Kriegsmarine Angriffscheibe Handbuch

STRENG GEHEIM

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Version 2.0

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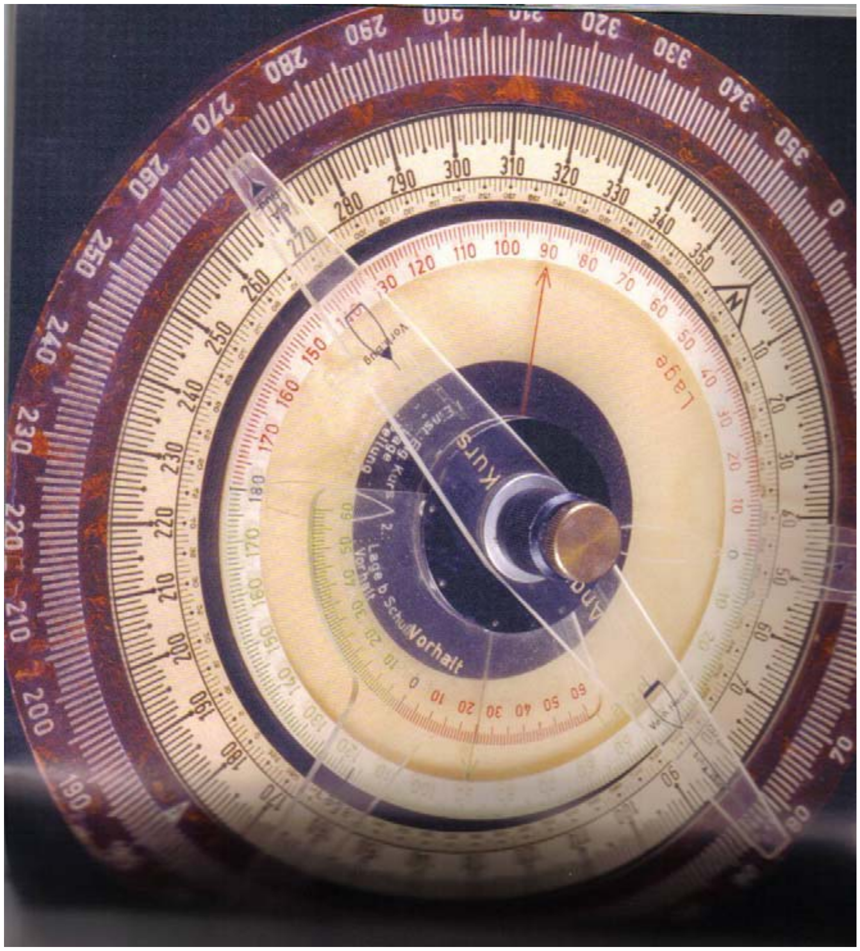


Compiled and Edited by Kapitänleutnant Hähl (klh)

This simple guide was written for use with the German Attack Disc (a.k.a. Whiz Wheel, Is-Was) in Ubisoft's U-boat simulation "Silent Hunter III". While not exhaustive, it is intended to show some of the ways this device can be used for gathering data on a potential target. It may be freely distributed or modified for any non-profit purposes.

This handbook was written based on research on-line, including the US Navy "Submarine Attack Course Finder Mark 1 Model 3 Manual" at www.hnsa.org. In addition, special thanks and recognition go to the following individuals who frequent the www.subsim.com forums:

Hitman – the creator of the printable templates
Dertien – the creator of the Flash version (from which the included illustrations came)
Terrapin – the creator of the printable recognition book
Joegrundmann – for help and expertise

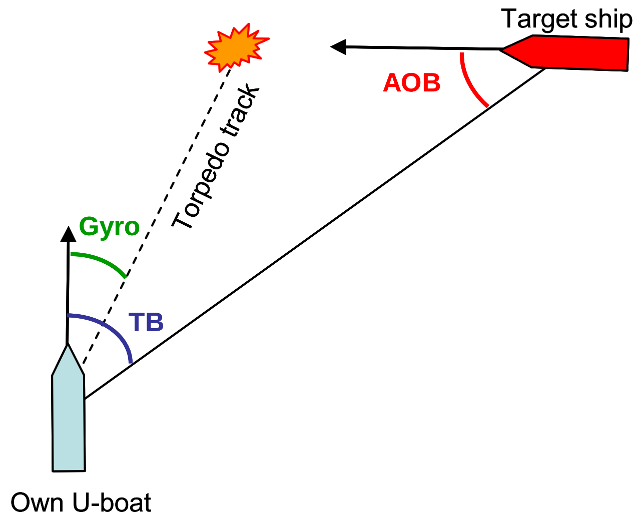
Visit www.subsim.com to find further information and Attack Disc downloads (including templates to build your own, a Macromedia Flash version, and an in-game version).

Edition History:

1.0 - original release (December 2007)
2.0 - corrected some errors, added further examples (January 2008)

Targeting Geometry

The goal of a firing solution can be stated as firing a torpedo so that it reaches a specific place at the same time as the target.



As simple as that sounds, the calculation of an accurate firing solution can be complex. There are many variables involved. In most cases, however, we can simplify the calculation by making some assumptions, and quickly determine an adequate firing solution. This handbook will not, for example, take into account variables such as the turning time and radius of the torpedo, nor the error in parallax due to the periscope being away from the torpedo tubes. For close range attacks (<1000 metres) at low gyro angles (<30°), ignoring these variables will have little effect on the success of the attack.

The following abbreviations will be used throughout this guide:

TB = Target Bearing – the angle from the target lies, (0° being the bow of the U-boat).
AOB = Angle on the Bow – the angle from the target's bow that their crew would see you (0° being the bow of the target ship).
Gyro = Gyro Angle – the angle that the torpedo is programmed to turn once it leaves the U-boat.

The examples that follow illustrate the use of the German Attack Disc during the three phases of the U-boat attack:

1. Acquisition (determining target identity, course, and speed)
2. Interception (maneuvering the U-boat into a favorable attack position)
3. Attack (knowing when and in which direction to fire torpedoes)

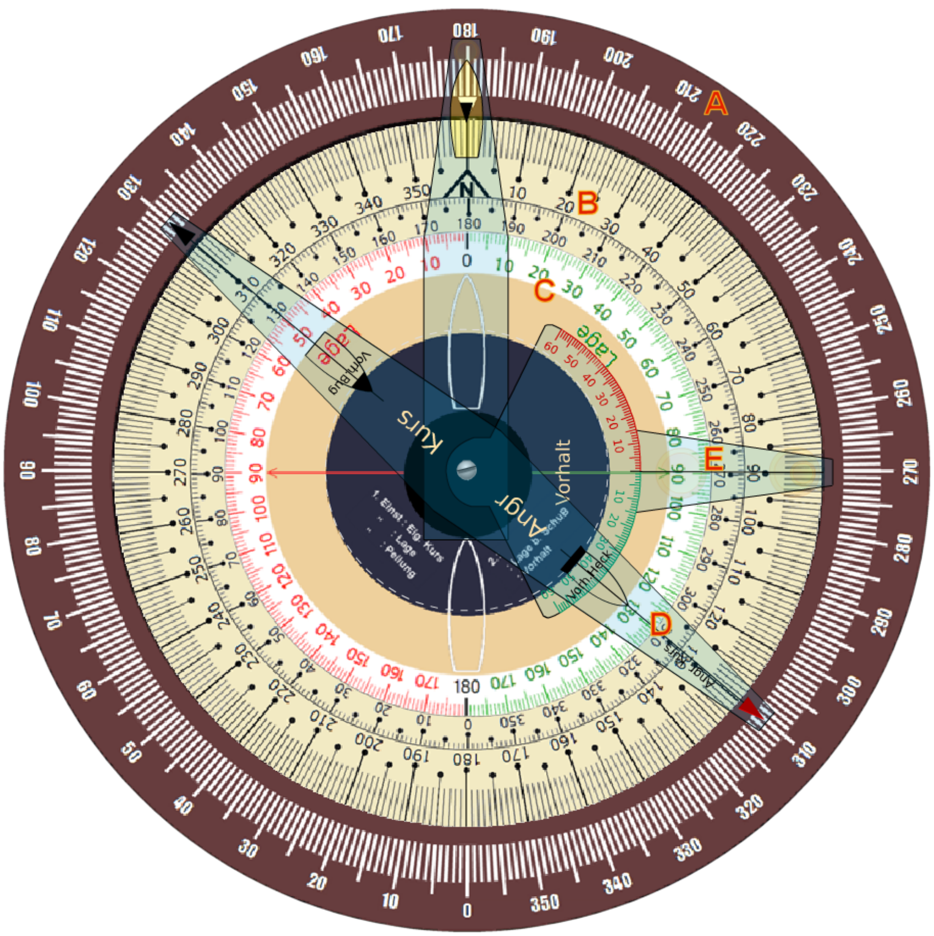
Front Side – Angle Solver

The front side of the German Attack Disc is an angle solver primarily used to determine the course, heading, and angle on the bow of a target. It is composed of three concentric discs:

A. Uboat – the outer disc, which represent the point of view of your U-boat (0° being the bow, 180° the stern)
B. Compass – the middle disc, which represents the compass or true direction (0° being true north); by aligning your true course with the Uboat disc reference point (at 180), all of your observations are easily translated to true compass headings
C. Target – the inner disc, which represents the target's course and angle on the bow (AOB)

and two transparent rotors:

D. Bearing – the long thin transparent marker representing your line of sight or relative bearing to the target (TB)
E. Lead Angle – the wedge shaped marker which can be used to calculate the gyro angle to fire torpedoes at the target



Assuming you always know your own course, and if you know two of three target variables; the target's course, the target's angle on the bow (AOB), the relative bearing to the target (TB), you can find the third. Once the target's course is known, this tool can be used to calculate an intercept course.

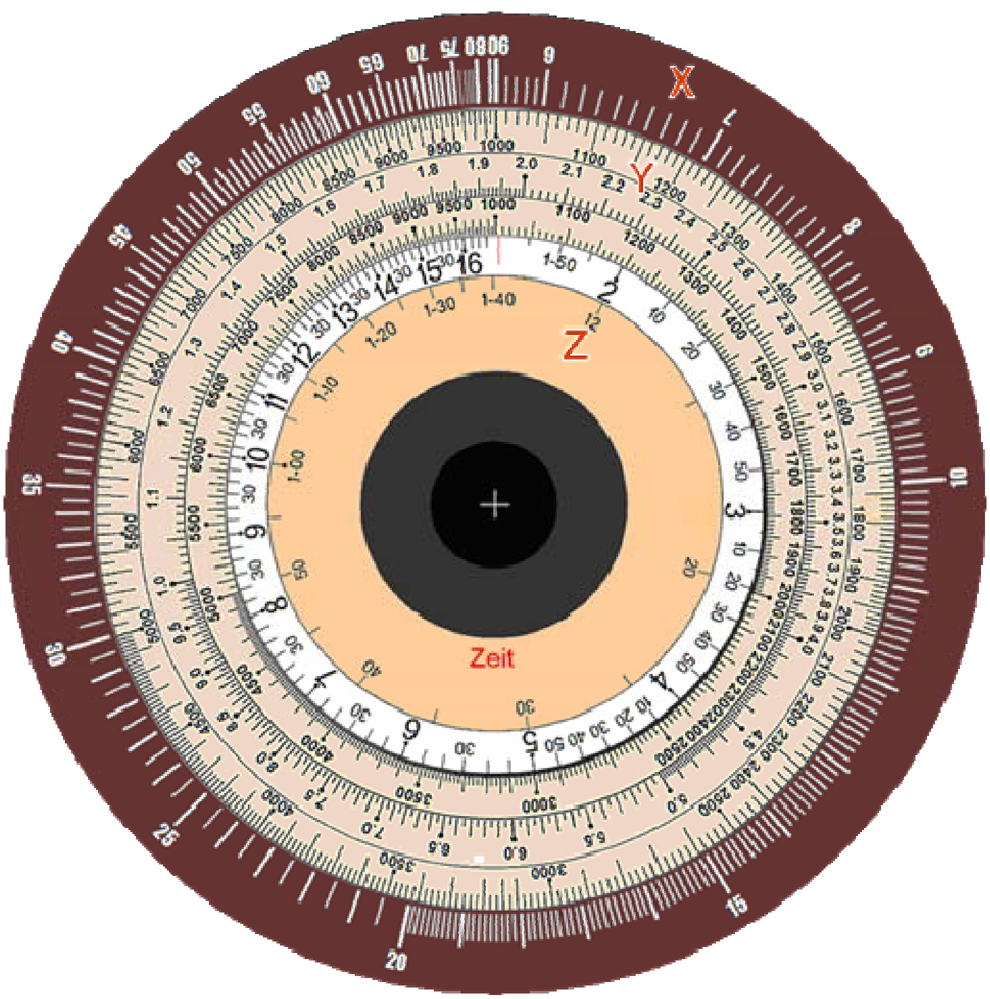
Always start with the base oriented so that the 180 mark is at the top (indicated by the white triangle).

Rear Side - Speed Calculator

The rear side of the Attack Disc is primarily used for determining variables related to speed. It is composed of three discs:

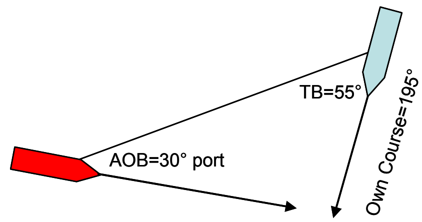
X. Degrees – the outer disc is a sine function which can represent a relative bearing to the target or the angle on the bow of a target
Y. Speed and Distance – the middle disc which has scales for both distance in metres (outer two scales) and speed in knots (center scale)
Z. Time – the inner disc which represents time in minutes and seconds; the red line is the index

There are several ways to use the calculator to determine speed of a target. If you know a distance the target travels over time, you can use the middle two wheels to solve for speed (it is a simple circular slide rule). Slightly more complicated methods utilize the sine scale which allows you to calculate the speed of a target if you know your speed and certain angles such as the bearing of the target (TB), the angle on the bow (AOB), and the range of the target. By using the sine function, this side can also be used to calculate an angle on the bow (AOB) based on comparing the observed aspect ratio (AR = length/height) to a reference aspect ratio (at a 90° AOB).

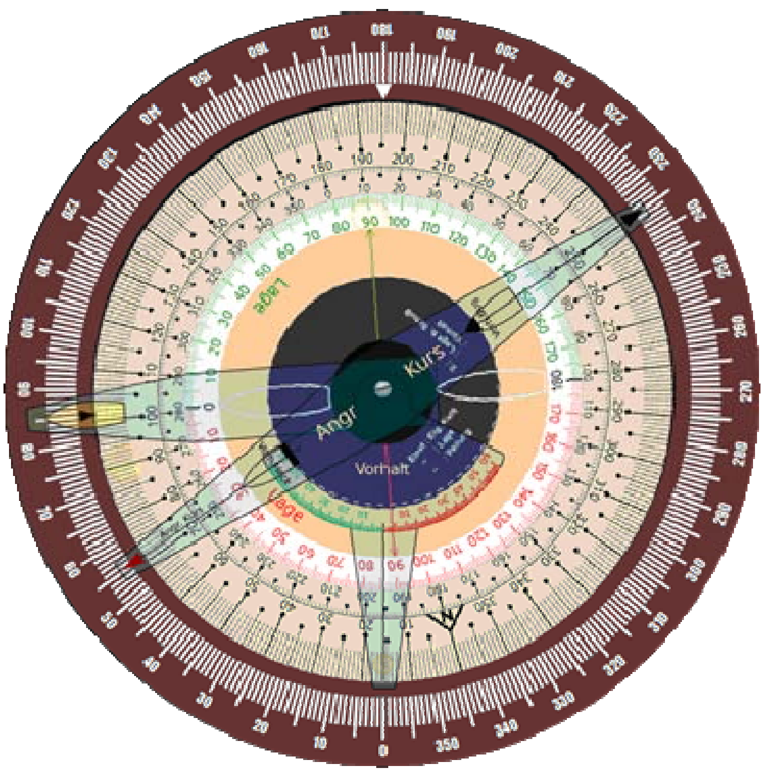


Example 1: Determine a target's true course knowing bearing and AOB

A potential target is 55° off your starboard bow, and you estimate an AOB of 30° port. Your course is 195°. Find the target's course.

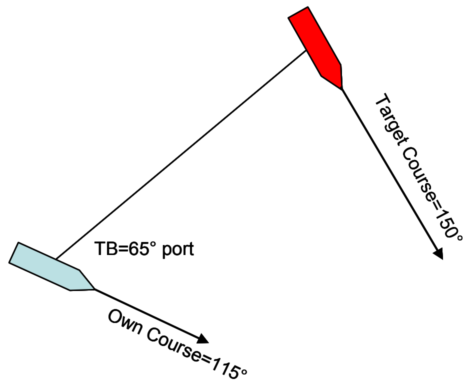


1. Place the A disc with 180° at the top.
2. Turn the B disc until your true course (the 195° mark) is aligned with the triangle mark at the top of the A disc.
3. Move the D rotor to the target's bearing (55°) mark on the A disc.
4. Turn the C disc to where the AOB of the target (30° port) crosses the D rotor.
5. Read the target's true course from where the C disc index points on the B disc. The target is running on course 100°.

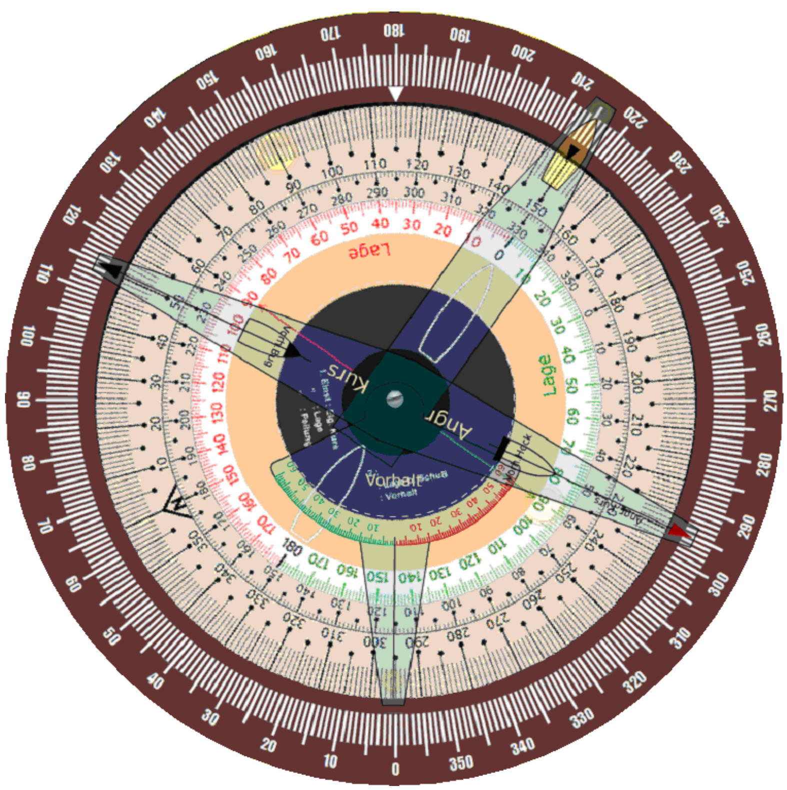


Example 2: Determine a target’s angle on the bow knowing bearing and course

A target is spotted at 65° to port, and you have plotted their course as 150°. Your course is 115°. Find the target’s angle on the bow (AOB).

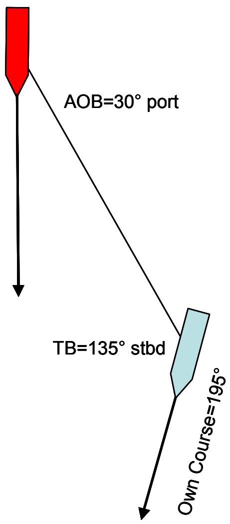


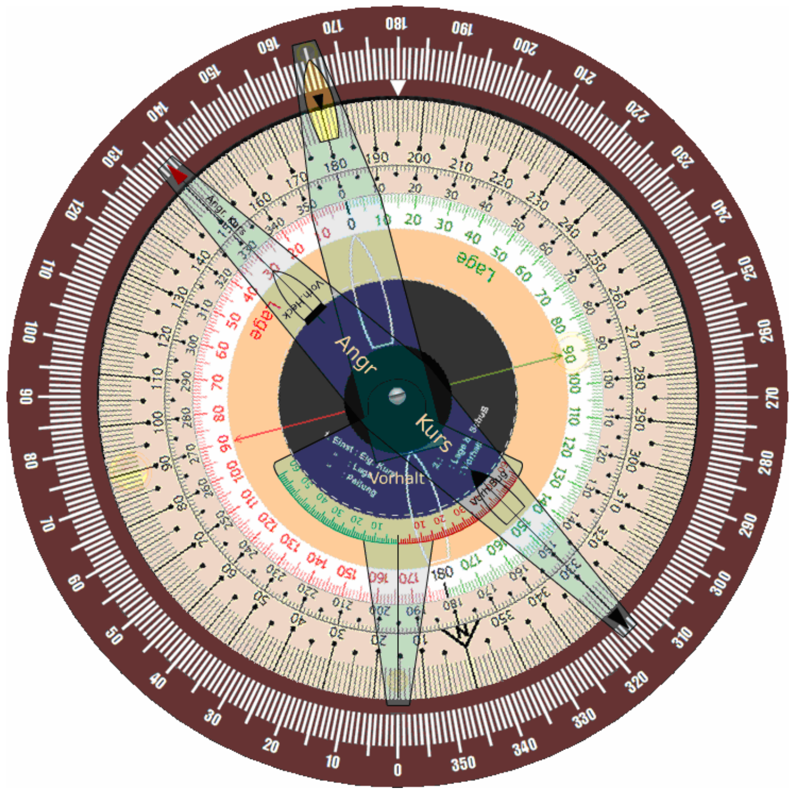
1. Place the A disc with 180° at the top.
2. Turn the B disc until your true course (the 115° mark) is aligned with the 180° triangle mark on the A disc.
3. Move the D rotor to the target’s bearing (295° = 360° minus 65°) on the A disc.
4. Turn the C disc so it points to the target’s true course (150°) on the B disc.
5. Read the target's AOB from the C disc where the D rotor crosses it. The target’s AOB is 80° starboard.



Example 3: Find a perpendicular intercept course to the target

Your course is 195°. A potential target is spotted astern at 135° to starboard, and you estimate an angle on the bow of 30° port. What course should you adopt to intercept on a perpendicular course?





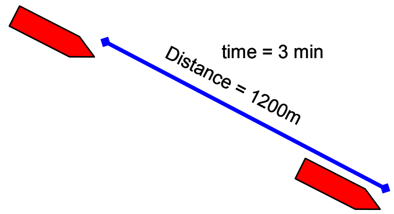
1. Place the A disc with 180° at the top.
2. Turn the B disc until your true course (195°) is aligned with the 180° triangle mark on disc A.
3. Move the transparent D rotor to the target's bearing (135°) on the A disc.
4. Rotate the C disc so it intersects the D transparent pointer at the estimated AOB (30° port).
5. Read the target's course from the B disc where the C disc index points. The target's course is 180°.
6. To find your perpendicular intercept course read where the perpendicular line on the C disc points to the B disc. Since the target is off our starboard (right) side, then read the intercept course from the green line. You should come right to intercept course 270° true.

Note: If you wish to run an intercept course for a stern shot, then read the opposite side of disc C. In this case, turn left to heading 90° true.

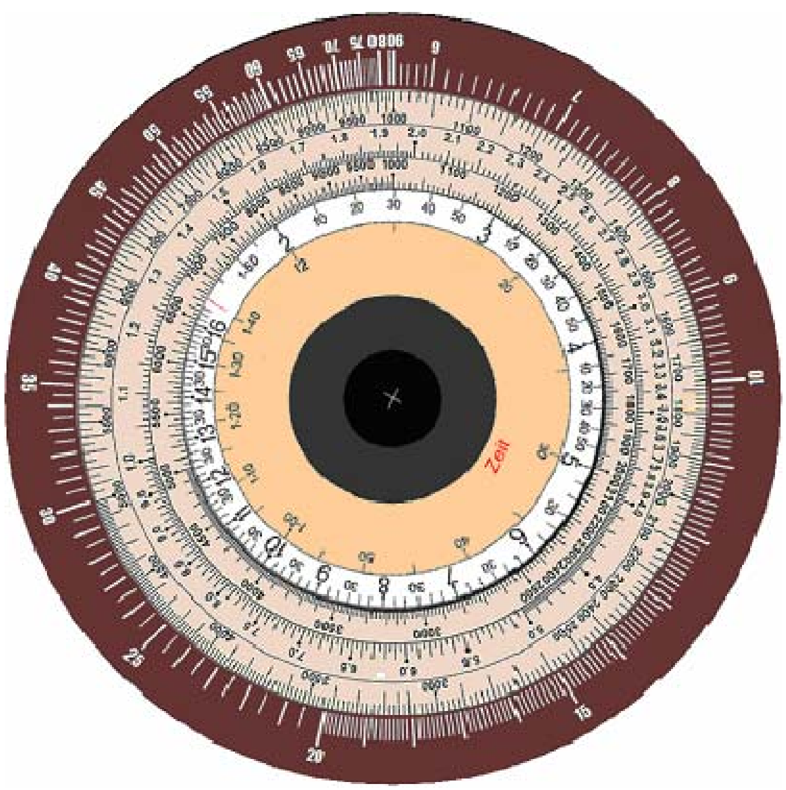
Example 4: Determine the speed of a target by plotting position over time

This is simple division problem. Distance over time equals speed (with a correction built into the disc to change metres into nautical miles).

You are stalking a target and plotting its position on a map or maneuvering board using range and distance. After 3 minutes, the target has traveled 1200 metres. Find the target's speed.



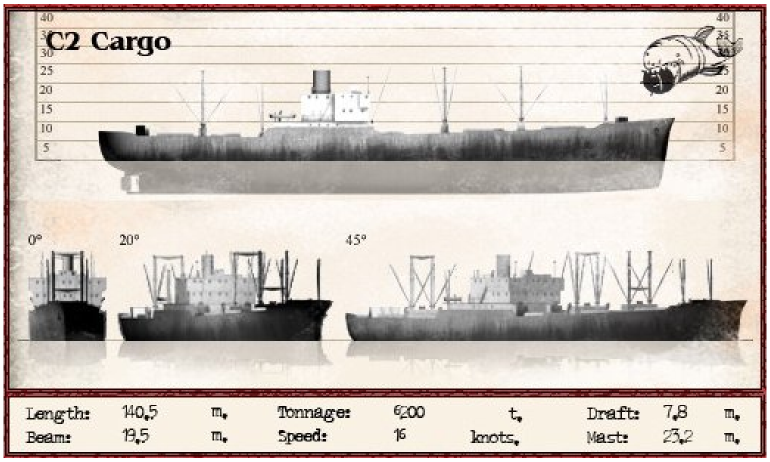
1. Align the 3 minute mark on of the inner Z disc with the 1200 metre mark on middle Y disc.
2. Read the target's speed in knots from where the index mark (red line) on inner disc Z meets middle disc Y, and correct the decimal place if necessary. The target speed is about 13 knots.



Example 5: Determine the speed of a target knowing the target length

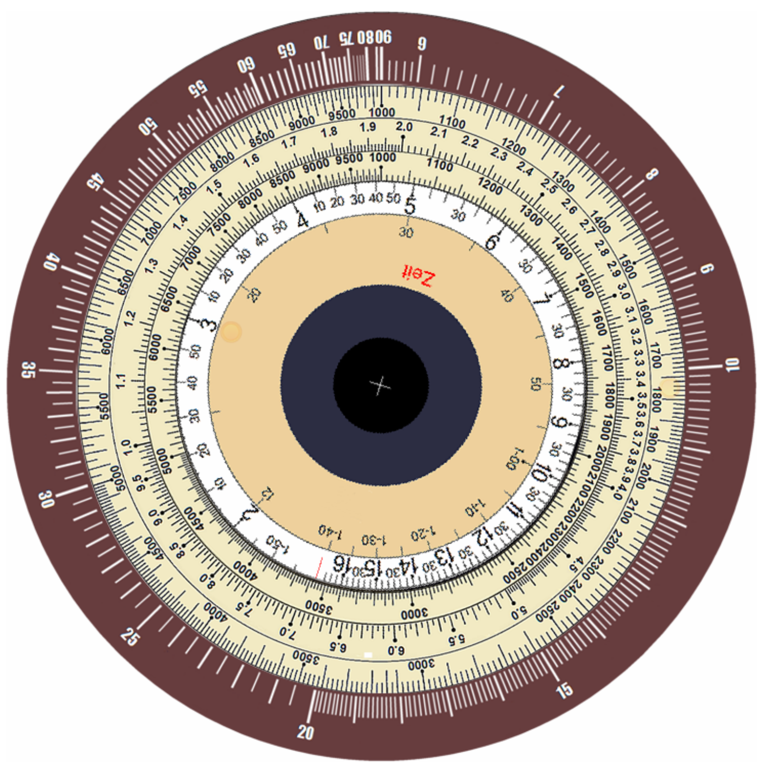
This technique, sometimes called the fixed wire method, is similar to the previous example. It assumes that you know the length of your target, and that its relative speed across your field of vision is unaffected by the movement of your Uboat. In other words, this method is less susceptible to error if your Uboat is traveling slow and the target bearing is closer to your bow or stern.

You have a target in your scope that you have identified as a C2 Cargo Ship. The length (from your identification book) is 140.5 metres.



Using your stopwatch, you see that it takes 40 seconds for the target to cross the vertical line (from bow to stern) in your periscope. Assuming your boat's movement during that time is negligible, find the target's speed.

1. Align the 40 second mark on the inner disc Z with the 1405 metre mark on middle disc Y.
2. Read the target's speed in knots from where the index mark (red line) on inner disc Z meets middle disc Y and correct the decimal place if necessary. The target speed is about 6.9 knots.

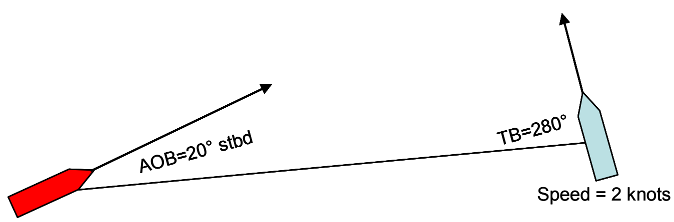


Example 6: Find the speed of a target with constant relative bearing

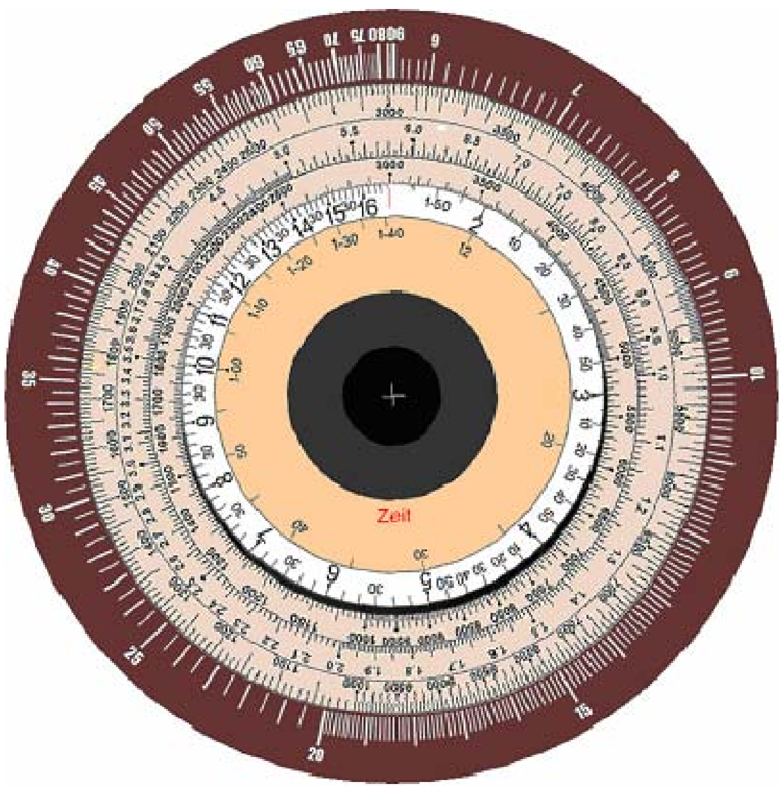
This technique takes advantage of the fact that if you are on a convergent course (moving towards each other), and the target's bearing is not changing over time, then you are actually on a collision course. Since you know your Uboat's speed and two angles of the triangle (AOB and target bearing), you can calculate the target's speed.

Target speed = Own speed [sin (TB) / sin (AOB)]

You are maintaining 2 knots on an intercept course with a potential target. At the original observation, it was on a bearing of 280° with an observed angle on the bow of 20 ° starboard. After several minutes, the bearing was still 280°. Find the target's speed.



1. Align your speed (2 knots) on the Y disc with the original AOB observed (20°).
2. Note where the relative bearing on the X disc aligns with the speed disc. In this case, the relative bearing will be 80° (360° - 280°). The target's speed is approximately 5.8 knots (and you are on a collision course).

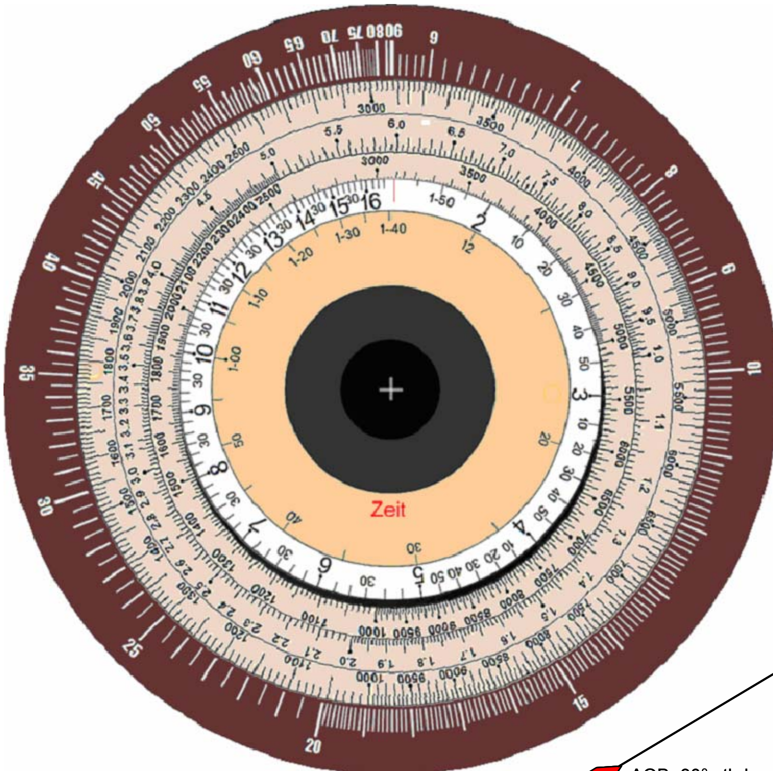


Note: Although you may not be able to achieve an attack position, this technique will also work to calculate the target's speed if you are on divergent courses. If an angle is greater than 90°, then simply subtract it from 180° (since the sine function is symmetrical around 90°).

Target speed = Own speed [sin (180° - TB) / sin (180° - AOB)]

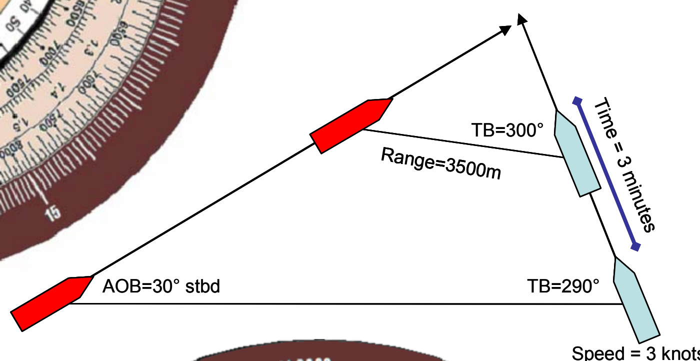
Example 7: Find the speed of a target with a changing relative bearing

If the target bearing is changing over time, you are not on a collision course, and a correction to the speed must be applied.

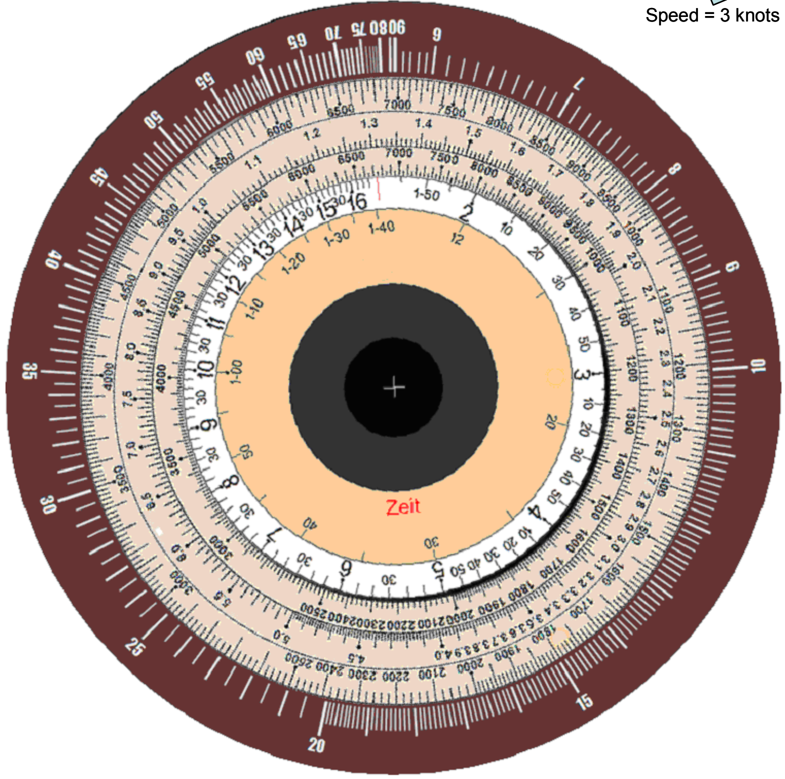


You are maintaining 3 knots on a convergent course with a potential target on a bearing of 290° with an angle on the bow of 30°. After three minutes, the bearing was 300° with a range of 3500 metres. Find the target's speed.

1. Align your speed (3 knots) on the Y disc with the AOB (30°).
2. Read the reference speed where the relative bearing matches the speed disc. The relative bearing is 70° (360° - 290°), and the reference speed is about 5.6 knots.



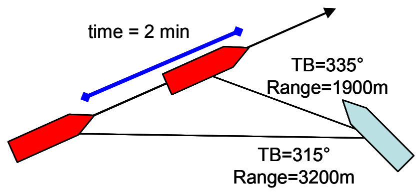
3. Because the bearing to target changed, perform a speed correction. Set the second observed range on the Y disc (3500 m) to the original AOB (30°).
4. Align the change in bearing of 10° (300°-290°) on the X disc with the time interval (3 minutes) on the Z disc.
5. The index (red line) on the Z disc is now pointing at the speed correction value on the Y disc. The speed correction is 1.3 knots.
6. The target is pulling ahead, so add the speed correction (1.3 knots) to the reference speed (5.6 knots). The target's speed is approximately 6.9 knots.



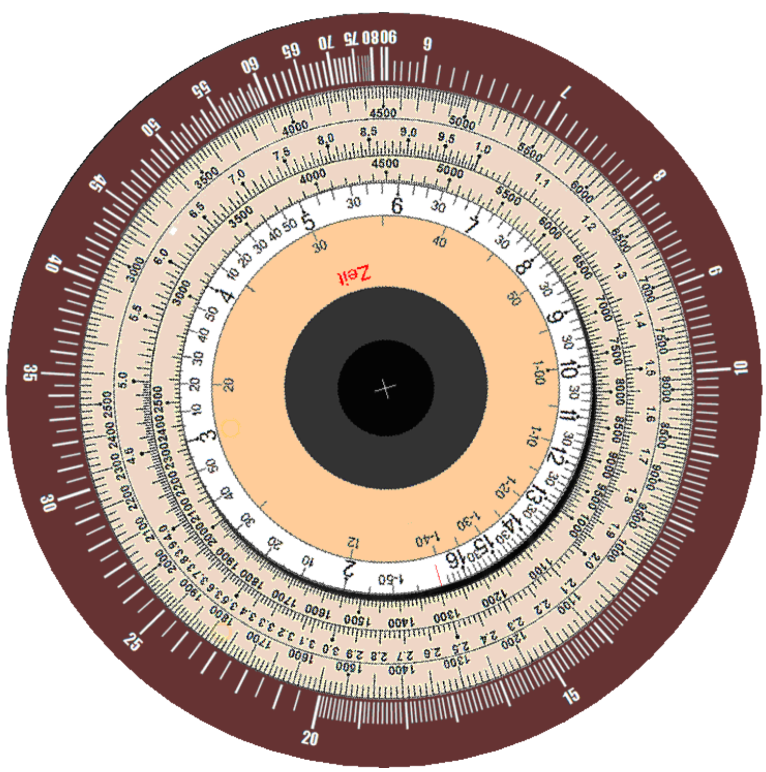
Example 8: Find the speed of a target with two bearing and range observations

This is method is similar to manual plotting in that you take two observations of bearing and range. However, instead of plotting the target's position (accounting for your movement) and measuring a distance traveled, you can directly calculate a speed which will be fairly accurate if your Uboat is traveling at a slow speed relative to the target.

You are running silent at 1 knot. You have spotted a fast-moving warship on bearing 315 at a range of 3200 metres. After two minutes you raise the scope again and record a bearing of 335°, and a range of 1900 metres. Find the target's speed.



1. Calculate the change in bearing (335° - 315° = 20°).
2. We have to account for a 20° change between 3200 and 1900 metres, so find both 3200 and 1900 on middle disc Y.
3. Turn disc Y until there are exactly 20° on the outer disc X between these two points. This takes some trial and error. In this case, the solution is to align 1900m with about 25° and 3200m will then be next to 45°. (By the way, these angles correspond to the AOB at the first and second observations respectively, so we can now enter an AOB of 45° into the TDC.)
4. Read the distance traveled from the Y disc next to the change in bearing (20°). The target traveled 1550 metres.
5. Divide the distance by the time (1550 metres divided by 2 minutes). Align the two minutes mark on the inner disc Z with 1550 metres. The index on disc Z is now pointing to the target speed on disc Y. The target is running approximately 25 knots (don't forget to correct the decimal place).

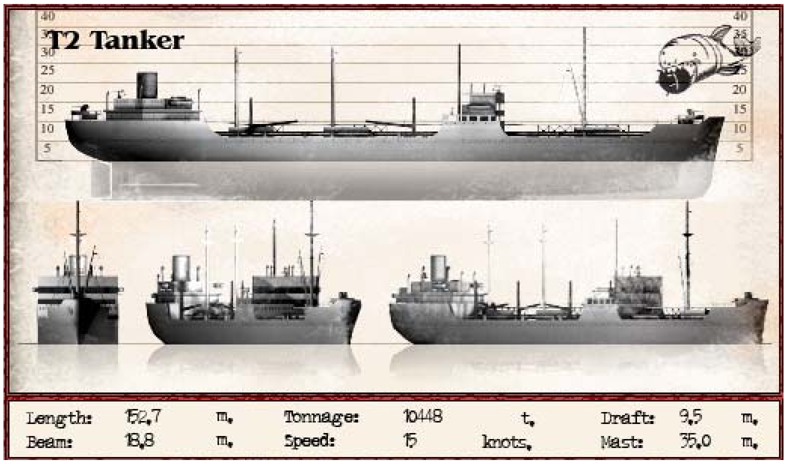


Example 9: Find the AOB of a target with the Aspect Ratio method

This method is less accurate as the AOB approaches zero because the beam (width) of the ship will distort your measurements. If the beam of the ship was zero, then mathematically:

$$AOB = \operatorname{asin}(AR_{observed}/AR_{reference})$$

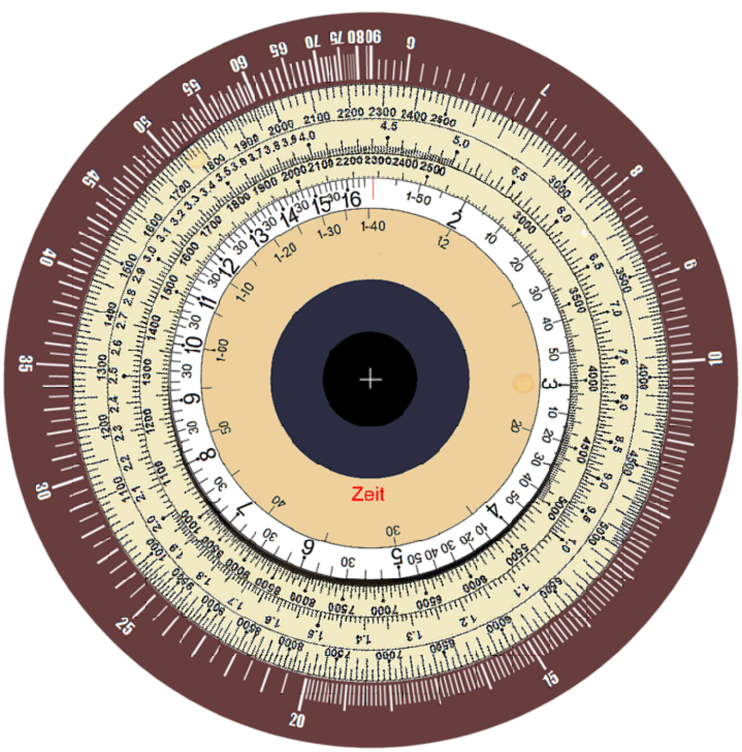
You observe a T2 Tanker at long range.



The reference Aspect Ratio (AR) is 4.4 (length/mast height=152.7/35.0).

Checking through the attack scope, the mast is 3 ticks high, and the bow to stern is 7.5 ticks wide, to give an observed AR of 2.5 (7.5/3).

1. Use the middle row of numbers on the middle wheel (which usually represent knots). Find the reference AR (4.4) on the middle disc Y, and align it with the 90° line of the outer disc X.
2. Find the observed AR (2.5) on the middle disc Y and read the AOB from the outer disc X. The AOB is approximately 35°.



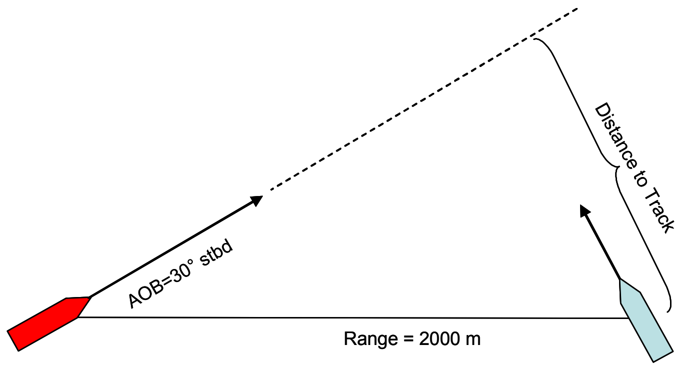
Note that if the mast is too hard to see, use the top of the funnel and substitute its height in your calculations (about 22.5 m in this example).

Example 10: Determine the distance to the track of a target

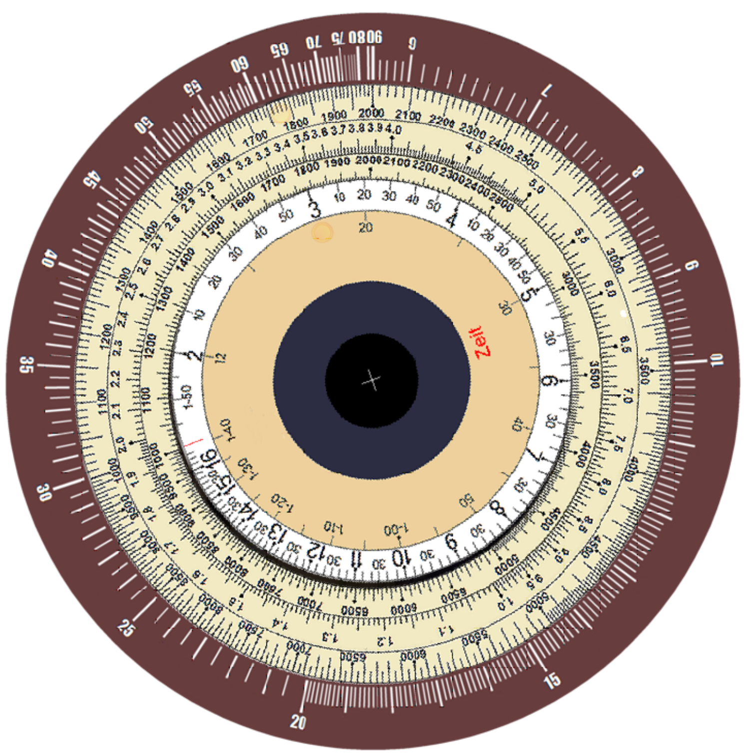
As you maneuver into a firing position, it is useful to know your distance to the track of your target. Knowing the range and AOB of the target:

Distance to Track = Range [sin (AOB)]

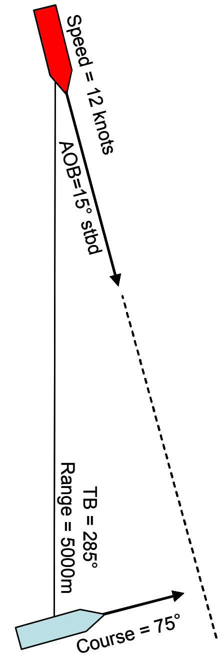
A target has been spotted at 2000 metres with an Angle on the Bow of 30° port. What is your distance to the target's track?



1. Align 2000 on disc Y with the top (90° mark) on disc X.
2. Read the distance to the target track where 30° on disc X aligns on disc Y. You are currently 1000 metres from the target track.



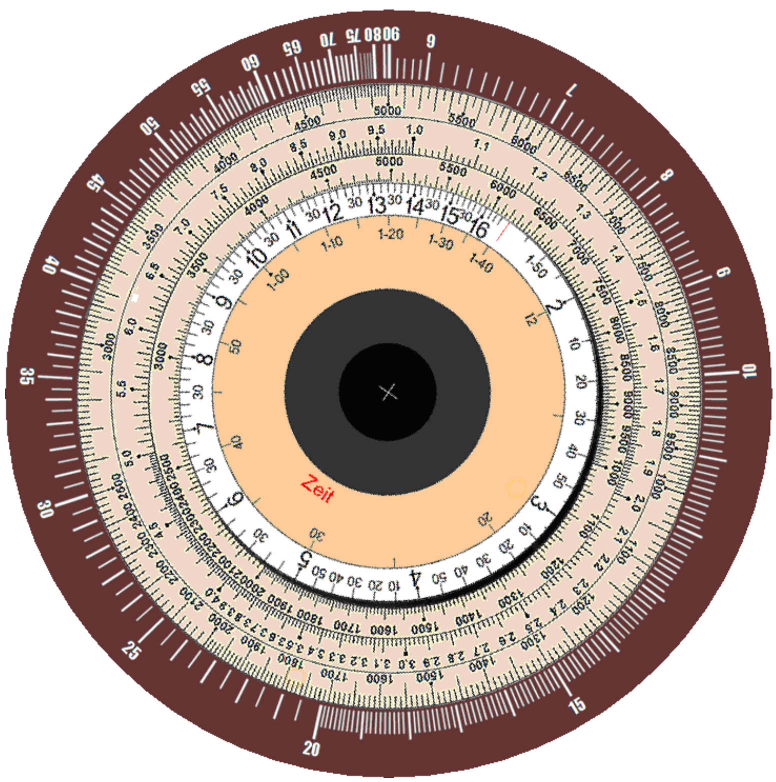
Example 11: Determine an optimum speed for attack position



Even though you are on a perpendicular intercept course, you can still be too close or too far away from the target's track to fire when it crosses your bow. Using this method will allow you to adjust your speed and place your Uboat into the perfect firing position.

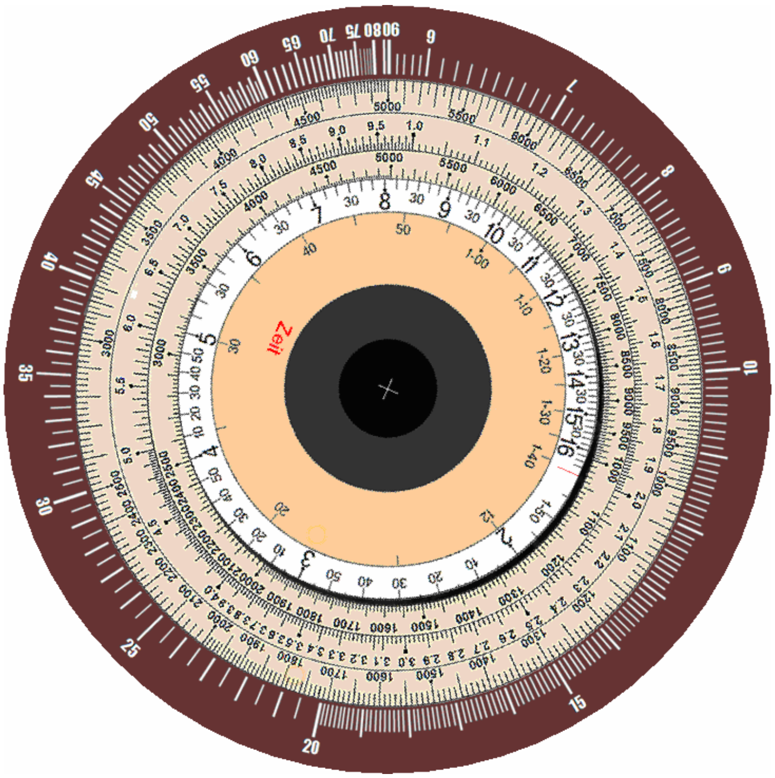
You are on coarse 75° true, perpendicular to a target's track. The target is running at 12 knots at relative bearing 285° with a range of 5000 metres and an AOB of 15° starboard. Determine your course and speed to be 500 metres from the target track as it crosses your bow.

1. First, use the back side of the attack disc to determine the distance the target has to travel to the crossover point. Align the range of 5000 metres on disc Y with the index (90°) on disc X. Read the distance on disc Y across from 75° on disc X (a target bearing of 285 corresponds to 75° from your bow). The target must travel approximately 4830 metres.
2. Calculate the time for the target to cross your bow. Rotate disc Z so that the index (red line) aligns with 12 knots (or 1.2) on the middle scale of disc Y. Now find 4830 metres on disc Y and read the time from disc Z. The target will cross your bow in approximately 13 minutes.



3. Determine your distance to the target track (see previous example). Read the distance on disc Y that aligns with the AOB (15°) on disc X. Your distance to the track is approximately 1300 metres.

4. Subtract 500 metres from your distance to the track. Divide the new distance you need to cover (800 metres) by the time to cross (13 minutes). Rotate disc Z so that 13 minutes is opposite 800 metres on the middle scale of disc Y (use 8000). Read your speed from disc Y where it aligns with the index (red line) on disc Z. A speed of 2 knots will put you in perfect firing position.



Note: If you are too close to the target track to make an attack, then you can either run parallel until the target closes, then turn onto the attack course and set up your shot, or run across the target track and fire from a stern tube. To cross the target track, add a suitable distance (say 500m) to your distance to track and calculate your speed from that. In this case, a speed of about 4.5 knots will line up a perfect stern shot.

Example 12: Determine the lead angle for a perpendicular attack with 0° gyro angle

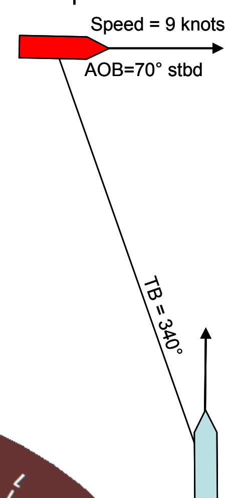
Once you are turned onto a perpendicular intercept course, this method calculate when to fire. The lead angle is simply the target bearing at the moment you fire. The range is irrelevant to the calculation (although it is best to have planned your attack within 500-1000 metres).

lead angle = arctan [target speed / torpedo speed]

Unfortunately, the attack disc does not have a tangent scale. You can, however, get the same result using the law of sines. If you are on a perpendicular course at the point of firing, the sum of the target bearing and the angle on the bow will equal 90°, and their sines will be proportional to the ratio of the target and torpedo speeds.

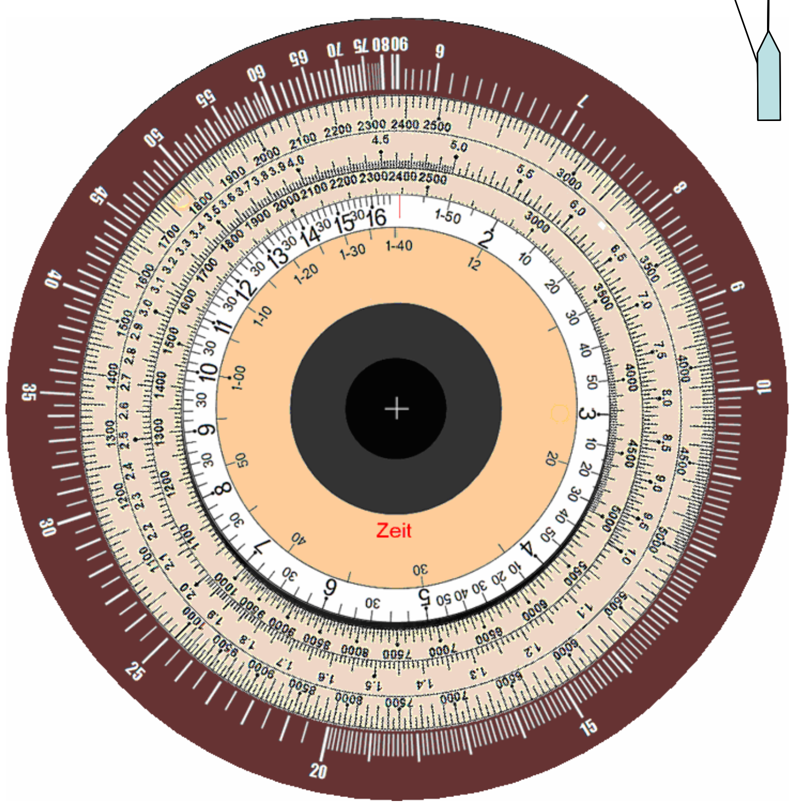
sin (lead angle) / sin (AOB) = (target speed) / (torpedo speed)

The difficulty lies in the fact that we are calculating an AOB and lead angle at some point in the future. To solve for the lead angle, find both the target and torpedo speeds on disc Y. Then turn disc Y until the angles on disc X that align with the target and torpedo speeds sum up to 90°.



A target is identified running 9 knots on relative bearing 340° with an AOB of 70° starboard. Calculate the lead angle for a 45 knot torpedo to be fired from the bow tubes with a 0° gyro angle.

1. You are on a perpendicular intercept course. Using the back side of the attack disc, align 45 knots on disc Y (4.5 on the middle scale) with the index or 90° on disc X.
2. Find the target's speed 9 knots (correcting for decimal places, find 0.9) on the middle scale of disc Y. Find the corresponding angle on disc X is the lead angle (11.5°). Note that for slower targets (relative to your torpedo speed), this lead angle is accurate enough.
3. Because the sum of the two angles (90° +11.5° = 100.5°) is greater than 90°, rotate disc Y counterclockwise until the sum of the two angles is equal to 90°. The solution is correct at an AOB of 79° and lead angle of about 11°.
4. Open outer doors and fire torpedoes when the target reaches 11° relative bearing (349° relative).



Note: This method is also useful to pinpoint parts of a target to hit. Fire torpedoes as the part of the target you wish to hit cross the lead angle.

Example 13: Determine the torpedo gyro angle

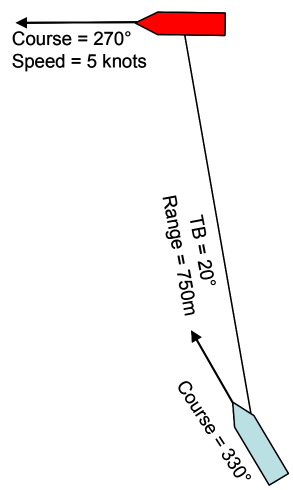
This example will show how to calculate the required gyro angle for a firing solution. This method is somewhat simplified and is best for smaller gyro angles (<30°) and shorter ranges (<1000 metres).

In this case, the law of sines is helpful. Because we are firing now and know the AOB and both the target and torpedo speeds, we can easily calculate the lead angle.

sin (lead angle) / sin (AOB) = (target speed) / (torpedo speed)

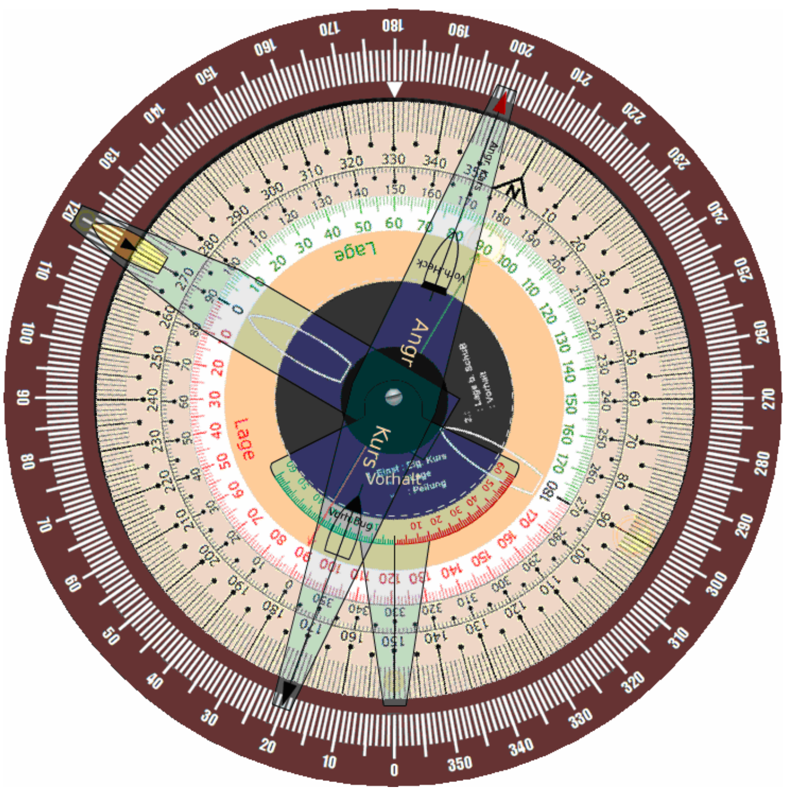
Then the gyro angle will be the difference between the lead angle and the current target bearing.

gyro angle = target bearing – lead angle

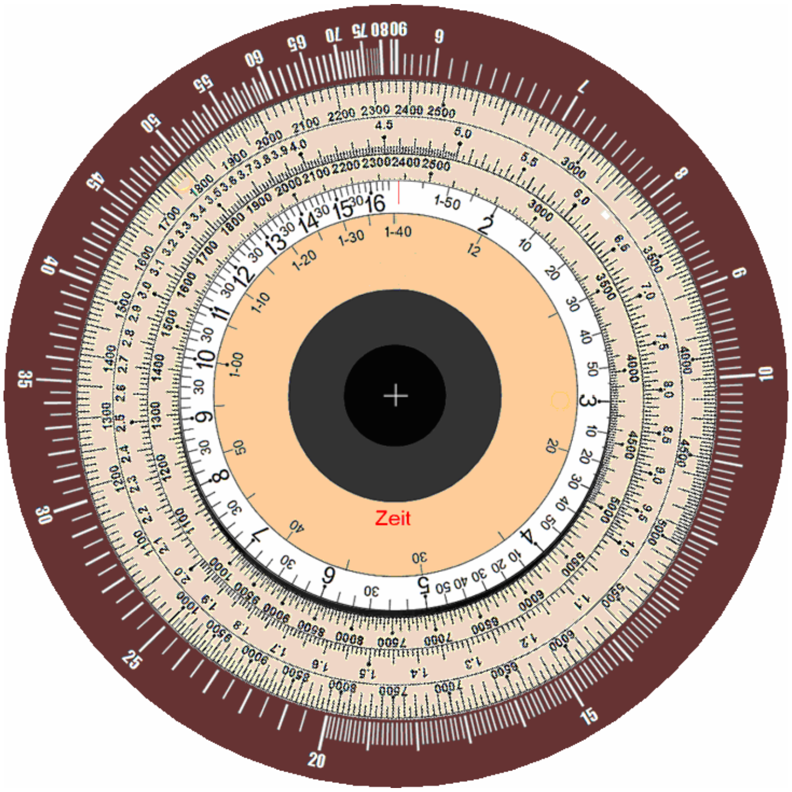


Your course is 330° true. You are tracking a convoy steaming due west (270° true) at 5 knots. You confirm a target bearing of 20° and a range of 750 metres. What gyro angle is required to immediately fire a 45 knot torpedo?

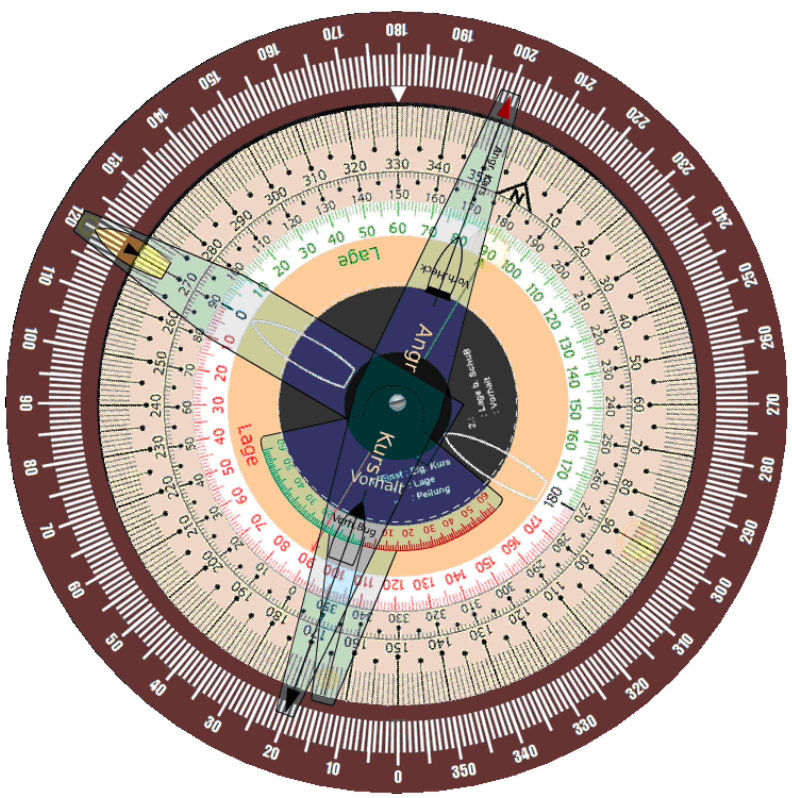
1. Determine the AOB of the target using the front side of the attack disc. Rotate disc B so that your course 330° aligns with the index on disc A (the 180° mark). Turn rotor D to your line of sight to the target of 20° on disc B. Turn disc C to the target's course of 270° on disc B. Read the AOB where the rotor D crosses disc C. The target's AOB is 100°.



2. Calculate the lead angle using the back side of the attack disc. For any angle α, sin α = sin (180 – α). Therefore, use 80 degrees for the AOB (180° – 100°). Align 45 knots (4.5) on disc Y with 80° on disc X. Read the lead angle where 5 knots on disc Y aligns with disc X. The lead angle is approximately 6°.



3. Calculate the gyro angle by subtracting the lead angle (6°) from the target bearing (20°). Using the front side of the attack disc, turn rotor E so that rotor D aligns with 6° on the green scale. Read the gyro angle where rotor E aligns with disc A. Set your gyro angle for 14° and fire.



Kriegsmarine Target Data Log

Time	Own Speed	Own Course	Target Bearing	Target AOB	Target Range	Target Speed	Comments

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He, who sees first, has won!