Validation Reference Data Report

Single Engine Piston Aeroplane

Aerospace Software and Technologies Institute (ASTI) TUDelft	Inspectie Verkeer en Waterstaat Divisie Luchtvaart (IVW/DL)
Name: Ir. M.P. Oosten Accountable Manager	Name:
Date: December 11, 2008	Date:
Signature:	Signature:

Contents

Record of revisions

REV NO.	ISSUE DATE	REASON OF REVISION
0	23 August 2007	FIRST ISSUE
1	1 February 2008	Re-orderded tests according to JAR-STD 3A order Converted units of graph in test 2a1, 2a2, and 2a3 Added flap operating times, test 2b5

Introduction

This engineering report presents a set of Validation Data obtained on a Cessna 172 Skyhawk aeroplane. These Validation Data will be used for the initial qualification testing of a Flight Navigation and Procedure Trainers Type I modeled after a single engine piston class of aeroplane.
The substantiation of the set of Validation Data is done by measurements on the aeroplane and the performance of video taped flight tests on the Cessna 172 Skyhawk aeroplane.

1 References

[1] Cessna Aircraft Company, *Cessna 1979, Skyhawk Cessna Model 172N Pilot's Operating Handbook*, The Cessna Aircraft Company, Date of original issue: 1 July 1978.

[2] Cook, M.V., *Flight Dynamics Principles*, Arnold Publishers 1997, ISBN 0-340-63200-3.

[3] Etkin, Bernard & Reid, Lloyd Duff, *Dynamics of Flight, Stability and Control*, John Wiley & Sons, Inc. 1996, Third Edition, ISBN 0-471-03418-5

[4] Dept. of Transportation Federal Aviation Administration, *Type Certificate Data Sheet No. 3A12*, Revision 73 February 14, 2006

[5] International Civil Aviation Organization, *Manual of Criteria for the Qualification of Flight Simulators*, Doc. 9625, January 2002.

[6] Joint Aviation Authorities, *Aeroplane Flight & Navigation Procedures Trainers*, Joint Aviation Requirements JAR-STD 3A, June 1999.

[7] Lycoming Engine Specifications, *Certificated Piston Aircraft Engines and Installation Guide*, SSP-204, February 2004.

[8] National Aerospace Laboratory (NLR), *Kalibratie-Certificaat*, Raad voor Accreditatie (RvA) Certificaatnummer: 2005-037, 16 December 2005.

[9] Royal Aeronautical Society, *Aeroplane Flight Simulator Evaluation Handbook, International Standards for the Qualification of Aeroplane Flight Simulators*, Third Edition January 2005, ISBN 1 85768 154 1.

[10] Royal Aeronautical Society, *Aeroplane Flight Simulator Evaluation Handbook Volume II, International Standards for the Qualification of Aeroplane Flight Simulators*, Third Edition January 2005, ISBN 1 85768 154 1.

[11] Ruijgrok, G.J.J., *Elements of airplane performance*, Delft Univeristy Press (1994), ISBN 90 6275 608 5.

[12] Textron Lycoming Aircraft Engines, *Operator's Manual Series O-360, HO-360, IO-360, AIO-360, HIO-360 & TIO-360*, Publication Number 60297-12, Revision Number 60297-12-2, March 1990.

2 Specifications of the reference aeroplane

2.1 General description

The aeroplane that was used for flight testing and gathering of validation reference data is a Cessna 172N; a single engine piston aeroplane.

Registration	PH-SLR
Type Aircraft	Cessna 172N
Type Engines	1 O-360-A4M
Serial Number	17271965
Manufacturing year	1979
MTOM	1157
Airworthiness Category Code	CS-23 Normal Utility

Table 2.1: Aeroplane specifications

Figure 2.1: The PH-SLR on Rotterdam Zestienhoven Airport

2.2 Engine specifications

The PH-SLR is equipped with a Lycoming four cylinder piston engine model O-360-A4M. The engine specifications are as described in [7].

Manufacturer	Lycoming
Model	O-360-A4M
Engine Type	4 cylinder piston engine
Maximum power	180 HP
Take-off RPM	2700
Approved Fuel Grades	100/100LL
Compression Ratio	8.50:1

Table 2.2: Engine specifications

2.3 Weight & balance

The mass of the Cessna 172N PH-SLR was determined with maximum fuel tank weight. For this purpose an Evergreen Weigh Road Runner I aircraft scale and three portable wheel weighers of the National Aerospace Laboratory of the Netherlands were used. The digital weight indication device is displayed in Figure 2.2. With the use of ramps and tire stops, the aeroplane was rolled onto the three wheel weighter pads. The weigher pads were placed under the nose and left & right main wheels. See Figure 2.3. The wheel weigher system specifications are as in the calibration certificate [8].
The total weight on ground (full fuel, without passengers) was determined to be 851 kg = 1876.1 lbs. The basic empty weight of the PH-SLR is reported to be 1608.4 lbs and the matching center of gravity lays 39.7 inch from STA 0.0.

	Weight (lbs)	Arm (inch)	Moment (lbs.inch)
Basic empty weight	1608.4	39.7	63870.5
Usable fuel	263.2-F	48	12633.6 -48·F
Pilot and front passenger	A	37	37·A
Rear passengers	B	73	73·B
Baggage area	4.5	95	427.5
Total weight	1876.1 - F + A + B	X_{CG}	76931.6 -48·F + 37·A + 73·B

Table 2.3: Determination of center of gravity

The following equation shows the location of the centre of gravity as a function of the fuel used, the mass of pilot and front passenger and the mass of rear passenger(s).

$$X_{CG} = \frac{76931.6 - 48 \cdot F + 37 \cdot A + 73 \cdot B}{1876.1 - F + A + B} \quad \text{(inch)} \tag{2.1}$$

Figure 2.2: Digital weight indication device

Figure 2.3: The PH-SLR on wheel weighers

Figure 2.4 shows the change of the center of gravity X_{CG} over the course of a test flight of about 100 minutes in a configuration of a pilot and a front passenger on board and tests started with full tank weight

A	=	Mass of pilot and front passenger (lbs)
B	=	Mass of rear passenger(s) (lbs)
F	=	Fuel weight (lbs)
X_{CG}	=	Location of center of gravity from STA 0.0 (inch)

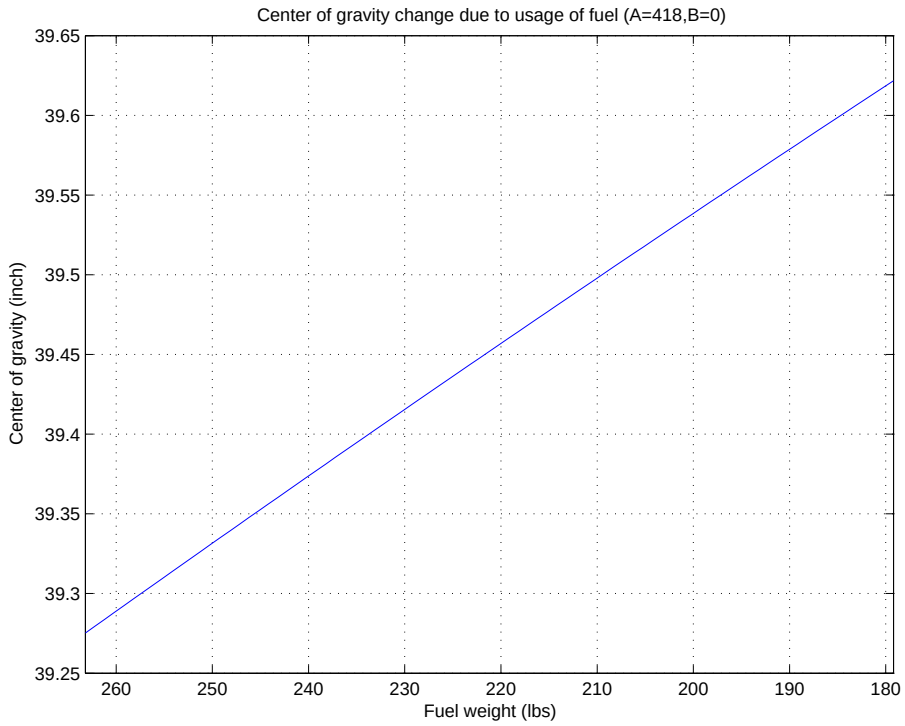

Figure 2.4: Center of gravity range. Pilot and front passenger

Figure 2.5: Installation of two wire extension direct reading indicators

Figure 2.6 shows the change of the center of gravity X_{CG} over the course of a test flight of about 100 minutes in a configuration of a pilot and one rear passenger on board. This is the configuration where the two wire extension direct reading indicators were installed according approval EASA.A.C.04171 and tests started with full tank weight. See also Figure 2.5 and Appendix A.

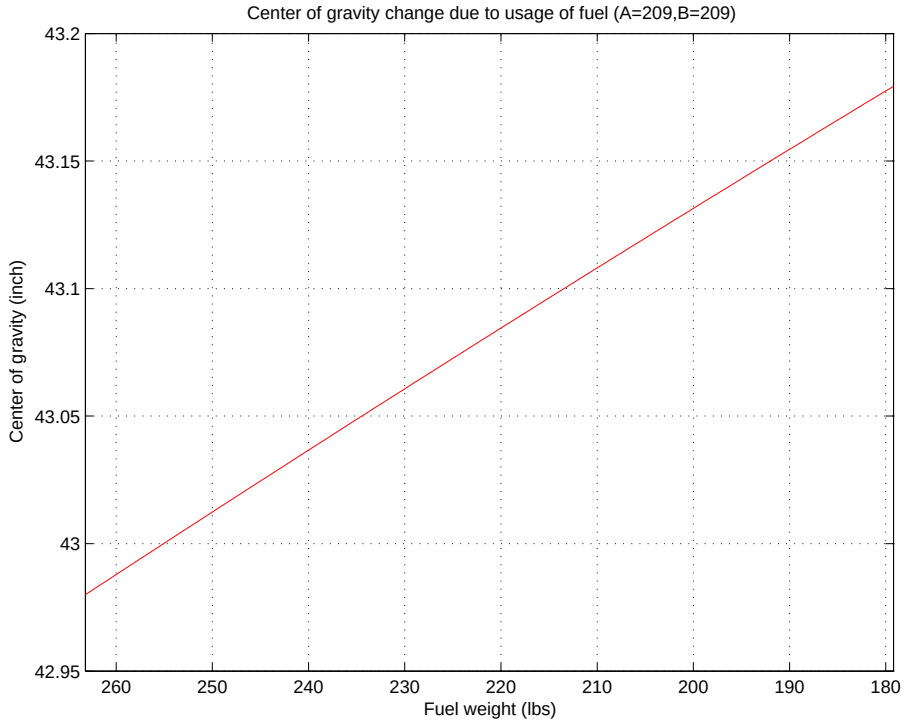

Figure 2.6: Center of gravity range. Pilot and one rear passenger

2.4 Flight tests

For obtaining information about BANK ANGLE, ENGINE SPEED, INDICATED AIRSPEED, PITCH ANGLE, PRESSURE ALTITUDE and RATE OF CLIMB the flight tests were video taped and later analyzed frame by frame for their time responses. Steelyards were used to measure the control force and position reference strip (roll control) and two wire extension direct reading indicators (pitch control, rudder pedal) were installed to obtain data about the controller positions.

BANK ANGLE	Attitude Indicator
ENGINE SPEED	Tachometer
INDICATED AIRSPEED	Speed Indicator
PITCH ANGLE	Attitude Indicator
PITCH CONTROLLER FORCE	Steelyard
PITCH CONTROLLER POSITION	Wire extension direct reading indicator
PRESSURE ALTITUDE	Altimeter
RATE OF CLIMB	Vertical Speed Indicator
ROLL CONTROLLER FORCE	Steelyard
ROLL CONTROLLER POSITION	Position Reference Strip
RUDDER PEDAL FORCE	Steelyard
RUDDER PEDAL POSITION	Wire extension direct reading indicator
THROTTLE SETTING	Ruler

Table 2.4: Evaluated parameters and means of recording

2.5 Control systems

The elevator angle versus pitch controller position, the left & right aileron angle versus roll controller position and the rudder angle versus rudder pedal position were calibrated on 26 July and 27 July 2006. See Table 2.5, Table 2.6, Table 2.7 and Table 2.8 and Figure 2.7 and Figure 2.10.

PITCH CONTROLLER POSITION (min)	ELEVATOR ANGLE (deg)
572	-30
576	-28
580.5	-24
585	-20
591	-16
596	-12
601	-8
606	-4
611	0
616	+4
621	+8
624	+12
629	+16
631.5	+18

Table 2.5: Calibration of elevator angle vs. pitch controller position

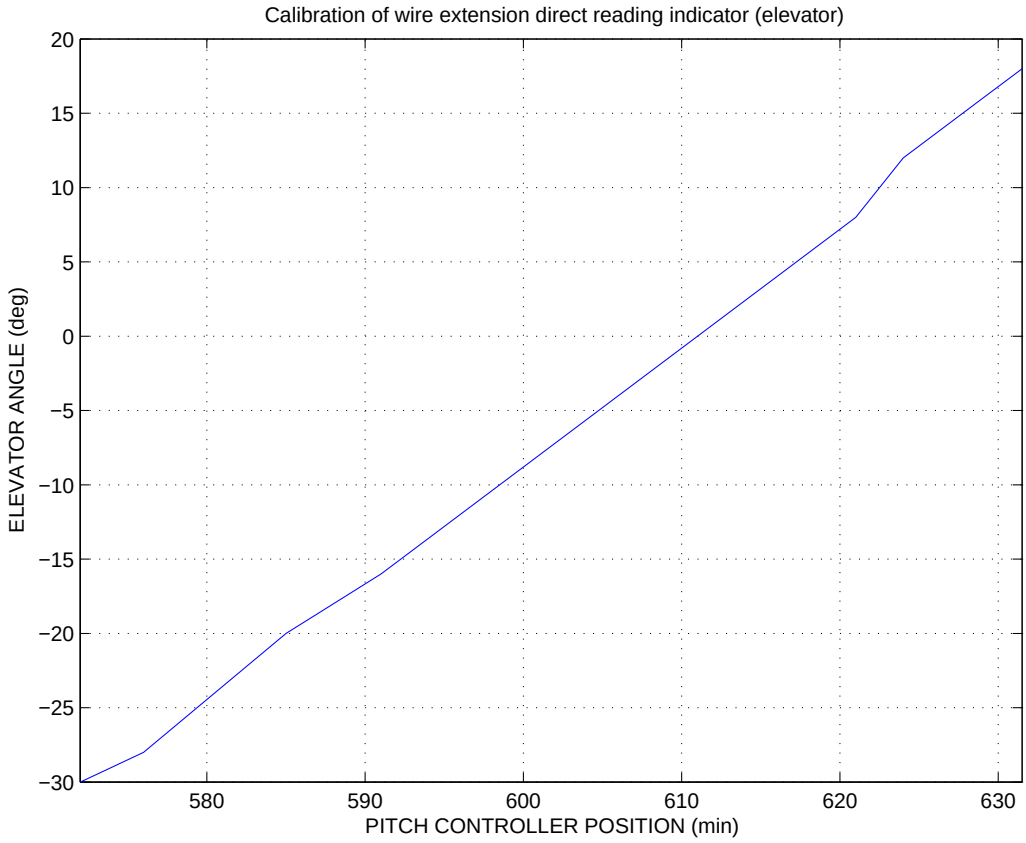

Figure 2.7: Calibration of elevator angle vs. pitch controller position

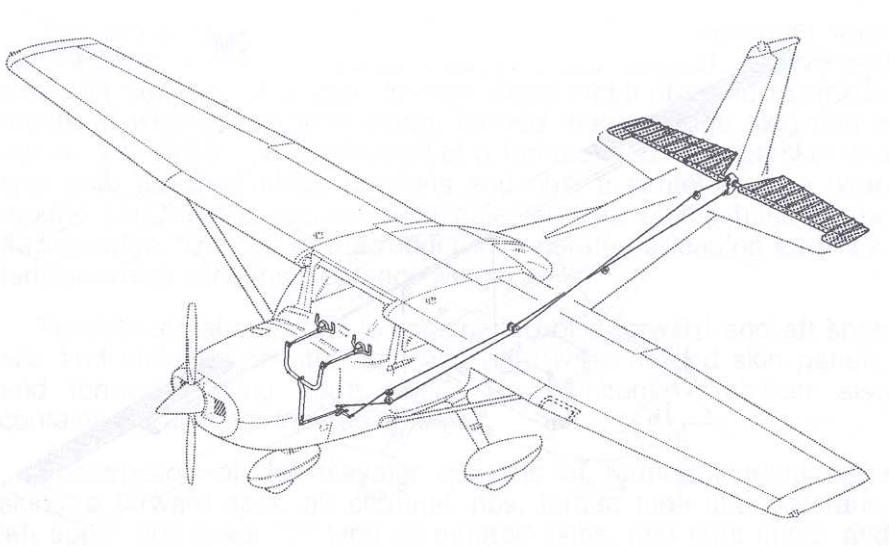

Figure 2.8: The elevator control system

ROLL CONTROLLER POSITION (deg)	RIGHT AILERON ANGLE (deg)
-95	-17
-90	-16
-45	-8
+45	+8
+90	+16

Table 2.6: Calibration of right aileron angle vs. roll controller position

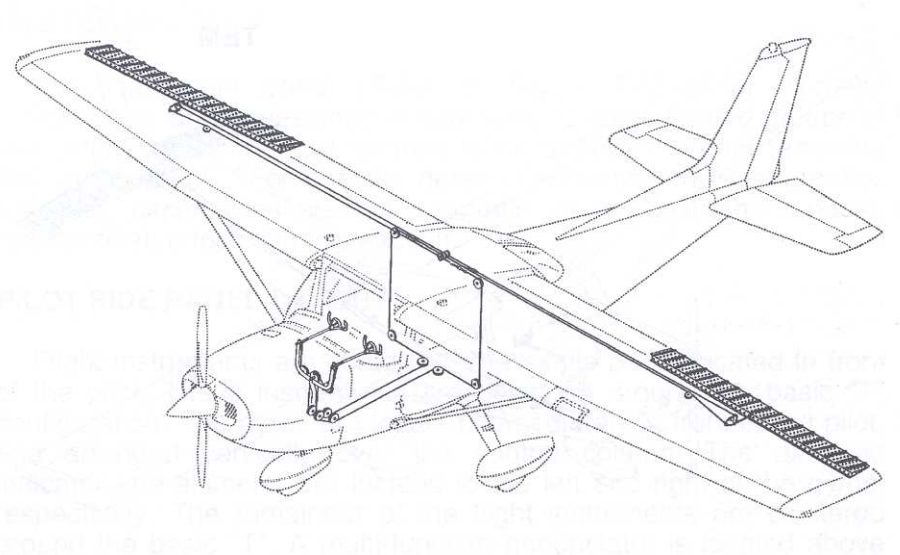

Figure 2.9: The aileron control system

ROLL CONTROLLER POSITION (deg)	LEFT AILERON ANGLE (deg)
-95	-18
-90	-17
+90	+17

Table 2.7: Calibration of left aileron angle vs. roll controller position

RUDDER PEDAL POSITION (min)	RUDDER ANGLE (deg)
379	-16
380	-14
385	-10
390	-6
396	0
400	+1
405	+3
410	+6
415	+8
420	+10
425	+12
430	+14
435	+16

Table 2.8: Calibration of rudder angle vs. rudder pedal position

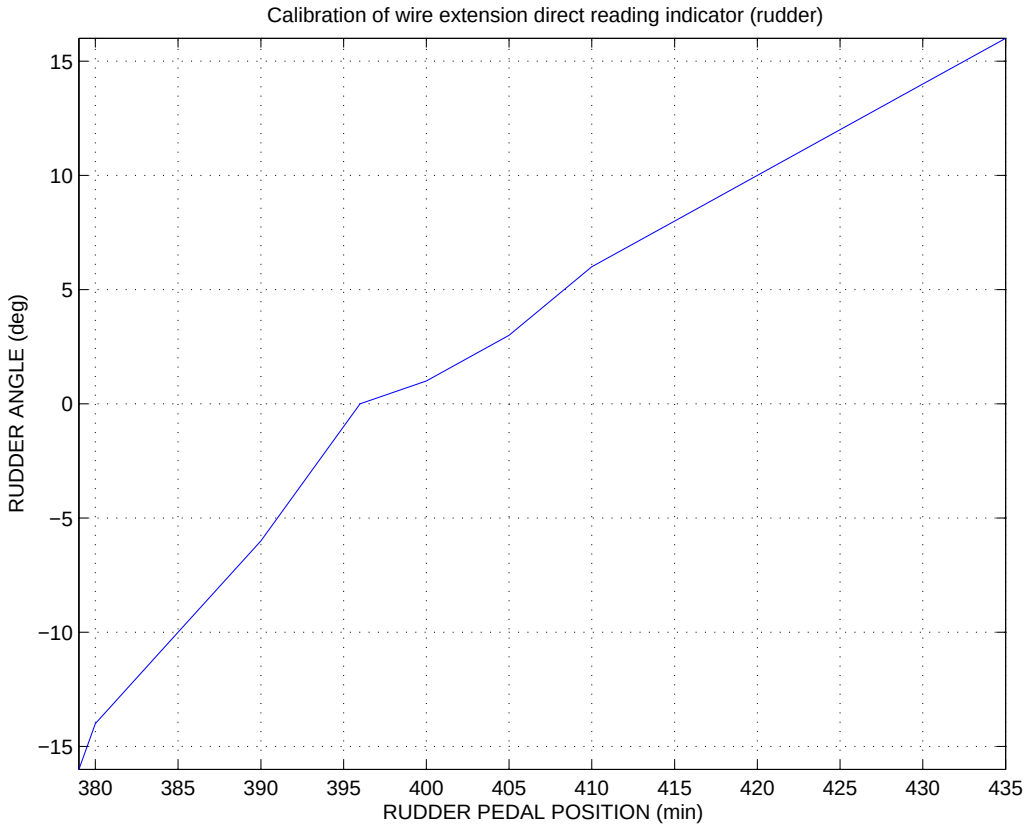

Figure 2.10: Calibration of rudder angle vs. rudder pedal position

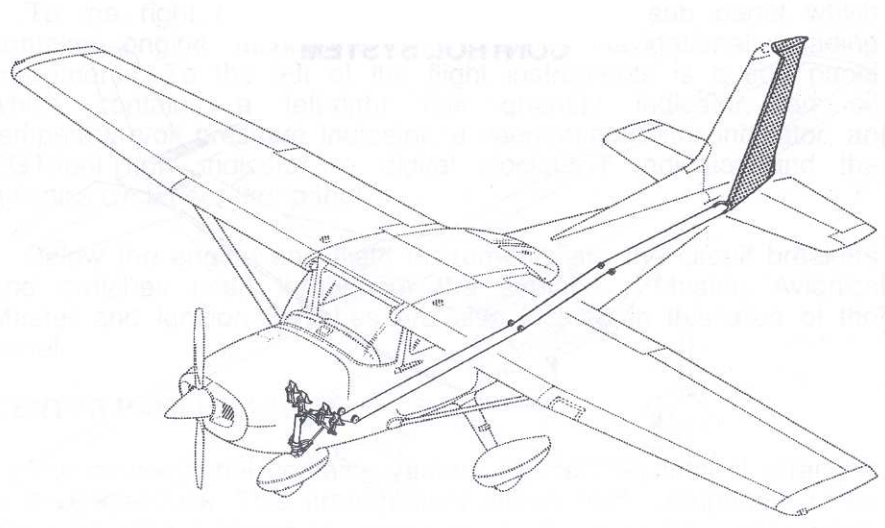

Figure 2.11: The rudder control system

3 Validation tests

3.1 Normal climb engine operating (1a1)

Test procedures
With full throttle setting and with the rudder pedal in the neutral position, climb from 2000 feet to 4000 feet. Measure the elapsed time between altitude increments of at least 200 feet.

Test results
Table 3.1 and Figure 3.1 and Figure 3.2 display the test results of the normal climb test of June 6th 2006. See also movie file `06JUN2006_06_FSTD_1c1_Normal_climb.m2p`.

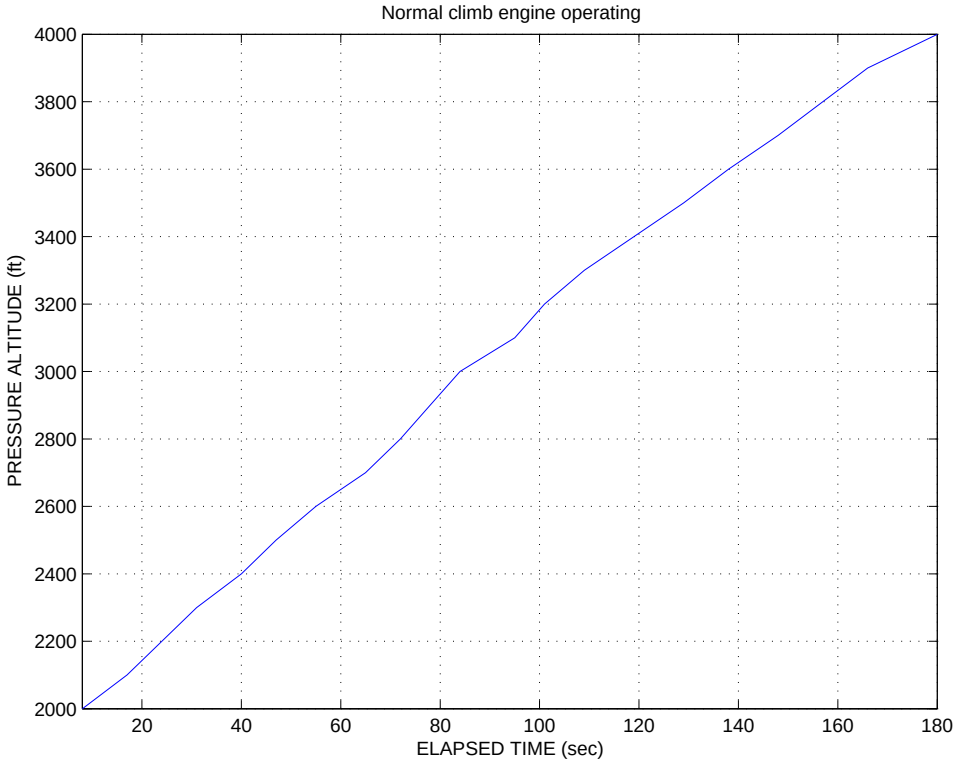

Figure 3.1: Pressure altitude versus elapsed time

ELAPSED TIME (sec)	PRESSURE ALTITUDE (feet)	INDICATED AIRSPEED (knots)
8	2000	88
17	2100	88
24	2200	85
31	2300	80
40	2400	81
47	2500	79
55	2600	80
65	2700	81
72	2800	82
78	2900	81
84	3000	75
95	3100	79
101	3200	79
109	3300	77
119	3400	78
129	3500	79
138	3600	78
148	3700	77
157	3800	76
166	3900	75
180	4000	84

Table 3.1: Test results normal climb engine operating

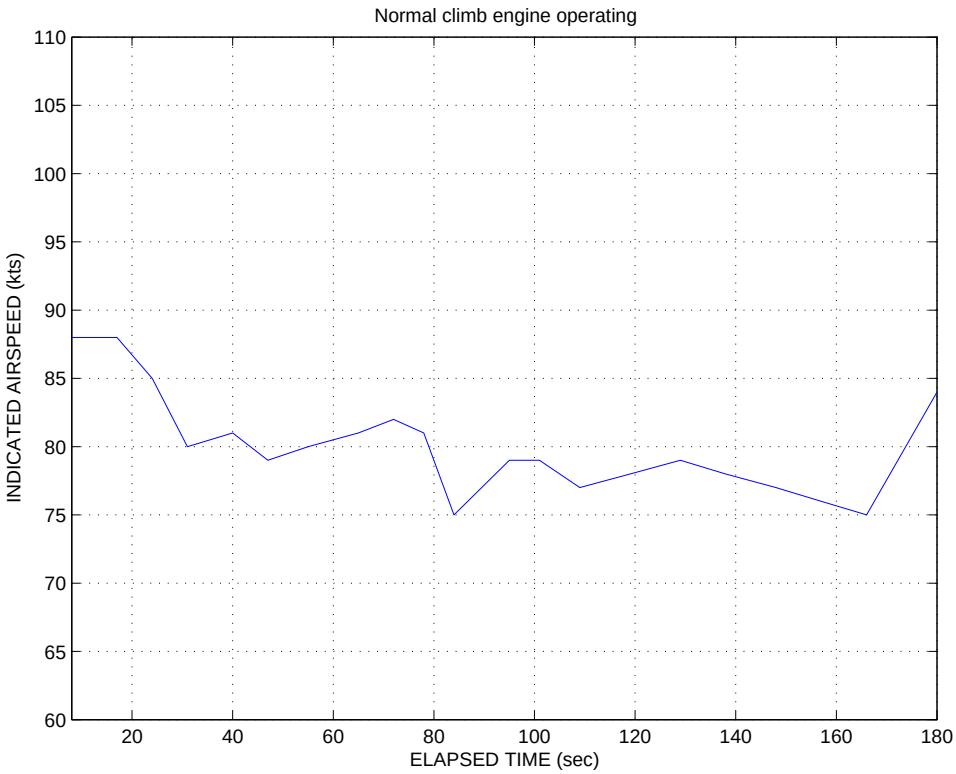

Figure 3.2: Indicated airspeed versus elapsed time

The initial conditions are the conditions in flight as total flight test time is at second 8.

Initial conditions

Climb flight condition:

CONTROL INPUTS:

THROTTLE SETTING	=	55	(mm)
MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	39.5	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	88	(kts)
RATE OF CLIMB	=	825	(fpm)
PRESSURE ALTITUDE	=	2000	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	2.0	(deg)
BANK ANGLE	=	0	(deg)
HEADING ANGLE	=	355	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	2300	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON

SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation
Engine speed at full throttle setting ranges from 2300 to 2350 rpm during the course of the climb from 2000 to 4000 feet. The average rate of climb and the average indicated airspeed are also determined for the segment of the climb from 2300 feet to 3700 feet. The average rate of climb of the climb from 2000 to 4000 feet is $60 \times (4000 - 2000)/(180 - 8) = 698$ feet/min. The average rate of climb of the climb from 2300 to 3700 feet is $60 \times (3700 - 2300)/(148 - 31) = 718$ feet/min. The pitch angle during the climb was about 3°. Average indicated airspeed is 80.1 knots during the climb from 2000 to 4000 feet and 79.1 knots during the climb from 2300 to 3700 feet.

3.2 Stall warning actuation (1b1)

3.2.1 Stall warning actuation (Climb)

Test procedures
With the throttle setting at the initial trim condition:
1. Pull the throttle to the idle position. Turn the trimwheel to hold the initial altitude. Use the Yoke in roll position to remain wings-level.
2. After the stall warning has gone off, push the throttle to its initial trim condition to initiate a recovery.

Test results
Table 3.3 displays the test results of the flap stall warning actuation tests of June 6$^{\text{th}}$ 2006 for movie file `06JUN2006_04_FSTD_2c8_Stall_warning_actuation_Climb.m2p` and `06JUN2006_05_FSTD_2c8_Stall_warning_actuation_Climb.m2p`.

STALL WARNING SPEED (kts)	WING FLAP ANGLE (deg)	BANK ANGLE (deg)
50	0	0
50	0	0

Table 3.3: Test results stall warning actuation (Climb). Pressure altitude = 2000 (ft)

3.2.2 Stall warning actuation (Approach)

Test procedures
With the throttle setting at the initial trim condition:
1. Pull the throttle to the idle position. Turn the trimwheel to hold the initial altitude. Use the Yoke in roll position to remain wings-level.
2. After the stall warning has gone off, push the throttle to its initial trim condition to initiate a recovery.

Test results
Table 3.4 displays the test results of the stall warning actuation test of June 6th 2006 for movie file `06JUN2006_17_FSTD_2c8_Stall_warning_actuation_Approach.m2p`.

STALL WARNING SPEED (kts)	WING FLAP ANGLE (deg)	BANK ANGLE (deg)
40	10	8

Table 3.4: Test results stall warning actuation (Approach). Pressure altitude = 3000 (ft)

Test evaluation

A flap extension leads to an increase of maximum lift coefficient. Since the stalling speed is proportional to the inverse of the square root of the maximum lift coefficient [11], a lower stalling speed is found for the configuration with Flaps 10 than for the configuration with Flaps 0.

3.3 Engine acceleration (1c1)

Test procedures
From the idle throttle setting, push the throttle to its maximum, i.e. throttle setting is 55 mm.

Test results
Test results to show Correct Trend & Magnitude where obtained during the engine acceleration test on June 6th 2006. See also movie file `06JUN2006_16_FSTD_1f1_Engine_acceleration.m2p`

The initial conditions are the conditions in flight as total flight test time is at second 11.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

THROTTLE SETTING	=	0	(mm)
MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	39.5	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	59	(kts)

RATE OF CLIMB	=	-220	(fpm)
PRESSURE ALTITUDE	=	3940	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	-1.5	(deg)
BANK ANGLE	=	0	(deg)
HEADING ANGLE	=	155	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	800	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation
As observed, EGT and fuel flow increase after the throttle has been pushed from its idle to its full setting. The engine speed increases from 800 rpm to 2300 rpm. The pressure altitude initially decreases after the throttle has been pushed from idle to maximum power. The indicated airspeed initially increases from 59 knots to 63 knots and decreases in less than five seconds to 60 knots as pressure altitude and pitch angle start to increase. After 11 seconds have elapsed, rate of climb starts to decrease again followed by a decrease of pressure altitude five seconds afterwards. This decrease of pressure altitude goes together with an increase of indicated airspeed.
Since thrust is generated by the propeller, engine thrust will increase as engine speed and

propeller speed increase. The useful power available for propulsion is given by the product of thrust and airspeed [11]. As thrust has settled with propeller speed, the power available varies will then vary only with airspeed.
The propulsive efficiency of the propeller is defined as the ratio of the power available to shaft brake power [11]. This implies that as thrust, fuel flow, EGT have reached their increased values after the engine speed has increased to 2300 rpm, the brake power will reach its increased value and propulsive efficiency will only vary with airspeed.

3.4 Engine deceleration (1c2)

Test procedures
Starting on ground with the throttle setting at 55 mm:
From the maximum throttle setting, pull the throttle towards idle, i.e. throttle setting is 0 mm.

Test results
Test results to show Correct Trend & Magnitude where obtained during the engine deceleration tests on June 6th 2006. See also movie files `06JUN2006_01_FSTD_1f2_Engine_deceleration.m2p` and `06JUN2006_02_FSTD_1f2_Engine_deceleration_(ENGINEPAR).m2p`
At maximum throttle setting, the an engine speed of 2210 rpm is obtained. A rapid movement of the throttle setting from full to idle leads to immediate decreases of exhaust gas temperature and fuel flow. The engine speed decreases to 675 rpm in less than four seconds. The cylinder head temperature does not change significantly over the course of the test.

Initial conditions

Ground flight condition:

CONTROL INPUTS:

THROTTLE SETTING	=	55	(mm)
MIXTURE SETTING	=	55	(mm)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

PRESSURE ALTITUDE	=	-15	(ft)

ENGINE PARAMETERS:

ENGINE SPEED	=	2210	(rpm)
CYLINDER HEAD TEMPERATURE	=	15	(deg c)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	ON
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation
The two prime engine parameters not observed in this test flight, engine shaft brake power and engine thrust, will come close to their maxima as engine speed reaches its maximum, and will decrease as engine speed decreases.

3.5 Pitch controller force vs. position (2a1)

3.5.1 Pitch controller force vs. position (Cruise)

Test procedures
This test is combined with the longitudinal static stability test under cruise flight conditions of Section 3.19.

Test results
Figure 3.3 shows the pitch controller force versus position results of Table 3.31.

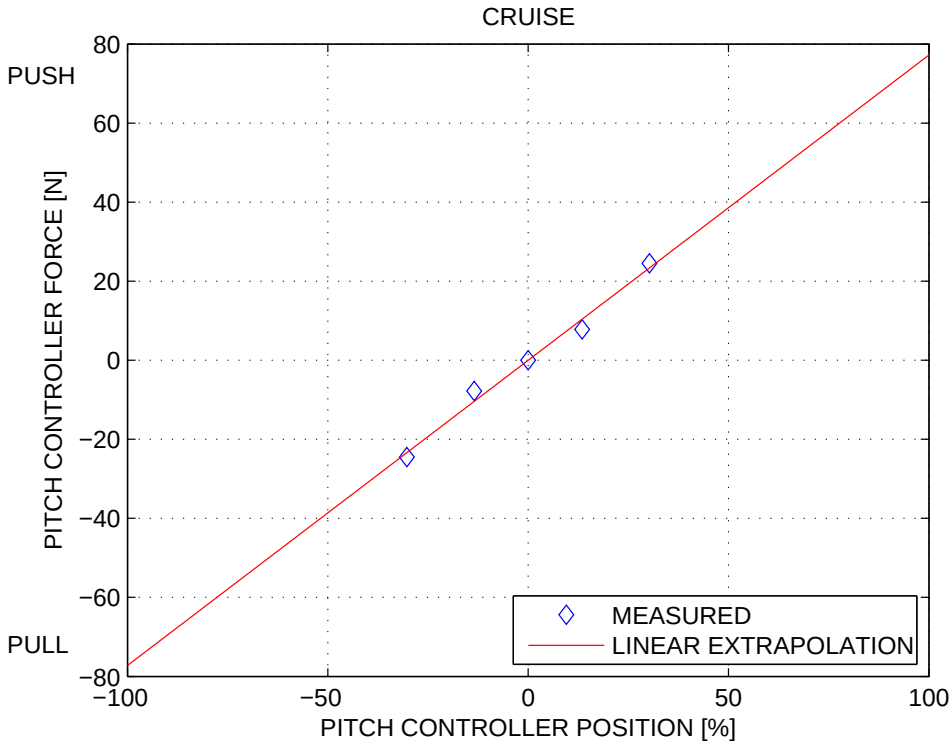

Figure 3.3: Pitch controller force vs. position (Cruise, Flaps 0)

3.5.2 Pitch controller force vs. position (Approach)

Test procedures
This test is combined with the longitudinal static stability test under approach flight conditions of Section 3.19.

Test results
Figure 3.4 shows the pitch controller force versus position results of Table 3.33.

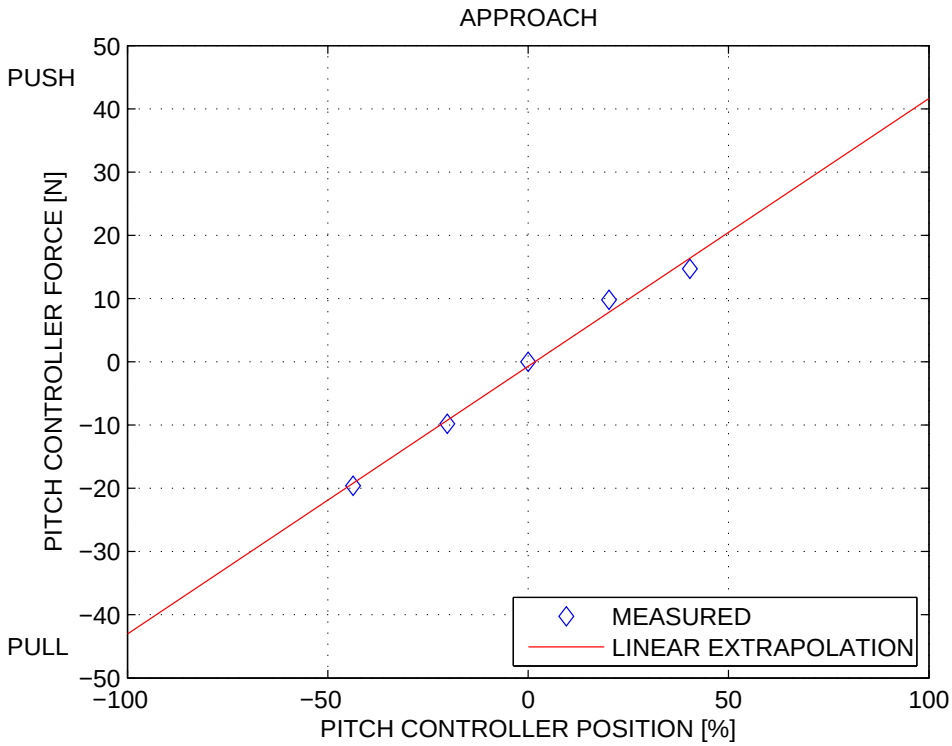

Figure 3.4: Pitch controller force vs. position (Approach, Flaps 10)

Test evaluation

A forward Yoke movement involves a push (i.e. control force has positive sign) and an aft Yoke movement involves a pull (i.e. control force has negative sign).

3.6 Roll controller force vs. position (2a2)

3.6.1 Roll controller force vs. position (Cruise)

Test procedures
This test was performed during the test flight session of 27 October 2006. From the initial trimmed flight condition the force needed for a roll controller input of -30 and +30 degrees were measured. For maintaining the initial heading after a roll controller input of ±30 degrees, the pilot had to use full rudder pedal input.

Test results
Table 3.7 and Figure 3.5 display the results obtained during the test flight session of 27 October 2006.

ROLL CONTROLLER POSITION (%)	ROLL CONTROLLER FORCE (N)
-33	-41.7
0	0
+33	+41.7

Table 3.7: Roll controller force vs. position (Cruise, Flaps 0, 100% = 90 deg roll control)

The initial conditions of the cruise flight condition are shown below.

Initial conditions **Cruise flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
ROLL CONTROLLER POSITION	=	0	(%)

RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	90	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4600	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

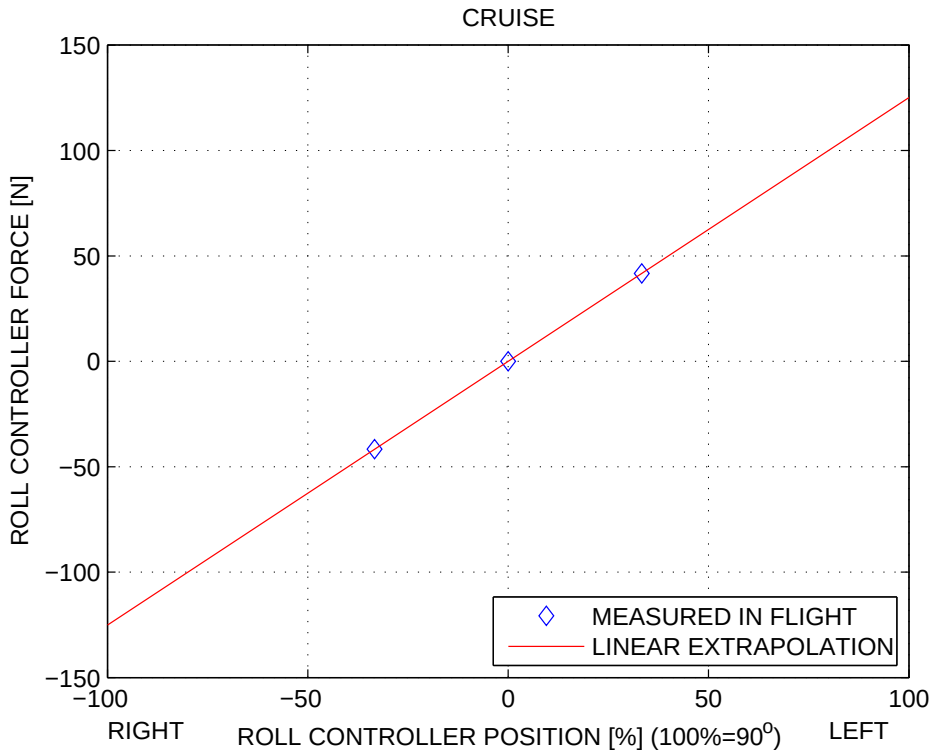

Figure 3.5: Roll controller force vs. position (Cruise, Flaps 0, 100% = 90 deg roll control)

3.6.2 Roll controller force vs. position (Approach)

Test procedures
This test was performed during the test flight session of 27 October 2006. From the initial trimmed flight condition the force needed for a roll controller input of -30 and +30 degrees were measured. For maintaining the initial heading after a roll controller input of ±30 degrees, the pilot had to use full rudder pedal input.

Test results
Table 3.9 and Figure 3.6 display the results obtained during the test flight session of 27 October 2006.

ROLL CONTROLLER POSITION (%)	ROLL CONTROLLER FORCE (N)
-33	-24.5
0	0
+33	+24.5

Table 3.9: Roll controller force vs. position (Approach, Flaps 10, 100% = 90 deg roll control)

The initial conditions of the approach flight condition are shown below.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	2050	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

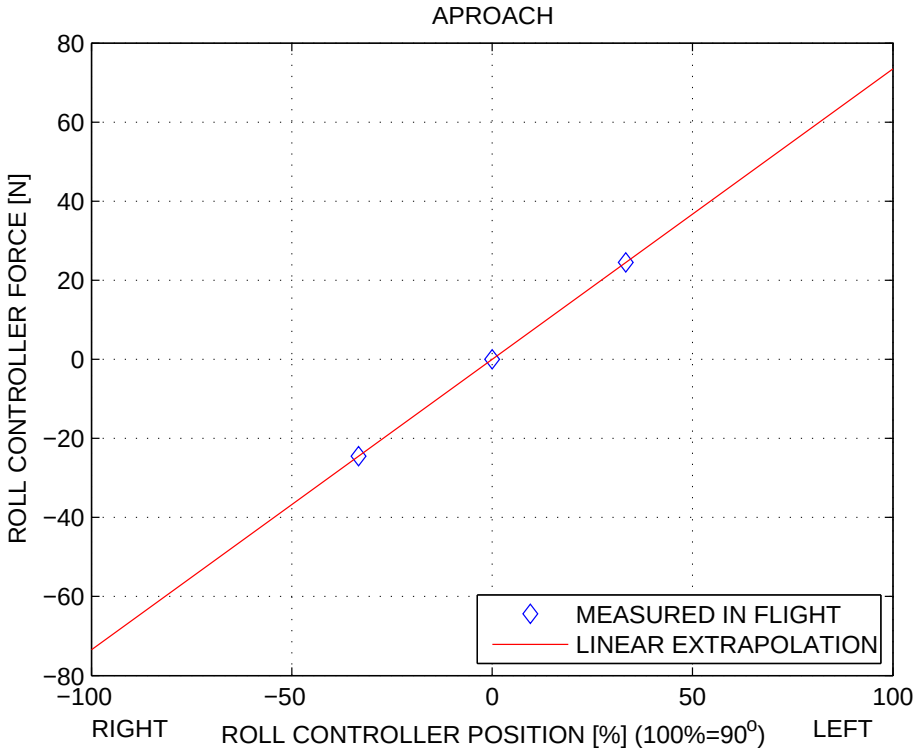

Figure 3.6: Roll controller force vs. position (Approach, Flaps 10, 100% = 90 deg roll control)

Test evaluation

Under approach flight conditions i.e. flaps 10 and an indicated airspeed of 75 knots, the roll controller forces are lower than under cruise flight conditions at an indicated airspeed of 90 knots and flaps 0. During the test procedure full rudder pedal inputs were required to maintain the initial heading. Therefore, a significant part of the roll controller forces that were needed are due to the slip movement of the aeroplane.

3.7 Rudder pedal force vs. position (2a3)

3.7.1 Rudder pedal force vs. position (Cruise)

Test procedures
This test was performed during the test flight session of 26 July 2006. From the initial trimmed Cruise flight condition the rudder pedal position versus rudder pedal force measured while maintaining the initial heading.

Test results
Table 3.11 and Figure 3.7 display the test results of the rudder pedal force vs. position test.

RUDDER PEDAL POSITION (%)	RUDDER PEDAL FORCE (N)
0	0.0
25	49.0
43	78.5
61	98.1

Table 3.11: Rudder pedal force vs. position (Cruise, Flaps 0)

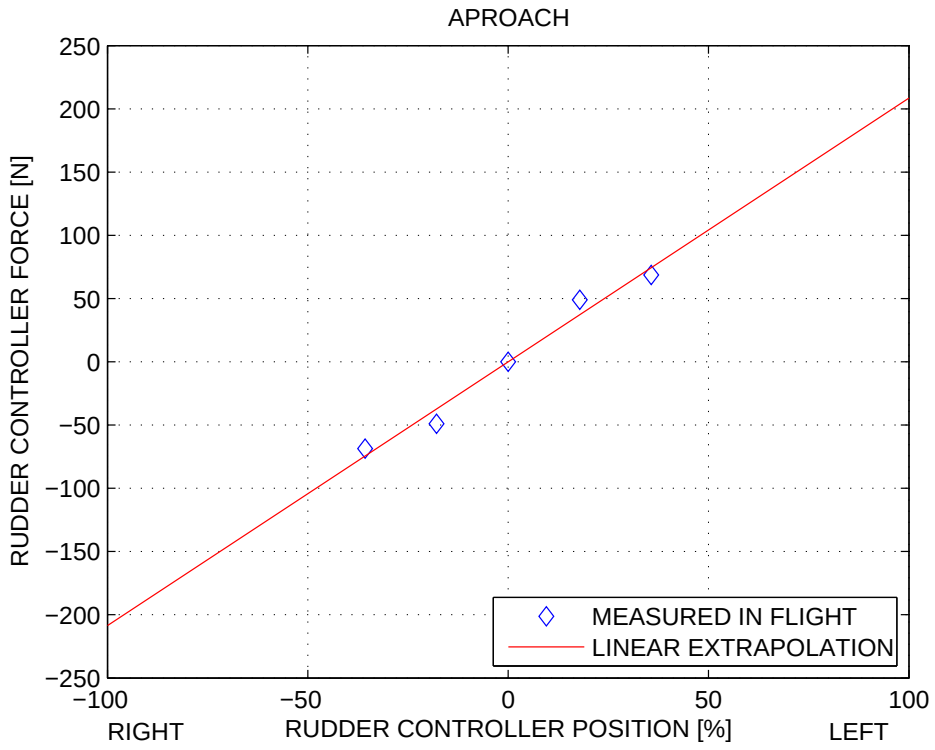

Figure 3.7: Rudder pedal force vs. position (Cruise, Flaps 0)

The initial conditions of the cruise flight condition are shown below.

Initial conditions **Cruise flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	32	(deg C)
BARO PRESSURE AT SEALEVEL	=	1016	(mbar)
WIND SPEED	=	6	(kt)
WIND SPEED DIRECTION	=	030	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	90	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	3000	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	2100	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON

SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

3.7.2 Rudder pedal force vs. position (Approach)

Test procedures
This test was performed during the test flight session of 26 July 2006. From the initial trimmed Approach flight condition the rudder pedal position versus rudder pedal force measured while maintaining the initial heading.

Test results
Table 3.13 and Figure 3.8 display the test results of the rudder pedal force vs. position test.

RUDDER PEDAL POSITION (%)	RUDDER PEDAL FORCE (N)
0	0.0
18	49.0
36	68.6

Table 3.13: Rudder pedal force vs. position (Approach, Flaps 10)

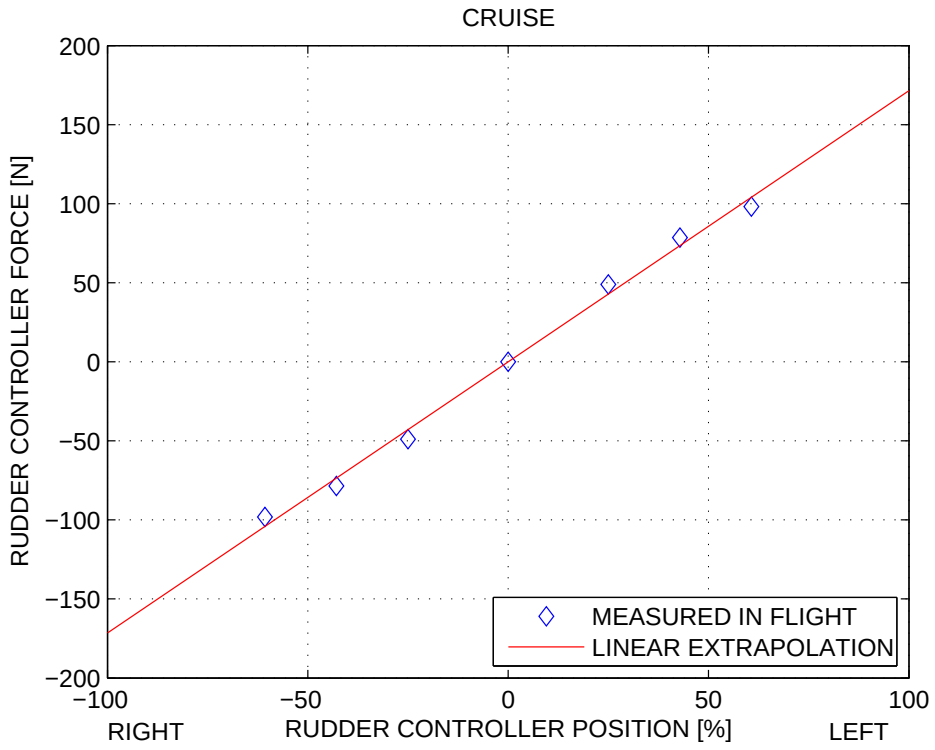

Figure 3.8: Rudder pedal force vs. position (Approach, Flaps 10)

The initial conditions of the approach flight condition are shown below.

Initial conditions

Approach flight condition:

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

atmosphere/weather:

TEMPERATURE AT SEALEVEL	=	32	(deg C)
BARO PRESSURE AT SEALEVEL	=	1016	(mbar)
WIND SPEED	=	6	(kt)
WIND SPEED DIRECTION	=	030	(deg)

speed/altitude/temperature:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	3000	(ft)

euler & aero angles/rates:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

engine parameters:

ENGINE SPEED	=	2000	(rpm)

control surfaces:

WING FLAP ANGLE	=	10.0	(deg)

switches/brakes:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON

SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation

A left rudder pedal movements involves a control force that has a positive sign and right rudder pedal movements involves a control force that has a negative sign by definition. The transmission of travel versus force is smooth and linear. Maximum left rudder pedal and maximum right rudder pedal movements agree with maximum control forces.
Table 2.8 and Figure 2.10 show that the travel of the left rudder pedal is much larger (435-396 = 39 mins) than the travel of the right rudder pedal (396-379 = 17 mins). It becomes clear that the springs in the rudder control system (see Figure 2.11) contribute for a large part to the rudder pedal force in addition to the small contribution due to aerodynamic loading of the rudder control surface. The contribution to the rudder pedal force due to aerodynamic loading of the rudder control surface is proportional to the square of the airspeed at the rudder control surface.

3.8 Trimwheel position vs. trim tab angle (2a4)

Test procedures
Measure the deflection of the elevator trim tab over the full range of the trimwheel.

Test results
Table 3.15 and Figure 3.9 display the test results of the trimwheel position vs. trim tab angle test of 27th July 2006.

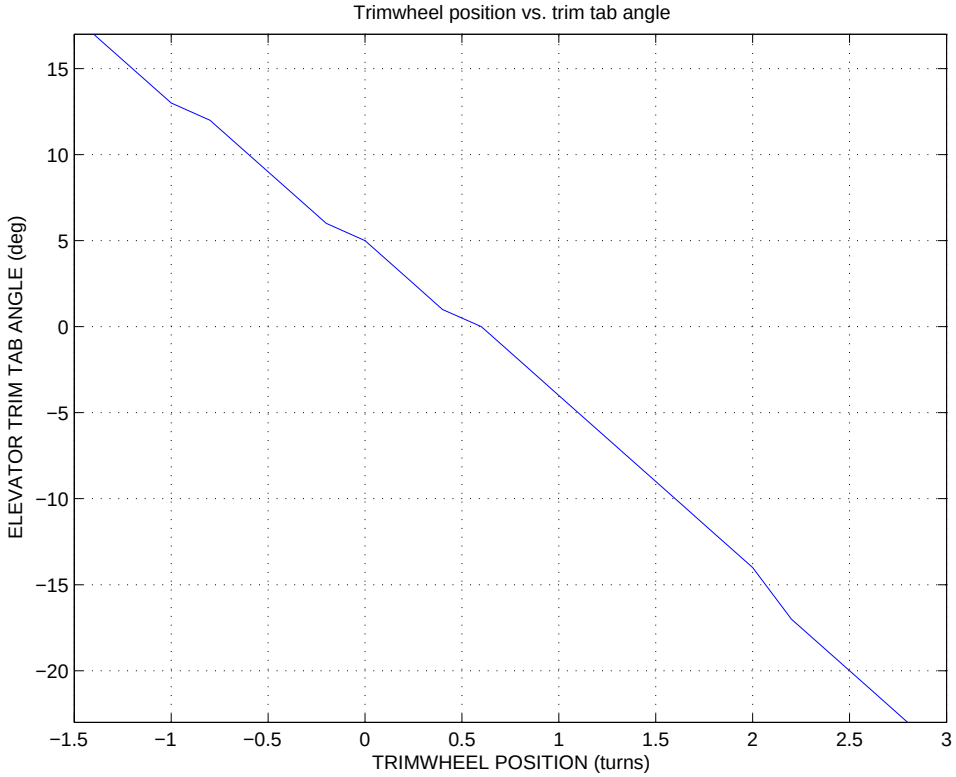

Figure 3.9: Trimwheel position vs. trim tab angle (test result)

Initial conditions **Ground flight condition:**

CONTROL INPUTS:

THROTTLE SETTING	=	0	(mm)
MIXTURE SETTING	=	0	(mm)

CONTROL SURFACES:

ELEVATOR ANGLE	=	0.0 (deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	OFF
PARKING BRAKE	=	ON
SWITCH MASTER ALT	=	OFF
SWITCH MASTER BAT	=	OFF
AVIONICS BUS 1	=	OFF
AVIONICS BUS 2	=	OFF
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation
A trimwheel movement maximum nose up of -1.4 turns corresponds with a maximum down (positive) elevator trim tab deflection. A trimwheel movement maximum nose down of +2.8 turns corresponds with a maximum down (negative) elevator trim tab deflection. The transmission of the movement of the trimwheel to the elevator trim tab deflection can be assumed to be linear. See also the elevator trim control system in Figure 3.10.

TRIMWHEEL POSITION (turns)	ELEVATOR TRIM TAB ANGLE (deg)
-1.4	17
-1.2	15
-1.0	13
-0.8	12
-0.6	10
-0.4	8
-0.2	6
0.0	5
0.2	3
0.4	1
0.6	0
0.8	-2
1.0	-4
1.2	-6
1.4	-8
1.6	-10
1.8	-12
2.0	-14
2.2	-17
2.4	-19
2.6	-21
2.8	-23

Table 3.15: Trimwheel position vs. trim tab angle

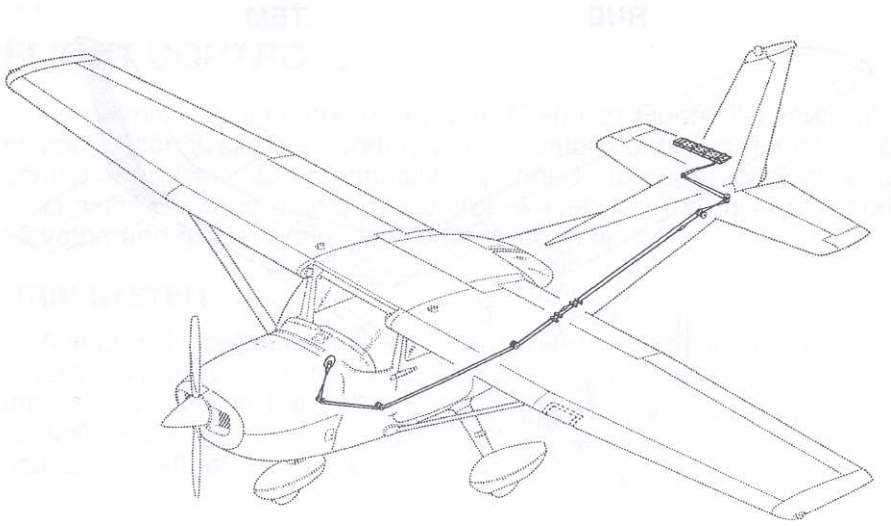

Figure 3.10: The elevator trim control system

Figure 3.11: The elevator trim tab

3.9 Alignment of throttle vs. selected engine parameter (2a5)

Test procedures
Note the engine speed with the throttle at the idle position.
Note the throttle setting at an engine speed of 1000 RPM.
Note the throttle setting at an engine speed of 1500 RPM.
Note the throttle setting at an engine speed of 2000 RPM.
Note the engine speed with with full throttle setting.

Test results
Table 3.17 and Figure 3.12 display the test results obtained in the Cessna 172N on June 6th 2006. The throttle setting is given in millimeters where 0 millimeters represents an idle throttle setting and 55 millimeters means that the throttle is fully pressed.

THROTTLE SETTING (mm)	ENGINE SPEED (rpm)
0	675
4	1000
11	1500
22	2000
55	2210

Table 3.17: Test results alignment of throttle vs. selected engine parameter

As observed during the test, engine torque, exhaust gas temperature and fuel flow all increased as the throttle setting increased.

Initial conditions **Ground flight condition:**

CONTROL INPUTS:

THROTTLE SETTING	=	0	(mm)
MIXTURE SETTING	=	55	(mm)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

PRESSURE ALTITUDE	=	-15	(ft)

ENGINE PARAMETERS:

ENGINE SPEED	=	675	(rpm)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	ON
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

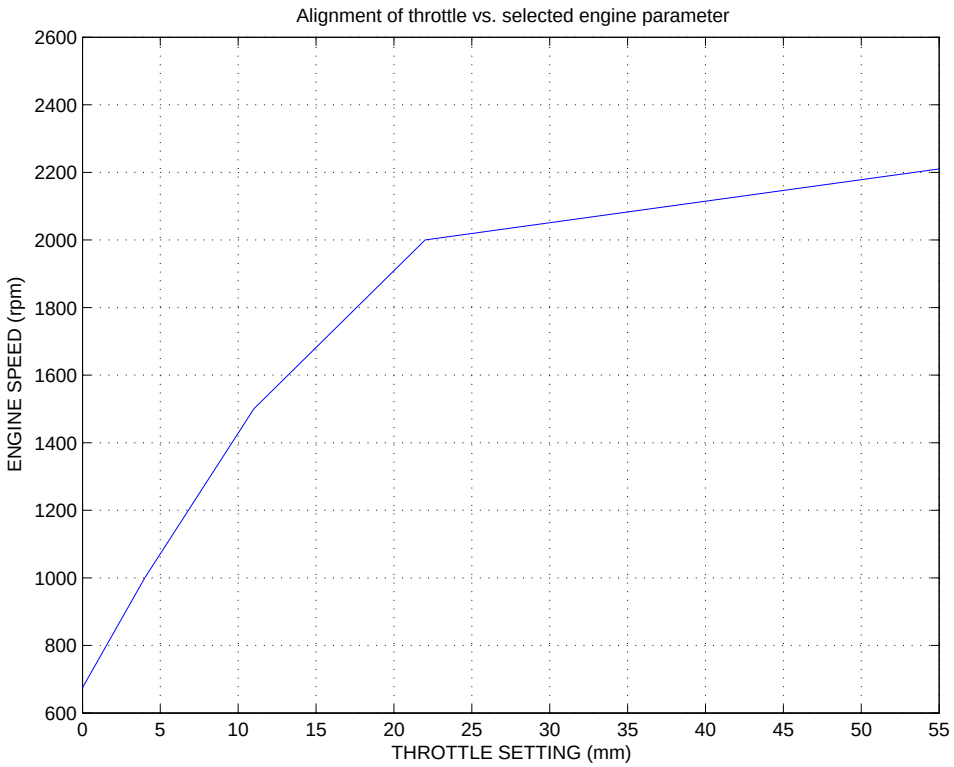

Figure 3.12: Test results alignment of throttle vs. selected engine parameter

Test evaluation

On ground the maximum engine speed of 2700 rpm is not reached at full throttle (full rich mixture). Instead, the maximum static engine speed is found to be 2210 rpm.

3.10 Power change force (2b1-1)

Not available.

3.11 Power change dynamics (2b1-2)

Test procedures
From a trimmed and wings-level cruise flight condition, push the throttle to the maximum setting of 55 mm and let the aeroplane respond freely.

Test results
Table 3.19 and Figure 3.13 to Figure 3.15 display the test results of the power change dynamics test of June 6th 2006. See also movie file `06JUN2006_07_FSTD_2c1_Power_change_dynamics.m2p`.

ELAPSED TIME (sec)	INDICATED AIRSPEED (kts)	PITCH ANGLE (deg)	PRESSURE ALTITUDE (ft)
5	100	0	3990
7	101	0	3995
9	102	0	4000
11	102	1	4010
13	101	2	4030
15	99	3	4070
17	96	4	4110
19	92	4	4150
21	90	3	4190
23	90	2	4210
25	90	1	4240
27	90	1	4250
29	90	0	4270
30	90	0	4270

Table 3.19: Test results power change dynamics

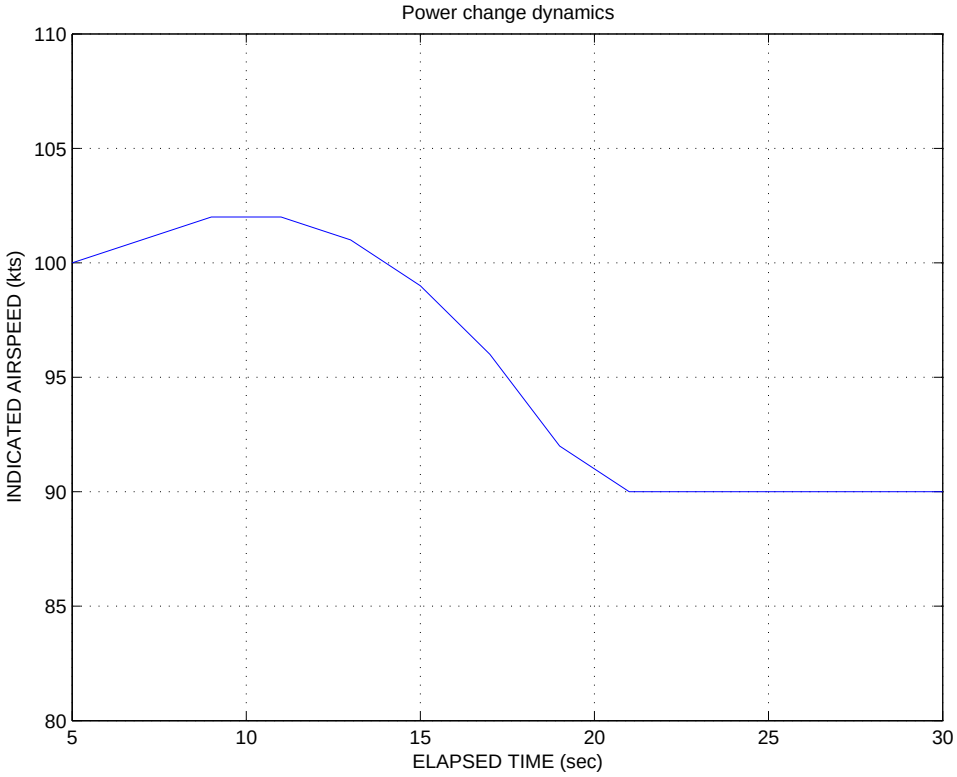

Figure 3.13: Indicated airspeed versus elapsed time

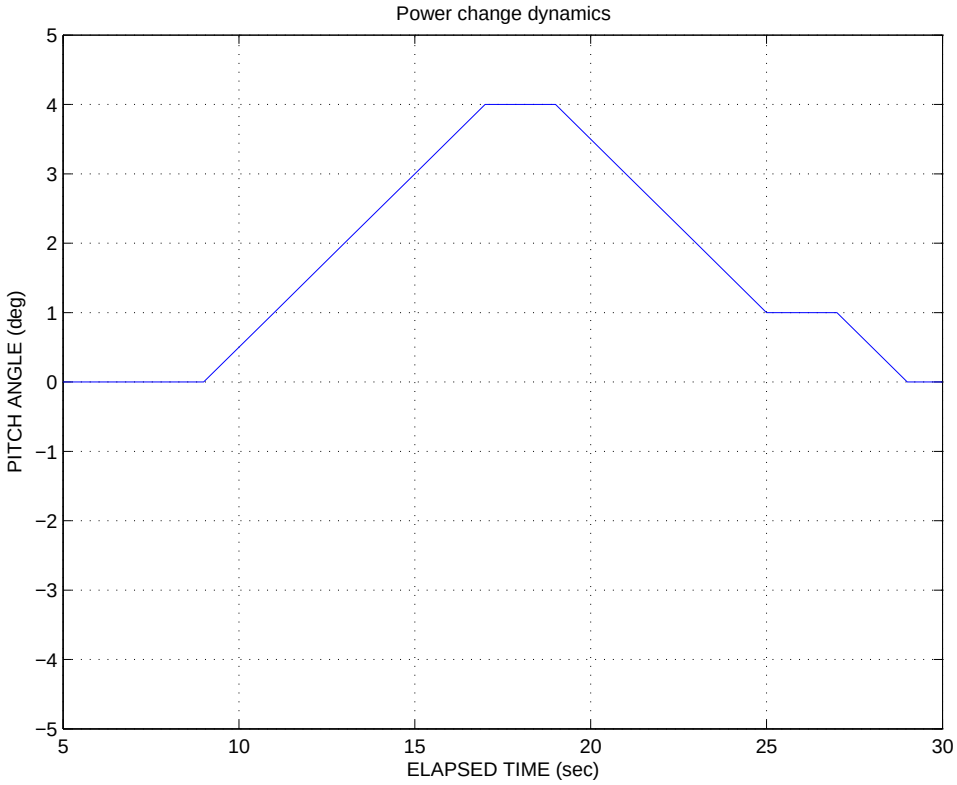

Figure 3.14: Pitch angle versus elapsed time

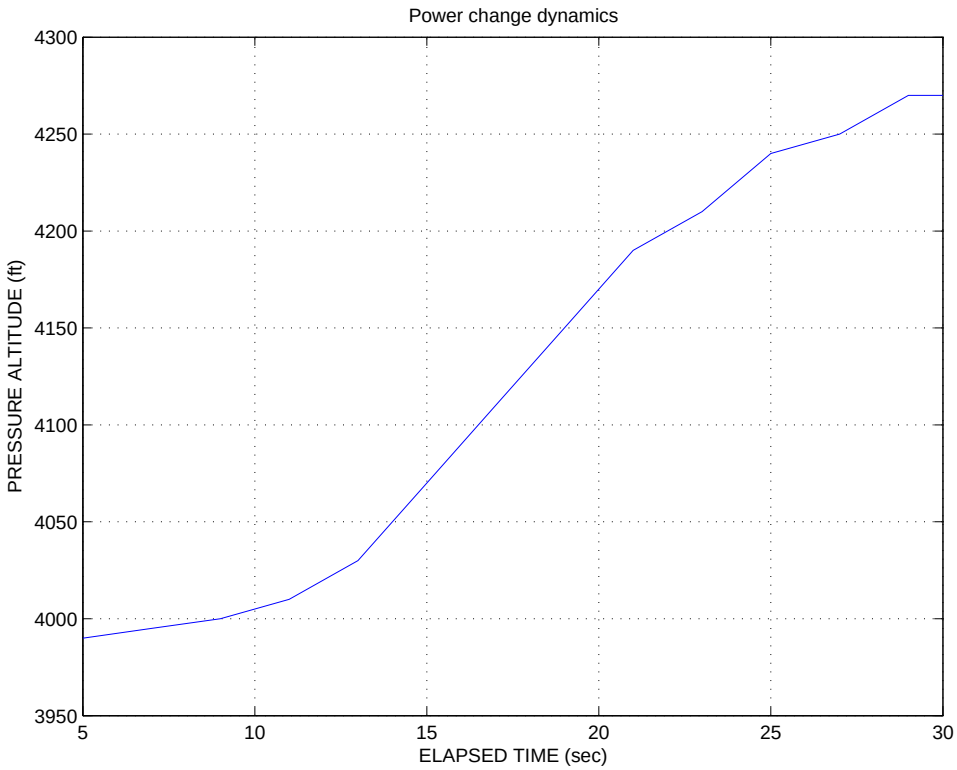

Figure 3.15: Pressure altitude versus elapsed time

The initial conditions are the conditions in flight as total flight test time is at second 5.

Initial conditions **Cruise flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	39.5	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	100	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	3990	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
HEADING ANGLE	=	240	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	2050	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH

SWITCH FUEL CUTOFF = OFF

Test evaluation
An increase of throttle setting while the elevator and elevator trim tab angle remain fixed, initially leads to an increase in airspeed. The ultimate result of increasing the throttle setting is a change in flight path angle (or pitch angle).

3.12 Flap change force (2b2-1)

Not available.

3.13 Flap change dynamics (2b2-2)

3.13.1 Flap change dynamics (retraction)

Test procedures (retraction)
Starting from a takeoff flight condition with the flap lever and the wing flap angle at 10 degrees:
1. From the 10 degrees position, move the flap lever to the flaps 0 degrees position.
2. Let the aeroplane respond freely and record until 20 seconds have elapsed.

Test results (retraction)
Table 3.21 and Figure 3.16 to Figure 3.18 display the test results of the flap change dynamics test of June 6th 2006. See also movie file `06JUN2006_03_FSTD_2c2_flap_change_dynamics_(retraction).m2p`. The pilot had to take control over the aircraft after ten seconds i.e. after a total of 15 seconds of test flight time had elapsed.

ELAPSED TIME (sec)	INDICATED AIRSPEED (kts)	PITCH ANGLE (deg)	PRESSURE ALTITUDE (ft)
5	74	0	2050
7	74	-1	2050
9	80	-5	2050
11	89	-10	2020
13	102	-12	1940
15	120	-13	1825
17	129	-10	1650
19	138	-6	1530
21	137	-1	1455
23	130	2	1440
25	132	4	1455

Table 3.21: Test results flap change dynamics (retraction)

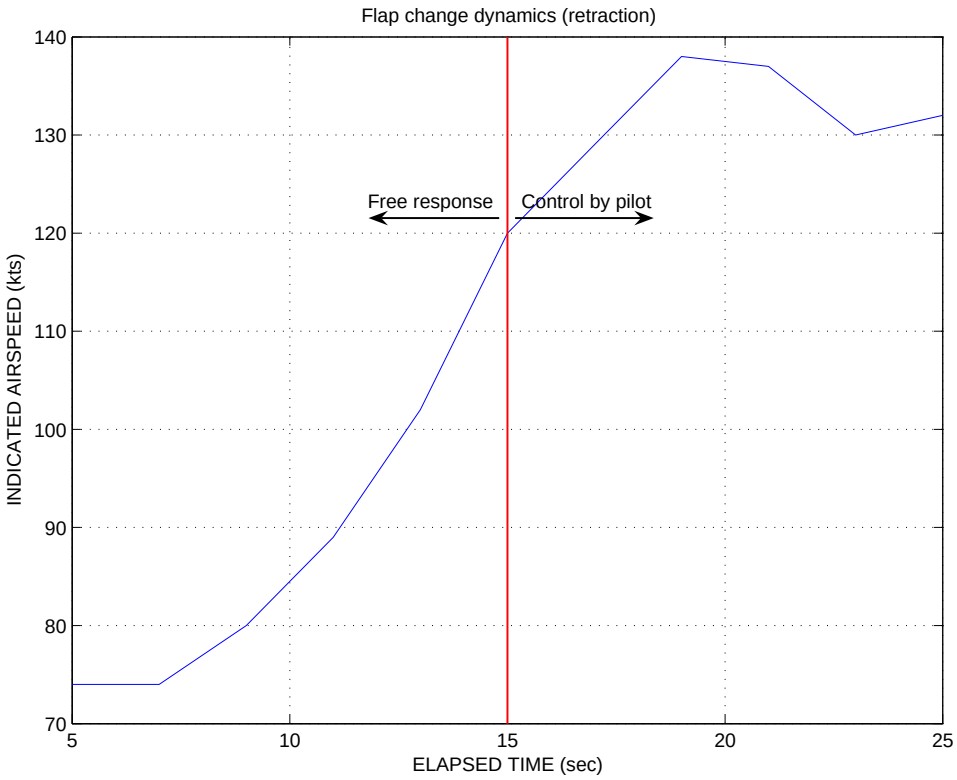

Figure 3.16: Indicated airspeed versus elapsed time (retraction)

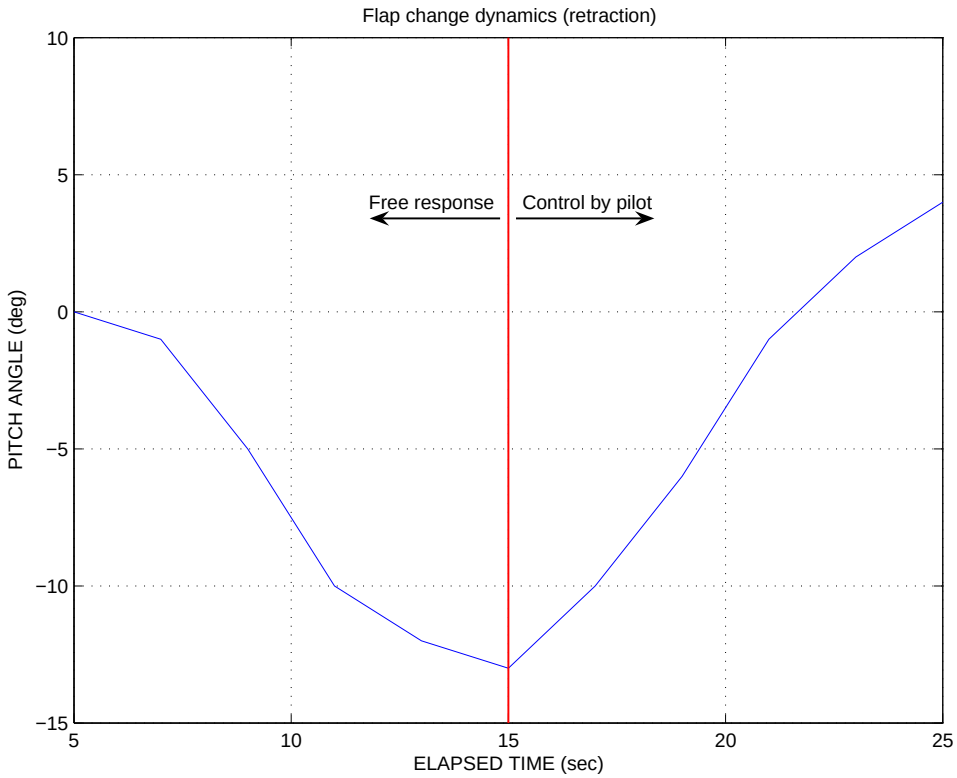

Figure 3.17: Pitch angle versus elapsed time (retraction)

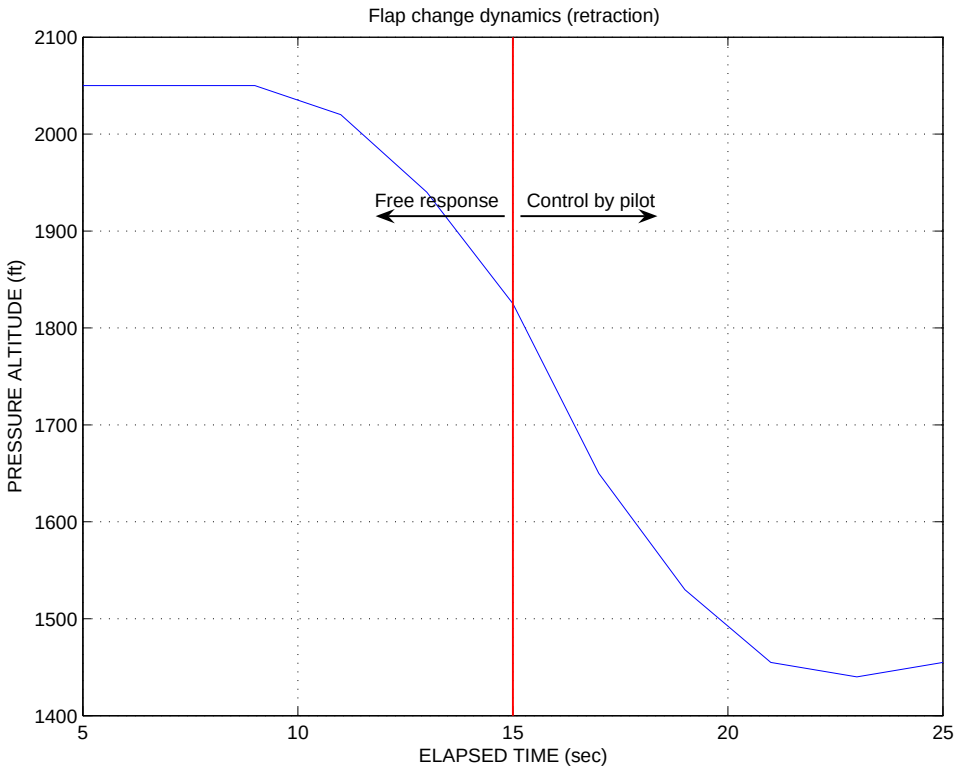

Figure 3.18: Pressure altitude versus elapsed time (retraction)

The initial conditions are the conditions in flight as total flight test time is at second 5.

Initial conditions **Takeoff flight condition (retraction):**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	39.5	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	74	(kts)
RATE OF CLIMB	=	120	(fpm)
PRESSURE ALTITUDE	=	2050	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
HEADING ANGLE	=	255	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	1900	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

3.13.2 Flap change dynamics (extension)

Test procedures (extension)
Starting from an approach flight condition with the flap lever and the wing flap angle at 0 degrees:
1. From the 0 degrees position, move the flap lever to the flaps 10 degrees position.
2. Let the aeroplane respond freely and record until 20 seconds have elapsed.

Test results (extension)
Table 3.23 and Figure 3.19 to Figure 3.21 display the test results of the flap change dynamics test of June 6th 2006. See also movie file `06JUN2006_14_FSTD_2c2_flap_change_dynamics_(extension).m2p`. The pilot had to take control over the aircraft after five seconds i.e. after a total of 23 seconds of test flight time had elapsed.

ELAPSED TIME (sec)	INDICATED AIRSPEED (kts)	PITCH ANGLE (deg)	PRESSURE ALTITUDE (ft)
18	75	0	4050
20	75	2	4050
22	70	8	4050
23	64	10	4060
24	60	10	4100
26	50	5	4160
28	50	3	4170
30	50	3	4160
32	52	3	4150
34	53	4	4150
36	58	4	4150

Table 3.23: Test results flap change dynamics (extension)

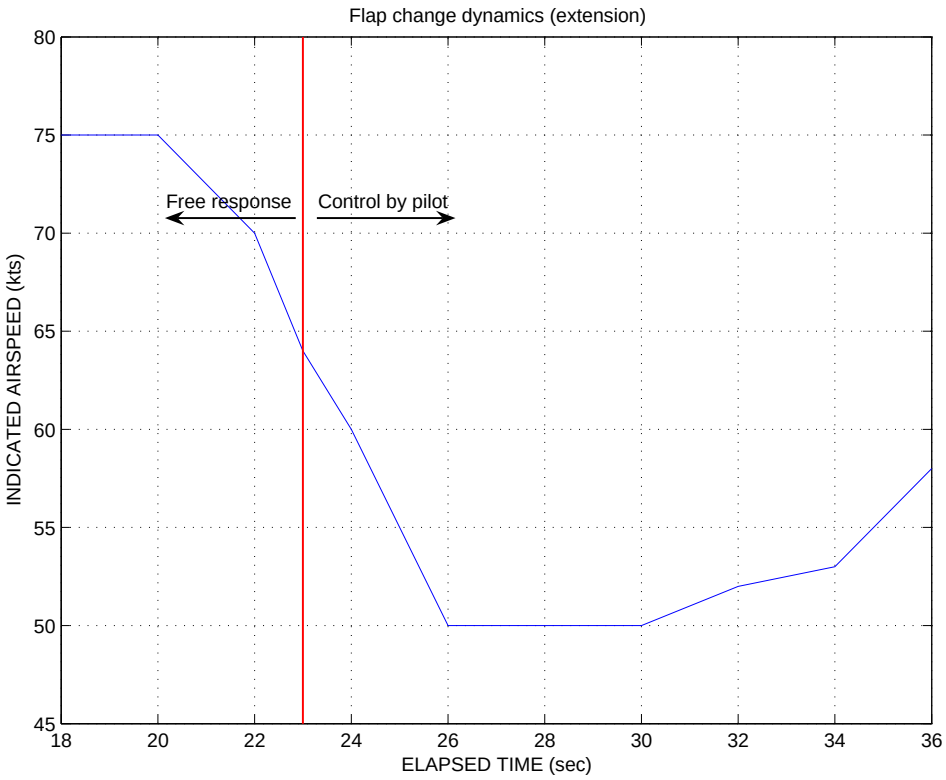

Figure 3.19: Indicated airspeed versus elapsed time (extension)

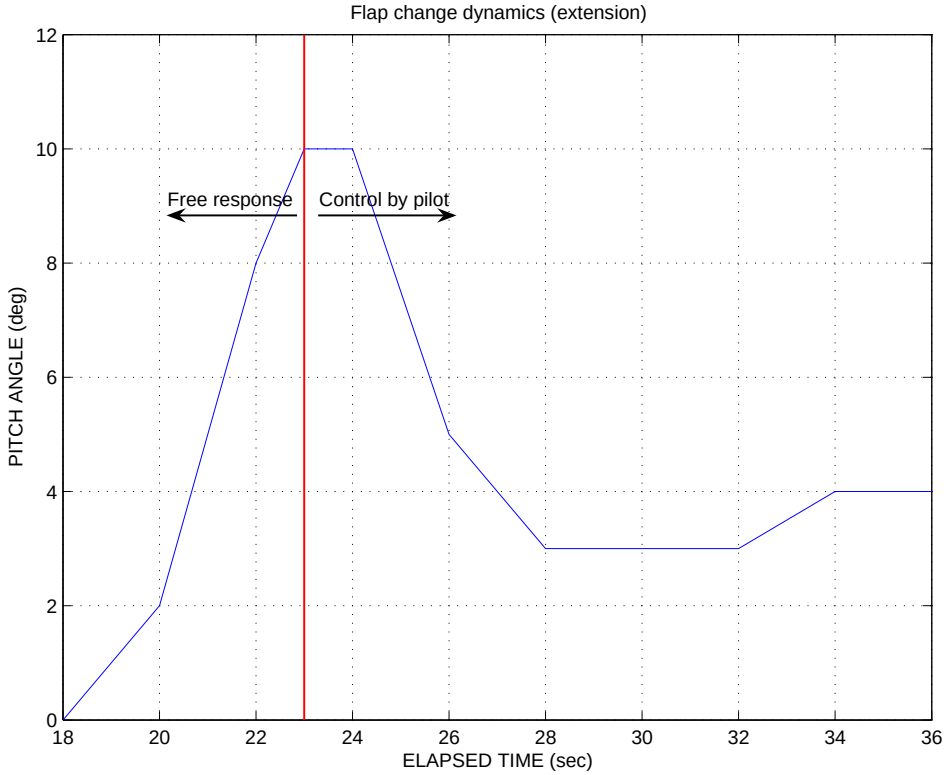

Figure 3.20: Pitch angle versus elapsed time (extension)

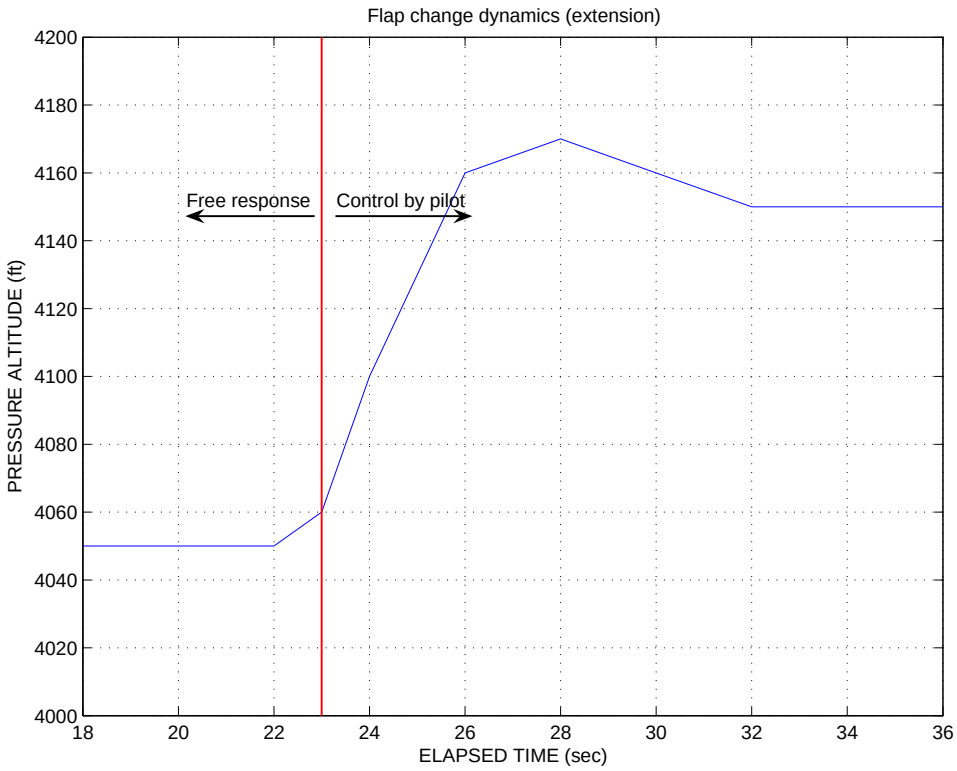

Figure 3.21: Pressure altitude versus elapsed time (extension)

The initial conditions are the conditions in flight as total flight test time is at second 18.

Initial conditions

Approach flight condition (extension):

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	39.5	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	100	(fpm)
PRESSURE ALTITUDE	=	4050	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
HEADING ANGLE	=	195	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	1900	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH

SWITCH FUEL CUTOFF = OFF

Test evaluation

A flap extension leads to a positive increments in drag, lift and moment coefficients of the wing [3]. This means that from a trimmed flight condition, the airspeed decreases as drag increases, pitch angle increases as the moment coefficient increases and pressure altitude increases due to an increment of lift force. A flap retraction has an opposite effect on airspeed, pitch angle and pressure altitude.

3.14 Gear change force (2b4-1)

Not applicable (fixed gear).

3.15 Gear change dynamics (2b4-2)

Not applicable (fixed gear).

3.16 Gear and Flap/Slat operating times (2b5)

Test procedures
Flap positions are selected and time to extension/retraction is measured with a stop-watch. Gear operating times are not applicable (fixed gear).
The flap extension and retraction tests were performed in a Cessna 172 in November 2008.
See also movie file`NOV2008_FSTD_2b5_Flap_Operating_Times.avi`.

Test results - extension
UP (0 deg) to APPROACH (10 deg) = 3 seconds
APPROACH (10 deg) to DOWN (20 deg) = 3 seconds

Test results - retraction
DOWN (20 deg) to APPROACH (10 deg) = 3 seconds
APPROACH (10 deg) to UP (0 deg) = 3 seconds

3.17 Longitudinal trim (2b6)

3.17.1 Longitudinal trim (Cruise)

Test procedures
Establish steady state wings level constant altitude flight condition, setting thrust as required to achieve target speed. Trim the aeroplane for a Cruise flight condition i.e flaps 0.

Test results
The longitudinal trim test was performed during the test flight session of 27 October 2006. See also movie file `27OCT2006_01_FSTD_2c5_Longitudinal_trim_Cruise.m2p`.

BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
ELEVATOR TRIM TAB ANGLE	=	-6.0	(deg)
ENGINE SPEED	=	2000	(rpm)
INDICATED AIRSPEED	=	88	(kts)
PITCH ANGLE	=	0	(deg)
PRESSURE ALTITUDE	=	5000	(ft)
TEMPERATURE AT SEALEVEL	=	15	(deg C)
TRIMWHEEL POSITION	=	1.2	(-)

Table 3.25: Longitudinal trim (Cruise)

3.17.2 Longitudinal trim (Approach)

Test procedures
Establish steady state wings level constant altitude flight condition, setting thrust as required to achieve target speed. Trim the aeroplane for an Approach flight condition i.e flaps 10.

Test results
The longitudinal trim test was performed during the test flight session of 27 October 2006. See also movie file `27OCT2006_08_FSTD_2c5_Longitudinal_trim_Approach.m2p`.

BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
ELEVATOR TRIM TAB ANGLE	=	-8.0	(deg)
ENGINE SPEED	=	1950	(rpm)
INDICATED AIRSPEED	=	75	(kts)
PITCH ANGLE	=	0	(deg)
PRESSURE ALTITUDE	=	4500	(ft)
TEMPERATURE AT SEALEVEL	=	15	(deg C)
TRIMWHEEL POSITION	=	1.4	(-)

Table 3.26: Longitudinal trim (Cruise)

Test evaluation

For a well trimmed flight condition, while time advances and while the control inputs stay unchanged, the aircraft and engines states remain constant to, or only slowly drift away from, their initial equilibrium values. In other words, aircraft and/or engine states like angle of attack, engine power, engine speed, fuel flow, pitch angle and pressure altitude remain close to their initially trimmed values and only slowly divert from their initial values as time progresses. Similar statements can be made for the indicated airspeed (not a state by definition) and engine output parameter thrust.
Pitch angular acceleration, rate of climb, roll angular acceleration and yaw angular acceleration are time derivatives of states and are have their values close to zero as time advances.

3.18 Longitudinal manoeuvring stability (stick force/g) (2b7)

3.18.1 Longitudinal manoeuvring stability (Cruise)

Test procedures
The rudder pedal position, the flap setting, the throttle setting, the mixture setting and the trimwheel position must remain constant over the course of this test.

Starting with the pitch controller in the neutral position:
1. In 10 seconds move the Yoke in roll position in a counterclockwise direction such that the bank angle becomes 60 degrees. Use pitch control force to maintain the trim speed.
2. In 10 seconds move the Yoke in roll position in a clockwise direction such that the bank angle becomes 60 degrees. Use pitch control force to maintain the trim speed.

Test results
The longitudinal manoeuvring stability test was performed during the test flight session of 26 July 2006.

ROLL CONTROLLER POSITION (deg)	PITCH CONTROLLER FORCE (N)
5	0
30	10.8
45	17.2

Table 3.27: Longitudinal manoeuvring stability (Cruise)

The initial conditions of the cruise flight condition are shown below.

Initial conditions	**Cruise flight condition:**
	CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	90	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	5000	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

3.18.2 Longitudinal manoeuvring stability (Approach)

Test procedures
The rudder pedal position, the flap setting, the throttle setting, the mixture setting and the trimwheel position must remain constant over the course of this test.

Starting with the pitch controller in the neutral position:
1. In 10 seconds move the Yoke in roll position in a counterclockwise direction such that the bank angle becomes 60 degrees. Use pitch control force to maintain the trim speed.
2. In 10 seconds move the Yoke in roll position in a clockwise direction such that the bank angle becomes 60 degrees. Use pitch control force to maintain the trim speed.

Test results
The longitudinal manoeuvring stability test was performed during the test flight session of 26 July 2006.
The initial conditions of the approach flight condition are shown below.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
HEADING ANGLE	=		(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation

A change in bank angle from 0 to 60 degrees leads to an increase in lift of 100%. This means that the lift induced drag also doubles. For maintaining our initial trim speed with constant power and trimwheel settings, while the bank angle increases, the aeroplane looses altitude. In other words, the potential energy is used for kinetic energy in terms of airspeed. The aeroplane needs to pitch nose down by means of pushing the Yoke in pitch control position. A push of the Yoke for pitch control was defined by a force with a positive sign.
While the normal load factor increases due to an increase in bank angle, the pitch controller force needs to be increased to maintain the initial trim speed. The gradient of pitch controller force versus the normal loadfactor has a positive sign.

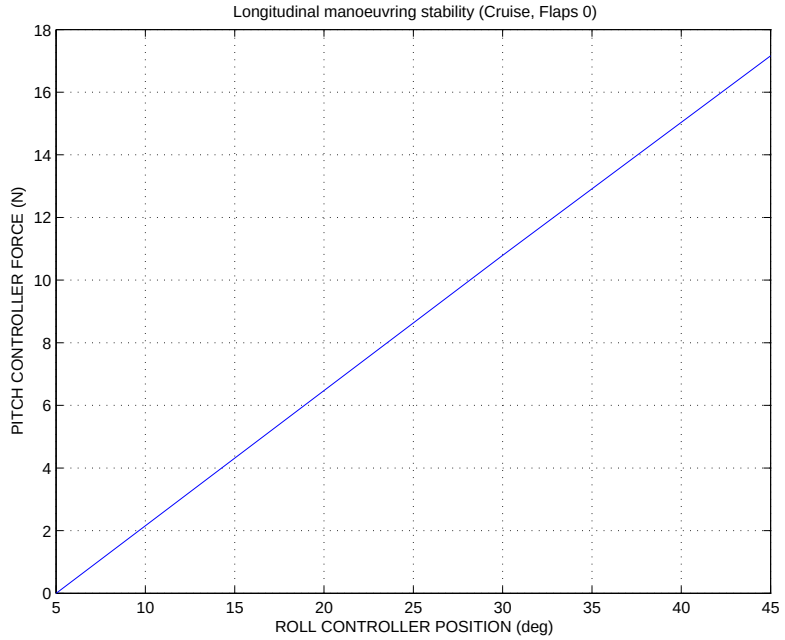

Figure 3.22: Longitudinal manoeuvring stability (Cruise)

ROLL CONTROLLER POSITION (deg)	PITCH CONTROLLER FORCE (N)
5	0
30	17.2
45	22.1

Table 3.29: Longitudinal manoeuvring stability (Approach)

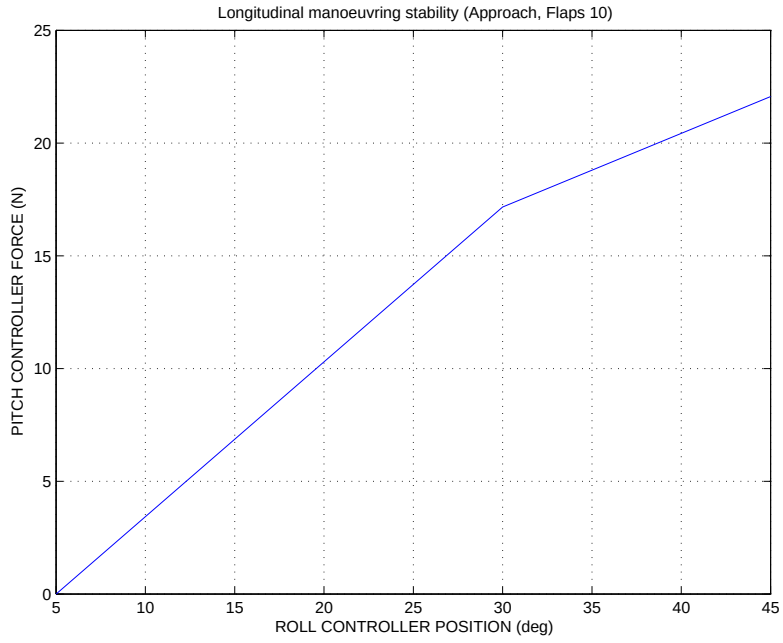

Figure 3.23: Longitudinal manoeuvring stability (Approach)

3.19 Longitudinal static stability (2b8)

3.19.1 Longitudinal static stability (Cruise)

Test procedures
From the trimmed flight condition with an indicated airspeed of 90 knots,, move the pitch controller such that the indicated airspeed reaches 80, 70, 100 and 110 knots respectively. As a target speed is obtained, keep hold of this speed for at least 5 seconds. The rudder pedal position, the flap setting, the throttle setting, the mixture setting and the trimwheel position must remain constant over the course of this test. Only small roll controller inputs may be given for keeping wings level.

Test results
The longitudinal static stability test was performed during the test flight session of 27 October 2006.

INDICATED AIRSPEED (knots)	PITCH CONTROLLER FORCE (N)	PITCH CONTROLLER POSITION (%)
70	-24.5	-30
80	-7.8	-13
90	0	0
100	7.8	13
110	24.5	30

Table 3.31: Longitudinal static stability (Cruise)

The initial conditions of the cruise flight condition are shown below.

Initial conditions	**Cruise flight condition:**
	CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	90	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=		(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

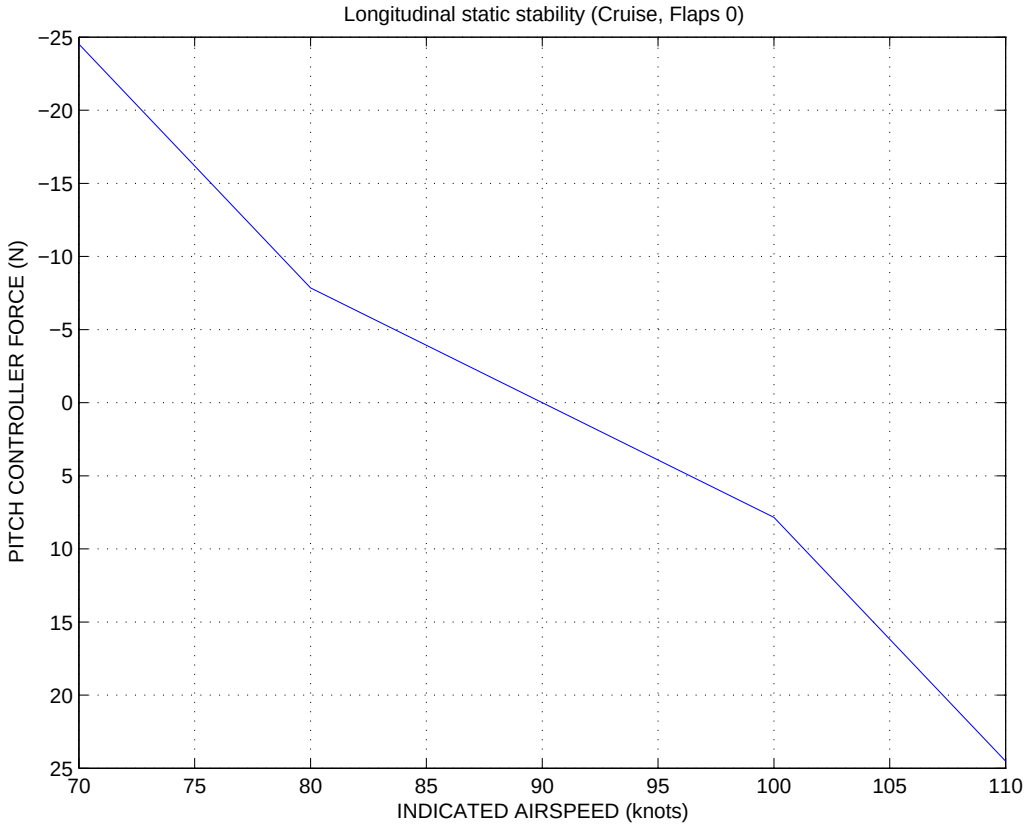

Figure 3.24: Longitudinal static stability (Cruise, Flaps 0)

3.19.2 Longitudinal static stability (Approach)

Test procedures
From the trimmed flight condition with an indicated airspeed of 75 knots, move the pitch controller such that the indicated airspeed reaches 65, 55, 85 and 95 knots respectively. As a target speed is obtained, keep hold of this speed for at least 5 seconds. The rudder pedal position, the flap setting, the throttle setting, the mixture setting and the trimwheel position must remain constant over the course of this test. Only small roll controller inputs may be given for keeping wings level.

Test results
The longitudinal static stability test was performed during the test flight session of 27 October 2006.

INDICATED AIRSPEED (knots)	PITCH CONTROLLER FORCE (N)	PITCH CONTROLLER POSITION (%)
55	-19.6	-44
65	-9.8	-20
75	0	0
85	9.8	20
95	14.7	44

Table 3.33: Longitudinal static stability (Approach)

The initial conditions of the approach flight condition are shown below.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)

ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation

The target speeds of 70 and 80 knots are below the trim speed of around 96 knots. The pilot needs to pull the Yoke (i.e. a negative force by definition) to obtain these speeds. The absolute value of the force to obtain a speed of 70 knots is larger than the absolute value of the force to obtain a speed of 80 knots. The target speeds of 100 and 110 knots are above the trim speed. The pilot needs to push the Yoke (i.e. a positive force by definition) to obtain these speed. The value of the force to obtain a speed of 110 knots is larger than the value of the force to obtain a speed of 100 knots.

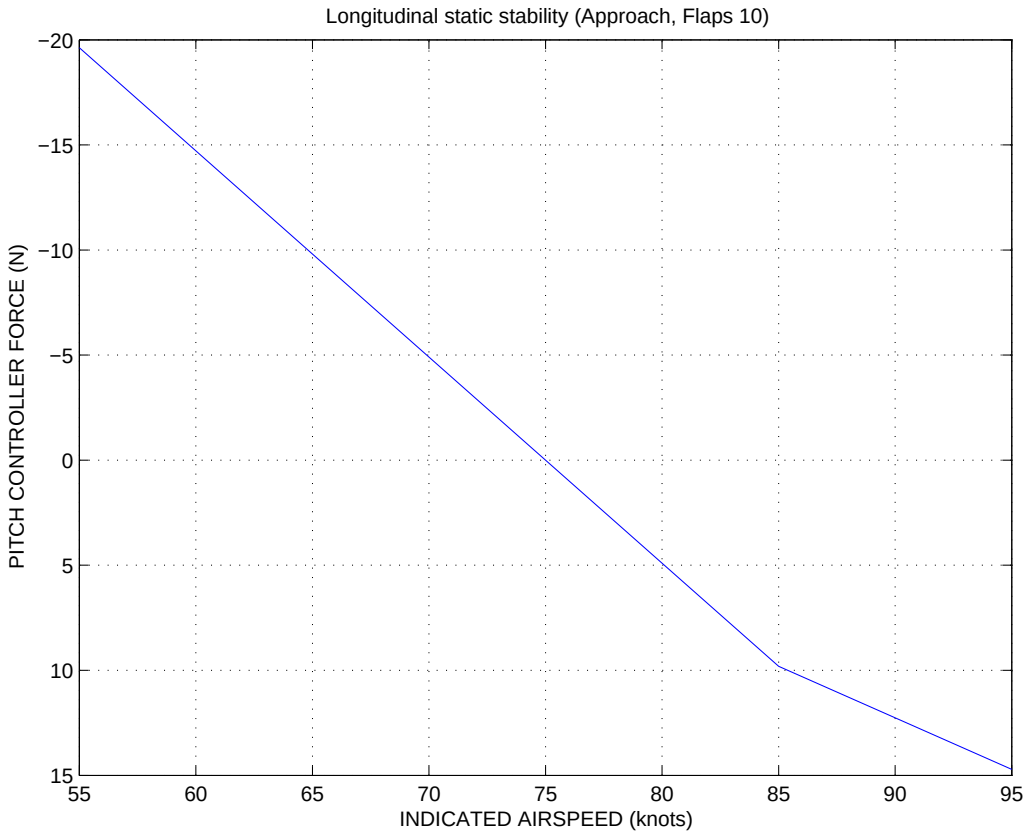

Figure 3.25: Longitudinal static stability (Approach, Flaps 10)

3.20 Phugoid dynamics (2b9)

Test procedures
With the pitch controller position in the neutral position:
1. From the neutral position, pull the Yoke to a setting away such that the aeroplane pitches up around 10 degrees.
2. Release the Yoke such that the pitch controller position comes back in its neutral position.
3. Let the aircraft respond freely. Only the roll controller may be used to keep the wings level during the course of this test.
4. Stop recording after the aeroplane has carried out three full cycles or after the time to half amplitude has been reached, whichever is less.

Test results
Table 3.35, Figure 3.26 and Figure 3.27 display the test results of the phugoid dynamics test of June 6th 2006. See also movie file `06JUN2006_08_FSTD_2c9_phugoid_dynamics.m2p`.

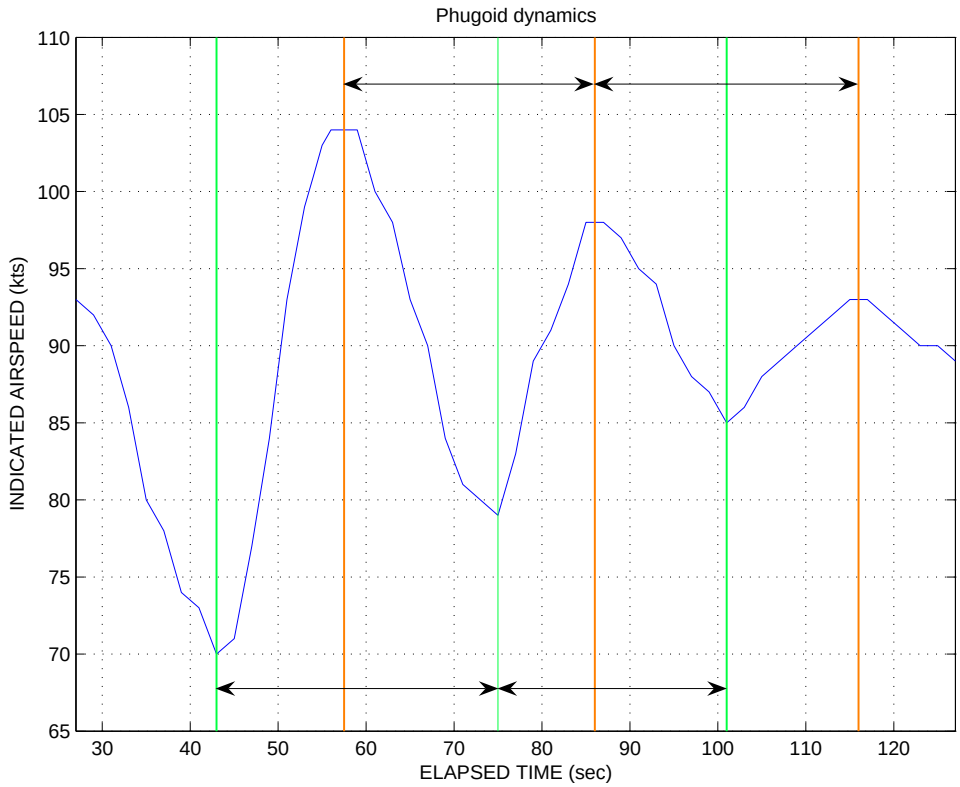

Figure 3.26: Indicated airspeed versus elapsed time

ELAPSED TIME (sec)	INDICATED AIRSPEED (kts)	PRESSURE ALTITUDE (ft)	ELAPSED TIME (sec)	INDICATED AIRSPEED (kts)	PRESSURE ALTITUDE (ft)
27	93	3980	75	79	4100
29	92	3990	77	83	4100
31	90	3995	79	89	4090
33	86	4020	81	91	4060
35	80	4050	83	94	4030
37	78	4070	85	98	4020
39	74	4090	87	98	4000
41	73	4100	89	97	4000
43	70	4120	91	95	4000
45	71	4140	93	94	4020
47	77	4140	95	90	4030
49	84	4120	97	88	4060
51	93	4060	99	87	4080
53	99	4020	101	85	4090
54	101	4000	103	86	4090
55	103	3980	105	88	4090
56	104	3970	107	89	4090
57	104	3960	109	90	4090
58	104	3950	111	91	4070
59	104	3950	113	92	4060
60	102	3950	115	93	4060
61	100	3950	117	93	4060
63	98	3980	119	92	4060
65	93	3980	121	91	4060
67	90	4020	123	90	4080
69	84	4050	125	90	4090
71	81	4080	127	89	4100
73	80	4090			

Table 3.35: Test results phugoid dynamics

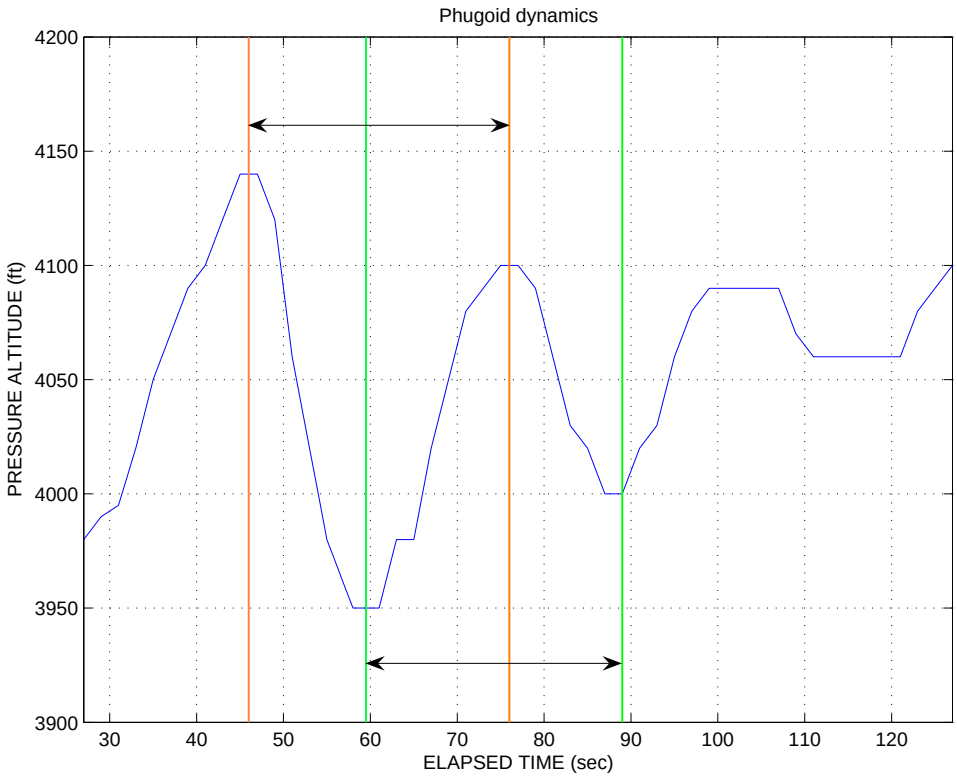

Figure 3.27: Pressure altitude versus elapsed time

The initial conditions are the conditions in flight as total flight test time is at second 27.

Initial conditions **Cruise flight condition**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	39.5	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	13	(deg C)
BARO PRESSURE AT SEALEVEL	=	1029	(mbar)
WIND SPEED	=	4	(kt)
WIND SPEED DIRECTION	=	010	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	93	(kts)
RATE OF CLIMB	=	100	(fpm)
PRESSURE ALTITUDE	=	3980	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
HEADING ANGLE	=	175	(deg)
SIDESLIP ANGLE	=	0	(deg)
PITCH RATE	=	0	(deg/sec)
ROLL RATE	=	0	(deg/sec)
YAW RATE	=	0	(deg/sec)

ENGINE PARAMETERS:

ENGINE SPEED	=	2100	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH

SWITCH FUEL CUTOFF = OFF

Test evaluation
The phugoid mode is most commonly a lightly damped low frequency oscillation in airspeed which couples into pitch angle and altitude.
Starting from the trimmed flight condition, when a disturbance is exited in the form of a deflection of the elevator angle, the aeroplane pitches up which is accompanied by an increase in lift causing the aircraft to gain altitude. While the aeroplane moves up from its initial altitude, it looses speed and lift causing it to decelerate and pitch down until the altitude starts to decrease. The aircraft subsequently moves down, goes through its initial altitude, and airspeed increases causing the aeroplane to pitch up again and gain lift. Due to these increases in pitch angle and lift force, altitude increases and the aeroplane moves up and go through its initial, trimmed altitude. Consequently a new cycle of the oscillation is started.
The effects of drag cause the motion variable maxima and minima at each peak to reduce gradually in magnitude until the motion eventually damps out [2]. The angle of attack and pitch rate do not significantly change when the phugoid mode is exited.

The period of the eigenmotion is determined as the average of six cycles from from Figure 3.26 and Figure 3.27 as:

PERIOD OF EIGENMOTION = {(75-43)+(101-75)+(89-57.5)+(116-89)+(76-46)+(89-59.5)}/6 = 29.3 (sec)

3.21 Roll response (rate) (2c2)

3.21.1 Roll response (rate) (Cruise)

Test procedures
From a trimmed flight condition:
1. From the initial roll controller position, rotate the the Yoke such that the roll controller position is 30%.
2. Hold this roll controller position of 30% until steady roll rate is established.

Test results
Test results to show Correct Trend & Magnitude where obtained during the roll response (rate) tests on October 27$^{\text{th}}$ 2006.

Movie file `27OCT2006_06_FSTD_2d2_Roll_response_(rate)_Cruise_Left.m2p` shows the test results for rotation of the Yoke to the left.

ELAPSED TIME (sec)	Left Turn Roll Angle (deg)	Right Turn Roll Angle (deg)
0	0	0
2	-30	30
5	-60	30

Table 3.37: Test results roll response rate in approach

The initial conditions are the conditions in flight as total flight test time is at second 5.

Initial conditions **Cruise flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)

ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	90	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4000	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

The steady roll rate of approximately 12 deg/s (left and right turns) establishes without any large time delay after the roll controller position of 30% is reached.

Movie file `27OCT2006_07_FSTD_2d2_Roll_response_(rate)_Cruise_Right.m2p` shows the test results for rotation of the Yoke to the right.

The initial conditions are the conditions in flight as total flight test time is at second 4.

Initial conditions **Cruise flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)

BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	90	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4000	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

The steady roll rate of approximately 12 deg/s (left and right turns) establishes without any large time delay after the roll controller position of 30% is reached.

3.21.2 Roll response (rate) (Approach)

Test procedures
From a trimmed flight condition:
1. From the initial roll controller position, rotate the the Yoke such that the roll controller position is 30%.
2. Hold this roll controller position of 30% until steady roll rate is established.

Test results
Test results to show Correct Trend & Magnitude where obtained during the roll response (rate) tests on October 27$^{\text{th}}$ 2006.

Movie file `27OCT2006_09_FSTD_2d2_Roll_response_(rate)_Approach_Left.m2p` shows the test results for rotation of the Yoke to the left.

ELAPSED TIME (sec)	Left Turn Roll Angle (deg)	Right Turn Roll Angle (deg)
0	0	0
2	-30	30
5	-60	30

Table 3.40: Test results roll response rate in approach

The initial conditions are the conditions in flight as total flight test time is at second 2.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4600	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

The steady roll rate of approximately 12 deg/s (left and right turns) establishes without any large time delay after the roll controller position of 30% is reached.

Movie file `27OCT2006_10_FSTD_2d2_Roll_response_(rate)_Approach_Right.m2p` shows the test results for rotation of the Yoke to the right.

The initial conditions are the conditions in flight as total flight test time is at second 3.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4600	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

The steady roll rate of approximately 12 deg/s (left and right turns) establishes without any large time delay after the roll controller position of 30% is reached.

Test evaluation

For the four test cases; left & right movements of the roll controller position of 30% and under

Cruise and under Approach flight conditions, the steady roll rate of approximately 12 deg/s establishes without any large time delay.

3.22 Spiral stability (2c4)

3.22.1 Spiral stability (Cruise)

Test procedures
From a trimmed flight condition:
1. From the initial roll controller position, rotate the the Yoke such that the aeroplane rolls to the left. Release the Yoke, allowing the aeroplane to respond freely, from an establishes bank angle of 30 degrees.
2. Stop recording when the bank angle reaches 10 degrees if decreasing, or approximately 45 degrees if increasing, or when a total of 65 seconds have elapsed.
3. Repeat the procedure for rolling to the right.

Test results
Test results to show Correct Trend & Magnitude where obtained during the spiral stability tests on October 27th 2006.

Movie file `27OCT2006_04_FSTD_2d4_Spiral_stability_Cruise Left.m2p` shows the test results for banking to the left.

The initial conditions are the conditions in flight as total flight test time is at second 2.

Initial conditions **Cruise flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	90	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	3400	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

The bank angle very slightly decreased as the aeroplane was allowed to respond freely.

Movie file `27OCT2006_05_FSTD_2d4_Spiral_stability_Cruise Right.m2p` shows the test results for banking to the right.

The initial conditions are the conditions in flight as total flight test time is at second 2.

Initial conditions **Cruise flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	90	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	3000	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)

SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

The bank angle increased as the aeroplane was allowed to respond freely.

3.22.2 Spiral stability (Approach)

Test procedures
From a trimmed flight condition:
1. From the initial roll controller position, rotate the the Yoke such that the aeroplane rolls to the left. Release the Yoke, allowing the aeroplane to respond freely, from an establishes bank angle of 30 degrees.
2. Stop recording when the bank angle reaches 10 degrees if decreasing, or approximately 45 degrees if increasing, or when a total of 65 seconds have elapsed.
3. Repeat the procedure for rolling to the right.

Test results
Test results to show Correct Trend & Magnitude where obtained during the spiral stability tests on October 27th 2006.

Movie file `27OCT2006_11_FSTD_2d4_Spiral_stability_Approach_Left.m2p` shows the test results for banking to the left.

The initial conditions are the conditions in flight as total flight test time is at second 1.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)

WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

The bank angle very slightly increased as the aeroplane was allowed to respond freely. The pilot was had to take over control over the aeroplane due to the airspeed increase

Movie file `27OCT2006_12_FSTD_2d4_Spiral_stability_Approach_Right.m2p` shows the test results for banking to the right.

The initial conditions are the conditions in flight as total flight test time is at second 1.

Initial conditions **Approach flight condition:**

control inputs:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

center of gravity /weights:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

atmosphere/weather:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

speed/altitude/temperature:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

euler & aero angles/rates:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

The bank angle very slightly increased as the aeroplane was allowed to respond freely. The pilot was had to take over control over the aeroplane due to the airspeed increase.

Test evaluation

If the damping-in-roll derivative as defined in [3] is negative, the bank angle decreases as the aeroplane is allowed to respond freely. When the damping-in-roll derivative has a positive sign, the bank angle increases as the aeroplane is allowed to respond freely. This particular type of aeroplane, i.e. a single piston engine propeller driven aeroplane, has a damping-in-roll derivative being very small in value with either a negative or positive sign.

3.23 Rudder response (2c6)

Test procedures
From a trimmed flight condition:
1. From the initial rudder pedal position, push the left pedal such that it reaches 25% of its full travel. Abruptly release the pedal and allow the aeroplane to respond freely.
2. Stop recording after a total of 30 seconds have elapsed.

Test results
Test results to show Correct Trend & Magnitude where obtained during the rudder response test on October 27th 2006.

Movie file `27OCT2006_14_FSTD_2d6_Rudder_response.m2p` shows the test results for 30% of full travel and full travel of the left rudder pedal.

The initial conditions are the conditions in flight as total flight test time is at second 4.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4600	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation
The damping-in-yaw derivative as defined in [3] has a negative value This means that there is a resistance in yaw motion due to contributions of the aeroplane's wings and tail. A small sideslip angle arises due to the rudder displacement. Due to the weathercock stability (or: yaw stiffness), the yawing moment produced is such that it tends to restore the initial symmetric flight [3]. As observed in the movie file, the produced yawing moment restores the initial symmetric flight

state very quickly for this type of single engine piston aeroplane.

3.24 Dutch roll (2c7)

3.24.1 Dutch roll (Cruise)

Test procedures
From a trimmed flight condition:
1. In a time frame of 5 seconds, from the initial rudder pedal position, push the left pedal such that it reaches 90% of its full travel, immediately followed by push the right pedal such that it reaches 90% of its full travel before pushing the left pedal such that it reaches 90% of its full travel again.
2. Release the rudder pedals and allow the aeroplane to respond freely.
3. Stop recording after a total of 25 seconds have elapsed.

Test results
Test results to show Correct Trend & Magnitude where obtained during the Dutch roll test on October 27th 2006. See also movie file `27OCT2006_02_FSTD_2d7_Dutch_roll_Cruise.m2p`.

The initial conditions are the conditions in flight as total flight test time is at second 10.

Initial conditions **Cruise flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	0	(deg)
FLAP INDICATOR POSITION	=	0	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)

WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	90	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	0.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

3.24.2 Dutch roll (Approach)

Test procedures
From a trimmed flight condition:
1. In a time frame of 5 seconds, from the initial rudder pedal position, push the left pedal such that it reaches 80% of its full travel, immediately followed by push the right pedal such that it reaches 80% of its full travel before pushing the left pedal such that it reaches 80% of its full travel again.
2. After a total of 10 seconds have elapsed, release the rudder pedals and allow the aeroplane to respond freely.
3. Stop recording after a total of 25 seconds have elapsed.

Test results
1. In a time frame of 5 seconds, from the initial rudder pedal position, push the left pedal such that it reaches 90% of its full travel, immediately followed by push the right pedal such that it reaches 90% of its full travel before pushing the left pedal such that it reaches 90% of its full travel again.
2. Release the rudder pedals and allow the aeroplane to respond freely.
3. Stop recording after a total of 25 seconds have elapsed.

Test results
Test results to show Correct Trend & Magnitude where obtained during the Dutch roll test on October 27th 2006. See also movie file `27OCT2006_18_FSTD_2d7_Dutch_roll_Approach.m2p`.

The initial conditions are the conditions in flight as total flight test time is at second 8.

Initial conditions

Approach flight condition:

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	1950	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation

The Dutch Roll mode is a damped oscillation in yaw which couples into roll and, to a lesser extent, into sideslip.
Starting from the trimmed flight condition, due to the aircraft aerodynamics, the aircraft produces a restoring yawing moment to the rudder pedal input initiating a yaw oscillation. The oscillation in yaw/sideslip angles induces an oscillation in roll due to differential lift and drag perturbations being opposite in sign between the forward and the aft going wing.
As observed in both movie files, the Dutch roll is very well damped for this type of single engine piston aeroplane.

3.25 Steady state sideslip (2c8)

Test procedures
From a trimmed flight condition:
1. From the initial rudder pedal position, push the left pedal such that it reaches 30% of its full travel. Use the Yoke in roll control to maintain the initial heading.
2. Repeat the test for full travel of the left rudder pedal, 30% of full travel and full travel of the right rudder pedal.

Test results
Test results to show Correct Trend & Magnitude where obtained during the steady state sideslip tests on October 27th 2006.

Movie file `27OCT2006_16_FSTD_2d8_Steady_state_sideslip_Approach_Left.m2p` shows the test results for 30% of full travel and full travel of the left rudder pedal.

The initial conditions are the conditions in flight as total flight test time is at second 2.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)

WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)
SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Movie file `27OCT2006_16_FSTD_2d8_Steady_state_sideslip_Approach_Right.m2p` shows the test results for 30% of full travel and full travel of the right rudder pedal.

The initial conditions are the conditions in flight as total flight test time is at second 1.

Initial conditions **Approach flight condition:**

CONTROL INPUTS:

MIXTURE SETTING	=	55	(mm)
FLAP LEVER POSITION	=	10	(deg)
FLAP INDICATOR POSITION	=	10	(deg)
ROLL CONTROLLER POSITION	=	0	(%)
RUDDER PEDAL POSITION	=	0	(%)

CENTER OF GRAVITY /WEIGHTS:

CENTER OF GRAVITY	=	43.1	(inch)
EMPTY WEIGHT	=	1608.4	(lb)
PAYLOAD WEIGHT	=	422.5	(lb)
TOTAL FUEL WEIGHT	=	209.2	(lb)
LEFT FUEL TANK WEIGHT	=	104.6	(lb)
RIGHT FUEL TANK WEIGHT	=	104.6	(lb)

ATMOSPHERE/WEATHER:

TEMPERATURE AT SEALEVEL	=	15	(deg C)
BARO PRESSURE AT SEALEVEL	=	1020	(mbar)
WIND SPEED	=	12	(kt)
WIND SPEED DIRECTION	=	240	(deg)

SPEED/ALTITUDE/TEMPERATURE:

INDICATED AIRSPEED	=	75	(kts)
RATE OF CLIMB	=	0	(fpm)
PRESSURE ALTITUDE	=	4500	(ft)

EULER & AERO ANGLES/RATES:

PITCH ANGLE	=	0	(deg)
BANK ANGLE	=	0	(deg)

SIDESLIP ANGLE	=	0	(deg)

ENGINE PARAMETERS:

ENGINE SPEED	=	2000	(rpm)

CONTROL SURFACES:

WING FLAP ANGLE	=	10.0	(deg)

SWITCHES/BRAKES:

ENGINE STARTER KEY	=	BOTH
PARKING BRAKE	=	OFF
SWITCH MASTER ALT	=	ON
SWITCH MASTER BAT	=	ON
AVIONICS BUS 1	=	ON
AVIONICS BUS 2	=	ON
SWITCH FUEL PUMP	=	ON
SWITCH PITOTHEAT	=	ON
FUEL TANK SELECTOR	=	BOTH
SWITCH FUEL CUTOFF	=	OFF

Test evaluation
A push of the left rudder pedal and subsequent rudder deflection, induces a yawing moment causing the right wing to move forward and the left wing to move aft. Due to this motion, the airspeed over the right wing increases and the airspeed over the left wing decreases causing the aeroplane to roll to the left. For maintaining the wings level and to maintain the initial heading, the pilot needs to move the Yoke in roll control to the right.
For pushing the right rudder pedal, the same characteristic as described above applies only in opposite directions.

A Approval EASA.A.C.04171

Replace this page with the EASA Approval page in "TRCreports/VRDR/EASA A C 04171.pdf"