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

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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…?

Cessna 150L
0.71 fatalities/100,000 hrs

Cessna 152
0.04 fatalities/100,000 hrs
10 events:
C150/ C152 stall/ spin fatalities

Events

- Aircraft: Cessna 150 L/M
- Aircraft: Cessna 152
- Environment: Wind 30 kts+
- Pilot: 2 POB
- Pilot: Instructor
- Task: Baulked Ldg
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

(f.o.c.)
Flight Test Programme Build-up

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

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<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 2</th>
<th>Phase 3</th>
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<tbody>
<tr>
<td>Baseline (Aircraft 1)</td>
<td>Aircraft 2</td>
<td>Aircraft 3</td>
<td>Aircraft 4</td>
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<tr>
<td>CG1</td>
<td>CG2</td>
<td>CG3</td>
<td>CG2</td>
</tr>
<tr>
<td>Mid</td>
<td>Mid-Aft</td>
<td>Aft</td>
<td>Mid</td>
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<td>C152</td>
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<td>TOW@% MAC: 1617 lbs @ 23.81%</td>
<td>TOW@% MAC: 1756 lbs @ 25.23%</td>
<td>TOW@% MAC: 1655 lbs @ 23.78%</td>
<td>TOW@% MAC: 1570 lbs @ 23.39%</td>
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<td>F150L</td>
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<tr>
<td>TOW@% MAC: 1599 lbs @ 23.83%</td>
<td>TOW@% MAC: 1599 lbs @ 23.83%</td>
<td>TOW@% MAC: 1599 lbs @ 23.87%</td>
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<td>F150M</td>
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<td>TOW@% MAC: 1599 lbs @ 25.66%</td>
<td>TOW@% MAC: 1421 lbs @ 27.22%</td>
<td>TOW@% MAC: 1598 lbs @ 27.00%</td>
<td>TOW@% MAC: 1598 lbs @ 27.00%</td>
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<td>F150G</td>
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$ 4,500

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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)

Polynomial Curve Fit for Apparent LSS - Cruise

Polynomial Curve Fit for Apparent LSS - Landing (30)
Climbing Flight: Cessna 150M

BTP/Sortie: 2008-06-08
A/C = Cessna F150M G-BCRT
Date: 12/06/09
Gross Wt.: 1425lbs
CG = 30.2" A&D (72% Mid/AFT-CG/27% MAC)
Vtrim = 75 MIAS (65 KCAS)

Radio Calls >> Increased Workload??
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

$4,000
Typical simulator test results:
margin of safety & effect of stick forces

![Graph showing pilot capacity and workload](image)

- Pilot Capacity
- Pilot Workload
- Optimum arousal
- Current fit & healthy
- Well-trained rested

**Phase of Flight**
- Take-off & Climb-out @67 kts
- Cruise @90 kts @3000' AGL
- 10nm Heading 080
- Approach & Landing @65 kts, Rwy 08R
- 3nm 1000'AGL PAPI off

**Mental Demand**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>High Stick Force Gradient</th>
<th>Low Stick Force Gradient</th>
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</thead>
<tbody>
<tr>
<td>Practice Circuit BRS Rwy 27</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Circuit BRS Rwy 27</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Approach &amp; FULL Flap Landing @65 kts, Rwy 27 3nm 700'AGL (with Go-around)</td>
<td>5</td>
<td>4</td>
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<tr>
<td>Base to Final's Turn BRS Rwy 37 F/H Mid-base 750'AGL</td>
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Example: Pilot 24
Go-around, Full Pwr / Full Flap

Non-dimensionalised AoA .v. Elevator

Pilot 24 (high hrs):
- ATPL
- 12,000+ hrs PIC
- Age 60~64
- Avge 350+ hrs per yr

Pilot 23 (medium hrs):
- PPL (no IMC)
- 1200+ hrs PIC
- Age 65~69
- Avge 33+ hrs per yr

Key:
- Stick Force Gradients
  - High
  - Medium
  - Low
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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