**LOP sight reduction comparisons using longhand Doniol (Hv only), replica Fuller 2 Cos, miniFuller2cos, Bygrave replica and original Otis King slide rules. 11/11/14.**

**Target ideal method**

* Non electronic, minimal space/paperwork/tables.
* Quick, easy, accurate and minimal “error prone” stages and mental arithmetic..
* For me, the “Chichester test”.( Practical in an open cockpit biplane, single handed, low altitude over the Tasman sea!)

**Example supplied by Greg Rudzinski, 9/11/14.**

DEC 16˚45’, LHA 50˚23’, Lat 34˚10’N.

1. **Doniol longhand, Haversine only formula (Hanno Ix,)**

For process, see Greg’s attachment.

Column A involves an addition, subtraction, to give L+D and L-D. The Hvs are obtained from the compact tables, added to obtain the sum, and subtracted from 1. The Hv of the LHA is obtained from the tables and multiplied by the 1-sum to give the Product P. The long multiplication can be done longhand or by slide rule (Otis King in half the time.)

Column B . Hv (L+D) +P=sum. Arc Hv(sum) =ZD. 90˚-ZD=HC. The Az from Hanno’s graph took a couple of minutes and was easy.

This process took me about **8-10 minutes**, but I suspect practice will improve this. I found the Hv tables by Hanno (2’,no interpolation) easier and more accurate than Greg’s which require interpolation. I made several mistakes here.

**Conclusions**

This is the probably the easiest and quickest longhand method I have tried. I doubt whether it would pass my “Chichester test. I made several errors doing the interpolation on Greg’s compact Hv tables, but found Hanno’s easier and made no errors. There is too much writing and paper work for single handed flying.

1. **Bygrave slide rule.**

See attachment. I always use Gary LaPook’s excellent work sheet, which looks complicated but is actually easy to do and helps reduce transcription errors etc.

The only mental arithmetic involves finding the LHA, Co-Lat (i.e 90˚-lat. I always use 89˚60’ which makes the subtraction easier and less error prone.). X and Az,/Zn.

I did this example in **2 minutes with no errors**, but I have a lot of experience with the Bygrave. This does pass the Chichester test, since he used it and survived! The main potential problem is slippage. The original Bygrave does not have an anti-slip break. This could be retro-fitted.(see minifuller 2 below). My Bygrave has never slipped, but requires regular maintenance of the friction felts to prevent this. The Bygrave is not a general slide rule and is really only used for LOP reduction and great circle calculations. ( have found a way of using it for Lunar clearances, but that is another story).

1. **Otis King slide rule, sine/cosine compact 1 page table, cosine formula.**

**Formula**

1)SinHc=(cos LHA x cos Lat x cos Dec)+/- 2) (sin lat x sin Dec).

**Process**

From compact 1 page sin/cosine table: (see attachment)

Cos LHA =0.6376, cos Lat=0.8274, cos Dec=0.9575, sin Lat=0.5616, sin Dec=0.2881.

1. A few easy moves give intermediate answer 0.5051
2. = 0.1617
3. Subtract 2 from 1 (contrary lat/dec) =0.3434= sin Hc
4. Tables give 20˚5’=Hc.

**Conclusions**

This was easy and relatively fast, but the sin/cosine table requires interpolation and I made **several errors.**

The process took about **5-6 minutes** and would not pass the Chichester test. However, Otis King+sin/cos table is very compact and fits into small, minimalist crash bag.(see attachment).

 **4)Cosine formula using minifuller2cos slide rule**

This prototype homemade slide rule is about the same size as the Bygrave, but the reduced scales from the Fuller original are small and require magnifiers.

**Process moves**

1 )S>top1, cos50˚23’>L, L>red dot (0.6376 is at S).

Cos 34˚10’>L, L>red, cos 16˚45’>L, L>red, **Read 0.5051 at S (record)**

2 )S> top1,sin 34˚10’>L, L>red, sin16˚45’>L, L>red. **Read 0.1617 at S, (record)**

Subtract 1-2= 0.3434>S, red dot >L, S>bottom 1, **read 20˚5’ at L.**

**Conclusions**

This only requires 2 written recordings, intermediate results 1 and 2 and then one subtraction to get sin Hc. This took me **about 4 minutes,** mostly due to the small scale requiring magnifiers. Potentially this would be as quick, easy and error free as the Bygrave. This slide rule can be used for all my celnav calculations, including Lunar clearance. It also has an “anti-slip break” of Gary LaPook’s design. This would pass the Chichester test.

The Full sized Fuller has a few more moves but large, clear scales and takes about the same time. It is however a very big device for a small plane cockpit, so I’m not sure if Chichester would have used it.

**Overall conclusions**

* The Hv only Doniol must be the best compact longhand method available.(congratulations to Greg and Hanno for making this happen.)
* The Bygrave remains for me the fastest and easiest method, with the minifuller2cos, using the cos formula a close second. Neither slide rule fits into the mini crash bag, so if minimal size/volume is important, the Otis King +sin table works well.