

NauticTools2

Compendium

Coastal navigation, celestial navigation and tides
Methods, formulas, examples

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NauticTools2 Compendium
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The tidal calculations are approximations. Tidal curves are redrawn and are not original curves of the UKHO or the BSH.

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Preface

In the 1990s I learned to sail dinghies on Lake Constance. Back then a friend took me along on a night passage across the lake in a small keelboat. On that trip he showed me how to fix our position with cross bearings.

It fascinated me, and that fascination for navigation has stayed with me ever since. Step by step I took all the German sailing licences. I took the SHS, the German offshore licence, only to learn how celestial navigation works. To me it is still the supreme discipline of navigation.

Once I no longer had to study for exams, I started writing a small program for myself so that I could apply what I had learned on the PC as well. When my friends saw what it had become, they urged me to offer the program on the internet.

In 2000 I put the first version of NauticTools online, and I was delighted by the reactions and feedback from its users.

Because of my job I then lacked the time to keep NauticTools up to date. It remained available for download until the end, but it was built for Windows XP and was barely usable on newer versions of Windows.

I always regretted that NauticTools was about to sink into oblivion. So at the beginning of 2026 I decided to rewrite the program from scratch. The result surprised even me: thanks to the new possibilities of modern programming, it has become, in my eyes, a complete and modern program. The 18 tools of the old NauticTools have grown to more than 30, and they cover almost everything that can be calculated in navigation.

On 11 September 2026 I released NauticTools2 in the Microsoft Store, and a little later on Google Play as well. Once again the response was very positive. Many users still remember the old NauticTools and are glad that there is something new. I have also made interesting new contacts who support me.

This compendium explains every tool in the app. Besides formulas and examples, it also contains valuable background knowledge on each navigation method.

I hope you enjoy using this compendium, and of course NauticTools2, as much as I enjoyed programming it.

Markus Eisenbart
Kirchlengern, Germany, November 2026

PART I

Coastal Navigation

Courses, bearings, tidal streams and dead reckoning: everything you can work out with chart, compass and log.

PART I · COASTAL NAVIGATION

1 Time Systems

Time at sea – from UTC to apparent local time

On board, several clocks run side by side: **UTC** for radio, weather and celestial navigation, **ship's time** for the watch system, the **legal time** of the next port – plus the times that follow from your own longitude. NauticTools2 works them all out from a single UTC moment and your longitude.

`UTC` `Zone time` `Longitude in time` `Local mean time` `Apparent time` `Equation of time`

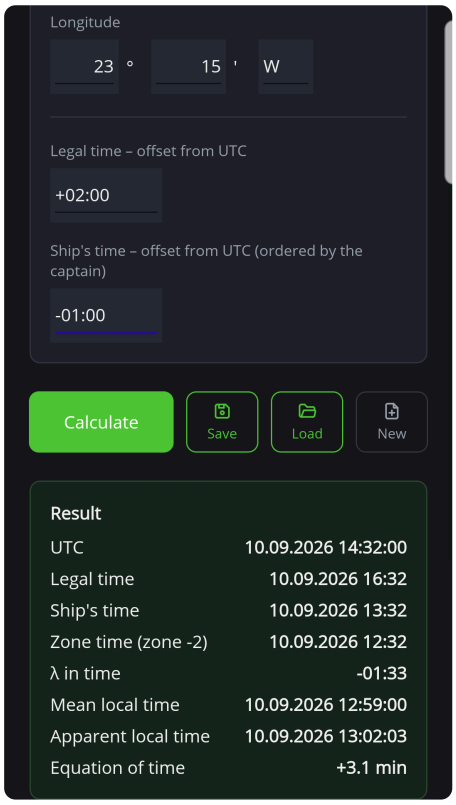


Figure 1.1 Time systems in the Android version: enter UTC and longitude, and every time system appears in one list.

1.1 Which time systems are there?

- **UTC** (Coordinated Universal Time) – the common reference, formerly called GMT. The nautical almanac, radio traffic and weather reports all use UTC.
- **Zone time** – the earth is divided into 24 zones of 15° of longitude, one hour apart. Zone time is the standard time of the zone you are in.
- **Legal time** – the time a country sets officially, including daylight saving time. It is a political decision and cannot be derived from position.
- **Ship's time** – the time life on board runs by. The skipper sets it and, on long passages, changes it step by step.
- **Longitude in time** – your longitude expressed in hours and minutes.

- **Local mean time (LMT)** – the time of your own meridian, based on an imaginary, evenly moving “mean sun”.
- **Local apparent time (LAT)** – the time a sundial shows at your position. At 12:00 LAT the sun is exactly due south (or due north).
- **Equation of time** – the difference between apparent and mean time.

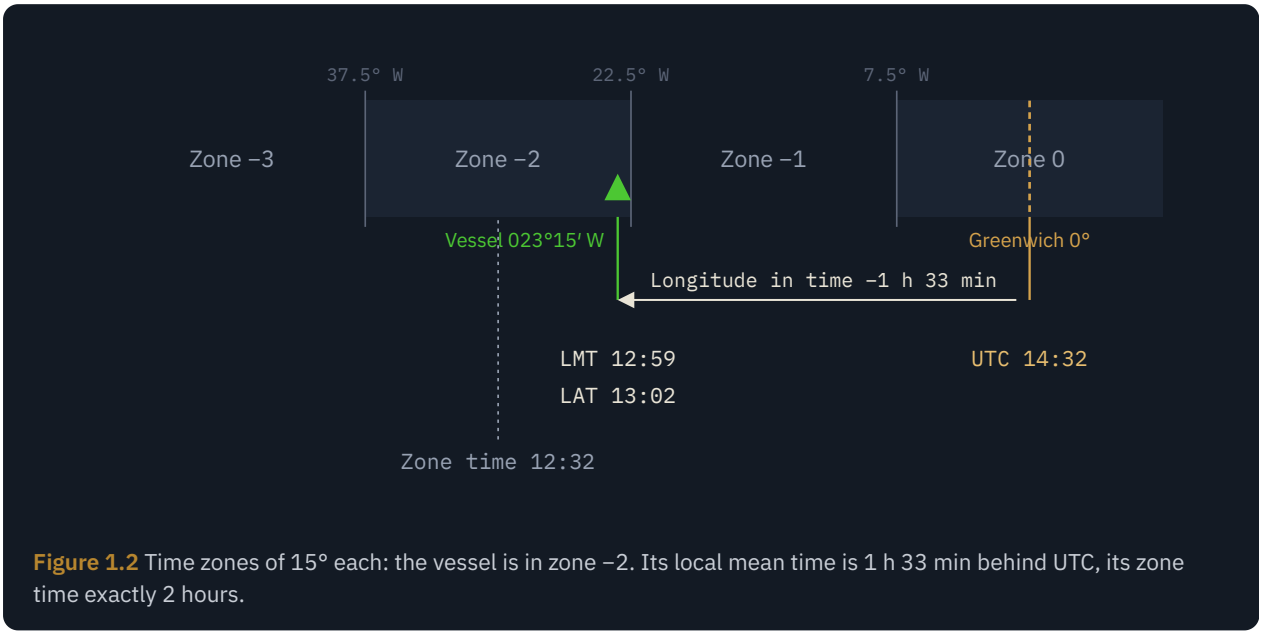


Figure 1.2 Time zones of 15° each: the vessel is in zone −2. Its local mean time is 1 h 33 min behind UTC, its zone time exactly 2 hours.

1.2 When do you need it?

- **Celestial navigation:** The positions of celestial bodies in the nautical almanac are tabulated against UTC. If you note the time of a sight in ship's time, convert it to UTC first.
- **Planning a noon sight:** The sun culminates at 12:00 apparent local time. With the equation of time and longitude in time you get the UTC and ship's time of the noon sight.
- **Long passages:** Sailing east or west you cross the zones. Ship's time is then changed an hour at a time, usually at night, so that daylight and watches stay in step.
- **Radio, weather and port:** Weather reports and navigational warnings come in UTC, while harbour offices and locks work to legal time.

1.3 Formulas and working

> `LMT = UTC + longitude in time` · `LAT = LMT + EoT`

East longitude counts positive, west longitude negative. The individual steps, as the working in NauticTools2 shows them:

1. **Zone number**
   Longitude divided by 15°, rounded to the nearest whole number: `zone = λ / 15°`
2. **Zone time**
   `ZT = UTC + zone number` (in hours)

3. **Longitude in time**
   15° equal one hour, so `1° = 4 min` and `1′ = 4 s`.
4. **Local mean time**
   `LMT = UTC + longitude in time`
5. **Equation of time**
   The difference between the true and the mean sun, expressed in time. NauticTools2 calculates it for the exact moment from the position of the sun.
6. **Local apparent time**
   `LAT = LMT + equation of time`
7. **Legal time and ship's time**
   `UTC + the offset you enter`, for example +1 h for British Summer Time.

Zone description: In British and US practice the zone is often given as the *zone description* (ZD), the correction from zone time to UTC – with the opposite sign. Zone −2 in NauticTools2 corresponds to ZD +2: UTC = ZT + 2 h. The old rhyme still helps: “Longitude west, Greenwich time best; longitude east, Greenwich time least.”

1.4 Worked example

A vessel is at 023°15.0′ W on 10 September 2026 at 14:32 UTC. Legal time at the port of destination is UTC+2, and the ship keeps UTC−1 on board. Which times apply right now?

```
Zone number = −23.25° / 15° = −1.55 → zone −2 (ZD +2)
Zone time = 14:32 − 2 h = 12:32
Longitude in time = 23° · 4 min + 15′ · 4 s = 92 min + 60 s = −1 h 33 min
Local mean time = 14:32 − 1:33 = 12:59:00
Equation of time ≈ +3.1 min (on 10 September)
Apparent time = 12:59:00 + 3 min 03 s = 13:02:03
Legal time = 14:32 + 2 h = 16:32
Ship's time = 14:32 − 1 h = 13:32
```

1.5 Things to watch out for

- **Signs:** East of Greenwich local time is later than UTC, west of it earlier.
- **Date:** At large longitudes or close to midnight, the date changes along with the time. That is why NauticTools2 shows the date with every time.
- **Sign of the equation of time:** Some textbooks define it the other way round (mean minus apparent time). Here: apparent time = mean time + equation of time.
- **Don't guess legal time:** Many countries differ from “their” zone – Spain and France, for example – and daylight saving time comes on top. Look the offset up and enter it.

1.6 How it works in NauticTools2

1. **Enter UTC**
   Date and time in UTC. Short forms such as `100926` for the date or `1432` for the time are completed automatically.
2. **Enter longitude**
   Degrees, minutes and east/west. If a GPS position is available, the longitude is already filled in.
3. **Enter offsets (optional)**
   Legal time and ship's time as an offset from UTC, for example `+2:00` or `-1:30`. Leave them empty and NauticTools2 works out only the times that follow from longitude.
4. **Calculate**
   All time systems appear in one list, with the working below. Inputs can be saved, loaded and printed as a calculation record.

1.7 Frequently asked questions

How do you convert longitude into time?
15° of longitude equal one hour, so 1° = 4 minutes and 1′ = 4 seconds. 023°15′ W is 92 minutes plus 60 seconds, that is 1 h 33 min.

What is the difference between zone time and legal time?
Zone time follows from longitude alone. Legal time is set by each country, often different from the zone and with daylight saving time. At sea you keep zone time, in port legal time.

Why does a sundial differ from local mean time?
The earth moves on an elliptical orbit and its axis is tilted, so the true sun crosses the sky unevenly. The equation of time makes up for this. In February a sundial is about 14 minutes slow, in early November about 16 minutes fast.

1.8 See also

- **Meridian Passage** (chapter 21) – when the sun crosses your meridian
- **Ephemeris Calculation** (chapter 17) – positions of celestial bodies for a UTC moment
- **Latitude by Meridian Altitude** (chapter 22) – latitude from the sun's altitude at noon

PART I · COASTAL NAVIGATION

2 Magnetic Declination

Magnetic variation – where does the compass really point?

A compass needle does not point to the geographic North Pole but to **magnetic north**. The angle between the two is the **magnetic variation**, also called magnetic declination. It depends on where you are and changes over the years. NauticTools2 calculates it for any position and any date from 1900 to 2030.

Position | Date | Variation east/west | Annual change | IGRF model

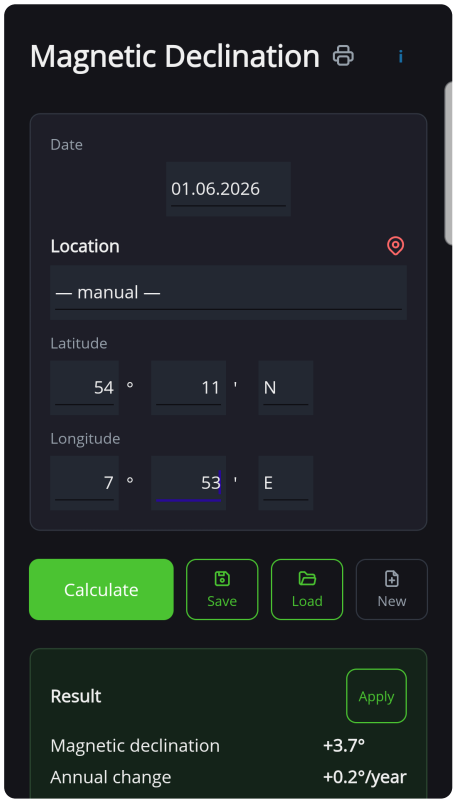


Figure 2.1 Magnetic declination in the Android version: enter date and position, and the variation and its annual change appear at once.

2.1 What is magnetic variation?

There are two “norths”: **true north** points to the geographic North Pole, which charts and meridians refer to. **Magnetic north** is the direction an undisturbed compass needle points – it follows the field lines of the earth's magnetic field.

The angle between them is the variation. If the needle points east of true north, the variation is **east** and counts positive; if it points west of true north, it is **west** and negative.

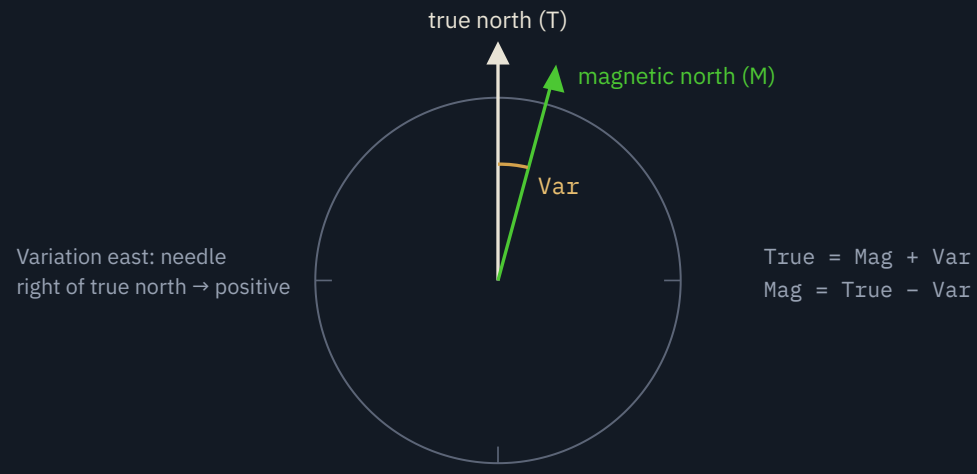


Figure 2.2 Variation east: the compass needle points slightly to the right of true north. The angle is exaggerated for clarity.

2.2 When do you need it?

- **Converting courses and bearings:** Every course taken from the chart is true, every compass course is magnetic (plus deviation). Without the variation you cannot turn a chart course into a course to steer.
- **Old charts and textbook exercises:** The variation on a chart applies to a certain year. NauticTools2 gives you the exact value for today – or for the year of an old exercise.
- **Checking the compass:** To find the deviation of a steering compass you need the variation at your current position.

2.3 Calculation and the chart value

NauticTools2 calculates the variation with the **IGRF** (International Geomagnetic Reference Field), the official reference model of the earth's magnetic field. The international association IAGA publishes a new edition every five years; it describes the field as a series of spherical harmonics, so there is no hand formula for it. The model in the app covers the years 1900 to 2030.

Without a calculator, you update the variation printed on the chart. The compass rose gives a value with a reference year and the annual change:

```
Var now = Var on chart + annual change · years
```

1. **Read the chart**
   Variation, reference year and annual change from the compass rose.
2. **Count the years**
   Number of years from the reference year to today.
3. **Update**
   Add annual change times years to the chart value – mind the signs: east positive, west negative.

2.4 Worked examples

What is the variation at Heligoland (54°11′ N, 007°53′ E) on 1 June 2026?

```
Variation = +3.7° (3.7° east)
Annual change = +0.2° per year (about 10′ east)
```

An old chart gives for Heligoland: Var 1.6° W (1990), annual change 6′ E. What does updating give for 2026 – and what does the model say?

```
Updated chart value = −1.6° + 36 · 6′ = −1.6° + 3.6° = +2.0°
IGRF for 2026 = +3.7°
Difference ≈ 1.7°
```

The second example shows why old chart values need care: the annual change is not constant itself. At Heligoland it has sped up from 6′ to about 10′ per year since 1990.

2.5 Things to watch out for

- **Signs:** East positive, west negative – throughout NauticTools2. Mixing them up is one of the most common mistakes in course conversion. The old rhyme helps: “Variation east, compass least; variation west, compass best.”
- **Local magnetic anomalies:** In some sea areas, ore deposits in the seabed make the variation differ noticeably from the model. Such areas are marked on the chart as “local magnetic disturbance”.
- **Variation is not deviation:** Variation comes from the earth's magnetic field, deviation from your own boat (engine, steel, electronics). Together they make up the compass error.
- **Model limits:** The IGRF is a very good approximation, but it does not replace official charts in areas with known anomalies.

2.6 How it works in NauticTools2

1. **Choose the date**
   Today's date is filled in. For old exercises, simply enter the year of the exercise.
2. **Enter the position**
   Latitude and longitude by hand, from a saved waypoint or – if available – from GPS. A position you enter can be saved as a waypoint straight away.
3. **Calculate**
   NauticTools2 shows the variation and its annual change.
4. **Use as reference value**
   “Apply” makes the value the default for all other tools, such as course and bearing conversion.

2.7 Frequently asked questions

Are variation and declination the same?
Yes. “Magnetic declination” is the term used in geophysics, while navigators usually say “variation”. Both mean the same angle. Do not confuse it with the declination of a celestial body in celestial navigation.

How accurate is the calculation?
In open waters the IGRF is usually within half a degree of the actual value – about as precise as a boat compass can be read.

Why does the variation change?
The earth's magnetic field is generated by currents in the liquid outer core and changes constantly. The magnetic North Pole moves by dozens of kilometres a year.

2.8 See also

- **Course Conversion** (chapter 4) – from chart course to course to steer and back
- **Bearing Conversion** (chapter 10) – convert a compass bearing into a true bearing
- **Compass Check by the Sun** (chapter 24) – find compass error and deviation with the sun

PART I · COASTAL NAVIGATION

3 Current Triangle

Current triangle – where does the stream set me?

A vessel steering a course through the water is also set by the tidal stream or current. Its track over the ground is the **water track** plus the **current** – drawn as the **current triangle**. NauticTools2 solves all three classic tasks, draws the triangle and shows the full working.

`CTW · STW` `COG · SOG` `Set · drift` `Correction angle` `Plot`

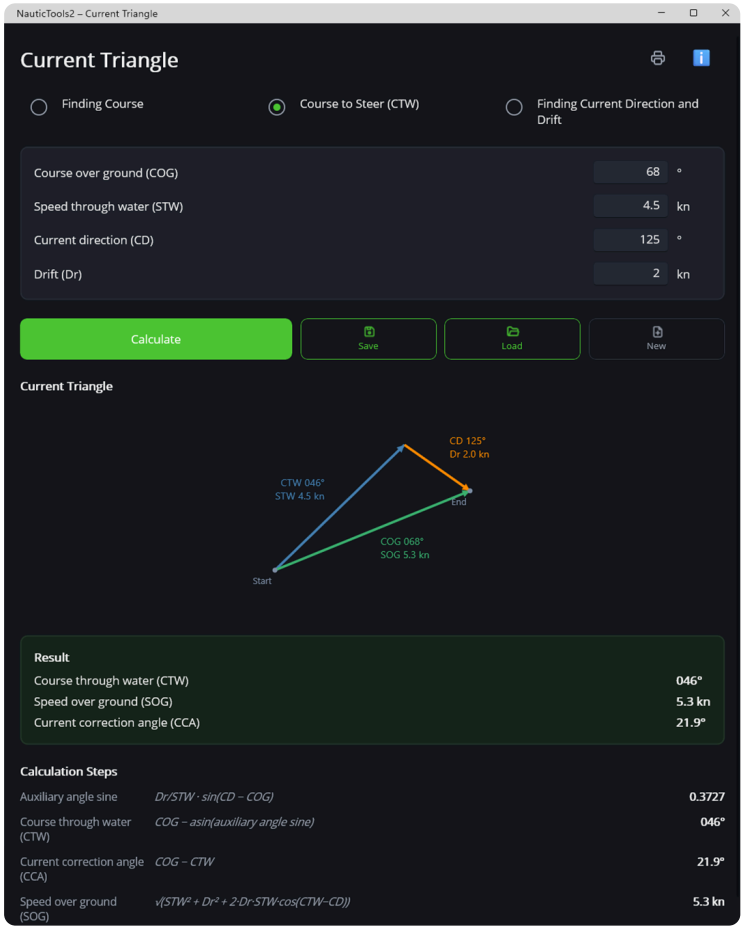


Figure 3.1 Current triangle in the Windows version: choose the task, enter four values – triangle, result and working.

3.1 What is the current triangle?

Six values describe a passage in a stream: course and speed through the water (**CTW, STW**), the direction and rate of the current (**set and drift**), and course and speed over the ground (**COG, SOG**). Laid end to end as arrows they form a triangle: water track plus current gives the ground track. Know four of the six and the other two follow.

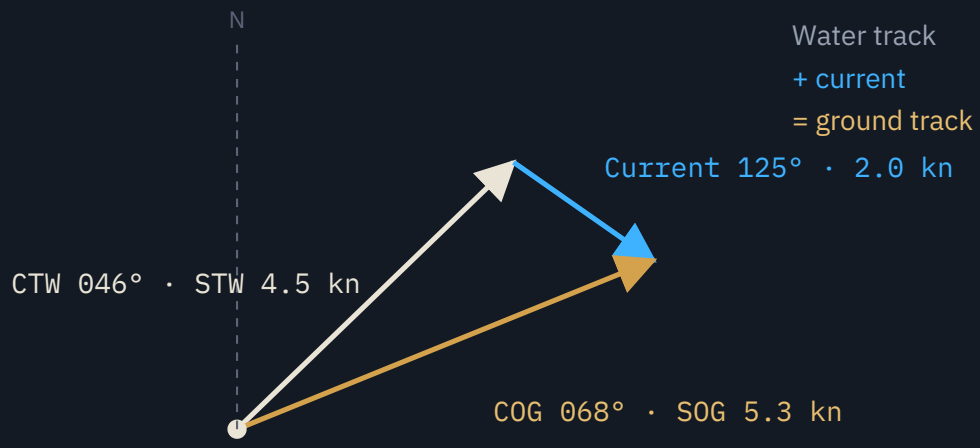


Figure 3.2 The triangle of the example below: steering 046° at 4.5 kn through the water with a 2 kn current setting 125° gives 068° at 5.3 kn over the ground.

3.2 The three tasks

- **Where will I end up?** Known CTW, STW, set and drift – find COG and SOG.
- **What course do I steer?** Known COG, STW, set and drift – find the course to steer (CTW) and the SOG.
- **What is the current?** Known CTW, STW, COG and SOG (for example from GPS) – find set and drift.

All three also give the **current correction angle (CCA)** between CTW and COG, which feeds into course conversion.

3.3 When do you need it?

- **Shaping a course in tidal waters:** What course must I steer to reach the fairway buoy across the stream?
- **Dead reckoning:** Where will I be after an hour if the stream sets me sideways?
- **Finding the current:** GPS (COG, SOG) together with log and compass (CTW, STW) reveal the actual current – for comparison with the tidal stream atlas.

3.4 Formulas and working

NauticTools2 works with the north and east components of the arrows. For “where will I end up?”:

> `N = STW · cos CTW + drift · cos set  ·  E = STW · sin CTW + drift · sin set`

1. **Course over ground**
   `COG = arctan(E / N)`, in the right quadrant.
2. **Speed over ground**
   `SOG = √(N² + E²)`

3. **Correction angle**
   `CCA = COG − CTW`

Course to steer: Use the auxiliary angle α between CTW and COG: `sin α = drift · sin(set − COG) / STW`, then `CTW = COG − α` and `SOG = STW · cos α + drift · cos(set − COG)`. If the current is stronger than your own speed there may be no solution – the destination cannot be reached against the stream.

3.5 Worked examples

What course do I steer? You want to make good 068° over the ground. The log shows 4.5 kn, the current sets 125° at 2 kn.

```
set − COG = 125° − 068° = 57°
sin α = 2 · sin 57° / 4.5 = 0.373 → α = 21.9°
CTW = 068° − 21.9° ≈ 046°
SOG = 4.5 · cos 21.9° + 2 · cos 57° = 4.18 + 1.09 ≈ 5.3 kn
```

Where will I end up? You steer 046° at 4.5 kn, the current sets 125° at 2 kn.

```
N = 4.5 · cos 46° + 2 · cos 125° = 3.13 − 1.15 = 1.98
E = 4.5 · sin 46° + 2 · sin 125° = 3.24 + 1.64 = 4.88
COG = arctan(4.88 / 1.98) ≈ 068°, SOG = √(1.98² + 4.88²) ≈ 5.3 kn
```

3.6 Things to watch out for

- **Set means “towards”:** Unlike wind, the direction of a current is where it flows *to*. A current setting 125° comes from the north-west.
- **The stream changes:** In tidal waters set and rate change every hour. For longer passages work the triangle hour by hour or use an average.
- **Leeway first:** Leeway belongs in course conversion between true course and water track. The current triangle starts from the course through the water.
- **Speed through the water, not over the ground:** The log measures speed through the water – that is what goes into the triangle.

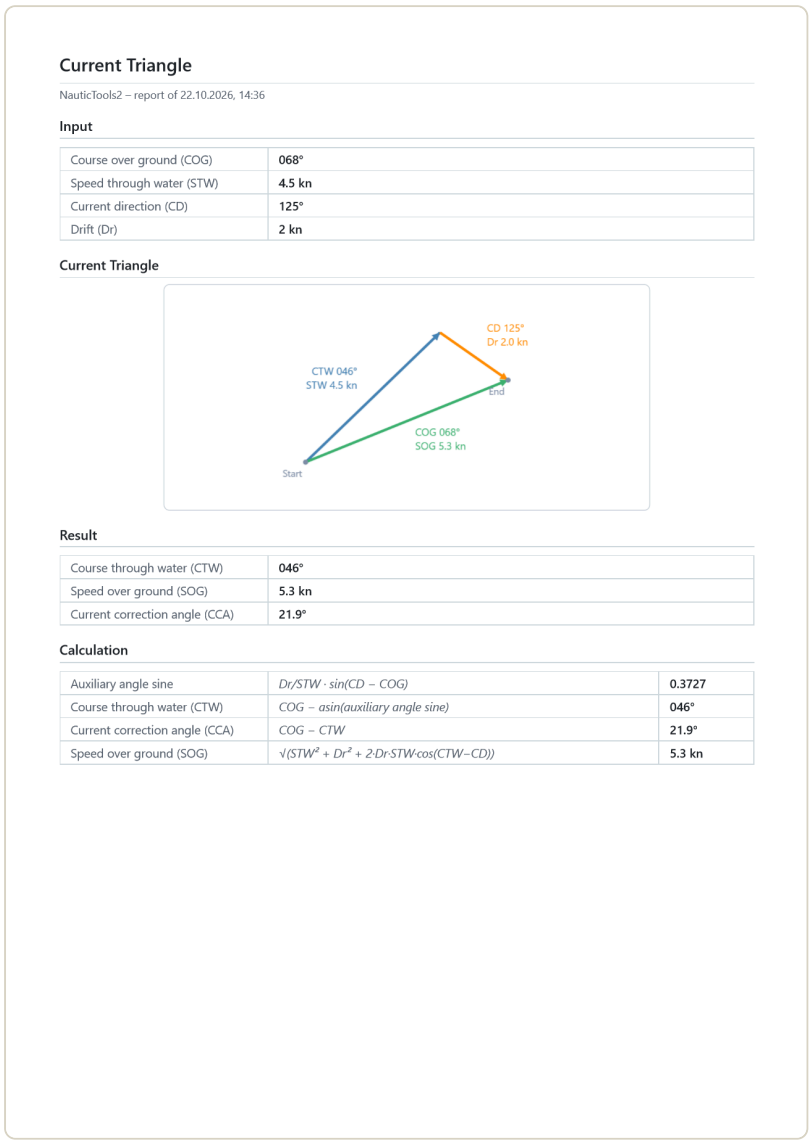
3.7 How it works in NauticTools2

1. **Choose the task**
   Where will I end up, what course do I steer, or what is the current.
2. **Enter four values**
   The known courses and speeds.

3. **Calculate**
   The triangle is drawn and the result and working appear. If course conversion is open, it takes over the correction angle and course automatically.

3.8 Printable calculation record

Every current calculation can be printed as a clear record or saved as a PDF – with inputs, current triangle, result and the full working.



Current Triangle

NauticTools2 – report of 22.10.2026, 14:36

Input

Course over ground (COG)	068°
Speed through water (STW)	4.5 kn
Current direction (CD)	125°
Drift (Dr)	2 kn

Current Triangle

Result

Course through water (CTW)	046°
Speed over ground (SOG)	5.3 kn
Current correction angle (CCA)	21.9°

Calculation

Auxiliary angle sine	*Dr/STW · sin(CD − COG)*	0.3727
Course through water (CTW)	*COG − asin(auxiliary angle sine)*	046°
Current correction angle (CCA)	*COG − CTW*	21.9°
Speed over ground (SOG)	*√(STW² + Dr² + 2·Dr·STW·cos(CTW−CD))*	5.3 kn

Figure 3.3 The printed record of the example COG 068°, STW 4.5 kn, current 125°/2 kn.

3.9 Frequently asked questions

What is the difference between current and leeway?

The current moves the whole body of water with the boat in it; leeway is the wind pushing the boat sideways through the water. That is why leeway belongs in course conversion and the current in the current triangle.

Where do I get set and drift from?
From the tidal stream atlas, the tidal diamonds on the chart or tide tables – or afterwards from GPS and log with the third task.

Why is speed over the ground sometimes higher than through the water?
When the current has a component in your direction of travel, it pushes you along. Against the stream, speed over the ground is lower.

3.10 See also

- **Course Conversion** (chapter 4) – from compass course to course over ground
- **Dead Reckoning** (chapter 12) – position from course and distance
- **Distance, Speed and Time** (chapter 7) – arrival time with speed over ground

PART I · COASTAL NAVIGATION

4 Course Conversion

Course conversion – from compass course to course over ground

The course the helmsman steers on the compass is not the course the boat makes over the ground. In between lie **deviation**, **variation**, **leeway** and **tidal stream**. Course conversion works through this chain in both directions – NauticTools2 from any of the five courses.

`Compass` `Magnetic` `True` `Through water` `Over ground` `Steering table` `Gyro compass`

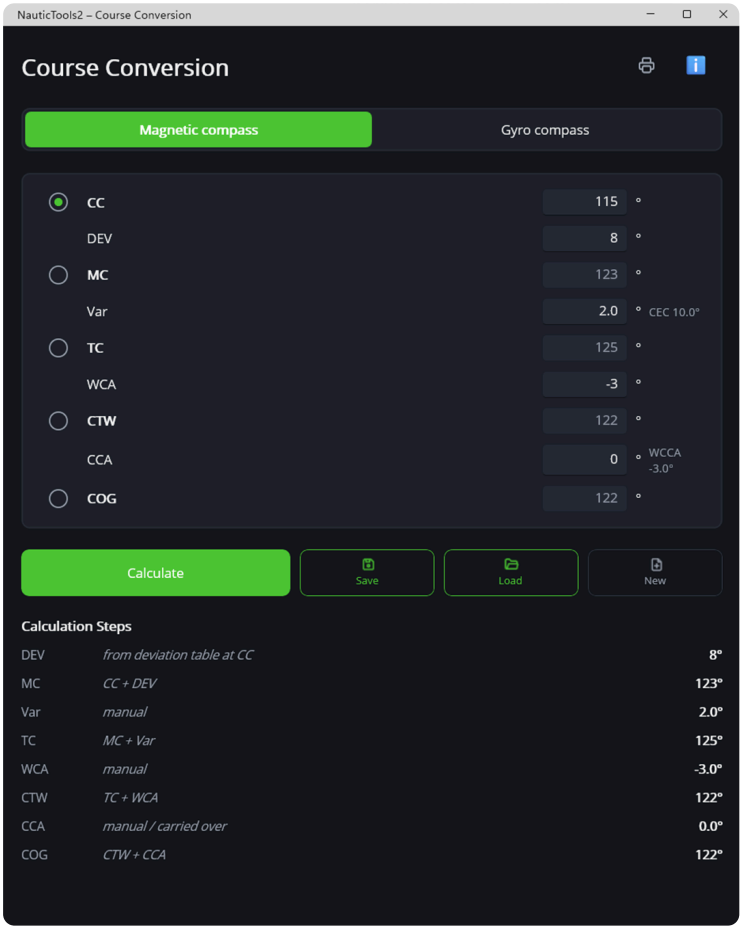


Figure 4.1 Course conversion in the Windows version: choose the known course, enter the corrections, and the whole chain appears with full working.

4.1 The course chain

Each step in the chain has its own course and its own correction. NauticTools2 uses the abbreviations shown in brackets:

- **Compass course** (CC) – the course on the compass.
- **Deviation** (DEV) – compass error caused by the boat itself (engine, steel, electronics). It depends on the heading and comes from the deviation card.

- **Magnetic course** (MC) – relative to magnetic north.
- **Variation** (Var) – the difference between magnetic and true north.
- **True course** (TC) – relative to true north: the course on the chart.
- **Wind correction angle** (WCA) – the leeway caused by the wind.
- **Course through the water** (CTW) – the water track.
- **Current correction angle** (CCA) – the angle by which the tidal stream or current sets the boat.
- **Course over ground** (COG) – the ground track the boat actually makes good.

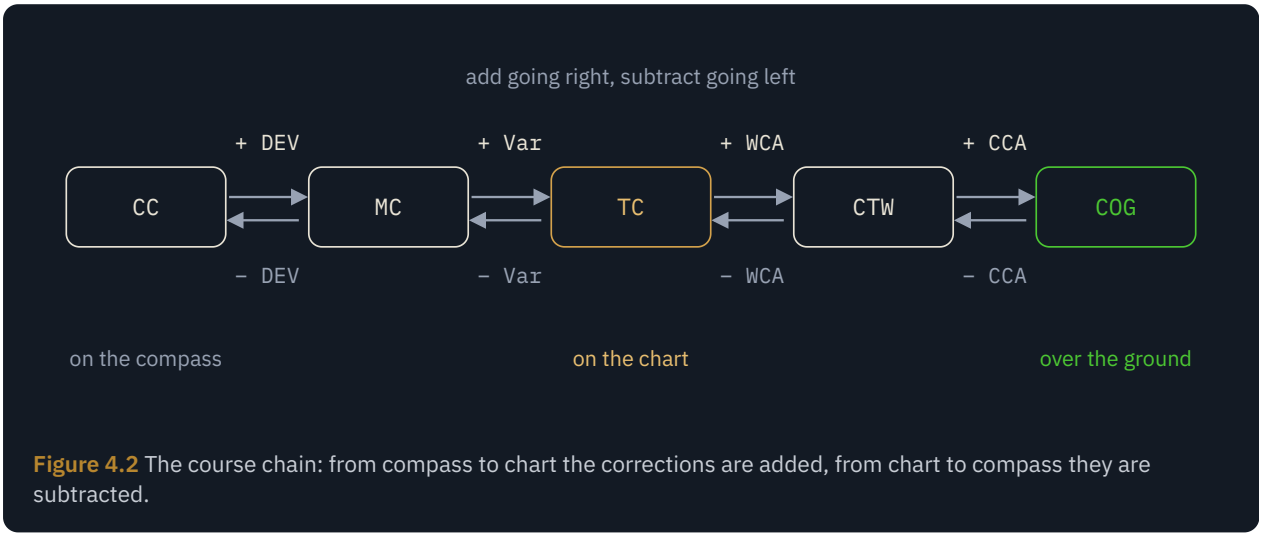


Figure 4.2 The course chain: from compass to chart the corrections are added, from chart to compass they are subtracted.

4.2 When do you need it?

- **Laying off a course:** On the chart you draw a course over ground. The helmsman, however, needs a compass course – the chain is worked from right to left.
- **Dead reckoning:** The compass course steered gives the course over ground used to plot the DR or EP – the chain is worked from left to right.
- **Checking your track:** If the actual course over ground differs from the planned one, the chain helps to find out whether tide, leeway or the compass is to blame.

4.3 Formulas and working

> `CC + DEV + Var + WCA + CCA = COG`

Signs: deviation and variation east are positive, west negative. Leeway and set to starboard are positive, to port negative. The classic memory aid is **CADET**: “Compass ADd East to get True”.

1. **Deviation**
   `MC = CC + DEV` – deviation from the deviation card for the compass course steered.
2. **Variation**
   `TC = MC + Var`

3. **Leeway**
   `CTW = TC + WCA` – wind on the port side: positive, on the starboard side: negative.
4. **Tidal stream**
   `COG = CTW + CCA` – the stream correction comes from the current triangle.

Converting back and the steering table: Working from course over ground to compass course you subtract the corrections. In the last step, though, the deviation is missing – it depends on the compass course you are looking for. The answer is a **steering table**: it is ordered by magnetic course and gives the matching deviation. NauticTools2 derives it automatically from the deviation card.

4.4 Worked examples

You steer 115° by compass. Deviation is +8°, variation 2° E, leeway −3°, and there is no tidal stream. What is your course over ground?

```
MC = 115° + 8° = 123°
TC = 123° + 2° = 125°
CTW = 125° − 3° = 122°
COG = 122° + 0° = 122°
```

Otherwise unchanged, you want to make good 110° over the ground. What compass course do you steer? The steering table gives a deviation of +9° for a magnetic course of 111°.

```
CTW = 110° − 0° = 110°
TC = 110° − (−3°) = 113°
MC = 113° − 2° = 111°
CC = 111° − 9° = 102°
```

4.5 With a gyro compass

On ships with a gyro compass, deviation and variation do not apply. Instead there is the fixed gyro error **(GA)** and the **speed error correction (SEC)**:

```
GC + GA + SEC = TC
```

NauticTools2 can work out the speed error itself from latitude and speed: `sin SEC = −v · cos GC / (902.46 · cos ϕ)`. From the true course onwards the chain continues as usual.

You steer GC 000° at 20 kn in 54° N. GA is +0.5°, WCA +2°, CCA −3°.

```
SEC = arcsin(−20 · cos 0° / (902.46 · cos 54°)) = −2.2°
TC = 000° + 0.5° − 2.2° = 358°
CTW = 358° + 2° = 000°
COG = 000° − 3° = 357°
```

4.6 Things to watch out for

- **Be consistent with signs:** Almost all mistakes in course conversion are sign errors. East and starboard are positive – for every correction.
- **Deviation for the right heading:** The deviation card applies to the compass course. Looking it up for the true or magnetic course can be several degrees out, depending on the card.
- **Whole degrees:** Courses are steered in whole degrees. NauticTools2 rounds all courses and the deviation from the card accordingly.
- **Beyond 360°:** If the result is more than 360° or less than 0°, subtract or add 360°.

4.7 How it works in NauticTools2

1. **Choose the known course**
   On the left, choose which of the five courses is known – NauticTools2 works in both directions from there.
2. **Enter the corrections**
   Deviation and variation are filled in automatically: deviation from the active deviation card, variation from the settings. A value you type yourself takes priority.
3. **Take over the tidal stream**
   If the current triangle is open, course conversion takes over its result live, without pressing a button.
4. **Gyro compass**
   The switch at the top replaces the magnetic compass with gyro course, gyro error and speed error.

4.8 Printable calculation record

Every conversion can be printed as a clear record or saved as a PDF – with the whole course chain from compass course to course over ground and the working of each step, including the deviation from the deviation table.



Course Conversion

NauticTools2 – report of 22.10.2026, 14:08

Course chain

CC (known)	115°
+ DEV	8°
MC	123°
+ Var	2.0°
TC	125°
+ WCA	-3°
CTW	122°
+ CCA	0°
COG	122°

Calculation

DEV	*from deviation table at CC*	8°
MC	*CC + DEV*	123°
Var	*manual*	2.0°
TC	*MC + Var*	125°
WCA	*manual*	-3.0°
CTW	*TC + WCA*	122°
CCA	*manual / carried over*	0.0°
COG	*CTW + CCA*	122°

Figure 4.3 The printed record of a course conversion from CC 115° to COG 122°.

4.9 Frequently asked questions

What is the difference between deviation and variation?
Variation comes from the earth's magnetic field and depends on where you are. Deviation comes from your own boat and depends on the heading. Together they make up the compass error: `error = Dev + Var`.

Where does the tidal stream correction come from?
From the current triangle: course and speed through the water together with the set and rate of the stream give the course over ground. The angle between water track and ground track is the stream correction.

How do I find the deviation of my compass?
By comparing it with a known true direction, such as a transit or the azimuth of the sun. The results for all headings go into a deviation card.

4.10 See also

- **Current Triangle** (chapter 3) – the current triangle and the stream correction
- **Magnetic Declination** (chapter 2) – current variation for any position and date
- **Bearing Conversion** (chapter 10) – the same chain for bearings
- **Compass Check by the Sun** (chapter 24) – find the deviation with the sun

PART I · COASTAL NAVIGATION

5 Geographical Range of Lights

Geographical range – how far away is the light?

When a lighthouse first appears above the horizon on your approach to the coast, it is **rising**. At that very moment the distance to the light follows from just two numbers: your **height of eye** and the **height of the light** – no radar, no second bearing.

`Height of eye` `Height of light` `Distance to horizon` `Distance in nm` `Full working`

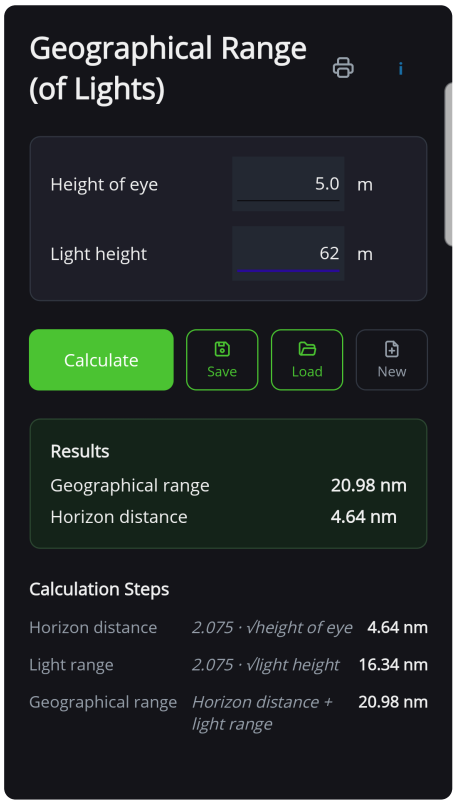


Figure 5.1 Geographical range in the Android version: enter height of eye and height of the light, and the distance, the distance to the horizon and the working appear at once.

5.1 What does “rising” and “dipping” mean?

Because the earth is curved, a distant light is hidden below the visible horizon. As you close the coast, the light eventually appears just above the horizon for the first time – it is **rising**. Sailing away, it sinks below the horizon again and disappears – it is **dipping**. The distance at that moment is the **geographical range** of the light for your height of eye.

This distance is made up of two parts that meet exactly at the horizon: from your eye to the horizon, and from the horizon to the light.

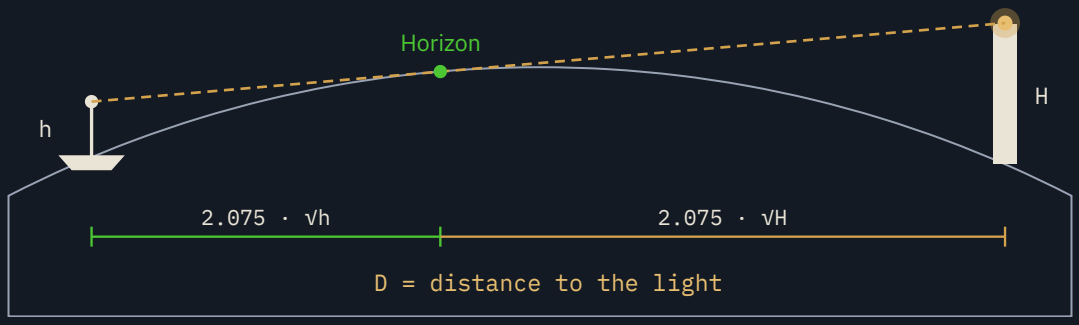


Figure 5.2 The curvature of the earth is greatly exaggerated. h = height of eye, H = height of the light.

5.2 When do you need it?

- **Fixing your position at night:** Take a bearing of the light the moment it rises and you have a bearing and a distance from a known point – a fix without a second object.
- **Planning a landfall:** Estimate in advance when and at what distance a light should come into view. If it stays out of sight longer than expected, your dead reckoning position is probably off.

5.3 Formula and working

```
D = 2.075 · ( √h + √H )
```

- **D** – distance to the light in nautical miles (nm)
- **h** – height of eye in metres: the height of your eye above the water
- **H** – height of the light in metres, from the chart or the list of lights

The calculation takes three steps – exactly as the working in NauticTools2 shows it:

1. **Distance to the horizon**
   How far does your own horizon reach? `2.075 · √h`
2. **Range of the light**
   From how far away is the light visible above the horizon? `2.075 · √H`
3. **Geographical range**
   Add both parts: `D = distance to horizon + range of the light`

Why 2.075? Pure geometry would give a factor of about 1.93. Light is bent slightly towards the earth in the atmosphere (*terrestrial refraction*), so you can see a little further. Some textbooks round it to 2.08 or 2.1; with heights in feet the factor is about 1.15. The result changes only slightly.

5.4 Worked example

From a height of eye of 5 m, a light with a height of 62 m rises on the horizon. How far away is the light?

```
Distance to horizon = 2.075 · √5 = 2.075 · 2.236 ≈ 4.64 nm
Range of the light = 2.075 · √62 = 2.075 · 7.874 ≈ 16.34 nm
Geographical range = 4.64 + 16.34 ≈ 20.98 nm
```

How far away is the horizon from a height of eye of 3 m?

```
Distance to horizon = 2.075 · √3 = 2.075 · 1.732 ≈ 3.59 nm
```

5.5 Things to watch out for

- **Luminous range:** The calculation only holds if the light is bright enough. If its luminous range (given in nm on the chart) is shorter than the calculated distance, the light only becomes visible within that range – it does not rise on the horizon.
- **Loom:** With powerful lights you often see their glow in the sky or on the clouds well before. What counts is the moment the light itself appears above the horizon.
- **Be honest about height of eye:** On a sailing yacht it is usually 2 to 3 m in the cockpit. Stand up or climb onto the coachroof and you see further.
- **An approximation:** Refraction varies with the weather, so the result is a good guide rather than an exact distance.

5.6 How it works in NauticTools2

1. **Enter the heights**
   Height of eye and height of the light in metres.
2. **Calculate**
   NauticTools2 shows the distance to the light and the distance to the horizon, with the full working of all three steps below.
3. **Save and print**
   Inputs can be saved under a name of your choice and loaded again later, and the result can be printed as a calculation record – handy for exercises.

5.7 Frequently asked questions

How do I work out just the distance to the horizon?

With 2.075 · √height of eye. From 2 m that is about 2.9 nm, from 10 m about 6.6 nm.

What is the difference between luminous range and geographical range?

The luminous range depends on the brightness of the light and is printed on the chart. The geographical range – what is calculated here – depends only on the heights and the curvature of the earth. You see the light only when you are within both.

And if the light is already well above the horizon?

Then this formula no longer helps. You can find the distance instead with a **vertical sextant angle** (chapter 6): measure the angle between the waterline and the light.

5.8 See also

- **Distance by Vertical Angle** (chapter 6) – distance to an object of known height from the sextant angle
- **Bearing Conversion** (chapter 10) – convert the bearing of the light to a true bearing
- **Distance, Speed and Time** (chapter 7) – when will you reach the light at your current speed?

PART I · COASTAL NAVIGATION

6 Distance by Vertical Angle

Distance by vertical sextant angle – measuring range with a sextant

Measure the **vertical angle** of an object of known height – a lighthouse, a church tower or a mountain – with a sextant, and you can work out its **distance**. Together with a bearing, that gives you a fix.

`Vertical angle` `Object height` `Base visible / hidden` `Height of eye` `Distance in nm`

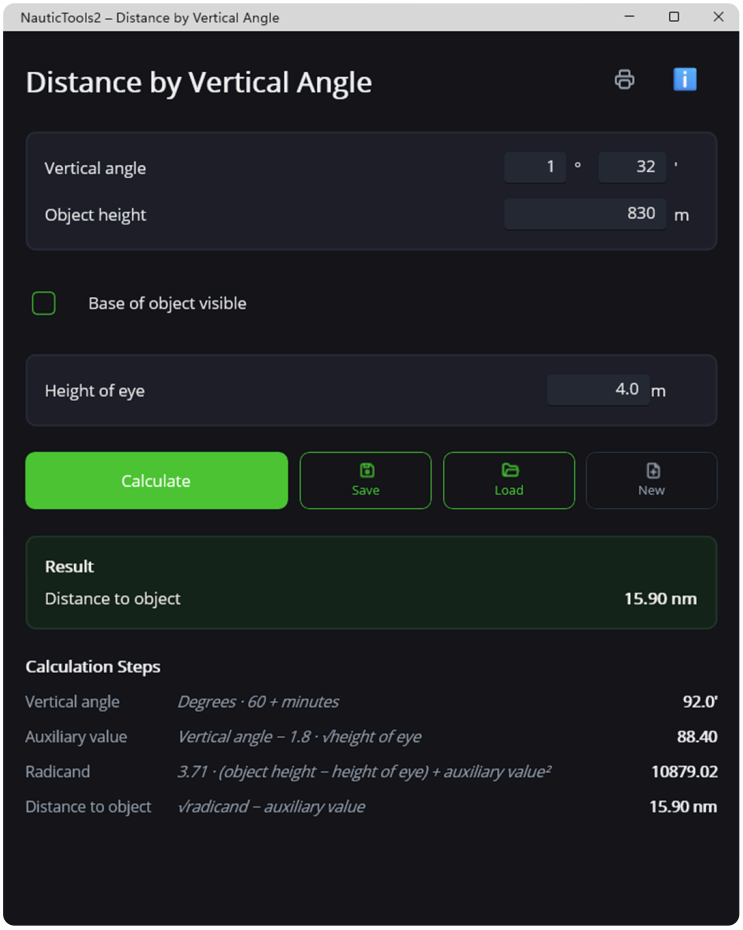


Figure 6.1 Distance by vertical angle in the Windows version: enter the angle, the object height and, if needed, the height of eye – distance and working appear at once.

6.1 What is the vertical angle?

The vertical angle is the angle at which you see an object from its base to its top. The closer you get, the larger the angle. Because the height is known, the angle gives the distance.

There are two cases:

- **Base visible:** You can see the object down to the waterline. The angle is measured from the waterline to the top.

- **Base beyond the horizon:** The object is so far away that its lower part is hidden behind the horizon – typical for mountains. You then measure from the horizon to the top, and your height of eye comes into it.

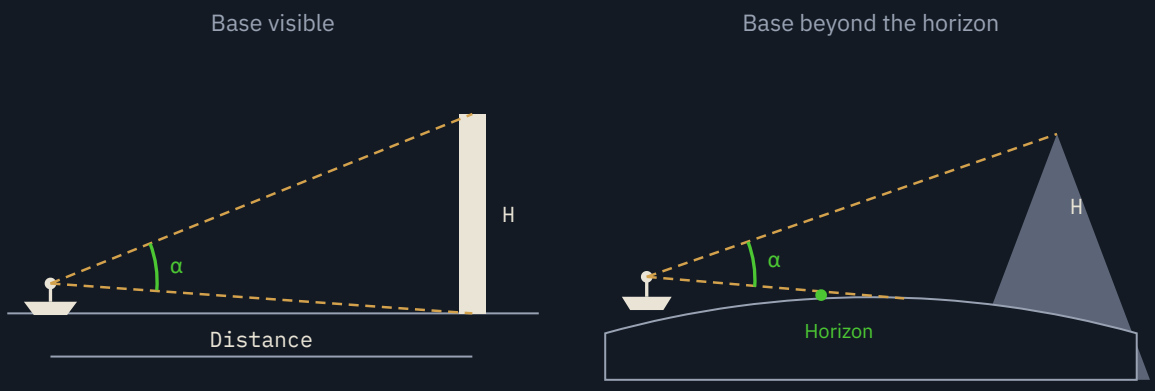


Figure 6.2 On the left the angle is measured from the waterline to the top of the tower, on the right from the horizon to the summit. Angles and curvature are exaggerated.

6.2 When do you need it?

- **Fix from bearing and distance:** A bearing and a vertical angle of the same object give a position – without radar and without a second object.
- **Keeping clear:** Off a coast with shoals you can set a minimum distance and check continuously with the vertical angle of a lighthouse that you stay far enough off – the classic *vertical danger angle*.
- **Making a landfall by day:** Mountain tops show up long before the coast. Their vertical angle gives an idea of the distance from far away.

6.3 Formulas and working

Base visible

```
Distance = 13/7 · H / α
```

- **Distance** in nautical miles
- **H** – object height in metres
- **α** – vertical angle in minutes of arc (1° = 60′)

Why 13/7? For small angles the distance equals the height divided by the angle in radians. One minute of arc is 1/3438 radian and a nautical mile is 1852 m. 3438 / 1852 gives 1.857 – almost exactly 13/7. With the height in feet the factor becomes about 0.566.

Base beyond the horizon

Here the height of eye h comes in, because the angle is measured above the horizon:

1. **Auxiliary value**
   Vertical angle minus dip: `A = α − 1.8 · √h`
2. **Root term**
   `W = 3.71 · (H − h) + A²`
3. **Distance**
   `Distance = √W − A`

6.4 Worked examples

The vertical angle of a 47 m tower whose base you can see is 42′. How far away is the tower?

```
Distance = 13/7 · 47 / 42 = 1.857 · 1.119 ≈ 2.08 nm
```

From a height of eye of 4 m you measure the vertical angle of an 830 m mountain whose base is beyond the horizon as 1°32.0′. How far away is the mountain?

```
Vertical angle = 1 · 60′ + 32′ = 92.0′
Auxiliary = 92.0 − 1.8 · √4 = 92.0 − 3.6 = 88.4
Root term = 3.71 · (830 − 4) + 88.4² = 3064.5 + 7814.6 = 10879.0
Distance = √10879.0 − 88.4 = 104.30 − 88.4 ≈ 15.90 nm
```

6.5 Things to watch out for

- **Index error:** Always correct the sextant reading for index error first. With small angles, a single minute of arc makes a big difference.
- **The right height:** The object height must match the angle you measured. Measuring from the waterline, you need the height of the top above the water, not above the ground. For lights, the chart gives the elevation of the light, not the height of the tower.
- **Tides:** Chart heights refer to a high water level. At low water the object is a little higher than charted – noticeable at short distances.
- **Large angle, short distance:** The simple formula is meant for small angles. At a few cables and large angles it becomes less accurate.

6.6 How it works in NauticTools2

1. **Enter the vertical angle**
   Degrees and minutes, already corrected for index error.
2. **Enter the object height**
   In metres, from the chart or the list of lights.
3. **Base visible or not**
   If the base is hidden, untick the box and enter the height of eye – it is filled in from the settings.

4. **Calculate**
   NauticTools2 shows the distance and the full working. Inputs can be saved, loaded and printed.

6.7 Frequently asked questions

Where does the factor 13/7 come from?

From converting minutes of arc to radians and metres to nautical miles: 3438 / 1852 ≈ 1.857 ≈ 13/7.

Do dip and refraction matter?

Hardly, when the base is visible, because both ends of the angle are on the object. With the base hidden you measure against the horizon – which is why the dip (1.8 · √h) is part of the extended formula.

Can you do it without a sextant?

Roughly, for example with binoculars with a reticle. For useful distances, though, a sextant is far more accurate.

6.8 See also

- **Geographical Range of Lights** (chapter 5) – distance to a light just rising on the horizon
- **Index Error** (chapter 20) – find the sextant's index error
- **Bearing Conversion** (chapter 10) – convert the bearing of the object to a true bearing

PART I · COASTAL NAVIGATION

7 Distance, Speed and Time

Distance, speed and time – the rule of three at sea

How far will you get in two hours? How fast were you really going? When will you arrive? All three questions come down to one relationship: **distance = speed × time**. Know two values and you get the third – and NauticTools2 also works out your **estimated time of arrival (ETA)**.

`Distance in nm` `Speed in kn` `Time in hh:mm` `ETA` `Duration from start and end`

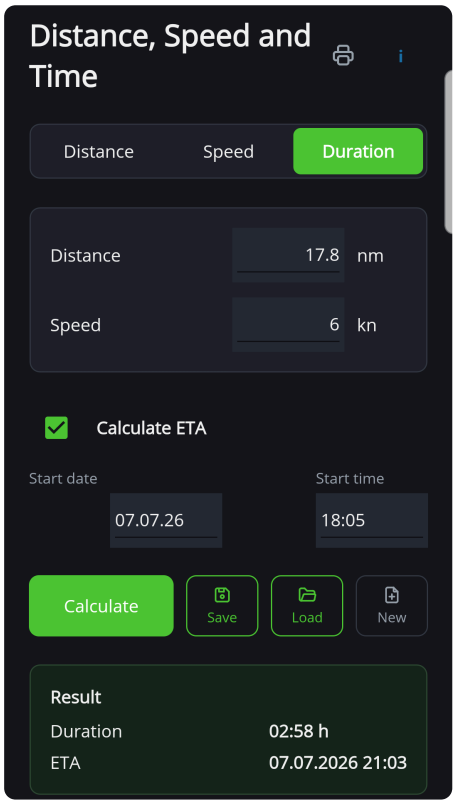


Figure 7.1 Distance, speed and time in the Android version: choose what to solve for and enter two values – with duration and arrival time.

7.1 The three quantities

- **Distance** – in nautical miles (1 nm = 1852 m).
- **Speed** – in knots. One knot is one nautical mile per hour, about 0.51 m/s.
- **Time** – the passage time in hours and minutes.

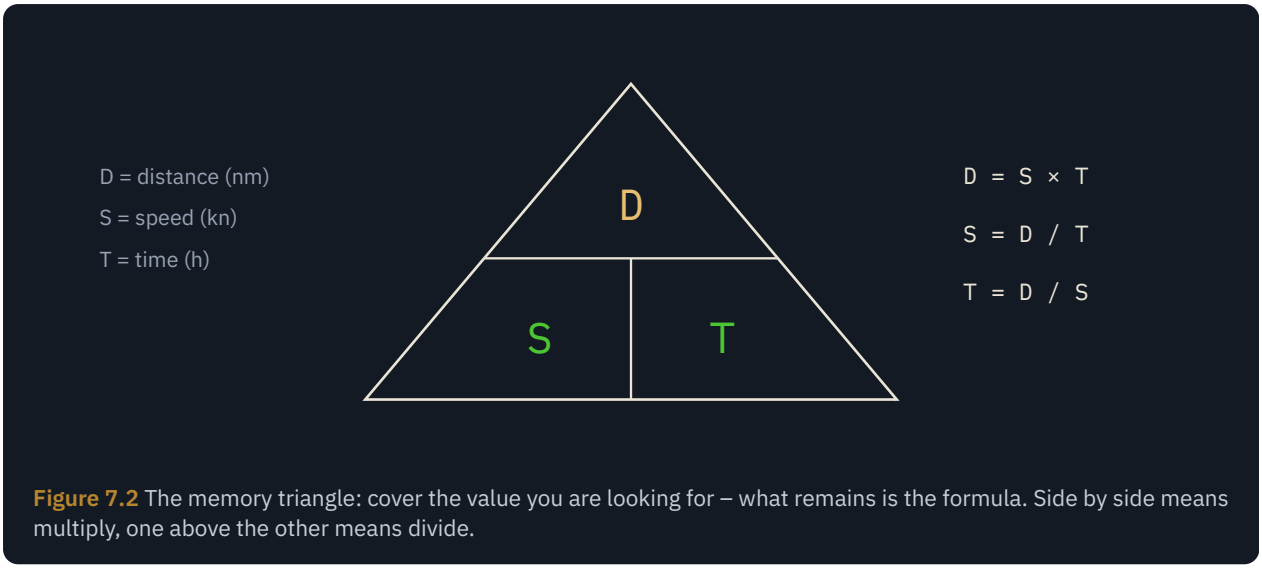


Figure 7.2 The memory triangle: cover the value you are looking for – what remains is the formula. Side by side means multiply, one above the other means divide.

7.2 When do you need it?

- **Planning your arrival:** When will you reach the harbour, the lock or the bar that can only be crossed with enough water?
- **Dead reckoning:** How far have you come since the last fix? The distance is laid off on the chart from the last position.
- **Finding your speed:** Two fixes and the time between them give your actual speed over the ground – a good check against the log.

7.3 Formulas and working

> `Distance = Speed × Time`

1. **Solve for distance**
   `D = S × T`
2. **Solve for speed**
   `S = D / T`
3. **Solve for time**
   `T = D / S`, and optionally `ETA = departure + T`

Six-minute rule: Six minutes are a tenth of an hour, so in six minutes you cover a tenth of your speed in nautical miles – at 7 kn that is 0.7 nm. Handy for dead reckoning in your head and for radar plotting.

7.4 Worked examples

You have been sailing for 2 hours 15 minutes at 5.3 kn. How far have you come?

```
T = 2 h 15 min = 2 + 15/60 = 2.25 h
D = 5.3 kn × 2.25 h ≈ 11.93 nm
```

A yacht covers 17.4 nm in 3 hours 45 minutes. What is her speed?

```
T = 3 h 45 min = 3.75 h
S = 17.4 nm / 3.75 h = 4.64 kn
```

The destination is still 17.8 nm away and your speed is 6 kn. How long will it take, and when will you arrive if you leave on 7 July 2026 at 18:05?

```
T = 17.8 nm / 6 kn = 2.967 h = 2 h 58 min
ETA = 07.07.2026 18:05 + 2:58 = 07.07.2026 21:03
```

7.5 Things to watch out for

- **Minutes are not decimals:** 2 h 15 min is 2.25 h, not 2.15 h – the most common slip in this calculation. That is why NauticTools2 takes time directly as hh:mm.
- **Speed through the water or over the ground?** The log measures speed through the water. For arrival times, though, speed over the ground is what counts – against a foul tide the difference can be large.
- **Past midnight:** If a passage runs past midnight, the date changes. NauticTools2 therefore always shows the ETA with its date.

7.6 How it works in NauticTools2

1. **Choose what to solve for**
   Distance, speed or time – the other two become the input fields.
2. **Enter the values**
   Time as hh:mm, for example `2:15`. The colon can be left out: `215` works just as well. Long passages such as `101:23` are fine too.
3. **Calculate the ETA**
   When solving for time, the departure date and time give the arrival time. The current time is filled in.
4. **Duration from start and end**
   When solving for distance or speed, the time can also be calculated from a start and an end time – handy for passages past midnight.

7.7 Frequently asked questions

How do you convert knots to km/h or mph?
Multiply by 1.852 for km/h or by 1.151 for mph: 6 kn are about 11.1 km/h or 6.9 mph.

What is the six-minute rule?
In six minutes you cover a tenth of your speed in nautical miles. At 5 kn that is 0.5 nm, at 12 kn 1.2 nm.

How do I find my actual speed?
Take two fixes, measure the distance between them on the chart and divide by the time elapsed. That gives your speed over the ground.

7.8 See also

- **Rail Log** (chapter 8) – measure your speed without a log
- **Current Triangle** (chapter 3) – speed over the ground in a tidal stream
- **Dead Reckoning** (chapter 12) – position from course and distance

PART I · COASTAL NAVIGATION

8 Rail Log

Dutchman's log – measuring speed without a log

The log has failed or is clearly reading nonsense? With a **float**, the known **length of the boat** and a **stopwatch** you can still find your speed through the water – just as seafarers have done for centuries. In NauticTools2 this tool is called *Rail Log*.

`Length in m` `Time in s` `Speed in kn`



Figure 8.1 Rail log in the Android version: enter the length and the timed seconds, and the speed appears at once.

8.1 How does it work?

An object drifting in the water stays practically still relative to the water while the boat sails past it. Drop it at the bow and time how long it takes to reach the stern: you then know how long the boat needed to cover its own length – and that gives the speed through the water.

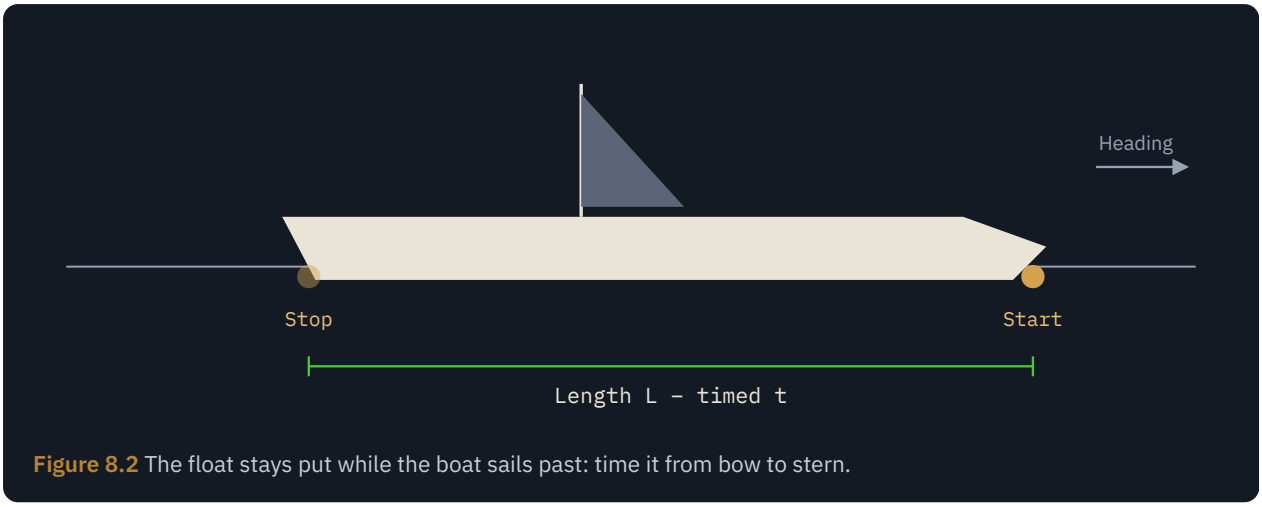


Figure 8.2 The float stays put while the boat sails past: time it from bow to stern.

8.2 When do you need it?

- **Log failure:** Fouling on the transducer, a jammed paddle wheel or an electrical fault – without speed through the water a key input for dead reckoning is missing.
- **Checking the log:** Is the log over- or under-reading? A few runs with the Dutchman's log give an independent comparison.
- **Small boats without a log:** Dinghies and tenders often have none at all.

8.3 Formula and working

```
Speed (kn) = L / 0.5144 / t
```

- **L** – measured distance in metres, usually the length of the boat or a marked distance along the rail
- **t** – timed seconds

1. **Convert the distance**
   Distance in units of 0.5144 m (the distance covered in one second at 1 knot): `L / 0.5144 m`
2. **Speed**
   Divide by the time: `speed = (L / 0.5144) / t`

Why 0.5144? At 1 knot a vessel covers a 3600th of a nautical mile per second: 1852 m / 3600 = 0.5144 m, or about 1.688 ft. **Rule of thumb:** speed ≈ 2 × L (m) / t – about 3 % high, but fine for a quick check. With feet: speed ≈ 0.6 × L (ft) / t.

8.4 Worked example

A float takes 5.2 seconds to drift aft along a 12 m hull. How fast is the boat going?

```
Distance units = 12 m / 0.5144 m = 23.3
Speed = 23.3 / 5.2 s ≈ 4.49 kn
Rule of thumb = 2 × 12 / 5.2 ≈ 4.6 kn
```

8.5 Things to watch out for

- **Speed through the water:** The method measures speed relative to the water, not over the ground. Tidal streams are not included.
- **Longer distance, several runs:** On a short boat at speed a run lasts only a few seconds – a tenth of a second of reaction time is already several per cent. Better use two people at bow and stern and average several runs.
- **Don't throw anything overboard that doesn't belong there:** A piece of wood or a float on a thin line that you pull back in is ideal.
- **Avoid light objects:** Something blown along the surface by the wind spoils the result. It should sit as deep in the water as possible.

8.6 How it works in NauticTools2

1. **Enter the length**
   The measured distance in metres.
2. **Enter the time**
   The timed seconds, decimals welcome.
3. **Calculate**
   NauticTools2 shows the speed in knots and the intermediate step. Measurements can be saved and printed.

8.7 Frequently asked questions

Where does the word "knot" come from?

Speed used to be measured with a chip log: a wooden board on a line with knots at regular intervals. The crew counted how many knots ran out over the stern in a fixed time – hence the unit.

How accurate is it?

With careful timing and several runs, to about 5 to 10 per cent – good enough for dead reckoning and for checking the log.

What if I have no stopwatch?

Every phone has one. At a pinch counting ("one thousand and one …") works too, though much less accurately.

8.8 See also

- **Distance, Speed and Time** (chapter 7) – use the measured speed for distance and ETA
- **Current Triangle** (chapter 3) – from speed through the water to speed over the ground

PART I · COASTAL NAVIGATION

9 Limiting Course

Limiting course – which course can the other vessel be on?

At night you often see nothing of another vessel but its lights. The combination of visible **navigation lights** and your own **true bearing** to the vessel gives a fixed sector of possible courses. NauticTools2 calculates the two **limiting courses** and draws the sector.

`Navigation lights` `Sidelights · stern light` `True bearing` `Course sector` `Diagram` `Slider`

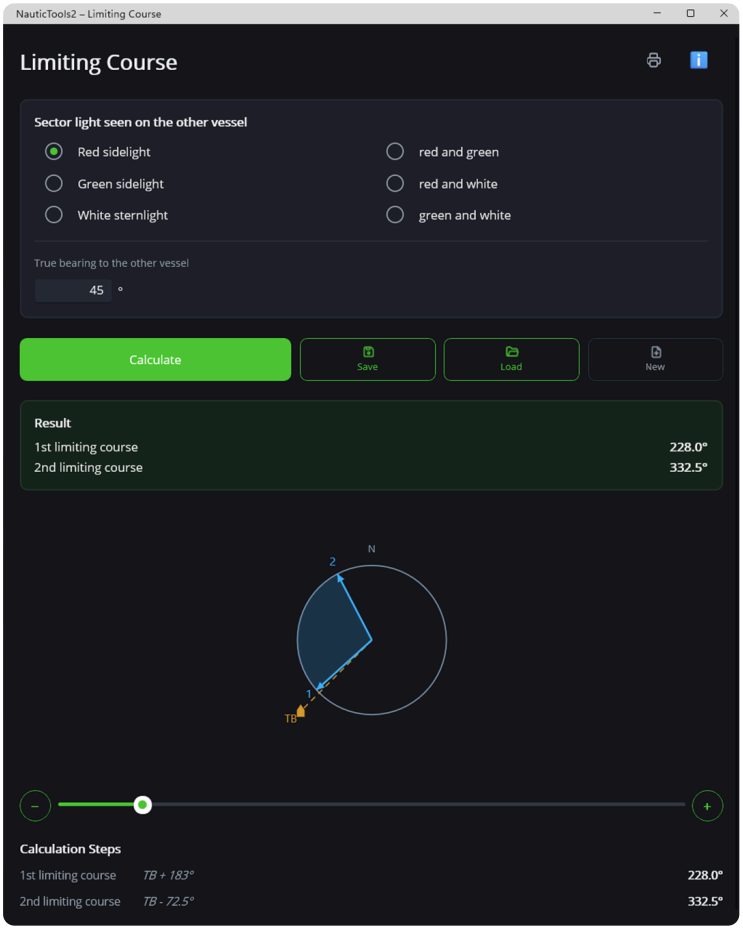


Figure 9.1 Your own bearing (dashed) and the possible course sector of the other vessel; the slider below moves your own position.

9.1 What is a limiting course?

Every navigation light shows only within a standard sector: the sidelights 112.5° each from the bow to starboard (green) and port (red), the stern light 135° aft. Which lights you see therefore tells you from which direction you are looking at the other vessel. Together with your own bearing this gives a range of possible courses – bounded by the two **limiting courses**.

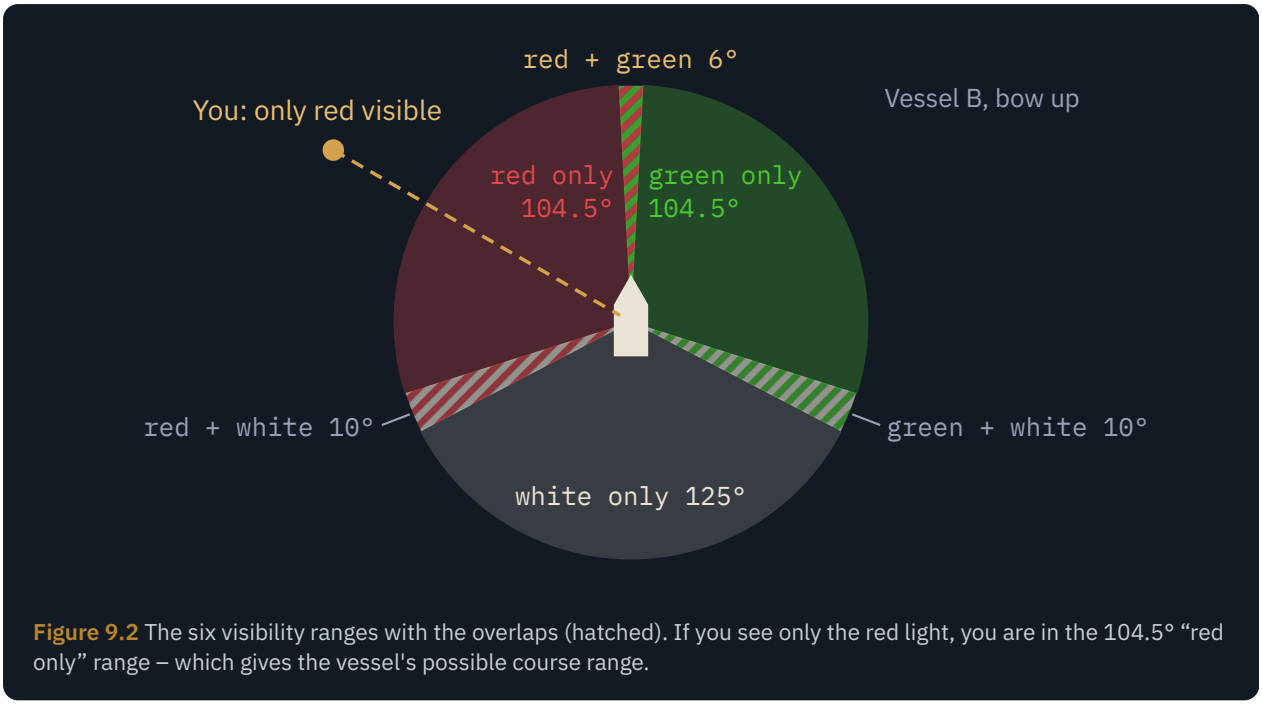


Figure 9.2 The six visibility ranges with the overlaps (hatched). If you see only the red light, you are in the 104.5° “red only” range – which gives the vessel's possible course range.

9.2 The six light combinations

The overlapping sectors give six combinations, each with a fixed sector width:

- red and green – 6° (the vessel is heading straight for you)
- green only – 104.5°
- green and white – 10°
- white only – 125°
- red and white – 10°
- red only – 104.5°

The overlaps come from COLREG Annex I, Section 9: towards ahead each sidelight may show up to 3° across to the other side – 6° of red and green together. Aft, sidelight and stern light may each overlap by up to 5° – 10° together. That leaves 112.5° – 3° – 5° = 104.5° for “red only” and 135° – 2 · 5° = 125° for “white only”. These are maximum values, so the calculation covers the worst case.

9.3 When do you need it?

- **Assessing the situation at night:** Is the vessel meeting you, crossing, or ahead of you? The course sector answers it.
- **Who gives way:** Under the collision regulations the give-way vessel depends on how the courses cross.
- **Narrowing down sailing vessels:** For a vessel under sail, the wind direction narrows the sector further.

9.4 Calculation

```
Limiting course = TB + 180° − sector boundary
```

1. **Reciprocal bearing**
   The bearing from the other vessel to you: `TB + 180°`.
2. **Sector boundaries**
   The visible lights tell you in which range of relative bearing (seen from the other vessel) you are – for the red light, on its port bow.
3. **Limiting courses**
   Reciprocal bearing minus the two sector boundaries gives the two limiting courses. The true course lies between them.

NauticTools2 combines reciprocal bearing and sector boundary into one fixed value per light combination – for “red only”, 180° + 3° = 183° and 180° − 252.5° = −72.5°. Results below 0° or above 360° are corrected by 360°. This is also how the app shows the working:

Visible	1st limiting course	2nd limiting course	at TB 045°
red only	`TB + 183°`	`TB − 72.5°`	`228.0° / 332.5°`
green only	`TB − 183°`	`TB + 72.5°`	`222.0° / 117.5°`
white only	`TB − 62.5°`	`TB + 62.5°`	`342.5° / 107.5°`
red and green	`TB + 177°`	`TB + 183°`	`222.0° / 228.0°`
red and white	`TB − 72.5°`	`TB − 62.5°`	`332.5° / 342.5°`
green and white	`TB + 72.5°`	`TB + 62.5°`	`117.5° / 107.5°`

9.5 Example

A vessel bears 045° true and only its red sidelight is visible. Within which course range can it be?

```
Reciprocal bearing = 045° + 180° = 225°
1st limiting course = 228.0°
2nd limiting course = 332.5° (sector width 104.5°)
```

9.6 Things to watch

- **True bearing:** The bearing must be true – convert a compass or radar relative bearing first with the bearing conversion.
- **Boundaries are blurred:** At the sector boundaries the lights overlap by a few degrees – hence the narrow “red and white” and “green and white” sectors.
- **Watch other lights:** Masthead lights, deck lights or special lights give further clues to the vessel's type and course.

9.7 How it works in NauticTools2

1. **Choose visible lights**
   Select the combination you can see on the other vessel.
2. **Enter the bearing**
   Enter the true bearing (TB) to the other vessel.
3. **Calculate**
   NauticTools2 shows the 1st and 2nd limiting course and draws the sector.
4. **Move your position**
   The slider under the diagram moves your own position around the other vessel – the bearing runs from 0° to 360°. Limiting courses and diagram update instantly while dragging, so you can see how the course sector turns with the bearing.

9.8 Frequently asked questions

Why do you sometimes see red and green at the same time?

Then you are looking almost straight at the other vessel's bow – it is heading directly for you. The possible course sector is only 6° wide.

What does white only mean?

You see the stern light, so you are astern of the other vessel. It is moving more or less away from you – if you are faster, you are the overtaking vessel.

Does this apply to power-driven vessels too?

Yes, sidelights and stern light are standardised for all power-driven and sailing vessels. Power-driven vessels additionally carry one or two masthead lights.

9.9 See also

- **Bearing conversion** (chapter 10) – from relative bearing to true bearing
- **Radar plotting** (chapter 11) – course and speed of the other vessel from radar fixes
- **Course conversion** (chapter 4) – compass, magnetic and true course, CTW and COG

PART I · COASTAL NAVIGATION

10 Bearing Conversion

Bearing conversion – from compass bearing to position line

A bearing can only be plotted on the chart once it is **true**. Whatever you read on the steering compass, the radar or a hand bearing compass has to be corrected for **deviation** and **variation** first. NauticTools2 works through the chain in both directions – for steering compass, radar, hand bearing compass and gyro.

RB / RRaB | CB | MB | TB | Hand bearing compass | Gyro compass

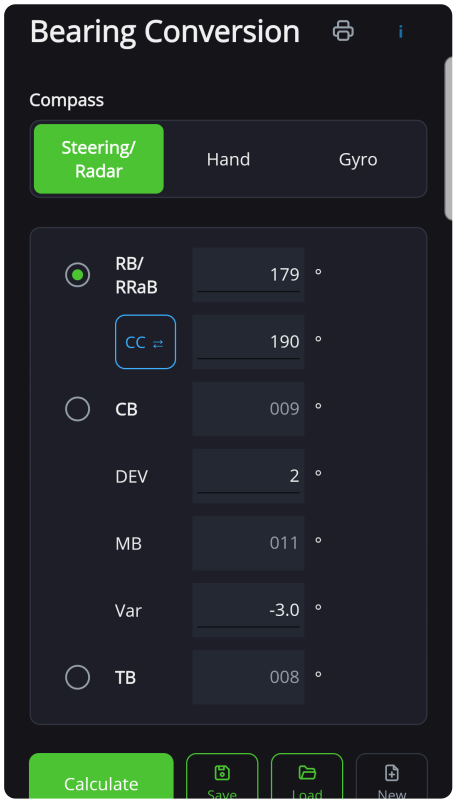


Figure 10.1 Bearing conversion in the Android version: choose the compass, enter the known bearing and the heading, and the whole chain appears.

10.1 The bearing chain

- **RB / RRaB** – relative bearing: the angle from your own bow to the object, clockwise. On the radar it is the relative radar bearing.
- **CC** – compass course (heading). It is needed to turn a relative bearing into a bearing and to look up the deviation.
- **CB** – compass bearing on the steering compass.
- **DEV** – deviation for the ship's heading.
- **MB** – magnetic bearing.

- **Var** – variation.
- **TB** – true bearing: the line you draw on the chart.

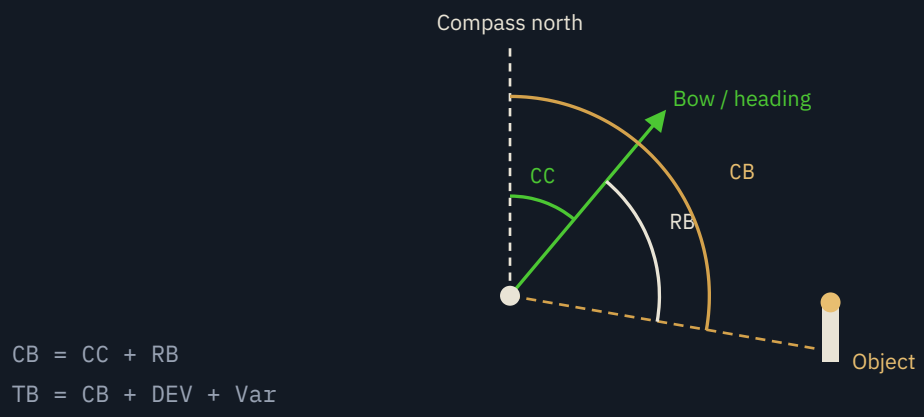


Figure 10.2 The relative bearing is measured from the bow, the compass bearing from compass north. Heading plus relative bearing gives the compass bearing.

10.2 When do you need it?

- **Position lines:** Cross bearings, a bearing and distance or a running fix – every bearing must be true before it goes on the chart.
- **Radar:** The radar usually shows relative bearings. Only together with the heading does it become a bearing.
- **Planning bearings ahead:** From the chart you can see on what true bearing a lighthouse lies at the alter-course position. Working backwards tells you what you should see on the compass or the radar.

10.3 Formulas and working

> `TB = CC + RB + DEV + Var`

1. **Relative to compass bearing**
   `CB = CC + RB` – subtract 360° if the result exceeds 360°.
2. **Deviation**
   `MB = CB + DEV` – deviation for the *heading*, not for the bearing.
3. **Variation**
   `TB = MB + Var`

The classic trap: Deviation depends on the ship's heading, not on the direction of the bearing. Taking a bearing of 090° while heading 190°, you need the deviation for 190°. Working back from TB to CB and RB uses the same chain with the signs reversed.

10.4 Worked examples

A yacht steers 190° by compass. A church tower bears 179° relative. Deviation is +2°, variation −3°. What is the true bearing?

```
CB = 190° + 179° = 369° − 360° = 009°
MB = 009° + 2° = 011°
TB = 011° − 3° = 008°
```

On compass course 090° you are to alter course as soon as a lighthouse bears 220° true. Deviation +10°, variation −3°. What should you see on the compass and on the radar?

```
MB = 220° − (−3°) = 223°
CB = 223° − 10° = 213°
RB = 213° − 090° = 123°
```

10.5 Hand bearing compass and gyro compass

Hand bearing compass: It is used on deck well away from iron and electrics and usually has no deviation. The chain shrinks to `TB = CB + Var` – no heading and no deviation needed.

Gyro compass: Deviation and variation do not apply. Instead `TB = GB + GA + SEC` with the gyro error GA and the speed error correction SEC. Conversely, a check bearing gives the gyro error:

A transit bears 001° true according to the chart. On the gyro it bears 359°, and the gyro corrects its own speed error (SEC = 0°). What is the gyro error?

```
GA = TB − GB − SEC = 001° − 359° − 0° = +2.0° (east)
```

10.6 Things to watch out for

- **Deviation for the heading:** see above – the single most important point.
- **Bearing and heading at the same moment:** For a relative bearing the heading at the moment of the bearing counts. If the boat yaws, the bearing moves with it.
- **Signs:** East positive, west negative – for deviation, variation and gyro error.
- **Using a hand bearing compass:** Take bearings away from shrouds, engine and loudspeakers, or the hand compass will have deviation too.

10.7 How it works in NauticTools2

1. **Choose the compass**
   Switch between steering compass/radar, hand bearing compass and gyro at the top.
2. **Choose the known bearing**
   On the left, choose whether RB, CB or TB is known. The heading can be entered as CC or TC – with TC, NauticTools2 takes the deviation from the steering table.

3. **Deviation and variation**
   Both are filled in automatically from the active deviation card and the settings. A value you type yourself takes priority.
4. **Calculate**
   The whole chain appears with full working and can be saved and printed.

10.8 Frequently asked questions

What is the difference between a relative bearing and a bearing?
A relative bearing is measured from your own bow and changes when the boat turns. A bearing is measured from north and stays the same wherever the bow points.

Why does a hand bearing compass have no deviation?
Because it is used where iron and electrics are far enough away. At the fixed position of the steering compass, the engine and the boat's electrics always have an effect.

What does RRaB mean?
Relative radar bearing: the relative bearing as read off the radar. Mathematically it is the same as a relative bearing.

10.9 See also

- **Course Conversion** (chapter 4) – the same chain for courses
- **Magnetic Declination** (chapter 2) – current variation for any position and date
- **Distance by Vertical Angle** (chapter 6) – distance to the object you are bearing
- **Compass Check by the Sun** (chapter 24) – find the deviation with the sun

PART I · COASTAL NAVIGATION

11 Radar Plotting

Radar plotting – how close will the other vessel come?

Two radar observations are enough to answer the key questions: how close will the other vessel come (**CPA**), when (**TCPA**), and what are its real **course** and **speed**? NauticTools2 works the radar plot out exactly and draws it – right up to avoiding action.

`North up / head up` `CPA / TCPA` `Relative motion` `Vector triangle` `Second vessel` `Avoiding action`

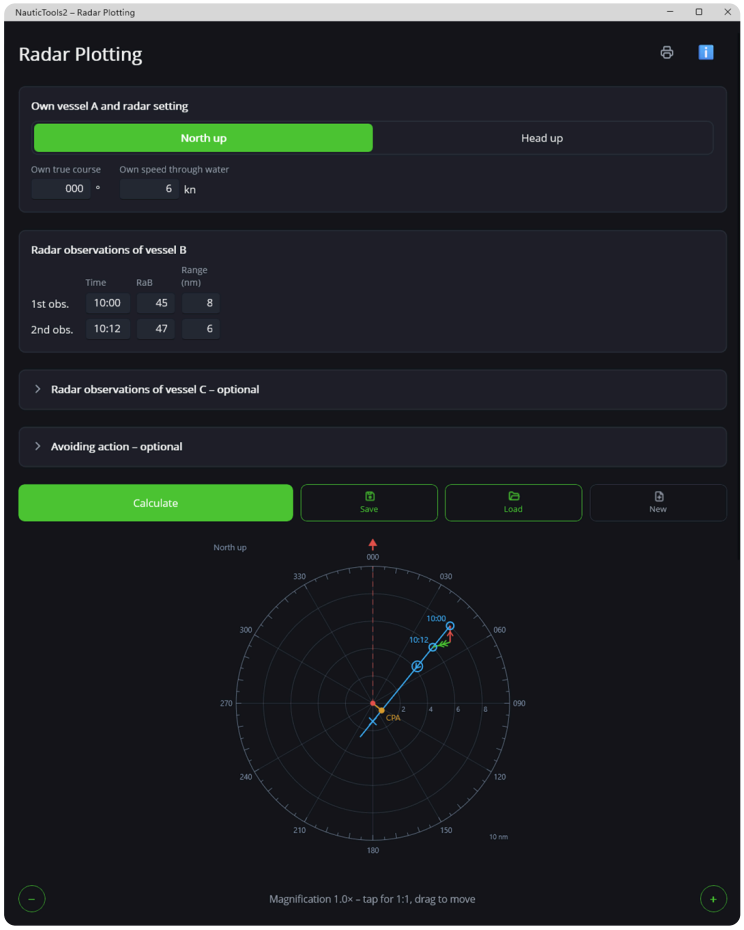


Figure 11.1 Radar plotting in the Windows version: enter two observations – radar plot with relative track, CPA and vector triangle.

11.1 What does radar plotting tell you?

On the radar screen your own ship always sits in the centre. When an echo moves from one observation to the next, that is not its true motion but the **relative motion** – the other vessel's motion *relative to yours*. Extend the line through the two echoes and you see how the vessel will pass.

- **CPA** – closest point of approach: the shortest distance to the relative track, the perpendicular from the centre.

- **TCPA** – the time at which that point is reached.
- **Course and speed of B** – the other vessel's true course and speed from the vector triangle.

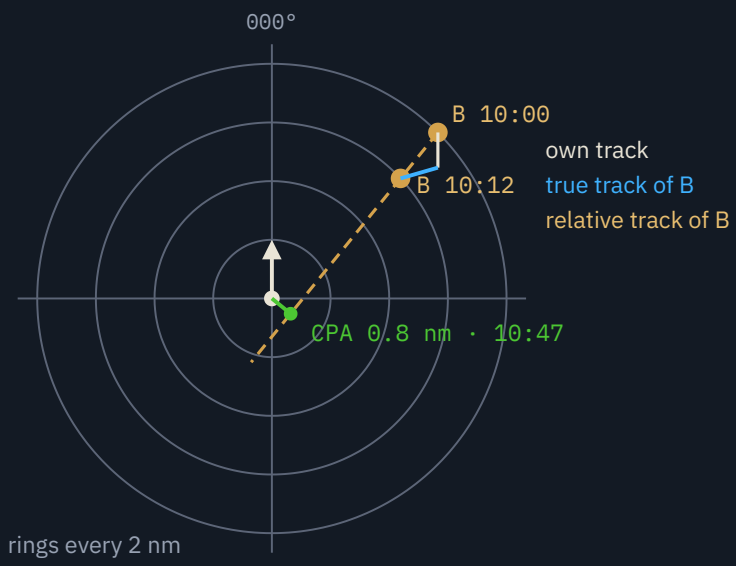


Figure 11.2 The two echoes of B and their extension (relative track). The perpendicular from the centre is the CPA. Own track plus relative track gives the true track of B.

11.2 When do you need it?

- **Collision avoidance in restricted visibility:** Under Rule 19 of the COLREGs you must determine in fog whether a close-quarters situation is developing – which is exactly what the CPA tells you.
- **Judging the other vessel:** Is it on a reciprocal course, overtaking, crossing? The vector triangle shows its true course.
- **Planning avoiding action:** Which course or speed gives a safe passing distance?
- **Spotting stationary objects:** If the echo's true speed comes out as 0 kn, it is stationary – a buoy, a vessel at anchor or an island.

11.3 Working

```
true track of B = own track + relative track
```

1. **Plot the observations**
   Bearing and range of both observations; with head up, first convert relative bearings to true with your heading.
2. **Relative motion**
   Direction and length from the 1st to the 2nd observation give the relative course; length divided by time gives the relative speed.
3. **CPA and TCPA**
   The perpendicular from the centre to the relative track gives the CPA. The distance to its foot divided by the relative speed gives the time to CPA.

4. **Vector triangle**
   Lay off your own track for the observation interval to the 1st observation. From its start to the 2nd observation runs the true track of B – its direction is B's course, its length over time B's speed.

11.4 Worked example

> **You steer 000° true at 6 kn, radar north up. At 10:00 vessel B bears 045° true, 8.0 nm. At 10:12 B bears 047°, 6.0 nm. How close will B come, when, and what are B's course and speed?**
>
> ```
> Relative: course 219°, speed 10.1 kn
> CPA: 0.8 nm at 10:47, bearing 129°
> True: course 254°, speed 6.6 kn
> Own track: B crosses at 10:54, 1.3 nm astern
> ```

At 0.8 nm, B enters the close-quarters zone. In restricted visibility, Rule 19 requires early action:

> **At 10:18 you want to alter course so that B passes at 2 nm. What course do you steer?**
>
> ```
> B at 10:18: 5.0 nm bearing 049°
> New course: 070° (70° to starboard), CPA 2.0 nm at 10:40
> Alternative: on course 000° the speed would have to drop to 0.2 kn – practically
> stopping
> ```

11.5 Things to watch out for

- **Use the first and last observation:** With more than two observations, the widest interval gives the most accurate result.
- **Course and speed must stay the same:** The plot only holds while both vessels keep course and speed. Further observations confirm this – or show that the other vessel has altered.
- **Through the water or over the ground:** Using your course and speed through the water gives the other vessel's course through the water – the right reference for collision avoidance.
- **Drawn versus calculated:** NauticTools2 works the plot exactly. A hand-drawn solution will differ by a few tenths of a mile, degrees or minutes – down to drawing accuracy.

11.6 How it works in NauticTools2

1. **Choose the radar display**
   North up (true bearings) or head up (relative bearings). The radar plot is oriented accordingly – just like the exam sheet.
2. **Own ship**
   True course and speed through the water.
3. **Observations**
   Time, bearing and range for both observations – times can be typed as 1537. A second vessel C has its own block.

4. **Avoiding action**
   Optionally from a given time: course for a required CPA (starboard under Rule 19, port if needed), speed for a required CPA, or a given manoeuvre. Everything appears in magenta in the plot.

11.7 Printable calculation record

Radar plotting can be printed as a record or saved as a PDF too – with inputs, the plotting diagram and all results from CPA and TCPA to the other vessel's course and speed.



Radar Plotting

NauticTools2 – report of 22.10.2026, 14:22

Input

Radar setting	North up
Own true course	000°
Own speed through water	6 kn
1st obs.	10:00, RaB 045°, 8 nm
2nd obs.	10:12, RaB 047°, 6 nm

Radar Plotting

Result

Closest point of approach (CPA)	0.8 nm
Time of CPA (TCPA)	10:47
True bearing at CPA	129°
Relative bearing at CPA	129°
Relative course of B	219°
Relative speed of B	10.1 kn
True course of B	254°
True speed of B	6.6 kn
B crosses own course line	10:54, 1.3 nm astern

Figure 11.3 The printed record of a radar plot with two observations, North up.

11.8 Frequently asked questions

How do I recognise a risk of collision?

If the bearing stays steady while the range decreases, the relative track runs through the centre – the CPA is zero. Even a small CPA means a close-quarters situation.

What do the arrows in the plot mean?

Following the German standard DIN 13312: single arrow = own motion, double arrow = true motion of the other vessel, arrow in a circle = relative motion.

Can I plot two vessels at once?

Yes. The second vessel C gets its own colour and result block. For avoiding action, NauticTools2 also shows which CPA results for the other vessel.

11.9 See also

- **Bearing Conversion** (chapter 10) – convert relative radar bearings into true bearings
- **Limiting Course** (chapter 9) – course sector of a vessel from its lights
- **Distance, Speed and Time** (chapter 7) – six-minute rule and speed from fixes

PART I · COASTAL NAVIGATION

12 Dead Reckoning

Dead reckoning by calculation – plotting with a calculator

Where will you be after 124 miles on course 309°? What are the course and distance between two positions? Dead reckoning by calculation answers both without dividers and plotter – by **mean latitude sailing** or the more accurate **Mercator sailing**.

`Find destination` `Find course and distance` `Mean latitude` `Mercator sailing` `Waypoints`

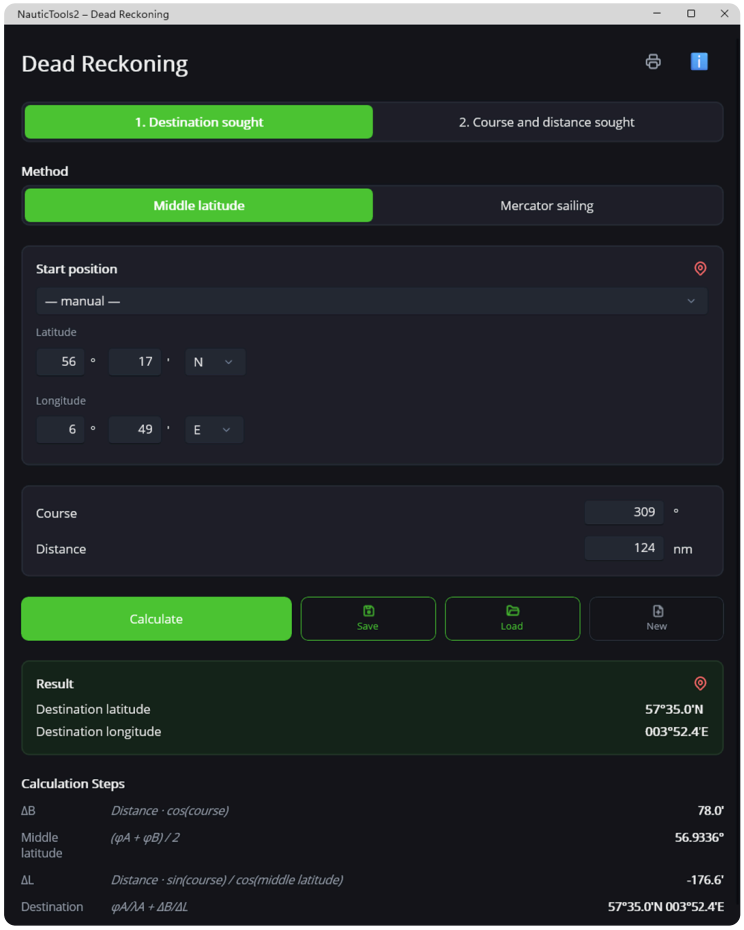


Figure 12.1 Dead reckoning in the Windows version: choose the task and method, enter start, course and distance – destination with full working.

12.1 How does it work?

The track is split into a north-south part, the **difference of latitude (d.lat)**, and an east-west part, the **departure**. The departure is then converted into a **difference of longitude (d.long)** – which depends on latitude, because the meridians converge towards the poles.

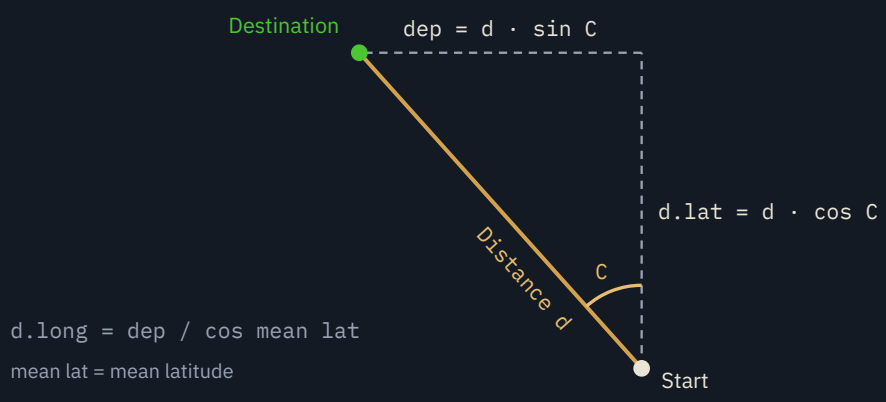


Figure 12.2 The course triangle: the distance splits into difference of latitude and departure. Departure is converted into difference of longitude using the mean latitude.

12.2 When do you need it?

- **A DR position without a suitable chart:** On small-scale passage charts, or with no chart at all, the calculation is more precise than plotting.
- **Passage planning:** Course and distance between two harbours or waypoints, for example to estimate the passage time.
- **Cross-checking:** A plotted DR position can be checked by calculation.

12.3 Formulas and working

Find the destination (mean latitude)

> `d.lat = d · cos C` · `d.long = d · sin C / cos mean lat`

1. **Difference of latitude**
   `d.lat = d · cos C` (in minutes of arc, 1′ = 1 nm)
2. **Destination latitude and mean latitude**
   Add d.lat to the start latitude; the mean latitude lies halfway between.
3. **Departure**
   `dep = d · sin C`
4. **Difference of longitude**
   `d.long = dep / cos mean lat`, then add it to the start longitude.

Find course and distance

The other way round: `dep = d.long · cos mean lat`, `C = arctan(dep / d.lat)` (in the right quadrant), `d = √(d.lat² + dep²)`.

Mercator sailing: Instead of the mean latitude it uses the *difference of meridional parts*, which matches the Mercator projection of the chart: `d.long = DMP · tan C`. It stays accurate over long distances and in high latitudes. Mean latitude becomes inaccurate beyond about 600 nm or 60° latitude – NauticTools2 points this out.

12.4 Worked examples

From 56°17′ N 006°49′ E you sail 124 nm on course 309°. Where are you? (mean latitude)

```
d.lat = 124 · cos 309° = +78.0′ = 1°18.0′ N → 57°35.0′ N
mean = 56°56′
dep = 124 · sin 309° = −96.4 nm (west)
d.long = −96.4 / cos 56°56′ = −176.6′ = 2°56.6′ W → ≈ 003°52.4′ E
```

On passage from Lizard Point (49°58′ N 005°12′ W) to Lisbon you are off Cape Finisterre (42°53′ N 009°16′ W). What course and distance have you made good? (mean latitude)

```
d.lat = −7°05′ = −425′, d.long = −4°04′ = −244′, mean lat = 46°25.5′
dep = −244 · cos 46°25.5′ = −168.3 nm
C = 180° + arctan(168.3 / 425) = 201.6°
d = √(425² + 168.3²) = 457.1 nm
```

12.5 Things to watch out for

- **Rhumb line, not shortest route:** This calculation assumes a constant course. Over long distances the great circle is shorter.
- **Signs:** North and east positive, south and west negative. The course decides the direction of d.lat and departure.
- **The 180th meridian:** Crossing it switches east to west or vice versa – count the change of longitude carefully across 180°.
- **Course over the ground:** For a DR or EP, course and distance over the ground count – allow for tidal stream and leeway first.

12.6 How it works in NauticTools2

1. **Choose the task**
   Find destination, or find course and distance – in the bar at the top.
2. **Choose the method**
   Mean latitude (called *Middle latitude* in the app) or Mercator sailing.
3. **Enter positions**
   Latitude and longitude by hand or from saved waypoints. A calculated destination can be saved as a new waypoint straight away.

4. **Calculate**
   Result with full working; can be saved and printed.

12.7 Printable calculation record

Every calculation can be printed as a clear record or saved as a PDF – with method, inputs, destination and the full working. Handy for the logbook, in the classroom and for your files.



Dead Reckoning

NauticTools2 – report of 22.10.2026, 14:11

Input

Method	Middle latitude
Start position	56°17.0'N 006°49.0'E
Course	309°
Distance	124 nm

Result

Destination latitude	57°35.0'N
Destination longitude	003°52.4'E

Calculation

ΔB	*Distance · cos(course)*	78.0'
Middle latitude	*(φA + φB) / 2*	56.9336°
ΔL	*Distance · sin(course) / cos(middle latitude)*	-176.6'
Destination	*φA/λA + ΔB/ΔL*	57°35.0'N 003°52.4'E

Figure 12.3 The printed record of a middle-latitude dead reckoning: course 309°, distance 124 nm.

12.8 Frequently asked questions

Why is a nautical mile equal to a minute of arc?

That is how it is defined: one minute of arc along a meridian is very nearly 1852 m. A change of latitude can therefore be read directly in miles – a change of longitude only at the equator.

How does this differ from great circle navigation?
Dead reckoning uses a constant course (rhumb line), great circle navigation the shortest route on the sphere, on which the course changes continuously.

How accurate is mean latitude sailing?
Practically exact for a few hundred miles in mid latitudes. Beyond that, use Mercator sailing.

12.9 See also

- **Great Circle Navigation** (chapter 13) – the shortest route over long distances
- **Course Conversion** (chapter 4) – from compass course to course over ground
- **Distance, Speed and Time** (chapter 7) – distance from speed and time

PART I · COASTAL NAVIGATION

13 Great Circle Navigation

Great circle navigation – the shortest way across the ocean

On the chart, the straight line between two harbours is not the shortest route. The **great circle** is shorter – on long east-west passages in higher latitudes often by dozens of miles. NauticTools2 calculates the distance, the **initial and final course**, the **vertex** and the waypoints to sail the route.

`Great circle distance` `Initial and final course` `Vertex` `Meridian crossings` `Rhumb line comparison`

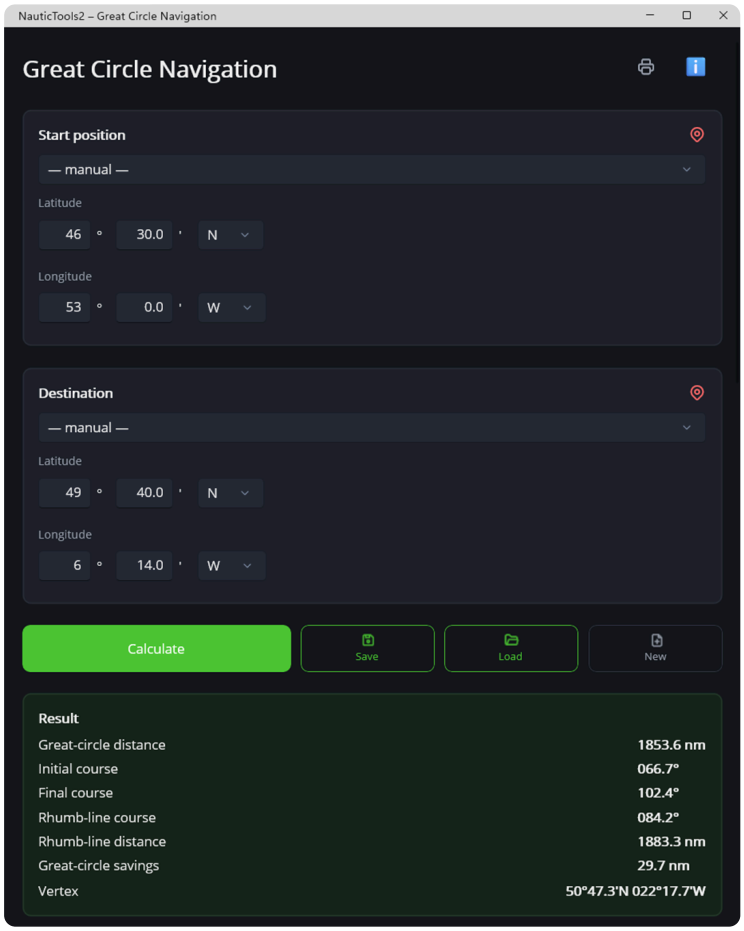


Figure 13.1 Great circle navigation in the Windows version: enter start and destination – distance, courses, vertex and meridian crossings.

13.1 What is a great circle?

A great circle is any circle on the earth whose centre is the centre of the earth – the equator, for example, or any meridian. The arc of a great circle between two positions is their **shortest connection**. The catch: it crosses the meridians at ever-changing angles, so the course changes all the time.

A **rhumb line**, by contrast, keeps a constant course. On a Mercator chart it is a straight line, but on the globe it is a detour. The great circle appears on the chart as a curve bowed towards the pole.

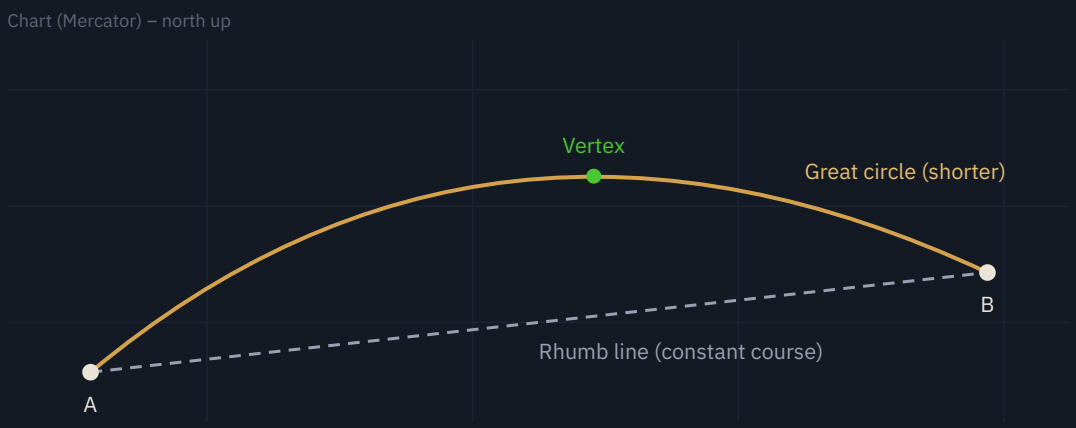


Figure 13.2 On the chart the rhumb line is straight and the great circle bows towards the pole. At the vertex it reaches its highest latitude.

13.2 When do you need it?

- **Ocean passages:** Over long distances the great circle saves time and provisions – across the North Atlantic easily 30 nm or more.
- **Route planning:** The great circle is split into several rhumb-line legs. Each is sailed on a constant course; together they follow the great circle.
- **Knowing the limits:** The vertex shows how far towards the pole the route goes – important with ice limits or storm areas.

13.3 Formulas and working

```
cos d = sin latA · sin latB + cos latA · cos latB · cos d.long
```

1. **Great circle distance**
   Find the angle d from the formula above; `distance = d (degrees) · 60 nm`.
2. **Initial course**
   `tan C = sin d.long / (cos latA · tan latB − sin latA · cos d.long)`, then put it in the right quadrant.
3. **Final course**
   Work out the initial course from B to A and add 180°.
4. **Vertex**
   `cos latV = sin C · cos latA` – the highest latitude of the great circle. Its longitude follows from the difference of longitude to the start.

5. **Meridian crossings**
   The great circle's latitude at every whole degree of longitude between start and destination, plus course and distance of each leg.

13.4 Worked example

From a position south of Cape Race (46°30.0′ N 053°00.0′ W) to a position south of the Isles of Scilly (49°40.0′ N 006°14.0′ W): how long is the great circle, what are its courses, and where is the vertex?

```
Great circle distance = 1853.6 nm
Initial course = 066.7°, final course = 102.4°
Vertex = 50°47.3′ N 022°17.7′ W
Rhumb line = course 084.2°, 1883.3 nm → saving 29.7 nm
```

13.5 Things to watch out for

- **The course keeps changing:** Steer the initial course only to the next waypoint, then take the new course.
- **Not always worth it:** In low latitudes and on north-south passages the saving is small. On a meridian or the equator, great circle and rhumb line are the same.
- **Weather and currents matter more:** For sailing yachts, wind systems and currents often decide the route more than pure distance.
- **High latitudes:** The vertex can lie far towards the pole. If necessary, plan a composite route with a limiting latitude.

13.6 How it works in NauticTools2

1. **Start and destination**
   By hand or from saved waypoints. Any position you enter can be saved as a waypoint straight away.
2. **Calculate**
   Distance, initial and final course, vertex and the rhumb line comparison appear with full working.
3. **Meridian crossings**
   The table lists the latitude at each whole degree of longitude plus course and distance to the next point. The whole route can be saved as waypoints with one click.

13.7 Printable calculation record

Every calculation can be printed as a clear record or saved as a PDF – with inputs, result, full working and, here, all meridian crossings too. Handy for passage planning, in the classroom and for your files.



Great Circle Navigation

NauticTools2 – report of 22.10.2026, 14:01

Input

Start position	46°30.0'N 053°00.0'W
Destination	49°40.0'N 006°14.0'W

Result

Great-circle distance	1853.6 nm
Initial course	066.7°
Final course	102.4°
Rhumb-line course	084.2°
Rhumb-line distance	1883.3 nm
Great-circle savings	29.7 nm
Vertex	50°47.3'N 022°17.7'W

Calculation

ΔB	*φB − φA*	3.1667°
ΔL	*λB − λA*	46.7667°
Rhumb line	*meridional parts, for comparison*	084.2° / 1883.3 nm
Great-circle distance	*Central angle A↔B · 60*	1853.6 nm
Initial course	*from φA/λA, φB/λB*	066.7°
Final course	*Reverse course B→A + 180°*	102.4°
Savings	*Rhumb line − great circle*	29.7 nm
Vertex	*Clairaut, from unrounded initial course*	50°47.3'N 022°17.7'W

Meridian Crossings

053°00.0'W	46°30.0'N	052°00.0'W	46°47.4'N	051°00.0'W	47°04.2'N	050°00.0'W	47°20.2'N
049°00.0'W	47°35.6'N	048°00.0'W	47°50.3'N	047°00.0'W	48°04.3'N	046°00.0'W	48°17.7'N
045°00.0'W	48°30.5'N	044°00.0'W	48°42.6'N	043°00.0'W	48°54.2'N	042°00.0'W	49°05.1'N
041°00.0'W	49°15.5'N	040°00.0'W	49°25.2'N	039°00.0'W	49°34.4'N	038°00.0'W	49°43.0'N
037°00.0'W	49°51.0'N	036°00.0'W	49°58.5'N	035°00.0'W	50°05.4'N	034°00.0'W	50°11.8'N
033°00.0'W	50°17.7'N	032°00.0'W	50°23.0'N	031°00.0'W	50°27.8'N	030°00.0'W	50°32.0'N
029°00.0'W	50°35.7'N	028°00.0'W	50°38.9'N	027°00.0'W	50°41.6'N	026°00.0'W	50°43.8'N
025°00.0'W	50°45.4'N	024°00.0'W	50°46.5'N	023°00.0'W	50°47.2'N	022°00.0'W	50°47.3'N
021°00.0'W	50°46.9'N	020°00.0'W	50°45.9'N	019°00.0'W	50°44.5'N	018°00.0'W	50°42.6'N
017°00.0'W	50°40.1'N	016°00.0'W	50°37.1'N	015°00.0'W	50°33.6'N	014°00.0'W	50°29.6'N
013°00.0'W	50°25.0'N	012°00.0'W	50°19.9'N	011°00.0'W	50°14.3'N	010°00.0'W	50°08.1'N
009°00.0'W	50°01.4'N	008°00.0'W	49°54.2'N	007°00.0'W	49°46.4'N		

Figure 13.3 The printed record of the Cape Race – Scilly example.

13.8 Frequently asked questions

Why is the great circle shorter although it looks longer on the chart?

Because the Mercator chart distorts the earth: everything is stretched towards the poles. What looks like a detour on the chart is the direct route on the globe.

What is the vertex?

The point of the great circle nearest the pole. There the great circle runs exactly east-west; its course is 090° or 270°.

How do you sail a great circle in practice?

Put waypoints on the great circle, for example at the meridian crossings, and sail a rhumb line from waypoint to waypoint. The course then stays constant leg by leg.

13.9 See also

- **Dead Reckoning** (chapter 12) – course and distance on the rhumb line
- **Distance, Speed and Time** (chapter 7) – passage time from distance and speed

PART II

Celestial Navigation

From the celestial body to the position line: sextant, ephemeris, sight reduction and fixing your position.

PART II · CELESTIAL NAVIGATION

14 Meridian Diagram

Meridian diagram – how high does a body stand at meridian passage?

The **meridian diagram** is the classic construction of celestial navigation: zenith, celestial pole, celestial equator and body in one drawing. NauticTools2 draws it for any **latitude** and **declination**, calculates the upper and lower **meridian altitude** and shows whether a body rises and sets, is circumpolar or never rises.

Zenith · nadir | Celestial pole | Celestial equator | Meridian altitude | Circumpolar | Altitude and azimuth

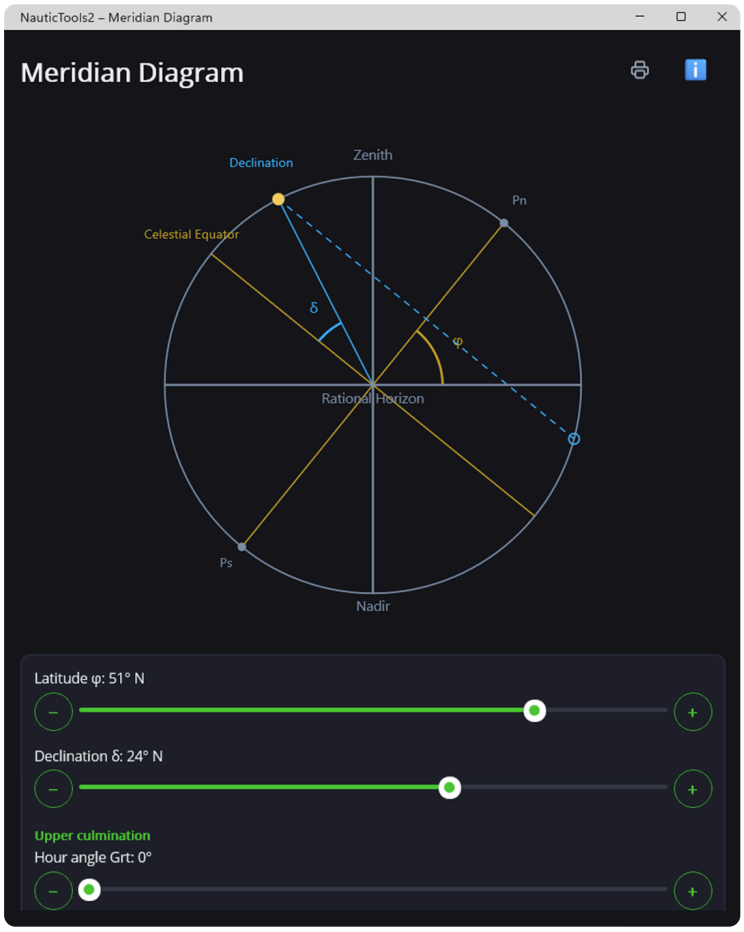


Figure 14.1 The meridian diagram for 51° N and a body with 24° N declination at upper transit.

14.1 What is the meridian diagram?

The circle is the plane of the **observer's meridian**: zenith at the top, nadir at the bottom, the rational horizon across with north and south. The **celestial pole** stands exactly the observer's latitude φ above the horizon, the **celestial equator** at right angles to it. A body with declination δ lies δ away from the equator – and on its daily circle, parallel to the equator, it crosses the meridian once a day at the top, the **upper transit**, and once at the bottom, the **lower transit**.

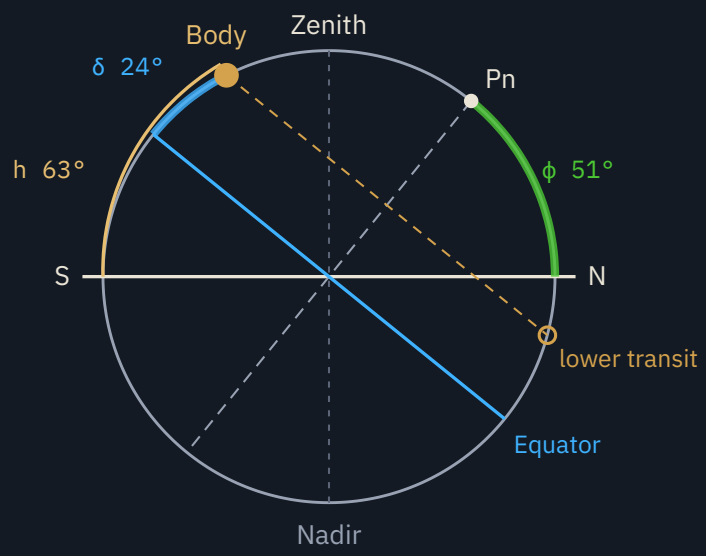


Figure 14.2 Meridian diagram for 51° N, north on the right as in the app: the pole Pn stands 51° above the northern horizon, the equator at right angles to it. The body with 24° N declination culminates 63° high in the south; its lower transit (dashed daily circle) is below the horizon.

14.2 When do you need it?

- **Understanding the noon sight:** The formula φ = 90° − h + δ follows directly from the meridian diagram – once you have drawn it, you won't mix up the signs again.
- **Planning observations:** How high is the sun at noon, does a star cross the meridian to the north or south, does it rise at all?
- **Recognising circumpolar bodies:** Stars that never set can be shot all night – even at their lower transit.
- **A feel for celestial navigation:** Moving the sliders shows at once how latitude, declination and hour angle relate.

14.3 Formulas and working

$$h_{upper} = 90° - |\varphi - \delta| \cdot h_{lower} = |\varphi + \delta| - 90°$$

1. **Zenith distance**
   $z = \phi - \delta$, north positive, south negative. If $z \geq 0$, the body crosses the meridian on the equator side of the zenith (in the northern hemisphere to the south), otherwise on the pole side.
2. **Upper transit**
   $h = 90° - |z|$. If it is 0° or less, the body never rises.
3. **Lower transit**
   $h = |\phi + \delta| - 90°$, on the pole side. If it is 0° or more, the body is circumpolar and never sets.

4. **Altitude and azimuth at any time**
   For any local hour angle t: `H = asin(sinφ · sinδ + cosφ · cosδ · cos t)` and `Az = atan2(−sin t, cosφ · tanδ − sinφ · cos t)`.

14.4 Worked examples

Observer at 51° N, body with declination 24° N. How high does it cross the meridian?

```
z = 51° − 24° = 27° → equator side, i.e. south
upper transit h = 90° − 27° = 63° S
lower transit h = 75° − 90° = −15° → below the horizon
The body rises and sets.
```

Observer at 54° N, star with declination 60° N. Does it set?

```
z = 54° − 60° = −6° → pole side, i.e. north
upper transit h = 90° − 6° = 84° N
lower transit h = 114° − 90° = 24° N
The star is circumpolar and never sets.
```

14.5 Things to watch out for

- **Signs:** Use signed latitude and declination – north positive, south negative. With contrary names (e.g. 51° N and 20° S), z becomes larger than φ.
- **Rational horizon:** The diagram shows altitudes above the rational horizon. Sextant altitudes must be corrected first (dip, refraction, semi-diameter, parallax).
- **In-between positions:** Strictly, a body lies in the meridian plane only at transit. Between upper and lower transit the movement in the diagram is a simplified picture – the altitude and azimuth shown next to it are still calculated exactly.

14.6 How it works in NauticTools2

1. **Set latitude and declination**
   With the sliders or the arrows next to them, one degree at a time; north and south of the equator.
2. **Move the hour angle**
   The hour-angle slider takes the body once through the whole day (0° to 360°): at 0° it is at upper culmination, at 180° at lower culmination. Two buttons jump straight there.
3. **Read the result**
   Current altitude and azimuth, the status “rises and sets”, “circumpolar – never sets” or “never rises”, and the working with both meridian altitudes.
4. **Print**
   Inputs, result, working and the diagram can be printed as a record or saved as a PDF.

14.7 Frequently asked questions

What is meridian passage?
The moment a body crosses the observer's meridian. At upper transit it reaches its greatest altitude, at lower transit its smallest – which you only see for circumpolar bodies.

When is a body circumpolar?
When its lower transit is above the horizon too: $|\varphi + \delta| \geq 90°$, with latitude and declination of the same name. At 54° N this applies to all stars with more than 36° N declination.

How does the meridian diagram relate to the noon sight?
The noon sight is the meridian diagram worked backwards: from the measured meridian altitude h and the declination δ you get the latitude $\varphi = 90° - h + \delta$ (for a southern transit in the northern hemisphere).

14.8 See also

- **Fix from 2 or 3 altitudes** (chapter 25) – position lines and fix from celestial sights
- All celestial navigation tools – from the star chart to the compass check

PART II · CELESTIAL NAVIGATION

15 Star Chart

Star chart – which navigational stars are up right now?

The **star chart** shows the sky for any place and time – with the **navigational stars**, sun, moon and the four navigational planets, constellations and the current **twilight status**. A rotatable **crosshair** helps you pick three well-spread stars for a fix.

57 navigational stars + Polaris | Sun · moon · planets | Constellations | Altitude and azimuth | Twilight | Crosshair

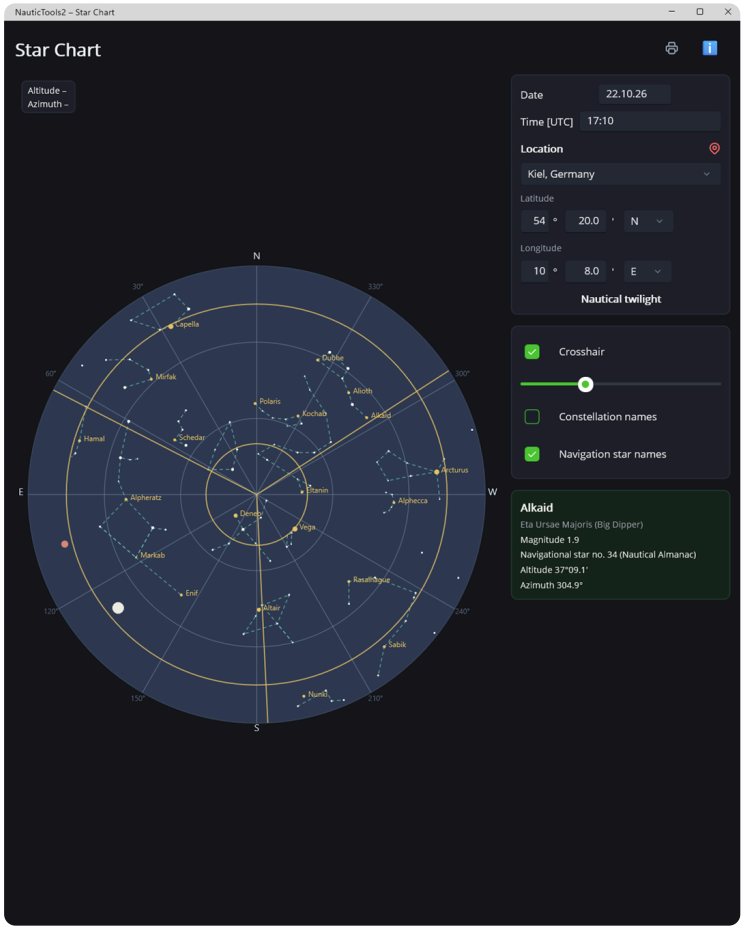


Figure 15.1 Kiel on 22 October 2026 at 17:10 UTC in nautical twilight – with the crosshair and navigational star names; bottom right the details of the tapped star Alkaid.

15.1 What does the star chart show?

The chart is the view from the **zenith** (centre) down to the **horizon** (edge) – as if you were lying on deck looking straight up. North is at the top, **east on the left** and west on the right. A horizon grid with altitude circles at 30° and 60° and azimuth lines every 30° helps with estimating. The brighter a star, the larger its dot; the 57 navigational stars of the Nautical Almanac plus Polaris are highlighted in colour, with their almanac names and numbers. The other stars are only there so you can recognise the constellations.

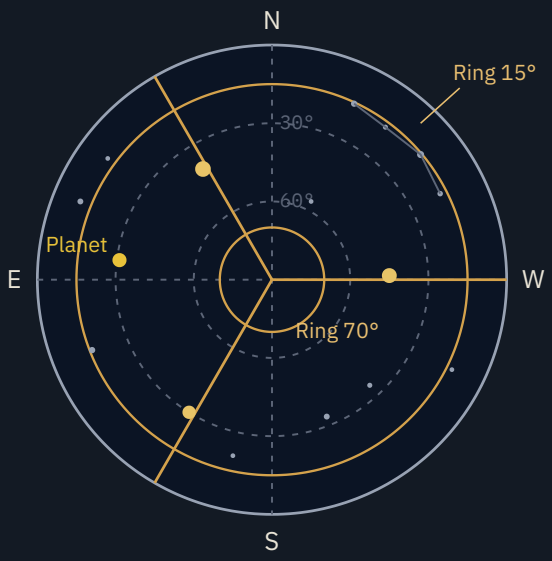


Figure 15.2 View from the zenith: north at the top, east on the left. The crosshair has three arms 120° apart and two rings at 15° and 70° altitude. A highlighted navigational star lies on each arm between the rings – ideal for a fix from three altitudes.

15.2 When do you need it?

- **Planning star sights:** Which navigational stars are at a good altitude at twilight, and how are they spread across the sky?
- **Identifying stars:** A tap shows name, constellation and almanac number – useful when you can't place a bright star from the deck.
- **Telling planets apart:** Venus, Mars, Jupiter and Saturn wander through the constellations and are easily mistaken for stars.
- **Catching twilight:** The chart shows whether it is day, civil or nautical twilight, or night.

15.3 The crosshair

For a good fix from three altitudes the bodies should be spread as evenly as possible around the horizon – the position lines then cross at about 60° or 120°. The crosshair has three arms 120° of azimuth apart and can be turned with a slider. The two rings mark 15° and 70° altitude: below that refraction becomes uncertain, above it the altitude is hard to measure with the sextant. If a navigational star lies on each arm between the rings, you have a good selection.

15.4 For instructors: create your own celestial exercises

The star chart is the ideal starting point for new exercises on a fix from star altitudes – with stars that genuinely fit the place and time:

1. **Choose a position**
   Pick any coordinates, for example in the Caribbean off Martinique (14° 30' N, 061° 20' W). This is the true position and therefore the answer to the exercise.

2. **Find twilight**
   Choose a date and move the time (UTC) until the chart shows “nautical twilight”.
3. **Pick three stars**
   Turn the crosshair until a highlighted navigational star lies on each arm between the rings. Tap each star and note its name, altitude and azimuth.
4. **Set the exercise**
   Give your students a DR position a few miles away from the true position and alter the altitudes slightly – a few minutes of arc, just as a real sextant sight would. If the exercise should start from the sextant reading, work the altitudes back to Hs with height of eye, index error and refraction.
5. **Check the answer**
   Work the exercise yourself with **Fix from 2 or 3 altitudes** (chapter 25): the cocked hat should lie close to the chosen position.

In a few minutes you have realistic exercises for any sea area – not just the same textbook examples over and over.

15.5 How the chart is calculated

$$\sin H = \sin\varphi \cdot \sin\delta + \cos\varphi \cdot \cos\delta \cdot \cos LHA$$

1. **Ephemerides**
   For the chosen time (UTC), Greenwich hour angle and declination of all stars, the sun, the moon and the planets are calculated – as in the ephemeris calculation.
2. **Local hour angle**
   $LHA = GHA + \lambda$ (east longitude positive).
3. **Altitude and azimuth**
   Altitude H from the formula above, the azimuth from the same navigational triangle. Bodies below the horizon are not drawn.
4. **Twilight**
   From the sun's altitude: above 0° day, down to −6° civil twilight, down to −12° nautical twilight, below that night.

15.6 Things to watch out for

- **Time in UTC:** The chart works in universal time, not ship's time or summer time.
- **A finding aid:** The star chart is not a planetarium. It deliberately shows only the stars that matter for navigation and for recognising the constellations; the constellation lines are simplified.
- **Calculated altitudes:** The altitudes shown refer to the rational horizon. For the position line what counts is the measured and corrected sextant altitude.

15.7 How it works in NauticTools2

1. **Choose place and time**
   Enter date, time (UTC), latitude and longitude or pick a saved waypoint. Without your own input the chart uses the current GPS position, if available – so it shows what is overhead right now. Every change is applied immediately.
2. **Set up the display**
   Show or hide constellation and navigational star names, switch on the crosshair and turn it with the slider.
3. **Tap a star**
   Name, constellation, magnitude, number in the Nautical Almanac and altitude and azimuth appear in the info panel. On Windows the mouse also shows altitude and azimuth anywhere on the chart.
4. **Save and print**
   Save the place as a waypoint, or print the chart as a record or save it as a PDF.

15.8 Frequently asked questions

Why is east on the left?

Because the chart shows the sky as you see it looking up. With north at the top, east is on the left and west on the right – mirrored compared with a map you look down on.

When do you take star sights?

During nautical twilight, when the sun is between 6° and 12° below the horizon. The bright stars are already visible and the horizon can still be seen. The star chart shows this status directly.

How many navigational stars are there?

The Nautical Almanac lists 57 navigational stars plus Polaris – exactly the stars highlighted on the chart, with their almanac names and numbers. (The German version of the app uses the 80 stars of the German Nautisches Jahrbuch instead.)

15.9 See also

- **Fix from 2 or 3 altitudes** (chapter 25) – from star altitudes to the ship's position
- **Meridian diagram** (chapter 14) – meridian altitude and circumpolar bodies explained

PART II · CELESTIAL NAVIGATION

16 Rising and Setting Times

Rising and setting – when does the sun set, when does nautical twilight begin?

NauticTools2 calculates the **rising and setting times** of the sun, the moon and the planets Venus, Mars, Jupiter and Saturn for any place and date. For the sun you also get **meridian passage** and all three kinds of **twilight** – civil, nautical and astronomical. All times in UTC.

`Sun · moon · planets` `True and visible rising/setting` `Meridian passage` `Civil twilight` `Nautical twilight` `Astronomical twilight`

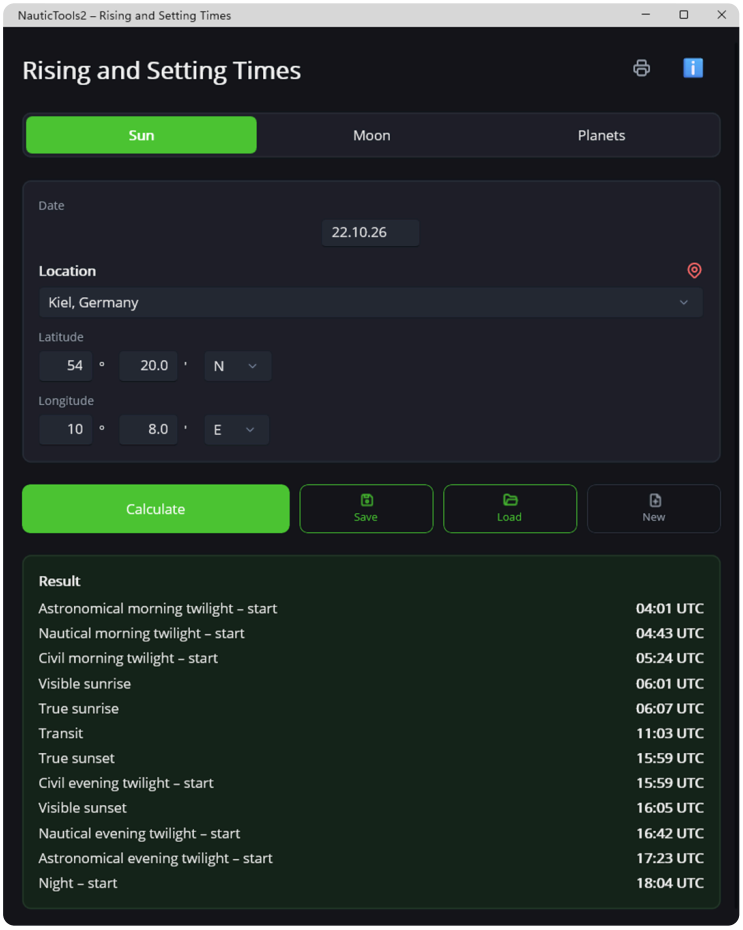


Figure 16.1 The sun at Kiel on 22 October 2026: from the start of astronomical morning twilight to the start of night.

16.1 What is calculated?

In each case the tool looks for the moment the centre of the body reaches a certain altitude above the rational horizon. Which altitude depends on the event:

Event	Altitude of the centre
True sunrise/sunset	0°
Visible sunrise/sunset	−50′
Civil twilight	down to −6°
Nautical twilight	−6° to −12°
Astronomical twilight	−12° to −18°
Moonrise/moonset	+8′
Planets	−34′

The sun's −50′ consist of refraction at the horizon (about 34′) and the sun's semi-diameter (about 16′). For the moon, its large horizontal parallax more than cancels the refraction – hence +8′. Planets are practically point sources, so only refraction counts. **Meridian passage** (shown as “Transit” in the app) is the crossing of the meridian, the highest point in the sky.

The dachshund rule – an old sailors' rule of thumb for true sunrise and sunset:

The sun stands just high enough above the horizon for a dachshund to walk comfortably underneath it without bumping its head. That is surprisingly accurate: at true sunset the sun's centre is at 0° by calculation, but refraction lifts the sun by about 34′. Its lower limb is then about 18′ above the horizon – a good third of the sun's diameter, about the height of a dachshund. The sun only sets visibly once its upper limb has disappeared too.

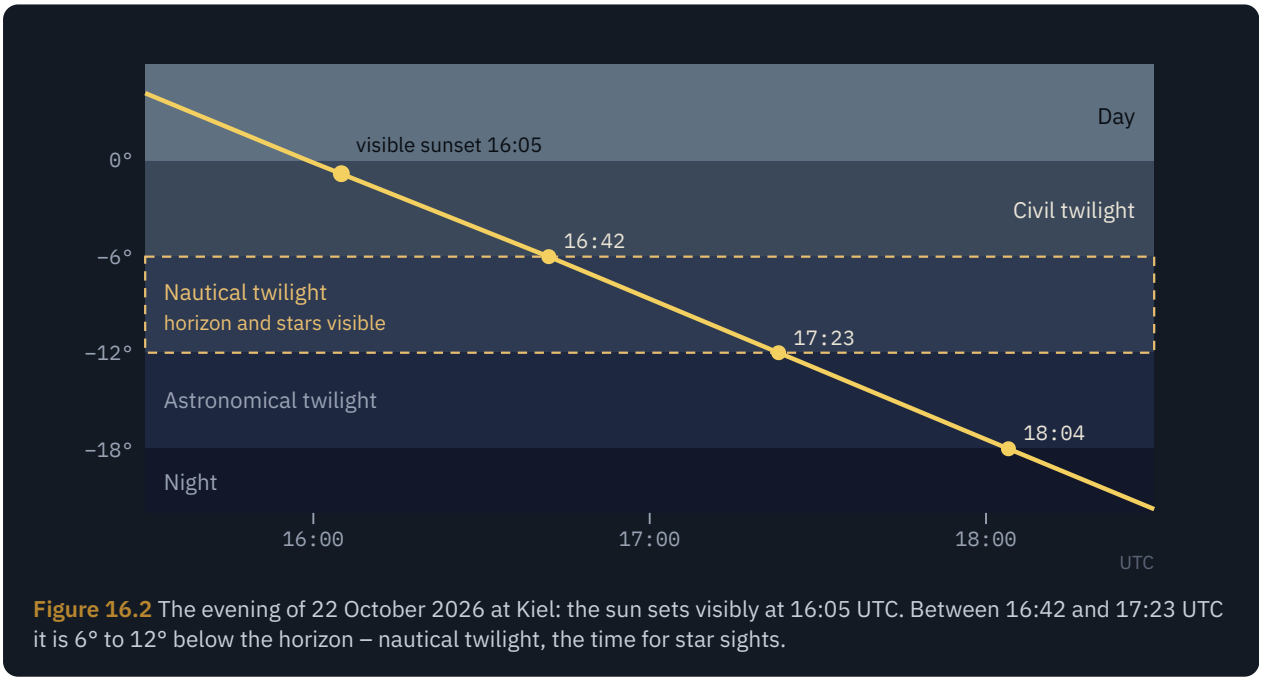


Figure 16.2 The evening of 22 October 2026 at Kiel: the sun sets visibly at 16:05 UTC. Between 16:42 and 17:23 UTC it is 6° to 12° below the horizon – nautical twilight, the time for star sights.

16.2 When do you need it?

- **Planning star sights:** Nautical twilight sets the window in which horizon and stars are both visible. Then pick suitable stars with the **star chart** (chapter 15).

- **Preparing the noon sight:** The sun's meridian passage is the moment for the noon latitude.
- **Navigation lights:** Navigation lights are shown from sunset to sunrise – here you get the times for any place.
- **Planning a night passage:** When does the moon rise and set? A bright moon keeps the horizon and the fairway visible at night.

16.3 Calculation

$$\cos t = (\sin h_0 - \sin\varphi \cdot \sin\delta) / (\cos\varphi \cdot \cos\delta)$$

1. **Target altitude**
   h_0 from the table above, e.g. −50′ for visible sunset or −12° for the end of nautical twilight.
2. **Local hour angle**
   From latitude φ and declination δ the formula gives the local hour angle t at which the body has this altitude – west for setting, east for rising.
3. **Time**
   From t and the longitude follows the Greenwich hour angle, and from the ephemerides the corresponding time in UTC. Because declination and hour angle change during the day – especially for the moon – NauticTools2 uses the values for the moment in question.
4. **Special cases**
   If the fraction lies outside −1 to +1, the body does not reach that altitude on that day: it is always visible (midnight sun) or not visible (polar night).

16.4 Examples

Kiel (54° 20′ N, 010° 08′ E) on 22 October 2026 – when is evening nautical twilight?

```
Visible sunset 16:05 UTC (true sunset 15:59 UTC)
Nautical twilight 16:42 – 17:23 UTC
Night from 18:04 UTC · meridian passage 11:03 UTC
```

Textbook example: 22 October 2026 off Martinique at 14° 30.0′ N, 061° 20.0′ W – sunrise and sunset?

```
Nautical twilight 09:11 UTC and 22:28 UTC
Visible sunrise 09:57 UTC · meridian passage 15:49 UTC · visible sunset 21:41 UTC
True sunrise 10:01 UTC · true sunset 21:37 UTC
```

16.5 Things to watch out for

- **Times in UTC:** Add the zone time for ship's time – at Kiel in October (summer time) two hours. The **time systems** (chapter 1) tool does the conversion.

- **High latitudes:** In summer the sun may not reach the target altitude at all – then “always visible” or “not visible” appears instead of a time. In northern European waters this mainly affects astronomical twilight in June.
- **Moon:** It rises on average about 50 minutes later each day, so on some calendar days there is no moonrise or no moonset.
- **Height of eye:** The times apply to the horizon at sea level. From a high vantage point you see the sun a little longer.

16.6 How it works in NauticTools2

1. **Choose the body**
   Sun, moon or planets using the bar at the top.
2. **Enter date and place**
   Enter latitude and longitude or pick a saved waypoint; the location icon also saves the place as a new waypoint.
3. **Calculate**
   The times appear in chronological order – for the sun from the start of astronomical morning twilight to the start of night.
4. **Save and print**
   Save inputs under a name and load them later, print the result as a record or save it as a PDF.

16.7 Frequently asked questions

What is the difference between true and visible sunset?
At true sunset the sun's centre reaches the horizon by calculation. The sun is still visible then, because refraction lifts it and its upper limb is higher. Visible sunset is at −50′ – a few minutes later in mid-latitudes.

When is nautical twilight?
When the sun is 6° to 12° below the horizon. The bright stars are already visible and the horizon can still be seen – the classic time for star sights.

Why does the moon sometimes not rise on a given day?
Because it is about 50 minutes later every day. Roughly once a month the moonrise slips past midnight into the next day.

16.8 See also

- **Star chart** (chapter 15) – which navigational stars are up at twilight
- **Time systems on board** (chapter 1) – convert UTC, zone time and local time
- **Meridian diagram** (chapter 14) – meridian altitude and circumpolar bodies explained

PART II · CELESTIAL NAVIGATION

17 Ephemeris Calculation

Ephemeris calculation – GHA and declination for any moment

Every celestial position line needs the **Greenwich hour angle** and the **declination** of the body. NauticTools2 calculates them for the sun, moon, Venus, Mars, Jupiter, Saturn and 83 stars – to the second, for any date, without looking up and interpolating in the Nautical Almanac.

GHA | Declination | SHA and GHA Aries | HP and semi-diameter | Local hour angle | 83 stars

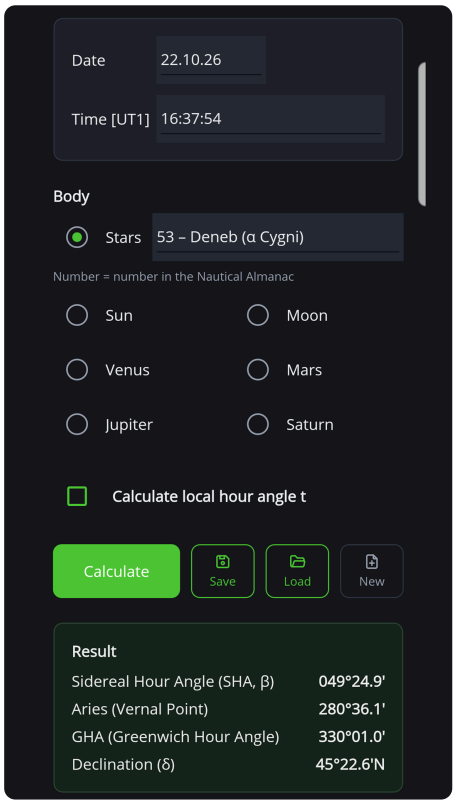


Figure 17.1 Deneb on 22 October 2026 at 16:37:54 UT1 – in the Android version.

17.1 What is calculated?

- **GHA (Greenwich hour angle):** the angle from the Greenwich meridian to the body, measured westward from 0° to 360° – for every body.
- **Declination:** the body's "latitude" in the sky, ±90°.
- **SHA and GHA Aries:** for stars, the two building blocks of the GHA.
- **Semi-diameter** (sun) and **horizontal parallax HP** (moon, Venus, Mars): corrections for the sextant altitude.
- **Sun's Greenwich transit:** the time the sun crosses the Greenwich meridian.
- **Local hour angle:** optionally included if you enter your own longitude.

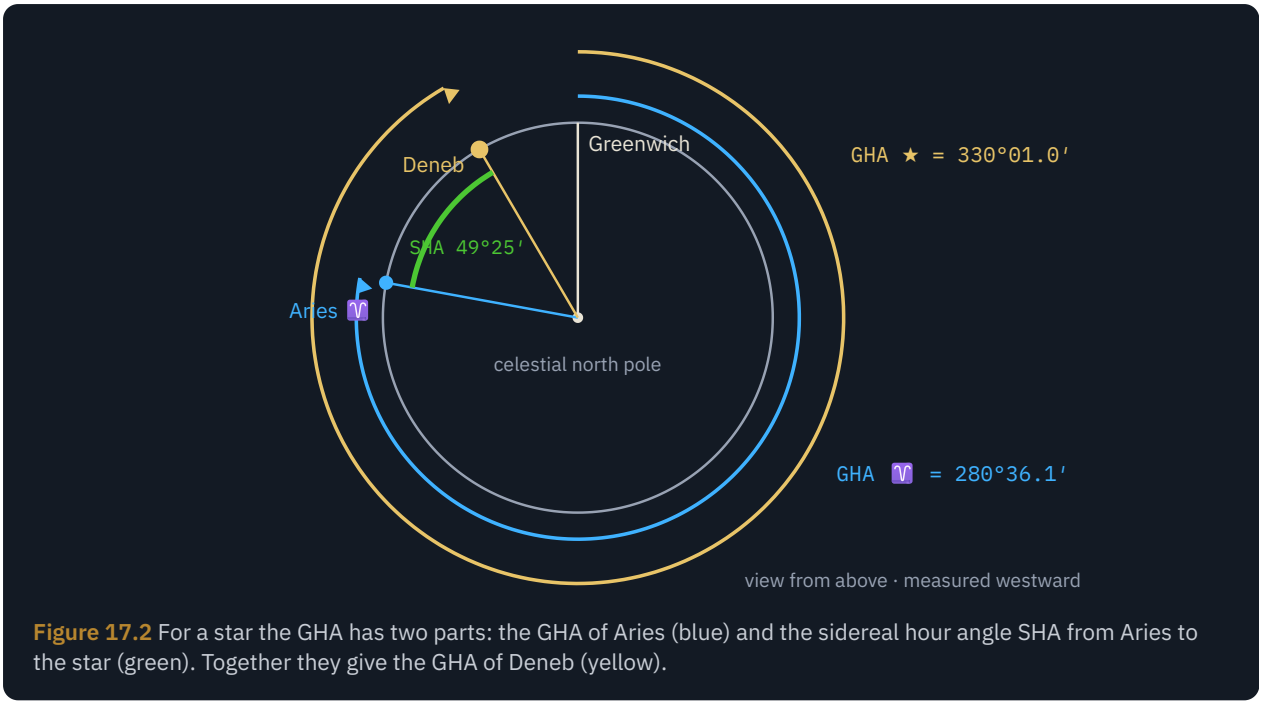


Figure 17.2 For a star the GHA has two parts: the GHA of Aries (blue) and the sidereal hour angle SHA from Aries to the star (green). Together they give the GHA of Deneb (yellow).

17.2 When do you need it?

- **Working a position line:** GHA and declination are the inputs for computed altitude and azimuth – and so for every celestial position line.
- **Replacing or checking the almanac:** No more page-turning and interpolating – or check your own almanac working.
- **Solving older exercises:** Many exercises date from years for which you no longer have an almanac. The calculation works for any date.

17.3 Formulas and working

> `GHA ★ = GHA ♈ + SHA · LHA = GHA + λ`

1. **Time**
   Date and time in UT1, to the second – the sun's GHA grows by 15′ per minute.
2. **Sun, moon and planets**
   GHA and declination come from a modern astronomy library that runs offline – reliable even far outside 1950 to 2050.
3. **Stars**
   SHA and declination are brought from epoch 2000.0 to the date (precession, nutation, aberration). The GHA of Aries comes from sidereal time; the sum is the GHA of the star.
4. **Local hour angle**
   `LHA = GHA + λ` – add east longitude, subtract west longitude.

17.4 Example

GHA and declination of Deneb on 22 October 2026 at 16:37:54 UT1 – and the local hour angle at Kiel (010° 08.0′ E)?

```
SHA = 049°24.9′
GHA ♈ = 280°36.1′
GHA = 280°36.1′ + 049°24.9′ = 330°01.0′
Declination = 45°22.6′ N
LHA = 330°01.0′ + 010°08.0′ = 340°09.0′
```

17.5 Things to watch out for

- **To the second:** One second of time error is 0.25′ of GHA – a quarter of a mile in the position line. Take the time of the sight carefully.
- **UT1 and UTC:** The calculation uses UT1, the Earth rotation time. It differs from UTC by at most 0.9 seconds – negligible for navigation.
- **Sign of longitude:** For the local hour angle add east longitude and subtract west longitude; reduce results above 360° by 360°.
- **Small differences from the almanac:** The printed almanac is rounded to 0.1′ and interpolated linearly, so differences of one or two tenths of a minute are normal.

17.6 How it works in NauticTools2

1. **Enter the time**
   Date and time (UT1); the current time is filled in.
2. **Choose the body**
   Sun, moon, one of the planets or a star from the list. The list starts with the 57 navigational stars of the Nautical Almanac with their numbers, then Polaris, then further bright stars in alphabetical order.
3. **Local hour angle**
   Optionally tick “Calculate local hour angle t” and enter your longitude.
4. **Calculate, save, print**
   The values appear in the result; inputs can be saved and loaded, the result printed as a record or saved as a PDF.

17.7 Frequently asked questions

What is the Greenwich hour angle?

The angle between the Greenwich meridian and the body, measured westward. Together with the declination it fixes the point on Earth directly beneath the body – its geographical position.

Why do you get SHA and GHA Aries for stars?

The stars hardly move relative to each other. So the almanac gives each star only its sidereal hour angle from Aries, plus the GHA of Aries for every hour. Their sum is the GHA of the star – NauticTools2 shows both parts.

Does the tool replace the Nautical Almanac?

It gives the same values for any moment and any year. For exams and as a backup on board, the printed almanac is still worth having.

17.8 See also

- **Fix from 2 or 3 altitudes** (chapter 25) – from GHA, declination and sextant altitudes to the fix
- **Star chart** (chapter 15) – which stars are up right now
- **Rising and setting times** (chapter 16) – twilight times for star sights

PART II · CELESTIAL NAVIGATION

18 Sextant Altitude Corrections

Sextant altitude corrections – from the reading Hs to the observed altitude Ho

The altitude read off the sextant is not yet the altitude you work with. Only after **index error**, **dip**, **refraction** and – depending on the body – **semi-diameter** and **parallax** do you get the observed altitude Ho. NauticTools2 works the whole chain and shows every step.

`Index error` `Dip` `Refraction` `Semi-diameter` `Horizontal parallax` `Sun · moon · planets · stars`

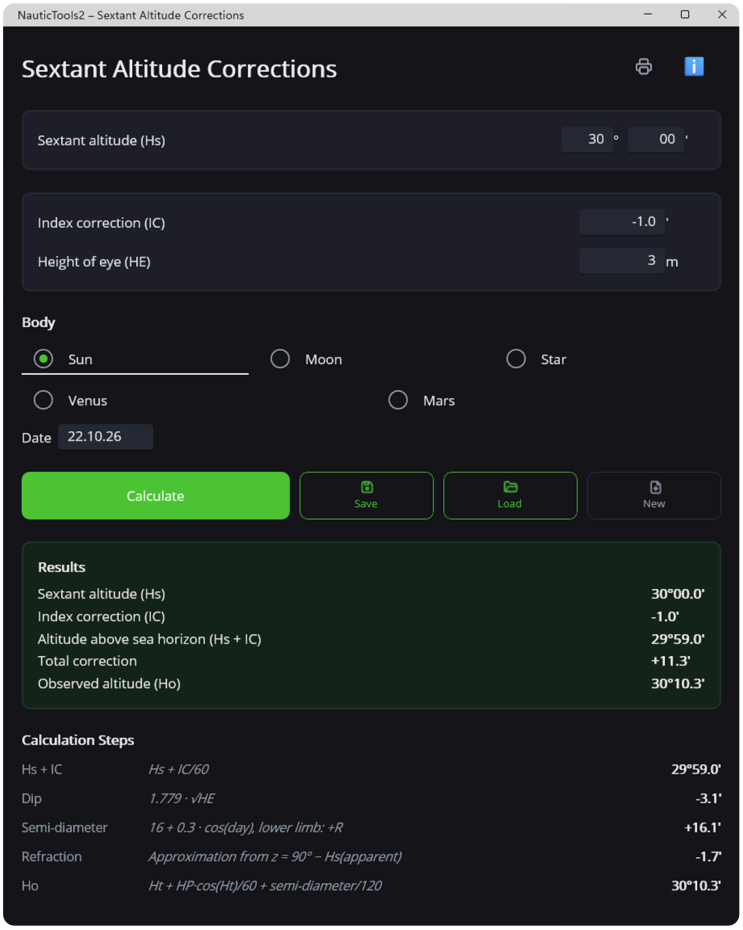


Figure 18.1 Sun's lower limb on 22 October 2026: Hs 30°00.0′ becomes Ho 30°10.3′ – with every correction in the working. The line under “Sun” shows that the lower limb is selected.

18.1 Which corrections are applied?

Correction	Size	Applies to
Index error	`± a few '`	all bodies
Dip	`− 1.779 · √HE`	all bodies
Refraction	`− 0' to 34'`	all bodies
Semi-diameter	`± about 16'`	sun, moon
Parallax	`+ HP · cos H`	moon, Venus, Mars

The **index correction** compensates the error of the sextant itself. **Dip** arises because the eye is above the water: the visible sea horizon lies below the rational horizon. **Refraction** lifts every body apparently – by over half a degree near the horizon, not at all at the zenith. For the sun and moon you measure a limb; the **semi-diameter** refers the altitude to the centre. **Parallax** converts from the observer to the centre of the Earth for the nearby moon and the planets Venus and Mars.

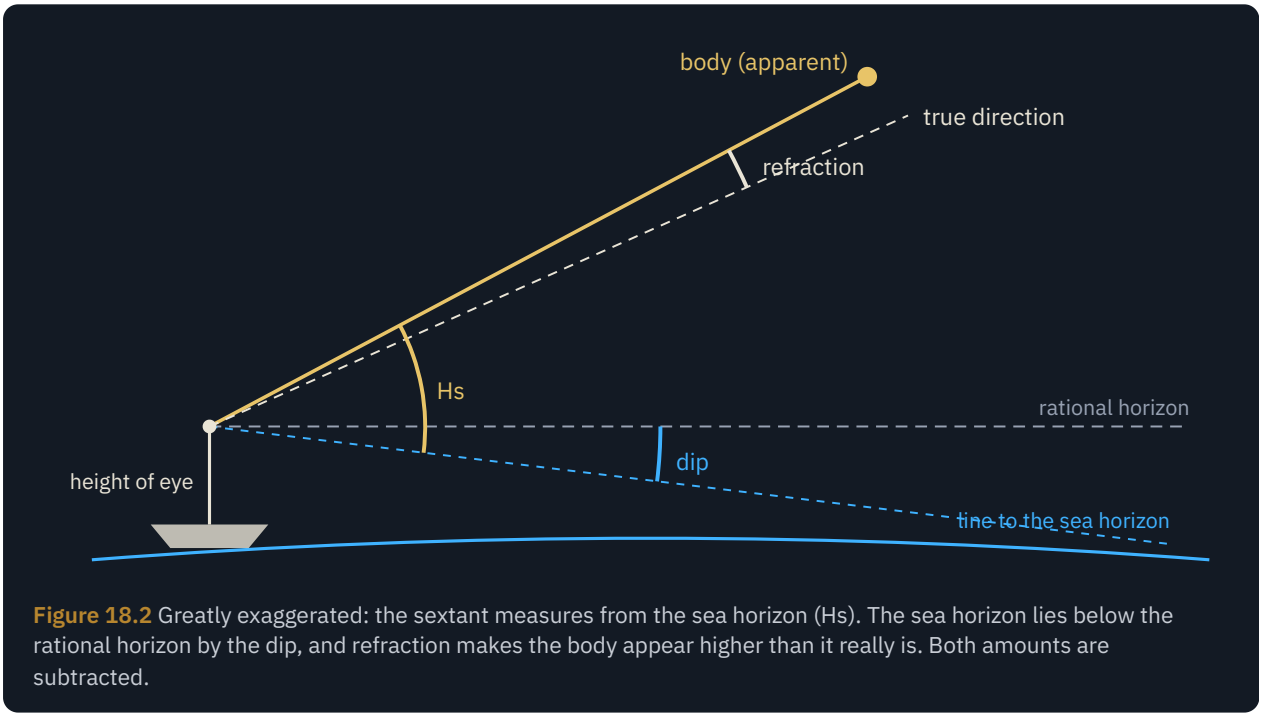


Figure 18.2 Greatly exaggerated: the sextant measures from the sea horizon (Hs). The sea horizon lies below the rational horizon by the dip, and refraction makes the body appear higher than it really is. Both amounts are subtracted.

18.2 When do you need it?

- **Every celestial position line:** The observed altitude Ho is compared with the computed altitude – without corrections the position line would be several miles out.
- **Noon sight:** Latitude from the meridian altitude also needs the corrected altitude.
- **Checking exercises:** The working shows every correction with its sign.

18.3 Formulas and working

```
Ho = Hs + IC − dip − refraction ± SD + parallax
```

1. **Index correction**
   `Hs + IC` – the reading corrected for the index error.
2. **Dip**
   `1.779 · √HE` in minutes of arc, with the height of eye HE in metres; subtracted.
3. **Semi-diameter**
   For the sun about 15.7′ to 16.3′ depending on the season, for the moon `0.2725 · HP`. Lower limb: add, upper limb: subtract.
4. **Refraction**
   Depends on the apparent altitude – about 34′ at the horizon, about 2.6′ at 20°, just under 1′ at 45°. Subtracted.
5. **Parallax**
   `HP · cos H` for the moon, Venus and Mars; NauticTools2 calculates the horizontal parallax HP from date and time. Added.
6. **Result**
   Observed altitude Ho and the total correction.

18.4 Worked examples

Star Vega: Hs = 58°33.0′, index correction −1.0′, height of eye 3 m. What is Ho?

```
Hs + IC = 58°33.0′ − 1.0′ = 58°32.0′
Dip = −3.1′ · refraction = −0.6′
Total correction = −3.7′
Ho = 58°28.3′
```

Sun, lower limb, on 22 October 2026: Hs = 30°00.0′, index correction −1.0′, height of eye 3 m.

```
Hs + IC = 29°59.0′
Dip −3.1′ · semi-diameter +16.1′ · refraction −1.7′
Total correction = +11.3′
Ho = 30°10.3′
```

Star Shaula: Hs = 26°59.0′, index correction −1.0′, height of eye 3 m.

```
Hs + IC = 26°58.0′ · total correction = −5.0′
Ho = 26°53.0′
```

18.5 Things to watch out for

- **Sign of the index correction:** The correction is the opposite of the error – if the sextant reads too high, the correction is negative. NauticTools2 can determine it with the **index error** (chapter 20) tool.
- **Estimate height of eye honestly:** It means the height of the eye above the waterline, not above the deck. Between 2 m and 3 m height of eye there is already 0.6′ of dip.

- **Avoid low altitudes:** Below about 15° refraction becomes uncertain because it depends strongly on temperature and pressure.
- **Choose the right limb:** For the sun and moon specify lower or upper limb; the wrong limb means an error of over 30′.

18.6 How it works in NauticTools2

1. **Enter the reading**
   Sextant altitude Hs in degrees and minutes, index correction and height of eye.
2. **Choose the body**
   Sun, moon, Venus, Mars or star (also for Jupiter and Saturn). For the sun and moon the app asks for lower or upper limb; a line under or over the name shows the choice.
3. **Date and time**
   For the sun only the date, for the semi-diameter. For the moon, Venus and Mars also the time: NauticTools2 calculates the horizontal parallax from it, which can still be overwritten.
4. **Calculate**
   Altitude above the horizon, total correction and Ho appear in the result, every correction with its sign in the working. Inputs can be saved and the result printed.

18.7 Frequently asked questions

What is the difference between Hs and Ho?

Hs is the sextant reading. Corrected for index error it becomes the altitude above the sea horizon. After dip, refraction and – depending on the body – semi-diameter and parallax you get the observed altitude Ho.

How large is the dip?

1.779 · √(height of eye) in minutes of arc: about 3.1′ at 3 m, about 5.6′ at 10 m.

Why is the sun usually measured on its lower limb?

The lower limb can be set on the horizon most precisely. To refer the altitude to the centre, the semi-diameter of about 16′ is added; for the upper limb it is subtracted.

18.8 See also

- **Fix from 2 or 3 altitudes** (chapter 25) – from corrected altitudes to position lines and the fix
- **Ephemeris calculation** (chapter 17) – GHA, declination and horizontal parallax
- **Vertical sextant angle** (chapter 6) – the sextant in coastal navigation

PART II · CELESTIAL NAVIGATION

19 Computed Altitude and Azimuth

Computed altitude and azimuth – solving the navigational triangle

Every celestial position line needs the altitude the body should have from the **DR position** and the direction in which it lies. From DR latitude, declination and local hour angle NauticTools2 calculates the **computed altitude Hc** and the **azimuth** – the working step between the ephemeris and the position line.

`DR latitude φ` `Declination δ` `Local hour angle` `Computed altitude Hc` `Azimuth` `Navigational triangle`

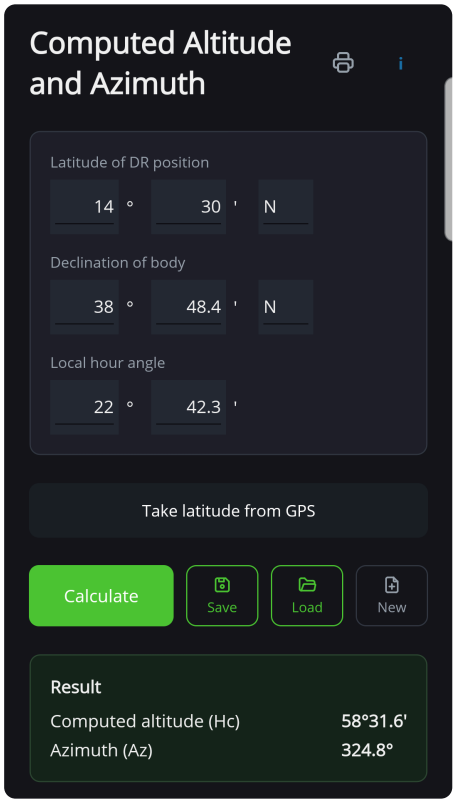


Figure 19.1 The Vega textbook example – in the Android version.

19.1 The navigational triangle

The celestial north pole, the observer's zenith and the body form a spherical triangle. Two sides and the angle between them are known: from pole to zenith **90° – φ**, from pole to body **90° – δ**, and the angle at the pole is the **local hour angle**. Wanted are the third side – the zenith distance **90° – Hc** – and the angle at the zenith, the **azimuth**.

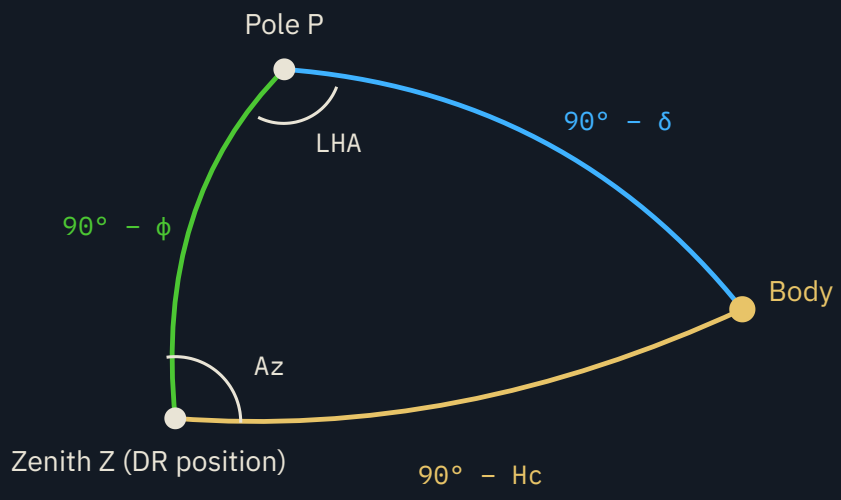


Figure 19.2 The navigational triangle: from the sides 90° − φ and 90° − δ and the included angle LHA follow the zenith distance 90° − Hc and the azimuth at the zenith.

19.2 When do you need it?

- **Altitude position line:** Hc and azimuth, together with the observed altitude Ho, are the building blocks of the position line by the intercept method (Marcq St. Hilaire).
- **Pre-computing a body:** Where and how high will a star be at twilight? With Hc and azimuth you can preset it on the sextant and look in the right direction.
- **Compass check:** The computed azimuth of the sun is the basis for finding the compass error.

19.3 Formulas and working

$$\sin Hc = \sin \varphi \cdot \sin \delta + \cos \varphi \cdot \cos \delta \cdot \cos LHA$$

1. **Inputs**
   DR latitude φ, declination δ (both signed, north positive) and local hour angle $LHA = GHA + \lambda$ from the ephemeris calculation.
2. **Computed altitude**
   With the formula above, the cosine rule of the navigational triangle.
3. **Azimuth**
   From the auxiliary values $hy = -\sin LHA$ and $hz = \cos \phi \cdot \tan \delta - \sin \phi \cdot \cos LHA$; their ratio and the sign of hy fix the quadrant, azimuth from 0° to 360°.
4. **Intercept**
   With the observed altitude Ho from the sextant corrections: $intercept = Ho - Hc$, in minutes of arc equal to nautical miles.

19.4 Worked examples

22 October 2026 off Martinique, DR position 14° 30′ N, 061° 20′ W. For the star Vega at 22:08:35 UT the ephemeris gave declination 38°48.4′ N and local hour angle 022°42.3′. What are Hc and azimuth?

```
Hc = 58°31.6′
Azimuth = 324.8°
With Ho = 58°28.3′ from the sextant corrections: intercept = 3.3 nm away, i.e.
offset 3.3 nm in direction 145°
```

Same DR position, star Shaula at 22:09:55 UT: declination 37°07.2′ S, local hour angle 038°38.5′.

```
Hc = 26°51.8′ · azimuth = 213.9°
With Ho = 26°53.0′: intercept = 1.2 nm towards, in direction 214°
```

19.5 Things to watch out for

- **Signs:** South latitude and declination are negative. A forgotten sign with contrary names gives a completely wrong altitude.
- **Forming the LHA correctly:** add east longitude, subtract west longitude, bring it into 0° to 360°.
- **Body below the horizon:** If Hc is negative, NauticTools2 says so instead of showing a meaningless result – usually a sign of an input error.
- **DR position instead of assumed position:** NauticTools2 works directly from the DR position. Rounding to an “assumed position” as with sight reduction tables is not needed.

19.6 How it works in NauticTools2

1. **Enter the values**
   DR latitude, declination and local hour angle in degrees and minutes, each with N/S. At sea, “Take latitude from GPS” fills in the current latitude as DR latitude.
2. **Calculate**
   Hc and azimuth appear in the result, the working below.
3. **Carry on**
   For two or three bodies, **Fix from altitudes** (chapter 25) brings all steps together to the fix. Inputs can be saved and the result printed.

19.7 Frequently asked questions

What is the computed altitude Hc?

The altitude the body should have at the time of the sight as seen from the DR position. Comparing it with the observed altitude Ho gives the intercept by which the position line is offset from the DR position.

What does a positive intercept mean?

The observed altitude is greater than the computed one – you are closer to the body's geographical position. The position line then lies intercept miles towards the body along the azimuth; a negative intercept means away from it.

Why is one minute of arc one nautical mile?

A nautical mile is defined as one minute of arc on a great circle of the Earth. An altitude difference of 1′ therefore offsets the position line by exactly 1 nm.

19.8 See also

- **Ephemeris calculation** (chapter 17) – GHA and declination for the time of the sight
- **Sextant altitude corrections** (chapter 18) – from the reading Hs to the observed altitude Ho
- **Fix from 2 or 3 altitudes** (chapter 25) – position lines and the fix

PART II · CELESTIAL NAVIGATION

20 Index Error

Index error – checking the sextant with the sun

Hardly any sextant reads exactly zero when set to zero. The **index correction** compensates this residual error and goes into every set of sextant altitude corrections. NauticTools2 finds it from two readings on the sun – **off the arc** and **on the arc** – and checks the sights straight away via the measured sun's radius.

`Off the arc` `On the arc` `Index correction IC` `Sun's radius` `Accuracy check` `Saved to Settings`

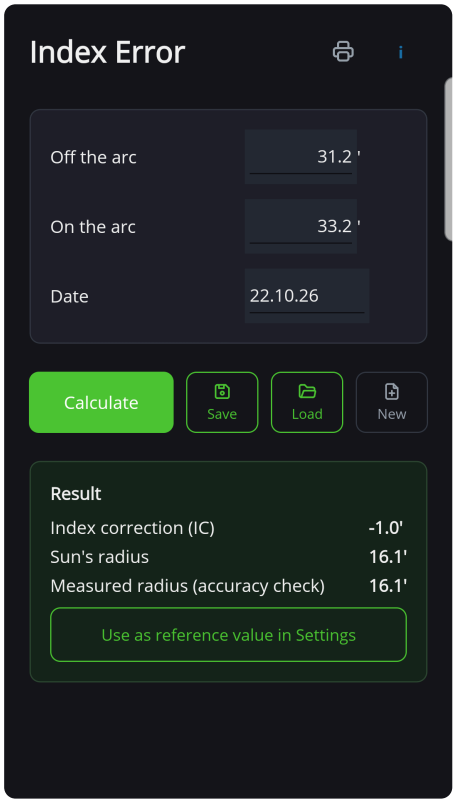


Figure 20.1 31.2′ off the arc and 33.2′ on the arc give IC = −1.0′ – in the Android version.

20.1 How is it measured?

With the sun shades in place, point the sextant at the sun and set it near zero. Two sun images appear in the telescope: the direct and the reflected one. First move the reflected image across the direct one until the limbs touch and read off – the index arm is then just **off the arc**, before zero. Then do the same the other way, just past zero **on the arc**. The two readings are one sun's diameter either side, four radii in total; the midpoint between them is the true zero.

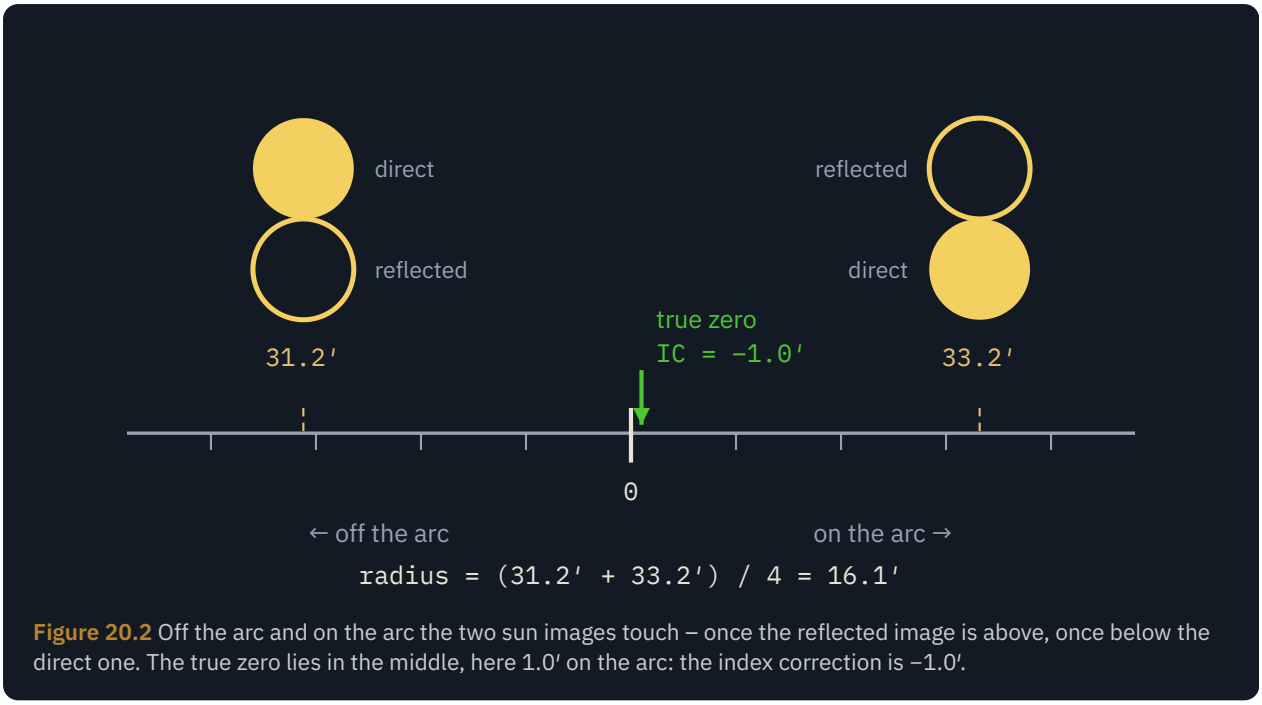


Figure 20.2 Off the arc and on the arc the two sun images touch – once the reflected image is above, once below the direct one. The true zero lies in the middle, here 1.0′ on the arc: the index correction is −1.0′.

20.2 When do you need it?

- **Before every round of sights:** The index error can change with temperature and knocks. Found shortly before the sights, it is most reliable.
- **Sextant altitude corrections:** The index correction is the first correction – an error of 1′ shifts every position line by 1 nm.
- **Adjusting the sextant:** If the index error grows beyond a few minutes, it is worth adjusting the horizon mirror.

20.3 Formulas and working

```
IC = (off − on) / 2 · R = (off + on) / 4
```

1. **Index correction**
   Half the difference of the two readings. If the reading off the arc is larger, the true zero lies off the arc and IC is positive; otherwise negative.
2. **Measured radius**
   A quarter of the sum of both readings.
3. **Check**
   Compare with the true sun's radius, about 15.8′ in July to 16.3′ in January. If they differ by more than about 0.2′, repeat the sights.

20.4 Worked example

> **On 22 October 2026 you read 31.2′ off the arc and 33.2′ on the arc. What is the index correction?**
>
> ```
> IC = (31.2′ − 33.2′) / 2 = −1.0′
> Measured radius = (31.2′ + 33.2′) / 4 = 16.1′
> True sun's radius 16.1′ – the sights were good
> ```

20.5 Things to watch out for

- **Sun shades:** Never look at the sun without adequate shades in front of the telescope and mirrors – it damages your eyes permanently.
- **Reading off the arc:** Off the arc the micrometer drum runs “backwards”. Read the amount before zero, not the figure on the drum itself – this is where most mistakes happen.
- **Take several readings:** Three readings each way and their mean give a much more accurate result.
- **Sign:** The index correction is the opposite of the index error – NauticTools2 consistently works with the correction.

20.6 How it works in NauticTools2

1. **Enter the readings**
   Off the arc and on the arc in minutes of arc, plus the date for the sun's radius.
2. **Calculate**
   Index correction, true and measured sun's radius appear in the result.
3. **Save it**
   “Use as reference value in Settings” stores the index correction; sextant altitude corrections and fix from altitudes then fill it in automatically.

20.7 Frequently asked questions

How do you find the index error with the sun?

Bring the direct and reflected sun images into contact once off the arc and once on the arc and read both values. The index correction is half the difference: (off – on) / 2.

What is the measured sun's radius for?

It is a built-in check. If it agrees within about 0.2′ with the true radius, both readings were good.

Can you do it without the sun?

Yes, on the horizon or a star: bring the reflected and direct images into line and read off. The sun method is more accurate, though, because it gives two readings and a check.

20.8 See also

- **Sextant altitude corrections** (chapter 18) – from the reading Hs to the observed altitude Ho

- **Vertical sextant angle** (chapter 6) – the sextant in coastal navigation
- **Fix from 2 or 3 altitudes** (chapter 25) – position lines and the fix

PART II · CELESTIAL NAVIGATION

21 Meridian Passage

Meridian passage – when does the sun cross the meridian?

For the noon sight you need to know when the sun reaches its highest point at your position. NauticTools2 calculates the sun's **meridian passage** at Greenwich for any date, plus the **equation of time** and – with your own longitude – the **longitude in time** and the **local meridian passage**.

`Mer. Pass.` `Equation of time` `Longitude in time` `Local meridian passage` `Arc to time` `Any date`

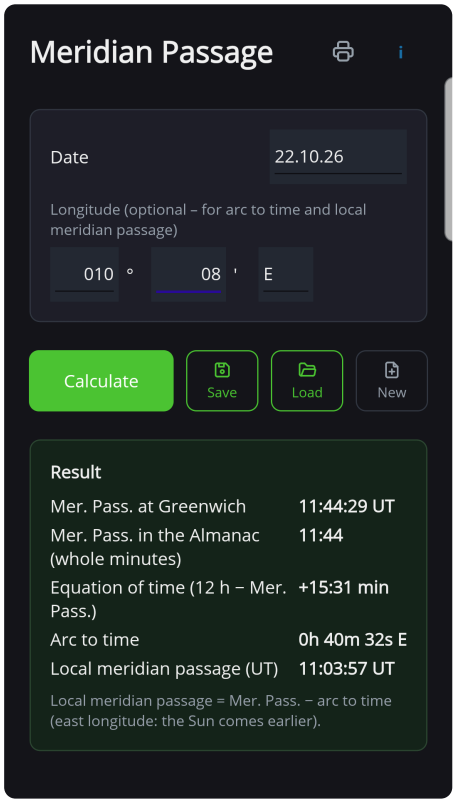


Figure 21.1 Meridian passage on 22 October 2026 and the local transit at Kiel – in the Android version.

21.1 What is meridian passage?

Meridian passage – “Mer. Pass.” in the Nautical Almanac – is the time in UT at which the sun crosses the Greenwich meridian. If the sun moved evenly, it would be 12:00 every day. Because the Earth's orbit is elliptical and its axis is tilted, the true sun runs ahead of or behind the imaginary mean sun. The difference is the **equation of time**; over the year it varies between about −14 and +16 minutes.

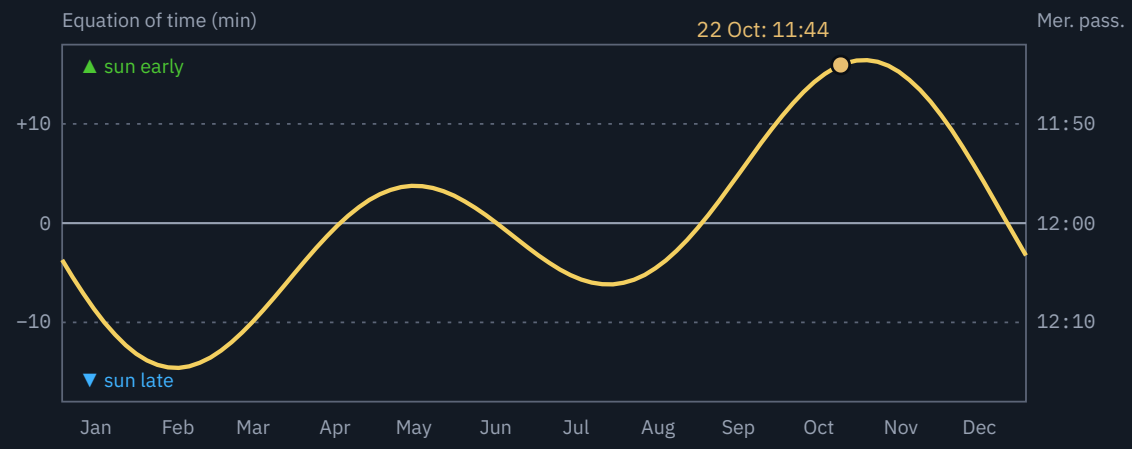


Figure 21.2 The equation of time over the year. In early November the sun crosses the Greenwich meridian as early as 11:44, in mid-February not until 12:14. Four times a year the meridian passage is exactly 12:00.

21.2 When do you need it?

- **Noon sight:** The sun's altitude is measured at meridian passage. The time at your position is the Mer. Pass. plus or minus the longitude in time.
- **Planning a sun-run-noon fix:** Morning position line, then noon latitude – knowing the time of transit lets you plan the sights.
- **Arc to time:** The longitude in time is also needed for local and zone time.

21.3 Formulas and working

```
Local meridian passage = Mer. Pass. ± longitude in time
```

1. **Mer. Pass.**
   Calculated to the second for the date, and below that rounded to the whole minute as in the almanac.
2. **Equation of time**
   `equation of time = 12:00 − Mer. Pass.`; positive when the true sun is ahead of the mean sun.
3. **Longitude in time**
   360° = 24 h, so `1° = 4 min` and `1′ = 4 s`.
4. **At your position**
   In west longitude add the longitude in time – the sun comes later; in east longitude subtract it – it comes earlier.

21.4 Worked examples

Kiel (010° 08′ E) on 22 October 2026 – when does the sun cross the meridian?

```
Mer. Pass. = 11:44:29 UT (almanac: 11:44) · equation of time = +15 min 31 s
Longitude in time = 10 · 4 min + 8 · 4 s = 0 h 40 min 32 s E
Meridian passage at Kiel = 11:44:29 − 0:40:32 = 11:03:57 UT
```

18 October 2026, DR longitude 006° 35′ W – when is noon?

```
Mer. Pass. = 11:45 UT
Longitude in time = 0 h 26 min 20 s W
Local meridian passage ≈ 12:11 UT
```

21.5 Things to watch out for

- **Times in UT:** Add the zone time for ship's time – at Kiel in October two hours, so noon is at 13:03 ship's time.
- **DR longitude is enough:** One minute of longitude error is only four seconds – plenty for the time of the sight. The noon altitude hardly changes around transit anyway.
- **Steaming east or west:** Fast passages east or west meet the sun earlier or run away from it. Then use the DR longitude at the expected noon.

21.6 How it works in NauticTools2

1. **Enter the date**
   Meridian passage and equation of time appear straight away.
2. **Enter longitude (optional)**
   With your own longitude NauticTools2 also calculates the longitude in time and the local meridian passage.
3. **Carry on**
   Measure the sun's altitude at transit and find your latitude with the **sextant altitude corrections** (chapter 18) and the noon latitude. Inputs can be saved and the result printed.

21.7 Frequently asked questions

What is meridian passage?
The time in UT at which the sun crosses the Greenwich meridian – between about 11:44 and 12:14 depending on the season. In the Nautical Almanac it is listed as “Mer. Pass.”.

How do you convert longitude to time?
1° is 4 minutes, 1′ is 4 seconds. 10°08′ is therefore 40 minutes and 32 seconds.

Why isn't noon always at 12 o'clock?

Because the Earth moves on an ellipse around the sun and its axis is tilted. The true sun is therefore sometimes ahead of and sometimes behind the evenly moving mean sun – that is the equation of time. On top comes your own longitude.

21.8 See also

- **Rising and setting times** (chapter 16) – meridian passage is listed there too
- **Time systems on board** (chapter 1) – UT, zone time and local time
- **Meridian diagram** (chapter 14) – how high the sun stands at transit

PART II · CELESTIAL NAVIGATION

22 Latitude by Meridian Altitude

Latitude by meridian altitude – the noon sight

The **noon sight** is the simplest celestial fix: at transit the sun lies exactly in your own meridian, and its altitude gives your latitude directly. NauticTools2 finds the time of transit and the declination from date and longitude and calculates the **latitude** – with the sun bearing south or north.

`Meridian altitude` `Zenith distance` `Declination` `Time of transit` `Sun bearing S or N` `Latitude φ`

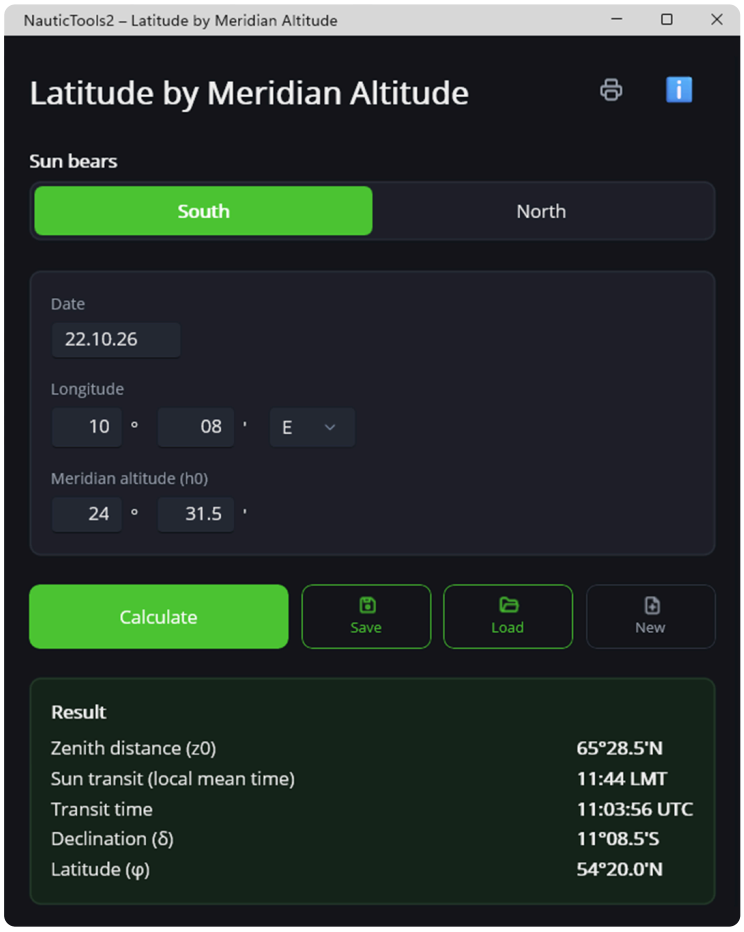


Figure 22.1 Kiel on 22 October 2026: meridian altitude 24°31.5′ bearing south gives latitude 54°20.0′ N.

22.1 The principle

At transit, zenith, sun and celestial equator lie in one plane, the observer's meridian. The distance from the zenith to the equator is your latitude φ. It is made up of the sun's **zenith distance** (`z = 90° − Ho`) and its **declination** δ, the sun's distance from the equator.

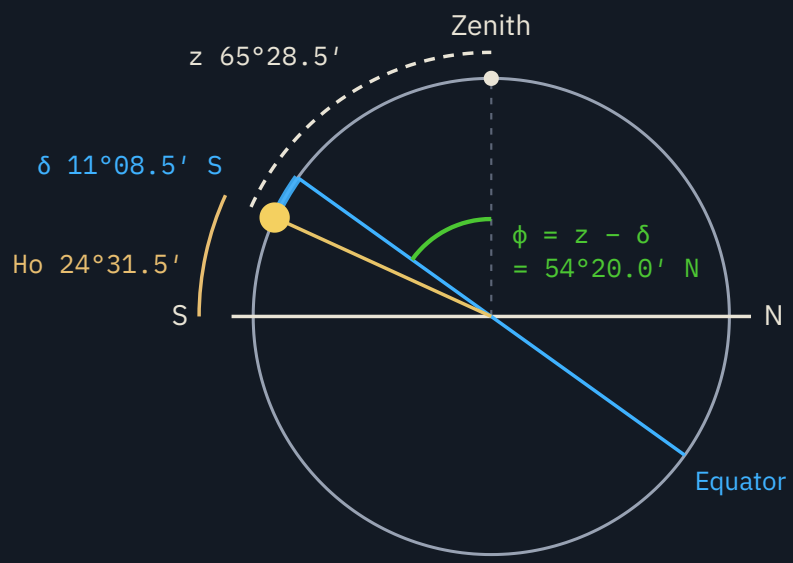


Figure 22.2 Kiel on 22 October 2026 at transit: the sun is 24°31.5′ above the southern horizon, i.e. 65°28.5′ from the zenith. Because it is 11°08.5′ south of the equator, the distance from zenith to equator is smaller by δ – the latitude 54°20.0′ N.

22.2 When do you need it?

- **Daily latitude check:** One sun sight at noon and the latitude is known – without working a position line.
- **Sun-run-noon fix:** Together with a morning position line, the noon latitude gives a complete fix.
- **Latitude sailing:** If you want to sail along a given latitude to your destination, check it daily with the noon sight – as seafarers did for centuries.

22.3 Formulas and working

> `z = 90° − Ho · φ = z ± δ`

1. **Zenith distance**
   `z = 90° − Ho`. If the sun bears south, z is named north; if it bears north, z is named south.
2. **Time of transit and declination**
   From date and longitude NauticTools2 finds the time of local transit and the sun's declination at that moment.
3. **Same name**
   If z and δ have the same name (both N or both S): `ϕ = z + δ`, with that name.
4. **Contrary names**
   Otherwise the latitude is the difference: `ϕ = δ − z` named like the declination if δ is larger, otherwise `ϕ = z − δ` named like the zenith distance.

22.4 Worked example

> **22 October 2026, DR longitude 010° 08.0′ E (Kiel). At transit the sun bears south, the corrected altitude is 24°31.5′. What is the latitude?**
>
> `z = 90° − 24°31.5′ = 65°28.5′ N`
> `Transit at 11:03:56 UTC · declination 11°08.5′ S`
> `Contrary names, z larger: φ = 65°28.5′ − 11°08.5′ = 54°20.0′ N`

22.5 Things to watch out for

- **Corrected altitude:** Enter the meridian altitude after the **sextant altitude corrections** (chapter 18), not the sextant reading.
- **Measure the greatest altitude:** Around noon the sun hardly rises any more. Keep taking sights until the altitude starts to fall; the greatest value is the meridian altitude.
- **Choose south or north correctly:** In mid-northern latitudes the sun bears south at noon. In the tropics it can be north of the zenith – then the name of the zenith distance changes.

22.6 How it works in NauticTools2

1. **Choose the bearing**
   Does the sun bear south or north at transit?
2. **Date, longitude, altitude**
   Enter date, DR longitude and the corrected meridian altitude – no time is needed.
3. **Calculate**
   Zenith distance, meridian passage, time of transit, declination and latitude appear with the working. Inputs can be saved and the result printed.

22.7 Frequently asked questions

How do you work a noon sight?
Zenith distance z = 90° – Ho. With same names φ = z + δ, with contrary names the difference – named like the larger value.

Why doesn't it need an exact time?
Around transit the altitude hardly changes, and the declination changes by at most about 1′ per hour. Date and approximate longitude are enough.

Can you get a meridian latitude from stars?
Yes, every body crosses the meridian once a day. For stars that is at night, though, when the horizon is usually not visible. The exception is Polaris, whose altitude is almost directly the latitude.

22.8 See also

- **Meridian passage** (chapter 21) – when the sun crosses the meridian
- **Sextant altitude corrections** (chapter 18) – from the reading to the corrected altitude
- **Meridian diagram** (chapter 14) – zenith, equator and body at a glance
- **Sun-run-noon fix** (chapter 23) – noon latitude plus the morning sun gives a fix
- **Fix from 2 or 3 altitudes** (chapter 25) – cross the noon latitude with any other position line

PART II · CELESTIAL NAVIGATION

23 Sun-Run-Noon Fix

Sun-run-noon fix – morning sun line plus noon latitude

The classic daily fix on an ocean passage: a **sun line** in the morning, the **noon latitude** at midday. NauticTools2 runs the morning line on with COG and SOG to meridian passage, works out the noon DR position from it and gives the **observed position**, the fix run and a plotting sheet.

`Morning sun line` `Noon latitude` `Run with COG/SOG` `Meridian passage` `Plotting sheet` `Fix run`

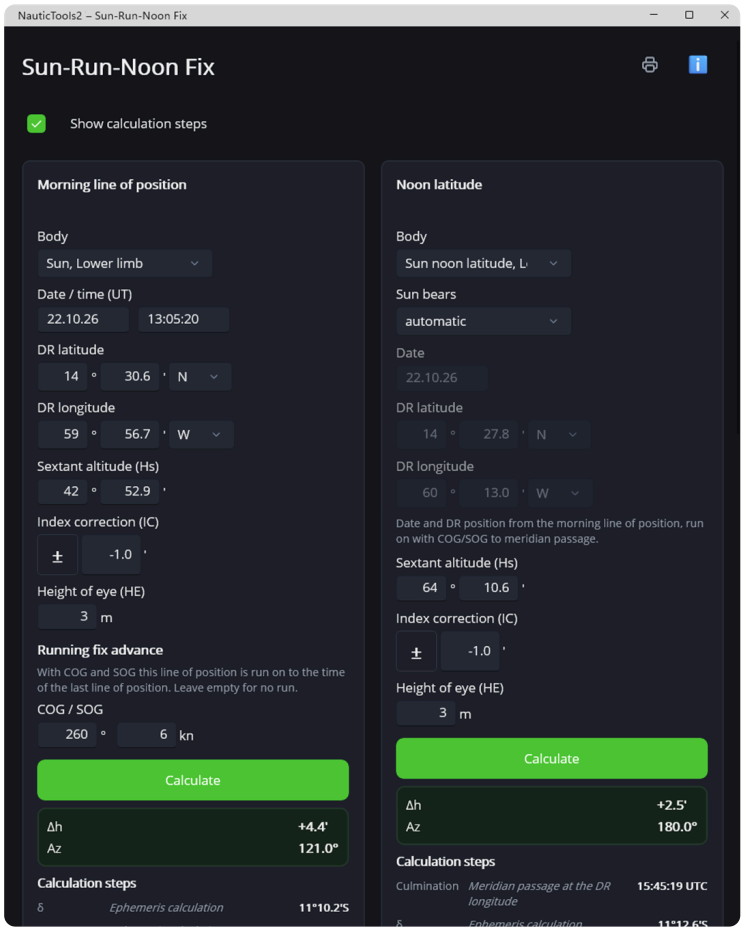


Figure 23.1 Morning line of position with COG/SOG and the noon latitude – the app fills in its date and DR position.

23.1 What is a sun-run-noon fix?

During the day the sun is often the only body you can shoot. A single sun line only tells you which line you are on. About three hours later, at **meridian passage**, the sun bears due south (or north) – its altitude gives the **latitude** directly, an east-west parallel. Run the morning line on by the distance sailed in between, and it crosses the noon latitude at the vessel's position at noon.

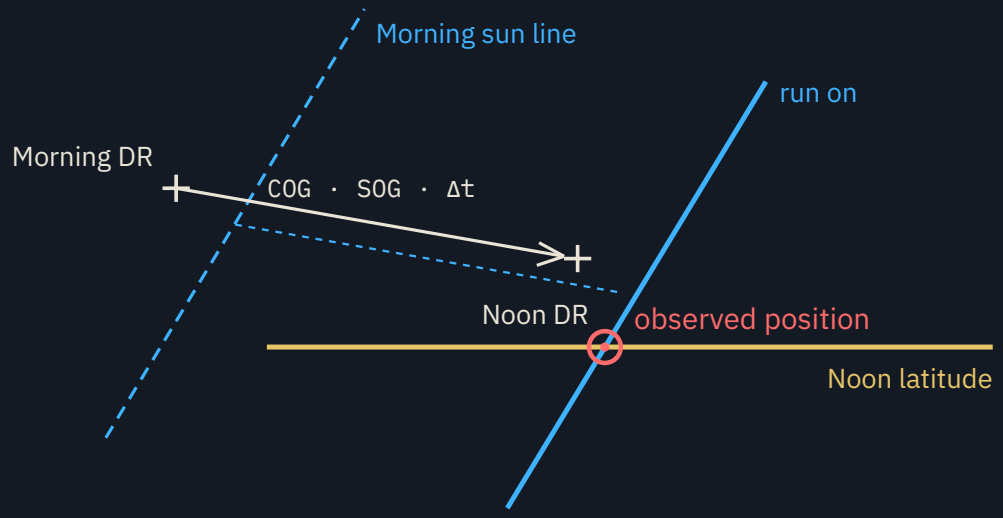


Figure 23.2 The morning line moves with the vessel: by SOG · Δt along COG. Where it crosses the noon latitude is the vessel's position at meridian passage.

23.2 When do you need it?

- **Daily routine offshore:** morning sun and noon latitude give a fix every day without waiting for twilight and stars.
- **Day's run:** from noon position to noon position you get the distance made good in 24 hours.
- **Little arithmetic, few errors:** the noon latitude needs no hour angle, and the time hardly matters for it.
- **Checking the GPS:** pick up the sextant once a day and cross-check the satellite position.

23.3 Formulas and working

```
Lat = 90° − Ho + Dec (sun bearing south)
```

1. **Morning position line**
   Like any position line: ephemeris, sextant corrections, computed altitude Hc and azimuth, giving the intercept `Δh = Ho − Hc` (see **fix from altitudes** (chapter 25)).
2. **Noon DR position**
   Morning DR position plus `SOG · Δt` along COG up to meridian passage (mid-latitude). The time of meridian passage depends on the longitude and is found together with it.
3. **Noon latitude**
   Sun's altitude at meridian passage, corrected to the observed altitude Ho, declination at meridian passage, giving the latitude. As a position line: `Hc = 90° − (Lat − Dec)` at the noon DR position, azimuth 180°.

4. **Run and intersection**
   The morning line is moved by SOG · Δt along COG and crossed with the noon latitude – that is the observed position.

5. **Fix run**
   Direction and distance from the noon DR position to the observed position.

23.4 Worked example

22 October 2026, a yacht approaching Martinique from the east. At 13:05:20 UT (09:05 ship's time) the sun's lower limb is observed from the DR position 14° 30.6′ N, 059° 56.7′ W: Hs 42°52.9′ (index error −1.0′, height of eye 3 m). Until noon the yacht makes good 260° at 6 kn. At meridian passage the sun's lower limb is observed at Hs 64°10.6′. Where is the yacht at noon?

```
Morning line: intercept +4.4′, azimuth 121.0°, run 16.0 nm on 260°
Noon DR position: 14° 27.8′ N, 060° 13.0′ W · meridian passage 15:45 UT
Noon latitude: Ho 64°22.1′ → 14° 25.3′ N
Angle of cut 59° · fix run 124.9° / 4.4 nm
Observed position: 14° 25.3′ N, 060° 09.3′ W
```

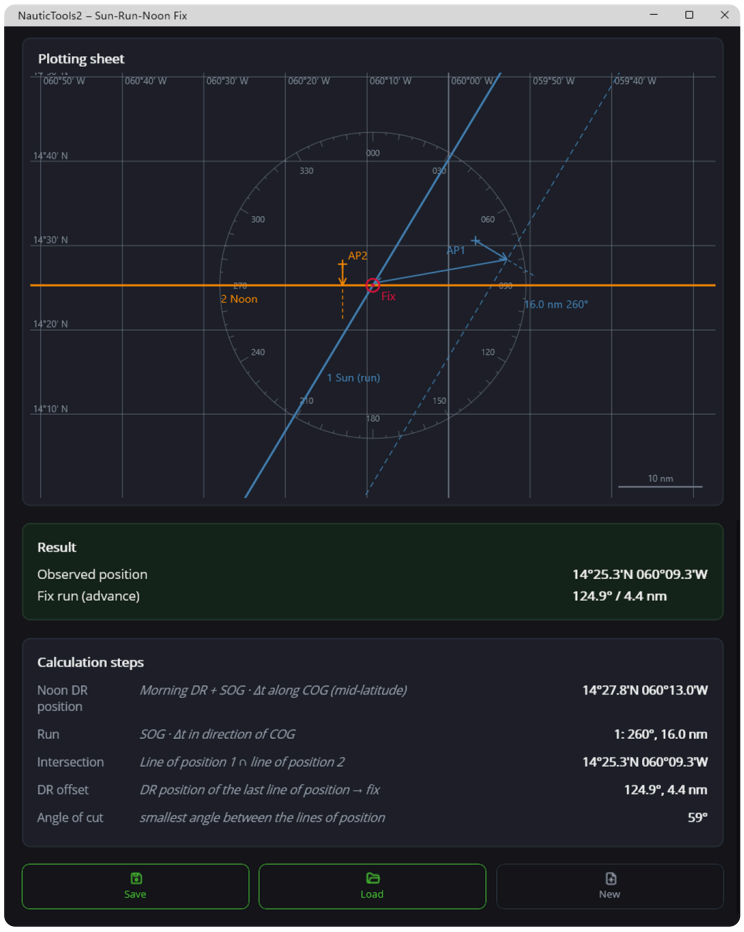


Figure 23.3 Plotting sheet for the example: the morning line, run 16 nm on 260°, and the noon latitude; result and working below.

23.5 Things to watch out for

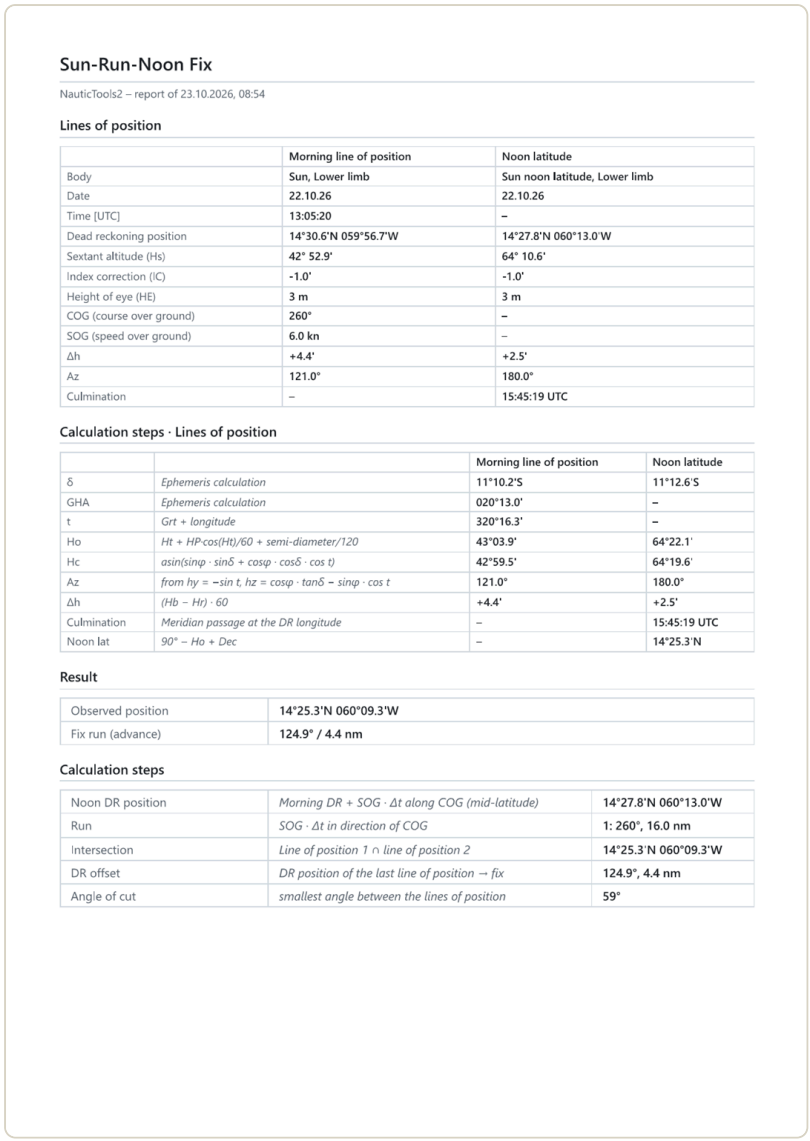
- **Interval:** take the morning sight about three hours before meridian passage. The morning line and the noon latitude then cross at a useful angle – 59° in the example.
- **Catching meridian passage:** shortly before noon the sun rises only slowly. Start about 15 minutes early and take the highest altitude. The **meridian passage** (chapter 21) tool tells you when.
- **Run over the ground:** COG and SOG, not heading and speed through the water – current and leeway add up over three hours.
- **Sun near the zenith:** in the tropics the sun can stand almost overhead at noon. The altitude is then hard to measure, and you should choose deliberately whether it bears south or north.

23.6 How it works in NauticTools2

1. **Morning line of position**
   Sun with limb, date and time, DR position, sextant reading, index correction and height of eye, plus COG and SOG until noon.
2. **Noon latitude**
   Date and DR position are filled in by the app – from the morning, run on to meridian passage. You only enter the sun's limb, sextant reading, index correction and height of eye; south or north is determined automatically.
3. **Read off the fix**
   Plotting sheet, observed position, fix run and working appear straight away.
4. **Print and save**
   Both position lines with their working on one page, the plotting sheet on the second. Exercises can be saved and loaded again.

23.7 Printable record

The sun-run-noon fix can be printed as a record or saved as a PDF: both position lines side by side with their working, the noon DR position, the result and the working on one page, the plotting sheet on the second.



Sun-Run-Noon Fix

NauticTools2 – report of 23.10.2026, 08:54

Lines of position

	Morning line of position	Noon latitude
Body	Sun, Lower limb	Sun noon latitude, Lower limb
Date	22.10.26	22.10.26
Time [UTC]	13:05:20	–
Dead reckoning position	14°30.6'N 059°56.7'W	14°27.8'N 060°13.0'W
Sextant altitude (Hs)	42° 52.9'	64° 10.6'
Index correction (IC)	-1.0'	-1.0'
Height of eye (HE)	3 m	3 m
COG (course over ground)	260°	–
SOG (speed over ground)	6.0 kn	–
Δh	+4.4'	+2.5'
Az	121.0°	180.0°
Culmination	–	15:45:19 UTC

Calculation steps · Lines of position

		Morning line of position	Noon latitude
δ	*Ephemeris calculation*	11°10.2'S	11°12.6'S
GHA	*Ephemeris calculation*	020°13.0'	–
t	*Grt + longitude*	320°16.3'	–
Ho	*Ht + HP·cos(Ht)/60 + semi-diameter/120*	43°03.9'	64°22.1'
Hc	*asin(sinφ · sinδ + cosφ · cosδ · cos t)*	42°59.5'	64°19.6'
Az	*from hy = −sin t, hz = cosφ · tanδ − sinφ · cos t*	121.0°	180.0°
Δh	*(Hb − Hr) · 60*	+4.4'	+2.5'
Culmination	*Meridian passage at the DR longitude*	–	15:45:19 UTC
Noon lat	*90° − Ho + Dec*	–	14°25.3'N

Result

Observed position	14°25.3'N 060°09.3'W
Fix run (advance)	124.9° / 4.4 nm

Calculation steps

Noon DR position	*Morning DR + SOG · Δt along COG (mid-latitude)*	14°27.8'N 060°13.0'W
Run	*SOG · Δt in direction of COG*	1: 260°, 16.0 nm
Intersection	*Line of position 1 ∩ line of position 2*	14°25.3'N 060°09.3'W
DR offset	*DR position of the last line of position → fix*	124.9°, 4.4 nm
Angle of cut	*smallest angle between the lines of position*	59°

Figure 23.4 Page 1 of the printed record for the example off Martinique.

23.8 Frequently asked questions

What is a sun-run-noon fix?

A fix from two sun sights: a position line in the morning and the noon latitude. The morning line is run on to noon and crossed with the parallel of latitude.

How much time should pass between the two sights?

About three hours. The shorter the interval, the flatter the morning line crosses the noon latitude.

How is the morning line run on to noon?

With course and speed over ground: by SOG times the time to meridian passage, along COG. The noon DR position follows in the same way.

Can the noon latitude be combined with another body?

Yes – **Fix from 2 or 3 altitudes** (chapter 25) offers the noon latitude as its own type of position line, for example together with Jupiter in the evening.

23.9 See also

- **Fix from 2 or 3 altitudes** (chapter 25) – position lines from any body, including the noon latitude
- **Noon latitude** (chapter 22) – latitude from the meridian altitude alone
- **Meridian passage** (chapter 21) – when the sun crosses the meridian
- **Sextant altitude corrections** (chapter 18) – from the reading Hs to the observed altitude Ho

PART II · CELESTIAL NAVIGATION

24 Compass Check

Compass check – compass error and deviation by the sun

Where the sun lies true can be calculated for any moment. Take a compass bearing of it and the difference gives the **compass error** – and after subtracting the variation, the **deviation** on the current heading. NauticTools2 works this as an **azimuth bearing** or at **true sunrise or sunset** (amplitude), for magnetic and gyro compasses.

`Azimuth bearing` `Amplitude` `Compass error` `Deviation` `Variation from IGRF` `Gyro compass`

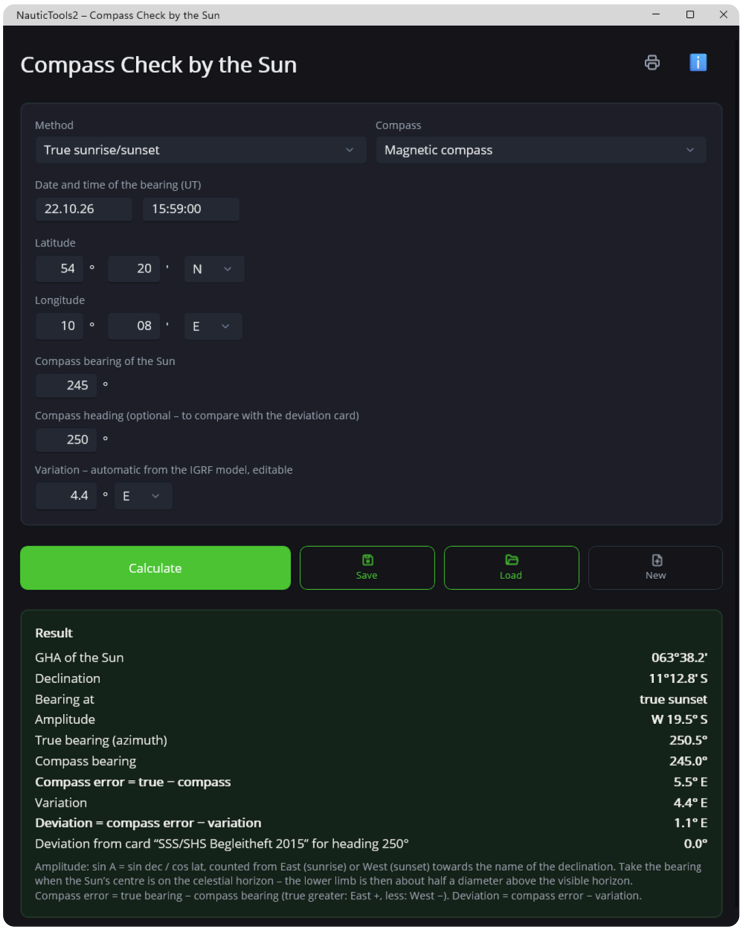


Figure 24.1 Compass check at true sunset off Kiel on 22 October 2026.

24.1 The principle

The compass does not point true. **Variation** depends on the place, **deviation** on the ship and the current heading. Together they make up the **compass error**. From time and position NauticTools2 calculates the sun's true bearing; comparing it with the compass bearing gives the compass error, and with the variation from the IGRF model the deviation remains.

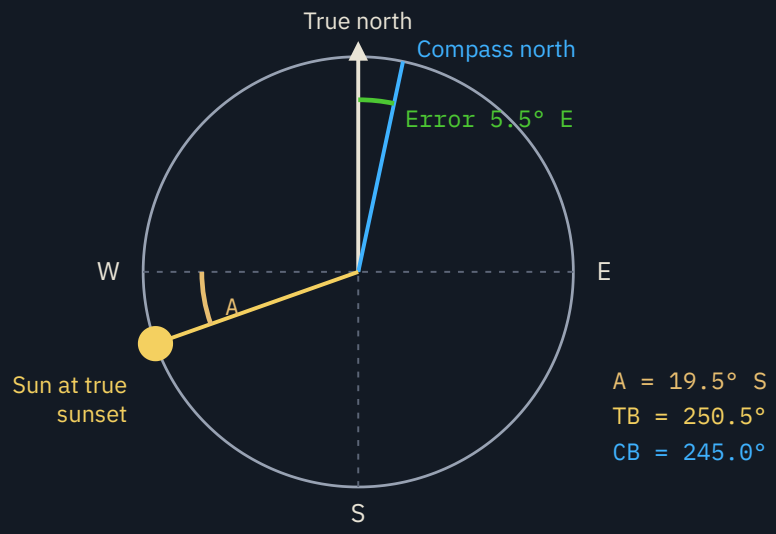


Figure 24.2 The sun sets 19.5° south of west, i.e. at a true bearing of 250.5°. The compass shows 245°: compass north lies east of true north by the compass error of 5.5° (exaggerated in the sketch).

24.2 Two methods

- **Azimuth bearing:** The sun is taken at any time. NauticTools2 calculates its azimuth from latitude, declination and local hour angle. Most accurate with a low sun – above 30° altitude the app warns you.
- **True sunrise or sunset (amplitude):** The sun is taken when its centre is on the rational horizon – to the eye the lower limb is then about half a sun's diameter above the horizon. A bearing on the horizon is particularly accurate, and the calculation only needs the declination.

24.3 When do you need it?

- **Checking the deviation card:** Does the deviation on the current heading still match the card? NauticTools2 shows the card value for comparison if you enter the compass heading.
- **On long passages:** Without landmarks, the sun is the only reference for the compass.
- **Gyro compass:** The gyro error can be found the same way.

24.4 Formulas and working

```
Error = TB − CB · Dev = Error − Var
```

1. **Sun's position**
   GHA and declination of the sun for the time of the bearing, and with the longitude the local hour angle.

2. **True bearing**
   Azimuth bearing: the azimuth from latitude, declination and LHA. Amplitude: `sin A = sin δ / cos φ`, counted from east (sunrise) or west (sunset) towards the side of the declination; `TB = 90° − A` at sunrise, `270° + A` at sunset (A north positive).
3. **Compass error**
   `Error = TB − CB`: if the true bearing is larger, the error is east (+), otherwise west (−).
4. **Deviation**
   `Dev = Error − Var`, valid for the heading at the time of the bearing. Variation comes from the IGRF model and can be overwritten, e.g. with the value from the chart.
5. **Gyro compass**
   `gyro bearing + gyro error + speed error = TB`, with the speed error from speed, gyro heading and latitude.

24.5 Worked examples

Off Kiel (54° 20′ N, 010° 08′ E) on 22 October 2026 at 15:59:00 UT you take a compass bearing of the sun at true sunset: 245°. What are compass error and deviation?

```
Declination 11°12.8′ S → amplitude A = 19.5° S
TB = 270° − 19.5° = 250.5°
Error = 250.5° − 245° = +5.5° (east)
Variation (IGRF) = 4.4° E → deviation = 5.5° − 4.4° = +1.1° (east)
```

The deviation card “SSS/SHS Begleitheft 2015”, however, gives 0.0° for compass heading 250°. The difference of 1.1° is exactly what a compass check is meant to reveal – time to check the card on this heading.

Azimuth bearing: 18 October 2026, 09:47:32 UT, position 47° 45′ N, 006° 20′ W, compass bearing of the sun 143°, variation 2° W.

```
TB ≈ 140.8° → error ≈ −2.2° (west)
Deviation = −2.2° − (−2.0°) ≈ −0.2° (west)
```

24.6 Things to watch out for

- **Time to the second in UT:** The sun moves about 1° in four minutes – a time error goes straight into the compass error.
- **Note the heading:** The deviation only applies to the heading at the time of the bearing. For the deviation card, check several headings.
- **True, not visible sunset:** For the amplitude take the moment when the lower limb is about half a diameter above the horizon – not when the sun disappears.
- **Plausibility:** The app flags unusually large compass errors – usually time, position or bearing is wrong.

24.7 How it works in NauticTools2

1. **Choose method and compass**
   Azimuth bearing or true sunrise/sunset, magnetic or gyro compass.
2. **Time and position**
   Date and time of the bearing in UT, latitude and longitude.
3. **Enter the bearing**
   Compass bearing of the sun, optionally the compass heading for comparison with the deviation card. Variation is filled in from the IGRF model and can be changed.
4. **Result**
   True bearing, compass error and deviation with the working; for the gyro, speed error and gyro error. Inputs can be saved and the result printed.

24.8 Frequently asked questions

How do you check the compass by the sun?

Take a compass bearing of the sun and note the exact time. Time and position give the true bearing; the difference from the compass bearing is the compass error, and after subtracting the variation the deviation remains.

What is the amplitude?

The angle between east or west and the direction of the sun at true sunrise or sunset: $\sin A = \sin \delta / \cos \varphi$.

When is the compass error east?

When the true bearing is greater than the compass bearing. The error is then positive, otherwise negative (west).

24.9 See also

- **Magnetic variation** (chapter 2) – variation from the IGRF model for place and date
- **Bearing conversion** (chapter 10) – compass, magnetic and true bearings
- **Rising and setting times** (chapter 16) – when true sunset is

PART II · CELESTIAL NAVIGATION

25 Fix from 2 or 3 Altitudes

Fix from 2 or 3 altitudes – position lines, cocked hat and plotting sheet

The goal of all celestial navigation: the **vessel's position** from two or three measured altitudes. NauticTools2 turns every sight into a **position line**, runs earlier lines on to the time of the last one, draws everything on a **plotting sheet** and gives the observed position, the **fix run** from the DR position and the complete working.

`Intercept method` `Position lines` `Running fix with COG/SOG` `Cocked hat` `Noon latitude as a position line` `Plotting sheet`

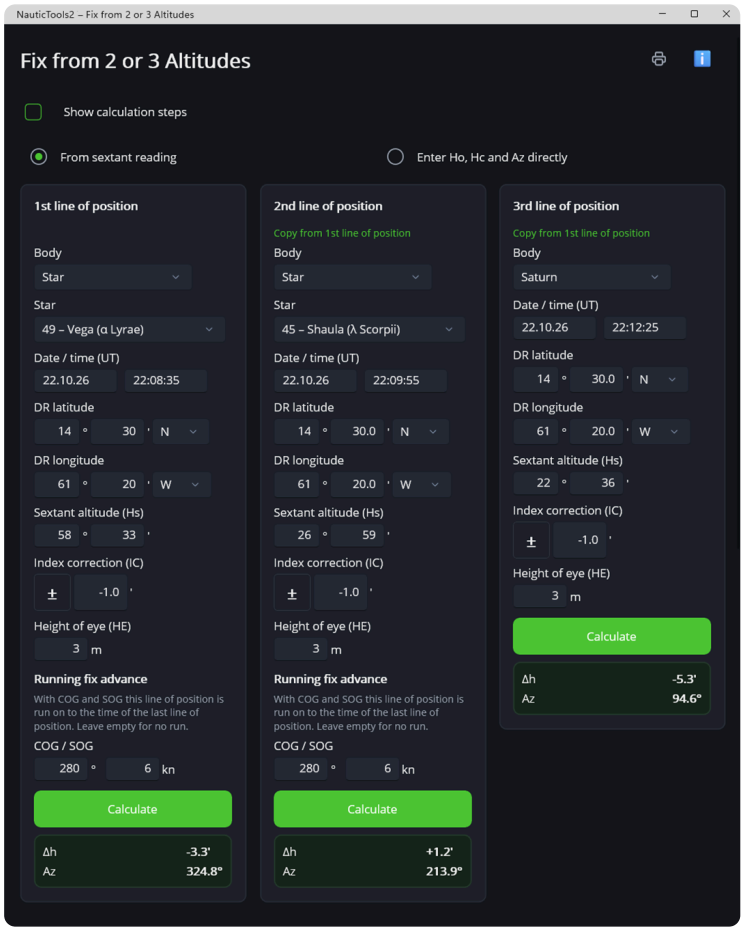


Figure 25.1 Vega, Shaula and Saturn off Martinique: three position lines, two of them run on, on the plotting sheet.

25.1 The road to the fix

Behind every position line there is a whole chain of calculations. NauticTools2 works through it automatically for every sight – but each step is also available as a tool of its own, to follow it in detail or to practise by hand:

1. **Ephemeris (chapter 17)**
   Declination and Greenwich hour angle (GHA) of the body at the time of the sight; with the DR longitude this gives the local hour angle (LHA).
2. **Sextant altitude corrections (chapter 18)**
   From the sextant reading Hs via index correction, dip, refraction, semi-diameter and parallax to the observed altitude Ho.
3. **Altitude and azimuth (chapter 19)**
   The altitude Hc the body should have from the DR position, and its bearing – from the navigational triangle.
4. **Position line**
   Intercept `Δh = Ho − Hc`: that many nautical miles from the DR position towards the body (away from it if negative), at right angles to the azimuth.
5. **Fix**
   Crossing two or three position lines – that is this tool.

25.2 What is a position line?

All places from which a body appears at the same altitude at the same moment lie on a circle around its geographical position. The circle is so large that the part near the DR position is drawn as a straight line – the **position line**. It is laid off from the DR position: the intercept in nautical miles along the azimuth, then at right angles to it. A second position line from a body in a different direction crosses the first at the **observed position**.

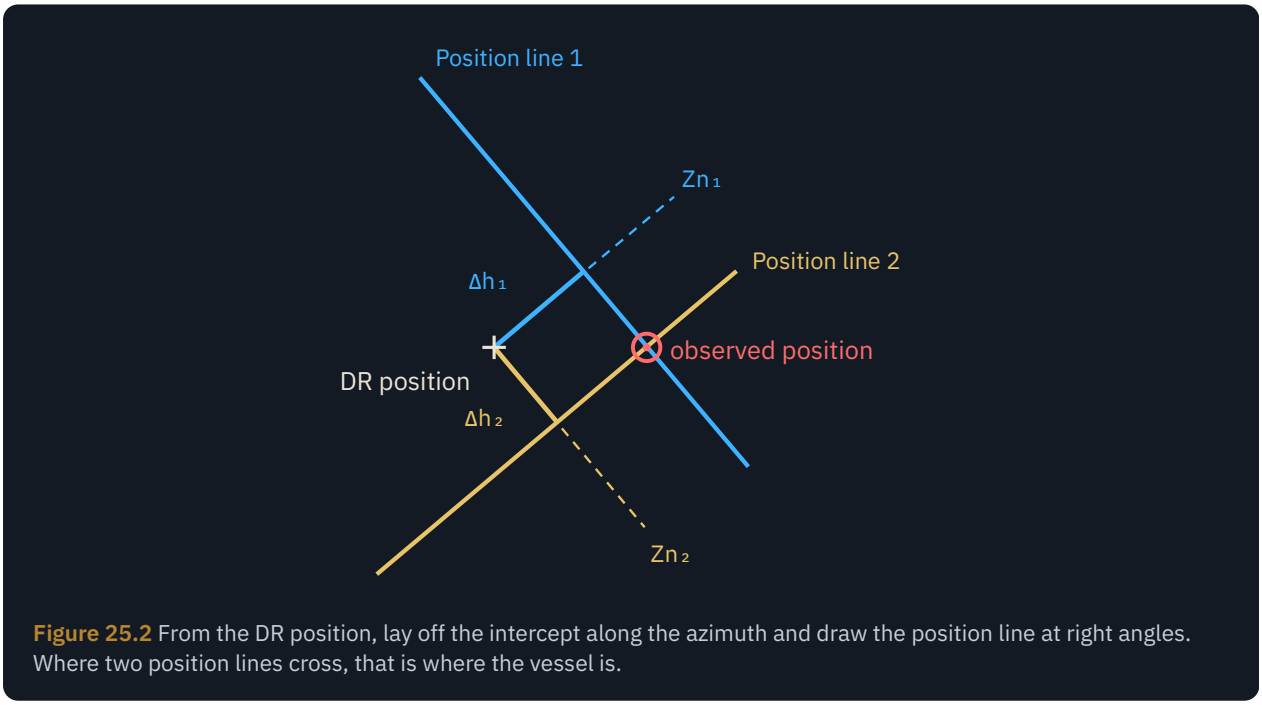


Figure 25.2 From the DR position, lay off the intercept along the azimuth and draw the position line at right angles. Where two position lines cross, that is where the vessel is.

25.3 When do you need it?

- **At sea without GPS:** if the electronics fail, celestial navigation is the only independent way of fixing the position offshore.
- **Checking the GPS:** a celestial fix shows whether the satellite position is plausible – and keeps your sextant skills fresh.
- **Stars at twilight:** during nautical twilight the horizon and bright stars are visible at the same time. Three stars in well spread directions give a fix with a cocked hat.
- **The sun through the day:** a sun line in the morning, the noon latitude at midday, another sun line in the afternoon – each run on to the time of the last.

25.4 Formulas and working

> `Δh = Ho − Hc · run = SOG · Δt along COG`

1. **For each position line**
   Ephemeris, sextant corrections, Hc and azimuth as above; from these the intercept. Each position line starts from its own DR position.
2. **Noon latitude as a position line**
   The time is the meridian passage at the DR longitude, the computed altitude is `Hc = 90° − (Lat − Dec)` with the sun bearing south, azimuth 180°. The position line is the east-west parallel of the noon latitude.
3. **Running fix**
   Earlier position lines are moved parallel by `SOG · Δt` along COG to the time of the last sight. Without COG and SOG they stay where they are.
4. **Intersection**
   Two position lines: the point where they cross. Three position lines: the centre of the cocked hat formed by the three pairwise intersections.
5. **Fix run**
   Direction and distance from the DR position of the last position line to the observed position, plus the smallest angle of cut as a measure of how well the lines cross.

25.5 Worked example

22 October 2026, nautical twilight off Martinique. From the DR position 14° 30.0′ N, 061° 20.0′ W, Vega, Shaula and Saturn are shot one after another (index error −1.0′, height of eye 3 m). The yacht makes good 280° at 6 kn.
Vega 22:08:35 UT, Hs 58°33.0′ · Shaula 22:09:55 UT, Hs 26°59.0′ · Saturn 22:12:25 UT, Hs 22°36.0′. Where is the yacht?

```
Vega: intercept −3.3′, azimuth 324.8°, run 0.4 nm on 280°
Shaula: intercept +1.2′, azimuth 213.9°, run 0.2 nm on 280°
Saturn: intercept −5.3′, azimuth 094.6°
Angle of cut 50° · fix run 227.8° / 4.3 nm
Observed position: 14° 27.1′ N, 061° 23.3′ W
```

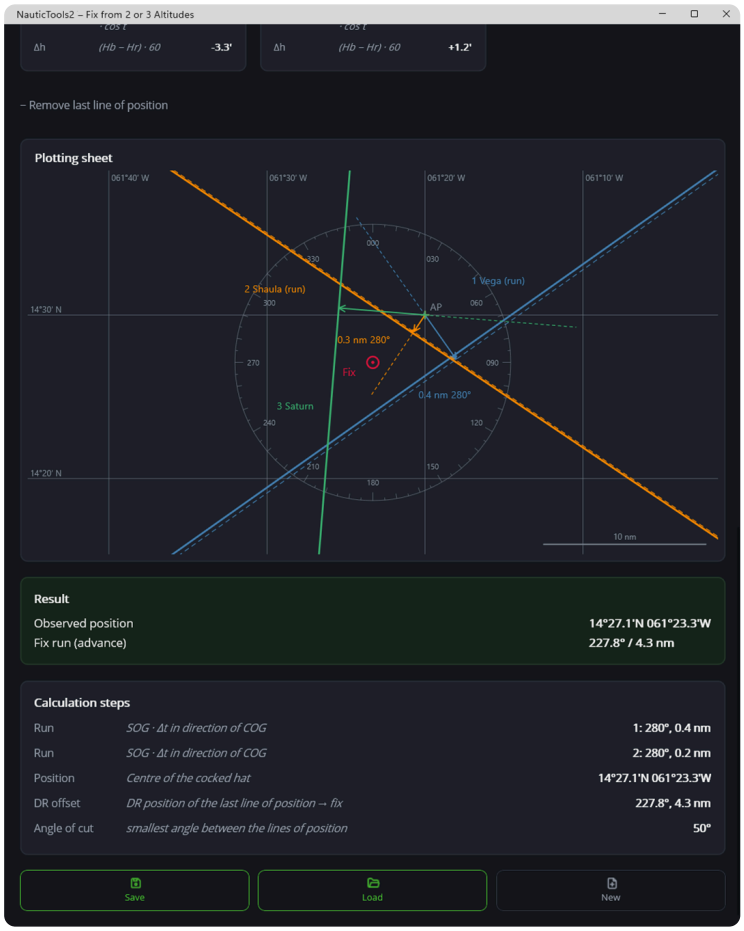


Figure 25.3 The plotting sheet for the example: DR position, azimuths, advanced position lines and the observed position, with the result and working below.

25.6 Things to watch out for

- **Angle of cut:** two position lines should cross at 30° or more, ideally around 90°. With three bodies, bearings about 120° apart are ideal.
- **Size of the cocked hat:** a few nautical miles are normal. If it is much larger, check the sight, the time or the body chosen.

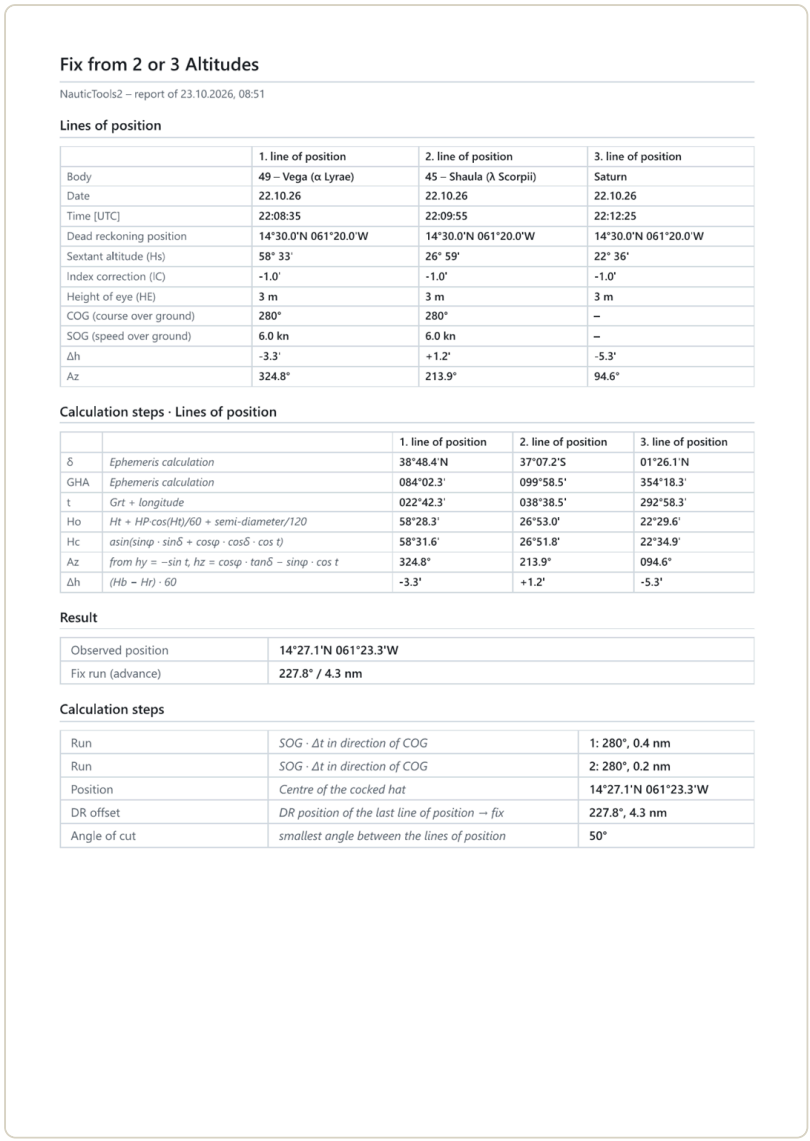
- **Be realistic about the fix run:** three to five nautical miles are already a good result in practice – a sextant on a rolling yacht is not a laboratory instrument.
- **Take the time accurately:** four seconds of time error shift the fix by up to one minute of longitude.
- **Order:** the last position line is the latest sight – the others are run on to its time, so it has no run itself.

25.7 How it works in NauticTools2

1. **First position line**
   Choose the body (sun or moon with limb, Venus, Mars, Jupiter, Saturn, a star or the noon latitude), then date and time, DR position, sextant reading, index correction and height of eye. Labels shown in blue tell you what is still missing.
2. **More position lines**
   "+ Add line of position" – up to three. "Copy from 1st line of position" copies date, DR position, index correction, height of eye and COG/SOG. With COG and SOG a position line is run on.
3. **Read off the fix**
   As soon as two position lines cross, the plotting sheet, position, fix run and working appear.
4. **Print and save**
   The printout fits even three position lines with their working on one page, with the plotting sheet on the second. Exercises can be saved and loaded again.
5. **Exercises with Ho, Hc and azimuth**
   For exercises where observed altitude, computed altitude and azimuth are already given, there is the input mode "Enter Ho, Hc and Az directly".

25.8 Printable record

Every fix can be printed as a record or saved as a PDF. Even with three position lines, the inputs, the working of each position line, the result and the working of the fix fit on one page – the plotting sheet follows on the second.



Fix from 2 or 3 Altitudes

NauticTools2 – report of 23.10.2026, 08:51

Lines of position

	1. line of position	2. line of position	3. line of position
Body	49 – Vega (α Lyrae)	45 – Shaula (λ Scorpii)	Saturn
Date	22.10.26	22.10.26	22.10.26
Time [UTC]	22:08:35	22:09:55	22:12:25
Dead reckoning position	14°30.0'N 061°20.0'W	14°30.0'N 061°20.0'W	14°30.0'N 061°20.0'W
Sextant altitude (Hs)	58° 33'	26° 59'	22° 36'
Index correction (IC)	-1.0'	-1.0'	-1.0'
Height of eye (HE)	3 m	3 m	3 m
COG (course over ground)	280°	280°	–
SOG (speed over ground)	6.0 kn	6.0 kn	–
Δh	-3.3'	+1.2'	-5.3'
Az	324.8°	213.9°	94.6°

Calculation steps · Lines of position

		1. line of position	2. line of position	3. line of position
δ	*Ephemeris calculation*	38°48.4'N	37°07.2'S	01°26.1'N
GHA	*Ephemeris calculation*	084°02.3'	099°58.5'	354°18.3'
t	*Grt + longitude*	022°42.3'	038°38.5'	292°58.3'
Ho	*Ht + HP·cos(Ht)/60 + semi-diameter/120*	58°28.3'	26°53.0'	22°29.6'
Hc	*asin(sinφ · sinδ + cosφ · cosδ · cos t)*	58°31.6'	26°51.8'	22°34.9'
Az	*from hy = −sin t, hz = cosφ · tanδ − sinφ · cos t*	324.8°	213.9°	094.6°
Δh	*(Hb − Hr) · 60*	-3.3'	+1.2'	-5.3'

Result

Observed position	14°27.1'N 061°23.3'W
Fix run (advance)	227.8° / 4.3 nm

Calculation steps

Run	*SOG · Δt in direction of COG*	1: 280°, 0.4 nm
Run	*SOG · Δt in direction of COG*	2: 280°, 0.2 nm
Position	*Centre of the cocked hat*	14°27.1'N 061°23.3'W
DR offset	*DR position of the last line of position → fix*	227.8°, 4.3 nm
Angle of cut	*smallest angle between the lines of position*	50°

Figure 25.4 Page 1 of the printed record for the example off Martinique.

25.9 Frequently asked questions

How many bodies do you need for a fix?

Two position lines give an intersection and therefore a fix. Three are better: they form a cocked hat whose size shows how well the sights agree.

What is a cocked hat?

Because of small errors in the sights and the timing, three position lines hardly ever meet in one point. The observed position is taken as the centre of the triangle; a large triangle points to a mistake.

What is a running fix?

If the vessel moves between two sights, the earlier position line is moved parallel by SOG times the time difference along COG. All position lines then refer to the time of the last sight.

Can the noon latitude be combined with other position lines?

Yes. It is itself a position line, an east-west parallel, and NauticTools2 offers it as its own type of position line – for example with the sun in the morning or a planet in the evening. The classic case is also covered by the **sun-run-noon fix** (chapter 23).

25.10 See also

- **Ephemeris calculation** (chapter 17) – declination and Greenwich hour angle
- **Sextant altitude corrections** (chapter 18) – from the reading Hs to the observed altitude Ho
- **Computed altitude and azimuth** (chapter 19) – Hc and azimuth from the navigational triangle
- **Noon latitude** (chapter 22) – latitude from the sun's meridian altitude
- **Sun-run-noon fix** (chapter 23) – the sun in the morning plus the noon latitude
- **Star chart** (chapter 15) and **rising and setting** (chapter 16) – which stars are up at twilight

PART II · CELESTIAL NAVIGATION

26 Sight Reduction

Sight reduction – the position line with the Nautical Almanac and Pub. 249

Celestial navigation the paper-and-pencil way – just without the pencil. You look up every value yourself in the **Nautical Almanac** and in **Pub. 249**; NauticTools2 is the form: it does the sums, shows for every line where the value comes from, **checks each entry on request** and draws the position lines on a **plotting sheet**.

Nautical Almanac | Pub. 249, volumes 2 and 3 | Sun, moon, planets, stars
Polaris, noon sight, compass check | Check and automatic | Plotting sheet

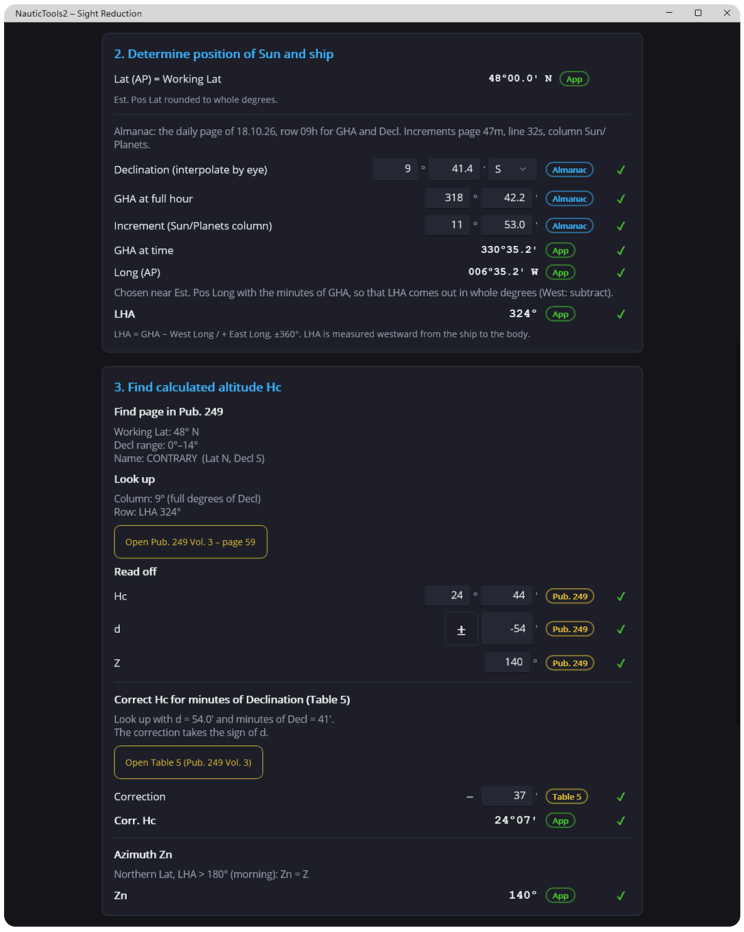


Figure 26.1 The sun sight form: every line shows whether the value comes from your own sight, the Almanac, Pub. 249 or the app. The green ticks from “Check” confirm each value.

26.1 What is sight reduction?

It is working out a position line with tables instead of trigonometry. Because **Pub. 249** only contains whole-degree latitudes and local hour angles, you do not work from the DR position but from an **assumed position** (AP) close to it: latitude to the whole degree, longitude chosen so that the local hour

angle LHA comes out in whole degrees. For this position the tables give the computed altitude Hc and the angle Z. The difference from the observed altitude Ho is the **intercept** – the number of nautical miles from the assumed position to the position line, towards or away from the body.

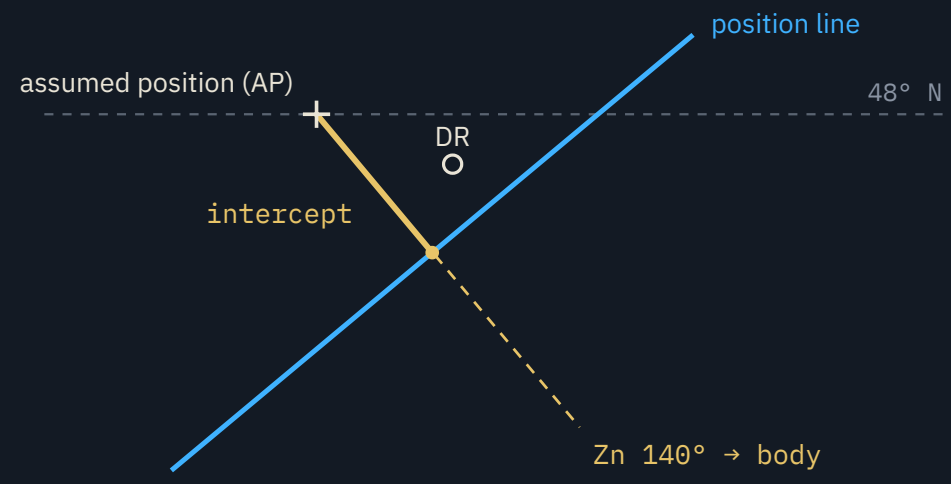


Figure 26.2 The assumed position lies on a whole-degree latitude near the DR position. From there the intercept is laid off along Zn; the position line runs at right angles to it.

26.2 When do you need it?

- **With tables on board:** if you carry the Almanac and Pub. 249, you can work a position line without a calculator – the app only replaces the paper form.
- **Checking your own working:** with “Check” every line shows ✓, ≈ or ✗. You find the mistake yourself – the app only tells you where it is.
- **Working by hand at the chart table:** on the templates by Cassens & Plath – then check your working with the app.
- **Understanding the method:** “Automatic” fills in all table values, so you can follow every step before looking them up yourself.

26.3 The five steps of the form

> `Intercept = Ho − Hc · LHA = GHA + longitude (east +, west −)`

1. **Observed altitude Ho**
   Sextant angle Hs, index error, dip and the correction for sun, moon, planet or star from the Almanac give Ho – rounded to whole minutes, because Pub. 249 works in whole minutes.
2. **Position of body and ship**
   GHA for the whole hour and the increment for minutes and seconds, declination from the Almanac. Latitude to the whole degree (working lat), longitude chosen so that LHA comes out in whole degrees.

3. **Computed altitude Hc**
   In Pub. 249 with working lat, declination (whole degrees, same or contrary name) and LHA: Hc, d and Z. Table 5 corrects Hc for the minutes of declination; Z becomes the azimuth Zn.
4. **Compare altitudes**
   Intercept = Ho − Hc, in nautical miles. Ho greater: Closer, towards the body; Ho smaller: Away.
5. **Plot**
   Assumed position, Zn and intercept – ready for the plotting sheet.

26.4 The five steps by Leon Schulz

NauticTools2 owes the layout of its form to **Leon Schulz**, RYA Yachtmaster Ocean Instructor & Examiner. The method itself has been standard for decades – over the last ten years Leon has systematised the way it is taught: five clearly separated steps, a note for every value saying where to find it, and arrows showing where each piece of information comes from. More on reginasailing.com:

- **Free video courses** on celestial navigation – step by step with the templates.
- **Theory courses in Malta** for the RYA Yachtmaster Ocean.
- **Templates to fill in** (sun sight and noon sight) – from the shop of Cassens & Plath.

NauticTools2 is the digital counterpart: for practice and for checking your own working on paper.

26.5 Worked example

> **18 October 2026, 09:47:32 UT in the Bay of Biscay, DR position 47° 45′ N, 006° 20′ W. Sun's lower limb Hs 24°14.8′, index error −1.5′, dip −2.8′, sun correction +14.0′. Almanac: GHA 09h 318°42.2′, increment 11°53.0′, Dec S 9°41.4′. Pub. 249 (lat 48°, dec 9° contrary, LHA 324°): Hc 24°44′, d −54, Z 140°; Table 5 −37′.**
>
> ```
> Ho = 24°25′ · assumed position 48° 00′ N, 006° 35.2′ W, LHA 324°
> Hc = 24°44′ − 37′ = 24°07′ · Zn = 140°
> Intercept 18 nm Closer
> ```

26.6 All forms

- **Sun, moon, planet, star sight:** the position line; for the moon with HP and second correction, for the planets with the additional correction, for the stars with SHA. The 57 navigational stars of the Almanac are available.
- **Polaris sight:** latitude from the pole star with the Polaris tables (a0, a1, a2).
- **Noon sight:** ship's noon from meridian passage and arc to time, then latitude from the noon altitude.
- **Compass check:** the sun's Zn from Pub. 249 against the compass bearing – compass error and deviation.
- **Plotting sheet:** two or three saved sights, run on with the log or with course and speed over ground, and the fix.

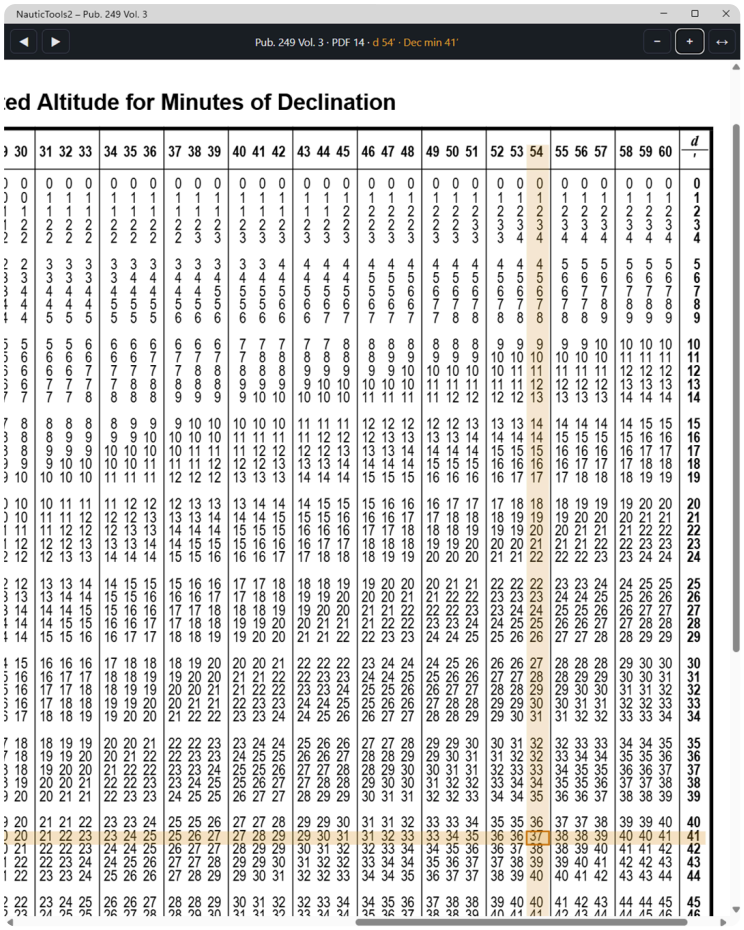


Figure 26.3 Pub. 249 is included: the right page opens with row and column marked – reading the value is up to you.

26.7 Pub. 249 included

Volumes 2 and 3 of Pub. 249 (latitudes 0° to 89°, declinations up to 29°) are included as a book, as is Table 5. A button in the form opens the right page and marks row and column. Reading off the value and entering it is still the navigator's job – just like the printed book next to the form.

26.8 Check and automatic

Check compares every entry with the value that should be in the Almanac and Pub. 249 and shows ✓, ≈ or ✗. Tap an ✗ to see the expected value. **Automatic** fills in all table values; switch it off again and your own values return. Both are switches – working by hand is and remains the normal case.



Figure 26.4 The plotting sheet: Aldebaran in the morning, the sun before noon and the moon in the evening from the examples, run on with the log and course over ground.

26.9 Almanac and tables for practice

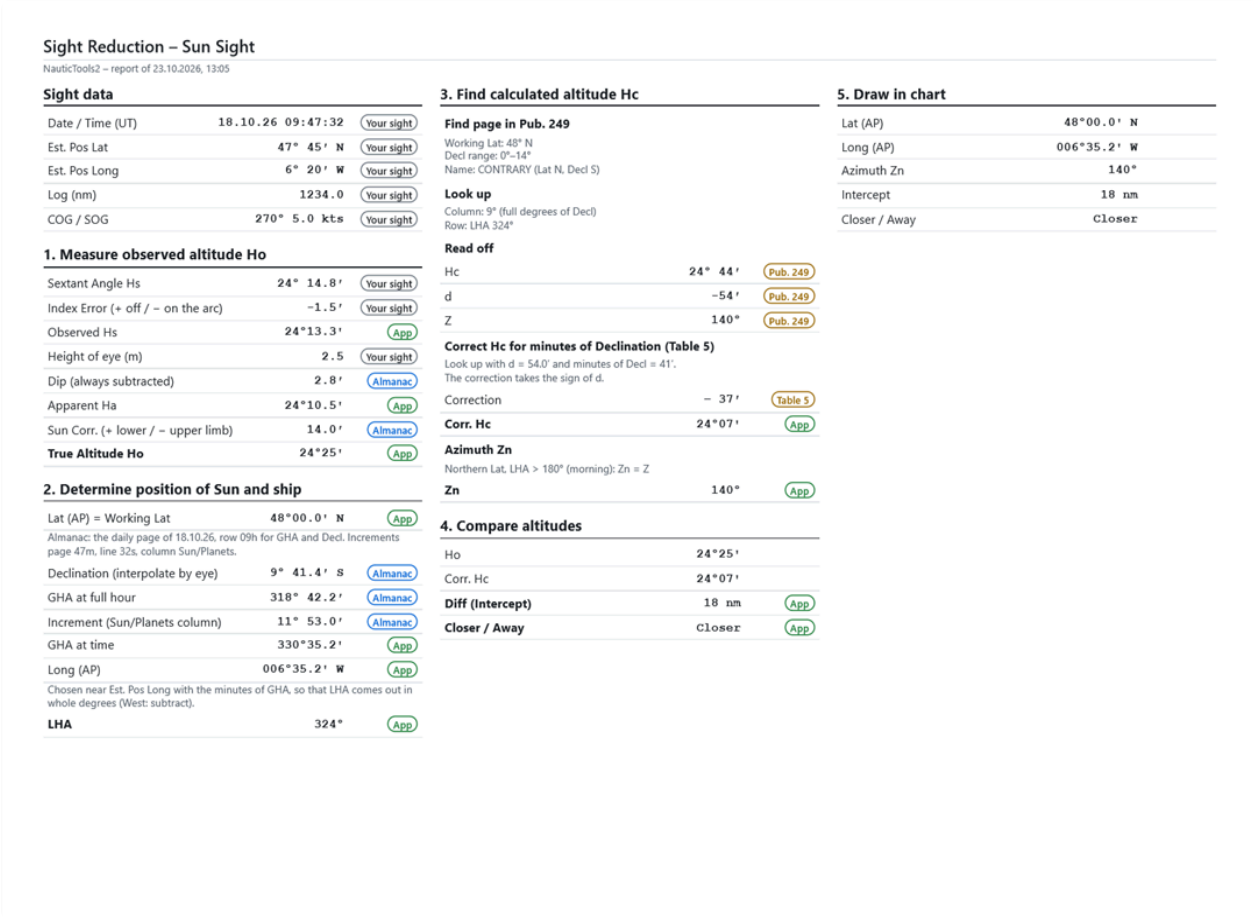
If you want to work the examples with your own tables, the practice data is available free as PDF from TheNauticalAlmanac.com (source of all the links below). The examples in NauticTools2 are dated 18 October 2026 – for them you need the 2026 Almanac, Pub. 249 volume 3 (latitude 48°) and Table 5.

- **Nautical Almanac:** 2026 (6.8 MB) · 2027 (6.9 MB) · earlier years: 2020, 2021, 2022, 2023, 2024, 2025
- **Pub. 249:** Volume 2 (latitudes 0°–39°, 4.7 MB) · Volume 3 (latitudes 40°–89°, 4.2 MB) · Volume 1, Selected Stars, epoch 2025 (58 MB)
- **Table 5:** Correction to Tabulated Altitude for Minutes of Declination (40 KB)

Source: All files come from TheNauticalAlmanac.com and are hosted there, not by NauticTools2. Pub. 249 is published by the US NGA.
For practice only: The linked almanacs and tables are offered here solely for practising and working through the examples. Their publisher expressly rules out their use for navigation – on board you need an official Nautical Almanac. Volumes 2 and 3 and Table 5 are already included in the app.

26.10 Printable record

Every form can be printed filled in or saved as a PDF, on one A4 landscape page: sight data and the five steps with the source of every value. The plotting sheet prints the chosen sights, the drawing and the fix on one A4 portrait page.



Sight Reduction – Sun Sight

NauticTools2 – report of 23.10.2026, 13:05

Sight data

Date / Time (UT)	18.10.26 09:47:32	Your sight
Est. Pos Lat	47° 45' N	Your sight
Est. Pos Long	6° 20' W	Your sight
Log (nm)	1234.0	Your sight
COG / SOG	270° 5.0 kts	Your sight

1. Measure observed altitude Ho

Sextant Angle Hs	24° 14.8'	Your sight
Index Error (+ off / − on the arc)	-1.5'	Your sight
Observed Hs	24°13.3'	App
Height of eye (m)	2.5	Your sight
Dip (always subtracted)	2.8'	Almanac
Apparent Ha	24°10.5'	App
Sun Corr. (+ lower / − upper limb)	14.0'	Almanac
True Altitude Ho	24°25'	App

2. Determine position of Sun and ship

Lat (AP) = Working Lat	48°00.0' N	App

Almanac: the daily page of 18.10.26, row 09h for GHA and Decl. Increments page 47m, line 32s, column Sun/Planets.

Declination (interpolate by eye)	9° 41.4' S	Almanac
GHA at full hour	318° 42.2'	Almanac
Increment (Sun/Planets column)	11° 53.0'	Almanac
GHA at time	330°35.2'	App
Long (AP)	006°35.2' W	App

Chosen near Est. Pos Long with the minutes of GHA, so that LHA comes out in whole degrees (West: subtract).

LHA	324°	App

3. Find calculated altitude Hc

Find page in Pub. 249

Working Lat: 48° N
Decl range: 0°–14°
Name: CONTRARY (Lat N, Decl S)

Look up

Column: 9° (full degrees of Decl)
Row: LHA 324°

Read off

Hc	24° 44'	Pub. 249
d	-54'	Pub. 249
Z	140°	Pub. 249

Correct Hc for minutes of Declination (Table 5)

Look up with d = 54.0' and minutes of Decl = 41'.
The correction takes the sign of d.

Correction	− 37'	Table 5
Corr. Hc	24°07'	App

Azimuth Zn

Northern Lat, LHA > 180° (morning): Zn = Z

Zn	140°	App

4. Compare altitudes

Ho	24°25'	
Corr. Hc	24°07'	
Diff (Intercept)	18 nm	App
Closer / Away	Closer	App

5. Draw in chart

Lat (AP)	48°00.0' N
Long (AP)	006°35.2' W
Azimuth Zn	140°
Intercept	18 nm
Closer / Away	Closer

Figure 26.5 The record for the sun example in the Bay of Biscay.

26.11 Things to watch out for

- **Almanac for the right year:** GHA and declination only apply to the year printed.
- **Same or contrary name:** if latitude and declination have the same name (both north or both south), use the same-name side of Pub. 249, otherwise contrary. Mixing them up gives a completely wrong Hc.
- **Assumed position, not DR:** the intercept is laid off from the assumed position, not from the DR position – otherwise the position line is off by the difference.
- **Stars with high declination:** Pub. 249 volumes 2 and 3 go up to 29° declination. Stars beyond that need volume 1 (Selected Stars), which is not included.

26.12 How it works in NauticTools2

1. **Choose the form**
   At the top: sun, moon, planet, star, Polaris, noon sight, compass check or plotting sheet.

2. **Sight data**
   Date and time (UT), DR position, log, course and speed over ground.
3. **Enter the values**
   Block by block, as on paper. Coloured labels show where to look: Almanac, Pub. 249, Table 5 – or the app works it out.
4. **Save, plot, print**
   Saved sights can be chosen on the plotting sheet. The form prints filled in on A4 landscape.

26.13 Frequently asked questions

What is Pub. 249?
A set of tables published by the US NGA (Sight Reduction Tables for Air Navigation). For an assumed position they give Hc and Z – you look them up instead of working the trigonometry.

Do I need a Nautical Almanac?
Yes, you enter the values yourself as on paper. If you just want to see the method, let “Automatic” fill them in.

Why work from an assumed position?
Because Pub. 249 only contains whole-degree latitudes and local hour angles. The assumed position is therefore on a whole-degree latitude, and its longitude makes LHA a whole number.

What do Closer and Away mean?
If Ho is greater than Hc, the position line lies that many miles towards the body (Closer), otherwise away from it (Away).

26.14 See also

- **Fix from 2 or 3 altitudes** (chapter 25) – the same task, with the app working everything out
- **Noon latitude** (chapter 22) and **sun-run-noon fix** (chapter 23) – latitude from meridian passage
- **Compass check** (chapter 24) – compass error from the sun's azimuth, fully computed
- **Sextant altitude corrections** (chapter 18) – from Hs to Ho

PART III

Tides

Moon phases, depth of water and the methods of the BSH and the Admiralty Tide Tables.

PART III · TIDES

27 Moon Phases

Moon phases – new moon, full moon and the two quarters

When is the next full moon, and when was the last new moon? For any date NauticTools2 works out the four **moon phases** of the current lunation and the following new moon, to the minute in **UTC** and with no internet connection.

New moon | First quarter | Full moon | Last quarter | Next new moon | Times in UTC

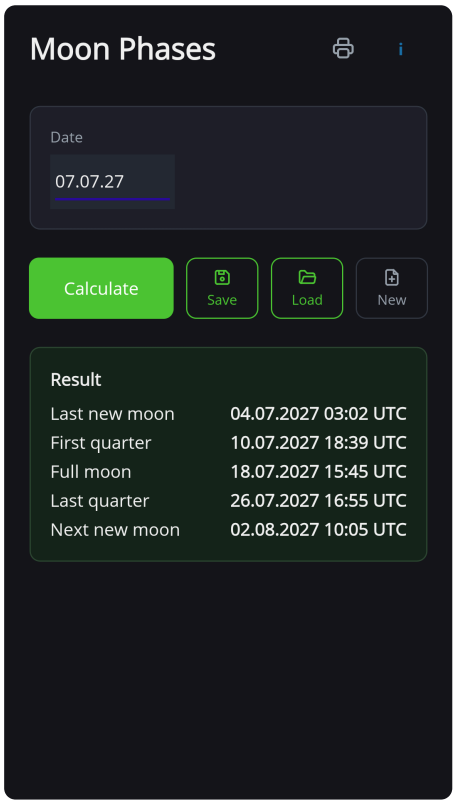


Figure 27.1 Moon Phases in the Android version: enter a date and the phases of the lunation appear with date and time.

27.1 What are moon phases?

The moon orbits the earth and is always lit by the sun. From the earth we see a different part of the lit half, depending on where the moon stands relative to the sun. On the same side as the sun it is **new moon**. Opposite the sun it is **full moon**. Between them lie the **first** and **last quarter**. One new moon to the next is a **lunation**, 29.53 days on average.

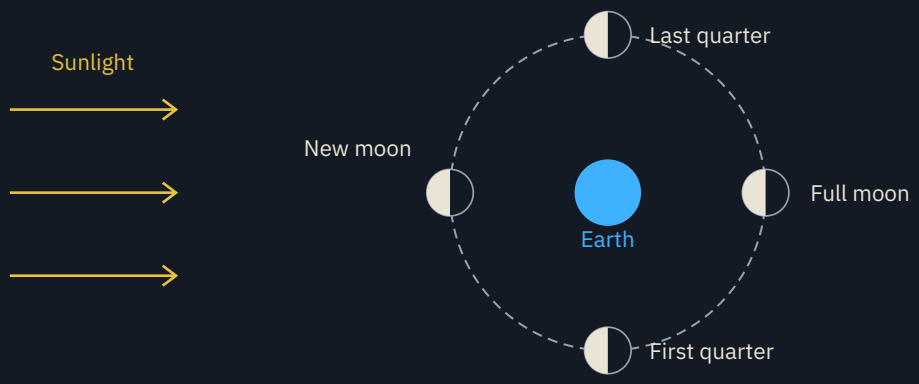


Figure 27.2 Seen from the north, not to scale: the sun always lights the half of the moon that faces it.

27.2 When do you need it?

- **Tides:** springs follow new and full moon, neaps follow the quarters. The phases are the starting point for **Age of Tide** (chapter 28), **Tides BSH** (chapter 30) and **Tides ATT** (chapter 31).
- **Planning night passages:** a crossing around full moon is far brighter than one around new moon.
- **Anchoring and landfall:** if you reach an unfamiliar harbour at night, you know in advance how much moonlight to expect.
- **Checking:** the calculated times can be compared directly with the moon phases in an almanac or tide table.

27.3 The working

```
Phase angle = ecliptic longitude of the moon − ecliptic longitude of the sun
```

- **0°** – new moon
- **90°** – first quarter
- **180°** – full moon
- **270°** – last quarter

So the phases are exact moments, not whole days. NauticTools2 searches for the moment the phase angle reaches each value, using the same astronomy library as **Ephemeris** (chapter 17). It runs entirely on the device and needs neither tables nor the internet.

27.4 Worked example

> **Which moon phases belong to 7 July 2027?**
>
> ```
> Last new moon = 04.07.2027 03:02 UTC
> First quarter = 10.07.2027 18:39 UTC
> Full moon = 18.07.2027 15:45 UTC
> Last quarter = 26.07.2027 16:55 UTC
> Next new moon = 02.08.2027 10:05 UTC
> ```

This lunation lasts 29 days, 7 hours and 3 minutes, a little shorter than the average. The new moon of 4 July is the same one the example under **Tides ATT** (chapter 31) shows on the form.

27.5 What to watch out for

- **Always UTC:** all times are in UTC. A phase shortly before midnight may fall on the next calendar day in ship's time. **Time Systems** (chapter 1) helps with the conversion.
- **The day starts at 00:00 UTC:** the tool works from the start of the date you enter. On the day of a new moon it therefore still shows the previous lunation if the new moon only occurs later that day.
- **Last new moon:** the new moon at the top always lies before or exactly on the date entered, the other three phases follow it.
- **Moon phase is not moonlight:** the tool does not say when the moon rises and sets. That is what **Rising and Setting** (chapter 16) is for.

27.6 How it works in NauticTools2

1. **Open the tool**
   The **Moon Phases** tile opens with today's date and shows the current lunation straight away.
2. **Enter a date**
   Enter another date, also as six digits such as 070727, and tap **Calculate**.
3. **Save and print**
   Save and **Load** keep a date, **New** returns to today. The printout contains the input and the result.

27.7 Frequently asked questions

How long is a lunation?

29.53 days on average. Because the moon's orbit is elliptical and disturbed by the sun, the length varies by several hours from one lunation to the next.

Why does the app show different times from my calendar?

NauticTools2 gives times in UTC, while calendars usually use local time. Add or subtract your zone difference to compare them.

Do I need an internet connection?

No. The moon phases are calculated on the device, at sea as well and for any year.

27.8 See also

- **Age of Tide** (chapter 28) – springs, mean or neaps for a date, with a yearly table
- **Rising and Setting** (chapter 16) – when the sun and moon rise and set
- **Ephemeris** (chapter 17) – GHA, declination and other values of the sun, moon and planets

PART III · TIDES

28 Age of Tide

Age of tide – springs, neaps and the delay after new and full moon

Is a given day at **springs**, **mean** or **neaps**? NauticTools2 answers this from the date, by the same rule as Table 4 of the German BSH tide tables. It also produces a **yearly table** with every day of a year and all moon phases.

Springs | Mean | Neaps | Age of tide | Rule of BSH Table 4 | Yearly table

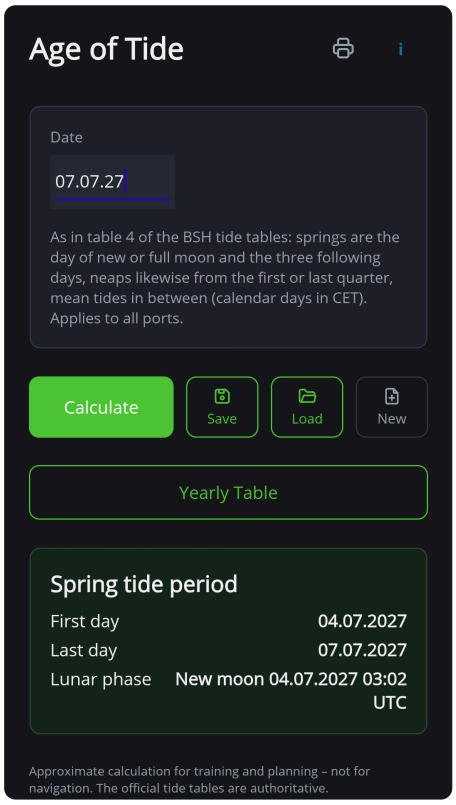


Figure 28.1 Age of Tide in the Android version: state, period and the moon phase that sets it off.

28.1 What does age of tide mean?

The tides are raised mainly by the moon, and the sun strengthens or weakens them. At new and full moon the sun, earth and moon lie in a line, their forces add up and the range is at its greatest: **springs**. At the two quarters they act across each other and the range is at its smallest: **neaps**. In between lie the **mean** tides.

28.2 The delay after new and full moon

The spring tide does not arrive on the very day of new or full moon. Water responds slowly, friction and the shape of the ocean basins hold back the tidal wave, and into marginal seas such as the North Sea it first has to run in from the Atlantic. So the greatest range follows the moon phase by some days. This

interval is the **age of tide**, in German *Springverspätung* or *Alter der Gezeit*.

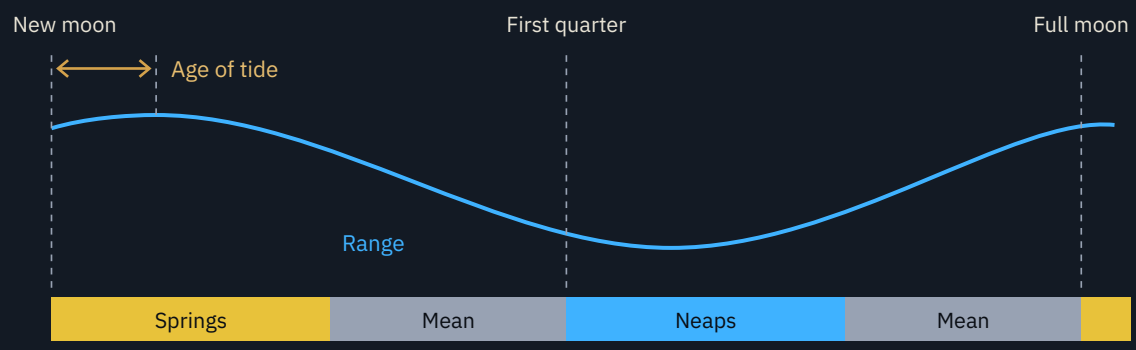


Figure 28.2 Schematic of half a lunation: the range lags behind the moon phase.

How large the age of tide is depends on the place. The German tide tables used to give it for each reference port. Today's BSH tide tables no longer do: Table 4 gives springs, mean and neaps uniformly, with the delay of the German Bight already included. That is why this tool has no reference port and no value to set. The result agrees with Table 4 day by day, checked against the 2027 table on all 365 days.

The **Admiralty Tide Tables**, by contrast, give each standard port its own age of tide. **Tides ATT** (chapter 31) works with this value: on the tidal prediction form it appears in the line “Springs occur”, and the status springs, mean or neaps follows from it.

28.3 When do you need it?

- **Tidal calculations:** working with mean spring and neap curves needs the state. **Tides BSH** (chapter 30) takes it over automatically.
- **Passage planning:** at springs the tidal streams run harder, high water is higher and low water lower.
- **Drying out:** if you take the ground at high water springs, you may not float off again for days.
- **Shallow harbours and tidal flats:** the yearly table shows at a glance which weeks are suitable.

28.4 The rule

```
Springs: day of new or full moon + 3 days · Neaps: day of the quarter + 3 days
```

1. **Find the moon phase**
   The times of the phases come from the calculation in **Moon Phases** (chapter 27).
2. **Calendar day in CET**
   The calendar day in CET (UTC+1) counts, as in the BSH tide tables. A full moon shortly before midnight UTC therefore already belongs to the next day.
3. **Count four days**
   Springs and neaps last four calendar days each, starting with the day of the moon phase. Their middle therefore lies about a day and a half after the phase, which matches the delay of the German Bight.

4. **Mean**
   All the days in between are mean tides.

28.5 Worked example

> **What is the state on 7 July 2027?**
>
> ```
> New moon: 04.07.2027 03:02 UTC = 04:02 CET, so 4 July
> Springs: 04.07. + 3 days = 04.07. to 07.07.2027
> 7 July is the last day: springs
> ```

8 and 9 July are already mean tides. The first quarter on 10 July then starts the neaps from 10 to 13 July. The example of Scharhörn, Bake C under **Tides BSH** (chapter 30) shows the same state.

28.6 What to watch out for

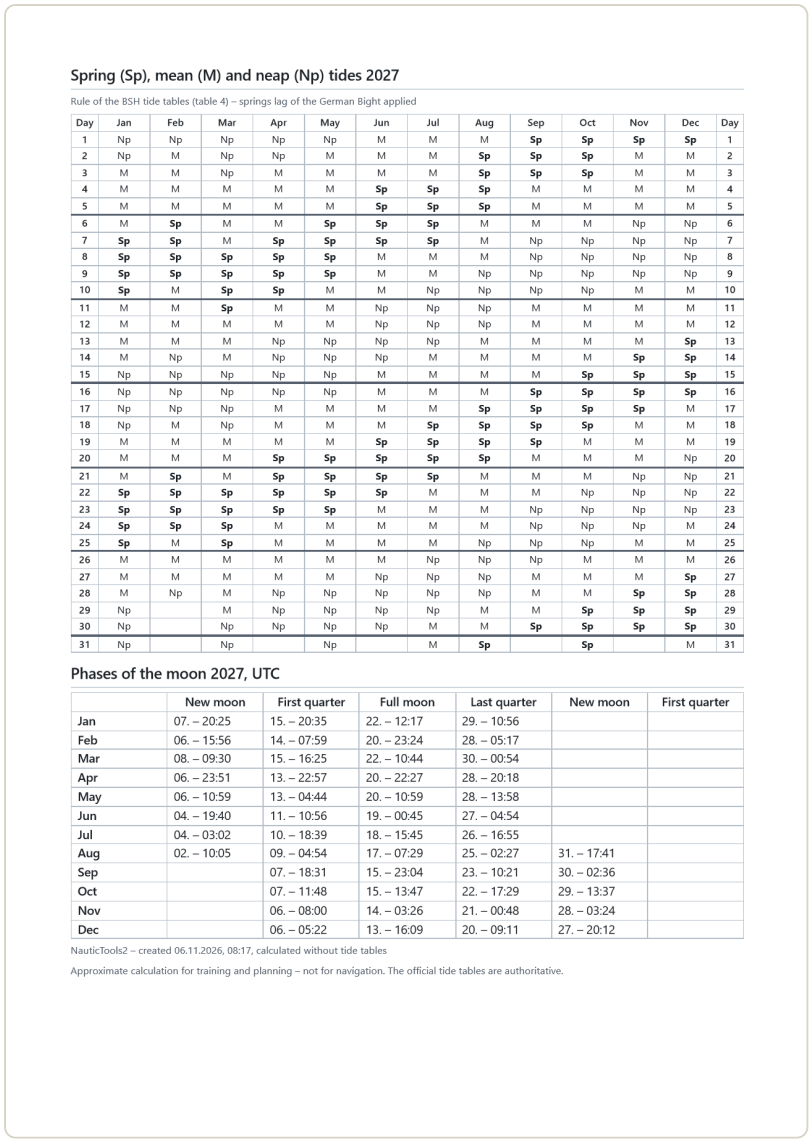
- **The limits are not sharp:** nature does not jump from one day to the next. The division is a working rule for choosing the curves.
- **One rule for all places:** by Table 4 the result applies uniformly. Outside the German Bight the true age of tide can differ.
- **Not all springs are equal:** how high a spring tide runs also depends on the moon's distance from the earth and the time of year. The rule does not distinguish this.
- **Calendar day in CET:** this applies in summer as well, the division does not follow summer time.

28.7 How it works in NauticTools2

1. **Enter a date**
   In the **Age of Tide** tile, enter a date and tap **Calculate**.
2. **Read the result**
   You see the state, the first and last day of the period and the moon phase that sets it off. Mean tides have no such phase.
3. **Save and print**
   Save and **Load** keep a date. The result can be printed as a report.

28.8 Yearly table to print

The **Yearly Table** button produces the whole overview for a chosen year: springs, mean and neaps for every day (as in Table 4) and all moon phases in UTC (as in Table 5). It is calculated and needs no printed tables. Handy for passage planning and for pinning up on board.



Spring (Sp), mean (M) and neap (Np) tides 2027

Rule of the BSH tide tables (table 4) – springs lag of the German Bight applied

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Day
1	Np	Np	Np	Np	Np	M	M	M	**Sp**	**Sp**	**Sp**	**Sp**	1
2	Np	M	Np	Np	M	M	M	**Sp**	**Sp**	**Sp**	M	M	2
3	M	M	Np	M	M	M	M	**Sp**	**Sp**	**Sp**	M	M	3
4	M	M	M	M	M	**Sp**	**Sp**	**Sp**	M	M	M	M	4
5	M	M	M	M	M	**Sp**	**Sp**	**Sp**	M	M	M	M	5
6	M	**Sp**	M	M	**Sp**	**Sp**	**Sp**	M	M	M	Np	Np	6
7	**Sp**	**Sp**	M	**Sp**	**Sp**	**Sp**	**Sp**	M	Np	Np	Np	Np	7
8	**Sp**	**Sp**	**Sp**	**Sp**	**Sp**	M	M	M	Np	Np	Np	Np	8
9	**Sp**	**Sp**	**Sp**	**Sp**	**Sp**	M	M	Np	Np	Np	Np	Np	9
10	**Sp**	M	**Sp**	**Sp**	M	M	Np	Np	Np	Np	M	M	10
11	M	M	**Sp**	M	M	Np	Np	Np	M	M	M	M	11
12	M	M	M	M	M	Np	Np	Np	M	M	M	M	12
13	M	M	M	Np	Np	Np	Np	M	M	M	M	**Sp**	13
14	M	Np	M	Np	Np	Np	M	M	M	M	**Sp**	**Sp**	14
15	Np	Np	Np	Np	Np	M	M	M	M	**Sp**	**Sp**	**Sp**	15
16	Np	Np	Np	Np	Np	M	M	M	**Sp**	**Sp**	**Sp**	**Sp**	16
17	Np	Np	Np	M	M	M	M	**Sp**	**Sp**	**Sp**	**Sp**	M	17
18	Np	M	Np	M	M	M	**Sp**	**Sp**	**Sp**	**Sp**	M	M	18
19	M	M	M	M	M	**Sp**	**Sp**	**Sp**	**Sp**	M	M	M	19
20	M	M	M	**Sp**	**Sp**	**Sp**	**Sp**	**Sp**	M	M	M	Np	20
21	M	**Sp**	M	**Sp**	**Sp**	**Sp**	**Sp**	M	M	M	Np	Np	21
22	**Sp**	**Sp**	**Sp**	**Sp**	**Sp**	**Sp**	M	M	M	Np	Np	Np	22
23	**Sp**	**Sp**	**Sp**	**Sp**	**Sp**	M	M	M	Np	Np	Np	Np	23
24	**Sp**	**Sp**	**Sp**	M	M	M	M	M	Np	Np	Np	M	24
25	**Sp**	M	**Sp**	M	M	M	M	Np	Np	Np	M	M	25
26	M	M	M	M	M	M	Np	Np	Np	M	M	M	26
27	M	M	M	M	M	Np	Np	Np	M	M	M	**Sp**	27
28	M	Np	M	Np	Np	Np	Np	Np	M	M	**Sp**	**Sp**	28
29	Np		M	Np	Np	Np	Np	M	M	**Sp**	**Sp**	**Sp**	29
30	Np		Np	Np	Np	Np	M	M	**Sp**	**Sp**	**Sp**	**Sp**	30
31	Np		Np		Np		M	**Sp**		**Sp**		M	31

Phases of the moon 2027, UTC

	New moon	First quarter	Full moon	Last quarter	New moon	First quarter
Jan	07. – 20:25	15. – 20:35	22. – 12:17	29. – 10:56		
Feb	06. – 15:56	14. – 07:59	20. – 23:24	28. – 05:17		
Mar	08. – 09:30	15. – 16:25	22. – 10:44	30. – 00:54		
Apr	06. – 23:51	13. – 22:57	20. – 22:27	28. – 20:18		
May	06. – 10:59	13. – 04:44	20. – 10:59	28. – 13:58		
Jun	04. – 19:40	11. – 10:56	19. – 00:45	27. – 04:54		
Jul	04. – 03:02	10. – 18:39	18. – 15:45	26. – 16:55		
Aug	02. – 10:05	09. – 04:54	17. – 07:29	25. – 02:27	31. – 17:41	
Sep		07. – 18:31	15. – 23:04	23. – 10:21	30. – 02:36	
Oct		07. – 11:48	15. – 13:47	22. – 17:29	29. – 13:37	
Nov		06. – 08:00	14. – 03:26	21. – 00:48	28. – 03:24	
Dec		06. – 05:22	13. – 16:09	20. – 09:11	27. – 20:12	

NauticTools2 – created 06.11.2026, 08:17, calculated without tide tables

Approximate calculation for training and planning – not for navigation. The official tide tables are authoritative.

Figure 28.3 The yearly table for 2027.

28.9 Frequently asked questions

Why can't I set an age of tide?

The BSH tide tables no longer give it for each place. Table 4 already includes the delay of the German Bight, and the tool follows the same rule. Tides ATT uses the value of each standard port.

Does the age of tide differ from place to place?

Yes. That is why the Admiralty Tide Tables give a value for each standard port. This tool follows the uniform rule of the German BSH tide tables.

Which years does the yearly table cover?

It is produced from the calculated moon phases, so it does not depend on a printed volume. It has been checked against Table 4 for 2027.

Not for navigation: all tidal values are approximations for training, exam preparation and passage planning. Wind and air pressure change the tide further. For navigation, the official tide tables are authoritative.

28.10 See also

- **Moon Phases** (chapter 27) – new moon, full moon and the two quarters for a date
- **Tides BSH** (chapter 30) – height of tide by the method of the German BSH tide tables
- **Tides ATT** (chapter 31) – tidal predictions with standard and secondary ports

PART III · TIDES

29 Depth of Water

Depth of water – charted depth, height of tide and water under the keel

Will my keel clear the shoal? From **charted depth** and **height of tide** NauticTools2 works out the depth of water, compares the **water under the keel** with your safety margin and gives the height of tide you need at least. Sliders and a cross-section let you try out what happens as the water rises or falls.

Charted depth | Height of tide | Water under the keel | Safety margin | Recreational and commercial | Cross-section

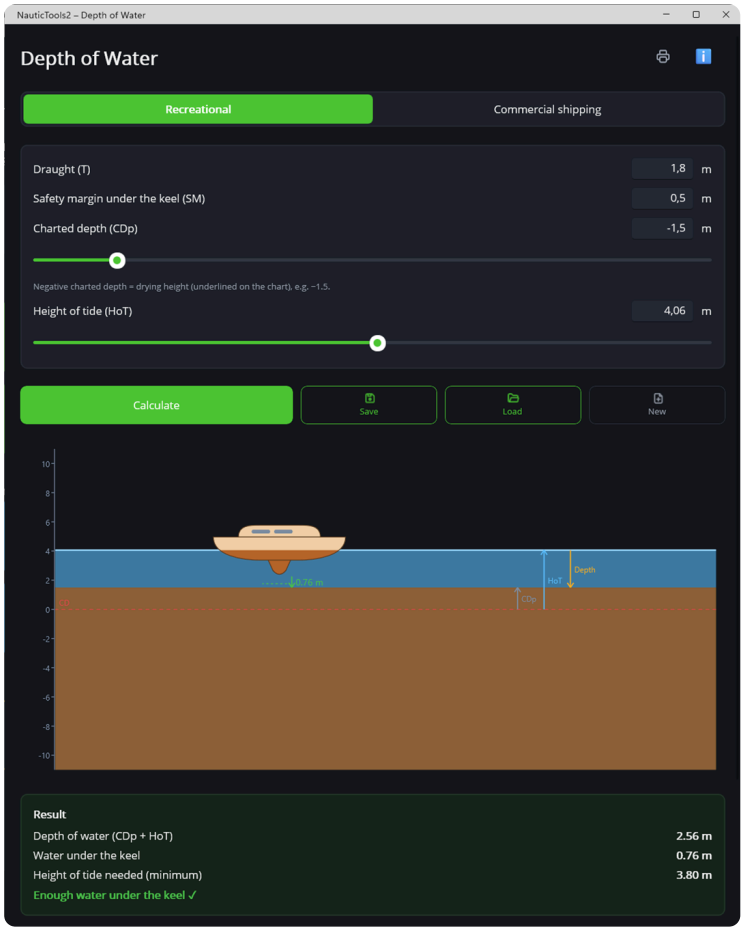


Figure 29.1 Inputs, sliders and the cross-section with the vessel above the seabed.

29.1 What is the depth of water?

The chart does not show how much water is there right now, but the **charted depth** (CDp): the depth below **chart datum** (CD). The water usually stands above chart datum, and this difference is the **height of tide** (HoT). Together they give the actual depth of water. Because both refer to the same chart datum, its exact definition does not matter for the calculation.

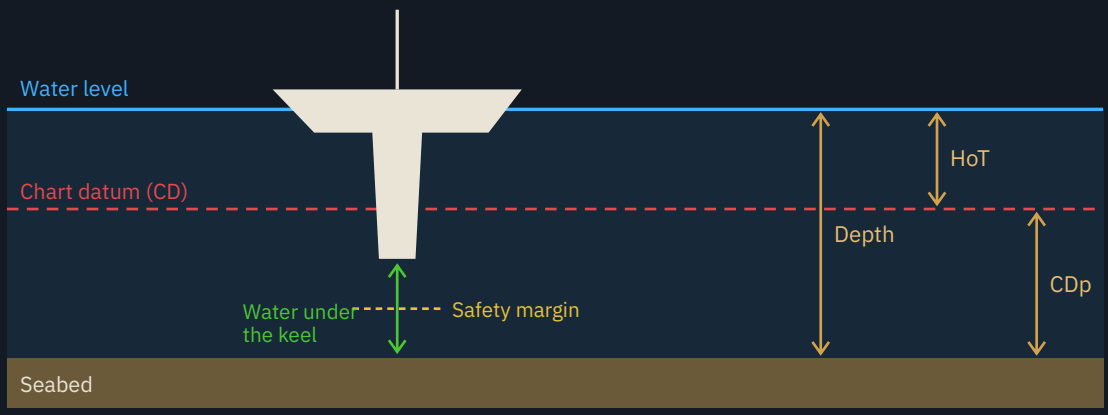


Figure 29.2 Not to scale: the depth of water is the charted depth plus the height of tide.

29.2 When do you need it?

- **Shoals and bars:** is there enough water for my vessel, and how much reserve is left?
- **Drying areas:** from what height of tide can a drying patch be crossed?
- **Berths and anchorages:** how much water will be left at low water?
- **Commercial shipping:** is the under keel clearance sufficient when it is set as a percentage of the draught?

29.3 The working

```
Depth = CDp + HoT
```

- **Depth** – depth of water
- **CDp** – charted depth, measured down from chart datum; drying heights are negative
- **HoT** – height of tide, measured up from chart datum

1. **Depth of water**
   Add charted depth and height of tide.
2. **Water under the keel**
   Subtract the draught from the depth of water.
3. **Compare with the safety margin**
   The water under the keel must be at least as large as the safety margin (SM).
4. **Height of tide needed**
   Minimum HoT = draught + SM − CDp. This value is the link to the tide tools.

29.4 Worked example

> **A yacht drawing 1.80 m wants to cross a patch charted as drying 1.5 m (CDp = −1.5 m) with a safety margin of 0.50 m. The height of tide is 4.06 m, as in the example under Tides BSH. Is there enough water?**
>
> ```
> Depth of water: −1.50 + 4.06 = 2.56 m
> Water under the keel: 2.56 − 1.80 = 0.76 m
> Compared with SM: 0.76 m ≥ 0.50 m, sufficient
> Height of tide needed: 1.80 + 0.50 + 1.50 = 3.80 m
> ```

Enter the 3.80 m as the required minimum height in **Tides BSH** (chapter 30) or **Tides ATT** (chapter 31), and these tools give the times during which the patch can be crossed.

29.5 What to watch out for

- **Drying heights:** a depth underlined on the chart is entered as a negative value, for example −1.5.
- **Safety margin:** wind, air pressure and swell change the water level. Squat and heel change the draught. The tool does not include any of these, so the safety margin has to cover them.
- **Height of tide:** the result is only as good as this value. For navigation, the official tide tables are authoritative.
- **Old surveys:** in shallow, changing waters the true depth can differ from the charted depth.

29.6 How it works in NauticTools2

1. **Choose the type of vessel**
   At the top you choose **Recreational** or **Commercial shipping**. This sets the ranges of the sliders, the scale of the graphic and the vessel drawn. Recreational covers charted depths from −3 to 10 m and heights of tide from 0 to 8 m, commercial from −2 to 25 m and from 0 to 10 m.
2. **Enter the values**
   Enter draught, safety margin, charted depth and height of tide. For commercial shipping the safety margin can be given in metres or as a percentage of the draught.
3. **Try it out with the sliders**
   Charted depth and height of tide can also be set with the sliders. Graphic, result and working follow at once.
4. **Read the graphic**
   The cross-section shows seabed, chart datum, water level and the vessel. With enough water the vessel is green, otherwise red.
5. **Save and print**
   Save and **Load** keep a calculation, and the printout contains the inputs, result and working.

29.7 Frequently asked questions

Where do I get the height of tide?
From the tide tables or from the tools Tides BSH, Tides ATT and Simplified Harmonic Method.

How do I enter a drying height?
As a negative charted depth. A drying height of 1.5 m is entered as −1.5.

How large should the safety margin be?
That depends on the vessel, the area, the seabed and the sea state. It has to cover everything the tool does not calculate: wind, air pressure, swell, squat and heel.

29.8 See also

- **Tides BSH** (chapter 30) – height of tide and time window for a minimum height by the German BSH tide tables
- **Tides ATT** (chapter 31) – tidal predictions and crossing a bar by the Admiralty Tide Tables
- **Age of Tide** (chapter 28) – springs, mean or neaps for a date

PART III · TIDES

30 Tides BSH

Tides BSH – height of tide and minimum height by the German BSH tide tables

What is the height of tide at a given time, and when is a required minimum height reached? NauticTools2 works this out by the method of the German **BSH tide tables**, with the mean spring and neap curves of the **reference ports** and, if you wish, for a **secondary port**.

BSH 2027 | 38 reference ports | Secondary ports | Springs, mean, neaps | Minimum height as a time window | Tidal curve

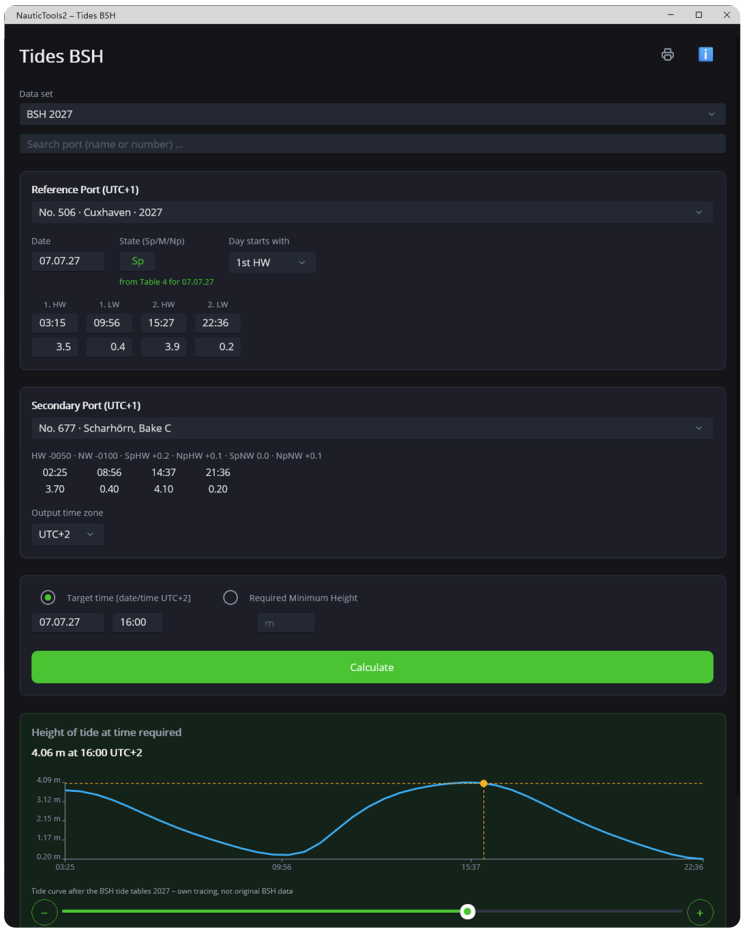


Figure 30.1 Tides BSH with reference port, secondary port and the result on the tidal curve.

30.1 What is the method of the BSH tide tables?

The tide tables of the German Federal Maritime and Hydrographic Agency (BSH) give the time and height of every high and low water at the **reference ports**. In between, the tide does not run evenly, so each reference port has mean tidal curves for springs and neaps. The actual duration of rise or fall on a given day differs from the mean: the target time is therefore related to the duration on that day and transferred to the mean curve. The height read there is converted in proportion to the heights of the day.

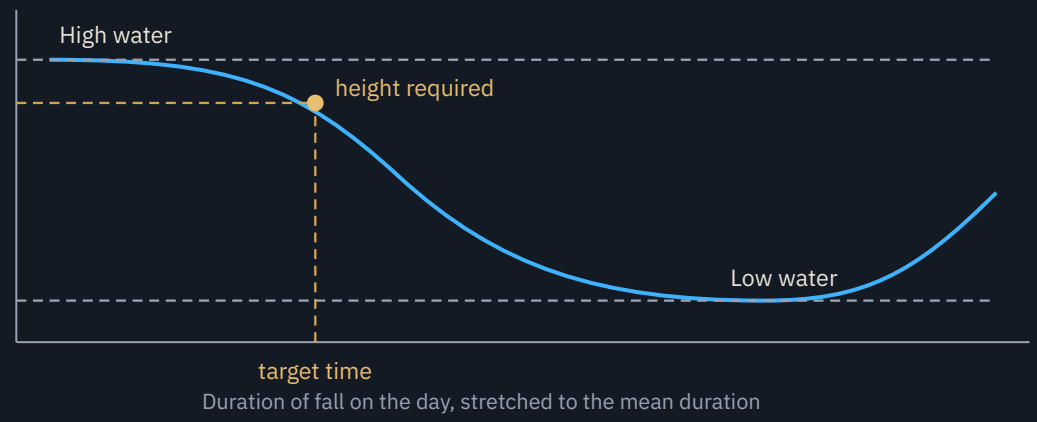


Figure 30.2 Simplified diagram: the height on the mean curve is read from the share of the target time in the duration of fall.

30.2 When do you need it?

- **Draught and shoals:** is there enough water over a shallow patch at the planned time?
- **Planning a window:** from when to when are there at least 2.50 m at the harbour or in the channel?
- **Drying out:** when does the boat take the ground, and when does she float again?
- **Passage planning in tidal waters:** the German Bight, the Netherlands, Great Britain and Ireland, France, Spain, Portugal, Gibraltar and Norway are available as reference ports.

30.3 The working

1. **Springs, mean or neaps**
   The state follows from the date by Table 4 of the BSH tide tables. It can be overwritten by hand. At mean tides the average of the spring and neap results applies.
2. **Apply the secondary port**
   Time and height differences are applied to all high and low waters of the reference port. The shape of the curve stays that of the reference port.
3. **Place the target time**
   The target time is related to the actual duration of rise or fall and transferred to the mean duration of the curve.
4. **Read the height**
   The height on the curve is converted in proportion to the heights of the day. For a minimum height the same calculation runs in reverse and gives the times at which the curve crosses that height.

30.4 Worked example

> **Scharhörn, Bake C as a secondary port of Cuxhaven on 7 July 2027, springs. The table gives for Cuxhaven (times in UTC+1) HW 15:27 at 3.9 m and LW 22:36 at 0.2 m. The differences for Scharhörn are HW −50 min, LW −60 min, and at springs HW +0.2 m, LW 0.0 m. What is the height of tide at 16:00 UTC+2?**
>
> ```
> HW Scharhörn: 15:27 − 50 min = 14:37 · 3.9 + 0.2 = 4.1 m
> LW Scharhörn: 22:36 − 60 min = 21:36 · 0.2 + 0.0 = 0.2 m
> Target time: 16:00 UTC+2 = 15:00 UTC+1, so 23 min after HW
> Duration of fall: 6:59 h, mean at springs 6:49 h
> On the mean curve: 23 min · 6:49 / 6:59 ≈ 22 min after HW
> Share from the curve: about 0.99 of the range of 3.9 m
> Height of tide ≈ 4.06 m
> ```

This task is saved in NauticTools2 and can be opened with **Load**.

30.5 What to watch out for

- **Day starts with:** enter the points in the order of the table. If the setting does not fit the heights, a red note appears.
- **Only within the day:** target time and minimum height must lie between the first and the last point entered. The app deliberately does not extrapolate beyond them.
- **Double low water:** at places like Hoek van Holland the table gives only one of two low waters. If the duration differs greatly from the mean, the app warns that the result is unreliable.
- **Secondary ports that dry out:** if the table gives no low water, as at Neuwerk, the low water values of the reference port apply. The app points this out as well.
- **Traced curves:** the tidal curves are traced after the BSH tide tables and are not original BSH data. Small differences from the original are possible.

30.6 How it works in NauticTools2

1. **Check the places in “BSH Ports”**
   The **BSH Ports** tile manages reference and secondary ports. The **BSH 2027** data set comes with the app: all 38 reference ports of the 2027 tide tables with mean heights, time zone and tidal curve, plus a few secondary ports as examples. You add others from Part II of the tables yourself.

   One-off data supply: the BSH 2027 data set is supplied once only, so that the traced tidal curves can be included. There is no yearly data update. You maintain new editions yourself: the ⋯ menu copies the data set into a new year, and you then compare it with the new tide tables.

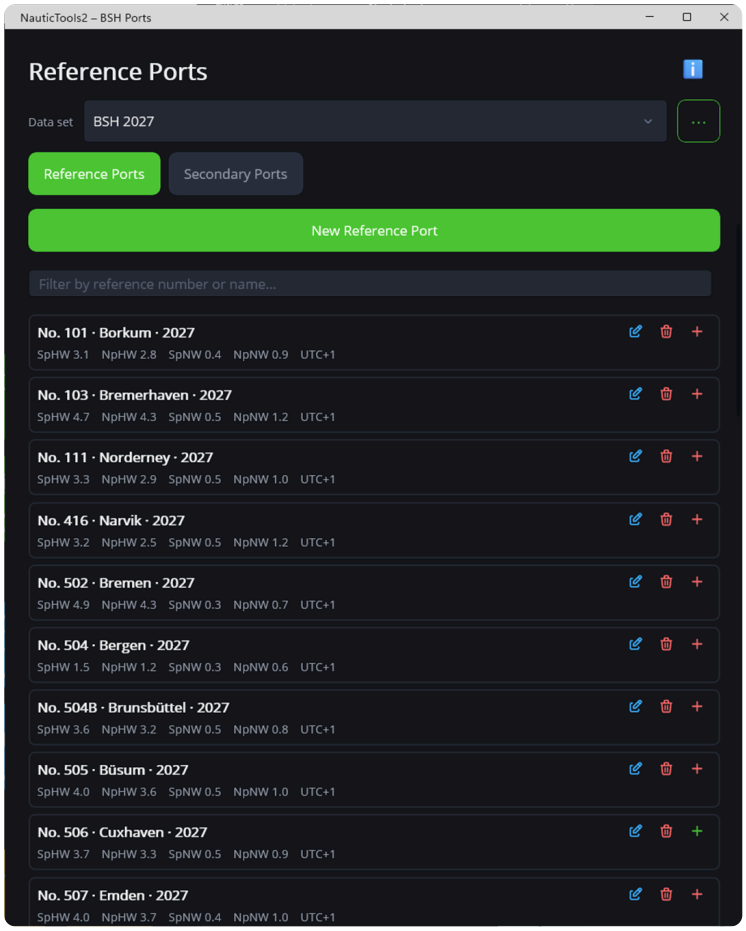


Figure 30.3 BSH Ports: reference and secondary ports, separated by data set.

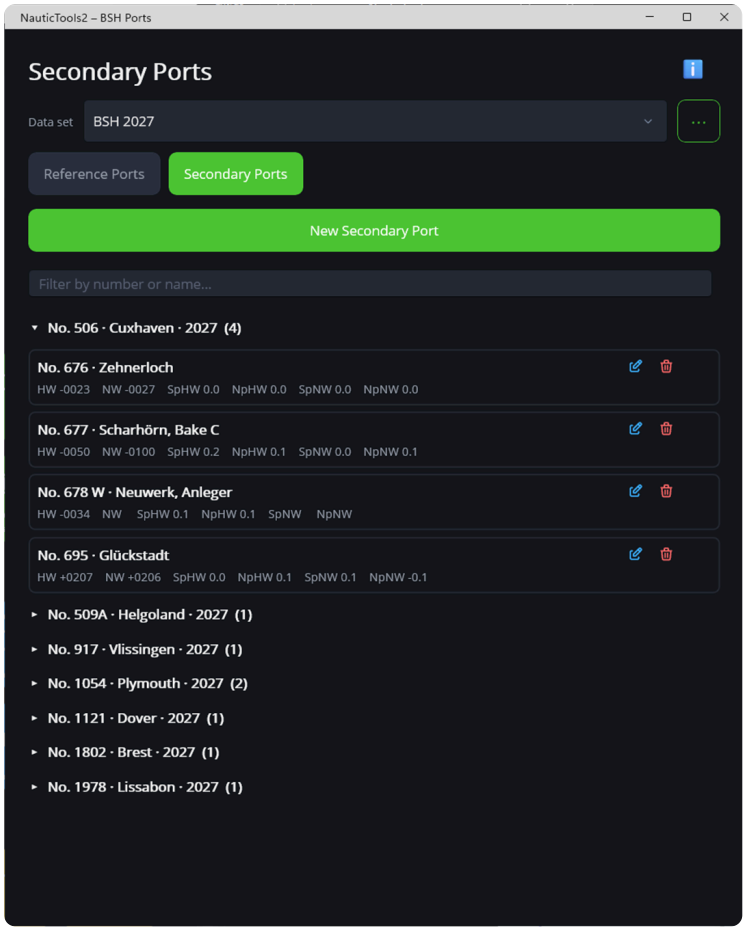


Figure 30.4 Secondary ports with their differences, grouped by reference port.

2. **Choose the place**
   In **Tides BSH**, enter a name or number in the port search. A secondary port selects its reference port as well.

3. **Enter the table values**
   Choose the date and enter the time and height of the high and low waters from the table, in the time zone of the reference port. The values of the secondary port appear while you type.

4. **Target time or minimum height**
   A target time gives the height of tide, for example “4.06 m at 16:00 UTC+2”. A minimum height gives the time window, for example “at least 5.00 m from 07:43 to 12:47 and from 19:56 UTC”. The slider moves along the curve.

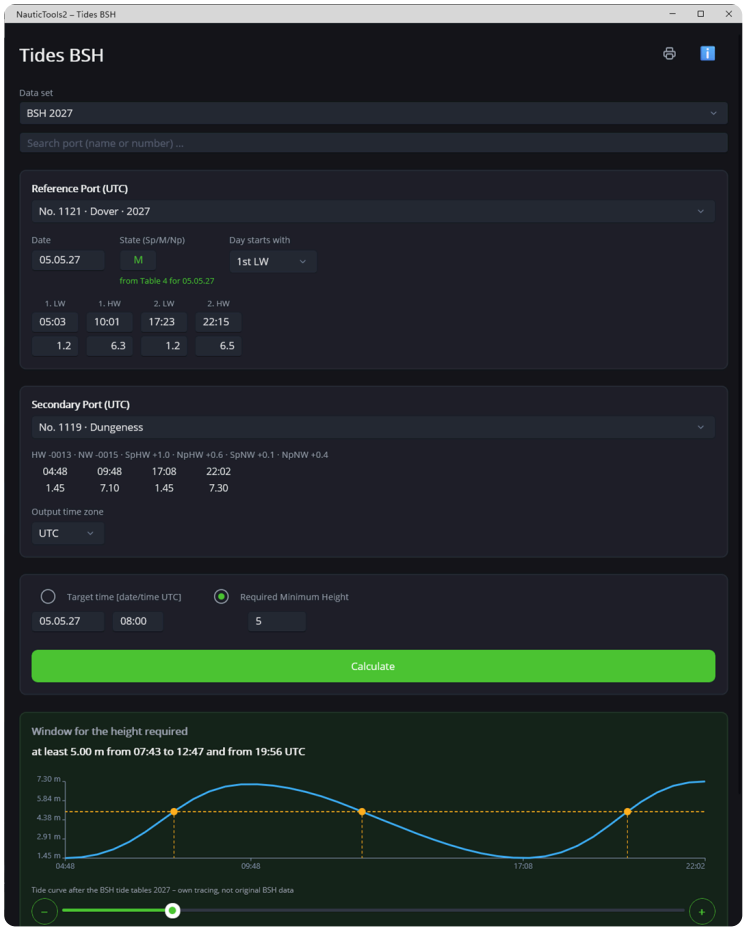


Figure 30.5 The time window for a minimum height, with the crossing points on the curve.

5. **Save and print**
   Tasks belong to the chosen data set. The printout contains the inputs, the result and the diagram.

30.7 New editions

The ⋯ menu next to the data set copies BSH 2027 into a new year. All entries of the copy count as unchecked until they have been compared with the new tide tables. Results calculated with it carry a red warning. The tidal curves stay valid through the port number.

30.8 Report to print

Every calculation can be printed as a report or saved as a PDF, with the inputs, the tidal curve and the result.



Tides BSH

NauticTools2 – report of 06.11.2026, 08:16

Input

Reference Port	No. 1121 · Dover · 2027
Secondary Port	No. 1119 · Dungeness
Date	05.05.27
State (Sp/M/Np)	Mid Tide
1. LW	05:03 UTC, 1.2 m
1. HW	10:01 UTC, 6.3 m
2. LW	17:23 UTC, 1.2 m
2. HW	22:15 UTC, 6.5 m
Required Minimum Height	5 m

Tides BSH

Result

Window for the height required	at least 5.00 m from 07:43 to 12:47 and from 19:56 UTC

Approximate calculation for training and planning – not for navigation. The official tide tables are authoritative.

Figure 30.6 The printed report of the Dungeness task with a minimum height.

30.9 Frequently asked questions

Which places are included?

All 38 reference ports of the 2027 BSH tide tables, from the German Bight through the Netherlands, Great Britain and Ireland, France, Spain, Portugal and Gibraltar to Norway. Secondary ports can be added from Part II of the tables.

What is the difference between a reference port and a secondary port?

For reference ports the table gives every high and low water. A secondary port has no predictions of its own, its values follow from time and height differences to a reference port.

Do I still need the tide tables?

Yes. You enter the times and heights of the day from the tide tables. NauticTools2 uses them to work out the height of tide or the time window between those points.

Not for navigation: all tidal values are approximations for training, exam preparation and passage planning. Traced tidal curves and calculation methods differ from the actual tide, and wind and air pressure change it further. For navigation, the official tide tables are authoritative.

30.10 See also

- **Tides ATT** (chapter 31) – tidal predictions with the Admiralty Tide Tables
- **Age of Tide** (chapter 28) – springs, mean or neaps for any date
- **Depth of Water** (chapter 29) – depth of water from charted depth and height of tide

PART III · TIDES

31 Tides ATT

Tidal predictions with the Admiralty Tide Tables – tidal prediction form and crossing a bar

NauticTools2 derives high and low water at a **secondary port** from the daily predictions of a standard port by the method of the **Admiralty Tide Tables (ATT)**, lays out the result like the **tidal prediction form** and then answers the question that matters on board: how much water is there at a given time, and from when to when is it enough for my draught?

ATT 2027 · Standard and secondary ports · Seasonal changes · Tidal prediction form · Tidal curves · Full working



Figure 31.1 The completed tidal prediction form, with the tidal curve and the result below it.

31.1 What is a tidal prediction with the ATT?

The Admiralty Tide Tables give daily predictions for a limited number of major ports, the **standard ports**. For all other ports, the **secondary ports**, Part II lists time and height differences to a standard port. To find the tide at a secondary port you convert the daily predictions of the standard port. The height between high and low water is then read from the mean spring and neap curves of the standard port.

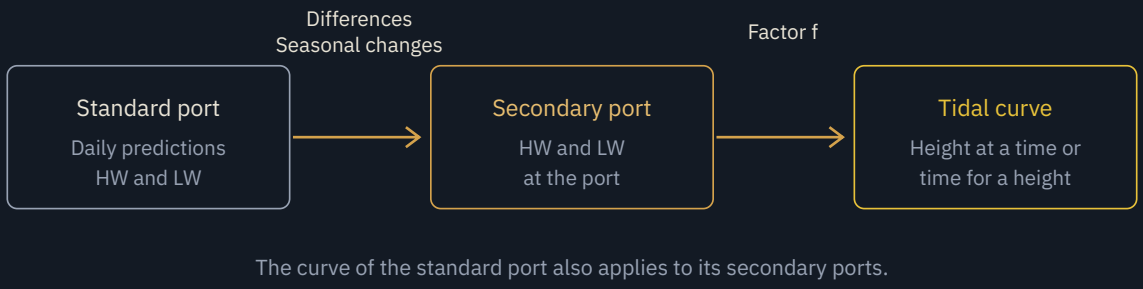


Figure 31.2 The path of the calculation, in the same order as the form.

31.2 When do you need it?

- **Entering over a bar or sill:** from when to when is there enough water for your draught?
- **Berths and locks:** high and low water at a port without daily predictions of its own.
- **Passage planning:** matching departure and arrival times to the tide, in ship's time if you like.
- **Checking your own working:** every step is shown, so a calculation on paper can be compared line by line.

31.3 The working

```
H = LWH + (HWH − LWH) · f
```

- **H** – height of tide required, above chart datum
- **HWH, LWH** – high and low water heights at the secondary port
- **f** – factor from the tidal curve, read with the interval from high water

The calculation follows the order of the form, and that is how NauticTools2 shows it:

1. **Status**
   From the new or full moon nearest to high water, the age of the tide leads to the middle of springs. Up to 2 days away counts as springs, up to 5 days as mean, beyond that as neaps.
2. **Seasonal changes**
   The seasonal change of the standard port is subtracted from its height, that of the secondary port is added at the end. The value of the nearest first of the month applies.
3. **Time differences**
   If the time lies between two column headings of Part II, the difference is shared out evenly and rounded to whole minutes.
4. **Height differences**
   They depend on where the corrected height lies between the neap and spring levels, and are rounded to 0.1 m.
5. **Height or time on the tidal curve**
   The spring and neap curves are weighted by the range at the standard port, then the factor is read off.

31.4 Worked example

> **Scharhorn, Beacon C (No. 1437a), referred to Cuxhaven (No. 1438), on 7 July 2027. The daily predictions for Cuxhaven give HW 15:27 at 3.9 m and LW 22:36 at 0.2 m, zone UTC+1. What is the height of tide at 16:00 ship's time (UT+2)?**
>
> ```
> Status: new moon 04.07.27 + 3 days = springs
> Seasonal change (1 July): standard port 0.0 m, secondary port −0.1 m
> HW: 15:27 − 45 min = 14:42 · 3.9 + 0.2 − 0.1 = 4.0 m
> LW: 22:36 − 62 min = 21:34 · 0.2 − 0.1 − 0.1 = 0.0 m
> Target time: 16:00 UT+2 = 15:00 UTC+1, so 18 min after HW
> Factor on the tidal curve: f = 0.993
> H = 0.0 + (4.0 − 0.0) · 0.993 ≈ 3.97 m
> ```

This task is saved in NauticTools2 and can be opened with **Load**.

31.5 What to watch out for

- **Time zone:** the times of the standard port are entered in the zone of its table, because the column headings refer to it. Set ship's time under **Time on Board**.
- **Fields with § or ⊙:** the book gives no value here. NauticTools2 does not carry on with 0, it tells you so.
- **Limits of the curves:** if the duration of rise or fall lies outside 5 to 7 hours, or shallow-water corrections apply, the Tide Tables call for the **Simplified Harmonic Method** (chapter 32). The tool points this out.
- **Seasonal changes:** only some of the ranges are supplied. If one is missing, a red note gives the number. Add the range from the book or enter the value by hand.
- **Poole and the Solent:** Poole Harbour and the Solent ports are not included yet, because their tidal curves refer to low water.
- **Traced curves:** the tidal curves are our own tracing after the Admiralty Tide Tables, not original curves of the UKHO. Small differences from the original are possible.

31.6 How it works in NauticTools2

1. **Check or add the ports in “ATT Ports”**
   The **ATT Ports** tile holds the master data in five tabs: standard ports, secondary ports, seasonal changes, SHM ports and practice packages. The **ATT 2027** data set comes with the app: the standard ports of Table V with levels, age of tide, time zone and column headings, plus 145 traced tidal curves of European ports. A few secondary ports are included as examples, you add others from Part II yourself.

   One-off data supply: the ATT 2027 data set is supplied once only, so that the traced tidal curves can be included. There is no yearly data update. You maintain new editions yourself, as described under “New editions and practice data”.

   Recommended order: complete the master data first, then calculate.

1. Check or add the **standard port**.
2. Add the **secondary port** from Part II and link it to the standard port.
3. Add the **seasonal changes** for the number ranges of both ports, if they are missing.
4. Only then open the **Tides ATT** tool.

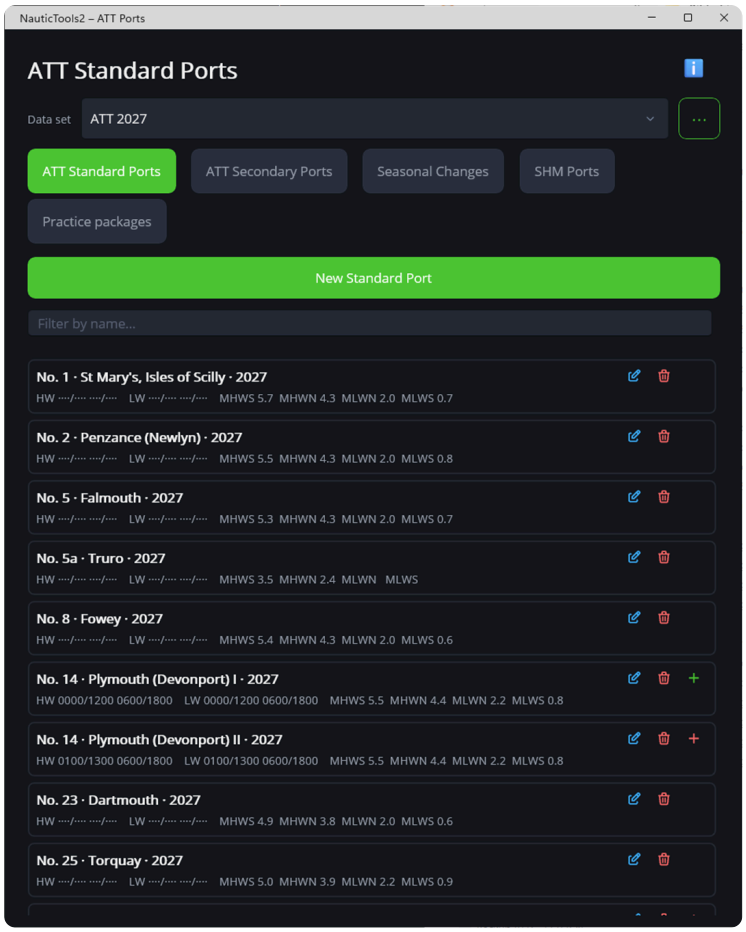


Figure 31.3 ATT Ports: all master data in one place, separated by data set.

2. Find the port

In **Tides ATT**, enter the name or number at the top. A match selects the secondary port and the standard port together, even for ports divided in the book into sections (I, II) with their own column headings.

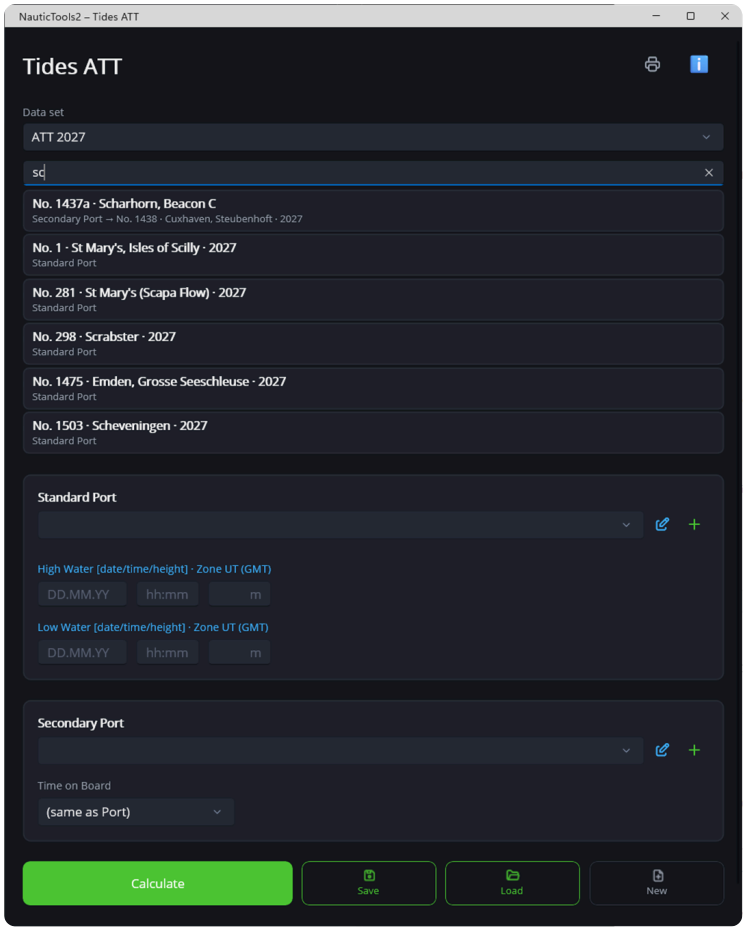


Figure 31.4 The search finds secondary and standard ports by name or number.

3. **Enter the daily predictions**
   Enter date, time and height of high and low water at the standard port. The first date is copied to the other empty fields. The app fills in the seasonal changes from the management.

4. **Calculate the tidal prediction form**
   Calculate fills in the form: the header with both ports, the status with springs, mean or neaps framed, and the lines from standard port to duration.



Figure 31.5 The tidal prediction form with all its lines.

5. Crossing a bar

This block only appears afterwards, because as in the instructions of the Tide Tables the tidal calculation comes first. Choose the **height at a target time** or the **time window for a minimum height**. The slider below the tidal curve moves the time or reads off a height.



Figure 31.6 Time window for a minimum height on the traced tidal curve.

6. **Working, printing and saving**
   The working shows every intermediate step. The printout contains the form, the curve and the working. **Save** stores the ports, daily values and task in the chosen data set.

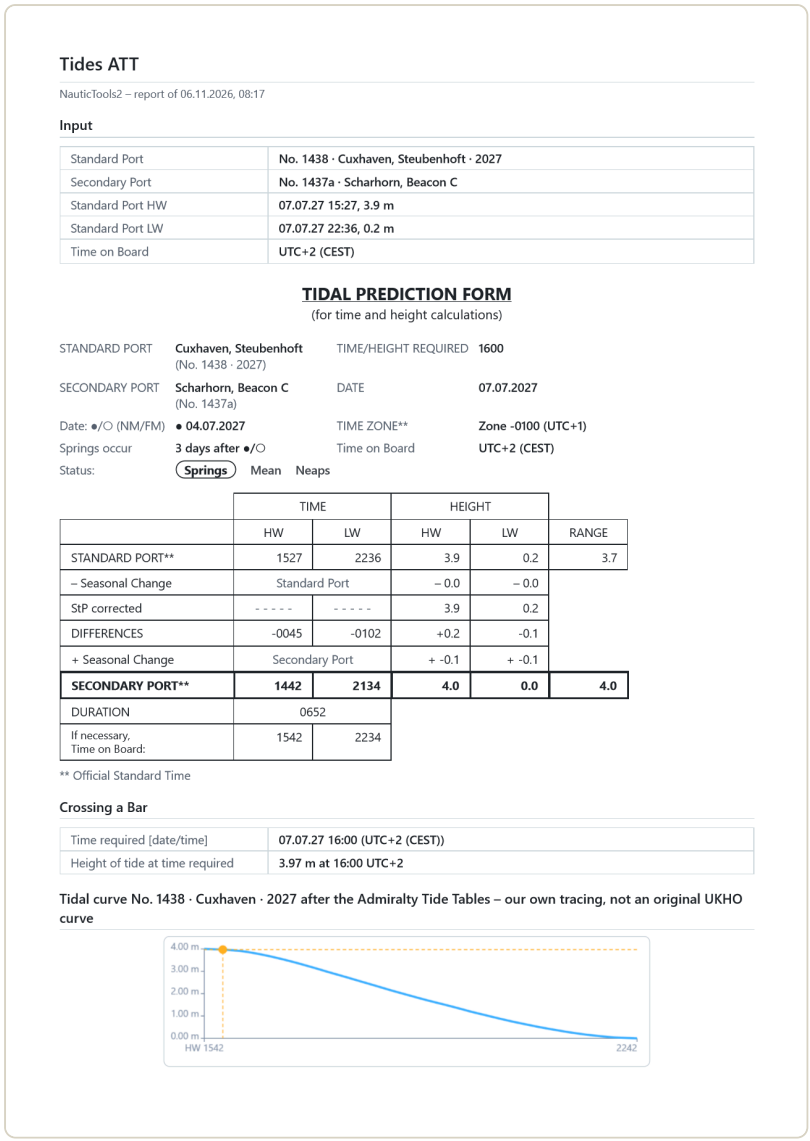
31.7 New editions and practice data

Standard ports, secondary ports, seasonal changes and saved tasks always belong to a **data set**, so editions do not get mixed up. The ⋯ menu copies ATT 2027 into a new year, for example. The copy counts as unchecked until it has been compared with the new book. Results calculated with it carry a red note.

Practice packages offer ready-made data: the RYA Training Almanac and the ATT 2005 extracts from the German DSV course booklet. Each pack gets its own data set and can be removed again.

31.8 Report to print

Every calculation can be printed as a report or saved as a PDF, with the inputs, the completed tidal prediction form, the result, the tidal curve and the full working.



Tides ATT

NauticTools2 – report of 06.11.2026, 08:17

Input

Standard Port	No. 1438 · Cuxhaven, Steubenhoft · 2027
Secondary Port	No. 1437a · Scharhorn, Beacon C
Standard Port HW	07.07.27 15:27, 3.9 m
Standard Port LW	07.07.27 22:36, 0.2 m
Time on Board	UTC+2 (CEST)

TIDAL PREDICTION FORM

(for time and height calculations)

STANDARD PORT	Cuxhaven, Steubenhoft (No. 1438 · 2027)	TIME/HEIGHT REQUIRED	1600
SECONDARY PORT	Scharhorn, Beacon C (No. 1437a)	DATE	07.07.2027
Date: ●/○ (NM/FM)	● 04.07.2027	TIME ZONE**	Zone -0100 (UTC+1)
Springs occur	3 days after ●/○	Time on Board	UTC+2 (CEST)
Status:	Springs Mean Neaps		

	TIME		HEIGHT		
	HW	LW	HW	LW	RANGE
STANDARD PORT**	1527	2236	3.9	0.2	3.7
– Seasonal Change	Standard Port		– 0.0	– 0.0	
StP corrected	- - - - -	- - - - -	3.9	0.2	
DIFFERENCES	-0045	-0102	+0.2	-0.1	
+ Seasonal Change	Secondary Port		+ -0.1	+ -0.1	
SECONDARY PORT **	**1442**	**2134**	**4.0**	**0.0**	**4.0**
DURATION	0652				
If necessary, Time on Board:	1542	2234			

** Official Standard Time

Crossing a Bar

Time required [date/time]	07.07.27 16:00 (UTC+2 (CEST))
Height of tide at time required	3.97 m at 16:00 UTC+2

Tidal curve No. 1438 · Cuxhaven · 2027 after the Admiralty Tide Tables – our own tracing, not an original UKHO curve

Figure 31.7 The printed report of the Scharhorn, Beacon C example.

31.9 Frequently asked questions

What is the difference between a standard port and a secondary port?

The Admiralty Tide Tables give daily predictions for standard ports. For secondary ports Part II gives only time and height differences to a standard port, and their tide is calculated from those.

Do I have to enter the ports myself?

The standard ports of the ATT 2027 and 145 tidal curves of European ports are included in the app. You add secondary ports from Part II yourself, a few are included as examples.

Do I still need the Admiralty Tide Tables?

Yes. The daily predictions of the standard port and the differences of the secondary ports come from the book. NauticTools2 does the calculation and shows every step.

Not for navigation: all tidal values are approximations for training, exam preparation and passage planning. Traced tidal curves and calculation methods differ from the actual tide, and wind and air pressure change it further. For navigation, the official tide tables are authoritative.

31.10 See also

- **Tides BSH** (chapter 30) – height of tide by the method of the German BSH tide tables
- **Simplified Harmonic Method** (chapter 32) – height of tide from harmonic constants
- **Depth of Water** (chapter 29) – depth of water from charted depth and height of tide

PART III · TIDES

32 Simplified Harmonic Method

Simplified Harmonic Method – height of tide from harmonic constants

The **Simplified Harmonic Method of Tidal Prediction** from the Admiralty Tide Tables works out the height of tide at any time directly from the **harmonic constants** of a port, with no standard port and no tidal curve. NauticTools2 follows **forms A and B** line by line and calculates the values of Table VII itself.

Part III | Harmonic constants | M2 · S2 · K1 · O1 | Table VII | Forms A and B | Hourly heights

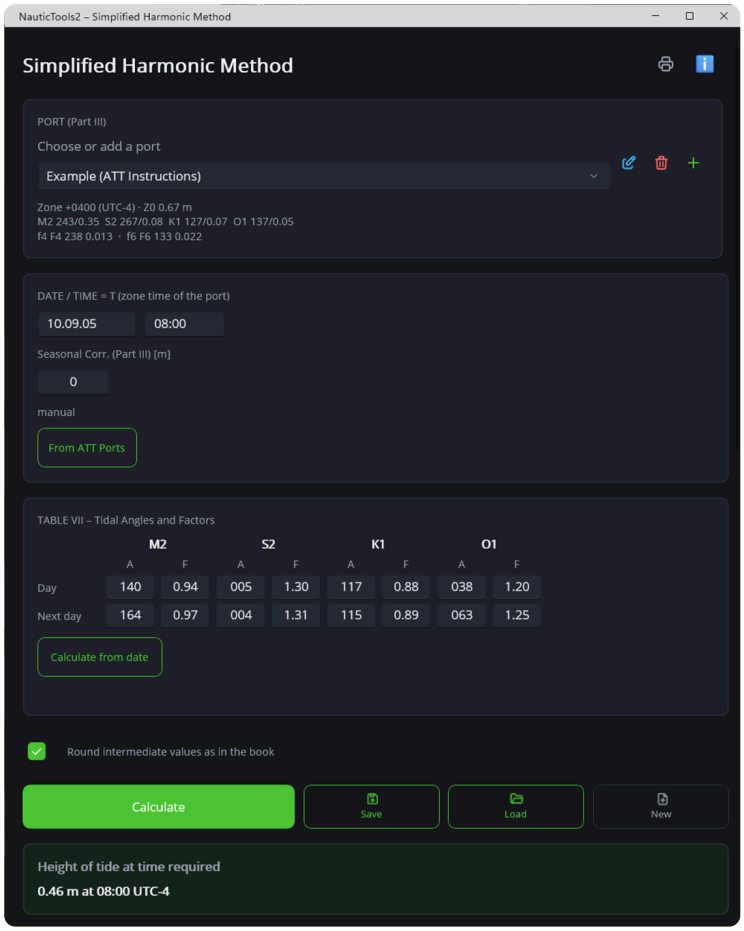


Figure 32.1 Simplified Harmonic Method with port, date, Table VII and result.

32.1 What is the Simplified Harmonic Method?

The tide can be described as the sum of individual oscillations, the **constituents**. At a given port each has its own amplitude **H** and phase **g**: the harmonic constants of Part III of the Tide Tables. The simplified method takes the four main constituents **M2, S2, K1 and O1** plus two shallow-water terms. Table VII supplies the astronomical values for each day that place the oscillations at the time required.

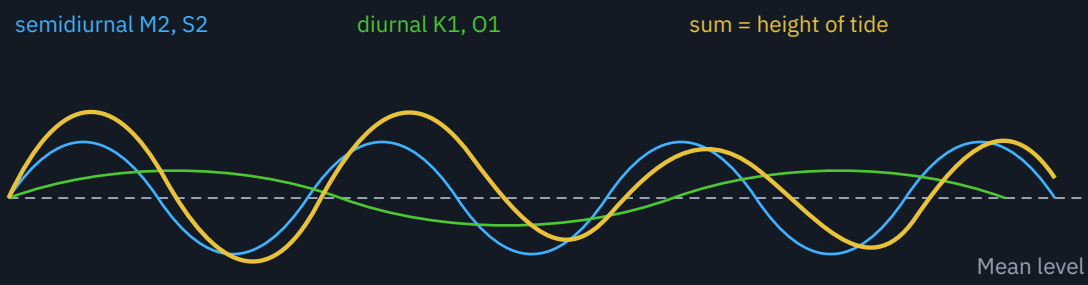


Figure 32.2 Schematic: the height of tide is the mean level plus the sum of the oscillations.

32.2 When do you need it?

- **Ports in Part III:** for many ports the Tide Tables give only harmonic constants, not daily predictions.
- **Where the standard curves do not apply:** the Tide Tables call for the method with shallow-water corrections (f4, F4, f6, F6) and with a duration of rise or fall outside 5 to 7 hours.
- **Teaching and checking:** every line of the forms is visible and can be compared with a calculation by hand.

32.3 The working

```
Height = ML + Seasonal + K1 + O1 + R + D4 + D6
```

- **ML** – mean level of the port (Z_0, or the value from Table VI for ports marked w)
- **Seasonal** – seasonal correction
- **K1, O1** – contributions of the diurnal constituents
- **R** – contribution of the semidiurnal constituents, as a vector of M2 and S2
- **D4, D6** – shallow-water terms

1. **Form A (lines 1–16)**
   Applies to the whole day: mean level, A1 and A2 from Table VII, the hourly rates p/24, A1 + g and the factors F.
2. **Form B (lines 17–40)**
   Works out the height for one time: angle θ, Ft, the contributions of the constituents, the semidiurnal vector R and the shallow-water terms. Line 40 is the sum.
3. **Hourly heights**
   As note 1 of the instructions recommends, the tool also calculates the hours from T−3 h to T+3 h. This shows the course of the tide around the time required.

32.4 Worked example

> **The example from the instructions of the Tide Tables: port “Example”, 10 September 2005, 08:00 zone time. Mean level 0.67 m, seasonal correction 0.0 m. What is the height of tide?**
>
> ```
> Mean level = 0.670 m
> K1 = −0.034 m
> O1 = +0.028 m
> R (vector of M2 and S2) = −0.203 m
> D4 and D6 = −0.002 m
> Sum, line 40 ≈ 0.46 m
> ```

This example is included in NauticTools2 as “Example (ATT Instructions)”, together with examples for Bermuda and Dover.

32.5 What to watch out for

- **Table VII:** the app calculates the values itself. Compared with the printed table they differ at most in the last digit (1° or 0.01). It does not overwrite values you enter yourself. If they no longer fit the date, the calculation is blocked until they do.
- **Mark w:** with large fortnightly variations, the mean level from Table VI applies instead of Z_0. The tool shows how many days the chosen day lies before or after springs.
- **Mark v:** with large seasonal variations, Part III gives monthly values of H or g. Enter the value for the month in the calculation.
- **Seasonal correction:** the field is pre-filled from the seasonal changes under **ATT Ports**. If there is no matching range, a red note appears.
- **Rounding:** with “Round intermediate values as in the book” ticked, every line is rounded as on the form. Without it the tool calculates without intermediate rounding.

32.6 How it works in NauticTools2

1. **Choose or add a port**
   In the **Simplified Harmonic Method** tile, choose a port or add one with + : name, number from Part III, time zone, Z_0, the constants H and g for M2, S2, K1 and O1, and f4/F4 and f6/F6. The same list is under **ATT Ports** in the SHM ports tab. Where Part III shows ⊙, leave the field empty.
2. **Enter date and time**
   The time is the zone time of the port. Table VII fills itself in from the date. It is laid out as in the book, one row per day and columns A and F for each constituent.

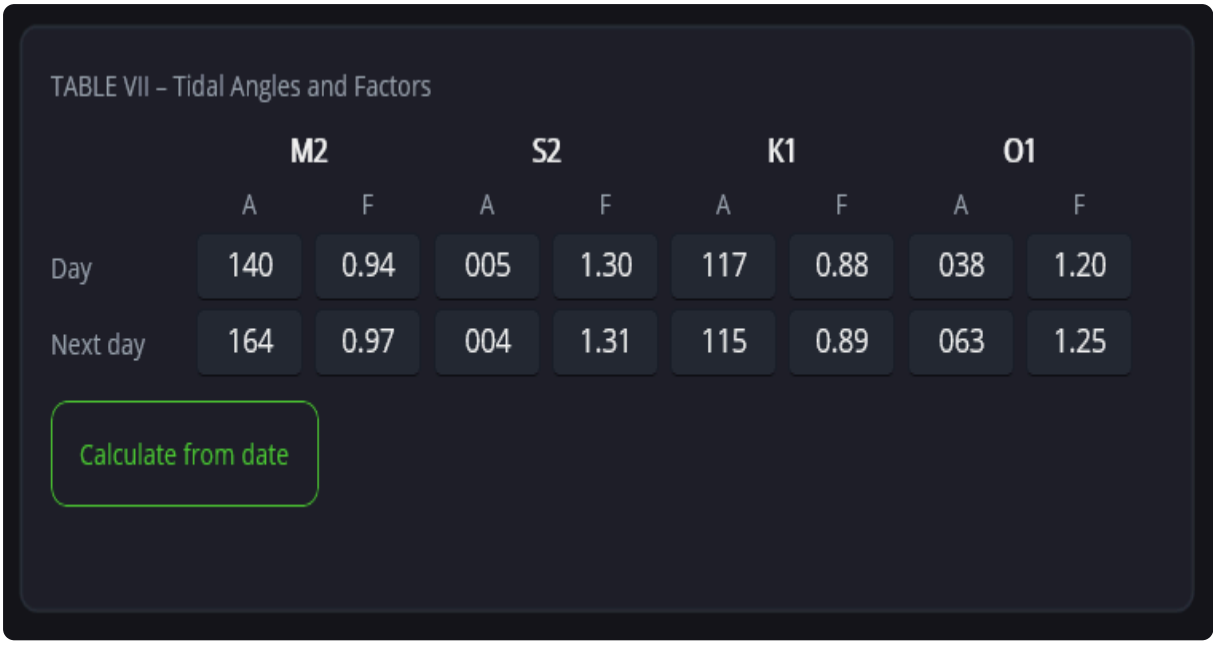


Figure 32.3 Table VII, calculated from the date and laid out as in the book.

3. Calculate

The height at time T is at the top, followed by forms A and B and the hourly heights, with the time required highlighted.

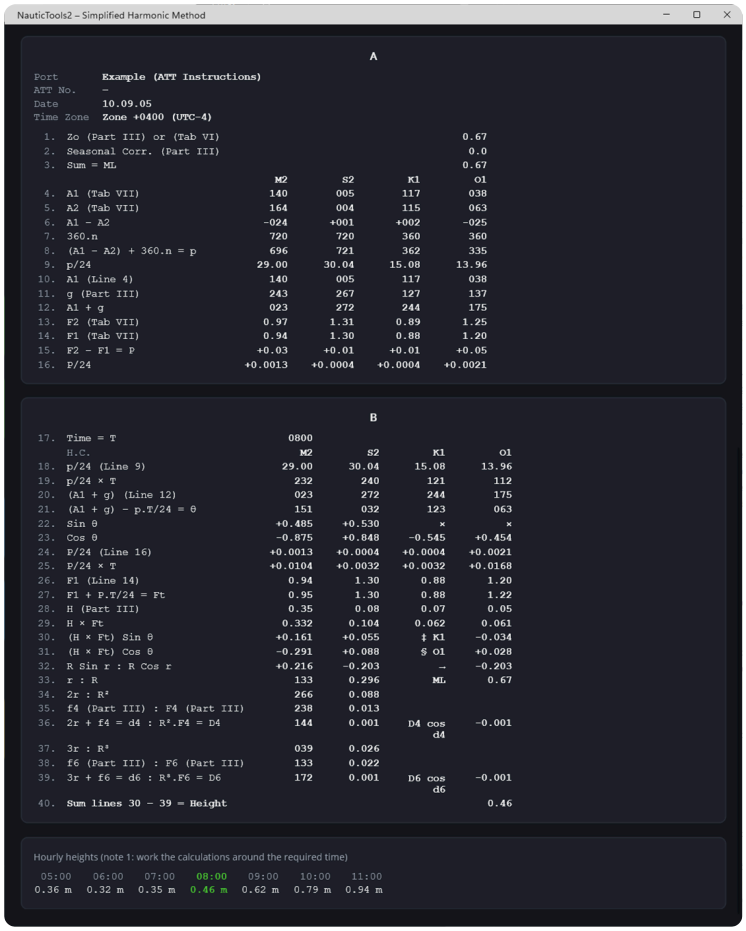
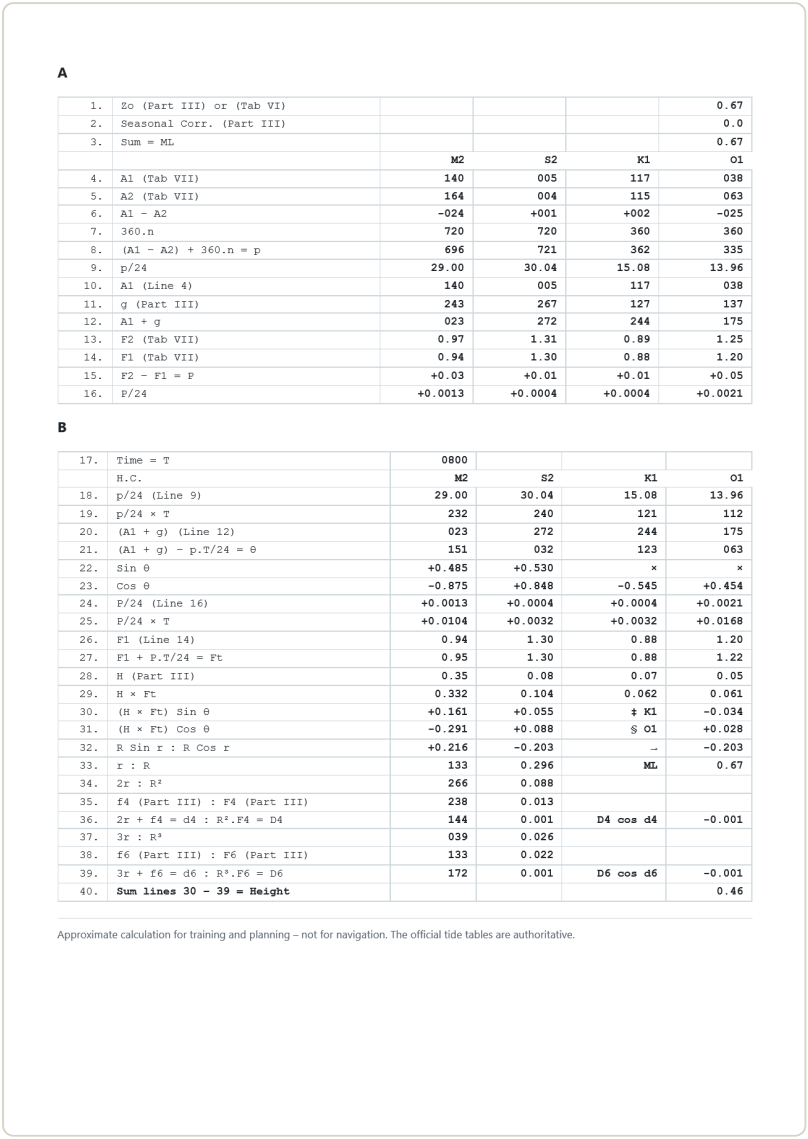


Figure 32.4 The forms as in the Tide Tables, with one column per hour.

4. **Save and print**
   Port, date, time, Table VII and the daily values are saved. The printout contains the inputs, the result, both forms and the hourly heights.

32.7 Report to print

Every calculation can be printed as a report or saved as a PDF. Page 1 holds the inputs, the result and the hourly heights, page 2 forms A and B.



A

1.	Zo (Part III) or (Tab VI)				0.67
2.	Seasonal Corr. (Part III)				0.0
3.	Sum = ML				0.67
		M2	S2	K1	O1
4.	A1 (Tab VII)	140	005	117	038
5.	A2 (Tab VII)	164	004	115	063
6.	A1 − A2	−024	+001	+002	−025
7.	360.n	720	720	360	360
8.	(A1 − A2) + 360.n = p	696	721	362	335
9.	p/24	29.00	30.04	15.08	13.96
10.	A1 (Line 4)	140	005	117	038
11.	g (Part III)	243	267	127	137
12.	A1 + g	023	272	244	175
13.	F2 (Tab VII)	0.97	1.31	0.89	1.25
14.	F1 (Tab VII)	0.94	1.30	0.88	1.20
15.	F2 − F1 = P	+0.03	+0.01	+0.01	+0.05
16.	P/24	+0.0013	+0.0004	+0.0004	+0.0021

B

17.	Time = T	0800			
	H.C.	M2	S2	K1	O1
18.	p/24 (Line 9)	29.00	30.04	15.08	13.96
19.	p/24 × T	232	240	121	112
20.	(A1 + g) (Line 12)	023	272	244	175
21.	(A1 + g) − p.T/24 = θ	151	032	123	063
22.	Sin θ	+0.485	+0.530	×	×
23.	Cos θ	−0.875	+0.848	−0.545	+0.454
24.	P/24 (Line 16)	+0.0013	+0.0004	+0.0004	+0.0021
25.	P/24 × T	+0.0104	+0.0032	+0.0032	+0.0168
26.	F1 (Line 14)	0.94	1.30	0.88	1.20
27.	F1 + P.T/24 = Ft	0.95	1.30	0.88	1.22
28.	H (Part III)	0.35	0.08	0.07	0.05
29.	H × Ft	0.332	0.104	0.062	0.061
30.	(H × Ft) Sin θ	+0.161	+0.055	‡ K1	−0.034
31.	(H × Ft) Cos θ	−0.291	+0.088	§ O1	+0.028
32.	R Sin r : R Cos r	+0.216	−0.203	→	−0.203
33.	r : R	133	0.296	ML	0.67
34.	2r : R²	266	0.088		
35.	f4 (Part III) : F4 (Part III)	238	0.013		
36.	2r + f4 = d4 : R².F4 = D4	144	0.001	D4 cos d4	−0.001
37.	3r : R³	039	0.026		
38.	f6 (Part III) : F6 (Part III)	133	0.022		
39.	3r + f6 = d6 : R³.F6 = D6	172	0.001	D6 cos d6	−0.001
40.	**Sum lines 30 − 39 = Height**				0.46

Approximate calculation for training and planning – not for navigation. The official tide tables are authoritative.

Figure 32.5 Page 2 of the printed report with forms A and B.

32.8 Frequently asked questions

Do I need the printed Table VII?

No. NauticTools2 calculates the values from the date. Compared with the book they differ at most in the last digit. You can still enter your own values from the book.

How accurate is the Simplified Harmonic Method?

It is an approximation with four main constituents and two shallow-water terms. Results can differ from official predictions by a few centimetres to decimetres.

How does it differ from Tides ATT?

Tides ATT works from a standard port through differences and tidal curves. The Simplified Harmonic Method needs neither and uses the harmonic constants of the port itself.

Not for navigation: the Simplified Harmonic Method is an approximation with four main constituents and two shallow-water terms. Results can differ from official predictions by a few centimetres to decimetres. For navigation, the official tide tables are authoritative.

32.9 See also

- **Tides ATT** (chapter 31) – tidal predictions with standard and secondary ports
- **Tides BSH** (chapter 30) – height of tide by the method of the German BSH tide tables
- **Depth of Water** (chapter 29) – depth of water from charted depth and height of tide

PART IV

Sharing Data

Exchanging exercises and master data as data packages.

PART IV · SHARING DATA

33 Data Packages

Data packages – share exercises and master data

With **data packages** you put together exactly the data others need in NauticTools2 – for example the waypoints, reference ports and tasks of an exercise – and pass them on as a single file. Intended for **instructors** at universities and sailing schools, for groups sharing master data, and as a **backup** to transfer your own data between Windows and Android.

`Explorer-style selection` `.nautictools file` `Preview before import` `New versions` `Remove again` `Backup`

33.1 What a data package can contain

- Waypoints
- Deviation tables
- Tides ATT: standard ports, secondary ports, seasonal changes and tidal curves
- Tides BSH: reference ports and secondary ports
- Saved inputs of all tools – i.e. ready-made tasks

Settings such as language, appearance or variation are not transferred.

33.2 How many packages? – planning the split

Before you create your first package, it is worth thinking briefly about how to split your material. Each package appears on the students' devices as a separate entry under “Installed data packages” and can be updated or removed on its own.

One package per exercise

Each task is self-contained and can be removed again after the exercise. Over a semester, however, students quickly end up with many separate files and packages.

One package per semester or course

Students receive one package at the start, e.g. “Navigation winter term 2026/27”, which you extend with new exercises during the semester. At the end it can be removed as a whole.

One package for the entire navigation syllabus

Students only ever receive **one** file. You maintain all waypoints, reference ports, deviation tables and tasks in it and redistribute it via “New version of …” as often as needed. Whoever imports the new version automatically has the current state: new tasks are added, corrected ones updated, deleted ones removed – and whatever students have changed themselves is kept.

The variants can also be combined, e.g. one permanent package with the master data (waypoints, reference ports, deviation tables) plus separate packages for exam preparation or special tasks.

33.3 Creating a package

1. **Open the export**
   In **Settings**, choose the **Data** tab and tap **Export data**.
2. **Describe the package**
   Under **Package**, choose “New package”. The **package name** is what students see in the preview and under “Installed data packages” – for a package you will maintain for a long time, a general name such as “Navigation winter term 2026/27” or “Navigation – full syllabus” works well; for a single task, a specific one such as “Exercise 3 – radar plotting”. As the **sender**, e.g. your name and university or sailing school. The **description** is shown before import: this is the place for notes on the task and, in later versions, what has changed, e.g. “Version 3: exercise 7 added, deviation table corrected”.
3. **Select the data**
   Each type of data has its own block. A tick on the block selects everything in it; tapping the title expands it so each entry can be selected individually. “None” starts with an empty selection.
4. **Export**
   On Windows, NauticTools2 asks where to save the file, suggesting the Downloads folder. On Android, the share menu opens, e.g. for e-mail, WhatsApp or “Save to Files”.
5. **Pass it on**
   Distribute the file with the extension **.nautictools** by e-mail, learning platform (Moodle …), messenger or USB stick. The file name does not matter – name, sender and content are stored in the file itself.

33.4 Opening a package

1. **Open the file**
   On Windows, double-click the file; on Android, tap the attachment in your e-mail or messenger. If Android asks which app to use, choose “NauticTools2”, ideally “Always”. Alternatively: **Settings → Data → Import data** and select the file.
2. **Check the preview**
   NauticTools2 shows the package name, sender, date and description, and below them all the data included. Entries that already exist on the device are marked “present”. Simply deselect anything you do not want.

3. **Import**
   If entries already exist with different content, the app asks once whether to replace them. Identical entries are left untouched. Finally it shows what was added.

The package then appears under **Settings → Data → Installed data packages**.

33.5 Distributing a new version

To extend or correct an exercise, choose “New version of …” under **Package** when exporting. Name, sender, description and the previous selection are carried over and can be adjusted. On the recipient's device NauticTools2 recognises the update (“you have version 1, this file contains version 2”): unchanged entries are updated and entries no longer included are removed – **your own changes are always kept**.

This is also how teams work together: a colleague extends a package they received, exports it as a new version, and everyone else simply imports it.

33.6 Removing a package

Under **Settings → Data → Installed data packages**, every package has a “Remove” button. Only what the package brought along and has not been changed since is deleted. Entries that were on the device before and your own changes remain; the message shows how many entries were removed and how many were kept. Packages you created on the device yourself do not appear in this list – so “Remove” can never delete an instructor's own data.

33.7 Backup and changing devices

Choose “Backup” under **Package**: all data is selected automatically and the list of installed data packages is included. A backup is for safekeeping and for transferring all your data between your own devices, for example from your Windows PC to your phone and back. Restoring **adds to the existing data, nothing is deleted**, and the installed packages are listed individually again. The backup itself never appears as a package.

33.8 Good to know

- How to split your material into packages is described above under “How many packages?”.
- Keep the extension **.nautictools** so that double-click and “Open with” work.
- Older export files (.json) can still be read via “Import data”.
- There is no server and no cloud: a data package is a plain file that is only passed on when you send it yourself.

33.9 See also

- **Tides ATT** (chapter 31) – standard and secondary ports that can be shared as a package
- All tools – their saved inputs can be distributed as exercises

Abbreviations

AP	assumed position	**ATT**	Admiralty Tide Tables
BSH	Federal Maritime and Hydrographic Agency (Germany)	**CB**	compass bearing
CC	compass course	**CCA**	current correction angle
CD	chart datum	**CDp**	charted depth
CET	Central European Time	**COG**	course over ground
CPA	closest point of approach	**CTW**	course through the water
DEV	deviation	**DR**	dead reckoning
ETA	estimated time of arrival	**GA**	gyro error
GB	gyro bearing	**GC**	gyro course
GHA	Greenwich hour angle	**GPS**	satellite navigation
Hc	computed altitude	**HE**	height of eye
Ho	observed altitude	**HoT**	height of tide
HP	horizontal parallax	**Hs**	sextant altitude
HW	high water	**HWH**	high water height
IC	index correction	**IGRF**	International Geomagnetic Reference Field
LAT	local apparent time	**LHA**	local hour angle
LMT	local mean time	**LW**	low water
LWH	low water height	**MB**	magnetic bearing
MC	magnetic course	**ML**	mean level
RB	relative bearing	**RRaB**	relative radar bearing
SEC	speed error correction	**SHA**	sidereal hour angle
SHM	Simplified Harmonic Method	**SM**	safety margin
SOG	speed over ground	**STW**	speed through the water
TB	true bearing	**TC**	true course
TCPA	time to CPA	**UT**	Universal Time
UTC	Coordinated Universal Time	**Var**	variation
WCA	wind correction angle	**ZD**	zone description
Zn	azimuth		

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