STALL SPEED

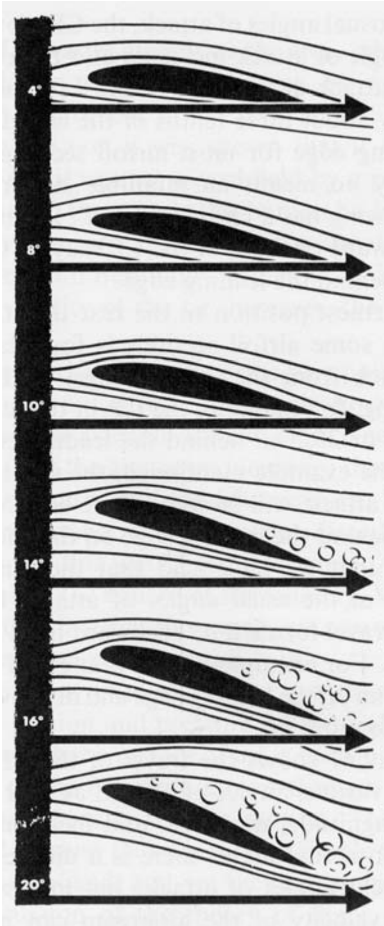
To maintain flight,

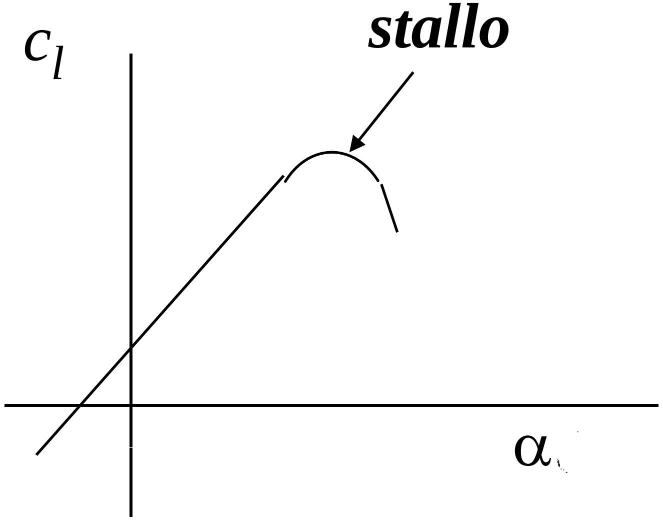
$$L = W = C_L\left(\frac{1}{2}\rho_o V_e^2\right) S$$

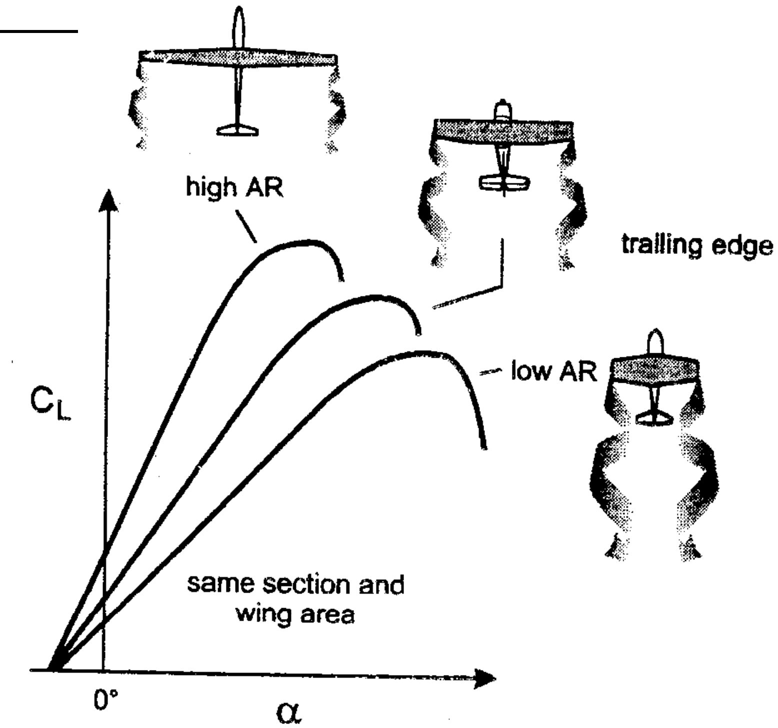
$$V_S = \sqrt{\frac{2W}{C_{L_{max}}\ \rho_o S}}$$

$$W = C_{L_{max}}\left(\frac{1}{2}\rho_o V_s^2\right) S$$

STALL SPEED







$$V_S = \sqrt{\frac{2W}{C_{L_{max}} \rho_o S}}$$

STALL SPEED definition

FAR 23

Point at which airplane first develops an unmistakable nose-down pitching motion

or

Elevator control reaches its full aft stop

or

Minimum steady speed at which airplane is controllable

STALL SPEED definition

FAR 25

One or more of the following:

-- Pitch control reaches full aft stop

-- Uncommanded, distinctive nose-down pitch

-- Unmistakable, inherent aerodynamic warning of magnitude and severity to deter further speed reduction

-- Activation of a stall prevention device (stick pusher)

STALL SPEED definition

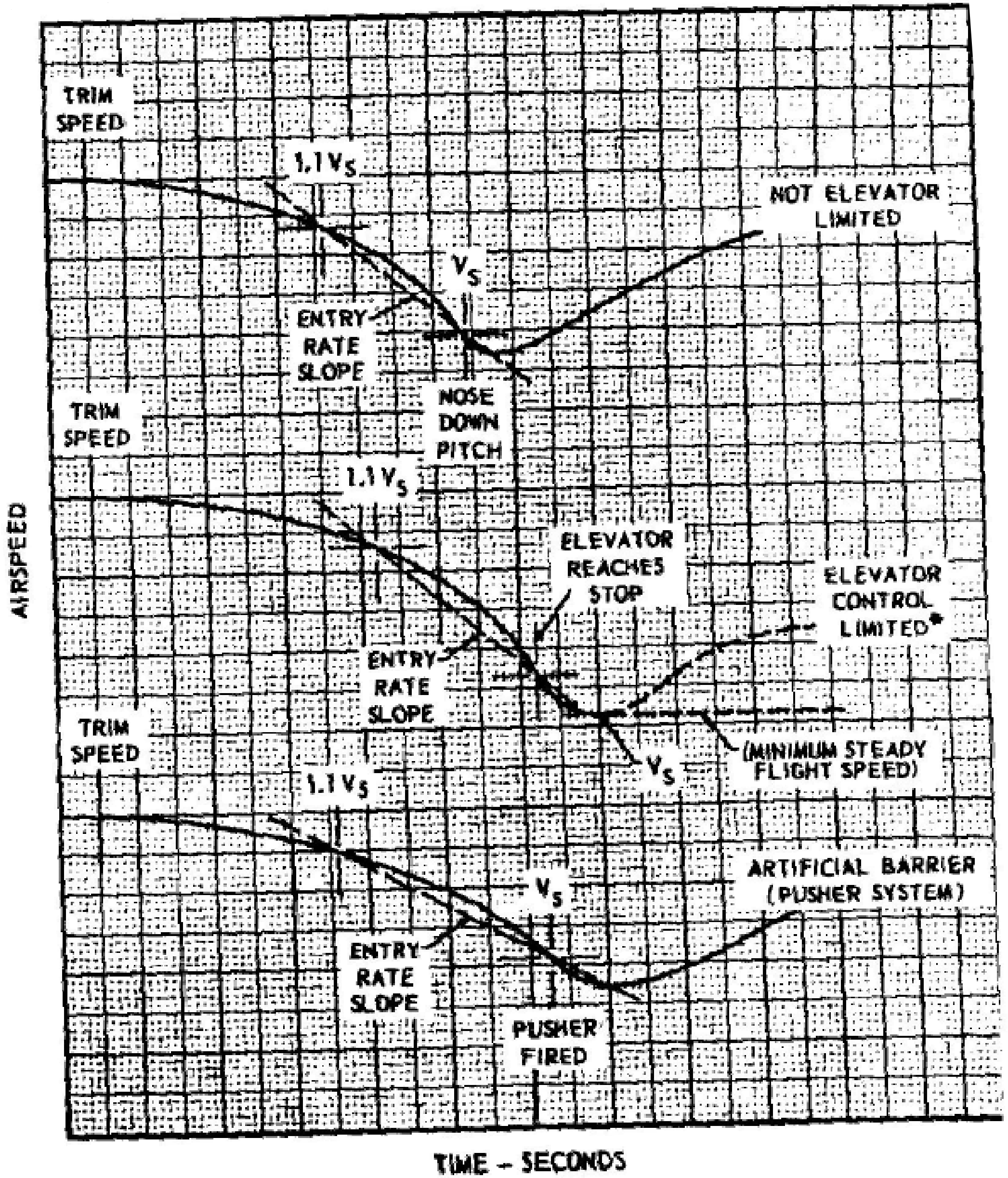


Fig. 4.1 FAA stalling speed definitions.[3]

STALL SPEED

4.3.1 Two-Dimensional Effects

Two-dimensional effects upon the stall and the angle of attack at which it occurs include:

1) Reynolds number
2) wing camber
3) wing thickness
4) size of the leading edge radius
5) surface roughness
6) leading and trailing edge devices such as slots and slats and flaps

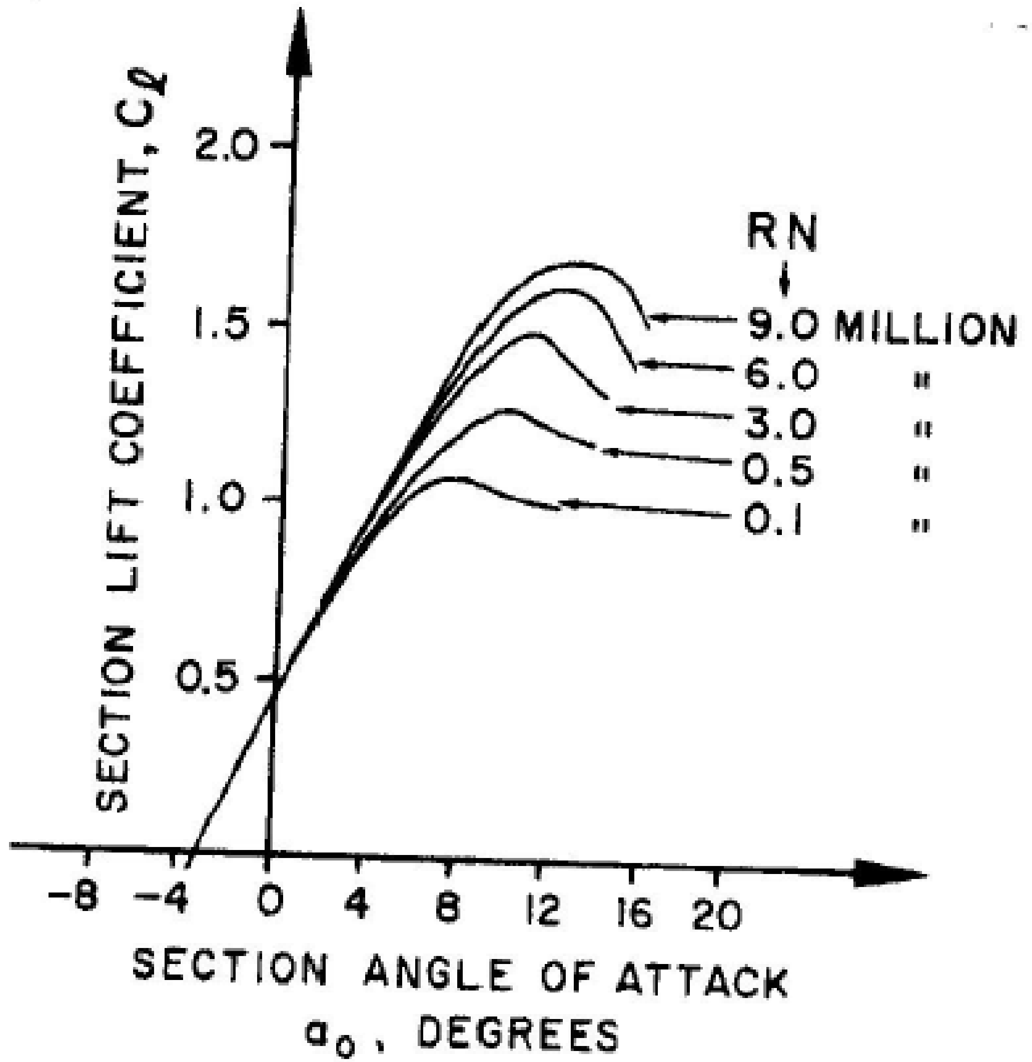


Fig. 4.2 Effect of Reynolds number—NACA 4412 (Ref. 4).

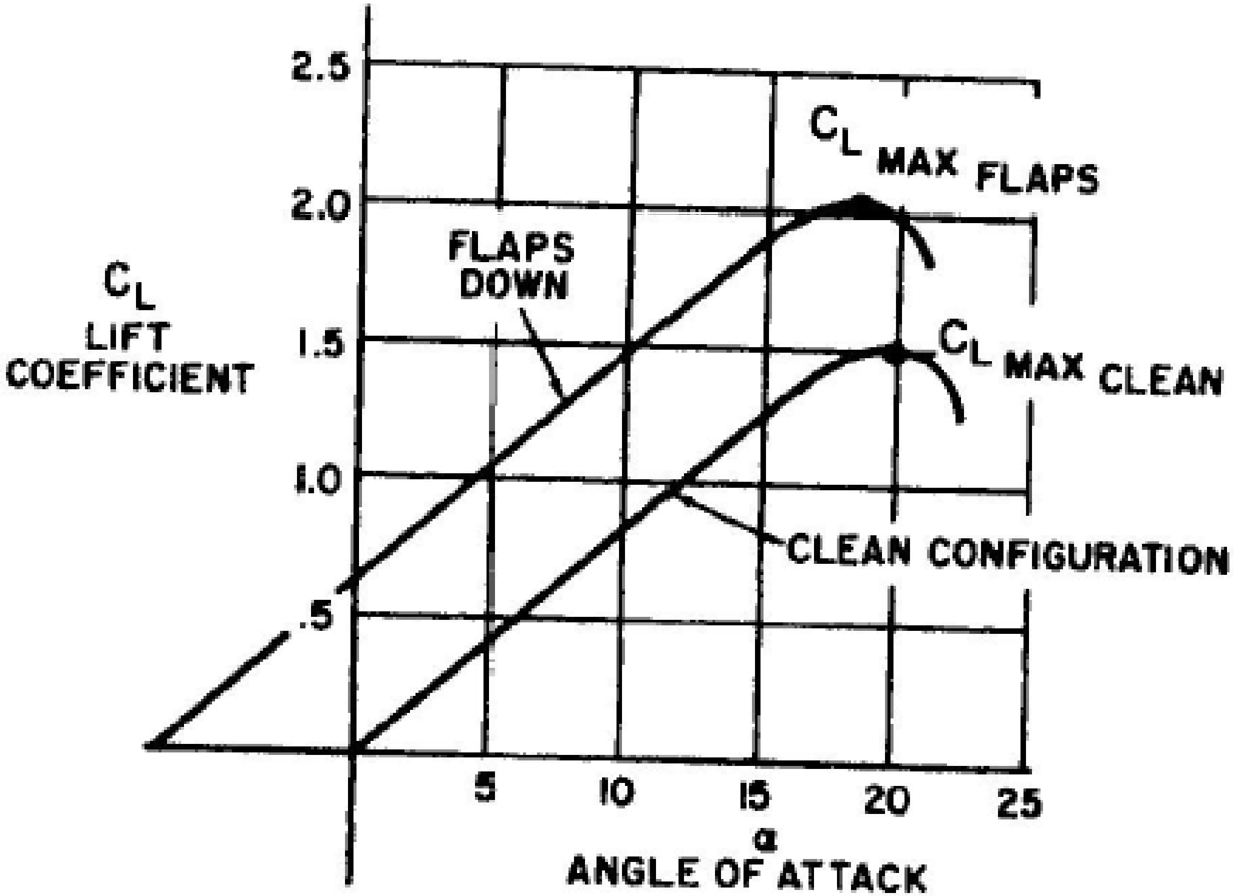


Fig. 4.3 Effects of flaps on the lift curve.[4]

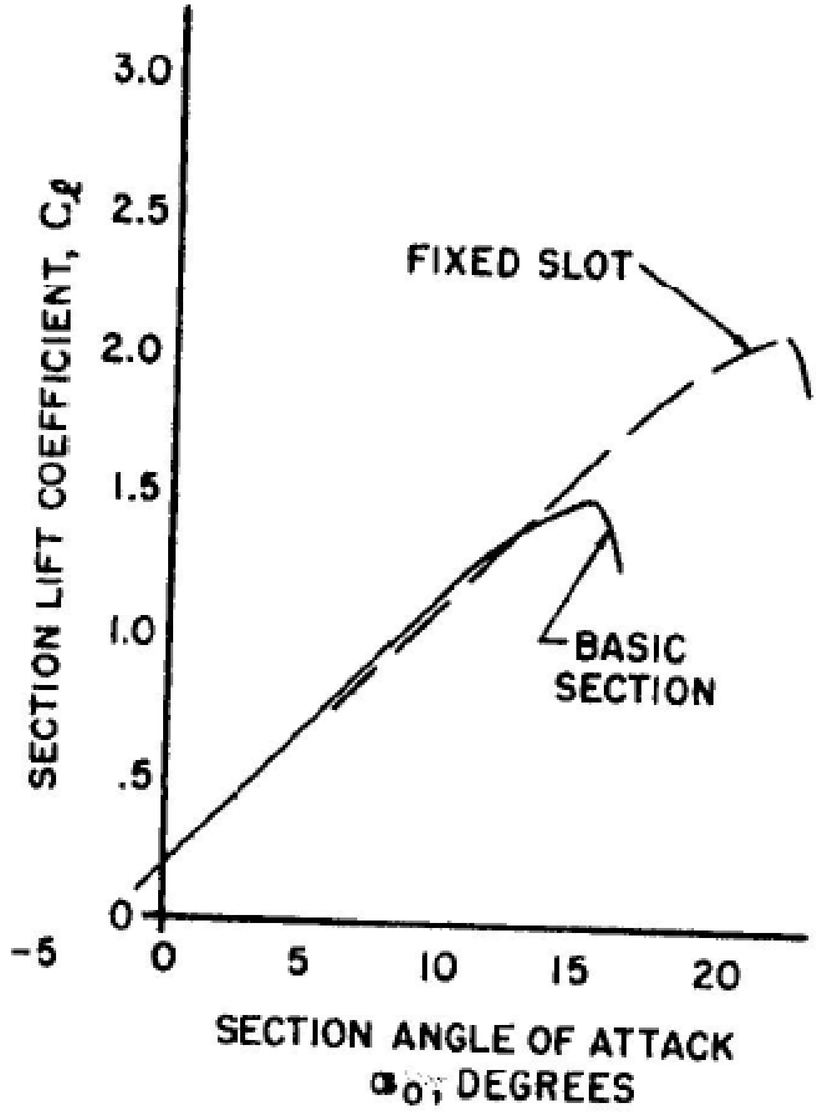


Fig. 4.4 Effects of slots or slats on the lift curve.[4]

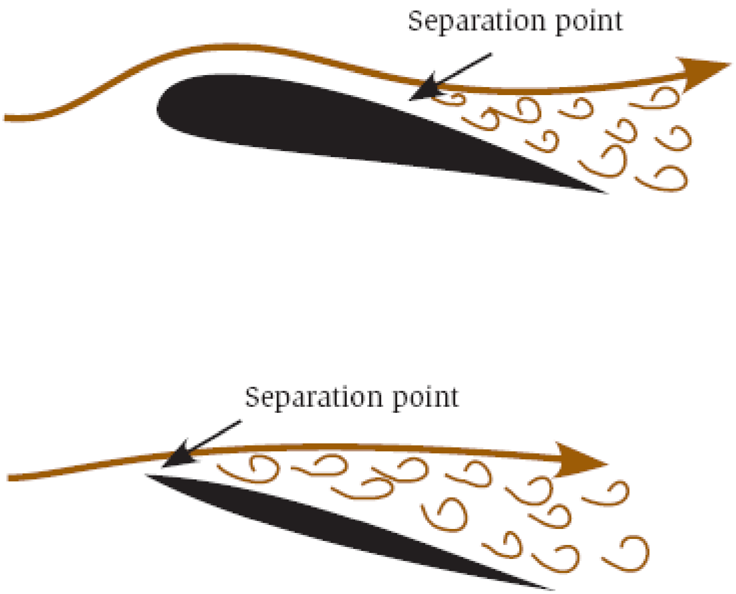


Fig. 3.1. Flow separating from two different airfoils.

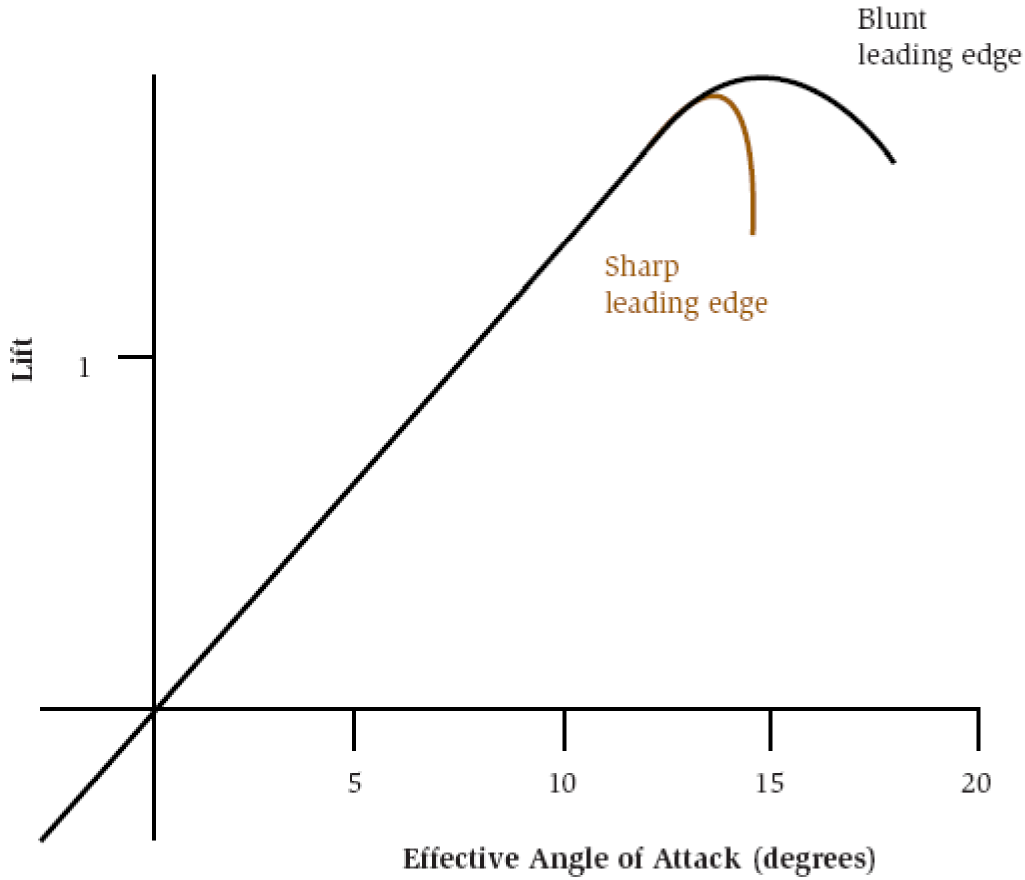


Fig. 3.2. The effect of leading edge shape on stall characteristics.

4.3.2 Three-Dimensional Effects

Three-dimensional effects upon the stall and the angle of attack at which it occurs include:

1) Reynolds number
2) wing planform
3) wing sweep
4) wing aspect ratio
5) effects of aircraft weight
6) effects of c.g. location

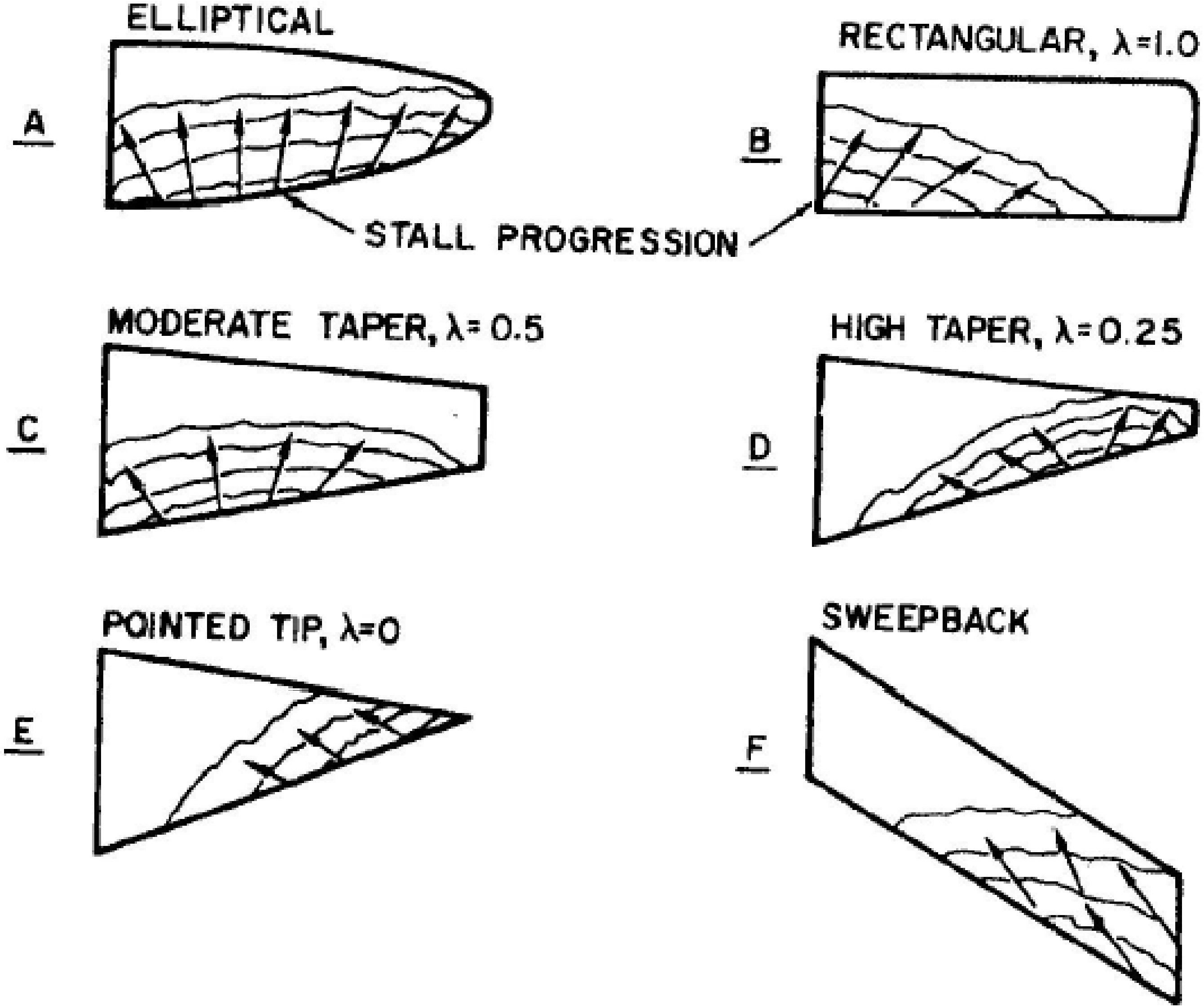


Fig. 4.5 Effects of wing planform on stall patterns.[4]

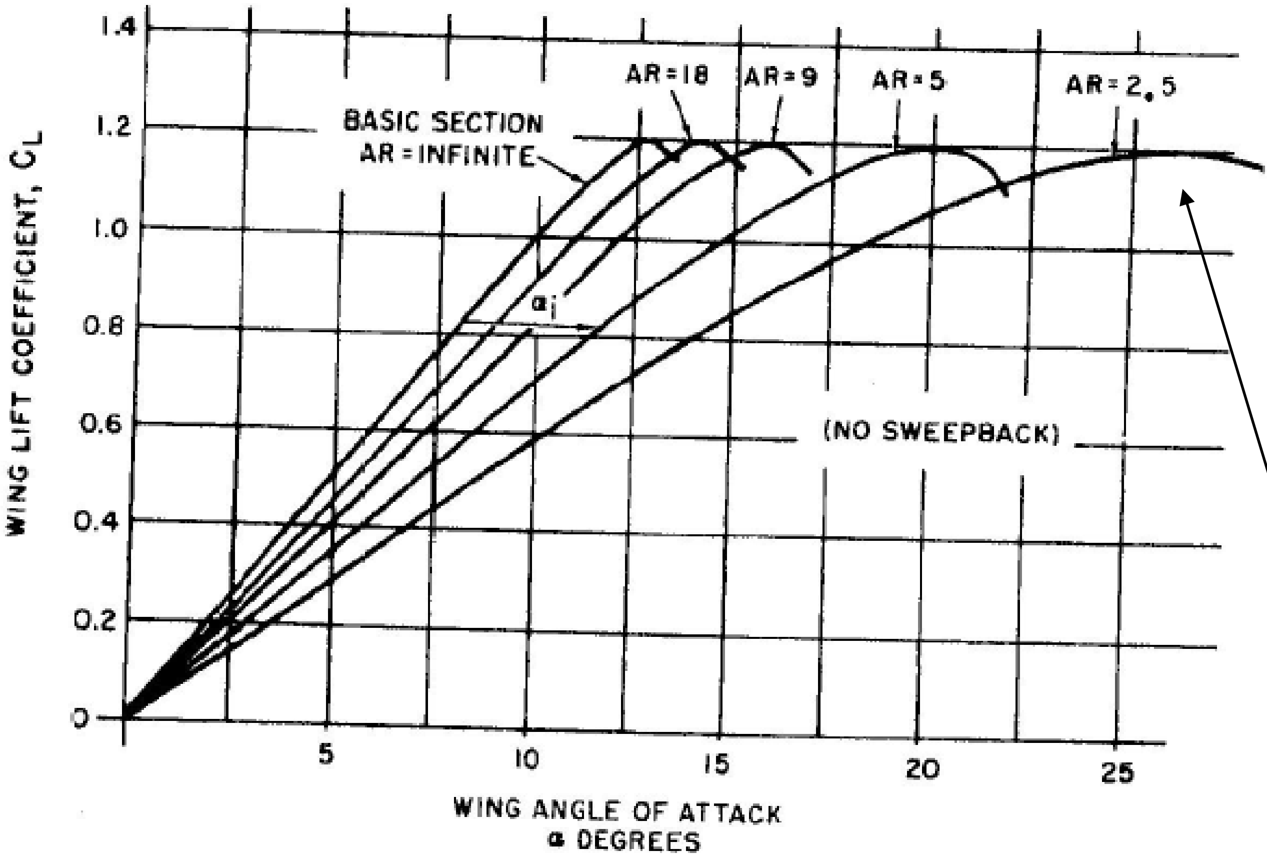


Fig. 4.6 Effects of aspect ratio on three-dimensional wing stall.[4]

Attenzione ali di basso AR:
⇒ L'angolo è molto elevato
⇒ Lo stallo non è ben definito
(nel caso del vel F102 con ali a delta alcuni
casi di incidente in atterraggio

4.4.1 Weight and c.g. Tolerances

The weight tolerances as specified by the FAA in both CAM 3 and FAR Part 23 are +5% to −1% of the gross weight at the c.g. where the stalling speed is being determined. It is generally best to overload the aircraft to near the +5% tolerance so that as the flight progresses and fuel is burned the weight does not decrease below the −1% limit.

The c.g. tolerance is ±7% of the total allowable c.g. travel. However, unless it is not possible to do so, it is better to load the aircraft forward of the desired c.g. location particularly if fuel burn off results in aft c.g. movement.

Prove di certificazione in volo

Prova n°	JAR-VLA	Descrizione	Modalità
2	**§49 §201**	***Velocità di stallo***	**Determinazione della Velocità di Stallo alle seguenti condizioni:** ➢ **Peso massimo al decollo CG max avanzato, potenza al min, flap retratti.** ➢ **Idem *cs* flap max estensione** ➢ **Idem *cs* flap estensione decollo**

Prove di stallo

$$V_S = \sqrt{\frac{2}{\rho}}\sqrt{\frac{W}{S}}\sqrt{\frac{1}{CL_{MAX}}}$$

$$CL_S = \frac{2}{\rho}\frac{W}{S}\frac{1}{V_S^{\,2}}$$

Non è così banale

La velocità di stallo è definita come la minima velocità (tendenza pitch-down quando si raggiunge lo stallo) oppure la minima velocità Alla quale il velivolo risulta controllabile sui 3 assi

CORREZIONI

Correzione peso

$$V_S = V_{S\_test}\sqrt{\frac{W_{std}}{W_{test}}}$$

Correzione pos CG

$$CL_{ref} = CL_{test}\left[1 + \frac{c}{l_{tail}}\left(\frac{CG_{ref} - CG_{test}}{100}\right)\right]$$

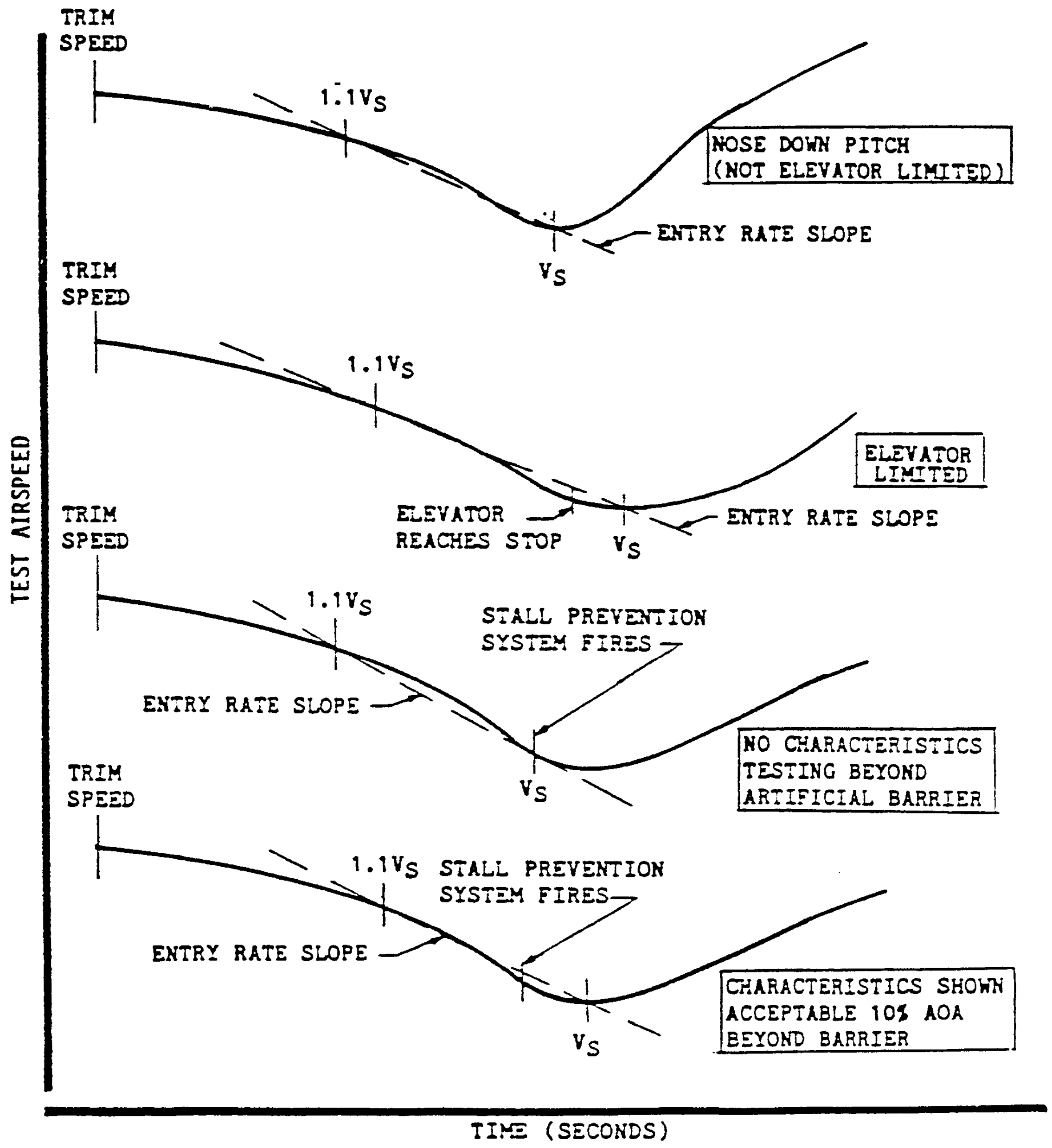
Prove di stallo

Procedura:

- Trim V=1.2 Vs
- Motore al minimo
- Equilibratore a cabrare
- Entry rate < 1 Kt/sec

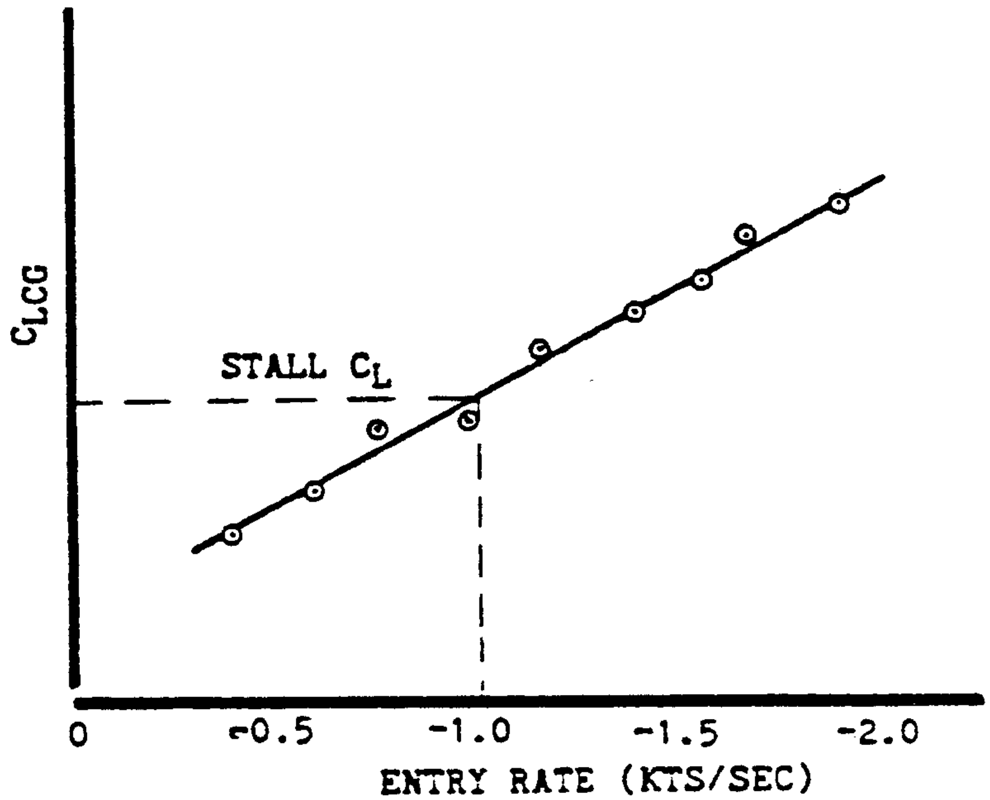
FAR Entry Rate

$$ER = \frac{1.1 \cdot V_S - V_S}{\Delta t}$$



Prove di stallo

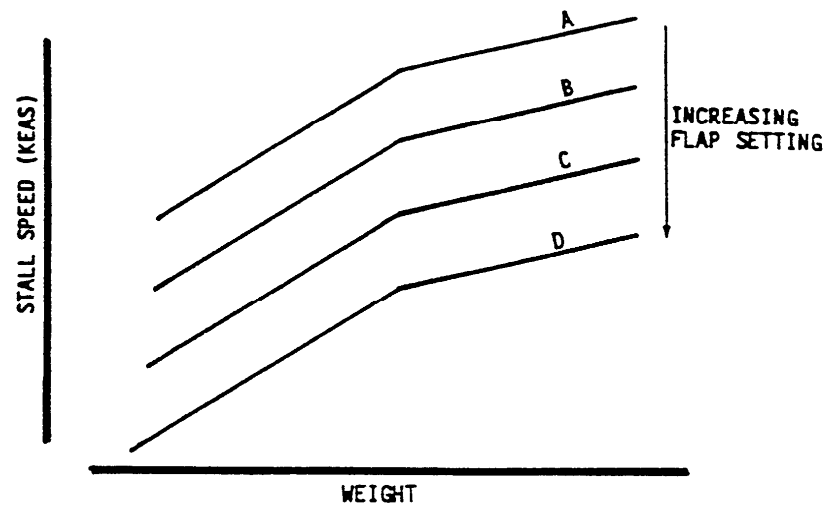
STALL C_{LCG} vs ENTRY RATE



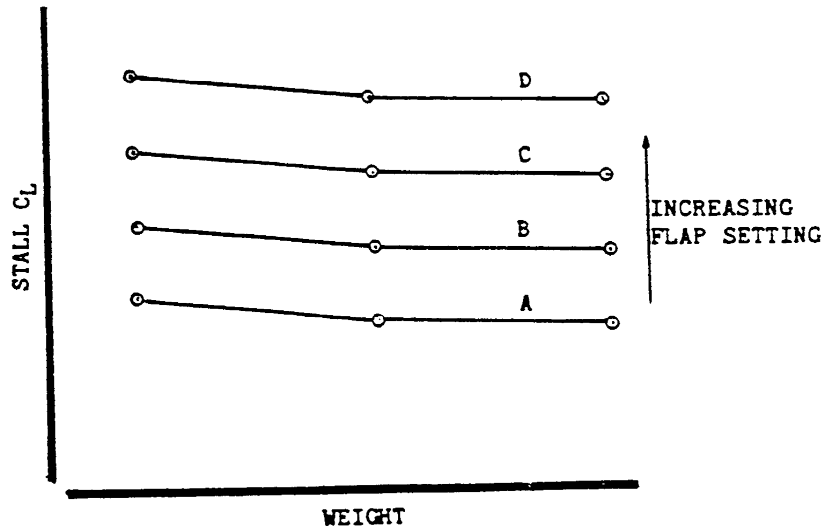
Prove di stallo

Il peso può far variare la velocità di stallo per effetti aeroelastici

STALL SPEEDS vs WEIGHT & FLAP SETTING

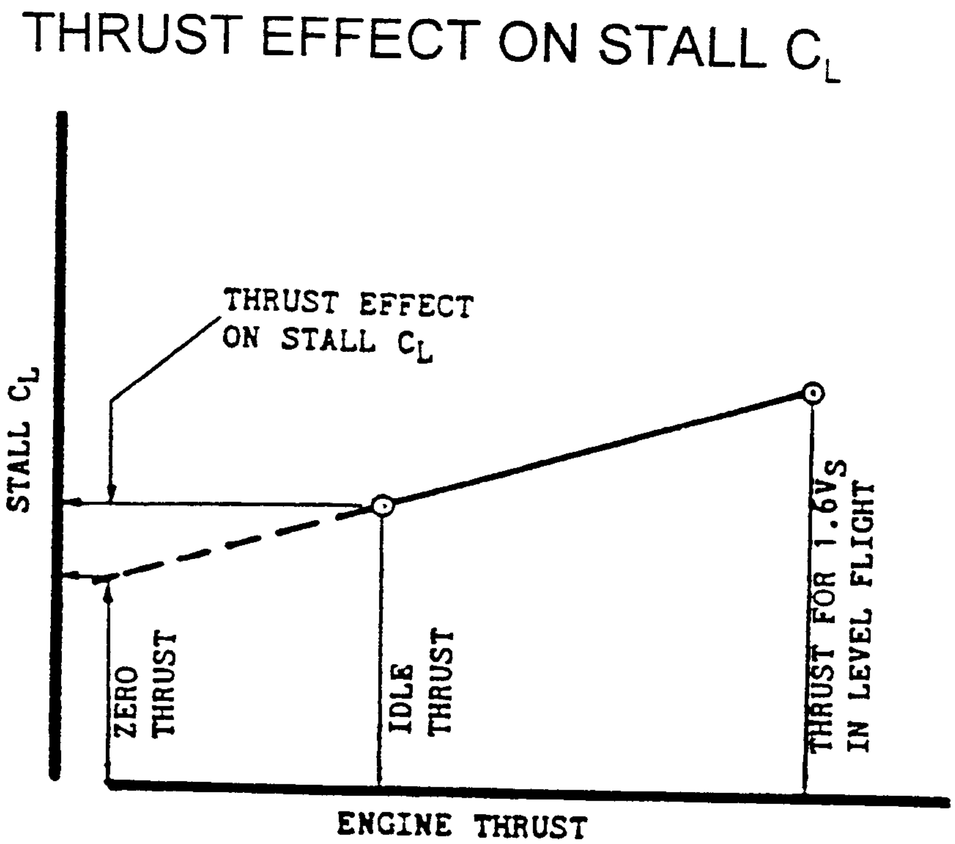


STALL C_L vs WEIGHT & FLAP SETTING

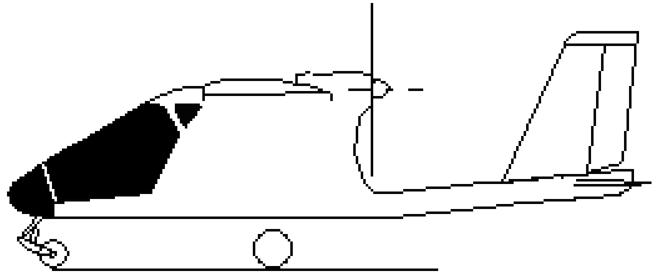


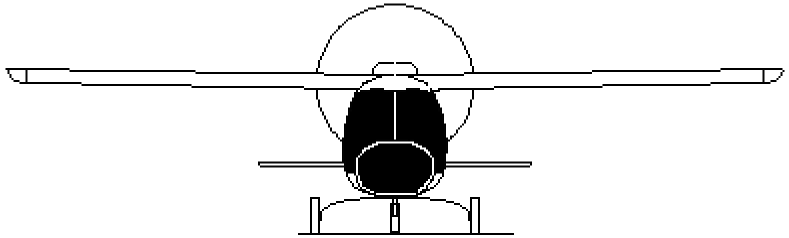
Prove di stallo

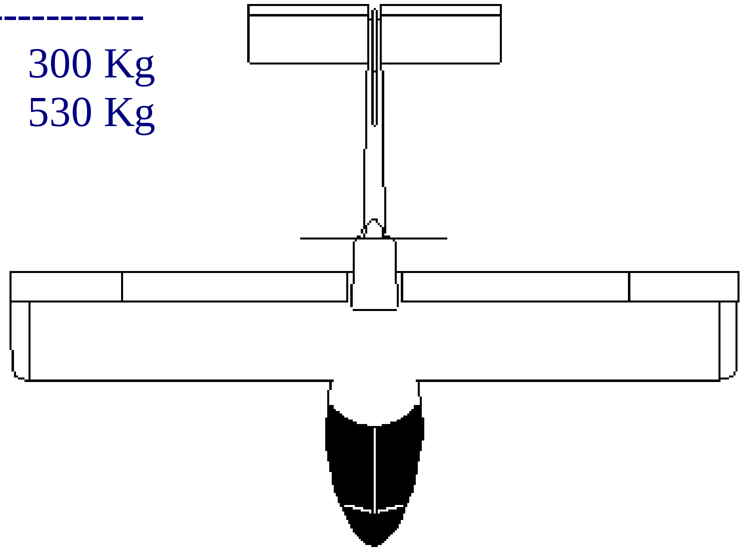
Effetto della spinta residua



Light aircraft







Dimensions		Weight	ULM	V.EL.
wing span	8.25 m	empty	270 Kg	300 Kg
wing chord	1.25 m	W_{TO}	450 Kg	530 Kg
wing area	10.3 m^2			
wing AR	6.6			
length overall	6.1 m			
height	1.92 m			
cabin width	1.08 m			

Engine & propeller

Rotax 912 max power

80 hp @ 5800 rpm

2 blade 1.70 m diameter

MAIN PERFORMANCES:

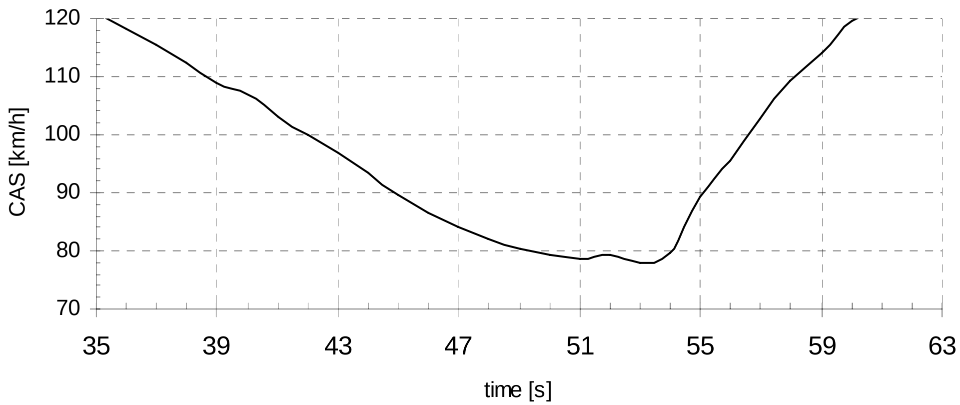
Max leveled speed	190 Km/h
Max R/C	4.5 m/s
Stall speed (full flap)	61 Km/h

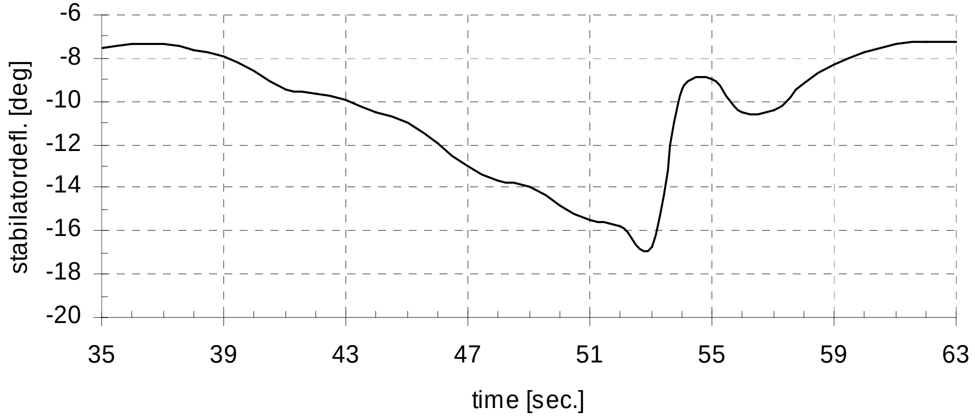
Velivolo G97 Spotter

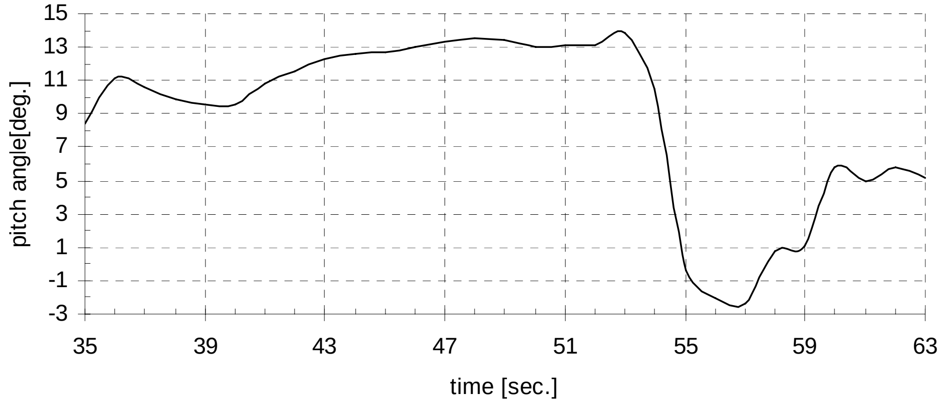
Prove di stallo

FAR
Entry rate
0.86 Kt/s

Clean W=503 CG 25%







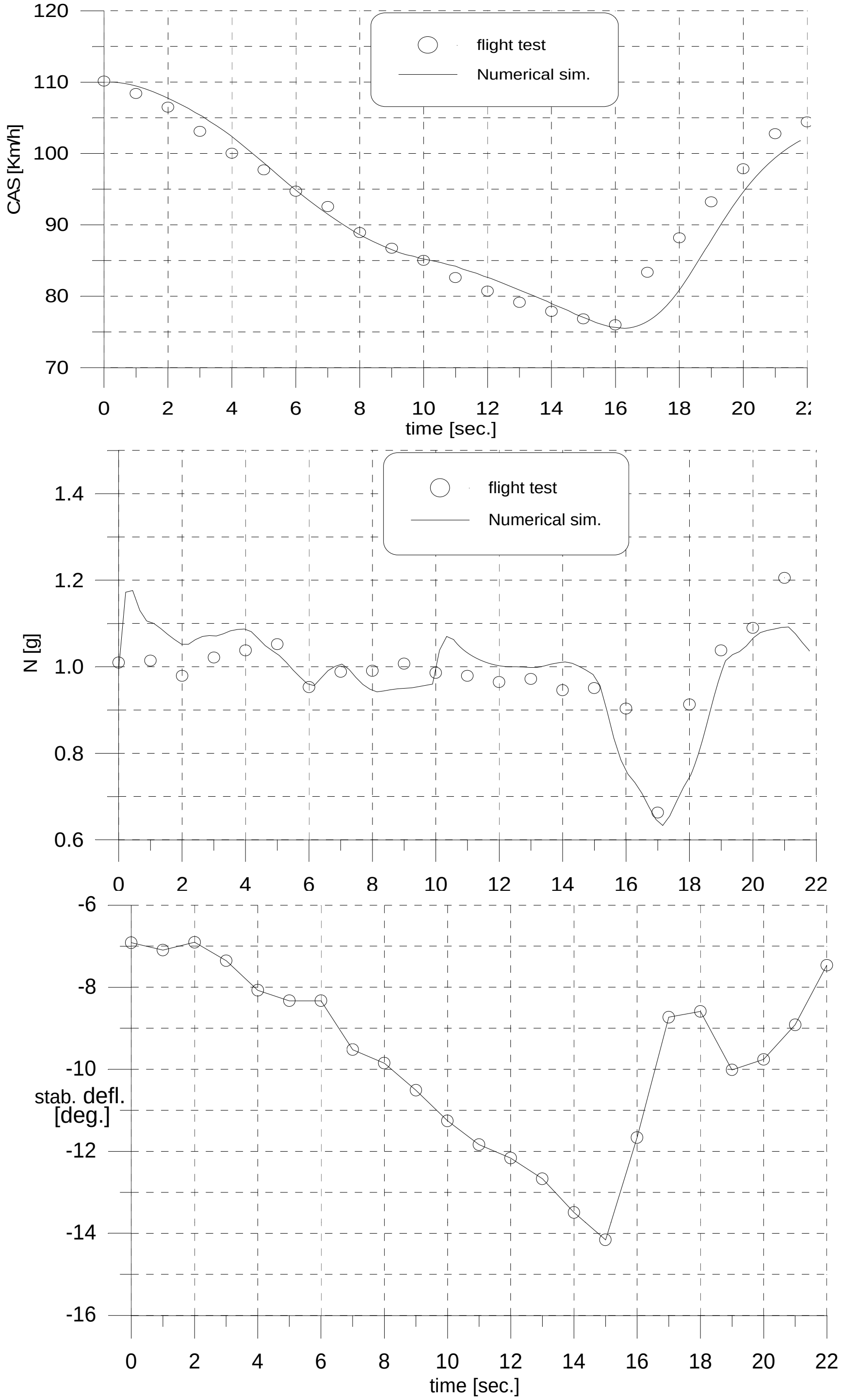
Velivolo G97 Spotter

FAR
Entry rate
0.86 Kt/s

Prove di stallo

Clean W=483 CG 27%

Confronto con simulazione di volo



Velivolo G97 Spotter

Prove di stallo

Conf.	W [Kg]	CG	Vmin [Km/h]	n	CLmax	Vs corr [Km/h]
Clean	418	36	75.2 72	1.00 0.97	1.52 1.60	81.1
Clean	503	25	78 77	0.93 0.88	1.58 1.54	78.97
Clean	483	27	76.8 75.9	0.95 0.90	1.60 1.55	79.59
TO	503	25	68.03	0.955	2.14	69.83
LAN *	483	27	66.28	1	2.21	69.43 *

Vs (average)
80 Km/h

* STALLO NON RAGGIUNTO

La velocità minima va corretta per ottenere la velocità di stallo al peso massimo previsto (530 Kg)

Risultati :

⇒ **Velocità di stallo con flap < 75 Km/h (cert. V.EL.)**

⇒ **Buon comportamento allo stallo**

Bimotore Tecnam P2006T

Caratteristiche geometriche

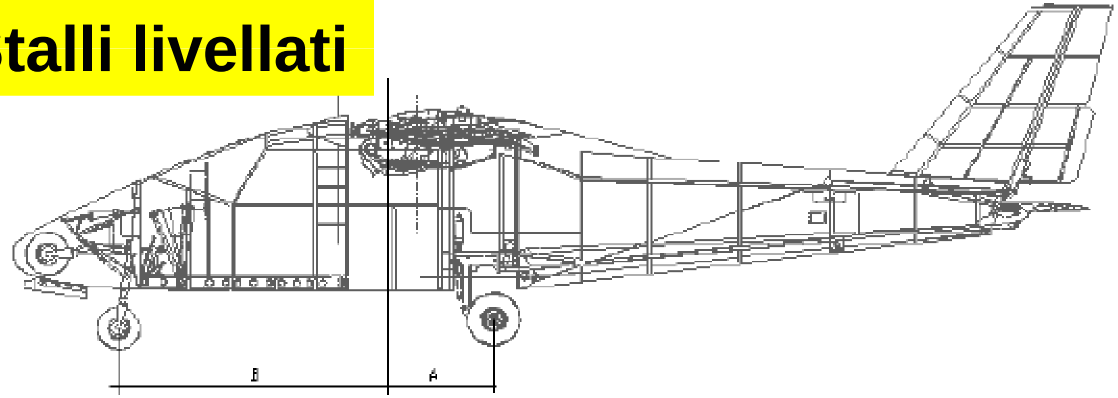
Wto	1180 kg
We	640 kg
S	14.4 m^2
B	10.6 m
AR	7.8
Lf	8.66 m
Cg range	16.5% - 30.5%

Prestazioni

RC	1360 ft/min
RC OEI	380 ft/min
Vmax	153 kts
Vcr	147 kts
TO run	420 m
L run	340 m

WING LEVEL STALLS – Stalli livellati

TESTS made
@max FWD Position
CG: 16.5% MAC



Volo	Prova	Stallo	Flap	MAP	Carrello	C.G.
1	1	Livellato	0	IDLE	RET	16.5%
	2		15			
	3		40			
	4		0	75%		
	5		15			
	6		40			
	7		0	IDLE	EXT	
	8		15			
	9		40			
	10		0	75%		
	11		15			
	12		40			

TEST CARS
STALL TESTS

Wing Level Stall
- IDLE-

TECNAM FLIGHT TESTING DATE

WINGS LEVEL STALL

P2006 I-TETW s/n 001 TEST N° 2

CS 23.201

CREW : ____ FUEL SX___ FUEL DX___

WEIGHT :________ CG%: MAX FWD (16.5%)

- ALTITUDE **1000 FT**
- FLAP **0°**
- POWER **IDLE**
- PROPELLERS **FULL INCREASE RPM**
- V_{TRIM} **84 KIAS (1.5VS1)**
- LANDING GEAR **RETRACTED**

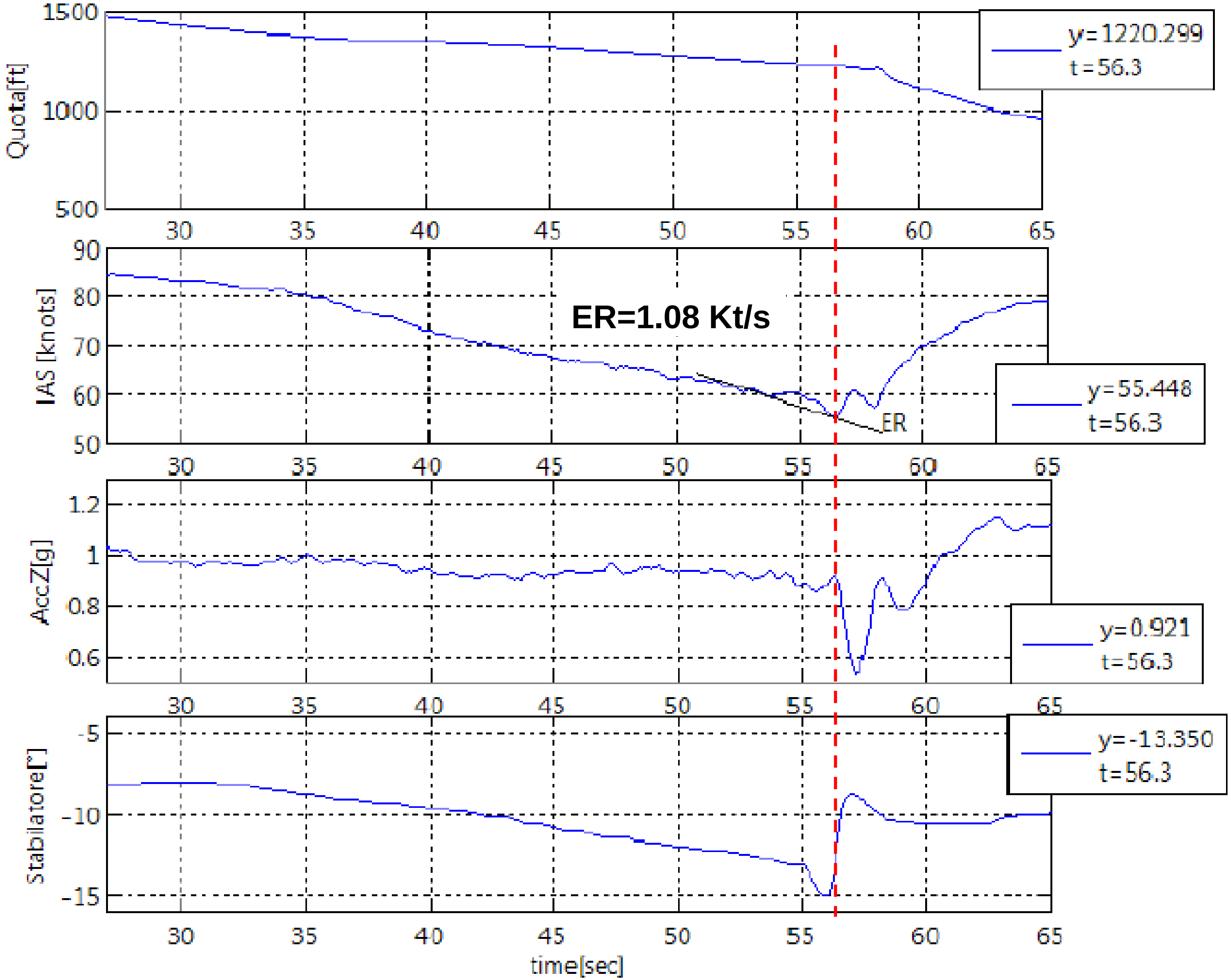
STARTING FROM A SPEED AT LEAST 10 KNOTS (ABOUT 62 KIAS) ABOVE THE STALL SPEED, THE ELEVATOR CONTROL MUST BE PULLED BACK SO THAT THE RATE OF SPEED REDUCTION WILL NOT EXCEED ONE KNOT PER SECOND UNTIL A STALL IS PRODUCED.

VERIFY THAT DURING THE ENTRY INTO AND THE RECOVERY FROM THE MANOUVRE IT IS POSSIBLE TO PRODUCE AND CORRECT ROLL AND YAW BY UNREVERSED USE OF THE ROLLING AND DIRECTIONAL CONTROL.
VERIFY THAT AFTER THE DOWNWARD PITCHING MOTION HAS BEEN PRODUCED OR AFTER THE CONTROL HAS BEEN HELD AGAINST THE STOP FOR NOT LESS THAN THE LONGER OF 2SECONDS, THE NORMAL USE OF THE ELEVATOR CONTROL FOR RECOVERY IS ALLOWED.
VERIFY THAT IT IS POSSIBLE TO PREVENT MORE THAN 15° OF ROLL OR YAW BY THE NORMAL USE OF CONTROLS.

TEST RESULT: OK ☐ NOT OK ☐

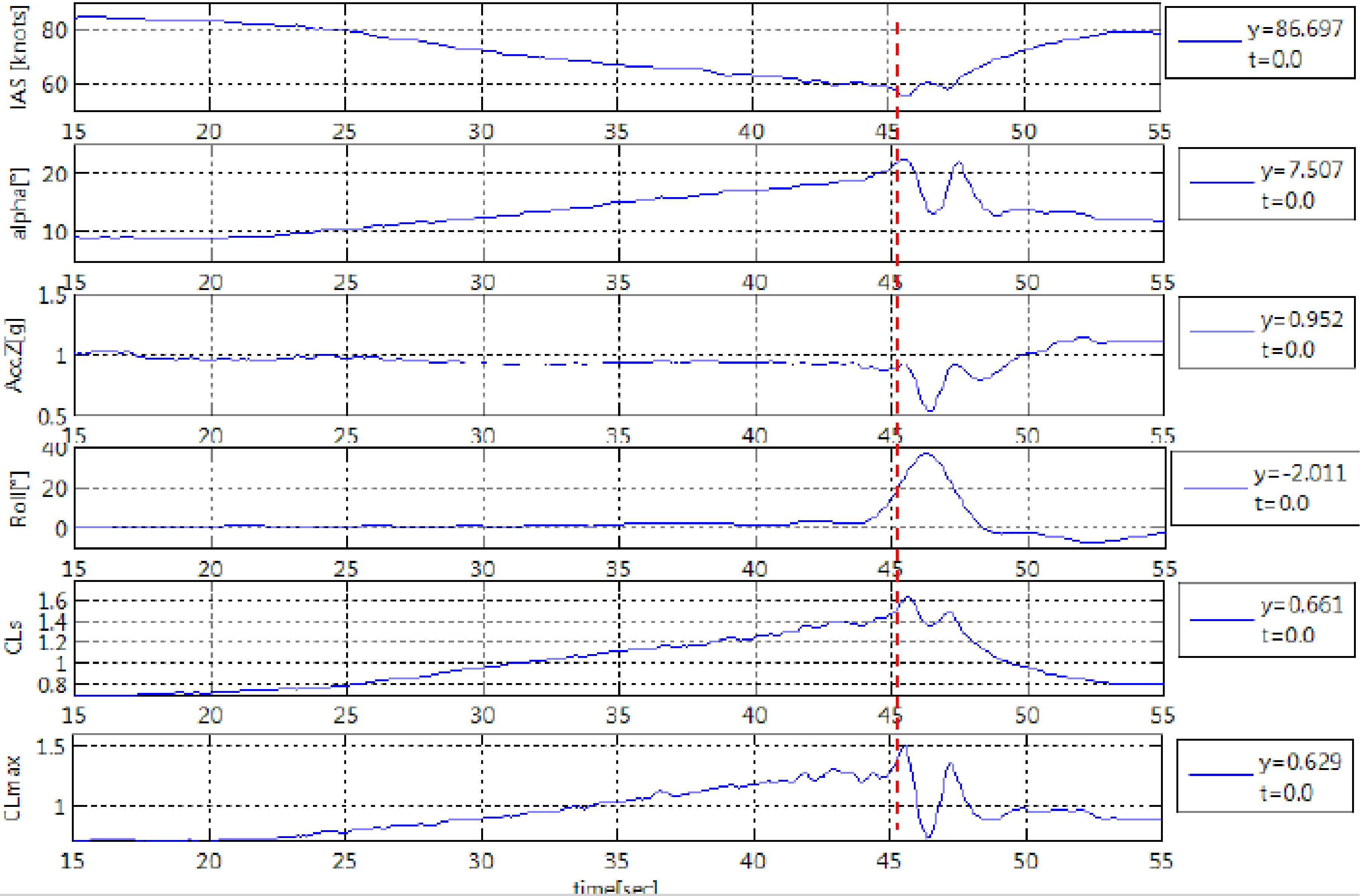
TEST PILOT ____________ ENAC _______________

P2006T STALL TESTS



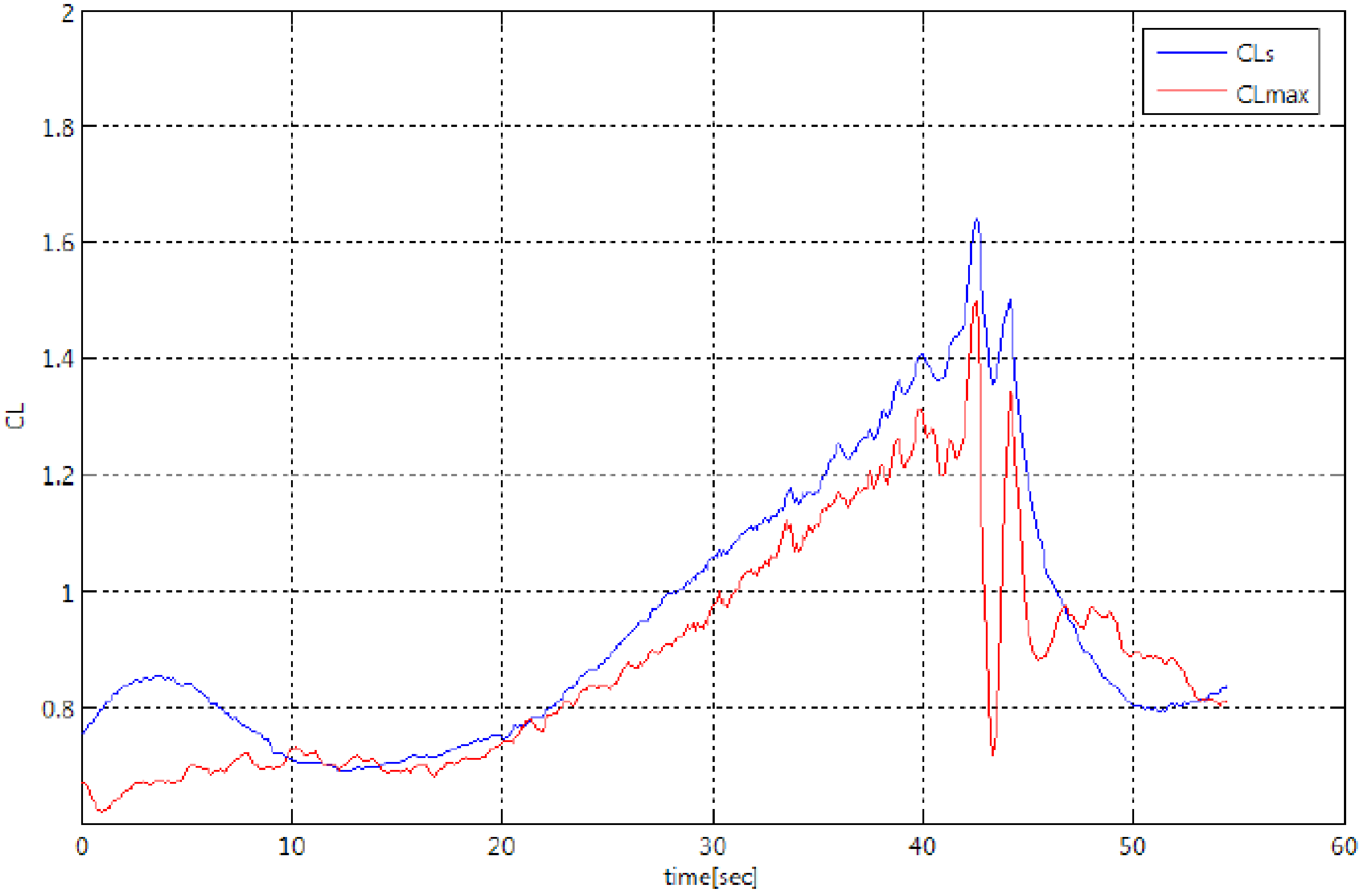
Wing Level Stall – IDLE- FLAP 0° - test 1

P2006T STALL TESTS



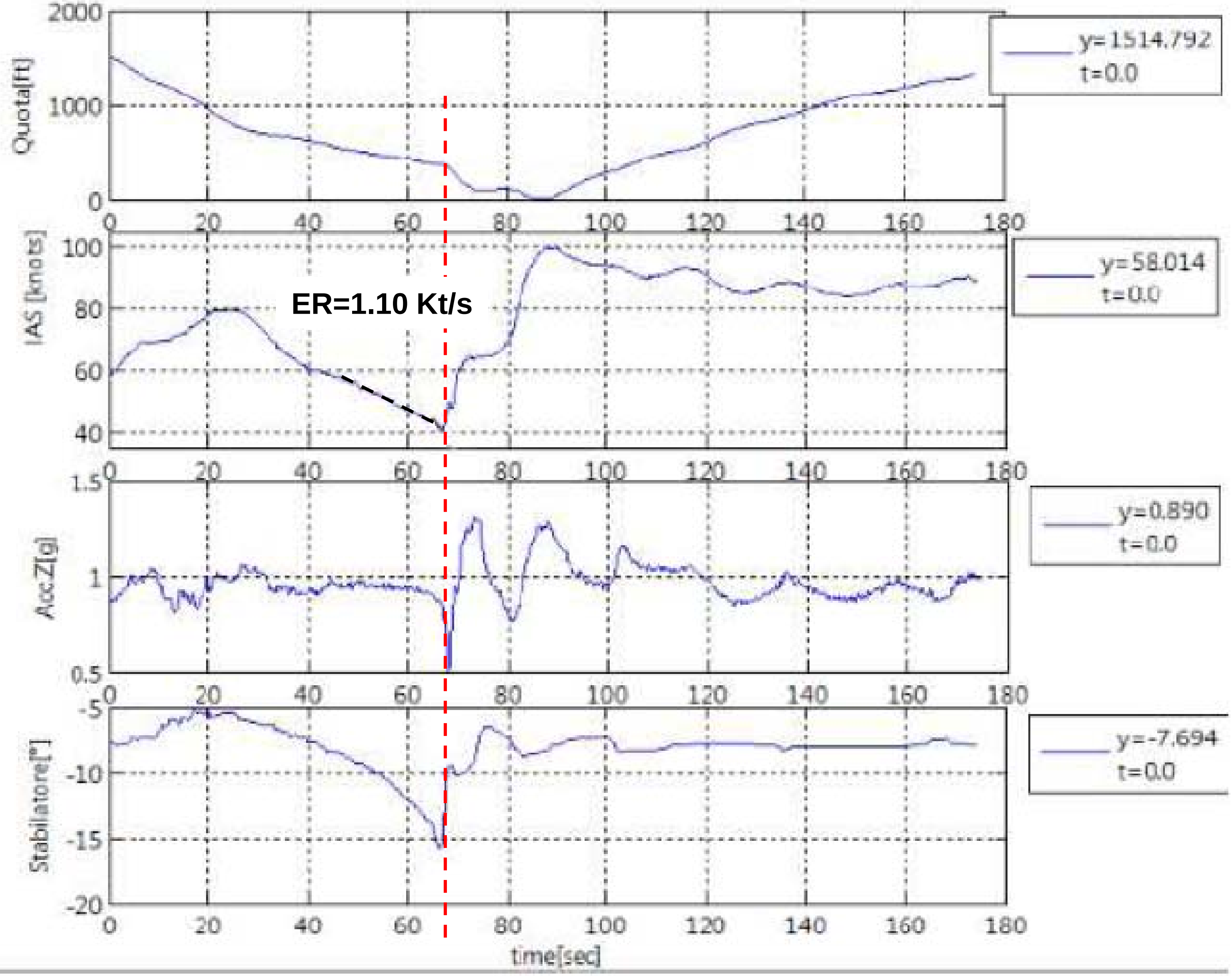
Wing Level Stall – IDLE- FLAP 0° - test 1

P2006T STALL TESTS



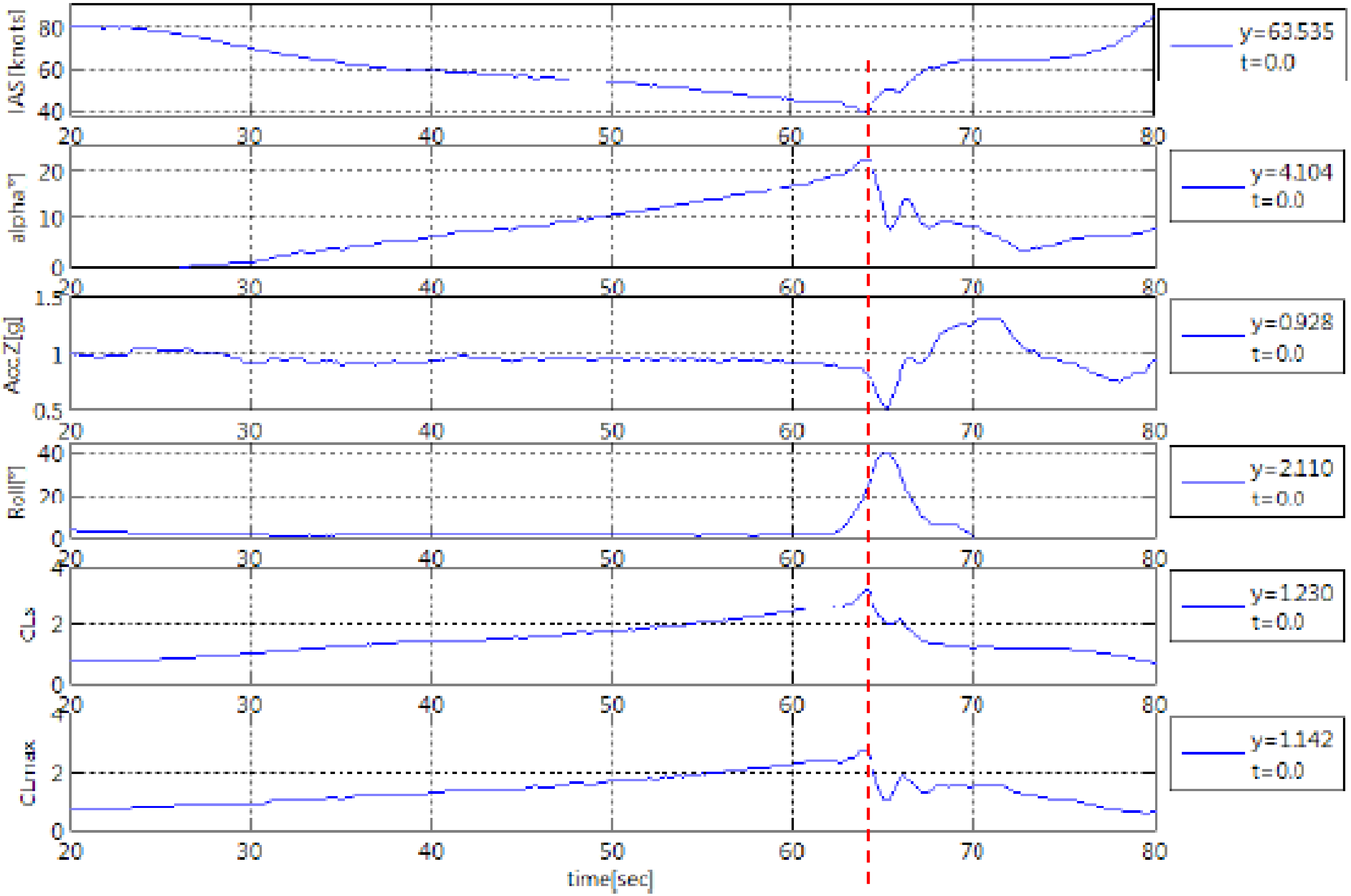
Wing Level Stall – IDLE- FLAP 0° - test 1

P2006T STALL TESTS



Wing Level Stall –IDLE – flap 40° test 3

P2006T STALL TESTS



Wing Level Stall –IDLE – flap 40° test 3

P2006T STALL TESTS

COSTRUZIONI AERONAUTICHE TECNAM

Volo	Prova	Stallo	Flap	MAP	Carrello	C.G.
1	1	Livellato	0	IDLE	RET	16.5%
	2		15			
	3		40			
	4		0	75%		
	5		15			
	6		40			
	7		0	IDLE	EXT	
	8		15			
	9		40			
	10		0	75%		

ANALISI DEI RISULTATI

Wing Level Stall
MAX FWD CG

L'ENTRY Rate è sempre buono. Il CG max avanzato favorisce un ingresso in stallo graduale.

Prova	V_s kts	g	V_{min} kts	ER kts/sec	CL_s	CL_{max}	FLAP
1	55.5	0.921	55.053	1.078	1.458	1.343	0
2	49	0.873	49	1.135	1.836	1.603	15
3	41.3	0.885	39.364	1.099	2.51	2.222	40
4	51	0.813	50.4	0.929	1.705	1.386	0
5	39.5	0.822	38.079	0.834	2.721	2.237	15
6	22.509	0.823	22.1		7.29	5.999	40
7	60	0.921	35.455	0.844	1.261	1.161	0
8	45.8	0.845	27.729		2.079	1.756	15
9	43	0.847	38.457	0.716	2.333	1.976	40

Eff MAP

Eff LAND GEAR

Tabella 4.14: Prove di stallo: analisi volo 1

P2006T STALL TESTS COSTRUZIONI AERONAUTICHE TECNAM

ANALISI DEI RISULTATI

Wing Level Stall
MAX FWD CG

- **L'ENTRY Rate è sempre buono. Il CG max avanzato favorisce un ingresso in stallo graduale.**
- **L'effetto della potenza è di far ridurre la velocità di stallo. I valori con i flap estesi sono poco significativi.**
- **Il carrello ha un leggero effetto di far aumentare la velocità di stallo.**

Prova	V_s kts	g	V_{min} kts	ER kts/sec	CL_s	CL_{max}	FLAP	
1	55.5	0.921	55.053	1.078	1.458	1.343	0	
2	49	0.873	49	1.135	1.836	1.603	15	
3	41.3	0.885	39.364	1.099	2.51	2.222	40	
4	51	0.813	50.4	0.929	1.705	1.386	0	
5	39.5	0.822	38.079	0.834	2.721	2.237	15	Eff MAP
6	22.509	0.823	22.1		7.29	5.999	40	
7	60	0.921	35.455	0.844	1.261	1.161	0	
8	45.8	0.845	27.729		2.079	1.756	15	Eff LAND GEAR
9	43	0.847	38.457	0.716	2.333	1.976	40	

Tabella 4.14: Prove di stallo: analisi volo 1

P2006T STALL TESTS

COSTRUZIONI AERONAUTICHE TECNAM

ANALISI DEI RISULTATI

TURNING & ACCELERATED STALLS
MAX FWD CG

Volo	Prova	Stallo	Flap	MAP	Carrello	C.G.
2	13	Turn	0	IDLE	RET	17.1%
	14		15			
	15		40			
	16		0	75%		
	17		15			
	18		40			
	19		0	IDLE	EXT	
	20		15			
	21		40			
	22	Acc	0	IDLE	RET	
	23		15			
	24		40			
			0	75%	EXT	

Prova	V_s kts	g	V_{min} kts	ER kts/sec	CL_s	CL_{max}
13	65.734	0.976	65.734	0.85	1.062	1.037
14	53.809	1.053	53.809	1.053	1.544	1.626
15	54.058	1.143	54.058	0.5	1.531	1.75
16	57.547	0.993	57.547	1.4	1.363	1.353
18	38.62	1.026	38.62	0.6	2.834	2.908
19	68.218	1.060	68.218	0.48	0.991	1.050
22	72.773	1.189	59.72	4.22	0.877	1.043
23	64.749	1.105	62.232	1.638	1.093	1.208
24	56.45	1.203	50.476	3.192	1.412	1.699

Tabella 4.15: Prove di stallo: analisi volo 2

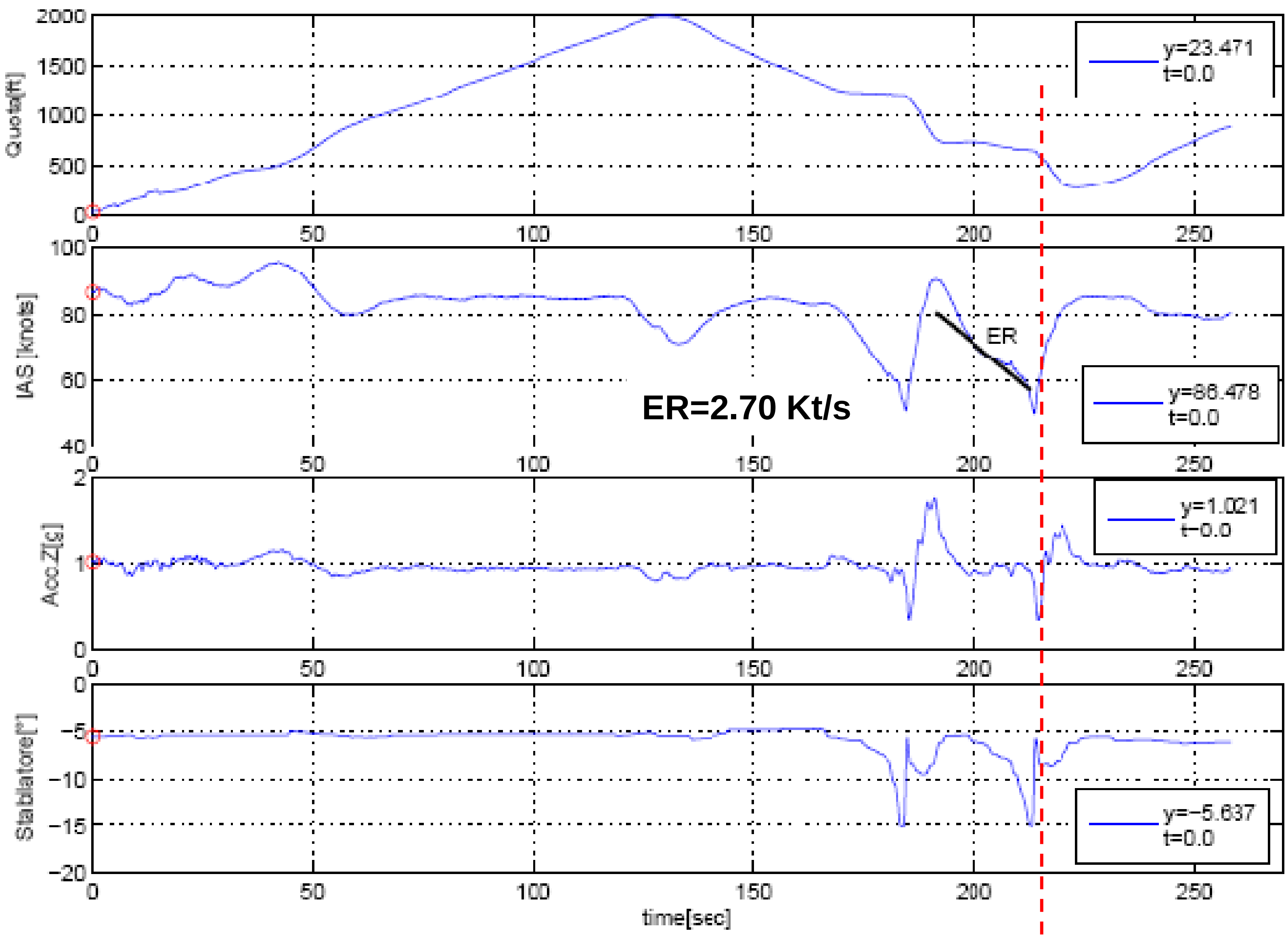
FLAP		
0, 15, 40	Idle	Turn.
0, 40	75%P	Turn.
0	Idle LG ext.	Turn.
0, 15, 40	Idle	Acc. Turn.

P2006T STALL TESTS

EFFECT OF CG POSITION

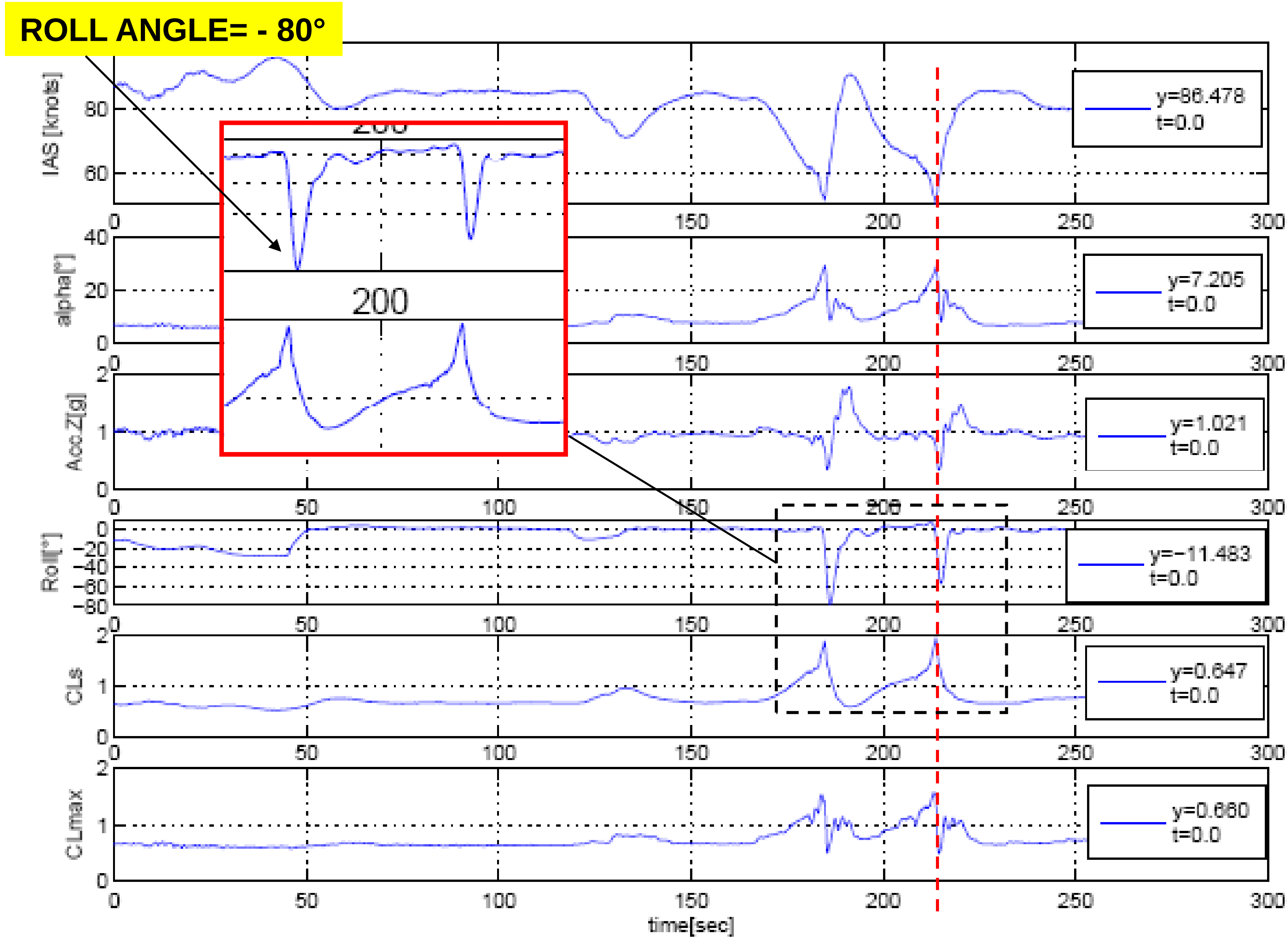
TESTS made
@max AFT Position
CG: 30.5% MAC

olo	Prova	Stallo	Flap	MAP	Carrello	C.G.
3	28	Livellato	0	IDLE	RET	30.5%
	29		15			
	30		40			
	31		0		EXT	
	32		15			
	33		40			
	34		0	75%	RET	
	35		15			
	36		40			
	37		0		EXT	
	38		15			
	39		40			
	40	TURN	0	IDLE	RET	
	41		15			
	42		40			
	43		0		EXT	
	44		15			
	45		40			
	46	TURN	0	IDLE	RET	
	47		15			
	48		40			
	49		0		EXT	
	50		15			
	51		40			



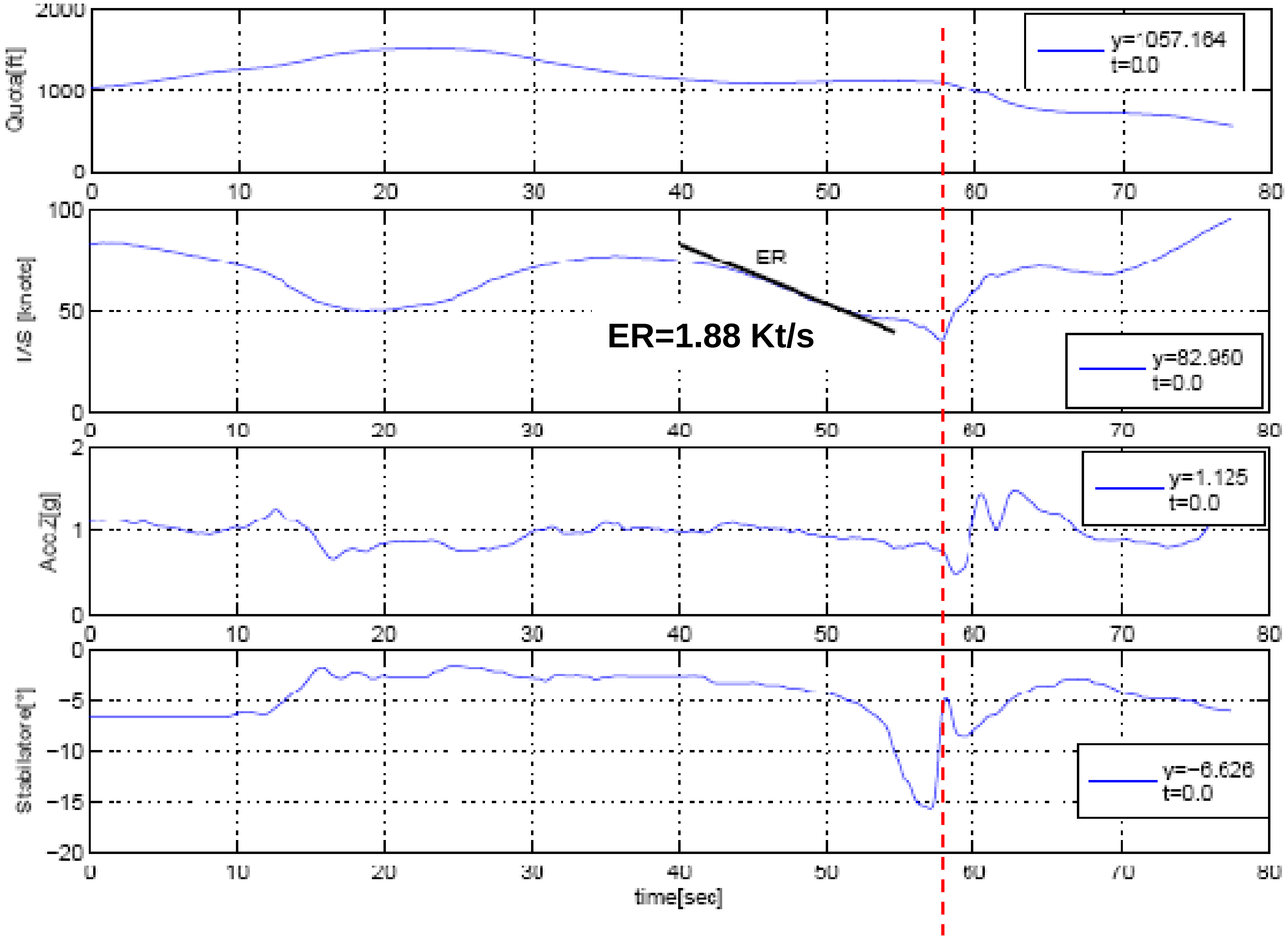
WING LEVEL Stall FLAP 0° –MAX AFT CG – test 28

P2006T STALL TESTS COSTRUZIONI AERONAUTICHE TECNAM



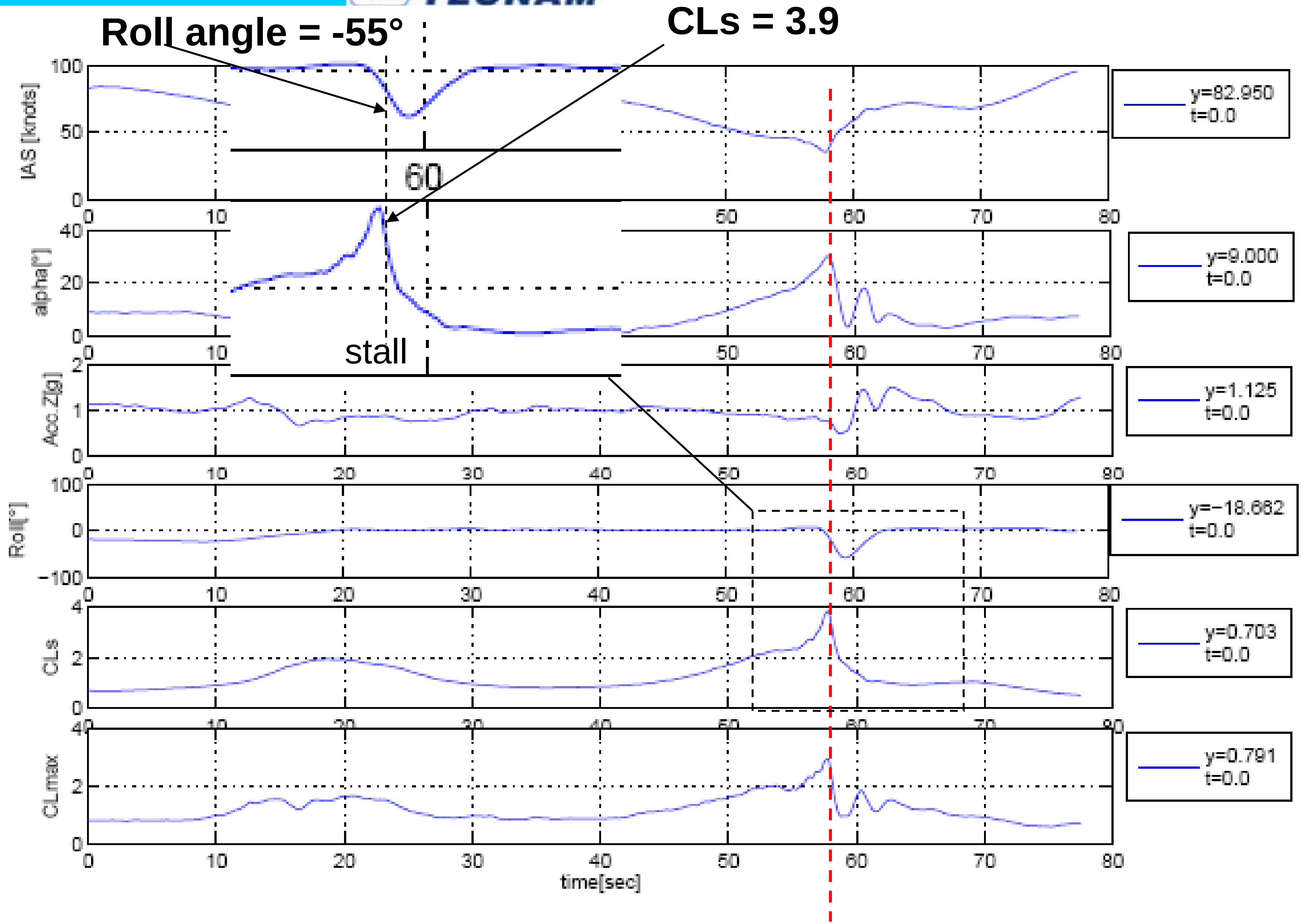
WING LEVEL Stall FLAP 0° –MAX AFT CG – test 28

P2006T STALL TESTS

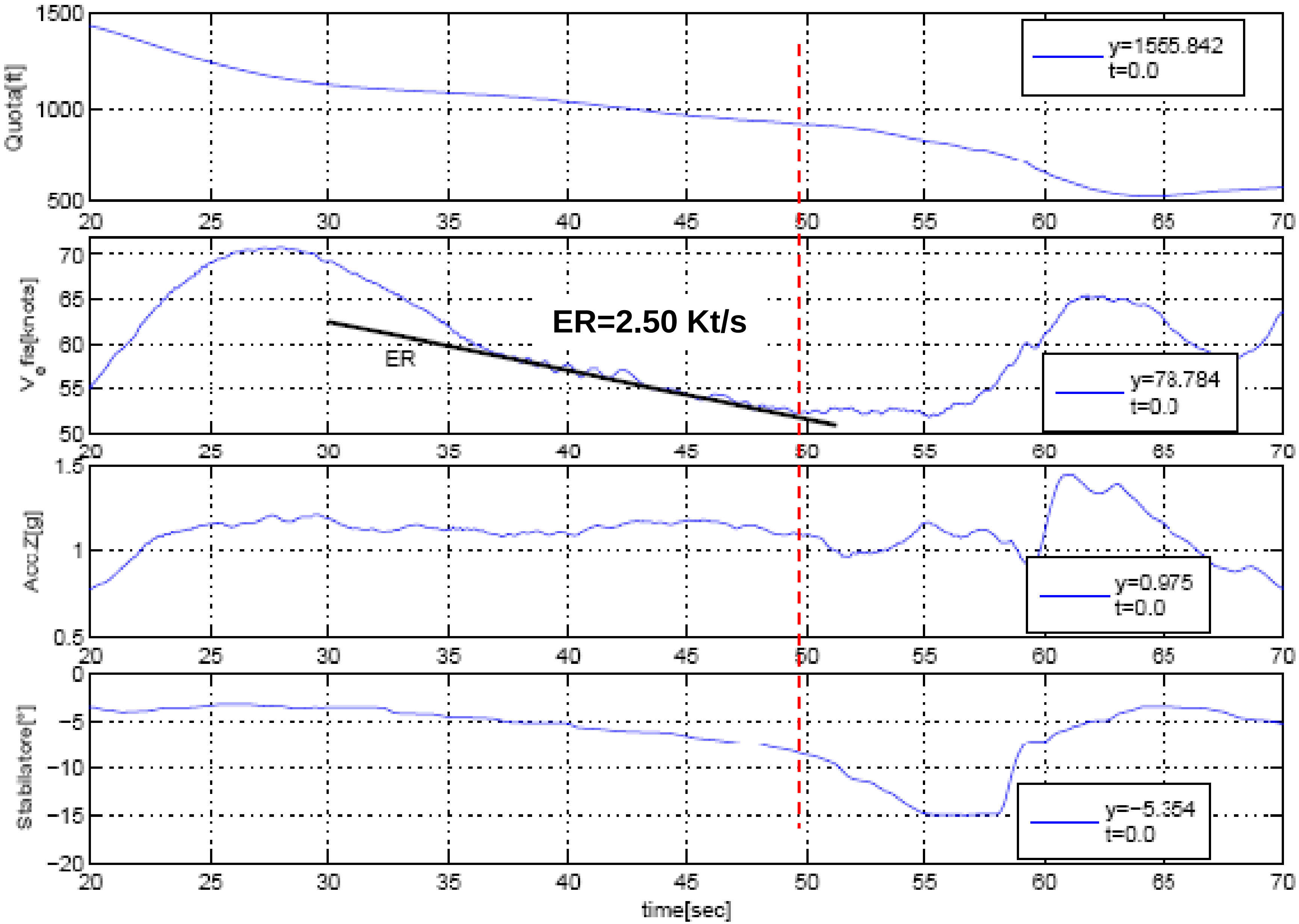


WING LEVEL Stall –MAX AFT CG FLAP 40° – test 30

P2006T STALL TESTS

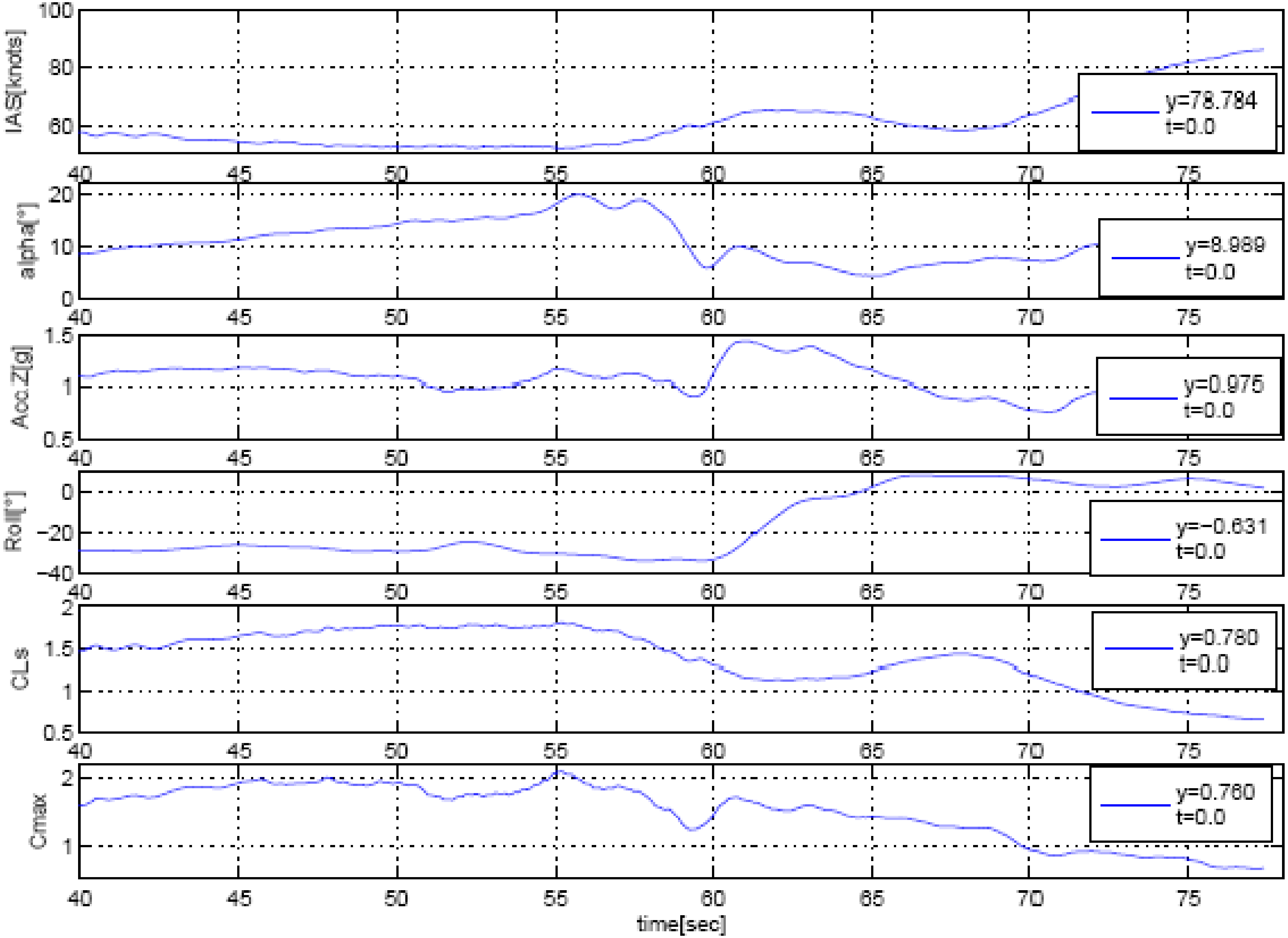


WING LEVEL Stall –MAX AFT CG FLAP 40° – test 30



TURNING Stall –MAX AFT CG –FLAP 40° - test 42

P2006T STALL TESTS



TURNING Stall –MAX AFT CG –FLAP 40° - test 42

EFFECT OF CG POSITION

Le prove mostrano che con il CG arretrato il velivolo entra sempre in uno stallo "profondo". Il pilota, per il margine di stabilità non elevato, raramente riesce a tenere un rateo di decelerazione inferiore ad 1 Kt/s.
Dopo lo stallo gli angoli di bank spesso superano i 50-60 °, con conseguente superamento dei limiti consentiti.

RIMEDI :
-Viene limitata l'escursione del comando longitudinale (di circa 1°) in modo da evitare un ingresso "profondo" in stallo.
- Vengono inserite delle "stall strip" al bordo d'attacco nella zona di radice (tra la fusoliera e la gondola) in modo da promuovere lo stallo anticipato della zona di radice ed evitare grosse tendenze al rollio.

Prova	V_s kts	g	V_{min} kts	ER kts/sec	CL_s	CL_{max}
28	55.179	0.938	50.927	2.7	1.474	1.382
29	48	0.893	43.2	4	1.907	1.703
30	47	0.899	35.7	1.88	1.982	1.782
31	51	0.868	44.417	5	1.705	1.48
32	36	0.81	36		3.216	2.605
33	42	0.803	29.951	1.34	2.435	1.955
34	43.5	0.809	36.746	2.175	2.284	1.848
35	36.728	0.86	32.358	1.78	3.103	2.668
36	24.887	0.86	24.887	3.44	6.146	5.285
37	42.213	0.8	39.31	2.81	2.412	1.93
38	38.366	0.878	36.109	1.82	2.868	2.518
39	26.598	0.813	26.598	1.41	5.481	4.456
40	62	0.972	60.458	1.278	1.186	1.152
41	58	0.914	43.026	2.9	1.343	1.227
42	53	0.972	50	2.5	1.588	1.544
43	61	0.963	61	0.924	1.222	1.177
44	62	0.824	60	2.92	1.186	0.977
45	51.6	1.054	49.255		1.669	1.759
46	55	0.895	52.717	3	1.483	1.327
47	50	0.988	48.144		1.769	1.748
48	42.783	0.815	38.173	2.5	2.354	1.919
49	59	0.923	49.173	3.68	1.301	1.201
50	52	0.947	49	2	1.645	1.558
51	43	0.876	39.421		2.333	2.043

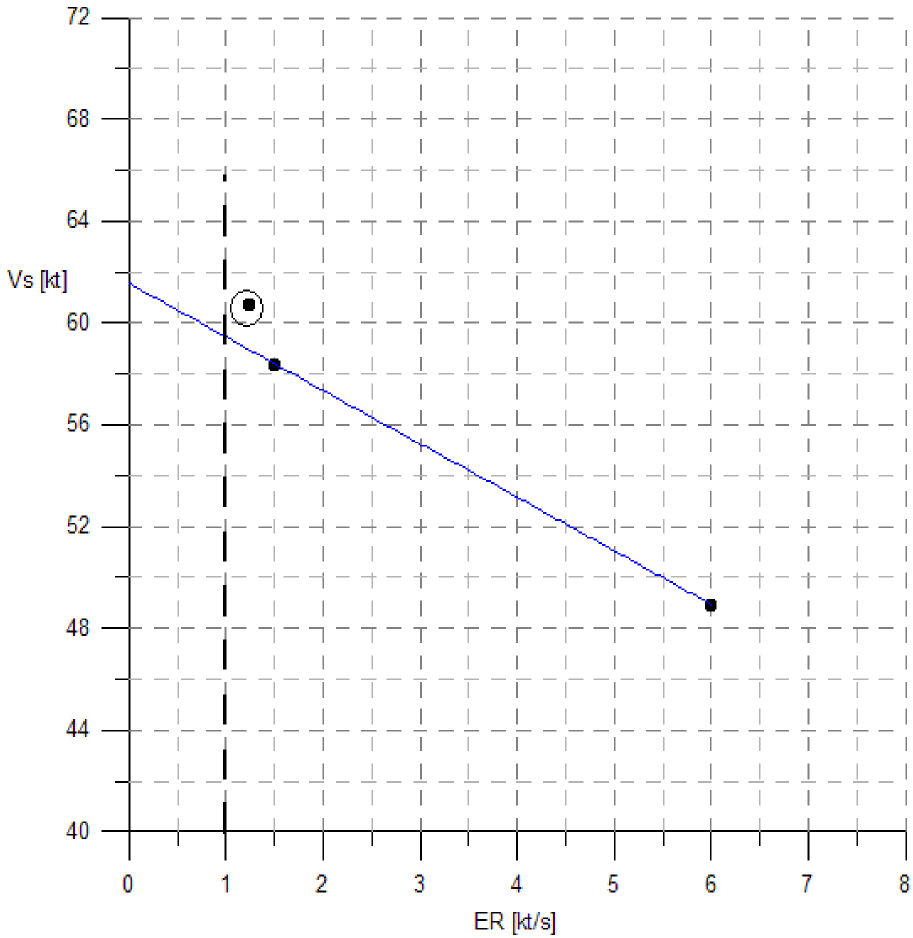
Tabella 4.16: Prove di stallo: analisi volo 3

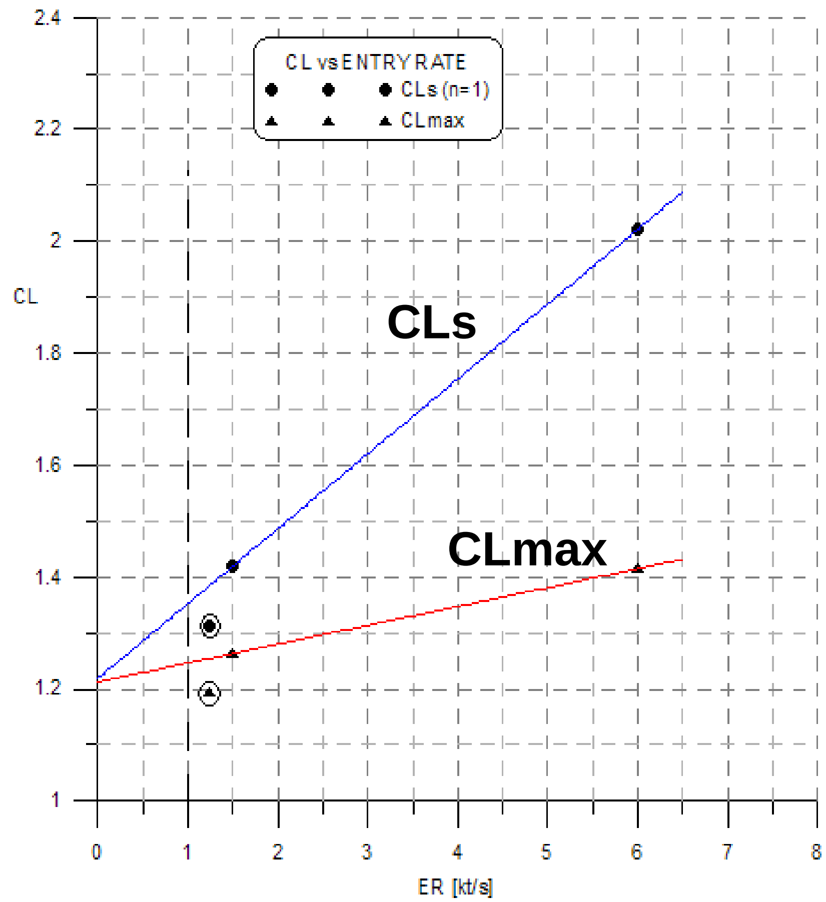
STALL TEST RESULTS

Prova	Con.	C.g. [%]	Flap [°]	Carr.	Pot.	Vs [kts]	g	ER [ft/min]	CLs	CLmax
1	Liv	16.5	0	R	IDLE	55.5	0.92	1.078	1.46	1.34
3	Liv	16.5	40	R	IDLE	41.3	0.88	1.099	2.51	2.22
7	Liv	16.5	0	E	IDLE	60	0.92	0.844	1.26	1.16
9	Liv	16.5	40	E	IDLE	43	0.85	0.716	2.33	1.98
15	Turn	17.1	0	R	IDLE	65.7	0.98	0.85	1.06	1.04
21	Turn	17.1	40	R	IDLE	54	1.14	0.5	1.53	1.75
22	Acc	17.1	0	R	IDLE	72.8	1.19	4.22	0.87	1.04
28	Liv	30.5	0	R	IDLE	55.2	0.94	2.7	1.47	1.38
30	Liv	30.5	40	R	IDLE	47	0.9	1.88	1.98	1.78
31	Liv	30.5	0	E	IDLE	51	0.87	5	1.7	1.48
33	Liv	30.5	40	E	IDLE	42	0.8	1.34	2.43	1.95
42	Turn	30.5	0	R	IDLE	53	0.97	2.5	1.58	1.54
45	Turn	30.5	40	R	IDLE	51.6	1.05	5	1.67	1.76

P2006T - Effetto entry rate

Risultati dell'analisi di alcune prove di stallo in configurazione clean e baricentro al 30.5% al variare dell'entry rate.





PROVE DI STALLO BOEING 747

Prove in galleria del vento:
- Re=1 mil.
- Re=7 mil. (galleria NASA pressurizzata)

$\Rightarrow$Re di volo allo stallo (basato su MAC) = 40 mil.

IMPORTANZA PER LE PRESTAZIONI DI DECOLLO ED ATTERRAGGIO

Se il velivolo fosse progettato per una data lunghezza di decollo ed atterraggio al suo peso massimo un errore del 5% sulla stima della Vs comporta :
- -38% di carico pagante !
- -55% di PROFITTO !!!

Stime iniziali nel 1966
- 4000 ore di galleria del vento in 3 anni e mezzo

Le correzioni erano basate sui risultati relativi ai velivoli Boeing precedenti.
- Previsione dell'influenza del peso, del CG e della configurazione

IL FLAP però era piuttosto diverso ed innovativo !!!!

PROVE DI STALLO BOEING 747

Campagna di prove di volo per la velocità di stallo :

636 STALLI in varie configurazioni di flap, peso e pos del CG

- La velocità fu misurata da un trailing cone (per correzione della statica)
- Accelerometri
- Gyro rates
- misure angoli
- sonda calibrata con fori sulla fusoliera per la misura di alfa

PROVE DI STALLO BOEING 747

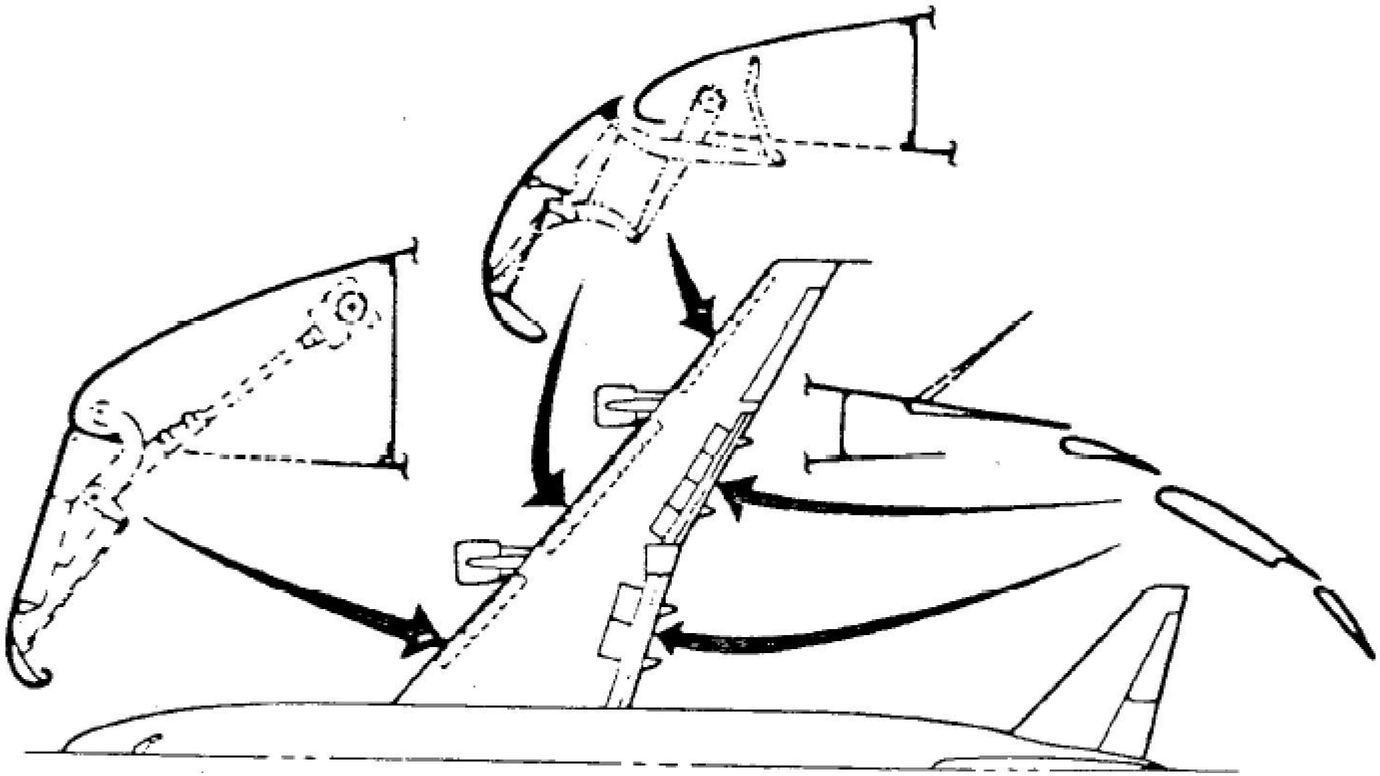


FIGURE 1: 747 HIGH LIFT SYSTEM

PROVE DI STALLO BOEING 747

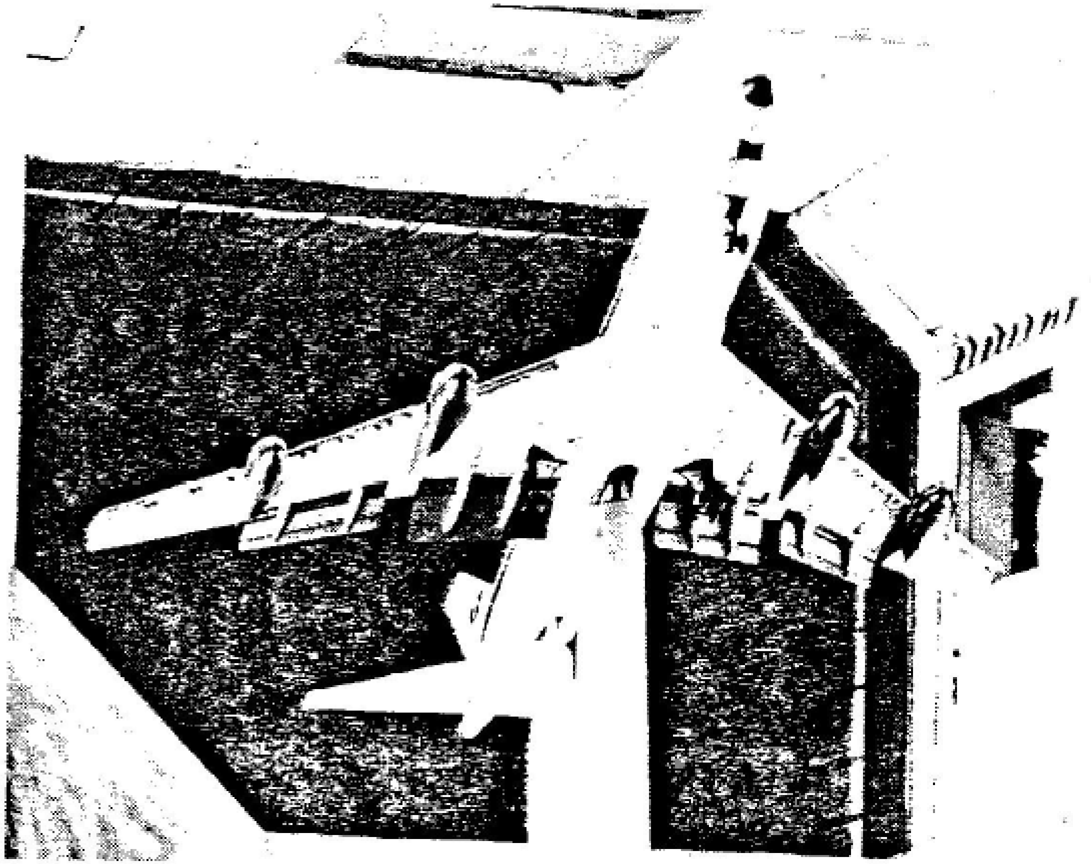


FIGURE 2: 747 HIGH LIFT WIND TUNNEL MODEL

PROVE DI STALLO BOEING 747

Prove su di un modello con
ala twisted per simulare la torsione
che l'ala reale subisce in volo al
massimo carico

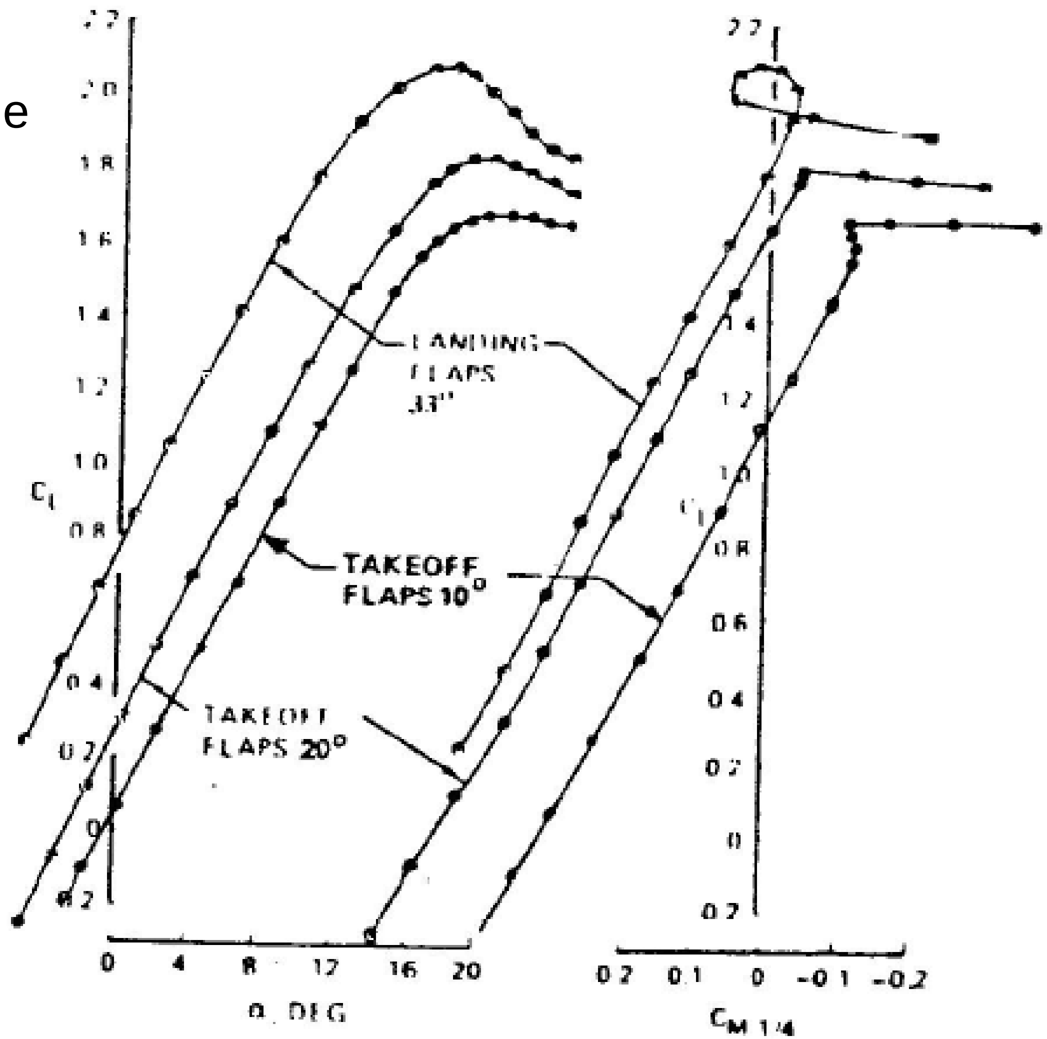


FIGURE 3: HIGH LIFT WIND TUNNEL DATA (LOW REYNOLDS NUMBER)

PROVE DI STALLO BOEING 747
Take-Off Config (flap 10°)

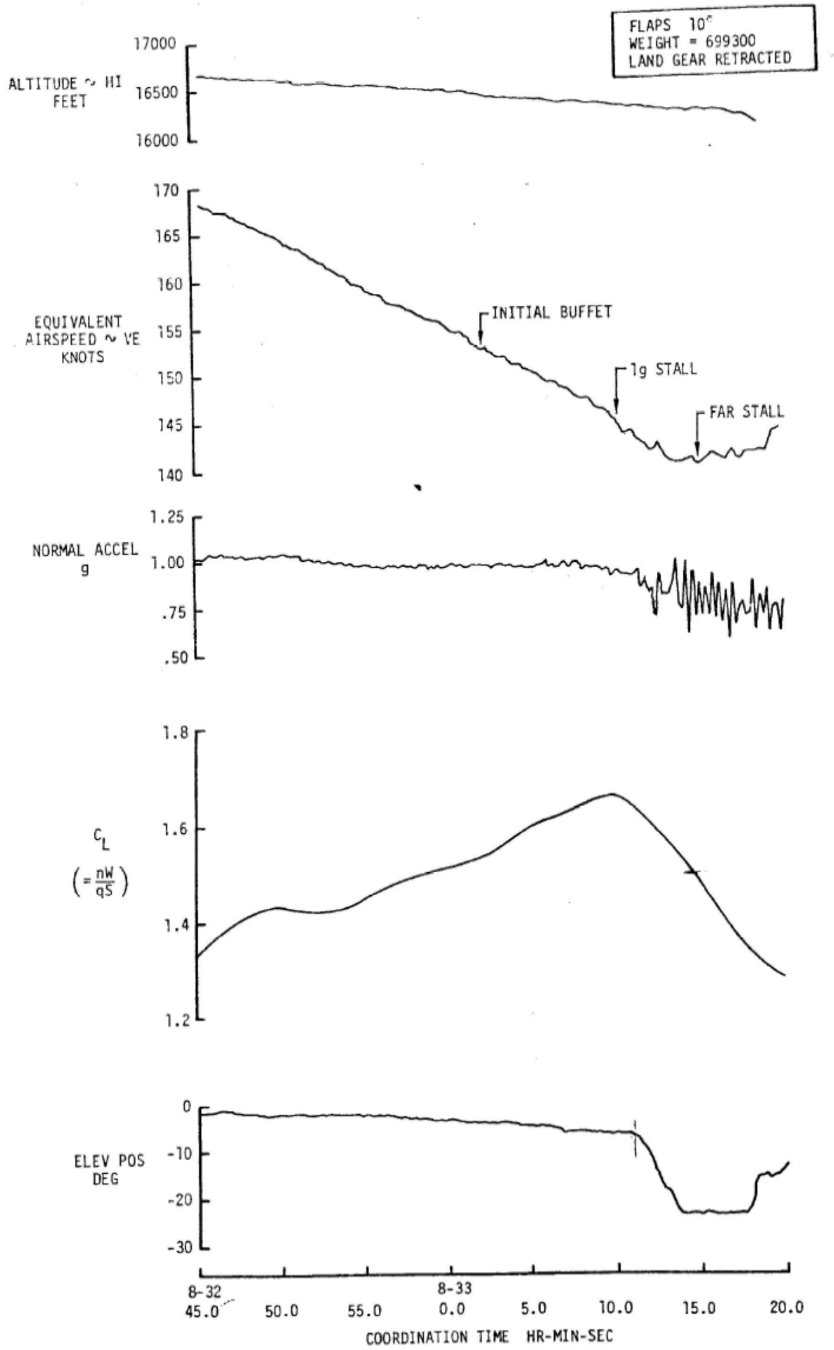
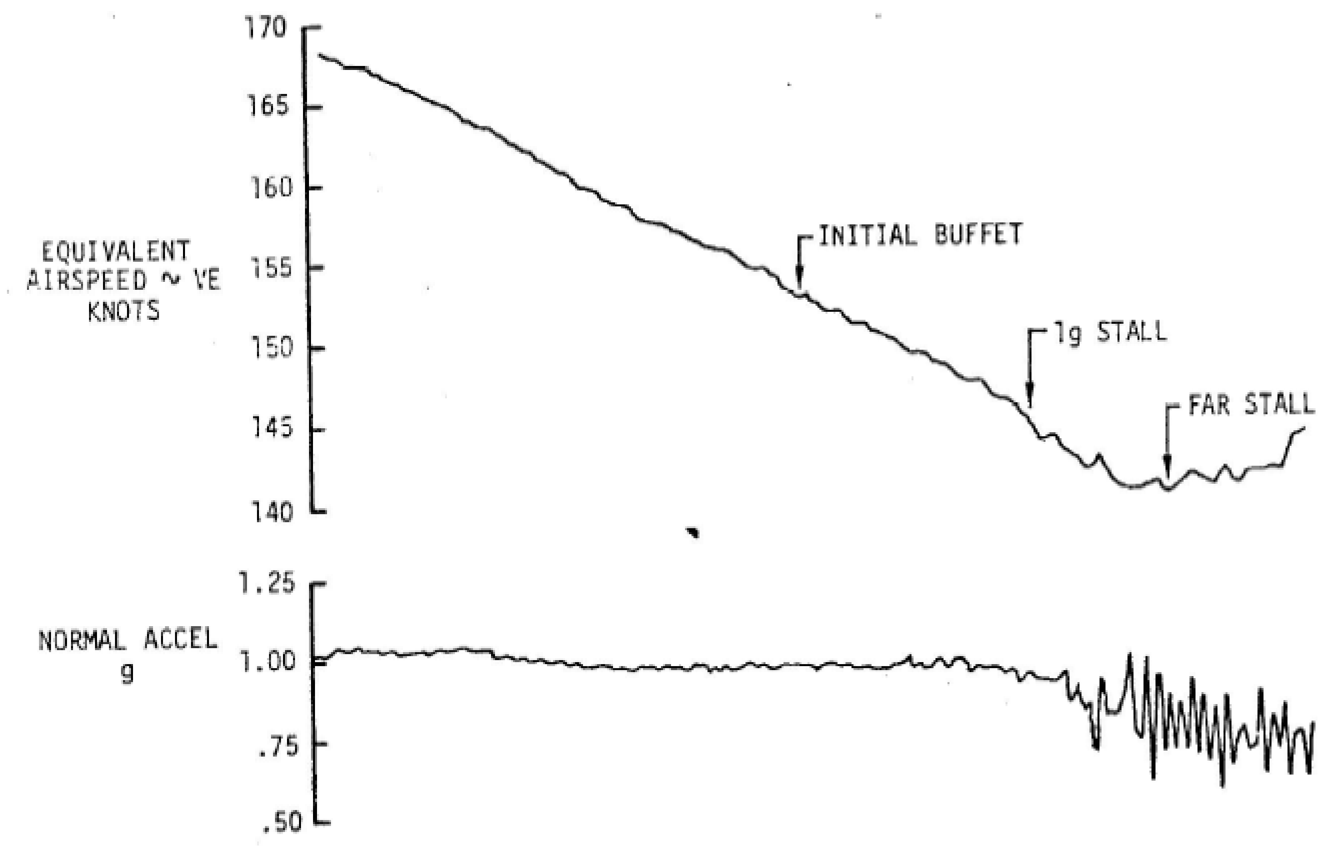


FIGURE 4: FLIGHT RECORD OF A STALL MANEUVER

PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)



PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)

FAR $\check{C}_{L_{Stall}}$

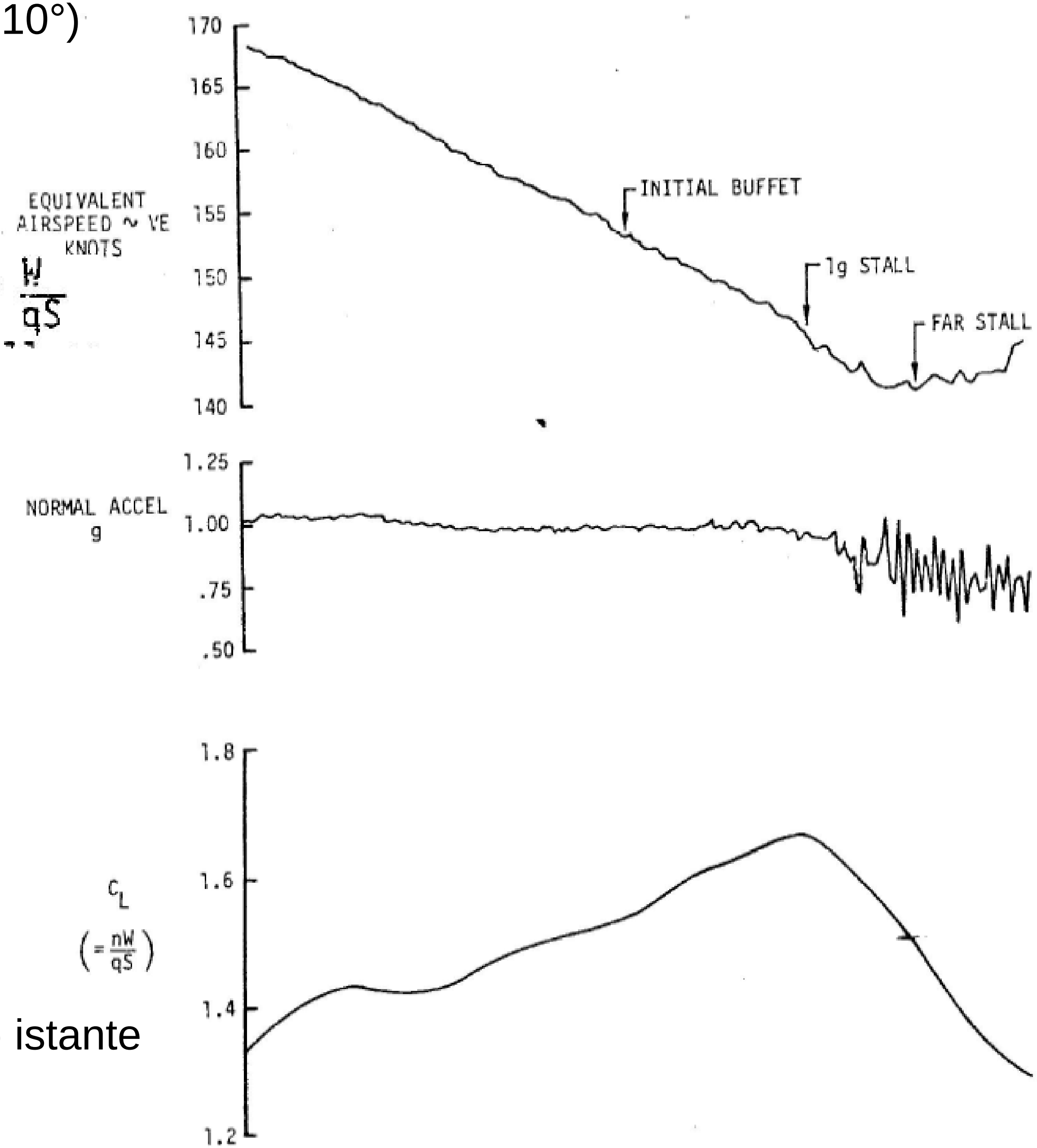
$$C_{L_{Stall}} = \frac{W}{1/2\rho V^2_{Stall} S} = \frac{W}{qS}$$

1 g stall speed

Quando il fattore di carico subisce il g-brake

$C_{L_{max}}$ $\frac{nW}{qS}$

Definita considerando
Il valore di n (fatt carico) istante per istante



NOTA che CLmax non si ottiene allo stesso istante di CLs

PROVE DI STALLO BOEING 747

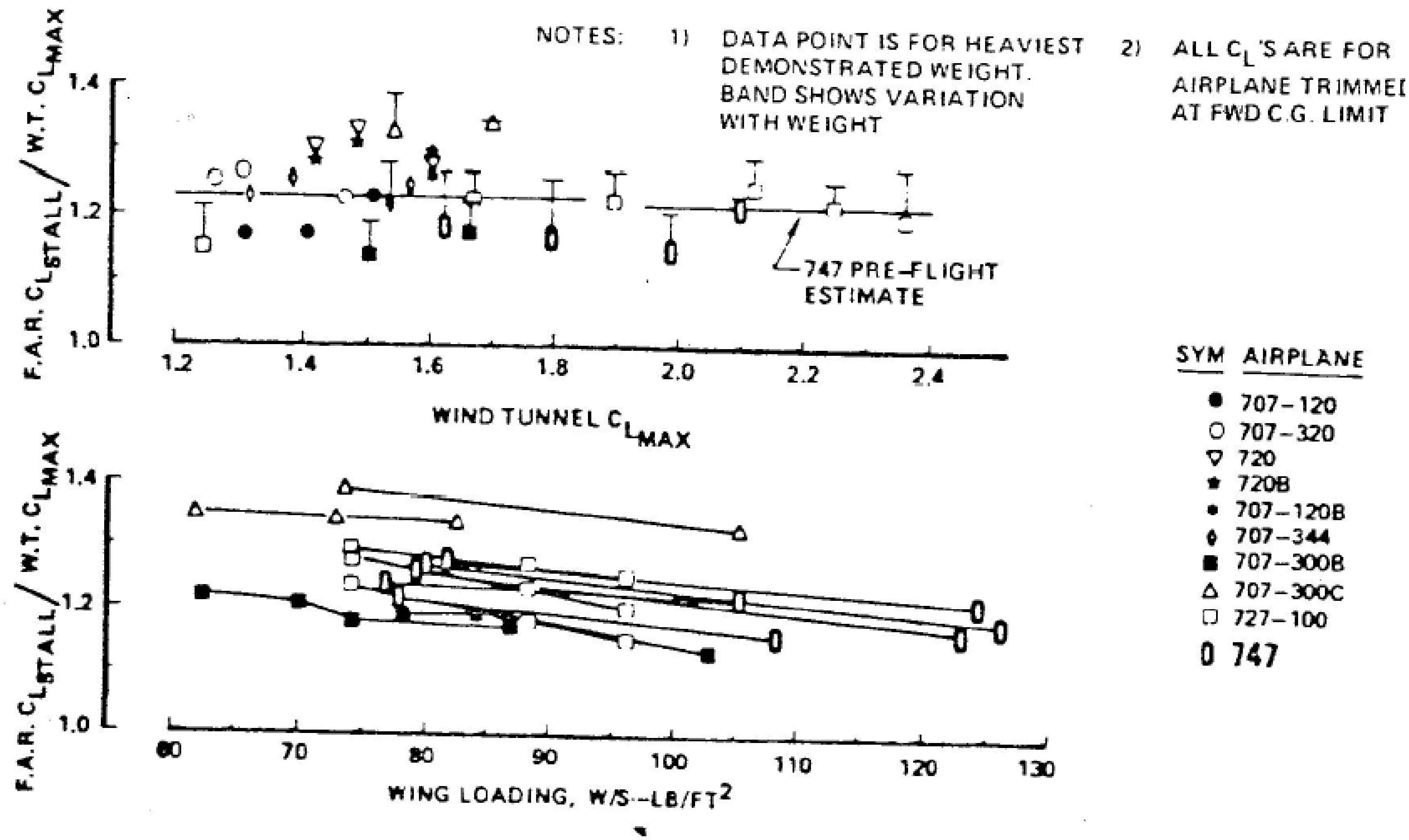


FIGURE 5: COMPARISON OF FLIGHT FAR $C_{L_{STALL}}$ AND WIND TUNNEL $C_{L_{MAX}}$

PROVE DI STALLO BOEING 747

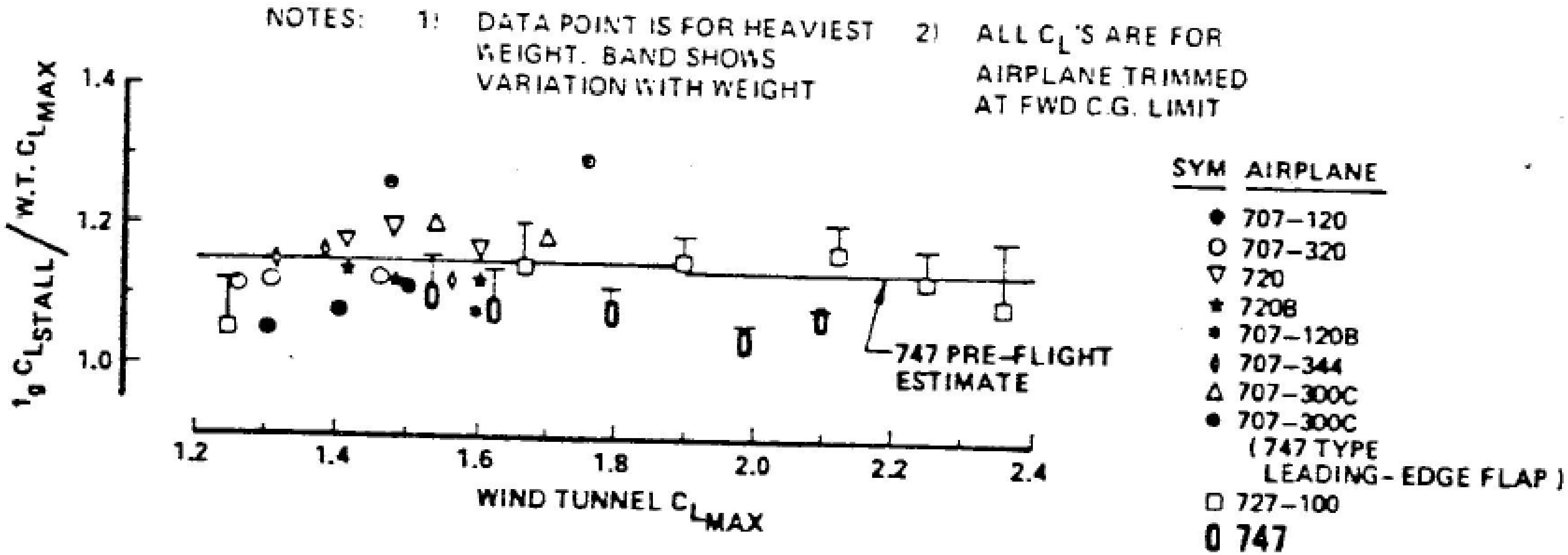
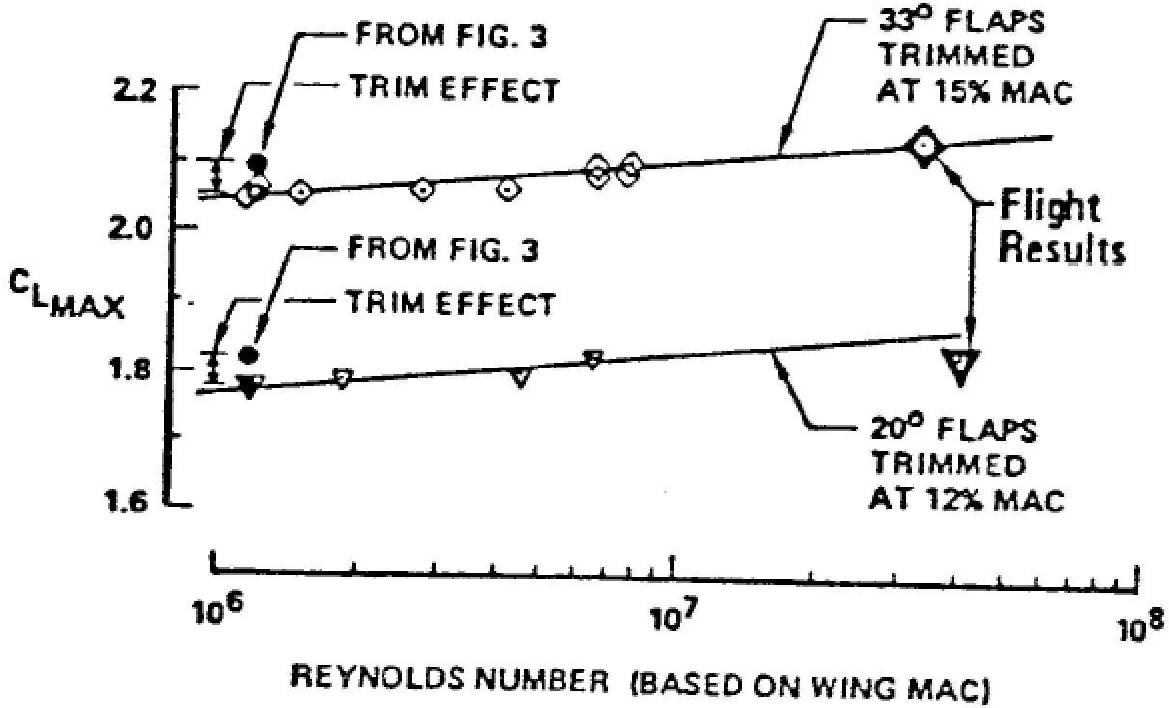


FIGURE 6: COMPARISON OF FLIGHT $1gC_{L_{STALL}}$ AND WIND TUNNEL $C_{L_{MAX}}$

PROVE DI STALLO BOEING 747



PROVE DI STALLO BOEING 747

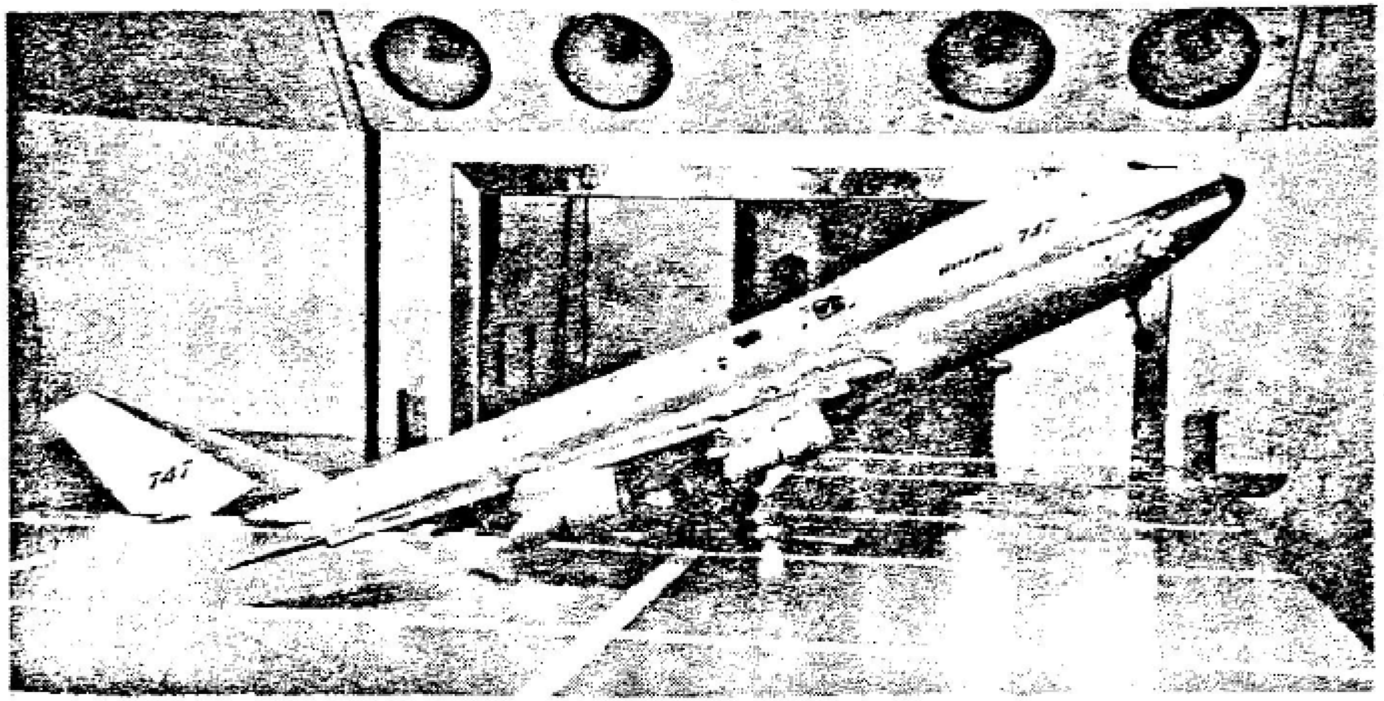


FIGURE 8: TEST FOR $C_{L_{MAX}}$ IN GROUND EFFECT

- TEST in galleria per la determinazione della VMu (minimum Unstick Speed)

PROVE DI STALLO BOEING 747

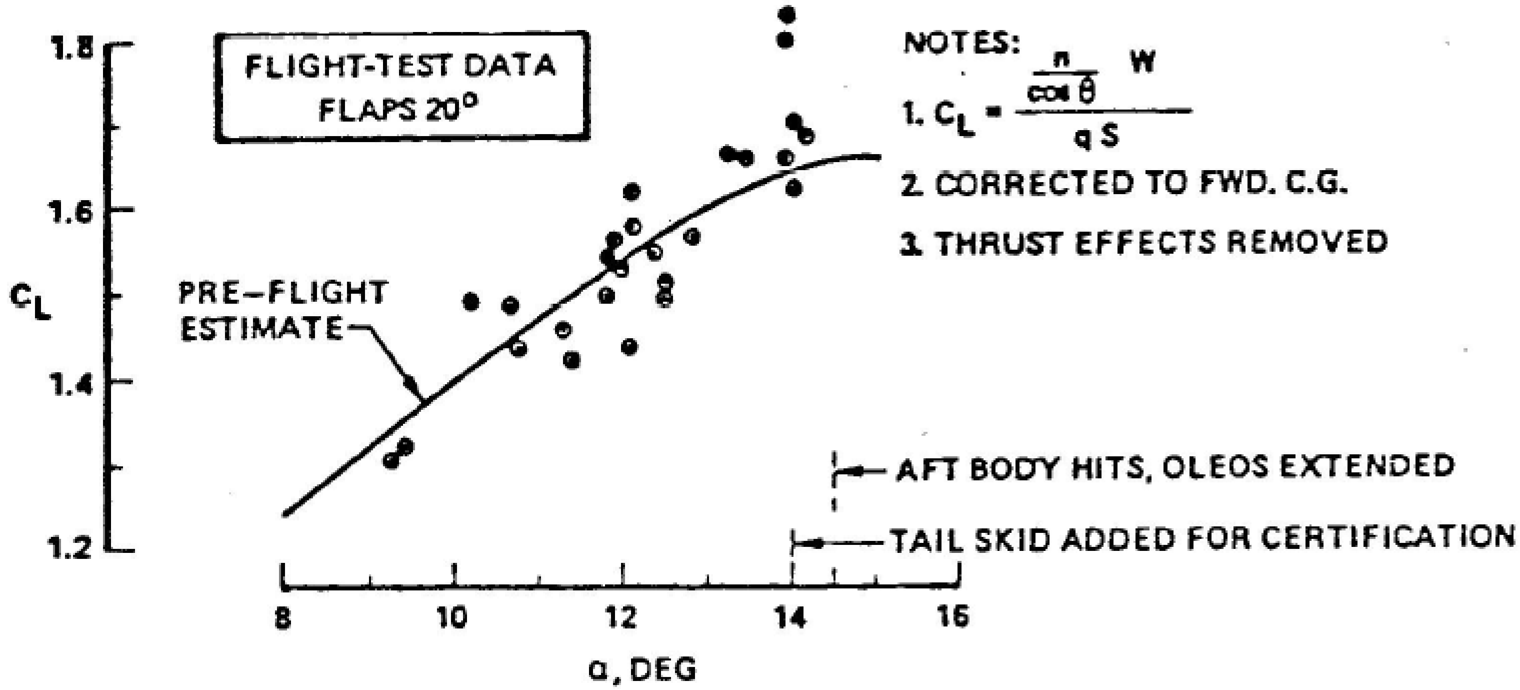


FIGURE 9: LIFT CURVE IN GROUND EFFECT

PROVE DI STALLO BOEING 747

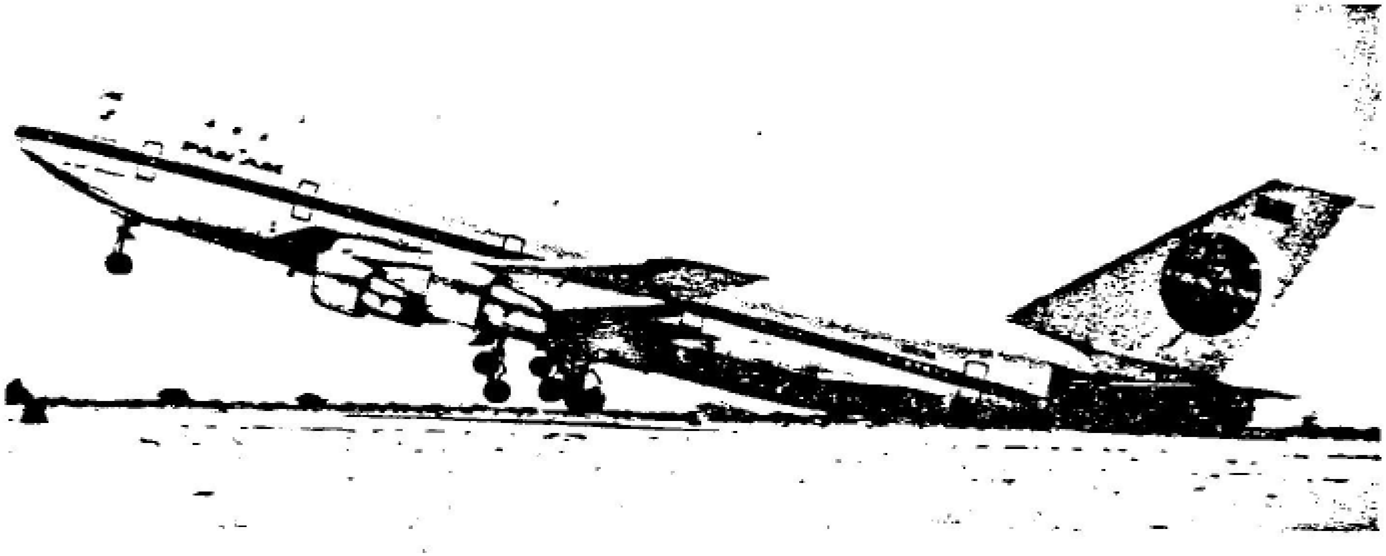
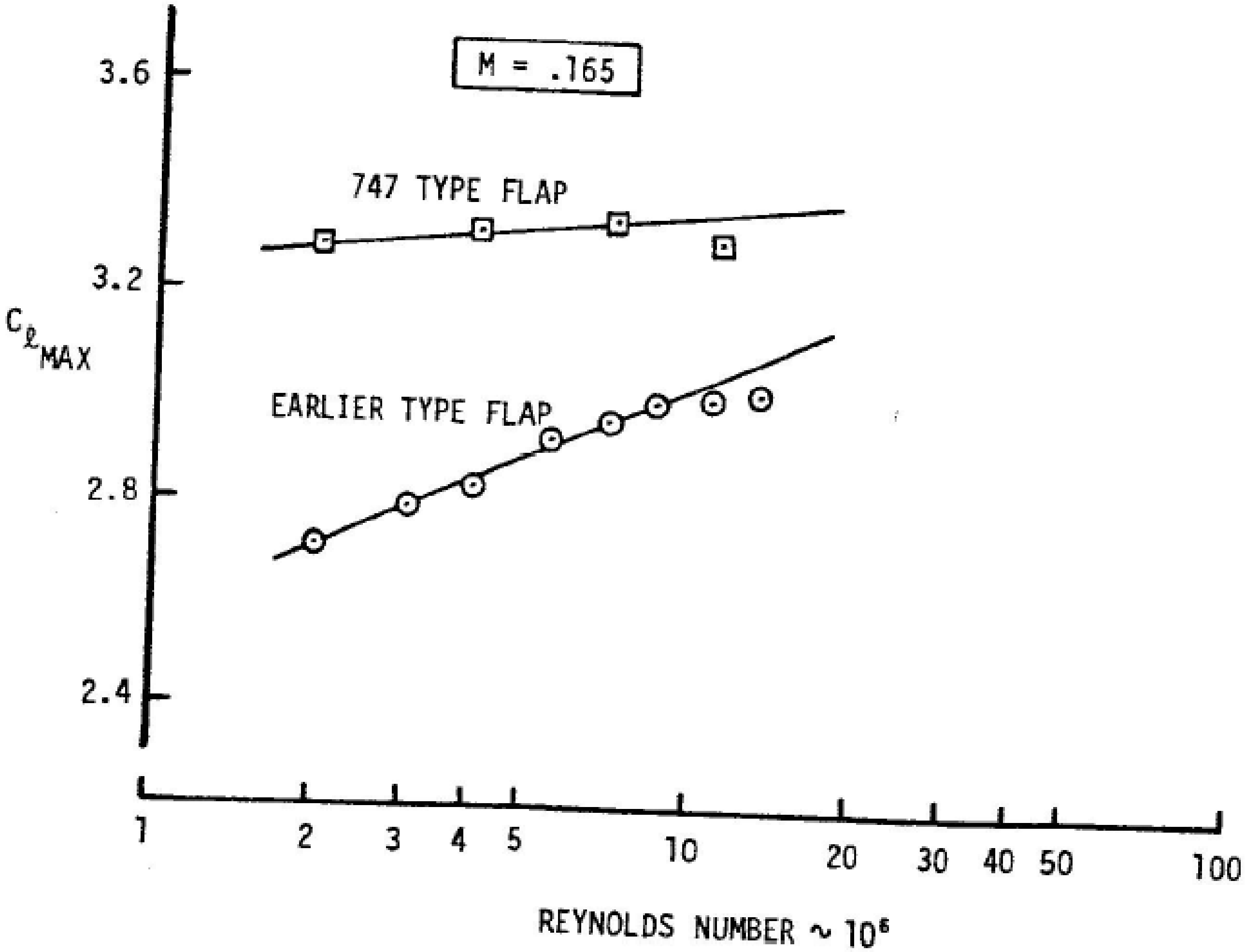


FIGURE 10: V_{MU} FLIGHT TEST

PROVE DI STALLO BOEING 747



ꓤE 12: EFFECT OF FLAP TYPE AND REYNOLDS NUMBER ON TWO DIMENSIONAL MAXIMUM LIFT

PROVE DI STALLO BOEING 747

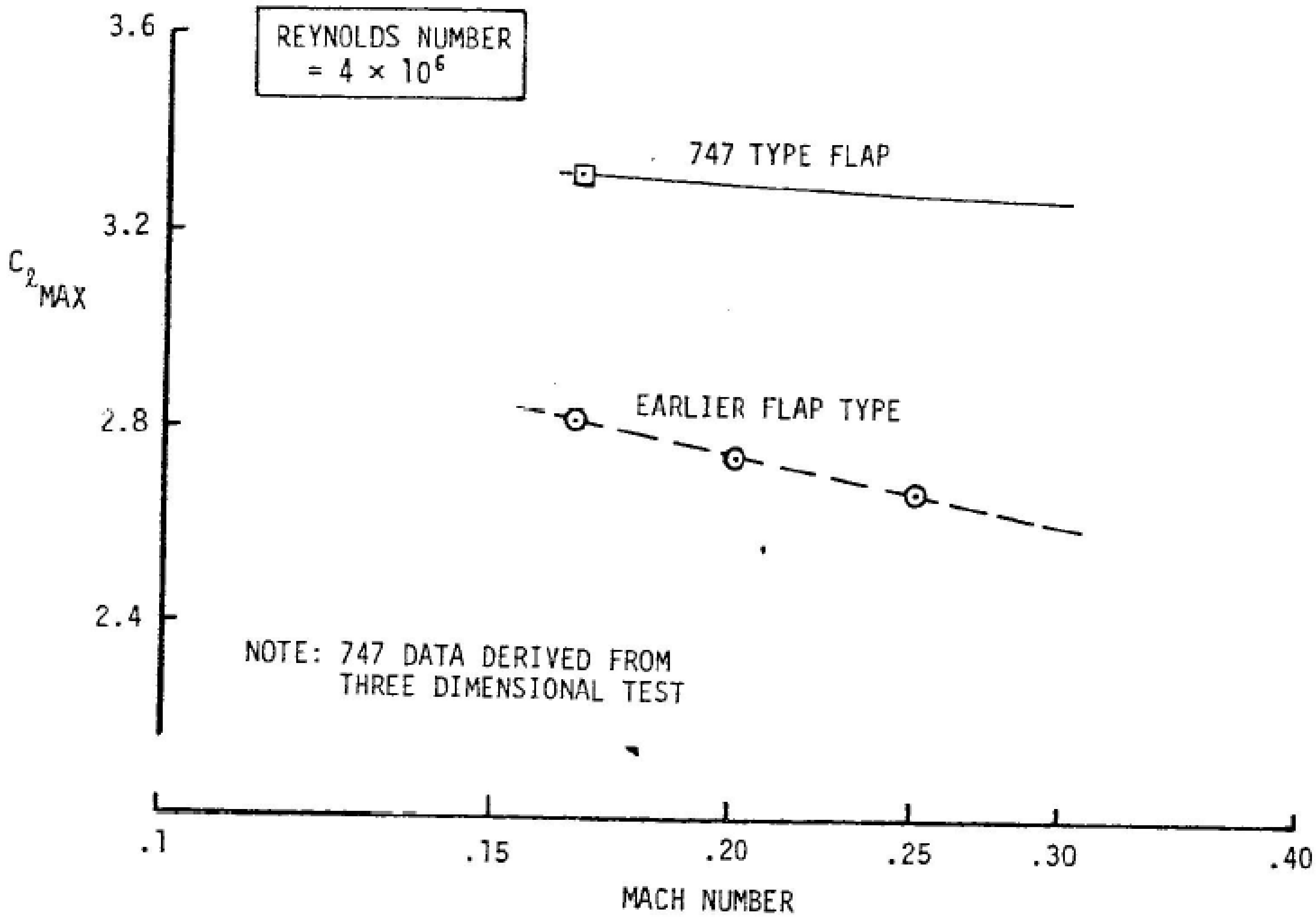


FIGURE 13: EFFECT OF FLAP TYPE AND MACH NUMBER ON TWO DIMENSIONAL MAXIMUM LIFT

PROVE DI STALLO BOEING 747

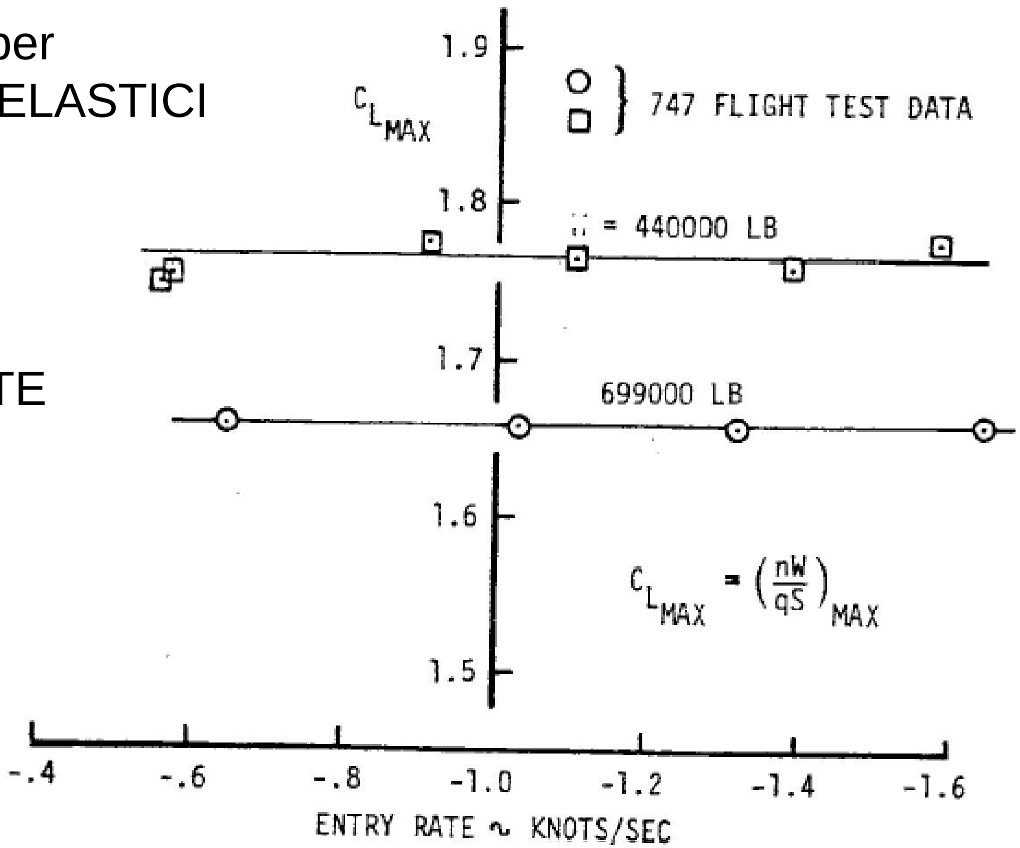
Take-Off Config (flap 10°)

WEIGHT LBS	WING FUEL LBS	UNRELIEVED WEIGHT LBS
1. 335,000	0	335,000
2. 440,000	50,000	390,000
3. 699,000	150,000	549,000

Il peso influisce sul CLmax per
La presenza di effetti AEROELASTICI
(Torsione dell'ala)

NOTA che il CLmax
Non risente dell'ENTRY RATE

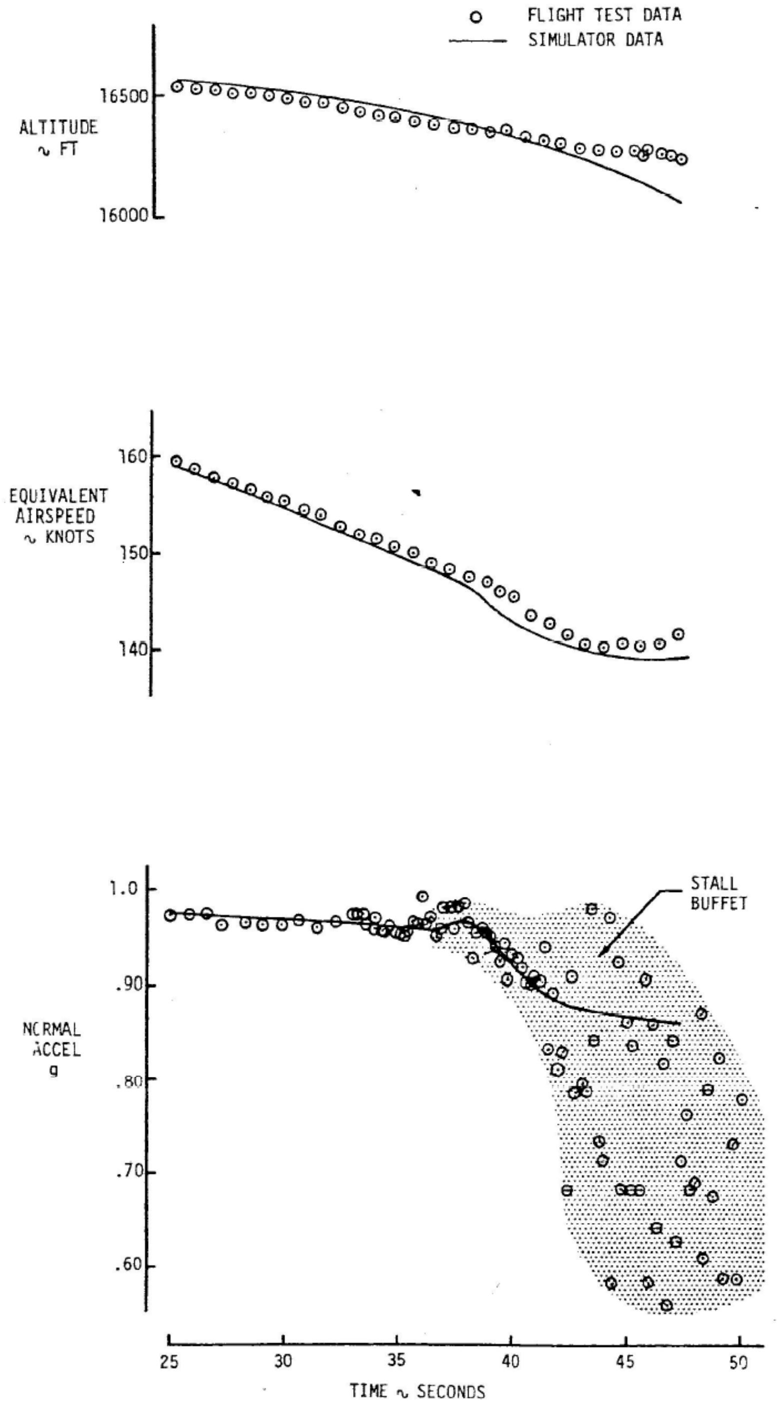
(Il CLs ed il CL1g
ne risentono molto !!)



1: EFFECT OF GROSS WEIGHT AND ENTRY RATE ON $C_{L_{MAX}}$ ACHIEVED IN STALL

PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)



SIMULAZIONI DI VOLO

Verifica influenza vari parametri :

-Torsione

- Entry rate

- Tipo di manovra (FAST/SLOW)

PROVE DI STALLO BOEING 747

SIMULAZIONI DI VOLO

Take-Off Config (flap 10°)

Tipo di manovra (FAST/SLOW)

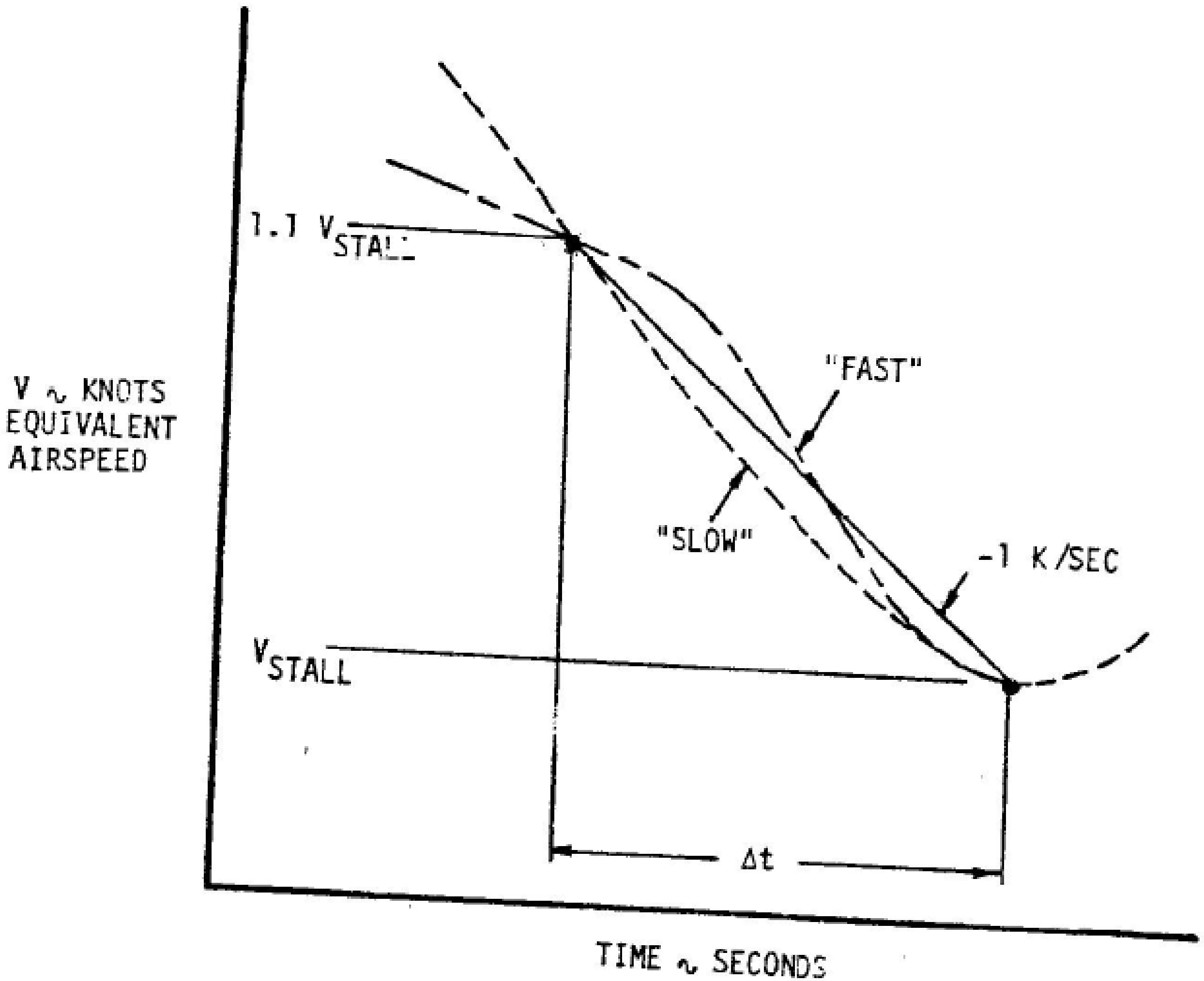
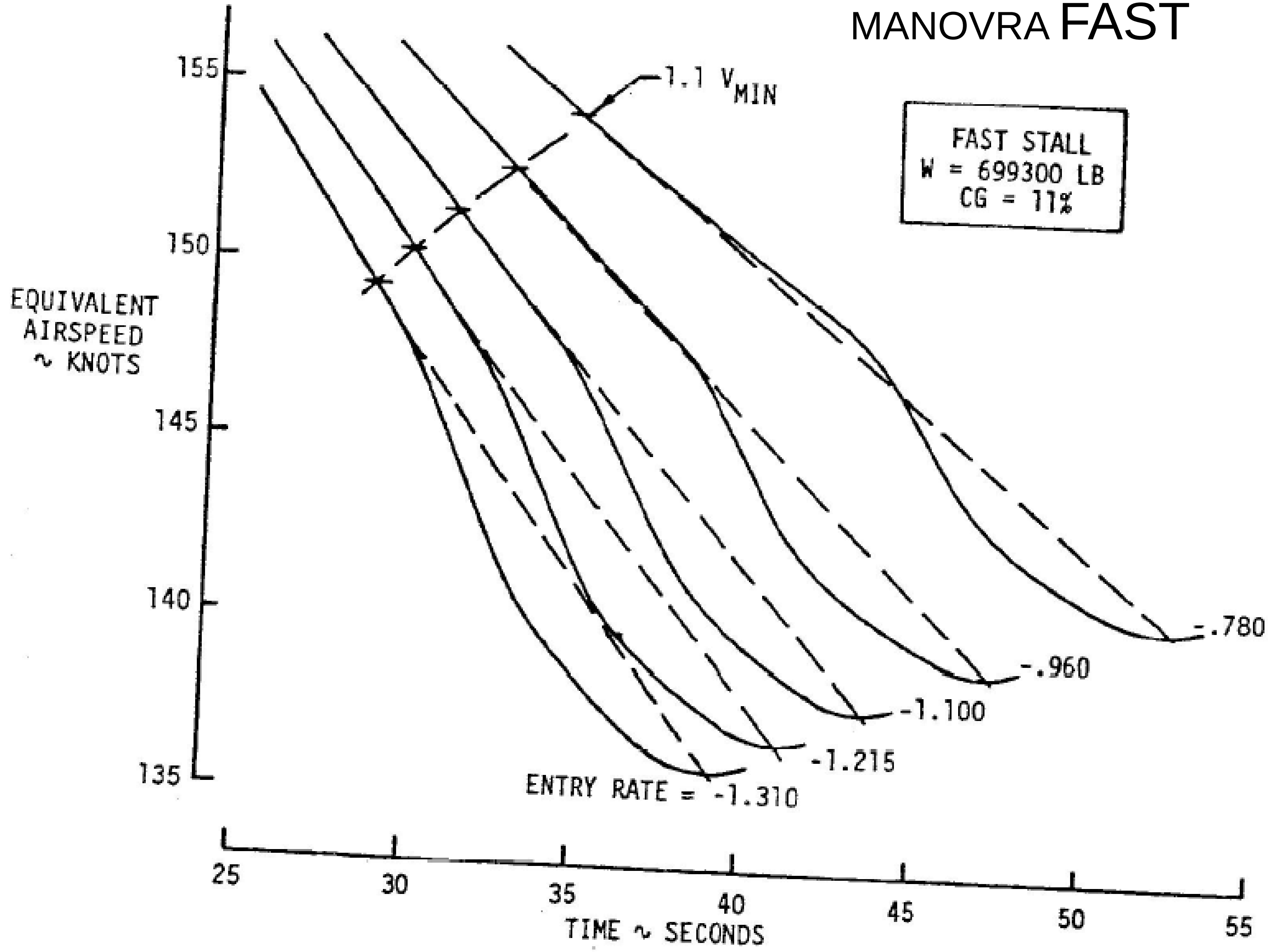


FIGURE 16: TWO TYPES OF STALL ENTRY RATE USED FOR STALL DYNAMICS STUDY

PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)

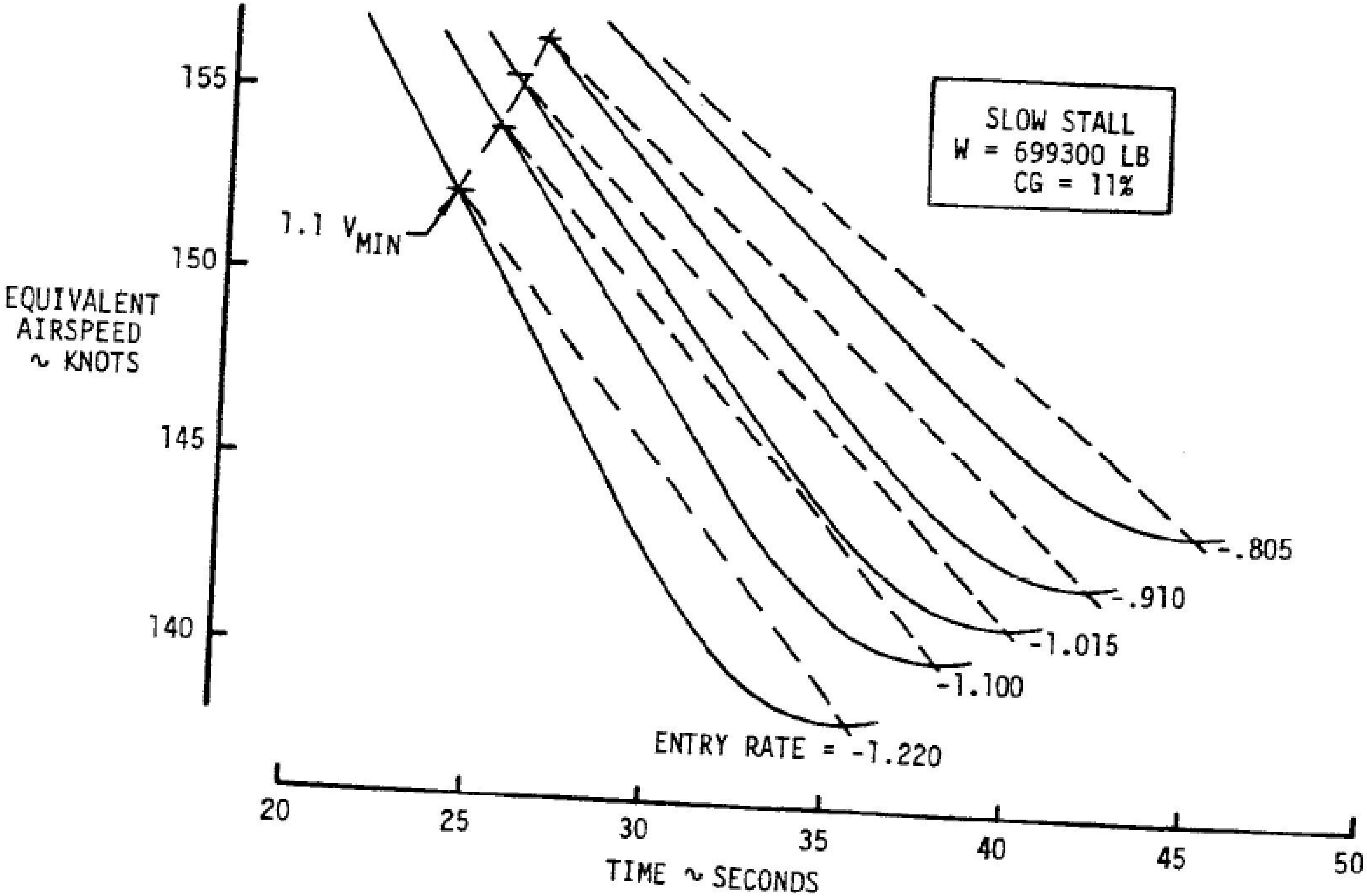
MANOVRA FAST



PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)

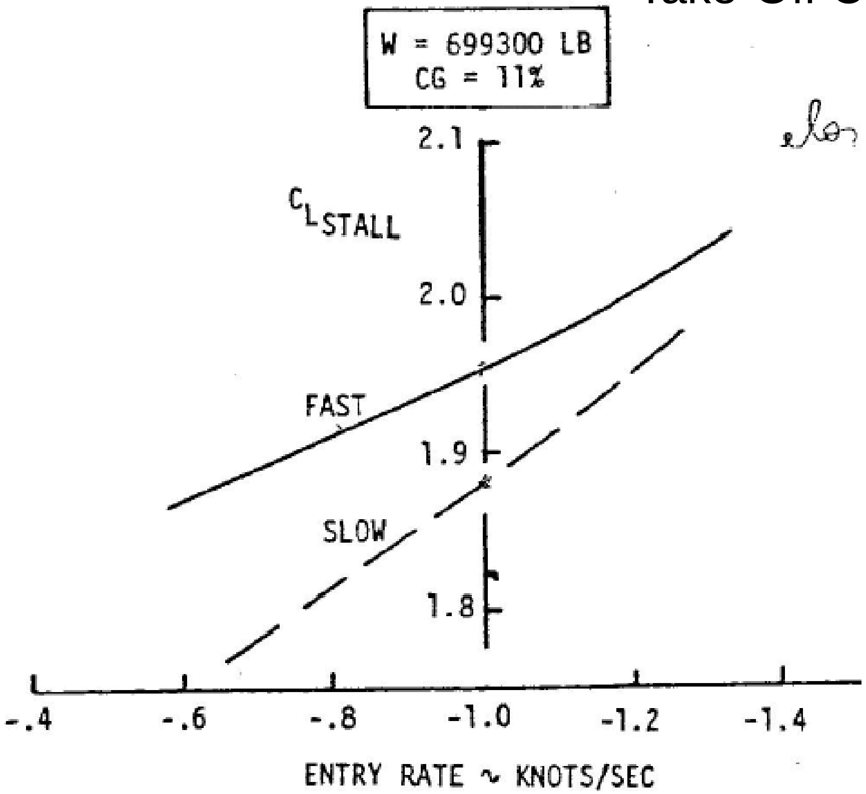
MANOVRA SLOW

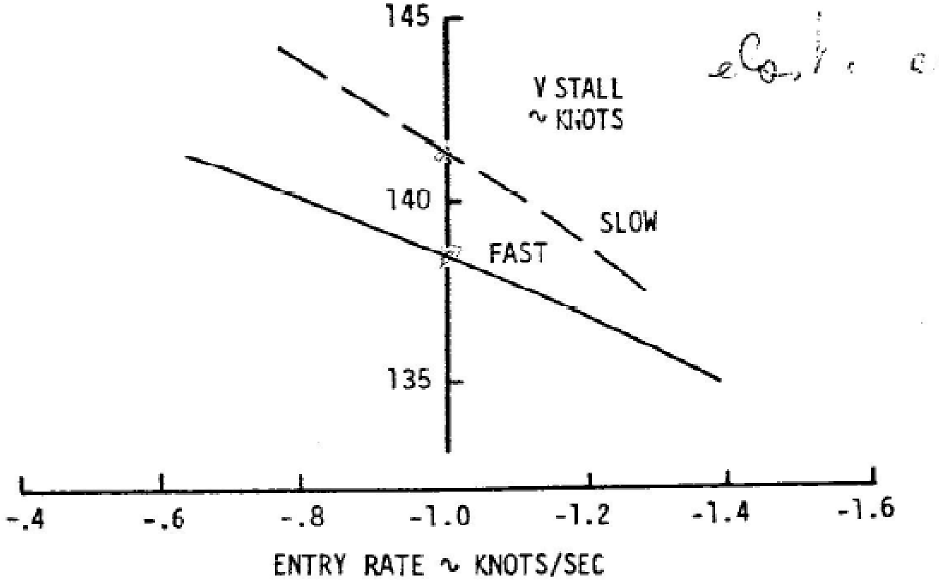


PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)

RIS simulazioni





PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)

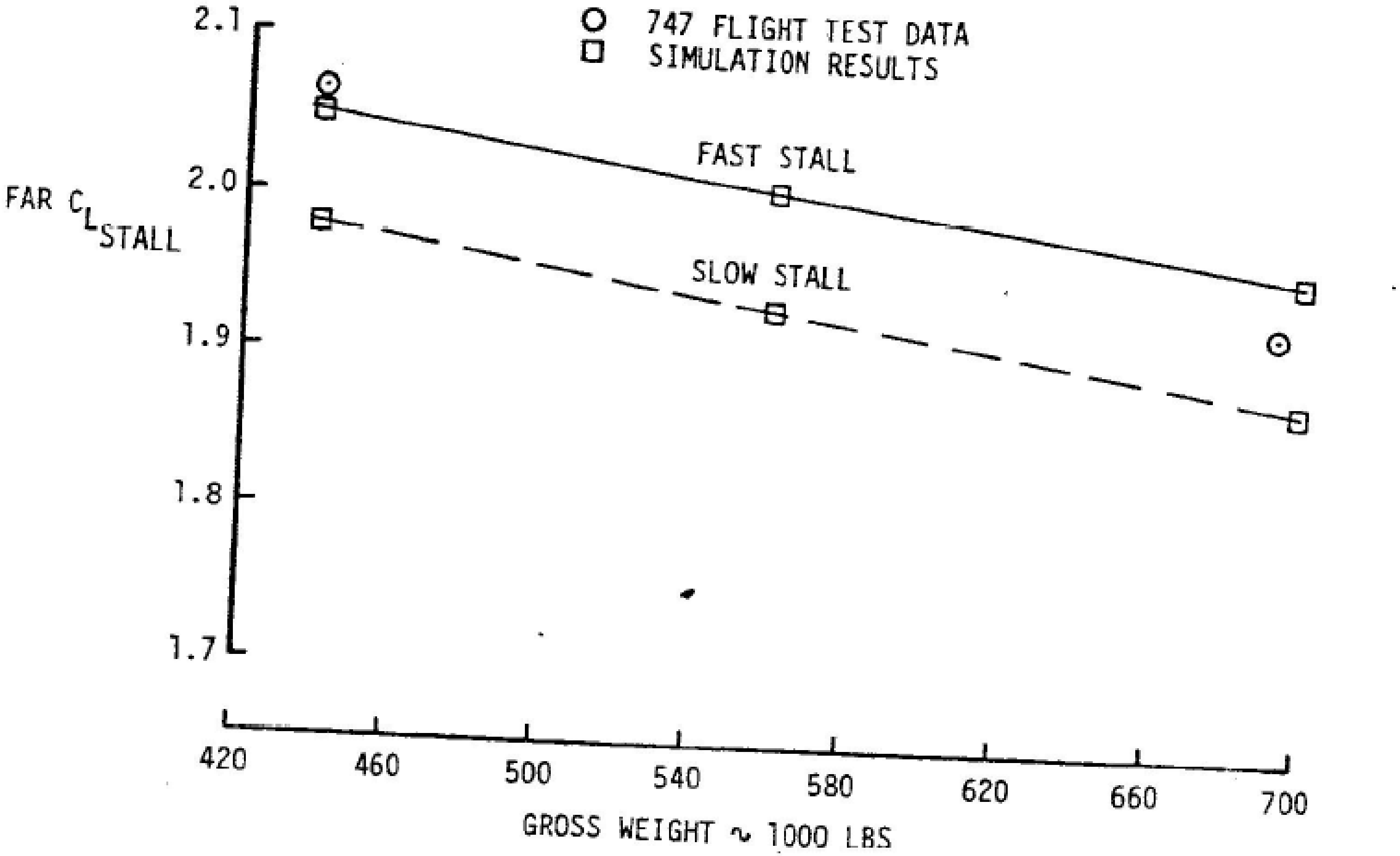


FIGURE 20: EFFECT OF STALL TECHNIQUE AND GROSS WEIGHT ON STALL LIFT COEFFICIENT

PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)

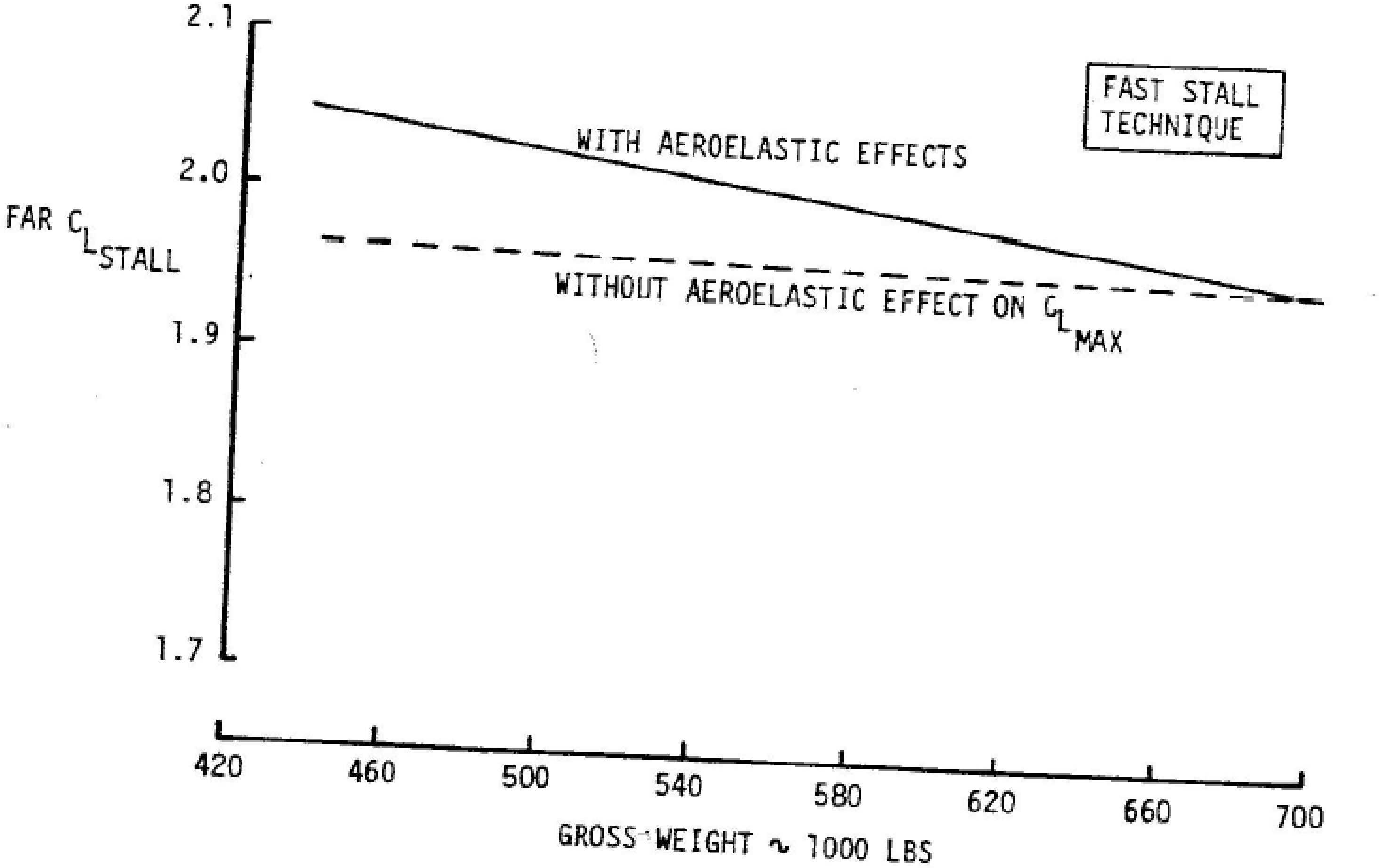
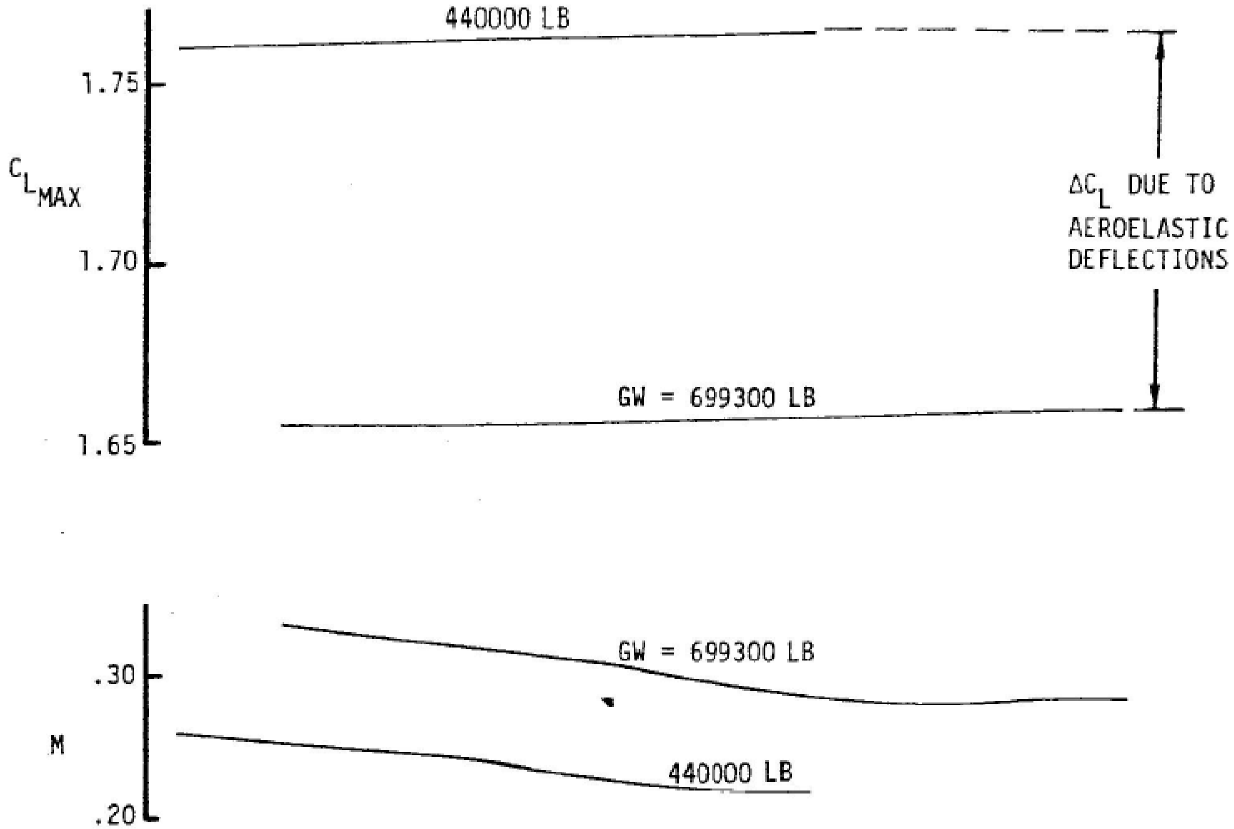


FIGURE 21: EFFECT OF AEROELASTIC LIFT INCREMENT ON STALL LIFT COEFFICIENT

PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)



PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)

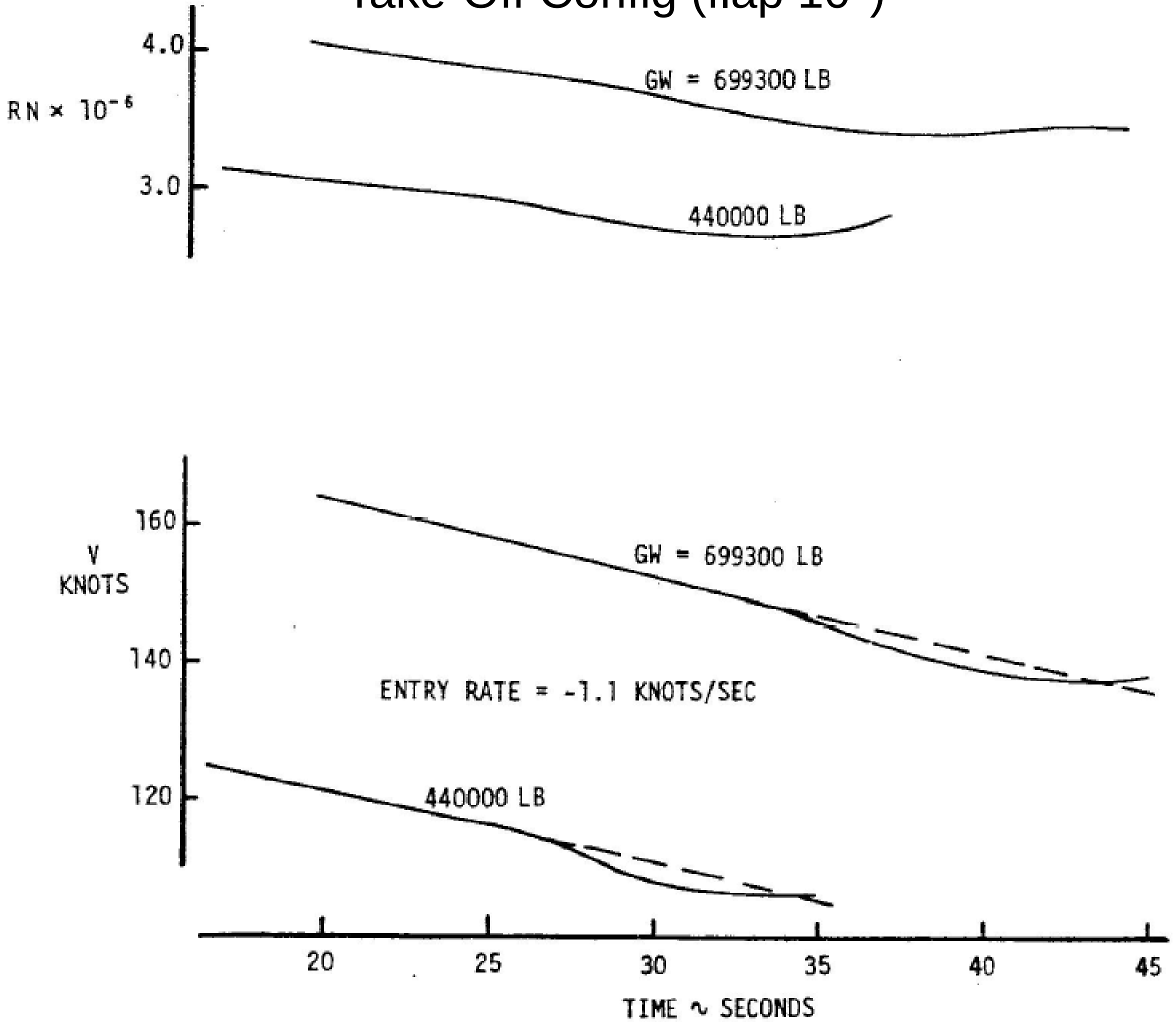


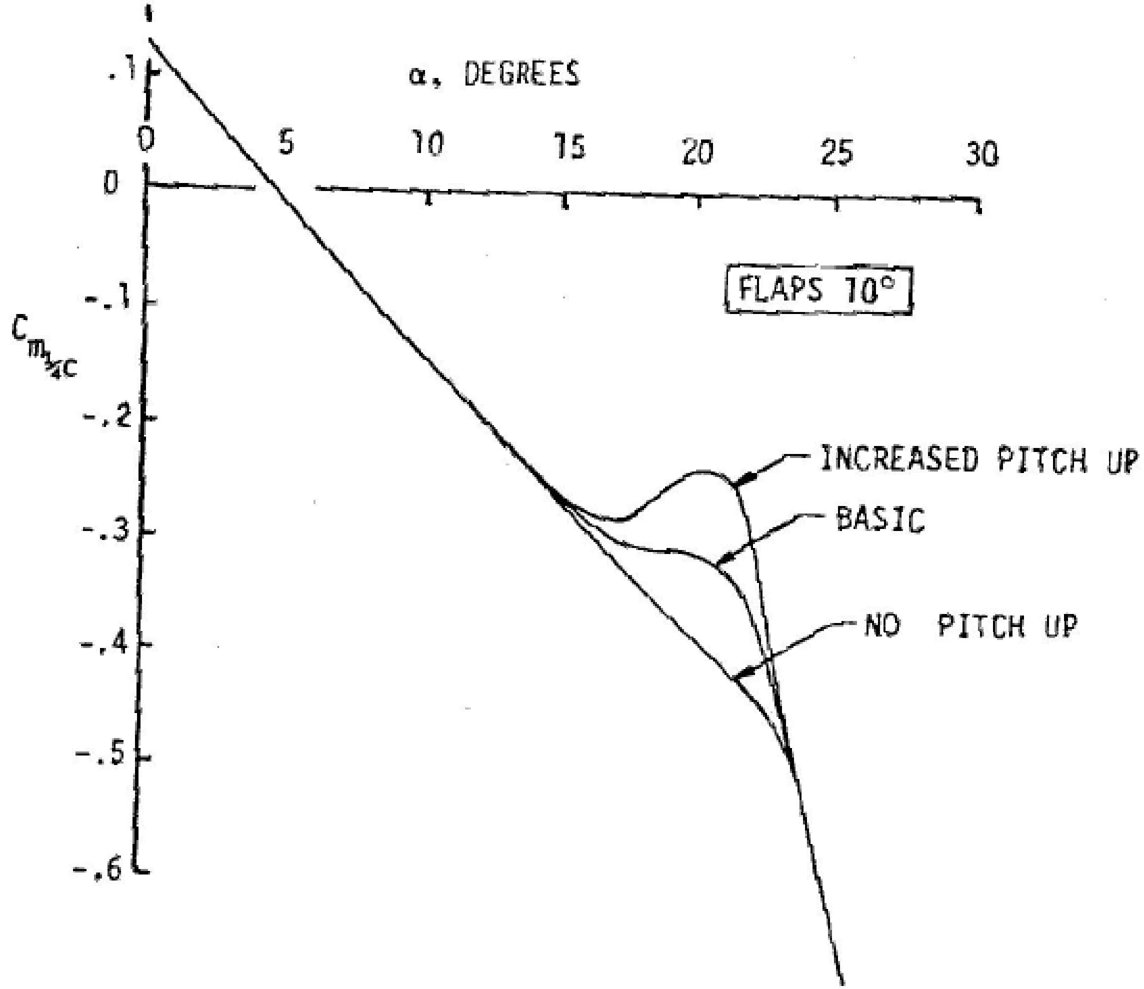
FIGURE 22: VARIATION OF MACH AND REYNOLDS NUMBER DURING TYPICAL STALL AND EFFECT ON $C_{L_{MAX}}$

PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)

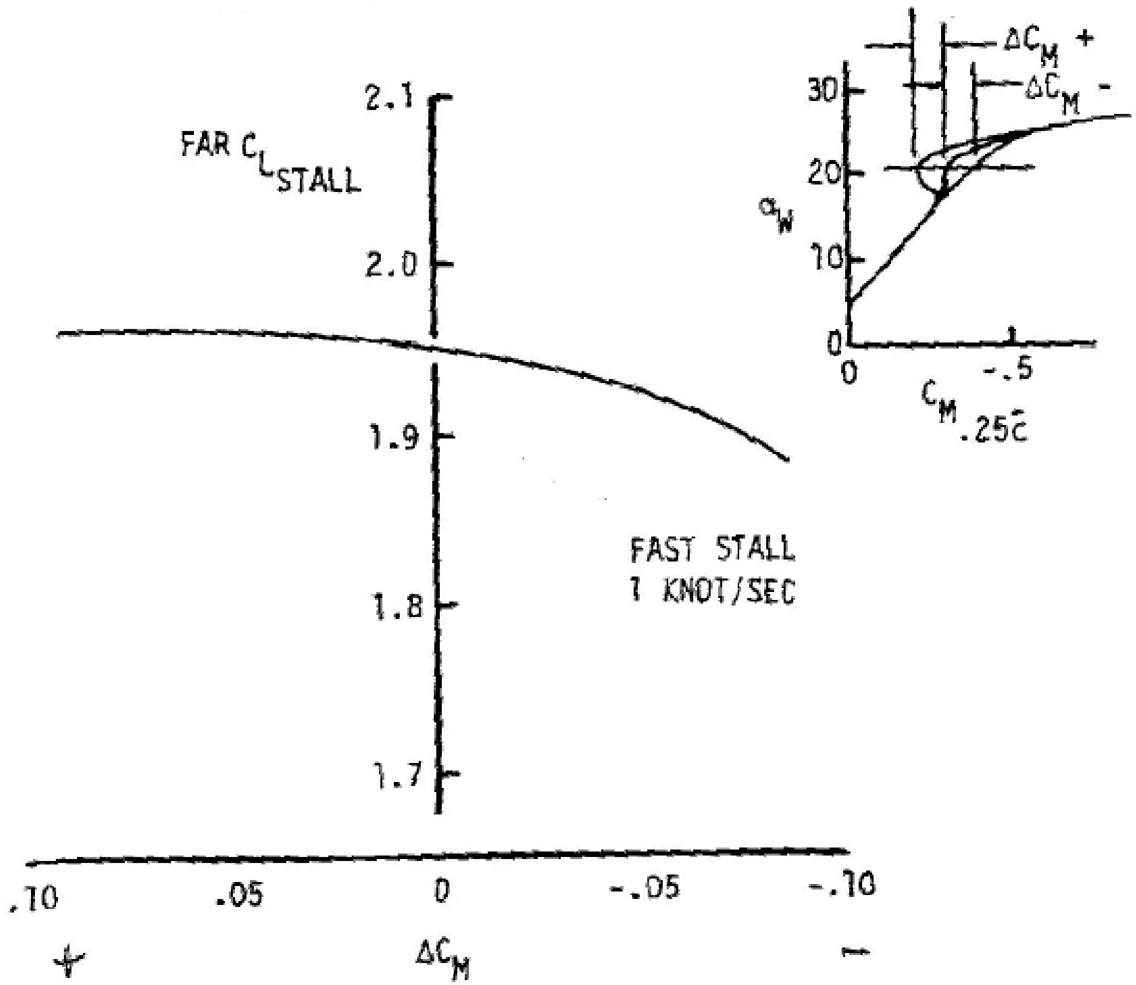
Simulazione di volo:

- Verifica influenza della curva di Cm sul comportamento in stallo e post-stallo



PROVE DI STALLO BOEING 747

Take-Off Config (flap 10°)



PROVE DI STALLO BOEING 747

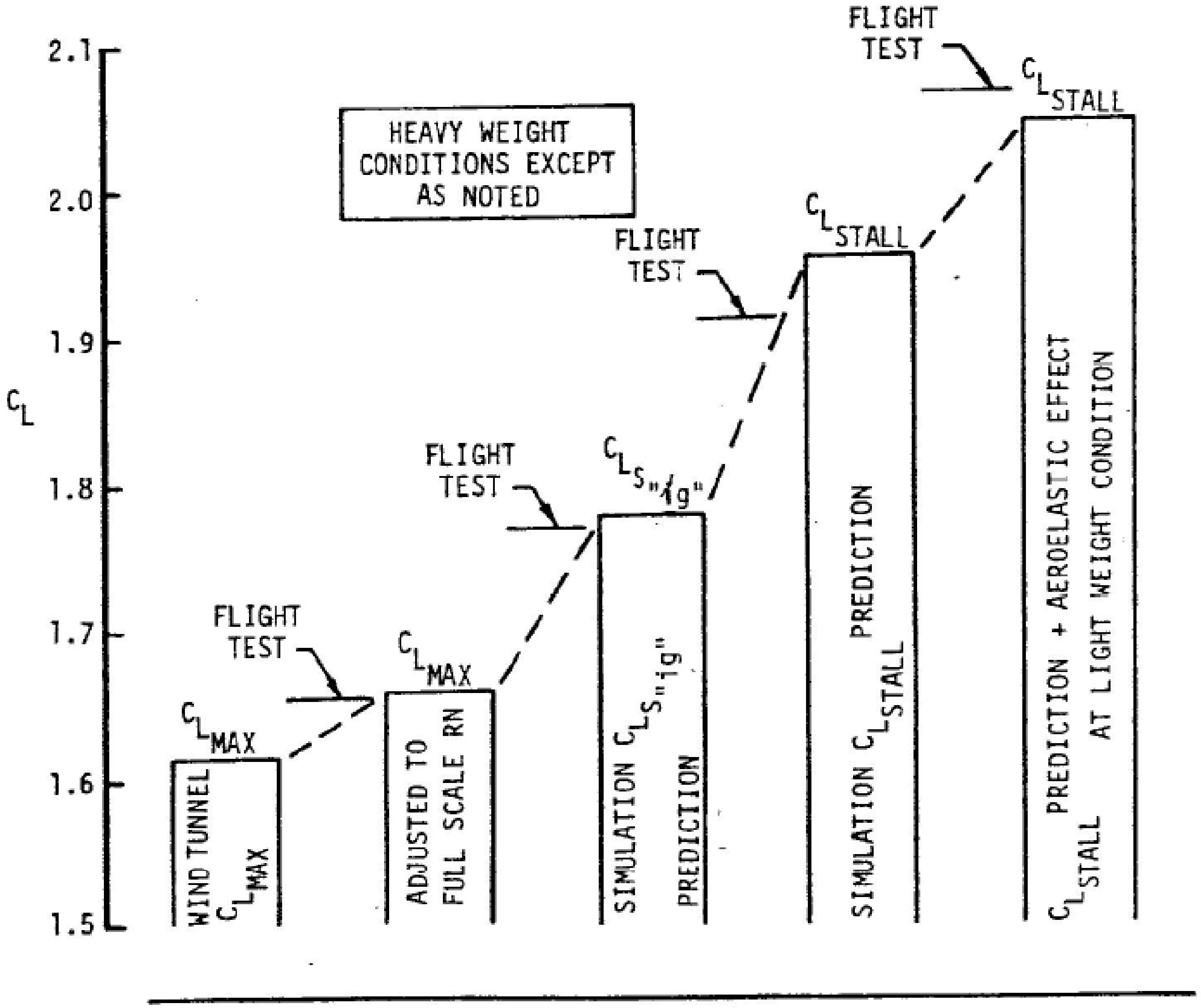


FIGURE 26: SUMMARY BUILDUP OF FAR STALL LIFT COEFFICIENT FROM LOW REYNOLDS NUMBER TUNNEL DATA