Radar Recertification (Renewal)

Published by **Columbia Pacific Maritime**

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This workbook is provided as a free reference to prepare mariners for the renewal of any Radar Observer Endorsement.

Contents:

FREE

Lesson 1 Radar Plotting Review

The expected learning outcome is that the student will review and discuss rapid radar plotting methods including the use of the 6-minute rule for making speed and distance calculations; and the meaning of the rm, er, and em vectors.

6-Minute Rule

The six-minute rule is a quick way to solve speed and distance problems when using a 6-minute time interval.

1 hour = 60 minutes
6 minutes = 0.1 hours (one-tenth of an hour) 6 ÷ 60 = 0.1 6 x 10 = 60

To find the distance traveled in 6-minutes move the decimal point one place to the left.

Example

- A vessel making 6 knots moves 0.6 miles in 6 minutes 6 x 0.1 = 0.6
- A vessel making 15 knots moves 1.5 miles in 6 minutes 15 x 0.1 = 1.5

To find the speed traveled by observing the distance for 6-minutes move the decimal point on place to the right.

Example

- A vessel that travels 0.7 miles in 6 minutes is making 7 knots 0.7 x 10 = 7
- A vessel that travels 1.2 miles in 6 minutes is making 12 knots 1.2 x 10 = 12

REM Plotting Symbols, Terms, & References

REM Plotting Vectors		
Vector	Direction	Meaning
er	From e to r	Our own ship’s initial course and speed
em	From e to m	Them; contacts course and speed
rm	From r to m	Relative Motion; direction and speed of the relative motion setup between the two vessels
er’	From e to r’ (r-prime)	Our own ship’s new course and speed

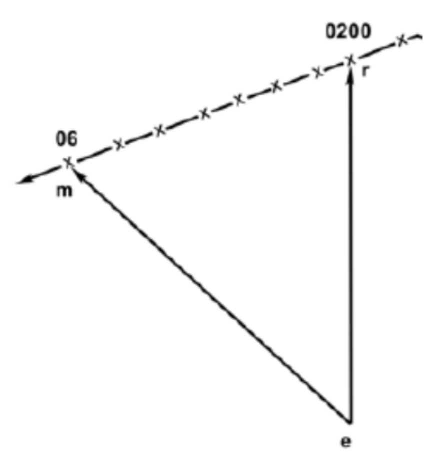
REM Plotting Symbols	
Symbol	Meaning
CPA	Closest Point of Approach
TCPA	Time of Closest Point of Approach
DRM	Direction of Relative Motion
SRM	Speed of Relative Motion

Quick Reference Solutions	
To Find This	Do This
CPA	Draw a line from r through m extending past the middle of the plot sheet. This is the RML. Measure from the center of the plot sheet to the closest point on the RML
TCPA	Measure the distance from r to m. This represents six minutes of relative motion. Mark off the RML from r to the CPA in six minute intervals and count the minutes from r to CPA.
DRM	Measure the direction from r to m
SRM	Measure the distance from r to m and multiply by 10
Contacts Course	Measure the direction from e to m
Contacts Speed	Measure the distance from e to m and multiply by 10

The 6-minute Vector Triangle

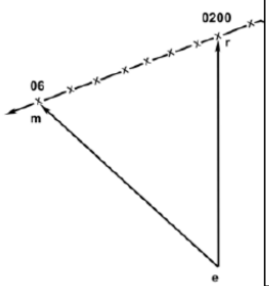
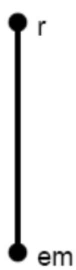
A vector is simply a line that represents the direction and distance traveled over a specific time frame. In the case of most radar plots the time frame will be 6-minutes; although they can be more or less depending on the situation. The important thing to remember is that all sides of a vector triangle represent the same amount of time. The Six-Minute vector triangle explained.

- Point “r” was plotted using the range and bearing to the contact taken at 0200.
- Point “m” was plotted using the range and bearing to the contact taken at 0206.
- The “x’s” represent the contact vessel as viewed on the radar scope.
- Vector “er” is a 6-minute vector that represents our own ship’s course and speed.
- Vector “em” is a 6-minute vector that represents the contacts course and speed.
- Vector “rm” is a 6-minute vector that represents the relative motion setup between the two vessels.



Five Common Vector Triangle Situations

The following are some common vector situations that can be confusing because the three sides of the vector triangle (em, rm, and er) may not be quickly recognized.

Vector Triangle	Situation	Explanation
	Crossing	A crossing situation exists when you are observing the port or starboard side of the contact. This situation will always plot as a triangle.
	Station Keeper (SK)	A station keeper means that the contact is keeping the same station on the radar. This happens when the contacts course and speed are equal to our ship and the relative motion is zero.
	Dead in the Water (DIW)	When the contacts speed is zero the contact is drifting or dead in the water.
	Overtaking Situation	When m is plotted between e and r the contact and our ship are on the same course at different speeds. This is an overtaking situation.
	Meeting Situation	When e is plotted between r and m the contact and our ship are on reciprocal courses. This is a meeting situation.

6-minute Vector Triangle Steps for Rapid Radar Plotting

The purpose of 6-minute plot is to reproduce an image of what happened on the radar on a plot sheet in order to assess the relative motion of the contact to determine risk of collision. The following four steps can be used to construct a 6-minute plot.

1. Plot the first time you observe the contact as “r”.
2. Plot the second time you observe the contact as “m”.
   a. Draw a line from r through m to the other side of the plot sheet. This is the relative motion line. From this line you can determine the:
      i. CPA
      ii. TCPA
      iii. DRM
      iv. SRM
3. Plot “e” so that “er” is our own ships course and speed.
   a. Draw a line from e through m. This line represents the contacts true motion. From this line you can determine the:
      i. Situation (crossing, meeting, overtaking, SK, DIW)
      ii. Contacts true course
      iii. Contacts true speed
4. Mark where the new relative motion line crosses the 4-mile range ring. This is the maneuvering point (mx) when maneuvering at 4-miles for a 2-mile CPA.
   a. From mx draw a line tangent to the 2-mile range ring. This is the new relative motion line (NRML).
5. Transfer this line to m in the vector triangle and draw the new NRML in a reciprocal direction, this is the $NRML^1$. To determine the new course and speed solutions move the “er” vector so that r becomes a point on the $NRML^1$.
   a. New speed solution: Keep the direction from e to r the same and shorten the length of the vector to a point on the new relative motion line. The general rules for a speed solution are:
      i. There is never a speed solution for a meeting situation.
      ii. There is always a speed solution for an overtaking situation.
      iii. There is a speed solution for a crossing situation only when the new $NRML^1$ crosses the triangle.
   b. New course solution: Keep the distance from e to r the same and rotate the direction of the vector to a point on the new relative motion line. Measure from e to the new r to determine the new course to steer to avoid collision.

Lesson 2 Transfer Plotting: First Triangle

The expected learning outcome is that the student will review the first vector triangle solution and demonstrate the ability to complete the first vector triangle to evaluate risk of collision; and identify the relative motion (rm), and True motion (em) vectors.

Students will reference the review material as needed to complete the following radar transfer plots. Explanations and examples will be provided by the instructor. Each radar transfer plot should be completed within the following assessment standards:

Bearings	± 1°
Ranges	± 0.1 nm
CPA	± 0.5 nm
TCPA	± 3 minutes
Directions	± 5°
Speeds	± 2 knots

Example of First Vector Triangle Solution Follow the steps outlined below to complete the first vector triangle.

At 0900 our own ship is on course 000° at 15 knots when the following observations were made.

Time	Bearing	Distance
0900	033.7°	9.0 nm
0906	030.3°	6.9 nm

Prepare the plot sheet by plotting the heading of 000° and recording our ship's speed as 15 knots.

Step 1 Plot the first observation of the contact and label as "r".
The first observation was at 0900 at a bearing of 033.7° and 9.0 nautical miles. Plot this range and bearing from the center of the plot sheet and label this point as "r' noting the time as 0900.

Step 2 Plot the second observation of the contact and label as "m".
The second observation was a 0906 (6-minutes later) at a bearing of 030.3° and 6.9 nautical miles. Plot this range and bearing from the center of the plot sheet and label this point as "m' noting the time as 0906.

Draw a line from point r through point m and continuing across the plot sheet. This is the relative motion line. This line is used to determine the:

- CPA
- TCPA
- DRM
- SRM

Step 3 Plot "e" from "r" so that "er" is our own ship's course and speed.
Our ship's course and speed is 000° and 15 knots. At a speed of 15 knots our ship will travel a distance of 1.5 miles (15 ÷ 10) in 6-minutes.

Draw a line down scope from r parallel to our ship's own heading and measure along that line 1.5 miles. Label this point as "e". Note that direction from e to r is 000°.

Draw a line from "e" to "m", this is the "em" line and represents them; the contacts true course and speed. This line is used to determine the:

- Situation (crossing, meeting, overtaking, SK, DIW)
- Contact's true course
- Contact's speed

Plot 1 (first triangle solution)

Our own ship is on a course of 000° T at a speed of 12 knots when a contact is observed at the following radar ranges and bearings.

Time	Bearing (T)	Range (nm)
0300	035.0°	11.1
0306	031.1°	9.2

1. The contact could best be described as ____________ (meeting, crossing, overtaking).

2. The CPA of contact is _______________.

3. TCPA __________ (Time of CPA)

4. DRM __________ (Direction of Relative Motion)

5. SRM __________ (Speed of Relative Motion)

6. Contacts Course __________

7. Contacts Speed __________

Answer Key

1. Crossing
2. CPA 3.5 nm
3. TCPA 0332
4. DRM 233°
5. SRM 20 k
6. C 270°
7. S 16 k

Plot 2 (first triangle solution)

At 0300 our own ship is on a course of 030° T at a speed of 23 knots when a contact is observed at the following radar ranges and bearings.

Minute	Bearing (T)	Range (nm)
0300	081.0°	10.8
0306	083.1°	7.7

1. The contact could best be described as ____________ (meeting, crossing, overtaking).

2. The CPA of the contact is _______________.

3. TCPA __________ (Time of CPA)

4. DRM __________ (Direction of Relative Motion)

5. SRM __________ (Speed of Relative Motion)

6. Contacts Course __________

7. Contacts Speed __________

Answer Key

1. Crossing
2. CPA 1.0 nm
3. TCPA 0321
4. DRM 255°
5. SRM 31 k
6. C 304°
7. S 22 k

Lesson 3 Transfer Plotting: Second Triangle

The expected learning outcome is that the student will review the second vector triangle solution and demonstrate the ability to complete the second vector triangle to determine new course and new speed solutions to avoid collision.

Students will reference the review material as needed to complete the following radar transfer plots. Explanations and examples will be provided by the instructor. Each radar transfer plot should be completed within the following assessment standards:

Bearings	± 1°
Ranges	± 0.1 nm
CPA	± 0.5 nm
TCPA	± 3 minutes
Directions	± 5°
Speeds	± 2 knots

Example of First and Second Vector Triangles Follow the steps outlined below to complete the first and second vector triangles.

At 0900 our own ship is on course 000° at 15 knots when the following observations were made.

Time	Bearing	Distance
0900	033.7°	9.0 nm
0906	030.3°	6.9 nm

Prepare the plot sheet by plotting the heading of 000° and recording our ship's speed as 15 knots.

Step 1 Plot the first observation of the contact and label as "r".
The first observation was at 0900 at a bearing of 033.7° and 9.0 nautical miles. Plot this range and bearing from the center of the plot sheet and label this point as "r' noting the time as 0900.

Step 2 Plot the second observation of the contact and label as "m".
The second observation was a 0906 (6-minutes later) at a bearing of 030.3° and 6.9 nautical miles. Plot this range and bearing from the center of the plot sheet and label this point as "m' noting the time as 0906.

Draw a line from point r through point m and continuing across the plot sheet. This is the relative motion line. This line is used to determine the:

- CPA
- TCPA
- DRM
- SRM

Step 3 Plot “e” from “r” so that “er” is our own ship’s course and speed.

Our ship’s course and speed is 000° and 15 knots. At a speed of 15 knots our ship will travel a distance of 1.5 miles (15 ÷ 10) in 6-minutes.

Draw a line down scope from r parallel to our ship’s own heading and measure along that line 1.5 miles. Label this point as “e”. Note that direction from e to r is 000°.

Draw a line from “e” to “m”, this is the “em” line and represents them; the contacts true course and speed. This line is used to determine the:

- Situation (crossing, meeting, overtaking, SK, DIW)
- Contact’s true course
- Contact’s speed

Step 4 Draw the New Relative Motion Line (NRML)

Locate the point where the 4-mile range ring crosses the RML and label this point as Mx. From Mx draw a line, on the left side of the RML, tangent to the 2-mile range ring. Label this line as the NRML.

Step 5 Transfer the NRML to the first vector triangle (NRML^1)

Transfer the NRML to the first vector triangle by plotting a parallel line from m in the reciprocal direction as the NRML.

Step 6 New course and speed solutions

Evaluate the new course solution be observing if the NRML^1 crosses the original er line. There is a speed solution. To find the new speed solution measure the distance from e to r^1 and multiple by 10.

Place one point of the dividers on e and the other point on r; then rotate the point on r to the right until it just touches the NRML^1. Label this point as r^1 and measure the direction from e to r^1 to determine the new course solution.

Plot 1 (second triangle solution)

At 0600 our own ship is on a course of 000° T at a speed of 11 knots when a contact is observed at the following radar ranges and bearings.

Minute	Bearing (T)	Range (nm)
0600	080.0°	12.0
0606	080.0°	10.8

1. The contact could best be described as ____________ (meeting, crossing, overtaking).

2. The CPA of the contact is _______________.

3. TCPA __________ (Time of CPA)

4. DRM __________ (Direction of Relative Motion)

5. SRM __________ (Speed of Relative Motion)

6. Contacts Course __________

7. Contacts Speed __________

8. New Course for a CPA of 2 nm using an Mx of 4 nm __________

9. Is there a speed solution? (Yes / No)

Answer Key

1. Crossing
2. CPA 0.0 nm
3. TCPA 0700
4. DRM 260°
5. SRM 12 k
6. C 307°
7. S 14.8 k
8. NC 087°
9. NS Yes

Plot 2 (second triangle solution)

At 1300 our own ship is on a course of 020° T at a speed of 12 knots when a contact is observed at the following radar ranges and bearings.

Minute	Bearing (T)	Range (nm)
1300	021.0°	11.0
1306	021.3°	8.3

1. The contact could best be described as ____________ (meeting, crossing, overtaking).

2. The CPA of the contact is _______________.

3. TCPA __________ (Time of CPA)

4. DRM __________ (Direction of Relative Motion)

5. SRM __________ (Speed of Relative Motion)

6. Contacts Course __________

7. Contacts Speed __________

8. New Course for a CPA of 2 nm using an Mx of 4 nm __________

9. Is there a speed solution? (Yes / No)

Answer Key

1. Meeting
2. CPA 0.2 nm
3. TCPA 1324
4. DRM 200°
5. SRM 27 k
6. C 200°
7. S 15 k
8. NC 094°
9. NS No

Lesson 4 Transfer Plotting: Multiple Contacts

The expected learning outcome is that the student will review the first and second vector triangle solutions and demonstrate the ability to complete a transfer plot for multiple contacts to evaluate risk of collision and determine the action of avoid collision with all contacts.

Students will reference the review material as needed to complete the following radar transfer plots. Explanations and examples will be provided by the instructor. Each radar transfer plot should be completed within the following assessment standards:

Bearings	± 1°
Ranges	± 0.1 nm
CPA	± 0.5 nm
TCPA	± 3 minutes
Directions	± 5°
Speeds	± 2 knots

Plot 1 (multiple contacts)

At 1900 our own ship is on a course of 000° T at a speed of 15 knots when the following radar ranges and bearings were observed.

Time	Contact A		Contact B	
	Bearing	***Distance***	***Bearing***	***Distance***
1900	350.2°	7.7 nm	031.0°	11.4 nm
1906	350.2°	7.7 nm	031.0°	9.2 nm

Questions 1 thru 3 refer to Contact A.

1. CPA _______________ 2. DRM _______________ 3. SRM _______________

Questions 4 thru 6 refer to Contact B.

4. CPA _______________ 5. DRM _______________ 6. SRM _______________

Questions 7 thru 12 refer to the contact with the smallest CPA. Use an MX of 4 miles and a CPA of 2 miles when solving for new course and new speed solutions.

7. What is the TCPA? _______________
8. Which would best describe this situation? (meeting, crossing, overtaking)
9. What is the contact's True Course? _______________
10. What is the contact's True Speed? _______________
11. What is the new course? _______________
12. Is there a new speed solution? _______________

Answers

1. 7.7 nm
2. None
3. None
4. 0.0 nm (0.0-0.5)
5. 211° (206-221)
6. 22 knots (20-24)
7. 1931 (1928-1934)
8. Crossing
9. 251° (246-256)
10. 12 knots (10-14)
11. 054° (049-059)
12. Yes

Plot 2 (multiple contacts)

At 2000 our own ship is on a course of 067° T at a speed of 11 knots when the following radar ranges and bearings were observed.

Time	**Contact A**		**Contact B**	
	Bearing	***Distance***	***Bearing***	***Distance***
2000	040.9°	6.2 nm	137.4°	9.5 nm
2006	035.5°	5.2 nm	137.6°	8.1 nm

Questions 1 thru 3 refer to Contact A.

1. CPA _______________ 2. DRM _______________ 3. SRM _______________

Questions 4 thru 6 refer to Contact B.

4. CPA _______________ 5. DRM _______________ 6. SRM _______________

Questions 7 thru 12 refer to the contact with the smallest CPA. Use an MX of 4 miles and a CPA of 2 miles when solving for new course and new speed solutions.

7. What is the TCPA? _______________
8. Which would best describe this situation? (meeting, crossing, overtaking)
9. What is the contact's True Course? _______________
10. What is the contact's True Speed? _______________
11. What is the new course? _______________
12. Is there a new speed solution? _______________

Answers

1. 2.7 nm (2.2-3.2)
2. 247° (242-252)
3. 11 knots (9-13)
4. 0.1 nm (0.0-0.6)
5. 317° (312-322)
6. 14 knots (12-16)
7. 2030 (2027-2033)
8. Crossing
9. 000° (355-005)
10. 15 knots (13-17)
11. 153° (148-158)
12. Yes

Plot 3 (multiple contacts)

At 2200 our own ship is on a course of 290° T at a speed of 12 knots when the following radar ranges and bearings were observed.

Time	Contact A		Contact B	
	Bearing	***Distance***	***Bearing***	***Distance***
2200	271.1°	6.5 nm	322.4°	11.1 nm
2206	262.0°	4.5 nm	322.4°	8.3 nm

Questions 1 thru 3 refer to Contact A.

1. CPA ________________ 2. DRM ________________ 3. SRM ________________

Questions 4 thru 6 refer to Contact B.

4. CPA ________________ 5. DRM ________________ 6. SRM ________________

Questions 7 thru 12 refer to the contact with the smallest CPA. Use an MX of 4 miles and a CPA of 2 miles when solving for new course and new speed solutions.

7. What is the TCPA? ________________
8. Which would best describe this situation? (meeting, crossing, overtaking)
9. What is the contact's True Course? ________________
10. What is the contact's True Speed? ________________
11. What is the new course? ________________
12. Is there a new speed solution? ________________

Answers

1. 2.1 nm (1.6-2.6)
2. 110° (105-115)
3. 22 knots (20-24)
4. 0.0 nm (0.0-0.5)
5. 142° (137-147)
6. 28 knots (26-30)
7. 2224 (2221-2227)
8. Crossing
9. 162° (157-167)
10. 19 knots (17-21)
11. 012° (007-017)
12. No

Plot 4 (multiple contacts)

At 0000 our own ship is on a course of 025° T at a speed of 13 knots when the following radar ranges and bearings were observed.

Time	**Contact A**		**Contact B**	
	Bearing	***Distance***	***Bearing***	***Distance***
0000	090.0°	8.8 nm	064.5°	11.2 nm
0006	102.8°	7.5 nm	064.5°	9.6 nm

Questions 1 thru 3 refer to Contact A.

1. CPA _______________ 2. DRM _______________ 3. SRM _______________

Questions 4 thru 6 refer to Contact B.

4. CPA _______________ 5. DRM _______________ 6. SRM _______________

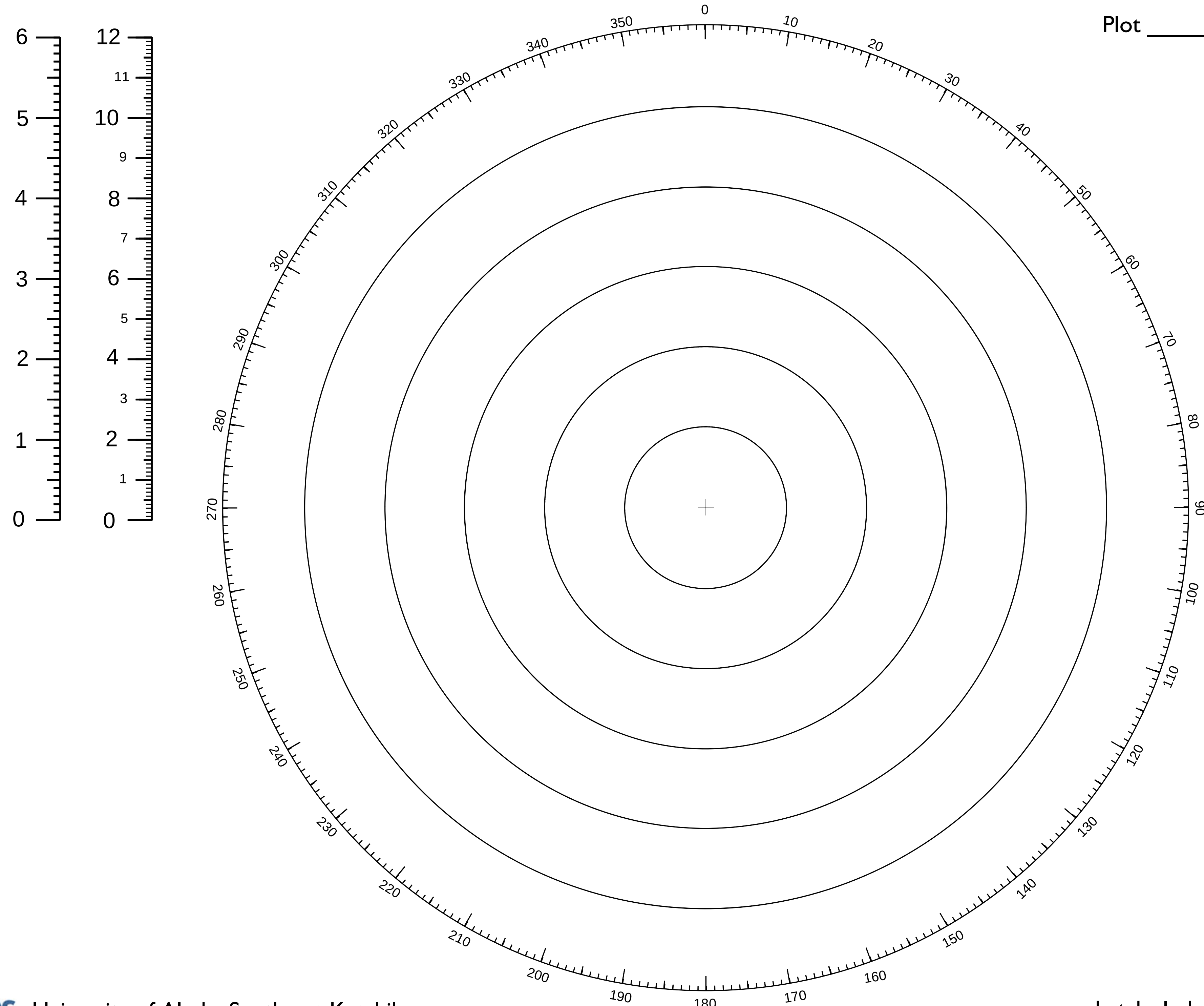
Questions 7 thru 12 refer to the contact with the smallest CPA. Use an MX of 4 miles and a CPA of 2 miles when solving for new course and new speed solutions.

7. What is the TCPA? _______________
8. Which would best describe this situation? (meeting, crossing, overtaking)
9. What is the contact's True Course? _______________
10. What is the contact's True Speed? _______________
11. What is the new course? _______________
12. Is there a new speed solution? _______________

Answers

1. 6.7 nm (6.2-7.2)
2. 221° (216-226)
3. 22 knots (20-24)
4. 0.0 nm (0.0-0.5)
5. 245° (240-250)
6. 16 knots (14-18)
7. 0043 (0040-0046)
8. Crossing
9. 300° (295-305)
10. 10 knots (8-12)
11. 076° (071-081)
12. Yes

Plot ________


0 1 2 3 4 5 6
0 1 2 3 4 5 6 7 8 9 10 11 12
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350