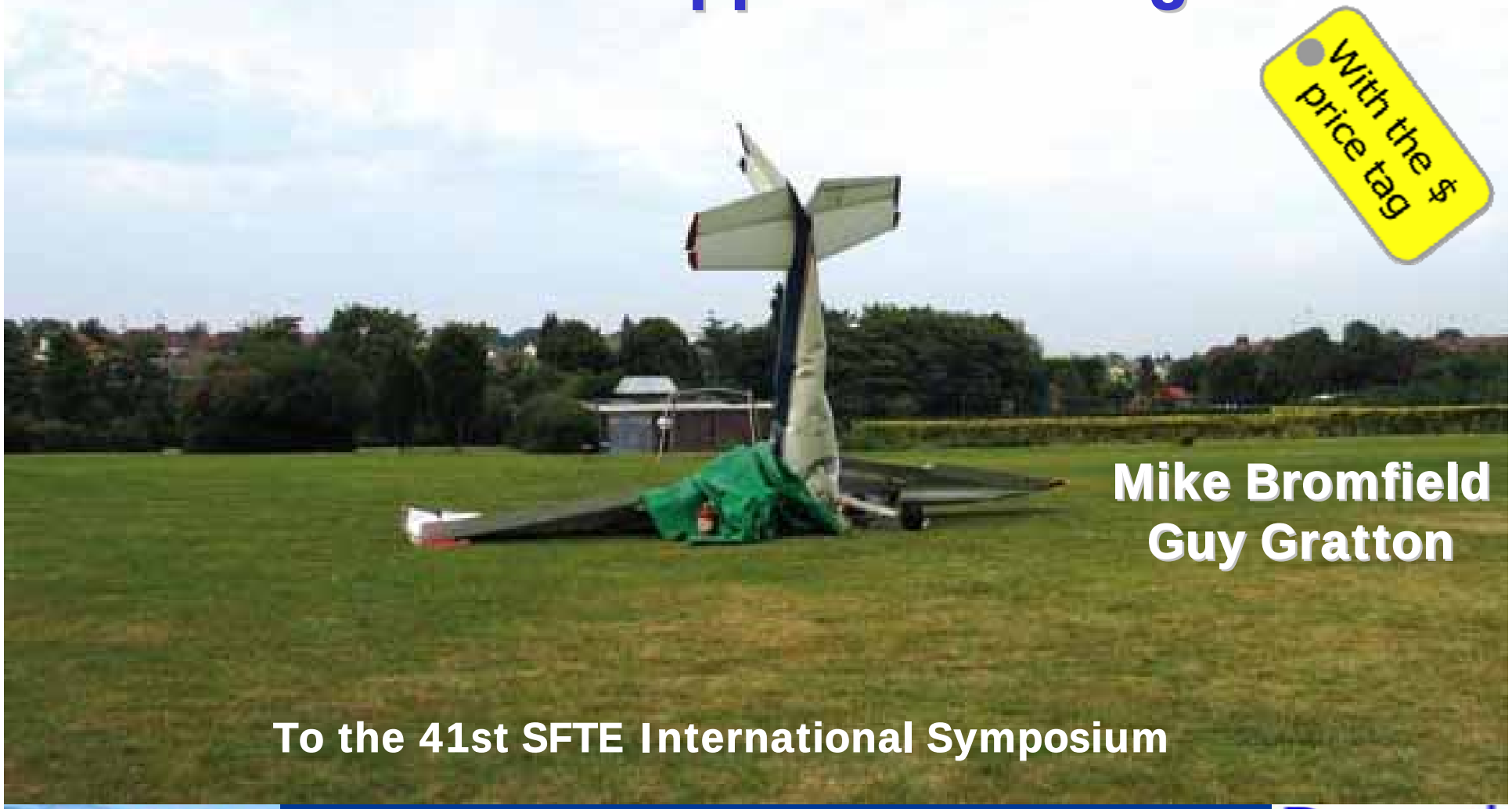
Loss of Control of Light Aircraft: A cost effective approach to Flight Test



Mike Bromfield
Guy Gratton

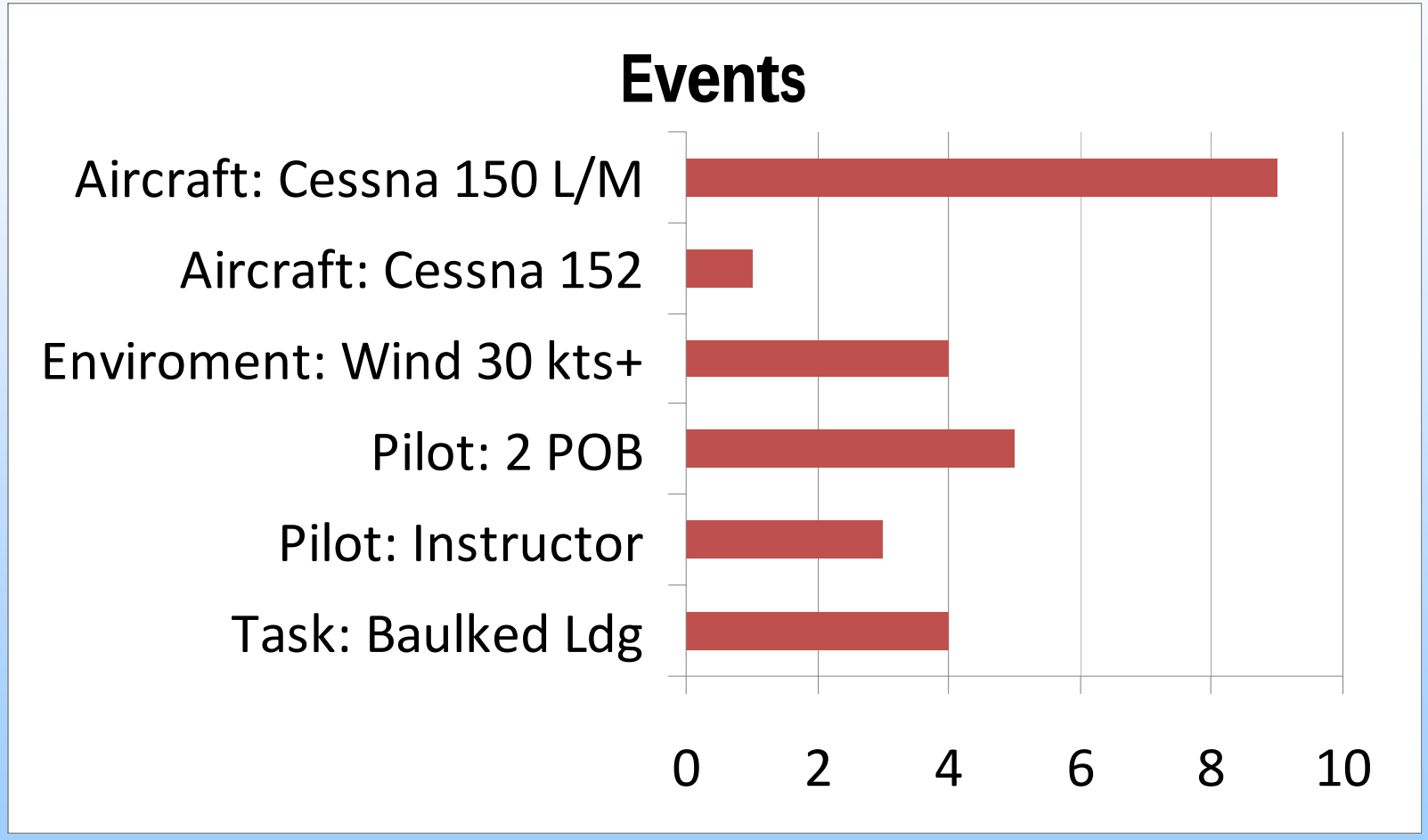
To the 41st SFTE International Symposium

What's the question?

- GASCo 28 year review of GA fatal accidents
  - 35-50% stall/spin
  - Significant type variations
- Why type variations
  - C150 rate >> C152 rate (~17:1)
  - PA28 "Hershey Bar" wing ~population mean, tapered wing no fatalities
- Understand the reasons
  - For flying training
  - For design

Spot the difference…?

10 events: C150/C152 stall/spin fatalities



Methods & Equipment

Flight Test basics
Total
~$150

Go-Pro Cockpit
mounted camera
~$450

Appareo
GAU1000A
Flight Data
Recorder
~$2000

Garmin 296

~$1500

Total
$ 4,100

Flight Test Programme Build-up

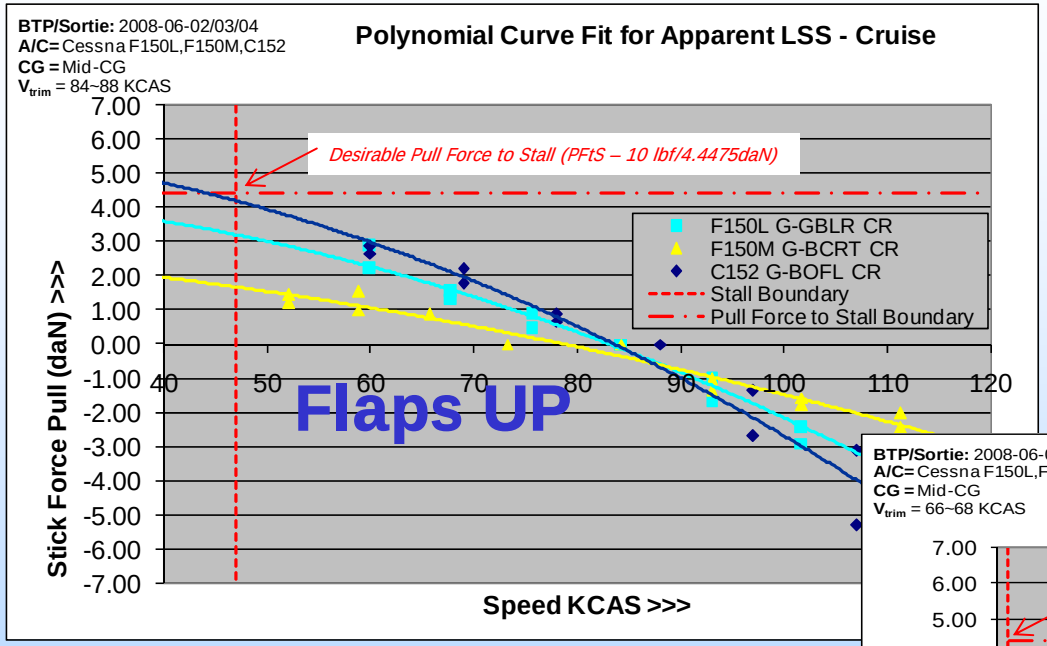
	Phase 1			Phase 2		Phase 2		Phase 3	
							A/c 2		A/c 2
Baseline (Aircraft 1)	CG1 Mid	CG2 Mid-Aft	CG3 Aft	**Aircraft 2**	CG2 Mid	**Aircraft 3**	CG2 Mid	**Aircraft 4**	CG2 Mid
C152	G-BOFL	G-BOFL	3	C152	G-BPEO	F152	G-BFLU		
TOW@% MAC:	1637 lbs@23.81%	1 lbs@25.28%		TOW@% MAC:	1670 lbs@23.39%	TOW@% MAC:	1655 lbs@23.78%		
Flt Test/Sortie:	BTP-2008-06-04 (BTP-2008-06-01)	BTP-2008-06-05	BTP-2008-06-06	Flt Test/Sortie:	BTP-2008-06-09	Flt Test/Sortie:	BTP-2008-06-10		
F150L	G-GBLR								
TOW@% MAC:	1599 lbs@25.8%								
Flt Test/Sortie:	BTP-2008-06-02	n/a	n/a						
F150M	G-FCRT	G-FCRT	G-FCRT	C150M	G-NWFA	F150M	G-FCUH		
TOW@% MAC:	1600 lbs@25.68%	1425 lbs@27.22%	1598 lbs@27.90%	TOW@% MAC:	1580 lbs@27.00%	TOW@% MAC:	1599 LBS@25.87%		
Flt Test/Sortie:	BTP-2008-06-03	BTP-2008-06-08	BTP-2008-06-07	Flt Test/Sortie:	BTP-2008-06-11	Flt Test/Sortie:	BTP-2008-06-12		
F150G								F150G	G-AVGU
TOW@% MAC:								TOW@% MAC:	1591 LBS@26.57%
Flt Test/Sortie:								Flt Test/Sortie:	BTP-2008-06-14
Crew:	2							Crew:	2

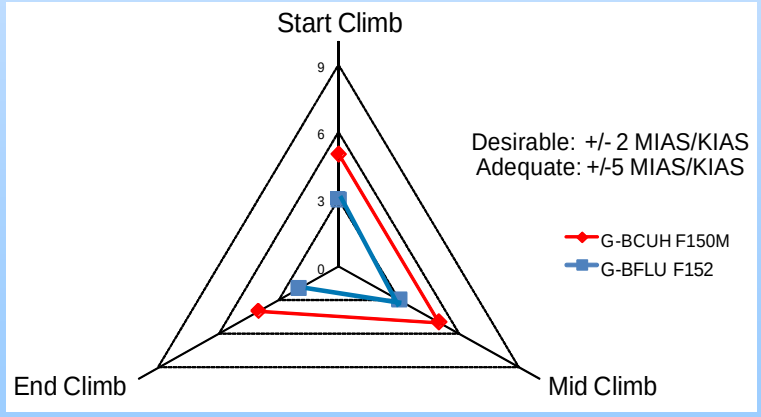
- *8 aircraft*
- *17 test sorties + 3 checkouts + 1 decline*
- *25hrs 35mins flight test*

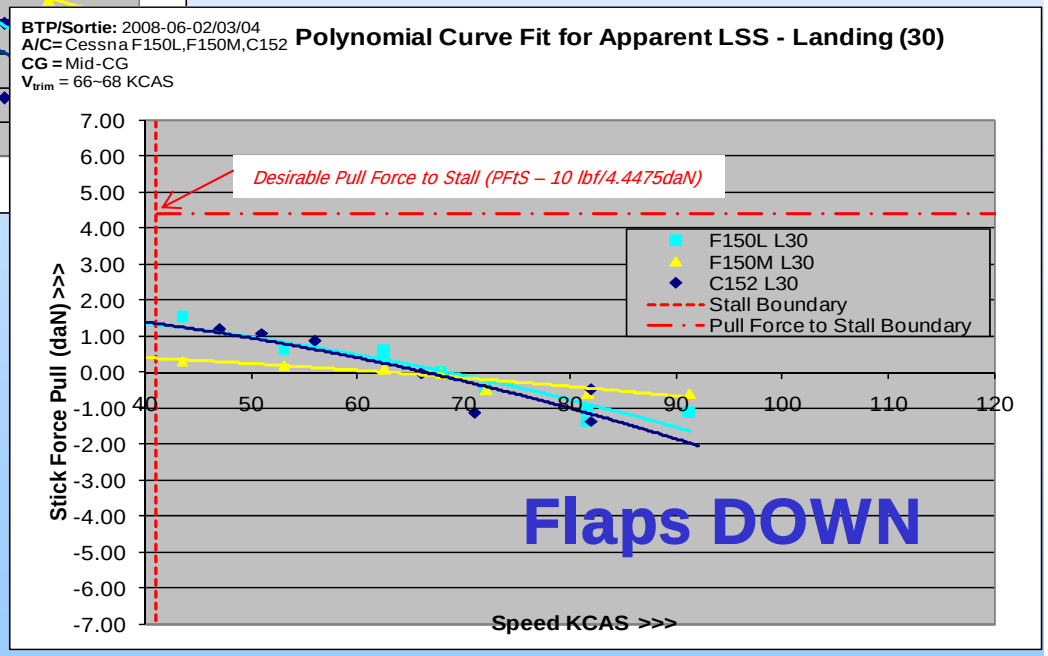
Flight Test using Rental Aircraft

- Aircraft Variables (ageing?)
  - maintenance, performance, W&CG
- Organisation
  - Different priorities
    - Flight test .v. Flight School
      - Aft CG stalling at 3000ft anybody?
- Local environment
  - Area & procedures, controlled airspace, ATC, Wx

Stick Force to Change Airspeed
Cessna 150L,M & 152 with Flaps a) UP b) DOWN (L30)

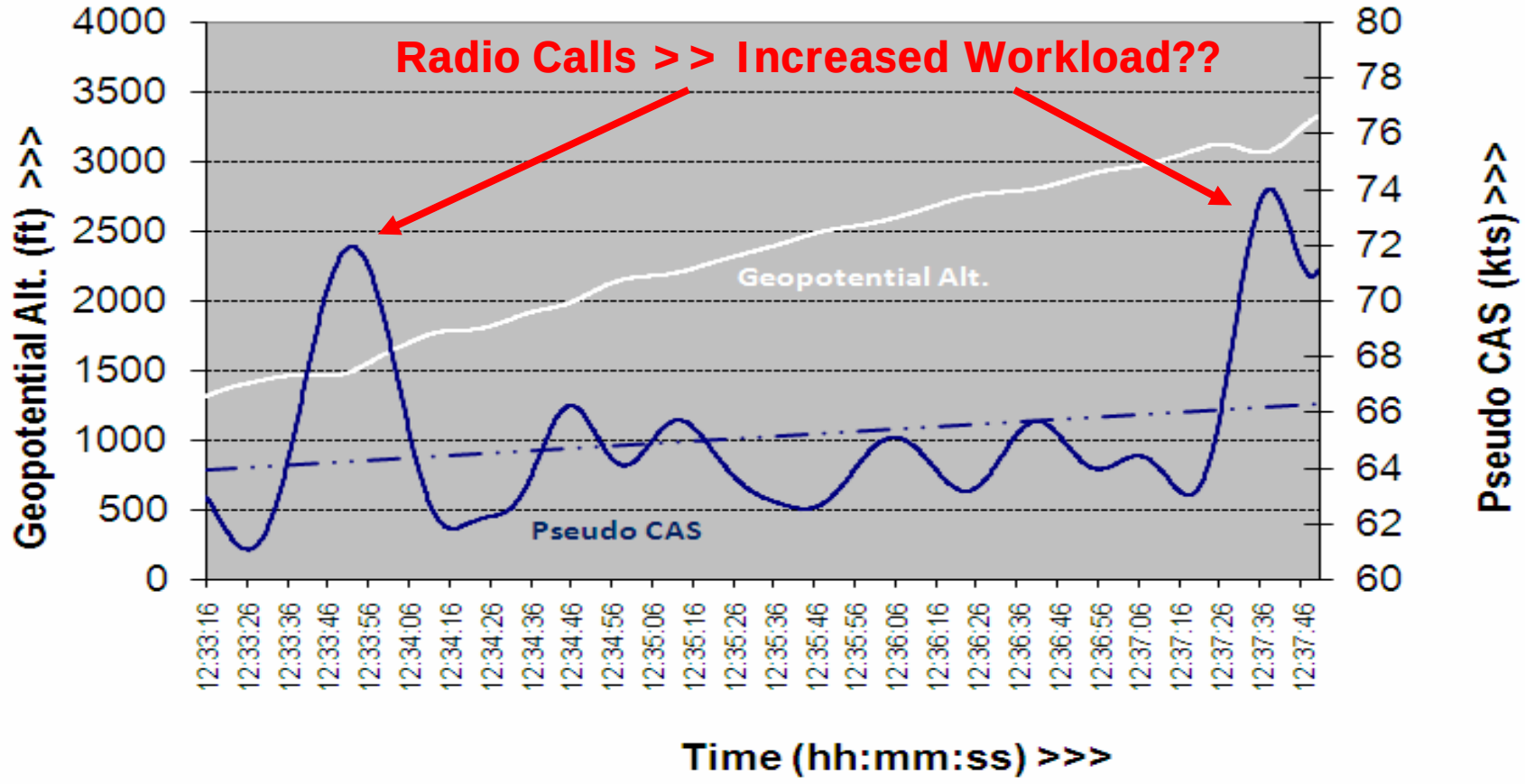






Climbing Flight: Cessna 150M

BTP/Sortie: 2008-06-08
A/C = Cessna F150M G-BCRT
Date: 12/06/09
Gross Wt. = 1425lbs
CG = 36.2" AoD (72% Mid/Aft-CG/27% MAC)
Vtrim = 75 MIAS (65 KCAS)



Flight Test Results

- Variability between aircraft, C150 consistently lower pitch forces
  - Mean gradient factors ~2-3
  - C150 sometimes neutral (e.g. L40)
- Stick force dependent on:-
  - (1) Flaps, (2) Power, (3) Trim, (4) CG
- Low stick force >>high mental w'load >>poor airspeed mgt
- Stall warning
  - C150 non-compliant with (current) part 23 in certain configs.
  - Simultaneous stall warning + aerodynamic stall

Simulation Experiments - Scenario-based Testing

Simulator

- PC7 Fixed-base research simulator
  - Controllable force feedback
  - 150 x 40 deg. Visuals

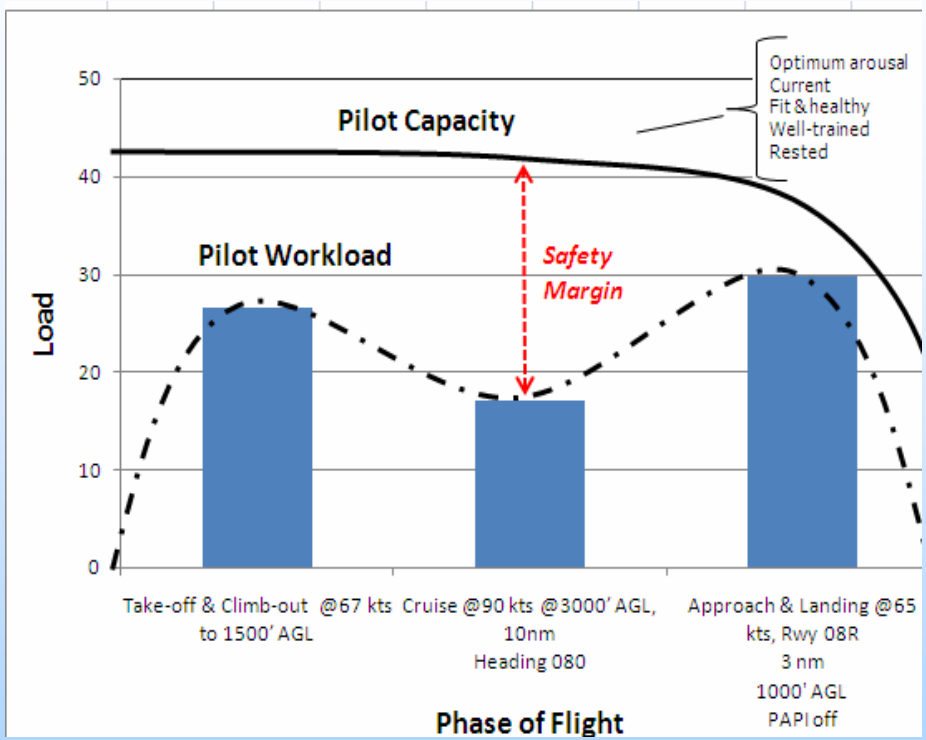
Scenarios

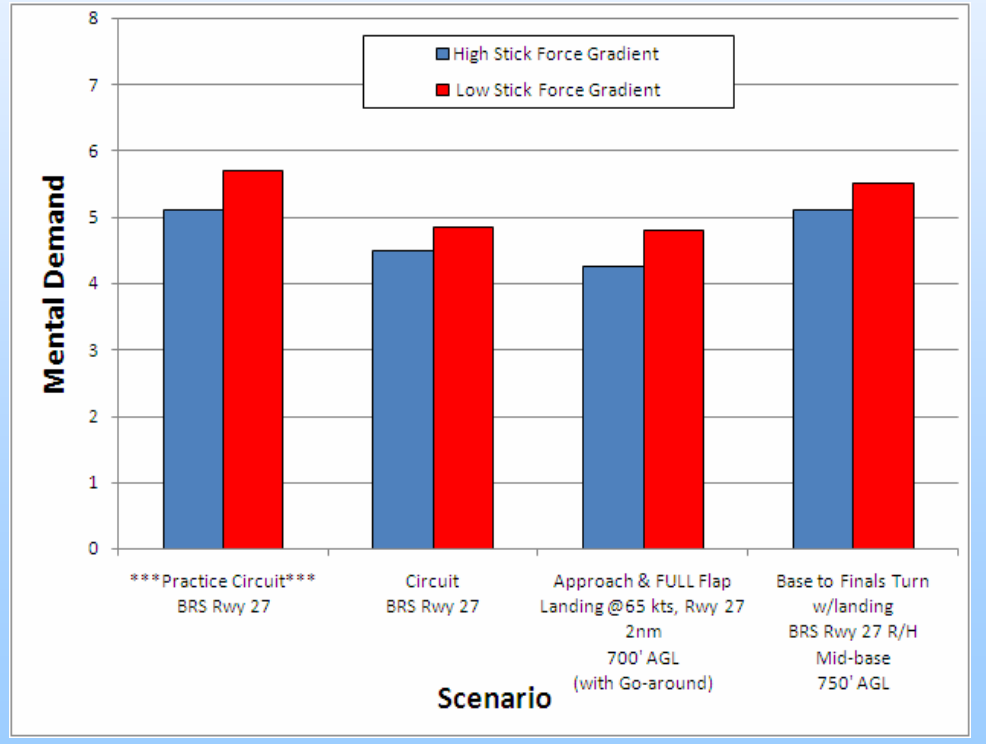
- 20 pilots x 5 scenarios x 3 stick force gradients
  - Circuits, EFATO, Climb-out, Go-around, Base to Finals Turn

Data / Analysis

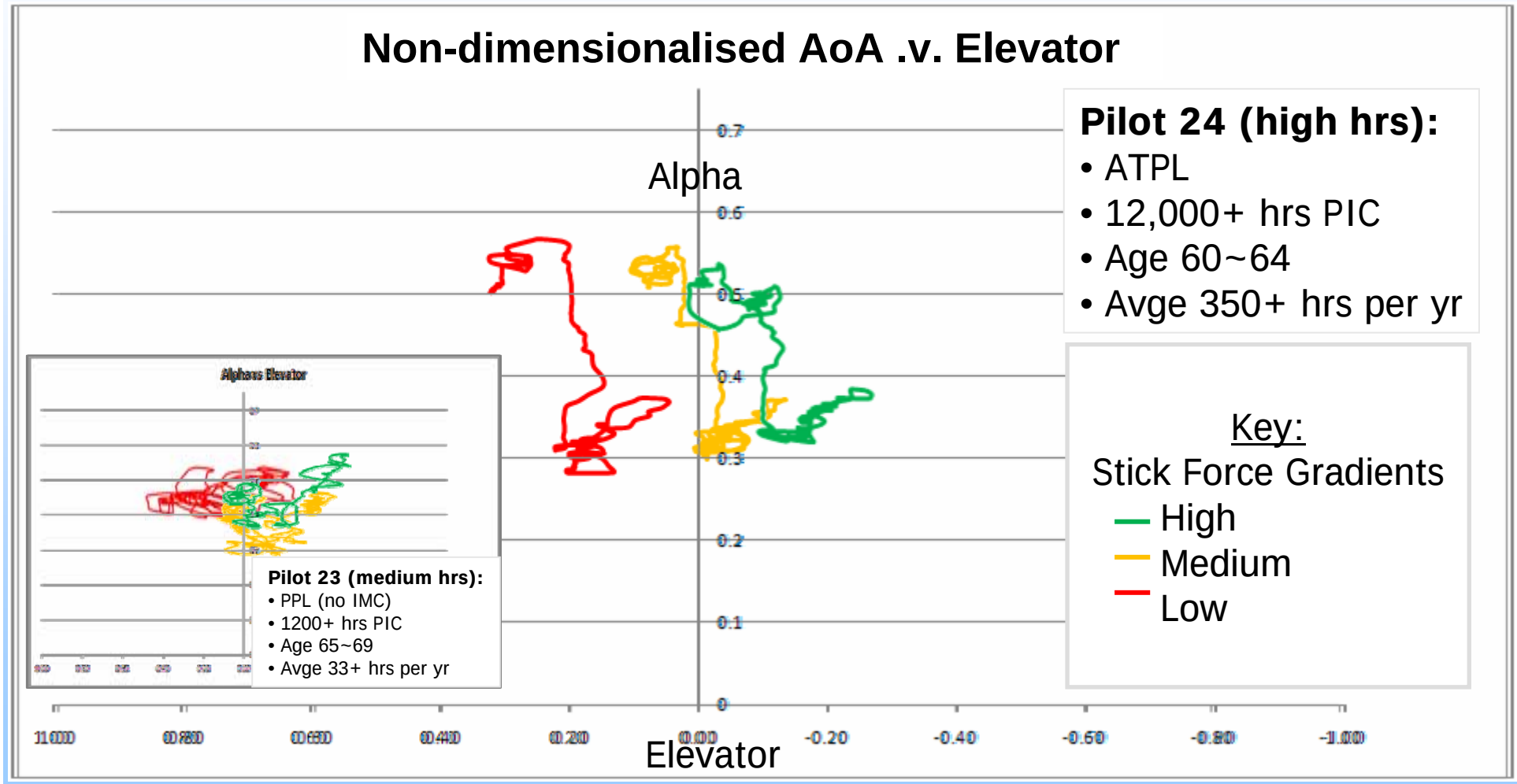
  - Workload (Heart Rate, NASA TLX)
  - Flight dynamics + RT/intercom

Typical simulator test results: margin of safety & effect of stick forces





Example: Pilot 24
Go-around, Full Pwr / Full Flap



Conclusions – Causes of LoC

- Stall Boundary crossing (not point tracking)
  - Handling characteristics & workload
- Type training
  - A C150 is not a C152
- Design factors
  - Certification standards are too subjective
  - Consider Human Factors tools
- Further work needed
  - Historical certification standards for stalling
  - Apparent LSS results and models (FCMC in longstab calcs)

Lessons Learned

- Independence
  - Manage FTI, check maintenance
  - Always check W&CG reports
- Workup
  - Essential but spread across sites and aircraft
  - Use learning curve
- Efficiency
  - Critical test points
  - Concentrate flying periods
    - But always review data between sorties
- Best practice
  - Qualified pilot opinion
  - Redundancy in data collection

Any Questions?

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