Technical Note IV: Exact Flyup Altitude + Risk of G-LOC= Anti-G-LOC GCAS

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Summary

After obtaining the expression of the exact flyup altitude, I define a new type of GCAS where *Gflyup* is variable and adjusted such that the pilot will never take a risk greater than *RiskG-LOC* to have a G-LOC during an automatic flyup. This is a great improvement over commercialized GCAS that consider a fixed *Gflyup* to make an automatic flyup. I finish with a discussion of some implementation issues.

Introduction

In a real combat situation we have to take more risks but we do not want to have a G-LOC during a flyup!

With actual GCAS this is difficult to achieve, since the *Gflyup* with which the automatic flyup is made is fixed, and if we take a value greater than 5g the risk of G-LOC will increase. Although the system triggers an automatic flyup, nevertheless we may have a G-LOC during it.

I propose a solution to this problem where I maximize *Gflyup* but I guarantee that we will never take a risk of G-LOC greater than a maximum value *RiskG-LOC*.

The idea behind this new approach is very simple: the system continuously calculates *Gflyup_max* that guarantees a risk < *RiskG-LOC* and from it calculates *Hflyup_min* and if *h* < *Hflyup_min* it triggers an automatic flyup with *Gflyup=1.2 Gflyup_max*.

The Exact Flyup Altitude

Observing the geometry of the flyup described in figure 1, we have

$$Hflyup = \frac{V_{flyup}^2}{G_{flyup} - g} - \frac{V_{flyup}^2 \cos\alpha_1}{G_{flyup} - g\cos\alpha_1} + CA + \left(TR + \frac{G_{flyup}}{GonSetRate}\right)V_{flyup}\sin\alpha_1 \quad (1)$$

where α_1 is the descending angle, *TR* the pilot reaction time and *CA* is the clearance altitude under which we do not want to go.

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Proceedings of the 2004 International Conference on Computational & Experimental Engineering & Science
26-29 July, 2004, Madeira, Portugal

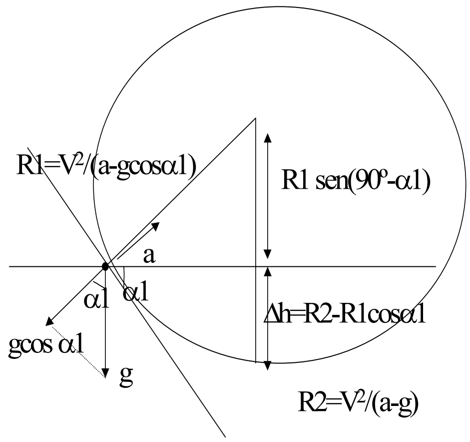

Figure 1- Geometry of the flyup.

The Maximum Gflyup and Minimum Hflyup

Remembering from [1] that the risk of G-LOC is given by

RiskG-LOC=Tflyup / Δt_G-LOC ~ Δα Vflyup Gflyup / Kpilot (2)

Solving (2) in order to *Gflyup* we get its maximum value

Gflyup_max=Kpilot RiskG-LOC / (Δα Vflyup) (2')

Substituting *Gflyup=Gflyup_max* in (1) we will get *Hflyup_min*. This latter expression and (2') are all that we need to implement the Anti-G-LOC GCAS. You may ask, *and what about* $\Delta\alpha$? We may put simply $\Delta\alpha=\alpha_1$ which means that the automatic flyup will stop at level flight and return control to the pilot, after confirming that he is conscious, or we can maximize $\Delta\alpha$, assuming constant the motor impulse, defining $\alpha_2<0$, the final angle of the trajectory where the flyup stops, such that speed tends to a value V_{min} that assures a safe flight with an angle of trajectory α_2. If the aircraft is descending at a stabilized speed V_{fltup} with an angle of trajectory α_1 we have

$$F + mg\sin\alpha_1 \approx \frac{1}{2}\rho CxSxV_{flyup}^2 + \frac{mg\cos\alpha_1}{L/D} \quad (3)$$

or

$$F \approx \frac{1}{2}\rho CxSxV_{flyup}^{2} + \frac{mg\cos\alpha_1}{L/D} - mg\sin\alpha_1 \qquad (3')$$

Now, as you must be guessing, α_2 is defined by

$$F = \frac{1}{2}\rho CxSxV_{\min}^{2} + \frac{mg\cos\alpha_2}{L/D} - mg\sin\alpha_2 \qquad (4)$$

A Very Small *GoffSetRate* Can Be Dangerous

In the previous section I showed how to maximize $\Delta\alpha$ without altering the engine impulse. Nevertheless if our aircraft has a very small *GoffSetRate* this would imply a non negligible $\Delta\alpha_{after\_flyup}$ and so we must use instead $\Delta\alpha' = \Delta\alpha - \Delta\alpha_{after\_flyup}$. Next I will deduce the exact expression of $\Delta\alpha_{after\_flyup}$.

$$\Delta\alpha_{after\_flyup} = \int_0^{\Delta t_{offsetRate}} \omega(t)dt = Area = \frac{\Delta t_{offset}.\omega_{flyup}}{2} = \frac{\frac{-Gflyup^2}{GoffsetRate * V_{flyup}}}{2} \qquad (5)$$

(5) tells us that if we have a very small *GoffsetRate* and V_{flyup} and a great G_{flyup} we may have a non negligible $\Delta\alpha_{after\_flyup}$.

Some Implementation Issues

The main problem that could arise in the implementation of this system is in the adjustment of *Gflyup_max*. If $h(t+\Delta t) << Hflyup\_min$ which can happen when the sample rate, $1/\Delta t$, is small, to prevent a crash we may need a *Gflyup* > 9g and we will then have surely a crash!

Conclusions and Future Work

I showed that the Anti-G-LOC GCAS is very simple but its implementation needs a careful study for each aircraft because a very low sample rate in the acquisition of flight data may provoke a situation of *Gflyup_min* > 9g that is a crash!

In the near future I will simulate the Anti-G-LOC GCAS with various sample rates. Nevertheless it seems we can solve the problems provoked by a low sample rate $1/\Delta t$, simply adding Δt to the 'total reaction time'=Pilot Reaction Time(*TR*) + Aircraft Reaction Time (*Gflyup/GonSetRate*) + Δt in (1) resulting

$$Hflyup = \frac{V_{flyup}^2}{G_{flyup} - g} - \frac{V_{flyup}^2 \cos\alpha_1}{G_{flyup} - g\cos\alpha_1} + CA + \left(TR + \frac{G_{flyup}}{GonSetRate} + \Delta t \right) V_{flyup} \sin\alpha_1 \qquad (6)$$

Reference

1 Barahona da Fonseca, J. (2004): "Technical Note III: The Risk of G-LOC and the Time to G-LOC Meter", *In Press, Proceedings of ICCES 2004.*