Radar Plotting Workbook

By Dennis A Degner Edition: 2019-03-15

The intent of this workbook is to provide a rapid radar plotting review for mariners preparing renew any Radar Observer Endorsement. **A printable radar plot sheet is available on the last page of this workbook.**

Columbia Pacific Maritime provides a Radar Recertification Course that will satisfy the renewal of any Radar Observer Endorsement, including Rivers, Inland, or Unlimited. This course is available by appointment any day the school is open, 7-days a week.

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Lesson 1.1 Radar Plotting Review

The expected learning outcome is that the student will review and discuss with the instructor rapid radar plotting methods including:

a. The 6-minute rule for making speed and distance calculations.
b. The meaning of the rm, er, and em vectors.
c. The meaning of the acronyms CPA, TCPA, DRM, and SRM.
d. How to determine the CPA, TCPA, DRM, SRM, and the contacts true course and speed from a radar transfer plot.

Read the following information and discuss it with the instructor:

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 or divide by 10.

- 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

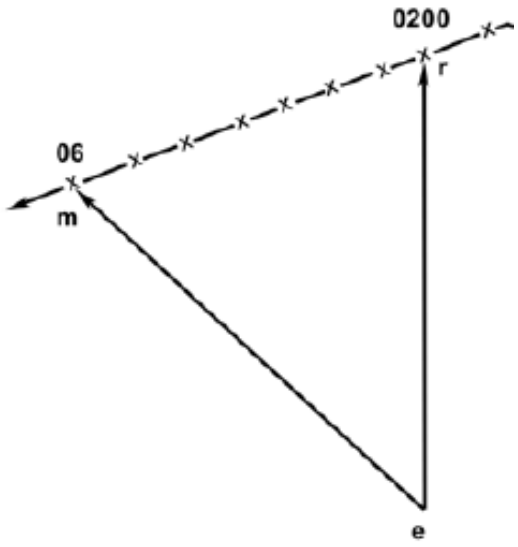
To find the speed traveled by observing the distance for 6-minutes move the decimal point on place to the right or multiply by 10.

- 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 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 Acronyms	
Symbol	Meaning
CPA	Closest Point of Approach
TCPA	Time of Closest Point of Approach
DRM	Direction of Relative Motion

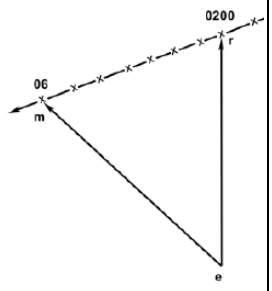
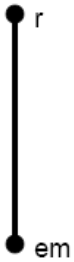
The 6-minute Vector Triangle Explanation.
A vector is simply a line that represents the direction and distance traveled over a specific time frame. In the case of most radar plots the time frame will be 6-minutes; although they can be more or less depending on the situation. The important thing to remember 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.

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

Five Common Radar Contact Situations. The following are some common situations that can be confusing because the three vectors (em, rm, and er) may overlap each other.

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.

Lesson 1.2 Transfer Plotting: Relative Motion Line

The expected learning outcome is that the student will complete a rapid radar transfer plot to determine the:

a. CPA
b. TCPA
c. DRM
d. SRM

The relative motion line (RML) is used to determine the contacts CPA, and thereby to determine risk of collision. The following steps outline the how to plot a contacts RML on a radar transfer plot sheet. The example exercises will use the 12-mile scale with a time interval of 6-minutes.

Complete these steps to plot the RML.

- Plot our own ship's heading.
- Plot the first (00 Min) range and bearing to the contact and label this point as "R".
- Plot the second (06 min) range and bearing to the contact and label this point as "M".
- Draw a line from "R" through "M" and past the center of the plot sheet. This is the Relative Motion Line (RML).

Quick Reference Solutions	
To Find This	Do This
CPA	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

Lesson Exercise

Follow the steps provided to plot the relative motion line for the contact on a Radar Transfer Plot Sheet. Check your answers and discuss the plot with the instructor when finished. Please ask for assistance immediately if needed.

Plot 1

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. What is the CPA? _____

2. What is the TCPA? _____

3. What is the DRM? _____

4. What is the SRM? _____

Answers:

1. CPA 3.5nm (within 0.5nm)
2. TCPA 0332 (within 3-minutes)
3. DRM 233° (within 5°)
4. SRM 20 knots (within 2 knots)

Plot 2

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.		
Time	**Bearing (T)**	**Range (nm)**
0600	081.0°	10.8
0606	083.1°	7.7

1. What is the CPA? _____

2. What is the TCPA? _____

3. What is the DRM? _____

4. What is the SRM? _____

Answers:

1. CPA 1.0nm (within 0.5nm)
2. TCPA 0621 (within 3-minutes)
3. DRM 255° (within 5°)
4. SRM 31 knots (within 2 knots)

Lesson 1.3 Transfer Plotting: Contacts Course and Speed

The expected learning outcome is that the student will complete a rapid radar transfer plot to determine the:

a. CPA and TCPA
b. DRM and SRM
c. Situation
d. Contacts True course and speed

The RML shows the contacts relative motion, which is generally very different than the contacts true motion. To determine the contacts true motion our own ship's vector (er) is plotted from point "R" on the relative motion line. Once "ER" has been plotted then the contacts true course and speed (EM) becomes apparent. Collectively, the points E, R, and M are called the first vector triangle. The situation is determined by comparing our own ship's course and speed to the contacts true course and speed. Review the table on page 5 for more information on the five situations. Follow these steps to plot the first vector triangle.

1. Plot our own ship's heading and then plot the first (00 Min) range and bearing to the contact and label this point as "R".
2. Plot the second (06 min) range and bearing to the contact and label this point as "M". Then draw a line from "R" through "M" and past the center of the plot sheet. This is the Relative Motion Line (RML).
3. From point "R" draw a line parallel to our own ship's heading down-scope and then measure a distance of 1/10th of our own ship's speed along this line and label this point as "E".
4. Draw a line from "E" to "M". This line (E to M) represents the contacts true course and speed.

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

Lesson Exercise

Follow the steps provided to plot the first vector triangle for the contact on a Radar Transfer Plot Sheet. Check your answers and discuss the plot with the instructor when finished. Please ask for assistance immediately if needed.

Plot 1

Our own ship is on a course of 025° T at a speed of 18 knots when a contact is observed at the following radar ranges and bearings.		
Time	**Bearing (T)**	**Range (nm)**
1100	349.8°	10.6
1106	349.3°	8.8

1. What is the CPA? _____

2. What is the TCPA? _____

3. What is the DRM? _____

4. What is the SRM? _____

5. What is the contacts true course? _____

6. What is the contacts true speed? _____

7. Which best describes the situation? A. Meeting B. Crossing C. Overtaking

Answers:

1. CPA 0.5nm (within 5°)
2. TCPA 1136 (within 3 minutes)
3. DRM 173° (within 5°)
4. SRM 18 knots (within 2 knots)
5. Contacts course 097° (within 5°)
6. Contacts speed 10 knots (within 2 knots)
7. B

Plot 2

Our own ship is on a course of 315° T at a speed of 10 knots when a contact is observed at the following radar ranges and bearings.		
Time	**Bearing (T)**	**Range (nm)**
1200	316.4°	11.1
1206	316.7°	9.0

1. What is the CPA? _____

2. What is the TCPA? _____

3. What is the DRM? _____

4. What is the SRM? _____

5. What is the contacts true course? _____

6. What is the contacts true speed? _____

7. Which best describes the situation? A. Meeting B. Crossing C. Overtaking

Answers:

- CPA 0.3nm (within 0.5nm)
- TCPA 1232 (within 3 minutes)
- DRM 135° (within 5°)
- SRM 21 knots (within 2 knots)
- Contacts course 135° (within 5°)
- Contacts speed 11 knots (within 2 knots)
- A

Lesson 1.4 Transfer Plotting: New Course and Speed Solutions

The expected learning outcome is that the student will complete a rapid radar transfer plot to determine:

a. The CPA and TCPA
b. The DRM and SRM
c. The Contacts True course and speed
d. The New course solution to avoid collision with a safe CPA
e. If a speed reduction will allow the contact to pass at a safe CPA

Plotting the first vector triangle to determine risk of collision is an important first, the second step is collision avoidance. What action should be taken by our own ship to avoid collision and pass the contact at a safe distance. This is called the second vector triangle. Follow these steps to plot the second vector triangle and determine the new course and new speed solutions to avoid collision and pass the contact at a safe distance. For these exercises a safe distance is a 2-mile CPA, and the maneuvering point (Mx) will be 4-miles.

1. Plot our own ship's heading and then plot the first (00 Min) range and bearing to the contact and label this point as "R".
2. Plot the second (06 min) range and bearing to the contact and label this point as "M". Then draw a line from "R" through "M" and past the center of the plot sheet. This is the Relative Motion Line (RML).
3. From point "R" draw a line parallel to our own ship's heading down-scope and then measure a distance of 1/10th of our own ship's speed along this line and label this point as "E". Draw a line from "E" to "M". This line (E to M) represents the contacts true course and speed.
4. Mark Mx at the point where the 4-mile range ring crosses RML. From this point draw a line tangent to the 2-mile range ring on the left side of our own ship. This is the New Relative Motion Line (NRML).
5. From "M" draw a line in reciprocal direction as the NRML, this is called the NRML1 and evaluate the course and speed solutions.
    a. If the NRML1 crosses the original ER vector than there is a speed solution, if it does then reducing our ship's speed will not result in passing the contact at a safe distance.
    b. To find the new course solution place one point of the dividers on point E and the other on point R and then rotate point R clockwise until it touches the NRML1. Label this point as R1. Measure direction of ER1 to find the new course solution.

Lesson Exercise

Follow the steps provided to plot the first and second vector triangles for the contact on a Radar Transfer Plot Sheet. Check your answers and discuss the plot with the instructor when finished. Please ask for assistance immediately if needed.

Plot 1

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.		
Time	**Bearing (T)**	**Range (nm)**
0600	080.0°	11.4
0606	080.0°	10.2

1. What is the CPA? _____

2. What is the TCPA? _____

3. What is the DRM? _____

4. What is the SRM? _____

5. What is the contacts true course? _____

6. What is the contacts true speed? _____

7. Which best describes the situation? A. Meeting B. Crossing C. Overtaking

8. What is the new course solution for a 2nm CPA using an Mx of 4nm? _____

9. Is there a speed solution? A. Yes B. No

Answers:

1. CPA 0.0nm (within 0.5nm)
2. TCPA 0700 (within 3 minutes)
3. DRM 260° (within 5°)
4. SRM 12 knots (within 2 knots)
5. Contacts course 307° (within 5°)
6. Contacts speed 15 knots (within 2 knots)
7. B
8. New course 087° (within 5°)
9. A

Plot 2

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.		
Time	**Bearing (T)**	**Range (nm)**
1300	021.0°	11.0
1306	021.3°	8.3

1. What is the CPA? _____

2. What is the TCPA? _____

3. What is the DRM? _____

4. What is the SRM? _____

5. What is the contacts true course? _____

6. What is the contacts true speed? _____

7. Which best describes the situation? A. Meeting B. Crossing C. Overtaking

8. What is the new course solution for a 2nm CPA using an Mx of 4nm? _____

9. Is there a speed solution? A. Yes B. No

Answers:

1. CPA 0.2nm (within 0.5nm)
2. TCPA 1324 (within 3 minutes)
3. DRM 200° (within 5°)
4. SRM 27 knots (within 2 knots)
5. Contacts course 200° (within 5°)
6. Contacts speed 15 knots (within 2 knots)
7. A
8. New course 094° (within 5°)
9. B

Lesson 1.5 Transfer Plotting: Multiple Contacts

The expected learning outcome is that the student will complete a rapid radar transfer plot for multiple contacts to determine:

a. For all contacts the CPA, DRM, and SRM
b. For the contact with the greatest risk of collision the TCPA, Contacts true course and speed, the new course solution to avoid collision with a safe CPA, and if a speed reduction will allow the contact to pass ahead at a safe CPA.

When plotting multiple contacts plot the RML for all contacts on the same plot sheet to evaluate risk of collision and then maneuver for the contact with the greatest risk of collision. Follow the steps provided in the previous lessons to complete these exercises and please contact an instructor immediately if assistance is needed.

Lesson Exercise

For all contacts determine the:

- CPA
- DRM
- SRM

For the contact with the greatest risk of collision (smallest CPA) determine the:

- TCPA
- Contacts true course
- Contacts true speed
- Situation

Maneuver for a 2nm CPA using an Mx of 4nm and:

- Determine the new course solution.
- Evaluate if there is a speed solution.

Plot 1

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 (T)	**Range (nm)**	**Bearing (T)**	**Range (nm)**
2000	040.9°	6.2	137.4°	9.5
2006	035.5°	5.2	137.6°	8.1

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.

7. What is the TCPA? _____

8. Which best describes the situation? A. Meeting B. Crossing C. Overtaking

9. What is the contact's True Course? _____

10. What is the contact's True Speed? _____

11. What is the new course for a 2nm CPA using an Mx of 4nm? _____

12. Is there a new speed solution? A. Yes B. No

Answers:

1. CPA 2.7nm (within 0.5nm)
2. DRM 247° (within 5°)
3. SRM 11 knots (within 2 knots)
4. CPA 0.1 nm (within 0.5nm)
5. DRM 317° (within 5°)
6. SRM 14 knots (within 2 knots)
7. TCPA 2040 (within 3 minutes)
8. B
9. True course 000° (within 5°)
10. True speed 15k (within 2 knots)
11. New course 153° (within 5°)
12. A

Plot 2

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 (T)	**Range (nm)**	**Bearing (T)**	**Range (nm)**
1900	350.2°	7.7	031.0°	11.4
1906	350.2°	7.7	031.0°	9.2

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.

7. What is the TCPA? _____

8. Which best describes the situation? A. Meeting B. Crossing C. Overtaking

9. What is the contact's True Course? _____

10. What is the contact's True Speed? _____

11. What is the new course for a 2nm CPA using an Mx of 4nm? _____

12. Is there a new speed solution? A. Yes B. No

Answers:

1. CPA 7.7nm (within 0.5nm)
2. DRM NA
3. SRM NA
4. CPA 0.0 nm (within 0.5nm)
5. DRM 211° (within 5°)
6. SRM 22 knots (within 2 knots)
7. TCPA 1931 (within 3 minutes)
8. B
9. True course 251° (within 5°)
10. True speed 12k (within 2 knots)
11. New course 054° (within 5°)
12. A

Plot 3

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 (T)	**Range (nm)**	**Bearing (T)**	**Range (nm)**
2200	344.1°	7.8	000.0°	11.3
2206	343.1°	7.3	000.0°	8.6

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.

7. What is the TCPA? _____

8. Which best describes the situation? A. Meeting B. Crossing C. Overtaking

9. What is the contact's True Course? _____

10. What is the contact's True Speed? _____

11. What is the new course for a 2nm CPA using an Mx of 4nm? _____

12. Is there a new speed solution? A. Yes B. No

Answers:

1. CPA 2.1nm (within 0.5nm)
2. DRM 180° (within 5°)
3. SRM 5 knots (within 2 knots)
4. CPA 0.0 nm (within 0.5nm)
5. DRM 180° (within 5°)
6. SRM 27 knots (within 2 knots)
7. TCPA 2325 (within 3 minutes)
8. A
9. True course 180° (within 5°)
10. True speed 12k (within 2 knots)
11. New course 054° (within 5°)
12. B

Plot 4

Our own ship is on a course of 000° T at a speed of 14 knots when the following radar ranges and bearings were observed.				
Time	**Contact A**		**Contact B**	
	Bearing	**Range**	**Bearing**	**Range**
2100	356.2°	8.1	045.0°	11.6
2106	355.9°	7.4	054.8°	8.8

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.

7. What is the TCPA? _____

8. Which best describes the situation? A. Meeting B. Crossing C. Overtaking

9. What is the contact's True Course? _____

10. What is the contact's True Speed? _____

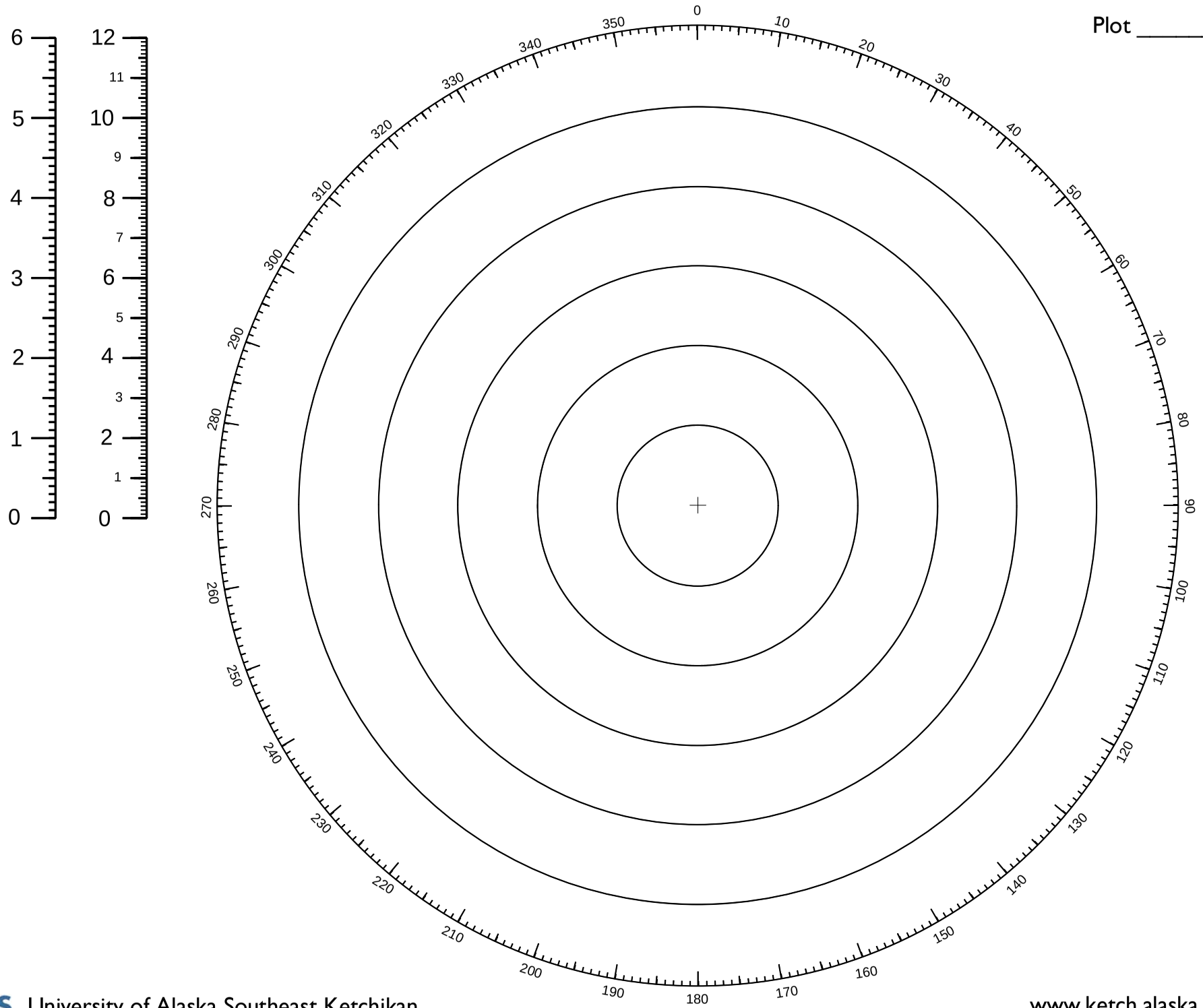
11. What is the new course for a 2nm CPA using an Mx of 4nm? _____

12. Is there a new speed solution? A. Yes B. No

Answers:

1. CPA 0.5nm (within 0.5nm)
2. DRM 180° (within 5°)
3. SRM 7 knots (within 2 knots)
4. CPA 5.3 nm (within 0.5nm)
5. DRM 198° (within 5°)
6. SRM 33 knots (within 2 knots)
7. TCPA 2207 (within 3 minutes)
8. C
9. True course 000° (within 5°)
10. True speed 7k (within 2 knots)
11. New course 012° (within 5°)
12. A

Plot _____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