DOCKET NO. **SA - 510**

EXHIBIT NO. **13X - F**

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

737 FLIGHT TEST DOCUMENTATION

CONTENTS OF EXHIBIT

1. Simulator Calibration Flight Test Conditions

737-300 Simulator Data for the Lateral/Directional Axes - FT-B

Prep by [redacted] 15 SEPT 95 Conc [redacted] 9-15-95
Engineer Date Lead Test Ops Eng Date

App [redacted] 09/15/95 App [redacted] 9/15/95
Lead Analysis Engineer Date Analysis Supervisor Date

PURPOSE OF TEST

To gather selected lateral and directional maneuver response data of the 737 for the purposes of simulator expansion and validation.

REFERENCES

(a) EWA 34-15039F, Rev.C, "Reduced Scope 727/737 Wake Encounter Flight Test", dated 11 April 1995.

RISK ASSESSMENT

All conditions in this TI are LOW RISK

CONFIGURATION

The test airplane is a Model 737-300, Airplane PP053, USAir N533AU.

-PADDS data recording system installed, including one strip chart recorder, one quick-look video monitor and one printer. Analog measurements to be recorded.

FLIGHT TEST PREREQUISITES

The following tests must be completed before testing can begin:

1) Ground test conditions, to validate the proper operation and intended function of the Flight Data Recorder, are successfully completed.

DATA REQUIRED

PADDS	-	ON
Manual Notes	-	Correlate events with IRIG time
Control Sweeps	-	pre and post test

737-300 Simulator Data for the Lateral/Directional Axes - FT-B

FLIGHT TEST CONDITIONS

STEADY HEADING SIDESLIPS.

1) Trim the airplane to the condition specified. Gather "hands-off" trim for 20 seconds prior to each maneuver.

2) Perform steady heading sideslips at 1/3, 2/3 and full left rudder (NOTE: Maximum or "full" rudder may be limited by lateral control available. Record full rudder magnitude.). Maintain heading and airspeed at each rudder setting without changing thrust, stabilize and collect trim data for 10-20 seconds at each rudder deflection after which and while maintaining the specified rudder position with pedal, a wheel release will be performed. Allow the airplane to roll until rate has stabilized or the condition is terminated at pilot discretion. Return aircraft to trim.

3) Repeat Step 2 with the right rudder.

4) Turn OFF Yaw damper. Perform steady heading sideslips at 1/3, 2/3 and full left rudder. Maintain heading and airspeed at each rudder setting without changing thrust, stabilize and collect trim data for 10-20 seconds at each rudder deflection. Maximum or "full" rudder may be limited by lateral control available. Return aircraft to trim. Note full rudder magnitude.

5) Repeat Step 4 with the right rudder.

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Yaw Damper (on/off)	Thrust	Rudder Direction
.001	1/UP	< 120	12-24	6-10	V2	on	TLF	Left
.002	1/UP	< 120	12-24	6-10	170	on	TLF	Left
.003	1/UP	< 120	12-24	6-10	190	on	TLF	Left
.004	1/UP	< 120	12-24	6-10	210	on	TLF	Left
.005	1/UP	< 120	12-24	6-10	225	on	TLF	Left
.006	1/UP	< 120	12-24	6-10	V2	on	TLF	Right
.007	1/UP	< 120	12-24	6-10	170	on	TLF	Right
.008	1/UP	< 120	12-24	6-10	190	on	TLF	Right
.009	1/UP	< 120	12-24	6-10	210	on	TLF	Right
.010	1/UP	< 120	12-24	6-10	225	on	TLF	Right
.011	1/UP	< 120	12-24	6-10	V2	off	TLF	Left
.012	1/UP	< 120	12-24	6-10	170	off	TLF	Left
.013	1/UP	< 120	12-24	6-10	190	off	TLF	Left

737-300 Simulator Data for the Lateral/Directional Axes - FT-B

FLIGHT TEST CONDITIONS(Con't)

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Yaw Damper (on/off)	Thrust	Rudder Direction
.014	1/UP	< 120	12-24	6-10	210	off	TLF	Left
.015	1/UP	< 120	12-24	6-10	225	off	TLF	Left
.016	1/UP	< 120	12-24	6-10	V2	off	TLF	Right
.017	1/UP	< 120	12-24	6-10	170	off	TLF	Right
.018	1/UP	< 120	12-24	6-10	190	off	TLF	Right
.019	1/UP	< 120	12-24	6-10	210	off	TLF	Right
.020	1/UP	< 120	12-24	6-10	225	off	TLF	Right

ROLL RESPONSE WITH WHEEL ONLY

1) Trim the airplane to the condition specified. Gather "hands-off" trim for 20 seconds prior to each maneuver.

2) Roll the aircraft to -30 degrees bank (left bank) and stabilize.

3) Roll the aircraft through +30 degrees bank (right bank) with the specified wheel deflection. Once beyond +30 degrees, gently initiate recovery and stabilize at +30 degrees bank.

3) Roll the aircraft through -30 degrees bank (left bank) with the specified wheel deflection. Once beyond -30 degrees, gently initiate recovery and stabilize to wings level.

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Yaw Damper (on/off)	Thrust	Wheel Deflection
.021	1/UP	< 120	12-24	6-10	190	on	TLF	1/3
.022	1/UP	< 120	12-24	6-10	190	on	TLF	1/3, Repeat with A/P on and in CWS mode
.023	1/UP	< 120	12-24	6-10	190	on	TLF	2/3
.024	1/UP	< 120	12-24	6-10	190	on	TLF	Full
.025	1/UP	< 120	12-24	6-10	190	off	TLF	1/3

737-300 Simulator Data for the Lateral/Directional Axes - FT-B

FLIGHT TEST CONDITIONS(Con't)

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Yaw Damper (on/off)	Thrust	Wheel Deflection
.026	1/UP	<120	12-24	6-10	190	off	TLF	1/3, Repeat with A/P on and in CWS mode
.027	1/UP	<120	12-24	6-10	190	off	TLF	2/3
.028	1/UP	<120	12-24	6-10	190	off	TLF	Full
.029	1/UP	<120	12-24	6-10	170	on	TLF	1/3
.030	1/UP	<120	12-24	6-10	170	on	TLF	1/3, Repeat with A/P on and in CWS mode
.031	1/UP	<120	12-24	6-10	170	on	TLF	2/3
.032	1/UP	<120	12-24	6-10	170	on	TLF	Full
.033	1/UP	<120	12-24	6-10	170	off	TLF	1/3
.034	1/UP	<120	12-24	6-10	170	off	TLF	1/3, Repeat with A/P on and in CWS mode
.035	1/UP	<120	12-24	6-10	170	off	TLF	2/3
.036	1/UP	<120	12-24	6-10	170	off	TLF	Full

ROLL RESPONSE WITH PEDAL ONLY

1) Trim the airplane to the condition specified. Gather "hands-off" trim for 20 seconds prior to each maneuver.

2) Input rudder trim to the right the specified amount while holding the pedals at neutral. Establish a -30 degree banked (left bank) turn with wheel and stabilize.

3) Release the pedals and wheel and allow the aircraft to roll right to +30 degrees (right bank). Arrest roll rate at +30 degrees with wheel and pedal as required. Recover to wings level and return the rudder trim to neutral.

4) Input rudder trim to the left the specified amount while holding the pedals at neutral. Establish a +30 degree bank (right bank) turn with wheel and stabilize.

737-300 Simulator Data for the Lateral/Directional Axes - FT-B

FLIGHT TEST CONDITIONS(Con't)

5) Release the pedals and wheel and allow the aircraft to roll left to -30 degrees (left bank). Arrest roll rate at -30 degrees with wheel and pedal as required. Recover to wings level and return the rudder trim to neutral.

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Yaw Damper (on/off)	Thrust	Rudder Deflection
.037	1/UP	< 120	12-24	6-10	190	on	TLF	1/4
.038	1/UP	< 120	12-24	6-10	190	on	TLF	1/4, Repeat with A/P on. Establish initial 30 degree bank with A/P
.039	1/UP	< 120	12-24	6-10	190	on	TLF	1/2
.040	1/UP	< 120	12-24	6-10	190	on	TLF	1/2, Repeat with A/P on. Establish initial 30 degree bank with A/P
.041	1/UP	< 120	12-24	6-10	190	on	TLF	3/4
.042	1/UP	< 120	12-24	6-10	190	on	TLF	1/2, Initial bank angle with pedal only
.043	1/UP	< 120	12-24	6-10	190	off	TLF	1/4
.044	1/UP	< 120	12-24	6-10	190	off	TLF	1/4, Repeat with A/P on. Establish initial 30 degree bank with A/P
.045	1/UP	< 120	12-24	6-10	190	off	TLF	1/2
.046	1/UP	< 120	12-24	6-10	190	off	TLF	1/2, Repeat with A/P on. Establish initial 30 degree bank with A/P
.047	1/UP	< 120	12-24	6-10	190	off	TLF	3/4

737-300 Simulator Data for the Lateral/Directional Axes - FT-B

FLIGHT TEST CONDITIONS(Con't)

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Yaw Damper (on/off)	Thrust	Rudder Deflection
.048	1/UP	< 120	12-24	6-10	190	off	TLF	1/2, Initial bank angle with pedal only.
.049	1/UP	< 120	12-24	6-10	170	on	TLF	1/4
.050	1/UP	< 120	12-24	6-10	170	on	TLF	1/4, Repeat with A/P on. Establish initial 30 degree bank with A/P
.051	1/UP	< 120	12-24	6-10	170	on	TLF	1/2
.052	1/UP	< 120	12-24	6-10	170	on	TLF	1/2, Repeat with A/P on. Establish initial 30 degree bank with A/P
.053	1/UP	< 120	12-24	6-10	170	on	TLF	3/4
.054	1/UP	< 120	12-24	6-10	170	on	TLF	1/2, Initial bank angle with pedal only.
.055	1/UP	< 120	12-24	6-10	170	off	TLF	1/4
.056	1/UP	< 120	12-24	6-10	170	off	TLF	1/4, Repeat with A/P on. Establish initial 30 degree bank with A/P
.057	1/UP	< 120	12-24	6-10	170	off	TLF	1/2
.058	1/UP	< 120	12-24	6-10	170	off	TLF	1/2, Repeat with A/P on. Establish initial 30 degree bank with A/P
.059	1/UP	< 120	12-24	6-10	170	off	TLF	3/4

737-300 Simulator Data for the Lateral/Directional Axes - FT-B

FLIGHT TEST CONDITIONS(Con't)

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Yaw Damper (on/off)	Thrust	Rudder Deflection
.060	1/UP	< 120	12-24	6-10	170	off	TLF	1/2, Initial bank angle with pedal only.

ROLL RESPONSE WITH CROSS CONTROLS

1) Trim the airplane to the condition specified. Gather "hands-off" trim for 20 seconds prior to each maneuver. Insure that the Yaw Damper is ON.

2) Input rudder trim to the specified amount while holding the pedals at neutral. Maintain wings level with wheel and stabilize.

3) Release the pedals and simultaneously input the cross-control wheel input specifed. Allow the aircraft to roll to 30 degrees bank then initiate recovery to wings level with wheel and pedals.

4) After recovery to wings level, return the rudder trim to neutral and collect trim data for 20 seconds.

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Thrust	Wheel Deflection	Rudder Deflection
.061	1/UP	< 120	12-24	6-10	190	TLF	1/4 Right	1/4 Left
.062	1/UP	< 120	12-24	6-10	190	TLF	1/2 Right	1/2 Left

ROLL RESPONSE WITH COMBINED CONTROLS

1) Trim the airplane to the condition specified. Gather "hands-off" trim for 20 seconds prior to each maneuver. Insure that the Yaw Damper is ON.

737-300 Simulator Data for the Lateral/Directional Axes - FT-B

FLIGHT TEST CONDITIONS(Con't)

2) Input rudder trim to the left the specified amount while holding the pedals at neutral. Establish a +30 degree bank (right bank) turn and stabilize.

3) Release the pedals and simultaneously input the specified left wheel input. Allow the aircraft to roll to -30 degrees bank (left bank) then initiate recovery to wings level with wheel and pedals.

4) Recover to wings level and return the rudder trim to neutral.

Condition Number	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Thrust	Wheel Deflection	Rudder Deflection
B1.41.0081								
.063	1/UP	< 120	12-24	6-10	190	TLF	1/4 Left	1/4 Left
.064	1/UP	< 120	12-24	6-10	190	TLF	1/2 Left	1/2 Left

AUTOPILOT TURNS

1) Trim the airplane to the condition specified. Gather "hands-off" trim for 20 seconds prior to each maneuver. Insure that the Yaw Damper is ON.

2) Engage the "A" autopilot and autothrottle to maintain 6000 ft. and 190 kts.

3) With Heading Select mode disengaged, input a 40 degree heading change and set a 15 degree bank limit.

4) Engage Heading Select and perform the turn and stabilize. Collect trim data for 20 seconds.

5) Disengage Heading Select. Perform a 40 degree heading change in LNAV mode.

6) Engage LNAV mode and perform the turn and stabilize. Collect trim data for 20 seconds.

737-300 Simulator Data for the Lateral/Directional Axes - FT-B

FLIGHT TEST CONDITIONS(Con't)

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Yaw Damper (on/off)	Thrust	Autopilot Mode
.065	1/UP	< 120	12-24	6-10	190	on	TLF	Heading Select
.066	1/UP	< 120	12-24	6-10	190	on	TLF	LNAV

SLOWDOWN TURN

1) Trim the airplane to the condition specified. Gather "hands-off" trim for 20 seconds prior to each maneuver.

2) Establish a 50 degree bank turn.

3) Once the turn is stabilized at 50 degrees bank, reduce thrust to idle power and decelerate with column to maintain 1.5 g's and 50 degrees bank.

4) Terminate the condition upon stick shaker activation and recover to wings level.

Condition Number B1.41.0081	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Trim Speed (KCAS)	Yaw Damper (on/off)	Thrust	Comments
.067	1/UP	< 120	12-24	6-10	220	on	TLF	

2. Wake Vortex Encounter Flight Test Conditions

737-300 Wake Encounter - FT-B

Prep by [redacted] 8 Sept 95 Conc [redacted] 9-14-95

Engineer Date Lead Test Ops Eng Date

App [redacted] 09/11/95 App [redacted] 9/11/95

Lead Analysis Engineer Date Analysis Supervisor Date

PURPOSE OF TEST

To examine 737 response to 727 wake vortex.

REFERENCES

(a) EWA 34-15039F, Rev.C, "Reduced Scope 727/737 Wake Encounter Flight Test", dated 11 April 1995.

RISK ASSESSMENT

All conditions in this TI are LOW RISK

CONFIGURATION

The test airplane is a Model 737-300, Airplane PP053, USAir N533AU.

-Video cameras installed in the following locations: forward looking wing-tip mounted both left and right wings, vertical fin mounted with wide angle forward view, cabin seat track mounted (both left and right side) with upper wing surface view and two cockpit mounted with a forward view out the windshield and of flight crew activity.

-Seperate video monitors, with channel switching, for each of the cameras to be provided at a station within the airplane.

-PADDS data recording system installed, including one strip chart recorder, one quick-look video monitor and one printer. Analog measurements to be recorded.

FLIGHT TEST PREREQUISITES

The following tests must be completed before testing can begin:

1) Ground test conditions, to validate the proper operation and intended function of the Flight Data Recorder, are successfully completed.

DATA REQUIRED

PADDS	-	ON
Manual Notes	-	Correlate events with IRIG time
Control Sweeps	-	pre and post test

737-300 Wake Encounter - FT-B

FLIGHT TEST SUPPORT

1) Boeing T-33 chase to support with aerial video coverage.

737-300 Wake Encounter - FT-B

FLIGHT TEST CONDITIONS

WAKE ENCOUNTER TESTING.

INITIAL CONDITIONS and DEFINITIONS FOR ALL TEST CONDITIONS:

737	727
-Trim speed: 190 kts. -Flaps 1/Gear UP	-Trim speed 190 kts -Flaps UP/Gear UP

-Intercept angle relative to wake trail
-Yaw Damper-ON
-Separation distance 2 to 4 miles.
-Altitutde differential is between vortex core and aircraft.
-Initial offset is the distance between the middle of the vortex pair and the aircraft's centerline

1) Trim the airplane to the condition specified.

2) Initiate wake encounter as specified. With Autopilot engaged encounters, disengage the A/P after exiting the wake.

3) Recover aircraft to wings level as required.

Condition Number B1.42.0065	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Initial Offset (Feet)	Altitude Differential (Feet)	Intercept Heading (Degrees)	Comments
Direct Intercept: (727 Level Flight)								
.001	1/UP	103-113	15-24	10-15AGL	500L	0	5	Airplane Free response
.002	1/UP	103-113	15-24	10-15AGL	500L	0	5	Pilot to control airplane throughout wake.
.003	1/UP	103-113	15-24	10-15AGL	500L	0	5	Use A/P to setup intercept and allow A/P to control upset.
.004	1/UP	103-113	15-24	10-15AGL	500L	0	5	Use A/P to setup intercept and pilot to control roll upset. (A/P in CWS mode)

737-300 Wake Encounter - FT-B

FLIGHT TEST CONDITIONS(Con't)

Condition Number B1.42.0065	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Initial Offset (Feet)	Altitude Differential (Feet)	Intercept Heading (Degrees)	Comments
Direct Intercept: (727 Level Flight)								
.005	1/UP	103-113	15-24	10-15AGL	1000L	0	10	Airplane Free response
.006	1/UP	103-113	15-24	10-15AGL	1000L	0	10	Pilot to control airplane throughout wake.
.007	1/UP	103-113	15-24	10-15AGL	1000L	0	10	Use A/P to setup intercept and allow A/P to control upset.
.008	1/UP	103-113	15-24	10-15AGL	1000L	0	10	Use A/P to setup intercept and pilot to control roll upset. (A/P in CWS mode)
Approach from Below: (727 Level Flight)								
.009	1/UP	103-113	15-24	10-15AGL	0	-100	0	Airplane Free response
.010	1/UP	103-113	15-24	10-15AGL	0	-100	0	Pilot to control airplane throughout wake.
.011	1/UP	103-113	15-24	10-15AGL	0	-100	0	Use A/P to setup intercept and allow A/P to control upset.
.012	1/UP	103-113	15-24	10-15AGL	0	-100	0	Use A/P to setup intercept and pilot to control roll upset. (A/P in CWS mode)

737-300 Wake Encounter - FT-B

FLIGHT TEST CONDITIONS(Con't)

Condition Number B1.42.0065	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Initial Offset (Feet)	Altitude Differential (Feet)	Intercept Heading (Degrees)	Comments
Turn onto right core and approach from below: (727 Level Flight)								
.013	1/UP	103-113	15-24	10-15AGL	500L	TBD	5	Airplane Free response
.014	1/UP	103-113	15-24	10-15AGL	500L	TBD	5	Pilot to control airplane throughout wake.
.015	1/UP	103-113	15-24	10-15AGL	500L	TBD	5	Use A/P to setup intercept and allow A/P to control upset.
.016	1/UP	103-113	15-24	10-15AGL	500L	TBD	5	Use A/P to setup intercept and pilot to control roll upset. (A/P in CWS mode)
Turn onto right core: (727 gamma=-3 degrees)								
.017	1/UP	103-113	15-24	10-15AGL	500L	TBD	5	Airplane Free response
.018	1/UP	103-113	15-24	10-15AGL	500L	TBD	5	Pilot to control airplane throughout wake.
.019	1/UP	103-113	15-24	10-15AGL	500L	TBD	5	Use A/P to setup intercept and allow A/P to control upset.
.020	1/UP	103-113	15-24	10-15AGL	500L	TBD	5	Use A/P to setup intercept and pilot to control roll upset. (A/P in CWS mode)

737-300 Wake Encounter - FT-B

FLIGHT TEST CONDITIONS(Con't)

Condition Number B1.42.0065	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Initial Offset (Feet)	Altitude Differential (Feet)	Intercept Heading (Degrees)	Comments
Approach from Below: (727 gamma=-3 degrees)								
.021	1/UP	103-113	15-24	10-15AGL	0	-100	0	Airplane Free response
.022	1/UP	103-113	15-24	10-15AGL	0	-100	0	Pilot to control airplane throughout wake.
.023	1/UP	103-113	15-24	10-15AGL	0	-100	0	Use A/P to setup intercept and allow A/P to control upset.
.024	1/UP	103-113	15-24	10-15AGL	0	-100	0	Use A/P to setup intercept and pilot to control roll upset. (A/P in CWS mode)

737-300 Wake Encounter - FT-B

FLIGHT TEST CONDITIONS(Con't)

FOR THE FOLLOWING CONDITIONS:

-Autopilot OFF
-Yaw Damper ON

1) Trim the airplane to the condition specified.

2) Initiate wake encounter as specified and attempt to keep the aircraft within the wake for at least 10-20 seconds..

3) Recover aircraft to wings level as required.

Condition Number B1.42.0065	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Initial Offset (Feet)	Altitude Differential (Feet)	Intercept Heading (Degrees)	Comments
.025	1/UP	103-113	15-24	10-15AGL	500L	-100	0	Rt. wing in left core
.026	1/UP	103-113	15-24	10-15AGL	500R	-100	0	Lt. wing in right core
.027	1/UP	103-113	15-24	10-15AGL	40R	-100	0	Vert. fin in right core

FOR THE FOLLOWING CONDITIONS:

-Autopilot ON-CWS Mode
-Yaw Damper ON

1) Trim the airplane to the condition specified.

2) Initiate wake encounter as specified and attempt to keep the aircraft within the wake for at least 10-20 seconds.

3) Recover aircraft to wings level as required.

Condition Number B1.42.0065	Flaps/ Gear	GW (1000 Lbs)	CG (% MAC)	Initial Alt (1000 Feet)	Initial Offset (Feet)	Altitude Differential (Feet)	Intercept Heading (Degrees)	Comments
.028	1/UP	103-113	15-24	10-15AGL	500L	-100	0	Rt. wing in left core
.029	1/UP	103-113	15-24	10-15AGL	500R	-100	0	Lt. wing in right core
.030	1/UP	103-113	15-24	10-15AGL	40R	-100	0	Vert. fin in right core

3. Boeing Engineering Work Authorization (EWA)

BOEING COMMERCIAL AIRPLANE GROUP

AIR SAFETY INVESTIGATION

RAPIDFAX LEAD SHEET

LEAD + 19 Page(s)
DATE: 30 Aug 95

TO: **Tom Jacky**
NTSB
Fax: ([redacted]
Phone:

FROM: **Rick Howes**
Fax: ([redacted]
Phone
Home:

Tom,

Reference: Our telecon August 30, 1995

Per your request this morning, I have enclosed a copy of EWA 34-15039F revision C. This revision was written under the assumption that the wake vortex testing would be done in Seattle. Cost information will be submitted by our contracts department to Craig Keller for remote testing in Atlantic City. Please provide a copy of this EWA to Tom Haueter, Greg Phillips, Jim Cash, Craig Martin and others that you believe should have access to this information on a need to know basis.

Please contact me if you have any questions.

Thank you,

[redacted].

Rick Howes

EWA REVISION RECORD SHEET

EWA TITLE	EWA NUMBER	PAGE
Reduced Scope 727/737 Wake Encounter Flight Test	34-15039F	B1 OF 1

DATE REVISED	AFFECTED PAGES	DESCRIPTION OF CHANGE	APPROVAL AND DATE
	C1.	REVISION C	
7/24/95	1,2,5	Revised purpose and procedure of test to eliminate rudder control system measurements.	/S/ JE Wilborn 9U-UH
	2,5	Revised instrumentation list to reflect use of the FDR and PADS system for data measurement.	/S/ JW Kerrigan 9U-UH
	1,2,3,6,7	Added details of procedure for proof-of-concept flight testing of smoke generators on the 727.	[redacted] 7/27/95 KD Thoreson
	1,3,8,9 10,11,11a 11b,11c, 11d	Miscellaneous administrative changes.	/S/ JA McGrew

cc: All holders

X-24165 ORIG 11/83

EWA REVISION RECORD SHEET

EWA TITLE: Reduced Scope 727/737 Wake Encounter Flight Test	EWA NUMBER 34 -15039F	PAGE A1 of 1

DATE REVISED	AFFECTED PAGES	DESCRIPTION OF CHANGE	APPROVAL AND DATE
5/19/95	A1, 1, 2, 5	REVISION A Revised purpose and procedure of test to include rudder control system measurements	[redacted] Castelluccio
	2, 6, 10, 10a, 10b	Added autopilot turns, wheel & rudder combined rolls to conditions	[redacted] for R.W. Crouch
	2, 4, 5	Updated instrumentation list to include use of ADAMS system and additional parameters to support rudder control system testing	
	7	Added low speed condition to steady heading sideslips	
	2, 7, 8	Revised procedures to include yaw damper OFF conditions	[redacted] J.A. McGrew
		Change Charge No. to: 5-R9775-5421-15039F (FLT TEST SALCO# 7328320)	cc:all holders
7/7/95	A1, 1 2	REVISION B Add procedures for proof-of-concept testing of the 727 wingtip-mounted smoke generators. Change EWA Coordinator to: Mike Schultz, 237-7394, M/S 70-47	/S/ J.Metzer for J. McGrew 7/7/95 /S/ J.E.Wilborn 7/7/95 KD Thoreson cc: all holders

ROUTING WRITE IN NAME NOT INITIALS	DATE M/S
J. E. Wilborn	9U-UH 7/25/95
J. W. Kerrigan	9U-UH 7/25/95
R. S. Breuhaus	9U-UH
R. J. Halvarson	9U-UA
R. A. Woodling	74-38
S. Pennington	6X-3R
J. Kirk	9U-RF
JB Ballas	
W. K. Castelluccio	70-47
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J. W. Purvis	14-HM
D. W. Boston	1W-03
B. Predmore	6X-KU
E. Langhout	9U-RF
R. Crater	1W-03

MFG. SCHED OR AUTHOR

MFG. MGR. AUTHORIZATION

EWA NUMBER | DASH NO'S.

737 ENGINEERING WORK AUTHORIZATION NO. 34 | 15039F

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DATE 4/11/95

TO: R. J. Halvarson & G. J. Zanatta
(ENGINEER RESPONSIBLE FOR PROGRAM)

REVISIONS

REV./ AUTH	LTR	DATE
	A	5/19/95
	B	7/7/95
	C	7/24/95

TITLE: REDUCED SCOPE 727 / 737 WAKE ENCOUNTER FLIGHT TEST

PURPOSE:

The purposes of the testing are: 1) to determine the magnitude and severity of an upset to a 737 due to an encounter with the wake of a 727 for the purpose of validating and improving the wake encounter simulation model, and 2) to evaluate the sounds associated with a wake encounter for comparison with sounds on the Cockpit Voice Recorder on USAir 427, ~~and 3) to obtain data on the behavior of the rudder control system during normal flight operation.~~ C C C

PRIORITY:

URGENT

GENERAL DESCRIPTION

A 727 will be equipped with smoke generating devices near the wingtips to mark the wake vortices. It will be flown in descent configuration in calm air. A ~~partially instrumented~~ 737 equipped with a modified Flight Data Recorder (FDR) configured specifically for the wake encounter test program will follow at distances between 2 and 4 miles and penetrate the wake vortices from various angles. The dynamic response of the 737 will be measured for free responses, autopilot responses and pilot controlled responses. Cockpit sounds will be retrieved from the Cockpit Voice Recorder. A chase plane will film the encounters. C C

The data will be used to determine the qualitative characteristics of a wake-induced upset, and to validate the current 737 simulator wake encounter model. ~~Data on the rudder control system during normal flight operation will also be gathered.~~ C C

FAA CONFORMITY INSPECTION REQUIRED: NO X YES ____

DER: _____ DATE _____

IS THIS TEST PROPOSED AS A DER PROJECT? NO X YES ____

PHASE NO.	NAME OF PHASE	UNITS DOING WORK	SEE PAGES	
I	Smoke Generator Concept Testing	B-154R	7	C
II	Wake Encounter Testing	B-154R	8-10	C
III	Simulator Flaps 1 Database Correlation	B-154R	11-15	C

EWA PREPARED BY: James E. Wilborn, 237-9393, M/S 9U-UH, B-154R

CONTRACTUAL AUTHORITY FOR EXPENDITURES : 3167062 (SALCO NUMBER)

EWA COORDINATOR: Mike Schultz, 237-7394 C

SCHEDULE AND COST ESTIMATE AUTHORIZED BY: 5-R9775-5421-15039F (FLT TEST SALCO#7328320) A

CHARGE NO.: ~~5-R4521-3415-039F00 (FLT TEST SUST SALCO# 3490165)~~

	SCHEDULED	ACTUAL
TOTAL COST $		
TEST COMPLETION DATE		
REPORT COMPLETION DATE		

PROGRAM AUTHORIZED BY: [redacted]
J. A. McGrew
(Engineer responsible for Authorizing Work Under Applicable Contract)

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D. TEST PROCEDURE (cont'd)

Phase III: Simulator Flaps 1 Database Validation C

Some maneuvers will be flown in order to expand the current flaps 1 simulator database. The maneuvers to be flown are:

Rolls using wheel at three roll rates (yaw damper ON and OFF) A
Rolls using rudder at three roll rates (yaw damper ON and OFF)
Rolls using wheel and rudder at two roll rates (yaw damper ON and OFF) A
Steady sideslips to left and right using rudder and wheel (yaw damper ON and OFF)
Autopilot turns A

Procedures for the maneuvers are provided in Attachment 2.

Test Environment Requirements

Phases I and II require calm, stable air and good visibility. Light, steady winds of speeds below 15 kts are acceptable. Criteria for atmospheric lapse rate will be determined for the test. C

E. UNIT(S) RESPONSIBLE FOR TEST

Renton Aerodynamics Staff: Stability & Control, R.S. Breuhaus C

F. OBSERVERS REQUIRED

Three Aerodynamics Stability & Control Staff members and one Noise Staff member are required for this testing.

G. TEST REPORTS

All manual notes and PL&D's will be provided by Flight Test soon after the completion of testing. No formal flight test reports are required. Data should be made available as soon as is reasonably possible after each flight for analysis. A
Analysis of the Flight Data Recorder will be done by the Stability and Control group.

H. TEST INSPECTION REQUIRED

Normal flight test inspection procedures will be required. Prior to flight testing, the airplanes will be shown to satisfy all functional requirements as well as any supplementary inspections necessitated by configuration and hardware changes.

I. SPECIAL CONSIDERATIONS

The FAA owns a 727 that has been used previously in wake measurement flight tests, and at one time may have had smoke generating devices mounted for visualization. Consideration should be given to performing this testing jointly with the FAA in order to share the burdens of expense and to take advantage of all available resources. Use of the FAA 727 will preclude the need to lease or purchase a 727 from the fleet.

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ATTACHMENT 1. INSTRUMENTATION REQUIREMENTS

727 Instrumentation:

The following parameters should be recorded as specified on the 727 FDR (if possible):

Altitude	1 SPS
Airspeed	1 SPS
Pitch attitude (if available)	4 SPS
Bank angle (if available)	4 SPS
Heading	4 SPS
Normal load factor	8 SPS
Latitude (GPS if possible)	1 SPS
Longitude (GPS if possible)	1 SPS

The following parameters may be hand recorded and correlated with IRIG:

Flap handle position or flap position
Gear handle or gear position
Airplane gross weight
Center-of-gravity

737 Instrumentation

The following parameters should be recorded on the Flight Data Recorder at the specified minimum sample rates:

Airspeed	2 SPS
Altitude	1 SPS
Pitch attitude	4 SPS
Heading	4 SPS
Bank angle	4 SPS
Normal load factor	8 SPS
Longitudinal acceleration	8 SPS
Lateral acceleration	8 SPS
Control column position	4 SPS
Elevator deflection	4 SPS
Pedal position	4 SPS
Rudder deflection	4 SPS
Control wheel position	4 SPS
Aileron deflection	4 SPS
Stabilizer position	1 SPS
N1, left and right	1 SPS
Latitude (GPS if possible)	1 SPS
Longitude (GPS if possible)	1 SPS
Oustide air temperature	1 SPS
Autopilot A and B switch positions	1 SPS
Heading select push button	1 SPS
Level change push button	1 SPS
Altitude hold push button	1 SPS
LNAV and VNAV push buttons	1 SPS
MCP selected heading	1 SPS
MCP selected altitude	1 SPS
MCP selected airspeed	1 SPS
Autothrottle switch position	1 SPS
Autopilot commanded column force	1 SPS
Autopilot commanded wheel force	1 SPS
Autopilot commanded stabilizer trim	1 SPS

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ATTACHMENT 1. INSTRUMENTATION REQUIREMENTS (cont'd)

~~737 Instrumentation (cont'd)~~ C

~~The following analog parameters should be recorded from flight test instrumentation using the ADAMS system at 20 SPS:~~

~~Yaw damper position~~
~~Servo valve internal pressure near endcap~~
~~Hydraulic system A & B input and return pressures in PCU~~ C

The following parameters may be hand recorded and correlated with IRIG:

Flap handle or flap position
Gear handle or gear position
Airplane gross weight
Center-of-gravity
Airplane moments-of-inertia

Any digital parameters should also be recorded at 20 samples per second using the PADS instrumentation system. C

A forward-looking video camera will be mounted in the cockpit which provides a view of both pilots and the view out the front windows. If possible, cameras will also be mounted on the 737 wingtips and on the tip of the vertical tail. All video will be synchronized with FDR time to enable correlation of the wake's position with the aircraft's time history response. Pilot comments and cockpit area sounds will be recorded in conjunction with the cockpit video system. If possible, the Cockpit Voice Recorder information for the whole flight should be available, if provisions can be made to exchange recorders in-flight or download the information from the recorders in some other way.

~~In addition, a video camera will be mounted internally in the vertical tail torque box with a field of view encompassing the rudder PCU, rudder rods and PCU input rods and summing levers.~~ C C

Chase Plane Instrumentation

Video equipment

ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES

The test conditions and procedures for the 3 phases of this test are outlined in the following sections. All 737 configurations will be flown at flaps 1, mid C.G. with the gear retracted. All 727 configurations will be flown at flaps up with the gear retracted. C

PHASE I: SMOKE GENERATOR CONCEPT TESTING C

C

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ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd) C

PHASE I: SECTION 1

Test Title: Smoke Observation from Chase Plane

Objective: Determine maximum following distance behind the 727 at which the smoke adequately highlights the wake vortices; determine which fuel(s) can be used for combustion in the smoke generators to provide adequate smoke for test purposes.

727 Configuration:

Cond No.	Weight (lbs)	C.G. (%MAC)	Flaps / Gear	Thrust	Altitude (ft)	Trim Vc
1	Optional	Mid	UP / UP	TLF	6K	190
2	X	X	X	X	10K	190

Procedure:

(a) For each condition, trim the 727 in straight and level flight. Using TCAS or ground based radar, position the chase plane 2 miles behind the 727, on the same flight track, at an altitude 500-1000 feet below that indicated for the 727. The pilot should use discretion in the altitude setup; the intention is to be just below the wake of the 727.

(b) Once the aircraft have been positioned properly, engage both smoke generators on the 727. Allow the smoke to run for four minutes, then disengage. During smoke emission maintain the trim speed and altitude.

(c) The chase plane pilot should obtain a good visual contact with the smoke-highlighted wake vortices, and then begin widening the following distance from the 727. Distance measurements should be obtained from TCAS or ground based radar and correlated with wake visual clarity. The pilot should also make comments on any differences between the left and right vortex visualization, as each side will be generated using different combustion fuels. Continue widening the following distance up to five miles.

(d) Next, fly to a following distance along the trail where the pilot has a good visualization of the vortices, and note the following distance. The pilot may then, at his discretion, attempt to penetrate the smoke trail to locate the wake cores and assess the relative difficulty of flying in various points in the wake, as well as to confirm that the wake effects are measurable when the visualization appears adequate.

(e) Discontinue when the smoke visualization trail terminates, or at any point if the pilot feels the maneuvering may become hazardous. C

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ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE II: SECTION 1 C

Test Title: Wake Encounter Testing C

Objective: Measure the dynamic response of a 737 encounter with a 727 wake C

All wake penetrations will be flown heading directly upwind or downwind. The 727 will be at flaps up and the 737 at flaps 1. Both aircraft will have the gear retracted and will fly at 190 KCAS. The 737 will attempt to maintain a separation of 2 to 4 miles behind the 727. Set-up position and intercept parameters are described in Figure 1 of this attachment.

As a safety guideline, wake encounters will first be flown at a minimum of 10,000 ft above the terrain until more understanding of the wake effects on the aircraft is available. Later flights will be flown at lower altitudes to better simulate the atmospheric conditions of the accident scenario, if it is determined by the pilots that such flying will not impose any hazards.

The following parameters are for pilot reference only as guidelines for setting up various entry scenarios through the wake. Piloted simulator sessions will be conducted prior to the testing to determine the feasibility of these setup scenarios.

Note: The random nature of the wake and the difficulty in flying the encounters may necessitate several attempts for each condition to achieve a satisfactory encounter response.

Cond. No.	727 Flight Mode	Initial Offset (FT)	Altitude Differential (FT)	Intercept Heading (DEG)	Comments
1	Level	500 L	0	5°	Direct intercept
2	X	1000 L	X	10°	Direct intercept
3	X	0	-100	0°	Approach from below
4	X	500 L	TBD	5°	Turn onto right core
5	-3°	500 L	TBD	5°	Turn onto right core
6	-3°	0	-100	0°	Approach from below
7	Level	500 L	-100	0°	Right wing in left core
8	X	500 R	-100	0°	Left wing in right core
9	X	40 R	-100	0°	Vertical tail in right core

Conditions 1-6

Procedure:

(a) Set up the aircraft at the specified position relative to the wake. Yaw damper ON. Perform the first wake encounter by flying the aircraft into the wake as specified and then releasing the controls upon entering the wake. Record the free response of the aircraft. After exiting the wake return to straight and level flight.

(b) Repeat step (a) without releasing the controls upon entering the wake (i.e., control the aircraft through the encounter). After exiting the wake return to straight and level flight.

(c) Repeat step (a) using the autopilot to set up the intercept. Allow the autopilot to attempt to control the aircraft roll response through the maneuver. After exiting the wake disconnect the autopilot and return to straight and level flight.

(d) Repeat step (a) using the autopilot to set up the intercept. Upon entering the wake, control the aircraft roll response without disengaging the autopilot (i.e., in CWS mode). After exiting the wake disconnect the autopilot and return to straight and level flight.

ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE II: SECTION 1

Test Title: Wake Encounter Testing (cont'd)

Conditions 7-9

Procedure:

(a) Trim the aircraft at the specified condition. Yaw damper ON.

(b) With the autopilot OFF, approach the wake from the specified direction and attempt to hold the aircraft steady in the wake as specified, using all controls as necessary.

(c) Repeat with the autopilot ON and the airplane in CWS mode.

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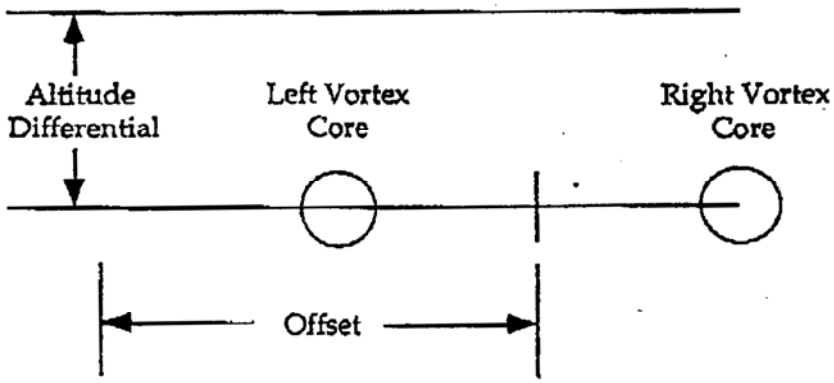
ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE II: SECTION 1 C

Test Title: Wake Encounter Testing (cont'd) C



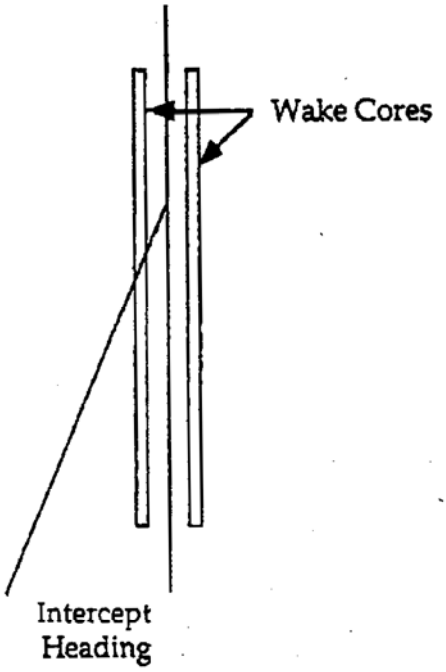


FIGURE 1. Intercept parameter definitions

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ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE I: SECTION 5

Test Title: Autopilot turns

Objective: Provide autopilot turn data for comparison with the accident aircraft.

Cond No.	Weight (lbs)	C.G. (%MAC)	Flaps / Gear	Thrust	Altitude (ft)	Trim Vc	Autopilot Mode
1	Optional	Mid	1 / UP	TLF	6K	190	Heading Select
2	X	X	X	X	X	X	LNAV

Procedure:

(a) For condition 1 trim the aircraft in hands-off straight and level flight as specified. Record trim data for 20 seconds.

(b) Make sure the yaw damper is ON. Engage the "A" autopilot and the autothrottle to maintain 6000 ft and 190 knots. With Heading Select mode disengaged, dial in a 40° heading change. Set the autopilot bank limit at 15°.

(c) Engage Heading Select and perform an autopilot turn. End condition 20 seconds after airplane has stabilized on its new heading.

(d) Disengage Heading Select. Dial in an additional 40° heading change in the same direction as the first turn, if airspace and ATC allow.

(e) Engage the LNAV mode and perform the autopilot turn. End condition 20 seconds after airplane has stabilized on its new heading.

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ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE II: WAKE ENCOUNTER TESTING

All wake penetrations will be flown heading directly upwind or downwind. The 727 will be at flaps up and the 737 at flaps 1. Both aircraft will have the gear retracted and will fly at 190 KCAS. The 737 will attempt to maintain a separation of 2 to 4 miles behind the 727. Set-up position and intercept parameters are described in Figure 1 of this attachment.

As a safety guideline, wake encounters will first be flown at a minimum of 10,000 ft above the terrain until more understanding of the wake effects on the aircraft is available. Later flights will be flown at lower altitudes to better simulate the atmospheric conditions of the accident scenario, if it is determined by the pilots that such flying will not impose any hazards.

The following parameters are for pilot reference only as guidelines for setting up various entry scenarios through the wake. Piloted simulator sessions will be conducted prior to the testing to determine the feasibility of these setup scenarios.

Note: The random nature of the wake and the difficulty in flying the encounters may necessitate several attempts for each condition to achieve a satisfactory encounter response.

Cond. No.	727 Flight Mode	Initial Offset (FT)	Altitude Differential (FT)	Intercept Heading (DEG)	Comments
1	Level	500 L	0	5°	Direct intercept
2	X	1000 L	X	10°	Direct intercept
3	X	0	-100	0°	Approach from below
4	X	500 L	TBD	5°	Turn onto right core
5	-3°	500 L	TBD	5°	Turn onto right core
6	-3°	0	-100	0°	Approach from below
7	Level	500 L	-100	0°	Right wing in left core
8	X	500 R	-100	0°	Left wing in right core
9	X	40 R	-100	0°	Vertical tail in right core

Conditions 1-6

Procedure:

(a) Set up the aircraft at the specified position relative to the wake. Yaw damper ON. Perform the first wake encounter by flying the aircraft into the wake as specified and then releasing the controls upon entering the wake. Record the free response of the aircraft. After exiting the wake return to straight and level flight.

(c) Repeat step (a) without releasing the controls upon entering the wake (i.e., control the aircraft through the encounter). After exiting the wake return to straight and level flight.

(d) Repeat step (a) using the autopilot to set up the intercept. Allow the autopilot to attempt to control the aircraft roll response through the maneuver. After exiting the wake disconnect the autopilot and return to straight and level flight.

(e) Repeat step (a) using the autopilot to set up the intercept. Upon entering the wake, control the aircraft roll response without disengaging the autopilot (i.e., in CWS mode). After exiting the wake disconnect the autopilot and return to straight and level flight.

Conditions 7-9

Procedure:

(a) Trim the aircraft at the specified condition. Yaw damper ON.

(b) With the autopilot OFF, approach the wake from the specified direction and attempt to hold the aircraft steady in the wake as specified, using all controls as necessary.

(c) Repeat with the autopilot ON and the airplane in CWS mode.

ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE III: SECTION 1 C

Test Title: Steady heading sideslips

Objective: Evaluate cross-controlled flight characteristics.

Cond No.	Weight (lbs)	C.G. (%MAC)	Flaps / Gear	Thrust	Altitude (ft)	Trim Vc	
1	Optional	Mid	1 / UP	TLF	5-10K	V_2	A
2	X	X	X	X	X	170	
3	X	X	X	X	X	190	
4	X	X	X	X	X	210	
5	X	X	X	X	X	230	

Procedure:

(a) For each condition, trim the aircraft in hands-off straight and level flight as specified. Record trim data for 20 seconds.

(b) Perform steady state sideslips to the left using 1/3, 2/3, and full rudder (or use the maximum rudder that can be controlled with full wheel, if applicable). Trim with wheel and bank angle to maintain a constant heading and airspeed without changing thrust. Stabilize at each rudder deflection and record data for 10-20 seconds.

(c) Return to straight and level flight. Repeat condition to the right.

(d) Return to the hands-off trim in (a). Record trim data for 20 seconds.

(e) Repeat each condition with the yaw damper OFF. A

ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE III: SECTION 2 C

Test Title: Roll responses using wheel

Objective: Evaluate lateral control power.

Cond No.	Weight (lbs)	C.G. (%MAC)	Flaps / Gear	Thrust	Altitude (ft)	Trim Vc	Wheel
1	Optional	Mid	1 / UP	TLF	6-10K	190	1/3
2	X	X	X	X	X	X	2/3
3	X	X	X	X	X	X	Full

Procedure:

(a) For each condition, trim the aircraft in hands-off straight and level flight as specified. Record trim data for 20 seconds.

(b) With the yaw damper ON, roll the aircraft into a 30° bank to the left and stabilize using the wheel.

(c) Roll the aircraft from 30° left to 60° right bank using the specified amount of wheel for the condition.

(d) Roll back to 30° right bank and stabilize. Input the specified amount of wheel for the condition in the opposite direction and roll the aircraft from 30° right to 60° left bank. Roll the aircraft back to wings level flight.

(e) Return to the hands-off trim specified in (a). Record trim data for 20 seconds.

(f) Repeat each condition with the yaw damper OFF. A

ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE III: SECTION 3 C

Test Title: Roll responses using rudder

Objective: Evaluate rudder power and roll-due-to-sideslip characteristics.

Cond No.	Weight (lbs)	C.G. (%MAC)	Flaps / Gear	Thrust	Altitude (ft)	Trim Vc	Rudder*
1	Optional	Mid	1 / UP	TLF	6-10K	190	1/4
2	X	X	X	X	X	X	1/2
3	X	X	X	X	X	X	3/4
4**	X	X	X	X	X	X	1/2

Procedure:

(a) For each condition trim the aircraft in hands-off straight and level flight as specified. Record trim data for 20 seconds.

(b) Make sure the yaw damper is ON. Using the wheel to maintain wings level and while holding the pedals centered with the feet, input the amount of rudder specified *to the right* for each condition using the rudder trim knob. After stabilizing, use wheel to roll the aircraft into a 30° bank to the left and stabilize.

(c) When stable, release the pedals and roll the aircraft from 30° left to 30° right bank. Allow the aircraft to roll through 30° right bank, and then stop the roll using wheel and pedals as needed. After recovery, and with the pedals centered, return rudder trim to neutral and roll the airplane to wings level flight.

(d) Repeat steps (b)-(c) for a left rudder input and rolling from 30° right bank to 30° left bank. Again use wheel and pedals to recover after passing 30° left bank, and return rudder trim to neutral after centering the pedals.

(e) Return to the hands-off trim in (a). Record trim data for 20 seconds.

(f) Repeat steps (a) - (e) for each condition, turning the yaw damper OFF after stabilizing at the initial 30° bank in (b) or (d) before releasing the pedals.

(g)** For condition 4 only, roll the aircraft by using the rudder only to establish the initial 30° bank before each pedal release.

* Use the maximum rudder determined in Phase I Section 1 part (b) as the value for "full rudder" when determining the 1/4, 1/2 and 3/4 rudder inputs.

ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE III: SECTION 4 C

Test Title: Roll responses using wheel and rudder A

Objective: Evaluate roll rate due to wheel and rudder input combinations.

Cond No.	Weight (lbs)	C.G. (%MAC)	Flaps / Gear	Thrust	Altitude (ft)	Trim Vc	Wheel	Rudder*
1	Optional	Mid	1 / UP	TLF	10K	190	1/4 Right	1/4 Left
2	X	X	X	X	X	X	1/2 Right	1/2 Left
3	X	X	X	X	X	X	1/4 Left	1/4 Left
4	X	X	X	X	X	X	1/2 Left	1/2 Left

Conditions 1-2: Cross controlled roll rate

Procedure:

(a) For condition 1 trim the aircraft in hands-off straight and level flight as specified. Record trim data for 20 seconds.

(b) Make sure the yaw damper is ON. Using the wheel to maintain wings level and while holding the pedals centered with the feet, input the amount of rudder specified for each condition using the rudder trim knob.

(c) Release the pedals and simultaneously input the specified amount of wheel and allow the aircraft to roll to 30° of left or right bank, depending upon the control input configuration. After rolling through 30°, center the pedals with the feet and arrest the roll with wheel.

(d) Return to level flight, maintaining wings level with wheel and holding the rudder pedals centered. Repeat steps (b) and (c) using the amount of wheel and rudder specified for condition 2.

(e) When complete, return the rudder trim to neutral and trim the aircraft as specified in (a). Record trim data for 20 seconds.

Conditions 3-4: Wheel and rudder combined roll rate

Procedure:

(a) For condition 3 trim the aircraft in hands-off straight and level flight as specified. Record trim data for 20 seconds.

(b) Make sure the yaw damper is ON. Using the wheel to maintain wings level and while holding the pedals centered with the feet, input the amount of rudder specified for each condition using the rudder trim knob. Roll the aircraft using the wheel to a 30° right bank and stabilize.

(c) Release the pedals and simultaneously input the specified amount of wheel and allow the aircraft to roll to 30° of left bank. After rolling through 30°, center the pedals with the feet and arrest the roll with wheel.

(d) Return to level flight, maintaining wings level with wheel and holding the rudder pedals centered. Repeat steps (b) and (c) using the amount of wheel and rudder specified for condition 4.

(e) When complete, return the rudder trim to neutral and trim the aircraft as specified in (a). Record trim data for 20 seconds. A

ATTACHMENT 2. TEST CONDITIONS AND PROCEDURES (cont'd)

PHASE III: SECTION 5 C

Test Title: Autopilot turns A

Objective: Provide autopilot turn data for comparison with the accident aircraft.

Cond No.	Weight (lbs)	C.G. (%MAC)	Flaps / Gear	Thrust	Altitude (ft)	Trim Vc	Autopilot Mode
1	Optional	Mid	1 / UP	TLF	6K	190	Heading Select
2	X	X	X	X	X	X	LNAV

Procedure:

(a) For condition 1 trim the aircraft in hands-off straight and level flight as specified. Record trim data for 20 seconds.

(b) Make sure the yaw damper is ON. Engage the "A" autopilot and the autothrottle to maintain 6000 ft and 190 knots. With Heading Select mode disengaged, dial in a 40° heading change. Set the autopilot bank limit at 15°.

(c) Engage Heading Select and perform an autopilot turn. End condition 20 seconds after airplane has stabilized on its new heading.

(d) Disengage Heading Select. Dial in an additional 40° heading change in the same direction as the first turn, if airspace and ATC allow.

(e) Engage the LNAV mode and perform the autopilot turn. End condition 20 seconds after airplane has stabilized on its new heading. A

4. Special Airworthiness Certificate Application and Operating Limitations

U.S. Department of Transportation
Federal Aviation Administration

Transport Airplane Directorate
Aircraft Certification Service
1601 Lind Avenue, S.W.
Renton, Washington 98055-4056

BOEING COMMERCIAL AIRPLANE GROUP
EXPERIMENTAL OPERATING LIMITATIONS

These operating limitations form a part of the Special Airworthiness Certification issued for the aircraft described below, and must be displayed in the aircraft in accordance with 14 Code of Federal Regulations (CFR) part 91.203(b).

MAKE: Boeing **MODEL**: 737-3B7 **SERIAL NO.**: 24515 **REG. NO.**: N533AU

1. No person may operate this aircraft for other than the purpose of:

RESEARCH and DEVELOPMENT

to accomplish the test (s) outlined in Boeing Program Letter B-XF04-WMB-077 dated September 15, 1995 describing compliance with 14 CFR part 21.193(d), and made available to the pilot in the aircraft. Additionally, this aircraft shall be operated in accordance with applicable air traffic and general operating rules of 14 CFR Part 91, and all additional limitations herein prescribed under the provisions of 14 CFR 91.319(e).

2 When conducting the flight test, the airplane may be deployed anywhere within the Continental United States and adjacent coastal waters, but operation must be limited to areas consistent with the purpose of the flight in accordance with the Operating Limitations. Except for takeoff and landing, this aircraft shall not be operated over densely populated areas or in congested airways.

3. The pilot-in-command of this aircraft must, as applicable, hold an appropriate category/class rating, have a large multiple jet aircraft rating, or possess a "Letter of Authorization" issued by the FAA Flight Standards Operations Inspector.

4. This aircraft shall not be flown unless it is maintained and operated in accordance with the appropriate Boeing Maintenance Instructions.

5. Day/Night VFR and IFR Operation is authorized.

BOEING COMMERCIAL AIRPLANE GROUP
EXPERIMENTAL OPERATING LIMITATIONS

MAKE: Boeing **MODEL**: 737-3B7 **SERIAL NO.**: 24515 **REG. NO.**: N533AU

7. This aircraft shall contain the placards, markings, and flight manual required by 14 CFR part 91.9.

8. The cognizant FAA Manufacturing Inspection District Office must be notified and their response received in writing, prior to flying this aircraft after incorporating a major change as defined by 14 CFR part 21.93.

9. If aircraft, engine or propeller operating limitations are exceeded, an appropriate entry will be made in the historical records.

10. The aircraft does not meet the requirements of the applicable comprehensive and detailed airworthiness code as provided by Annex 8 to the convention on International Civil Aviation. This aircraft may not be operated over any foreign country without the special permission of that country.

11. **The pilot-in-command shall read and understand the operating limitations specified for this aircraft and make an entry in the aircraft flight log signifying compliance with this limitation.**

12. These operating limitations expire concurrently with the Special Airworthiness Certificate on **October 31, 1995.**

[redacted] ASI	September 18, 1995	ANM-108S
Name	Date	Designation or Office

Boeing Commercial Airplane Group
P.O. Box 3707
Seattle, WA 98124-2207

September 15, 1995
B-XF04-WMB-M95-077

Department of Transportation
Federal Aviation Administration
1601 Lind Avenue SW
Renton, WA 98055-4056

BOEING

Attention: Carl Pike, Manager
Manufacturing Inspection District Office

Subject: Application for Special Airworthiness Certificate -
Model 737-3B7, PP053

Reference: FAR 21.193

Gentlemen:

Enclosed is a completed FAA Form 8130-6, Application for Special Airworthiness Certificate, for the following airplane:

Model	S/N	Registration
737-3B7	24515	N533AU

The following information is submitted in accordance with the referenced FAR, as noted:

The certificate is required for the purpose Research and Development. [FAR 21.193(a)]

The airplane is a Boeing model 737, as listed in Type Certificate Data Sheet No. A16WE. [FAR 21.193(b)]

The airplane will be used for the purpose of wake vortex encounter flight testing. Approximately 10 flights are currently planned. During conduct of this testing the airplane may be deployed anywhere within the continental United States and adjacent coastal waters. Flights into foreign airspace will be with the specific approval of the foreign government. [FAR 21.193(d)]

Records of the persons carried will be maintained and made available to the FAA upon request.

The airplane is owned by USAir, but will be flown by Boeing flight crews under contractual agreement with USAir.

The certificate is requested to be issued effective September 18, 1995, with an expiration date of October 31, 1995.

BOEING

The airplane is located and is based at Boeing Field and will be available for your inspection at a time convenient to you and your staff.

Very truly yours,

FLIGHT TEST

[redacted]

for William M. Broadhurst
Supervisor
FAA Coordination

GEW:km

Enclosure

Form Approved
O.M.B. No. 2120-0018

US Department of Transportation
Federal Aviation Administration

APPLICATION FOR AIRWORTHINESS CERTIFICATE

INSTRUCTIONS — Print or type. Do not write in shaded areas; these are for FAA use only. Submit original only to an authorized FAA Representative. If additional space is required, use an attachment. For special flight permits complete Sections II and VI or VII as applicable.

I. AIRCRAFT DESCRIPTION

1. REGISTRATION MARK	2. AIRCRAFT BUILDER'S NAME (Make)	3. AIRCRAFT MODEL DESIGNATION	4. YR MFR	FAA CODING
N533AU	Boeing	737-3B7	1989	
5. AIRCRAFT SERIAL NO	**6. ENGINE BUILDER'S NAME (Make)**	**7. ENGINE MODEL DESIGNATION**		
24515	CFM International	CFM56-3		
8. NUMBER OF ENGINES	**9. PROPELLER BUILDER'S NAME (Make)**	**10. PROPELLER MODEL DESIGNATION**	**11. AIRCRAFT IS (Check if applicable)**	
2	N/A	N/A	IMPORT	

II. CERTIFICATION REQUESTED

APPLICATION IS HEREBY MADE FOR: (Check applicable items)

A	1		STANDARD AIRWORTHINESS CERTIFICATE (Indicate category)		NORMAL		UTILITY		ACROBATIC		TRANSPORT		GLIDER		BALLOON
B		XX	SPECIAL AIRWORTHINESS CERTIFICATE (Check appropriate items)												
	2		LIMITED												
	5		PROVISIONAL (Indicate class)	1		CLASS I									
				2		CLASS II									
	3		RESTRICTED (Indicate operations to be conducted)	1		AGRICULTURE AND PEST CONTROL	2		AERIAL SURVEYING	3		AERIAL ADVERTISING			
				4		FOREST (Wildlife conservation)	5		PATROLLING	6		WEATHER CONTROL			
				7		CARRIAGE OF CARGO	0		OTHER (Specify)						
	4	XX	EXPERIMENTAL (Indicate operations to be conducted)	1	XX	RESEARCH AND DEVELOPMENT	2		AMATEUR BUILT	3		EXHIBITION			
				4		RACING	5		CREW TRAINING			MKT. SURVEY			
				0		TO SHOW COMPLIANCE WITH FAR									
	8		SPECIAL FLIGHT PERMIT (Indicate operation to be conducted, then complete Section VI or VII as applicable on reverse side)	1		FERRY FLIGHT FOR REPAIRS, ALTERATIONS, MAINTENANCE OR STORAGE									
				2		EVACUATE FROM AREA OF IMPENDING DANGER									
				3		OPERATION IN EXCESS OF MAXIMUM CERTIFICATED TAKE-OFF WEIGHT									
				4		DELIVERING OR EXPORT	5		PRODUCTION FLIGHT TESTING						
				6		CUSTOMER DEMONSTRATION FLIGHTS									
C	6		MULTIPLE AIRWORTHINESS CERTIFICATE (Check ABOVE "Restricted Operation" and "Standard" or "Limited," as applicable.)												

III. OWNER'S CERTIFICATION

A. REGISTERED OWNER (As shown on certificate of aircraft registration) — IF DEALER, CHECK HERE →

NAME: Wilmington Trust Company Trustee

ADDRESS: Rodney Square North
Wilmington, DE 19890

B. AIRCRAFT CERTIFICATION BASIS (Check applicable blocks and complete items as indicated)

AIRCRAFT SPECIFICATION OR TYPE CERTIFICATE DATA SHEET (Give No. and Revision No.): A16WE	AIRWORTHINESS DIRECTIVES (Check if all applicable AD's complied with and give latest AD No.): 94-21-05 Rev. 1
AIRCRAFT LISTING (Give page number(s)): N/A	SUPPLEMENTAL TYPE CERTIFICATE (List number of each STC incorporated): See Attached

C. AIRCRAFT OPERATION AND MAINTENANCE RECORDS

CHECK IF RECORDS IN COMPLIANCE WITH FAR XXXX 91.417 AEW	TOTAL AIRFRAME HOURS	3	EXPERIMENTAL ONLY (Enter hours flown since last certificate issued or renewed)
	20,994 + 22		-0-

D. CERTIFICATION — I hereby certify that I am the registered owner (or his agent) of the aircraft described above, that the aircraft is registered with the Federal Aviation Administration in accordance with Section 501 of the Federal Aviation Act of 1958, and applicable Federal Aviation Regulations, and that the aircraft has been inspected and is airworthy and eligible for the airworthiness certificate requested.

DATE OF APPLICATION	NAME AND TITLE (Print or type)	SIGNATURE
September 15, 1995	G. E. Wingo FAA Coordination Boeing Flight Test	[redacted]

IV. INSPECTION AGENCY VERIFICATION

A. THE AIRCRAFT DESCRIBED ABOVE HAS BEEN INSPECTED AND FOUND AIRWORTHY BY (Complete appropriate section(s) if FAR 21.183(c) applies)

2	FAR PART 121 OR 127 CERTIFICATE HOLDER (Give Certificate No.)	3	CERTIFICATED MECHANIC (Give Certificate No.)	6	CERTIFICATED REPAIR STATION (Give Certificate No.)
5	AIRCRAFT MANUFACTURER (Give name of firm)				

DATE	TITLE	SIGNATURE

V. REPRESENTATIVE CERTIFICATION

(Check ALL applicable blocks in items A and B)

A. I find that the aircraft described in Section I or VII meets requirements for: ☑ THE CERTIFICATE REQUESTED; 4 ☐ AMENDMENT OR MODIFICATION OF CURRENT AIRWORTHINESS CERTIFICATE

B. Inspection for a special flight permit under Section VII was conducted by: ☐ FAA INSPECTOR; ☐ FAA DESIGNEE; ☐ CERTIFICATE HOLDER UNDER; ☐ FAR 65; ☐ FAR 121, 127 or 135; ☐ FAR 145

DATE	DISTRICT OFFICE	4	DESIGNEE'S SIGNATURE AND NO.	1	FAA INSPECTOR'S SIGNATURE
9/18/95	AAM-108S				[redacted]

FAA Form 8130-6 (11-88) SUPERSEDES PREVIOUS EDITION

Enclosure to B-XF04-WMB-M95-077

Supplemental Type Certificates applicable to USAir aircraft N533AU (S/N 24515)

SA2725SO
SA553NE
SA6081NM
SA2065SO
SA3443NM
SA2401SO
SA2455SO