Feature

Straight Running Torpedo Attacks

by Guest Writer **Don Simon**

Introduction

WW II era destroyers were, by today's standards, relatively small vessels. Although capable of high speeds, they carried no armor and thus succumbed relatively fast to battle damage, if hit. Their 5" gun armament was generally useful against their own counterparts or smaller vessels, but against an armored capital ship they weren't likely to be the victor in a guns only shooting match. However, most WW II era destroyers carried a powerful torpedo battery, one no capital ship commander could ignore. For the above reasons, destroyers can be described as "Eggshells armed with hammers", or in the case of Japanese destroyers armed with the Type 93 "Long Lance" torpedo, "Eggshells armed with sledge hammers."

Destroyer Command (DC) does a very creditable job of simulating straight running torpedoes. In addition, the player is provided with a fairly realistic and useful torpedo director station (F12). In this article I will touch on the technical requirements of the straight running torpedo firing problem. Pattern running and homing torpedoes are not simulated in DC and are not covered here.

Torpedo Advantages/Disadvantages

Like any weapon system, torpedoes have their advantages and disadvantages. DC does a very good job of simulating these advantages and disadvantages. Here are some of the factors to consider:

Advantages

1. Massive damage per hit. Even battleships can not ignore this weapon.

2. Fire and forget. Once launched it requires no further guidance from the launch platform.

3. Difficult to spot. Especially at night or in low visibility, the target may not even know it's under attack until *KA-BOOM!*

Disadvantages

1. Slow missile. A torpedo is, in general, not much faster than its target, and in some cases it is even slower. This results in large "lead" angles and long run times, giving the target more opportunities to evade.

2. Limited number of torpedoes carried. The most number of torpedoes carried by a US destroyer class was 16 aboard the Bagley/Benham/Gridley class, and the destroyers of most nations carried about half that number.

3. No at sea reload capability (except Japanese destroyers). This factor, along with 2, above, make torpedoes a sort of "Silver Bullet."

4. Killer robot. Be careful of where you shoot these weapons. Once launched they have no friends and there are no means to self destruct them. They will just as easily blow your friends out of the water as they will your enemies.

Basic Problem

As with any weapon system, one must be within the weapon's release envelope to even have a possibility of a hit. In naval parlance the weapon's release envelope is called the Torpedo Danger Zone (TDZ). This is the first part of the problem. Once in the TDZ, the aiming problem must be solved. However, just being in the TDZ and solving the aiming problem does not say anything about the probability of a hit. The optimum firing position is influenced by the aiming problem itself and the ability of the target to evade the attack. In general, one wants the torpedo to cross the target's path at a right angle in order to maximize the hit probability. In addition, one wants to shoot from as close a range as possible in order to minimize the target's opportunity to evade.

TDZ Definition

As previously stated, you *must* get inside the TDZ to even have a chance of hitting. For our purposes the TDZ must meet two criteria:

a. The torpedo warhead is armed. This requires the torpedo to have traveled its minimum arming distance, generally 450-500 yards.

b. The torpedo can reach its target, i.e., it does not run out of fuel before target interception.

The inner size and shape of the TDZ depends on three factors. They are:

a. The distance the torpedo must travel to arm.

b. The chosen torpedo speed setting.

c. The target speed.

The outer size and shape of the TDZ depends on three factors. They are:

d. The maximum distance the torpedo can travel at the chosen torpedo speed setting.

e. The chosen torpedo speed setting.

f. The target speed.

The size and shape of the TDZ holds only as long as these factors remain constant. The moment any one of them changes is the moment the size and shape of the TDZ is redrawn. Also, note that the TDZ is *relative to the target ship*. You might be in the TDZ when a change of course or speed by the target throws you out of the TDZ.

TDZ - Stationary Target

Constructing the TDZ around a stationary target is very simple. First, since the warhead must arm, draw a circle around the target with a radius equal to the arming distance. Don't shoot from inside this circle! If you do (and you hit), nothing will happen as the dud torpedo impacts without exploding. Second, since the torpedo must reach its target, draw a circle around the target with a radius equal to the torpedo range for the chosen speed setting. Don't shoot from outside this circle! If you do you won't hear anything because the torpedo will never reach the target.

TDZ - Moving Target

Things get a bit more interesting when the target is moving because the TDZ gets shifted along the target's line of motion.

At a chosen speed setting, a torpedo has a finite amount of run time before it exhausts its fuel. Let's assume we are shooting a hypothetical torpedo with a speed of 60 knots (!) and a range of 6,000 yards. This torpedo has a maximum run time of 3 minutes. In addition, let's assume our target is travelling at a speed of 25 knots.

If the torpedo is fired from dead astern of the target, the torpedo obviously has to catch up to the target. At a range where the torpedo must use its maximum run time (here 3 minutes), the range to target at the time of firing will be considerably less than the maximum distance the torpedo can travel. During the 3 minute run time, the target will travel 2,500 yards and the torpedo will travel 6,000 yards. This means the maximum range we can fire from astern and still hit the target is 3,500 yards astern of the target.

Likewise, if the torpedo is fired from dead ahead of the target, we can fire from as far as 8,500 yards ahead and still hit the target.

The standard method of constructing a TDZ is as follows:

1. Compute the distance (*PP-AP*) from the target's present position (*PP*) to its advanced position (*AP*) as follows:

$$PP - AP = \frac{(\text{Torpedo Range}) \times (\text{Target Speed})}{(\text{Torpedo Speed})}$$

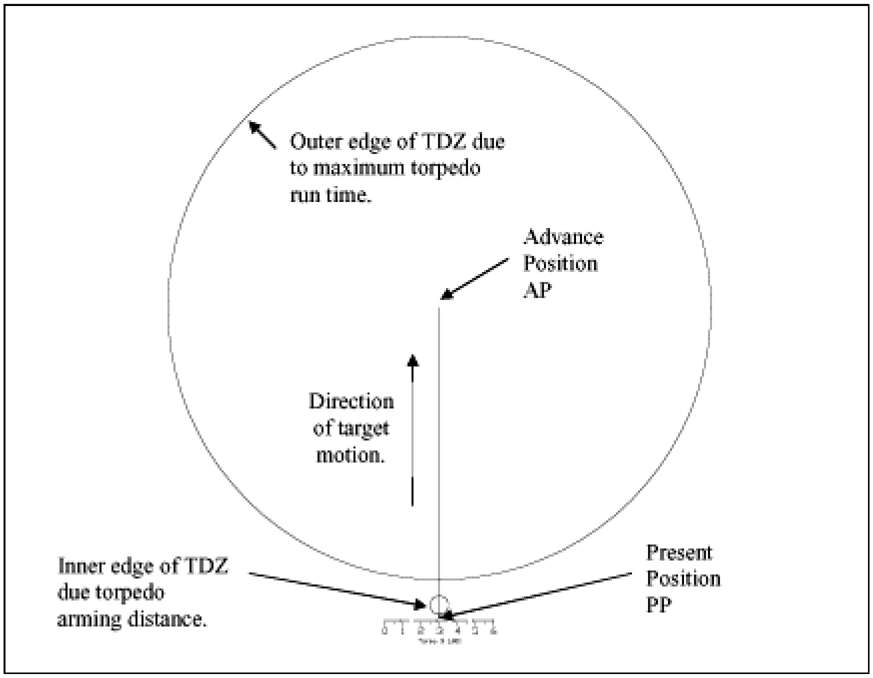
2. Plot point AP along the target's line of motion at a distance = *PP-AP* from the target's present location.

3. Draw a circle centered at AP with a radius = Torpedo Range. This circle defines the outer limit of the TDZ. *Don't shoot from outside this circle!*

The inner edge of the TDZ is drawn in the same manner, except the radius = arming distance. Again, don't shoot from inside this circle. In general, it will be very rare indeed that you will need to worry about arming distance. Note that the inner TDZ boundary is not necessarily within the circle describing the outer TDZ boundary.

Figure 1 illustrates the TDZ for a Mk 15 torpedo at its 26.5 knot setting against a 30 knot target. The arming distance is 450 yards and the maximum range is 15,000 yards.

Figure 1 - TDZ for a Mk 15 Torpedo at the 26.5 knot setting against a 30 knot target.



Aiming Problem

For a straight running torpedo, the aiming problem is actually a simple two dimensional interception problem. Barring a malfunction of the torpedo's propulsion system, the problem is simplified by the fact that the torpedo maintains a constant speed. In addition, the torpedo depth control system hopefully keeps the torpedo at a constant depth, so gravity effects are not a consideration. Figure 2 shows the geometry of the torpedo aiming problem. To solve the aiming problem we need to know the target's course and speed, the torpedo's speed, and our location relative to the target's line of motion.

The line between you and the target is called the Line of Sight (LOS). If the target is moving we obviously need to shoot ahead of the target in order to intercept it. The direction we shoot the torpedo in is called the Line of Fire (LOF). The angle between the LOS and LOF is called the Sight Angle (SA). SA is our "lead" angle. Finally, the angle between the target's line of motion (or velocity vector) and the LOS is called the Angle on the Bow (AOB). AOB is measured from 0° (dead ahead of the target) to 180° (dead astern of the target), with AOB = 90° meaning you are on the target's beam. AOB is usually given a designator to denote which side of the target you are on, e.g., "AOB: 125° Port."

The sides of the triangle representing the target's motion and the torpedo's motion are vectors. As such they must be drawn in their correct directions, and their lengths must be in correct proportion the each other. Solving for SA is a simple trigonometry problem with the length of two sides and one angle known. The solution for angle SA is given by:

$$SA = \sin^{-1}\left(\frac{(\text{Target Speed})\times(\sin(AOB))}{(\text{Torpedo Speed})}\right)$$

Here, (Target Speed) and (Torpedo Speed) must be in the same units (usually they are given in knots, although any compatible speed units could be used). Note that if (Target Speed) = 0, SA = 0° (of course, (Torpedo Speed) > 0).

I can hear the groans now — "Do I have to calculate this on the fly?" The answer is **NO**. Your F12 Torpedo Director station calculates this for you.

If you draw a line parallel to LOF through the present position of the target, you'll notice that the angle between the LOS and the line parallel to LOF is the same as SA. This angle is called Track Angle (TA). TA + AOB give the angle between the target's motion and the torpedo's motion, or in other words, the angle of impact. Ideally you want the impact angle to be 90° as this maximizes the target's length presented to the torpedo, thus maximizing the chances of a hit. If the impact angle is 0° or 180° then only the target's beam is presented to the torpedo. A ship's beam is typically 1/9 to 1/6 of its length. This means a "Down the Throat" shot (impact angle = 0°) or an "Up the Kilt" shot (impact angle = 180°) has about 1/9 to1/6 the probability of hitting as a beam shot (impact angle = 90°), all other factors being equal.

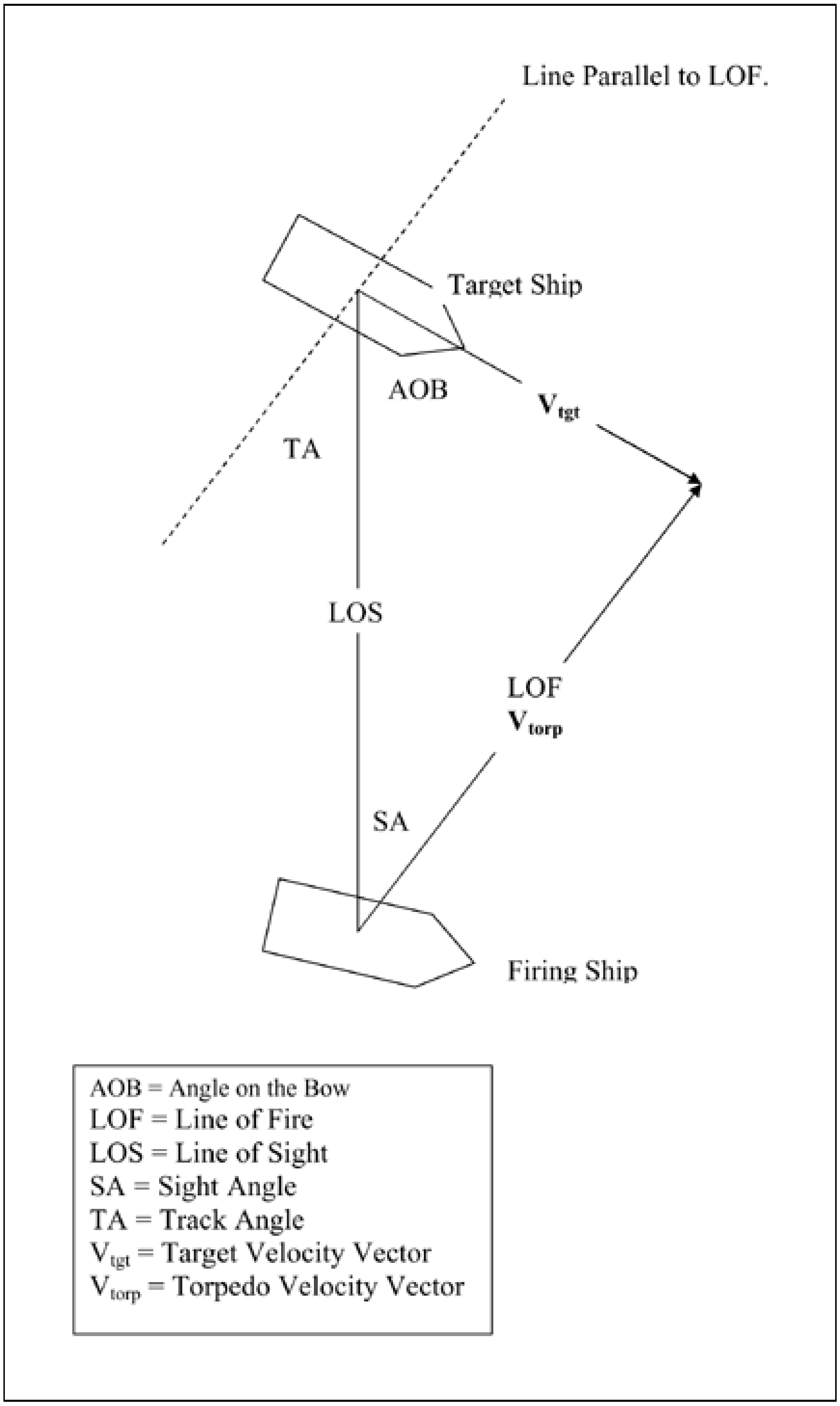
Other items to note:

1. The firing ship's course and speed are irrelevant to the aiming problem. Note — this is opposite to air-air weapons employment, where the velocity vector of the launch platform has a large influence.

2. The firing ship's heading relative to the LOF only determines if the LOF is in a clear arc for the torpedo launcher.

3. Solving the aiming problem says nothing about whether or not your torpedo actually has enough run time to reach its target. You must be in the TDZ or the torpedo will not hit its target.

Figure 2 - Torpedo Aiming Problem Geometry



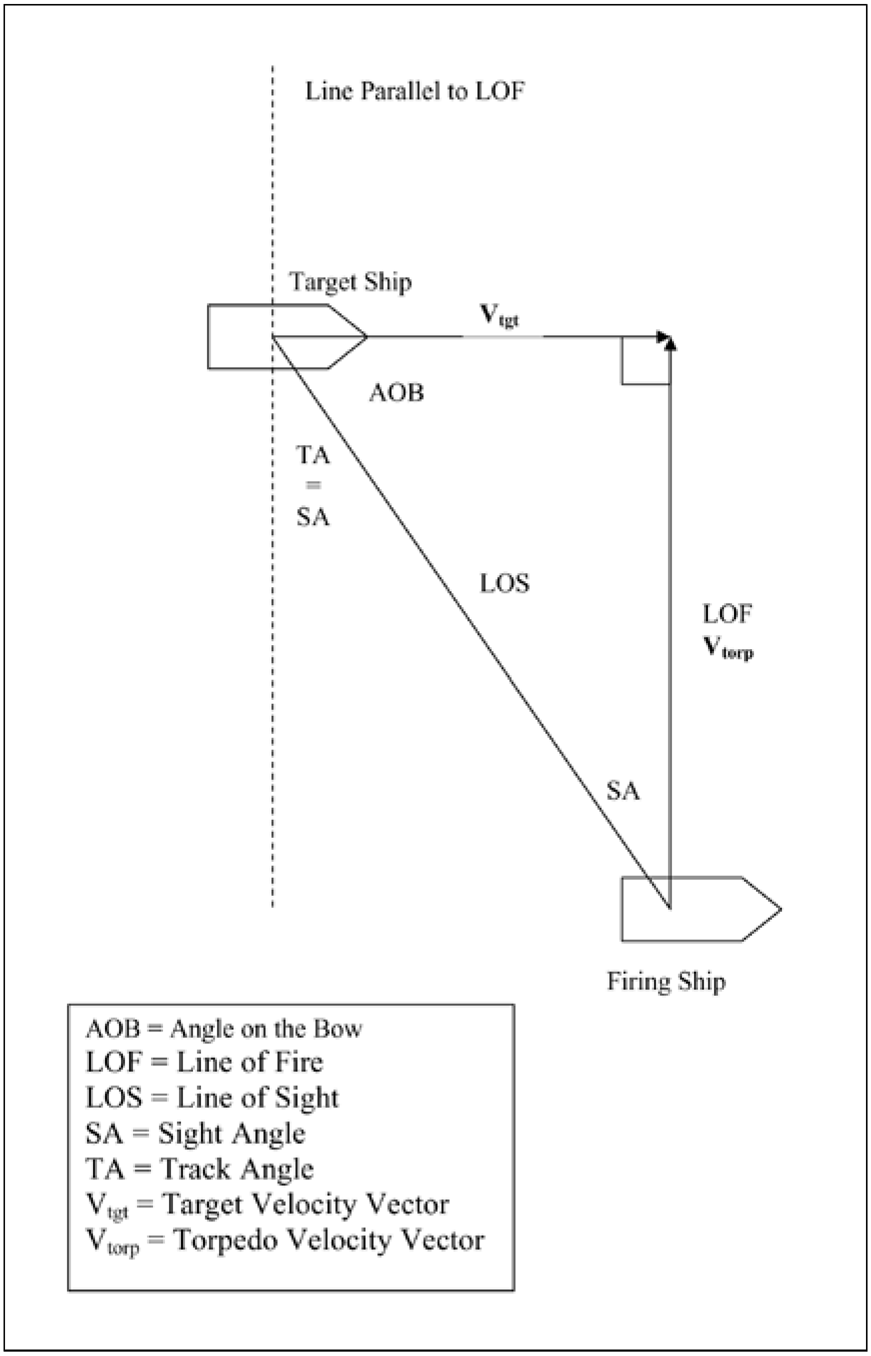
Optimum Firing Position Within the TDZ

Barring flukes in the exploder mechanism, one ideally wants the torpedo's path to cross the target's path at a 90° angle. This means TA + AOB = 90° for an ideal shot. Such an interception ensures the maximum length of the target is exposed to the attack. Under actual conditions you will be doing well to get a shot having TA + AOB within ± 30° of the target's beam.

If the target is stationary, we want to shoot from its beam (AOB = 90° , Port or Starboard) and SA = 0°. You will rarely get this opportunity. Most of the time you will need to fire from forward of the target's beam in order to get a

TA + AOB = 90° . Numerically TA = SA, so we can say SA + AOB = 90° . *In the special case of SA + AOB = 90°, SA will equal the angle forward of target's beam we need to be in order to get a crossing angle of 90°*. See Figure 3.

Figure 3 - Special Case of 90° Crossing Angle



Just how much does SA need to be? That depends on the ratio of (Target Speed)/(Torpedo Speed), which I call K. The following table shows what SA must be to yield a 90° crossing shot for various values of K. You can see that a high torpedo speed brings many advantages – the higher the torpedo speed, the lesser the value of K, thus the lesser value of SA we need to get a more optimum shot. A higher torpedo speed also reduces time to target, which reduces the target's ability to evade.

Table 1 - Optimum Sight Angle (SA) and Angle On The Bow (AOB) for a 90° Crossing Shot, Various Values of K.

K	SA	AOB (= 90° - SA)
0	0°	90°
.25	14°	76°
.50	27°	63°
.75	37°	53°
1.00	45°	45°
1.25	51°	39°

Getting to the optimum firing position is a relative motion change of station problem. Essentially you need to "aim" your ship ahead of the target ship the same as you aim the torpedo. The entire subject of relative motion is really beyond the scope of this article and the reader is referred to several standard texts on the subject. Among the two best references are:

1. NIMA PUB 217 Maneuvering Board Manual
2. Dutton's Navigation and Piloting

To illustrate how long it takes to get to an optimum firing position, I worked out the relative motion problem for several cases of a hypothetical scenario. The maneuvering board solution for one of the cases is illustrated in Figure 4. In all cases I assume the target is on a course of 000° T at a speed of 25 knots, and that it does not maneuver. All starting positions for our ship are at a range of 10,000 yards, and our ship has a speed of 35 knots. In addition, I am assuming the optimum firing position is 30° ahead of the target's beam and the desired range at launch is 3,000 yards. This scenario assumes the torpedo speed is approximately twice the tarfet's speed. Here are the times it will take to get to firing position, assuming no maneuvering by the target:

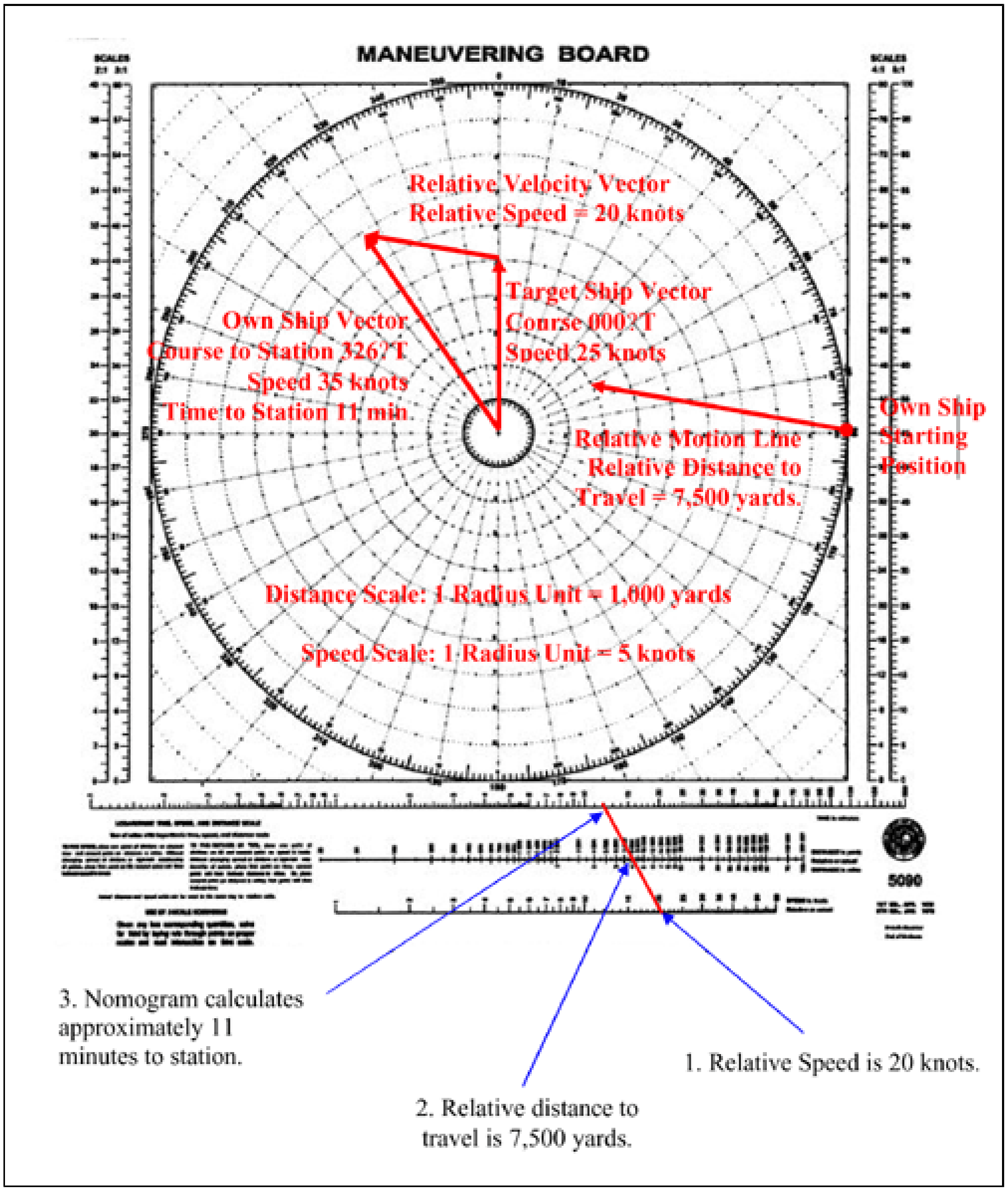
AOB	Starting Position:	Course to Firing Position @ 35 knots	Time to Firing Position
180°	Dead astern of Target	004° T	34 min
135°	On Target's Starboard Quarter	352° T	26 min
090°	On Target's Starboard Beam	326° T	11 min
045°	On Target's Starboard Bow	245° T	4 min
000°	Dead Ahead of Target	152° T	5 min

It should be obvious that if you are chasing a capital ship you will be subjected to heavy gunnery for quite a long time. In daylight, if there are no friendly heavies to distract an enemy's heavy guns, this can be suicidal. A destroyer’s best chances of delivering a successful torpedo attack, and living to tell about it, are at night or in low visibility. Attacking in large numbers also helps. The best position to be in is ahead of your target on roughly a reciprocal course, offset somewhat from his track. Go in at flank speed, get to a range between approximately 750 - 3,000 yards, and when you are about 20 - 40° ahead of his beam launch your torpedo attack. At this point, if DC modeled smoke screens, I would be turning hard away and laying a smoke screen.

It should also be obvious that a submarine has a far greater chance of delivering a torpedo attack. At night it is nearly impossible to visually spot a submarine on the surface, allowing it the opportunity to get in close. By day the ability to submerge provides the same stealth advantage, albeit at a severe speed disadvantage. "Hide With Pride" is the submariner’s motto, and it is fully justified. I don’t yet have Silent Hunter II, but I am confident those who have played that simulation will find the above comments to be accurate.

Finally, while the above describes the optimum firing position, the tactical situation may require that you fire before reaching the "ideal" firing position. The target length presented to a torpedo attack is proportional to sin (SA + AOB). If (SA + AOB) = 70°, then sin (70°) = .940, which means you have 94% of the probability of hitting as firing from the ideal position. Keep this in mind – it’s better to launch from a position that’s "good enough" and to get away, than to get ripped apart by large caliber gunfire before you can reach that "ideal" firing position.

Figure 4 - Example of a relative motion problem. The target ship is on a course of 000° T at 25 knots. Our ship is on his starboard beam at a range of 10,000 yards and has a maximum speed of 35 knots. To reach a position 30° forward of the target’s beam and at a range of 3,000 yards, our ship must steer course 326° T at 35 knots. It will take approximately 11 minutes to reach the desired position.



F12 Torpedo Director

DC has a very realistic, functional torpedo director built in. Most of the time one will probably order torpedo attacks from F2 CIC, but the F12 Torpedo Director is an excellent resource to maximize your chances of hitting. It also provides some additional control over your torpedo attack, if desired. For example, you can use it to release torpedoes at an optimum firing position, or to control the number of torpedoes fired.

The main part of the display is in the center, which displays the same information shown in Figure 2. The upper "dial" is always the target vessel, and the lower "dial" is always your vessel. A vertical line connecting the centers of the two "dials" is the LOS.

The upper "dial" has three disks stacked upon each other to display relevant target information. The top disk is a TA pointer, which points in the correct direction relative to the LOS. The middle disk has an outline of the target vessel, which rotates to point the target ship's bow in the correct direction relative to the LOS. Around the circumference of the middle disk is a relative bearing scale, which indicates directions relative to the target ship's bow. The scale is marked at each 10° and labeled at each 20° . A whole number is used to indicate tens of degrees. 0 (000° R) is dead ahead of the target, 9 (090° R) is off the target's starboard beam, 18 (180° R) is dead astern of the target and 27 (270° R) is off the target's port beam. To maximize chances of a hit, we want the TA pointer pointing at 9 or 27.

The lowest disk is a true bearing indicator. It is marked every 10° with a whole number indicating tens of degrees. This disk indicates the target's true course and our bearing from the target, but it's not essential to solving the aiming problem.

The lower "dial" also has three disks stacked upon each other to display relevant own ship information. The top disk is an SA pointer, which points in the correct direction relative to the LOS. Note that the SA pointer on the own ship "dial" and the TA pointer on the target "dial" are always parallel to each other and offset from the LOS by the same angle. The middle disk has an outline of your ship, which rotates to point the your ship's bow in the correct direction relative to the LOS. Around the circumference of the middle disk is a relative bearing scale, marked in the same manner as the relative bearing scale on the target "dial." It indicates directions relative to your ship's bow. The SA pointer must be pointing in a direction that allows the torpedo launcher to fire (note: we can use the offset angle knob to be able to shoot — more later). The lowest disk is a true bearing indicator, marked in the same manner as the target "dial." This disk indicates your true course and the target's true bearing from you, but again, it's not essential to solving the aiming problem. Note that both the target "dial" true bearing indicator and the own ship "dial" true bearing indicator are always aligned with each other.

At the top center of the director is a "Solution" indicator, marked from 0 to 100%. The manual doesn't define what this means, but from what I can tell it only tells if the director has solved for SA. It does not check to see if the torpedo is in a clear arc or can actually reach the target.

To the right of the main display is an information display regarding the selected torpedo settings. One of the most useful indicators is the run time indicator. This is the quickest means of determining if you are in the TDZ. If the run time is less than the maximum run time for the selected speed setting, you are in the TDZ and have a possibility of hitting the target. Note that one revolution of the run time indicator is 20 minutes. Unfortunately, there's no indicator to show if the displayed run time is > 20 minutes. To be honest, you are wasting your torpedoes if your run time is over 20 minutes. In Table 2 the run times are listed for the torpedoes used in DC. If you were assigned as the Torpedo Director Officer for your ship you would have been expected to have this data memorized for your torpedoes.

The Target Speed, Torpedo Speed and Torpedo Depth indicator show what your virtual "Torpedo Director Officer" has entered into the torpedo director. If you switch to manual you can enter these values yourself. I usually prefer to leave the torpedo director in automatic.

Spread angle is the angle the torpedo spread covers. The spread angle selector switch defaults to 2°. This is what your AI ships always seem to fire at. If I have confidence in my aiming solution I set the spread angle to 0° in order to maximize the number of hits.

At the top left is a Tube Offset Adjust Knob and Tube Offset Indicator. The Tube Offset Adjust Knob allows you, up to a point, to unmask the torpedo launcher. For example, if you want to fire to port but SA puts the LOF forward of the torpedo launcher's clear arc, you can dial in a left tube offset angle (up to 30°). This offsets the launcher up to 30° to the left of the LOF and it inputs an equal right turn into the torpedo's guidance mechanism. In effect, your torpedo launcher's clear arcs are increased by ± 30°. This is a very handy feature to allow you to get a shot off and get the hell out of there.

Below the Tube Offset Adjust Knob are the Gyro Angle indicators for the forward and aft tube mounts. The angle index mark at the top center must be in a clear arc (i.e., not a red arc) in order to be able to launch torpedoes.

At the bottom right are switches and knobs which allow you to fire torpedo tubes individually or to salvo all tubes from a mount. This feature gives the player great flexibility to fire the number of torpedoes as required by the tactical situation. For example, if you are commanding USS O'BANNON (DD 450) in the November 13th, 1942, night action off Guadalcanal, you might want to fire all 10 tubes at IJN HIEI as the chances of regaining a firing position (and surviving) are pretty slim. However, if you are part of a destroyer Surface Action Group (SAG) that has intercepted a weakly defended convoy, maybe only one or two torpedoes (at most) per merchant vessel are justified. You certainly don't want to fire every torpedo from a mount at just one ship, which is what will happen if you order the torpedo attack from F2 CIC. Unfortunately, AI controlled destroyers seem to shoot everything when ordered to conduct a torpedo attack, and there does not appear to be any means to order them to conserve torpedoes.

Figure 5 is a screen shot of the F12 Torpedo Director taken in the stock torpedo training scenario. At first glance you might think this is a great shot — Solution Indicator shows 100%, a near right angle impact (TA relative to target's bow) and SA in a clear arc for the torpedo launcher. However, look at the Run Time indicator and the Range Indicator. The range is over 17,000 yards and the run time is 21 minutes. You can now see why having no total run time indication (one might mistakenly think run time here is 1 minute) can be confusing. A Mk 15 torpedo at its lowest speed setting of 26.5 knots has a total run time of 17 minutes. In this case, YOU ARE NOT IN THE TDZ — GET CLOSER! MUCH CLOSER!!

Figure 6 is how the approach to firing position looks from the F12 Torpedo Director. Again, don't be fooled by the 100% Solution Indicator. Although we are in the TDZ (run time = 10 minutes), the torpedo tubes do not yet have a clear shot. This is due to the course our ship needs to steer in order to reach a closer firing position. The 30° tube offset is not sufficient to unmask the tubes. We will need to alter course to starboard when we get near the firing position. One other item to note – at Flank Speed our destroyer makes 37 knots, while the torpedo speed setting must be at 26.5 knots in order to have sufficient endurance to reach the target. If you could shoot forward you would run over your own torpedoes! Again, get closer.

Figure 7 is another screen shot of the F12 Torpedo Director, only this time we are in an ideal firing position. We are well within the TDZ, allowing the torpedoes to use their maximum speed setting, and our port side tubes are unmasked. The impact angle is near 90° and the run time is less than one minute. If all 8 tubes on the port side are fired we are virtually guaranteed of at least one hit, and 2-3 hits are certainly within reason. This type of damage will cripple or sink a heavy cruiser.

The training scenario represents, of course, an ideal situation. We have a cooperative target that isn't shooting back at us. Against an AI or a human opponent that is fighting back it will be much more difficult to deliver a torpedo attack, but all of the principles outlined above still apply.

Figure 5 - The torpedo director as seen in the torpedo training scenario. Don't be fooled by the 100% Solution Indicator — we are way out of range (here 17,412 yards) for our Mk 15 Torpedoes. The Run Time is 21 minutes, 4 minutes more than a Mk 15 will run, even at its lowest speed setting.

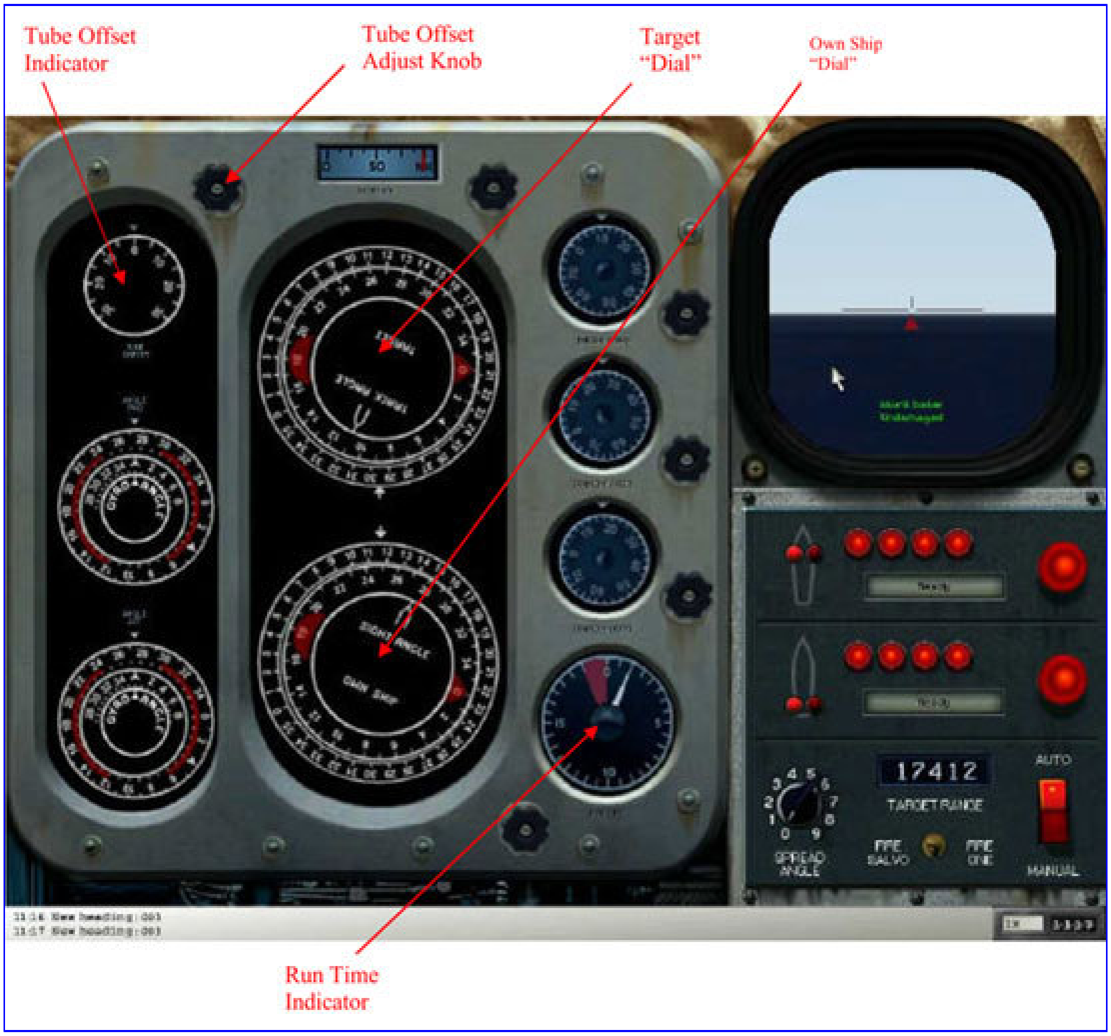


Figure 6 - The approach to firing position as seen from the torpedo director station. Note that the interception course steered by our ship causes the torpedo tubes to be masked – even the tube offset feature won't help here.

Figure 7 - An ideal shot as seen from the torpedo director station in the torpedo training scenario. The torpedoes have a crossing angle of near 90° , they are at their fastest speed setting and the run time is less than one minute. Due to the high torpedo speed (45 knots) and the low speed of the target vessel (10 knots), the sight angle is very small, about 15° here.

Conclusion

In this article we have discussed torpedo advantages and disadvantages, the concept of the TDZ, the aiming problem and the optimum firing position for a straight running torpedo attack. All of the concepts discussed apply, regardless if the launch platform is a destroyer, a PT boat, a submarine, etc. The following are some rules of thumb to use when conducting straight running torpedo attacks:

1. Know your torpedo capabilities, especially their maximum run times at different speed settings.

2. Make sure you are in the TDZ before you even think of firing. If you use the F12 Torpedo for nothing else, at least use the run time indicator to ensure you are in the TDZ.

3. Get in as close as possible to reduce the target's ability to evade. If you are using the F12 Torpedo Director in manual, use the highest speed setting that will still allow the torpedo to reach the target.

4. Don't get in so close that the torpedo doesn't arm! In general shoot from 750 yards or more.

5. Shoot from forward of the target's beam — you want the torpedo to cross the target's line of motion at as near a right angle as possible. In general you will find, for a moderate speed moving target, that you need to be 20 - 40° forward of the target's beam for a good crossing angle (TA+AOB).

6. If at all possible, shoot when the TA pointer is pointing to the target ship's beam.

7. Shoot only the number of torpedoes warranted by the target. The F12 Torpedo Director allows you to fire less than full salvoes if desired.

Table 2 - Torpedo Run Times

Torpedo	Range, nm:	Speed, kts:	Run Time, min:
FR 23DT	7.1	35	12.2
	4.92	39	7.6
FR 24V	4.375	35	7.5
	2.2	45	2.9
FR 26V	1.65	35	2.8
	1.1	44	1.5
GB MK II	4	29	8.3
GB MK V	6.75	25	16.2
	5	29	10.3
	4	35	6.9
GB MK VII	2.85	35	4.9
GB MK VIII	3.5	41	5.1

	2.5	45.5	3.3
GB MK IX	7.5	35	12.9
	5.5	41	8.0
GB MK X	6.565	29	13.6
	4.375	36	7.3
	2.16	45	2.9
GB MK XII	1.75	37	2.8
	0.75	40	1.1
GE F5	1.25	33	2.3
GE F5b	3.25	24	8.1
	1.1	40	1.7
GE G7a	6.85	30	13.7
	4.1	40	6.2
	2.75	44	3.8
GE G7e	2.6979	30	5.4
GE G7e 17T	4.047	30	8.1
GE G7es	3.075	24	7.7
GE TI	6.25	30	12.5
	3.75	40	5.6
	2.5	44	3.4
IT SI170	1.1	37	1.8
IT SI270	6.55	29	13.6
	4.38	35	7.5
	2.2	46	2.9
JP 6th Yr	8.2	26	18.9
	5.45	32	10.2
	3.825	36	6.4
JP 8th Yr	10.95	28	23.5
	8.2	32	15.4
	5	38	7.9
JP Type 89	5.45	35	9.3

	3.275	43	4.6
	3	45	4.0
JP Type 91m2	1.5	43	2.1
JP Type 93m1	21.85	37	35.4
	17.5	41	25.6
	10	49	12.2
JP Type 95m1	4.925	46	6.4
	6.55	50	7.9
JP Type 98	1.75	41	2.6
NE II53	5.4	28	11.6
	2.16	42	3.1
US MK 8	8	36	13.3
US MK 13	3.15	33.5	5.6
US MK 14	4.5	31	8.7
	2.25	46	2.9
US MK 15	7.5	26.5	17.0
	5	33.5	9.0
	3	45	4.0
US MK 24	2	12	10.0