

Determining distance off

The vessel's distance off (its range) from a charted feature enables position fixing; this being critical for the vessel's safety to pass outlying dangers, to approach a river bar or to come to anchor close to. Accurate ranges are electronically derived from GPS, AIS and radar, however, traditional techniques described below enable useful approximations.

Approximation from observable features

Observations with naked eye from a yacht's deck (2 metres height of eye) in good visibility.

Less than 100m



Individuals and car types are recognised, architectural details and road signs are easily read.

Less than 250m



Man or woman, car or van, window or door are distinguished. Business name boards are readable.

Less than 450m



See people and cars, identify large vehicles, recognise standard size flags, read large civic clocks.

Less than 900m



See surf, beach and main roads. See moving people and cars but cannot read large signs.

1 Mile



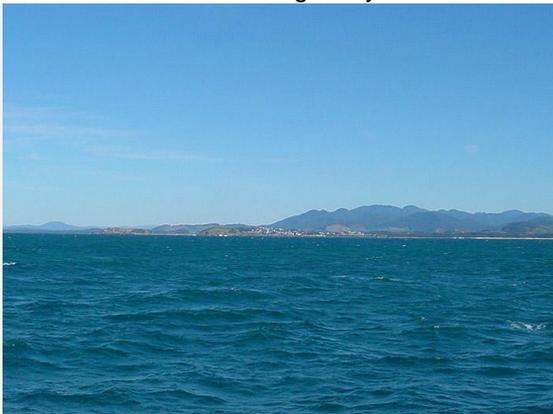
See road traffic and adults as moving dots. See buildings but with unclear architectural detail.

2 M



See the outline of buildings only. See wide beaches. Cannot see people or cars.

3 M



The visual horizon at 2 metre height of eye. See only heavy surf, low dunes. Towers discernable.

4 M



Beaches are under the horizon from a yacht's deck. Forest, buildings, dunes seen as outlines only.

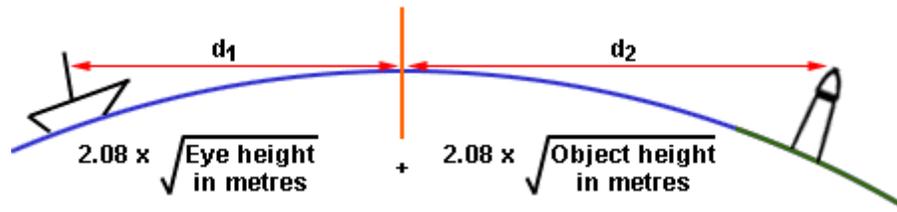
Geographical range and Dipping distance by tables or formula

A *Geographical range* is the distance that a coastal feature will be visible over the curvature of the earth from a particular height of eye. A sighted object can be entered using the pre-calculated Geographical range tables or calculated by trigonometry. Allowance for the height of the observers eye is required. For instance, in the table below a 20 mtr high tower will dip at 11.9 mtrs from a yachts deck at 2 mtrs height of eye.

Elevation		Observer's Height of Eye																					
feet		3	7	10	13	16	20	23	26	30	33	39	46	52	59	66	72	79	85	98	115	131	148
	mtrs	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	22	24	26	28	30	40	45
Range in Miles																							
0	0	2.0	2.9	3.5	4.1	4.5	5.0	5.4	5.7	6.1	6.4	7.0	7.6	8.1	8.6	9.1	9.5	9.9	10.4	10.7	11.1	12.8	13.6
3	1	4.1	4.9	5.5	6.1	6.6	7.0	7.4	7.8	8.1	8.4	9.1	9.6	10.2	10.6	11.1	11.6	12.0	12.4	12.8	13.1	14.9	15.6
7	2	4.9	5.7	6.4	6.9	7.4	7.8	8.2	8.6	9.0	9.3	9.9	10.5	11.0	11.5	11.9	12.4	12.8	13.2	13.6	14.0	15.7	16.5
10	3	5.5	6.4	7.0	7.6	8.1	8.5	8.9	9.3	9.6	9.9	10.5	11.1	11.6	12.1	12.6	13.0	13.5	13.9	14.3	14.6	16.4	17.1
13	4	6.1	6.9	7.6	8.1	8.6	9.0	9.4	9.8	10.2	10.5	11.1	11.7	12.2	12.7	13.1	13.6	14.0	14.4	14.8	15.2	16.9	17.7
16	5	6.6	7.4	8.1	8.6	9.1	9.5	9.9	10.3	10.6	11.0	11.6	12.1	12.7	13.2	13.6	14.1	14.5	14.9	15.3	15.7	17.4	18.2
20	6	7.0	7.8	8.5	9.0	9.5	9.9	10.3	10.7	11.1	11.4	12.0	12.6	13.1	13.6	14.1	14.5	14.9	15.3	15.7	16.1	17.8	18.6
23	7	7.4	8.2	8.9	9.4	9.9	10.3	10.7	11.1	11.5	11.8	12.4	13.0	13.5	14.0	14.4	14.9	15.3	15.7	16.1	16.5	18.2	19.0
26	8	7.8	8.6	9.3	9.8	10.3	10.7	11.1	11.5	11.8	12.2	12.8	13.3	13.9	14.4	14.8	15.3	15.7	16.1	16.5	16.9	18.6	19.4
30	9	8.1	9.0	9.6	10.2	10.6	11.1	11.5	11.8	12.2	12.5	13.1	13.7	14.2	14.7	15.2	15.6	16.0	16.4	16.8	17.2	18.9	19.7
33	10	8.4	9.3	9.9	10.5	11.0	11.4	11.8	12.2	12.5	12.8	13.5	14.0	14.5	15.0	15.5	15.9	16.4	16.8	17.2	17.5	19.3	20.0
39	12	9.1	9.9	10.5	11.1	11.6	12.0	12.4	12.8	13.1	13.5	14.1	14.6	15.2	15.6	16.1	16.6	17.0	17.4	17.8	18.2	19.9	20.6
46	14	9.6	10.5	11.1	11.7	12.1	12.6	13.0	13.3	13.7	14.0	14.6	15.2	15.7	16.2	16.7	17.1	17.5	17.9	18.3	18.7	20.4	21.2
52	16	10.2	11.0	11.6	12.2	12.7	13.1	13.5	13.9	14.2	14.5	15.2	15.7	16.2	16.7	17.2	17.6	18.1	18.5	18.9	19.2	21.0	21.7
59	18	10.6	11.5	12.1	12.7	13.2	13.6	14.0	14.4	14.7	15.0	15.6	16.2	16.7	17.2	17.7	18.1	18.6	19.0	19.4	19.7	21.5	22.2
66	20	11.1	11.9	12.6	13.1	13.6	14.1	14.4	14.8	15.2	15.5	16.1	16.7	17.2	17.7	18.2	18.6	19.0	19.4	19.8	20.2	21.9	22.7
72	22	11.6	12.4	13.0	13.6	14.1	14.5	14.9	15.3	15.6	15.9	16.6	17.1	17.6	18.1	18.6	19.0	19.5	19.9	20.3	20.6	22.4	23.1
79	24	12.0	12.8	13.5	14.0	14.5	14.9	15.3	15.7	16.0	16.4	17.0	17.5	18.1	18.6	19.0	19.5	19.9	20.3	20.7	21.1	22.8	23.6
85	26	12.4	13.2	13.9	14.4	14.9	15.3	15.7	16.1	16.4	16.8	17.4	17.9	18.5	19.0	19.4	19.9	20.3	20.7	21.1	21.5	23.2	24.0
92	28	12.8	13.6	14.3	14.8	15.3	15.7	16.1	16.5	16.8	17.2	17.8	18.3	18.9	19.4	19.8	20.3	20.7	21.1	21.5	21.9	23.6	24.4
98	30	13.1	14.0	14.6	15.2	15.7	16.1	16.5	16.9	17.2	17.5	18.2	18.7	19.2	19.7	20.2	20.6	21.1	21.5	21.9	22.2	24.0	24.7
115	35	14.0	14.9	15.5	16.1	16.5	17.0	17.4	17.8	18.1	18.4	19.0	19.6	20.1	20.6	21.1	21.5	22.0	22.4	22.8	23.1	24.8	25.6
131	40	14.9	15.7	16.4	16.9	17.4	17.8	18.2	18.6	18.9	19.3	19.9	20.4	21.0	21.5	21.9	22.4	22.8	23.2	23.6	24.0	25.7	26.5
148	45	15.6	16.5	17.1	17.7	18.2	18.6	19.0	19.4	19.7	20.0	20.6	21.2	21.7	22.2	22.7	23.1	23.6	24.0	24.4	24.7	26.5	27.2
164	50	16.4	17.2	17.9	18.4	18.9	19.3	19.7	20.1	20.4	20.8	21.4	21.9	22.5	23.0	23.4	23.9	24.3	24.7	25.1	25.5	27.2	28.0
180	55	17.1	17.9	18.6	19.1	19.6	20.0	20.4	20.8	21.1	21.5	22.1	22.7	23.2	23.7	24.1	24.6	25.0	25.4	25.8	26.2	27.9	28.7

See the full [Geographic range tables](#) (courtesy of Tom Obre).

The extreme range or *Dipping distance* is the distance in nautical miles to a light just seen to appear above the horizon (to dip), as is shown below.



$$\text{Distance miles} = 2.08 \times (\sqrt{\text{eye height metres}} + \sqrt{\text{height of light metres}})$$

In practice a suitable lighthouse is chosen in advance. On the approach, its loom in the sky above the horizon would first be observed. At the moment that the light itself shines clear over the horizon, the dipping distance is reached.

The lighting characteristics of a suitable light will be detailed on the chart; for instance, *Fl 3 every 20 seconds 120m 20M*. In this case the height of the centre of the light is given as 120 metres and its *nominal range* (its power) given as 20 nautical miles. Care must be taken as the nominal range is a measure of the intensity of the light in candle power, and how far this power of light is likely to penetrate through average meteorological visibility. The Bureau of Meteorology broadcasts the changing local meteorological visibility, ranging from less than one nautical mile (fog), to ten nautical miles (average visibility) to greater than twenty five nautical miles (perfect visibility).

To find the *luminous range* (how far you will see the light in the prevailing meteorological visibility) you would enter the graph below with the nominal range of the charted lighthouse and the prevailing meteorological visibility curve. The point where these intersect is transferred and read off on the left hand luminous range scale.

Example 1:

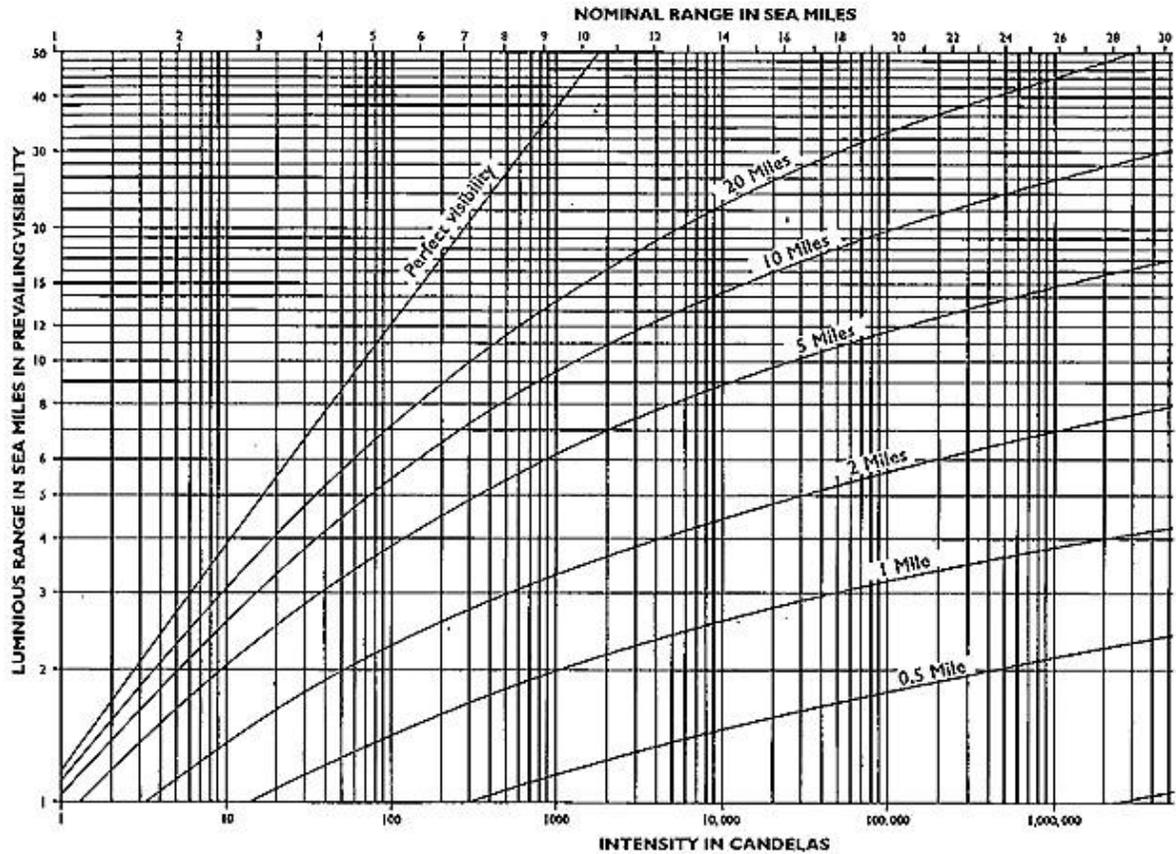
Lighthouse Fl 3 20 secs 120m 20M and meteorological visibility of 20 nautical miles.
Enter NR 20 and met. vis. 20 miles = Luminous range of 34 nautical miles.

Example 2:

Lighthouse Fl 3 20 secs 120m 20M and meteorological visibility of 20 nautical miles.
Enter NR 20 and met. vis. 5 miles = Luminous range of 12 nautical miles.

Important note:

Clearly to use dipping for range determination, the navigator must ensure that the luminous range in the prevailing meteorological visibility is at least equal to the calculated or tabulated dipping distance; i.e. the visibility is good enough to see it.

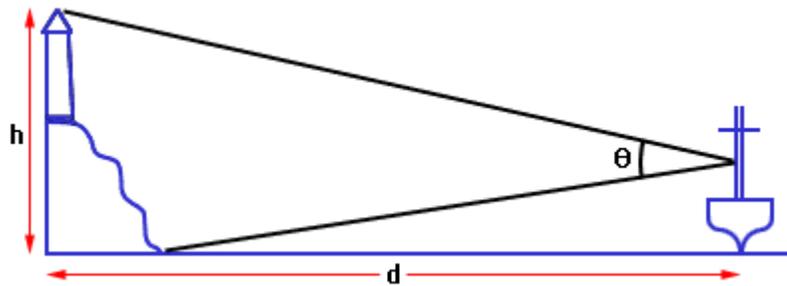


Vertical sextant angles

The angle between a coastal feature's height (the centre of a light) and the waterline can be measured using a navigational instrument called a sextant. This vertical sextant angle can then be used to find the distance off by entering the pre-calculated VSA tables or by trigonometry. Below, a 38 mtr tower giving a 1° 11' angle is 1.0 nautical miles distant.

		Height of Object																						
feet		33	36	39	43	46	49	52	56	59	62	66	72	79	85	92	98	105	112	118	125	131	148	164
metres		10	11	12	13	14	15	16	17	18	19	20	22	24	26	28	30	32	34	36	38	40	45	50
miles																								
0.1		3 05	3 24	3 42	4 01	4 19	4 38	4 56	5 15	5 33	5 51	6 10	6 46	7 23	7 59	8 36	9 12	9 48	10 24	11 00	11 36	12 11	13 39	15 07
0.2		1 33	1 42	1 51	2 01	2 10	2 19	2 28	2 38	2 47	2 56	3 05	3 24	3 42	4 01	4 19	4 38	4 56	5 15	5 33	5 51	6 10	6 56	7 41
0.3		1 02	1 08	1 14	1 20	1 27	1 33	1 39	1 45	1 51	1 58	2 04	2 16	2 28	2 41	2 53	3 05	3 18	3 30	3 42	3 55	4 07	4 38	5 09
0.4		0 46	0 51	0 56	1 00	1 05	1 10	1 14	1 19	1 24	1 28	1 33	1 42	1 51	2 01	2 10	2 19	2 28	2 38	2 47	2 56	3 05	3 29	3 52
0.5		0 37	0 41	0 45	0 48	0 52	0 56	0 59	1 03	1 07	1 11	1 14	1 22	1 29	1 36	1 44	1 51	1 59	2 06	2 14	2 21	2 28	2 47	3 05
0.6		0 31	0 34	0 37	0 40	0 43	0 46	0 49	0 53	0 56	0 59	1 02	1 08	1 14	1 20	1 27	1 33	1 39	1 45	1 51	1 58	2 04	2 19	2 35
0.7		0 27	0 29	0 32	0 34	0 37	0 40	0 42	0 45	0 48	0 50	0 53	0 58	1 04	1 09	1 14	1 20	1 25	1 30	1 35	1 41	1 46	1 59	2 13
0.8		0 23	0 26	0 28	0 30	0 32	0 35	0 37	0 39	0 42	0 44	0 46	0 51	0 56	1 00	1 05	1 10	1 14	1 19	1 24	1 28	1 33	1 44	1 56
0.9		0 21	0 23	0 25	0 27	0 29	0 31	0 33	0 35	0 37	0 39	0 41	0 45	0 49	0 54	0 58	1 02	1 06	1 10	1 14	1 18	1 22	1 33	1 43
1.0		0 19	0 20	0 22	0 24	0 26	0 28	0 30	0 32	0 33	0 35	0 37	0 41	0 45	0 48	0 52	0 56	0 59	1 03	1 07	1 11	1 14	1 24	1 33
1.1		0 17	0 19	0 20	0 22	0 24	0 25	0 27	0 29	0 30	0 32	0 34	0 37	0 40	0 44	0 47	0 51	0 54	0 57	1 01	1 04	1 07	1 16	1 24
1.2		0 15	0 17	0 19	0 20	0 22	0 23	0 25	0 26	0 28	0 29	0 31	0 34	0 37	0 40	0 43	0 46	0 49	0 53	0 56	0 59	1 02	1 10	1 17
1.3		0 14	0 16	0 17	0 19	0 20	0 21	0 23	0 24	0 26	0 27	0 29	0 31	0 34	0 37	0 40	0 43	0 46	0 49	0 51	0 54	0 57	1 04	1 11
1.4		0 13	0 15	0 16	0 17	0 19	0 20	0 21	0 23	0 24	0 25	0 27	0 29	0 32	0 34	0 37	0 40	0 42	0 45	0 48	0 50	0 53	0 60	1 06
1.5		0 12	0 14	0 15	0 16	0 17	0 19	0 20	0 21	0 22	0 24	0 25	0 27	0 30	0 32	0 35	0 37	0 40	0 42	0 45	0 47	0 49	0 56	1 02
1.6		0 12	0 13	0 14	0 15	0 16	0 17	0 19	0 20	0 21	0 22	0 23	0 26	0 28	0 30	0 32	0 35	0 37	0 39	0 42	0 44	0 46	0 52	0 58
1.7		0 11	0 12	0 13	0 14	0 15	0 16	0 17	0 19	0 20	0 21	0 22	0 24	0 26	0 28	0 31	0 33	0 35	0 37	0 39	0 41	0 44	0 49	0 55
1.8		0 10	0 11	0 12	0 13	0 14	0 15	0 16	0 18	0 19	0 20	0 21	0 23	0 25	0 27	0 29	0 31	0 33	0 35	0 37	0 39	0 41	0 46	0 52
1.9		0 10	0 11	0 12	0 13	0 14	0 15	0 16	0 17	0 18	0 19	0 20	0 21	0 23	0 25	0 27	0 29	0 31	0 33	0 35	0 37	0 39	0 44	0 49
2.0		0 09	0 10	0 11	0 12	0 13	0 14	0 15	0 16	0 17	0 18	0 19	0 20	0 22	0 24	0 26	0 28	0 30	0 32	0 33	0 35	0 37	0 42	0 46
2.1		0 10	0 11	0 11	0 12	0 13	0 14	0 15	0 16	0 17	0 18	0 19	0 21	0 23	0 25	0 27	0 28	0 30	0 32	0 34	0 35	0 37	0 40	0 44
2.2		0 09	0 10	0 11	0 12	0 13	0 14	0 15	0 16	0 17	0 18	0 19	0 20	0 22	0 24	0 25	0 27	0 29	0 30	0 32	0 34	0 38	0 42	
2.3		0 10	0 10	0 11	0 12	0 13	0 14	0 15	0 16	0 17	0 18	0 19	0 21	0 22	0 24	0 26	0 27	0 29	0 31	0 32	0 34	0 38	0 40	
2.4		0 09	0 10	0 11	0 12	0 13	0 14	0 15	0 16	0 17	0 18	0 19	0 20	0 22	0 24	0 25	0 27	0 28	0 29	0 31	0 32	0 35	0 39	

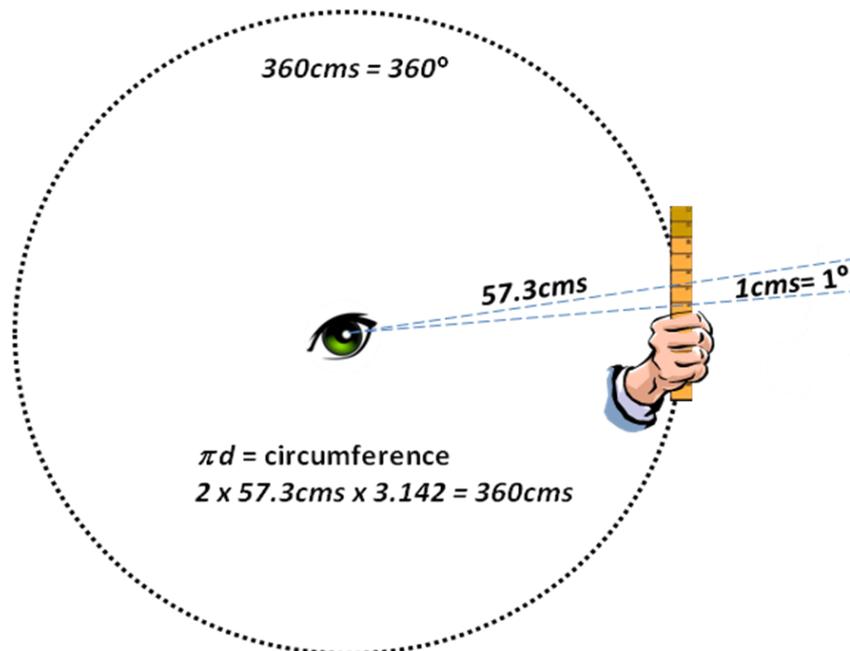
See the full [VSA tables](#) (courtesy of Tom Obre).



$$\text{Distance miles} = \frac{1.854 \times \text{height of object metres}}{\text{Sextant angle in minutes}}$$

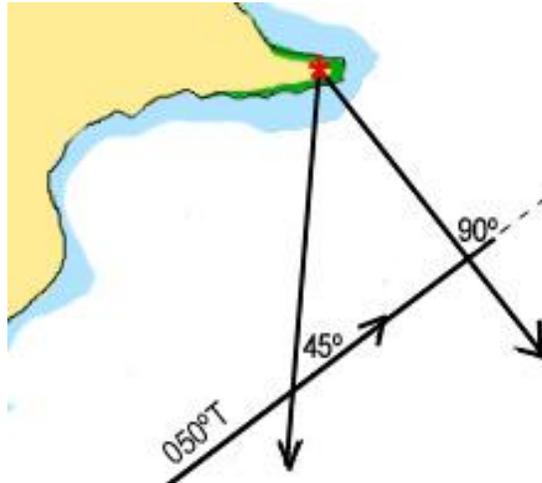
Measuring elevation by traditional means

For eons ancient mariners without modern sextants have determined the angle between a celestial or coastal feature and the horizon by simply comparing the width of a hand, finger or multiple fingers. The drawing below proves that a radius of 57.3 cms (approximate to an arms length) can describe a circle of 360 cms. Each of those 360 cms can be sighted on a ruler as equivalent to 1°. This comparison provides a rough and ready rule of thumb for distance off angles. For instance, to round a 13 mtr headland by at least 0.4 M clear, a 1 cms height on the ruler (equivalent to 1° angle) must be maintained.



Doubling the angle on the bow

The angle on the bow of a coastal feature is first taken; in the case below, the first relative angle to the bow is 45° Red. The time is noted and the feature watched until the angle on the bow doubles to 90° Red. The triangle formed by such two position lines and the course line is isosceles, therefore the range at the time of the second bearing is equal to the distance run between the bearings, or *distance run is equal to distance off*. The distance run is calculated (speed x time).



In the example above, waiting until the angle is abeam (090° Red) is of academic interest only if a safe distance off is required to round a headland. However, any isosceles triangle will provide *distance run is equal to distance off*. The example below demonstrates how earlier and finer bearings would have provided forewarning of the intended course line's proximity to the headland.

Example:

A ship steaming 050° (True) at 12 knots observes a lighthouse at 12:00 which bears 030° (Red). At 12:30 the lighthouse 060° (Red).

Time between bearings	=	30 minutes (0.5 hrs)
So distance run	=	12×0.5 miles = 6.0 nautical miles
So distance off	=	<u>6.0 n.miles</u>