Using the Mk1 Mod3 Submarine Attack Course Finder to conduct a passive sonar only approach

joegrundman

Conducting a passive sonar only approach

Introduction

I have made this tutorial to describe an effective way to make submerged approaches when all you have is a sonar bearing. It takes advantage of the Mk1.Mod3 Submarine Attack Course Finder (SACF) (http://www.subsim.com/radioroom/showthread.php?t=106923) and the accompanying manual (http://www.hnsa.org/doc/attackfinder/index.htm). This tutorial will only make sense if you have built yourself a SACF and have read and understood the manual.

Generally, trying to intercept a ship which is moving much faster than you are is an unreliable process whose success depends on the speed and course of the target as well as the strength of your own tactics. However, assuming the target is reachable, this approach will get you close to a firing position without using the periscope, even if you are targeting warships.

Without active sonar, some periscope sightings are still necessary. At least one is necessary for your range for the firing solution, but of course all periscope observations that can be made are useful and will improve the reliability of this method. However, even if the seas are very heavy or fog and rain have reduced visibility to 1000m or less this method will have you in a position to make an effective attack very quickly after the first periscope sighting is made.

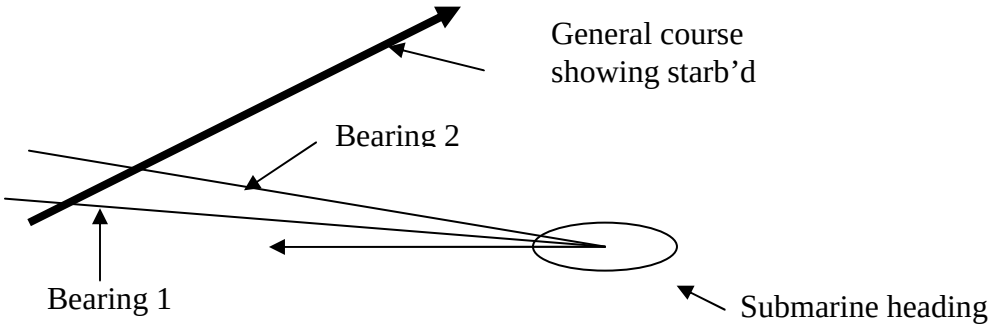
This also promotes quite a different style of play. My most rewarding moments using this method have been lying in the English Channel or any other crowded waterway darting at sonar contacts, letting uncatchable ones go but killing those within your grasp.

However the principles involved are closely related to the actual principles of submerged attack for both US and German submarines in WW2.

Contact phase – establish general heading of target

Once your sonar officer has given you a contact report, take a note of type, relative bearing, whether or not closing, speed and range. Unless it is closing, forget about it. If it is moving fast, then you will require more luck to catch it. Set your true course on the Submarine Attack Course Finder (SACF) and position the periscope on the bearing given by the sonar officer. Read off the target true bearing and draw this on your map.

To establish whether the target will show you its port of starboard side, either come to a stop, turn directly towards the target or directly away from it, whichever is quickest. Once stable, if the relative bearing to target increases it will show you its starboard side, if it decreases it will show you its port side. In addition, you can also take advantage of known characteristics regarding shipping lanes and access to ports to help you determine the general heading of the target.

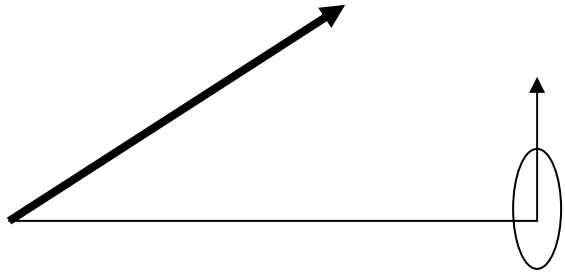


Approach course

Set normal approach course

Using the SACF, or working it out yourself, set a course for your submarine that will bring the target to a relative bearing of 90 or 270 degrees, whichever will intercept the target. Immediately set speed to Full Ahead.

Once on the new course, set your submarine's true course and the target relative bearing on the SACF.



Estimate AOB and target speed

You now have to guess the target speed. Ships often travel at predictable speeds.

Merchant at slow speed: 6 or 7 knots
Merchant at medium speed: 8 or 9 knots
Warship at medium speed: 12 – 14 knots

So, a reasonably accurate guess is quite feasible. If your guess proves wildly wrong, you will find out eventually and you will likely not have a good opportunity to hit it. Lucky for him.

Reduce your speed so that your target maintains a constant relative bearing from you, close to the 90/270 degree relative bearing for a period of 2 or 3 minutes. Once you have a constant bearing to the target, you and it are on a collision course.

As you know your own speed, the following formula will provide an estimate of AOB

Own speed / Target speed = sine AOB

The following table has the range of values you will need for a type VII U-boat, I have this stuck to the side of my monitor. Read off sub speed from the top and target speeds down the side to provide the AOB in the middle cells

Sub speed x Target speed	3kts	4kts	5kts	6kts	7kts
5kts	AoB 37	53	90	-	-
6kts	30	42	56	90	-
7kts	25	35	46	59	90
8kts	22	30	39	49	61
9kts	19	26	34	42	51
10kts	17	24	30	37	44
11kts	16	21	27	33	40
12kts	15	20	25	30	36
13kts	13	18	23	27	33
14kts	12	17	21	25	30
15kts	11.5	15	19	24	28
16kts	11	14	17	22	26

Alternatively, you can use the slide-rule side of the SACF to obtain an AOB estimate in a few seconds. Set the 90 degree mark to the estimated target speed, and then look at the degree marking under your own speed. The results are the same as given for the table a

It is optimal if you have an AOB between 20 and 35 degrees.

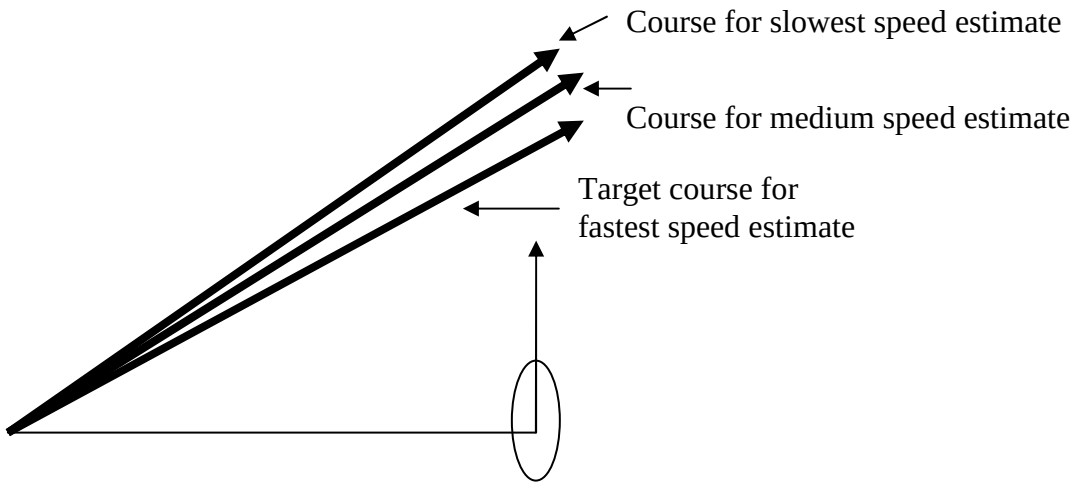
If you find you can’t get a quite stable AOB, make micro adjustments to your course to return the target to a relative bearing of 90/270 degrees until it stabilizes. If the target appears to be off the scale you can manage, then it is too fast or has turned away from you or is otherwise uncatchable. Forget about it and return to waiting for a better contact.

If you find you can only get a constant speed match at very low speeds (1 or 2 knots) then it appears that you have a very small AOB. In that case you should try approaching maintaining a smaller relative bearing. See below for what to do in this situation.

Read off the appropriate AOBs for your chosen target speed and the speeds either side of it. E.g. Your speed 4kts, estimated target speed 8kts, AOB 30. Note also 7kts give AOB 35 and 9kts gives AOB 26.

Double check that the periscope marker on the SACF is set to the target relative bearing, and then set the enemy wheel to show the correct AOB and note down the target true courses for the three AOBs given. Mark these down on your map for quick visual reference.

Note: AI ships tend to follow courses that are multiples of 5 degrees. I.e. Ships will follow courses such as 060, 065 and 070, but not 067 or 068. This means that you can effectively round off your options to produce a 10 degree spread of possible target trajectories. My friends with experience of navigation say that this is not unreasonable, as at sea people tend to adopt these courses as it makes navigation easier.



Estimate target range

Reset your stopwatch and drop the sub's speed by 3 knots, e.g. from 6 to 3 knots. Use power back to increase deceleration if traveling at slow speeds. Alternatively, if you are already moving slowly, you should speed up 3kts, e.g. from 3 to 6kts, and subtract instead of add for the speed calculations.

Once at your new speed, wait until the sonar operator reports the bearing clicking forward or back one degree and immediately start the stopwatch. Note the exact bearing and wait until the bearing has changed three degrees. Note the exact time at which this occurred. (It is important to wait until the a new bearing is noted before starting the

stopwatch as otherwise, at long ranges, you will not necessarily have exactly three degrees and the error could represent a moderate error in your range estimate).

Note: It is not essential that it be three degrees exactly. Obviously any number of degrees will do, but I find three degrees a typically useful number.

Stop the stopwatch. Speed up to maximum to try to regain some lost ground, or slow down to previous speed setting. (It is not vital that you regain lost ground, if we have got this far you will probably be able to intercept the target and you would ultimately like it if the target is a little in front of you when you make visible contact)

Now you need to use the range finder on the reverse side of your SACF. Set the arm to your current speed and set the degree wheel to the estimated AOB (use the median value of the three) and read off from the 90 degree mark the estimated target speed assuming no change in bearing. For example, if dropping speed from 6kts to 3 kts with an estimated AOB of 30 and target speed of 12kts, we note the predicted target speed of 6kts.

Then wait for the relative bearing to move forward 3 degrees, and note the exact time when this point has been reached. Place the arm on the range solver side of the SACF on to the speed that represents the difference between your estimated speed and the predicted speed noted just before. In our example, with the estimated speed of 12kts and a predicted speed of 6kts, 12-6=6, we place the arm on 6kts. We then rotate the degree wheel until the 3 degrees mark is in line with the exact time passed, in our case 4min50sec. We then read off the range in line with the angle on bow - in our case 30 degrees gives a range of 9100yds.

As we are playing SH3, ranges need to be converted to meters. Just knock off 10% for an acceptable conversion, so 9100yds gives 8200 meters range to target.

Mark range to target on the map.

<u>What to do for very small angles on bow</u>

The 1950 US submarine doctrine (http://hnsa.org/doc/attack/) prescribes the following approaches for very small angles on bow:

AOB	use lead angle (ie periscope bearing to target)	use speed
0	0	2 kts
5	30	1/3 speed
10	45	1/3 speed
15	65	standard
20 or greater	90	standard to full

I find that the recommended speeds are somewhat large for the Atlantic given the slower typical speeds of merchants, and I can generally use slow ahead for AOB's of 15 degree with a 90 degree lead angle.

However there are still many occasions when it is not effective to use a 90 degree approach and therefore a narrower approach angle should be adopted.

The mathematical problem to solve the AOB can be solved by me in a couple of minutes with pen and paper, but using the SACF it can be solved in about 5 seconds.

The problem is a trigonometry problem for a non-right angle triangle.

In the following example, the periscope angle to target (lead angle) is 60 degrees. Let's say your speed is 5 kts and you have guesstimated the target speed as 8 kts.

To solve it you need to drop a line, y, in the triangle to create two right angled triangles.

The "length" of line, y, is:

y = sin periscope angle x submarine speed.

In our case, y = sin 60 x 5 = 0.875 x 5 = 4.375

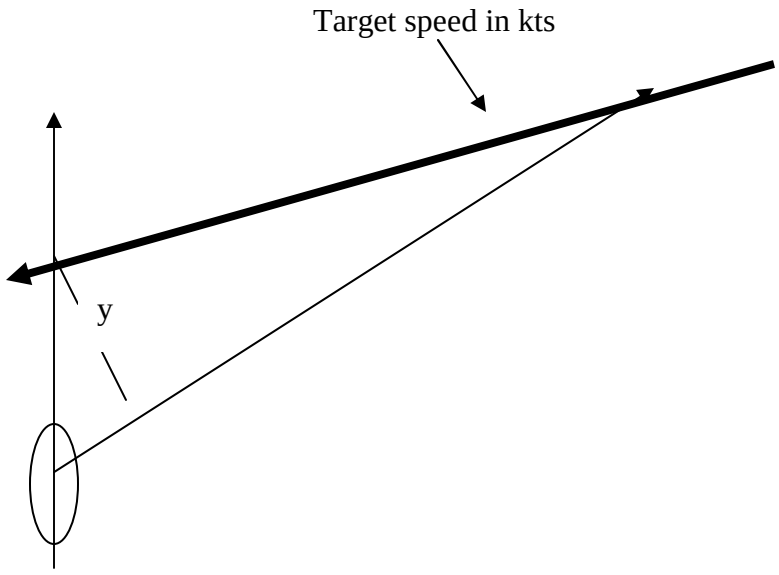
AOB is then given by

y/target speed = sin AOB

In our case:

4.375/ 8 = sin AOB = 0.546875

Therefore AOB = 33 degrees.



However, using the SACF this can be solved much, much more quickly! On the slide rule side, set the guesstimated TARGET SPEED to the LEAD (periscope) ANGLE. In our case, set 8kts to 60 degrees. Read off the AOB under the SUB SPEED. In our case 5kts gives, yes, AOB 33 degrees! Sehr einfach Herr Kaleun!

This method can also be used for lead angles of 90 degrees too, instead of writing the table, and is scarcely any slower.

<u>If target changes course</u>

If you have a stable track and the target suddenly changes relative bearing, then the target has changed course. It may not be possible to catch up with the target, but if you still have plenty of range and it is not moving too fast then you may be able to keep up with the target. Bear in mind that most course changes are of 30 degrees.

<u>Preparing for attack</u>

Now mark true courses for the different possible AOB's on the map, with the courses passing through the measured range. There will be an area in which you expect the target to appear. Mark in a point on your course at which range to target is 3000m and again at 2000m. Also note the angles at which you will intercept the target track. You should plan ahead for the firing course, and the final AOB solutions, you will adopt once you have made visual contact. Any mental preparation you can make in advance will save you valuable time once visual contact has been made. Prepare for the speed and AOB solution assuming the target is on the nearest track (i.e. the smallest AOB and the fastest speed)

If you already know the range of visibility, mark the point on your track at which you expect the target will become visible.

These precautions are necessary because you do not want to miss the first possible observation, especially if visibility is very poor.

Make regular scope observations. Once visual contact is made, look to see if its apparent range and AOB falls within your predicted area. If so, prepare for attack.

If you have passed the nearest planned for track and the target is clearly not on the nearest track, plan target speed and AOB for the target to be on the next estimated track. Repeat if the target is clearly not on this track either.

Attack Phase

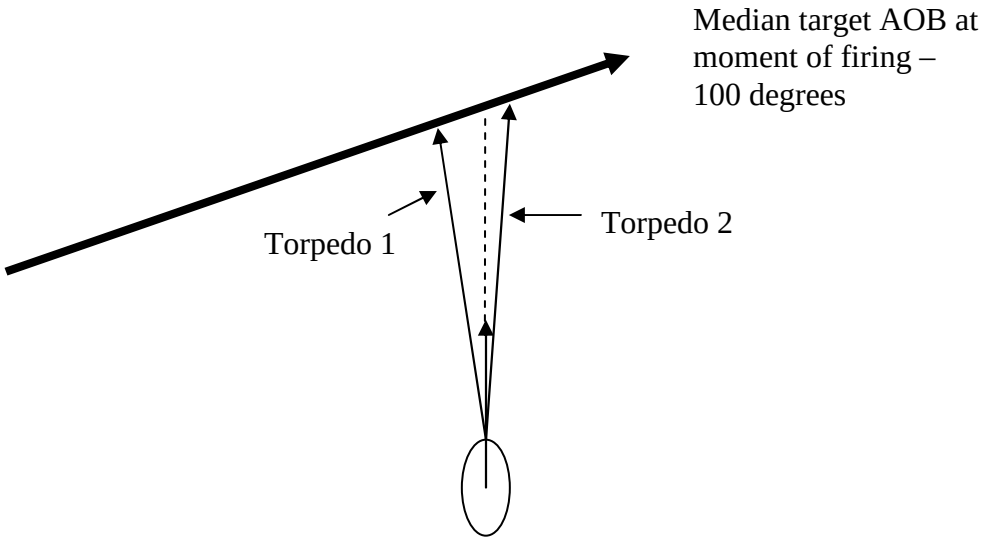
In situations of poor visibility or severe sea conditions, your firing solution is going to be weak. In order to minimize the error there are three things that should be considered essential.

Firstly, you want a gyro angle as near to 000 as possible, in order to eliminate errors due to torpedo tube parallax (the difference between the angle to the target from the front of the submarine and the angle to the target from the periscope in the middle of the submarine). This error becomes significant when range solutions are weak.

Secondly, you want to be firing on the optimum torpedo track to hit the target. It is not 90 degrees from the target's bow. For a fast running torpedo it is about 100 degrees on the bow for a slow merchant and about 110 degrees on the bow for a warship at medium speed. See the Submarine Torpedo Fire Control Manual (http://hnsa.org/doc/attack/) for further information.

For a slow running torpedo, the optimum attack course is 105 degrees for a merchant and 120 degrees for a warship at medium speed. These values are a bit different in the pacific as merchants tend to move faster. The above mentioned manual has a couple of charts for computing optimum track angle for different torpedo speeds.

To obtain this optimum firing course using the SACF, assuming it is already set up accurately to represent the sub's and the target's courses, move the periscope marker to the desired firing course on the appropriate side of the target's bow, e.g the position for an AOB 100 course. Read off the correct firing course on the true course wheel on the opposite side of the scope.



Thirdly, just as in real life, you must use spreads if you have any reason to doubt the accuracy of your range and AOB solutions. Single shots are not sufficient. I prefer to make my spreads manually as I then have more control over the angle and time between shots. For a two shot spread, aim the first to near the stern and the second a few seconds later to near the bow. If you use a third one, send it down the middle.

Extended Example

We are cruising at 3kts on silent mode at 25m depth about 50km north of Scapa Flow on heading 275 degrees.

Contact

"Contact. Warship. Closing. Medium Speed. Bearing 005. Long range" Set course bearing 275 on SACF. Set periscope to 005 on SACF and read off true bearing to target, 281. Mark this bearing on the map. As the target is close to directly ahead of the sub it soon gives a new relative bearing of 006 without having to maneuver. This means the target will show its starboard side and pass to my north.

Begin approach By now target is at relative bearing 008. Read off from periscope view on SACF the 90 degree approach course (normal approach course), which is 015. Turn to 015 and speed up to 6kts. Reset submarine's true course on SACF. Reset Periscope view on SACF to the now presented target relative bearing – 272 degrees.

The relative bearing to target appears stable after a few seconds, so I start the stopwatch. After 2mins the relative bearing still hasn't changed, therefore I consider us to be on a collision course.

Estimate AOB

Assuming the target is cruising at a typical speed of 12-15kts, I use the AOB table to get possible AOB's of 30 for 12kts, 27 for 13kts, 25 for 14kts and 24 for 15kts. Using the

SACF I obtain target true courses of 075, 078, 080 and 082 degrees. I mark these on the map as a reference

Estimate Range

I reset stopwatch and set speed to 3kts, and note the exact bearing to target, 272 degrees.

Once the speed reaches 3kts, start the stopwatch.

On the SACF rangefinder, set speed to 3kts, AOB to 25 and read off predicted range for stable 270 degree relative bearing, which is 7kts.

The bearing moves forward 3 degrees to 275 at exactly 4mins and 50seconds. Set speed to 7kts to regain some lost ground, but this is not urgent, as ultimately I do not wish to collide.

Estimated target speed is, say 14 knots, and 14-7 gives 7. Put the arm of the range finder on the 7 knot mark. Keeping the arm steady, rotate the degree wheel until the 3 degrees marker on the degree wheel matches the time of 4mins and 50secs. Read off the range in line with the estimated AOB of 25 degrees. 9000yds.

Now we have to convert yards to meters, 9000 yards – 90 = 8100 meters

Now we plot the estimated courses at the correct range.

I also draw a line of sight bearing indicating when the 2000 m range to target is coming up.

I note that my track angle on the target is close to the optimum of 110 degrees, so I do not need to change my course to get a better firing position, and so can begin to program the TDC assuming I contact the target on the earlier course.

At about 2000m from the target I make visual contact. It is very heavy weather and accurate range, or even type recognition, is impossible. However, range and AOB appear to fall within my estimated range.

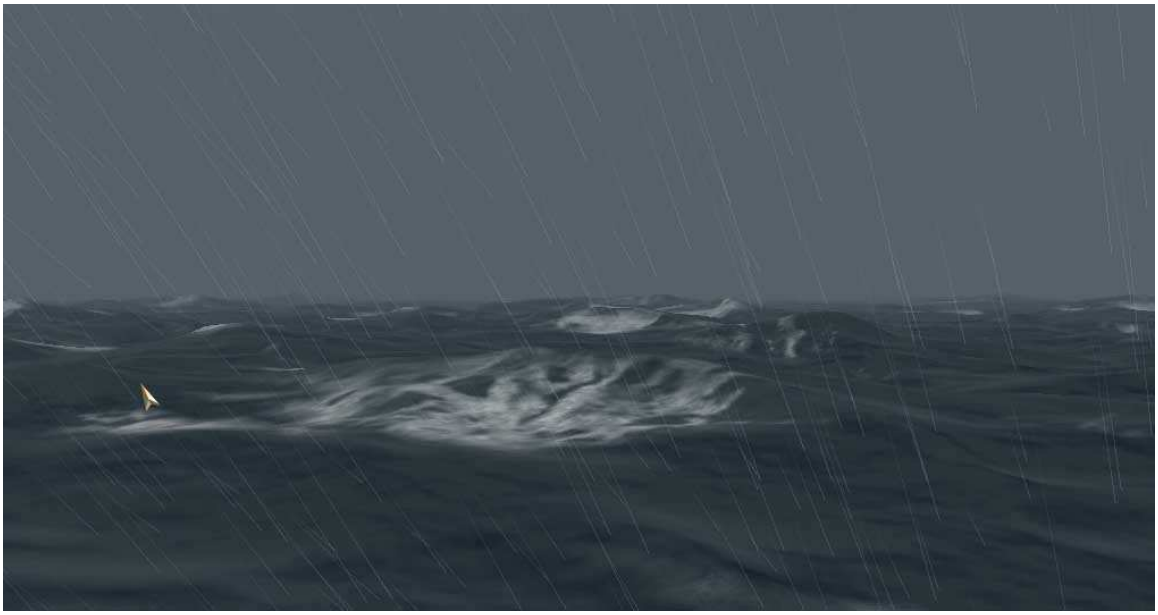
At about 1000m I can see that the target is too far to be on the nearest estimated track, I shift the AOB wheel on the TDC 4 degrees. I identify target as V&W destroyer. Range is still a bit far.

I am in firing position, and have only a 350 degree gyro angle, I make a final observation, realize range is about 500 m further than estimated; giving a total 1500m range, but my position is optimal, so my figures should work. Send range to TDC.

At 358 gyro I send tube 1 at the stern of the target, 4secs later at 001 gyro I send tube 2 at the bow.

Boom! First torp hits forward of the center. Second torp skips past the bow but the damage is done. The destroyer knifes straight down to the bottom. It was a C-class destroyer.

Illustrated Example Using U-jagd Tools Mod 1.3

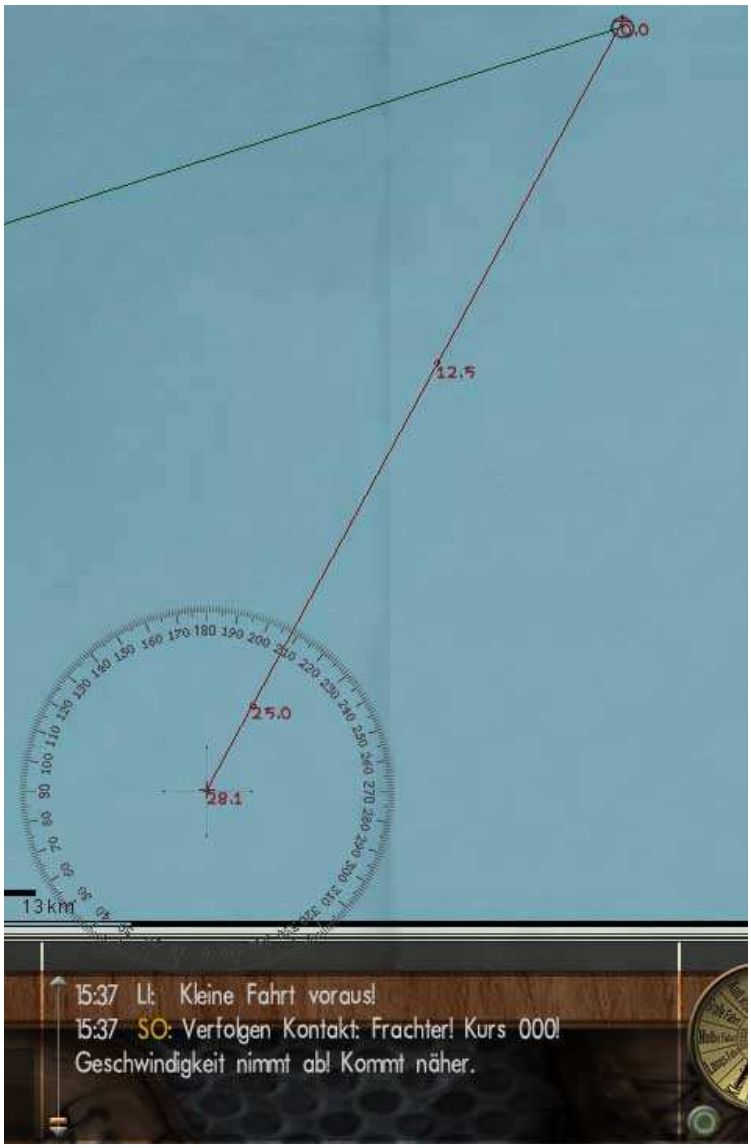


This is the weather, with visibility only slightly more than the minimum torpedo run distance.

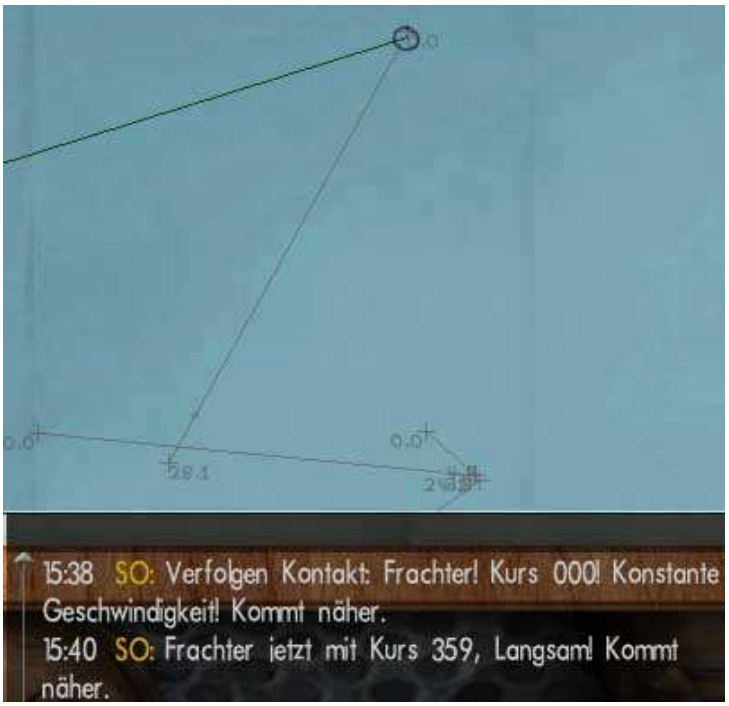
I'm moving at 3 knots at periscope depth. This is the first contact from the Sonar man.

First thing I need to do is determine whether the target will show me his starboard or port side. To do so, I speed up to Full Ahead and turn to head directly towards the contact (which I do by moving the scope view 72 degrees to starboard and pressing Set Course To Heading, =).

With the target directly ahead, I slow down again to improve listening, I set my Sonar officer to follow the contact and I plot the direction to the target on the navmap.



I now hold this course and speed until the sonar man reports the bearing to target has changed. If the bearing goes down (to 359) the target will show me his starboard, if it goes up (to 001) it will show port. After two minutes the course has changed to 359, so I mark the general direction of motion of the target on the map.



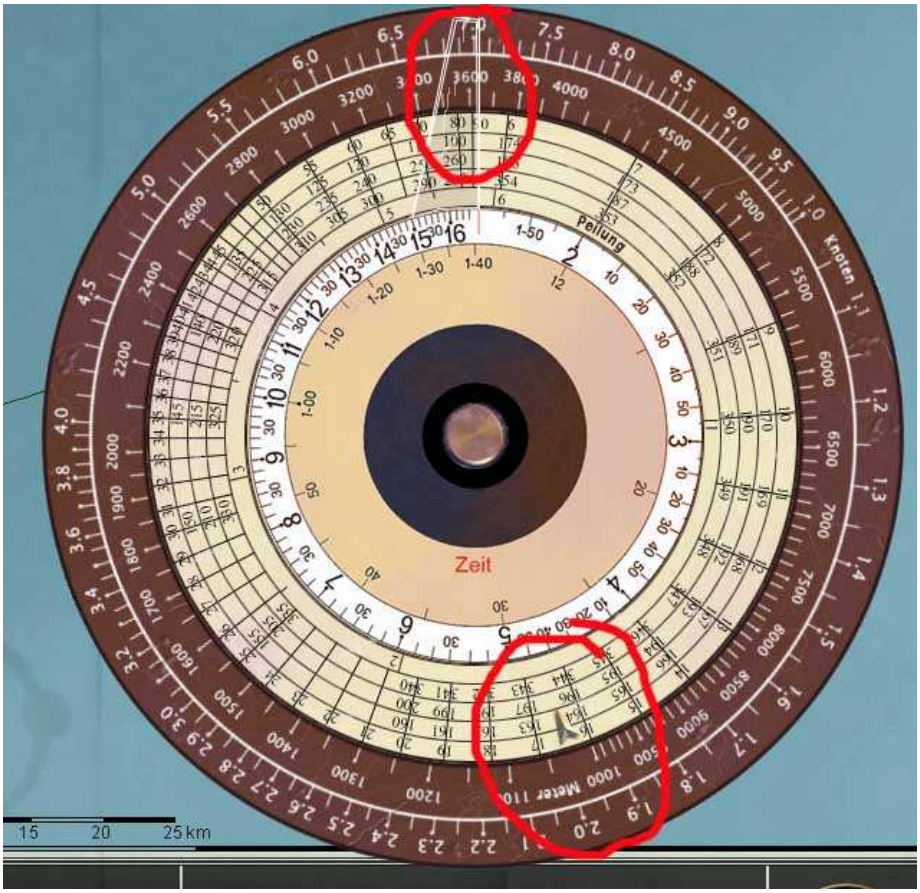
I now set a course that will bring the target more or less on a bearing of 090. So I speed up and turn 90 degrees to port. I mark my own heading on the navmap. The target bearing is now 086, which is fine.

I now need to find the correct speed that will hold a constant bearing to the target. That is, I want the target to stay on the same bearing of about 085 without changing for a few minutes. I get the feeling the target is very slow because of how long it took to change bearing from 000, so I first set my speed to 2 knots to try to keep constant bearing.

This turns out to be the right choice and there is no need for me to adjust it. After 10 minutes at 2 knots the target is fixed on 086. I consider this to be satisfactory evidence that we are on a collision course.

Now I need to make some guesses about target speed. The sonar operator reports it is traveling slow (langsam!). Experience tells us that slow for a merchant means 7 knots or below. As I said before, my feeling was that it was traveling really quite slow, so I'm guessing at 5 knots. But the preciseness of the guess doesn't matter as we will work out a series of options for the speeds 7 knots, 6 knots, 5 knots and 4 knots. That will cover all options.

So having selected my speeds, it's time to get a picture of AOB. For this we need the circular slide rule under the watchman icon.

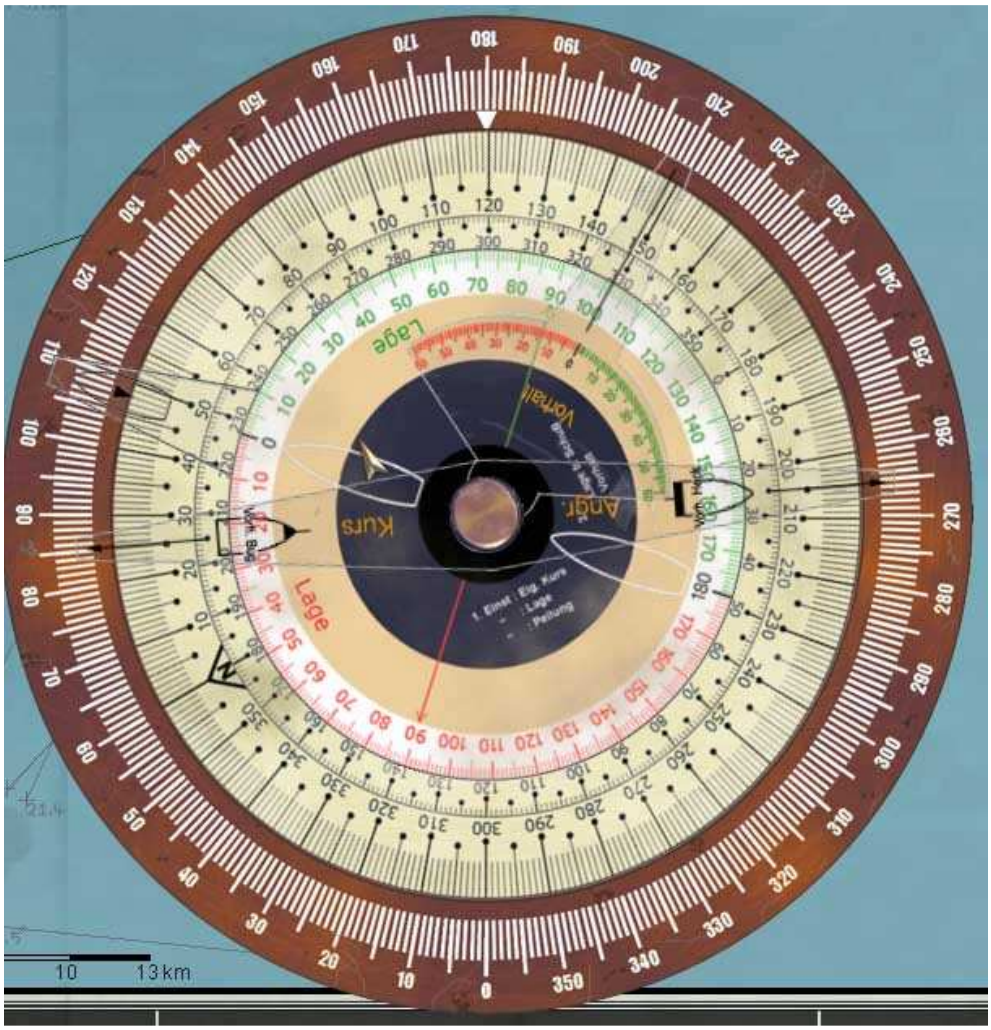


The formula describes a triangle, where my speed makes one side, target speed makes another, bearing to target makes one angle and AOB makes another. Using the sliderule, it is easy to solve the 4 th if 3 of these quantities are known.

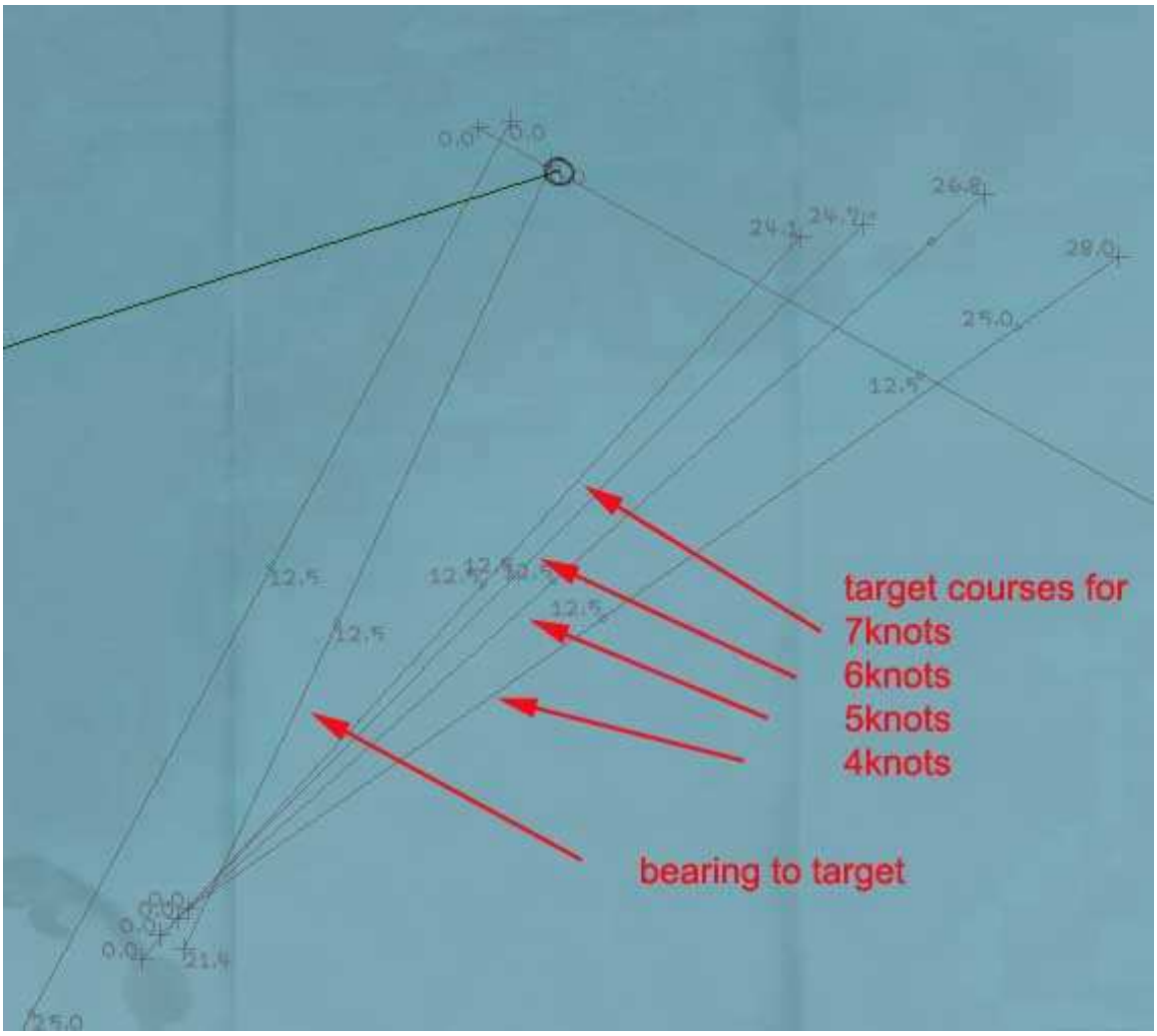
On the slide rule, I match the bearing to target, 86 degrees opposite the supposed target speed of 7 knots. Under my speed of 2 knots I read off the AOB. It shows 16.5 and we know it is starboard.

I then repeat the process assuming target speeds of 6knots, 5 knots and 4 knots and obtain AOB's of 19, 23 and 29 respectively.

Then using the Attack Disk under the Navigator I convert those AOB's to target course. To do that, I rotate the bearing arm to the 86 position, then rotate the Target course wheel until the correct AOB crosses the bearing arm. I do this for each of the AOBs. In this case for the AOB of starboard 23, I get a target course of 048.



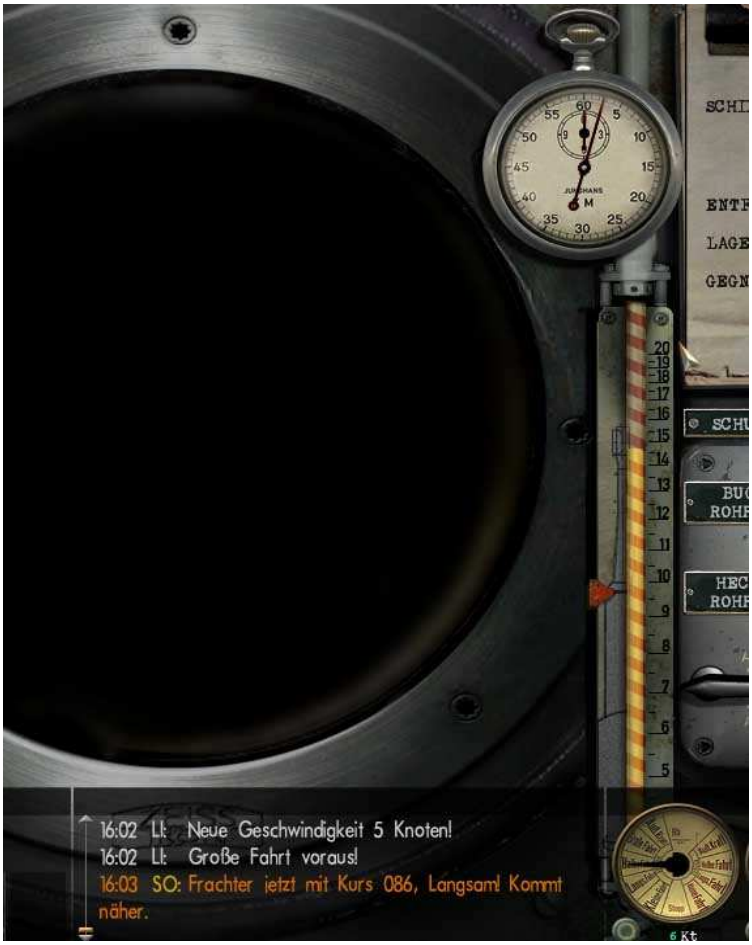
I then draw in all the determined target courses for each of the different speeds on the Nav map.



At this stage you can begin to get a feel for how the attack will pan out.

Having done this, and remain satisfied that we are on a collision course, it is time to get a rough range estimate.

We wish to change our speed significantly. Because we are traveling slow, we will speed up to standard, which is 6 knots. Wait until we reach that speed and then wait until you have a new bearing to target. Immediately then start the stopwatch.



Start the stopwatch!

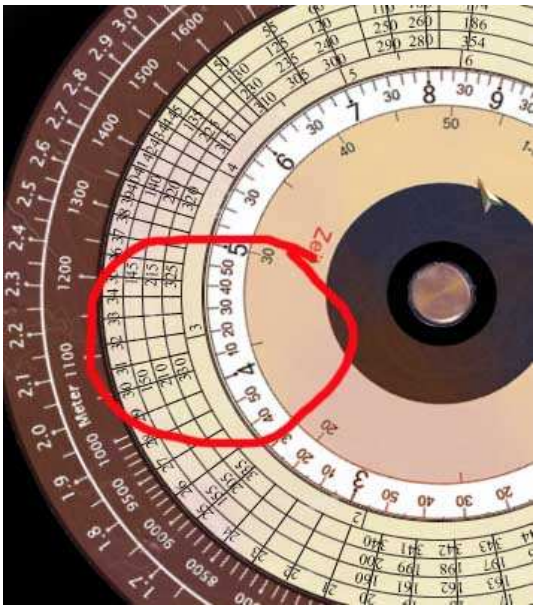
Now wait until the bearing to target has shifted 3 degrees. Exactly at that point, stop the stopwatch.

You can see here, it took 4 minutes and 20 seconds for the bearing to target to move exactly 3 degrees.

In this maneuver I have lost position on the collision course and I risk passing ahead of the target. I don't want this to happen, so I come to full stop and wait until the bearing to target has come to 80.

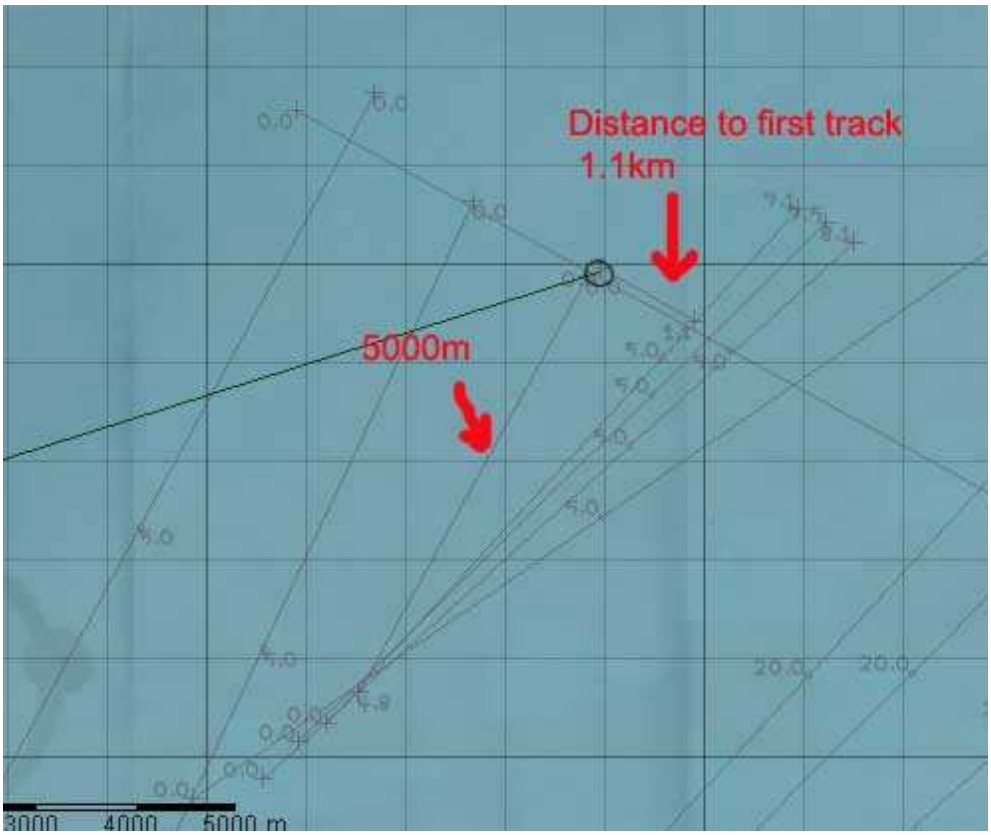
In the meantime I perform the calculation to get a ROUGH range estimate. Please note this really is not an accurate range reading, but it gives you a picture of the situation.

Open the circular sliderule and set the time wheel so that 4 minutes 20 seconds is directly under the 3 degree mark on the middle wheel.



Now rotate the outer wheel until one of the speed estimates is in line with the plastic indicator on the time wheel. We'll use the 7knots estimate, for no particular reason.Then look for the range against the point on the degree wheel that shows the AOB estimate for that speed that you are using – in our case 16.5, if you remember, gives 5000m.

I now then draw the complete situation on the map, with all the possible target courses going through a point that is 5000m away on a relative bearing of 86.



I note the distance to track is a minimum of only 1.1 km. I use the nomograph to tell me that at 7 knots the target will meet me in about 20 mins and at 5 knots in about 40 mins.

Now that the target is on my 80, the next step is to begin the attack approach. I adopt a course of 135 to give me an approximately 90 degree angle on the target track and set speed to 2 knots.

Given the very poor visibility, I hope to meet the target at a bit more than the minimum torpedo range with the target roughly straight ahead from me so that I just have time to check nationality and fire, without needing further maneuvers.

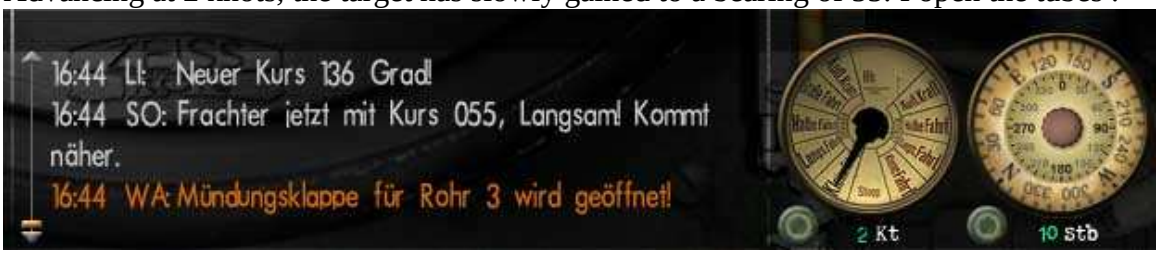
One needs to bear in mind that as the AOB increases, you need a higher speed to sustain a collision course, but as said, we don't actually want a collision course. We want the target to pass about 500m in front of us.

So this means you need to carefully use speed as you advance towards the target track in such a way that the rate of target advance remains kind of constant – and not too quick at that. Certainly no more than 4 degrees per minute, otherwise it may pass you beyond visible distance. You can still take shots even when you can't see the target, and hit, but it's better to have visual contact.

So, I now program my TDC for a 90 degree shot. That is set the scope to look down the 000 heading, then go to the TDC. Turn on manual update, set AOB to 90 starboard, range to 500m, speed to 6 knots. Turn Auto update on. Don't forget to also set torpedo speed to fast and depth to shallow and fuse to contact.

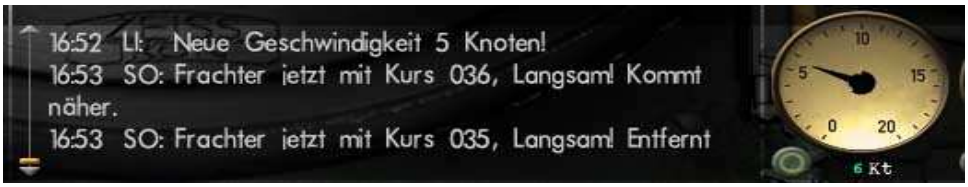
This has you set for a snap shot against the target. Maybe we can refine the speed estimate later.

Advancing at 2 knots, the target has slowly gained to a bearing of 55. I open the tubes .



At a bearing of 043 I set speed to 3 knots as the rate of advance is beginning to pick up.

Still nothing in sight! It's now been about 40 mins since the range estimate so I am confident the target is moving at 5 knots. I adjust the TDC speed setting to 5.
I keep on increasing speed to maintain a favourable position. I'm now at 6 knots with the target on my 35 and still not in sight.



There he is! Faint in the rain on a bearing of 27, and about 700 m ahead.

He's showing a good AOB, and I check the flag is indeed British. I waste no more time, no adjustments, no maneuvers, and no new settings. Fire one! Los!

Torpedo treffe! He sinks about 20 minutes later, with me following behind. Perhaps normally I'd fire a spread, but it was traveling so slow I was very confident of a hit.

That's it!

Joe

Acknowledgements

Thanks to Captain Krunch for his research and excellent vision in building the first SACF replica. Thanks to the admin of hnsa.org for coming up with the declassified submarine doctrine manuals. I am a changed man now! Thanks also to Hitman for encouragement and his kind offer to host this tutorial on his filefront location. Finally thanks to my wife, Abigail, for extreme patience with my submarine obsession as well as practical trigonometric help.