Prüf Nr. 13

STRENG GEHEIM

Kriegsmarine Angriffsscheibe Handbuch

Beschreibung und Bedienungsvorschrift
mit Zeichnungen

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März 2008

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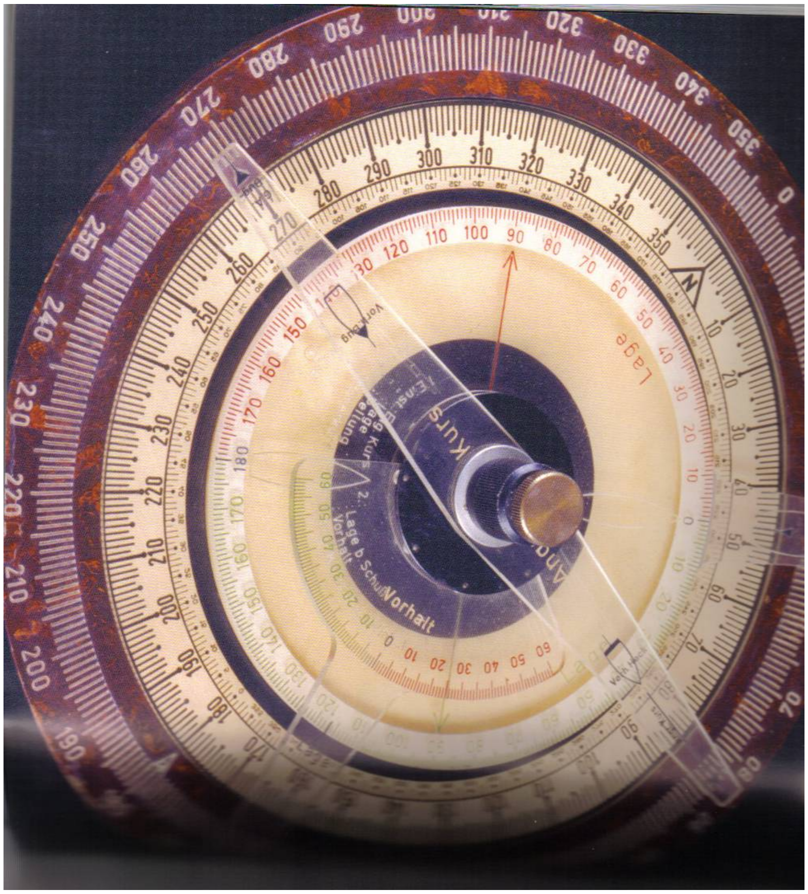


This guide was written for use with the replica of the German Attack Disc (a.k.a. Angriffsscheibe 2 mit Kompaßscheibe, Whiz-Wheel, Is-Was) in the Ubisoft U-boat simulation “Silent Hunter III”. While not exhaustive, it is intended to demonstrate some of the ways this device can be used for preparing an attack on a potential target. While effort has been made to be historically accurate, there are no guarantees that the disc was used exactly as described.

A key resource in writing this handbook was 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 – creator of the printable templates and source of valuable help and expertise
Joegrundman – creator of U-jagd tools and source of valuable help and expertise
Dertien – creator of the Flash version (source of many illustrations)
Terrapin – creator of the printable recognition book (source of some illustrations)

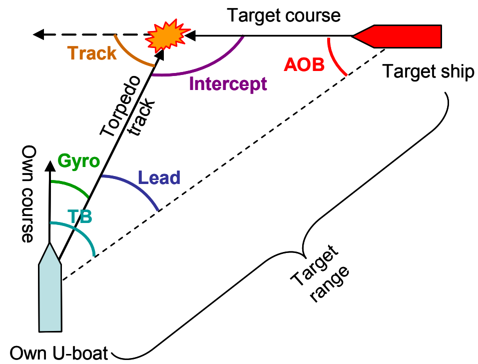
Visit www.subsim.com to find further information and Attack Disc downloads (including templates to build your own, a Flash version, and an in-game version).

Edition History:
- 1.0 – original release (December 2007)
- 2.0 – added more examples, corrected errors (January 2008)
- 3.0 – added more examples, corrected errors (March 2008)

Targeting Geometry

The goal of the torpedo attack is for the torpedo and the target to reach the same place at the same time.

As simple as that sounds, the calculation of an accurate firing solution can be quite complex due to the many variables involved. In most cases, however, you 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 acceleration, turning time, and turning radius of the torpedo, nor the error in parallax due to the periscope being away from the torpedo tubes. For close range attacks (<1000 meters) at low gyro angles (<30°), ignoring these variables will have little effect on the success of the attack.



The U-boat commander must be familiar with these terms used throughout this guide:

- **Target Bearing** or **TB** (Schiffspeilung, Seitenwinkel, or omega ω) – the angle from the bow of the U-boat to the target (0° being the bow of the U-boat)
- **Angle on the Bow** or **AOB** (Lagenwinkel or gamma γ) – the angle from the target's bow that their crew would see you (0° being the bow of the target ship)
- **Lead Angle** (Vorhaltewinkel or beta β) – the angle ahead of the target bearing that the torpedo or U-boat must run to intercept the target (also called the deflection angle)
- **Intercept Angle** (Schneidungswinkel or alpha α) – the angle between the target's course and the torpedo's track (also equal to 180° – Track Angle)
- **Track Angle** – the angle at which the torpedo will intercept the target (0° being the bow of the target ship)
- **Gyro Angle** (Schußwinkel) – the angle that the torpedo is programmed to turn once it leaves the U-boat (0° being the bow of the U-boat)
- **Own Course** (Eigenerkurs) – the true direction the U-boat is traveling (0° being north)
- **Own Speed** (U-bootgeschwindigkeit) – the speed of the U-boat in knots
- **Target Course** (Gegnerkurs) – the true direction the target is traveling (0° being north)
- **Target Speed** (Gegnergeschwindigkeit or V_g) – the speed of the target in knots
- **Target Range** (Entfernung) – the distance to the target in meters
- **Torpedo Speed** (Torpedogeschwindigkeit or V_t) – the speed of the torpedo in knots
- **Firing Range** (Schußweite) – the distance the torpedo will travel to hit the target

The triangle formed by the angles α, ß, and γ is called the Firing Triangle (Torpedo-Schußdreieck). The sum of these three angles will always be 180°, so once two angles are known, the third angle can be determined.

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

1. Acquisition (finding target and determining identity, course, and speed)
2. Approach (maneuvering the U-boat into a favorable attack position)
3. Attack (firing torpedoes at precisely the right time and direction to hit the target)

Once the U-boat is in position and the necessary target data is gathered (usually bearing, AOB, range, and speed), the Torpedo Data Computer (Torpedovorhaltrechner) or TDC can calculate the gyro angle. It is also possible to set up a shot manually using the techniques described in this handbook.

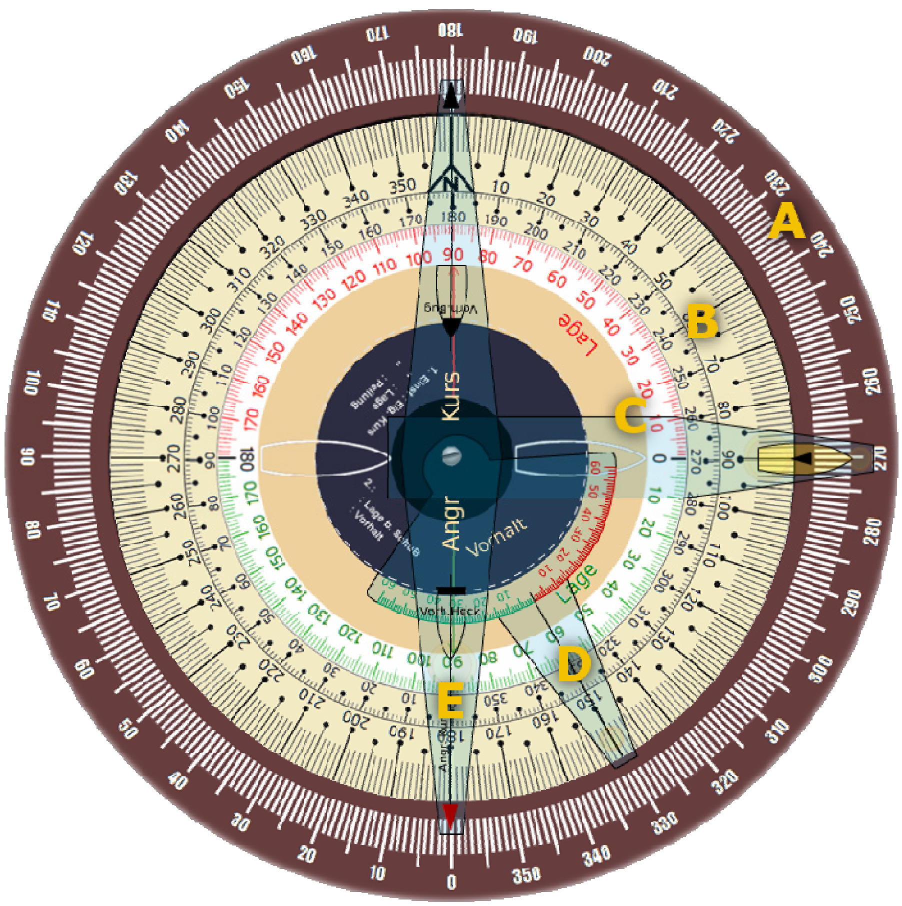
Front Side – Angle Solver

The front side of the German Attack Disc is an angle solver primarily used to determine the course or angle on the bow of a target as well as a course to intercept if the lead angle is known. It is composed of three concentric discs:

A. **Relative Bearing** (Schiffspeilung) – the outer disc, which represents the point of view from your U-boat (0° being the bow, 180° the stern)
B. **Compass Rose** (Kompaßrose) – the middle disc, which represents the compass or true direction (0° being true north), inner scale shows reciprocal direction; by aligning your true course with the disc A reference mark (at 180°), all of your observations are easily translated to true compass headings
C. **Target Disc** (Lagenwinkelscheibe mit Gegnerkursarm) – the inner disc, which represents the target's angle on the bow (AOB) with an attached pointer showing the target's course

and two transparent pointers:

D. **Bearing and Lead Angle** (Vorhaltwinkelscheibe mit Peilarm) – the wedge shaped pointer represents your line of sight bearing to the target (TB) and can be used to calculate a lead or deflection angle from that bearing
E. **Attack Course Pointer** (Angriffskurs-Zeiger) – the long thin pointer is used to represent an attack course (Angr. Kurs) for a bow (Bug) shot or stern (Heck) shot. When the bow or stern shot markers align with the desired lead angle on pointer D, the marker labeled Angr. Kurs shows the attack course. It can also be used to show a torpedo track.



Assuming you know your own true course, and two of these three variables; the target's true course, the target's angle on the bow (AOB), and 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.

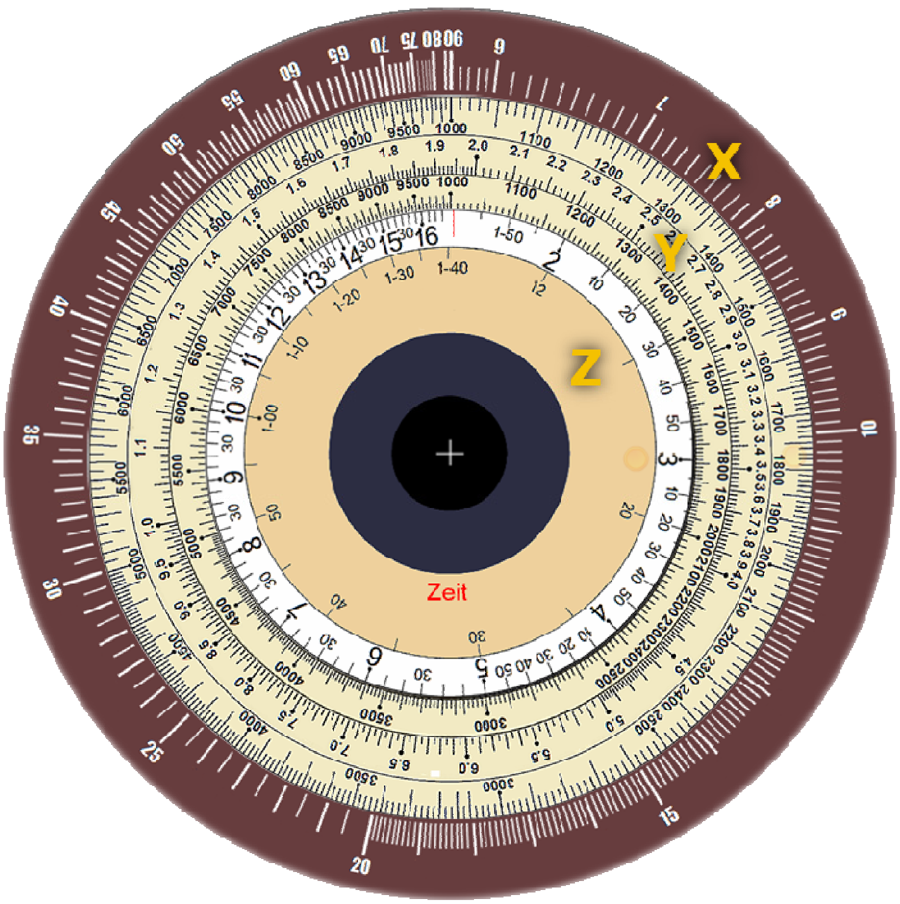
Always start with disc A oriented so that the reference mark at 180° is at the top (indicated by the white triangle).

Note that the red and green colors used on the attack disc (and the TDC) follow the convention that **red** (rot) is port (Backbord) or left side, and **green** (grün) is starboard (Steuerbord) or right side.

Rear Side – Speed Calculator

The rear side of the Attack Disc is primarily used for determining variables related to distance, time, speed, and changes in bearings. The historical Kriegsmarine Angriffsscheibe 2 did not have a rear side, but the replicas include a speed omnimeter modeled after the US Navy Submarine Attack Course Finder Mark 1 Model 3. It is composed of three concentric discs:

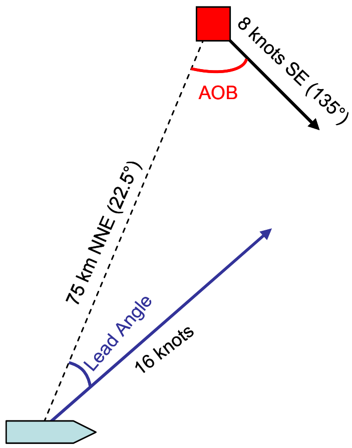
- **X. Degrees** – the outer disc is a sine function which can represent a relative bearing to the target or the angle on the bow of a target
- **Y. Speed and Distance** – the middle disc has scales for both distance in meters (outer two scales) and speed in knots (center scale)
- **Z. Time** – the inner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



Note that discs Y and Z are log scales, and you will frequently have to manage the decimal places manually in your calculation. Also note that although the X scale only goes up to 90°; this is not a problem when you know that the sine function is symmetrical around 90°, and that for any angle θ, sin (θ) = sin (180° – θ).

There are several ways to use this calculator. 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 AOB based on comparing the observed aspect ratio (AR = length/height) to a reference aspect ratio (at a 90° AOB).

Example 1: Determine the fastest course to intercept a reported contact

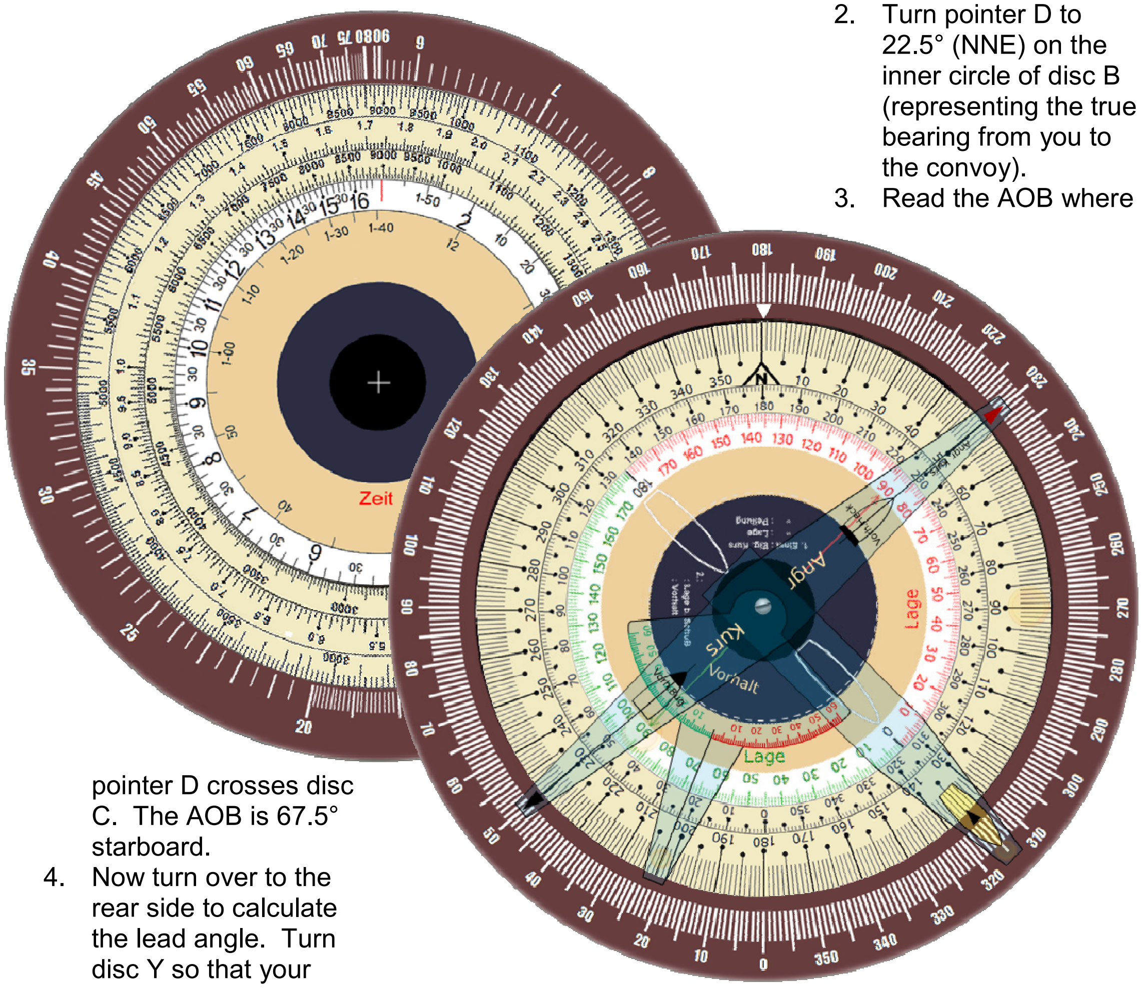


You have been ordered by BdU to join a gathering wolfpack to attack a convoy currently 75 km north by northeast of your position steaming southeast at 8 knots. Assuming you can maintain an average speed of 16 knots, what course should you set to intercept the convoy as quickly as possible? How long before you expect to make contact with the convoy?

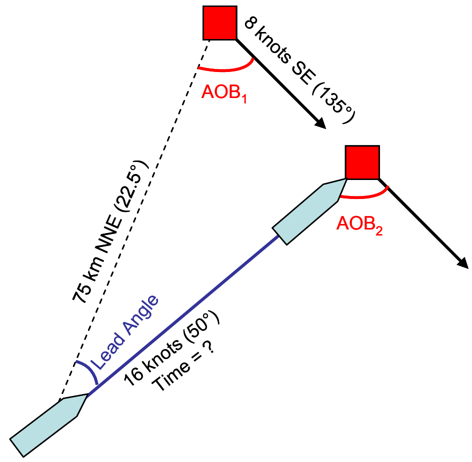
First you must find the AOB, and then you can determine an intercept course from the lead angle using this formula:

Lead angle = arcsin [(Target speed / Own speed) * sin(AOB)]

1. Using the front side, turn disc C so that it points to the contact's true course of 135° (southeast) on disc B.
2. Turn pointer D to 22.5° (NNE) on the inner circle of disc B (representing the true bearing from you to the convoy).
3. Read the AOB where pointer D crosses disc C. The AOB is 67.5° starboard.



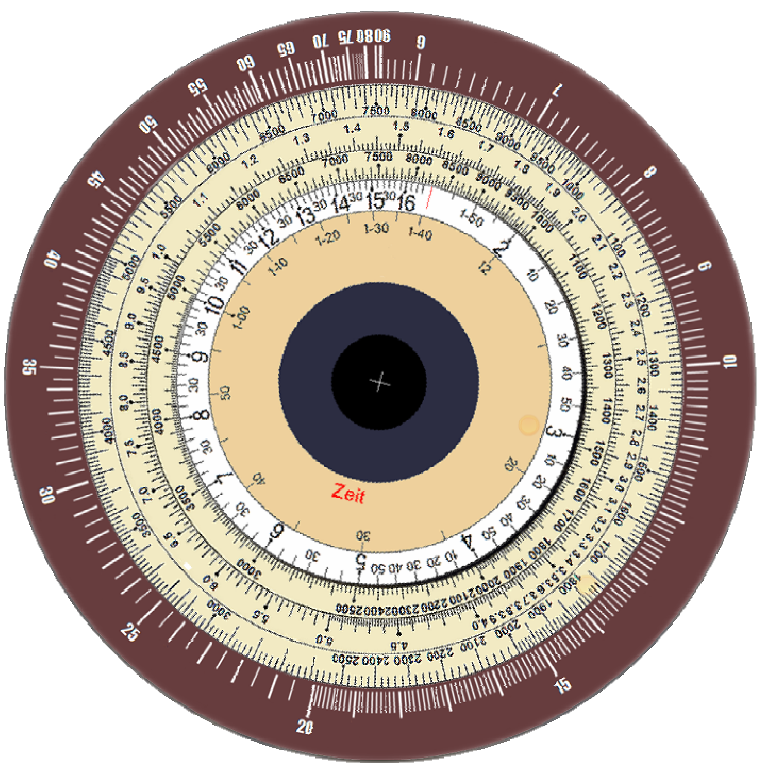
4. Now turn over to the rear side to calculate the lead angle. Turn disc Y so that your speed (use 1.6) is across from the AOB (67.5°) on disc X.
5. Read the lead angle from disc X next to the target speed (8.0) on disc Y. The lead angle is 27.5°.
6. Return to the front side and rotate pointer E so that the "Vorh. Bug" on it aligns with a lead angle of 27.5° green on pointer D. Read the attack course where the "Angr. Kurs" end of pointer E crosses disc B. Set your course to 050° and maintain 16 knots.



7. To solve for the time required to intercept, you must first find the AOB at the interception point (AOB_2). You can read the AOB_2 at the interception point where pointer E now crosses disc C. Assuming the target makes no course changes, the new AOB_2 will be 95° starboard. (You can also find AOB_2 by adding the original AOB_1 of 67.5° and the lead angle of 27.5° to get 95°.)
8. The distance to intercept is represented by this equation:

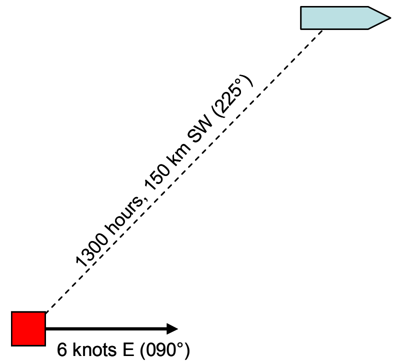
   $$\text{Distance} = \text{Range} * \sin(AOB_1) / \sin(AOB_2)$$

   Using the rear side, align the range (use 7500) on disc Y with the interception AOB_2 (use 85°). (Note that since AOB_2 is greater than 90°, you must subtract from 180° to use the sine function on the attack disc.) Read the distance to intercept where the original AOB_1 (67.5°) on disc X aligns with disc Y, correcting the decimal place. The distance to intercept is approximately 70 km.
9. Now divide by your speed of 16 knots to get the time to intercept. Rotate disc Z so that the index matches up with your speed (1.6) on disc Y. Read the time where the range (7000) on disc Y crosses disc Z. Correcting for the decimal place, 14 becomes 140 minutes.
10. Send a message to BdU that you expect to make contact in approximately 2 hours 20 minutes.



Note that this method will allow you to reach the target's track at the same time as the target (as fast as possible), but you will miss the intercept if any of the contact information is inaccurate. If you wish to arrive in position before the target, then you must run at a faster speed or increase the lead angle.

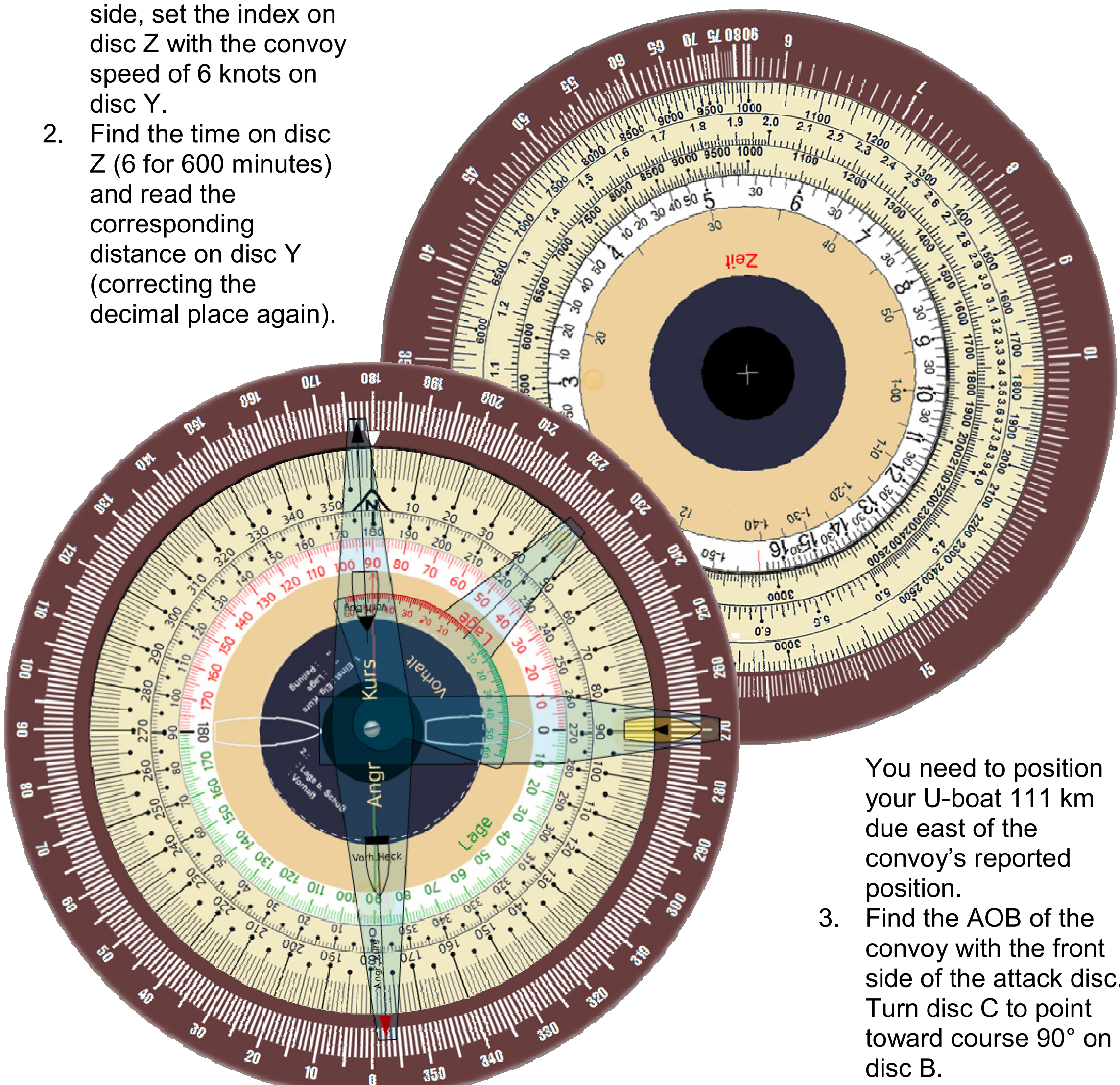
Example 2: Determine a course and speed to waylay a reported contact



You received a radio report at 1300 hours from another U-boat reporting a convoy 150 kilometers southwest of your position steaming due east at 6 knots. You wish to mount an attack in complete darkness which should be at 2300 hours. What course and speed should you set to arrive about two hours ahead of the convoy?

First you must determine where the convoy will be at 2300 hours, then plot a course to be at that location at 2100 hours.

1. Calculate the distance the convoy will travel in 10 hours. This will set your destination. Using the rear side, set the index on disc Z with the convoy speed of 6 knots on disc Y.
2. Find the time on disc Z (6 for 600 minutes) and read the corresponding distance on disc Y (correcting the decimal place again).

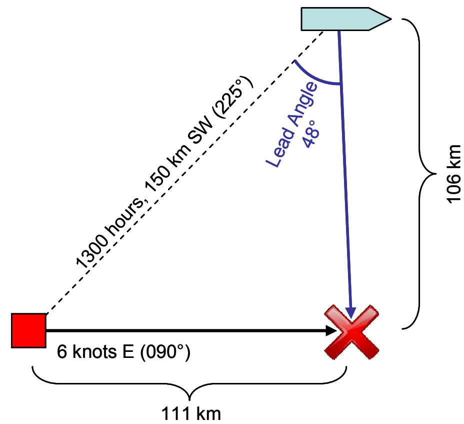


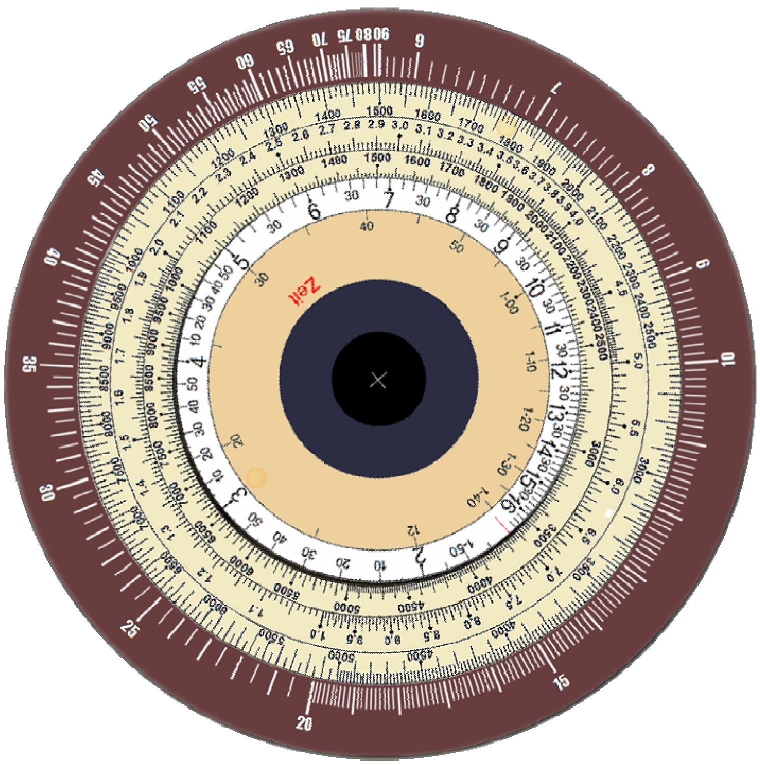
You need to position your U-boat 111 km due east of the convoy's reported position.

3. Find the AOB of the convoy with the front side of the attack disc. Turn disc C to point toward course 90° on disc B.
4. Rotate pointer D to a true target bearing of 225° on the reciprocal bearing (inner) scale on disc B.
5. Read the AOB of the convoy where pointer D crosses disc C, which is currently 45° port.
6. You now have two sides and the included angle of a triangle. There are ways to calculate the third side (such as using the law of cosines*), but assume for this example you are plotting on a map. Mark your position, then draw a line from your position with a

225° bearing and a length representing 150 km to the present position of the convoy. Now draw a line on a 90° bearing from the convoy a length representing 111 km due east of its present position. This is your destination.

7. Complete the triangle by marking your course to that point. Measure your lead angle as the angle between the current bearing of the convoy and your destination. Your lead angle is 48°.
8. On the front side, rotate pointer E so that the "Vorh. Bug" on it aligns with a lead angle of 48° red on pointer D.
9. Read your attack course where the "Angr. Kurs" mark on pointer E crosses disc B. Your attack course should be 177°.





10. To determine the distance you must travel to the interception point, you can either measure the length of your course line on your map, or use the rear side of the disc. Align 111 km (use 1110) on disc Y with 48° on disc X.
11. Find 45° on disc X and read the distance on disc Y, correcting the decimal place. You need to travel 106 km.
12. Determine the speed required to reach the attack position in eight hours (two hours before the convoy). Rotate disc Z so that 8 hours lines up with the distance (1060) on disc Y. Since disc Z is in minutes, you must line up 480 minutes (use 4.8 which would be the equivalent of 4 minutes 48 seconds).
13. Your speed is read from disc Y across from the disc Z index line. Set your speed to 7 knots, and leave orders for the 1WO to dive for sound checks at 2100 hours.

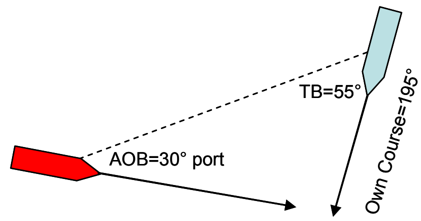
Note that the dimensions of the intercept triangle are now represented on the rear side of the disc. The distances of 1500, 1110, and 1060 on disc Y align with their opposite angles of 87°, 48°, and 45° respectively.

* The law of cosines states that for a triangle with sides a, b, and c, with opposite angles A, B, and C respectively, the following equation holds true:

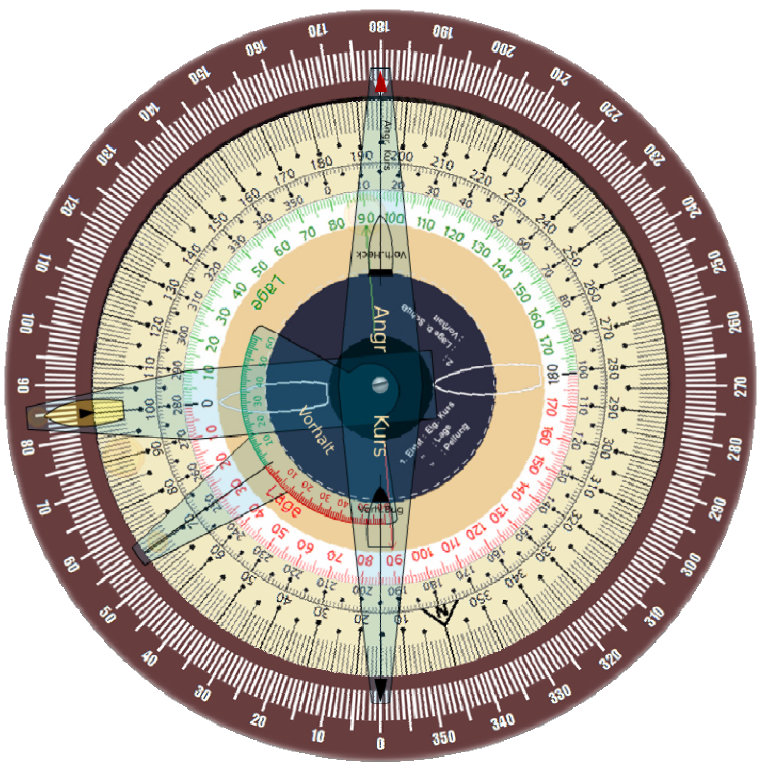
$$a^2 = b^2 + c^2 - 2(bc) \cos A$$

Example 3: Determine the true course of a target from bearing and angle on the bow

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

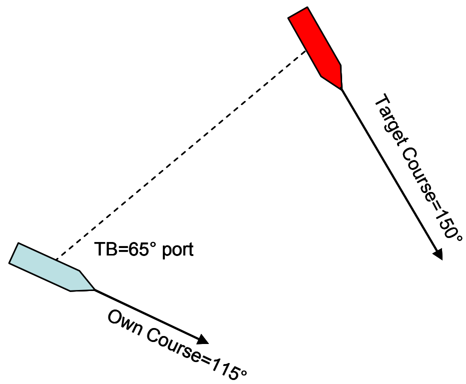


1. Turn disc B until your true course (the 195° mark) is aligned with the triangle mark at the top of disc A.
2. Move pointer D to the target's relative bearing (55°) mark on disc A.
3. Turn disc C so that the AOB of the target (30° port) aligns with pointer D.
4. Read the target's true course from where the arm on disc C points on disc B. The target is running on course 100°.

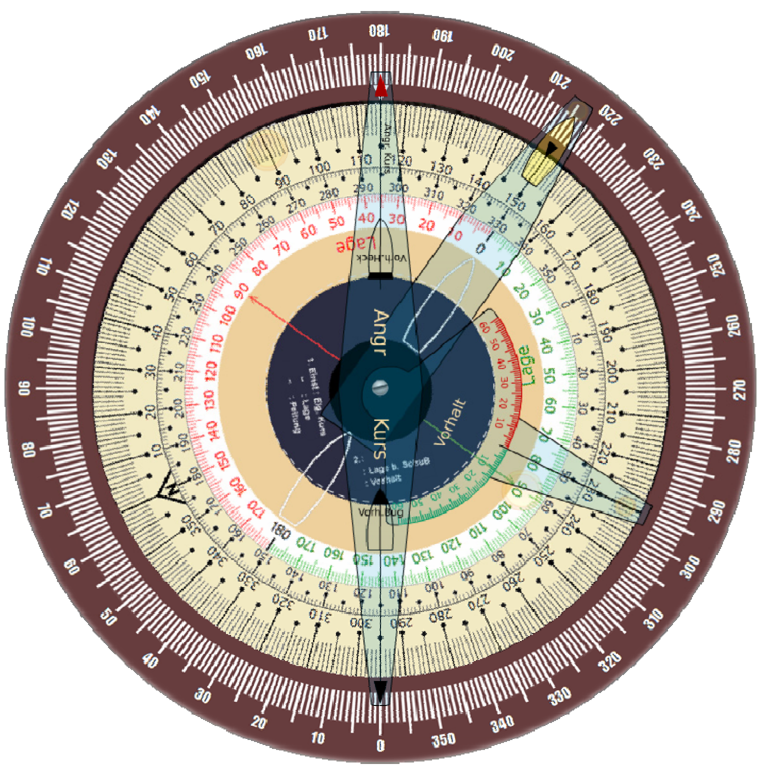


Example 4: Determine the angle on the bow of a target from bearing and course

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

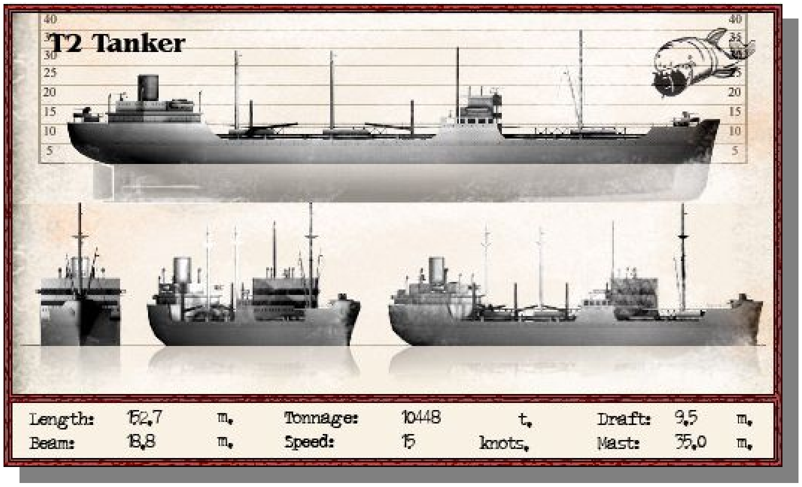


1. Place disc A with 180° at the top.
2. Turn disc B until your true course (the 115° mark) is aligned with the 180° triangle mark on disc A.
3. Move pointer D to the target's bearing (295° = 360° - 65°) on disc A.
4. Turn disc C so it points to the target's true course (150°) on disc B.
5. Read the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



Example 5: Determine the angle on the bow of a target from its aspect ratio

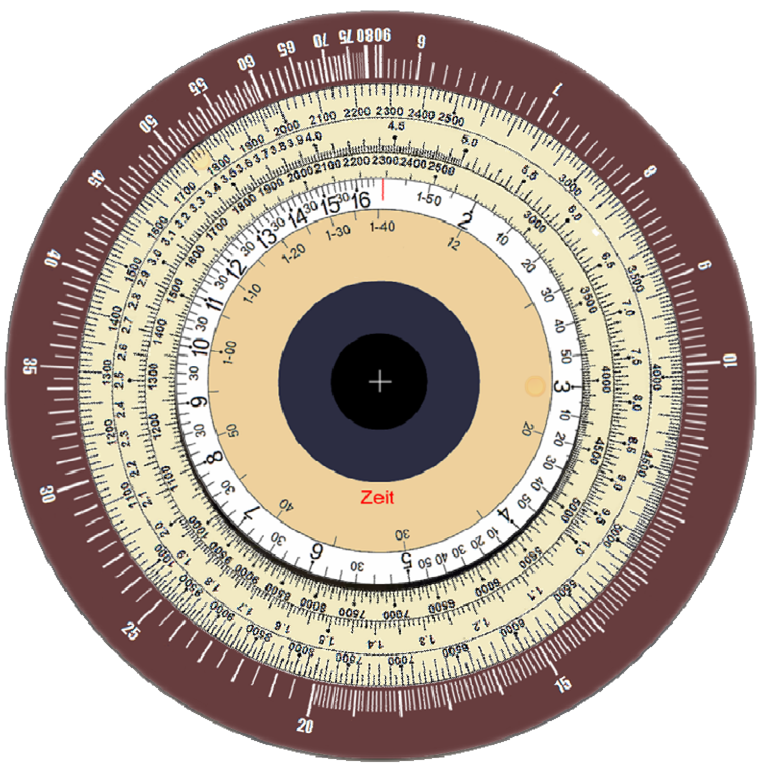
You observe a T2 Tanker at long range. Looking through the attack scope, the bow to stern is 7.5 ticks long, and the mast is 3 ticks high, to give an observed Aspect Ratio (AR=length/height) of 2.5 (7.5/3). What is the target's angle on the bow (AOB)?



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:

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

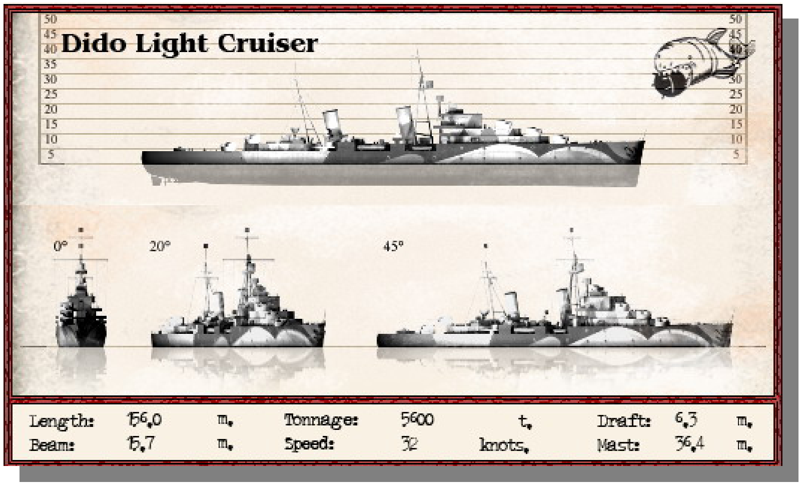
1. From the Recognition Handbook, calculate the reference Aspect Ratio ($AR_{reference}$) which is the length divided by height at a 90° AOB. Taking a length of 152.7 and dividing by a mast height of 35.0, you find that the $AR_{reference}$ is 4.4.
2. Use the middle row of numbers on disc Y (which usually represent knots). Find the $AR_{reference}$ (4.4) on the middle of disc Y, and align it with the 90° line of the disc X.
3. Find the $AR_{observed}$ (2.5) on the middle of disc Y and read the AOB across from it on disc X. The AOB is approximately 35°.



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

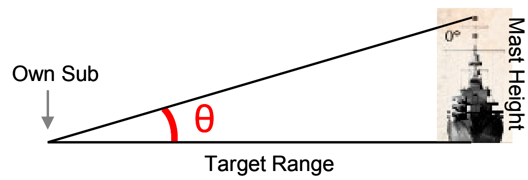
Example 6: Determine the range of a target from its mast height

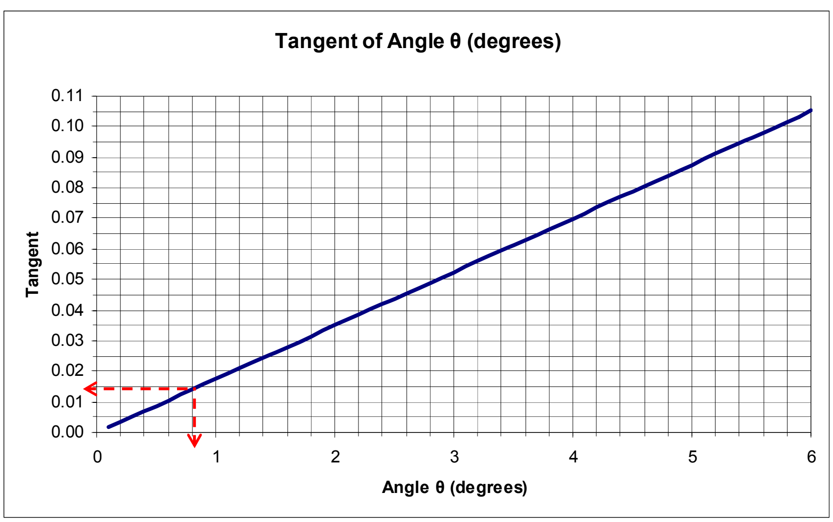
You have identified a ship as a British Light Cruiser, Dido class. Using your attack periscope, you determine the angle between the water line and the top of the mast to be 0.75°. What is the range to the target?



The target range can be calculated as follows:

Target Range = Mast Height / tan (θ)





Because the Attack Disc does not have a tangent scale, you must do the calculation using charts or a slide rule. (Note that for small angles, the approximation of sin (θ) ≈ tan (θ) will give satisfactory results. However, the sine scale on the Attack Disc does not give results for angles < 6°, and if the angle is greater than 6°, you are already at very close range.)

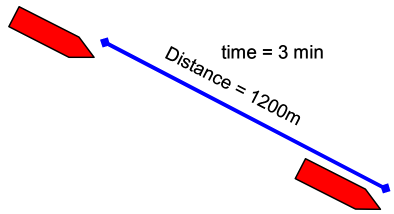
1. Once you have visually identified the class of ship using your Ship Recognition Manual (Schiffserkennungshandbuch), you know the mast height of the Dido is 36.4 meters.
2. Using your optics, measure the angle from the waterline to the top of the mast (see Appendix A). Angle θ is 0.75 degrees.
2. From the chart above, you find that the tangent of 0.75 degrees is approximately 0.013.
3. Divide 36.4 meters by 0.013. The target range is approximately 2800 meters.

See Appendix A for a chart to directly convert mast height and vertical angle to target range.

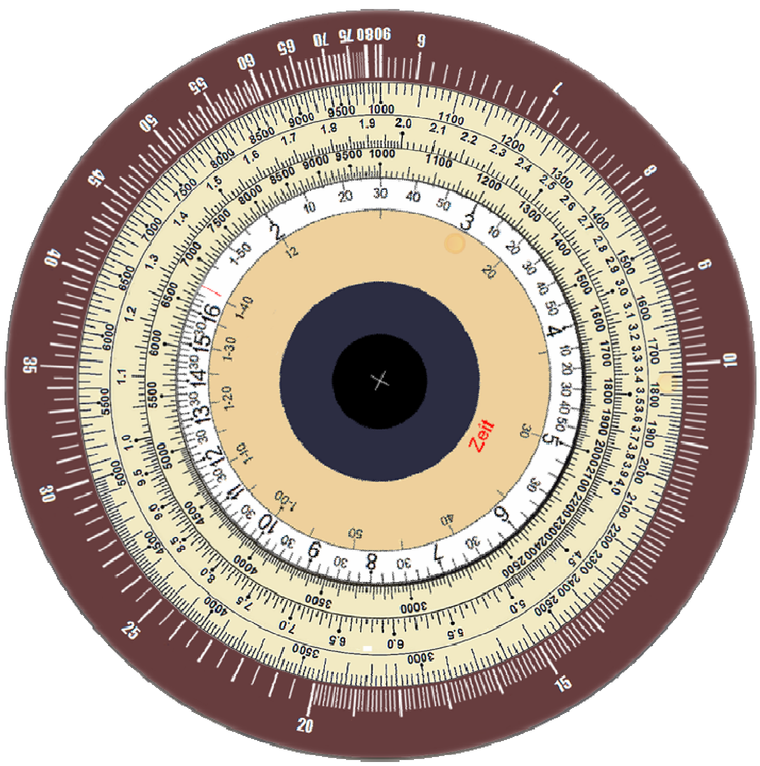
Example 7: Determine the speed of a target by plotting its position over time

You are stalking a target and plotting its position on a map or maneuvering board using bearing and range measurements. After 3 minutes, the target has traveled 1200 meters. What is the target's speed?

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



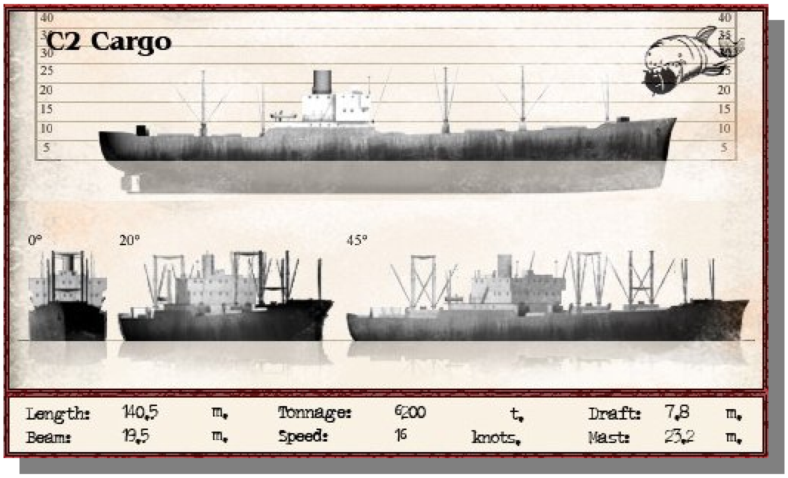
1. Align the 3 minute mark on disc Z with the 1200 meter mark on disc Y.
2. Read the target's speed in knots from where the index mark (red line) on disc Z meets disc Y (using the middle scale), and correct the decimal place if necessary. The target speed is about 13 knots.



Note that for a time of 3 minutes 15 seconds, the calculation works out that the speed (knots) is equal to the distance (meters) divided by 100. In this example, if the target traveled 1200 meters in 3 minutes 15 seconds, its speed would have been 12 knots.

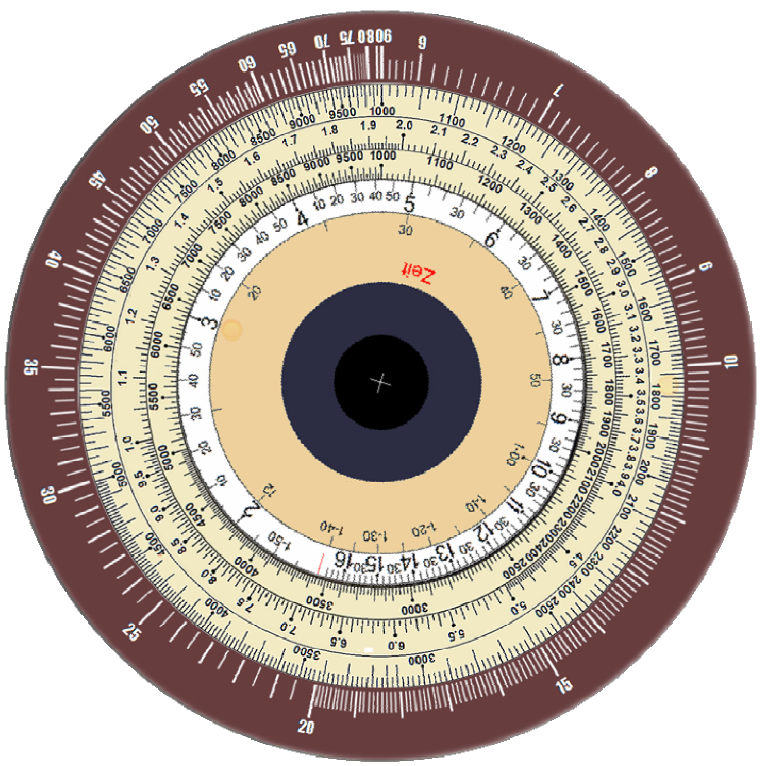
Example 8: Determine the speed of a target from its length

You have a target in your scope that you have identified as a C2 Cargo Ship. The recognition handbook gives its length as 140.5 meters. 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, what is the target's speed?



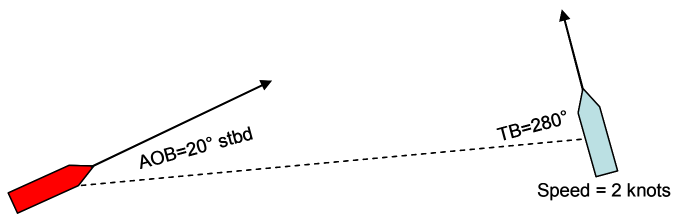
This technique, sometimes called the fixed wire method, is similar to the previous example in that you are measuring a distance traveled by the target and dividing by time. It assumes that you know the length of your target, and that its relative speed across your field of vision is unaffected by the movement of your U-boat. This method is therefore less susceptible to error if your U-boat is traveling slowly and the target bearing is closer to your bow or stern.

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



Example 9: Determine the speed of a target with constant relative bearing

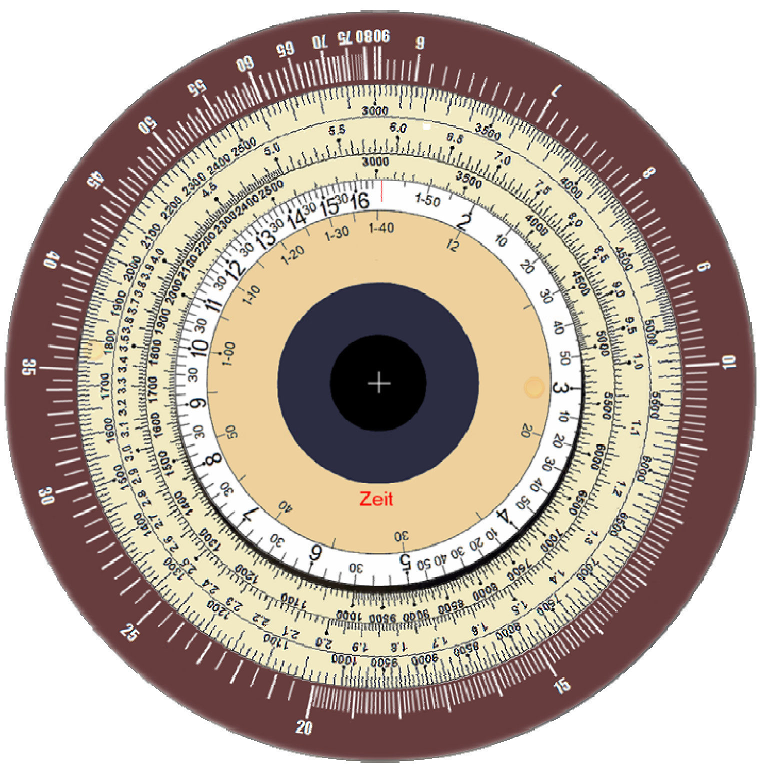
You are maintaining 2 knots on an intercept course with a potential target. At the original observation, it was on a bearing of 280° with an observed angle on the bow of 20 ° starboard. After several minutes, the bearing was still 280°. What is the target's speed?



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 U-boat'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)]

1. Align your speed (2 knots) on disc Y with the original AOB observed (20°) on disc X.
2. Note where the relative bearing on disc X aligns with the speed on disc Y. 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).

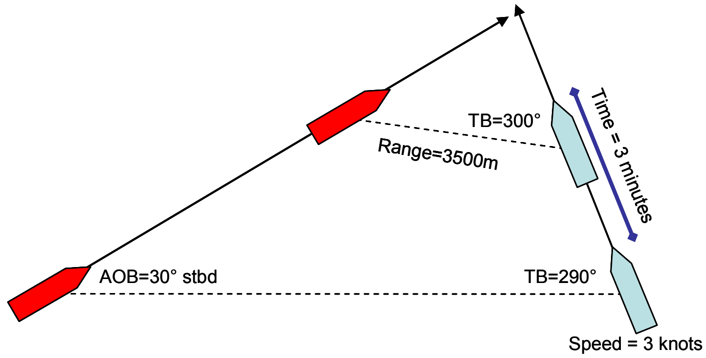


Note: Although you may not be able to achieve an attack position, this technique will also work if you are on divergent courses. If an angle is greater than 90°, then simply subtract it from 180° (since the sine function is symmetrical around 90°).

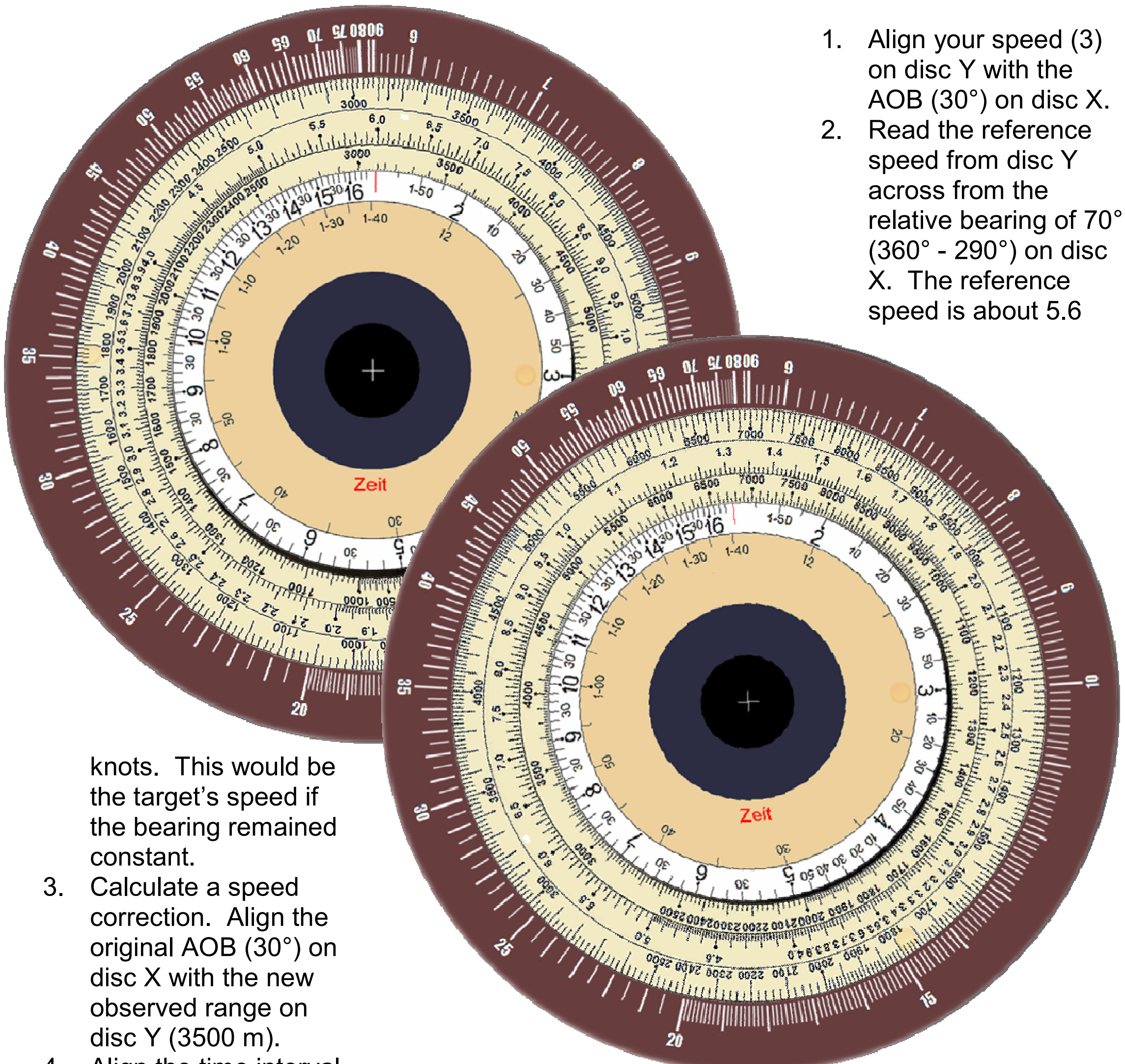
Target speed = Own speed [sin (180° - TB) / sin (180° - AOB)]

Example 10: Determine the speed of a target with a changing relative bearing

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 meters. What is the target's speed?



If the target bearing is changing, you calculate the speed as if you are on a collision course, and then apply a correction.

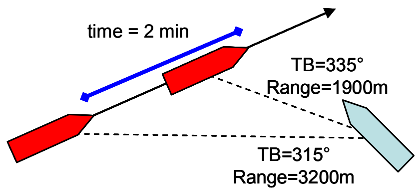


1. Align your speed (3) on disc Y with the AOB (30°) on disc X.
2. Read the reference speed from disc Y across from the relative bearing of 70° (360° - 290°) on disc X. The reference speed is about 5.6 knots. This would be the target's speed if the bearing remained constant.
3. Calculate a speed correction. Align the original AOB (30°) on disc X with the new observed range on disc Y (3500 m).
4. Align the time interval (3 minutes) on disc Z with the change in bearing of 10° (300°-290°) on disc X.
5. The index (red line) on disc Z is now pointing at the speed correction value on disc Y. 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.

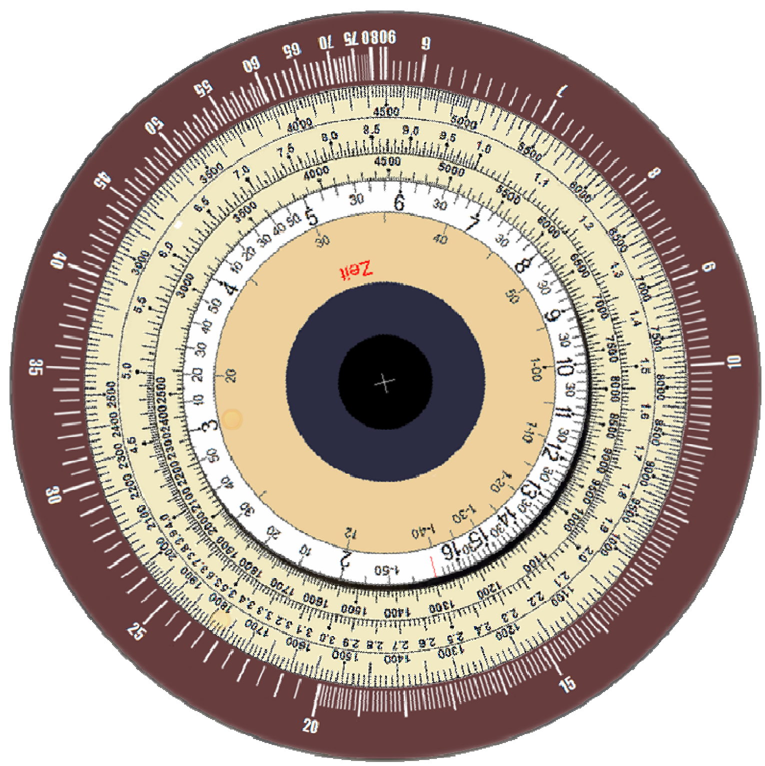
Example 11: Determine the speed of a target with two bearing and range observations

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

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 U-boat is traveling at a slow speed relative to the target.

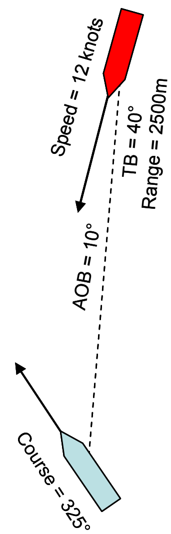


1. Calculate the change in bearing (335° - 315° = 20°).
2. We have to account for a 20° change between 3200 and 1900 meters, so find both 3200 and 1900 on disc Y.
3. Turn disc Y until there are exactly 20° on the disc X between these two points. This takes some trial and error. In this case, the solution 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 disc Y next to the change in bearing (20°) on disc X. The target traveled 1550 meters.
5. Divide the distance traveled by the time (1550 meters divided by 2 minutes). Align the two minutes mark on disc Z with 1550 meters on disc Y. The index on disc Z is now pointing to the target speed on disc Y (remember to correct the decimal place). The target is running approximately 25 knots.



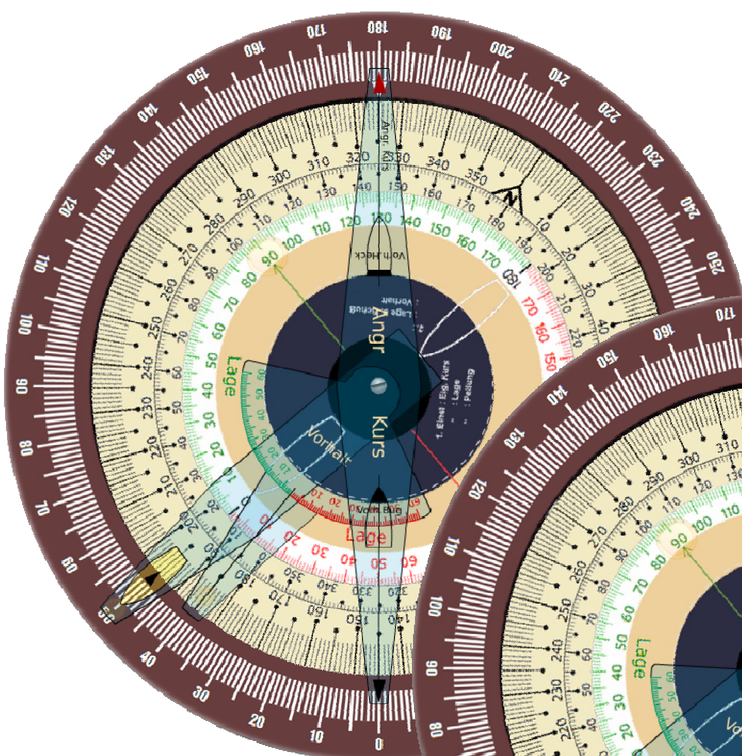
Example 12: Determine the time for a target to reach a future bearing

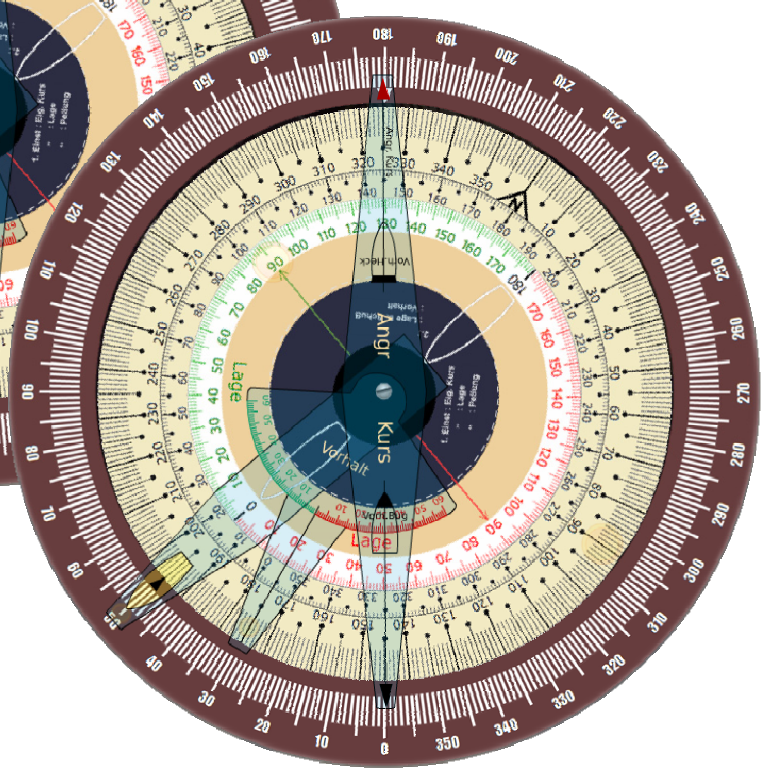
An escort carrier is spotted through your scope at 40° to starboard. You estimate a range of 2500 meters, an AOB of 10° port, and speed of 12 knots. Your U-boat is on course 325° at silent speed. How much time should you let pass before the target will be 30° off your starboard bow and you raise your scope to confirm your target data? What are the target's expected AOB and range at that time?



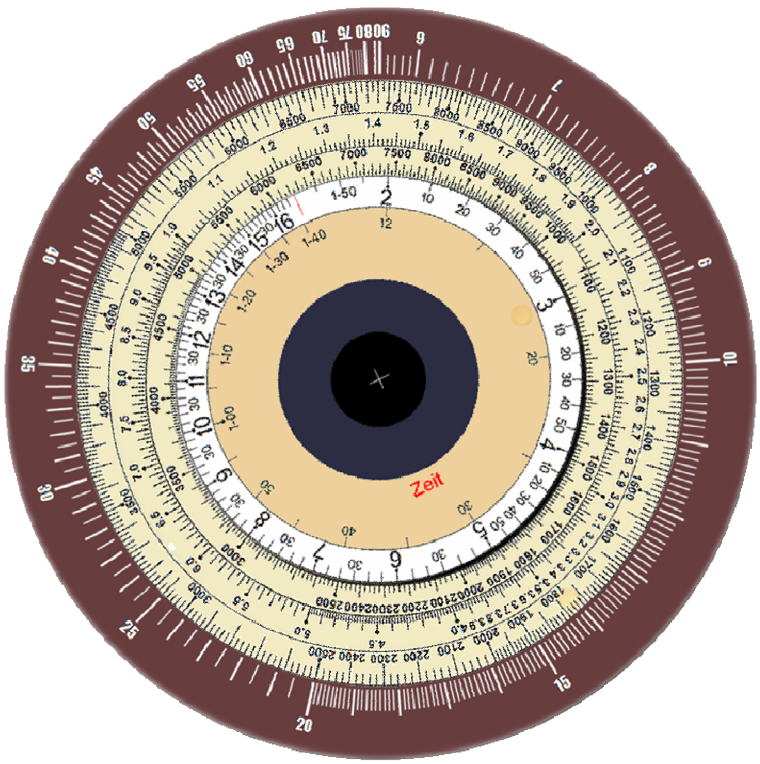
This technique is useful to confirm target data when you wish to minimize your risk of detection. It can also be used to determine the firing solution at some point in the future which can be used to "preset" the TDC. This example assumes the movement of your U-boat relative to the target is negligible.

1. Using the front side, orient disc A with the 180° mark at the top, and rotate disc B so that your course of 325° aligns with the top of disc A.
2. Rotate pointer D to 40° on disc A to show your visual bearing to the target.
3. Rotate disc C so that the red 10° mark on the AOB scale aligns with the pointer D. Disc C now points to the target's true course of 195° on disc B.
4. Assuming that neither the target nor your U-boat change course, you can now find the AOB at any target bearing by simply rotating pointer D to an observed target bearing on disc A and read the AOB scale on disc C. Rotate pointer D to a bearing of 30° and read the new AOB where pointer D crosses disc C. The target will be presenting an AOB of 20° port.



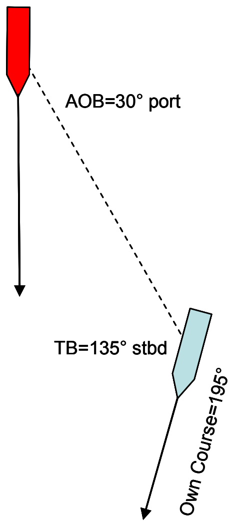


5. Turn to the rear side to calculate the distance the target has traveled. Align the initial range (2500) on disc Y with the new AOB (20°) on disc X.
6. The distance the target has traveled is found on disc Y where it aligns with the change in bearing on disc X (10°). The target will travel approximately 1270 meters.
7. The range is shown on disc Y opposite the initial AOB (10°), which in this example is also 1270 meters.
8. Align the index (red line) on disc Z with the target speed (use 1.2) on disc Y.
9. The time required is shown on disc Z where it aligns with the range on disc Y (1270). Order “up periscope” in 3 minutes, 26 seconds, and your target should be on bearing 30° with an AOB of 20° port.

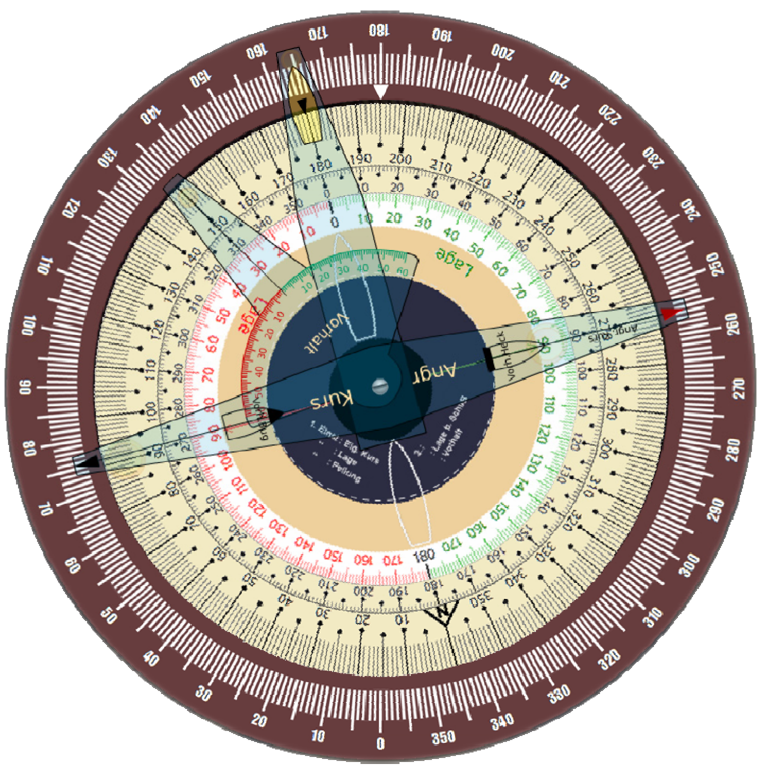


Example 13: Determine a perpendicular attack course to a target

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 attack on a perpendicular course?



1. Place disc A with 180° at the top.
2. Turn disc B until your true course (195°) is aligned with the 180° triangle mark on disc A.
3. Move the transparent D pointer to the target's bearing (135°) on the A disc.
4. Rotate disc C so it intersects the transparent pointer D at the estimated AOB (30° port).
5. Read the target's course from disc B where the disc C arm points. The target's course is 180°.
6. To find your perpendicular intercept course, simply look where the perpendicular red line (since you are intercepting the target on its port side) on disc C points to disc B. However, we need to read the inner (reciprocal) scale, as the outer scale represents the target's course to you. You can also use pointer E by aligning the bow shot symbol with the red line and read disc B where the attack course (Angr. Kurs) marker points. You should come right to course 270° true.



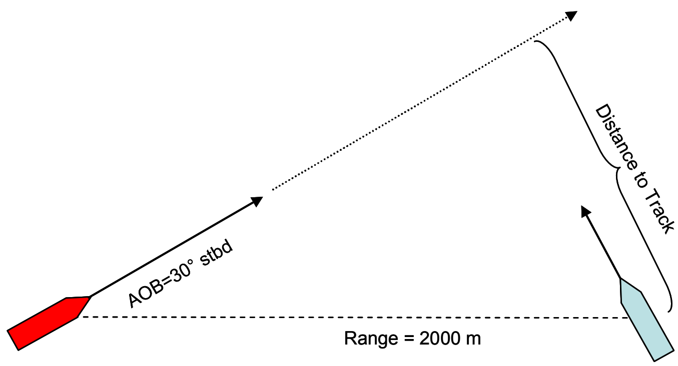
Note: If you wish to line up for a stern shot, then read the larger scale on disc B, or swing pointer E 180° so that the stern shot symbol overlays the red line and read the attack course. In this example you would turn left to heading 90° true.

Example 14: Determine the distance to the track of a target

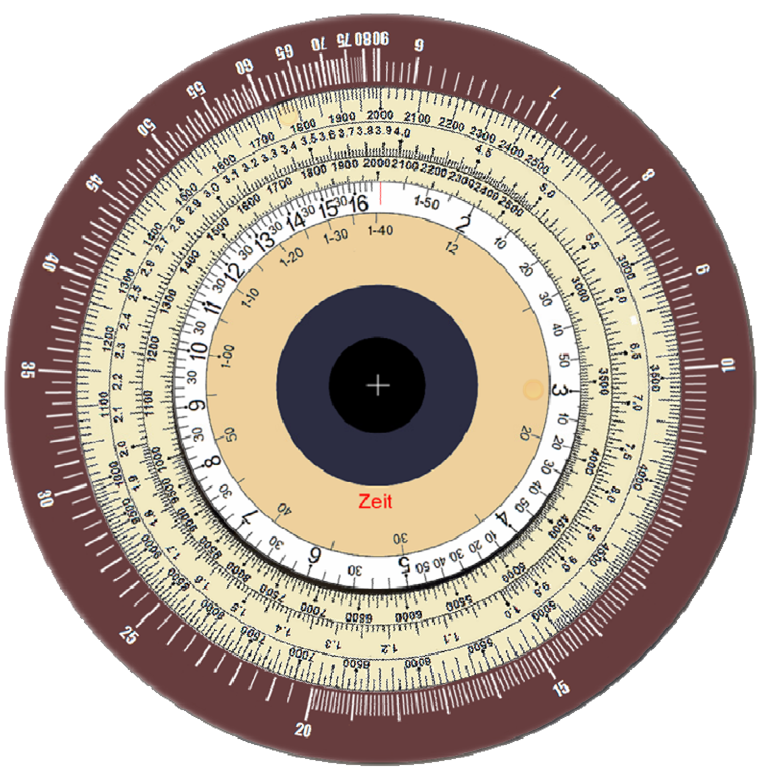
A target has been spotted at 2000 meters with an Angle on the Bow of 30° port. What is your distance to the target's track?

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:

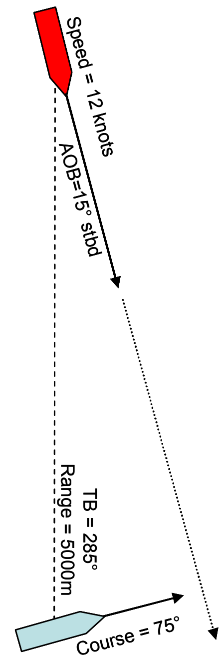
Distance to Track = Range [sin (AOB)]



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 meters from the target track.



Example 15: Determine an optimum speed for attack position



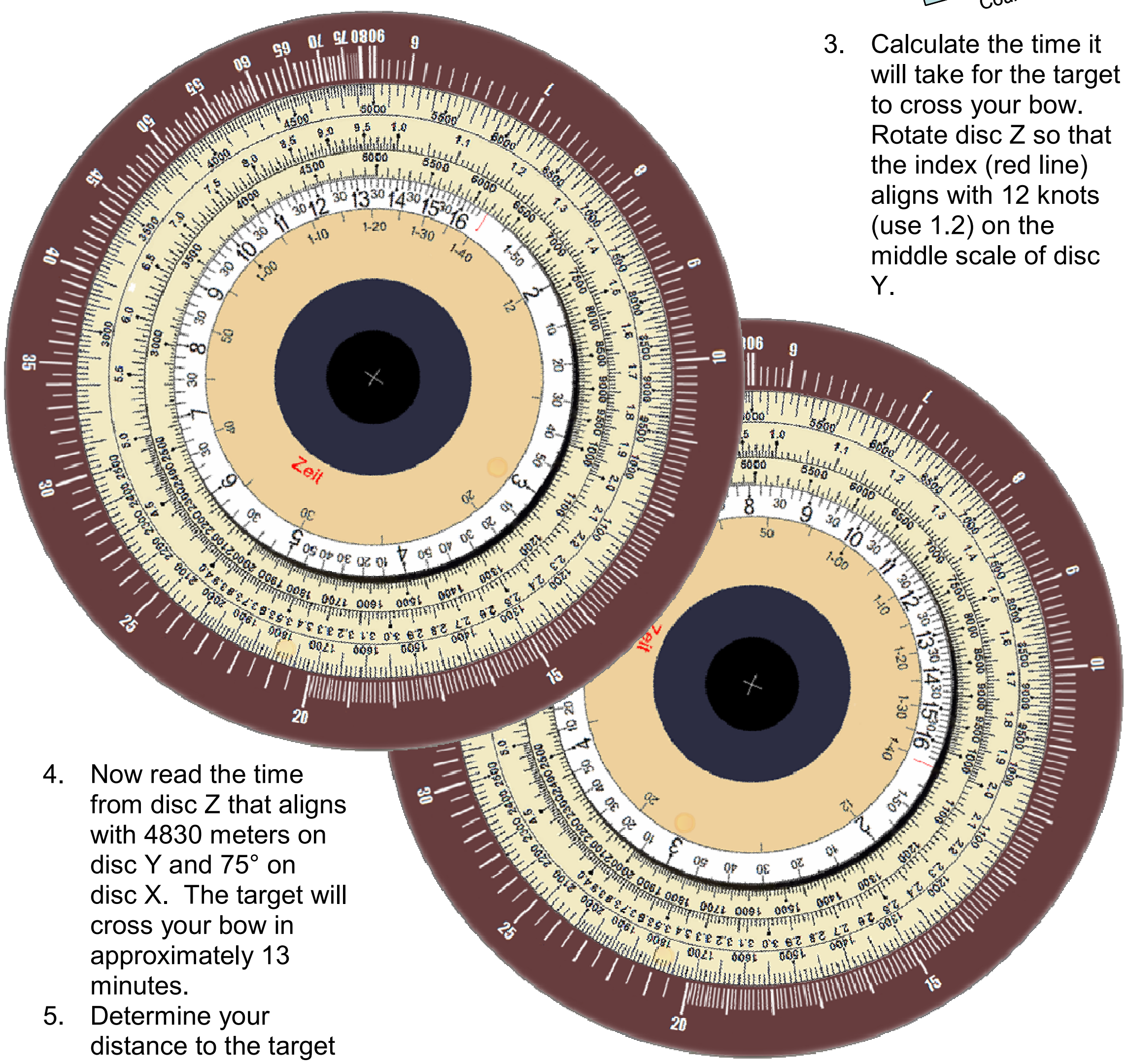
You are on coarse 75° true, perpendicular to a target's track. The target is running at 12 knots at relative bearing 285° with a range of 5000 meters and an AOB of 15° starboard. What should be your course and speed so that you are 500 meters from the target track as it crosses your bow?

Although you are on a perpendicular course, you may be too close or too far away from the target's track as it crosses your bow. With this method, you can adjust your speed and place your U-boat into a perfect firing position.

Knowing the range and AOB of a target on a perpendicular course:

Target's Distance to Cross = Range [sin (TB)]

1. Use the rear side of the attack disc to determine the distance the target has to travel to the crossing point. Align the range of 5000 meters on disc Y with the index (90°) on disc X.
2. 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 meters.



3. Calculate the time it will take for the target to cross your bow. Rotate disc Z so that the index (red line) aligns with 12 knots (use 1.2) on the middle scale of disc Y.
4. Now read the time from disc Z that aligns with 4830 meters on disc Y and 75° on disc X. The target will cross your bow in approximately 13 minutes.
5. Determine your distance to the target

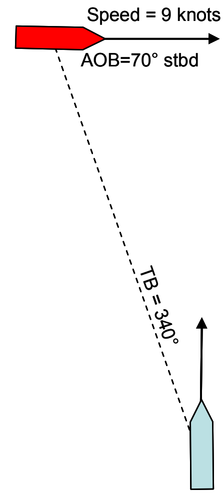
track. Read the distance on disc Y that aligns with the AOB (15°) on disc X. Your distance to the track is approximately 1300 meters.

6. Subtract 500 meters from your distance to the track to get the distance you need to travel. Divide that distance (800 meters) by the time to cross (13 minutes). Rotate disc Z so that 13 minutes is opposite 800 meters on the middle scale of disc Y (use 8000).
7. 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 for the longer distance. In this case, traveling 1800 meters at a speed of about 4.5 knots will line up a perfect stern shot.

"Packaging for the Attack Disc and Compass Disc"
from a 1942 Kriegsmarine Instruction Manual

Example 16: Determine the lead angle for a perpendicular attack with 0° gyro angle



You are heading due north and have identified a target running 9 knots on relative bearing 340° with an AOB of 70° starboard. What is the correct lead angle for a 44 knot torpedo to be fired from the bow tubes with a 0° gyro angle?

Once you are turned onto a perpendicular intercept course, this method calculates 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 meters).

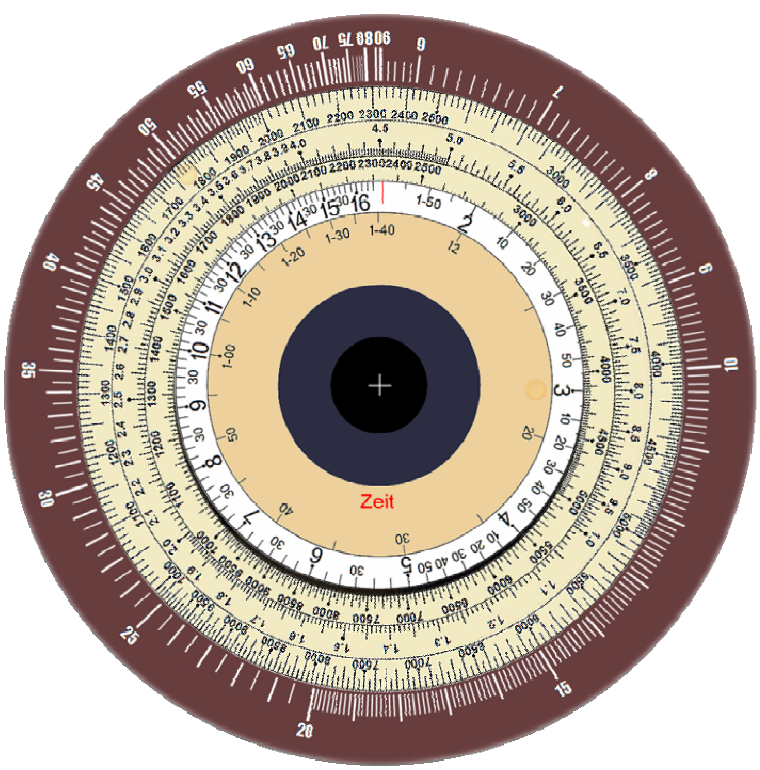
lead angle = arctan [target speed / torpedo speed]

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 the ratio of their sines will be proportional to the ratio of the target and torpedo speeds.

lead angle = arcsin [sin (AOB) *(target speed) / (torpedo speed)]

The difficulty lies in the fact that you 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°.

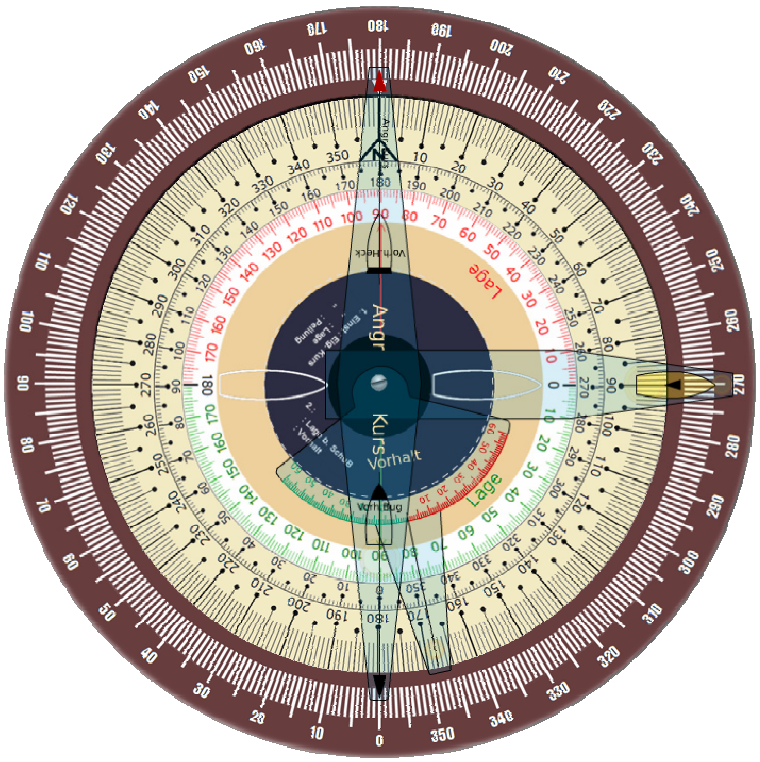
1. You are on a perpendicular intercept course. Using the rear side of the attack disc, align 44 knots on disc Y (4.4 on the middle scale) with the index or 90° on disc X.
2. Find the target's speed 9 knots (correcting for decimal places, find 0.9) on the middle scale of disc Y. Find the corresponding angle on disc X is the lead angle (~11.8°). 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° = 101.5°) 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 about 78° and lead angle of about 12°.
4. Turn to the front side with 0° (N) on disc B aligned with the reference mark on disc A.
5. Rotate pointer D to bearing 340° on disc A.
6. Turn disc C so that an AOB of 70° green aligns with pointer D.

The target is on course 90° (E).

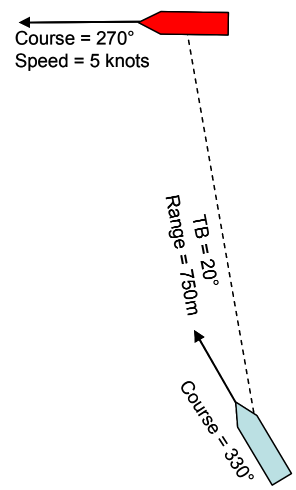
7. Align pointer E straight vertical with the bow shot marker pointing toward the green side of disc C. The “Angr. Kurs” marker on pointer E will be aligned to 0° (N) on disc B representing the torpedo course for a 0° gyro angle.
8. Rotate pointer D so that a lead angle of 12° right (green) is crossing pointer E.
9. Pointer D is now aligned with the bearing on disc A that represents when you should fire the torpedo. Set the gyro angle manually to 0° and open outer doors. Fire your torpedo when the target reaches a relative bearing of 348° (12° left).



Note: This method is also useful to pinpoint specific parts of a target to hit. Fire a torpedo as the part of the ship you wish to hit crosses the calculated bearing angle.

Example 17: Determine the torpedo gyro 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 meters. What gyro angle is required to immediately fire a 28 knot torpedo?

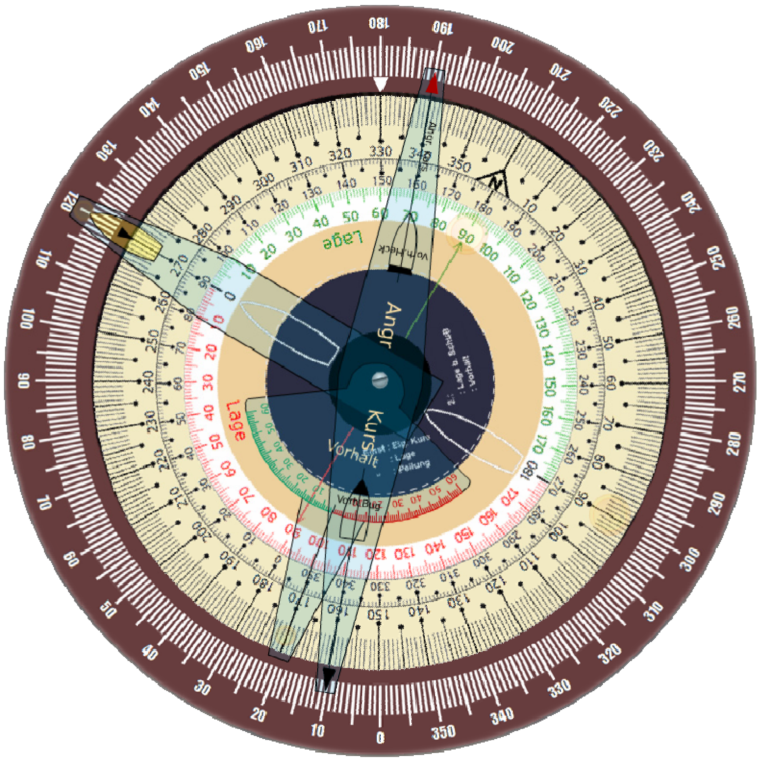


This calculation of the required gyro angle for a firing solution is somewhat simplified and is best for smaller gyro angles (<30°) and shorter ranges (<1000 meters).

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

lead angle = arcsin [sin(AOB) * (target speed) / (torpedo speed)]

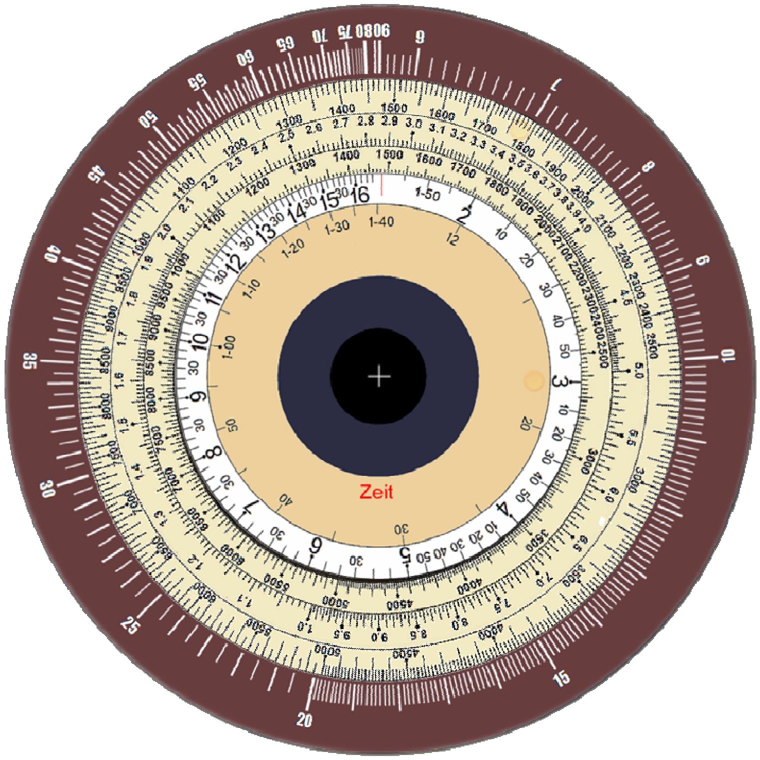
The desired torpedo track is found by taking the current target bearing and adding (if target is moving right) or subtracting (if target is moving left) the lead angle. The gyro angle is simply the difference between the desired torpedo track and the bow of your U-boat.

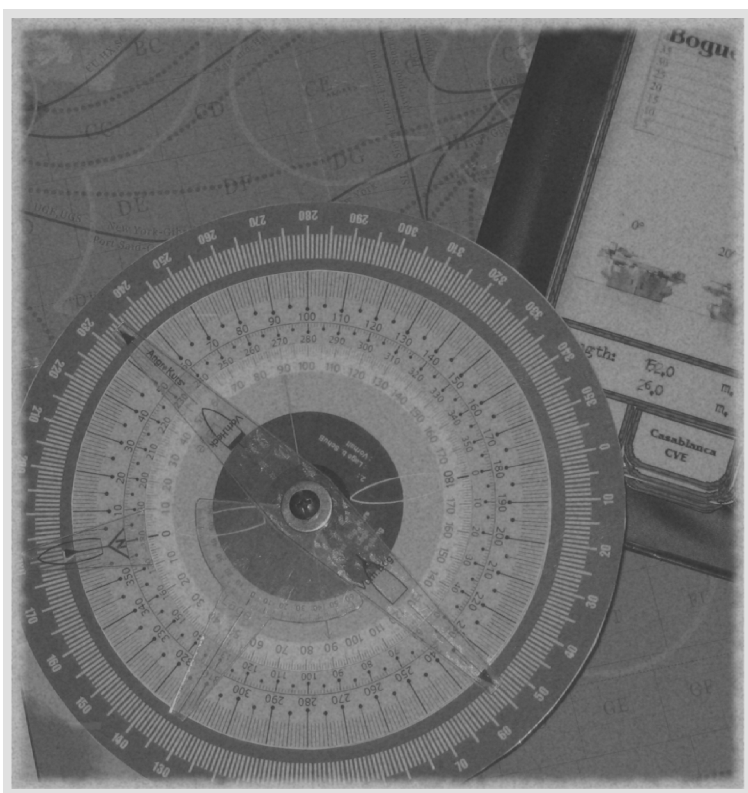


1. Determine the AOB of the target using the front side of the attack disc. Rotate disc B so that your course 330° aligns with the reference mark on disc A (at 180°).
2. Turn pointer D to your line of sight to the target of 20° on disc B.
3. Turn disc C to the target's course of 270° on disc B.
4. Read the AOB where the pointer D crosses disc C. The target's AOB is 100° port.
5. Calculate the lead angle using the rear side of the attack disc. For any angle α, sin α = sin (180 – α). Therefore, use 80 degrees for the AOB (180° – 100°). Align 28 knots (use 2.8) on disc Y with 80° on disc X.
6. Read the lead angle where 5 knots on disc Y aligns with disc X. The lead angle is approximately 10°.

7. Returning to the front side of the attack disc, turn pointer E so that the bow shot indicator aligns with a 10° lead angle on the red scale.
8. Read the gyro angle where pointer E aligns with disc A. Set your gyro angle for 10° right (10° relative bearing) and fire.

Note that you can also see the torpedo's true course where the Angr. Kurs indicator on pointer E aligns with disc B. The torpedo track angle shows where pointer E crosses disc C. The torpedo will be on course 340° and will hit the target at an angle of 110° left.

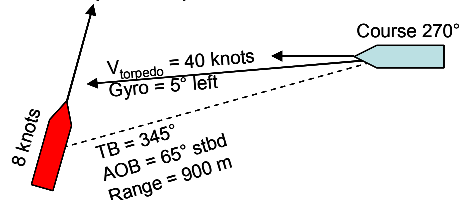




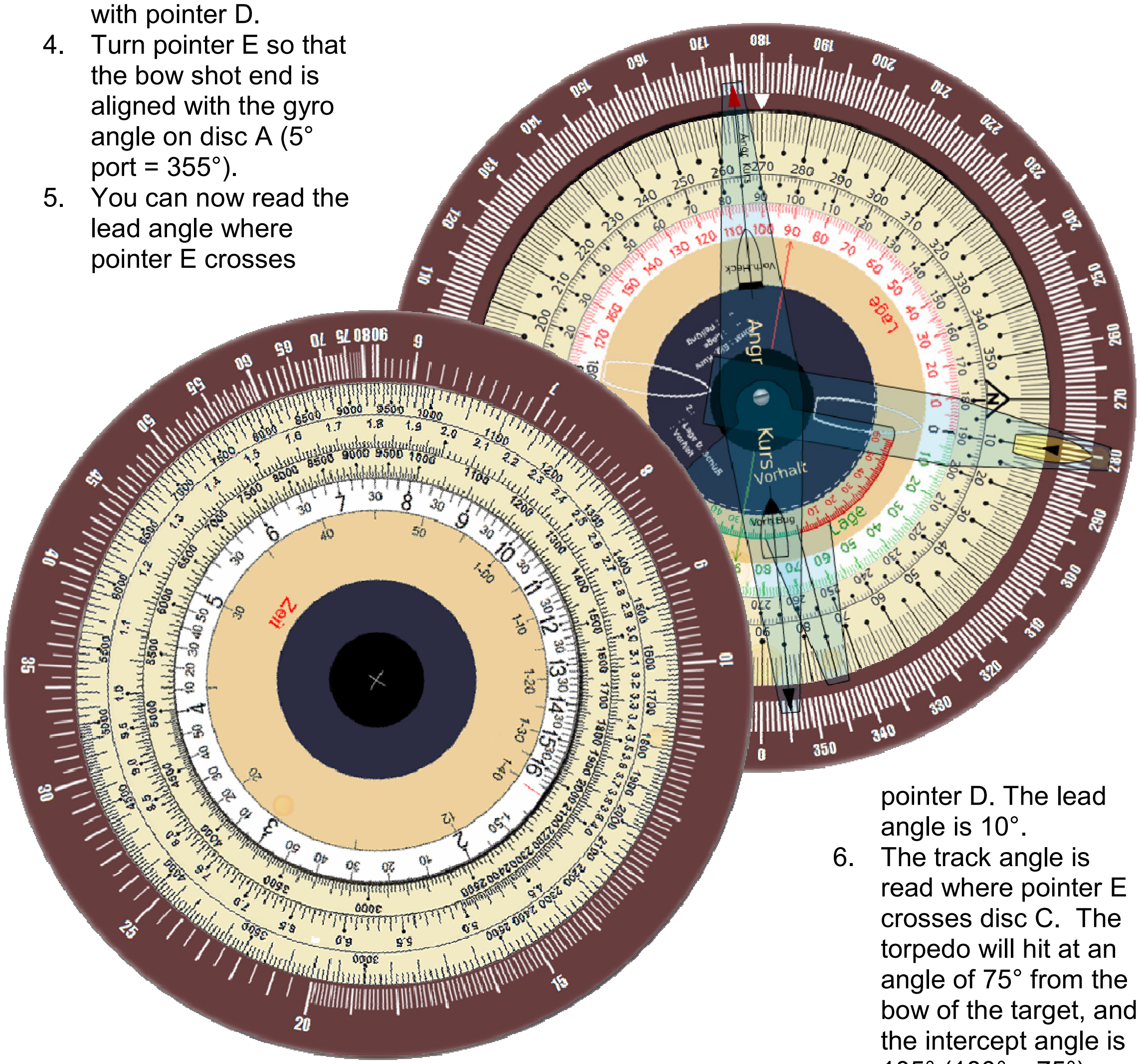
A home-made Attack Disc for Silent Hunter III

Example 18: Determine the torpedo run time

You are on course 270° and prepared to fire at a target running 8 knots at a range of 900 meters on bearing 345° with an AOB of 65° port. The gyro angle from the TDC is 5° port. The torpedo is set for medium speed (40 knots). How long before you should expect impact?



1. The lead angle can be found using the front side. Set your course (270°) on disc B with the reference mark on disc A.
2. Set pointer D to the target bearing (345°) on disc A.
3. Rotate disc C so that an AOB of 25° red aligns with pointer D.
4. Turn pointer E so that the bow shot end is aligned with the gyro angle on disc A (5° port = 355°).
5. You can now read the lead angle where pointer E crosses pointer D. The lead angle is 10°.
6. The track angle is read where pointer E crosses disc C. The torpedo will hit at an angle of 75° from the bow of the target, and the intercept angle is 105° (180° – 75°).

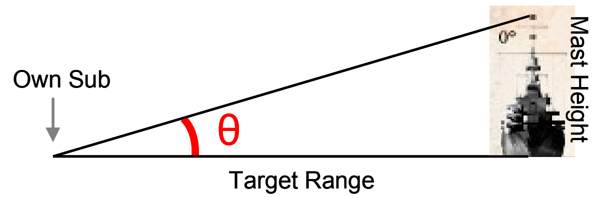


7. Switch to the rear side to determine the firing range (the distance the torpedo must travel). Align the target range (use 9000) on disc Y with the track angle (75°).
8. Read the firing range where the AOB (65°) on disc X aligns with disc Y. Correcting the decimal place, the torpedo must travel approximately 845 meters.
9. Divide the firing range by torpedo speed to calculate the time. Align the index on disc Z with the torpedo speed (use 4.0 knots) on disc Y.
10. Find the range (use 8450) on disc Y, and read the time on disc Z (the inner scale in this case). Torpedo los! Start your stopwatch and wait approximately 41 seconds for impact!

Appendix A: Target Range Calculations

To find the range of a visual contact:

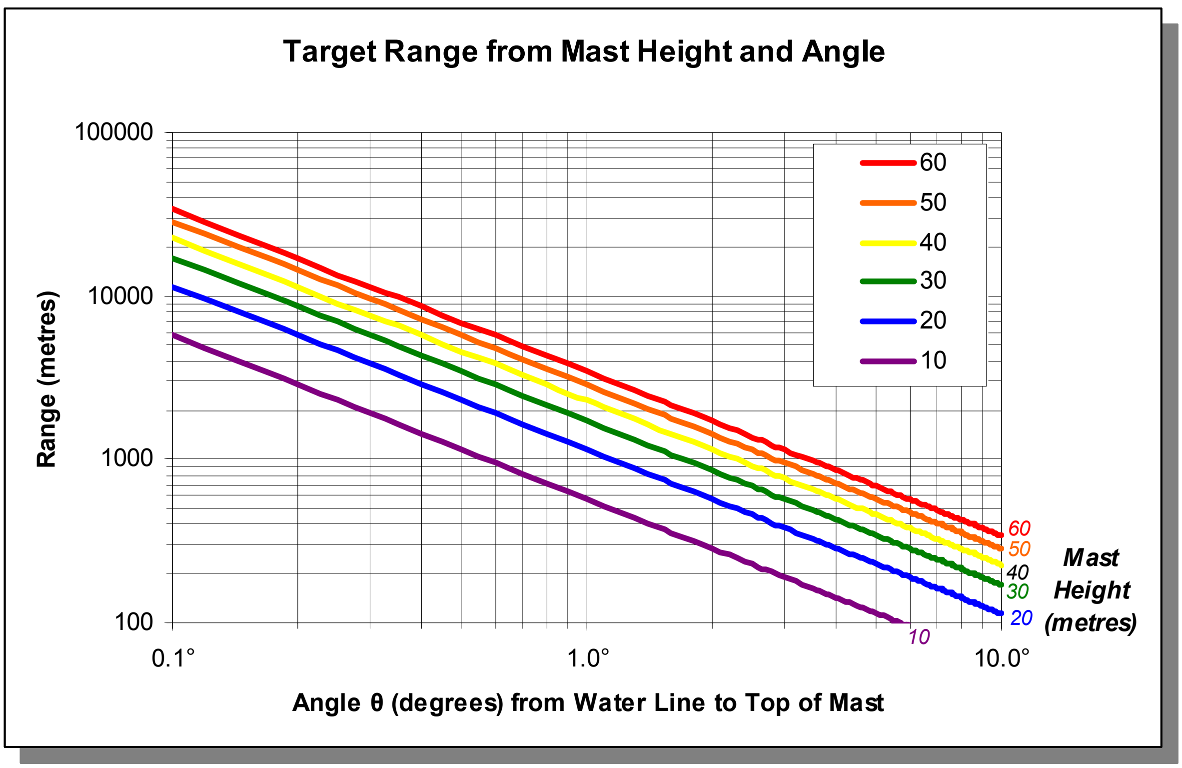
1. Use the Ship Recognition book to identify the target and determine its mast height.
2. View the target through the periscope or U-bootzieloptik (UZO), and use the reticule to measure the angle (θ) from the waterline to the top of the mast. (Note that if the mast can not be clearly seen, substitute the height of the funnel or other visible part of the superstructure.)



3. Using the graph below, find that angle on the X axis, then move up to the line closest to the mast height in meters (extrapolate between the lines if necessary).
4. Read the target range in meters from the Y axis.

In the stock version of Silent Hunter III, the angle (θ) can be measured from the reticule markings in the periscopes and UZO as follows:

OPTIC	SMALL MARKS	LARGE MARKS
Periscopes (1x or 1.5x)	1°	5°
Zoomed View Periscopes (4x or 6x)	0.25°	1.25°
UZO (7x)	0.2°	1.0°

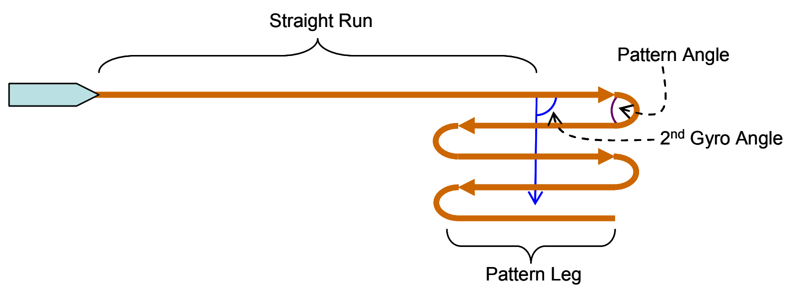


Appendix B: Torpedo Reference Data

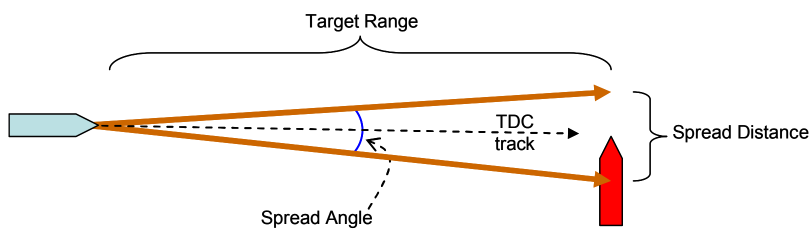
The running speed and range of the most common torpedoes in Silent Hunter III:

Torpedo Type	Speed (knots)	Range (meters)
T I Steam (slow setting)	30	12500
T I Steam (medium setting)	40	7500
T I Steam (fast setting)	44	5000
T II Electric	28	3000
T III Electric	30	5000
T V Acoustic *	24.5	5700

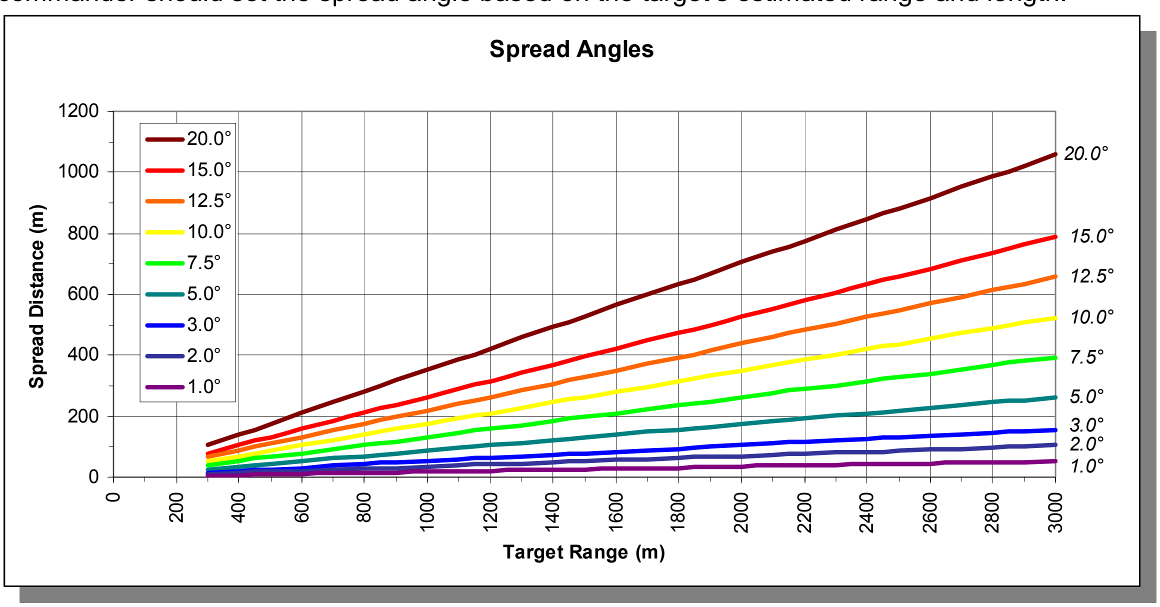
* The Type V torpedo is only effective against targets moving faster than 12-15 knots.



Pattern-running torpedoes can conduct a series of turns after a preset run distance in order to increase the likelihood of success if the initial run fails. These modifications, such as the Federapparat Torpedo (FaT) and the Lagenunabhängiger Torpedo (LuT), are modeled in Silent Hunter III to allow the setting of up to four variables: straight run, second gyro angle, pattern angle, and pattern leg.



A spread of torpedoes is intended to cross the target's track at different points to increase the likelihood of success in case the target data is inaccurate. The number of torpedoes in the salvo is divided evenly across the spread angle which centers on the TDC torpedo track. The commander should set the spread angle based on the target's estimated range and length.



Appendix C: Target Data Log

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

Wer zuerst sieht, hat gewonnen!