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FOR THE COMMANDER

C. B. WESTBROOK
Chief, Control Criteria Branch
Flight Control Division

IN-FLIGHT SIMULATION OF MINIMUM LONGITUDINAL STABILITY FOR LARGE DELTA-WING TRANSPORTS IN LANDING APPROACH AND TOUCHDOWN

VOLUME II: SUPPORTING TECHNICAL DATA AND ANALYSIS

Richard Wasserman, John F. Mitchell, William W. Rickard,
Ronald W. Huber and Arno E. Schelhorn

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FOREWORD

This final technical report was prepared by Calspan Corporation (formerly Cornell Aeronautical Laboratory, Inc.), Buffalo, New York, under Contract F33615-72-C-1386, Project No. 920K, "Flight Research Program for Large Aircraft." The work was performed under the sponsorship of the Federal Aviation Administration (FAA), and was administrated under the direction of the Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. Mr. Jerome Teplitz (RD-741) was Project Manager for the FAA, and Mr. James R. Pruner (AFFDL/FGC) was the Project Engineer for the Air Force.

The work reported herein was performed by the Flight Research Department of Calspan. Dr. P.A. Reynolds was Program Manager, Mr. G.J. Fabian was Assistant Program Manager, Mr. R. Wasserman was the Project Engineer, and Mr. J.F. Mitchell served as Assistant Project Engineer and Safety Pilot. Acknowledgement is given to the evaluation pilots on this program: Mr. R.P.Harper, Jr. of Calspan, Lt/Col. T.D. Benefield, USAF (currently assigned to the FAA), Mr. F.J. Drinkwater, III of NASA/AMES, and Mr. D. Tuck, FAA. The efforts of Mr. R. Abrams (FAA), who assisted in the performance of the evaluation phase of the program, are also appreciated.

The successful completion of this investigation was largely due to the excellent performance of the TIFS flight and ground crew who are especially acknowledged here. Safety Pilots: Nello Infanti, Franklin Eckhart, Edward Boothe; Electronic Engineers: Arno Schelhorn, James Dittenhauser, Ronald Huber; Electronic Technicians: David Begier, Fred Juliano; Crew Chiefs: Raymond Miller and David Kostrubanic; Computer Programming: Clarence Mesiah.

This report was submitted by the authors in December 1972. It is being published simultaneously as Calspan Report No. AK-5084-F-1. The report is in two volumes: Volume I contains the technical results of the experiment, and Volume II presents specific background information on the experiment and the complete pilot comments.

This technical report has been reviewed and approved.

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

ABSTRACT

An in-flight simulation to investigate minimum longitudinal stability for large delta-wing transports in landing approach and touchdown (including ground effect) was conducted using the USAF/Calspan Total In-Flight Simulator (TIFS) airplane. The airplane nonlinear equations of motion, as well as the representation of the engine characteristics and the control system used in this in-flight investigation are presented. Details of the simulation of representative piloting tasks for the landing approach (e.g., artificial cross-wind landing) are described. Detailed pilot comments, touchdown parameters, measures of turbulence and pilot workload obtained during the in-flight evaluation are included in this report. Analysis of the landing approach maneuver indicates the importance of precise attitude control, and the influence of ground effect on large delta-wing transports. Pilot compensation required to obtain a specified performance level of attitude control was analyzed indicating the need for extreme lead compensation for longitudinally unstable airplanes.

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LIST OF SYMBOLS

b	=	Reference span of wing, feet
$(BW)_{MIN}$	=	Value of the closed-loop bandwidth which the pilot is trying to achieve in precision tracking tasks, rad/sec
$\bar{c}$	=	Mean aerodynamic chord, feet
C_D	=	Drag coefficient = $D/\bar{q}S$
C_{D_α}	=	$\partial C_D/\partial\alpha$, rad^{-1}
$C_{D_{\delta_e}}$	=	$\partial C_D/\partial\delta_e$
C_L	=	Lift coefficient = $L/\bar{q}S$
C_{L_o}	=	Lift coefficient at zero angle of attack
C_{L_α}	=	$\partial C_L/\partial\alpha$, rad^{-1}
$C_{L_{\dot\alpha}}$	=	$\partial CL/\partial\left(\frac{\dot\alpha \ell}{V}\right)$, rad^{-1}
$C_{L_{\delta_e}}$	=	$\partial C_L/\partial\delta_e$, rad^{-1}
C_{L_q}	=	$\partial C_L/\partial\left(\frac{q\ell}{V}\right)$, rad^{-1}
C_ℓ	=	$L/\bar{q}\ell S$
C_m	=	Pitching moment coefficient = $M/\bar{q}\ell S$
C_{m_o}	=	Pitching moment coefficient at zero angle of attack
$C_{m_{1,2,3}}$	=	Coefficients of power series expansion of C_m as a function of α
C_{m_α}	=	$\partial C_m/\partial\alpha$, rad^{-1}
$C_{m_{\dot\alpha}}$	=	$\partial C_m/\partial\left(\frac{\dot\alpha\ell}{V}\right)$, rad^{-1}
C_{m_q}	=	$\partial C_m/\partial\left(\frac{q\ell}{V}\right)$, rad^{-1}
C_{m_V}	=	$\partial C_m/\partial V$, (ft/sec)$^{-1}$
C_n	=	$N/\bar{q}\ell S$
C_{n_β}	=	$\partial C_n/\partial\beta$, rad^{-1}

LIST OF SYMBOLS (cont.)

$C_{n_{\delta_a}}$ = $\partial C_n / \partial \delta_a$, rad^{-1}

C_x = $-C_D = -D\bar{q}S$

d = Height of mean aerodynamic chord/semi-span

D = Drag, positive along negative x wind axis, lb

dB = Decibel units for Bode amplitude, where amplitude in dB = $20 \log_{10}$ (amplitude)

E = Constant term of longitudinal characteristic equation

$F(d)$ = Normalized lift ground effect function

$F_1(d)$ = Normalized pitching moment ground effect function

F_{AW} = Aileron wheel force, lb

F_{ES} = Elevator wheel force, positive aft, lb

F_{RP} = Rudder pedal force, lb

F_S = Elevator stick force, positive aft, lb

$F_{x_B}, F_{y_B}, F_{z_B}$ = Component of aerodynamic and thrust forces along the x , y , z body axes, respectively, lb

g = Gravitational constant, 32.17 ft/sec^2

h = Absolute altitude of airplane c.g., feet

h_{P_C} = Commanded change in airplane altitude at the pilot station, feet

h_p/δ_e = Open-loop altitude transfer function of airplane at pilot station, ft/deg or ft/rad

h_{P_e} = $(h_{P_c} - h_p)$, Error between the commanded altitude and the airplane altitude at the pilot station, feet

i_m = $(\alpha_M - \alpha_{MT})$, Incidence angle between body axis of the model and that axis system parallel to the TIFS body axis, degrees

i_T = Incidence angle of engine thrust line with respect to body axis in the x-z plane (positive for thrust vector pointed upwards), deg

I_{xx}, I_{yy}, I_{zz} = Moments of inertia about the x , y , z body axes, respectively, slug-ft^{-2}

LIST OF SYMBOLS (cont.)

I_{xz}	=	Product of inertia about the x, z body axes, slug-ft^{-2}
K_D	=	Induced drag coefficient
K_p	=	Steady-state pilot gain, lb/deg or lb/rad
$(K_1+K_2 s)$	=	Forward loop lead compensator for altitude closure
ℓ	=	Reference length of simulated airplane, feet
L	=	Lift, positive along negative z wind axis, lb
ℓ_x	=	Distance along the fuselage reference line between the c.g. and the pilot's station, positive for c.g. aft of the pilot station, feet
L, M, N	=	Moment vector components about the x, y, z body axis, respectively, ft-lb
M_α	=	$\frac{1}{I_{yy}} \frac{\partial M}{\partial \alpha}$, rad/sec^2/rad
m	=	Mass of airplane, slugs
n	=	Normal load factor, g units
n_y, n_z	=	Lateral, normal acceleration respectively, g units
p, q, r	=	Roll, pitch, and yaw rates, respectively, deg/sec
p_I, q_I, r_I	=	Inertial angular velocity components about the x, y, z body axes, respectively, degrees/second
$\bar{q}$	=	Dynamic pressure = $\frac{1}{2} \rho V^2$, lb/ft^2
s	=	Laplace operator, sec^{-1}
S	=	Reference area of wing, (feet)^2
T_m	=	Total model thrust, lb
T_2	=	Time to double amplitude computed from the unstable aperiodic root of the linearized longitudinal characteristic equation, seconds

LIST OF SYMBOLS (cont.)

$T_{1/2_{sp}}$ = Time to half amplitude calculated from short period approximation of attitude, seconds

$T_{2_{sp}}$ = Time to double amplitude calculated from short period approximation of attitude, seconds

T_{2_α} = Time to double amplitude measured from angle of attack response to elevator, seconds

$T_{1/2_\theta}$ = Time to half amplitude of equivalent short term attitude response to elevator, seconds

T_{2_θ} = Time to double amplitude of equivalent short term attitude response to elevator, seconds

u_I, v_I, w_I = Inertial velocity components along the x, y, z body axes, respectively, feet/second

V = True airspeed of the airplane center of gravity, ft/sec

V_I = Inertial airspeed of the airplane in earth surface axes, feet/second

W = Airplane weight, lb

x, y, z = Body axes, x-z plane is in the plane of symmetry of the airplane with x directed forward parallel to the fuselage reference line, z directed downward, and y directed out the right wing

Y = Touchdown distance from runway threshold, feet

Y_W = Side force, positive along positive y wind axis, lb

$\tilde{z}_T$ = Thrust pitching moment arm component (positive along + z body axis measured relative to the c.g.), ft

$(\dot{\ })$ = First derivative with respect to time, sec^{-1}

$(\ddot{\ })$ = Second derivative with respect to time

α = Total angle of attack with respect to true airspeed, rad or deg

α_I = Inertial angle of attack referenced to inertial velocity vector, degrees

α/δ_e = Open-loop angle-of-attack transfer function of the airplane

LIST OF SYMBOLS (cont.)

β	=	Total angle of sideslip with respect to true airspeed rad or deg
β_I	=	Inertial angle of sideslip referenced to inertial velocity vector, degrees
γ	=	Flight path angle, deg
$d\gamma/dV$	=	Flight path stability parameter, deg/knot
δ_a	=	Equivalent aileron surface deflection, positive right T.E. down, deg or rad
δ_e	=	Equivalent elevator surface deflection, positive T.E. down, deg or rad
δ_e/F_s	=	Open-loop transfer function of elevator surface to elevator stick force, deg/lb or rad/lb
δ_r	=	Equivalent rudder surface deflection, positive T.E. left, deg or rad
δ_x	=	Throttle lever position, deg
$[\Delta A/\Delta \measuredangle]_\theta$	=	Slope of Bode amplitude with phase for the airplane plus pilot time delay at reference frequency, dB/deg
ζ_{FS}	=	Damping ratio of feel system
ζ_{SP}	=	Damping ratio of the longitudinal short period mode
θ	=	Pitch angle, deg or rad
$\measuredangle_\theta$	=	Phase angle of the airplane plus pilot time delay at the reference frequency, deg
θ_c	=	Commanded change in airplane pitch attitude, deg or rad
θ_e	=	$(\theta_c - \theta)$, Error between the commanded pitch attitude and the airplane pitch attitude, deg or rad
θ/δ_e	=	Open-loop pitch transfer function of airplane
θ/θ_e	=	Open-loop pitch transfer function of airplane plus control system plus pilot
λ	=	Aperiodic root magnitude, sec^{-1}

LIST OF SYMBOLS (cont.)

ρ = Air density, slugs/ft^3

σ = Mean square gust intensity

$\sigma_{v_{g_{MAX}}}$ = Maximum value of total velocity mean square gust intensity, ft/sec

τ_{p_1} = Time constant of pilot's lead element, sec

τ_{p_2} = Time constant of pilot's lag element, sec

ϕ = Bank angle, deg or rad

ψ = Yaw angle, deg or rad

ω_θ = Reference frequency, rad/sec

$\omega_{n_{FS}}$ = Undamped natural frequency of feel system, rad/sec

$\omega_{n_{SP}}$ = Undamped natural frequency of the longitudinal short period mode, rad/sec

SUBSCRIPTS

A	=	Aerodynamic
B	=	Body axis
CW	=	Crosswind
g	=	Gust
GE	=	Ground effect
I	=	Inertial
IGE	=	In ground effect
M	=	Model body axis
MT	=	Axis system in the model parallel to the TIFS body axis
NT	=	Nonequilibrium
O	=	Initial condition
OGE	=	Out of ground effect
p	=	Pilot's location
S	=	Stability axis
t	=	Trim
T	=	Thrust
TCG	=	At the TIFS center of gravity

SECTION I

INTRODUCTION

This report presents supporting technical data and analysis of the results of an in-flight simulation program to generate data on the minimum longitudinal stability of large delta-wing transports in the landing approach flight phase.

The objective of this program was to generate data for use in establishing flight characteristics criteria for airworthiness certification and issuance of operational limitations for supersonic transports during landing approach. The evaluation program was specifically directed toward definition of a minimum acceptable level of longitudinal stability of the unaugmented delta-wing transport airplane. This was accomplished by a systematic variation of static longitudinal stability of the airplane. In addition, the effects of (1) curvature of the pitching moment vs. angle-of-attack curve, (2) increased pitch damping, and (3) backsidedness (variation of induced drag) on airplane acceptability were also examined to determine their influence on a minimum level of static stability. The basic data package used for this program was supplied by the FAA and consisted of aerodynamic data and control system characteristics of an unaugmented prototype Concorde airplane. This data defined a reference airplane configuration from which the above parameter variations were made.

For this experiment the in-flight simulator used was the TIFS airplane. The TIFS airplane is a research tool which permitted a duplication of the motion of the simulated airplane pilot station, and the instrument and visual cues experienced in the actual performance of the landing approach task to a simulated touchdown. This permitted the evaluation pilot to assess the complete approach problem including localizer acquisition, glide slope acquisition under instrument conditions and control of flare and touchdown (with ground effect) under visual conditions. Glide slope errors, localizer offset error, crosswind and turbulence were introduced electronically into the evaluation task to allow the evaluation pilot to examine the simulated aircraft under various operational requirements.

The report is divided into two volumes. Each volume is subdivided into various sections. Volume I is essentially a summary of the experiment, while Volume II documents the experiment and the analysis of data in greater detail and provides specific background information for the contents of Volume I. The following is presented in the sections of Volume II.

Section II - Development of the Equations of Motion Used for the TIFS Simulation of Large Delta-Wing Transport Airplanes

Section III - Summary of Aerodynamics, Control System and Thrust Representations

Section IV - Task Mechanization

Section V - Quasi-Steady Trajectory Analysis of the Landing Maneuver

Section VI - Pilots' Comments

Section VII - Tabulation of Touchdown Parameters

Section VIII - Closed-Loop Analysis

Section IX - Approximate Measures of Turbulence and Pilot Workload

SECTION II

DEVELOPMENT OF THE EQUATIONS OF MOTION USED FOR THE TIFS SIMULATION OF LARGE DELTA-WING TRANSPORT AIRPLANES

The purpose of this section is to develop the equations of motion that were programmed on the TIFS airplane analog computer for the evaluation study presented in Volume I of this report. The contents of this section are divided into the following order; (1) development of the generalized equations of motion of the model at the model center of gravity, (2) approximations used for simplification of the exact nonlinear equations, (3) effect of rotation due to incidence mismatch, and (4) transformation of output states to the center of gravity of the TIFS aircraft. The last part of this section describes the data used to drive the instrument displays in the evaluation cockpit.

2.1 DEVELOPMENT OF MODEL EQUATIONS AT MODEL C.G.

Reference 1 presents the exact nonlinear equations of motion in body axes and also illustrates that the model following system is based on the V_I, α_I, β_I states of the airplane and their respective time derivatives rather than on the components of the velocity vector. The reference also introduces a non-orthogonal axis system to simplify the computation of V_I and $\dot{V}_I$ from the drag equation and introduces approximations into the other force equations to obtain an approximate nonlinear representation of the X and Y force equations to obtain the desired outputs, angle of attack and angle of sideslip. The treatment in this section will be first to recast the equations of motion into a form which produces the desired output states prior to the introduction of simplifying assumptions.

The force equations in body axes at the model c.g. may be written as (Reference 2)

$$\dot{u}_I + w_I q_I - v_I r_I = \frac{F_{x_B}}{m} - g \sin\theta \qquad (1)$$

$$\dot{v}_I - w_I p_I + u_I r_I = \frac{F_{y_B}}{m} + g \cos\theta \sin\phi \qquad (2)$$

$$\dot{w}_I - u_I q_I + v_I p_I = \frac{F_{Y_B}}{m} + g \cos\theta \cos\phi \qquad (3)$$

while the relationships between the velocity components and angle of attack and sideslip are as follows:

$$u_I = V_I \cos\alpha_I \cos\beta_I \qquad (4)$$

$$v_I = V_I \sin\beta_I \qquad (5)$$

$$w_I = V_I \sin\alpha_I \cos\beta_I \qquad (6)$$

Substitution of Equations (4), (5), (6) into Equations (1), (2), and (3) yields the following nonlinear form of the force equations of motion

$$\dot{V}_I = \frac{1}{m} \left\{ F_{x_B} \cos\alpha_I \cos\beta_I + F_{z_B} \sin\alpha_I \cos\beta_I + F_{y_B} \sin\beta_I \right\} - g \sin\gamma \qquad (7)$$

$$\dot{\alpha}_I = \frac{1}{mV_I \cos\beta_I} \left\{ F_{z_B} \cos\alpha_I - F_{x_B} \sin\alpha_I \right\} + \frac{g}{V_I \cos\beta_I} \left\{ \cos\theta \cos\phi \cos\alpha_I + \sin\theta \sin\alpha_I \right\}$$

$$+ q_I - \left[p_I \cos\alpha_I + r_I \sin\alpha_I \right] \tan\beta_I \qquad (8)$$

$$\dot{\beta}_I = \frac{1}{mV_I} \left\{ F_{y_B} \cos\beta_I - F_{x_B} \cos\alpha_I \sin\beta_I - F_{z_B} \sin\alpha_I \sin\beta_I \right\}$$

$$+ \frac{g}{V_I} \left[\cos\theta \cos\beta_I \sin\phi - (\cos\theta \cos\phi \sin\alpha_I - \sin\theta \cos\alpha_I) \sin\beta_I \right]$$

$$+ p_I \sin\alpha_I - r_I \cos\alpha_I \qquad (9)$$

where

$$\sin\gamma = \sin\theta \cos\alpha_I \cos\beta_I - \sin\beta_I \cos\theta \sin\phi - \sin\alpha_I \cos\beta_I \cos\theta \cos\phi$$

The force terms are next separated into aerodynamic and engine contributions. Thus

$$T_{x_B} = T \cos i_T \qquad F_{x_B} = F_{x_{AB}} + T_{x_B}$$

$$T_{z_B} = -T \sin i_T \qquad F_{y_B} = F_{y_{AB}} + T_{y_B}$$

$$T_{y_B} = 0 \qquad F_{z_B} = F_{z_{AB}} + T_{z_B}$$

Substitution of the relationships between the aerodynamic forces in wind, stability and body axis systems yields the following equations.

$$\dot{V}_I = \frac{1}{m}\left[T\cos(\alpha_I + i_T)\cos\beta_I - D\right] - g\sin\gamma \tag{10}$$

$$\dot{\alpha}_I = -\frac{\left[L + T\sin(\alpha_I + i_T)\right]}{mV_I\cos\beta_I} + \frac{g}{V_I\cos\beta_I}\left\{\cos\theta\cos\phi\cos\alpha_I + \sin\theta\sin\alpha_I\right\}$$

$$+ q_I - \left[p_I\cos\alpha_I + r_I\sin\alpha_I\right]\tan\beta_I \tag{11}$$

$$\dot{\beta}_I = \frac{\left[Y_w - T\sin\beta_I\cos(\alpha_I + i_T)\right]}{mV_I} - \left[r_I\cos\alpha_I - p_I\sin\alpha_I\right]$$

$$+ \frac{g}{V_I}\left\{\cos\theta\cos\beta_I\sin\phi - \sin\beta_I\left(\cos\theta\cos\phi\sin\alpha_I - \sin\theta\cos\alpha_I\right)\right\} \tag{12}$$

where

$$D = -\left[F_{y_{AB}}\sin\beta_I + \cos\beta_I\left(F_{x_{AB}}\cos\alpha_I + F_{z_{AB}}\sin\alpha_I\right)\right]$$

$$= -\left[F_{y_{AB}}\sin\beta_I + \cos\beta_I F_{x_{AS}}\right] \tag{13}$$

$$L = -\left[F_{z_{AB}}\cos\alpha_I - F_{x_{AB}}\sin\alpha_I\right] = -F_{z_{AS}} \tag{14}$$

$$Y_w = \left[F_{y_{AB}}\cos\beta_I - \left(F_{x_{AB}}\cos\alpha_I + F_{z_{AB}}\sin\alpha_I\right)\sin\beta_I\right]$$

$$= \left[F_{y_{AB}}\cos\beta_I - F_{x_{AS}}\sin\beta_I\right] \tag{15}$$

The preceding force equations are exact; no simplifications have been introduced. The force equations as written in this section require information concerning Euler angles and rotational rates in body axes. Thus the exact moment equations are written in body axes with the effects of thrust offset introduced.

Pitching moment

$$\dot{q}_I = \frac{1}{I_{yy}}\left[M_{AB} + M_T\right] - \frac{1}{I_{yy}}\left[(I_{xx} - I_{zz})\, p_I r_I + I_{xz}(p_I^2 - r_I^2)\right] \tag{16}$$

Rolling moment

$$\dot{p}_I - \frac{I_{xz}}{I_{xx}}\dot{r}_I = \frac{1}{I_{xx}}\left[L_{AB} + L_T\right] - \frac{1}{I_{xx}}\left[r_I\,(I_{zz} - I_{yy}) - I_{xz}\, p_I\right] q_I \tag{17}$$

Yawing moment

$$\dot{r}_I - \frac{I_{xz}}{I_{zz}}\dot{p}_I = \frac{1}{I_{zz}}\left[N_{AB} + N_T\right] - \frac{1}{I_{zz}}\left[p_I\,(I_{yy} - I_{xx}) + I_{xz}\, r_I\right] q_I \tag{18}$$

Where M_T, L_T and N_T are dependent upon the location and incidence of the engines with respect to the body axis reference system and center of gravity location. The Euler angle equations may be written as:

$$\dot{\theta} = q_I \cos\phi - r_I \sin\phi \tag{19}$$

$$\dot{\phi} = p_I + \dot{\psi}_I \sin\theta \tag{20}$$

$$\dot{\psi} = \frac{q_I \sin\phi + r_I \cos\phi}{\cos\theta} \tag{21}$$

2.2 APPROXIMATE NONLINEAR EQUATIONS OF MOTION

The approximate nonlinear equations of motion are determined from the exact nonlinear equations by introduction of simplifying assumptions. For the Phase I and II TIFS programs, (References 3 and 4), the simplifying assumptions in the force equations were small angle assumptions on both α_I and β_I, and neglecting higher-order cross-coupling terms in the moment equations. For this program, it is assumed that in the force equations only sideslip may be treated under small angle assumptions, since the trim angle of attack for the airplane configurations examined was approximately 14 degrees. Thus the force equations may be written as follows:

$$\dot{V}_I = \frac{1}{m}\left[T\cos(\alpha + i_T) + F_{x_{AS}} + \beta_I F_{y_{AB}}\right] - g\,\sin\gamma \tag{22}$$

where

$$\sin\gamma \doteq \cos\alpha_I \sin\theta - \sin\alpha_I \cos\theta\cos\phi - \beta_I(\cos\theta\sin\phi) \tag{23}$$

$$\dot{\alpha}_I = -\frac{1}{mV_I}\left[L + T\sin(\alpha + i_T)\right] + \frac{g}{V_I}\left\{\cos\theta\cos\phi\cos\alpha_I + \sin\theta\sin\alpha_I\right\}$$
$$+ q_I - \left[p_I\cos\alpha_I + r_I\sin\alpha_I\right]\beta_I \tag{24}$$

$$\dot{\beta}_I = \frac{F_y}{mV_I} - \frac{\beta_I}{mV_I}\left[F_{x_{AS}} + T\cos(\alpha + i_T)\right]$$
$$-\left[r_I\cos\alpha_I - p_I\sin\alpha_I\right]$$
$$+\frac{g}{V_I}\left[\cos\theta\sin\phi - \beta_I(\cos\theta\cos\phi\sin\alpha_I - \sin\theta\cos\alpha_I)\right] \tag{25}$$

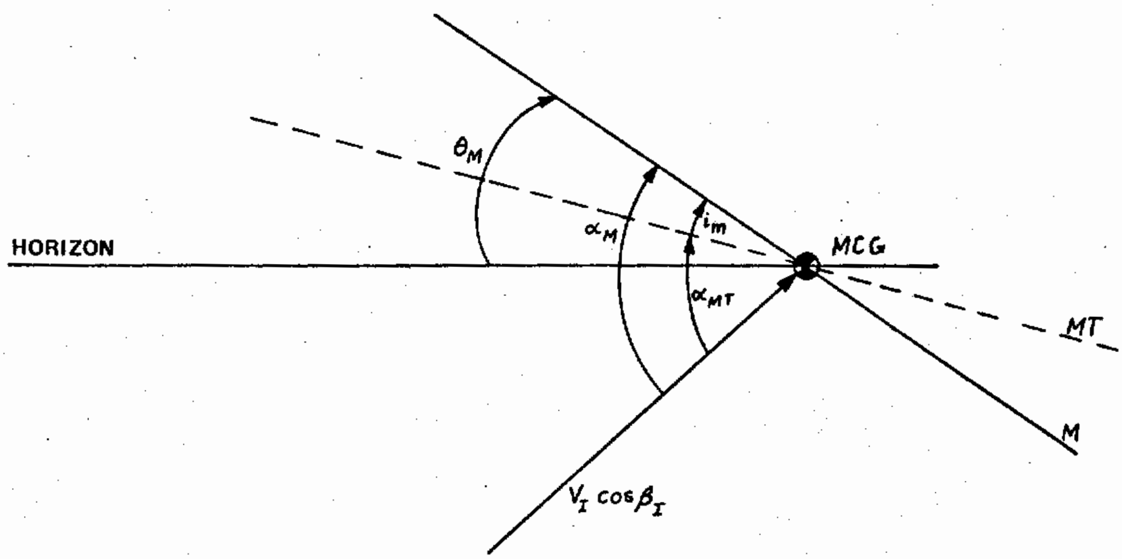
Substitution of Equations (22) and (23) into Equation (25) yields:

$$\dot{\beta}_I = -\frac{\beta_I\dot{V}_I}{V_I} + \frac{g}{V_I}\cos\theta\sin\phi - \left[r_I\cos\alpha_I - p_I\sin\alpha_I\right] + \frac{F_{y_{AB}}}{mV_I} \tag{26}$$

The moment equations were simplified by neglecting higher order coupling in the rolling and yawing moment equation and by neglecting as higher order the term $\frac{I_{xz}}{I_{yy}}(p_I^2 - r_I^2)$ in the pitching moment equation.

2.3 INCIDENCE MISMATCH EFFECTS ON THE EQUATIONS OF MOTION

The TIFS model following system is designed to function using the states of the model at the TIFS c.g. in the TIFS body axis system. For the experiment conducted, in order to achieve an operational envelope which would not overly restrict the evaluations, it was necessary to operate the TIFS aircraft at a lower angle of attack than the model. It is necessary to introduce an axis system in the plane of symmetry of the model which is parallel to the TIFS aircraft prior to translating the model state information to the TIFS c.g. The following development generalizes attitude mismatch simulation and introduces additional approximations into the equations of motion based on the mismatch considerations. For the purposes of the following treatment it is first necessary to define the generalized axis system rotation in the plane of symmetry of the model as shown on the following figure where the subscript M refers to the model in its own axis system, and MT refers to the model in an axis system parallel to that of the TIFS airplane.



Thus an incidence angle i_m exists between the body axis of the model and that axis system parallel to the TIFS body axis. A generalized rotation matrix can be written to relate the states of the model, etc. in the two axis systems, thus:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{MT} = \begin{bmatrix} X_{MT} \end{bmatrix} = \begin{bmatrix} L_{MT} \end{bmatrix} \begin{bmatrix} X_M \end{bmatrix} \qquad \text{where} \quad \begin{bmatrix} L_{MT} \end{bmatrix}$$

is defined as

$$\begin{bmatrix} L_{MT} \end{bmatrix} = \begin{bmatrix} \cos i_m & 0 & +\sin i_m \\ 0 & 1 & 0 \\ -\sin i_m & 0 & \cos i_m \end{bmatrix}.$$

Quantities which are only a function of the motion of the model c.g. with respect to an earth surface inertial axis system are not affected by the transformation, thus $V_{MT} = V_M$, $\gamma_{MT} = \gamma_M$, $h_{MT} = h_M$, $\dot{V}_{MT} = \dot{V}_M$, etc. Relationships between the Euler angles may be determined by examination of the components of the gravitational vector in the two axis systems, thus

$$\sin\theta_M = \cos i_m \sin\theta_{MT} + \sin i_m \cos\theta_{MT} \cos\phi_{MT} \tag{27}$$

$$\cos\theta_M \sin\phi_M = \cos\theta_{MT} \sin\phi_{MT} \tag{28}$$

$$\cos\theta_M \cos\phi_M = \cos\theta_{MT} \cos\phi_{MT} \cos i_m - \sin i_m \sin\theta_{MT} \tag{29}$$

It should be noted that θ_M only equals $\theta_{MT} + i_m$ when $\phi_M = \phi_{MT} = 0$; however, it can be shown that $\alpha_{MT} + i_m = \alpha_M$ is an identity. This result is obtained by examination of the definition of the vertical velocity of the airplane in the two axis systems:

$$\sin\alpha_M = \frac{w_M}{V_M \cos\beta_M} \tag{30}$$

$$\sin\alpha_{MT} = \frac{w_{MT}}{V_M \cos\beta_M} = \frac{w_M \cos i_m - u_M \sin i_m}{V_M \cos\beta_M} \tag{31}$$

recall $u_M = V_M \cos\beta_M \cos\alpha_M$, thus

$$\sin \alpha_{MT} = \sin \alpha_M \cos i_m - \cos \alpha_M \sin i_m$$

$$= \sin(\alpha_M - i_m) \qquad (32)$$

Therefore, $\alpha_{MT} + i_m = \alpha_M$ as stated above. If $\alpha_m - i_m$ is small, then several of the angles in the transformed axis may be approximated by small angle assumptions. The following equations that result from the use of small angle assumptions were mechanized for this program:

Longitudinal Equations

Drag Equation

$$\dot{V}_I = \frac{1}{m}\left[(F_{x_{AS}}) + T\left\{\cos(i_m + i_T) - \alpha_{I_{MT}}(i_m + i_T)\right\}\right] + \frac{1}{m}\beta_{IM}(F_{y_{AB}}) - g \sin \gamma_{MT} \qquad (33)$$

where $\sin \gamma_{MT} = \theta_{MT} - \alpha_{I_{MT}} \cos \phi_{MT} - \beta_{I_M} \sin \phi_{MT}$ (34)

$\alpha_{MT} = \alpha_M - i_m$ (35)

Lift Equation

$$\dot{\alpha}_{IM} = \frac{1}{mV_I}\left[F_{z_{AS}} - T(\alpha_I + i_T)\right] + q_{I_M} + \frac{g}{V_I}\cos \phi_{MT} - p_{I_{MT}}\beta_{I_M} \qquad (36)$$

where

$\dot{\alpha}_{I_M} = \dot{\alpha}_{I_{MT}}$ (37)

$q_{I_M} = q_{I_{MT}}$ (38)

$p_{I_{MT}} = p_{I_M} \cos i_m + r_{I_M} \sin i_m$ (39)

Pitching Moment Equation

$$\dot{q}_{I_M} = \frac{1}{I_{yy}}\left[M_{AB} + T\tilde{z}_T\right] + \frac{(I_{zz} - I_{xx})}{I_{yy}}(p_{I_M} r_{I_M}) \qquad (40)$$

where $\tilde{z}_T$ = thrust pitching moment arm for all four engines

Lateral-Directional Equations

Side Force Equation

$$\dot{\beta}_{I_M} = -\frac{\beta_{I_M}\dot{V}_{I_M}}{\dot{V}_I} - r_{I_{MT}} + p_{I_{MT}}(\alpha_{I_{MT}}) + \frac{g}{V_I}\sin\phi_{MT} + \frac{F_{y_{AB}}}{mV_I} \quad (41)$$

Rolling Moment Equation

$$\dot{p}_{I_M} - \frac{I_{xz}}{I_{xx}}\dot{r}_{I_M} = \frac{1}{I_{xx}}\left[L_{AB} + \ell_1(T_1 - T_4) + \ell_2(T_2 - T_3)\right] \quad (42)$$

Yawing Moment Equation

$$\dot{r}_{I_M} - \frac{I_x}{I_{yy}}\dot{p}_{I_M} = \frac{1}{I_{yy}}\left[N_{AB} + n_1(T_1 - T_4) + n_2(T_2 - T_3)\right] \quad (43)$$

where ℓ_i , n_i are the rolling and yawing effective moment arms of the engines, respectively.

The following auxiliary equation was also programmed.

$$\dot{h} = V_{I_M}\sin\gamma_{MT} \quad (44)$$

The Euler angle equations were solved in the transformed axis system and the relationships between the gravitational vector (Equations (27), (28), (29)) were solved to determine the Euler angles of the model in its own axis system, thus:

$$\dot{\theta}_{MT} = q_{I_M}\cos\phi_{MT} - r_{I_{MT}}\sin\phi_{MT} \quad (45)$$

$$\dot{\phi}_{MT} = p_{I_{MT}} + \dot{\psi}_{MT}\,\theta_{MT} \quad (46)$$

$$\dot{\psi}_{MT} = q_{I_M}\sin\phi_{MT} + r_{I_{MT}}\cos\phi_{MT} \quad (47)$$

where p_I is determined by Equation (39) and

$$r_{I_{MT}} = r_{I_M}\cos i_m - p_{I_M}\sin i_m \quad (48)$$

Accelerations at the model c.g. were computed in the transformed axis system (MT) using the following equations:

$$(n_{y_B})_{MT} = \frac{1}{mg} F_{y_{AB}} \qquad (49)$$

$$(n_{y_B})_{MT} = \frac{1}{mg}\left[(F_{y_{AS}}) + (F_{x_{AS}})\alpha_{MT} - T(i_{?} + i_T)\right] \qquad (50$$

2.4 TRANSFORMATION OF MODEL STATES FROM MODEL C.G. TO TIFS C.G. AND THE EVALUATION COCKPIT

The response variables of the model computed were determined in an axis system parallel to the TIFS body axis by the preceding equations. The transformation of the model states to the TIFS c.g. were accomplished essentially using the equations presented in Reference 5, and are listed below. Modifications and additions were introduced as necessary since certain states of the model in the transformed axis were not computed. The transformations used, neglecting higher order terms, are:

$$\dot{\alpha}_{I_{M_{TCG}}} = \dot{\alpha}_{I_M} - \frac{\dot{q}_{I_M}}{V_{I_M}} (\ell_{x_{M_{TCG}}}) \qquad (51)$$

$$\alpha_{I_{M_{TCG}}} = \alpha_{I_{MT}} - \frac{q_{I_M}}{V_{I_M}} (\ell_{x_{M_{TCG}}}) \qquad (52)$$

$$\dot{\beta}_{I_{M_{TCG}}} = \dot{\beta}_{I_M} + \frac{1}{V_I}\left[\dot{r}_{I_M} \ell_{x_{M_{TCG}}} - \dot{p}_{I_M} \ell_{z_{M_{TCG}}}\right] \qquad (53)$$

$$\beta_{I_{M_{TCG}}} = \beta_{I_M} + \frac{1}{V_I}\left[r_{I_{MT}} \ell_{x_{M_{TCG}}} - p_{I_{MT}} \ell_{z_{M_{TCG}}}\right] \qquad (54)$$

$$\dot{V}_{I_{M_{TCG}}} = \dot{V}_{I_M} + \frac{\dot{q}_{I_M}}{57.3} (\ell_{z_{M_{TCG}}}) \qquad (55)$$

$$V_{I_{M_{TCG}}} = V_{I_M} + \frac{q_{I_M}}{57.3} \left(\ell_{y_{M_{TCG}}}\right)$$

$$(n_{y_B})_{M_{TCG}} = (n_{y_B})_{MT} + \frac{1}{(57.3)(32.2)}\left[\dot{r}_{I_M} \ell_{\bar{x}_{M_{TCG}}} - \dot{p}_I \ell_{\bar{z}_{M_{TCG}}}\right] \quad (57)$$

$$(n_{y_B})_p = (n_{y_B})_{MT} + \frac{1}{(57.3)(32.2)}\left[\dot{r}_I \ell_{x_{Mp}} - \dot{p}_{I_M} \ell_{z_{Mp}}\right] \quad (58)$$

$$(n_{z_B})_{M_{TCG}} = (n_{z_B})_{MT} - \frac{\dot{q}_{I_M}}{(57.3)(32.2)} \left(\ell_{x_{M_{TCG}}}\right) \quad (59)$$

$$(n_{z_B})_p = (n_{z_B})_{MT} - \frac{\dot{q}_{I_M}}{(57.3)(32.2)} \left(\ell_{x_{pT}}\right) \quad (60)$$

where the appropriate transformation distances are defined by the following systems

$$\ell_{x_{M_{TCG}}} = \ell_{x_{pT}} - \ell_{x_{p_{TCG}}} \quad (61)$$

$$\ell_{z_{M_{TCG}}} = \ell_{z_{pT}} - \ell_{z_{p_{TCG}}} \quad (62)$$

$$\ell_{x_{pT}} = \ell_{x_{Mp}} \cos i_m + \ell_{z_{Mp}} \sin i_m \quad (63)$$

$$\ell_{z_{pT}} = \ell_{z_{Mp}} \cos i_m - \ell_{x_{Mp}} \sin i_m \quad (64)$$

$$\ell_{\bar{x}_{M_{TCG}}} = \ell_{x_{Mp}} + \ell_{z_{p_{TCG}}} \sin i_m - \ell_{x_{p_{TCG}}} \cos i_m \quad (65)$$

$$\ell_{\bar{z}_{M_{TCG}}} = \ell_{z_{Mp}} - \left(\ell_{z_{p_{TCG}}} \cos i_m + \ell_{x_{p_{TCG}}} \sin i_m\right) \quad (66)$$

Note:

$$\ell_{x_{P_{TCG}}} = 35.0 \text{ ft}, \quad \ell_{z_{P_{TCG}}} = 2.75 \text{ ft}$$

for the TIFS airplane

$$i_m = 10 \text{ degree}, \quad \ell_x = 90.12 \text{ ft}, \quad \ell_{z_M} = -7.59 \text{ ft}$$

for the simulated airplane

$$\sin \gamma_{M_{TCG}} = \sin \gamma_{MT} + \frac{1}{57.3 V_{I_M}} \Big[q_{I_M} \cos \phi_{MT} \ell_{x_{M_{TCG}}} + \sin \phi_{MT} (p_{MT} \ell_{z_{M_{TCG}}} - r_{MT} \ell_{x_{M_{TCG}}}) \Big] \tag{67}$$

$$\dot{h}_{M_{TCG}} = V_{I_{M_{TCG}}} \sin \gamma_{M_{TCG}} \tag{68}$$

2.5 DATA FOR EVALUATION PILOT INSTRUMENT DISPLAYS

For this program, it was decided that the data displayed to the pilot should be that of the airplane model, at the model c.g. and in the body axis system of the model. The TIFS sensors however would measure information in the transformed system at the TIFS c.g., therefore it was necessary to compute Euler angle information for the attitude displays from the following equations rather than using the TIFS sensor outputs directly.

$$\sin \theta_M = \theta_{MT} \cos i_m + \sin i_m \cos \phi_{MT} \tag{69}$$

$$\sin \phi_M = \frac{1}{\cos \theta_M} \Big[\sin \phi_{MT} \Big] \tag{70}$$

$$\cos \phi_M = \frac{1}{\cos \theta_M} \Big[\cos \phi_{MT} \cos i_m - \theta_{MT} \sin i_m \Big] \tag{71}$$

where $\cos \theta_M$ was obtained from a function generator using $\sin \theta_M$ determined above as the input signal to the function generator. The angle of attack, sideslip angle and velocity displays were driven electronically from computed model information.

SECTION III

SUMMARY OF AERODYNAMICS, CONTROL SYSTEMS AND THRUST REPRESENTATIONS

3.1 AERODYNAMICS

The aerodynamic stability and control derivatives mechanized on the analog computers in TIFS for this experiment were obtained from a simplification of the data supplied by the FAA. The detailed procedures involved in developing the final expressions are contained in References 6 and 7. There were two primary reasons for expending so much effort in simplifying the data package. One factor was that the model was very complex and had many nonlinearities and the other was because of the limited analog equipment in TIFS and the absence of any digital computers on board the aircraft.

In general, the assumptions made were based on an aircraft weighing 231,483 pounds and flying a nominal 160 knots (M = 0.25 at 2000 feet) approach speed. The moments of inertia, reference length, and other physical data are presented in Table I.

Table I

LARGE DELTA-WING TRANSPORT (CONCORDE)

PHYSICAL CHARACTERISTICS

I_{xx}	=	1,700,430 slug-ft^2
I_{yy}	=	15,118,400 slug-ft^2
I_{zz}	=	16,526,100 slug-ft^2
I_{xz}	=	-355,830 slug-ft^2
W	=	231,483 pounds
$\bar{c}$	=	90.748 feet
b	=	84 feet
length	=	193 feet
s	=	3856 ft^2

For the flight condition, the trim angle of attack was approximately 14 degrees with the airplane out of the influence of the ground. The variation in angle of attack was assumed to range six degrees above and below the trim angle of attack. This assumption was made because it was the useable range for the approach and because much of the data could be linearized between 8 and 18 degrees. An example of a data package that indicated this trend is the change in C_L with α. The slope was definitely nonlinear below 8 degrees. The angle of attack assumption was also valid when the airplane entered ground effect because, although the trim α decreased to approximately 11 degrees at touchdown, there was still a 3 degree increment in which the airplane could be maneuvered before crossing into the nonlinear region.

Much of the data was a function of Mach number. At the low speed end, sets of data were usually supplied for a Mach number of 0.0 and a Mach number of 0.4. Therefore linear interpolations were made whenever necessary to a Mach number of 0.25, the trim Mach number for this experiment. After reviewing the records of the data at the completion of the flight program, it was obvious that the variation of Mach number from the trim value was minimal.

The incorporation of ground effect required the greatest number of approximations to the data. In general, the equations of motion were changed by ground effect in two ways. First, a substantial change to the basic derivatives (for example, C_{m_α} or C_{n_β}) occurred when the airplane was in close proximity to the ground. Secondly, the elevon derivatives (e.g., $C_{L_{\delta_e}}$ or $C_{n_{\delta_a}}$) were significantly influenced by ground effect. The approximations involved were due to a normalization technique that assumed two discrete functions $F(d)$ and $F_1(d)$ which modified the affected stability derivatives as a function of wheel height.

Plots of $F(d)$ and $F_1(d)$ versus center of gravity height above the ground are shown in Figure 1. The $F_1(d)$ function applied only to the pitching moment equation whereas the $F(d)$ factor related to the other five equations. Following discussions at NASA/Ames, the ground effect representation of the pitching moment change with angle of attack, $\Delta C_{m_{\alpha_{GE}}}$, was allowed to vary depending on the configuration. Instead of being represented as a constant -.0023 per degree, $\Delta C_{m_{\alpha_{GE}}}$ was altered as shown by the following equation (Reference 8):

$$\Delta C_{m_{\alpha_{GE}}} = -.0023 + \frac{\Delta C_{L_{\alpha_{GE}}}}{C_{L_\alpha}} \left[C_{m_{\alpha_{CONFIG}}} - C_{m_{\alpha_{BASIC}}} \right] \qquad (72)$$

where $C_{m_{\alpha_{CONFIG}}}$ and $C_{m_{\alpha_{BASIC}}}$ referred to the linearized C_{m_α} for any configuration and the basic expression, respectively. An example of the calculation for the basic C_{m_α} was performed as follows:

$$C_{m_{BASIC}} = .00427 - .0026\alpha + .0001\alpha^2 + .00000035\alpha^3$$

$$C_{m_{\alpha_{BASIC}}} = -.0026 + 2(.0001)\alpha + 3(.00000035)\alpha^2 \qquad (73)$$

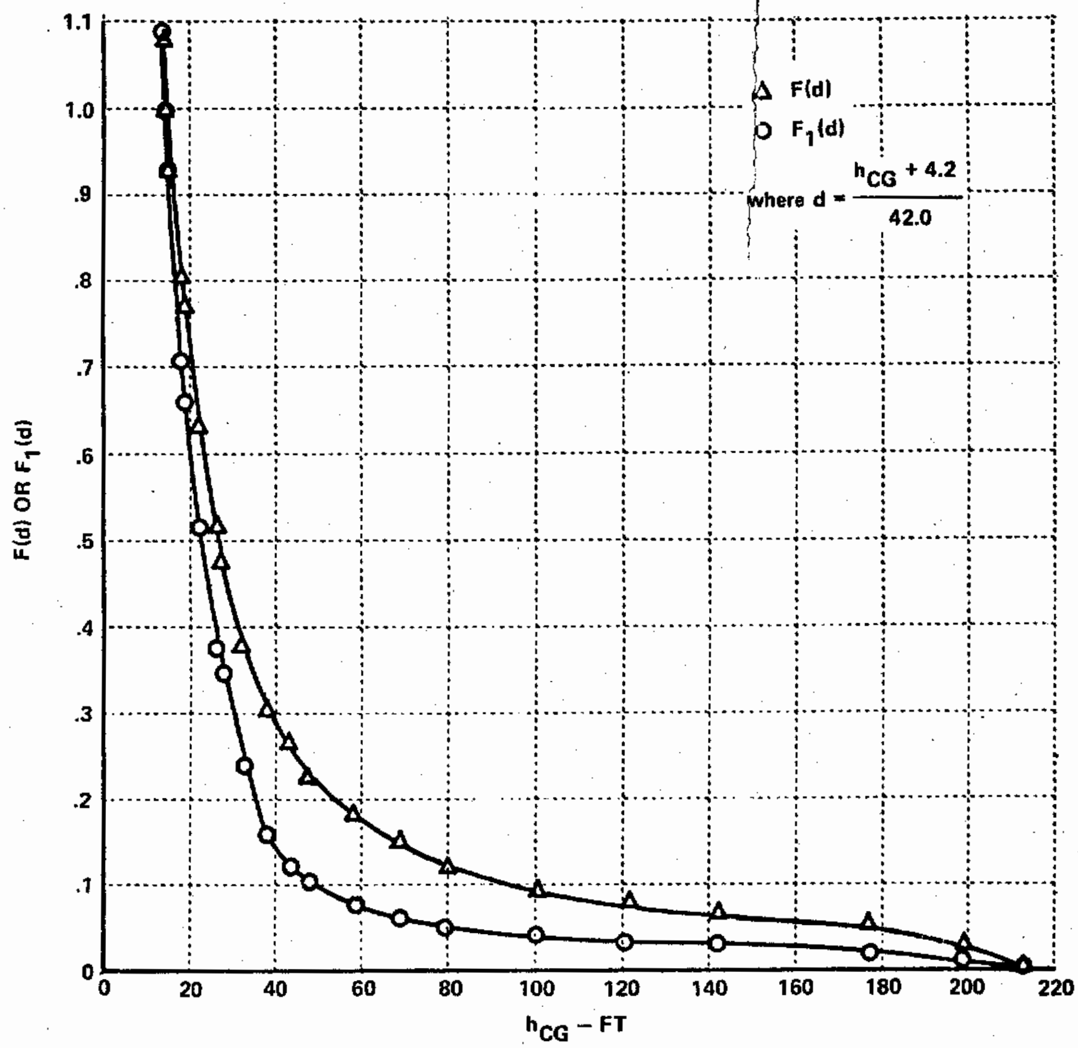


Figure 1 VARIATION OF GROUND EFFECT FUNCTIONS WITH C.G. HEIGHT

and $C_{m_{\alpha_{BASIC}}}$ = + .00037 for a trim α of 13.8°. Therefore, after inserting the appropriate constants for $\Delta C_{L_{\alpha_{GE}}}$ and C_{L_α}, the equation for $\Delta C_{m_{\alpha_{GE}}}$ becomes:

$$\Delta C_{m_{\alpha_{GE}}} = \left[-.0023 + .421\left(C_{m_{\alpha_{CONFIG}}} - .00037\right)\right] \quad (73)$$

The following is a summary of the six simplified expressions developed in References 6 and 7 and modified by the changes to the ground effect representation as shown in the previous paragraph. The center of gravity position has been converted from 50% to 53% MAC. Angle of attack, sideslip angle and the control surface deflections are in degrees. All the rates are in degrees per second. Velocity is in feet per second. The reference length is 90.748 feet. The C_L and C_X equations are in stability axes and the other four equations are in body axes.

$$C_L = -.177 + .0606\alpha + .01184\delta_e + \left[.00575\dot{\alpha} + .00548q\right]\frac{\ell}{V} + F(d)\left[.0210\alpha + .00262\delta_e\right]. \quad (74)$$

$$-C_X = .0303 + .324C_{L_{NT_{IGE}}}^2 + \left[.000298\alpha - .000838 + .0000494\delta_e\right]\delta_e + F(d)\left[-.110C_{L_{NT_{IGE}}}^2\right]. \quad (75)$$

$$C_m = .00427 - .0026\alpha + .0001\alpha^2 + .00000035\alpha^3 - .00342\delta_e - \left[.00137\dot{\alpha} + .00257q\right]\frac{\ell}{V} + F_1(d)\left\{.0059 + \left[-.0023 + .421\left(C_{m_{\alpha_{TRIM}}} - .00037\right)\right]\alpha - .00038\delta_e\right\}. \quad (76)$$

$$C_Y = -.01\beta + \left[.003665r - .002265\dot{\beta} + \left(.000401 + .000061\alpha\right)p\right]\frac{\ell}{V} + .00229\delta_r + .00197\delta_a + F(d)\left[.00021\beta\left(\alpha - 6.5^\circ\right) - .000077\delta_a\left(\alpha - 4.5^\circ\right)\right]. \quad (77)$$

$$C_\ell = \left[-.00048 - .000152\,\alpha - .0000131\,\delta_e\right]\beta + .000327\,\delta_r - .001885\,\delta_a$$
$$+ \left[-.00192\,p - .0000244\,\alpha\dot{\beta} + \left(-.0002584 + .00008274\,\alpha\right) r\right]\frac{\ell}{V}$$
$$+ F(d)\left[.0006\ \beta + .0000445\left(\alpha - 17.5^\circ\right)\delta_a\right]. \qquad (78)$$

$$C_n = \left[.00131 + .000049\,\alpha + .0000162\,\delta_e\right]\beta - .00150\,\delta_r - .000723\,\delta_a$$
$$+ \left[\left(-.000154 + .000002\,\alpha\right) p + .00096\,\dot{\beta} + \left(-.001062 - .00013\,\alpha\right) r\right]\frac{\ell}{V}$$
$$+ F(d)\left[-.000103\ \beta\ (\alpha - 8^\circ) + .0000397\,\delta_a(\alpha - 4.5^\circ)\right]. \qquad (79)$$

Further simplifications were made based on equipment limitations imposed by the TIFS analog computer. These modifications affected only the lateral-directional equations as follows:

$$C_Y = -.01\beta + \left[.003665\,r - .002265\,\dot{\beta} + \left(.000401 + .000061\,\alpha\right) p\right]\frac{\ell}{V}$$
$$+ .00229\,\delta_r + .00167\,\delta_a + 5F(d)\left[.00021\ \beta - .0001068\,5\delta_a\right]. \qquad (80)$$

$$C_\ell = \left[-.00048 - .000152\,\alpha - .0000131\,\delta_e\right]\beta + .000327\,\delta_r - .001885\,\delta_a$$
$$+ \left[-.00192\,p - .000349\,\dot{\beta} + \left(-.0002584 + .00008274\,\alpha\right) r\right]\frac{\ell}{V}$$
$$+ F(d)\left[.0006\ \beta - .000267\,\delta_a\right]. \qquad (81)$$

$$C_n = \left[.00131 + .000049\alpha + .0000162\delta_e\right]\beta - .00150\delta_r - .000723\delta_a$$
$$+ \left[\left(-.000154 + .000002\alpha\right)p + .00096\dot{\beta} + \left(-.001062 - .00013\alpha\right)r\right]\frac{\ell}{V}$$
$$+ 5F(d)\left[-.000064\ \beta + .0000513\delta_a\right]. \qquad (82)$$

3.2 CONTROL SYSTEMS

The control system mechanized for this experiment was based on the FAA data. The control system representation was simplified to make it compatible with the availability of analog equipment on board the TIFS. The principal simplification made was in the development of an effective elevon angle which in general does not correspond physically to an actual elevon angle. It was necessary to use this approximation to preclude mechanizing six different elevon surfaces for longitudinal and lateral control. Therefore, for elevator control, the symmetric deflection of the elevons was taken to have a mean deflection angle that was equivalent to a single elevator control surface. Similarly, for lateral control, an effective aileron angle was used to represent the antisymmetric deflection of the elevons. The development of the simplifications used for the model of the control system is described in detail in Reference 9.

The feel system dynamics for the elevator, aileron and rudder were held constant throughout the experiment at a frequency of 15 radians per second and a damping ratio of 0.85. The elevator and aileron were represented as a second order system at a frequency of 32.9 radians per second and a damping ratio of unity. The rudder was represented with no control system lag. The control system characteristics were held constant throughout the evaluations at the values listed in Table II.

Table II

CONTROL GEARINGS AND FEEL SYSTEM CHARACTERISTICS

	Elevator	Aileron	Rudder
Force Gradient	11.0 lb/in.	.6 lb/deg	15.75 lb/in.
Breakout Force	± 4.0 lb	± 2.0 lb	± 30 lb
Hysteresis	± .50 lb	± 2.0 lb	± 10 lb
Control Travel (max)	± 7 in.	± 46 deg	± 4 in.
Surface Travel	± 18 deg	± 18 deg	± 30 deg
Control Gearing	- 2.57 deg/in.	- .39 deg/deg	- 7.5 deg/in.
Trim Rate	- .804 deg/sec	- .585 deg/sec	- 1.0 deg/sec

3.3 THRUST

The engine dynamics mechanized on the analog computer on board the TIFS were principally based on data supplied by the FAA, and from analog records from the FSAA at NASA/Ames. Both data sources were used in Reference 10 to simplify the thrust representation. The throttle sensitivity mechanized was 757 pounds per degree of throttle quadrant and the thrust time constant was set at 1.0 second. The gradient of thrust versus throttle displacement was assumed to have a linear relationship. This approximation was not valid below approximately 34,000 pounds of thrust. However, since the trim thrust was 58,000 pounds for level flight and 52,000 pounds when stabilized on a 2 1/2 degree glide slope, it was assumed that the evaluation pilot would not be manipulating the throttle in the nonlinear region. A first-order approximation to the thrust response dynamics was used and seemed reasonable even though the data indicated there were some nonlinearities. The time constant of 1.5 seconds recommended in Reference 10 was mechanized for the calibration and checkout flying prior to the first evaluation. Two of the three primary evaluation pilots flew on these flights and complained that the time constant was too long. Therefore, it was shortened to 1.0 second and held at that value for the in-flight evaluations.

SECTION IV

TASK MECHANIZATION

Four circuits were mechanized on the analog computer to achieve various tasks during each evaluation. These circuits are the following:

1. Localizer offset circuit
2. Glide path offset circuit
3. Simulated crosswind circuit
4. Turbulence augmentation circuit

These circuits were used separately or in combination to provide tasks for each evaluation. The mechanization of these circuits is discussed in detail in this section.

4.1 MECHANIZATION OF LOCALIZER OFFSET CIRCUIT

The localizer offset was accomplished by biasing the vertical steering position on the attitude director indicators and the course deviation pointers on the horizontal situation indicator either to the right or left of center on the instruments. Thus, when the pilot had the needles centered with the offset circuit on, the airplane would actually be left or right of the localizer centerline as determined by a manual potentiometer setting. Offset to the left of centerline was used when intercepting the localizer from the right and offset to the right was used when intercepting the localizer from the left.

Figure 2 is a block diagram of the circuit used to generate the localizer offset. Figure 3 shows the effect of the offset circuit on the airplane's deviation from localizer centerline.

Two potentiometers and one function switch control the operation of the circuit. Potentiometer 41 sets the amount of localizer bias and is variable from 2 dots left of center to 2 dots right of center. A setting corresponding to 1 dot either right or left of centerline was used on the program. Potentiometer 170 sets the height above ground level at which the localizer bias signal was automatically removed. This was 200 feet for this program. The localizer offset function switch was used to switch in the offset circuit whenever required for the approach.

The model wheel height above touchdown signal (h_e) was computed from a radar altimeter signal. The electronic switch and comparator were used to sense the 200 feet above ground level point in the approach and disconnect the localizer offset circuit. The localizer deviation indicators then indicated a one dot error provided the pilot had the indicators centered just prior to the 200 foot point in the approach. This one dot error then required a lateral

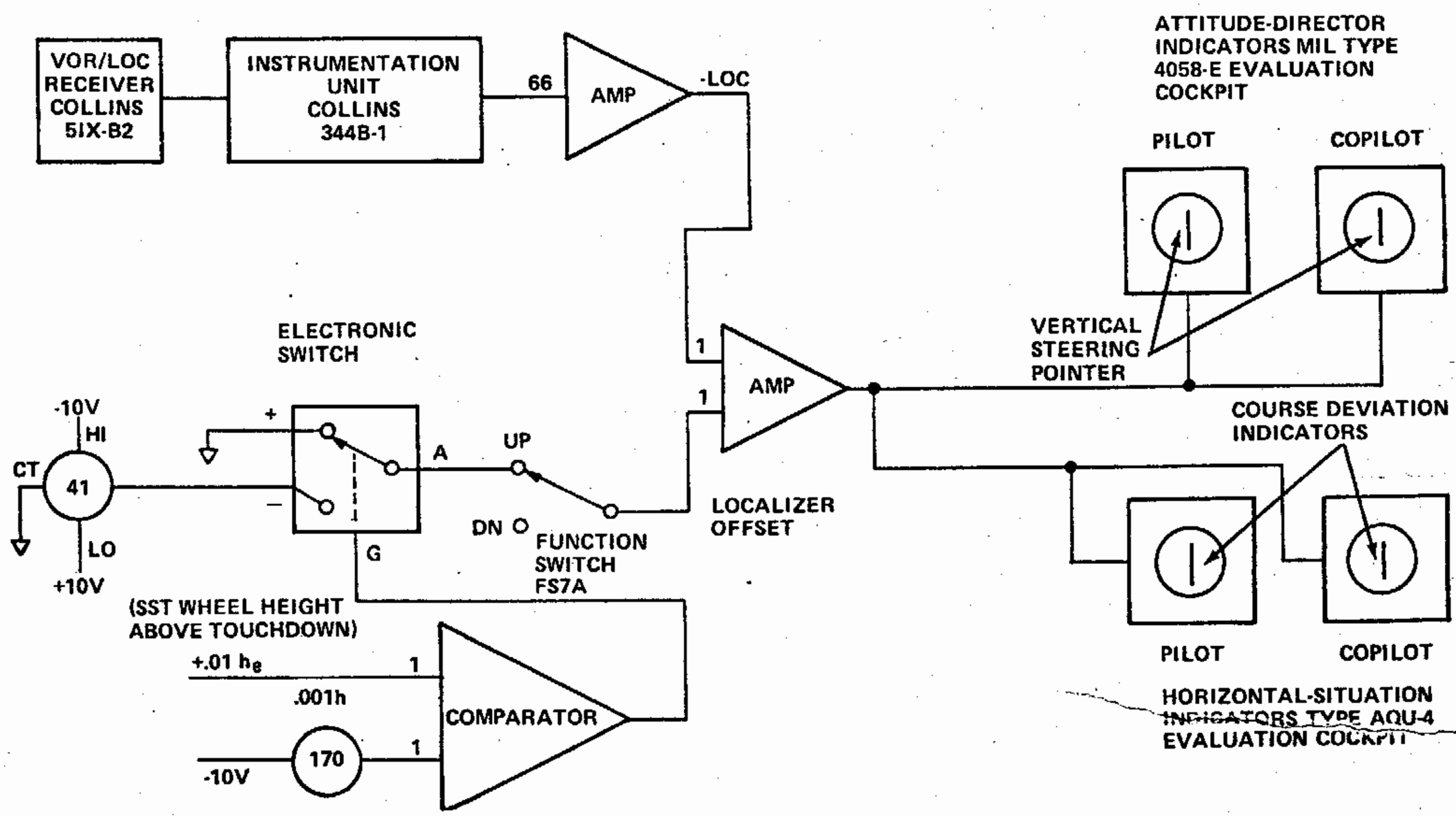


Figure 2 **BLOCK DIAGRAM, LOCALIZER OFFSET CIRCUIT**

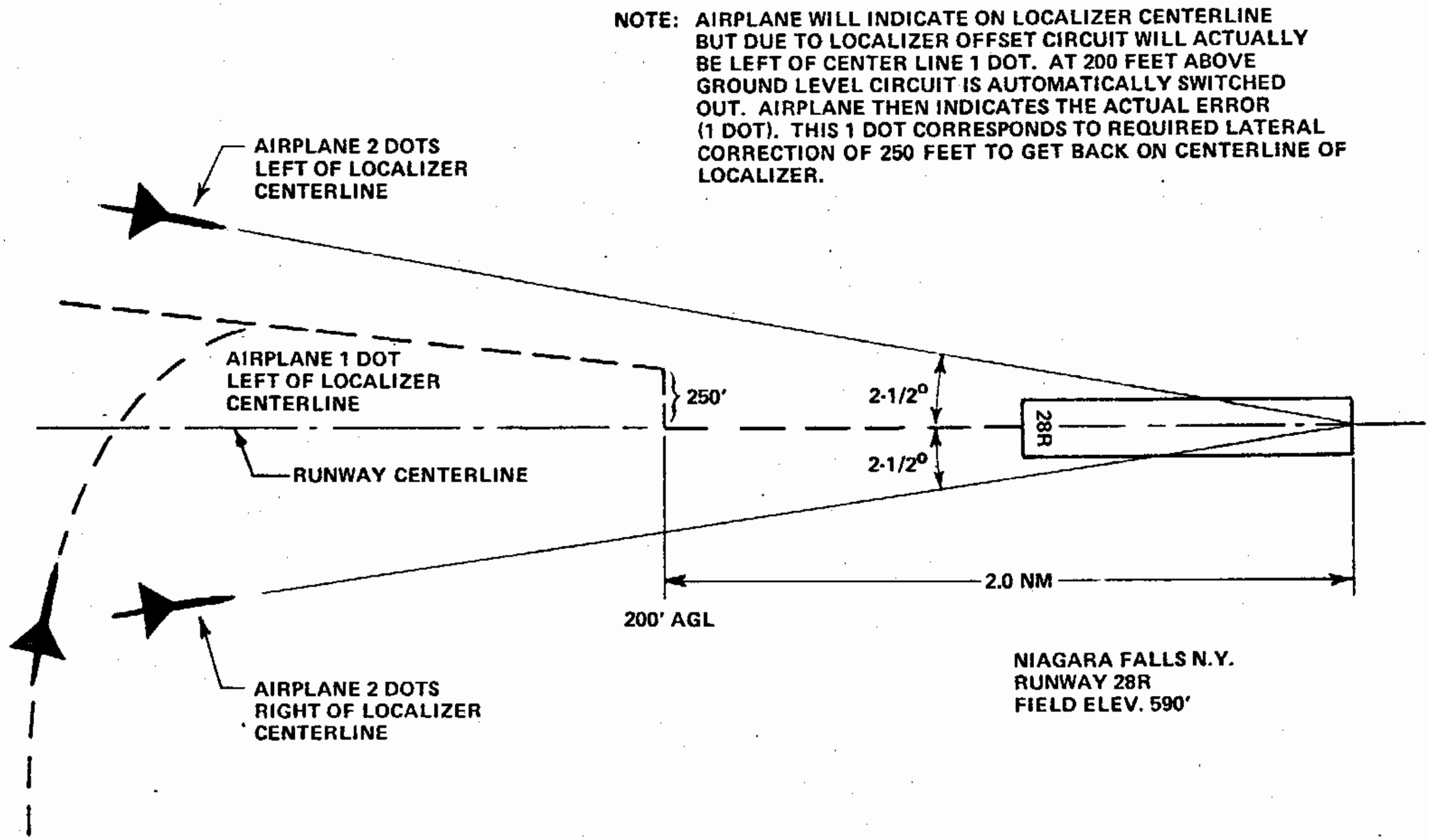


Figure 3: EFFECT OF LOCALIZER OFFSET CIRCUIT ON AIRCRAFT DURING INSTRUMENT APPROACH (TOP VIEW)

correction of approximately 250 feet to get back on centerline of the localizer.

4.2 MECHANIZATION OF THE GLIDE PATH OFFSET CIRCUIT

The glide path offset was accomplished by biasing the glide slope deviation indicators (pilot and copilot instruments) either above or below the glide path a fixed amount as determined by a manual potentiometer setting.

Figure 4 is a block diagram of the circuit used to generate the offset and Figure 5 shows a typical glide path profile during an instrument approach in which the glide slope offset was used.

Two potentiometers and a function switch control the operation of the circuit. Potentiometer 42 sets the amount of glide path error and is variable from 2 dots above to 3 dots below the glide path. Settings corresponding to 0.7 dot above and below glide path were used in the approaches. Potentiometer 171 sets the height above ground level at which the glide slope bias signal was removed automatically (800 feet for this program). The glide slope offset function switch selected bias to the indicators when the glide slope offset was used in the approach.

The model wheel height above touchdown signal (h_e) was computed using the airborne radar altimeter signal. The comparator and electronic switch circuiting sensed the 800 feet above ground level point in the approach and disconnected the glide slope bias. The glide slope indicators then indicated the actual error, ± 0.07 dot if the glide slope deviation indicators were centered prior to the 800 feet point in the approach. This then required an altitude change of 50 feet (at 800 above ground level) to get back on glide path. See Figure 5 for a typical pointer deflection profile.

4.3 SIMULATED CROSSWIND SIMULATION MECHANIZATION

One of the tasks required of the evaluation pilot in the SST program was making instrument approaches with a 15 knot crosswind. A circuit was mechanized as shown in Figure 6 which was used to supplement the existing natural crosswind existing at the time of the approach.

The controls required for this circuit were a potentiometer calibrated in terms of dial reading versus crosswind in knots and a function switch FS4A (simulated crosswind function switch) which was used to apply simulated crosswind to the TIFS airplane when required.

The existing crosswind component was calculated using current surface wind information supplied by the control tower and potentiometer 44 was set to supplement the natural crosswind such that the total crosswind (natural plus simulated) equaled 15 knots. Potentiometer 44 supplied the error in sideslip signal (β_{cw}) which is used as the command signal to generate a simulated crosswind on the TIFS airplane. Small rolling moments on the airplane are cancelled by a signal to the aileron surface command amplifier and small side

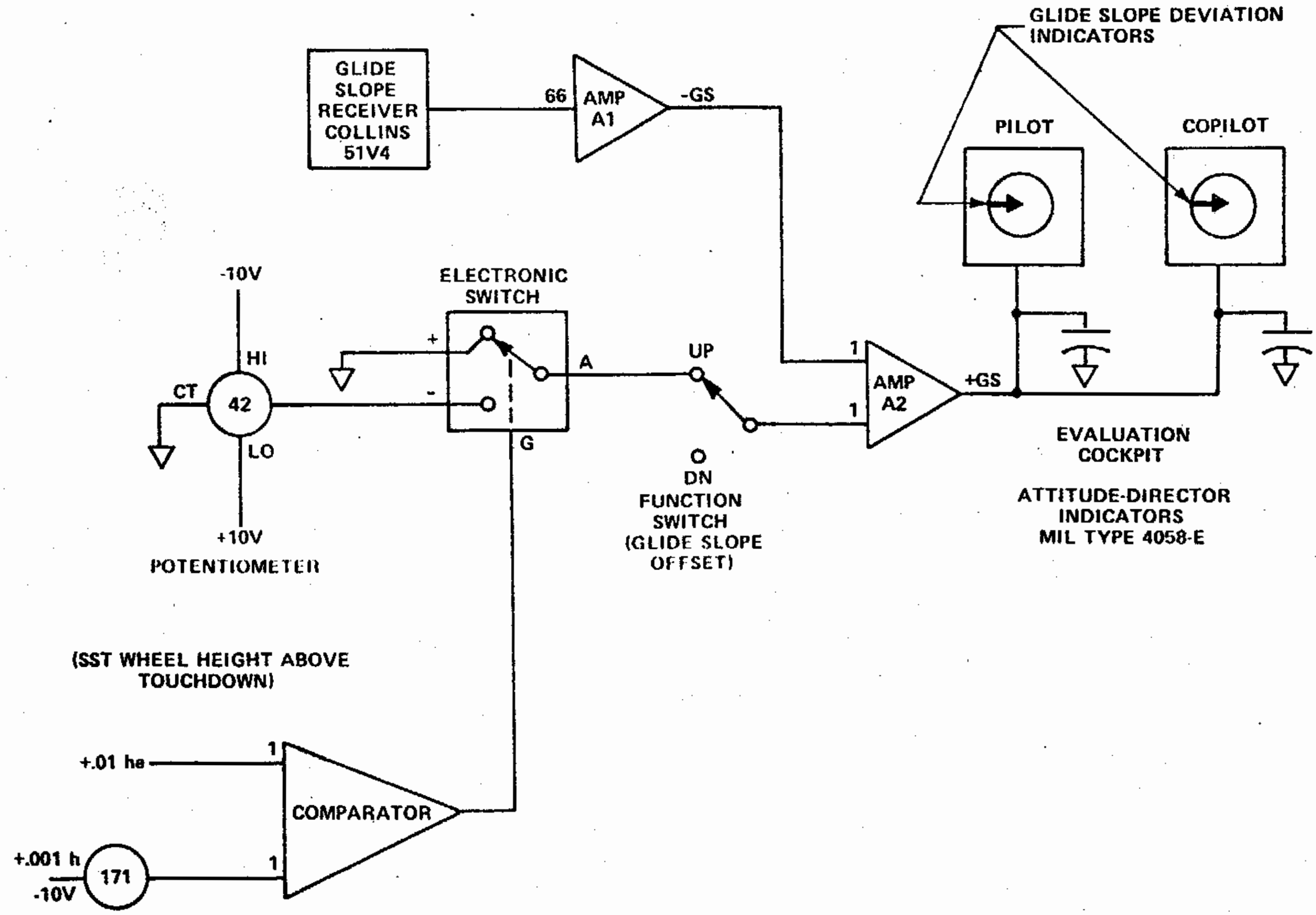


Figure 4 BLOCK DIAGRAM, GLIDE PATH OFFSET CIRCUIT

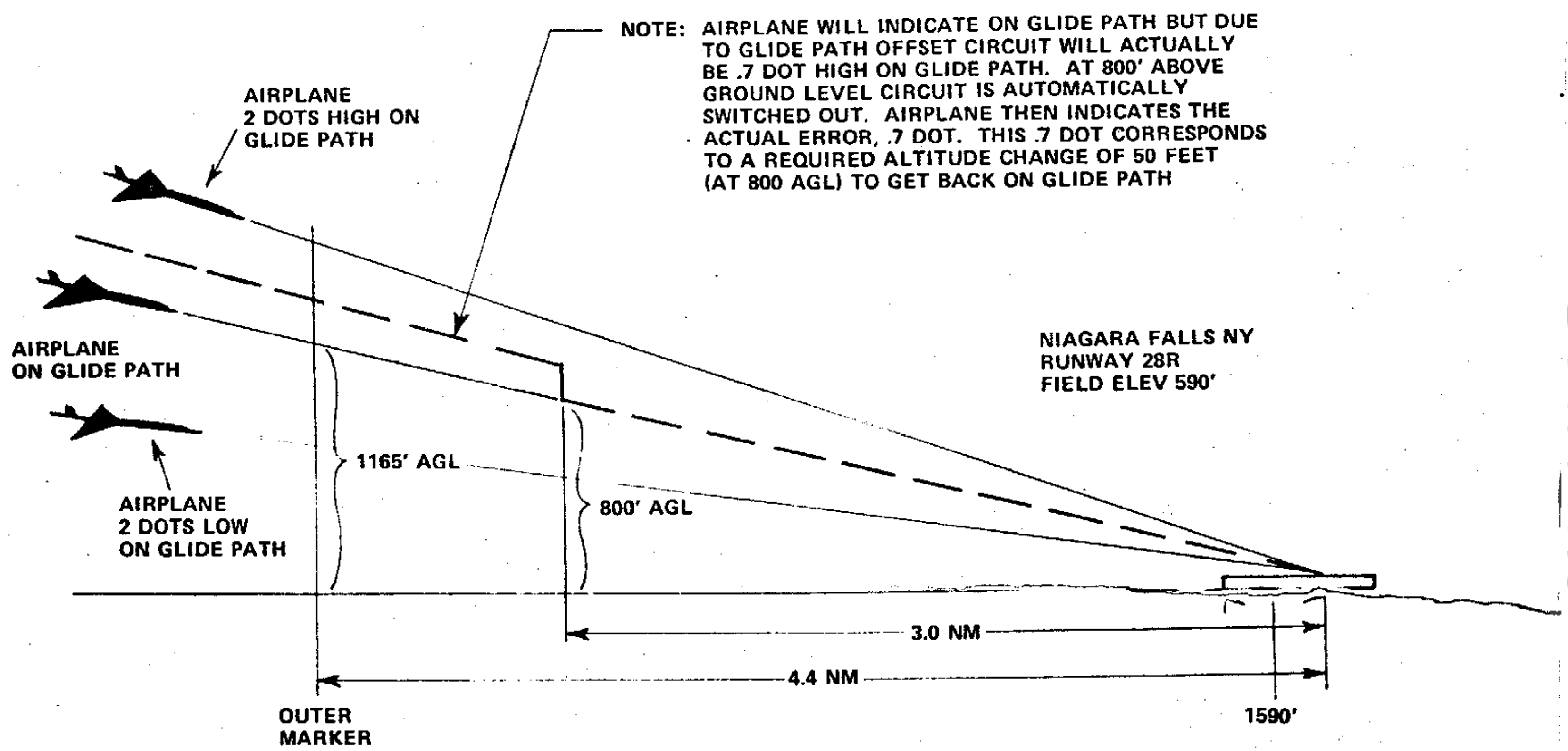


Figure 5   GLIDE PATH PROFILE, EFFECT OF GLIDE PATH OFFSET CIRCUIT

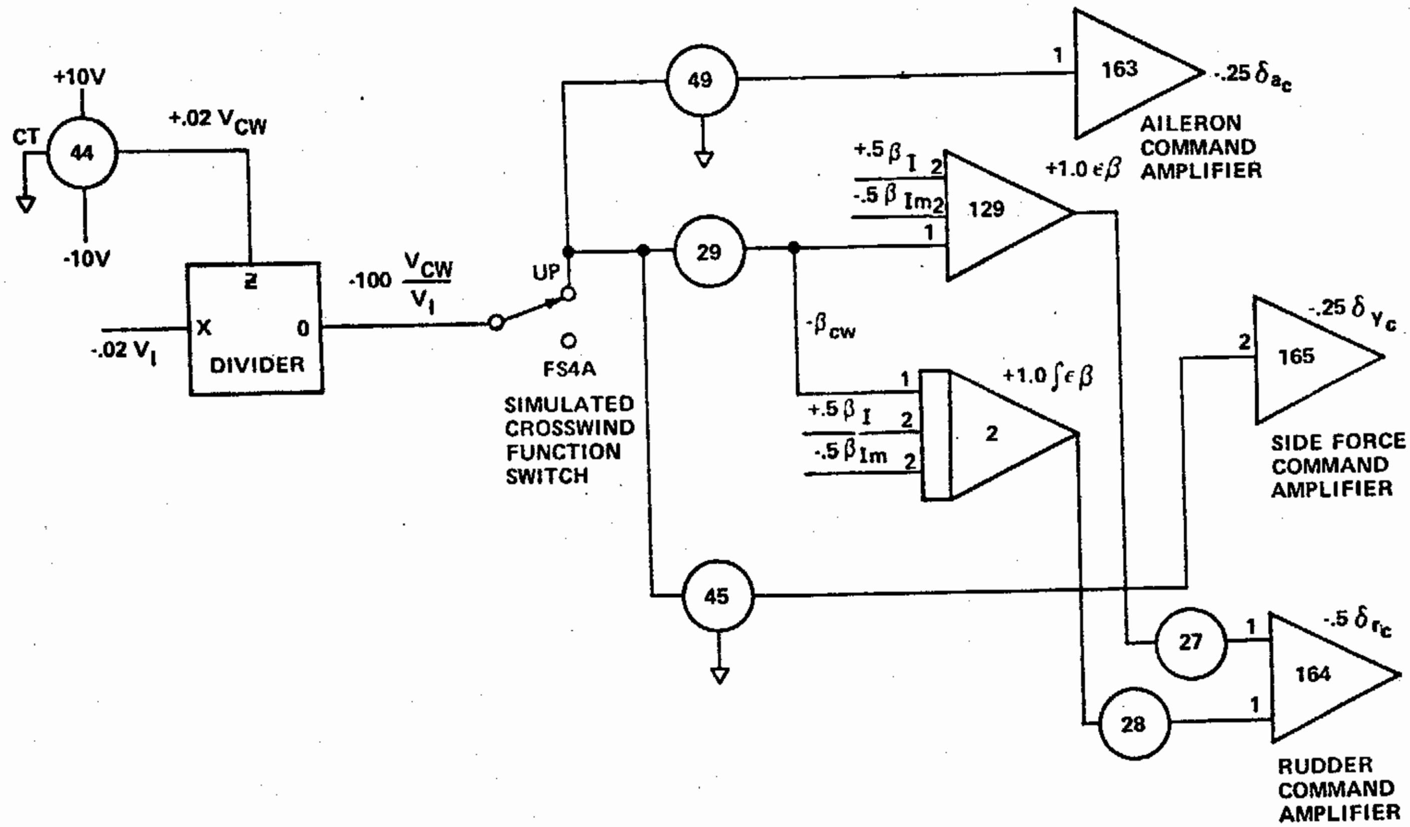


Figure 6 ANALOG DIAGRAM, SIMULATED CROSSWIND SIMULATION CIRCUIT

accelerations (n_y) are cancelled by inputs to the side force surface command amplifier. Potentiometer 49 is used to eliminate rolling moments and potentiometer 45 is used to eliminate side accelerations (n_y).

Since no rolling moments or side accelerations result from the crosswind mechanization, model bank angle equals TIFS bank angle and n_y of the model equals n_y of TIFS. Dynamically, sideslip of the TIFS equals sideslip of the model; however, statically, the two are different by the amount of sideslip required to generate the desired crosswind on the TIFS airplane.

The command signal (β_{cw}) required in the crosswind mechanization was mechanized from the equation:

$$\beta_{cw} = \frac{v_{cw}}{57.3\, V_I}$$

where β_{cw} = sideslip due to crosswind in degrees

v_{cw} = crosswind component of velocity of TIFS along y axis in feet/second

V_I = inertial velocity of TIFS along wind axis in feet/second

4.4 TURBULENCE MECHANIZATION

For each evaluation, it was desirable to provide an adjustable level of turbulence. This could be accomplished by total gust alleviation of the TIFS aircraft and then injecting a fixed amount of canned turbulence of α_g, β_g, V_g and p_g into the model. The magnitude and rate of surface motions required make the technique undesirable. Also, total gust alleviation has not been developed to the point where it is useable. The approach used consisted of applying the full amount of natural measured turbulence to the model. During each evaluation where turbulence was used, the RMS level of this turbulence was measured in a continuous fashion. If the sigma level of the natural turbulence was below the desired amount, an appropriate amount of the canned turbulence was automatically added to achieve the desired sigma level.

Figure 7 is a circuit of the analog mechanization which achieved this combination of the measured and canned turbulence. If the measured turbulence was above the sigma desired, the full natural turbulence would go to the model. If the natural turbulence was less than the desired sigma value, the circuit added the natural and canned in such a fashion to provide the desired sigma level of turbulence. The desired level of turbulence is adjusted by the sigma potentiometer.

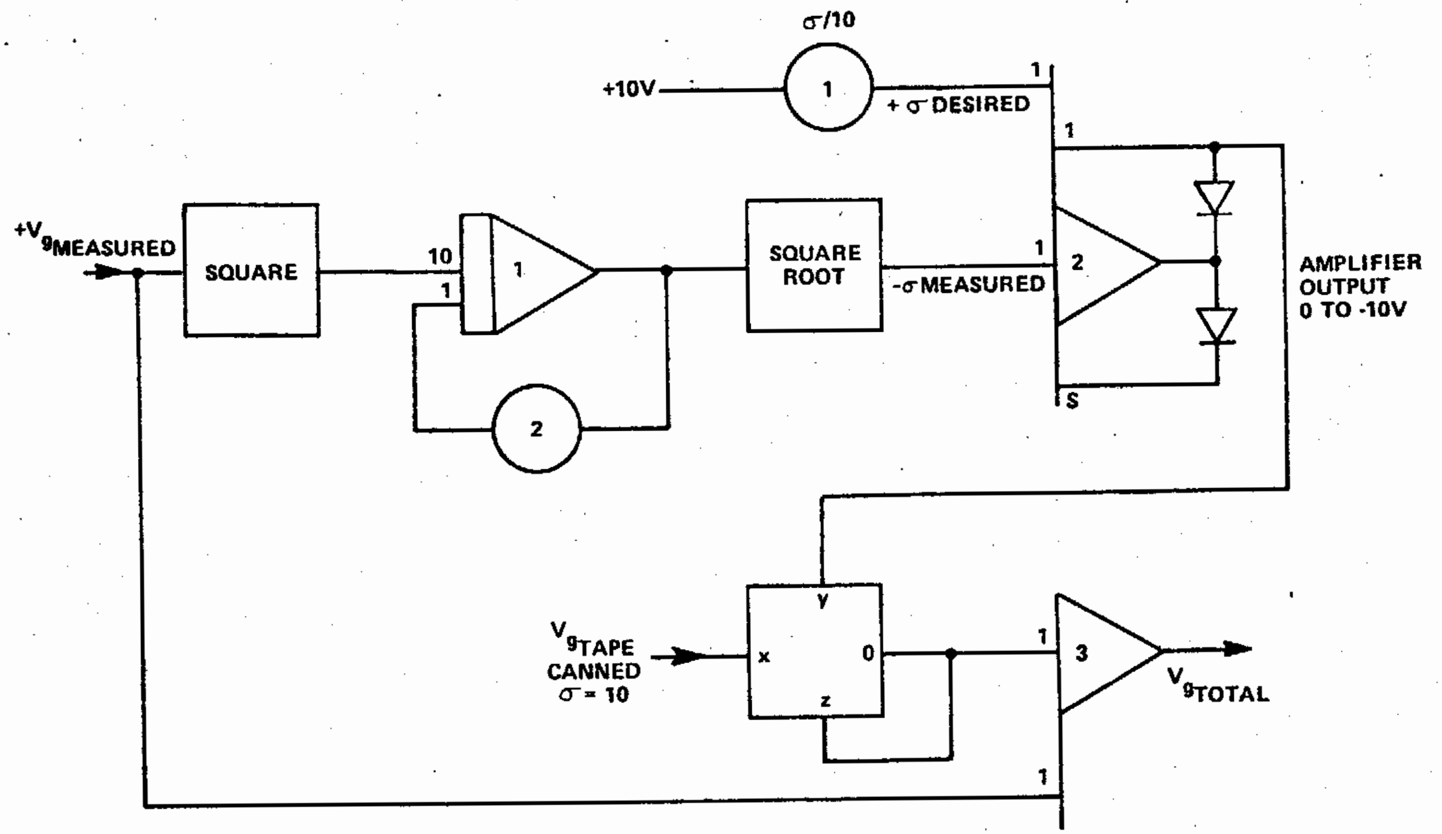


Figure 7 AUGMENTED TURBULENCE MECHANIZATION

The circuit operates in the following manner. The RMS value of the measured turbulence is computed by squaring the gust signal, integrating this signal over a period of time and then taking the square root. The output of the square root circuit is scaled such that an RMS turbulence level of a sigma of 10 (10 ft/sec) corresponds to - 10 volts. The output of amplifier 2 is the difference of the natural turbulence sigma level and the desired sigma level set in by potentiometer 1.

The output of this amplifier is tabulated as follows for a desired sigma value of 3.

Natural Turbulence RMS feet/second	Potentiometer 1 setting	Amplifier 2 output
0	0.3	-3V
1	0.3	-2V
2	0.3	-1V
3	0.3	0V
5	0.3	0V
7	0.3	0V
10	0.3	0V

The canned turbulence signal is obtained from an FM tape playback unit. Random noise filtered such that the power spectral density is correct was pre-recorded on each of the four channels. The output is scaled such that the sigma level is 10. This canned signal is multiplied by the output of amplifier 2 and summed with the measured turbulence signal. The total turbulence signal is then the sum of the natural turbulence and whatever canned component is necessary to achieve the desired sigma level. This relationship is valid until the measured turbulence exceeds the desired level. At this time, the canned turbulence signal is cut off by the multiplier and the total turbulence signal at the output of amplifier 3 is the measured natural turbulence.

Similar channels were mechanized for α, β, and V. The p cannot be measured and is reasonably well alleviated by the model following feedback loops of p and ϕ. Thus, only the canned turbulence is used in the p_q channel. The statistical properties of these four canned turbulence signals were set to conform with MIL-F-8785B(ASG) Backup Data, Section 3.7 (Reference 11). Verification of the statistical properties is contained in AF/TIFS Memo No. 567 (Reference 12).

SECTION V

QUASI-STEADY TRAJECTORY ANALYSIS

A set of quasi-steady trajectories have been computed using aircraft trim data to determine the influence of ground effect on the aircraft landing trajectory. The trim data was generated by solving the trim equations for α_t, δ_{e_t}, T_t, θ_t, and γ_t at altitudes of 400, 200, 100, 50, 25 and 16 feet c.g. height (c.g. height = 14.7 feet at touchdown) for sink rates of 0, 2, 4, 8, 12, 16 and 20 feet per second at a forward speed of 272 feet per second. Trajectories were then constructed from the trim data by selecting values at each altitude of either T_t or θ_t. This would be used to determine the rest of the variables. The time along the flight path was determined by the equation

$$\Delta t = t_2 - t_1 = \int_{h_1}^{h_2} \frac{1}{\dot{h}}\, dh \, . \qquad (83)$$

This allowed all the variables to be plotted as functions of time. Distance along the ground track could be approximated by the equation

$$D = 272t \qquad (t \text{ in seconds}) \qquad (84)$$

The trajectories shown in Figures 8 through 13 are for constant attitude approaches for Configurations 1, 3, 4, 5, and 8. Trajectories were constructed for Configuration 8 with ground effect deleted from the moment equation and for Configuration 8 with ground effect deleted from the lift equation. The former was plotted as Figure 13, but the latter was not, as its sink rate increased rather than decreased. Plots are presented for altitude and required elevator activity versus time along the flight path. Although the profiles are all quite similar, it should be noted that a slight difference in $\dot{h}$ at h = 16 feet can make a significant difference in the time it takes to reach 16 feet. In actuality, Configuration 5 has a positive rate of climb at 16 feet, as does Configuration 8 with the ground effect removed from the moment equation. It should also be noted that while the elevator traces are similar, the less stable the configuration is, the less total elevator travel is required. This is illustrated by Configurations 3, 4, and 5, where 3 is the least unstable, and 5 the most unstable. Figure 13 indicates that the required elevator activity was negligible when the ground effect was removed from the moment equation. Thus, it was concluded that the increase in elevator deflection when the airplane is close to the ground is primarily required to compensate for trim changes related to the effect of ground proximity on the pitching moment equation. The reduction in sink rate for the constant attitude landing trajectory is due to the increase in lift as the airplane enters ground effect. Reference 2 indicates the influence of wing aspect ratio and semi-span on the lift-slope curve in ground effect. Thus, pilot control requirements in the flare and touchdown would be influenced by the wing size and shape.

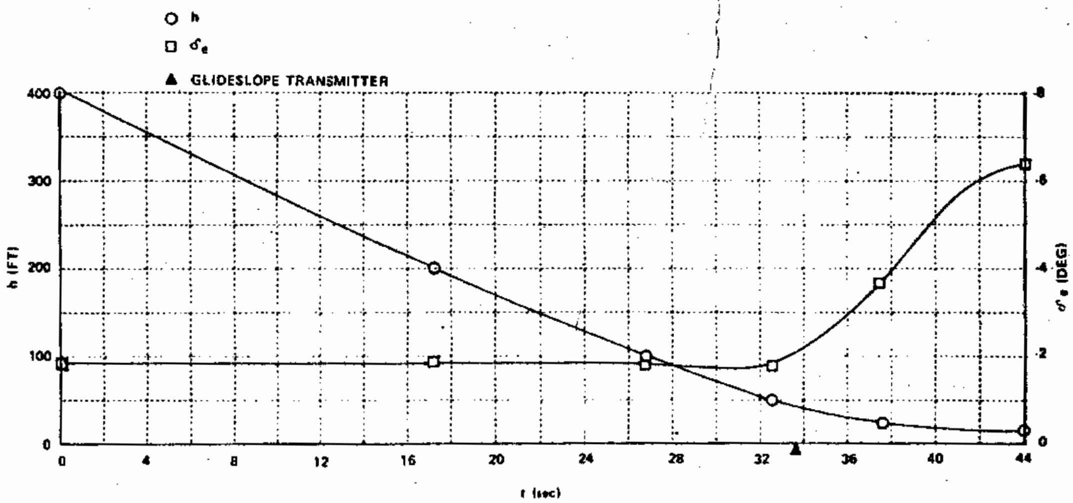


Figure 8 APPROACH TRAJECTORY (CONFIGURATION 1)

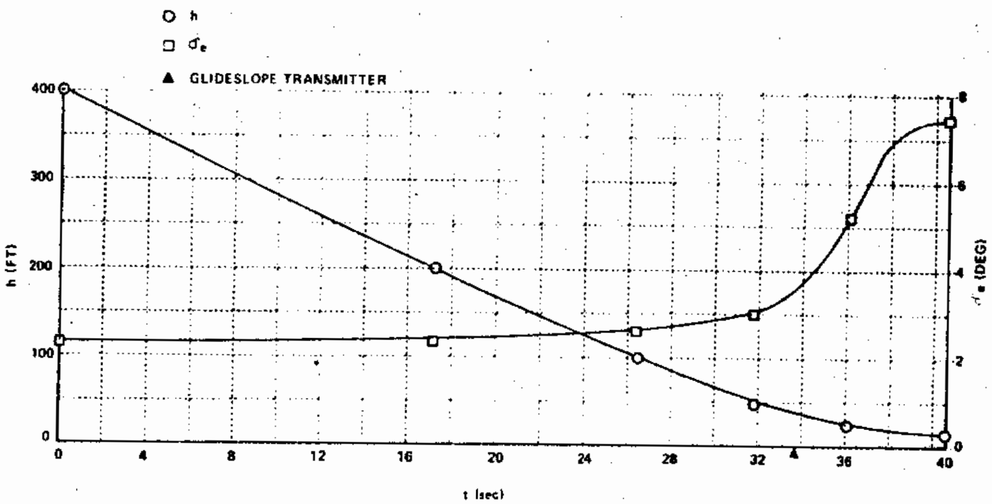


Figure 9 APPROACH TRAJECTORY (CONFIGURATION 3)

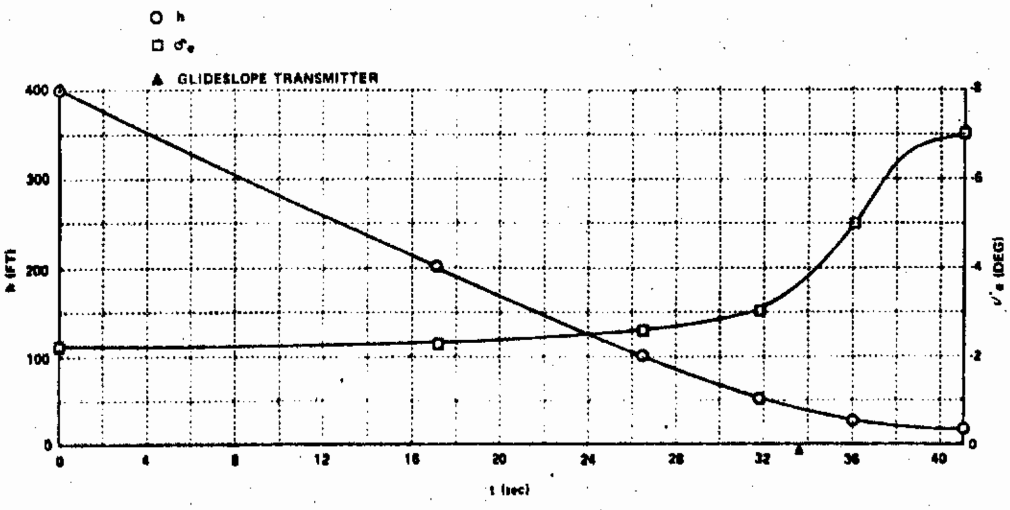


Figure 10 APPROACH TRAJECTORY (CONFIGURATION 4)

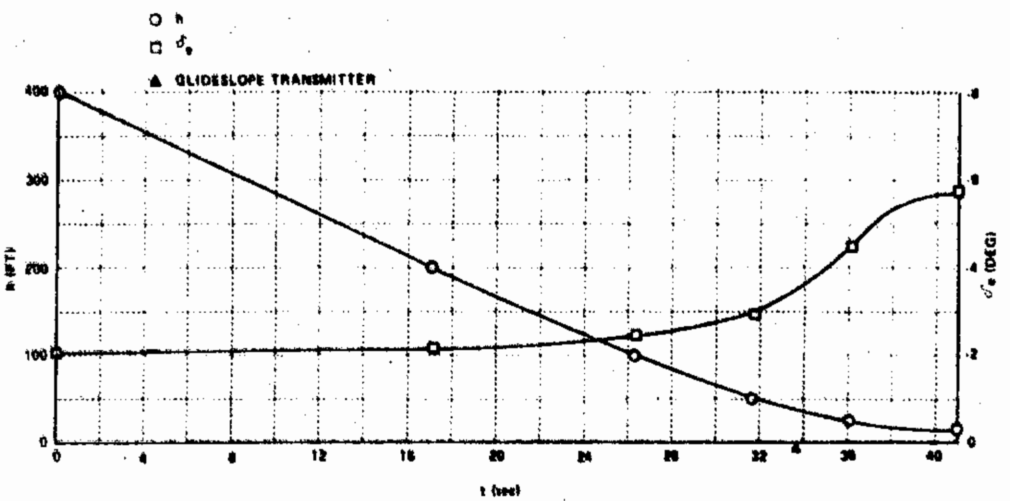


Figure 11 APPROACH TRAJECTORY (CONFIGURATION 5)

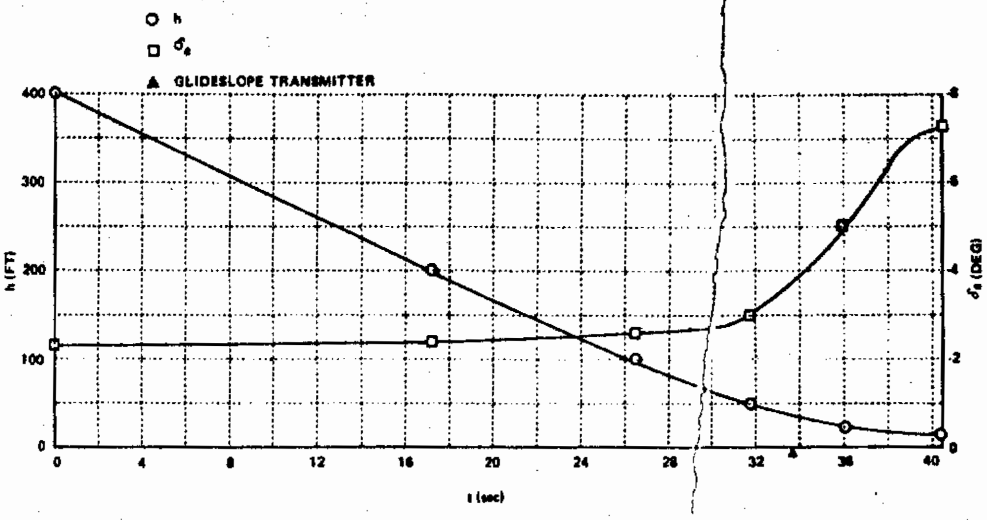


Figure 12 APPROACH TRAJECTORY (CONFIGURATION 8)

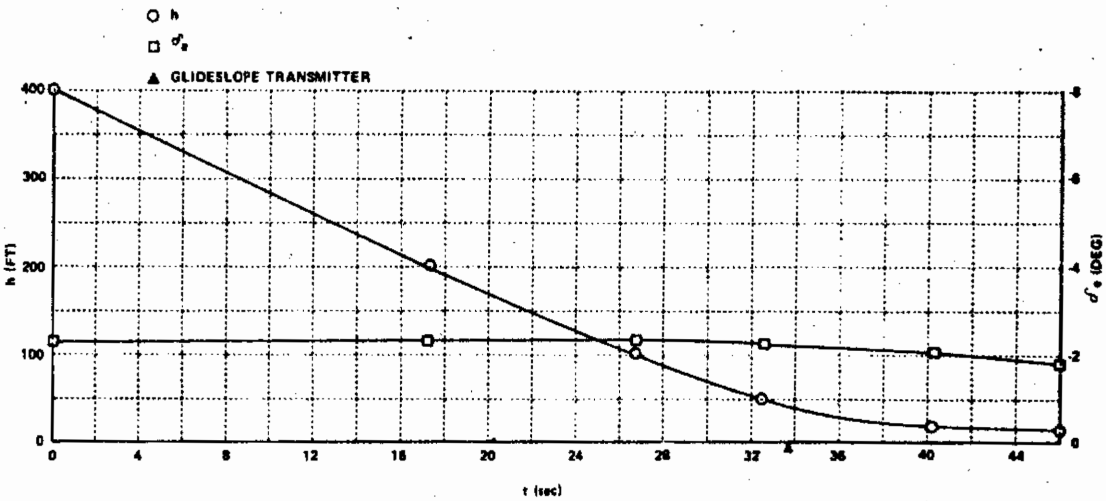


Figure 13 APPROACH TRAJECTORY WITH GROUND EFFECT REMOVED FROM MOMENT EQUATION (CONFIGURATION 8)

Figure 14 illustrates the relationship between flight path angle and angle of attack for the constant attitude trajectory of Configuration 5. For the trajectories analyzed, the thrust required for the flare and touchdown portion is essentially equal to the approach thrust on the 2.5 degree glide slope.

These profiles indicate that for a constant speed approach beginning at $\gamma = -2.5^{\circ}$ above 400 feet, a reasonably good landing could be performed if attitude was kept constant.

A similar type of analysis was reported in Reference 13, a study of the landing flare of large transport aircraft. The effect of initial approach conditions was shown to have a significant effect on the amount of sink rate reduction caused by the ground effect. It was concluded that "pitch attitude is a useful term in the flare of aircraft subject to a powerful ground effect.."

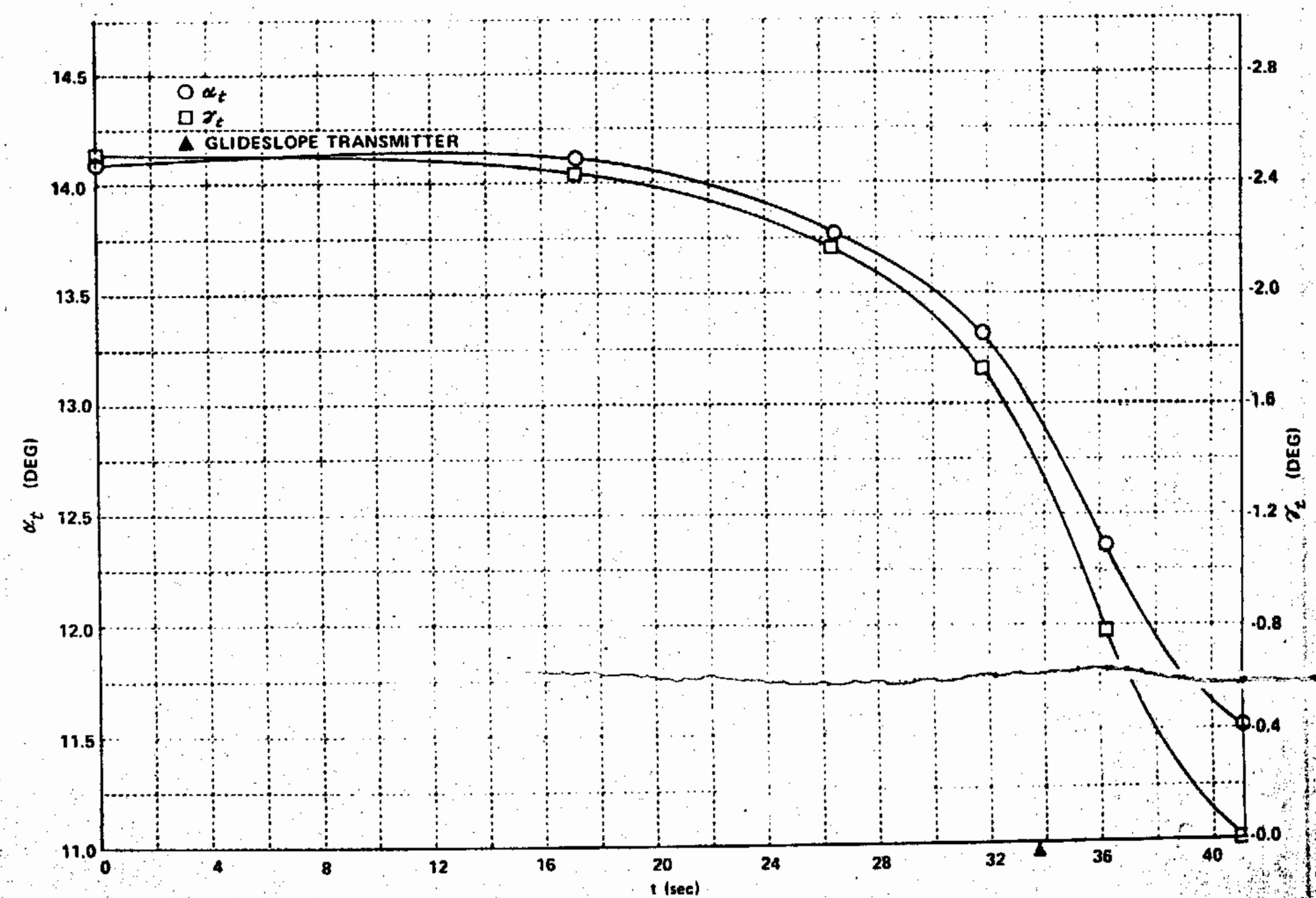


Figure 14 ANGLE OF ATTACK AND FLIGHT PATH IN THE APPROACH MANEUVER (CONFIGURATION 5)

SECTION VI

PILOTS' COMMENTS

This section contains the complete pilot comments transcribed from tape recordings made in flight. The comments have been edited for clarification. Miscellaneous comments that were irrelevant to the evaluation were not included. Instructions to the evaluation pilots , comment cards, etc., are discussed in Section III, Volume I of this report.

CONFIGURATION 6 PILOT A FLIGHT NO. 165-1

PILOT RATING 5 TURBULENCE EFFECT RATING

Trimming is more difficult than a stable airplane but it's not real bad. I was a little surprised that trimming wasn't as difficult as I expected it to be. It's unstable and it's unstable in such a way that it hesitates and then it just creeps on off so it's kind of insidious the way it acts. It's kind of weird. It didn't cause a real big workload, just an increase in workload because you've got to watch it but not a heck of a lot more than you'd normally be watching it because in turbulence you expect the thing to drift off anyway. It just takes a doublet to start and stop the pitch changes and that's true about the maneuvering. You have to pull the nose up to start it and then you've got to push it to stop it and that's the queer part of it. It feels like you just get a gust that's pushing you up or something. Airspeed control, it's a funny situation on this airspeed. Evidently I had more trouble with airspeed then because it required less power than I had anticipated. I wound up with trim power a lot less than I normally did and I was using bigger power changes then. I don't know why. It was weird. I didn't hold my airspeed as close then as I was able to do this morning on the pre-evaluation flight. I don't know why. Lateral control, altitude and pitch control was the same comments. Localizer acquisition and tracking prior to glide slope angle, the pitch causes some increase in the workload and we were at odd places, or almost on that localizer a couple of times but one time I went on through, then kicked it back. Some increase in workload in pitch task. The altitude wasn't any real big problem, just the power changes involved. Glide slope acquisition, again the pitch adds a little increase in the problem but the turbulence is causing me just as much a problem as the instability. I know it was unstable because I checked it. If I just started out with this thing, I'd figure I had a sloppy airplane, but it's insidious in that it will stop and then it will creep off slowly on you and it doesn't give you any feel of the pitching. Tracking in glide slope and localizer, the turbulence is causing me more trouble in the configuration but the two combined make it a fair increase in workload. Maintaining and re-acquiring glide slope, I was having trouble getting the airspeed. I had down to less than 40% thrust there one time trying to get that airspeed down after I got on that glide slope and it may have been one of the bucket configurations. I don't know but it was weird. I had trouble keeping my airspeed low down. It was on the high side most of the time which is unusual. Ability to maintain and re-acquire localizer, I was re-acquiring it all the way down. No big problem. Does your pitch task affect heading control adversely? Yes. The pitch does cause it because I was overcontrolling in pitch occasionally. In the turn there was a slight increase. No, there wasn't any unusual use of the display. I still found myself occasionally confused as to where I was on that gyro. I'd be up at 15 degrees pitch attitude and thinking I was at 10 there one time, I remember. Control technique: elevator and throttle, I don't know what the heck I was controlling. I was controlling sink rate, trying to control sink rate and the glide slope with the pitch but I'm not sure I ever got that far. Inputs are step like but I've already described that for the pitch response. You pull up until you start to see it start to move and then you've got to put a doublet to slow it down and stop it. How suitable to the task is the resulting airplane motion? I don't really know how to answer. The airplane doesn't feel like it's trying to get away. It just feels like it's imprecise control. It doesn't act like it's running away. The only time it felt like it was trying to get away from me was when I was trying to turn and trying to control the pitch, and I'd have to pull and stop. I was hunting all the way through. Ability to correct lateral offset errors on breakout, no problem. Some slight pull. You're pushing and pulling and working that elevator all the time throughout that approach but it didn't cause me any big problem on the offset. The maneuvering didn't cause me any problem on touchdown point or sink rate. In the flare, there's a lag in the effectiveness of the elevator. By the time I feel the nosedown pitching, I pull and I pull too much and it causes a porpoising down the runway and the third time I thought I had it pretty well locked and I tried to lock the pitch in but I still couldn't do it. I still was porpoising all the way through. You're just pulsing - working the elevator up and down like a bilge pump again but it's not as bad as some of them. It is a porpoising though in ground effect and I think that it's the delay in the input of the elevator before the airplane moves that's actually causing the problem. In crosswind landing, I don't know whether we're in a crosswind or not now. We're probably pretty well straight into the wind so I won't worry about that. Control feel hasn't changed from what we saw before. The same comments still hold on it. The rudder's too high and I'm a little jerky on the ailerons but the main thing is I'm bilge pumping this elevator. Friction and feel hasn't changed. Throttle feel and friction haven't changed but I don't know what the heck is going on in that configuration on that power. I think the airspeed control was the worst part of that and the ability to flare precisely, those two things were the biggest differences that I saw between what we did this morning on the pre-evaluation flight and now. I had more trouble with the flare and the power control on those than I did on anything else. Has rough air brought out any characteristics? No. I think the rough air wasn't causing all the problems. The thing seemed to ride the roughness pretty well, reasonably well. I think you could fly it for 30 minutes no problem. The uncomfortable part of the turbulence is this bouncing up and down. It causes about a "C" for the turbulence effect rating. The bouncing up and down on my body plus all the gustiness that we had on final causes a minor, somewhere between a "C" and a "D". More effort is required, minor deterioration of the task, I think on that case, probably a "C" or a "D". This level of turbulence for that configuration, probably a "C". As for the configuration rating, it is controllable. Is adequate performance attainable with a tolerable pilot workload? I think yes on that one. And I think I'd put it about deficiencies do warrant improvement. It isn't satisfactory without improvement. The annoying thing about it is the delay in that elevator. It seems to sit where you put it for a while and then you had to work to get it up. I'm toying between a 4 and a 5. And the flare is coming into this thing. I'm going to put it at 5. Make it a 5 partly because of the flare because I can't get a precise flare and partly because of the way the thing acts in pitch. So we'll call that a 5 and a C.

CONFIGURATION 12 PILOT A FLIGHT NO. 165-2

PILOT RATING 10 TURBULENCE EFFECT RATING F

It's very difficult to trim the configuration. It is pretty unstable. It appeared that nosedown was worse but I'm not sure of the trim. It pitched down very drastically when I gave her a nosedown pulse but it didn't go quite as bad nose up but the trim could have been the problem because I'm not positive I was that well in trim on that point. Attitude control becomes the primary concern. The "g" cues that I get in this in-flight simulator help me because I can feel the over-controlling - the pitching and the "g". I can actually feel the g. I didn't specifically look and see what kind of magnitude but I can feel the inputs as it starts pitching and it helps me. It warns me that something is happening. The airspeed control hasn't been a problem so far in this level flight at least. I could hold my altitude fairly well. There wasn't any big problem with that. As for maneuvering, it is so sensitive in pitch that I restricted the turn to about a 20° bank because there isn't any doubt that you could pull a lot of g's in this configuration so I wouldn't worry about elevator power and I just made a nice easy turn around and lost 200 feet down to 2300 feet just to see what that would do. Pitch control, pitch control, pitch control. It's just changing your cross check and making you concentrate on the pitch which causes everything else to go off. The turbulence excites the instability and I have to use the doublet technique to stop it, push like heck to stop it and pull the other way slightly to keep it from going. Sometimes it's not a doublet in force, it's a heavy push and then a relaxing of the push rather than a doublet in force - reversal of force. As for maneuvering forces, if there are any, it's hard to see. It's so light and it's so squirrelly in pitch. I did run a check to see if I had a positive stick force gradient but I couldn't tell. It could have been covered by the turbulence. The turbulence was causing so many pitch problems in the turn I couldn't determine whether it was a positive stick force gradient or not. Not with what we were doing in this air. The gradient is probably so light that the turbulence masks it. Regarding the localizer acquisition and tracking prior to glide slope interception, the pitch is squirrelly. That is it's much worse than the last one. It's a bad pitch situation. It seems that I have to pull like blazes to get it started. It looks like it's almost like a damper. You've got to bust through but once you start it takes off and it's insidious that way. I was making gross pitch changes as much as 2-1/2 or 3° sometimes with the result that the cue was on the g. Glide slope acquisition wasn't any problem but when I got about half way down the glide slope each time, I had a heck of a time keeping the airplane slowed down and maintaining the glide slope. It looked like the bottom. It just went away from me and I'd get that thrust down below 40% at times. I don't know what was causing that. The pitch is now the primary instrument. It's just a gross degradation of the performance. Probably not from the tracking performance I do, because I'm pretty sloppy anyway the way I fly this airplane. The pitch caused a fair amount of trouble in getting back up to the glide slope because I was constantly varying in pitch. The control technique I used was a step input. A big heavy input and then something like a big heavy input to stop it. It diverged fairly fast and it was insidious. It felt like we had very little elevator power along with a bad instability. I may have made a mistake when I performed the in-flight maneuvering because I was hitting the stops on the elevator in ground effect. I don't know what the heck is causing that. The pitch task affects everything because you've spent more time on it. If you play with the pitch it just affects your ability to track. You lose track in a hurry. As for the throttle, it looked for a while there that it was almost in the bucket, but then on the glide slope I'd get confused. I'd think I knew what I was doing with the throttles on the glide slope but I'd just give up because I'd just have to make 15 or 20% thrust changes just to make it do what I wanted it to do. Pretty gross! The pitch task is not so good for tracking. Lateral offset errors on breakout didn't seem to be any problem. I could get over and get lined up on the runway. Manuevering didn't affect my control of the touchdown point or the sink rate. I didn't have much control over the touchdown point and sink rate. The performance and workload in flare is not representative of an airplane. This is worrying me. I'm afraid that this ground effect just may not be right. If it was as strong as they think it was, then it may be that it's coming in so quickly that it's causing the propoises. I am confused about how to judge these configurations based on that ground effect. Crosswind landing, I don't know if we had a crosswind or not. I wasn't concerned about it. I didn't notice any crosswind problem on these landings. The wind was almost down the runway. Elevator feel, there's no change in that feel system so I'm just going to bypass that. I don't think it was causing me any problem. It might have been a little worse in this configuration for the elevator because of the force gradients but I don't really think it bothered me enough to really count it. Maybe some small increase in workload in this configuration due to the breakout on the elevator but the other two (aileron and rudder) there was no problem. Throttle control, feel and friction is okay. Not changed. It had enough. I felt the relatively lower throttle time constants helped some. There's no doubt about that. The flare was most degraded. I think that's one thing that bothered me more than anything else, the flare for touchdown. Turbulence effects were very bad on that one. Turbulence in this stage of the game has about an "F". You could still do the task but it's a major change in effort due to the turbulence. Yes, I could fly that configuration in the air today and in turbulence but the only thing is I can't flare it and predict the touchdown point. It's not like the B-26 and it isn't like what I remember the Concorde and it isn't like what we saw at Ames. Is it? So, I'm worried about that ground effect right now. I think I would have to put a 10 on that one with this situation. You'd have to put a 10 on it. And that's qualified mainly by the touchdown and I hate to put it that way. I'd put a 9 on it if the flare hadn't been so squirrelly but we'll put it as a 10 for the time being.

CONFIGURATION 3 PILOT A FLIGHT NO. 166-1

PILOT RATING 6-7 TURBULENCE EFFECT RATING D

The trim is not bad. It is relatively easy to find the instability. It diverges aperiodically at a fairly low rate, a moderate rate, let's call it moderate to low rate. The static instability is so low or negative that there isn't much feel force required to fly 10 or 15 knots off trim. I got up as high as almost 180 knots. It wasn't bad. There was no objectionable behavior off trim airspeed. While maneuvering, the attitude control is no big problem. I have to pull to get the thing started, fairly light, fairly good input, almost a normal input to start the nose pitching and then I have to reverse the elevator to neutral and reverse the input to stop it. That's the big change, or the abnormal change to the configuration. Airspeed control didn't seem to be much of a problem. There was a high induced drag, fairly high, because we were sinking pretty fast when we did the wind-up-turn. We have a good strong crosswind, a fairly good crosswind and it's turbulent. The air is turbulent. Even with this light instability, trying to hold a constant attitude is almost impossible when I go into ground effect. I was consciously trying to keep that nose moving with a relatively low divergence, moderate or light divergence in pitch. I could do it until the last bit and then as I got very near the ground, that ground effect is causing me to go right into a PIO. For the second approach I had a grease mark on the windshield trying to get a little bit better reference for holding the pitch. I had to duck down to use it but it helped a little bit. It's just obvious that I'm beginning to get into my mind that I think that ground effect may not be representative but we'll have to wait and see how that works out. It appeared to have a fairly high decay on airspeed when maneuvering. So it looked like we were backside at 160 knots in maneuvering flight. Attitude control wasn't too bad, it was a mild divergence that we had. Airspeed control was a problem during some of the approaches because it appeared to be backside. Altitude some problem but not much of a problem. Maneuvering forces for the wind-up-turn were varied greatly because I couldn't exactly find the right pitch I wanted. I'd wind up starting excursions with the pitch. It felt like for a while we had a positive stick force gradient and it may have been. I couldn't tell for sure because about the time I thought it was positive, it would start pitching and I'd be pushing trying to keep it from pitching. So it's rather difficult to determine any kind of a stick force gradient with an unstable configuration because if it is positive it's light. Not being able to control the pitch that well, you had to almost take a time history when trying to do wind-up-turns to see what it looked like. Localizer acquisition and tracking prior to glide slope, my only big problem in checking the localizer was the fact that I don't have a pointer telling me when I'm getting close to it. All of a sudden the needle is coming off the peg and you have a 30° bank turn to make at 160 knots. You overshot the localizer each time. If you had more instrumentation, there wouldn't be any problem. If you had an ADF showing you where the field was like you normally would have on the flight director, there wouldn't be any problem. You'd be able to just glance at it and as you got within 5 to 10° of localizer you just start a nice easy turn and cut down the intercept rate. The pitch problem causes a slight increase in the workload. There's no problem on being able to fly an ILS this way in spite of this bad turbulence and the airplane's reaction to it. On the glide slope acquisition that time I noticed I was a little slow in airspeed so I just eased the nose down. You just have to brute force check the airplane around and make it do what you want to do with all this turbulence - the wind blowing you sideways, etc. There is a small impact because of the configuration on the ability to fly the glide slope but it's not a big impact. It's an increase in workload but not a large increase. Control of airspeed was a problem that time because I keep pulling the throttles back more than I think I have to or should have to. I wind up with the throttles pretty far back and the airspeed stayed up pretty high and evidently there's a drastic reduction between 160 and 170 but it never gets past 10 knots. I almost went to idle one time trying to get that airspeed to slow down. No unusual use of the display, I made that grease pencil mark a little bit better. Control technique -- it's an input and a stop. It's a doublet but everytime I think I got a doublet going the turbulence hits me and I don't know where I am so it's not a smooth operation because of the turbulence. I think some of the griping I'm doing must be the deadband in the control system because we didn't have this kind of a deadband out at Ames. I'm seeing bad things because of the control system which makes the task unsuitable. There's no problem in taking care of the lateral offset. You can maneuver the airplane real well and the maneuvering doesn't affect my touchdown point or sink rate. It's just the phugoid that does that. The performance workload in the flare and touchdown is too high, definitely too high because of the phugoid. I put two grease pencil marks on the windshield trying to give myself a better picture so I could try to hold that attitude a little better but I still get the phugoid with it. I wind up pulling like blazes at the last moment because it starts to pitch. That nose down pitching moment due to ground effect causes the instability to take off. I had to pull relatively hard just before touchdown on that last approach. When I was told that it looked like the sink rate went almost to zero at touchdown, I said it was shear luck. All the landings were made with a crosswind and I've been trying to use a little wing down. It's just a normal crosswind operation. Regarding the elevator feel, it may be the breakout in the hysteresis which is causing me some problems in pitch. I'm beginning to get that feeling from these approaches. The rudder force breakout is much too high for this situation and I've been griping about that all along. The travels are all right. The rudder is too high. The aileron is probably a little too high for the sensitivity that we have but it's acceptable. The elevator I thought was acceptable but maybe it's hysteresis that's causing me the problem. The breakout force is probably acceptable too. The hysteresis is maybe too big. Throttle control feel including friction is okay. It doesn't cause me any problems. The time lag in that thrust is still longer than I'd like to see it but it's acceptable for the problem. Which of the required evaluation tasks was most degraded by the configuration? It's just pitch control and that's all. I'm back commenting on that ground effect again. I think we're wrong on that ground effect. I think the flare is the worst thing. The instability causes a PIO in ground effect. The turbulence effect rating is "D". More effort is required because of the motions of the cockpit. Also, the turbulence excites the instability. It's more effort required with moderate deterioration of task performance, "D ". I've gone through the handling qualities rating scale and it is controllable. Is adequate performance attainable with a tolerable pilot workload? Under all these conditions I'm going to put a 6 on this one. Adequate performance requires extensive pilot compensation and it would be somewhere between a 6 and a 7. I'm having a hard time deciding whether that's a tolerable pilot workload or not mainly because of the ground effect. If I let myself hang up with the ground effect it would be a 7. Controllability is not in question except in ground effect and the ground effect is muddying up this evaluation. I'm calling it a 6 but it's because I have to try to hold something constant and let it sink into the ground in ground effect. That's all I can do.

CONFIGURATION 11 PILOT A FLIGHT NO. 165-2

PILOT RATING 5 TURBULENCE EFFECT RATING D

Trim isn't much more difficult than a normal airplane. This configuration has a very slow divergence in pitch after a pulse and it's relatively easy to trim. It's a little more difficult than a stable airplane of course, but it's still not real hard. It's just a slight increase in the problem. It's unstable off trim speed. Objectionable behavior is that it's just moderately unstable, lightly unstable. Maneuvering about level flight didn't seem to be any big problem. I have to watch my pitch attitude a little more than I normally would. Turning flight is difficult. It felt like it was almost a zero gradient and as I relaxed to zero force and let it float a while, the nose started down. So it appeared to be a slightly positive stick force gradient. The airspeed appeared to be a backside. Most of my intercept problem in overshooting the localizer is the fact that I don't have anything telling me when I'm getting close to it. There's no big problem maneuvering the airplane. It maneuvers quite nicely at this speed. I can pull the g in but I'm still making the 30° intercept at this high speed. I just zip right through the localizer and I have to make a correction back and so it's an S turn getting on the localizer. The work is degraded just slightly because of the configuration. As for glide slope staying right on it is a real workload in this kind of turbulence. There appeared to have been some kind of a bucket in that glide slope. Each time I wound up diving down and then pulling up to get back to the glide slope. The airspeed wasn't too much of a problem. I usually wind up getting fast on these last three approaches but there is no big workload on airspeed. Tracking in localizer and glide slope was mainly a function of the atmospheric conditions. The pitch task affects both the localizer and the glide slope because I have to pay a little more attention to it. Every once in a while a gust would cause the pitch to take off and it would go 2-1/2 or 3° off while I was looking at something else other than the attitude indicator. I could feel the acceleration which told me to get back on the attitude indicator. I got a physical sensation to look back at the attitude indicator which I did not get in that simulator at Ames. It's a plus for the TIFS. Elevator and throttle, it's so turbulent that I'm using pitch primarily to keep me on the glide slope and sink rate but power for airspeed and sink rate and in that order. The pitch response is normally an overcontrol - slight overcontrol in pitch due to the instability. It feels like it would get away if I didn't pay attention to it. But it diverges enough where you get a g sensation that causes you to look back at the attitude indicator. Lateral offset errors on breakout are no problem. I could see an over g one time but the airplane and the pitch rate is quite easy to maintain until you get down into ground effect. Then, the forces, the pitching moments are changing so drastically with height that it's difficult. On the last approach, I floated. I used the throttle somewhere in there and finally pulled it back and just let it float along and got both hands on the wheel trying to hold the thing. That's not a normal technique, I don't believe. The pitching in ground effect affects the sink rate and the touchdown. No doubt about it. It's mostly a ground effect. It's a nose problem. All I was trying to do was hold a constant attitude and it's difficult to do because the pitching moment in ground effect right at the last causes the nose to start down. You have to yank with a pull and you might catch it just as you touch and I think it worked that way on the last one. Control feel is unchanged, and throttle feel is unchanged. Response is noticeably slow but it's acceptable. The pitch control in all of its ramifications is a problem which is most degrading. I could fly it for 30 minutes obviously in turbulence but the turbulence excites the instability and causes all kinds of counter problems, like reading the gauges. You're just uncomfortable because of the level of turbulence we're having. Also it excites the pitching mode, the instability. It requires moderate more effort, I'd say. Call it a "D". There wasn't any big difficulty on the crosswind. Is it controllable? Yes, it's controllable. Is adequate performance attainable with a tolerable pilot workload? I'd say yes. I'm torn between 5 and 6 on that one. The divergence rate is not too great on that one and I may be learning how to control it in ground effect. Maybe that's it. I'm learning how to compensate for the ground effect. Let's give that one a 5. It's a doubtful 5. It's between 5 and 6. The reason for the rating, even that high, is that the divergence is fairly slow and I had time enough to look around at other things and worry about other things. Then finally when I felt it going off I could stop it before it got dangerously far off. Never any problem about whether a pilot could control it or not but it increased the workload considerably somewhere between considerable and extensive.

CONFIGURATION 7 PILOT A FLIGHT NO. 167-1

PILOT RATING 6 TURBULENCE EFFECT RATING E

It is unstable but it doesn't diverge at a real high rate. The divergence is moderate to fast, but it's not real fast, I don't think it's the 2 second time to double amplitude, but it's a moderately good divergence. It looked like a fairly high induced drag situation - backside. It was difficult to trim. The forces seemed a little higher than I've been used to. My first impression was that the elevator forces are higher than I like. Maneuvering about level flight required a moderate amount of increased workload due to the pitch instability. It takes a fair little input to start it and a fair little input to stop it. The airspeed control is not too bad. It looked like a backside. Airspeed and altitude control was just a matter of powering, it shouldn't be too much problem. Just maintain the pitch control. And the turning flight, it felt like it was a positive stick force gradient, but again it's so squirrelly that it's difficult to tell for sure. Deviations of airspeed and of everything else are caused by the instability in pitch. I used the technique of applying lots of rudder to turn the airplane. It seems to work a lot better if you make kind of a fighter turn out of it. I tried using a lot of rudder leading into the turn. It seems to be less trouble from the lateral-directional characteristics and so I did it that way. I'm mostly leading with rudder into the turn. It makes it a lot easier to handle the airplane if you use the rudder to start the turn. It's got a strong dihedral effect and by pushing in on the rudder, it starts a nose turn to the right and also starts the airplane rolling a little bit and it works out much easier and smoother on the turns. There's no big problem with the localizer acquisition and tracking. Divergence is moderate so that there's a little oscillation in g in turning. It doesn't require a lot of attention. It requires an increased workload but not a lot of attention. If I was keeping a tight loop on everything, I could probably keep it within 50 or 100 feet of altitude without any trouble and if I really was working at it, I could keep it almost right on the altitude. Airspeed is a problem. I had trouble keeping the airspeed right on 160 knots. It varied off 5 knots, and it was going low more than it was high. That was until I got on the glide path and then I had trouble keeping it from speeding up. Glide slope acquisition was no problem. What I try to do if I'm slow is to shove forward on the control column before I pull the power back. In other words, I make my pitch change before I move the power back. If I'm on speed I start easing the nose down and pulling the power back simultaneously. I'm using the off speed, the throttles and the pitch change to help me gain airspeed back as I get up to the glide slope. It's not much of an increase in workload except that a doublet is required. I had to push to start the nose moving and then kind of modulate the movement and then stop it. I'm not just letting off, but using a reversal. Regarding tracking, most of the problem is caused by the turbulent ambient conditions. I had a little trouble with the airspeed. It's more difficult. I had a little problem because of the increased workload from the normal airplane. I used the same old control technique - pitch to set up my glide path and controlling airspeed, and then I controlled sink rate secondarily with the throttle. And it's a doublet for the desired pitch response, but not a bad one, it's moderate on the instability.

Airplane doesn't seem to want to run away from me, it just will drift off if I'm not watching it, but I had plenty of time for the cross check. Lateral offset errors on breakout was compounded by the crosswind which put me a little further down the runway. When I get close to the ground I am just reducing the sink rate and flying through the flare. On the fourth approach, I didn't feel as much trouble getting down to the runway as I did on the others. It was easier to fly down but I landed with a relatively high sink rate. I felt all three touchdowns because I'm landing with a little higher sink rate than I've been using. On this flight, I'm just breaking the sink rate and letting it fly into the ground and this technique has been working. I was crabbing down on a crosswind approach. I was crabbing the course on the final and crabbing at the breakout and then I was trying to use a little bit of a wing down, whatever it took. I used less rudder to keep me going down the runway. The control feel hasn't changed. Throttle control feel and friction have not changed. For the turbulence effect rating, I'm going to call that a D or an E, and we'll make it an E on the turbulence today. With this configuration and with the airspeed getting off as much as it has been, I'd say that was an E. Turbulence was causing me more trouble than anything else. As for the configuration rating, it is controllable. I don't think the airline pilot would have much trouble controlling it. A lot of this stuff would be masked by the turbulence. Is adequate performance attainable with a tolerable workload? I'm undecided about that. I feel like saying yes. I'm going to put it up at a 6, adequate performance requires extensive pilot compensation. If he can get adequate performance out of it but it does require a lot of compensation.

CONFIGURATION 2 PILOT A FLIGHT NO. 167-2

PILOT RATING 4 TURBULENCE EFFECT RATING D

Trimming was a little bit more difficult than the stable airplane. The configuration has real light forces when it's off the trim. The stability level is lightly unstable. It's lightly unstable so that the forces off trim are not bad. The divergence on the pulse was relatively slow to diverge and airspeed didn't seem to be any problem. I had no problem with airspeed control at least in level and in turning flight. I didn't get way off on it. I did get about 10 knots off, but it was when I "honked" it up to see if I could get about 1.4 g's. There wasn't any problem doing that. As for maneuvering forces, I think it's positive stick force per g. There's a tendency to overcontrol. When I honked it on up to get the g and then reversed the forces, the airspeed bled off. Maneuvering forces are light, but appeared to be positive. Altitude and pitch control didn't seem to be much of a problem. The pitch is unstable off trim, but it's a slow and light instability so there's no big problem. The localizer tracking and acquisition was no problem. The increased workload due to the light instability is moderate, it's not very much of an increase in workload because the divergence is relatively slow. Glide slope acquisition, there's no problem. Airspeed is more of a problem than the pitch control on that one. It caused me more trouble manipulating the throttles to keep the airspeed than it did in pitch. Glide slope acquisition and tracking of the localizer and the glide slope, I think I spent more time with the airspeed management than I did with the pitch management. The divergence was so slow and the turbulence was causing as much or more of a problem than the divergence was. There were so many things going on, I'm not sure a pilot just walking into the airplane in this kind of turbulent air with the backside of the power required curve would know that he had an unstable airplane. There are too many things pushing it around. There's no big problem maintaining or re-acquiring the glide slope. The control of airspeed was the only problem. Pitch task didn't affect the heading control adversely, only very little. The power management or the airspeed management caused most of the additional workload. No unusual use that time. The cross check was almost a normal one, except that I was looking at airspeed plenty more than I normally do. I used kind of a doublet to get the pitch response. In many cases the response was not noticeable because the turbulence caused things to stop and start and change. The resultant airplane motion from the input was almost like I was getting a rate from an input rather more than an acceleration. No, it didn't feel like it was trying to get away from me except in airspeed due to the turbulence. Lateral offset errors on breakout were no big problem. A little bit of additional work maintaining that airspeed, but the stability was only a minor effect in maneuvering. For the last two landings, I played the flare to let it float and try to seek the runway. I was able to feel my way through the ground effect much better, I thought on the second one. I saw a PIO. I felt I had more positive control. Crosswind landing is no difficulty, a little wing down, a little opposite rudder, no problem. And it had little effect on the sink rate on touchdown. The force feel I don't think has changed. The throttle control and friction hasn't changed. The turbulence rating, on that configuration, I'd say a D. It's a moderate increase in workload force. There was a moderate deterioration of task performance.

C or D, I'd probably make it a D. And the configuration itself, control was never bad on that one. I'd jump right up. It is controllable and adequate performance is attainable with a tolerable workload. Yes, I think I could just go on up there. And yes, the deficiencies do warrant improvement. It's backside, but the stability is quite low. It requires 4 or 5 for an airline pilot, moderate to considerable, somewhere between 4 and 5. And I'd say probably just 4. He might not even know that he had anything but a backside and if he just lets it sink on it and touch, he could get an acceptable landing. 4+, not quite 5, it wouldn't require extensive compensation. I can almost circle the 4 and forget it. And the main reason I say the 4 is that the pitch isn't causing any problems. The backside of the power curve was causing me the problem more than the pitch. The only time he'd feel any lightness would be when he was really trying to swing it on over on an offset or something like that and then the ground effect would cause a problem. If we didn't have the ground effect and that backside, I'd have put it up to 3. But 4+ may be for an airline pilot.

CONFIGURATION 7 PILOT D FLIGHT NO. 168-1

PILOT RATING 9 TURBULENCE EFFECT RATING

Basically, it's a configuration that doesn't want to stop pitching once it is started and you had to watch pitch attitude very closely. It tends to depart in pitch attitude. It doesn't really depart but when you put an input in, it's always going where you don't want it to go. It's difficult to fly straight and level at the trim airspeed and trim altitude. It's relatively difficult to re-acquire trim airspeed or trim altitude. In turns it requires like 80% thrust if you're a little slow on airspeed to hold the altitude in a steady turn. Again, it's not a terribly demanding configuration in the sense you're about to lose control but it's a very unforgiving configuration also. (1) Ease of achieving trim, it's difficult, difficult to know when you've got it. (2) Behavior off-trim airspeed is mostly difficult in that it's hard to re-acquire trim. (3) Maneuvering, attitude control -- you must do it in kind of pulses because once it starts going, it keeps going. Airspeed control is difficult. It tends to keep departing the desired airspeed. (4) Maneuvering in turning flight, the lateral control was fairly good, rudder coordination with the aileron. Altitude and pitch control is poor and you really have to watch that the pitch doesn't depart way out, and airspeed control is required. Maneuvering forces are near zero. Comments following the first ILS approach. All I can say is, this is one S.O.B. of a configuration. It's a handful. I thought it was a lot more controllable in up-and-away flight than it turned out to be. I noticed that in up-and-away flight, I had difficulty flying constant altitude and that the flight path was very sensitive to the airspeed being on. If I used attitude to control flight path, I would be in error and quite a bit in error any time the airspeed was a little bit off. The throttle required is a function of airspeed in order to keep the airspeed from departing. The nominal value was considerably different when you were off airspeed. In other words, I might be 5 knots slow and it's sitting there with 72% to hold level flight. This lack of correspondence between attitude and power setting and what's going on in the flight path is extremely objectionable. When I got on the approach, I was either way low or way high and it wasn't because I started it wrong because I was actually right on when I intercepted the glide slope. I didn't have any trouble initially acquiring the glide slope but then it started off and everything I seemed to do was ineffective in bringing it back until I finally really overpowered it. In a sense I took gross actions and when I did that I went right up through it. I had been low and I went up through it and I became high and then I had to correct that back down. It was kind of like a galloping situation in which I was only partially in control of the situation. So, I think you can tell from the comments that I don't think very much of this configuration. Pilot comments following the second run. I don't know what they gave me on that. That could have been a glide slope error because it did seem the glide slope went off. It didn't go in a step fashion but anyway I did get off on the glide slope as I got close in. The localizer and glide slope tracking and altitude holding on that approach was considerably better than on the first approach. I don't know whether this was a learning effect on my part or what. I did notice that there is an absence of correspondence between the thrust necessary for level flight between the two runs. I'm sure it has to do with trying to engage the system in turbulence. The controllability of the configuration is very demanding on the part of the pilot. You had to stay very tight in attitude with a good strong crosscheck in airspeed and altitude all the time you're trying to fly the approach. Throttle was in that loop too. Heading, localizer, glide slope. You're busy, busy and when I went visual, I had to restrain myself from putting in inputs that would normally control pitch attitude. Instead I put in a little input and waited for something to happen before I put in another one. That seemed to work fairly well until I got down close to the ground. The initial flare seemed to go all right but I apparently had pulled off too much power. I got one glance at my airspeed and saw it was low, but I didn't want to screw everything up by adding a bunch of power at that point when I was entering ground effect, so I just left it that way. Then, the nose started to pitch down and I tried to stop it and I probably had enough control authority but I couldn't do it quickly enough and I think we hit pretty darn hard. Comments following the third approach. The approach terminated in a no-landing because the safety pilots didn't like the attitude. The level flight and initial glide slope and localizer tracking went fairly well. It's objectionable. It required a lot of pilot compensation on the part of the pilot but the throttle activity was definitely diminishing as I was learning to fly the configuration. I think it was more that I was keeping the departures from trim airspeed and trim attitude to small numbers. As long as you do that, this configuration can be handled. Comments following the fourth approach with Beta gust fed to the model. The IFR task was more difficult and more burdensome to the evaluation pilot and I think more troublesome to the passengers because of the lateral-directional response of the model to turbulence. It was significantly different from what the first three runs were like with no Beta gust to the model. If you ask me, is it going to change my rating? I'll contemplate that a little more later but I don't think it would have. Unfortunately, there was an automatic dump below about 200 feet. And so we did not complete the landing and I don't think I can make a valid judgment as to the effects of the turbulence going into the model whether that really affects the results or not without actually carrying it down to landing. Going back to my comments on run 3, on that one it was much like run 2 until I got off the glide slope when I got close in but at least I had it contained. I think I could have safely made a 300 ft ceiling, on that particular approach. In attempting to carry it down to a landing, I over-rotated apparently due to ground effect. The airplane nosed upward and while we were climbing up I added some power and I was going to just re-land it again when the safety pilot took it. So there was no landing on run No. 3. Running through the comments. (5) Localizer acquisition and tracking prior to glide slope interception, a) the performance capability was fair to poor, particularly on the initial one. I had a great deal of trouble holding airspeed and altitude and that detracted from my localizer performance capability. b) The workload was very high because of the altitude and airspeed tasks. (6) Glide slope acquisition, a) the control technique that works best is to nose over to make the required attitude change and then gradually bring back the power. I have a tendency to bring back the power first but the airspeed will diminish too far before I get the nose down if I do the throttle first. Then, the problem is to keep the attitude at the proper value while the flight path stabilizes going down hill. If you are able to keep the attitude close to what you want, then things go fairly well. If you look away and try to worry about your heading and your localizer, then your attitude will get off. The airspeed will get off, the altitude, the glide slope and everything will get off and then you have a hard time trying to get it back. (7) The tracking of the localizer and glide slope, a) ability to maintain is fair to poor. If you could spend all your time on the glide slope without worrying about the localizer, I guess you could do it a lot better but that isn't the task. So the ability to maintain and re-acquire the glide slope I'll have to say is poor. The control of airspeed is fair to poor. b) Localizer is a bit easier and my performance was better. When you attempt to re-acquire it and if you make much of a turn, you tend to screw up your pitch because you have to make throttle changes. c) The pitch task definitely does affect the heading control adversely. d) No unusual use of the display. Just a tight attitude and airspeed and heading control as required and the poor old altimeter really suffers. I don't pay as much attention to altitude as any good pilot should on the approach and all I can say is thank goodness I've got a co-pilot who will be watching it too. e) The control technique, I use elevator to control attitude, throttle to control airspeed and a nominal rate of climb and descent. f) The input required is basically pulse-type inputs to provide the desired pitch rate and a pulse to stop it. g) The resulting airplane motion is poor and not suited. It's too slow and sluggish operating that way. You don't have the precise control of flight path. h) I have that feeling that it is trying to get away from me but if I can restrain myself from putting in inputs, it doesn't really tend to diverge very rapidly but when you're getting close in, you're constantly putting in inputs and you get this feeling that it's definitely trying to get away from you. And trying to keep on that glide slope close in is very, very difficult. I was not very successful, and I usually tended to be low. (8) The ability to correct lateral offset errors on breakout wasn't too bad but pitch control when you're making the turn back is a problem. There is a tendency for it to get away from what you want it to be. The required maneuvering affected somewhat my control of landing touchdown point but it didn't introduce as much error as just the general poor pitch control. (9) Control technique in flare and touchdown was to try to keep from putting in inputs that would bring about the desired result in terms of airplane response without getting too much response which you couldn't correct within the time available. The performance was quite variable as you can tell. The workload was extremely high and the basic problem is the airplane is sluggish and once it gets going you can hardly get it stopped and going in the other direction if that need occurs. (10) I don't know when they gave me the crosswind and when they didn't because I had a natural crosswind. The difficulty is it's just another task that tends to load you up but I was able to correct for the drift well enough that it would have been a safe landing. b) I did use the wing down and c) it had some adverse effect on touchdown point control but just how much I couldn't tell you. (11) The control feel on the elevator - I would like to have seen it with a little heavier forces. At one point I even asked for twice as heavy. Control travel was okay, the breakout forces were not noticeable and the friction was not noticeable. The aileron forces were fine. The control travel was fine. The breakout forces and friction were not noticeable. The rudder forces were okay. The travel was small and okay. The breakout forces were high and I'd like them less but they were acceptable and the friction was not noticeable. (12) The throttle control feel was adequate. The friction level was okay. (13) The flare and touchdown were definitely most degraded by the configuration characteristics. (14) Rough air definitely adversely affected my ability to fly the configuration. There were times that the turbulence was sharp enough that as in a regular airplane, you were jarred from looking at your displays. The turbulence effects on the fourth approach with the Beta gust fed to the model were significantly more significant but I didn't get to carry it to a touchdown. The turbulence primarily causes disturbances to the airplane and caused me problems by upsetting what I'm trying to control. (15) Yes, I could continue to fly this configuration for 30 minutes, but I'd be tired, mighty tired. (16) Configuration rating -- is it controllable? I had decided after the first approach that yes, it was controllable. I had looked through and thought about what I'd rate it and I decided that it definitely was not adequate and therefore intense pilot compensation was required to retain caontol. After approach No. 2 I wasn't sure. After approach No. 3, I would have taken a waveoff and gone around and shot another approach and I don't know whether I'd of gotten it on the ground on that one or not. So, I'm wavering between a 9 and 10 as you can see and so I have to answer the fundamental question, is it controllable in the mission? And I think I'm seeing it under fairly severe circumstances. It certainly isn't adequate performance and I think I will rate it as being controllable, definitely not adequate and a rating 9. And the primary reason for the rating was the pitch control. The inability to control the flare and touchdown portion with enough accuracy to be reasonably sure of making a safe landing, not an adequate one, a safe one. The second most objectionable one is the control of the IFR portion in pitch. I thought that was definitely not adequate there. I would rate it unacceptable for an IFR approach. I wouldn't be too much concerned about the controllability. Controllability concern comes from the flare and touchdown. b) The best feature, I guess the roll control characteristics. I forgot to give the turbulence effect rating. I didn't see it without turbulence. So it's kind of hard for me to answer this increase of pilot effort with turbulence but I think it causes the best efforts to be required. The deterioration, again it's difficult to talk about it and I'm guessing. I think it is at least moderate and perhaps major. I'll call it an "F". It almost could go down to a "G". I would like to know what to rate it with the turbulence in but I didn't carry that to a landing so I'll ignore that so I'll say "F".

CONFIGURATION 2 PILOT D FLIGHT NO. 168-2

PILOT RATING 6-7 TURBULENCE EFFECT RATING

Pilot comments following the up-and-away portion. I made that very, very brief and all I can tell you is that it flies better than the last configuration by a significant amount. It's still slow and sluggish in pitch but the control of altitude and airspeed is substantially better. The control characteristics seem reasonable. By that I mean the feel and gearing. (1) Ease of achieving trim, I didn't pay too much attention to it. It looked pretty good. By pretty good, I simply mean by comparison to the other one. So for what I looked at it, I'd have to say it's fairly good in ease of achieving trim. (2) I didn't really look at it too much off airspeed so I can't answer very well but none discerned. (3) Maneuvering about level flight, attitude control is sluggish but appeared adequate. Airspeed control - you had to add a lot of throttle in turning flight. Airspeed control was adequate. (4) Maneuvering in turning flight, lateral control was okay. The altitude and pitch control was sluggish. Adequate airspeed control took a lot of throttle to keep it where you wanted it but I was able to do it. Maneuvering forces were relatively light. Evaluation comments following the first approach. This is definitely a more controllable configuration than the preceding one but it's still a handful in this turbulence that we have. That time I noticed the ground effect for the first time independent of other inputs. On those other approaches I couldn't tell what was ground effect and what was the result of inputs that I had put in a few seconds before. The approach went fairly well in the sense that I was able to bound the excursions and when I got off, I could get back on. Down hill on the approach, my glide slope following was very much better. The throttle required in straight and level flight was about 61 to 62% which is a variable from run to run. I just have to recognize the fact that a given percentage doesn't call for level flight from run to run. The localizer tracking was demanding but adequate. The glide slope tracking was demanding also, but adequate. About the time I got to the breakout altitude, I was beginning to feel the workload and if I hadn't broken out soon I probably might have wanted to go around and try it again and this is in the real situation. But when I broke out, I went visual, and flew it down. There is hardly any crosswind so that wasn't a problem. Lineup was not a problem. I flew it down and flared it and I definitely felt the ground effect. I was a little behind the pitch attitude in countering the nosedown pitch but I don't know what my sink rate was but it seems safe and okay to me. It was probably a little hard but it was safe. Comments following the third approach. Things were all screwed up on that approach and I don't know how I'm going to rate this configuration or even how meaningful it's going to be for me to try to do it but I will go through the comments on the third approach. The localizer and glide slope tracking on that one was lots better, really unlike the second one and basically I stayed on pretty close. I was able to make small corrections and correct errors it was all good. It was slow and sluggish in its pitch response and I had to fly tight pitch attitude but again it seemed to work and I carried it down to the breakout. I didn't lose my pitch attitude particularly in the lineup correction turn and carried it on down. I had a little feeling that I was behind the airplane and I used the marks on the windshield. Maybe that's what happened anyway. I stabilized it in pitch and I over-rotated once in the flare. I didn't climb back up but I just held what I had and I felt behind the airplane but enough in control that I thought I knew what it was going to do next. Then the airplane started on down again and I kind of held what I had, except I added a little bit of back elevator and we got a touchdown. I had a crosswind from the right. I put in a crosswind correction and it seemed to have a minimum of drift at touchdown. That configuration was most unlike the one before it. So, I don't think it's really fair for me to try to rate this thing. If I ignore the second approach, I would say it was a controllable configuration and it might be in the vicinity of a marginally adequate performance. In other words, I use either barely adequate or just inadequate. In other words, it was down around that boundary somewhere. But that second approach would make it a question of controllability. However, thinking that it probably would be controllable if I had made three approaches with it, it was definitely not adequate and it would have been probably somewhere down around an 8. So you can see that I have enough variability there that I don't think that it means very much if I attempt to do much more than comment as I just did. I should note that on that last approach, the trim angle of attack indicated on my meter was about around 10 to 11°. Turbulence was so strong that I never did get all that steadied down so I could pin it down exactly. We were between 10 and 11°. I saw 10 probably more than 11 and the power required in the approach seemed a little high. I'm not real sure of that last comment on the power. So, I think the configuration that you were trying to give me that time was a more controllable configuration than what I saw before and it probably is somewhere around the adequate boundary and which side it would be on I'm not sure. If I didn't see approach No. 2, I'd probably say it was on the adequate side of the boundary and probably rate it as something like a 6 but I don't know.

CONFIGURATION 14 PILOT A FLIGHT NO. 169-1

PILOT RATING 4 TURBULENCE EFFECT RATING C

Trim was no problem. It was easy. The configuration is almost stable. It's either just neutrally stable or just a little bit unstable. It depends on what kind of input I'm putting in, but it's almost neutral stability. The objectionable behavior was it didn't seem to want to go back to trim. No real objectional behavior off trim airspeed. It just didn't announce that it was off either by being unstable or stable. There was a tendency to overcontrol in g when maneuvering about level flight. Attitude control was just a minor problem. It appeared to be almost a pitch rate. The stick force per g appeared to be positive but you did tend to overcontrol in pitch and overdo the g a little bit. Airspeed was a fair amount of problem. It took a lot of throttle to recover the airspeed. It looks like high induced drag. Localizer acquisition and tracking and glide slope acquisition and tracking were no problem at all due to the configuration. It appears that an elevator input causes almost a rate displacement when you stop. It just coasts to a stop so you usually just do a little bit of a doublet. A little bit of elevator to counter the motion and then it stops. It almost stays where you put it so the big workload problem on all of this was the power control for airspeed. It seemed to be a backside and the pitch task had minimal effect. I did tend to overcontrol a little bit when I was pulling g's. I noticed that for the input used, the airplane's response was desired. I got a desired response except for some overcontrolling when I'd forget to reverse the elevator to stop the rate. The airplane didn't seem like it was really trying to get away from me except when I was making large maneuvering. The lateral offset errors on breakout were no problem even though I had to maneuver into the wind. I was downwind on the offset so that made it a little harder to get back over to the runway. Regarding the flare and touchdown, I made a little bit of an over-flare because I didn't back off on the force but that's minimal. Crosswind landing was no problem because I used a sideslipping approach and there was very little effect on rate of sink rate or touchdown point. Control feels aren't changed. Throttle feels aren't changed. The airspeed was most degraded by the configuration. Turbulence effects we'll call it a "B" or a "C", make it "C", a minor deterioration in task. Very minor "B" or "C". Yes, I could continue to fly this configuration for 30 minutes in turbulence doing landing approach tasks. I picked a 4. I was toying between a 3 and a 4 on the configuration so we called it a 4. It's on the high side of a 4. The reason for the rating is that the nose tends to stay where I put it and it just takes a little bit of a doublet type of maneuver to stop it. It's almost a rate command with the elevator. I was toying between a 3 and a 4 on it and I put it as a 4 to compensate a little bit more for the airline jock. He might have to work harder because he wouldn't be used to it.

CONFIGURATION 16 PILOT A FLIGHT NO. 169-2

PILOT RATING 10 TURBULENCE EFFECT RATING E

It's a backside and it's a strong instability. It's very difficult to trim the airplane and as soon as you get off trim, it just accelerates in pitch away from the trim point and it requires a lot of elevator deflection and a lot of not real high but fairly good stick forces. It takes high forces and large deflections to stop it. Then, if you aren't very careful with it and you're not able to stop it, you'll start it going the other way and it will go right back to trim. For control of pitch, you almost glue your eye to that attitude indicator for this configuration. About everything that is done in level flight requires a lot of attention to the attitude indicator. You have to watch the power too, so the workload is real high. Maneuvering in turning flight, it feels like it's almost neutral on stick force per g. I'm so busy maintaining that pitch attitude to try to keep it from oscillating in g that it's a difficult task. A wind-up-turn is a difficult task with both the airspeed control and the pitch attitude. The pitch attitude requires most of the increased workload but the airspeed is right there with you causing you problems. That's a grossly unstable configuration along with being a backside. I used a technique of dropping below the glide slope for that very unstable configuration and setting up a little bit shallower approach. Then I eased it down slowly so as not to go into those wild PIO maneuvers. By using this technique in the ground effect, I had time to compensate for the ground effect. I could ease it down and float it a little bit, a little bit of PIO'ing but not the wild PIO'ing I've seen before on the touchdown. It seemed an easier task than some of the runs I had the other day but it may be the atmospheric change in the turublence level but it seemed to work that time. As for localizer acquisition, there is a good chance that you'll just drive on through it. You realize only at the last minute that the localizer needle is off the peg and then you turn, because most of your time is spent watching the pitch attitude. You try to fly the pitch and airspeed, pitch and airspeed in that order. The workload is increased. The localizer task adversely affected the altitude performance because you spend so much time maintaining the airspeed and pitch attitude that you can't watch the altimeter. It's just that simple. You catch it every once in a while but you're busy. Regarding glide slope acquisition, again, just maintaining control of pitch attitude, and keeping it within a little sloppy boundary and keeping the airspeed under control - matching those two, you tend to not pay as much attention to anything else. Everything degrades, just everything, because you're spending most of your time maintaining an attitude or trying to maintain an attitude and then trying to keep that airspeed under control so the whole problem just degrades at this level of instability. That was the problem all the way through and not just when acquiring it. You would PIO a little bit going in when you're acquiring the glide slope but everything is muddied up by the instability because you just have to devote most of your time keeping the pitch under control. Then, what little time you have left is used trying to maintain airspeed and then occasionally to glance at everything else. But you can herd it down obviously. The forces and deflections are so high, due to the instability, that you have to trim. I trimmed an awful lot and the trim rate is slow for this bad of an instability. It's too slow. I had to hold the trim and while I was holding the trim my attention was diverted and everything else went "haybag". So just anything like smoking or anything else just blows the task. The airplane motion is not suitable to the task at all. You have to pull it up, stop it, stomp it, and then it's almost instead of a doublet, it's a quadruplet or sextuplet trying to get away from you and it will if you're not extremely cautious. I had more trouble with an offset on this one than the last configuration I flew today because I would PIO in pitch, if I racked it up very much. I knew I'd have more trouble and it did adversely affect the touchdown point. But it may put you shorter because if you happen to dive out of the turns, it might put you down lower. You can't control it precisely. The maneuvering has an adverse effect. It is noticeable. The difficulty of the crosswind is a minor additional problem. It is just a pitch, pitch, pitch, pitch, pitch, and airspeed. The flare is all the pitch problem just wrapped up tight. Control feel: The forces feel higher because of the instability but the trim is too slow. The elevator trim is too slow because of the high forces, higher deflections required to control this thing. And when I'd get a little off and I was holding the force and had it stopped I'd have to wait. It was poorly harmonized between the trim rate and the instability. Throttle control, friction and feel, is unchanged, but the thrust lag causes more of a problem in this configuration than any other because I can't pay as much attention to the throttle. The rough air just excites it. What turbulence there is just starts it off. As soon as I can stop it, the turbulence just starts the airplane going and away it goes on you. So it accentuates the problem. It was light turbulence. Yes, I could fly it for 30 minutes but I don't think the average airplane pilot could. And that's an egotistical thing. Turbulence effect rating would have been "E" on that. An "E" for turbulence, because it is constantly exciting the instability. As far as the pilot rating, first of all, I've already made up my mind that that's a 10. I don't think the average airline pilot could be expected to make a reasonable approach and landing. He would lose control somewhere during the approach or landing and there's just no way around it. The instability is at such a level that any distraction at all and he'd be out of control and depending on where he was, he might get so wrapped up that he couldn't regain control before he hit the ground. It's just that simple. One thing I meant to comment on is about the fact that I could give up a little runway distance and make it ease into ground effect to get the thing down without some of that PIO'ing that I had.

CONFIGURATION 20 PILOT A FLIGHT NO. 170-1

PILOT RATING 3 TURBULENCE EFFECT RATING C

The trim is easy to achieve. No objectionable behavior off trim that I could see. Maneuvering about level flight is pretty easy. The airplane appeared to have either neutral or maybe slightly positive stability longitudinally. If it is unstable, it's very light on stability. The maneuvering, had a positive stick force gradient. I took it to 1.4 g. No problem at all. Pitch control was no problem. It seemed like a pretty easy airplane to fly. Maneuvering forces were moderate, I'd say. Airspeed control wasn't any problem in the wind-up-turn so it appeared to be a pretty simple airplane. Workload is minimal. No problem at all. The localizer appears to be a little bit squirrelly instrument-wise. Localizer acquisition or tracking is no problem at all. The configuration is good enough to where the only problem is the lateral-directional. The adverse yaw, I just lead with the rudder. The same configuration lateral-directionally that we've seen before. Glide slope acquisition just ease the nose down and re-trim and workload is minimal. Power and airspeed was very little problem. It was just no big workload at all. The tracking was relatively easy to maintain as was re-acquiring the glide slope. Airspeed was very little problem. I had a tendency to be a little sloppy and let it go high a little bit but other than that no problem. By high I mean six knots, maybe seven. I don't think I got over that far on the high side. On the slow side maybe two or three knots was about as far as it went. The pitch task did not affect the heading control adversely. No unusual use of the display. I used almost a routine crosscheck, or instrument crosscheck. No problem. Elevator was controlling pitch and throttle was controlling airspeed sink rate. No problem at all. Bare minimal task due to the configuration. The biggest problem was the lateral-directional on the lateral offset approach with the turbulence but it was no big problem. Just kind of ride through it, just a little added workload. Not much. It's almost a rate input on the elevator, just ease the nose down, the forces are moderate and no problem. The resulting airplane motion was quite suitable, just push it over until you hit it. The only place I have a little bit of trouble was in the flare, I'd overcontrol a little bit and porpoise just a little bit on the end of flare. It doesn't feel like it's trying to get away from me. The lateral offset was no problem at all. It's just the lateral-directional characteristics are the worst thing -- the worst part of this configuration and that's not real bad, it's just poor. It's not desirable lateral-directionally. Maneuvering might have affected the touchdown point but I don't think it affected the sink rate. Making the offset probably did put us a little further down the runway on touchdown but that's nothing gross, I don't believe. A little bit of porpoising, a little bit of overcontrolling in pitch during the flare on that configuration. I was pumping the stick a little bit in ground effect trying to maintain the attitude I needed to let the thing touch. But other than the first one when I touched down too soon, the sink rate's are like around 2 or 3 ft per second. No problem. I used the wind-down, sideslipping approach with the crosswind and there was no difficulty at all. I don't think it affected the touchdown rate. I think the maneuvering had more affect on the touchdown point than the crosswind. Control feel, no change that I can detect. The breakout and the gradient seemed about the same. The only noticeable difference was that there was a definite positive stick force per g on a wind-up-turn, so that the forces, the feel system for this one is pretty good. Throttle is unchanged. In fact, the most degraded part of this one is lateral-directional. The turning wasn't as precise as it should have been especially with the turbulence on the last configuration. About the only bad characteristic is the lateral-directional, not as good as it should be for a good flying airplane. The turbulence rating on that one would be "C" minor deterioration of task performance. The configuration itself is definitely controllable. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement?, well, you ought to improve the lateral-directional. The only problem is, I'm undecided between a 3 and a 4. For a really good airplane, I'd say you'd have to improve the lateral -directional to make a good airplane out of it but from a pitch standpoint, the only place that I did any bumping at all was in the ground effect. You can probably improve the damping a little bit or something and make it better. I'd give it a 3 I guess. I don't think anybody would have any trouble with that one. So make it a 3 and a "C" for that configuration. The most objectionable feature is the lateral-directional response of the airplane. Also, I would add the adverse yaw to aileron inputs. The least objectionable, the best feature of the configuration is that I kind of like the way it handles in pitch. I think I was going to make a comment about the elevator control power in the flare. I was overcontrolling a little bit in the flare. It's almost neutrally stable. It looked like it was just slightly positive stability. I couldn't separate it out whether it was the ground effect or what but I was overcontrolling a little bit in flare and getting into a little bit of PIO'ing. So it looked to me like there was plenty of elevator power. I couldn't tell you whether you should decrease it for the flare or not because that kind of thing depends on too many other things. The only thing that I had trouble with was the lateral-directional handling in the flare and I was overcontrolling in pitch.

CONFIGURATION 10 PILOT A FLIGHT NO. 170-2

PILOT RATING 5 TURBULENCE EFFECT RATING D

It's a very slow divergence. I really didn't play with the trim much on that one. It's lightly divergent. Very little trouble with the trim on that. It didn't do much with the trim. It's so lightly unstable and you think you're in trim anyway. The forces were quite light off trim speed. Level flight looked like it wouldn't be much of a problem with the configuration. Airspeed didn't seem to be too big of a problem. Maneuvering was light forces for the g. I went right on up to 1.4 g. There was very little stick movement. It looked like we had lots of available elevator power on that one. The maneuvering forces were quite light and there is a tendency to overcontrol in pitch. Localizer acquisition and tracking, there is a slight increase in workload due to the pitch because I had to pay more attention to pitch, and airspeed was a little harder to control. It seemed to take a fair amount of power to get it back. I was invariably a little bit low when I went on the system and had to climb back to 1800 which is fine, but I wound up almost 10 knots low, about 8 knots low and didn't really recover until after I was back up at altitude, which is an inefficient way to do it. At least we got back. Slight increase in workload. The localizer wasn't any problem on altitude. It's just that pitch makes a little more work, not much on the altitude performance task. It just required a little more attention to the pitch. Acquisition of the glide slope was no problem. Again, you have to pay more attention to the pitch and it tended to wander a little, but I don't think that the workload caused much degradation in the performance on the acquisition. There's no big problem acquiring, maintaining or re-acquiring the glide slope. I got off a little bit and airspeed required a fair amount of attention. Airspeed required a fair amount of attention but the main thing was that I had to change my cross-check a little bit to maintain the same level of performance. I had to pay more attention to glide slope and to maintain pitch attitude, and I tended to over-control in pitch. The pitch attitude didn't affect the heading control much except it did detract just a little bit because of the attention that you had to pay to pitch. It reduces the time for everything else. Control technique on the throttle was a big step input to get airspeed or rate of climb, whatever I wanted to do, airspeed mainly, and then come back to about where it started it out. Elevator input consists of a light push, then something to stop what you started. The elevator seems almost a rate controller. If we go back to neutral you almost stop and you just tend to overshoot just a little bit on pitch. The airplane motion is not as good as it should be for the task that you're trying to do in pitch. It overshoots a little bit. You have to stop it and it's not real suitable. It just detracts a little bit from the task. The airplane does feel like it'll wander off in pitch. Of course the bank was doing the same thing with the turbulence that we had. No big problem on the offsets. You just have to be careful with that pitch while you were doing it. There was a tendency to overcontrol as you pull the nose up or down in the turn. If you do the maneuvering too late, it's going to affect your touchdown point. It depends on when you break out. It just takes so much time to do an S-turn and if you're worried about the pitch, you have to be careful not to dive it into the ground. This configuration caused very little problem in turning because I only overcontrolled it a little bit and I'd feel the g and then back off on it. I watched the nose. No gross effect on the touchdown point or sink rate. There was some overcontrolling on the flare. A little more workload than a normal airplane would be but it was controllable and it just required a little adaption to the different technique of doing it. Crosswind landing was no problem at all. A little overcontrolling, but that's always been a pitch problem. I don't think the crosswind had any effect on the sink rate and it might have made the touchdown point a little far down the runway but not much. The breakout forces for this configuration and elevator may be a little high. That and the hysteresis might be part of the overcontrolling problem although they appeared to be unchanged from what we've been used to. Throttle control feel, friction is unchanged. No problem. The whole problem is degraded because of the instability of the nose. The overcontrolling of the nose requires that you pay more attention to the attitude indicator. So although it was an acceptable task, I had to keep it within reasonable limits on the ILS. You degrade the whole problem because of the increased attention to pitch, and also the increased attention needed on the airspeed for this configuration. No single thing, it's just an overall workload. The rough air excited both the light instability and the lateral-directional characteristics. It just increased the workload to watch it. Again, an increase in the workload to keep the wings level and maintain your heading but the turbulence effect rating is a "C" or a "D". Call it moderate. Make it a "D" on the turbulence and for this configuration it just excites the pitch problem and excites the lateral-directional. Now as far as the airplane, you could do this for 30 minutes. No problems. Just a little more work. Configuration rating - is it controllable? Yes, it is controllable. Okay, yes on the second question. I'd say yes. Performance is attainable with a tolerable pilot workload. It wouldn't be satisfactory without improvement, I don't think. I'd put this somewhere about a 5 or 6. For an airline pilot, let's try 5 which is considerable pilot compensation for the average airline pilot. So make it a 5. I don't know whether it would be moderate or considerable so we'll make it 5 D. The most objectionable feature in the configuration is that it required a little more work than you would like to see in pitch, a little more attention, and there was some overcontrol in the flare although the touchdown was never in doubt. Not that you were going to make a reasonable landing. I think the best feature of this configuration is that it's almost a pitch rate controller on the elevator but it does tend to wander a little bit and you tend to overcontrol with the elevator power that you have.

CONFIGURATION 6 PILOT A FLIGHT NO. 170-3

PILOT RATING 4.5 TURBULENCE EFFECT RATING C

It was very light off trim and I didn't have any force to speak of even though I was 10 knots off one time. I didn't realize it. So that's one objectionable behavior off trim speed, almost neutral stick force, almost no stick force gradient. Level flight maneuvering didn't appear to be any problem. Airspeed control looked like it could be a problem. It got 10 knots off and it took a heck of a lot of power to get me back but it just looked like it might be a backside, a little bit of a problem. Maneuvering in turning flight, I got what looked to me like a stable point and it was either zero force or a light push force, either zero stick force per g or slightly negative stick force per g gradient. And it appeared to be a stable point. For airspeed control it took lots of power and lots of nosedown in the turn. Pitch control is touchy and appeared to be either neutrally stable or it kept going. It was unstable and diverging to a fairly good pulse at a fair rate but the real light pulse didn't seem to do much to it. I only made one approach on that configuration. It was a funny one. There wasn't much of an increase on workload due to the pitch. I had to watch it fairly carefully just to make sure that nothing got out of hand but it was kind of a weird one. Trim didn't appear to be much of a problem. I trimmed a few times on final after I pushed over and I had very little problem on trimming. Localizer acquisition and tracking prior to glide slope interception was no problem. Maybe a slight increase in workload due to the looseness of the pitch but I didn't think it tended to wander quite as much as the configuration before this one. It tends just to stay where you put it more or less and I didn't make a big change in the crosscheck. It was loose but it didn't seem to be wandering off all the time. I had plenty of time to observe everything else that was going on and take care of the airspeed etc. I didn't appear to be spending too much time on the attitude indicator. Glide slope acquisition was no problem. I had plenty of time to check the airspeed and to get it back on before we got down low. On tracking there was no problem on the ability to maintain and reacquire glide slope. Control of airspeed required a little work but not a lot. Once I got the power set some place, it tended to stay there fairly well. Ability to maintain and re-acquire didn't appear to be much of an added workload for the configuration. Pitch task didn't appear to be bothering the heading control. The turbulence caused more problem on heading control than the pitch task. Very little unusual use of the display, maybe a little more attention to attitude but you'd almost have to run an eye movement check to find out. Elevator for pitch and throttle for airspeed mainly and sink rate but the pitch kind of takes care of itself. As for the input, there's so much turbulence, just ease the nose up almost to stop it, and it then kind of just stays there. There is very little wandering. The resulting airplane motion is reasonably suitable to the task. The airplane motion I got was probably about what I was asking it to do. I didn't overcontrol it too much. It didn't feel like it was trying to get away very much, if it was trying it at all. I could look away without having to rush right back to that attitude indicator, at least on the basis of one approach. I didn't do an offset. There was a little bit of oscillation in the flare and touchdown, a little bit of PIO'ing. Crosswind was no problem. Wing down, very little effect, little or no effect on sink rate or touchdown point. Control feel is unchanged. I don't know if that elevator breakout is causing me any problems or not. Throttles were unchanged. I really can't answer which of the required evaluation tasks was most degraded. It wouldn't have been much. I didn't notice much of a change in what I was doing. I may be basing this on my last three approaches before this one and I did notice a change but it might have been that more attention had to be paid to the pitch control but not to pitch, but it didn't tend to wander off too much. That would be the most objectionable. The turbulence is causing lateral-directional oscillations which are just as undesirable as the pitch. No problem on turbulence. The turbulence effect rating is "C" based on one approach. Put about a "C" minor deterioration because of the configuration. And if I have to make a configuration rating, it is controllable, I think you could get an adequate performance out of it. Somewhere between 4 and 5. That would be hard to say, 4 or 5. So we'll decide 4 probably on that one if I had to pick one number, then 4+ maybe. It wasn't as hard as the last one. 4 -- that's on the basis of one approach. The reason for the rating was that I didn't have to spend a lot of time with pitch. I had plenty of time to just wander around, crosscheck around the instruments and pick up everything else but that's on the basis of one approach during which we did have a crosswind and we did have turbulence in there. Lateral-directional was disturbing me as much and that turbulence was disturbing me as much as the instability but it was just a minor deterioration of the task due to the turbulence.

CONFIGURATION 6 PILOT D FLIGHT NO. 171-1

PILOT RATING 8 TURBULENCE EFFECT RATING C

Pilot comments following the up-and-away maneuvering. General comments are that the air is relatively smooth and in the smooth air, it's a flyable configuration. The little bit of instability imparts a very slow tendency to diverge in attitude and a little more of a tendency to diverge in airspeed. I am able to maneuver the airplane in g fairly well and there is a definite lag in the g response but it's not as bad as some I've seen. I am able to fly level. It does require considerable attention to airspeed. These are the comments. (1) Ease of achieving trim? It's fair. I have to stabilize it but it is possible. I can achieve the desired airspeed and altitude. (2) Behavior off trim airspeed, the main objection is it takes more throttle when you get slow, quite a large amount of throttle to get the airspeed back. (3) Maneuvering about level flight, attitude control is fair. You can achieve the desired attitude but you had to monitor closely what you do achieve and particularly you have to watch the airspeed for fear that it will back off and get slow on you. Altitude control is also fair. I was able to maneuver back to my desired altitude and stay there fairly well. It's the kind of configuration that requires a reasonably tight scan pattern to stay where you want it in terms of level flight but you can look away and attend to other things for short intervals. (4) Manuevering in turning flight, lateral control is fairly good and requires a little bit of rudder with the aileron. The rudder breakout forces are noticeable and somewhat objectionable. The altitude and pitch control is fair. The turns require a fair amount of attention to pitch control and to pitch attitude and to airspeed in order to make it go where you want it to go. The maneuvering forces are very light. Pilot comments following the first approach. That approach was made in what I would call light turbulence and the turbulence itself was not a particular problem. The approach went fairly well. I over-compensated in acquiring the glide slope. In other words, I acquired it low so that I had to climb back up onto the glide slope and everything held fairly well. The major problem was the tendency of the airspeed to get low which required throttle corrections to get back. So everything was fairly normal down to becoming visual at 300 ft. It is a relatively high attention configuration. You didn't want to look away too long. But after I went visual, I had an offset to the right. I made a lineup correction back. I almost overshot it and I was a little high down to the flare altitude, but I made the corrections fairly well. I leveled off high and I pulled off too much throttle, the airspeed got low and when I expected to be on the ground, I wasn't. The airspeed was getting lower and lower and then the nose pitched down and I told the safety pilot to take it because I just ran out of elevator control. I think the major problem was that I pulled off too much throttle and so it was a pilot technique problem rather than a configuration oriented difficulty in the fact that I didn't actually complete the landing. Second approach. That one was a real IFR approach because when he called 300 ft and I went visual, I couldn't find the runway. It was not in sight until we got down to about 200 ft. So, everything at that point had gone fairly well. It's a moderately high workload configuration staying on the glide slope and correcting errors. I had a high glide slope error to correct that time and that required pulling an awful lot of throttle off but I was able to do it. It was moderate difficulty. I didn't have any real troubles until I went visual and got close to the ground and I had a definite tendency to PIO in pitch. I overcontrolled and I had to kind of grab hold of myself and force myself not to put in too much input. In other words, I had to generate some lead and in so doing, everything went fine until I got down. I flared a little high and then I came on down a little more and I felt like I should have been on the ground but I didn't get the touchdown. Either I've forgotten what this thing looks like at touchdown or else we're low. I have to assume that it's me and my perspective and that I'm landing this thing nowhere near the ground contact. I'm sure I'm 20 ft off in my perspective and I really wonder if it is all me, because when 50 ft was called I know I went down at least 50 ft from there. I thought that was going to be a good landing and I hadn't even touched down. Then this ground effect comes in real strong and pitches it down as I'm trying to get the nose down to lose that extra few feet. I yelled take it again because I can't stop it once it gets going. Pilot comments following the third approach. That one was successful down to a landing. I'm not so sure that it was a very great sink rate and I had one wing down a little bit but at least I found out where the ground was. That approach was characterized by being high and fast part of the time and a typical backside operation. It's hard to correct. It requires you to pull off so much throttle which you're kind of unwilling to do. So it takes a long time to get the airspeed back for the kind of throttle correction I'm willing to make. But the IFR portion went all right. It's a high workload task but this was in real IFR. I had my hood down but when I went visual I didn't have the runway momentarily. When I went visual, the indications in the cockpit were that I was pretty near on but I had a definite offset to the left. Strobe lights were to the right of me and by the time I acquired the high intensity approach lights, I was fairly close in and yet I still could make the lineup correction comfortably. I was noticeably more comfortable with the configuration on that approach in that I did not overdrive it nearly so much and my corrections were smaller. I suspect that this configuration is one that I would be happier with heavier elevator forces, because then I'd be tempted even less to put in sustained inputs like I have a tendency to do. I proceeded with the approach down to the flare and as I said, I wasn't happy with my lineup on the centerline of the runway. I was really concentrating on flying the airplane in attitude,that is, I was preventing the attitude from starting to depart and in so doing I found that I was able to carry it all the way down to touchdown. The perspective appeared about right when I touched down so all I can assume is that on the first two appraoches the reason for flaring high must have been attributable to the evaluation pilot's loss of perspective of the height at touchdown. I think I have it back now. I think we need also to take note of the fact that when you do have that problem, this airplane can become a bear. So you don't want to let that airspeed get slow or otherwise you just don't have enough control to stop the nose pitch down in the ground effect. So it's kind of good I made the mistakes. I'm going to make one more approach now that I've learned where the ground is. Evaluation pilot comments following the fourth approach. I really think this configuration needs heavier elevator forces. Part of my problem is putting in inadvertent inputs when I'm controlling the airplane in roll. When I have a crosswind and I put the correction in, then I was also putting in elevator inputs that made it difficult for me to make the attitude come out the way I wanted it to. The approach in up-and-away flight was about the way the other approaches have been. Again I had a tendency to be fast in the initial part of the approach and it was difficult to correct the high and fast. I did get it back and the conditions at breakout were nominal as far as my instruments said. When I looked up, I appeared to be just about on the centerline but with a crab of the nose to the right which I interpreted, of course, as being a crosswind from the right. I had been carrying about a 5° drift correction most of the way in. From visual on, I tended to be high. I looked down at my airspeed several times and tried to make sure I didn't get too low on airspeed but I did have the perspective feeling it was high. I kept coming down and it seemed like I was eating up a fair amount of runway trying to control the airplane in ground effect and as I came in to ground effect, I thought I had the touchdown but I didn't. I apparently held off and then the nose started down on me. When you get behind the nose, it takes a long time to get your corrective elevator input to produce a result. So you get this terrible feeling of the nose pitching down away from you and you're pulling back on the yoke. I don't know what the touchdown sink rate was but I didn't like it and as a pilot I don't like that out-of-control feeling that I had. So I have flown enough approaches with this configuration, I think, to identify my piloting difficulties with it and I think I don't like the configuration. I don't like it particularly in combination with the ground effect. So we start with question No. 5, the localizer acquisition and tracking prior to the glide slope interception. a) The performance capability was fair. The workload is moderately high and the localizer task did disturb my altitude performance somewhat. It is not easy to fly constant altitude because the airspeed tends to go one way or the other, as you try to make a correction in altitude. It's not like an ordinary airplane which you can fly up to the altitude and then settle it down immediately at that new altitude. Even though you know the power setting required, it's hard to get everything back, the attitude and the throttle setting and the airspeed and the altitude and the rate of climb zero. (6) The glide slope acquisition, on the first approach I was low on the glide slope initially and the rest of the time I was high and tended to get fast. So, it's not an easy configuration at all to intercept the glide slope but it's adequate. You have to positively nose it over and make sure you get back on the power before the airspeed increases very far. The performance capability is fair and the workload is moderate. (7) The tracking of the glide slope and the localizer, a) ability to maintain is only fair. The control of airspeed is somewhat difficult. There is a tendency to get fast. b) Ability to maintain and re-acquire localizer was fair and the only problem was the attention that this pitch task required which tended to detract from holding your heading. c) Pitch task does affect the heading control adversely. d) No unusual use of the display. e) Elevator was used to control attitude and throttle used to control airspeed. f) Input required to produce a desired response is a nose up input and then if you're smart, you take it out again and let it respond. I usually get into trouble when I attempt to pull it to where I want it to go and then it goes too far. g) Resulting airplane motion is only fair. I don't get the motion that I really want all the time, just some of the time. h) Yes, the airplane feels like it's getting away from me unless I am continuously controlling it although I can look away for longer periods with this one than I could with some airplanes that I've flown. (8) Ability to correct lateral offset errors on breakout is fairly good. You had to pay a lot of attention to the pitch task though to make sure that it doesn't get off. The reason I think I got high was that I would get a little nose up during the lateral offset correction turn and consequently would get high up off the glide slope. And it did affect my control of touchdown point by making me long. (9) Control technique in the flare and touchdown, what I tried to do was to maintain attitude carefully and make the airplane work its way on down in altitude. My imperfection was mostly in controlling pitch attitude. The workload was moderately high and it got higher the closer I got to the ground. The ground effect was very noticeable close to the ground and there was a tendency to nose me down into the ground. I found that I usually was behind it in my corrections. (10) The crosswind landing was not difficult due to the lateral characteristics but it is difficult in pitch due to inadvertent inputs. b) Wing down, c) it did affect adversely my sink rate and touchdown point control. (11) The control feel, the elevator is very light except for that final nose down pitch in the ground effect. I think other than that I would like heavier elevator forces. The travel is moderately small and the breakout forces are small. Friction is not noticeable. The ailerons are light and good, the travel is small. The breakout forces are small and the friction is not noticeable. The rudder breakout forces are objectionably high. The gradient forces are reasonably light and acceptable. The travel is small. The breakout forces, as I said, were high and the friction was not noticeable. On that last approach, I had trimmed the ball in the center because we didn't engage with the ball in the center. The right rudder bothered me during the approach primarily because of the high breakout forces. (12) The throttle control feel was basically good. The friction is reasonable. (13) The flare and touchdown was most degraded by the characteristics of the configuration. Yes, I could fly this in turbulence. (14) The rough air did not particularly bring out anything other than what it was like to fly it in turbulence. (16) The configuration rating is yes, it is controllable. And the next question is the hard one for me. Is adequate performance attainable with a tolerable pilot workload? And the answer to that is definitely yes for everything except the final flare and touchdown. In that regard, for my level of training that I achieved here in these four approaches, I'd have to say the answer to that is no. But, I will admit that I am not fully trained and with training I can improve. I noticed a definite improvement as I went along. And what bothers me is how well trained is the pilot going to be when he first does this? I've been practicing these configurations and this task off and on for several weeks now and yet I haven't flown for probably four or five days and I had a significant amount of difficulty. So I have to say that adequate performance for this configuration for the flare and touchdown with this ground effect is not attainable with a tolerable pilot workload. The deficiencies do require improvement. I don't feel I'm about to lose control of the configuration on those flares and touchdowns where I was out of control. Certainly intense pilot compensation is not required to retain control except possibly for the flare and touchdown but with those, I think I'd just have gone around and set myself up better for another approach. I think I made two landings out of four and I think I can do better than that. Because part of my problem is my perception of height I'll exclude the rating 9 and say it's either a 7 or an 8. The only time I felt like I was losing control was on that final nose down pitch and so I'd say loss of controllability is not in serious question. I'm not sure whether it's a 7 or an 8 and I think that considerable pilot compensation is required to control. I hate to say that controllability is not in question on the basis of my performance. I think I'll rate it an 8, considerable pilot compensation is required for control. In turbulence more effort was required but there was minor deterioration in task performance. I think I'll say the turbulence part is a minor and make it a "C". The most objectionable feature of the configuration is the pitch control in the flare and touchdown and/or altitude and sink rate control in flare and touchdown and b) the least objectionable with this would be the lateral-directional characteristics.

CONFIGURATION 16 PILOT D FLIGHT NO. 171-2

PILOT RATING 10 TURBULENCE EFFECT RATING F

I'll say it's a very unstable configuration. Speed unstable. It looks like everything's unstable almost. You get slow on speed and you end up with very heavy forward pressure and vice versa, high on speed, heavy back pressure. Okay, (1) Ease of achieving trim is very difficult. (2) Objectionable behavior off trim due to high forces you're holding and you're trying to control an unstable airplane with these high forces. (3) Maneuvering about level flight is difficult. Response is slow and sluggish to your elevator inputs. Attitude control is difficult. You tend to PIO in attitude. Airspeed control is difficult and altitude control is difficult. That's all you can say. (4) Maneuvering in turning flight, lateral control is good but the altitude and pitch control is difficult. Airspeed control is very difficult. Maneuvering forces, the steady forces, I'm not sure whether they're zero or reversed. I didn't check that well. Comments following the first approach. It was really interesting to make that approach with that configuration and the real weather we have here. You could say it shouldn't make any difference to me under the hood, but it does make a difference on the breakout. On most of these approaches, I can only see a part of the runway. I can't see the whole runway up ahead. So attitude control is at best marginal and I want to say that the couple of markers that were put on the windshield are very, very helpful in discerning small changes in attitude after you go visual. And so maybe we ought to legislate that any airplane that's going to be landed like this should have some good marks on the windshield up there. What I mean is that any kind of attitude reference that you can get on a day like this in the real weather, low visibility, is of considerable value. This particular configuration is a stinkeroo. It's very unstable in the sense that the control forces when you get off airspeed are very strong and heavy. If you get slow on airspeed, you got a push force, and if you are high on airspeed, you got a pull force. The problem is that the airplane is not very responsive in pitch. So you don't know whether you're holding the right force when you're off airspeed until some time later when the attitude starts to change and by then you've got a real correction problem on your hands to get back to the attitude that you want. And so flying airspeed is very, very critical and I purposely got slow, inadvertently got slow and tried both. It's a bear. And I was talking to myself and everything else. So even IFR, this configuration is very marginal as far as controllability. It's easy to have the airspeed and attitude depart far enough that you really have to wrestle with it to get it back. It requires continuous closed loop control on the part of the pilot in pitch. So I guess I will run through the evaluation comments because I'm going to rate it on the basis of one approach and I did land it but it was about half way down the runway. (Question 5) Localizer acquisition and tracking, a) performance capability was fair to poor because of the distraction of flying a demanding pitch task and I tended to really get off altitude and airspeed and then, in correcting those back, my localizer would tend to be off. The workload was very high and of course the localizer task adversely affected my altitude performance but it was really almost the other way around. The altitude performance affected my localizer task and caused the performance degradation. (6) The glide slope acquisition was difficult.

The control technique was very tight, as tight as I could get the attitude control with the elevator. Then I used the throttle to try to control the airspeed and the average throttle to control the rate of descent. The performance was poor and the workload was very, very high. It's hard to change the flight path precisely. (7) The tracking of the glide slope and the localizer - a) ability to maintain the glide slope was poor. The control of airspeed was poor. b) Ability to maintain and re-acquire localizer, that's where I noticed myself coming unglued. My localizer tracking was poor because it required so much attention on the attitude indicator to keep this configuration in hand. c) The pitch task affects heading control. Most adversely. d) No unusual use of the display. I'd like to have had twice as much time. I wish I could have slowed down everything that was going on so I could look at everything. It would have been helpful. e) Control technique, elevator used to control attitude, throttle to control airspeed and throttle to control rates of climb and descent. Not too well at that. f) The input required to produce the desired pitch response, it took elevator in the direction that you wanted it to go and how much depended on where you were to start with. Then you spend the rest of your time trying to stop it where you wanted it and re-acquire what you wanted. g) The resulting airplane motion is unacceptable. h) Yes, it does feel like it's continuously trying to get away from me. And it really is, honest. (8) Lateral offset errors, I only did one approach and I didn't have an offset so I'll skip that. (9) The control technique in flare was tight attitude control trying to detect departures from the desired attitude and correct them as early as I could. I didn't have any precise control of sink rate and consequently it took me a long time to get down on the runway and I ate up a lot of runway. So the performance was poor. I guess we'd of probably run off the end or come close to it on that one and I couldn't promise very much better than that on the next one. (10) Crosswind landing, I didn't do it. I didn't have any. Pilot comments continuing and I guess the first tape got screwed up somewhere. I'll start with Question 7, tracking of the glide slope and localizer. a) Ability to maintain and re-acquire is very poor and the control of airspeed is very poor. b) Ability to maintain and re-acquire the localizer, if you have the time to spend on it it's okay but I noticed my localizer tracking was considerably degraded by the pitch task workload. Consequently, you don't have much time to maintain and re-acquire. You do well to maintain and when you get off, you've got to get it back but it is a high workload situation overall. c) Pitch task definitely adversely affects the heading control. d) No unusual use of the display. e) Control technique is elevator to control attitude, throttle to control airspeed, throttle to try to control rate of descent. And of course you use attitude to control rate of descent also in the sense of trying to hold the attitude which will, at the right airspeed, give you the right rate of descent. f) Input that is necessary is in the direction of the desired pitch response and then every effort thereafter is to stop it and make it stay where you wanted it to go. Then the big worry is how do you control the airspeed. g) The airplane motion that results is very poor and very objectionable. It's difficult to make this airplane do what you want it to do. h) Yes. (8) Didn't have a lateral offset error. (9) The control technique in the flare and touchdown, I was talking to Dick a little bit about this since he was commenting on the fact that I didn't pull the power off on the flare and touchdown. The fact is I actually added power because I found that I didn't have enough control of pitch attitude, good and precise to adequately control my sink rate. So I had to actually add a little power to keep the airspeed up while I gradually worked my way down to the surface of the runway. I landed very, very long. I felt that the only thing I could do was to land long trying, through the use of the marks on the windshield, to control pitch attitude and gradually bleed off my altitude and make contact with the runway. I felt that if I did any maneuvering to expedite this, I would lose control of the configuration so I landed long. I think it was a controlled landing in the sense that I don't think we crashed, but we probably ran off the end. (11) The elevator feel was, in general, a somewhat heavy feeling in that when you got off airspeed, the elevator forces were quite high in an unstable direction. The travel was moderate, the breakout forces were not noticeable and the friction wasn't noticeable. The ailerons were light and desirable. The travel was small and desirable. The breakout forces weren't noticeable. The friction wasn't noticeable. The rudder breakout was less noticeable on this configuration because I was so busy doing everything else. I didn't have time to hardly think about my rudder but it was definitely there and objectionable. Travel was small. The regular forces were fairly light. The breakout forces were high. The friction was not noticeable. The throttle control feel was adequate. The friction was desirable. (13) The evaluation tasks were all degraded by this configuration. In flying straight and level IFR, it was difficult to hold the altitude because it required continuous attention. The acquisition of the localizer, flying level in the turn in was difficult. The acquisition of the glide slope was difficult trying to keep the airspeed under control and the fact when you got off airspeed, you had this unstable pitch one way or the other. The visual part was difficult and required real precise attention to attitude in order to keep from getting into an unbounded oscillation. The flare and touchdown was difficult. I thought everything was difficult, which is kind of interesting to me. I would have thought this configuration would have been much worse in the flare and touchdown than it was IFR. So the pitch instabilities associated with this configuration are quite objectionable. When I say plural instabilities I mean that this airplane is unstable in pitch attitude and it's also unstable in airspeed. And I call this two instabilities because I have flown configurations that were unstable in airspeed when I was doing the task but were not unstable in pitch attitude. (15) I guess I could fly this configuration for thirty minutes in turbulence. I sure wouldn't want to. To fly it thirty minutes in the landing approach task, in other words, making approaches like this for thirty minutes in turbulence, I think there would be a substantial risk of actually losing control of the configuration. I didn't really have that much turbulence. I think I'd probably answer that no, but you realize I'm not real sure because I didn't fly it in that much turbulence. (16) The configuration rating -- is it controllable? I did not lose control of it in the simulation maneuver. I came close a couple of times. I got 20 knots off airspeed in a plus and a minus direction and I got the control back again. I flew it all the way down to touchdown and I didn't actually lose control of it but I felt I was on the verge of losing control of it. If I'd of had even the slightest distraction, I'm sure I would have lost it, particularly in some of the places where I was flying it. Is it controllable in the mission? The mission has to include day and night. I actually saw it in fairly low visibility. I made the one approach. I really think to be 100% sure, I should have made it in turbulence. I think if I had, I wouldn't have as much of a question here, but I think I will say that no, it is not controllable and rate it a 10. And I am bothered slightly with the fact that under the circumstances that I flew it in, I actually did fly it all the way, but I was fairly close to losing control a couple of times. I'd like to go on record as saying that this is a configuration that would be interesting to fly at night. I would like to actually make an approach at night because I used those marks on the windshield as a crutch. I'm not so sure that without those marks I would have really lost control of the machine before I got it touched down. It's my judgment that it's a 10. Turbulence effects? Well, I had a little bit of turbulence on that. It wasn't without turbulence but I'm going to have to extrapolate upward, and I'll have to say the increase in pilot effort with turbulence required best efforts. No doubt about that. And really it isn't fair to narrow it down any further than that because I really didn't do it in enough turbulence to probably accurately extrapolate but it's probably an "F". It's more than moderate deterioration. Large? It possibly could be large in the sense that some tasks cannot be performed but I didn't see it that way so I think I'd have to exclude the "G" and I don't think it's an "E" so I'll make it an "F". (18) The primary reason for the rating is a) the most objectionable feature was the pitch control -- lack of pitch controllability - not only pitch but airspeed, pitch control and airspeed control, the lack thereof, and b) the best feature is the lateral-directional characteristics.

CONFIGURATION 20 PILOT D FLIGHT NO. 172-1

PILOT RATING 4 TURBULENCE EFFECT RATING C

First of all, it's nice to fly an airplane again. I get to thinking with some of these configurations you give me that I'm never going to get to see something that flies like an airplane again and I have now seen such. Basically it's what I would term a stable configuration. The elevator forces are moderately heavy but acceptable. The pitch response is relatively prompt and predictable. There doesn't seem to be any instability in pitch attitude or g. And interestingly enough, the airspeed instability is either gone or greatly diminished. I think it's very slightly unstable but nowhere near the magnitude of instability that I've seen on some other configurations. What I'm talking about being unstable is the tendency of the airspeed to diverge from trim airspeed when you're trying to maintain altitude such as in a steady 20° bank level turn. What I observed was that if I made a 20° bank turn and held altitude (I added a little bit of power but only about 3% because I wanted to see what happened), the airspeed did drop down to around 152 or 3 and then very, very slowly would back off to about 149 but it was a slow departure and no problem at all for the pilot. The lateral-directional characteristics, the roll characteristics are light and responsive and the rudder breakout forces are still there and objectionable. It requires rudder coordination when operating the ailerons. (1) Ease of achieving trim - trim was fairly easy to achieve and not a problem to me. (2) Objectionable behavior off trim airspeed, none. I guess I didn't really look at the elevator forces significantly off trim airspeed so I'll scratch that comment. No observed objectionable behavior off trim airspeed. (3) The maneuvering about level flight; attitude control was fairly good. The response is sluggish as you'd expect a larger airplane to be but compared to what I've been looking at, it's pretty good. Airspeed control was much better than it has been and not a significant problem. There is definitely an increase in drag with changes in angle of attack but airspeed control in level flight seemed to be relatively easy. Altitude control, although I didn't spend a whole lot of time doing it, seemed to be pretty good too. (4) Maneuvering in turning flight, the lateral control is sensitive but desirable and good. The rudder coordination requirements are only really objectionable in that I have to operate through the large rudder breakout force. Altitude and pitch control were basically pretty good. The elevator forces in a turn were heavy but the maneuverability precision was pretty good. Airspeed control required attention. You had to add the necessary power and there's some tendency to either add too much or too little. I had a tendency to add too much and got a few knots fast but again the speed seemed to go to a new value and stay there. And the maneuvering forces as I said were fairly heavy. Evaluation comments following the first approach. I'd say there was light to moderate turbulence on that approach. I was surprised I had a little more trouble with airspeed than I thought I would have based on the up-and-away maneuvering. It was nothing major. It was just that I was not rock steady on the approach or anything like that. I had to make continuous corrections in pitch angle or power setting as I was going down the approach to stay on the glide path but actually it came out all right. The approach itself was quite satisfactory but it was not a low workload. It was more of a moderate workload for a raw ILS approach. And the most noticeable thing is the elevator forces are heavy particularly in the flare.

As I entered ground effect, the magnitude of up elevator force and control deflection required was substantial. Finally, at touchdown I'd say the yoke was about 2 or 3 inches from the aft stop and it was certainly adequate for the task so far. Evaluation pilot comments following the second approach. That time the characteristics I observed during the approach were similar to the first one. Light to moderate turbulence I got a couple of gusts during the approach that caused a rolling oscillation which was very natural for this kind of an airplane. The character, as I said, on that approach was similar to the first one. I had to make continuous changes in attitude and throttle setting to hold the airspeed and glide slope, as you came down the tube. So it was a moderate workload for a raw ILS approach. It's interesting to me that you do definitely have the feeling that this is a big airplane as you're going down the approach. You have to anticipate and make your attitude corrections early so that the flight path changes come about at the proper time. This is noticeable but you do have adequate control. In the breakout, I had an offset to the left which was easy to correct with the bank. The flare requires fairly large elevator forces to control the touchdown. It didn't really seem quite as much as they were on the first approach but they were noticeable. I could feel the ground effect and the final touchdown was adequate although it wasn't a greaser. I dropped it in a little bit. Evaluation pilot comments following the third approach. On that one, we had a crosswind which I could tell because the heading, to hold the approach course was about 5° to the right. When I broke out, I was crabbed about 5° to the runway. This approach was about the same as the other ones in that it required continuous correction. I also had a glide slope error on that approach because as I was just getting it settled down on the glide slope, suddenly, I was below the glide slope. I made the correction with power and that went adequately. I got back on the glide slope and continued on down the tube. In performing the crosswind landing correction, the rudder breakout forces do bother me. The crosswind correction was a wing down and a little difficult to put in because of the rudder breakout forces, not the rudder gradient. I think the correction finally was adequate and the landing was adequate. The turbulence on that approach was moderate because I noticed the rolling, the response of the configuration. It's not excessive but it's noticeable. (5) Localizer acquisition and tracking prior to glide slope, a) performance capability was adequate and the workload was moderate. The localizer task on the first of the three approaches did affect the altitude performance a little bit. In other words, I got about 150 ft below my desired altitude apparently because of the crosswind. I crossed the localizer from right to left and ended up on the left side. So in trying to get that turn in rapidly, I did get off my altitude a little bit. (6) Glide slope acquisition was a) the techniques to acquire was to nose over with the elevator and throttle back to keep the airspeed from increasing. The performance was adequate on the acquisition. You do have to lead it. It felt like a big airplane and the workload was light to moderate. (7) Tracking of glide slope and localizer, a) ability to maintain the glide slope was only fair. To re-acquire was fairly good. Control of airspeed required some attention but it did not tend to diverge. b) The ability to maintain the localizer was somewhat difficult because of the glide slope task I had on that last approach. It really wasn't too bad in that turbulence. To re-acquire the localizer is pretty straightforward. c) The pitch task on the last approach with the glide slope error that was introduced did affect my heading control somewhat but it was still adequate. (9) No unusual use of the display. I should note that I don't have the 10° mark on the attitude indicator for this evaluation and I haven't missed it so far. e) Elevator to control attitude, throttle to control airspeed and rate of descent and f) Input required to produce the desired pitch response is a normal airplane-like. You pull back on the yoke to generate a pitch rate and when you get to the desired attitude, you can relax and it'll generally stop there. g) The resulting airplane motion is adequate and really not too bad. If it were a little quicker I would like it better. h) No. (8) Lateral offset was correctable without difficulty and the maneuvering did not affect my control of touchdown point or sink rate. (9) The control technique in the flare is the elevator to control attitude and particularly to supply additional back elevator as you enter ground effect to keep it from nosing down. At the same time the elevator is used to prevent over-rotation due to the somewhat sluggish pitch response. Power management is such that I definitely take off power as I near the ground. The airspeed control I felt was fairly good, at least I felt like I knew what the airspeed was doing. The workload was moderate and the only real two objections in the flare and touchdown is the sluggish pitch response and the large nose down trim change in ground effect. (10) The cross-wind landing was not more than moderate difficulty. In other words, all cross-wind landings, if you got any significant crosswind are some difficulty. b) The wing down technique and c) I was able to adequately control sink rate and touch-down point. I might have been a little bit long because of the crosswind. Again, I had a little trouble with the rudder pedals and the breakout force. (11) The control feel, elevator is heavy, travel is moderate. Breakout forces and friction are noticeable. Aileron forces are light. Travel is small. Breakout forces and friction are not noticeable. Rudder, the forces are moderate. The travel is small. The breakout forces are excessive and the friction is not noticeable. (12) Control feel on the throttle is adequate and the friction is of a good level. (13) The flare, the last probably 20 or 30 ft of ground effect is the most degraded task. (15) Yes, I could fly it in turbulence for 30 minutes. (16) Configuration rating, is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? No. Therefore the decifiencies warrant improvement. Deficiencies I talked about are the somewhat sluggish pitch response and the large elevator forces in the flare and touchdown. It's definitely not a 6, because you can achieve desired perfor-mance with moderate pilot effort in attention and so I eliminate the 5 because of the same reason. It says adequate performance requires considerable compensation so I'm zeroed in quite comfortably on the rating of 4, minor but annoying deficiencies Desired performance requires moderate pilot compensation. Rating 4. Then I go to question 14, turbulence effects, rough air did degrade the configuration some-what but didn't bring out any significant characteristics that I noticed. The turbulence effect rating is that more effort was required and minor deterioration so I'd say a "C" and (18) Primary reasons, a) most objectionable feature would be elevator forces in the final portions of the touchdown and secondly the some-what sluggish pitch response and then the rudder pedal breakout forces, in that order and b) Least objectionable or best feature would be the lateral handling characteristics and the fact that you finally gave me an airplane that flew like an airplane in pitch and also the fact that the airspeed didn't go scooting all over the place.

CONFIGURATION 10 PILOT D FLIGHT NO. 172-2

PILOT RATING 7 TURBULENCE EFFECT RATING D

Pilot comments following the up-and-away portion. Generally speaking, this is a configuration that is unstable in pitch attitude. I guess I'll say it that way. It tends to diverge in airspeed and attitude open loop. Basically requires a pulse-type of control, in other words, inputs to initiate the pitch response that you want, then a pulse to stop it where you want it to stop. For maneuvering, it isn't quite like that. It's intermediate in the sense that it's just a sluggish pitch response that you have to overdrive a little bit but there is this definite tendency to have to start it and stop the attitude with elevator control. The speed characteristics with me flying the airplane seem basically stable in the sense that the airspeed doesn't tend to diverge on me rapidly when I'm trying to fly a straight and level turn, holding altitude. I have to add power at the higher angles of attack but it doesn't seem to diverge. At least if it diverges, it diverges slowly. Okay, (1) Ease of achieving trim. It's a moderately difficult configuration to trim. One reason is because it takes a while to get it settled down at the trim altitude and airspeed; so, it's not very precise for achieving trim. (2) The behavior off trim airspeed really isn't too bad except that you don't have any stick force warning that you're going off airspeed. The stick forces vs. airspeed are only slightly unstable. There is a very small pull force at higher airspeed. (3) Manuevering about level flight, attitude control requires pretty continuous attention. Airspeed control requires less continuous attention but you still have to at least monitor it and make compensations for the changes in angle of attack. Altitude control certainly requires attention and comes out about as good as you manage on your pitch attitude control. (4) Maneuvering in turning flight, lateral control is good. The altitude, pitch control is fair. The airspeed control is fair and the maneuvering forces are very, very light. This configuration possibly could stand heavier forces. Comments following the first approach. The characteristics of the configuration during the approach were, I suppose, about as I expected except that the pitch attitude control required pretty continuous attention. The errors in pitch attitude, of course, led to flight path errors from where you wanted to be and then you'd have the task of correcting back, so it was a busy approach. The localizer tracking deteriorated because of the attention required in pitch. However, it was adequate. The glide path tracking was degraded from what I'd like it to be because of the pitch control problems and it was adequate. I was able to do the job, I think. It's rate of divergence when I did look away was not so rapid that I felt I was in trouble. The airspeed was bothersome. It didn't tend to diverge. It always just seemed to be low. I had more trouble keeping my airspeed up and that possibly might be due to the fact that there was turbulence and we may have engaged such that the power setting required for level flight was a little higher than nominal and I always tend to come back to nominal power settings. That may have cuased the airspeed to be slow but it didn't seem to get away from me. Everything was handleable down to the flare. I was lined up to the right and had to correct back to the left. The line up turn went okay. Everything went fine until I got probably somewhere around 50 ft, then the pitch attitude started going nose down without my being aware of it until it was already in motion and so it required a fairly large elevator input to stop it, which I did use. But in stopping it, I caused a pitch rate nose up which again I stopped with a nosedown elevator. Then that caused a pitch rate nose down that I did manage to stop at touchdown. I thought it was going to be a very hard landing, but I saved it at the last minute. I got myself into trouble because of the long response time. The pitch control makes it very difficult to get yourself re-stabilized again. I was using the marks on the windshield but not as diligently as I should have perhaps and the result was what I would call a poor landing. Evaluation pilot comments following the second approach. The configuration was very similar in the difficulties that I had on the first approach. It had some tendency to be slow and I had to keep the power up but airspeed did not tend to diverge. I had to pay close attention to pitch attitude. Whenever I looked away, it usually would go someplace that I didn't want it to go. The turbulence on that approach was, I'd say, light to moderate and the workload was fairly high in order to fly a good precise approach. The handling characteristics were demanding but they were adequate for the IFR portion. There was a crosswind from the right on that approach and when I broke out, I was about essentially on centerline with the nose crabbed to the right. I had a tendency to be high as I approached the boundary and was a little bit afraid to make any gross changes in the attitude of the airplane, primarily because of what happened on the first approach. So I just accepted a little bit long landing. I got my drift correction in. Again the breakout forces on the rudder bother me but I can handle them. But then the pitch control started to get away from me and I leveled off once. I thought I was there and I was making power reductions in ground effect but I just didn't get down to the runway. I think I was plain ground shy because of the pitch control problems. The last time it pitched down, I sat there for, it felt like two seconds; it probably wasn't that long, with back elevator in before I hollered take it, because it wasn't responding. Comments following the third approach. That time the performance in the IFR portion was better than on the preceding two approaches. I'm not just sure why. As I think about it, I relaxed perhaps a little more and since I observed that the airspeed was basically stable, I didn't fight too much with the power setting and made fewer power corrections during the approach. I just flew a little bit better IFR portion in terms of precision. It is again a demanding configuration in the sense that you had to supply a pretty continuous pitch attitude control in order to keep the attitude from going someplace that you don't intend it to. Also, I think the turbulence level was lower on that approach than it had been before. So, on the breakout, the runway was to my right. I had a lineup correction to make. It was apparently induced electronically. It required a moderately prompt turn because I didn't go visual until I was fairly close in, at about the middle marker. That maneuver went all right and I made the final approach flare and the touchdown reasonably well without ever getting very far off. The difference in the technique between this and the preceding approaches was I simply used a much tighter attitude perception, paying attention to the outside world and trying to catch any changes before they amounted to very much in the way of attitude errors. The touchdown appeared to have a moderate sink rate but was adequate. So we're going to make a fourth approach. I would like to see it again in a crosswind because that was the principal place that I had pitch control problems that were serious enough. The fourth approach was a crosswind approach. In a sense I almost wish I hadn't made that approach. I made some big altitude corrections coming in and I was able to do them. I made glide slope error corrections and was pretty nominal in my approach. After I broke out, I had a little initial difficulty in keeping my pitch attitude where I wanted it so I got a little high. I chose to accept that high rather than trying to maneuver it out. I got my crosswind correction in, wing down, and by careful attention to the pitch attitude I was able to make a reasonable although a little hard landing. So I think that particular approach was adequate and the other one with the crosswind wasn't, so I've got to think about that for a while. (5) Localizer acquisition and tracking prior to glide slope interception, the performance capability was adequate. It requires careful attention to pitch attitude and the altitude errors were the greatest ones that came about there. The workload was moderate to high and the localizer task did tend to degrade the altitude performance. (6) The glide slope acquisition was not terribly difficult. I flew a tight pitch attitude control and with some anticipation. I used the elevator to nose down to the right attitude and the throttle was used to control the rate of descent and also to control the nominal airspeed. The airspeed did not tend to diverge in this configuration. The performance capability was adequate and the workload was moderate. (7) The tracking of the glide slope and localizer, a) the ability to maintain was fair to poor. Primarily the poor performance comes about due to inattention or looking at heading and things like that which cause attitude errors that become glide slope errors. You can make the ability fair by high workload. Control of airspeed was not difficult and was a lesser task. b) To maintain and re-acquire the glide slope went fairly well. The biggest problem is to be able to devote enough time to tracking the heading and I did notice that in the turbulence that existed, heading errors of up to 5^{o} were common. They seemed to be in part induced by the turbulence and the rolling response to turbulence but again you could adequately maintain the localizer and adequately re-acquire it. c) The pitch task does affect the heading control adversely. d) There was no unusual use of the display. e) Elevator was used to control pitch attitude and throttle to control the nominal rate of descent and airspeed. f) The input required to produce the desired pitch response was a little elevator to initiate and a little elevator to stop it in the tracking process. Mostly, it turned out to be elevator to get it started back where you wanted it and elevator to stop it once you got it where you wanted it. h) The airplane does feel like it is trying to get away from you although it's not trying to get way rapidly. It kind of sneaks away from you. (8) The ability to correct lateral offset errors was certainly adequate and the maneuvering in one case did not affect my control of the touchdown point. (9) The control technique in flare was tight control of pitch attitude and by tight I mean the detection of incipient pitch rates that were going to lead to pitch attitude errors. The correction of those errors had to be done immediately without having to put in large pitch corrections because when you get to trying to make large pitch attitude corrections, you are in trouble. As for the power management, as I got close to the ground, I tried to consciously bring the power gradually back some and the airspeed control appeared adequate. (10) The crosswind landing was of moderate difficulty, principally in controlling pitch attitude while you're also paying attention to lineup and drift and all that. I think my tendency was not to watch the pitch attitude as closely as I needed to and hence attitude errors would creep up on me. Once you have them in, they're difficult to correct. The wing down technique was used and the effect on sink rate and touchdown point control was definitely there and I tended to land long. The performance and workload in the flare and the touchdown maneuver was quite variable. When I had pitch errors or flight path errors to correct, I found it difficult to correct them. Basically, I tended to produce a PIO in pitch and in flight path and if I kept the flight path errors small, I was able to perform pretty well. By pretty well, I mean for the configuration, the performance was adequate when I kept the excursions small and it was inadequate when the excursions were large. The workload was high. It's not as high in the flare and touchdown. The airspeed seemed much better behaved than it did on the configurations I flew yesterday. There was an unloading effect and an improvement. But the pitch control, when there are flight path errors was pretty poor but with training you can develop your technique so that you could do the job. The question is are you going to be able to do it when you have to. (11) Elevator feel, forces are fairly light. The travel is moderate. The breakout forces and friction, I could feel the breakout forces. They were not objectionable. The friction was not noticeable. Aileron forces were light, the travel was small and the breakout forces I could detect but they were not objectionable and I didn't notice the friction. The rudder forces were moderate and the travel was small. The breakout forces on the rudder were high and objectionable and most noticeably objectionable on the cross-wind landing. The friction was not noticeable. (12) The throttle control feel is basically pretty good and the friction is of a desirable level. (13) The flare and touchdown maneuver was most degraded by the sluggish pitch response. (15) Yes, I could fly this for 30 minutes in turbulence during landing approach task. (16) Configuration rating -- and this is where I get to my problem and I'll start and say is it controllable? The answer is definitely yes. Is adequate performance attainable with a tolerable pilot workload? I have to say yes and no. I really feel that this configuration can be landed. And it can be landed adequately. The problem here is whether it will be landed adequately and I'm not sure. If we can always be assured that we're going to make approaches such that we have small errors to correct, and we have good perception of pitch attitude in the cockpit that we're looking out of then, yes. I believe this is an adequate configuration and I would answer the question, yes. On the other hand, I am concerned about the fact that sitting up here is a real airplane and doing the real job, on two occasions out of four, I got myself into situations where I would have had to go around. I think the configuration was controllable enough that I could go around safely and so you say, well, all right, if you make a bad approach or if you get it going in a PIO, can you go around and do it again? The answer is this configuration has enough controllability that I think I can. I guess my problem is whether I really buy it and I don't think it's the instability that's bothering me in this configuration. It's probably that in combination with the pitch response. I would like very much to have flown this configuration with twice the elevator forces or half the gearing and I suspect that the controllability would have been improved. I don't think that's in our matrix but if we have an opportunity later it would be nice to be able to do it. For the IFR portion of the thing, I would definitely answer that adequate performance is attainable with a tolerable pilot workload. It's a high workload configuration but it is tolerable. So I'm really torn. I am convinced that you can train the average airline pilot to fly this configuration well enough that he can land it. That isn't what's bothering me. The question is how long will he retain that state of training. I'd like to comment that this configuration is to me significantly better than the one I flew second yesterday because I don't have the airspeed control problems that I had in the configuration yesterday. But I still have some difficulty in the flare and touchdown. I think the response time in pitch is too long in this configuration to have adequate control of touchdown point and sink rate for the air transport mission. I'm going to say, no, adequate performance is not attainable with a tolerable pilot workload. And part of the reason for rating it this way is what the capability of the pilot will be with this set of handling characteristics under the range of circumstances that are likely to be encountered in airline operation. What the capability will be when he gets close to the ground and I think it's got to be marginal. This configuration is just not susceptible to error. It's landable. If you can go around and try it again and get set up better, I think I'd be willing to fly it and land it but I don't think it's right for the mission that we have defined with the state of training and the state of proficiency which we have hypothesized. I end up with the conclusion that the deficiencies require improvement and I say adequate performance is not attainable with a maximum tolerable pilot compensation and I'd say controllability is not in question here in the sense that I'm not about to lose control of it. In a sense I don't have enough controllability to perform the mission adequately and I'd have to go around. I do have controllability but I don't have the ability to achieve adequate performance. The pilot rating is 7. (14) Turbulence effects, rough air was not a significant factor except that it does create these disturbances that have to be corrected with pitch control and (17) the turbulence effect rating. More effort was required and moderate deterioration and "D" on the rating for turbulence. Primary reasons for the ratings. a) Most objectionable is the difficulty in correcting flight path errors close to the ground because of the sluggish pitch response, and a tendency to PIO. The need for very good pitch attitude control and pitch attitude perception. Also, I've got to include those rudder pedal breakout forces too. b) The least objectionable I was glad that airspeed was not any more of a problem than it was and the lateral-directional characteristics are good.

CONFIGURATION 17 PILOT D FLIGHT NO. 175-1

PILOT RATING 6 TURBULENCE EFFECT RATING D

Comments following the up-and-away maneuvering. The general feeling about the configuration is that it is sluggish in response to pitch maneuvering commands and is unstable in airspeeds when you're trying to hold zero rate of climb. In level turns you have to add a lot of power at increased angle of attack and you have to take off power with decreased angle of attack. I looked at the speed changes and that confirmed my opinion that it appeared to be on the backside of the power-required curve. It took higher power settings at lower speeds and lower power settings at higher speeds. But it did require a lot more incremental power at the low speeds, than it did at high speeds; so it appeared to me that the thing was nonlinear. I'm not sure that is so. The pitch trim forces were similar to that also. The out-of-trim was much more noticeable, tending to pitch it up at speeds below trim, than tending to pitch it down at speeds above trim. (1) The ease of achieving trim is relatively easy in the sense of trimming to zero force, but it does take tight attitude stabilization because it appears that the airplane is just a little bit unstable in pitch. I was able to achieve the trim flight conditions with considerable attention to power management and attitude. It was a little bit difficult to keep the airplane at the trim conditions required for the report, but it wasn't too bad. (2) Behavior off trim airspeed was particularly difficult in terms of the power management. The lower airspeeds require great additions of throttle and higher airspeeds require only slight power reductions. (3) The maneuvering about level flight was adequate for up-and-away flight in attitude control but does require a large amount of attention to make sure you don't depart from the desired attitude. Airspeed control was a relatively high workload and somewhat difficult because any angle of attack you went to required a different power setting to keep the airspeed from changing. Altitude control was related to your attitude control and if you did that pretty well the altitude control came out reasonable but it was difficult. (4) When maneuvering in turning flight, the lateral control is adequate. I don't like the rudder breakout forces and I commented the rudder breakouts were non-symmetrical; that is, requiring less rudder pedal force to breakout on the left rudder as compared to right. Altitude and pitch control in turns were moderate difficulty, principally due to airspeed and power management. That answers the airspeed question too, because for every bank angle there is a different angle of attack to hold level flight which required a different throttle. If you got off a little on your bank angle and you didn't make a power correction, the airspeed would get off. The maneuvering forces are relatively light. I was able to get to 1.2g but it took a little while in the sense that the response is sluggish.

These are the pilot comments following the first approach. I was in light turbulence. Sometimes I would almost have said moderate but that would smooth out, it was about light turbulence. I was a little late there on the capture of the glideslope and so I ended up a little high. Also, in acquiring the glideslope I got fast and took a long, long time to get rid of. In other words, I pushed the nose down to a pitch attitude of about 8° and I took the power off to about 50%. The airspeed bled very slowly which was alright but the lower down in altitude it is before you get that airspeed nailed, the more difficult it is to actually nail it. Consequently I was probably down about 800 ft. above the ground when the airspeed come down to trim and then I actually got slow on airspeed in trying to get the power set to hold the glideslope. So I would say it was an approach of moderate difficulty and weather conditions were not too aggravating. I found the biggest problem to be airspeed management. There was a cross wind from the left and the cross wind correction went in alright but the sink rate on touchdown was probably moderate as I wasn't quite ready for touchdown when it actually occurred. It was flaring itself so I don't think it was too bad. But touchdown occurred earlier than I intended it to. Response is sluggish in pitch.

Evaluation pilot comments following the second approach. This approach was a much better performance approach in terms of what I was able to achieve and the major difference was I have the experience of the first approach. Also, as I approached the glideslope, I anticipated the glideslope more and I didn't get fast. So I kept my airspeed pretty much on and by use of throttle and elevator control, I found that my performance was very much better. The glideslope is still a little difficult to stay on. It requires very close attention to attitude because your attitude can be off a couple of degrees producing airspeed and rate of climb changes. You just don't have any anticipation of this through the feel in the controls so you get your only cues from what your instruments say, but it can be done and be done adequately.

The flare on touchdown and crosswind correction. I did have a glideslope change, I don't know whether they are real or put in there electronically, but I had a high to correct. That correction I was able to perform moderately well. Mostly because I was pretty well stabilized when it occurred. The airplane is sluggish in it's pitch response and consequently you had a feeling that the nose was going down and you are pulling back and its quite a long time before it shows signs of responding to your will. There was a small tendency to get into a PIO which I countered with anticipation and seemed to stop. I landed long in an attempt to get that PIO and sink rate under control and then, of course, there was still a cross wind from the left. The cross wind correction went alright. So I still say that the airplane is sluggish responding. It is objectionably sluggish for performing the flare and touchdown task in particular.

Pilot comments following the third approach. That one went fairly well. I seem to be either learning to fly the configuration or else perhaps it was a little less turbulent, I don't know which. All the way through the approach my performance was not the best. At times I was letting some errors develop and at other times I was looking to see how well I could bring them back. The localizer did get off when I was correcting back towards the end of the approach. I had some difficulty in getting it back. I had the feeling that the localizer was coarse, in otherwords, there was no change and then very quickly a relatively large change in localizer close in. The flare and touchdown portion went fairly well and airspeed control was a little better in the flare and touchdown. Actually that particular touchdown was a bit of a greaser in terms of my normal skill. Its still a slow sluggish pitch response and one that if you are right on glideslope is relatively easy to deal with. If you get off, it's very difficult to get the attitude and flight path back on in the flare portion with the necessary promptness for the task. (5) Localizer acquisition and tracking prior to glideslope interception. (a) Performance capability is fair in everything except airspeed control and by that I would have to say it was poor. Actually, I had trouble with airspeed and altitude and the altitude I thought stayed within fair deviations. The airspeed would get off so I would say the performance was worse than fair, definitely poor airspeed excursions. (b) Workload is moderate particularly on airspeed and throttle control. Also attention is required to attitude. You can look away from attitude longer almost than you can look away from airspeed and your throttle, particularly in turns. (c) The effect of the localizer task in altitude performance was noticeable but not unacceptable. In other words, you can pin the localizer down but the airspeed and altitude performance did deteriorate. (6) Glideslope acquisition (a) Control techniques to acquire, basically you cannot reduce the throttle and depend on the natural airspeed or angle of attack stability to take care of the attitude for you. You had to remember to push the nose down so what I tend to do is to start easing the nose down and then gradually reduce the power (b) The performance capability was fair, but if you get off, the glideslope acquisition is difficult (c) Workload depends on how close to nominal you stay. It's a high workload if, due to inattention you get off the nominal glideslope. It's very difficult to correct the fast and high, and you do have a tendency to get a high and fast. (7) Tracking the glideslope and localizer (a) Ability to maintain the glideslope was fair. Control of airspeed was moderately difficult. (b) the ability to maintain or reacquire the localizer was adequate but not too difficult. Your attention to throttle and airspeed detracted from your heading control and fortunately the lateral directional characteristics weren't of such a nature as to cause me difficulty. As far as reacquiring the localizer that went all right except when you are close in and then the task of reacquiring the localizer without losing the glideslope and airspeed was a bit of a problem. (c) The pitch task does affect heading control adversely but it's not so demanding. It's really a combination of the pitch task, the throttle setting task and the airspeed control which all detract from heading. The turbulence level was such that there wasn't too much of a problem. I shouldn't say too much of a problem but I was able to do it adequately. (d) No unusual use of the display but this configuration does require more throttle and airspeed control than many. (e) Elevator is used to control attitude and throttle is used to control airspeed and rate of descent. (f) The input required to produce the desired response was an extra elevator to initiate it; then, you back off and wait for the attitude and g to come up to where you want them. You don't have to consciously stop it except when you get down close to the ground and you are trying to make attitude and flightpath corrections quickly. Then you overdrive, apparently, so much that you can make the response oscillatory and in that case you end up with corrective control inputs in the opposite direction.

(g) The resulting airplane motion is adequate but it's attention demanding in the IFR portion. Down near the ground the resulting airplane motion is marginal but in the turbulence level I had it was adequate. (h) The airplane does not feel as though it was trying to get away from me but the airspeed sometimes seems like its near diabolical in the sense that its always tending to get away from me, particularly if any turns are required. (8) Lateral offset errors were corrected adequately on breakout. There was some tendency for the attitude to get a little off there. Our marks on the windshield have been erased, so I think the analysts should take note of the fact that we have no attitude references on our windshield now, whereas we did before. The required maneuvering probably did effect my control of landing touchdown point on that second approach. Actually I think I had the lateral offset on the third approach but I was correcting back at the time and I think I had more offset on the second approach than I did on the third. (9) In the flare and touchdown, elevator was used to control attitude and throttle to control airspeed. Attitude was then used to control flight path but throttle was used there, too. Mostly it was attitude to control flight path with the throttle to make the airspeed come out right. Power management in the flare and touchdown, I usually had an airspeed error when I got on the center line and so I was making a corrective throttle for the airspeed error. Then, as I got down into the flare and touchdown I would tend to pull off a little throttle. The workload in the flare and touchdown was high. (10) The cross wind landing (a) was not too difficult (b) wing down (c) perhaps some effect on that second approach but on the first and third not too much. (11) Control feel, elevator force is kind of light except when you are trying to maneuver and then the force was moderate. The travel was small except when you are trying to maneuver rapidly. Breakout forces were negligibly small and the friction was not noticeable. Aileron forces were light and the travel was small and the breakout forces were there but acceptable; the friction was not noticeable. The rudder breakout forces as I have noted is a little lighter on the left rudder than on the right. The forces themselves were moderate and the travel was small and the friciton was not noticeable. (12) The throttle control feel was adequate and basically good. Friction was adequate. I had some trouble with keeping the throttles evened up on this flight. I don't know why more so than I have had on others but it didn't affect the evaluation. On the throttle control feel,between the first approach and the second approach, there was a change in the throttle required for trim flight and the attitude for trim flight changed too. (13) I think the evaluation task of the IFR approach in turbulence and the flare and touchdown were most degraded by the configuration characteristics. (a) The turbulence just acted as a disturber in attitude and added to my lateral-directional task which took me away from pitch attitude and that was a major effect I think. (15) Yes, I could continue to fly this configuration for 30 minutes in turbulence doing landing approach tasks. (16) The configuration rating is it controllable? Yes, Is adequate performance attainable with a tolerable pilot workload? I didn't think about that as I went through here and I think that I finally decided that I would say yes. I really would like to see it in a little more turbulence than I had today so I will answer it as yes. Is it satisfactory without improvement? Do deficiencies warrant improvement? I certainly would eliminate the rating 4 because I don't get desired performance at all. So it's either a 5 or a 6 in that phraseology, because adequate performance was attainable but I throw out a 5 because it required more than considerable compensation. I would say adequate performance requires extensive compensation. I would say there were very objectionable but tolerable deficiencies particularly the backsidedness. The unstable airspeed required lots of attention as did the sluggish pitch response in flare and touchdown. So I come up with a 6. Turbulence effect rating - I didn't have that much turbulence but I think the configuration is somewhat turbulent sensitive. So I have to say more effort was required and moderate deterioration in performance because when I did get the turbulence it did bother me. I will rate it a Delta. That's for what I saw. (18) The most objectionable feature is twofold - the fact the airspeed was always departing from where I wanted it and it required so much thrust addition when I got a little slow on airspeed. I think that was approaching an unacceptable characteristic. You would have to have your people very well trained for this kind of configuration. Another thing was the fact that the attitude control is sluggish and there is a slow departure from the trimmed attitude. In other words, you can't just put it on an attitude and expect it to stay there. The least objectionable or best characteristic was I suppose the lateral-directional characteristics but also the lack of turbulence. That's not fair but I just had to say it.

CONFIGURATION 9 PILOT D FLIGHT NO. 175-2

PILOT RATING 6 TURBULENCE EFFECT RATING D

Comments following the up-and-away portion. The airplane seems unstable in pitch attitude and of course g. It was more stable in terms of power than the preceding configuration. I was able to manage airspeed better except for the airspeed errors induced by pitch attitude errors. But the airplane is more unstable in pitch so the pitch attitude requires more attention. I really got surprised when I tried to pull two-tenths of a g because I don't know whether I put in too much but when I got up to two-tenths and tried to stop it, I almost had the forward stop. The airspeed went down very, very rapidly. So I did it again and it wasn't quite as uncomfortable. It didn't require as much forward pressure to stop it, so I am sure I had overdriven it a little too much. But it sure did startle me. You wouldn't want to do too much of that kind of stuff; in other words, you wouldn't want to be pulling g unless you are very careful on your angle of attack and attitude. (1) Ease of achieving trim was somewhat difficult. It was easy to achieve force trim but it was difficult to get the attitude rate to zero with the right airspeed and altitude combination. Any time I would look away at airspeed or something else the attitude would be changing on me. (2) The objectionable behavior off trim airspeed was not too much. I tried 10 and 20 and there was noticeably more forward pressure 20 knots slow than back pressure 20 knots fast. (3) The maneuvering about level flight - attitude control requires lots of pilot attention. It requires pulses to initiate it and opposite control to stop it. Airspeed control was not as difficult as preceding but it does require attention probably in large part because of the attitude errors. The altitude control wasn't very good so far. (4) Maneuvering in turning flight - the lateral control was o.k. except for the rudder breakout forces. The altitude and pitch control were somewhat difficult. Airspeed control was somewhat difficult. Maneuvering forces were a little heavier and you had to be ready to counter with the control in the opposite direction. I did pull the g and as I said, when I pulled the 1.2g in the turn, I ended up with almost full nose down elevator to stop it from departing in a pitch up sense.

Comments following the first approach. That was an interesting one, it didn't fly on the approach like I expected it to fly from what I did in my up-and-away maneuvering. I guess I was a little bit rushed in my up-and-away maneuvering and didn't get to see as much about the configuration as I should have. I had a much more difficult time flying altitude on the approach than I would have expected although I didn't comment adversely on that in the up-and-away maneuvering. I didn't see that it was going to be that bad. Now after I watched what I did during the approach, my throttle activity seemed to be relatively small for managing airspeed, but I really had to work hard on attitude. When my airspeed got slow I still had that characteristic I commented on in the first configuration in that when it got slow it took quite a bit of extra power to get it back. But once I was on the trim airspeed it tended to stay a lot better than the first configuration. The flare and touchdown was surprisingly better than I had expected. For one thing my airspeed was a little bit high whereas, if anything, I tended to get slow on my airspeed during my approaches after I go visual. On that approach I would say that the turbulance was light to moderate and at times it did bother me.

Comments following second approach. This is the last approach we can make on this configuration and I really feel bad about that because I realize that I have to make a rating on the basis of those two approaches. I feel that I would like to have at least one more approach particularly with this configuration. For that particular approach, I was in moderate turbulence and the airspeed excursions were unusually large. I don't know how much of that was due to the turbulence, but for example, I saw airspeeds from 152 up to 166 that were quite unintentional and occurred fairly quickly. I ended up putting in some rather large throttle corrections to stop those excursions but then when I was around the right attitude I didn't seem to have to put much throttle corrections in. I guess what I am saying is that some of the time I acted with the throttles like I was on the back side of the power required curve and at other times I acted like I wasn't and it was a confusing configuration to me. I remember thinking when we were doing the up-and-away maneuvering that they had given me a configuration in the bucket or not far on the back side, but then some of the maneuvering requirements and throttle activity that I had during some portions of the approaches it behaved as if I was on the back side. I will admit that I am thoroughly confused at the moment and all I can tell you is that the airplane is somewhat unstable in pitch attitude. It does tend to diverge unless I do something about it and I am having great difficulty deciding whether it is adequate or not. The IFR portion on that second approach was a pretty high workload. I felt like I was hanging on a bit. I had this feeling of not really being as much in command of my situation and destiny as I think is necessary for the mission that we are talking about and yet things never got away from me too far. (5) The localizer acquisition and tracking prior to glideslope interception - I didn't have too much of that in the two approaches because we were working pretty close in, but (a) my performance was no better than fair. I did have trouble controlling the altitude well during this portion. The localizer acquisition performance actually was quite good but the altitude tracking during that portion was not so good, and (b) the workload was moderate and principally was involved with pitch attitude control in the turn. The effect of turning on the airspeed and altitude tended to degrade some from my heading but I still had adequate heading control. The altitude performance was affected by the localizer task rather than vice versa. (6) The glideslope acquisition was adequate. (a) The control techniques were to nose the airplane down. To cause that to happen you have to initiate a nose down pitch and then stand by to stop it at the right place and keep it at the right place. While you are doing that make throttle reductions to account for the rate of descent. I noticed on the first approach that airspeed seemed to be low and seemed to stay low. So I had to work the throttle a bit on the first approach to get it back to where I wanted it. I had to carry a little higher power than I thought I should have had to get the airspeed to stay up there, but then on the second approach that wasn't the case and if anything I was a little on the fast side. The performance capability was adequate and the excursions and airspeed were o.k. You did have to pay careful attention to pitch attitude because it was always tending to be where you didn't want it to be when you looked back again. (c) The workload was moderately high. You had to pay close attention to what you were doing or else you would get well off. If you payed close attention you had sufficient control capability to accomplish it with reasonable precision.

(7) The tracking of the glideslope and localizer (a) You could maintain and reacquire the glideslope reasonably well if airspeed didn't depart too far. On the first configuration I had today, airspeed would just tend to be a bit diabolical in that it would get off and tend to keep going, but with this configuration it seemed to be off but bounded. The control of glideslope was very dependent on attitude control and you couldn't afford to look away for very long because then the attitude would go to some place that it shouldn't be either nose up or nose down. The airspeed would start getting low and you would be off glideslope. So the secret was to pay careful attention to pitch attitude and that tended to take you away from the localizer but still you had enough time to look at the localizer to get adequate performance. (c) The pitch task detracts from the heading control definitely but the pitch task is not so demanding that your heading control was unacceptable. (d) No unusual use of the display. (e) Elevator to control attitude, throttle to control airspeed and rate of descent. Of course, the attitude to produce the rate of descent is controlled by the elevator. (f) Input required to produce the desired pitch response is elevator to initiate and then elevator to definitely stop. It doesn't stop unless you do it yourself. (g) The resulting airplane motion is adequate for the tracking task but it isn't desired. (h) The airplane does feel as though it is trying to get away from me. You can control it if you look away and attend to other tasks but you can't be negligent about coming back to pitch attitude. (8) Lateral offset on approach, on my second one I had a considerable lateral offset and I would say that it was about the limit of my capability to just be able to land. When I first started to initiate my turn back to the center line I thought I wasn't going to be able to make it especially because my pitch attitude got away from me a little bit. I thought I would never be able to hack this but I stayed with it and actually succeeded in getting my pitch attitude under control while completing the lineup turn on to the center line. I got my cross wind correction in. So the maneuvering did adversely effect my control but actually it wasn't a bad touchdown and it wasn't a bad touchdown location. But the lateral maneuvering did effect my pitch task and I really had to jump on the airplane and work hard to achieve what I did. (9) The control technique in the flare and touchdown, I had to be very careful when I put an input in to wait for it to produce à result on the elevator; that is, I had to be ready to put in an opposite input. In other words, I had to generate a lot of lead. The power management was not really difficult in the flare and touchdown. I pulled off power and as I entered ground effect it went on and touched down. There is a definite tendency to overcontrol the configuration which you could suppress by carefully timing your inputs. The workload for pitch control was very high in the lineup on the second approach. I felt like I was working hard in the flare and touchdown but it came out fairly well. (10) Crosswind landing. There was a natural cross wind out there. (a) the difficulty was not too great. You did notice on this configuration that you felt loaded in getting the wing down and the lineup corrrected. At the same time you could not let attitude errors or flight path errors creep in because of your inability to correct large ones. (b) Wing down. (c) Not a significant effect but it did effect the workload.

(11) Elevator forces felt a little heavier than the preceding configuration but still quite acceptable. The travel is low to moderate. The breakout forces were not noticeable nor was the friction. The aileron forces were light, the travel small, the breakout forces small and the friction not noticeable. The rudder forces were moderate. The travel small, the breakout forces objectionable but acceptable and the friction not noticeable. (12) Throttle feel was adequate and o.k. the friction was of the right level. (13) The flare and touchdown was most degraded by the configuration characteristics. In other words, the control of sink rate near touchdown and also the approach in turbulence. This business of airspeed wandering so much. It seemed bounded; it didn't act like the farther it got away from the nominal value, the more rapidly it was going to diverge or anything like that, but the excursions were relatively large. I hope to get to see more of that this afternoon. So the turbulence effects in rough air has brought out characteristics that I don't know how to evaluate but they do have a noticeable effect on the ability to fly the configuration. They certainly effect the precision with which you can fly it. I would fly it for 30 minute in turbulence . For a configuration rating, it's certainly controllable Then, I get down to that terrible decision about - is adequate performance attainable with a tolerable pilot workload? I guess I am in a sense weaseling in that I would like definitely to have seen one more approach in order to make up my mind. It's definitely an unstable airplane. I have to constantly be on top of the airplane in order to achieve the necessary precision for this kind of approach. One of the saving features is that when the attitude gets off the airspeed doesn't do crazy things. In other words, the airspeeds has a more bounded feel than it did with the first configuration. I think I'll say that adequate performance was attainable even though the airplane is unstable in attitude. I think that the consequences of the errors that do creep in didn't ever seem large enough to cause the airplane to get away from me. So I think with reasonably intensive pilot training and with these kind of handling characteristics the average airline captain would be able to handle these characteristics. A couple of things disturbed me in coming up with that kind of an answer. One of them was that there is a definite pitch up tendency with this configuration that you don't see much of in straight and level flight in the maneuvering in up-and-away flight. I have the feeling that this configuration is reasonably good as long as your excursions are not too large. But, if your excursions and angle of attack or airspeed get very far off, particularly, in the low speed direction, it really makes me wonder whether in truth it is acceptable. I had forgotten in the up-and-away maneuvering that I did pull 1.4g. That kind of maneuvering is not necessary for these approaches. I guess I'll still say its adequate and rate it a 6. I can't even discuss whether its a 4 or 5 or not because its not anywhere near that good. I will be interested to see what I think about it this afternoon if they let me make another approach. I'll say that it is not satisfactory without improvement and say that the deficiencies warrant improvement. They are very objectionable but tolerable. Adequate performance requires extensive pilot compensation. Turbulence effect rating, I don't guess I even made the approach without turbulence. I always had the natural turbulence. So I will have to guess at this rating. There is definitely more effort required in turbulence and it adversely effects this configuration. I guess more effort is required and moderate deterioration, Delta. I almost made it a best efforts moderate, Echo, but this configuration, in terms of pitch control,

is not as good as the first configuration that I had today. In terms of airspeed control it is better. When I think about comparing the two, I think, would you rather put up with a little attitude instability but with the benefit of less airspeed instability? That seems to be the decision I am making here in comparing the two. I think this configuration is a little worse than the first one but still barely acceptable. So the primary reason for the rating and the most objectionable feature was the attitude instability and also this business of a pitch-up tendency. The least objectionable or best feature was the lateral-directional characteristics or a compensating thing was the less demanding airspeed control task and that kind of saved the configuration as far as I was concerned.

CONFIGURATION 9 PILOT D FLIGHT NO. 176-1

PILOT RATING 7 TURBULENCE EFFECT RATING

The approach was not a very good one. Considerable localizer and glide slope errors developed during the IFR portions. I had trouble with the airspeed getting fast and airspeed getting slow but more times with the airspeed getting fast. Also, I had trouble with getting high on the localizer. A high and a fast are difficult to correct with the configuration. When I went visual, I was correcting a localizer error so I didn't have too much of a lineup problem but I did have a substantial crosswind from the left. The crosswind correction was okay. The control of pitch was slow and sluggish and there was a little tendency to oscillate. The touchdown was a little long and I was still in a small oscillation when I tried to stop it. There wasn't much I could do about controlling it much more precisely than that. On the basis of this one approach that I flew as the second configuration of the first flight today, I think more poorly of the configuration than I did this morning so I have asked for another approach.

Comments following the second approach which is the fourth approach on the second configuration that I looked at on Flight 175. It was an interesting configuration in that I don't know what you gave me in the way of thrust characteristics. It was a very confusing configuration. At times it flew like it was on the backside of the power required curve and at other times it flew like it was rather indifferent. This second approach was fairly good in performance and a high workload. The pitch instability makes careful attention to pitch attitude important and the throttle activity is not exactly continuous. There are times that I seem to be fairly active on the throttle to control airspeed and other times I can sit there and not do very much with the throttles. As I review the evaluation of this configuration, I have to think in terms of, did I see anything on these two approaches this afternoon that affected my evaluation from this morning? I think that the configuration was about as I saw it this morning in terms of difficutly. I find it still a difficult configuration to rate and I have a definite tendency to PIO it in the flare and touchdown. Do I have adequate control of it for the mission that we're talking about? And even there I have some reservations with the configuration that is this difficult. You have to think in terms of maybe making a couple of approaches because you're not going to be in good enough control the first time. One of the things that bothered me this afternoon on this flight that did not on the preceding one is that, on this last approach as I entered ground effect and was attempting to control pitch attitude and hence rate of sink, the nose got away from me on the last half cycle of oscillation before I touched. There was a definite nosedown pitch that I don't realize is coming in until the nose is going down. Then my control effectiveness is so poor or the response time to my control inputs to attempt to correct it takes so long that I feel a bit out of control. So if I go through the comments or the questions on the rating scale and I say, is it controllable? Definitely. And then I say, is adequate performance attainable with a tolerable pilot workload? For the approach maneuvering I have to conclude that the answer to that question is yes for the IFR portion. When I come down into the control of flare and touchdown, on the basis of what I saw this morning, I answered that, yes, adequate performance was attainable, and on this morning, I answered that, yes, adequate performance was attainable, and on this afternoon, I think it's marginal. I'm still finding it very difficult to answer the question. I think adequate performance was not attainable with a tolerable pilot workload and so I would answer that question, no, this afternoon as compared to this morning's yes and then say that the deficiencies require improvement. In other words, that one was too bad. The rating is not an 8 or a 9 because I don't think I'm at the control limits so that considerable pilot compensation is required to just keep control of the vehicle. In other words, I'm able to obtain more control than that. But I don't think that what I got was adequate performance. The big question is whether I could train well enough for the flare and touchdown part to handle that situation with adequate performance with a tolerable pilot workload. I don't think I did attain it and so I'd have to rate it a 7 saying that the controllability wasn't in question. In other words, I didn't feel I was going to crash but I don't think I had adequate performance in the flare and touchdown, in particular. Again, I would emphasize that adequate performance can be achieved and I think I did achieve adequate performance on about three of the four touchdowns that I made with this configuration. But there were two approaches where the disturbances were large enough that I would have had to go around and try it again and I don't think that's adequate performance with a tolerable workload. So I'm going to call it a 7.

CONFIGURATION 17 PILOT D FLIGHT NO. 176-2

PILOT RATING 6 TURBULENCE EFFECT RATING D

Pilot comments following the first approach. This was an extra approach with the right level of turbulence for the first configuration of Flight 175. In other words, I looked at it with three approaches this morning but I never did have quite as much turbulence as I was supposed to have. So this was kind of a little extra to see if I would be adversely affected in my ratings by what I saw. Again I would comment that this configuration is noticeable, as I said this morning, in its workload on airspeed and throttle control and it is easier to fly in pitch control to the elevator. It's slow and sluggish so that when you are attempting to control the flare and touchdown accurately, you could quite noticeably detect the lags, in particular, when the ground effect comes in and gives you a nosedown pitching moment which you don't detect until after it has started to change the airplane's attitude. Then, you just can't produce the attitude changes as rapidly as you feel it is desirable and necessary but I do think that this is a trainable configuration. This is one that you can learn to fly as opposed to the one that preceded it this afternoon, which your state of training would make a great deal of difference in whether you were able to successfully fly it. This configuration is what I would say is barely adequate performance attainable with a tolerable pilot workload for the mission as we've defined it. So I'd stay with my rating which was a 6 commenting that it's still sluggish pitch response in control of flare and touchdown and definitely difficult to fly during the approach because of the airspeed control problems. You can fly it well enough IFR with the amount of attention that you'd have available in this two-pilot airplane, one pilot flying it. You can achieve sufficiently good performance with a reasonable workload, high but reasonable, that I think I would buy it for the mission but I certainly would comment that this is also an airplane you'd have to train for and it's different from those that most of us have been flying for a long time. So, I'd rate it acceptable, in other words adequate performance. Yes, adequate performance is attainable with a tolerable pilot workload and I'd still rate it a 6. Compensation required for adequate performance is extensive and for that reason I certainly would not rate it a 4 or 5. The turbulence effects rating, I was particularly bothered by the rolling in the turbulence. It made me tighten my heading loop a little more, so definitely more effort was required. It is hard for me to separate the effects of turbulence on my performance. It would probably be minor or moderate. I'm searching between the two, between "C" and "D". Oh, I don't even remember what I rated it this morning so I'm doing it all over again. I'd say a "D" is probably correct, leaning if anything towards a "C". But I'll make it a "D".

CONFIGURATION 19 PILOT D FLIGHT NO. 15-3

PILOT RATING 10 TURBULENCE EFFECT RATING F

Following the up-and-away portion, It's quite unstable in pitch and it's also unstable in airspeed. I have no idea what the time to double is but all I can say is you're approaching my limits in up-and-away flight. I can still keep control of it but I'd sure hate to have very much going in the cockpit without having somebody I could say to, hang on a minute. 1) The ease of achieving trim, very difficult to get anything to come out where you want it to. If you were trying to get the right airspeed at the right altitude at the right power setting and everything stabilized, if that's what you mean by trim, I think it's well nigh impossible to get them all to come out the same without just taking an inordinate amount of time. But to define trim in a zero pitch rate, in terms of elevator force, that seemed to be possible. 2) The objectionable behavior off trim airspeed, I find that only plus or minus 10 knots is reasonable. When you get any further than that you're near your controllability limits. You're already off trim in terms of forces and you don't really know how much trim force to hold to sustain zero pitch rate once you even achieve it. So you're all the time pitching up or pitching downward and after you get much more than 10 knots off the trim airspeed unless you would retrim, it gets rather objectionable. I did not retrim. 3) The maneuvering about level flight, attitude control is one of keeping it bounded between plus or minus 5° attitude changes. Airspeed control is generally plus or minus 10 knots and altitude control is very, very poor. I do well to keep control of attitude and airspeed or let's say to keep it bounded and I find it rather difficult at the same time to make the altitude come out anywhere near reasonable. We'll see how I do on the approaches. 4) Maneuvering in turning flight, the lateral control is okay but the altitude control is very poor and the pitch control is very demanding. Airspeed control is very demanding and maneuvering forces are relatively heavy in attempting to stop the divergences once they get going. To maneuver to the 1.2 g is very easy. The question is how to try to keep it stopped from going even further in either the same direction or to .2 g in the opposite direction.

That I think was the most difficult configuration I've flown in this whole program. I really was hanging on there toward the last trying to get things back under control well enough to continue the approach. I think if I'd have been in a real airplane I'd of gone around at about 400 ft above the ground because I didn't have the thing well enough under control. By a real airplane I mean under real instrument conditions without anybody looking over my shoulder like I have here. I did hang on to see how well I could recover from it. What happened was I was coming down really fairly well stabilized in terms of attitude and airspeed and the attitude got away from me a little bit. The airspeed started getting slow and I went high. Then I added power to try to get the airspeed back, at the same time trying to get the nose back. I got the nose down too low and I was afraid it was going to get away from me nosedown which of course you worry about that close to the ground. This was maybe 800 ft. above the ground when this was going on and I did get things back to nominal at about the breakout altitude. It was such a great relief to be given the okay to go visual. When I went visual, it was much more stable in terms of pitch attitude control. This is a configuration I think you need to fly IFR to really appreciate it. The control of attitude during flare and touchdown was very marginal. I actually was using nearly full authority on the yoke in attempting to control attitude and flight path. I leveled off high and I went around by myself voluntarily. I suppose I was probably 20, 30 ft. in the air and I just didn't think I had a good enough control to get it back down there without encountering a high sink rate.

Comments following the second approach. That one went a little better. For one thing I never let it get very far off, particularly I flew very tight attitude and I got high on the glide slope. I think they gave that to me electronically but I couldn't really tell. It just went high and it's very difficult to correct. I think I'm on the backside of the power required curve and I'm unstable in g and attitude control. I don't know about g control but I'm unstable in attitude and also in airspeed and when you get high and fast, it's very difficult to correct if you're just high. So I had the power off to about 48% thrust or something like that but gradully got the airplane back down. I got my correction throttle back in again and stayed on the glide slope. That really was a pretty decent approach. I was working like heck but I was not panicked like I about was on the first approach. During the flare and the touchdown, I was using full control at times. I actually felt the stops in each direction -- once I think in each direction, but I was able to stay with the configuration. Then I delayed my touchdown until I gradually sank lower and lower and finally touched down somewhere around 5 or 6,000 left to go. The airspeed was low on touchdown because I couldn't get it to come down with attitude and I had to just pull off power and let it sink down onto the ground. That was the only way I could get it to come down that last little bit. I probably got a tail strike if it was a Concorde or probably any other SST but I guess I got it on.

Pilot comments following third approach. Touchdown airspeed was about 134 knots. Actually, it was a salvageable touchdown. I don't know what the sink rate was but it didn't seem too horrendous, but I was only marginally in control. I was just trying to hold what I had, attitude-wise, and let it sink on down. I was on the back side of the power required curve and settling and I think the slower I got, the more I'd sink down. Then for the same attitude the more lift I would get and kind of make up for what lift I was losing due to airspeed. Essentially I was sitting there just getting slower and anyway I finally touched down. The configuration is basically extremely difficult and it was interesting to me in that it's as difficult IFR as it is visual. In some respects it's easier to fly visually than it is to fly on instruments. Whereas most of our configurations have been more difficult to fly in the flare and touchdown portion, this one was very difficult to fly there but it was also very difficult to fly in the instrument part of the task. There are a couple of things that happened on the last approach that happened every time, which are very peculiar. When I got the configuration, it would depart nose up and when I would attempt to correct it with just elevator the airspeed would be bleeding and I'd end up in this high angle of attack, low airspeed situation. Control-wise this is difficult, because I've got an out-of-trim, pushdown force necessary to hold zero pitch rate at that low airspeed. I can't tell exactly how much force to hold so I'm always in essence supplying an out-of-trim input on the elevator that is calling for a pitch rate either nose up or nose down.

Continuing with the comments, question 5) Localizer acquisition and tracking prior to glide slope interception. The performance capability is very, very poor. I found it difficult to stay on trim airspeed, almost impossible to stay at the desired altitude and constantly required to use the elevator and throttle to control pitch attitude and airspeed. The workload was very, very high. I don't know whether the localizer task affected my altitude performance too much. I think I just basically had a problem of flying constant altitude. The workload was very, very high and in fact too high and the localizer task was interesting in that when the needle came off the peg and I initiated my right turn onto localizer final, invariably I would pitch up and it was the craziest thing. Everytime I started a turn in either direction, it seemed that I pitched up. It was interesting to me that it always pitched up and I suppose you could learn to handle that. As it was, I'd initiate a turn and the first thing you know, the pitch attitude would have increased a couple of degrees or 3 degrees and I'd be pushing like mad and pushing would do little good because the airspeed would have bled. With the airspeed bleeding and the airplane out of trim, a nosedown force was required just to keep the airplane from pitching up any more rapidly. So even though I was pushing, the nose wasn't going down and by this time the altitude was decreasing because I'm low on airspeed and since I didn't add any power and I'm on the backside, I'm sinking. I would be usually at least 100, 150, 200 ft. low by the time I got around on the glide slope and it was very difficult to get everything back together again. If you got it back together again and held it very close to the trim value, your performance was fairly good but the things like I had just described tended to keep errors in there that were very difficult to correct. 6) Glide slope acquisition was easier because generally speaking I was nearly on my localizer as I hit the outer marker. My task was more or less one of tight pitch attitude control to change the nosedown and take the power off. My problems on glide slope interception were principally airspeed. I tended to get fast so a) as I said, the control techniques were elevator for attitude, throttle to try to control airspeed and rate of descent, b) the performance capability was adequate for glide slope interception but very poor, and c) the workload was very high. Then 7) The tracking of the glide slope and localizer, a) if you got off the glide slope, it was difficult indeed to get back on and generally speaking, it took a lot of anticipation to keep from going through it in the other direction. Principally, the problem was the airspeed control and that was very, very poor; b) to maintain and reacquire the localizer, let me comment that I did something differently on this configuration since I had to in order to fly it. I don't remember consciously doing this before. I flew pitch attitude tightly and watched the localizer situation with my peripheral vision. I didn't have to go as frequently to look at heading and localizer because I kind of mentally integrated bank angle to keep my heading excursions small. Also, you can get some perception of heading error especially if it gets more than 2 or 3 degrees off by noticing that your localizer needle is no longer vertical, so then you know you have a crab angle. I was utilizing that aid which I never consciously noticed doing before. It was necessary because the time required on the pitch attitude instrument or conversely the penalties involved in looking away from the pitch attitude instrument were too great. So maintaining and reacquiring the localizer was not very difficult on the first approach, but on the second and third was better, but I did make use of this peripheral vision. The penalties involved in looking away from the attitude instrument in terms of attitude excursions that you get in order to look and read the heading, the airspeed and everything else are large so you try to make use of some crutch like this; c) The pitch attitude task does affect heading control adversely and leads to the technique that I described above. d) I just described an unusual use of the display, unusual for me anyway in that I use my peripheral vision to supply localizer deviation information, and e) The control technique, as tight an elevator as possible and with as much lead as you can generate to control pitch attitude. The throttle is used to try to bound the airspeed excursions and get the airspeed back to the trim value as reasonably quick as you can without causing pitch control problems due to extreme use of the throttle. f) The input desired to produce a desired pitch response really consists of stopping it if it starts in the right direction and a big input to start it if it's going in the wrong direction. A small input is used to start it if it's not doing anything which is hardly ever, and then anticipation with elevator to stop it at the desired pitch rate or at the desired pitch attitude. g) Very poor. I couldn't produce a desired response and I couldn't very often produce even an adequate response. h) Yes. 8) It was interesting to me that with the lateral offset, I didn't use big bank angles or large roll rates. I didn't induce the sort of attitude excursions in making those corrected turns that I would have thought I would have induced by the pitch control problem that I had in making turns IFR. So, I was able to correct the lateral offset errors that I had but if I had one as large as I had earlier today I would have had to go around with this configuration. You have to be fairly well lined up. The required maneuvering did not seemingly affect the control of landing touchdown point or sink rate. By that I mean that I had enough problems on my hands controlling touchdown point and sink rate that the additional effect of offset maneuvering was lost in the wash. In flare and touchdown, it was kind of interesting. My control activity in the cockpit necessary to produce the desired attitude control were large excursions of the elevator occasionally even touching the control limits. This only happened when I had attitude rates or flight path errors that were very large. In other words, when I had things fairly well nailed as in the final portions of the touchdown, my control activity was not nearly so large but as I was crossing the railroad track and approaching the boundary, the control activity was very, very large. When I heard 100 ft. called, I still had pretty large elevator inputs. Power management, mainly I just tried to keep the airspeed up around 160 but after about 100 ft., that was about my last look at the airspeed, and I would not really do very much with the throttles. I'd take a little bit off, but when I got down in ground effect and was going pretty far down the runway, I'd take some more off, but generally speaking, I'd be getting slow anyway and I didn't have to take throttle off. Of course, I suppose if I'd taken it off sooner maybe I'd have landed sooner but I didn't feel that I was anywhere near in good enough control to take off any more power than I did. The workload was as high as you could make it and still do it.

10) Crosswind landing, it surprised me in that it was not as difficult to perform as I expected it to be; it was of moderate difficulty, and b) the wing down technique was used. c) Again, it's effect on sink rate and touchdown point control is not observable. In other words, it didn't seem to have any additional adverse effect. 11) Control feel is difficult to talk about here. Elevator feels basically heavy. The control travel at times is very large. Other times, it is moderate. Breakout forces and friction are not noticeable. The aileron forces are light. The travel is small and the breakout forces are small and friction is negligible. The rudder -- I can't honestly say I noticed the breakout forces on the rudder on that configuration. I used very small bank angles and I probably didn't do much in the way of rudder coordination. For the crosswind landings, I put the rudder in smoothly and I still didn't particularly remember noticing the breakout forces. I'm sure they were there though. Throttle was relatively small and the friction was not noticeable. 12) The throttle feel was okay. Friction was okay. 13) This is kind of interesting on 13. The evaluation task most degraded, I believe, was IFR flight close to the ground, when the localizer and glide slope get very sensitive. And then probably next it was a tossup between the control in flare and touchdown and the control in turns. In trying to turn and hold level flight I found it difficult. 14) The turbulence effects, if I remember correctly turbulence appeared as an upsetter. It was not an especially sensitive configuration to turbulence but it was a situation where I couldn't get the airplane to settle down as well as I had been able to before, which wasn't very good. So the comparison is difficult to make. I don't think it brought out any particular characteristics except it just intensified my already intense workload. 15) The problem was not so much flying it 30 minutes in turbulence as to fly it 30 minutes. During landing approach tasks I could do it but I would be very tired. I noticed this was a fatiguing configuration but, yes, I guess I could but it would be marginal. I guess I came pretty close to doing it 30 minutes. 16) The configuration rating -- is it controllable? I have to answer no. I did fly it and I flew all the evaluation tasks. I took a waveoff on the first approach. I didn't lose it in the waveoff but I'm completely convinced that the landing of configurations like this, in the circumstances that we hypothesize in the mission, that you would lose a totally unacceptable number of the airplanes so I have to rate this a 10. So I can't get any farther up in the rating scale than that. The turbulence effect rating -- this is where I find it very difficult to use this turbulence effect rating scale. I'm already using the best efforts and it says increase of pilot effort with turbulence. It's hard for me to measure an increment when I'm already using the best, almost the best efforts. I've been using this in more of an absolute sense in that the best efforts are required. The deterioration in task performance I can answer better. It would probably be major but evaluation task can still be performed, "F". You have to understand that I'm not happy with my use of this scale and these ratings, I don't really know what they mean. 18) The primary reason for the rating -- a) Most objectionable feature is the longitudinal control, the pitch control, and the airspeed. Elevator and throttle control required to fly this thing IFR particularly close in was extremely objectionable also. The control difficulties in the flare and touchdown. b) Least objectionable -- I guess the lateral-directional characteristics. Thank goodness

for the fact I didn't have to spend any more time on the heading and bank angle control than I did.

It was very realistic and it sure was interesting to me that we can go do these things through the kinds of excursions in attitude and airspeed and I guess g. I wasn't looking at the g-meter but the control activity anyway was from stop to stop and the throttle at times from 90% down to 40% thrust. It all feels realistic and like an airplane, well, hopefully, not like you'd build an airplane but it didn't feel like a simulation anyway and I was scared to death everytime that ground was coming up when flying this configuration.

CONFIGURATION 6 PILOT B FLIGHT NO. 178-1

PILOT RATING 5; 10 TURBULENCE EFFECT RATING

The configuration seems to have a mild divergence and I won't completely describe the configuration I will just give my ratings. The approach rating is a 5. There is no problem with the approach. It requires considerable pilot attention but then the amount isn't too much greater than a normal approach in a more conventional airplane in rough air. The back side of the power curve is quite evident; there is a very realistic feeling of it and the major problem of the configuration was in the flare and touchdown. In each case, I have entered a PIO in ground effect. I get out of phase with it and I feel that the airplane would have crashed and so the pilot rating for the approach is 5, but for the flare and touchdown, I would give it a pilot rating of 10. I found no way that I really could have managed it to a safe landing.

The last approach had a system dump at 50 feet. It had a crab angle. I was about 5° right of the runway and I was trying to feel the directional control. As I started to apply a slight amount of crosscontrol, the dump occurred. On the fourth approach, I had a good view of the approach. I was slightly low on the glideslope and I felt like I was in a much better slot for a landing; whereas in the three previous approaches, I didn't feel that by following the glideslope I was getting the airplane in the proper slot for a normal landing. On the fourth approach I was in a good position at 200 ft. and would have been happy to have gone ahead and landed. However, I must admit that I was low on the glideslope at that point. I had to get below it in order to get the airplane into position for a landing. The first three approaches I was trying to use the glideslope to position the airplane and I felt that I was always in an improper position for a touchdown. On the first three approaches I felt like I was diving for the deck and I don't mean diving for the deck after entering ground effect in the PIO, but diving for the deck just prior to entering the ground effect. At 100 ft., I felt that my attitude was wrong and I was just screaming on down rather than being pitched up in a good landing attitude. On the fourth approach I think that by getting a little bit lower on the glideslope and getting into better position I didn't feel like I was overflying the whole airfield and I was actually in a position to land the airplane.

I think the general problem with the airplane just is the high workload necessary to fly it and to manage it and to maintain altitude and attitude. It is a problem during localizer and glideslope acquisition. The workload is high, the attention required to maintain pitch attitude distracts from any reasonable ability to monitor the peripheral instruments so its just pretty bad news during the approach. Performance is not degraded terribly as it is possible to obtain acceptable performance but only by really staying with it is it possible to track the glideslope and localizer. I think Item 7(e) deserves some comment. Airspeed was a problem. It requires as much attention as pitch attitude. Airspeed and attitude management were constantly distracting me from normal instrument monitoring. The pitch attitude task was affecting the heading control a bit, mostly because of the distraction. The airplane does seem a little divergent as though it is trying to get away unless I am consciously trying to control it. The divergence is very noticeable and although it wasn't very rapid it surely detracts from the ability to fly an approach. No problem with lateral offsets, however, the control technique in the flare was just entirely irrational. It wasn't possible for me to really control it through the flare. The nose down moment was strong and tended to produce overcontrolling which caused a PIO in the approach through the flare and touchdown. I thought that the approaches were reasonable but the flare and touchdowns were unreasonable and would have been unacceptable and would have resulted in crashes. So the most objectionable thing about the configuration was the divergence, there is no question about that. I could have managed the speed divergence if I had better control of attitude but the combination of the speed and attitude divergence was very distracting. The control problem in the approach wasn't half bad compared to the flare and touchdown. I felt again, as the pilot ratings reflect (a pilot rating of 5 in the approach and a 10 in the flare and touchdown) that there is a big difference in the two configurations. I felt the airplane was manageable, I could fly it during the approach but I had no way in the exposure that I had to overcome the PIO with any reasonable piloting techniques.

I didn't find the turbulence deteriorated the configuration significantly.

There wasn't any best feature to it, it just was all bad except for the lateral-directional characteristics which were reasonable. I think the problem during the flare and touchdown is definitely a ground effect control problem. The pitching moment in ground effect was what excited the PIO. Without that or with a less noticeable change in pitching moment in ground effect, I should think that the handling qualities would allow a decent landing. So I think I could have managed a smoother flare and touchdown, if the only thing that I had to control was the airplane rather than handling the pitching moment in ground effect.

CONFIGURATION 13 PILOT B FLIGHT NO. 178-2

PILOT RATING 1-2 TURBULENCE EFFECT RATING

The airplane is stable and trimmable and it seems very reasonable off trim airspeed. The maneuvering involved was normal; the climb and descent control was good, and I felt like it was a very reasonable kind of airplane. Maneuvering stability is reasonably high, in fact it is quite high I would say. The problem I have with it is that it is quite limited in the "g" capability that is available but it seems quite normal, that is, it is about what I would expect. I was able to hold probably 1.3 g and sometimes a little bit more before things became a little bit unreal. So it seems like a very conventional configuration and a very normal airplane and I had no problem with it.

I have completed three approaches. The configuration is longitudinally stable; it trims easily and there is no PIO in the flare and ground effect. Power management is simple and easy as it appears to be a configuration in the bucket of the drag curve. No problem with localizer acquisition or glideslope acquisition. All control techniques are normal and tracking of the glideslope was simple and straightforward using conventional technique and the most important thing is that the airplane is trimmable and offsets were easy to correct.

I guess no comments are really necessary on Items 9 and 10, 11, 12 - no problem and all the way down through 15, still no problem. The rating is a 1 to 2. I couldn't find any real objectionable features of the configuration so it was just a good configuration. The only other comment that I would have is that it is vastly different than the first configuration.

CONFIGURATION 12 PILOT B FLIGHT NO. 179-1

PILOT RATING 6-7; 10 TURBULENCE EFFECT RATING D

The configuration is difficult to trim and it has a divergence. It makes trimming a big problem. The airplane is reasonably easy to maneuver and to execute controlled rates of climb and controlled rates of descent. Maneuvering stability is effectively negative. I suppose if we worked at it we could find out that maybe that isn't true but effectively for just that kind of maneuver it appears to be negative. I wasn't able to really hold the airspeed constant. I can tell that it is a very poorly damped sluggish configuration. Using maximum control deflection pitch up or pitch down, I can't really get any pitch response. Moving the controls at about half a cycle per second produces barely perceptible pitch oscillation so the airplane is extremely sluggish. The instability is such that at about 20 knots off of trim speed I run out of elevator. In a dynamic maneuver with a slight pitch uprate at about 140 knots, it takes full nose down elevator to affect a recovery. So the instability is a real pain near the maneuvering limits. In the trim condition, that is, if you can find trim, the airplane again is reasonably easy to fly on instruments while making controlled rates of climb and rates of descent. I wouldn't hesitate to fly it for long periods but it would require lots of pilot attention to speed.

The configuration is a bad one. It is divergent and nonlinear except that speed isn't divergent so it's not too wild. I can intercept the localizer and acquire and intercept the glide slope reasonably. Speed management was probably the best thing about the whole configuration. Tracking requires a lot of compensation and occasionally when gusts or pilot inattention causes a pitch rate the management of pitch attitude overrides any consideration of maintaining heading control. Occasionally, because there is a list of priorities, heading control gets a little bit lost in the woods at least to me on that configuration during the localizer acquisition and tracking. The airplane does feel like it is trying to get away from me unless I am consciously trying to control it. It does not trim out and it will diverge, especially in rough air. The biggest place that I had a problem was in ground effect during management of pitch attitude rates and flare. Again, PIO's are continually encountered. There didn't seem to be anything I could do about it. I was using the real world cues looking out below 300 feet and even with intense concentration on pitch rates I couldn't keep it damped. I couldn't keep it in the attitude I wanted down below about 100 feet. The pitch down in ground effect used quite a bit of control and I did induce the PIO. Turbulence seemed to affect the configuration more than I had expected and the turbulence rating is D. The primary reason for the rating is the divergence and the pilot rating on the approach is a 6 to a 7. On the touchdown it is a 10. The most objectionable feature was the pitch rate divergence and the least objectionable was the relatively good speed stability. Again, it was one that I could manage during the approach and I would feel comfortable making an approach with the configuration. I thought touchdown management through ground effect was intolerable and I felt that each one of those landings would have resulted in a crash. I do feel though that without that ground effect I could have managed a landing quite decently even in the kind of turbulence that we were simulating. The last minute pitch down moment that occurs is enough to cause a disturbance that can't reasonably be damped by me and so it is a rating of 10. I was crashing at the end of each approach.

CONFIGURATION 10 PILOT B FLIGHT NO. 179-2

PILOT RATING 5; 9 TURBULENCE EFFECT RATING C

I think this configuration is slightly divergent but at a fairly slow rate and it doesn't seem to have any nonlinearities in the pitching moment curve. The speed divergence seems to be negligible so I think I'm going to treat it as though it's in the bucket. On the approach it is possible to control pitch attitude decently within a couple of degrees and it doesn't seem to be too distracting even though maneuvering stability is low to negative. With what tests I can do within the limits it seems to be neutral to unstable in maneuvering stability. Generally I can tell that it is going to require some attention on the approach. It is sluggish but the divergence rates seem to be all that will be bothering me and they don't seem to be too bad. So starting right off I'll be expecting an airplane in the bucket as far as speed stability goes and no nonlinearities in pitching moments so that speed errors aren't going to be too terrifying.

The task and the approach isn't too difficult. It requires considerable pilot compensation and you can't really relax and get it trimmed up, however, I find that at the touchdown there is still an oscillation and I don't really have the airplane under control below 50 feet and so I am going to rate the approach as a 5, and the flare and touchdown as a 9. It looks like there may be an occasional chance of success but most of the time looking at the conditions I saw it would crash. But again, it is the ground effect that causes the difficulty. I feel I can manage the airplane except for that last minute nose down moment and it induces a transient which is enough to cause a PIO and an undetermined condition at touchdown. So, pilot comments starting with items 5 and 6. There is no problem with acquisition of the localizer or glideslope. No problem tracking the glideslope or the localizer. The airplane doesn't feel too bad although it is trying to get away from me, referring to question 7h. But it is very sluggish and it can't be trimmed out. Constant attention is required to manage pitch attitude which is very distracting. I just don't like that, of course, but there was no great problem in correcting the lateral errors on the breakout.

That was all managed very easily and no great problem. I can't say much about control technique. Performance during the approach seemed to be adequate or good. Good performance can be maintained even in the rough air. It just requires a lot of looking but I feel that I could continue to make approaches in that configuration without worrying even with some turbulence. The flare and touchdown are something else. I haven't been able to manage that with any of these configurations, lately. Speed control was good and there didn't seem to be any nonlinearities in pitch so there just seemed to be a problem in trying to manage the pitch divergence and I wasn't having any luck with that even before the touchdown. I had plenty of luck with it in the approach - no problem there at all. On down through items 11 and 12, no comments. I think that the flare and touchdown was the most degraded by the configuration and that has been true with all of these of course. Turbulence effect - I rated this one as a C. It didn't have a great deal of effect. It had a little bit less than I would have expected from the previous one. Item 15, the answer is yes, I could go ahead and fly it for 30 minutes. No problem. But it's the flare and touchdown that really is hard. Turbulence rating is C. The primary reason for the rating was the ground effect moment disturbing the airplane during the flare and touchdown exciting a half or a complete cycle oscillation which I didn't seem to be able to manage decently at all. The airplane just didn't seem to respond like the previous ones. I didn't have the kind of control in pitch attitude and attitude rates for touchdown. So that is the reason for the 9.

CONFIGURATION 4 PILOT B FLIGHT NO. 179-3

PILOT RATING 5; 7 TURBULENCE EFFECT RATING D

It tends to have a divergence. It doesn't seem to be too rapid a divergence since I was able to manage pitch attitude quite reasonably. It has an unstable drag speed relationship which I expect to give me a problem on the approach. Attitude control as I've mentioned seemed to be reasonably good although I didn't look at it too long. There could be a nonlinearity in it. It seemed to be either that or it was a little bit more divergent than the previous configuration. But in any case, I would expect that if I was making an approach in the airplane, I would expect to have a speed divergent condition from what I have seen of it so far and I will expect to have a problem controlling pitch attitude during the approach but I wouldn't expect it to be any worse than the previous configuration. I expect to crash at the end of this approach if everything is the same as the previous configuration or slightly worse, and that is what it looks like it will be. Looks like the previous condition only with the speed divergence as well.

I have completed two landings and I think that would be sufficient to evaluate it. The landings were reasonable. I felt like I had some control of it through the flare and touchdown through both the approaches and landings. I would say that it was actually different than on the previous ones where I had a difference between the approach rating and my flare and touchdown rating. But that doesn't seem to be necessary on this configuration. Localizer and glide slope acquisition were normal and required more than the stable airplane from the pilot in terms of attention but there wasn't anything really wild about tracking the glide slope and localizer. Speed management was a problem as well as pitch attitude management but either I am getting used to it or the combination wasn't as bad as I thought it was going to be. I was still using throttle for speed control I suppose more than the other way around but I'm sure I'm blending the two for the errors. Lateral offset is no problem around the breakout altitude. Again there is no great problem when I go visual below 300 feet. The performance was satisfactory for a raw data approach on the backside or with a slightly divergent configuration. The response of the airplane is still poor. The ability to get a pitch rate out of it quickly on all these configurations is a big problem. I am really identifying that for the first time. The pitch angle acceleration that I am able to produce is too small to really fly a very tight loop. Control feel and friction was no problem. Turbulence effect - there was moderate turbulence on the approach. It was moderate on both of those approaches and I have no way to give a turbulence rating other than to say that it didn't really seem to affect performance. It must have affected the workload but I can't tell yet. (Item 15 on the question sheet.) I could fly it for 30 minutes during approaches. I think that it would be interesting, the divergence is interesting, it's fast enough to keep me busy but it didn't really spoil the approach. As for ratings, 5 in the approach and I think I will call the whole thing through the flare somewhere on the border of a 6 to a 7. I'll call it a 7 on the flare and touchdown. I didn't get into a PIO but again I wasn't getting the kind of response I wanted out of the airplane so I'll call it a rating of 7 for flare and touchdown. The most objectionable part was the pitch rate divergence. It really isn't so bad but it requires that you spend more time on it than you really should. It detracts from other tasks in the cockpit. The next most objectionable feature was the backside kind of operation. I would give it a turbulence rating of D but it really doesn't affect my performance. The breakout forces are really too high for nice control of de-crab, for me at least. I just don't like them that high. The handling qualities of the airplane aren't affected by that except that I tend to put in a jerky motion rather than a nice blending of control. That's about the biggest problem I have with the de-crab maneuver. Handling qualities are okay, yawing moment is okay, but it just can't be blended in as smooth as I would like - primarily rudder control - I had no comments on my lateral control.

CONFIGURATION 8 PILOT B FLIGHT NO. 180-1

PILOT RATING 7; 8 TURBULENCE EFFECT RATING D

Basically it looks like a reasonable airplane to handle. I will be looking for an airplane on the approach that is in the bucket. That is what it feels like so far. It has a very slow divergence so it seems like it will be quite reasonable to handle.

The localizer acquisition isn't a problem. Glide slope acquisition is a problem because of the speed management problem during the approach and the poor response of the airplane. Tracking of the glide slope and localizer is a problem because of speed management. Primarily speed and power management are difficult because of the backside kind of operation. The airplane feels like it is (I guess this is a 7 h question) trying to get away from me. That is not a good way to put it but it requires too much attention in both pitch attitude and speed management. No problem with the lateral errors or lateral control. There really is a problem in the flare and touchdown. Again, it is consistent all the way through with all of its configurations. The airplane is simply not responsive. The more I fly it the more I feel that there is another problem which may be control power rather than anything to do with stability. I think that if the control power were higher, then even if there were some delays in the response of the airplane it might be easier to manage. However, it is difficult to manage the flare and touchdown generally with all of these configurations. I didn't notice the ground effect half so much on this configuration nor the last one of the previous flight as I did on all the configs prior to this. That makes a great difference. The turbulence rating on this flight is difficult to describe because I haven't had any smooth air around so I'm guessing at a pilot rating of D for turbulence; and on your item 18, the objectionable features are still the pitch response and of course the speed divergence. There wasn't anything good about the config. but it is hard to get a good look at it because the air is rough. It is hard to say anything precise about it because we are just banging along in rough air all the time and I don't think that flying in consistently rough air is the way to decide on the details of airplane handling qualities. On this flight with all the turbulence on my first approach I rated the approach as a 5 and I wanted to hold off on the touchdown rating but by the time I got to my last approach, I indicated that the approach rating would be a 7 with the final approach flare and touchdown as an 8. The turbulence really does interfere with an evaluation. It is also good for the evaluation because it's a very practical thing but then I'm going to rate the airplane as a 7 for the approach and an 8 for the flare and touchdown. We have to note that the turbulence level is considerably different than the first flight. It is like it was on the last part of the second flight, just a little bit steadier, a little more consistent turbulence. The other thing that concerns me, still thinking back about all of these configs. is that the overriding problem they all seem to have (not considered in the test matrix) is the airplane just doesn't respond quick enough. The pitch response of the airplane is poor regardless of the stability and the divergences and the backside operation. The pitch response of the airplane is inadequate to manage a flare decently. I would like to make a real big point of that because I think that the more I look at the pitch response to the pilot's inputs very closely the more I doubt that they match existing values for Concorde. You can't really go around flying an airplane very long that doesn't respond in pitch. The frequency response to a pilot's cycling of the elevator is just grim and I think that is really what has been the biggest problem on all of these approaches. It is overriding the effect, of the straight divergences and it seems to be overriding the effects of being on the backside. You can see all those things are a problem but the basic pitch response of the airplane is poor. It isn't a matter of overshooting or of constantly wandering or speed management, it just simply will not respond even with very large control inputs. That has been true on all the configurations and I would like to make sure that we note that and indicate that in the evaluation of the stability levels.

CONFIGURATION 2 PILOT B FLIGHT NO. 181-1

PILOT RATING 7; 10 TURBULENCE EFFECT RATING

The configuration isn't really trimmable. The stability off trim airspeed is okay, it doesn't change characteristics significantly plus or minus 10 to 20 knots. Maneuvering is reasonably precise; the airplane has effectively no divergence but it also has no indication of any significant pitch rate damping so that any motion that the pilot induces continues to exist without any significant damping in pitch. The maneuvering forces are light and again the maneuvering stability is essentially neutral. As far as I can tell there is no real ability to pull any g but with the small amounts of g that I am able to pull, it appears to have neutral maneuvering stability.

I have completed three landing approaches. There was a bit of an unusual condition for these approaches. There was a 10-knot downwind condition and the turbulence was moderate on all the approaches. I guess it is just natural turbulence. It is a difficult configuration to fly decently in that condition. The localizer acquisition and glide slope acquisition are normal, there isn't any problem really with either one of them except while on the glide slope. Trying to establish the proper rate of descent is very difficult. Because of the downwind condition and some other changes it requires large attitude changes to get stabilized. The attitude indicator is really bothering me again this morning. This unmarked attitude indicator is really unacceptable because it takes several approaches to get used to it again. That's the major thing. If it had degree marks or a proper scale allowing me to come back to a reference attitude, it would be a great improvement. The other thing about it is that I am becoming much, much less of a fan, if I ever was one, of the expanded pitch attitude scale on the approach because the pitch rate that I see on the indicator looks like I am really pitching rapidly but of course I'm not.

The rate of horizon movement is too high for what my side vision indicates is going on in the real world. Okay, enough of the attitude indicator and glide slope acquisition problem. Tracking is very difficult and I had the greatest problem with airspeed. The airspeed feeds back into the glide slope in this configuration and the flight path angle. It was just a difficult airplane to try to track glide slope and localizer. It didn't really feel like it was trying to get away from me, however, question 7h I think is a very good one for this particular configuration. It didn't seem like it was trying to get away it was just hard to manage the glide slope and localizer tracking. Lateral error at the breakout was no problem to correct and the workload on the flare and touchdown was moderate. I had very little tendency to induce a PIO on the last final approach, but on the first two I had considerable trouble with a long period of PIO that I was inducing in the airplane. It felt as though it was surging up and down with a very long period without me feeling that I was inducing it directly. It was sort of a secondary kind of thing. The configuration was so difficult on the approaches (the first time) that I thought the approach was the most difficult thing as compared to the flare and touchdown. I didn't like the flare and touchdown because again I noticed the ground effect. I think it would have caused a very hard landing on any of those if I had gone right on down. Something is masking ground effect and it probably is the turbulence or the rate we are penetrating it. In any case the configuration on the approach is a 7 and I'll call it 10 on the flare and touchdown. Again, I don't think that it is a reasonable configuration to do touchdowns with at least in the level of turbulence and the downwind conditions existing. There weren't any least objectionable features in the configuration. Pitch attitude didn't appear to be diverging too badly and it was fairly reasonable to control, but it wasn't easy. On the last approach there weren't any simulation malfunctions. There was one on the second approach. I didn't really get a good look at it on the second approach because I was concentrating on the fact that I didn't have proper instrument indications to make the approach. A little bit of that on the first one too, but I think I've got a good evaluation approach out of it.

CONFIGURATION 18 PILOT B FLIGHT NO. 181-2

PILOT RATING 7; 10 TURBULENCE EFFECT RATING

The airwork indicates that it had a nonlinear pitching moment and it looks like it has about the same basic stability of the previous configuration. I can expect poorer longitudinal characteristics and probably the only good thing about it so far is that it is in the bucket. Maybe it is, it kind of looks like it might be. I didn't really have any trouble flying it or maintaining control of it in the smooth air at altitude.

This configuration is about the same as the previous one. Localizer acquisition and tracking is not a great problem. Glide slope acquisition is no problem. Tracking of it is a problem because on the backside the change in pitch attitude required to maintain a reference attitude on the approach changes with speed drastically. It makes an interesting task of it. I noticed it more today than I have on some of the previous approaches.

Continuing with the comments after three landings. The pilot rating is 7 and the landing rating is probably the same as the previous one, 10. The airplane looks like it would try to get away from me because as I get slower the pitch up tendency is greater. The lateral errors are no real problem. I didn't really see much of a crosswind landing on any of these yet. I was bouncing around so much that I didn't pay a lot of attention to the crosswind. I got it straightened out but that's about all. It could be flown for 30 minutes during approach tasks but it's not really possible to give a turbulence rating because I wouldn't know what it would be like in smooth air. I'm not going to give a turbulence rating yet. There hasn't been any smooth air to allow an evaluation of the effect of turbulence. The most objectionable feature is the unstable pitching moment as it gets slower during the speed deviations on the approach. Speed/power management was just too wild. I don't like that at all. I feel that it is very dangerous and that is the reason for rating of 7, on the approaches. Primarily it is a speed control problem.

CONFIGURATION 6 PILOT B FLIGHT NO. 182-1

PILOT RATING 6 TURBULENCE EFFECT RATING E

It is an innocuous configuration. It looks like it is in the bucket and the divergence is very small. If anything at least it looks reasonable from up here. It is not possible to trim it so it is probably slightly divergent. There is no noticeable change in trim characteristics or pitching moment at the off air speed condition and it is farily reasonable in pitch attitude control. Of course it is poorly damped and there is a considerable or continuous overshoot if I apply normal control techniques. Maneuvering stability is, as ususal, low to nothing.

The localizer and glideslope acquisition were normal. Glideslope acquisition was a problem in each case but it got better on the third approach. The tracking was poor on the first approach but I think the biggest problem that I have been having with the glideslope has been not understanding the glideslope offset inputs which occur as transients and which cause an erroneous indication of altitude at the outer marker. Because the error is so significant I know that either the altitude is wrong or the glideslope is wrong and this has been confusing to me. I know now that this is caused by the way you are introducing the offsets. The airplane feels sluggish. Question 7 (h) asks if it trys to get away from me and the answer is yes, it feels a bit like that. The lateral offset at breakout is easy to control and the last flare and touchdown was no problem at all. Everything worked just fine and I didn't have any trouble with the ground effect moment. In fact I didn't even notice it and the air was reasonably smooth from about 100-200 ft on down. The air seemed to be reasonably smooth and I had a good feeling for the flare and touchdown. For the previous ones I just didn't have that feeling at all. I rated each of the approaches and by the second approach I had the configuration rated as a 7. I rated it a 7 for both the approach and for the flare and touchdown. By the third approach I would rate the configuration as a 6. I didn't have half the trouble with speed control as I had on the previous approaches and so I am a bit confused. The problem seems to be mostly associated with the difference in the air conditions and so I am going to say that the turbulence has a significant effect on it and rate the turbulence as an "E". I did see it for a brief period of time without turbulence and it was quite reasonable to fly but in the approach it is a rating of 6. The most objectionable feature again is speed power management which is unstable and I don't like that at all. It was causing me to fly in a very awkward way. But once I got a hold of that why it ended up a rating of 6. The least objectionable feature of course, is the lateral-directional characteristics which are no great problem at all.

CONFIGURATION 1 PILOT B FLIGHT NO. 182-2

PILOT RATING 2 TURBULENCE EFFECT RATING C

The first approach was good. The airplane was stable and I thought it was flying in the bucket. It was a very good approach, a good flare, and a good touchdown. I rated it a 2. The same with the second approach. On the third approach it seemed like there was a bigger problem getting everything in the right ball park. I am convinced that the management of the glideslope error is more confusing to a pilot than helpful in determining whether the configuration is good, bad or indifferent. So I don't think that the glideslope error the way it is implemented is a good representation. I think that it should be eliminated from the task. I can't emphasize that enough, I think it has been a very confusing thing all through the evaluation so far. First I didn't understand how it was being put in and taken out and second, even after I did know how it was being done it is beyond the capability of the airplane on some of these configurations to manage. That is, I get way out of a reasonable power or thrust range to decelerate. For example, if I am a little fast and I am coming down on the steeper portion with the backside configuration, it really means that I've got the power way, way back and I am screaming on down and the attitude gets unreasonable. I had a standard approach attitude of about 10° nose up. However on some of those fast conditions with the glideslope error, I had a 7° nose down. In other words it took only about 3° nose up attitude to recapture the glideslope or to stay on the glideslope once I got fast and so I think steepening and shallowing the glideslope to produce the offset error task has an adverse effect on the evaluation. The pilot must know the glideslope angle and relate that to his wind to know what rate of descent he is going to expect to stay on the glideslope. The unknown angle coupled with really not being told what kind of an airplane you have, whether you are on the backside or not means that the whole thing is done blind and I sure wouldn't think that that's the best way to conduct an evaluation. I don't think a pilot flies an airplane like that, nor does it really help in evaluating because it takes too many approaches and wastes too much time trying to figure out just what nominal should be and then planning and thinking ahead from that to determine how you are going to handle the approach. It seems to be wasting a lot of pilot's time sorting out a configuration when he should already know what it is and what he is going to expect and then be able to plan ahead. The problem here is not being able to plan ahead, and not being able to plan ahead even to knowing the glideslope angle much less the handling qualities. I think that you really are stretching the evaluation pilot's ability to give you rational numbers by this combination of unknowns. If you leave that glideslope error in, the pilot should know that this is an approach that has a steeper glideslope so he could plan ahead for that or at least anticipate it. You just have to be able to anticipate those things in order to manage some of these configurations or even to manage any airplane decently. That configuration was a very simple one, it is nice and stable and could be trimmed in level flight and was staticly stable. It appeared to have positive maneuvering stability. I didn't really do much to see whether it was nonlinear and frankly I couldn't tell whether it was in the bucket or not. On the first approach it seemed speed stable and pretty good but then I didn't get very many very large errors. After that things were a little worse but in any case it seemed to be easily managed all the way down through the flare and touchdown and the pilot rating would be a 2 all the way through. 2 for the approach and 2 for the flare and touchdown. The only thing that I didn't like about the airplane was that it was a little bit too springy. It could have used a little bit more pitch rate damping but in any case it was a stable airplane and it flew decently. I couldn't tell whether we had turbulence on or off. I just couldn't tell whether we had turbulence on or off and that means that I think you should tell the pilot whether you are attempting to give him smooth air or rough air too. He ought to know those things and I couldn't tell so I never really was sure whether I was supposed to be in smooth air or supposed to be in rough air. It seemed like the turbulence rating would be something like a "C". Unfortunately I have very little confidence in those turbulence ratings because of the mix of natural turbulence and simulated turbulence.

CONFIGURATION 17 PILOT B FLIGHT NO. 183-1

PILOT RATING 5; 8 TURBULENCE EFFECT RATING C

The configuration is on the backside of the drag curve and with just about neutral static margin. There is some divergence nose up and there doesn't appear to be any nose down. I suppose if anything it is a neutral or very slightly divergent case. I am going to be expecting an airspeed problem on the approaches and a minimum amount of trouble with pitch rate divergence. It is really not trimmable. There isn't any change in trim with speed at all and there didn't seem to be any significant non-linearity in the pitching moment. Maneuvering stability was neutral like all of these are, neutral to negative.

During the first approach I had a PIO problem after 300 ft. The flare was poor because the ground effect overpowered the control moments that I had at the time and it was very poor at touchdown. The second was a little bit better, the flare was still poor. I think I was a little low on speed but the third approach was a good approach. None of the approaches were too bad but the flare is still poor. I didn't have any trouble with a PIO. On the Pilot Comment Sheet, glideslope or acquisition and tracking of both localizer and glideslope was no problem. The airplane doesn't feel like it's trying to get away from me. It isn't a real divergent kind of thing but I know that I have to watch it because it is constantly moving. The beneficial effect is that it doesn't feel like it is going to diverge. Lateral errors at breakout are easy to manage. The lateral control is as usual very good and there is no problem with correcting those errors. The workload in the flare is high and if I tighten up too much I can overcontrol and get it into a PIO. The control power problem is still apparent. Speed control is difficult and it requires extensive throttle manipulation and management. There wasn't any nice stabilized power that I could settle in on at any time. All questions 10 through 12 are the same as before. The ground effect is pulling the nose through and there doesn't seem to be a way that I can find of anticipating it and then flying through the ground effect with a decent control over rate of descent from 50 ft on down. The air is midly turbulent and the rough air rating would be a "C". It isn't any problem flying it for 30 minutes in turbulence during approach tasks. The approach isn't a great problem. It is the flare and touchdown through ground effect that is a problem. The pilot rating for the approach is a 5, and the flare and touchdown is an 8 and the most objectionable part of it is the speed divergence and the inability to control rate of descent through the flare.

CONFIGURATION 9 PILOT B FLIGHT NO. 183-2

PILOT RATING 6 TURBULENCE EFFECT RATING

It is not trimmable and it has a divergence, a slight divergence at least. It appears to be a little worse at higher angles of attack. It is not real easy to see but there is no question about it being a divergent condition and it is a little more dangerous at the lower speeds. It wants to get away from me a little faster. The maneuvering stability is as before. It is negative to neutral but this one seems to be negative. Again I can't really look at maneuvering stability with the kind of g's I am pulling but its gradient is in the wrong direction. I couldn't really get a feel for whether it was on the backside or not or in the bucket. It appeared to be more in the bucket during the brief time that I looked at it at altitude. I didn't do any specific tests to check it out but what I would be anticipating on an approach would be that I would want to stay on air speed, I wouldn't want to get at all slow or to higher angles of attack, and I would be very concerned about pitch rate divergence. Especially at the higher angles of attack.

I have completed three approaches and the configuration isn't so bad. I was surprised how reasonable it is on the approach. Localizer and glideslope acquisition were reasonable and easy. No great problems there in tracking. It was good, even easy. Speed management was fairly simple. It looked like it was probably in the bucket and the divergence was a minimum except at the higher angles of attack which probably indicated it was probably one of those nonlinear configurations, I don't know, but that is what it seemed like. As long as I was right on speed it was a pretty good airplane. Getting off speed it was slow to respond and produced a pitch up and it was uncomfortable. I was surprised that it flared easy and I think that is because coming back on the power and slowing down on the flare produced a pitch up moment which counteracted the ground effect and made the thing flareable and so it did flare at touchdown pretty decently. I was very surprised at that. The task degraded by the configuration most was still the flare and touchdown but not very much. I was surprised at how straightforward it was. I would fly it for 30 minutes in turbulence. I think I would fly it on the fast side though, thinking it would be a little more stable at the lower angles of attack. I would rate that configuration a 6 on the approach and a 6 for flare and touchdown. I hesitate a little bit because of the nonlinear pitching moment. It is a little bit scary but all of the three approaches that I made and all the tasks were readily accomplished with it without any great difficulty and I was particularly impressed with the fact that the instability at the higher angles of attack helped to fly the airplane through the ground effect on touchdown.

CONFIGURATION 3 PILOT B FLIGHT NO. 184-1

PILOT RATING 6 TURBULENCE EFFECT RATING

It is not a trimmable condition and it is fairly divergent. It seems to be nonlinear, that is, it wants to pitch up a little bit more at higher angles of attack than it does at the trim case of 160 knots. It doesn't seem too wild at altitude in reasonably smooth air. The only objectionable behavior off trim speed is the slow case where it tends to pitch up a little bit more than it does at 160 knots. Maneuvering and altitude control are reasonable and maneuvering stability is negative. In maneuvering I really feel the divergence. I will be expecting an airplane on the approach that should be kept at approach speed or slightly faster rather than slow. It won't be able to be trimmed. I didn't really get a feeling for whether it was in the bucket or on the backside. I would guess though that it was the configuration in the bucket and will be planning the approach for that kind of throttle activity.

I have completed three approaches with the first configuration. Localizer, acquisition and tracking, glideslope acquisition and tracking are all OK. Normal corrections are easy to make primarily because the speed control is reasonable with throttle movements; it is not good, but it's not bad. It seems to be in the bucket and the tracking of the glideslope and localizer is relatively easy as long as the speed is maintained. Going to higher angles of attack causes it somewhat to feel like it's going to pitch up and get away and I don't particularly like that, but as long as I keep the speed very close to 160 knots which is relatively easy to do, there isn't any problem. A lateral offset is easy to do and the workload in the flare has changed. I find that I can compensate for the sluggishness by putting very large inputs in and taking them right out again. Really not waiting for some sign of response but just to get the control. Putting a very large input in and out a pumping kind of effect and by doing that it seemed like it helps the performance in the flare and the touchdown. It doesn't seem like the way to fly an airplane, but it works reasonably well. I think it might be called an unusual kind of control but it does work. Maybe if I had done that on some of the earlier configurations the flare and touchdown ratings would be changed a little bit. However, I will have some more to say about that when I finish the second configuration on this flight. Yes, I could fly it for 30 minutes on approaches but I'd be sure that I kept the speed up. I wouldn't want to get slow. I would rate this configuration a 6 and a 6. That's 6 for both the flare and touchdown and the approach. The most objectionable feature is the pitch up as I get slow.

CONFIGURATION 7 PILOT B FLIGHT NO. 184-2

PILOT RATING 7; 8 TURBULENCE EFFECT RATING C

I have done the air work and it looks like it is a neutrally stable airplane. There is very little divergence about the trim airspeed but it tends to diverge more at the higher angles of attack. It is slightly unstable through 160 knots but it tends to diverge more at the higher angle of attack I think, at least that's my impression. It feels like it is on the backside of the curve so in the approach I will be looking for an airplane that has a speed power problem and will be concerned about using power for flight path management. The only objectionable behavior off the trim airspeed is the tendency to pitch up but that seems evident only when you are 15-20 knots slow. It's not really trimmable. I didn't really use the trim, because it would just get me out of "sync" with it. In most of these cases, I haven't really used any trim or found it useful. Maneuvering stability is negative. Whether it is maneuvering stability or something else, it's hard to say but it does tend to pitch up before I get to any higher angles of attack.

It seemed fairly reasonable on the approach. In the beginning I was having a great problem with it. It never did seem very good on flare and touchdown. I never really had control over the final sink rate. Localizer acquisition and tracking were no great problem. Glideslope acquisition the same and the tracking the same. The airplane did feel like it would try to get away from me. If it would get a little bit slow then it was divergent and it was that usual problem. Lateral offsets were no problem. Workload in the flare was a problem and so was flare control. I didn't have adequate elevator power to produce a flare to overcome the ground effect and to actually complete the final flare and touchdown. The crosswind landing was the usual problem with the rudder breakout forces producing a dynamic overshoot. Sometimes I get a sort of step input because of the breakout force and it causes an overshoot. The flare and touchdown is the biggest problem. The turbulence rating is "C" and it could be flown for 30 minutes. It doesn't require that kind of compensation as long as you keep the speed up and watch the speed control. The speed stability was bad and speed management on the backside is a bit of a problem. If I kept it under control though it could be flown for long periods of time. My initial rating on it, that is after the first approach, was an 8 for the approach and a 9 for the flare and touchdown and after doing two more I found that approach management, except for speed, was reasonable but it is still a rating of a 7 on the approach and an 8 for flare and touchdown. The reason for the rating on the approach for the downgrading was speed management. I just felt that there was much too much attention required to speed management. The most objectionable feature, of course, was the inability to flare the airplane properly in touchdown, so I would end up with the rating of 8.

CONFIGURATION 2 PILOT B FLIGHT NO. 184-3

PILOT RATING 5; 8 TURBULENCE EFFECT RATING

I have completed one approach and I had very little time to look at it at altitude. It seemed to have a mild divergence, probably linear C_{m_α}. It didn't seem to be a greater problem at higher angles of attack. During the one approach that I made, it felt like it was probably in the bucket. I got a little fast so I didn't get a big opportunity to have a look at the speed control. But it was bad on the flare and touchdown since I had so little flare control power. I'd rate the flare and touchdown as an 8 and rate the approach itself a 5.

CONFIGURATION 1 PILOT D FLIGHT NO. 185-1

PILOT RATING 5 TURBULENCE EFFECT RATING D

Comments following the up-and-away flight portion.

They have given me a nice flying airplane because I let it fly itself for a minute and nothing happened. It's very unusual in this program to have a configuration that you can essentially do nothing for a minute. Then I started flying it around and found that basically it's a stable airplane. In the g-response sense it's moderately easy to fly it straight and level. In turns there is a little difficulty in holding altitude or if you attempt to hold altitude in keeping airspeed right on where you want it but this seems to be thus far only a minor problem. When in level flight you go off airspeed above or below, the handling characteristics don't seem to be a problem. The speed changes at constant altitude are difficult to make and that is where you discover that the airplane apparently is on the back side. For example, if you want to increase speed you have to add throttle to increase the speed. Then, when you get to the new speed you have to reduce the throttle below that which is required to maintain the lower speed that you had been at before, and the converse is true. What this does is make it difficult to hold altitude when you are making aprecision speed change. (1) The ease of achieving trim is in terms of finding the elevator trim position that will give you zero pitch rate when you are at the right airspeed and that's easy. The ease of achieving a trim flight condition at the desired airspeed and precise altitude is noticeably more difficult but you can do it. It requires a lot of manipulating of throttle and attitude to keep the airspeed going in the direction you want it to without having the wrong altitude come up. (2) Behavior off trim airspeed is not objectionable in terms of controllability. The airplane has a moderately strong stick force vs. speed but it is strong and apparently not undesirable level of stick force. The only objectionable behavior is the throttle management required to attain and hold the airspeed off trim, in that, we apparently are on the back side and it makes the power management more difficult. (3) Maneuvering about level flight - attitude control is fairly good. The response in pitch seems to be adequate for the up-and-away portion of the maneuvering. Airspeed control is a little more difficult but manageable. It appeared to be on the back side and so you have to attend to airspeed but if you are just trying to hold a given airspeed and not depart too far from it, its not bad. But when you want to make changes in airspeed you do have difficulties as I have described them above. Altitude control is only fair. It's not as good as I have seen or as I would like. (4) lateral control was fairly good. I do notice the breakout forces on the aileron; they are noticeable but not objectionable. The lateral control was really pretty good and rudder breakout forces are noticeable but I don't have to use too much rudder so I can live with them. The altitude and pitch control in turning flight, the pitch control was fairly good. The altitude control is a bit of a problem and it seems to be linked up with airspeed control. In otherwords, if I keep the airspeed proper, altitude control is relatively easy but you do have to use the power properly to keep the airspeed under control. Maneuvering forces are acceptable, a little on the heavy side in pitch.

Pilot's comments following the first approach. On that approach I never did get settled down. I never did achieve trim flight at 1800 ft. Prior to interception of the glideslope the power settings to achieve trim flight had changed. I think the problem was that we couldn't hold the throttle set light on. It flickered from high to low to set to high to low to set very rapidly. When we actually engaged it said low and I assume that was because of the initial out of trim engage. I had the power back below 40% thrust and my rate of descent was not high enough and the airspeed was a little high about 8 knots high. I realize that we are on the back side and that would require less thrust but I don't think that totally explained the difficulty. I didn't get squared away on the altitude and airspeed before glideslope interception. I was not squared away on the localizer either and that is partly because of the big crosswind. Then I couldn't get on the glideslope. I got off in the beginning and I started correcting back but then I got off again. I was high at breakout and the glideslope needle was almost pegged indicating I was that high. When I broke out visually I pulled off power even more and stuck the nose down. I went down quite rapidly even a little more rapidly than I intended. My flare was very short and I had a crosswind correction in but I don't really think I had quite enough. I wasn't quite ready to touchdown when I actually did. I would be interested in knowing what the sink rate was. I think it was moderately high but I think it was within the acceptable limits.

Evaluation pilot comments following the second approach. Its an interesting configuration. When I first got it in the up-and-away flight I though it was pretty good, but what I find is that the backsideness of the configuration is very definitely objectionable. That was a very unusual approach and I don't think I will penalize it too much because I made a 360 degree turn inside the outer marker but it did give me a chance to make 30° bank turns relatively close to the ground trying to hold airspeed. I actually intercepted the glideslope still in the turn angling in. I got way below the glideslope in the localizer acquisition part of rolling out of that 360° turn and again the problem was the throttle management to hold airspeed. I just got low and when I went visual the glideslope needle was out of sight, I was that far below. I essentially flew in level, intercepted the glideslope again visually and went on down and made a good crosswind landing and touchdown. So the pitch controllability of that configuration is quite adequate and works pretty good. It's the backsidedness affecting the altitude and airspeed flight path control that really gives me the problem. Just to make a 360° turn, the throttle has to go up to 90% thrust, at least, to make small corrections in airspeed. And when you roll out you have to get it right back off to the 62% that it took for straight and level flight or the 53% or so that it took on the glideslope. You had to get it promptly back or you end up with an airspeed error that is quite substantial in very short time when you roll out of the turn. So I think all my problems with the configuration are centered on the backsidedness of the configuration and the diffciulty in maintaining precise flight path control.

Comments following the third approach - we lost that one as we went across the railroad track, the system dumped. So I have asked for a fourth approach. We had similar problems on that approach. When we engage I no longer had my attitude reference where it was before. In other words, on that one it took 12° of pitch attitude instead of 13° for level flight and it took less power, I think it was 55% rather than the 58%. It's just aggravating that you don't get to fly it enough to find out what that is before you start down. I don't mind it being different but you don't really get a chance to get it sorted out. The airplane was out of trim nose up when given to me that time, so I had to retrim. You can consider these as tasks but it does make comparison more difficult. When I say comparison I mean comparison in terms of task difficulties by which the pilot tends to relate to the characteristics of the configuration. The backsidedness of the configuration continues to give me trouble, it's hard to hold airspeed and flight path and glideslope and localizer, all of them in there together. Turbulence is moderate and a distraction.

Comments following the fourth approach. That was really the first approach I think that I got the plane in trim. With this configuration, if you are working on small perturbations about a nominal condition that you have got reasonably set up, it's reasonably controllable. You can fly it quite accurately. I flew the localizer and glideslope on that one very accurately. The turbulence was at least moderate and was distracting to me and bothersome physiologically I guess, but inspite of that I could handle all the tasks I had here and I performed well. One of the main differences is that I was never very far off and I tried my best on that one. The flare and touchdown was not very good and I thought the sink rate was a little too high on touchdown. I think I pulled off a little too much power. I didn't catch the airspeed at touchdown but it was almost down to 150. (5) Localizer acquisition and tracking prior to glideslope interception (a) Performance capability was not better than fair and at times poor (b) The workload is moderate and the (c) The localizer task did effect the altitude performance. With this configuration you have a definite tendency not to have the nose high enough on entering a turn. In otherwords, I just seem to have a real tendency to drop the nose pitch attitude-wise, every time I would roll into a turn. The sequence of events in turning flight with me is that when I roll into the bank I lose altitude. Then I gain altitude and get back on. There is a kind of a nose dip there every time and this detracts from my performance on the localizer. The turbulence adversely effects that too. So I would say the localizer task was only fair at the best and sometimes poor and but mostly fair, and the altitude performance was degraded. (6) The glideslope acquisition (a) The control techniques to acquire was positive nose down to get the flight path pointed downward and power reduction of about 10%. (b) The performance capability was fairly good on that last approach. On the other ones it was pretty poor so it varied from poor to good and again the secret on the last one was I never got very far off. If you get far off it is very difficult to reacquire with accuracy. (c) The workload was moderate and the workload I can't describe as high. It's just that my control technique does not produce the desired result very fast. It doesn't produce it with very good precision if I have gotten very far off. (7) Tracking of the glideslope and localizer (a) I have already answered that the ability to maintain and reacquire varied from good to poor. It was good when I had it acquired and tracked it very tightly. If I got off, it was degraded to fair and sometimes to poor, as far as ability to reacquire it or sometimes even to maintain its rate of departure. In otherwords, there were times when I knew I was low and made a control correction in power and attitude to reacquire it. Then I went to work with the localizer because I had problems there too and by the time I got back to the glideslope I was farther off than I had been before. (b) Ability to maintain and reacquire localizer, that was degraded on this configuration principally by the bank angle response to turbulence inputs. It was quite substantial. The bank angle errors that were introduced by turbulence are as much at 10°. You had to put corrections in the opposite direction to correct the heading error that had accrued from the bank angle error. I had a bit of a feeling of a rolling approach. It wasn't bad but it was noticeably more objectionable than some of the smoother approaches that I have made with these same lateral-directional characteristics. I have to go back up to (a) I didn't mention control of airspeed - control of airspeed was a problem but the control of flight path seemed to be more of a problem. The airplane had a natural stiffness in angle of attack, apparently. To attempt to keep the airspeed to where it belonged was done at the sacrifice of the altitude tracking performance. (c) The pitch angle task doesn't effect heading control too much. It's o.k. The pitch task in terms of glideslope does effect the heading control adversely and that was part of my localizer difficulties (d) No unusual use of the display. (e) control technique, elevator just generally to produce a pitch rate and I relax it when you get to the desired pitch angle, if you need to do it more rapidly you put in larger inputs. Throttle was used to principally control airspeed and rate of climb errors, in conjunction with pitch angle. In otherwords, throttle was used in conjunction with pitch angle to control altitude and altitude rate. (f) Input, I answered that elevator was used to generate a pitch rate until you get the desired angle and then you relax it or go to another elevator angle. (g) Airplane motion due to elevator responses was reasonably decent and (h) the answer is no except in altitude (8) No difficulty correcting offsets. I didn't have very big ones. I must have been off the localizer in the correct direction when they gave me the localizer offset. I did have a lineup correction to make but it wasn't any problem. The answer is no - it did not effect my control of touchdown point. (9) The control technique in the flare and touchdown was pretty normal airplane-like. As I got close to the ground a small amount of elevator input was required to correct a nose down tendency in the ground effect. Elevator was used to control the pitch attitude of the airplane and power reduced so it would land. The performance workload was reasonable and normal airplane-like. (10) The crosswind landing, every one was a crosswind, the last two were less of a crosswind. The difficulty was just normal difficulty - nothing in particular abnormal (b) wing down (c) no more effect than you would ordinarly encounter with airplanes. (11) Elevator forces were a little on the heavy side but o.k. Mostly they are heavy because of airspeed errors. The travel was relatively small. Breakouts were not particularly noticeable. The aileron forces weren't as light on this evaluation as they have been on others. Mostly it was because I was maneuvering more with the ailerons because of the turbulence. The aileron forces are quite acceptable. The travel was relatively small and desireable, although I still don't have the feeling they were as small as they have felt to me on other occasions. Again, I think it was because I was maneuvering more. The breakout forces were not objectionable. The friction was not noticeable. Rudder breakout force, the rudder forces were moderate and desirable the travel was small and desirable. The breakout force was large and objectionable and the friction was not noticeable. (12) The throttle control feel was adequate and the friction was the desirable level. (13) The evaluation task most degraded by the configuration was getting off flight path or off airspeed when you are on flight path. (14) The turbulence effects, the rough air did bring out objectionable characteristics by tending to induce flight path errors that were difficult to control and bring back. (15) Yes, I could continue to fly in turbulence, but the answer is just yes. (16) The configuration rating is - Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? The answer is Yes. Is it satisfactory without improvement? The answer is clearly, No. The deficiencies do warrant improvement. I will eliminate a rating 4 from consideration because I could not really attain the desired performance in the turbulence we had, if I had offsets. I guess I could have with a lot of training and more than moderate compensation, but I think I would eliminate the 4 and I think I would eliminate the 6 which says adequate performance requires extensive compensation. The performance I am talking about is not as in the ordinary case in the flare and touchdown part. Adequate performance that I am worried about is in the IFR approach. I can achieve adequate performance but it does require considerable pilot compensation. I would call the backsidedness of the flight path control problems as moderately objectionable deficiencies and I would rate it a 5. The turbulence effect rating I didn't really fly it much in no turbulence so its hard for me to talk about the increase of pilot effort with turbulence. In the up-and-away maneuvering I saw some hints of control problems but they didn't manifest themselves to the extent that they did on the approach. I would extrapolate from that and say that definitely more effort was required but not best efforts due to the turbulence. The deterioration was either minor or moderate so its either Charlie or Delta. I think the deterioration in flight path control probably was moderate so I will rate it a Delta in terms of turbulence effect rating. (18) Primary reasons for the rating, the flight path control in pitch primarily was the most objectionable feature of the configuration. There was a difficulty in maintaining airspeed but the task difficulty was more in trying to get the flight path to where you wanted it without excessive airspeed excursions. Secondary objection was the bank angle response in turbulence. The least objectionable or best maybe I have to say the longitudinal angle of attack stability or tendency to stay pointed the way it's going. I found that what we normally call short period response to be quite predictable and basically fairly good. Also the bank angle controllability except for the disturbances in turbulence was quite good too.

CONFIGURATION 4 PILOT D FLIGHT NO. 185-2

PILOT RATING 7 TURBULENCE EFFECT RATING

Evaluation comments following the up-and-away maneuvering. I find this to be a very interesting configuration, I think we are on the back side the same amount we were in the other configuration. I judge that primarily from the power settings required to hold the trim airspeed when I am off airspeed. This configuration is a little unstable in pitch and yet in many respects I can fly this configuration more precisely so far than I could the preceeding configuration in terms of flight path. Now I only do it because I spend a lot more time on pitch attitude. I fly pitch attitude much more tightly on this configuration. If I flew pitch attitude as tightly with the first configuration, I would undoubtedly fly it probably even more precisely than this one. I was almost lulled into a false sense of security by the angle of attack stability of the first configuration and I'm not so lulled by this one. I know I have to be on top of pitch angle all the time to do a better job. Also, the airplane doesn't have this strong will to nose down when the airspeed is low and consequently my flight path errors are not as large before I detect them. Pilot comments following the first approach. The approach went really fairly well in the sense that I tried real hard to be on altitude, glide slope and on localizer and basically, performed fairly well. The airplane is unstable in pitch, it's quite noticeable, but I was tight enough on the attitude indicator that I could handle the configuration and the performance I achieved was really pretty good. The configuration is definitely back-sided and so you really have to sweat a little on the airspeed control. Again, if you work the airspeed hard enough and keep it close enough to nominal, you don't really have too much problem. I didn't see the configuration when I really got off glide slope and airspeed, which I will do in the subsequent approaches, but I guess that'll be on another day. I really would like to emphasize with this configuration the fact that the decrease in angle of attack stability on the backside offers the pilot some advantages in the control precision which I think I can achieve. In other words, when I get off airspeed, my problem is to try to correct the airspeed error with a throttle input and I don't have to simultaneously sweat a pitch angle correction too. I have to do this if I have a strong angle of attack stability and get off airspeed. So I found it to be a very interesting configuration and one that, in terms of IFR flying, I could even achieve a little better performance in turbulence than I could with the other one. The workload was definitely higher, but achievable performance seemed to be better. However, I'm talking about IFR now. Everything came unglued during the flare and touch-down portion because I didn't have adequate control of the configuration, I got in a PIO and I hadn't really generated enough lead to fly as tight a flight path as was necessary for a precisely controlled touchdown. Now I may be able to develop that capability with subsequent approaches, but at least on that first one, it was like a galloping elephant. I touched down at the bottom of one of those oscillations, realizing I was going to, but not doing a heck of a lot about it. So I think I touched down fairly hard. I also was amazed by the fact that I didn't have a crosswind. I kept trying to correct for it, but it had been taken out electronically. It didn't affect the evaluation, I just didn't have a crosswind on that one. Yes, it's controllable. Is adequate performance attainable with a tolerable pilot workload? And I think the answer probably would be No, based on what I saw about the flare and touchdown. But IFR, the answer would be yes. Then I would say, No, it's not satisfactory without improvement. On the No part, as far as the flare and touchdown portion goes, it probably is not an 8 or a 9, it's probably a 7.

CONFIGURATION 4 PILOT D FLIGHT NO. 186-1

PILOT RATING 8 TURBULENCE EFFECT RATING E

This configuration is the same configuration as the previous flight. Since it was the same configuration, I did not do the up-and-away part of the evaluation and we started right in with an approach. The configuration in terms of performance was rather poor. It was not a standard localizer interception. When they gave me the airplane, I was just crossing through the localizer and so I made a right 270 to intercept and it worked out all right except that during that turn, altitude control was difficult and I unintentionally lost about 300 ft. Then, when I reacquired the localizer, I still had trouble flying at constant altitude at the right airspeed. The configuration is back-sided and somewhat unstable in pitch. The turbulence is moderate and there is a fair crosswind from the left on this runway 28 approach. On the IFR portion, the unstable pitch required a lot of attention and I had a tendency to put inputs in that I should not have put in but I kind of cut my gain down a little bit and my performance improved. I still found that the configuration required a lot of attention. The controllability in the flare requires a lot of lead in order to generate the right flight path response at the right time. I don't like the configuration very well. I don't like it as well as I remember liking it on the one approach I did on the last flight. Evaluation pilot comments following the second approach. The turbulence level was lower on that approach, most of the way, and it was noticeably easier to fly when you got out of the turbulence. My performance was noticeably better. We're going to make one more quick short approach. The only reason I asked for that I really have not evaluated the controllability in the flare and touchdown, because the system dumped on that first approach. On that approach, I kept things much closer to nominal and consequently had a much easier time of it. You're definitely on the backside and you do have to go after the airspeed errors promptly. If you go after them promptly, they don't depart too far from the nominal, everything seems to come out much nicer. In the flare portion, the controllability was marginal and I had to generate a lot of lead. I ended up on that approach with a pretty good touchdown. I don't know whether there is learning involved or just what but I don't have any airspeed information because I'm so busy looking out the window to capture the pitch attitude changes that I require. There was no apparent crosswind that time. I just don't have time to look at the airspeed and that time I touched down considerably slower than I intended to. It looked like 142 or 3 knots. So in that sense it wasn't a good touchdown but in terms of the sink rate and position on the runway and minimum drift, I thought it was a pretty good one. Comments following the third approach. I got fast on that approach. I got a little high and fast and I don't know whether they gave me that error on the glide slope or what, but there was an error. A high and fast is difficult to correct and yet I did it and I did it with adequate precision. But you are indeed busy and you feel relieved when you go VFR. There was turbulence at times on that approach of a magnitude that interfered somewhat with the task. Basically, I saw what I wanted to see which was that the control requirements in pitch could be learned. The action on the part of the pilot in order to achieve the necessary flight path control could be learned and I always had some part of that PIO going, a little tiny bit anyway. But I could manage it and so I would say that the configuration is controllable; but that when I get to rating it, that it won't be acceptable. So let's go to the questions. (5) localizer acquisition prior to glide path interception. a) The performance was adequate. With this configuration I didn't have the problem of my nose ducking down everytime I entered a turn like I had with the first configuration this morning. And so I was able to turn in and acquire the localizer fairly well. When I was in turbulence the bank angle control precision was interfered with by the turbulence causing bank angle errors which caused heading errors and which made me devote a fair amount of time to the heading tracking task. If I did that, the pitch angle would get off or if I controlled the pitch angle, the heading would get off. So that performance I would say was fair and b) the workload was moderately high, and c) the localizer task did affect the altitude performance but I was able to achieve a safe level of performance. (6) a) the glide slope acquisition, I had to be careful to nose it down and stop the attitude rate at the desired attitude and get the power off so that was control technique. b) The performance was fair and the workload was again moderately high. You had to pay close attention to pitch attitude and you had to continue to worry about your localizer corrections and the heading angles to provide those corrections. (7) the tracking of the glide slope and localizer -- a) Ability to maintain was fair. The ability to reacquire was fair to poor and the control of airspeed was, I don't know whether to say fair or fair to poor. As long as you caught the airspeed errors early you could get them back and then you'd say it was fair. If you let the airspeed get farther away, like 5 or more knots off, the throttle changes were substantial but that what's necessary to correct an airspeed error. Let's suppose that we're 5 knots slow in airspeed. Well, first of all, because you're 5 knots slow, you're going to pick up a rate of sink because you need more power than nominal because of being slow on the airspeed. So you need so much throttle just to keep from sinking below the glide path. Conversely, if you adjust the attitude to keep from sinking below, then your airspeed is going to decrease that much more rapidly. Either way you need an increment of throttle just to keep the airspeed from not getting any lower and then you need another increment of throttle to start it back to the trim value, so you ended up having to make a pretty large throttle correction. Then, as the airspeed starts approaching the desired value, you've got to be real careful to get all of that extra throttle back out or else you'll accelerate right through it. So it is a rather demanding task and requires rechecking with airspeed and throttle setting enough that it interferes with your heading, localizer and glide slope tracking tasks. Combined with all this, you've got an attitude instability that you've got to keep track of which further compounds the issue. b) Maintaining and reacquiring the localizer was fair and the difficulties were mostly interference of the pitch and flight path task. c) Yes. d) No. e) Throttle was used to control airspeed and to set up rates of climb and descent. Elevator to control attitude. f) It takes an elevator to initiate the desired pitching velocity and an elevator to stop it when it gets there. g) It's fair except that when you open the loop to look at something else, it tends to depart from the desired pitch attitude. The necessity for stopping the pitch at a desired attitude is demanding. h) Yes. But it isn't so violently unstable that you can't look away and tend to other things but you have to remember to come back in a few seconds. (8) That I could do fairly well. Some tendency to get a little low when I did that. But no substantial effect on the touchdown point. (9) Elevator with a lot of lead to control pitch attitude which in turn is used to control the flight path. The throttle is used to control airspeed and remembering to take a little throttle off when you got down into ground effect. The performance was, I would say, poor but safe as long as you have adequate training. Workload is high and skill required is high. (10) Crosswind landing, a) Normal difficulty but I did notice that my lineup attention tended to degrade my control of pitch. b) Wing down. c) It did affect the pitch control adversely. (11) Elevator is I guess moderate. The maneuvering forces are almost zero. The forces necessary to control were just modest. The travel, steady state-wise is small, but maneuvering like in the flare and touchdown a couple times stop to stop. c) Breakout is not noticeable. d) Friction is not noticeable. Aileron forces are fairly light. Travel is small. Breakout is fair but not bothersome. Friction is not noticeable. Rudder forces are light to moderate. Travel is small. Breakout is large and objectionable but acceptable. Friction is not noticeable. (12) Throttle control feel is adequate and friction is not objectionable. (13) The flare and touchdown. (14) The turbulence definitely degrades this configuration. The performance that you achieve and also the workload necessary to achieve a given level of performance. (15) Yes. (16) Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload. No. Deficiencies require improvement. I'll eliminate a 9. It's not intense compensation required to retain control. I look at a 7 and 8. If I were to say controllability wasn't in question, that bothers me a little bit because if I don't supply the right inputs, controllability certainly is in question. But when I do, I don't think the controllability is in question. An 8, considerable pilot compensation required for control, that's a true statement I think. I find that a little hard to answer, a 7 or an 8. I'll rate it an 8. Mostly because of the flare and touchdown part. Okay, (17) turbulence effect rating -- the increase of pilot effort with turbulence, when I got up to the moderate turbulence, I think that best efforts were required and the deterioration of task performance with turbulence is moderate and so I'd rate it an "E". (18) Primary reason, most objectionable feature is the control of the touchdown sink rate and touchdown point. You have to sacrifice touchdown point for control of touchdown sink rate. I was able to do it. There was a time this morning I didn't feel I had control. The two times I went to touchdown this afternoon, I did have control and so that's why I ended up rating it an 8 because I said considerable pilot compensation is required for control. I think with training you might even bring this up to a 7 but I had to make a decision so I called it an 8. b) The least objectionable I guess would be the lateral-directional characteristics.

CONFIGURATION 8 PILOT D FLIGHT NO. 186-2

PILOT RATING 5 TURBULENCE EFFECT RATING C

In up-and-away flight, it's not a very good configuration. It's sluggish in pitch. I don't really know what to say about it. I could do all the maneuvering. I didn't like that configuration very well. For small airspeed changes, it's probably at the bottom of the bucket but it is surprising to me that on the slow side, running it down to 140 knots, it took 80% thrust to hold level flight. It took the same power setting to hold 180, 170, or 160 knots and only slightly more power to hold 150, but a whole lot more to hold 140. So I didn't see any unusual characteristics in the speed changes. If anything, it became a little more unstable at the slower speeds and that made me think about a nonlinear C_m vs α but I don't know whether I've got it or not. So the control behavior didn't seem to be substantially different as the speed changed, except for this business of the power required and that was a significant function of speed, at the low speed. The real proof is going to be the approaches and the flare and touchdown with this configuration. I would rate the controllability of the response in pitch to be very sluggish from what I've seen so far, but in terms of any instability there is a little here, but it's not a real strong thing. It just mostly appears sluggish. 1) Ease of achieving trim, I've seen worse and, of course, I have seen a lot better. It was of intermediate difficulty. It wasn't easy and it wasn't real difficult. 2) No real objectionable behavior off trim airspeed except for the fact that when I got to 140 knots it required an awful lot more power and that would be a little bit of a bobby trap I think. 3) Attitude control, it's sluggish, but adequate for up-and-away flight. Airspeed control, it wasn't too bad. Most of the airspeed errors seemed to be induced by attitudes errors that crept in. Altitude control was only fair. In other words, I wasn't able to keep it on altitude as well as I would like. 4) For maneuvering in turning flight, lateral control was okay. Rudder pedal breakout continue to bother me. Altitude control and pitch control, it required a lot of throttle in the turn to keep from either losing airspeed or losing altitude and it required attention but you could do it. Airspeed control was only fair and maneuvering forces were very, very light. In other words, the steady forces were very light. Comments following the first approach. I had to make a 360° turn right at the outer marker and that's kind of an interesting maneuver especially on your first approach when you don't know the configuration too well. If you can hack it without screwing up completely, it gives you some confidence in the handling characteristics of the configuration. What I really found was the configuration was better than I had anticipated in that I could make the 360° turn. It was a fairly high workload, 30° bank angle, but I did it. I got it coming down hill on the glide slope all right and the localizer task was fairly difficult in that I had a 30° cut there inside the marker but I made it and airspeed and glide slope didn't get too far away from me. As for the visual part, I broke out with a lateral offset and corrected it without much effect on the flight path. The airspeed stayed pretty constant during that maneuvering which was nice to see. During the flare and touchdown maneuver. maneuver, I didn't really have as much pitch control as I'd like. I noticed the ground effect quite considerably and it gave me a nosedown tendency but it was a fairly hard landing. In other words, it was not a greaser by a stretch but it certainly was an acceptable one. Comments following the second approach. It was a fairly standard approach but I was late getting the marker. In other words, I intercepted the glide slope outside the marker. The tracking was surprisingly comfortable. It's noticeable with this configuration that I can relax a little and fly the airplane. Things stay bounded and pretty well under control. It's not a good comfortable airplane on the approach but it's a noticeable improvement over the last one, for example. The throttle activity is certainly greatly reduced. It is still necessary to keep the airpseed under control and, particularly, I do notice that a lot of throttle is required in a turn. You have to learn this but I think it's the sort of thing you can learn about a configuration in an airplane. But you can't go to sleep with the throttles or the airspeed just bleeds right off at the higher angles of attack. This is quite noticeable. The increases in angle of attack do demand substantial throttle increases in turns. But outside of that, it's sluggish in pitch but you can fly it. I was surprised again on the flare and touchdown maneuver that, although it is sluggish, I seemed to be able to make it do what I wanted it to do, but not precisely. It's a big ponderous, slow, sluggish airplane, but staying on top of it, you can get adequate control of sink rate and reasonable control of touchdown point without the airspeed getting out of hand. Although as you sink into that last bit of ground effect, you do feel like you're a little out of control but again you can achieve what seems to be a tolerable sink rate. I had a crosswind on that one and the crosswind correction came out all right. I had an offset and it came out all right. Comments following the third approach. Well, unfortunately we dumped on that one shortly after we crossed the railroad tracks so we're going around to make another short approach. The configuration was IFR as it had been before. It did seem to me that the engineers are screwing me up electronically with and without the crosswind. That's quite all right. I'm sure they must have taken the crosswind out on that one because the heading inbound was about the localizer course. It took me a minute or two to get adjusted to that but just before I broke out, I had some turbulence that caused a heading change of about 10°. Getting a heading change that big that close in caused me to lose the localizer and I was trying to get it back when they told me to go visual. I think that approach was supposed to have an offset, but it wasn't much of an offset. I was low on the glide slope after I went visual and a little low on airspeed, and I was making that correction in power and flight path when the system dumped. Pilot comments following the fourth approach. I had to work on that approach. I didn't have my airspeed and everything nailed when I was close in. It came out all right but it required hard work to make it happen. The flare and touchdown was beautiful up to probably the last ten feet or so. I've noticed on each approach that you get a strong nosedown pitching moment which I don't see until the nose is starting down. When I pull back it doesn't really do a heck a lot of good. I pull back and actually I have the feeling on that one I would have kissed and gone back into the air. Whether you get another nosedown pitch depends on what happends when the gear contacts the ground. What I noticed if I just take it down to the point of touchdown was the nosedown pitch at the very last few feet and the fact that I was behind in making the correction for that. So the configuration is characterized in three ways. I think one is the sluggish response but basically it is not unstable. The airspeed situation feels like the bottom of the bucket, in that you don't have any real airspeed stability but you don't have an airspeed instability either. But there is a definite requirement for significant additional power at higher angles of attack than trim. I think you can learn to accommodate that and when I was evaluating it I didn't notice a strong noseup pitching moment associated with it. So I don't really find it very objectionable. 5) Localizer acquisition and tracking, prior to glide slope interception -- a) performance capability is fair. Workload is moderate and the effect on altitude performance is not very great. What really happens, when you roll into your turn, you don't get too much of this nosedown pitching moment so that you don't get much of an altitude error initially. You do have to be careful that you don't get slow in airpseed through. That's the main thing. Because as you roll into the turn, you got to program some throttle with it. If you do that, localizer acquisition came out as I said with fair capability. 6) The glide slope acquisition -- a) Techniques to acquire was nosedown and then throttle reduction to maintain the rate of descent. If the airspeed stayed on during this transition to the glide slope which it usually did fairly well, and if you made the right power reduction and the right attitude change, you didn't have too much problem initially on the acquisition. b) Performance capability therefore was fair and the workload was moderate. 7) The tracking of the glide slope and localizer -- a) To maintain and reacquire the glide slope, to maintain it was fair. The main problem was in turbulence if your attitude got off. It took a while to get the nose back down or back up and in the course of that time, I would acquire a glide slope error which required correcting the flight path error even though the attitude was back where you wanted it. To reacquire was fair also. The control of airspeed required attention but it wasn't a high workload item. Not the way some of these back-sided configurations have been. b) Localizer went fairly well except that one approach where I hit the turbulence close in. I guess the fact that we get a large roll bank angle response to turbulence is part of the deficiencies of this configuration. It's not serious but it does cause heading errors and if you hit turbulence close in it's pretty hard to hold the localizer. c) The pitch task does require attention, particularly because of the sluggishness of the response and it does affect the heading control somewhat but it's not as strong as some of the configurations I've seen. d) No unusual use except I find myself using the peripheral vision while I'm looking at the pitch attitude. I'm also seeing the localizer on the HSI. e) Elevator is primarily used for attitude, throttle to control airspeed and rate of climb. f) Regarding the input, I overdrive it to get it going and then I usually make a conscious effort to stop it. I don't let it stop by itself, but it does seem to be just a sluggish airplane. g) Not too bad, just a little sluggish. h) No, except in turbulence. 8) Not a real problem doing that. I think the lateral offset went fairly well. No, it did not seem to adversely affect the landing touchdown or sink rate control. 9) The principal thing in the control technique area is to get your corrections in early to get stabilised on your approach path and not to have any requirement for rapid maneuvering. If you do that, you can land this airplane not well, but adequately. The power management is not too much of a requirement and the airspeed hangs in there pretty well if you just remember to take a little off as you get in ground effect. Workload is moderate in the control activity required in pitch because the response is sluggish and you have to get after it and get it corrected. 10) Crosswind landing was of nominal difficulty except that you had to be careful that you didn't inadvertently put an input in in pitch. The consequence of that inadvertent input when you're putting in aileron would not be felt for a while and then it adds to your touchdown control problem. b) Wing down. c) Some small effect. Small, adverse effect but adequate. 11) Elevator has moderate forces, moderate travel, no breakout or friction. Aileron has light forces and small travel. Some breakout but it's not objectionable and no noticeable friction. Rudder forces are moderate. Travel is small. Breakout forces are large but acceptable. Friction is not noticeable. 12) Throttle control feel is okay and friction is an acceptable level. 13) Flare and particularly the real close to the ground part of the flare, the touchdown part. Control of sink rate, really controlling the nose down pitch tendency close to the ground. 14) yes, rough air aggravates you and produces errors. It's a sluggish airplane that you have to correct them but outside of that there are no unusual characteristics. 15) Yes. 16) Is it controllable? Yes. The pilot rating and turbulence effect rating is 5C.

CONFIGURATION 5 PILOT D FLIGHT NO. 187-1

PILOT RATING 7 TURBULENCE EFFECT RATING D

Air is quite smooth this morning and we did the up-and-away maneuvering at 2,000 ft., just below the overcast. The configuration is unstable in pitch in that if I don't do anything it departs either noseup or nosedown in pitch attitude with an ever increasing rate. I noticed that there is an out of trim noseup pitching moment in a steady turn that requires a steady downward push. The behavior off airspeed is kind of interesting. It looks like we're on the bottom of the power required curve in that for increasing airspeed about the same power setting will hold 170 and 180 knots which held 160. There are only small differences at these speeds but when you get to 140 it does require considerably more power for level flight. In a sense it is like a configuration I had yesterday that just seems peculiar. Also it seemed to me that when I did the speed changes, it took an unstable force to hold trim flight condition at higher or lower airspeeds than that for which you were trimmed. In other words, at 170 and 180 knots I ended with a back elevator force and 180 seemed about twice as much as 170. When I went to the lower speed, it seemed I had more problems, as I said before. I had to add considerably more power above trim at 140 knots and furthermore, it seemed that I had a larger noseup pitching moment. From all this and from the feel I get, it feels like at higher angles of attack it's a little more unstable. 1) Ease of achieving trim, it's a difficult airplane to trim due to its unstable nature but you can achieve some semblance of pitch trim at a given airspeed. 2) The behavior off trim airspeed is objectionable in that it's unstable and you have to try to hold an unstable force and it's hard to know that you have the right amount of force in because the response takes fairly long to develop. The objectionable behavior at low airspeed is the additional power required and the apparent increased instability. This is mostly at 140 knots. 3) Maneuvering about level flight, you can do it in this nice smooth air and I think you can keep control of things as long as you're not diverted. You can fly straight and level. It's certainly not a good airplane but I could do it. The airspeed control wasn't too difficult. You had to watch it and be careful, but it wasn't as difficult as the ones I've seen that have been on the backside. Altitude control in straight and level is adequate but it required lost of attention. 4) Maneuvering in turning flight, lateral control was good except for the rudder breakout forces. The altitude and pitch control required a lot of attention but you could do it. Actually my altitude control in 30° bank turns VFR wasn't half bad. It wasn't as good as you'd expect with an ordinary airplane but it was adequate. Evaluation comments following the first approach. It's quite interesting to me to fly on a day like it is today, nice and smooth. No turbulence at all. After having just flown configurations of comparable difficulty yesterday where there was a significant amount of turbulence. The initial portion of that approach was quite poor, though. Localizer acquisition was poor. I crossed over and came back and that isn't so much the configuration's fault as that I was busy on the localizer. I could handle the glide slope, also. It was an unstable airplane. It requires a lot of attention, a lot of scanning but the fact that nobody was busting the airplane around except me, I really had a great deal of calming and moderating influence on the performance that I was able to achieve. So even though I did get it squared away and I got in there, there are a number of things that bothered me. One thing was that when I broke out I was low on airspeed and after I went visual, I got down to 150 knots which I don't like to do and I didn't intend to do and I just put the power up to gain a little bit and then I held it that way. The fact I wasn't on the backside made that much easier to do. There was one part of the approach where I ran into a little bit of turbulence and it was quite distracting with this configuration. I find the workload is high and I had the feeling when I hit the little bit of turbulence that quite noticeably degraded my feeling about the performance and my feeling that I was kind of hanging on by my fingertips. So the results came out really quite good. The landing, no sweat. I had adequate control of pitch and flight path and all that. I mean the word adequate, but understand it was perfectly glassy smooth air and I thing in that situation, this is a very landable configuration but I don't think it will be in turbulence. Comments following the second approach. I forgot to say something on the first approach. I was reminded on this one. Airspeed control was a problem and difficult for me. Everytime you make a turn you've really got to remember to add throttle or else you just automatically bleed some six or seven knots before you get it stopped. If you happen to be six or seven knots fast, you can take advantage of that just by not making a power correction but, when you initiate a turn, if you're on speed or a little low, you really better get in there with your power or it does bleed off rapidly. The other problem with the configuration is when I had crosswind. The crosswind landing part went alright except that I didn't have good enough control of pitch to set the airplane down where I wanted it. Then I ended up landing very, very long. And yet I didn't have the strong larger amplitude PIO's that I've had in other configurations. So I don't know how much of this is due to the smooth air. I'm just reporting the situation. I did have turbulence during the approach. The turbulence was degrading. My pitch task was more demanding. I felt considerably more loaded and my performance had deteriorated quite substantially. However, I did make the approach. I did do it. I had good enough performance to complete the approach and be safe but it sure doesn't allow you much margin and if that would have been in a real airplane, I would have gone around. The reason I continued down to the touchdown was to see what my control difficulties really were and whether I could pin the thing down well enough to land with a controllable sink rate and I did but I didn't land anywhere near where I wanted to. One thing in the configuration's favor though is that when you get down there, if you got the power somewhere set about right, the airspeed doesn't seem to bleed off on you. I had a configuration yesterday that was a real problem, that when I quit looking at airspeed it very rapidly would decrease sometimes, and this one did not seem to do that as bad. Comments following the third approach. On that approach I had some turbulence, nothing like what I had yesterday, but some turbulence. There was an offset on breakout and the offset correction went fairly well. You had to pay careful attention to pitch and keep that under control while you're making that maneuver but I was able to do it and again, there wasn't much turbulence in the final part of the landing. It's a configuration that with lots of training, I think you could land. You had to learn to add the power every time you make a turn. You have to learn to watch pitch attitude very carefully. You have to learn to put in lots of lead and use lots of large control inputs during the flare and touchdown. You don't have good control of touchdown point but you have enough control of attitude if you use a lot of lead in your inputs. You have enough control of pitch attitude that you can land with a controllable sink rate at least in the relatively smooth air that I had. 5) Localizer acquisition and tracking prior to glide slope. a) Performance was not very good. As far as the localizer acquisition, that was adequate but the airspeed control generally was not too good. If I didn't get the throttle in quick enough when I was making the turn, I'd get low on airspeed. If I got in slightly too much power, I ended up high on airspeed. So the localizer performance capability was adequate, however, b) The workload was high due to the altitude and airspeed tracking. This required a continuous workload of monitoring pitch attitude and controlling it. c) The localizer task did affect the altitude performance somewhat but it had a larger effect on the airspeed performance and it was degrading it. 6) Glide slope acquisition -- a) control techniques -- was to nose down and retard the throttle and I still had some learning to do even on the last configuration because I definitely tended to get fast everytime I did that. I think this is one of the things in switching back and forth between the different configurations that we have to pay a lot of attention to this learning bit, because each time I got fast on this one. I have a tendency when I'm on the backside to get slow. This wasn't a serious fast; it's just that I couldn't keep the numbers coming out airspeed wise the way I wanted them to. But, the acquisition was adequate and b) performance was adequate, although there was a tendency to get fast on airspeed at acquisition, and c) the workload was pretty high because you had to spend enough time on pitch attitude and keeping that loop closed tightly, in order to keep it from departing from the attitude you wanted and at the same time monitoring airspeed, heading, localizer and throttle, etc. 7) Tracking of the glide slope and localizer, a) actually this configuration is better than some I've seen for maintaining and particularly reacquiring the glide slope. With ordinary airplanes, if you got a little bit of speed, you can trade the energy in that speed for a little bit of altitude. So if you're a little fast and a little low on the glide slope, you can ease the nose up and go back on the glide slope and also get the speed back. With many of the configurations I've flown, you can't really do this. You pull the nose up and you momentarily go up on the glide slope but sometimes you don't even go up on it, you just pull the nose up and you slow down and sink. With this one I could pull the nose up and trade a little bit of excess speed for a little bit of altitude and so I found that to reacquire the glide slope was easier, but control of airspeed was somewhat difficult. I had a tendency to get fast more than slow and when you get fast, I guess because you're on the bottom of the bucket, you have to retard the throttle and let it come back to normal. It tended to hang up there because if you got the power setting right for 160 knots and you end up with 168 with the same power setting it will still stay there. So to get it back you have to consciously bring the throttle back and then readvance it again. But that control of airspeed was adequate but demanding. b) Ability to maintain and reacquire the localizer, I found the localizer performance adequate but I found it hard to keep my heading and the salvation was that I wasn't having much turbulence in most of the approaches. I didn't have the situation which

I had yesterday which turbulence would bring a wing up, cause a heading rate which caused a heading error. The only heading errors I really got were due to my not flying bank angle as precisely as I should have. I mean my own inadequacies and that I can account for. So the attention required for the pitch task does degrade the localizer tracking but you can maintain and reacquire it but it is degraded. Your ability is degraded in turbulence because you can't look away from pitch as much; also, the effect on heading is greater. c) The pitch task definitely adversely affects the heading control as I noted above. d) No unusual display use. e) Throttle used to control airspeed, elevator used to control pitch attitude, throttle also used to set up rate of climb and descent. f) Requires a small input to initiate the response unless it already happens to be going in that direction and then a definite input to stop it and almost always a steady input to sustain the attitude. You had to hold forward pressure in the steady turn. You had to hold back pressure at higher speeds and you had to hold forward pressure at lower speeds, things like that. g) Adequate but high workload to attain it. h) Yes. 8) Adequate. I didn't see that my touchdown point was any more poorly controlled when I had the offset than any other situations. The problems in controlling touchdown point are more associated with the pitch characteristics, not the fact I had to maneuver for offset. 9) Flare and touchdown control technique, I didn't have a very demanding throttle management situation. That was kind of nice. But the elevator had to be used to control an unstable airplane and to control flight path. There were definite lags in the response but this for some reason didn't seem quite as bad lag-wise as some of the configurations that I've seen. I felt more in command of the situation but my touchdown performance certainly was degraded. I landed long two out of the three times. One of them was unacceptably long. The workload is high. Regarding the control activity, I don't think I touched the stop, but when I got a significant error in my flight path, I used very large control inputs in order to get it back and to control the PIO tendency. 10) The crosswind landing was not of unusual difficulty. The main thing is that it adds workload to the already difficult pitch task. b) Wing down. c) It by itself affected the touchdown point somewhat adversely. 11) Elevator forces felt in the maneuvering sense, a little on the heavy side but desirable I think for the configuration. Travel -- I don't ever know how to answer that. At the end of flare and touchdown I used very large motions. Most of the other time, moderate motions. Breakout forces and friction weren't noticeable. Aileron forces were light. The travel was small. The breakout was noticeable but not objectionable and the friction was small. Actually I didn't really notice the aileron breakout forces so I should say the aileron breakout forces and friction weren't particularly noticeable. The rudder forces were moderate, the travel was small, the breakout forces were large and objectionable and the friction was not noticeable. 12) Throttle feel was adequate and the friction was a desirable level. 13) I guess I'd have to say the flare and touchdown and it was more evident in the touchdown point. Also lack of good enough control of sink rate that I could control the touchdown point as well as I feel is necessary. 14) Turbulence effects, rough air does bring out the difficulty in controlling this configuration. I didn't have much of it but when I did it did adversely affect my ability to fly it. It was mostly an effect of somebody else kicking the airplane around. I was already having enough trouble with the airplane moving around due to my own inputs. 15) Yes. 16) Configuration rating -- is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? No. Deficiencies require improvement. I would certainly eliminate a rating 9 because it didn't require intense compensation for control. I think I'd have to rate it a 7 although I think I might have rated it 8 in turbulence, if I'd had more of it. But I didn't have the strong PIO tendency. I felt like the pilot/airplane dynamics were better in the flare and touchdown than some of the configurations that I've had. So I think I'll say its controllability is not in question but the touchdown control -- perhaps I could learn that better, so I'll rate it a 7. Turbulence effect rating, I think I'd say more effort and moderate deterioration and "D". 18) The primary reasons for the rating, the most objectionable feature is the demands on the pilot and the consequences of any inattention on his part. Too unstable an airplane to bring a load of passengers back and land them. I landed them three times. I think all with safe sink rates. I think one of the three landings was definitely too long to stop on the runway. I would have run off the end. One of the other two, I would have been on the binders and reverse thrust and everything else to have gotten it stopped on the runway and the other approach was really a pretty good landing. So the main thing though is the compensation required on my part to achieve that level of performance. So it's back to the flare and touchdown as being the most objectionable. But I'd like to put in second place the fact that this configuration has got a trap at higher angles of attack and I don't particularly care for that. The trap is the speed bleedoff at higher angles of attack unless you're right in with the throttle and also the fact that it seems to want to pitch up more at the higher angles of attack. b) Least objectionable -- lateral-directional characteristics, I guess.

CONFIGURATION 11 PILOT D FLIGHT NO. 187-2

PILOT RATING 6 TURBULENCE EFFECT RATING D

Evaluation pilot comments on the second configuration for up-and-away flight. Just in general real quick, the weather is moving in here fairly rapidly so I'll try to shorten my comments. We have a small divergence here in pitch, relatively low rate of divergence which allows you to look away. The airplane feels sluggish in its response to corrective inputs. The speed characteristics looks like its bottomside. You have still, of course, the characteristic of having to add power in the turn. It isn't too bad, for example, in a 45° bank turn here at about 1000 ft. above the ground, so it can't be too horrible. 1) Ease of achieving trim is better than some but not as good as I'd like. 2) Behavior off trim airspeed, a little bit of unstable forces when you're off airspeed. But the magnitude is relatively low. I didn't see any particularly objectionable behavior off the trim airspeed other than the little unstable forces you had to hold. 3) Maneuvering about level flight, it's sluggish but doesn't diverge too rapidly. Attitude control is adequate and airspeed control is adequate. The altitude control is only fair. 4) Maneuvering in turning flight, lateral control is good except for the rudder breakout and the fact you had to hold steady force in a steady turn. I kept forgetting to put that in yesterday. Steady rudder in the steady turn. Altitude and pitch control required attention but I was able to supply it. I had adequate performance, but airspeed control required attention. You've got to have throttle in. It's a function of bank angle or g but if you do it you can keep the airspeed not on but bounded. Maneuvering forces are moderate. Comments following the first approach. It flies almost like an airplane, not quite, but almost. I could spend enough time on the localizer and heading strategy because the pitch was not so demanding. I got high on the glide slope. Actually, I flew through it. I was late intercepting it and the pitch was manageable enough that I could make a large correction. I got back on fairly early. By 1300 or 1400 MSL, I was fairly well established, I think. So, again I was not so saturated and loaded that I couldn't plan ahead and do the sort of things an instrument pilot expects to be doing, instead of just flying the airplane. The flare and touchdown portion however was objectionable. The touchdown point control was improved over the preceding configuration but the airplane is very sluggish in its pitch response. It's hard to keep the attitude proper as you enter the ground effect and I'll be interested to see if I improve. But if you get behind the airplane it requires large inputs and its sluggish and you don't have good precision making the flight path corrections. That landing was acceptable but I wasn't very happy with it. Comments following the second approach. Turbulence is light. I had a lateral offset on that breakout. I had a big glide slope error there. I think I created it myself. I never know when you create it or when I create it. But again I was able to correct back down and the configuration is manageable in that respect. It's sluggish responding, it has a small tendency to depart from where you left it, partly because when you leave it, you don't have it quite settled down. It doesn't, by its own nature, stop pitching if you don't have it settled down. But all this is manageable. I don't like it very well but it's manageable.

You can stay on top of it. You can make instrument approaches and I think it's so far safe enough for my kids to ride in although I don't like it and I prefer they didn't ride in it unless it was an emergency situation that we have reference to here. And I sure as heck want to make sure the pilots are well trained and reasonably current in the configuration. The flare and touchdown part is manageable but it's a sluggish beast and I'm fortunate to have reasonably smooth air here. I wonder whether it would be good enough in rough air but I have to evaluate it for what I see and so far it's good enough. Comments following the third approach. That was an interesting experience. We made the turns short and I screwed it up initially by turning instead of to 230 to 150 degrees. The altitude was off and I was trying to get back to 1800. In the course of acquiring the localizer, my airspeed went as low as 150. My heading went to about 250 instead of 230 during the intercept, then back to 230 just about the time that the needle came off the peg and since we were close in it was as you imagine an S turning approach. The altitude correction went from 1600 to 1800 then to 2000. I was high on the glideslope and I had lots and lots of errors and corrections. My pitch attitude was on occasion as much in error as 5° to 7° while I was attending to other things. In spite of being a badly screwed up approach and one that you just wouldn't put yourself in that kind of a box in the real mission, I was able to get it back on and by the time I got to the breakout altitude things were about nominal again. I had a little localizer error but I was correcting back in a manageable fashion. I had a little bit of offset and it was easily correctable. Then down to the flare and touchdown, I did some maneuvering and the airplane is definitely slow and sluggish and objectionable. I don't like it but I believe it is good enough for the task. 5) Localizer acquisition and tracking prior to interception of glide slope. a) Performance is fair. The workload is moderate and the effect of the localizer task on altitude performance does affect the altitude performance somewhat but it is still manageable. 6) Glide slope acquisition, a) the elevator is used to nose down and throttle reduction is used to provide the rate of sink and also to keep the airspeed from changing. b) Performance capability is fair at best but because I had a tendency to get fast all the time, I'd say you probably could achieve a fair performance and the workload is moderate. 7) Tracking of the glide slope and localizer. a) To maintain and reacquire the glide slope, the airplane is a reasonably sensible one. In other words, I could pull the power off fairly far and make a fairly rapid correction and it came out fairly well. Control of airspeed is a bit of a problem but not a significant one. It has a tendency if it gets off to stay off and it requires positive action on the part of the pilot but it doesn't tend to diverge. b) Ability to maintain and reacquire the localizer, in turbulence, I had problems sharing time between pitch and heading and so the pitch task did degrade the heading control as the question (c) asks. b) ability to maintain and reacquire the localizer was fair minus. d) No unusual use of the display. e) Control technique, elevator for attitude and throttle for rate of sink and airspeed control. f) Input, definite extra input to get response initiated and an input to stop it but it doesn't tend to diverge very fast. g) Reasonably adequate but it does require attention. h) A little but the amount of time you can look away is substantial. In other words, you can predict mentally what is going on for several seconds. 8) Adequate, but you do have to pay careful attention that you control pitch attitude during that maneuver, because once the attitude gets away from you and you start sinking or climbing, the response is sluggish. It takes definite time to get the pitch and airspeed back again. 9) It is definitely a sluggish airplane that you must overdrive. It takes fairly large control inputs. Power management during the flare, some power reduction in the ground effect, but basically power isn't a real problem. The airspeed doesn't bleed off in any unwanted unrealistic fashion. It's basically a real high workload to get the performance that's adequate but I think it can be done. I would like to see it in more turbulence than we had. 10) Crosswind landing, the lateral task is of normal difficulty. It's not unusual but you do have to pay careful attention to your pitch situation while you're trying to correct the drift. So the big problem is to make sure that errors don't develop in pitch because it takes a long time to correct them. b) Wing down and c) there is some effect on sink rate and touchdown point control but I think it still comes within the adequate quality level. 11) The control feel, the elevator forces are heavy and the travel is large for any rapid maneuvering, I was thinking mostly there of the flare and touchdown part. For most of the IFR portion, I would say the forces are moderate and the travel was moderate. c) The breakout forces and friction are not noticeable. Aileron forces are light to moderate, the travel small, the breakout forces, although there, are not particularly noticeable and the friction is not noticeable. Rudder forces are moderate, travel is relatively small and the breakout forces are high and still objectionable but acceptable. The friction is not noticeable. 12) The throttle control feel is adequate and seems essentially of a desirable level and the friction is of a desirable level. 13) The control of flight path for flare and touchdown is the most difficult thing with the configuration. But I would like to comment on the fact that maneuvering this airplane particularly in turning flight with the kind of precision that you want in the IFR situation is a pretty high workload task. You've got to add power, you've got to monitor your airspeed and you've got to make definite throttle corrections if the airspeed is off. You've got to make another throttle correction when the airspeed gets back on. Any time your angle of attack changes you've got to have the throttle in there. The pitch response is sluggish and if you looked away at the heading it usually has gotten off several degrees or a couple of degrees and you've got to correct it back down and it all takes time. It's the workload aspect of this configuration in order to achieve an adequate level of performance. 14) The turbulence effects, I wished I'd had more turbulence. Rough air generates disturbances that I didn't create and I think this is where this configuration would show up most poorly. But it was nice to have what turbulence I had and the characteristics that it brings out are it generates errors in either flight path or attitude more generally which integrated into flight path errors. It just takes time and attention to correct. 15) Yes, I could. 16) The rating is yes, it's controllable. Yes, adequate performance is attainable with a tolerable pilot workload. No, it is not satisfactory without improvement. The deficiencies warrant improvement. I would eliminate the 4 immediately just saying that the deficiencies are more than minor but annoying and furthermore I don't think I achieved desired performance very much. If I do, it requires more than moderate compensation so I come down to the 5 and 6 area for consideration. It is adequate performance that's achieved and in the 5 it says considerable compensation and 6 extensive. I have to use the phraseology in 6 for the control of sink rate at touchdown and touchdown point. It does require extensive compensation and so I would rate it a 6 based primarily on the flare and touchdown. 17) The turbulence effect rating, increase of pilot effort, I think more effort is required. The deterioration of task performance with turbulence, again there is some and it's objectionable and it's either minor or moderate. I guess it would be moderate and a "D" rating. 18) Primary reasons -- a) The most objectionable feature is a sluggish response in touchdown point control and I keep forgetting to mention this but this is affected by the ground effect. If that ground effect wasn't there, my job would be less difficult and it's possible the rating would be different or better. But it's the control of the sink rate as you get down. First of all as you approach the flare point, it's the sluggish response that doesn't allow you the control of flight path so that you can land somewhere near where you want to land. Then, it's the sluggish pitch response as the ground effect takes over and tries to nose down. You just don't have a rapid enough control of the flight path without really a lot of effort or compensation on the part of the pilot. b) Well, I had to put two things in here. 1) My usual lateral-directional characteristics. But also the fact, at least at the nominal angle of attack, that the airspeed isn't always increasing or decreasing on you. In other words, airspeed control with this configuration is much less of a factor in the workload that's demanded by the configuration. However, the airspeed control in turning flight and in making altitude changes that are perhaps required is demanding. But in the straight and level part of the approach you can certainly manage this configuration better than many I've seen.

CONFIGURATION 9 PILOT D FLIGHT NO. 188-1

PILOT RATING 5.5 TURBULENCE EFFECT RATING C

The configuration itself has a slight pitch instability. I find it a little bit confusing in the speed change parts, because it feels slipperier than I have noticed configurations like this. I don't know whether I ever saw this one before. So, I tried to look rather carefully at whether I was on the frontside or backside and I'm not real sure which I am. It's a confusing configuration. It's not as clearly bottomside as some configurations I have seen and it seems a little bit backsided for increases in speed and it seems strongly backsided for decreases in speed. The effect, from my point of view, is that the airspeed is elusive. It doesn't want to hang in there and stay on airspeed as well as I would like and there is a mild or slow instability in pitch which requires attention. But basically, the up-and-away task of flying turns etc. could be handled and handled adequately, I think. Although my altitude control, even straight and level was not as good as I would like to see. (1) Ease of achieving trim. Moderate difficulty, by no means impossible, but the elevator trim is relatively easy to achieve. But the airspeed and altitude control is not as easy. A bit of a problem. (2) The behavior off trim airspeed, the main thing is it's hard to stabilize it, to stop it at a given speed and to find the power setting that would really hold it at zero rate of climb at that new speed. For increases in speed, it seems to be very nearly the same power setting, but actually a little bit less and for decreases in speed, at least at 140 knots, substantially more power. Maneuvering about level flight, attitude control was sluggish, but seems adequate and the rate of departure from the trim condition is not so rapid as to give me a great deal of trouble. Airspeed control is kind of slippery and altitude control is not as precise as I would like. Maneuvering and turning flight, I could make fairly steep turns and make them halfway decently. So I think I would call it adequate. Lateral control was basically pretty good, except for those rudder breakout forces. Altitude and pitch control were not so hot, but I believe airspeed control was slippery and maneuvering forces were almost zero. Comments following the first approach. The only unusual thing, I got high on initial acquisition of the glide slope and corrected it back down adequately. I had some trouble with the localizer tracking beam and pinning down a heading, but I don't think anything unusual. The air was basically pretty smooth. After I went visual, the control, although sluggish, seemed adequate. In the final part of the landing the airplane went nose down and I didn't compensate adequately for that and I landed hard. I don't blame the configuration too much because there were a whole bunch of birds on the runway and I was more concerned with whether we were going to hit those or whether I was going to tell somebody to take it around or what. So I really wasn't fully involved with making a good landing. So I'll have to look at the final protions of the flare carefully on the next approach. Comments following the second approach. We turned the camera on that one as I was turning to intercept the localizer and I think we were in and out of clouds. I couldn't tell for sure, it just gets dark and light, when I have my hood down. I was a little late in intercepting the glide slope and consequently got fast, significantly fast, 168 knots. About the time I was correcting back on to the glide slope (I wasn't quite down there yet, the glide slope marker went zap, indicating I was higher. In other words, the needle went down and so I had another big correction to make and I got fast in correcting for that and I had the throttle off as low as 30% thrust. But I got there and as I was coming back on airspeed and on the glide slope, I really had to get that power back on in a hurry because I had the feeling I was going to sink right through it. My point is, I was able to do all that, and do it I think adequately, but with a pretty high workload. It was a crosswind approach and I was able to put in the crosswind correction without difficulty but I had to pay close attention to the pitch attitude control. The final portions of flare went much better on that one than they did on the first approach when I was watching the birds. The airplane is sluggish. I didn't seem to have too much of a PIO. It was just that I had to stay well ahead of the airplane in order to have my inputs cause the effect that I wanted before the flight path deviated too far. So, it's a peculiar configuration. I don't like it very much. It makes me think of one that I had on the flight this morning. It makes me think of somethink I've seen before like it, although this one just has a slippery feeling, but I am able to do the task, and I think so far, adequately. Pilot comments following the third approach. We had turbulence on that approach, I presume canned turbulence causing some lateral-directional disturbances, but not much disturbance in pitch. I'd like to comment that the amount of disturbance in the turbulence approach is not anywhere near equivalent, to the kind of turbulence that I had in my evaluations yesterday. And then I have to say that I think the handling characteristics for this configuration are adequate for the task, but I don't like them. This configuration bothers me a little bit because it's kind of slippery. That's the word that just keeps coming in my mind, but I seem to be able to do everything that's required of me and do it with a workload that's quite heavy, but within reason. And I do have the feeling that I'd sure like to see it with a little more turbulence because days like yesterday are not all that infrequent. And we did have a look at this configuration with the turbulence intensified in pitch in the up-and-away portion. So the third approach went pretty well and the breakout, VFR visual portion, all that went acceptably well. (5) Localizer acquisition and tracking prior to glide slope, a) performance is adequate. Workload is fairly high due to the thrust addition that is necessary with angle of attack, and the somewhat slippery airspeed. b) the workload. The workload is fairly high, moderately high. I mean you're loaded and busy. c) the localizer task. It does tend to affect the altitude performance, but also it affects the airspeed performance and that's more of a problem. But when the airspeed gets off, I have some altitude difficulties in getting it back. (6) Glide slope, a) techniques to acquire is a nose over. In this configuration I have to be careful to retard the throttle promptly or else I accelerate in speed very quickly. b) performance I think is adequate, although I wasn't very good because every time I tended to be fast. High and fast with this configuration is difficult to correct. And when I say things like that, it makes me think I'm on the backside, but I didn't really see that in the up-and-away flight. c) The workload is moderate. (7) Tracking the glide slope and localizer, a) To maintain the glide slope, the ability is fair to fair-minus and to re-acquire again, you can handle but you have to watch your darned airspeed. My control of airspeed is poor. b) Maintain and reacquire localizer -- that went fairly well, but I can do it, but the pitch task and the airspeed task took some attention away from it. c) The pitch task does affect heading control somewhat, but I think it's of a handable level. d) No unusual use of display. e) Elevator to control attitude and throttle to control airspeed and rate of climb or descent and also to account for angle of attack changes. f) Pitch is sluggish and so you overdrive it initially to get it going and you do put in an opposite input to stop it. g) It's adequate, but you have this tendency that you have to really look at it to make sure that it doesn't go away from the proper attitude. I mean you have to look at it long enough to stop and make sure it's stopped before you can look away. If you look away before it really gets stopped, particularly on a nose up correction, it will tend to keep going. h) Not too much except that it tends to slowly depart from what you want it to do unless you come back and keep track of it. (8) The lateral offset didn't seem to be too much of a problem. The maneuvering didn't have too much of a result on my touchdown, but I did have to pay careful attention to make sure that it didn't generate attitude errors which would lead to flight path errors. (9) Control technique, overdriving of the elevator in order to generate prompt attitude control changes. Power management, not much and slight power reduction in ground effect. Performance was adequate but not desired. Workload was moderately high. (10) Cross-wind landing, a) Not particularly difficult, but you had to pay attention to pitch while you were doing it. b) Wing-down. c) No significant effect. (11) Elevator forces are on the heavy side. The travel is moderate. The breakout forces and friction are not noticeable. The aileron forces are light to moderate. The control travel is small. The breakout forces are there, but not noticeable. The friction is not noticeable. The rudder forces are moderate. The travel is small. The breakout force is high and objectionable. The friction is not noticeable. (12) Throttle control feel is adequate, and the friction is a desirable level. (13) It's a toss-up here. You've got to watch the pitch control in flare and touchdown carefully. Also, the IFR tasks are fairly high workload. So are airspeed and altitude control and particularly airspeed in the turns and airspeed on the glide slope. (14) Not enough rough air to particularly affect this configuration much but it created bank angle and heading errors. (15) Yes. (16) Is it controllable? Yes. Is adequate performance attainable? Yes. Is it satisfactory without improvement? No. Eliminate a 4 because I wasn't able to attain a desired performance. So it's between a 5 and 6. The flare and touchdown was better than I think the one that I rated a 6 this morning. I don't remember the characteristics, but I remember the control in the flare and touchdown. I had better with this configuration, yet the workload in the IFR portion was not enough to call it a 5. I guess I'll call it a 5-1/2 because I don't know which it is, but I really think it's more of a 6. I'll call it a 5-1/2, I don't really know what the heck it is and I know we're in a hurry. 5.5. Turbulence rating. I didn't see much, so more effort required, minor deterioration, Charley. (18) The most objectionable feature was the combination of the control of touchdown, sink rate and landing, and the IFR performance in turns and on the glide slope, the airspeed control. b) The least objectionable or best feature -- well, two, the lateral-directional characteristics and the other one I'd like to point out is the fact that airspeed is not a problem in the flare and touchdown.

CONFIGURATION 14 PILOT D FLIGHT NO. 18?-2

PILOT RATING 6 TURBULENCE EFFECT RATING D

Comments following the up-and-away portion. To do it real quick. The airspeed feels less slippery. It looks to me like I'm bottom-side except when I get to the slow speed point. It looks like I'm bottom-side and I'm almost neutrally stable as far as the steady forces and things like that. Actually it's just a little bit unstable on the high speed, but on the low speed, it's quite noticeably unstable. I think this is probably a nonlinear one, but I do feel like I'm bottom-side. The response is sluggish to elevator control but fairly manageable. I made a 45° bank turn at 1000 feet above the ground and the airspeed kind of got a little low and when it gets low, you've really got to sock it to it with the power. I guess this is a typical Delta wing problem. (1) ease of achieving trim was fair. (2) Behavior off-trim airspeed was not particularly objectionable except down at 140 knots when it was tending to pitch nose up and additional power was required. (3) Maneuvering about level flight, I did it quick and I can't tell you a whole lot about it, but attitude control was fair, airspeed control was fair, altitude control was fair. (4) Maneuvering in turning flight, lateral control was good. Altitude and pitch control was fair. Airspeed control was fair. Maneuvering forces were low to zero. Comments following first approach. Not as high a workload approach as some and this kind of configuration makes me think I rated that other one too generously. This has a little bit of the character that I have time enough to use strategy and plan ahead a little more than with most of the configurations. I guess the workload is down enough with this configuration that I can do a little bit of thinking and that's desirable. I had a tendency to get fast on that first approach and when I get fast, it's not so hard to get it back but you have to really make a positive power reduction and I was able to do it successfully without losing the glide slope. My interception of the glide slope was better. As I said, I was thinking ahead a little bit, I got the power off early enough that I didn't get high and fast but eventually going down the tube, I got fast and I was able to correct it though. I had enough time to spend on heading that my localizer tracking was fairly good. There wasn't much turbulence. The main thing I don't like about the configuration, besides being sluggish is when you get slow or at high angles of attack, it gets unstable in pitch. It wants to pitch up on me and I don't like that very much. With the characteristics I have, I think it's manageable, but I don't like it. Comments following the second approach. My opinion of the configuration is degraded following that approach and I can't tell you all the reasons behind it, but what I saw was a performance deterioration for a reasonably intense workload, not real high. But for a moderate workload I saw a performance really worse than I think it should be. I got fast, I got slow, I got low, I got all the usual errors that you kind of expect on an ILS approach, but at different times with different airplanes under different conditions. But considering how hard I was working, things weren't coming out as good as I would have liked. So that's about the best I can report, I had a crosswind, I spent a lot of time on heading and localizer, and the pitch task deteriorated and that's probably half of what was the problem. And then when I went visual, I could see the crosswind was from the right. As I approached the threshold, I yawed the nose to line up with the runway and stuck the wing down and the crosswind correction went very, very well, but the pitch flight path performance deteriorated and surprisingly so. I was also concerned with airspeed, the airspeed was low. I had added a little power and I was careful not to take it off and it didn't get too low. It was around 148 at touchdown, which is a little lower than I desire, but I floated halfway down the runway trying to achieve a reasonable sink rate. So I'd have to say that the crosswind and the attention to the crosswind correction did adversely affect the pitch task. I still thought it ought to have been better than it appeared in that approach, but we'll see what shows up on the third one. Comments following the third approach. It was interesting. I got high and fast again and I had power back to 40% for a long, long time trying to correct it. It may well be that either the winds have changed or something, but there sure was a surprising characteristic. If I had just seen that, I would have thought that I was definitely on the backside of the power required curve. So I'm a little bit puzzled by the configuration and the characteristics that I saw. It started out being a pretty good configuration. I was thinking of rating it somewhere up in the 5 category and I now think it's adequate, but I don't think it's that good and I'm not sure exactly why. Things just didn't come out as good as I wanted. And I've got to tell you that we had turbulence on these approaches. We were flying in actual rain showers and in the clouds and there was the accompanying turbulence. I think this intensified the task difficulty and accounted for some of this deterioration. So, on that approach I had some turbulence. I had an offset which was not too difficult to correct. Prior to touchdown there was a fair amount of control activity on my part to make it come out right. But either due to the natural or canned turbulence, I don't know which, but there was some perturbations that I had to correct for and they required substantial elevator movement. The airspeed hung in there pretty nicely and I didn't have much difficulty with it but I achieved a reasonable touchdown. I think the performance generally was adequate, but not any better than adequate. (5) The localizer acquisition, every time it seemed I would end up getting a little high so, a) my performance capability in terms of the localizer itself was adequate and b) the workload was moderate, and c) the localizer task did affect the altitude performance. (6) Glide slope acquisition, I would nose over and reduce power. I would nose over with the elevator and reduce power with the throttle to achieve the glide slope acquisition, b) The performance generally was pretty good. I didn't have too much difficulty. Acquiring it was not too difficult and c) The workload was only moderate. (7) The tracking of the localizer and glide slope, a) To maintain and re-acquire the glide slope was not real easy. It was somewhat difficult to maintain it and when it was off, I could get it back on. But the control of airspeed in doing this was degrading. I tended to get high and fast, that was my general tendency. b) Ability to maintain and re-acquire the localizer, that seemed to go fairly well. I had enough time to look down and track my heading so the localizer task went fairly well. c) The pitch task, I'll change that to say the pitch and the airspeed task tended to adversely affect heading control. d) No unusual use of the display. e) Throttle used to control airspeed and rate of climb and descent, and elevator to control attitude. I'd like to comment, the attitude that you have to hold in this class of an airplane with its relatively low n_z/α to get you a given flight path angle is quite variable with airspeed. It's variable enough that I sometimes get fooled into rates of climb and descent that I didn't intend because I had my attitude right, but my airspeed was wrong. That's not just confined to this configuration and I wanted to point it out. f) Pitch response is sluggish. It requires an input to get it started and then one to stop it. g) The resulting short period motion is adequate, sluggish, but adequate. For the flare and touchdown, it's slow and sluggish and it's too slow, but it is adequate. h) No, the airplane doesn't really feel like it's tending to get away from me. Airspeed does sometimes. Well, I should modify that. Under h) It does, when I get to low speeds. If I'm on the trim airspeed it has a little tendency, but not very much to get away from me. But if the speed gets just a couple of knots low, then it really starts to go. (8) Ability to correct lateral offset errors -- that went all right. The maneuvering didn't seem to affect my touchdown point control too much. You do have to pay careful attention to the pitch control task during the maneuvering to make sure that the flight path doesn't get pointed down or up in which case you have a real problem getting it back. But I was able to manage it all right. (9) In the flare, the control technique is to overdrive the airplane with elevator control to make the flight path come out the way that you want to. You have to generate lead, but you don't have the PIO problems that I've had with some configurations. The performance was pretty good in two of the three landings. The third one I landed quite long. It was a crosswind landing, so I worry about this configuration as to how it would be to control it in a lot of turbulence, but we had some turbulence and I was able to do it adequately. (10) The crosswind landing, as far as the drift correction, was not difficult and was done fairly well using a wing down technique, but there was a definite adverse effect on the touchdown point control. In other words, I couldn't seem to get the thing to come down. (11) Elevator forces were heavy feeling. The travel, most of the time was only modest. During the flare and touchdown, they were a little larger. Breakout forces and friction weren't noticeable. The aileron forces were generally light. And the travels were small and the breakout force was there but it didn't bother me. Friction wasn't noticeable. Rudder forces were moderate and travels small. Breakout forces were high, objectionable but adequate. Friction was not noticeable. (12) Throttle control feel was adequate. Friction was of a desirable level. (13) I guess the multiple task of flare and crosswind landing correction. I feel sure that the pitch characteristics were good enough that you could do better than I did on that particular one, with training. How well or how long you would retain the training, I don't know. So that's one of the required tasks that was degraded. But the other one is anything that leads to lower airspeeds. This configuration is bothersome in that regard. It tends to want to pitch up further when you get to lower airspeeds, and also the drag rises substantial at the higher angles of attack. (14) Turbulence effects -- definitely there and bothersome, mostly by creating errors in attitude or in flight path that had to be corrected. It's kind of a ponderous-type configuration. But in some respects it's a configuration that you can look around and check other things with if you've got everything right at nominal. (15) Yes. (16) Configuration rating -- Is it controllable? Yes. Was adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? No. I'll eliminate a 4 because I don't think I got desired performance with anything like moderate compensation. So it's a 5 or a 6. I'm mostly affected by that long touchdown and I'd like to comment, I think my ratings are affected by what I see. They have to be and if you could make more approaches, I think you'd get a better handle on what your rating really should be. In other words, I would have liked to have gone back and done another crosswind approach and say that was my first crosswind approach with these characteristics. Would a second approach produce better results? I don't have that information so I have to take that into account. I was thinking on the first approach in terms of a 5 rating, but I was unloaded enough in performing that approach. The deficiencies I saw were not of a serious enough nature to rate it a 6, but the more I flew it, the more I saw that airspeed tended to get away from me in the fast direction. But when it did tend to get away in the slow direction, I didn't have as good control to bring it back. I started out thinking it was a 5 and decided it was a 6. I have a feeling that this one is probably comparable to the first configuration in quality and so if I rate this one a 6, it probably meant that I rated the first one a little too good, but I'm not sure now. So for this one, I look at the adequate performance requires extensive pilot compensation and I think that is true in the flare and touchdown part, when I have the added task of the crosswind correction. When I look over at the aircraft characteristics and I see "very objectionable, but tolerable deficiencies", I hate to categorize what those deficiencies were. Basically, the pitch up tendency and the fact that I didn't achieve a very good performance in the crosswind landing. If I read up at the 5 rating, I read "Moderately objectionable deficiencies, moderately objectionable". That doesn't quite put enough emphasis on it, so I don't feel like it's a 5 and "Adequate performance requires considerable pilot compensation". It's more than "considerable". I've eliminated the 5 from my considerations. I look at 6, "Adequate performance requires extensive pilot compensation" and that's probably a little bit severe. And "very objectionable, but tolerable deficiencies" perhaps a little severe, but I think I'll rate it a 6 anyway. And the turbulence effect rating -- more effort required, and moderate deterioration. It's a Delta. (18) Most objectionable feature, the change of characteristics when I get slow and the control of touchdown point in the flare. b) "Least objectionable or best feature". The lateral-directional is good. The other thing is that I could look away from the configuration a little bit. When I got it set up it didn't tend to diverge from me if I was on trim and on airspeed. As I reflect back on the flight, when we first started making approaches, the turbulence level was almost zero and when we finished I had some definite natural turbulence that was affecting my performance. I am not real sure how well I take into account the effects of something that is not there. I guess I am not intentionally weaseling on my ratings, but I had a little bit of concern that we really need to continue our efforts to supply reasonably intense turbulence so that the evaluation pilot can distinguish between how it flies in smooth air and how it flies in rough air. In other words, I had the feeling with that first configuration that I flew it mostly in smooth air and my rating was affected by that. In the second evaluation, I had the feeling that there was enough natural turbulence around that my evaluation properly reflects the effects of turbulence. I think this is a most important part of this simulation, because with these slow, sluggish ponderous type handling characteristics, particularly in the flare and touchdown portion, the necessity to correct disturbances that you didn't create, tends to result in poorer performance. If there is turbulence present I think it has an adverse effect on the ratings.

CONFIGURATION 8 . PILOT A FLIGHT NO. 191-1

PILOT RATING 5 TURBULENCE EFFECT RATING A

Trim is relatively easy, no problem. Off trim airspeed it's a little bit unstable and it's light forces in the wrong direction. You get off airspeed. When maneuvering about level flight, airspeed and altitude control is no big problem. Just a slight divergence. It feels like a sloppy airplane. The divergence rate is very slow, or relatively slow. Maneuvering is a bit sticky. The stick force per g is positive but very low. It felt like you could sustain the g pretty easily. If the stick force per g is positive, it's very light. Localizer acquisition and tracking is no big problem. There was a little more workload than with a stable airplane because of the low divergence rate. I tend to lose a little airspeed when turning but the airspeed is no big problem. It's easy to recover, no problem. Glide slope acquisition is no problem. Just a three degree pitch change. I had a tendency in this configuration to overshoot on airspeed more than to undershoot when adjusting the power. Pitch control is the same as before. You start it and stop it with a doublet. Control of airspeed was basically with power. Glide slope control technique was with pitch. This configuration just feels like a sloppy airplane. The airplane didn't noticeably try to get away from me more except a couple of times when I had to abruptly stop the pitching. Lateral offset errors on breakout were no problem. I don't think the maneuvering affected the touchdown point. I floated in the flare on the lateral offset approach when I didn't know where the ground was. That could have happened on any approach. I don't think the offset affected the sink rate or the touchdown point on that configuration. Regarding the workload in the flare and touchdown maneuver, if you tend to float you tend to get into a little bit of a PIO due to the pitch problem. I didn't know where the ground was on the lateral offset approach and so I just eased the power back a little bit and let it sink to the ground. As for the control forces, I still feel like the rudder breakout is too high. And the elevator is a little bit heavy. Other than that, lateral is okay and everything around the feel is okay. Throttle control, feel, and friction is satisfactory. Pitch control is probably most degraded by the configuration, regarding the configuration rating, it is controllable. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? I'd say, No. You need to do something about the sloppy pitching. You need a pitch damper. Between a 4 and a 5. Moderate to considerable. I'd say 5 for the airline pilot. I didn't have a heck of a lot of turbulence, just a little going through the clouds. For the level of turbulence I had I'd put "A" on it. "A", no significant deterioration due to this level of turbulence. The most objectionable feature was the tendency to wander in pitch and the least objectionable was the power response. Lots of power.

CONFIGURATION II PILOT A FLIGHT NO. 191-2

PILOT RATING 6 TURBULENCE EFFECT RATING B

It's not stable. It diverges in pitch after about a degree input. It just kind of eased on up. It appears to be a little more unstable than the last configuration but not a lot. It just diverges. I wouldn't guess on the time to double amplitude but it appears that there is a little bit greater divergence than in the first configuration. Trim was relatively easy to achieve. I slowed 15 knots and there were no objectionable characteristics. I added a little power and it's relatively simple to fly it 15 knots slow. I didn't do a wind-up-turn. I just did a 180° turn with about a 30° bank and there was no problem to maintain level flight. The maneuvering at altitude was no problem. Stick forces were quite light. The localizer tracking, acquisition and tracking was no big problem. I have to lead with rudder to fly the airplane due to the lateral-directional characteristics. The pitch control requires a disproportionate amount of effort; it's not a normal cross check. The same comments we've had before. The pitch control is the biggest problem of the whole thing. I was getting about 2° more at times than I asked for or wanted but it didn't seem to race away with me like some of the configurations I've seen. The control technique is still input to start the pitch rate and then a reverse to stop it and then a jiggling of the controls. That is, a little sinusoidal oscillation to keep it where you have it. As long as the airspeed doesn't diverge much there's not much trim change with the pitch and the forces remain relatively light. I did some trimming, not a lot. As long as the stick forces were real light, there's so much going on in pitch and so many different inputs that it's almost non-productive to trim as long as your airspeed isn't too far off. As soon as the airspeed gets off, then you need to retrim it. The glide slope and localizer tracking was no big problem except for one time it seemed to take about two or three extra degrees nosedown to get back to the glide slope. But I was high on speed at that point so the increased sink rate combined with the speed required the big pitch change. It was a little startling but it was no problem controlling it at that point. The airplane does feel like it's going to wander away but not real fast. It's not too gross. The lateral offset error was no big problem. I was intentionally diving at the time and I was still floating and looking for the ground. But that's my problem not the simulation. I just don't know where the ground is yet. I don't think the maneuvering adversely affected our touchdown point. It may have a little bit but not marginally. I think it's still just me looking for the ground. The main problem in flare and touchdown right now is the little tendency to PIO and to hunt for the ground. But the biggest problem is the hunting for the ground. Crosswind landing was relatively easy. I did it with a wing down technique and I don't really think that had much effect on our touchdown point, possibly some but not much. I set the sidestep up to 150, 75 ft. in the air and just let it ride on down. No problem. The comments on the control feel and throttles are the same as before. No problem. No change. The continued change in the pitch task was still the most degraded. For the configuration rating, is it controllable? Yes, it's controllable. Is adequate performance attainable with a tolerable pilot workload? I'm toying between a 6 and a 7 on that. Make it a 6. It requires extensive pilot compensation for an airlife pilot. And that's just compensating. The turbulence effect rating is "B" on that. The kind of turbulence we're getting is thermals and it pitches us up and we lose some airspeed so it's increasing the workload some. No significant deterioration, just more effort. That's reasonable.

CONFIGURATION 5 PILOT A FLIGHT NO. 192-1

PILOT RATING 10 TURBULENCE EFFECT RATING E

Trim is not too difficult if you can keep the nose still long enough to trim. It's got a fairly high stick force gradient on the unstable side so that you can tell when you're in trim fairly well. If you're out of trim the forces build up so fast in the negative sense that you can tell when your airspeed is a little off. The forces build up in the negative sense but it makes trimming easier than some of the other configurations. The objectionable behavior off trim speed is a high stick force gradient. The negative static gradient is objectionable plus the fact that the airspeed decays like heck and it takes a lot of power in a turn. The induced drag is quite high. That was the biggest problem. Pitch control is primary in this configuration. It tends to run away with you and it's difficult to chase it. It's a bad configuration.

I just completed two approaches. I had my mind made up after the first approach it would be a No. 10 and the localizer acquisition and tracking was all tempered by the instability. The whole crosscheck changes. Pitch attitude becomes a primary concern to the pilot, that is, maintaining control of the pitch attitude. Everything else becomes sloppy on the basis of the time and attention that the pilot has to spend on that pitch. He just has to be on top of the pitch attitude all the time or the airplane takes off and he'll lose control. All of the workloads of acquiring or tracking of the localizer and glide slope were messed up by the pitch problem.

Everytime you'd turn you'd normally go into a PIO. The airspeed was a good backside operation and I had to add power in the turns because of the good strong backside. On the last approach, once I got the localizer offset taken care of (and it was kind of wild), I just held an attitude and eased my way into the ground. It ran me further down the runway but I was trying to just control the pitch attitude and let the power take us to the ground. Then, I reduced the power and just let it float on down to the ground. I think I anticipated the pitchdown in the flare pretty well that time. I caught it just right and I made a pretty decent touchdown out of that one but it was sheer luck. The control feel is unchanged and the throttle feel is unchanged from before. The evaluation task most degraded by the configuration was turning. I had more trouble maneuvering the airplane directionally than in any other and that was mainly because of the PIO's in pitch. The turbulence gave better characteristics than I would have expected in the turbulence we're getting. We're getting thermals more than anything else and but it's no big problem. Yes, I could continue to fly this configuration for 30 minutes doing landing approach tasks. But it's a mess. The configuration is a 10 and the turbulence effect rating is "D" on this configuration. More effort required because of turbulence but it's only a moderate increase in the level. Reason for the rating was that the airplane was constantly attempting to get away from me in pitch and that was the primary reason for the rating. Least objectionable feature was the lateral directional for a change.

CONFIGURATION 18 PILOT A FLIGHT NO. 192-2

PILOT RATING 6 TURBULENCE EFFECT RATING D

Trim is a little harder to find because the instability is less. It's still relatively easy but it's a little bit rougher than the last configuration. It's unstable statically and aperiodic in the motion. The maneuvering is very light and it tends to pitch up on you when you're trying to get a given g. It's difficult to maintain a g in a turn. Altitude control was no big problem but the maneuvering amplifies the pitch task. Localizer acquisition and tracking was no big problem. You have to concentrate on the pitch control a bit, much less than the last configuration but it's still a job. You have to keep on working at it. And it degrades you some on both localizer and glide slope. Same kind of trouble with pitch as we had before. The lateral offset is no big problem. You have to concentrate on the pitch control a bit, much less than the last configuration but it's still a job. You have to just keep on working at it. And it degrades you some on both localizer and glide slope. Same kind of trouble with pitch as we had before. The lateral offset is no big problem. The pitch creates some problems in the maneuvering but it's no big problem. It's controllable and there's no problem with losing control. You just get irritated at yourself for ballooning. The flare and the touchdown was real wierd. It felt to me like we were getting kicked around in the ground effect rather than just a smooth entry into ground effect. Maybe it was me just overcontrolling but I wound up lucking out at touchdown fairly well but I have to fight like blazes when I get into that PIO'ing. It's uncomfortable. You don't really think you have control over the airplane. Crosswind landing, didn't add too much to the misery. It's just normal, wing down type of flare. Control feel is unchanged. Throttle is unchanged. It is controllable. I think I'd rate that about a 7 or 6, that is 6. Extensive pilot compensation. Call it a 6 and "D" at this level.

CONFIGURATION 15 PILOT A FLIGHT NO. 197-1

PILOT RATING 6 TURBULENCE EFFECT RATING B

It's somewhere between a mild to moderate instability. It doesn't diverge real fast. It will get away from you. It seems to be reasonably well damped. It doesn't take off immediately but it builds up to a fairly moderate pitch rate. It's a moderate instability and there is no great trouble with the pitch attitude if you just stay right on it. I spend more time on the pitch attitude than I do anything else. The airspeed control was fairly easy but it has a lot of induced drag. I lucked out in the turn and got the proper power set and maintained airspeed all the way around the 180° turn. The approach was again a moderate increase in workload. Airspeed was no great task. I made a few manipulations with the power but it didn't require much. Altitude control, attitude control, airspeed control, etc., were no big problem. Although it required attention and this increased workload a little. Fairly good increase in workload over a stable airplane. The approaches included an offset and crosswind. The second one was an offset and the third one was a crosswind. The glide slope was decreased a little by about one dot which compensated for a tailwind. It's a little flatter approach but the pilot can't see that much difference. It's just a slightly different picture but not much. The doublet type control inputs caused by the instability is the main thing that's unusual. I have to watch the attitude indicator much more because it's unstable. A couple of times it felt like it was stable because the trim was wrong and I'd pull the nose up and it would stop going up by itself and then go back toward something. It is trying to get away but it didn't seem to diverge at a very high rate. I didn't look up on the offset until about between 250 to 200 feet altitude. It required an immediate S-turn and the sink rate probably went up a little bit but I whipped it on down. It's a matter of quickly acquiring the runway and making an immediate correction. Otherwise, you're closing so fast at this speed, relatively fast. It's typical of all approach speeds that are higher. It's just a matter of how much time you have to do the maneuver. No big difficulty. You get into a little bit of a PIO when you start to turn because of pulling some g in the pitch. If you stop watching the pitch except externally you can get into a little bit of a PIO. Crosswind landing was no difficulty. I just put the wing down and I don't know if there was enough bank to scrape a pod or not but I doubt it. Crosswind didn't have much of an effect on sink rate. The main thing is that the nosedown pitch that came on in ground effect, will cause you to start into a PIO unless you correct just right. That's probably what's doing it. The more I look at that nosedown pitch change, if you don't touch right at the bottom of it, then you boom right into the PIO. The feel hasn't changed or throttle friction hasn't changed. I'm still using lots of rudder to go into the turn to counteract the adverse yaw and that was the way I remembered the airplane. I lead the turn with a fair amount of rudder. I lead the turn with rudder and power because it's a backside. The configuration is controllable. You can attain adequate performance with a tolerable workload. There are lots of deficiencies that will warrant improvement. Between a 5 and 6. For an airline pilot, I'd weight it toward the 6, but 5 to 6. They gave me some turbulence I think on that last one. There's a minor degradation so make it a "B" or a "C" on the turbulence rating. Probably "B". Minor, no significant deterioration and the task was just a little increase in workload. The configuration was unstable, moderately unstable. It didn't seem to take off directly, just kind of hung there, and then gradually it eased on off. It picked up a rate. I used a bit different task for the flare and landing on that one. I tried to use a combination of visual and instruments and tried to keep the pitch attitude just about 10°. Then I eased it up just a little to break the sink rate and just counteract the pitching moment. I think I didn't PIO on that. This configuration looks like it's a little bit damped but a fairly good divergence rate. May not be much different than the last one. It's a little higher but it's hard to tell. It appears to be backsided. I'm not positive of that because I didn't let it diverge very much but it took some pretty large throttle movements to keep it close to 160 and you had to stay right on top of that pitch. It is an increased workload - fairly high workload. It was increased due to pitch and because a fair amount of throttle movement was needed to keep the airspeed near trim speed. But if you happen to be lucky enough you could hit it right. If you know your airplane and how much to pull off when you intercept the glide slope, that would make it a lot easier, but that seems to be getting into the learning curve bit. On the straight in approach, I tried a combination, of maintaining about a 10° pitch attitude by just trying a combination of the visual scene outside and the pitch attitude inside to see if that would make it easier and avoid the PIO. It did on that one.

CONFIGURATION 4 PILOT A FLIGHT NO. 198-1

PILOT RATING 5 TURBULENCE EFFECT RATING C

It has a mild divergence. The trim was not hard to find and the divergence is light to moderate. It's the reversal of the stick force which is an objectionable behavior off trim airspeed--pulling when you're fast and pushing when you are slow. Altitude-attitude control requires a little more attention on the attitude indicator. Airspeed control requires a fair amount of attention but not bad. Altitude control was no problem. As for attitude control, you still have to watch it or it will walk away from you a bit. For this moderate or slight to moderate instability, the localizer tracking is no problem at all. Precision in tracking is no problem. The sensitivity of the localizer makes you perform a S-turn back during acquisition but that's common to this simulation. No degradation in altitude performance really because of the localizer task. The glide slope acquisition is no problem at all, just a pitch change and then a power change. It takes a doublet because of the instability. I have to push it over and then stop it. There is a minor increase in work load but not a great one, because of the instability. Tracking-airspeed control was kind of lazy; I stayed about 4 to 5 knots fast. I never did get very slow while on the glide slope. Maintaining and reacquiring localizer is no problem. The pitch task caused a minor decrease in heading control performance, but only minor. It just takes a little more attention to the attitude. Not much change in the cross check pattern but I come back to the attitude indicator a little bit more often. The control technique is a doublet, just like all the instabilities. The airplane motion is reasonable. The turbulence masks part of the instability. I don't know if it's turbulence causing what little disturbance we have. Sometimes I have this rising sensation like we're in a thermal which gives you a pitching sensation. The relatively mild degree of instability is partially hidden by the turbulence but it does tend to walk away from you if you don't watch it a little bit. Regarding the lateral offset errors, there is a little bit of tendency to PIO during the maneuvering. When you start your maneuver, you'll just pull up a little too much but it's not great. I don't think it adversely affected control of the touchdown point or the sink rate. The touchdown point was a little longer on the lateral offset approach, but I was easing it to the ground and there was very little PIO tendency--almost none at the level we were working. I just kept easing it to the ground and holding the nose and not letting it move. After I went visual on that last approach, all I checked was the airspeed at about 50 feet and then made the landing from there. I made a fair power reduction. At that point it doesn't slow down much unless you really cut the power. I was in ground effect by the time I cut the power off. I could feel the ground effect and I held it off and made a relatively low sink rate touchdown. There was no big difficulty on the crosswind approach. I used the wing down technique and there was not much of a problem with sink rate nor touchdown point either. Control feel is unchanged and the rudder breakout forces are still too high. Throttle control feel and friction is unchanged. The pitch control was most degraded by the configuration characteristics. As for the rating, it is controllable and I'd say adequate performance is attainable with a tolerable pilot workload. Is it satisfactory without improvement? Not for a good airplane - no. The deficiencies do warrant improvement, 4 to 5. It requires moderate, somewhere between moderate and considerable for an airline pilot. Rating is 4 to 5. The turbulence rating would be B or C--something like that. Maybe a minor deterioration in the performance, but not much, B or C. Make it a C. I don't have any strong feeling between 4 or 5. We can make it a 5. The most objectionable feature of this configuration was the rudder breakout. That's a nasty one but the fact that I've had to watch the pitch a little bit more was probably the most objectionable. Best feature was the lateral control.

CONFIGURATION 13 PILOT A FLIGHT NO. 198-2

PILOT RATING 3 TURBULENCE EFFECT RATING C

Trim is relatively easy to achieve. It appears to be either just slightly unstable or neutral to slightly unstable, depending on which way I pulsed and where the trim was. It looked like just a gradual divergence, fairly slow divergence. During maneuvering, the airspeed is no problem. It looked like a very mild induced drag. Attitude control was relatively easy and altitude control was no problem. I can change the angle of attack and add some power and it goes right on up or down depending upon where it is. The stick force per g is much higher than we have seen on any of these unstable configurations so the forces to turn are fairly substantial. Without a doubt it's a positive stick force per g gradient. The airspeed control in turns is no problem at all. The most drastic change in this configuration is the fact that it does require fairly strong stick force per g to maneuver the airplane. The trim change in ground effect is marked. The forces required are relatively higher than other configurations. I was nursing it in trying to find the ground each time. It is not really a PIO but just kind of pulling and then letting them stop - just overcontrolling a little. I was just a little worried about how much elevator and how much force was going to be required. I was overcontrolling just a little more to make sure I had positive control getting a flare for touchdown. Glide slope acquisition with this configuration is a fairly simple task; I just lower the nose and beep the trim just once or twice and then change the throttle. It takes a fair throttle reduction for the 3° glide slope or whatever we're using. The crosswind task was no problem at all. I could get a wing down and set up the sideslip in the descent and it would flare and touchdown. I had a good offset on the third approach. The primary things are the higher forces to maneuver and the almost neutral stability. I don't think if the average pilot flew this configuration without playing with it, he would know that he was unstable. Trimming is no problem. It definitely requires trim and stick forces. The technique for intercepting the localizer is just a high pull. You pull the g's to get around as quickly as you can. The pitch task doesn't have any effect on the heading control. I made no unusual use of the display on that configuration. The elevator and throttle are almost normal on that configuration, like a normal airplane. The airplane does not feel like it's trying to get away in pitch. The lateral offset was no big problem except that it does require a hell of a pull force to suck that airplane in. It's not a real high force, but it's larger than what I saw in those other configurations. The workload on flare and touchdown is no problem at all. I have been making fairly large power reductions in the flare which surprised me but it may just be the power characteristics of this simulation. The forces to counteract this pitching moment in ground effect are pretty high, relatively high. Crosswind landing is no problem. I probably floated a little bit because of the stick forces I was playing with going into ground effect. Control feel I think is unchanged. Throttle control feel, friction is no problem. I think the maneuvering was most degraded because I was used to the light forces with the unstable airplanes and the change with this configuration makes it feel like you've got a high stick force per g. As for the configuration rating, it is controllable. Yes, adequate performance is attainable with pilot workload. Is it satisfactory without improvement? I would like to see some things changed - I'd put an interconnect in with the aileron for one thing. It has some mildly unpleasant characteristics, minimal compensation required; I'd say somewhere about a 3 maybe a little bit over, between 3 and 4. I think people would recognize this as a big old heavy airplane, transport type. Eastern Airlines would probably like it as a 3. I think it's a 3. Minor deterioration of task performance with turbulence C, 3C, 3 1/2C or something like that.

CONFIGURATION 9 PILOT A FLIGHT NO. 199-1

PILOT RATING 6.5 TURBULENCE EFFECT RATING D

Trim was no problem, I had to hunt a little bit with the trim switch but no big problem. It was unstable, kind of a moderate instability. Maneuvering wasn't any big problem, airspeed control was a fair amount of trouble, because of the induced drag. I had to watch that it didn't diverge too fast, just kind of keep my eye on the attitude indicator. I had to cross check--but no big deal. I had to place more emphasis on the attitude indicator. Maneuvering was no problem as for lateral control, I still lead with the rudder. Part of the difficulty was the rudder pedal breakout force that caused just a little bit of a PIO. But I can handle it. Localizer acquisition and tracking was no real big problem except for a little PIO tendency when I was pulling g's or turning. As for glide slope acquisition and tracking I retard the power and fly down the glideslope and just maintain pitch control with an elevator doublet. The only unusual use of the display was more attention to the attitude indicator than with a regular airplane. I had to use doublets to control it. Start it and stop it and then jiggle it around there. Control forces are fairly light. The workload due to the control forces was not too great in this configuration. The resulting motion of these doublets is not exactly what I would want - I can't just put it up and stop it quite as easily. But you can control if you stay right on top of the attitude. Lateral offsets were no problem, little bit of a tendency to PIO as I turn but if I am really careful and watch the attitude real closely I could make my turn and do it alright. I don't think it affected touchdown point or the sink rate very much anyway. I just kind of broke that sink rate and let it settle on in and I pulled the power back pretty far. Fairly good power reduction as I went into the ground effect and then I just kind of held the attitude and anticipated the ground effects so that I'd touch just as I'd pull. I was maintaining an attitude more than anything else. Crosswind landing was no difficulty using the wing down technique. The touchdown point might have been just a little bit longer on the crosswind but not much. I don't think touchdown control was any problem. Control feel and throttle control feel are all unchanged. The stick gradient for a good airplane would have created a flare problem because you had a little bit of a tendency to PIO and I think I've learned how to outsmart it. Configuration rating? - It is controllable. Tolerable pilot workload? I'm afraid the average airline pilot would be a 6 on that, without any trouble, maybe even a 6-1/2. Somewhere from 6 to 6-1/2. The turbulence effect rating would be a C to D on that configuration. Make it a D. (Moderate turbulence.) There was moderate turbulence but as I got lower, there was less. Most objectionable feature? I just had to watch the pitch all the time. That was the most objectionable feature. Best feature of the configuration, lots of lateral control I guess, and lots of power. Use of longitudinal trim? All I do is trim the forces until I'm oscillating about a point. I don't try to achieve them. The forces are so light and I'm getting so many pitch changes that -- on these light instabilities, I don't tend to trim when it's near neutral because you don't know where trim is. It's harder to define the trim when it's a moderate instability. And 2 seconds to double amplitude requires more trimming, than a 6 second or a 8 second because as you go toward neutral on it the trim is harder to find. That time I couldn't tell you exactly where I was on trim. One time on the up-and-away maneuvering I thought I was trimming and pulsed the aircraft and it went down and came back up. I don't know if it was with this configuration or the pre-evaluation configuration before, but on the light instabilities, trim is difficult to achieve whereas in the heavy instability, it's really easy to achieve. You don't even know the forces are reversed. When you're near or aft of neutral, there'd be no trim. If it was an absolute neutral stability, you'd have a trim but you'd have a hard time finding it. I just got it one time, may be going in and then after that I didn't. This longitudinal trim rate was reasonable. Sometimes on the heavy instabilities you are trimming the forces and that's all you are doing. And if there are no forces, you don't have to trim. When the forces are light, then you don't notice out of trim unless it's grossly out of trim. Whereas with a strong instability, 5 knots off is a heavy force so you'd trim. And 5 knots off here doesn't make that much difference. I didn't attempt to trim in ground effect, it's too late and it's too quick, you don't have time for that.

CONFIGURATION 1 PILOT C FLIGHT NO. 199-2

PILOT RATING 2 TURBULENCE EFFECT RATING B

Aircraft is relatively easy to trim. Airplane appeared stable. The induced drag at 160 knots was quite apparent, little harder to control thrust and airspeed. Maneuvering was very easy in this configuration. Maneuvering in turning flight was very easy. Pitch control was quite easy. Attitude and altitude were quite easy to maintain. Localizer, acquisition and tracking prior to glide slope interception. Performance is quite good, workload was moderate, airplane apparently statically stable or near neutral. Localizer task and altitude performance were quite compatible for good performance. Glide slope acquisition was quite easy. The throttle technique in what apparently was a stable configuration caused a slight tendency to overshoot glide slope because I didn't anticipate it. The attitude and control force and throttle changes were a little larger than some of the unstable configurations might be. It was quite easy to acquire and maintain the glide slope. Airspeed control was noticeable in that when I got on the slow side, it took quite a bit of power to obtain and maintain the target airspeed. The aircraft appeared to lose airspeed quite rapidly with small increases of angle of attack or load factors. All displays were used normally. The airspeed attitude control was normal in the way I normally control airspeed in that I make adjustment to the glide slope with throttles and hold airspeed with pitch attitude. The airplane felt quite suitable to the task. The airplane felt stable and didn't require continuous attention to fly. It was quite easy to glance away and scan the various instruments without losing the desired numbers. Lateral offset was quite easy - no pitch changes or divergences or PIO's noticeable with roll corrections for lateral offset. Control technique in performance, workload, touchdown maneuver were quite normal. The pitching moment in ground effect was noticeable but quite controllable. Crosswind landing was quite normal. I used the decrab rather than wing down which is normal for most of the large transports. Sink rate seemed to break itself with very little flare. All it required was an increase in stick force to maintain the attitude. Control feel, rudder forces make it very difficult to control adverse yaw with small roll inputs. Breakout forces and gradients would be much easier with a much lighter force. Roll forces were a little bit on the high side. Roll breakout forces seemed a little bit on the high side for more precise tracking. Throttle feel was quite good, friction was quite good, appeared near optimum. The evaluation task most degraded? I would be hard-put to find one. The airplane flew quite well. Appeared to be very much like a normal transport. I'd give the configuration a 2. Turbulence effect? Rough air made it very slightly harder but it didn't really detract very much from the task. I would say flying this configuration for 30 minutes would not be excessively tiring turbulence effect I would give it a B on that configuration. Most objectionable feature in this configuration I would say would be the rudder pedal breakout forces and the force gradients on the rudder - making it difficult to control adverse yaw. Least objectionable feature - I guess was that the airplane was quite stable. The forces were moderately high requiring quite a bit of push - pull in both the longitudinal and lateral.

CONFIGURATION 7 PILOT C FLIGHT NO. 200-1

PILOT RATING 6 TURBULENCE EFFECT RATING D

The airplane appears mildly divergent. It is trimmable to a degree. When I get on the slow side the airspeed tends to bleed off fairly rapidly because of the increased induced drag. Attitude control takes some considerable attention to keep you from drifting off. Altitude control is not too difficult, as long as you watch the attitude carefully. Airspeed control is moderately difficult. It's easier to lose a little than it is to gain a little if you get slow. The rudder breakout forces make it difficult to coordinate turns - there's a tendency to let the adverse yaw get you as soon as you roll into a little turn. Pitch control for the unstable condition - the forces are a little bit high to pull and check for very find adjustments on attitude. Makes attitude tracking a little bit difficult. Localizer acquisition is slightly difficult because of attention required to pitch control while trying to scan localizer and glide slope instruments. Localizer task slightly degrades altitude performance due to the constant attention required to pitch attitude. Glide slope acquisition is not too difficult although there is some distraction due to the constant attention required on the pitch attitude due to its divergence. Workload at this point becomes noticeably heavy because of the increasing scan rate required to prevent the attitude divergence. Maintaining and acquiring glide slope and airspeed is considerably more difficult than a normally stable airplane. There is a tendency for the airspeed to more easily go slow than it is to go on the fast side. However, on one occasion during the approach where airspeed was allowed to build up to 168-169 knots it did take a pretty good power reduction to get it back while maintaining glide slope. The pitch task did affect the heading control somewhat adversely as well as the scan of the other instruments. It's difficult to maintain a rapid enough scan to keep everything glued together during the approach. The display was used normally although during the approach the scan rate necessarily picks up a much higher frequency in order to keep everything gathered up. Control is normally throttle for rate of descent and pitch attitude for airspeed. I find it much simpler to glue the attitude down and adjust the airspeed where possible especially in this kind of an unstable configuration. If you try to make attitude changes, the divergence and the short period catch up with you. This configuration requires a noticeable input to obtain a pitch response and then as the pitch rate builds up it requires a very positive opposite check maneuver on the stick of possibly 8 or 10 pounds to make these small 1 or 2 degree pitch attitude changes. The airplane motion is a little disturbing in that it does tend to try to get away from you if you don't keep looking at it very closely. The airplane does feel like it's trying to get away from you unless you are continually and consciously controlling it, in pitch. Lateral offset error on breakout was a little difficult in that when I make a very rapid roll, to get back on there is some tendency for pitch to diverge. Then I have to make a pitch correction which sets up a mild PIO, which does tend to spoil my control of flare and landing. The control technique for power management was one of trying to hold attitude to maintain the airspeed, holding a fixed attitude up to the glide slope interception and dropping the nose slightly, perhaps 2 degrees and reducing power slightly to maintain rate of sink. Crosswind landing was not much more difficult - used flat attitude decrab. Sink rate and touchdown point control were not largely affected by the cross wind landing. Control feel - again the rudder pedal breakout forces are unusually high and should be reduced for a better airplane. Control travel with this configuration - larger inputs are required to maintain the attitude. The breakout forces could be a little lighter and the control force gradients could be a little lighter to make the use of larger inputs to start and stop pitch rates a little more easier. Throttle control feel and friction are about optimum - it feels very good. The task most degraded was the control of pitch which requires constant attention. I feel that if your attention was distracted to some other system for 5 to 10 seconds, the airplane would be too far off in pitch or roll to continue an approach. For a configuration rating, based on my idea of an airline pilot I'd give it a 6. Rough air degraded the ability to track and maintain and perform somewhat slightly. I feel that you could fly the configuration for 30 minutes in turbulence almost as well as you could without turbulence, however, either task is quite demanding. I'd give it a turbulence effect rating of D. Primary reason for the rating is the divergence in pitch because it is a little high and in itself is the most demanding piece of the flying task. This is the most objectionable feature of the configuration. I guess the least objectionable is the attention required to maintain airspeed - it's noticeable and does require some attention especially on the slow side.

CONFIGURATION 15 PILOT C FLIGHT NO. 200-2

PILOT RATING 5 TURBULENCE EFFECT RATING C

This configuration is a little easier to trim than the previous configuration. It tends to diverge fairly rapidly however but is a little easier to control and a little easier to stop pitching rate as it diverged from the desired attitude. Attitude control takes some attention because of the divergence but the initial divergence doesn't seem to be quite as rapid - it's easier to catch and check. Airspeed control I think is a little bit easier. I'm not sure whether it is because of the difference in attitude or the drag characteristics. Maneuvering in turning flight is slightly easier than the previous configuration. Once the pitch divergence gets started it is quite rapid. Initially it seems to start a little slower. Perhaps that is the reason it's a little bit easier to fly than the last one. I noticed on the first approach when I overshot the glideslope and pushed the nose down a little bit the airspeed increased very rapidly. It took quite a bit of power reduction to control the airspeed. Much more so than the previous configuration. There is still a slight tendency to PIO if you make any pitch attitude corrections while entering ground effect. On that particular approach I made a small flare which resulted in overflaring and it was very difficult to check until it was too late and resulted in a little higher sink rate than I should have experienced on a good touchdown. Localizer acquisition and tracking. It was a little easier than the previous configuration. A little slower to diverge initially which made it a little easier to monitor and scan all the instruments. Workload is moderately high. Localizer task affects altitude performance in that when you are trying to watch the localizer movement, you must also scan the attitude instruments fairly rapidly. It does degrade the altitude performance somewhat. Glideslope technique is the same as before. Slight pitch down attitude, maybe two degrees, as the glideslope is intercepted and a slight reduction in throttle. The glideslope acquisition is fairly easy. Workload on the glideslope is moderate. There is a slight tail wind existing which requires a larger power reduction and there is some noticeable wind shearing existing in the conditions of this flight. The ability to maintain and reacquire glideslope is not too difficult. You make pitch changes as necessary to pull and check because of the pitch divergence. The pitch task does affect heading control somewhat in that the heading will tend to drift off one or two degrees before you notice it. The displays were used in a fairly normal method. Control technique is the same as before. Input required to produce pitch response is half to one inch pull to initiate a pitch rate and then it takes that or possibly more to check the pitch response partially where you want it. Very difficult to stop it exactly where you want it because of the response characteristics in the short period. The airplane motion appears somewhat incongruous with the small changes you make with the pitch control because of the short period characteristics and the divergence. The airplane does feel as though it will try to get away from you if you let the pitch rate build up. However, if you catch very small pitch rates they are not the same feeling as the previous configuration which felt like it would get away from you very rapidly. In this configuration the tendency was to diverge much more gradually initially for the first degree or so and it was much easier to control providing you made very, very small changes in pitch attitude. Lateral offset errors were only difficult in that you would induce pitch attitude changes and induce drag changes due to accelerations required for maneuvering. This set up a mild PIO tendency because of the characteristics that I've just mentioned. Item 9 is the same as before. Crosswind landing is the same as before. The difficulties are not that evident for crosswind as it is for the other tasks. Control - feel the elevator response is a little better than the last configuration providing you make pull and check corrections for very small changes in attitude. Control travels were a little more than you would like to see in a transport airplane to make minor pitch corrections. Breakout forces again were a little more because you have to move the wheel an appreciable amount. However, the breakout forces appear high but also the force gradient. Friction level appears about right. Throttle control feel again is about optimum. Most degraded task I think was the pitch divergence which requires pretty constant attention to prevent attitude divergence. This configuration I think I would rate one number better than the last. Rate it at a 5. Turbulence effect - there again very slightly degraded ability to fly the configuration. I would almost as soon fly for 30 minutes in turbulence as I would in nonturbulence. It takes a considerable amount of pitch in either way. The turbulence effect rating is a C which is one number better than the last one. The reason for the rating is primarily because it does require a considerable amount of attention to fly it. You can't trim it up and let it alone for long periods as you would expect a good airplane to be left alone. I think that if a pilot were distracted in cruise with this kind of configuration or was distracted in the approach because of some system malfunction or other emergency this configuration could get him into real trouble. The approach can be flown providing the pilot only has to fly and has nothing else to do except to maintain his attention on the primary flight instruments.

CONFIGURATION 6 PILOT C FLIGHT NO. 201-1

PILOT RATING 6; 8 TURBULENCE EFFECT RATING D

The airplane is trimmable. It seems quite heavily damped. But it appears quite unstable and once a pitch rate develops, it diverges fairly rapidly. However, it appears a little bit less of a task to hold pitch attitude constant, than some of the other configurations, as long as it doesn't diverge any appreciable amount. Maneuvering about level flight-attitude control is good as long as a close watch is kept on it. It can't be allowed to start to diverge. It tends to be damped and can be flown hands-off in smooth air for several seconds before it does start to diverge. Airspeed control is not too difficult. The drag characteristics seemed to be there, but it's not too difficult to maintain airspeed. On that approach I got a little low on glide slope into the last 100 feet trying to break the glide slope and set up a PIO in the final phases of the approach to flare. And although the actual touchdown is probably not too bad, it was quite a bit of luck in that I was in a fairly long-period PIO during the flare itself. Localizer acquisition and tracking is not too difficult. Considerable attention is still required for pitch control. If you allow a pitch rate to set up, it will diverge fairly rapidly. Localizer task degrades altitude performance somewhat and as you intercept the localizer the scan rate has to be increased to keep from flying through the localizer, of course. It takes split seconds away from attitude monitoring. Glide slope acquisition is the same thing. It requires very, very rapid scan through all the flight instruments. It is possible to fly the glide slope and localizer at the same time, but it is a demanding task. On tracking glide slope and localizer the ability to maintain and reacquire glide slope is there. It's possible to do. It's quite a demanding task though and as I'm making corrective maneuvers I actually generate pitch rate divergences and between that and the short-period, there's a mild tendency to PIO. However, the worst part of the PIO occurs in ground effect where a pitch change is produced. A pitch rate cannot be allowed to be set up or else a satisfactory landing cannot be made with any degree of reliability. The pitch task does affect heading control somewhat in that you find yourself trying to stay more on the vertical gyro than you do heading and you have to force yourself to scan rapidly and not concentrate on pitch attitude. Control technique is the same as before; you keep using throttles to control rate of sink and pitch attitude to control primarily the airspeed. Entering the glide slope from level flight, lowering the nose slightly and reducing throttle about 8% on the thrust, sets you up pretty well on the glide slope. Input required to produce pitch response is a fairly large input compared to what you'd expect from a stable airplane and once you set a pitch rate up, it does require an opposite check input on the control column. The airplane motion is not too bad as long as you make very small corrections of 1° or less. Larger attitude corrections become more, and more difficult and the larger the attitude changes, the more likely you are to get into a mild PIO. PIO can be damped manually, however, by concentrating on the vertical gyro. The airplane feels like it's going to get away from you, unless you are continually and consciously controlling it especially during maneuvers requiring thrust changes, trim changes and airspeed changes. Airspeed control is a little bit difficult in that if you inadvertently or intentionally lower the nose slightly, the airspeed does scoot away 10 knots in a very short period of time. It requires some very precise monitoring in order to maintain airspeed and does increase the workload appreciably. The workload in the flare is quite high. I think it would be difficult to land the airplane if I have any corrections to make during the last part of the approach. The only satisfactory way to land the airplane apparently is to lock in the attitude and change nothing during the last 100 feet of the approach. The lateral offsets, of course, increases the workload for the same reasons in that this requires vertical acceleration in the turn and sets up pitching moment changes which require some pitch attitude corrections and this also fouls up your attitude control during the final flare. Crosswind landing increases the workload appreciably during the approach. It's a little more difficult to hold an offset heading and hold it precisely than it is one directly on the courseline. It's much easier to monitor during your scan, than it is one offset 4 or 5°. Control feel, again the forces for an unstable airplane are quite high although they would appear normal for a stable airplane. Rudder is quite high and I guess will remain so. The control travels are large because of the large inputs required to generate and stop pitch rates. The friction appeared to be very low in the system. Breakout forces are fairly normal except rudder which is quite high. Throttle control feel is about optimum. The task most degraded by the configuration I guess as in all the other unstable configurations is the flare and landing. In this configuration where you have the large pitch down moment during ground effect, it requires very precise attention and responses to prevent a pitch rate from developing during the entry into ground effect. Configuration rating -- I'd give it a 7. I think that the airplane would be very difficult to fly by the average airline pilot. He would have some considerable difficulty with it, as I did in taking it down to the landing. On the turbulence effects -- the turbulence effects deteriorated somewhat, not greatly. I actually find this true in most big airplanes, even for stable airplanes. Rough air is not as hard to handle as it is in small airplanes. I'd given it a turbulence rating of D, Delta. I could fly this configuration 30 minutes in or out of turbulence during landing approach tasks providing nothing went wrong, as long as everything was perfect and could provide complete concentration on the instruments it could be done. However, this is not always the real-world and there would be some instances where there are distractions due to various reasons in the airplane and I think if this were the case, the approach would either have to be abandoned or there would be a high degree of hazard involved. I guess the most objectionable feature is the unstable pitch divergence. The inability to make anything but very, very small corrections. And the difficulty in maneuvering for normal maneuvers that you would expect around the traffic pattern and in normal flight, the task then becomes too difficult. The best feature of the configuration I guess, is power controlling. The throttles are very well matched. For the approach task alone, I would give it a 6 and for the landing and flare, I'd give it an 8 as a separate evaluation for that configuration. And actually it is very objectionable, but there are tolerable deficiencies for the approach task, providing again, that you can give your complete concentration to the task of flying the basic "T" instruments and nothing else. In the flare an 8 is given because if anything goes wrong or any maneuvering is required, you're likely to end up with an excessively hard landing and result in serious damage to the airplane.

CONFIGURATION 3 PILOT C FLIGHT NO. 201-2

PILOT RATING 9; 10 TURBULENCE EFFECT RATING F

The airplane is trimmable. Objectionable behavior off trim airspeed -- it does diverge in pitch. It diverges very easily and quickly although divergent rates are not as exciting as some I have seen. The ease of which it comes off the target attitude is very quick and it sets up a pitch rate and holds it, but damping appears to be fairly low for this amount of instability. Attitude and altitude control (we're flying in moderate turbulence) becomes quite difficult and the attitude is continuously trying to diverge and requires constant attention and pulse inputs to hold the pitch attitude constant. The airspeed control is somewhat difficult in that when the airspeed diverges, you can see the high induced drag on the airspeed directly with pitch attitude. It will diverge very rapidly on the fast side. It requires a large amount of power application on the slow side to maintain airspeed control. Maneuvering is quite demanding in that the attitude in airspeed requires constant attention. Maneuvering forces are acceptable and the task required for turning flight maneuvering is somewhat more demanding than it should be. Localizer acquisition and tracking. On the last approach there was some natural turbulence on the localizer. Performance capability was degraded. Very difficult because of the very quick divergence from desired attitude. Workload is very high. It requires constant attention and constant corrections in the natural turbulence. Localizer task was very difficult. I could track, but it was a very difficult task. Required very close attention to the instruments. Glide slope acquisition was a little bit easier since the glide slope indication is on the attitude indicator, whereas the localizer indication is not. Performance capability is not too difficult on acquising the glide slope. It's the heading changes that require the highest workload item. When tracking on the glide slope and localizer it is very difficult to maintain and re-acquire the glide slope. Airspeed control is somewhat difficult although, it's easier to keep it from the target airspeed to the fast side than it is to fly it on the slow side and correct back to the fast side. The pitch task does affect heading control adversely. It's very difficult to divide your attention to the heading and localizer indicator when the pitch task requires such intense concentration. The displays were used usually with as rapid as possible a scan. Control techniques are the same as before. Inputs required are positive input required to generate pitch rate and another positive opposite movement to check pitch rate and these were occurring very rapidly and very quickly because of the quick divergence of the pitch attitude. The task in the resulting airplane motion was frequent pitch input pulses to control pitch attitude. Very high workload, very tiring workload. The task is not very suitable for the airplane motions in that you're continuously working the control column to maintain a pitch attitude. It does feel like it's trying to get away from you unless you're continuously and consciously controlling it to a very close tight loop. The lateral offset error again induces this pitch correction requirement which gets you started in a mild PIO, fairly long period for a PIO. The movement does adversely affect your control of landing touchdown point and sink rate. On the last approach at the end of the maneuver I made a very large input to arrest the pitch down and the high sink rate. By accident it worked out alright. Control technique and workload - In the flare it was very difficult. Crosswind landing again was not as difficult as the maneuvering. It is more difficult to make that last "s" turn maneuver than it is anything else with the unstable configuration. Comments on the forces are the same as the previous run. Throttle control again is about optimum. The evaluation task most degraded again was the landing flare although the approach was very difficult. Configuration rating - I would say for the approach task I would give it a 9 and for the landing I would give it a 10. Turbulence effect - rough air. Because of the quick divergence and apparent low damping, turbulence makes it much more difficult. I would give it an F rating. Flying the configuration for 30 minutes would be very difficult, very tiring and probably would approach pilot concentration fatigue limits in something about that time. I wouldn't want to have to be forced to do it. The pilot rating I guess is worse than some of the other configurations because it is very quick to leave the desired attitude. It diverges very rapidly and requires continuous and very rapid pulses to hold the attitude such that the pilot's workload is reaching the point of being completely saturated.

CONFIGURATION 5 PILOT C FLIGHT NO. 201-3

PILOT RATING 10; 10 TURBULENCE EFFECT RATING F

It is trimable, however, it will not stay in trim. You can trim the forces out at any point but it just diverges so quickly, so rapidly that you can almost not blink without losing it. Maneuvering about level flight requires very rapid, very large pulses. To maneuver, large quick pulses are required to maintain any relative, satisfactory degree of attitude control. Maneuvering turns, a 30-degree bank turn requires tremendous input of power to keep airspeed from dropping below 150 knots. Evidently drag increase with the g's is fairly large. Acceptability for mission -- I could say it was completely unacceptable, unflyable except for very short periods of intense concentration. I have accomplished one approach straight in. Localizer acquisition and tracking is very difficult because of the intense concentration required on attitude. It is very divergent, very rapid, very quick to diverge in pitch. The localizer task kind of degrades itself because I am trying to hold altitude and attitude. Naturally, I am trying to control attitude a little more closely than the localizer task. So, I think the localizer task is degraded. Altitude and attitude performance required most of the attention. It is very difficult to force yourself to take your eyes off the vertical gyro when it seems like it is going to get away from you. Glide slope acquisition again was degraded because of the intense concentration. Ability to maintain and reacquire glideslope; airspeed control is a little difficult partly because of the intense concentration required. I was allowing the airspeed to wander ten knots on the fast side during the glideslope tracking. I was kind of just letting it go because of the difficulty in taking my eyes off the vertical gyro for more than enough time to indicate any trend in airspeed movement. The pitch task affects heading control adversely and again it is hard to take my eyes off the vertical gyro because of the feeling that it is going to get away from me. Displays are used normally. Control techniques are the same as before. Input required to produce pitch responses were very large, very quick, two or three inches just to maintain within a half a degree or so of pitch attitude. Like pumping the airplane up with a hand pump. The task is totally unsuitable. It would tire one out in a very short period and result in extreme fatigue and degradation of pilot ability. The airplane feels like it is going to get away from you if you even blink. I did not do the offset errors but feel that for this configuration it would be impossible as was the workload in the flare for the normal approach and landing. The difficulty in controlling pitch divergence and the very large inputs required would lead to a PIO and high probability of a hard landing. I did not accomplish any crosswind landings. Control feel, forces, because of the large inputs the force gradients require very high forces to get these two to three inch inputs very rapidly but would be tiring to your arm to do it for very long. Throttle feel again is about optimum. Task most degraded was the flare and touchdown for this configuration. Flare and touchdown is literally an impossible task, 99% of the time. Configuration rating, I would rate it a 10 without any hesitation. Both on approach and landing. Although, the landing is probably to a higher degree more improbable. You can't go any worse than a 10, so they both got a ten. Turbulence effect, again this is in natural turbulence as was the second run and I feel like the natural turbulence is far more degrading to the pitch attitude task for the unstable configurations then with model turbulence from the computer. In both the second and third configuration, the pitch rate divergence was excited very quickly by the natural turbulence on the airplane itself. This could have influenced the ratings on the second and third configuration somewhat..However, on the third configuration I don't feel that even in smooth air it would get any better than a 10. Primary reasons for the rating, I feel that on this last one with this amount of divergence it would get away from me so quick that the slightest distraction - the reaching for a switch or if I forgot the marker beacon or something and I had to just quickly turn around to turn it on, I'd lose the airplane. Again, the most objectionable feature was the flare and landing. You feel like it's impossible to expect to make a satisfactory landing. The approach task however is also a very impossible task. I have to give both of them a 10. Turbulence rating did degrade appreciably in natural turbulence and again the natural turbulence is quite a bit worse than the model turbulence as far as degradation and I would give it an F.

CONFIGURATION 6 PILOT D FLIGHT NO. 202-1

PILOT RATING 6 TURBULENCE EFFECT RATING D

In general, the airplane isn't half bad. I can maneuver and I can fly straight and level. At the trim altitude I can make turns at constant altitude without any unusual control techniques. I could make the speed changes that were required although I had a little more difficulty. The airplane seems to be slightly unstable statically in terms of stick force versus speed. It's a very small amount and not bothersome. The drag characteristics make it look like we're probably supposed to be around the bottom of the bucket. When we get to the 20 knot speed changes it looks like it's a little bit backside but for the 10 knots it looks like it's at the bottom. 1) ease of achieving trim - it's a fairly reasonable airplane. I don't have much stick force change with speed. The main difficult to achieve a speed change is you have to change the power to get the speed. Then you have to bring the power back to about the same value that you had keeping in mind that if you make a turn there is quite a bit of power change required with the angle of attack changes. 2) behavior off trim airspeed seems reasonable and not objectionable. The little bit of out-of-trim was bothersome at the twenty knot speed situation in that it did tend to pitch up a little bit. I had to monitor the speed and control it with throttle quite carefully, but again it was still handleable. 3) maneuvering about level flight - attitude control is fair to good. The altitude control is fair. The airspeed control is fair, approaching fair to poor for stopping at a given airspeed when you're trying to make a change. 4) maneuvering in turning flight - the lateral control is light and good. Altitude and pitch control is fair to almost fair to good. The stick force in turns is almost zero which is kind of nice. Airspeed control is fair in turns and the maneuvering forces are light to zero. Acceptability for the mission - it's definitely acceptable and the ability to pull the 1.2 g is quite adequate. Comments following the first approach. The acquisition of the localizer really went fairly well. I just came up on the glide slope at the marker which appeared to be alright, when because of traffic reasons we had to make a 360° turn to the North. During that 360 the initial part was all right. I rolled out on the heading of 090 momentarily to get a little separation from the marker and started a right turn around to 240. I had just checked the airspeed a few seconds before, 15 at the most, but in the entry of that turn, even though I had added power, the airspeed got quite low. It was quite inadvertent and I still don't know why it did get so low. I had to use a lot of throttle around 85-90% but I was able to bring the airspeed back during the turn and then re-acquire the localizer and the glide slope. The second acquisition of the glide slope was not too good. I got high and I was high most of the way down. I didn't ever have the localizer heading really pegged either, but I was still always in control. The airspeed was fast throughout the approach as I was trying to correct the high. I went visual perhaps about 100 feet lower than normal because we had a little mixup in the call. I was aware of it, though. In general, it was not a very good approach. It was safe but not a very good one and it was a moderate workload approach. I should say that even though I had an offset pretty close in I was able to correct the offset and even though I could feel a tendency to PIO I did manage to get the flight path under control. I think the touchdown was really pretty good and I had about the right location down the runway. So I salvaged it with some fair errors. I think it's acceptable but not a very good configuration. Eval. pilot comments following the second approach. Once again I see that my performance is worse than I expected from the characteristics that I saw in the up-and-away flight. The difficulties seemed centered around the glide slope acquisition. Again, on that approach I was high and fast and I finally got almost down to it when I discovered I had a significant localizer error. I'm not sure why that crept in but I think this was the approach where you gave me two different glide slopes, because I was coming down on one and then an error came in and required my attention and distracted me from my localizer tracking. It really made a big difference. I was quite far off, although I did recapture it before I went visual. In fact, I even crossed the center line. Then, when I went visual I was crossing right to left with a heading to the left so I made the line up correction and that included a flight path error that had to be corrected and I could feel the sluggish response in correcting it. I was in a PIO down to a landing although it was damped and I don't think the touchdown was too bad. It was a little hard but I was rounding up a bottom of an oscillation. If I had not touched down I would have been relatively long because I would have to go through another full cycle of the PIO, but as it was, it came out fairly well. I had a strong crosswind correction to put in and I was able to do that and manage the pitch flight path control but it was an arduous task. It was really coming out safe, but not very good. The thing that bothers me most I guess is the instrument flying. It seems that I get everything set up and it doesn't stay set up and I find this bothersome. I don't know what in the configuration characteristics are causing this because sometimes I get it set up and it stays there and at other times I get it set up and it does not. In my proficiency I haven't flown an instrument approach in a week so I can't blame my lack of proficiency too much. Comments following the third approach configuration. That approach was pretty nominal until I got down to about 500-600 feet above the ground at which time I picked up a glide slope error. I don't know whether it was because I had been monitoring my rate of descent very carefully and also trying to watch the airspeed to make sure that I didn't get fast. The glide slope error came in relatively rapidly and I caused it because the rate of climb had sneaked up to about 600 feet per minute. At this approach speed, it's pretty hard to correct a glide slope error that close in, unless you catch it right away which I didn't do. But I had it coming back toward nominal. I don't ever like to push the nose over steeply, I'd rather land a little long. When I went visual I was pretty near back on the glide slope and the localizer wasn't too far off. I had a line-up offset which I was able to correct and actually it wasn't as bad as the one I had on the first approach. On this particular approach, even though I was offset I had a heading back to the center line when I went visual. So the maneuvering I had to do was relatively small. The airspeed got low on me in attempting to correct the glide slope error. It responded rapidly and well to throttle but the error still did exist. I finally concluded after having made three approaches with this configuration, that I don't really like it very well. On that last landing I got lined up okay and the touchdown point appeared to be about right. I was not in a PIO as I had been on the second approach. I was really pretty nominal and it was just as I started approaching touchdown the ground effect started nosing me down. It got a little bit ahead of me and I touched down a little harder than I would have preferred to, but still I think it was an acceptable touchdown. 5) localizer acquisition and tracking prior to glide slope interception - (a) performance was adequate, each time I tended to overshoot the localizer but I was able to correct back. Workload was moderate and localizer task didn't affect the altitude performance there very much. As long as I remembered to add the power with bank angle, the altitude performance was acceptable. 6) In the turn, if I tried to look away at something else, I did tend to get a pitch angle error which led to an altitude error. This airplane doesn't have good feel in a turn, I don't know whether I am compensating too much for back elevator and hence the nose gets high or just what it is, but I simply report it. 6) glide slope acquisition (a) the control techniques are to nose down and reduce power. (b) performance was only fair. I had a tendency to get high. In order to whip that, I had to go to a tight rate of climb/rate of sink loop. I couldn't use just attitude. (c) the workload was moderate. 7) tracking the glide slope and localizer (a) ability to maintain and re-acquire the glide slope was poor and the control of airspeed was fair to poor. (b) maintain and re-acquire localizer was fair. It was degraded mostly by the attention required in the pitch task. (c) Yes, the pitch task does affect heading control adversely. It requires considerable attention in the pitch task and hence you tend to get away from the heading information. (d) only unusual use of the display was an increase in monitoring of rate of descent. (e) elevator was used to control attitude, throttle was used to control airspeed and rates of climb and descent. (f) to produce a desired pitch response requires an input to get it going and some inputs to stop it and also you had to monitor it to make sure that it doesn't then depart on its own. There is an instability whose rate of onset is slow but you have to supply corrective elevator input to prevent it. (g) for maneuvering, the resulting airplane motion is adequate, although I don't consider it very good. The main problem in the resulting airplane motion is this tendency to depart from where you put it and you think it came to rest. (h) only in a long term sense, but the answer is yes. The tendency to get away from you is more of an incipient thing. In other works, much of the time you can put it where you want it and it seems like it's going to stay there. You look away and attend to something else and when you come back you find that sometimes it's departed and other times it hasn't. It's not a very consistent behavior. 8) I was able to correct the lateral offset errors fairly well. I had some fairly good ones on breakout. The required maneuvering did not seem to adversely affect my control of the landing touchdown point or sink rate. What it seemed to affect more than anything else is my airspeed. That affect on the airspeed then required a throttle change and added to my workload. 9) the control technique in the flare and touchdown was careful control of attitude with the elevator. You tend to overdrive it with the elevator. The power management, I had to check the airspeed and make throttle corrections accordingly, but then as I would get down approaching the ground, I'd usually make a small power reduction. The performance, I had a tendency to develop flight path PIO particularly if I was doing any maneuvering, such as correcting an offset or putting in a crosswind correction. The workload was fairly high, but the performance I was able to achieve on touchdown seemed to be adequate. 10) The cross wind landing (a) the difficulty I guess kind of normal difficulty lateral-directional, but you do have a fairly high workload in monitoring the pitch while you are doing that, because I have a tendency to start a PIO. (b) there was a wing down and (c) it did affect the sink rate and touchdown point control by seemingly heading to a tendency to PIO. I do think the cross-wind landing performance was adequate. 11) the control feel, the elevator forces were relatively light. The travel was relatively small except when I was trying to tightly control the airplane near the ground and then the travel became larger. The breakout forces and friction on the elevator were negligibly small. Aileron forces were light. The travel was small and the breakout forces were there but not objectionable. Friction was not noticeable. The rudder forces were light to moderate. Travel was relatively small. The breakout forces were relatively large, but acceptable and the friction was not noticeable. 12) the throttle control feel was basically good and the friction level was good. 13) I think both the flare and touchdown and the glide slope performance were both degraded by the configuration characteristics and hence objectionable, in about equal amounts. 14) the configuration rating - is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? I soul-searched a bit on this and I think I would say barely yes. Is it satisfactory without improvement? and the answer is Heavens NO. After I finished the up-and-away portion I thought I would be able to say that the characteristics were very objectionable but tolerable. I clearly can say that now after having flown three approaches definitely these are more than moderately objectionable deficiencies. If I look over at the words - adequate performance is all that is attainable, and it requires more than considerable pilot compensation. I would say it requires extensive pilot compensation and therefore I rate it a 6. The turbulence effects, the rough air did bring out some characteristics that were objectionable, the rough air approach was my poorest performance because of a noticeably higher workload in the pitch task and the localizer task degraded also from this. 16) the answer is certainly yes. 17) the turbulence effect rating - definitely more effort was required and moderate deterioration in task performance - rating D (Delta). The primary reason for the rating (a) the most objectionable feature was the pitch characteristics twofold - there is a lag in the pitch response that was objectionable so the sluggish pitch response bothered me down in the ground flare and touchdown maneuvering. But also, the IFR portion was equally objectionable in that ability to fly the glide slope was not good and led to poorer performance on the localizer (b) the best characteristic of the configuration probably was the lateral-directional.

CONFIGURATION 15 PILOT D FLIGHT NO. 202-2

PILOT RATING 7.5 TURBULENCE EFFECT RATING D

Comments following the up-and-away maneuvering portion. In general, it's an objectionable configuration. It looks like we are on the backside of the power required curve. It's unstable in pitch, at least, it's statically unstable in the sense that stick force versus speed is unstable. It's also unstable in the sense that it tends to diverge on you following a disturbance and you have to counter this with control. I was able to do the speed changes and I'm not sure whether it's some feeling on my part that the unstable stick force, in a nose down sense, was less, for a 20 knot speed change, than it was in a nose up sense. So it might be somewhat nonlinear. (1) Ease of achieving trim is rather difficult. You have to spend time with the elevator and throttles both to achieve trim. You can do it but it takes activity and so the ease has gone down and is now poor. (2) Behavior off trim airspeed, the unstable forces are bothersome in that if you don't have exactly the right amount in, it tends to diverge one way or the other. In other words, if you have too much nose down force, it will diverge the nose down and if you've got too little, it continues to diverge nose up. This is if you are slow on speed. So, yes, I think the behavior off trim airspeed is objectionable. It's further objectionable because airspeed control is now difficult because to initiate a speed reduction you have to take off power but you end up at a given lower speed with more power than you had initially. It's just getting to be a more difficult task for the pilot. (3) The maneuvering about level flight. You have adequate attitude control but it's demanding in that you have to pay attention to it. Altitude control, I was able to maintain the altitude within 100 feet for what I was doing and so I would say it was adequate but a relatively high workload. Airspeed control was generally difficult and demanding but the performance achieved was adequate. (4) Maneuvering in turning flight - the lateral controls are still good and rudder coordination is used with the turn. The pitch and altitude control requires attention but for 90 degree turns left and right I was able to do it. Airspeed control during those turns required additional attention and workload. Maneuvering forces were small. Actually this configuration has the feeling that the elevator forces are heavier than the preceding configuration. Acceptability for the mission for the up-and-away portion is acceptable. The ability to pull the g - you have enough g capability here it's just a question of stopping it so it doesn't pull too much. Pilot comments following the first approach. The turbulence was fairly light on that approach and I had much less to do and so I was able to keep things fairly well under control for the whole approach. I did get high on the glide slope, but not too high. I was able to correct back and was approaching getting on when I went visual. The airspeed didn't get too far out of bounds and when I went visual I was pretty well lined up and I had a minimum of maneuvering to do. I had a little tendency to balloon as I entered the ground effect. The touchdown, itself, seemed to be one of my better landings. So, on that particular approach I never got very far off from nominal any time and it wasn't really too bad an approach. One thing, I did get slow on the turn in to intercept the localizer and I had added quite a bit of power to make the turn. I did get slow during the turn, but I think I had gained about 100 feet also. When I rolled out of the turn I was down around 148 and even though I had 73% thrust or something like that on, in other words, a substantial increase in power, the airplane did not accelerate. I expected it to accelerate by reducing the angle of attack when I leveled out to level flight. This is one of the characteristics of being on the backside in that, when you get slow, it takes increased power just to hold the slow airspeed and even more power to start the airspeed back toward the trim value. So I stayed slow for longer than I would like to have because of this characteristic. Comments following the second approach. That one I had to work moderately hard on, but the performance came out really fairly good. On the localizer intercept I got a little slow and I had that same problem getting the airspeed back but I anticipated it a little bit more. The glide slope interception, I did a little better on that one. I stayed closer to nominal, really all the way down. The localizer stayed fairly close, although it got a little off from about 500 feet, on down to 300 feet although I was correcting back. When I went visual I had an offset to the left so I corrected back. The turn wasn't the problem but in the turn I detected the sluggish pitch response and control of attitude. I was able to achieve adequate performance holding on the center line and flew it down and made a really fairly good landing. So with this configuration now I've got two fairly good landings. Airspeed was a little high after I went visual, it got up to around 164-165, but I think that's certainly acceptable. I pulled a little extra power off to compensate for it and I think my touchdown was around 153, which is probably just about right. Except for the difficulty in correcting back on airspeed, particularly low, and for the sluggish pitch response that was a fairly high workload but fairly good approach. Eval. pilot comments following the third approach. The third approach was one of those that the evaluation pilot in one sense wants to have happen and in the other sense hates to have happen. On the third approach the instrument work was fairly good performance-wise and everything was fairly nominal down to breakout. It was a fairly high workload but still things were coming out pretty good. Then as I went visual, I had a small lineup correction plus I had a crosswind and I was late getting over to the center line and getting the crosswind correction in. I assumed this is what caused the difficulty but anyway I started a PIO in pitch in attempting to make the flare and touchdown and it really did surprise me. It surprised me in that, in the beginning, I thought this configuration because of its heavy feeling for maneuvering would be PIO-prone. I could detect that the pitch response was sluggish and I expected to see some PIO's in landing approach. In my first two landings they were much better than my average landings and so you might say I was initially surprised that I didn't have any PIO tendency. But after two good landings I was beginning to think that perhaps I had misjudged the configuration as far as its pitch controllability. But then on the third approach I ran head-on into this PIO and I was using cockpit control motions up here that were not quite full throw, but a large percentage of full throw. I landed at the bottom of one oscillation. I thought I had it nailed and I actually ended up OK. The sink rate was about 5 ft/sec but if I hadn't landed in that second PIO, I probably would not have gotten on the runway because I was about half-way down at this point. I had been PIOing all the way and therefore unable to get my sink rate under good enough control to touchdown. I went through two really quite good landings to one rather horrible one. This was what I mean about the evaluation pilot both liking it in the sense that I would hate to have rated this configuration without having experienced this deficiency. But on the other hand, I dislike it in the fact that I went to the last of three approaches before I even detected the PIO tendency was there. I suspected it because of the sluggish response but I didn't actually encounter it. 5) Localizer acquisition and tracking prior to glide slope interception. (a) performance capability was, as far as flight path, about the same as I achieved with most of these configurations. However, there is a tendency with this configuration to nose down everytime you roll into a turn. It's quite decided and it kept catching me by surprise. I was able to control it well enough that the flight path didn't significantly diverge in the sense of altitude excursions beyond that I would tolerate. It did cause airspeed control difficulties and pitch control difficulties and a pretty high workload which is the answer to (b). (c) Effect of that on the altitude performance was not large; there was some effect but it was not large. 6) Glide slope acquisition, (a) technique - nose down on the interception to the desired pitch attitude and monitoring the rate of descent and bringing the power back to around 50-52%. Then you had to monitor the attitude very closely and also monitor the rate of descent very closely to stay on the glide slope. (b) Performance was adequate and the workload was moderate. 7) Tracking glide slope and localizer. (a) This configuration was not easy to maintain nor was it easy to reacquire the glide slope but I could do it and I could do it adequately for the mission. The control of the airspeed required attention and I couldn't fly constant airspeed but I could keep it within bounds while I was on the glide slope. (b) The pitch task did detract from my localizer and heading tracking but my performance was adequate. (c) Yes, but adequate performance was attainable. (d)----no unusual use of display. (e) Control technique, elevator to control attitude, throttles to control airspeed and nominal rates of climb and descent. (f) Input required to produce a desired pitch response - you definitely have to overdrive it. At times you even have to manhandle it, such as when you roll into a turn. The nose tends to drop and you really have to put a large input in to stop it and you have to monitor pitch attitude tightly to get it back. You also require an input to stop it at the desired attitude and again you have to watch that it doesn't depart or correct for its departure from the desired attitude after you've gotten it there. (g) It's not desirable but it's adequate. (h) Yes, you do have this feeling that you are hanging on a bit, but you are able to hang on well enough for the mission although it's a pretty poor configuration. 8) The lateral offset correction, I could make adequately well. On the breakout there was a tendency to inadvertently have an attitude change or a flight path error creep in as you made the line up correction. The airplane was sluggish in responding to the corrective inputs. 9) In the flare, the first two all I did was kind of nudge it each way as I came down flying attitude grossly and with relatively small inputs. I was able to essentially hold constant attitude. Maybe I made a very slight flare but I was able to arrest the rate of sink and touchdown at small sink rates on the first two. The power management just involved a slight power reduction as I got close to the ground and the performance on those two was good and the workload was moderate and much lower than I expected. But on the third approach, the control technique was one of large control inputs to attempt to suppress the tendency to oscillate in pitch and power management glances at airspeed. I'm not sure what I was doing with the power but trying to make sure that the airspeed didn't get too far out ahead, which it did not. The performance on the flare and touchdown was very, very poor and unacceptable on that last one. The workload was very, very high so you can see there is quite a difference in the answers to question 9 among the three approaches. 10) The crosswind landing. (a) The difficulty initially did not appear to be too difficult even though I was a bit late in putting in my correction but the effect on the pitch control was exceedingly difficult. (b) Wing down. (c) The effect on sink rate and touchdown point was very bad and unacceptably bad. I ended up landing half-way down the runway and at the bottom of an oscillation which if I hadn't touched down then I would have gone around. The fact is I would have gone around anyway had that been a for-real landing because I was too far down the runway. 11) Control feel. The elevator forces felt heavy and the travel was relatively large, the breakout forces and friction were not noticeable. The aileron forces were light. Travel was small. The breakout was there but not objectionable and no friction noticeable. Rudder forces were all light to moderate and the travel was small. The breakout forces were large and objectionable and the friction was not noticeable. 12) The throttle control feel was basically good and the friction was of a good level. 13) Without any hesitation, the control of flare and touchdown in the crosswind landing was the most degraded by the configuration characteristics. There was a sluggish pitch response that bothered me on other maneuvers such as trying to stop the nose down tendency in rolling into a turn, but I was always able to achieve adequate control. But down in the flare and touchdown in that third approach, I certainly did not have adequate control. 14) The configuration rating - is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? On the basis of those three approaches I have to answer that no, as deficiencies require improvement. Here's where I get into a bit of trouble in trying to come up with a rating. If we had the fuel I would like to have done one more approach. This is a configuration that I don't think three approaches lead to an adequate examination to give a very reliable rating. If I were to rate it entirely on the basis of the last approach I would have had to say that considerable pilot compensation is required for control and I would have to rate it an 8. But then I take into account the first two approaches and they went so well that I hate to rate it that poorly, but if every crosswind landing is going to result in that kind of a performance, then 8 is the correct rating. On the basis of the IFR portion and the sluggish pitch response I've been thinking in terms of a 7 with possibly a 6, because I had such good success with the first two landings that I was even thinking of making it adequate for the mission. But after having seen the third I definitely wouldn't call that adequate and so it's either a 7 or an 8. I think it's not a 9 because it doesn't really require intense pilot compensation for control. I think if I made another crosswind landing my pilot technique would have improved. In a sense I think I was caught flat-footed there and so the performance I achieved on that third approach I think is poorer than I think is reasonable to expect with a reasonably well trained pilot. So I wouldn't rate it a 9. I'm going to do something I try not to do, but I think it's justified in this instance. I'm going to rate it a 7.5 and I'm using the half rating here to indicate my uncertainty. I'm just not quite willing to say controllability not in question. Although I think if I had made another approach, there is some possibility that the controllability question is just to achieve adequate performance and not to retain safe control of the configuration. So, I might be able to rate that controllability not in question but adequate performance not attainable with the maximum tolerable pilot workload. In other words that rating remains a possibility. But on the basis of the three approaches that I flew and in particular the third one, I can't really say that and so I have to come down and say considerable pilot compensation required for control. I'm a little bothered by that because if I hadn't flown the third approach I would never have said that. Again, to indicate my unwillingness to assign it firmly to either block, 7 or an 8, I rate it a 7.5. 15) Turbulence effects definitely more efforts required and I think I'll rate it a D (Delta). I considered an Echo, but I think it's a Delta. The deterioration was definitely there and I guess I'd call it moderate. 16) Yes. 17) The rough air brought out characteristics. It really adds to my anxiety flying it IFR. That's the main thing I noticed. It's hard to keep everything together with this configuration. I mean the attitude, the airspeed, the rates of climbs and descents and altitude. Turbulence effects intensify this anxiety. 18) (a) Most objectionable feature would be the sluggish pitch response, particularly in the flare and touchdown and a secondary but objectionable feature is the backsideness and the power management problems to keep airspeed constant. (b) The least objectionable feature or best feature would be the lateral control.

CONFIGURATION 7 PILOT D FLIGHT NO. 203-1

PILOT RATING 7 TURBULENCE EFFECT RATING D

Generally speaking, the airplane is unstable in pitch, in that, if unattended the pitch attitude tends to diverge. There is also an unstable stick force vs. speed gradient. The thrust characteristics are somewhat backside but not as deeply backside as some of the configurations I've seen. I was able to do the maneuvering in up-and-away flight adequately well VFR. 1) Ease in achieving trim, it's not easy. It's somewhat difficult but it can be done in terms of altitude and airspeed. 2) Off trim airspeed, the stick force is unstable and this tends to cause a problem in finding and holding the pitch attitude constant, and in finding the stick force necessary to keep the attitude from changing. It takes less power for higher speeds and more power for lower speeds. 3) Maneuvering about level flight, the attitude control requires pilot attention. Elevator to initiate a response, elevator to stop it, and also elevator to keep it there as you tend to look away at other things. Altitude control requires a careful attention to attitude and airspeed but is adequate. Airspeed tends to bleed off fairly rapidly in turns. In straight and level flight airspeed control is a little bit slippery. 4) Maneuvering and turning flight, the lateral control has light forces and good feel. Altitude and pitch control requires attention, tends to be unstable and departs, particularly, nose up but also nose down sometimes. Airspeed control requires attention and throttle management. Maneuvering forces are essentionally zero statically. I think it's barely acceptable for the mission for up-and-away flight. You do have enough g maneuvering capability. Comments following the first approach. Frankly, that one went better than I expected it to. I initially intercepted just inside the marker and made a steep 180-degree turn. I went back out a little bit, then came back in, reintercepted and came on down the tube. I flew that approach as carefully as I could. It was pretty close to centerline all the way down. There was some turbulence but it didn't seem to affect the airplane too much. Airspeed control was adequate. Glide slope control was fairly good and I stayed reasonably well on. I was just a little high and holding and I kind of left it that way. Gradually I corrected it as I got close in but in correcting it, I got a little off the localizer to the right. The lineup was pretty good when I went visual. The approach path was about right on and I followed it through basically constant attitude all the way down to the touchdown. I tried consciously to keep from flaring it. Sink rate at touchdown appeared a little bit high but definitely acceptable. So, that one was an approach that was pretty close to nominal all the way and didn't exhibit any real difficult characteristics. However, during the turn you really do have to get on with the power and it takes an awful lot of power. A 45° bank angle is a definite limit. The fact is, I recommend not over about 35° because you start running out of power to hold level flight or constant airspeed. Comments following the second approach. In that approach, I had a glide slope error which I saw come out and I had a crosswind on the landing and although it was a moderate workload, moderate even approaching high workload, it came off fairly well. The errors that were induced were correctable. I seemed to have the biggest difficulty with airspeed control and throttle management. I had to make throttle corrections on the glide slope. When the glide slope jumped, it gave me a high and I had to push over and take quite a bit of throttle off. There's a definite tendency to not get all of that throttle back on. You really had to look over and spend a couple of seconds on the thrust gauges in order to be sure you have the power back to the nominal setting. Otherwise, the airspeed will bleed or increase. When I was concentrating on the glide slope correction, I got off on the localizer but I was able to get the glide slope back on and also bring the localizer error back to almost zero at the breakout. Since I was about on the flight path, I didn't have too much difficulty with the visual portion. I had a crosswind from the left. It didn't seem to be too big of a crosswind and consequently I was able to stick the crosswind correction in and land acceptably well, although a little long. I had some trouble with sluggish response in the control of flight path but I didn't develop a full blown PIO although I was using control deflections that were fairly large there towards the last. The basic problem is that as you get close in, if you have an error in sink rate or attitude, you want to get it corrected rapidly and this requires large control inputs. You also have to be sure you do them precisely because it takes a lot of throw input to get the response started and a lot to stop it. Pilot comments following the third approach. Generally speaking, this configuration surprises me a little bit in that I was able to do better than I expected. I found that any tendency that I had to PIO in the flare I was able to generate enough lead by corrective inputs to bound the oscillation and keep it small. The control inputs in the cockpit were fairly large but again they seemed to be effective in controlling the flight path in the flare and touchdown. I thought that went better than I really anticipated from the handling characteristics that I had seen in the IFR maneuvering. This configuration is a bit slippery in the sense of controlling airspeed and requires a fair amount of throttle manipulating to reacquire the desired airspeeds. I was able to do it all the way through although with a fairly high workload. 5) Localizer and acquisition and tracking prior to glide slope interception. (a) The performance was adequate although you had to be careful not to get slow in the turn and the pitch attitude control required attention in the roll in to keep it from departing the desired attitude. (b) The workload was moderate and (c) there was some effect on the altitude performance on this last approach. I ended up maybe 120 feet low on the rollout, apparently due to concentration on the localizer acquisition. 6) Glide slope acquisition. (a) Control technique was to nose down and reduce power. (b) The performance was adequate and the workload was moderate. Again, the principal difficulty is in anticipating the glide slope interception well enough that you can smoothly nose over, reduce the power, acquire and hold the right rate of descent without the airspeed going off either high or low. That's the real problem. The airspeed does tend to depart one way or the other. The performance as I said was adequate and the workload was moderate. 7) Tracking of the glide slope and localizer. (a) Ability to maintain and reacquire the glide slope, on all three approaches I tended to stay fairly close within a dot above or below; more generally I would be above the glide slope. On the purposeful glide slope error on the second approach, I was able to correct that and again the principal problem is to make sure that the airspeed stays within bounds. You keep cross checking your airspeed to make sure your throttle positions are correct. (b) The ability to maintain and reacquire the localizer was fair. When I was having glide slope acquisition problems, I tended to neglect my heading and I would induce a localizer error but I was able to reacquire the glide slope generally. c) Yes, it does. I can't spend as much time on heading as I would like because of the tendency of the airplane to depart in pitch from the desired attitude. It requires close attitude control. d) Any unusual use, I don't think so. Some tight pitch attitude control and tight airspeed control. e) Elevator used to control attitude, throttle used to control airspeed and nominal rates of climb and descent. f) To generate the desired pitch response it takes an input to get it going and an input to stop it and then careful attention to supply the necessary inputs to keep it from departing the attitude that you put it to. g) It's adequate but it requires so much attention that it's not very desirable. h) Yes, but not at an alarming rate. 8) Actually, I really didn't have much of a lateral offset on any of those. Even the approach I was supposed to have had one, I apparently was enough on the localizer that I negated much of the intentional offset. However, I was able to correct the ones that I had, and the maneuvering did not seem to affect the control of sink rate or touchdown point. 9) The flare basically was a problem in controlling pitch attitude to make sure it was where I wanted it to be which was generally pretty constant attitude. This did require some substantial manipulation of the elevator. The power management was one of frequently checking the airspeed and making sure it had not departed or if it did to make a throttle correction. Performance, I wouldn't say I achieved the desired performance on the touchdowns but I think all three of them were adequate barely. The workload in the flare and touchdown maneuver was high. I was working pretty hard to achieve that performance. The main question in my mind now is was that a tolerable pilot workload? 10) Crosswind landing, a) Difficulty was not too great. It didn't seem like I had too much crosswind but I had some. b) Wing down. c) I landed a little long on that one so it did affect it somewhat. But I think it was an acceptable effect. 11) Elevator, I had moderate forces and moderate travel, except large travel in the flare and touchdown. Breakout forces and friction were negligible. Aileron had light forces, small travel, some breakout but not objectionable and there was not any noticeable friction. Rudder had moderate forces, small travel, relatively large breakout forces and there was no noticeable friction. 12) Throttle feel was adequate and the friction was okay,too. This was a configuration that sure would be nice if you had some kind of force feel on the throttle so you'd know where the nominal throttle setting is. I felt some need for that. I could get it by looking back at the gauges but that took a little time. 13) I suppose the flare and touchdown but some of the IFR maneuvering was bothersome too because of the airspeed control and the tendency of the pitch attitude to diverge. 14) The configuration rating, Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? And here I come back to my problem. It was a pretty high workload configuration. It was certainly definitely better than the second configuration that I had this morning. If I say that the performance is adequate, then it's definitely no better than a 6. If I say the performance is not adequate, it's definitely no worse than a 7. So that's what I'm thinking about. I think I'll say adequate performance is not attainable with a tolerable pilot workload and rate it a 7. I did actually obtain adequate performance on those approaches and so I'm trying to evaluate the workload whether I thought it was too high or not and that's a good question. I'll say it's a [illegible]. Turbulence effects, rough air, it was rough on all three approaches so I can't separate the turbulence from nonturbulence. 16) Yes. 17) More effort probably is required, moderate deterioration, "D". I seem to be stuck on that "D". 18) Reasons for the rating, primarily was the workload involved in the IFR portion, particularly in the glide slope and airspeed control on the glide slope. The flare and touchdown flight path control was also pretty high workload although I was able to achieve adequate performance. b) I guess the lateral-directional characteristics.

CONFIGURATION 3 PILOT D FLIGHT NO. 203-2

PILOT RATING 5; 6 TURBULENCE EFFECT RATING D

In-up-and-away flight, it doesn't seem half bad. I can make level turns and things like that with a minimum altitude loss and I could make a 45° bank turn. It is a little unstable in pitch but only a little and it seems to be on the bottom side except at high angles of attack or low speeds. At 140 knots, you're definitely on the backside but fundamentally it seems that it's adequate for the up-and-away task. 1) Ease of achieving trim compared to the ones I've been flying is fairly easy, but compared to a normal type airplane, it's fair to poor because you had to pay careful attention to pitch attitude. There was some tendency of the pitch attitude to diverge at a very slow rate and the pitch response is sluggish. 2) Off trim airspeed it's really not too bad. It's about at the bottom of the bucket except for the lowest speed and the amount of instability seems to be small in terms of stick force. 3) Maneuvering about level flight, attitude control is fair. Altitude control is fair. Airspeed control is fair. It requires attention as do most of these configurations but with the attention that I supplied, it was okay. In other words, I could produce adequate and sometimes even desired performance but desired only came with a pretty high workload. 4) Maneuvering in turning flight, lateral control, it had light ailerons which is good. The rudder pedal breakout forces are objectionable as usual. I forget to comment on that on every configuration. Altitude and pitch control requires attention but is manageable and adequate for turning and maneuvering in up-and-away flight. Airspeed control again requires some attention but it doesn't tend to depart rapidly. Maneuvering forces are almost zero. In other words, the steady force in a steady turn is just about zero. It is acceptable for the mission and the g capability is adequate. Evaluation pilot comments following the first approach. It's a sluggish configuration that doesn't have the airspeed control problems that I've seen on other configurations. Airspeed requires some attention but it doesn't seem to depart. It doesn't seem to be as elusive as many of these configurations. Hence, I was able to concentrate on the glide slope and the heading and the localizer to a much greater extent than I have with some of the other configurations. To that extent it was an improvement. After I went visual, at the breakout I was just about on the glide slope. But I must have had a nose down attitude and I did get low. In other words, I ducked under the glide slope after I went visual because it had been suggested that I try this and then comment on the difficulty of controlling it in the ground effect. With this configuration, since it's my first approach, I don't know how it compares, but it wasn't too difficult. I had my flight path well under control before I entered ground effect and there were lots of spots from bugs on the windshield and so I was able to perceice small attitude changes. I, basically, was able to achieve a very shallow flight path and a very low rate of descent at touchdown. I did note that the rate of onset of the nosedown pitching moment was much more slower, more graceful, and I could compensate for it easier with smaller errors. I don't know how much of that's due to the control characteristics of the configuration and how much is due to the shallow final approach. I'll try on the next one to make sure it's not a shallow one and maybe have some basis for comparison. So far, it has adequate performance for the mission. That was a lateral offset and the maneuvering involved in getting the lineup was handleable. The thing that saves this configuration is the fact that the airspeed is not a particular problem. The maneuvering in pitch is objectionable and bothersome in that it won't stay at any particular attitude very long. It requires a lot of attention and tends to be off in attitude whenever I come back to the attitude indicator. I seem to be able to devote enough time to the attitude because my airspeed even if it gets off doesn't seem to diverge. In other words, it will be sitting at 164 or something like that. It's not increasing. So I can leave it alone while I get everything else under control and go back and it's still somewhere around 164, still on the fast side, let's say. Then I can make a power adjustment and kind of take care of the airspeed in its own time and to that extent, this is a pretty good configuration. However, those words don't really tell the whole story because it is not a good configuration. It is slow and sluggish in pitch and it has a tendency to wander off in attitude because it's a little bit unstable. The combination of those two things makes the pitch task demanding but the fact that the airspeed task is not as demanding as it has been on many of the configurations I've seen, moderates the total workload and makes this pitch workload a little more tolerable. So far, the configuration is adequate although the worst part of it is down near the flare and touchdown where the responsiveness is sluggish, but I still haven't gotten into any significant difficulty with it. I still have got a crosswind landing coming up so maybe I'll have some fun with that. I did make a 360 there right at the outer marker on that approach and that's a task that seems to be very demanding with some of the configurations and yet with this one it was quite manageable. I had to pay a lot of attention to pitch attitude but if you do and get the power on in the turn, as is necessary with all these configurations, then the airspeed stays pretty well under control. Comments following the third approach. That was a crosswind. There was quite a bit of turbulence on that approach. I guess that was the main problem and I got bothersome heading errors that were induced by turbulence. I got glide slope errors and they were induced apparently by turbulence. But soon I was able to attack both the glide slope and localizer errors and get them back. The principal reason is because of the attention I could devote to the attitude and heading because I didn't have to worry so much about airspeed. So when I went visual I was just about right on and with a crosswind from the right, I carried it on down. I felt the sluggish pitch response. I stuck in the crosswind correction and landed just a little long with a fair amount of elevator manipulation but I was able to control pitch attitude well enough. I think I had an acceptable touchdown so the nosedown pitching moment on all these is large but I was able to catch it and I didn't really get into what I would call a PIO even though I was manipulating the controls quite a bit. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? The answer is no. Deficiencies warrant improvement, definitely. These are not minor but annoying deficiencies because I don't think the desired performance was ever attained with moderate pilot compensation. So it leaves the 5 and 6 and I think it's probably a 6.

Adequate performance requires extensive pilot compensation. 5) Localizer acquisition and tracking prior to glide slope interception -- a) Performance capability, pitch attitude required a fair amount of attention in order to keep the attitude and altitude performance where you wanted it but it wasn't too bad. b) The work load was moderate. It was primarily in attitude although in the turn, airspeed was a problem, in the sense that you have to increase the power when you're in a bank angle in order to keep the speed constant. Also, you have to increase the power with g. Again, you could do this but airspeed does require some attention during the localizer acquisition. And that adds to the workload. c) The localizer task didn't have much of an effect on the altitude performance, certainly not as much as many of the configurations. 6) Glide slope acquisition -- a) control techniques to acquire, elevator to nose down, throttle reduction to about 50, 52% to stay on the glide slope. b) The performance seemed really about fair to fair plus. I started to say fair to good and I decided it really wasn't that good. You do have to definitely nose down and that attitude change does require enough workload that I think it's only fair on the performance and the workload is moderate. 7) The tracking of the glide slope and localizer--a) Ability to maintain and reacquire was fair. The control of airspeed was not good. It was fair though and it was one of the better features of the configuration that didn't require as much attention as so many of the configurations. It would tend to get off but it would just hang off. It wouldn't keep departing. b) To maintain and reacquire the localizer was easier than most of configurations in that I had time to spend on heading because I didn't have to spend so much time on airspeed and throttle management. c) It affects it a little. It definitely did but it wasn't a major problem. d) None. e) Elevator to control attitude, throttle to control airspeed and nominal rates of climb and descent. Also under e) I keep forgetting to put in throttle was used to provide for the drag increase in level turns. f) Takes an input to get it going and an input to stop it but it doesn't tend to depart very rapidly although it does tend to depart slowly from the desired pitch attitude. g) You're able to get adequate airplane motion on the glide slope and localizer. h) A little but it's not a dominant feeling. In other words, it tends to get away, it tends to depart but only slowly. 8) Fair ability to correct lateral offset and the required maneuvering had a small effect on the touchdown point but only a small effect. 9) Control technique in the flare was principally elevator with some overdriving to hold the attitude where you wanted it. Airspeed wasn't much of a problem. It did require just an occasional cross-check and perhaps a throttle adjustment accordingly. The flare and touchdown response, pitch response was sluggish and you had to overdrive it but in so doing you were able to achieve adequate performance with a workload that was acceptable. 10) The crosswind landing, there was some increase in difficulty as compared to a regular landing. The technique was a wing down but I could certainly do it all right. And c) It had a small affect on the sink rate and touchdown point control. 11) Elevator forces were light to moderate. The travel was moderate. The breakout forces and friction were negligible. The aileron forces were light. The travel was small. The breakout was there but not objectionable. The friction was not noticeable. Rudder forces were moderate. The travel was small. The breakout was large and objectionable but acceptable. The friction wasn't noticeable. I'd like to comment on those rudder breakout forces. On one engage they were asymmetric, in that I had more on the right rudder than on the left. I don't know why and just that additional amount over what I'd normally have was quite objectionable. So maybe I've gotten used to what I had but any more is certainly quite objectionable. 12) Throttle feel was adequate. The friction was of a desirable level. 13) The task which was most difficult was probably the flare and touchdown and mostly due to the sluggish pitch response. 14) The configuration rating I've already given you but I'll do it again. Yes, it's controllable. Yes, adequate performance is attainable with a tolerable pilot workload. No, it is not satisfactory without improvement. Therefore the deficiencies warrant improvement and I don't think I was really able to get desired performance at least not with moderate pilot compensation so I'd eliminate 4. I would rate it a 5 in terms of the adequate performance requiring considerable pilot compensation for the IFR portion. But, in the flare and touchdown adequate performance requires extensive compensation, especially in turbulence and with the crosswind. So I would rate it a 6 overall and 15) Turbulence effects, rough air, it certainly is a most important thing to have in the evaluation. In this particular configuration, it added to my workload principally by causing more heading errors. 16) Yes. 17) I repeat I have difficulty using this turbulence effect rating scale when I don't fly it without turbulence. When you ask me a question about deterioration of task performance with turbulence if I've got turbulence on all the approaches, with just a little more on one of the approaches it's kind of hard for me to say. With this configuration, it's probably more effort required, moderate deterioration and a "D". 18) Primary reasons for the rating, the most objectionable feature is the sluggish pitch response in flare and touchdown, particularly encountering the ground effect when I'm trying to produce the desired sink rate on touchdown and b) the least objectionable or best feature I'd have to include my normal lateral-directional characteristics but in addition I'd certainly want to say that the very greatly reduced workload on airspeed was another most desirable feature of this configuration. I'm sure that the airspeed characteristics could be even better but the improvement with this configuration was most noticeable and appreciated.

CONFIGURATION 5 PILOT D FLIGHT NO. 203-3

PILOT RATING 10 TURBULENCE EFFECT RATING F

I made another approach and some up-and-away maneuvering on another configuration. I had a very brief look at the up-and-away. I didn't make the speed changes. I just made a couple of turns and then we made an approach. My comments on that configuration are as follows. It's quite an unstable configuration and furthermore it appeared to me that it had pitchup. In other words, it seemed more unstable in the low speed direction than it did in the high speed, low angle of attack direction. I really didn't get to look at it enough to be sure. The impressions that I have on the approach was that it was very demanding in terms of workload. I was sweating a bit here from both the mental and physical activity. It required a lot of manipulation of the elevator to keep the attitude within bounds. I had a lot of throttle manipulations to keep the airspeed within bounds. It was possible to do it. I did make an approach which wasn't very good but the performance that I achieved was adequate. The workload was very, very high and I think totally unacceptable. When I went visual, I had a lineup offset to correct which I was able to do. The airspeed got very, very fast just before I went visual but I managed to get the airspeed back under control by the time I had finished my lineup correction. I came on down to the runway and got into a longitudinal PIO which I thought I had in hand although I admit it was oscillating but I've been in worse. It did require grossly abnormal elevator movements on the part of the evaluation pilot and in fact I was hard against the stop probably for a whole second in the nosedown direction once. I touched the stop a couple of times but I still think I could have landed it although nobody else in the airplane seemed to think so. It did seem I had a fair amount of turbulence on that approach too. The workload was high in the turbulence. I didn't see it without turbulence but I think you'd have to say best efforts were required and something like major deterioration of task performance, something like a "F" rating. And then the pilot rating for the configuration. Is it controllable? that's the big question for me. On the basis of one approach I'd have to say no it's not. And improvements are mandatory and it's a rating of 10. It is possible that with successive approaches and training, you might work that one up to be a 9 but even at best you'd have to say intense pilot compensation is required to retain control. On the basis of my one approach, I think for the flare and touchdown portion it was a rating 10 and probably for the IFR portion it was a rating 9. I won't go through the comments since I didn't do a full evaluation.

SECTION VII

TABULATION OF TOUCHDOWN PARAMETERS ACHIEVED ON APPROACHES

A total of nine touchdown parameters were either recorded directly or computed during each evaluation approach which terminated with a touchdown. Five of these performance measures have been cataloged in Table III. True airspeed (V_T), rate of descent ($\dot{h}$), pitch attitude (θ), and thrust (T) were recorded directly on the digital tape. Touchdown distance (Y) from the runway threshold was computed three ways depending on the availability and/or reliability of the required information. The first method was to use the location of the TACAN station in relation to the threshold and the recorded DME signal. Triangulation was used to compute touchdown distance from the approach end of the runway. The second method was to use the location of the glide slope station in relation to the threshold and the recorded glide slope signal. A series of rapid fluctuations of the signal indicated passage of the aircraft by the station. The difference in time between that occurrence and touchdown multiplied by the ground speed gave the distance the aircraft touched before or after passing the glide slope station. It was then a simple procedure to calculate the touchdown point knowing the location of the station from the runway threshold. The third method utilized a known landmark within a half mile of the runway end that showed up as a "blip" on the radar altitude trace. The elapsed time after crossing the landmark and touchdown multiplied by the ground speed yielded a gross distance. From this value the exact distance of the landmark from the threshold was subtracted to give the touchdown point. Whenever the information was recorded, calculations were performed using all three methods for each approach that resulted in a touchdown. The particular value of the touchdown location listed in Table III was selected based on the accuracy of the available data.

The touchdown parameters were determined by reading strip chart records obtained by playing back the in-flight data from the digital recorder. The resolution of the strip chart determines the correctness of the data. The accuracy of the performance parameters measured at touchdown were as follows:

airspeed ± 5 knots

rate of descent ± .25 feet per second

touchdown distance ± 500 feet

pitch attitude ± .25 degree

thrust ± 1,250 pounds

Table III presents configuration number, evaluation pilot, flight number, and the reported surface wind in addition to the five touchdown parameters for each approach. The programmed evaluation tasks were as follows:

1. Task A - straight-in approach, low turbulence level
2. Task B - glide slope error, 15 knot crosswind, low turbulence level
3. Task C - localizer error, moderate turbulence level

TABLE III
TOUCHDOWN PARAMETERS

CONFIG.	PILOT	FLT. NO.	TASK	SURFACE WIND (deg/knots)	V_T (knots)	$\dot{h}$ (fps)	Y (ft)	θ (deg)	T (lb)
1	B	182-2	A	020/4	157	-5.0	2,000	10.1	37,000
			C	020/4	163	-2.5	1,800	8.0	45,000
			B	020/4	164	-2.5	1,900	7.2	47,000
1	C	199-2	A	020/5	155	-4.0	2,400	10.4	48,000
			B	020/5	160	-4.5	1,800	9.8	45,000
			C	030/6	157	-2.0	1,700	10.5	46,000
1	D	185-1	A	200/20G25	159	-5.0	800	11.2	25,000
			B	200/22	159	-3.0	2,100	11.4	33,000
			C	200/18G25	159	-4.5	1,900	11.5	33,000
2	A	167-2	A	330/12	154	-8.0	900	10.8	22,000
			C	340-360/14	145	-3.0	3,300	12.1	44,000
			B	310-350/14	*	-5.0	1,400	*	*
2	B	180-2	A	340/8	151	-4.0	-100	12.7	32,000
2	B	181-1	A	080/12	163	-2.5	1,500	10.2	33,000
			C	090/12	160	-0.5	1,400	11.5	38,000
2	B	184-3	A	070/10	163	-8.0	900	12.2	5,000
2	D	168-2	A	280/28G34	151	-3.0	600	13.0	36,000
3	A	166-1	A	330/10	165	-8.0	2,200	10.4	46,000
			B	320/15	153	-4.0	1,900	11.5	32,000
			C	320/18	148	-1.0	1,200	13.0	35,000
3	B	184-1	A	220/10	154	-4.0	300	10.8	28,000
			B	240/8	163	-4.5	1,100	10.8	30,000
			C	230/8	163	-3.0	500	11.2	28,000
3	C	201-2	A	350/3	160	-4.0	2,400	9.8	52,000
			B	CALM	161	-11.0	2,000	7.5	50,000
			C	CALM	160	-3.0	2,500	11.5	50,000
3	D	203-2	A	220/6	152	-2.5	2,100	11.5	50,000
			C	230/7	159	-3.5	1,400	9.0	42,000
			B	300/6	151	-5.0	2,800	10.5	35,000
4	A	198-1	A	050/4	163	-0.5	500	12.5	45,000
			B	050/4	155	-5.0	1,100	10.4	35,000
			C	050/4	151	-3.0	1,300	10.8	32,000
4	B	179-3	A	300/10	163	-6.5	2,000	11.2	37,000
			B	350/10	159	-2.5	800	12.3	43,000
4	D	185-2	A	210/22	163	-3.5	3,100	13.0	42,000
4	D	186-1	C	220/18	148	-1.0	1,300	13.0	48,000
			B	220/18	164	-1.0	3,200	10.7	45,000
5	A	192-1	A	230/8	163	-2.0	1,700	11.5	33,000
			C	230-330/5	157	-4.0	2,400	11.8	37,000

*DATA NOT RECORDED

TABLE III (Cont.)
TOUCHDOWN PARAMETERS

CONFIG.	PILOT	FLT. NO.	TASK	SURFACE WIND (deg/knots)	V_T (knots)	$\dot{h}$ (fps)	Y (ft)	θ (deg)	T (lb)
5	D	187-1	A	210/3	160	-4.5	2,500	10.1	60,000
			B	210/3	149	-3.0	4,800	12.7	41,000
			C	190/8	153	-4.0	3,300	10.7	44,000
6	A	165-1	B	070/15	154	-7.0	2,000	13.0	42,000
6	A	170-3	A	230/10	151	-1.5	1,500	12.9	31,000
6	B	178-1	A	290/10	153	-1.5	1,800	13.0	55,000
			A	270-340/10	165	-9.0	1,500	7.5	44,000
			C	290/10	165	-9.0	1,400	10.1	50,000
6	B	182-1	A	030/7	173	-1.0	1,500	9.9	48,000
			B	030/7	160	-6.0	1,100	10.4	30,000
			C	020/4	151	-2.0	1,200	10.5	40,000
6	C	201-1	A	270/3	145	-3.0	800	13.6	43,000
			B	CALM	151	-5.0	2,400	10.1	48,000
			C	CALM	163	-3.0	3,900	10.8	50,000
6	D	171-1	A	300/7	141	-11.5	4,100	13.2	30,000
			B	360/3	133	-11.5	4,400	13.5	40,000
			C	290/2	148	-8.0	400	14.0	40,000
			B	L/V	151	-12.0	4,500	11.5	38,000
6	D	202-1	A	250/5	159	-2.5	1,400	9.8	38,000
			B	L/V	151	-2.0	2,700	13.0	48,000
			C	180/5	161	-5.5	1,700	9.1	43,000
7	A	167-1	A	310/18	151	-5.0	1,200	11.8	34,000
			B	340/15	143	-3.5	1,200	12.7	14,000
			A	340/14	148	-4.5	1,100	11.8	40,000
7	B	184-2	A	040/12	161	-6.0	1,500	10.1	25,000
			B	060/10	151	-7.0	900	11.5	30,000
			C	070/6	160	-7.5	600	9.3	30,000
7	C	200-1	A	060/8	159	-0.5	3,000	11.5	52,000
			B	060/8	145	-6.0	-100	13.2	42,000
			C	050/8	157	-6.5	1,800	10.8	44,000
7	D	168-1	A	230/17	155	0.0	1,200	14.2	38,000
			B	250/14G20	136	-4.5	400	14.2	40,000
7	D	203-1	A	230/8	161	-4.5	800	10.1	47,000
			B	200/6	157	-1.0	3,200	11.5	45,000
			C	200/6	160	-4.5	2,600	10.1	40,000
8	A	191-1	A	360/4	151	-5.0	1,000	9.8	42,000
			B	300/4	148	-1.0	1,700	11.8	38,000
			C	300/4	151	-4.5	2,900	10.5	42,000
8	B	180-1	A	360/14	145	-4.5	900	11.5	51,000
			B	360/14	163	-7.5	600	8.6	30,000
			C	350/12	148	-11.0	500	8.6	48,000

TABLE III (Cont.)
TOUCHDOWN PARAMETERS

CONFIG.	PILOT	FLT. NO.	TASK	SURFACE WIND (deg/knots)	V_T (knots)	$\dot{h}$ (fps)	Y (ft)	θ (deg)	T (lb)
8	D	186-2	A	220/20	160	-1.5	1,900	13.0	39,000
			B	220/20	163	-4.5	2,600	11.2	41,000
			C	210/23	163	-2.5	1,600	19.8	34,000
9	A	199-1	A	050/10	154	-3.0	1,700	10.8	40,000
			B	070/10	160	-2.0	1,500	12.1	34,000
			C	070/4	151	-4.0	900	12.0	42,000
9	B	183-2	A	250/8	163	-2.0	1,600	11.8	23,000
			B	190/10	160	-1.5	1,100	12.7	40,000
			C	190/10	160	-8.0	900	10.1	33,000
9	D	175-2	A	230/15	159	-5.0	1,000	10.1	38,000
			C	230/15	155	-2.0	2,200	12.2	46,000
9	D	176-1	B	200/10	151	-3.5	2,500	11.5	36,000
			C	210/10	153	-5.5	2,200	10.8	25,000
9	D	188-1	A	180/3	155	-8.0	1,200	9.8	50,000
			B	070/2	161	-3.0	2,500	11.0	32,000
			C	060/4	159	-3.5	2,600	10.2	46,000
10	A	170-2	A	230/10	148	0.0	1,900	14.0	30,000
			C	240/13	145	-3.0	2,200	12.7	29,000
			B	230/10	148	-3.5	2,800	13.0	29,000
10	B	179-2	A	320/12	161	-10.0	1,100	10.1	30,000
			B	300/12	163	-5.0	1,000	12.7	52,000
			C	330/11	160	-6.0	600	11.5	43,000
10	D	172-2	A	340/10	148	-10.0	700	14.5	41,000
			C	320/5	151	-3.5	1,000	11.2	35,000
			B	320/5	155	-8.0	3,200	10.5	38,000
11	A	166-2	A	310/18	154	-4.5	1,400	10.0	46,000
			C	320/15	153	-2.0	2,600	10.8	47,000
			B	320/17-20	163	-0.5	1,000	11.2	45,000
11	A	191-2	A	290/3	148	-7.0	1,600	11.8	37,000
			B	350/4	137	-5.0	2,100	12.3	35,000
			C	240/5	149	-5.0	2,100	10.4	33,000
11	D	187-2	A	240/7	154	-6.0	1,400	9.8	36,000
			C	200/3	163	-3.0	1,900	10.8	44,000
			B	200/3	151	-3.0	2,800	11.2	44,000
12	A	165-2	C	075/15	160	-2.0	3,700	12.6	42,000
			B	070/10	*	-3.0	*	*	*
12	B	179-1	A	350/10	145	-8.5	3,600	13.2	42,000
			B	330/12	160	-3.5	2,700	11.8	38,000
13	A	198-2	A	050/7	154	-1.0	1,100	10.8	35,000
			B	050/7	151	-4.5	1,600	11.2	38,000
			C	060/8	151	-3.0	1,800	11.8	35,000

*DATA NOT RECORDED

TABLE III (Cont.)

TOUCHDOWN PARAMETERS

CONFIG.	PILOT	FLT. NO.	TASK	SURFACE WIND (deg-knots)	V_T (knots)	$\dot{h}$ (fps)	Y (ft)	θ (deg)	T (lb)
13	B	178-2	A	320/10	154	-3.0	600	9.8	32,000
			B	320/10	159	-3.5	1,500	8.6	37,000
			C	320/10	151	-2.0	1,400	9.8	36,000
14	A	169-1	A	360/12	160	-2.0	700	12.8	29,000
			C	330-360/5	146	-3.0	1,500	13.7	24,000
			B	350/9	151	-3.0	2,600	13.0	31,000
			A	340/10	149	-1.5	500	12.7	35,000
14	D	188-2	A	060/9	161	-5.0	3,100	10.4	30,000
			B	050/8	151	-8.5	4,600	10.4	46,000
			C	040/8	163	-2.0	2,300	9.8	39,000
15	A	197-1	A	150/10	161	-6.0	600	11.4	40,000
			B	130/10	151	-4.5	800	12.2	28,000
			C	160/11	145	-3.0	900	12.9	32,000
15	C	200-2	A	020/5	159	-4.0	1,500	10.1	48,000
			B	010/5	161	-5.5	1,400	10.1	50,000
			C	010/5	161	-5.5	2,300	10.1	50,000
15	D	202-2	A	180/4	166	-4.0	2,300	8.6	38,000
			C	280/5	160	0.0	1,900	10.1	34,000
			B	290/5	148	-2.5	4,400	11.8	49,000
16	A	169-2	B	320/10	136	0.0	3,500	14.9	36,000
			C	330/12	163	-3.0	1,700	14.5	44,000
			B	360/10	163	-3.5	1,400	13.7	32,000
16	D	171-2	A	170/2	151	-2.0	4,800	14.5	53,000
17	B	183-1	A	230/10	170	-11.5	1,000	10.1	22,000
			C	210/10	157	-1.5	-300	14.0	25,000
			B	240/4	160	-9.5	1,200	11.2	30,000
17	D	175-1	A	250/16	153	-5.0	300	11.5	42,000
			B	250/15	148	-2.5	2,200	11.5	47,000
			C	230/15	152	-1.5	900	12.7	44,000
17	D	176-2	C	240/10	151	-3.0	2,200	13.0	37,000
18	A	192-2	A	240/10	160	-5.0	900	12.2	20,000
			B	260/11	157	-4.0	3,200	13.5	35,000
18	B	181-2	B	100/7	172	-5.0	2,000	10.2	28,000
			C	070/10	163	-2.0	2,800	9.8	50,000
19	D	176-3	B	210/8	145	-3.0	4,400	12.6	32,000
			C	230/10	133	-3.5	4,300	14.2	50,000
20	A	170-1	A	230/10	154	-4.0	300	12.3	31,000
			B	200/10	148	-1.5	1,600	13.6	34,000
			C	200/10	151	-1.0	1,800	12.7	35,000
20	D	172-1	A	290/8	139	-3.0	1,100	13.8	29,000
			B	310/6	148	-1.0	2,300	12.1	36,000
			B	345/10	149	-3.5	2,800	12.5	38,000

SECTION VIII

CLOSED-LOOP ANALYSIS

8.1 INTRODUCTION

A number of theoretical analyses have been examined in an attempt to find a method of predicting pilot rating, or some analytic measure of the acceptability or unacceptability of an airplane. The obvious route was to perform loop closures using "pilot" or autopilot transfer functions. Two basic types were examined, attitude closures and altitude closures.

The first analysis used the phase lag and the slope of the magnitude versus phase locus of the $\frac{\theta}{F_s}(s)$ transfer function plus a time delay. This technique was then modified to yield better results for the evaluation configurations. The next analysis applied was a technique which predicts the frequency and magnitude of control pumping. Finally, a set of height control loop closures was examined to indicate the major characteristics of such closures.

8.2 PITCH MANEUVER RESPONSE REQUIREMENTS

8.2.1 Proposed MIL-F-8785B(ASG) Requirement

The pitch maneuver response requirements of the proposed revision to MIL-F-8785B(ASG), as given in Reference 14, were applied to the evaluation configurations. This technique required that phase angle versus dB magnitude plots (Nichols chart plots) be made of the transfer function.

$$\frac{\theta}{\theta_e}(s) = e^{-0.3s}\,\frac{\theta}{F_s}(s) = e^{-0.3s}\,\frac{\delta_e}{F_s}(s)\,\frac{\theta}{\delta_e}(s) \qquad (85)$$

A typical plot is given in Figure 15. From the plot are read the parameters $[\Delta A/\Delta\measuredangle]_\theta$ and $\Delta\measuredangle_\theta$, which are a slope and a phase difference defined in Reference 14. The parameter $\Delta\measuredangle_\theta$ is either: "(a) the difference between the phase at ω and - 90°, or, (b) the difference between the phase at ω_θ and the first local phase maximum, if a well defined maximum exists, whichever results in the larger negative value of $\Delta\measuredangle_\theta$." The parameter $[\Delta A/\Delta\measuredangle]_\theta$ is either:"(a) the most negative average slope of a line drawn from ω_θ to any lower frequency for which the phase is more positive, or, (b) the most negative local tangent between ω_θ and the frequency for which the phase is - 180°, whichever is more negative." The reference frequency, ω_θ, is 1.2 rad/sec in testing for Levels 1 and 2, and 1.1 rad/sec in testing for Level 3, for the evaluation configurations. The Level boundaries correspond to pilot ratings as follows: Level 1, PR = 3.5; Level 2, PR = 6.5; Level 3, PR = 9.

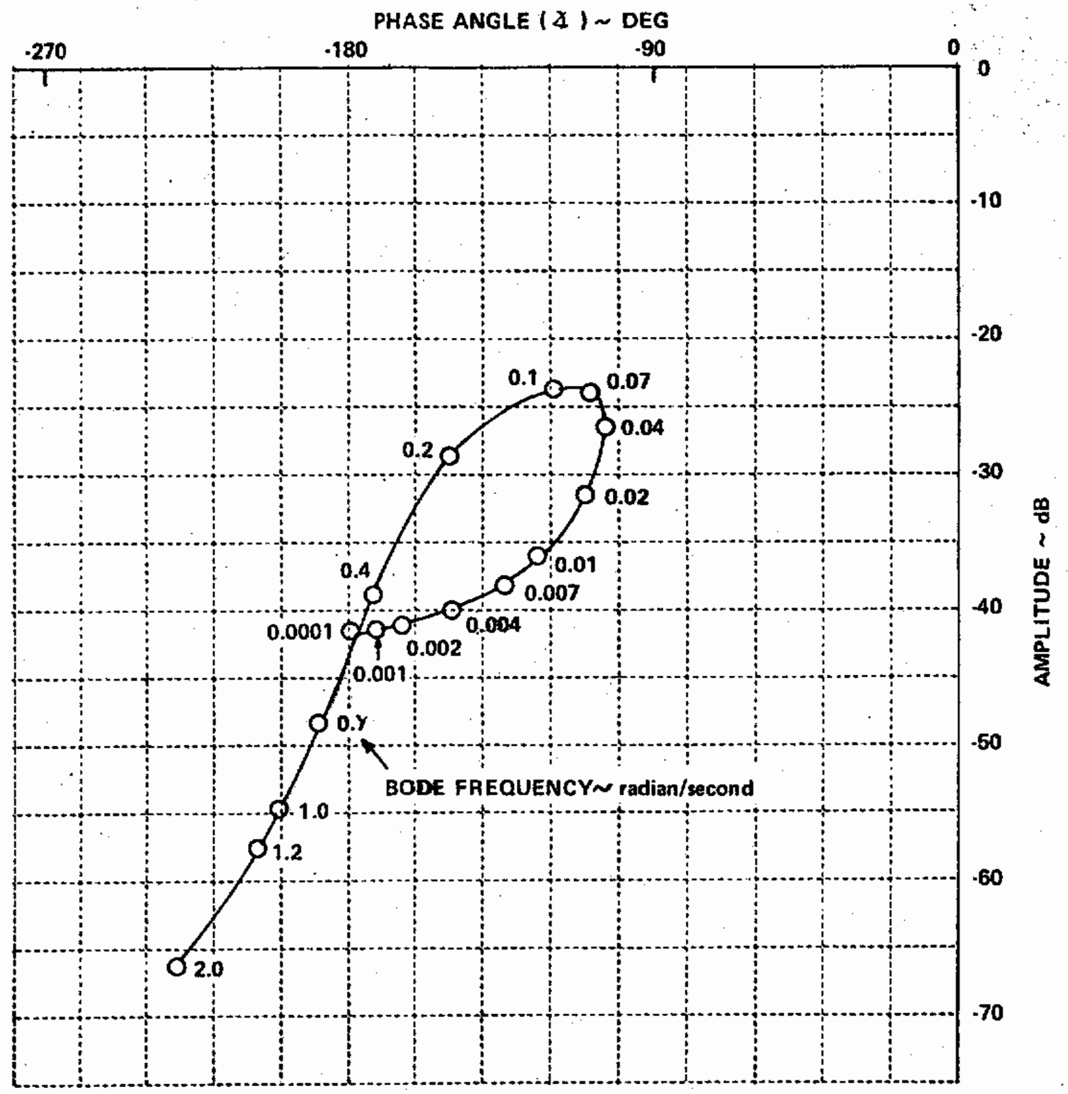


Figure 15 $\frac{\theta}{\theta_e}$ AMPLITUDE-PHASE PLOT FOR CONFIGURATION 3

The parameters $[\Delta A/\Delta \measuredangle]_\theta$ and $\Delta \measuredangle_\theta$ were computed for the evaluation configurations. The results were tabulated in Table IV and plotted against the Level boundaries in Figures 16 and 17. Figure 16 is the test for Levels 1 and 2. Those configurations which were not at least Level 2 were tested in Figure 17 against Level 3. Levels 2 and 3 have the same boundary, but are tested at different reference frequencies. It appeared that the requirement is too conservative, since 8 configurations were rejected which the pilots rated as acceptable. Changing the boundaries as shown yielded better agreement between the pilot ratings and the requirement. There is a dearth of data to substantiate any boundary at the value of slope, $[\Delta A/\Delta \measuredangle]_\theta$, observed for the evaluation configurations.

8.2.2 Extension of Pitch Maneuver Response Requirements

The response requirement discussed in the previous section was based on a performance measure developed in Reference 15. The pilot was represented by a gain, a time delay, and a forward loop lead compensator. While the work was done using only open loop characteristics, the assumption of unity negative feedback yielded a one-to-one correspondence with closed loop performance. The open loop transfer function was

$$\frac{\theta}{\theta_e}(s) = K_p e^{-0.3s} \left(\frac{\tau_{p_1} s+1}{\tau_{p_2} s+1}\right) \frac{\delta_e}{F_s}(s) \frac{\theta}{\delta_e}(s) \tag{86}$$

The configurations considered in Reference 15 were all represented by a short period approximation. Their phase angle - dB magnitude plots resembled the three shown in Figure 18.

The pilot model was required to add the minimum amount of gain and lead which will cause all of the loci at frequencies below the bandwidth frequency to be above the performance standard boundaries as illustrated by curve C. These boundaries are the closed loop response lines for - 90° phase shift and 3 dB attenuation. This means that the closed loop system will lag by no more than 90° and will be attenuated by no more than 3 dB up to the bandwidth. The performance criterion was then found from a plot of isolines of pilot opinion in a plane of phase compensation required versus closed loop resonance of the system. The closed loop resonance can be read directly from the Nichols chart.

In contrast, the evaluation configurations of this investigation were generally unstable. Figure 19 is an s-plane representation of a typical configuration. The Nichols chart plot for this configuration is given in Figure 15.

TABLE IV

PITCH MANEUVER RESPONSE REQUIREMENTS (REFERENCE 14)

CONF.	P.R.*	ω = 1.2 rad/sec $(\Delta\measuredangle)_\theta$ (deg)	$\left(\frac{\Delta A}{\Delta\measuredangle}\right)_\theta$ (dB/deg)	ω = 1.1 rad/sec $(\Delta\measuredangle)_\theta$ (deg)	COMPLIANCE LEVEL
1	3	-86.02	0.15		2
2	6	-114.88	0.43	-111.42	>3
3	6	-115.98	0.46	-112.70	>3
4	6½	-118.44	0.52	-115.55	>3
5	10	-124.98	0.64	-122.96	>3
6	6	-116.14	0.46	-112.89	>3
7	7	-118.59	0.51	-115.72	>3
8	6	-116.10	0.46	-112.80	>3
9	6½	-118.74	0.48	-115.89	>3
10	6	-116.00	0.46	-112.73	>3
11	6	-111.59	0.43		3
12	8½	-125.14	0.70	-123.18	>3
13	3½	-66.22	0.12		1
14	5	-98.48	0.33		2
15	7	-104.59	0.41		2
16	10	-116.71	0.68	-114.82	>3
17	6½	-98.83	0.38		2
18	7	-104.89	0.42		2
19	10	-116.91	0.68	-115.04	>3
20	3½	-65.88	0.12		1

* COMPENSATED PILOT RATING, σ = 3.0 FEET/SEC (SECTION IV, VOL I)

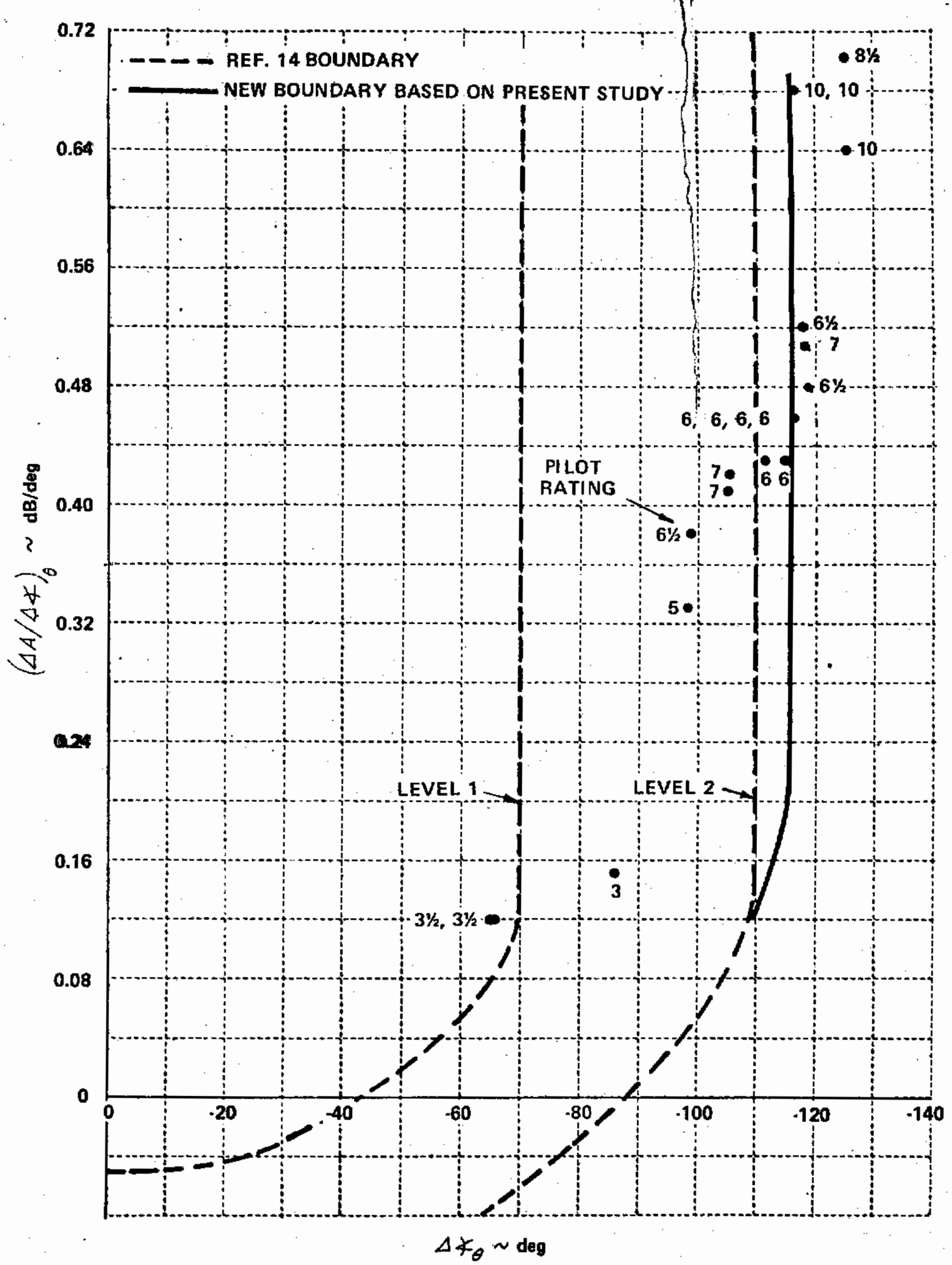


Figure 16 PITCH MANEUVER RESPONSE REQUIREMENTS

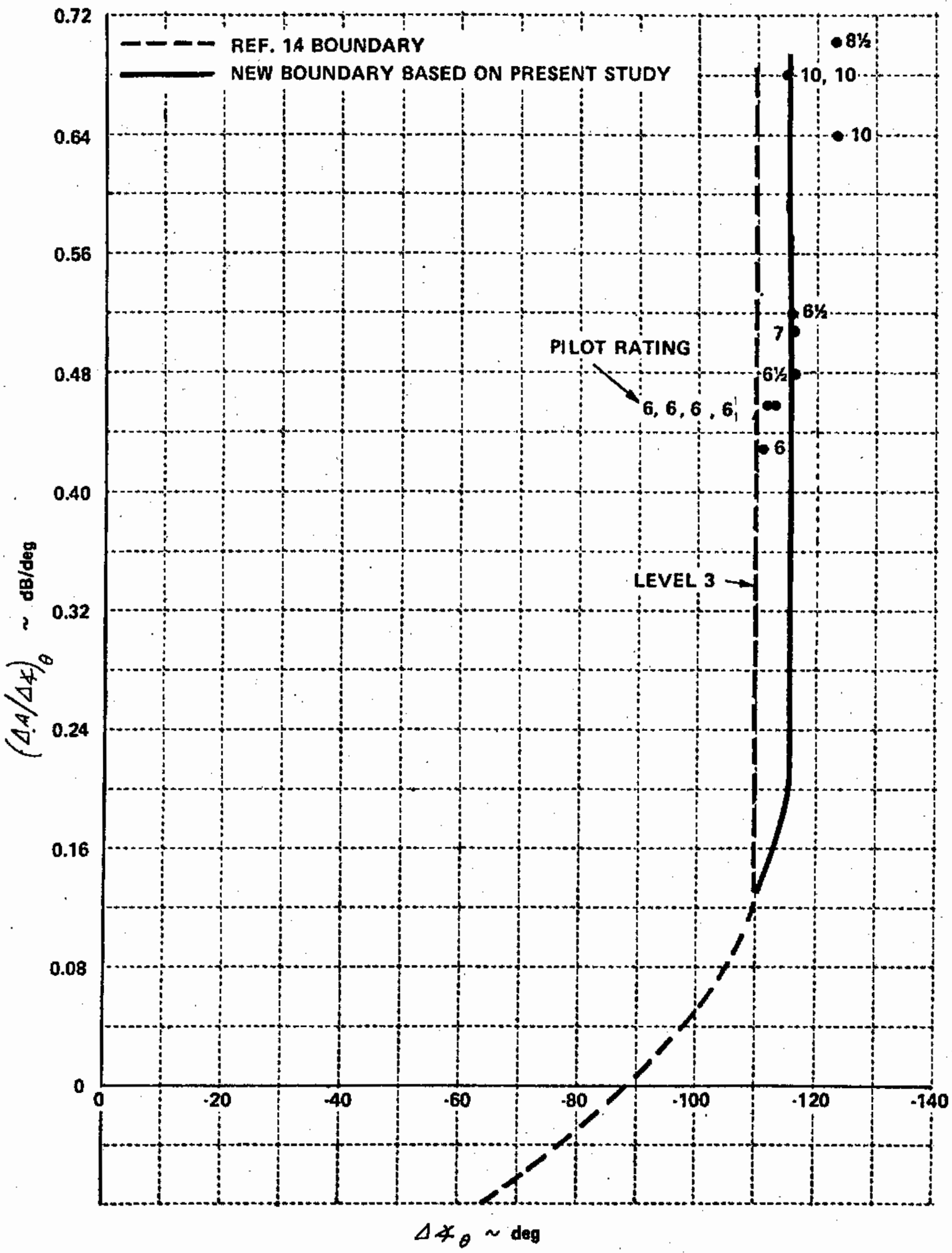


Figure 17 PITCH MANEUVER RESPONSE REQUIREMENTS

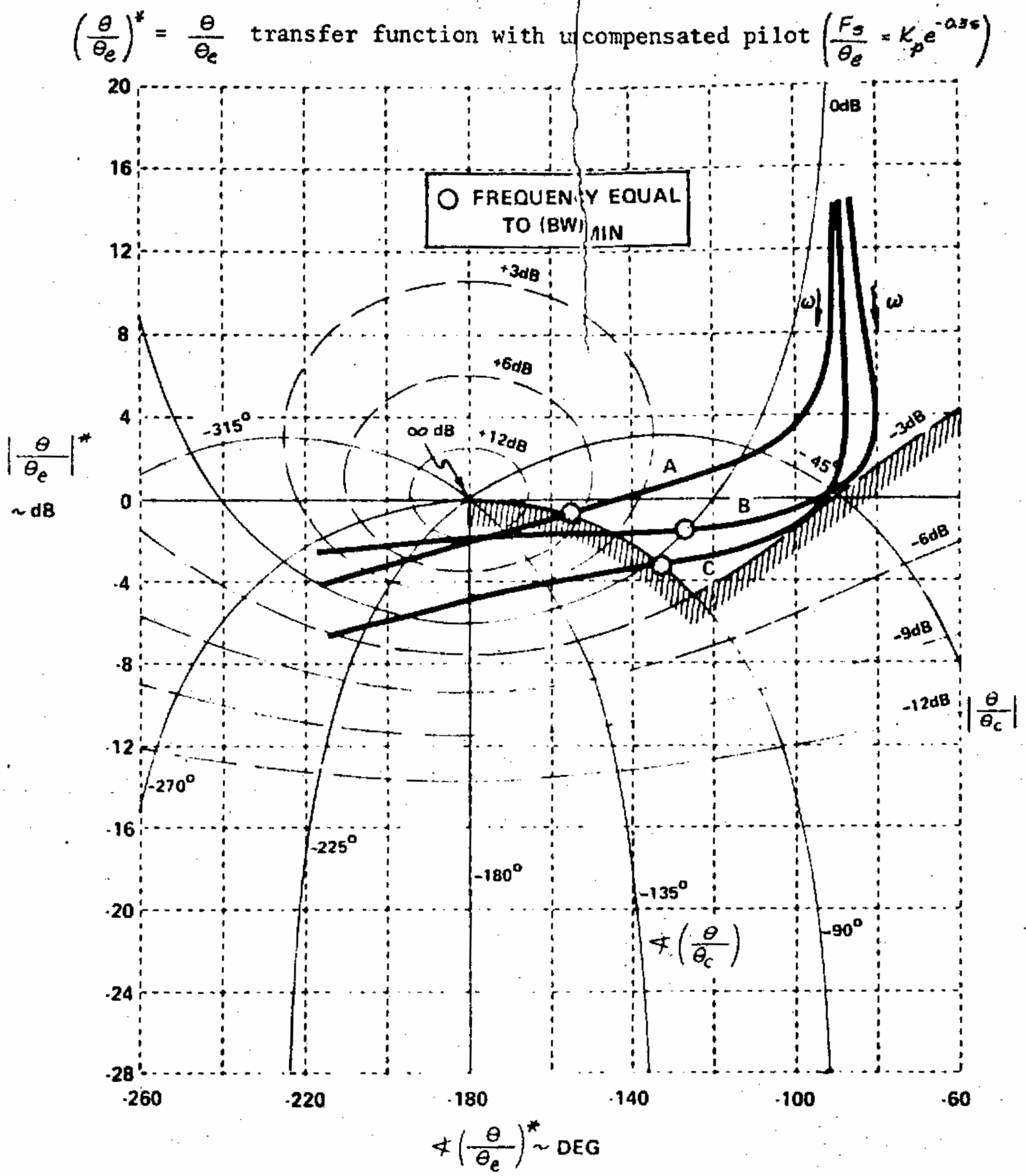


Figure 18 TYPICAL OVERLAYS OF $|\theta/\theta_e|$ vs. $\measuredangle(\theta/\theta_e)$ ON A NICHOLS CHART (FROM REFERENCE 15)

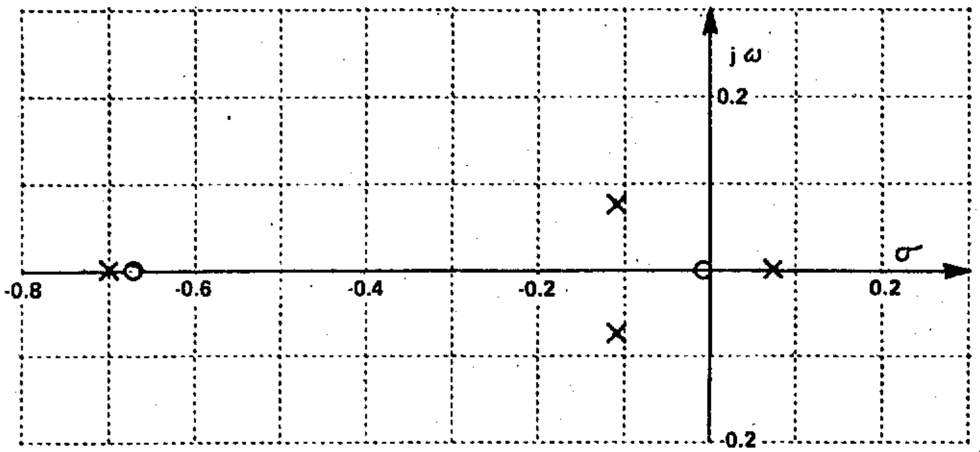


Figure 19 S-PLANE REPRESENTATION OF θ/δ_e TRANSFER FUNCTION FOR CONFIGURATION 3 (OGE)

The performance requirement of Reference 15, that the locus be entirely above the - 90°, - 3 dB boundary up to the bandwidth, cannot be used here. Addition of sufficient gain to compensate the locus would result in excessive closed loop resonance and phase shift at the low frequency end of the locus. Thus, the model was arbitrarily required to yield good performance only in the region of the bandwidth frequency. In particular, the model was required to add sufficient compensation to cause the locus to pass through the point defined by the intersection of the closed loop response lines for - 90° phase and - 3 dB amplitude at the bandwidth frequency. Figure 20 illustrates the requirement, with an uncompensated and a compensated locus.

Uncompensated
$$\left(\frac{\theta}{\theta_e}\right)_1 = e^{-0.3s} \frac{\theta}{F_s}(s) \qquad (87)$$

Compensated
$$\left(\frac{\theta}{\theta_e}\right)_2 = K_p e^{-0.3s} \left(\frac{\tau_{p_1} s+1}{\tau_{p_2} s+1}\right) \frac{\theta}{F_s}(s) \qquad (88)$$

Because the system is a unity negative feedback system, open loop

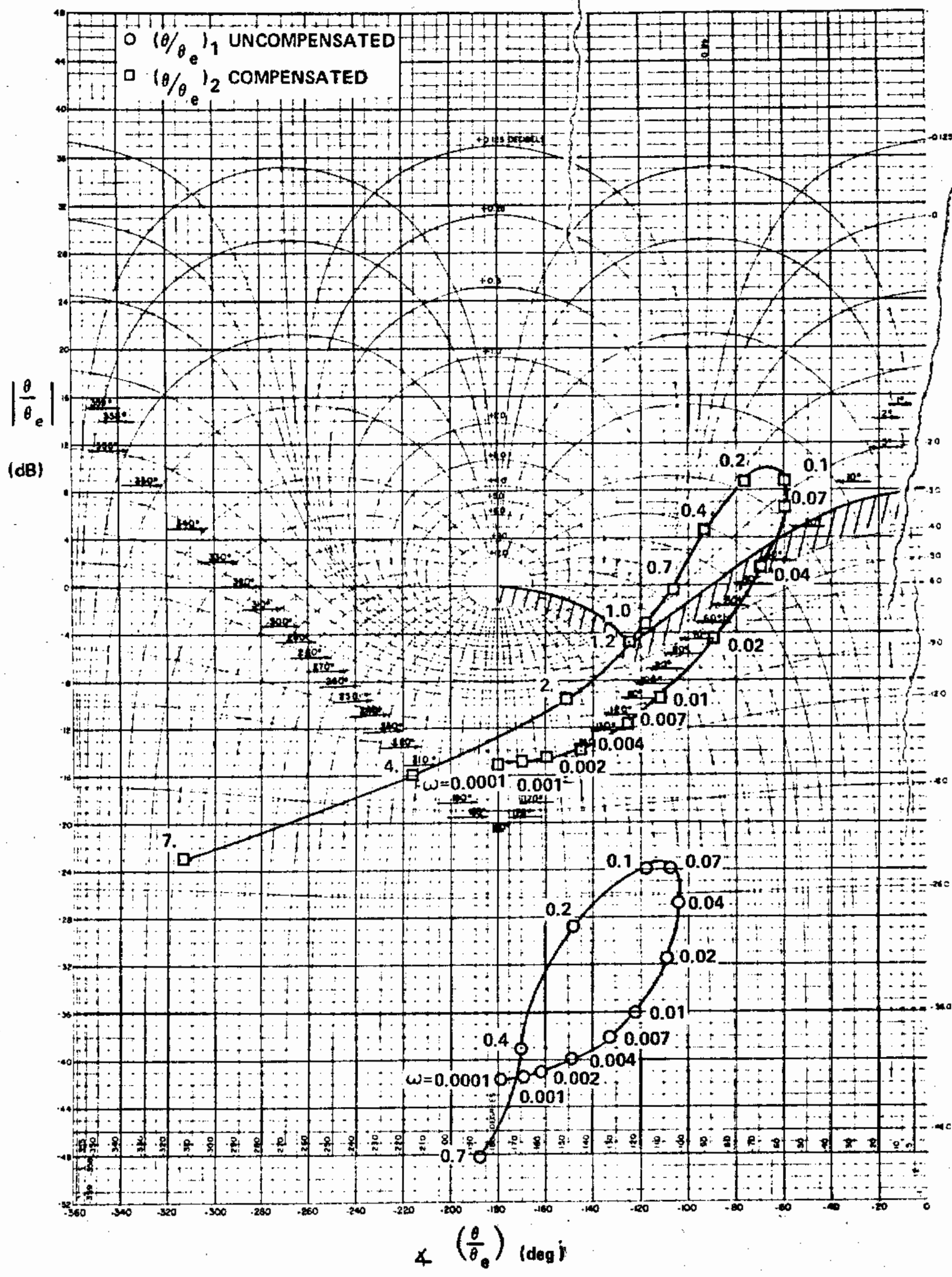


Figure 20 UNCOMPENSATED AND COMPENSATED SYSTEM, CONFIGURATION 3

parameters can be used as well as closed loop ones to describe the system performance. The open loop gain and phase of the $\frac{\theta}{F_s}(s)$ transfer function at the bandwidth, $\omega_\theta = 1.2$ rad/sec, were taken to be measures of system performance. They can be related directly to the amount of gain and lead the pilot must supply. It was found that while this yields reasonably consistent results, there is very little separation between acceptable and unacceptable configurations. Referring to Figure 21 and acknowledging the inexactness of pilot ratings, the pilot ratings alone do not define a distinct boundary.

While the pilot model has not been required to compensate the low frequency portion of the locus, it does not follow that performance of the precision tracking task is not affected by poor low frequency characteristics. A low frequency divergence, for example, would require considerable attention during a precision tracking task. The arbitrary performance requirement assumed for this analysis does not guarantee closed loop stability; indeed, most configurations were not completely stabilized by this closure. Thus, the magnitude of the unstable closed loop pole has been shown with the pilot rating on Figure 21. The minimum acceptable boundary shown on Figure 21 is based on limiting the required pilot lead compensation angle to 85 degrees and that the closed-loop system will not have an unstable aperiodic root at $\lambda > .06$ second $^{-1}$. The pumping of the elevator control observed from in-flight records is considered to be indicative of the pilot's necessity to generate lead.

While it appears that this approach will yield similar results for other statically unstable airplanes, the magnitudes of the boundary parameters may be dependent upon airplane characteristics not examined in this program.

8.3 CONTROL PUMPING

A technique was developed in Reference 16 to predict the frequency and amplitude at which the pilot will pump the pitch control of an aircraft during flare and touchdown. It was postulated that the pilot pumps the control to obtain dynamical information about the system as it enters ground effect. Thus, he can be expected to pump in a manner that maximizes the information extracted while minimizing the resulting interference with his other tasks. The pumping frequency can be predicted by application of a set of rules to a Bode plot of $\ddot{\theta}/\delta_e(s)$. The pilot will pump at a frequency above the natural frequency resulting in: (a) the maximum attainable angular acceleration per unit control input, (b) the minimum attainable phase shift between the control input and the resulting pitching acceleration, and (c) negligible flight path response and small pitching rate response. The magnitude of the pumping can then be predicted from the magnitude of the $\ddot{\theta}/\delta_e(s)$ transfer function at the pumping frequency by use of the following equation:

$$\frac{\ddot{\theta}}{\delta_e}_{\text{pump}} \times \delta_{e_{\text{pump}}} = \ddot{\theta}_{\text{threshold}}$$

where $\ddot{\theta}_{\text{threshold}} = 6.5$ deg/sec^2 (Reference 16)

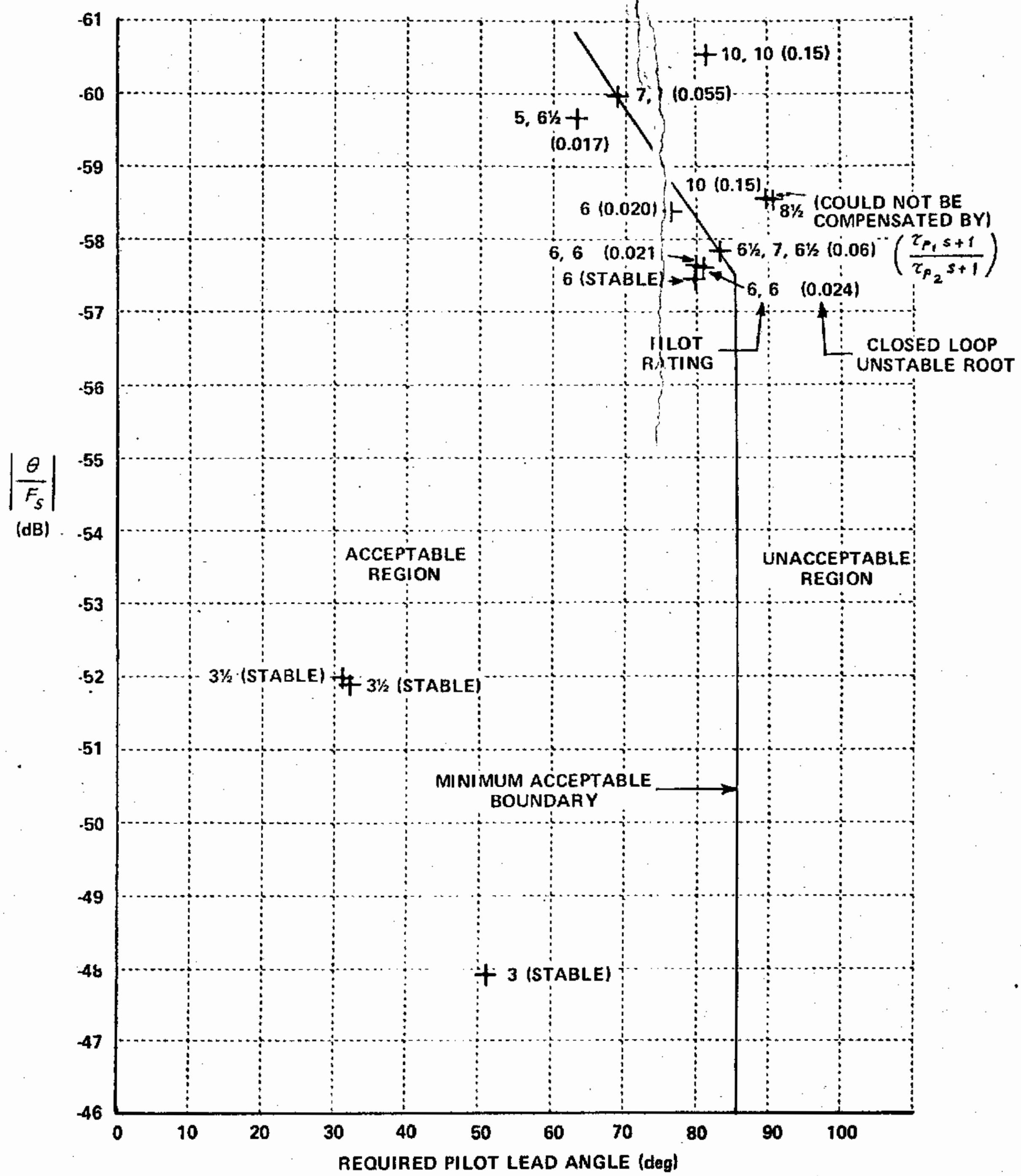


Figure.21 REVISED PERFORMANCE CRITERION

Figure 22 illustrates the type of Bode plot considered by the analysis of Reference 16.

This technique was applied to the 20 evaluation configurations, but did not in any case predict the frequency or magnitude of the pumping action. Predicted and observed pumping magnitudes are given in Table V. The predicted magnitude is always larger than the observed magnitude. The predicted frequency of pumping is about the same for all configurations. Rule (a), the maximum attainable angular acceleration, indicates a frequency of 0.3 rad/sec or greater. Rule (b), minimum phase shift, indicates a frequency of 1.0 rad/sec or greater. The pumping frequency observed from in-flight records was in every case 0.9 rad/sec or larger. Figure 23 illustrates a typical configuration, giving both the three degree of freedom and the short period approximation for $\frac{\theta}{\delta_e}(s)$.

The lack of agreement in the pumping amplitude between the predictions of the control pumping theory and the observed results indicates that either the control pumping theory may not hold in general for the present case, or the threshold value of $\ddot{\theta} < 6.5$ rad/sec^2. It was assumed in Reference 16 that the pilot pumps the pitch control to obtain additional information as the airplane approaches the ground, while in the present case the flight records indicate that the pilot pumps the control throughout the approach. The evaluation configurations generally have an aperiodic divergence, requiring continuous pilot inputs for precision tracking. As noted in Volume I the control input required is likely to be a pumping action because of the double pulse technique required to control attitude.

8.4 HEIGHT CONTROL

A common assumption is that the primary task of a pilot during the final portion of a landing approach is the control of height, or flight path, by use of elevator. A theoretical analysis was undertaken in Reference 17 to determine the characteristics of and limitations on this approach. The pilot was represented as a forward loop lead compensator, $K_1 + K_2 s$, in a unity negative feedback system. The open loop transfer function was

$$\frac{h}{h_e}(s) = \left(K_1 + K_2 s\right) \frac{h}{\delta_e}(s) = K_2 \left(s + \frac{K_1}{K_2}\right) \frac{h}{\delta_e}(s) \qquad (90)$$

where

$$\frac{h}{\delta_e}(s) = \frac{1}{s} \left[\left[\ell_x s + V_t\right] \frac{\theta}{\delta_e}(s) - V_t \frac{\alpha}{\delta_e}(s)\right] \qquad (91)$$

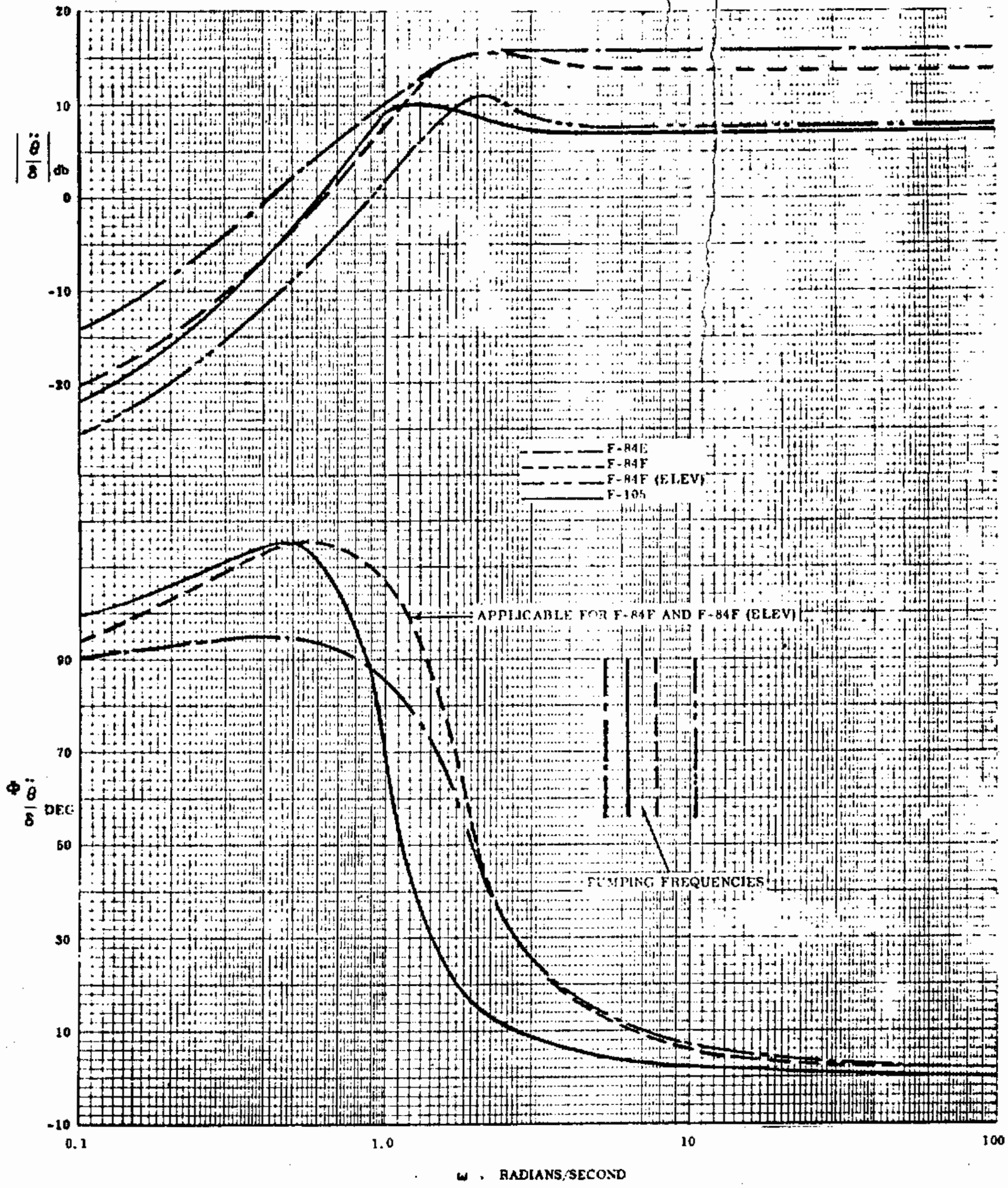


Figure 22 FREQUENCY RESPONSE IN ANGULAR ACCELERATION FOR VARIOUS AIRCRAFT IN THE LANDING CONFIGURATION (FROM REFERENCE 16)

TABLE V

PREDICTED VS. OBSERVED PUMPING AMPLITUDES

CONF.	$\left\lvert \frac{\ddot{\theta}}{\delta_e} \right\rvert_{PUMP}$ $\frac{deg/sec^2}{deg}$	PREDICTED $\delta_{e_{PUMP}}$ (deg)	δ_e OBSERVED PILOT			
			A	B	C	D
1	0.805	8.07	–	3.4-4.0	2.5	4-6
2	0.390	16.7	7.5-10	9-10	–	5-9
3	0.390	16.7	5-7.5	8-9	3-7.5	4-12.5
4	0.390	16.7	7.5	6.5-8	–	9-13
5	0.390	16.7	9-10	–	9	12.5-14
6	0.390	16.7	3.5-6	6.5-10	10	3.2-10
7	0.390	16.7	1.8-4.4	7.5-9	3.5-4	4-10
8	0.392	16.6	10	7-10	–	7.5
9	0.390	16.7	4-5	9-10	–	4-10
10	0.390	16.7	6-9	6-8	–	5-12.5
11	0.390	16.7	5-10	–	–	7.5
12	0.390	16.7	5.5-6	9-12.5	–	–
13	0.780	8.33	4-7	4-6	–	–
14	0.366	17.8	4-6.5	–	–	4-9
15	0.366	17.8	7-9	–	3.5-5.5	11
16	0.366	17.8	7-11	–	–	4-7.2
17	0.366	17.8	–	8-10.5	–	2-6
18	0.366	17.8	8-12.5	6-6.5	–	–
19	0.366	17.8	–	–	–	10-15
20	0.780	8.33	3.5-5	–	–	3-5

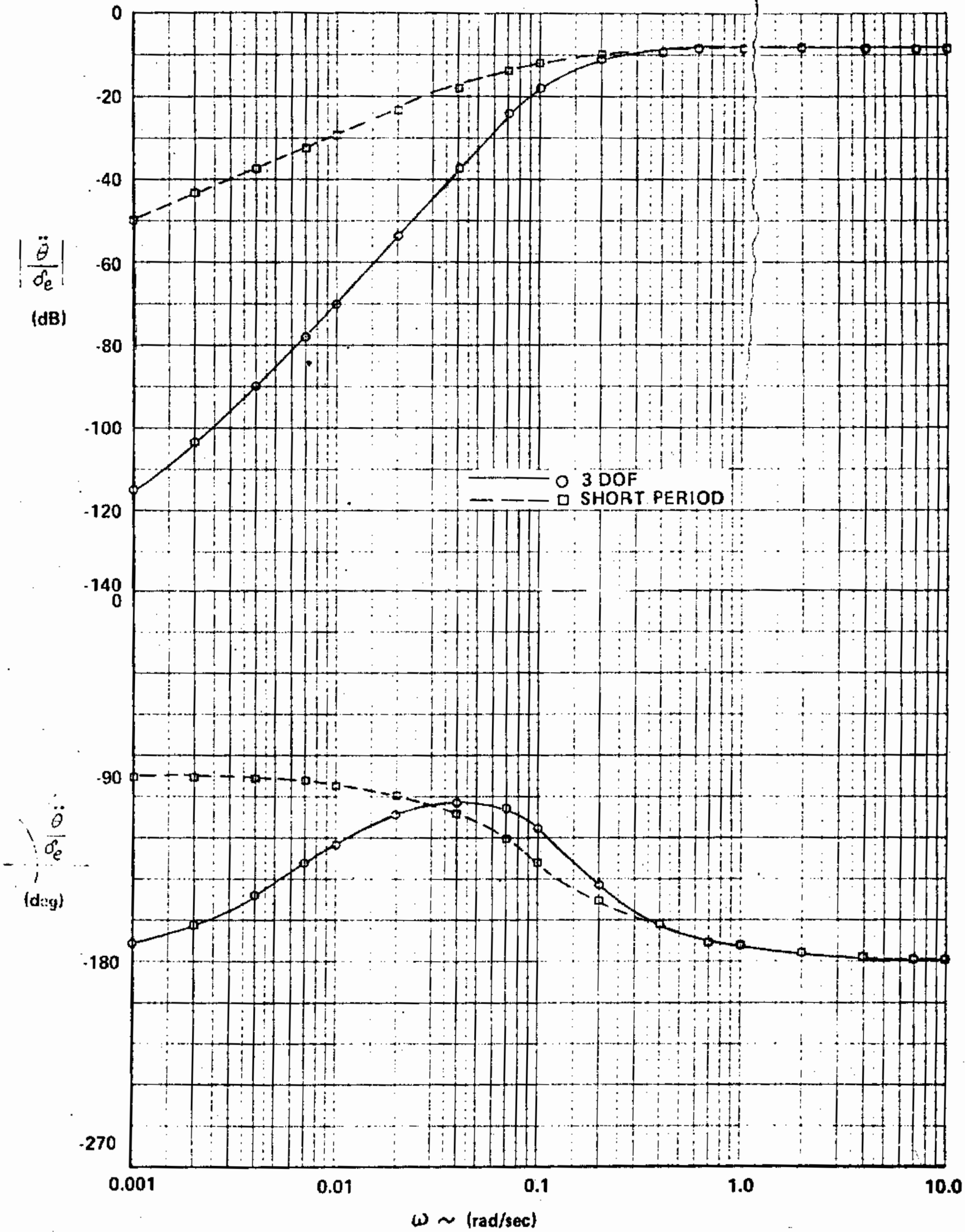


Figure 23 ANGULAR ACCELERATION FREQUENCY RESPONSE FOR CONFIGURATION 3

Analytic stability criteria were used to determine boundaries between stable and unstable regions in the K_1, K_ℓ plane. The most fundamental conclusion was that there are upper as well as lower limits on the magnitudes of the lead and gain constants for stability. The shape of the boundaries indicated that the system in general requires more lead than gain, or, $K_1/K_\ell < 1$. The distance between the pilot and the aircraft c.g., ℓ_x, also had a marked effect on the boundaries. Decreasing ℓ_x decreases the region of stability, with the region of stability vanishing as ℓ_x vanishes. Increasing ℓ_x increases the region of stability, with the region becoming infinite for large ℓ_x. It was also shown that increasing angle of attack stiffness increases the region of stability. In Reference 17, the approach and flare were executed at constant velocity. The aircraft was stable, being represented by a short period approximation. The stability derivatives did not change as the aircraft descended into ground effect. In the present study, most configurations were unstable, and the short period approximation may not accurately represent the entire nature of the pilot's task. There were significant aerodynamic changes as ground effect was encountered. Most of the evaluation configurations could not be stabilized by the "altitude closure" ($h \rightarrow \delta_e$) only, due to the fact that they were on the backside of the power required curve.

Similar conclusions were reached in Reference 18, a study of auto-flare landings of a supersonic transport, including ground effects. A control law was postulated which operated on θ, $\dot{\theta}$, $\int h$, and h to control the elevator. Thrust was reduced during the flare, to reduce the duration of the flare. It was found that increasing the gains for the θ and $\dot{\theta}$ terms significantly reduced flight path oscillations. Pilot controlled flares were performed on an analog computer, aided by a display of altitude and attitude. All of the pilots felt that they could consistently perform smooth flares without stability augmentation after sufficient familiarization with the system.

An optimal control law for flare maneuvers was derived in Reference 19. The analysis determined the control law which would minimize the dispersion of touchdown points and the time integral of the square of the normal acceleration. Throttle was reduced in an exponential manner during the flare, from an initial value to a final value; ground effect was taken into account. The optimum control law, which included all of the flight path variables, was considered to be too unwieldy for practical application. It was found that an excellent approximation to the optimal law required only h, $\dot{h}$, and a_n (normal acceleration). For the aircraft studied, the best approximation to the optimal control law was:

$$\delta_e = h(t) + 4.4\dot{h}(t) + 8.8 + 3.5a_n \tag{92}$$

It was shown in Reference 19 that closing on altitude alone is not sufficient to approximate the optimal solution.

SECTION IX

APPROXIMATE MEASURES OF TURBULENCE AND PILOT WORKLOAD

The tables in this section summarize some approximate measures of the atmospheric turbulence and pilot workload for each pilot's evaluation of the test configurations. Values in brackets indicate the data obtained on repeat evaluation flights by the cited pilot.

Table VI summarizes the approximate measures of the standard deviations of the gust variables α_g, V_g, and β_g. These quantities were measured from flight records, with the maximum excursion of a variable for each approach assumed to be the $\pm 3\sigma$ value. This technique is based on the property of Gaussian distribution that 99.74% of the variable will lie between $+3\sigma$ and -3σ. The data shown in Table VI represents the range in the measured values for all of the approaches used to evaluate a given configuration on that flight. This table also includes pilot rating (PR), the pilot's turbulence effects rating (PTER), and the evaluation flight number. An equivalent vertical gust or side gust can be obtained from α_g or β_g by use of the following equations:

$$w_g \text{ (ft/sec)} = 4.75\, \alpha_g \text{ (deg)}$$
$$v_g \text{ (ft/sec)} = 4.75\, \beta_g \text{ (deg)}$$

Table VII summarizes a measure of the pilot's workload, in terms of the elevator control force envelope $|F_S|$ and the predominant frequency of operation of this control (ω). These measures are given for two regions, denoted by subscripts 1 and 2. Region 1 refers to the portion of the approach above 200 feet, with region 2 the portion below 200 feet. The major differences between the regions are that in region 1, the pilot is flying by instruments and ground effect is negligible, while in region 2 the pilot transition to visual flight and ground effect gradually becomes quite important. The force envelope contains the maximum excursions of the control force. It should be noted that in region 1, the force only occasionally reaches the limits of the envelope, while in region 2, the force often reaches these limits.

Table VI

APPROXIMATE MEASURES OF TURBULENCE

CONFIG.	QUANTITY	PILOT			
		A	B	C	D
1	α_g(deg)		0.43-0.47	0.38-0.53	0.53-0.60
	V_g(ft/sec)		2.0 -2.5	2.1 -2.3	2.8 -4.0
	β_g(deg)		0.4 -0.8	0.57-1.47	0.73-0.87
	PTER		C	B	D
	PR		2	2	5
	Flight #		182	199	185
2	α_g(deg)	0.47-0.60	0.42-0.50		0.57-0.63
	V_g(ft/sec)	1.33-1.50	1.8 -2.3		3.0 -3.7
	β_g(deg)	0.47-0.60	0.4 -0.6		0.5 -0.8
	PTER	D	-		-
	PR	4	7, 10		6 - 7
	Flight #	167	181		168
3	α_g(deg)	0.5 -0.7	0.4 -0.5	0.37-0.43	0.4 -0.5
	V_g(ft/sec)	2.7 -3.7	2.3 -2.5	1.8 -2.2	1.7 -2.5
	β_g(deg)	0.6 -0.9	0.4 -0.5	0.33-0.47	0.47-0.73
	PTER	D		F	D
	PR	6 - 7	6	9, 10	5, 6
	Flight #	166	184	201	203
4	α_g(deg)	0.28	0.53		0.53-0.57
	V_g(ft/sec)	1.7	2.3 -2.5		3.0 -3.7
	β_g(deg)	0.6	0.4 -0.5		0.73-0.87
	PTER	C	D		E
	PR	5	5, 7		8
	Flight #	198	179		186

Table VI

APPROXIMATE MEASURES OF TURBULENCE (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
5	α_g (deg)	0.34		0.43	0.2 -0.3 (0.5)
	V_g (ft/sec)	2.1		2.2	1.3 -1.4 (2.7)
	β_g (deg)	0.5		0.37	0.23-0.67 (0.7)
	PTER	E		F	D (F)
	PR	10		10	7 (10)
	Flight #	192		201	187 (203)
6	α_g (deg)	0.4-0.5 (0.48)	0.13-0.28 (0.3-0.4)	0.15-0.23	0.3-0.4 (0.45)
	V_g (ft/sec)	2.7-3.3 (2, 17)	0.8 -1.3 (1.8-2.2)	1.2 -1.7	1.2-1.8 (1.9-2.5)
	β_g (deg)	0.4-0.5 (0.5)	0.2 -0.5 (0.5-0.6)	0.17-0.33	0.3-0.7 (0.4-0.5)
	PTER	C (C)	- (E)	D	C (D)
	PR	5 (4.5)	5, 10 (6)	6, 8	8 (6)
	Flight #	165 (170)	178 (182)	201	171 (202)
7	α_g (deg)	0.4-0.6	0.4 -0.5	0.1 -0.5	0.4-0.6 (0.4)
	V_g (ft/sec)	1.2-1.7	2.3-3.7	0.7-0.8	3.2-5.0 (2.0)
	β_g (deg)	0.5-0.7	0.4-0.7	0.2-0.6	0.6-0.9 (0.5)
	PTER	E	C	D	F (D)
	PR	6	7, 8	6	9 (7)
	Flight #	167	184	200	168 (203)

Table VI

APPROXIMATE MEASURES OF TURBULENCE (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
8	α_g (deg)	0.4	0.5-0.6		0.5-0.7
	V_g (ft/sec)	1.75	2.7-3.3		3.3-4.0
	β_g (deg)	0.35	0.6-0.7		0.6-0.8
	PTER	A	D		C
	PR	5	7, 8		5
	Flight #	191	180		186
9	α_g (deg)	0.4-0.6	0.52		0.23-0.33 (0.2-0.3)
	V_g (ft/sec)	2.3-2.8	2.3-3.0		1.3 -1.5 (1.2-1.4)
	β_g (deg)	0.5-0.7	0.4-0.5		0.3 -0.6 (0.3-0.7)
	PTER	D	-		(C)
	PR	6.5	6		7 (5.5)
	Flight #	199	183		176 (188)
10	α_g (deg)	0.4-0.5	0.4-0.5		0.3-0.5
	V_g (ft/sec)	1.8-2.0	1.8-2.3		3.3-4.3
	β_g (deg)	0.5-0.75	0.5-0.7		0.7-1.0
	PTER	D	C		D
	PR	5	5, 9		7
	Flight #	170	179		172

Table VI

APPROXIMATE MEASURES OF TURBULENCE (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
11	α_g (deg)	0.7-0.8 (0.40)			0.3
	V_g (ft/sec)	3.0-3.7 (1.8-2.0)			1.5-1.7
	β_g (deg)	0.5-0.8 (0.35)			0.3-0.7
	PTER	D (B)			D
	PR	5 (6)			6
	Flight #	166 (191)			187
12	α_g (deg)	0.5	0.43		
	V_g (ft/sec)	3.3-4.0	2.0-2.3		
	β_g (deg)	0.4-0.6	0.4-0.5		
	PTER	F	D		
	PR	10	6-7, 10		
	Flight #	165	179		
13	α_g (deg)	0.4-0.5	0.2-0.3		
	V_g (ft/sec)	2.0-2.2	1.0-1.5		
	β_g (deg)	0.4-0.5	0.3-0.6		
	PTER	C	-		
	PR	3	1-2		
	Flight #	198	178		

Table VI

APPROXIMATE MEASURES OF TURBULENCE (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
14	α_g (deg)	0.5			0.15-0.25
	V_g (ft/sec)	2.0-2.7			1.1 -1.3
	β_g (deg)	0.46			0.25-0.65
	PTER	C			D
	PR	4			6
	Flight #	169			188
15	α_g (deg)	0.25		0.4-0.5	0.5-0.6
	V_g (ft/sec)	1.5-1.8		0.6-0.7	2.4-2.7
	β_g (deg)	0.5-0.6		0.1-0.7	0.4-0.5
	PTER	B		C	D
	PR	6		5	7.5
	Flight #	197		200	202
16	α_g (deg)	0.4-0.55			0.2
	V_g (ft/sec)	1.5-2.5			1.1
	β_g (deg)	0.4-0.6			0.3
	PTER	E			F
	PR	10			10
	Flight #	169			171

Table VI

APPROXIMATE MEASURES OF TURBULENCE (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
17	α_g (deg)		0.4-0.5		0.2-0.4
	V_g (ft/sec)		2.0-2.2		1.3-2.3
	β_g (deg)		0.4-0.5		0.3-0.6
	PTER		C		D
	PR		5, 8		6
	Flight #		183		176*
18	α_g (deg)	0.3-0.4	0.5		
	V_g (ft/sec)	2.0-2.3	2.3-2.5		
	β_g (deg)	0.4	0.5-0.7		
	PTER	D	-		
	PR	6	7, 10		
	Flight #	192	181		
19	α_g (deg)				0.3
	V_g (ft/sec)				1.2-1.5
	β_g (deg)				0.3-0.7
	PTER				F
	PR				10
	Flight #				176

*Flt. 176 was continuation of Flt. 175.

Table VI

APPROXIMATE MEASURES OF TURBULENCE (Cont.)

CONFIG.	QUANTITY	PILOT			
		A	B	C	D
20	α_g (deg)	0.3-0.4			0.4-0.5
	V_g (ft/sec)	1.5-1.7			3.3-4.0
	β_g (deg)	0.4-0.6			0.7-0.8
	PTER	C			C
	PR	3			4
	Flight #	170			172

Table VII

APPROXIMATE MEASURES OF PILOT WORKLOAD

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
1	$\lvert F_{S_1} \rvert$ (lb)		37-45	21-25	20-38
	ω_1 (rad/sec)		1.9	1.6	1.3
	$\lvert F_{S_2} \rvert$ (lb)		37-45	29	42-59
	ω_2 (rad/sec)		1.9	3.15	1.9-2.5
	PR		2	2	5
2	$\lvert F_{S_1} \rvert$ (lb)	28-42	47-59		28-30
	ω_1 (rad/sec)	1.5	1.25		1.0
	$\lvert F_{S_2} \rvert$ (lb)	72-93	85-93		50-85
	ω_2 (rad/sec)	1.9-2.5	1.3-1.7		[illegible]
	PR	4	7; 10		6-7
3	$\lvert F_{S_1} \rvert$ (lb)	28-33	38	28-32	28-43
	ω_1 (rad/sec)	1.25	1.25-1.6	1.1	1.0
	$\lvert F_{S_2} \rvert$ (lb)	50-72	76-85	33-72	42-110
	ω_1 (rad/sec)	2.0	1.6-1.9	1.25-2.5	1.6-1.9
	PR	6-7	6	9; 10	5; 6

Table VII

APPROXIMATE MEASURES OF PILOT WORKLOAD (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
4	$\|F_{S_1}\|$ (lb)	42	50-66		41-45
	ω_1 (rad/sec)	1.6	1.75		1.25
	$\|F_{S_2}\|$ (lb)	72	63-76		85-119
	ω_1 (rad/sec)	1.9	1.8		1.5-1.9
	PR	5	5, 7		8
5	$\|F_{S_1}\|$ (lb)	48-52		45	45-55 (55)
	ω_1 (rad/sec)	1.6-1.9		1.1	1.3 (0.9)
	$\|F_{S_2}\|$ (lb)	85-93		85	110-130 (110)
	ω_2 (rad/sec)	1.7-1.9		1.4	1.8 (2.0)
	PR	10		10	7 (10)
6	$\|F_{S_1}\|$ (lb)	23-28 (59)	33-45 (42-50)	23-28	28-30 (28-33)
	ω_1 (rad/sec)	1.25-1.5 (2.0)	1.1-1.9 (1.1-1.6)	1.2	0.9-1.1 (1.1)
	$\|F_{S_2}\|$ (lb)	37-55 (59)	76-93 (63-72)	93	35-42 (50-93)
	ω_2 (rad/sec)	1.5-1.9 (2.5)	1.5-1.9 (1.9-2.2)	1.4	1.25-1.5 (1.5-1.9)
	PR	5 (4.5)	5, 10 (6)	6, 8	8 (6)

Table VII

APPROXIMATE MEASURES OF PILOT WORKLOAD (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
7	$\lvert F_{S_1} \rvert$ (lb)	42-72	42-56	26-32	31-50 (34)
	ω_1 (rad/sec)	1.6	1.6	1.25	0.9-1.25 (0.9-1.4)
	$\lvert F_{S_2} \rvert$ (lb)	23-45	72-85	37-42	42-85 (85)
	ω_2 (rad/sec)	1.25-1.5	1.8	1.9	1.2 (3.1)
	PR	6	7, 8	6	9 (7)
8	$\lvert F_{S_1} \rvert$ (lb)	26-34	31-46		31-42
	ω_1 (rad/sec)	1.25	1.25-1.5		1.0
	$\lvert F_{S_2} \rvert$ (lb)	93	67-93		72
	ω_2 (rad/sec)	1.5	1.25-2.2		1.5-2.5
	PR	5	7, 8		5
9	$\lvert F_{S_1} \rvert$ (lb)	25-34	45-49		23 (26-32)
	ω_1 (rad/sec)	1.2-1.5	0.9-1.25		1.0 (0.75-1.1)
	$\lvert F_{S_2} \rvert$ (lb)	29-51	90		76 (46)
	ω_2 (rad/sec)	1.5-2.5	1.5-1.9		1.9 (1.5-1.9)
	PR	6.5	6		7 (5.5)

Table VII

APPROXIMATE MEASURES OF PILOT WORKLOAD (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
10	$\|F_{S_1}\|$ (lb)	21-33	38-47		25-33
	ω_1 (rad/sec)	0.8-1.4	0.9-1.4		0.9-1.25
	$\|F_{S_2}\|$ (lb)	59-85	59-76		50-115
	ω_2 (rad/sec)	1.9-2.2	1.4-2.0		1.25-1.9
	PR	5	5, 9		7
11	$\|F_{S_1}\|$ (lb)	28-34 (31-38)			33-37
	ω_1 (rad/sec)	1.1-1.6 (1.1-1.4)			0.9
	$\|F_{S_2}\|$ (lb)	50-85 (67-93)			72
	ω_2 (rad/sec)	1.9-2.2 (1.9)			1.9
	PR	5 (6)			6
12	$\|F_{S_1}\|$ (lb)	28-33	70-76		
	ω_1 (rad/sec)	1.6-1.9	1.1-1.5		
	$\|F_{S_2}\|$ (lb)	55-60	85-115		
	ω_2 (rad/sec)	1.6-2.2	1.4-1.75		
	PR	10	6-7, 10		

Table VII

APPROXIMATE MEASURES OF PILOT WORKLOAD (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
13	$\lvert F_{S_1} \rvert$ (lb)	21-42	31-38		
	ω_1 (rad/sec)	1.25-2.2	1.25-1.6		
	$\lvert F_{S_2} \rvert$ (lb)	42-68	42-59		
	ω_2 (rad/sec)	1.9-3.2	3.2		
	PR	3	1 - 2		
14	$\lvert F_{S_1} \rvert$ (lb)	31-37			30-35
	ω_1 (rad/sec)	1.25			0.75-1.0
	$\lvert F_{S_2} \rvert$ (lb)	42-63			42-85
	ω_2 (rad/sec)	1.25-3.1			1.4-1.9
	PR	4			6
15	$\lvert F_{S_1} \rvert$ (lb)	33-38		26-33	33-42
	ω_1 (rad/sec)	1.5		0.9-1.25	1.1
	$\lvert F_{S_2} \rvert$ (lb)	67-85		37-55	102
	ω_2 (rad/sec)	1.6-2.2		1.8-3.14	1.45
	PR	6		5	7.5

Table VII

APPROXIMATE MEASURES OF PILOT WORKLOAD (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
16	$\lvert F_{S_1} \rvert$ (lb)	55-68			69
	ω_1 (rad/sec)	1.6-2.2			1.25
	$\lvert F_{S_2} \rvert$ (lb)	67-102			42
	ω_2 (rad/sec)	1.6			1.25
	PR	10			10
17	$\lvert F_{S_1} \rvert$ (lb)		38-50		25-28
	ω_1 (rad/sec)		1.0		0.75-1.25
	$\lvert F_{S_2} \rvert$ (lb)		63-98		42-72
	ω_2 (rad/sec)		1.6-3.15		1.05-1.4
	PR		5, 8		6
18	$\lvert F_{S_1} \rvert$ (lb)	38-59	59		
	ω_1 (rad/sec)	0.9-1.6	1.15		
	$\lvert F_{S_2} \rvert$ (lb)	76-115	59-63		
	ω_2 (rad/sec)	1.25-1.75	1.25-1.6		
	PR	6	7, 10		

Table VII

APPROXIMATE MEASURES OF PILOT WORKLOAD (Cont.)

CONFIG.	QUANTITY	PILOT A	PILOT B	PILOT C	PILOT D
19	$\lvert F_{S_1} \rvert$ (lb)				50-66
	ω_1 (rad/sec)				1.4-1.6
	$\lvert F_{S_2} \rvert$ (lb)				93-132
	ω_2 (rad/sec)				1.1-1.6
	PR				10
20	$\lvert F_{S_1} \rvert$ (lb)	20-25			21-23
	ω_1 (rad/sec)	0.9			1.25
	$\lvert F_{S_2} \rvert$ (lb)	37-50			33-50
	ω_2 (rad/sec)	3.15			3.15
	PR	3			4

APPENDIX

DATA RECORDING

A 60 channel digital recording system was used for the acquisition of quantitative data. Two channels were used for "bookkeeping", such as record numbers and calibrations. The remaining 58 channels recorded model parameters, aircraft attitude data, control data and cockpit instrument data.

The model parameters recorded were as follows:

$$\left.\begin{array}{c} \Delta\theta_{m_T} \\ \Delta\alpha_{I_{m_{TCG}}} \\ \Delta V_{I_{m_{TCG}}} \\ \Delta n_{z_{p_m}} \\ \Delta\delta_{e_m} \\ \Delta\delta_{a_m} \\ \left|\Delta\delta_{e_m}\right| + \left|\Delta\delta_{a_m}\right| \end{array}\right\} \text{incremental values from time of engage}$$

$$\Delta\delta_{r_m}$$

$$\sin\theta_m$$

$$q_{I_m}$$

$$\sin\gamma_{m_{TCG}}$$

$$\dot{\alpha}_{I_{m_{TCG}}}$$

$$\dot{V}_{I_{m_{TCG}}}$$

$$\sin\phi_m$$

$$\phi_{m_T}$$

$$p_{I_{m_T}}$$

$$r_{I_{m_T}}$$

$$\beta_{I_{m_T}}$$

$$y$$

$$h_e$$

$$\dot{\beta}_{I_{m_{TCG}}}$$

$n_{y_{p_m}}$

$\dot{h}_{m_{TCG}}$

T_m

α_{T_m} } Total model values, include gust terms

V_{T_m}

The following airplane (TIFS) data, incremental and total were recorded. Details of TIFS sensor signals are presented in Reference 1.

$\Delta\theta$

$\Delta\alpha_I$ } incremental values from time of engage

ΔV

Δn_{z_p}

$\sin \epsilon \psi$ (ϵ = error)

q

$\sin \gamma$

$\dot{\alpha}_I$

$\dot{V}$

ϕ

p

r

β_I

$\dot{\beta}_I$

n_{y_p}

$\dot{h}$

V

p_g

V_g

β_g

α_g

The following (TIFS) control data were also recorded.

δ_e

δ_a

δ_r

δ_z^{L}

δ_y^{R}

δ_z^{R}

F_{e_W} }
F_{A_W} } Force inputs by evaluation pilot.
F_{R_P} }

Instrument data recorded were

ILS localizer
ILS glide slope

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13. ABSTRACT

An in-flight simulation to investigate minimum longitudinal stability for large delta-wing transports in landing approach and touchdown (including ground effect) was conducted using the USAF/Calspan Total In-Flight Simulator (TIFS) airplane. The airplane nonlinear equations of motion, as well as the representation of the engine characteristics and the control system used in this in-flight investigation are presented. Details of the simulation or representative piloting tasks for the landing approach (e.g., artificial crosswind landing) are described. Detailed pilot comments, touchdown parameters, measures of turbulence and pilot workload obtained during the in-flight evaluation are included in this report. Analysis of the landing approach maneuver indicates the importance of precise attitude control, and the influence of ground effect on large delta-wing transports. Pilot compensation required to obtain a specified performance level of attitude control was analyzed indicating the need for extreme lead compensation for longitudinally unstable airplanes.

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