**Lunar clearance with calculator, Mini Fuller and Bygrave Cylindrical slide rules. (John Karl Method page 93.)**

* Apparent Alts. Ha (sun alt) and ha (moon alt) corrected for IC and dip
* Hsd and hsd, ha corrected for +/- SD from almanac daily pages
* LDa corrected for ic but not dip.
* LDsd +/- SD both moon and sun. Usually + both for closest limbs.
* Fully corrected Ho, ho,
	+ Use Ha almanac alt correction (ref+SD+par) to give Ho
	+ Ha main correction + use HP from daily pages, to get 2nd correction, gives ho

**Calculator**

1. **Find RBA. (Dif. Az)**

***Cos RBA=(cosLDsd-sinHsdsinhsd)/cosHsd.coshsd***

=(cos 52023.2’-(sin 38039.8’xsin30036.3’)/cos 38039.8’xcos30036.3’

=0.61032- ( 0.62474x0.50911=0.31806)/(0.70808x0.8607=0.6720)

0.61032-0.31806=0.29226.

0.29226/0.6720=0.43491=Cos RBA

**RBA =64013.2’**

1. **Find LDo**

***CosLDo=(sinHo.sinho )+(cosHo.cosho.cos RBA)***

= ( sin 38038.7’xsin 31021.4’) + (cos38038.7’xcos 31021.4’)

 =(0.62449 x0.5204) +(0.7810 x 0.85349 x0.43491)

 = 0.3249 + 0.2899 =0.6148

**0.6148 cos-1  =5203.7’**

 **Fuller 2 clearance of Lunars, John Karl page 93**

**Find RBA (mini Fuller old version with no cosines)**

1. Change cos >sin (new version will have cos scale going opposite direction)
* Cos LDsd = sin 900-52023.2’=sin 37036.8’
* CosHsd =sin 900-38039.80 =sin 51020.2’
* Coshsd=sin 900-30036.3’ =sin 59023.7’
1. ***Cos RBA(ΔAz)= (sin LDsd 37036.8’ ) – (sin Hsd 38039.8’ x sin hsd30036.3’)/(sin 51020.8’ x sin 59023.7’).*** **Fuller 2 mini operations. 0.6247 (0.31806) 0.5091**

 3)sin Hdsxsinhsd S to 0. Inner tube 38039.8’ move to L, L move to red, read 0.6247 at S

Inner tube 30036.3’ move to L. Move L to red. Read 0.31806 at S. Record

4)sin LDsd S to 0. Innertube 37036.8’ move to L. Move L to red, read 0.6103 at S

0.6103-0.31806= 0.29224. Record.

 5)cos Hsdxcoshsd S to 0. Innertube 51020.2’ move to L. Move L to red. Read 0.7809 at S

. Move inner tube 59023.2’ to L. Move L to red. Read0.6721 at S.Record

6 divide)S to 0.2922, move inner tube 0.6721 to L, move L to 0 read 0.4349 at S. Innertube to red, s to 0, read 25046.5’ at L, 900-25046.5’= 640 13.46.5’

900- 25046.5’=**RBA =640 13’**

**Find LDo (can also do this with Bygrave using a different formula)**

**Cos LDo = SinHox Sinho + CosHo x Cosho  x Cos RBA.**

1. ***Change Cos>Sin***
* CosHo = 900- 38038.7’ = sin 51021.3’
* Cosho =900 – 31021.4’= sin 58038.6’

=(sin 38038.7’ x sin 31021.4’) + (sin 51021.3’ x sin58038.6’x0.4349)

 0.6249 0.5204

 (0.3249) (0.2899)

**Fuller 2 operations.**

2) S to 0. Innertube 38038.7’ move to L

 L move to red, read 0.6244 at S

move 31021.4’ to L, move L to red, read 0.3249 at S. Record

3) S to 0. Innertube 51021.3’ move to L,

 L move to red, read 0.7810 at S

 58038.6’ move to L, move L to red, read 0.6666 at S

 25046.7’ (sin RBA) to L, move L to red, read 0.2899 at S. Record

 4) 0.3249 + 0.2899 = 0.6148 .Record

 5) S to 0.6148, move L to red, move S to 0, read 37056.2’ at L

900 – 37056.2’= **LD0 = 5203.8’**

**Find LDo using Bygrave.**

H = RBA (dif Az) =64˚13.2’

Dec = ho= 31˚21.4’

Lat = Ho= 38˚38.7’

Co-lat ==90 – lat = 51˚21.8’

Uses Bygrave to calculate “great circle distance =90-hc.

Tan y(W)=tan dec/cosH

Tan Az =TanH.xcosy/CosY

**Bygrave Operations**

1)Set S (cos) to 0, set L(cotan) to Dec (31˚21.4’), set S to RBA (64˚13.2’**), read y (or W) at L= 54˚32’** Record

2) X =co-lat +y = 105˚53’18”, W>90, **so Y**=180-**X =74˚6’42” Record**

3) Set S to y **= 54˚32’** , set RBA (dif Az) =64˚13.2’ to L, set S to Y **74˚6’42” ,read Az 77˚9’ at L record**

4) S to **Az 77˚9’,** set Y **74˚6’42”** to L, set S to 0, read **a = 37˚58’ at L.**

**5)LDo = 90- 37˚58’= 52˚2’ (correct figure from Karl is 52˚2.9’)**

**Possible method using Azimuth measurements of sun and moon using compass.(works in theory, but not yet tried in practice).**

* “Simultaneous” Az of moon and sun using adapted hand bearing compass. (? Only accurate to about 5˚ ?
* Use Difference in Az (ΔAzc)
* Do Bygrave ops to calculate LDsd(c) (compass)
* Compare with actual LDsd from sextant reading
* Ratio LDsd actual/LDsdc= correction factor. (may need Fuller or Otis King for the ratios?)
* Obtain fully corrected LDo.
* Multiply by the correction factor= cleared LDo
* Likely to be less accurate and just as time consuming as the full method using Fuller 2.