Introduction

It has come to my attention that several members of the Sub Command community experience some frustration and confusion about the details of TMA. I have presented some examples and explanations to treat some of these misunderstandings. It is hoped that you come out of this with a better understanding of the variables and underlying dynamics involved.

Email questions and responses to toptorp92@yahoo.com

What is TMA?

TMA is the set of techniques used to estimate target course, speed and range. Yet target motion analysis (TMA) will also involve making assumptions about target speed, course and range. Once these assumptions are made, adjusting the solution comes next.

At any rate, there are three variables you are estimating, only three and no more. They are course, speed and range.

Other factors used to make inferences (guesses based on reason) about the three variables above include bearing rate, range rate, bearing drift and maybe a few others. The most frequently used variable is bearing rate. It is also important to note that these variables are measured, there's no estimating bearing rate, for example. In addition, Sub Command does not provide this information; you must construct it yourself.

Other sub simulators distinguish between relative and true bearing, like SHII. Sub Command (SC) doesn't; SC always uses true bearings. If you are knowledgeable about the difference, this may be useful. If not, then it doesn't matter anyway.

Bearing rate is a measured variable representing the change in bearing over time. Likewise, it is measured in degrees per minute. Sub Command does not give you this information; you must construct it yourself. In order to do this, observe the bearing to the target and the time upon initial detection and compare it with a second observed bearing later during the leg. If the bearing gets bigger over time, then the target is drawing right. Likewise, if the bearing diminishes in value then the target is moving left. For those instances where the target moves across bearing 000, make the appropriate inference. That is, if the initial bearing is 000 and the second bearing on the second observation is 355, the target is drawing left not right.

You should have some knowledge about the line-of-sight (LOS.) This is a simplification used to visualize the situation. Not everyone uses this simplification. Others prefer to use the Geo-Plot.

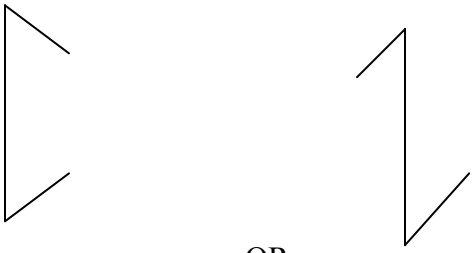
What the LOS looks like:

The LOS is a vertical line with own ship (OS) on the bottom and the target on the top. It is always this way. It is simply a snap-shot of OS and a target taken from the geo-plot.

The vertical line represents true target bearing.

In addition, two vectors – another line with direction and length to represent course and speed – are used to show both OS and target course and speed.

An LOS may look something like this:



OR

Sub Command doesn't provide an LOS. You must construct it yourself.

What are the different LOSs?

Lead

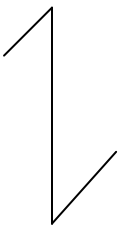
A lead LOS is one in which both OS and the target travel in the same direction across the LOS. You can expect relatively minor changes in the bearing rate. It means that both vessels are traveling in the same quadrant; that is, both may be traveling easterly or westerly, whichever the case.

It looks like this:

Lag

A lag LOS is one in which ship's direction is opposite the target's direction.

It looks like this:



Overlead

An overlead LOS is a special case of lead LOS. OS has more speed across the LOS.

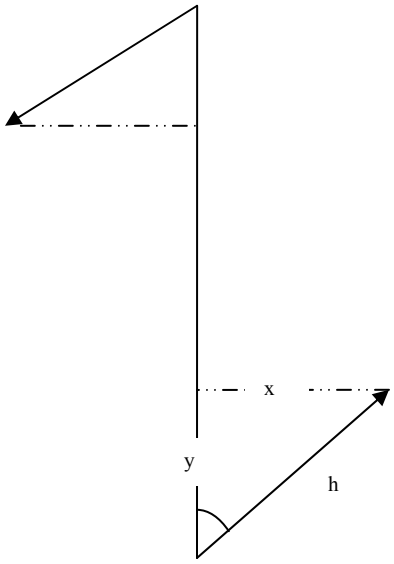
It looks like this:

Point
A point LOS is one in which OS points the target. When other variables are generally unknown, it is considered unsafe and risks collision. In this case, OS has zero speed across the LOS.

It looks like this:

If you suspect a point LOS like this, you have problems, especially if other variables, like range, are unknown. You can also expect a bearing rate of zero.

More definitions



- Speed across the LOS refers to the X component of OS in the LOS. If you notice, it forms the opposite side of the triangle.

- Speed in the LOS refers to the Y component. It forms the adjacent side of a triangle.

Using the basic trigonometry formulas, you can infer OS speed across and in the LOS.

These variables are constructed from OS course and speed. That is, you know OS course which is indicated with the curve and you know the value of OS speed, indicated by h.

Knowledge of the speed in the LOS can help you construct range rate. That is, you can get some sense of the rate of closure. When you track a submarine on narrowband information only, the bearings include a larger error than with broadband. So, keeping track of range rate in the absence of reliable bearing data is helpful. In Sub Command, it probably doesn't matter.

But, here is an example.
Given
OS Course: 225
Speed: 8kts
Target bearing: 350

Compute OS range rate:
350-225=125
180-125=55
cos(55)*8=4.6
So, OS has 4.6 kts in the LOS (moving away)

Range rate:
(4.6nm/60min)*(2000)=153 yds/min – opening.

Why does the LOS matter?

If the LOS isn't provided in the game, why bother?

The LOS, once constructed and the specific situation identified, can help you make future tactical choices. For example, if you want to close range to the target, you may choose a lag LOS rather than a lead LOS. Why? A lag LOS will place the future position of OS in the target's baffles, thereby optimizing your firing opportunities. The target will likely not detect launch and remain unaware of the incoming torpedo until it has acquired.

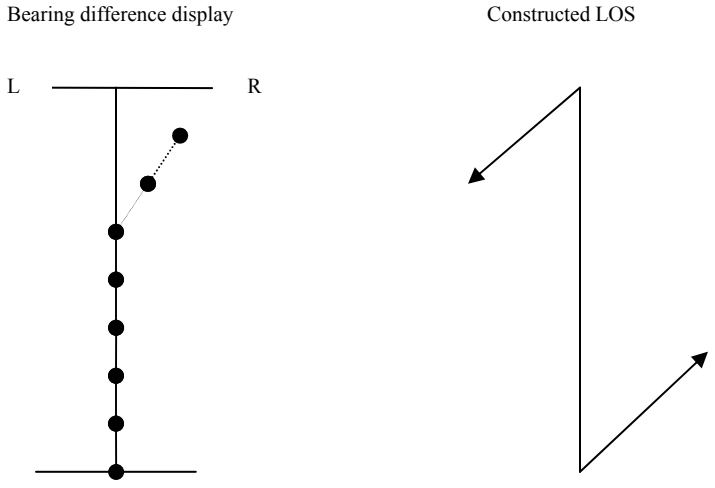
Knowledge of the LOS helps make safety choices as well. For example, a point LOS is not preferred since it risks collision, especially when target range is unknown.

How is this knowledge applied in Sub Command?

SC gives you the bearing difference display and a plot with the lines of bearing. It doesn't provide a LOS. You construct this yourself.

Combined with the bearing difference display provided in the simulation, the LOS helps analyze a target zig.

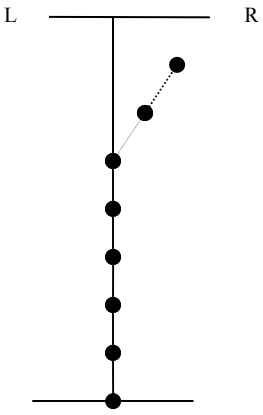
For example:



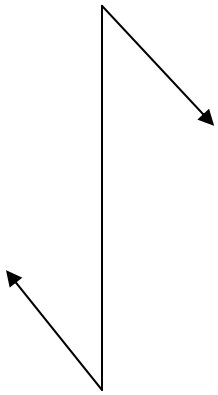
When bearing difference dots move right, this indicates a solution tracking to the right. The target is actually more to the left than the solution. Since targets cannot zig in range, this target either turned to his left, sped up or both.

Another example:

Bearing difference display



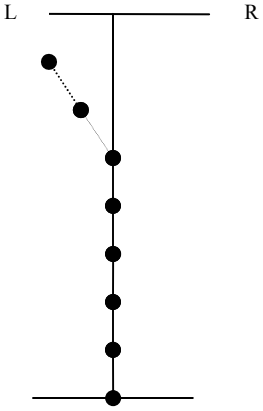
Constructed LOS



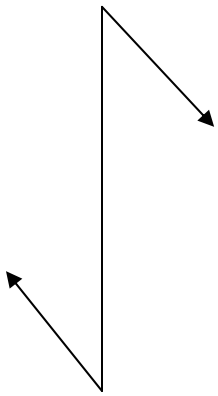
This target slowed, turned to his right or both. Further TMA will tell you his end maneuver.

Another example:

Bearing difference display



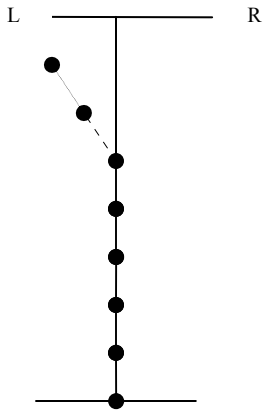
Constructed LOS



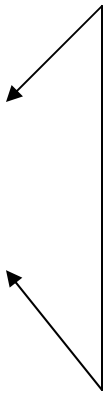
This target turned to his left, sped up or both.

Another example:

Bearing difference display



Constructed LOS

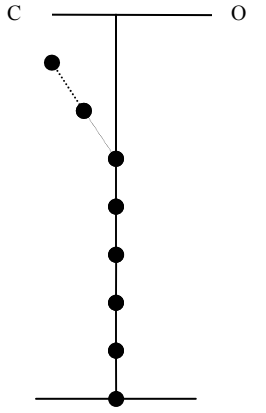


This target turned to his left, slowed or both.

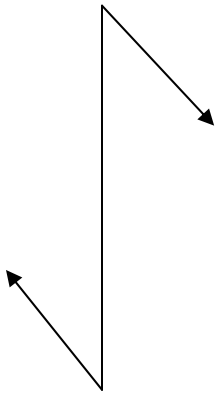
Range rate data is ***not*** provided in Sub Command. However, it greatly assists in making inferences about target maneuvers, especially when combined with bearing difference data.

Like the bearing difference plot, it would look something like this:

Range Rate Difference display

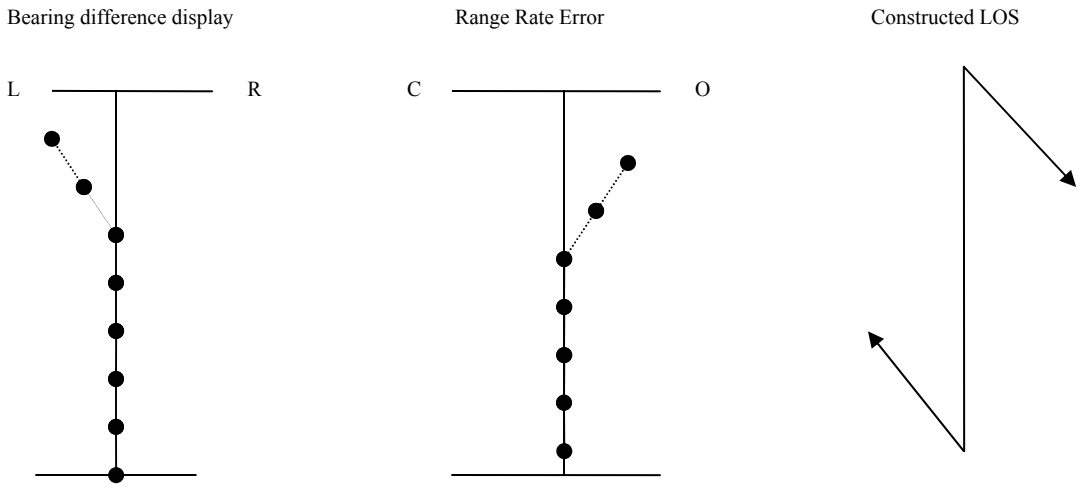


Constructed LOS



The target is relatively opening now. This means he slowed, turned away or both.
When combined with a bearing difference plot, the ambiguity is removed.

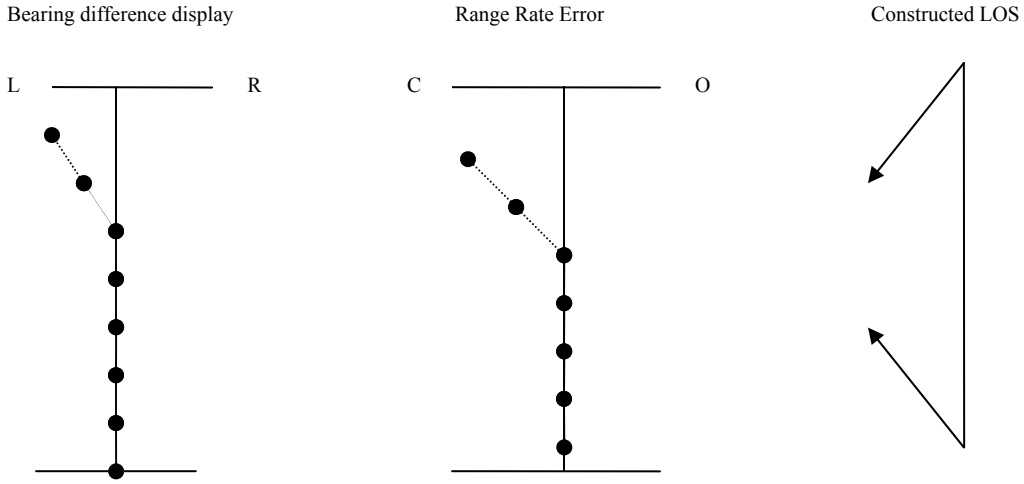
For example:



In this case, the target has moved both to the right and it is closing at a relatively higher rate. This can only mean a speed increase. This excludes a target course change because it is impossible for a target to both turn left and close the range rate. That's illogical.

So, the advantage to having range rate difference information is that it removes some of the ambiguity associated with analyzing target zigs.

Another example:



This target has moved right and is relatively opening. He slowed down.
Of course, you must analyze other plot information to determine the target's end maneuver.

Keep in mind that range rate error information as well as LOS information is not provided in the game. You must construct this information.

Finally, if you suspect that a target has changed speed based on a change in range rate, you may be able to confirm the speed change using DEMON, if available.

Sonar Clues

The best sonar clue in SC is the DEMON display. It helps you make an inference about target speed. You must know the target TPK or turns per knot which is provided in the database. You insert this estimate in your TMA solution.

The Sea Wolf sonar comes with an extra feature. If available, the sonar can tell you target range. This information is available in the target data window of the broadband display, called WAA. When I was in service, the a wide aperture array was a concept, not a reality. That's changed. Simply, insert this range in your solution and keep track of changes in range.

SNR or signal-to-noise ratio may be useful, but more frequently, not a reliable indicator in target movements. Generally in SC, an increasing SNR means that the range to target is closing. Nothing more to say. It provides little useful insight, since this value is highly dependant on environmental factors. The presence of other shipping and sea state affect SNR highly. Don't use it.

Interpreting the geo-plot

Guidance on making an interpretation from the geo-plot can be found in the Blue Book. In sum, this will tell you about max and min ranges and to which LOS they belong. I will not treat those concepts here.

Preferred Firing Position

The preferred position to fire a torpedo is deep in the target's baffles, on a lag LOS. This enables you to drive away as the torpedo closes the target. If the target fires a torpedo in response, it will do so using the bearing to the incoming torpedo. With a lag LOS, you drive for bearing separation from your fired torpedo, thus frustrating the target's attempt to locate you.

With surface ships, this preferred firing position doesn't matter. Surface ships have baffles, but they also have helos. So, another set of principles applies to surface encounters.

Thoughts and reflections

Since SC comes with all the auto features, most of the brain work is done for you. It's all too easy to just sit back in the arm chair and let the auto sonarman do all the work, or the auto TMA formulate solutions to your TMA problems. If that's you, you missed the point of the simulation. Go fly a jet or get Duke Nukem.