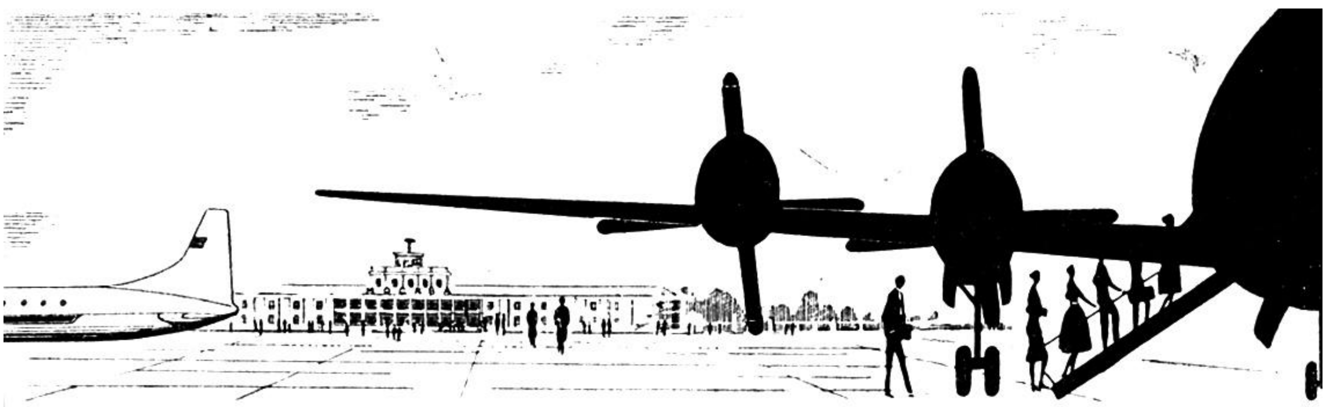
# ILYUSHIN IL-18

## Passenger and Cargo Aircraft

### for Microsoft Flight Simulator 2024



**TECHNICAL DESCRIPTION**

**PART 4 – NAVIGATION**

*by Nemeth Designs Aviation Bureau*

## 1. Philosophy of the System

The Il-18 is flown with a dedicated navigator working an integrated station. The station is built around one idea worth holding in mind throughout this manual:

> *Keep a continuous dead-reckoning (DR) estimate of where the aircraft is, and discipline that estimate periodically with fixes from radio aids and the radar.*

Everything else serves that idea. An accurate, drift-managed **heading** is the foundation, because both the DR computer and the autopilot steer from it. On top of heading sits the **NI-50**, which turns heading, airspeed and wind into a live position. Around both sit the **radio bearing pointers** and the **radar**, which provide independent fixes the navigator uses to correct the heading reference and reset the position. The job in flight is the rhythm of estimate → fix → correct → estimate.

## 2. The Systems

### 2.1 KS-6 Course System — the master heading source

The КС-6 (KS-6) is the heart of the station. It produces a gyro-stabilised heading and distributes it to every heading repeater (USH, UK-1, the RMI cards), to the NI-50, and to the autopilot's course channel. Because so much hangs off it, most of the navigator's heading work is really КС-6 management.

It runs in one of three modes, selected on the PU-1 control panel:

- **GPK — free directional gyro.** The gyro holds its orientation in space and the heading is read against it. This is the orthodromic (great-circle) mode used for long cruise legs and for high latitudes where magnetic information is poor. Its weakness is **apparent drift**: the Earth turns under the fixed gyro, so the reading slowly walks off and must be re-synchronised periodically and compensated for latitude.
- **MK — magnetic correction.** The gyro is slaved to the aircraft's magnetic heading, corrected to true by the declination set on the КМ-4. It is self-correcting and drift-free, but carries the usual magnetic vices (turning and acceleration errors, local anomalies). It suits shorter, loxodromic legs and is the natural mode for erecting and aligning on the ground.
- **AK — astro correction.** The datum is driven toward an astrocompass reference Used as a heading discipline on very long, radio-silent stretches. In this mode, the KS-6 functions as the GPS source in the simulator.

**Main and reserve gyros.** The system carries two gyro units. A **Main / Reserve selector** chooses which one feeds the displays and the autopilot, giving redundancy. The reserve channel carries the magnetic-plus-declination heading, so it doubles as a magnetic cross-check. The pilot can select between Main and Reserve gyro with the gyro selector switch on the main instrument panel.

**Smooth re-alignment.** When you change mode or press SYNC on the PU-1, the datum is rate-limited as it re-aligns (a gentle slew rather than a jump). This is deliberate: it keeps the heading repeaters and the autopilot from being jolted when you re-reference the gyro in flight.

**What it outputs.** A true-referenced gyro heading (with meridian convergence added before it reaches the cards — see 2.7) and a separate magnetic reserve heading.

### 2.2 PU-1 Control Panel

The PU-1 is where the navigator commands the КС-6:

- **Mode knob** — GPK / MK / AK (GPS).

- **Course-set / course-assign switch** — nudges the gyro datum to a known value (setting a runway heading, or a small manual correction).
- **Latitude and hemisphere selectors** — feed the earth-rate compensation. In GPK the gyro's apparent drift depends on latitude and hemisphere; setting these cancels most of it automatically.
- **SYNC button** — snaps the gyro datum onto the current magnetic-corrected heading. The primary tool for re-aligning the free gyro in flight.

### 2.3 KM-4 Correction Mechanism

Sets the magnetic declination, ±15°. In МК mode it converts magnetic heading to true. Declination changes along any long route, so this is not a set-and-forget value — it must be kept current as the aircraft crosses isogonic lines. In reality, the KM-4 had its own control panel, usually positioned next to the navigator's instrument panel, but in the simulation its function is incorporated into the UGA-1U gauge on the navigator's panel.

### 2.4 GPK-52 Directional Gyro — independent backup

A self-contained gyro-half-compass that provides a heading independent of the KC-6. Its value is as a cross-check and a fallback: if you suspect the KC-6 datum, the GPK-52 gives a second opinion, and if a KC-6 gyro fails it carries the heading. The control panel of the GPK-52 is located above the navigator's main instrument panel.

### 2.5 NI-50 Navigation Indicator — automatic dead reckoning

The NI-50 is an air-data dead-reckoning computer. Given the aircraft's true airspeed and the **wind the navigator sets into it**, it continuously integrates the aircraft's motion relative to the planned track and drives two counters:

- **S** — distance made good along the route (the path / thousands counter).
- **Z** — lateral deviation, left or right of the set track. (hundreds counter).

In use, the navigator sets the leg's wind (direction and speed) and the desired track, confirms the airspeed source, and **zeroes the counters over a known fix** to begin a fresh DR run. Between radio fixes, S and Z are the aircraft's position estimate — and that estimate is only as good as the wind the navigator has fed it, which is why wind updating is a constant chore.

### 2.6 Heading and Bearing Repeaters

- **USh — the navigator's bearing instrument.** A rotating compass card (driven by the KC-6 heading plus convergence) carrying the two VOR bearing pointers and a course / OBS readout. The navigator's primary situational display. Two indicator lamps on the navigator's panel serve as VOR signal validation flags.
- **UK-1 — pilot / copilot course indicators (RMI-type).** A compass card with an autopilot-track needle (the autopilot's commanded heading in the gyro frame) and a course (VOR bearing) needle.
- **RMI / main-panel bearing needles and the ADF (ARK) radio-compass pointers** — point to tuned NDBs.

### 2.7 Meridian Convergence and Declination — the geometry that makes it agree

Two corrections let the gyro world, the magnetic world and the chart read the same heading:

- **Declination** ties **magnetic to true**. It is what KM-4 applies in MK mode and what you carry in the flight log per segment.

- **Meridian convergence** is needed for **orthodromic (GPK) flight**. A free gyro holds a constant direction in space, but the meridians fan together toward the poles, so the angle between your reference meridian and your present meridian grows as you fly. Adding the convergence angle keeps the cards reading correctly against the local meridian even though the gyro has not moved.

Together these are why the main (gyro) heading, the magnetic reserve and the paper chart can be made to coincide

For the sake of making it more convenient in the simulator, these values are displayed on the screen of the "drift scope" on the navigator's radar control panel. The datum of the meridian convergence is defaults to the flight's stating position, but can be reset with the "Reset" switch on the same panel.

### 2.8 Navigator's Radar

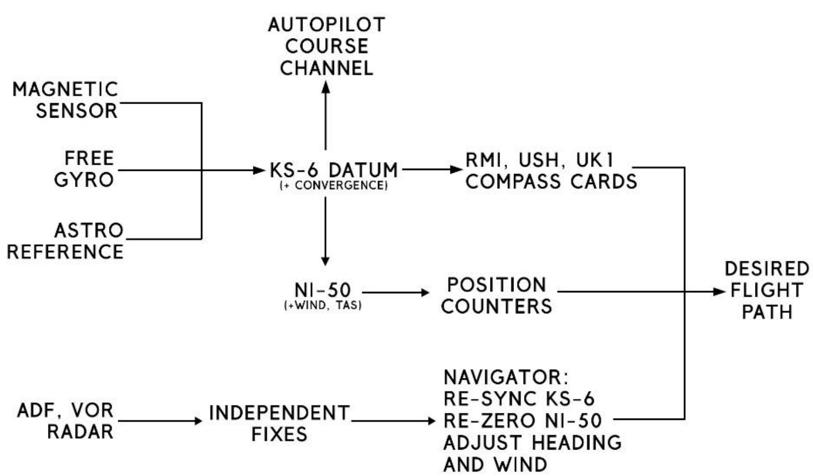
The radar provides navigation as well as weather. Its modes are **weather**, **terrain (ground-mapping)** and **traffic**. Ground-map is the navigation tool: coastlines, rivers and large towns give a **radar fix**. The drift scope's purpose originally was to help calculate the ground speed and drift caused by the wind. The navigator took the altimeter reading, picked a landmark feature on the ground and with a watch, measured the movement of that landmark across the scope with markers. Then set the calculated ground speed and the wind data into the NI-50 system. In the simulator, readout already shows **ground speed** and the **wind** (direction and speed). Allow about fifteen seconds of warm-up before the picture is usable.

### 2.9 Autopilot Coupling (AP-6E course channel)

The autopilot's course channel takes its heading reference from the same KC-6 (or GPK-52) datum the navigator manages. The coupling is built so that when the navigator re-synchronises, changes mode, or moves the gyro datum, the change is folded in **without commanding a turn** — the aircraft holds its commanded magnetic heading while the underlying datum shifts. In practice the navigator's heading housekeeping and the pilots' autopilot live in one heading world and do not fight each other.

### 2.10 How it all connects (data flow)

The KC-6 produces heading; the NI-50 turns heading into position; the radio pointers and radar provide outside truth; the navigator closes the loop by correcting the heading reference and the DR counters:




That loop is the whole job.

## 3. Pre-flight Preparation

### 3.1 Data to prepare before walking to the aircraft

Assemble the following in the flight log, leg by leg:

1. **Track angles** for each leg — the planned magnetic / true track, and for GPK legs the orthodromic track from your reference meridian.
2. **Leg distances and turning points.**
3. **Reference meridian and convergence angle** for each orthodromic leg.
4. **Magnetic declination** for each segment.
5. **Forecast winds aloft** — direction and speed at cruise level for each leg.
6. **Cruise true airspeed** schedule.
7. **Initial position** — the departure point or a known start fix.
8. **Latitude band and hemisphere** for the route.
9. **Radio aids** — NDB / VOR frequencies and idents for departure, en-route and arrival, plus the radar landmarks you intend to fix on.

### 3.2 Setting it into the systems — order matters

Follow this order; several steps depend on the ones before them.

1. **Power up** the gyro system.
2. **Select the Main gyro** (Reserve held as backup).
3. **Choose the working mode.** A common technique is to erect and align in MK on the ground, then switch to GPK for the orthodromic cruise. Use MK throughout for short, magnetic-friendly routes.
4. **Set latitude and hemisphere** on PU-1 (the earth-rate compensation for GPK).
5. **Set the departure declination** on KM-4.
6. **Align the heading.** In MK, let the system slave to magnetic. Alternatively set the known parking / runway heading with the course-set, then press **SYNC** so the datum matches the magnetic-corrected heading.
7. **Set up the NI-50.** Enter the first leg's **wind** (direction and speed) and **track**, confirm the **airspeed source**, and **zero the S and Z counters** over the start fix.
8. **Tune the first radio aids.** Confirm the bearing pointers come alive — they should lift off the horizontal park and point at the stations. Verify validity of signals.
9. **Cross-check the three headings.** KC-6 Main, the reserve / magnetic channel, and the GPK-52 should all agree within tolerance before taxi. A disagreement now is far cheaper to resolve on the ground than airborne.

## 4. In-flight Workflow

The flight is run as a repeating **navigation cycle**, tightened around waypoints. Nothing here is exotic; the discipline is in doing it regularly rather than waiting until the picture has drifted.

### 4.1 The periodic cycle (continuously through a leg)

**Watch the DR.** Read S and Z (travelled distance and drift) on the NI-50 and compare to the plan. Z is your lateral error from track — steer to keep it small; S drives your ETA.

**Keep the heading honest.** This is mode-dependent:

- In **GPK**: re-SYNC to magnetic at regular intervals (a typical habit is every fifteen to twenty minutes, and always shortly before a fix) to cancel the free gyro's drift. Update the **latitude** setting when you change latitude band, and update the **KM-4 declination** as you cross isogonals.
- In **MK**: confirm the system is slaving and watch for magnetic disturbance or turning / acceleration errors; still keep the declination current.

**Update the wind.** The NI-50 is only as good as its wind. From observed **drift** and **ground speed** (the scope readout gives both, or derive ground speed from fix-to-fix timing), recompute the actual wind and feed the corrected figures back in. Stale wind is the most common cause of a DR plot quietly going wrong.

**Take a fix.** Cross-cut two ADF / VOR bearings, or take a radar fix off a mapped landmark, and compare with the NI-50 / DR position.

**Correct.** At a good fix: re-zero the NI-50 counters to the known position, adjust heading to regain track, and revise ground speed and ETA. This is the moment the cycle closes.

### 4.2 At each waypoint / turning point

1. Confirm you are overhead by a fix.
2. Re-zero the NI-50 to the waypoint.
3. Set the **next leg's track and wind** into the NI-50.
4. Set the next leg's **declination** (KM-4) and **convergence**.
5. **SYNC** the gyro.
6. **Retune** the radios for the next segment and confirm the pointers re-acquire.

### 4.3 Habits, tolerances and fallbacks

- **Trust the DR, but discipline it.** The NI-50 plot is your continuous truth between fixes; the fixes exist to correct it, not to replace it.
- **Keep three things current:** the gyro sync, the declination, and the wind. Most navigation error traces back to one of these going stale.
- **Cross-check sources** rather than believing a single instrument — heading against the reserve and GPK-52, DR position against radio and radar.
- **Fallbacks:** A KC-6 gyro failure → the reserve gyro or the GPK-52.

  Loss of radio aids → continue on DR and tighten the sync / wind discipline

  Magnetic disturbance or high latitude → favor GPK with frequent astro / visual discipline.

  Radio-silent ocean legs → ГПК + НИ-50 + astro is the classic combination.

## 5. Quick Reference

**Pre-flight set order:** Power → Main gyro → mode (MK to align, GPK to cruise) → latitude / hemisphere → declination (KM-4) → align & SYNC → NI-50 wind / track / TAS & zero → tune radios → cross-check three headings.

**Every-leg cycle:** Read S / Z → sync / latitude / declination as due → update wind → take a fix → re-zero NI-50 → correct heading & ETA.

**At each waypoint:** Fix overhead → re-zero NI-50 → next-leg track & wind → next-leg declination & convergence → SYNC → retune radios.

**If something fails:** Gyro → reserve gyro / GPK-52; radio → DR on NI-50; magnetic trouble → GPK; long silent leg → GPK + NI-50 + astro.

# Worked Examples

*These walk the systems through real flying. The first leg is the primary worked example, set up and flown in full; Scenarios 2 and 3 add a high-latitude case and a radio-silent case, detailing only the discipline that changes. Speeds and distances are in km/h and km to match the cockpit; numbers are representative, the procedure is the point.*

## Scenario 1 — A standard mid-latitude cruise leg

### The leg at a glance

Two en-route reporting points, **ALPHA → BRAVO**, taken from the navigator's chart and flight log:

| Item | Value | Where it comes from |
|---|---|---|
| Desired track (true) | 075° T | route line on the chart |
| Distance | 420 km | measured ALPHA→BRAVO |
| Magnetic declination | +6° E | isogonals on the chart (or drift scope display) |
| Desired track (magnetic) | 069° M | 075 − 6 |
| Forecast wind (cruise) | 290° / 70 | upper-wind forecast |
| Cruise TAS | 600 | cruise schedule |
| Reference meridian | ALPHA's meridian | chosen for the orthodromic run |

From the forecast wind and TAS the navigator works the wind triangle (on the NI-50 / wind computer):

- The wind is from the left-forward quarter, blowing the aircraft slightly **right** of track, so crab **left**: wind correction ≈ **4° left**.
- **Heading to fly: 071° T = 065° M.**
- Tailwind component ≈ 57, so **ground speed ≈ 656**.
- Time ALPHA→BRAVO: 420 ÷ 656 ≈ **38 min** → the first ETA.

So before the aircraft moves, the navigator already knows: fly **065° M**, expect **656** over the ground, expect **BRAVO in 38 minutes**.

### Before engine start — dialing it in

Following the manual's set-up order, with this leg's numbers:

1. **Power up**, let the gyros erect; start the radar warming.
2. **Select the Main gyro.**
3. **Mode MK** to align on the ground (we go to GPK once airborne).
4. **Latitude / hemisphere** set on PU-1 for the route band (northern, mid-latitudes).
5. **KM-4 declination → +6.** Now magnetic reads as true.
6. **Align:** let MK slave to magnetic; confirm the heading matches the known parking heading, **SYNC**.
7. **NI-50 set-up:** enter **track 075**, **wind 290 / 70**, confirm **TAS 600**, and **zero the S and Z counters** — to be zeroed again exactly overhead ALPHA.

8. **Tune radios:** the ALPHA NDB and the first en-route VOR. Confirm the bearing pointers lift off the horizontal park and point at the stations; the USh VOR indicator lamp is ON.
9. **Cross-check:** KC-6 Main, the magnetic reserve, and the GPK-52 all read within a degree or two. Ready to taxi.

### Departure and top of climb

Climbing out, the navigator keeps the NI-50 fed and, levelling at cruise, **switches the KC-6 to GPK** for the orthodromic run, pressing **SYNC** at the moment of the switch so the free-gyro datum starts matched to magnetic. **Overhead ALPHA**, the S and Z counters are **zeroed** — the DR clock for this leg now starts from a known point. Heading **065° M**, ground speed about **656**, ETA BRAVO at **+38 min**.

### Cruise — first cycle

A few minutes along, the routine pass:

- **NI-50: S** climbing steadily, **Z** near zero — tracking well.
- **Heading:** in GPK, **SYNC** is due on the ~15–20-minute habit; the datum nudges only a fraction of a degree, so drift is small. Declination still +6, latitude band unchanged.
- **Wind:** scope readout shows ground speed and wind close to plan. Nothing to change.

No fix needed yet; the DR is trusted. On to the next pass.

### The halfway fix

About **20 minutes** in, the navigator takes a proper fix: a **VOR / NDB cross-cut**, backed by a **radar landmark** (a river bend on the ground-map). Two things come out of it, and neither matches the plan:

- The fix puts the aircraft **12 km right of track** — but the NI-50's **Z reads only +3 km right**. The DR has under-counted the drift.
- The aircraft reached the abeam point (210 km along track) in **20.5 min**, not the planned 19 — so the **actual ground speed is about 614**, lower than the planned 656.

Both symptoms point the same way: **the wind is not what was forecast.** Less tailwind and more right-drift means the wind has **veered and strengthened**. Working it backwards from the observed drift and ground speed, the navigator gets an **actual wind of about 330° / 80**.

Now the corrections, in order:

1. **Re-compute the heading** for the new wind to hold track 075° T: the crab grows to about **7° left**, so **heading 068° T = 062° M**. Ground speed settles around **616**.
2. **Regain track:** the aircraft is 12 km right, so steer a few degrees further left — say **058° M for a couple of minutes** — to converge, then settle on **062° M**.
3. **Update the NI-50 wind** to **330 / 80** so the DR stops under-counting drift.
4. **Re-zero the NI-50** to the fix position — the DR now restarts from known truth rather than from accumulated error.
5. **SYNC the KC-6** while you are at it, so the heading reference is fresh for the second half.
6. **Revise the ETA:** 210 km remaining at ~616 → about **20.5 min**, so BRAVO is now a couple of minutes later than first planned.

That single fix is the whole philosophy in miniature: the DR had quietly drifted because its wind was stale; an outside fix exposed it; the navigator corrected the heading, refreshed the wind, and re-zeroed the position. Estimate → fix → correct → estimate.

### Second half and arrival

Settled on **062° M**, wind **330 / 80** in the NI-50, the navigator runs the cycle again: Z should now hold near zero, one more **SYNC** before BRAVO, declination checked (still +6). Approaching BRAVO the navigator confirms the point with a final cross-cut and radar, then, **overhead BRAVO**, performs the waypoint drill — re-zero the NI-50, set the **next** leg's track and wind, set its declination and convergence, SYNC, and retune the radios.

### What this leg shows

- The planning numbers are not decoration — each is **physically dialed into a specific device** (declination into KM-4, wind and track into the NI-50, heading flown off the KC-6), and together they produce the heading, ground speed and ETA.
- The **NI-50 is only as honest as its wind.** The error here was not a broken instrument — it was a forecast wind gone stale, which the DR faithfully propagated into a 12 km cross-track error.
- A **fix** is what makes the system self-correcting. Without the cross-cut and radar, the navigator would have flown on believing $Z \approx 0$ and arrived well right of BRAVO.
- The **gyro discipline** and the **DR discipline** are the two habits that keep the picture accurate. Let either lapse and the plot drifts; keep both and the aircraft stays on track between fixes minutes apart.

## Scenario 2 — A high-latitude GPK leg, where the sync discipline matters

**The setting.** A leg in the far north, crossing from about 70° N to 74° N. Two things change from the mid-latitude leg. The magnetic compass becomes unreliable — declination is large and shifting fast, and the needle grows sluggish as you approach the magnetic pole. And the free gyro's apparent drift from the Earth's rotation is large: it rises with latitude, reaching roughly 14° per hour near 70° N before compensation. The heading reference is therefore the free gyro in GPK, flown as a grid heading and disciplined by astro correction — **not** by magnetic.

**What you set differently.**

- Hold GPK throughout; do not drop to MK, because magnetic is not trustworthy here.
- Keep the PU-1 **latitude setting current**. The earth-rate compensation is computed from it, and at these latitudes the figure changes quickly; a stale setting quietly lets the gyro drift.
- Tighten the sync interval to roughly every ten minutes instead of twenty — there is less margin before drift matters.
- Sync against the **astro** reference AK or a positively identified fix, never against the magnetic compass.

**Complication.** Twenty minutes in, the grid heading and an astro line disagree by about two degrees. The reflex carried over from the mid-latitude leg is to press SYNC and let the system slave to magnetic — but at 73° N the magnetic heading is garbage, and that "correction" would slew the gyro by several degrees of nonsense. The navigator catches it. Instead they re-sync to the **astro** reference, and — finding the PU-1 latitude still set to 68° N from before the climb while the aircraft is now at 73° N — updates the latitude so the earth-rate compensation tracks again, then re-zeros the NI-50 at the fix.

**Conclusion.** Up here the rules invert: magnetic is not a sync source, it is a trap; the free gyro plus astro plus a current latitude is the heading reference, and it has to be tended about twice as often. The orthodromic GPK mode that was a convenience at mid-latitude is now a necessity.

## Scenario 3 — A radio-silent stretch on pure dead reckoning

**The setting.** A long over-water or over-wilderness leg — two and a half hours with no NDB, no VOR, and no radar landmarks to fix on. For most of that time the NI-50 dead-reckoning plot is the only statement of where the aircraft is, and its accuracy rests entirely on the wind fed into it.

**What you lean on.**

- **Wind is everything.** With no fixes to re-zero against, any error in the set wind integrates straight into position. Measure the actual wind by drift observation every thirty to forty minutes and feed the corrected figures to the NI-50.
- **Astro for heading.** Over a leg this long the gyro will wander with no positional cross-check to expose it, so discipline the heading with astro A rather than letting it run open-loop.
- **Astro for position.** The only position truth out here is the periodic astro fix — plan one roughly hourly. Between fixes it is pure DR, and you accept that the error grows with time.

**The arithmetic that makes the point.** Position error from a wind error grows at about the size of that error per hour: a 10 km/h error in the wind becomes roughly 10 km of position error after an hour, and some 25 km over the leg. Nothing corrects it until the next fix — so the whole game is keeping the wind honest and the fixes regular.

**Complication.** At the first astro fix, one hour in, the aircraft is 18 km right of and a little short of the DR position. That 18 km over one hour is, in effect, an 18 km/h error in the wind vector the NI-50 had been using. The navigator works the actual wind back out of that displacement, updates the NI-50, re-zeros it to the astro fix, and — having seen how fast it built — shortens the wind-check interval for the next hour. Then back to pure DR until the next fix.

**Conclusion.** Without radio aids the system has no self-correction except what the navigator supplies by astro and by disciplined wind-keeping. The DR will hold a tidy plot whether or not it is right; only the wind work and the hourly fix keep “tidy” and “right” the same thing.

## Across the three scenarios

The same loop runs through all three, but a different part of it carries the weight each time. On the standard mid-latitude leg the work is **balanced routine** — read, sync, update wind, fix, correct. On the high-latitude leg the **heading and gyro discipline** dominates, because the magnetic reference has fallen away and the gyro drifts fast. On the radio-silent leg the **wind and DR discipline** dominates, because the fixes that normally bail you out are gone. The system is one method whose emphasis shifts with the conditions, rather than three separate procedures to memorize.

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