



C-O CHECK

GNSS · GYRO · MOTION · C-O

User Manual

Sensor calibration and verification
for GNSS, gyros and motion sensors

Version 1.0 · formerly The Sensor Checker

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1 Introduction

C-O Check does the daily comparison of a vessel's navigation sensors from one logged file. Open the file, choose the reference sensor and the sensors to check, and the program works out the C-O and the statistics and makes a PDF report. It replaces copying logged data into comparison spreadsheets, and gives the same answers.

Comparison	What is compared	Main results
GNSS	The easting, northing (and height) of two positioning systems	Mean ΔE / ΔN / ΔH , the mean offset and its bearing, 2DRMS, spread
Gyro	The headings of two gyros or heading sensors	Heading C-O and standard deviation
Motion (MRU)	The pitch and roll of two motion sensors	Pitch and roll C-O and standard deviation

Every check is one of two kinds, and the program asks which when it starts:

Purpose	Use it to...	The report gives
Calibration	find the C-O of each checked sensor against the reference, to enter in the navigation software.	The new C-O for each sensor, and whether it was accepted.
Verification	check that the C-Os already in the navigation software are still right.	PASS or FAIL for each comparison against your limits, and an overall result.

The file can hold any number of GNSS, gyro and motion sensors, in any order. The log can be long or short, taken alongside (static) or under way (dynamic), with or without a date column.

Note

C-O Check was called **The Sensor Checker**. Only the name and the look have changed: your settings, saved jobs, limits and licence carry straight on.

2 Getting started

2.1 What you need

- A Windows PC.
- The program file, **C-O-Check.exe**. Nothing else needs to be installed.
- A logged comparison file from the navigation software, for example an .NPD file or a comma separated .txt / .csv file.

2.2 Installing and starting

Copy **C-O-Check.exe** into a folder of your choice and double-click it. There is no installer. You can also drag a logged file onto C-O-Check.exe (or its shortcut) to open the program with that file ready.

Tip

For quick access, right-click C-O-Check.exe and choose **Send to > Desktop (create shortcut)**, or pin it to the Start menu or taskbar.

Note

The first time you start the program, Windows may show a **Windows protected your PC** message. Click **More info**, then **Run anyway**.

2.3 The main window



The main window, here on the GNSS tab of a verification.

Along the top are **Open logged file...**, **Sensors...**, the purpose and check type in use (for example VERIFICATION - static), the overall result and **Create PDF report....** Below are six tabs:

Tab	What it is for
Job	Calibration or verification, and the job details printed on the report.
Data	The file: its times, epochs and gaps, the sensors found, the part of the log to use, static or dynamic, and the Columns window.
GNSS	The GNSS reference and the systems to check, with the results and graphs.
Gyro	The gyro reference and the gyros to check, the applied C-Os, results and graphs.
Motion	The MRU reference and the MRUs to check, the applied pitch and roll C-Os, results and graphs.
Limits & Report	The PASS / FAIL limits and the button to make the PDF report.

The results are worked out again straight away whenever you change a selection, a C-O or a limit. There is no Calculate button.

3 A check, step by step

The start screen: choose the purpose, static or dynamic, then open the file.

1. Start the program. Click **CALIBRATION** or **VERIFICATION**, and choose **Static (alongside)** or **Dynamic (under way)**.
2. Click **Open the logged file...** and choose the file. (If you dragged a file onto the program, click **Start**.)
3. If anything about the file needs checking, such as a column with no heading or no date, the **Checking the file** window says so (section 4.5).
4. In the **Choose the sensors** window, pick the reference (the calibrated instrument) of each type and tick the instruments to check (section 6).
5. On the Data tab, check the sensors found and the times. Trim the start or end of the log if needed.
6. On the Gyro and Motion tabs, type the C-Os applied in the navigation software where asked.
7. In a calibration, set **New C-O accepted?** to Yes or No for each sensor.
8. Fill in the Job tab, or pick a saved job, and check the Limits.
9. Click **Create PDF report...**, choose where to save it, and open it.

Tip

The job details, limits, applied C-Os and the sensors you chose are remembered, and can be saved as a named job, so the next day's check is usually just: open the file, look at the results, make the report.

4 The logged file

4.1 Files it reads

The program reads comma separated text with one line per epoch and a Time column (hh:mm:ss or hh:mm:ss.sss). It looks for the column headings in the first lines of the file:

- **.NPD files.** The header line lists each field as Type: Name: Component, for example *Position: Vessel Ref (Priority 1): East, Gyro: Vessel Heading or Motion: MRU1 (Vessel) R*. Fields that follow without a type (North, Height, P, H) belong to the sensor before them. The date in the header is used as the date of the log.
- **Other text files with a heading line**, such as *Time, GPS1 East, GPS1 North, Gyro1 Heading, MRU1 Roll, MRU1 Pitch*. The last word of each heading says what it holds; the rest is the sensor name.
- **Files with no headings.** The columns are numbered and you name them in the Columns window (section 4.4).

Words recognised in the headings:

Holds	Recognised words
Easting / Northing / Height	East, Easting, X · North, Northing, Y · Height, Hgt, H, Z, Elevation, Alt

Holds	Recognised words
Heading	Heading, Hdg, Gyro, Course
Roll / Pitch / Heave	Roll, R · Pitch, P · Heave (H after a motion sensor is heave)
Time / Date	Time, UTC · Date

4.2 Sensors

Columns with the same sensor name make one sensor. A sensor with an easting and northing is a GNSS, one with a heading is a gyro, and one with roll or pitch is a motion sensor. There can be any number of each, in any order in the file.

4.3 Dates and midnight

- If the file has a Date column (or a date and time in one column), the date is used.
- If not, the date at the start of an .NPD header line is used, then a date in the file name (for example ..._20260927_201139_C.NPD).
- If there is no date anywhere, the program asks for it when the file is opened. You can also type or correct it in the **Date** box on the Data tab.
- A log that runs past midnight is handled: when the time goes back to 00:00, the next day is assumed.

4.4 The Columns window

Click **Columns...** on the Data tab to see how every column has been read, and to change it. For each column, choose what it **Holds** and type the **Sensor name**. **Detect again** puts back what the program found; **OK** uses your changes.



The Columns window: what each column holds and the sensor it belongs to.

4.5 Columns with no heading, and no date

Logging software sometimes writes a field in every data line but leaves its name out of the heading line, so the data has more columns than the headings. When a file is opened the program checks for this, works out where the extra column is from the values (a date looks like a date, the eastings of two GNSS are close together, headings agree, and so on) and lines the headings up again. The **Checking the file** window says what it found:

- A date or time with no heading is used as the Date or Time, and the check carries on.
- Any other column with no heading is left out, and shown in orange in the Columns window. Click **Columns...** to say what it holds if you need it.
- No date in the file: type the date the data was logged. If a date was found in the file name, it is filled in for you to check.



A file with no date column: the date is taken from the file name, for you to check.

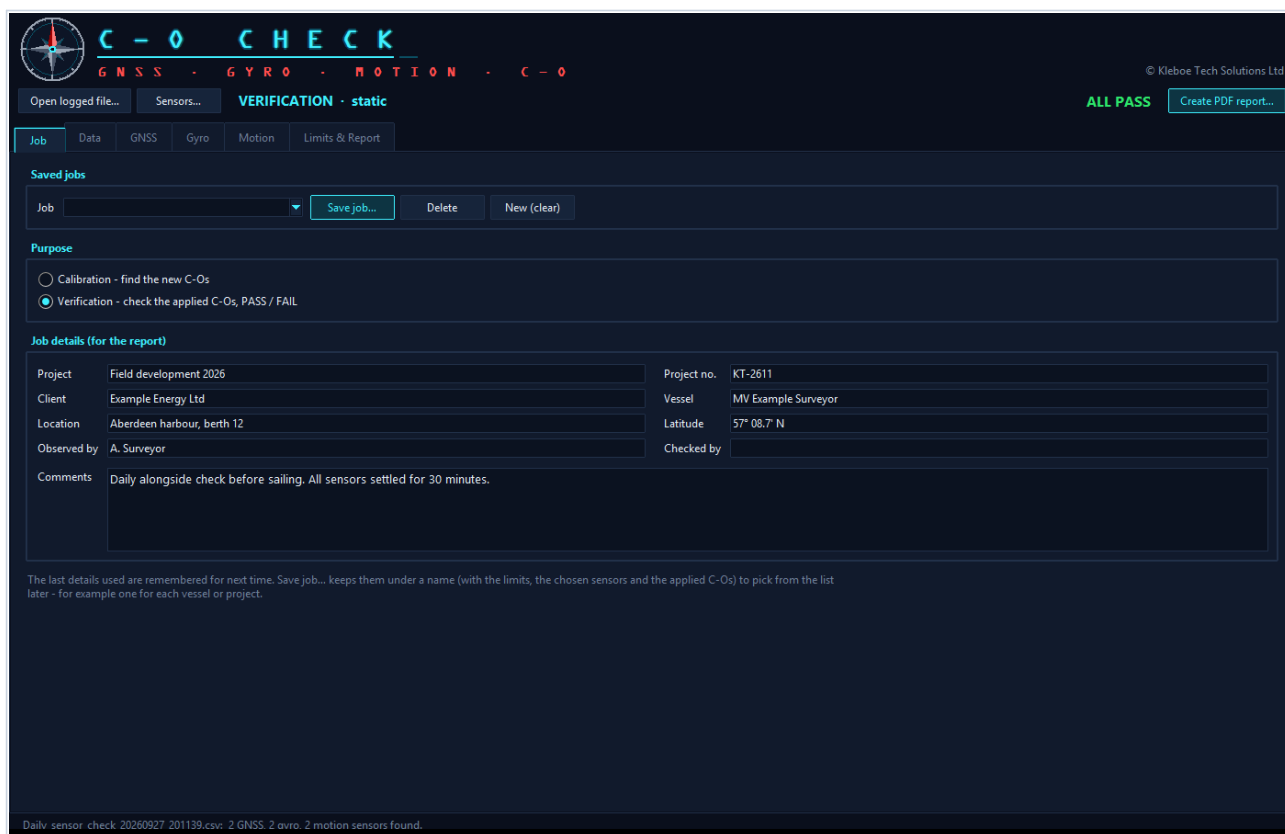
Note

If the extra column is just numbers that look like the columns either side, check the results and the Columns window, as the program can't always tell where it belongs.

5 The Job and Data tabs

5.1 Job

Choose Calibration or Verification (you can change it here at any time), and fill in the project, client, vessel, location, latitude, observed by and checked by, and any comments. These go at the top of the report. The last details used are filled in again the next time the program starts.



The screenshot shows the 'C - O CHECK' software interface. At the top, there's a compass icon and the title 'C - O CHECK' in large letters, with 'GNSS · GYRO · MOTION · C - O' below it. On the right, it says '© Kleboe Tech Solutions Ltd'. Below the title, there are buttons for 'Open logged file...', 'Sensors...', and 'VERIFICATION · static'. A green status bar indicates 'ALL PASS' and a button for 'Create PDF report...'. A tab bar at the top includes 'Job', 'Data', 'GNSS', 'Gyro', 'Motion', and 'Limits & Report', with 'Job' currently selected.

Saved jobs

Job: Save job... Delete New (clear)

Purpose

☐ Calibration - find the new C-Os
☒ Verification - check the applied C-Os, PASS / FAIL

Job details (for the report)

Project	Field development 2026	Project no.	KT-2611
Client	Example Energy Ltd	Vessel	MV Example Surveyor
Location	Aberdeen harbour, berth 12	Latitude	57° 08.7' N
Observed by	A. Surveyor	Checked by	
Comments	Daily alongside check before sailing. All sensors settled for 30 minutes.		

The last details used are remembered for next time. Save job... keeps them under a name (with the limits, the chosen sensors and the applied C-Os) to pick from the list later - for example one for each vessel or project.

Daily sensor check: 20260927 201139.csv: 2 GNSS, 2 gyro, 2 motion sensors found.

The Job tab.

5.2 Saved jobs

To keep the details for a vessel or project, fill them in and click **Save job...**, then give it a name. A saved job holds the job details, the limits, the reference and checked sensors and the applied C-Os.

- Pick a job from the **Job** list to fill everything in again.
- **Save job...** with the same name updates it, for example after a new C-O is accepted.
- **Delete** removes the selected job; **New (clear)** empties the job details for a new one.

5.3 Data



The Data tab: the file, the sensors found, the time window and an overview of the log.

- **Logged file** shows the start and end of the log, the part in use, the number of epochs, the logging interval and any gaps (breaks of more than five intervals).
- **Date:** the date of the log and where it came from (date column, file header, file name or typed in). If it isn't from a date column you can change it and click **Set**.
- **Sensors found** lists each GNSS, gyro and motion sensor and what it holds.
- **Use the data between:** type a start and end time (hh:mm:ss) and click **Apply** to leave out the start or end of the log, for example while the vessel was still moving. **Whole file** uses everything. The overview graphs shade the part in use.
- **Vessel:** static (alongside) or dynamic (under way). The mean speed and the largest rate of turn are shown; if a check marked static was taken with the vessel moving, it says so.

6 Choosing what to compare

When a file is opened, the **Choose the sensors** window asks, for each type, which sensor is the reference (the calibrated instrument) and which to check against it. Your last choice is filled in. Open it again at any time with **Sensors...** at the top of the window. Untick **Ask every time a file is opened** to skip it; your choices are still used.

Choose the sensors

For each type, pick the reference (the calibrated instrument) and tick the instruments to check against it.

GNSS

Reference (calibrated)
DGNSS 1

Instruments to check
☒ DGNSS 2

Gyro

Reference (calibrated)
Gyro 1

Instruments to check
☒ Gyro 2

Motion (MRU)

Reference (calibrated)
MRU 1

Instruments to check
☒ MRU 2

☒ Ask every time a file is opened

OK Cancel

The Choose the sensors window.

The same choices can be changed on the GNSS, Gyro and Motion tabs, which work the same way:

- **Reference** (the calibrated instrument): the sensor the others are compared with. The first sensor of each type in the file is chosen to start with.
- **Instruments to check**: tick each sensor to compare with the reference. Each ticked sensor is a separate comparison, with its own results, graphs and report page.
- **Graph**: when more than one sensor is ticked, choose which comparison to show.

6.1 Applied C-Os (gyro and motion)

Under each gyro or MRU there is a box for the C-O applied to it, in degrees:

Purpose	Box	What to type
Verification	C-O applied (°)	Optional: the C-O in the navigation software. The report then also gives the C-O it should be (applied + measured).
Calibration	C-O applied while logging (°)	Leave blank if the checked sensor was logged with no C-O. If one was applied, type it so the new C-O includes it.

6.2 New C-O accepted? (calibration)

In a calibration, each gyro heading, pitch and roll has **New C-O accepted?**. Set it to Yes or No once the result has been agreed; it is printed in the report.

7 GNSS

For each epoch the differences are reference minus checked (ΔE , ΔN and, if both have a height, ΔH). The results box shows:

Result	Meaning
Mean offset	The distance between the mean positions, with its bearing (from the checked system to the reference). Checked against the GNSS mean offset limit.
2DRMS	$2 \times \sqrt{SD(\Delta E)^2 + SD(\Delta N)^2}$: how much the difference wanders. Checked against the GNSS 2DRMS limit.
dE / dN mean, dH mean	The mean differences in easting, northing and height.
Spread	The largest horizontal difference in the accepted epochs.
Rejected	Epochs left out as outliers (section 12).

The graph on the left plots every ΔE / ΔN with the mean (+) and the 2DRMS circle; rejected epochs are red crosses. On the right, ΔE and ΔN against time show any drift or jumps. In the example in section 2.3, a few epochs of multipath

on DGNSS 2 have been rejected.

Note

GNSS comparisons are a check of two positions. They don't produce a C-O, so in a calibration the GNSS results are reported without a new C-O.

8 Gyro



The Gyro tab in a verification, with the C-O applied to Gyro 2 entered.

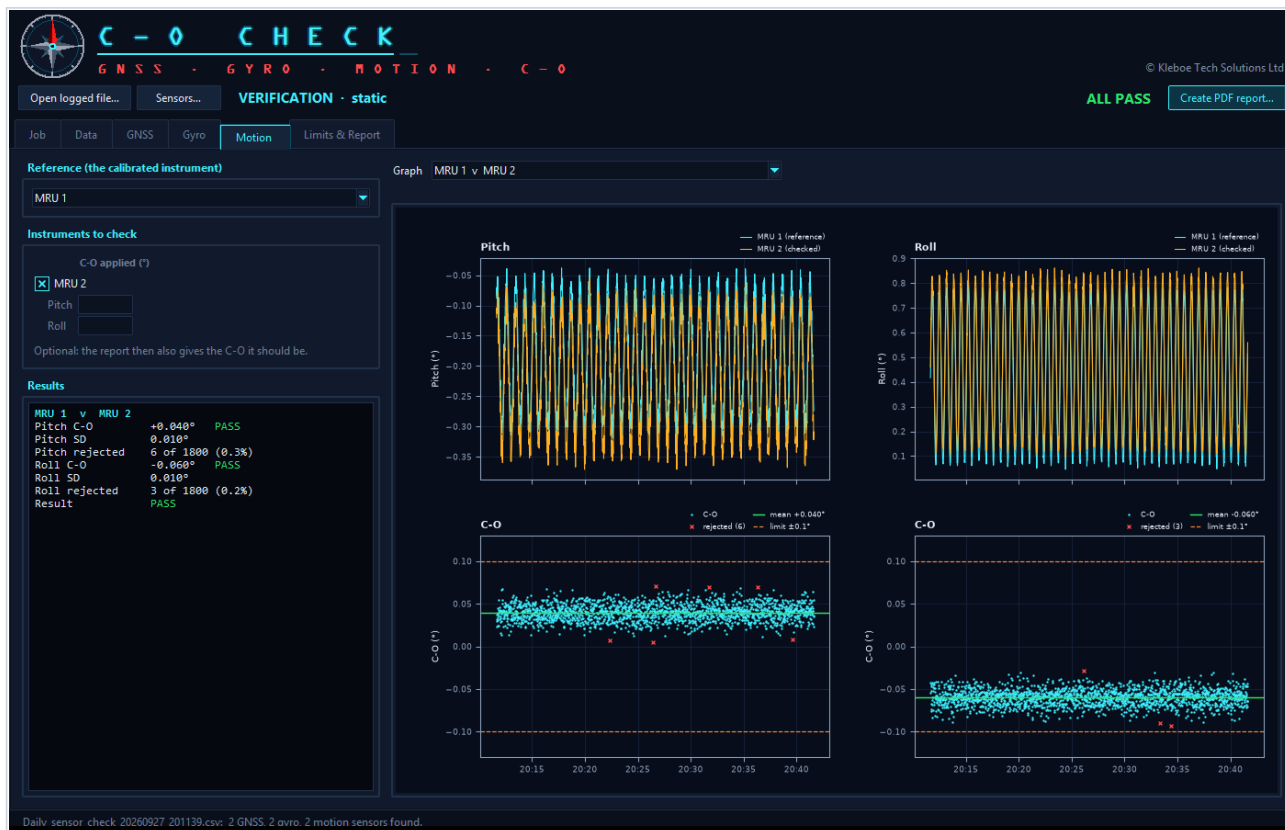
The C-O is the reference heading minus the checked heading, taken the short way round, so 359.9° against 0.1° is a C-O of -0.2° , not 359.8° . The top graph shows both headings; the bottom graph shows the C-O of every epoch with the mean (green), the limits (orange, in a verification) and the rejected epochs (red).

Result	Meaning
C-O	The mean C-O of the accepted epochs. In a verification, checked against the gyro heading C-O limit.
SD	The standard deviation of the accepted C-Os. Checked only if a gyro SD limit is set.
new C-O (calibration)	The C-O to enter for the checked gyro: the C-O applied while logging + the measured C-O.
should be (verification)	Shown when the applied C-O is entered: applied + measured.
Result	PASS or FAIL (verification).



The Gyro tab in a calibration: the new C-O, and New C-O accepted? for the report.

9 Motion



The Motion tab: pitch on the left, roll on the right.

Pitch and roll are compared separately, each as reference minus checked, with the same rejection and statistics as the gyro. A motion comparison passes only if both pitch and roll pass. Heave is read from the file but not compared. The applied pitch and roll C-Os, the new C-Os and **New C-O accepted?** work as for the gyro (sections 6.1 and 6.2).

10 Limits

The screenshot shows the 'Limits' tab with a list of parameters and their default values. A 'Restore the defaults' button is at the bottom. Below the limits, a note states: 'Use your company's or the client's limits - these are remembered. The PASS / FAIL is only given in a verification.' The 'Report' tab is also visible, with a description: 'One PDF with the summary, every comparison's statistics and graphs, and a sign-off table.' and a 'Create the PDF report...' button.

Parameter	Default Value	Unit / Description
Gyro heading C-O	0.2	°
Gyro heading SD	blank	
Pitch C-O	0.1	°
Roll C-O	0.1	°
Pitch / roll SD	blank	
GNSS mean offset	0.5	m
GNSS 2DRMS	1	m
Rejected warning	5	%
Rejection	3	SD

Restore the defaults

Use your company's or the client's limits - these are remembered. The PASS / FAIL is only given in a verification.

Report

One PDF with the summary, every comparison's statistics and graphs, and a sign-off table.

Create the PDF report...

The Limits & Report tab.

Type the limits used by your company or the client. Leave a box blank to not check that value. The limits are remembered; **Restore the defaults** puts back the starting values.

Limit	Default	A comparison fails when...
Gyro heading C-O	0.2°	the size of the mean heading C-O is more than this
Gyro heading SD	blank	the heading SD is more than this
Pitch C-O / Roll C-O	0.1°	the size of the mean pitch or roll C-O is more than this
Pitch / roll SD	blank	the pitch or roll SD is more than this
GNSS mean offset	0.5 m	the mean offset is more than this
GNSS 2DRMS	1.0 m	the 2DRMS of the differences is more than this
Rejected warning	5 %	(a warning only) more than this share of epochs was rejected
Rejection	3 SD	(not a limit) epochs further than this from the mean are rejected

Note

The defaults are starting values only. Set the limits from your project specification or procedures before you rely on a PASS or FAIL.

The result at the top of the window shows **ALL PASS**, or how many comparisons failed. PASS / FAIL is only given in a verification.

11 The PDF report

Click **Create PDF report...** (top right, or on the Limits & Report tab). The file name is filled in from the purpose, vessel and date; choose a folder and click **Save**, and the program offers to open it. One report covers all the comparisons:

- **Page 1:** the title (Sensor Calibration Report or Sensor Verification Report), the job details, the data (file, start and end, duration, epochs, interval, gaps, vessel movement), a results table for every comparison, the overall result, any comments and a sign-off table.
- **Then one page per comparison:** the statistics, the applied and new C-Os, PASS / FAIL or accepted, and the graphs.

SENSOR VERIFICATION REPORT

MV Example Surveyor · Field development 2026

Sensor Verification Report

MV Example Surveyor · Aberdeen harbour, berth 12 · 27/09/2026

Project	Field development 2026	Project no.	KT-2611
Client	Example Energy Ltd	Vessel	MV Example Surveyor
Location	Aberdeen harbour, berth 12	Latitude	57° 08.7' N
Purpose	Verification	Check type	Static (alongside)
Observed by	A. Surveyor	Checked by	

Data

Data file	Daily_sensor_check_20260927_201139.csv
Start / end	27/09/2026 20:11:39 to 27/09/2026 20:41:38 (UTC)
Duration	29 min 59 s, 1800 epochs at 1.0 s
Gaps in the data	none
Vessel movement	speed mean 0.17 kn, max 0.29 kn; heading range 0.6°, max rate of turn 0.3°/min

Results

Sensor	Reference	Checked	Result	SD	Obs.	Rejected	Limit	Pass / fail
GNSS	DGNSS 1	DGNSS 2	offset 0.142 m, 2DRMS 0.241 m	0.085 / 0.085 m	1800	5 (0.3%)	≤ 0.5 / 1 m	PASS
Gyro heading	Gyro 1	Gyro 2	C-O +0.080°	0.020°	1800	4 (0.2%)	±0.2 °	PASS
MRU pitch	MRU 1	MRU 2	C-O +0.040°	0.010°	1800	6 (0.3%)	±0.1 °	PASS
MRU roll	MRU 1	MRU 2	C-O -0.060°	0.010°	1800	3 (0.2%)	±0.1 °	PASS

ALL CHECKS PASSED

C-O = reference – checked, with both sensors' C-Os applied in the navigation software, so a valid C-O gives a result close to 0. Where the applied C-O was entered, the C-O it should be (applied + measured) is shown in each sensor's section.

Comments: Daily alongside check before sailing. All sensors settled for 30 minutes.

Sign-off

Name	Signature	Date
Surveyor	A. Surveyor	
Checked by		
Client representative		

C-O Check · Kleboe Tech Solutions Ltd

Page 1

The summary page of a verification report.

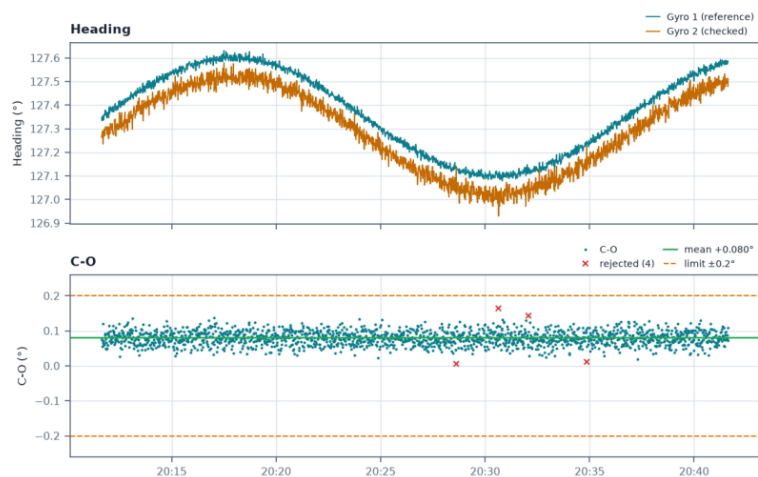
SENSOR VERIFICATION REPORT

MV Example Surveyor · Field development 2026

2 Gyro heading: Gyro 1 v Gyro 2

Reference **Gyro 1**, checked **Gyro 2**. Points more than 3 standard deviations from the mean are rejected.

	Heading
Start / end time	20:11:39 - 20:41:38
C-O min / max (all)	+0.006° / +0.164°
C-O mean / SD (all)	+0.0796° / 0.0200°
C-O mean (accepted)	+0.0796°
SD (accepted)	0.0198°
Observations / rejected	1800 / 4 (0.22%)
C-O applied in the navigation software	+0.050°
C-O it should be (applied + measured)	+0.130°
Result	PASS



A gyro page from the same report.

SENSOR CALIBRATION REPORT

MV Example Surveyor · Field development 2026

Sensor Calibration Report

MV Example Surveyor · Aberdeen harbour, berth 12 · 27/09/2026

Project	Field development 2026	Project no.	KT-2611
Client	Example Energy Ltd	Vessel	MV Example Surveyor
Location	Aberdeen harbour, berth 12	Latitude	57° 08.7' N
Purpose	Calibration	Check type	Static (alongside)
Observed by	A. Surveyor	Checked by	

Data

Data file	Daily_sensor_check_20260927_201139.csv
Start / end	27/09/2026 20:11:39 to 27/09/2026 20:41:38 (UTC)
Duration	29 min 59 s, 1800 epochs at 1.0 s
Gaps in the data	none
Vessel movement	speed mean 0.17 kn, max 0.29 kn; heading range 0.6°, max rate of turn 0.3°/min

Results

Sensor	Reference	Checked	Result	SD	Obs.	Rejected	New C-O	Accepted
GNSS	DGNSS 1	DGNSS 2	offset 0.142 m, 2DRMS 0.241 m	0.085 / 0.085 m	1800	5 (0.3%)	—	—
Gyro heading	Gyro 1	Gyro 2	C-O +0.080°	0.020°	1800	4 (0.2%)	+0.080°	Yes
MRU pitch	MRU 1	MRU 2	C-O +0.040°	0.010°	1800	6 (0.3%)	+0.040°	Yes
MRU roll	MRU 1	MRU 2	C-O -0.060°	0.010°	1800	3 (0.2%)	-0.060°	Yes

C-O = reference – checked. New C-O = the C-O applied to the checked sensor while logging (0 if none) + the measured C-O; enter it for the checked sensor in the navigation software. GNSS comparisons are a check of the two positions and are not converted to a C-O.

Comments: Daily alongside check before sailing. All sensors settled for 30 minutes.

Sign-off

	Name	Signature	Date
Surveyor	A. Surveyor		
Checked by			
Client representative			

The summary page of a calibration report, with the new C-Os and accepted.

Tip

If the report can't be saved, it is probably open in a PDF viewer. Close it and try again, or save with another name.

12 How the results are worked out

12.1 Gyro, pitch and roll

For every epoch in the time window where both sensors have a value:

$$C-O = \text{reference} - \text{checked}$$

Headings are wrapped into -180° to $+180^\circ$. Outliers are found from the mean and standard deviation of all the C-Os:

$$\text{standardised C-O} = |C-O - \text{mean}_{\text{all}}| / \text{SD}_{\text{all}}$$

An epoch with a standardised C-O above 3 (the Rejection setting) is rejected. The reported C-O is the mean of the accepted C-Os, and the SD is their sample standard deviation.

12.2 GNSS

$$\Delta E = E_{\text{ref}} - E_{\text{chk}} \quad \Delta N = N_{\text{ref}} - N_{\text{chk}} \quad \text{radial} = \sqrt{(\Delta E)^2 + (\Delta N)^2}$$

An epoch is rejected if its radial is more than 3 standard deviations from the mean radial and above the mean (small differences are never rejected). From the accepted epochs:

$$2\text{DRMS} = 2 \sqrt{(\text{SD}(\Delta E))^2 + (\text{SD}(\Delta N))^2} \quad \text{mean offset} = \sqrt{(\text{mean}(\Delta E))^2 + (\text{mean}(\Delta N))^2}$$

The spread is the largest radial. The report gives these for the raw data and after rejection, with the mean, SD, maximum and minimum of each system's easting and northing.

12.3 The new C-O

Purpose	Worked out as
Calibration	new C-O = C-O applied while logging (0 if blank) + measured C-O
Verification	C-O it should be = applied C-O + measured C-O (when the applied C-O is entered)

The sign convention is that a C-O is added to the sensor's reading to correct it to the reference.

12.4 Vessel movement

The speed is worked out from the reference GNSS positions and the rate of turn from the reference gyro, both smoothed over about 10 seconds so that position noise doesn't look like movement.

13 Trial and licence

The program runs as a free 48-hour trial with everything working. The bar under the title shows how long is left:

FREE TRIAL · 47 h 58 min left of your 48-hour trial

Buy the licence...

Enter licence key...

The trial bar.

After that it needs a Survey Software Utilities licence key: click **Enter licence key...**, paste the key from the email and click **Activate**. One key unlocks every Survey Software Utilities program on the PC, on up to 4 PCs. With a licence the bar goes, and the window title shows **Licensed until** and the date. The licence is checked online now and then and works for up to 30 days at a time without internet.

14 Troubleshooting

Problem	What to check
“Couldn't find the column headings”	The file needs comma separated lines with a time in hh:mm:ss. Check it is the logged data file.
“Column n has no heading in the file”	The logging software wrote a field without its heading. A date or time is used automatically; for anything else, set it in Columns... if you need it (section 4.5).
The date is missing or wrong	Type it in the Date box on the Data tab and click Set.
A sensor is missing or split in two	Open Columns... and give its columns the same sensor name and the right Holds.
“needs at least two sensors to compare”	Only one sensor of that type was found. Check the Columns window, or log the second sensor.
A sensor can't be ticked	It is the reference. Choose another reference first.
The C-O is about 180° or 360° out	Check that both columns are headings in degrees.
Many epochs rejected	Look at the C-O graph for jumps or a turn, and trim the time window to the steady part of the log.
The result says “Set the limits”	A verification needs at least one limit set for each comparison.
Times show without a date	The file has no date column or header date; the report gives times only.
The report won't save	Close it in the PDF viewer, or save with another name.