ARPA Study Guide

*Automatic Radar Plotting Aids. Plotting notation throughout is **E · R · M**. Standards are IMO Res. A.823(19); carriage and the accuracy figures are at 33 CFR 164.38.*

1 · What ARPA does

A navigational system that automatically tracks the positions of multiple vessels, predicts their future movements, and improves collision avoidance and overall safety. It works by analysing radar data and showing target information as vectors.

IT GIVES YOU	WHEN
Range and bearing	Immediately
Relative track of the target	After 1 minute
True course and speed of the target	After 3 minutes
CPA and TCPA	Once tracking
Bow crossing range and time	Once tracking

The point is workload and situational awareness — it takes the arithmetic off the watchkeeper, which matters most in congested or restricted waters. Traditional radar required manual plotting: slow, and prone to human error.

2 · Carriage requirements

VESSEL	REQUIREMENT
10,000 GT +	ARPA if carrying dangerous cargo (SOLAS, via 33 CFR 164.38)
15,000 GT +	ARPA otherwise
300 GT + and all passenger vessels	9 GHz radar and an electronic plotting aid
500 GT +	An automatic tracking aid to plot range and bearing of other targets
3,000 GT +	A 3 GHz radar OR a second 9 GHz radar functionally independent of the first; AND a second automatic track

3 · What ARPA requires

INPUT	SOURCE	ERROR ALLOWED
True heading	Own ship gyro compass (ship's true course)	Calibration error 0.5 deg; normal distribution, o = 0.12 deg
Speed	Own ship speed log, THROUGH THE WATER	Calibration error 0.5 kt; normal distribution, 3o = 0.2 kt
Target bearing	Radar	Every radar limitation in section 12
Target range	Radar	Every radar limitation in section 12

> **Errors in input go straight into the answer.**
> ARPA cannot know its gyro is out. It will hand you a confident, precise and wrong true vector, with no indication whatever that anything is amiss.

4 · What ARPA must be able to do

- Acquire targets automatically or manually
- Track, process and display continuous updates
- Be available on range scales of **0.1, 0.2, 3, 4, 12 and 16 NM**
- Obtain quick range and bearings

- Provide for trial manoeuvres
- Provide operational warnings, which can be activated or de-activated:
  - — targets closing to within a minimum range and time chosen by the operator
  - — lost or out-of-range target
  - — ARPA malfunction
  - — lost sensors

ALSO IN THE STANDARD	THE FIGURE
Targets tracked	20 if acquisition is automatic; 10 if manual only
Relative speeds	Up to 100 knots
Trial manoeuvre	With or without a time delay, and WITHOUT interrupting tracking

Note 1. For successful acquisition the target should be within **0.2 to 32 nm** and not obscured by sea or rain clutter.

Note 2. When the capacity for manual acquisition is reached a message appears in the text area. Cancel tracking of non-threatening targets if you want to acquire more by hand.

5 · The plotting symbols

ARPA Symbol	Meaning
	Immediately after acquisition.
	Within 20 scans of the antenna after acquisition, a vector appears to show a trend of movement.
	Within 60 scans of the antenna after acquisition, the plotting symbol changes to a small circle, indicating steady-state tracking condition.
 (flashing)	**Lost target** is indicated by flashing diamond symbol. The diamond is formed from two equal triangles.

6 · Accuracy — and why the symbols change when they do

Accuracy is set at 95% probability across four defined scenarios. Learn the shape of it, not sixteen numbers:

AFTER	REL COURSE	REL SPEED	CPA	TCPA	TRUE COURSE	TRUE SPEED
1 minute	7 to 15 deg	0.6 to 2.8 kn	1.6 to 2.0 nm	not specified	not specified	not specified
3 minutes	2.3 to 4.6 deg	0.3 to 0.9 kn	0.5 to 0.7 nm	1.0 min	2.6 to 7.5 deg	0.8 to 1.2 kn

At one minute you have a TREND. At three minutes you have a DECISION.
After a minute the standard promises CPA only to within **1.6 to 2.0 miles** — nothing anybody would alter course on. After three it is 0.5 to 0.7. That is precisely why the symbol shows a vector at **20 scans** and only becomes a steady-state circle at **60 scans**: the machine is telling you which of the two you are holding. It is Rule 7(c) with a number attached.

7 · The three zones — know which one alarms

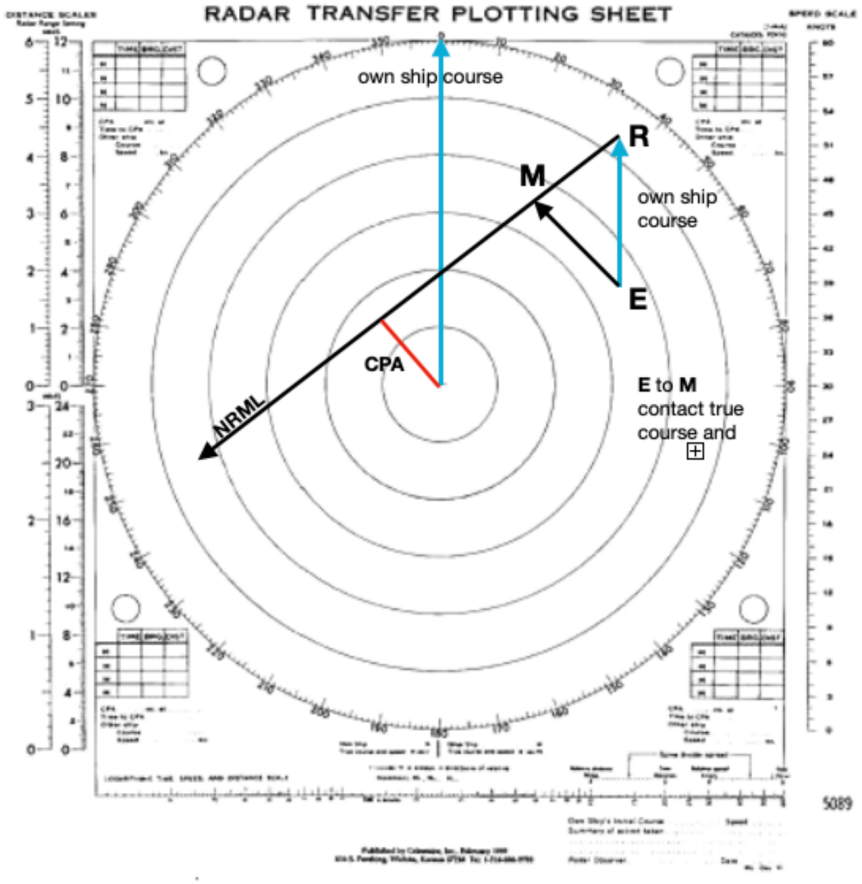
ZONE	WHERE	BEHAVIOUR
Auto acquire zone	ARPA	Defaults between 3 and 4 nm. Create it LEFT TO RIGHT. NO alarm on acquisition.

ZONE	WHERE	BEHAVIOUR
Exclusion area	ARPA	Turns off auto-acquire over a specific area
Guard zone	Radar + ARPA	ANY encroachment will sound the alarm

8 · First vector triangle

LEG	WHAT IT IS
R to M	RELATIVE MOTION line for the CONTACT
E to R	(Our) OWN SHIP true course and speed
E to M	(Them) CONTACT true course and speed

R is the first bearing and range, say 0600. **M** is the second, 0606, six minutes later. R to M is therefore also the distance the contact travelled in six minutes. Own ship plus relative equals true — **ER + RM = EM**. Use the same interval on every leg or the triangle lies.



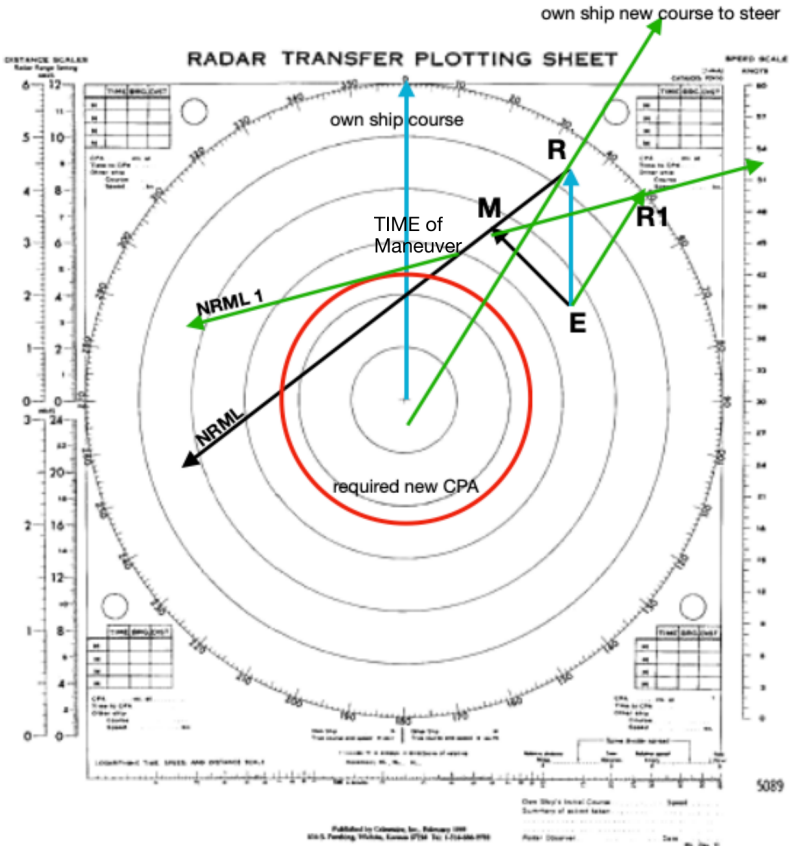
The first triangle worked on the plotting sheet. RML run on past own ship gives the CPA.

9 · Second vector triangle — new course to steer

1. Start at **MX** (course change time) and plot the **NRML** (New Relative Motion Line) past the tangent of the CPA circle required.
2. Plot a parallel NRML from **M** in the opposite direction, past the E to R line. That is the **Reference Line (REF)**.
3. Swing the **R** point to the right to intersect the Reference Line. That is **R1**.
4. **E to R1** is your new course to steer. (Distance is the new speed option.)

To find the NEW CPA

1. Parallel own ship's new course from **E** of each contact.
2. Swing the **R** point to the right to intersect the Reference Line. That is **R1**.
3. Plot a line from **R1** to **M**. That is the new REF line for the contact.
4. At course change point **MX**, plot a parallel line from MX of the contact out past own ship.
5. The closest distance that provides (the tangent) is the **CPA**, and the **TCPA**.



The manoeuvre worked on the sheet. NRML 1 runs tangent to the required new CPA; swinging E to R over to it creates R1, and E to R1 is the course to steer.

10 · The six-minute rule, both directions

YOU HAVE	YOU WANT	DO THIS	EXAMPLE
Speed	Distance in 6 minutes	Divide by 10	20 kt / 10 = 2 nm
Distance in 6 minutes	Speed	Multiply by 10	2 nm x 10 = 20 kt

To determine the time of a speed or course change, or to find CPA and TCPA: measure from R to M on the first vector triangle, and mark every six minutes along the NRML. At the tangent point to own ship you can measure the distance for CPA and read off the time for TCPA.

11 · Relative and true vectors

Relative Vectors

1. acquire targets
2. increase vector length
3. wait **1 minute**

Relative vectors never change even if
- Gyro error
- ground stabilized

Provides for close quarters data and risk of collision

True Vectors

1. acquire targets
2. increase vector length
3. wait **3 minutes**

True vectors provide aspect of target

> **This is the real reason relative vectors are the collision-avoidance tool.**
> They do not change even with a **gyro error**, and they do not change if the display is **ground stabilised** — the two things most likely to be quietly wrong. A true vector inherits both. Relative for close quarters and risk of collision; true for aspect and for navigation.

TRIAL MANOEUVRE — marked T on the display — to work out speed change or course change issues. A trial with no delay in it assumes you act instantly; put in the time it will really take to order it, get it on, and have her answer.

12 · Stabilisation and orientation

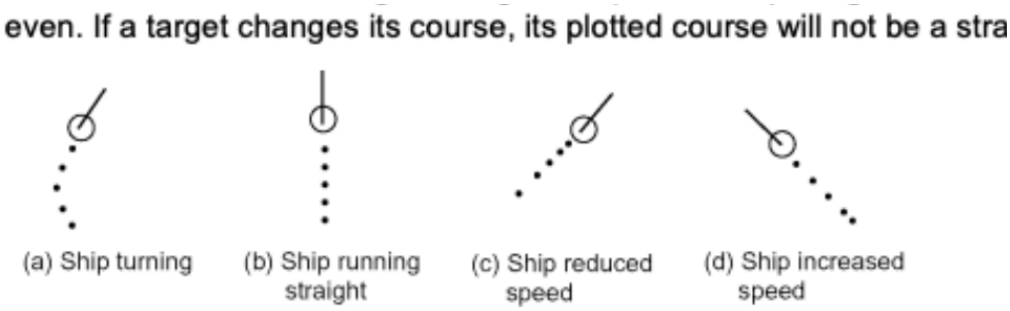
MODE	WHAT IT IS FOR
North up, sea stabilised	Matches the chart
Course up, sea stabilised	Matches your view
Ground stabilised	Provides set and drift
Head up, un-stabilised	Does NOT support true vectors. Relative vectors only.

13 · To increase target size on radar

Reduce range · increase gain · switch to **LP** (long pulse) · switch to **S band**.

14 · History dots

History dots are 1 minute intervals, up to 2 hours. ARPA marks the past positions of any tracked target with equally time-spaced dots. A new dot is added every minute, or at another preset interval, until the preset number is reached. If a target changes speed the spacing goes uneven; if it changes course the plotted track is not a straight line.



Free proof that a track is real and has not swapped — and the quickest way to see a target manoeuvring before the vector catches up.

15 · Limitations

- **Small, slow or highly manoeuvrable targets** may not be acquired or held.
- **Rain, fog and sea clutter** degrade performance badly, losing targets and producing unreliable data. Precipitation also throws spurious echoes that look like contacts.
- **Accuracy depends entirely on the sensors** — gyro and speed log. See section 3.
- **Busy water** can exceed the tracking capacity, or induce **target swap** when two contacts pass close. After a swap the vectors go wild, then settle down looking perfectly reasonable. History dots are how you catch it.
- **Blind and shadow sectors** from your own structure — ARPA cannot track what the radar cannot see.
- **Second trace echoes**, from delayed returns, place a target where it is not.
- **Delays in display**, especially during acquisition or when a target manoeuvres.
- **Minimum range** is limited by pulse length. **Range and bearing discrimination** is limited by pulse length and beam width — two contacts close together may be one blip.
- **It lags YOUR manoeuvre too.** Alter course and every vector on the screen is wrong until the tracker re-settles, and that is exactly when you are relying on it hardest.
- **Over-reliance is the big one.** Keep a proper lookout and keep your hand in at manual plotting — it is the only way you will ever notice the machine is wrong.

16 · The COLREGS hooks

RULE	WHAT IT SAYS THAT TOUCHES ARPA
Rule 5	Lookout by sight AND hearing AND all available means. ARPA is one of the means, never a substitute.
Rule 6	Safe speed. Radar and ARPA capability and limitations are named factors.
Rule 7(b)	Proper use shall be made of radar if fitted, including long-range scanning and radar plotting or equivalent systematic observation.
Rule 7(c)	Assumptions shall not be made on the basis of scanty information, ESPECIALLY scanty radar information.
Rule 7(d)	Risk exists if the compass bearing does not appreciably change; also at close range or with a large vessel even when it does.
Rule 8	Any alteration must be large enough to be readily apparent visually or by radar. Avoid a succession of small alterations.
Rule 19	Restricted visibility. A vessel detecting another BY RADAR ALONE shall determine whether a close-quarters situation is developing

17 · Say these until they are automatic

- **Constant bearing, decreasing range.** Same bearing, getting bigger — you are going to meet.

- **Relative vectors for collision avoidance. True vectors for navigation.**
- **Relative track at one minute. True course and speed at three.**
- **ARPA does not keep a lookout, does not know the Rules, and does not take the decision.** It removes arithmetic, not responsibility.

Georgia Hilton's ARPA notes and plotting diagrams, with the IMO accuracy figures and COLREGS references added. Check any figure a student will memorise against your own syllabus text before the exam.