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Master Reference

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1. Returning to Track — Introduction

If you find yourself off track during a flight, the most common en-route cause is a **change in wind** since the flight plan was prepared. Other causes include failure to fly the planned heading accurately, or making too shallow a turn at the last waypoint.

✂ Rapid Navigation Assumption

For these techniques it is assumed that for *small* heading changes, a change of **track** equals the same change of **heading**. In practice drift changes slightly when you alter heading, but the error is negligible for the corrections involved.

There are **three basic techniques** for returning to track, plus the recommended practical method:

1. Double Track Angle Error Method
2. Track Error Angle and Closing Angle
3. Combined TEA + CA Single Calculation
4. **New Track Reference** — the preferred method

2. Track Error Angle vs Drift — Critical Distinction

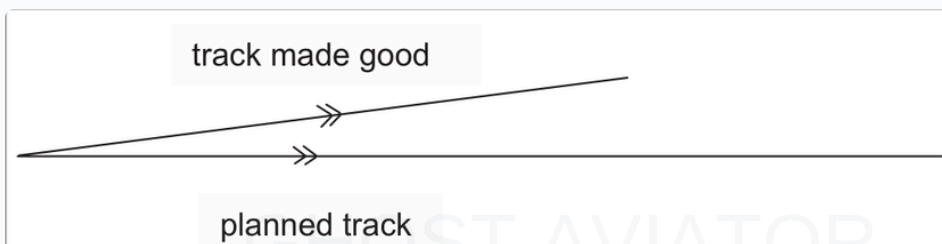


Figure 1 — Planned track vs Track Made Good (TMG)

The track you intended to fly is the **Planned Track**. The track actually made over the ground is the **Track Made Good (TMG)**. The angle between them is the **Track Error Angle (TEA)**.

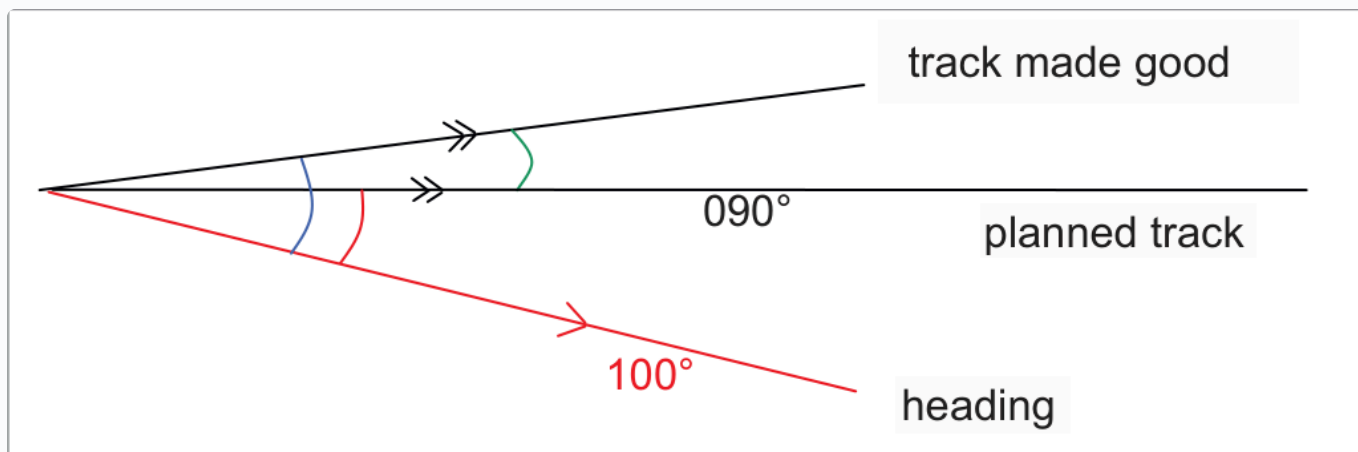


Figure 2 — Heading, expected drift, actual drift, and track error angle

⚠ Common Exam Trap — TEA is NOT Drift

Drift is the angle between *Heading* and *Track* (either planned track or TMG).

Track Error Angle is the angle between *Planned Track* and *TMG* only.

TEA is the difference between expected drift and actual drift — but TEA is not drift.

You **cannot** calculate drift if the heading is not given.

Term	Definition	Diagram colour (Fig 2)
Track Error Angle	Planned track – TMG	Green
Expected Drift	Heading – Planned track	Red
Actual Drift	Heading – TMG	Blue

3. Double Track Angle Error Method

Situation: planned track 090°(T). After 30 NM you get a visual fix 4 NM *left* of track.

Step 1 — Calculate Track Error Angle

$$\text{TEA} = (4 / 30) \times 60 = \mathbf{8^\circ \text{ left}}$$

left of track.

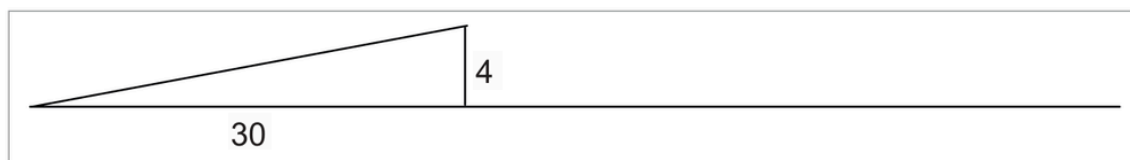


Figure 3 – 4 NM left of track after 30 NM along track

If no action is taken, the aircraft will continue to diverge from track at the same rate:

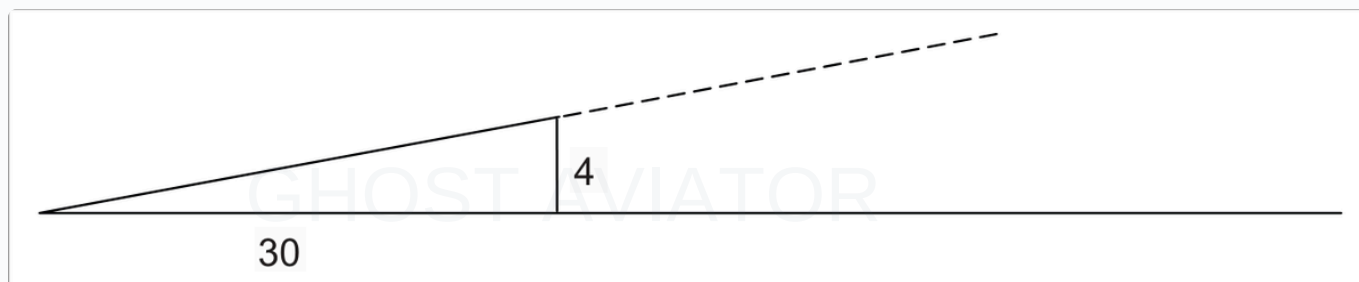


Figure 4 – Continuing to diverge from track – no correction applied

Turning **8° right** stops the divergence but only *parallels* track – the aircraft is still 4 NM off:

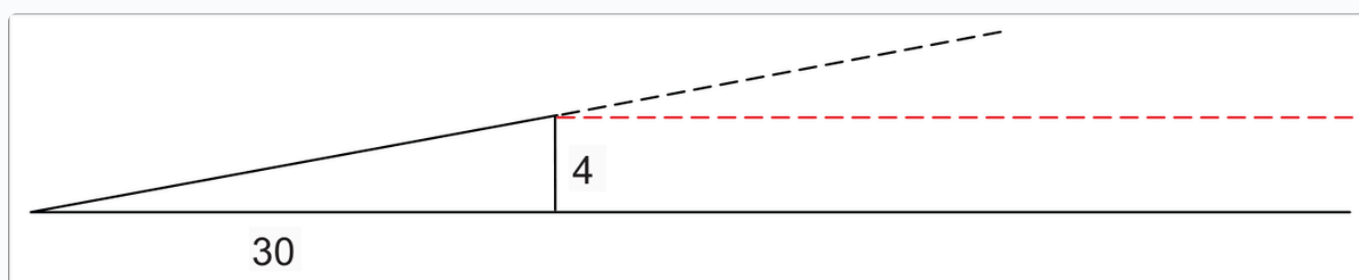


Figure 5 – Paralleling track after initial 8° right correction

Step 2 – Turn **DOUBLE** the TEA (**16° right**)

Total turn = $2 \times 8^\circ =$ **16° right**

This creates an **isosceles triangle** – the aircraft converges back to track at a closing angle equal to the TEA (8°)

Time to regain track = time taken to go off track (symmetrical triangle)

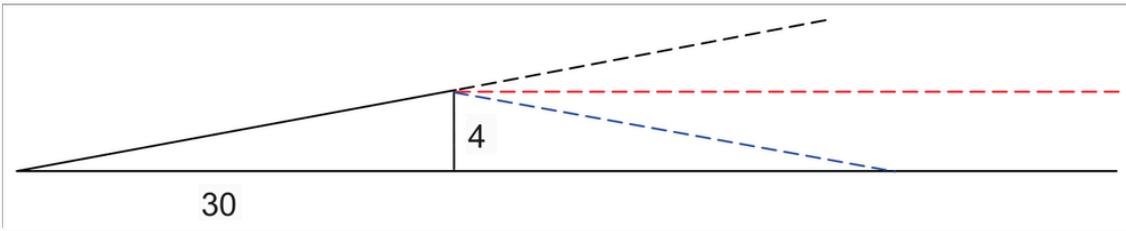


Figure 6 — Isosceles triangle formed by turning double the track error angle

✈ No Map-Reading Required

By turning double the TEA you create a symmetrical triangle. If you deviated 1000–1020, you will regain track at exactly **1040** — just watch the clock.

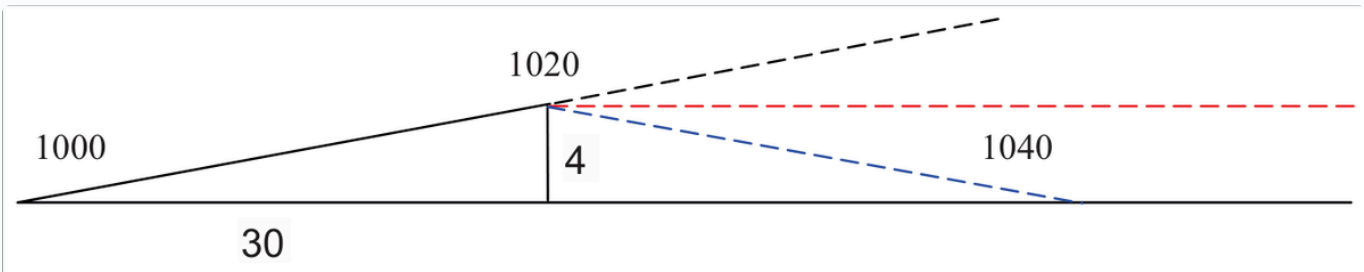


Figure 7 — Back on track at the predicted time — no map-reading required

Once back on track, **do not maintain that heading** — you will diverge to the *other* side:

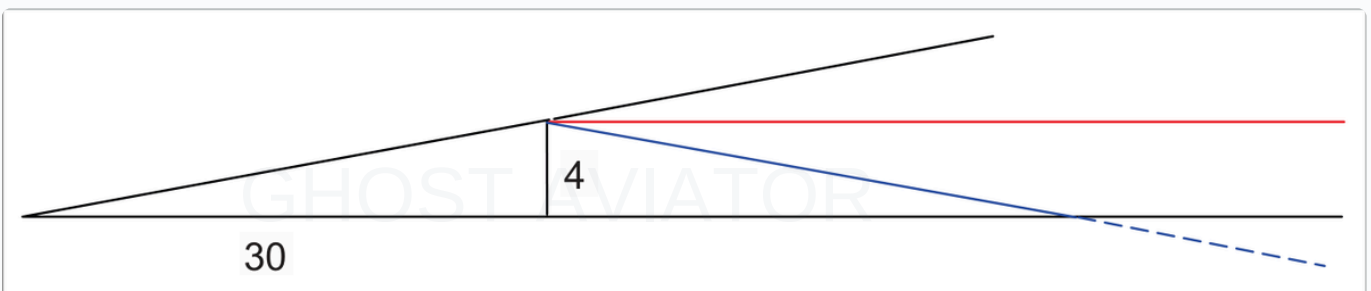


Figure 8 — Diverging to right of track if no correction made on regaining track

Turn **8° left** on regaining track. You now fly on a heading 8° right of your original — which is the correct heading for the actual wind conditions.

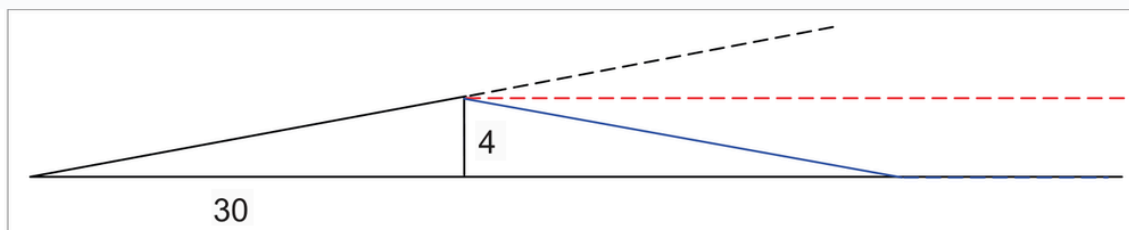


Figure 9 — Maintaining track by turning 8° left on regaining track

✖ Limitation of Double TEA Method

If you are more than **half-way along the leg** when you get your first pinpoint, the doubled correction will not return you to track before the next waypoint. Use the TEA + Closing Angle method instead.

4. Track Error Angle and Closing Angle

Use this method to fly *direct to destination* rather than regain track, or when more than half-way along the leg.

Situation: total track = 78 NM, after 30 NM you are 4 NM left of track (TEA = 8° left).

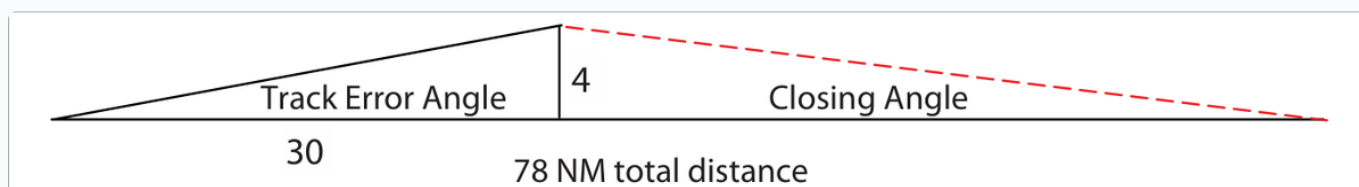


Figure 10 — Track error angle and closing angle to destination

Calculation

Remaining distance: $78 - 30 = 48$ NM

Closing Angle: $(4 / 48) \times 60 = 5^\circ$

Total turn: $TEA + CA = 8^\circ + 5^\circ = \mathbf{13^\circ \text{ right}}$

Turn required to fly direct to destination

$$\text{Turn} = \text{Track Error Angle} + \text{Closing Angle}$$

5. Combined TEA + CA — Single Calculation Method

This gives *exactly* the same answer as the TEA + CA method but skips calculating the TEA. You only need the Closing Angle, then multiply by an inverted fraction.

Consider exactly the same problem. We have a track 78 miles long and after 30 miles along track, we are 4 miles left of track. This time, do not bother to work out the Track Error Angle. Just consider the Closing Angle.

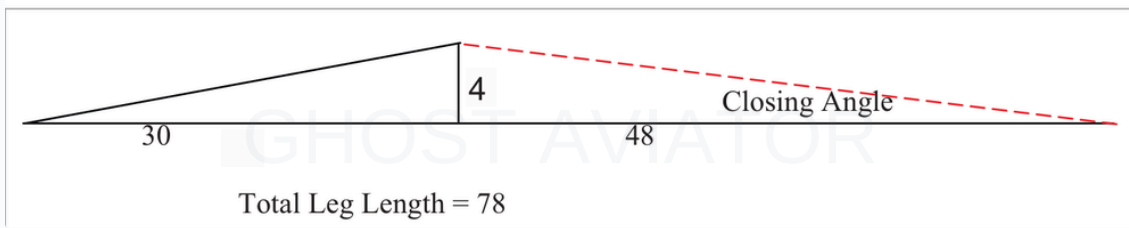


Figure 11 — Closing angle only — combined single-calculation method

Same problem: 78 NM track, 30 NM along, 4 NM left

Closing Angle: $(4 / 48) \times 60 = 5^\circ$

Proportion flown: $30 / 78 \rightarrow$ **Inverted:** $78 / 30$

Total turn: $(78/30) \times 5^\circ = \mathbf{13^\circ}$ — identical to TEA + CA

Combined single-calculation turn

$$\text{Turn} = \text{CA} \times (\text{Total distance} / \text{Distance gone})$$

No separate TEA needed — geometrically equivalent

In Practice

Simply estimate your position as approximately $1/4$, $1/3$, or $1/2$ along the leg, then multiply the closing angle by 4, 3, or 2 respectively.

6. Using These Methods Practically

Join live classes for guided practice and doubt clearing.

i Not EASA ATPL Examined

The practical map-marking techniques in this section are **not examined** in the EASA ATPL. They are used in practical VFR flying training.

Mark the chart during preflight with **angle guidelines** and **distance-to-go markers** so in-flight calculations can be done rapidly by eye.

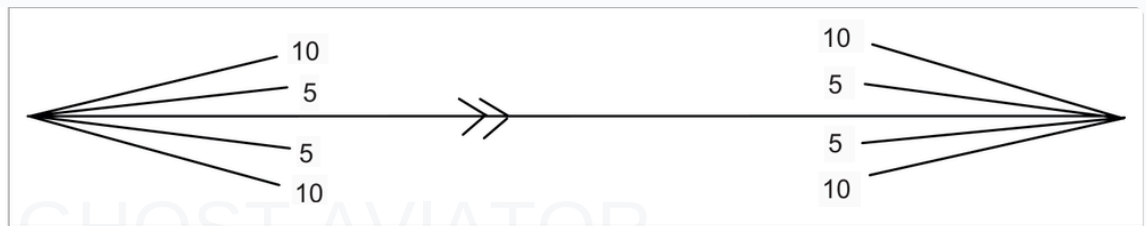


Figure 11.12 5° and 10° guidelines

Figure 12 — 5° and 10° closing-angle guidelines drawn on the map

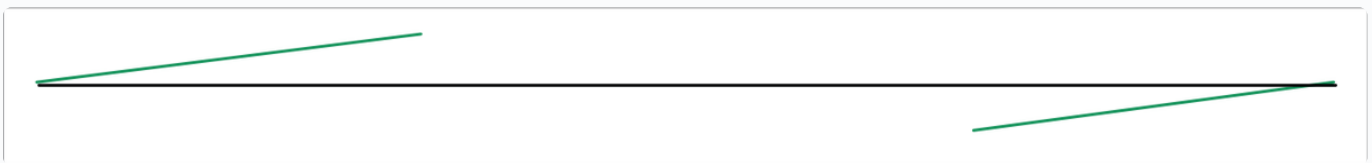


Figure 13 — Single 10° guideline at each end of track

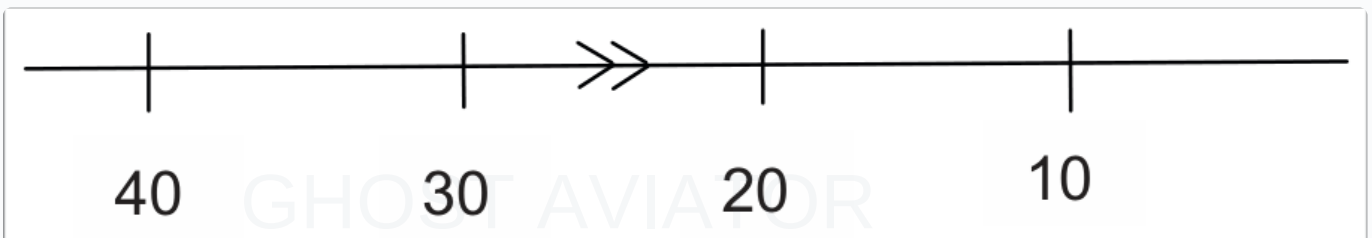


Figure 14 — Distance-to-go markers at 10 NM intervals

With 10° guidelines at each end of track and 10 NM distance-to-go markers, you can read off the closing angle and estimate your proportion along track at a glance — then apply the combined calculation immediately.

7. New Track Reference — The Preferred Method

New Track Reference combines the single-calculation method with a systematic re-correction procedure whenever a new fix is obtained.

✈ New Track Reference Procedure

1. Maintain steady heading until position is *definitely* established — no hasty corrections.
2. Estimate the proportion of the *current* leg distance covered (e.g., $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$).
3. Invert that fraction.
4. Multiply the inverted fraction by the Closing Angle to the destination.
5. Alter heading by that amount, toward the destination.

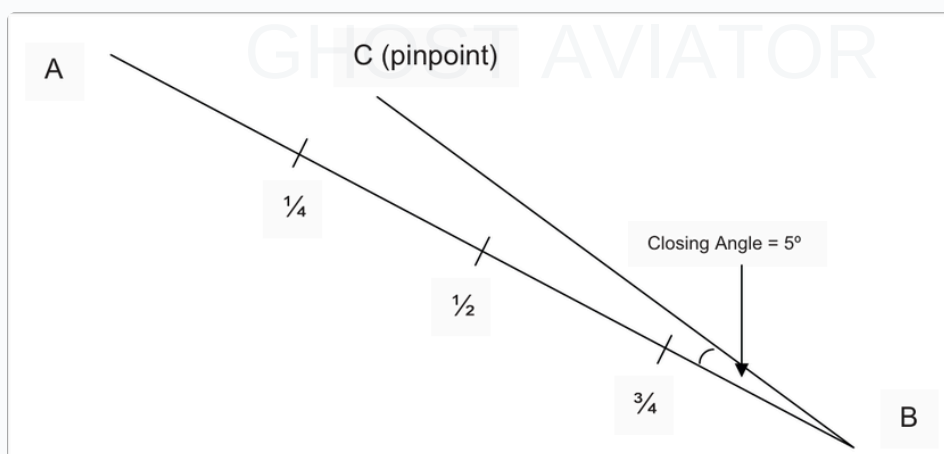


Figure 15 — New Track Reference — initial heading correction at pinpoint C

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Navigation Using the 1 in 60 Rule

Example — First Correction at C ($\frac{1}{4}$ along leg A–B, CA = 5°)

Proportion flown = $\frac{1}{4}$ → Inverted = $\frac{4}{1}$

Turn = $4 \times 5^\circ = \mathbf{20^\circ \text{ starboard}}$

Aircraft now tracks from C toward B on the new heading

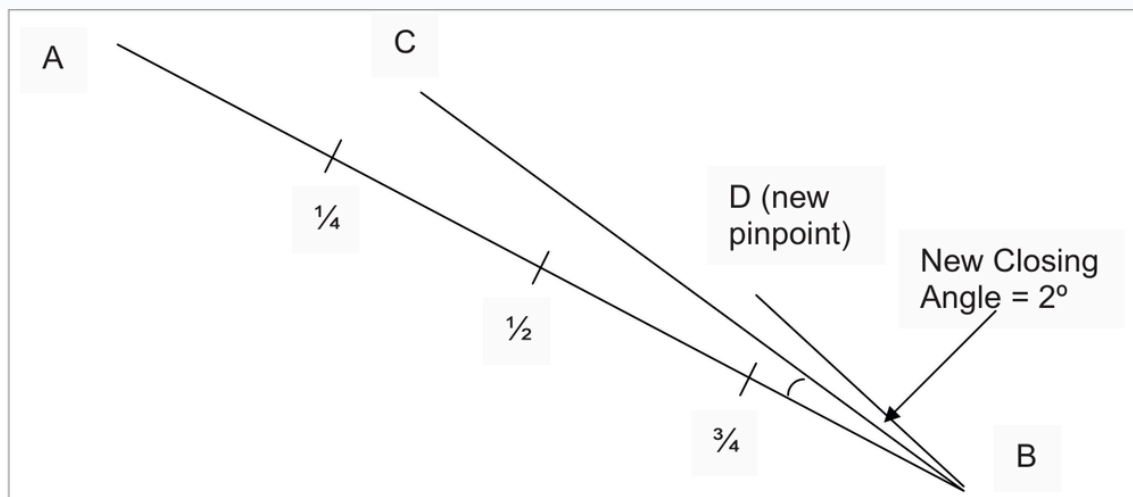


Figure 11.16 Further pinpoint and track correction

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We apply the system again, this time with respect to our 'new' track C-B. Suppose the 10° lines show that angle DRC which is the closing angle with respect to our 'new' desired track

Figure 16 — New Track Reference — further pinpoint D and second correction

Example — Second Correction at D ($\frac{1}{2}$ along new leg C-B, new CA = 2°)

Proportion of C-B flown = $\frac{1}{2} \rightarrow$ Inverted = $\frac{2}{1}$

Turn = $2 \times 2^\circ = 4^\circ$ starboard

Aircraft now tracks from D toward B

Key Points for New Track Reference

- The Closing Angle must be measured from the *new* (current) track, not the original planned track
- The proportion estimate must be of the *new* leg (e.g., C-B), not the original leg (A-B)
- Angle guidelines on the chart were drawn for the original track — mentally adjust for each new leg

Chapter 11 Quick Revision

- TEA is **not** drift — drift requires knowledge of heading
- Double TEA method: turn $2 \times$ TEA $\rightarrow$ regain track in same time as it took to go off $\rightarrow$ **only effective when less than halfway along leg**
- TEA + CA method: fly direct to destination; turn = TEA + CA
- Combined calc: Turn = CA $\times$ (total/gone) — same result, one step
- New Track Reference: hold steady $\rightarrow$ estimate fraction $\rightarrow$ invert $\rightarrow$ multiply CA $\rightarrow$ turn

Practice Questions & Detailed Answers

5 questions (21 sub-parts) • Track error, TMG, drift, heading corrections, ETA

Q1. An aircraft is 3° off its required track at a range of 120 NM from its departure point. How far in NM is it off track?

Answer: 6 NM

$$\text{Distance off} = (\text{TEA} \times \text{distance gone}) / 60 = (3 \times 120) / 60 = \mathbf{6 \text{ NM}}$$

Instructor's Note: Source key: 6 NM. Verified.

Q2. An aircraft is 2 NM off its required track at a range of 40 NM from departure. What is the track error angle?

Answer: 3°

$$\text{TEA} = (2 / 40) \times 60 = \mathbf{3^\circ}$$

Instructor's Note: Source key: 3° . Verified.

Q3. An aircraft leaves A to fly to B, total distance 95 NM. Having flown 35 NM, a pinpoint puts the aircraft **7 NM right of track**.

- (a) What is the track error angle?
- (b) What alteration of heading is required to fly direct to B?
- (c) What is the drift?

Answer: (a) 12° right | (b) 19° left | (c) Cannot be calculated

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(a) Track Error Angle:

$$\text{TEA} = (7 / 35) \times 60 = \mathbf{12^\circ \text{ right}}$$

(b) Heading alteration to fly direct to B:

$$\text{Remaining} = 95 - 35 = 60 \text{ NM} \quad \text{CA} = (7 / 60) \times 60 = 7^\circ$$

$$\text{Total turn} = \text{TEA} + \text{CA} = 12^\circ + 7^\circ = \mathbf{19^\circ \text{ left}}$$
 (aircraft is right of track, so turn left)

(c) Drift:

Cannot be calculated — drift is the angle between *heading* and track. No heading is given, so drift cannot be found. This is an intentional trap: TEA $\neq$ drift.

Instructor's Note: Source key: (a) 12°R, (b) 19°L (TE=12, CA=7), (c) cannot calculate. Verified. Classic exam trap.

Q4. An aircraft is flying from *Airfield W* to Cambridge, planned track **074°(M)**, distance **70 NM**, heading **065°(M)**. Having flown **30 NM**, the pilot pinpoints overhead Cranfield, **4 NM left** of planned track.

- (a) Track error overhead Cranfield? (b) TMG from Airfield W? (c) Expected drift?
(d) Actual drift? (e) Heading alteration to fly direct to Cambridge? (f) New heading from Cranfield?

Answer: (a) 8°L | (b) 066°M | (c) 9°S | (d) 1°S | (e) 14°R | (f) 079°M

(a) Track Error Angle at Cranfield:

$$\text{TEA} = (4 / 30) \times 60 = \mathbf{8^\circ \text{ left}}$$

(b) Track Made Good:

Aircraft is left of planned track $\rightarrow$ TMG < planned

$$\text{TMG} = 074^\circ - 8^\circ = \mathbf{066^\circ(M)}$$

(c) Expected drift:

$$\text{Expected drift} = \text{Planned track} - \text{Heading} = 074^\circ - 065^\circ = \mathbf{9^\circ \text{ Starboard}}$$

(Heading is left of track $\rightarrow$ wind forecast to push aircraft right/starboard)

(d) Actual drift:

$$\text{Actual drift} = \text{TMG} - \text{Heading} = 066^\circ - 065^\circ = \mathbf{1^\circ \text{ Starboard}}$$

(Wind pushed only 1°S, not 9°S as forecast $\rightarrow$ aircraft ended up left of track)

(e) Alteration to fly direct to Cambridge:

Remaining = $70 - 30 = 40$ NM $CA = (4 / 40) \times 60 = 6^\circ$

Total turn = TEA + CA = $8^\circ + 6^\circ = 14^\circ$ right

(f) New heading from Cranfield:

New heading = $065^\circ + 14^\circ = 079^\circ(M)$

Instructor's Note: Source key: (a)8°L (b)066°M (c)9°S (d)1°S (e)14°R [TE=8,CA=6] (f)079°M. All verified. Departure airfield name changed to remove source reference.

Q5. An aircraft is flying from Norwich to *Airfield X*, planned track **250°(M)**, distance **96 NM**, heading **260°(M)**, ground speed **180 kt**. Departs Norwich at **1000**. At **1012**, overhead Ely, **3 NM right** of planned track.

- (a) Planned drift? (b) Track error at 1012? (c) TMG 1000–1012? (d) Actual drift?
(e) Alteration to fly direct to destination? (f) Heading direct?
(g) Alteration to regain track at 1024? (h) Heading 1012–1024?
(i) Change at 1024 and heading from 1024? (j) ETA at destination?

Answer: (a)10°P (b)5°R (c)255°M (d)5°P (e)8°L (f)252°M (g)10°L (h)250°M (i)5°R→255°M (j)1032

(a) Planned drift:

Planned drift = Planned track – Heading = $250^\circ - 260^\circ = 10^\circ$ Port

(Track is left of heading → wind forecast to push aircraft port/left)

(b) Track error at 1012:

Distance flown = $180 \text{ kt} \times 12 / 60 = 36$ NM

TEA = $(3 / 36) \times 60 = 5^\circ$ right

(c) TMG 1000–1012:

Aircraft right of planned track → TMG > planned

TMG = $250^\circ + 5^\circ = 255^\circ(M)$

(d) Actual drift 1000–1012:

Actual drift = TMG – Heading = $255^\circ - 260^\circ = 5^\circ$ Port

(Wind pushed 5°P, not 10°P as forecast → aircraft went right of track)

(e) Alteration to fly direct to destination:

Remaining = $96 - 36 = 60$ NM $CA = (3 / 60) \times 60 = 3^\circ$

Total turn = TEA + CA = $5^\circ + 3^\circ = \mathbf{8^\circ \text{ left}}$

(f) Heading direct to destination:

$260^\circ - 8^\circ = \mathbf{252^\circ(M)}$

(g) Alteration to regain track at 1024 (Double TEA):

Turn = $2 \times TEA = 2 \times 5^\circ = \mathbf{10^\circ \text{ left}}$

(h) Heading 1012–1024:

$260^\circ - 10^\circ = \mathbf{250^\circ(M)}$

(i) Change at 1024 and heading from 1024:

At 1024 aircraft regains track. Turn 5° right (half of the 10° double-TEA correction).

New heading = $250^\circ + 5^\circ = \mathbf{255^\circ(M)}$

This is the corrected heading for the actual wind conditions experienced.

(j) ETA at destination:

$1000-1012 = 36$ NM | $1012-1024 = 36$ NM $\rightarrow$ 72 NM covered by 1024

Remaining = $96 - 72 = 24$ NM | Time = $(24/180) \times 60 = 8$ min

ETA = $1024 + 8 = \mathbf{1032 \text{ hrs}}$

Instructor's Note: Source key: all 10 sub-parts verified. Destination name changed to remove source reference.

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Master Reference — Chapter 11

The Four Methods Compared

Method	Formula	Result	Best used when
Double TEA	Turn = $2 \times \text{TEA}$	Returns to track in same time as deviation	< halfway along leg
TEA + CA	Turn = TEA + CA	Flies direct to destination	Any time
Combined	Turn = CA $\times$ (total/gone)	Same as TEA + CA; one step	Any time
New Track Ref	Turn = CA / fraction along leg	Direct to dest.; re-applicable at any fix	Preferred always

Key Definitions

Term	Formula
Track Error Angle	Planned track – TMG (cross-track / along-track) $\times$ 60
TMG (left of track)	Planned track – TEA
TMG (right of track)	Planned track + TEA
Expected drift	Planned track – Heading
Actual drift	TMG – Heading
Closing Angle	(cross-track error / remaining distance) $\times$ 60

Answer Key — No ✕ Flags

Q	Answer(s)
1	6 NM
2	3°
3	(a) 12°R (b) 19°L [TE=12, CA=7] (c) Cannot calculate — heading not given
4	(a) 8°L (b) 066°M (c) 9°S (d) 1°S (e) 14°R [TE=8, CA=6] (f) 079°M
5	(a)10°P (b)5°R (c)255°M (d)5°P (e)8°L (f)252°M (g)10°L (h)250°M (i)5°R→255°M (j)1032

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DGCA CPL/ATPL General Navigation Study Notes

Chapter 11 — Navigation Using the 1 in 60 Rule

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