRES A LITTLE MORE FORCE GEAR RATIOS ARE A LITTLE LOW
DIFFERENCES IN IFR AND VFR	NO DIFFERENCE.	NO REAL DIFFERENCES, HOWEVER, IN IFR UNABLE TO SQUEEZE ON SMALL RUDDER CORRECTIONS. A FEW DEGREES OF BANK USED AND, THINKING CORRECTIONS MADE, BANK REMOVED AND NO HEADING CHANGE NOTICED. A MINOR POINT.	OSCILLATORY CHARACTERISTICS MORE ANNOYING UNDER IFR THAN VFR.
EFFECTS OF TURBULENCE	NEGLIGIBLE. LOW DUTCH ROLL FREQUENCY POSSIBLY TENDS TO MAKE NOSE STAY OFF AT SMALL ANGLES FOR LONGER TIME BUT DOESN'T APPEAR TO DEGRADE HANDLING QUALITIES OF A/C EVEN IN TURBULENCE. NO PARTICULAR PROBLEM IN MAKING SMALL ANGLE HEADING CORRECTIONS.	NOTICEABLE BUT NOT BOTHERSOME.	PRESENT BUT MINOR, PARTICULARLY EFFECTS ON HANDLING QUALITIES. VERY LITTLE EFFORT REQUIRED FOR COORDINATED TURNS. OVERALL CONTROL IN GUSTING CONDITIONS PRETTY GOOD. NO OBJECTIONS TO OSCILLATIONS UNDER MODERATE TURBULENCE.
CONTROL IN CROSSWIND	NOT TESTED.	NO NOTICEABLE CROSSWINDS.	NO REAL PROBLEM, STRAIGHT CRAB TECHNIQUE USED.
FAVORABLE FEATURES	A/C MANEUVERABLE ABOUT ALL AXES.	GOOD A/C. SMOOTH WITH MINIMUM OF COORDINATION REQUIRED.	OVERALL CONTROL ADEQUATE AND COMFORTABLE.
OBJECTIONABLE FEATURES	A LITTLE BIT MORE EFFORT REQUIRED TO COORDINATE TURNS.	NO COMMENTS.	SLOWNESS OF A/C TO CORRECT BACK TO COORDINATED FLIGHT ATTITUDE WITH GUST WHICH PRODUCED A SIDESLIP
PRIMARY REASON FOR PILOT RATING	VERY GOOD A/C IN PERFORMANCE OF TASK.	A/C CONTROLLABLE, PERFORMANCE ADEQUATE AND SATISFACTORY WITH NEGLIGIBLE DEFICIENCIES.	A/C HAS DEFICIENCIES THAT WARRANT IMPROVEMENT.

GROUP 8	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.06$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT TO MODERATE 10	MODERATE 20	MODERATE 10
PR/TR	8.5/F	6/D	8/E
GENERAL COMMENTS	EXTREME COORDINATION PROBLEMS. A/C GOT INTO DIRECTIONAL OSCILLATION THAT GOES DIVERGENT IF ONLY AILERONS ARE USED. UNSUITABLE FOR LANDING APPROACH.	OVERALL SUITABILITY FOR LANDING APPROACHES FAIR TO POOR, PROBABLY CLOSER TO POOR.	JUST TO CONTROL A/C WAS STRIKINGLY DIFFICULT. PILOT FOUND HIMSELF OVER-WORKING AILERONS TO COUNTER ROLL OSCILLATIONS. POOR SUITABILITY FOR LANDING APPROACH, YET ILS PERFORMANCE NOT TOO BAD.
ABILITY TO TRIM	LATERALLY, TERRIBLE, VERY DIFFICULT. IMPORTANT TO GET BALL IN CENTER; DIFFICULT TO DETERMINE IF BALL CENTERED IN TERMS OF TRIM.	TRIM DOESN'T SEEM TO BE TOO BAD ABOUT ANY AXIS.	EXCEPTIONALLY DIFFICULT TO GET ANY KIND OF TRIM ACCOMPLISHED.
SELECTION OF CONTROL SENSITIVITIES	NO COMPLAINTS ABOUT RUDDER. LATERAL A PROBLEM. WOULD NOT WANT AILERONS ANY MORE SENSITIVE FOR PRECISION OF CONTROL, YET RATHER LARGE FORCES EXISTED DURING SOME OF THE MANEUVERS; THEREFORE, A COMPROMISE.	PRETTY GOOD FORCES' DISPLACEMENTS, AND GEAR RATIOS. WHEEL FORCES A LITTLE HEAVY WITH TURBULENCE.	(PREVIOUSLY SELECTED VALUES WERE ASSIGNED.) AT FIRST FELT GOOD, BUT LATER, IN TURBULENCE, PILOT FOUND THAT HE COULD HAVE USED MORE SENSITIVITY LATERALLY.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	5.47 11.4	3.90 8.35	3.90 8.35
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL SEEMED REASONABLE FOR SMALL BANK ANGLE CHANGES. AILERON ONLY TURNS PRODUCED LARGE ADVERSE YAW INITIALLY, THEN WOULD RAPIDLY SWING TO PROVERSE, WITH ENORMOUS EFFECTS ON LATERAL CONTROL. SEEMED TO HAVE TO FIGHT IT INTO A TURN, THEN SUDDENLY, AS BALL WOULD SWING OUT OF TURN, IT WOULD OVERBANK. CORRECTING THIS WITH AILERONS STARTED A DIRECTIONAL OSCILLATION. IF PILOT DIDN'T GET ON RUDDER QUICKLY, BALL WOULD BE AGAINST STOPS VERY QUICKLY. NO QUESTION OF BEING PRECISE; JUST A MATTER OF CONTROLLING A/C.	VERY FAST ROLL RESPONSE WITH ONLY LIGHT TO MODERATE ADVERSE YAW DUE TO ROLL. RUDDER MANIPULATION REQUIRED FOR COORDINATED TURNS. VERY HIGH ϕ/β RATIO WITH OSCILLATIONS MAINLY AROUND ROLL AXIS. DIRECTIONAL EXCURSIONS VERY SMALL; DUTCH ROLL FREQUENCY RELATIVELY LOW AND NOT VERY WELL DAMPED. OSCILLATION MORE OF A ROLLING ONE THAN A SNAKING ONE. VERY HIGH POSITIVE DIHEDRAL EFFECT.	ROLL CONTROL ADEQUATE. YAW DUE TO ROLL ADVERSE; HOWEVER, WHEN TURN ESTABLISHED, NOT TOO DIFFICULT TO COORDINATE. VERY SMALL AMOUNT OF RUDDER INITIATED QUITE A LARGE ROLL RATE IN DIRECTION OF RUDDER APPLICATION.
DIFFERENCES IN IFR AND VFR	USING LARGE INPUTS, AS IN VFR, REALLY PRODUCED DIFFICULTIES. WITH SMALLER INPUTS, IFR, AS ON ILS, THINGS SOMEWHAT IMPROVED, BUT THESE ARE REALLY RELATIVE SHADES OF BEING MISERABLE.	NO BIG DIFFERENCE.	NO GREAT DIFFERENCE NOTED.
EFFECTS OF TURBULENCE	TURBULENCE COMPOUNDED DIFFICULTIES IN COORDINATION SINCE ANY LATERAL DISTURBANCE HAD ENORMOUS INFLUENCE ON LATERAL FORCES. THEREFORE, BALL HAD TO BE KEPT CENTERED TO TOLERATE LATERAL FORCES.	SMALL HEADING CORRECTIONS IN LIGHT TURBULENCE SEEM EASY TO MAKE. NOTICED A LITTLE MORE DIRECTIONAL EXCURSIONS; HOWEVER, LATERAL CONTROL STILL MAIN PROBLEM. DIHEDRAL EFFECT MORE EVIDENT IN TURBULENCE. BOTH LATERAL AND DIRECTIONAL CONTROL A PROBLEM. WITHOUT TURBULENCE, MORE OF A LATERAL PROBLEM. MODERATE EFFECT ON HANDLING QUALITIES.	QUITE PRONOUNCED; OFFERED A REAL DEGRADATION. SUSTAINED LATERAL OSCILLATION OF LARGE MAGNITUDE IN EVEN SLIGHTEST TURBULENCE.
CONTROL IN CROSSWIND	CROSSWIND APPROACH TRULY STAGGERING. AILERON FORCES IN WING-DOWN APPROACH LARGE AND UNCOMFORTABLE WITH TWO HANDS. TECHNIQUE PROBABLY DOESN'T MATTER ON THIS ONE; WOULDN'T WANT TO LAND IT, CERTAINLY NOT IN TURBULENCE.	DIRECTIONAL CONTROL REQUIRED PREDOMINANT RUDDER REVERSAL. CONSTANT MANIPULATION OF LATERAL CONTROLS PRESENTED A PROBLEM. BEGAN WITH STRAIGHT CRAB TECHNIQUE; HOWEVER, ENDED UP USING WING-LOW AS WELL.	CROSSWIND APPROACH WOULD OFFER NO BIG PROBLEM EXCEPT IN TURBULENCE.
FAVORABLE FEATURES	NONE.	NONE OUTSTANDING.	NO COMMENTS.
OBJECTIONABLE FEATURES	TURN COORDINATION, INTERACTION BETWEEN DIRECTIONAL AND LATERAL, AND SPEED WITH WHICH ONE COULD GO DIVERGENT DIRECTIONALLY IF NOT ON RUDDER QUICKLY WERE ALL OBJECTIONABLE.	CONSTANT PILOT ATTENTION REQUIRED BOTH DIRECTIONALLY AND LATERALLY IN TURBULENCE.	MAJOR OBJECTION WAS LARGE ROLL RESPONSE TO SMALL RUDDER INPUTS. TURBULENCE THEN COMPOUNDED CONTROL PROBLEMS BECAUSE IT EXCITED LATERAL OSCILLATIONS. THIS LED TO DIFFICULTY IN CONTROLLING BANK ANGLE WITHOUT VERY HIGH LATERAL CONTROL FORCES. ACTUAL MANEUVERABILITY NO PARTICULAR PROBLEM, BUT NOT WITHOUT SIGNIFICANT INCREASE IN PILOT WORKLOAD.
PRIMARY REASON FOR PILOT RATING	CONSIDERABLE PILOT COMPENSATION REQUIRED FOR CONTROL; COULD QUICKLY GET DIVERGENT LATERALLY. TURBULENCE REQUIRED BEST PILOT EFFORT.	TOLERABLE, BUT VERY OBJECTIONABLE DEFICIENCIES REQUIRED EXTENSIVE PILOT COMPENSATION ON EITHER IFR OR VFR.	REQUIRED IMPROVEMENT. EVEN WITH MAXIMUM PILOT EFFORT, A/C WOULD GET INTO EXTREMELY UNCOORDINATED SITUATIONS. HOWEVER, CONTROLLABILITY NEVER SEEMED TO BE IN QUESTION. SHOULD PILOT HAVE BEEN TAXED WITH ANOTHER TASK, HE WOULD CERTAINLY HAVE BEEN IN VERY UNTENABLE SITUATION. BEST EFFORTS WERE REQUIRED IN TURBULENCE.

GROUP 8 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.025$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT (+) 20	LIGHT (+) 4	LIGHT 3
PR/TR	9/F	9/F	9/E
GENERAL COMMENTS	VERY BAD A/C. UNSUITABLE FOR LANDING APPROACH, BUT COULD DO A REASONABLE JOB ON ILS. REALLY HAD TO WORK AT THIS ONE AND HAD NO CONFIDENCE IN IT AT ALL, PARTICULARLY NEAR GROUND.	VERY BAD A/C. DEFINITELY NOT SUITABLE FOR LANDING APPROACH. THIS CONFIGURATION REALLY REQUIRES ALERTNESS; RUDDER MUST BE USED. TRYING TO FLY IT WITHOUT USING RUDDER STARTS BALL EXCURSIONS THAT GET LARGER WITH EACH CYCLE.	ALL TASKS WERE PERFORMED WITH ADEQUATE CONTROL POWER AVAILABLE TO PILOT FOR MANEUVERING, BUT REQUIRED INTOLERABLE PILOT WORKLOAD.
ABILITY TO TRIM	COULD BE TRIMMED SATISFACTORILY.	LATERAL TRIM REALLY DIFFICULT BECAUSE OF INTERACTION BETWEEN LATERAL AND DIRECTIONAL. PILOT NEVER KNEW IF HE HAD IT TRIMMED OR NOT.	DIRECTIONAL TRIM IMPOSSIBLE BECAUSE OF CONTINUOUS A/C OSCILLATIONS.
SELECTION OF CONTROL SENSITIVITIES	NO COMPLAINTS ABOUT RUDDER. SELECTED AILERON SENSITIVITY WAS AS LIGHT AS PILOT WOULD WANT TO GO FOR PRECISION MANEUVERING, AS IN IFR. HOWEVER, DURING CROSSWIND APPROACH, OR ANY GROSS MANEUVERS, LATERAL FORCES EXCESSIVE.	NO COMMENTS ON RUDDER. SELECTED AILERON SENSITIVITY THAT SEEMED REASONABLE BUT LATER FOUND WHILE FLYING WITH ONE HAND, CLOSE TO THE GROUND, THAT AILERON FORCES WERE INTOLERABLY HIGH. GEARING HAD TO BE RESELECTED TO GET FORCES THAT COULD BE FLOWN WITH ONE HAND	NO COMMENTS.
$L'_{\delta_{AW}}$	5.64	INITIALLY 4.34, LATER 6.46	3.01
$N'_{\delta_{RP}}$	6.57	13.0	9.46
LATERAL AND DIRECTIONAL CONTROL	TREMENDOUS CROSSTALK BETWEEN DIRECTIONAL AND LATERAL. NOTHING WRONG WITH ROLL ITSELF. YAW DUE TO ROLL A REAL PROBLEM. UPON ENTERING A TURN, BALL WOULD INITIALLY GO INTO TURN AND SHORTLY AFTERWARDS WOULD SWING RATHER MAGNIFICENTLY TO OUTSIDE OF THE TURN. THIS WOULD CAUSE SUDDEN OVERBANKING, REQUIRING RUDDER TO CORRECT. VERY DANGEROUS PROBLEM. BALL SWINGS WILDLY BACK AND FORTH AS RESULT OF AILERON INPUT. IT ALL HAPPENS AT A DECEPTIVE RATE. JUST WHEN THINGS SEEMED TO BE SORTED OUT, BALL WOULD SWING OUT AND PILOT WOULD OVERBANK RATHER SMARTLY. COORDINATION EXTREMELY DIFFICULT.	ROLL CONTROL ITSELF SEEMED ADEQUATE. LARGE INTERACTION BETWEEN ROLL AND SIDESLIP. TRYING TO FLY WITH AILERONS ALONE PRODUCES LARGE DIRECTIONAL OSCILLATIONS COORDINATION NECESSARY AND DIFFICULT. MUCH RUDDER USE NECESSARY TO CALM THINGS DOWN. DURING TURNS, BALL WOULD CONTINUALLY SLIDE TO THE OUTSIDE OF THE TURN; LEAVING IT THERE WOULD CAUSE OVERBANKING. USING RUDDER TO STOP SIDESLIP COMPOUNDED LATERAL CONTROL PROBLEMS. TENDENCY TO OVERCONTROL AND OSCILLATE THROUGH A COUPLE OF CYCLES WHEN TRYING TO CENTER BALL	A/C EXHIBITS DIVERGENT DUTCH ROLL MODE. NOTICED REQUIREMENT TO CROSS CONTROL ON SEVERAL OCCASIONS IN BANK.
DIFFERENCES IN IFR AND VFR	LIKELY SATISFACTORY FOR IFR WHEN MAKING SMALL CORRECTIONS. IN VFR, AND IN TURBULENCE, IT'S A WILD ONE.	WITH SMALL CORRECTIONS IN IFR, COULD PERFORM SATISFACTORILY, BUT REALLY HAD TO WORK AT IT WITH RUDDER. VERY UNCOMFORTABLE WITH HIGH AILERON FORCES DUE TO COORDINATION PROBLEM. ON VFR, REALLY MISERABLE.	NO PARTICULAR DIFFERENCE, BOTH WERE WORMY.
EFFECTS OF TURBULENCE	VERY NOTICEABLE. WITH PECULIAR DIRECTIONAL-LATERAL COUPLING, DIFFICULT TO GET IN PHASE WITH, AND SUPPRESS, TURBULENCE EFFECTS. TURBULENCE EFFECTS ARE IN BOTH AXES AND A PROBLEM TO CONTEND WITH.	MODERATE TO SEVERE, WITH COORDINATION PROBLEM, VERY UNCOMFORTABLE TO FLY IN TURBULENCE PILOT HAD TO STAY ON TOES: CONSTANTLY OVERBANKING WITH BALL EXCURSIONS TO EXTREME. DISLIKED IT VERY MUCH.	QUITE PRONOUNCED.
CONTROL IN CROSSWIND	COULD DO THE JOB WITH EITHER METHOD, BUT REALLY HAD TO WORK HARD. EXCESSIVE LATERAL FORCES IN WING-DOWN METHOD.	DIDN'T NOTICE THE CROSSWIND; IT WAS FLYING BADLY ENOUGH WITHOUT WORRYING ABOUT CROSSWINDS	NOT OBSERVED
FAVORABLE FEATURES	NONE.	NO COMMENT.	NONE NOTED, TOO BUSY COMPENSATING FOR OBJECTIONABLE ONES.
OBJECTIONABLE FEATURES	WILD COORDINATION PROBLEM. YAW DUE TO ROLL IS A REAL PROBLEM. TURBULENCE RESPONSE LARGE AND DIFFICULT TO CONTROL.	EXTREME INTERACTION BETWEEN LATERAL AND DIRECTIONAL, AND HAVING TO COORDINATE IN AN UNATURAL MANNER IN TURNS ARE MOST OBJECTIONABLE. TURBULENCE IS A PROBLEM.	DUTCH ROLL DIVERGENCE, WHICH REQUIRED ALMOST COMPLETE PILOT ATTENTION TO COMPENSATE FOR IT WAS MOST OBJECTIONABLE.
PRIMARY REASON FOR PILOT RATING	A/C CONTROLLABLE, BUT ADEQUATE PERFORMANCE NOT ATTAINABLE WITH TOLERABLE PILOT WORKLOAD. INTENSE PILOT COMPENSATION REQUIRED TO RETAIN CONTROL.	CONTROLLABLE: ON IFR JOB CAN BE DONE, BUT PILOT HAS TO WORK AT IT ON VFR, JOB COULD NOT BE DONE TO PILOT'S SATISFACTION. CONSIDERABLE PILOT COMPENSATION REQUIRED FOR CONTROL. TURBULENCE IS IN "BEST EFFORTS REQUIRED."	TURBULENCE AFFECTED PR ONE WHOLE NUMBER. INTENSE PILOT COMPENSATION REQUIRED TO GAIN CONTROL, PARTICULARLY UNDER GUSTING CONDITIONS. PILOT CANNOT ADEQUATELY PERFORM ASSIGNED TASK UNDER GUSTING CONDITIONS WITHOUT INTENSE COMPENSATION.

<table>
<tr><th>GROUP 9</th><th colspan="2">$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$
PILOT A</th><th colspan="2">$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$
PILOT A</th><th colspan="2">$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$
PILOT B</th></tr>
<tr><td>NATURAL TURBULENCE
MAX. X-WIND (~KT)</td><td colspan="2">LIGHT
CALM</td><td colspan="2">LIGHT
13</td><td colspan="2">MODERATE
12</td></tr>
<tr><td>PR/TR</td><td colspan="2">9/E</td><td colspan="2">8/D</td><td colspan="2">8.5/F</td></tr>
<tr><td>GENERAL COMMENTS</td><td colspan="2">IN VFR, A/C WORMY AND HARD TO HANDLE. POOR FOR LANDING APPROACH.</td><td colspan="2">IN VFR, A/C WORMY AND NEEDS MUCH PILOT ATTENTION. A/C VERY DIFFICULT TO CONTROL FOR SMALL HEADING CHANGES. OVERALL LATERAL-DIRECTIONAL HANDLING QUALITIES POOR. YET A/C NOT UNCONTROLLABLE AT ANY POINT.</td><td colspan="2">INTERACTION BETWEEN DIRECTIONAL AND LATERAL ENORMOUS. ROLL RESPONSE TO ANY OUT OF TRIM LARGE AND VERY DIFFICULT TO CENTER BALL LONG ENOUGH TO SEE TRIM. A/C CAN QUICKLY GET CROSSED CONTROLS. UNSUITABLE FOR THE LANDING APPROACH.</td></tr>
<tr><td>ABILITY TO TRIM</td><td colspan="2">A/C DIFFICULT TO TRIM BOTH DIRECTIONALLY AND LATERALLY.</td><td colspan="2">VERY DIFFICULT TO TRIM BOTH IN ROLL AND DIRECTIONAL CONTROL.</td><td colspan="2">INTERACTION BETWEEN DIRECTIONAL AND LATERAL ENORMOUS SO THAT ROLL RESPONSE TO ANY OUT OF TRIM WAS GREAT. VERY DIFFICULT TO GET THE TWO TOGETHER LONG ENOUGH TO LOOK AT TRIM.</td></tr>
<tr><td>SELECTION OF CONTROL SENSITIVITIES</td><td colspan="2">NO COMMENTS.</td><td colspan="2">FEEL FORCES QUITE HIGH. TO MAINTAIN PARTICULAR BANK ANGLE, AILERON FORCES QUITE HIGH, BUT NOT OUT OF PILOT'S CAPABILITY. MORE AILERON CONTROL POWER DESIRED.</td><td colspan="2">VERY CONFUSING TO DECIDE ON FORCE LEVELS. GOOD FORCES AND DISPLACEMENTS WHEN BALL CENTERED. BUT WHEN BALL WAS DRIVEN OFF CENTER BY TURBULENCE OR COORDINATION REQUIREMENTS, LARGE LATERAL FORCES RESULTED, REQUIRING A COMPROMISE. SELECTED SATISFACTORY SENSITIVITIES FOR COORDINATIED FLIGHT BUT ANY KIND OF MIS-COORDINATION PRODUCED EXTREME OVERBANK TENDENCY WITH HIGH FORCE LEVELS REQUIRED TO COUNTERACT</td></tr>
<tr><td>$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$</td><td>4.72</td><td>11.1</td><td>3.35</td><td>8.85</td><td>3.83</td><td>11.4</td></tr>
<tr><td>LATERAL AND DIRECTIONAL CONTROL</td><td colspan="2">INITIAL COMMENTS - ADVERSE YAW DUE TO ROLL. SLIGHTLY MORE STABLE IN SPIRAL MODE WITH A LOT OF DUTCH ROLL COUPLED IN; QUITE AN OSCILLATORY MOTION IN CONSTANT BANK ANGLE. A/C GOES UNSTABLE UPON VERY SLIGHT RUDDER INPUT; WIDE EXCURSIONS ARE PICKED UP DIRECTIONALLY AND AT SAME TIME VERY HIGH ϕ/β CAUSES OSCILLATIONS TO GET COMPLETELY OUT OF HAND. SOME ADVERSE YAW DUE TO AILERON; A/C WALLOWS BACK AND FORTH WITH NO APPLICATION OF CONTROL MAKING HANDLING DIFFICULT ON GO-AROUND FROM ILS APPROACH - APPLICATION OF LEFT AILERON WITH CONSIDERABLE RIGHT RUDDER NEEDED TO COORDINATE THE MANEUVER. CONSTANT CHANGING OF RUDDER APPLICATION TO MAINTAIN COORDINATION ANNOYING. TURNING TO BASE ON AN OFFSET APPROACH - USED OPPOSITE AILERON AND OPPOSITE RUDDER FOR COORDINATED TURN. ILS - SURPRISINGLY, WITH MUCH PILOT EFFORT, A FAIRLY GOOD ILS.</td><td colspan="2">A/C VERY CAPABLE OF PICKING UP WING WITH TOP RUDDER WITH QUITE HIGH ϕ/β. A/C RESPONSE DUE TO PILOT INPUT IN ROLL MARGINAL, PARTICULARLY TRYING TO MAINTAIN A MEDIUM BANK ANGLE. A/C VERY MANEUVERABLE WITH RUDDER IN BANK ANGLE. COORDINATION OF MANEUVERS QUITE A PILOT TASK DUE TO COMBINATION OF ROLL DUE TO YAW. WHEN YAW WAS DEVELOPED, A/C CAME UP WITH SUCH AN ANGLE OF BANK THAT PILOT COMPENSATED FOR ANGLE OF BANK TO EXTENT THAT NO REAL OSCILLATION SET UP</td><td colspan="2">REASONABLE AILERON RESPONSE TO PILOT INPUT WHEN BALL COULD BE CENTERED. YAW DUE TO ROLL IN THE NORMAL SENSE REQUIRED RUDDER INTO THE TURN SOMEWHAT AFTER TURN STARTED. IN STEADY TURN CONTROL A LITTLE UNCOORDINATED AND ANY RUDDER TO COMPENSATE PRODUCED MORE ROLL INTO THE TURN. AILERONS TO COUNTERACT THE ROLL PRODUCED CROSSED CONTROL SITUATION. COORDINATION A PROBLEM.</td></tr>
<tr><td>DIFFERENCES IN IFR AND VFR</td><td colspan="2">NONE NOTICEABLE, A/C BAD IN BOTH</td><td colspan="2">NOT MUCH.</td><td colspan="2">NO PROBLEMS IN IFR DUE TO SMALL CONTROL INPUTS. IN VFR, INTERACTION BETWEEN AILERONS AND RUDDER CAN RESULT IN CROSSED CONTROLS.</td></tr>
<tr><td>EFFECTS OF TURBULENCE</td><td colspan="2">QUITE PRONOUNCED. PROBLEMS IN NON-TURBULENT CONDITIONS MAGNIFIED IN TURBULENCE; PILOT MUST COPE WITH RUDDERS AND SOME AILERON TO KEEP A/C IN CONTROL.</td><td colspan="2">QUITE PRONOUNCED, PARTICULARLY IN ROLL CONTROL. DEGRADING INFLUENCE ON THE OVERALL A/C HANDLING QUALITIES.</td><td colspan="2">LARGE AND UNACCEPTABLE. IF PILOT HOLDS AGAINST LARGE CONTROL FORCES GENERATED, PILOT BECOMES TOTALLY CONFUSED REGARDING RUDDER PEDALS AND WHEEL BECAUSE OF INTERACTION.</td></tr>
<tr><td>CONTROL IN CROSSWIND</td><td colspan="2">NOT OBSERVED.</td><td colspan="2">COMBINATION YAW AND WING LOW TECHNIQUES USED. PROBLEMS WERE AS PRONOUNCED AS AT OTHER TIMES.</td><td colspan="2">MINOR CONSIDERATION. CLOSE TO GROUND, PILOT MORE CONCERNED WITH KEEPING UPRIGHT THAN ABOUT SUBTLE CORRECTIONS DUE TO CROSSWIND.</td></tr>
<tr><td>FAVORABLE FEATURES</td><td colspan="2">NO PARTICULARLY GOOD FEATURES.</td><td colspan="2">NONE.</td><td colspan="2">NONE.</td></tr>
<tr><td>OBJECTIONABLE FEATURES</td><td colspan="2">EXTREMELY DIFFICULT TO KEEP DIRECTIONAL CONTROL. ALMOST CONSTANT RUDDER USE FOR COORDINATION AND ALMOST CONSTANT AILERON USE TO KEEP DESIRED BANK ANGLE. PRONOUNCED TURBULENCE RESPONSE.</td><td colspan="2">VERY HIGH ROLL DUE TO YAW MADE AILERON CONTROL OR LATERAL CONTROL EXCEPTIONALLY DIFFICULT ESPECIALLY DURING PERIODS OF TURBULENCE.</td><td colspan="2">LARGE ROLL DUE TO YAW, TURN COORDINATION PROBLEMS, AND CONTENDING WITH LARGE LATERAL WHEEL FORCES.</td></tr>
<tr><td>PRIMARY REASON FOR PILOT RATING</td><td colspan="2">CONSTANT PILOT ATTENTION NEEDED TO KEEP A/C IN CONTROL.</td><td colspan="2">CONSIDERABLE PILOT COMPENSATION REQUIRED FOR ACTUAL CONTROL OF A/C ESPECIALLY DURING GUSTS.</td><td colspan="2">ADEQUATE PERFORMANCE NOT ATTAINABLE WITH TOLERABLE PILOT WORKLOAD. PILOT STRUGGLED ON CROSSWIND LANDING, NEAR GROUND, TO KEEP A/C UNDER CONTROL. CONSIDERABLE PILOT COMPENSATION REQUIRED.</td></tr>
</table>

GROUP 9 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.15$ PILOT
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT 10	LIGHT 8	MODERATE (–) 22
PR/TR	5.5/D	5/C	9/G
GENERAL COMMENTS	GOOD ILS PERFORMANCE. NO PROBLEMS. HIGH INTERACTION BETWEEN DIRECTIONAL AND LATERAL.	FAIR TO POOR OVERALL LATERAL-DIRECTIONAL HANDLING QUALITIES. A/C NOT DIFFICULT TO FLY WITHOUT TURBULENCE. FAIR FOR LANDING APPROACH.	BORDERS ON DANGEROUS. NOT SUITABLE FOR LANDING APPROACH. VERY LITTLE RUDDER INPUT COULD USE UP TREMENDOUS AMOUNT OF ROLL CONTROL. REQUIRED PILOT CARE WITH RUDDER.
ABILITY TO TRIM	LATERAL TRIM DIFFICULT HIGH INTERACTION BETWEEN DIRECTIONAL SIDESLIP AND ROLL. SLIGHT BALL EXCURSIONS CAUSED PROBLEM IN TRIMMING	DIRECTIONAL TRIM VERY SENSITIVE. LATERAL ALSO SENSITIVE.	LATERALLY DIFFICULT TO TRIM WITH FORCES SOMETIMES AT HIGH LEVELS LATERALLY. LATERAL TRIM WAS USED AND GROSS MISTRIM WAS PRODUCED. NOT DIFFICULT TO TRIM IF THAT'S ALL PILOT HAS TO DO.
SELECTION OF CONTROL SENSITIVITIES	INITIALLY PILOT SELECTED RUDDER TOO SENSITIVE. AFTER ILS PILOT RESELECTED SENSITIVITY THAT SEEMED MORE APPROPRIATE. CONSTANT CHANGE PRODUCED IN LATERAL FORCES DEPENDING ON WHAT WAS HAPPENING DIRECTIONALLY. THUS PILOT SELECTED LATERAL SENSITIVITY BASED ON ROLL ALONE; WHENEVER PILOT COULD ISOLATE IT MORE SENSITIVITY NOT DESIRED BUT STILL HAD A NOTICEABLE, NOT EXTREME, FORCE ON CROSSWIND APPROACH.	CONTROL FORCES AND DISPLACEMENTS NO PROBLEM. GEAR RATIOS SELECTED, NO PROBLEM.	SELECTED RUDDER SATISFACTORY LOOKING AT FORCES AND DISPLACEMENTS FOR NORMAL MANEUVERING. REASONABLE AILERON SENSITIVITY SELECTED. LOOKING AT FORCES AND DISPLACEMENTS FOR NORMAL MANEUVERING, MORE SENSITIVITY NOT DESIRED YET DURING FLIGHT IN TURBULENCE AND IN PARTICULAR ON CROSSWIND APPROACH, HOLDING RUDDER, LATERAL FORCES WERE ENORMOUS.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	6.67 8.42 (FINAL SELECTION)	2.74 9.40	2.98 13.0
LATERAL AND DIRECTIONAL CONTROL	GOOD INITIAL RESPONSE AND NO TENDENCY TO OVERCONTROL. ANY SMALL BALL EXCURSION PRODUCED NOTICEABLE FORCE IN AILERON. AILERON FORCE SEEMED HEAVY STARTING A TURN BUT AS SIDESLIP ZEROED, IT WOULD LIGHTEN. NOTICEABLE DIRECTIONAL OSCILLATION WHEN PILOT USED AILERONS ONLY. NO STEADY STATE COORDINATION REQUIRED.	VERY GOOD ROLL RESPONSE LONGER TIME CONSTANT IN ROLL, SLOWER IN THE BEGINNING AND THEN MOVES OUT. YAW DUE TO ROLE IS NOT TOO PREVALENT. COORDINATED TURNS NOT A PROBLEM. ALMOST IMPOSSIBLE TO CENTER RUDDER TRIM FOR COORDINATED FLIGHT, BUT NOT MUCH OF A PROBLEM. DUTCH ROLL RELATIVELY LOW FREQUENCY AND DAMPED BUT NOT SURE BECAUSE OF THE HIGH ϕ/β	GENERALLY TENDED TO OVERBANK AND FOR ROLL TO ACCELERATE. ROLL RESPONSE NOT PREDICTABLE. RUDDER USE COUNTERACTED WITH AILERON, USING UP LARGE AMOUNT OF ROLL CONTROL AND REQUIRING HEAVY FORCES. RUDDER USED ONLY WHEN REQUIRED. DURING TURNS, SMALL BALL MOTION OUT OF TURN AND INTO TURN. SLIGHT RUDDER COORDINATION USED WITH MINOR EFFECT BALL MOTIONS TOO FAST FOR PILOT REACTION BUT WITH TREMENDOUS INTERACTION BETWEEN ROLL AND DIRECTIONAL. LARGE EFFECTS ON ROLL RESPONSE PRODUCED. CONSISTENT WITH THE LANDING APPROACH TASK, BEST TO LEAVE RUDDER ALONE. UNFORTUNATELY IN TURBULENCE AND ON CROSSWIND APPROACH THIS CAN'T BE DONE AND LEADS INTO DIFFICULTIES.
DIFFERENCES IN IFR AND VFR	SATISFACTORY A/C IN IFR, OUT OF TURBULENCE. VFR DEGRADED BY FORCE CHANGES IN LATERAL CONTROL. ADD EFFECTS OF TURBULENCE AND VFR BECAME BAD, ESPECIALLY WITH LARGE BALL EXCURSIONS RESULTING IN LARGE LATERAL FORCES.	VERY SLIGHT.	NO COMMENTS.
EFFECTS OF TURBULENCE	MODERATE AND DEGRADING. ANY TURBULENCE DISTURBING THE ROLL COMPOUNDED LATERAL TRIM PROBLEMS.	VERY HIGH POSITIVE DIHEDRAL EFFECT PRODUCED VERY LARGE ROLLING MOTIONS WITH YAW, COMPOUNDING PROBLEM OF LATERAL DIRECTIONAL CONTROL SINCE LARGE WHEEL FORCES REQUIRED TO KEEP A/C UNDER CONTROL. MOTION ONE OF UNCOMFORTABLE WALLOWING. SMALL HEADING CORRECTIONS QUITE A PROBLEM.	LARGE. COUPLED WITH THE ROLL RESPONSE, AILERONS TOO SENSITIVE, BUT NOT TOO SENSITIVE IN THEMSELVES. TURBULENCE BOTHERSOME LATERALLY AND, COUPLED WITH ROLL CONTROL RESPONSE, MADE PILOT TASK DIFFICULT RUDDER USE COMPOUNDED DIFFICULTIES DRAMATICALLY.
CONTROL IN CROSSWIND	JITTERY DIRECTIONALLY EVEN WITH PILOT CORRECTION ON RUDDER SENSITIVITY. PILOT DIFFICULTY IN HOLDING NOSE STRAIGHT AND LATERAL FORCES HEAVY WITH WING DOWN TECHNIQUE. WING DOWN TECHNIQUE PREFERRED.	NOT ENOUGH CROSSWIND FOR JUDGMENT.	LATERAL FORCES ENORMOUS. VERY LARGE FORCE REQUIRED TO COUNTERACT RUDDER INPUTS WITH AILERON.
FAVORABLE FEATURES	NO TENDENCY TO OVERCONTROL LATERALLY. PILOT COULD BE PRECISE. NO STEADY STATE COORDINATION REQUIRED OUT OF TURBULENCE.	POOR IN CERTAIN AREAS, FAIR TO POOR IN OTHERS, OVERALL PROBABLY LEANING TOWARD FAIR SIDE.	NONE.
OBJECTIONABLE FEATURES	CHANGES IN LATERAL FORCES THAT RESULTED FROM DIRECTIONAL EXCURSIONS BOTHERSOME. TURBULENCE RESPONSE CONSIDERED UNREASONABLE FOR A SATISFACTORY A/C.	VERY HIGH DIHEDRAL EFFECT RESULTING IN EXTREME TRIMMING DIFFICULTY AND MAINTAINING COORDINATION.	ROLL RESPONSE AND TENDENCY TO "TAKE OFF" OR LURCH IN ROLL UNDESIRABLE. TREMENDOUS ROLL RESPONSE TO RUDDER OBJECTIONABLE IF NOT DANGEROUS NEAR THE GROUND. VERY HEAVY LATERAL FORCES DURING CROSSWIND LANDING WERE MORE THAN PILOT COULD CONTEND WITH AND A/C BECAME VERY "TWITCHY" NEAR THE GROUND. SMALL RUDDER CORRECTION LED TO LARGE LATERAL "TWITCHES".
PRIMARY REASON FOR PILOT RATING	UNSATISFACTORY. INTERACTION DIRECTIONALLY AND LATERALLY AND FORCE LEVELS CONTENDED WITH, UNIMPRESSIVE, ESPECIALLY WITH CROSSWINDS AND TURBULENCE.	COORDINATED TURNS ARE PROBLEM. MODERATELY OBJECTIONABLE DEFICIENCIES IN A/C BUT PERFORMANCE ADEQUATE WITH CONSIDERABLE PILOT COMPENSATION.	ADEQUATE PERFORMANCE NOT ATTAINABLE. DEFICIENCIES REQUIRE IMPROVEMENT. CROSSWIND APPROACH CAN NOT BE DONE PROPERLY IN THE PRESENCE OF TURBULENCE.

GROUP B STICK CONTROLLER	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.05$ PILOT B	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.06$ PILOT A	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = 0$ PILOT B
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT 7	MODERATE 30	MODERATE 0
PR/TR	8/F	9/E	7/E
GENERAL COMMENTS	INTERACTION RAPID HERE. DIFFICULT TO SORT OUT EXACTLY WHAT IS HAPPENING. PROBLEMS IN OSCILLATORY SENSE, DIRECTIONAL AND LATERAL. IN LATERAL OSCILLATIONS, A/C BUILT UP SIDESLIP, INTERACTING AGAIN WITH LATERAL. THESE CHARACTERISTICS PROBABLY NOT SUITABLE FOR LANDING APPROACH. WHEN OSCILLATION WOULD GET GOING IN SIDESLIP, FORCE VARIATIONS LATERALLY REALLY DRAMATIC. HAD TO BE GENTLE WITH THIS A/C AND SORT IT OUT BY USING RUDDER AS ROLL CONTROL.	LATERAL DIRECTIONAL HANDLING QUALITIES POOR TO VERY POOR. i.e., A WORMY A/C. SUITABILITY FOR LANDING APPROACH POOR TO FAILING. INTENSE PILOT APPLICATION REQUIRED TO MAINTAIN DIRECTIONAL CONTROL IN ILS.	REALLY HOPPED AROUND VERY QUICKLY LATERALLY IN RESPONSE TO TURBULENCE. UNSUITABLE FOR LANDING APPROACH. COULD GET INTO TROUBLE QUICKLY; HAD TO BE CAREFUL. ON ILS, COULD DO JOB, BUT REALLY HAD TO WORK AT IT.
ABILITY TO TRIM	LATERALLY, EXTREMELY DIFFICULT TO TRIM. EVEN MORE DIFFICULT TO TRY TO FIGURE OUT WHAT TO DO. TREMENDOUS INTERACTION BETWEEN RUDDER AND AILERON; RUDDER WAS EFFECTIVE ROLL CONTROL. LATERALLY WOULD FEEL IT WAS TRIMMED, LOOK AWAY, AND END UP WITH EITHER TREMENDOUS SIDESLIP OR ROLLING OVER QUICKLY. VERY DANGEROUS.	ALMOST NON-EXISTENT LATERALLY AND DIRECTIONALLY.	VERY DIFFICULT TO FIGURE OUT LATERAL TRIM. CONTINUAL LATERAL DISTURBANCE DUE TO TURBULENCE. HOW A/C TRIMMED LATERALLY SEEMED VERY CRITICAL.
SELECTION OF CONTROL SENSITIVITIES	LATERAL FORCES EXTREMELY DIFFICULT TO PIN DOWN. ANY SIDESLIP PRODUCED LOTS OF ROLL; IF THE BALL WAS OUT TO RIGHT, REQUIRING RIGHT RUDDER, A/C WOULD BE ROLLING LEFT. IF SIDESLIP NOT KEPT EXACTLY ZERO, ROLL CONTROL WOULD BE EATEN UP, PILOT ENDING UP HOLDING HEAVY AILERON FORCES TO COUNTERACT ROLL DUE TO RUDDER COORDINATION ATTEMPTS. LATERAL FORCES CHANGED DRAMATICALLY FROM SIDE TO SIDE; HARD TO PIN THEM DOWN. SINCE RUDDER HAD TO BE USED A LOT, WANTED REASONABLY LIGHT RUDDER FORCES.	FORCES AND DISPLACEMENTS PRETTY GOOD.	BIT OF A PROBLEM TRYING TO FIGURE OUT WHAT TO SELECT BECAUSE OF INTERACTION BETWEEN DIRECTIONAL AND LATERAL. A TOUCH OF RUDDER PRODUCED SNAPPY ROLL RESPONSE, SO LARGE LATERAL COMPENSATIONS HAD TO BE MADE TO TAKE OUT EFFECTS OF RUDDER. THEREFORE RUDDER HAD TO BE HEAVY ENOUGH TO PREVENT INADVERTENT INPUTS AND OVERCONTROL. AILERON FORCES SET AT WHAT SEEMED REASONABLE VALUES.
$L'_{\delta_{AS}}$ $N'_{\delta_{RP}}$	43.1 9.99	54.7 11.4	38.3 11.4
LATERAL AND DIRECTIONAL CONTROL	IF PILOT TRIED DRIVING AROUND WITHOUT REGARD TO BALL USING AILERON ONLY, HE COULD QUICKLY GET INTO HORRIBLY UNCOORDINATED MANEUVERS. YAW DUE TO ROLL CONFUSING AT LEAST, BUT SEEMED TO BE SOMEWHAT IN NORMAL SENSE. COORDINATION SURELY REQUIRED. IF BALL NOT KEPT CENTERED, IT LED TO MANY PROBLEMS. WITH AILERONS ONLY, COULD GET INTO SERIOUS PROBLEMS. BALL WOULD GO TO ONE CORNER; COULD RUN OUT OF ROLL CONTROL. IMPERATIVE TO USE RUDDER; REQUIRED CONSTANT ATTENTION.	ROLL CONTROL PRETTY GOOD, BUT QUITE A BIT OF YAW INVOLVED WITH APPLICATION OF AILERON; APPEARS TO BE ADVERSE; MAYBE SOME ADVERSE YAW DUE TO ROLL, TOO. QUITE A HIGH POSITIVE DIHEDRAL EFFECT; REQUIRES QUITE A BIT OF PILOT ATTENTION TO COORDINATE TURN. SEEMS TO BE CONTINUOUS REQUIREMENT FOR RUDDER REVERSALS.	ROLL HAD UNSETTLING FEELING. UNPREDICTABLE. PILOT HAD FEELING IT WOULD KEEP ON GOING; SLIGHT TENDENCY TO OVERCONTROL. YAW DUE TO ROLL CONFUSING. INITIALLY A LITTLE RUDDER COORDINATION REQUIRED IN DIRECTION OF TURN, SO MUCH ROLL RESPONSE TO SIDESLIP THAT AT TIMES COULDN'T SEE ANY BALL DEVIATIONS. YET ROLL CONTROL WAS BEING DISSIPATED BECAUSE OF SIDESLIP EFFECTS. IN STEADY-STATE TURNS, HAD TO HOLD AILERON FORCE AGAINST TURN. SMALL CHANGES IN TRIM WOULD ACCENTUATE EFFECT.
DIFFERENCES IN IFR AND VFR	A/C MORE DANGEROUS VFR THAN IFR. OUT OF TURBULENCE AND RIGHT ON TOP OF IT, BY KEEPING THE BALL CENTERED AND USING A LOT OF SMALL HIGH FREQUENCY INPUTS, COULD GET JOB DONE IFR.	NO DIFFERENCE IN FLIGHT, BUT PILOT COULD COPE WITH VFR SITUATION A LITTLE BETTER DUE TO INCREASED REFERENCES.	IN VFR, PROBLEMS WERE JUST MAGNIFIED BY USING FASTER INPUTS. SOME DIFFICULTY BEING PRECISE WITH BANK ANGLE ON ILS.
EFFECTS OF TURBULENCE	DRAMATIC AND DISCONCERTING BECAUSE OF INTERACTIONS BETWEEN LATERAL AND DIRECTIONAL. COULD END UP WITH BALL OVER IN SIDE POCKET. TRYING TO FIGHT IT LATERALLY, JUST WITH AILERONS, SOME VERY HEAVY FORCES CAN BE PRODUCED.	SIGNIFICANT ON HANDLING QUALITIES; MAKES A LOT OF DIFFERENCE IN OVERALL A/C CONTROL.	DRAMATIC; VERY FAST ROLL RESPONSE TO TURBULENCE.
CONTROL IN CROSSWIND	REALLY BECAME CONFUSING IN CROSSWIND. FELT AS IF IT WERE GOING TO SWAP ENDS IF LET GO INTO WIND. DISLIKED BOTH TECHNIQUES; BOTH UNCOMFORTABLE.	DIDN'T SEEM TO DETER THE HANDLING QUALITIES; ALREADY SO BAD, DIFFICULT TO TELL ANYTHING. STRAIGHT CRAB TECHNIQUES WITH SMALL WING-LOW USED.	NO COMMENTS.
FAVORABLE FEATURES	UNKNOWN IF ANY.	NONE OUTSTANDING.	NONE.
OBJECTIONABLE FEATURES	PRINCIPALLY, THE LARGE CROSS-COUPLING BETWEEN LATERAL AND DIRECTIONAL. ALWAYS HAD TO BE ON TOP OF IT WITH FEET AND KEEP SIDESLIP AT ZERO TO KEEP A/C UNDER CONTROL.	EFFECTS OF TURBULENCE SIGNIFICANT. HIGH ROLL TO SIDESLIP OF DUTCH ROLL IS OBJECTIONABLE.	DEFINITE LACK OF CONFIDENCE IN CONFIGURATION BECAUSE OF TAKING OFF IN ROLL CONTROL AND EXTREME ROLL RESPONSE TO RUDDER. COORDINATION REQUIRED BUT WITH RESPONSIVENESS OF THE RUDDER AS ROLL CONTROL, WISER NOT TO USE IT, ESPECIALLY CLOSE TO THE GROUND. EASY TO USE UP ROLL CONTROL WITH SIDESLIP AS RESULT OF RUDDER INPUTS.
PRIMARY REASON FOR PILOT RATING	ADEQUATE PERFORMANCE NOT ATTAINABLE WITH TOLERABLE WORKLOAD. JOB COULD BE DONE, BUT PILOT HAD TO WORK TOO HARD. SURELY DISLIKED TURBULENCE RESPONSE. ALTHOUGH EVALUATION TESTS COULD BE ACCOMPLISHED, BEST EFFORTS REQUIRED TO KEEP CONTROL.	A/C HAS MAJOR DEFICIENCIES; INTENSE PILOT COMPENSATION REQUIRED TO RETAIN CONTROL. QUITE DIFFICULT TO RATE FOR TURBULENCE BECAUSE BASIC A/C SO BAD. A/C WOULD PROBABLY BE MODERATELY AFFECTED BY TURBULENCE.	CERTAINLY UNSATISFACTORY; DEFICIENCIES VERY OBJECTIONABLE. JOB COULD BE DONE, BUT REALLY HAD TO WORK AT AT. OCCASIONAL EXCURSIONS CLOSE TO GROUND WHERE THINGS MOVED MORE RAPIDLY THAN DESIRED COULD REALLY CAUSE TROUBLE. TURBULENCE RESPONSE REQUIRED BEST EFFORTS TO CONTEND WITH.

GROUP 9 (Cont.) STICK CONTROLLER	$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.05$ PILOT A	$N'_{\delta_{AS}}/L'_{\delta_{AS}} = +0.10$ PILOT B
NATURAL TURBULENCE MAX. X-WIND (~KT)	MODERATE 18	MODERATE 8
PR/TR	5/D	5.5/D
GENERAL COMMENTS	GOOD OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES. A/C FAIRLY EASY TO CONTROL.	LATERAL OSCILLATIONS WITH ANY DISTURBANCE, FAIRLY LARGE BANK ANGLE EXCURSIONS. OSCILLATIONS DAMP OUT RAPIDLY. NO PROBLEM. UNSUITABLE FOR LANDING APPROACH. DURING LATERAL OFFSET MANEUVER, REALLY OVERCONTROLLED BECAUSE OF RAPID ROLL RESPONSE; JUST CAME ON TOO FAST. ILS PERFORMANCE GOOD.
ABILITY TO TRIM	NO PARTICULAR PROBLEMS.	WITH LARGE, CRISP ROLL RESPONSE TO TURBULENCE, FAIRLY DIFFICULT TO TELL WHAT'S GOING ON WITH LATERAL TRIM. DOESN'T SEEM TO FALL OFF. OSCILLATES ABOUT CENTER.
SELECTION OF CONTROL SENSITIVITIES	GOOD FORCES, DISPLACEMENTS, AND CONTROL HARMONY.	BIT OF COMPROMISE IN SELECTING LATERAL GEARING, IN TERMS OF TURN COORDINATION. RUDDER SUCH A GOOD ROLL CONTROL THAT COORDINATION ATTEMPTS CAUSE OVERBANKING. PILOT ENDS UP HOLDING AILERON AGAINST TURN WITH HIGH FORCES. PREFER FORCES A LITTLE HEAVY TO PREVENT INADVERTENT INPUTS, BUT NOTICED, PARTICULARLY IN VFR SETTING UP AGAINST CROSSWIND, THAT LARGE LATERAL FORCES EXISTED. WHEN STEADY AILERON INPUTS HAD TO BE HELD, FORCES NOTICEABLE AND UNSATISFACTORY
$L'_{\delta_{AS}}$ $N'_{\delta_{RP}}$	30.1 9.70	30.1 9.70
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL NOT BAD FOR THIS CLASS. ADVERSE YAW DUE TO ROLL SEEMS TO BE PRESENT. SOME PROVERSE YAW DUE TO AILERON INPUT. COORDINATION CAN BE ACHIEVED WITHOUT MUCH DIFFICULTY. SMALL HEADING CORRECTIONS EASILY MADE. ILS PERFORMANCE REQUIRED CONSIDERABLE EXTRA PILOT EFFORT.	ROLL RESPONSE TENDED TO TAKE OFF, UNPREDICTABLE. INITIAL RESPONSE SATISFACTORY. YAW DUE TO ROLL PRODUCED SMALL EXCURSION, BUT BALL WOULD STAY DISPLACED IN STEADY-STATE TURN. ATTEMPTS TO COORDINATE PRESENTED PROBLEMS BECAUSE OF LARGE ROLL DUE TO RUDDER. BEST TO LEAVE IT ALONE AND NOT TRY TO CENTER BALL PRECISELY.
DIFFERENCES IN IFR AND VFR	LESS PROBLEMS WITH VFR. DIFFICULTY IN MAKING SMALL HEADING CORRECTIONS TO LOCALIZER UNDER IFR CONDITIONS. ILS DIFFICULT TO PERFORM IN PRECISION-LIKE MANEUVER.	MORE PROBLEMS ON VFR, WHERE LARGE MANEUVERS INVOLVED AND JOBS HAD TO BE DONE FASTER THAN ON ILS, WHICH INVOLVED SMALLER CORRECTIONS.
EFFECTS OF TURBULENCE	NOT TOO MUCH, ALTHOUGH ANYTIME DISTURBANCES CAUSED AN OUT OF COORDINATION MANEUVER, HAD PROBLEM IN BRINGING A/C BACK INTO COORDINATED FLIGHT.	QUITE NOTICEABLE, PARTICULARLY LATERALLY WHERE RESPONSE VERY SHARP, QUICK, AND LARGE IN AMPLITUDE.
CONTROL IN CROSSWIND	NO APPARENT EFFECT; NO PROBLEM; USED STRAIGHT CRAB TECHNIQUE.	TRYING WING-LOW METHOD, HAD TO HOLD LARGE AILERON AND RUDDER FORCES. SO, CRAB METHOD TRIED; IT WAS ALL RIGHT UNTIL PILOT TRIED TO DECRAB. STARTLING BECAUSE OF TREMENDOUS ROLL RESPONSE TO ANY ABRUPT RUDDER INPUT. FORCES WERE O.K. IN CRAB METHOD
FAVORABLE FEATURES	NONE OUTSTANDING.	DIDN'T REALLY NEED COORDINATION TO MAKE TURN AT REASONABLE RATE COULD LEAVE BALL DISPLACED AND TURN AT RATE ADEQUATE FOR LANDING APPROACH.
OBJECTIONABLE FEATURES	DIFFICULTY IN COORDINATION, IN TRIMMING, AND WITH FORCES INVOLVED TO BRING A/C BACK INTO COORDINATED FLIGHT. MAKING SMALL HEADING CORRECTIONS IN TURBULENCE WAS PROBLEM.	PRIMARILY ROLL RESPONSE. TENDENCY TO ACCELERATE IN ROLL. ↓
PRIMARY REASON FOR PILOT RATING	NOT PARTICULARLY HAPPY WITH PERFORMANCE. DIFFICULTY IN BRINGING A/C BACK INTO COORDINATED FLIGHT IN TURBULENCE.	(WIRE RECORDER MALFUNCTION PREVENTED FURTHER COMMENTS)

GROUP 10	$N'\delta_{AW}/L'\delta_{AW} = -0.05$ PILOT B	$N'\delta_{AW}/L'\delta_{AW} = -0.05$ PILOT A	$N'\delta_{AW}/L'\delta_{AW} = 0$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE 24, GUSTING TO 28	LIGHT (+) 16	MODERATE (–) 17
PR/TR	7/E	9/E	3/B
GENERAL COMMENTS	SLOPPY, PRINCIPALLY IN DIRECTIONAL. BALL MOVES VERY SLOWLY THROUGH LARGE EXCURSIONS. CROSS-TALK BETWEEN WHAT BALL WAS DOING AND WHAT PILOT HAD TO DO LATERALLY, SO LATERAL CONTROL WAS KIND OF LUMPY. UNPLEASANT A/C TO FLY. SOME DIFFICULTY ON FINAL STAGES OF ILS. UNSUITABLE FOR LANDING APPROACH.	LATERAL CONTROL QUITE STRANGE. OVERALL LATERAL DIRECTIONAL CONTROL CAPABILITIES OF PILOT WITH A/C POOR. COORDINATION VERY DIFFICULT. VERY LITTLE TENDENCY TO OSCILLATE, JUST FLOPS OFF TO ONE SIDE AND STAYS THERE UNTIL IT IS BROUGHT BACK. SUITABILITY FOR LANDING APPROACH VERY POOR. VERY DIFFICULT TO MANEUVER PRECISELY, REQUIRING ALMOST CONSTANT RUDDER APPLICATION.	OVERALL, LOOKED GOOD; SUITABLE FOR LANDING APPROACH. AFTER CONSTANT BANK ANGLE ESTABLISHED, RUDDER REQUIRED INTO TURN.
ABILITY TO TRIM	LATERAL TRIM A PROBLEM; i.e., NEVER COULD BE SURE THAT BALL WAS STATIONARY. IT WOULD LOOK LIKE IT WAS TRIMMED AND THEN BALL WOULD DRIFT OFF TO ONE SIDE AND UPSET LATERAL TRIM.	LATERALLY AND DIRECTIONALLY, QUITE POOR.	A LITTLE TOUCHY DIRECTIONALLY; LATERAL NO PROBLEM.
SELECTION OF CONTROL SENSITIVITIES	RUDDER NO PROBLEM. LATERAL FORCES GOT NOTICEABLE; HOWEVER, IN NORMAL FLYING, WITH PRECISION CONTROL, IT FELT GOOD. PROBABLY LATERAL COULD HAVE BEEN A LITTLE MORE SENSITIVE BUT NOT A LOT.	FORCES AND DISPLACEMENTS NO PROBLEM UNDER NON-TURBULENT CONDITIONS, BUT UNDER TURBULENCE MUCH MORE RUDDER CONTROL POWER DESIRED BECAUSE PILOT BEGINS TO TIRE. WHEEL FORCES BECAME QUITE HEAVY.	(VALUES WERE ASSIGNED.) GEAR RATIOS APPEARED GOOD; FORCES VERY LIGHT.
$L'\delta_{AW}$	5.51	3.01	3.49
$N'\delta_{RP}$	9.82	9.95	11.7
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL, IN ITSELF, WAS PRECISE AND PREDICTABLE. YAW DUE TO ROLL SEEMED TO BE A PROBLEM. EVERYTHING HAPPENED VERY SLOWLY; PILOT HAD TO PAY ATTENTION TO BALL DIRECTLY AND USE RUDDER TO CENTER BALL. COORDINATION REQUIREMENTS GAVE A NOTICEABLE EFFECT LATERALLY. ONLY WAY TO DO IT WAS TO USE RUDDER TO KEEP BALL CENTERED.	QUITE PRONOUNCED ADVERSE YAW DUE TO ROLL CONTROL, REQUIRING A LOT OF COORDINATION AND MAKING DIRECTIONAL AND LATERAL TRIM QUITE DIFFICULT TO OBTAIN. NOSE GOES BACK AND FORTH ACROSS THE HORIZON; PILOT BRINGS IT BACK AND IT GOES OFF IN THE OTHER DIRECTION. A/C, HOWEVER, IS CONTROLLABLE. VERY LITTLE TENDENCY FOR NOSE TO OSCILLATE RAPIDLY. NOSE GOES OFF IN ONE DIRECTION AND SEEMS TO STAY THERE, BUILDING UP QUITE A LARGE YAW ANGLE; PILOT MUST BRING IT BACK TO CENTER. DIFFICULT TO COORDINATE; SIGNIFICANT OPPOSITE AILERON MUST BE USED TO KEEP IT FROM ROLLING IN DIRECTION OF BANK.	ROLL CONTROL VERY GOOD; NO PROBLEMS. UPON ENTERING A TURN, THERE WAS A BALL EXCURSION IN DIRECTION OF TURN; HOWEVER, ONCE BANK ANGLE ESTABLISHED, BALL REMAINED DEFLECTED INTO TURN. SO, THERE WAS A REQUIREMENT FOR STEADY RUDDER INTO TURN TO MAINTAIN COORDINATION. SMALL RUDDER INPUTS PRODUCED LARGE ROLL RATIOS IN DIRECTION OF INPUT
DIFFERENCES IN IFR AND VFR	WITH PRECISION CONTROL REQUIRED IFR, CONCENTRATING ON KEEPING HEADING EXCURSIONS SMALL, COULD DO A BETTER JOB THAN VFR, WHERE REAL SLOPPINESS OF A/C WAS A PROBLEM.	EASIER TO CONTROL NOSE WANDERING ON VFR, BUT VFR AND IFR BOTH POOR IN TERMS OF EFFORT REQUIRED TO PERFORM ASSIGNED TASKS.	NO DIFFERENCES.
EFFECTS OF TURBULENCE	BOTHERSOME LOW FREQUENCY OSCILLATION, PRINCIPALLY DIRECTIONALLY. FED THROUGH LATERAL AS WELL.	PILOT WORK LOAD SIGNIFICANTLY INCREASED IN TURBULENCE, PARTICULARLY FOR RUDDER CONTROL. MAKING SMALL HEADING CORRECTIONS ALMOST IMPOSSIBLE.	TURBULENT CONDITIONS PRODUCED SMALL EXCURSIONS IN YAW ACCOMPANIED BY LARGE ROLLING MOTIONS.
CONTROL IN CROSSWIND	SOME DIFFICULTY IN TRYING TO KEEP NOSE STRAIGHT. HAD TO OVERCONTROL DIRECTIONALLY BECAUSE IT WAS RATHER LOOSE.	NO MORE DIFFICULT THAN ANY OTHER ASPECT OF THIS WORMY A/C.	CRAB METHOD USED; NO PROBLEMS.
FAVORABLE FEATURES	NONE.	NONE NOTED.	OVERALL MANEUVERABILITY GOOD.
OBJECTIONABLE FEATURES	BALL ALWAYS SEEMED TO BE SLIDING OUT TO ONE SIDE OR THE OTHER. TURBULENCE RESPONSE A PROBLEM. DIRECTIONAL WAS FEEDING THROUGH, CAUSING LATERAL FORCES TO VARY QUITE A BIT.	BUILD-UP OF YAW RATES AND NOT CORRECTING THEM REQUIRES PILOT TO KEEP VERY CLOSE TRACK OF DIRECTIONAL CONTROL AND TO MANIPULATE THE RUDDERS ALMOST CONSTANTLY.	REQUIREMENT FOR CONSTANT RUDDER INTO TURN OBJECTIONABLE, BUT COULD PROBABLY BECOME ACCUSTOMED TO IT.
PRIMARY REASON FOR PILOT RATING	A/C COULD BE CONTROLLED AND PILOT BELIEVES HE COULD GET IT ON GROUND EVEN IN CROSSWIND. HOWEVER, ADEQUATE PERFORMANCE NOT ATTAINABLE WITH TOLERABLE WORKLOAD. TURBULENCE RESPONSE REQUIRED BEST PILOT EFFORTS.	INTENSE PILOT COMPENSATION REQUIRED TO MANTAIN CONTROL.	MINIMAL PILOT COMPENSATION REQUIRED FOR DESIRED PERFORMANCE. SLIGHTLY MORE EFFORT REQUIRED, BUT NO DETERIORATION IN TURBULENCE.

GROUP 10 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$ PILOT B
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT(+) 20, GUSTING TO 24	MODERATE (+) 26, GUSTING TO 32
PR/TR	3/C	4/D
GENERAL COMMENTS	WIRE RECORDER MALFUNCTION.	MARGINALLY SATISFACTORY. ONE PROBLEM IS THE COMPROMISE IN ADJUSTING LATERAL SENSITIVITIES. WITH SOME RESERVATIONS, SUITABLE FOR LANDING APPROACH.
ABILITY TO TRIM		DIFFICULT TO TRIM LATERALLY. SMALL BALL EXCURSIONS REQUIRED LARGE COUNTERACTING DISPLACEMENTS AND HEAVY FORCES LATERALLY.
SELECTION OF CONTROL SENSITIVITIES		NO PROBLEMS WITH RUDDER. LATERAL CONTROL NOT SMOOTH; FORCES CONSTANTLY CHANGING. SENSITIVITIES INITIALLY SELECTED PROVED HEAVY LATER IN FLIGHT. INCREASED SENSITIVITY TO WHERE WOULD WANT TO GO NO MORE SENSITIVE, BUT IT STILL FELT TOO HEAVY SO COMPROMISED.
$L'_{\delta_{AW}}$	6.77	4.34
$N'_{\delta_{RP}}$	11.5	11.8
LATERAL AND DIRECTIONAL CONTROL		ROLL CONTROL PREDICTABLE; NO TENDENCY TO OVERCONTROL. ONE PROBLEM IS THAT IT ROLLS VERY EASILY WITH RUDDER, SO ANY SLIGHT BALL DISTURBANCE MAKES A NOTICEABLE IMPACT ON LATERAL FORCES. DIDN'T SEEM TO BE VERY MUCH YAW DUE TO ROLL, BUT THERE WAS A LOT OF VARIABILITY IN THE LATERAL FORCES DURING MANEUVERS. COORDINATION POSSIBLY A PROBLEM, i.e., EFFECTS OF SMALL DIRECTIONAL COORDINATION REQUIREMENTS QUITE LARGE LATERALLY.
DIFFERENCES IN IFR AND VFR		ON IFR, GOOD, PILOT COULD BE PRECISE; NO PROBLEMS. ON VFR, ONLY COMPLAINT IS VARIABILITY IN LATERAL FORCES.
EFFECTS OF TURBULENCE		LATERAL RESPONSE TO TURBULENCE A BIT MORE THAN DESIRED. VERY CRISP, MOVES IMMEDIATELY; CONSTANT TASK LATERALLY TO CONTEND WITH.
CONTROL IN CROSSWIND		DID CROSSWIND APPROACHES WITH ORIGINAL GEARING; NOTICED RATHER LARGE LATERAL FORCES. PROBABLY WOULD HAVE BEEN BETTER WITH FINAL GEARING SELECTIONS MADE. COULD CONTROL THINGS BUT HAD TO WORK AT IT.
FAVORABLE FEATURES		NOTHING SPECIFIC.
OBJECTIONABLE FEATURES		LARGE SENSITIVITY TO RUDDER INPUTS IN LATERAL PLANE THAT MADE COORDINATION A BOTHERSOME REQUIREMENT. ALSO A LARGE TURBULENCE RESPONSE IN LATERAL AXIS. MAIN OBJECTION WAS LUMPINESS IN AILERONS. THE EVER CHANGING FORCE REQUIREMENT. IN STEADY TURNS A LITTLE RUDDER HAD TO BE USED INTO THE TURN WHICH MEANT CORRECTING WITH BANK.
PRIMARY REASON FOR PILOT RATING		UNSATISFACTORY WITHOUT IMPROVEMENT.

GROUP 10 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.15$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE 10	LIGHT 1	LIGHT (+) 1
PR/TR	4.5/D	4/D	3.5/D
GENERAL COMMENTS	EVERYTHING SEEMED TO BE IN MIDDLE GROUND; WISHY-WASHY. A LITTLE TENDENCY TO OVERBANK IN SIDESLIP MANEUVER. THAT WAS THE ONLY TIME PILOT NOTICED IT.	LATERAL DIRECTIONAL HANDLING QUALITIES GOOD.	CLOSE TO SATISFACTORY, YET SOMETHING ABOUT IT DISLIKED. ROLL CONTROL SEEMS LUMPY; FORCES ERRATIC. FLYING A/C A LITTLE UNPLEASANT. WITH SOME MINOR QUALIFICATIONS, SUITABLE FOR LANDING APPROACH.
ABILITY TO TRIM	SOME DIFFICULTY WITH LATERAL TRIM.	TRIM SOMEWHAT SLOW WITH AILERON. SLIGHTLY DIFFICULT TO CENTER BALL WITH RUDDER.	NO DIFFICULTIES: SATISFACTORY.
SELECTION OF CONTROL SENSITIVITIES	MODERATE INTERACTION BETWEEN RUDDER AND AILERONS LED TO SOME COMPROMISE LATERALLY. MAKING IT SENSITIVE ENOUGH TO CONTEND WITH HIGH FORCES GENERATED WHEN NOT PERFECTLY COORDINATED, MAKES A/C TOO SENSITIVE IN COORDINATED MANEUVERS. RUDDER SENSITIVITY SELECTED SO THAT RESIDUAL BALL EXCURSIONS IN STEADY TURN COULD BE SQUEEZED OUT WITHOUT RUDDER FORCES BEING TOO HIGH.	FORCE AND DISPLACEMENT OF CONTROLS NO PARTICULAR PROBLEM. GEARING RATIOS O.K.	NO PROBLEMS WITH FORCES OR DISPLACEMENTS DIRECTIONALLY. LATERALLY, WOULDN'T WANT TO GO ANY MORE SENSITIVE. FAIRLY HIGH ROLL DUE TO RUDDER, AND A SHARP, SMALL AMPLITUDE RESPONSE TO TURBULENCE. IF HIT BY GUST IN RIGHT DIRECTION WHEN INITIATING TURN OR PUSHING RUDDER, ROLL RESPONSE MODIFIED SIGNIFICANTLY. THEREFORE, DIFFICULT TO SETTLE ON A ROLL SENSITIVITY. SELECTED WHAT SEEMED A HAPPY COMPROMISE.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	3.90 12.7	2.57 13.0	3.04 9.95
LATERAL AND DIRECTIONAL CONTROL	ROLL RESPONSE BY ITSELF SATISFACTORY. INITIAL RESPONSE AND FINAL RESPONSE PREDICTABLE. YAW DUE TO ROLL WAS IN NORMAL SENSE. TURN COORDINATION REQUIRED; BOTHERSOME. USE OF RUDDER TO CENTER BALL IN STEADY TURN WOULD CAUSE OVERBANKING, THEN AILERON WOULD HAVE TO BE HELD OUT OF THE TURN.	ROLL RESPONSE VERY GOOD. CONTINUOUS RUDDER INPUTS ARE REQUIRED FOR COORDINATED TURNS; HOWEVER, FORCE DISPLACEMENT NOT GREAT. VERY LITTLE TENDENCY FOR NOSE TO WANDER. DUTCH ROLL MODE SEEMED A MODERATE FREQUENCY BUT WELL DAMPED. VERY HIGH ϕ/β. LITTLE BIT OF RUDDER APPLICATION REALLY CRANKS IN A LOT OF ROLL, BUT NOT PARTICULARLY NOTICEABLE.	ROLL CONTROL SEEMED SATISFACTORY. WHEN STEPPED ON RUDDER IN CONJUNCTION WITH ROLL INPUT, FELT IT WAS LURCHING. TENDENCY TO BE SOMEWHAT UNPREDICTABLE IN ROLL WHEN HIT BY GUST OR WHEN USING RUDDER. MAJOR OBSERVATION ON YAW DUE TO ROLL WAS THE REQUIREMENT FOR STEADY-STATE COORDINATION AND HAVING TO PUT A LITTLE FORCE CORRECTION IN AILERONS WHEN CENTERING BALL. NO PROBLEM TO COORDINATE.
DIFFERENCES IN IFR AND VFR	NOTHING STANDS OUT.	WIRE RECORDER MALFUNCTION.	NO DIFFERENCES EXCEPT IN NATURE OF MAGNITUDES OF MANEUVERS.
EFFECTS OF TURBULENCE	EFFECTS OF TURBULENCE MODERATE. BOTHERSOME IN THAT SIDE GUSTS GAVE PROBLEMS WITH BALL AND WITH LATERAL CONTROL.		CERTAINLY NOTICEABLE AND PRIMARILY LATERAL IN SMALL, SHARP ROLL INPUTS. ONCE PILOT DISCOVERED THAT A/C DIDN'T GO ANYWHERE AND NOTHING COULD BE DONE ABOUT TURBULENCE RESPONSE, NO PROBLEM TO KEEP UNDER CONTROL.
CONTROL IN CROSSWIND	NOTHING STANDS OUT.		NO CROSSWIND; MAY HAVE CHANGED SENSITIVITY SELECTIONS.
FAVORABLE FEATURES	NO COMMENTS.		NO COMMENTS.
OBJECTIONABLE FEATURES	DISLIKED INTERACTION BETWEEN RUDDERS AND AILERONS. COULDN'T COORDINATE WITHOUT THINKING ABOUT IT. IT WAS A TWO-STEP OPERATION; NEVER COULD GET RUDDER AND AILERONS TO WORK TOGETHER.		PRIMARY COMPLAINT WAS VARIABILITY OF LATERAL FORCES. COORDINATION REQUIRED; LARGE INTERACTION BETWEEN RUDDER INPUTS AND ROLL RESPONSE.
PRIMARY REASON FOR PILOT RATING	JOB COULD BE DONE, BUT UNSATISFACTORY AS PILOT SAW IT. TURBULENCE BOTHERSOME; AND PILOT HAD TO MAKE SOME EFFORT TO CONTEND WITH IT; COULDN'T BE DONE WITHOUT SOME THOUGHT IN CATEGORY OF "MODERATELY MORE EFFORT REQUIRED."		DEFICIENCIES RANGE BETWEEN MILDLY UNPLEASANT AND ANNOYING. TURBULENCE RESPONSE IN "MORE EFFORT REQUIRED" CATEGORY.

GROUP 11	$N'\delta_{AW}/L'\delta_{AW} = -0.10$ PILOT A	$N'\delta_{AW}/L'\delta_{AW} = -0.10$ PILOT A	$N'\delta_{AW}/L'\delta_{AW} = -0.05$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT TO MODERATE. 2	LIGHT (+) 9	LIGHT TO MODERATE 6
PR/TR	4/B	5/D	5/D
GENERAL COMMENTS	OVERALL LATERAL-DIRECTIONAL HANDLING QUALITIES A LITTLE LESS THAN FAIR. ANNOYING FOR A/C TO WALLOW AROUND IN SKY. SUITABILITY FOR LANDING APPROACH IS FAIR.	OVERALL, FAIR. SLOW OSCILLATIONS MOSTLY DIRECTIONAL. VERY LITTLE ROLLING ASSOCIATED WITH OSCILLATION.	SOME RESERVATIONS ABOUT SUITABILITY FOR LANDING APPROACH. MODERATE ROLL RATE GENERATES LARGE, UNCOMFORTABLE ADVERSE YAW. NO TECHNIQUE AVAILABLE FOR GOOD TURN COORDINATION.
ABILITY TO TRIM	NOT BADLY DEGRADED, BUT SENSITIVE IN DIRECTIONAL AND LATERAL CONTROL, MOSTLY DIRECTIONALLY.	DIFFICULT TO TRIM DIRECTIONALLY, MAKING IT PRETTY TOUGH TO TRIM LATERALLY	SATISFACTORY; NOTHING NOTICED.
SELECTION OF CONTROL SENSITIVITIES	FORCES APPEAR GOOD, WITH NO LARGE EXCURSIONS IN DISPLACEMENTS. GOOD GEAR RATIOS. FAIRLY HEAVY AILERON AND RUDDER FORCES REQUIRED FOR SMALL CORRECTIONS	(PREVIOUSLY SELECTED VALUES WERE ASSIGNED.) SENSITIVITIES NOT BAD. FORCES AND DISPLACEMENTS GOOD	NO COMMENTS ON LATERAL GEAR SELECTION. RUDDER POSSIBLY SELECTED A LITTLE TOO SENSITIVE. DURING LATTER PART OF EVALUATION, REQUIREMENT FOR RUDDER INTO TURN BECAME MORE NOTICEABLE; IN TRYING TO COUNTERACT, PILOT TENDED TO OVERCONTROL WITH RUDDER.
$L'_{\delta_{AW}}$	3.42	3.49	3.90
$N'_{\delta_{RP}}$	8.04	8.10	8.04
LATERAL AND DIRECTIONAL CONTROL	PRETTY GOOD ROLL CONTROL. CONSIDERABLE ADVERSE YAW DUE TO ROLL. YAW DUE TO AILERON INPUTS NOT DETECTABLE. COORDINATION SOMEWHAT SHAKY. QUITE A BIT OF RUDDER REQUIRED TO MAINTAIN COORDINATED TURNS, BUT SLACKS OFF AFTER TURN ESTABLISHED. DUTCH ROLL APPEARS TO BE PURELY A SNAKING MOTION WITH ZERO DIHEDRAL EFFECT. RUDDER INPUT AND RELEASE RESULTS IN RELATIVELY LOW DAMPED, STRAIGHT YAWING MOTION AT A LOW FREQUENCY.	ROLL CONTROL ADEQUATE; QUITE RESPONSIVE. ON ENTERING A TURN, NOSE WOULD SWING OUT OF THE TURN, AND MUCH EFFORT REQUIRED TO MAINTAIN COORDINATED FLIGHT. AFTER TURN ESTABLISHED, MINIMUM EFFORT REQUIRED FOR COORDINATION. ROLL DUE TO RUDDER INPUTS VERY LIMITED; WING COULDN'T BE RAISED WITH RUDDER. NOSE WANDERED CONTINUOUSLY BACK AND FORTH ALONG HORIZON, MAKING IT DIFFICULT TO MAINTAIN SPECIFIC HEADING.	ROLL CONTROL GOOD. INITIAL RESPONSE AND PREDICTABILITY SATISFACTORY. YAW DUE TO ROLL SEEMED TO WORSEN AS A/C FLOWN. NOSE WOULD "HANG UP", AND USING RUDDER TO BRING IT AROUND WOULD RESULT IN SLIGHT OVERCONTROL. DIDN'T DO THE JOB SATISFACTORILY. RUDDER COORDINATION WAS IN NORMAL SENSE, BUT DISLIKED COORDINATION REQUIRED
DIFFERENCES IN IFR AND VFR	NONE NOTICEABLE	YAWING MOTIONS COULD BE DAMPED OUT IN VFR MUCH EASIER THAN IN IFR. QUITE DIFFICULT, WHEN ON IFR AND TRYING TO FLY PRECISION TASK, PARTICULARLY IN TURBULENT CONDITIONS.	MAJOR DEFICIENCIES SHOW UP IN LARGER AMPLITUDE MANEUVERS REQUIRED IN VFR SITUATION, SUCH AS SIDESLIP MANEUVER. GOOD DEGREE OF PRECISION OBTAINED ON IFR.
EFFECTS OF TURBULENCE	PILOT UNCORRECTED EXCURSIONS SOMEWHAT LARGE, BUT DAMP THEMSELVES OUT NICELY. MAINTAINING PRECISE HEADING QUITE DIFFICULT, SLIGHTLY MORE THAN IT SHOULD BE. CONSIDERABLE OSCILLATIONS ABOUT CHOSEN HEADING, BUT PERFORMS FAIRLY WELL UNDER INSTRUMENT CONDITIONS AS LONG AS PILOT DOESN'T TRY TO FIGHT IT. PRETTY GOOD FORCES REQUIRED ON WHEEL TO MAKE SMALL CORRECTIONS IN BANK. FOR COORDINATED MANEUVERS, RUDDER FORCES RELATIVELY HIGH.	SIGNIFICANT; BIG DEGRADING FACTOR, BECAUSE OF THE PROBLEM OF CONTROLLING YAWING OSCILLATIONS	RESPONSE TO TURBULENCE WAS ONLY DIRECTIONAL. GENERAL SLOPPINESS IN BALL. REALLY HAD TO WORK AT SUPPRESSING TURBULENCE EFFECTS
CONTROL IN CROSSWIND	CROSSWIND TOO LIGHT TO ASSESS.	EASY, WITH PLENTY OF CONTROL CAPABILITY.	NO COMMENTS
FAVORABLE FEATURES	NOTHING OUTSTANDINGLY GOOD.	VERY RESPONSIVE, LATERALLY AND DIRECTIONALLY	ROLL CONTROL ITSELF GOOD. RESPONSIVE, PREDICTABLE, AND OVERALL, SATISFACTORY
OBJECTIONABLE FEATURES	WHEEL AND RUDDER PEDAL FORCES REQUIRED WERE HIGH FOR COORDINATED MANEUVERS AND FOR SMALL CORRECTIONS IN BANK	LIGHTLY DAMPED, LOW FREQUENCY YAWING OSCILLATION CAUSED QUITE A DETERIORATION, PARTICULARLY IN TURBULENCE.	LARGE ADVERSE YAW REQUIRED RUDDER INTO TURN. REALLY NOTICEABLE IN RAPID VFR MANEUVERING. COULDN'T GET NOSE TO COME AROUND AS FAST AS DESIRED WITHOUT OVERCONTROLLING. TURBULENCE RESPONSE ALSO OBJECTIONABLE. SIDESLIP BOTHERSOME.
PRIMARY REASON FOR PILOT RATING	MODERATE PILOT COMPENSATION REQUIRED. DEFICIENCIES WARRANT IMPROVEMENT. A LITTLE BETTER DAMPING AND A LITTLE HIGHER FREQUENCY OF DUTCH ROLL MODE REQUIRED.	IN PILOT'S ESTIMATION, DEFICIENCIES CERTAINLY WARRANT IMPROVEMENT. MODERATELY OBJECTIONABLE. ADEQUATE PERFORMANCE COULD BE OBTAINED, BUT ONLY WITH CONSIDERABLE PILOT COMPENSATION. TASK PERFORMANCE MODERATELY DETERIORATED WITH TURBULENCE, REQUIRING MORE PILOT EFFORT.	ADEQUATE PERFORMANCE ATTAINABLE, HOWEVER, MUST BE WORKED AT. THEREFORE, UNSATISFACTORY. ONE THING THAT STANDS OUT IS SIDESLIP MANEUVER AND THE EXPERIENCE WITH THE ADVERSE YAW. REQUIREMENT FOR RUDDER INTO TURN WHEN INITIATING MODERATE RATE TURN CLASSIFIED AS MODERATELY OBJECTIONABLE RESULTING IN RATING OF FIVE.

GROUP 11 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	NONE CALM	LIGHT 6	LIGHT 13
PR/TR	4/D	2.5/C	3.5/C
GENERAL COMMENTS	SEEMED TO BE A DEGRADATION WHILE IN TURBULENCE, AT LEAST IN ROLL CONTROL. SOME WANDERING OF NOSE BACK AND FORTH. WITH NO WIND OR TURBULENCE, SUITABLE FOR LANDING APPROACH. UNDER TURBULENT CONDITIONS, WOULD REQUIRE INCREASED PILOT ATTENTION.	A/C IS SATISFACTORY. SUITABLE FOR LANDING APPROACH. ALMOST MINIMUM TURN COORDINATION REQUIRED NO SPECIAL PILOTING TECHNIQUE REQUIRED. ONE COMPLAINT WAS DIRECTIONAL TURBULENCE RESPONSE WITH OCCASIONAL LARGE BALL EXCURSIONS.	LARGE EXCURSIONS IN HEADING; i.e., NOSE CONTINUOUSLY WANDERED BACK AND FORTH. NO PROBLEM WITH ILS. SUITABLE FOR LANDING APPROACH VERY LITTLE, IF ANY, ROLL RESULTED FROM RUDDER INPUTS
ABILITY TO TRIM	SEEMED SOMEWHAT HARDER THAN NORMAL TO TRIM. LATERAL TRIM WAS LITTLE SLOW.	GOOD, NO COMPLAINTS.	NO BIG PROBLEM LATERALLY OR DIRECTIONALLY.
SELECTION OF CONTROL SENSITIVITIES	FORCES NOT OBJECTIONABLE BUT WHEEL DISPLACEMENTS SEEMED A LITTLE EXCESSIVE. PILOT FELT HE NEEDED A LITTLE MORE AILERON CONTROL BECAUSE HE COULDN'T COMFORTABLY CONTROL A/C LATERALLY. SHOULD HAVE WHATEVER COMPROMISE NECESSARY FOR LESS WHEEL DISPLACEMENT FOR LATERAL CONTROL. PARTICULARLY NOTICEABLE IN TURBULENCE.	SELECTED SENSITIVITY WITH VERY CRISP, PRECISE ROLL RESPONSE. MINIMUM COORDINATION REQUIRED, SO NO PROBLEM TO FIND ACCEPTABLE GEAR SELECTIONS.	PILOT WOULDN'T WANT TO CHANGE ANY GEAR RATIOS. A LITTLE MORE AILERON CONTROL POWER WOULD BE GOOD.
$L'_{\delta_{AW}}$	2.29	3.83	3.08
$N'_{\delta_{RP}}$	5.65	11.4	7.37
LATERAL AND DIRECTIONAL CONTROL	ROLL RESPONSE TO PILOT INPUT TOO SLOW. SHOULD BE INCREASED. COORDINATION NO PROBLEM EXCEPT DURING MANEUVERS WITH LARGE AILERON INPUTS	ROLL RESPONSE VERY GOOD; SMOOTH, FAST, AND PREDICTABLE. AND PRESENTED NO TENDENCY TO OVER CONTROL. YAW DUE TO ROLL NOT A FACTOR IN EVALUATION. WITH SMOOTH INPUTS, WHICH SEEM TO BE CONSISTENT WITH TYPE OF MISSION BEING EVALUATED, REQUIREMENT FOR TURN COORDINATION NOT NOTICEABLE. A/C COULD NOT ROLL WITH RUDDER ONLY.	ROLL CONTROL GOOD. YAW DUE TO ROLL ALMOST NON EXISTENT, NOT MUCH REQUIREMENT FOR COORDINATION. CONSTANT SNAKING MOTION OF THE NOSE, REQUIRING CONSTANT WORK WITH RUDDER TO MAINTAIN HEADING. COULD DAMP DIRECTIONAL OSCILLATIONS WITH CONTINUOUS RUDDER USAGE
DIFFERENCES IN IFR AND VFR	IN VFR, NOSE WOULD SWING BACK AND FORTH. DURING IFR, NOSE SWING NOT NOTICEABLE	NO DIFFERENCES NOTED.	NO PARTICULAR DIFFERENCES.
EFFECTS OF TURBULENCE	COULDN'T COMFORTABLY CONTROL IT LATERALLY IN TURBULENCE. MUCH AILERON DISPLACEMENT HAS TO BE USED; PARTICULARLY NOTICEABLE ON LATERAL OFFSET APPROACH COULD HAVE USED MORE AILERON CONTROL POWER UNDER THAT CONDITION.	TURBULENCE NOTICEABLE, BUT ONLY DIRECTIONALLY.	QUITE PRONOUNCED BY EXCITATION OF SNAKING MOTIONS. A/C SOMEWHAT DEGRADED, BUT NO SERIOUS CONTROL PROBLEM.
CONTROL IN CROSSWIND	NO COMMENTS	COULD USE BOTH CRAB AND WING-DOWN METHODS; GOOD DEGREE OF CONFIDENCE IN CONFIGURATION WITH EITHER METHOD.	NO PARTICULAR PROBLEMS ENCOUNTERED. NOSE WANDERING FROM SIDE TO SIDE DIFFICULT TO CONTROL, BUT MORE A NUISANCE THAN A PROBLEM.
FAVORABLE FEATURES	NO PARTICULARLY OUTSTANDING GOOD FEATURES.	ROLL CONTROL RESPONSE OUTSTANDING. LACK OF NEED TO COORDINATE TURNS WAS GOOD. A/C WAS SMOOTH; OUT OF TURBULENCE, VERY NICE TO FLY.	QUITE MANEUVERABLE
OBJECTIONABLE FEATURES	MAIN OBJECTION WAS ROLL CONTROL POWER IN TURBULENT CONDITIONS. SEEMED TO BE MARGINALLY ADEQUATE FOR PERFORMING THE JOB IN THIS AREA.	IN TURBULENCE, A LOT OF DIRECTIONAL RESPONSE, SIDESLIP RESPONSE, WHICH COULD BE CONTROLLED BUT DETRACTED SOMEWHAT FROM CONFIGURATION.	DIRECTIONAL OSCILLATIONS BOTHER SOME. REQUIRING EXTRA EFFORT. VERY LITTLE ROLL RESPONSE TO RUDDER INPUTS.
PRIMARY REASON FOR PILOT RATING	MINOR BUT ANNOYING DEFICIENCIES WARRANTING IMPROVEMENT. MODERATE PILOT COMPENSATION REQUIRED. DETERIORATION UNDER RAPID ROLL REQUIREMENTS DURING EITHER PRECISION APPROACH OR WAVE OFF IN TURBULENCE.	COULD CERTAINLY DO THE JOB; A/C SATISFACTORY. WITHOUT TURBULENCE, DEFINITELY A TWO; WITH DEGRADATION DUE TO TURBULENCE, RATING IS 2.5. TURBULENCE RATING IS C.	MILDLY UNPLEASANT DEFICIENCIES. MORE THAN AVERAGE INPUTS REQUIRED TO COUNTER SNAKING MOTIONS. EFFECTS OF TURBULENCE WERE A LITTLE EXTRA PILOT REQUIREMENT.

GROUP 11 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE 12	LIGHT 8	LIGHT (+) 15
PR/TR	1/A	2/A	2/B
GENERAL COMMENTS	CERTAINLY SUITABLE FOR LANDING APPROACH. COULD CERTAINLY DO AS GOOD A JOB IN ILS PERFORMANCE AS PILOT CAPABILITIES ALLOW.	OVERALL HANDLING QUALITIES APPEAR TO BE GOOD. LANDING APPROACH VERY GOOD. NO UNDUE INCREASE IN PILOT WORKLOAD. ILS PERFORMANCE VERY GOOD. VERY EASY TO COORDINATE A/C IN TURNS.	OVERALL, GOOD; ILS PERFORMANCE GOOD. NO SPECIAL PILOT TECHNIQUES REQUIRED.
ABILITY TO TRIM	NO DIFFICULTIES ENCOUNTERED.	SOMEWHAT DIFFICULT TO TRIM LATERALLY, BUT PERHAPS NOT AS DIFFICULT DIRECTIONALLY. VERY TOUCHY DIRECTIONALLY, BUT RUDDER TRIM EASILY ATTAINED.	NO PROBLEMS.
SELECTION OF CONTROL SENSITIVITIES	MUCH FREEDOM OF CHOICE; PILOT COULD CHOOSE JUST WHAT HE LIKED.	FORCES NO PROBLEM.	PREVIOUSLY SELECTED VALUES WERE ASSIGNED. SENSITIVITY GOOD.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	4.34 7.99	4.79 8.85	4.71 7.99
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL SMOOTH AND PREDICABLE. AN INPUT PRODUCES NICE, SMOOTH, LIVELY RESPONSE, CONSTANT RATES. SMOOTHNESS OUTSTANDING. YAW DUE TO ROLL OF NO CONSEQUENCE. BALL EXCURSIONS VERY RAPID AND SMALL. COORDINATION NOT A FACTOR; REALLY NOT REQUIRED.	VERY LITTLE YAW DUE TO ROLL APPARENT, MAKING TURN COORDINATION EASY. NOT QUITE SURE WHETHER YAW DUE TO ROLL, CERTAINLY NOT ADVERSE, IF PRESENT IT IS PROVERSE. ROLL CONTROL GOOD. COORDINATION IN TURNS NO PROBLEM. DUTCH ROLL DAMPED OUT PRETTY WELL. PERHAPS FREQUENCY A LITTLE BIT LOWER THAN DESIRED, BUT IT IS WELL DAMPED AND DOES NOT ADVERSELY AFFECT ABILITY TO FLY A/C.	ROLL CONTROL GOOD. ON INPUTTING AN AILERON, NOSE WOULD IMMEDIATELY SWING IN DIRECTION OF THE TURN, HENCE, LITTLE REQUIREMENT FOR COORDINATION. BALL SEEMED QUITE SENSITIVE TO RUDDER ON ENTERING A TURN. COULDN'T ROLL A/C WITH RUDDER.
DIFFERENCES IN IFR AND VFR	NO REAL DIFFERENCES NOTICED BETWEEN IFR AND VFR.	NONE.	NO PARTICULAR DIFFERENCE.
EFFECTS OF TURBULENCE	OCCASIONAL BLAST OF NATURAL TURBULENCE, BUT GENERALLY, EFFECTS OF TURBULENCE VERY MUCH.	NEGLIGIBLE.	OSCILLATION IN HEADING WITH NO ROLLING ASSOCIATED. NEITHER UNCOMFORTABLE NOR HARD TO CONTROL.
CONTROL IN CROSSWIND	NO GREAT EFFECT NOTICED. COULD USE EITHER METHOD SATISFACTORILY.	CRAB TECHNIQUE USED WITH NO PROBLEMS.	NO PROBLEMS USING CRAB TECHNIQUE.
FAVORABLE FEATURES	ROLL CONTROL OUTSTANDING, VERY SMOOTH. NO RUDDER COORDINATION REQUIRED; TURBULENCE RESPONSE NOT A FACTOR.	VERY EASY TO COORDINATE IN TURNS WITH MINIMAL EFFORT.	GOOD HANDLING A/C.
OBJECTIONABLE FEATURES	NONE.	NONE.	NO SERIOUS OBJECTIONS. COULDN'T ROLL WITH RUDDER; OSCILLATION IN HEADING.
PRIMARY REASON FOR PILOT RATING	CERTAINLY SATISFACTORY; BETTER THAN A TWO. WHY RUDDER SHOULD BE USED TO ROLL UNKNOWN, RATING IS A ONE FOR GOOD FEATURES MENTIONED. TURBULENCE RATING IS A.	GOOD A/C WITH NEGLIGIBLE DEFICIENCIES. PILOT COMPENSATION NOT A FACTOR FOR DESIRED PERFORMANCE.	GOOD A/C WITH NEGLIGIBLE DEFICIENCIES. PILOT COMPENSATION NOT A FACTOR. TURBULENCE SLIGHTLY INCREASED PILOT EFFORT.

GROUP 11 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.10$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.15$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT (+) 24, GUSTING TO 28	LIGHT (+) 20
PR/TR	2/B	3/C
GENERAL COMMENTS	NO REAL PROBLEMS FLYING A/C. ILS PERFORMANCE O.K., NO PROBLEMS. SUITABLE FOR LANDING APPROACH. IT WAS BEST NOT TO FOOL WITH RUDDER TOO MUCH.	SATISFACTORY BUT SEEMED TO GROW LESS SATISFACTORY THE MORE PILOT LOOKED AT IT. TENDENCY TO OSCILLATE DIRECTIONALLY IN TURBULENCE AND IN ATTEMPTS TO COORDINATE TURNS, SEEMED TO SLOSH NOSE AROUND A BIT. DEFICIENCIES REALLY QUITE MINOR; SUITABLE FOR LANDING APPROACH TASK.
ABILITY TO TRIM	NO PROBLEMS NOTED.	NO COMPLAINTS.
SELECTION OF CONTROL SENSITIVITIES	(PREVIOUSLY SELECTED VALUES WERE ASSIGNED.) FEEL CHARACTERISTICS FINE IN ALL AXES.	SELECTED RUDDER SENSITIVITY THAT WAS PERHAPS A LITTLE TOO SENSITIVE, BUT A COMPROMISE; i.e., DURING THE WING-DOWN CROSSWIND APPROACH, RUDDER FORCES VERY NOTICEABLE. WOULDN'T WANT TO HAVE TO HOLD THEM FOR VERY LONG. DIRECTIONAL DISCONNECTED FROM LATERAL; THEREFORE, PILOT COULD SELECT FAIRLY HIGH AILERON SENSITIVITY, THE SORT THAT HE LIKED WITH NO COMPROMISES. FORCES AND DISPLACEMENTS EXCELLENT LATERALLY.
$L'_{\delta_{AW}}$	4.31	6.15
$N'_{\delta_{RP}}$	8.60	11.8
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL GOOD. YAW DUE TO ROLL WAS IN ABNORMAL SENSE; i.e., BALL INITIALLY WENT OUT OF TURN BUT CAME BACK TO CENTER FAST ENOUGH SO THAT PILOT COULDN'T DO ANYTHING ABOUT IT ANYWAY. DOUBTFUL IF PILOT WOULD KNOW HOW TO COORDINATE; COULDN'T DO IT FAST ENOUGH ANYWAY, SO DIDN'T HAVE TO BOTHER ABOUT COORDINATION.	ROLL CONTROL OUTSTANDING. SMOOTH, WITH GOOD INITIAL RESPONSE. FINAL RESPONSE PREDICTABLE WITH NO TENDENCY TO OVERCONTROL. A/C COULD BE FLOWN SATISFACTORILY WITHOUT USING RUDDER. HOWEVER, ATTEMPTS TO COORDINATE SEEMED TO PRODUCE BIT OF AN OSCILLATION DIRECTIONALLY. NOTICED SOME TENDENCY TO OVERCONTROL DIRECTIONALLY.
DIFFERENCES IN IFR AND VFR	NONE NOTED.	IN IFR, BECAUSE OF NICE LATERAL CONTROL, COULD BE VERY PRECISE AND SMOOTH. IN VFR, IF NOT CAREFUL WITH RUDDER, COULD GET BALL FAR OUT TO ONE SIDE BECAUSE OF LOOSE DIRECTIONAL CHARACTERISTICS.
EFFECTS OF TURBULENCE	NOTICEABLE A/C SEEMED TO BOUNCE AROUND FAST ENOUGH AND WITH SMALL ENOUGH EXCURSIONS SO THAT PILOT DIDN'T FEEL IT NECESSARY TO TRY TO COUNTERACT IT. SEEMED A LITTLE WEIRD, BUT REQUIRED NOTHING OF PILOT.	MAINLY NOTICEABLE IN DIRECTIONAL SENSE; COULD BE EASILY SUPPRESSED BY PILOT.
CONTROL IN CROSSWIND	BUILT-IN WING-DOWN CROSSWIND MAKER WITH RUDDER. PUSHING A LITTLE LEFT RUDDER GIVES A LITTLE RIGHT WING-DOWN, CONTROLLABLE WITH ONE FOOT. IT WAS A LITTLE DIFFERENT. DE-CRABBING WAS A SUDDEN MOVING OF THE NOSE OUT OF THE CRAB. WITH EXISTING CRAB ANGLES, IT WAS A PRETTY EXCITING MANEUVER. CRAB TECHNIQUE NOT RECOMMENDED.	CROSSWIND NO PROBLEM WITH EITHER TECHNIQUE. RUDDER FORCES GOT HIGH WITH THE WING-DOWN METHOD.
FAVORABLE FEATURES	ROLL CONTROL FELT NICE, WAS SMOOTH AND PRECISE. SENSITIVITY WAS NICE.	ROLL CONTROL CERTAINLY GOOD, PRINCIPALLY IN SMOOTHNESS.
OBJECTIONABLE FEATURES	OCCASIONALLY, A/C SEEMED TO JUMP INTO THE TURNS, JUST TAKE OFF A LITTLE BIT, BUT NOT A CONSTANT OBSERVATION.	WITH A GENERAL LIGHTNESS DIRECTIONALLY, NOSE SORT OF WANDERS AROUND. RUDDER COORDINATION A LITTLE UNNATURAL, BUT PILOT COULD GET AWAY WITHOUT USING ANY.
PRIMARY REASON FOR PILOT RATING	ADEQUATE PERFORMANCE ATTAINABLE AND SATISFACTORY.	THE MORE PILOT FLEW IT, THE LESS HE LIKED IT, BUT ADEQUATE PERFORMANCE CERTAINLY ATTAINABLE.

GROUP 11 STICK CONTROLLER	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.10$ PILOT A	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.05$ PILOT B	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = 0$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	MODERATE 16	NONE 0	MODERATE 20, GUSTING TO 29
PR/TR	6.5/D	4.5/C	3/B
GENERAL COMMENTS	FAIR TO POOR LATERAL DIRECTIONAL HANDLING QUALITIES. POOR FOR LANDING APPROACH. ILS ADEQUATE BUT WITH EXTRA PILOT EFFORT.	LOW FREQUENCY DIRECTIONAL OSCILLATION CONTINUALLY EXCITED. SUITABLE, WITH SOME RESERVATIONS, FOR LANDING APPROACH BUT LIKELIER IS UNSATISFACTORY. ON ILS, JOB COULD BE DONE, BUT MAKING QUICK PRECISE HEADING CHANGES DIFFICULT SINCE IT STIRRED UP OSCILLATION. PILOT CAREFUL NOT TO USE RUDDER TOO MUCH. IF FLOWN SLOWLY AND SMOOTHLY ENOUGH OSCILLATION WAS NOT AS EXCITABLE.	FAIR TO GOOD OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES. GOOD FOR LANDING APPROACH. TURBULENCE AFFECT SURPRISINGLY LOW.
ABILITY TO TRIM	POOR, PROBABLY WORSE DIRECTIONALLY THAN LATERALLY.	SATISFACTORY.	DIRECTIONAL TRIM SLIGHTLY UNDESIRABLE BUT LONGITUDINAL AND LATERAL TRIM GOOD.
SELECTION OF CONTROL SENSITIVITIES	GOOD FORCES. DISPLACEMENTS AND CONTROL HARMONY PRETTY WELL SET. GEAR RATIOS ADEQUATE.	NO PROBLEMS LATERALLY, NO COMPROMISES. RUDDER ATTEMPTED LIGHT ENOUGH TO COUNTERACT DIRECTIONAL PROBLEMS. COMPROMISE REQUIRED BECAUSE OF OVERCONTROL PROBLEMS IN TRYING TO KEEP UP WITH DIRECTIONAL OSCILLATION, THEREFORE PILOT NEEDED A LITTLE HEAVIER FORCES.	HOWEVER A/C A BIT SLUGGISH IN AILERON CONTROL BECAUSE OF TOO LOW A GAIN. CONTROL HARMONY GOOD.
$L'_{\delta_{AS}}$ $N'_{\delta_{RP}}$	33.9 6.45	38.3 9.95	34.2 9.64
LATERAL AND DIRECTIONAL CONTROL	ADEQUATE ROLL CONTROL. ADVERSE YAW DUE TO ROLL OF MODERATE MAGNITUDE. ADVERSE YAW DUE TO AILERON INPUT BUT NOT AS HEAVY. COORDINATION DIFFICULT REQUIRING RUDDER REVERSAL INPUTS IN A CONSTANT BANK ANGLE TURN. A/C OSCILLATORY IN DUTCH ROLL MODE WITH MOSTLY A YAWING MOTION. LIGHT DAMPING AND FAIRLY LOW FREQUENCY OF DUTCH ROLL MAKES A/C WADDLE.	GOOD INITIAL ROLL RESPONSE, PREDICTABLE FINAL RESPONSE AND NO TENDENCY TO OVERCONTROL ROLL. YAW DUE TO ROLL PRODUCED NOSE "HANG UP" WITH MODERATE TO RAPID ROLL INPUT THEREFORE PILOT USED RUDDER. USING ROLL INPUTS COMPATIBLE WITH LANDING APPROACH THIS WAS ONLY MODERATE COMPLAINT. USING ANY INPUTS FASTER THAN THAT SOME BALL EXCURSIONS PRODUCED, DIRECTIONAL OSCILLATION EXCITED AND THUS PROBLEM MAGNIFIED. COORDINATION A PROBLEM BECAUSE PILOT TRIED TO KEEP UP WITH OSCILLATION.	ADEQUATE ROLL CONTROL. VERY MINIMAL YAW DUE TO ROLL. VERY EASY TO PUT IN ENOUGH COORDINATION FOR TURNS TO THE POINT WHERE ACTUAL RUDDER REVERSALS OCCUR. SO THERE'S NOT A WHOLE LOT OF YAW ASSOCIATED WITH ENTRY INTO TURNS. COORDINATION FAIRLY EASY BUT EXTRA WORK REQUIRED WITH REVERSALS. DIHEDRAL EFFECT PRACTICALLY NEUTRAL. UNABLE TO LIFT WING WITH RUDDER TOO EASILY, IF AT ALL. DUE TO LOW OR PRACTICALLY NEUTRAL DIHEDRAL EFFECT, OSCILLATIONS MOSTLY A SNAKY MOTION. GOOD ABILITY TO MAINTAIN HEADING, AND MAKE SMALL HEADING CORRECTIONS, BUT DURING ILS BALL GOES OFF AND STAYS OFF LONG TIME.
DIFFERENCES IN IFR AND VFR	SLIGHTLY DIFFICULT TO MAINTAIN DIRECTIONAL CONTROL WITH IFR.	PILOT TENDED TO BE A LITTLE VIGOROUS IN VFR AND THEREFORE NOSE "HANG UP" AND COORDINATION PROBLEM MAGNIFIED BECAUSE RUDDER INPUTS WERE LARGER AND STIRRED UP DIRECTIONAL OSCILLATION.	NO DIFFERENCE, HOWEVER THE ABILITY TO KEEP DIRECTIONAL OSCILLATIONS UNDER CONTROL IS BETTER IN VFR CONDITIONS, BECAUSE OF BETTER REFERENCE.
EFFECTS OF TURBULENCE	MORE PILOT EFFORT REQUIRED IN MAINTAINING DIRECTIONAL CONTROL. MAKES YAWING MOTION EVEN MORE PRONOUNCED. VERY DIFFICULT, IF NOT IMPOSSIBLE, FOR ROLL CONTROL WITH RUDDER. CONSIDERABLE PILOT EFFORT REQUIRED ON RUDDERS. DIFFICULT TO MAINTAIN CONSTANT HEADING.	NOTICEABLE. LOW FREQUENCY OSCILLATION IN SIDESLIP BUT FAIRLY EASY TO COUNTERACT.	MINOR DEGRADATION OF HANDLING QUALITIES. UNDER IFR CONDITIONS, THE HEADING EXCURSIONS ARE MORE NOTICEABLE AND BOTHERSOME. MORE DIFFICULT TO KEEP SNAKING MOTION UNDER CONTROL IN IFR, SINCE INSTRUMENTS ONLY REFERENCE. HOWEVER, NO REAL PROBLEM IN MAINTAINING ASSIGNED HEADINGS.
CONTROL IN CROSSWIND	NO PROBLEM.	NO COMMENTS.	NO REAL PROBLEM AND USED MOSTLY CRAB TECHNIQUE TO ENCOUNTER CROSSWIND, HOWEVER, SLIGHT COMBINATION WITH A WING LOW A FEW TIMES WAS USED WHERE GUSTS WERE PRESENT.
FAVORABLE FEATURES	NO PARTICULARLY OUTSTANDING FEATURES.	GOOD ROLL RESPONSE.	GOOD HANDLING QUALITIES.
OBJECTIONABLE FEATURES	DIFFICULTY WITH TRIM AND VERY SLOW WALLOWING BECAUSE OF LOW FREQUENCY, LOW DAMPED DUTCH ROLL MODE. MOSTLY A YAWING OSCILLATION	MODERATE TO LARGE NOSE "HANG UP" FOR AILERON ONLY TURNS REQUIRING RUDDER COORDINATION FOR ROLL RATES USED IN LANDING APPROACH. THEN STIRRED DIRECTIONAL OSCILLATION USING RUDDER. TURBULENCE RESPONSE OBJECTIONABLE. ALL DIRECTIONAL REQUIRING RUDDER USE.	LIGHTLY DAMPED SNAKING OR DIRECTIONAL OSCILLATIONS AND RELATIVELY LOW FREQUENCY WITH COMBINED LOW DAMPING CAUSED THE NOSE TO WANDER AROUND.
PRIMARY REASON FOR PILOT RATING	CONSTANT MANIPULATION OF RUDDERS REQUIRED IF CLOSE WATCH KEPT ON DIRECTIONAL CONTROL AND PRECISION TRACKING TASK. SMALL HEADING CORRECTIONS AND MAINTAINING HEADING DIFFICULT. INCREASED PILOT EFFORT REQUIRED.	TOO MUCH NOSE "HANG UP" AND FLAT TURBULENCE RESPONSE UNDESIRABLE. BOTH ANNOYING. TROUBLE DEVELOPING TECHNIQUE NOT REQUIRING PILOT THOUGHT.	MILDLY UNPLEASANT CHARACTERISTICS BUT MINIMAL PILOT COMPENSATION REQUIRED.

GROUP 11 (Cont.) STICK CONTROLLER	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = 0$ PILOT B	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.05$ PILOT B	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.10$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE 0	NONE 0	LIGHT (+) 22
PR/TR	3/C	2/A	3.5/B
GENERAL COMMENTS	NO BOTHERSOME OSCILLATORY CHARACTERISTICS. WITH SOME RESERVATIONS, SUITABLE FOR LANDING APPROACH. ON ILS PILOT COULD DO THE JOB AS WELL AS DESIRED.	SMOOTH ON ILS AND FELT GOOD. SUITABLE FOR LANDING APPROACH.	GOOD LATERAL-DIRECTIONAL HANDLING QUALITIES. LANDING APPROACH PHASE FAIR TO GOOD. SLIGHTLY DEGRADED ILS PERFORMANCE BECAUSE OF DIFFICULTY IN MAKING SMALL COORDINATED TURNS AND HENCE DIFFICULTY WITH PRECISION TRACKING.
ABILITY TO TRIM	TURBULENCE LEVEL HIGH ENOUGH THAT PILOT COULDN'T ANALYZE WHAT WAS GOING ON WITH TRIM, BUT NO PROBLEM.	GOOD, SATISFACTORY.	NOT MUCH OF A PROBLEM LATERALLY OR DIRECTIONALLY.
SELECTION OF CONTROL SENSITIVITIES	NOTHING OUTSTANDING, NO COMPROMISES.	INITIALLY AILERON GEARING SELECTED SO THAT FORCES WERE NOT TOO BAD. TWO OR THREE CHANGES MADE IN GEARING, LIGHTENING IT UP BECAUSE DISPLACEMENTS WERE TOO LARGE AND THEREFORE FORCES WERE NOTICEABLE. ENDED WITH GOOD ROLL RESPONSE.	GOOD FORCES, DISPLACEMENTS, AND CONTROL HARMONY.
$L'_{\delta_{AS}}$	43.1	38.3	51.3
$N'_{\delta_{RP}}$	5.34	11.4	11.4
LATERAL AND DIRECTIONAL CONTROL	GOOD ROLL CONTROL, PREDICTABLE, NO TENDENCY TO OVERCONTROL. WITH MODEST ROLL RATES NO COORDINATION REQUIRED. WITH FASTER ROLL RATES, BUT NOT TOO FAST FOR THE TASK, PILOT USED SOME RUDDER IN NORMAL SENSE.	SMOOTH RESPONSE, FELT GOOD, PREDICTABLE. YAW DUE TO ROLL PRESENT BUT COULD BE IGNORED REGARDING LANDING APPROACH. SORTED ITSELF OUT AND ENDED WITH BALL IN CENTER SO NO REAL COORDINATION REQUIRED. FOR PRECISION, RUDDER REQUIRED INTO TURN, AFTER SLIGHT HESITATION AND THEN HAD TO BE TAKEN OUT AGAIN.	A/C VERY RESPONSIVE IN ROLL WITH VERY LITTLE INITIAL COORDINATION REQUIRED. LOT OF PROVERSE YAW DUE TO AILERON INPUT. VERY LITTLE EFFORT REQUIRED TO MAINTAIN COORDINATED TURNS, BUT RUDDER REQUIREMENTS INCREASE AS THE TURN PROGRESSES. RELATIVELY SLOW MOTION OF NOSE ON THE HORIZON, HOWEVER IT IS SELF-CENTERING SITUATION THAT INITIALLY COMES BACK TO COMMANDED HEADING. VERY LITTLE, IF ANY, DIHEDRAL EFFECT PRESENT ALTHOUGH PILOT CAN PICK UP WING WITH THE RUDDER. THE SPIRAL MODE ALMOST NEUTRALLY STABLE, IF ANYTHING SLIGHTLY DIVERGENT.
DIFFERENCES IN IFR AND VFR	ONLY DIFFERENCE IN MAGNITUDE OF INPUTS.	NONE.	NO APPRECIABLE DIFFERENCE.
EFFECTS OF TURBULENCE	CERTAINLY NOTICEABLE, NOSE KEPT SWINGING BACK AND FORTH AT TIMES. CONSIDERED MORE THAN SATISFACTORY.	MAINLY DIRECTIONAL, NOTICEABLE IN THE TURN RATE BUT DIDN'T DETRACT FROM PERFORMANCE. THE NOSE WOULD SWING AT MODERATE SPEEDS BUT PRESENTED NO HEADING CHANGES TO CONTEND WITH.	SLOW SNAKING MOTION. A/C WALLOWS SLIGHTLY AROUND IN A TURN. SMALL HEADING CORRECTIONS EASY TO MAKE. TURBULENCE EFFECTS NOT TOO SIGNIFICANT.
CONTROL IN CROSSWIND	NO CROSSWIND, THEREFORE NO COMMENTS.	NO COMMENTS.	COMBINATION CRAB AND WING LOW TECHNIQUE USED WITH NO PROBLEM.
FAVORABLE FEATURES	SMOOTH, KIND OF LAZY A/C. PILOT CONFIDENCE IN FLYING IT. GOOD ROLL RESPONSE AND MINIMUM AMOUNT OF COORDINATION REQUIRED.	SMOOTH PREDICTABLE ROLL CONTROL. GOOD FLYING A/C, OVERALL FEELING OF BEING PRECISE AND SMOOTH.	GOOD MANEUVERABILITY OF A/C IN ROLL DUE TO PROVERSE YAW DUE TO AILERON.
OBJECTIONABLE FEATURES	DIRECTIONAL TURBULENCE RESPONSE, PRODUCED BALL EXCURSIONS LARGER THAN DESIRED. PILOT COULD NOT SUPPRESS IT EVEN WORKING HARD WITH RUDDER.	NOSE EXCURSIONS DUE TO TURBULENCE MODERATELY OBJECTIONABLE BUT DIDN'T REALLY ENTER TASK AT ALL.	SPECIAL EFFORT REQUIRED IN COORDINATION OF TURNS. COORDINATION REQUIREMENTS SEEM TO CHANGE THROUGHOUT TURN.
PRIMARY REASON FOR PILOT RATING	MINOR PROBLEM WITH DIRECTIONAL TURBULENCE RESPONSE MILDLY UNPLEASANT DEFICIENCY. CATEGORY OF MINOR OR MODERATE AMOUNT OF MORE EFFORT REQUIRED.	PILOT COMPENSATION WAS NOT A FACTOR IN ACHIEVING PERFORMANCE, IT HAS NEGLIGIBLE DEFICIENCIES.	DIFFICULTY IN MAKING SMALL HEADING CORRECTIONS WHICH WARRANTS IMPROVEMENT, BUT MINIMUM PILOT COMPENSATION REQUIRED.

GROUP 12	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.10$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.05$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT 6	LIGHT 10	LIGHT CALM
PR/TR	3/A	2.5/B	2/B
GENERAL COMMENTS	SMOOTH A/C; A BIT SLOPPY DIRECTIONALLY, BUT NO PROBLEM. A/C SUITABLE IN LANDING APPROACH.	GOOD TO VERY GOOD OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES. OSCILLATORY CHARACTERISTICS MOSTLY SNAKING MOTIONS.	GOOD TO VERY GOOD OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES. COORDINATION FOR MANEUVERING IN TURNS VERY EASILY MAINTAINED AND NOT OBJECTIONABLE. ADEQUATE FOR EASY MANEUVERING FOR LANDING APPROACH, BOTH IFR AND VFR, AND FOR OFFSET APPROACHES FROM IFR TO VFR TOUCHDOWN. SLIGHT DEGRADATION IN TURBULENCE.
ABILITY TO TRIM	SATISFACTORY	VERY GOOD LATERALLY AND DIRECTIONALLY.	VERY GOOD.
SELECTION OF CONTROL SENSITIVITIES	SELECTED LATERAL GEARING PLEASANT THROUGHOUT MISSION. SELECTED DIRECTIONAL GEARING ACCEPTABLE WITH NO COMPROMISES.	GOOD FORCES AND DISPLACEMENTS. GOOD HARMONY OF CONTROL. GOOD GEAR RATIOS.	GOOD FEEL CHARACTERISTICS, FORCES, DISPLACEMENTS, AND CONTROL HARMONY. GOOD SENSITIVITIES
$L'_{\delta_{AW}}$	6.16	3.90	3.83
$N'_{\delta_{RP}}$	13.0	10.1	6.26
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL SMOOTH AND PREDICTABLE WITH NO TENDENCY TO OVERCONTROL. COORDINATION REQUIRED BUT NOT PRECISE. WHEN TURNING, BALL INITIALLY WENT SLIGHTLY OUTSIDE THE TURN, THEN TOOK RELATIVELY LARGE EXCURSION INTO THE TURN FOLLOWED BY SLOW RETURN TO CENTER. TRYING TO KEEP THE BALL CENTERED COULD LEAD TO OVERCONTROL PROBLEMS. PILOT IGNORED LARGE EXCURSION AND PUT A LITTLE RUDDER INTO TURN.	RESPONSIVE ROLL CONTROL. SLIGHT TO MODERATE ADVERSE YAW DUE TO ROLL REQUIRING SOME EFFORT FOR COORDINATION. OSCILLATORY CHARACTERISTICS MOSTLY SNAKING MOTION. VERY SLIGHT DIHEDRAL EFFECT. LOW DUTCH ROLL FREQUENCY AND WELL DAMPED CAUSING NO PROBLEM IN LATERAL DIRECTIONAL CONTROL UNDER NONTURBULENT CONDITIONS. SMALL HEADING CORRECTIONS EASILY MADE. COORDINATION IN TURNS REQUIRES A SMALL, ALMOST CONSTANT, RUDDER IN THE DIRECTION OF TURN. ALTHOUGH CONSIDERABLE EXCURSIONS IN YAW PRESENT, THE PILOTS PROBLEM NOT TOO SERIOUS BECAUSE IT CORRECTED ITSELF. BALL WAS ALWAYS MOVING RATHER THAN MOVING OUT TO ONE SIDE AND REMAINING THERE FOR EXTENDED TIME. GOOD ILS. MODERATE YAW DUE TO ROLL AND REQUIRES COORDINATION.	VERY GOOD ROLL CONTROL. YAW DUE TO ROLL NO PROBLEM.
DIFFERENCES IN IFR AND VFR	NO COMMENTS.	NO NOTICEABLE DIFFERENCE	MORE WORK FOR PILOT WHEN FLYING IFR THAN VFR.
EFFECTS OF TURBULENCE	MINIMUM EFFECTS DIDN'T AFFECT PILOT PERFORMANCE.	LIGHT TO NEGLIGIBLE. NO SIGNIFICANT DEVIATION OF HANDLING QUALITIES. SMALL HEADING CORRECTIONS ARE MORE DIFFICULT, BUT NO REAL PROBLEM MAINTAINING BANK ANGLES.	MORE DIFFICULT TO CONTROL IN TURBULENCE.
CONTROL IN CROSSWIND	NOTHING NOTICEABLE.	NO PROBLEMS WERE NOTED. RUDDER FORCES A LITTLE HIGH BUT NOT DISTRESSING TO PILOT.	NOT ASSESSED.
FAVORABLE FEATURES	SMOOTH. EVEN WHEN NOT PERFECTLY COORDINATED, JOB DONE SATISFACTORILY.	GOOD FLYING A/C	GOOD OVERALL HARMONY OF AIRPLANE CONTROL RESPONSE; i.e., EASILY MANEUVERED ABOUT ALL 3 AXES.
OBJECTIONABLE FEATURES	SLOPPINESS DIRECTIONALLY AND THE BALL WAS SLOW TO CENTER IN AN AILERON ONLY TURN.	LOW FREQUENCY DUTCH ROLL MODE CAUSED HEADING EXCURSIONS IN TURBULENCE TO BE A LITTLE LONGER THAN PILOT DESIRED, BUT NO ADDITIONAL PILOT EFFORT REQUIRED SINCE THEY WERE SELF-ELIMINATING.	NO COMMENTS.
PRIMARY REASON FOR PILOT RATING	MINIMAL PILOT COMPENSATION REQUIRED TO ACHIEVE DESIRED PERFORMANCE.	DEFICIENCIES WERE NEGLIGIBLE, PILOT COMPENSATION MINIMAL.	SMALL PILOT COMPENSATION REQUIRED IN TURBULENCE.

GROUP 12 (Cont.)		$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT B		$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.15$ PILOT B	
NATURAL TURBULENCE MAX. X-WIND (~KT)		LIGHT (+) 22		MODERATE + 26, GUSTING TO 33	
PR/TR		2/A		1.5/A	
GENERAL COMMENTS		WIRE RECORDER MALFUNCTION		LESS THAN IDEAL OPERATING CONDITIONS IN TERMS OF TURBULENCE, BUT WAS GOOD A/C. TURBULENCE RESPONSE SATISFACTORY. DIRECTIONAL AND LATERAL SEEMED SEPARATED. GOOD ILS PERFORMANCE. SUITABLE FOR LANDING APPROACH.	
ABILITY TO TRIM				SATISFACTORY.	
SELECTION OF CONTROL SENSITIVITIES				NO COMPLAINTS IN ANY AXIS, NO COMPROMISES.	
$L'_{\delta_{AW}}$	$N'_{\delta_{RP}}$	7.15	9.64	6.16	11.4
LATERAL AND DIRECTIONAL CONTROL				ROLL CONTROL "LOVELY AND SMOOTH". GOOD INITIAL RESPONSE, PREDICTABLE FINAL RESPONSE WITH NO TENDENCY TO OVERCONTROL. YAW DUE TO ROLL HARDLY NOTICEABLE, EVEN WITH SHARP INPUTS. COORDINATION NOT A REQUIREMENT.	
DIFFERENCES IN IFR AND VFR				NONE.	
EFFECTS OF TURBULENCE				IN "MODERATE-PLUS" TURBULENCE AND EFFECTS OF TURBULENCE NOT A PROBLEM.	
CONTROL IN CROSSWIND				A BIT EXTREME BUT EVEN THEN IT WAS POSSIBLE TO DO THE JOB. O.K. IN THE CRAB BUT HAD RATHER LARGE SIDESLIP ANGLES USING WING-DOWN METHOD.	
FAVORABLE FEATURES				SMOOTH AND PRECISE ROLL CONTROL, COORDINATION NOT A FACTOR AND TURBULENCE RESPONSE LOW.	
OBJECTIONABLE FEATURES				NONE.	
PRIMARY REASON FOR PILOT RATING				CLOSE TO EXCELLENT, HIGHLY DESIRABLE.	

GROUP 13	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT 26, GUSTING TO 32	LIGHT (+) 12	LIGHT 0
PR/TR	3/B	4/D	4/C
GENERAL COMMENTS	PILOT SEEMED TO ADAPT TO A/C, IMPROVING AS HE FLEW IT. REASONABLY NATURAL COORDINATION REQUIRED. A/C SUITABLE FOR LANDING APPROACH WITH MINOR DISTRACTIONS. SINCE A/C COULD NOT ROLL WITH RUDDER, WHEN MAKING SMALL CORRECTIONS, i.e., ILS, PILOT HAD TO HOLD A BANK ANGLE AND WAIT FOR HEADING TO CHANGE.	OVERALL LATERAL-DIRECTIONAL QUALITIES SEEM FAIR.	A/C LOOSE DIRECTIONALLY. BALL MOVES OUT AND TAKES A LONG TIME TO COME BACK IN AN AILERON ONLY TURN. ALL DIRECTIONAL TURBULENCE RESPONSE SEEMS SLOW AND SLOPPY.
ABILITY TO TRIM	SATISFACTORY.	COULD OBTAIN FAIRLY GOOD TRIM WITHOUT APPRECIABLE AMOUNT OF TIME.	SATISFACTORY.
SELECTION OF CONTROL SENSITIVITIES	FORCES AND DISPLACEMENTS SATISFACTORY. NO COMPROMISES.	LATERAL CONTROL QUITE RESPONSIVE. SLIGHT DISPARITY CREATED WITH LONGITUDINAL CONTROL.	NO NOTICEABLE COMPROMISES IN FEEL SELECTIONS. COULD SELECT AILERON GEARING LIKED.
$L'_{\delta_{AW}}$	2.98	2.98	3.01
$N'_{\delta_{RP}}$	9.70	9.82	8.04
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL SMOOTH, INITIAL RESPONSE GOOD, AND FINAL RESPONSE PREDICTABLE. AS PILOT FLEW A/C, HE BEGAN TO LIKE ROLL CONTROL. FAIR AMOUNT OF YAW DISTURBANCE DURING AILERON ONLY ROLLS. BALL WOULD GO INTO TURN ONE OR TWO WIDTHS, SWING OUT OF TURN SLIGHTLY, THEN BACK TO CENTER. SEEMED AWKWARD AT FIRST, BUT LATER COULD GET JOB DONE WITHOUT AWKWARDNESS. COORDINATION REQUIRED, BUT NO LARGE WORKLOAD.	INITIAL NOSE MOVEMENT QUITE OPPOSITE TO TURN DIRECTION BECAUSE OF ADVERSE YAW DUE TO ROLL AND AILERON. ONCE ESTABLISHED, NO PARTICULAR PROBLEM MAINTAINING COORDINATION IN TURN. RUDDER APPLICATION RESULTS PRIMARILY IN YAWING MOTION WITH VERY LITTLE ROLL.	ROLL CONTROL GOOD, INITIAL RESPONSE SATISFACTORY, AND FINAL RESPONSE PREDICTABLE, WITH NO TENDENCY TO OVERCONTROL. MUCH YAW DUE TO AILERON IN THE NORMAL SENSE, REQUIRING RUDDER INTO THE TURN. ESPECIALLY NOTICEABLE UP AND AWAY WITH ANY KIND OF BRISK MANEUVER. COORDINATION REQUIRED, SOMEWHAT DIFFICULT UP AND AWAY LOOKING AT THE TURNS BY THEMSELVES. LANDING APPROACH MISSION NO PROBLEM, BUT OVERALL EFFORT SLOPPY. PILOT NEVER DID GET IT COORDINATED AS SMOOTHLY AS HE WOULD HAVE LIKED IN THE OFFSET MANEUVER.
DIFFERENCES IN IFR AND VFR	A/C SATISFACTORY IN IFR, EVEN THOUGH SMALL CHANGES REQUIRED PUTTING IN A BANK ANGLE AND WAITING FOR A HEADING CHANGE. IN VFR, NOTICED COORDINATION PROBLEMS BUT JOB COULD BE DONE SMOOTHLY AND SATISFACTORILY.	NONE IN PARTICULAR.	GOOD A/C IN IFR, ON THE ILS. PILOT COULD GET HEADING CHANGES RAPIDLY AND SQUEEZE JUST ENOUGH RUDDER TO MAKE PRECISE HEADING CHANGES.
EFFECTS OF TURBULENCE	NOSE SEEMED TO DO SOME SLOSHING AROUND; HOWEVER, EFFORT TO SUPPRESS TURBULENCE WAS SMALL.	CERTAINLY MORE EFFORT REQUIRED IN TURBULENCE. TASK PERFORMANCE DETERIORATION IS MINOR TO MODERATE.	ONLY DIRECTIONALLY. BALL WAVED BACK AND FORTH; SLOPPY IS A GOOD DESCRIPTION.
CONTROL IN CROSSWIND	CROSSWINDS NO PROBLEM. BOTH TECHNIQUES TRIED WITH NO PROBLEMS; WING-DOWN IS PERSONAL PREFERENCE.	NO PROBLEM WITH SLIGHT CROSSWIND ENCOUNTERED.	NO COMMENTS.
FAVORABLE FEATURES	GOOD SMOOTHNESS OF ROLL CONTROL AND PREDICTABLE RESPONSE.	A/C RESPONSIVE LATERALLY; NO PROBLEMS OBTAINING REQUIRED LATERAL CONTROL.	ROLL CONTROL SATISFACTORY. TURBULENCE RESPONSE SLOW AND NO GREAT PROBLEM TO CONTEND WITH.
OBJECTIONABLE FEATURES	SOME DIFFICULTY AT FIRST ADJUSTING TO COORDINATION.	COORDINATION REQUIRED ON ENTERING TURNS IS OBJECTIONABLE DUE TO ADVERSE YAW EFFECTS. LIGHT DUTCH ROLL DAMPING AND LOW FREQUENCY ARE OBJECTIONABLE. CONTINUOUS REQUIREMENT FOR RUDDER INPUTS DURING TURBULENCE IS ANNOYING.	GENERAL SLOPPINESS DIRECTIONALLY. BALL TENDED TO WANDER IN TURBULENCE. DIFFICULT TO COORDINATE WITHOUT BEING MECHANICAL ABOUT IT.
PRIMARY REASON FOR PILOT RATING	MILDLY UNPLEASANT DEFICIENCIES.	A/C HAS MINOR, ANNOYING DEFICIENCIES; DESIRED PERFORMANCE REQUIRES MODERATE PILOT COMPENSATION.	NOT SATISFACTORY WITHIN THE MISSION. THE JOB COULD BE DONE, BUT A/C WAS JUST SLOPPY. TURBULENCE RESPONSE IN "MORE EFFORT REQUIRED" CATEGORY.

GROUP 13 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT B
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT (+) 14	LIGHT (+) 20	LIGHT (+) 33
PR/TR	5/D	5/C	5/D
GENERAL COMMENTS	OVERALL HANDLING QUALITIES FAIR TO GOOD. A/C CONSTANTLY LOLLS ALONG IN SKY, EVEN IN LIGHT TURBULENCE.	DISLIKED WAY A/C FLEW. PILOT SEEMED TO BE CONTINUALLY WORKING WITH LATERAL TRIM.	WHEN RUDDER NOT NECESSARY, NOT A BAD A/C. ANYTIME PILOT ATTEMPTED TO USE RUDDER' SUCH AS TO SUPPRESS DIRECTIONAL OSCILLATIONS IN TURBULENCE, HE REALLY COMPOUNDED THE DIRECTIONAL OSCILLATORY DIFFICULTIES. ON ILS, HE COULD DO THE JOB BUT DIDN'T THINK A/C SUITABLE FOR LANDING APPROACH.
ABILITY TO TRIM	NO PROBLEM.	WHEN LOOKED AT INDEPENDENTLY, BOTH LATERAL AND DIRECTIONAL SATISFACTORY; HOWEVER, IN CONTEXT OF DOING THE JOB, PILOT HAD TO PAY ABNORMAL ATTENTION TO LATERAL TRIM.	NOTHING NOTICED.
SELECTION OF CONTROL SENSITIVITIES	GOOD FORCES, DISPLACEMENTS, AND GEAR RATIO.	LATERALLY, PILOT MAY HAVE SELECTED FORCES TOO LIGHT. MILD TENDENCY TO OVERCONTROL, POSSIBLY A LITTLE TOO SENSITIVE RUDDER COULD NOT HAVE BEEN TOLERATED ANY LESS SENSITIVE THAN SELECTED, YET WHEN COORDINATION TRIED WITH RUDDER, PILOT HAD SMALL OVERCONTROL PROBLEMS. POSSIBLY A COMPROMISE IN DIRECTIONAL SENSE.	ALL SATISFACTORY
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	2.33 8.96	2.12 8.04	3.01 9.70
LATERAL AND DIRECTIONAL CONTROL	A/C APPEARS TO BE VERY LIGHTLY DAMPED WITH MODERATELY LOW FREQUENCY RESULTING IN CONTINUOUS WANDERING WITH FEET OFF RUDDERS. BUT IT CAN BE POINTED IN RIGHT DIRECTION WITH A LITTLE PILOT EFFORT. ROLL CONTROL PRODUCES FAIRLY FAST RESPONSE TO COMMANDED AILERON INPUT. COORDINATION IN TURNS QUITE DIFFICULT. DUTCH ROLL IS LIGHTLY DAMPED AND HAS FAIRLY LOW FREQUENCY, MAKING OSCILLATORY TENDENCY QUITE ANNOYING. SMALL HEADING CORRECTIONS REQUIRE ONLY BANK ANGLE RATHER THAN COMBINATION OF AILERON AND RUDDER UNDER TURBULENCE.	INITIAL ROLL RESPONSE SATISFACTORY; FINAL RESPONSE PREDICTABLE; BUT MILD TENDENCY TO OVERCONTROL. ATTEMPTS TO COORDINATE WITH RUDDER LED TO OVERCONTROL PROBLEMS, STARTING AN OSCILLATION THAT WAS PARTICULARLY NOTICEABLE DIRECTIONALLY. IF PILOT FLEW SMOOTHLY WITHOUT COORDINATING, BALL WOULD EVENTUALLY COME BACK TO CENTER.	INITIAL ROLL RESPONSE GOOD. FINAL RESPONSE AT TIMES SEEMED PRECISE; AT OTHER TIMES FELT AS IF IT WERE TAKING OFF JUST A BIT. ON INITIATING AN AILERON ONLY TURN, BALL WOULD SLIDE OUT QUITE A DISTANCE. IF PILOT TRIED TO DO ANYTHING ABOUT IT WITH RUDDER, HE USUALLY ENDED UP OVERCONTROLLING IN OTHER DIRECTION. ON ITS OWN, IN AN ACCEPTABLE LENGTH OF TIME, NOSE WOULD SWING AROUND AND LITTLE OR NO COORDINATION WOULD BE REQUIRED. BEST TO LEAVE RUDDER ALONE.
DIFFERENCES IN IFR AND VFR	A/C EASIER TO CONTROL IN IFR BECAUSE OF BETTER REFERENCE.	ON IFR, A REASONABLE A/C. DISLIKED VFR COORDINATION PROBLEMS AND RESULTING OSCILLATIONS.	MAJOR PROBLEMS NOTICEABLE WHILE VFR IN TURBULENCE WITH LARGE EXCURSIONS IN YAW.
EFFECTS OF TURBULENCE	QUITE DEGRADING EFFECT ON A/C HANDLING QUALITIES. ALMOST IMPOSSIBLE TO KEEP NOSE CONTINUOUSLY ALIGNED WITH DESIRED DIRECTION. QUITE PRONOUNCED, BOTH IFR AND VFR. WIDE EXCURSIONS IN SIDESLIP PRODUCED AND SUSTAINED DUE TO LOW FREQUENCY DUTCH ROLL MODE.	MODERATE. DIRECTIONAL OSCILLATIONS AND SOME PROBLEMS WITH LATERAL OSCILLATIONS. TRYING TO CONTROL BALL EXCURSIONS WITH RUDDER SEEMED TO MAKE IT WORSE.	CERTAINLY NOTICEABLE; MAIN PROBLEM IN THE DIRECTIONAL.
CONTROL IN CROSSWIND	NO PROBLEM; COMPENSATION TECHNIQUE WAS TO CRAB.	HIGH RUDDER FORCES WITH WING-DOWN METHOD. COULD JUST GET JOB DONE WITHOUT CONSIDERING FORCES ENORMOUS. USING CRAB METHOD, SIMPLY UNCOMFORTABLE NEAR GROUND. KICKING OFF A LARGE CRAB ANGLE WITH THIS A/C WOULD BE UNDESIRABLE.	PILOT JUST WOULD NOT WANT TO BE DE-CRABBING THIS A/C SUDDENLY, JUST BEFORE LANDING BECAUSE HE COULD GET INTO OVERCONTROL PROBLEMS WITH KEEPING THE NOSE STRAIGHT. WING-DOWN METHOD PREFERRED, BUT HAD A LITTLE PROBLEM GETTING IT SETTLED DOWN DIRECTIONALLY.
FAVORABLE FEATURES	GOOD ROLLING CAPABILITIES WITH WHAT APPEARS TO BE VERY LIGHT YAW DUE TO ROLL.	NO SPECIFIC COMMENTS.	ROLL CONTROL SATISFACTORY; IN SMOOTH AIR REQUIRED NO COORDINATION. IT COULD BE LET GO AND NOSE WOULD COME AROUND ON ITS OWN.
OBJECTIONABLE FEATURES	LIGHTLY DAMPED AND LOW FREQUENCY DUTCH ROLL MODE AND NEGATIVE DIHEDRAL EFFECT WERE OBJECTIONABLE.	NO SPECIFIC COMMENTS.	DIRECTIONAL OSCILLATORY CHARACTERISTICS EVIDENT WHENEVER RUDDER USED; MAGNIFIED BY TURBULENCE.
PRIMARY REASON FOR PILOT RATING	EXTRA PILOT ATTENTION REQUIRED TO KEEP DIRECTIONAL CONTROL UNDER WRAPS IN BOTH VFR AND IFR. PILOT COMPENSATION CONSIDERABLE TO PERFORM ASSIGNED TASK, PARTICULARLY IN TURBULENCE.	A/C UNSATISFACTORY. DEFICIENCIES WARRANT IMPROVEMENT. TURBULENCE RESPONSE PUTS A/C IN "MORE EFFORT REQUIRED" CATEGORY.	ADEQUATE PERFORMANCE ATTAINABLE, BUT UNSATISFACTORY BECAUSE OF DIRECTIONAL PROBLEMS. TURBULENCE RESPONSE REQUIRED MODERATELY MORE EFFORT.

<table>
<tr><th colspan="2">GROUP 13 (Cont.)</th><th colspan="2">$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$
PILOT A</th><th colspan="2">$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$
PILOT B</th><th colspan="2">$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.15$
PILOT B</th></tr>
<tr><td colspan="2">NATURAL TURBULENCE
MAX. X-WIND (~KT)</td><td colspan="2">LIGHT (+)
8</td><td colspan="2">LIGHT (+)
20</td><td colspan="2">LIGHT
10</td></tr>
<tr><td colspan="2">PR/TR</td><td colspan="2">3/C</td><td colspan="2">3/B</td><td colspan="2">3/B</td></tr>
<tr><td colspan="2">GENERAL COMMENTS</td><td colspan="2">GOOD LATERAL DIRECTIONAL HANDLING A/C. VERY EASILY CONTROLLED IN ROLL, AND MAKING SMALL CORRECTIONS IN HEADING WAS EASY. IN TURBULENCE, QUITE A BIT MORE OSCILLATORY AND NOSE MOVES AROUND HORIZON QUITE A BIT; HOWEVER, NO PROBLEM TO CONTROL AS LONG AS PILOT DOESN'T FIGHT IT.</td><td colspan="2">WIRE RECORDER MALFUNCTION.</td><td colspan="2">SATISFACTORY A/C; SEEMED SUITABLE, WITH SOME RESERVATIONS, FOR LANDING APPROACH. GENERAL SLOPPINESS DIRECTIONALLY WAS ONLY BOTHERSOME FEATURE</td></tr>
<tr><td colspan="2">ABILITY TO TRIM</td><td colspan="2">GOOD. POSSIBLY, A SLIGHT DEGRADATION IN ABILITY TO TRIM RUDDER ACCURATELY, BUT PILOT CAN SUCCESSFULLY TRIM WITHOUT TOO MUCH EXTRA EFFORT.</td><td colspan="2"></td><td colspan="2">SATISFACTORY.</td></tr>
<tr><td colspan="2">SELECTION OF CONTROL SENSITIVITIES</td><td colspan="2">FORCES AND DISPLACEMENTS ALL GOOD.</td><td colspan="2"></td><td colspan="2">SELECTED LATERAL SENSITIVITY A LITTLE HEAVY, BUT STILL SATISFACTORY. RUDDER SENSITIVITY SELECTION SATISFACTORY. NOTICED NO COMPROMISES.</td></tr>
<tr><td>$L'_{\delta_{AW}}$</td><td>$N'_{\delta_{RP}}$</td><td>1.50</td><td>8.04</td><td>3.01</td><td>7.49</td><td>3.01</td><td>9.70</td></tr>
<tr><td colspan="2">LATERAL AND DIRECTIONAL CONTROL</td><td colspan="2">ROLL CONTROL GOOD; SOME ADVERSE YAW DUE TO ROLL. ALSO SOME ADVERSE YAW DUE TO AILERON INPUT, BUT SEEMED SMALL. COORDINATION IN TURNS FAIR TO GOOD. SLOW, LOW FREQUENCY DUTCH ROLL TENDENCY. OSCILLATORY CHARACTERISTICS MORE PRONOUNCED IN TURBULENCE, BUT NO REAL PROBLEM IF PILOT DID NOT FIGHT IT; JUST ANNOYING. THESE CHARACTERISTICS SUITABLE FOR LANDING APPROACH.</td><td colspan="2"></td><td colspan="2">ROLL RESPONSE GOOD INITIALLY, AND PREDICTABLE. TURN COORDINATION REQUIRED, BUT AWKWARD. BALL EVENTUALLY RE-CENTERED ITSELF. SEEMED TO HAPPEN SLOWLY, EMPHASIZING SLOPPY DIRECTIONAL CHARACTERISTICS. PILOT BECAME MECHANICAL WITH RUDDER AND ENDED UP MORE UNCOORDINATED THAN IF HE HAD LEFT IT ALONE. EASIER NOT TO TRY TO COORDINATE.</td></tr>
<tr><td colspan="2">DIFFERENCES IN IFR AND VFR</td><td colspan="2">ALMOST NONE.</td><td colspan="2"></td><td colspan="2">NONE.</td></tr>
<tr><td colspan="2">EFFECTS OF TURBULENCE</td><td colspan="2">RELATIVELY NOTICEABLE; i.e. NO OSCILLATION WITHOUT TURBULENCE. WITH TURBULENCE, MODERATE NOSE WANDERING ON HORIZON.</td><td colspan="2"></td><td colspan="2">TURBULENCE RESPONSE NOTICEABLE DIRECTIONALLY; LAZY SLOSHING AROUND OF NOSE WHICH WAS BOTHERSOME. IF PILOT REALLY GOT IN THERE AND FLEW IT, COULD BE TAKEN CARE OF.</td></tr>
<tr><td colspan="2">CONTROL IN CROSSWIND</td><td colspan="2">STRAIGHT CRAB TECHNIQUE USED FOR VERY LIGHT CROSSWIND.</td><td colspan="2"></td><td colspan="2">SOME TENDENCY TO OVERCONTROL WHEN TRYING TO KEEP NOSE STRAIGHT USING WING-DOWN METHOD, BUT COULD BE DONE. WITH TENDENCY TO OVERCONTROL DIRECTIONALLY, WOULD DISLIKE TO KICK OUT A LARGE CRAB ANGLE NEAR THE GROUND. BOTH TECHNIQUES SUCCESSFUL</td></tr>
<tr><td colspan="2">FAVORABLE FEATURES</td><td colspan="2">NO DIFFICULTIES. RELATIVELY GOOD FLYING A/C, PARTICULARLY UNDER CALM CONDITIONS. NOT DEGRADED A LOT IN TURBULENT CONDITIONS.</td><td colspan="2"></td><td colspan="2">ROLL CONTROL GOOD</td></tr>
<tr><td colspan="2">OBJECTIONABLE FEATURES</td><td colspan="2">A LITTLE MORE OSCILLATION IN TURBULENCE THAN DESIRABLE.</td><td colspan="2"></td><td colspan="2">DIRECTIONAL SLOPPINESS LED TO OVERCONTROL TENDENCIES. WHEN USING THE RUDDERS PILOT HAD TO BE MECHANICAL TO BE PRECISE, A BOTHERSOME FEATURE.</td></tr>
<tr><td colspan="2">PRIMARY REASON FOR PILOT RATING</td><td colspan="2">GOOD A/C, BUT SLIGHT DEGRADATION IN TURBULENCE.</td><td colspan="2"></td><td colspan="2">A/C SATISFACTORY; MILDLY UNPLEASANT DEFICIENCIES.</td></tr>
</table>

GROUP 14	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT CALM	LIGHT TO MODERATE 12	LIGHT 0
PR/TR	4/C	2/A	1/A
GENERAL COMMENTS	LATERAL DIRECTIONAL HANDLING QUALITIES FAIR TO GOOD, CLOSER TO FAIR. GOOD TECHNIQUE MAY BE TO MAKE SMALL HEADING CHANGES WITH RUDDER ONLY. COULD BE FLOWN, HANDS OFF, WITH THE RUDDER ONLY.	CONFIGURATION SUITABLE FOR LANDING APPROACH; FELT COMPLETE CONFIDENCE.	SMALL HEADING CORRECTIONS AND SMALL BANK ANGLE CHANGES COULD BE MADE WITHOUT PROBLEMS. HEADING MAINTENANCE GOOD. OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES VERY GOOD TO EXCELLENT.
ABILITY TO TRIM	SOME DIFFICULTY TRIMMING BOTH LATERALLY AND DIRECTIONALLY. HIGH YAW DUE TO ROLL ADDS TO TRIM PROBLEMS.	NO PROBLEMS; SATISFACTORY.	BOTH AILERON AND RUDDER QUITE GOOD
SELECTION OF CONTROL SENSITIVITIES	GAIN SELECTED FOR AILERONS SEEMED SOMEWHAT LOW; HOWEVER, FORCES WERE PRETTY GOOD.	COULD HAVE GONE A LITTLE LIGHTER ON RUDDER FORCES. FOR NORMAL FLYING RUDDERS WERE LIGHT ENOUGH AND SENSITIVITY OK. BUT WHEN WING-LOW METHOD USED ON A CROSSWIND APPROACH, MORE RUDDER FORCE HAD TO BE USED THAN PILOT WOULD LIKE TO HOLD FOR VERY LONG. COULD HAVE SELECTED LIGHTER FORCES ON RUDDER.	FEEL FORCES NO PROBLEM, BUT SEVERAL SITUATIONS REQUIRED SOMEWHAT HIGH AILERON FORCE. NO LARGE DISPLACEMENTS; GEARING RATIO SELECTION GOOD.
$L'_{\delta_{AW}}$	2.12	3.01	1.64
$N'_{\delta_{RP}}$	8.11	11.4	7.25
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL SOMEWHAT SLOPPY. ALTHOUGH DUTCH ROLL OSCILLATION PRESENT, IT IS MODERATELY WELL DAMPED AND OF A RELATIVELY LOW FREQUENCY; DAMPS OUT WITH NO PROBLEM. A/C QUITE DIFFICULT TO COORDINATE IN TURNS, REQUIRING FREQUENT RUDDER REVERSALS, AND VERY DIFFICULT TO MAKE SMALL HEADING CHANGES WITH AILERONS. YAW DUE TO ROLL CAUSES HEADING TO HANG UP AND BREAK LOOSE ALL AT ONCE. LANDING APPROACH FAIR TO GOOD. EASY TO CONTROL A/C IN BANK WITH JUST RUDDERS.	FOR ROLL CONTROL, INITIAL RESPONSE SATISFACTORY. IT WAS PREDICTABLE; NO TENDENCY TO OVERCONTROL. SOME TENDENCY TO OVERSHOOT DESIRED BANK ANGLE, BUT NOTHING A LITTLE ATTENTION COULDN'T CURE. YAW DUE TO ROLL WAS IN THE NORMAL SENSE REQUIRING RUDDER INTO THE TURN INITIALLY AND THEN TAKING RUDDER OUT. COORDINATION REQUIRED, BUT SEEMED TO COME QUITE NATURALLY AND WAS BEING TAKEN CARE OF WITHOUT MUCH THOUGHT. ROLL SEEMS SOMEWHAT OSCILLATORY. WHEN DISTURBED BY A LATERAL GUST, IT TENDS TO CONTINUE OSCILLATING, BUT NOT NOTICEABLE DURING FLYING. ALMOST NO EFFORT REQUIRED, TO GET RID OF IT.	YAW DUE TO ROLL NEGLIGIBLE. COORDINATION NO PROBLEM. NO BOTHERSOME LATERAL DIRECTIONAL OSCILLATIONS. VERY SUITABLE IN LANDING APPROACH CONFIGURATION.
DIFFERENCES IN IFR AND VFR	NO APPRECIABLE DIFFERENCES; HOWEVER, BOTH ARE SOMEWHAT DEGRADED IN TURBULENCE.	UNDER IFR WITH THE SMALL CONTROL MOTIONS, COORDINATION REQUIREMENTS DIDN'T SHOW UP AS THEY DO UNDER VFR WITH LARGER MAGNITUDE INPUTS.	NONE.
EFFECTS OF TURBULENCE	NOSE OSCILLATION WITH ADDITION OF TURBULENCE SEEMS TO INCREASE THE PROBLEMS. UNDER IFR CONDITIONS, A/C MOTION SOMEWHAT DISTURBING. YAW ANGLE BUILDS UP AND A/C VERY SLOW TO RETURN TO CENTER POSITION. BUT NO PROBLEM. SMALL HEADINGS COULD BE MADE ADEQUATELY WITH MUCH RUDDER USE AND LIMITED AILERON USE.	NOT AFFECTED AT ALL; HARDLY NOTICEABLE.	NONE.
CONTROL IN CROSSWIND	NO COMMENT	COULD SEE WHAT WAS HAPPENING WITH BOTH CROSSWIND APPROACH TECHNIQUES AND WAS QUITE PREPARED TO DECRAB OR USE WING-DOWN METHOD. SOME COMPLAINT ABOUT RUDDER FORCES WITH WING-DOWN METHOD, BUT THAT COULD HAVE BEEN CURED BY SELECTING HIGHER RUDDER SENSITIVITY. IN THIS CASE, CRAB APPROACH BETTER BECAUSE DISLIKED HOLDING RUDDER FORCES IN WING-DOWN APPROACH.	NO DIFFICULTIES.
FAVORABLE FEATURES	NONE PARTICULARLY GOOD	LACK OF TURBULENCE RESPONSE AND COORDINATION REQUIRED BOTH FAVORABLE. COORDINATION REQUIRED, PILOT DIDN'T HAVE TO THINK ABOUT HOW TO USE FEET.	A/C EASILY MANEUVERED IN BOTH ROLL AND HEADING. OVERALL LATERAL-DIRECTIONAL MANEUVERABILITY GOOD.
OBJECTIONABLE FEATURES	INABILITY TO TRIM AND VERY HIGH YAW DUE TO ROLL REQUIRED MUCH COORDINATION ON TURN COMMENCEMENT. ALSO CONSIDERABLE OSCILLATION, UNDER TURBULENCE, REQUIRING SPECIAL PILOTING TECHNIQUE: i.e., A LOT OF RUDDER USE WITH SMALL AILERON INPUTS TO MAINTAIN HEADING.	NO COMMENTS.	NONE.
PRIMARY REASON FOR PILOT RATING	MODERATE PILOT COMPENSATION AND APPLICATION OF A SPECIAL PILOTING TECHNIQUE WAS REQUIRED. VERY HIGH ROLL DUE TO YAW AND THE EFFECTS OF TURBULENCE WARRANT IMPROVEMENT.	SOME COMPENSATION IN TERMS OF RUDDER COORDINATION REQUIRED. IF STUDIED UP AND AWAY BY PUTTING IN ROLL INPUTS, THINGS LOOK A LOT WORSE THAN THEY DO JUST DOING THE JOB. PILOT COMPENSATION REQUIRED, BUT NOT A FACTOR.	A/C QUITE RESPONSIVE TO ALL PILOT INPUTS WHILE MANEUVERING AND DURING LANDING APPROACH.

GROUP 14 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.10$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT 5	LIGHT 24, GUSTING TO 30
PR/TR	3/B	3/B
GENERAL COMMENTS	WHEN TIME WAS SPENT TO GET TRIMMED UP JOB COULD BE DONE. SUITABLE FOR LANDING APPROACH, AND IS IN NO WAY A HANDICAP.	GOOD OVERALL LATERAL-DIRECTIONAL HANDLING QUALITIES.
ABILITY TO TRIM	SOME DIFFICULTY WITH LATERAL TRIM DURING ILS APPROACH; MISTRIMMED ON OCCASION. WHEN TIME WAS SPENT, JOB COULD BE DONE	NO PROBLEM ENCOUNTERED WITH AILERON OR RUDDER
SELECTION OF CONTROL SENSITIVITIES	SLIGHT COMPROMISE. PILOT WOULD HAVE LIKED TO INCREASE SENSITIVITY BUT WAS GETTING SOME TENDENCY TO OVERCONTROL. LATERAL CONTROL SLIGHTLY HEAVIER THAN DESIRABLE.	FORCE REQUIRED DURING OFFSET APPROACH WAS A LITTLE HEAVIER TO GET REQUIRED RESPONSE THAN PILOT WOULD HAVE LIKED, BUT IT WAS WELL WITHIN HIS LIMIT; GOOD DISPLACEMENTS AND HARMONY. WOULD REQUEST NO CHANGES IN INITIAL GEARING SELECTIONS.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	2.12 8.05	1.30 6.45
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL INITIAL RESPONSE GOOD. FINAL RESPONSE PREDICTABLE WITH SOME TENDENCY TO OVERSHOOT. COORDINATION REQUIRED. A LITTLE MORE THAN HAVING TO SQUEEZE IT ON. ALTHOUGH NOT A BIG PROBLEM, REQUIRED SOME THOUGHT.	GOOD ROLL CONTROL. SMALL PROBLEM WITH HEADING OVERSHOOT. WHEN TRYING TO MAKE SMALL HEADING CORRECTIONS, VERY SLOW TO RESPOND INITIALLY, AND AFTER ROLLING WINGS LEVEL, TENDED TO OVERSHOOT. NO COORDINATION PROBLEM IN TURNS.
DIFFERENCES IN IFR AND VFR	NOTHING NOTICED IN ONE THAT WASN'T PRESENT IN THE OTHER.	DURING IFR OVERSHOOT IN HEADING NOT NOTICEABLE. DURING VFR, SMALL PROBLEM NOTICED WITH HEADING OVERSHOOT WHEN 3° TO 4° HEADING CORRECTIONS ATTEMPTED.
EFFECTS OF TURBULENCE	CERTAINLY NOTICEABLE AND SOMEWHAT BOTHERSOME AT TIMES BECAUSE OF CROSSTALK BETWEEN DIRECTIONAL AND ROLL. SIDE GUSTS REQUIRED NOT ONLY RUDDER COMPENSATION BUT ALSO AILERON COMPENSATION.	NO SIGNIFICANT DETERIORATION AS A RESULT OF TURBULENCE
CONTROL IN CROSSWIND	NO CROSSWIND NOTICED.	UNDER FAIRLY HEAVY CROSSWIND CONDITIONS, SUITABLE FOR LANDING APPROACH, BUT WHEEL FORCE A LITTLE HIGH WHEN MAKING CORRECTIONS DURING FINAL APPROACH. WITH A 20-KT CROSSWIND COMPONENT, CONTROL WAS EASY AND DIDN'T OVERTAX PILOT WITH A WORKLOAD.
FAVORABLE FEATURES	ROLL CONTROL SATISFACTORY AND ABILITY TO DO THE SIDESTEP MANEUVER GOOD.	GOOD OVERALL CONTROL.
OBJECTIONABLE FEATURES	NOTHING EXCEPTIONALLY GOOD OR BAD. SOME RUDDER COORDINATION REQUIRED. TURBULENCE NOTICEABLE, REQUIRING A LITTLE EFFORT TO COMPENSATE FOR IT.	SOME OSCILLATION, BUT NOT PARTICULARLY BAD.
PRIMARY REASON FOR PILOT RATING	ADEQUATE PERFORMANCE ATTAINABLE; SATISFACTORY WITH MILDLY UNPLEASANT DEFICIENCIES.	MINIMAL PILOT COMPENSATION REQUIRED.

GROUP 14 STICK CONTROLLER	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.10$ PILOT A	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.10$ PILOT B	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = -0.05$ PILOT B
NATURAL TURBULENCE MAX. X-WIND (~KT)	MODERATE 28	LIGHT ZERO	LIGHT TO MODERATE 5
PR/TR	3/C	4/C	3/B
GENERAL COMMENTS	FAIR TO GOOD OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES - FAIR TO GOOD FOR LANDING APPROACH.	COORDINATION DIFFICULTIES IMPLIED. SUITABLE FOR LANDING APPROACH WITH SOME MINOR CORRECTIONS.	SUITABLE FOR LANDING APPROACH. GOOD ILS PERFORMANCE. NO PROBLEMS BUT THERE WAS NO TURBULENCE. RUDDER USED TO LEAD TURNS.
ABILITY TO TRIM	GOOD LATERAL TRIM. SLIGHTLY DEGRADED DIRECTIONAL TRIM.	NO COMMENTS.	NO PROBLEMS.
SELECTION OF CONTROL SENSITIVITIES	GOOD STICK FORCES AND DISPLACEMENTS. GOOD CONTROL HARMONY AND GEAR RATIOS.	A LOT OF SMALL AMPLITUDE RUDDER COORDINATION REQUIRED, SATISFACTORY LATERAL AND RUDDER FORCES DIFFICULT TO GET. PRECISE LATERAL FORCES MADE FOR PRECISE BANK ANGLE CHANGES. DANGER OF RUDDER GETTING TOO LIGHT CAUSING PROBLEMS BY RUDDER OVERCONTROL. UNABLE TO COORDINATE WITHOUT OVERCONTROL CAUSING PROBLEMS SELECTING RUDDER FORCES.	SLIGHT FORCE NOTICEABLE WITH SELECTED LATERAL SENSITIVITY. NO COMPROMISES. RUDDER COORDINATION REQUIRED SO RUDDER SENSITIVITY SELECTED FOR EASE OF RUDDER COORDINATION.
$L'_{\delta_{AS}}$ | $N'_{\delta_{RP}}$	25.7 | 11.4	30.1 | 13.0	21 2 | 8.04
LATERAL AND DIRECTIONAL CONTROL	RESPONSIVE ROLL CONTROL BUT CONSIDERABLE ADVERSE YAW DUE TO ROLL. SMALL ADVERSE YAW DUE TO AILERON. COORDINATION PROBLEM IN INITIAL RUDDER REQUIREMENTS, WHEN INITIATING TURNS IS DIFFICULT BECAUSE OF YAW DUE TO ROLL RATE. GAIN SMALL BUT OK FOR OTHER MANEUVERING. LIGHTLY POSITIVE DIHEDRAL EFFECT. THE DUTCH ROLL MODE SHOWN BY NOSE WANDERING ON HORIZON, SLOWLY SELF-CENTERING. NO PROBLEM MAINTAINING HEADING AND SMALL HEADING CORRECTIONS.	AMPLE INITIAL LATERAL RESPONSE; PREDICTABLE AND NO TENDENCY TO OVERCONTROL; ADVERSE YAW DUE TO ROLL. RUDDER USED WHEN NOSE WOULD HANG UP AND BALL SLIDE OUT. OVERCONTROLLED WITH RUDDER. CONTROL NOT SMOOTH DUE TO COORDINATION PROBLEMS.	GOOD ROLL CONTROL. GOOD INITIAL RESPONSE AND PREDICTABLE FINAL RESPONSE WITH NO TENDENCY TO OVERCONTROL. ADVERSE YAW DUE TO ROLL AND MODERATE BALL MOTION UPON AILERON INPUTS. EXCESSIVE INITIAL BALL EXCURSION FORCED COORDINATION OF TURNS WITH RUDDER. SLIGHT COORDINATION IN STEADY STATE WAS NEEDED.
DIFFERENCES IN IFR AND VFR	NONE.	NO OUTSTANDING DIFFERENCES EXCEPT USUAL VFR PROBLEM MAGNIFICATION DUE TO LARGER INPUTS.	GOOD IN ILS. COORDINATION EASIER ON INSTRUMENTS. IN VFR COORDINATION SOMETIMES FORGOTTEN, POSSIBLY BECAUSE OF LARGER MANEUVERS AND COORDINATION REQUIRED MORE EFFORT.
EFFECTS OF TURBULENCE	MODERATE EFFECT ON COORDINATION PROBLEMS. RELATIVELY HIGH RUDDER FORCES FOR COORDINATION IN SMALL TURNS. EASY LATERAL CONTROL. SLIGHTLY DEGRADED DIRECTIONAL CONTROL DUE TO EXCURSIONS BUT EASILY CONTROLLED WITH MODERATE RUDDER MANIPULATION. MUCH RUDDER APPLICATION FOR COORDINATION IN SMALL TURNS.	NOTICEABLE BUT SUPPRESSIBLE TURBULENCE EFFECTS.	NOTICEABLE TURBULENCE BUT COUNTERACTION NOT REQUIRED.
CONTROL IN CROSSWIND	NO DIFFICULTIES, PLENTY OF CONTROL AVAILABLE FOR CRAB OR COMBINATION CRAB AND WING LOW CORRECTIONS FOR CROSSWIND.	NO COMMENTS.	NO PROBLEM.
FAVORABLE FEATURES	USUALLY FAIR TO GOOD A/C.	SATISFACTORY ROLL RESPONSE WITH SLIGHT TENDENCY TO OVERCONTROL.	GOOD ROLL CONTROL WITH POSITIVE FEELING.
OBJECTIONABLE FEATURES	VERY LOW FREQUENCY AND DAMPING OF DUTCH ROLL MODE (SELF CORRECTING), BUT MORE STABILITY IN THE DUTCH ROLL MODE DESIRED ESPECIALLY IN TURBULENCE.	RUDDER USED ON HEADING HANG UP ON AILERON ONLY TURNS CAUSING PILOT TO OVERCONTROL. RUDDER INPUTS FED BACK INTO THE REQUIRED LATERAL CONTROL FORCES TO HOLD STEADY BANK ANGLE CAUSING COORDINATION PROBLEM, MORE BOTHERSOME THAN DIFFICULT.	ANNOYING INITIAL BALL EXCURSIONS WITH MODEST ROLL RATE.
PRIMARY REASON FOR PILOT RATING	TURBULENCE ANNOYING, MODERATE PILOT COMPENSATION REQUIRED.	ADEQUATE BUT NOT SATISFACTORY. DIDN'T CATCH ON TO COORDINATION REQUIREMENTS. ANNOYING MINOR DEFICIENCIES.	MILDLY UNPLEASANT DEFICIENCES. EXTRA EFFORT FOR TURN COORDINATION AND RESPONSE TO TURBULENCE, ILS SURPRISINGLY EASY. EASIER TO FLY WHEN TRYING REAL PRECISION CONTROL.

GROUP 14 (Cont.) STICK CONTROLLER	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = 0$ PILOT A	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.05$ PILOT A	$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.05$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE 20, GUSTING TO 26	MODERATE 20	NIL 4
PR/TR	2/A	2/B	2/A
GENERAL COMMENTS	FAIR TO GOOD OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES. GOOD FOR LANDING AND GOOD ILS PERFORMANCE.	GOOD LATERAL DIRECTIONAL HANDLING QUALITIES. GOOD OVERALL HANDLING QUALITIES IN LIGHT TURBULENCE.	SATISFACTORY FOR LANDING APPROACH. ON ILS, VERY GOOD.
ABILITY TO TRIM	SLIGHT PROBLEM IN DIRECTIONAL TRIM BUT PILOT ABILITY TO TRIM LATERALLY NOT AFFECTED TOO MUCH.	SLIGHTLY DEGRADED DIRECTIONAL AND LATERAL TRIM PARTICULARLY DIRECTIONALLY, BUT NOT A BIG PROBLEM.	NO COMMENTS.
SELECTION OF CONTROL SENSITIVITIES	DEAD ZONE ± 1/2 INCH, BOTH LONGITUDINALLY AND LATERALLY. STICK HAS A LITTLE PLAY AROUND CENTER BUT IS GOOD. GOOD STICK FORCES AND DISPLACEMENTS.	GOOD FORCES AND DISPLACEMENTS. GOOD CONTROL HARMONY AND SELECTION OF GEAR RATIOS.	NO COMMENTS.
$L'_{\delta_{AS}}$	21.2	21.2	17.1
$N'_{\delta_{RP}}$	9.64	11.4	6.45
LATERAL AND DIRECTIONAL CONTROL	GOOD ROLL RESPONSE. SLIGHT ADVERSE YAW DUE TO ROLL OR DUE TO AILERON YET NEEDS LITTLE EFFORT TO MAINTAIN COORDINATION IN TURNS. SET UP OSCILLATION TAKES TIME TO SETTLE OUT, HORIZON MOTION DAMPENS OUT PRETTY SLOW SLIGHTLY POSITIVE DIHEDRAL EFFECT. ONLY SLIGHT CAPABILITY TO LIFT WING WITH RUDDER. OSCILLATION SLOW IN DUTCH ROLL MODE. GOOD ABILITY TO MAINTAIN HEADING AND MAKE SMALL CORRECTIONS.	ADEQUATE TO GOOD ROLL CONTROL. LIGHT AND ADVERSE YAW DUE TO ROLL. LIGHT AND PROVERSE YAW DUE TO AILERON. NO PROBLEM IN COORDINATION OF TURNS, BUT RUDDER KEPT IN THROUGHOUT THE TURN. DAMPING PRESENT AND LIGHT, IN THE FAIRLY MEDIUM OSCILLATORY FREQUENCY: BUT NO PROBLEM IN MAKING SMALL HEADING CORRECTIONS. ILS PERFORMANCE NEEDED MORE THAN USUAL RUDDER APPLICATION FOR COORDINATED TURNS BUT NOT A PROBLEM.	PRECISE AND RESPONSIVE ROLL CONTROL WITH NO TENDENCY TO OVERCONTROL. SLIGHT ADVERSE YAW DUE TO ROLL REQUIRING MINOR NORMAL COORDINATION
DIFFERENCES IN IFR AND VFR	NONE.	NONE	NOT NOTICEABLE
EFFECTS OF TURBULENCE	SLIGHTLY REDUCED MAINTENANCE OF DIRECTIONAL CONTROL. SLIGHTLY DEGRADED SMALL CORRECTION ABILITY.	NO EFFECT. SMALL DIRECTIONAL AND BANK EXCURSIONS. SMALL HEADING CORRECTIONS EASY TO MAKE.	A/C JARRED AROUND BUT NO EFFECT ON PILOT PERFORMANCE.
CONTROL IN CROSSWIND	EASILY CONTROLLED IN STIFF CROSSWIND USING MOSTLY CRAB TECHNIQUE. SLIGHT CORRECTIONS USING WING DOWN INTO THE WIND AND EASILY CONTROLLED.	NO PROBLEM. USED CRABBED TECHNIQUES WITH WING LOW CORRECTIONS.	NO COMMENTS
FAVORABLE FEATURES	A/C CONTROLLABLE DIRECTIONALLY, LONGITUDINALLY, AND LATERALLY. FLIES VERY WELL.	RELATIVELY MANEUVERABLE, VERY RESPONSIVE AND GOOD FLYING A/C	SOLID, RESPONSIVE A/C
OBJECTIONABLE FEATURES	SLOW SELF-CENTERING IN LOW FREQUENCY OSCILLATIONS.	EXTRA EFFORT IN TRIMMING AND MORE RUDDER CONTROL FOR COORDINATION	REQUIRED HEAVIER FORCES LATERALLY THEN DESIRED. REASONABLE COMPROMISES REQUIRED
PRIMARY REASON FOR PILOT RATING	SLOW RESPONDING OSCILLATIONS, BUT A/C IS FINE. PILOT COMPENSATION NOT A FACTOR FOR DESIRED PERFORMANCE.	GOOD A/C WITH NEGLIGIBLE DEFICIENCIES. PILOT COMPENSATION NOT A FACTOR.	TURBULENCE NOT A FACTOR. SLIGHT COORDINATION REQUIRED. NOT A DEGRADING FACTOR

<table>
<tr><th colspan="2">GROUP 14 (Cont.)
STICK CONTROLLER</th><th colspan="2">$N'_{\delta_{AS}} / L'_{\delta_{AS}} = +0.10$
PILOT A</th></tr>
<tr><td colspan="2">NATURAL TURBULENCE
MAX. X-WIND (~KT)</td><td colspan="2">LIGHT +
19</td></tr>
<tr><td colspan="2">PR/TR</td><td colspan="2">2.5/B</td></tr>
<tr><td colspan="2">GENERAL COMMENTS</td><td colspan="2">VERY GOOD OVERALL LATERAL-DIRECTIONAL HANDLING QUALITIES. VERY GOOD FOR LANDING APPROACH TASK. GOOD ILS PERFORMANCE.</td></tr>
<tr><td colspan="2">ABILITY TO TRIM</td><td colspan="2">NO DIFFICULTIES WITH LATERAL TRIM; RUDDER MORE DIFFICULT THAN DESIRED, BUT NOT A PROBLEM.</td></tr>
<tr><td colspan="2">SELECTION OF CONTROL SENSITIVITIES</td><td colspan="2">GOOD SELECTED GAINS (AILERON AND RUDDER GEARING RATIOS)</td></tr>
<tr><td>$L'_{\delta_{AS}}$</td><td>$N'_{\delta_{RP}}$</td><td>25.7</td><td>6.45</td></tr>
<tr><td colspan="2">LATERAL AND DIRECTIONAL CONTROL</td><td colspan="2">RESPONSIVE IN ROLL. PECULIAR IN YAW DUE TO ROLL: A/C ROLLS INTO A BANK WITH SLIGHT COORDINATION BUT AFTER ROLL RATE IS GENERATED, RUDDER REQUIREMENT INCREASES MODERATELY, THUS SLIGHTLY ADVERSE IN YAW DUE TO ROLL PROVERSE YAW DUE TO AILERON COMBINATION OF DUTCH ROLL FREQUENCY AND DAMPING MAKE OSCILLATIONS DAMP OUT IN 3 OR 4 CYCLES BUT OSCILLATION IS SLOW. A/C RESPONSIVE WHEN MAKING SMALL HEADING CORRECTIONS AND KEEPING SPECIFIED HEADING.</td></tr>
<tr><td colspan="2">DIFFERENCES IN IFR AND VFR</td><td colspan="2">NONE NOTICEABLE.</td></tr>
<tr><td colspan="2">EFFECTS OF TURBULENCE</td><td colspan="2">MINIMAL EFFECTS NOTICED. YAWING MOTIONS ARE CONSIDERABLY LARGER IN TURBULENCE. LITTLE ROLLING MOTION WITH THE OSCILLATION. ILS TRACKING NOT DIFFICULT.</td></tr>
<tr><td colspan="2">CONTROL IN CROSSWIND</td><td colspan="2">NO DIFFICULTY WITH COMBINATION CRAB AND LOW WING TECHNIQUE</td></tr>
<tr><td colspan="2">FAVORABLE FEATURES</td><td colspan="2">A/C EASILY CONTROLLED LATERALLY AND DIRECTIONALLY, EVEN IN TURBULENCE.</td></tr>
<tr><td colspan="2">OBJECTIONABLE FEATURES</td><td colspan="2">MORE ATTENTION REQUIRED TO COORDINATE MANEUVERS, POSSIBLY DUE TO THE PROVERSE YAW DUE TO AILERON WHICH MAY BE PARTIALLY CANCELLED WITH YAW DUE TO ROLL.</td></tr>
<tr><td colspan="2">PRIMARY REASON FOR PILOT RATING</td><td colspan="2">GOOD A/C FOR LANDING APPROACH. MINIMAL PILOT COMPENSATION REQUIRED FOR DESIRED PERFORMANCE.</td></tr>
</table>

GROUP 15	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.10$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = -0.05$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = 0$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT 20	LIGHT (1) 9	MODERATE 20
PR/TR	6.5/E	5/B	5/C
GENERAL COMMENTS	LARGE INTERACTION BETWEEN DIRECTIONAL AND LATERAL. PILOT HAD TO HOLD TREMENDOUS AILERON FORCES IF THERE WAS ANY MIS-COORDINATION DURING TURN ENTRY MUST LEAD WITH RUDDER OTHERWISE FORCE LEVELS GET HIGH AND ERRATIC LATERALLY IN ILS, COULD DO REASONABLE JOB, BUT A/C UNSUITABLE FOR LANDING APPROACH AS IT STANDS.	OVERALL HANDLING QUALITIES WITH SELECTED GAIN APPEAR POOR OVERALL ACCEPTABILITY FOR LANDING APPROACH TASK IS FAIR	OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES APPEAR FAIR DEGRADING EFFECT ON ILS PRECISION TRACKING TASK NOTICED SOME OSCILLATIONS IN BANK ANGLE
ABILITY TO TRIM	DIFFICULTY WITH LATERAL TRIM INITIALLY AFTER A/C HAD BEEN FLOWN AWHILE, AND FORCES HAD BECOME MORE REASONABLE, COULD TRIM REASONABLY WELL PROBABLY UNSATISFACTORY BUT LIKELY ACCEPTABLE	EXCEPTIONALLY DIFFICULT TO TRIM BOTH DIRECTIONALLY AND IN ROLL QUITE A BIT OF OPPOSITE AILERON REQUIRED TO KEEP A/C UNDER CONTROL WHEN INTERCEPTING LOCALIZER OF ILS IN TURBULENCE TRIM VERY DIFFICULT	NO PROBLEM, PERHAPS A LITTLE SLOW LATERALLY RUDDER TRIM FAIRLY EASY TO ACHIEVE EVEN IN MODERATE TURBULENCE
SELECTION OF CONTROL SENSITIVITIES	NO PROBLEMS WITH RUDDER FORCES OR DISPLACEMENTS SELECTED AILERON SENSITIVITY AS LIGHT AS DESIRED FOR PRECISION SMALL BANK ANGLE TASK QUITE NICE WITH PROPER COORDINATION WITH ANY MIS-COORDINATION COULD END UP WITH LARGE FORCES IN CROSSWIND APPROACH, AILERON FORCES BORDERED ON UNACCEPTABLE DIFFICULT TO REALLY ISOLATE LATERAL CASE BECAUSE SO IMPORTANT TO USE RUDDER	NO COMMENTS	GOOD FORCES AND DISPLACEMENTS BUT CONSIDERABLE RUDDER FORCE INVOLVED IN KEEPING TURN COORDINATED
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	3.42 9.70	2.50 9.52	2.12 8.04
LATERAL AND DIRECTIONAL CONTROL	WITH REASONABLE COORDINATION IF PROPERLY LEADING TURNS WITH RUDDER, ROLL CONTROL SATISFACTORY YAW DUE TO ROLL WAS IN ADVERSE SENSE WITH AILERON ONLY TURNS, BALL WENT INTO TURN QUITE A LARGE AMOUNT COORDINATION A DEFINITE REQUIREMENT, BUT PILOT QUICKLY LEARNED A COMBINATION OF AILERON AND RUDDER TO GIVE SMOOTH TURN ENTRY AND EXIT ATTEMPTS TO COORDINATE WITH RUDDER WOULD CAUSE TENDENCY TO OVERBANK. COUNTERACTED WITH AILERON AND HELD A SMALL FORCE ONCE BALL SETTLED IN CENTER FORCES HARDLY NOTICEABLE	YAW DUE TO AILERON INPUTS ADVERSE ALTHOUGH NOT MUCH OF A FEEL FOR MAGNITUDE DISCONCERTING YAWING MOTIONS INVOLVED WITH RAPID ROLL MOTIONS, REQUIRING MUCH COORDINATION MODERATELY POSITIVE DIHEDRAL EFFECT WITH WHAT APPEARS TO BE VERY LOW DUTCH ROLL FREQUENCY. NOSE SEEMED TO WANDER WITHOUT EVEN CENTERING MUCH ANGLES OF SIDESLIP SEEM TO CONTINUE TO BUILD WITH A SLIGHT OSCILLATION TRYING TO TRIM RUDDER TO CENTER BALL CAUSED NOSE TO KICK BACK VERY RAPIDLY AND EVEN GO OFF TO OTHER SIDE MUCH INTERACTION BETWEEN ROLL AND SIDE SLIP IN TRIM BOTH DIFFICULT TO OBTAIN WITH YAW ANGLE BUILD UP WHEEL FORCES BECOME QUITE HIGH AND MAINTAIN ROLL UNTIL QUITE A BIT OF RUDDER FORCE PUT IN TO BRING BALL BACK TO CENTER AILERON OUT OF TURN REQUIRED TO MAINTAIN BANK ANGLE WHEN RUDDER PUT INTO TURN FOR COORDINATION	ROLL RESPONSE SOMEWHAT DEGRADED BY WHAT APPEARS TO BE RELATIVELY LONG ROLL TIME CONSTANT SMALL HEADING CORRECTIONS MORE DIFFICULT BECAUSE OF ROLL CONTROL COORDINATION REQUIRED IN NORMAL SENSE BUT AN EXCESSIVE AMOUNT OF RUDDER REQUIRED VERY LARGE ROLL RATES CAN BE DEVELOPED BY APPLICATION OF RUDDER AN ALMOST CONSTANT AILERON CORRECTION REQUIRED TO MAINTAIN WINGS LEVEL WHENEVER BANK ANGLES REACHED 30° OPPOSITE AILERON AND CONSIDERABLE RUDDER FORCE INTO THE TURN WAS REQUIRED TO KEEP TURN COORDINATED
DIFFERENCES IN IFR AND VFR	IN IFR OUT OF TURBULENCE, REASONABLE JOB COULD BE DONE IF PILOT REMEMBERED TO LEAD WITH RUDDER IN VFR OCCASIONALLY RAN INTO PROBLEMS GETTING SOME RATHER LARGE MIS-COORDINATION BEING A LITTLE DUMB WITH RUDDER USAGE COULD LEAD TO QUITE A PROBLEM WITH LATERAL CONTROL	NO SIGNIFICANT DIFFERENCES.	NO SIGNIFICANT DIFFERENCES
EFFECTS OF TURBULENCE	NOTICEABLE AND BOTHERSOME ROLL RESPONSE QUITE LARGE GIVING MODERATE CONTROL TASK TO KEEP CONSTANT BANK ANGLE OR WINGS LEVEL WHILE USING RUDDER TO KEEP BALL REMOTELY CLOSE TO CENTER	LARGE DIRECTIONAL EXCURSIONS INCREASED WITH TURBULENCE CONSIDERABLE EFFORT REQUIRED TO MAINTAIN DIRECTIONAL CONTROL IN COORDINATED FLIGHT BECAUSE A LITTLE BANK ANGLE PRODUCES CONSIDERABLE AILERON FORCES WHICH ARE REQUIRED OPPOSITE TO BANK TO KEEP BANK FROM INCREASING	DIRECTIONALLY SMALL EXCURSIONS BUT CONSTANT LATERAL CORRECTION REQUIRED TO MAINTAIN WINGS LEVEL
CONTROL IN CROSSWIND	LATERAL FORCES USING WING DOWN METHOD, WERE GETTING LARGE PERHAPS ACCEPTABLE BUT CERTAINLY NOTICEABLE LARGE ROLL DUE TO ANY RUDDER INPUT CREATED A PROBLEM IN DE-CRABBING LARGE ROLL WAS PRODUCED, PILOT ENDED UP WITH LARGE AILERON FORCE TO COUNTERACT ROLL, AN UNCOMFORTABLE TRANSIENT CLOSE TO THE GROUND THEREFORE, DISLIKED CRAB METHOD	NO PROBLEMS	NO PARTICULAR PROBLEMS
FAVORABLE FEATURES	NONE	NOTHING OUTSTANDING	FAIRLY EASY MANEUVERING IN CERTAIN CONDITIONS, HOWEVER NO OUTSTANDING FEATURES
OBJECTIONABLE FEATURES	LARGE ROLL DUE TO YAW AND REQUIREMENT TO USE RUDDER CONSTANTLY TURBULENCE RESPONSE EXCESSIVE DIFFICULT CONTROL TASK WITH INTERRELATIONSHIPS REQUIRED BETWEEN RUDDER AND AILERON	VERY LOW PERIOD FREQUENCY COUPLED WITH RELATIVELY MODERATE YAW DUE TO ROLL CAUSED EXCEPTIONAL PROBLEMS IN BOTH LATERAL AND DIRECTIONAL TRIM LITTLE BIT OF RUDDER TRIM STARTS BALL MOVING RAPIDLY TO OTHER SIDE	ANY TIME BANK ANGLE GETS ABOVE 30 DEGREES A LOT OF RUDDER AND OPPOSITE AILERON COORDINATION REQUIRED TO KEEP BANK FROM INCREASING CONSTANT PILOT EFFORT IS REQUIRED TO MAINTAIN A ZERO BANK ANGLE PILOT EFFORT INCREASED BY PROBLEMS OF COORDINATION IN TURNS ALMOST CONSTANT ATTENTION REQUIRED TO MAINTAIN BANK ANGLE UNDER CONTROL AND TO MAKE REQUIRED SMALL CORRECTIONS FOR ILS AND PRECISION TRACKING TASKS UNDER IFR
PRIMARY REASON FOR PILOT RATING	DISLIKE FLYING A/C BOTHERSOME CLOSE TO GROUND. "BEST EFFORTS REQUIRED" IS TURBULENCE CATEGORY	CLOSE PILOT ATTENTION REQUIRED TO DIRECTIONAL CONTROL WITH MODERATE EFFORT OBJECTIONABLE BUT TOLERABLE DEFICIENCIES. CONSIDERABLE PILOT COMPENSATION REQUIRED IF ATTENTION DIVERTED TO OTHER TASKS, MIGHT GET INTO A LOT OF TROUBLE	DEFICIENCIES WARRANT IMPROVEMENT AND ARE MODERATELY OBJECTIONABLE MAINLY A ROLL PROBLEM WHICH REQUIRES INCREASED PILOT WORK LOAD

GROUP 15 (Cont.)	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.10$ PILOT A	$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.15$ PILOT B
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT 6	LIGHT 6	LIGHT 0
PR/TR	5/C	4/B	5/D
GENERAL COMMENTS	MARGINAL CONFIGURATION. MANY LITTLE THINGS WRONG; NUMBER OF COMPROMISES.	LATERAL DIRECTIONAL HANDLING QUALITIES SOMEWHAT BETTER THAN FAIR.	LURCHING ROLL CONTROL; ALWAYS TENDED TO OVERBANK. MUCH RUDDER COORDINATION REQUIRED IN STEADY STATE TURNS. NOT ENTIRELY SUITABLE FOR LANDING APPROACH.
ABILITY TO TRIM	GOOD.	DIFFICULT TO TRIM LATERALLY OR DIRECTIONALLY.	NOTHING NOTICEABLE; SATISFACTORY.
SELECTION OF CONTROL SENSITIVITIES	WITH SOMEWHAT UNPREDICTABLE ROLL CONTROL, PILOT THOUGHT HEAVIER LATERAL FORCES WOULD LIMIT OVER-CONTROL TENDENCIES BUT RATHER SLOW INITIAL RESPONSE AND FAST LATERAL TURBULENCE RESPONSE SEEMED TO DEMAND LIGHTER AILERON FORCES. BEST COMPROMISE SEEMS TO GO WITH LIGHTER FORCES AND NOT HAVE SOME OF PROBLEMS WITH HEAVY FORCES COMBATTING TURBULENCE AND INITIATING ROLLS. FINAL SELECTION OF AILERON GEARING SLIGHTLY HEAVIER THAN INITIAL SELECTION. RUDDER SENSITIVITIES SELECTED SATISFACTORY. SINCE TURN COORDINATION REQUIRED FOR STEADY TURNS, SELECTED RUDDER FAIRLY SENSITIVE TO ELIMINATE HOLDING CONSTANT HEAVY FORCES IN TURNS.	RUDDER FORCES QUITE HIGH	DIRECTIONAL NO PROBLEM; SATISFACTORY. LATERAL FORCES, AT TIMES, WERE APPROACHING BEING A LITTLE HEAVY, BUT WOULDN'T HAVE WANTED TO SELECT THEM ANY MORE SENSITIVE. COMPROMISE IN AILERON SENSITIVITY SELECTION, i.e., ROLL CONTROL TENDS TO BE UNPREDICTABLE, OVERBANKING OR LURCHING. THIS, COUPLED WITH THE ROLL SENSITIVITY TO RUDDER INPUTS, PRODUCES OVERALL EFFECT OF LATERAL CONTROL FEELING QUITE LIGHT. HOWEVER, IN GUSTS OR GENERAL MANEUVERING, LATERAL FORCES CAN SOMETIMES FEEL HEAVY
$L'_{\delta_{AW}}$	2.98	1.71	2.15
$N'_{\delta_{RP}}$	11.4	8.10	9.70
LATERAL AND DIRECTIONAL CONTROL	DISLIKED ROLL RESPONSE. FORCES SEEMED TO GO FROM HEAVY TO LIGHT BECAUSE OF TENDENCY FOR ROLL TO ACCELERATE. TAKES HEAVY FORCES TO GET ROLL GOING, THEN UNPREDICTABLE FINAL RESPONSE TAKES LARGE AILERON INPUTS TO STOP ROLL. STEADY BANKED TURNS REQUIRED CONSTANT RUDDER. USING RUDDER TO CENTER BALL REQUIRED COUNTERACTION WITH AILERON BECAUSE OF LARGE ROLL DUE TO RUDDER	REDUCED ROLL RESPONSE REQUIRES HEAVIER WHEEL FORCES FOR REQUIRED MANEUVER AND SLOW A/C RESPONSE TO ASSUME ROLL RATE FROM COMMANDED AILERON INPUT. YAW DUE TO ROLL APPARENTLY ADVERSE AND LIGHT. CAN'T TELL MUCH ABOUT YAW DUE TO AILERON; APPEARS ADVERSE BUT CAN'T TELL ABOUT MAGNITUDE. DIHEDRAL EFFECT POSITIVE. COULD DEVELOP PRETTY GOOD ROLL WITH APPLICATION OF RUDDER. SLIGHT DELAY BUT THEN PRETTY GOOD ROLL RATE DEVELOPS. ROLL OSCILLATION APPEARS TO BE LIGHTLY DAMPED; TAKES QUITE A FEW OSCILLATIONS FOR ALL MOTION TO DIE OUT. INITIAL ROLL RESPONSE SLOW, REQUIRING QUITE A LARGE INPUT, THEN ROLL RATE BUILDS RAPIDLY	INITIAL ROLL RESPONSE, THE WAY A/C FLOWN, SEEMED ALL RIGHT. FINAL RESPONSE DIFFICULT TO PREDICT. YAW DUE TO ROLL MOST NOTICEABLE BY REQUIREMENT FOR RUDDER, QUITE A REASONABLE AMOUNT, IN STEADY TURN COORDINATION A FACTOR. ANNOYING.
DIFFERENCES IN IFR AND VFR	NO COMMENTS	NOT MUCH NOTICEABLE	NONE EXCEPT IN DIFFERENCE IN MANEUVERS PERFORMED IN IFR AND VFR TASKS
EFFECTS OF TURBULENCE	MUCH ROLL RESPONSE TO TURBULENCE NEVER OF LARGE AMPLITUDES, BUT A LOT OF SMALL DISTURBANCE. A BIT NERVOUS LATERALLY, BUT NOT DIFFICULT TO DEPRESS.	TURBULENCE SLIGHTLY DECREASED HANDLING QUALITIES. QUITE NOTICEABLE ROLLING CHARACTERISTIC WITH VERY LITTLE NOSE WANDERING, BUT ANY EXCURSIONS APPEAR TO DAMP THEMSELVES OUT. A/C HEADING FAIRLY EASILY MAINTAINED, BUT REQUIRES A LOT OF RUDDER FOR COORDINATION.	NOTICEABLE; PROVIDED MODERATE CONTROL TASK IN ROLL. INITIALLY OVERCONTROLLED TO SUPPRESS TURBULENCE. DIFFICULT TO SUPPRESS LATERAL TURBULENCE RESPONSE
CONTROL IN CROSSWIND	EITHER TECHNIQUE WOULD BE SATISFACTORY	USED CRABBED TECHNIQUE, NO DIFFICULTIES.	NO CROSSWIND; SUSPECT, BECAUSE OF COMPROMISE IN LATERAL SENSITIVITY SELECTION, THAT LATERAL FORCE WOULD BE QUITE HIGH USING WING DOWN METHOD.
FAVORABLE FEATURES	NOTHING STANDS OUT AS REALLY GOOD	FAIR A/C.	NO COMMENT
OBJECTIONABLE FEATURES	NOTHING REALLY BAD BUT TENDENCY TO OVERBANK COUPLED WITH TURN COORDINATION REQUIREMENT FOR STEADY RUDDER WAS BOTHERSOME. COORDINATION PROBLEM SOMEWHAT COMPLICATED. TURBULENCE RESPONSE ANNOYING.	REQUIRES CONSIDERABLE RUDDER FORCE FOR COORDINATION IN SMALL BANK ANGLE TURNS. RAPID ROLL RATE INCREASE AFTER SHORT PERIOD OF FAIRLY SLOPPY AILERON ROLL RESPONSE	ROLL CONTROL IS PRIMARY OBJECTION. COORDINATION NEXT; TURBULENCE RESPONSE ALSO BOTHERSOME, MOSTLY BECAUSE OF ROLL CONTROL
PRIMARY REASON FOR PILOT RATING	UNSATISFACTORY. OVERBANK TENDENCY STANDS OUT. TURN COORDINATION A PROBLEM.	MAJOR DEGRADING FACTORS WERE HEAVY RUDDER FORCE FOR COORDINATING SMALL ANGLE OF BANK TURNS AND RAPID ROLL RATE RESPONSE AFTER INITIAL DELAY. THESE DEFICIENCES WARRANT IMPROVEMENT. MODERATE PILOT COMPENSATION REQUIRED	UNSATISFACTORY AS IT STOOD. COMBINATION OF ROLL CONTROL AND COORDINATION MAJOR DISLIKE. ATTEMPTS TO COORDINATE WITH RUDDER LED TO HOLDING LARGE AILERON FORCES OUT OF TURN. IN TURBULENCE, A REAL BOTHER TRYING TO KEEP WINGS LEVEL.

<table>
<tr><th colspan="2">GROUP 16</th><th colspan="2">$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.10$
PILOT B</th><th colspan="2">$N'_{\delta_{AW}} / L'_{\delta_{AW}} = -0.05$
PILOT A</th><th colspan="2">$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$
PILOT A</th></tr>
<tr><td colspan="2">NATURAL TURBULENCE
MAX. X-WIND (~KT)</td><td colspan="2">LIGHT (+)
20</td><td colspan="2">LIGHT (+)
18</td><td colspan="2">LIGHT
9</td></tr>
<tr><td colspan="2">PR/TR</td><td colspan="2">4.5/C</td><td colspan="2">4/C</td><td colspan="2">2/B</td></tr>
<tr><td colspan="2">GENERAL COMMENTS</td><td colspan="2">REASONABLE AIRPLANE EXCEPT FOR LURCHING ROLL CONTROL. WITH SOME RESERVATIONS, ACCEPTABLE FOR LANDING APPROACH.</td><td colspan="2">OVERALL LATERAL-DIRECTIONAL HANDLING QUALITIES GOOD IN LIGHT NATURAL TURBULENCE. LITTLE EFFORT REQUIRED FOR COORDINATED TURNS. LANDING APPROACH SUITABILITY - FAIR. OVERALL SUITABILITY FOR LANDING APPROACH - POOR IN TURBULENCE.</td><td colspan="2">OVERALL - GOOD. NO MAJOR PROBLEMS ON THE ILS. SUITABLE FOR LANDING APPROACH PHASE.</td></tr>
<tr><td colspan="2">ABILITY TO TRIM</td><td colspan="2">SATISFACTORY.</td><td colspan="2">LATERAL-DIRECTIONAL TRIM IS FAIR TO GOOD, BUT RUDDER IS EXCEPTIONALLY DIFFICULT TO TRIM.</td><td colspan="2">GOOD.</td></tr>
<tr><td colspan="2">SELECTION OF CONTROL SENSITIVITIES</td><td colspan="2">SELECTED RUDDER SENSITIVITY WAS SATISFACTORY. LURCHING ROLL CONTROL MADE PILOT RELUCTANT TO SELECT LIGHTER FORCES, BUT HE SOMETIMES NOTICED AILERON FORCES; SOMEWHAT OF A COMPROMISE.</td><td colspan="2">FEEL FORCES AND DISPLACEMENTS SELECTED PRESENT NO PROBLEMS. ADDITIONAL LATERAL FORCE AND DISPLACEMENT REQUIRED FOR RAPID MANEUVERING AND PRECISE TRACKING.</td><td colspan="2">(PREVIOUSLY SELECTED VALUES WERE ASSIGNED.) THEY WERE GOOD.</td></tr>
<tr><td>$L'_{\delta_{AW}}$</td><td>$N'_{\delta_{RP}}$</td><td>2.12</td><td>11.4</td><td>1.30</td><td>9.64</td><td>1.40</td><td>11.41</td></tr>
<tr><td colspan="2">LATERAL AND DIRECTIONAL CONTROL</td><td colspan="2">ROLL CONTROL SOMEWHAT UNPREDICTABLE. A/C LURCHES TO ONE SIDE; DISCONCERTING WHEN NEAR THE GROUND. YAW DUE TO ROLL WAS IN NORMAL SENSE; COORDINATION REQUIRED, BUT DID NOT SEEM TO BE A PROBLEM. SOME STEADY RUDDER INPUT REQUIRED IN STEADY TURNS.</td><td colspan="2">A/C SEEMS TO HAVE RELATIVELY LONG τ_R , SOMEWHAT DEGRADING IMMEDIATE ROLL RESPONSE. MODERATE ADVERSE YAW DUE TO ROLL. RELATIVELY HIGHER POSITIVE DIHEDRAL EFFECT. TENDS TO OSCILLATE ABOUT CONSTANT BANK ANGLE. BECAUSE OF LONG ROLL-MODE TIME CONSTANT, DIFFICULT TO DETERMINE IF ANY YAW DUE TO AILERON. DUTCH ROLL FREQUENCY SLOW AND FAIRLY WELL DAMPED; VERY LITTLE PILOT EFFORT NEEDED TO DAMP OUT</td><td colspan="2">ROLL CONTROL QUITE RESPONSIVE. SLIGHT TENDENCY FOR NOSE TO HANG UP ON A TURN INITIATION. YAW DUE TO ROLL WAS ADVERSE, REQUIRING RUDDER INPUTS IN DIRECTION OF TURN. SOME RUDDER WAS REQUIRED IN THE STEADY STATE TURN. COORDINATION WAS NO PARTICULAR PROBLEM. ROLL WAS AFFECTED BY RUDDER; i.e., RUDDER INPUTS PRODUCED FAIRLY GOOD ROLL RATES.</td></tr>
<tr><td colspan="2">DIFFERENCES IN IFR AND VFR</td><td colspan="2">NO COMMENT.</td><td colspan="2">NONE.</td><td colspan="2">NO NOTICEABLE DIFFERENCES.</td></tr>
<tr><td colspan="2">EFFECTS OF TURBULENCE</td><td colspan="2">NOTICEABLE; SEEMED TO STIR THINGS UP, BUT CAUSED NO PROBLEM.</td><td colspan="2">VERY LITTLE NOSE WANDER ACROSS HORIZON. BIGGEST PILOT PROBLEM IS ROLLING TENDENCY; i.e., OVERWORKED AILERONS. DIRECTIONAL CONTROL BECOMES A LITTLE MORE DIFFICULT AND THE RUDDERS HARDER TO TRIM. CAN MAINTAIN HEADING FAIRLY WELL WITHOUT MUCH EFFORT.</td><td colspan="2">INSIGNIFICANT TURBULENCE EFFECTS WERE PRESENT.</td></tr>
<tr><td colspan="2">CONTROL IN CROSSWIND</td><td colspan="2">WITH GUSTY CROSSWINDS, WHEN PILOT MUST MANIPULATE LATERAL CONTROL NEAR GROUND, TENDENCY TO OVERSHOOT IN ROLL RESPONSE IS NOT GOOD. BOTH CROSSWIND TECHNIQUES WERE TRIED. AMOUNT OF CRAB EXPERIENCED WOULD BE DIFFICULT TO KICK OFF IN ANY A/C. THEREFORE, WING-DOWN METHOD PREFERRED, BUT SHOULD BE APPROACHED WITH CAUTION.</td><td colspan="2">AFTER RELATIVELY LARGE CORRECTIONS WERE BEGUN, LOW ROLL RESPONSE WAS QUITE NOTICEABLE. A/C SOMEWHAT DEFICIENT IN THIS AREA. OVERALL EFFECT OF CROSSWIND NEGLIGIBLE.</td><td colspan="2">INSUFFICIENT CROSSWIND FOR EVALUATION.</td></tr>
<tr><td colspan="2">FAVORABLE FEATURES</td><td colspan="2">NO COMMENTS.</td><td colspan="2">NOTHING OUTSTANDING.</td><td colspan="2">A/C QUITE MANEUVERABLE AND COORDINATION NOT A BIG PROBLEM.</td></tr>
<tr><td colspan="2">OBJECTIONABLE FEATURES</td><td colspan="2">WITH ROLL CONTROL RESPONSE DESCRIBED, MANEUVERING CLOSE TO GROUND DISLIKED.</td><td colspan="2">DISLIKED DELAY IN ROLL RESPONSE AND THE LITTLE MORE UPSET IN ROLL WITH THE GUST DISTURBANCE. ADDITIONAL FORCE AND DISPLACEMENT ARE REQUIRED FOR RAPID MANEUVERING AND PRECISE TRACKING.</td><td colspan="2">NOTHING SERIOUS.</td></tr>
<tr><td colspan="2">PRIMARY REASON FOR PILOT RATING</td><td colspan="2">UNSATISFACTORY WITH ROLL CONTROL CHARACTERISTICS DESCRIBED. IN TURBULENCE, IN CATEGORY OF "MORE EFFORT REQUIRED."</td><td colspan="2">MODERATE PILOT COMPENSATION REQUIRED UNDER CERTAIN CONDITIONS BUT COMPROMISE OVER A GREAT PERIOD OF TIME WAS NOT NECESSARY. DEGRADATION DUE TO TURBULENCE REQUIRES A LITTLE MORE PILOT EFFORT WITH MINOR DEGRADATION IN TASK PERFORMANCE.</td><td colspan="2">NEGLIGIBLE DEFICIENCIES. PILOT COMPENSATION NOT A FACTOR. TURBULENCE EFFECTS REQUIRED SLIGHTLY MORE EFFORT, BUT NO SIGNIFICANT DETERIORATION IN ACCOMPLISHING TASK.</td></tr>
</table>

GROUP 16 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = 0$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT 12	LIGHT TO MODERATE 10	LIGHT (+) 15
PR/TR	4/D	5/D	2.5/B
GENERAL COMMENTS	CAN ACCOMPLISH MANY TASKS, BUT ENOUGH DEFICIENCIES TO BE UNSATISFACTORY.	ANNOYING TENDENCY TO ALWAYS OVERBANK. MODERATE CONTROL INPUTS GIVE AN UNCOMFORTABLE FEELING THAT THE BANK CONTROL IS GETTING AWAY. UNSUITABLE FOR LANDING APPROACH BECAUSE OF THE ROLL CHARACTERISTICS. PILOT MUST APPROACH THIS CONFIGURATION WITH CAUTION, AVOID LARGE CONTROL INPUTS, AND MUST NOT BE VERY AGGRESSIVE WITH THIS A/C.	OVERALL LATERAL-DIRECTIONAL HANDLING QUALITIES GENERALLY GOOD.
ABILITY TO TRIM	SOMEWHAT DIFFICULT TO TRIM LATERALLY.	NO COMMENTS, SATISFACTORY.	LATERAL TRIM SOMEWHAT DEGRADED.
SELECTION OF CONTROL SENSITIVITIES	LATERAL FORCES SEEMED HEAVY WHEN STARTING AND STOPPING TURNS.	MUST COMPROMISE IN SELECTING LATERAL GEARING. IF I ADJUSTED TO GET THE RIGHT SENSITIVITY FOR SMALL INPUTS, SUCH THAT FORCES WERE REASONABLE AT THE START OF THE ROLL, THEN THE FORCES SEEMED TO LIGHTEN DRAMATICALLY AS THE ROLL RATE INCREASED. TENDENCY FOR ROLL RATE TO SEEMINGLY ACCELERATE, MAKING IT DIFFICULT TO CHOOSE THE LATERAL SENSITIVITY. RUDDER SENSITIVITY WAS CHOSEN AT A LEVEL TO EASILY ALLOW THE REQUIRED RUDDER COORDINATION.	AILERONS POSSIBLY TOO SENSITIVE, CREATING SOME DISHARMONY WITH THE HEAVIER ELEVATOR CONTROL FORCES.
$L'_{\delta_{AW}}$	1.40	1.40	1.54
$N'_{\delta_{RP}}$	11.4	11.4	8.10
LATERAL AND DIRECTIONAL CONTROL	AIRCRAFT TENDS TO TAKE OFF IN ROLL AND TO OVERBANK. COORDINATION NO PROBLEM, BUT SOME OSCILLATION WHEN TRYING TO STOP AT A GIVEN BANK ANGLE.	POOR ROLL CONTROL - TENDENCY TO OVERBANK; FEELS AS IF IT'S GOING TO GET AWAY, DESTROYING PILOT CONFIDENCE. THE COORDINATION IN THE NORMAL SENSE REQUIRES THAT THE RUDDER INPUT INTO THE TURN BE SOMEWHAT DELAYED. THE PROBLEM WITH THE COORDINATION IS THE FAIRLY LARGE ROLL RESPONSE TO RUDDER INPUTS. A RUDDER INPUT FOR TURN COORDINATION MAKES THE BANK ANGLE CONTROL PROBLEM EVEN WORSE, ACCENTUATING THE TENDENCY TO OVERBANK, MAKING IT NECESSARY TO COMPENSATE WITH AILERONS. WHILE FLYING A/C IN THE LANDING PATTERN, NO NEED FELT FOR LARGE RUDDER INPUTS.	ROLL CONTROL VERY GOOD. LIGHT TO MODERATE ADVERSE YAW DUE TO ROLL. ALMOST NO OSCILLATORY CHARACTERISTICS. A/C SENSITIVE IN LATERAL CONTROL MODE.
DIFFERENCES IN IFR AND VFR	IFR NO PROBLEM. VFR-TENDENCY TO OVERBANK.	IFR NO PROBLEM BECAUSE ONE IS MAKING SMALL INPUTS AND GENERALLY FLYING CAREFULLY SO THAT THE OVERBANKING TENDENCY IS NOT APPARENT.	NO APPRECIABLE DIFFERENCE.
EFFECTS OF TURBULENCE	TURBULENCE RESPONSE WAS MORE THAN PILOT WOULD LIKE.	NOTICEABLE, PRINCIPALLY LATERAL "WALLOWING." MODERATE TO LARGE ROLL RESPONSE TO TURBULENCE INPUTS. NOT HARD TO SUPPRESS TURBULENCE IF ENOUGHT TIME TO CONCENTRATE ON IT. COULD DO A GOOD JOB ON ILS, BUT MUST WORK TO SUPPRESS ANY TURBULENCE INPUTS.	MINIMAL, NO APPRECIABLE EFFECTS ON HANDLING QUALITIES.
CONTROL IN CROSSWIND	UNABLE TO EVALUATE.	PILOT REALLY DISLIKED FLYING THIS CONFIGURATION IN A CROSSWIND; e.g., USING CRAB TECHNIQUE, WHEN RUDDER WAS USED TO DECRAB HE HAD TO COMPENSATE WITH AILERONS. ABRUPT MANEUVERS WITH A/C CLOSE TO GROUND, INVOLVING ROLL INPUTS WITH ROLL CONTROL, ARE NOT DESIRABLE. WING-DOWN TECHNIQUE WOULD BE PREFERABLE HERE.	VERY LITTLE WIND AVAILABLE FOR CROSSWIND, BUT LANDING IN A CROSSWIND WOULD BE NO PROBLEM.
FAVORABLE FEATURES	NO GREAT COORDINATION REQUIRED. PILOT COULD USE FEET TO HELP WITH THE ROLL CONTROL.	NOT AN ABSOLUTELY GOOD CONFIGURATION. JUST NOT A REAL BAD ONE.	GOOD FLYING A/C.
OBJECTIONABLE FEATURES	MOST OBJECTIONABLE TENDENCY WAS TO OVERBANK IN TURNS. TURBULENCE RESPONSE AND FORCES REQUIRED TO START ROLLING AND TO STOP ON A BANK ANGLE WERE MILD OBJECTIONS.	PRINCIPALLY, TENDENCY TO OVERBANK. ROLL RESPONSE TO AILERON INPUTS IS PROBABLY NOT SATISFACTORY BECAUSE OF THE ROLL CONTROL.	SOME DIFFICULTY IN COORDINATING TURN ENTRIES NOTED DURING OFFSET LANDING APPROACH.
PRIMARY REASON FOR PILOT RATING	TENDENCY TO OVERBANK AND TURBULENCE RESPONSE ARE ANNOYING DEFICIENCIES.	ADEQUATE PERFORMANCE IS ATTAINABLE WITH A TOLERABLE WORK LOAD, BUT A/C SEEMS UNSATISFACTORY BECAUSE OF THE ROLL CONTROL.	SOME COORDINATION REQUIRED DURING TURN ENTRIES.

GROUP 16 (Cont.)	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$ PILOT B	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.05$ PILOT A	$N'_{\delta_{AW}} / L'_{\delta_{AW}} = +0.10$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT (+) 24, GUSTING TO 28	LIGHT (+) 3	LIGHT 20
PR/TR	3/D	4/C	4/B
GENERAL COMMENTS	OUT OF TURBULENCE, QUITE DECENT A/C. IT FELT SOLID, AT TIMES A BIT HEAVY. IT WAS SUITABLE FOR THE LANDING APPROACH.	OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES FAIR TO GOOD. ONLY DEGRADING FEATURE IS INABILITY TO OBTAIN COMMANDED ROLL RATES QUICKLY. SUITABILITY FOR LANDING APPROACH IS FAIR TO GOOD, PROBABLY CLOSE TO THE GOOD.	DISLIKED ROLL CONTROL. ANNOYING TENDENCY TO OVERBANK. ILS CAN BE FLOWN WITHOUT PROBLEMS. ROLL CONTROL SHOULD BE IMPROVED BEFORE GIVING IT AN UNQUALIFIED YES ON LANDING APPROACH SUITABILITY.
ABILITY TO TRIM	NO PROBLEMS.	NOT TOO MUCH OF A PROBLEM EITHER DIRECTIONALLY OR LATERALLY.	SATISFACTORY.
SELECTION OF CONTROL SENSITIVITIES	(PREVIOUSLY SELECTED VALUES ASSIGNED.) RUDDER FORCES FEEL HEAVY IN CROSSWIND APPROACH, USING THE WING-DOWN METHOD. IN TURBULENCE THE AILERONS FELT HEAVY.	FORCES AND DISPLACEMENTS ARE ALL RIGHT.	IF PILOT WERE SELECTING THE RUDDER GEARING DURING THE CROSSWIND APPROACH, INSTEAD OF UP AND AWAY WHILE MAKING TURNS, HE WOULD SELECT GREATER SENSITIVITIES AND LIGHTER FORCES. THERE WAS SOME COMPROMISE IN THE LATERAL GEARING SELECTION. WITH LIGHT ENOUGH FORCES THERE WAS SOME TENDENCY TO OVERCONTROL BECAUSE OF THE ROLL RESPONSE. WHEN INITIATING A ROLL, AND WHEN STOPPING IT, THE FORCES GO FROM HEAVY TO LIGHT.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	1.61 6.94	1.54 8.10	2.12 8.04
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL WAS GOOD. SINCE NOSE WOULD HANG UP IN TURNS, A NEED WAS FELT TO PUT IN SOME RUDDER. IN IFR, NOTICEABLE THAT RUDDER WAS REQUIRED TO GET FAST HEADING CHANGE. COORDINATION NOT EXTREMELY DIFFICULT, BUT NECESSARY.	SINCE IT TAKES QUITE A WHILE TO BUILD UP THE DESIRED ROLL RATE, SMALL HEADING CORRECTIONS USING AILERONS IS A LITTLE BIT TAXING. ROLL CONTROL IS GOOD, BUT WAITING FOR THE COMMANDED ROLL RATE TO TAKE PLACE IS ANNOYING. ADVERSE YAW DUE TO ROLL IS PRESENT AND REQUIRES MODERATE EFFORT TO TRIM IN TURNS TO MAINTAIN COORDINATION MANEUVERS. DUTCH ROLL CAN BE KICKED OFF FAIRLY EASILY AND ALTHOUGH IT'S A SLOW PERIOD, IT DAMPS OUT IN 3 TO 4 CYCLES. HIGH ϕ/β THRESHOLD; A LITTLE BIT OF YAW PUTS IN QUITE A GOOD ROLL RATE. AGAIN THIS IS APPARENTLY AFFECTED BY THE τ_R BECAUSE IT STARTS OFF RELATIVELY SLOWLY AND BANKS IN RATHER RAPIDLY.	ROLL CONTROL DEFICIENT. INITIAL RESPONSE WAS SLOW WHICH CAUSED PILOT TO PUT IN TOO MUCH AILERON. THE ROLL SEEMED TO ACCELERATE THEN AND HE WOULD HAVE TO COUNTER ABRUPTLY WITH AN INPUT TO STOP THE ROLL. IT WASN'T PREDICTABLE. A MODERATE AMOUNT OF COORDINATION IN THE NORMAL SENSE WAS REQUIRED. A SMALL AMOUNT OF RUDDER HAD TO BE HELD IN A STEADY TURN.
DIFFERENCES IN IFR AND VFR	NOTHING OUTSTANDING.	NONE NOTICED; HOWEVER, BIT OF A PROBLEM MAKING SMALL HEADING CORRECTIONS WHILE IFR.	IFR NO PROBLEMS. VFR - WITH LARGER AMPLITUDE MANEUVERS, OVERBANK TENDENCY VERY NOTICEABLE, PARTICULARLY CLOSE TO THE GROUND WHERE NOT BEING ABLE TO PREDICT FINAL RESPONSE WAS UNCOMFORTABLE.
EFFECTS OF TURBULENCE	A/C WALLOWED AROUND BOTH DIRECTIONALLY AND LATERALLY BUT RESPONSE WAS SLOW. ALTHOUGH PILOT COULD CONTEND WITH IT, IT CAME THROUGH AS A BIT OF WORK LOAD LATERALLY BECAUSE THE AILERONS FELT HEAVY.	MODERATE TURBULENCE EFFECTS RUDDER FREE. YAW ANGLES ARE SUSTAINED FOR A CONSIDERABLE AMOUNT OF TIME AND DO NOT IMMEDIATELY CORRECT BACK TO CENTER EXCEPT WITH PROPER RUDDER COORDINATION. MAKING SMALL COORDINATED CORRECTIONS IS A BIT MORE OF A CHORE IN TURBULENCE.	NOTICEABLE, BUT NOTHING TO COMMENT ON.
CONTROL IN CROSSWIND	BOTH CROSSWIND TECHNIQUES WERE TRIED. PILOT'S PERSONAL PREFERENCE IS THE WING-DOWN METHOD, BUT RUDDER FORCES GET NOTICEABLE IN HOLDING THE NOSE STRAIGHT.	EFFECTS ON HANDLING QUALITIES NOT TOO PRONOUNCED; A STRAIGHT CRAB TECHNIQUE WAS USED.	RUDDER FORCES WERE HEAVY IN EITHER METHOD. COULD HAVE SELECTED BETTER SENSITIVITIES FOR THIS. WITH THIS WIND, DISLIKED LARGE CRAB ANGLES CLOSE TO THE GROUND BUT DECRABBING WOULD PROBABLY BE NO PROBLEM. WING DOWN TECHNIQUE IS PERSONAL PREFERENCE.
FAVORABLE FEATURES	A/C FELT REAL SOLID OUT OF TURBULENCE. ROLL CONTROL WAS GOOD. JUST FELT LIKE A BIG A/C.	EVERYTHING SEEMED PRETTY GOOD EXCEPT FOR THE ROLL RESPONSE.	NO COMMENTS.
OBJECTIONABLE FEATURES	MINOR OBJECTION IS NECESSITY FOR COORDINATION. TURBULENCE RESPONSE WAS NOTICEABLE AND CAUSED A DETERIORATION. LATERALLY, IT FELT QUITE HEAVY IN TURBULENCE.	ROLL RESPONSE AND A LITTLE BIT OF YAW DUE TO ROLL. PILOT ANTICIPATION OF THE INCREASE IN ROLL RATE IS VERY SIGNIFICANT.	ROLL CONTROL RESPONSE WAS THE ONE OBJECTION.
PRIMARY REASON FOR PILOT RATING	SATISFACTORY WITHOUT IMPROVEMENT.	THE MINOR BUT ANNOYING DEFICIENCIES IN DESIRED PERFORMANCE REQUIRE MODERATE PILOT COMPENSATION.	BECAUSE OF THE ROLL RESPONSE, A/C UNSATISFACTORY WARRANTING IMPROVEMENT. TURBULENCE RESPONSE IS IN CATEGORY OF "MORE EFFORT REQUIRED."

B. Roll Control Power Experiment

All groups were evaluated with a wheel controller.

GROUP 6 $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$	$L'_{\delta_{AW}}\delta_{AW} = 47.8\ \frac{DEG}{SEC^2}$ PILOT A	$L'_{\delta_{AW}}\delta_{AW} = 35.8\ \frac{DEG}{SEC^2}$ PILOT B	$L'_{\delta_{AW}}\delta_{AW} = 31.0\ \frac{DEG}{SEC^2}$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE (–) 15	LIGHT (+) 30 GUSTING TO 35	LIGHT TO MODERATE 12
PR/TR	3/6	4/D	1.5/A
GENERAL COMMENTS	FAIR TO GOOD A/C	SOME DIRECTIONAL OSCILLATION AND FEEDBACK INTO LATERAL NOTICED. NO PROBLEMS ON ILS USING JUST ROLL CONTROL TO MAKE PRECISE HEADING CHANGES. PILOT HAD PROBLEMS AT TIMES AND AT OTHER TIMES NOT. VERY PUZZLING BUT TURBULENCE PROBLEMS MAY HAVE KEPT IT STIRRED UP.	SUITABLE FOR LANDING APPROACH GOOD ILS PERFORMANCE. GOOD JOB WITH MINIMUM EFFORT
ABILITY TO TRIM	HYPERSENSITIVE DIRECTIONAL TRIM. SLIGHT RUDDER TRIM MOVES BALL TOO FAR.	NO PROBLEMS NOTED.	SATISFACTORY
SELECTION OF CONTROL SENSITIVITIES	GOOD OVERALL GEAR SELECTION BUT COULD BE IMPROVED.	(PREVIOUSLY SELECTED VALUES ASSIGNED.) TOWARD END LATERAL STARTED FEELING HEAVIER AND HEAVIER. NOT SERIOUS COMPLAINT BUT FORCES NOTICED.	NO COMPROMISES IN GEAR SELECTIONS LATERAL CONTROL SELECTED AS SENSITIVE AS DESIRED WITH NO TENDENCY TO OVERCONTROL
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	4.78 11.37	4.78 11.37	4.78 11.37
LATERAL AND DIRECTIONAL CONTROL	VERY GOOD ROLL RESPONSE. COORDINATION DIFFICULT IN TURN REQUIRING VARYING AMOUNTS OF RUDDER.	FOR ROLL CONTROL ITSELF, INITIAL AND FINAL RESPONSE OKAY WITH SMOOTH, SLOW AILERON INPUTS BALL REMAINED IN CENTER, IF IT DID MOVE OUT IT WOULD RETURN RATHER QUICKLY. HOWEVER, WITH ABRUPT AILERON INPUT, BALL OSCILLATION WITH LARGE DELAY BETWEEN BALL EXCURSIONS AND ANY EFFECT ON ROLL AXIS. THESE EVENTS DIDN'T OCCUR CONSISTENTLY. ONE CASE IT APPEARED TO "WIND UP" DIRECTIONALLY AND THEN DIRECTIONAL OSCILLATION OCCURRED WITH FEEDBACK TO THE AILERONS CAUSING BANK ANGLE CONTROL PROBLEMS. NORMALLY, COORDINATION NO PROBLEM. AT TIMES PILOT HAD COORDINATION DIFFICULTIES.	EXCELLENT ROLL CONTROL, WITH THE SENSITIVITY SELECTED. INITIAL RESPONSE AND PREDICTABILITY EXCELLENT NORMAL YAW DUE TO ROLL WITH CRISP AILERON INPUT BALL WOULD FALL INTO TURN BUT IT WOULD RETURN CENTER QUITE RAPIDLY DURING NORMAL MANEUVERS, BALL WOULD REMAIN CENTERED AND IF IT MOVED TO ONE SIDE IT WOULD QUICKLY RETURN TO CENTER TURN COORDINATION WAS NOT REQUIREMENT OCCASIONALLY A LITTLE RUDDER USED TO HELP THINGS OUT BUT WASN'T NECESSARY
DIFFERENCES IN IFR AND VFR	NO APPRECIABLE DIFFERENCE.	NOTHING NOTICEABLE.	MORE COORDINATION REQUIRED IN VFR BECAUSE OF LARGER, MORE ABRUPT CONTROL INPUTS
EFFECTS OF TURBULENCE	MINIMAL.	A PROBLEM MAINLY DIRECTIONALLY BUT ALSO AFFECTED BANK ANGLE CONTROL.	SLIGHTLY LONG PERIODS OF NO NATURAL TURBULENCE IN WHICH TURBULENCE RESPONSE SEEMED QUITE SMALL BALL EXCURSIONS, DIRECTIONAL RESPONSE TO TURBULENCE, FAST AND SMALL NO PROBLEM
CONTROL IN CROSSWIND	NOT ENOUGH CROSSWIND TO EVALUATE EFFECTS.	NOT OBSERVED. PILOT HAD VERY LARGE CRAB ANGLES.	WING DOWN OR CRAB METHOD USED WITH EQUAL EASE HAD PILOT SELECTED RUDDER SENSITIVITY FOR THE CROSSWIND APPROACH PILOT MIGHT HAVE TAILORED RUDDER SENSITIVITY TO CROSSWIND APPROACH BY SELECTING MORE SENSITIVE RUDDER THAT WAY LESS RUDDER FORCE WOULD HAVE BEEN REQUIRED DURING WING DOWN APPROACH NO PROBLEMS IN DECRABBING FROM CRAB APPROACH BOTH APPROACH METHODS USED AND WING DOWN METHOD PREFERRED BUT OTHER ONE JUST AS GOOD
FAVORABLE FEATURES	VERY NICE HANDLING A/C. GOOD PILOT ABILITY TO DAMP OUT OSCILLATIONS. VERY GOOD ROLL RESPONSE.	ROLL RESPONSE ITSELF OKAY.	OUTSTANDING LATERAL CONTROL LACK OF NEED FOR TURN COORDINATION GOOD AND TURBULENCE RESPONSE MINIMAL SMOOTH A/C AND CAME AROUND CORNERS VERY NICELY, i.e., DURING OFFSET MANEUVER
OBJECTIONABLE FEATURES	DIRECTIONAL TRIM SENSITIVITY AND DIFFICULTY OF COORDINATING TURNS MINOR OBJECTIONS.	PECULIAR COORDINATION PROBLEM AT TIMES. AT TIMES IT TENDED TO GET A DIRECTIONAL OSCILLATION GOING. WAS NOT ALWAYS SEEN IN TURBULENCE BUT APPEARED TO BE TURBULENCE MIXED IN THAT RESULTED IN SEEMINGLY INTERMITTENT PROBLEMS.	NO COMMENTS
PRIMARY REASON FOR PILOT RATING	MINIMAL PILOT COMPENSATION TO PERFORM LANDING APPROACH TASK; HOWEVER, SOME MILDLY UNPLEASANT DEFICIENCIES EXIST.	A CONFUSING CONFIGURATION. TURBULENCE RESPONSE REQUIRED MODERATELY MORE EFFORT.	SATISFACTORY A/C SLIGHT DOUBT ABOUT A/C IN TURBULENCE

GROUP 6 (Cont.) $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$	$L'_{\delta_{AW}}\delta_{AW} = 30.8\ \frac{DEG}{SEC^2}$ PILOT A	$L'_{\delta_{AW}}\delta_{AW} = 23.9\ \frac{DEG}{SEC^2}$ PILOT B	$L'_{\delta_{AW}}\delta_{AW} = 7.7\ \frac{DEG}{SEC^2}$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT (+) 22	MODERATE (-) 25, GUSTING TO 33	LIGHT (+) 24
PR/TR	3/C	6/C	9/C
GENERAL COMMENTS	SUITABLE FOR LANDING APPROACH. NO SPECIAL PILOT TECHNIQUES REQUIRED. DIRECTIONAL OSCILLATION, BUT NOT SERIOUS.	CONFIGURATION APPEARED WORSE AS TIME ELAPSED. A FEW TIMES DURING THE TURN TO CROSSWIND RUNWAY PILOT DOUBTED HE HAD CONTROL.	POOR FOR LANDING APPROACH. PILOT RELIED HEAVILY ON RUDDER FOR MAINTAINING LATERAL CONTROL. LATERAL CONTROL ALMOST IMPOSSIBLE USING AILERONS ALONE.
ABILITY TO TRIM	NO PROBLEMS. A LITTLE TROUBLE INITIALLY BUT FOR ACTUAL CONTROL OKAY.	TROUBLE DURING APPROACHES.	NO PARTICULAR PROBLEMS, LATERAL SEEMED SLIGHTLY SLOW.
SELECTION OF CONTROL SENSITIVITIES	(PREVIOUSLY SELECTED VALUES ASSIGNED.) FORCES SLIGHTLY HIGHER LATERALLY THAN DESIRED. MORE CONTROL POWER LATERALLY DESIRABLE.	(PREVIOUSLY SELECTED VALUES ASSIGNED.) INITIALLY AILERON FORCES SEEMED LIGHT, HOWEVER, WHEN WRAPPED UP IN TURN FORCES SEEMED TO GET HIGHER. AILERON AND RUDDER FORCES AND SENSITIVITIES OKAY INITIALLY BUT AILERON FORCES AT THE END UNDESIRABLE.	(PREVIOUSLY SELECTED VALUES ASSIGNED.) LATERAL CONTROL FORCES VERY HIGH MAKING LATERAL CONTROL ALMOST IMPOSSIBLE.
$L'_{\delta_{AW}}$	3.08	4.78	3.08
$N'_{\delta_{RP}}$	6.14	10.38	6.14
LATERAL AND DIRECTIONAL CONTROL	GOOD ROLL CONTROL, IN TERMS OF MANEUVERING. COORDINATION IN TURNS EASY TO MAINTAIN. A SLIGHT AMOUNT OF RUDDER IN DIRECTION OF ROLL REQUIRED. NOSE WANDERED CONSIDERABLY, BUT RETURNED TO DESIRED HEADING. DIRECTIONAL CONTROL NO PROBLEM.	SATISFACTORY INITIAL ROLL RESPONSE ANYTHING OCCURRING IN SIDESLIP OCCURRED VERY SLOWLY AND SMALL BALL EXCURSIONS SEEMED TO EAT WILDLY INTO ROLL CONTROL.	FULL WHEEL DEFLECTION PRODUCED VERY SMALL ROLL RATES. ROLL RATE NOT BUILT UP ENOUGH TO INVESTIGATE YAW DUE TO ROLL. COORDINATION NOT MUCH OF PROBLEM. PILOT ASSISTED ROLL CONTROL BY USING RUDDER IN ADDITION TO MAXIMUM LATERAL CONTROL DEFLECTION.
DIFFERENCES IN IFR AND VFR	NO APPRECIABLE DIFFERENCES.	A/C BETTER MAKING SMALL CORRECTIONS THAN LARGE ONES.	NO NOTICEABLE DIFFERENCES.
EFFECTS OF TURBULENCE	PRESENT BUT NOT SIGNIFICANT.	TURBULENCE NO REAL PROBLEM.	MINOR.
CONTROL IN CROSSWIND	CRABBED TECHNIQUE USED A/C QUITE CONTROLLABLE.	EITHER TECHNIQUE USABLE BUT WING-DOWN METHOD PREFERRED. DIFFICULTY BEING PRECISE WITH RUDDERS WHEN COMING OUT OF CRAB MANEUVER DUE TO SLOW DIRECTIONAL OSCILLATION.	ONCE ON FINAL APPROACH NO PROBLEMS. MANEUVERING TO FINAL DIFFICULT BECAUSE "OVER-MANIPULATION" OF AILERONS AND RUDDER.
FAVORABLE FEATURES	EASILY CONTROLLED, BOTH VFR AND IFR AND IN TURBULENT AND NON-TURBULENT CONDITIONS.	INITIALLY ROLL CONTROL GOOD BUT DETERIORATED IN TIME.	NO COMMENTS.
OBJECTIONABLE FEATURES	MORE AILERON CONTROL POWER DESIRABLE. MORE RAPID CENTERING IN DIRECTIONAL OSCILLATIONS WOULD BE IMPROVEMENT.	LOW FREQUENCY NATURE AND LARGE EFFECTS OF SMALL SIDESLIPS TO ROLL CONTROL CREATED OBJECTIONABLE COORDINATION PROBLEM. LARGE OVERBANKS DUE TO MISCOORDINATION.	AILERON CONTROL POWER NOT ENOUGH TO ADEQUATELY PERFORM MISSION.
PRIMARY REASON FOR PILOT RATING	DEFICIENCIES MILDLY UNPLEASANT BUT MINIMAL PILOT COMPENSATION REQUIRED.	IN ONE TURN TO CROSSWIND RUNWAY PILOT FELT HE COULD GET INTO SERIOUS TROUBLE. PILOT FELT PROBLEMS SNEAKING UP DUE TO COORDINATION PROBLEM.	INTENSE PILOT COMPENSATION REQUIRED TO RETAIN CONTROL BECAUSE OF LATERAL CONTROL PROBLEM. TURBULENCE RESPONSE REQUIRED MORE EFFORT WITH ONLY MINOR DETERIORATION OF TASK PERFORMANCE.

GROUP 9 $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$	$L'_{\delta_{AW}}\,\delta_{AW} = 93.2\ \frac{DEG}{SEC^2}$ PILOT B	$L'_{\delta_{AW}}\,\delta_{AW} = 66.6\ \frac{DEG}{SEC^2}$ PILOT B	$L'_{\delta_{AW}}\,\delta_{AW} = 53.3\ \frac{DEG}{SEC^2}$ PILOT B
NATURAL TURBULENCE MAX. X-WIND (~KT)	MODERATE 25 GUSTING TO 30	MODERATE 30	LIGHT 10
PR/TR	5/F	8/F	5.5/D
GENERAL COMMENTS	PROBLEM OF TURBULENCE RESPONSE. WITH TURBULENCE RESPONSE A/C UNSUITABLE FOR LANDING APPROACH. ILS PERFORMANCE OKAY.	TURBULENCE ENVIRONMENT EXCESSIVE. WINDS GUSTING TO 37 KNOTS. A/C HAS VERY FAST LATERAL RESPONSE TO TURBULENCE.	GOOD ILS PERFORMANCE. NO PROBLEMS. HIGH INTERACTION BETWEEN DIRECTIONAL AND LATERAL
ABILITY TO TRIM	NOTHING NOTICED.	NO COMMENT.	LATERAL TRIM DIFFICULT. HIGH INTERACTION BETWEEN DIRECTIONAL SIDESLIP AND ROLL. SLIGHT BALL EXCURSIONS CAUSED PROBLEM IN TRIMMING
SELECTION OF CONTROL SENSITIVITIES	(PREVIOUSLY SELECTED VALUES ASSIGNED.) SATISFACTORY AILERON FORCES AND DISPLACEMENTS FOR NORMAL FLYING. COUNTERACTING SOME LARGE ROLL TURBULENCE RESPONSES, FORCES OCCASIONALLY NOTICEABLE. GEARING SELECTIONS APPEARED GOOD COMPROMISE.	(PREVIOUSLY SELECTED VALUES ASSIGNED.) PILOT'S INITIALLY THOUGHT AILERONS TOO SENSITIVE. HOWEVER, THIS HIGH SENSITIVITY WAS USED TO ADVANTAGE IN COUNTERACTING EXTREME LATERAL TURBULENCE RESPONSE.	INITIALLY PILOT SELECTED RUDDER TOO SENSITIVE. AFTER ILS PILOT RESELECTED SENSITIVITY THAT SEEMED MORE APPROPRIATE. CONSTANT CHANGE PRODUCED IN LATERAL FORCES DEPENDING ON WHAT WAS HAPPENING DIRECTIONALLY. THUS PILOT SELECTED LATERAL SENSITIVITY BASED ON ROLL ALONE WHENEVER PILOT COULD ISOLATE IT. MORE SENSITIVITY NOT DESIRED BUT STILL HAD A NOTICEABLE, NOT EXTREME FORCE ON CROSSWIND APPROACH.
$L'_{\delta_{AW}}$	6.66	6.66	6.66
$N'_{\delta_{RP}}$	8.41	8.04	8.41
LATERAL AND DIRECTIONAL CONTROL	NO COMPLAINTS ABOUT ROLL CONTROL. PILOT DID NOT ATTEMPT COORDINATION BECAUSE OF MODERATE ROLL RESPONSE TO RUDDER. BEST TO LEAVE IT ALONE RATHER THAN CREATE MORE LATERAL CONTROL PROBLEMS BY TRYING TO BE PRECISE.	ROLL CONTROL PREDICTABLE AND PRECISE. NO YAW DUE TO AILERON AND COORDINATION NO PROBLEM.	GOOD INITIAL RESPONSE AND NO TENDENCY TO OVERCONTROL. ANY SMALL BALL EXCURSION PRODUCED NOTICEABLE FORCE ON AILERON. AILERON FORCE SEEMED HEAVY STARTING A TURN BUT AS SIDESLIP ZEROED IT WOULD LIGHTEN. NOTICEABLE DIRECTIONAL OSCILLATION WHEN PILOT USED AILERONS ONLY. NO STEADY STATE COORDINATION REQUIRED.
DIFFERENCES IN IFR AND VFR	NONE.	ILS REQUIRED WORKING AT IN ANY KIND OF TURBULENCE.	SATISFACTORY A C IN IFR OUT OF TURBULENCE. VFR DEGRADED BY FORCE CHANGES IN LATERAL CONTROL. ADD EFFECTS OF TURBULENCE AND VFR BECAME BAD ESPECIALLY WITH LARGE BALL EXCURSIONS RESULTING IN LARGE LATERAL FORCES.
EFFECTS OF TURBULENCE	GUST RESPONSE LARGELY IN ROLL AND CONSTANT PROBLEM TO CONTEND WITH. PARTICULARLY ANNOYING WHEN TURNING FINAL. COULD OVERBANK 10 TO 15 OR MORE DEGREES.	TURBULENCE MAJOR PROBLEM WITH A/C ESPECIALLY BANK ANGLE. DIRECTOINAL PROBLEMS PRESENT WHICH CAUSED ROLL UPSETS.	MODERATE AND DEGRADING. ANY TURBULENCE DISTURBING THE ROLL COMPOUNDED LATERAL TRIM PROBLEMS.
CONTROL IN CROSSWIND	CROSSWIND HANDLED SATISFACTORILY WITH WING DOWN METHOD.	NO LIMITS IN CONTROLS THAT PREVENTED PILOT FROM DOING EITHER TYPE CROSSWIND APPROACH. CROSSWIND COMPONENT STAGGERING AND SIDESLIP ANGLES EYE-POPPING.	JITTERY DIRECTIONALLY EVEN WITH PILOT CORRECTION ON RUDDER SENSITIVITY. PILOT DIFFICULTY IN HOLDING NOSE STRAIGHT AND LATERAL FORCES HEAVY WITH WING DOWN TECHNIQUE. WING DOWN TECHNIQUE PREFERRED.
FAVORABLE FEATURES	ROLL CONTROL OKAY. TURN COORDINATION NO PROBLEM.	ROLL CONTROL CRISP AND PRECISE, ALTHOUGH LITTLE OVERSENSITIVE. WITH TURBULENCE SENSITIVE ROLL CONTROL ADVISABLE.	NO TENDENCY TO OVERCONTROL LATERALLY. PILOT COULD BE PRECISE. NO STEADY STATE COORDINATION REQUIRED OUT OF TURBULENCE
OBJECTIONABLE FEATURES	UNSATISFACTORY TURBULENCE RESPONSE.	LATERAL UPSETS DUE TO TURBULENCE. REQUIRED A LOT OF AILERON TO GET WING UP.	CHANGES IN LATERAL FORCES THAT RESULTED FROM DIRECTIONAL EXCURSIONS BOTHERSOME. TURBULENCE RESPONSE CONSIDERED UNREASONABLE FOR A SATISFACTORY A C
PRIMARY REASON FOR PILOT RATING	ADEQUATE PERFORMANCE ATTAINABLE EVEN WITH TURBULENCE RESPONSE. TURBULENCE RESPONSE REQUIRED PILOT'S BEST EFFORTS.	LARGE LATERAL UPSETS DUE TO TURBULENCE CLOSE TO GROUND ON LANDING APPROACHES.	UNSATISFACTORY. INTERACTION DIRECTIONALLY AND LATERALLY AND FORCE LEVELS CONTENDED WITH. UNIMPRESSIVE ESPECIALLY WITH CROSSWINDS AND TURBULENCE

GROUP 9 (Cont.) $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$	$L'_{\delta_{AW}}\delta_{AW} = 50.0\ \frac{DEG}{SEC^2}$ PILOT B	$L'_{\delta_{AW}}\delta_{AW} = 30.1\ \frac{DEG}{SEC^2}$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	MODERATE 25 GUSTING TO 30	NONE 14
PR/TR	10/E	8/F
GENERAL COMMENTS	EXTREME COMPROMISE INVOLVED IN LATERAL GEARING. IN CROSSWIND THERE WERE LARGE FORCES LATERALLY AND PILOT UNABLE TO BE PRECISE BUT, UP AND AWAY, TOO SENSITIVE. ILS PERFORMANCE O.K. NOT SUITABLE FOR LANDING APPROACH BECAUSE CROSSWIND APPROACH COULDN'T BE HANDLED.	GENERAL COMMENTS: ILS PERFORMANCE, CROSSWIND AND LATERAL OFFSET APPROACHES SATISFACTORY, BUT ILS REQUIRED EFFORT WITH LATERAL CONTROLS. POOR SUITABILITY FOR LANDING APPROACH. A LOT OF RUDDER USED TO CONTROL A/C IN SOME SITUATIONS.
ABILITY TO TRIM	NO PROBLEMS.	INITIALLY, PROBLEMS TRIMMING DIRECTIONALLY, BUT ONCE TRIMMED, IT HELD PRETTY WELL. VERY SLOW LATERAL TRIM RESPONSE APPARENT.
SELECTION OF CONTROL SENSITIVITIES	(PREVIOUSLY SELECTED VALUES ASSIGNED.) LATERAL FORCES IN CROSSWIND EXTREMELY HIGH; AT A LEVEL PILOT COULDN'T CONTROL. UP AND AWAY LATERAL TOO SENSITIVE AND ON CROSSWIND NOT SENSITIVE ENOUGH, AT LEAST AUTHORITY NOT HIGH ENOUGH.	(PREVIOUSLY SELECTED VALUES ASSIGNED.) PRETTY GOOD AT FIRST. LATER LATERAL FORCES QUITE HIGH, AS ON CROSSWIND APPROACH.
$L'_{\delta_{AW}}$	6.66	3.01
$N'_{\delta_{RP}}$	8.41	8.59
LATERAL AND DIRECTIONAL CONTROL	TENDENCY TO OVERCONTROL ROLL, UP AND AWAY, WHICH PILOT CONTRIBUTED TO HIGH SENSITIVITIES. SOME STEADY RUDDER REQUIRED IN TURN HOWEVER MISCOORDINATION WITHOUT IT NOT NOTICEABLE. ROLL RESPONSE TO RUDDER SO GREAT THAT IF PILOT TRIED TO COORDINATE MORE PROBLEMS CAUSED. COORDINATION NOT A PROBLEM.	ROLL CONTROL LESS THAN SATISFACTORY. LAG IN LATERAL CONTROL WHICH COUPLED WITH HIGH FORCES, YET SEEMED GOOD IN NORMAL MANEUVERING. PILOT OVERWORKED LATERAL CONTROLS TO MAINTAIN CONTROL. COORDINATION A PROBLEM, HOWEVER, ONCE ESTABLISHED EASILY MAINTAINED. CONSTANT RUDDER INPUT REQUIRED IN DIRECTION OF TURN TO STAY COORDINATED IN TURN.
DIFFERENCES IN IFR AND VFR	A/C FALTERED IN GROSS VFR MANEUVERS, HIGH SENSITIVITIES. NECESSARY FOR CROSSWIND, UPSET PRECISION CONTROL NEEDED VFR.	NO NOTICEABLE DIFFERENCE.
EFFECTS OF TURBULENCE	VERY SHARP LATERAL RESPONSE TO GUSTS. IN TURBULENCE PILOT FATIGUED BECAUSE IT WAS A CONSTANT BOTHER. PILOT COUNTERACTED TURBULENCE BUT CONSTANT EFFORT REQUIRED.	IN TURBULENCE PILOT OVERWORKED, PARTICULARLY WITH AILERONS. EFFECTS OF TURBULENCE DEGRADED A/C QUITE A BIT.
CONTROL IN CROSSWIND	PILOT DOUBTED A/C COULD BE LANDED WITH PREVAILING CROSSWIND, ONE COULD GET INTO SEVERE OVERCONTROLLING IN CROSSWIND WHEN TRYING TO LAND STRAIGHT AHEAD WITH WING DOWN METHOD. PROBLEMS WITH SIDESLIP.	CRAB TECHNIQUE USED, AND CROSSWIND NOT STRONG, BUT PILOT WORKED "FULL TIME" ON CROSSWIND APPROACH.
FAVORABLE FEATURES	NO COMMENTS.	NOT TOO BAD OUT OF TURBULENCE.
OBJECTIONABLE FEATURES	MAINLY ROLL DUE TO RUDDER THAT HINDERS IN CROSSWIND, EXTREME CROSSTALK BETWEEN RUDDER AND ROLL. TURBULENCE RESPONSE UNPLEASANT AND A PROBLEM WITH COMPROMISE IN LATERAL GEARING SELECTION.	DEGRADATION DUE TO TURBULENCE EFFECTS AND UNCOMFORTABLE RIDE ASSOCIATED WITH LATERAL OSCILLATIONS. A LOT OF RUDDER USED TO CONTROL A/C IN SOME SITUATIONS. MAXIMUM LATERAL CONTROL USED FREQUENTLY.
PRIMARY REASON FOR PILOT RATING	BECAUSE OF CROSSWIND, PILOT DOUBTED A/C COULD BE LANDED.	MAJOR DEFICIENCIES WHICH WARRANT IMPROVEMENT AND REQUIRE CONSIDERABLE PILOT COMPENSATION FOR CONTROL. IN TURBULENCE MAJOR DETERIORATION IN PERFORMANCE.

GROUP 9 (Cont.) $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$	$L'_{\delta_{AW}}\delta_{AW} = 16.6 \frac{DEG}{SEC^2}$ PILOT B	$L'_{\delta_{AW}}\delta_{AW} = 12.9 \frac{DEG}{SEC^2}$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT 10	MODERATE 12
PR/TR	8.5/G	9/G
GENERAL COMMENTS	BAD A/C, TREMENDOUS ROLL DUE TO SIDESLIP. AT TIMES ALL ROLL CONTROL USED WHEN TRYING TO COUNTER ROLLING MOTIONS DUE TO SIDESLIP.	POOR SUITABILITY FOR LANDING APPROACH. A/C VERY DIFFICULT TO CONTROL BECAUSE OF HIGH POSITIVE DIHEDRAL EFFECT PLUS LIMITED AILERON CONTROL POWER TO COUNTER THESE EFFECTS.
ABILITY TO TRIM	VERY DIFFICULT A/C TO TRIM.	SLIGHT DIRECTIONAL TRIM ERROR SHOWN IN VERY DIFFICULT A/C TO CONTROL, SO ABILITY TO TRIM DEGRADED.
SELECTION OF CONTROL SENSITIVITIES	AILERON FORCES BECAME EXTREMELY LARGE AT TIMES, PARTICULARLY IN TURBULENCE. PILOT COULD RUN OUT OF AILERON CONTROL WITH ANY KIND OF MISCOORDINATION. IN TURBULENCE PILOT COULD KEEP CRANKING ON AILERONS AND GET NO RESPONSE. THE FORCES WOULD BUILD UP TO ENORMOUS LEVEL.	MORE AILERON CONTROL POWER REQUIRED IN CERTAIN OFF-TRIM CONDITIONS. ALMOST IMPOSSIBLE AMOUNT OF AILERON WHEEL FORCE NECESSARY AT TIMES TO KEEP A/C UNDER CONTROL.
$L'_{\delta_{AW}}$	6.66	2.57
$N'_{\delta_{RP}}$	8.41	8.29
LATERAL AND DIRECTIONAL CONTROL	ROLL RESPONSE WITH BALL IN CENTER OKAY. VERY SMALL MOTIONS OF BALL LEAD TO CONTROL PROBLEMS IN ROLL. RUDDER PEDALS CAN BE USED AS EFFECTIVE ROLL CONTROLLER HOWEVER, ANY KIND OF PRECISION BANK ANGLE CONTROL CAN NOT BE ACHIEVED.	ROLL CONTROL NOT GREATEST DUE TO REQUIREMENT FOR LARGE PILOT INPUTS. IF PILOT CAN MAINTAIN A/C FAIRLY CLOSE TO WINGS LEVEL THERE ARE NO CONTROL PROBLEMS, BUT ONCE IN BANK PILOT REQUIRED TO USE HIGH POSITIVE DIHEDRAL EFFECT TO KEEP A/C FROM DIVERGING.
DIFFERENCES IN IFR AND VFR	NO REAL PROBLEM IFR WITH SMALL MOTIONS REQUIRED BUT VFR WAS WHERE PILOT COULD GET INTO DIFFICULTIES, PARTICULARLY IN TURBULENCE.	NO APPRECIABLE DIFFERENCE.
EFFECTS OF TURBULENCE	EFFECTS OF TURBULENCE REALLY NOTICEABLE AND SEVERE PROBLEM. IN ANY KIND OF TURBULENCE, A/C NOT SUITABLE FOR LANDING APPROACH.	A/C BARELY CONTROLLABLE IN MODERATE TURBULENCE. WHEEL STOPS HIT IN TRYING TO MAINTAIN LATERAL CONTROL. TURBULENCE ON AND OFF MAKES BIG DIFFERENCE. EFFECTS OF TURBULENCE QUITE PRONOUNCED ON HANDLING QUALITIES.
CONTROL IN CROSSWIND	NO CROSSWIND FOR EVALUATION BUT PILOT CAN NOT HOLD STEADY SIDESLIP WITHOUT EATING UP ALL ROLL CONTROL. A REAL PROBLEM AND MIGHT BECOME UNCONTROLLABLE IN A CROSSWIND.	WITHOUT TURBULENCE THE CROSSWIND NOT TOO BAD, BUT UPSETTING EFFECTS OF TURBULENCE PUTS PILOT IN VERY DIFFICULT LATERAL CONTROL SITUATION.
FAVORABLE FEATURES	RUDDER PEDALS MAY BE USED AS EFFECTIVE ROLL CONTROLLER IN EMERGENCIES, WHICH OCCUR RATHER OFTEN IN TURBULENCE.	NONE.
OBJECTIONABLE FEATURES	INTERACTIONS BETWEEN SIDESLIP AND ROLL SO LARGE THAT ONE CAN EASILY USE UP ALL ROLL CONTROL AUTHORITY. MAGNIFIED SEVERELY BY TURBULENCE RESPONSE.	EXTREME TURBULENCE EFFECT AND LACK OF ROLL CONTROL POWER.
PRIMARY REASON FOR PILOT RATING	A/C CONTROLLABLE BECAUSE PILOT CAN USE FEET TO CONTROL ROLL BUT NOT SATISFACTORILY. IN TURBULENCE CLOSE TO THE GROUND, LANDING EXTREMELY DIFFICULT USING THIS METHOD.	A/C BARELY CONTROLLABLE IN SOME SITUATIONS WITH PILOT HITTING AILERON STOPS WHEN TRYING TO MAINTAIN 30° BANK IN MODERATE TURBULENCE. IF TRYING TO MAINTAIN LARGER BANK ANGLE, UNCONTROLLABLE SITUATION PROBABLY WOULD RESULT.

GROUP 11 $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$	$L'_{\delta_{AW}}\delta_{AW} = 49.3 \frac{DEG}{SEC^2}$ PILOT A	$L'_{\delta_{AW}}\delta_{AW} = 46.0 \frac{DEG}{SEC^2}$ PILOT B	$L'_{\delta_{AW}}\delta_{AW} = 30.6 \frac{DEG}{SEC^2}$ PILOT B
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT 13	LIGHT 6	LIGHT (+) 26
PR/TR	3.5/C	2.5/C	2.5/C
GENERAL COMMENTS	LARGE EXCURSIONS IN HEADING; i.e., NOSE CONTINUOUSLY WANDERED BACK AND FORTH. NO PROBLEM WITH ILS. SUITABLE FOR LANDING APPROACH. VERY LITTLE, IF ANY, ROLL RESULTED FROM RUDDER INPUTS.	A/C IS SATISFACTORY. SUITABLE FOR LANDING APPROACH. ALMOST MINIMUM TURN COORDINATION REQUIRED. NO SPECIAL PILOTING TECHNIQUE REQUIRED. ONE COMPLAINT WAS DIRECTIONAL TURBULENCE RESPONSE WITH OCCASIONAL LARGE BALL EXCURSIONS.	PRETTY REASONABLE AIRPLANE, NO COORDINATION REQUIRED. LARGE YAW EXCLUSIONS FELT A FEW TIMES. PILOT MIGHT HAVE CHOSEN AILERONS SLIGHTLY MORE SENSITIVE IF CHOICE AVAILABLE. NO PROBLEMS WITH ILS.
ABILITY TO TRIM	NO BIG PROBLEM LATERALLY OR DIRECTIONALLY	GOOD. NO COMPLAINTS	SATISFACTORY.
SELECTION OF CONTROL SENSITIVITIES	PILOT WOULDN'T WANT TO CHANGE ANY GEAR RATIOS. A LITTLE MORE AILERON CONTROL POWER WOULD BE GOOD	SELECTED SENSITIVITY WITH VERY CRISP, PRECISE ROLL RESPONSE. MINIMUM COORDINATION REQUIRED, SO NO PROBLEM TO FIND ACCEPTABLE GEAR SELECTIONS	(PREVIOUSLY SELECTED VALUES ASSIGNED.) NO PROBLEMS WITH RUDDER BUT THE LATERAL FORCES NOTICEABLE AT TIMES.
$L'_{\delta_{AW}}$	3.08	3.83	3.83
$N'_{\delta_{RP}}$	7.37	11.37	11.37
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL GOOD. YAW DUE TO ROLL ALMOST NON-EXISTENT. NOT MUCH REQUIREMENT FOR COORDINATION. CONSTANT SNAKING MOTION OF THE NOSE, REQUIRING CONSTANT WORK WITH RUDDER TO MAINTAIN HEADING. COULD DAMP DIRECTIONAL OSCILLATIONS WITH CONTINUOUS RUDDER USAGE	ROLL RESPONSE VERY GOOD. SMOOTH, FAST, AND PREDICTABLE, AND PRESENTED NO TENDENCY TO OVERCONTROL. YAW DUE TO ROLL NOT A FACTOR IN EVALUATION WITH SMOOTH INPUTS, WHICH SEEM TO BE CONSISTENT WITH TYPE OF MISSION BEING EVALUATED. REQUIREMENT FOR TURN COORDINATION NOT NOTICEABLE. A/C COULD NOT ROLL WITH RUDDER ONLY	GOOD INITIAL ROLL RESPONSE. SATISFACTORY FINAL RESPONSE. NO NOTICEABLE YAW DUE TO ROLL. COORDINATION NOT A FACTOR.
DIFFERENCES IN IFR AND VFR	NO PARTICULAR DIFFERENCES	NO DIFFERENCES NOTED	NONE EXCEPT TYPE OF CONTROL INPUTS REQUIRED.
EFFECTS OF TURBULENCE	QUITE PRONOUNCED BY EXCITATION OF SNAKING MOTIONS. A/C SOMEWHAT DEGRADED BUT NO SERIOUS CONTROL PROBLEM	TURBULENCE NOTICEABLE, BUT ONLY DIRECTIONALLY	NOTICEABLE BUT NOT A PROBLEM. DURING APPROACH A FEW NOSE EXCURSIONS GETTING LARGE. NOSE SEEMED TO OSCILLATE AROUND DIRECTIONALLY IN TURBULENCE.
CONTROL IN CROSSWIND	NO PARTICULAR PROBLEMS ENCOUNTERED. NOSE WANDERING FROM SIDE TO SIDE DIFFICULT TO CONTROL, BUT MORE A NUISANCE THAN A PROBLEM	COULD USE BOTH CRAB AND WING DOWN METHODS. GOOD DEGREE OF CONFIDENCE IN CONFIGURATION WITH EITHER METHOD	A/C A LITTLE LOOSE DIRECTIONALLY. NOSE MOVED AROUND QUITE EASILY WITH RUDDER. A LITTLE TENDENCY TO OVERCONTROL WHEN TAKING OUT CRAB. BOTH METHODS TRIED AND BECAUSE OF LOOSENESS DIRECTIONALLY WING DOWN METHOD PREFERRED.
FAVORABLE FEATURES	QUITE MANEUVERABLE	ROLL CONTROL RESPONSE OUTSTANDING. LACK OF NEED TO COORDINATE TURNS WAS GOOD. A/C WAS SMOOTH, OUT OF TURBULENCE. VERY NICE TO FLY	GOOD ROLL CONTROL NO COORDINATION REQUIRED. NO YAW DUE TO ROLL AND NO CROSS TALK BETWEEN AXES, LATERALLY AND DIRECTIONALLY.
OBJECTIONABLE FEATURES	DIRECTIONAL OSCILLATIONS BOTHER SOME. REQUIRING EXTRA EFFORT. VERY LITTLE ROLL RESPONSE TO RUDDER INPUTS	IN TURBULENCE, A LOT OF DIRECTIONAL RESPONSE. SIDESLIP RESPONSE WHICH COULD BE CONTROLLED BUT DETRACTED SOMEWHAT FROM CONFIGURATION	TURBULENCE RESPONSE AND SLIGHT HEAVINESS IN AILERONS WERE MINOR
PRIMARY REASON FOR PILOT RATING	MILDLY UNPLEASANT DEFICIENCIES. MORE THAN AVERAGE INPUTS REQUIRED TO COUNTER SNAKING MOTIONS. EFFECTS OF TURBULENCE WERE A LITTLE EXTRA PILOT REQUIREMENT.	COULD CERTAINLY DO THE JOB. A/C SATISFACTORY WITHOUT TURBULENCE, DEFINITELY A TWO. WITH DEGRADATION DUE TO TURBULENCE RATING IS 2.5. TURBULENCE RATING IS C	MILDLY UNPLEASANT DEFICIENCIES. THE LARGE EXCURSIONS IN TURBULENCE WERE LARGE GUST. TURBULENCE RESPONSE REQUIRED MORE EFFORT BUT MINOR.

GROUP 11 (Cont.) $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$	$L'_{\delta_{AW}}\delta_{AW} = 23.1 \frac{DEG}{SEC^2}$ PILOT A	$L'_{\delta_{AW}}\delta_{AW} = 15.4 \frac{DEG}{SEC^2}$ PILOT A	$L'_{\delta_{AW}}\delta_{AW} = 9.6 \frac{DEG}{SEC^2}$ PILOT B
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	MODERATE 19	LIGHT (+) 10	LIGHT 24
PR/TR	5/D	7/C	7/B
GENERAL COMMENTS	FAIR HANDLING QUALITIES BECAUSE OF DEGRADATION IN TURBULENT CONDITIONS.	POOR LATERAL DIRECTIONAL HANDLING QUALITIES BECAUSE OF VERY LOW ROLL RATES ATTAINABLE. AILERON CONTROL POWER MARGINAL AND OCCASIONALLY WHEEL HIT AGAINST STOPS.	A/C CANNOT BE MOVED QUICKLY. DOES NOT RESPOND QUICKLY IN ROLL. FORCES GET ENORMOUS AND YET IN NORMAL FLYING WHEN NOT CONCERNED ABOUT DOING ANYTHING RAPIDLY, LIKE ON ILS, A/C FELT GREAT. ILS PERFORMANCE DECENT, PILOT CONFIDENT ON ILS BUT YET NOT SUITABLE FOR LANDING APPROACH.
ABILITY TO TRIM	NO PROBLEM IN EITHER AXIS.	REDUCED ABILITY TO TURN DIRECTIONALLY.	GOOD.
SELECTION OF CONTROL SENSITIVITIES	(PREVIOUSLY SELECTED VALUES ASSIGNED.) LITTLE MORE AILERON CONTROL POWER DESIRABLE FOR THIS CONFIGURATION. WITH A LITTLE BIT MORE AILERON CONTROL POWER CONTROL HARMONY WOULD BE OUTSTANDING.	(PREVIOUSLY SELECTED VALUES ASSIGNED.) HIGH LATERAL FORCES REQUIRED POOR HARMONY OF LATERAL AND LONGITUDINAL CONTROLS. '	(PREVIOUSLY SELECTED VALUES ASSIGNED). PILOT USED LARGE INPUTS WITH NO EFFECT. YET, FOR SMALL INPUTS, IT WASN'T TOO BAD. TRYING TO MANEUVER RAPIDLY IN ROLL, FORCES ENORMOUS. NO PROBLEMS WITH RUDDER.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	3.08 7.98	3.08 7.37	3.83 11.37
LATERAL AND DIRECTIONAL CONTROL	GOOD ROLL CONTROL WITH EXCEPTION OF A BIT OF EXTRA FORCE REQUIRED AND SOME DIFFICULTY IN BUILDING UP VERY HIGH ROLL RATIS. ROLL RATE BUILDS UP IMMEDIATELY BUT WITH KIND OF A LOW MAXIMUM. NO COORDINATION PROBLEM. DUTCH ROLL MODE PRACTICALLY ALL YAWING WITH PRACTICALLY ZERO DIHEDRAL EFFECT.	MARGINAL ROLL CONTROL POWER COORDINATION NOT MUCH OF A PROBLEM BECAUSE EVERYTHING HAPPENS SLOWLY. SMALL ROLL MODE TIME CONSTANT, VERY SMALL ROLL RATE REACHED IN A HURRY. DUTCH ROLL APPEARS MOSTLY IN YAW. DIHEDRAL EFFECT NEAR ZERO.	ROLL CONTROL GOOD FOR SMALL INPUTS AND IF PUT IN SLOWLY. POOR IF SPEED OF RESPONSE NEEDED WHEN CLOSE TO THE GROUND AND WANTING TO MANEUVER. RUDDER COULD BE USED A LITTLE MORE TO ASSIST THE ROLL. RUDDER USED TO HELP ON ILS. RUDDER INPUTS NOT A REQUIREMENT FOR COORDINATION, YAW DUE TO ROLL CAUSED NO PROBLEMS, IT MERELY ASSISTED ROLL.
DIFFERENCES IN IFR AND VFR	NO APPRECIABLE DIFFERENCE.	NO PARTICULAR DIFFERENCE.	TALKING ABOUT ILS APPROACHES AND CRUISING FLIGHT, IFR NO PROBLEM. VFR, WHERE PILOT WANTED TO DO THINGS QUICKLY, ESPECIALLY CLOSE TO GROUND MANEUVERING, PILOT UNABLE TO DO JOB WITH A/C.
EFFECTS OF TURBULENCE	TURBULENCE SHOWS UP MOSTLY AS SNAKING NOTION. DIFFICULT TO DAMP OUT NOSE OSCILLATION IN MODERATE TURBULENCE. REQUIRES EFFORT AND DOES DETERIORATE TASK PERFORMANCE. OVERALL GOOD A/C TO FLY UNTIL IN TURBULENCE.	TURBULENCE DID NOT CAUSE LARGE INCREASES OF PILOT WORKLOAD. MORE EFFORT REQUIRED, BUT DETERIORATION OF TASK PERFORMANCE WITH TURBULENCE MINOR.	NO PROBLEMS.
CONTROL IN CROSSWIND	CROSSWIND DID NOT AFFECT HANDLING QUALITIES. CRAB-DECRAB MANEUVER USED.	WITH ONLY 10 KNOTS OF CROSSWIND NO PARTICULAR PROBLEMS ENCOUNTERED.	BOTH TECHNIQUES TRIED AND NO PROBLEMS. JOB COULD BE DONE BECAUSE PILOT PERFORMED IN LATERAL AXIS SLOWLY AND COULD AFFORD TO PUT IN A LITTLE CONTROL AND WAIT FOR THINGS TO HAPPEN.
FAVORABLE FEATURES	OVERALL GOOD A/C TO FLY IN TURBULENCE. GOOD ROLL CONTROL.	NONE.	EXCELLENT AS LONG AS RAPID MANEUVERS NOT REQUIRED. BY "RAPID" IS MEANT LATERAL OFFSET MANEUVER OR GETTING WING BACK UP QUICKLY TO STOP SLIDING ACROSS RUNWAY.
OBJECTIONABLE FEATURES	MORE DIFFICULTY ON OFFSET MANEUVER THAN ANTICIPATED. TURBULENCE A MAJOR OBJECTION.	INABILITY TO OBTAIN DESIRED ROLL RATES FOR A MODERATE MANEUVERING CAPABILITY AND TURNING PERFORMANCE.	LACK OF ROLL CONTROL POWER SHOWN BY HUGE FORCES PILOT FELT.
PRIMARY REASON FOR PILOT RATING	A/C HAD MODERATELY OBJECTIONABLE DEFICIENCIES WHICH REQUIRED CONSIDERABLE PILOT COMPENSATION ESPECIALLY IN TURBULENCE.	IN OFFSET APPROACH MANEUVER, PILOT UNABLE TO OBTAIN ADEQUATE PERFORMANCE WITH FULL AILERON DEFLECTION.	INTENDED JOB COULD NOT BE DONE PROPERLY. LATERAL OFFSET COULD NOT BE DONE PROPERLY. CONTROL (LATERAL) POWER DETERMINING FACTOR.

GROUP 14 $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.06$	$L'_{\delta_{AW}}\delta_{AW} = 17.0\ \frac{DEG}{SEC^2}$ PILOT B	$L'_{\delta_{AW}}\delta_{AW} = 15.9\ \frac{DEG}{SEC^2}$ PILOT B	$L'_{\delta_{AW}}\delta_{AW} = 15.7\ \frac{DEG}{SEC^2}$ PILOT A
NATURAL TURBULENCE MAX. X-WIND (~KT)	LIGHT 5	LIGHT 30	LIGHT (+) 20
PR/TR	3/B	3/B	2/B
GENERAL COMMENTS	WHEN TIME WAS SPENT TO GET TRIMMED UP JOB COULD BE DONE SUITABLE FOR LANDING APPROACH, AND IS IN NO WAY A HANDICAP	NOSE HAD SLIGHT BOTHERSOME TENDENCY TO HANG UP WHEN TRYING TO MAKE SMALL CORRECTIONS IFR. AILERONS HAD A HEAVY FEELING. A LOW FREQUENCY DIRECTIONAL OSCILLATION SOMETIMES NOTICED BUT DIDN'T INTERFERE WITH ANYTHING. SUITABLE FOR LANDING APPROACH.	SUITABLE FOR LANDING APPROACH. NO PROBLEMS WITH ILS.
ABILITY TO TRIM	SOME DIFFICULTY WITH LATERAL TRIM DURING ILS APPROACH. MISTRIMMED ON OCCASION WHEN TIME WAS SPENT JOB COULD BE DONE	NO DIFFICULTIES.	NO PROBLEMS ABOUT ANY AXIS.
SELECTION OF CONTROL SENSITIVITIES	SLIGHT COMPROMISE PILOT WOULD HAVE LIKED TO INCREASE SENSITIVITY BUT WAS GETTING SOME TENDENCY TO OVERCONTROL LATERAL CONTROL SLIGHTLY HEAVIER THAN DESIRABLE	(PREVIOUSLY SELECTED VALUES ASSIGNED.) RUDDER OKAY. AILERON FORCES NOTICED.	(PREVIOUSLY SELECTED VALUES ASSIGNED.) LATERAL FORCES A LITTLE HEAVY, BUT NO PROBLEM.
$L'_{\delta_{AW}}$	2.12	2.12	1.57
$N'_{\delta_{RP}}$	8.04	8.04	7.37
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL INITIAL RESPONSE GOOD FINAL RESPONSE PREDICTABLE WITH SOME TENDENCY TO OVERSHOOT. COORDINATION REQUIRED A LITTLE MORE THAN HAVING TO SQUEEZE IT ON ALTHOUGH NOT A BIG PROBLEM REQUIRED SOME THOUGHT	INITIAL ROLL RESPONSE SATISFACTORY, FINAL RESPONSE PREDICTABLE. YAW DUE TO ROLL SHOWN AS NOSE HANG UP, STAYED THERE AND CAME ALONG A NOTICEABLE TIME LATER. SO, PILOT WANTED TO USE A TOUCH OF RUDDER TO GET NOSE COMING AROUND AS SOON AS PILOT STARTED TO ROLL. COORDINATION NOT DIFFICULT AND CAME QUITE NATURALLY.	ADEQUATE ROLL CONTROL. AFTER BANK ANGLE ESTABLISHED RUDDER HELD STEADY INTO TURN, BUT BALL DISPLACEMENT WAS IN OPPOSITE DIRECTION TO TURN. COORDINATION REQUIRED BUT NOT DIFFICULT.
DIFFERENCES IN IFR AND VFR	NOTHING NOTICED IN ONE THAT WASN'T PRESENT IN THE OTHER	PRECISION IFR IS MORE OF A PROBLEM THAN VFR BECAUSE OF SLIGHT NOSE HANG UP.	NO APPRECIABLE DIFFERENCES NOTED.
EFFECTS OF TURBULENCE	CERTAINLY NOTICEABLE AND SOMEWHAT BOTHERSOME AT TIMES BECAUSE OF CROSSTALK BETWEEN DIRECTIONAL AND ROLL SIDE GUSTS REQUIRED NOT ONLY RUDDER COMPENSATION BUT ALSO AILERON COMPENSATION	NOTICEABLE BUT NO PROBLEM TO CONTEND WITH ON EITHER AXIS.	NOTEICABLE BUT NOT PRONOUNCED. NO SIGNIFICANT INCREASE IN CONTROL REQUIREMENTS.
CONTROL IN CROSSWIND	NO CROSSWIND NOTICED.	BOTH METHODS TRIED. A LITTLE DIFFICULT TO CONTROL NOSE WHEN USING WING DOWN METHOD. FAIRLY LARGE RUDDER FORCES USED AND NOT AS PRECISE AS DESIRED.	CRABBED TECHNIQUE USED WITH NO DIFFICULTIES.
FAVORABLE FEATURES	ROLL CONTROL SATISFACTORY AND ABILITY TO DO THE SIDESTEP MANEUVER GOOD	ROLL CONTROL GOOD, AND PRECISE. COORDINATION EASY TO DO ALMOST UNCONSCIOUSLY.	OVERALL EASY A/C TO FLY IN OR OUT OF TURBULENCE.
OBJECTIONABLE FEATURES	NOTHING EXCEPTIONALLY GOOD OR BAD SOME RUDDER COORDINATION REQUIRED TURBULENCE NOTICEABLE REQUIRING A LITTLE EFFORT TO COMPENSATE FOR IT	TENDENCY FOR NOSE TO HANG UP IN TURNS BOTHERSOME WHEN FLYING IFR AND TRYING TO MAKE PRECISION CHANGES. PILOT PUT IN BANK AND NOTHING HAPPENED SO RUDDER USED.	NO COMMENTS.
PRIMARY REASON FOR PILOT RATING	ADEQUATE PERFORMANCE ATTAINABLE SATISFACTORY WITH MILDLY UNPLEASANT DEFICIENCIES	SATISFACTORY A/C BUT NOSE HANG UP BOTHERSOME WHEN IFR, COULD QUALIFY AS MILDLY UNPLEASANT. NO SIGNIFICANT DETERIORATION IN PERFORMANCE AS RESULT OF TURBULENCE RESPONSE.	EASY TO FLY, WITH NEGLIGIBLE DEFICIENCIES. TURBULENCE CAUSED NO SIGNIFICANT DETERIORATION.

<table>
<tr><th colspan="2">GROUP 14 (Cont.)
$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$</th><th colspan="2">$L'_{\delta_{AW}}\delta_{AW} = 7.8 \frac{DEG}{SEC^2}$
PILOT A</th><th colspan="2">$L'_{\delta_{AW}}\delta_{AW} = 5.3 \frac{DEG}{SEC^2}$
PILOT B</th></tr>
<tr><td colspan="2">NATURAL TURBULENCE
MAX. X-WIND (~KT)</td><td colspan="2">MODERATE(–)
19</td><td colspan="2">LIGHT (+)
26</td></tr>
<tr><td colspan="2">PR/TR</td><td colspan="2">6/D</td><td colspan="2">10/C</td></tr>
<tr><td colspan="2">GENERAL COMMENTS</td><td colspan="2">NOT A BAD A/C EXCEPT IF DEMANDING RAPID ROLL RATES. SHORTAGE OF ROLL POWER AND FORCES REQUIRED TO GET ADEQUATE ROLL RESPONSE ARE BIGGEST SHORTCOMINGS OF CONFIGURATION.</td><td colspan="2">BAD A/C. PILOT LIMITED IN AMOUNT OF ROLL AUTHORITY, FORCES GOT ENORMOUS. PILOT CONTROLLED WITH RUDDER BUT NOT VERY PRECISE. DANGEROUS IN A CROSSWIND. ENDED UP IN DOUBTFUL SITUATIONS. DEFINITLY NOT SUITABLE FOR LANDING APPROACH.</td></tr>
<tr><td colspan="2">ABILITY TO TRIM</td><td colspan="2">A/C TRIMS SLOWLY BUT NO REAL PROBLEM.</td><td colspan="2">NO DIFFICULTIES.</td></tr>
<tr><td colspan="2">SELECTION OF CONTROL SENSITIVITIES</td><td colspan="2">SINCE LOT OF STICK FORCE REQUIRED FOR ROLL CONTROL REAL WORK PROBLEM CAUSED FOR PILOT AND REDUCES HARMONY OF CONTROLS. RUDDER DOESN'T SEEM TOO BAD.</td><td colspan="2">(PREVIOUSLY SELECTED VALUES ASSIGNED.) RUDDER OKAY. AILERON FORCES ENORMOUS AT TIMES.</td></tr>
<tr><td>$L'_{\delta_{AW}}$</td><td>$N'_{\delta_{RP}}$</td><td>1.57</td><td>7.98</td><td>2.12</td><td>6.94</td></tr>
<tr><td colspan="2">LATERAL AND DIRECTIONAL CONTROL</td><td colspan="2">WHEN RAPID ROLL RESPONSE REQUIRED A LITTLE MORE ANTICIPATION OR LEAD TIME REQUIRED TO GET A/C TO RESPOND AS DESIRED. GREAT AMOUNT OF FORCE REQUIRED FOR ROLL CONTROL. COORDINATION NOT TOO BAD.</td><td colspan="2">ROLL CONTROL IN ITSELF PRECISE ENOUGH EXCEPT PILOT COULD NOT ACHIEVE DESIRED INITIAL RESPONSE. WHERE RAPID MOTIONS REQUIRED DIFFICULTIES AROSE. FLYING STRAIGHT AND LEVEL PILOT PRECISE WITH NO PROBLEMS. EVIDENCE OF NORMAL COORDINATION REQUIREMENTS BUT PILOT HESITANT TO USE RUDDER BECAUSE OF "EATING INTO" ROLL CONTROL OF WHICH LITTLE REMAINED.</td></tr>
<tr><td colspan="2">DIFFERENCES IN IFR AND VFR</td><td colspan="2">NO APPRECIABLE DIFFERENCE.</td><td colspan="2">PROBLEMS IN VFR. IF MANEUVERING CLOSE TO GROUND; I.E., LATERAL OFFSET MANEUVER, PROBLEMS AROSE QUICKLY.</td></tr>
<tr><td colspan="2">EFFECTS OF TURBULENCE</td><td colspan="2">FAIRLY PRONOUNCED BUT NOT SO MUCH THAT PILOT CANNOT OVERCOME THEM. MAKING LARGE CORRECTIONS WITH TURBULENCE A DIFFICULT TASK.</td><td colspan="2">NONE.</td></tr>
<tr><td colspan="2">CONTROL IN CROSSWIND</td><td colspan="2">A/C SUITABLE FOR CROSSWIND LANDING AS LONG AS NO RAPID ROLLING MANEUVERS REQUIRED.</td><td colspan="2">VERY BAD A/C IN CROSSWIND. CRAB COULD BE DONE STRAIGHT DOWN RUNNWAY BUT TRYING TO DE-CRAB OR USE WING DOWN METHOD GREAT PILOT DIFFICULTES AROSE TRYING TO DE-CRAB FROM A RIGHT CROSSWIND WITH RUDDER. A/C WOULD ROLL LEFT AND PILOT DID NOT HAVE ENOUGH ROLL CONTROL TO HOLD NOSE STRAIGHT AND STOP LEFT ROLL.</td></tr>
<tr><td colspan="2">FAVORABLE FEATURES</td><td colspan="2">A/C NOT TOO BAD EXCEPT WHEN TRYING TO MAKE RAPID ROLLING MANEUVERS.</td><td colspan="2">NO COMMENTS.</td></tr>
<tr><td colspan="2">OBJECTIONABLE FEATURES</td><td colspan="2">SHORTAGE OF ROLL POWER AND HIGH FORCES REQUIRED TO GET ADEQUATE ROLL RESPONSE. BARELY ADEQUATE CONTROL POWER AVAILABLE TO PERFORM OFFSET MANEUVER.</td><td colspan="2">LACK OF ROLL AUTHORITY. A/C CAN NOT BE MOVED QUICKLY LATERALLY EVEN WHEN USING UNREASONABLE FORCES ON AILERONS. WHEN RUDDER USED TO HELP ROLL, BANK COULD NOT BE CONTROLLED. A/C LURCHES WITH LARGE EFFECT IN LATERAL AXIS. WITH LIMITED ROLL CAPABILITY RUDDER USAGE COMPOUNDED DIFFICULTIES. PROBLEM REALLY NOTICEABLE IN CROSSWIND.</td></tr>
<tr><td colspan="2">PRIMARY REASON FOR PILOT RATING</td><td colspan="2">VERY OBJECTIONABLE LACK OF ROLL CONTROL POWER ESPECIALLY IN PERFORMING OFFSET MANEUVER. WARRANTS IMPROVEMENT. EXTENSIVE PILOT COMPENSATION REQUIRED FOR ADEQUATE PERFORMANCE.</td><td colspan="2">UNABLE TO LAND FROM CROSSWIND APPROACH. PILOT WOULD LOSE CONTROL.</td></tr>
</table>

<table>
<tr><td colspan="2">GROUP 16
$N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$</td><td colspan="2">$L'_{\delta_{AW}}\delta_{AW} = 24.6\ \frac{DEG}{SEC^2}$
PILOT A</td><td colspan="2">$L'_{\delta_{AW}}\delta_{AW} = 23.1\ \frac{DEG}{SEC^2}$
PILOT A</td><td colspan="2">$L'_{\delta_{AW}}\delta_{AW} = 16.1\ \frac{DEG}{SEC^2}$
PILOT B</td></tr>
<tr><td colspan="2">NATURAL TURBULENCE
MAX. X-WIND (~KT)</td><td colspan="2">LIGHT (+)
15</td><td colspan="2">LIGHT (+)
3</td><td colspan="2">LIGHT
14</td></tr>
<tr><td colspan="2">PR/TR</td><td colspan="2">2.5/B</td><td colspan="2">4/C</td><td colspan="2">4/C</td></tr>
<tr><td colspan="2">GENERAL COMMENTS</td><td colspan="2">OVERALL LATERAL-DIRECTIONAL HANDLING QUALITIES GENERALLY GOOD</td><td colspan="2">OVERALL LATERAL DIRECTIONAL HANDLING QUALITIES FAIR TO GOOD. ONLY DEGRADING FEATURE IS INABILITY TO OBTAIN COMMANDED ROLL RATES QUICKLY. SUITABILITY FOR LANDING APPROACH IS FAIR TO GOOD, PROBABLY CLOSE TO THE GOOD</td><td colspan="2">THE CLOSER ONE LOOKS AT A/C THE WORSE IT APPEARS, BUT JOB CAN BE DONE WITHOUT MUCH EFFORT.</td></tr>
<tr><td colspan="2">ABILITY TO TRIM</td><td colspan="2">LATERAL TRIM SOMEWHAT DEGRADED.</td><td colspan="2">NOT TOO MUCH OF A PROBLEM EITHER DIRECTIONALLY OR LATERALLY</td><td colspan="2">NO PROBLEM.</td></tr>
<tr><td colspan="2">SELECTION OF CONTROL SENSITIVITIES</td><td colspan="2">AILERONS POSSIBLY TOO SENSITIVE, CREATING SOME DISHARMONY WITH THE HEAVIER ELEVATOR CONTROL FORCES</td><td colspan="2">FORCES AND DISPLACEMENTS ARE ALL RIGHT</td><td colspan="2">FAIRLY HIGH INITIAL AILERON FORCES AND A LOT OF FORCE REQUIRED TO STOP ROLL RATE. THIS IS RESULT OF ROLL RESPONSE. IN GENERAL, FORCES NOT SERIOUS PROBLEM.</td></tr>
<tr><td>$L'_{\delta_{AW}}$</td><td>$N'_{\delta_{RP}}$</td><td>1.54</td><td>8.10</td><td>1.54</td><td>8.10</td><td>1.61</td><td>9.21</td></tr>
<tr><td colspan="2">LATERAL AND DIRECTIONAL CONTROL</td><td colspan="2">ROLL CONTROL VERY GOOD. LIGHT TO MODERATE ADVERSE YAW DUE TO ROLL. ALMOST NO OSCILLATORY CHARACTERISTICS. A/C SENSITIVE IN LATERAL CONTROL MODE.</td><td colspan="2">SINCE IT TAKES QUITE A WHILE TO BUILD UP THE DESIRED ROLL RATE, SMALL HEADING CORRECTIONS USING AILERONS IS A LITTLE BIT TAXING. ROLL CONTROL IS GOOD, BUT WAITING FOR THE COMMANDED ROLL RATE TO TAKE PLACE IS ANNOYING. ADVERSE YAW DUE TO ROLL IS PRESENT AND REQUIRES MODERATE EFFORT TO TRIM IN TURNS TO MAINTAIN COORDINATION MANEUVERS. DUTCH ROLL CAN BE KICKED OFF FAIRLY EASILY AND ALTHOUGH IT'S A SLOW PERIOD, IT DAMPS OUT IN 3 TO 4 CYCLES. HIGH $\phi\ \beta$ THRESHOLD. A LITTLE BIT OF YAW PUTS IN QUITE A GOOD ROLL RATE. AGAIN THIS IS APPARENTLY AFFECTED BY THE ζ_{ϕ} BECAUSE IT STARTS OFF RELATIVELY SLOWLY AND BANKS IN RATHER RAPIDLY</td><td colspan="2">ROLL CONTROL NOT AS PREDICTABLE AS DESIRED. SLIGHT TENDENCY TO OVERSHOOT DESIRED BANK ANGLE. PILOT ABLE TO GET AWAY WITHOUT COORDINATING, HOWEVER, BALL EXCURSIONS QUITE LARGE AND THEN GRADUALLY MOVE BACK TO CENTER. SOME COORDINATION REQUIRED BUT IT'S NOT DIFFICULT TO PROVIDE</td></tr>
<tr><td colspan="2">DIFFERENCES IN IFR AND VFR</td><td colspan="2">NO APPRECIABLE DIFFERENCE</td><td colspan="2">NONE NOTICED; HOWEVER, BIT OF A PROBLEM MAKING SMALL HEADING CORRECTIONS WHILE IFR</td><td colspan="2">SLIGHT TENDENCY FOR NOSE TO HANG UP IN TURN IS MORE BOTHERSOME IFR. UNABLE TO MAKE PRECISE CHANGES ON ILS WITHOUT THINKING ABOUT IT.</td></tr>
<tr><td colspan="2">EFFECTS OF TURBULENCE</td><td colspan="2">MINIMAL. NO APPRECIABLE EFFECTS ON HANDLING QUALITIES</td><td colspan="2">MODERATE TURBULENCE EFFECTS RUDDER FREE. YAW ANGLES ARE SUSTAINED FOR A CONSIDERABLE AMOUNT OF TIME AND DO NOT IMMEDIATELY CORRECT BACK TO CENTER EXCEPT WITH PROPER RUDDER COORDINATION. MAKING SMALL COORDINATED CORRECTIONS IS A BIT MORE OF A CHORE IN TURBULENCE.</td><td colspan="2">NOTICEABLE BUT NOT A PROBLEM. SLOW RESPONSE.</td></tr>
<tr><td colspan="2">CONTROL IN CROSSWIND</td><td colspan="2">VERY LITTLE WIND AVAILABLE FOR CROSSWIND, BUT LANDING IN A CROSSWIND WOULD BE NO PROBLEM</td><td colspan="2">EFFECTS ON HANDLING QUALITIES NOT TOO PRONOUNCED, A STRAIGHT CRAB TECHNIQUE WAS USED.</td><td colspan="2">NO CROSSWIND.</td></tr>
<tr><td colspan="2">FAVORABLE FEATURES</td><td colspan="2">GOOD FLYING A/C</td><td colspan="2">EVERYTHING SEEMED PRETTY GOOD EXCEPT FOR THE ROLL RESPONSE.</td><td colspan="2">JOB COULD BE DONE. COORDINATION REQUIRED NOT A PROBLEM, IT ALMOST CAME NATURALLY.</td></tr>
<tr><td colspan="2">OBJECTIONABLE FEATURES</td><td colspan="2">SOME DIFFICULTY IN COORDINATING TURN ENTRIES NOTED DURING OFFSET LANDING APPROACH</td><td colspan="2">ROLL RESPONSE AND A LITTLE BIT OF YAW DUE TO ROLL. PILOT ANTICIPATION OF THE INCREASE IN ROLL RATE IS VERY SIGNIFICANT.</td><td colspan="2">ROLL RATE TENDED TO TAKE OFF SLIGHTLY INITIALLY AND STOPPING AT BANK ANGLE REQUIRED NOTICEABLE FORCES.</td></tr>
<tr><td colspan="2">PRIMARY REASON FOR PILOT RATING</td><td colspan="2">SOME COORDINATION REQUIRED DURING TURN ENTRIES.</td><td colspan="2">THE MINOR BUT ANNOYING DEFICIENCIES IN DESIRED PERFORMANCE REQUIRE MODERATE PILOT COMPENSATION.</td><td colspan="2">ONE CAN ANALYZE A/C AND FIND MANY THINGS THAT APPARENTLY LOOK BAD BUT A/C CAN BE FLOWN AND GET JOB DONE WITHOUT TOO MUCH EFFORT.</td></tr>
</table>

GROUP 16 (Cont.) $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.05$	$L'_{\delta_{AW}}\delta_{AW} = 13.7\ \frac{\text{DEG}}{\text{SEC}^2}$ PILOT B	$L'_{\delta_{AW}}\delta_{AW} = 11.5\ \frac{\text{DEG}}{\text{SEC}^2}$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT (+) 24, GUSTING TO 28	LIGHT 10
PR/TR	3/D	3/B
GENERAL COMMENTS	OUT OF TURBULENCE, QUITE DECENT A/C. IT FELT SOLID, AT TIMES A BIT HEAVY. IT WAS SUITABLE FOR THE LANDING APPROACH.	FAIR TO GOOD SUITABILITY FOR LANDING APPROACH.
ABILITY TO TRIM	NO PROBLEMS	NO PROBLEM.
SELECTION OF CONTROL SENSITIVITIES	(PREVIOUSLY SELECTED VALUES ASSIGNED.) RUDDER FORCES FEEL HEAVY IN CROSSWIND APPROACH USING THE WING DOWN METHOD. IN TURBULENCE THE AILERONS FELT HEAVY	(PREVIOUSLY SELECTED VALUES ASSIGNED.) GOOD GEAR RATIO. GOOD FEEL CHARACTERISTICS, FORCES AND DISPLACEMENTS.
$L'_{\delta_{AW}}$	1.61	1.54
$N'_{\delta_{RP}}$	6.94	8.10
LATERAL AND DIRECTIONAL CONTROL	ROLL CONTROL WAS GOOD. SINCE NOSE WOULD HANG UP IN TURNS, A NEED WAS FELT TO PUT IN SOME RUDDER. IN IFR, NOTICEABLE THAT RUDDER WAS REQUIRED TO GET FAST HEADING CHANGE. COORDINATION NOT EXTREMELY DIFFICULT BUT NECESSARY	ROLL MODE TIME CONSTANT A LITTLE LONG. A WHILE BEFORE COMMANDED ROLL RATE REACHES STEADY STATE. COORDINATION REQUIRES MORE RUDDER APPLICATION THAN DESIRED. HOWEVER, NO PROBLEM.
DIFFERENCES IN IFR AND VFR	NOTHING OUTSTANDING	NO APPRECIABLE DIFFERENCE.
EFFECTS OF TURBULENCE	A/C WALLOWED AROUND BOTH DIRECTIONALLY AND LATERALLY BUT RESPONSE WAS SLOW. ALTHOUGH PILOT COULD CONTEND WITH IT, IT CAME THROUGH AS A BIT OF WORK LOAD LATERALLY BECAUSE THE AILERONS FELT HEAVY	NOT TOO PRONOUNCED. MORE EFFORT REQUIRED BUT NO SIGNIFICANT DETERIORATION.
CONTROL IN CROSSWIND	BOTH CROSSWIND TECHNIQUES WERE TRIED. PILOT'S PERSONAL PREFERENCE IS THE WING DOWN METHOD BUT RUDDER FORCES GET NOTICEABLE IN HOLDING THE NOSE STRAIGHT	CROSSWIND LIGHT, SO NO WAY OF ASSESSING CROSSWIND CAPABILITY. OTHER MANEUVERS INDICATE THERE WOULD BE NO PROBLEM.
FAVORABLE FEATURES	A/C FELT REAL SOLID OUT OF TURBULENCE. ROLL CONTROL WAS GOOD. JUST FELT LIKE A BIG A/C	GOOD A/C IN LANDING APPROACH.
OBJECTIONABLE FEATURES	MINOR OBJECTION IS NECESSITY FOR COORDINATION. TURBULENCE RESPONSE WAS NOTICEABLE AND CAUSED A DETERIORATION. LATERALLY, IT FELT QUITE HEAVY IN TURBULENCE	ROLL CONTROL. A LITTLE MORE LAG THAN DESIRED BETWEEN TIME OF LATERAL INPUT AND RESPONSE. CONSTANT CHANGE IN ROLL RATE AND LAG INVOLVED FOLLOWING AILERON INPUT GIVES PILOT PROBLEM WITH ANTICIPATING CONTROL INPUTS. PARTICULARLY NOTICEABLE DURING OFFSET LANDING MANEUVER.
PRIMARY REASON FOR PILOT RATING	SATISFACTORY WITHOUT IMPROVEMENT	SOME MILDLY UNPLEASANT DEFICIENCIES HOWEVER, MINIMAL PILOT COMPENSATION REQUIRED.

GROUP 16 (Cont.) $N'_{\delta_{AW}}/L'_{\delta_{AW}} = +0.06$	$L'_{\delta_{AW}}\,\delta_{AW} = 8.1\ \frac{\text{DEG}}{\text{SEC}^2}$ PILOT B	$L'_{\delta_{AW}}\,\delta_{AW} = 3.9\ \frac{\text{DEG}}{\text{SEC}^2}$ PILOT A
NATURAL TURBULENCE **MAX. X-WIND (~KT)**	LIGHT (+) 25 GUSTING TO 33	NONE 10
PR/TR	7/E	9/F
GENERAL COMMENTS	A/C UNDESIRABLE. A/C LURCHES OVER AND "TAKES OFF" IN BANK WHEN IT GETS UPSET AND SOME FORCES PILOT CONTENDED WITH WERE ABOUT AS LARGE AS PILOT COULD GENERATE WITH ONE HAND. ON OCCASION WALLOWING IN ROLL NOTICED. NOT SUITABLE FOR LANDING APPROACH. FOR PRECISION IFR TASK JOB COULD BE DONE WITH A LITTLE EFFORT.	UNSATISFACTORY FOR LANDING APPROACH. POOR ILS PERFORMANCE BECAUSE SMALL HEADING CHANGES COULD NOT BE MADE WITH AILERONS. THUS CROSS CONTROL IN BANK AND MAXIMUM LATERAL CONTROL DEFLECTIONS USED TO KEEP FROM LOSING CONTROL.
ABILITY TO TRIM	NO PROBLEMS.	SLIGHT DIFFICULTY WITH DIRECTIONAL TRIM, OTHERWISE GOOD TRIM ABILITY.
SELECTION OF CONTROL SENSITIVITIES	(PREVIOUSLY SELECTED VALUES ASSIGNED.) RUDDER ESPECIALLY GOOD. FORCES HARDLY NOTICEABLE AND YET NOT TOO SENSITIVE. UNCOMFORTABLE LATERAL FORCES FOR ONE-HANDED OPERATION, YET MORE SENSITIVE NOT DESIRED BECAUSE OF ROLL CHARACTERISTICS.	(PREVIOUSLY SELECTED VALUES ASSIGNED.) LATERAL CONTROL VERY HEAVY, ESPECIALLY WHEN COMPARED TO LONGITUDINAL. MORE LATERAL CONTROL POWER DESIRED.
$L'_{\delta_{AW}}$ $N'_{\delta_{RP}}$	1.61 6.94	1.54 7.98
LATERAL AND DIRECTIONAL CONTROL	ROLL TENDED TO "TAKE OFF" AND OVERBANK. PILOT OVERDROVE TO GET A/C MOVING AND THEN PUT IN FAIR FORCE IN OPPOSITE DIRECTION TO STOP IT. FINAL RESPONSE IN ROLL NOT PREDICTABLE AND PRODUCED UNEASY FEELING WHEN NEAR GROUND. YAW DUE TO ROLL PRESENT. FAIRLY LARGE RUDDER REQUIRED INTO TURN, BUT WITH RUDDER SENSITIVITIES PRESENT, PILOT EASILY TOOK CARE OF IT.	RESPONSE TO ROLL VERY SLOW, SLOPPY. SO LITTLE ROLL RATE AVAILABLE THAT IT WAS DIFFICULT TO SORT OUT ANY YAW CHARACTERISTICS. COORDINATION A PROBLEM; DIFFICULT TO MAINTAIN. RELATIVELY LOW LATERAL CONTROL POWER AVAILABLE WAS BIG PROBLEM.
DIFFERENCES IN IFR AND VFR	VFR, COULD GET PILOT IN TROUBLE WHERE HE MIGHT BE PREOCCUPIED LOOKING AT RUNWAY AND GET INTO OVERBANK CONDITION NEAR GROUND. PROBLEMS IN LARGER MANEUVERS.	SOME PROBLEMS BECAUSE OF "SLUGGISHNESS" IN ROLL.
EFFECTS OF TURBULENCE	NOTICEABLE PRINCIPALLY IN ROLL. A FEW UPSETS NEAR GROUND MADE PILOT DOUBT IF ENOUGH AILERON LEFT TO GET WING UP. TURBULENCE RESPONSE A PROBLEM.	MAJOR DEGRADATION.
CONTROL IN CROSSWIND	EITHER METHOD USEABLE WITH NO PREFERENCE. RUDDER AND AILERON FORCES NO PROBLEM.	CROSSWIND EXPERIENCED NOT MUCH OF PROBLEM, BUT WITH MORE WIND, THINGS WOULD HAVE BEEN WORSE. PILOT WOULD USE WING DOWN METHOD. IN TRYING TO ROLL, EITHER FOR CROSSWIND OR LATERAL OFFSET MANEUVER, ONLY WAY TO KEEP A/C FROM CONTINUING TO ROLL WAS TO USE FULL AILERON DEFLECTION AND RUDDER OPPOSITE ROLL TO RETURN TO LEVEL FLIGHT, LEADING TO UNCOORDINATED SITUATIONS.
FAVORABLE FEATURES	GOOD RUDDER SENSITIVITIES.	NO COMMENTS.
OBJECTIONABLE FEATURES	ROLL CONTROL TENDED TO TAKE OFF AND NOT PREDICTABLE. COUPLED WITH SLOW BUT LARGE TURBULENCE RESPONSE CAUSED A/C TO LURCH OVER TO LARGE BANK ANGLES UNEXPECTEDLY.	AT TIMES VERY CLOSE TO LOSING CONTROL OF A/C, BECAUSE OF ROLL CONTROL, WHILE TRYING TO ACCOMPLISH ASSIGNED TASKS.
PRIMARY REASON FOR PILOT RATING	ADEQUATE PERFORMANCE NOT ATTAINABLE BECAUSE OF OVERBANKING TENDENCIES AND LARGE FORCES REQUIRED TO GET WING BACK UP. TURBULENCE RESPONSE REQUIRES BEST EFFORTS.	INTENSE PILOT COMPENSATION REQUIRED TO RETAIN CONTROL. MAXIMUM LATERAL CONTROL DEFLECTIONS REQUIRED. MAJOR DEFICIENCY. TURBULENCE EFFECTS REQUIRED BEST EFFORTS AND RESULTED IN MAJOR DETERIORATION OF TASK PERFORMANCE.

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11. SUPPLEMENTARY NOTES

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13. ABSTRACT

Lateral-directional handling qualities and roll control power requirements for executive jet and military Class II Airplanes in the landing approach flight phase were investigated in the USAF/CAL variable stability T-33 airplane. Particular emphasis was placed on the effects of crosswinds and turbulence. Simulated IFR ILS approaches and VFR offset and crosswind approaches were made. Specifically, two Dutch roll frequencies, three Dutch roll damping ratios, three roll-to-sideslip ratios and three roll mode time constants were investigated. It was found that lateral-directional dynamics do not establish a limiting crosswind value; however, they do determine the ease or difficulty with which a crosswind approach can be accomplished. Roll control power requirements were determined from actual control usage data obtained throughout the evaluation program. In addition, a number of configurations were reevaluated with limited roll control power to determine minimum acceptable levels. Available roll control power can establish a limiting crosswind component. A number of configurations were evaluated with a stick controller in place of the normally used wheel controller to determine if the type of controller affected the lateral-directional dynamics for acceptable handling qualities. No difference was found to exist. A detailed comparison with MIL-F-8785B(ASG) requirements is included and generally shows the present requirements to be too conservative in the landing approach flight phase.

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Airplane controllers						
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