Investigation of Factors Affecting Loss of Control of GA Aircraft

Mike Bromfield & Guy Gratton (M)
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Fixed Wing <5,700kg (non-microlight) fatal accident causal factors: 1980 to 2006 (UK)

- Loss of Control VFR: 25%
- Loss of Control IMC: 8%
- Low Flying/Aeros: 16%
- CFIT: 12%
- Forced Landing: 6%
- Mid-air Collision: 5%
- Collision with Grnd Obj: 4%
- Airframe Failure: 4%
- Low Approach: 3%
- Medical/Suicide: 5%
- Undetermined: 12%

Source: GASCo
GA fatal accident causal factors cont’d...

- UK, US, Canada & Australia, 300+ GA fatal accidents annually
  - Likely 100-200 LoC related

- Usually LoC at low level
  - Take-off, landing, go-around, forced landings
  - “Low, slow and dirty”
Programme Objectives

• Why does LoC happen?

• Why certain types and not others?

• How can we improve operational safety?

• “LoC-proof” future GA designs.
1984-2006: selected statistics
UK Fatalities per 100,000hrs

- ALL SEP: 0.70
- Cessna 150: 0.68
- Cessna 152: 0.05

Source:
Ferris R., Data Request 281107, UK CAA Nov. 2007. based on 3,395,056 flying hours
Spot the difference...?

Cessna 150L

Cessna 152
## What’s the difference?

<table>
<thead>
<tr>
<th></th>
<th>Cessna 150L ('74)</th>
<th>Cessna 150 M ('75)</th>
<th>Cessna 152 ('80)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Powerplant</strong></td>
<td>100 hp Continental</td>
<td></td>
<td>110 hp Lycoming</td>
</tr>
<tr>
<td><strong>Weight (lbs)</strong></td>
<td>1600</td>
<td>1670</td>
<td></td>
</tr>
<tr>
<td><strong>CG Range (in)</strong></td>
<td>31.5~37.5</td>
<td>(19.9~30.1 %MAC)</td>
<td>31~36.5</td>
</tr>
<tr>
<td></td>
<td>31~36.5</td>
<td>(19.1~28.4 %MAC)</td>
<td></td>
</tr>
<tr>
<td><strong>Flap Range (deg)</strong></td>
<td>0~40, no detents</td>
<td></td>
<td>0~30, detents @ 0/10/20/30</td>
</tr>
<tr>
<td><strong>Flap Activation/ Monitoring</strong></td>
<td>2-way switch, LH Door post Indicator</td>
<td>Gated 4 position switch, adj. indicator</td>
<td></td>
</tr>
<tr>
<td><strong>CR Speeds@60% Pwr/ 2000'/ Std T(KTAS)</strong></td>
<td>89</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>91</td>
</tr>
<tr>
<td><strong>V_{S0} (KCAS) Pwr Off/ Aft CG/ MTOW: L(30) L(40)</strong></td>
<td>42 41</td>
<td>41 N/A</td>
<td></td>
</tr>
</tbody>
</table>
Is it CG?
- Typical CGs, 2POB + Wf to MTOW

CGLOCATION (INCHES AFT OF DATUM)
## Flight Test Programme

<table>
<thead>
<tr>
<th>Phase</th>
<th>A/c 1</th>
<th>A/c 2</th>
<th>A/c 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>CG1 Mid</td>
<td>CG2 Mid-Fwd</td>
<td>CG3 Mid-Aft</td>
</tr>
<tr>
<td><strong>C152</strong></td>
<td>1 53%</td>
<td>4</td>
<td>6 62%</td>
</tr>
<tr>
<td><strong>F150L</strong></td>
<td>2 52%</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td><strong>F150M</strong></td>
<td>3 57%</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>
Methods & Equipment

• TPS basics
  – Handheld force/displacement/timing
  – Portable CVR

• Headset mounted video for debrief

• Appareo FDR
  +Garmin 296 GPS supplement / positional awareness
Methods & Equipment

Appareo GAU 1000A FDR
- 16 Channels@ 4Hz
- WAAS enabled GPS
- 3 x Gyroscopes
- 3 x Accelerometers
- Barometric pressure sensor
- Solid state compass
- AS Flight Analysis software
- US$ 2000

J31 Calibration Test Flt
Methods & Equipment

Flight Analysis software
• 2d/3d playback
• Google earth integration
• Instrument panel
• Own or external GPS
• Data export

Normal Take-off

Flight Evaluator Software

FDR Parameters
• Time
• Lat/Long
• True Gnd Speed
• Pitch/Roll/Yaw Attitude
• Pitch/Roll/Yaw Rate
• Geo-potential Altitude
• Normal, Lat., Long.
Accelerations & Velocities
BFSL safety model - the questions

Tracking point (optimal condition) → Condition error → Actual condition → Boundary (Unsafe Condition)

Aircraft characteristics → Condition cues → Safety cues

Planned margin → Safety margin → Pilot capacity to respond → Pilot response

HQ assessment: Point tracking versus boundary avoidance

www.brunel.ac.uk/about/acad/sed/sedres/cem/bfs
Cooper-Harper task selection
- Climb out speed control

\[ \text{RoC} = 0 \text{ fpm} \]

\[ V_{\text{climbout}} \quad (67 \text{ KIAS}) \]

1.2 \( V_S \)
(53 KIAS)

1.1 \( V_S \)
(49 KIAS)

\( V_S \)
(44 KIAS)

HQR 1~3
HQR 4~6
HQR 7~9

CH Point Tracking Task (Maintain)

CH Boundary Tracking Tasks (Avoid)
Comparison of Apparent LSS (CR), 150M vs 152

Stick Force Pull (daN) vs Speed KCAS

- C152
- F150M
- F150L
Comparison of Apparent LSS (L30), 150M vs 152

Apparent LSS

Stick Force Pull (daN)

Speed KCAS >>>

C152
F150M
F150L
Comparison of Apparent LSS (CR), 150M vs 152/CG mid-aft

Apparent LSS

Stick Force Pull (daN) vs Speed KCAS

- C152
- C152(mid-aft CG)
- F150M
- F150L
Initial findings

- Apparent LSS
  - Low speed LSS much steeper in C152 than C150 models
  - C150 / LAND / PLF → MCP, near-neutral
  - Indications of CG dependency
  - Possible cliff-edge change?

- Flaps
  - Large out of trim forces on retraction
  - C150 Flap indicator widens scan
  - Readability issues

- Stall
  - Power on / flapped stall: C150 only attitude warnings, spin risk

- Visible pitch attitude changes constantly close to GND
Mike’s lessons - academic FT

- Equipment portability
- Limited budget – time is money
- Use a ‘calibrated’ TP
- Data reduction takes considerable time
  - plan for this time between sorties
  - design test cards for data reduction
- Don’t rely on the technology
- Reporting – brevity vs academic rigour
- Be prepared for the unexpected!
Guy’s lessons - test conduct

• “Safe” GA aircraft can still bite, and without inanition
  - Brief for all emergencies

• Flying club environment
  - Sub-optimal aircraft
  - At-least 1 in 3 W&CG schedules contain errors
    • Consider re-weighing
  - Weather press-on-itis
    • Check everything
    • Know and stick to no-go criteria
  - Keep talking
Next Steps...

**More aircraft**
- Are we looking at the fleet?
- Critical cases

**Simulator work**
- Cycle pilots through critical cond.
- Pilot workload measurement
- Find the HQR 3-4, 6-7, 9-10 boundaries
- Be willing to crash!
FDR + CVR: F150L PLF Stall
Questions?

More Information:

michael.bromfield@brunel.ac.uk

guy.gratton@brunel.ac.uk
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