Sunshot via excel spreadsheet:

At Fugro I took part in a gyro verification by using the sun. The azimuth was calculated using an excel spreadsheet with an internal astronomical library. The uncertainty of the Octans gyro is established at ± 0.03°.

Methodology:

- The total-station is placed on the ship's center line facing the bow;the sun is observed clockwise relative to the ship's center line.
- The Azimuth is calculated using the UTC fixtime with an astronomy library.

Calc. Vessel Heading: 360° – Observed sun + Calc. Sun Azimuth

C – O Gyro compass: Calc. Vessel Heading – Obs. Gyro (T)

GYRO CALIBRATION FROM SUN OBSERVATIONS

Intership report L Blauw

Project no:	MIWB	Gyro name:	Octans
Vessel:	Fugro Pioneer	Date :	31-dec-19
Position :	52° 57' 26.9"	Location :	Den Helder
	004°46'37.5"	Datum :	ED50
		Projection :	UTM31
		CM :	3° E
		Hemisphere :	North

Obs. vessel north		
Deg	Min	Sec
0	0	0

Fix No.	UTC hh:mm:ss	Observed Sun Deg	Min	Sec	Calc Sun Azimuth Deg	Min	Sec	Obs. Gyro deg true	Calc. Vessel deg true	C-O deg
1	08:41:44	343	41	24	138	52	24	155.063	155.18	0.12
2	08:43:16	344	6	0	139	11	33	154.985	155.09	0.11
3	08:44:12	344	16	44	139	23	14	155.055	155.11	0.05
4	08:44:52	344	22	5	139	31	34	155.058	155.16	0.10
5	08:46:01	344	35	30	139	45	59	155.076	155.17	0.10
6	08:46:42	344	45	20	139	54	33	155.043	155.15	0.11
7	08:47:21	344	60	38	140	2	43	154.94	155.03	0.09
8	08:48:12	345	27	4	140	13	24	154.667	154.77	0.11
9	08:48:58	345	41	55	140	23	2	154.588	154.69	0.10
10	09:07:08	349	18	14	144	13	48	154.765	154.93	0.16
11	09:07:24	349	23	44	144	17	14	154.764	154.89	0.13
12	09:07:45	349	27	35	144	21	43	154.762	154.90	0.14
13	09:08:03	349	33	42	144	25	34	154.783	154.86	0.08
14	09:08:19	349	34	26	144	28	60	154.783	154.91	0.13
15	09:08:34	349	38	59	144	32	12	154.779	154.89	0.11
16	09:08:50	349	42	35	144	35	38	154.768	154.88	0.12
17	09:09:13	349	51	28	144	40	34	154.733	154.82	0.09
18	09:09:33	350	3	0	144	44	51	154.597	154.70	0.10
19	09:09:57	350	16	46	144	49	60	154.509	154.55	0.04
20	09:10:20	350	18	0	144	54	56	154.505	154.62	0.11
									Average:	0.10
									St. dev.	0.03

Sun-shot Azimuth via python with Skyfield:

The Python library Skyfield is used in this jupyter notebook;
(https://github.com/BlueReson/sunshot/blob/main/sunshot.ipynb)

Input: *Fixtime in UTC, Observed Sun & Obs. Gyro*

output:

```
               datetime_UTC  obs_sun_decimal  azimuth  obs_gyro_true  \
fix_nr
1       2019-12-31 08:41:44       343.690000  138.873        155.063
2       2019-12-31 08:43:16       344.100000  139.192        154.985
3       2019-12-31 08:44:12       344.278889  139.387        155.055
4       2019-12-31 08:44:52       344.368056  139.526        155.058
5       2019-12-31 08:46:01       344.591667  139.766        155.076
6       2019-12-31 08:46:42       344.755556  139.909        155.043
7       2019-12-31 08:47:21       345.010556  140.045        154.940
8       2019-12-31 08:48:12       345.451111  140.223        154.667
9       2019-12-31 08:48:58       345.698611  140.383        154.588
10      2019-12-31 09:07:08       349.303889  144.230        154.765
11      2019-12-31 09:07:24       349.395556  144.287        154.764
12      2019-12-31 09:07:45       349.459722  144.361        154.762
13      2019-12-31 09:08:03       349.561667  144.426        154.783
14      2019-12-31 09:08:19       349.573889  144.483        154.783
15      2019-12-31 09:08:34       349.649722  144.536        154.779
16      2019-12-31 09:08:50       349.709722  144.593        154.768
17      2019-12-31 09:09:13       349.857778  144.676        154.733
18      2019-12-31 09:09:33       350.050000  144.747        154.597
19      2019-12-31 09:09:57       350.279444  144.833        154.509
20      2019-12-31 09:10:20       350.300000  144.915        154.505

        calc_gyro_true       c-o
fix_nr
1           155.183000  0.120000
2           155.092000  0.107000
3           155.108111  0.053111
4           155.157944  0.099944
5           155.174333  0.098333
6           155.153444  0.110444
7           155.034444  0.094444
8           154.771889  0.104889
9           154.684389  0.096389
10          154.926111  0.161111
11          154.891444  0.127444
12          154.901278  0.139278
13          154.864333  0.081333
14          154.909111  0.126111
15          154.886278  0.107278
16          154.883278  0.115278
17          154.818222  0.085222
18          154.697000  0.100000
19          154.553556  0.044556
20          154.615000  0.110000
mean  c-o: 0.10
stdef c-o: 0.03
```

Single Azimuth angle with Skyfield in Python:

```
# location Port of Den Helder, Nieuwe diep:
lat = 52+(57/60)+(26.9/3600)
lon =  4+(46/60)+(37.5/3600)
height_m = 6
# fix1 @ 2019-12-31 08:41:44 UTC >>> 2019,12,31,08,41,44

# src:
https://rhodesmill.org/skyfield/positions.html#azimuth-and-altitude-from-a
-geographic-position
# Sunshot Azimuth - hour angle method
from skyfield.api import N,S,E,W, wgs84
from skyfield.api import load
import pandas as pd

ts = load.timescale()
t = ts.utc(2019, 12, 31)
planets = load('de421.bsp')
earth, sun = planets['earth'], planets['sun']

# Altitude and azimuth in the sky for a specific geographic location
earth = planets['earth']
Nieuwe_diep = earth + wgs84.latlon(lat * N, lon * E, elevation_m=height_m)
astro = Nieuwe_diep.at(ts.utc(2019, 12, 31, 8, 41, 44)).observe(sun)
app = astro.apparent()

alt, az, distance = app.altaz()
#print('alt: ' + alt.dstr())
print('az: ' + az.dstr())
#print(distance)

#print('lat, lon: ' + str(lat), str(lon))
#dt_utc = df2['datetime_UTC']

print('az: {:.3f}'.format(az.degrees)) # desired output for azimuth in
decimal degrees
print('az: '+ az.dstr(format=u'{0}{1}°{2:02}′{3:02}.{4:0{5}}″'))
```

output:

```
az: 138deg 52' 22.3"
az: 138.873
az: 138°52′22.3″
```