NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Washington, D.C. 20594

September 15, 2003

Rudder Pedal Ground Tests Study Addendum 3 to the Flight Data Recorder Group Chairman's Solid State Flight Data Recorder Factual Report

A. EVENT

NTSB #: DCA02MA001
Location: Belle Harbor, New York
Date: November 12, 2001
Time: 0916 Eastern Standard Time (EST)
Aircraft: Airbus Industrie A300-600, registration: N14053

B. PURPOSE

The main purpose of the rudder pedal sensor ground tests was to establish the linearity of the rudder pedal position sensor installed in the accident aircraft. During the readout of N14053's FDR, it was determined that the conversion equation supplied by American Airlines for the rudder pedal position FDR parameter was not correct. Using N14053's FDR data, a new rudder pedal position conversion was established[1] but it was necessary to establish the linearity of the rudder pedal position sensor. Therefore, three separate rudder pedal ground tests were performed on the same make and model aircraft as the accident aircraft along with the same rudder pedal position sensor installation. All three rudder pedal sensor ground tests occurred at American Airlines' Maintenance Facility in Tulsa, Oklahoma on three different aircraft (refer to Table 1). All parties to the investigation had the opportunity to participate in each rudder pedal ground test.

Rudder Pedal Ground Test Number	Date of Test	Aircraft Type	Aircraft Identification
1	February 1, 2002	Airbus Industrie A300-600	N33069
2	May 8, 2002	Airbus Industrie A300-600	N70073
3	May 22, 2002	Airbus Industrie A300-600	N7062A

Table 1

This report includes test data from the May 8 and May 22, 2002 tests but not from the February 1, 2002[2] test. In addition, this report focuses only on establishing the linearity of the rudder pedal position sensor, whereas, the February 1, 2002 FDR Rudder Pedal & Rudder Surface Sensors Ground Test Study also included details on the relationship between

[1] Refer to the Flight Data Recorder Group Chairman's Solid State Flight Data Recorder Factual Report for more information on the new rudder pedal position conversion equation.
[2] Refer to the February 1, 2002 FDR Rudder Pedal & Rudder Surface Sensors Ground Test Study for details on the February 1, 2002 test.

the rudder pedal position and the rudder surface position under static and dynamic conditions and verifies the rudder surface position conversion algorithm.

C. ANALYSIS

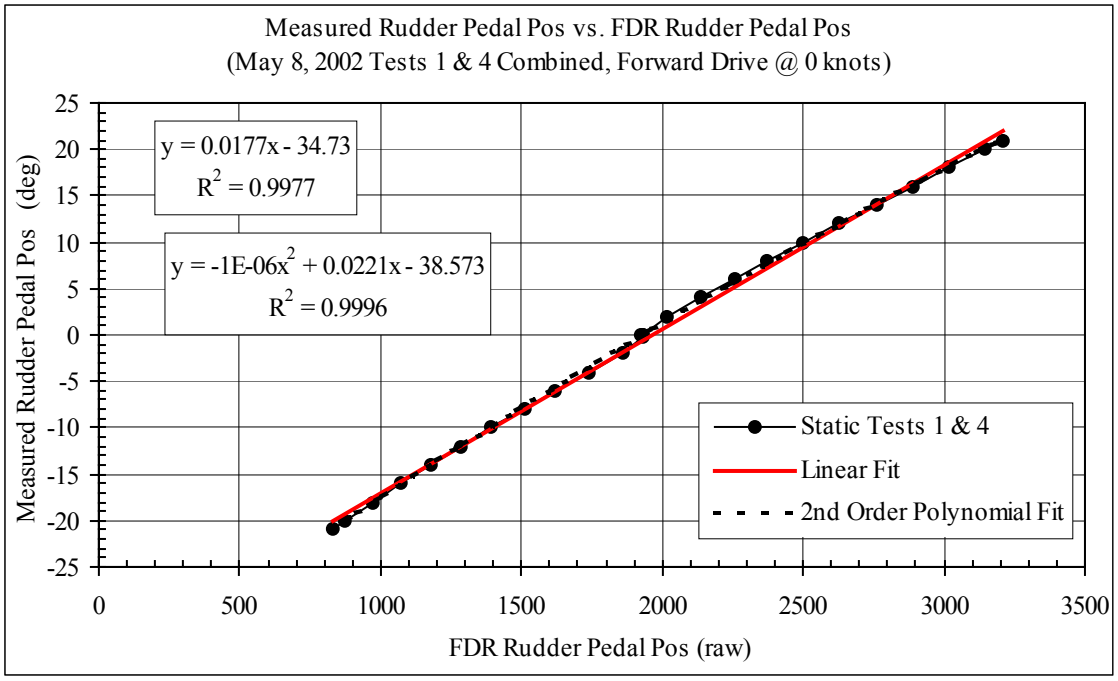
The following graphs and tables are the combined results of Tests 1 and 4 for both the May 8 and May 22 tests. Tests 1 and 4 calibrated the full range of motion of the rudder pedals under static conditions by using the right and left First Officer's rudder pedals. The right rudder pedal values were given positive values and the left rudder pedal values were given negative values.

The linear relationship between the observed clinometer readings and the corresponding FDR rudder pedal decimal values were evaluated using Microsoft Excel Trendline calculations. Excel Trendline "linear" and "2nd order polynomial" regressions were used to calculate the coefficient of determination (R^2), which will lie between 0 and 1 and will indicate how closely the derived equation fits the test data. The closer R^2 is to 1, the better the fit. Excel Trendline solves for the coefficients a0 and a1 in the linear regression equation $y = (a1)(x) + (a0)$, where y=rudder pedal angle and x=FDR rudder pedal decimal value and similarly for the coefficients a0, a1, and a2 for the equation $y = (a2)(x^2)+ (a1)(x) + (a0)$ in the 2nd order polynomial regression equation.

Graph 1 presents the resulting Trendlines from the May 8 test. The coefficients and R^2 for the linear and 2nd order curve fits are as follows:

Linear: a1 = 0.0177 and a0 = -34.73 with $R^2 = 0.9977$;

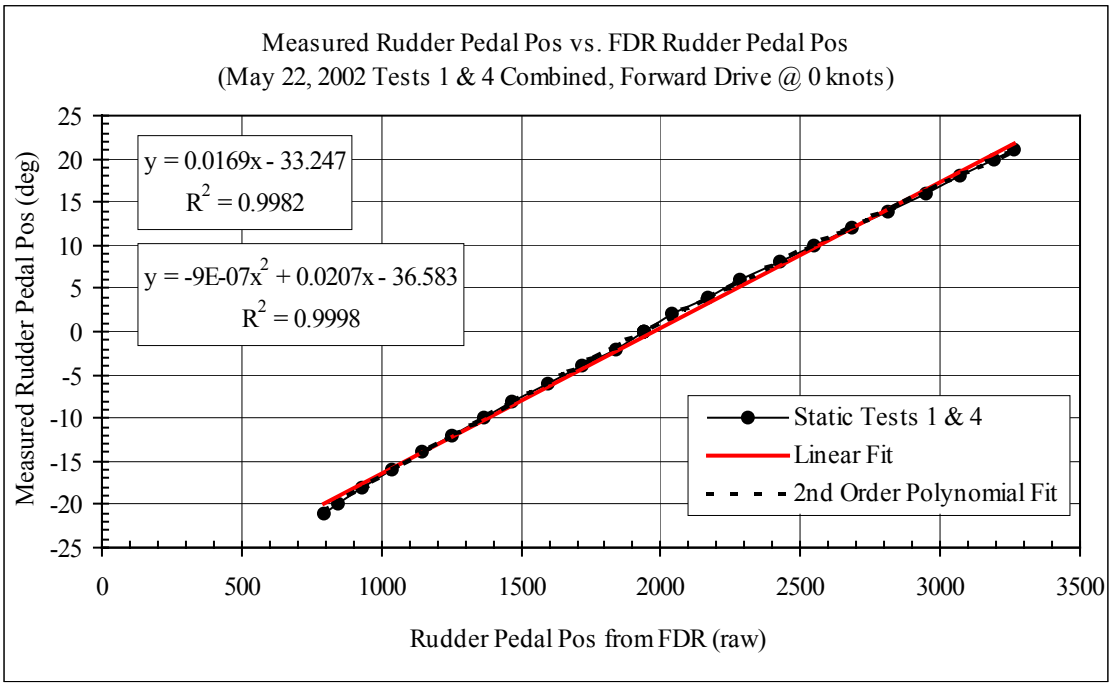
2nd Order: a2 = -1e-06, a1 = 0.0221, and a0 = -38.573 with $R^2 = 0.9996$.



Graph 1: May 8, 2002 Rudder Pedal Test

Graph 2 presents the resulting Trendlines from the May 22 test. The coefficients and R^2 for the linear and 2nd order curve fits are as follows:

Linear: a1 = 0.0169 and a0 = -33.247 with R^2 = 0.9982;
2nd Order: a2 = -9e-07, a1 = 0.0207, and a0 = -36.583 with R^2 = 0.9998.



Graph 2: May 22, 2003 Rudder Pedal Test

The FDR rudder pedal position (x) test data were applied to the linear and 2nd order regression conversion algorithms and the results are presented in Tables 2 and 3 for both the May 8 and May 22 rudder pedal tests, respectively.

May 8 Rudder Pedal Test 4				**May 8 Rudder Pedal Test 1**			
FDR Rudder Pedal Pos (raw)	Measured Rudder Pedal Pos (deg)	Rudder Pedal Pos using Linear Fit	Rudder Pedal Pos using 2nd Order Polynomial Fit	FDR Rudder Pedal Pos (raw)	Measured Rudder Pedal Pos (deg)	Rudder Pedal Pos using Linear Fit	Rudder Pedal Pos using 2nd Order Polynomial Fit
832	-21	-20.00	-20.88	1925	0	-0.66	0.26
874	-20	-19.26	-20.02	1934	0	-0.50	0.43
972	-18	-17.53	-18.04	2015	2	0.94	1.90
1071	-16	-15.77	-16.05	2135	4	3.06	4.05
1182	-14	-13.81	-13.85	2257	6	5.22	6.21
1286	-12	-11.97	-11.81	2373	8	7.27	8.24
1389	-10	-10.14	-9.81	2500	10	9.52	10.43
1513	-8	-7.95	-7.42	2629	12	11.80	12.62
1617	-6	-6.11	-5.45	2764	14	14.19	14.87
1736	-4	-4.00	-3.22	2889	16	16.41	16.93
1859	-2	-1.83	-0.94	3019	18	18.71	19.03
1931	-0.2	-0.55	0.37	3147	20	20.97	21.07
1933	0	-0.52	0.41	3206	21	22.02	22.00

Table 2: May 8, 2002 Rudder Pedal Test

May 22 Ruder Pedal Test 4				May 22 Rudder Pedal Test 1			
FDR Rudder Pedal Pos (raw)	Measured Rudder Pedal Pos (deg)	Rudder Pedal Pos using Linear Fit	Rudder Pedal Pos using 2nd Order Polynomial Fit	FDR Rudder Pedal Pos (raw)	Measured Rudder Pedal Pos (deg)	Rudder Pedal Pos using Linear Fit	Rudder Pedal Pos using 2nd Order Polynomial Fit
794	-21	-19.83	-20.71	1943	0	-0.41	0.24
842	-20	-19.02	-19.79	1941	0	-0.44	0.20
930	-18	-17.53	-18.11	2040	2	1.23	1.90
1041	-16	-15.65	-16.01	2170	4	3.43	4.10
1144	-14	-13.91	-14.08	2286	6	5.39	6.03
1252	-12	-12.09	-12.08	2427	8	7.77	8.35
1364	-10	-10.20	-10.02	2551	10	9.86	10.37
1468	-8	-8.44	-8.13	2686	12	12.15	12.52
1593	-6	-6.33	-5.89	2811	14	14.26	14.49
1718	-4	-4.21	-3.68	2947	16	16.56	16.60
1843	-2	-2.10	-1.49	3067	18	18.59	18.44
1941	0	-0.44	0.20	3189	20	20.65	20.28
1942	0	-0.43	0.22	3264	21	21.91	21.39

Table 3: May 22, 2002 Rudder Pedal Test

D. CONCLUSION

Tables 2 and 3 demonstrated that the linear and 2nd order regression conversion algorithms produce nearly identical results. Hence, the rudder pedal sensors installed on the aircraft tested produced a linear output through the full range of rudder pedal movement. Therefore, it can be concluded that the rudder pedal sensor installed on the accident aircraft (N14053) also produced a linear output through the full range of rudder pedal movement.

E. ATTACHMENTS

The following table describes the Attachments included in this report.

Attachment	Total Pages	Description
I	12	Rudder Pedal Ground Test Study Procedures
II	4	May 8, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)
III	4	May 22, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Table 4

Cassandra Johnson
FDR Specialist, Mechanical Engineer

Attachment I – Rudder Pedal Ground Test Study Procedures

Attachment I: Rudder Pedal Ground Test Study Procedures

I. PURPOSE

1. Calibrate rudder pedal position
    a. Determine linearity of rudder pedal sensor
    b. Derive new engineering units conversion algorithm;
2. Establish relationship between the rudder pedal position and the rudder surface position under static condition;
3. Evaluate rudder pedal position and rudder surface position relationship under selected dynamic conditions.

II. EQUIPMENT LIST

1. **An American Airline A300-600** - fitted with Supplemental Type Certificate (STC) Number ST0199AT installation (i.e., rudder pedal potentiometer P/N FSA342455A);
2. **Measuring Equipment:**
    a. Rudder Pedal Operating Loads Measuring Tool, Airbus P/N 98A27203250002;
    b. Clinometer, Airbus P/N 3028000 or equivalent;
3. **Recording Equipment**:
    a. Flight Data Recorder (FDR), L-3 Communications solid-state FDR part number is 2100-4042-99 or 2100-4042-00. (Same as accident aircraft)
    b. FDR Line Test Unit (FDR LTU) provided by American Airlines;
    c. L3 Communications Portable Interface Unit (P/N 17ES0043) NTSB;
    d. Log sheets (Manually record pretest conditions and test results);
4. **Teledyne Flight Data Acquisition Unit** (FDAU) (P/N 775110-21-006), (Same as accident aircraft);

III. INFORMATION TO BE RECORDED

1. Rudder pedal angular deflection:
    a. Measuring Device – Clinometer,
    b. Units Degrees,
    c. Record on - Calibration log sheet;
2. Rudder Pedal Loads:
    a. Measuring Device - Rudder Pedal Loads Measuring tool,
    b. Units – Pounds,
    c. Record on - Calibration log sheet;
3. Rudder Pedal sensor output:
    a. Measuring Device - FDR LTU,
    b. Units - Raw Octal Counts,
    c. Record on - Calibration log sheet;
4. Rudder Surface sensor output:
    a. Measuring Device - FDR LTU,
    b. Units - Raw Octal Counts,
    c. Record on - Calibration log sheet;

Attachment I: Rudder Pedal Ground Test Study Procedures

IV. PRETEST CHECK AND SETUP PROCEDURES

(refer to the Section XII: Pretest Check and Setup Log Sheet)

1. Visual inspect rudder pedal position sensor to determine STC conformity and detect any condition that might invalidate test;
2. Visually inspect rudder surface sensor for any condition that might invalidate test;
3. Position both the Captain's and 1st Officer's rudder pedal adjustment to **mid** position (note: keep in mid position during the entire ground test);
4. **Install the Clinometer** or equivalent device on 1st officer's **right** rudder pedal arm (Bellcrank Assembly P/N A27010297) See attached drawings for more details);
5. Power airplane electrical and hydraulic systems;
6. Rudder Rigging and Position Sensors Check
    a. Connect FDR LTU to FDR;
    b. Exercise rudder pedals through full range while monitoring output of rudder pedal and surface position sensors on FDR LTU and visually verify that the rudder surface linkage mechanical stop located near the servo-controls is reached before the pilot control (rudder pedal) reaches its mechanical stop in the cockpit;
7. Verify that position sensor outputs signals are within operational limits;
    a. Center rudder trim, and secure rudder pedals with rig pin or equivalent;
    b. Set rudder surface to streamline position and secure with rig pin or other means;
    c. Record null values on "Pretest Check and Setup Log Sheet";
    d. Remove all rudder pedal and surface devices used to secure systems;
    e. Record max values on "Pretest Check and Setup Log Sheet";
8. Initialize Clinometer to 0° and Install Airbus's loads measurement tool (must repeat this step when installing Clinometer and Airbus's Loads Measurement Tool onto the 1st Officer's left rudder pedal);
    a. Center rudder trim, and secure rudder pedals with rig pin or equivalent;
    b. Set rudder surface to streamline position and secure with rig pin or other means;
    c. **Install Airbus's loads measurement tool** onto the 1st Officer's **right** rudder pedal;
    d. Set Clinometer or equivalent to indicate 0° angle per equipment manufacturer's specifications;
    e. Record values displayed on FDR LTU and Clinometer on "Pretest Check and Setup Log Sheet";
9. Synchronize timing of the FDR LTU with Airplane clock recorded on FDR and record time on Pretest Check and Setup Log;
10. Remove all rudder pedal and surface devices used to secure systems and reapply hydraulic pressure;

V. STATIC TEST PROCEDURES

(refer to Section VIII: Static Test Reference Listing and to Section XIII: Static Calibration Test Log Sheet)

1. Forward Drive the Rudder Pedals Static Test
    a. With flight recorder system powered, open Captain's microphone for 3 seconds to identify start of 1st test, also record GMT on Static Calibration Log Sheet,

b. Position **right** rudder pedal using Rudder Pedal Loads Measuring Tool until Clinometer indicates 0° loads position and record all values as described in ***Information To Be Recorded***
c. Repeat the previous step in 2-degree increments until full right pedal deflection is achieved (approximately 20º to 24º), holding at each increment for approximately 10 seconds, record all values at each increment;
d. Re-position Rudder Pedal Loads Measuring Tool to zero loads position and record all values;
e. Cycle Captain's microphone open 3-seconds, close 3-seconds and open 3-seconds, to identify end of test, also record GMT on calibration log sheet;
f. Repeat steps **V.1.a** through **V.1.e** with 240 knots simulated.
g. Remove the Rudder Pedal Loads Measuring Tool.

2. Back-Drive the Rudder Pedals Static Test (240 knots & then 0 knots)
   a. Keep the 240 Knots simulated;
   b. Open Captain's microphone for 3 seconds to identify start of test, also record GMT on Static Calibration Log Sheet,
   c. Position the Rudder Trim to indicate 0ºand record all values (except the information from the Rudder Pedal Loads Measuring Tool since it is not installed) as described in ***Information To Be Recorded***
   d. Repeat the previous step in 2-degree increments holding at each increment for approximately 10 seconds each until full **right** pedal deflection is achieved (approximately 20º to 24º);
   e. Once rudder surface trim limit is reached, manually position the Captain's right rudder pedal to the pedal stop and hold for 10 seconds.
   f. Reposition Rudder Trim to indicate 0º and record all values;
   g. Cycle captain's microphone open 3-seconds, close 3-seconds and open 3-seconds, to identify end of test, also record GMT on calibration log sheet;
   h. Repeat steps **V.2.b** through **V.2.g** but with 0 knots.
3. Remove the Clinometer or equivalent device and install it onto the 1st Officer's **left** rudder pedal Arm (Bellcrank Assembly P/N A27010297) and install the Rudder Pedal Loads Measuring Tool onto the 1st Officer's **left** rudder pedal and repeat step **IV.8** to initialize the system;
4. Repeat steps **V.1** through **V.2** but reference the **left** Rudder Pedal.

VI. DYNAMIC TEST PROCEDURES

(Refer to Section IX: Dynamic Test Reference Listing and to Section XIV: Dynamic Calibration Test Log Sheet)

1. Remove Rudder Pedal Loads Measuring Tool and Clinometer (or equivalent)
2. Open captain's microphone for three seconds and record GMT on calibration log sheet;
3. Move rudder pedals to full right and left positions to simulate normal flight crew preflight, holding at maximum positions for 5-seconds.
4. Move rudder pedals to full right and left positions at maximum rate without holding at full rudder pedal position;
5. Repeat the previous step but hold at each full travel position for 5 seconds;
6. Move rudder pedals to full right and left positions at nominal rate without holding at full rudder pedal position;

7. Repeat the previous step but hold at each full travel position for 5 seconds;
8. Cycle captain's microphone open 3-seconds, close 3-seconds and open 3-seconds, to identify end of dynamic test, also record GMT on calibration log sheet;

VII. RECOVERY AND PROCESSING OF TEST DATA

1. FDR Recording
    a. Download recording onto NTSB Portable Interface Unit;
    b. Remove recorder from airplane and secure recording;
2. Calibration Log Sheets
    a. Develop engineering unit conversion algorithm to convert raw decimal values recorded on FDR for rudder pedal and rudder surface position to engineering units in accordance with AC 20-141;
    b. Develop comparison plots of values recorded on FDR with observed values.

Attachment I: Rudder Pedal Ground Test Study Procedures

VIII. STATIC TEST REFERENCE LISTING

Conditions For Both Static and Dynamic Tests
1. Captain's and 1st Officer's Rudder Pedal Adjustment set to "Middle".
2. Must have at least one hydraulic system on.
3. Remember to reset the Clinometer to 0° at the beginning of each test.

Static Test 1 (Forward Drive Right Rudder Pedals, 0 knots)

- Rudder Pedal Operating Loads Measuring Tool installed on 1st Officer's **Right** Rudder Pedal;
- Clinometer installed on 1st Officer's **Right** Rudder Pedal Arm;
- Reset the Clinometer to 0° at beginning of the test;
- Using Rudder Pedal Operating Loads Measurement Tool, move the 1st Officer's **Right** Rudder Pedal from 0 to Full at 2 ° increments; Each increment measured under static conditions for >10 seconds.

Static Test 2 (Forward Drive Right Rudder Pedals, 240 knots)

- Repeat Static Test 1 but with 240 knots Simulated (make sure the Clinometer is zeroed at the beginning of the test).

Static Test 3A (Back Drive Right Rudder Pedals, 240 knots)

- Simulate 240 knots;
- Rudder Pedal Operating Loads Measuring Tool not installed;
- Clinometer remained installed on 1st Officer's **Right** Rudder Pedal Arm;
- Reset the Clinometer to 0° at beginning of the test;
- Using Right Rudder Trim move rudder at approximately 2 ° increments through full range of trim +/- 21, Each increment measured under static conditions for >10 seconds;
- Once the rudder surface trim is reached, push the **Captain's Right** Rudder Pedal to the pedal stop and hold for >10 seconds.

Static Test 3 (Back Drive Right Rudder Pedals, 0 knots)

- Repeat Static Test 3A but with 0 knots (make sure the Clinometer is zeroed at the beginning of the test).

Static Test 4 (Forward Drive Left Rudder Pedals, 0 knots)

- Rudder Pedal Operating Loads Measuring Tool installed on 1st Officer's **Left** Rudder Pedal;
- Clinometer installed on 1st Officer's **Left** Rudder Pedal Arm;
- Reset the Clinometer to 0° at beginning of the test;
- Using Rudder Pedal Operating Loads Measurement Tool, move the 1st Officer's **Left** Rudder Pedal from 0 to Full at 2 ° increments, Each increment measured under static conditions for >10 seconds.

Static Test 5 (Forward Drive Left Rudder Pedals, 240 knots)

- Repeat Static Test 4 but with 240 knots Simulated (make sure the Clinometer is zeroed at the beginning of the test).

Static Test 6A (Back Drive Left Rudder Pedals, 240 knots)

- Simulate 240 knots;
- Rudder Pedal Operating Loads Measuring Tool not installed;
- Clinometer installed on 1st Officer's **Left** Rudder Pedal Arm;
- Reset the Clinometer to 0° at beginning of the test;
- Using Rudder Trim, move rudder at approximately 2 ° increments through full range of trim +/- 21 for left pedal, Each increment measured under static conditions for >10 seconds;
- Once the rudder surface trim is reached, push the **Captain's Left** Rudder Pedal to the pedal stop and hold for >10 seconds.

Static Test 6 (Back Drive Left Rudder Pedals, 0 knots)

- Repeat Static test 6A but with 0 knots (make sure the Clinometer is zeroed at the beginning of the test);

IX: DYNAMIC TEST REFERENCE LISTING

Conditions For All Static and Dynamic Tests
1. 1st Officer's Rudder Pedal Adjustment set to "Middle".
2. Captains Rudder Pedal Adjustment set to "Middle".

Conditions Dynamic Tests 7-11
• Rudder Pedal Loads Measuring Tool Removed; • Clinometer Removed; • Engines running, if possible; • All Three Hydraulic Systems Running; • Yaw Damper "On"; • 0 Knot Input;

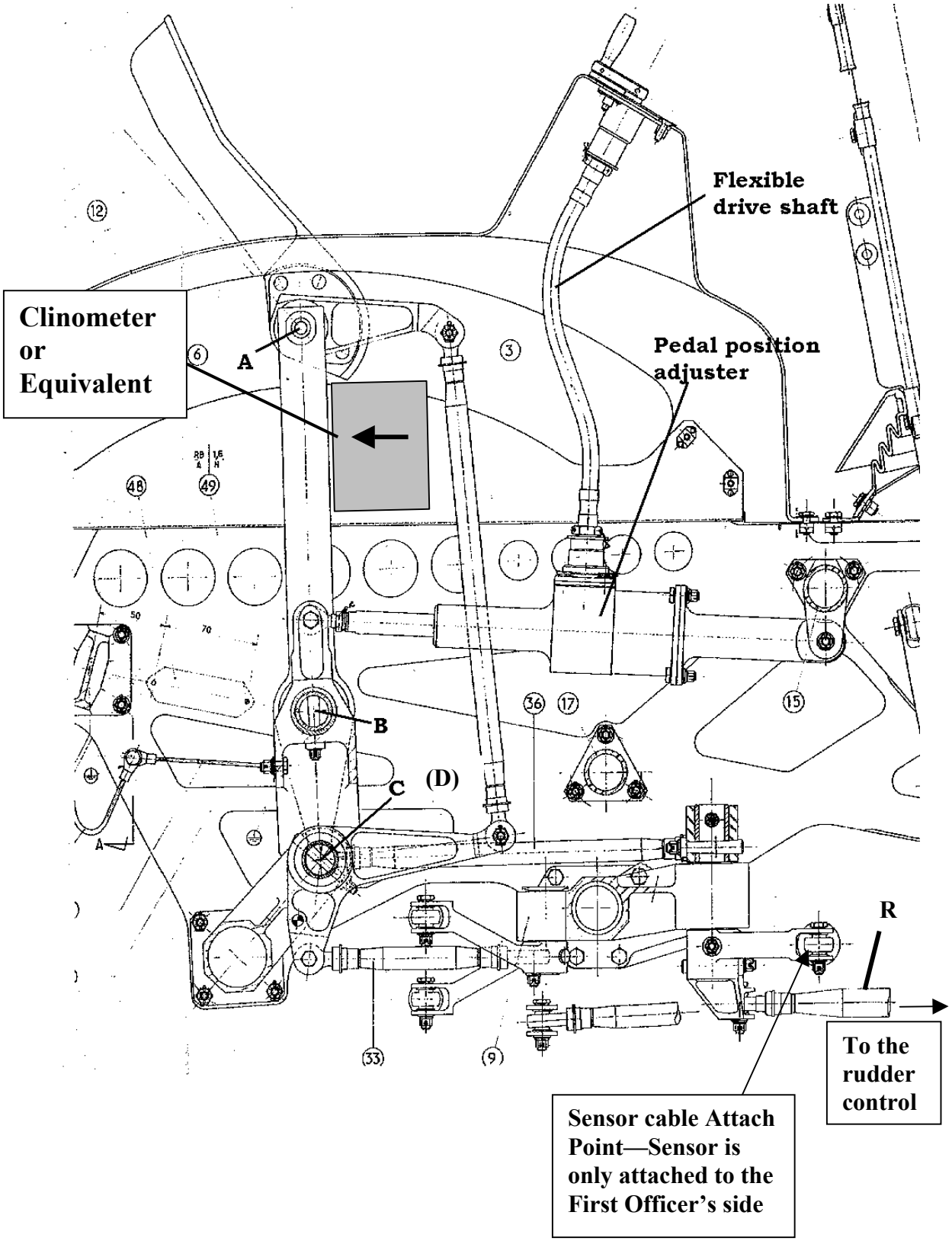
Dynamic Test 7	Captain's Position; Simulation of Preflight Flight Control Check, holding at full travel for 5 seconds;
Dynamic Test 8	Move Captain's Rudder Pedals at Max Rate - Full Right/Left, without pausing at maximum position;
Dynamic Test 9	Move Captains Rudder Pedals at Max Rate - Full Right/Left, pausing at each maximum position for 5 seconds;
Dynamic Test 10	Move Captain's Rudder Pedals at Nominal Rate - Full Right/Left, without pausing at maximum position;
Dynamic Test 11	Move Captains Rudder Pedals at Nominal Rate - Full Right/Left, pausing at each maximum position for 5 seconds;

Conditions for Dynamic Tests 12-16
• Rudder Pedal Loads Measuring Tool Removed; • Clinometer Removed; • Engines running, if possible; • All Three Hydraulic Systems Running; • Yaw Damper "On"; • 240 Knot Input.

Dynamic Test 12	Captain's Position, Simulation of Preflight Flight Control Check, holding at full travel for 5 seconds;
Dynamic Test 13	Move Captain's Rudder Pedals at Max Rate - Full Right/Left, without pausing at maximum position;
Dynamic Test 14	Move Captains Rudder Pedals at Max Rate - Full Right/Left, pausing at each maximum position for 5 seconds;
Dynamic Test 15	Move Captain's Rudder Pedals at Nominal Rate - Full Right/Left, without pausing at maximum position;
Dynamic Test 16:	Move Captains Rudder Pedals at Nominal Rate - Full Right/Left, pausing at each maximum position for 5 seconds;

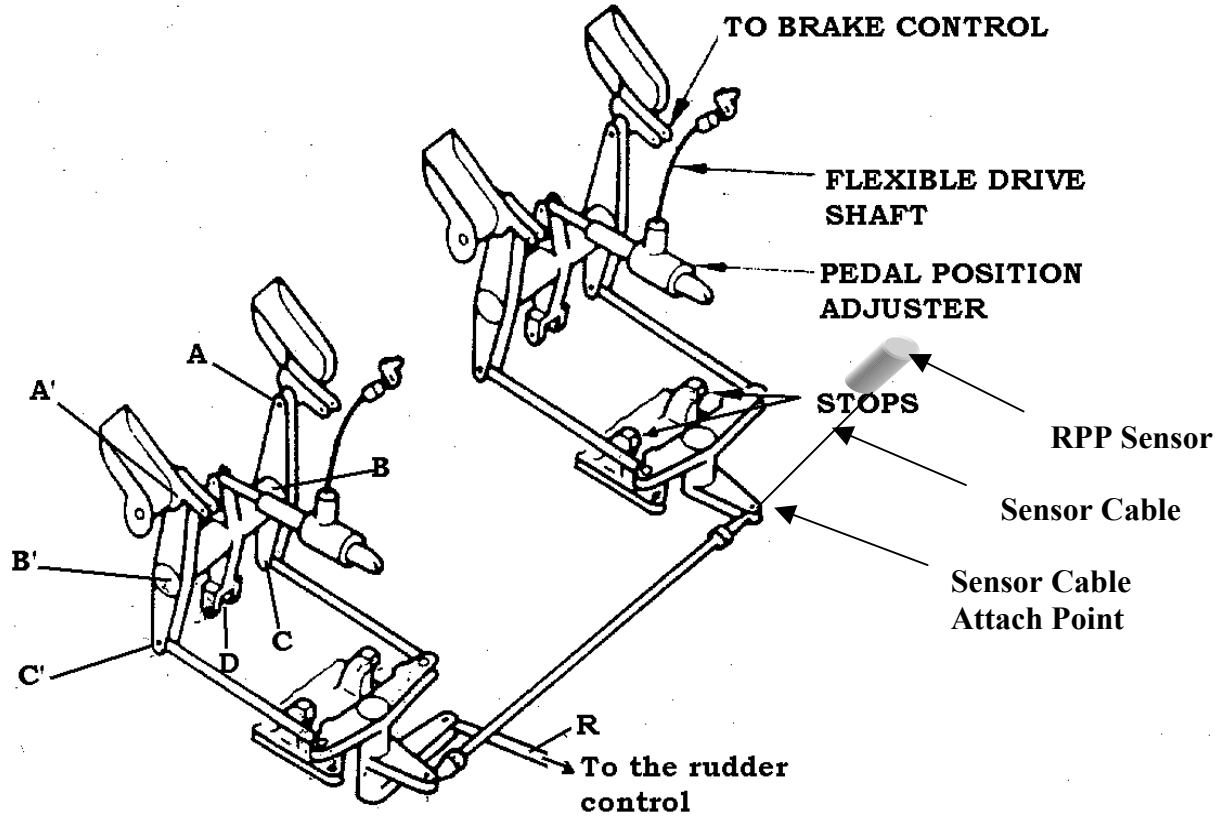
Attachment I: Rudder Pedal Ground Test Study Procedures

X: PEDALS KINEMATICS



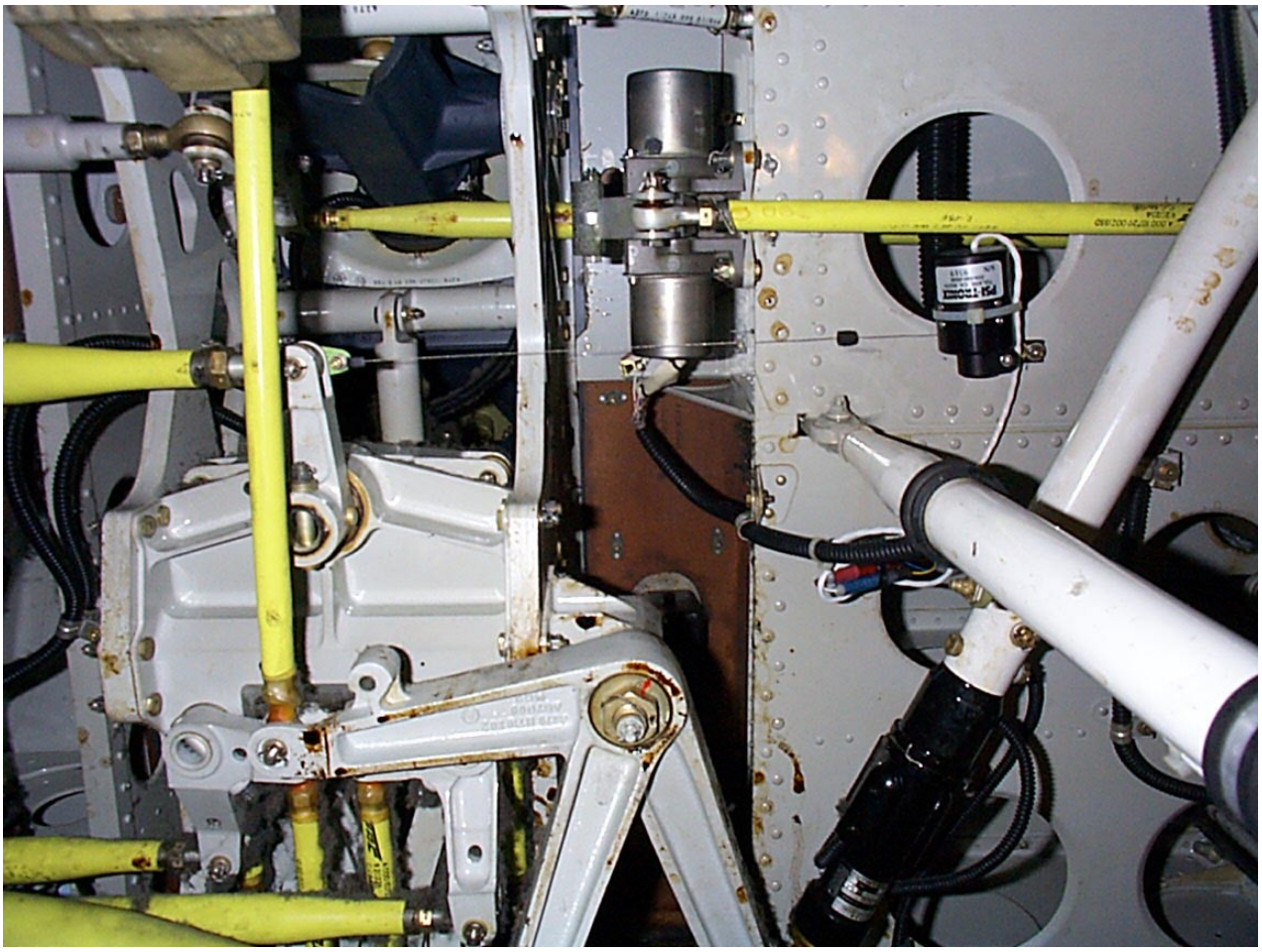
Attachment I: Rudder Pedal Ground Test Study Procedures

X: PEDALS KINEMATICS CONTINUED



Attachment I: Rudder Pedal Ground Test Study Procedures

XI: RUDDER PEDAL SENSOR AND CABLE ATTACH POINT



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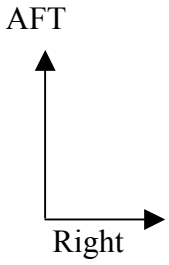
(Installed on First Officer's side only)



Attachment I: Rudder Pedal Ground Test Study Procedures

XII: PRETEST CHECK AND SETUP LOG SHEET

Test Date: _____;

Time of Setup (local) HR:_____ Min: _____ Sec:_____;

Test Airplane: _____, S/N_____;

Observer(s) Name (Print): _____;

_____; _____;

_____; _____;

_____; _____;

Ambient Conditions If Test Conducted Outside: **Temperature- _____**
Wind Speed-_____
Wind Direction- _____
Airplane Heading- _____

<u>Rudder Rigging and Position Sensors Check</u>:
Rudder Pedal Adjustment in Mid Position, Clinometer installed and Hydraulics Off (if need to for safety)

RPP and RSP (Null) <u>Octal .</u>
Raw Value From FDR LTU - RPP _____ (3545-3717),
Raw Value From FDR LTU - RSP _____ (____-____)

Rudder Pedal (Full Right): <u>Octal .</u>
Raw Value From FDR LTU - RPP _____ (6100-6480)
Raw Value From FDR LTU – RSP_____ (____-____)

Rudder Pedal (Full Left): <u>Octal .</u>
Raw Value From FDR LTU - RPP _____ (1270-1470)
Raw Value From FDR LTU – RSP_____ (____-____)

<u>Initialize Clinometer To "0" Setting with the Airbus Loads Measuring Tool Installed:</u>
Rudder Pedals Secured in Neutral Position and Rudder Surface Secured in Streamline Position

Equipment on 1st Officer's Left Rudder Pedal:
Raw Value From FDR LTU - RPP _____ (3545-3717)
Clinometer Reading _____
Raw Value From FDR LTU - RSP _____ (____-____)

Equipment on 1st Officer's Right Rudder Pedal:
Raw Value From FDR LTU - RPP _____ (3545-3717)
Clinometer Reading _____
Raw Value From FDR LTU - RSP _____ (____-____)

<u>Time Synchronization of Electronic Recording Devices:</u>
Airplane Clock, FDR Line Test Unit and Rigmaster Clocks Synchronized at time:
HR: _____ Min: _____ Sec:_____

Attachment I: Rudder Pedal Ground Test Study Procedures

XIII: STATIC CALIBRATION TEST LOG SHEET

Test Reference Number: _____;
Test Date: _____;
Time of Setup (local) HR: _____ Min: _____ Sec: _____;
Test Airplane: _____, S/N_____;
Observation Position: _____;

Observer(s) Name (Print): _____;

(Signature): _____;

Target Test Points (deg)	FDR Line Test Unit		Selected Rudder Trim (deg)	Rudder Load Equip		Start of Test Airplane GMT Hr:Min:Sec
	Rudder Pedal Position	Rudder Surface Position		Force (Lbs)	Clinometer Angle (deg)	
	Octal / Decimal	Octal / Decimal				
0						
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						
21 (max)						End of Test Airplane GMT Hr:Min:Sec
0						

Attachment I: Rudder Pedal Ground Test Study Procedures

XIV: DYNAMIC CALIBRATION TEST LOG SHEET

Test Date: _____;
Time of Setup (local) HR: _____ Min: _____ Sec: _____;
Test Airplane: _____, S/N_____;
Observation Position: _____;

Observer(s) Name (Print): _____;

(Signature): _____;

Dynamic Test #	Description	GMT Start Time	GMT End Time
7	Captain's Position; Simulation of Preflight Flight Control Check, holding at full travel for 5 seconds;		
8	Move Captain's Rudder Pedals at Max Rate - Full Right/Left, without pausing at maximum position;		
9	Move Captains Rudder Pedals at Max Rate - Full Right/Left, pausing at each maximum position for 5 seconds;		
10	Move Captain's Rudder Pedals at Nominal Rate - Full Right/Left, without pausing at maximum position;		
11	Move Captains Rudder Pedals at Nominal Rate - Full Right/Left, pausing at each maximum position for 5 seconds;		
12	Captain's Position, Simulation of Preflight Flight Control Check, holding at full travel for 5 seconds;		
13	Move Captain's Rudder Pedals at Max Rate - Full Right/Left, without pausing at maximum position;		
14	Move Captains Rudder Pedals at Max Rate - Full Right/Left, pausing at each maximum position for 5 seconds;		
15	Move Captain's Rudder Pedals at Nominal Rate - Full Right/Left, without pausing at maximum position;		
16	Move Captains Rudder Pedals at Nominal Rate - Full Right/Left, pausing at each maximum position for 5 seconds;		

Attachment II – May 8, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Attachment II: May 8, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Static Tests 1 & 4: Forward Drive F/O's Rudder Pedals @ 0 knots

	FDR Rudder Pedal Pos (raw)	FDR Rudder Surface Pos (raw)	Selected Rudder Trim (deg)	Measured Rudder Pedal Pos (deg)	Comments
Test 4	782	3753	0	-21.2	manually push Capt's left rudder pedal
left rudder pedal	832	3766	0	-21	
	874	3783	0	-20	
	972	3819	0	-18	
	1071	3854	0	-16	
	1182	3890	0	-14	
	1286	3923	0	-12	
	1389	3956	0	-10	
	1513	3990	0	-8	
	1617	4022	0	-6	
	1736	4055	0	-4	
	1859	4090	0	-2	
	1931	3	0	-0.2	back to neutral @ end of test 4
	1933	3	0	0	start test 4
Test 1 right rudder pedal	1925	3	0	0	start test 1
	1934	3	0	0	back to neutral @ end of test 1
	2015	11	0	2	
	2135	46	0	4	
	2257	83	0	6	
	2373	114	0	8	
	2500	148	0	10	
	2629	183	0	12	
	2764	219	0	14	
	2889	254	0	16	
	3019	290	0	18	
	3147	325	0	20	
	3206	341	0	21	
	3273	347	0	21.3	manually push Capt's right rudder pedal

Attachment II: May 8, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Static Tests 3 & 6: Back Drive Rudder Pedals Using Rudder Trim Selector @ 0 knots

	FDR Rudder Pedal Pos (raw)	FDR Rudder Surface Pos (raw)	Selected Rudder Trim (deg)	Measured Rudder Pedal Pos (deg)	Comments
Test 6 left rudder pedal	782	3751	20.9	-20.2	manually push Capt's left rudder pedal
	1157	3851	20.9	-13.2	
	1190	3862	20	-12.6	
	1250	3890	18	-11.4	
	1330	3914	16	-10.1	
	1398	3937	14	-8.8	
	1470	3959	12	-7.6	
	1515	3971	11	-7	
	1552	3983	10	-6.3	
	1621	4007	8	-5	
	1702	4031	6	-3.7	
	1784	4054	4	-2.4	
	1866	4079	2	-1.1	
	1917	3	0	-0.1	return to neutral pos
	1922	3	0	0	start test 6
Test 3 right rudder pedal	1968	3	0	0	start test 3
	1972	3	0	0.1	return to neutral pos
	2033	27	2	1.2	
	2107	50	4	2.4	
	2183	75	6	3.7	
	2258	101	8	4.9	
	2334	122	10	6.2	
	2408	147	12	7.4	
	2500	170	14	8.7	
	2581	194	16	9.9	
	2672	220	18	11.2	
	2757	246	20	12.5	
	2784	255	20.9	13	
	3220	348	20.9	19.4	manually push Capt's right rudder pedal

Attachment II: May 8, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Static Tests 2 & 5: Forward Drive F/O's Rudder Pedals @ 240 knots

	FDR Rudder Pedal Pos (raw)	FDR Rudder Surface Pos (raw)	Selected Rudder Trim (deg)	Measured Rudder Pedal Pos (deg)	Comments
Test 5 left rudder pedal	1167	3975	0	-16.0	
	1243	3975	0	-14.0	
	1331	3978	0	-12.0	
	1410	3978	0	-10.0	rudder surface at the stops
	1513	3991	0	-8.0	
	1619	4023	0	-6.0	
	1736	4058	0	-4.0	
	1866	4091	0	-2.0	
	1931	3	0	-0.2	back to neutral @ end of test 5
	1940	3	0	0.0	start test 5
Test 2 right rudder pedal	1934	3	0	0.0	start test 2
	1930	3	0	0.0	back to neutral @ end of test 2
	2008	10	0	2.0	
	2135	44	0	4.0	
	2256	81	0	6.0	
	2377	114	0	8.0	
	2489	126	0	10.0	
	2529	127	0	11.0	
	2588	130	0	12.1	
	2693	131	0	14.1	
	2789	131	0	16.0	

Attachment II: May 8, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Static Tests 3A & 6A: Back Drive Rudder Pedals Using Rudder Trim Selector @ 240 knots

	FDR Rudder Pedal Pos (raw)	FDR Rudder Surface Pos (raw)	Selected Rudder Trim (deg)	Measured Rudder Pedal Pos (deg)	Comments
Test 6A left rudder pedal	1542	3979	12	-6.5	
	1542	3979	11	-6.5	rudder surface at the stops
	1559	3983	10	-6.2	
	1622	4007	8	-4.9	
	1699	4030	6	-3.7	
	1785	4054	4	-2.4	
	1863	4078	2	-1.1	
	1913	3	0	0.0	start test 6A
	1921	3	0	0.0	back to neutral @ end of test 6A
Test 3A right rudder pedal	1958	6	0	0.0	start test 3A
	1967	3	0	0.0	back to neutral @ end of test 3A
	2030	27	2	1.2	
	2109	51	4	2.5	
	2180	75	6	3.7	
	2263	100	8	5.0	
	2335	122	10	6.2	
	2353	126	12	6.4	
	2352	127	14	6.5	

Attachment III – May 22, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Attachment III: May 22, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Static Tests 1 & 4: Forward Drive Rudder Pedal @ 0 knots

	FDR Rudder Pedal Pos (raw)	FDR Rudder Surface Pos (raw)	Selected Rudder Trim (deg)	Measured Rudder Pedal Pos (deg)	Comments
Test 4 left rudder pedal	750	3746	0	-21.1	manually pushed Capt's left rudder pedal
	794	3749	0	-21	
	842	3767	0	-20	
	930	3803	0	-18	
	1041	3842	0	-16	
	1144	3875	0	-14	
	1252	3911	0	-12	
	1364	3946	0	-10	
	1468	3979	0	-8	
	1593	4014	0	-6	
	1718	4047	0	-4	
	1843	4082	0	-2	
	1941	4	0	0	back to neutral @ end of test 4
	1942	2	0	0	start test 4
Test 1 right rudder pedal	1943	4086	0	0	start test 1
	1941	4087	0	0	back to neutral @ end of test 1
	2040	5	0	2	
	2170	42	0	4	
	2286	75	0	6	
	2427	113	0	8	
	2551	146	0	10	
	2686	182	0	12	
	2811	218	0	14	
	2947	254	0	16	
	3067	288	0	18	
	3189	322	0	20	
	3264	343	0	21	
	3338	355	0	21.4	manually pushed Capt's right rudder pedal

Attachment III: May 22, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Static Tests 3 & 6: Back Drive Rudder Pedal @ 0 knots

	FDR Rudder Pedal Pos (raw)	FDR Rudder Surface Pos (raw)	Selected Rudder Trim (deg)	Measured Rudder Pedal Pos (deg)	Comments
Test 6	745	3743	21.1	-20.4	manually pushed Capt's left rudder pedal
left	1148	3851	21.1	-12.8	
rudder	1186	3866	20	-12.2	
pedal	1261	3890	18	-10.9	
	1331	3914	16	-9.6	
	1389	3937	14	-8.5	
	1468	3963	12	-7.2	
	1499	3974	11	-6.6	
	1538	3976	10	-6	
	1618	4009	8	-4.8	
	1705	4031	6	-3.6	
	1785	4055	4	-2.3	
	1851	4079	2	-1.1	
	1925	2	0	0	return to neutral pos
	1925	6	0	0	start test 6
Test 3	1940	2	0	0	start test 3
right	1951	4087	0	0.3	return to neutral pos
rudder	2021	24	2	1.3	
pedal	2086	50	4	2.5	
	2166	74	6	3.8	
	2254	98	8	5	
	2324	122	10	6.1	
	2412	146	12	7.4	
	2494	170	14	8.6	
	2567	191	16	9.8	
	2654	218	18	11	
	2737	242	20	12.2	
	2778	255	21.1	12.9	
	3329	357	21.1	21.3	manually pushed Capt's right rudder pedal

Attachment III: May 22, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Static Tests 2 & 5: Forward Drive Rudder Pedal @ 240 knots

	FDR Rudder Pedal Pos (raw)	FDR Rudder Surface Pos (raw)	Selected Rudder Trim (deg)	Measured Rudder Pedal Pos (deg)	Comments
Test 5 left rudder pedal	1124	3978	0	-16.0	
	1209	3978	0	-14.0	
	1297	3979	0	-12.0	
	1385	3981	0	-10.0	
	1473	3983	0	-8.0	
	1606	4025	0	-6.0	
	1720	4055	0	-4.0	
	1837	4089	0	-2.0	
	1942	6	0	0.0	back to neutral @ end of test 5
	1943	6	0	0.0	start test 5
Test 2 right rudder pedal	1941	4087	0	0.0	start test 2
	1942	4083	0	0.0	back to neutral @ end of test 2
	2039	4	0	2.0	
	2150	39	0	4.0	
	2283	76	0	6.0	
	2420	110	0	8.0	
	2537	130	0	10.0	
	2587	130	0	11.0	
	2639	131	0	12.1	
	2750	134	0	14.1	
	2853	135	0	16.0	

Attachment III: May 22, 2002 Rudder Pedal Sensor Ground Test Data (Static Tests Only)

Static Tests 3A & 6A: Back Drive Right & Left Pedal @ 240 knots

	FDR Rudder Pedal Pos (raw)	FDR Rudder Surface Pos (raw)	Selected Rudder Trim (deg)	Measured Rudder Pedal Pos (deg)	Comments
Test 6A	1524	3980	12	-6.3	
left	1525	3979	11	-6.3	
rudder	1540	3986	10	-6.0	
pedal	1615	4007	8	-4.7	
	1712	4033	6	-3.2	
	1777	4055	4	-2.3	
	1849	4078	2	-1.1	
	1925	7	0	0.0	start test 6A
	1924	4	0	0.0	back to neutral @ end of test 6A
Test 3A	1946	4095	0	0.0	start test 3A
right	1952	4095	0	0.1	back to neutral @ end of test 3A
rudder	2022	23	2	1.3	
pedal	2094	48	4	2.5	
	2181	74	6	3.8	
	2254	96	8	4.9	
	2331	120	10	6.1	
	2375	130	12	6.6	
	2377	129	14	6.7	
	2378	131	16	6.7	